STATE OF MAINE

LAND USE PLANNING COMMISSION

IN RE: PICKETT MOUNTAIN MINE REZONING APPLICATION Applicant: Wolfden Mt. Chase LLC Location: T6R6 WELS Commission Application Number: ZP 779A	))))))	**PRE-FILED DIRECT TESTIMONY OF CATHERINE JOHNSON**

This pre-filed direct testimony of Catherine Johnson is submitted on behalf of Intervenors Penobscot Nation, Houlton Band of Maliseet Indians, Natural Resources Council of Maine, and Conservation Law Foundation, in opposition to the rezoning application ("Application") filed with the Land Use Planning Commission ("LUPC") by Wolfden Mt. Chase LLC, a wholly owned subsidiary of Wolfden Resources LLC (collectively "Wolfden"). Wolfden has proposed to rezone the current location from M-GM to D-PD to operate a metallic mineral mine. The purpose of D-PD subdistrict is to allow for "large scale, well-planned development."[1] The Commission can consider D-PD proposals provided they are not detrimental to other values established in the Comprehensive Land Use Plan ("CLUP"), and if they depend on a particular natural feature or location that is available at the proposed site.[2] Applications may be granted only when the location of the site is the best reasonably available for the proposed use *and* that the goals and policies of the Comprehensive Land Use Plan are served. Furthermore, the CLUP's goal

[1] LUPC Rules 10.21, H.
[2] *Id*.

pertaining to mineral resource mining is to only allow mining when there is “not overriding, conflicting public values which require protection.”[3]

The CLUP prioritizes the undeveloped character of the North Woods and the preservation of its natural resources, while allowing for recreational activities and economic activities based on outdoor recreation, forestry, and farming. Despite Wolfden’s contention that the location of the zinc deposit is the most important consideration of the rezoning, the CLUP requires the Commission to balance its four principal values and to avoid approving projects that will have undue adverse impacts on the area and its resources. The North Woods and the Katahdin region are important undeveloped wildlife and recreation areas, and Wolfden’s mine would threaten all that makes these areas unique.

I. QUALIFICATIONS

I worked for the Natural Resources Council of Maine (NRCM) as its Forests and Wildlife Project Director (formerly called North Woods Project) for 30 years before retiring in 2020. In that capacity, I participated in numerous legislative debates regarding LUPC’s governing statutes, and in policy development, planning processes, rulemaking, rezoning, and permitting proceedings before the Land Use Planning Commission (formerly the Land Use Regulation Commission), the Maine Forest Service, the Bureau of Parks and Lands, the Maine Natural Areas Program, and the Land for Maine’s Future program. I participated in the development of Land for Maine’s Future model conservation easement, and I reviewed the conservation easements for a large number of North Woods conservation easement projects, including the Pingree, West Branch, Katahdin Forest, and Down East projects.

[3] CLUP at 15.

I am very familiar with LUPC's Comprehensive Land Use Plan having been actively involved in the 1997 and 2010 revisions. I participated in multiple revisions of LUPC regulations and reviewed every significant development project proposed in LUPC's jurisdiction between 1990 and 2020. I actively participated on behalf of NRCM in multiple proposed significant development projects in LUPC's jurisdiction. For example, I directed NRCM's extensive involvement in Plum Creek's proposed concept plan for the Moosehead region, reviewed multiple revisions of that plan and the proposed conservation easement over five years, and was NRCM's principal witness in that proceeding. I also directed NRCM's involvement in the Fish River Chain of Lakes concept plan and was its principal witness in that proceeding as well.

I was also the Growth Management Project Director for NRCM for four years. In that capacity, I participated in numerous legislative debates, and rulemaking and policy development proceedings involving Maine's Growth Management Program. I evaluated draft comprehensive plans submitted by dozens of Maine towns to the state for certification. I authored portions and oversaw NRCM's publication of several handbooks for use by towns involved in growth management planning, as well as a periodical which addressed then current growth management issues.

I was concurrently a staff attorney for NRCM for 15 years and then the Senior Staff Attorney for NRCM for an additional 15 years, advising the organization on a variety of legal issues.

After retiring, I was appointed to the Town of Alna's Planning Board and currently serve as the Chair of the Alna Planning Board.

I received my bachelor's degree in human ecology from the College of the Atlantic in 1974 and my law degree from the University of Maine in 1983. Prior to working for NRCM, I was a trial attorney in Damariscotta, handling a wide variety of civil and criminal cases, including real estate disputes, timber trespass cases, and contract disputes. Before becoming a lawyer, I worked for the U.S. Forest Service as a forestry technician in the field, laying out forested areas to be pre-commercially thinned or sprayed with herbicides. I also planted trees for a private timber company.

I am an avid hiker, canoeist, camper, and cross-country skier. I have spent my entire adult life hiking, canoeing, back country skiing, and exploring Maine's mountains, forests, rivers, and lakes. I have been able to spend even more time enjoying these activities in Maine's North Woods since retiring.

II. MAINE'S NORTH WOODS ARE UNIQUE

Maine's North Woods (also known as the Wildlands of Maine) are the largest, relatively undeveloped forest in the U.S. east of the Mississippi. The size of the region with its forests, lakes, rivers, wildlife, and ecosystems in their natural condition make it unique. While there are blocks of undeveloped land in southern Maine and through the eastern U.S., Maine's North Woods include the largest area with a combination of natural ecosystems including alpine, forest, wetland, riparian, and river ecosystems. The size of this area is critical for allowing natural processes to continue and sustainable populations of wildlife to thrive, both of which are essential for the long-term conservation of biodiversity, which itself is the key to maintaining life on earth.

III. REZONING WOULD DEGRADE ALL FOUR OF THE PRINCIPAL VALUES OF THE JURISDICTION

The 2010 revision of the CLUP incorporated the vision for the jurisdiction from earlier CLUPs. The vision identifies four principal values: natural character, diverse, abundant and unique high-value natural resources and features, diverse and abundant recreational opportunities, and economic value derived from working forests and farmlands. These four values, "taken together, define the distinctive character of the jurisdiction" and are interconnected.[4] While the Commission must balance potentially competing priorities and values, the Commission cannot adopt or amend a land use district boundary if the proposed district is not consistent with the CLUP.[5]

A. Natural Character

The Commission's jurisdiction is a vast forested area that is largely undeveloped and remote from population centers. This natural character including remoteness and the absence of development is the most distinctive of the four principal values, because these types of areas are so rare in the Northeastern United States. These values may be difficult to quantify but they are integral to the jurisdiction's identity and to its overall character.[6]

The remoteness and general lack of development is conducive to natural resource protection, and provides a landscape for various forms of primitive recreation, such as hiking, canoeing, hunting, fishing, camping, and opportunities to simply get away from daily life filled with stress and an overabundance of technology. Allowing the rezoning of this area for industrial zinc mining would be the opposite of preserving the region's natural character.

B. Diverse, abundant and unique high-value natural resources and features

A second value defining the distinctive character of the jurisdiction is its diverse, abundant and unique high-value natural resources and features. These resources and features include lakes, rivers, wetlands, streams, fish, wildlife, plants, natural communities, scenic and cultural resources, and mountain areas. These resources and features are particularly valuable in

[4] CLUP at 2.
[5] 12 M.R.S. § 685-A(8-A)(A).
[6] CLUP at 2.

combination with each other in a large unfragmented landscape where they can survive and thrive over time, rather than in isolated areas.

Wolfden's proposed mine will fragment, destroy, and degrade critical habitats for Atlantic salmon and Canada lynx, as well as multiple water bodies, including Pleasant Lake, Mud Lake, Grass Lake, and Pickett Mountain Pond, and the West Branch of the Mattawamkeag River, which has important significance to the Penobscot Nation, and for Atlantic salmon. According to Wolfden's own report, the headframe of the mine will likely be visible from Pickett Mountain Pond, parts of Pleasant Lake, and the summit of Mount Chase.[7]

C. Diverse and abundant recreational opportunities

A third value defining the distinctive character of the jurisdiction is its diverse and abundant recreational opportunities. The Katahdin region, in which the proposed Wolfden mine is located, is extremely valuable for its abundance and diversity of recreational opportunities, with both motorized and non-motorized activities including both designated trails and dispersed primitive backcountry recreation.

The region around the proposed mine includes popular snowmobile, ATV, and hiking trails, and is also ideal for off-trail backcountry hunting, fishing, paddling and nature exploration. Large stretches of undeveloped land such as that found around Pickett Mountain provide unique opportunities both for long distance trails and for primitive recreation where solitude and remoteness are desired. Both Pleasant Lake and Mud Lake are used for backcountry fishing, paddling and camping.

D. Economic value derived from working forests and farmlands

[7] Stantec Consulting Services Inc., Land Use Planning Commission Application for Zone Change: Pickett Mountain Metallic Mine, LUPC No. ZP779A at 727 (Jan. 19, 2023) ("Application"). All Application page numbers cited refer to PDF pagination, not internal document pagination.

A fourth value defining the distinctive characteristic of the jurisdiction is the economic value derived from working forests and farmlands. This economic value is focused on maintaining working forests and farmland because that type of economic value is compatible and inter-connected with the other principal values. In fact, the four principal values can enhance each other. By contrast, any economic value Wolfden may claim is not the type of economic development that defines the distinctive character of the jurisdiction and would come at the expense of the other three principal values.

In addition to the four principal values, the CLUP promulgates a vision of a sustainable pattern of land use that retains the jurisdiction's unique principal values and is essential to achieving the Commission's vision for the future.[8] Wolfden's proposed mine is not a sustainable pattern of land use that will meet present and future needs without compromising the principal values of the jurisdiction.

IV. REZONING WOULD HAVE UNDUE ADVERSE IMPACTS ON MULTIPLE EXISTING USES AND RESOURCES

Both the relevant statute and rules require that the project not have an undue adverse impact on existing uses or resources.[9] In fact, the proposed mine would have significant undue adverse impacts on multiple existing uses and resources.

A. <u>The remote location of the proposed mine would have undue adverse impacts on the largest undeveloped forest in the U.S. east of the Mississippi.</u>

The Maine North Woods is the largest relatively undeveloped forest east of the Mississippi River. The proposed mine is in a remote section of the jurisdiction. In an effort to suggest that the location is not remote, Wolfden cites the town of Hersey, as only 4.5 miles away.

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[8] CLUP at 3.

[9] *See* LUPC 10.21, H ("the application for zone change must include . . . evidence that the proposed subdistrict will have no undue adverse impact on existing uses or resources"); 12 M.R.S. § 685-A(8-A).

Wolfden neglects to note that Hersey has a population of only 73 (as of the 2020 census). Patten, the vast region's service center located 14.5 miles from the proposed mine, has a population of only 881 (as of the 2020 census). The size of these communities and the distance from the mine suggests that this is the type of remote area the CLUP is intended to protect.

The application also suggests that because the area has been heavily logged, it is not remote or natural. While a heavily logged landscape in Maine will require time to recover, it will recover. Parts of Baxter State Park were heavily logged before they became part of the Park, yet today the Park has some of the most diverse, healthy and remote forests in the state.

If a new industrial facility is located in a remote area, the character of that area changes forever and that degrades the larger landscape. Project by project it leads to the loss of the large undeveloped forest that Maine still has. This type of incremental loss occurs over time but never-the-less results in an undue adverse impact.

B. The mine would have undue adverse impacts on Katahdin Woods and Waters National Monument

Katahdin Woods and Waters National Monument (KWW) is located approximately five miles southwest of the proposed mine site. It was established as a federally protected area of 87,500 acres in 2016 and since that time has seen steady growth in visitation. Even the application acknowledges "robust growth" in Maine's tourism economy between 2010 and 2021.[10] According to the application, tourism in the Patten area increased by almost 30% during that time period.[11] Visitors come to KWW for a remote, North Woods experience, dispersed recreation opportunities, a chance to see iconic wildlife such as moose, bear and neotropical breeding birds, its clean air and waters, its dark skies, and the opportunity to learn about its past

[10] Application at 301.
[11] *Id*. at 300.

including both its Wabanaki history and its more recent lumbering history. All of these uses would be degraded by the nearby establishment of an industrial mining operation resulting in an undue adverse impact of existing uses and resources.

In 2020, KWW was designated a Dark Skies Sanctuary by Dark Skies, a nonprofit organization that certifies Dark Sky places around the world.[12] Dark Skies Sanctuaries are the most remote (and often darkest) places in the world, and those whose conservation status is most fragile.[13] A Dark Skies Sanctuary has an exceptional or distinguished quality of starry nights. The Wolfden application fails to mention KWW's Dark Skies designation and has only cursory mention of lighting plans for the proposed mine. Wolfden claims that all lighting will be less than 160 watts and all lighting fixtures will face downwards, which they claim will minimize light pollution.[14] However, Wolfden did not study the potential impacts of this light pollution on the area. The lighting that would be needed to enable the type of 24 hour a day mining proposed by Wolfden and to ensure security of the mining site would threaten the dark skies of the region and KWW's Dark Skies Sanctuary, resulting in an undue adverse impact on the dark skies resource and KWW.

The proposed mine would also result in significantly more trucks, dust, and noise on Rt. 11 and in Patten, the gateway community for the north end of KWW. Virtually every visitor to the north end of KWW will pass through Patten. This increase in trucks, dust, and noise would degrade the region's North Woods "brand" of clear air, clean water, and quiet that brings visitors to KWW, Patten, and the surrounding region. This would result in fewer visitors to KWW and

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[12] *See Katahdin Woods and Waters National Monument*, DarkSky (May 8, 2020), https://darksky.org/places/katahdin-woods-and-waters-dark-sky-sanctuary/ (last accessed Sept. 21, 2023).
[13] *International Dark Sky Places*, DarkSky, https://darksky.org/what-we-do/international-dark-sky-places/ (last accessed Sept. 21, 2023).
[14] Application at 729.

would unduly adversely affect both the Monument and the local outdoor recreation economy that has grown since the designation of KWW.

Many food and lodging establishments, guides, outfitters, shuttle providers, and retail stores are dependent on visitors coming to the region for its remote unspoiled outdoor recreation opportunities, including hunting, fishing, hiking, paddling, wildlife and bird watching, dark skies viewing, ATV riding, and, in winter, cross country skiing, snowmobiling, snow shoeing and ice fishing. All of these small businesses would be unduly adversely affected by the proposed mine and the resulting degradation of the area's reputation. While the mine is only projected to operate for 10 – 15 years, the loss of the North Woods brand and mystique would last, affecting those businesses both in the immediate term and for many decades.

C. The proposed mine would have undue adverse impacts on the remoteness of the jurisdiction and remote recreational opportunities

In addition to Katahdin Woods and Waters, there are a variety of other remote recreational uses and resources that would be adversely affected by the proposed mine.

There is a very popular day hiking trail up Mt. Chase where hikers climb in both winter and summer. They climb the mountain for the spectacular views from the top. To the south stretch the undeveloped forests and mountains of KWW and Baxter State Park. To the north stretch undeveloped forests and views of Pleasant Lake. The proposed mine site would be directly below the summit, between the summit and the lovely view of Pleasant Lake. The above ground industrial facilities associated with the mine fragment the landscape and destroy the sense of endless forests and lakes that current hikers experience looking north from the summit.

The International Appalachian Trail (IAT), running from Baxter State Park to the Canadian border and beyond, is located just south of the proposed mine site and intersects the Mt. Chase hiking trail. Curiously, the application fails to even mention this international recreational resource. Long distance hikers on the IAT also hike the Mt. Chase trail and will be even more unduly adversely impacted by the view of an industrial mining facility in the otherwise relatively undeveloped landscape they are hiking through day after day.

The application also fails to acknowledge the existence of the recently upgraded Sebois River Trail. This trail has been dramatically improved in recent years with high quality amenities for users including a warming hut, an improved trail surface, parking area, and a designated picnic area. Significant investments in recreational infrastructure like these will be discouraged and have an undue adverse impact on the local recreational economy if the region becomes known, not for its pristine North Woods character, but for a noisy, industrial mine. The economic analysis included in the application asserts "little-to-no" negative impact on the recreational economy yet fails to consider the negative impact to the North Woods brand. Notably, the economic analysis includes a crucial "caveat: the assessment of little-to-no negative tourism impact assumes, importantly, that the Project does not harm the environmental quality of the larger region."[15] The applicant has not provided information sufficient to justify that assumption.

There are also multiple ATV trails in the area. During a recent trip to the mine site, I encountered multiple ATV riders who were quite forthright about their opposition to a new mine in that area and the negative impact that would have on their North Woods experience.

In addition, the area, including Pleasant and Mud Lakes, provides endless opportunities for remote camping, fishing, hunting, and exploring. Mud Lake, in particular, is a spectacular mosaic of water and open bog/shrub wetlands where the quiet visitor can see moose, loons, geese, ducks and other waterfowl, wading birds, uncommon songbirds associated with the bog/shrub habitat, as well as other wildlife. This type of wildlife-filled primitive recreation

[15] *Id.* at 346.

experience is increasingly rare. An industrial mining facility with its associated hundreds of vehicles a day coming and going on roads just steps away from the lakes would totally destroy the sense of remoteness and the experience of primitive recreation in this region.

V. REZONING WILL HAVE UNDUE ADVERSE IMPACTS ON WILDLIFE AND IMPORTANT HABITATS

The biodiversity of the North Woods is especially important to its character. In addition to recreational hunting and fishing and the guiding economy, protecting biodiversity is part of the area's natural character. Maine is the only state in the Northeast with a nearly full complement of predators—including weasels, otters, martens, foxes, bobcats, coyotes, and lynx—precisely because we have such expansive, relatively unfragmented forested habitat for them to meet all their needs, including places to drink, feed, den, raise young, and hide from other predators. These animals all have large home ranges and need even larger spaces to enable healthy populations to survive, to find mates, maintain a healthy genetic pool, raise kits etc. The same can be said for some of our large ranging mammals such as moose and black bear.

In addition to these charismatic megafauna, Maine's forests are home to many kinds of birds, including songbirds, wading birds, and waterfowl. There are approximately 90 species of songbirds that nest in Maine's forests, and these forests are considered the "baby bird factory" of the Atlantic flyway. In fact, much of western and northern Maine has been designated as a globally significant Important Bird Area because so many different bird species come here to raise their young every year. Many of these songbirds are area-sensitive, which means they prefer forest patches of at least 250 or more contiguous acres to establish a territory, find a mate, nest and raise their young, and hide from predators. Songbirds nesting in smaller patches of forest often experience poor nesting success because of increased disturbance and predation from development and human activity in adjacent non-forest patches. Species such as the black-throated blue warbler, Canada warbler, and northern parula all prefer forest blocks of at least 1000 acres; species such as the pileated woodpecker, wood and hermit thrushes, black-throated green warblers, black-and-white warblers, ovenbirds and northern waterthrush can all be found in forest blocks of 500 or more acres; whereas veerys, American redstarts, and scarlet tanagers can be found in forest blocks of 250 acres or more.[16] To maintain a healthy population of a species, areas many times the size required by a specific pair of birds is needed to find mates and maintain a healthy genetic pool.

These birds—most of whom are neotropical migrants—depend on Maine's expansive forestlands for breeding and raising their young. Most of these birds are experiencing dramatic population declines, with eastern forest birds having seen a 17% decline and boreal birds having seen a 33% decline since 1970 based on several long-term monitoring datasets.[17] Maine's woods offer a unique opportunity to provide high quality breeding bird habitat for these migrants and residents and stem the tide of further population decline. Though there are many threats to birds all along their travels, if they can't breed successfully and make more chicks, their populations will certainly continue to decline.

Wading birds and waterfowl, could be impacted by the Wolfden mine if zinc leaks into the surrounding groundwater, streams, or ponds. Such birds include those that feed or breed in the Inland Wading Bird and Waterfowl Habitat-designated lakes, ponds, and marshes that lie east and north of Pickett Mountain, as well as numerous sparrows and warblers that breed and feed in

[16] *See* Maine Audubon, *Conserving Wildlife in Maine's Developing Landscape* (2000), available at https://maineaudubon.org/wp-content/uploads/2017/03/MEAud-Conserving-Wildlife-Developing-Landscape.pdf.
[17] *See* Kenneth V. Rosenberg et al., *Decline of the North American avifauna*. 366 Science 120 (2019), DOI: https://doi.org/10.1126/science.aaw1313; *see also* 3 Billion Birds, https://www.3billionbirds.org/ (last accessed Sept. 21, 2023).

the surrounding peatlands/shrubland.[18] Some of the species I have seen previously in these settings and are likely to occur here include mallards, ring-necked ducks, common goldeneyes, common loons, great blue herons, yellowthroats, song sparrows, Lincoln's sparrows, swamp sparrows, savannah sparrows, and palm warblers.

In addition to its value for wading birds and waterfowl, MNAP has identified the fen between Pleasant and Mud Lakes as a priority site for a botanical survey. But there is no indication in the application that the botanical survey has taken place and no recognition of the threat that pollution from zinc or sulfur could pose to this valuable habitat. IF&W also noted that Pleasant, Mud, and Grass Lakes are Maine Heritage Fish Waters and "are native and wild brook trout lakes and ponds which represent unique, valuable, and irreplaceable ecological and angling resources."[19]

The needs of waterfowl do not stop at the border of the lake or wetland. IFW Inland Wading Bird and Waterfowl Habitat includes a 250-foot ring around the water/wetland area to filter runoff, protect the shoreline, minimize disturbance, and allow room for ground and cavity nesting ducks to find a nest site, which may be as far as a half mile or more from water. Some of the roads on which the hundreds of vehicles to and from the mine site will be traveling are well within this range.

Amphibians may also be adversely affected by the Project. Amphibians are particularly sensitive to pollution as they absorb chemicals through their skin. Mink frogs, pickerel and leopard frogs, wood frogs, and spotted salamanders likely occur in the waters around Pickett Mountain and could be affected by leaching of zinc and other toxic minerals.

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[18] See Maine Audubon, *Conserving Maine's Significant Wildlife Habitat: Waterfowl & Wading Birds* (2009), available at https://www.maineaudubon.org/wp-content/uploads/2017/03/MEAud-Conserving-Wildlife-Waterfowl-Wading-birds.pdf.
[19] Application at 1158.

This diversity and abundance of species is part of the draw of the area to hikers, campers, anglers and hunters. Any diminishment of this wildlife would in turn, adversely affect the tourism and traditional economy of the region.

And the possibilities for diminishment are not limited to a decline in water quality due to acid mine drainage or deforestation. Roads and traffic pose a particular challenge for wildlife. Roads can be lethal, they can introduce pollutants into the area from gas and oil residues, they can increase dust, runoff, and sedimentation into nearby areas, they can disturb wildlife and interfere with wildlife movement through avoidance or by being either a complete or partial barrier, and these impacts can extend up to 3300 feet away from the road.[20]

In the United States, about 365 million vertebrates are killed on roads each year, a number that is likely an undercount.[21]

Road noise is also a problem for wildlife. Migrating birds are adversely affected by road noise and end up in worse body conditions than they otherwise would be.[22] In the absence of traffic noise, birdsongs, a communication device for those species, change and allow for more complex songs.[23]

While Wolfden does not propose any new road construction, they plan to expand existing roads.[24] They plan to significantly increase truck traffic on the current logging road by trucking

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[20] *See* Maine Audubon, *Conserving Wildlife On and Around Maine's Roads* (2007), available at https://maineaudubon.org/wp-content/uploads/2017/03/MEAud-Conserving-Wildlife-On-Maine-Roads-2007.pdf.
[21] *See* Federal Highway Administration, Wildlife-Vehicle Collision Reduction Study: Report to Congress, FHWA-HRT-08-034, U.S. Department of Transportation at 47 (2008), available at https://www.fhwa.dot.gov/publications/research/safety/08034/08034.pdf (citing Lalo, J. 1987. The problem of road kill. *American Forests* 93 (9/10): 50–52, 72.).
[22] *See* Heidi E. Ware, et al., *A phantom road of experiment reveals traffic noise is an invisible source of habitat degradation*, 112 Proceedings of the National Academy of Sciences of the United States of America, 12105-12109 (2015), DOI: https://doi.org/10.1073/pnas.1504710112.
[23] *See* Erik Stokstad, *When COVID-19 Silenced Cities, Birdsongs Recaptured Ots Former Glory*, Science (Sep. 24, 2020), https://www.science.org/content/article/when-covid-19-silenced-cities-birdsong-recaptured-its-former-glory (last accessed Sept. 21, 2023).
[24] Application at 844–845.

ore material off site twelve hours per day by 80,000-pound trucks making about 55 round trips per day, in addition to additional traffic from mine employees, contractors, and delivery vehicles.[25] This increased traffic will result in undue adverse impacts to any wildlife in the area, particularly those attempting to cross the road as part of their movement or migration patterns.

VI. REZONING WILL NEGATIVELY IMPACT THE CHARACTER OF THE REGION, WHICH LUPC HAS A MANDATE TO PROTECT

The LUPC can only approve a rezoning to a D-PD subdistrict if 1) the change would be consistent with D-PD subdistrict standards, the CLUP, and the purpose, intent and provisions of 12 M.R.S.A. Ch. 206-A, and 2) the change will not have an undue adverse impact on existing uses or resources. As previously stated, the proposed rezoning will have an undue adverse impact on the natural character of the region, recreation and the recreational economy, and wildlife. In addition, the change is not consistent with D-PD subdistrict standards, the purpose, intent, and provisions of 12 M.R.S.A. Ch. 206-A, or the CLUP.

LUPC's polices permit major metallic mining developments only in areas zoned for planned development, and provide a rezoning procedure for this purpose which broadly considers impacts and benefits, competing uses and public values.[26] The policy also requires LUPC to "avoid undue adverse impacts on fisheries, wildlife, botanical, natural, historic, archaeological, recreational and socioeconomic values."[27]

As noted above, the proposed rezoning would degrade and be inconsistent with all four principal values of the jurisdiction. In stating that its proposal is consistent with the CLUP, Wolfden focuses particularly on the location of the development and economic development, without acknowledging that the type of economic development it is proposing is not part of the

[25] *Id.* at 738, 842–843.
[26] *See* LUPC, § 12.4, ¶ B.
[27] CLUP at 15.

principal values the CLUP is intended to protect. Wolfden ignores the natural character of the area, natural resources, and recreational opportunities. Yes, the zinc deposit is located in a specific place, but so are the local natural resources. Just as the zinc deposit cannot move, neither can Pleasant Lake, Mud Pond, Grass Pond, Mount Chase, or Pickett Mountain Pond. Despite Wolfden's claims that the mine will not impact water quality or wildlife, these claims are unlikely to be accurate. Furthermore, Wolfden claims that after the mine deposit has been exhausted, it will return the site to the way it is today.[28] Even if this were achievable, it does not account for the disruption to the natural character and natural resources during the mine's operation, and the long-term adverse impacts to the region's natural resources, brand, and recreational economy. Wolfden's plan therefore ignores the principal values of the CLUP.

Wolfden also claims that because its final site design requires permits through Maine Department of Environmental Protection, it will prevent the degradation of natural values resulting from its development.[29] But Wolfden cannot say at this point what other agencies will require or approve, and that is not relevant to this proceeding. Likewise, Wolfden's contention that environmental impacts will be dealt with in the mine permitting process is irrelevant. LUPC's responsibility during rezoning is to ensure that the standards for approval of a D-PD subdistrict rezoning are met now.

Wolfden relies heavily on the 2012 Guidance for interpreting the CLUP, placing an increased emphasis on regional interests, in particular the jobs it claims the mine will bring to the region.[30] While the 2012 guidance does increase consideration of regional interests, it also

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[28] Application at 271–272.
[29] *Id.* at 275.
[30] *Id.* at 270.

continued to "recognize the unique value of the lands and waters to the state as a whole."[31] LUPC reaffirmed its "existing purpose… including strong environmental protection."[32] LUPC also focused on the importance on sustainability.[33] Mining is not sustainable. The natural resource-based economy the legislature and LUPC intended to foster was forestry and non-intensive outdoor recreation both of which are economic uses compatible (if done sustainably) with natural resource conservation and environmental protection. The 2012 language does not direct that regional interests trump statewide interests that are the principal focus of the CLUP.

VII. CONCLUSION

Wolfden's proposal for D-PD redistricting is not consistent with the CLUP and will have undue adverse impacts on existing uses and resources in the area closest to the project and the region as a whole. While one of LUPC's goals is to "allow environmentally responsible exploration and mining of metallic and non-metallic mineral resources where there are not overriding, conflicting public values which require protection,"[34] the evidence in this case is clear that allowing a zinc mine in this remote, undeveloped area will negatively affect wildlife and wildlife habitat, recreation, and the outdoor economy. It is the opposite of well-planned development and will harm the distinctive character of the jurisdiction including the region's natural character, diverse, abundant, high-value natural resources, diverse and abundant recreational opportunities, and economic value based on working forests and farmlands. In this case, there are overriding, conflicting public values which require protection.

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[31] 2012 Guidance at 4.
[32] *Id.* at 5–6.
[33] *Id.* at 6.
[34] CLUP at 15.

Dated: ____September 21, 2023___________

/s/ Cathy Johnson
Cathy Johnson

VERIFICATION

I, Catherine B. Johnson, being first duly sworn, affirm that the above testimony is true and accurate to the best of my knowledge.

Date: Sept. 21, 2023 Name: Catherine B. Johnson

Personally appeared the above-named Catherine B. Johnson and made oath that the foregoing testimony was true and correct to the best of her knowledge and belief.

Dated: Sept 21, 2023 Sarah Perkins

Notary Public

Sarah Louise Perkins
NOTARY PUBLIC
State of Maine
My Commission Expires
April 4, 2030

INDEX OF ATTACHMENTS FOR CATHERINE JOHNSON PRE-FILED TESTIMONY

ATTACHMENT 1

3 BILLION BIRDS GONE

Together we can bring them back

HOW TO HELP (/WHY-BIRDS-MATTER)

> *Birds are telling us we must act now to ensure our planet can sustain wildlife and people*

Update Spring 2020: Why should anyone care about birds? Here are 5 key ways that birds help people (/why-birds-matter)—download a flier and/or share on social to help others.

We've Lost One in Four Birds Since 1970

ACROSS THE CONTINENT, NUMBERS HAVE PLUMMETED, EVEN AMONG COMMON SPECIES

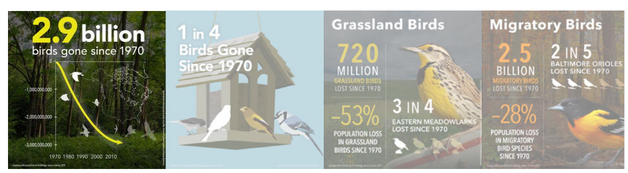
In less than a single lifetime, North America has lost more than one in four of its birds, according to a report in the world's leading scientific journal.

Published in *Science* by researchers at seven institutions, the findings show that 2.9 billion breeding adult birds have been lost since 1970, including birds in every ecosystem.

The losses include iconic songsters such as Eastern and Western Meadowlarks (down by 139 million) and favorite birds at feeders, such as Dark-eyed Juncos (down by 168 million) and sweet-singing White-throated Sparrows (down by 93 million).

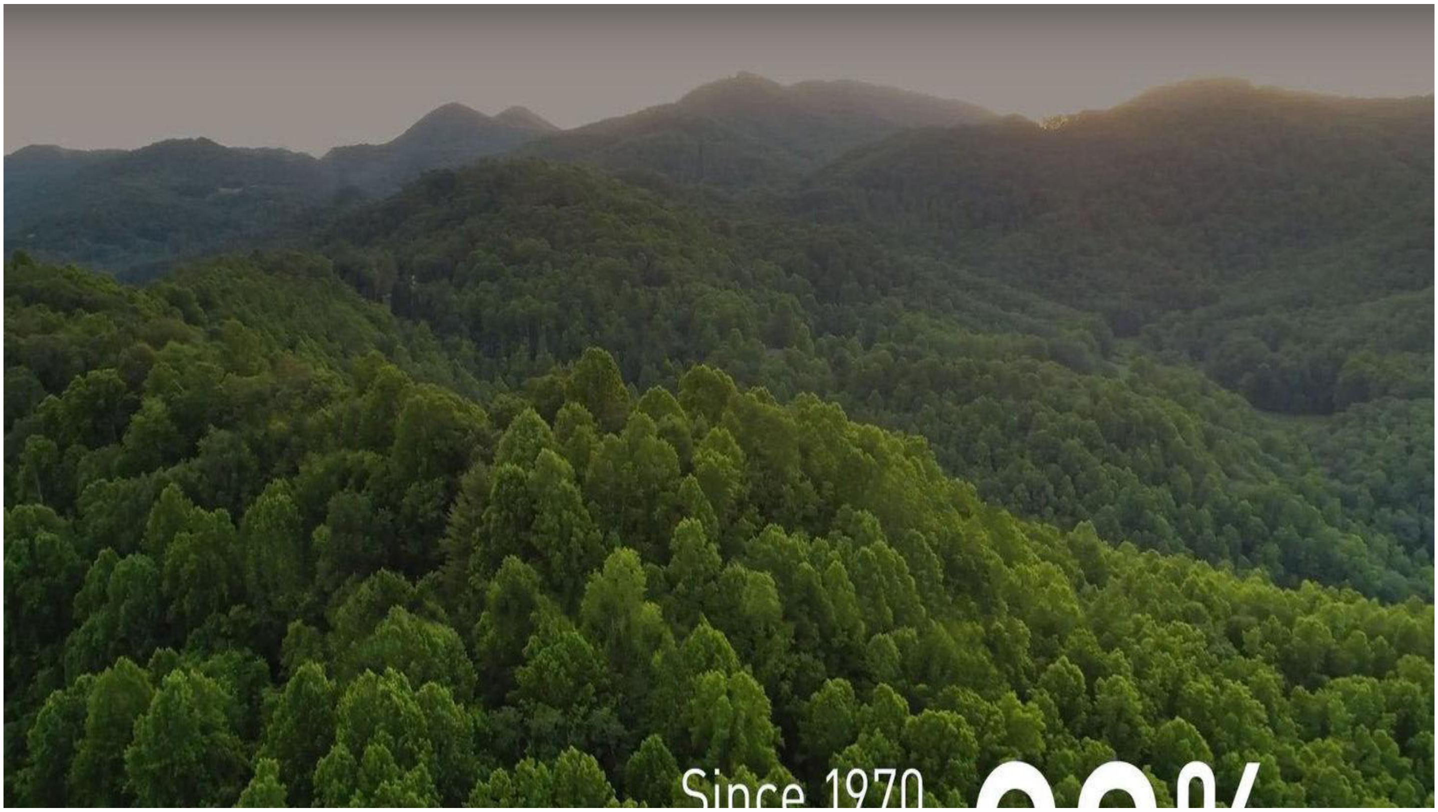
The disappearance of even common species indicates a general shift in our ecosystems' ability to support basic birdlife, the scientists conclude.

Note: This graph has been updated to reflect the [illegible] from the *Science* paper.



What's Behind The Declines?

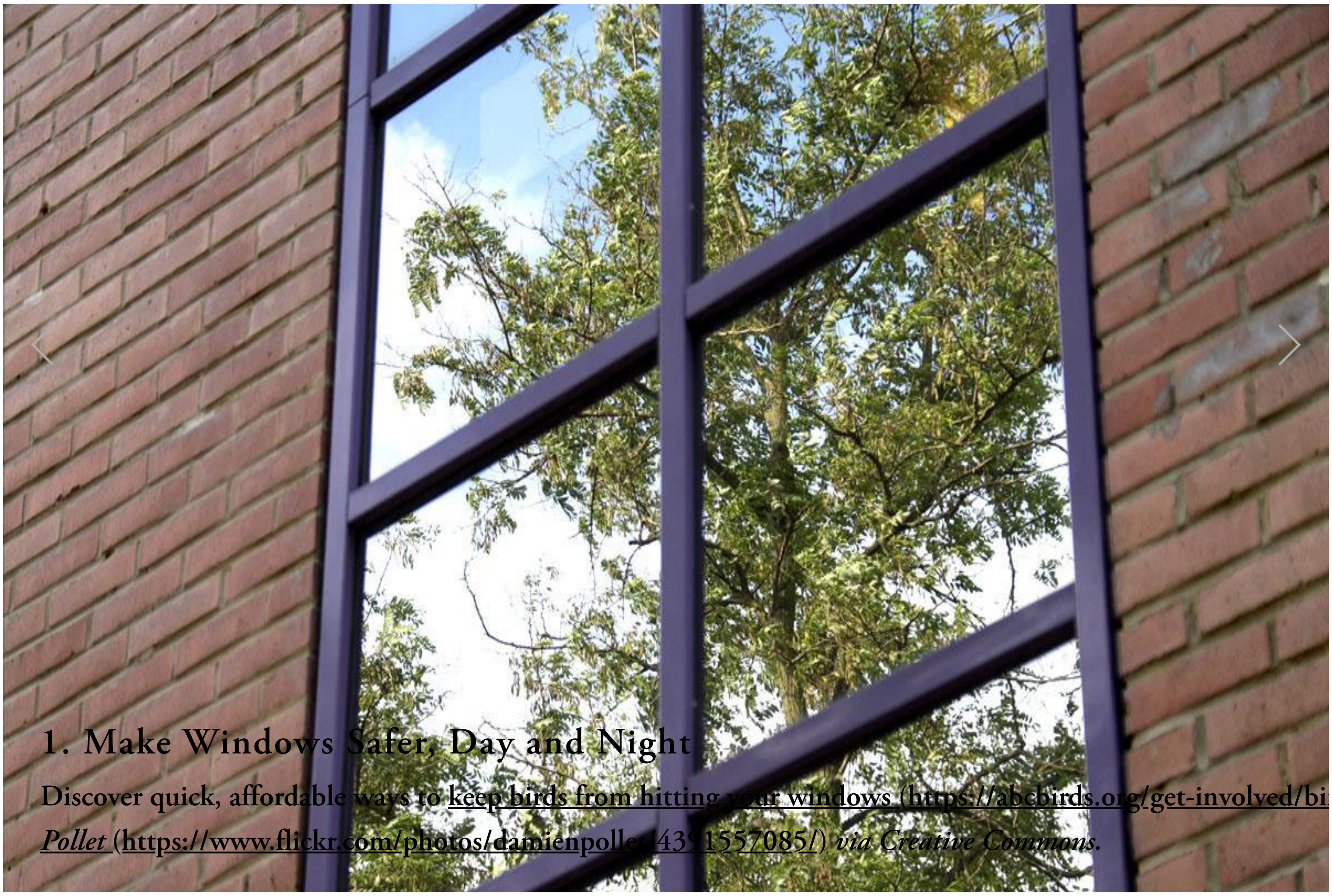
WATCH VIDEO



Watch the video: The decline of birds signals a broader crisis in the natural world already echoed by global losses in insects, amphibians, and other wildlife. Our quality of life—the water we drink, the food we eat, and the beauty of natural landscapes that we enjoy—all depend on keeping our planet healthy. Conservation actions work, and there is no time to lose.

How Can You Help Make a Bird-Friendly Planet?

7 SIMPLE ACTIONS TO HELP BIRDS



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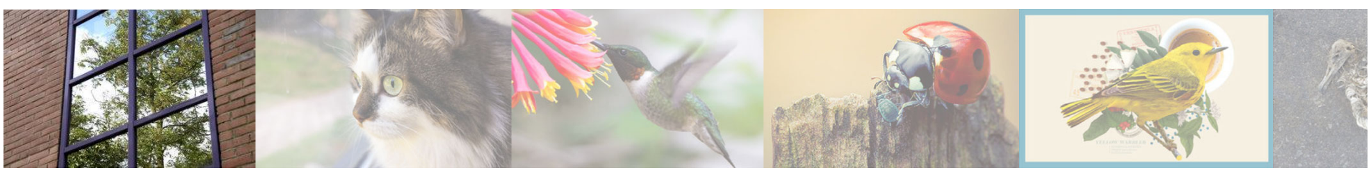

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ATTACHMENT 2

NEWS PLANTS & ANIMALS

When COVID-19 silenced cities, birdsong recaptured its former glory

White-crowned sparrows sang softer, more complex songs during the quiet of the pandemic lockdown

24 SEP 2020 • BY ERIK STOKSTAD

White-crowned sparrows can cope with noisy cities, but their songs suffer. JN PHILLIPS

Science's COVID-19 reporting is supported by the Pulitzer Center and the Heising-Simons Foundation.

White-crowned sparrows are tough birds, able to survive the hustle and bustle of many North American cities. But growing noise pollution has forced males to sing louder, less effective songs in order to be heard by rivals and mates. During the pandemic lockdown this spring, the background din quieted. A new study shows that, in just a matter of weeks, the sparrows' songs recovered the acoustic quality of songs sung decades ago, when city life was less noisy.

Elizabeth Derryberry, a behavioral ecologist at the University of Tennessee, Knoxville, and her colleagues have studied white-crowned sparrows in and around San Francisco for more than 2 decades, comparing their songs with recordings made in the 1970s. As traffic levels increased, the lowest frequencies of the sparrows' songs rose, so as not to be drowned out by the background hum of vehicles. But their top frequencies remained about the same, narrowing the total bandwidth of their communication.

For many bird species, songs degraded in this way are less effective at deterring rivals and attracting females. Birds sing louder in noisy environments, and research has shown the resulting stress can speed aging and disrupt their metabolisms. Noise can also keep them from hearing their own chicks—or the warnings of fellow birds; it may even be driving down bird diversity in many cities.

When the pandemic lockdown began in mid-March, Derryberry remembers seeing a striking photo of the Golden Gate Bridge. "I was like, ‘Oh my God, it's empty.'" And that made her wonder how the sparrows were responding to the quieter conditions.

Derryberry couldn't travel to California, but her colleague, Jenny Phillips, a behavioral ecologist at California Polytechnic State University, recorded the birds in San Francisco and the surrounding areas (below). Her recordings revealed that the sparrows were singing 30% softer, on average, than before the lockdown. What's more, they were singing songs with bandwidths typical of birds recorded in the 1970s. The combination of less background noise and the better signal from wider bandwidth meant the males could likely hear each other from twice as far away than before, they report today in *Science*.

The improved communication may have helped rival males avoid each other, meaning fewer fights. Phillips has previously found that urban birds are generally quicker to attack rivals. "I think that the aggression levels might have gone down so that everybody chilled out," Derryberry says.

The new finding is "good news from the point of view of the birds," says Sue Anne Zollinger, an ornithologist at Manchester Metropolitan University, who was not involved in the work. By showing the sparrows can adjust their songs to their environment, the study suggests species with more flexible behaviors can cope with aspects of changing environments. Reducing noise might allow other noise-sensitive bird species, such as California quail, to return to cities where they once sang. "If we can work to make things quieter, it will really have a big impact."

But the respite provided by the pandemic has been short lived, as traffic and noise return to cities. When the birds start their springtime serenades next year, Derryberry and her colleagues plan to see whether their songs are suffering again.

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RELEVANT TAGS:

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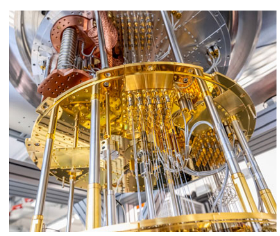

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ATTACHMENT 3

Making America's Highways Safer for Drivers and Wildlife

Wildlife-Vehicle Collision Reduction Study

REPORT TO CONGRESS

U.S. Department of Transportation

Federal Highway Administration

FHWA-HRT-08-034

August 2008

CHAPTER 4. IMPACTS TO WILDLIFE

Roads and traffic can negatively affect wildlife in various ways, including habitat loss, reduced habitat quality, reduced habitat connectivity (and associated potential demographic and genetic consequences), and direct road mortality. (See references 83, 84, 85, and 86.) This chapter focuses on the effects of direct road mortality on wildlife only, specifically for threatened and endangered species.

As previously stated, in most cases, an animal that has been hit by a vehicle dies immediately or shortly after the collision. For example, in Michigan, Allen and McCullough estimated that a minimum of 91.5 percent of all white-tailed deer that were hit by a vehicle died at the scene or shortly thereafter.(81) In Newfoundland, 88.5 percent of all moose collisions resulted in the death of the animal (4,800 moose fatalities out of 5,422 collisions). Many different wildlife species representing a wide variety of species groups have been observed as roadkill, sometimes in massive numbers. Seiler provided a review of estimates of the number of road-killed animals.(23) The combined number of road-killed amphibians, birds, ungulates, and other vertebrates runs in the multiple millions per year for most of the countries that were reviewed. In the United States the total number of road-killed vertebrates was estimated at 365 million per year.(87) The number of DVCs in the United States was estimated to exceed 500,000 per year, around 538,000 per year, and greater than 1,000,000 per year.(3,4,45)

The number of WVCs and animal carcasses is often underestimated (as previously discussed in chapter 2); researchers have calculated the underestimation by 10.3 percent, 25 percent, 50 percent, 77.5 percent, and 87.9 percent. (See references 4, 68, 72, and 88.) These estimates for underreporting apply especially to deer, as this species is involved in the vast majority of all reported AVCs or large WVCs in North America; for example, 80 percent in Saskatchewan, and 81.4 percent in Maine.(68,89) Underreporting may have various causes, including infrequent carcass checks, poor visibility of the carcass from the road, mutilation of the carcass by traffic to the point that the species can no longer be identified or that little to none of the carcass remains, decomposition, (illegal) removal by humans other than the data collectors, and scavengers.(90)

While deer are the species of primary interest from a safety perspective, their survival probability is typically not a concern. Species most affected in their population survival probability seem to be species that have relatively low population density, large home ranges, travel long distances, are long lived, and have a relatively low reproduction rate. (See references 85, 91, 92, and 93.)

Roads and traffic can reduce population densities for some species such as different frogs and toads, the western European hedgehog (*Erinaceus europaeus*), and the desert tortoise (*Gopherus agassizii*).(94, 95, 96) For some species, the survival probability of local or regional populations can be impacted too, especially if the species concerned also suffer from other human-related disturbances such as large-scale intensive agriculture and urban sprawl.(97,98) The effect of road mortality on the population viability of a species can not always be separated from other effects associated with roads and traffic, but road mortality is believed to have affected the population survival probability for multiple species representing different species groups: amphibians (moor frog (*Rana arvalis*)), (leopard frog (*Rana pipiens*); spotted salamander (*Ambystoma maculatum*)), reptiles (timber rattlesnakes (*Crotalus horridus*)), (land and large bodies pond turtles including the box turtle (*Terrapene ornata*)), mammals (western European hedgehog), (Eurasian badger (*Meles meles*)), (otter (*Lutra lutra*)), (ocelot (*Leopardus pardalis*)), (Florida panther (*Felis concolor coryi*)), (Iberian lynx (*Lynx pardinus*)), (Florida Key deer (*Odocoileus virginianus clavium*)). (See references 91, 92, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, and 110.)

THREATENED AND ENDANGERED SPECIES

This section reviews federally listed threatened and endangered animal species in the United States for which direct road mortality is among the major threats to the survival of the species or certain populations of that species. The threatened and endangered species were not reviewed with regard to other effects associated with roads and traffic such as habitat loss, reduced habitat quality, and the barrier effect of transportation infrastructure. Note that the list in this chapter (table 7) has no regulatory status and that it does not replace potential consultation with the appropriate agencies about the impact of road improvement projects on local endangered species. In addition, because the required data were often difficult to access, and since only limited time was available for this effort, the list in this chapter is not necessarily complete.

METHODS

All threatened and endangered animal species (clams, snails, crustaceans, arachnids, insects, fishes, amphibians, reptiles, birds, and mammals) in each of the 50 states and Washington, DC, were combined into one list. If different populations of the same species were listed, they were treated separately.[(111)] Species (or populations) were identified for which direct road mortality is among the major threats to the survival probability of the species. Species that are aquatic were not reviewed with regard to vehicle collisions. Mortality as a result of collisions with trains and off-road vehicles was also excluded from the review. This review focused solely on the effect of direct mortality resulting from vehicle collisions (e.g., cars and trucks) on paved roads (e.g., asphalt or concrete).

The following sources were used to evaluate whether direct road mortality is a major threat to the survival probability of threatened and endangered species: (1) documents that provided a rationale for the listing of threatened and endangered species (*Federal Register* publications), (2) the 2006 International Union for Conservation of Nature and Natural Resources Red List of Threatened and Endangered Species, (3) other sources, including publications on individual species or species groups and expert opinions (appendix A).[(112)] If an expert opinion was the sole source of information that direct road mortality is among the major threats to the survival of a certain species, additional quantitative information was sought out on the importance of road mortality before the species was added to table 7. In addition, speculations alone about the potential impact of direct road mortality were not sufficient for a species to be listed in this chapter.

The list presented in this chapter is not necessarily complete because the required information was difficult to access and the time available for this effort was limited. Furthermore, some species have been listed for decades and circumstances have changed or more and better knowledge about the threats to individual species has become available since the original listing documents were published. For these reasons one cannot only rely on the original listing documents. Other sources have to be included in determining whether the survival probability of a species is substantially impacted by road mortality.

Even though the information available was carefully evaluated, the process of including and excluding species from the species listed in this chapter was at least partially subjective. Because of the diverse and inconsistent nature of the sources and data available, the inclusion or exclusion from the list could not be based on a simple definition. The inclusion or exclusion of the species listed relied, at least to a certain extent, on expert judgment that is open to debate. Furthermore, just as the status of species and circumstances have changed since the original listing documents were published (discussed above), the status and circumstances will continue to change and the list presented in this chapter will become less applicable over time.

RESULTS

For the 21 species listed in table 7, direct road mortality is considered a major threat to the survival of the species. The table includes three amphibian species, seven reptile species, three bird species, and eight mammal species. A brief discussion for each species follows table 7.

Table 7. Threatened and endangered species in the United States for which direct road mortality is among the major threats to the survival probability of the species.[111]

Species Group	Species Name	Sources Justifying the Inclusion of the Species Concerned in this Table		
		Federal Listing Documents	**International Union for Conservation of Nature and Natural Resources**	**Other Source(s)**
Amphibians	California tiger salamander (*Ambystoma californiense*), C. CA, S. Barb., Son. county	[113]	[112]	[114,115,116] Dave Johnston, California Department of Fish and Game, California, personal communication
Amphibians	Flatwoods salamander (*Ambystoma cingulatum*)	[117]	[112]	Bruce Means, Coastal Plains Institute and Land Conservancy, Tallahassee, FL, personal communication, John Palis, Palis Environmental Consulting, Jonesboro, IL, personal communication
Amphibians	Houston toad (*Bufo houstonensis*)	Threats not discussed	[112]	[118]
Reptiles	American crocodile (*Crocodylus acutus*)	[119]	Threats not discussed	[120,121]
Reptiles	Desert tortoise (*Gopherus agassizii*), except in Sonoran Desert	[122]	Threats not discussed	(See references 96, 123, 124, and 125.)
Reptiles	Gopher tortoise (*Gopherus polyphemus*), W of Mobile/Tombigbee Rs.	[126]	Threats not discussed	[125,127,128]
Reptiles	Alabama red-bellied turtle (*Pseudemys alabamensis*)	Collisions not listed as a threat	Threats not discussed	[125,129] D. Nelson, Dep. of Biol. Sc., Univ. S. AL, personal communication, Matthew J. Aresco, Nokuse Plantation, Bruce, Florida, personal communication
Reptiles	Bog turtle (Muhlenberg) northern population (*Clemmys muhlenbergii*)	[130]	Threats not discussed	
Reptiles	Copperbelly water snake (*Nerodia erythrogaster neglecta*)	[131]	Not listed	[132]

Table 7. Threatened and endangered species in the United States for which direct road mortality is among the major threats to the survival probability of the species—continued.

Species Group	Species Name	Sources Justifying the Inclusion of the Species Concerned in this Table		
		Federal Listing Documents	**International Union for Conservation of Nature and Natural Resources**	**Other Source(s)**
Reptiles	Eastern indigo snake, eastern indigo (*Drymarchon corais couperi*)	Collisions not listed as a threat	Not listed	[133,134,135] Bruce Means, Coastal Plains Institute and Land Conservancy, Tallahassee, FL, personal communication; John Palis, Palis Environmental Consulting, Jonesboro, IL, personal communication
Birds	Audubon's crested caracara (*Polyborus plancus audubonii*), FL pop.	[136]	Threats not discussed	[137]
Birds	Hawaiian goose (*Branta sandvicensis*)	Threats not discussed	[112]	[138] K. Misajon, NPS, personal communication
Birds	Florida scrub jay (*Aphelocoma coerulescens*)	[139]	[112]	[140]
Mammals	Lower Keys marsh rabbit, (*Sylvilagus palustris hefneri*)	Collisions not listed as a threat	Threats not discussed	[141,142]
Mammals	Key deer (*Odocoileus virginianus clavium*)	Threats not discussed	Threats not discussed	[143]
Mammals	Bighorn Sheep, Peninsular CA pop. (*Ovis canadensis*)	[144]	Threats not discussed	
Mammals	San Joaquin kit fox (*Vulpes macrotis mutica*)	Threats not discussed	[112]	[145]
Mammals	Canada lynx (*Lynx canadensis*), lower 48 states	[146]	Collisions not listed as a threat	[147] Alison Michael, U.S. Fish and Wildlife, personal communication; Phil Delphey, U.S. Fish and Wildlife Service, personal communication
Mammals	Ocelot (*Leopardus pardalis*)	Collisions not listed as a threat	Collisions not listed as a threat	[107,148]
Mammals	Florida panther (*Felis concolor coryi*)	Threats not discussed	Collisions not listed as a threat	[149]
Mammals	Red wolf (*Canis rufus*), except where XN	Collisions not listed as a threat	[112]	

Amphibians

The California tiger salamander (*Ambystoma californiense*) is affected by habitat loss due to urbanization and agriculture, unnatural hydrology, predation by nonnative species (bullfrogs, crayfish, various fish species), reduced availability of burrows as a result of rodent control programs, vehicle collisions, reduced food availability through the use of pesticides for mosquito control, hybridization with nonnative tiger salamanders, and storm water road runoff (Dave Johnston, California Department of Fish and Game, CA, personal communication). (See references 112, 113, 114, 115, and 116.)

The flatwoods salamander (*Ambystoma cingulatum*) was listed because of habitat loss and habitat alteration.[117,150] However, direct mortality (road mortality during migration, capture by bait collectors) is also a potential or a major threat to this species (Bruce Means, Coastal Plains Institute and Land Conservancy, Tallahassee, FL, personal communication; John Palis, Palis Environmental Consulting, Jonesboro, IL, personal communication).[112,117] At one location where a substantial population decline has been observed, road mortality was not considered substantial. In this case, habitat loss and habitat degradation (agriculture, silviculture, urbanization, and changes in hydrology, predation by nonnative fish species) are thought to be the primary cause of the decline.[151] Silviculture is the cultivation and management of forest trees or woodlands for producing timber and other wood products.

The Houston toad (*Bufo houstonensis*) is affected by habitat loss and habitat alteration, mostly through urbanization, recreational development, and agriculture.[112,118] However, direct road mortality through increased habitat fragmentation by road construction has also been identified as a major threat to the survival probability of the species.[112,118] Other threats include predation by nonnative species (e.g., Brazil fire ants).[112]

Reptiles

The American crocodile (*Crocodylus acutus*) is affected by changes in hydrology and consequent changes in salinity levels.[121] In addition, direct mortality of adult American crocodiles is considered higher than the population can sustain.[121] Of the deaths recorded between 1971 and 2001, the majority were hit by cars.[119,120,121] Warning signs and fences were installed along the major highways throughout crocodile habitat in south Florida.[119] However, it appears that some or all of the planned underpasses may not have been built (U.S. Highway 1) and that some of the fencing that was installed (State Route 905) was not flush with the ground so that American crocodiles could enter but not exit the right of way. Some of these fence sections have now been removed (Frank Mazzotti, Department of Wildlife Ecology and Conservation, Fort Lauderdale Research and Education Center, Davie, FL, personal communication).

The desert tortoise (figure 22) is affected by habitat loss (agriculture, landfills) and habitat degradation (e.g., through off-road vehicle use, overgrazing, invasive plant species). (See references 96, 123, 152, and 153.) Substantial direct mortality occurs on highways as well as off highways (nonintentional and intentional crushing by off-road vehicle operators, trampling of their burrows by off-road vehicles and livestock, shooting). (See references 96, 122, 123, 124, 125, 152, and 153.) Other mortality causes are disease, drought, mining, wildfires, garbage and litter, handling by humans, collection by humans, and predation by common ravens (*Corvus corax*). (See references 96, 123, 125, 152, 154, and 155.)

Figure 22. Photo. Desert tortoise (copyright: Marcel Huijser).

The gopher tortoise (*Gopherus polyphemus*) is affected by habitat loss (urbanization, agriculture, silviculture, mining) and habitat degradation (silviculture, fire suppression, nonnative plant species).[126,127,128] Collection by humans and road mortality also affected the species substantially. (See references 125, 126, 127, and 128.) Furthermore, the species is affected by predation, including by nonnative fire ants.[128] Fences and culverts were installed along a section of Highway 63 in Green County, south of Leakesville, MS (Matthew J. Aresco, Nokuse Plantation, Bruce, FL, personal communication; Claiborne Barnwell and Chuck Walters, Mississippi Department of Transportation, personal communication). The aim of the mitigation measures is to reduce gopher tortoise road mortality and to allow for gopher tortoises to cross under the road (Claiborne Barnwell and Chuck Walters, Mississippi Department of Transportation, personal communication) (figure 23). Highway 63 has 24.1 km (15 mi) of road length with gopher tortoise fencing, and, because of the nature of the terrain, there is only one culvert that was specifically designed for the gopher tortoise (between Lucedale and Leakesville, MS) (Chuck Walters, Mississippi Department of Transportation, personal communication). At the site of the culvert, the fence stretches out about 914 m (3,000 ft) to either side of the culvert (Chuck Walters, Mississippi Department of Transportation, personal communication). Some of the fencing was installed as early as 1998, and along those road sections the number of reported road-killed gopher tortoises was reduced from one to two per year to zero (Chuck Walters, Mississippi Department of Transportation, personal communication).

Figure 23. Photo. Fences lead gopher tortoises towards a culvert along Highway 63 in Green County, south of Leakesville, MS (copyright: Chuck Walters, Environmental Division, Mississippi Department of Transportation).

The Alabama red-bellied turtle (*Pseudemys alabamensis*) is affected by egg predation, human disturbance, and road mortality (David Nelson, Department of Biological Sciences, University of South Alabama, personal communication; Matthew J. Aresco, Nokuse Plantation, Bruce, FL, personal communication).[125,129,156] The small population size and low recruitment rates of the species make recovery a difficult process. A weekly road mortality survey along the Mobile Bay Causeway (6.5 mi from Spanish Fort to Mobile, AL) between 2001 and 2004 reported 324 Alabama red-bellied turtle carcasses (David Nelson, Department of Biological Sciences, University of South Alabama, personal communication) (figure 24 and figure 25).[129] In a typical year, 12–15 adult females, most of them with eggs, are found dead on the Mobile Bay Causeway (David Nelson, Department of Biological Sciences, University of South Alabama, personal communication). In addition, several dozen juveniles and a few males are killed by vehicles each year as well (David Nelson, Department of Biological Sciences, University of South Alabama, personal communication).

Figure 24. Photo. A section of the Mobile Bay Causeway that has relatively many road-killed Alabama red-bellied turtles (copyright: Marcel Huijser).

Figure 25. Photo. Road-killed Alabama red-bellied turtle (copyright: Marcel Huijser).

The northern population of the bog turtle (*Clemmys muhlenbergii*) is affected by habitat degradation and fragmentation from agriculture and development, habitat succession due to invasive exotic and native plants, and illegal trade and collecting.[130] In addition, roads contribute “significantly” to mortality, especially where roads are adjacent to or within wetlands.[130]

The copperbelly water snake (*Nerodia erythrogaster neglecta*) is affected by habitat loss and habitat fragmentation, primarily because of agriculture, drainage and damming of wetlands, coal mining, channelization, damming and diversion of streams and rivers, and residential and commercial development.[131] In addition, predation by pets and vehicle-caused mortality are a concern.[131,132] Traffic mortality may account for mortality of 14–21 percent of the population per year.[132] The species seems especially vulnerable as it frequently crosses overland to different wetland sites.[132]

The eastern indigo snake (*Drymarchon corais couperi*) is affected by habitat loss due to development, collection and commercial trade, intentional killing, vehicular traffic, and residual pesticide exposure.[135,157] In addition, gopher tortoise burrows that are gassed to kill rattlesnakes also unintentionally kill indigo snakes.[157] Bolt reported that road mortality was the highest cause of death in a study where 81 individuals were followed, some for more than three consecutive years.[133] At least 15 of the 38 known mortalities (39 percent) in the field were due to vehicles. In that study, twice as many males were killed on the road as females (M. Rebecca Bolt, The Dynamac Corporation, Kennedy Space Center, FL, personal communication). In another study, of the 31 indigo snakes documented, 5 were found dead on a road (16 percent of total number of individuals followed), accounting for 55 percent of all known mortalities.[134]

Birds

The crested caracara in central Florida (*Polyborus plancus audubonii*) is affected by habitat alteration for agriculture and housing, illegal killing, and vehicle collisions.[136,137] In a 3-year study, 52 percent of all fledgling mortality (14 out of 27 deaths) was caused by vehicle collisions.[137] The crested caracara spends substantial time close to roads as it searches for and feeds on road-killed animals (Dan Smith, Western Transportation Institute, Montana State University, personal communication).

The Hawaiian goose, or nene (*Branta sandvicensis*), is affected by habitat loss, predation by the nonnative small Indian mongoose (*Herpestes auropunctatus*), dogs, and perhaps rats and cats.[112] Poaching and roadkills are also important causes of mortality (Kathleen Misajon, National Park Service, personal communication).[112,138] Road mortality is the most common known cause of mortality in adults.[158] The species may also be affected by diseases and parasites, inbreeding depression, loss of adaptive skills in captive-bred birds, and dietary deficiencies.[112]

Haleakala National Park reported 35 road-killed Hawaiian geese between 1973 and 2006, and Hawai'i Volcanoes National Park reported 33 road-killed Hawaiian geese between 1996 and 2006 (Kathleen Misajon, National Park Service, personal communication). The population size of the Hawaiian goose fluctuated between 140 and 200 between 1996 and 2006 (Kathleen Misajon, National Park Service, personal communication). In Hawai’i Volcanoes National Park, five adult Hawaiian geese have been killed on the road in 2006 between January 1 and August 28, out of a total of 160 individuals (Kathleen Misajon, National Park Service, personal communication).

In Hawai'i Volcanoes National Park, the Hawaiian goose is attracted to roads because of feeding by park visitors, especially around parking areas (Kathleen Misajon, National Park Service, personal communication) (figure 26). This practice habituates the birds to roads and cars, and it encourages them to spend more time on and alongside roads, increasing their exposure to vehicles. Furthermore, some road sections in the park split roosting habitat from feeding habitat. When they have young, Hawaiian geese walk between roosting and feeding sites for 3–4 months and cross the road frequently, mostly at dawn or dusk, with relatively low visibility (Kathleen Misajon, National Park Service, personal communication). Pairs with goslings are basically pedestrian until the goslings fledge at 3–4 months of age.

Permanent warning signs have been installed in known Hawaiian goose kill areas (Kathleen Misajon, National Park Service, personal communication) (figure 27). In addition, temporary warning signs can be installed at new or unexpected locations. Nonetheless, all five individuals that were killed by vehicles between January 1 and August 28, 2006 were within signed crossing zones (Kathleen Misajon, National Park Service, personal communication). There are also indirect effects of roadkills to the Hawaiian goose population. For example, mates are left without partners, often for at least one breeding season, resulting in one less nesting attempt that year (Kathleen Misajon, National Park Service, personal communication). In addition, goslings without one or both parents have substantially reduced survival probability (Kathleen Misajon, National Park Service, personal communication).

Figure 26. Photo. "Do Not Feed Nene" sign (copyright: Hawai'i Volcanoes National Park, National Park Service).

Figure 27. Photo. Hawaiian goose (nene) warning sign (copyright: Haleakala National Park, National Park Service).

The Florida scrub jay (*Aphelocoma coerulescens*) is affected by habitat loss (housing developments, citrus-groves) and reduced habitat quality (disrupted fire regimes, human disturbance), predation by nonnative species (feral cats) and roadkill. (See references 112, 139, 140, and 159.) Annual mortality rates of the Florida scrub jay have been recorded to be 65 percent higher in road territories compared to nonroad territories.[140] Furthermore, roadside territories are a population sink, and the high mortality rate appears to be caused by vehicle collisions rather than other factors associated with a roadside environment.[140]

Mammals

The Lower Keys marsh rabbit (*Sylvilagus palustris hefneri*) is or has been affected by wetland drainage for residential, commercial and military purposes, habitat destruction associated with road building, hunting, predation by feral house cats, road mortality, mowing practices, and off-road vehicle use.[117,160] In a combination of a field and modeling study, almost one-third of all mortalities were caused by vehicle collisions, and modeling showed that theoretical removal of road mortality would eliminate the chance of extinction for the Big Pine metapopulation.[141] Dispersing subadult males seem especially vulnerable to traffic mortality.[117]

The Florida Key deer (*Odocoileus virginianus clavium*) is affected by vehicle collisions, habitat loss, and human disturbance.[110,143] Vehicle collisions account for more than 50 percent of the total deer mortality, mostly on U.S. Highway 1.[143]

The bighorn sheep, peninsular California population, (*Ovis canadensis*) is affected by a range of issues including disease, low recruitment, habitat loss, habitat degradation, habitat fragmentation, residential and commercial development and high predation rates.[144] This population, especially small groups that have low recruitment, is also threatened by road mortality.[144]

The San Joaquin kit fox (*Vulpes macrotis mutica*) is threatened by habitat conversion (agriculture, urban development, industrial development), habitat fragmentation, loss of prey species (e.g., eradication of prairie dog towns), predation (coyotes, bobcats, nonnative red foxes, and domestic dogs), and vehicle mortality.[112,145,161] In the San Joaquin Valley of California, habitat conversion for agriculture has slowed, but habitat loss, reduction of habitat quality, and habitat fragmentation are still a primary threat. Road mortality varies between studies: 20 out of 225 adult deaths (9 percent), 11 out of 142 juvenile deaths (8 percent), 1 out of 60 deaths (2 percent), 1 out of 22 deaths (5 percent), 2 out of 49 deaths (4 percent), 2 out of 17 deaths (12 percent), 15 out of 23 adult deaths (65 percent), and 6 out of 12 juvenile deaths (50 percent).[145] After predation, vehicle collisions are likely to be the second most common cause of mortality.[145]

Canada lynx (*Lynx canadensis*) is likely impacted by urbanization and forestry practices (including fire suppression) and trapping.[162,163] In addition, its population size fluctuates with the availability of its main prey species, the snowshoe hare (*Lepus americanus*).[163] In the United States, road mortality may limit the reestablishment of the Canada lynx in Wisconsin and Michigan.[146] A total of 218 adult lynx were released between 1999 and 2006, and there were 80 known mortalities as of June 30, 2006.[147] Starvation was a substantial cause of mortality in the first year of the releases only. About 31.3 percent of the known mortalities were human induced (including collisions with vehicles or shooting by humans).[147] Malnutrition and disease or illness accounted for 21.3 percent of the deaths, while 32.5 percent of the deaths were from unknown causes.[147] Closer and more recent analyses showed that road mortality accounted for a minimum of 44 percent (11 out of 25) of human-caused mortalities (Alison Michael, U.S. Fish and Wildlife, personal communication). This percentage may be higher as this estimate only included confirmed vehicle-caused mortality and excluded suspected vehicle-caused mortality (Alison Michael, U.S. Fish and Wildlife, personal communication). In Maine, 11 road-killed Canada lynx have been reported since 1999; nine on two-lane logging roads that are also accessible to the public and two on paved public roads.[164] Recent data from Minnesota show that Canada lynx have died from shooting, trapping, collisions with trains, and road mortality (Phil Delphey, U.S. Fish and Wildlife Service, personal communication). Road mortality on paved highways amounted to 17 percent (5 out of 30) of all known mortalities since the species was listed in 2000 (Phil Delphey, U.S. Fish and Wildlife Service, personal communication).

The ocelot is affected by habitat loss (loss of dense thorn shrub habitat), mortality vehicle collisions, and genetic erosion.[107,148,165] Vehicle collisions constituted 35 percent of all mortality.[148]

The Florida panther is affected by habitat loss (agriculture, urbanization), habitat fragmentation, road mortality, and loss of genetic diversity .[166,167,168] Road mortality is substantial, 25 out of 73 deaths were caused by vehicles.[149]

The red wolf (*Canis rufus*) went extinct in the wild by 1980 and was reintroduced in 1987 in North Carolina.[112] After reintroduction, the species was affected by hybridization with coyotes (*Canis latrans*) .[112,169,170] Direct mortality (vehicle collisions, shooting) can be substantial.[112]

Other Species

In addition to the species listed in table 7, the authors of this report recognize that other federally threatened and endangered species may be substantially affected by road mortality too. However, species that had insufficient data available, at least to the authors of this report at the time of publication, were excluded from table 7.

Summary

This chapter identified 21 federally listed species from four species groups (amphibians, reptiles, birds and mammals) for which direct road mortality is among the major threats to the survival of the species. However, road mortality is typically only one of the major threats to these species. Habitat loss (e.g., due to agriculture, urbanization, mining, and changes in hydrology), reduced habitat quality (e.g., due to agricultural and silviculture practices such as livestock grazing, logging, fire suppression, introduction of nonnative plant species, and water contamination with pollutants, and the use of pesticides, in general), habitat fragmentation (e.g., due to roads or other unsuitable habitat), competition and predation by nonnative species, other sources of natural and unnatural mortality (e.g., off-road vehicles, poaching, direct killing or collection by humans, disease), and low recruitment and loss of genetic diversity due to small populations also threaten the survival of the species listed in this chapter. This implies that a substantial reduction in road mortality is not necessarily sufficient for the recovery of the species listed in this chapter. For successful species recovery, including mitigation for effects related to roads and traffic, it is advisable to use an integrated approach.[171]

ATTACHMENT 4

SEE COMMENTARY

A phantom road experiment reveals traffic noise is an invisible source of habitat degradation

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Decades of research demonstrate that roads impact wildlife and suggest traffic noise as a primary cause of population declines near roads. We created a "phantom road" using an array of speakers to apply traffic noise to a roadless landscape, directly testing the effect of noise alone on an entire songbird community during autumn migration. Thirty-one percent of the bird community avoided the phantom road. For individuals that stayed despite the noise, overall body condition decreased by a full SD and some species showed a change in ability to gain body condition when exposed to traffic noise during migratory stopover. We conducted complementary laboratory experiments that implicate foraging-vigilance behavior as one mechanism driving this pattern. Our results suggest that noise degrades habitat that is otherwise suitable, and that the presence of a species does not indicate the absence of an impact.

traffic noise pollution | songbird migration | habitat degradation | foraging-vigilance trade-off | perceived predation risk

Human infrastructure shapes animal behaviors, distributions, and communities (1, 2). A meta-analysis of 49 datasets from across the globe found that bird populations decline within 1km of human infrastructure, including roads (2). Observational studies of birds near roads implicate traffic noise as a primary driver of these declines (3). Road ecology research has also shown negative correlations between traffic noise levels and songbird reproduction (4, 5). Birds that produce low frequency songs, likely masked by traffic noise, show the strongest avoidance of roads (6).

There is now substantial evidence that anthropogenic noise has detrimental impacts on a variety of species (3, 7–10). For example, work in natural gas extraction fields has demonstrated that compressor station noise alters songbird breeding distribution and species richness (11–13). However, explicit experiments would help to further rule out other characteristics of infrastructure, such as visual disturbance, collisions, chemical pollution, and edge effects, which might be driving these patterns (3). In addition, although these studies implicate noise as a causal factor in population declines, many individuals remain despite noise exposure (3), but at what cost? Proposed causes of decreased fitness for birds in noise include song masking, interference with mate evaluation, nonrandom distribution of territorial individuals, disruption of parent-chick communication, reduced foraging opportunities, and/or alterations in the foraging/vigilance trade-off (3, 4).

Here we parse the independent role of traffic noise from other aspects of roads experimentally by playing traffic sounds in a roadless area, creating a 'phantom road'. We focus on birds during migratory stopover, because energy budgets are streamlined; foraging, vigilance, and rest dominate activity (14). To meet the amplified physiological needs of sustained nocturnal migratory flights, birds must increase foraging during periods of stopover while maintaining appropriate vigilance levels (14, 15). Any interference with foraging will decrease stopover efficiency and thus reduce migration speed, a likely surrogate for fitness (14), thereby increasing exposure to significant mortality risks during what can be the most perilous stage of a migratory bird's life cycle (16). Anthropogenic noise might disrupt the foraging-vigilance tradeoff by acting as a form of perceived predation risk (17, 18) or by reducing sensory awareness via distraction or acoustic masking (3, 19). Using the "phantom road" experimental approach, we previously conducted count surveys of bird distributions at this site, finding a decrease in overall bird numbers of more than 25% (20). We hypothesized that the subset of birds choosing to stay at the site would experience other negative effects of traffic noise, and we predicted that the birds that remained would exhibit lower body condition and reduced ability to increase body condition (i.e., reduced stopover efficiency) in noise.

To test these predictions we used an array of speakers to recreate the soundscape of a ∼0.5 km section of highway along a ridge in southwest Idaho. This approach enabled us to turn the traffic noise *on* and *off* throughout fall migration at our phantom road site, and compare it with a nearby quiet control site, creating a modified before-after-control-impact design (Fig. 1). Alternating noise on/off every four days, we sampled a different set of migrants during each block as birds arrived and departed from the stopover site (*SI Text*). We measured sound levels (hourly level-equivalent, or LEQ) continuously during the season using acoustic recording units placed at mist net locations (Fig. 1*A*). We compared mist-net capture rate (birds/net/hr) across site (control vs. phantom road) and noise treatment (on vs. off) to investigate whether birds were leaving or staying when exposed to traffic noise (*SI Text*). Similar to our survey work (20), our best-fitting model indicated that capture rate decreased by 31% during phantom traffic noise playback, demonstrating that anthropogenic noise, independent of other road forces, fundamentally shapes bird distributions. However, 69% of birds remained despite the noise (Table S1, Dataset S1, and *SI Text*).

Significance

Using landscape-scale traffic noise playbacks to create a "phantom road," we find that noise, apart from other factors present near roads, degrades the value of habitat for migrating songbirds. We found that nearly one third of the bird community avoided the phantom road. For some bird species that remained despite noise exposure, body condition and stopover efficiency (ability to gain body condition over time) decreased compared with control conditions. These findings have broad implications for the conservation of migratory birds and perhaps for other wildlife, because factors driving foraging behavior are similar across animals. For wildlife that remains in loud areas, noise pollution represents an invisible source of habitat degradation.

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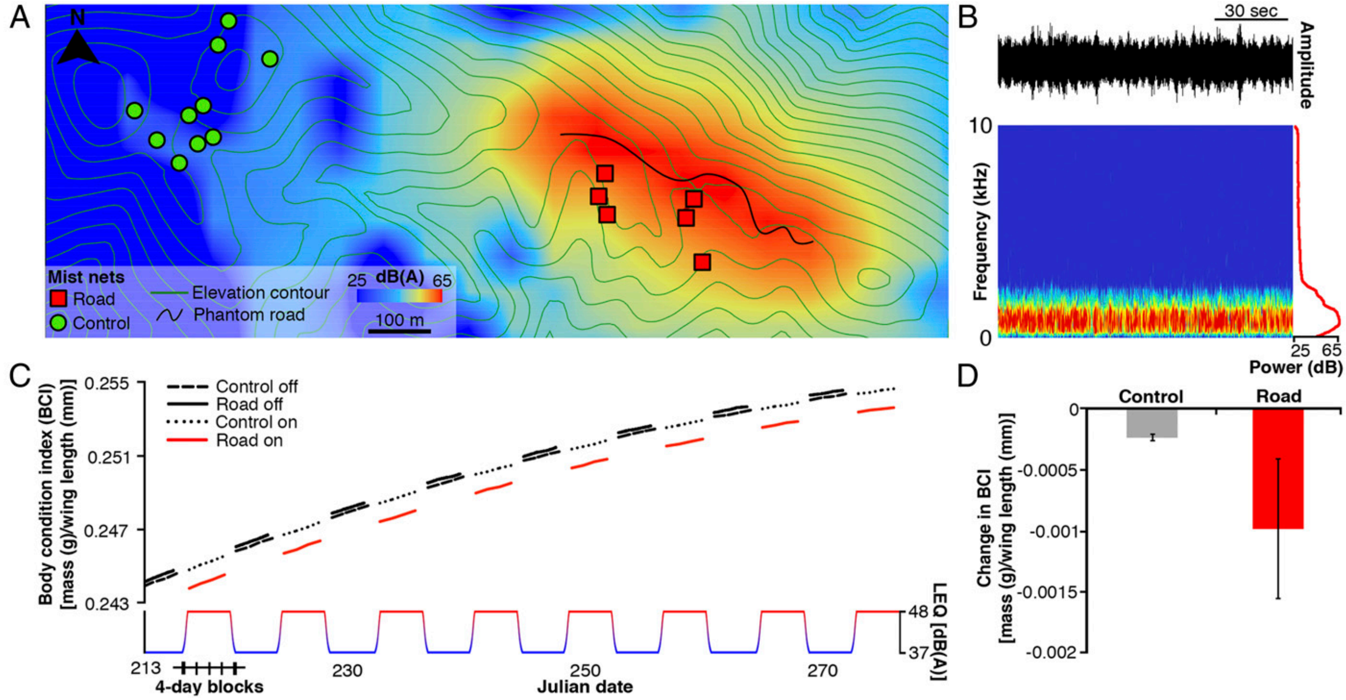

Fig. 1. Phantom road playback causes songbird body condition decline. (*A*) Estimated sound levels [dB(A) 1 h LEQ: The level of a constant sound over a specified time period that has the same energy as the actual (unsteady) sound over the same interval] during periods when speakers were on: from August through October 2012–2013 in the Boise Foothills, Idaho. Sound level was modeled using NMSim (Wyle Laboratories) (20). Circles (control) and squares (road) represent capture sites. With the noise on, mean sound levels at the phantom road capture sites increased by 11 dB(A) to 48 dB(A) (SE = 0.3), whereas the control site averaged 2 dB(A) louder with noise on (mean± SE; 41 dB(A) ± 0.2). With noise off, sound levels averaged 39 dB(A) (SE = 0.2) at the control capture sites and 37 dB(A) (SE = 0.3) at the phantom road. Elevation contours are 50 m. (*B*) A 2-min sample of the phantom road file displayed as an oscillogram, a spectrogram and a power spectrum. (*C*) Predicted values for body condition index (BCI) as birds add fuel throughout fall migration. Estimates are based on the AIC-best model for BCI for all captures combined, with species as a random intercept. A consistent full SD change in BCI is evident during each noise-on block (pattern of noise on blocks displayed along the *x* axis) throughout the migratory period. (*D*) Predicted mean change in BCI at the control and phantom road sites between noise off and noise on periods across the entire study. Error bars represent SE. These differences in BCI (and associated error) are derived from the average of the predictions presented in *C*.

Focusing on birds exposed to a gradient of sound levels, we examined differences in body condition index (BCI) of newly captured birds. BCI is a size-adjusted metric of body mass calculated as mass (g)/natural wing chord (mm). Small changes in BCI represent large differences in condition (21). During migration, high body condition signifies birds with the energy stores needed for long migratory flights (15). The best-fitting model showed that as noise exposure increased, overall BCI of the bird community remaining at the road site decreased (Fig. 1*C*, Table S1, Datasets S1 and S2, and *SI Text*). In fact, BCI in noise declined by a full SD compared with the community mean in control conditions. In the absence of noise, BCI of the songbird community at the phantom road site did not differ from the values at the control site, indicating both were suitable stopover locations (Fig. 1*C*). Models for individual species showed 5 of 21 species significantly decreased BCI in noise. Iterative exposure to noise during the multiple stopovers of saltatory migration may ultimately result in mortality (16) or, in a better case scenario, reduced fitness manifested from slower migration speed (14) which would likely impact fitness and survival in the subsequent life history stage (22).

Because we turned the phantom road off overnight to match typical diel traffic patterns, it is likely that nocturnal migrants (the majority of species in this study; see ref. 23) chose to land at our site when it was quiet, before the phantom road playbacks began in the morning. In effect, diurnally varying traffic noise might function as an ecological trap (24) for migrants. Although staying in traffic noise has a cost, the energetic outlay for individuals to leave a given site might be even greater. Birds with low body condition are less likely to embark on migratory journeys than those in good condition, and depending on the suitability of surrounding habitat, it may not be worth the risk to disperse once landed (25). We cannot differentiate whether the lower BCI we documented in traffic noise is the result of (*i*) higher body condition birds leaving the population or (*ii*) birds losing body condition over the duration of noise exposure. We saw both reduced mean body condition and reduced bird numbers, suggesting that at least some birds with the energetic stores to migrate chose to leave the site and escape the costs of remaining in noise (25).

To examine if the birds that remained in noise were suffering reduced ability to add migratory fuel (i.e., increase BCI), we regressed BCI of new captures against time of day to estimate stopover efficiency. Comparing stopover efficiency of individuals between sites provides an essential metric to compare the relative value of stopover habitat (*SI Text*). The best-fitting model for the entire songbird community included noise intensity level [dB(A)] although the confidence intervals overlapped zero (*SI Text*). For nine individual species, the best-fitting model included a noise variable, however the confidence intervals overlapped zero for all but 3 of these species (Table S1).

For MacGillivray's warblers, the best-fitting model showed that stopover efficiency substantially decreased with increasing decibel levels. MacGillivray's warblers did not show reduced capture rates in noise, and were the species that showed the strongest negative responses for both BCI and stopover efficiency, indicating that individuals stayed but did poorly in noise (Fig. 2*A* and Tables S1 and S2). In contrast, Cassin's finches had significantly increased stopover efficiency in noise and a decreased capture rate (Fig. 2*B* and

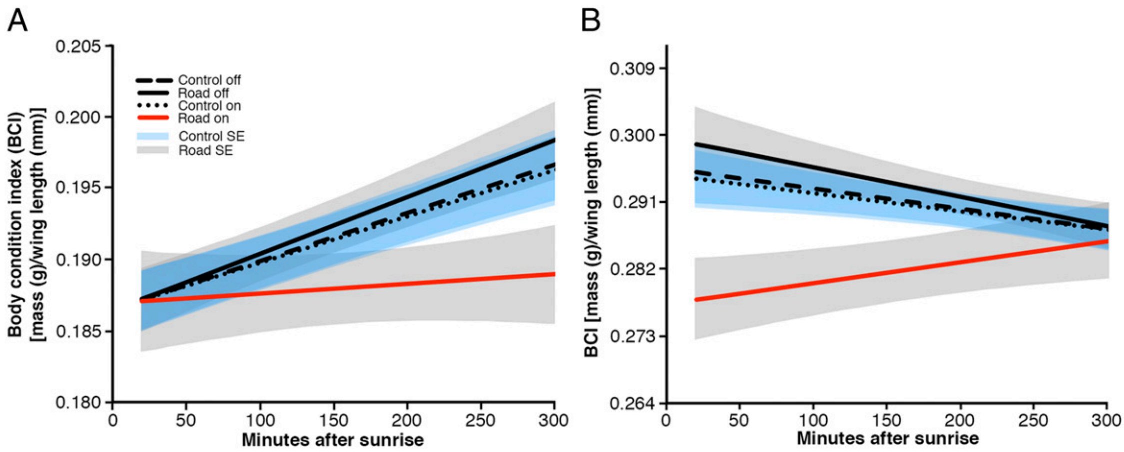

Fig. 2. Stopover efficiency is altered in noise. Predicted values for stopover efficiency for MacGillivray's warblers (*A*) and Cassin's finches (*B*). Estimates were made using average day of season using the AIC-best model for BCI for all captures combined. Values were predicted by inputting average dB(A) levels for each site. Values are shown for the control site noise off [avg. 42 dB(A)], control site noise on [43 dB(A)], phantom site noise off [40 dB(A)], and phantom site noise on [51 dB(A)]. Blue shading represents SE for the control site whereas gray shading represents SE for the phantom road.

Tables S1 and S2). This increase in stopover efficiency might reflect decreased competition for food resources in noise. Although stopover efficiency was increased in noise (Fig. 2*B*), Cassin's finches showed lower initial BCI in traffic noise (Fig. 2*B*), perhaps indicating individuals with higher BCI left the site during noise exposure. The best models for spotted towhees showed a reduced capture rate and also indicated different stopover efficiencies between on-off periods at the control and road sites with efficiency being negatively affected by noise along the phantom road (Fig. S1 and Tables S1 and S2).

It seems that for species impacted by noise, different strategies exist for managing the consequences, which might be based on differences in life history traits such as territoriality during stopover, migratory strategy, or flocking behavior. Our species-specific results show that birds may stay and incur a cost of remaining in noise (e.g., MacGillivray's warblers), or choose to leave (e.g., Cassin's finches). Leaving the noisy area may allow some species to avoid the costs of noise or a species may still experience the impacts of noise despite some individuals leaving (e.g., spotted towhees). Together, our observations of overall changes in the BCI of the entire bird community and of several individual species, as well as the changes in stopover efficiency of spotted towhee and MacGillivray's warbler, demonstrate that addition of traffic noise alone, without the other variables associated with actual roadways, can significantly decrease the value of a stopover site.

In support of our field results, we conducted a controlled laboratory study to test whether traffic noise alters the foraging-vigilance tradeoff in songbirds and could thus mechanistically underpin our field data (*SI Text*). We focused on the second most common species from our field study, white-crowned sparrow (*Zonotrichia leucophrys*), a species that also decreased BCI in noise, to investigate the reduction in foraging and increase in vigilance implied by our community-wide body condition analysis. We quantified head-down duration (i.e., foraging) and head-up rate (i.e., vigilance), because these are known measures of avian visual vigilance that change when auditory surveillance is limited and that correlate with food intake and ability to detect predator attacks (26). We also measured feeding duration (no. seconds per 8-min trial spent feeding) to quantify overall feeding bout duration. Using the same playback file as our field experiment, we played 61 dB(A) and 55 dB(A) traffic noise treatments, plus a silent control track [32 dB(A)] to foraging sparrows (n = 20). White-crowned sparrows decreased foraging by ∼8%, increased vigilance levels by ∼21%, and decreased feeding duration by ∼30% when exposed

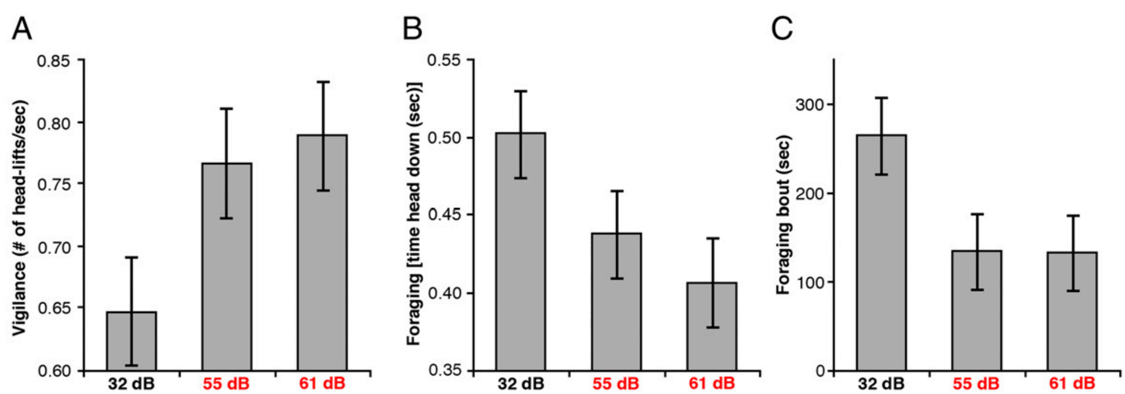

Fig. 3. The foraging/vigilance trade-off is altered in noise. White-crowned sparrows foraging in traffic noise at 61 and 55 dB(A) had reduced foraging rates (*A*), increased vigilance (*B*), and decreased foraging bout duration (*C*) compared with trials in ambient conditions [32 dB(A)]. Data are means ± SE. [Mean head up rate (head lifts/s) for 61 dB(A) = 0.79 ± 0.06, 55 dB(A) = 0.77 ± 0.05, 32 dB(A) = 0.65 ± 0.05. Mean head down duration (s): 61 dB(A) = 0.41 ± 0.03, 55 dB(A) = 0.44 ± 0.04, 32 dB(A) = 0.50 ± 0.04. Mean foraging bout duration (s): 61 dB(A) = 159.25 ± 28.0 55 dB(A) = 147 ± 32.5 32 dB(A) = 228 ± 33.7]. Birds showed more head lifts/s (β = 0.005 ± 0.002), decreased the amount of time spent with their heads down searching for seeds (β = −0.003 ± 0.001), and decreased total feeding duration (β = −4.589 ± 1.944; Movies S1 and S2) during noise playback compared with ambient conditions.

to traffic noise [61 dB(A); Fig. 3, Movies S1 and S2, and Dataset S3]. Vigilance behavior of individuals did not change based on the number of trials experienced, indicating birds did not habituate to the noise (*SI Text* and Table S2). During energetically demanding periods in a bird's life, increasing vigilance can reduce survival because of increased starvation risk (27). In contrast to song masking, which can be partially overcome by frequency shifting (28), release from masking is not possible for auditory cues necessary for aural vigilance (7). With limited auditory information, animals must resort to other methods such as visual scans to compensate for the increase in perceived predation risk, perhaps driven by masking of communication calls and predator-generated sounds (26, 29).

Our behavioral investigations in the laboratory offer compelling evidence that the body condition changes measured in the field were due at least in part to a change in foraging and vigilance behavior, but our field results could be due to a combination of factors that also deserve consideration. For example, noise might also increase physiological stress levels (ref. 30, but see ref. 31) that could cause additional declines in body condition. However, we view it as unlikely that noise can cause a stress response independent of a change in behavior. In addition, noise might indirectly change foraging rates through alterations in prey search time, sleep, or territoriality. For instance, our phantom road might have disrupted foraging behavior by reducing the acoustic detectability of insect prey (32) or reducing insect numbers. We did not test for changes in insect abundance or distribution, but because we found noise impacts on a mixed community of both frugivorous and insectivorous birds (Table S1 and Dataset S1), it seems unlikely that altered insect numbers explain a significant component of the observed patterns. Effects were consistent between the 4-d noise-on blocks throughout migration, despite documented seasonal variation in fruit and arthropod availability at the site (33), so it is more likely that changes in bird behavior drove these responses. Our experimental design was not able to determine whether noise disrupts territoriality or dominance hierarchies during stopover. However, both territorial and nonterritorial species showed negative effects of noise (23) (Table S1 and Datasets S1 and S4). We expect that a subset of these indirect effects plus the behavioral changes quantified in the laboratory contributed to the body condition declines seen in our field experiment. Because provisioning is a constant requirement for birds throughout the year, other effects of noise that occur outside of migration (e.g., refs. 4 and 5) would be in addition to, rather than instead of, the impacts we document here.

Previous work that failed to find a change in animal distributions near roads or other infrastructure has assumed a lack of negative impacts from loud human activities (2, 3). Our results demonstrate that individuals may remain in an area with high levels of noise yet suffer significant costs. We found that different species chose different strategies: to either leave noisy areas, or stay and perhaps incur the costs of noise (Fig. 1, Fig. S2, and Table S1). We exposed the bird community at our phantom road to sound levels similar to some suburban neighborhoods [~55 dB(A) hourly LEQ] (34). Many protected areas and high-value habitats are currently exposed to these levels, and would benefit from noise relief measures (35, 36). The impact of noise reaches far beyond the physical footprint of human infrastructure. Unlike other aspects of roads, noise impacts can be minimized without removing the road itself. Substrate alteration and speed limit reduction on existing roads can significantly lower decibel levels (34).

Our results reveal the need for attention to noise impacts beyond distributional shifts (3). For individuals that remain in areas disturbed by loud human activities, noise pollution represents an invisible source of habitat degradation that has been largely ignored: Traffic noise degrades habitat value but leaves no physical signs of change. Stopover habitat loss and degradation have been identified as major contributing factors to migratory songbird declines worldwide (37, 38). Migrants are exposed to an unknown risk landscape at stopover sites and must therefore rely heavily on increased vigilance to compensate (39–41). Unlike resident species, successful conservation of migratory species requires protection of habitats in breeding, wintering, and stopover locations (41). In addition, reduction in condition or delay in migration could have carry-over effects into the overwintering or breeding seasons (42). Further understanding of anthropogenic noise's impact on body condition is key, as it is an important predictor of fitness across taxa and life stage (22). When managing natural systems, we should ensure that the habitat we protect remains of high quality, including the quality of the acoustic environment.

All birds caught during this project were mist-netted and banded under the Intermountain Bird Observatory's federal permit (22929) and Idaho Department of Fish and Game permit (764–13-000039). All experiments were approved by Boise State University's Institutional Animal Care and Use Committee (006-AC12-007 and 006-AC13-002).

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ECOLOGY

ATTACHMENT 5

DarkSky

Donate / renew

What we do

International Dark Sky Places

The International Dark Sky Places (IDSP) program certifies communities, parks, and protected areas around the world that preserve and protect dark sites through responsible lighting policies and public education.

Find a Dark Sky Place

Dark Sky Places are all over the world

DarkSky has certified more than 200 Places since Flagstaff, Arizona, was named the first International Dark Sky City in 2001.

There are now over 160,000 square kilometers of protected land and night skies in 22 countries on 6 continents, and the list grows every year as new places achieve certification.

200+

Dark Sky Places around the world

22

Countries represented

160,798+

Square kilometers of protected land and night sky

Visit a Dark Sky Place

Why Dark Sky Places are a conservation priority

The night sky and nocturnal environment are naturally, culturally, and historically important resources worthy of conservation.

The International Astronomical Union recommends that “to safeguard the right of any citizen to enjoy the vision of the starred sky, national and local governments [should] establish a suitable number of ‘Dark Sky Oases’ and protect them from excessive artificial light at night.”

Dark Sky Places connect us to nighttime nature

International Dark Sky Places protect ecologically sensitive areas and our universal heritage in the starry night sky.

Certified Places are required to use quality outdoor lighting, effective policies to reduce light pollution, ongoing stewardship practices, and more.

More about conservation

TYPES

Dark Sky Place certifications

International Dark Sky Parks

Publicly or privately owned conservation areas that implement good outdoor lighting and provide dark sky programs.

View all Parks

International Dark Sky Sanctuaries

The most remote (and often darkest) places in the world, whose conservation state is most fragile.

View all Sanctuaries

International Dark Sky Reserves

Dark "core" zones surrounded by a populated periphery where policy controls protect the darkness of the core.

View all Reserves

Urban Night Sky Places

Urban sites that promote an authentic nighttime experience despite being in the midst of significant artificial light.

View all Urban Places

International Dark Sky Communities

Cities and towns with quality outdoor lighting ordinances that educate residents about the importance of dark skies.

View all Communities

View all Places A–Z

HISTORY

Protecting the night since 2001

In 2001 Flagstaff, Arizona, U.S.A., was recognized by DarkSky (formerly, the International Dark-Sky Association) for its efforts in outdoor lighting policy and retrofits. The International Dark Sky Places (IDSP) program was created to provide an incentive for communities and protected places to follow Flagstaff's example, encouraging people to choose better lighting and implement it through effective public policy.

Your browser can't play this video.
Learn more

In the years since, the IDSP program developed best practices in the management of outdoor lighting with conservation professionals, and deployed them in appropriate settings as the program expanded to include International Dark Sky Parks, Reserves, and Sanctuaries, as well as Urban Night Sky Places.

The IDSP program received the National Environmental Excellence Award in 2015.

With the subsequent introduction of the categories called Dark Sky Communities and Urban Night Sky Places, we're now bridging the gap between cities and protected areas — in a way, bringing this effort almost full circle over 20 years on.

Learn why nocturnal conservation is important.

Frequently asked questions

What is the benefit of becoming certified as an International Dark Sky Place?

Certification of a Place alerts visitors to the problem of light pollution and the need to preserve the night sky as a natural resource. The certification supports management agencies in achieving long-term conservation targets and connecting people to nature. Additionally, it serves as an economic driver by fostering increased tourism and local economic activity. Learn more

How do I find the nearest International Dark Sky Place to me?

They're all listed by country and region on the All Places page.

What kind of an experience can I expect at an International Dark Sky Place?

All certified Places provide a quality nighttime experience that will allow you to connect with nature at night. As you move through the light-to-dark gradient, the veil of light pollution will recede and reveal a magical sight — a sky astoundingly *full* of stars and, depending on the time of year, a view of the Milky Way with the unaided eye. Parks, Sanctuaries, and Reserve cores ensure that this view is available on a typical night.

Be filled with awe and wonder while you stargaze

Go for a night hike under the illumination of the moon or the brilliant Milky Way

Listen to a story that shares the lessons learned from the night sky passed down through generations

Practice your astrophotography skills and capture celestial phenomena

Experience the nocturnal environment when animals like bats, fireflies, owls, nightjars, and foxes are active

See quality outdoor lighting fixtures in action

Whom can I talk to about getting certified in the International Dark Sky Places Program?

You can contact the Dark Sky Places Program Associate. Detailed guidance on developing documents or other aspects of certification can only be provided after a site has passed an eligibility check and has submitted the one-time application fee to initiate an application.

More FAQs

Apply

The Dark Sky Places program certifies a range of places within the dark-to-very-dark gradient, from national parks, observatories, and lands managed by non-governmental organizations, to villages and cities.

Certification almost always begins with a small group of individuals seeking formal protection of their nightscape and setting a positive example for their communities and countries.

Learn about the process

INTERNATIONAL DARK SKY PLACES

In this section

Visit a Dark Sky Place

All Dark Sky Places A–Z

Sanctuaries

Reserves

Parks

Urban Places

Communities

Developments of Distinction

Learn about Dark Sky Places

Nocturnal conservation

Dark Sky Place types

Dark Sky Places FAQ

Apply for Dark Sky Place certification

Application process

Application FAQ

Application

ATTACHMENT 6

DarkSky

Donate / renew

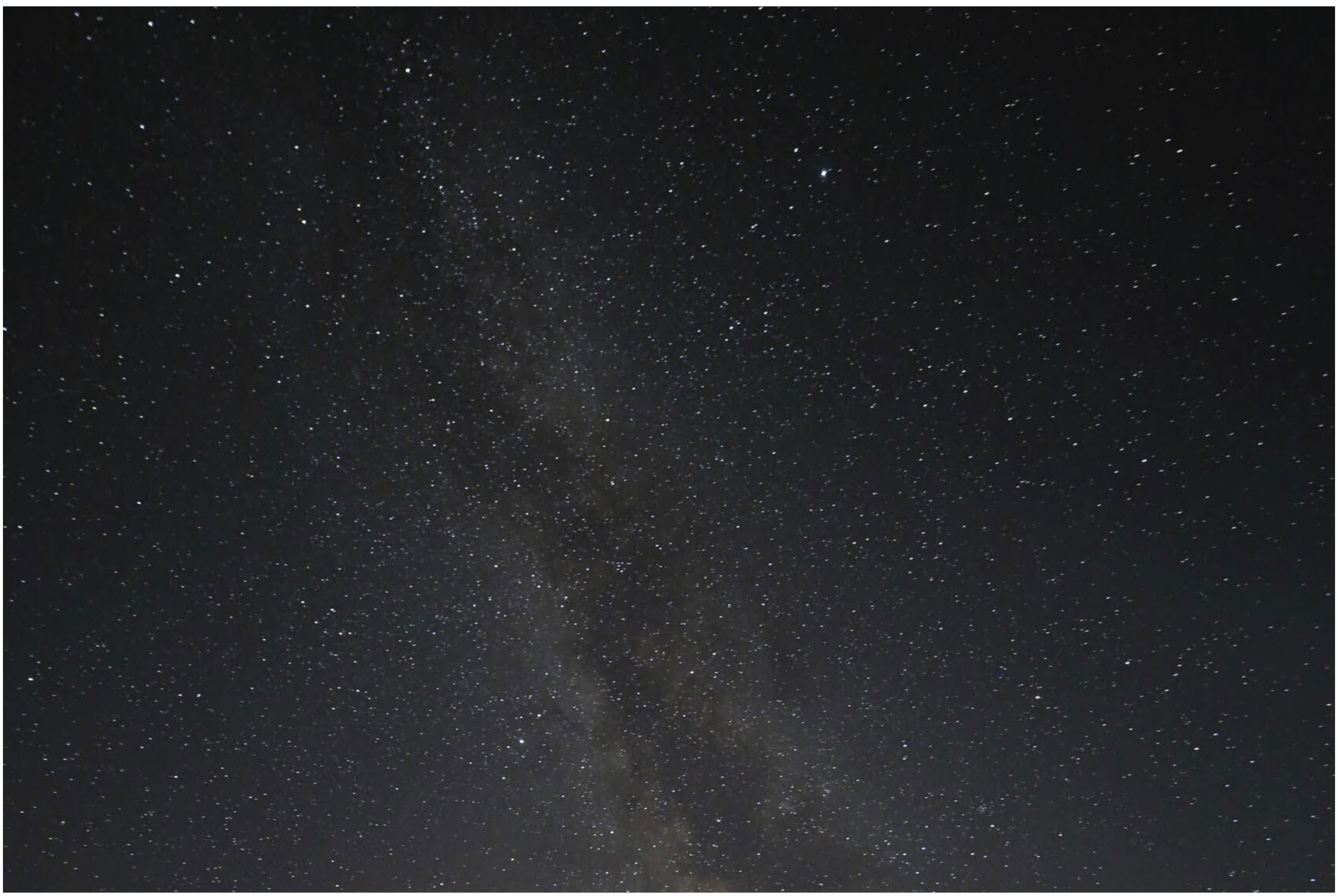
What we do

International Dark Sky Places

Katahdin Woods and Waters National Monument

-

Published May 8, 2020



What we do

International Dark Sky Places

International Dark Sky Communities

Communities

Parks

International Dark Sky Parks

Reserves

International Dark Sky Reserves

International Dark Sky Sanctuaries

Sanctuaries

Urban Places

About

Within the North Woods of Maine, Katahdin Woods and Waters National Monument covers an area of approximately 87,500 acres within a larger landscape already conserved by public and private efforts starting a century ago. Katahdin Woods and Waters contains a significant piece of the extraordinary natural and cultural landscape which includes the mountains, woods, and waters east of Baxter State Park (home of Mount Katahdin, the northern terminus of the Appalachian Trail), where the East Branch of the Penobscot River and its tributaries, including the Wassataquoik Stream and the Seboeis River, run freely. Since the glaciers retreated 12,000 years ago, these waterways and associated resources —the scenery, geology, flora and fauna, night skies, and more —have attracted people to this area. Native Americans still cherish these resources. Lumberjacks, river drivers, and timber owners have earned their livings here. Artists, authors, scientists, conservationists, recreationists, and others have drawn knowledge and inspiration from this landscape.

Designated

2020

Category

International Dark Sky Sanctuary

Address

Patten, ME 04765

U.S.

Google Maps

Contact

Jeanne Roy
Isabel Ashton
Website
Tel.: 1-207-456-6001

Land Area

354 km^2

Documents

Application
Press Release
Annual Reports

AUTHOR

Staff

PUBLISHED

May 8, 2020

Updated August 6, 2023

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ATTACHMENT 7

BIODIVERSITY LOSS

Decline of the North American avifauna

Kenneth V. Rosenberg[1,2]*, Adriaan M. Dokter[1], Peter J. Blancher[3], John R. Sauer[4], Adam C. Smith[5], Paul A. Smith[3], Jessica C. Stanton[6], Arvind Panjabi[7], Laura Helft[1], Michael Parr[2], Peter P. Marra[8]†

Species extinctions have defined the global biodiversity crisis, but extinction begins with loss in abundance of individuals that can result in compositional and functional changes of ecosystems. Using multiple and independent monitoring networks, we report population losses across much of the North American avifauna over 48 years, including once-common species and from most biomes. Integration of range-wide population trajectories and size estimates indicates a net loss approaching 3 billion birds, or 29% of 1970 abundance. A continent-wide weather radar network also reveals a similarly steep decline in biomass passage of migrating birds over a recent 10-year period. This loss of bird abundance signals an urgent need to address threats to avert future avifaunal collapse and associated loss of ecosystem integrity, function, and services.

Slowing the loss of biodiversity is one of the defining environmental challenges of the 21st century (*1*–*5*). Habitat loss, climate change, unregulated harvest, and other forms of human-caused mortality (*6*, *7*) have contributed to a thousandfold increase in global extinctions in the Anthropocene compared to the presumed prehuman background rate, with profound effects on ecosystem functioning and services (*8*). The overwhelming focus on species extinctions, however, has underestimated the extent and consequences of biotic change, by ignoring the loss of abundance within still-common species and in aggregate across large species assemblages (*2*, *9*). Declines in abundance can degrade ecosystem integrity, reducing vital ecological, evolutionary, economic, and social services that organisms provide to their environment (*8*, *10*–*15*). Given the current pace of global environmental change, quantifying change in species abundances is essential to assess ecosystem impacts. Evaluating the magnitude of declines requires effective long-term monitoring of population sizes and trends, data that are rarely available for most taxa.

Birds are excellent indicators of environmental health and ecosystem integrity (*16*, *17*), and our ability to monitor many species over vast spatial scales far exceeds that of any other animal group. We evaluated population change for 529 species of birds in the continental United States and Canada (76% of breeding species), drawing from multiple standardized bird-monitoring datasets, some of which provide close to 50 years of population data. We integrated range-wide estimates of population size and 48-year population trajectories, along with their associated uncertainty, to quantify net change in numbers of birds across the avifauna over recent decades (*18*). We also used a network of 143 weather radars (NEXRAD) across the contiguous United States to estimate long-term changes in nocturnal migratory passage of avian biomass through the airspace in spring from 2007 to 2017. The continuous operation and broad coverage of NEXRAD provide an automated and standardized monitoring tool with unrivaled temporal and spatial extent (*19*). Radar measures cumulative passage across all nocturnally migrating species, many of which breed in areas north of the contiguous United States that are poorly monitored by avian surveys. Radar thus expands the area and the proportion of the migratory avifauna that is sampled relative to ground surveys.

Results from long-term surveys, accounting for both increasing and declining species, reveal a net loss in total abundance of 2.9 billion [95% credible interval (CI) = 2.7–3.1 billion] birds across almost all biomes, a reduction of 29% (95% CIs = 27–30%) since 1970 (Fig. 1 and Table 1). Analysis of NEXRAD data indicates a similarly steep decline in nocturnal passage of migratory biomass, a reduction of 13.6 ± 9.1% since 2007 (Fig. 2A). Reduction in biomass passage occurred across the eastern United States (Fig. 2, C and D), where migration is dominated by large numbers of temperate- and boreal-breeding songbirds; we observed no consistent trend in the Central or Pacific flyway regions (Fig. 2, B to D, and table S5). Two completely different and independent monitoring techniques thus signal major population loss across the continental avifauna.

Species exhibiting declines (57%, 303 out of 529 species) on the basis of long-term survey data span diverse ecological and taxonomic groups. Across breeding biomes, grassland birds showed the largest magnitude of total population loss since 1970—more than 700 million breeding individuals across 31 species—and the largest proportional loss (53%); 74% of grassland species are declining. (Fig. 1 and Table 1). All forest biomes experienced large avian loss, with a cumulative reduction of more than 1 billion birds. Wetland birds represent the only biome to show an overall net gain in numbers (13%), led by a 56% increase in waterfowl populations (Fig. 3 and Table 1). Unexpectedly, we also found a large net loss (63%) across 10 introduced species (Fig. 3, D and E, and Table 1).

A total of 419 native migratory species experienced a net loss of 2.5 billion individuals, whereas 100 native resident species showed a small net increase (26 million). Species overwintering in temperate regions experienced the largest net reduction in abundance (1.4 billion), but proportional loss was greatest among species overwintering in coastal regions (42%), southwestern aridlands (42%), and South America (40%) (Table 1 and fig. S1). Shorebirds, most of which migrate long distances to winter along coasts throughout the hemisphere, are experiencing consistent, steep population loss (37%).

More than 90% of the total cumulative loss can be attributed to 12 bird families (Fig. 3A), including sparrows, warblers, blackbirds, and finches. Of 67 bird families surveyed, 38 showed a net loss in total abundance, whereas 29 showed gains (Fig. 3B), indicating recent changes in avifaunal composition (table S2). Although not optimized for species-level analysis, our model indicates that 19 widespread and abundant landbirds (including two introduced species) each experienced population reductions of >50 million birds (data S1). Abundant species also contribute strongly to the migratory passage detected by radar (*19*), and radar-derived trends provide a fully independent estimate of widespread declines of migratory birds.

Our study documents a long-developing but overlooked biodiversity crisis in North America—the cumulative loss of nearly 3 billion birds across the avifauna. Population loss is not restricted to rare and threatened species, but includes many widespread and common species that may be disproportionately influential components of food webs and ecosystem function. Furthermore, losses among habitat generalists and even introduced species indicate that declining species are not replaced by species that fare well in human-altered landscapes. Increases among waterfowl and a few other groups (e.g., raptors recovering after the banning of DDT) are insufficient to offset large losses among abundant species (Fig. 3). Notably, our population loss estimates are conservative because we estimated loss only in breeding populations. The total loss and

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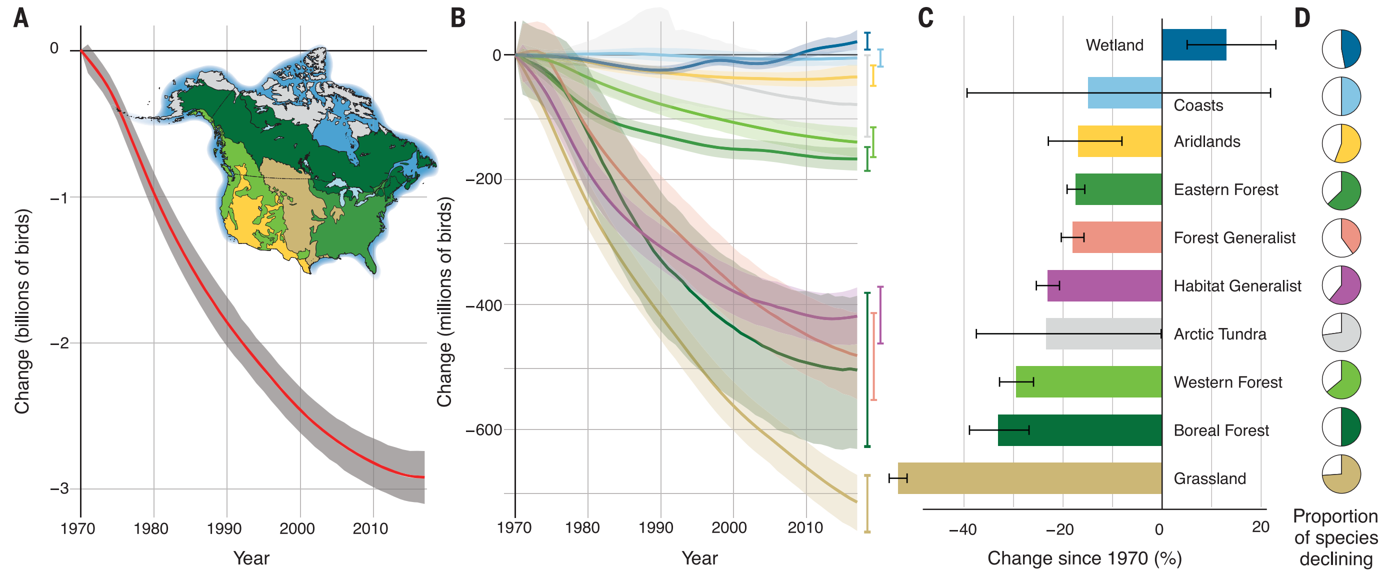

Fig. 1. Net population change in North American birds. (**A**) By integrating population size estimates and trajectories for 529 species (*18*), we show a net loss of 2.9 billion breeding birds across the continental avifauna since 1970. Gray shading represents the 95% credible interval (CI) around total estimated loss. Map shows color-coded breeding biomes based on Bird Conservation Regions and land cover classification (*18*). (**B**) Net loss of abundance occurred across all major breeding biomes except wetlands (see Table 1). (**C**) Proportional net population change relative to 1970, ±95% CI. (**D**) Proportion of species declining in each biome.

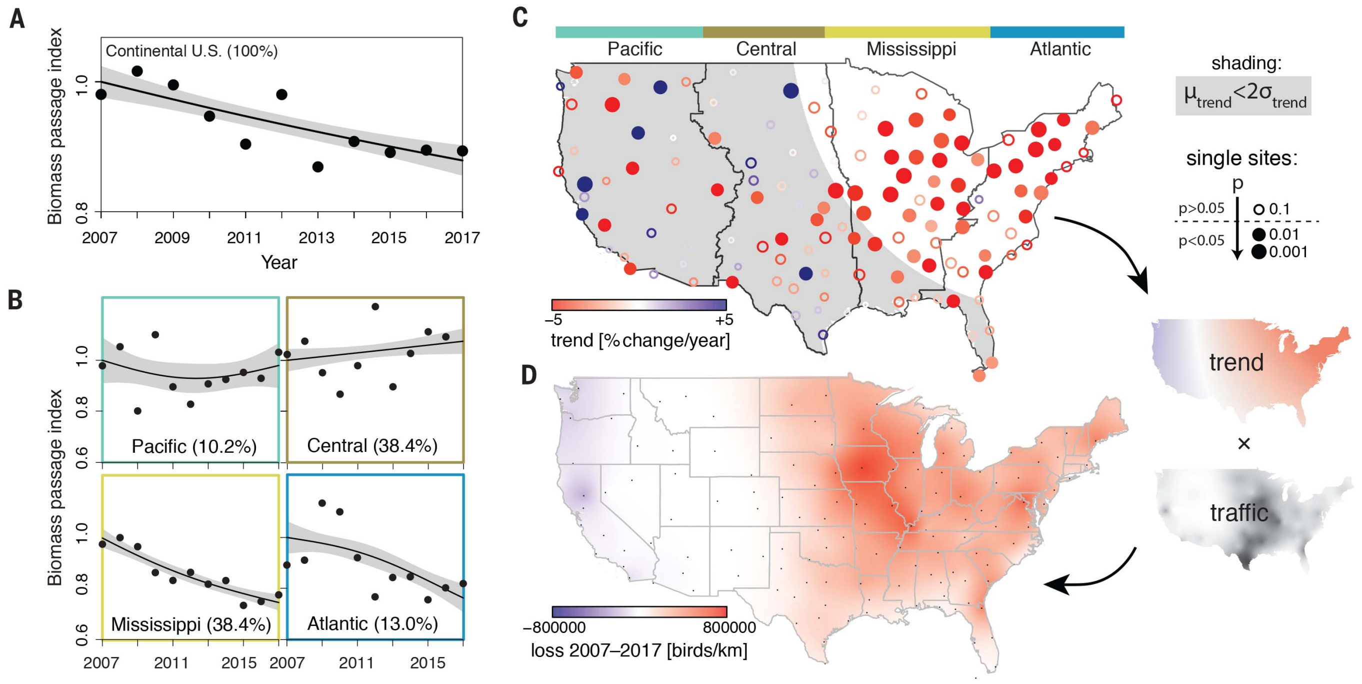

Fig. 2. NEXRAD radar monitoring of nocturnal bird migration across the contiguous United States. (**A**) Annual change in biomass passage for the full continental United States (black) and (**B**) the Pacific (green), Central (brown), Mississippi (yellow), and Atlantic (blue) flyways [borders indicated in (C)], with percentage of total biomass passage (migration traffic) for each flyway indicated; declines are significant only for the full United States and the Mississippi and Atlantic flyways (tables S3 to S5). (**C**) Single-site trends in seasonal biomass passage at 143 NEXRAD stations in spring (1 March to 1 July), estimated for the period 2007–2017. Darker red colors indicate higher declines and loss of biomass passage, whereas blue colors indicate biomass increase. Circle size indicates trend significance, with closed circles being significant at a 95% confidence level. Only areas outside gray shading have a spatially consistent trend signal separated from background variability. (**D**) Ten-year cumulative loss in biomass passage, estimated as the product of a spatially explicit (generalized additive model) trend, times the surface of average cumulative spring biomass passage.

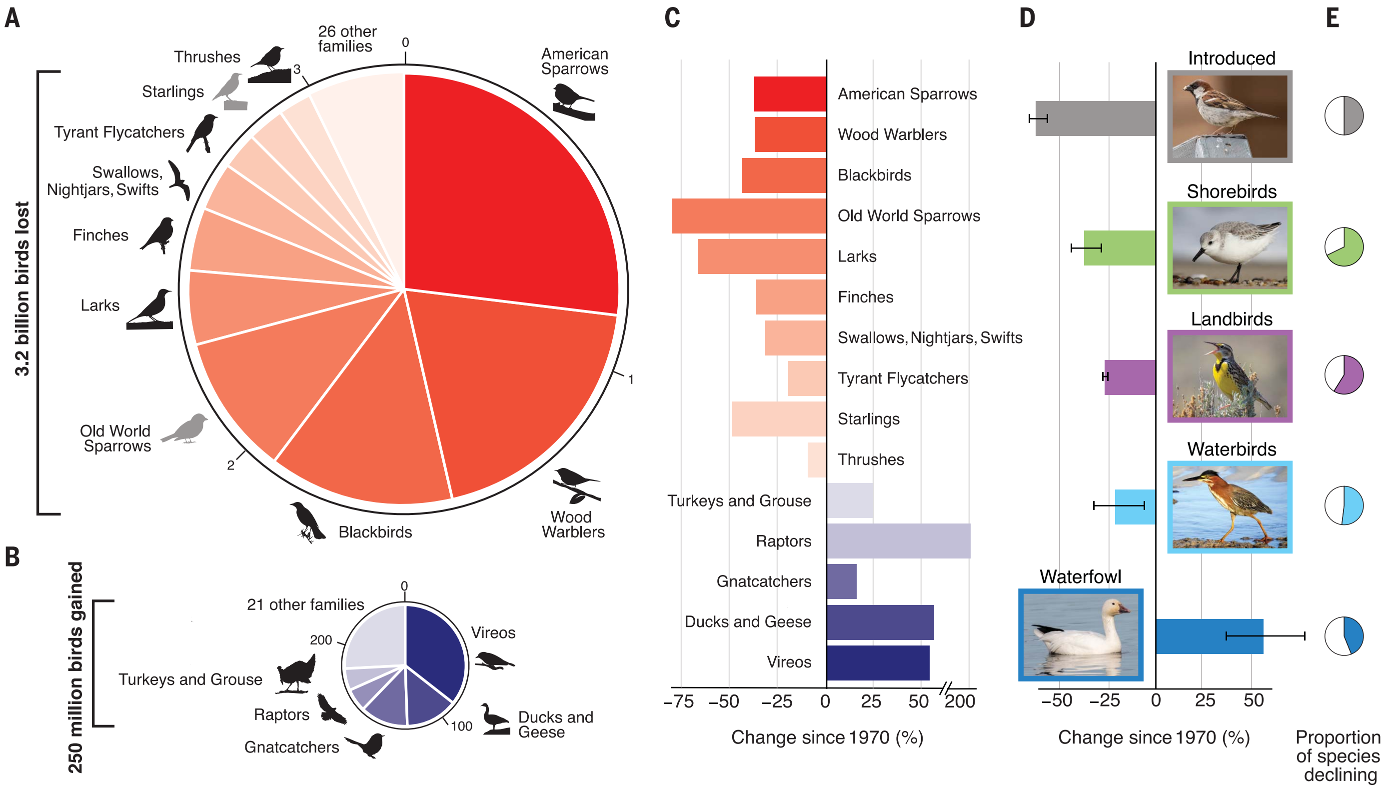

Fig. 3. Gains and losses across the North American avifauna over the past half-century. (**A**) Bird families were categorized as having a net loss (red) or gain (blue). Total loss of 3.2 billion birds occurred across 38 families; each family with losses greater than 50 million individuals is shown as a proportion of total loss, including two introduced families (gray). Swallows, nightjars, and swifts together show loss within the aerial insectivore guild. (**B**) Twenty-nine families show a total gain of 250 million individual birds; the five families with gains greater than 15 million individuals are shown as a proportion of total gain. Four families of raptors are shown as a single group. Note that combining total gain and total loss yields a net loss of 2.9 billion birds across the entire avifauna. (**C**) For each individually represented family in (B) and (C), proportional population change within that family is shown. See table S2 for statistics on each individual family. (**D**) Percentage population change among introduced and each of four management groups (*18*). A representative species from each group is shown (top to bottom, house sparrow, *Passer domesticus*; sanderling, *Calidris alba*; western meadowlark, *Sturnella neglecta*; green heron, *Butorides virescens*; and snow goose, *Anser caerulescens*). (**E**) Proportion of species with declining trends.

impact on communities and ecosystems could be even higher outside the breeding season if we consider the amplifying effect of "missing" reproductive output from these lost breeders.

Extinction of the passenger pigeon (*Ectopistes migratorius*), once likely the most numerous bird on the planet, provides a poignant reminder that even abundant species can go extinct rapidly. Systematic monitoring and attention paid to population declines could have alerted society to its pending extinction (*20*). Today, monitoring data suggest that avian declines will likely continue without targeted conservation action, triggering additional endangered species listings at tremendous financial and social cost. Moreover, because birds provide numerous benefits to ecosystems (e.g., seed dispersal, pollination, pest control) and economies [47 million people spend U.S.$9.3 billion per year through bird-related activities in the United States (*21*)], their population reductions and possible extinctions will have severe direct and indirect consequences (*10*, *22*). Population declines can be reversed, as evidenced by the exceptional recovery of waterfowl populations under adaptive harvest management (*23*) and the associated allocation of billions of dollars devoted to wetland protection and restoration, providing a model for proactive conservation in other widespread native habitats such as grasslands.

Steep declines in North American bird populations parallel patterns of avian declines emerging globally (*14*, *15*, *22*, *24*). In particular, depletion of native grassland bird populations in North America, driven by habitat loss and more toxic pesticide use in both breeding and wintering areas (*25*), mirrors loss of farmland birds throughout Europe and elsewhere (*15*). Even declines among introduced species match similar declines within these same species' native ranges (*26*). Agricultural intensification and urbanization have been similarly linked to declines in insect diversity and biomass (*27*), with cascading impacts on birds and other consumers (*24*, *28*, *29*). Given that birds are one of the best monitored animal groups, birds may also foreshadow a much larger problem, indicating similar or greater losses in other taxonomic groups (*28*, *30*).

Pervasiveness of avian loss across biomes and bird families suggests multiple and interacting threats. Isolating spatiotemporal limiting factors for individual species and populations will require additional study, however, because migratory species with complex life histories are in contact with many threats throughout their annual cycles. A focus on breeding season biology hampers our ability to understand how seasonal interactions drive population change (*31*), although recent continent-wide analyses affirm the importance of events during the nonbreeding season (*19*, *32*). Targeted research to identify limiting factors must be coupled with effective policies and societal change that emphasize reducing threats to breeding and nonbreeding habitats and minimizing avoidable anthropogenic mortality year-round. Endangered species legislation and international treaties, such as the 1916 Migratory Bird Treaty between Canada and the United States, have prevented extinctions

Table 1. Net change in abundance across the North American avifauna, 1970–2017. Species are grouped into native and introduced species, management groups (landbirds, shorebirds, waterbirds, waterfowl), major breeding biomes, and nonbreeding biomes [see data S1 in (*18*) for assignments and definitions of groups and biomes]. Net change in abundance is expressed in millions of breeding individuals, with upper and lower bounds of each 95% credible interval (CI) shown. Percentage of species in each group with negative trend trajectories is also noted. Values in bold indicate declines and loss; those in italics indicate gains.

Species group	No. of species	Net abundance change (millions) and 95% CIs			Percent change and 95% CIs			Proportion species in decline
		Change	LC95	UC95	Change	LC95	UC95	
Species summary								
All N. Am. species	529	**–2,911.9**	–3,097.5	–2,732.9	**–28.8%**	–30.2%	–27.3%	57.3%
All native species	519	**–2,521.0**	–2,698.5	–2,347.6	**–26.5%**	–28.0%	–24.9%	57.4%
Introduced species	10	**–391.6**	–442.3	–336.6	**–62.9%**	–66.5%	–56.4%	50.0%
Native migratory species	419	**–2,547.7**	–2,723.7	–2,374.5	**–28.3%**	–29.8%	–26.7%	58.2%
Native resident species	100	*26.3*	7.3	46.9	*5.3%*	1.4%	9.6%	54.0%
Landbirds	357	**–2,516.5**	–2,692.2	–2,346.0	**–27.1%**	–28.6%	–25.5%	58.8%
Shorebirds	44	**–17.1**	–21.8	–12.6	**–37.4%**	–45.0%	–28.8%	68.2%
Waterbirds	77	**–22.5**	–37.8	–6.3	**–21.5%**	–33.1%	–6.2%	51.9%
Waterfowl	41	*34.8*	24.5	48.3	*56.0%*	37.9%	79.4%	43.9%
Aerial insectivores	26	**–156.8**	–183.8	–127.0	**–31.8%**	–36.4%	–26.1%	73.1%
Breeding biome								
Grassland	31	**–717.5**	–763.9	–673.3	**–53.3%**	–55.1%	–51.5%	74.2%
Boreal forest	34	**–500.7**	–627.1	–381.0	**–33.1%**	–38.9%	–26.9%	50.0%
Forest generalist	40	**–482.2**	–552.5	–413.4	**–18.1%**	–20.4%	–15.8%	40.0%
Habitat generalist	38	**–417.3**	–462.1	–371.3	**–23.1%**	–25.4%	–20.7%	60.5%
Eastern forest	63	**–166.7**	–185.8	–147.7	**–17.4%**	–19.2%	–15.6%	63.5%
Western forest	67	**–139.7**	–163.8	–116.1	**–29.5%**	–32.8%	–26.0%	64.2%
Arctic tundra	51	**–79.9**	–131.2	–0.7	**–23.4%**	–37.5%	–0.2%	56.5%
Aridlands	62	**–35.6**	–49.7	–17.0	**–17.0%**	–23.0%	–8.1%	56.5%
Coasts	38	–6.1	–18.9	8.5	–15.0%	–39.4%	21.9%	50.0%
Wetlands	95	*20.6*	8.3	35.3	*13.0%*	5.1%	23.0%	47.4%
Nonbreeding biome								
Temperate N. America	192	**–1,413.0**	–1,521.5	–1,292.3	**–27.4%**	–29.3%	–25.3%	55.2%
South America	41	**–537.4**	–651.1	–432.6	**–40.1%**	–45.2%	–34.6%	75.6%
Southwestern aridlands	50	**–238.1**	–261.2	–215.6	**–41.9%**	–44.5%	–39.2%	74.0%
Mexico–Central America	76	**–155.3**	–187.8	–122.0	**–15.5%**	–18.3%	–12.6%	52.6%
Widespread neotropical	22	**–126.0**	–171.2	–86.1	**–26.8%**	–33.4%	–19.3%	45.5%
Widespread	60	–31.6	–63.1	1.6	–3.7%	–7.4%	0.2%	43.3%
Marine	26	**–16.3**	–29.7	–1.2	**–30.8%**	–49.1%	–2.5%	61.5%
Coastal	44	**–11.0**	–14.9	–6.7	**–42.0%**	–51.8%	–26.7%	68.2%
Caribbean	8	–6.0	1.4	–15.7	12.1%	–2.8%	31.7%	25.0%

and promoted recovery of once-depleted bird species. History shows that conservation action and legislation work. Our results signal an urgent need to address the ongoing threats of habitat loss, agricultural intensification, coastal disturbance, and direct anthropogenic mortality, all exacerbated by climate change, to avert continued biodiversity loss and potential collapse of the continental avifauna.

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SUPPLEMENTARY MATERIALS

science.sciencemag.org/content/366/6461/120/suppl/DC1
Materials and Methods
Figs. S1 to S7
Tables S1 to S5
Databases S1 and S2
References (*36*–*101*)

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Science
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Decline of the North American avifauna

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Science, **366** (6461), .
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Staggering decline of bird populations
Because birds are conspicuous and easy to identify and count, reliable records of their occurrence have been gathered over many decades in many parts of the world. Drawing on such data for North America, Rosenberg *et al.* report wide-spread population declines of birds over the past half-century, resulting in the cumulative loss of billions of breeding individuals across a wide range of species and habitats. They show that declines are not restricted to rare and threatened species—those once considered common and wide-spread are also diminished. These results have major implications for ecosystem integrity, the conservation of wildlife more broadly, and policies associated with the protection of birds and native ecosystems on which they depend.

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ATTACHMENT 8


Common moorhen


Snowy egret


Wood ducks

conserving maine's significant wildlife habitat

WATERFOWL & WADING BIRDS

Maine Wetlands: Valuable to Humans and Birds Alike

There are over five million acres of fresh and saltwater wetlands in Maine, four times the wetland area of all other New England states combined! Recognized for their beauty and recreational opportunities, these wetlands are incredibly valuable to the state's economy as well as its wildlife.

Performing critical functions in our environment, such as filtering pollutants, holding floodwater, recharging our drinking water supplies, and reducing shoreline erosion, wetlands also provide habitat for over 50 species of Maine's water birds. But development that is too close to sensitive waterfowl and wading bird nesting and feeding areas, or that happens at times that are critical to bird breeding activities, put these species at risk. Luckily, there are ways to balance appropriate development with wetland conservation.

The designation of moderate- and high-value wetlands as Significant Wildlife Habitat for waterfowl and wading birds is an important tool to keep our wetlands performing their vital functions for both people and wildlife.

What is Significant Wildlife Habitat?

Significant Wildlife Habitat is an area protected under Maine's Natural Resources Protection Act. The Department of Inland Fisheries and Wildlife (DIFW) has identified and mapped high-to moderate-value coastal and inland wetlands as Significant Wildlife Habitat for waterfowl and wading birds. Permits from the Department of Environmental Protection (DEP) are required for regulated activities in Significant Wildlife Habitat, including but not limited to dredging, bulldozing, draining, filling, and construction or alterations of permanent structures. The permit review process ensures that activities are done at a time or in a way that minimizes harm to water birds and their habitat.


Glossy ibis

About Maine's Unique Waterbirds

Waterfowl

Maine's location at the southern limit of some species' range and the northern limit of others gives it a unique mix of waterfowl, including ducks, geese, and even occasional migrant swans. Eighteen species breed in Maine each summer, and another 20 species spend the winter months off the coast or migrate through the state in spring or fall.

Most waterfowl species nest on the ground in the uplands next to wetlands, streams, or lakes, then move their young to open water after they hatch. Some species, like wood ducks and hooded mergansers, nest in tree cavities. They need forested habitat with fairly large dead or dying trees that have the holes they need for nesting. Cavity-nesting ducks will sometimes go more than 600 feet from a wetland in order to find a nesting tree.

Waterfowl eat a variety of food items. Some species are primarily vegetarian, feeding on leaves, roots, and seeds in and around shallow water. Others, like mergansers, forage in deeper waters for fish. Many species feed on aquatic invertebrates–small soft-bodied animals–that are abundant in healthy wetlands.

Wading Birds

Wading birds are a diverse group of birds that include herons, egrets, bitterns, ibises, coots, moorhens, and rails. Maine's wading birds include 21 species that either breed here or migrate through the state each year.

Most wading birds have relatively long legs and long necks, though two uncommon species–American coots and common moorhens–both look more like ducks than typical wading birds. There is a wide variation in size among wading birds, from the yellow rail at just nine inches tall to the great blue heron, which is about five times that size. While some secretive species like rails and soras are rarely seen, the larger egrets, ibises, and herons often feed visibly in open wetlands, sometimes close to human activity.

Wading birds nest in a variety of places. Some, like herons and egrets, nest in colonies that can number over 100 pairs. Building loose stick nests in the tops of tall trees, these birds reuse nests for up to several decades, long after the trees they are in die from the weight and stress of the nest. Other wading bird species nest closer to the ground, building nests of reeds and grasses among wetland plants.

Wading birds feed on fish, amphibians, invertebrates, and plants found in shallow wetlands. Clean water that supports healthy populations of their prey is vital to their survival.

Black-crowned night-heron

Blue-winged teal

Hooded mergansers

Wetland Habitats at Risk


Mallard ducklings

Both the Atlantic Northern Forest Bird Conservation Plan and the North American Waterfowl Management Plan have identified the loss of wetlands from draining, dredging and filling as the primary threat to water birds in our region. Development near a wetland can degrade wildlife habitat by increasing disturbance, stormwater runoff, sedimentation, and pollution. Changes in water chemistry as a result of development can lower the abundance of invertebrates, reduce plant diversity, and increase the presence of invasive, non-native species. These changes can make the habitat unsuitable for water birds.


Ring-necked duck

The designation of moderate- and high-value wetlands as Significant Wildlife Habitat for waterfowl and wading birds is an important tool balancing development with conservation. By managing regulated activities in these habitats we can maintain or even improve habitat and water quality while minimizing impacts to both migratory and breeding water birds.

Why Protect Wetlands?

Healthy wetlands maintain property values. Wetlands store excess water, providing flood control during times of heavy rain. They buffer shorelines from waves and hold soil in place, preventing loss of shoreline from erosion. Wetlands also filter sediments and pollutants from surface run off, which keeps water clean and clear. If we had to build man-made structures and systems to provide these services, they would be *extremely* expensive and not nearly as effective at protecting property values.

Wetlands provide valuable wildlife habitat. Water birds are not the only species that depend on wetland habitat. Coastal wetlands provide critical habitat for shellfish like clams and mussels. Many mammals, including furbearers like mink, beaver and muskrat, live in or near wetlands. Other birds like ospreys, herons and bald eagles feed in both freshwater and saltwater wetlands. Finally, healthy populations of fish, an important recreational resource, depend on food sources that grow in wetland habitat.

Hunting and fishing are important to Maine's economy. By protecting the quality of our wetlands, we improve nesting success for breeding waterfowl and attract migratory waterbirds in spring and fall. Waterfowl hunters in Maine take an average of 50,000 freshwater ducks and another 20,000 sea ducks each year, generating critical license revenue for DIFW as well as spending additional money in local communities where they hunt. Wetlands ultimately drain into our favorite brook trout streams and coastal bays, providing a source of clean water far beyond the wetland boundary.

Heron colonies are under threat. Great blue herons are a treasured species in Maine, but anecdotal reports of long-standing heron colonies indicate declining numbers. Repeated human disturbance from building, industrial development, water recreation, and highway construction are known causes of colony failure.


Scarborough Marsh

DOUG HITCHCOX

Green-winged teal

Which Areas Qualify as Significant Wildlife Habitat?

All wetlands are not created equal, and not all wetlands qualify as Signficant Wildlife Habitat (SWH). Wetlands that do qualify have habitat characteristics that make them valuable for wildlife like large size, complex shape, and for tidal wetlands, large areas of mudflats or eelgrass beds. Maps of SWH for waterfowl and wading birds can be found at the Maine DEP website (www.maine.gov/dep, search "bird habitat"). Inland SWH includes a 250-foot buffer around the wetland complex. Tidal SWH includes only the identified tidal wetland habitat. Shoreland zoning rules and other DEP protections apply to coastal upland buffers.

What You Can Do:

- If you think you have a high-or moderate-value wetland on your property that might qualify as Significant Wildlife Habitat, documentation by a regional biologist from DIFW may be required. Call (207) 287-8000 to request a visit.
- If you are planning to build or conduct other regulated activities in Significant Wildlife Habitat, contact your local DEP office for more information about the permit process so you can efficiently plan your activities and get advice about steps you can take to avoid impacts.
- If you live near Significant Wildlife Habitat, avoid using chemicals that may run into the wetland, harming food sources for waterfowl and wading birds.
- If you are working on local land conservation efforts in your town or region, learn more about Significant Wildlife Habitats in your community by looking at SWH maps from the Maine DEP website (www.umaine.gov/dep) or by consulting your town's High Value Plant and Animal Habitat map from Beginning With Habitat (www.beginningwith habitat.org).
- If you are paddling, or walking in and around wetlands, beware of ground-nesting ducks. If you have a dog with you, keep it leashed. Watch migratory waterfowl with binoculars to avoid disturbing feeding or resting flocks.
- If you are near a nesting colony of wading birds, watch them with binoculars and keep your distance. Repeated human disturbance can cause nest abandonment.

For More Information:

Department of Environmental Protection
www.maine.gov/dep, search for "bird habitat"

Bureau of Land and Water Quality *(Augusta)*
(207)287-3901 or 1-800-452-1942

Southern Maine Regional Office *(Portland)*
(207)822-6300 or 1-888-769-1036

Eastern Maine Regional Office *(Bangor)*
(207)941-4570 or 1-888-769-1137

Northern Maine Regional Office *(Presque Isle)*
(207)764-0477 or 1-888-769-1053

Department of Inland Fisheries and Wildlife
www.mefishwildlife.com

For questions about SWH regulations, please contact the Environmental Coordinator *(207) 287-5258*

For questions about wildlife and habitats, please contact staff at Beginning with Habitat *(207) 287-5254* or visit www.beginningwithhabitat.org

Maine Audubon
(207)781-2330, www.maineaudubon.org/swh

BIRD PHOTOS COURTESY OF RAY SPENCER

MAINE AUDUBON

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ATTACHMENT 9

MAINE AUDUBON SOCIETY SPRING 2000

CONSERVING WILDLIFE

MARK McCOLLOUGH

CHARLES JOSLIN

ROBERT SAVANNAH

in Maine's Developing Landscape

SOUTHERN MAINE'S POPULATION IS GROWING. More importantly, people are moving away from town centers and cities into rural areas. A 1997 State Planning Office study reports that the fastest growing areas in Maine are 10 to 25 miles from metropolitan areas. Two- to ten-acre house lots in fields and forests are common. As people move into these areas, new and wider roads follow and additional services are needed such as sewers, water, and convenience stores. As a result, habitat for some species of wildlife is becoming increasingly fragmented and lost. According to a study by Witham and Hunter (1992), southern Maine and New Hampshire forest area decreased by 7%, agriculture by 9%, and non-forested upland by 12%, while rural residential area increased by 23% and urban/industrial by 4% in a twenty-year period from the mid 1960s to the mid 1980s. When habitat is altered, the numbers and types of wildlife present on the landscape can change dramatically.

Maine Audubon Society believes we should strive to maintain healthy populations of all our native wildlife species and the habitat or plant communities upon which they depend. We recognize that change is inevitable, but believe the land use decisions we make now can minimize impacts to wildlife as development of the rural landscape continues across Maine. With thoughtful planning and management of both developed and open space, people and wildlife can successfully coexist. In Maine, we are in the fortunate situation, if we act now, of being able to avert the types of wildlife and habitat losses often experienced by our neighbors to the south. Over half of all owl, salamander, frog and toad species that breed in Maine are listed as special concern, threatened or endangered in other northeastern states. We have a chance of keeping new species from being added to Maine's list of endangered species and to protect species that are still common but add greatly to our enjoyment of nature.

Open space can help conserve wildlife, provide recreational opportunities, enhance quality of life for residents and provide an economic benefit to the town. In this piece we focus on how landowners, land trusts, and municipalities involved with protecting green space can actively conserve wildlife and wildlife habitat as part of their protection efforts.

What happens to Wildlife as we develop the landscape?

WE KNOW FROM STUDIES done in the agricultural Midwest and the suburbanized Mideast coast that as human development increases, wildlife habitat is destroyed, and only small habitat fragments remain. Some common wildlife species thrive in this human altered habitat. These animals are opportunistic generalists that can be found in large numbers living near and benefiting from humans, such as house sparrows, grackles, blue jays, skunks and raccoons. Often, species that depend on large contiguous tracts of forest, such as fisher, wood thrush, and American redstart begin to disappear or decline in numbers. These animals are easily disturbed by human activity or fall prey to the more abundant generalists.

Habitat specialists are also vulnerable to habitat loss. Specialists are species that are tied to one or more type of plant community to complete their life cycle. For example, spotted salamanders need vernal pools for breeding and upland forests for feeding and hiding, and piping plovers need frontal dunes for nesting and sand and mud flats for feeding. If either one of these habitat types is lost, the species will no longer thrive.

In addition to the direct loss of usable habitat, small isolated habitat patches can be "population sinks" from a regional landscape perspective. Individuals who can not reproduce successfully in the altered habitat may still use the remaining small patches. The results may be a reduced regional population. A study by Robinson (1989) in central Illinois showed that neo-tropical (long-distance) migrant birds were unsuccessful at breeding in forest tracks because of increased predation in these small habitat patches. A different study by Friesen (1995) in Ontario found fewer neo-tropical migrants in forest tracts adjacent to a high amount of residential housing.

Initially these species become extinct locally, then regionally, and finally a species may become extinct throughout its range. As development increases, regional diversity decreases, leaving us with a subset of animals that thrive in an urban/suburban environment.

What happens to Plant Communities as we develop the landscape?

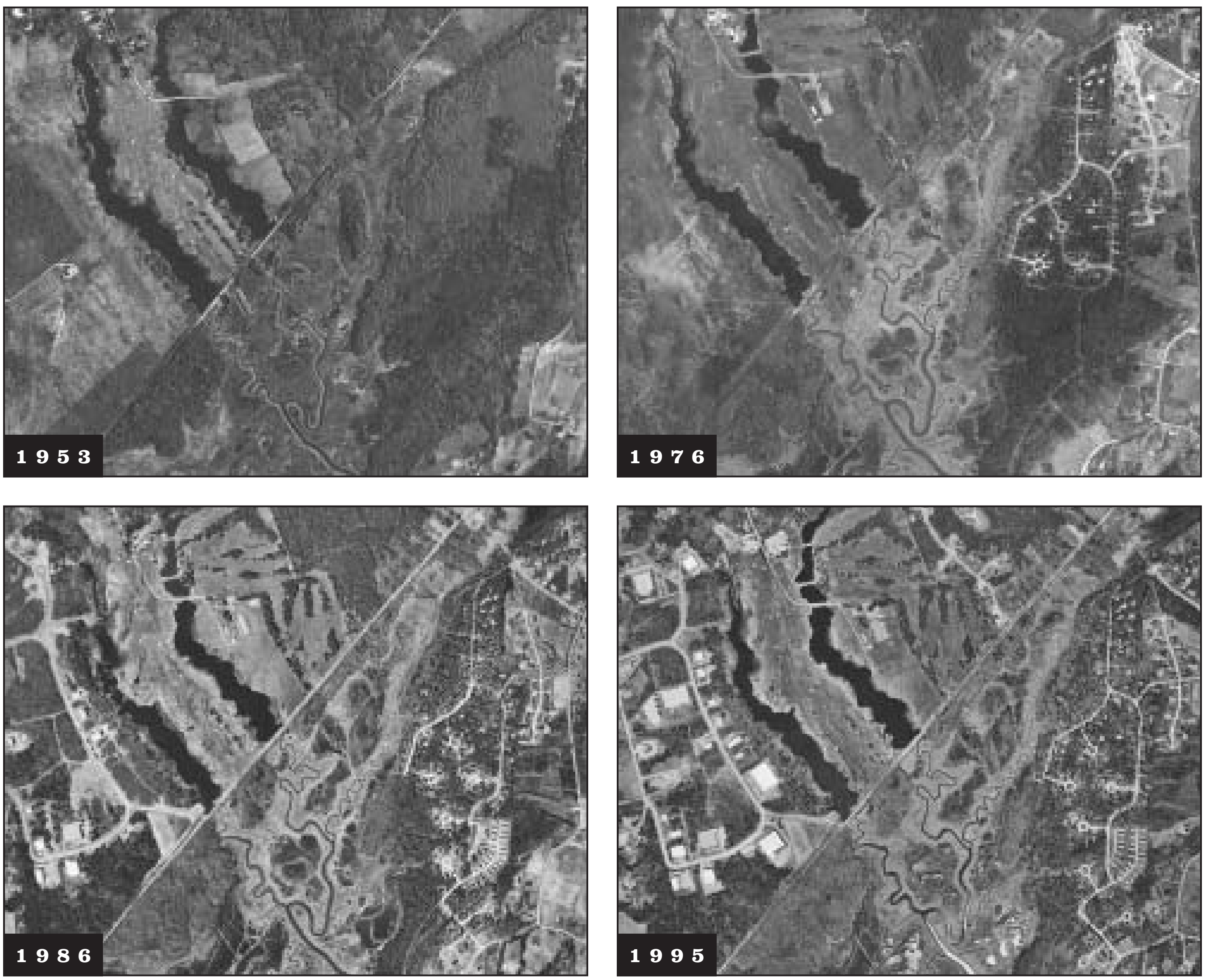
THROUGH SEVERAL MECHANISMS, habitat fragmentation may also have significant impacts on plant communities. First and most importantly, fragmentation reduces available habitat size. Native plants, like animals, need minimum population sizes to remain viable. As habitat patches decrease in size, the amount of suitable microhabitat needed to maintain individual plant populations decreases. The end result is often the reduction of native plant diversity (Carleton and Taylor 1993, Gibson et al. 1988). This is particularly true in Southern Maine, where some of the state's rarer plant communities have been lost or altered due to development.

Secondly, just as fragmentation often favors wildlife generalists at the expense of specialists, the same pattern is true for plants. Roads and fragmentation alter patterns of sunlight and moisture, creating habitat more suitable to generalists. Plants adapted to interior mature forests typically have low dispersal capacities as compared to aggressive "weedy" plants adapted to disturbed areas and younger forests (Harris and Silva-Lopez 1992). Those weedy plants — often non-native — colonize forest edges and may penetrate over 330 feet into the forest interior, altering or eliminating habitat for native plants. With roughly one-third of Maine's flora comprised of non-native plant species (and most of these in the southern part of the state), the linkage between fragmentation and non-native plant species forms a significant threat to native habitats.

Edges and reduced habitat size may also affect plant reproduction through changes in the way seeds are produced and released. Moreover, studies have shown that development and habitat fragmentation may also affect the way plants and animals interact. A proliferation of non-native plants can have a direct negative effect on wildlife species by replacing traditional foods with inedible alternatives. Effected animals would include pollinators (such as bees, moths, beetles and hummingbirds), fruit and seed eaters (such as fox, squirrels, cedar waxwings and bears), and herbivores (such as cottontails, deer and moose).

Could this happen in Maine?

IN SOME AREAS OF MAINE SIGNIFICANT HABITAT loss has already begun, especially in York and Cumberland counties, and it is likely to spread in the foreseeable future. In Maine, it is unclear which of the following issues are causing the most problems for wildlife at this time. Maine is different from many of the states where research on the effects of development on wildlife have been conducted in that we are still primarily a forested landscape rather than an agricultural or suburban landscape dotted with remnant forest blocks. There has been little direct research on these issues in the state. However, as development continues it is likely that all or some of the following issues will become problems for Maine's wildlife sometime in the next 50 years depending on the part of the state.



These aerial photographs show changes in the landscape in Scarborough, Maine.

Photographs courtesy of Greater Portland Council of Governments

LOST HABITAT

The greatest threat to wildlife is the direct loss of habitat. Habitat is each animal's home and provides food, water, shelter, and a place to raise their young. As we convert a field, forest or wetland into a parking lot, store, house, or road, we destroy that habitat, reducing the area available for wild animals to live. When an old field reverts back to a forest, this change benefits species that can use forest habitat, but some species can only survive in an open environment. Many species in Maine that rely on field habitat or early successional habitat are declining, such as the eastern meadowlark, bobolink, American woodcock and New England cottontail. Grassland habitats and the birds associated with them, including the upland sandpiper, northern harrier, short-eared owl, horned lark, vesper sparrow, savannah sparrow, grasshopper sparrow, dickcissel and sedge wren, are particularly at risk. Wetland habitats are also at risk in Maine, especially those that are not adequately protected by regulations including vernal pools and forested wetlands. Many species depend on wetlands for part or all of their life cycle including frogs, salamanders, American bittern, least bittern, and great-blue heron. In addition, habitat can be changed or lost due to an invasion of exotic species and loss of native plant species, and through degradation from soil erosion, nutrient overload, decreased water quality, and contaminants.

FRAGMENTED HABITAT

Development fragments, or breaks apart, wildlife habitat. Fragmentation occurs when roads, utility corridors, buildings, parking lots, or clearings create breaks in the natural landscape. For some species, the roads, clearings, and corridors act as barriers, preventing animals from using habitat that is nearby for breeding or feeding. Populations become subdivided and eventually animal species are lost from an area as it gets too small to support an isolated population.

HABITAT SIZE

Different types of wildlife need different amounts of habitat to thrive. A mouse needs less than an acre compared to a moose that needs hundreds of acres. When we fragment habitat, the size of the remaining block of habitat limits the type of animals that can live there. As habitat size decreases, bobcat will start disappearing, then moose, osprey, beaver, turtles and so on.

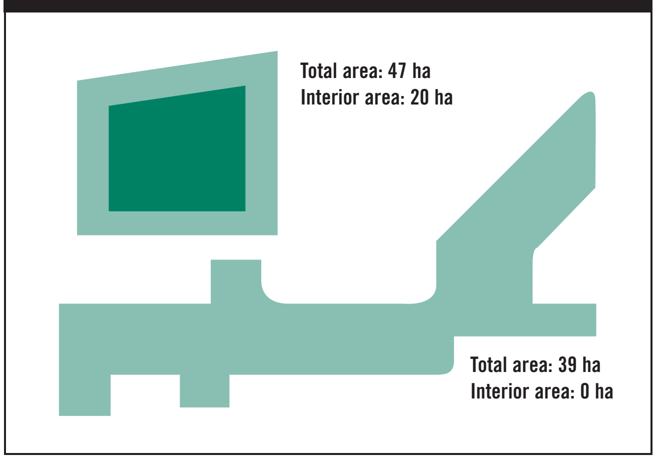
Some species of wildlife, called "area-sensitive species", need large blocks of uninterrupted habitat. They are sensitive to human disturbance and are often predated by species that are found on the edge of two different habitat types. Some area-sensitive birds in Maine include the upland sandpiper, wood thrush, northern parula warbler, rose-breasted grosbeak, and pileated woodpecker. Other wildlife species need access to more than one habitat type in order to maintain a population. For example, Blanding's and spotted turtles need multiple wetlands for feeding and resting and upland areas for breeding. In this case a large block must consist of multiple habitats to be of value.

At another scale, enough habitat must be available for the minimum number of individuals of a given species to interbreed and maintain a healthy and genetically diverse population. Animals must be able to travel to habitat nearby if enough habitat is not present within one block. Though few parcels of land will be large enough to support a self-sustaining population of most vertebrates, a well-placed parcel can contribute towards the total amount of habitat needed for the survival of a mobile population.

HABITAT EDGE

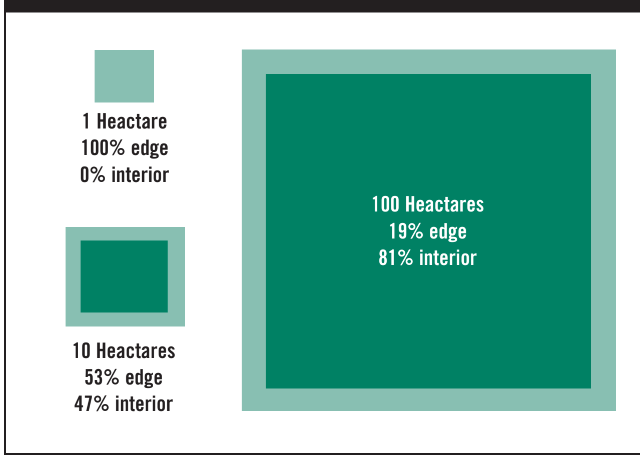
'Edge' is the area where two habitat types meet. For example, edge would be the place where a field and forest meet, or where a road corridor ends and a forest begins. It can be a natural transition between two habitat types such as a pond and upland

FRAGMENT SHAPE



A comparison of the interior area available in two different shaped blocks of land.
Adapted from Verner et al. *Wildlife 2000* 1986, reprinted by permission of University of Wisconsin Press.

FRAGMENT SIZE



A comparison of the interior area of 3 different size blocks. As fragment size increases, the relative proportion of edge habitat decreases, and interior habitat increases.
Adapted from *Landscape and Urban Planning*, (36) Collinge, pg. 64, 1996, reprinted by permission of Elsevier Science.

forest, or a human-made border like a road, backyard, parking lot or utility corridor.

For certain types of animals such as deer and grouse, edge habitat is favored. The animals that are attracted by edge are opportunists, such as crows, blue jays, deer, and raccoons, which can use a variety of habitats. Many of these animals prey on area-sensitive species. Many studies show that neo-tropical migrant birds that nest in open cups on the ground or in low shrubs are not breeding successfully in edge habitat. This is due to highly elevated rates of parasitism by brown headed cowbirds (currently not a big problem in Maine) or predation by small mammals such as red squirrels and birds such as blue jays.

ROSLYN ALEXANDER

Backyard birdfeeders can increase numbers of these cute and fiesty red squirrels who are serious predators of nesting forest songbirds.

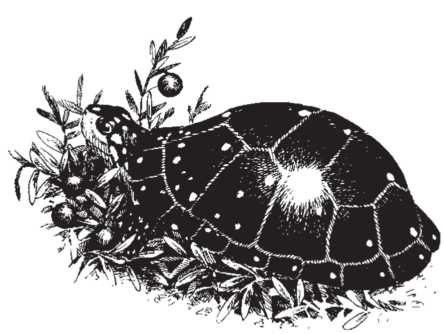
In urban/suburban areas, a study by Matlack (1993) found that human activity could extend up to 270 feet into natural areas on the edge of human development. These activities can reduce the value of the edge habitat for wildlife. Dumps, litter, pruned and hacked trees, cleared understory vegetation, established campsites and extensive firewood gathering, can all reduce the vegetation birds use to nest and cause general disturbance which may keep animals out of the area. In addition, habitat adjacent to residential housing often has elevated numbers of gray squirrels (due to supplemental feeding at bird feeders) and house cats, both of which are effective predators on nesting birds.

ROADS

Roads have many negative effects on wildlife in addition to fragmenting habitat (Andrews 1990). Roads are often a conduit for invasive plant species such as the purple loosestrife and Eurasian milfoil that can degrade wildlife habitat. Roads that go into or through a natural area bring the edge effect into the area, reducing its value for area-sensitive species. Where roads are built, habitat is lost or changed and development often follows along the road. In addition, roads increase human access to natural areas and bring increased human disturbance and poaching. Traffic lights and noise disturb some individual animals and vehicles kill many animals. For example, since many turtle species spend at least some of their life traveling in uplands, either feeding or nesting or both, they inevitably cross roads. Mortality from roads may be enough to wipe out an entire local population over time. In Connecticut, there are no wood turtle populations found within a mile of paved roads (Line 1998).

SUMMARY

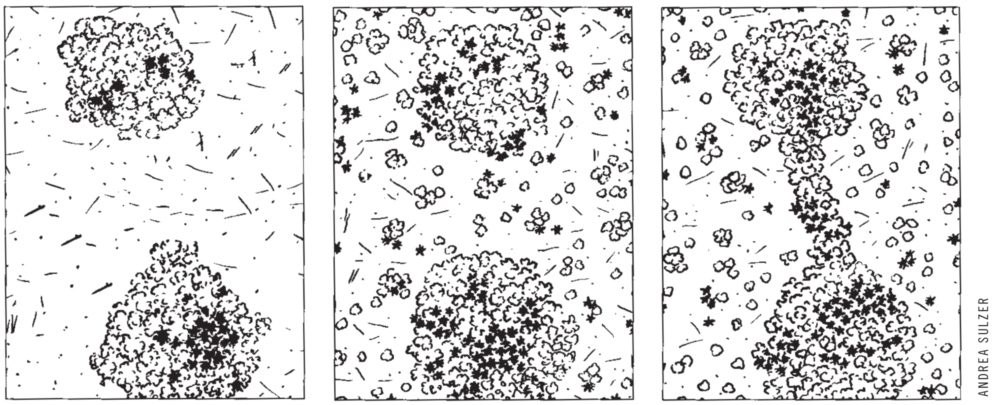
If we act now, we will be able to avert the type of wildlife habitat loss being experienced in so many other parts of the country. Fragmentation of habitat, the edge effect, and habitat destruction are all factors which can cause a decline in wildlife. In some places their cumulative effect has been shown to be devastating to wildlife. In Maine, it is unclear whether all or just one of these elements is affecting wildlife at this time. Based on current research, it is clear that over time, if Maine loses enough habitat to development, fragmentation and edge effect will become serious problems for many of our wildlife species.



MARK McCOLLOUGH

DESIGN CRITERIA:

What to Consider When Conserving Open Space for Wildlife



Habitat blocks that are (**left**) islolated from one another and surrounded by unusable, different or inhospitable habitat are less valuable for wildlife than blocks that are either (**center**) isolated but surrounded by marginal but still usable habitat or (**right**) connected by the same type of habitat and surrounded by marginal but still usable habitat.

MOST PARCELS OF LAND CAN CONTRIBUTE to maintaining Maine's diverse wildlife for both local communities and a larger region. To stretch limited conservation dollars, plans to protect open space for aesthetics or recreation can also incorporate some of these principles benefiting wildlife, in addition to achieving the primary goals for the open space. When human recreation and wildlife conservation are both goals for conserving open space, it is important to assess whether there may be any conflicts between the goals. If identified and addressed during the planning process, it is usually possible to provide for and to balance many different uses.

Because resources are limited, it may be best to prioritize protection of the largest parcels first. In addition, lands adjacent to conservation parcels where land-use practices allow dispersal of wildlife between tracts are more valuable than narrow corridors (Wilcove et al. 1986). Looking beyond the boundaries of the parcel to the present and future potential uses of the surrounding land is critical to achieving the original goals of conserving wildlife in a parcel. The following criteria can be used to help evaluate a parcel for its value to wildlife.

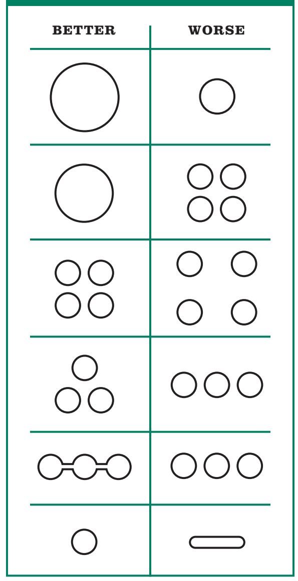
SIZE

Larger is better and is usually the most important design criteria. Larger pieces of land provide habitat for more types of animal species, are generally less influenced by the 'edge effect', and may be less influenced by human activities surrounding the open space. Many parcels over 250 acres start to have productive breeding habitat for forest interior nesting bird species. These are birds that nest away from the edge where two habitat types meet (Yahner 1988). Parcels of 30 acres or more will provide valuable habitat for many grassland bird species. Large contiguous tracts of grasslands, from 250 to 500 acres and larger, are needed to support a greater diversity of grassland birds including the grasshopper sparrow and upland sandpiper. "To conserve regional biodiversity, maintenance of habitats for species with large-area needs is essential" (Schroeder 1996).

SHAPE

Minimize the amount of edge habitat by designing open space to have a generally circular shape. Assuming edge effects have impacts as far as 650 to 2000 feet into a parcel (Andren 1988 & Yahner 1988), a 7000-acre circular parcel will be comprised of 90% interior habitat (Collinge 1996). Long narrow parcels are often entirely edge and provide no productive habitat for interior species. Open space along waterways needs to be as wide as possible to minimize the amount of edge habitat. Buffers on waterways of 250 feet or less, which is Maine's current shoreland zoning, will function primarily as edge habitat if not adjacent to a larger parcel.

Reserve Design Principles



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PROXIMITY

Whenever possible, maximize the size of an open space parcel by selecting one adjacent to or in close proximity to existing conservation land or lands likely to remain undeveloped, including certain wetlands, land in conservation easements, tree growth, or open space status. In addition, take into consideration the neighboring land use, such as zoning for rural residential versus urban or commercial. For those parcels less than 250 acres, the smaller parcels adjacent to parcels with compatible land use may be more valuable than larger parcels in highly urban/suburban areas.

BARRIERS

Barriers such as roads, railroads, utility corridors and fences may be difficult or dangerous for some animals to cross. Avoid parcels (especially small parcels) completely surrounded by barriers, particularly major highways.

CORRIDORS

Corridors are sections of habitat that may be used by some wildlife species to travel from one habitat block to another. The value of corridors is not clearly understood and may vary greatly in individual situations. On the positive side, the corridor itself serves as wildlife habitat; may provide travel lanes for wildlife movement; links habitat that was originally interconnected; may minimize pollution by preventing runoff into a body of water; and may provide recreational trails for people. One of the best examples of this would be a buffer along side streams, rivers, ponds, lakes, and wetlands, typically referred to as a riparian area. On the negative side, the corridor may create more edge habitat and be a breeding sink for some wildlife; may not be needed by many bird species; provides travel lanes for predators including domestic predators that already may be found in elevated numbers due to proximity to humans; may increase the transmission of contagious diseases such as rabies; and may take a large amount of funds that could be applied better elsewhere.

HABITAT TYPE

Certain habitats in southern Maine are in decline, including uncultivated (fallow) fields, small wetlands, grasslands, and both early successional and old forests. Consider conserving parcels that include these habitats and be sure to consider what types of management activities would be necessary to maintain these habitats. If ongoing management is necessary (e.g. old field habitat must be maintained by mowing, brush hogging or prescribed burning), it is also important to devise a plan that includes how the management will be paid for over the years.

CONCLUSION

These recommendations are based on the best available information from an evolving body of scientific literature. They are meant to be guidelines and not prescriptive in nature. We have included a listing of related bird, turtle and mammal species home range or area requirements to help emphasize points made in the text regarding fragmentation, size requirements and edge effect. In addition, we have listed all species that are either currently designated as an endangered, threatened or special concern species, in decline, or useful as an umbrella species (one whose protection ensures protection of a host of other species along with it). We hope this information can help guide specific protection efforts.

Table 1. Area requirements of selected Maine wildlife species.

I. Area-Sensitive+ Forest Birds Found in Maine

Bird Species	May Occur in Blocks <250 Acres	Occur in Blocks 250-500 Acres	Occur in Blocks 500-1000 Acres	Occur in Blocks >1000 Acres
Red-shouldered hawk			X	X
Yellow-billed cuckoo**	X	X	X	X
Downy woodpecker**	X	X	X	X
Hairy woodpecker		X	X	X
Pileated woodpecker*			X	X
Least flycatcher		X	X	X
Great crested flycatcher*	X	X	X	X
Common crow	X	X	X	X
Tufted titmouse*	X	X	X	X
White-breasted nuthatch	X	X	X	X
Brown creeper*			X	X
Blue-gray gnatcatcher				X
Veery		X	X	X
Hermit thrush			X	X
Wood thrush			X	X
Gray catbird**	X	X	X	X
Yellow-throated vireo*	X	X	X	X
Red-eyed vireo*	X	X	X	X
Northern parula				X
Chestnut-sided warbler*		X	X	X
Black-throated blue warbler				X
Black-throated green warbler*			X	X
Black-and-white warbler			X	X
American redstart		X	X	X
Ovenbird			X	X
Northern waterthrush			X	X
Louisiana waterthrush			X	X
Mourning warbler			X	X
Canada warbler				X
Scarlet tanager		X	X	X
Rose-breasted grosbeak*	X	X	X	X
Rufous-sided towhee**		X	X	X

(See bibliography for references)

+ Bird species that are uncommon in smaller forests.

* Some studies did not classify these species as area-sensitive.

** Some studies classified these species as area-sensitive, but most did not. These are more likely not area-sensitive.

II. Area-Sensitive+ Grassland Birds found in Maine

Bird Species	Minimum Block Size	Preferred Block Size
Upland Sandpiper	150 acres	500 acres
Bobolink	5 acres	75 acres
Eastern meadowlark	15 acres	20 acres
Grasshopper sparrow	30 acres	250 acres
Vesper sparrow	30 acres	50 acres
Savannah sparrow	20 acres	40 acres

(Jones & Vickery 1997; Vickery et al. 1997)

+ Bird species that are uncommon in smaller grasslands.

III. Large Mammals Found in Southern and Central Maine

Species	Home Range*
Black Bear	19,200 acres
Bobcat	5760 acres
Fisher	4747-9600 acres
Mink	20-50 acres (females), 1280-2010 acres (males)
Moose	1280-12,800 acres
River Otter	15-30 linear miles

(DeGraaf & Rudis 1986)

IV. Turtles Found in Maine

Species	Home Range*	Additional Distances Traveled *(for nesting, migrating, feeding)*
Snapping Turtle	4.50-22 acres	Up to 5 miles
Common Musk Turtle	2.4 (females) acres 4.4 (males)	Less than 0.5 miles
Spotted Turtle	5-7 acres	Up to 1.25 miles
Wood Turtle	1446 river feet	Up to 6 river miles Up to 0.10 miles over land (500 feet)
Eastern Box Turtle	0.8-3 acres	Up to 0.2 miles
Eastern Painted Turtle	0-2 acres	Up to 1 mile or more
Blanding's Turtle	0-300 acres	Up to 4.20 miles

(DeGraaf & Rudis 1986; Ernst et al. 1994; Hunter, Albright & Arbuckle 1992; McCollough per comm.)

* Home range is the primary area in which an individual animal lives, and includes areas for resting, sleeping, feeding and breeding.

Table 2. Wildlife Species that occur in southern and central Maine likely to decline or whose local populations may be lost due to increased development.

Each species is followed by their Maine State endangered and threatened status (**E**=endangered, **T**=threatened, **SC**=special concern). Bird and mammal species are followed by their area requirements (**AS**=area-sensitive, **LA**=requires large area, **W**=requires water front habitat). In addition, bird species are followed by their United States Fish & Wildlife Service breeding bird survey status (**–**=declining, **+**=increasing, blank=not encountered in survey)

Butterflies & Moths

Spicebush Swallowtail ....SC
Clayton's Copper..........................E
Edwards' Hairstreak ....E
Olive Hairstreak.........................SC
Hessel's Hairstreak........................E
Bog Elfin ....SC
Western Pine Elfin ....SC
Regal Fritillary ....SC
Barrens Itame.............................SC
Twilight Moth.............................T
Pine-Devil Moth........................SC
Inland Barrens Buck Moth ....SC
Pine Sphinx ....SC
Huckleberry Sphinx ....SC
Pine Barrens Zanclognatha ....T
Oblique Zale..............................SC
Pine Barrens Zale ....SC
Precious Underwing...................SC
Similar Underwing....................SC
Acadian Swordgrass Moth..........SC
Pine Pinion ....SC
Thaxter's Pinion.........................SC
Ceromatic Noctuid Moth ....SC
Red-winged Sallow ....SC
A Noctuid Moth........................SC
Trembling Sallow ....SC
Broad Sallow.............................SC

Damselflies & Dragonflies

Ring Boghaunter ....E
Pygmy Snaketail..........................T
Harpoon Clubtail ....SC
Extra-striped Snaketail ....SC
Zigzag Darner............................SC
Muskeg Darner..........................SC
Ocellated Darner ....SC
Ebony Boghaunter.....................SC
Delicate Emerald ....SC
Warpaint Emerald......................SC
Black Meadowfly ....SC
Superb Jewelwing.......................SC
Subartic Bluet ....SC
New England Bluet....................SC
Turquoise Bluet..........................SC
Big Bluet....................................SC
Pine Barrens Bluet ....SC
Citrine Forktail ....SC
Lilypad Forktail ....SC
Cyrano Darner...........................SC
Boreal Snaketail ....SC
Single-striped Clubtail ....SC
Rapids Clubtail ....SC
Cobra Clubtail ....SC
Riverine Clubtail........................SC
Elusive Clubtail..........................SC

Mollusks

Tidewater Mucket........................T
Yellow Lampmussel.....................T
Brook Floater ....SC
Triangle Floater ....SC
Squawfoot.................................SC

Fish

Swamp Darter.............................T
Redfin Pickerel...........................SC

Amphibians

Northern Leopard Frog.............SC
Spring Salamander ....SC
Four-toed Salamander...............SC

Reptiles

Wood Turtle..............................SC
Common Musk Turtle ....SC
Ribbon Snake ....SC
Blanding's Turtle..........................E
Box Turtle ....E
Black Racer ....E
Spotted Turtle ....T

Mammals

Southern Flying Squirrel ....SC
New England Cottontail...........SC
Little Brown Bat ....SC
Eastern Small-footed Myotis ......SC
Northern Long-eared Bat...........SC
Silver-haired Bat ....SC
Eastern Pipistrelle ....SC
Big Brown Bat ....SC
Red Bat......................................SC
Hoary Bat ....SC
Black Bear.................................LA
Fisher ....LA
River Otter ....LA
Bobcat ....LA
Moose..LA
Mink ....W

Birds

Common loon ....–
Leach's storm-petrel...................SC
Great blue heron..........................–
Black-crowned night heron ....SC
Least bittern..............................SC
American bittern ....–
Northern goshawk ....SC
Cooper's hawk ....SC
Red-shouldered hawk................AS
Bald eagle....................................T
American kestrel ....–
Ruffed grouse ....–
Common gallinule ....SC
American coot...........................SC
Killdeer..–
Piping plover ....E
Whimbrel ....SC
Upland sandpiper........................T
Common snipe ....–
Laughing gull............................SC
Common tern ....SC
Least tern ....E
Black tern....................................E
Yellow-billed cuckoo** ....AS
Eastern.....................................SC
Reech owl ....SC
Short-eared owl.........................SC
Chimney swift ....–
Belted kingfisher..........................–
Yellow-shafted flicker ....–
Pileated woodpecker* ....+AS
Hairy woodpecker....................+AS
Downy woodpecker** ....+AS
Eastern kingbird ....–
Great crested flycatcher*...........+AS
Alder flycatcher............................–
Least flycatcher........................–AS
Eastern wood-pewee ....–
Olive-sided flycatcher................SC
Tree swallow ....–
Bank swallow...............................–
Barn swallow ....–
American crow ....+AS
Tufted titmouse* ....AS
White-breasted nuthatch..........+AS
Brown creeper*........................–AS
House wren ....–
Gray catbird** ....–AS
Brown thrasher ....–
American robin............................–
Wood thrush ....–AS
Hermit thrush ....+AS
Swainson's thrush.........................–
Veery ....–AS
Blue-gray gnatcatcher ....AS
Ruby-crowned kinglet ....–
Loggerhead shrike ....SC
Yellow-throated vireo* ....AS
Red-eyed vireo* ....+AS
Black-and-white warbler...........–AS
Tennessee warbler ....–
Nashville warbler ....–
Northern parula ....–AS
Yellow warbler ....–
Magnolia warbler.........................–
Cape May warbler ....–
Black-throated blue warbler .....+AS
Black-throated green warbler* ..+AS
Chestnut-sided warbler*...........–AS
Bay-breasted warbler....................–
Ovenbird.................................+AS
Northern waterthrush ....+AS
Louisiana waterthrush ....AS
Mourning warbler ....+AS
Common yellowthroat.................–
Canada warbler ....–AS
American redstart ....–AS
House sparrow.............................–
Bobolink......................................–
Eastern meadowlark.................SC-
Red-winged blackbird..................–
Orchard oriole ....SC
Baltimore oriole ....–
Common grackle ....–
Brown-headed cowbird................–
Scarlet tanager ....+AS
Rose-breasted grosbeak* ....–AS
Indigo bunting ....–
Purple finch ....–
Rufous-sided towhee** ....–AS
Grasshopper sparrow ....E
Vesper sparrow ....SC
Slate-colored junco ....–
White-throated sparrow................–
Song sparrow ....–

* Some studies classified these species as not area-sensitive

** Some studies classified these species as area-sensitive, but most did not. These are more likely not area-sensitive.

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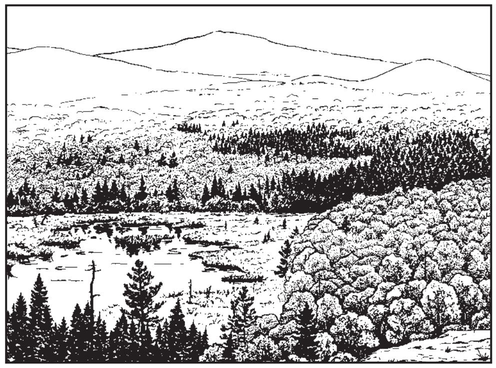

ANDREA SULZER

An extensive bibliography is available upon request for more detailed and technical information. Another fine resource that complements this piece titled *Integrating Wildlife Habitat Into Local Planning: A Handbook for Maine Communities*, by Sharri Venno and published by the Maine Agricultural Experiment Station of the University of Maine in 1991, should be available at your town office. In addition, all towns should have maps of state significant wildlife habitats and many have National Wetland Inventory maps.

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ATTACHMENT 10

Beginning with HABITAT

MAINE AUDUBON

MaineDOT

CONSERVING WILDLIFE

On and Around Maine's Roads

Maine's wildlife habitat is some of the healthiest and most expansive in the Northeast. It's also threatened by an increasing number of roads.[1]

Over the last 50 years, residential development has spread further and further from cities and towns into rural areas, requiring more roads and contributing to what is commonly referred to as "sprawl." The great majority of new roads are private subdivision and local roads.

What these roads mean for Maine's wildlife is alarming: wildlife-vehicle collisions, commonly known as "road kill," are the number one human cause of wildlife mortality in the United States. They're also the cause of many human injuries and fatalities. And what many people don't realize is that the impacts of roads on wildlife and surrounding habitat occur far beyond the pavement's edge.

The good news is that road planning and building strategies and wildlife-crossing structures can help make Maine roads less dangerous to wildlife and people.

This brochure outlines how Maine's local planning boards, comprehensive planning committees, local public works departments, regional transportation planning groups, and state transportation agencies can use these strategies to improve and maintain Maine's wildlife habitats.

How do roads affect wildlife and habitat?

Roads not only cause wildlife-vehicle collisions, they also fragment and destroy habitat.

A HIGHLY EFFECTIVE network of roads keeps people mobile in the United States, taking us to work and school, to visit with friends and family, and to shop for goods that support our lives. We demand good roads for our safety and convenience, and we've been willing to pay the costs. But what about the hidden costs?

Imagine if someone built a road separating your bedroom and kitchen. For species such as the wide-ranging moose, their "kitchens" (the ponds where they eat aquatic plants in summer) and "bedrooms" (uplands where they rest with their young) are often separated by roads.

Building and using roads often fragments and destroys habitat, and causes some wildlife to avoid it. It also brings humans into the area, with results such as wildlife-vehicle collisions. Roads also bring invasive species and chemical contaminants into the areas surrounding them.

Quite simply, the impact on some wildlife is disastrous. Over time, species sensitive to habitat disruption decrease in number. Fragmented habitat limits natural dispersal of young animals, which leads to a loss of genetic diversity in some animal populations. Numbers of species and individuals decrease overall and, at the extreme, species become locally and regionally extinct.

Estimates show 15 to 20 percent of the land base of the United States suffers ecological impacts from roads, because the effects of roads extend significantly beyond the road and its immediate surrounding area.[2] (See Figure 1.)

Direct Habitat Loss

WILDLIFE HABITAT IS DIRECTLY lost when roadbeds and associated rights-of-ways are constructed. Across the country, approximately 20 million acres (an area about the size of Maine) has been lost from the construction of four million miles of public highways, streets, and rights-of-way.

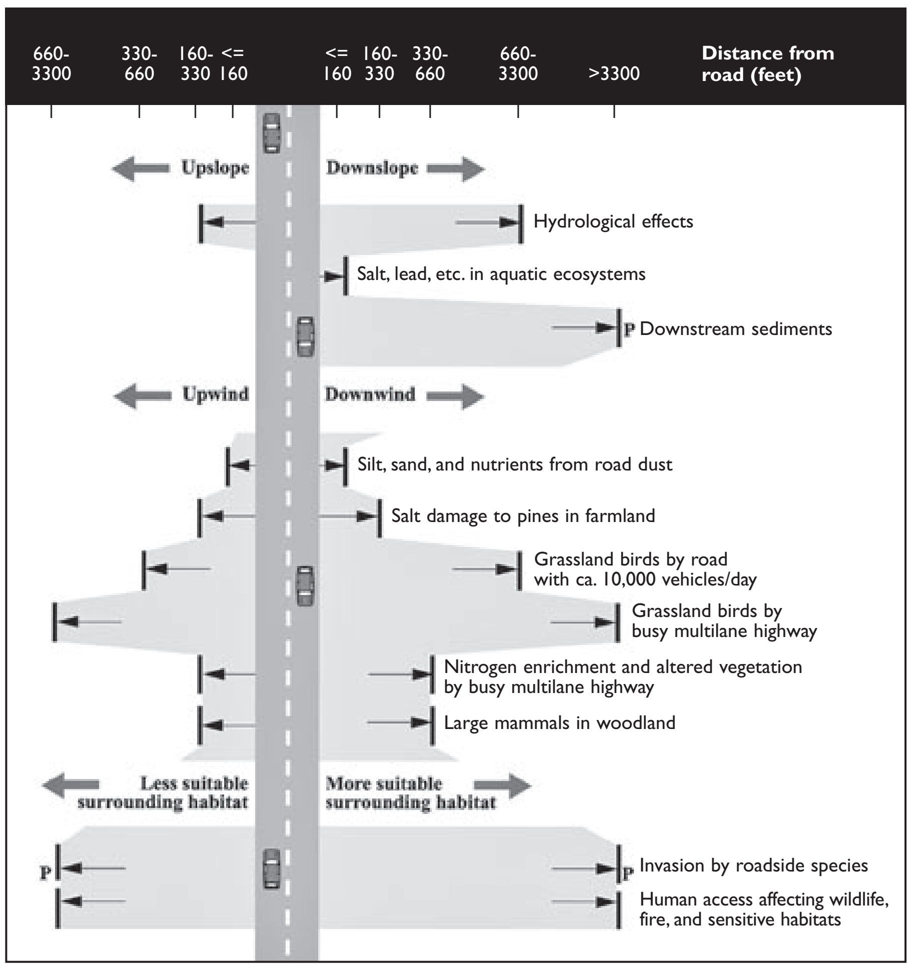


FIGURE 1. Sample distances of road-effect zones that affect wildlife habitat. Gravity (upslope/downslope), wind (upwind/downwind), and behavior or habitat suitability (less/more)—in addition to walls or hills near the road—produce greater effect-distances on one side of the road than on the other. Shaded areas = road-effect zone. Each effect typically extends outward along a stretch of road; (P) = an effect extending from a point on the road.

Bobcats need to move across a large landscape and are likely to disappear from habitat fragmented into smaller areas.

In Maine, the amount of habitat lost to public roads (22,750 miles) is approximately 115,000 acres, more than half the size of Baxter State Park. Roughly one-third of this acreage corresponds with the footprint of Maine's major roadways managed by the Maine Department of Transportation (MaineDOT) and the Maine Turnpike Authority (MTA); the remainder falls within the jurisdiction of Maine's nearly 500 municipalities and its Unorganized Territories. (These numbers don't include the approximately 44,000 miles of private and forestry roads in Maine.) A Maine study found that 210 pairs of breeding birds were displaced from every mile of the four-lane I-95 built in forested habitat. Most displaced birds will not breed successfully since adjacent habitat is usually occupied by other birds that vigorously defend their nesting territories against intruders. The intruders cannot find food or nesting sites. This represents a direct loss of habitat not only for the 210 pairs of breeding birds but also for the next generation of birds that would have lived there, leading to declines in total populations for the region.[4]

Habitat Fragmentation

WHEN A ROAD IS BUILT through large, formerly intact habitat blocks—whether forest, grassland, or wetland—it fragments them into smaller areas and isolates the animals within them. Some wildlife species can continue to thrive in relatively smaller habitat blocks. However, animal species that need to move across a large landscape, such as moose and bobcat, are likely to disappear from smaller habitat areas. Species such as wood thrush and northern parula warblers—which are especially sensitive to habitat changes, increased predation, or human disturbance—are likely to abandon fragmented habitat.

One study of traffic and wildlife showed that no small mammals moved across roads with average annual daily traffic volumes of over 11,000 vehicles per day—comparable to a busy two-lane highway in central Maine.[5]

Isolating animal populations into smaller groups by fragmenting their habitat reduces their genetic diversity and can lead to local extinction, and in some cases listing as an endangered species.

HOW DO ROADS AND TRAFFIC FRAGMENT HABITAT?

- Roads can create impassable barriers for terrestrial animals because of road width and altered habitat alongside roads.
- Roads constructed through wetlands and across streams can fragment habitat for aquatic animals.
- Culverts can restrict connections between habitat for fish and other aquatic animals.
- Noise, lights, and vehicle movements and emissions can restrict wildlife movement, particularly at high traffic volumes.

Habitat Avoidance

WILDLIFE EXPERTS BELIEVE traffic noise may be a major reason animals avoid habitat near roads. Other factors include visual disturbance, pollutants, and an increased numbers of predators.[6]

Traffic noise may interfere with breeding birds' ability to hear birdsong, which they rely on to attract mates and establish breeding territories. Because noise travels farther in open habitats, a decrease in population density adjacent to roads has been found to be greatest for grassland birds, less for birds in

Grassland birds, such as the meadowlark, may avoid habitat along noisy roads.

Collisions between vehicles and deer pose the greatest hazard for motorists, but do not put the deer population at risk.

deciduous woods, and least for birds in coniferous woods.[7,8,9] Researchers have found that negative impacts on the density and nesting success of grassland birds extend more than a quarter mile from a rural road and more than a half mile from a highly traveled, four-lane highway. [10,11]

Human Access and Land Use

WHEN NEW ROADS INCREASE access to Maine's undeveloped natural areas, they bring new opportunities for human activity such as development, agriculture, logging, mining, and the use of all-terrain vehicles. These activities can degrade, change, or even eliminate wildlife habitat.

New roads intended to alleviate congestion lead to increased residential and commercial development alongside the road, unless access is controlled. Private roads constructed to facilitate practices such as forestry, which may have relatively low impact on wildlife habitat, increase access to remote areas. As recreational use of these remote areas increases, and seasonal and permanent homes are built, road improvements are often expected—posing further threats to wildlife.

Chemical Contamination

CHEMICALS INTRODUCED ALONG roadways from vehicles, deicing salts, road surface wear, and herbicide and pesticide use can pollute wildlife habitat by providing a source of heavy metals, salt, organic pollutants, and excessive nutrients.[12] Such water and soil pollution poses a lethal risk to wildlife that depend on the resources.

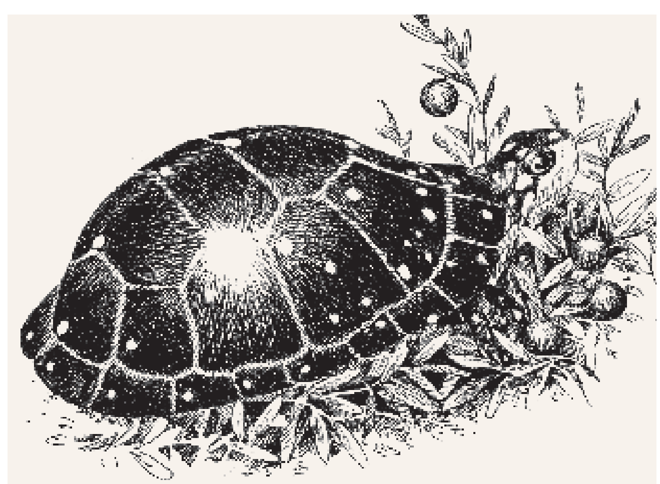
Contamination of soil, plants, and animals extends up to 66 feet from a road, and elevated levels of heavy metals often extend 650 feet or more from the road, occurring at greater concentrations along roads with high traffic volume.[13] Aquatic systems are particularly vulnerable to contamination, which streams may carry over long distances. Road salt, particularly sodium chloride, is toxic to many species of plants, fish, and other aquatic organisms. Increased salt in the water often helps invasive plants grow. In addition, concentrations of salt along roadsides may attract deer and moose, increasing the risk of vehicle collisions.

Wildlife-Vehicle Collisions

THE TYPES AND NUMBER OF animals killed by vehicles is related to road width, traffic volume, and vehicle speed. For example, amphibians and reptiles have the highest mortality rates on two-lane roads with low to moderate amounts of traffic, whereas large and midsize mammals are more susceptible to collisions on two-lane, high-speed roads. Birds and smaller mammals are more at risk from collisions on wider, high-speed highways.[14]

It's important to note that roads through and adjacent to wetlands, ponds, and other waterways have some of the highest road-kill rates.[15,16] With 85 percent of Maine's vertebrate species living in or using these habitats during some or all of the year, the need for animals to move safely from and around them is clear.

Although wildlife-vehicle collisions do not currently put the health of large-mammal populations such as deer and moose at risk, collisions between vehicles and large mammals pose the greatest hazard for motorists in Maine and should be minimized (see table on page 5).



For this spotted turtle, wildlife-vehicle collisions may lead to extinction.

However, for slower-moving species with lower reproduction rates and/or small populations, wildlife-vehicle collisions can be the major factor contributing to extinction. In Maine, this high-risk group includes the endangered Blanding's turtle and threatened spotted turtle, which regularly travel great distances between wetland feeding areas and upland nesting habitat. These turtles, which can live up to 75 years but do not breed until they are about 10 years old, have a very low rate of hatchling survival. Most of the turtles that cross roads are females traveling to and from nest sites.

Maine wildlife population models suggest that unless road kill can be substantially reduced, turtle extinctions in Maine are inevitable. Research that MaineDOT supports in southern Maine around Mount Agamenticus will help scientists and planners better understand the needs of these animals and develop some potential solutions.

Invasive Species

INVASIVE PLANTS AND ANIMALS that are not native to a region can seriously harm wildlife habitats. Invasive species spread rapidly and displace native species by outcompeting them for breeding sites, prey, and other resources. They can disrupt food webs, degrade habitats, and alter wildlife diversity.

Roadside erosion-control plantings, drainage ditches, maintenance and construction fill, automobiles and boats traveling from areas infested by invasive species, and animals traveling along roadways all provide a means for invasive species to disperse. Roadside erosion into wetlands and streams allows invasive species to gain a foothold as native vegetation is scoured or smothered by eroding soils. MaineDOT plants only native species on construction sites to reduce the spread of invasive species in Maine.

Maine Wildlife Species Most Vulnerable to Road Impacts

Species	Type of Road Impact	Reasons for Concern
Moose*	Vehicle collision	*From 2000-2004:* 14 human fatalities 3,391 accidents $83 million economic loss
Deer*	Vehicle collision	*From 2000-2004:* 2 human fatalities 18,289 accidents $62 million economic loss
Wide-ranging mammals: **Moose, Bear, Bobcat, Fisher, Canada lynx**	Road mortality Habitat loss Habitat fragmentation	Species loss on a local level
Riparian mammals: **Mink, Otter**	Habitat fragmentation Blocked riparian passage	Species loss on a local level
Low-reproducing/fairly wide-ranging mammal:** **Porcupine**	Road mortality	Species loss on a local level
Area-sensitive and declining birds:*** **Least flycatcher, Brown creeper, Wood thrush, Veery, Black-and-white warbler, Northern parula warbler, Chestnut-sided warbler, Canada warbler, American redstart, Rose-breasted grosbeak, Rufous-sided towhee, Upland sandpiper, Bobolink, Eastern meadowlark, Grasshopper sparrow, Vesper sparrow**	Habitat fragmentation Habitat avoidance/disturbance	Decline in populations Species loss on a local level
Fish: **Brook trout, American eel, Swamp darter**	Habitat loss/fragmentation Blocked riparian passage Chemical contamination/ sedimentation	Population reduction Species loss on a local level
Slow-moving/slow-reproducing/wide-ranging turtles: **Blanding's turtle, Spotted turtle, Wood turtle, Snapping turtle**	Road mortality Habitat loss	State extinction Species loss on a local level
Amphibians: **Spotted salamanders, Blue-spotted salamanders, Four-toed salamanders, Wood frogs, Leopard frogs**	Road mortality Habitat loss Chemical contamination	Population reduction Species loss on a local level Disease/deformation

* MaineDOT, *Collisions Between Wildlife Species and Motor Vehicles in Maine 2000-04*
** Dan Harrison, personal communication
*** Maine Audubon, *Conserving Wildlife in Maine's Developing Landscape*

Planning and Building for Wildlife Conservation

With careful land-use planning, we can do a great deal to reduce the impacts of roads on Maine's wildlife.

MOVING PEOPLE ACROSS Maine does not have to occur at great cost to wildlife. Through engineering and land-use planning, we can do a great deal at the state, regional, and local levels to enhance public safety and protect wildlife habitat while planning, designing, constructing, and maintaining our transportation networks. The financial cost of these projects and solutions varies widely—from thousands, to hundreds of thousands, to millions of dollars. However, solutions such as wildlife crossings can save human life and property, are used over many decades, and are a relatively small percentage of the cost of highway projects. With advanced planning, some projects may be readily incorporated into new roads, or upgrades and maintenance of existing roads. Others may be beyond the scope of current funding and would require special funding.

Citizen Involvement Can Make a Difference

CITIZENS CAN ENCOURAGE road planning, design, construction, and maintenance that protect wildlife populations, and enhance safety and our quality of life by sharing road and wildlife information with their local planning boards and public works departments. *Beginning with Habitat* maps (see "Need More Information?" on page 8) and this publication about roads and wildlife are a good start.

Participating in planning at the local and regional level ensures that the habitat and transportation sections of a town's comprehensive plan are linked, and reflect habitat and road issues. Each town's comprehensive plan determines its future land-use decisions, including where new roads will be needed to support new growth. To become involved at the local level, attend municipal planning board public hearings on subdivision proposals involving road construction or modification, and request changes to the plan that will benefit wildlife. To become involved on the regional and state level, refer to the guide *Working Together to Build a Better Maine: Participate in the Maine Department of Transportation Planning Process,* available from MaineDOT and at www.maine.gov/mdot/public-involvement/publicinvolvement.php.

Culverts installed to allow brook trout to pass can also be designed to allow small mammals, reptiles, and amphibians to pass under roads.

Road Planning and Construction Strategies

SPECIFIC STEPS CAN BE TAKEN to reduce impacts of roads on wildlife. Many have been used successfully elsewhere and others are being studied around the world. These recommendations were adapted in part from *Road Ecology*, a recent book authored by experts in this science.[17]

PLANNING

1. Use *Beginning with Habitat* maps to identify riparian habitats, high-value plant and animal habitats, and large blocks of undeveloped habitat in a project area. Steer development and road construction away from these important habitats to the greatest extent possible.
2. Where not possible to avoid important habitats, design and construct roads to minimize impacts to sensitive or fragile resources.
3. Develop and adopt town land-use plans and ordinances that promote village and neighborhood centers that reduce the

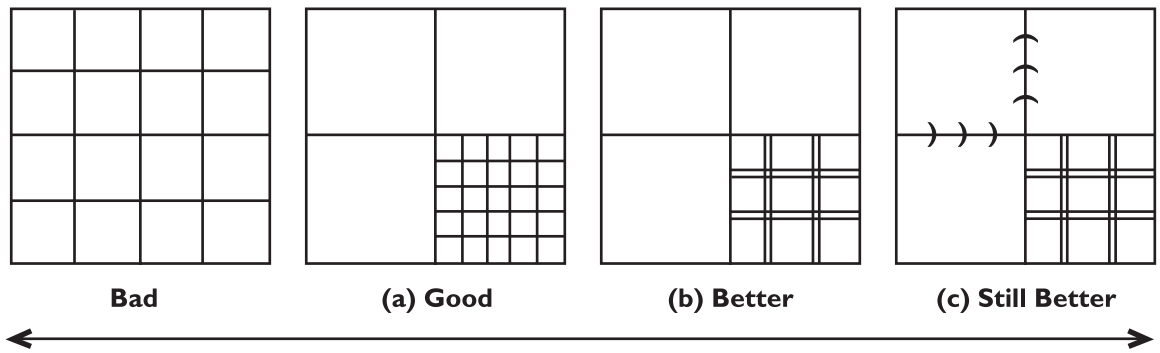


FIGURE 2: A hypothetical road network showing three principles for the ecologically best possible network. The principles: (a) Maintain a few large, roadless natural areas. (b) Concentrate the bulk of traffic onto a small number of large roads. (c) Connect habitat across roads that separate the large natural areas. ⌢ = wildlife crossing

FROM FORMAN, R.T.T. 2006.[18] WITH PERMISSION.

need to drive for daily goods and services; discourage building new roads in rural areas; and prohibit approval of long, dead-end roads. As much as possible, accommodate increasing traffic by upgrading existing major roads instead of developing multiple new minor roads. (See Figure 2.)

4. Minimize the number of breaks for new roads and driveways off main roads in areas of unfragmented and high-value habitat to reduce leapfrog development.
5. Develop a regional map showing where wildlife can travel between large habitat areas separated by roads. Preserve these important wildlife travel routes through local land-use management or wildlife crossing structures. The *Beginning with Habitat* program is developing such information.
6. Identify locations on roadways, culverts, and bridges that can be restored or retrofitted with wildlife crossing structures to improve wildlife movement.
7. Compensate for unavoidable habitat loss and fragmentation by identifying opportunities to purchase and conserve high-value habitat in the region.
8. Site and design roads to reduce runoff of chemicals that can contaminate water and soil. In consultation with MaineDOT, reduce salt use and designate "salt free" zones where appropriate.

CONSTRUCTION

1. Install wildlife underpasses and overpasses (see insert "Wildlife Crossing Structures") along existing roads to reduce habitat fragmentation and travel barriers, particularly in conservation lands, high-value habitat, and areas where wildlife travel.
2. Span streams or design culverts to mimic natural stream conditions so fish and other wildlife can pass under roads.
3. Use soil berms and vegetation as well as road surface improvements to mute noise and reduce other ecological disturbances that traffic creates for wildlife.
4. Use only native species for roadside plantings, erosion control, and slope stabilization. Plant maintenance-free native wildflowers and other plants along roadsides to prevent nonnative plant species from invading.

Wildlife-Friendly Road Planning and Projects Under Way in Maine

DURING ITS PLANNING PROCESS, MaineDOT routinely uses *Beginning with Habitat* and other habitat data to screen projects, as well as field visits to verify natural resources present at project locations. For large projects, such as the highway bypasses around Gorham and Presque Isle, MaineDOT studies not just the roadway but the entire transportation corridor, adjusting the final road alignment where possible to minimize impacts.

Where impacts to important habitats cannot be avoided, MaineDOT mitigates the negative effects of road building by conserving or restoring sites that have similar ecological functions and values. MaineDOT hopes to soon be a primary user of Maine's new "in lieu fee" program that proactively identifies regional sites of statewide value to best meet the goal of habitat mitigation. This program, administrated by Maine's Department of Environmental Protection, will be the first of its kind in New England.

Ten years ago culverts were designed only to pass a stream under a road; today they are also designed to allow passage of fish and wildlife. As of 2006, MaineDOT is building Maine's first large (13-foot-wide by 7-foot-high) concrete box culvert with a shelf inside to let small mammals, reptiles, and amphibians pass. This culvert, also designed to allow brook trout to pass, is on Bog Brook on Route 117 in Buckfield. In Phillips, in an effort to keep moose from bolting onto the road, MaineDOT began in 2006 to experiment with a five-foot-wide blanket of rocks along the shoulder in areas with many moose-vehicle collisions.

Maine Audubon works with MaineDOT and *Beginning with Habitat* to develop outreach materials and promote planning and projects that benefit wildlife and meet Maine citizen's transportation needs.

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Need More Information?

Beginning with Habitat: (207) 287-8042, www.beginningwithhabitat.org

Maine Audubon: (207) 781-2330, www.maineaudubon.org

Maine Department of Transportation: (800) 380-7822, www.mainedot.gov

Defenders of Wildlife Habitat and Highways Campaign: www.defenders.org/habitat/highways

Federal Highways: www.fhwa.dot.gov/environment/hconnect

Eco-Logical: www.environment.fhwa.dot.gov/ecological/eco_index.asp

International Conference on Ecology and Transportation: www.icoet.net

River and Steam Continuity Project: www.streamcontinuity.org

Wildlife Crossing Toolkit USDA Forest Service: www.wildlifecrossings.info

Wildlife and Roads: www.wildlifeandroads.org

CREDITS AND ACKNOWLEDGEMENTS

Researched and written by Barbara Charry, Maine Audubon wildlife biologist. All wildlife illustrations by Mark McCollough.

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Maine Audubon, a founding member of the award-winning *Beginning with Habitat* program, thanks its fellow members, Maine Coast Heritage Trust, Maine Department of Inland Fisheries and Wildlife, Maine Natural Areas Program, Maine State Planning Office, The Nature Conservancy, and U.S. Fish and Wildlife Service.

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MAINE AUDUBON

20 Gilsland Farm Rd. ▪ Falmouth, Maine 04105 ▪ (207) 781-2330 ▪ www.maineaudubon.org

Maine Audubon works to conserve Maine's wildlife and wildlife habitat by engaging people of all ages in education, conservation, and action.

Wildlife Crossing Structures

Planning to avoid the need for wildlife crossing structures is the first step. But, in the right locations, wildlife crossing structures can effectively allow animals to move across roads.

BY MAKING IT POSSIBLE for animals to move across roads, wildlife-crossing structures help them maintain access to the different habitats they need and avoid wildlife-vehicle collisions. However, crossings can be expensive and only address some of the problems created by new roads. The first rule is to locate roads in the appropriate places. Wildlife crossing structures should not be used to justify inappropriately located new roads. But retrofitting existing roads, often with minor changes, presents a huge opportunity to reconnect and maintain habitats. Wildlife crossings are an emerging science and new information is rapidly becoming available. Some things to keep in mind are:

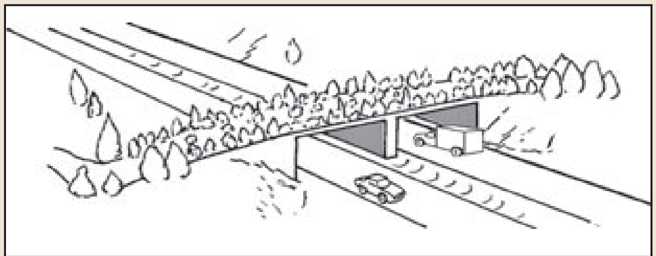
- ❑ Construction projects for wildlife are site specific, and their potential effectiveness needs to be assessed on a case-by-case basis, including up-front and long term maintenance costs.
- ❑ No one-size-fits-all solution exists for wildlife crossing structures; species prefer and adjust differently to various types of structures.
- ❑ Structures, such as fencing and culverts, need regular maintenance to be effective over time.
- ❑ Though some large wildlife crossing structures can be quite expensive, the most effective mitigation measure need not be the most expensive nor the most difficult to achieve.
- ❑ It's more economical to plan wildlife-friendly roadway expansion or major upgrade projects ahead of time than to retrofit an existing roadway.
- ❑ Ongoing resurfacing, bridge and culvert maintenance, and reconstruction often provide excellent cost-effective opportunities to mitigate for wildlife passage.

Crossing structures include directed fencing (barriers), signage, noise barriers, underpasses (small and large), and overpasses. The following illustrations from the United States Department of Agriculture Forest Service's Wildlife Crossings Toolkit show some of the common types and sizes of wildlife passage structures. For more information about wildlife crossing structures, visit www.wildlifecrossings.info.

FENCING

Fencing keeps animals—from deer and moose to frogs and turtles—off roadways while guiding them to designated crossing structures (see "Wildlife Underpasses"). Fencing, when combined with crossing structures such as overpasses or underpasses and escape ramps, is very effective in keeping wildlife off roadways and providing habitat connections. For deer, fences are typically 7 to 10 feet high with fine mesh on the bottom 1 1/2 to 3 1/2 feet to prevent small animals from getting through. The fence may be buried 8-16 inches to prevent animals from digging under, or folded into an "L" shape that extends away from the base of the fence. Gaps or holes in the fence over 13 inches are enough for deer to get through.

Extensive fencing to keep deer and moose off controlled-access highways can be costly and must be used with escape ramps to allow animals to get out of the right-of-way areas alongside roads. Fencing does not work to keep large animals off urban or rural roads with numerous driveways.



Wildlife Overpass or Green Bridge

WILDLIFE OVERPASSES

A wide range of animals, from insects to large mammals including deer, use wildlife overpasses, or "green bridges," that range in width from 66 to 1,000 feet (most are 98-164 feet). They are designed to resemble natural habitat, with native vegetation and in some cases even small ponds. These are most successful when combined with fencing to keep animals off the road and landscaping around the entrance to provide cover for approaching wildlife. Cost for these structures may be well over $1 million. Two wildlife overpasses are being used successfully over the Trans-Canada Highway in Banff National Park. Wildlife passageways and fencing have reduced wildlife and vehicle collisions by more than 80 percent. Moose, deer, bears, snowshoe hare, marten, and other wildlife use these overpasses. For more details go to the Trans-Canada Highway Twinning Banff National Park of Canada web site, www.pc.go.ca/pn-np/ab/banff/docs/routes.

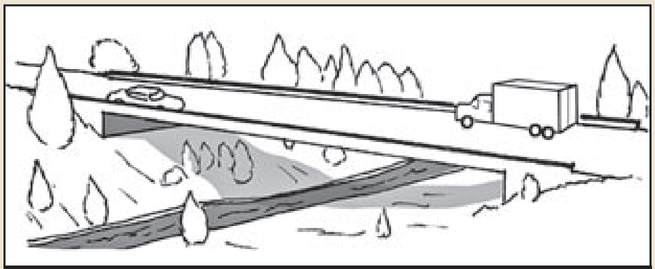
WILDLIFE UNDERPASSES

Many designs of small passages allow amphibians, reptiles, and small mammals to cross underneath roads. Dry tunnels two feet wide that are designed primarily for small and medium-size mammals work well and are inexpensive. Culverts designed for amphibians range from 1 to 3 1/3 feet wide to up to 66 feet long. Concrete tunnels with earthen floors are most effective. Trenches, fencing, or curbs can direct animals to the underpass.

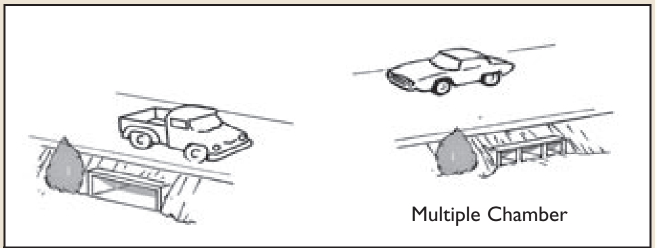
Waterway culverts with raised, dry ledges can help animals move along the waterway. These structures may be up to four feet wide and have ledges 1 1/2 feet wide. When replacing a culvert, use an arch shape or consider a span instead of a culvert to include some of the stream bank. Stream simulation is a new approach to culvert design to allow passage of fish and other aquatic animals and which can also be adapted to accommodate terrestrial wildlife. This method avoids constricting the stream channel and maintains the continuity of the stream bottom and hydrolic conditions by construction of a streambed within the culvert.

Large passages range from 6 1/2 to 16 feet wide for most large culverts to more than 330 feet for extended bridges or viaducts. Culvert passages may be made of metal or concrete, be bottomless (having a natural bottom) or continuous, and may be box, circular, arch, or elliptical in shape. Rocks, stumps, and plants may need to be added near the entrance to provide cover for animals moving through the underpass. Many species will use these large passages, including bear, bobcat, and moose. Deer tend to prefer passages that are at least 20 feet wide and 8 feet high with vegetation for cover nearby. The amount of light visible due to the width, height, and length of the tunnel (referred to as "openness ratio") determines whether animals are willing to use the underpass.

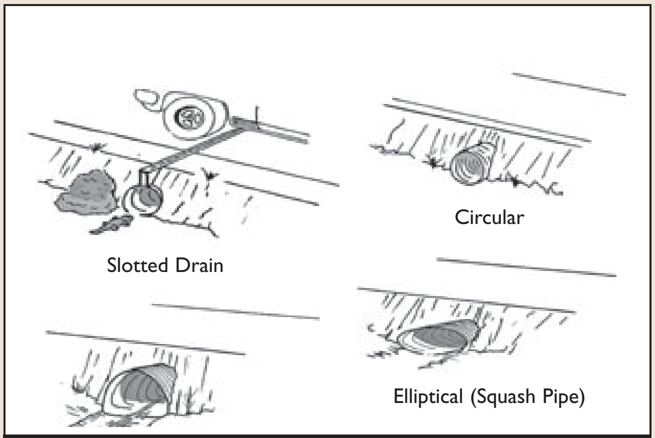
When wildlife crossing modifications are added to bridge contruction projects over water, costs can be a small percentage of the overall project budget, starting from $200,000. However, costs can range to over $1 million for wildlife underpass bridges over land. The cost of strategically placed underpasses can be more than matched by the savings from reducing vehicle collisions and loss of human life.[19]



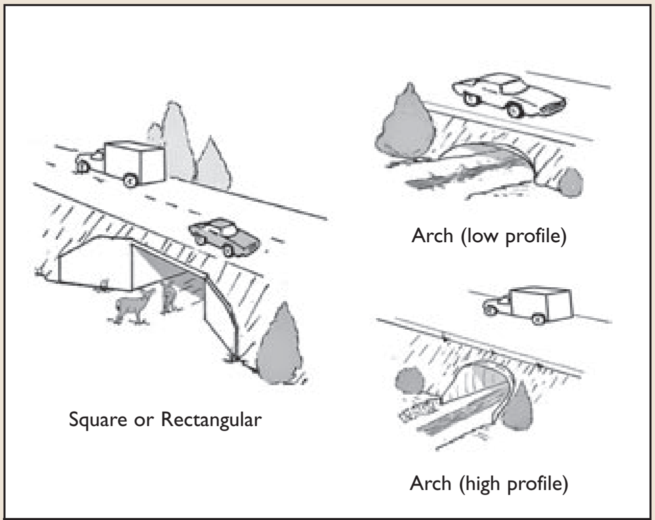
Wildlife Underpass Bridge



Box Culverts



Culverts



Bottomless Culverts

DRIVER WARNINGS

Traditional warning signs, like "Moose Crossing Next 3 Miles," have had limited success preventing collisions with deer and moose. This is unfortunate since slower speeds in areas with high rates of collisions would result in significantly fewer collisions.[20] However, dynamic message signs (electronic signs with changing messages) with wildlife advisory messages are showing promise in reducing motorist speed, particularly at night. Turtle crossing signs are being tested in areas around Maine's Mount Agamenticus with high concentrations of endangered Blanding's and threatened spotted turtles.

NOISE BARRIERS

Vegetated earthen berms along roads bordering fields, wetlands, on overpasses, and above underpasses reduce highway noises disturbing to wildlife. They should be used judiciously to make sure they do not cause or exacerbate habitat fragmentation. Trees are natural noise barriers and should be left where they occur next to roads.

ATTACHMENT 11

January 18, 2023
File: 195602317

Attention: Tim Carr
Land Use Planning Commission
Department of Agriculture, Conservation, and Forestry
Harlow Building
18 Elkins Lane
Augusta, ME 04333

Dear Mr. Carr,

Reference: Wolfden Mount Chase LLC Application for Zone Change

On behalf of Wolfden Mount Chase LLC., Stantec Consulting Services is pleased to submit the attached Application for Zone Change for consideration of rezoning of approximately 374 acres in T6R6 WELS from General Management (M-GN) to Planned Development (D-PD). If rezoned and then ultimately approved by the Department of Environmental Protection under Maine's *Metallic Mineral Exploration, Advanced Exploration and Mining* regulations the rezone area would be used for development of an underground mining operation and associated structures. The purpose of the operation is to extract metallic ore that is rich in copper, lead, zinc, silver and gold. The proposed rezone area does not include facilities for ore concentration or tailings.

The document has been produced in a format that addresses the Land Use Planning Commission (LUPC) Chapter 10 and Chapter 12 regulations, including 27 Exhibits designed to provide the information that is required to support the proposed rezoning. In Table 2-2 of the Application, we have provided a matrix linking the applicable regulatory requirements to the relevant Application Exhibits.

Three hard copies are being submitted by hand delivery to your attention at Elkins Lane in Augusta. Please advise on how best to transmit an electronic copy compatible with State security and file size restrictions. In addition, hard copies are being posted via FedEx as follows:

- LUPC East Millinocket office – 1 copy;
- LUPC Ashland office – 2 copies; and
- Aroostook and Penobscot County Commissioners offices – 1 copy to each.

By separate transmittal Wolfden Mount Chase LLC is today submitting the Application fee ($14,350) and the Extraordinary Project Processing fee ($79,387.28).

Thank you for your attention to this submission. We look forward to working with the LUPC staff and Commission as you all undertake your review of these materials.

Respectfully yours,

Stantec Consulting Services Inc.

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Attachment: Application for Zone Change
c. Jeremy Ouellette, Wolfden Mount Chase LLC

EXHIBIT 9.0 CONSISTENCY WITH THE COMPREHENSIVE LAND USE PLAN

The LUPC Comprehensive Land Use Plan (CLUP) provides for sound planning practices in the public interest to encourage and manage multiple uses of land and resources within the LUPC's jurisdiction (LUPC 2010). In 2012, the Legislature made a number of changes that impact the Commission and the role of the CLUP. Subsequently, the Commission approved guidance for interpreting the CLUP that reflects these statutory changes. (Guidance for Interpreting the 2010 CLUP, Approved October 5, 2012.) Importantly, and as reflected in the Guidance, the statutory changes place an increased emphasis on serving the regions in which the unorganized and deorganized areas located; honoring the rights and participation of residents and property owners; and encouraging and facilitating regional economic viability. (Guidance at 3.) The following subsections describe how the proposed rezoning for the Project fits within the CLUP, and how the proposed Project meets the CLUP's principal values, goals, and policies as informed by the 2012 statutory changes and Guidance.

9.1 CLUP PRINCIPAL VALUES AND BROAD GOALS

The LUPC Commission has identified four **principal values** that, taken together, define the distinctive character of the jurisdiction (LUPC 2010):

1. The economic value of the jurisdiction derived from working forests and farmlands, including fiber and food production, largely on private lands. This value is based primarily on maintenance of the forest resource and the economic health of the forest products industry. The maintenance of farmlands and the viability of the region's agricultural economy is also an important component of this value.

2. Diverse and abundant recreational opportunities, including many types of motorized and non-motorized activities. Unique opportunities exist for recreational activities which require or are significantly enhanced by large stretches of undeveloped land, ranging from primitive recreation in certain locations to extensive motorized trail networks. Recreation is increasingly an economic driver in the jurisdiction and the State.

3. Diverse, abundant and unique high-value natural resources and features, including lakes, rivers and other water resources, fish and wildlife resources, plants and natural communities, scenic and cultural resources, coastal islands, mountain areas and other geologic resources.

4. Natural character, which includes the uniqueness of a vast forested area that is largely undeveloped and remote from population centers. Remoteness and the relative absence of development in large parts of the jurisdiction are perhaps the most distinctive of the jurisdiction's principal values, due mainly to their increasing rarity in the Northeastern United States. These values may be difficult to quantify but they are integral to the jurisdiction's identity and to its overall character.

The LUPC policies shall be directed toward the achievement of the vision for the jurisdiction and the following three broad goals:

1. Support and promote the management of all the resources, based on the principles of sound planning and multiple use, to enhance the living and working conditions of the people of Maine and property owners and residents of the unorganized and deorganized townships, to ensure the separation of incompatible uses, and to ensure the continued availability of outstanding quality water, air, forest, wildlife, and other natural resource values of the jurisdiction.

2. Conserve, protect and enhance the natural resources of the jurisdiction primarily for fiber and food production, outdoor recreation and plant and animal habitat.

3. Maintain the natural character of certain areas within the jurisdiction having significant natural values and primitive recreational opportunities.

9.2 THE PROJECT SATISFIES CLUP DEVELOPMENT GOALS AND POLICIES

LUPC has defined specific goals and policies that are intended to guide its actions. The Project's relationship to each of these goals is discussed separately and, where applicable, specific policies of the CLUP are also referenced. Only the goals and policies of particular applicability are discussed below.

9.3 LOCATION OF DEVELOPMENT

<u>CLUP Goal: Guide the location of new development in order to protect and conserve forest, recreational, plant or animal habitat and other natural resources, to ensure the compatibility of land uses with one another and to allow for a reasonable range of development opportunities important to the people of Maine, including property owners and residents of the unorganized and deorganized townships.</u>

The Project location is dictated by the unique geologic conditions that resulted in the formation of a mineral deposit of economic value. The Project must locate where the resource is found and the CLUP policy on adjacency is not applicable (see **Exhibit 7, Figure 7-3**). The location and physical relationship of the mineralized zones to surrounding topography and water bodies allows the deposit to be developed by underground mining methods, which, when combined with carefully managed mine water collection and treatment systems, will allow mine development, operation, and closure without impacting water quality of these adjacent resources. This approach allows for an optimal compatibility of uses, limiting the footprint to approximately 129 acres. The way the Project is designed avoids and minimizes, to the extent possible, protected natural resources including but not limited to wetlands, vernal pools, rare and endangered plant and wildlife species (see **Section 10.5 of Exhibit 10 – Surrounding Uses and Anticipated Impacts**).

The Project is also unique in having a finite duration currently anticipated to be from 10 to 15 years for mining operations, up to 25 to 30 years for the solar facility. The reclamation of the proposed site will sequentially remove all buildings and structures including the water treatment systems when they are no longer required. Once the access to underground workings is permanently sealed and the mine site is regraded and revegetated it will attain the natural character and values that existed prior to mining (See **Section 2.4 of Exhibit 2 – Project Description**). The solar facility will be decommissioned and removed at the end of its useful life or at the end of the Project life, in accordance with MDEP decommissioning requirements, allowing that portion of the site to also return to its natural character.

While consistent with the CLUP location of development goal, the Project is also consistent with CLUP polices including:

Policy 1 Development that is directed to a suitable area and retains the principal values including a working forest, and integrity of natural resources.

The Project location is dictated by the unique geologic conditions that resulted in the formation of a mineral deposit of economic value. The Project will support the long-term conservation of select areas of working forests in the Project Area as well as protecting high-value natural resources such as surface water bodies, streams, wetlands, vernal pools, and flora and fauna. The project has a limited lifespan and will return to principal uses. After completion of the project, the footprint will return to forested lands that can be harvested in future years post closure.

Policy 2 Guide development to areas near existing towns and communities and other areas appropriate for development.

*The Project location is near existing towns with proximity and connectivity by public roads to other organized town and economic centers, with adequate available public infrastructure and services. The nearest communities are relatively close to the Project, including Hersey (4.5 miles) and Patten (9.5 miles). The nearby communities and service providers have confirmed adequacy of services and infrastructure for each Project aspect. See **Exhibit 17 – Fire, Police, and Ambulance, Exhibit 18 – Educational Services, Exhibit 19 – Solid Waste Disposal, Exhibit 20 – Electricity and Telephone,** and **Exhibit 21 – Public Roads**.*

Policy 3 Discourage growth which results in scattered and sprawling development patterns.

*As discussed in **Exhibit 2 – Project Description** and **Exhibit 10 – Surrounding Uses & Anticipated Impacts**, the Project footprint is necessarily located at the mineral deposit and will be of limited duration on approximately 129 acres to be cleared and 104 acres of actual development, minimizing the Project footprint to the extent practicable. The Wolfden property surrounding the Project will remain forested.*

Policy 7 In areas that are not appropriate as new development centers, allow for (a) planned developments which depend on a particular natural feature, subject to site plan review, and (b) other development, subject to concept plan review.

The Project depends on the unique geologic conditions that resulted in the formation of a particular natural feature, a mineral deposit of economic value.

*The Project will provide for parking at the mine operations site and the transportation routes, described in **Exhibit 2 – Project Description,** would not adversely affect traffic circulation.*

c. Limiting the number and size of signs in order to prevent undue visual impacts or hazardous conditions.

The only signage visible to the public associated with the Project would be for transportation safety at the location where vehicles egress and exit from SR-11 to private roads.

Policy 2 Prevent the degradation of natural and cultural values resulting from cumulative impacts of incremental development.

The Project final design will be permitted through the MDEP, and efforts will be made to minimize impacts to the principal values of the jurisdiction, including avoidance and minimization of impacts to protected natural resources. Due to the location-specific nature of this mineral deposit, development of this Project will not result in incremental development.

9.3.3 Infrastructure

<u>CLUP Goal: Ensure that infrastructure improvements are well planned and do not have an adverse impact on the jurisdiction's principal values.</u>

The Project meets the CLUP's goal of ensuring that infrastructure improvements are well planned and do not have an adverse impact on the jurisdiction's principal values. These improvements will include upgrading existing gravel access roads located on private lands and the intersection of the private road with Route 11 for public safety purposes (see **Exhibit 21 – Public Roads).** The Project will also, separate from this application, establish a new power transmission service line to supply additional needed electrical power for the Project.

The power transmission route has been planned with Versant Power and would run from their substation located on Route 11, located approximately 0.6 miles south of downtown Patten, Maine. The transmission line would run north and northeast along Route 11 then follow the same gravel access road proposed for the mine for a total distance of approximately 11 miles. The access road upgrades to be considered in the design for the permit application submittal will be developed concurrently with the transmission line design. See **Exhibit 20 – Electricity and Communications.**

The Project is also consistent CLUP policies including the following items:

Policy 1 Consider the capacity of existing infrastructure and services to accommodate proposed development, as well as the costs associated with the provision of these services to proposed development.

It is Wolfden's objective that the primary workforce be employed locally from residents. This will require training for that work force since many unique skills are required of miners working underground. The mine will employ approximately 233 workers (employees and local contractors), composed of 91 shift decreased by 19%, while the rest of Maine has grown 11.8%. Many young people have left in search of employment and the remaining population is notably older than the state average, especially in the Millinocket LMA. Incomes are relatively low and poverty rates exceed the state average, especially among children.

The population of the Region has declined steadily since the 1970s and 1980s, mirroring changes in the forest products industry that once dominated the region. A series of mill layoffs and closures reduced employment opportunities, causing many residents to relocate. While some sites are being redeveloped, technological advances mean new operations do not require the thousands of workers mills once employed. Since 1990, Mount Chase's population has decreased by 26%, Patten's by 30%, Millinocket LMA's by 31%, and Houlton LMA's by 10%. As the region's population has declined, the age of its residents has risen, suggesting many emigrants were young people seeking opportunities outside the region.

Incomes in the Region are significantly lower than elsewhere in Maine, most likely reflecting the region's lack of well-paying jobs and the age of its population. In Houlton LMA, poverty across all age groups significantly exceeds the state average. In Millinocket LMA, poverty among those under age 65 exceeds the state average, but those age 65 and older are slightly less poor than their peers statewide. Childhood poverty is particularly prevalent in the region. In both LMAs, approximately 1 in 3 children under age 5, or 28.8% in Houlton LMA and 34.8% in Millinocket LMA, is living in poverty. Maine's overall child poverty rate measures significantly lower from 2016-2020, at fewer than 1 in 6 Maine children (15.4%).

Recent employment statistics suggest a labor market with limited employment opportunities. In 2021, average employment was 6,876 in Houlton LMA and 3,033 in Millinocket LMA. Unemployment exceeded the state average (6.2% and 7.6%, respectively, compared to 4.6% statewide). Employment opportunities in the Region appear to model the seasonal fluctuations that typify Maine's economy. In 2021, employment was highest during the summer travels months, slightly lower in fall and winter, and lowest during spring "mud season". Within the Region, the fact that employment remains relatively high through the winter months compared to elsewhere in Maine likely reflects its popularity as a destination for snowmobiling and other winter recreation.

In 2021, average wages in the Region were 25%-35% lower than elsewhere in Maine. The average weekly pay of a Maine job was $1,051, compared to $798 in Houlton LMA and $720 in Millinocket LMA. "Living wages" for Aroostook and Penobscot counties calculated by researchers at the Massachusetts Institute of Technology suggest local jobs may not pay enough to support a minimum standard of living. In 2020, the average weekly wage in these counties was $836 and $951, respectively. This would cover the needs of a single adult living alone but falls far short for an adult with one child. In 2016-2020, the percentage of residents in Houlton LMA (88.2%) with health insurance coverage trailed the state average, while Millinocket LMA was equivalent to the statewide coverage rate of 92.4%. The lack of health insurance coverage for the overall population may reflect a lack of jobs providing this benefit to younger residents.

Compared to the rest of Maine, in 2021 the Region had a higher concentration of businesses in the agriculture, forestry, fishing, and hunting industry classification; transportation and warehousing; and public administration. There was a lower concentration of businesses in wholesale trade and professional and technical services. The overall number of business establishments in the region across all industries has declined in the past two decades. Mirroring the mix of business establishments, a disproportionate share of employment in the Region is in retail trade, educational services, and health care and social assistance.

The Maine Office of Tourism (MOT) publishes visitor information for the “Maine Highlands” region, which encompasses Penobscot and Piscataquis counties, and includes the Region (**Figure 10-5**). Tourism is a significant contributor to the Region economy. In 2021, taxable sales from the Region (including the Maine Revenue Service Economic Summary Areas [ESA] of Houlton, Patten, and Millinocket) were $36 million, which represented 0.8% of statewide restaurant and lodging sales. Across Maine, sales at these tourism-related businesses accounted for 14,7% of all retail sales. In the Houlton ESA and Patten ESA, that percentage was lower (10.0% and 11.5% respectively) while in Millinocket ESA it was significantly higher (22.6%). Maine’s tourism economy has grown robustly in recent years with statewide restaurant and lodging sales rising 78.3% from 2010 to 2021. Growth was much lower in the Region over this time period, ranging from 29.4% in Patten to 36.7% in Houlton and 40.1% in Millinocket. Snowmobiling and ATV use provide significant tourism revenue to the region and state. Spending on trips (as opposed to spending on the snowmobile itself) during the 2018-2019 season was more than $200 million. Forty-six percent of resident snowmobilers and 45% of non-resident snowmobilers visited the “Maine Highlands” region as defined by the Maine Department of Transportation (MDOT) (**Figure 10-5**), making it the most visited tourism region in Maine with resident snowmobilers and the second most popular with non-residents. In all, an estimated 523,000 “snowmobiling days” took place in the Maine Highlands region during the 2018-2019 season. A 2005 study found that ATV user activity contributed $200 million to the state economy in the 2003-04 season. This value is likely significantly larger now, both due to cost inflation and the increased popularity of ATV use. In 2003-2004, the Maine Highlands region was the most popular region for ATV riders, with an estimated 24% of all rides happening in the region and 35% of all riders riding in the area.

10.10.2 Potential Positive Impacts

In total, the Project expects to spend $622 million dollars during fourteen years of planning and operations of the Project (excluding contingency spending), of which $340 million is expected to be spent with businesses located within the economic region of Aroostook and Penobscot Counties. As that spending ripples through the regional economy, creating indirect and induced economic benefits, a total impact of $715 million in business sales and $248 million in earnings will be created within the regional economy. The Project is expected to create 4,540 job-years (roughly 324 jobs per year inclusive of 272 Project-associated jobs for 14 years). Roughly 11% (510 job-years) are expected to be created in the start-up phase and 89% (4,030 job years) in the operations phase. The estimated 324 annual jobs represent 0.4% of the total jobs in the economic region and 4.1% of jobs in the Houlton and Millinocket labor market areas. While the economic data does not allow for a hyper-local estimate of the economic impacts, it is fair to assume that the economic impacts are expected to be felt most acutely by the towns closest to the project and will dissipate with distance. The jobs created by the Project are further detailed in **Table 17 and 18 of Attachment 10-A**. There are a total of 16 administrative supervisory and management staff for the Project. Additionally, there are 103 daily project operators, who work 10.5 hours dayshifts and nightshifts over a 7 days-on and 7 days-off rotational schedule. In addition, there are 14 hired staff that work-day shift only but follow the similar 7 days-on and 7 days-off working rotation. Note that the Preliminary Economic Assessment (PEA) does not specify each of the of the mill operators and

Attraction	% Visiting	Aprox. Driving Miles from Pickett Mine
Patten Lumberman's Museum	6%	10
Gulf Hagas	5%	99
Maine Forest and Logging Museum (Bradley)	5%	97
Penobscot Theatre (Bangor)	5%	100
Curran Homestead (Orrington)	5%	108
Katahdin Iron Works (Brownville)	4%	83
Wabanaki Art Center	4%	118
Thomas Hill Standpipe (Bangor)	4%	100

Snowmobiling and ATV riding are also important parts of tourism and local recreation in the Maine Highlands region. For snowmobilers, the Highlands region is the most visited tourism region with residents and the second most visited with non-residents;[27] for ATV riders, it is the most visited.[28] Both snowmobilers and ATV riders generally ride long distances: for example, resident snowmobilers drove an average of 780 miles in 2018-19, while non-residents drove an average of 973 miles. No snowmobile or ATV trails are within the proposed rezone area.

Publicly available data on other forms of recreation like hiking, hunting, and fishing taking place within the Pickett region are sparse and it is unclear how large an economic market these forms of recreation make up, and how many people from outside the region come to the Pickett region to recreate. While there are trails nearby, none are within the Project boundaries. Pickett Mountain is not a world-class tourism attraction like Mount Katahdin, nor does it have "gateway-community" amenities close by. The Project's footprint will be less than a square mile in a region of thousands of square miles of recreational opportunities. Wolfden has also publicly stated it does not intend to revoke public access to its more than 6,800 acres of adjacent land for hunting or trail use. All of these factors lead to the reasonable conclusion that the proposed Project will have little to no negative effect on the regional tourism industry, with one caveat: the assessment of little-to-no negative tourism impact assumes, importantly, that the Project does not harm the environmental quality of the larger region.[xxii]

Impact on the Housing Market

Home prices and rents in the Pickett region are affected by myriad factors that drive the overall supply and demand for housing in the region. Two primary drivers of demand, today, are a declining population and residents' relatively low incomes, both of which constrain demand for both new and/or higher-end housing options. A third demand driver – an aging population – is poised to impact preferences for the type and location of housing in the region as the housing needs for older residents change as they age. The supply of the region's housing is also complex, influenced in large part by its history as an industrial powerhouse. The region's housing stock is predominantly single-family homes, which are relatively older and less expensive than in other regions. Today, all these factors interact in the form of house prices and rents that are lower than the statewide average and a housing vacancy rate that is above the state average, particularly in Houlton LMA (32%) and Millinocket LMA (41%). There are over 6,900 vacant housing units in the two labor market areas.

[xxii] Note that this is a qualitative assessment only as we are not aware of studies that have quantified or correlated the economic impact, if any, of small-scale mining on broader regional tourism.

16.1.1.2 Results

Results of both Viewshed Analyses are shown in **Figure 16-1** and **Figure 16-2**. In general, geomorphology, site and surrounding topography, and forest cover will provide a visual screen of the project from most vantage points.

The headframe has potential visibility from the following locations under the conservative ground level elevation only analysis:

- The snowmobile/ATV trail immediately south of the Project Area
- Pickett Mountain Pond
- Northern shore of Pleasant Lake
- Northern shore of Mud Lake
- Eastern shore of Tote Road Pond
- Northern face and summit of Mount Chase (summit based on field observations)

With consideration of forested areas within the 3-mile radius area of analysis, potential visibility of the headframe is reduced to the following:

- The snowmobile/ATV trail immediately south of the Project Area
- Pickett Mountain Pond
- Northern shore of Pleasant Lake
- Summit of Mount Chase (based on field observations)

16.1.2 Line of Sight Analysis of Pleasant Lake

TJD&A Landscape Architects and Planners (TJD&A) completed an additional line-of-site analysis from Pleasant Lake (**Attachment 16-A**). This study focused on visibility of the headframe and Project solar components from the water and a cluster of four camps along the north shore of Pleasant Lake. The analysis indicates the solar array will not be visible from the water or camps and there may be limited visibility of the headframe due to screening vegetation. The effects of distance, terrain, and vegetation will screen (or partially screen) all other Project components. TJD&A concluded that the headframe structure may be partially visible over the tree line but will not dominate the landscape when viewed from Pleasant Lake and the immediate shoreline.

16.2 NOISE ASSESSMENT

WSP conducted a noise assessment of the mining operation, which modeled sound levels of mining equipment and vehicles with potential to generate significant cumulative sound levels (**Attachment 16-B**).

- A 400-foot-wide undisturbed area along the outer-edge of Project area and within the rezone area will be included.
- Structures and facilities have been sited to avoid streams and wetlands.
- Lighting will be less than 160 watts and housed in downward facing full cut-off fixtures to minimize light pollution.
- The below ground operation results in a small footprint when compared to a surface mine.
- After mine operation ceases, the site will be restored to its pre-mining state, except for the solar area, which will be decommissioned at the end of its life pending approval by the utility to continue operations post mining. All buildings and equipment will be removed. The site will be restored to natural contours and revegetated.

The low sound and noise impacts and harmonious project design elements combine to achieve a Project with insignificant impacts that fits in well with the surrounding area of predominantly commercial logging forests and access roads.

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Vibration Dynamics and Noise (VDN)
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Technical Memorandum

To: Jeremy Ouellette, Wolfden Resources Corporation **Date:** October 12, 2022

From: Juan Vences – Acoustics & Vibration Analyst, Wood VDN

CC: Henrik Olsen, Principal Consultant – Acoustics & Vibration, Wood VDN

Mike Cyca, Service Lead Americas – Noise, Wood VDN

Peter Baker, Senior Program Manager – WPS USA Environment and Infrastructure, Inc.

Ref: Noise Model – Pickett Mountain – Wolfden Resources Corporation

Re: Noise Assessment Report

1.0 INTRODUCTION

Wood Environment & Infrastructure Solutions (Wood), has been retained by Stantec to support Wolfden Resource Corporation's Pickett Mountain Project ("Project"). Wood's Vibration, Dynamics and Noise (VDN) team was engaged to prepare the noise model for this project.

This memorandum presents the results of the VDN's team noise modelling as well as an assessment of the noise modelling results against the applicable noise criteria for the Project.

This memorandum takes into account the noise assessment requirements for the Project identified in the letter from the State of Maine, Department of Agriculture, Conservation & Forestry: Land Use Planning Commission (LUPC) [1]. Recommendations from the Third-Party Peer Review TPPR for revisions to the noise study have been taken into consideration in this memorandum.

2.0 PROJECT DESCRIPTION

The Project is located in Northern Maine in Township 6, Range 6 of Penobscot County, approximately 4.4 miles west of state Highway 11. The land that the Project site is located on is currently zoned by LUPC as a General Management subdistrict (M-GN) [4]. Figures which provide information regarding the Project location, surrounding land uses and the site layout are provided in Appendix A.

The mine only operation will produce an estimated 1200 tonnes per day (tpd) of ore. of the ore material will be hauled off site using 80,000lbs trucks 12 hours per day. The site and associated activities are planned to operate 24 hours per day.

EXHIBIT 21.0 PUBLIC ROADS

21.1 NEAREST PUBLIC ROAD

Access to the Project Area is through well developed and well-maintained private gravel roads, currently used for logging. The nearest public road to the Project Area is Route 11, located approximately 4.4 miles southeast of the Project Area and along private gravel logging roads.

21.2 TRAFFIC ROUTES

Traffic routes along private and public roads will be needed to support the mine operations, which includes transportation of ore to the Tailings Management Facility (TMF) for processing and subsequent hauling of the concentrate to market. **Figure 21-1** details the conceptual transportation route to a TMF located in either Hersey or Patten, while **Figure 21-2** details the conceptual route to a TMF located in Stacyville. WSP prepared a technical memorandum with additional details on the conceptual routes and roads likely to be used (**Attachment 21-A).** These conceptual routes are further discussed in **Section 21.4.** WSP's analysis concluded that the additional traffic levels from mine operations do not represent a major impact to the existing road infrastructure.

21.3 PRIVATE ROADS

Access between the Project Area and Route 11 is along 4.4 miles of well-developed and well-maintained private gravel roads (consisting of Pleasant Lake Road, Bear Mountain Road, and Hale Pond Road) that were established and are maintained for commercial logging trucks. These roads are also used for recreational purposes including all-terrain vehicles and snowmobiles. These routes will be used by employees, contractors, delivery vehicles, and ore rock transportation trucks. A right of way easement for use of these roads for the duration of the project is included in **Exhibit 3 – Deed, Lease, Sales Contract, or Easement.**

21.4 PUBLIC ROADS

21.4.1 Public Roads – Routine Traffic

Public roads will be used by mine employees, contractors, and delivery vehicles. It is expected that the majority of onsite employees and contractors will be from the local work force traveling to the site along Route 11 from surrounding roads, many of whom already use portions of this route for their current employment. Delivery vehicles will also use Route 11 and surrounding roads to access the site at the Bear Mountain intersection. Many of these public roads are outside of LUPC jurisdiction but are discussed here for completeness and per request of the LUPC. Based on the estimated additional level of Project traffic, there may be incremental effects to noise, dust, and emissions levels. The minimal increase, relative to current traffic, is not expected to negatively impact health and safety to local residents and businesses in the area. See **Attachment 21-A** for additional information on these routes and volumes.

21.4.2 Public Roads – Potential Ore and Concentrates Transport Routes

As previously noted, public roads will also be used for the transport of ore concentrate from the Project Area to the TMF. After processing, the processed concentrate will then be transported to market. Wolfden has not finalized the location of the TMF, so this exhibit presents conceptual traffic routes for three potential locations under consideration. Note that the actual transportation route may vary depending on the final location of the TMF. See **Attachment 21-A** for additional information on these routes.

21.4.2.1 Hersey TMF

From the Project Area, ore rock trucks would travel on private gravel roads to an ore processing and concentrator facility. The location of the ore processing facility in Hersey is still to be determined. Trucks carrying concentrate from the process facility will continue to travel south on Route 11 to Maine State Route 159 (SR-159) in Patten. Trucks carrying mineral concentrate will travel east on SR-159 to an access ramp to I-95 in Island Falls traveling northeast to Houlton and the Canadian-US border and proceed to the Canadian National Highway in Woodstock New Brunswick (see **Figure 21-1**).

21.4.2.2 Patten TMF

From the Project Area, ore rock trucks would travel on private gravel roads to Route 11, hence south-southwest to Patten to an ore processing and concentrator facility. The location of the ore processing facility in Patten is still to be determined. Trucks carrying concentrate will travel east on SR-159 to an access ramp to I-95 in Island Falls traveling northeast to Houlton and the Canadian-US border and proceed to the Canadian National Highway in Woodstock New Brunswick (see **Figure 21-1)**.

21.4.2.3 Stacyville TMF

From the Project Area, ore rock trucks would travel on private gravel roads to Route 11, hence south to Stacyville to an ore processing and concentrator facility. The location of the ore processing facility in Stacyville is still to be determined. Trucks carrying concentrate will travel southeast along Route 11 to Maine State Route 158 (SR-158) or Main Street in Sherman to an access ramp to I-95 traveling northeast to Houlton and the Canadian-US border and proceed to the Canadian National Highway in Woodstock New Brunswick (see **Figure 21-2)**.

21.5 TRAFFIC VOLUMES

Anticipated traffic volumes from the Project are presented in WSP's technical memorandum provided as **Attachment 21-A.** WSP's analysis concluded that the additional traffic levels from mine operations do not represent a major impact to the existing road infrastructure.

21.5.1 Routine Traffic

Onsite traffic will be from employees and contractors commuting to and from the site, visitors, and delivery vehicles. **Attachment 21-A** provides further details on the estimates of approximate visitors to the Project on a daily basis.

21.5.2 Ore and Concentrate Transport Traffic

Ore trucks will be 32,000-pound (empty truck weight) semi-tractor trailer dump trucks, with a loaded weight of 80,000 pounds (48,000-pound payload). The mine will generate approximately 55 round trips per day between the mine and the concentrator/TMF. Shipping of ore via trucks will only occur during daytime hours with a preference to utilize private roads. Concentrate transport trucks going to market will have similar empty and loaded weights to the ore haul trucks. The TMF will generate approximately 11 round trips per day by trucks travelling to and from market on public roads.

21.6 SUFFICIENCY OF EXISTING ROADS

21.6.1 Private Roads

Existing private gravel roads are currently in good condition and have been well maintained for logging operations conducted on and around the Project Area. Appendix B of **Attachment 21-A** details the results of the field assessment completed by Wood engineers to assess the adequacy of the existing private roads for mine-related vehicles. Engineers determined that with a few routine improvements the roads will function adequately for the Project.

21.6.2 Public Roads

Route 11 and SR-158 are the two primary public roads that ore trucks may travel on between the mine and concentrator/TMF, and for concentrate transport. Route 11 is characterized by rolling hills ranging in elevation from approximately 485 to 955 feet MSL. Posted speed limits on Route 11 ranges from 50 MPH to 35 MPH. SR-158 has gradual slope from approximately 542 to 490 from west to east with a posted speed limit of 35 MPH. Each road typically has an approximate 11 feet wide travel lane with 3-foot shoulder in both directions. Some portions of both Route 11 and SR-158 have three lanes. Roads are in good to fair condition and include several bridge crossings; and intersections along state routes have good turning radiuses.

Average Annual Daily Traffic (AADT) presented on the MDOT website ranged from 620-2848 along Route 11 and 3090 AADT for SR-158 in 2021. Eight crashes were reported from 2018-2021 along Route 11 and the short section of SR-158 to access ramps at I-95, according to MDOT Crash Portal. The Level of Service is A (light & free flowing) on all state roads within the route. State roads allow for up to 88,000 lbs for 5 axel configurations of unconsolidated rock material. The increase in ore truck, commuter vehicles, delivery vehicle and concentrate truck trips per day as noted in **Attachment 21-A** is minor compared to current volumes and well within existing capacity of public roads to be utilized for the mine operations.

21.7 IMPROVEMENTS TO PRIVATE AND PUBLIC ROADS

21.7.1 Private Roads

To support safe travel of additional traffic, road widths will be expanded to meet MDOT Standards along with some additional clearing of up to 10’ on each side of the roadway in areas where visibility is constricted.

In addition, a total of 18 feet (inclusive of the 10' visibility clearing) of clearing will be completed along the access road to accommodate a new overhead power line leading to the mine.

Improvements on existing gravel roads will be conducted to improve year-round use, safe passage of vehicles on a single lane road and public safety as follows.

- Maintenance of spring thaw impacts along the gravel roads will be undertaken by Wolfden. Wolfden will evaluate the scope of maintenance and improvements during the design analysis for the mine under the mining application (mine design and permitting phase).
- During the mine design analysis widening of the gravel roads will be evaluated for safe passage of logging trucks, ore rock trucks, and workers. A maximum width between 22 and 25 feet to the road shoulder should be sufficient for safe passage of large vehicles and recreational traffic (ATVs and snowmobiles in winter).
- During that analysis, consideration will also be given to providing a separate lane for safe passage of recreational vehicular traffic (ATVs and snowmobiles).
- Maintenance of bridge decking at Pickett Pond outlet crossing may include improvement or replacement of the wood decking as dictated by normal wear and tear of truck traffic. The bridge currently handles traffic from logging trucks and consists of a single 16-foot lane. Traffic over the bridge will be managed with traffic controls consisting of traffic lights as well as signage ("Single Lane Bridge Ahead" and "Traffic Signal Ahead") on both approaches to the bridge to allow only single-direction traffic over the bridge at a time. The exit from the bridge on each end of the bridge will transition to a full two-lane width to allow traffic from the bridge to pass safely by vehicles stopped in the opposite lane.
- A cooperative road maintenance agreement will be established between Wolfden and commercial loggers who access their own private property as well the Wolfden property.
- Appropriate signage and if required for traffic management, traffic lighting systems will be utilized throughout the length of the traffic gravel roads.

21.7.2 Public Roads

Potential Improvements to state highways may be implemented to improve traffic safety. Wolfden will hire a MDOT approved transportation engineer familiar with the area to consider, evaluate and design improvements, as identified by MDOT, during the mine design and permitting phase. These improvements may include:

- Signage will be added to the approaches to the intersection of Hale Pond Road and Route 11 indicating truck entering and leaving Hale Pond Road (i.e., "Trucks Turning and Entering").
- Overhead lighting will be added at the intersection of Hale Pond Road and Route 11 to provide illumination at the intersection.
- Paving of the entrance to Hale Pond Road for the full width of the entrance and minimum of 50 feet from the intersection.
- Addition of 12-foot deceleration and acceleration lanes at the intersection of Hale Pond Road and Route 11 for trucks to avoid obstruction of traffic during acceleration and deceleration periods. The deceleration and acceleration lanes will be designed in accordance with MDOT standards based on the road grades and speed limits.

typically occurs along the edge of calcareous (limestone) wetlands. It can also be found in old fields, but these stands are typically short-lived because of forest succession. All of the currently known occurrences for Clayton's copper are in enriched fens and bogs, and streamside shrublands or meadows. Please contact MDIFW's Reptile, Amphibian, and Invertebrate Biologist, Beth Swartz (beth.swartz@maine.gov, 207- 941-4476), for further guidance. If MDIFW-approved surveys are conducted and indicate that shrubby cinquefoil is not present, or if it can be demonstrated that the Wolfden proposal will not adversely affect shrubby cinquefoil and will avoid Take or Harassment of the Maine Threatened Clayton's copper butterfly, MDIFW anticipates having no concerns for this species.

Bat Habitat Creation, Post-Closure

During the September 3, 2020 site visit, we briefly explored the potential to create habitat for at-risk bat species as part of the post-operational site remediation plan. As I understand it, the main underground portal will consist of an approximately 16-foot x 16-foot opening surrounded by a larger rock face. There will also be both east and west ventilation raises with approximately 10-foot x 10-foot openings. Wolfden intends to fill and add concrete around the openings to prevent water intrusion after closure. We briefly discussed the potential to slope and berm around the openings to discourage water entry and to leave gated openings as possible caves for bat hibernacula. We also discussed the possibility of installing some piles of rock rubble on the closed tailings storage area as potential hibernacula. These discussions were conceptual but, Wolfden expressed interest in further exploring the concept to determine the potential for creating viable habitat conditions while also meeting site closure needs.

Aquatic Resources

The proposed project site is located in the Rockabema Lake subwatershed (HUC 12), in proximity and west of Pickett Mountain Pond, which flows to Grass Pond, then to Mud Lake, and other waters downstream. It is also east and south of the West Branch of the Mattawamkeag River, which flows to Pleasant Lake, Mud Lake, Duck Pond, Rockabema Lake, and other downstream resources along the West Branch of the Mattawamkeag River. The watershed contains other resources including intermittent and perennial streams, associated riparian habitats, and freshwater wetlands, and is considered important for brook trout.

Pickett Mountain Pond has a maximum depth of seven feet, with warm, well oxygenated water. The initial fisheries survey (1958) indicated that the inlet tributary had no potential for brook trout spawning, rearing, or adults, and the outlet had little potential. One trout was captured during the initial survey, none in subsequent samples (1996, 2004). MDIFW Regional Fisheries Biologist Kevin Dunham indicates that Pickett Mountain Pond contains white sucker, fine-scale dace, red-belly dace, fallfish, creek chub, golden shiner, common shiner, red-breasted sunfish, black-nose dace, and pearl dace, and would make a great place to harvest bait fish.

Pleasant Lake, Mud Lake, and Grass Pond are all designated as Heritage Fish Waters. Maine Heritage Fish Waters are native and wild brook trout lakes and ponds which represent unique, valuable, and irreplaceable ecological and angling resources. MDIFW recognizes the unrivaled historic and economic importance of Maine's wild and native brook trout resource and focuses on the conservation and protection of this uniquely valuable resource. MDIFW's primary intent for managing wild brook trout in lakes and ponds is the protection and conservation of these self-sustaining fisheries. The inlets of these lakes originate in the West Branch of the Mattawamkeag River as well as Picket Mountain Pond, positioned west and east of the proposed project site, respectively.

STATE OF MAINE

LAND USE PLANNING COMMISSION

IN RE: PICKETT MOUNTAIN MINE REZONING APPLICATION Applicant: Wolfden Mt. Chase LLC Location: T6R6 WELS Commission Application Number: ZP 779A	))))))	**PRE-FILED DIRECT TESTIMONY OF DAN KUSNIERZ**

This pre-filed direct testimony of Dan Kusnierz is submitted on behalf of Intervenors Penobscot Nation, Houlton Band of Maliseet Indians, Natural Resources Council of Maine, and Conservation Law Foundation, in opposition to the rezoning application ("Application") filed with the Land Use Planning Commission ("LUPC") by Wolfden Mt. Chase LLC, a wholly owned subsidiary of Wolfden Resources LLC (collectively "Wolfden").

I. QUALIFICATIONS

I currently serve as the Water Resources Program Manager for the Penobscot Nation's Department of Natural Resources, a position I have held for over 30 years. As Water Resources Program Manager, I manage and develop the Penobscot Nation's water resources program and water chemistry laboratory. As a result, I have decades of experience in the water quality, management, and water resources of the Penobscot River watershed. We collect and analyze water quality samples and data from over 110 sites in the Penobscot River watershed and Penobscot Nation Territory, develop and implement the Penobscot Nation's Tribal Water Quality Standards for tribal waters, and monitor compliance of wastewater discharges affecting the Penobscot River watershed. I investigate toxic contaminants in tribal wetlands and waterbodies and have written reports for multiple federal agencies about issues affecting water quality. I've worked on the Penobscot River Restoration Project and have developed and carried out studies of contaminant levels in fish, wildlife, and plant tissues and sediments.

I have also worked collaboratively with multiple federal and state agencies on tribal water quality issues and have provided oral and written testimony to state agencies, including the Board of Environmental Protection and the Land Use Planning Commission. I also serve on the boards of directors for Maine Lakes and Maine Rivers and am the Region 1 representative to the National Tribal Water Council. I have a Bachelor of Science in Wildlife Biology from the University of Vermont and completed coursework towards a Master of Science in Wildlife Ecology from the University of Maine.

II. PENOBSCOT NATION BACKGROUND

The *penawahpkekeyak* (Penobscot), the people of the place of the white rocks, is a member of the *Wabanaki* (Dawnland People or People of the First Light) Confederacy. The term Dawnland People refers to the people who live where the sunrise first touches each day. Wabanaki presence in the area is from time immemorial and as such they developed a close relationship with the natural world.

The Confederacy consists of the Algonquian-speaking Tribes Penobscot, Passamaquoddy, Maliseet, and Micmac. The Penobscot Nation has over 2,000 members, with over 400 members living at Indian Island. The Penobscot Nation has more than 4,900 acres of Reservation land, which includes over 200 islands in the Penobscot River. In addition to its Reservation land, the Penobscot Nation protects and manages in excess of 90,000 acres of trust land in nine locations in Maine. The map at Attachment 1 shows the location of Penobscot Nation land, Houlton Band of Maliseet Indians land, the West Branch Mattawamkeag, Katahdin Woods and Waters National

Monument, and Baxter State Park, along with the designated critical habitat of the Atlantic salmon.

The Penobscot traditionally followed a hereditary Chief system. Today, the Nation operates as a democracy, with leaders elected by the Tribal membership. The Nation has a Chief, currently Kirk Francis, a Vice-Chief, and a twelve-person Council. The Penobscot Nation also has a Tribal Ambassador, who is appointed by the Chief and Council, that serves as a liaison with the federal government and Maine. The Penobscot Nation is known as one of the oldest continuously operating governments in the world.[1]

III. THE PENOBSCOT RIVER IS CULTURALLY IMPORTANT TO THE PENOBSCOT NATION

The Penobscot River watershed is the largest watershed in Maine and New England's second largest river system, with a drainage area of 8,570 square miles. There are 1,224 lakes and 188 named rivers and streams totaling 7,127 river miles. The Penobscot River has five major subwatersheds: West Branch, East Branch, Mattawamkeag, Piscataquis, and Lower Penobscot. The subwatershed of the West Branch, or *kettetegwewick*, in Penobscot, meaning main branch, occupies twenty-five (25) percent of the land in the entire watershed. It is also the canoe route to Katahdin, the Tribe's most sacred place. The East Branch, or *wassategwewick*, meaning important for fishing in Penobscot, is vital to the restoration of self-sustaining populations of Atlantic salmon. The East Branch subwatershed is remote and occupies thirteen percent of the watershed. The Mattawamkeag, or *matáwamkik*, is a tributary that is named for the gravel bar that marks its confluence with the main stem of the Penobscot. The Mattawamkeag subwatershed occupies seventeen percent of the watershed. The Piscataquis, or little branch stream, was

[1] *Penobscot Nation, penawahpkekeyak*, Wabanaki All., https://wabanakialliance.com/penobscot-nation/ (last accessed Sept. 24, 2023).

historically an important Penobscot travel route and contains Atlantic salmon spawning habitat. The Piscataquis subwatershed occupies seventeen percent of the watershed. Finally, the Lower Penobscot bears the rock drops—waters of descending ledges—that are the basis of the name for both the Penobscot River and the Tribe. The Lower Penobscot subwatershed occupies twenty-eight percent of the watershed.[2]

The Penobscot River and its watershed have sustained the Penobscot Nation's people for thousands of years. The Penobscot are a riverine people, with their culture rooted in their relationship with the river, which is the source of life that provides for the citizens' needs. The river is a source of wild food, including fish, wildlife, medicine, and connection. The Penobscot River is home to numerous fish species, including native brook trout, landlocked salmon, smallmouth bass (non-native), white perch and chain pickerel. Sea-run species include Atlantic salmon, alewives, blueback herring, American shad, American eel, sea lamprey, striped bass, tomcod, rainbow smelt, shortnose sturgeon, and Atlantic sturgeon.[3]

The Penobscot have lived in the watershed of the Penobscot River, including its many tributaries, lakes, and ponds, since time immemorial. Penobscot Nation's primary village and seat of government on Indian Island is located above Old Town Falls, a traditional fishing place for spearing and netting salmon, shad, and alewives. The Penobscot consider the Penobscot River a living relative with rights. The Penobscot River is a tribal citizen based on a Tribal Resolution enacted on June 1, 2019.

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[2] Penobscot Nation Dep't of Nat. Res., *The Penobscot Nation and the Penobscot River Basin: A Watershed Analysis & Management (WAM) Pilot Project at II-4* (Jan. 2001), available at https://www.penobscotnation.org/wp-content/uploads/2022/04/The-Penobscot-Nation-and-the-Penobscot-River-Basin_WAM.pdf.

[3] Barbara Harper & Darren Ranco, U.S. Env't Protection Agency, *Wabanaki Traditional Cultural Lifeways Exposure Scenario* 39 (July 9, 2009), available at https://www.penobscotnation.org/wp-content/uploads/2022/04/DITCA.pdf.

Historically, the Penobscot River and its tributaries, including the West Branch Mattawamkeag River, once saw 75,000 -100,000 Atlantic salmon per year return to spawn.[4] In spring, salmon, as well as other fish would find their way into Penobscot weirs, nets, and traps. Salmon and other fish would sustain Penobscot families throughout the year. Salmon was also used culturally. Fish, including salmon, continue to be an important cultural sustenance food source.

The Penobscot Nation's traditional cultural lifeways did not fade away as new settlements intruded and are still being practiced today. Atlantic salmon and brook trout are more than just a sustenance food for Penobscot—salmon in particular, are a critical aspect of the culture. Salmon are embedded in Penobscot culture and traditional beliefs. The Penobscot are connected to salmon and all creatures for survival.

The Penobscot River hosts the largest run of Atlantic salmon left in the United States.[5] However, salmon numbers are greatly reduced over what they were in historic times. The recovery of Atlantic salmon on the Penobscot River likely depends on a return of healthy populations of alewives, blueback herring, American shad and other diadromous species.[6] The Penobscot River is still the largest Atlantic salmon run remaining in the U.S., with 1,000-1,500 adult salmon annually, compared to 75,000-100,000 adult salmon historically.[7]

IV. THE PENOBSCOT NATION HAS MADE SIGNIFICANT EFFORTS TO IMPROVE WATER QUALITY IN THE PENOBSCOT WATERSHED

In recent history, the Penobscot watershed was not of high-water quality. We had issues with high bacteria levels, low dissolved oxygen (which is the amount of oxygen available to

[4] *Penobscot River Salmon Run Highest Since 2011*, NOAA Fisheries (Aug. 06, 2019) https://www.fisheries.noaa.gov/feature-story/penobscot-river-salmon-run-highest-2011.
[5] *Id.*
[6] Harper & Ranco, *supra* note 3, at 41.
[7] NOAA Fisheries, *supra* note 4.

living aquatic organisms), algae blooms, dioxins, mercury, and industrial products and chemicals such as PCBs. Even those who didn't measure water quality knew something was wrong with the watershed—our waterways had an unpleasant odor and color and were foaming. Since then, the Penobscot Nation implemented water management programs and I've overseen a vast improvement in water quality in the past thirty years. The river has healed—the main stem of the Penobscot River improved from a Class C water to a Class B water and its tributaries improved from Class B to Class A or even AA.[8] Class AA, the highest classification waters can have, means the water is an outstanding natural resource which should be preserved because of its ecological, social, scenic, or recreation importance, and Class A waters, the second highest classification, are waters that are also very high quality, but they allow for dams and the discharge of effluent that is as clean as the natural water in the stream.[9] We've also made great progress towards restoring our anadromous fisheries.

In 2014, the Penobscot Nation published our own water quality standards so that we could protect, maintain, and improve the quality of the Penobscot River and its tributaries for drinking, to promote native and other desirable aquatic plant and animal life, and to protect existing and future uses.[10] The standards state that we will maintain and protect tribal waters to support existing uses and not allow the waters to degrade.[11] The water quality standards also require that all Penobscot waters stay free from pollution that adversely affects human health and adversely affects our aquatic plant and animal communities.[12] The standards were designed to continue the use of the waters of the Penobscot River and its tributaries for sustenance fishing

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[8] *See* Attachment 2.
[9] 38 M.R.S.A. § 465(1).
[10] Penobscot Nation, Water Quality Standards §101 (Sept. 5, 2014), available at https://www.penobscotnation.org/images/natural-resources/Documents/2014-09-05FinalPenobscotWQS-redline.pdf.
[11] *Id.* at § 201.
[12] *Id.* at § 301.

that is necessary for sustaining tribal members.[13] None of our water quality standards were developed to allow for pollutant levels associated with acid mine drainage.

In addition to the water quality standards developed and implemented by the Penobscot Nation, Maine also has water quality standards which classify water bodies based on quality, set limits on water discharges, and have their own antidegradation policy.[14] These standards, like the Penobscot Nation's, state that existing water uses and the level of water quality necessary to protect those existing uses must be maintained and protected.[15] Water bodies classified as "outstanding natural resources," such as Class AA streams, must be maintained and protected as such.[16] For metals and toxics discharged into waters, the preservation of aquatic life and the protection of human health are the relevant criteria for allowing any such discharges.

Nearly all streams surrounding the proposed mine area are Class A, with some Class AA streams in the Seboeis and East Branch Penobscot watersheds. As stated previously, Class AA streams are outstanding natural resources. Class A streams require dissolved oxygen levels to be protective of all life stages of salmonid species, including spawning and egg incubation. Spawning salmonids are very sensitive, requiring very high levels of dissolved oxygen and a very specific environment. Because young salmonids are particularly sensitive to acidity and elevated dissolved metals in the water, acid mine drainage can easily upset this fragile environment during spawning season, which could lead to the eventual demise of the entire fishery.

Sustenance fishing is very important to tribal citizens and to the Nation as a whole. Matagamon Lake, and the East Branch and mainstem Penobscot River all have the designated

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[13] *Id.* at § 401(I).
[14] 38 M.R.S.A. § 464.
[15] *Id.* at 4(F)(1).
[16] *Id.* at 4(F)(2).

use of sustenance fishing under both Maine and Penobscot Nation water quality standards. The West Branch Mattawamkeag River (which is close to the proposed site), also has the designated use of sustenance fishing under Maine water quality standards. Because of their high fish consumption rates, tribal citizens are at higher risk of ingesting unsafe levels of metals and other toxins through the fish—much higher than for recreational anglers. Therefore, the allowable concentrations of metals and other toxics must be significantly lower in these waterbodies than would otherwise be allowed, so that tribal sustenance uses and rights can be protected.[17] Additionally, portions of the Penobscot River, Mattawamkeag River, West Branch Mattawamkeag, and East Branch Penobscot River are considered "outstanding river segments" and are afforded special protection.[18] While water quality has improved thanks to these and other protections and cleanup efforts, fish consumption advisories prevent Penobscot tribal citizens from fully exercising sustenance fishing rights due to the levels of dioxins, PCBs, mercury, and PFAS in some species from Penobscot River waters.[19] Levels of these contaminants are decreasing, but preventing additional toxic contaminants, such as those from acid mine drainage, from entering the food chain is critical for restoring and protecting sustenance fishing practices.

V. ALL STREAMS IN THE AREA WOULD REQUIRE TREATMENT OF WASTE TO BACKGROUND LEVELS

All of the streams in the area around the proposed mine site, as well as near the proposed locations of the tailings and ore processing facilities,[20] are high quality—either Class A or Class

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[17] *See* 38 M.R.S.A. §§ 466-A, 467(7).
[18] 38 M.R.S.A. § 480-P(10), (12).
[19] *See Freshwater Fish Safe Eating Guidelines*, Maine Ctr. for Disease Control & Prevention https://www.maine.gov/dhhs/mecdc/environmental-health/eohp/fish/2kfca.htm (last accessed Sept. 24, 2023).
[20] Wolfden proposes to locate these facilities in either Hersey, Patten, or Stacyville. *See* Stantec Consulting Services Inc., Land Use Planning Commission Application for Zone Change: Pickett Mountain Metallic Mine, LUPC No. ZP779A at 843 (Jan. 19, 2023) ("Application"). All Application page numbers cited refer to PDF pagination, not internal document pagination.

B streams with a drainage area of less than ten square miles.[21] Discharges to Class A waters are permitted only if "the discharged effluent will be equal to or better than the existing water quality of the receiving waters."[22] Anyone applying for a discharge permit into Class A waters must objectively demonstrate that the discharge is necessary and that there are no other reasonable alternatives available.[23] Discharges to Class B waters may not cause adverse impact to aquatic life—all species indigenous to the waters must still be able to live there healthfully.[24]

Waters having a drainage area of less than ten square miles are specially protected due to the lack of adequate dilution. Discharge licenses may not be issued for the direct discharge of pollutants to these waters except under specific circumstances, none of which apply to Wolfden.[25] This being the case, Wolfden seemingly cannot discharge to most waters in the area, and those it could discharge to, it would have to treat to background levels. Streams near Wolfden's proposed processing and tailings facilities in Patten, Hersey, or Stacyville are either too small to allow a discharge—Class B waters are found only in Stacyville, and they have drainage areas less than 1.5 square miles—or they are Class A, which would require treating wastewater to be as clean as the natural stream[26]. Discharge to groundwater in these areas would have to be as clean as the natural groundwater, again a very high burden.

VI. CULTURALLY IMPORTANT AQUATIC LIFE IS SENSITIVE TO ACID MINE DRAINAGE

The proposed Wolfden Pickett Mountain Mine has a high likelihood of creating acid mine drainage ("AMD") because its operation involves extracting and processing rocks containing sulfur-bearing minerals that will become exposed to water and air. AMD that enters the

[21] *See* Attachment 2.
[22] 38 M.R.S.A. § 465(2)(C).
[23] *Id.*
[24] *Id.* at (3)(C).
[25] *See* 38 M.R.S.A. § 464(4)(A)(1).
[26] *See* Attachment 2.

watershed may contaminate and impair surface and ground water because it has a low pH (high H+ concentration) and because of leached heavy metals that it can carry, including copper, lead, mercury, and zinc.[27] The more acidic the water, the more likely it will harm aquatic organisms.

Once AMD is created, metals are released into the surrounding environment and become readily available to organisms. When fish are exposed directly to metals and H+ ions through their gills, their respiration is impaired from acute and chronic toxicity. Fish can be exposed indirectly to metals by ingesting contaminated sediments and foods (e.g., insects). Iron hydroxides and oxyhydroxides, a common weathering product of sulfide oxidation, (red/orange precipitate found in thousands of miles of AMD affected streams) physically coats the surface of streambeds, destroying habitat and diminishing clean gravels needed for spawning and incubation.[28] This coating also reduces food items such as benthic insects. Surface water contaminated by AMD can be toxic to aquatic organisms, leaving streams devoid of most living creatures.[29] Receiving waters may have pH levels of 2.0 – 4.5, well below Maine Water Quality Standards, and which are toxic to most forms of aquatic life.[30] The toxicity and solubility of many compounds, such as metals, are affected by pH. For example, lowering pH is an important factor in releasing aluminum from bottom or suspended sediments into the water column where it accumulates on fish gills and leads to respiratory dysfunction and death. Some streams in the

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[27] Water Resources Mission Area, U.S. Geological Survey, *Mine Drainage* (Feb. 18, 2019), https://www.usgs.gov/mission-areas/water-resources/science/mine-drainage (last accessed Sept. 24, 2023).
[28] S.R. Jennings, et al., *Acid Mine Drainage and Effects on Fish Health and Ecology: A Review, U.S. Fish and Wildlife Service* 5 (June 2008), available at https://earthworks.org/assets/uploads/2018/12/55-S.R.-Jenning-et-al.-2008.-Acid-Mine-Drainage-and-Effects-on-Fish-Health-and-Ecology-A-Review.pdf.
[29] *Id.* (citing W.G. Kimmel, *The impact of acid mine drainage on the stream ecosystem*, *in* Pennsylvania Coal: Resources, Technology, and Utilization 424-437 (Shyamal Majumdar & E. Willard Miller, eds. 1983)).
[30] Ronald D. Hill, *Mining impacts on trout habitat*, *in* Proceedings of a Symposium on Trout Habitat, Research, and Management, U.S. Dep't of Agriculture 47, 48 (1974).

Boulder River watershed in Montana impacted by abandoned metal mines are devoid of all fish near mine sources.[31]

A. Fish Is An Important Sustenance Food Source For Penobscot Nation Citizens

Historically, fish and seafood comprised forty-five percent of Wabanaki citizens' diets.[32] Even as the Penobscot River has been subject to contamination, local fish and seafood continue to be a significant component of Penobscot citizens' diets for nutrition and cultural importance. Furthermore, consumption of fish from these waters for sustenance is a treaty-reserved right.[33]

1. *Atlantic salmon*

Gulf of Maine Atlantic salmon were designated as an endangered species in 2000.[34] The designated critical habitat for Atlantic Salmon includes the Penobscot River watershed, which in turn includes the West Branch Mattawamkeag River and its tributary waters.[35] Since those designations, millions of dollars and thousands of hours have been invested by the Penobscot Nation, state and federal agencies, and a number of public and private interests to restore Atlantic salmon across its critical habitat.

The West Branch Mattawamkeag's designation as critical habitat for Atlantic salmon means that it contains the physical and/or biological features that are essential to the conservation and restoration of endangered Atlantic salmon. It also accords to those waters protections from actions or developments that would adversely affect their water quality.[36] For almost four

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[31] *See* Aïda Farag, et al., *Characterizing aquatic health using salmonids mortality, physiology, and biomass estimates in streams with elevated concentrations of arsenic, cadmium, copper, lead, and zinc in the Boulder River Watershed, Montana*, 132 Transaction of the American Fisheries Society 450 (2003).
[32] Harper & Ranco, *supra* note 3, at 62.
[33] *Id.*
[34] Final Endangered Status for a Distinct Population Segment of Anadromous Atlantic Salmon (Salmo salar) in the Gulf of Maine, 65 Fed. Reg. 69459 (Nov. 17, 2000).
[35] *See* Attachment 1.
[36] *Critical Habitat: What Is It?*, U.S. Fish and Wildlife Serv. (March 2017), available at https://www.fws.gov/sites/default/files/documents/critical-habitat-fact-sheet.pdf.

decades, the Penobscot Nation Department of Natural Resources has worked with federal (National Oceanic and Atmospheric Administration and the Fish & Wildlife Service) and state (Departments of Marine Resources and Inland Fisheries & Wildlife) agencies to co-manage the population of Atlantic salmon and other diadromous fish species in the Penobscot watershed.

Of special importance for salmon are the high-quality headwater streams like those of the West Branch Mattawamkeag that are in the vicinity of Wolfden's proposed mine. These streams provide cool water refugia for Atlantic salmon and are increasingly rare.

While at present the critical habitat area in the West Branch Mattawamkeag is largely inaccessible to Atlantic salmon because of the presence of dams downstream, the Penobscot Nation takes a long-term view of the situation – preserving and improving the water quality of the waters in the Penobscot River watershed is critical to the effort to eventually restore Atlantic salmon's historic access to all of its native habitat.

Those efforts have made significant progress over the last two decades under the aegis of the Penobscot River Restoration Trust.[37] Initiated in 1999, this public-private partnership ultimately resulted in restoring access to 2,000 miles of rivers and streams to Atlantic salmon and other diadromous fish by removing two dams and installing an innovative, river-like bypass around a third. This year, by early August, the largest number of Atlantic salmon – almost 1,500 – had been counted by the Maine Department of Marine Resources in the Penobscot. Even more impressive, almost 5.5 million alewives and blueback herring were counted in the river, nearly doubling the largest previous number documented by Department of Marine Resources last year.

These results are clear evidence that if access to habitat is provided and water quality maintained, Maine's native, diadromous fish runs will be restored. The Penobscot Nation is

[37] *Penobscot River Restoration Project*, Nat. Res. Council of Maine, https://www.nrcm.org/programs/waters/penobscot-river-restoration-project/ (last accessed Sept. 24, 2023).

committed to that restoration and to ensuring that any development in the Penobscot River watershed, including the West Branch Mattawamkeag, is compatible with that goal. Given the progress made in recent years to restore salmon to waters previously made inaccessible by dams, it is both vitally important and realistic to preserve the West Branch Mattawankeag's high water quality and protect it from potentially damaging toxic pollutants so that Atlantic salmon may return there in the future.

Atlantic salmon thrive in waters that range in pH from 6.5 to 8.2.[38] Moderately acidic conditions, even if only episodic, can be fatal for young salmon, especially when pre-smolts develop into saltwater-tolerant smolts. During this transition period, young salmon undergo the changes necessary to allow them to survive in saltwater. For example, in laboratory studies, a week's exposure to pH 5 during the May smoltification period led to 70% mortality.[39] Furthermore, exposure to moderately acidic conditions for short duration causes significant reduction in saltwater tolerance, gill structural changes and aluminum accumulation.[40]

As previously described, low pH can cause metals to increase in surface waters and affect the toxicity of these metals to fish. Even if the levels of pollution from copper and zinc mines like the one proposed by Wolfden aren't high enough to kill Atlantic salmon, it has long been recognized that the mere presence of pollution from mining will cause Atlantic salmon to avoid those waters.[41]

The enormous amount of resources in terms of dollars and hours to restore Atlantic salmon populations in the Penobscot River watershed reflect the fact that this habitat represents

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[38] Magne Staurnes et al., *Water Quality Requirement of Atlantic Salmon (Salmo salar) in Water Undergoing Acidification or Liming in Norway*, 85 Water, Air & Soil Pollution 347 (1995).
[39] *Id.* at 348.
[40] *Id.* at 351
[41] Richard L. Saunders & John B. Sprague, *Effects of Copper-Zinc on Mining Pollution on a Spawning Migration of Atlantic Salmon*, 1 Water Rsch. 419 (1967).

the best chance for the recovery of the species. To allow a metallic mineral mine to be developed so close to the headwaters of the West Branch Mattawamkeag River would unnecessarily put all those efforts at risk.

2. *Brook Trout*

Maine is by far the most important state for wild brook trout in the eastern U.S. It is the only state with extensive, intact, self-reproducing brook trout populations in lakes and ponds[42] among the 17 states comprising the eastern brook trout's native range from Maine to Georgia.[43] MDIFW states that, "Maine is the last true stronghold for stream dwelling populations of wild brook trout, supporting more than twice the number of intact subwatersheds as the other 16 states in the eastern range combined."[44]

Brook trout also help to support an enormous economic engine for Maine. According to the United States Fish and Wildlife Service, sport fishing related expenditures are more than $370 million per year in Maine.[45] Based on my personal knowledge and experience, a lot of that is related to brook trout.

The cream of the crop of Maine's brook trout ponds are the State Heritage Fish Waters, which are ponds containing either brook trout or artic char "that have never been stocked according to any reliable records authorized for adoption by Resolve 2005, chapter 172, as amended, and waters identified as eastern brook trout waters and arctic char waters that according to reliable records have not been stocked for at least 25 years."[46] As part of the

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[42] Tim Obrey, Maine Dep't of Inland Fisheries and Wildlife, Brook Trout Technical Work Group Presentation, Slide 3, available at https://www.maine.gov/ifw/docs/BrookTroutTechnicalWorkGroupNov2019.pdf.
[43] *Id.*
[44] *Wild Brook Trout*, Maine Dep't of Inland Fisheries & Wildlife, https://www.maine.gov/ifw/fish-wildlife/fisheries/wild-brook-trout.html (last accessed Sept. 22, 2023).
[45] U.S. Fish & Wildlife Service, *2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation: State Overview* 18 (Sept. 2012), available at https://digitalmedia.fws.gov/digital/collection/document/id/858/.
[46] 12 M.R.S.A. § 12461.

strategy to protect these unique fisheries, MDIFW may not stock these ponds and no one fishing them may use live bait.

There are three State Heritage Fish Waters in the vicinity of the proposed Pickett Mountain mine site: Pleasant Lake, Mud Lake, and Grass Pond, all of which are located in the West Branch Mattawamkeag watershed. I have visited these ponds and they are spectacular—and the state of Maine agrees.

MDIFW regional fisheries staff consider Pleasant Lake and Mud Lake to be some of the best brook trout and landlocked salmon waters available in the region. Pleasant Lake's cool-water spring holes support "an excellent" trout and landlocked salmon fishery.[47] The lake also has ideal dissolved oxygen levels and recent surveys captured multiple age classes of brook trout, indicating that Pleasant and Mud Lakes have year to year holdover.[48] MDIFW further states that the lakes: "*support healthy populations of salmonids* (and other fish including smelt) *and it is vitally important to protect the tributaries as well as the lakes since they contain an abundance of spawning and rearing habitat* [italics in original]."[49]

According to Trout Unlimited, the small streams that flow from the proposed mining area to the West Branch Mattawamkeag River and the West Branch Mattawamkeag River itself are also very high-quality habitat for brook trout.[50]

In spite of all the evidence on the outstanding nature of the coldwater fisheries in the vicinity of its proposed mine, Wolfden falsely states, citing outdated MDIFW studies from the 1950s, that Mud Lake and Pleasant Lake are not good coldwater fisheries in its second rezoning

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[47] Application at 1159.
[48] *Id.*
[49] *Id.* (citing Letter from Robert D. Stratton, Maine Dep't of Inland Fisheries & Wildlife, to Stacie R Beyer, LUPC, No. ZP779 at 3 (Sept. 11, 2020)).
[50] Letter from Jeff Reardon, Trout Unlimited, to Stacie R. Beyer, LUPC, No. ZP779 at 2–3 (Sept. 10, 2020).

application, just as it did in its first. Wolfden further states that more recent MDIFW data "suggested Pleasant Lake could support a landlocked salmon and brook trout fishery."[51] Wolfden doesn't even acknowledge this as a possibility for Mud Lake.

But to say that Pleasant Lake could potentially support a fishery mischaracterizes the facts. Pleasant Lake, Mud Lake, and Grass Pond ***are*** outstanding fisheries and that is why they are State Heritage Fish Waters. MDIFW submissions to the record for both the previous application in 2020 and the current application make this clear. By characterizing these fisheries as potential rather than actual, Wolfden sidesteps the issue of whether its mine will harm them. However, given that these lakes and ponds *do* currently support landlocked salmon and brook trout, the appropriate question is whether or not AMD from Wolfden's proposed mine would or could harm these fisheries.

As is the case with Atlantic salmon, AMD is a major threat to brook trout, especially in streams with low buffering capacity,[52] like those in the vicinity of the proposed Pickett Mountain Mine. It is not an accident that Maine has the vast majority of remaining Eastern brook trout and their habitat. Although not the only factor in brook trout decline, AMD from both coal and metal mines has rendered enormous numbers of streams in the mid-Atlantic and Appalachian historic ranges of brook trout unlivable for them. For example, the Eastern Brook Trout Joint Venture estimates that AMD is impacting about 2,500 miles of rivers and streams in Pennsylvania.[53]A Pennsylvania state report describes the effect of acid and heavy metal pollution associated with AMD on brook trout as follows:

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[51] Application at 297.

[52] Buffering capacity refers to a stream's ability to resist changes in pH even if acids are added. The presence of limestone in a steam, for example, would increase its buffering capacity for acids. The streams around Pickett Mountain have very low levels of solutes that would increase buffering capacity.

[53] Conservation Strategy/Habitat Working Group & Eastern Brook Trout Joint Venture, *Conserving the Eastern Brook Trout: Action Strategies* 39 (Jan. 2011), available at http://www.fishhabitat.org/files/uploads/EBTJV_Conservation_Strategy-Nov2011.pdf.

> Adult brook trout can tolerate a pH range of 5.0 to 9.5 and remain relatively healthy. However, even at the high and low ends of this pH tolerance level, fish become stressed..,
>
> Another problem is gill damage and a decrease in sodium in the fish's blood. Fish eggs and fry (young fish) are also affected. The young born for an entire year can die. This leaves only older, more resistant fish left in a community. Eventually, without the fry, the community will be void of fish. Often, however, the pH of AMD is so low that the entire community is wiped out.
>
> Metal toxicity caused by AMD is another common stream killer. Aluminum, iron and manganese enter our waters from abandoned mines. These metals are toxic to the brook trout and other aquatic life. Small amounts of these metals can stress fish or even cause death, especially in young, developing fish.[54]

Thus, mining and resulting AMD present a clear risk to the outstanding brook trout resources in the Pickett Mountain area.

Brook trout are also an important resource for the Penobscot Nation and other Maine Tribes. Many tribal guides make their living by taking people to catch brook trout, which are also a good source of food. Because many of the common species of fish in the mainstem Penobscot River are contaminated by dioxin, PCBs, and mercury from past industrial uses, cleaner fish, such as brook trout, from remote ponds and streams are safer consumption choices for Penobscot tribal citizens. Brook trout have among the lowest levels of contaminants of any fish species in Maine and therefore, the Maine Center for Disease Control issues less stringent advice about consuming them. They are one of the only game species that vulnerable individuals, such as pregnant women and small children, should eat at all. Consumption advice for brook trout is similarly less stringent for less vulnerable individuals compared to other game species.[55] Thus,

[54] *The Basics of Water Pollution in Pennsylvania*, Pennsylvania Angler & Boater, Jan./Feb. 2001, at 35, 37, 40, available at https://www.fishandboat.com/About-Us/Angler-and-Boater/AnglerBoater2001/JanuaryFebruary/Documents/waterpoll.pdf.
[55] Maine Ctr. for Disease Control and Prevention, *supra* note 19.

brook trout are a good species for tribal citizens who practice sustenance fishing to consume compared to other species of fish.

VII. CONCLUSION

Wolfden's proposal for redistricting to allow a mine in the Pickett Mountain area will have undue, adverse impacts on water quality of important tribal waters and fisheries. Penobscot and other Wabanaki Tribes have already experienced severe adverse cultural impacts as a result of the contamination of fisheries. AMD could kill off those fisheries entirely and completely ruin these the watershed and culturally significant species that are so important to the Penobscot Nation and the state of Maine.

Dated: September 25, 2023

Dan Kusnierz

VERIFICATION

I, Dan Kusnierz, being first duly sworn, affirm that the above testimony is true and accurate to the best of my knowledge.

Date: 9/25/2023 Name: [signature]

Personally appeared the above-named Dan Kusnierz and made oath that the foregoing testimony was true and correct to the best of their knowledge and belief.

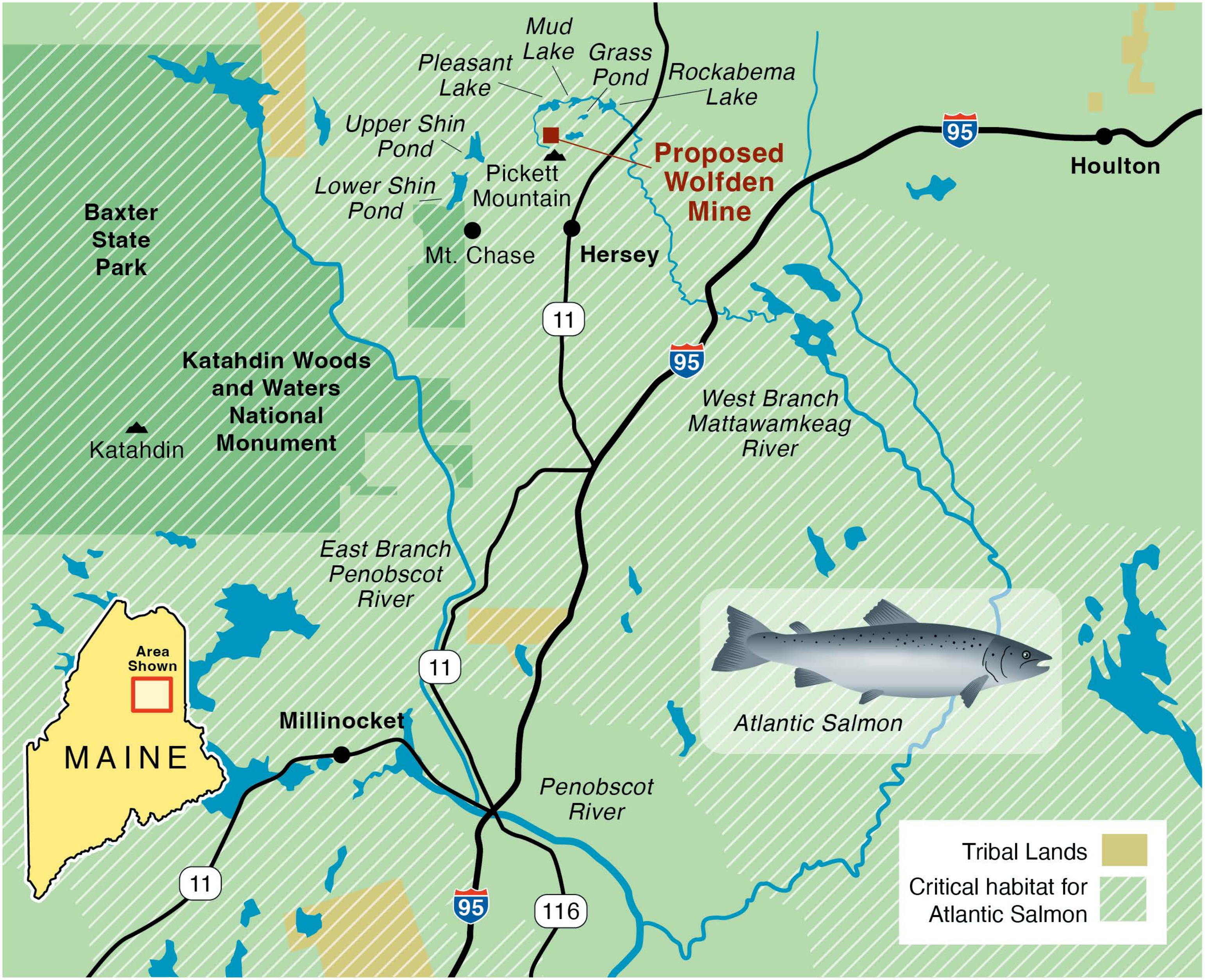
Dated: 9/25/2023

[signature]
Notary Public

Faye A. Lawson
Notary Public, State of Maine
My Commission Expires February 5th, 2028

INDEX OF ATTACHMENTS FOR DAN KUSNIERZ PRE-FILED TESTIMONY

ATTACHMENT 1



Mud Lake
Pleasant Lake
Grass Pond
Rockabema Lake
Upper Shin Pond
Lower Shin Pond
Pickett Mountain
Proposed Wolfden Mine
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Houlton
Baxter State Park
Mt. Chase
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Area Shown
MAINE
11
Atlantic Salmon
Millinocket
Penobscot River
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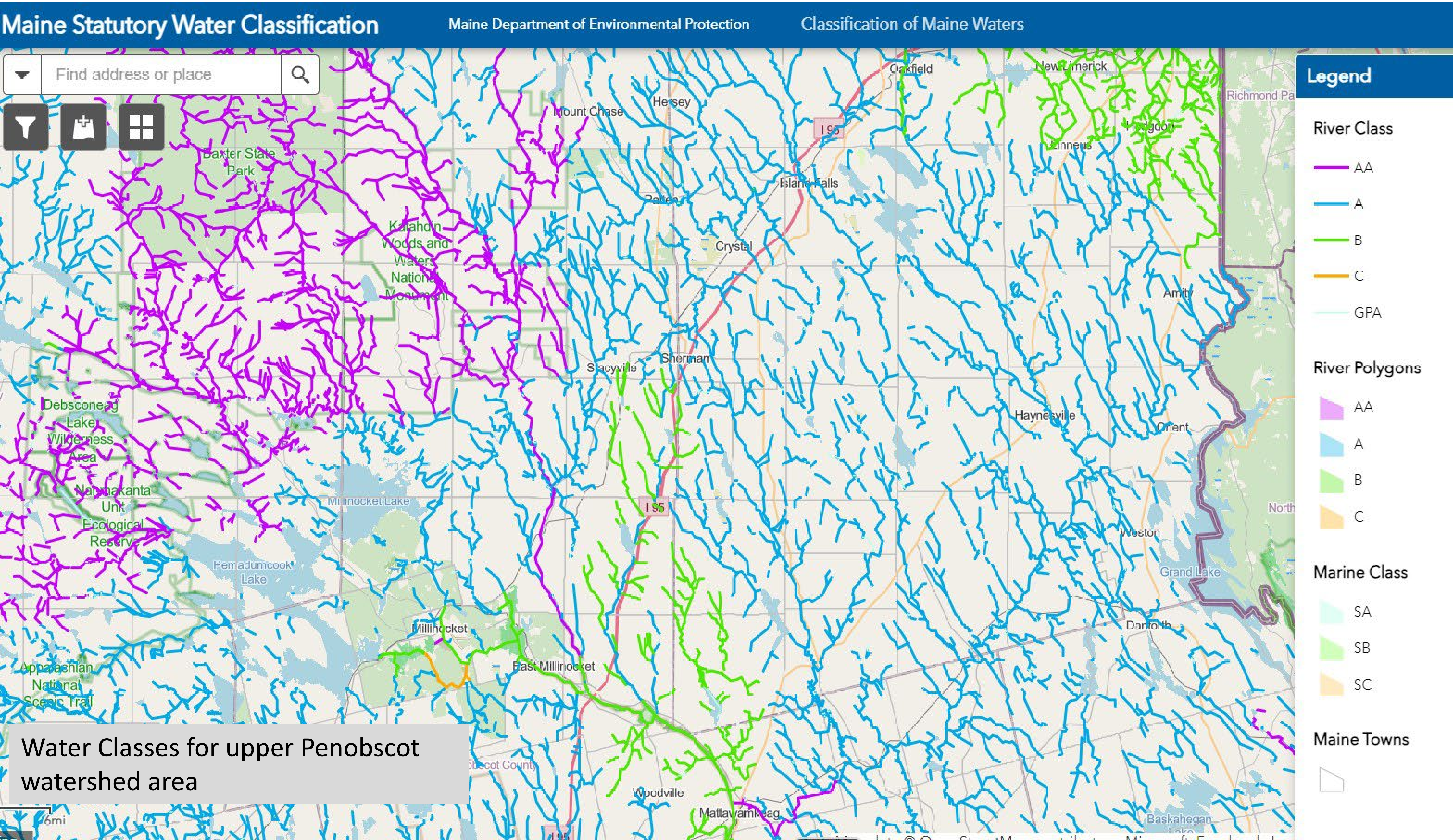
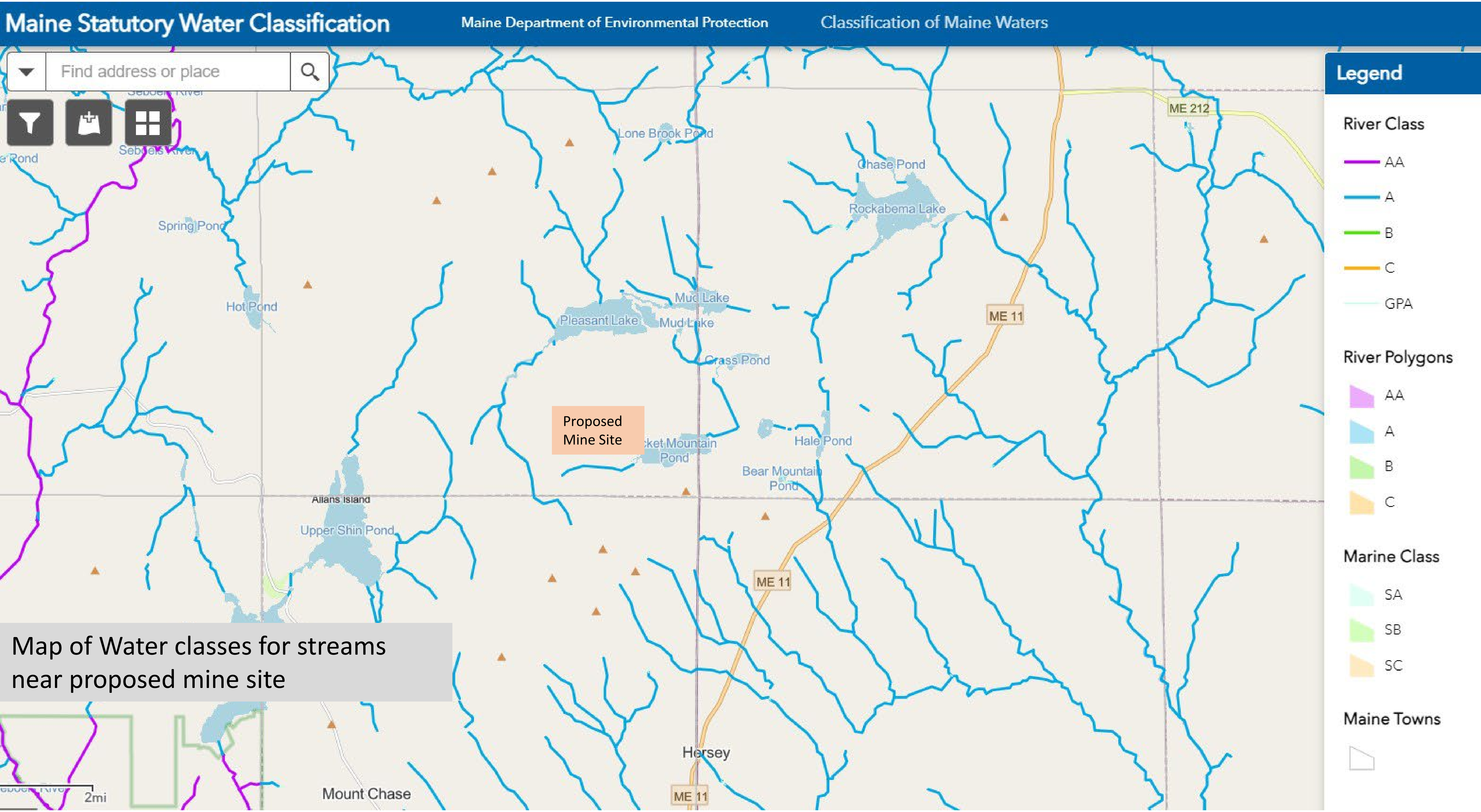
Tribal Lands
Critical habitat for Atlantic Salmon

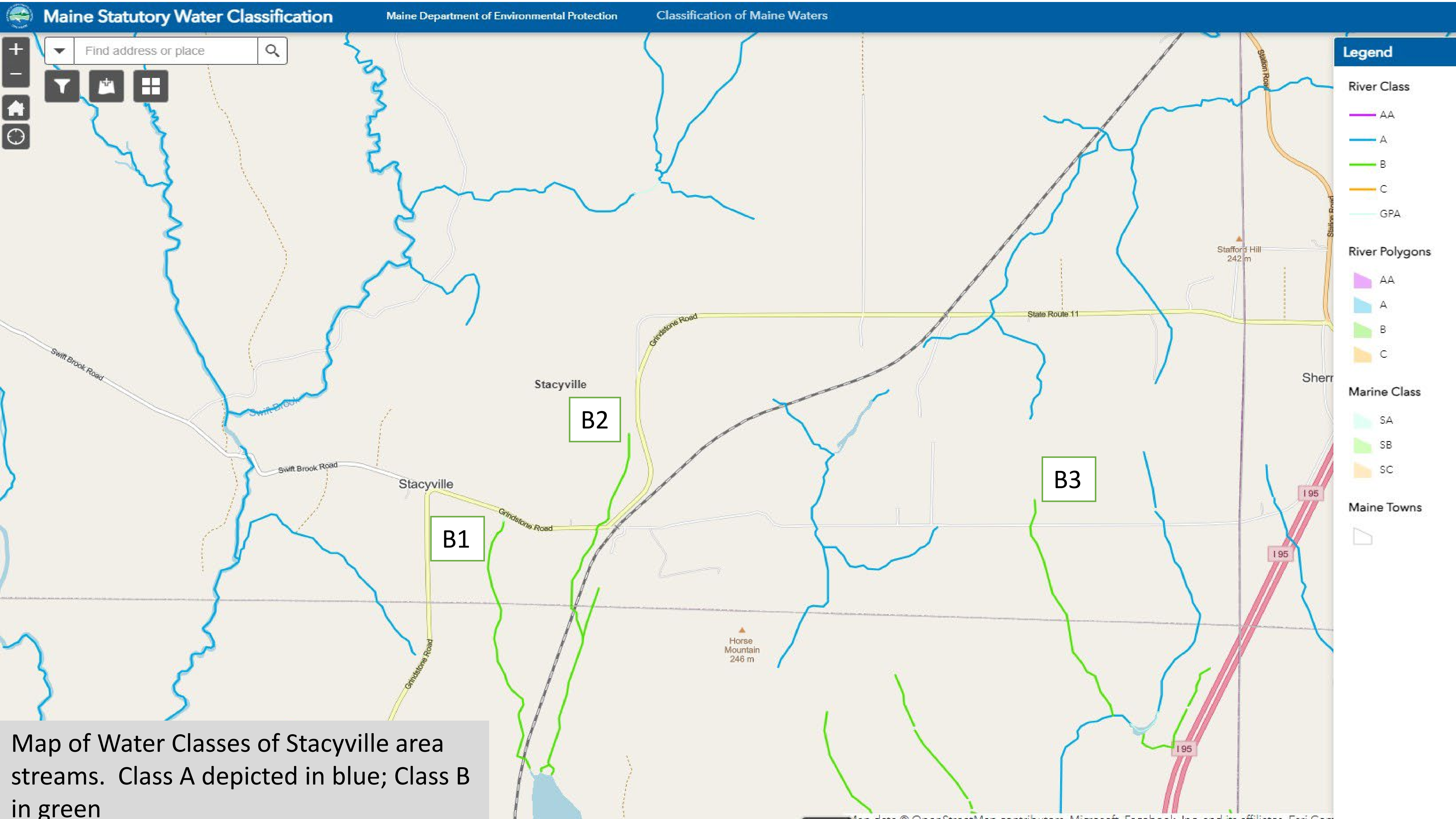
ATTACHMENT 2



Water Classes for upper Penobscot watershed area



Map of Water classes for streams near proposed mine site



Map of Water Classes of Stacyville area streams. Class A depicted in blue; Class B in green

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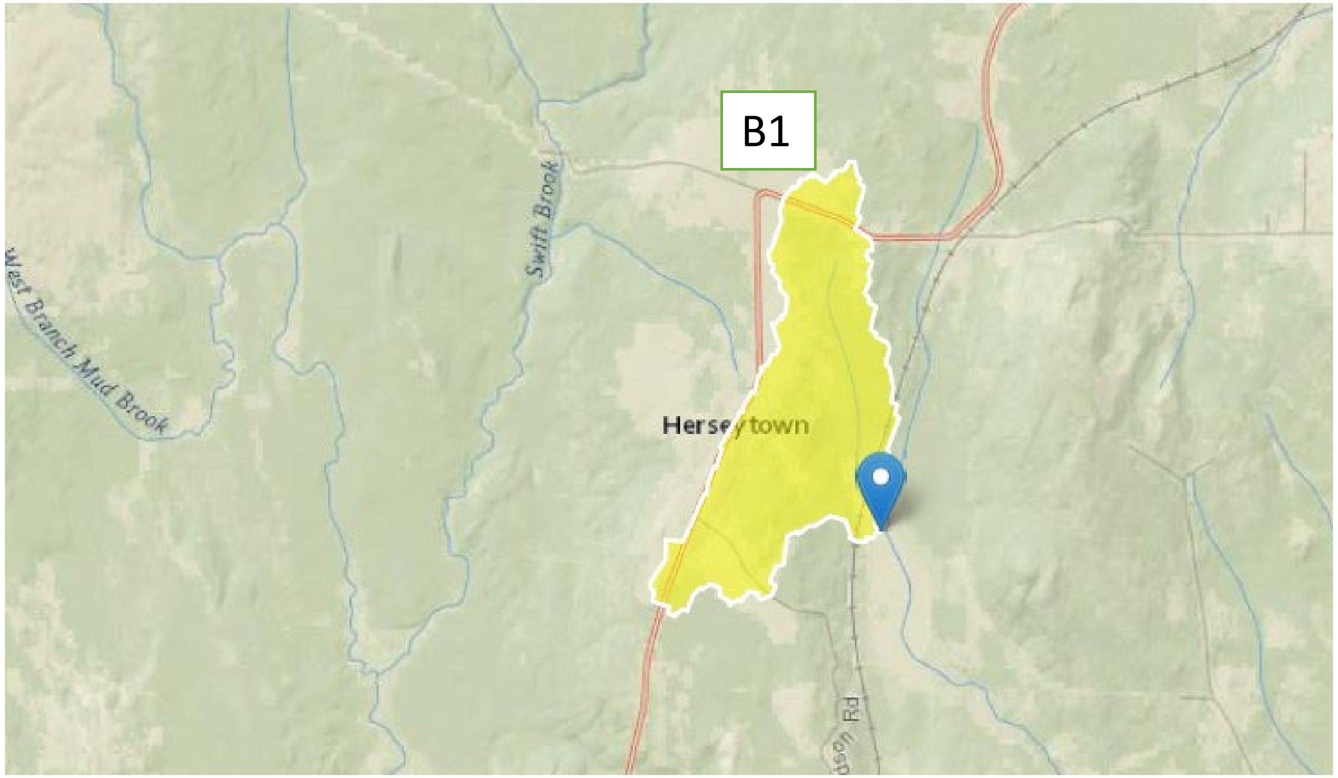

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Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	0.95	square miles

Drainage area of Class B Stream B1

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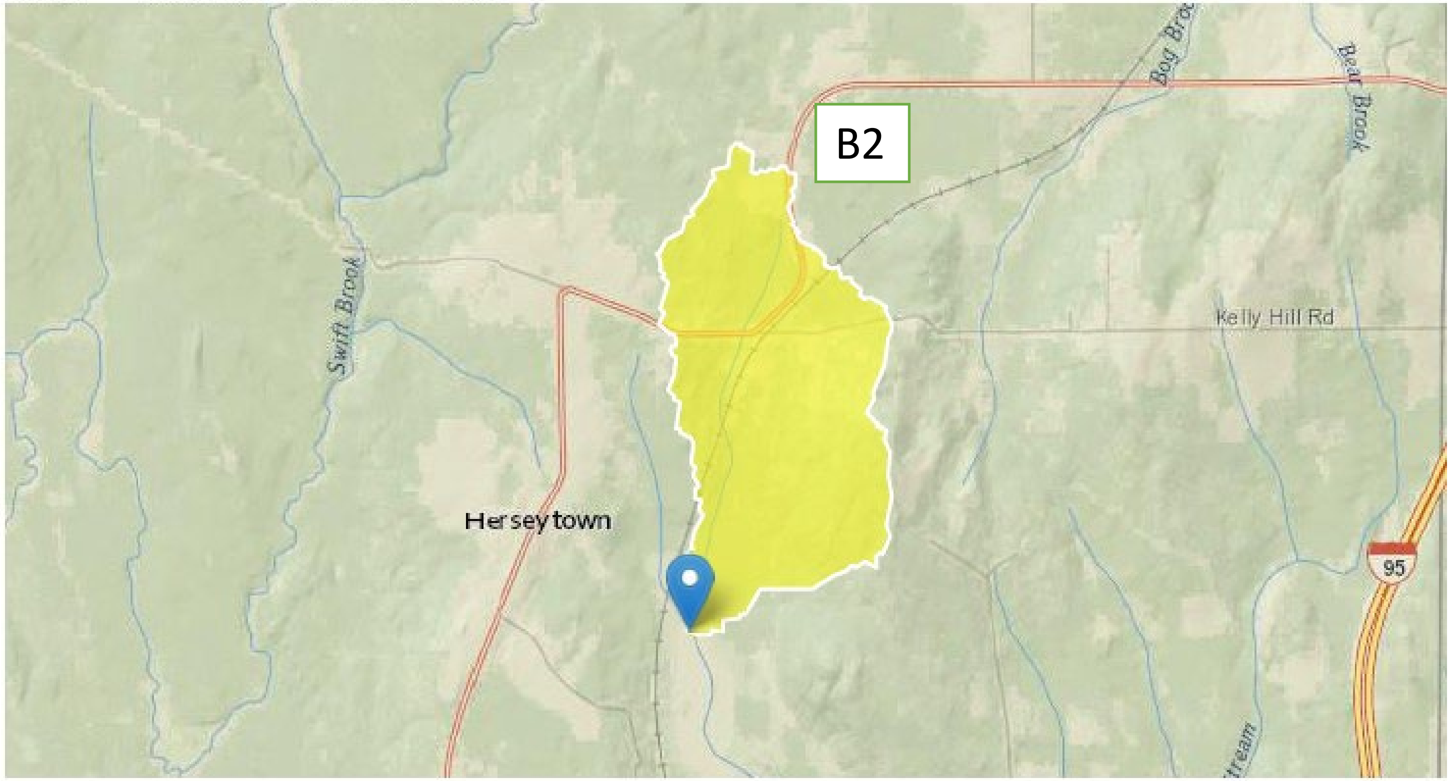

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Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	1.42	square miles

Drainage area of Class B Stream B2

StreamStats Report

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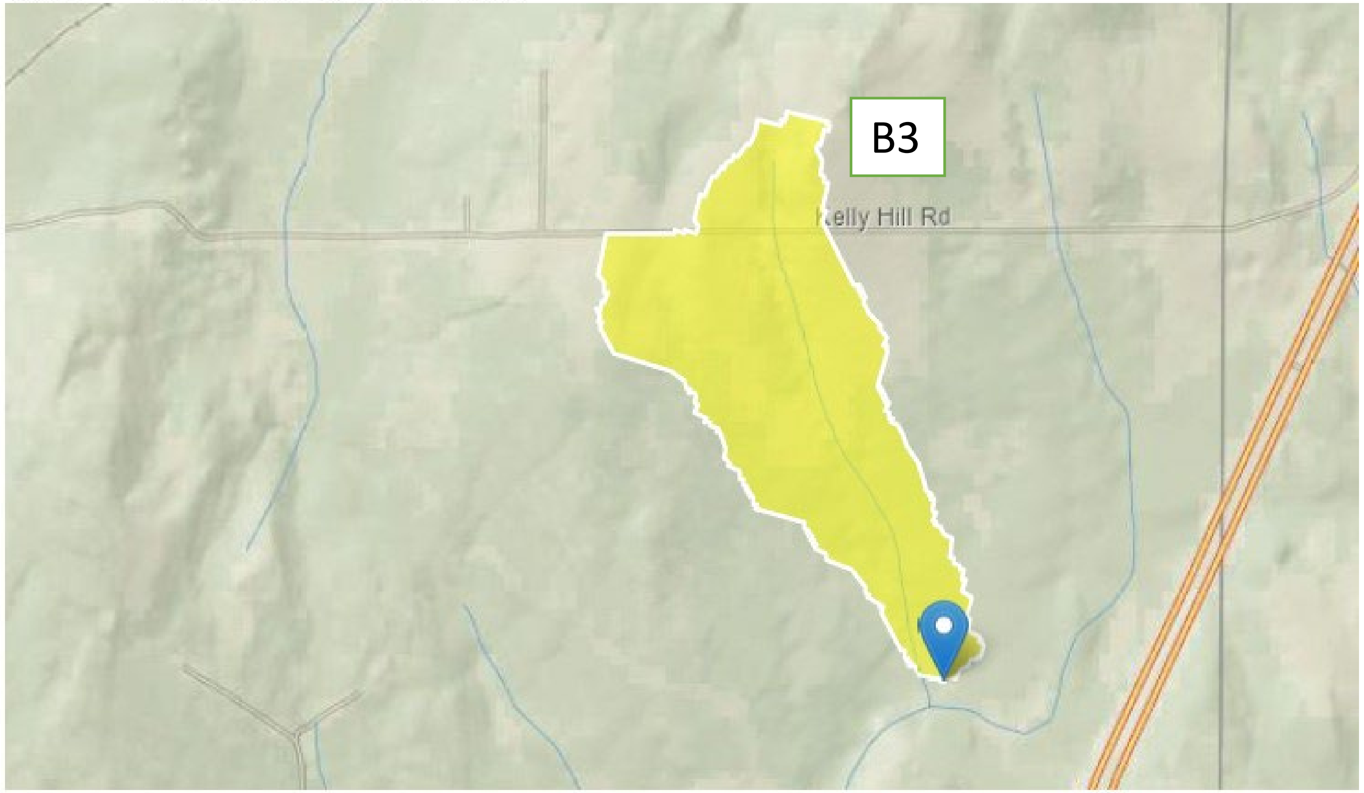

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Basin Characteristics

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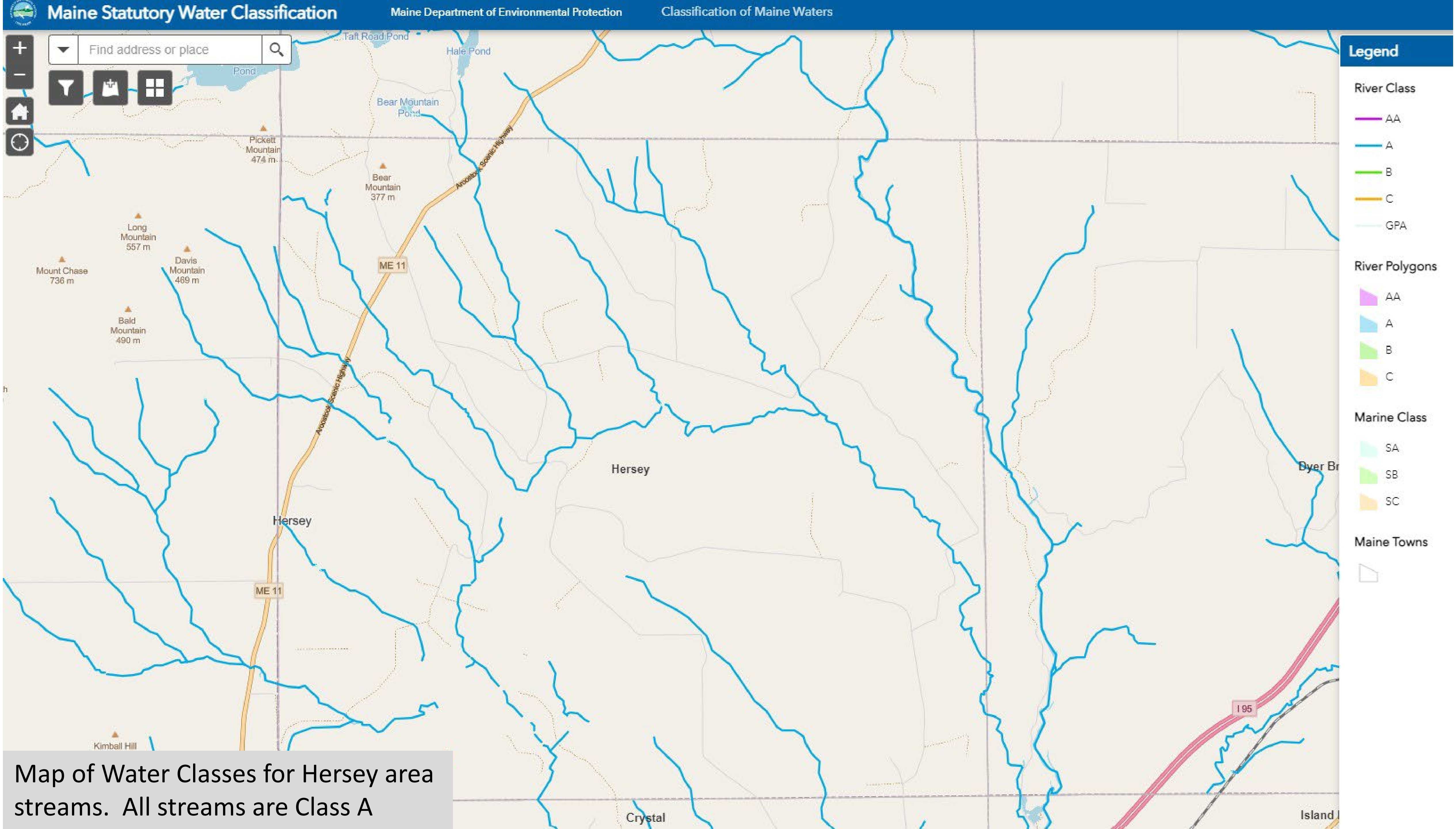
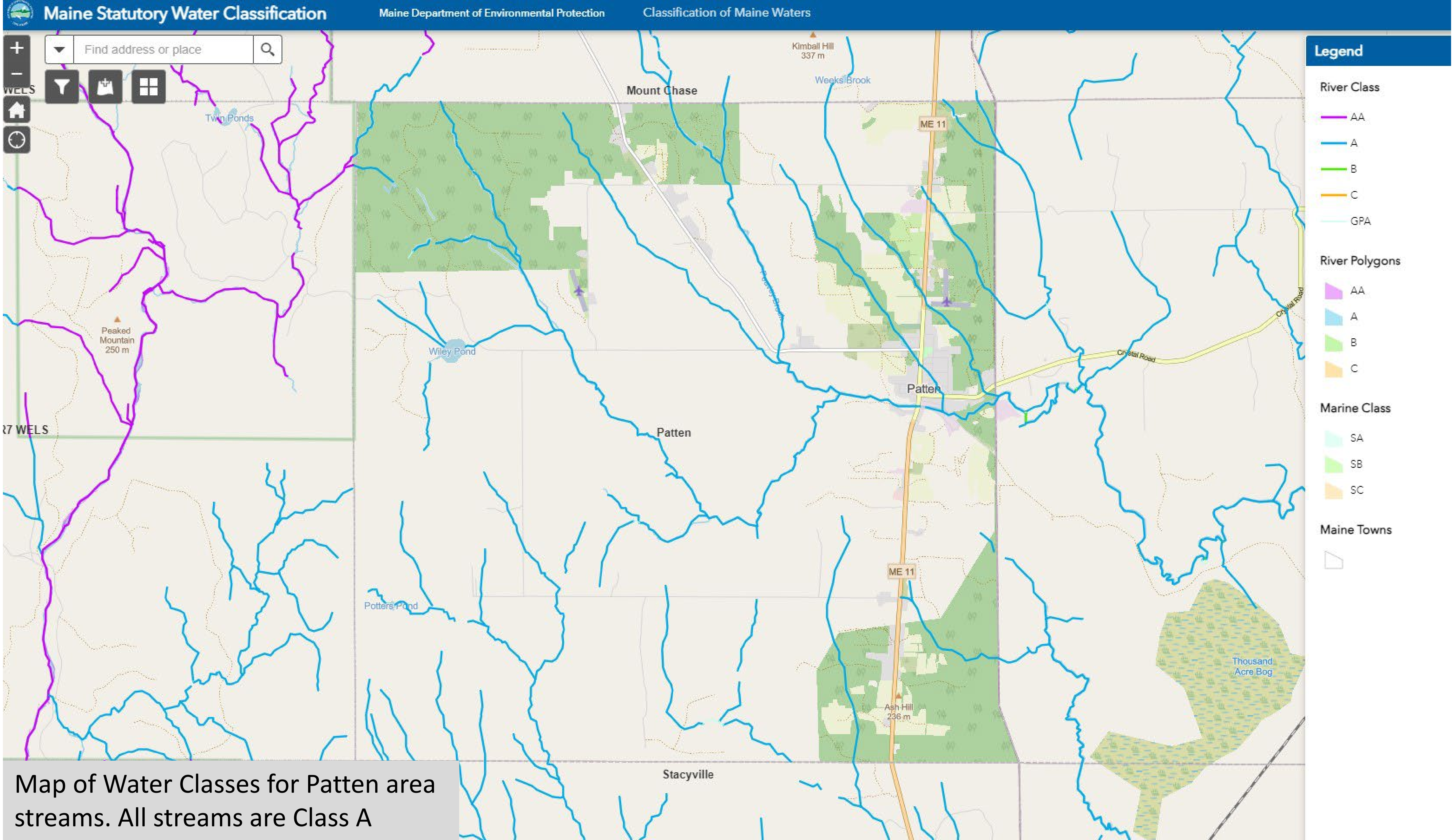
Drainage area of Class B Stream B3



Map of Water Classes for Hersey area streams. All streams are Class A



Map of Water Classes for Patten area streams. All streams are Class A

ATTACHMENT 3

Transactions of the American Fisheries Society 132:450–467, 2003

Characterizing Aquatic Health Using Salmonid Mortality, Physiology, and Biomass Estimates in Streams with Elevated Concentrations of Arsenic, Cadmium, Copper, Lead, and Zinc in the Boulder River Watershed, Montana

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Abstract.—Abandoned tailings and mine adits are located throughout the Boulder River watershed in Montana. In this watershed, all species of fish are absent from some tributary reaches near mine sources; however, populations of brook trout *Salvelinus fontitalis,* rainbow trout *Oncorhynchus mykiss,* and cut-throat trout *O. clarki* are found further downstream. Multiple methods must be used to investigate the effects of metals released by past mining activity because the effects on aquatic life may range in severity, depending on the proximity of mine sources. Therefore, we used three types of effects—those on fish population levels (as measured by survival), those on biomass and density, and those at the level of the individual (as measured by increases in metallothionein, products of lipid peroxidation, and increases in concentrations of tissue metals)—to assess the aquatic health of the Boulder River watershed. Elevated concentrations of Cd, Cu, and Zn in the water column were associated with increased mortality of trout at sites located near mine waste sources. The hypertrophy (swelling), degeneration (dying), and necrosis of epithelial cells observed in the gills support our conclusion that the cause of death was related to metals in the water column. At a site further downstream (lower Cataract Creek), we observed impaired health of resident trout, as well as effects on biomass and density (measured as decreases in the kilograms of trout per hectare and the number per 300 m) and effects at the individual level, including increases in metallothionein, products of lipid peroxidation, and tissue concentrations of metals.

Measures of physiological function, tissue residues, and fish biomass or density can provide a clear picture of exposure related to physiological malfunction and a resulting decrease in biomass or density of fish. These data interpreted simultaneously can provide a more complete assessment of the ecological health of a river and its tributaries (Johnson 1968).

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Streams in the Boulder River watershed in southwestern Montana receive drainage from abandoned mine adits and runoff from old tailings piles. All species of fish are absent from some reaches below draining mine adits, but populations of brook trout *Salvelinus fontinalis*, rainbow trout *Oncorhynchus mykiss*, and cutthroat trout *Oncorhynchus clarki* are found further downstream (Montana Fish, Wildlife, and Parks 2002). Additionally, viable populations of native, genetically pure, westslope cutthroat trout *O. c. lewisi* exist in High Ore Creek above the Comet Mine (Figure 1).

Investigations of the effects of mining on aquatic life in the Boulder River began in 1975. Nelson (1976) found reductions in the survival of fish eggs during an egg bioassay and reductions in biomass (density) at sites on the Boulder River below Cataract Creek and High Ore Creek. Gardner (1977) found that the diversity of the invertebrate community in the Boulder River below High Ore Creek was reduced compared with the upstream station below Red Rock Creek. In both studies, the differences between sites upstream and downstream of High Ore Creek were attributed to the greater concentrations of zinc (Zn) in the water at the site below High Ore Creek.

It was not until the 1990s that other investigations of the watershed were initiated. Gless (1990) designated Basin Creek as a ''stream of concern,'' Cataract Creek as ''degraded,'' and High Ore Creek as ''extremely degraded.'' These classifications were based on elevated concentrations of arsenic (As) in the water column and the rare presence of aquatic life in some stream reaches. Gless (1990) observed metal stains and dead vegetation as high as 1.5 m above the stream banks of Cataract Creek. Martin (1992) documented elevated concentrations of cadmium (Cd), copper (Cu), and Zn in the water, as well as in the sediment, aquatic invertebrates, and fish of Cataract Creek, and related these concentrations to the sources of metals in the drainage.

There are three tributaries of concern in the Boulder River watershed: Basin Creek, Cataract Creek, and High Ore Creek. Some of the major sources of mine waste in the watershed enter these three creeks. For example, wastes from the Bullion Mine are discharged into Jack Creek, which flows into Basin Creek. Six miles downstream, Basin Creek then flows into the Boulder River. The Crystal Mine in Uncle Sam Gulch provides almost all of the metal input into Cataract Creek, which flows into the Boulder River downstream of Basin Creek. The Comet mine is located along High Ore Creek, which flows into the Boulder River upstream of Galena Gulch.

One objective of this study was to determine the survivability of westslope cutthroat trout in sections of creeks that lack fish. Some reaches of Boulder River tributaries are devoid of fish. Fishless reaches in Jack Creek, Uncle Sam Gulch, and High Ore Creek coincide with metal concentrations in the ambient water exceeding 50 μg Cd/L and up to 5,000 μg Zn/L (Nimick and Cleasby 2000). We also examined the whole-body ion status and histological changes in fish during the survival studies to provide insight into the mechanisms of acute toxicity.

Our second objective was to estimate the biomass and density (measured as kilograms of trout per hectare) for all trout and health of rainbow trout in the Boulder River watershed. Metal exposures can affect aquatic biota and the overall ecological health of a river system (Farag et al. 1995). No assessments of individual fish health had been previously performed in the Boulder River, and changes in fish health have not been studied in conjunction with biomass surveys.

Physiological malfunction can be defined with measurements of metallothioneins and products of lipid peroxidation (Farag et al. 1994, 1995). In laboratory experiments, measures of metallothioneins have been associated with reduced fish growth and with metal exposure (Dixon and Sprague 1981; Roch and McCarter 1984; Marr et al. 1995). Measures of lipid peroxidation have been similarly associated with reduced growth (Woodward et al. 1995) and with metal exposure (Stern 1985; Wills 1985; DiGiulio et al. 1989).

Metallothioneins are proteins that bind metals (e.g., Cu, Cd, and Zn; Hogstrand and Haux 1991; Stegeman et al. 1992). Because metallothionein synthesis and the resulting concentrations increase when fish are exposed to metals, the induction of these proteins indicates metal exposure in fish. The induction of metallothioneins in trout has also been associated with slowed growth of trout that maintain induced metallothionein concentrations (Marr et al. 1995). Therefore, elevated metallothionein concentrations may indicate reduced fitness of trout.

Elevated concentrations of products of lipid peroxidation indicate cell death and tissue damage (Farag et al. 1995). Cell membranes are composed of polyunsaturated fatty acid side chains and generally have a fluid composition. However, these side chains are targets of lipid peroxidation, a process that changes the structural integrity of the cell

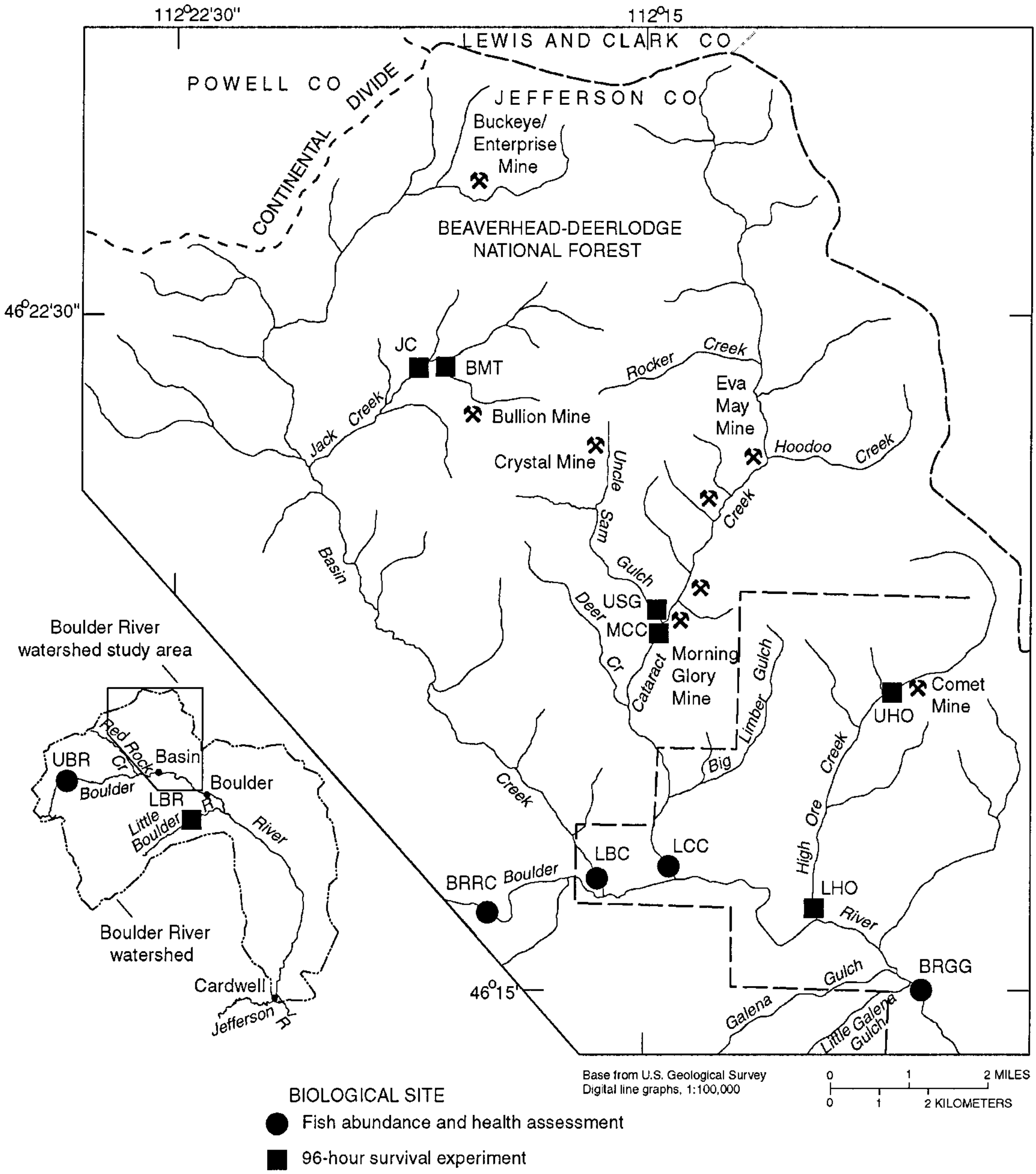


FIGURE 1.—Map of the Boulder River watershed and designated sites where survival until 96 h was studied (LBR = Little Boulder River, BMT = Bullion Mine Tributary, JC = Jack Creek, USG = Uncle Sam Gulch, MCC = Middle Cataract Creek, LHO = Lower High Ore, and UHO = Upper High Ore) and sites where fish abundance and health assessments were investigated (UBR = Upper Boulder River, LBC = Lower Basin Creek, LCC = Lower Cataract Creek, BRRC = Boulder River below Red Rock Creek, BRGG = Boulder River Below Galena Gulch).

membrane and may ultimately result in cell death and tissue damage (Halliwell and Gutteridge 1985; Wills 1985). Metals that exist in more than one valence state, such as Cu, may directly initiate lipid peroxidation (Wills 1985). Metals may also initiate lipid peroxidation because they inhibit antioxidant enzymes such as glutathione peroxidase and transferase (Reddy et al. 1981).

To meet our second objective, we used measures of metallothionein and the products of lipid peroxidation to define physiological malfunction. These physiological malfunction data were then interpreted with tissue residue and biomass and density data to determine the overall ecological health of sites within the Boulder River watershed.

Methods

The survival of westslope cutthroat trout from the Washoe Park State Fish Hatchery, Anaconda, Montana, was determined with 96-h in situ experiments at six sites located in the upper reaches of Basin and Cataract creeks and in lower High Ore Creek during low-flow conditions in 1998 (all sites used in our study are presented in Figure 1 and have been identified with two- to four-letter abbreviations).

The experiment was repeated in 1999 with the addition of a seventh site located in upper High Ore Creek. This site was added because of its close proximity to the Comet Mine and remediation efforts that were initiated during 1999. This site was also in close proximity to a native population of westslope cutthroat trout that resides upstream of the Comet Mine. A site on the Little Boulder River, which lacked historical mine activity, was designated as the reference site.

We used age-1 trout; in 1998, they were about 150 mm (total length) and weighed 30 g, whereas in 1999 a subsample of 23 age-1 trout measured 103± 16 mm (mean ± SD) and weighed 11 ± 5 g. During both years, the fish were transported to each site in Little Boulder River water maintained at 12.5 ± 2°C and greater than 6.4 mg/L dissolved oxygen (DO). At each site, fish were tempered for approximately 30 min in mixtures of site water and water from the Little Boulder River. Piper et al. (1982) suggested that fish be tempered with site water if a temperature difference of more than 2.5°C exists between site and transport water. We believed that 30 min to temper was acceptable, and no hyperactivity was observed in the site water (100%). Site water temperatures ranged from 13°C to 17°C among sites at the beginning of the experiment. The highest temperature was recorded at the reference site because fish were tempered at this site late in the day. The 4-L polyethylene enclosures were rinsed three times with site water before fish were placed in them. We placed 20 fish at each site, separated into groups of 5 fish in each of four enclosures. Fish that were put in enclosures deployed at the reference site had been first transported to other sites; therefore, handling stress was introduced to all experimental fish. During the experiments, fish were considered dead when gill action ceased.

We used two approaches to investigate the mechanisms of acute toxicity that might occur. We investigated the whole-body ion status of experimental fish during 1998 to determine if ionoregulatory failure due to elevated metals in the water column was the cause of death. During 1998, three to five experimental fish held at each site were collected, frozen, and shipped to the U.S. Geological Survey (USGS) Columbia Environmental Research Center (Columbia, Missouri) for whole-body analyses of (Ca), potassium (K), and sodium (Na). In 1999, we studied changes in histology to determine whether such changes would be consistent with those generally found as a result of metal stress. We also held five additional experimental fish at each site, and these whole fish were subsequently fixed in Davidson's solution and transferred to the Fish Technology Center, Bozeman, Montana, for histological analyses. Tissues were processed by standard histological methods and examined by light microscopy (Humason 1979).

Water quality was monitored at each site during the 96-h survival experiments. Frequency of sampling varied among sites and between years. Specific conductance, pH, and dissolved oxygen concentration were measured daily in 1998 at all sites, and electronic instruments with data-loggers were deployed to collect measurements every 15 min at JC, LHO, and LBR. In 1999, electronic instruments were deployed to collect measurements every 15 min in each tributary. Water samples for metal analyses were collected daily, except in 1999, when dissolved Zn samples were collected hourly at some sites. The sample design was altered in 1999 to define whether the time of day that a sample was collected affected the concentration of metals in that sample.

Water samples for metal analyses were collected using depth- and width-integrated methods (Edwards and Glysson 1988). Sample filtration and preservation were performed according to procedures described by Horowitz et al. (1994) and Ward and Harr (1990). Samples were filtered through 0.45-μm filters and were analyzed by the USGS National Water Quality Laboratory, Lakewood, Colorado. These data are reported as dissolved constituents, although we acknowledge the potential presence of particulates less than 0.45 μm (e.g., colloids) in this fraction.

Five sites inhabited by fish were selected to estimate biomass and density and study physiology. Two of these sites with little or no known historical mining activity were designated as the reference sites. The three tributary sites included UBR in the upper Boulder River (reference), LCR in lower Cataract Creek, and LBC in lower Basin Creek (Figure 1). Two other sites were studied on the Boulder River below Galena Gulch (BRGG) and below Red Rock Creek (BRRC, reference). The differences in discharge between the tributary and main-stem sites required that different methods be used to study these two types of sites. Multiple-pass depletion was used to estimate biomass and density in the smaller tributary sites: two-step removal estimates (Seber and Le Cren 1967) and three- or four-step removals (Zippen 1958). For the main stems, we used modified Peterson mark–recapture techniques (Chapman 1951). Fish were collected by electrofishing and, except those sampled for physiological measurements, were anesthetized with tricaine methanesulfonate (MS-222). Total lengths and weights were recorded, and scales were collected to age fish. Scales were analyzed with the Fraser-Lee method that uses a linear regression between scale and body length to back-calculate lengths at age (DeVries and Frie 1996).

Using methods described by Platts et al. (1983), depth, velocity, and substrate were measured at sites sampled for fish abundance (data not presented). Microhabitat features were also measured in accordance with guidelines described by Bovee (1986) for inclusion in the PHABSIM models for simulating amount of weighted usable area, which could be used to differentiate available habitat among sites. Suitability indices for all life stages of brook trout were from Chapman (1995), while those for rainbow trout fry were from Raleigh et al. (1984) and those for rainbow trout juveniles and adults from Ken Bovee (USGS, personal communication) for the South Platte River, Colorado.

Water quality conditions were monitored periodically between October 1996 and September 1999 at the five fish health assessment sites. Data for these samples were summarized to characterize metal concentrations typical of high-flow and low-flow conditions at these sites.

Thirteen to 25 rainbow trout (203 $\pm$ 43 mm total length, 89 $\pm$ 62 g) were collected from each site for physiological analyses during low-flow conditions in 1997. The species composition available at the lower Cataract Creek site dictated that we collect rainbow trout as a surrogate species to determine the physiological health of trout in the watershed. Each fish was pithed and a necropsy was performed immediately to identify any gross abnormalities (e.g., nodules on internal organs, discolored or frayed gills; Goede 1989). Samples of gill and liver were dissected from each fish, frozen immediately with liquid nitrogen, and transported to the USGS, Jackson Field Research Station, Jackson, Wyoming, where they were stored at $-90°C$ to adequately preserve tissues for biochemical analyses. Five additional rainbow trout (same size as above) were collected from each site and frozen for measurements of whole-body metal concentrations.

At least five composite samples of each tissue from each site were prepared in the laboratory by combining tissues from two to five rainbow trout. The tissues were removed from the $-90°C$ freezer and ground in mortars cooled with liquid nitrogen. To define the physiological condition of fish from the sites, concentrations of tissue metals, products of lipid peroxidation, and metallothionein were measured in aliquants of the composite samples.

Arsenic, Cd, Cu, lead (Pb), and Zn were measured in gills, livers, and whole fish ($N \geq 5$ for each tissue type). All tissue samples were lyophilized to a constant dry weight. Approximately 100 mg of each sample was digested in 1 mL of nitric acid and 1 mL 30% hydrogen peroxide. Concentrations of the elements were determined by inductively coupled plasma–mass spectroscopy (PE/SCIEX Elan 6000 ICP-MS). Quality control included measurements of predigestion spikes, postdigestion spikes, digestion replicates, and reference tissue samples.

Quality control tissues for metal analyses included whole striped bass *Morone saxatilis*, International Atomic Energy Agency (IAEA) fish fillet, National Institute of Standards and Technology RM-50 tuna fillet, and National Research Council of Canada Dorm-1 dogfish muscle and bovine liver. Recoveries for the 25 reference samples measured between 87% and 121% with two exceptions. One bovine liver sample measured 132% recovery for As, and a Pb result for one IAEA fish fillet measured 53% recovery. The relative percent difference among triplicate analyses were generally less than 4% for liver, 15% for gill, and 16.5% for whole body. Deviations from these were noted in a few measurements of Pb. The analyses of predigestion and postdigestion spikes ranged from 85% to 122% for all tissues.

A competitive double-antibody radioimmuoassay (RIA) developed by Hogstrand and Haux (1990) and later modified by Hogstrand et al. (1994) was used to measure metallothionein (MT) in groundfish gills and livers. The MT assay used rabbit antiserum raised against MT for yellow perch *Perca flavescens* as the first antibody, ^{125}I-labeled rainbow trout MT as a tracer, and goat anti-rabbit IgG as a second antibody. A 10,000 × gravity supernatant prepared from livers of Cd-injected rainbow trout was used as a MT standard. The MT content of the standard was calibrated against a standard curve prepared from rainbow trout MT (Hogstrand et al. 1994). The working range of the RIA was 10–100 ng rainbow trout MT per assay tube, which corresponds to 0.6–6.0 μg/g liver wet weight.

A fluorometric assay that measures the relative intensity of fluorophores formed during lipid peroxidation (Dillard and Tappel 1984; Fletcher et al. 1973; Farag et al. 1995) was used to measure products of lipid peroxidation. Ground tissue (200 mg frozen weight) was combined with a 2:1 mixture of high-performance-liquid-chromatography-grade chloroform:methanol (7 mL for a 200-mg sample) in a glass homogenizer. The tissue was homogenized with a glass pestle, diluted with an equal volume of water, homogenized again, and vortexed for 1.5 min. The mixture was centrifuged at 1,200 × gravity for 1.5 min in a Corex tube, and the chloroform layer was removed. Fluorescence was measured (Hitachi f-2000) at a wavelength of 435 nm emission during excitation at 340 and 360 nm.

Data for tissue concentrations of metals, metallothionein, products of lipid peroxidation, length at age, and biomass and density estimates were analyzed with one-way analysis of variance (ANOVA; SAS Institute 1989). The data were tested for equality of variances with the Levene's test for homogeneity of variances (Toxstat 1994) and were transformed if they did not pass the test. Means for tissue metal concentrations were compared by a Fischer's least-significant-difference test, those for metallothionein and products of lipid peroxidation by Tukey's test, and those for biomass and density by Dunnett's test (Zar 1984). A statistical criterion of $\alpha = 0.05$ was used for all comparisons. The percent survival data were not statistically analyzed.

Results

Survival Experiments

Compared with the LBR reference site, the survival of caged westslope cutthroat trout at 96 h was less at all experimental sites in 1998 and 1999 (BMT, JC, USG, MCC, LHO, and UHO; Figure 2). Survival at 96 h was 0% at all experimental sites during both years, except survival at LHO

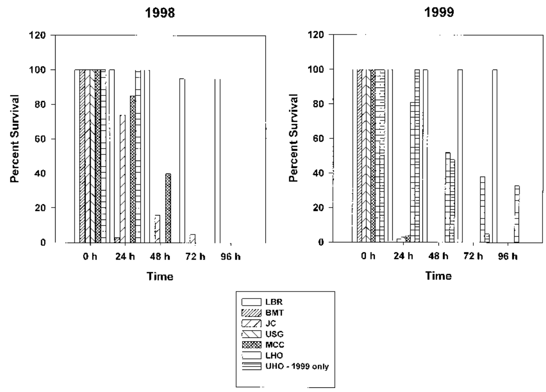
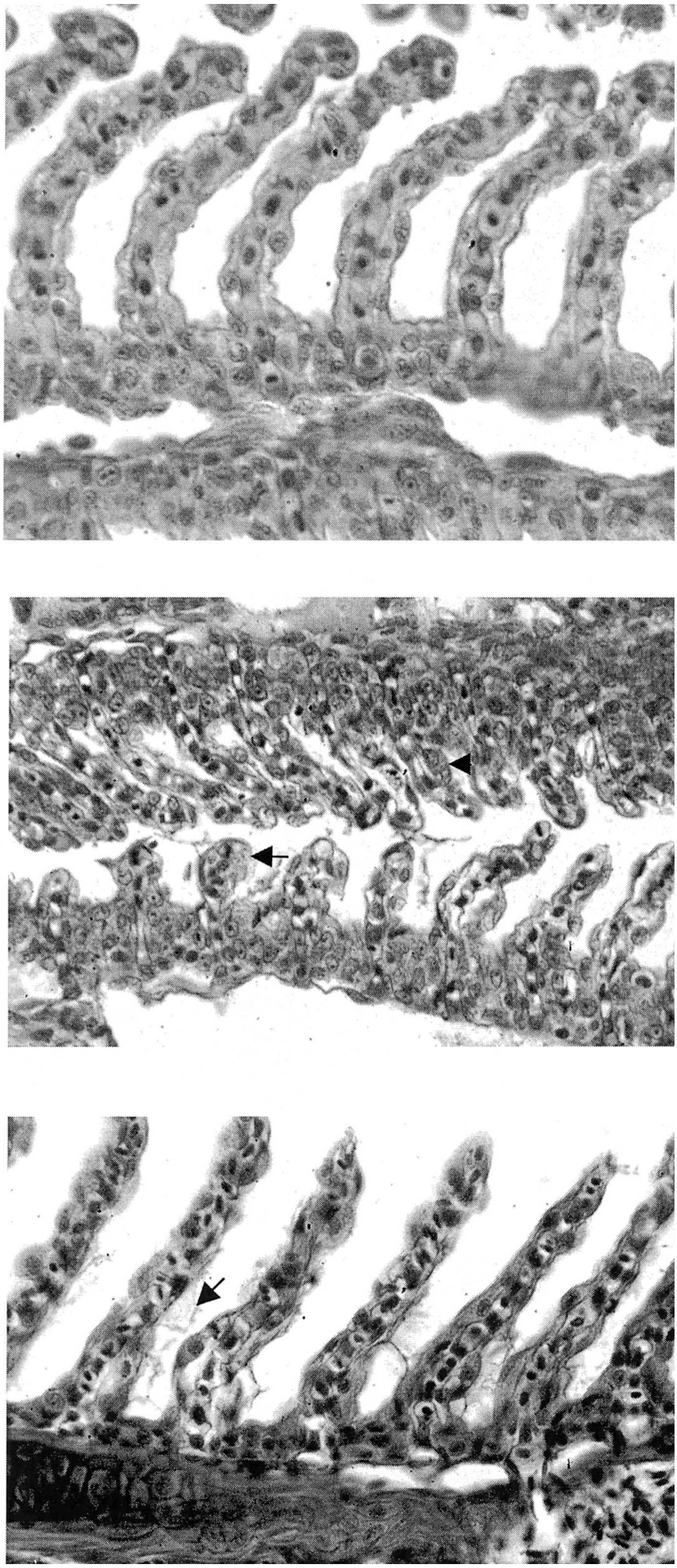


FIGURE 2.—Survival of hatchery cutthroat trout placed in various tributaries of the Boulder River for up to 96 h during 1998 and 1999. See Figure 1 for site abbreviations.

was 33% during 1999. In most cases, survival was affected in 24–48 h during 1999. Fish died more quickly in JC and MCC during 1999 compared with 1998. In the two most extreme cases, cutthroat trout placed in USG and BMT died in 5 and 8 h, respectively, during 1999. Survival was reduced to 5% at UHO at 72 h, and the experiment at this site was ended at that time.

The concentrations of whole-body ions in 1998 did not differ significantly among sites (reference site included). Concentrations of ions ranged from 22,533–24,860 μg Ca/g, 12,000–15,140 μg K/g, and 2,046–3,178 μg Na/g, the highest concentrations noted in fish from USG. The histological analyses during 1999 indicated that degeneration (dying) and necrosis (death) of gill epithelia was the most significant tissue lesion. Excessive mucous production and hypertrophy (swelling) were also noted in gill epithelia of fish from experimental sites (Figure 3). Spongiosis, a condition of edema and necrosis, was also observed in the nares of fish held in the test sites. Additionally, excessive mucous was noted in the skin of fish from all test sites. There was some hypertrophy in the gill lamellae and abundant mucous in the nares of fish held at the reference site, but these changes were less severe than those at the experimental sites. The proliferation of epithelial cells noted in gills of fish from UHO and LHO indicate that toxicity was less acute at these sites, which is consistent with the longer times to death at these sites in 1999. Additionally, the pseudobranchs of fish from LHO contained cystic (fluid filled) areas, an abnormal condition not noted at other sites. We noted dark longitudinal coloration in the skin at death



a

b

c

for UHO and LHO fish. This discoloration was about 0.5 cm wide and was observed across the length of the fish. Correspondingly, an increased accumulation of melanocytes was noted in the skin of fish collected from LHO.

Water Chemistry of Survival Experiments

Water chemistry was variable in stream reaches where 96-h survival experiments were performed in 1998 and 1999. The on-site experiments were conducted between mid-July and early August during both years, but stream-flow conditions were different each year. During the 1999 experiments, streams had base-flow conditions typical of late summer, whereas the 1998 experiments were conducted about the end of spring runoff. Therefore, stream flow was higher during the 1998 experiments, and trace-element concentrations generally were lower in 1998 than in 1999. In both years, Cd and Zn were almost entirely dissolved and Cu was divided about equally between the dissolved and particulate phases (the dissolved concentrations are presented in Table 1). Arsenic and lead generally measured in low concentrations compared with the other metals (<3 μg As/L, except at LHO and UHO [22–33 μg As/L] and <1 μg Pb/L except at BMT [3.1 μg Pb/L]; data not otherwise presented). The pH values were neutral to slightly basic: 7.0–8.3, except for BMT where pH was 5.2–5.4. Temperature appeared to fluctuate more with time of day rather than among sites (Table 1). As expected, the manual temperatures recorded during 1998 did not capture the temperature range defined during 1999 when electronic measurements were recorded every 15 min. The maximum daily temperature recorded was 21°C (High Ore Creek), which is below the lethal limits for trout.

The relationship between metal concentrations and mortality followed a consistent pattern, with higher concentrations resulting in greater and more rapid mortality. At the reference site (LBR) hardness (48–56 mg/L) and metal concentrations were low (<0.3 μg Cd/L, 2 μg Cu/L, 2–5 μg Zn/L). Water quality at this site was similar in 1998 and 1999. Stream flow was 4–8 times higher during the experiments in 1998 than in 1999 in the Jack Creek and Cataract Creek drainages. Consequently, constituent concentrations were higher in 1999 at all four sites (BMT, JC, USG, and MCC) in these two drainages. In 1999, concentrations of Cd, Cu, and Zn were about 100% higher and hardness values were about 50% higher than the corresponding 1998 levels at each site. Hardness was generally higher at the two High Ore Creek sites (LHO and UHO 130–140 mg/L) compared with all other sites. Concentrations of metals were similar between LHO and UHO in 1999 and somewhat higher at LHO in 1999 compared with 1998, apparently as a result of stream flow (Table 1).

Results of hourly sampling in 1999 indicated that dissolved Zn concentrations typically varied at many sites during the 1999 experiments (D.A. Nimick, USGS, unpublished data). These variations resulted from normal diel concentration cycles and from the effect of storm runoff, which occurred during the toxicity experiments at JC in 1999. Diel cycles resulting in 2–3-fold changes in dissolved Cd and Zn concentrations have been documented at several sites in and near the study area and are thought to be caused by the effects of water temperature and pH on the partitioning of Cd and Zn between dissolved and sorbed phases (Brick and Moore 1996; D.A. Nimick, unpublished data). Therefore, a wide range of concentrations may occur daily at each site.

Biomass and Density Estimates

Of the three tributaries studied, the combined biomass of all brook and rainbow trout observed (on either an area or linear basis) was the smallest at LCC (Table 2): 13.5 ± 3.9 kg/ha versus 63.6 ± 2.1 kg/ha at UBR (reference) and 63.7 ± 2.1 kg/ha at LBC. Brook and rainbow trout were the two trout species found in the tributaries; brook trout predominated at UBR, whereas rainbow trout predominated at LCC. Our decision to compare combined biomass estimates was based on the assumption that this combination provides the best estimate of the biomass-producing capacity of a

←

FIGURE 3.—**(a)** Gill section of a cutthroat trout held in the Little Boulder River reference site during the 96-h survival experiment in 1999; **(b)** gill section of a cutthroat trout held at the Middle Cataract Creek site during the same experiment, with the upper arrowhead pointing to hypertrophied cells and the lower one to a degenerative epithelial cell; and **(c)** gill section of a cutthroat trout held in High Ore Creek during the experiment, with an arrow pointing to a degenerate epithelial cell. The sections were 5 μm thick, stained with hematoxylin and eosin, and magnified 250 times.

TABLE 1.—Physical and chemical data for stream sites during 96-h survival experiments performed on-site (see Figure 1 for site abbreviations) in the Boulder River watershed of Montana. Dissolved metal concentrations are median values when multiple samples were collected during an experiment.

Site	Sample date	Temperature (°C)	Cd (μg/L)	Cu (μg/L)	Zn (μg/L)	pH	Hardness as $CaCo_3$ (mg/L)	Discharge (m^3/s)
LBR (reference)	Jul 21, 1998	13–19	<0.3	2.0	2.0	7.9–8.1	48	0.18
	Aug 2, 1999	13–18	<0.3	2.4	2.5	8.0–8.2	56	0.07
BMT	Jul 21, 1998	15–16[a]	20	113	2,160	7.4	39	0.03
	Aug 2, 1999	12–16	38	557	3,970	5.2–5.4	66	0.00067
	Aug 3, 1999	9–15	35	314	3,920	5.9		
JC	Jul 21, 1998	10–14[a]	3.4	33	377	7.7–7.8	29	0.92
	Aug 2, 1999	9–16	8.0	51	656	7.0–7.4	44	0.03
USG	Jul 21, 1998	16[a]	22	84	1,830	7.6	41	0.14
	Aug 2, 1999	14–17	75	377	5,730	7.3		
	Aug 4, 1999	12–14	59	206	4,840	7.5	63	0.02
MCC	Jul 21, 1998	14–16[a]	4.4	34	391	7.8–8.2	36	0.58
	Aug 2, 1999	11–18	9.6	48	714	7.9		
	Aug 4, 1999	11–18	9.3	48	651	7.8–7.9	48	0.13
UHO	Aug 3, 1999	12–21[a]	2.5	3.7	550	8.2	140	0.01
LHO	Jul 21, 1998	11–21	3.7	5.0	987	8.1–8.3	130	0.05
	Aug 2, 1999	12–21	2.0	3.6	459	8.1–8.3	140	0.02

[a] Range of measurements recorded manually, where $N = 2–6$.

stream, and that the biomass of one species is not independent of (and is in fact affected by) the occurrence of another salmonid species. This interdependency among trout species in stream environments was demonstrated by Shepard et al. (in press) in White's Gulch, Montana, where cutthroat trout biomass increased after brook trout were physically removed. Therefore, measurements of biomass that do not include all trout species would probably be inadequate for comparative purposes.

The species were evenly represented at LBC. The species composition in LCC and LBC seemed to generally reflect the composition of the nearest mainstem sites; BRRC had a similar composition to LBC, and BRGG was similar to LCC. Although there was a trend of less biomass at BRGG compared with the reference, BRRC, the difference was not significant. Differences among lengths at age calculated from scales of rainbow trout samples from the three tributary sites (Figure 4) were not significant, nor were differences in length at age between fish sampled from the main-stem sites (data not presented). The observations for density (number/300 m) have the same pattern as biomass results for all sites (Table 2).

Fish species observed at the five fish abundance sites between 1997 and 1999 included three native species (longnose sucker *Catostomus catostomus*, mottled sculpin *Cottus bairdi*, and mountain whitefish *Prosopium williamsoni*) and four nonnative species (Yellowstone cutthroat trout *Oncorhynchus clarki bouvieri*, rainbow trout, brook trout, and brown trout *Salmo trutta*). The main-stem sites had a greater number of species than did the tributary sites and contained all of the species listed, except that cutthroat trout were not found at either mainstem site and brown trout were not found at BRRC (reference). Most of the brown trout and mountain whitefish captured in the main stem (in 1998 and 1999) were in spawning condition and may have migrated from sites farther downstream. Mottled sculpin were found at UBR (reference) and LBC and mountain whitefish were found at LBC. Neither mottled sculpin nor mountain whitefish were found at LCC. None of the rainbow, cutthroat, or brook trout collected from the tributary sites appeared to be spawning.

Habitat Characterization of Fish-Abundance Sites

Microhabitat was quantified in terms of weighted usable area and was based on one set of measurements taken along 10 or 11 transects at each site between late September and early October. For both brook and rainbow trout, weighted usable area in the tributaries was greatest in LBC for fry and juveniles and greatest for adults in UBR. LCC had the least weighted usable area for all three life stages (Table 3). In the main stem, juvenile and adult weighted usable area was greatest for both species in BRGG, but fry weighted usable area was greatest for both species at BRRC.

Water Chemistry of Resident Fish Biomass and Density and Health

Data from water samples collected in 1996–1997 at the five biomass and fish health sites in-

TABLE 2.—Size ranges and biomass and density estimates of brook and rainbow trout in the tributaries and main stem of the Boulder River, Montana. The estimates were obtained during late July 1997 and early October 1998 and 1999. Asterisks indicate significant differences from the reference site ($P \leq 0.05$). Fish species include rainbow trout (RBT) and brook trout (EBT). Because few brook trout were located each year in lower Cataract Creek and Galena Gulch, they are not represented separately in the table. Similarly, few cutthroat trout were observed in the tributaries, and they are included in the numbers for rainbow trout. See Figure 1 for site abbreviations.

Site and year	Species	Size range (cm)	Number/300 m ± SE	Biomass ± SE (kg/ha)
		Tributaries		
UBR (reference)				
1997	RBT	8.1–25.9	22 ± 1	10.8 ± 0.7
	EBT	6.9–31.5	189 ± 52	53.0 ± 14.7
	RBT and EBT	6.9–31.5	211 ± 52	63.8 ± 14.7
1998	RBT	5.1–24.4	42 ± 3	14.9 ± 1.2
	EBT	6.4–22.6	167 ± 20	45.0 ± 5.0
	RBT and EBT	5.1–24.4	209 ± 19	59.9 ± 5.2
1999	RBT	6.4–25.9	57 ± 2	16.4 ± 0.7
	EBT	6.1–22.9	263 ± 19	61.7 ± 4.5
	RBT and EBT	6.1–25.9	320 ± 19	78.0 ± 4.5
Mean	RBT and EBT		247 ± 37	63.6 ± 2.1
LBC				
1997	RBT	4.1–33.5	75 ± 10	38.0 ± 5.0
	EBT	9.7–24.4	67 ± 20	23.4 ± 7.0
	RBT and EBT	4.1–33.5	142 ± 22	61.4 ± 8.6
1998	RBT	5.1–26.2	154 ± 4	37.6 ± 0.9
	EBT	7.1–26.7	53 ± 7	24.2 ± 3.0
	RBT and EBT	5.1–26.7	207 ± 8	61.8 ± 3.1
1999	RBT	4.3–28.2	328 ± 12	56.7 ± 2.1
	EBT	5.3–25.1	47 ± 0.3	11.1 ± 0.1
	RBT and EBT	4.3–28.2	375 ± 12	67.8 ± 2.1
Mean	RBT and EBT		241 ± 70	63.7 ± 2.1
LCC				
1997	RBT and EBT	6.9–21.1	40 ± 14	5.8 ± 2.0
1998	RBT and EBT	3.6–21.8	139 ± 12	16.1 ± 1.3
1999	RBT and EBT	8.4–21.8	92 ± 3	18.6 ± 0.6
Mean	RBT and EBT		90 ± 29*	13.5 ± 3.9*
		Boulder River		
BBRC (reference)				
1997	RBT	11.2–27.7	44 ± 13	9.7 ± 3.0
	EBT	11.9–30.0	24 ± 10	5.3 ± 2.1
	RBT and EBT	11.2–30.0	68 ± 13	15.0 ± 3.7
1998	RBT	10.7–30.0	73 ± 5	17.9 ± 1.8
	EBT	11.9 ± 29.0	72 ± 30	16.7 ± 6.8
	RBT and EBT	10.7–30.0	146 ± 30	34.6 ± 7.1
1999	RBT	9.9–30.2	135 ± 7	28.1 ± 1.9
	EBT	14.2–31.8	86 ± 14	27.4 ± 6.1
	RBT and EBT	9.0–31.8	221 ± 14	55.5 ± 6.1
Mean	RBT and EBT		146 ± 45	35.0 ± 11.7
BRGG				
1997	RBT and EBT	10.4–31.0	79 ± 19	10.9 ± 2.6
1998	RBT and EBT	10.2–32.0	179 ± 12	21.5 ± 1.5
1999	RBT and EBT	10.9–35.1	236 ± 25	32.4 ± 3.4
Mean	RBT and EBT		165 ± 44	21.6 ± 6.2

dicated that dissolved and total recoverable concentrations of aluminum (Al), antimony (Sb), As, barium (Ba), beryllium (Be), chromium (Cr), cobalt (Co), iron (Fe), manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), silver (Ag), and uranium (U) were either less than method detection levels or less than concentrations established by the U.S. Environmental Protection Agency to protect aquatic life (EPA 1987). In contrast, concentrations of Cd, Cu, Pb, and Zn frequently were elevated at sites downstream of mining activity (LBC, LCC, and BRGG).

Trace element concentrations generally were low (Table 4) during all flow conditions in sites upstream of historical mining activities (i.e., UBR and BRRC). In BRRC, concentrations of Cu during

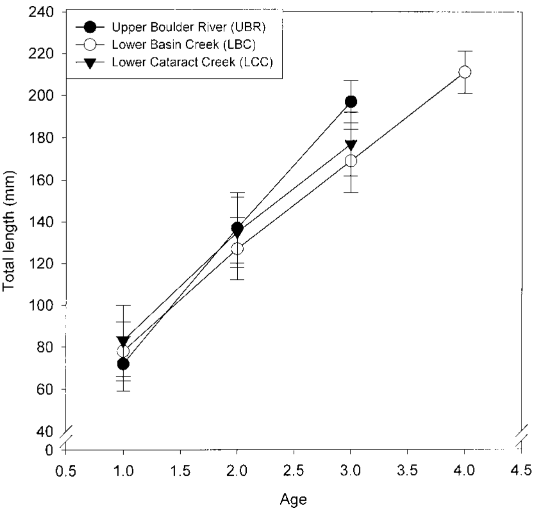


FIGURE 4.—Comparisons of trout growth at three sites in tributaries of the Boulder River watershed.

high-flow periods exceeded the acute and chronic water quality criteria in 2 of 4 samples measured for dissolved Cu and 6 of the 10 samples measured for total recoverable Cu. Some total recoverable Pb concentrations also exceeded the chronic but not acute water quality criteria at BRRC. Trace element concentrations were higher at the other three sites. The highest concentrations of metals occurred at LCC, where dissolved Cd, Cu, and Zn concentrations exceeded acute standards in every sample. Dissolved Zn concentrations also exceeded acute standards in all samples from LBC and BRGG. Water at these two sites frequently exceeded Cd and Cu standards during high flows, and BRGG exceeded the standards during low-flow conditions as well.

The concentrations of dissolved Cd and Zn at LCC were similar to concentrations associated with mortality in the 96-h survival experiments. Median concentrations (Table 4) at this site were higher than at MCC and JC during the 1998 experiments when 100% mortality was observed at 96 h. Dissolved metal concentrations at the other four fish-assessment sites during low-flow conditions were considerably less than the concentrations associated with mortality in the survival experiments.

Tissue Metals

The concentrations of most metals measured in the livers of resident rainbow trout were greatest in fish from LCC (dry weights: >1,000 μg Cu/g, 60 μg Cd/g, and 13 μg As/g; Figure 5). Concentrations of metals in the livers of fish from LBC and BRGG were also elevated above those measured at the reference sites (UBR and BRRC). In general, the pattern of metal accumulation in livers was greatest at LCC, followed by LBC, BRGG, BRRC, and UBR, an exception to this pattern being that the greatest concentration of Pb was observed in fish from BRGG.

The pattern of metal concentrations observed in livers was similar in gills (Figure 6). The greatest concentrations of Cu and Cd were observed in the gills of fish from LCC (20 μg Cu/g and >60 μg Cd/g). Although lesser amounts of Cu and greater amounts of Zn were observed in gill than in liver tissue, the amounts of Cd in livers and gills of fish from LCC were nearly identical. Concentrations of Zn in the gills (>600 μg/g) of rainbow trout from the reference site (UBR), however, were greater than we have measured in other reference streams in the intermountain west (Farag et al. 1998). As was noted for liver, the greatest concentrations of Pb were observed in gills of BRGG fish. However, unlike liver, there was no significant accumulation of As in the gills.

The pattern of metal accumulation described for livers was similar in whole fish. Again, the greatest concentrations of most metals in whole fish were observed in samples collected from LCC (>20 μg Cu/g, 5 μg Cd/g, and 8 μg As/g were measured; Figure 7). Although less Cd was observed in the whole body versus liver and gill, a mean of 5 μg Cd/g was measured in the whole fish from LCC. There was no significant accumulation of Pb in whole fish.

Metallothionein

Concentrations of metallothionein were greatest in the livers of rainbow trout collected from LCC (921 μg/g). The mean concentration of metallothionein in livers of fish from LCC was signifi-

TABLE 3.—Weighted usable area (m^2; WUA) per 1,000 m^2 of stream (Boulder River watershed, Montana) for brook and rainbow trout fry (<5 cm), juveniles (5–20 cm), and adults (>20 cm). The WUA is based on the product of suitability index values for depth, velocity, and substrate. Site abbreviations are provided in Figure 1.

	Brook trout			Rainbow trout		
Site	Fry	Juvenile	Adult	Fry	Juvenile	Adult
UBR	49.3	59.8	293	222	103	39.4
LBC	55.7	60.5	277	254	168	33.8
LCC	48.9	59.8	212	192	92.2	22.7
BRRC	44.6	27.2	156	133	172	57.3
BRGG	24.1	27.4	229	195	251	64.9

TABLE 4.—Physical and chemical data for sites (see Figure 1 for abbreviations) where fish health was assessed in the Boulder River watershed of Montana. Data were collected between October 1996 and September 1999. Median total recoverable (TR) and dissolved (disv.) trace element concentrations are listed; *N* represents the number of samples collected on different dates throughout the flow condition.

					Median trace element concentration (μg/L)									
					As		Cd		Cu		Pb		Zn	
Site	*N*	Discharge (m^3/s)	pH	Hardness (mg/L as $CaCO_3$)	TR	Disv.	TR	Disv.	TR	Disv.	TR	Disv.	TR	Disv.
High flow conditions														
UBR	2	0.4–2.3	7.6–8.1	21–38	4.0	2.5	<1	<0.3	3	1.5	<1	<1	<10	1
BRRC	10	3.0–20.5	7.6–8.2	22–50	5.5	3.3	<1	<0.3	5	3.3	1.1	<1	11	3
LBC	10	0.4–7.1	7.0–8.0	12–35	11	4.0	<1	0.4	12	8.7	2.6	<1	81	61
LCC	11	0.4–4.8	6.8–8.0	18–54	17	3.4	1.8	1.3	46	33	6.7	<1	177	139
BRGG	11	5.0–29.7	7.5–8.2	19–48	12	4.0	<1	0.3	20	11	5.9	<1	73	46
Low flow conditions														
UBR	2	0.1–0.1	8.0	52–53	2.5	2.0	<1	<0.3	1.5	<1	<1	<1	<10	<1
BRRC	8	0.2–0.7	7.4–8.3	54–61	3.0	2.4	<1	<0.3	1.4	1.7	<1	<1	<10	2.3
LBC	7	0.1–0.2	7.5–8.2	39–42	7.0	4.0	<1	0.4	4.0	3.0	<1	<1	66	63
LCC	7	0.1–0.2	7.5–8.3	59–69	4.8	3.0	5.0	4.9	24	22	<1	<1	419	397
BRGG	8	0.5–1.0	7.7–8.5	61–68	6.0	5.0	<1	0.8	10	9.0	<1	<1	180	160

cantly greater than livers of fish from the reference site, UBR (Table 5). Although there was a trend of greater metallothionein in livers of fish from LBC, this finding was not significant. The gills generally had small concentrations of metallothionein, and concentrations in gills measured at LBC were less than those collected from LCC and BRGG. There were no significant differences between concentrations of metallothionein measured in livers or gills of fish collected from the mainstem sites, BRRC and BRRG.

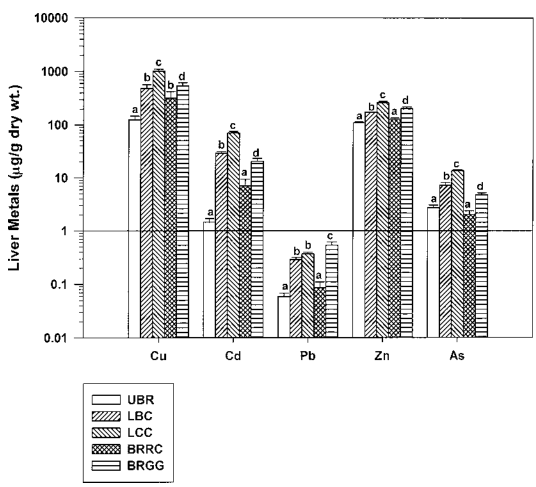


FIGURE 5.—Metal concentrations in the livers of resident rainbow trout collected from sites in the Boulder River watershed. Whiskers are SEs; columns with different lowercase letters are significantly ($P \leq 0.05$) different.

Lipid Peroxidation

We found a significant amount of products of lipid peroxidation (at 340 nm excitation) in the livers of rainbow trout from LCC relative to UBR fish(Table 6). The mean amounts of products of lipid peroxidation in livers of fish from the two mainstem sites, BRRC and BRGG, did not differ significantly, nor did differences in lipid peroxidation in the gills of fish among tributary or mainstem sites. Products of lipid peroxidation measured at 360 nm excitation showed an increasing trend, but the difference was not significant (data not presented).

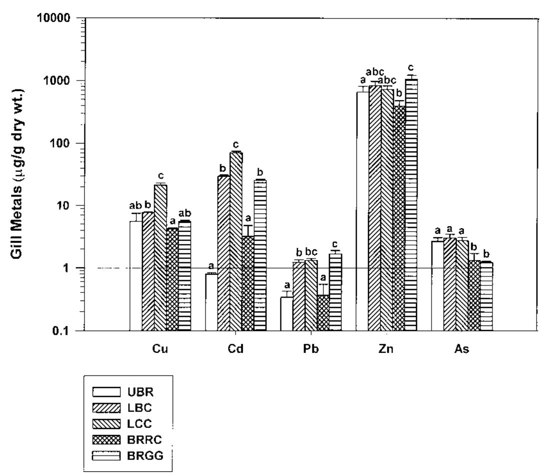


FIGURE 6.—Metal concentrations in the gills of resident rainbow trout collected from sites in the Boulder River watershed. See Figure 5 for additional details.

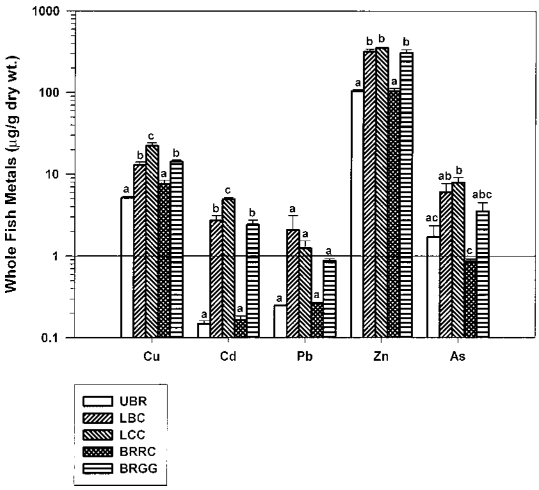


FIGURE 7.—Metal concentrations in whole resident rainbow trout collected from sites in the Boulder River watershed. See Figure 5 for additional details.

Discussion

The multiple tools we used to investigate the effects of historical mining in the Boulder River watershed allow us to define where metals affect the aquatic health of the watershed. In the most extreme cases, where concentrations of metals were greatest in the water column, population-level effects existed and fish survival was poor. The relation between metal concentrations and mortality was consistent, and greater concentrations were associated with greater and more rapid mortality.

The association between fish mortality and the elevated concentrations of metals in the water provides evidence that metals caused the observed mortalities. Although the water quality criteria are hardness dependent, we can calculate standards for the average hardness measured at various sites in this watershed based on water quality criteria established by the U.S. Environmental Protection Agency for the chronic and acute protection of aquatic life (USEPA 1987). These acute criteria are 12 μg Cu/L and 82 μg Zn/L in Basin and Cataract creeks at a hardness of 66 mg/L. Hardness was greater at lower High Ore Creek (140 mg/L) and this may explain why survival was slightly better in this creek.

To further investigate the cause–effect relationship of metals and fish mortality, we studied the ionoregulatory status and histopathology of fish near death. Metals in water have often been associated with ionoregualtory upset (Laurén and McDonald 1985). A disturbance of the ionoregulatory status in fish may result as metals compete for calicium-binding sites at the gill or inhibit Na^+, K^+-ATPase (Evans 1987; Reid and McDonald 1988). Previously, we demonstrated reductions in whole-body potassium in juvenile fish exposed to Cd, Cu, and Pb in the water and diet (Farag et al. 1994). However, whole-body concentrations of metals were not affected at the end of the on-site survival experiments in the Boulder River watershed during 1998. This lack of measured response may be due to the size of fish studied. Although fish examined during 1998 were juveniles, they were several times the size of the 1–2.5-g fish studied by Reid and McDonald (1988) and Farag et al. (1994). The greater size of fish used in this study may have limited the usefulness of whole-body ion measurements to define ionoregulatory upset.

The lack of a measurable response with whole-body ion measurements in 1998 led us to collect histological samples in 1999 to better characterize the cause of death. The hypertrophy noted in gills of fish in this study are consistent with edema noted previously in the secondary lamellae of rainbow trout exposed to 40 mg Zn/L for 3 h (Skidmore and Tovell 1972). Skidmore and Tovell (1972) also observed severe curling of the secondary lamellae,

TABLE 5.—Mean ± SE metallothionein concentrations in gill and liver samples of resident rainbow trout collected from selected sites (see Figure 1 for site abbreviations) in the Boulder River watershed of Montana. Within columns, means with different letters are significantly different ($P \leq 0.05$); sample size was five for all sites except Galena Gulch, where it was six.

	Metallothionein (μg/g wet weight)	
Site	Gill	Liver
Tributaries		
UBR (reference)	9.37 ± 0.63 zy	31.23 ± 7.70 z
LBC	7.61 ± 1.0 z	596.81 ± 288.89 zy
LCC	12.00 ± 1.18 y	921.05 ± 215.58 y
Boulder River		
BRRC (reference)	12.42 ± 0.52 y	271.39 ± 194.67 zy
BRGG	11.07 ± 1.15 zy	292.51 ± 60.47 zy

TABLE 6.—Mean ± SE lipid peroxidation of tissues sampled from resident rainbow trout collected from selectd sites (see Figure 1 for site abbreviations) in the Boulder River watershed of Montana. Lipid peroxidation is expressed as the fluorometric measurement (relative intensity) of a chloroform extract of tissue. The relative intensity was measured at 340 nm excitation and 435 nm emission when 0.05 μg/mL of quinine sulfate measured 322 with settings to measure gill tissue and 136 with settings to measure liver tissue. Within columns, means with different letters are significantly different ($P \leq 0.05$); sample size was five for all sites except Galena Gulch, where it was six.

Site	Relative intensity: Gill	Relative intensity: Liver
Tributaries		
UBR (reference)	73.14 ± 8.19 z	113.98 ± 5.31 z
LBC	66.38 ± 6.91 z	115.34 ± 11.74 z
LCC	73.78 ± 3.77 z	141.00 ± 7.28 y
Boulder River		
BRRC (reference)	79.17 ± 6.57 z	125.11 ± 11.87 zy
BRGG	73.08 ± 4.09 z	127.15 ± 4.63 zy

a finding not unlike the twisting that was noted in the gills of fish collected from middle Cataract Creek, where concentrations of Zn ranged from 400 to 700 μg/L. Cutthroat trout near death experienced excess mucous production in this study. Handy and Eddy (1991) suggested that excess mucous production is part of a general stress response in rainbow trout. Therefore, it is likely that ionoregulatory upset (though we could not measure this upset directly) caused hypertrophy (swelling), degeneration (dying), and necrosis (death) of epithelial cells in the gills. Also, mucous production occurred simultaneously as a general response to stress.

Biomass, Density, and Health

The concentrations of Cd, Cu, and Zn in water at LCC are near the concentrations reported at MCC, where mortality was observed during in situ experiments. Therefore, resident fish at LCC may have acclimated to the elevated concentrations of metals. Simultaneously, a metabolic cost of acclimation may be expressed at LCC because acclimation coincides with a decreased mass (kg) of trout in LCC, though not decreased growth.

Metallothioneins are proteins that bind metals and may play a role in the acclimation of fish to metals (Stegeman et al. 1992). Marr et al. (1995) demonstrated that a physiological cost of acclimation exists for brown trout in the Clark Fork River, Montana, where trout acclimated to metals in the river had elevated concentrations of metallothionein in their livers and grew less than trout not acclimated to the metals. Furthermore, Dixon and Sprague (1981) concluded that decreased growth resulted from the metabolic costs associated with acclimation to Cu in the laboratory. Rainbow trout from LCC had elevated metallothionein in their livers. Similar to Marr et al. (1995), we found metallothionein to be greatest in the livers of fish that also had the greatest concentrations of metals in the liver.

The greater amounts of products of lipid peroxidation in the livers of LCC fish, further indicates their compromised health. Peroxidation of fatty acid side chains in cell membranes can change the structural integrity of cell membranes and may lead to cell death and tissue damage (Halliwell and Gutteridge 1985; Wills 1985). These findings imply that the livers of trout in LCC are compromised, and this state is associated with elevated concentrations of metals in the liver (As, Cu, Cd, Pb, and Zn) that exceed the concentrations at the reference site (UBR). In fact, the copper concentraion (>1,000 μg/g) at LCC is much greater than the upper limit of an effect concentration of 480 μg Cu/g suggested by Farag et al. (1995) for the Clark Fork River, Montana.

The weighted usable area suggests that habitat differences explain some of the difference in the biomass and density between LCC and the reference site (UBR). For all three life stages, LCC had an average of 91% and 78% of the weighted usable area that the reference site had for brook and rainbow trout, respectively. However, the extent of the reduced biomass and density at LCC cannot be explained completely by habitat differences. The number of trout per 300 m of stream bed in LCC was only 36% of the number calculated for UBR, and on an area basis, the reduction in biomass in LCC was even greater, being 20% of the amount in UBR. This biomass difference between LCC and the UBR was much greater than the difference in weighted usable area. Thus, it is unlikely that habitat differences are sufficient to explain the reduced biomass at LCC.

We observed decreases in the number per 300 m and in kilograms per hectare of trout at LCC but did not observe differences among sites in the lengths –at age for rainbow trout. However, the lower density of trout at LCC may have masked the growth-suppressing effects of metals. Jenkins et al. (1999) found that growth of individual brown trout increased with lower densities. During electrofishing activities on Cataract Creek, we only collected fish from what we observed to be the most energy-efficient feeding locations, which may have allowed for good growth (Bachman 1984).

These observations of compromised aquatic health coincide with elevated concentrations of metals in the water column of LCC (median dissolved concentrations under low-flow conditions: 4.9 μg Cd/L, 22 μg Cu/L, and 397 μg Zn/L) compared with the UBR reference site (<0.3 μg Cd/L, <1 μg Cu/L, and <1 μg Zn/L). Concentrations of metals in sediment, biofilm, and invertebrates were also elevated (Fey et al. 1999; Farag et al. unpublished data) at this site, which suggests that fish are accumulating metals through both water and dietary pathways.

Mottled sculpin were not found at LCC, where the concentrations of Zn in the water were 14 times greater than the concentrations found to cause 32% mortality in wild mottled sculpin (Woodling et al. 2002). Woodling et al. (2002) attributed the lack of sculpin at sites on the Eagle River, Colorado, to elevated Zn in the water column. They noted that sculpin were not present in the Eagle River, Colorado, when concentrations of Zn ranged from 315 to 711 μg/L, but they observed some sculpin at a site further downstream with less Zn (<166 μg/L). Our data support the findings of Woodling et al. (2002) because sculpin were not found at LCC but were observed at LBC (63 μg Zn/L) and the URB reference site (<1 μg Zn/L).

The water quality in BMT, JC, MCC, USG, and to a lesser degree LHO and UHO may render the survival of trout in these reaches unlikely and these areas may act as barriers to limit the colonization of upper reaches of the Boulder River watershed. Additionally, because biomass and density are decreased, and metallothionein, products of lipid peroxidation, and tissue metals are simultaneously increased in resident fish at LCC, we conclude that the aquatic health of LCC is compromised. Furthermore, the association of elevated metal concentrations in tissue, water, and sediment lead us to conclude that metals are the cause of the compromised aquatic health in LCC. Therefore, resident fish populations would benefit greatly if cleanup efforts were directed to minimize the concentrations of metals in the water, sediment, and biota of LCC downstream from USG.

There are also elevated metal concentrations (As, Cd, Cu, Pb, and Zn) in some tissues of trout from LBC and BRGG. Lowe et al. (1985) and Schmitt and Brumbaugh (1990) reported the 85th percentiles (values for which 85% of samples are below) were 1.1 μg As/g, 0.33 μg Cd/g, 5.0 μg Cu/g, 1.31 μg Pb/g, and 201 μg Zn/g for whole fish collected from over 100 stations across the United States (80% moisture was assumed to calculate μg/g dry weight). The mean concentrations of metals in whole fish collected from LCC, LBC, and BRGG exceeded these 85th percentiles (e.g., Cd was >121 times the 85th percentile at LCC, >60 times at LBC, and >60 times at BRGG and As in whole fish was 8 times at LCC, 6 times at LBC, and 3 times at BRGG).

Although the concentrations of metals in fish from LBC and BRGG are greater than fish sampled from across the country, the concentrations were not as great as those at LCC, nor did we observe significant changes in kilograms of trout per hectare, metallothionein, or lipid peroxidation at LBC or BRGG. Therefore, the impacts of metals at these two sites are less than at LCC. This study provides a baseline of data for monitoring efforts in the future. As remediation proceeds in Basin and High Ore creeks, monitoring efforts that include the LBC and BRGG sites could document improved conditions or changes due to inadvertent releases of metals downstream when the tailings are disturbed.

Fey et al. (1999; Farag, unpublished data) found that As is elevated in the sediment, invertebrates, and fish of BRGG. The target organ of As toxicity is the skin (Goyer 1986), so the dark coloration and increased accumulation of melanocytes observed in the skin of fish held at LHO (located upstream of BRGG) during the on-site survival experiments may have been caused by the elevated arsenic present at this site. Obvious changes in coloration were observed during the necropsy evaluations, but histological evaluations are necessary to observe more subtle changes, such as increased numbers of melanocytes. Additionally, color changes during necropsies may not always be observed because there is an immediate loss of melanocyte regulation and control at death. For these reasons, we suggest that histological analyses be added to future assessments of aquatic health in an effort to more completely document any tissue pathology.

In this study, we used fish biomass and density estimates along with health assessments of individual fish to define the overall aquatic health of the Boulder River watershed. Combining toxicity studies, fish biomass and density estimates, and fish health assessments within a systematic design is an important accomplishment of this study. This study defines physiological changes that are linked to a biomass and density effect of elevated metals in the watershed. Although this concept is logical, it is unfortunately novel in application. We have performed health assessments of resident fish in three watersheds in the western United States: the Boulder River watershed (this study), the Coeur d'Alene River watershed (Woodward et al. 1999), and the Clark Fork River watershed (Farag et al. 1995). In each of these three watersheds, metallothionein measurements and tissue metal accumulations are related to decreased biomass and density estimates (Coeur d'Alene watershed and Boulder River watershed) or effects on growth measured as length at age (Clark Fork watershed). Lipid peroxidation is related to decreased biomass and density estimates or decreased growth in two of the three watersheds (lipid peroxidation was not measured by Woodward et al. 1999).

In summary, we studied population-level effects (survival) and biomass and density and individual-level effects to assess aquatic health in the Boulder River watershed, Montana. This study provides evidence that elevated concentrations of Cd, Cu, and Zn cause mortality in tributaries of Basin and Cataract creeks and in High Ore creek. Furthermore, the health of acclimated fish at these concentrations is impaired, as we observed at LCC. The aquatic health of trout at lower Cataract Creek is compromised, as indicated by the association of increased metallothionein, lipid peroxidation, and metal concentrations in tissues and a reduced number of trout per 300 m of streambed.

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ATTACHMENT 4

Wabanaki Traditional Cultural Lifeways Exposure Scenario

Netukulimk refers to the Mikmaq way of natural resource conservation and stewardship. The root words mean getting provisions and making a livelihood from the land, and elders translate it as 'taking only what you need in order to avoid not having enough.' ***Barsh, 2002***

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Penobscot Watershed.

Most of the following information is taken from http://www.mainerivers.org/penobscot.html. The Penobscot Rivershed spans the middle third of the state. New England's second largest river system, the Penobscot, drains an area of 8,570 square miles. Its West Branch rises near Penobscot Lake on the Maine/Quebec border; and the East Branch at East Branch Pond near the headwaters of the Allagash River. The river's total fall from Penobscot Lake on the South Branch is 1,602 feet. Tidal movement reaches as far inland as Bangor. Terrain ranges from steep mountains including Maine's highest, Mt. Katahdin, rolling hills and extensive bogs, marshes and wooded swamps. The Penobscot River is currently home to many fish, including native brook trout, landlocked salmon, smallmouth bass (non-native), white perch and chain pickerel are prevalent resident species. Sea-run species include Atlantic salmon, alewives, American shad, American eel, sea lamprey, striped bass, tomcod, rainbow smelt and occasional Atlantic sturgeon. Many place names and family names reflect fish, such as the translations 'shad place,' 'clam place,' 'place of overgrown eels', and 'abundance of eels' (Kenduskeag, or Bangor) (Penobscot Nation 2001; Prins, 1994; Speck, 1997). Most sea-run species are found in numbers far below historic levels because of non-existent or inadequate fish passage facilities on main-stem and tributaries, past pollution, and loss of habitat due to dam construction. The Penobscot is best known for its large historic salmon run (50,000 or more adults) and its much smaller contemporary run, which is nevertheless the largest Atlantic salmon run remaining in the United States.

St. John Watershed

One of the largest river basins on the East Coast, the St. John drains over 21,000 square miles of land. Its upper portions are some of the most remote stretches of river in all New England. Its length is 410 miles, and its discharge at the mouth is 25.5 billion gallons/day.

Kennebec Watershed

Originating from Moosehead Lake and the Moose River, the Kennebec flows gently for much of its course. The river had perhaps the most magnificent runs of anadromous fish on Maine's coast. Atlantic salmon, alewives, shad, sturgeon and striped bass all swarmed far upstream to spawning grounds. Its length is 230 miles, it drains an area of 5,870 square miles, and its discharge at Merrymeeting Bay is 5,893 million gallons/day.

Central Coastal Watershed

These rivers along the central coast of Maine are relatively short and drain much less of an area than the northern rivers. Several, like the Sheepscot and Ducktrap, still support small runs of anadromous fish.

Eastern Coastal Watersheds

The rivers along the Eastern coast of Maine are gentle- flowing and relatively undeveloped. These rivers are some of the last to support wild Atlantic salmon runs.

> fish at Treat's falls in a short time; we would sometimes take forty salmon in a day, and I think as many as five hundred were taken some days, in all. My father had a large seine in the eddy, just above the Bangor bridge, and we had much trouble with the sturgeon."

Currently the number of rivers supporting Atlantic salmon runs is greatly reduced, and the runs are primarily supported through stocking with hatchery fish.[20] In eight rivers - all in Maine (Sheepscot, Ducktrap, Cove Brook, Pleasant, Narraguagus, Machias, East Machias and Denys) the salmon are considered still wild (i.e. genetically correspond to historic populations), but endangered. The greatest remaining Atlantic salmon river in New England is the Penobscot. The recovery of Atlantic salmon on the Penobscot River likely depends on a return of healthy populations of alewives, blueback herring, American shad and other sea-run species (http://penobscotriver.org/)

Atlantic Pollock *(Pollachius virens)* is another important (non-anadromous) marine fish. The word Passamaquoddy is derived from "peskotomuhkatiyik" or people of the Pollock. Pollock is "peskotom." Pollock are predatory and chase schools of fish such as herring, and would arrive in great numbers along the coast at Pleasant Point. A watcher would report to the community that the Pollock were there, and the community would participate in pulling the pollock out by hand or with spears[21].

[20] http://www.mainerivers.org/atlantic_salmon.html
[21] Personal communication from Passamoquoddy cultural department.

particular, the literature describing complete and traditional food systems (for example, 3000 kcal; Brand-Miller, 1998) is very limited; most reports examine contemporary hybrid natural-western diets rather than describing the baseline fully subsistent diet.

The following pages show the nutritional information for the three Maine diets. Information is presented for average adults, and may be scaled up (athletes) or down (elders, children). As mentioned, iteration between estimated percent of calories and estimated quantities for each food category resulted in our best judgment of the complete diets. These estimates are based on a general consideration of resources present and reported to be used combined with nutritional information, but are not derived as statistically-derived calculations with ranges because that level of precision would not be warranted.

These diets are reasonable representations across locales within a general ecoregion, genders, seasons, and age groups (excepting children's diets, which were not estimated). The terminology for the three Maine diets is:

- "Inland-Anadromous" refers to inland communities living on rivers with anadromous fish runs;
- "Inland Non-Anadromous" refers to inland communities without access to anadromous fish runs;
- "Coastal" refers to communities living where coastal resources are available.

Table 2. Inland-Anadromous Diet

Inland - ANADROMOUS				
Food Category	***% of 2000 kcal***	***Equivalent kcal day***	***Rep kcal/ 100g***	***Grams per day***
Resident fish and other aquatic	10	200	175	114
Anadromous & marine fish, shellfish	35	700	175	400
Game, large and small	30	600	175	343
Fowl & Eggs	7	140	200	70
Bulbs	2	40	30	133
Berries, Fruits	2	40	100	40
Other vegetables	2	40	100	40
Greens, Tea	2	40	30	133
Honey, Maple Syrup, Other	2	40	275	15
Seeds, Nuts, Grain	6	120	500	24
Roots, Bulbs, Tubers	2	40	100	40
TOTALS	***100***	***1960***		***1312***

ATTACHMENT 5

Conserving the Eastern Brook Trout: Action Strategies

Prepared by:
Conservation Strategy/Habitat Work Group
Eastern Brook Trout Joint Venture

January 2011

Pennsylvania's Brook Trout Conservation Strategies

Background

Brook trout are the only native stream dwelling salmonid to Pennsylvania waters and are the official state fish. They are important to Pennsylvania not only from the many hours of recreational angling opportunities they provide but also as a symbol of our state's rich outdoor heritage. Despite numerous changes that have occurred in Pennsylvania's landscape since the pre-colonial era, brook trout continue to be distributed over a broad range of the state. Based on stream examination information collected by the Pennsylvania Fish & Boat Commission since 1976, wild brook trout populations have been documented in 1,524 stream sections covering a total of 5,044 miles of streams. This figure provides a conservative estimate of the miles of stream inhabited by wild brook trout in Pennsylvania, as it includes only those waters where wild brook trout populations have been confirmed via stream survey information. There are numerous miles of first and second order streams in Pennsylvania that have not been inventoried to date.

Over time, industrialization and urbanization have altered the distribution and abundance of brook trout across the Commonwealth. Pennsylvania was once dominated by vast stands of hemlock trees; these were essentially eliminated during the lumbering era during the late 1800's and early 1900's. The result of widespread lumbering led to increased erosion and elevated water temperatures, which undoubtedly caused many streams to become unsuitable for brook trout. Pennsylvania has also been a leading producer of coal which, following extraction, often resulted in chronic pollution from acid mine drainage. Currently, approximately 2,500 miles of flowing water are affected by acid mine drainage in Pennsylvania. Many of the streams affected by acid mine drainage historically supported wild brook trout.

The primary strongholds for wild brook trout populations occur within the Northern Tier and Center regions of Pennsylvania. For example, 1,875 miles of wild brook trout streams exist within the West Branch Susquehanna River basin, followed by 942 miles of stream within the upper Allegheny River basin, and 936 miles of stream within the North Branch Susquehanna River basin. Collectively, these three major drainage basins support 74.4% of the documented miles of wild brook trout streams in the state.

Overall, wild brook trout are the only species of salmonid that inhabit 607 sections of stream covering 1,730 miles of water. Currently, 247 stream sections and 679 miles of Pennsylvania streams have been designated as Class A wild brook trout waters. Class A wild brook trout waters are defined as those stream sections that support a minimum of 30 kg/ha of wild brook trout with a minimum of 0.1/kg/ha of wild brook trout less than 15 cm, and where brook trout biomass must comprise a minimum of 75% of the wild trout biomass within the stream section.

In Pennsylvania streams, wild brook trout often occur in combination with wild brown trout (596 sections, 1,984 miles) and to a much lesser degree in combination with wild rainbow trout populations (22 sections, 61.61 miles). Of the 5,044.3 miles of stream that support some level of brook trout reproduction, a total of 299 sections and 1,268.65 miles are also stocked with hatchery trout.

Although Pennsylvania supports a considerable wild brook trout resource, much of this resource is fragmented and primarily exists in first and second order headwater streams. Major threats to wild brook trout populations in Pennsylvania include poor land use practices stemming from agriculture and urbanization, sedimentation from road construction and dirt and gravel roads, water temperature elevations stemming from storm water runoff and the loss of riparian vegetation along the stream corridor, and the presence of non-native species such as, brown trout. Other threats include acid precipitation and acid mine drainage that continue to have a negative impact on water quality on a regional basis across the state.

The strategies outlined in this report are designed to focus on improving conditions for wild brook trout populations on a statewide basis. These should include preserving conditions for existing populations and enhancing conditions to allow wild brook trout to expand beyond their current range of waters.

Priority 1: Habitat Protection

Short Term Goal

1.1. Protect brook trout habitat.

Strategy 1.1.1. Coordinate with state and federal regulatory agencies to provide maximum protection of brook trout habitat within current regulatory standards.

Strategy 1.1.2. Incorporate recommendations and establish goals within local and regional watershed planning documents (river conservation plans, Chesapeake Bay Program, Delaware Estuary Program, etc.) to increase awareness and advance wild brook trout habitat protection.

Long Term Goal

1.2. Improve brook trout habitat.

Strategy 1.2.1. Pursue conservation easements on private property to provide protection to high value wild brook trout habitat.

Strategy 1.2.2. Coordinate with owners to implement conservation practices to protect wild brook trout habitat on private lands.

Strategy 1.2.3. Coordinate with appropriate state and federal agencies and local governments to implement conservation practices to protect wild brook trout habitat on public lands.

ATTACHMENT 6

U.S. Fish & Wildlife Service

Critical Habitat

What is it?

When the Fish and Wildlife Service proposes a species for listing under the Endangered Species Act, we are required to consider whether there are geographic areas that contain essential features on areas that are essential to conserve the species. If so, we may propose designating these areas as critical habitat.

Here are answers to some of the most frequently asked questions about critical habitat.

What is critical habitat?

Critical habitat is the specific areas within the geographic area, occupied by the species at the time it was listed, that contain the physical or biological features that are essential to the conservation of endangered and threatened species and that may need special management or protection. Critical habitat may also include areas that were not occupied by the species at the time of listing but are essential to its conservation.

An area may be excluded from critical habitat designation based on economic impact, the impact on national security, or any other relevant impact, if we determine that the benefits of excluding it outweigh the benefits of including it, unless failure to designate the area as critical habitat may lead to extinction of the species.

Critical habitat designations affect only Federal agency actions or federally funded or permitted activities. Critical habitat designations do not affect activities by private landowners if there is no Federal "nexus"—that is, no Federal funding or authorization. Federal agencies are required to avoid "destruction" or "adverse modification" of designated critical habitat. The ESA requires the designation of "critical habitat" for listed species when "prudent and determinable."

Photo of Ash Meadows National Wildlife Refuge
by Mike Bender, USFWS
Photo of the Devil's Hole pupfish
by Olin Feurerbacher, USFWS

What provisions of the Endangered Species Act relate to critical habitat?

To protect endangered and threatened species, the ESA makes unlawful a range of activities involving such species without a permit for purposes consistent with conservation goals of the ESA. These activities include take, import, export, and interstate or foreign commerce. "Take" includes kill, harm, harass, pursue, hunt, capture, or collect or to attempt to engage in any such conduct.

The ESA requires Federal agencies to use their authorities to conserve endangered and threatened species and to consult with the Fish and Wildlife Service about actions that they carry out, fund, or authorize to ensure that they will not destroy or adversely modify critical habitat. The prohibition against destruction and adverse modification of critical habitat protects such areas in the interest of conservation.

How does the Fish and Wildlife Service determine areas to designate as critical habitat?

Biologists consider physical and biological features that the species needs for life processes and successful reproduction. These features include:

- space for individual and population growth and for normal behavior;
- cover or shelter;
- food, water, air, light, minerals, or other nutritional or physiological requirements;
- sites for breeding and rearing offspring, germination, or seed dispersal; and

Myths & Realities

Does designating critical habitat mean no further development can occur?

No. A critical habitat designation does not necessarily restrict further development. It is a reminder to Federal agencies of their responsibility to protect the important characteristics of these areas.

Does a critical habitat designation affect all activities that occur within the designated area?

No. Only activities that involve a Federal permit, license, or funding, and are likely to destroy or adversely modify critical habitat will be affected. If this is the case, we will work with the Federal agency and landowners—including private landowners—to amend their project to enable it to proceed without adversely affecting critical habitat. Most Federal projects are likely to go forward, but some may be modified to minimize harm.

- habitats that are protected from disturbances or are representative of the historical geographical and ecological distributions of the species.

What is the process for designating critical habitat?

The Service may propose to list a species and concurrently propose to designate critical habitat, or it can address a species' critical habitat up to a year after the date of its listing. The Service proposes a critical habitat designation, publishing it in the *Federal Register* and requesting public comments. We may modify a proposal as a result of information provided in public comments. We base our final designation of critical habitat on the best scientific data available, after taking into consideration the probable economic and other impacts of the designation. After reviewing the comments, the Service responds to them and publishes a rule, including final boundaries, in the *Federal Register*.

Are Federal agencies required to consult with the Fish and Wildlife Service outside critical habitat areas?

Yes, even when there is no critical habitat designation, Federal agencies are required to fulfill their conservation responsibilities by consulting with the Service if their actions "may affect" listed species. The requirement helps to ensure that Federal agencies do not contribute to the decline of endangered and threatened species or their potential for recovery.

What is the purpose of designating critical habitat?

Designating areas as critical habitat does not establish a refuge or sanctuary for a species. Critical habitat is a tool to guide Federal agencies in fulfilling their conservation responsibilities by requiring them to consult with the Service if their actions may "destroy or adversely modify" critical habitat for listed species. A critical habitat designation helps to protect areas—occupied and unoccupied—necessary to conserve a species. Critical habitat has value in requiring the Service to gather more detailed information about a species than what is required for listing, thereby increasing knowledge to share with Federal agencies—and, in turn, increasing their effectiveness to conserve a listed species.

Are all the areas within the mapped boundaries considered critical habitat?

No. Our rules typically exclude developed areas such as buildings, roads, airports, parking lots, piers, and similar facilities. Accompanying text describes those areas.

Critical habitat is designed to protect the essential physical and biological features of a landscape and essential areas in the appropriate quantity and spatial arrangement that a species needs to survive and reproduce and ultimately be conserved.

Does the ESA require consideration of economic impacts as part of designating critical habitat?

Yes. The Service is required to consider potential economic impacts, as well as any other benefits or impacts of designating critical habitat—and may exclude an area if the benefits of excluding it outweigh the benefits of including it unless that would result in the extinction of the species.

Do economic considerations affect decisions to list a species as an endangered or threatened species?

No, the Act requires listing decisions to be made solely on the basis of the best available scientific and commercial information.

What is the impact of a critical habitat designation on economic development?

Most activities that require consultation by Federal agencies proceed without modification. In areas where the species is not present, some project modifications that would not have occurred without the critical habitat designation may be required. For example, the U. S. Army Corps of Engineers may schedule a beach renourishment project—that is, adding sand to a beach to stabilize it—before or after the nesting season of sea turtles to avoid harm to the sea turtles, their eggs, or their hatchlings.

Which species have critical habitat designated?

A list of all ESA protected species with designated critical habitat can be viewed online at https://ecos.fws.gov/ecp/report/table/critical-habitat.html

U. S. Fish and Wildlife Service
Endangered Species Program
5275 Leesburg Pike
Falls Church, VA 22041
703-358-2171
http://www.fws.gov/endangered/

March 2017

ATTACHMENT 7

Freshwater Fish Safe Eating Guidelines

April 2023 - The Maine CDC issued additional freshwater fish consumption advisories on six waterbodies in Maine. The updated advisories come after testing of fish in these locations found levels of per- and polyfluoroalkyl substances (PFAS) above Maine CDC's recommended levels for regular consumption. View the table of PFAS Guidelines. Download a tipsheet (PDF) on frequently asked questions and answers about the new advisories. Read the Press Release.

Fish are an important part of a healthy diet. However, some freshwater fish have PFAS, mercury, PCBs, and Dioxins in them. The Maine CDC issues safe eating guidelines for fish based on the presence of each of these chemicals. Follow the Mercury Guidelines, PFAS Guidelines, and Additional Guidelines below.

Mercury in Fish Guidelines

Warning: Mercury in Maine freshwater fish may harm the babies of pregnant and nursing mothers, and young children.

It's hard to believe that fish that looks, smells, and tastes fine may not be safe to eat. But the truth is that fish in Maine lakes, ponds, and rivers have mercury in them. Other states have this problem too. Mercury in the air settles into the waters. It then builds up in fish. For this reason, older fish have higher levels of mercury than younger fish. Fish (like pickerel and bass) that eat other fish have the highest mercury levels.

Safe Eating Guidelines: Mercury

Who	Guidleines
Pregnant and nursing women, women who may get pregnant, and children under age 8	DO NOT EAT any freshwater fish from Maine's inland waters. Except, for brook trout and landlocked salmon, 1 meal per month is safe.
All other adults and children older than 8	CAN EAT 2 freshwater fish meals per month. For brook trout and landlocked salmon, the limit is 1 meal per week.

Small amounts of mercury can harm a brain starting to form or grow. That is why unborn and nursing babies, and young children are most at risk. Too much mercury can affect behavior and learning. Mercury can harm older children and adults, but it takes larger amounts. It may cause numbness in hands and feet or changes in vision. The Safe Eating Guidelines identify limits to protect everyone. Download the Maine Family Fish Guide for tips on buying, cooking, and catching fish low in mercury.

PFAS in Fish Scientific Brief

Read the 2023 Scientific Brief (PDF) from Maine CDC about PFAS in recreationally caught freshwater fish.

(posted 04/27/2023)

Other Fish & Game Guidelines

- Fish and Game Safe Eating Guidelines
- Saltwater Fish Safe Eating Guidelines
- Choose Fish Low in Mercury
- Healthy Fish Preparation Methods

(posted 10/20/2021)

PFAS in Fish Guidelines

Fish tested in several locations found levels of per- and polyfluoroalkyl substances (PFAS) above Maine CDC's recommended levels for regular consumption. Exposure to certain PFAS chemicals has been associated with:

- changes in liver and kidney function,
- changes in cholesterol levels,
- decreased immune response to vaccines in children,
- complications during pregnancy, and
- increased risk of kidney cancer and possibly testicular cancer.

Limit or eliminate consumption of all fish or certain fish species from these waterbodies.

Safe Eating Guidelines: PFAS

Area	Waterbody	Guidleines
Albion	Fifteenmile Stream from the Yorktown Brook inlet at the Hussey Road to Route 137/202 in Albion	No more than 2 meals per month of brook trout.
China	All of China Lake	No more than 1 meal per month of any fish species.
Fairfield	Fish Brook, including any tributaries, from the headwaters to the confluence with Messalonskee Stream	Do not eat any fish from these waters.
Fairfield	Police Athletic League (PAL) Ponds	Do not eat any fish from these waters.
Fairfield	Kennebec River from the Carrabassett Stream inlet just north of Route 23 to the Lockwood Dam in Waterville	No more than 9 meals per year of smallmouth bass.
Limestone	All of Durepo Pond and Limestone Stream from Durepo to the Canadian border	No more than 4 meals per year of brook trout and do not eat smallmouth bass from these waters.
Sanford/Alfred	The Mousam River from below the Number One Pond Dam to Outlet Dam on Estes Lake, including all of Estes Lake	No more than 3 meals per year of any fish species.
Sanford	All of Number One Pond	No more than 1 meal per month of largemouth bass.
Thorndike/Unity	Halfmoon Stream from the Shikles Road in Thorndike to the Berry Road in Unity	No more than 2 meals per month of brook trout.
Unity	Unity Pond	No more than 6 meals per year of black crappie and no more than 12 meals per year for all other fish species.
Waterville/Oakland	Messalonskee Stream from the Rice Rips Dam in Oakland to the Automatic Dam in Waterville	No more than 3 fish meals per year of any fish species.
Westbrook/Falmouth	The Presumpscot River from Saccarappa Falls in Westbrook to Presumpscot Falls in Falmouth	No more than 4 fish meals per year of any fish species.

Additional Fish Guidelines: PCBs, Dioxins, and DDT

Warning: Some Maine waters are polluted, requiring additional limits to eating fish.

- Fish caught in some Maine waters have high levels of PCBs, Dioxins or DDT in them.
- These chemicals can cause cancer and other health effects.

The Maine Center for Disease Control and Prevention recommends additional fish consumption limits on the waters listed below. Remember to check the mercury guidelines. If the water you are fishing is listed below, check the mercury guideline above and follow the most limiting guidelines.

Safe Eating Guidelines: PCBs, Dioxins, and DDT

Area	Guidleines
Androscoggin River Gilead to Merrymeeting Bay:	No more than 6-12 meals a year of any fish species.
Dennys River Meddybemps Lake to Dead Stream:	No more than 1-2 meals per month of any fish species.
Green Pond, Chapman Pit, & Greenlaw Brook	Do not eat any fish from these waters.
Little Madawaska River & tributaries(Madwaska Dam to Grimes Mill Road):	Do not eat any fish from these waters.
Kennebec River Augusta to the Chops:	Do not eat any fish from these waters.
Shawmut Dam in Fairfield to Augusta:	No more than 5 meals per year of trout and no more than 1-2 bass meals per month.
Madison to Fairfield:	No more than 1-2 meals a month of any fish species.
Meduxnekeag River:	No more than 2 meals a month of any fish species.
North Branch Presque Isle River	No more than 2 meals a month of any fish species.
Penobscot River below Lincoln:	No more than 1-2 meals a month of any fish species.
Prestile Stream:	No more than 1 meal a month of any fish species
Red Brook in Scarborough:	No more than 6 meals a year of any fish species.
Salmon Falls River below Berwick:	No more than 6-12 meals a year of any fish species.
Sebasticook River (East Branch, West Branch & Main Stem)(Corinna/Hartland to Winslow):	No more than 2 meals a month of any fish species.

Read about other Fish & Game Guidelines.

Maine Department of Health & Human Services

DHHS Tribal Collaboration Policy (PDF)

Privacy

Division of Disease Prevention

ATTACHMENT 8

Maine Brook Trout Project
267 Scribner Hill Road
Manchester, ME 04351

Stacie R. Beyer, Planning Manager
Land Use Planning Commission

Via Electronic Mail

September 10, 2020

Dear Ms. Beyer:

I am writing on behalf of Trout Unlimited (TU) regarding the Commission's ongoing review of Wolfden Mount Chase LLC's application to rezone its Pickett Mountain Project near Mount Chase. Trout Unlimited is a national conservation organization whose mission is to conserve, protect and restore North America's trout and salmon and their watersheds. We have 6 active chapters and about 2,000 members in Maine. As you are aware, we were deeply involved in Maine's revisions to mining laws and rules from 2013 to 2017. It now appears that the Wolfden application will the first opportunity to use the revised LUPC rezoning process for mining projects. We have been following the application and your review of it since it was initially submitted last January.

The project is proposed in an area that is surrounded by rich natural resources and public lands, including Baxter State Park and the Katahdin Woods and Waters National Monument. Of more direct interest to TU is its setting at the headwaters of the West Branch Mattawamkeag River. The West Branch Mattawamkeag is particularly rich in trout and salmon habitat. The entire West Branch Mattawamkeag, a tributary to the Mattawamkeag and eventually the Penobscot River, is included within designated Critical Habitat for federally endangered sea-run Atlantic salmon. Trout Mattawamkeag River is a tributary to the Penobscot River. Trout Unlimited, through its participation in the Penobscot River Restoration Project with many other partners, spent more than a decade working to remove the Veazie and Great Works Dams and improve fish passage at the Milford Dam, with an eye to restoring Atlantic salmon and other sea run fish to Penobscot River tributaries like the West Branch Mattawamkeag. We are also deeply interested in brook trout habitat in the vicinity of the proposed mine. The West Branch Mattawamkeag River has its ultimate headwaters very near the proposed site of Wolfden's mine and the headwaters are especially rich in native brook trout habitat. Any runoff or discharge from the mine site to surface or ground water will drain to the tributaries of the West Branch Mattawamkeag.

We are writing as you and the Commission members prepare for the September 16 Commission meeting, at which you will discuss Wolfden's request that the Commission exclude information that Commission staff requested from your review of their application. Specifically, Wolfden, in an August

26 letter, has requested that the Commission exclude from its review information and review criteria that Wolfden believes will be covered in more detail in a potential future proceeding under the DEP's Chapter 200 Rules. Wolfden apparently expects the Commission to defer to DEP's review of these issue, and to either not evaluate them in the context of the current Rezoning Petition, or to review them without information the Commission staff have identified as necessary.

Of particular concern to TU are Wolfden's objections to Commission requests for information relating to potential impacts to resources and existing uses, particularly impacts to fish habitat and recreational angling; information relation to waste disposal and the mine's potential impacts on surface and groundwater quality (at the headwaters of a watershed with high value habitat brook trout and endangered Atlantic salmon that has long been enjoyed by Maine anglers); and information related to Wolfden's technical and financial capacity. The Commission must have enough information to evaluate these issues before approving a rezoning petition.

We also want to note some specific weaknesses we have identified in our review of the materials Wolfden has submitted to date—deficiencies that are directly related to the information LUPC staff are now requesting.

1. <u>Wolfden's description of the fisheries resources of the Upper West Branch Mattawamkeag River is woefully incomplete</u>. The application does not acknowledge that this proposal is being made on a parcel that is within designated Critical Habitat for endangered Atlantic salmon, and indeed there is no reference at all to Atlantic salmon or salmon habitat in the application package. The application acknowledges that native brook trout are present in the Upper West Branch Mattawamkeag watershed, but their discussion of that resource is limited to three paragraphs:

   > *The proposed development is not adjacent to the shoreland of a lake. Lakes within a one-mile radius include Pickett Mountain Pond and within a 3-mile radius include Pleasant Lake and Mud Lake and several smaller ponds including Bear Mountain Pond, Tote Road Pond, Grass Pond, Duck Pond and Huntley Pond.*
   >
   > *Pickett Mountain Pond, Pleasant Lake, Mud Lake Tote Road Pond and Grass Pond have been surveyed and were in general found to be shallow and muddy with uniform temperatures at all depths in summer months lacking desirable conditions for cold water species such as brook trout or salmon. The inlet and outlet streams however do provide habitat as spawning and nursery areas for trout.*
   >
   > *As discussed in Appendix A Section B(3)(d) water management and treatment will preclude water quality impacts to these lakes and ponds and associated streams. The proposed mining activities will in no way impact recreational use of these lakes or use of the surrounding area.*[1]

   Bill Bridgeo's May 13, 2020 letter provides a more accurate assessment of the native brook trout and landlocked salmon resource in these lakes and streams, and

[1] Wolfden Zoning Petition Form, revised June 30, 2020, page 46.

document his use and enjoyment of the fishery they provide over more than 50 years: *"[T]hese waters have been and continue to be some of the best brook trout and landlocked salmon fisheries I have experienced since my boyhood adventures in the wild expanses of northern Maine in the 1950's and 1960's."*

Publicly available information on the Maine Department of Inland Fisheries and Wildlife's website[2]—and viewable in a web-based GIS interface on the state's "Maine Stream Habitat Viewer"[3]—indicate that Pleasant Lake, Mud Lake and Grass Pond are designated as "State Heritage Fish Waters", indicating that they contain wild brook trout populations, have not been stocked with brook trout or any other fish for at least 25 years, and have specific legislative policy that restricts fish stocking and the use of live fish as bait to protect their unique brook trout resources. Pleasant and Mud Lakes were last stocked in 1956; Grass Pond has never been stocked.

Pickett Mountain Stream (above and below Pickett Mountain Pond), the West Branch of the Mattawamkeag River (from above Pleasant Lake to Rockabema Lake and continuing downstream to its confluence with the Mattawamkeag), and all of their tributaries are mapped in the Maine Stream Habitat Viewer as both "wild brook trout habitat" and as "modeled rearing habitat" for endangered Atlantic salmon. Notably, the West Branch Mattawamkeag and its tributaries are also mapped as not containing non-native fish that would compete with brook trout, salmon, and other native fish until downstream of Island Falls.[4] This combination of extensive high value stream habitat for brook trout and salmon connected to multiple designated State Heritage Fish Waters with no known non-native fish introductions is quite rare, even in northern Maine, and especially so at such a low elevation and so close to Route 1. In short, there is a lot more value here for fish habitat and recreational angling than Wolfden has represented.

2. <u>The lack of detail regarding water treatment and discharge in Appendix A, Section B (3)(D) provides no assurance that water quality—and therefore fish habitat—can be protected.</u> Although Wolfden cites this section of the application as evidence that "water management and treatment will preclude water quality impacts to these lakes and ponds and associated streams"[5], Appendix A, Section B (3)(D) does little more than boldly assert that this will occur. What Wolfden is proposing here—to collect and treat mine process, ore extraction, and tailings water, treat all of it, and discharge it to groundwater with no impacts—has, to our knowledge, never been done. The Commission would be remiss to accept this assertion without more detail than the vague generalities in Appendix A, Section B (3)(D).

3. <u>There is good reason to be concerned about Wolfden's financial and technical capacity.</u> Wolfden acknowledges in its application that it has limited financial capacity, that investments in the project to date consist of *"small equity raises and timber sales from*

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[2] Maine Department of Inland Fisheries and Wildlife, List of Designated Maine State Heritage Fish Waters, updated January 1, 2020. Downloaded from https://www.maine.gov/ifw/fish-wildlife/fisheries/wild-brook-trout.html

[3] https://webapps2.cgis-solutions.com/MaineStreamViewer/

[4] https://webapps2.cgis-solutions.com/MaineStreamViewer/

[5] Wolfden Zoning Petition Form, revised June 30, 2020, page 46.

> *the property"*; that *"investors may be more cautious to invest in the project until the principle regulatory requirements (such as rezoning, baseline studies, feasibility studies, and a mining permit) have been successfully completed"*; and that *"this trend will continue for the project until milestones like the rezoning have been achieved"*.[6] This essentially amounts to an admission that the company does not currently have financial capacity for a project of this scale, and a request that the Commission should approve the Petition in hopes that some day they will. With respect to technical capacity, to our knowledge Wolfden has never successfully developed a working mine anywhere in the world—much less the first mine designed to meet Maine's rigorous standards. The lack of attention to detail in the application package they have filed—for example, failing to acknowledge that the project site will drain into waters designated as Critical Habitat for Atlantic Salmon, and describing ponds designated by the Maine Department of Inland Fisheries and Wildlife as "State Heritage Fish Waters" as "lacking desirable conditions for coldwater species"—demonstrate their unfamiliarity with Maine's most important aquatic resources and the attention generally given to them in regulatory processes here.

Commission staff are right to be requesting the additional information requested in the May 27, 2020, Request for Additional Information. It is distressing that rather than address the information needs the Commission has identified, Wolfden is asking the Commission to disregard its own standards and important review criteria in hopes those issues will be addressed at a later date in a yet-to-be-initiated process with the DEP. The rationale for the information you are requesting is clearly laid out in staff's September 8, 2020 memo to the Commission. The "technical feasibility and financial practicability" of the project must be demonstrated before a Wolfden's rezoning petition can be approved. Prior to rezoning these lands the Commission needs to know whether Wolfden is proposing a technically sound and economically feasible development, or a pipe dream financed with the promise of a blank check at some unspecified future date. If it is the latter, Maine would be ill served to rezone the property and hope for the best from an industry with a long record of broken promises and environmental damage, and a company with no track record in Maine. We urge the Commission to dismiss Wolfden's request and continue to allow staff to collect any information they deem necessary to help the Commission make an informed decision.

Sincerely,

Jeffrey M. Reardon

Jeff Reardon
Maine Brook Trout Project Director

[6] Wolfden Zoning Petition Form, revised June 30, 2020, page 133.for

ATTACHMENT 9

WATER QUALITY REQUIREMENT OF ATLANTIC SALMON (*SALMO SALAR*) IN WATER UNDERGOING ACIDIFICATION OR LIMING IN NORWAY

M. STAURNES[1], F. KROGLUND[2] AND B.O. ROSSELAND[3]

[1]*Department of Zoology, University of Trondheim, AVH, N-7055 Dragvoll, Norway.* [2]*Norwegian Institute for Water Research, Regional Office South, Televn. 1, N-4890 Grimstad, Norway.* [3]*Norwegian Institute of Water Research, P.O. Box 173, Kjelsås, N-0411 Oslo, Norway.*

Abstract. Atlantic salmon are severely affected by acidification in Norway. Water quality criteria for the salmon have to be based on the most sensitive stage, the smolt stage. The sensitivity to acidic water increases enormously during smolting, the seawater tolerance being especially vulnerable. Even moderately acidic water (pH about 6) with low inorganic monomeric aluminium (LAl) concentrations (<20 μg L^{-1}) and short-term episodes may be harmful. Mixing zones in limed or unlimed rivers may also represent a problem for seaward migrating smolts. In limed salmon rivers, the national liming goal has been increased to pH 6.5 during smolting (1 February to 1 July) and to 6.2 the rest of the year as a result of our experiments. In contrast to what has been found for brown trout, salmon strains originating from watercources undergoing acidification were not more tolerant than those from non-acidic watercourses. At the moment no such "tolerant" strains are available for restocking limed rivers in Norway.

1. The decline in Atlantic salmon populations: a need for better knowledge about effects of acidification

Atlantic salmon populations in southernmost Norway are severely affected by acidification. Recently, there has been a marked decline in catches in several rivers also in southwestern and western Norway. Because of the influence of marine fisheries and oceanic factors on salmon populations, several hypotheses have been raised. It is, however, reasonable to assume that acidification also has contributed to the decline since decreases in inland fisheries and exceedence of the critical load has been documented in these regions (Kroglund *et al.*, 1994).

At present no established definitions of acidic water quality criteria for Atlantic salmon exist. In the following, we give a preliminary short summary of a series of experiments in water undergoing moderate acidification, or liming, to get such data.

2. The anadromous life pattern make Atlantic salmon especially vulnerable for acidification

SENSITIVITY INCREASE DURING SMOLTING

Atlantic salmon is the most sensitive of the salmonids naturally present in Norway to acidic water, and is more sensitive during parr-smolt transformation than at other stages (Rosseland and Skogheim, 1984; Staurnes *et al.*, 1993a). Several months before fulfilled

Water, Air and Soil Pollution **85**: 347–352, 1995.

parr-smolt transformation the presmolts are very sensitive to acidic water (Henriksen *et al.*, 1984). However, during the few weeks when presmolts develop into seawater-tolerant smolts, they become extremely sensitive (Staurnes *et al.*, 1993a). A week's exposure to acidic water hardly affected presmolts in early April, but was detrimental to smolts in May (Figure 1).

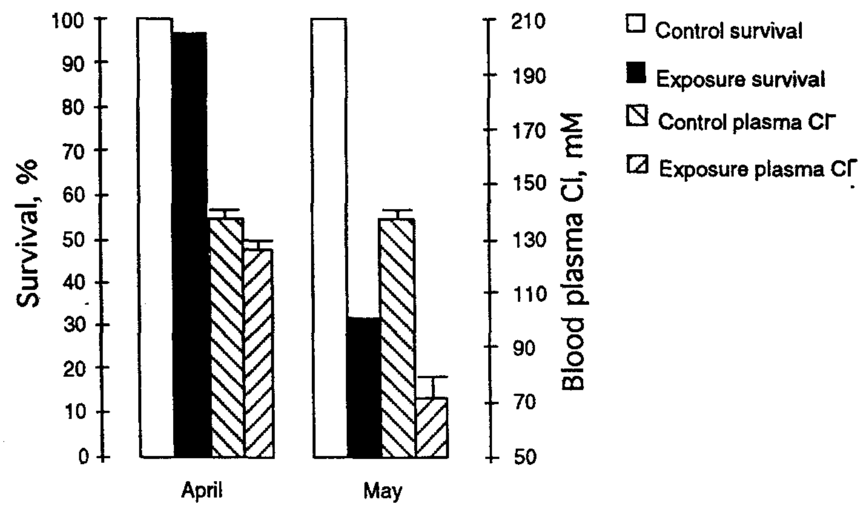


Fig. 1. Survival and blood plasma concentration of Cl^- (mean with SD indicated, N=12) of smolting Atlantic salmon held in water of pH 6.3-6.5 (control) or pH 5 with 50 μg L^{-1} Al added (exposure) in the periods 11-18 April and 16-24 May. After Staurnes *et al.* (1993a).

THE VULNERABILITY OF SEAWATER TOLERANCE: EVEN MODERATE ACIDIFICATION AND SHORT-TERM EPISODES MAY BE HARMFUL

Water quality criteria for Atlantic salmon have to be based on the most sensitive life stage, the smolt stage. This makes the definition more complicated than it is for inland fishes: the criteria can not only be based on effects in freshwater, but they also have to account for possible effects on marine performance. This applies both to the migratory behaviour and seawater tolerance. While possible effects on behaviour are not easily studied (but certainly warrant future research), seawater tolerance can be tested in standard challenge tests.

Such challenge tests have demonstrated that acidic water exposure impairs seawater tolerance during smolting (e.g. Farmer *et al.*, 1989; Kroglund *et al.*, 1993; Staurnes *et al.*, 1993a; Rosseland and Staurnes, 1994). In experiments where smolts were released in an acidic and a neighbouring limed river in southern Norway, challenge tests demonstrated a strong impairment of the seawater tolerance after a short-term exposure in the acidic river, and the marine survival of smolts released in the acidic river was negligible (Staurnes *et al.*, in press). Seawater challenge tests may be indicative for the prospects of survival in sea (See Staurnes *et al.*, 1993b), and should therefore be used as a standard test procedure related to effects of acidic water on smolts.

Because of the enormous sensitivity increase during smolting, Staurnes *et al.* (1993a) and Rosseland and Staurnes (1994) suggested that even moderately acidic episodes of short duration may be critical to salmon smolts, and may possibly lead to reduction of salmon stocks even in rivers that are not chronically acidic and not normally regarded as being in danger of acidification. Therefore, we conducted several experiments to study the effects of such moderate short-term exposures. The results from one of these experiments are shown in Figure 2. Despite no ionoregulatory effects after 12 h exposure in water of pH 5.2 and about 30 µg LAl L^{-1}, the exposure caused a significant reduction in the seawater tolerance.

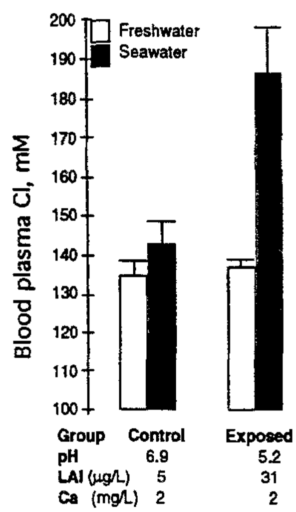


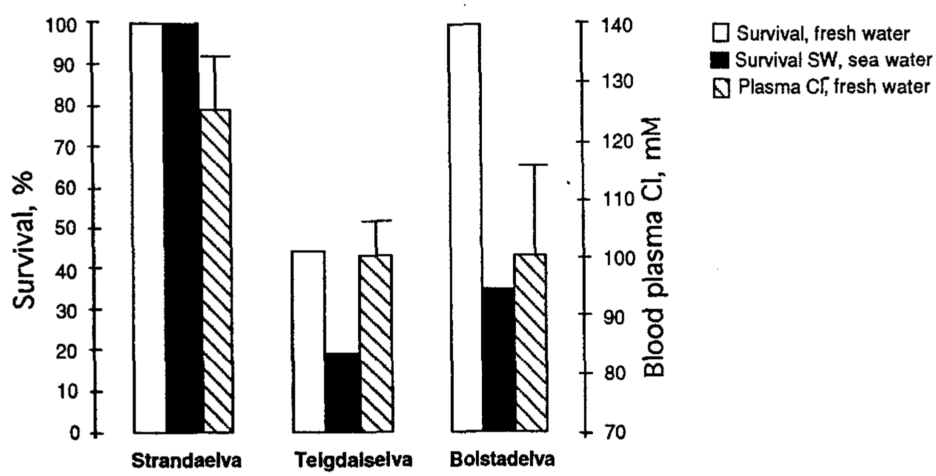
Fig. 2. Blood plasma concentration of Cl^- (mean with SD indicated, N=15) in freshwater or after 24 h in 35 ppt saltwater of Atlantic salmon smolts exposed 12 h in neutral water (control group) or acidic freshwater (exposed group). The fish were exposed to 5 or 31 µg inorganic monomeric aluminium (LAl) L^{-1} respectively.

MIXING ZONES MIGHT REPRESENT A PROBLEM FOR SEAWARD MIGRATING SMOLTS

When acidic water mixes with less acidic or limed water, it creates a zone of unstable Al chemistry. These "mixing zones", where inorganic Al goes from low to high molecular forms and polymerize, are especially toxic to fish. They are sometimes more toxic than the original acidic water, despite a higher pH and lower total Al concentration (Rosseland *et al.*, 1992).

Such mixing zones may be harmful for seaward migrating smolts (Rosseland and Staurnes, 1994). This is true not only in limed rivers receiving acidic water from tributaries, but also in unlimed semineutral rivers with major or minor acidified tributaries. The Vosso river in western Norway could be an example of such a watercourse. Over the last years, there has been a dramatic decline in the salmon catches in this river. Occasionally low pH (<6.0) has been measured in some of the tributaries. Fish kills were for the first time observed during spring 1993.

In an *in situ* experiment with hatchery-reared salmon smolts of the native population, marked differences in effects in freshwater, and especially on seawater tolerance, were observed for smolts exposed one to two weeks at different sites in the watercourse (Kroglund *et al.*, 1993). In the upper part of the River Strandaelva, the smolts behaved normally (Figure 3). In the lower part, both moderately acidic tributaries (e.g. River Teigdalselva) and less acidic tributaries drain into the main river. At all tested sites in this part of the main river, the smolts showed ionoregulatory disturbances in freshwater and low seawater tolerance, including an exposure site not far from the outlet of the river (River Bolstadelva). However, the water pH, LAl and Ca concentrations were not very much different from those measured in River Strandaelva, where the fish in freshwater had normal plasma concentration of chloride (Cl^-) and showed no mortality in seawater (Figure 3). Although there is no chemical evidence to support this, it could be hypothesized that the observed differences in effects are caused by unstable Al chemistry in the main river when acidic and more Al-rich water from tributaries drains into the river. This assumption is supported by the results from laboratory mixing zone experiments (unpubl. data). At the moment, however, the effects and importance of mixing zones for seaward migrating salmon smolts are not fully known, and therefore warrant future investigation.



River sites			
pH	6.1	5.7	6.1
LAl (µg/L)	6	12	7
Ca (mg/L)	1.4	1.5	1.5

Fig. 3. Survival and blood plasma concentration of Cl^- (mean with SD indicated, N=12) in freshwater or after 24 h in 35 ppt saltwater of Atlantic salmon smolts exposed one (River Teigdalselva) or two weeks in the upper part of the Vosso watercourse in western Norway (River Strandaelva), in an acidic tributary in the lower part (River Teigdalselva), or in the main river not far from the outlet (River Bolstadelva). Inorganic monomeric aluminium varied from 6 to 12 µg LAl L^{-1}. After Kroglund *et al.* (1993).

3. Mitigation strategies

If we are to manage Atlantic salmon stocks effectively it is important to establish the minimum water quality criteria that will ensure their existence.

IMPROVEMENT OF WATER QUALITY

In Norway, liming by fine powdered limestone added as slurry with automatic dosers is common. The liming goal is to yield a water quality good enough to ensure a self reproducing and healthy salmon population, but not more than necessary in order to minimize the costs. To attain this goal, it is obviously necessary to have the best possible information about water quality requirements of the fish. Since there always will be Al left in the water after liming of acidic Al-rich water, these requirements will not necessarily be the same as those of non-limed water, e.g. with respect to acidity.

To study these aspects, we conducted *in situ* experiments with hatchery-reared smolts in a river in western Norway (River Vikedalselva) that had been fullscale limed since 1987. The liming did not however bring about the expected increase in the salmon stock. During the smolting period, the river was limed to pH 6.2.

Compared to smolts held in water at pH>6.5, those held one to two weeks at pH<6.2-6.3 had suboptimal smolt quality, as shown by reduced blood plasma Cl^- concentration in freshwater, gill structural changes and Al accumulation, reduced gill Na-K-ATPase activity, and reduced seawater tolerance (Figure 4) (Kroglund and Staurnes, in press; Kvellestad *et al.*, 1995). The water qualities represented by pH values <6.2-6.3 were therefore suboptimal for the salmon smolts even though the concentration of LAI was as low as 15-20 μg L^{-1}.

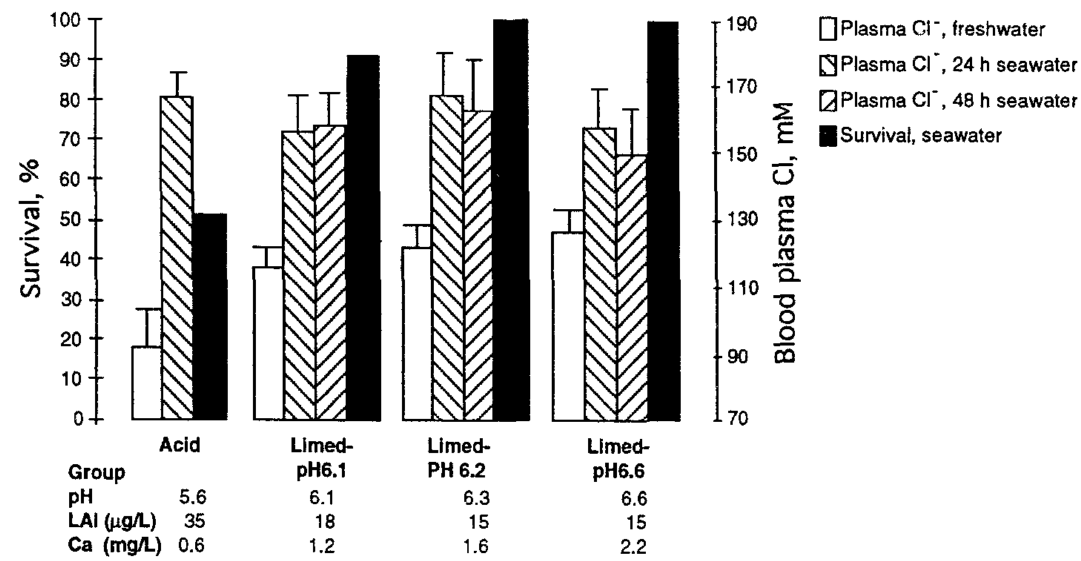


Fig. 4. Survival and blood plasma concentration of Cl^- (mean with SD indicated, N=12) in freshwater or after 24 or 48 h in 35 ppt saltwater of Atlantic salmon smolts exposed two weeks in different water qualities in the limed River Vikedalselva in western Norway, made by liming the acidic water (Acid group) upstream the lime doser. Inorganic monomeric aluminium varied from 15 to 35 μg LAl L^{-1}. After Kroglund and Staurnes (in press).

STOCKING BY "ACID-TOLERANT" STRAINS

In affected rivers still holding fish, stocking is normally only allowed with fish from the native salmon population. When restocking limed rivers were the native population is extinct, however, use of salmon strains that are more resistant to acidic water could be a proper management strategy. For inland brown trout, the existence of such strains is well documented (Dalziel *et al.*, in press).

Therefore, a series of experiments were performed to investigate if strains more resistant to acidic water could also be found for Atlantic salmon (Kroglund *et al.*, 1995). Two or three generations of fish from several strains originating from non-acidic rivers and rivers undergoing early and, at present, still moderate acidification, were tested at different water qualities (pH 4.3-5.8, LAl 50-200 μg L^{-1}, Ca 0.8-1.0 mg L^{-1}), and at different stages (alevins, fingerlings, parr, presmolts and smolts). However, in contrast to what is found for brown trout, the tested salmon strains originating from the watercourses undergoing acidification were not more tolerant than those from non-acidic watercourses. These results do not preclude that such "acid-tolerant" strains of Atlantic salmon exist, but at moment no such strains are available for restocking in limed rivers in Norway.

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ATTACHMENT 10

The Penobscot Nation and the Penobscot River Basin

A Watershed Analysis & Management (WAM) Pilot Project

by the Penobscot Nation
Water Resources Program
Department of Natural Resources
6 River Road, Indian Island, Maine

January 2001

Map 2

Penobscot Watersheds (Sub-Basins)

The Penobscot River Basin can be subdivided into five large watersheds or sub-basins, drained by the West Branch of the Penobscot River, the East Branch of the Penobscot River, the Mattawamkeag River, the Piscataquis River, and the Passadumkeag River.

West Branch - The vast West Branch drainage occupies 25% of the land area in the river basin and contains the largest privately owned hydroelectric complex in the country. The Penobscot name for the West Branch is *Kettetegwewick*, meaning "the main branch." This is the canoe route to Katahdin, the highest mountain in Maine, and the tribe's most sacred place. The West Branch drainage is heavily manipulated for hydropower generation and receives wastewater from two pulp and paper mills and two municipalities.

East Branch - The remote East Branch occupies 13% of the land area in the river basin and is extremely important to the restoration of self-sustaining populations of Atlantic salmon to the Penobscot River drainage. The Penobscot name is *Wassategwewick*, indicating its importance for fishing. Lake Matagamon, at the headwaters, is home to a tribal trust land valued for its fishing and hunting.

Mattawamkeag - The Mattawamkeag is named for the gravel bar that marks the river's confluence with the Penobscot River. This drainage occupies 17% of the land area in the river basin and is characterized by a low relief, numerous bogs and wetlands, and slow run-off.

Piscataquis – The Piscataquis occupies 17% of the land area in the river basin. This "little branch stream" was an extremely important Penobscot travel route and contains significant Atlantic salmon spawning habitat. The Piscataquis River is affected by discharges from two large municipal treatment plants, a textile mill, non-point source pollution from agricultural and forestry operations, and at least six dams.

Lower Penobscot - The lower Penobscot bears the rocky drops (now dammed) that were the basis for the name of the river and the tribe. The majority of Penobscot tribal members live along this stretch of the river. The lower Penobscot drainage contains 28% of the land area in the river basin, and receives the water quality problems that wash downstream from the rest of the river basin. Two kraft mills discharge here and as a result there are fish consumption advisories for dioxins, furans, and PCBs.

ATTACHMENT 11

For more information, visit the

[Penobscot Nation website]

Wabanaki History

Mi’kmaq Nation

Houlton Band of Malisset Indians

Passamaquoddy Tribe

Penobscot Nation

Penobscot Nation, *penawahpkekeyak*

Since time immemorial, the Penobscot Nation, *penawahpkekeyak,* the people of the place of the white rocks, has inhabited its ancestral homeland situated within the drainage area of the Penobscot River and its many tributaries, lakes, and ponds. The Tribe’s primary village and seat of government, established on Indian Island, *alenape meneha,* is located immediately above Old Town Falls, a traditional Penobscot fishing place for spearing and netting salmon, shad, and alewives during spring and early summer.

As a proud riverine people, Penobscot epistemology, culture, and society are rooted in their intimate relationship to the river- the source of life that provides all that is needed; the river to which the Penobscot people belong. The river habitat remains a nourishing source of food, medicine, connection, joy, and spirituality for Penobscot people who engage in and pass down to the next generation the ancient practices of fishing, hunting, gathering, and traveling on the same river that has sustained their people for thousands of years.

The Penobscot Nation supported the Americans in the Revolutionary War, largely on the basis of promises and assurances to respect Penobscot territory and provide aid. These promises were supported and endorsed by General George Washington in a 1777 letter, but were quickly forgotten once the Americans defeated the British. In the years to follow, Penobscot Nation petitioned Congress to honor their promises and provide aid but their requests were ignored. The Penobscot Nation fared little better under the stewardship of the Commonwealth of Massachusetts and after 1820, the State of Maine. Neither government honored the agreements to provide for the needs of Tribal people in exchange for the thousands of acres of land they occupied and sold.

By the mid-1830's, the Penobscot Nation had been dispossessed of much of its aboriginal territory, retaining possession of only the Penobscot River and its islands from Indian Island north. State appointed Indian Agents exercised total control over the dispensing of food, clothing, shelter, health care, and other necessities, purchased with the money from the sale of misappropriated Tribal lands. For many generations, the Penobscot people lived at a bare subsistence level.

Not until two hundred years after the Revolutionary War did the Federal Government acknowledge its obligation to the native tribes in Maine. Congress in 1790 had passed legislation to curtail exploitation of Indian lands (the Indian Trade and Intercourse Act, commonly referred to as the Nonintercourse Act). Since the United States historically took no action against states for violations of the Act, the legal presumption arose that the tribes in Maine were not protected by this legislation and that the Federal Government had no responsibility towards them.

In 1975, a United States District Court ruled that the Nonintercourse Act was applicable to the Passamaquoddy Tribe and also the Penobscot Nation (Passamaquoddy v. Morton). This ruling established a trust relationship with the United States and in effect ordered the Federal Government to litigate a Nonintercourse Act claim against the State of Maine for damages arising from the illegal taking of thousands of acres of tribal lands. The subsequent negotiated settlement of this case, culminating in passage by the U.S. Congress of the Maine Indian Claims Settlement Act (PL 96-420) in 1980, marked a critical turning point in the history of the Penobscot Nation.

The Maine Indian Claims Settlement Act, however, created a unique situation for the Penobscot Nation (and the other tribes in Maine). By virtue of the act and its accompanying state legislation (the Maine Implementing Act), the Penobscot Nation has both the sovereign status of a federally recognized Indian tribe and the subordinate status of a municipality under Maine law. While the State of Maine has no jurisdiction over the internal affairs of the tribe, it can (and has) required that the Penobscot Nation comply with provisions of state law that are applicable to non-Indian communities. This has the effect of imposing a vast range of mandates and regulations on the Penobscot Nation, in areas ranging from human services to natural resources management and environmental protection. This situation has led to various disputes between the State and the Tribe.

The Penobscot Nation's territory includes more than 4,900 acres of reservation land –

including 200+ islands in the Penobscot River. In addition, the Nation protects and manages in excess of 90,000 acres of trust land in nine locations throughout Maine.

Currently there are 2,398 enrolled members (2020 Tribal Census). Over 1,399 tribal members live in Maine and are within serviceable distance, and many visit the reservation regularly. There are 417 tribal members living at Indian Island, with a total population, including non-member residents, of 541.

The Penobscot Nation followed a hereditary Chief system until the early 1800s when they began operating as a democracy. While leaders are elected democratically, the entire adult tribal membership, constituted as the General Meeting, serves at the legislative body of the Nation. The executive and administrative functions of the Nation are delegated to Penobscot Nation Chief (Chief Executive Officer), a Vice-Chief, and a 12-person council.

A Tribal Ambassador, appointed by the Chief and Council, serves as a liaison between the Nation, the federal government, and the State of Maine government. The Nation's administrative functions, overseen by the Chief and Vice Chief, are carried out by 16 tribal departments and include housing, health, social services, and tribal court.

The Penobscot Nation Judicial System, comprised of the Tribal Court and the Court of Appeals, is the adjudicatory branch of the Nation's government. The Nation is governed in accordance with its thirty-one (31) chapters of Tribal Law. The Nation's government is funded by federal 638 contract funds, federal, state and private grants, and a modest amount of tribally generated funds. Notably, the Penobscot Nation's Healing to Wellness Court has been nationally recognized for innovative, culturally based intervention that combines judicial oversight with Tribal healing and wellness services.

During the forty years since the Maine Indian Claims Settlement Act was created, the Penobscot Nation has worked diligently to establish basic governmental services, physical infrastructure (roads, sewer, water, housing, and schools), and human and social services enjoyed by most of the nation's other Indian tribes for decades as a benefit of Federal recognition. At the same time, the Nation has struggled to address complex issues of tribal rights and responsibilities arising from its legally imposed status as a Maine municipality. The Penobscot Nation has been aggressive in implementing initiatives to foster and support the preservation and resurgence of tribal culture, traditions, and language and to protect the Penobscot River. The Penobscot Nation is known as one of the oldest continuous governments in the world, and we remain committed to protecting our territory, preserving Penobscot culture and ensuring that future generations can live as Penobscots.

To learn more, visit the Penobscot Nation website.

ATTACHMENT 12

Natural Resources Council of Maine

Menu

Penobscot River Restoration Project

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The Penobscot

New England's second largest river system, the Penobscot drains an area of 8,570 square miles. Its West Branch rises near Penobscot Lake on the Maine/Quebec border; the East Branch at East Branch Pond near the headwaters of the Allagash River. The main stem

empties into Penobscot Bay near the town of Bucksport.

The river is tidal from the base of the former Veazie Dam to its mouth near Bucksport (approx. 25 miles) and is brackish to the town of Hampden. The river's total fall from Penobscot Lake on the South Branch is 1,602 feet.

Restoring the River

The Penobscot River Restoration Project was a collaborative effort to balance fisheries restoration and hydropower production in Maine's largest watershed. NRCM is a proud founding member of this effort and, working with others, was been instrumental in its success. *View a full timeline of the Penobscot Project at the bottom of this page.*

The Penobscot Project:

1. Opened up 2,000 miles of rivers and streams to sea-run fish like the Atlantic salmon and shad.
2. Maintained hydropower production and is one of the nation's most innovative river restoration projects.
3. Removed two dams that blocked fish migrations for more than a century—the Great Works Dam and the Veazie Dam—and constructed an innovative, river-like bypass around the third dam on the river at Howland. Fish are using this bypass to access historic habitat.

Improved Access to 2,000 Miles of the Penobscot

The Penobscot River Restoration Project began in 1999. In June 2004, after five years of negotiations, the Penobscot River Restoration Trust signed an agreement for a public-private effort to maintain hydropower and restore sea-run fisheries on the Penobscot.

The Trust completed the project in 2016, and it has vastly improved access for Atlantic salmon and other sea-run fish to nearly 2,000 miles of their historic river and stream habitat.

The Trust removed the Great Works Dam in 2012 and the Veazie Dam in 2013 to open up the lower Penobscot.

The Trust also completed a stream-like bypass channel around the Howland Dam in 2016.

The Trust had purchased all three dams in previous years. The dams' owners increased hydropower production at six other sites, resulting in at least as much hydropower production as before the dam removals.

Now, communities are developing new economic opportunities and recreational activities related to the river's restoration.

Scientists are documenting the benefits of the project, and some Trust partners are improving fish passage on tributaries upstream from the project area.

Penobscot Project Benefits

The Penobscot and its tributaries flow from Mount Katahdin through the heart of Maine to Penobscot Bay. It is the **largest river system in Maine**—draining more than one-quarter of the state—and the second largest in New England. The river connects the mountains to the sea, delivering ecological benefits and opportunities for recreation, economic development, and cultural enrichment. The Penobscot Project benefits the watershed by:

- Providing unobstructed access to 100% of historic habitat for Atlantic and shortnose sturgeon and striped bass;
- Improving access to 2,000 miles of river and stream habitat for endangered Atlantic salmon and other species of sea-run fish;

- Restoring ecological systems that benefit native plants and animals in the river, estuary, and Gulf of Maine;
- Creating a cleaner, healthier river;
- Supporting the Penobscot Indian Nation’s culture and traditions;
- Offering new opportunities for economic and community development in riverside communities;
- Enhancing outdoor recreation such as fishing, paddling, and wildlife watching; and
- Maintaining hydropower generation.

The Penobscot Project has Restored the Connections between the Gulf of Maine and Inland Waters

Native sea-run fish—such as river herring and shad—have rebounded. These fish provide food for many fish-eating birds and mammals, including eagles, porpoises, and river otters. Over time, the increase in sea-run fish populations will help to restore commercial coastal ground fisheries as well.

Signs of Renewal are Already Evident

Sea-run fish are heading into newly accessible habitat. Almost no shad used the fishway at the former Veazie Dam, but in 2017, nearly 4,000 shad used the fish lift at the Milford Dam, now the first on the river. Anglers now catch shad in places that were inaccessible to this excellent game fish for a century. Nearly 1.2 million river herring used the Milford fish lift in 2017, up from essentially zero river herring passing upstream of this area just three years ago. Sturgeon are also reaching their historic spawning grounds and even entering the Milford fish lift! The Penobscot Nation has hosted three national whitewater canoe races on the newly free-flowing river above Old Town.

Dam owners increased hydropower generation at six dams in and near the Penobscot. This allowed energy generation to remain consistent with previous levels despite the removal of two dams and the decommissioning of a third.

Timeline of the Penobscot Project

The Penobscot Project happened incrementally over several years, and involved restoring the river through three major construction projects, changes in energy operations and re-licensing requirements, a variety of permit obligations, outreach to communities within the project area and to the public at large, planning for economic and community development activities related to the river's restoration, and significant private and public fundraising.

The final investment of the project came to $63 million, raised from private sources and federal government programs to support project implementation, including dam removal and modifications, complying with permit requirements, and engaging in economic development projects.

Timeline of work:

June 25, 2004: The Lower Penobscot River Settlement Accord, the multi-party agreement laying the framework for the project, was signed. Once energy enhancements were approved, PPL Corporation began implementing them, and addressed impacts of energy operations on Penobscot Indian Nation tribal lands.

Late 2007: The Penobscot Trust reached a fundraising goal of $25 million needed to purchase the Veazie, Great Works, and Howland Dams.

June 20, 2008: Exercised the option to move forward on dam purchases

November 7, 2008: The Penobscot Trust filed for federal and state permits required to purchase the dams. During the federal and state permitting process the public was encouraged to comment on multiple occasions. In addition, the Penobscot Trust held formal public scoping sessions in December of 2007 as part of this process.

December 17, 2010: After receiving necessary federal and state permits, and undergoing all necessary legal due diligence, the Penobscot Trust purchased the Veazie, Howland, and Great Works Dams.

2012: Great Works Dam was removed.

2013: Veazie Dam removal began.

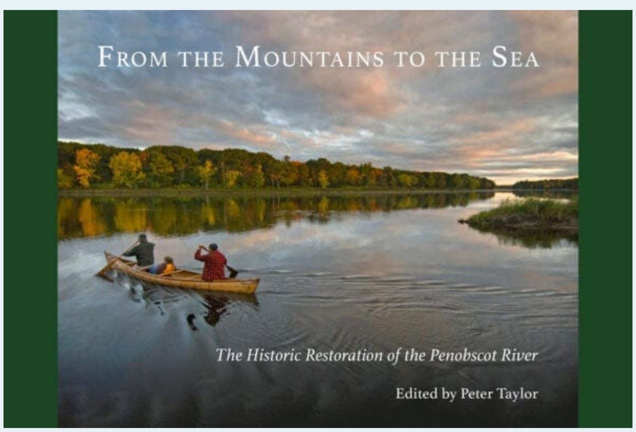
2016: Howland bypass was completed.

Partners

The Penobscot River Restoration Trust was a nonprofit organization consisting of the Penobscot Nation, American Rivers, Atlantic Salmon Federation, Maine Audubon, Natural Resources Council of Maine, The Nature Conservancy, and Trout Unlimited.

Additional Partners in the Project included PPL Corporation, Black Bear Hydro LLC, U.S. Fish and Wildlife Service, Bureau of Indian Affairs, National Park Service, National Oceanic and Atmospheric Administration, State of Maine’s Department of Marine Resources, Maine Department of Inland Fisheries and Wildlife, and the former Maine State Planning Office, Penobscot Indian Nation, and the Penobscot River Restoration Trust and its members.

NRCM was a founding member of the Penobscot River Restoration Trust, and this is one more example of our commitment to protecting and restoring Maine’s environment, now and for future generations.



Book Celebrates River Restoration

The book, *From the Mountains to the Sea,* tells the stories of people involved in this 16-year river restoration project. Order your copy from Islandport Press.

Watch Penobscot Webinar NRCM and our partners hosted a webinar about the Penobscot project, which you can watch below. Hear from John Banks of the Penobscot Indian Nation; Laura Rose Day, the executive director of the Penobscot River Restoration Trust; Kate Dempsey of The Nature Conservancy; Andy Goode of the Atlantic Salmon Federation; and NRCM's advocacy director Pete Didisheim.

ATTACHMENT 13

Penobscot River Salmon Run Highest Since 2011

August 06, 2019

After dam removals and fish passage improvements, endangered Atlantic salmon are returning to the Penobscot River in encouraging numbers.

2019's International Year of the Salmon proved to be a good year for biologists counting adult Atlantic salmon returns in Maine's Penobscot River. After a one-day count of 107 salmon at the Milford Dam fish lift set a record on June 20, numbers have continued to rise.

The latest count is more than 1,100—the highest since almost 3,000 returns were counted in 2011.

“That’s great news,” says NOAA Fisheries Atlantic Salmon Recovery Coordinator Dan Kircheis. Engaged in Atlantic salmon management for many years, Dan notes that high years can be followed by low years and building sustainable populations will take some time. “I’m cautiously optimistic about this year's returns.”

Historically Large Salmon Runs

The Penobscot River hosts the largest run of Atlantic salmon left in the United States. Atlantic salmon used to return by the hundreds of thousands to most major rivers along the northeastern United States, down into Connecticut. Salmon were big business—both commercial and recreational fishermen sought these prized fish. They in turn supported the local bait shops, gear stores, and more. Tribes relied on watersheds and their natural abundance of sea-run fish, including Atlantic salmon, for physical and spiritual sustenance. The Penobscot River once saw 75,000 to 100,000 Atlantic salmon per year return to spawn.

Dam-building in the United States in the 1800s to mid-1900s contributed to an almost complete elimination of many sea-run, migratory fish species in the Penobscot River. Dams blocked access to crucial spawning habitats. Pollution and overfishing also played a role. More than just the sea-run fish were affected by the dams. Tribal subsistence fishing, historically large commercial and recreational fisheries for salmon, and commercially-important species like cod that preyed on once-abundant river herring, were all hit hard.

A New Plan for Bringing Back Salmon

Since Atlantic salmon were declared endangered in 2000, NOAA Fisheries and U.S. Fish and Wildlife Service have been collaborating to help this iconic species recover.

Of this year’s returns, approximately 500 have been taken to the Craig Brook Hatchery, where U.S. Fish and Wildlife Service biologists will use them as broodstock. The rest have been released upstream to spawn in the wild. At the hatchery, they raise the eggs and release them as smolts (2-3-year-olds) or fry (a few months old), to help repopulate Maine’s rivers. The hatchery also functions as a living gene bank by conserving the remnants of genetic diversity in the population. Relying on hatchery-raised fish is one element of the new Atlantic Salmon Recovery Plan released by the agency earlier this year.

Another element of recovery is to focus on improving migration and water quality in rivers and estuaries. Improving survival through dams, increasing access to diverse habitats and improving habitat quality will help Atlantic salmon overcome challenges they face in both freshwater and marine environments.

We have been working with state agencies, hydropower dam owners, the Penobscot Indian Nation, and many conservation groups. We have developed an ambitious plan to undo two centuries of damage to habitat for sea-run fish. Since 2010, we have removed 15 dams in the Penobscot River watershed, including two large dams on the Penobscot River. Fish passage improvements have been made at another 13 dams. This has improved access to more than 2,000 miles of river and stream habitat for Atlantic salmon and other sea-run fish.

If all goes well, we estimate it will take about 75 years to return the population to levels that will allow them to be removed from the Endangered Species List. This is roughly 15 generations of fish.

Against the Odds

Unlike their Pacific counterparts, Atlantic salmon can return to spawn in rivers several times during their lives. Each female lays about 7,500 eggs, of which only 15 to 35 percent will survive their first year. After that, the fish face many threats including dams, pollution, predators, fishing nets, and disease. Dams are not just a problem for salmon swimming upstream. Smolts can also experience injury, increased predation, migration delay and death as they migrate downstream.

We have a long way to go before Atlantic salmon populations are restored to their former glory and place in our ecosystem. This increase in adult returns, and the presence of spawning adult salmon in the Penobscot River, provides renewed optimism for our ongoing efforts to recover Atlantic salmon.

Successful Fish Passage Efforts Across the Nation

Fish passage is important to the protection and restoration of fish and their habitats.

Read More ›

Last updated by Greater Atlantic Regional Fisheries Office on August 06, 2019

ATTACHMENT 14

Water Research, Pergamon Press, 1967. Vol. 1, pp. 419–432. Printed in Great Britain.

EFFECTS OF COPPER-ZINC MINING POLLUTION ON A SPAWNING MIGRATION OF ATLANTIC SALMON

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Abstract—Pollution from a base metal mine on a tributary of the Northwest Miramichi River caused many adult Atlantic salmon, which were on their normal upstream spawning migration, to return prematurely downstream through a counting fence on that river during summer and early autumn. These observations gave an opportunity to document avoidance reactions of salmon to pollution, which has seldom been done in the fishes' natural environment. Downstream returns of salmon rose from between 1 and 3 per cent during 6 years before pollution to between 10 and 22 per cent during 4 years of pollution. Early runs (June–July) of salmon to the headwaters were delayed and reduced in number. Chemical analyses of river water showed levels of Cu^{2+} and Zn^{2+} which varied with rates of river discharge. During some periods $Cu^{2+} + Zn^{2+}$ concentrations exceeded lethal levels for immature salmon, as established in another (laboratory) study. The threshold concentration for 50 per cent survival of fish under specified temperature conditions is designated as 1·0 toxic unit. Adult salmon in nature showed avoidance reactions at about 0·35–0·43 toxic unit of $Cu^{2+} + Zn^{2+}$. A level of 0·8 toxic unit may have blocked all upstream movement. Of the salmon returning downstream because of pollution, about 31 per cent reascended, 62 per cent were not seen again and 7 per cent were taken by angling and commercial fishing below the counting fence. Estimated losses from the stock available in the upper part of the river from 1960 to 1963 varied from 8 to 15 per cent of the total run. There is no evidence that successive year-classes of salmon are growing accustomed to the pollution.

INTRODUCTION

THIS PAPER is one of a series concerning "safe" levels of heavy metal pollution for fish and other aquatic life. A general summary of findings has been published (SPRAGUE *et al.*, 1965). The present paper deals with an aspect of water pollution which may frequently be important but is seldom documented—avoidance reactions of fish in their own habitat. The example studied is the effect of base metal pollution from mine wastes on the upstream migration of Atlantic salmon (*Salmo salar* L.).

This situation occurred in the Northwest Miramichi River, New Brunswick, where, since 1950, the Fisheries Research Board of Canada has studied the annual spawning run of salmon which has varied between 1000 and 8000 fish. A counting fence was operated from 1950 to 1963 at Curventon, a point 7 miles above tidehead. From 1957 to 1963, a second fence was operated at Camp Adams which is 33 miles upriver from Curventon. Starting in 1964, the fence at Camp Adams was not operated and a new fence was installed at Curventon, 0·5 mile upstream from the old one. It is intended to examine findings under these new conditions later.

A base metal mine and its mill were developed in 1956 near the Tomogonops River, a tributary entering the Northwest Miramichi between the counting fences. FIGURE 1 shows the locations of the mine and counting fences. The mine was operated in 1957 and early 1958 and then left idle. Operations recommenced in mid June 1960 and much water was pumped from the mineshaft into the tributary. The resulting heavy metal pollution coincided with large numbers of adult salmon returning downstream through the Curventon fence, a phenomenon which had not been observed in previous years. Moreover, large groups of salmon were often seen swimming and resting immediately above the fence in broad daylight, especially during the time of peak migration in June and July. Previously, salmon which had been counted through the fence had ascended immediately and disappeared upstream. This disturbance of migration through the lower part of the river resulted in a delay of the salmon in reaching the Camp Adams fence.

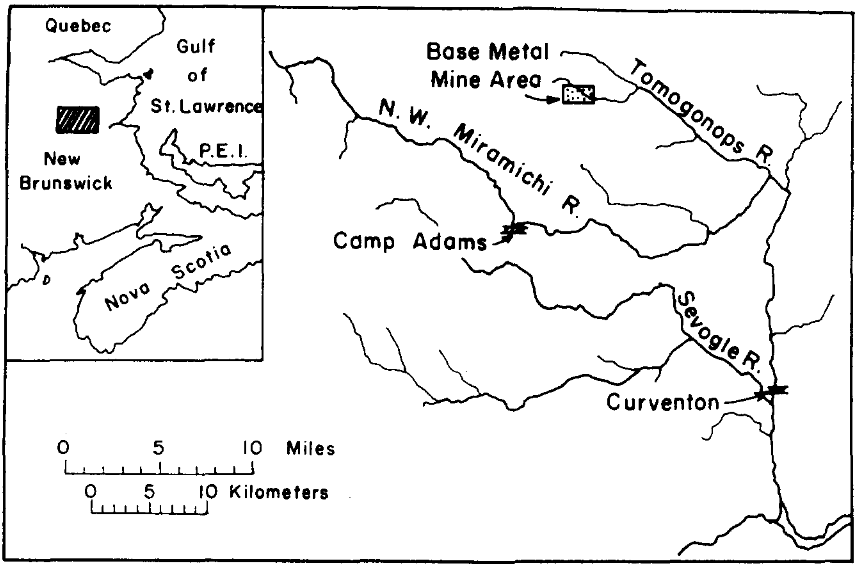

FIG. 1. Map of the Northwest Miramichi River system showing locations of the base metal mine, the salmon counting fences and tributaries.

MATERIALS AND METHODS

Fish movements

The data which show the effect of pollution on fish migrations include both the daily counts of fish moving upstream and downstream through the counting fences and the movements of individual fish which were tagged at the Curventon fence and subsequently recaptured.

The ascending salmon were of two classes as regards their period of sea life. The largest class each year was of one-sea-year salmon or grilse. The other class, called large salmon, spent 2 or more years at sea, some returning to fresh water for the first time and others after having returned and spawned previously. For the sake of simplicity and since grilse and large salmon appeared to be similarly affected by pollution, no distinction is made between them in this report.

The counting fences

The principal tools for following movements of fish were the Curventon and Camp Adams counting fences which were operated each year for as long as possible during the open water period. Fence operation was usually from June through October inclusive but varied by plus or minus approximately one week in spring and fall. This depended on the time of subsidence of the spring freshet and the onset of freezing in autumn. The straining surfaces of the counting fences were made with $\frac{1}{4}$-in. dia. steel rods positioned vertically with $\frac{3}{8}$-in. spaces and held in heavy wooden frames against the upstream face of the fences. Curventon counting fence had three traps or pounds, two for descending fish and one for ascending fish. These are called down- and up-traps respectively. Camp Adams fence had one up- and one down-trap. Additional description of the fences is given in HENDERSON *et al.* (1965).

The traps were inspected at least twice daily and if they contained fish, these were examined for previously applied tags, then passed through in the direction they had been travelling.

The counting fence operation was by no means perfect. During severe freshets parts of the fence were sometimes carried away and this resulted in incomplete records of salmon movements. During periods of high water it was sometimes necessary to open the pounds and release salmon without examination because confining them in heavy currents would have caused them to thrash about and injure themselves. It must be emphasized that few seasons were without fence wash-outs or malfunctions and that periods of high water are most likely times for salmon to ascend the river (FIG. 2 and HAYES, 1953).

Tagging and recapture of salmon

Tags were small plastic disks having a serial number on one side and an address on the other. These were attached to the salmon with 0·012-in. dia. stainless steel wire through the base of the dorsal fin. Some fish were recaptured after having carried a tag 1, 2, or 3 years.

Tagging done at various locations served to identify salmon for this study. Some had been previously tagged as descending smolts a year earlier, others as adults in a special commercial-type trap in the Miramichi estuary. Some were tagged as they were let through the up-trap and others as they were let through one of the down-traps. A special effort was made to tag many of the adult salmon appearing in the down-traps. In 1960–62 the proportion of descending fish tagged was less than half, but in 1963 it was increased to over three-quarters in an attempt to get as complete a picture as possible of fates of descending salmon. During the period 1960–63, some individuals were observed as many as four times during a season, moving up one time and down another, sometimes with less than a day between up and down movements, other times after a month or more.

The object of tagging descending salmon was to determine what proportion returned upriver during the same year and to find out what happened to those which did not return. To this end, a concerted effort was made to recover tags from recaptured salmon in the whole Miramichi system. Commercial fishermen and angling camps in the Miramichi system were visited regularly to encourage the return of tags and to obtain recapture data. A reward of 1 dollar was paid for a returned tag and pertinent information concerning the recaptured salmon. The Curventon counting fence accounted for most recaptures of salmon returning upriver. This fence was generally effective in trapping such salmon; few tags were recovered at the Camp Adams fence or through upriver angling from salmon which were not first observed returning through Curventon fence.

Chemical and physical measurements

The procedures used, and estimates of accuracy, have been documented in detail elsewhere (SPRAGUE and CARSON, 1963, 1964), but brief descriptions are given here.

The chemical part of this paper is based on daily water samples except for 1960, when sampling was sporadic and usually totalled six to eight samples a month, taken at times of changing water levels. Chemical analyses were done after shipment of samples to St. Andrews. Tests showed that this delay did not cause a significant change in the chemical qualities of the water, except for a steady loss of metals to walls of the sample bottle, and adequate corrections were developed for this.

Metal concentrations were measured spectrophotometrically. Copper was determined by using sodium diethyldithiocarbamate, and zinc by the mixed-colour dithizone method. The 95 per cent confidence limits for single measurements of a metal were estimated by making up unknowns, and were found to be ± 9 $\mu g/l$ for copper, and ± 6 per cent for zinc in the concentration ranges which concern us here. Averages of duplicate or triplicate analyses were used in 1961 and later, giving further confidence in the measurements.

Total hardness was titrated with EDTA, with the addition of potassium cyanide to prevent interference by metals. Specific conductance and pH were measured also, to make sure that there were no unusual disturbances of water quality. Conductance, pH, and twice-daily measurements of temperature are not thought to be of interest in the problem discussed here but have been recorded (SPRAGUE and CARSON, 1963, 1964).

River flows from October 1961 to September 1962 are those published by the CANADA WATER RESOURCES BRANCH, 1964. Subsequent flows have been provided by the same agency, and are provisional although changes before publication have usually been minor in the past. For 1955, 1960 and most of 1961, official measurements of flow are not available. They have been estimated by means of graphical correlation (SPRAGUE and CARSON, 1963), from water levels recorded daily at the Curventon counting fence. These estimates of flow in the earlier years are thought to be reasonably comparable with official flows for later years. Certainly they accurately depict the times of change in flow, and the general magnitude of freshets.

Toxic units

Copper and zinc seem to be the only significant pollutants entering the Miramichi from the mine. A fairly complete mineral analysis by the Industrial Waters section of Department of Mines and Technical Surveys did not reveal any other toxicants in significant concentrations (SPRAGUE and CARSON, 1963). Field tests by the Resources Development Branch of Department of Fisheries (personal communications) in which mortalities of immature salmon held in cages at the mouth of the Tomogonops River were compared with the concentrations of copper and zinc present, indicated that the copper and zinc alone were sufficient to account for mortalities. Therefore the toxic units used in this paper are based on copper and zinc as the only toxicants.

A simple index has been used to describe total metal pollution in the Northwest Miramichi (SPRAGUE and RAMSAY, 1965). This index expresses the concentration of each pollutant in toxic units, obtained from the calculation:

$$\frac{\text{Actual concentration as measured chemically}}{\text{Lethal threshold concentration}}.$$

A value equal to or greater than 1·0 toxic unit is thus lethal to at least 50 per cent of the fish, and values from 0 to 0·99 toxic unit are lethal to less than 50 per cent of the fish. This system seems to have originated in Europe with BERGSTRÖM and VALLIN (1937) who used the term "toxic units". British workers have developed the system further and have shown that when several pollutants are present in the same river, adding together toxic units contributed by each pollutant gives an accurate prediction of whether the mixture will be lethal or non-lethal to fish (LLOYD, 1961; HERBERT *et al.*, 1965).

This method of expressing pollution has been tested for the present circumstances and found to work well. The lethal threshold for mixtures of copper and zinc can be predicated accurately from total toxic units, using juvenile Atlantic salmon in the laboratory (SPRAGUE and RAMSAY, 1965). Furthermore, thresholds for avoidance reactions of juvenile salmon in the laboratory are reasonably predictable from total toxic units, although there seems to be slight potentiation of effect of the two metals acting together, compared to individual action in causing avoidance (SPRAGUE, 1964*b*).

Changing levels of water hardness, such as occur seasonally in the Miramichi, have a great effect on the lethal threshold of copper and zinc for fish. This effect has been incorporated into the calculations of daily toxic units by using values given by LLOYD and HERBERT (1962) of lethal thresholds for different degrees of water hardness. Although the thresholds of Lloyd and Herbert were obtained using rainbow trout, tests with Atlantic salmon in waters of two different hardness values (SPRAGUE, 1964*a*; SPRAGUE and RAMSAY, 1965) show that the sensitivities of the two species of *Salmo* are similar enough to be interchangeable for practical purposes.

Water temperature seems to have a strong effect on the lethal action of metals (unpublished). It seems that significant temperature corrections will have to be incorporated into toxic units when using them to describe lethal action of copper–zinc pollution. However, preliminary experiments show that temperature has a comparatively small effect on avoidance reactions to zinc, at least for temperatures greater than 10° C, which are of most interest to us in the present study. A lesser temperature correction may be required for another set of toxic units specifically for avoidance reactions. At present, this basic work has not proceeded far enough to allow us to apply any temperature correction. Accordingly this may be a minor limitation on our conclusions in this paper.

RESULTS AND DISCUSSION

Daily values for salmon movements, river flow, and degree of pollution are given only in graphical form in this paper. Detailed numerical data on salmon movements in the Northwest Miramichi River are available in a report (HENDERSON *et al.*, 1965). River flows for 1961–62 have been published (CANADA WATER RESOURCES BRANCH, 1964), other flow estimates for 1960–63 are in reports (SPRAGUE and CARSON, 1963, 1964) and flow estimates for 1955 are recorded in original manuscript No. 1034 on deposit at the Biological Station, St. Andrews. All chemical measurements are reported in the above two manuscripts by Sprague and Carson. Daily values of toxic units have not yet been reported because of the necessity of applying temperature corrections, but it is hoped that these will also be available in a manuscript report in the near future.

General effects

A summary of the salmon movements at Curventon counting fence in relation to pollution levels in the Northwest Miramichi River is given in TABLE 1. From 1955 through 1959 only small percentages of salmon (1 to 3 per cent) were observed moving downstream during the summer and early fall. At the Camp Adams fence, 18 miles above the polluted tributary, salmon were also seen moving downstream in similar small numbers during this period. At Curventon a few salmon from the Sevogle River, a large tributary entering the main river ¼ mile below Curventon fence, may have been "testing" the main river above the mouth of their home river. During the years of pollution (1960–63) downstream returns of salmon increased greatly to 10–22 per cent of the upstream migrants.

TABLE 1. TEN-YEAR SUMMARY OF SALMON MOVEMENTS AT CURVENTON COUNTING FENCE IN RELATION TO MINING ACTIVITY AND RESULTING POLLUTION IN THE NORTHWEST MIRAMICHI RIVER

Year	Mining activity	Average pollution level during year (Toxic units)*	Salmon ascending through counting fence	Salmon returning downstream†	
				Number	Per cent
1954	Before mining	—	3682	49	1
1955	Before mining	—	3540	72	2
1956	Before mining	—	1336	27	2
1957	Mining and milling	—	1581	46	3
1958	No mining activity‡	—	3000	76	3
1959	No mining activity‡	—	8357	52	1
1960	Pumping water from mineshaft	0·77	3169	708	22
1961	Exploration	0·24	1831	273	15
1962	Mining and milling	0·49	2509	283	11
1963	Mining and milling	0·67	6397	941	15

* Averages of samples for the year, giving a general measure of pollution. Values are expressed as a fraction of the incipient lethal level and are not corrected for the effect of low winter temperatures, which would change toxicity. Sampling in 1960 was less frequent and values were less precise than in later years.

† These values do not include kelts which are the spent salmon from the previous or present year's spawning.

‡ No mining during season of salmon migration

The marked increase in the number of fish moving downstream in 1960 was related to possible pollution from a newly reactivated base metal mine on the Tomogonops River (FIG. 1). Chemical analyses of the river water were started in June 1960. These have shown that the river carries unusually high levels of copper and zinc which vary with mining activity, mine waste treatment efforts and rates of river discharge. In the laboratory, young salmon avoid extremely low concentrations of copper and zinc when given a choice between "clean" water and solutions of various strengths of these metals (SPRAGUE, 1964*b*). It seems reasonable to conclude that the unusual movements of adult salmon at Curventon counting fence were in response to high levels of copper and zinc in the water.

Delay in movements to the headwaters

A major consequence of the disturbed migration through the polluted section of the Northwest Miramichi was that early runs of salmon to Camp Adams were delayed and reduced in number. SAUNDERS (1967) shows that there are distinct early (June–

July) and late (September–October) runs of salmon in the Northwest Miramichi and that with few exceptions only the early-run fish reach Camp Adams.

In 1960, no salmon were seen at Camp Adams counting fence by July 10. During the three previous years substantial numbers of salmon had reached that area of the river by the end of June. Accordingly, on July 10, 1960, 24 grilse were tagged at Curventon, transported upriver and released in the main river 5 miles above the mouth of the Tomogonops River (FIG. 1). Within 12 days, eighteen of them had reached Camp Adams, three were taken by anglers below Camp Adams and the remaining three were not seen again. Apparently, once salmon were past the outflow of the Tomogonops they moved quickly upriver. Later in the summer of 1960 pollution levels abated and many salmon ascended from Curventon to Camp Adams.

It was also observed in pre-pollution years that between 45 and 71 per cent of the number of salmon counted at Curventon were subsequently observed at Camp Adams. The comparable figure for 1960 was only 21 per cent (TABLE 2). During the seasons

TABLE 2. RELATION BETWEEN NUMBERS OF ASCENDING LARGE SALMON AND GRILSE (COMBINED) COUNTED AT CURVENTON AND CAMP ADAMS COUNTING FENCES

Year	Curventon	Camp Adams	C.A./Curv. × 100
1957	1581	711	45
1958*	3000	2133	71
1959*	8357	5409	65
1960	3169	663	21
1961	1831	626	34
1962	2509	1113	44
1963	6397	2484	39

Percentage relations Camp Adams/Curvention (C.A./Curv.) are indicated.
* No mining during season of salmon migration.

1961–63 the situation was improved somewhat but fewer salmon reached the upper part of the river than in pre-pollution years. It is not known whether the reduction in numbers of salmon migrating between Curventon and Camp Adams is owing to delay and consequent loss to anglers in intermediate stretches of the river, movement into tributaries or loss in vitality and inability to negotiate falls in the region 5–10 miles below Camp Adams.

Salmon movements and pollution levels

Daily movements of adult salmon at Curventon counting fence for 1955 and for 1960–63 are shown in FIGS. 2–4 with rates of river discharge and copper–zinc pollution expressed as toxic units. The year 1955 (FIG. 2) was chosen from the pre-pollution years because it shows a typical seasonal pattern of movement past the Curventon fence. There was a large upstream run of salmon in the spring, little activity during summer, and a variable run in autumn. Movements generally coincided with changes in river flow, and large runs of fish usually seemed to be stimulated by freshets as may be clearly seen in late September of 1955 (FIG. 2). There were few downstream movements. Judging by concentrations of zinc and copper in the unpolluted part of the

Miramichi during several years (SPRAGUE and CARSON, 1964) total toxic units for these metals would have been only about 0·03 throughout this year of no mining pollution.

The pictures for the years 1960–63 (FIGS. 3 and 4) stand in marked contrast with that for 1955. At first glance it may appear that pollution aids upstream migration, which is higher at times of increased pollution. However, this is because both are related to river flow. Freshets bring about increased fish movements as shown for 1955, but pollution also increases at such times, apparently because rain and increased stream

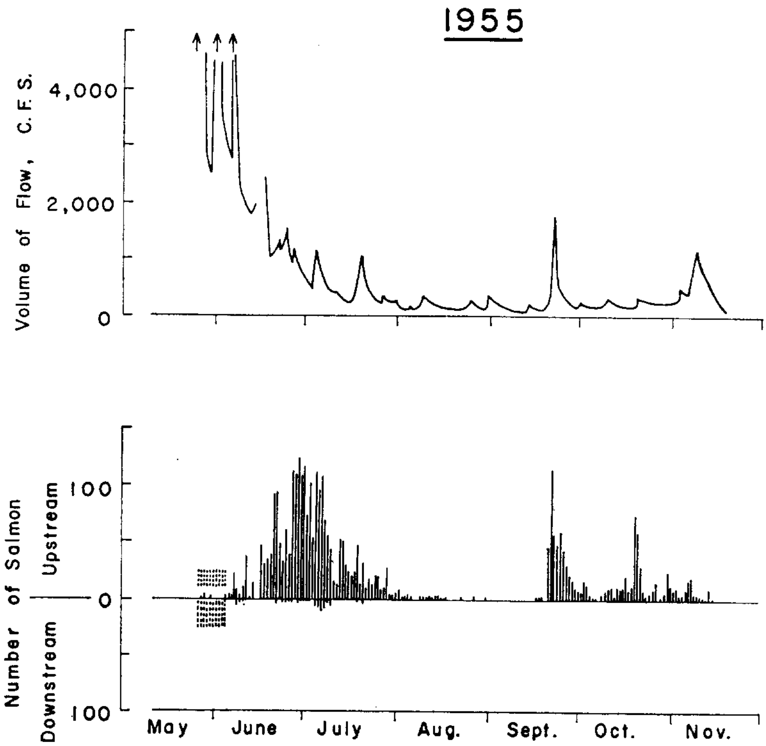

FIG. 2. Daily movements of adult salmon at the Curventon counting fence during 1955 in relation to river discharge. This is a normal seasonal pattern of migration before there was any mining pollution. Fish which were known to be spent (kelts) are excluded from counts. Periods of fence malfunction during freshets are indicated by broken lines. These lines indicate that the count, if any, was incomplete and are not intended as estimates of numbers of salmon moving past the fence during those periods. Salmon may have been moving before the fence was installed and after it was dismantled.

flow wash more metallic wastes into the rivers. It would seem that upstream migration took place in spite of increased pollution, not because of it.

In the years 1960–63 there were sizable downstream movements whenever pollution exceeded about 0·35–0·43 toxic unit, as indicated by the horizontal lines through the graphs for toxic units. These horizontal lines are subjective estimates of the threshold for avoidance reactions. More formal correlations were not successful because of the many factors influencing salmon migration, most of them having nothing to do with pollution. There are occasional inconsistencies in this picture, for example, about

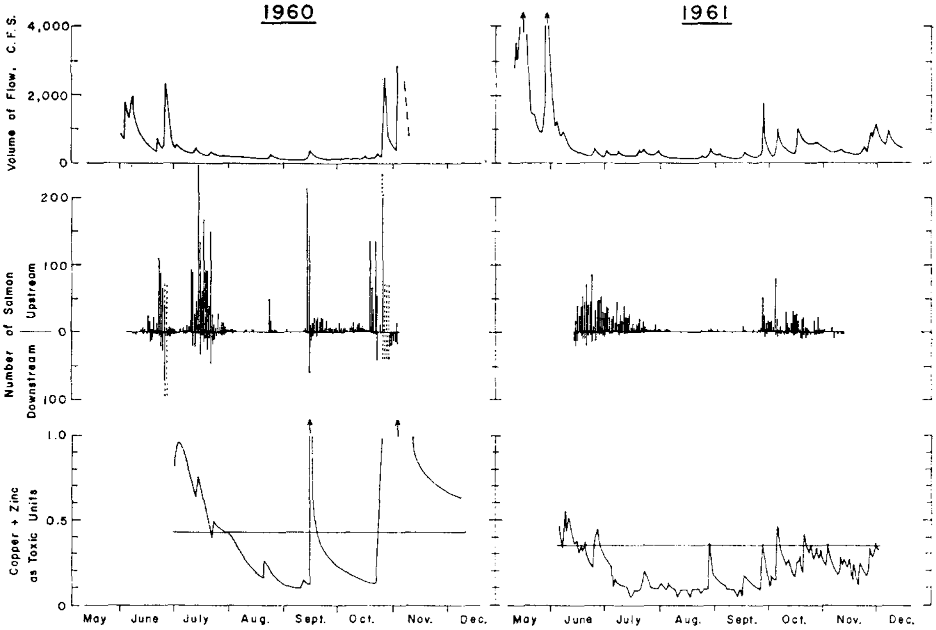

FIG. 3. Daily movements of adult salmon at the Curventon counting fence during 1960 and 1961, in relation to river discharge and copper–zinc pollution expressed as toxic units. There seemed to be abnormal downstream return of migrants at levels of pollution higher than those marked by horizontal lines at about 0·35 and 0·43 toxic unit. Other features as FIG. 2.

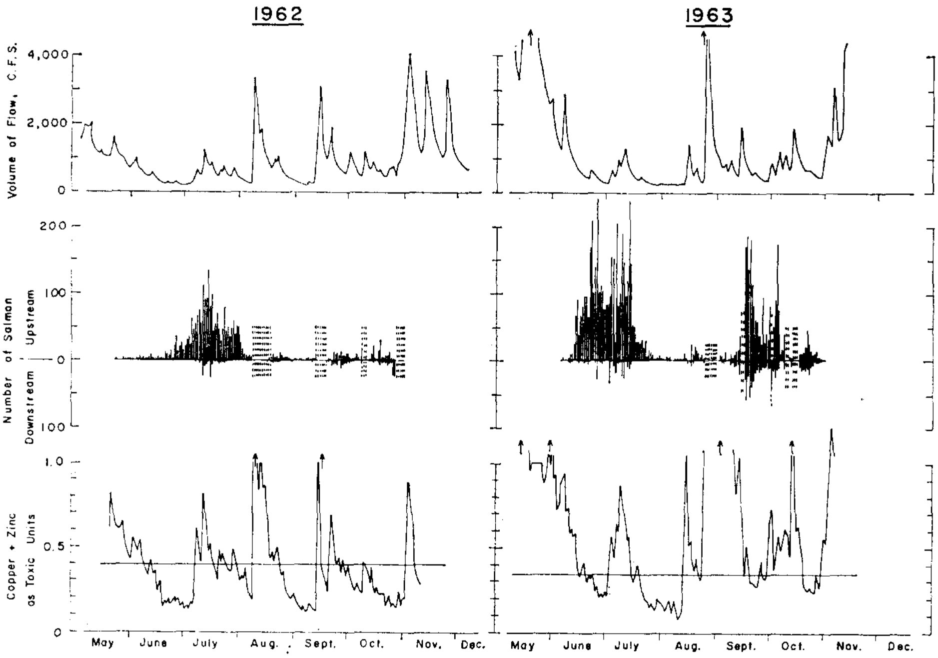

FIG. 4. Daily movements of adult salmon at the Curventon counting fence during 1962 and 1963, in relation to river discharge and copper–zinc pollution. There seemed to be abnormal downstream return of migrants at levels of pollution higher than 0·40 and 0·35 toxic unit. Other features as in FIGS. 2 and 3

twenty-five salmon came downstream on June 25, 1963, when pollution was only 0·27 toxic unit. It is possible that daily chemical sampling may have missed a peak of pollution. As further examples there were some downstream migrants late in 1962 and 1963 when pollution was low. Our colleague, Dr. Paul F. Elson, has suggested (personal communication) that salmon spawning in a particular area often swim up- and downstream between resting pools and spawning beds. These apparent inconsistencies in late fall may, then, represent fish spawning near the counting fence.

The avoidance thresholds of 0·35–0·43 toxic unit are higher than laboratory thresholds (SPRAGUE, 1964*b*), perhaps because the laboratory tests were with immature fish (parr), or perhaps because of motivation to move upstream, which was lacking in laboratory tests.

The values 0·43, 0·35, 0·40 and 0·35 toxic unit are taken as approximations of a maximum tolerable level for undisturbed upstream movement of adult salmon in the 4 years. Reasonable agreement among the four estimates gives confidence in their validity. Earlier attempts were made at correlating downstream movements with zinc alone, or with metal pollution with no allowance for the modifying effect of water hardness on toxicity. These attempts produced much poorer and less consistent correlations. It was not until all three factors, copper, zinc and water hardness, were incorporated into the index of pollution, that a fairly consistent relation was found.

There is no evidence that successive year-classes of salmon are growing accustomed to the pollution. Many of the adults moving upstream in 1962, and most of those moving up in 1963, must have swum down through the polluted section of the river on their way to sea as young fish in the spring seasons of 1961 and 1962. However there seems to be little or no difference between avoidance reactions of these fish and those moving upstream in 1960 and 1961, which presumably had encountered only mild levels of pollution when they moved to sea as young fish. This finding eliminates the possibility that avoidance reactions resulted merely from confusion as to whether the metal-contaminated Northwest Miramichi was actually the home stream being sought by the fish. It seems that the salmon recognized the river, entered it and remained in it when copper–zinc pollution was tolerable.

Complete barrier to upstream movement?

There is some indication in mid-August and mid-September 1963 that toxicity levels higher than 0·8 toxic unit completely prevented upstream movement. In particular, the sudden burst of upstream migration when pollution dropped below 0·8 toxic unit in mid-September indicates this. Flow in the river would seem to have been suitable for migration for some time previously, but pollution had been very high. Slight indications of blockage of migration at 0·8 toxic unit or higher are also found in July 1960 and September 1962. This hypothesis cannot be proved since it is a negative one.

It was observed that in late August and early September 1963, following the periods of pollution at 0·8 toxic unit or higher, which seems to have stopped all upstream movement, most of the few salmon ascending through the Curventon fence were dark colored, indicating that they had been in fresh water for some weeks. Moreover, many of them bore tags which had been applied earlier in the season as they descended through the counting fence. It is likely that these fish had been living near the confluence of the Sevogle and Northwest Miramichi Rivers, where pollution is diluted by about one-third, and were strongly motivated by freshet conditions to re-ascend their home river. Several veteran salmon anglers who fished the pool at the mouth of the Sevogle River were of the opinion that all the salmon they caught there during late August and early September had been in fresh water for some weeks; none had the bright silvery appearance of fresh-run salmon. This observation supports the hypothesis that pollution more severe than 0·8 toxic unit is a nearly complete barrier to upstream movement.

Later in September as the pollution level fell, there was a heavy run of silvery, fresh-run salmon corresponding with a pronounced but less spectacular freshet than that which occurred in August. During part of this period, pollution was still somewhat above the arbitrary level of 0·4 toxic unit which is considered as the tolerable level for upstream movement. These salmon must have been motivated to move upstream by the freshet conditions and the "urge" to reach the spawning areas in spite of high pollution levels. That they were moving upstream in spite of unfavourable pollution levels is

TABLE 3. FATES OF TAGGED ADULT SALMON AFTER THEY DESCENDED THROUGH CURVENTON COUNTING FENCE

Year	Tagged salmon descending	Finally reascended	No further record	Caught commercially in Miramichi estuary	Angled in Miramichi below counting fence	Angled in other rivers
1960	156	70	64	5	8	9
		45%	41%	3%	5%	6%
1961	54	22	27	3	1	1
		41%	50%	6%	2%	2%
1962	133	27	92	6	6	2
		20%	69%	5%	5%	2%
1963	734	210	489	10	17	8
		29%	67%	1%	2%	1%
Totals	1077	329	672	24	32	20*
		31%	62%	2%	3%	2%

Data are for recaptures during the same year and do not include a few records for fish caught one or two years later. Percentages to nearest whole number.

* Of this number sixteen were angled in the Sevogle River which is a major tributary joining the Northwest Miramichi ¼ mile below the counting fence.

attested by the large number which returned downstream during this same period (see FIG. 4).

Fates of descending salmon

During the period 1960–63, 1077 (slightly more than half) of the salmon observed descending through the Curventon fence were tagged in an effort to learn what happens to them after descending. The results of this investigation are given in TABLE 3. In all the years of study the largest group comprised those fish which descended and were not observed to reascend during the season of descent. Considering the total figures for each category in TABLE 3, 62 per cent of 1077 descending salmon were not observed again during the respective seasons of descent. Only 31 per cent of the total were finally observed reascending in the season of descent and 7 per cent were removed by angling and commercial fishing at various points below the counting fence.

Although the numbers of descending salmon tagged during the seasons 1960–62 did not comprise the majority of salmon descending in those years, their fates were, on a percentage basis, about the same as those for 1963 when about 78 per cent of descending salmon were tagged. Therefore, the fates of tagged fish each year are taken as representative of the total numbers of salmon descending each year.

Each year since 1959 large percentages of descending salmon were not heard of again after passing Curventon fence. It is likely that some of these fish did reascend the river and went unobserved because the counting fence was partly open at various times owing to severe freshets. On the other hand, it is also likely that salmon descended as they have been observed to do during freshets which have been shown to be periods of high pollution level (see FIG. 2).

Large numbers of adult salmon were observed to be descending during a time of year when little such descent was observed in 1959 and earlier. Accepting that on the average 62 per cent of descending salmon do not return upstream in a given year and that an additional 7 per cent of those descending are caught in the angling and commercial fisheries, it seems that during the years 1960–63, 69 per cent of the descending fish were lost from the stock available in the upper part of the river. By applying the average loss of 69 per cent to the yearly totals of descending adult salmon in TABLE 1, estimated losses from the upper part of the river are: 489; 188; 195 and 650 salmon. These losses are 15, 10, 8 and 10 per cent of the numbers ascending in 1960–63 respectively.

SUMMARY

Activity in 1960 at a base metal mine on a tributary of the Northwest Miramichi River resulted in copper–zinc pollution which caused large numbers of ascending adult Atlantic salmon to return downstream through a counting fence during summer and early fall, a phenomenon which had not been observed previously.

In four successive years of pollution, downstream returns of salmon amounted to 22, 14, 10, and 15 per cent of the upstream migrants. In six previous years, downstream returns had been only from 1 to 3 per cent.

Pollution resulted in a delay in arrival and reduction in numbers of early-run (June–July) salmon which constitute most if not all of the stock which reaches the headwaters of the river.

Analytical tests of the river water revealed levels of copper and zinc which fluctuated with river discharge conditions but remained serious throughout the period of observation. Concentrations frequently exceeded levels which had been shown in a laboratory study to be above the lethal threshold for young salmon and also exceeded the minute concentrations of copper and zinc which were avoided by young salmon in another laboratory study. Migrating adult salmon appear to be motivated to move upstream even in the face of such copper–zinc levels.

Estimates of the exact levels of pollution which caused avoidance reactions in the river must be regarded as tentative because of some uncertainties about modifying effects of temperature. However, using the lethal threshold at summer temperatures as a base of calculations (= 1·0 toxic unit) copper–zinc pollution more severe than about 0·35–0·43 toxic unit seemed to cause avoidance reactions resulting in downstream return of migrants.

Pollution levels of 0·8 toxic unit and higher seemed to completely prevent upstream migration although it is difficult to prove this point.

There is no evidence that successive year-classes of fish have grown accustomed to the metal pollution. Nor does it seem that the avoidance reactions merely resulted from confusion as to their home stream.

Of the salmon which returned downriver because of pollution (from 10 to 22 per cent of the uptream migrants in a given year), on the average only about 31 per cent finally reascended, 62 per cent were not observed again, and 7 per cent were taken by angling or commercial fisheries at some point below the counting fence. Estimated losses from the stock available for angling and spawning in the upper part of the Northwest Miramichi from 1960 to 1963 varied from 8 to 15 per cent.

Acknowledgements—This report results from a large team effort by the Anadromous Fish and Pollution Investigations at St. Andrews. The study of anadromous fish by means of the counting fence in the Northwest Miramichi was organized by, and through 1962 directed by, Dr. C. J. Kerswill. In 1963 Dr. M. W. Smith succeeded Dr. Kerswill as head of the Anadromous Fish Investigation and assumed responsibility for the work on salmon. The following field technicians and summer assistants of the Anadromous Fish Investigation gave valuable assistance: E. J. Schofield, I. M. Jones, W. G. Irving, W. R. Currie, W. H. MacLean, E. C. Tucker, R. J. Gibson, E. A. J. Chambers, R. H. Currie, C. D. Grant, F. W. Clark and R. H. Johansen. These men helped install, maintain and operate the counting fence and collect water samples, often under adverse conditions. Some were involved in the creel census operation to collect data pertinent to recaptures of tagged fish.

Mr. W. Victor Carson carried out the exacting job of analysing for extremely low concentrations of copper and zinc. Dr. R. W. Boyle and A. Y. Smith of the Geological Survey of Canada gave helpful advice on chemical procedures and analysed some of our 1960 samples for metal. J. E. Peters of the Department of Northern Affairs and National Resources kindly supplied provisional data on river flows before publication. Mr. J. F. J. Thomas of the Industrial Waters Section of the Department of Mines and Technical Surveys provided detailed chemical analysis of selected water samples.

Dr. M. H. A. Keenleyside was active in this project from 1955 till 1961 and gave much thought to the effects of mining pollution on salmon migratory behaviour.

We are grateful to Drs. J. L. Hart and C. J. Kerswill and Mr. K. R. Allen who offered valuable suggestions for the preparation of this report.

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ATTACHMENT 15

SYMPOSIUM ON TROUT HABITAT, RESEARCH, AND MANAGEMENT

Proceedings
September 5-6, 1974,
Western Carolina University,
Cullowhee, NC

SYMPOSIUM ON TROUT HABITAT RESEARCH and MANAGEMENT

Proceedings

SEPTEMBER 5-6, 1974
WESTERN CAROLINA UNIVERSITY
CULLOWHEE, NORTH CAROLINA

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MINING IMPACTS ON TROUT HABITAT

Ronald D. Hill[1/]

Abstract.--Mining by its very nature is a destructive process. Environmental damages from mining such as sediment, acid mine drainage, and heavy metals are discussed in terms of their effect on trout habitat and their control. Pollution control must be considered during all phases of mining, i.e., pre-mining planning, active mining, closure, and abandonment.

Additional keywords: Acid mine drainage, heavy metals, sediment, surface mines, underground mines.

INTRODUCTION

Mining is an extraction process. The disruption of the earth's surface and subsurface to remove the mineral wealth entombed therein, dictates that changes and possible damages will result to the environment. A certain price in environmental damage usually must be paid to obtain the minerals and energy required for our standard of living. The basic questions facing us are: (1) What is the price we must pay? (2) Can this price be reduced or eliminated? and (3) In what form do we desire to pay this price, i.e., loss of land values, recreational opportunities and fish, or higher prices for our commodities and energy? None of these questions are easy and the answers will vary from situation to situation. The only rational answer is to optimize both short-term and long-term costs and benefits to society. We must have mining if we are to survive, but this does not mean we must sacrifice the environment. Mining must be conducted in such a manner that environmental damages are held to a minimum.

The U. S. Bureau of Mines reported (Paone 1974) that the land utilized by the mining industry from 1930 through 1971 amounted to 3.65 million acres or 0.16 percent of the land mass of the United States. Land was utilized for surface mining, wastes from underground and surface mining, and wastes from mill operations. Some land was also lost to subsidence. The following figures were presented for land utilization by commodity over the 1930-71 period and 1971 alone.

These figures show that 58 percent of the land utilized is by the coal and sand-gravel industries. The following discussion on the impact of mining on trout habitat will cover the major sources of pollution from mining, and will emphasize the coal and sand-gravel industries.

1/ Chief, Mining Pollution Control Branch, Industrial Waste Treatment Research Laboratory, National Environmental Research Center, U. S. Environmental Protection Agency, Cincinnati, Ohio 45268.

	1930-71 Acres	1971 Acres
Bituminous Coal	1,470,000	73,200
Sand and Gravel	660,000	46,400
Stone	516,000	25,000
Clay	167,000	7,460
Copper	166,000	19,100
Iron Ore	108,000	8,620
Phosphate Rock	77,300	10,200
All Other Minerals	493,000	16,400

WATER PROBLEMS ASSOCIATED WITH MINING

Acid Mine Drainage

One of the most troublesome mine drainage problems is caused by acidity. Although the exact mechanism of acid mine drainage formation is not fully understood, it is generally believed that pyrite (FeS_2), which is usually associated with coal and heavy metal mining, is oxidized by oxygen (equation 1) or ferric iron (equation 2) to produce ferrous sulfate and sulfuric acid.

$$2FeS_2 + 2H_2O + 7O_2 \longrightarrow 2\ FeSO_4 + 2H_2SO_4 \qquad (1)$$

(Pyrite) ⟶ (Ferrous Iron) + (Sulfuric Acid)

$$FeS + 14Fe3 + 8H_2O \longrightarrow 15Fe^{2+} + 2SO_4^{2-} + 16H+ \qquad (2)$$

(Pyrite) + (Ferric Iron) (Ferrous Iron) + (Sulfate) (Acid)

The reactions may proceed to form ferric hydroxide and more acid:

$$4FeSO_4 + 2O_2 + 2H_2SO_4 \longrightarrow 2Fe_2\ (SO_4)_3 + 2H_2O \qquad (3)$$

$$Fe_2\ (SO_4)_3 + 6H_2O \longrightarrow 2Fe(OH)3 + 3H_2SO_4 \qquad (4)$$

A low pH water is produced (pH 2-4.5). At these pH levels, the heavy metals such as iron, calcium, magnesium, manganese, copper, and zinc are more soluble and enter into the solution to further pollute the water. A list of common pollutants found in acid mine drainage follows:

Pollutant	Range of Concentration
pH	1.5 - 6.5
Acidity	50 - 50,000 mg/l
Sulfate	50 - 50,000 mg/l

Iron	10 - 5,000 mg/l
Al	0 - 200 mg/l
Mn	0 - 100 mg/l
Cu	0 - 500 mg/l
Zn	0 - 400 mg/l
Ca	50 - 3000 mg/l
Mg	10 - 1000 mg/l
Cd	0 - 10 mg/l
Na	0 - 5000 mg/l
Ti	0 - 100 mg/l

Other heavy metals are occasionally found in acid mine drainage.

The above pollutants can harm trout habitat by several means including immediate or long-term toxicity to fish, inhibition of fish reproduction, (notably spawning and fish egg and larvae survival), and reduce or destroy the availability of fish food fauna. It is beyond the scope of this paper to discuss each of the pollutants and its toxicity limits, conditions, etc. The reader is referred to a U. S. Environmental Protection Agency publication by Kemp (1973).

An estimated 10,000 miles of streams have been degraded by acid mine discharges in Appalachia (Applachian Regional Commission, 1969). Additional acid problems have been documented in all of the coal and mineral producing states.

Alkaline Mine Drainage

Alkaline mine drainage may result where no acid-producing material is associated with the mineral seam or where *in situ* neutralization of that acid which is produced has taken place. Alkaline mine drainage may be, but is not usually, as bad as acid mine drainage. Drainage from freshly exposed strata usually has a higher mineral content than that from undisturbed land because the strata has high levels of readily leachable materials.

Curtis (1972) reported that he found the concentration of Ca, Mg, Al, SO_4, Fe, Mn, and Zn increased in three eastern Kentucky watersheds when surface mining occurred. The water had an alkaline pH.

Some alkaline waters have high concentrations of ferrous iron and, upon oxidation and hydrolysis, form acid which lowers the pH and changes the drainage to the acid type. These types of discharges are more common to underground mines than surface mines.

ATTACHMENT 16

Acid Mine Drainage and Effects on Fish Health and Ecology: A Review

For:

U.S. Fish and Wildlife Service, Anchorage Fish and Wildlife Field Office,

Anchorage, Alaska, 99501

Prepared by:

Reclamation Research Group, LLC, Bozeman, Montana

June 2008

Suggested Citation: Jennings, S.R., Neuman, D.R. and Blicker, P.S. (2008). "Acid Mine Drainage and Effects on Fish Health and Ecology: A Review". Reclamation Research Group Publication, Bozeman, MT.

that acid-generating tailings cover 12,000 hectares plus an additional 350 million tons of mine waste rock were noted (MEND 2001).

Effect of Acid Mine Drainage on Aquatic Resources

Once acid drainage is created, metals are released into the surrounding environment, and become readily available to biological organisms. In water, for example, when fish are exposed directly to metals and H^+ ions through their gills, impaired respiration may result from chronic and acute toxicity. Fish are also exposed indirectly to metals through ingestion of contaminated sediments and food items. A common weathering product of sulfide oxidation is the formation of iron hydroxide ($Fe(OH)_3$), a red/orange colored precipitate found in thousands of miles of streams affected by AMD. Iron hydroxides and oxyhydroxides may physically coat the surface of stream sediments and streambeds destroying habitat, diminishing availability of clean gravels used for spawning, and reducing fish food items such as benthic macroinvertebrates. Acid mine drainage, characterized by acidic metalliferous conditions in water, is responsible for physical, chemical, and biological degradation of stream habitat.

Water contaminated by AMD, often containing elevated concentrations of metals, can be toxic to aquatic organisms, leaving receiving streams devoid of most living creatures (Kimmel 1983). Receiving waters may have pH as low as 2.0 to 4.5, levels toxic to most forms of aquatic life (Hill 1974). Data relating to specific effects of low pH on growth and reproduction (Fromm 1980) may be related to calcium metabolism and protein synthesis. Fromm (1980) suggested that a “no effects” level of pH for successful reproduction is near 6.5, while most fish species are not affected when the pH is in a range from 5.5 to 10.5. Howells et al. (1983) reported interactions of pH, calcium, and aluminum may be important to understanding the overall effects on fish survival and productivity. Several reports indicate low pH conditions alter gill membranes or change gill mucus resulting in death due to hypoxia. Hatchery raised salmonids can tolerate pH 5.0, but below this level hemeostatic electrolyte and osmotic mechanisms become impaired (Fromm 1980).

A study of the distribution of fish in Pennsylvania streams affected by acid mine drainage (Cooper and Wagner 1973) found fish severely impacted at pH 4.5 to 5.5. Ten species revealed some tolerance to the acid conditions of pH 5.5 and below; 38 species were found living in waters with pH values ranging from 5.6 to 6.4; while 68 species were found only at pH levels greater than 6.4. Further, these investigators reported complete loss of fish in 90% of streams with waters of pH 4.5 and total acidity of 15 mg/L. Healthy, unpolluted streams generally support several species and moderate abundance of individuals; whereas impacted streams are dominated by fewer species and often low to moderate numbers of only a few organisms. Streams affected by acid mine drainage are poor in taxa richness and abundance. In older studies (Warner 1971), more species of insects and algae were found in unpolluted West Virginia streams (pH $\geq$ 4.5) compared to those streams polluted by acid (pH 2.8 to 3.8). Reductions of benthic fauna in a West Virginia stream severely affected by acid mine water were reported by Menendez (1978). In more recent studies (Farag et al. 2003), some streams in the Boulder River watershed in Montana impacted by nearly 300 abandoned metal mines are devoid of all fish near mine sources. Populations of brook trout *(Salvelinus fontinalis*), rainbow trout (*Oncorhynchus mykiss*), and cutthroat trout (*O. clarki*) were found further downstream and away from sources of acid mine drainage. In a 2003 study evaluating the effect of localized habitat degradation from a gold mine near the Yukon River (in AK?) on population structure of salmon, it was suggested that coho salmon (*O. kisutch*) may be at risk of losing genetic diversity due to localized habitat degradation (Olsen et al. 2004). The abandoned Britannia copper mine in British Columbia has been releasing acid mine drainage into local waters for many years. Investigators compared fish abundance, distribution and survival at contaminated and non-contaminated areas (Barry et al. 2000). Chum salmon (*O. keta*) fry abundance was significantly lower near the impacted waters (pH < 6 and dissolved copper > 1 mg/L) than the reference area. The investigators also reported that laboratory bioassays confirmed acid mine drainage from the Britannia Mine was toxic to juvenile chinook (*O. tshawytscha)* and chum salmon. Chinook salmon smolt transplanted to surface cages near Britannia Creek experienced 100% mortality within 2 days (Barry 2000).

The scientific literature is replete with studies designed to quantify the adverse environmental effects of acid mine drainage on aquatic resources. Most recent investigations focus on multiple bioassessments of large watersheds. These assessments include water and sediment chemistry, benthic macroinvertebrate sampling for taxa richness and abundance, laboratory acute water column evaluations, laboratory chronic sediment testing, caged fish within impacted streams, and development of models to explain and predict impacts of acid mine drainage on various aquatic species (Soucek et al. 2000, Woodward et al. 1997, Maret and MacCoy 2002, Hansen et al. 2002, Kaeser and Sharpe 2001, Baldigo and Lawrence 2000, Johnson et al. 1987, Griffith et al. 2004, Schmidt et al. 2002, Martin and Goldblatt 2007, Beltman et al. 1999, Hansen et al. 1999, Boudou et al. 2005).

ATTACHMENT 17

January 18, 2023
File: 195602317

Attention: Tim Carr
Land Use Planning Commission
Department of Agriculture, Conservation, and Forestry
Harlow Building
18 Elkins Lane
Augusta, ME 04333

Dear Mr. Carr,

Reference: Wolfden Mount Chase LLC Application for Zone Change

On behalf of Wolfden Mount Chase LLC., Stantec Consulting Services is pleased to submit the attached Application for Zone Change for consideration of rezoning of approximately 374 acres in T6R6 WELS from General Management (M-GN) to Planned Development (D-PD). If rezoned and then ultimately approved by the Department of Environmental Protection under Maine's *Metallic Mineral Exploration, Advanced Exploration and Mining* regulations the rezone area would be used for development of an underground mining operation and associated structures. The purpose of the operation is to extract metallic ore that is rich in copper, lead, zinc, silver and gold. The proposed rezone area does not include facilities for ore concentration or tailings.

The document has been produced in a format that addresses the Land Use Planning Commission (LUPC) Chapter 10 and Chapter 12 regulations, including 27 Exhibits designed to provide the information that is required to support the proposed rezoning. In Table 2-2 of the Application, we have provided a matrix linking the applicable regulatory requirements to the relevant Application Exhibits.

Three hard copies are being submitted by hand delivery to your attention at Elkins Lane in Augusta. Please advise on how best to transmit an electronic copy compatible with State security and file size restrictions. In addition, hard copies are being posted via FedEx as follows:

- LUPC East Millinocket office – 1 copy;
- LUPC Ashland office – 2 copies; and
- Aroostook and Penobscot County Commissioners offices – 1 copy to each.

By separate transmittal Wolfden Mount Chase LLC is today submitting the Application fee ($14,350) and the Extraordinary Project Processing fee ($79,387.28).

Thank you for your attention to this submission. We look forward to working with the LUPC staff and Commission as you all undertake your review of these materials.

Respectfully yours,

Stantec Consulting Services Inc.

Brooke Barnes
Principal
Phone: 207 406 5461
Fax: 207 729 2715
brooke.barnes@stantec.com

Attachment: Application for Zone Change
c. Jeremy Ouellette, Wolfden Mount Chase LLC

10.8 RECREATIONAL RESOURCES

10.8.1 Lakes and Ponds

Pleasant Lake, Mud Lake, and Grass Pond are all designated as Heritage Fish Waters by the MDIFW. Maine Heritage Fish Waters are native and wild brook trout lakes and ponds that represent unique ecological and valuable angling resources. Through discussion with local residents and users, there are various levels of use of the identified lakes and ponds within the 3-mile radius of the Project Area. Pleasant Lake has a higher level of use due the presence of six seasonal residences near or along its southern and northern shoreline as well as an unimproved boat launch along the southern shoreline. It has an average depth between 6 to 10 feet. Pickett Mountain Pond is accessible by foot, has no improved boat launch, and is very shallow (averaging 2 to 3 feet deep). The use of these ponds for recreation will not be restricted as part of the proposed Project. Some additional use of the boat launch on Pleasant Lake is anticipated due to increased traffic to the area by employees of the Project during operations. Correspondence from local residents on existing levels of use on Pleasant Lake and Pickett Mountain Pond are provided as **Attachment 10-F**.

Direct visual impacts of the top of the headframe may be experienced at Pickett Mountain Pond, the north side of Pleasant Lake, Mud Lake, Tote Road Pond, and Huntley Pond. Seasonal residences located along the north side of Pleasant Lake make may have visual line of sight to the top of the headframe. The headframe is 120 feet tall and could rise above the tree line approximately 80 feet. However, when viewed from Pleasant Lake, Mount Chase (elevation 2,440 feet) will be located behind the headframe and partially mask this structure from the horizon. In addition, most of the Project infrastructure will be well below 40 feet in total height and Wolfden intends to maintain a tree line surrounding the Project. When forest cover is incorporated into the visual analysis, the headframe is only visible from the north shore of Pleasant Lake and Pickett Mountain Pond. Sight-line analysis of the proposed solar array indicates that vegetation will completely screen views of the proposed solar panels from the Pleasant Lake and shoreline camps. The eastern shore of Upper Shin Pond is within the 3-mile radius as depicted in **Figure 10-1**; however, the Project Area is not visible from this location. See **Exhibit 16 – Harmonious Fit and Natural Character** for additional details on visual analyses.

Previous MDIFW surveys (1953, 1958) indicate both Pleasant Lake and adjoining Mud Lake are shallow mud bottom ponds with warm temperatures at all depths in summer months. However, inlet and outlet streams (i.e., West Branch of the Mattawamkeag River, Pickett Mountain Stream and Spring Brook) provided spawning and nursing areas for brook trout and landlocked salmon. The ponds did not have conditions supportive of cold-water fish species at the time of these older surveys. In 2019, MDIFW surveys suggested Pleasant Lake could support a landlocked salmon and brook trout fishery as they identified the presence of cold-water springs in the lake, ideal dissolved oxygen levels from across of the water column for this fishery, and excellent brook trout growth. A similar MDIFW survey of Pickett Mountain Pond from 1958 noted a maximum depth of seven feet and limited trout production. MDIFW noted that competition with other fish species, marginal water quality, and limited areas for reproduction reduced Pickett Mountain Pond's value as a brook trout fishery. Given the capture, collection, and treatment of impacted water to background level quality, the Project will not adversely impact surrounding water resources.

21.4.2 Public Roads – Potential Ore and Concentrates Transport Routes

As previously noted, public roads will also be used for the transport of ore concentrate from the Project Area to the TMF. After processing, the processed concentrate will then be transported to market. Wolfden has not finalized the location of the TMF, so this exhibit presents conceptual traffic routes for three potential locations under consideration. Note that the actual transportation route may vary depending on the final location of the TMF. See **Attachment 21-A** for additional information on these routes.

21.4.2.1 Hersey TMF

From the Project Area, ore rock trucks would travel on private gravel roads to an ore processing and concentrator facility. The location of the ore processing facility in Hersey is still to be determined. Trucks carrying concentrate from the process facility will continue to travel south on Route 11 to Maine State Route 159 (SR-159) in Patten. Trucks carrying mineral concentrate will travel east on SR-159 to an access ramp to I-95 in Island Falls traveling northeast to Houlton and the Canadian-US border and proceed to the Canadian National Highway in Woodstock New Brunswick (see **Figure 21-1**).

21.4.2.2 Patten TMF

From the Project Area, ore rock trucks would travel on private gravel roads to Route 11, hence south-southwest to Patten to an ore processing and concentrator facility. The location of the ore processing facility in Patten is still to be determined. Trucks carrying concentrate will travel east on SR-159 to an access ramp to I-95 in Island Falls traveling northeast to Houlton and the Canadian-US border and proceed to the Canadian National Highway in Woodstock New Brunswick (see **Figure 21-1)**.

21.4.2.3 Stacyville TMF

From the Project Area, ore rock trucks would travel on private gravel roads to Route 11, hence south to Stacyville to an ore processing and concentrator facility. The location of the ore processing facility in Stacyville is still to be determined. Trucks carrying concentrate will travel southeast along Route 11 to Maine State Route 158 (SR-158) or Main Street in Sherman to an access ramp to I-95 traveling northeast to Houlton and the Canadian-US border and proceed to the Canadian National Highway in Woodstock New Brunswick (see **Figure 21-2)**.

21.5 TRAFFIC VOLUMES

Anticipated traffic volumes from the Project are presented in WSP's technical memorandum provided as **Attachment 21-A.** WSP's analysis concluded that the additional traffic levels from mine operations do not represent a major impact to the existing road infrastructure.

21.5.1 Routine Traffic

Onsite traffic will be from employees and contractors commuting to and from the site, visitors, and delivery vehicles. **Attachment 21-A** provides further details on the estimates of approximate visitors to the Project on a daily basis.

MDIFW regional fisheries staff consider Pleasant Lake and Mud Lake to be some of the best brook trout and landlock salmon waters available in the Region. Kevin Dunham notes, "*Though the initial survey of the lakes in 1953 describes them as being shallow and having warm water throughout, it does go on to say, 'trout and salmon seek the cool water of spring holes…'. Pleasant Lake has an adequate amount of cool-water spring holes to support an excellent trout and salmon fishery. Subsequent fishery surveys, the most recent conducted in June 2019, found extraordinary growth of one-year old wild brook trout averaging 9.1", most of which probably took place in a cooler tributary stream. Additionally, while the lake does not stratify and temperatures remain homogenous throughout the water column, dissolved oxygen levels also remain ideal from top to bottom. Multiple age-classes of brook trout were captured during recent surveys as well, indicating year to year holdover is taking place at Pleasant and Mud Lakes."* Anecdotal evidence suggests moderate angling pressure in these waters and the fisheries resources are protected and managed through specialized regulations. "*The landlocked salmon fishery is not as robust as the trout fishery, but past surveys have sampled multiple age-classes in the 7-17" size ranges. While the lakes are somewhat limiting in cold-water refugia they do support healthy populations of salmonids* (and other fish including smelt) *and it is vitally important to protect the tributaries as well as the lakes since they contain an abundance of spawning and rearing habitat*."

Merry Gallagher, MDIFW's Native Fish Conservation Biologist, provided the attached map of preliminary stream resources, and noted that the orange stream lines *"signify streams that are of medium/moderate value for wild brook trout conservation according to* (MDIFW's) *recent effort to classify streams.*" As noted during our November 5, 2019 meeting, brook trout streams are plentiful throughout this region. During surveys conducted in September 2008, one survey site indicated on the map yielded 16 wild brook trout, while the second site provided two wild brook trout, along with common shiner, black nose dace, creek chub, white sucker, and black nose shiner.

MDIFW requests additional information on the proposed mining operation and associated activities to ensure that it will not result in unreasonable adverse impacts to these valuable resources.

<u>Streams and Wetlands</u>
Wolfden's plan during the mining operation includes capturing water from runoff and infiltration on site, treating it to equal to or better than ambient conditions, and discharging treated water into bedrock aquifers. During the September 3, 2020 site visit, MDIFW noted that intermittent and perennial streams and freshwater wetlands in the area are likely supplied by water from shallow features that flow through the overburden and less likely from bedrock sources. MDIFW expressed concern with the potential for these natural resources to be adversely affected by removing water from surficial and shallow horizons and discharging it to bedrock aquifers. The concern is with a potential dewatering and/or change in water chemistry, temperature, etc. of these natural resources that are important habitats by themselves as well as through their contributions to the larger resources described above. Also, additional information is necessary to demonstrate that the proposed mining operation and associated activities will not cause physical interruptions in subsurface flow patterns that supply these resources, even if Wolfden is able to maintain recommended undisturbed, forested buffer distances. During the site visit, we discussed investigating spray irrigation of the treated water to the ground surface during operation, allowing it to infiltrate the overburden and potentially provide flows to surface water resources. However, even if this is determined feasible and beneficial, the question remains of potential long term/permanent effects as this practice will not be in use after operations cease. MDIFW requests additional information to address concerns for potential direct and indirect impacts to surface and groundwater features and flow patterns that contribute to these resources.

ATTACHMENT 18

The Basics of

Water Pollution in Pennsylvania

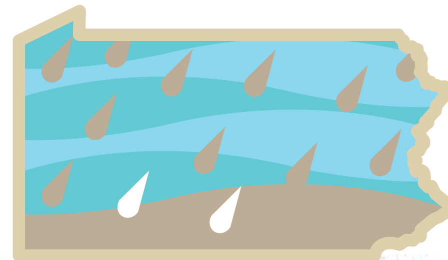


photo-Russ Gettig

Pennsylvania has more than 83,000 miles of streams and rivers. There are also some 4,000 lakes and impoundments providing 160,000 acres of recreation. These waters are home to more than 120 different species of fish, nearly 1,000 different species of aquatic insects and 38 species of clams and mussels. It's no surprise, then, that anglers and boaters spend more than 25 million days on the water in Pennsylvania. The total economic benefit to the Commonwealth of this water-based recreation exceeds $1.34 billion each year. Add to this benefit the large number of people depending on our surface water for drinking or industry, and it's easy to see that water is one of our state's greatest resources. It is also easy to see that protecting these resources is not something to be taken lightly. In the 1970s, Pennsylvania was a national leader by adopting strict water quality regulations to protect these aquatic resources. Pennsylvania has maintained its leadership by enforcing more stringest regulations than those set forth under the Federal Clean Water Act.

CATCH US ON THE WEB! Pennsylvania Fish & Boat Commission www.fish.state.pa.us

For the complete water quality assessment report from the PA DEP, visit www.dep.state.pa.us.

The Basics of Water Pollution in Pennsylvania

Some 43 percent of our streams and rivers have been surveyed to assess water quality. About one-quarter of our lakes and reservoirs have also been assessed. Waters that are unable to support the fish and other aquatic life that they once did or should are considered to be impaired, or degraded. According to a PA Department of Environmental Protection (DEP) water quality assessment report, one-fifth of our surveyed streams and half of our surveyed lakes (13 percent of the total) are impaired or polluted. Even though some of these waters still hold fish, many no longer sustain aquatic communities that should be present. This is a result of pollution. But how does pollution affect our aquatic resources? Read on to understand the effects of pollution on fish and other aquatic life.

Healthy habitats

Before we can repair unhealthy or polluted aquatic systems, we must understand how healthy ones function. All organisms have specific requirements to survive, including adequate amounts of food, water and shelter. When these requirements are met, the organism can survive. That is, a polar bear can survive only where its needs are met, whether that's in a zoo or in the Hudson Bay region of Canada. Aquatic organisms, like our state fish, the brook trout, are no different. The brook trout is found in waters where its needs are met.

Aquatic organisms survive under a range of conditions. If a condition like water temperature is outside that range, the organism can die. Biologists call this "tolerance." The brook trout can tolerate temperatures within a range of 32 degrees to about 75 degrees. Within the range of tolerance is a narrower range. Our brook trout can live a healthy existence and grow in this narrow water temperature range. The ideas of tolerances and ranges may seem complicated, but they're really this simple—an organism will do best in its ideal habitat. In addition, each kind of organism has a specific ideal habitat.

The combination of the ideal ranges of temperature, pH and dissolved oxygen (DO), and other water quality conditions, combined with an adequate amount of food and shelter, are needed for our brook trout to thrive. This is a healthy brook trout habitat. If the water temperature is less than 70 degrees and the DO is high, things are looking good. Add a pH between 6.5 and 7.5 (ideal), plenty of food, and places to seek shelter from the current or predators, and you have ideal brook trout habitat. Other fish, including other species of trout, and aquatic organisms have requirements similar to those of the brook trout. These organisms and the way they interact are called a "community." Some members of a fish community provide important food for the fish we want to catch.

Like our brook trout, smallmouth bass have specific habitat requirements. They are part of a community of fish found in our warmer streams and rivers. These waters provide the right conditions for this fish community to live. The same holds true for largemouth bass, muskies, northern pike, walleyes, panfish and other fish that anglers seek. These fish are found where their requirements for life are met. Water pollution can change all that. Pollution can alter one or many important components of a habitat. When that occurs, the health of individual organisms, and often the entire community, is at risk.

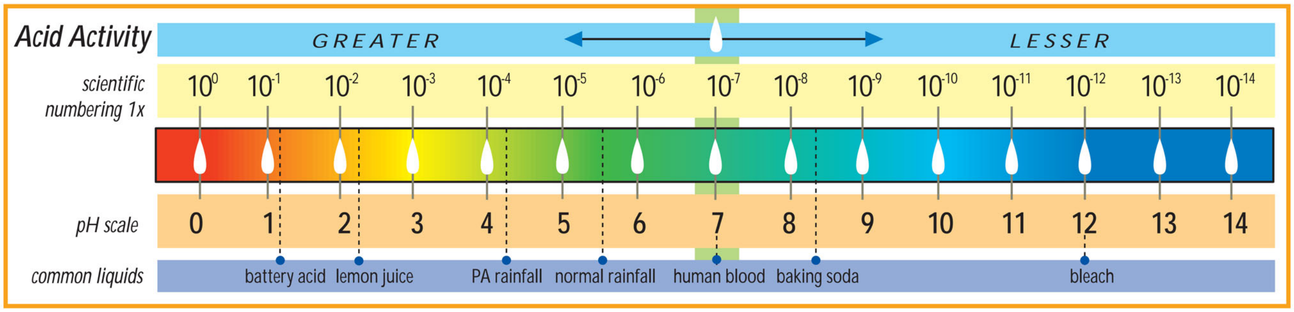
Requirements for life

Let's look at some important water quality factors, and how they may influence the fish community.

The measure of hydrogen ions or acidity in a solution like water is called pH. The pH scale ranges from 0 (most acidic) to 14 (most basic). A pH of 7 is considered neutral. The pH scale is logarithmic–it changes by tens. That is, a change of one whole number in the pH equals a tenfold change in the amount of acidity. Changes of two whole numbers indicate a 100-fold change in acidity. The pH of a solution also influences the amount of substances like heavy metals dissolved in it.

In aquatic habitats, pH has a strong effect on which fish, amphibians, invertebrates and plants can live in a community. The pH of a stream or lake depends on the water source and the kinds of rocks and soil that water contacts. Proper pH is an important life requirement for

photo-Barry & Cathy Beck



graphic-Ted Walke

all aquatic organisms. Developing eggs and larvae also have specific, more narrow pH requirements. Adult brook trout can tolerate a pH of between 5.0 to 9.5 and remain relatively healthy. However, even at the high and low ends of this pH tolerance level, fish become stressed. Aquatic invertebrates, with external skeletons or shells made of calcium, are extremely sensitive to pH below neutral. These organsisms are important members of aquatic food chain.

At the low end of this range, naturally occurring metals will dissolve into the water. This hits the aquatic life with a double whammy–low pH and high metals concentration. A fish that could tolerate water with a pH less than 5 will die at a pH of 5.5 if the water contains as little as 1.0 parts per million (ppm) of iron. One ppm is equivalent to a drop of chocolate in 16 gallons of milk. Biologists call these relationships synergism–where two substances combine to have effects much worse than just their sum. Water with low pH (less than 6.0) coming in contact with naturally occurring low concentrations of iron, lead, aluminum, magnesium or mercury creates a toxic cocktail. Therefore, pH is a critical factor in aquatic habitats.

These dissolved metals may interfere with body functions. They can also influence developing eggs and larvae. This leads to lower natural reproduction, if any at all. Ultimately the population declines, the food chain collapses and the community suffers.

Temperature

Fish can't maintain their internal body temperature as do humans. Fish have very specific temperature requirements. Water temperature can influence oxygen concentration, metabolism (body functions), reproduction and growth. Water temperature is influenced by the seasons, the amount of sunlight reaching the water, amount and speed of the water, the source of the water (springs or runoff) and the amount of material suspended in the water. Fish are found where the temperature range is within their tolerance, and better still, within the ideal range. For example, temperatures higher than 75 degrees are usually lethal for brook trout. But fish like the channel catfish and largemouth bass need temperatures that high to survive and reproduce successfully. Rapid changes in temperature can kill fish. But that same change in temperature over the course of a season (say, spring to summer) can have little effect on the aquatic community.

Dissolved Oxygen (DO)

Dissolved oxygen is another important water quality factor for fish and many aquatic invertebrates. DO is the amount of oxygen dissolved in the water. Even though the

Solubility of Dissolved Oxygen

Solubility: Amount of dissolved oxygen that distilled water can hold at a given temperature.

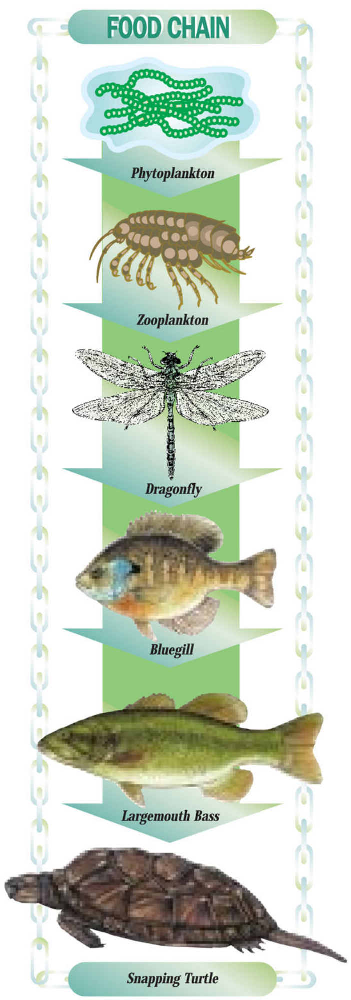
Temperature (C*):	Solubility (mg/l)
0:	14.6
1:	14.2
2:	13.8
3:	13.5
4:	13.1
5:	12.8
6:	12.5
7:	12.2
8:	11.9
9:	11.6
10:	11.3
11:	11.1
12:	10.9
13:	10.6
14:	10.4
15:	10.2
16:	10.0
17:	9.8
18:	9.6
19:	9.4
20:	9.2
21:	9.0
22:	8.9
23:	8.7
24:	8.6
25:	8.4
26:	8.2
27:	8.1
28:	7.9
29:	7.8
30:	7.7

*to convert Fahrenheit to Celsius: [(F-32) x 5]/9=C chemical formula for water is H_20, fish and other aquatic organisms can't remove the oxygen molecules. They depend on oxygen dissolved in the water for respiration. They extract the oxygen dissolved in the water through their gills or across their skin.

Temperature, water velocity, wind, water depth and plant growth influence DO in water. Temperature has great influence on the amount of DO. Warmer water contains less oxygen than colder water. The number of organisms using oxygen can also influence the amount of dissolved oxygen present. If more oxygen is used (respiration) than is being put in, dissolved oxygen levels decrease.

The dissolved oxygen needs for many aquatic insects and fish differ, but some ranges overlap. Fish such as blacknosed dace, brook and brown trout, and certain stoneflies have similar oxygen needs. That's one of the reasons they are found together in the same community. The same holds true for smallmouth bass, certain shiners and hellgrammites. Their dissolved oxygen needs and tolerances overlap.

Channel catfish and carp can tolerate DO as low as 2 mg/l. Generally, dissolved oxygen levels in aquatic habitats must be greater than 6.5 mg/l for fish and aquatic organisms to survive.



Food

Fish, like humans, need food to survive. When food is abundant at the right time of year, fish grow and stay healthy. But fish can go without food for long periods. Long-term survival of a fish population requires abundant food. That's why biologists study not only the fish we want to catch, but the food they eat. All members of the community—the food chain—are important to the survival of sport fish. The first links in a food chain are plants. In aquatic habitats, these plants may be single-celled phytoplankton, algae or larger submerged plants. Some small streams depend on leaves falling from nearby trees as an energy source. All members of the community have a role in providing food.

These plants are then eaten by smaller aquatic insects and other invertebrates similar to the way cattle may graze a field of grass. These insect grazers are then eaten by other insects and larger fish, which are called "consumers" in the food chain. Finally, large predator fish eat the smaller fish and insects.

Shelter, or cover

Fish need shelter from predators. They need places to hide from the time they hatch to the time they die of old age. Fish living in moving water also need places to rest from the current. The bottom of a lake, river or stream often provides important shelter. Vegetation, growing in the water or on its shores, also provides important shelter.

Brine discharge from an oil field production operation on Lewis Run, McKean County.

All the components for healthy brook trout (or any other fish's) habitat must come together in just the right amounts for it to survive. You can see that if any one of the conditions changes, the resident fish and other members of the community will have a tough time of it. If conditions change too much, the fish community may change. This change may not always be for the best. Water pollution can throw off this delicate balance.

Pollution

Water that has had the delicate balance upset is called "impaired." In Pennsylvania, two major kinds of pollution impair our waters: Agricultural runoff and abandoned mine drainage (AMD). These pollution sources put excess nutrients, siltation and metals into our waters. Even though there are many other pollution sources, none of the others combined affects as many stream miles or acres of lakes as these three.

Agricultural runoff

Agricultural runoff occurs when runoff from rain or melting snow carries soil, pesticides and fertilizers from fields into nearby waters. When soil is carried into a stream or river, it can suspend in the water to make it cloudy, or it

photo-PFBC file photo, graphic-Ted Walke photo-PFBC file photo

This stream flows through an unfenced pasture. The stream has no cover and its stream banks are eroded and unstable. The effects of livestock here include increased plant growth, decreasing amounts of dissolved oxygen (as manure breaks down), and elimination of important stream-bottom habitat.

settles to the bottom as silt. Silt in the water can damage some fish's gills and make breathing difficult. Cloudy water also absorbs more sunlight than clear water. This may raise the water temperature. A temperature that's too high can stress or kill aquatic organisms. It may also account for the reason why some fish have left a community where they have lived for years.

Silt that settles to the stream bottom is known as "sediment." Fish find some of the food they require on stream bottoms. An increase in a waterway's amount of sediment can kill invertebrates by suffocating them. Sediment can also smother fish eggs and alter natural repopulation patterns. It can also fill in the living spaces and destroy habitat.

photo-Ted Walke

A redeveloped riparian (stream bank) zone has plenty of cover, shading and stable stream banks.

Nutrients like nitrogen and phosphorus also enter our waters from farms. Manure and other fertilizers are used to increase crop production. When these nutrients reach our streams and rivers, they have the same effect on aquatic plants. Aquatic plant and algae growth can reach nuisance levels. Decomposing plants also consume dissolved oxygen. When less oxygen and warmer temperatures are combined, things change. Our brook trout, and mayflies, caddisflies and stoneflies, will move or die. In their place may be smallmouth bass, rock bass and catfish, which tolerate warmer water and require less DO. The community has been changed by pollution.

Livestock can also affect aquatic communities. Stream banks erode where livestock enter the water to drink or cross to reach other pastures. This increases the amount of silt. Manure is also deposited directly into the stream. The effects of livestock include increased plant growth, decreasing dissolved oxygen (as manure breaks down) and eliminating important stream bottom habitat.

To protect their crops, farmers use pesticides to remove pests. Most pesticides are designed to kill insects and are poisonous to aquatic life when they enter a waterway. In high concentrations pesticides can kill all aquatic life in a community. In low concentrations they can alter food chains by killing or injuring the most sensitive organisms.

Abandoned mine drainage (AMD)

AMD pollutes almost half of Pennsylvania's impaired waters. AMD is one of our waterway's worst pollutants. AMD occurs when water enters abandoned coal mines. Runoff from mine lands and refuse piles may also form AMD. Water reacts with iron pyrite in the coal and surrounding rocks and forms acids. These acids are then transported into our waters. Most of the sources of AMD today are long-abandoned mine sites. These mines were in their heyday at the turn of the century or from a time when regulations were less strict.

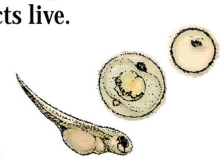
Little Sewickley Creek, Westmoreland County. The yellowish-orange stream-bottom staining of "yellow boy" is caused by acid mine drainage.

The most immediate effect of AMD is lowering the water's pH level. When pH decreases below 6.0, algae and rooted aquatic plants can die. The food supply for aquatic organisms is reduced. Healthy aquatic communities are then replaced by those more acid-tolerant.

Acidity can also stress a fish's body function. Another problem is gill damage and a decrease in sodium in the fish's blood. Fish eggs and fry (young fish) are also affected. The young born for an entire year can die. This leaves only older, more resistant fish left in a community. Eventually, without the fry, the community will be void of fish. Often, however, the pH of AMD is so low that the entire community is wiped out.

Metal toxicity caused by AMD is another common stream killer. Aluminum, iron and manganese enter our waters from abandoned mines. These metals are toxic to the brook trout and other aquatic life. Small amounts of these metals can stress fish or even cause death, especially in young, developing fish. Large amounts can settle on a stream bottom. This settling can make the stream water and bottom appear yellow (iron), white (aluminum) or black (manganese). The covering smothers the few invertebrates that may be left. It also eliminates shelter important to spawning and places where aquatic insects live.

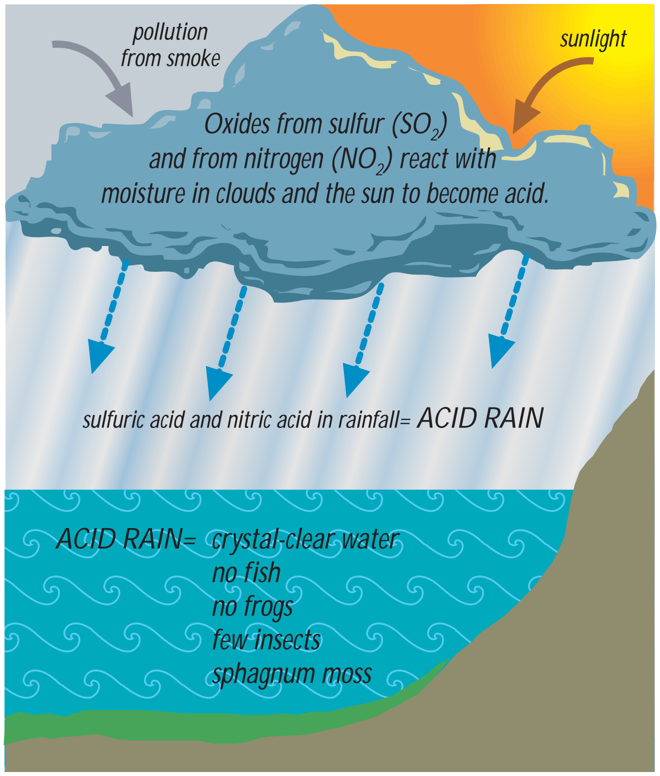
Acid rain



Acid rain is formed when moisture in the clouds mixes with sulfur or nitrogen in the air. Acid rain includes rain, sleet or snow with a pH level that falls below 5.6 (normal rainwater). The sulfur and nitrogen get into the air by the burning of fossil fuels such as coal and gasoline. The average pH of rainfall in Pennsylvania is 4.3. This level is some of the most acidic rain in the country. The effects of acid rain are often worse in the spring, following snowmelts. Large quantities of low pH snow melts and enters our streams.

The effects of acid rain on stream and lake communities are similar to those of AMD. Low pH combined with dissolved metals influences natural reproduction as well as day to day survival. Acid rain is such a problem in some Pennsylvania streams, especially in the spring, that the Commission changes its trout stocking schedules. These streams are stocked only after the "slug" of low pH snowmelt has moved through. The low pH of spring snowmelt may also have an effect on developing trout and aquatic insects, from eggs laid the previous year. Young developing organisms are more sensitive to lower pH and even small concentrations of metals than they are as adults.

photo-Russ Gettig graphic-Ted Walke



What the Fish and Boat Commission is Doing

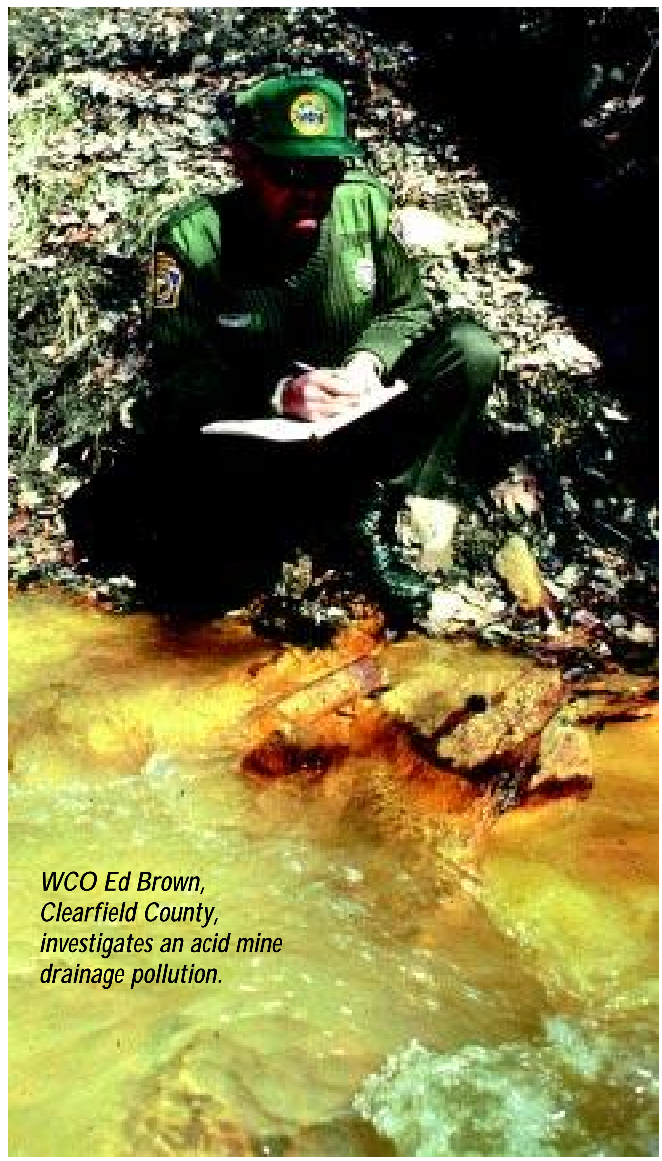
•**Permits and Regulations.** The best way to address pollution is to prevent it. The Commonwealth of Pennsylvania has laws in place protecting water quality. The PA DEP regulates the things industries release into the air or water. DEP also has regulations in place protecting banks and channels in rivers, lakes and streams. Before any activity can be done on the shoreline or to the stream or river bottom, a permit must be obtained. Before any substances can be discharged into a stream or lake, a permit must be obtained. The regulations contain standards for many water quality factors. Among them are pH, dissolved oxygen and temperature. The discharges must meet these standards or they are not allowed. In addition, the discharges and activities can't alter the aquatic community that lives downstream.

The Fish & Boat Commission plays an important role in the review of these permit applications and compliance with the permit. The Commission utilizes its technical expertise to ensure that fish communities are not harmed by the proposed activities. Commission staff reviews more than 1,500 permit applications each year. Permits for activities that have the potential to harm aquatic communities are often recommended for denial. The permit applicant and DEP negotiate to change the activity to reduce or eliminate the potential effect.

Other state, regional and local agencies may also be involved in the review of these permit applications. Local conservation districts and water authorities also have a vested interest in protecting water quality and aquatic life.

•**Monitoring, law enforcement.** Discharges are most often required to exceed specific standards, based on the chemicals discharged and the water receiving the discharge. Monitoring is achieved through routine sampling of elements such as pH, dissolved oxygen, metals and other chemicals. The results of these samples are reported to DEP, and often to the Fish & Boat Commission. Waters receiving a discharge are routinely surveyed by the Fish & Boat Commission or DEP biologists to assess water quality above and below the discharge. Data is also often compared to that collected before the discharge was approved.

If the quality of the water, or composition of the fish community, shows signs of impairment, the polluter may be fined by both DEP and the Fish & Boat Commission.


WCO Ed Brown, Clearfield County, investigates an acid mine drainage pollution.

Just as anglers are given a citation and a fine when violating fishing regulations, so are polluters fined for violating those regulations. Pollution fines are based on the damage done to the resource. Much of the money collected in fines is used to stop the effects of pollution. The Fish & Boat Commission collected more than $300,000 in fines in 1999.

The Commission's waterways conservation officers play important roles in enforcing water quality laws and regulations. They investigate pollution violations, collect evidence and often prosecute the cases in court. WCOs and the Fish & Boat Commission Division of Environmental Services staff also play an important role in reviewing permit applications.

So what can I do?

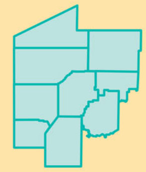
First, Pennsylvanians are truly blessed with high-quality aquatic resources, and it's important to understand and appreciate the abundant aquatic resources of our state. Often positive environmental qualities are overshadowed by the gloom and doom of pollution. Currently, some one-fifth of the waterways we have studied (13 percent of the total) are impaired, but we are making significant progress in reversing hundreds of years of abuse and neglect.

Second, you can become part of the solution. Evaluate your own use of fertilizers and pesticides at home in your yard. If you don't purchase a fishing license, consider doing so. Fishing license dollars help the Fish & Boat Commission do its job protecting Pennsylvania's fish and aquatic life. The Fish & Boat and PA DEP also offer several opportunities for people or groups that want to volunteer their time and services. For more information, visit our web site: www.fish.state.pa.us.

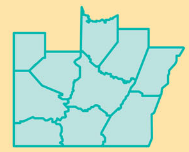
To report water pollution or disturbances to streams, lakes or watersheds, contact the Fish & Boat Commission Regional Law Enforcement office for your region or the Pennsylvania Department of Environmental Protection (DEP) at 1-800-541-2050.

"The people have a right to clean air, pure water, and to the preservation of the natural, scenic and esthetic values of the environment. Pennsylvania's public natural resources are the common property of all the people, including generations yet to come. As trustee for these resources, the Commonwealth shall conserve and maintain them for the benefit of all the people."
Article 1, Section 27, Pennsylvania Constitution

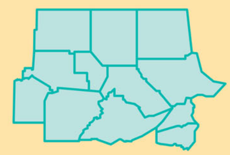
PFBC Regional Law Enforcement



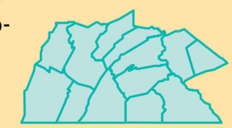
Northwest Region. 11528 SH 98, Meadville, PA 16335; 814-337-0444. Butler, Clarion, Crawford, Erie, Forest, Lawrence, Mercer, Venango and Warren counties.



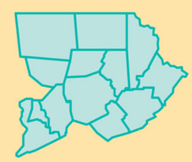
Southwest Region. 236 Lake Road, Somerset, PA 15501; 814-445-8974. Allegheny, Armstrong, Beaver, Cambria, Fayette, Greene, Indiana, Somerset, Washington and Westmoreland counties.



Northcentral Region. 450 Robinson Lane, Bellefonte, PA 16823; 814-359-5250. Cameron, Centre, Clearfield, Clinton, Elk, Jefferson, Lycoming, McKean, Northumberland (west of Rt. 147), Potter, Snyder, Tioga and Union counties.



Southcentral Region. 1704 Pine Road, Newville, PA 17241; 717-486-7087. Adams, Bedford, Blair, Cumberland, Dauphin, Franklin, Fulton, Huntingdon, Juniata, Lebanon, Mifflin, Perry and York counties.



Northeast Region. P.O. Box 88, Main Road, Sweet Valley, PA 18656; 570-477-5717. Bradford, Carbon, Columbia, Lackawanna, Luzerne, Monroe, Montour, Northumberland (east of Rt. 147), Pike, Sullivan, Susquehanna, Wayne and Wyoming counties.

Southeast Region. P.O. Box 8, Brubaker Valley Road, Elm, PA 17521; 717-626-0228. Berks, Bucks, Chester, Delaware, Lancaster, Lehigh, Montgomery, Northampton, Philadelphia and Schuylkill counties.

For answers to technical questions about the effects of pollution on fish and aquatic life:
Fish & Boat Commission
Division of Environmental Services,
450 Robinson Lane, Bellefonte, PA 16823; 814-359-5147.

SPORT FISH RESTORATION

Your purchase of fishing equipment and motor boat fuels supports Sport Fish Restoration and boating access facilities

ATTACHMENT 19

Brook Trout Technical Work Group

Brook Trout Species Author:

Tim Obrey
Fisheries Resource Supervisor
Moosehead Lake Region

Introduction

National Recognition

From the 2006 Eastern Brook Trout Joint Venture:

Maine is the only state with extensive intact populations of wild, self-reproducing brook trout in lakes and ponds, including some lakes over 5,000 acres in size. Maine's lake and pond brook trout resources are the jewel of the eastern range: lake populations are intact in 185 subwatersheds, in comparison to only six intact subwatersheds among the 16 other states.

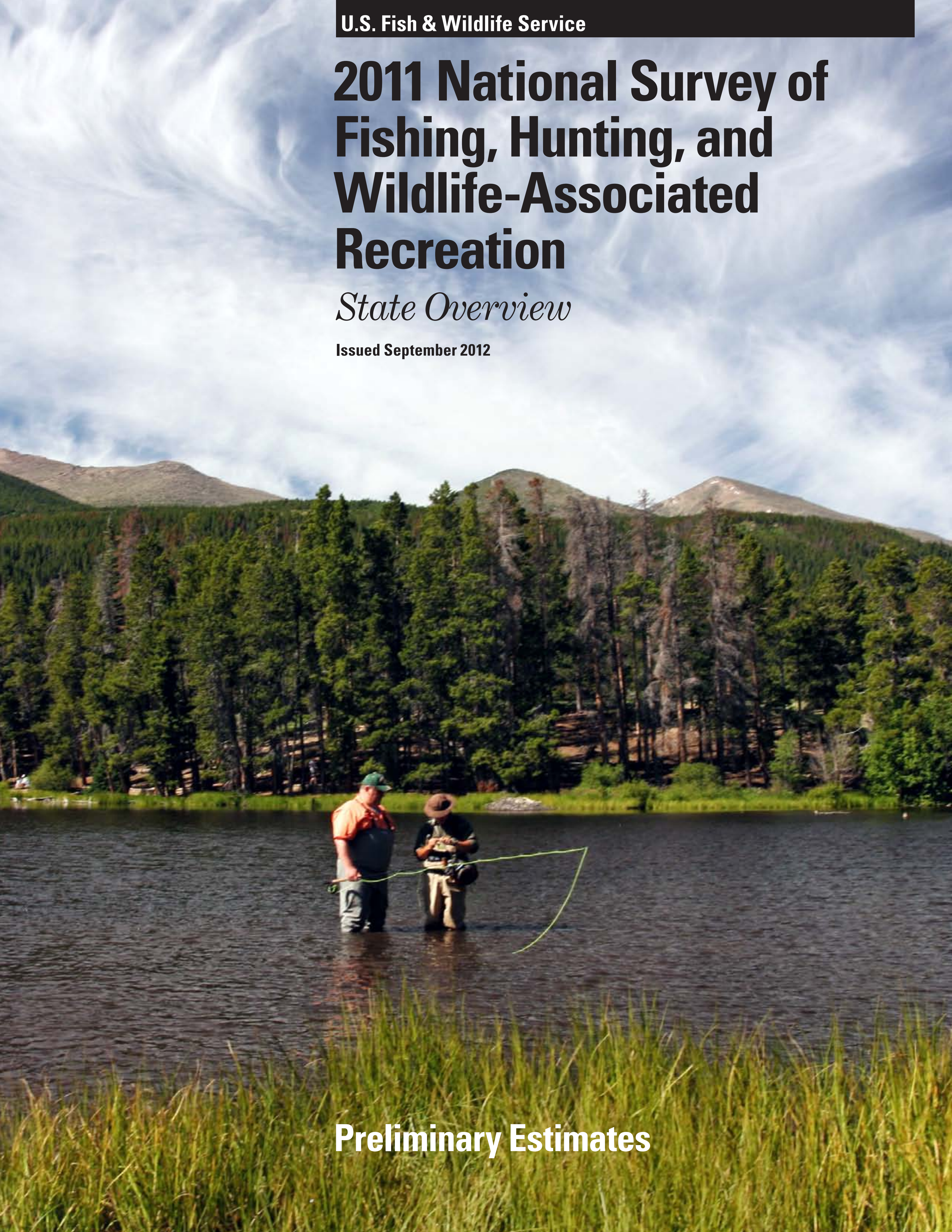
ATTACHMENT 20

U.S. Fish & Wildlife Service

2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation

State Overview

Issued September 2012



Preliminary Estimates

Preliminary Table 11. Expenditures for Fishing by State Where Spending Took Place: 2011

(Population 16 years old and older. Expenditures in thousands of dollars.)

		Trip-related expenditures				Expenditures for equipment				
State where spending took place	Total expen-ditures	Total trip-related	Food and lodging	Transpor-tation	Other trip costs	Total equipment	Fishing equipment	Auxiliary equipment	Special equipment	Expen-ditures for other items1
United States, total	**41,573,783**	**21,789,465**	**7,711,318**	**6,261,536**	**7,816,610**	**15,311,177**	**6,141,895**	**1,106,865**	**8,062,417**	**4,473,141**
Alabama	456,442	317,064	121,973	78,970	116,120	127,616	107,492	*16,676	…	11,762
Alaska	639,356	528,135	227,663	164,152	136,321	91,228	56,246	20,338	…	19,992
Arizona	755,027	357,472	123,342	95,693	138,437	337,188	62,790	*9,343	*265,056	60,366
Arkansas	495,584	339,640	153,245	117,488	68,907	142,292	45,750	…	…	13,651
California	2,267,130	1,620,329	576,406	462,576	581,347	577,356	320,577	141,384	*115,394	69,445
Colorado	648,563	403,569	134,342	193,604	75,624	213,528	121,723	*32,643	…	31,466
Connecticut	436,358	258,671	66,355	46,676	145,640	163,275	58,289	32,986	…	14,411
Delaware	104,618	48,959	20,848	12,124	15,987	21,411	12,965	*1,100	…	34,249
Florida	4,626,975	2,801,636	900,222	563,990	1,337,423	1,085,576	600,093	76,817	*408,666	739,763
Georgia	872,550	401,784	166,506	152,932	82,346	430,234	111,651	…	…	40,532
Hawaii	203,492	102,074	24,985	30,283	46,806	100,236	48,734	*2,525	…	*1,182
Idaho	421,491	261,072	96,171	123,836	41,065	105,933	78,610	*6,297	…	54,486
Illinois	972,299	372,361	124,642	98,210	149,509	387,439	100,569	*15,611	*271,258	212,500
Indiana	671,840	427,310	140,320	136,879	150,110	164,516	92,066	*12,805	…	80,015
Iowa	277,999	100,539	34,913	33,101	32,525	159,732	48,500	*7,180	*104,052	17,728
Kansas	210,303	98,165	28,249	35,760	34,156	68,046	24,341	…	…	44,092
Kentucky	807,293	259,128	92,732	93,334	73,062	463,240	51,282	…	*399,129	84,925
Louisiana	807,033	533,843	217,851	126,429	189,563	242,032	88,745	…	…	31,158
Maine	371,829	214,686	89,002	52,979	72,705	141,385	34,117	*11,210	*96,057	15,758
Maryland	535,232	195,536	60,387	37,093	98,056	332,279	77,882	…	…	7,417
Massachusetts	455,403	253,705	62,852	52,098	138,754	188,541	77,827	*4,947	*105,767	13,157
Michigan	2,427,110	1,092,735	373,964	344,495	374,276	1,117,911	259,043	*84,705	*774,162	216,464
Minnesota	2,414,257	924,573	372,819	269,690	282,064	1,448,648	375,809	*25,336	*1047,503	41,036
Mississippi	527,740	315,763	101,802	93,213	120,748	200,790	164,977	…	…	11,187
Missouri	665,170	374,215	146,842	146,217	81,157	262,939	143,930	*8,061	*110,948	28,015
Montana	339,383	141,885	54,909	57,950	29,027	140,728	83,447	…	…	56,770
Nebraska	182,574	56,840	20,029	24,374	12,437	112,780	65,105	*7,839	*39,836	12,954
Nevada	138,269	83,275	34,026	32,323	16,926	49,130	22,165	*5,180	…	5,864
New Hampshire	208,524	151,389	39,031	38,369	73,989	51,872	30,551	*4,093	…	5,263
New Jersey	1,120,018	486,978	129,828	103,695	253,455	319,118	151,784	41,474	*125,860	313,922
New Mexico	418,182	234,187	93,272	114,565	26,351	169,541	42,787	*11,780	*114,974	14,455
New York	1,945,147	1,057,916	333,483	306,506	417,927	758,530	395,723	75,814	*286,993	128,702
North Carolina	1,520,943	1,020,156	443,338	239,146	337,672	480,065	269,784	*25,767	*184,514	20,722
North Dakota	70,755	38,907	18,048	7,162	13,697	30,679	25,540	…	…	1,169
Ohio	1,794,642	594,519	171,728	165,782	257,009	460,353	220,277	*39,299	*200,776	739,770
Oklahoma	730,503	175,701	69,820	71,458	34,423	227,980	70,531	*69,769	…	326,822
Oregon	640,047	358,680	148,761	95,820	114,099	235,384	68,013	*14,338	*153,032	45,983
Pennsylvania	484,996	228,510	76,705	83,154	68,651	193,879	114,099	*12,696	…	62,607
Rhode Island	130,046	83,935	22,082	17,062	44,791	41,804	14,985	*813	*26,006	4,307
South Carolina	685,973	359,834	116,079	89,606	154,149	319,015	231,271	*9,818	…	7,125
South Dakota	202,797	133,078	44,159	64,968	23,951	64,834	45,547	*8,359	…	4,885
Tennessee	1,137,104	283,024	78,345	112,279	92,401	803,472	210,219	*20,154	…	50,608
Texas	1,540,434	1,045,330	422,885	297,817	324,629	471,190	203,698	*27,174	…	23,914
Utah	451,259	226,251	93,714	77,555	54,983	211,585	52,178	*10,909	…	13,423
Vermont	131,223	90,248	40,684	26,215	23,350	26,007	15,437	*819	…	14,968
Virginia	1,142,099	469,096	215,544	113,859	139,693	379,123	133,986	*6,264	*238,872	293,880
Washington	1,029,728	539,035	160,994	170,219	207,823	435,580	214,677	48,657	*172,245	55,113
West Virginia	428,646	326,275	158,734	77,728	89,813	97,553	56,130	…	…	4,819
Wisconsin	1,418,591	607,467	232,140	220,905	154,422	480,273	93,996	…	*380,740	330,851
Wyoming	463,814	393,984	34,547	91,201	268,236	44,907	30,752	…	…	24,923

** Estimate based on a sample size of 10-29. … Sample size too small (less than 10) to report data reliably.*

1 Includes expenditures for magazine subscriptions, membership dues and contributions, land leasing and ownership, and licenses, stamps, tags, and permits.

Note: U.S. totals include responses from participants residing in the District of Columbia.

ATTACHMENT 21

Mine Drainage

ACTIVE

By Water Resources Mission Area February 28, 2019

As settlers traveled west and mined the American landscape, thousands of new mines were created over the centuries and then abandoned. Now, these long forgotten remnants of a bygone area still haunt us, as their operations left behind materials and rock exposures that can be easily eroded and carried downstream. The USGS helps track the sources of acidic mine drainage and helps land managers develop better mitigation strategies.

BACKGROUND

Mine drainage refers to any surface water or groundwater that drains from an active or abandoned mining operation. Mine drainage can be high-quality similar to natural waters or contaminated by leftover materials. Polluted mine drainage can be extremely acidic and is often laden with high concentrations of toxic, heavy metals. In general, the more acidic the water, the more likely it is to be harmful to living organisms.

Mine drainage forms from a chemical reaction between water and rocks containing sulfur-bearing minerals. The resulting waters become rich in sulfuric acid and dissolved iron. As the iron settles out of the water, it can form red, orange, or yellow sediments in the bottom of streams. The acidic runoff further dissolves heavy metals such as copper, lead, mercury into groundwater or surface water. The rate and degree by which acid-mine drainage proceeds can be increased by the action of certain bacteria.

Sources/Usage: Public Domain.

Acid mine drainage can change the color of a stream into red or orange.

THE CHEMISTRY OF MINE DRAINAGE

Because the chemistry of water samples can rapidly change if removed from the mine, many mine drainage measurements are made in the field. The first measurement typically looks at acidity, which is reported as pH. A *neutral* pH has a value of 7. Any sample that reads below a pH of 7 is characterized as being *acidic*. Anything greater than 7 is described as being *basic*. The more acidic the water is, the better it is at eroding mining slag, rocks, and other materials. The water then transports the contaminated mine materials to nearby rivers before eventually depositing the materials downstream. Some mine drainage has been seen to have pH in the 2.5-4 range[1].

Another water-quality parameter that is useful for characterizing water quality of acid mine drainage is specific conductance. Conductance is a measurement of the electrical conductivity in a water sample and is a indicator of what's dissolved in a liquid. It is also very inexpensive to measure, unlike testing for metals and other pollutants. Different substances will affect the conductance of water, allowing scientists to use changes in conductance as an indicator of changes of whatever is in the water - in this case the amount of contaminants coming from the mine.

Sources/Usage: Public Domain.

Sampling acid mine drainage residuals in Elk County, Pennsylvania. The USGS has pioneered a new use for these residuals that are currently a disposal challenge, using them to filter phosphorus from agricultural and municipal wastewaters. (Credit: Philip Sibrell, USGS)

RELATED USGS RESEARCH

- USGS Mine Drainage Activities
- Contamination associated with active and abandoned hard-rock mining
- USGS Central Mineral Resources team

ATTACHMENT 22

Wild Brook Trout

Maine supports the most extensive distribution and abundance of wild brook trout (Salvelinus fontinalis) in their native range within the United States; more than 1,200 lakes and ponds are managed for brook trout, of which approximately 60% are sustained by natural reproduction. In addition, brook trout occur in an estimated 22,248 miles of stream habitat, the vast majority of which are wild. Although brook trout populations are declining across their historic range within the United States (Maine to Georgia), a 2006 range-wide assessment by the Eastern Brook Trout Joint Venture (EBTJV) concluded that:

"Maine is the only state with extensive intact populations of wild, self-reproducing brook trout in lakes and ponds, including some lakes over 5,000 acres in size. Maine's lake and pond brook trout resources are the jewel of the eastern range: lake populations are intact in 185 subwatersheds (18% of the historical range), in comparison to only six intact subwatersheds among the 16 other states." Furthermore, Maine is the last true stronghold for stream dwelling populations of wild brook trout, supporting more than twice the number of intact subwatersheds as the other 16 states in the eastern range combined.

Maine's wild brook trout waters are found throughout the state, but are most prevalent in the interior highlands, many of which are located in privately owned commercial forestlands. This cooler region provides more optimal conditions with fewer competing, non-native fish species than the southern or coastal parts of the state.

Maine's native and wild brook trout lakes, ponds, and flowing waters represent a unique and abundant resource not available elsewhere in the United States. Not surprisingly the MDIFW places a high priority on the management of this important resource, with a focus on protection, conservation, enhancement, and restoration of self-sustaining populations.

Your browser can't play this video.

DOWNLOADS

- Forest Management Recommendations for Brook Trout (PDF)
- Biology and Management (PDF)
- Maine's Heritage Fish Waters List (MS Word)

To view PDF documents, you will need the free Adobe Reader. If you need assistance, view our PDF Help page, or email us.

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STATE OF MAINE
LAND USE PLANNING COMMISSION

IN RE: PICKETT MOUNTAIN MINE	)	
REZONING APPLICATION	)	
	)	**PRE-FILED DIRECT TESTIMONY**
Applicant: Wolfden Mt. Chase LLC	)	**OF STU LEVIT**
Location: T6R6 WELS	)	
Commission Application Number: ZP 779A	)	

This pre-filed direct testimony of Stu Levit of the Center for Science in Public Participation is submitted on behalf of Intervenors Penobscot Nation, Houlton Band of Maliseet Indians, Natural Resources Council of Maine, and Conservation Law Foundation, in opposition to the rezoning application ("Application") filed with the Land Use Planning Commission ("LUPC") by Wolfden Mt. Chase LLC, a wholly owned subsidiary of Wolfden Resources LLC (collectively "Wolfden"). Note: All page references to the Application are to the pdf pagination of the Application as posted on LUPC's website, not the internal document pagination.

I. QUALIFICATIONS

I have served as a staff scientist with the Center for Science in Public Participation for 20 years, where I have provided research, analysis, technical reporting, and advice to non-governmental organizations, regulatory agencies, and indigenous communities regarding proposed and existing mines, with a focus on the impacts of mining on water and other natural resources, as well as mine reclamation, rehabilitation, and cleanup, and mining best practices. In the past, I worked for the Montana Department of State Lands in the Abandoned Mine Reclamation Bureau as a Land Reclamation Specialist. There, I assessed minesite problems and designed reclamation plans at coal mines and hard rock mines, with a focus on water quality and watershed improvement and acid mine drainage prevention and treatment. I obtained an M.S. in

Land Reclamation from Montana State University in 1989 and a J.D. from Montana State University in 1994.

II. THE PROJECT'S IMPACTS TO WATER

A. Treatment of Mine Process Water and Stormwater Runoff

Under Maine law, Wolfden's proposed mine would be required to ensure that all water discharges are of equal or better water quality to the pre-existing water quality.[1] Wolfden claims that it will treat all mine and mine waste contact water to background (pre-mining) quality levels prior to discharge.[2] However, Wolfden has not provided an example of a similar mine that accomplishes or has accomplished this and in my two-plus decades of experience I have not heard of a comparable hard rock mine achieving this. As discussed below, Wolfden's proposal is not adequate to show that its proposed methods will actually work.

In its review of Wolfden's prior application, the Maine Geological Survey ("MGS") specifically asked Wolfden to provide an example of a mine that treats wastewater to levels as clean as natural background, stating in its review comments:

> In considering the viability of a zoning change to allow for a polymetallic mine at the Pickett Mountain site, it is important for the State of Maine to be presented with evidential information of other mine sites throughout the world (mining for massive sulfide ore bodies for the same or similar metals) which have used the same or very similar approach to the mining and ore processing as is being proposed here (discussions of similarities and dissimilarities of the ore deposits and approach to mining, processing and waste storage).[3]

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[1] *See* Letter from Michael Clark, Maine Dep't Env't Protection, to Tim Carr, LUPC, No. ZP779A at 6–7 (July 5, 2023), https://www.maine.gov/dacf/lupc/projects/wolfden/review/ZP779A_AgencyReviewMemoranda.pdf.

[2] See e.g., Stantec Consulting Services Inc., Land Use Planning Commission Application for Zone Change: Pickett Mountain Metallic Mine, LUPC No. ZP779A at 6, 294 (Jan. 19, 2023) ("Application") ("The Project's water treatment approach (see Section 10.5.2.1) is designed to treat mine process and stormwater and remove chemicals to meet background levels prior to its return to the natural environment."). All Application page numbers cited refer to PDF pagination, not internal document pagination.

[3] Memorandum from Daniel B. Locke, Maine Geological Survey, to Stacie R. Beyer, LUPC, No. ZP779 at 1 (Oct. 15, 2020).

If Wolfden's proposed treatment methods and promised results were realistic and practicable, it is highly likely that there would be available examples of other comparable mines achieving similar results because the technologies that Wolfden proposes to use are not new or unique. However, in the two years since MGS asked for one, Wolfden has not provided such an example.

In addition to failing to provide a comparable example, Wolfden has also failed to demonstrate that achieving the promised water treatment results is financially feasible at this proposed mine. Wolfden proposes to use ultrafiltration ("UF") and reverse osmosis ("RO") at its mine water treatment plant. Both UF and RO use filtration to remove contaminants, requiring pressure to force water through the filters, with RO involving a finer filter. In order to potentially achieve the water quality levels that Wolfden promises, mine contact water and runoff might need to be run through these filtration systems multiple times.[4] While this is technologically possible, Wolfden has not demonstrated that it would be economically realistic and not be prohibitively expensive to effectively employ. As materials are captured by the RO filters, the filters clog and need to be cleaned or replaced. These filters can be expensive and can add significantly to operating costs. Both the water and dissolved ions rejected by the filter, and the water used to clean the filters, requires recycling and/or disposal, leading to greater costs.

Further, the physiochemical demands imposed by the need to achieve Wolfden's promised discharge pristine background water quality levels could reasonably require a large treatment facility that will be expensive to both construct and operate. Yet further adding to the water treatment costs is the fact that RO can generate a concentrated waste stream (or "brine") of

[4] Application at 293.

20–30% of the treated volume.[5] LUPC's consultant Linkan Engineering (an LUPC consultant from Wolfden's first application and whose 2020 report LUPC has already inserted into the record for this application) has noted "RO reject [i.e. brine] disposal can be a severe problem," and Wolfden's plans for such disposal "should be defined better."[6] Wolfden's water treatment scoping study states that this brine would be stored on site and then used as feed water to make cement for disposal underground.[7] But Wolfden has not demonstrated that it would be effective, and allowed under applicable regulations, to dispose of the brine in this way.

In addition, Boliden, a Swedish mining company with far more resources and actual mining experience than Wolfden,[8] examined the use of reverse osmosis for a different site in Maine and rejected it because of cost and difficulties with brine disposal. In the case of the proposed Bald Mountain Mine in Aroostook County, Boliden's consultants stated that the use of RO would not be "practical or justifiable" because the brine it would generate would be too toxic and voluminous to feasibly manage. [9] According to the consultants—the prominent mining consulting firm Steffen Robertson and Kirsten (B.C.) Inc.,—RO and a similar process called ion exchange, "are not preferred due to expense, complexity, and the problems associated with brine or regeneration solutions."[10] The consultants explained that "[t]he side streams produced from these processes contain very high concentrations of dissolved constituents.... A mine water

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[5] U.S. Env't Protection Agency, Reference Guide to Treatment Technologies for Mining-Influenced Water, EPA 542-R-14-001 at 42–43 (Mar. 2014), https://www.epa.gov/sites/default/files/2015-08/documents/reference_guide_to_treatment_technologies_for_miw.pdf.
[6] Memorandum from James J. Gusek and David A. Myers, Linkan Engineering, to Andrew Harley, SWCA, LUPC No. ZP779 at 7 (Nov. 24, 2020) ("Linkan Report"). The Linkan Report is Attachment B to the January 29, 2021 Report to LUPC from SWCA Environmental Consultants, which LUPC has designated as an exhibit for this hearing.
[7] Application at 464.
[8] *See e.g.*. Boliden Investor Relations, https://www.boliden.com/investor-relations (accessed Sept 20, 2023) and Boliden Operations, https://www.boliden.com/operations (accessed Sept 20, 2023).
[9] Steffen Robertson and Kirsten (B.C.), Opinion of Technical and Economic Aspects of Waste Management Bald Mountain Project, Report 80701/1 at 8-5 (Aug. 1990), https://www.nrcm.org/wp-content/uploads/2013/11/miningreportsupportingdocs.pdf#page=72.
[10] *Id*.

treatment system based on the advanced processes is not practical or justifiable."[11] The basic technology has not changed since the consultants issued their report in 1990, so unless the regulations have changed since then to allow easier disposal of the brine, the situation would likely be the same now.

The potentially prohibitively expensive costs of water treatment should not be overlooked at this stage because those costs directly affect whether the proposed project is technically and financially feasible. As discussed in more detail below in Section III, Wolfden does not demonstrate that the value of its relatively small, poorly characterized mineral deposit is sufficient to cover these costs, in addition to all of the other costs of constructing, operating, and properly closing the proposed mine, as well as its associated ore processing and tailings management facilities—which themselves would require costly RO and other water treatment.

Wolfden's failure to convincingly demonstrate that it will be able to economically[12] treat wastewater to be as clean as natural groundwater is not harmless. If Wolfden is allowed to proceed to construct and operate the proposed mine based on its unrealistic promises, it will likely fail to meet them. Moreover, not only does the potentially prohibitive cost of the proposed complex treatment systems pose a serious risk that Wolfden will fail to meet its water treatment promises, but examples abound of mines failing to treat water successfully due to operational failures, design flaw, and human error, among other reasons. In a well-documented and supported report comparing company-predicted impacts on waters around mines versus actual

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[11] *Id*.

[12] The economics are significant. RO technologies can be very effective at treating even the most degraded water. But the expense may be prohibitive as a practical matter, meaning that other potentially less effective but cheaper alternatives could be proposed during actual mine permitting. This underscores why the LUPC should look at this issue now, and not simply put it off to possible later permit reviews.

impacts after mining, three quarters of the mines studied exceeded water quality standards for ground or surface water (i.e. caused contamination levels worse than the standards).[13]

Wolfden presents nothing to demonstrate that Wolfden—a company without any experience operating, or even successfully developing, a mine—will be able to avoid similar problems. Further, the serious risk that the proposed mine will fail to live up to Wolfden's water treatment promises is compounded by the fact that Wolfden proposes to use groundwater as a sink for the mine's discharges. This will make any pollution from the mine's discharges difficult to detect, extract, or treat. In light of all of these concerns, Wolfden's failure to identify a comparable mine that has been able to achieve what Wolfden promises to achieve here is a red flag.

B. Water Balance

Water balance refers to the accounting of the inflows, water use, and outflows of the water before, during, and after mining. The mine must ensure that it does not alter the timing, location, and amount of pre-mine water volumes. Water balance may include, but is not limited to, impacts to water volume from construction, operations, and closure; physical alterations to flow from surface and underground features, including pit or underground workings; and consumption by mine processes. The goal is for mine operations and physical features to have as little impact on pre-mine flows as possible. One of the primary aspects of the proposed mine that could significantly impact the area's water balance is the mine's proposed discharge of treated wastewater and runoff into the groundwater at the site via surface spray irrigation and snowmaking.

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[13] James R. Kuipers et al., *Comparison of Predicted and Actual Water Quality at Hardrock Mines: The Reliability of Predictions in Environmental Impact Statements* ES-10 (2006), https://earthworks.org/files/publications/ComparisonsReportFinal.pdf.

For Wolfden's proposed water management plan to succeed and not impact pre-mine water balances, the water that the mine discharges to groundwater will have to be of similar volumes to the pre-mine conditions. Moreover, the discharged water will need to be placed into groundwater in comparable locations and volumes as existed under natural conditions before mining, and temporally approximating pre-mine flow and infiltration regimes.

Wolfden claims that it will maintain the site's pre-existing hydrology,[14] but Wolfden's application lacks sufficient site-specific information to reasonably evaluate its water balance claims. First, although Wolfden proposes to use snowmaking and spray irrigation to release its discharge waters, Wolfden fails to account for water that will be lost due to evaporation when using this discharge method, particularly in warm months. Evaporative loss fluctuates seasonally and should be estimated and included in water balance calculations.

Second, Wolfden fails to support its water balance promises with soil infiltration studies. But these studies are necessary to evaluate how sprayed waters will behave once discharged on the surface and thus to determine with a reasonable degree of confidence whether or not Wolfden's proposal will result in properly recharged surface and ground waters across the site's topography. If spray irrigation and snowmaking are proposed, the amount of infiltration needs to be estimated. Not all of the snow or sprayed water will infiltrate into the ground. The amount of infiltration possible, and where the water will go if it fails to infiltrate, need to be known. The spray irrigation water will infiltrate to some extent, but it will also become surface water runoff especially if the soil is wet. In addition, if the land-disposed water contains contaminants, the soil will only adsorb so much contamination before it becomes saturated and contaminant breakthrough occurs. Wolden has not provided LUPC with sufficient data to show that

[14] Application at 293.

discharging treated wastewater using spray irrigation and snowmaking will work at this site and maintain the water balance.

Most importantly, Wolfden's water balance calculations are premised on a highly speculative estimated mine "seepage" flow rate of 30 gallons per minute (gpm). This water forms a significant portion of the overall volume of water that will need to be removed from the mine ("dewatered"), treated, and discharged, thus heavily impacting water balance. But the only justification included in Wolfden's application for this 30 gpm figure is the following, vague statement: "Although engineering/hydrologic studies have not been conducted to quantify flow rates required to keep the working areas of the mine in a dewatered state, it is currently estimated based on similar site experience and the likelihood of low transmissivity bedrock at depth, that these 'seepage' flows are likely to be on the order of 30 gallons per minute (gpm) long term."[15] The application does not specify what "similar site experience" is referenced, further explain "the likelihood of low transmissivity bedrock at depth," or describe how those two ambiguous factors combined to result in the 30 gpm figure.

LUPC's consultant Linkan Engineering concurred with the conclusion that Wolfden's flow rate is too speculative for a water management plan or water balance during Wolfden's previous rezoning petition process. In its technical review memorandum prepared in response to Wolfden's initial rezoning application ("Linkan Report"), Linkan noted: "There is no real basis for estimate of mine dewatering flow rate. The water management plan needs to have flexibility in case flows are higher."[16] Indeed, actual flow rates can deviate quite significantly from estimates. For example, the Pogo Mine in Alaska, in 2003 initially estimated mine water flow to

[15] *Id.* at 409.
[16] Linkan Report at 1.

"average approximately 139 gpm, with a peak annual inflow of approximately 205 gpm."[17] By 2017 the actual number was 400 gpm.[18]

Such deviations matter. If the seepage flow rate is significantly higher than predicted, then the mine may need to treat and discharge additional water potentially causing additional contamination and potentially impacting ground and surface water flows. If the rate is significantly lower than predicted, then the mine may need to consume additional surface and ground water in its processes, potentially impacting existing uses of surface and ground waters. The lack of a reliable seepage flow rate also means that the company cannot reasonably estimate the time it will take any wastes disposed in the underground workings to become inundated by groundwater recharge after Wolfden stops pumping water out of the mine workings. This could significantly impact contaminant releases from rock faces or backfilled waste rock, as discussed below in Section C " Acid Mine Drainage." Instead of relying on speculation that could be wildly inaccurate, Wolfden should have undertaken groundwater and soil studies necessary to properly estimate seepage flow at this site. Without such studies, Wolfden's water balance claims are not adequately supported, cannot be effectively evaluated, and should not be relied upon.

C. Acid Mine Drainage

Wolfden's proposed project poses a significant risk of acid mine drainage ("AMD"), including from waste rock disposal, exposed mine walls, and ore dust. But its application does not demonstrate how it will prevent AMD from occurring, the technical and economic feasibility

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[17] Final Environmental Impact Statement Pogo Gold Mine Project, Nat'l Pollutant Discharge Elimination Sys. (NPDES) Permit Application No. AK-005334-1 at 2-24 (Sept. 2003), https://dnr.alaska.gov/mlw/mining/large-mines/pogo/pdf/pogp_feis_vol_%20I.pdf.

[18] 2017 Pogo Plan of Operations Revision 1, Alaska Dep't Env't Conservation at 41 (Feb. 2017), https://dnr.alaska.gov/mlw/mining/large-mines/pogo/pdf/pogo_poo_rev1.pdf. It should be noted that a 2012 underground seepage flow analysis estimated that the inflow rate could increase up to 650 gpm. *Id.*

of doing so, and how it will detect, contain, and treat this AMD if and when it does occur. Instead, the application devotes just two paragraphs to the topic of AMD and wrongly suggests that the only risk of acid mine drainage will come from the temporary surface storage of waste rock.[19] Acid mine drainage is a serious environmental contaminant that can cause significant harm to natural resources, take years or decades to become evident or remediate, and impose extremely high costs. The lack of a well-conceived plan to prevent, detect, and, if necessary, mitigate this predictable consequence of the proposed mining project is a significant example of Wolfden's failure to demonstrate that the project is well-planned, is technically and financially feasible, and will avoid undue adverse impacts to natural resources.

1. <u>Wolfden Fails to Demonstrate That it Will Prevent AMD</u>

As the United States Environmental Protection Agency explains:

> Acid mine drainage is the formation and movement of highly acidic water rich in heavy metals. This acidic water forms through the chemical reaction of surface water (rainwater, snowmelt, pond water) and shallow subsurface water with rocks that contain sulfur-bearing minerals, resulting in sulfuric acid. Heavy metals can be leached from rocks that come in contact with the acid, a process that may be substantially enhanced by bacterial action. The resulting fluids may be highly toxic and, when mixed with groundwater, surface water and soil, may have harmful effects on humans, animals and plants.[20]

AMD forms when three components are present together: sulfur-bearing (i.e., acid-generating) minerals, water, and oxygen (and in some circumstances, AMD can form without oxygen). Wolfden's project will bring all three of these components together, thus posing a significant risk of AMD.

The proposed mine will generate and expose large quantities of highly pyritic (i.e., acid-generating) rock. The deposit Wolfden seeks to mine is a sulfide mineral deposit. Therefore, as

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[19] Application at 289.
[20] *Abandoned Mine Drainage*, U.S. Env't Protection Agency, https://www.epa.gov/nps/abandoned-mine-drainage (last accessed Sept 20, 2023).

Wolfden acknowledges, the rock that Wolfden will excavate—both mineralized ore and the waste rock—will be acid-generating.[21] For the same reason, the exposed underground surfaces of the mine will be acid-generating. Wolfden's omission of the underground mine surfaces as a source of AMD is glaring. Specifically, Wolden states: "Within the Project Area, the potential sources of acid rock drainage are limited to mineralize [sic] rock from underground being temporarily stored on the surface."[22] It is unclear why Wolfden has not included acid generation from the exposed underground mine surfaces, but the issue is important and should not be ignored. As LUPC's consultant Linkan Engineering noted, acid generation from the underground mine surfaces "is an inevitable condition that either needs a mitigation plan to prevent it from happening or a water treatment plant capable of treating the additional loading or both.."[23] Although Linkan raised this concern in 2020, Wolden did not use the two years between its first and this LUPC application to develop a reliable plan to address and respond to it. All of these potential sources of acid-generating material—ore, waste rock, mine surfaces, and tailings—will be exposed to acid-generating conditions, but Wolfden fails to demonstrate that it will be able to successfully prevent, detect, and, if necessary, contain and treat AMD.

Wolfden proposes to dispose of waste rock by temporarily storing it above ground in piles on storage pads and then later backfilling it into the spent mine workings.[24] While the acidic waste rock is stored above ground, it will be exposed to water and oxygen, creating the

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[21] Application at 289; *see also* Linkan Report at 2 ("acidic waste rock"), 4 ("pyritic waste rock piles"), 5 ("the deposit contains high concentrations of pyrite").
[22] Application at 289.
[23] *See* Linkan Report at 2 ("The water quality of the seepage into the mine workings deteriorates over time as previously submerged or isolated sulfide rock (i.e., pyrite) is exposed to the mine atmosphere containing oxygen. This is an inevitable condition that either needs a mitigation plan to prevent it from happening or a water treatment plant capable of treating the additional loading or both.").
[24] Application at 28 ("Rock of no value will be stored on the waste rock storage pad until it can be returned underground for backfill.… Rock that is placed underground as backfill will be approved for use by MDEP. It is simply placed as rock fragments with or without the addition of binder (typically cement) to add strength.").

conditions for AMD to form. As noted by Linkan, "[t]he longer the acidic waste rock stays on the surface, the more acidic the backfill material might become."[25] This poses a risk of AMD both while the waste rock is stored on the surface, and after it is backfilled into spent mine workings. With regard to AMD generation while the waste rock is stored above ground, Wolfden's application fails to demonstrate how it will ensure that these waste rock piles do not generate AMD and that all leachate from the pile will be effectively collected and safely disposed of. It is not possible for collection systems to capture 100% of mine seepage. Further, all liners can leak. The challenge for both collection systems and liners is to make the leakage de minimis. The application does not discuss specific monitoring or other plans to detect contaminants that evade collection or how leaks, once they occur, will be managed.

Likewise, when the waste rock is backfilled into spent mine workings, the waste rock, as well as the surfaces of the spent mine workings, can generate AMD unless they are kept forever wet or forever dry.[26] Whenever the mine workings and backfill are neither completely wet nor completely dry, such as while the backfilled mine workings are refilling with groundwater or during wetting and drying cycles (if the backfilled area experiences fluctuating water levels), AMD would likely form if the mine workings and backfill have acid generating chemistry, as they would in this mine. As noted above, Wolfden's estimated seepage flow rate is entirely speculative and thus provides no reasonable basis on which to predict how long it would take for backfilled mine workings to become fully inundated. In any event, Wolfden does not even attempt such a prediction because it fails to recognize any risk of AMD from the backfilled waste

[25] Linkan Report at 2.
[26] The Application does not specify a backfilling schedule. The mine will be able to backfill the stopes being mined for ore as mining proceeds. In fact, it may be necessary to the mining to do this. Complete backfill of the waste rock will likely need to wait until mining is completed. It is unusual, *i.e.,* expensive, to backfill all of the waste rock. It is uncommon to have complete backfilling at mines, whether or not it has been proposed as part of planning and/or permitting.

rock and the surfaces of the mine workings, claiming, again, that "the potential sources of acid rock drainage are limited to mineralize [sic] rock from underground being temporarily stored on the surface."[27] Similarly, Wolfden does not attempt to demonstrate that the backfilled mine workings would not be subject to fluctuating water levels. But without reliable information regarding seepage flow and fluctuating water levels, Wolfden cannot demonstrate that its mining and backfilling of acid-generating waste rock will not cause a serious AMD problem.

One method that has been used at some mines to reduce the likelihood of AMD is "neutralization." This method involves adding neutralizing materials (such as lime or other high-pH material), or bactericides (because certain bacteria can speed AMD production) to the potentially acid-forming materials. Maine's Chapter 200 mining regulations require that any mining waste rock be neutralized before underground disposal.[28] But Wolfden's application does not mention this requirement, nor does it demonstrate that any neutralization proposed in the future will be effective. Moreover, it is important to note that neutralization cannot guarantee that AMD will not form. It is not realistically possible to cover with neutralizing compounds all of the rock materials that may begin an acid-forming reaction. In addition, the effectiveness of applying neutralizing materials, bactericides, or temporary spray sealants is highly dependent on many factors, including but not limited to the size and mineralogy of the rock to which they are applied, the methods and seasonal timing of application, and the climate. Thus, even if Wolfden had proposed to use these methods, it would not be reasonable to assume they would be effective absent a more site-specific analysis demonstrating their effectiveness.

[27] Application at 289.
[28] *See* Chapter 200, section 1(B)(5).

It should be noted that the Linkan Report recommends the use of these methods to reduce the likelihood of AMD,[29] but Wolfden has not provided information in its new application to support or demonstrate that it intends to employ any of these methods, or that any of them are applicable to, or would be effective at, the proposed mine.

LUPC should not leave obtaining more detailed information on dealing with AMD entirely in the future. Without knowing whether and how Wolfden will be attempting to prevent AMD, and without receiving an analysis demonstrating the effectiveness of the proposed methods under the conditions at the proposed mine site, the LUPC cannot determine whether the proposed mine can reasonably and effectively avoid serious adverse environmental damage from AMD, including toxic acidity levels and heavy metal contamination.

The only mention of neutralization in Wolfden's application comes from a report discussing the acid-generating or neutralizing potential of seven rock samples taken from Wolfden's property. This report found that four of the samples—the ones not from the area proposed to be mined—had some "net neutralizing potential," meaning that the ratio of acid-generating and acid-neutralizing materials suggested an ability to have some natural potential for management of acid production.[30] However, Wolfden's application specifies that this rock—which was found in areas some distance away from the proposed area of the mine workings—will *not* be mixed with the excavated waste rock to backfill the mine workings. Rather, the application states that "voids created during the Project's mining activities can be back filled utilizing a combination of material removed as part of the mining process and off-site sources….

[29] Linkan Report at 2.
[30] Application at 289, 402.

There is no intention of developing an on-site rock quarry for borrow rock material within the rezoned area of this application."[31]

Moreover, even if Wolfden were planning to attempt to neutralize the waste rock and mine workings by adding into the backfill some rock with neutralizing potential, this method would be highly suspect. The concept of neutralization cannot be reduced to simply balancing the site's total acid-producing potential and the acid-neutralizing potential. The mere fact of having rock with acid-producing potential and acid-neutralizing potential does not mean that potential acid will be neutralized and AMD prevented. Within the millions of tons of waste rock, the acid-producing and neutralizing chemistry will not likely be present at the same location and be chemically available and in appropriate quantities at the same time. Thus, this conception of neutralization, even if Wolfden were proposing to use it as a means of meeting the requirements of Chapter 200, would not likely be effective in preventing AMD. Wolfden should be required to explain how it will actively prevent AMD, including through neutralization or other means, and demonstrate that these methods will be effective. Wolfden provides no details on this. As Linkan noted, an AMD "mitigation plan should be in place during mine operations and not just for closure."[32] The LUPC should be able to review this critical information as part of its analysis of whether the proposed project is well-planned, is technically and financially feasible, and will avoid undue adverse impacts to natural resources.

In addition to waste rock and exposed mine surfaces, the proposed mine's ore (which similarly has high acid-generating potential) would be exposed to oxygen and water, creating the conditions for AMD. Once mined, Wolfden proposes to transport the ore to an offsite ore

[31] *Id.* at 28.
[32] Linkan Report at 4.

processing facility, to be located in Hersey, Stacyville, or Patten[33]—all relatively near to the proposed mine. Wolfden has not explained how it will prevent acid-generating, heavy metal-containing ore dust from escaping the transport trucks and being deposited along the transportation route and blowing further afield. David Rocque, Maine's former State Soil Scientist and a consultant reviewer of Wolfden's current petition, raised this concern and noted that Wolfden had provided no plan for controlling dust from trucks.[34] Wolden states that there would be 55 truck trips carrying ore from the mine to the concentrator each day, each with a payload of 48,000 pounds of ore.[35] Absent an effective plan for containing it, this dust, deposited during years of ore transportation, will be exposed to precipitation, creating a significant risk that acid could form and toxic heavy metals will leach out, contaminating surface and ground water through stormwater runoff. This contamination would occur in areas both within and adjacent to the LUPC's jurisdiction.

Finally, the tailings from ore processing will also be highly acid-generating and their disposal will expose them to air and water, creating the conditions for AMD. The risk of AMD from tailings disposal is discussed below in Section D "Ore Processing and Tailings Disposal."

2. **<u>Wolfden Fails to Demonstrate That it Will be Able to Detect and Treat AMD and Does Not Account For Those Costs</u>**

As noted above, AMD can be highly toxic and may contaminate surface and ground water with which it comes into contact both because of its low pH (acidity) and because of the leached heavy metals that it may carry[36] (such as copper, lead, mercury and zinc, all of which can be toxic to fish or other aquatic life). The longer AMD remains undetected, the more it can

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[33] Application at 852.
[34] Memorandum from David P. Rocque to Tim Carr, LUPC, No. ZP779A 8 (June 6, 2023), https://www.maine.gov/dacf/lupc/projects/wolfden/review/ZP779A_TechnicalReviewMemoranda.pdf.
[35] Application at 844.
[36] *See e.g.*, Water Res. Mission Area, *Mine Drainage*, U.S. Geological Survey (Feb 28, 2019), https://www.usgs.gov/mission-areas/water-resources/science/mine-drainage.

damage natural resources and the harder it is to control or remediate, to the extent control or remediation are even possible.

AMD detection is only possible through robust monitoring. But Wolfden does not identify a monitoring plan that is likely to detect AMD when and where it forms. Monitoring is expensive and involves drilling wells, taking and processing samples, and ensuring the monitoring plan is sufficiently robust (and can evolve) to actually detect AMD when and where it forms throughout the mine site. Without robust monitoring, AMD will not be detected until it has already caused observable environmental degradation, such as killing fish or vegetation or discoloring surface water. Further complicating detection is the fact that AMD may take years or decades to form, which necessitates long-term post closure monitoring. Wolfden should be required to demonstrate how it will detect AMD, if it forms, and should be required to account for those costs in its evaluation of financial viability. In the current application, Wolfden has done neither.

Once detected, AMD must be stopped and treated, to the extent either of those is possible. But Wolfden fails to explain how it will respond to AMD and does not demonstrate that such treatment will be effective or covered by the limited financial assurance that it proposes. Indeed, treatment is extremely difficult, expensive, and time-consuming. Treating AMD underground is highly difficult, as is collecting and pumping groundwater to the surface for treatment. The underground environment is complex because of the varied geologic and hydrologic networks that determine water movement. This complexity is magnified by mining activities that cause rock fracturing and create underground workings that can act as water and air sinks and conduits, create new connectivity and flows, and change how water interfaces with the surface. Pumping contaminated water from underground or pumping uncontaminated water from underground to prevent it from contacting acidic materials and becoming contaminated is expensive and complex. Moreover, contaminated water that is pumped must still be treated and uncontaminated water that is pumped must be disposed of to not add to the AMD problem. This all has the potential to disrupt local water balances, adding yet more to the expense and potential environmental damage. These expenses will continue to accrue until the AMD generation is stopped. In cases where the source of the AMD cannot be treated or removed, such as when the source of the AMD is the underground exposed rock walls of the mine workings and the backfilled waste, pumping and treating may have to continue in perpetuity.

In light of these difficulties and expenses, Wolfden's proposal to provide $13.7 million[37] for the financial assurance trust that Maine DEP's Chapter 200 rules require to cover a "worst case scenario" is inadequate, just as it was in the prior application. LUPC staff were right to note that "[t]his figure appears low" and to require Wolfden to "provide more information on how this figure was calculated and whether the amount is sufficient."[38] Wolfden failed to provide an adequate justification with its prior application,[39] and it has added no new justification this time. Given the massive potential impacts from hard rock mines and the long history of hard rock mines leaving a legacy of expensive environmental, human health, and other costs, having adequate financial assurance is essential. Financial assurance is particularly important in the case of AMD because, as noted above, it can take many years to be detected, at which point Wolfden, or any other mine operator, may no longer exist (within Maine or at all). Based on remediation costs at other mines Wolfden's proposed $13.7 million bond is grossly underestimated and unsupportable. A possible worst case scenario here, for example, would

[37] Application at 521 and 693.
[38] Letter from Stacie R. Beyer, LUPC, to Jeremy Oulette, Wolfden, No. ZP779 at 3 (Feb 4, 2021).
[39] *See* Memorandum from Stacie R. Beyer to LUPC Commissioners, No. ZP779 at Att. p.5 (Oct 7, 2021).

involve perpetual pumping and treatment of groundwater, which would impose remediation costs that are many times greater than Wolfden's proposed bond.

A well-known example helps to illustrate the dangers of relying on overly optimistic promises and predictions regarding AMD. The Pegasus Gold Corporation operated the Zortman and Landusky mines from 1979 through 1998.[40] Pegasus promised to control and manage AMD, but it failed. In 1998, the company declared bankruptcy, after which the US and Montana governments took over the sites to close the mines and conduct water treatment. Both sites were listed under the Comprehensive Environmental Response, Compensation and Liability Act. The average cost just to treat the water has been almost $2 million per year. Between 1999 and 2018, state and federal entities have spent over $77 million on reclamation and treatment at the two mines (the state's share was over $32 million). Total costs now approach $100 million, and costs will continue to increase far into the future (if not forever). This far exceeds Pegasus Gold's $46.5 million bond, which was the original amount calculated based on the mine's proposed plans and its operating permit.

D. Ore Processing and Tailings Disposal

Ore processing (also known as concentrating or flotation) removes the valuable minerals from the mined ore through a chemical-, water-, and energy-intensive process. The vast majority of the ore, typically 90 to 99%, is useless. This waste material, mixed together with the leftover dangerous chemicals from ore processing using flotation, is called tailings. While some mines dispose of their tailings in ponds or impoundments, Maine requires tailings to be stored in dry form. Ore processing and tailings management are integral parts of any mining project, including Wolfden's proposed mine.

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[40] *See* Larry D. Mitchell, Env't Quality Council, *Zortman & Landusky Mines: HJR 43 Water Quality Impacts* 2 (Oct. 2004) https://archive.org/details/B5E0EB73-9D38-4AB7-B3FF-EFFAD82FC1E4/mode/2up.

While Wolfden's first rezoning petition proposed to locate its ore processing and tailings disposal facilities on the mine site, Wolfden's revised application indicates that the ore processing and tailings disposal facilities will be located offsite, at a yet-to-be-determined location that Wolfden claims will be outside of the LUPC's jurisdiction. As noted above, Wolfden's application indicates that it is considering locations in Hersey, Stacyville, or Patten[41]—all close to the proposed mine and close to the boundary of LUPC's jurisdiction.

Moving the ore processing and tailings disposal facilities off the mine's footprint and a few miles away from the LUPC's jurisdiction does not eliminate those facilities' impacts on local watersheds and communities. As discussed in more detail below, these facilities pose significant risk to the surrounding environment. In addition, these integral elements of the project are expensive, with costs (including for environmental protection) that will vary based on the location, design, and operations of the facilities. Thus, it is impossible to fully assess the economic feasibility of Wolfden's proposal without considering the ore processing and tailings disposal facilities, including their specific location and design.

Moreover, in its rezoning application, Wolfden combines job numbers for the mine and the ore processing and tailings disposal facilities.[42] In response to an LUPC follow-up question, Wolfden clarified that its total jobs number includes both the mine and the ore processing and tailings disposal facilities.[43] This highlights the connection between the mine and the ore processing and tailings disposal facilities. It also highlights the fundamental inconsistency in the rezoning application with regard to Wolfden's treatment of the impacts of these facilities—

[41] Application at 852.
[42] *Id*. at 6, 316.
[43] *See* Letter from Jeremy Ouellette, Wolfden, to Tim Carr, LUPC, No. ZP779A at 3 (Apr. 13, 2023), https://www.maine.gov/dacf/lupc/projects/wolfden/review/ZP779A_WolfdenResponseToLUPC2-24InfoRequests_2023-04-13.pdf#page=3.

including their claimed benefits (jobs) while failing to discuss their adverse impacts to natural resources and failing to provide sufficient information to assess the costs of these facilities.

Because Wolfden has not provided a description of its ore processing and tailings disposal facilities in the current application, the project's impacts to natural resources and its feasibility cannot be fully assessed. However, to provide the LUPC with some context, I have reviewed the limited description of the ore processing and tailings management facilities that was included in Wolfden's 2021 withdrawn LUPC application. That description raises significant concerns and fails to demonstrate that Wolfden can develop and operate these facilities without harming the environment and incurring financially prohibitive costs.

1. <u>Ore Processing</u>

Ore processing facilities are complex and expensive and account for a large proportion of capital costs for a mine. Wolfden seeks to exclude its ore processing facilities from the LUPC's current rezoning review and does not provide any new information about it. Ore processing is essential to the mine's economic outlook. Without this information, it is impossible to estimate the mine's economic viability.

Ore processing facilities use toxic chemicals in order to separate the valuable minerals from the remainder of the ore. These chemicals may leak during transportation to, storage at, and operation of the facility. These leaks can come from human error or machinery breakdowns. These chemicals can also enter the environment from process water effluent discharges that are inadequately treated or leach from tailings disposal areas. Given the potential locations that Wolfden has disclosed, the impacted waters would be adjacent to the LUPC's jurisdiction and may impact local waters that overlap or are hydrologically connected to the Wolfden mine site or other areas within LUPC's jurisdiction. These adverse impacts are impossible to assess based on Wolfden's current application.

In addition, as Intervenor 2 expert witness Dan Kusnierz's testimony states, the streams near the towns where Wolfden is proposing to locate its processing facility are too small to allow a discharge or are Class A waters. This means that Wolfden would have to discharge process wastewater to groundwater that is as clean as natural background or discharge to a Class A stream, which requires that discharges be equal to or better than receiving water quality, essentially the same high hurdle as discharging wastewater that is as clean as natural groundwater (as is required at the mine site).

Again, Wolfden has not provided an example of a mine, even without ore processing facilities, that can treat wastewater to be as clean as unimpacted groundwater or surface water, and I am aware of no such mine that can. It would be much harder to treat wastewater from a processing facility to such stringent levels. Ore processing involves grinding ore into small pieces. This increases the surface to volume ratio of the ore and allows metals to leach out much more easily. Processing also involves adding surfactants and other chemicals to increase leaching. Toxic metals, such as lead, zinc, mercury, and copper, can remain in solution after chemical processing is complete, and require removal before discharge. The wastewater from chemical processing may have a higher metal load than contact wastewater from a mine-only operation. It will also contain toxic processing chemicals, which RO systems may not be able to remove. Expecting Wolfden to succeed in treating such wastewater to be as clean as natural groundwater or stream water in Northern Maine is not reasonable. Granting Wolfden's rezoning petition based on such an expectation would not be "well-planned" development.

2. Tailings Management

Tailings produced from the processing of sulfide ores, such as zinc, copper, and lead ores, will contain sulfide minerals. These tailings will have very high potential to generate acid and metal contamination.[44] Also, because dry tailings are composed of small mineral particles the size of fine sand and smaller, they can more readily react with air and water than larger rocks. Therefore, the potential to develop acidic conditions in pyrite-rich tailings is very high.[45] Thus, LUPC's consultant Linkan Engineering was correct to observe that the tailings "will likely be very geochemically reactive and prone to produce acid rock drainage."[46]

Despite the well-established significant risk of acid mine drainage from tailings disposal, Wolfden has not explained—either in its current or prior application—how it will site, design, and operate its tailings management facility to ensure AMD and other contaminants do not enter ground and surface water. While Wolfden's prior application mentioned certain technologies it would use in the tailings management facility, it did not propose how those technologies would be employed nor demonstrate that those technologies would effectively prevent AMD, heavy metal contamination, and other problems.

In the type of tailings management facility Wolfden broadly described in its prior application, dry tailings will be stacked outdoors and will be exposed to precipitation and thus acid-generating conditions until they are covered (and even after, if those covers leak). Wolfden's prior application claimed that "[o]nce compacted, these tailings will not be subject to infiltration of water and intrusion of atmospheric oxygen which will mitigate the oxidation of

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[44] *See* Linkan Report at 5 ("The level of pyrite in the ore (45% to 65%) will increase in the tailings when the minerals of value (chalcopyrite [Cu], galena [Pb], and sphalerite [Zn]) are recovered.").

[45] *See How Can Metal Mining Impact the Environment?*, Am. Geosciences Inst. https://www.americangeosciences.org/critical-issues/faq/how-can-metal-mining-impact-environment (last accessed Sept 20, 2023).

[46] Linkan Report at 5.

sulfide minerals."[47] But rainwater can infiltrate even compacted tailings and start the process of acid generation and contaminant leaching. Further, the liners that Wolfden proposes to put on top of and below stacked tailings can and do fail,[48] allowing tailings exposure, acid-forming reactions to begin, and potential contaminant release. As noted above, once these processes of acid generation and contaminant leaching start, they can be very difficult, and expensive, to control. By its failure to provide detailed information about ore processing in its application, Wolfden fails to provide sufficient information to analyze the costs and ramifications of these essential mine components. That they may be off-site and outside of the LUPC's jurisdiction does not change the fact that their environmental impacts will be felt in areas adjacent to and potentially within the LUPC's jurisdiction and that their costs and impacts are critical to the economic viability of the mine proposal.

III. WOLFDEN'S FINANCIAL CAPACITY AND THE PROJECT'S FINANCIAL VIABILITY

Wolfden has not demonstrated that it has the financial capacity, or financial support, to complete the proposed project. The primary asset of Wolfden Resources (the parent company to Wolfden Mt. Chase LLC) is its 100% ownership of the Pickett Mountain Project. It also has two

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[47] Wolfden Mt. Chase LLC, Petition to Rezone Portion of Township 6, Range 6 Penobscot County, Maine for Development of an Underground Metallic Mineral Deposit, LUPC No. ZP779 at 2-18 (Sept. 1, 2021).

[48] Liner failures can occur from multiple issues, such as manufacturing defects, improper or failed installation, human error (during installation or after), liners being exposed and degrading, tears such as from vehicle passage or slope settling, etc. Kuipers and Maest's report about ecological predictions at mines identify numerous examples. James R. Kuipers et al., *supra* note 13, at, e.g., ES-13, ES-14. At the Beal Mountain Mine in Montana the mining company declared bankruptcy and a leach pad liner failure and other problems required the Forest Service to continuously pump and treat water from the abandoned heap leach pile to protect surrounding waters from cyanide and metals and to ensure the heap did not catastrophically fail. The problems continue. Michael Cast, *Cleanup Costs Climb at Beal Mountain as DEQ Drops "Bad Actor" Case Against Former Pegasus Gold Executive*, Montana Standard (July 18, 2021), https://mtstandard.com/news/local/cleanup-costs-climb-at-beal-mountain-as-deq-drops-bad-actor-case-against-former-pegasus/article_2f78acdc-d083-5ab4-bdfd-be0dd60e5b3e.html. Other examples abound at mines. *See* e.g. Ray Ring, *Summitville: An Expensive Lesson,* High Country News (Jan. 19, 1998), https://www.hcn.org/issues/122/3882; Lindsay Newland Bowker, *Previously Unreported Liner Failure at Kokoya Gold Mine Liberia Puts Spotlight on Deficient International Cyanide Code*, Blog (June 25, 2018), https://lindsaynewlandbowker.wordpress.com/2018/06/25/previously-unreported-liner-failure-at-kokoya-gold-mine-liberia-puts-spotlight-on-deficient-international-cyanide-code/.

projects in Manitoba and one in New Brunswick.[49] Its 52-week high/low stock value has been $0.012–$0.26 and its market capitalization on September 8, 2023, was approximately $15.66 million CAD.[50]

Wolfden's First Quarter 2023 Financial Statements indicate that "the Corporation has no ongoing source of operating cash flows."[51]

> [Wolfden] incurred a net loss of $438,940 for the three months ended March 31, 2023, (net loss of $435,831 for the three months ended March 31, 2022) and has accumulated a deficit of $41,273,458 (December 31, 2022 - $40,834,518) since the inception of the Corporation. As of March 31, 2023, the Corporation had working capital of $2,661,638 (December 31, 2022 – $3,093,885).[52]

All of these figures are in Canadian dollars.

According to the financial statements, "[t]he Corporation's ability to continue as a going concern is largely dependent upon its ability to raise additional capital to continue the development of its mineral properties."[53] But the statement also states "the capital markets continue to be volatile and are largely out of the Corporation's control," and "[i]t is not possible to predict whether financing efforts will be successful or if the Corporation will attain profitable levels of operation."[54] Therefore, the financial statement concludes that "there remains material uncertainties that cast significant doubt on the Corporation's ability to continue as a going concern."[55] Wolfden's independent financial auditor concurred with this assessment, agreeing

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[49] *Projects*, Wolfden Res. Corps., https://www.wolfdenresources.com/projects/ (last accessed Sept. 20, 2023).
[50] *Wolfden Resources Corporation (WLFFF)*, Yahoo! Finance, https://finance.yahoo.com/quote/WLFFF?p=WLFFF&.tsrc=fin-srch (last accessed Sept 20, 2023).
[51] Wolfden Res. Corp., *March 2023 First Quarter Financial Statements*, 7 (May 24, 2023), https://www.wolfdenresources.com/wp-content/uploads/2023/06/WLF-Q1-FS-2023.pdf.
[52] *Id.*
[53] *Id.*
[54] *Id.*
[55] *Id.*

that these conditions "indicate the existence of a material uncertainty that may cast significant doubt about the Company's ability to continue as a going concern."[56]

While Wolfden states in its application that Kinross and Altius (large mining companies who are Wolfden shareholders) would have financial capacity to fund the project,[57] Wolfden has not yet attracted sufficient investments in the project from those companies to develop it nor has it included any proof that these companies are planning to fund the project in the future. Further, Wolfden's supposition that it will be able to fund the project from outside investors is called into question by the assertion in its financial statement that "[i]t is not possible to predict whether financing efforts will be successful or if the Corporation will attain profitable levels of operation."[58]

The poor classification of Picket Mountain's deposit is further evidence that Wolfden has not demonstrated the project's financial viability. Wolfden's September 2020 Preliminary Economic Assessment ("PEA") of the project, upon which it largely still relies in the current application, is based on an assumption of "a diluted mineral resource of 4.2 million tonnes at 8.56% Zn, 1.11% Cu, 3.4% Pb, 0.79 g/t Au, and 88.8 g/t Ag."[59] According to the PEA "[t]his resource is comprised of 50% Indicated Resources and 50% Inferred Resources."[60] These classifications mean:

> Inferred Resources: An Inferred Mineral Resource is that part of a Mineral Resource for which quantity and grade or quality are estimated on the basis of limited geological evidence and sampling. Geological evidence is sufficient to imply but not verify geological and grade or quality continuity. An Inferred Mineral Resource has a lower level of confidence than that applying to an Indicated Mineral Resource and must not be converted to a Mineral Reserve. It is reasonably expected that the majority of Inferred Mineral Resources could be

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[56] Wolfden Res. Corp., *Consolidated Financial Statement for the Years Ended December 31, 2022 and 2021*, at 1, https://www.wolfdenresources.com/wp-content/uploads/2023/06/WLF-AFS-Dec31-2022.pdf.
[57] Application at 503.
[58] Wolfden Res. Corp., *March 2023 First Quarter Financial Statements* at 7.
[59] Application at 706.
[60] *Id*.

upgraded to Indicated Mineral Resources with continued exploration.

> Indicated Resources: An Indicated Mineral Resource is that part of a Mineral Resource for which quantity, grade or quality, densities, shape and physical characteristics are estimated with sufficient confidence to allow the application of Modifying Factors in sufficient detail to support mine planning and evaluation of the economic viability of the deposit. Geological evidence is derived from adequately detailed and reliable exploration, sampling and testing and is sufficient to assume geological and grade or quality continuity between points of observation. An Indicated Mineral Resource has a lower level of confidence than that applying to a Measured Mineral Resource and may only be converted to a Probable Mineral Reserve.[61]

The PEA acknowledges that "Inferred Mineral Resources are considered too speculative geologically to have economic considerations applied to them that would enable them to be categorised [sic] as mineral reserves. Therefore, there is no guarantee that the economic projections contained in this PEA would be realised."[62] In addition, as noted in the definition above, indicated resources cannot be considered a proven mineral reserve either.

Disclaimers are required and may be reasonable in a preliminary economic assessment, but in this case the exceedingly speculative nature of the estimated mineral resources is problematic because it precludes the ability to demonstrate that the ore resources can support a viable project. If actual resources at the site prove to be less than predicted, or more expensive than planned to extract, then the value of the project would be reduced, meaning it might not be able be completed as planned and would likely be less attractive to prospective investors. The history of mining reflects a series of booms and busts where mineral prices fluctuate and with them the success and survival of mining companies. This history warrants careful scrutiny by LUPC of Wolfden's and the project's financial viability.

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[61] CIM Standing Comm. on Rsrv. Definitions, *CIM Definition Standards for Mineral Resources & Mineral Reserves,* Canadian Inst. of Mining 4–5 (May 19, 2014), https://mrmr.cim.org/media/1128/cim-definition-standards_2014.pdf.
[62] Application at 706.

IV. JOBS

Wolfden's application touts the jobs that the mine would create, but these jobs, especially the higher paying ones, may not go to the local workforce. According to Wolfden's application, the proposed project would employ 279 people, but as noted above, that figure includes jobs associated with the ore processing and tailings management facility.[63] The proposed mine itself would employ 233 people, according to Wolfden.[64] Wolfden's application asserts that "[i]t is Wolfden's objective that the primary workforce be employed locally from residents."[65] However, Wolfden does not specify how it will achieve this objective nor does it make binding commitments to hire locally. Moreover, Wolfden proposes that mine employees will have a 7-days-on, 7-days-off work schedule, which is conducive to a remote work force commuting in and out on a weekly basis. Such a schedule would make it reasonable for Canadian workers experienced in Canada's nearby mines to hold mining jobs at the proposed project.

Wolfden should be required to identify the specific jobs that will be created and the training level required by each job. Wolfden should also be required to describe how it will ensure that it trains and hires local or regional employees and should make specific commitments to do so. Further, the company should be required to analyze how its plans and economic predictions will be impacted if it fails to hire the promised significant local workforce.

Dated: 22 Sept 2023

Stuart M. Levit, M.S., J.D.

[63] Letter from Jeremy Ouellette, Wolfden, to Tim Carr, LUPC, *supra* note 43 at 3.
[64] *Id.*
[65] Application at 275.

VERIFICATION

I, Stu Levit, being first duly sworn, affirm that the above testimony is true and accurate to the best of my knowledge.

Date: 22 Sept 2023 Name: ____________________

Personally appeared the above-named Stuart Michael Levit and made oath that the foregoing testimony was true and correct to the best of their knowledge and belief.

Dated: September 22, 2023

____
Notary Public

TROY BONTRAGER
NOTARY PUBLIC for the
State of Montana
Residing at Missoula, MT
My Commission Expires
March 15, 2026.

TROY BONTRAGER NOTARIAL SEAL STATE OF MONTANA

INDEX OF ATTACHMENTS FOR STU LEVIT PRE-FILED TESTIMONY

ATTACHMENT 1

2017 Pogo Plan of Operations

Revision 1

Submitted to:

Alaska Department of Environmental Conservation
Division of Water
610 University Avenue
Fairbanks, Alaska 99709

Alaska Department of Natural Resources
Division of Mining, Land, and Water
550 West 7th Avenue, Suite 900D
Anchorage, Alaska 99501-3577

Prepared by:

Sumitomo Metal Mining Pogo LLC
P.O. Box 145
Delta Junction, Alaska 99737

February 2017

8.0 WATER MANAGEMENT

8.1 Overview

The purpose of the Pogo water management plan is to provide a framework for the collection and treatment of water to achieve the following objectives:

- Ensure the reliability of water supply for all process and potable needs;
- Protect the operations from flooding, erosion, interference from groundwater, precipitation and runoff; and
- Control and treat water that comes into contact with project facilities in an environmentally sound manner before discharge.

For additional background, see the Pogo "Water Management Plan" (February 2002 and June 2002).

Pogo is permitted to discharge treated water up to 600 gpm. Mine Water Treatment Plant #3 (MWTP#3) treats all underground water on site, was fully operational and approved for commissioning by DEC during January 2016. The groundwater or mine inflow has been increasing as the mine expands and deepens with the current inflow average of 400 gpm. The underground seepage flow analysis conducted in 2012 estimated that the inflow rate could increase up to 650 gpm.

An underground recycle system includes a filter and pumping system installed underground in 2010. This system is recycling mine services collected groundwater which reduces the amount of RTP surface water introduced into the mine and thus the amount of water that must be treated and discharged.

MWTP#3 was constructed in order to accommodate the increasing amount mine inflow water. Pogo's overall water management strategy and various water streams, inflows, and outflows are summarized below.

8.2 Overall Water Collection, Treatment & Discharge Strategy

The major components of the overall water collection, treatment, and discharge strategy for the project are shown in **Figure 8.1, Appendix B**. MWTP#3 construction began in 2014. MWTP#3 discharges to the final tank at MWTP#2 where the water can either be returned to the mill via RTP Head #1 Tank or discharged to the Off-River Treatment Works (ORTW). In case of an emergency, treated water can be pumped from the MWTP#2 to the RTP for storage. Pogo is capable of continuously monitoring the treated effluent for pH, turbidity, and conductivity. Plant performance is monitored using these parameters, allowing for the automatic shutoff of any discharge during process problems.

ATTACHMENT 2

Abandoned Mine Drainage

On this Page:

Overview

Abandoned mine drainage is water that is polluted from contact with mining activity, and normally associated with coal mining. It is a common form of water pollution in areas where mining took place in the past. There are several issues with abandoned mines that impact water quality:

- acid mine

Stream impacted by acid mine drainage from a Mid-Atlantic abandoned coal mine

drainage (the most prevalent; see below),

- alkaline mine drainage (this typically occurs when calcite or dolomite is present),
- metal mine drainage (high levels of lead or other metals drain from these abandoned mines).

Acid mine drainage is the formation and movement of highly acidic water rich in heavy metals. This acidic water forms through the chemical reaction of surface water (rainwater, snowmelt, pond water) and shallow subsurface water with rocks that contain sulfur-bearing minerals, resulting in sulfuric acid. Heavy metals can be leached from rocks that come in contact with the acid, a process that may be substantially enhanced by bacterial action. The resulting fluids may be highly toxic and, when mixed with groundwater, surface water and soil, may have harmful effects on humans, animals and plants.

Information Resources and Centers

- **U.S. Department of Interior's Office of Surface Mining**
  Resources, references and funding information for state and tribal professionals addressing surface mining issues.
- **Abandoned Mine Reclamation** Pennsylvania Department of Environmental Protection -This site provides information on the chemistry

of acid mine drainage and background and chemical information for passive treatment options available for acid mine drainage.

Guidance Documents and Reports

- Acid Mine Drainage Prediction (pdf)(218.87 KB, December 1994, EPA 530-R-94-036)
  This technical document provides a brief review of acid forming processes at mine sites, a summary of the current methods used to predict acid formation, selected state regulatory requirements, and case histories.
- Prevention of Acid Mine Drainage Generation from Open-pit Highwalls-Final Report MIne Waste Technology Program Activity III, Project 26 (pdf) (1.58 MB, July 2005, EPA/600/R-05/060)
  This document summarizes the results of performance data on the ability of four technologies to prevent the generation of acid mine drainage (AMD) from an open-pit highwall.
- Abandoned Mine Site Characterization and Cleanup Handbook (pdf)(641.9 KB, August 2000, EPA 910-B-00-001)
  This handbook is a resource for project managers working to address the environmental concerns posed by inactive mines and mineral processing sites. The focus of the handbook is the environmental hazards at abandoned mining sites.

Polluted Runoff: NPS Pollution Home
Basic Information
Types of NPS Pollution
Agriculture
Abandoned Mine Drainage
Forestry
Hydromodification and Habitat Alteration
Marinas and Boating
Highways and Bridges
Urban Areas
Wetland/Riparian Management
Success Stories

ATTACHMENT 3

MENY

Boliden as a sustainal

The share

Reports and presentations

Financials

Metal prices and currencies

IR calendar

Corporate governance

IR contact

BOLIDEN SEK 313,6 +9,9 (3,3%)

Operations

Career

Sustainability

Investor Relations

Media

IR contact

Boliden a

2023-09-20 11:30 BOLIDEN SEK 313.55 +9.90 (+3

Boliden - Investor Relations

Fire at Rönnskär and low grades in Mines

Second-quarter revenues amounted to SEK 18,442 m (21,568) and operating profit excluding revaluation of process inventory totaled SEK 833 m (4,532). Free cash flow totaled SEK -3,770 m (2,038).

More information

CEO Interview

Boliden's President and CEO comments on the report for the second quarter of 2023

See the interview

IR Events

20
OCT

Boliden Events 20 OCT 2023 ● STOCKHOLM

Q3 23 Interim report

20
OCT

External Events 20 OCT 2023 ● STOCKHOLM

Q3 23 roadshow

Organizer: Carnegie
Boliden team: CEO, IR & CFO

External Events 23 OCT 2023 - 25 OCT 2023 ● TORONTO, BOSTON, NEW YORK

ATTACHMENT 4

Metals for modern life

Boliden is a high-tech metal company with its own mines and smelters that work over the long term to guarantee society's supply of base metals and precious metals through the mining of ore (minerals) and the production and delivery of high quality metals to industry.

Our high productivity is based on experience, innovation and advanced technology, developed in collaboration with Nordic technology and engineering companies. Today, around 6000 people work at Boliden, which has operations in Sweden, Finland, Norway and Ireland.

Metals are needed in all sectors and without them, modern society would cease functioning.

Exploration

We search for new mineral deposits through exploration, both in the vicinity of our existing mines and in new areas. In this way, we contribute to secure the future of our business and take long-term responsibility for the supply of metals of the highest quality to society. We focus on mineral deposits containing zinc, copper, lead, nickel, gold, palladium, platinum and silver. Read more

Mines

We extract ore from open pits and underground mines. Thanks to modern technological developments, mining methods and our expertise in mining design, our production is of the highest class from drilling and blasting to loading and crushing. We separate minerals from crushed ore in our concentrators. The end products are various mineral concentrates that are shipped to smelters for further processing. Exhausted parts of the mine are refilled, and sand from the concentrators is collected in taillingdams Read more

Our mines

Smelters

In our smelters we refine mineral concentrates from our own and other mines into pure metals. Thanks to our technical expertise and flexible processes, we can extract metals from complex raw materials and produce metals of very high quality. We are also the market leader in electronics recycling and lead recovery from car batteries. This operation is governed by stringent environmental conditions in the same way as our mines and it is monitored both by ourselves and supervisory authorities. Read more

Our smelters

Products

Our products are mainly zinc and lead ingots, copper cathodes, gold bars and silver granules, but also other products such as sulphuric acid and iron sand. The major part of our metals is transported by rail or sea to industrial customers throughout Europe. Two important end users are the construction and automotive industries. Read more

Our products

90 years of knowledge and innovation

Over 90 years have passed since that chilly December day when the gold deposit – which came to be Boliden's foundation – was discovered in Fågelmyran, outside of Skellefteå.

VISION, VALUES AND STRATEGY

Care, courage and responsibility characterize our operations at every level. Our overall goal is to create profitability and growth in a responsible manner with consideration for people, the environment and society. We contribute to sustainable metal productio and a reliable supply of metals for society through ou strategy of owning our own mines and smelters.

More about vision, values and strategy

BOLIDEN'S GOVERNANCE

We are a public limited company with shares and securities listed on the NASDAQ Stockholm. Our internal policies, guidelines, procedures and codes of conduct together with external regulations make sure the company is run based on the best interests of the shareholders.

Read more about Boliden's governance

OUR HISTORY

In December 1924, gold fever breaks out around 30 k north west of Skellefteå. The first ore deposit is discovered in Fågelmyran, laying the foundations for what today is the Boliden Group. Two years later, the first ore is mined and a flourishing community soon grows up in Boliden.

More about our history

Contact

Boliden Head Office

ATTACHMENT 5

CIM Definition Standards for Mineral Resources & Mineral Reserves

Prepared by the
CIM Standing Committee on Reserve Definitions
Adopted by CIM Council May 19, 2014

Canadian Institute of Mining, Metallurgy and Petroleum
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Westmount, Quebec H3Z 3C1 CANADA
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mrmr.cim.org | www.cim.org

Contents

Foreword

The CIM Definition Standards on Mineral Resources and Reserves (CIM Definition Standards) establish definitions and guidance on the definitions for Mineral Resources, Mineral Reserves, and mining studies used in Canada. The Mineral Resource, Mineral Reserve, and mining study definitions are incorporated, by reference, into National Instrument 43-101 – *Standards of Disclosure for Mineral Projects* (NI 43-101). The CIM Definition Standards can be viewed at mrmr.cim.org.

Readers should be aware that reports written by persons issuing technical reports that disclose information about exploration or other mining properties to the public in Canada are governed by a number of securities regulations.

CIM Definition Standards

The CIM Definition Standards presented herein provide definitions and guidance on those definitions for Mineral Resource and Mineral Reserve and their confidence categories. The category to which a Mineral Resource or Mineral Reserve estimate is assigned depends on the level of confidence in the geological information available on the mineral deposit; the quality and quantity of data available on the deposit; the level of detail of the technical and economic information which has been generated about the deposit, and the interpretation of the data and information. In the document the definitions are in bold type and the guidance is in italics. Defined terms referenced to other CIM definitions are underlined and defined terms referenced to NI 43-101 are double underlined.

Throughout the CIM Definition Standards, where appropriate, "quality" may be substituted for "grade" and "volume" may be substituted for "tonnage". Technical reports dealing with estimates of Mineral Resources and Mineral Reserves, or summarizing the results of mining studies (preliminary feasibility or feasibility studies), must use only the terms and definitions contained herein.

Definitions

Qualified Person

Mineral Resource and Mineral Reserve estimates and any supporting technical reports must be prepared by or under the direction of a Qualified Person, as that term is defined in NI 43-101.

The Qualified Person(s) should be clearly satisfied that they could face their peers and demonstrate competence and relevant experience in the commodity, type of deposit and situation under consideration. If doubt exists, the person must either seek or obtain opinions from other colleagues or demonstrate that he or she has obtained assistance from experts in areas where he or she lacked the necessary expertise.

Determination of what constitutes relevant experience can be a difficult area and common sense has to be exercised. For example, in estimating Mineral Resources for vein gold mineralization, experience in a high-nugget, vein-type mineralization such as tin, uranium etc. Should be relevant whereas experience in massive base metal deposits may not be. As a second example, for a person to qualify as a Qualified Person in the estimation of Mineral Reserves for alluvial gold deposits, he or she would need to have relevant experience in the evaluation and extraction of such deposits. Experience with placer deposits containing minerals other than gold, may not necessarily provide appropriate relevant experience for gold.

In addition to experience in the style of mineralization, a Qualified Person preparing or taking responsibility *for Mineral Resource estimates must have sufficient experience in the sampling, assaying, or other property testing techniques that are relevant to the deposit under consideration in order to be aware of problems that could affect the reliability of the data. Some appreciation of extraction and processing techniques applicable to that deposit type might also be important.*

Estimation of Mineral Resources is often a team effort, for example, involving one person or team collecting the data and another person or team preparing the mineral resource estimate. Within this team, geologists usually occupy the pivotal role. Estimation of Mineral Reserves is almost always a team effort involving a number of technical disciplines, and within this team mining engineers have an important role. Documentation for a Mineral Resource and mineral reserve estimate must be compiled by, or under the supervision of, a Qualified Person(s), whether a geologist, mining engineer or member of another discipline. It is recommended that, where there is a clear division of responsibilities within a team, each Qualified Person should accept responsibility for his or her particular contribution. For example, one Qualified Person could accept responsibility for the collection of Mineral Resource data, another for the Mineral Reserve estimation process, another for the mining study, and the project leader could accept responsibility for the overall document. It is important that the Qualified Person accepting overall responsibility for a Mineral Resource and/or Mineral Reserve estimate and supporting documentation, which has been prepared in whole or in part by others, is satisfied that the other contributors are Qualified Persons with respect to the work for which they are taking responsibility and that such persons are provided adequate documentation.

Pre-Feasibility Study (Preliminary Feasibility Study)

The CIM Definition Standards requires the completion of a Pre-Feasibility Study as the minimum prerequisite for the conversion of Mineral Resources to Mineral Reserves.

A Pre-Feasibility Study is a comprehensive study of a range of options for the technical and economic viability of a mineral project that has advanced to a stage where a preferred mining method, in the case of underground mining, or the pit configuration, in the case of an open pit, is established and an effective method of mineral processing is determined. It includes a financial analysis based on reasonable assumptions on the Modifying Factors and the evaluation of any other relevant factors which are sufficient for a Qualified Person, acting reasonably, to determine if all or part of the Mineral Resource may be converted to a Mineral Reserve at the time of reporting. A Pre-Feasibility Study is at a lower confidence level than a Feasibility Study.

Feasibility Study

A Feasibility Study is a comprehensive technical and economic study of the selected development option for a mineral project that includes appropriately detailed assessments of applicable Modifying Factors together with any other relevant operational factors and detailed financial analysis that are necessary to demonstrate, at the time of reporting, that extraction is reasonably justified (economically mineable). The results of the study may reasonably serve as the basis for a final decision by a proponent or financial institution to proceed with, or finance, the development of the project. The confidence level of the study will be higher than that of a Pre-Feasibility Study.

The term proponent captures issuers who may finance a project without using traditional financial institutions. In these cases, the technical and economic confidence of the Feasibility Study is equivalent to that required by a financial institution.

Mineral Resource

Mineral Resources are sub-divided, in order of increasing geological confidence, into inferred, indicated and measured categories. An Inferred Mineral Resource has a lower level of confidence than that applied to an Indicated Mineral Resource. An Indicated Mineral Resource has a higher level of confidence than an Inferred Mineral Resource but has a lower level of confidence than a Measured Mineral Resource.

A Mineral Resource is a concentration or occurrence of solid material of economic interest in or on the earth's crust in such form, grade or quality and quantity that there are reasonable prospects for eventual economic extraction.

The location, quantity, grade or quality, continuity and other geological characteristics of a Mineral Resource are known, estimated or interpreted from specific geological evidence and knowledge, including sampling.

Material of economic interest refers to diamonds, natural solid inorganic material, or natural solid fossilized organic material including base and precious metals, coal, and industrial minerals.

The term Mineral Resource covers mineralization and natural material of intrinsic economic interest which has been identified and estimated through exploration and sampling and within which Mineral Reserves may subsequently be defined by the consideration and application of Modifying Factors. The phrase 'reasonable prospects for eventual economic extraction' implies a judgment by the Qualified Person in respect of the technical and economic factors likely to influence the prospect of economic extraction. The Qualified Person should consider and clearly state the basis for determining that the material has reasonable prospects for eventual economic extraction. Assumptions should include estimates of cutoff grade and geological continuity at the selected cut-off, metallurgical recovery, smelter payments, commodity price or product value, mining and processing method and mining, processing and general and administrative costs. The Qualified Person should state if the assessment is based on any direct evidence and testing.

Interpretation of the word 'eventual' in this context may vary depending on the commodity or mineral involved. For example, for some coal, iron, potash deposits and other bulk minerals or commodities, it may be reasonable to envisage 'eventual economic extraction' as covering time periods in excess of 50 years. However, for many gold deposits, application of the concept would normally be restricted to perhaps 10 to 15 years, and frequently to much shorter periods of time.

Inferred Mineral Resource

An Inferred Mineral Resource is that part of a Mineral Resource for which quantity and grade or quality are estimated on the basis of limited geological evidence and sampling. Geological evidence is sufficient to imply but not verify geological and grade or quality continuity.

An Inferred Mineral Resource has a lower level of confidence than that applying to an Indicated Mineral Resource and must not be converted to a Mineral Reserve. It is reasonably expected that the majority of Inferred Mineral Resources could be upgraded to Indicated Mineral Resources with continued exploration.

An Inferred Mineral Resource is based on limited information and sampling gathered through appropriate sampling techniques from locations such as outcrops, trenches, pits, workings and drill holes. Inferred Mineral Resources must not be included in the economic analysis, production schedules, or estimated mine life in publicly disclosed pre- feasibility or feasibility studies, or in the life of mine plans and cash flow models of *developed mines. Inferred Mineral Resources can only be used in economic studies as provided under NI 43-101.*

There may be circumstances, where appropriate sampling, testing, and other measurements are sufficient to demonstrate data integrity, geological and grade/quality continuity of a measured or Indicated Mineral Resource, however, quality assurance and quality control, or other information may not meet all industry norms for the disclosure of an indicated or Measured Mineral Resource. Under these circumstances, it may be reasonable for the Qualified Person to report an Inferred Mineral Resource if the Qualified Person has taken steps to verify the information meets the requirements of an Inferred Mineral Resource.

Indicated Mineral Resource

An Indicated Mineral Resource is that part of a Mineral Resource for which quantity, grade or quality, densities, shape and physical characteristics are estimated with sufficient confidence to allow the application of Modifying Factors in sufficient detail to support mine planning and evaluation of the economic viability of the deposit.

Geological evidence is derived from adequately detailed and reliable exploration, sampling and testing and is sufficient to assume geological and grade or quality continuity between points of observation.

An Indicated Mineral Resource has a lower level of confidence than that applying to a Measured Mineral Resource and may only be converted to a Probable Mineral Reserve.

Mineralization may be classified as an Indicated Mineral Resource by the Qualified Person when the nature, quality, quantity and distribution of data are such as to allow confident interpretation of the geological framework and to reasonably assume the continuity of mineralization. The Qualified Person must recognize the importance of the Indicated Mineral Resource category to the advancement of the feasibility of the project. An Indicated Mineral Resource estimate is of sufficient quality to support a Pre-Feasibility Study which can serve as the basis for major development decisions.

Measured Mineral Resource

A Measured Mineral Resource is that part of a Mineral Resource for which quantity, grade or quality, densities, shape, and physical characteristics are estimated with confidence sufficient to allow the application of Modifying Factors to support detailed mine planning and final evaluation of the economic viability of the deposit.

Geological evidence is derived from detailed and reliable exploration, sampling and testing and is sufficient to confirm geological and grade or quality continuity between points of observation.

A Measured Mineral Resource has a higher level of confidence than that applying to either an Indicated Mineral Resource or an Inferred Mineral Resource. It may be converted to a Proven Mineral Reserve or to a Probable Mineral Reserve.

Mineralization or other natural material of economic interest may be classified as a Measured Mineral Resource by the Qualified Person when the nature, quality, quantity and distribution of data are such that the tonnage and grade or quality of the mineralization can be estimated to within close limits and that variation from the estimate would not significantly affect potential economic viability of the deposit. This category requires a high level of confidence in, and understanding of, the geology and controls of the mineral deposit.

Modifying Factors

Modifying Factors are considerations used to convert Mineral Resources to Mineral Reserves. These include, but are not restricted to, mining, processing, metallurgical, infrastructure, economic, marketing, legal, environmental, social and governmental factors.

Mineral Reserve

Mineral Reserves are sub-divided in order of increasing confidence into Probable Mineral Reserves and Proven Mineral Reserves. A Probable Mineral Reserve has a lower level of confidence than a Proven Mineral Reserve.

A Mineral Reserve is the economically mineable part of a measured and/or Indicated Mineral Resource. It includes diluting materials and allowances for losses, which may occur when the material is mined or extracted and is defined by studies at pre-feasibility or feasibility level as appropriate that include application of Modifying Factors. Such studies demonstrate that, at the time of reporting, extraction could reasonably be justified.

The reference point at which Mineral Reserves are defined, usually the point where the ore is delivered to the processing plant, must be stated. It is important that, in all situations where the reference point is different, such as for a saleable product, a clarifying statement is included to ensure that the reader is fully informed as to what is being reported.

The public disclosure of a Mineral Reserve must be demonstrated by a Pre-Feasibility Study or Feasibility Study.

Mineral Reserves are those parts of Mineral Resources which, after the application of all mining factors, result in an estimated tonnage and grade which, in the opinion of the Qualified Person(s) making the estimates, is the basis of an economically viable project after taking account of all relevant Modifying Factors. Mineral Reserves are inclusive of diluting material that will be mined in conjunction with the Mineral Reserves and delivered to the treatment plant or equivalent facility. The term 'Mineral Reserve' need not necessarily signify that extraction facilities are in place or operative or that all governmental approvals have been received. It does signify that there are reasonable expectations of such approvals.

'Reference point' refers to the mining or process point at which the Qualified Person prepares a Mineral Reserve. For example, most metal deposits disclose Mineral Reserves with a "mill feed" reference point. In these cases, reserves are reported as mined ore delivered to the plant and do not include reductions attributed to anticipated plant losses. In contrast, coal reserves have traditionally been reported as tonnes of "clean coal". In this coal example, reserves are reported as a "saleable product" reference point and include reductions for plant yield (recovery). The Qualified Person must clearly state the 'reference point' used in the Mineral Reserve estimate.

Probable Mineral Reserve

A Probable Mineral Reserve is the economically mineable part of an indicated, and in some circumstances, a Measured Mineral Resource. The confidence in the Modifying Factors applying to a Probable Mineral Reserve is lower than that applying to a Proven Mineral Reserve.

The Qualified Person(s) may elect, to convert Measured Mineral Resources to Probable Mineral Reserves if the confidence in the Modifying Factors is lower than that applied to a Proven Mineral Reserve. Probable

Mineral Reserve estimates must be demonstrated to be economic, at the time of reporting, by at least a Pre-Feasibility Study.

Proven Mineral Reserve (Proved Mineral Reserve)

A Proven Mineral Reserve is the economically mineable part of a Measured Mineral Resource. A Proven Mineral Reserve implies a high degree of confidence in the Modifying Factors.

Application of the Proven Mineral Reserve category implies that the Qualified Person has the highest degree of confidence in the estimate with the consequent expectation in the minds of the readers of the report. The term should be restricted to that part of the deposit where production planning is taking place and for which any variation in the estimate would not significantly affect the potential economic viability of the deposit. Proven Mineral Reserve estimates must be demonstrated to be economic, at the time of reporting, by at least a Pre-Feasibility Study. Within the CIM Definition Standards the term proved Mineral Reserve is an equivalent term to a Proven Mineral Reserve.

Mineral Resource and Mineral Reserve Classification

The CIM Definition Standards provide for a direct relationship between Indicated Mineral Resources and Probable Mineral Reserves and between Measured Mineral Resources and Proven Mineral Reserves. In other words, the level of geoscientific confidence for Probable Mineral Reserves is the same as that required for the in situ determination of Indicated Mineral Resources and for Proven Mineral Reserves is the same as that required for the in situ determination of Measured Mineral Resources. Figure 1, displays the relationship between the Mineral Resource and Mineral Reserve categories.

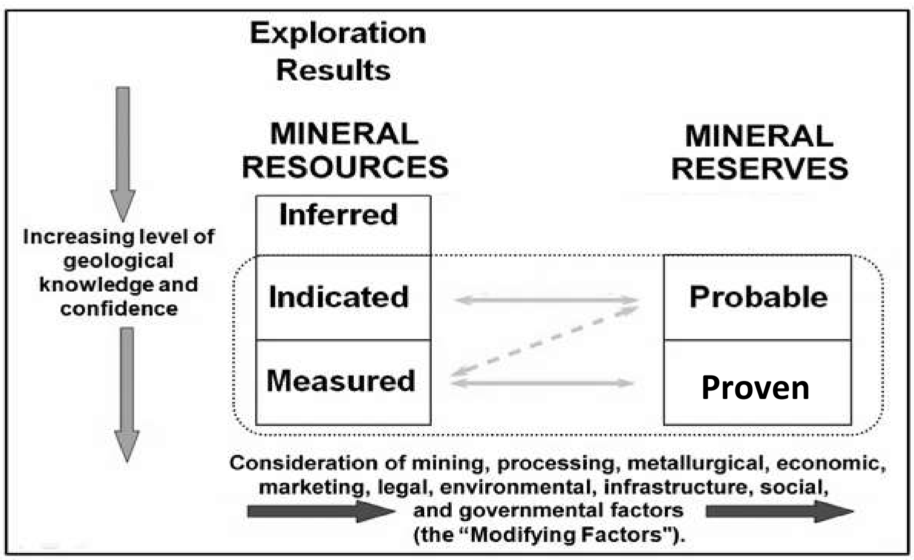

Figure 1, relationship between Mineral Reserves and Mineral Resources

Figure 1 sets out the framework for classifying tonnage and grade/quality estimates so as to reflect different levels of geological confidence and different degrees of technical and economic evaluation. Mineral Resources can be estimated by a Qualified Person, with input from persons in other disciplines, as necessary, on the basis of geoscientific information and reasonable assumptions of technical and economic factors likely to influence the eventual prospect of economic extraction. Mineral Reserves, which are a modified sub-set of the Indicated and Measured Mineral Resources (shown within the dashed outline in figure 1), require consideration of *modifying factors affecting profitable extraction, including mining, processing, metallurgical, economic, marketing, legal, environmental, infrastructure, social and governmental factors, and should be estimated with input from a range of disciplines. Additional test work, e.g. metallurgy, mining, environmental is required to reclassify a resource as a reserve.*

In certain situations, Measured Mineral Resources could convert to Probable Mineral Reserves because of uncertainties associated with the Modifying Factors that are taken into account in the conversion from Mineral Resources to Mineral Reserves. This relationship is shown by the dashed arrow in figure 1 (although the trend of the dashed arrow includes a vertical component, it does not, in this instance, imply a reduction in the level of geological knowledge or confidence). In such a situation these Modifying Factors should be fully explained. Under no circumstances can indicated resources convert directly to proven reserves.

In certain situations previously reported Mineral Reserves could revert to Mineral Resources. It is not intended that re-classification from Mineral Reserves to Mineral Resources should be applied as a result of changes expected to be of a short term or temporary nature, or where company management has made a deliberate decision to operate in the short term on a non-economic basis. Examples of such situations might be a commodity price drop expected to be of short duration, mine emergency of a non-permanent nature, transport strike etc.

Guidance for Reporting Mineral Resource and Mineral Reserve Information

Qualified Persons preparing public Mineral Resource and Mineral Reserve reports in Canada must follow the requirements in form 43-101f1 of National Instrument 43-101, available on the following websites: www.osc.gov.ca; www.bcsc.bc.ca; www.albertasecurities.com and www.cvmq.com.

The following discussion is included for additional guidance when preparing a technical report.

Qualified Persons are encouraged to provide information that is as comprehensive as possible in their technical reports on exploration information, Mineral Resources and Mineral Reserves. The Mineral Exploration Best Practices Guidelines, the Estimation of Mineral Resource and Mineral Reserve Best Practice Guidelines provide, in a summary form, a list of the main criteria which should be considered when reporting Mineral Resources and Mineral Reserve estimates. These guidelines are available on our website, mrmr.cim.org.

These Guidelines are not prescriptive and it may not be necessary to comment on each item in the guidelines, however, the need for comment on each item should be considered. It is essential to discuss any matters that might materially affect the reader's understanding of the estimates being reported. Problems encountered in the collection of data or with the sufficiency of data must be clearly disclosed at all times, particularly when they affect directly the reliability of, or confidence in, an estimate of Mineral Resources and Mineral Reserves; for example, poor sample recovery, poor reproducibility of assay or laboratory results, limited information on tonnage factors, etc.

Mineral Resources and Mineral Reserves must be reported on a site by site basis.

When reporting both mineral resources and mineral reserves, a clarifying statement must be included that clearly indicates whether Mineral Reserves are part of the Mineral Resource or that they have been removed from the Mineral Resource. A single form of reporting should be used in a report. Appropriate forms of clarifying statements may be:

- *"The Measured and Indicated Mineral Resources are inclusive of those Mineral Resources modified to produce the Mineral Reserves", or*

- *"The measured and Indicated Mineral Resources are additional to the Mineral Reserves".*

Inferred Mineral Resources are, by definition, always additional to Mineral Reserves.

Reporting of Coal Reserves

For consistency in public reporting of Mineral Resources and Mineral Reserves for coal, it is recommended that all issuers use the Mineral Resource and Mineral Reserve categories set out in the CIM Definition Standards. Qualified Person(s) should be guided by the estimation of Mineral Resources and Mineral Reserve best practices guidelines for coal and by GSC Paper 88- 21: a standardized coal resource/reserve reporting system for Canada. It is acceptable to use the GSC Paper 88-21 as a framework for the development and categorization of coal estimates, but the GSC 88-21 categories should be converted to the equivalent CIM Definition Standard categories for public reporting.

Reporting of Industrial Minerals

When reporting Mineral Resource and Mineral Reserve estimates relating to an industrial mineral site, the Qualified Person(s) should be guided by the Estimation of Mineral Resources and Mineral Reserves Best Practice Guidelines for Industrial Minerals.

Reporting of Diamonds and Gemstones

When reporting diamond Exploration Information and Mineral Resources and Mineral Reserves the Qualified Person is expected to comply with the CIM Guidelines for the Reporting of Diamond Exploration Results and the Estimation of Mineral Resources and Mineral Reserves Best Practice Guidelines for Rock Hosted Diamonds.

ATTACHMENT 6

Final Environmental Impact Statement
Pogo Gold Mine Project

Delta, Alaska

National Pollutant Discharge Elimination System (NPDES)
Permit Application No. AK-005334-1

September 2003

Prepared By:

U.S. Environmental Protection Agency
Region 10
Office of Water, NPDES Permits Unit

Cooperating Agencies:

U.S. Army Corps of Engineers

Alaska Department of Natural Resources

With Assistance From:

Baker
Engineering & Energy
Michael Baker Jr., Inc.

Volume I

Mine Water

Mine water inflows are expected to average approximately 139 gpm, with a peak annual inflow of approximately 205 gpm. The mine drainage water is expected to have low but measurable levels of cyanide and other metals. All available mine water would be used in the mill process before any additional makeup water were obtained from the RTP to ensure that the residual cyanide and metals in the mine water would be entrained in the tailings solids sent either to the underground as cemented backfill or to the dry stack. Mine water likely would satisfy all the process water requirements under most circumstances for the project. Mine drainage water would be collected in a large sump in the mine and pumped to treatment facilities either in the mine or near the mouth of the existing 1525 Portal in the Goodpaster Valley, from which it would be discharged to the injection wells or soil absorption system (SAS), sent to the mill as process water, or recycled to the RTP.

Recycle Tailings Pond

Water would accumulate in the RTP from snowmelt, stormwater runoff from the mill, camp and associated roads, seepage from the dry-stack tailings, and fresh water pumped to the RTP to provide water during dry periods when precipitation and mine water inflows were insufficient for process plant needs. RTP water would be used for process makeup requirements to fill demand not met by mine water flow.

The RTP would be built by constructing a dam downstream of the dry-stack tailings facility in Liese Creek Valley. A cross-section view of the 40-million-gallon RTP is shown in Figure 2.3-8. Although the bottom of the RTP would be unlined, the dam itself would be a lined, rock-fill structure with expansion capability. The RTP would provide storage for snowmelt runoff and the 100-year, 24-hour-intensity storm event. Summer season operating water levels in the dam would be kept below the 100-year, 24-hour-storm volume requirement. The RTP would provide a total of 40 million gallons of water storage. Modeling showed the RTP would overtop and discharge without treatment only infrequently (22 times in 1,000 years) during major storm or runoff events.

The dam would be constructed with nonmineralized development rock and local borrow materials from within the water storage basin. Because of the absence of adequate fine-grained soils in the vicinity for developing a dam core of high integrity, a composite synthetic liner system would be placed on the upstream face of the dam. This liner system would be tied into a vertical seepage cutoff trench and/or extended in a sloping trench at the upstream toe. Selection of the actual method of seepage cutoff would depend on the preferred technical alternative.

A seepage collection well and pump-back system would be incorporated into the downstream toe of the dam. The seepage wells would be installed through all overburden and into the bedrock beyond the immediate downstream toe of the 40-million-gallon dam. This system would allow for dam raising downstream, providing an appropriate degree of flexibility at this stage of design. A system of monitoring wells would be developed downstream of the seepage collection wells to monitor the performance of the seepage collection system.

Fresh Makeup Water

Fresh water would be added to the RTP for makeup water when the other water sources were inadequate for process requirements. This water would come from wells in a suitable area of alluvial sediments in the Goodpaster Valley and in upper Liese Creek Valley above the dry

ATTACHMENT 7

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How can metal mining impact the environment?

Material adapted from: Hudson, T.L, Fox, F.D., and Plumlee, G.S. 1999. [Metal Mining and the Environment](), p. 7,20-27,31-35,38-39. Published by the American Geosciences Institute Environmental Awareness Series.

Modern mining operations actively strive to mitigate potential environmental consequences of extracting metals, and such operations are strictly regulated in the United States. The key to effective mitigation lies in implementing scientific and technological advances that prevent or control undesired environmental impacts.

Operations and waste products associated with metal extraction and processing are the principal causes of environmental concerns about metal mining. Concerns include:

- Physical disturbances to the landscape
- Soil and water contamination
- Air contamination
- Public safety

Physical Disturbances

The largest physical disturbances at a mine site are the actual mine workings, such as open pits and the associated waste rock disposal areas. Mining facilities such as offices, shops, and mills, which occupy a small part of the disturbed area, are usually salvaged or demolished when the mine is closed. The open pits and waste rock disposal areas are the principal visual and aesthetic impacts of mining. Underground mining generally results in relatively small waste rock disposal areas ranging from a few acres in size to tens of acres (0.1 km2). These areas are typically located near the openings of the underground workings. Open pit mining disturbs larger areas than underground mining, and thus has larger visual and physical impacts. As the amount of waste rock in open pit mines is commonly two to three times the amount of ore produced, tremendous volumes of waste rock are removed from the pits and deposited in areas nearby.

Waste piles from processing, such as tailings impoundments, leach piles, and slag piles vary in size, but can be very large. The impoundments associated with some of the largest mills, such as at open pit copper mines, can cover thousands of acres (tens of km2) and be several hundred feet (about 100 m) thick. Heap leach piles can cover tens to hundreds of acres (0.1 to 1 km2) and be a few hundred feet (about 100 m) high. They resemble waste rock piles in location and size, but are more precisely engineered. Slag is a glassy by-product of smelting; slag piles can cover tens to hundreds of acres (0.1 to 1 km2) and be over 100 hundred feet (30 m) high.

These impacts remain on the landscape until the disturbed areas are stabilized and reclaimed for other uses, such as wildlife habitat or recreation areas, after mining has ceased.

Soil and Water Contamination from Waste Rock and Tailings

Mobilization of metals in waste rock

Waste rock disposal areas are usually located as close to the mine as possible to minimize haulage costs. If not properly managed, erosion of mineralized waste rock into surface drainages may lead to concentrations of metals in stream sediments. This situation can be potentially harmful, particularly if the metals are in a chemical form that allows them to be easily released from the sediments into stream waters. When this occurs, the metals are considered to be “mobilized” and “bioavailable” in the environment.

In some cases, bioavailable metals are absorbed by plants and animals, causing detrimental effects. Although current U.S. mining and reclamation practices guided by environmental regulations minimize or prevent waste rock erosion into streams, disposal of waste rock in places where it could erode into surface drainages has occurred historically. These conditions still exist at some old or abandoned mines.

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Slag is a by-product of the smelting process. Most slags, because they are composed primarily of oxidized, glassy material, are not as significant a potential source of metals released into the environment as mine wastes and mill tailings. However, some slags may contain remnant minerals that can be a potential source of metal release to the environment.

Acid rock drainage from waste rock

Although the character of waste rock varies with the type of ore, many waste rocks contain sulfide minerals associated with metals, such as lead, zinc, copper, silver, or cadmium. An important sulfide mineral common in waste rock is pyrite, iron sulfide. When pyrite is exposed to air and water, it undergoes a chemical reaction called "oxidation." The oxidation process produces acidic conditions that can inhibit plant growth at the surface of a waste pile. Bare, non-vegetated, orange-colored surface materials make some waste rock areas highly visible, and they are the most obvious result of these acidic conditions.

If water infiltrates into pyrite-laden waste rock, the resulting oxidation can acidify the water, enabling it to dissolve metals such as copper, zinc, and silver. This production of acidic water, is commonly referred to as "acid rock drainage." If acid rock drainage is not prevented from occurring, and if it is left uncontrolled, the resulting acidic and metal-bearing water may drain into and contaminate streams or migrate into the local groundwater. The acidity of contaminated groundwater may become neutralized as it moves through soils and rocks. However, significant levels of dissolved constituents can remain, inhibiting its use for drinking water or irrigation.

Where acid rock drainage occurs, the dissolution and subsequent mobilization of metals into surface and groundwater is probably the most significant environmental impact associated with metallic sulfide mineral mining. Acidic and metal-bearing groundwater occurs in abandoned underground mine workings and deeper surface excavations that encounter the groundwater of a mineralized area. Because they are usually located at or below the water table, underground mines act as a type of well which keeps filling with water. Because these waters migrate through underground mine workings before discharging, they interact with the minerals and rocks exposed in the mine. If sulfide minerals are present in these rocks, especially pyrite, the sulfides can oxidize and cause acid rock drainage.

Acid seepage from tailings

Tailings produced from the milling of sulfide ores — primarily copper, lead, and zinc ores — may have concentrations of pyrite that are greater than those common in waste rock. Also, because tailings are composed of small mineral particles the size of fine sand and smaller, they can react with air and water more readily than waste rocks. Therefore, the potential to develop acidic conditions in pyrite-rich tailings is very high.

Seepage from tailings can be prevented or minimized by placing an impermeable barrier, such as clay, at the bottom of the impoundment before tailings disposal. Many pre-1970s tailings impoundments did not have such barriers. The infiltration of surface water into tailings can be prevented by using reclamation methods that facilitate runoff rather than ponding of surface waters. If not prevented or controlled, the acidic and metal-bearing waters from tailings can impact stream habitats and groundwater.

Air Contamination

At some sites, gas and particulate emissions that were released to the atmosphere from historical smelting operations have been a source of human health concerns and environmental impacts. Recognizing the importance of minimizing and mitigating this impact, modern smelters use processes that drastically reduce particulate and sulfur dioxide emissions.

In the past, sulfur dioxide has been the most common emission of concern, because it reacts with atmospheric water vapor to form sulfuric acid or "acid rain." The acidic conditions that develop in the soils where these emissions precipitate can harm existing vegetation and prevent new vegetation from growing. Barren areas near smelting operations have been an enduring environmental impact of historical smelting. Some impacted areas that have existed for decades are now beginning to recover.

In some cases, the emissions from older metal smelters may have affected human health. For example, elevated levels of lead in blood have been measured in residents of some communities located near lead-zinc smelters during their operation. Today, smelting operations, combined with environmental controls, are implemented to prevent potential environmental and health issues related to emissions.

Public Safety

Old mining sites are inherently interesting to people, but potentially dangerous as well. They may have surface pits, exposed or hidden entrances to underground workings, or old intriguing buildings. Another safety consideration at some mine sites is ground sinking or "subsidence." The ground may sink gradually where underground workings have come close to the surface. Because an unexpected collapse can occur without warning, such areas usually are identified and should be avoided. When modern mines are closed, mine owners mitigate such hazards by closing off mine workings, regrading and decreasing the steep slopes of surface excavations, and salvaging or demolishing buildings and facilities.

In some states where old mining areas are common, such as Colorado and Nevada, current mine owners, government agencies, or other interested parties may undertake reclamation and safety mitigation projects that address hazards at these sites. At a minimum, these programs identify hazards, install warning and no trespass signs, and fence off dangerous areas. The closing of entrances to old underground workings may also be done as a part of these efforts. Some abandoned mine workings have become important habitats

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for bat colonies. Closure of mine openings can be designed to allow the bats continued access and protection. This practice is especially valuable for endangered bat species. Because many old mine sites may not be safe, the casual visitor to such sites is cautioned to exercise care and avoid entering them.

Learn More

- Metal Mining and the Environment (Booklet), *American Geosciences Institute*
  Provides basic information about the mining cycle, from exploration for economic mineral deposits to mine closure. The booklet discusses the environmental aspects of metal mining and illustrates the ways science and technology assist in preventing or reducing environmental impacts.

- Understanding Contaminants Associated with Mineral Deposits (Fact sheet), *U.S. Geological Survey*
  Significant contamination can come from natural deposits as well as inactive mines. This 2007 fact sheet provides an overview of USGS studies on how metals and acid waters are released from minerals and inactive mines.

- Contact your state mining agency: Links to State Mining Agencies, *Mine Safety and Health Administration*

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ATTACHMENT 8

Comparison of Predicted and Actual Water Quality at Hardrock Mines

The reliability of predictions in Environmental Impact Statements

Buka Environmental

Kuipers & Associates

EXECUTIVE SUMMARY

INTRODUCTION AND APPROACH

This study reviews the history and accuracy of water quality predictions in Environmental Impact Statements (EISs) for major hardrock mines in the United States. It does so by:

- identifying major hardrock metals mines in the United States and determining which major mines had EISs
- gathering and evaluating water quality prediction information from EISs
- selecting a representative subset of mines with EISs for in-depth study
- examining actual water quality information for the case study mines, and
- comparing actual water quality to the predictions made in EISs.

Based on the results of the evaluations conducted, an analysis was performed to identify the most common causes of water quality impact and prediction failures. In addition, an analysis was conducted to determine if there were inherent risk factors at mines that may predispose an operation to having water quality problems. Conclusions are provided about the effectiveness of the underlying scientific and engineering principles used to make water quality predictions in EISs. Finally, recommendations are made for regulatory, scientific and engineering approaches that would improve the reliability of water quality predictions at hardrock mine sites.

The National Environmental Policy Act (NEPA), enacted in 1969, was the first environmental statute in the United States and forms the foundation of a comprehensive national policy for environmental decision making. NEPA requires federal agencies to take a "hard look" at the environmental impacts of each proposed project to ensure the necessary mitigation or other measures are employed to meet federal and state regulations and other applicable requirements. Under NEPA, when a new mine is permitted, agencies have a duty to disclose underlying scientific data and rationale supporting the conclusions and assumptions in an EIS.

NEPA requires federal agencies proposing major actions that may substantially affect the quality of the human environment to prepare a detailed Environmental Impact Statement (EIS). A "major action" includes actions approved by permit or other regulatory action. If the agency finds that the project *may* have a significant impact on the environment, then it must prepare an EIS. As part of the EIS process, hardrock mines operating on federal lands or otherwise subject to NEPA are required to estimate impacts to the environment, including direct impacts to water quality and indirect impacts that occur later in time but are still reasonably foreseeable. The NEPA analysis process calls for performing original research, if necessary, and reasonable scientifically supported forecasting and speculation. A wide array of scientific approaches has been used to predict water quality that could result at mine sites, and many different engineering techniques were applied to mitigate these potential impacts. The primary subject of this report is the effectiveness of water quality predictions and mitigation that were applied over the past 30 years as a part of the EIS process at hardrock mines in the United States.

IDENTIFICATION OF MAJOR AND NEPA-ELIGIBLE HARD ROCK MINES

Major Hardrock Metal Mines in the United States

Hardrock metal mines in the United States produce gold, silver, copper, molybdenum, lead, zinc and platinum group metals from open pit and underground mining operations. For the purpose of this study, "major" mines were defined as: those that have a disturbance area of over 100 acres and a financial assurance amount of over $250,000; have a financial assurance of $1,000,000 alone (regardless of acreage); or have a production history (since 1975) of greater than 100,000 ounces of gold, 100,000,000 pounds of copper or the monetary value equivalent in another metal. Using those criteria, 183 major hardrock metal mines were identified as having operated since 1975.
The major hardrock mines are located in fourteen states (Alaska, Arizona, California, Colorado, Idaho, Michigan, Montana, Nevada, New Mexico, South Carolina, South Dakota, Utah, Washington and Wisconsin), with the vast

majority (178 of 183) located in western states. Nevada has the greatest number of major mines of any state, with 74 (40%) of the total major mines. Sixty-three percent (63%) of the mines produce gold and/or silver, 16% produce copper, 4% produce copper and molybdenum, 2% produce molybdenum only, 4% produce lead and zinc, and 1% produce platinum group metals (percentages add to greater than 100 because some mines produce multiple commodities).

Seventy-two percent (72%) of the major hardrock mines in the U.S. that have operated since 1975 are open pit mines, while 15% are underground. Sixty-six percent (66%) of the major hardrock mines use cyanide heap or vat leaching, 24% use flotation or gravity processing and 12% process ore by acid dump leaching and solvent extraction/ electrowinning.

Forty-five percent (45%) of the 183 major hardrock mines in operation since 1975 are still operating, and 49% have closed. Only one new major hardrock mine is currently (as of 2005) in construction, and seven others are in various stages of permitting. After the NEPA processes were completed, development proposals were withdrawn for four of the major hardrock mines identified in this study.

Major Hardrock Metal Mines Subject to NEPA

Mines located on federal land administered by the Bureau of Land Management or the Forest Service are subject to the requirements of NEPA. Also subject to NEPA regulations are certain National Pollution Discharge Elimination System (NPDES) permits issued by the Environmental Protection Agency, certain 404 Wetlands permits from the Army Corp of Engineers, and mines located on Native American trust lands administered by the Bureau of Indian Affairs (BIA). In addition, some states (California, Montana, Washington and Wisconsin) have a state-mandated process that is equivalent to NEPA.

NEPA requires environmental analysis of federal actions. As it has evolved, an EIS is required for any “major federal action significantly affecting the quality of the human environment,” and an Environmental Assessment (EA) is required for lesser actions. EAs do not require public comment; the results of an EA can determine whether the action is significant, which will trigger an EIS, but usually the EA is performed in lieu of an EIS.

Of the 183 major modern-era hardrock mines identified, 137 (75%) had federal actions that triggered NEPA analysis. Ninety-three (68%) were located on BLM land, thirty-four (25%) on Forest Service land, and nine (7%) on both BLM and Forest Service land. Disturbance of wetlands triggered NEPA analysis at five (4%) of the mines, requiring a 404 wetlands permits from the Corp of Engineers (COE); a discharge into a water of the United States was the only NEPA trigger at three (2%) mines; and NEPA analysis was triggered at two (1%) mines because they were located on Indian Lands. Twenty-three (19%) mines were located in states that have their own NEPA-equivalent statutes. In many cases, more than one federal agency may be involved in the NEPA process (e.g., Forest Service and BLM, based on location, or Forest Service and EPA, based on location and a NPDES discharge); in addition, state agencies may be responsible for carrying out their own NEPA-equivalent or alternative processes. When this occurs, a Memorandum of Understanding (MOU) is usually written among the various agencies describing their shared responsibilities in order to avoid duplication of efforts. When two or more federal and/or state agencies are involved, the agencies establish a formal agreement delineating which will act in the lead and cooperating roles. In some cases an EIS (or EA) may be developed that will satisfy both NEPA and a NEPA-equivalent state law.

The general makeup of the mines where NEPA is applicable is roughly similar to that of major mines. The NEPA-applicable mines are located in 11 states with all but one located in the western states. Nevada had the most NEPA-applicable major mines with 50% (69) of the total. Eighty-five percent (116) of the NEPA-applicable mines produced gold and/or silver, while 15% (21) produced copper. Seventy-six percent (104) of the NEPA-applicable major mines were open-pit, while 14% (19) were underground mines. Sixty-nine percent (95) used cyanide heap or vat leach, 20% (28) used flotation/gravity and 11% (15) used acid dump leach processing. Forty-seven percent (64) of the major mines subject to NEPA were still operating, 45% (61) have closed, one was in construction, six were in permitting, and five were withdrawn from consideration after undergoing the NEPA process.

EISs were performed at 82 (60%) of the 137 major mines subject to NEPA, either as part of new permitting actions or later expansions or other actions. EAs were performed at the remainder of the mines subject to NEPA. EISs and EAs were obtained by writing, e-mailing, and/or calling state and federal agencies, including the BLM, Forest Service, tribal agencies and by conducting library searches. The process of obtaining NEPA documents took approximately 16 months and involved numerous follow-up calls, and written and email contact. Of the 137 major mines subject to NEPA, 71 mines had documents that were obtained and reviewed. A total of 104 NEPA documents, either EISs or EAs, were reviewed for the 71 mines. The general characteristics of mines with reviewed EISs are similar to those of all major hard rock mines and all NEPA-eligible mines, as shown in Table ES-1.

EVALUATION OF WATER QUALITY PREDICTION INFORMATION IN NEPA DOCUMENTS

Information on the following elements related to water quantity and quality predictions was collected from the 104 NEPA documents: geology/mineralization; climate; hydrology; field and laboratory tests performed; constituents of concern identified; predictive models used; water quality impact potential; mitigation; potential water quality impacts; predicted water quality impacts; and discharge information. There are two types of water quality predictions made in EISs: "potential" water quality, which leans toward worst-case water quality that does not take mitigation into account; and "predicted" water quality, which does consider the beneficial effects of mitigation. Both types of water quality predictions were recorded and used for subsequent comparisons to actual water quality. For each type of information collected from the NEPA documents, a score was derived to characterize the element (e.g., geology/ mineralization used six scores, including one for no information provided). The scoring allowed numeric summaries (percentages) to be calculated based on the information collected from the NEPA documents. The results for the EIS information collected for each mine reviewed in detail (71 mines, 104 EISs) are contained in Section 5 of the report. Limited information on certain water quality elements is contained in Table ES-4.

A preliminary evaluation of the availability of operational water quality information was performed before selection of the case study mines. Operational and post-operational water quality information was available from EISs conducted after the new project EIS, especially for the states of Alaska, Montana and Idaho, where multiple EISs were often available. In other states, such as Arizona, California, Nevada and Wisconsin, technical reports and water quality data were available from state agencies that regulate mining activities.

SELECTION OF CASE STUDY MINES

The case study mines were selected based on:

- the ease of access to information on operational water quality
- the variability in general categories such as geographic location, commodity type, extraction and processing methods, and
- the variability in EIS elements related to water quality, such as climate, proximity to groundwater and surface water resources, acid drainage potential and contaminant leaching potential.

Case studies were developed for the twenty-five mines listed in Table ES-2.

Table ES-1. Comparison of General Categories for All Hard Rock Mines, NEPA-eligible Mines and Mines with Reviewed EISs (% of mines in sub-category)

Category	Sub-category	Major Mines (%)	NEPA-eligible Mines (%)	Mines with Reviewed EISs (%)
Location	Alaska	4.4%	5.1%	9.9%
	Arizona	10.9%	9.5%	11.3%
	California	8.2%	9.5%	11.3%
	Colorado	4.9%	0.0%	0.0%
	Idaho	7.7%	4.4%	8.5%
	Michigan	0.5%	0.0%	0.0%
	Montana	8.2%	10.9%	18.3%
	Nevada	40.4%	50.4%	32.4%
	New Mexico	3.8%	2.2%	2.8%
	South Carolina	1.6%	0.0%	0.0%
	South Dakota	2.7%	0.7%	1.4%
	Utah	3.8%	2.9%	1.4%
	Washington	2.2%	2.9%	0.0%
	Wisconsin	0.5%	0.7%	1.4%
Commodity	Primary Gold	12.6%	12.4%	19.7%
	Primary Silver	7.1%	6.6%	7.0%
	Gold and Silver	62.8%	65.7%	54.9%
	Copper	16.4%	15.3%	19.7%
	Copper and Molybdenum	4.4%	2.9%	1.4%
	Molybdenum	2.2%	0.7%	1.4%
	Lead and Zinc	3.8%	3.6%	5.6%
	Platinum Group	1.1%	1.5%	2.8%
Extraction Methods	Underground	14.8%	13.9%	18.3%
	Open Pit	72.1%	75.9%	71.8%
	Underground + Open Pit	12.0%	10.2%	9.9%
Processing Methods	Heap or Vat Leach	65.6%	69.3%	62.0%
	Flotation and Gravity	24.0%	20.4%	26.8%
	Dump Leach (SX/EW)	12.0%	10.9%	11.3%
	Heap Leach	39.3%	38.7%	25.4%
	Vat Leach	9.3%	10.2%	14.1%
	Heap Leach and Vat Leach	16.9%	20.4%	22.5%
	Smelter	3.3%	1.5%	1.4%
Operational Status	Operating	44.8%	46.7%	49.3%
	Closed	48.6%	44.5%	36.6%
	In Construction	0.5%	0.7%	1.4%
	Permitting	3.8%	4.4%	7.0%
	Withdrawn	2.2%	3.6%	5.6%
Total number of mines in category		183	137	71

Table ES-2. Case Study Mines

Mine	State	Mine	State
Greens Creek	AK	Golden Sunlight	MT
Bagdad	AZ	Mineral Hill	MT
Ray	AZ	Stillwater	MT
American Girl	CA	Zortman and Landusky	MT
Castle Mountain	CA	Florida Canyon	NV
Jamestown	CA	Jerritt Canyon	NV
McLaughlin	CA	Lone Tree	NV
Mesquite	CA	Rochester	NV
Royal Mountain King	CA	Round Mountain	NV
Grouse Creek	ID	Ruby Hill	NV
Thompson Creek	ID	Twin Creeks	NV
Beal Mountain	MT	Flambeau	WI
Black Pine	MT		

The major characteristics of the case study mines were similar to those of all mines with reviewed EISs, as shown in Table ES-3. The availability of information on operational water quality was also a major factor in the selection of case-study mines. The highest percentage of case study mines was from Nevada, and this state had the highest percentage of mines for all major mines, NEPA-eligible mines, and mines with reviewed EISs. Somewhat higher percentages of mines from California and Montana were selected for case studies because of the ease of obtaining operational water quality information from these states. Similar percentages of gold and/or silver mines were selected for the case studies as were present in all mines with reviewed EISs. However, a lower percentage of primary copper mines was selected for case study because of the difficulty in obtaining operational water quality information on these facilities. Case study mines had very similar percentages as all mines with reviewed EISs in terms of extraction and processing methods. In terms of operational status, no case study mines were in construction, in permitting, or withdrawn because operational water quality information would not be available for mines in these types of operational status.

Case study mines were also similar to all mines with reviewed EISs in terms of EIS elements related to water quality, as shown in Table ES-4. The elements listed in Table ES-4 are considered "inherent" factors that may affect water quality conditions. That is, these elements are related to conditions that either relate to climatic and hydrologic conditions at and near the mine site (in the case of climate, and proximity to water resources) or to qualities of the mined materials that may affect water quality (in the case of acid drainage and contaminant leaching potential). For a number of mines, little or no information on these elements was available in initial EISs, but subsequent NEPA documents either contained the first information or contained improved information after water quality conditions developed at the mine site during and after operation. Therefore, for acid drainage and contaminant leaching potential, the highest documented potential in any of the EISs was recorded.

Case study mines were similar to all mines with reviewed EISs in terms of climate and proximity to surface water resources. When compared to all mines with reviewed EISs, a higher percentage of case study mines had shallower depths to groundwater. However, six of the case study mines had groundwater depths greater than 50 feet below the ground surface. In terms of acid drainage potential, lower percentages of case study mines had low and high acid drainage potential, but higher percentages had moderate acid drainage potential. Therefore, the case study mines provide a somewhat more evenly distributed range of acid drainage potentials than all mines with reviewed EISs. Case study mines had nearly identical percentages of mines with low and high contaminant leaching potential, but more case study mines had moderate acid drainage potential, reflecting fewer mines in the "no information" category for case study mines.

Table ES-3. Comparison of General Categories for All Mines with Reviewed EISs and Case Study Mines (% of mines in subcategory)

Category	Subcategory	All Mines with Reviewed EISs	Case Study Mines
Location	Alaska	10%	4%
	Arizona	11%	8%
	California	11%	24%
	Colorado	0%	0%
	Idaho	9%	8%
	Michigan	0%	0%
	Montana	18%	24%
	Nevada	32%	28%
	New Mexico	3%	0%
	South Carolina	0%	0%
	South Dakota	1%	0%
	Utah	1%	0%
	Washington	0%	0%
	Wisconsin	1%	4%
Commodity	Primary Gold	20%	12%
	Primary Silver	7%	4%
	Gold and Silver	55%	64%
	Copper	20%	4%
	Copper and Molybdenum	1%	4%
	Molybdenum	1%	4%
	Lead and Zinc	6%	4%
	Platinum Group	3%	4%
Extraction Methods	Underground	18%	16%
	Open Pit	72%	76%
	Underground + Open Pit	10%	8%
Processing Methods	Heap and/or Vat Leach	62%	72%
	Flotation and Gravity	27%	28%
	Dump Leach (SX/EW)	11%	8%
	Heap Leach	25%	20%
	Vat Leach	14%	16%
	Heap Leach and Vat Leach	23%	32%
	Smelter	1%	0%
Operational Status	Operating	49%	52%
	Closed	37%	48%
	In Construction	1%	0%
	Permitting	7%	0%
	Withdrawn	6%	0%
Total number of mines		71	25

Table ES-4. Comparison of EIS Elements for All Mines with Reviewed EISs and Case Study Mines (% of mines with sub-element)

Element	Sub-element	All Mines with Reviewed EISs	Case Study Mines
Climate	Dry/Arid	20%	20%
	Dry/Semi-Arid	35%	28%
	Humid Subtropical	4%	12%
	Marine West Coast	4%	4%
	Boreal Forest	28%	32%
	Continental	3%	4%
	Sub-Arctic	4%	0%
Surface Water Proximity	No information	7%	4%
	Perennial Streams >1 mile	26%	24%
	Perennial streams <1 mile	25%	28%
	Perennial streams on site	44%	44%
Groundwater Proximity	No information	12%	4%
	Groundwater >200 ft deep	16%	8%
	Groundwater 50-200 ft deep	13%	16%
	Groundwater 0-50 ft deep/springs on site	59%	72%
Acid Drainage Potential (highest)	No information	9%	8%
	Low	58%	48%
	Moderate	6%	32%
	High	27%	12%
Contaminant Leaching Potential (highest)	No information	22%	12%
	Low	32%	32%
	Moderate	30%	40%
	High	17%	16%
Total number of mines		71	25

Overall, the case study mines display a variability in geographic location, commodity type, extraction and processing methods and in EIS elements related to water quality. Considering the additional limitation of having readily accessible operational water quality information, the case study mines reflect well the distribution of general categories and water quality-related elements that are present in the larger subsets of hard rock mines in the United States.

Case studies for each mine contain information collected from EISs and other documents, information on actual water quality, a comparison of predicted and actual water quality, and an analysis of the causes of water quality impacts and prediction errors.

COMPARISON OF PREDICTED AND ACTUAL WATER QUALITY

Operational and post-operational water quality information was collected from EISs conducted after the new project EIS for mines in Alaska, Montana and Idaho. Interviews of state agency personnel were conducted in California, Montana, Nevada and Wisconsin. Technical reports and water quality data from state agencies that regulate mining were collected for mines in Arizona, California, Nevada and Wisconsin. In some cases, the water quality data showed pre-mining and operational water quality, but baseline data were generally difficult to obtain. The information collected on actual water quality conditions was held in databases or in electronic and paper files for comparison to predicted water quality.

For this evaluation, a water quality impact is defined as increases in water quality parameters as a result of mining operations, whether or not an exceedence of water quality standards or permit levels has occurred. Information on whether groundwater, seep, or surface water concentrations exceeded standards as a result of mining activity is also included. Nearly all the EISs reviewed reported that they expected acceptable water quality (concentrations lower than relevant standards) after mitigation were taken into account. Indeed, if this prediction was not made in the EIS, the regulatory agency would not be able to approve the mine (with certain exceptions, such as pit water quality, in states where pit water is not considered a water of the state).

A comparison between potential (pre-mitigation), predicted, and actual surface water quality for the case study mines is presented in Table ES-5. Sixty percent of the case study mines (15/25) had mining-related exceedences in surface water. Of the mines with surface water quality exceedences, four (17%) noted a low potential, seven (47%) a moderate potential, two a high potential, and three had no information in their EISs for surface water quality impacts in the absence of mitigation measures. For the mines with surface water quality exceedences, only one mine, the McLaughlin Mine in California, was correct in predicting a moderate potential for surface water quality impacts with mitigation in place. However, this mine predicted low acid drainage potential, yet acid drainage has developed on site. Of the mines without surface water quality exceedences (7 or 28%), all were correct thus far in predicting no impacts to surface water with mitigation in place. Three of the seven are desert mines in California, one (Stillwater in Montana) has had increases in contaminant concentrations but no exceedences, and the other three have had no exceedences or increases in mining-related contaminant concentrations in surface water to date. Therefore, most case study mines predicted no impacts to surface water quality after mitigation are in place, but at the majority of these mines, impacts have already occurred.

A comparison between potential (pre-mitigation), predicted, and actual groundwater quality for the case study mines is presented in Table ES-6. The majority (64% or 16/25) of the case study mines had exceedences of drinking water standards in groundwater. However, exceedences at three of the mines, all in Nevada, may be related to baseline conditions; therefore, 52% of the case study mines clearly had mining-related exceedences of standards in surface water. Of the 13 mines with mining-related exceedences in groundwater, only two noted a low potential for groundwater quality impacts in the original EIS. The majority (9 or 69%) stated that there would be a moderate potential, and two stated there was a high potential for groundwater impacts in the absence of mitigation. In terms of predicted (post-mitigation) groundwater quality impacts, 77% (10/13) of the mines with exceedences predicted low groundwater quality impacts in their EISs, including mines predicting low impacts in the original EIS.

Of the mines with mining-related groundwater quality exceedences (13), only one mine – the same mine that correctly predicted that there would be surface water exceedences (McLaughlin, CA), was correct in predicting a high potential for groundwater quality impacts with mitigation in place; the others predicted a low potential (not exceeding standards) in at least one EIS. Of the mines without groundwater quality exceedences (5 or 25%), all were correct in predicting no impacts to surface water with mitigation in place. Again, three of the five are desert mines in California, one (Stillwater, MT) has had increases in contaminant concentrations but no exceedences, and the other (Greens Creek, AK) has had mining-related exceedences in seeps. Therefore, most mines predict no impacts to groundwater quality after mitigation were in place, but in the majority of case study mines, impacts have occurred.

Therefore, as with surface water, the predictions made about groundwater quality impacts without considering the effects of mitigation were somewhat more accurate than those made taking the effects of mitigation into account. Again, the ameliorating effect of mitigation on groundwater quality was overestimated in the majority of the case study mines.

A comparison between acid drainage and development for the case study mines is presented in Table ES-7a. Of the 25 case study mines, nine (36%) have developed acid drainage on site to date. Nearly all the mines (8/9) that developed acid drainage either underestimated or ignored the potential for acid drainage in their EISs.

Table ES-5. Summary of Predicted and Actual Impacts to Surface Water Resources at Case Study Mines

Element	Number/Total	Percentage
Mines with mining-related surface water exceedences	15/25	60%
Mines with surface water exceedences that predicted low impacts without mitigation	4/15	27%
Mines with surface water exceedences that predicted low impacts with mitigation	11/15	73%

Table ES-6. Summary of Predicted and Actual Impacts to Groundwater Resources at Case Study Mines

Element	Number/Total	Percentage
Mines with mining-related groundwater exceedences	13/25	52%
Mines with groundwater exceedences predicting low impacts without mitigation	2/13	15%
Mines with groundwater exceedences predicting low impacts with mitigation	10/13	77%

Table ES-7a. Summary of Acid Drainage Potential Predictions and Results for Case Study Mines

Element	Number/Total	Percentage
Mines predicting low acid drainage potential	18/25	72%
Mines that have developed acid drainage	9/25	36%
Mines with acid drainage that predicted low acid drainage potential	8/9	89%

The majority of the case study mines (18/25 or 72%) predicted low potential for acid drainage in one or more EISs. Of the 25 case study mines, 36% have developed acid drainage on site to date. Of these 9 mines, 8 (89%) predicted low acid drainage potential initially or had no information on acid drainage potential. The Greens Creek Mine in Alaska initially predicted moderate acid drainage potential but later predicted low potential for acid drainage for an additional waste rock disposal facility. Therefore, nearly all the mines that developed acid drainage either underestimated or ignored the potential for acid drainage in their EISs.

Of the 25 case study mines, 19 (76%) had mining-related exceedences in surface water or groundwater. However, nearly half of the mines with exceedences (8/19 or 42%) predicted low contaminant leaching potential in their EISs. The constituents that most often exceeded standards or that had increasing concentrations in groundwater or surface water included toxic heavy metals such as copper, cadmium, lead, mercury, nickel, or zinc (12/19 or 63% of mines), arsenic and sulfate (11/19 or 58% of mines for each) and cyanide (10/19 or 53% of mines).

Eight case study mines predicted low contaminant leaching potential (Table ES-7b). Of these eight mines, five (63%) had exceedences of standards in either surface water or groundwater or both after mining began. The three mines that predicted low contaminant leaching potential and had no exceedences of water quality standards were the three California desert mines: American Girl, Castle Mountain, and Mesquite.

Table ES-7b. Summary of Contaminant Leaching Potential Predictions and Results for Case Study Mines (percentages)

Element	Number/Total	Percentage
Mines predicting low contaminant leaching potential	8/25	32%
Mines with mining-related exceedences in surface water or groundwater	19/25	76%
Mines with exceedences that predicted low contaminant leaching potential	8/19	42%
Mines with exceedences that predicted moderate contaminant leaching potential	8/19	42%
Mines with exceedences that predicted high contaminant leaching potential	3/19	16%

Stated another way, 21 of the 25 case study mines (84%) had exceedences of water quality standards in either surface water or groundwater or both. The exceedences at two of these mines may be related to baseline conditions. Therefore, 76% of the case study mines had mining related exceedences in surface water or groundwater (Table ES-7b). Of the remaining 19 mines, 42% (eight) predicted low contaminant leaching potential (or had no information), 42% (eight) predicted moderate contaminant leaching potential, and only three (16%) predicted high contaminant leaching potential. Therefore, nearly half of the mines that had exceedences of water quality standards underestimated or ignored the potential for contaminant leaching potential in EISs. The constituents that most often exceeded standards or that had increasing concentrations in groundwater or surface water included toxic heavy metals such as copper, cadmium, lead, mercury, nickel, or zinc (12/19 or 63% of mines), arsenic and sulfate (11/19 or 58% of mines for each), and cyanide (10/19 or 53% of mines).

CAUSES OF WATER QUALITY IMPACTS AND PREDICTION ERRORS

Inherent Factors Affecting Water Quality at Mine Sites

This study attempts to determine if there are certain factors that make a mine more or less likely to cause water quality problems and more or less likely to accurately predict future water quality. Such factors could include inherent characteristics of the mined materials and the mine, management approaches to handling mined materials and water, and the type and number of geochemical tests that are performed on mined materials. The inherent factors evaluated include: geology and mineralization; proximity to water resources and climatic conditions; and geochemical characteristics of mined materials, such as acid drainage and contaminant leaching potential.

The relationship between inherent hydrologic and geochemical characteristics and water quality impacts shows that mines with close proximity to surface water or groundwater resources and with a moderate to high acid drainage or contaminant leaching potential have an increased risk of impacting water quality.

Surface water impacts for the mines with close proximity to surface water and high acid drainage or contaminant leaching potential are compared to surface water impacts for all the case study mines in Table ES-8. Overall, for the 13 mines with close proximity to surface water and high acid drainage or contaminant leaching potential, 12 (92%) have had some impact to surface water as a result of mining activity. For all case study mines, only 64% had some surface water quality impact. Eleven of the 13 (85%) have had exceedences of standards or permit limits in surface water as a result of mining activity.

Table ES-8. Surface Water Quality Impacts for Mines with Close Proximity to Surface Water and Elevated Acid Drainage Potential Compared to Surface Water Impacts for All Case Study Mines

	# Mines	Percent (%) with Impact to Surface Water	Percent (%) with Exceedences of Standards in Surface Water	Percent (%) with Exceedences that Predicted No Exceedences
Mines with close proximity to surface water and elevated acid drainage and contaminant leaching potential	13	92 (12/13)	85 (11/13)	91 10/11)
All case study mines	25	64 (16/25)	60 (15/25)	73 (11/15)

Of the 11 mines with surface water exceedences, ten (91%) predicted that surface water standards would not be exceeded. Considering the two mines that accurately predicted no surface water exceedences (Stillwater and Flambeau) and the one that accurately predicted exceedences (McLaughlin), 77% of mines with close proximity to surface water or direct discharges to surface water and moderate to high acid drainage or contaminant leaching potential underestimated actual impacts to surface water. For all case study mines, 73% of the mines with surface water quality exceedences predicted that there would be no exceedences. Compared to all case study mines, higher percentages of mines with close proximity to surface water and elevated acid drainage or contaminant leaching potential had surface water quality impacts and exceedences. EIS water quality predictions made before the ameliorating effects of mitigation were considered ("potential" water quality impacts) were more accurate at predicting operational water quality than predictions based on assumed improvements from mitigation.

Groundwater impacts for the mines with close proximity to groundwater and high acid drainage or contaminant leaching potential are compared to groundwater impacts for all the case study mines in Table ES-9. Of the 15 mines with close proximity to groundwater and high acid drainage or contaminant leaching potential, all but one (93%) have had mining-related impacts to groundwater, seeps, springs or admit water. For all case study mines, only 56% had mining-related impacts to groundwater. For the 15 mines with close proximity to groundwater and elevated acid drainage or contaminant leaching potential, 13 or 87% had mining-related exceedences in groundwater. For all case study mines, only 52% had exceedences in groundwater.

Table ES-9. Groundwater Quality Impacts for Mines with Close Proximity to Groundwater and Elevated Acid Drainage Potential Compared to Groundwater Impacts for All Case Study Mines

	# Mines	Percent (%) with Impact to Groundwater or Seeps	Percent (%) with Exceedences of Standards in Groundwater or Seeps	Percent (%) with Exceedences that Predicted No Exceedences
Mines with close proximity to groundwater and elevated acid drainage and contaminant leaching potential	15	93 (14/15)	93 (14/15)	86 (12/14)
All case study mines	25	68 (17/25)	68 (17/25)	52 (13/25)

These results, although not comprehensive, suggest that the combination of proximity to water resources (including discharges) and moderate to high acid drainage or contaminant leaching potential does increase the risk of water quality impacts and is a good indicator of future adverse water quality impacts. Although this finding makes intuitive sense from a risk perspective, a comprehensive study of cause and effect has never been conducted. Mines with these inherent factors are the most likely to require perpetual treatment to reduce or eliminate the long-term adverse impacts to surface water resources. Although all mines must rely on well executed mitigation measures to ensure the integrity of water resources during and after mining, mines with the inherent factors identified in this study must have mitigation measures that are even more carefully designed to avoid water quality impacts.

FAILURE MODES AND ROOT CAUSES OF WATER QUALITY IMPACTS

This section identifies the underlying causes of water quality impacts at the case study mines. It uses information gathered from the case studies and conducts a "failure modes" and "root cause" analysis. A failure is an outcome that is different than intended or predicted. A failure mode is the general type of failure that occurred or is predicted to occur (e.g., prediction failure, mitigation failure), while a root cause is the underlying, more specific, reason for the failure. The objective of the analysis presented in this section is to identify the most common types and causes of failures in protecting water quality at existing mines so that the failures can be prevented in the future. Results from this analysis can be used to make recommendations for improving both the policy and the scientific and engineering underpinnings of EISs.

Methodology and Approach

The approach uses existing ("historical") information from the 25 case study mines with EISs to identify the causes of water quality impacts that occurred during mining operations. In contrast, most similar risk analyses are conducted before operations begin and focus on generating predictions from engineering design information (e.g., likelihood of failure based on factor of safety calculations). Because our approach is retrospective rather than prospective, we know unequivocally whether a prediction has failed or a water quality failure has occurred. Therefore, the focus of this analysis is to determine what caused the failure to occur. The information used to determine how failure occurred is contained in the case studies, which summarize and compare water quality predictions in EISs with actual water quality conditions during mining operations.

Types of Characterization Failures

There are two types of characterization failures identified in the case studies: hydrologic and geochemical. Inaccuracies in hydrologic and geochemical characterization can lead to a failure to recognize or predict water quality impacts. The primary root causes of hydrologic characterization failures identified in this study are:

- dilution overestimated
- lack of hydrological characterization
- amount of discharge overestimated
- size of storms underestimated.

The primary root causes of geochemical characterization failures identified are:

- lack of adequate geochemical characterization
- sample size and/or representativeness.

The other failure mode identified in the case studies is mitigation failure in which the primary root causes are:

- mitigation not identified, inadequate or not installed
- waste rock mixing and segregation not effective
- liner leak, embankment failure or tailings spill
- land application discharge not effective.

Table ES-10 shows the various failures modes, root causes and identifies various mines that serve as examples of the failure modes. The results are summarized in Table ES-11 and are as described below.

Six of 25 mines exhibited inadequacies in hydrologic characterization.

- At two of the mines, dilution was overestimated.
- At two of the mines, a lack of hydrologic characterization was noted.
- At one of the mines, the amount of discharge generated was underestimated.
- At one of the mines, the size of storms was underestimated.

Eleven of 25 mines exhibited inadequacies in geochemical characterization. Geochemical failures resulted from:

- assumptions made about the geochemical nature of ore deposits and surrounding areas (e.g., mining will only be done in oxidized area)
- site analogs inappropriately applied to a new proposal (e.g., historic underground mine workings do not produce water or did not indicate acid generation)
- inadequate sampling (e.g., geochemical characterization did not indicate potential due to composite samples or samples not being representative of actual mining)
- failure to conduct and have results for long-term contaminant leaching and acid drainage testing procedures before mining begins
- failure to conduct the proper tests, or to improperly interpret test results, or to apply the proper models.

Sixteen of 25 mines exhibited failures in mitigation measures.

- At three of the mines mitigation was not identified, inadequate, or not installed.
- At four of the mines waste rock mixing and segregation was not effective.
- At nine of the mines liner leaks, embankment failures or tailings spills caused impacts to water resources.
- At one mine, land application disposal resulted in impacts to water resources.

Table ES-10. Water Quality Predictions Failure Modes, Root Causes and Examples from Case Study Mines

Failure Mode	Root Cause	Examples
Hydrologic Characterization	Lack of hydrologic characterization	Royal Mountain King, CA; Black Pine, MT
	Dilution overestimated	Greens Creek, AK; Jerritt Canyon, NV
	Amount of discharge underestimated	Mineral Hill, MT
	Size of storms underestimated	Zortman and Landusky, MT
Geochemical Characterization	Lack of adequate geochemical characterization	Jamestown, CA; Royal Mountain King, CA; Grouse Creek, ID; Black Pine, MT
	Sample size and/or representation	Greens Creek, AK; McLaughlin, CA; Thompson Creek, ID; Golden Sunlight, MT; Mineral Hill, MT; Zortman and Landusky, MT; Jerritt Canyon, NV
Mitigation	Mitigation not identified, inadequate, or not installed	Bagdad, AZ; Royal Mountain King, CA; Grouse Creek, ID
	Waste rock mixing and segregation not effective	Greens Creek, AK; McLaughlin, CA; Thompson Creek, ID; Jerritt Canyon, NV
	Liner leak, embankment failure or tailings spill	Jamestown, CA; Golden Sunlight, MT; Mineral Hill, MT; Stillwater, MT; Florida Canyon, NV; Jerritt Canyon, NV; Lone Tree, NV; Rochester, NV; Twin Creeks, NV
	Land application discharge not effective	Beal Mountain, MT

Table ES-11. Summary of Failure Modes for Case Study Mines

Failure Mode	Number of Case Study Mines Showing Failure Mode	Percent of Case Study Mines Showing Failure Mode
Hydrologic Characterization	6	24%
Geochemical Characterization	11	44%
Mitigation	16	64%

CONCLUSIONS AND RECOMMENDATIONS

Identification of Risk and Prevention of Impacts

- Actual water quality impacts are closer to potential (pre-mitigation) rather than predicted (post-mitigation) impacts in EISs; therefore, the threshold for significance determinations, and thus EIS (rather than EA) analysis, should be potential rather than predicted impacts.

- Cyanide is not specifically identified as a contaminant of concern often enough; whenever cyanide is being used in heap or vat leaching or flotation, it should be listed as a potential contaminant of concern.

- A minimum and relatively consistent set of geochemical tests should be required by federal and state mining agencies. See the companion report (*Predicting Water Quality at Hardrock Mines: Methods and Models, Uncertainties, and State- of-the-Art*) for recommendations for minimum required geochemical testing.

- Mines with close proximity or discharges to water resources, moderate to high acid drainage and/or contaminant leaching potential should undergo more scrutiny by agencies in the permitting process than mines with low inherent water quality impact factors.

- Hydrologic characterization failures are most often caused by over-estimation of dilution, failure to recognize hydrologic features and underestimation of water production quantities. They can be addressed by requiring adequate hydrologic characterizations and making environmentally conservative assumptions about water quality and quantity.

- Lack of adequate geochemical characterization is the single-most identifiable root cause of water quality prediction failures. Improvements in geochemical characterization can provide the greatest contribution to ensuring accurate water quality predictions at hardrock mine sites. As noted in the companion report, the same geochemical test units should be used for testing of all sources and parameters used to predict water quality impacts. In addition, more extensive information on mineralogy and mineralization should be included in EISs, and more attention should be paid to uncertainties in geochemical and hydrologic characterization.

- Mixing and segregation mitigation failures occur at a moderate frequency and are typically caused by using too little neutralizing material and not effectively isolating acid generating material from nearby water resources. This can be addressed by requiring adequate geochemical and hydrologic characterization and minimizing transport along hydrologic pathways.

- Mitigation frequently fails to perform according to plan. It is important to consider the likelihood and consequences of mitigation failure in EISs and identify additional mitigation measures that can be installed if failure occurs. Multiple mitigation measures (e.g., installation of liner and leachate collection system or pump-back system) should be required in most cases and planned for in the design phase.

- Improvements are needed in the prediction of appropriate mitigation measures. Preventive mitigation measures are more cost effective and environmentally protective than remediation after impacts have occurred.

- EISs for new mines should include comprehensive baseline water quality, hydrologic, and geochemical evaluations and careful and supportable identification of mitigation measures, including an evaluation of potential mitigation failures.

Data and Data Quality Issues

- Operational and post-operational water quality information for hard rock mine sites should be readily accessible to the public in a user-friendly web-based format.

- Information provided to the public should include: maps clearly showing the location of mine units, streams, and surface water and groundwater sampling locations; identification of facilities/source areas associated (upgradient) with wells and other sampling points; pre-mining and baseline/background water quality and quantity information; well depths; groundwater elevations in monitoring wells; and water quality data for all monitoring locations.

- In many cases existing conditions were explained by baseline water quality conditions with limited baseline water quality information. An independent review of baseline water quality data for hard rock mines should be conducted to verify those claims.

- With the cooperation of industry and regulators, a more systematic and complete effort should be undertaken to compare water quality predictions against actual water quality impacts as a follow-up to this study.

ATTACHMENT 9

Zortman & Landusky Mines

HJR 43
Water Quality Impacts

A staff paper presented to the Environmental Quality Council
October 2004
by Larry D. Mitchell

Cover Photos

Reclamation at Zortman Mine, 2004
EQC Staff Photo

Reclamation at Landusky Mine, 2004
EQC Staff Photo

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Figures and Tables

Introduction

House Joint Resolution 43

The preamble of HJR 43, enacted by the 2003 Montana Legislature, describes in general terms the status of the reclamation efforts that have been conducted at the Zortman and Landusky mines by the Montana Department of Environmental Quality (DEQ) and the federal Bureau of Land Management (BLM) following the bankruptcy of Pegasus Gold Corporation (Pegasus) and the abandonment of the mines by its operator, Zortman Mining Incorporated (ZMI). HJR 43 asks an appropriate interim committee to review how those efforts are addressing water quality issues at the mines and whether additional reclamation efforts are necessary. The mines are being reclaimed by the DEQ and its contractors with mine bond proceeds made available following a settlement agreement with the sureties, with supplemental funds from the bankruptcy settlement, and with state and federal funds.

Specifically, HJR 43 asks the interim committee to:

(1) identify the impacts on surface water and ground water, including the recent degradation of Swift Gulch, attributable to past or present activities at the mine sites;
(2) determine if there are identifiable downstream impacts on the Milk and Missouri River drainages attributable to past or present activities at the mine sites;
(3) determine whether the surface water and ground water resources in the watersheds affected by the mine operations are being protected by the current or proposed state reclamation; and
(4) determine the potential impacts to surface water and ground water resources if additional funding for water treatment and reclamation does not become available.

Response

The Legislative Council assigned HJR 43 to the Environmental Quality Council (EQC), and the EQC decided to combine a review of the issues in HJR 43 with a review of the current status of metal mine bonding in Montana (see *Metal Mine Bonding in Montana - Status and Policy Considerations*, Montana EQC staff report, Larry D. Mitchell, October 2004). The EQC decided that both topics would be reported in separate staff papers using currently available information from several sources. Additionally, the EQC heard presentations on the issues of metal mine bonding and the status of reclamation at the Zortman and Landusky mines at its regularly scheduled meetings during the interim.

Staff relied on key reports, court documents, and interviews with people who have a professional involvement with the mines and their reclamation.

Staff reviewed several of the many research reports and studies that have been prepared, especially since the early 1990s, on the operation and reclamation of the Zortman and Landusky mines and their impact on water quality. However, a thorough review and understanding of these complex and sometimes contradictory technical reports is beyond the scope of this paper. Staff relied on key reports, court documents, and interviews with people who have a professional involvement with the mines and their reclamation. For a partial list of reports and documents that have been produced on the Zortman and Landusky mines, see R1-R8, References, listed in the Final Supplemental Environmental Impact Statement for Reclamation of the Zortman and Landusky Mines, Phillips County, prepared by the DEQ and the BLM, December 2001.

Location

From 1979 until it filed for bankruptcy in early 1998, Pegasus Gold Corporation, through its subsidiary ZMI, operated two open-pit cyanide heap leach gold mines in the Little Rocky Mountains immediately south of the Fort Belknap Reservation in north-central Montana (**Figure 1**). The Zortman mine permit includes approximately 406 acres (122 acres BLM; 284 acres private mining claims) and the Landusky mine permit includes approximately 783 acres (472 acres BLM; 311 acres private mining claims).

The Zortman mine is located about 1 1/2 miles east of the much larger Landusky mine. Both mines are located on a mountain divide that separates the Missouri River drainage to the south from the Milk River drainage to the north. The Fort Belknap Reservation boundary is approximately 3 miles north of the Zortman mine and is approximately 1/4 mile to the nearest disturbance at the Landusky mine.[1]

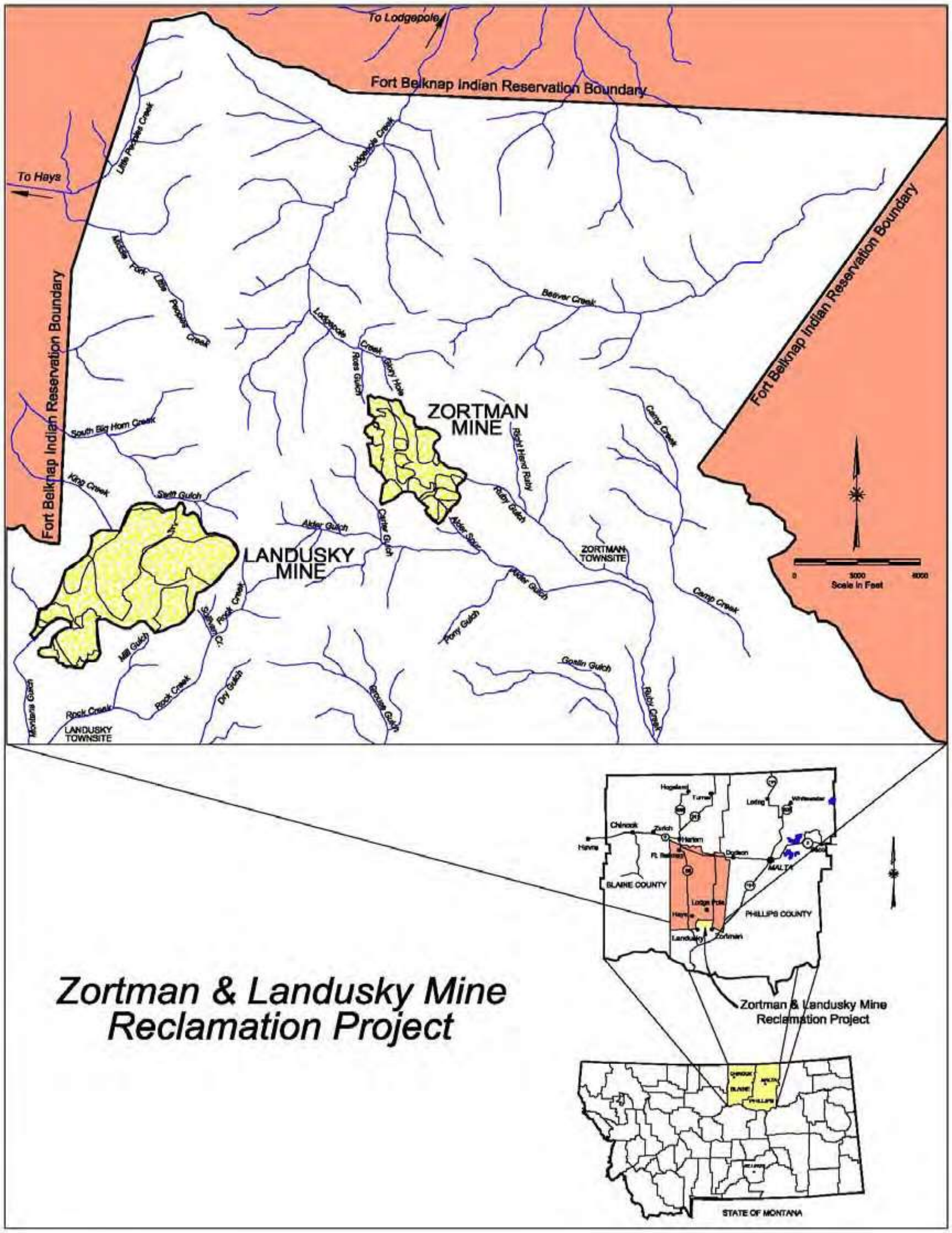
Background

The mines were granted a series of permit amendments that expanded the size of the operations until Pegasus applied for a major permit expansion in 1992, which was eventually not implemented. Discovery of significant acid rock drainage problems at both mines resulted in a need for a major revision of the existing mine reclamation plans and a review of existing bond amounts. It was determined that the proposed 1992 mine expansion would require a detailed analysis through the preparation of an environmental impact statement (EIS).

Landusky Mine, 1993. BLM Photo.

Between 1993 and 1995, litigation under the Water Quality Act was initiated in state and federal courts alleging unpermitted mine discharges to state waters. Settlement discussions resulted in the signing of a Consent Decree between Pegasus, the DEQ, the Environmental Protection Agency (EPA), a citizen's group, and the Fort Belknap Tribes effective in September 1996.[2] The Consent Decree obligated Pegasus to construct water collection systems and water treatment plants, bond for the immediate operation of the water treatment plants, and establish a trust reserve for their long-term operation and maintenance. It also provided for a penalty and required the company to perform ground water, aquatic, and health studies, implement monitoring programs, and provide improvements to drinking water systems on the reservation. The Consent Decree established temporary water quality standards and obligated the company to obtain Montana Pollution Discharge Elimination System (MPDES) permits for each discharge to state waters based on more stringent water quality standards once the water treatment plants and water discharge capture systems were in place and operational. The Consent Decree did not address surface reclamation of the mines because the decree was a settlement of alleged violations of the Water Quality Act, which did not include jurisdiction over surface reclamation requirements.

Figure 1: Map of the Zortman-Landusky Area



The BLM and the DEQ completed an EIS for the proposed mine expansion, which included a revised land reclamation plan, and the agencies issued a Record of Decision approving the expansion in October 1996. The BLM's decision to expand the mine was appealed to the federal Interior Board of Land Appeals (IBLA) by citizen groups and the Fort Belknap Tribes in late 1996. The state's decision to approve the mine expansion was challenged in state court by citizens' groups and the Fort Belknap Tribes in early 1997. The IBLA issued an order in June 1997 to stay the mine expansion approval pending further administrative review of the BLM decision. In January 1998, Pegasus and ZMI filed for bankruptcy protection before the IBLA issued a ruling, and in March 1998, the companies announced their decision to not proceed with the mine expansion but to close and reclaim the mines instead.

The agencies voided the now-moot 1996 mine expansion decision in June 1998, issued a new Record of Decision, and attempted to increase the surface reclamation bond based on the revised reclamation plan reviewed in the 1996 EIS, acknowledging at that time that the existing bonds were an estimated $8.5 million less than what was needed to implement the agencies' preferred reclamation alternative. Pegasus objected to the BLM's June 1998 selection of reclamation alternatives, which would have increased the bond amount and appealed the decision to the IBLA. The additional bonds were not provided as the bankruptcy actions moved forward.

In November 1998, the DEQ signed a settlement agreement with Pegasus' sureties, National Union Fire Insurance Company and the United States Fidelity and Guarantee Company, that made available to the state the balance of the unspent reclamation bonds and water treatment bonds required under the previously approved reclamation plan and the Consent Decree. The bond funds available to the DEQ for the Zortman and Landusky mines are as follows:

$10,024,000	Zortman reclamation bond
$19,600,000	Landusky reclamation bond
$ 2,040,970	Construction assurance - for water capture and treatment plants (bond was $10,100,000 but Pegasus had built much of the infrastructure)
$13,895,101	Water treatment bond for 20-year operation and maintenance (bond was $14,626,422 but Pegasus had paid for 1 of the 20 years prior to settlement)
$ 389,000	Exploration permit reclamation bond
$ 295,485	Open-cut mine reclamation bond for an offsite clay pit.

Additionally, the DEQ received $1,050,000 from the bankruptcy court in partial settlement of state claims filed against the assets based on an identified need for additional reclamation. The court directed that $450,000 be designated for reclamation at the Zortman site, with the balance to be used for interim site operations and maintenance at both sites until a reclamation contractor could be retained by DEQ.

In November 1998, the IBLA issued a decision on Fort Belknap's 1996 appeal of the BLM mine expansion decision, and it ordered the BLM to work with the Tribes on the selection of a reclamation alternative for the mines that considered potential impacts on tribal water resources. This action essentially vacated the decisions made under the 1996 EIS, which were based on the company's now-abandoned expansion plans. The BLM was also directed to develop additional information about ground water conditions at the mines. Since then, the BLM and the DEQ, in consultation with the Fort Belknap Tribes, the EPA, and others, produced a final Supplemental Environmental Impact Statement (SEIS), which was completed in December 2001. In May 2002, the agencies issued a new joint Record of Decision that selected reclamation alternative Z6 for the Zortman mine and reclamation alternative L4 for the Landusky mine.

However, these alternatives were dependent on the receipt of an additional $22.5 million in reclamation funds beyond what was available from the mine reclamation bonds. The record of decision also provided that the agencies would reclaim the mines under alternatives Z3 and L3, the "reserved selected alternatives", if the additional funding could not be found. These alternatives were less costly and perceived by some to be less protective than alternatives Z6 and L4. The DEQ and the BLM determined that all four alternatives would reclaim the mines in compliance with state and federal reclamation requirements while protecting human health, the environment, and tribal trust resources. With either choice, the SEIS also determined that the $14.8 million (the estimated 2017 value) trust fund provided by Pegasus under the Consent Decree for the long-term maintenance and operation of the water treatment facilities at the mines was $11 million less than what would be needed to run the plants beginning in July 2017 when the short-term water treatment bond was expended.

Following the May 2002 Record of Decision, the DEQ began reclaiming the two mine sites with reclamation bond settlement funds by performing tasks that were common to both the Z3 and Z6 alternatives at the Zortman mine site and common to both the L3 and L4 alternatives at the Landusky mine site. In June 2002, the Fort Belknap

Tribes filed an appeal of the Record of Decision with the IBLA on several grounds, including that failure to reclaim the sites in accordance with at least the selected alternatives, Z6 and L4, would violate the BLM's obligation to protect the Tribes' resources.[3] In July 2002, the Fort Belknap Tribes and three citizens' groups also filed suit in state District Court challenging the Record of Decision alleging that failure to implement alternatives Z6 and L4 would violate the Montana Constitution and the state Metal Mine Reclamation Act.[4] Both actions are currently pending. Through various cost-saving measures and the procurement of additional reclamation funds, the DEQ has been able to implement most of the components of alternatives Z6 and L4.

Impacts on Surface Water and Ground Water

HJR 43 asks the interim committee to identify the impacts on surface and ground water, including the recent degradation of Swift Gulch, attributable to past or present activities at the mine sites. A review of only a selection of the many documents prepared on this subject cannot help but lead to the conclusion that there have been impacts to both the surface water and ground water at the mine sites from both historic and more recent mining activities. However, the current, future, and long-term extent, severity, and effect of those impacts is more difficult to describe or predict with any certainty. It is clear that in the absence of continued water capture and treatment operations, there will be significant adverse impacts to surface and ground water quality, at least in the vicinity of the mines.

The 1993 and 1995 federal and state water quality complaints that resulted in the Consent Decree also resulted in a $2 million fine against Pegasus for alleged unlawful discharges to surface and ground waters. A review of agency files between 1977 and 1995 documented acid mine drainage from historic and contemporary mine workings, multiple releases of cyanide to surface and ground water from leaks, spills, overflows, and emergency cyanide solution disposals, and elevated metals in surface and ground water samples in many areas of the Zortman and Landusky mines.[5] In a recent case in which federal District Court Judge Donald Molloy declined to rule on whether the federal government broke its trust obligations to the Fort Belknap Tribes in its oversight of the mines, pending a decision by the IBLA in the Tribes' June 2002 appeal, Judge Molloy stated, without citing specifics, that "It is undisputed that the Zortman-

Landusky mines have devastated portions of the Little Rockies, and will have effects on the surrounding area, including the Fort Belknap Reservation for generations. That devastation, and the resulting impact on tribal culture cannot be overstated."[6] The BLM does dispute this statement and claims that, in litigation thus far, the Tribes have not shown any damage to their trust resources from the mines for which the BLM is at fault.[7] The Tribes dispute the BLM's conclusion.

In January 2004, the Tribes filed a federal Clean Water Act complaint in federal District Court in Missoula against the DEQ, the BLM, and Mr. Luke Ployhar who recently purchased 71 private mining claims totaling 1,080 acres from the Pegasus bankruptcy trustee and who now owns much of the mine property. The complaint alleges that the defendants discharged pollutants in excess of water quality standards and that they failed to obtain or issue state or federal water quality discharge permits as required by law.[8] The suit and its exhibits cite numerous instances in which watersheds have been contaminated by acid mine drainage and provide selected sampling data that allege violations of certain water quality standards for nitrates, cyanide, selenium, manganese, copper, and iron.

In response to another pending lawsuit, the DEQ admits that acid mine drainage, cyanide, selenium, and nitrates impact surface and ground waters that are hydrologically connected to the mines and that the impacts from acid mine drainage will continue in the long term.[9] The agency also claims that it is capturing and treating all waters that are hydrologically connected to the mines. However, the Fort Belknap tribal community, through comments and litigation, has repeatedly expressed its concern about the mines' impact on the water quality of the reservation.

Studies of reservation domestic water supplies prepared by the federal Agency for Toxic Substances and Disease Registry (ATSDR) in 1998 concluded that based on a review of available data, there was no apparent public health hazard to the residents of the Fort Belknap Reservation from mine activities.[10] The study found no evidence that people on the reservation were exposed to dangerous levels of contaminants in sediments, surface water, or ground water. Hydrologic studies conducted in 1983 and 1993 found that natural water quality on the reservation away from the mountains was naturally variable and often poor, but none of the studies cited mine activities as contributing to poor quality of the aquifers.[11] Further, at the request of the Tribes, the EPA conducted a sampling study of domestic water supplies and streams on the reservation in June 2000 and found no evidence of impacts to water resources from the mines. No cyanide was detected in any of the wells sampled on the reservation. Water quality in the reservation wells closest to the mines showed no exceedences of drinking water standards.[12] There are a number of public water supplies owned and operated by the Tribe in the Hays and Lodgepole area. Hays is downstream from the Landusky mine, and Lodgepole is downstream from the Zortman mine. The EPA is not aware of any violations of chemical standards in any of these community water supplies based on periodically required reporting requirements.[13]

The DEQ has stated that there have been no exceedences of water quality standards on the Fort Belknap Reservation,[14] but sampling data from DEQ's contractors show exceedences in water quality standards for iron, and sometimes arsenic, nickel, and zinc, in surface water upstream from the reservation boundary.[15]

Some conflicting information regarding water quality violations exists because there is a dispute over which water quality standards apply. The 1996 Consent Decree provided for temporary technology-based water quality standards that Pegasus was required to meet pending the completion of the ground water and surface water collection systems and the construction of the water treatment plants at Zortman and Landusky. Following construction of the systems, DEQ intended to issue Montana Pollution Discharge Elimination System (MPDES) permits to Pegasus that would have included more stringent effluent standards. Pegasus constructed the water collection and treatment systems, but the 1998 bankruptcy eliminated the existence of Pegasus as a MPDES permit applicant. Since then, the DEQ has been maintaining and operating the water collection and treatment systems under the Consent Decree standards. This is one of the complaints being argued in the Tribes' Clean Water Act lawsuit.

Some conflicting information regarding water quality violations exists because there is a dispute over which water quality standards apply.

In June 2004, the BLM prepared and signed an Action Memorandum stating that it considers the mines to be abandoned following the completion of the Pegasus bankruptcy and that it intends to use its authority under the federal Superfund Program (CERCLA) as a federal land management agency to maintain the mine water capture and treatment systems. A CERCLA designation negates the need for a National Pollution Discharge Elimination System (NPDES) or MPDES permit to be issued for mine discharges. CERCLA still obligates the agency and the DEQ to attain applicable or relevant and appropriate requirements (ARARS) of federal and state laws, including water quality requirements, to the extent practicable.

Swift Gulch

Chapter 3 of the final 2001 SEIS described the condition of surface and ground water near the mines in detail on a drainage-by-drainage basis. Swift Gulch is a tributary of the South Fork of Bighorn Creek, which crosses the reservation boundary and becomes a tributary of Little Peoples Creek, which flows through the town of Hays. Swift Gulch is in a canyon approximately 700 feet below and 500 feet north of the northern edge of the Landusky mine pit (**Figure 2**). Stream distance between the Landusky mine and the Fort Belknap Reservation boundary is approximately 6,000 feet. Swift Gulch flows during the spring runoff, but at other times it is intermittent, surfacing and submerging along its length until it is joined by the North Fork of Bighorn Creek, a perennial stream. The SEIS describes concerns about the water quality of Swift Gulch from ground water seeps that enter the stream between the Landusky mine pit and the stream. There was some indication in 2001 that the water was acidic and had elevated levels of sulfates and metals. Red orange iron precipitates coat a portion of the stream bottom. The water quality in the headwaters of Swift Gulch near the mine has been deteriorating since about 1999.[16] The water has become more acidic, decreasing from about pH 7.5 to pH 3.7 according to tribal officials, and it is high in iron. The iron precipitate discoloration appears to be moving downstream towards the reservation boundary and is now visible near the confluence of Swift Gulch and the South Fork of Bighorn Creek.[17]


Swift Gulch, 2004. Dean Stiffarm Photo.

The specific causes or sources of this degradation have not yet been conclusively identified. The seeps in Swift Gulch are not being captured or treated at this time. According to some sources, there is some evidence that the seeps may be hydraulically connected to the mine operations.[18] The quality of water coming out of the seeps has become worse since the Landusky mine pit was developed. Also, the mine pit intercepts a sheer zone or fault fracture area that generally runs southwest to northeast beneath the northern portion of the Landusky pit complex nearest Swift

Gulch. There is also some geologic evidence of historic iron staining in the canyon, so there may be a natural component to the some of the contamination.[19] The water quality situation in Swift Gulch is acknowledged by the agencies to be an issue that requires further study and analysis.

Swift Gulch Drainage, 2001. BLM Photo.

Pegasus partially backfilled the north end of the Landusky pit in 1995-1996 with rock that produced low pH acid. In 2002, the DEQ attempted to further isolate the area with additional nonacid-producing rock backfill, which was then covered with an impermeable barrier in an effort to limit the infiltration of precipitation to the area, including infiltration through the sheer zone. It was not anticipated that this effort would produce any immediate positive results if, in fact, this was the source of the contaminated water that was appearing in the seeps along the upper reaches of Swift Gulch. To date, the situation has not improved. There are several monitoring sites along Swift Gulch and the South Fork of Bighorn Creek that are monitored routinely. Although Swift Gulch is clearly impacted, as yet there have been no exceedences of the Consent Decree or draft MPDES water quality limits at the reservation boundary monitoring site designated as L-48.[20]

Impacts to the Milk and Missouri River Drainages

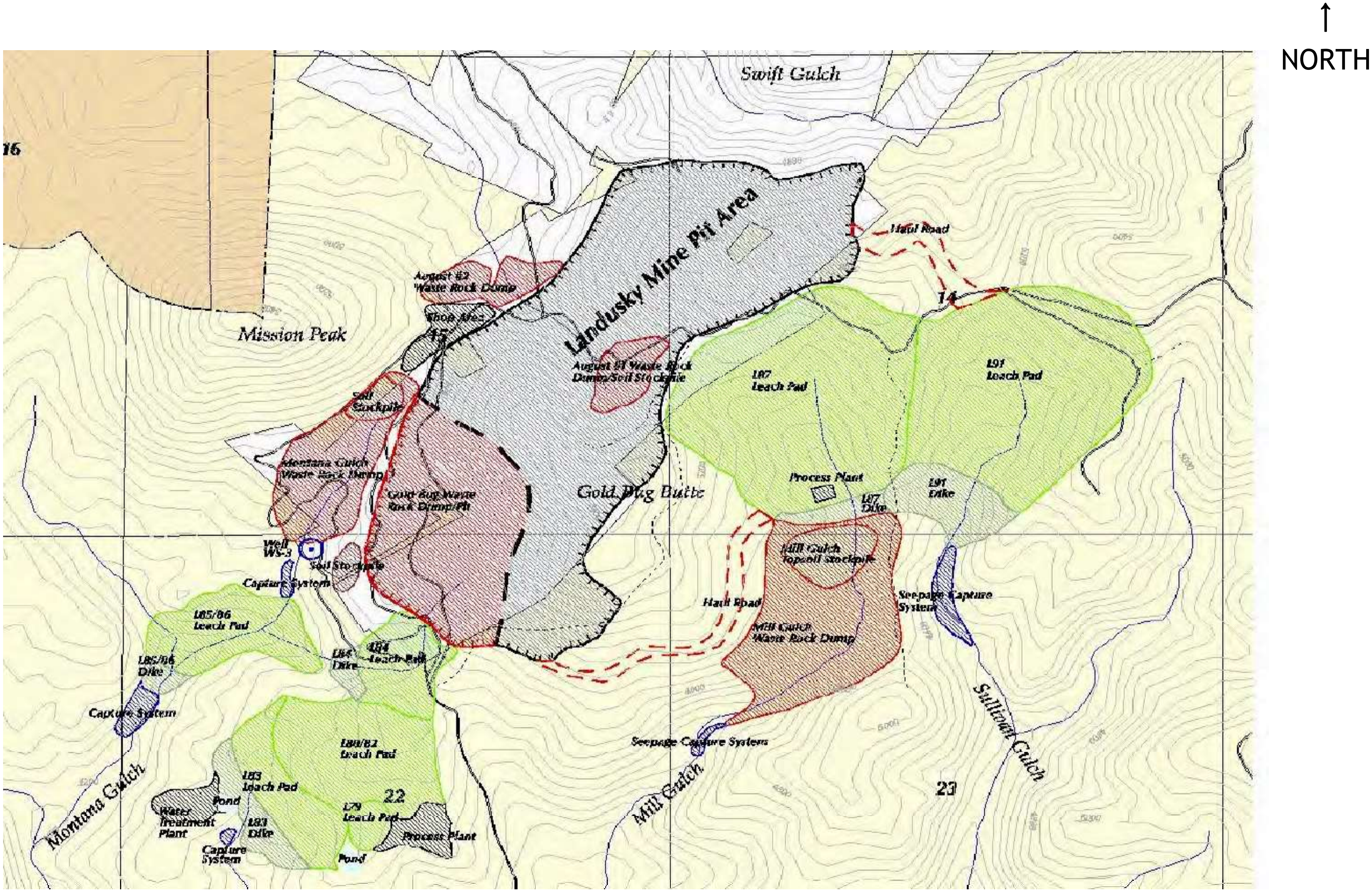
The Landusky mine is the headwaters area for King Creek and Swift Gulch, which drain to the northwest through the Fort Belknap Reservation as tributaries to Little Peoples Creek and on to the Milk River. The Landusky mine is also the headwaters area for Montana Gulch, Mill Gulch, and Sullivan Gulch--tributaries of Rock Creek, which flows south to the Missouri River. All of these streams are intermittent near the mine site. Perennial segments of Rock Creek and Little Peoples Creek several miles downstream of the mine support small brook trout populations.

The Zortman mine is a headwaters area for Lodgepole Creek, which drains north through the Fort Belknap Reservation and on to the Milk River, and for Ruby Gulch and Alder Gulch, which drain south to the Missouri River **(Figure 3)**. Lodgepole Creek is intermittent near the mine, but it flows perennially in its lower reaches and supports a brook trout population several miles north of the Zortman mine. Ruby Gulch and Alder Gulch are intermittent streams, but they may have significant flows following storm events or during spring runoff.[21]

The Milk River is an estimated 30-35 air miles from the Zortman and Landusky mines and further by stream miles along Little Peoples Creek and Lodgepole Creek. The Missouri River is an estimated 20-25 air miles from the mines and further by stream miles along Rock Creek and Ruby Gulch. The agencies have not developed any sampling data on the Missouri or Milk Rivers in the vicinity of the mines to indicate whether they have been impacted by the mining activity at Zortman and Landusky. The DEQ, the BLM, and their consultants consider both rivers to be far beyond the area that is potentially influenced by the mines, and according to the BLM, monitoring data does not show contamination that extends beyond the Little Rocky Mountains landform.[22]

The agencies have been following a sampling and monitoring plan in the Consent Decree. A more recent long-term water monitoring program was developed in 2002 by technical specialists from the agencies, the EPA, and the Tribes in anticipation of the issuance of MPDES permits, but that plan has not been implemented nor have the permits been issued.[23] Water monitoring is concentrated in the immediate area of the mines in areas most likely to be impacted. There are a few sampling stations approximately 2 miles from the mines, but they are no longer used.

Figure 2: Landusky Mine. Facilities and Land Status Map



Source: BLM Action Memorandum, June 2004

The current ground water monitoring plan involves sampling about 44 wells twice each year. Water quality trends in most wells are reportedly stable, and the ground water chemistry meets drinking water standards with some exceptions. Water samples from a few wells that are located between mine waste facilities and the water collection and treatment systems sometime exceed standards. Others that were drilled into unmined mineralized rock show results that exceed drinking water standards for arsenic with no evidence of any influence from mining activity. Also, deep monitoring wells located between the north edge of the Landusky pit and Swift Gulch have shown deteriorating water chemistry for the past few years.[24] The surface and ground water monitoring program costs approximately $60,000 per year, and it is deemed adequate for current needs.

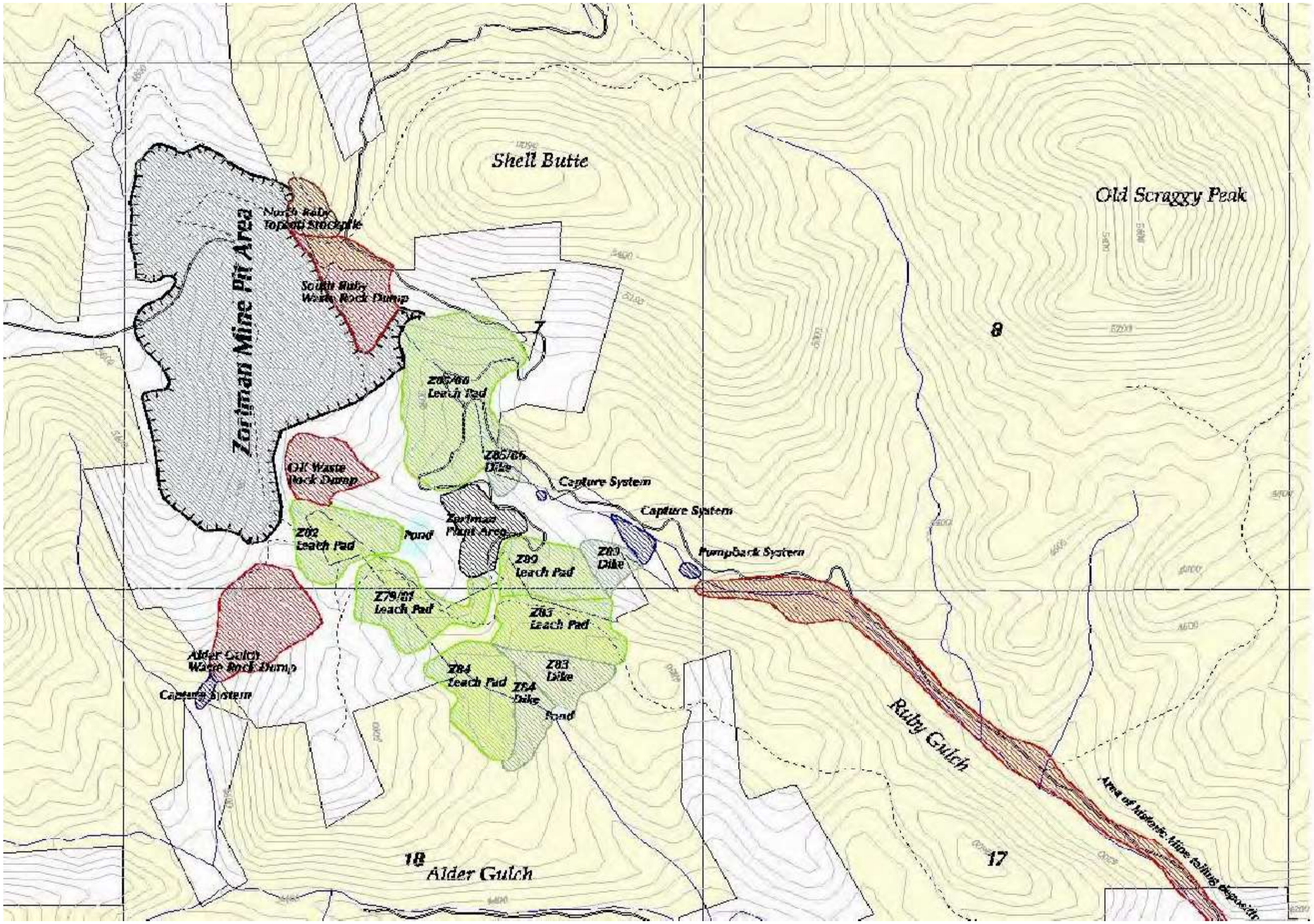
The current ground water monitoring plan involves sampling about 44 wells twice each year.

The SEIS concluded that the surface and ground water in Lodgepole Creek is not impacted by mining activities. Very little mining occurred at the Zortman mine in the headwaters of Lodgepole Creek. Water quality monitoring on Lodgepole Creek at the reservation boundary shows no change in water chemistry during mine operations. Alder and Ruby Gulch join near the town of Zortman, and Ruby Gulch typically infiltrates into the ground near there. Mine-impacted water near the mine site upstream from the town is captured at several locations and treated at the Zortman water treatment plant.

On the north side of the Landusky mine, there are no water capture and treatment facilities for King Creek and Swift Gulch. Swift Gulch wasn't identified as a problem when the Consent Decree was signed in 1996. As noted, there are contaminated seeps entering Swift Gulch from an as yet unidentified source and the water quality in Swift Gulch appears to be getting worse with time according to the DEQ. Pegasus was required to construct a water collection and passive treatment facility for King Creek but failed to complete the project prior to bankruptcy. In 2000, the EPA removed 78,000 cubic yards of tailings left from historic mining activities in King Creek. In 2002 and 2003, the DEQ's contractors removed the waste rock dump from the head of the King Creek drainage. The water in the headwaters of King Creek has been impacted by mining. Although the water is not acidic, nitrate and selenium levels exceed some standards.[25] The DEQ does not anticipate King Creek to be a serious future problem, but sampling is continuing.

Figure 3: Zortman Mine. Facilities and Land Status Map

↑
NORTH



Source: BLM Action Memorandum, June 2004

The intermittent streams that drain from the south side of the Landusky mine all have surface and ground water capture facilities that route water through the Landusky water treatment plant. Water monitoring below these capture facilities indicates that the water quality in Mill Gulch, Sullivan Gulch, Montana Gulch, and Rock Creek meets the Consent Decree standards as well as the draft MPDES permit standards.[26]

Much of the water at the mines is high in sulfates. There are no standards for sulfate in the Consent Decree or in the draft MPDES permits. A DEQ compliance report for violations of the Consent Decree standards at the Zortman and Landusky mines between May 2003 and May 2004 lists only five exceedences (**Table 1**).

Table 1: Exceedences of Consent Decree Standards - May 2003 to May 2004

LOCATION	PARAMETER	STANDARD	SAMPLE/DATE
Zortman water treatment plant	Total suspended solids	daily maximum level = 30 ppm	35.4 ppm / 7-31-03
Ruby Gulch pond underdrain	Copper	30-day average = 0.15ppm	0.442 ppm / 9-30-03
same	pH	range = 6.0 - 9.0	5.12 / 9-30-03
same	Zinc	30-day average = 0.75ppm	1.17 ppm / 9-30-03
Landusky - lower Montana Gulch pond overflow	Total suspended solids	daily maximum level = 30 ppm	34 ppm / 1-31-04

Source: Tom Reid, DEQ Water Protection Bureau, 7-1-04

Current Reclamation Efforts and Water Quality Status

With the exception of Swift Gulch, the DEQ believes that the surface and ground water resources in the area are being protected by the current and proposed mine reclamation and water treatment efforts. The purpose of the mine reclamation is spelled out in the SEIS and in the Record of Decision. Essentially, the reclamation of the mines has two primary components, both intended to address the protection of surface and ground water quality. The first is the physical reclamation of the mine pits, roads, waste rock dumps, and leach pads. This effort is designed to improve the long-term stability of mine excavation features, isolate and cover acid-producing materials, provide for proper drainage, reduce infiltration by precipitation and runoff, reestablish vegetation, and improve aesthetics. The second effort is to capture and treat surface and shallow ground water and leach pad drainage until contaminants can be reduced to acceptable levels. The magnitude and duration of the water treatment effort is largely dependent on the success of the land reclamation effort. But in no case short of the physical encapsulation of the mine facilities will the need for long-term water treatment be unnecessary.

The mine operations, particularly the larger and deeper Landusky mine, exposed sulfide rock that produces acid rock drainage when it is exposed to air and water. This acid rock drainage, or ARD, in the presence of the exposed surfaces of mineralized rocks, can mobilize metals in the rock and contaminate surface and ground water. The reclamation plans focus on identifying the sources of acid-generating materials and isolating them from surface and ground water infiltration to control the source of contaminated water and reduce the amount that needs to be treated.

Before the 1998 bankruptcy and in partial fulfillment of the requirements of the Consent Decree, Pegasus was required to capture all surface and shallow ground water at each discharge and construct a water treatment plant at each mine. Buried capture systems collect water from beneath the leach pads and below the waste rock dumps before it flows offsite and routes it to either the water treatment plant at the Zortman mine or the one at Landusky. These plants use lime to treat the acidity and precipitate metals out of the water collected by the capture systems. Since 1999, these plants have captured and treated over a billion gallons of mine drainage.[27]

The Zortman water treatment plant treats between 45 and 86 million gallons of water per year. The treated water from the Zortman plant meets the Consent Decree limits and would meet most of the draft MPDES limits most of the time **(Table 2)**. Treated water is returned to Ruby Gulch.

Table 2: Zortman Water Treatment Plant - Typical Chemistry*

Parameter	Water In	Water Out	**% Removal**	Consent Decree limit (daily max)	**Possible MPDES limits**	Water Quality Standard**
pH	**3.5** 3.5	**7.5** 7.5	---	6.0-9.0	**6.5-9.0**	6.5-8.5
TSS (total suspended solids)	20	25		30		20
arsenic	**0.015** 0.080	**<0.003** <0.003	**>80%**	NA	**0.018**	0.018
cyanide (total)	0.015	0.010		<0.005		0.0052
cadmium	**0.2** 0.2	**0.004** 0.005	**98%**	0.10	**0.005**	0.005
copper	3.50	0.015		0.30		0.031
iron	**35** 40	**0.2** 0.5	**99.7%**	NA	**1.0**	1.0
lead	**0.005** 0.005	**<0.003** <0.003	**50%**	0.60	**0.015**	0.015
manganese	**30** 35	**3** 3.5	**90%**	NA	**----**	0.05
mercury	ND	ND		0.002		0.00005
selenium	0.015	0.010		NA		0.005
sulfate	**3000** 3000	**2400** 2600	**20%**	NA	**---**	250
zinc	5.0	0.05		1.50		0.388

* in mg\L or parts per million (ppm): **bold source: Jepson, DEQ - EQC testimony**; other source: BLM Action Memorandum

** These include primary and secondary standards from a variety of sources and are presented only to assist in characterizing the potential for contaminants in a release.

The Landusky water treatment plant treats between 195 and 274 million gallons of water per year. The treated water from the Landusky plant achieves the Consent Decree standards and would likely meet most draft MPDES limits **(Table 3)**. Treated water is discharged to Montana Gulch.

Table 3: Landusky Water Treatment Plant -Typical Chemistry*

Parameter	Water In	Water Out	**% Removal**	Consent Decree limit (daily max)	**Possible MPDES limits**	Water Quality Standard**
pH	**6.0** 6.0	**7.5** 7.5	**---**	6.0-9.0	**6.5-9.0**	6.5-8.5
TSS (total suspended solids)	20	7		30		20
arsenic	**0.150** 0.15	**0.025** <0.025	**83%**	NA	**0.018**	0.018
cyanide (total)	0.05	ND		<0.005		0.0052
cadmium	**0.010** 0.015	**0.001** 0.004	**90%**	0.10	**0.005**	0.005
copper	0.03	0.005		0.30		0.031
iron	**10** 10	**0.3** 0.3	**97%**	NA	**1.0**	1.0
lead	**0.004** 0.004	**<0.003** <0.003	**>50%**	0.60	**0.015**	0.015
manganese	**3.0** 4.0	**1.5** 3.0	**50%**	NA	**---**	0.05
mercury	ND	ND		0.002		0.00005
selenium	0.005	0.005		NA		0.005
sulfate	**600** 650	**500** 900	**17%**	NA	**--**	250
zinc	0.80	0.05		1.50		0.388

* in mg/L or parts per million (ppm): **bold source: Jepson, DEQ - EQC testimony**; other source: BLM Action Memorandum
** These include primary and secondary standards from a variety of sources and are presented only to assist in characterizing the potential for contaminants in a release.

However, the lime precipitation water treatment plants are not effective in treating the cyanide, nitrate, and selenium from the leach pad process solution. An estimated 129 million gallons of residual cyanide process solution is stored above the leach pads within the leach pad circuits, with additional accumulations expected in the future from water infiltration. In 2001, the agencies built a bioreactor water treatment system on the Landusky mine site with remaining construction bonds from Pegasus' surety to treat the heap leach solutions that drain from the leach pads at the mine. Because the ore placed on the heap leach pads was treated with alkaline materials to enhance the gold recovery process, the heap leach solutions are not yet acidic, but they are generally too high in selenium, nitrates, and cyanide to meet stream discharge limits **(Table 4)**. The treated Landusky heap leach water from the bioreactor is discharged to a land application area on Goslin Flats below the town of Zortman, where it is sprinkler-irrigated. Prior to reclamation, approximately 80 million gallons of precipitation was collected in the Landusky leach pads and required treatment each year. DEQ is hopeful that land reclamation efforts will reduce this to 15-30 million gallons per year.


Landusky Bioreactor, 2004. BLM Photo.

The leach pad water from the Zortman mine is also collected and piped to the land application area on Goslin Flats. Prior to reclamation of the leach pads at Zortman, the pads drained approximately 30 million gallons of water per year. DEQ believes that the reclamation and revegetation of the leach pads may eventually reduce this flow to about 5-10 million gallons per year. This may make other disposal options available instead of using the land application area.[28]

Table 4: Bioreactor Chemistry for Leach Pad Process Water*

Parameter	Typical Heap Leach influent	Typical effluent to Land Applic or water treatment plant	Water Quality Standard**
pH	6.8	7.2	6.5 - 8.5
arsenic	0.010	0.002	0.018
cyanide(total)	0.37	0.29	0.0052
cadmium	0.75	0.03	0.005
copper	0.100	0.01	0.031
lead	0.002	ND	0.015
nitrates	82	1.0	10.0
selenium	0.47	0.06	0.005
zinc	2.00	0.75	0.388

* in mg/L or parts per million (ppm): Source; BLM Action Memorandum
**These include primary and secondary standards from a variety of sources and are presented only to assist in characterizing the potential for contaminants in a release.

The DEQ and its federal partner, the BLM, have been reclaiming the mines using bonds from the settlement agreement with Pegasus' sureties. The preferred alternative in the SEIS for the reclamation of the Zortman mine was option Z6, and the preferred alternative for the reclamation of the Landusky mine was option L4. As stated previously, these options were estimated to cost $22.5 million more that what the agencies had available from the sureties; $5 million more for Zortman and $17.5 million more for Landusky. Alternatives Z3 and L3 were reclamation choices that the agencies believed would also comply with the applicable laws and that could be accomplished with the available bond funds. These alternatives are perceived by the Tribes and others to be less protective of the environment than the preferred alternatives. The SEIS provides detailed descriptions and comparisons between each alternative. There is litigation pending in the courts to require the agencies to implement alternatives Z6 and L4.

The agencies, through competitive bidding and significant cooperation from Spectrum Engineering and its subcontractors and with the infusion of over $5 million in federal funds from the BLM, have been able to reduce costs and implement most of the reclamation projects in alternatives Z6 and L4. By June 2004, the BLM estimated that the $22.5 million reclamation shortfall had been reduced to about $1.53 million.[29] Reclamation at Zortman is complete under the Z6 alternative with the exception of relocating the top portion of the Alder waste rock dump to the North Alabama pit and covering and revegetating both areas. Reclamation at Landusky is complete under the L4 alternative with the exception of partially backfilling portions of the pit with the 85-86 leach pad, which is currently being removed from the headwaters of Montana Gulch, and the completion of some ongoing contracts. As of August 2004, the DEQ and its contractors determined that there were sufficient funds available to complete the L4 reclamation alternative for Landusky by the end of 2005, but that the agencies were still $1.423 million short in the amount of funds necessary to complete the Z6 alternative at the Zortman mine.[30]

Future Needs - Reclamation and Water Quality

Reclamation

Through March 2004, the DEQ had spent approximately $37,281,163 to reclaim the Zortman and Landusky mines including $33,666,658 in bond settlement funds, $2,017,905 in federal dollars, and $1,596,600 in state funds.[31] The agency's efforts at source control through mine reclamation appear to be nearing completion with the reclamation of the mines in accordance with the preferred alternatives Z6 and L4 despite the initial shortage of bond money.

The agencies determined they are short $1.423 million in the amount of funds necessary to complete the Z6 alternative at the Zortman Mine.

Recently, the BLM was able to obtain an additional $1.2 million through its abandoned mine program to complete the L4 alternative and remove and reclaim the Landusky 85-86 heap leach pad and use the material to help backfill and further isolate materials in the Landusky pit.[32] This leaves the reclamation project short by the $1.423 million for completion of the Z6 alternative at Zortman. The DEQ has submitted an application to the Department of Natural Resources and Conservation (DNRC) for a $300,000 Reclamation and Development Grant (RDG) to help cover some of those costs. Grant applications are ranked by the DNRC, and the priority projects will be recommended to the 2005 Legislature for approval and funding in House Bill 7. The revenue is generated from interest on the Resource Indemnity Trust Fund.


Landusky Water Treatment Plant, 2004. BLM Photo.

One major reclamation problem exists. The BLM, DEQ, and the Tribes are concerned about the seeps on the north side of the Landusky mine pit that are degrading Swift Gulch. The contamination is obvious, but the cause is not certain. Addressing this problem may be difficult and costly, given the dispersed nature of the seeps, the difficulty in identifying their source, and the uncertainties in trying to control ground water movement. Reclamation efforts intended to control what was assumed to be the source of the water have not produced the desired results so far. The BLM is currently conducting a $60,000 study of the problem in Swift Gulch.[33] The DEQ has also applied to the DNRC for a $300,000 RDG to investigate the hydrology of the area in an attempt to identify the source of the problem and craft a possible solution. Depending on the solution, additional reclamation funds or water treatment funds may be necessary in the future.

The DEQ also has some remaining funds from the Pegasus bonds that are earmarked for the construction of a water treatment system in the headwaters of King Creek if the source controls and waste rock removals that were implemented prove to be inadequate and if further water treatment is determined to be necessary.

Water Treatment

The BLM's June 2004 Action Memorandum describes threats to the public health and welfare and the environment that could result if operation of the water capture and treatment systems is not continued at the mines. If the systems fail or cease operation, the BLM maintains that "the release of hazardous substances would increase greatly without the benefit of treatment, creating significant environmental damage. This includes the release of solutions containing metals such as arsenic, cadmium, copper, selenium, and zinc; plus cyanide complexes, nitrates, and solutions having low pH (acidic) levels".[34] The document warns that drinking water supplies or sensitive ecosystems could be contaminated and that human and animal populations could be exposed to the toxic effects of these substances.

The major problem and most critical financial need at the Zortman and Landusky mines is the fact that there are insufficient funds to maintain the water treatment systems. Pegasus provided two sources of funding for the operation and maintenance of the water treatment plants. Both are considered to be insufficient.

The first is the $14,626,422 short-term (20-year) water treatment bond that was intended to pay for the maintenance and operation of the Zortman and Landusky water treatment plants from June 30, 1997, until June 30, 2017. One-twentieth of this bond or $731,321 is provided to DEQ by the surety each year. Since Pegasus operated the plants during 1997, the actual bond funds provided to DEQ will total $13,895,101. Actual costs to operate and maintain the water treatment plants are shown below.[35]

Year	Cost	Bond	Shortage
1999	~$1,200,000	$731,321	(~$468,700)
2000	$843,387	$731,321	($112,066)
2001	$879,727	$731,321	($148,406)
2002	$905,899	$731,321	($174,578)
2003	$758,267	$731,321	($ 26,936)
2004 (½ year)	$424,143	$365,660	($ 58,483)

The BLM has provided $500,000 to cover the shortfall for the past few years, but those funds are nearly expended. An August 2004 memorandum of agreement (MOU) between the DEQ and the BLM that was prepared in conjunction with the BLM's June Action Memorandum lists the obligations of both parties to maintain the water capture and treatment facilities at the mines. One provision of the agreement states that the "BLM will provide supplemental funding to DEQ, to the extent allowed in BLM's budgeting process, in order to maintain operation of the water treatment plants after the annual surety payment has been expended". Either party may terminate the MOU following a 60-day notice. The additional BLM funds are subject to congressional funding of BLM's budget. Still, this is an encouraging indication of BLM's willingness to provide continuing financial assistance for short-term water treatment.

In the absence of any additional funding, the DEQ's contractor currently estimates that there will be a $12.1 million shortage in what will be needed over the next 13 years to cover the costs of operating and maintaining the water treatment plants. This translates to a net present value of approximately $7.45 million if the funds were made available by January 2005 and invested at interest.[36] Meanwhile, the DEQ has applied to the DNRC for a third $300,000 RDG to help cover the shortages of operating the water plants for approximately 3 years.

The DEQ's contractor projects that it will cost $1.8 million to operate and maintain the water treatment plants in the year 2017 given current operating costs. The costs of operating the plants could increase or decrease over time, depending on the amount of water that requires treatment based on precipitation and the success of reclamation efforts and the inflationary costs of operation, repair, and maintenance. Added to the cost of water treatment is the maintenance and operation of the bioreactor water treatment process, which was not anticipated in the Consent Decree and not bonded for by Pegasus.

Perhaps more important in terms of budget shortfalls is the bond that is available for long-term water treatment after June 30, 2017. Pegasus was required to establish a trust fund that would pay for long-term water treatment defined in the SEIS until the year 2080. The difficulty of predicting needs, technology, and financing that far into the future or beyond are described in detail in the SEIS. A bond package of zero coupon bonds was purchased by Pegasus and by the DEQ following the Pegasus bankruptcy to provide a long-term trust reserve estimated to be worth approximately $14.8 million by the year 2017. The DEQ and its consultants have calculated that given the current costs of operating the water treatment plants, the $14.8 million is about $11.1 million dollars short of what may be needed to pay for long-term water treatment if the funds were made available by January 2005 and invested at 6%

interest. The SEIS also predicted that the trust reserve was $11 million less than what was needed to be invested in 2001 in order to fund long-term water treatment after 2017.

A simple annuity calculation shows that a trust reserve valued in 2017 at $14.8 million earning a 5% return would provide approximately $800,000 for 43 years or until the year 2060. Of course the annual costs are not likely to remain at $800,000 and there are no extra funds to pay for replacing the water treatment plants using whatever technology may be available or necessary at the time.

The 2003 Legislature in HB 2 authorized the sale of hard-rock mining reclamation bonds, backed by metaliferrous mine tax revenue, up to the amount of $2.5 million provided that Congress appropriates at least $10 million during the current biennium for the purpose of providing a total of $12.5 million to fund the long-term water treatment trust reserve for Zortman and Landusky. The federal Department of Interior and Related Agencies appropriations bill (S. 1391) for 2004 included a request for funds, but it was not accepted. In rejecting the request, the Committee on Appropriations stated that "the Committee understands a proposal is being prepared for FY 2005 to address the plan set forth in the Record of Decision for Reclamation. The Committee continues to believe protecting water quality in the region should be a top priority for the BLM budget request". There have been no federal appropriations to date.

Summary

A few specific water quality problems that originated with historic mining at Zortman and Landusky are better now than they were before the Pegasus mines began operating according to the DEQ.[37] The historic discharges from several old mine adits have been captured and are now being processed through water treatment plants that were built at the insistence of the agencies. Since the Pegasus bankruptcy, reclamation efforts funded by the DEQ, BLM, and EPA have removed the historic tailings in Ruby Gulch and the tailings dams and sediments in King Creek. Waste rock dump water discharges are now being captured and routed through one of the water treatment plants. The poor quality waters still draining from the leach pads are being captured and treated with some success. However, the scale of the disturbance from the Pegasus operations and the acid-producing rock at the mines have created reclamation and water treatment challenges that will continue for many years.

Much effort, research, and funding has been applied to these mines in an effort to produce and implement an environmentally sound reclamation plan in the absence of a mine operator. That task may not be complete given the continuing challenges involving discharge permits, water quality violations, diversions of water, and other issues that have been raised in pending litigation. There is no disagreement that conditions in Swift Gulch on the north side of the Landusky mine pit merit additional research and attention. With land reclamation efforts nearing completion, emphasis may need to be focused on implementing the surface and ground water monitoring plan in an effort to determine how successful the reclamation efforts have been. There will be a time lag between the completion of reclamation, the establishment of vegetation, and any noticeable changes in water quantity and quality at the mine site. There may be a need for additional reengineering and design. There may be a need for additional source isolation and reclamation. With the Pegasus bankruptcy proceedings now complete and with the imminent expenditure of the last of the reclamation bonds, any additional land reclamation funds must come from other sources. Meanwhile, water capture and treatment will be required at these mines for the indefinite future. Unless costs can be reduced, there are immediate and future needs for adequately funding these water treatment efforts.

There is no disagreement that conditions in Swift Gulch on the north side of the Landusky mine pit merit additional research and attention.

Endnotes

1. Record of Decision for Reclamation of the Zortman and Landusky Mines, Bureau of Land Management and Montana Department of Environmental Quality, May 2002 (ROD, 2002).

2. United States of America and State of Montana v. Pegasus Gold Corporation and Zortman Mining, Inc., Civil Action No. 95-95-BLG-JDS, and Gros Ventre Tribe, Assiniboine Tribe, Fort Belknap Community Council, and Island Mountain Protectors Association v. Pegasus Gold, Inc., Pegasus Gold Corporation, and Zortman Mining, Inc., Civil Action No. 95-96-BLG-JDS, Consolidated Consent Decree, (Consent Decree).

3. Assiniboine and Gros Ventre Tribes and Fort Belknap Community Council v. Bureau of Land Management, Before the United States Dept. of Interior Office of Hearings and Appeals Board of Land Appeals, BLM Nos. MTM 77778-77779, MT-0670-05-1990-01, June 27, 2002.

4. Assiniboine and Gros Ventre Tribes and Fort Belknap Indian Community Council, Montana Environmental Information Center, Mineral Policy Center, National Wildlife Federation v. Montana Department of Environmental Quality, Kelvin Buchanan in His Capacity as Bankruptcy Trustee for Zortman Mining, Inc., and Pegasus Gold Corporation, Montana First Judicial District Court, Cause No. ADV-2002-473, July 2002.

5. Impacts to Surface and Ground Water From Ten Montana Metal Mines, pp. 32-40, Stuart Levit, Public Education for Water Quality Project, August 1996.

6. Gros Ventre Tribe, Assiniboine Tribe, and the Fort Belknap Indian Community Council v. United States of America; Bureau of Land Management, et al., Order, p. 12, CV 00-69-M-DWM, June 28, 2004.

7. Scott Haight, BLM, Lewistown Area Office, report comments, August 16, 2004.

8. Assiniboine and Gros Ventre Tribes v. Luke Ployhar, Owner of Zortman and Landusky Mines; Jan P. Sensibaugh, Director of MDEQ; and Kathleen Clarke, Director of US BLM, Civil No. CV 04-17-M-DWM, January 28, 2004.

9. See endnote 4, Department of Environmental Quality's answer to complaint, p. 4.

10. Agency for Toxic Substances and Disease Registry (ATSDR), May 14, 1999. Petitioned Public Health Assessment for Kings Creek (a.k.a. Fort Belknap Indian Reservation/Zortman Mining Incorporated).

11. Final Supplemental Environmental Impact Statement for the Zortman and Landusky Mines; BLM and DEQ; December 2001, pp. 3-102, 6-71 (SEIS, 2001).

12. SEIS, 2001 p. 6-72.

13. Phone log, Jay Sinnott, EPA Water Program, Helena office, June 30, 2004.

14. Phone log, Jan Sensibaugh, DEQ Director, July 6, 2004.

15. Quarterly water quality monitoring reports for the Zortman and Landusky mine sites, Spectrum Engineering, 2004.

16. Wayne Jepson, DEQ, e-mail correspondence, June 23, 2004

17. Dean Stiffarm, Fort Belknap Environmental Office, phone log, July 9, 2004.

18. Andy Huff, Indian Law Resource Center, report comments, p. 4, August 19, 2004, and David Chambers, Second Supplemental Declaration of David Chambers, Cause No. CV 00-69-M-DWM, p. 3.

19. Supplemental Declaration of Scott Haight, BLM, Cause No. CV 00-69-M-DWM, p. 5.

20. Deposition of Wayne Jepson, DEQ, Cause No. CV 00-69-M-DWM, p. 59.

21. Action Memorandum for Zortman and Landusky Mines; Time Critical Removal, BLM, June 2004, pp. 5-6.

22. Scott Haight, report comments, e-mail, September 14, 2002.

23. Zortman and Landusky Mines Ground Water and Surface Water Monitoring Plan, April 2002, Interagency Technical Working Group.

24. Wayne Jepson, DEQ, e-mail correspondence, July 2, 2004.

25. Wayne Jepson, testimony before the EQC, October 9, 2003.

26. Deposition of Wayne Jepson, pp. 76-80.

27. Action Memorandum, pp. 4-5.

28. Wayne Jepson, DEQ, testimony before the EQC.

29. Action Memorandum, p. 4.

30. Wayne Jepson, DEQ, e-mail correspondence, August 17, 2004.

31. Fiscal spreadsheet, DEQ, June 9, 2004.

32. Bill Maehl, Spectrum Engineering, report comments, July 16, 2004.

33. Phone log, Bill Maehl, Spectrum Engineering, June 3, 2004.

34. Action Memorandum, pp. 6-7.

35. Action Memorandum, p. 4.

36. Spectrum Engineering, cash shortfall projection, August 17, 2004.

37. Personal communication with Wayne Jepson, DEQ project manager, June 2004.

Appendix 1

2003 Montana Legislature

HOUSE JOINT RESOLUTION NO. 43

INTRODUCED BY WINDY BOY, BALLANTYNE, BECKER, BERGREN, BIXBY, BRANAE, BUZZAS, CALLAHAN, CARNEY, P. CLARK, COONEY, CYR, DICKENSON, DOWELL, ELLINGSON, ELLIOTT, FACEY, FRANKLIN, GALLUS, GALVIN-HALCRO, GIBSON, GOLIE, GUTSCHE, HAINES, HANSEN, HARRIS, HEDGES, JACOBSON, JAYNE, JUNEAU, KITZENBERG, LAMBERT, LANGE, LENHART, LINDEEN, MATTHEWS, MUSGROVE, NEWMAN, PARKER, RASER, SMALL-EASTMAN, TESTER, TOOLE, WANZENRIED, WEISS

A JOINT RESOLUTION OF THE SENATE AND THE HOUSE OF REPRESENTATIVES OF THE STATE OF MONTANA REQUESTING AN INTERIM STUDY OF THE SURFACE WATER AND GROUND WATER IMPACTS OF THE ABANDONED ZORTMAN AND LANDUSKY MINE SITES ON THE MILK AND MISSOURI RIVER WATERSHEDS AND THE EFFECTIVENESS OF THE STATE RECLAMATION EFFORTS AT THE ZORTMAN AND LANDUSKY MINE SITES IN PROTECTING THE WATERSHEDS; AND REQUESTING THAT THE RESULTS OF THE STUDY BE REPORTED TO THE 59TH LEGISLATURE.

WHEREAS, Pegasus Gold Corporation (Pegasus), through its subsidiary, Zortman Mining Incorporated (ZMI) and its predecessors, owned and operated the Zortman mine and the Landusky mine located in the Little Rocky Mountains of Phillips County, Montana, from 1979 until ZMI entered Chapter 7 bankruptcy in 1998 and abandoned the site; and

WHEREAS, the State of Montana's Department of Environmental Quality (DEQ) is presently directing the land reclamation and water treatment activities and operating the water treatment plants at the mine sites; and

WHEREAS, in 2002, the Bureau of Land Management and the DEQ prepared a joint supplemental environmental impact statement to evaluate alternatives for the final reclamation of the Zortman and Landusky mine sites; and

WHEREAS, the effectiveness and sufficiency of the current and proposed reclamation are not universally acceptable, and the reclamation is admittedly underfunded; and

WHEREAS, water discharges from the mine sites require treatment efforts, possibly into perpetuity; and

WHEREAS, the Little Rocky Mountains are upland water recharge areas for several watersheds and tributaries that supply the Milk River and the Missouri River; and

WHEREAS, current reclamation plans for water treatment at the mine sites contemplate the complete cessation of water treatment as soon as the year 2028.

NOW, THEREFORE, BE IT RESOLVED BY THE SENATE AND THE HOUSE OF REPRESENTATIVES OF THE STATE OF MONTANA:

That the Legislative Council be requested to designate an appropriate interim committee, pursuant to section 5-5-217, MCA, or direct sufficient staff resources to review the reclamation efforts at the Zortman and Landusky mine sites to:

(1) identify the impacts on surface water and ground water, including the recent degradation of Swift Gulch, attributable to past or present activities at the mine sites;

(2) determine if there are identifiable downstream impacts on the Milk and Missouri River drainages attributable to past or present activities at the mine sites;

(3) determine whether the surface water and ground water resources in the watersheds affected by the mine operations are being protected by the current or proposed state reclamation; and

(4) determine the potential impacts to surface water and ground water resources if additional funding for water treatment and reclamation does not become available.

BE IT FURTHER RESOLVED, that the study be conducted by reviewing available research reports and by soliciting testimony and information from knowledgeable individuals, academic institutions, and the appropriate local, state, tribal, and federal agencies.

BE IT FURTHER RESOLVED, that, in particular, representatives of the Fort Belknap Reservation Environmental Department be included in the study and participate in developing findings and recommendations.

BE IT FURTHER RESOLVED, that, if the study is assigned to staff, any findings or conclusions be presented to and reviewed by an appropriate committee designated by the Legislative Council.

BE IT FURTHER RESOLVED, that all aspects of the study, including presentation and review requirements, be concluded prior to September 15, 2004.

BE IT FURTHER RESOLVED, that the final results of the study, including any findings, conclusions, comments, or recommendations of the appropriate committee, be reported to the 59th Legislature.

- END -

ATTACHMENT 10

April 13, 2023

Mr. Tim Carr
Land Use Planning Commission
22 State House Station
Augusta, ME 04333-0022

RE: Response to LUPC Comments of February 24, 2023

Dear Mr. Carr,

I'm pleased to reply to you and the LUPC with respect to your written request dated February 24, 2023.

Please accept the following as our responses and clarifications to your questions.

1. **Acreages of Current Zones**

   Surveys of the area to be rezoned have found intermittent streams. By rule these streams are bordered by Shoreland Protection subdistricts (P-SL2) of 75 ft. landward from the normal high-water mark on either side. Please provide a revised total acreage of General Management subdistrict (M-GN) and the total acreage of P-SL2 subdistrict that will be rezoned to the D-PD subdistrict. It is our understanding that the total area proposed for rezoning is 374 acres.

   The P-SL2 areas within the footprint represent 24 acres of the 374 rezone area as shown on Figure 1 below. This results in a General Management Subdistrict of 350 acres.

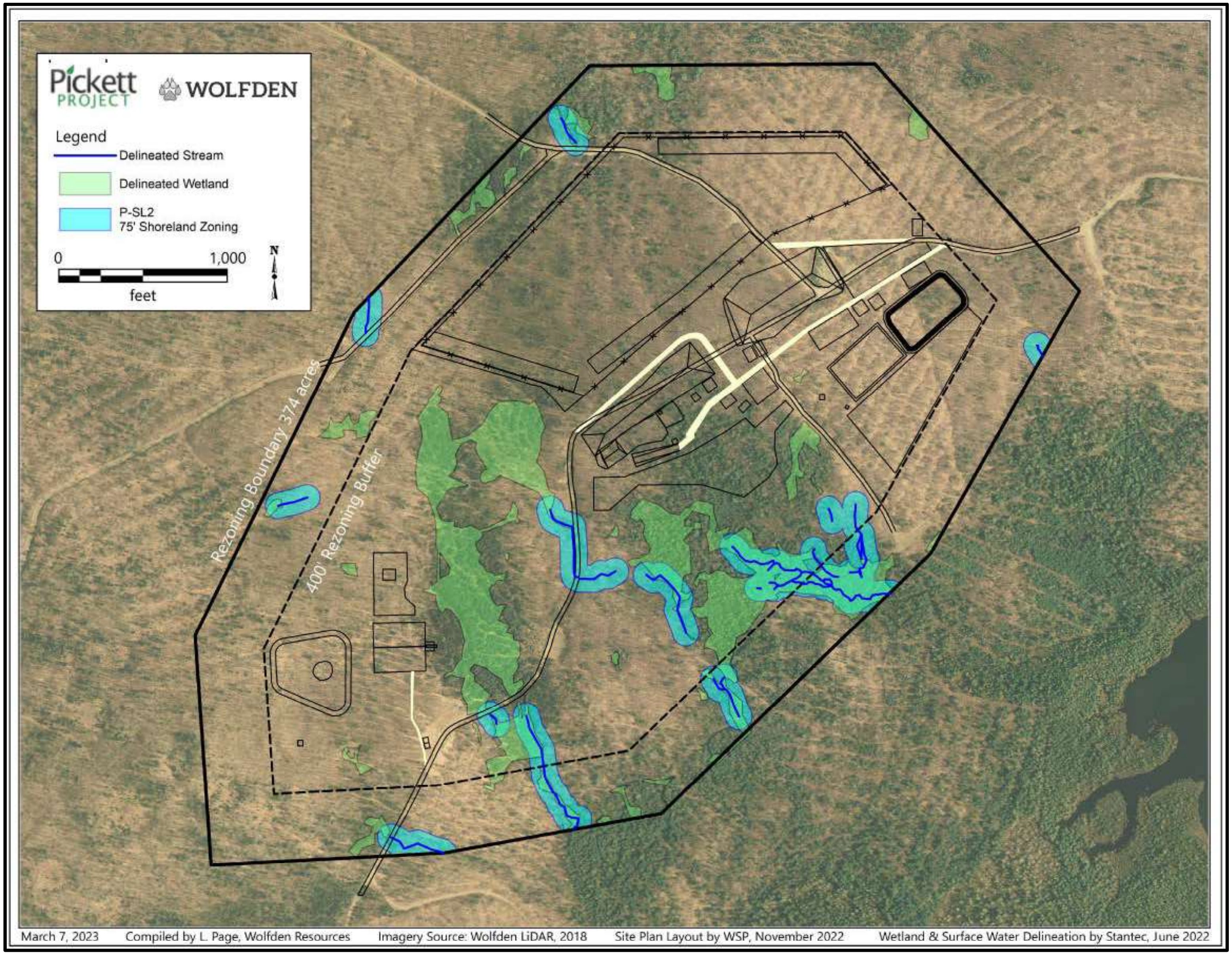


Figure 1: P-SL2 Areas Map

2. Total Number of Employees

Clarify the number of employees and contractors expected to work at the mine site as well as the total number of employees and contractors for the mine plus the offsite concentrator and tailings management facilities. The application provides varying numbers, some of which are described below.

- Executive Summary, ES.1: 272 “project related jobs”

272 includes contractor and full-time employees described in Tables 17/18 of Exhibit 10 – Attachment 10-A for the mine and the mill site combined. For additional clarity, please see Table 1 below for a summary of anticipated employees at the Pickett Project. Project related jobs includes direct employees as well as contract employees working at the project site.

Table 1: Pickett Employees Summary

Pickett Employee #'s Summary		
	Job Site	**Inputs**
Operations Timeframe	Mine/Concentrator	24hrs per day 365 days per year
Shift Work Schedule	Mine/Concentrator	7 days on 7 days off
Total General Administrative Employees	Mine	15
Total Shift Employees per 24 Hours (46 Dayshift/45 Nightshift)	Mine	91
Total Shift Employees Hired	Mine	182
Total Employees Hired	Mine	197
Total Local Contractors	Mine	36
Total Employeed at Mine Site	**Mine**	**233**
Total General Administrative Employees (7 for Each Cross Shift Rotation and 1 Mill Superintendent)	Concentrator	15
Total Shift Employees per 24 Hours	Concentrator	12
Total Shift Employees Hired	Concentrator	24
Total Employees Hired	Concentrator	39
Total Local Contractors	Concentrator	0
Total Employeed at Concentrator	**Concentrator**	**39**
Total Mine and Concentrator Employees	Mine/Concentrator	**236**
Total Employeed at both sites (Including Contractors)	Mine/Concentrator	**272**

- Consistency with the Comprehensive Land Use Plan (Exhibit 9), page 9.6: “233 workers:”

The reference to 233 workers is correct and includes the number of employees and contractors working at the mine site in T6R6; it does not include the 39 employees working at the concentrator site.

- Surrounding Uses and Anticipated Impacts (Exhibit 10), page 10.16: 272 “project associated jobs:”

The reference to 272 includes contractor and full-time employees described in Tables 17/18 of Exhibit 10 – Attachment 10-A; it includes both the mine site and the concentrator site.

ATTACHMENT 11

STATE OF MAINE
DEPARTMENT OF ENVIRONMENTAL PROTECTION

JANET T. MILLS
GOVERNER

MELANIE LOYZIM
COMMISSIONER

MEMORANDUM

To: Tim Carr, Senior Planner, Land Use Planning Commission

From: Michael Clark, Mining Coordinator, Bureau of Land Resources

Date: July 5, 2023 MC

Re: Department comments on Wolfden Mt. Chase, LLC's petition to rezone portion of Township 6, Range 6 Penobscot County, Maine for development of an underground metallic mineral deposit, January 18, 2023

The Department of Environmental Protection (Department or DEP) has reviewed the above noted zoning petition (the Petition), submitted to the Land Use Planning Commission (Commission or LUPC) by Wolfden Mt. Chase, LLC (Wolfden or Applicant). The Petition provides information in support of Wolfden's request to rezone approximately 374 acres that are currently within the General Management subdistrict, to allow construction, mining, closure, and reclamation activities over an estimated 10-15 years. The project is named Pickett Mountain and is located north of Patten, in Penobscot County near the border with Aroostook County. The Department's comments on the Petition follow.

In preparing these comments, the Department has attempted to (a) provide observations based on its experience and expertise that may assist the LUPC in its review, (b) identify any obvious issues with the proposed project that, if not addressed, would automatically preclude the Department from permitting the project under the Maine Metallic Mineral Mining Act (Mining Act), and (c) note additional information the Department would require before it could accept an application for the proposed project as complete for processing. This Petition review is similar to a Department memorandum dated January 28, 2021, which provided comments on a previously submitted, and subsequently withdrawn, petition revised June 30, 2020. The current Petition presents a notable difference from the prior petition in that no beneficiation structures, processes or activity is proposed for the mine site; the current Petition is for the underground mine and associated aboveground infrastructure only. The Petition makes several acknowledgements that much more detail and information would be provided in any permit application to the Department. Considering that context, the Department is providing proportionately fewer comments with respect to (c) above.

When considering the Department's comments, it is important to understand that the Department conducted a high-level review of the Petition. This is far more limited than the type of review the Department conducts when reviewing permit applications. Recognizing this, there may be important environmental considerations associated with the project, including considerations that could be identified from a closer review of the Petition, that are not reflected in the comments below.

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PORTLAND
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PRESQUE ISLE, MAINE 04769
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WEBSITE: www.maine.gov/dep

As noted appropriately throughout the Petition, it is also important to recognize that far more information would be required as part of any permit application filed pursuant to the Mining Act and the Department's accompanying rules, 06-096 CMR ch. 200, *Metallic Mineral Exploration, Advanced Exploration and Mining* (Chapter 200). This is inherent in the difference between a zoning petition and a metallic mineral mining permit application. The Department recognizes, however, that the Commission may require some similar information and that there is overlap between the information needed by the Commission to review a zoning petition and by the Department to review a permit application. Therefore, the Department includes references to Chapter 200 and notes some of the information that a permit applicant would be required to provide pursuant to this rule. This may help the Commission when evaluating its own information needs and assessing whether similar information, or a subset of similar information, is necessary as part of the rezoning process or more appropriately deferred to any subsequent permitting process.

Finally, should an application for a mining permit ever be filed with the Department by Wolfden or any other person, the Department would review that application under the governing statute and rules based on the information in that application and the accompanying record materials. Nothing in these comments is intended to prejudge any future application, should one be filed.

A. Clarity and Consistency

The Petition is voluminous and contains several sub-documents with Attachments. The Department suggests efforts be made to improve accessibility for readers, including the public, such as creating tabs to separate exhibits and using a whole-document page numbering system.

The Preliminary Economic Assessment (PEA) contains references to aspects of the prior petition, and while the Introduction in the Petition itself states that the current Petition is for the mine only, it still contains references to a Tailings Management Facility (TMF) and subsurface wastewater disposal options that are not part of the updated proposal. Suggestions include an edited PEA, or a preface to the PEA that identifies which aspects are no longer relevant or are revised for the current proposal.

There is a potential inconsistency pertaining to the applicant's intentions for providing potable water. According to Section 2.5.2, the Applicant apparently does not intend to operate a public water well at this site during the construction phase but will be providing drinking water from an offsite source, although this section of the application refers to "potable water via a drilled well and storage tank…within the footprint of the office complex." However, Section 16.14.2 of the PEA states that a "drilled well will be used to meet all of the potable water demand at the mine." If the Applicant does not intend to operate a public water system at this site, at a minimum, all taps served by on-site water sources would need to be clearly labelled as non-potable water or otherwise marked so that they are not used for drinking water. The applicant should review this proposal with the Drinking Water Program of the Maine Department of Health and Human Services to determine whether this or additional procedures are required for this well to not be considered a public water supply. Also note that, according to Section 17.4 of the PEA, the facility will require 325m^3/day (approximately 86,000 gallons/day) of makeup water, the source for which is not identified. Again, it is possible that these noted inconsistencies are rooted in parts of the PEA which may or may not be applicable to the current proposal.

A similar potential relic is described in Section 16.14.2 of the PEA, which states that the facility will include a "mine laydown yard...constructed near the portal." This is not clearly labeled on the preliminary site plans received for review. Is this intended to be a portion of the main infrastructure pad (PEA Section 13.3, Figure 18-2)?

The PEA indicates that exploration for exploitable resources is ongoing. If this is still the case, Wolfden should consider the availability of space or need for expansion of at least some proposed development areas if additional areas of the deposit are identified.

Figure 2-7 provides details for wastewater disposal, including an infiltration gallery without identifying that it is for a septic system design for the aboveground infrastructure sanitary wastewater disposal, as noted in the text of Exhibit 24, 'Sewage Water/Wastewater Disposal'. This led more than one DEP staff member to question if a subsurface mine and process water treatment option is also proposed.

B. Chapter 200 Prohibitions

The General Prohibitions section of Chapter 200 states, in relevant part, that:

> The Department may not approve a mining permit in an unorganized or deorganized area of the State unless the Maine Land Use Planning Commission certifies to the Department that:
>
> (1) The proposed mine is an allowed use within the subdistrict or subdistricts in which the project is located; and
> (2) The proposed mine meets any land use standard established by the Maine Land Use Planning Commission applicable to the project that is not considered in the Department's review.

If the LUPC grants rezoning approval and subsequently affirms the above criteria, Wolfden has indicated that it will file an application for a mining permit, subject to the provisions and requirements of Chapter 200. The Department has not identified any proposal within the Petition that is prohibited under Subchapter 1 (1)(B). The listed prohibitions include:

(1) Heap, Percolation or in-situ leaching;
(2) Mining for Thorium or Uranium ore;
(3) Block caving;
(4) Open-pit mining; and
(5) Wet mine waste units and tailings impoundments.

The Department also did not identify any aspects of the currently proposed mine location that would not meet the siting criteria of being greater than ¼-mile from the jurisdictional limits of specific geographical, ecological, or recreational features such as National and state parks, state or national historical sites, and wildlife refuges or management areas. The complete list of these areas is found in Chapter 200, Subchapter 5 (B)(4). Similarly, the Department has not identified that the proposed mine site is located wholly or partially in, on or under any state land listed in 12 M.R.S §549-B(7)(C-1), as would be prohibited by Chapter 200, Subchapter 5 (B)(5).

C. Ore processing and Waste Rock management

The Petition does not propose Beneficiation or other ore processing on-site, nor does it propose a specific off-site location for such. Any application to the Department for a mining permit under Chapter 200 must include a Mining Operation Plan to include processing of the metallic mineral ore and disposal of associated reactive mine waste. Processing and waste disposal may be proposed for an off-site location(s). If the off-site location(s) is within the state of Maine, the application must provide sufficient evidence that the processing and disposal activities will meet the Chapter 200 standards. Regardless of location, the plan must also include a Transportation Plan, including transport of lean ore, ore concentrate, or metallic product, as well as proposals to prevent leaks, fugitive dust, and contingency in the event of a transportation accident.

Attachment 10-B of the Petition presents limited mine waste characterization (Final Report: Static Acid Rock Drainage (ARD) Testing, April 16, 2021). While the testing did use material from the site, no information is presented showing the location of the samples and the extent to which they are representative of the likely waste rock, lean ore, and other rock materials requiring disposal on the site. An application for a mining permit would require more detailed ARD testing and characterization as part of a Mining Operation Plan.

Chapter 200 Subchapter 1 (1)(B) prohibition 5 states that a mining operation may place into a mine shaft waste rock that is neutralized or otherwise treated to prevent contamination of groundwater or surface water. Wolfden is proposing to backfill waste rock into the mine, with or without cement, as indicated in Section 2.5.3.1.2, 'Production Activities'. However, in the following section, 'Backfilling and Source of Backfill Material', there is not a specific discussion of the criteria that would be used to make a determination regarding whether cement will be necessary for neutralization of some waste rock; only whether the cement is needed for additional structural stability (Note: this section is also identified as Section 2.5.3.1.2 and is likely a typo that should be 2.5.3.1.3) Additional detailed discussion would be needed in any application under Chapter 200 in order to ensure that reactive mine waste would be properly characterized, neutralized and appropriately managed.

This section also indicates that an offsite borrow source will be used. Note that the letter in Attachment 2-C describing this material indicates that the estimate "is contingent on the ability of Sargent to successfully permit and utilize the quarry", suggesting that the proposed site is not a currently licensed quarry. If permitting under 38 M.R.S. Article 8-A is required for this quarry, the applicant and fill contractor should schedule this permitting so that the source would be available for use in a timely manner. For certain quarrying activities, a monitoring program with at least one year of background data may be required for excavation below certain depths, in addition to review and approval of other information.

D. Solid Waste

As presented, the Petition generally addresses solid waste disposal requirements and there are options near the mine site for management of the identified waste. "Organics Storage" is identified on the site plans, but without a specific description. If this is for temporary storage of ground land-clearing debris until being transported off site for the indicated use as erosion control material, that should be clarified.

E. Air Emissions / Licensing

The air quality within the area of the requested rezoning is currently designated as attainment/unclassifiable for all national ambient air quality standards (NAAQS), meaning the existing levels of air contaminants for which NAAQS have been established are below the levels which would trigger air quality concerns.

Exhibit 9.4.1, 'Air and Climate Resources,' addresses air quality almost exclusively with respect to dust control, including from rock crushing operations. Crushers and other heavy equipment may require air emissions licenses, and there may be other aspects of the mining operation that could generate air contaminants. Regulated air pollutants expected to be emitted from such equipment and activities include particulate matter (PM), particulate matter less than 10 microns (PM_{10}), particulate matter less than 2.5 microns ($PM_{2.5}$), sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), volatile organic compounds (VOC), and lead (Pb), as well as hazardous air pollutants (HAP).

Chapter 200, Subchapter 5 (20)(L) Air Quality Standards, requires that mining operations not discharge air contaminants into the ambient air in such a manner as to violate the Maine ambient air quality standards or emissions standards established pursuant to 38 M.R.S §§ 585, 585-B or 585-K. The Petition's exhibit section states, as Policy 1: "Require compliance with all state and federal air quality standards. Require compliance with more stringent standards where necessary to preserve the air quality or unique values of identified sensitive areas, or to improve the air quality of identified nonattainment areas."

Based on the limited information provided by Wolfden to the LUPC, the Department expects that the proposed facility would emit regulated air pollutants at levels requiring Wolfden to apply for and obtain an air emissions license in accordance with *Major and Minor Air Emission License Regulations*, 06-096 C.M.R. ch. 115 (Chapter 115). Chapter 115 provides for different application and licensing procedures depending on whether the proposed facility would be a minor source or a major source of emissions. The Chapter 115 licensing process would require Wolfden to provide additional information to the Department that would allow the Department to determine applicable requirements to control air pollution pursuant to state and federal laws and regulations, including control technology, emission standards and limitations, ambient air quality standard compliance demonstration, monitoring, equipment and operational restrictions, and recordkeeping and reporting.

F. Water Treatment (permitting)

Water resources within the area of the requested rezoning are currently classified as described in 38 M.R.S. § 464, Classification of Maine waters and 38 M.R.S. § 470, Classification of ground water. Standards associated with each of these waterbodies can be found in 38 M.R.S. § 465, Standards for classification of fresh surface waters; 38 M.R.S. § 465-A, Standards for classification of lakes and ponds; and 38 M.R.S. § 465-C, Standards of classification of ground water.

The surface water streams on the project site are classified as Class A waterbodies pursuant to 38 M.R.S. § 464. Maine law 38 M.R.S. § 465 for Class A waterbodies states in relevant part;

C. Except as provided in this paragraph, direct discharges to these waters licensed after January 1, 1986 are permitted only if, in addition to satisfying all the requirements of this article, the discharged effluent will be equal to or better than the existing water quality of the receiving waters. Prior to issuing a discharge license, the department shall require the applicant to objectively demonstrate to the department's satisfaction that the discharge is necessary and that there are no other reasonable alternatives available. Discharges into waters of this classification licensed prior to January 1, 1986 are allowed to continue only until practical alternatives exist.

(1) This paragraph does not apply to a discharge of storm water that is in compliance with state and local requirements.

D. Storm water discharges to Class A waters must be in compliance with state and local requirements.

E. Material may not be deposited on the banks of Class A waters in any manner that makes transfer of pollutants into the waters likely.

In addition to Maine statutes, Maine Department of Environmental Protection rule 06-098 C.M.R 586 establishes criteria for discharges to Class A waterbodies as follows;

1. Scope. Under 38 MRSA section 464 discharges to class A waters must be equal to or better than the receiving water in order to ensure that habitat, aquatic life, and bacteria are as naturally occurs. The following sections define effluent criteria necessary to ensure these requirements are met.

2. Criterion for pH. The pH of the discharged effluent shall not be greater than or less than a 0.2 pH unit difference from that of the seasonal median value of the receiving water upstream of the discharge.

3. Criterion for plant nutrients. Nutrients in the discharged effluent shall not exceed the seasonal median concentration of nutrients in the receiving water, or a value demonstrated by the applicant to be better than the seasonal median and which does not cause the aquatic life to be other than as naturally occurs.

The effluent shall not significantly alter the particle size distribution of the downstream floral community or otherwise alter the natural character of the downstream biotic community.

4. Criterion for temperature. The temperature of the discharged effluent shall not vary by more than 0.5°F from the temperature of the receiving water at the time of discharge.

5. Criterion for dissolved oxygen. In addition to the requirements of 38 MRSA section 465(2)(B) the dissolved oxygen content of the discharged effluent shall not be less than that of the receiving water at the time of discharge.

6. Criteria for other water quality parameters. Except as provided above, the concentration in the discharged effluent of biochemical oxygen demand and all constituents listed in Quality Criteria for Water 1986 (EPA 440/5-86-001) shall not exceed the seasonal median concentration as measured in the receiving water upstream of the discharge or prior to a discharge where a suitable upstream site is not available.

7. Establishment of seasonal values. For the purpose of establishing seasonal values in the receiving water pursuant to Sections 2, 3, and 6 of this rule, an applicant will provide data based on seasons and sample frequencies approved by the Department on a case-by-case basis.

The applicant has indicated the shallow ground water and surrounding wetlands will be recharged by way of treated wastewater being disposed of on-site via spray irrigation and snowmaking activities covering 15-29 acres. The Department has taken a long-standing position that wetlands that are hydraulically connected to a surface waterbody take on the same classification as the surface waterbody. For this project, any discharge to a wetland must meet the Class A criteria cited above. Given that streams are expression of ground water, the characteristics of the Class A surface waterbodies must not be adversely impacted by changes in the characteristics of the ground water as a result of the disposal of treated wastewater via spray irrigation or snowmaking. And lastly, as previously stated in the Department of Environmental Protection's January 28, 2021, memorandum to the Land Use Planning Commission, effluent discharged to wetlands or groundwater that reaches surface waters must be characterized as natural and may not alter the flow or the habitat of the surface waters. See 38 M.R.S. §§ 465(1 & 2), 465-A.

The Department notes that depending on final design, the proposed facility may be subject to the requirements of the Department's Multi-Sector General Permit (MSGP) for Stormwater Discharge Associated with Industrial Activity and the requirements of the Environmental Protection Agency's Ore Mining and Dressing Effluent Guidelines and Standards (40 CFR Part 440).

G. Water Treatment (proposal and site considerations)

Detailed soils mapping of application areas at a Class A level will be necessary to define application rates for any spray application or snowmaking area. Note that the soils analysis reports oxyaquic soils in many areas of the site (Soil Suitability Evaluation page 3-8, for example) proposed for wastewater application; the higher water table in these soils, often not associated with redoximorphic features in many cases, will need to be determined and used to define areas that can meet the necessary minimum depth to the seasonal high water table for spray application. In particular, high seasonal water tables during periods of extended snowmelt can lead to saturation of large areas of soil, with potential impacts on soil and vegetation characteristics, slope stability, and downgradient potential for seepage erosion. The Petition presents information regarding mine water treatment using the water chemistry obtained from a mine in generally similar deposits in New Brunswick (Water Treatment Scoping Study, Attachment 10-D). However, no information is presented demonstrating chemical similarity between this water and potential mine water at this site. It is expected that these waters would be generally similar, and the proposed treatment methods are known to be effective in general in systems designed, operated, and maintained correctly, but final approval by the Department will require analysis of waters from the site and generated from leaching tests and other means more accurately simulating conditions that could obtain at the site of the proposed development. It is also not explicitly stated whether the treatment goals (Water Treatment Scoping Study, Table 1) reflect ambient water quality, aquatic life criteria, or other factors relevant to specific conditions at the proposed mine site. Final approval of a wastewater treatment system will require more explicit evaluation of possible water inflow to the mine than is presented in this application (see for example Preliminary Economic Assessment Section 16.6.5, which does not include or reference a source for the values used), possible revision of the pre-and post-development runoff values and description of the volume available for contingency storage due to mechanical failures or other issues in the treatment system (Note that contingency sizing of the plant, rather than of water storage requirements, is discussed on p. 21 ff. of the Water Treatment Scoping Study).

H. Surface Water and Aquatic Life Protection

Chapter 200, Subchapter 3, Permits, Section 9(C) requires submission of a Baseline Site Characterization Report, which, among other things, must include documentation of aquatic and terrestrial flora and fauna species presence, distribution, and abundance, including the existence of endangered and threatened species and significant wildlife habitats. It must also contain a water balance of the affected area including, but not limited to, consideration of precipitation, evapotranspiration, infiltration, runoff, surface and groundwater flow, hydraulic gradients, velocity, flowpaths, elevations, and groundwater/surface water interactions. The report must contain an ambient water quality monitoring plan and monitoring results that provide baseline water quality information for any surface or groundwater that potentially may be impacted as a result of the mining activity. The baseline water quality monitoring shall include at least two (2) years of data collected over 24 or more consecutive months unless pre-existing data are approved for use by the Department. For this proposed project, potential impacts of concern to aquatic resources include erosion/sedimentation, nutrient enrichment, contamination of surface and groundwater from roads (e.g., road salt, petroleum, etc.,), stormwater and mine water, and impacts to vegetative communities caused by spray irrigation (water level changes, conversion of community type, introduction of invasive species, erosion/gullying).

The following comments are specific to Attachment 6A, Wetland and Watercourse Delineation and Potential Vernal Pool Survey Report, July 28, 2022:

Section 4.1. State and Federal Regulations: Under the Water Classification Program, all waters of the State are assigned a statutory water quality class by the Maine Legislature with associated management goals (designated uses) and water quality criteria, including criteria for aquatic habitat and aquatic life (biological criteria). Riverine waters and associated freshwater wetlands are assigned to Class AA, A, B, or C. There is a single classification for lakes and ponds (Class GPA).

Streams and freshwater wetlands in the vicinity of the project area are assigned statutory Class A (see §465-2 under Standards for classification of fresh surface waters: http://www.mainelegislature.org/legis/statutes/38/title38sec465-A.html). In addition, Chapter 579 Classification Attainment Evaluation Using Biological Criteria for Rivers and Streams (https://www.maine.gov/dep/water/rules/index.html) includes assessment methods based on aquatic macroinvertebrate communities to determine if rivers and streams attain numeric biological criteria for their assigned statutory class. Standards for classification of lakes and ponds are found in §465-A: http://www.mainelegislature.org/legis/statutes/38/title38sec465-A.html.

Section 6.1.1. Water Features: It is not clear from this section which waterbodies are in the project area as well as which are within a 3-mile radius. More details would be needed to fully evaluate potential impacts to aquatic resources.

Figure 1. Delineated Wetlands and Streams Map does not show connectivity with waterbodies outside the project area. This is pertinent information that is needed to evaluate potential adverse impacts to downstream waters. A comprehensive map depicting aquatic resources within the project area and 3-mile radius (required under LUPC guidance), including streams, lakes, and ponds (labeled with waterbody names if available), and wetlands (labeled with NWI classification) should be provided in any application for a mining permit.

Section 6.1.3 Wetlands: The Department was unable to locate a summary of acreages for various mapped wetland types. Is this information available?

The following comments are specific to Exhibit 10.0. Surrounding Uses and Anticipated Impacts:

Section 10.5.4. Wetlands/Streams/Waterbodies: Although lakes and ponds in the project area and 3-mile radius are listed, no details are provided regarding streams in the project area or within a 3-mile radius.

Section 10.5.2. Hydrology and Water Quality: It would be helpful to see discussion of the potential for unanticipated groundwater flow direction and depth and factors that may increase risks of contamination to aquatic resources.

Section 10.5.2.1. Water Treatment and Management Approach: Stormwater and mine water are proposed to be collected and stored in a lined 3.25-acre pond, then fed to an on-site wastewater treatment facility and tested before discharging via spray irrigation and snowmaking. Discharges would be upgradient of wetlands and streams so that existing hydrology is maintained, and at least 75 feet from the edge of the waterbody. An estimated 15-29 acres of land would be needed for recharge of treated water. Given the large extent of the area to be used for wastewater storage and discharge of treated water, are there contingency plans for accidental release of untreated or partially treated water due to unanticipated circumstances such as system failure or extreme weather events?

I. Stormwater Management

Chapter 200, Subchapter 5 (20)(C)(2) requires that stormwater management practices meet the standards of 06-096 C.M.R. ch. 500. While significantly more information would be needed for a complete review, the Department generally finds that the concept plan and preliminary calculations presented in the Petition can be reviewed under Chapter 500 and could meet the applicable standards.

J. Fuel Storage and Spill Prevention

The Petition identifies several above-ground and below-ground fuel and oil storage locations, including diesel storage, a fuel station, a maintenance facility, emergency power, an electrical substation, various transformer pads, and possibly facilities associated with the proposed solar array (see Section 2.3). A complete Spill Prevention Control and Countermeasures program, together with all elements of Groundwater Protection Plan (see Site Location Application Section 15(B)), would be required as part of the application for the mine; this would require significantly more detail than indicated in Section 18.9 of the Preliminary Economic Assessment.

K. Soils

The applicant has presented a Class D-level soils map for the facility, with field verification and additional analysis of site suitability prepared by a Maine Certified Soil Scientist. This information is consistent with the surficial geology and observations at the site, but additional information would be required for the Department to process any mining permit application. Although the Site Location of Development Law (M.R.S. 38 §§481-489-E) does not apply to the proposed development, developments such as that proposed for this site would be expected to meet comparable criteria for soils mapping levels and other relevant aspect of the development as those described in Section 11(B) of the Site Location of Development application, including Class A soil mapping in areas proposed for wastewater disposal. Where more detailed soils mapping exists or is performed for the application, the more detailed mapping should be used in preference to the Class D mapping for the purposes of evaluating predevelopment runoff conditions and other relevant information for the application; this could require substantial revision of, for example, Figure 10-1 and any predevelopment runoff calculations based on that figure and/or level of soils mapping, depending on the areas used for wastewater management or other purposes that would require more detailed soils mapping.

L. Closure / Reclamation

Section 2.5.4 of the Petition states that reclamation activities will be based on a reclamation plan that will be submitted as part of an application to the Department under Chapter 200.

Reclamation plans are required as part of the Mining Operation Plan and Reclamation standards are found in Chapter 200, Subchapter 5 (23).

Section 18.22.7 of the Preliminary Economic Assessment describes possible breaching of collection ponds as part of reclamation, as does Section 2.5.4 of the Petition itself. The permitting process under Chapter 200 could, however, identify stormwater management features that must be retained and maintained on the site as part of the long-term post-development hydrology management of the site, and it is premature to consider regrading of all such features at this time.

ATTACHMENT 12

STATE OF MAINE
DEPARTMENT OF AGRICULTURE, CONSERVATION & FORESTRY
LAND USE PLANNING COMMISSION
22 STATE HOUSE STATION
AUGUSTA, MAINE 04333-022

JANET T. MILLS
GOVERNOR

AMANDA E. BEAL
COMMISSIONER

JUDY C. EAST
EXECUTIVE DIRECTOR

February 4, 2021

Via E-mail Only

Jeremey Ouellette
Wolfden Mt. Chase, LLC.
1100 Russell St., Unit 5
Thunder Bay, Ontario P7B 5N2
Canada

Dear Mr. Ouellette;

The Land Use Planning Commission has continued its review of Wolfden Mt Chase, LLC.'s petition (ZP 779) to rezone 528.2 acres in T6 R6 WELS to a Planned Development subdistrict (D-PD) for the purpose of metallic mineral mining. Commission staff have also solicited review on aspects of the petition from other state agencies and independent consultants. In this review, Commission staff have identified areas where additional information is needed to complete review of the petition. Please submit the following as soon as possible, but at least within 60 days of the date of this letter. Please bear in mind that, depending on the materials that are submitted, additional questions and information requests may be forthcoming as the Commission, other state agencies, and the independent consultants reviewing the response to this letter.

Project Scope

1. Has Wolfden decided to change the scope of the proposal to include importation of material from a similar deposit? If yes, show that onsite facilities are sized to accommodate additional volume of materials from off-site. How will this impact other parts of the proposal- traffic projections and access travel routes, water use, waste disposal, socioeconomic impacts, etc.? Pickett Mountain Water Management Plan, 11/26/2020, p. 1.

2. The Preliminary Economic Assessment (PEA) lists several surface uses and structures that are not included in the Petition: backfill plant, mine rescue station, and compressor station. Sec. 16.6, p. 112. Also, it includes a cold storage building and a surface water pump house. Sec. 16.14.2, p. 134. And, it includes a waste oil depot and change house. Sec. 18.9, p. 145. These additional uses and structures need to be added to the Petition's project description, Exhibit D-2 Preliminary Site Plan (Site Plan), and Exhibit D-2 table. Provide the maximum height of the backfill plant.

3. The PEA lists underground facilities that are not included in the Petition: a breakdown maintenance shop with wash bay area, fuel stations, explosives and detonator magazines, water transfer stations and tanks, dirty water and clean water sumps, and electrical substations. Sec. 16.6, p. 112, p. 115, p. 116. These additional uses and structures need to be added to the Petition's project description. Figures in the PEA that show these underground facilities are too small and unclear. Larger scale conceptional drawings of all underground facilities are needed to better understand the scope, intensity and conceptual layout of these facilities.

4. The PEA indicates a possibility that an onsite quarry may be developed. Please clarify if Wolfden intends to develop a quarry to supply backfill materials for the mine. Sec. 16.14.2, p. 144. If yes, will it be located within the tailings management facility (TMF) or an alternative location within or outside of the proposed D-PD? For a quarry to be an allowed use in the proposed D-PD (i.e. not require a zoning amendment in the future), it will need to be located on the Site Plan described in the Petition and included in the development plan for the

subdistrict. Outside of the proposed D-PD subdistrict, in a General Management Subdistrict, a quarry less than 30 acres in size is an allowed use with a permit (less than 5 acres is allowed subject to standards). However, if a quarry greater than 30 acres is needed, the General Management Subdistrict would have to be rezoned to a development subdistrict for a quarry to be an allowed use. A proposed quarry within the TMF raises questions regarding compliance with Chapter 200. Consultation with the Maine Department of Environmental Protection (MDEP) would be needed for such a proposal.

5. If backfill material will be imported from offsite, describe generally where this material could come from, what impact that would have on traffic generated by the facility (Petition Attachment J), and where the materials would be stored onsite. Demonstrate that there will be sufficient area for storage onsite.

6. A diagram of how mined out stopes will be backfilled with cemented and uncemented rockfill would be helpful. According to the PEA, primary stopes will be backfilled with cemented rockfill and secondary stopes will be backfilled with uncemented rockfill. PEA, Sec. 16.7, p. 120.

7. The PEA indicates 103 employees for the mine. Sec. 16.16, p. 135. The current version of the Petition indicates approximately 60 employees. The list of positions in the Petition includes some roles that are not included in the PEA, such as concentrator and wastewater treatment plant operators, and health and safety, human resources, and IT staff. Appendix A, Section B(3)a, PDF p. 185-186. Please update the Petition regarding the total estimated number of employees, including a revised Traffic Increases section and Impacts section for Attachment J. Confirm that the proposed size for the employee parking area will be sufficient. Also, the socioeconomic assessment prepared in response to this letter should be based on the current projection of the total number of employees for the mine.

Soil Suitability

8. Based on the current record for this matter, the Land Use Planning Commission has significant concerns related to soil suitability for the proposed uses. Of particular concern are the proposals to construct wastewater storage ponds in soils that are shallow to groundwater and/or bedrock, particularly if blasting will be required for pond construction, proposals to store waste rock and low value ore on soils that have been classified in the Soil Suitability Evaluation as unsuitable for development due to the soil conditions, and proposals to construct ditches for surface water management in soils that the Soil Suitability Evaluation indicates as challenging. Given that the proposal involves a risk for potential impact to surface and groundwater resources and that the soils, particularly those in Areas 4,5, and 6, appear to pose significant challenges to manage appropriately over time, please provide an analysis of available alternatives for locating waste storage and disposal in areas with soils that are more suitable for those uses. (See comments from the State Soil Scientist, dated 12/08/2020). Additional soils evaluation may be necessary to address the soil suitability concerns for any on-site alternatives.

Financial Practicability

9. The Soil Suitability Evaluation for the project indicates significant limitations to overcome. It appears that the evaluation was not considered in drafting the PEA. How does the cost of overcoming soil limitations, including the needs to i. blast ledge, ii. potentially bring in a significant amount of additional fill, and iii. reclaim the site to match natural topography post operation, impact project costs? Demonstrate the cost is sufficiently covered in the PEA.

10. It appears that assay figures for gold and silver are used inconsistently in the PEA. Generally, where discussed in the text, the figure for gold is 0.79 grams/ton, and silver is 88.80 grams/ton. In Tables 1.6, p. 5 and 22.2, p. 183, these figures are reversed. Please confirm whether the tables are incorrect. Since these tables represent the inputs to the cashflow model, what are the implications of the errors for the output from the model?

11. The PEA uses a figure of $13.7 million for the Financial Assurance Trust. This figure appears low. Please provide more information on how this figure was calculated and whether the amount is sufficient to cover the financial assurance requirements under the MDEP's Chapter 200 Rules.

Reclamation and Benefits

12. If water storage ponds will be constructed by blasting ledge, how will they be restored to match natural topography following closure of the facility?

13. In addition, provide a response to MDEP comments, Section M, Closure/ Reclamation.

Waste Disposal

14. Please provide a response to MDEP comments, particularly Sections G and H regarding Water Treatment. In that response, demonstrate that it is possible to discharge wastewater onsite, either in subsurface treatment units as currently proposed or using other available technology, in a manner that would not result in the functional equivalent of a direct discharge to surface waters. Additional information may be required including more detailed information on soil type, depth to bedrock, distance to nearest surface water bodies, and discharge volume.

15. Additional information is needed to demonstrate that it is possible to treat and dispose of wastewater generated at the proposed Pickett Mountain Mine in compliance with applicable State rules, particularly the requirement to treat wastewater to background levels.

16. Given the change in the water management plan, with some wastewater from the concentrator/ TMF being treated in WTP 2 and released to the environment, it appears that the wastewater treatment plant for the Half-mile Mine is not a good comparison, because the Half-mile Mine has not concentrated mineral resources onsite (and it is our understanding that the mine only operated on a trial basis and has not operated since 2012). Please provide performance data from an existing, operating wastewater treatment plant similar to the one proposed for Pickett Mountain or other credible evidence that demonstrates that wastewater from the proposed process can be treated to achieve background levels.

17. In providing that demonstration, please address all potential contaminants in the wastewater and whether the treatment plant will be able to remove all those contaminants to background levels. With mining and processing onsite, the record indicates numerous potential contaminants that could be present in the wastewater:

    - The letter from SUEZ dated June 20, 2020, does not address two analytes found above background levels at the Half-mile Mine: manganese and molybdenum.

    - The potential for antimony, arsenic, bismuth, cadmium, cyanide, lead, and mercury to be in the wastewater. SWCA report, pg. 4 & 5; Att. E, pg. 42. Note, according Suez, "Non-metal species, that carry net negative charges, such as antimony and selenium, do not respond well to MetClear products." Wolfden letter dated 11/10/2020, Wastewater Treatment Submission, MetClear_EN, Heavy Metals Removed with MetClear Technology, PDF p. 115, report p. 9.

    - The chemicals that could potentially be used in the water and wastewater treatment plants including, Metclear, sodium hydroxide, coagulants, and flocculants, (Wolfden letter dated 11/10/2020, Wastewater Treatment Submission, Picket MT Mine WTP Block Diagram-01-Layout1, PDF p. 128); and in the mill, including NA2SO4, NaCN, Na2CO3, A325, Ca(OH)2, ZnSO4, SO2, CuSO2, M200, Lime, MIBC, CuSO4, and A343 (PEA, Sec. 13.1.3.1 -3, pp. 71 -73) and Aero 5100, SIPX/Aero 3418A, and PAX/AP404 (PEA, Sec. 13.3.3, p. 77).

- The SWCA report referencing "toxic surfactants used in concentrator". SWCA report, pg. 5.
- The below ground, breakdown maintenance shop and wash bay represent significant potential for fuel/oil/ grease discharges to mine water. PEA, Sec. 16.6.6, p. 115.

18. What is the basis for the WTP 2 design flow of 120 gpm? Demonstrate that the plant will be sized sufficiently to handle the anticipated process flow, as well as rain events. SWCA Report, Att. B, Linkan Memorandum dated 11/24/2020, Comment #14, p. 7.

19. A supporting memorandum for the SWCA report indicates that sludge levels could be high and recommends additional consideration for sludge handling. Given that sludge levels could be high and that the sludge will need to be characterized as a mine waste prior to disposal, show there is sufficient space for sludge handling and provide an alternative for disposal, if disposal as cemented backfill is not approved by the MDEP. SWCA report, Att. B, Linkan Memorandum, PDF p. 18, memo p. 2.

20. The SWCA report indicates that the conceptual wastewater treatment process needs some measure of additional treatment for RO concentrate (brine) to precipitate, "[t]his is not included and not trivial." SWCA report, Att. B, Linkan Memorandum dated December 2, 2020, Comment #23, p. 2. See also SWCA Report, Att. B, Linkan Memorandum dated 11/24/2020, Comment #14, p. 4. Please include what additional treatment could be proposed for precipitating RO concentrate, including any chemicals typically used in that treatment process. Show that the wastewater treatment process can remove those types of chemicals to background levels.

21. Explain what "byproduct water (reject water)" from the wastewater treatment plant is and how it is generated. Given that the byproduct water will need to be characterized as a mine waste prior to disposal, provide an alternative for disposal, if disposal as cemented backfill is not approved by the MDEP. Pickett Mountain Water Management Plan, Overall Water Balance, p. 4. See also SWCA Report, Att. B, Linkan Memorandum dated 11/24/2020, Comment #16, p. 7.

22. The clarified water pond is missing from the Site Plan and Figure 3 of the Water Management Plan. Please add this pond to the plan and figure. What is the estimated size and depth of this pond? Please explain what measures Wolfden could take if the pond is at capacity and test results show the pond is not meeting background water quality levels.

23. What sources of waste will be generated by operation of a backfill plant onsite and how will those wastes be treated and/or disposed of in compliance with State rules? How much water will be used in that process? How does that impact the overall water balance for the site? Are there any other potential sources of contaminants from the backfill plant operation, and how will potential adverse impacts be avoided or minimized? PEA, Sec. 16.11, p. 128.

24. Where will collected sediments dredged from both underground sumps and surface collection ponds be stored and disposed of? PEA, Sec. 16.6.5, p. 115. Also, the PEA indicates that the clear water sumps in the mine will be used to treat and store clear water. PEA, Sec. 16.6.5, p. 126. What water treatment is planned in the clear water sumps?

25. The PEA indicates that recycled, first phase, treated wastewater will be used in the mine for drilling and ancillary activities. In terms of a ratio, how much of the partially treated wastewater will be used for process water in the mine versus how much will be discharged to the environment? Given that the wastewater will only be partially treated and seepage from the tailings management facility, that could include process chemicals, will be a component of that wastewater, what is the safety risk for employees working in the mine?

26. Provide a description and conceptual layout for WTP 1. Will any chemicals be used? Will any sludge be generated? How will any waste products of that process be treated, stored and disposed of? Where would WTP 1 fit in Figure 4 of the Water Management Plan?

27. Respond to MDEP comments regarding disposal of land clearing debris. In particular, provide an estimate on the amount of biomass to be generated from stump grinding and provide evidence that there is an alternative available for exporting and use of any excess biomass. MDEP memo, Sec. A, p. 2

28. Also, please respond to MDEP comments regarding disposal of demolition debris. Describe the options that are available for disposal of demolition debris and provide a commitment that this material will be disposed of at a licensed facility in compliance with State environmental laws, rules, and permits. MDEP memo, Sec. M, p. 9

Tailings Management Facility (TMF)

29. It appears that there is an error in the revised Exhibit D-2 table submitted on 11/25/2020 for the size of the TMF. Given that the throughput for the concentrator has increased to as much as 1,300 tonnes/day, the discussion of having room for expansion in the TMF, and the plan to limit the TMF height, how can the TMF now be only 50 acres in size? Please provide a corrected Exhibit D-2 table. Alternately, if the size of the TMF has been reduced to 50 acres, provide evidence that 50 acres will be sufficient to handle the volume of tailings that will be generated.

30. Table 1 of The Pickett Mountain Water Management Plan, differentiates between "pyrite tails" and other "tailings." Explain the difference between the two categories, including discussion of any differences in management and disposal. Pickett Mountain Water Management Plan, Table 1, p. 4

31. Provide a report including a comparative analysis that addresses the recommendations of the Maine Geological Survey in their memo dated 10/15/2020 to demonstrate that the proposed approach for development, operation, and closure of the site can be done with no undue adverse impact to Maine's ground and surface waters, particularly given the climate in northern Maine.

32. Include in the above report evidence that the tailings can be stable over the long-term in climates similar to northern Maine. In particular, demonstrate that vacuum filtration of 14 µm materials is possible (SWCA Report, Att. B, Linkan Memorandum dated 11/24/2020, Comment #08, p. 6), confirm the design moisture content for the tailings, demonstrate that other northern mines have been able to achieve that moisture content, explain the long-term stability implications from infiltration of rainwater and snowmelt into the tailings before each TMF cell is closed, describe any provisions for temporary or intermediate cover over the TMF, and describe what measures will be considered to monitor stability of the TMF. Note that the Petition indicates that once compacted, tailings will not be subject to infiltration of water and intrusion of atmospheric oxygen (Petition Sec. B(3)(d), Tailings Treatment and Management Strategy, PDF p. 203); however, the PEA indicates that infiltration will occur (for example, Sec. 18.22.6, p. 152). The fact that infiltration will occur is also supported by the Greens Creek Mine Tailing Disposal Facility Expansion Final Environmental Impact Statement and Record of Decision Volume 1, published by the United States Department of Agriculture, September 2013 (EIS). Volume I, p. 3-75.

33. The PEA states that "[t]he design dry density [of tailings] may not be achievable during the winter months and may require temporary storage until spring when the thawed tailings may be compacted." Where will the temporary storage location be? Will that storage location be lined? How will runoff and spring melt-off from uncompacted tailings be managed/treated? What additional processing will be needed to achieve the design dry density in the spring, prior to disposal in the TMF? What would be the implications for TMF stability and decant water in the long run if the moisture content of a portion of the tailings is too high for any reason? Are Alaska's Greens Creek mine and other mines in northern climates able to meet tailings dry density requirements during the winter? How consistent are their results? If not, how do they handle winter conditions, runoff, and

spring melt-off? How are the conditions at those mines similar to and different from Maine's climate? Sec. 18.22, p. 149.

34. The PEA states that "If adequate and consistent filtering [of tailings] cannot be achieved, the system may not work." Sec. 18.22.3, p. 151. What factors could result in inadequate or inconsistent filtering of tailings? What mitigation measures can be used to overcome those factors, and what is the risk of failure?

    Include in the comparative analysis report requested above, information on the performance of liners and cover materials used for the TMF at other similar mines, particularly those in northern climates. The Greens Creek Mine Tailings Disposal Facility (TDF) Expansion EIS indicates that water draining from the TDF under all alternatives, including construction of a new TDF, would exceed water quality standards and therefore would require water treatment for at least 100 years after closure. Given that the MDEP's Chapter 200 rules require that affected areas meet water quality standards without requiring active treatment as soon as practicable, but in no case greater than 10 years post-closure, what measures are reasonably available to Wolfden to achieve better results than those reported in the Greens Creek Mine TDF Expansion EIS in terms of the quality and quantity of post-closure leachate or to provide for long-term passive treatment of the leachate from the TMF? EIS, Volume I, p. 3-38. See also SWCA Report, Att. B, Linkan Memorandum dated 11/24/2020, Comment #16, p. 4.

35. The petition proposes disposal of waste chemicals and chemical spills in the tailings management facility. Appendix A, Sec. B(3)(d), PDF p. 201. The LUPC is concerned about this proposal given that the tailings management facility is intended to be a dry stack facility and recommends alternative disposal provisions be submitted such as use of a contracted special or hazardous waste disposal contractor. If Wolfden does not propose an alternative disposal method, consultation with MDEP is recommended to determine if that disposal method complies with applicable MDEP rules.

36. The TMF collection pond is sized for 43,000 m^3 (151,831 ft^3). PEA, Sec. 18.22.6, p. 152 and 153. The updated table from Exhibit D-2 indicates a collection pond size of 172,946 ft^2. That will require an average pond depth of 8.8 feet. The nearest test pit to the collection pond, RTB-8, indicates a depth to bedrock of 22 inches. How will the necessary pond depth be achieved? If only fill and berms will be used, provide typical construction specifications and cross-sections. If blasting is required, provide evidence that the pond can be adequately lined after blasting to prevent leakage and groundwater contamination. What measures can be used to ensure that groundwater intrusion is prevented and for long-term leak detection?

37. Please describe what measures are reasonably available to minimize dust emissions from the TMF and water quality impacts from deposition on nearby vegetation. SWCA Report, Att. B, Linkan Memorandum dated 11/24/2020, Comment #12, p. 4, and Comment #19, p. 7.

Best Reasonably Available Site

38. The LUPC's Chapter 10 Rules state in the purpose of a D-PD subdistrict that "[a] petition to establish a D-PD subdistrict will be granted when the Commission concludes the location of the site is the best reasonably available for the proposed use and that the goals and policies of the Comprehensive Land Use Plan are served." 01-672 Chapter 10, Sec. 10.21,H,1. In considering that conclusion, the Commission will look at mining and ore processing, waste storage, and waste disposal as separate uses. Therefore, the Petition must demonstrate that the proposed locations are the best reasonably available for each of the proposed uses. Given the concerns discussed above regarding soil suitability, wastewater disposal, and the tailings management facility, additional evidence is required to demonstrate that the best reasonably available site criterion has been met. Please complete an alternatives analysis that demonstrates the proposed onsite locations for ore processing, waste storage, and waste disposal are the best reasonably available locations for these uses. In the analysis, please consider alternative locations on the Wolfden property as well as off-site locations that may be more suitable.

Surface Water Management

39. There appear to be significant inconsistencies between tables and figures in the Water Management Plan and the PEA. For example, the water management plan uses a concentrator throughput of 1,000 t/d (Table 1) and the PEA and other materials use 1,200- 1,300 t/d (For example, PEA Sec. 16.13, p. 131 and Table 17.3, p. 140), a 30% increase over 1,000 t/d. The difference influences the water balance, material balance (and presumably the size of the TMF), truck trips per day, and the project economics. Also, in the PEA (Sec. 16.6.3, p. 114), 1,160 m^3/day of water are needed for mine process activities and 1,420 m^3/day of dewatering from the mine is needed. In the Water Management Plan, at most 353 m^3/day are needed for mine process activities and 353 m^3/d of dewatering is needed. These are 3.3-4X differences. Similarly, the 401,285 m^3/yr. of service water required for the underground mine (PEA, Table 16.2) is not consistent with the service water requirements provided in the Water Management Plan. In addition, there appear to be errors and inconsistency between Table 1 of the Water Management Plan and a similar table presented in Table 17.3 in the PEA. The water management plan should be up-to-date and consistent with the PEA.

40. In the Water Management Plan, how were the rates determined for precipitation on tailings and pond, evaporation from tailings, underground mine water seepage, and precipitation from impacted surface areas? What are the rates based on and how were those numbers determined to be a reasonable estimate? Pickett Mountain Water Management Plan, p. 4.

41. The site water balance has 100% of the process water in the tailings on the TMF lost through evaporation and decant to the tailings water collection pond. This does not seem possible on a m^3/d basis. Please review and update Figure 4, the Site Water Balance, of the Water Management Plan, or explain why there would be no moisture content retained in the tailings.

42. Figure 3, Site Plan Identifying Water Management Flow Directions, will need to be updated to show flow from the TMF going to the storage pond and WTP 2, and to show flow from the WTP 2 going to the concentrator and the mine for process water. Pickett Mountain Water Management Plan, p. 3.

43. Provide additional information to demonstrate that snow/ and spring melt can be adequately managed onsite. Evidence on how this is handled at other northern mines would be helpful. SWCA Report, Att. B, Linkan Memorandum dated 11/24/2020, Comment #11, p. 3.

44. Where will impacted snow be stored until it melts in the spring? Is there sufficient area for storage? Will it be lined? Where will snow melt be collected and treated? Pickett Mountain Water Management Plan, p. 6.

45. What is the basis for the volume projected for spring melt/ runoff? What would happen if all the snow melts at once during a spring rain event instead of the estimated 2-month period for snow melt? Pickett Mountain Water Management Plan, p. 6.

46. The nearest test pit to the storage pond (Facility Item ID #27), RTP-9, indicates a depth to the hydraulically restrictive layer of 10 inches and to bedrock of 20 inches. How will the necessary pond depth be achieved? If fill and berms will be used, provide typical construction specifications and cross-sections. If blasting is required, provide evidence that the pond can be adequately lined after blasting to prevent leakage and groundwater contamination. What measures can be used to ensure that groundwater intrusion is prevented and for long-term leak detection?

47. Provide a response to comments from the MDEP regarding temporary shutdowns. In particular, demonstrate that there can be enough storage volume in onsite water storage ponds or provide alternative management practices that will be available to address temporary shutdowns of mining operations and/or the wastewater treatment plant. MDEP memo, Sec. C, p. 3.

48. The PEA indicates that contaminated stormwater from storms greater than 500-year events will be discharged to and stored in the mine shaft until the storm subsides and surface storage facilities regain storage capacity. How long would stormwater need to be stored in the mine before it could be pumped out, treated, and discharged? Will the portions of the mine that will be flooded include the mineralized zone? Would the workings be flooded above the level of groundwater? How will Wolfden prevent abandonment of portions of the workings that have been flooded? Given there is hydraulic head into the mine during operation, but that water flows through under non-working groundwater conditions, what would be the impact of introducing oxygenated water into the mine on ambient groundwater quality and the safety of mine workings?

Fish and Wildlife

49. Provide evidence to show that the proposed project can be constructed, operated, and closed out without unduly altering the hydrology of downgradient natural resources. If any flowing water, significant wildlife habitat or natural area of concern will receive more or less water than pre-development, provide evidence to demonstrate that there will not be undue adverse impacts on those habitats or the species depending on those habitats. Consider in this response the possibility that water could be diverted from one sub catchment area to another, and that water from mine shaft dewatering may not have reached the streams pre-development and therefore will be a source of additional volume. (See IF&W comments dated 9/11/2020, LUPC letter dated 09/12/2020, item 11(a), and MNAP comments dated 11/17/2020).

50. Please review and provide a response to comments submitted by the US FWS, in a letter dated 1/20/21, particularly those regarding potential habitat for and impacts to the Canada lynx. Provide an analysis of potential impacts; identify measures that could be used to avoid and minimize impacts to the species and habitat, including potential impacts from direct loss of habitat, traffic, pond construction, and fenced areas; describe possible measures to mitigate for any loss of habitat, including reclaiming disturbed areas to restore habitat and managing the remaining land on the parcel to improve habitat for the species; and indicate whether Wolfden commits to implementing measured needed to ensure no undue adverse impacts to the Canada lynx.

Water Supply

51. How much groundwater withdrawal will be needed to support the process until there is enough water for internal recycling? Demonstrate the cone of influence for a groundwater production well and that there will not be an unduly adverse impact on any nearby streams. PEA, Sec. 1.10, p. 7.

52. The PEA indicates that potable water must be drawn from an authorized site by the State of Maine to a suitable tank, and treated for organics, TSS, and metal ions. This statement is confusing. Is it meant to say that potable water must be drawn from a site authorized by the State? Water will not be provided by the State. Given that, what are the implications for the economic conclusions made in the PEA? What factors will be used to locate a potable well? Will a water treatment plant be needed? If yes, where will this be located, what is the conceptual layout, what process chemicals are typically needed, and how will backwash water and sludge be disposed of to comply with applicable State rules? Sec. 18.5, p. 144.

Noise Assessment

53. The PEA indicates that a backfill plant will be constructed onsite. This represents a noise source that was not considered in the noise assessment for the petition. The noise impact assessment must be revised to include operation of the backfill plant onsite as a noise source. Sec. 16.14.2, p. 133.

Socioeconomic Impact Assessment

54. Please provide a stand-alone socioeconomic impact assessment responsive to the comments provided by rbouvier consulting, dated 12/14/2020.

Recreation

55. Please respond to comments from the Maine Bureau of Parks and Lands, in a memo dated 11/9/2020, regarding their concerns about trail connectivity and traditional recreational activities.

Infrastructure

56. MaineDOT indicated a number of issues that will need to be addressed to ensure safe traffic movement into and out of the proposed mine. LUPC, in a letter dated 10/24/2020, requested that Wolfden respond to MaineDOT's comments. Although detailed infrastructure designs are more appropriate for the permitting phase of the project, LUPC does need to know that providing for safe traffic movement is technically feasible and financially practicable. In the letter dated 11/10/2020, Wolfden responded to the financial practicability of widening the access roads and provided road cross-sections (Soil Suitability Assessment, Engineering Details, Appendix E, PDF pp. 110-112), indicating technical feasibility to widen the roads. However, Wolfden did not address other MaineDOT recommendations including overhead lighting at the intersection of SR 11 and the access road, the deceleration lane on SR 11, the paving of the access road entrance, the extended shoulder width at the intersection of SR 11 and SR 212, nor the portable Changeable Message Signs for SR 212.

57. Wolfden has indicated during site visits that the bridge over the outlet stream for Pickett Mountain Pond, currently only one lane wide, will not be widened to support traffic from the proposed mine. Given the volume of traffic proposed, the need to truck hazardous chemicals into the site, and the co-use of the road with logging trucks, the Commission is concerned that a one-lane bridge will not provide safe and convenient traffic movement. Provide evidence that the bridge will be able to safely handle all the expected traffic or revise the proposal to indicate that the bridge will be widened to the full width proposed for expansion of the access road.

Security

58. Please add the gates and security building back onto the Site Plan.

In addition to the specific questions and information requests above, the LUPC recommends that Wolfden review all the State agency and contractor comments attached to this letter and ensure that all relevant matters have been addressed or are addressed in the response to this letter. If you have any questions about the ongoing review of the petition or the petition process, please feel free to contact me. I can be reached during normal business hours at telephone number 207-557-2535 or by e-mail at stacie.r.beyer@maine.gov.

Sincerely,

SRBeyer

Stacie R. Beyer
Planning Manager, Land Use Planning Commission

cc. Juliet Browne, Verrill Dana, LLC.

Enclosures: Contractor and Agency Comments

ATTACHMENT 13

lindsaynewlandbowker

PREVIOUSLY UNREPORTED LINER FAILURE AT KOKOYA GOLD MINE LIBERIA PUTS SPOTLIGHT ON DEFICIENT INTERNATIONAL CYANIDE CODE

Posted on June 25, 2018 by lindsaynewlandbowker
TAGS: International Cyanide Code; CIL Process Risk;Severity Rating Of Tailings Failures;Robert Moran;FrontPageAfricaOnline

CONTACT: Lindsay Newland BowkerLNBowker@BowkerAssociates.org (mailto:LNBowker@BowkerAssociates.org)

DATE: June 25, 2018

KOKOYA Tailings Facility Pre-Failure (Source Miner Annual Report)

Although it must have been widely known in mining circles, a liner failure releasing 11,500 cubic meters of cyanide tainted CIL tailings at the the Kokoya gold mine in Liberia on September 27, 017 was not reported in mainstream mining media or at WISE, the "official" world chronicler of "serious tailings incidents post 1960". It came to us via a google alert through a recent article in FRONTPAGEAFRICAONLINE (https://frontpageafricaonline.com/news/liberia-suspicions-heighten-over-undisclosed-reports-of-cyanide-pollution-of-communities-in-bong-county/) summarizing the Liberian government's legal findings of "public harm" related to measured evidence of consequence attributable to the cyanide levels in the tailings. Although the journalist was allowed to apparently read the full report in situ he/she was not , presumably allowed to make a copy and the government is now refusing to release the full report.

On reviewing the World Mine Tailings Failures data base from 1915 it became apparent that the absence of scientific assessment of the persistence and effects o cyanide tainted releases had not been taken into account in any of the narratives and therefore any of the the severity classifications of prior tailings releases from gold mine leach facilities. All but a few had been rated "minor failures" due to the absence of any science or examination of the actual cyanide consequences.

ATTACHMENT 14

STATE OF MAINE
INTER-DEPARTMENTAL MEMORANDUM

Department of Agriculture, Conservation and Forestry
Bureau of Geology, Natural Areas, and Coastal Resources
Maine Geological Survey
#93 State House Station
Augusta, ME 04333-0022
Tel. (207) 287-2801/FAX (207) 287-2353)

DATE: October 15, 2020

TO: Stacie R. Beyer, Planning Manager, Land Use Planning Commission

FROM: Daniel B. Locke, Hydrogeologist, Maine Geological Survey, Licensed Professional Geologist, Maine #240, Professional Hydrogeologist (AIH) #1501

SUBJECT: Rezoning to D-PD Subdistrict for the (proposed) Pickett Mountain Metallic Mineral Mine, ZP 779, Wolfden Mt. Chase, LLC, T6 R6 WELS -**Request for additional information**

****

As a part of the Maine Geological Survey's (MGS's) agreement with the Land Use Planning Commission (LUPC) concerning technical review assistance, I am providing review comments on the following document as well as supporting documents to this permit as provided by LUPC:

Rezoning to D-PD Subdistrict for the (proposed) Pickett Mountain Metallic Mineral Mine, ZP 779, Wolfden Mt. Chase, LLC, T6 R6 WELS – (Request for additional information)

After an examination of the submitted materials and supporting documentation, I respectfully offer the following comments and requests for additional information:

In considering the viability of a zoning change to allow for a polymetallic mine at the Pickett Mountain site, it is important for the State of Maine to be presented with evidential information of other mine sites throughout the world (mining for massive sulfide ore bodies for the same or similar metals) which have used the same or very similar approach to the mining and ore processing as is being proposed here (discussions of similarities and dissimilarities of the ore deposits and approach to mining, processing and waste storage). Also, it is important to note the climate of the mine sites and compare/contrast it to that of the Pickett Mountain site in northern Maine. It is our understanding that Hecla Mining Company has been mining for silver, gold, lead, and zinc at their Greens Creek Mine since 1989 (https://www.hecla-mining.com/greens-creek/). The Greens Creek Mine utilizes a dry-stack tailings storage approach which is thought to be the same or similar to what Wolfden Resources proposes. A discussion comparing and contrasting what Hecla is doing and what Wolfden proposes is in order. What issues and challenges have they (Greens Creek Mine) had pertaining to ground water and surface water quality? I understand that with the Greens Creek Mine, Hecla ceased operations for a few years in the mind 1990's because of low metal prices. Similarly, a discussion of how adverse metal prices would impact the continuity of operations (and environmental monitoring) with a Pickett Mountain mine is in order.

I appreciate the opportunity of making these preliminary comments. It is hoped that the requests for additional information can be reasonably addressed and that If there are any questions, please call me at 207-287-7171 or e-mail me at Daniel.B.Locke@maine.gov .

ATTACHMENT 15

MEMO

To: Tim Carr, Senior Planner, LUPC

From: David P. Rocque, Soil Scientist # 181, Consultant

Re: Pickett Mountain Mine, ZP 7794, Soil Suitability Review

Date: June 6, 2023

This is in regard to my review of the subject application concerning soil suitability for the proposed metallic mineral mine. I understand the applicant is proposing a mining operation in an area not currently zoned by LUPC to allow such a use and is therefore applying to have the area rezoned. My comments are based upon both the application materials and a site visit conducted late last fall.

General Comments:

Soil suitability for most development projects is based on three primary factors: soil wetness (groundwater hydrology), steepness of slope and depth to bedrock. In the case of a mining operation that requires extensive blasting of bedrock to obtain the desired material to process, depth to bedrock is not a significant limitation. In fact, blasted non-reactive rock is sometimes a desired product for use in other activities associated with the mining operation. Therefore, my comments will be limited to soil wetness and slope.

Though I did not have a high intensity soil survey to base my comments on, I did have a general soil assessment, prepared by Maine Licensed Soil Scientist, Roger St. Amand, and a site visit late last fall. Mr. St. Amand was of the opinion that the soils in the project development area were higher in clay content than indicated by NRCS soil scientists, which I agreed with. It is not unusual for soil scientists today to make different determinations than NRCS did when they did the field work for County Soil Surveys. That is because most of the original soil mapping was done 50 – 75 years ago and soil series concepts have changed over time. In fact, there are newly created soil series in use today that were not established back when this field work was done and some soil series have been dropped from the list of those recognized in Maine.

In contrast to the first application for the subject project, this application, for the most part, is proposing to site facilities on soils that are generally suitable for development. The one exception is for part of the proposed site for the Waste Rock Storage Pad #1, which will be on soils indicated by Mr. St. Amand as being somewhat poorly drained and which are oxyaquic (wetter than can be determined by soil morphology and plants). The applicant's intent to site actual processing facilities elsewhere as well as the Tailing Management Facility significantly reduces the potential impacts on the area requested to be rezoned. It should be noted that some of the proposed facilities for this project may actually be sited on less suitable soils than indicated by the general soil assessment and vice versa. These would be considered to be inclusions which would be identified by a more detailed high intensity soil survey.

Specific Comments:

My primary concern with this proposed project is with the potential for significant alteration to the natural hydrology. It is my understanding that the applicant is proposing to restore the site as close as possible to the condition in which it was prior to development. That would include restoring the natural hydrology which is important for downgradient wetlands and waterbodies but is also important for non-wetland soils. The applicant is proposing cuts as deep as 13 feet which will be well below the seasonal groundwater table and will require blasting of bedrock in many instances. It will be difficult to restore the natural hydrology when you excavate below a hardpan and/or bedrock. I also am concerned about the daily blasting of bedrock in order to remove mineral rich deposits for processing. This blasting will likely result in opening new fissures in the bedrock in surrounding areas and may close off others. I am not an expert in deep groundwater hydrology but recommend consulting others who do have expertise in this area to comment. I do though, have experience in shallow groundwater hydrology (upper 6 feet of soil) and realize that blasting can open up fissures in the bedrock of surrounding areas causing them to drain more quickly while sealing off others, making those soils wetter. If any of the wetlands are bedrock controlled, which I suspect they are, fractures may open up draining them. This possibility should be considered.

In order to minimize significant, permanent, alterations to the natural hydrology from deep cuts proposed for many of the pads and water treatment ponds, I suggest a combination rock sandwich/rock cannoli approach. I suggested its use for the Kibby Windfarm substation on Kibby Mountain and it has worked quite well. Where there is a proposed deep cut, below the groundwater table, use a rock sandwich on the cut face and downslope fill face with rock cannoli's (or a continuation of the rock sandwich) installed below the pad or pond liner system. This will ensure that the groundwater upslope of the facility will be re-introduced below the facility in as natural a manner as possible. It will also provide a much more stable surface to work on when constructing the liner system and the pad or pond. Otherwise, it will likely be wet and possibly soft unless dewatered.

I would also suggest a modification to the applicant's proposal to construct roads over "poor soils". Their proposal is to remove the poor soils and replace them with coarse granular fill (gravel). I do not remember ever seeing that approach to building a road over wet ground. That would alter the natural hydrology and create a curtain drain below the roadbed. I recommend using a rock sandwich to cross wet soil areas where the groundwater and/or surface water is moving from one side of the proposed road to the other. If the area is flat with no groundwater flow direction, the ground should be reinforced by using filter fabric. If the wet area to be crossed is bouldery, rocks can be placed in between the natural rocks and then filter fabric placed on top of the rocks before road fill material is added. This would act like a more natural rock sandwich.

A second concern is with the potential for acid leachate from the mine itself to impact groundwaters and, eventually, surface waters down gradient. The proposed mine shaft will be over a half mile deep with a number of laterals. The shaft and laterals will allow for oxygen to be introduced to areas that are now anaerobic which may result in sulfur being oxygenated.

A third concern is with the possibility of reintroducing process water into the soil by means of a subsurface system, similar to a standard septic system. The applicant's current intent is to return treated water to the site by using spray irrigation and snowfluent, which, in my opinion, is a much superior approach to the original application's proposal to use plastic chambers. It would be very difficult (I think impossible) to install very large plastic chamber beds into a site with such high clay content soils and have them effectively infiltrate the water into the soil. The soil would be compacted and smeared in the installation process, severely limiting its infiltrative capacity. I believe the water would follow a sand layer below the chamber beds, down to the lowest row where it would surface. By using spray irrigation, the soil can remain relatively undisturbed, with intact vegetation, an organic duff layer and good soil structure (which would be destroyed by construction associated with installing the plastic chamber beds). I strongly recommend avoiding any subsurface reintroduction of the process water, that would require excavating into the soil.

A fourth concern is with the Ore Removal and handling process - The mineral rich rock (ore), some of which is acid bearing, is to be removed by front end loaders, loaded into trucks and then hauled up to the surface where it will then be transported to an off-site location for processing, with the tailings to be permanently stored in a secure landfill type structure. It is likely that at least some of the ore rock will be wet, being below the groundwater table, which means that leachate may be generated in the transport process. There will also be days when it rains (or snows which may melt), adding moisture to the loaded trucks, if standard dump trucks are to be used. If leachate is generated, it is likely that some will escape truck bodies as they haul the ore off-site to be processed. This leachate could be acidic and have a detrimental environmental impact on soils and waterbodies if it falls on them or reaches them in runoff. If the ore is dry, wind could carry reactive dust particles to local soil and waterbodies during transport impacting those resources. Will secure, water tight, dust tight, trucks be used to transport the ore off-site? This process should be more fully detailed to properly assess the potential environmental impact.

A fifth concern is with mine sump pit sediment removal and disposal - The application explains that groundwater will be managed in mines by collecting it in sump pits where the muddy water will be retained until its sediment can settle out and collect on the pit bottom. These sump pits will periodically have to be dewatered so that the collected sediment can be handled and transported to its final destination. The application indicates that this is a process that might have some difficulty with the dewatering aspect. If this sediment contains reactive ore material, it will generate reactive leachate that could have an impact on local soil and water resources during the transport process. According to the application, this sediment is to be deposited into active backfill areas or blended with waste rock fill. If this sediment is reactive, blending it with waste rock and using it as fill could cause groundwater to become acidic, impacting downgradient soil and water resources.

Let me know if you have any questions or would like clarification of any of the points I have made.

ATTACHMENT 16

MEMORANDUM

DATE: November 24, 2020

TO: Andrew Harley, SWCA

FROM: James J. Gusek and David A. Myers

SUBJECT: Wolfden Mining Rezoning Petition and Preliminary Economic Assessment Technical Review

REFERENCE NO.: 96.01_504

INTRODUCTION

At the request of SWCA, Linkan Engineering (Linkan) reviewed two documents associated with the rezoning of a land parcel in Penobscot County, Maine for the development of an underground metal mine and its associated surface disturbances including a dry stack tailings facility. The Linkan review focused on technical issues related to the potential to contaminate ground and surface water and the mitigation plans proposed in the two documents:

- Petition to Rezone Portion of Township 6, Range 6 Penobscot County, Maine for Development of an Underground Metallic Mineral Deposit, and
- Preliminary Economic Assessment (PEA) Pickett Mountain Project

Linkan's comments follow. For convenience, the page number locations of Linkan's comments are cited below and they are also imbedded in the two Adobe Acrobat™ bookmarked PDF files that SWCA provided to Linkan. Page numbers referenced below refer to the location of the page in the total page count in the document (Adobe Acrobat™ page count) and not the page number listed at the bottom of the page (that was not consistently provided).

LINKAN ENGINEERING'S COMMENTS TO *PETITION TO REZONE PORTION OF TOWNSHIP 6, RANGE 6 PENOBSCOT COUNTY, MAINE FOR DEVELOPMENT OF AN UNDERGROUND METALLIC MINERAL DEPOSIT*

Linkan Comment #01, Page 163

There is no real basis for estimate of mine dewatering flow rate. The water management plan needs to have flexibility in case flows are higher. There does not appear to be a specific plan to deal with large storm events.

Linkan Comment #02, Page 163

The water quality of the seepage into the mine workings deteriorates over time as previously submerged or isolated sulfide rock (i.e., pyrite) is exposed to the mine atmosphere containing oxygen. This is an inevitable condition that either needs a mitigation plan to prevent it from happening or a water treatment plant capable of treating the additional loading or both.

Linkan Comment #03, Page 164

Removing the bacterial component of pyritic dissolution is also an effective strategy for preventing acid generation, but is not mentioned. Acidophilic microbes such as *Acidithiobacillus Ferrooxidans* accelerate the kinetics of pyrite oxidation and the generation of acid rock drainage (ARD) by several orders of magnitude. This aspect of ARD production has been well understood for almost 70 years (Leathen et al., 1953).

Linkan Comment #04, Page 164

Oxidation can still occur w/o Oxygen. If ferric iron (Fe^{+3}) is present in the water in contact with pyrite, oxidation can occur even though the pyrite is submerged. Ferric iron is produced in the pyrite dissolution process and can self-sustain to a degree. When the ground water rebounds after mine dewatering pumping is suspended, it might be necessary to neutralize the rising mine pool with alkalinity to minimize the presence of ferric iron in the pore spaces in contact with sulfide-bearing mine waste.

Linkan Comment #05, Page 164

Bactericides can also be effective in minimizing pyritic oxidation. Low concentrations of common anionic surfactant bactericides such as sodium lauryl sulfate, can minimize acid generation kinetic rates (Kleinmann and Ericson, 1983). Diluted milk has also been found to be an effective acidophilic bactericide (Jin, et al., 2008).

Linkan Comment #06, Page 164

The longer the acidic waste rock stays on the surface, the more acidic the backfill material might become. Preventing pyritic oxidation by removing oxygen and/or water or applying a bactericide during operations could minimize ARD generation in backstowed waste rock until closure, which would minimize the presence of ferric iron in the rising mine pool.

Linkan Comment #07, Page 164

General Comment

While Wolfden did not acknowledge the role of bacteria in the generation of ARD, it appears that they are cognizant of the problem and have taken appropriate measures (i.e., controlling water and air contact and addressing ARD in an active treatment plant) to deal with it both during operation and at closure. The use of ARD-preventive bactericides, a proven technology, might be a reasonable strategy to include in the plan.

Linkan Comment #08, Page 166

Tailings & waste rock co-disposal underground is a good idea. If there are reactive sulfides in the stope walls, after backstowing they would be placed in intimate contact with the very moist co-disposed tailings and that would cut off the oxygen supply. This is as close to pre-mining conditions as one could expect.

Linkan Comment #09, Page 166

Submergence of tailings is an acceptable practice, however it should be validated with some simple kinetic testing using drill core. The testing should be conducted in concert with planned acid-base accounting. Also, some residual flotation reagents are organic (such as A325, M200, and A343 [Table 17.2 in the PEA] which are xanthates and organic collectors). These will eventually turn the mine pool anoxic as they degrade. While arsenic is present in the waste rock and tailings as arsenopyrite and tetrahedrite which contains antimony, it is unlikely that these two constituents (As & Sb) would be mobilized by the anoxic conditions in the mine pool.

Linkan Comment #10, Page 166

Sub-aerial tailings deposition will encourage acid formation due to exposure to water and air. A plan for suppression of bacterial growth is needed.

Linkan Comment #11, Page 166

What happens to snowmelt? This is Maine... Consider a temporary sealant to increase runoff and avoid infiltration, especially on the 20% side slopes. A water-based polymer sealant was used successfully on a mine waste repository in Idaho at the end of the construction season to reduce infiltration. The photo is courtesy of Pacific Inter-Mountain Distribution LLC, Kalispell, Montana.

Figure 1 Spraying temporary sealant on a mine waste repository

Linkan Comment #12, Page 166

The final tailings might be finer than 400 mesh (37 microns) according to the PEA executive summary. Smooth drum rolling is an appropriate compaction method. We agree that this compacted material is likely to produce a very low permeability condition. However, dust control might be a problem during the drier months and the finer grained material is likely to contain a significant fraction of respirable dust.

Linkan Comment #13, Page 168

General Comment

An ARD mitigation plan should be in place during mine operations and not just for closure. The plan should include minimizing water and air exposure to pyritic waste rock piles such as spray-on sealant (say at the end of the fall season) and/or the inclusion of a bactericide to suppress microbial kinetics. Implementing these technologies would not add a significant cost component. As there will be a geomembrane cap as part of the closure design (i.e., complete encapsulation), the potential for ARD generation appears to be very small.

Linkan Comment #14, Page 169

Returning the RO reject back to the WTP feed tank will cause a build-up of salts and potentially gypsum to form in the system. A plan to remove sulfate is needed or a disposal plan for the brine. This is not a lot different than many larger mines…but they have very large tailings ponds to put the reject into.

Linkan Comment #15, Page 169

The proposed Process Flow Diagram seems credible (with possible exception of RO brine management – Linkan Comment #14). Linkan's experience is that well mixed round reaction tanks followed by lamella or other type of clarifiers and then Microfiltration followed by RO gives a robust system with consistent results.

Linkan Comment #16, Page 221

It is not reasonable to expect that all drainage water will no longer require treatment after 1 year. There should be a passive system to polish the final drainage water, and the WTP should be retained for a time as a contingency plan.

LINKAN ENGINEERING'S COMMENTS TO *PRELIMINARY ECONOMIC ASSESSMENT (PEA) PICKETT MOUNTAIN PROJECT*

Linkan Comment #01, Page 14

The grain sizes of the concentrates and the tailings are reported to be from 14 microns (µm) to 37 µm. This is very small compared to established norms by many mining operations. For comparison, talcum powder exhibits a "…a median diameter of 26.57 µm with a range of particle sizes from 0.399 µm to 100.237 µm" (Gilbert, et al., 2018).

The assumptions used to determine dry stacking (or sub-aerial tailings deposition) capacities and characteristics need to be vetted from experience/data with similar materials. Dry stacked tailings storage will reportedly reduce the tailings moisture content to about 20%; dust control may be an operational issue in drier seasons but there are numerous technologies available such as spray-on sealants to mitigate this potential problem. This would not be an issue at closure as the tailings storage facility (TSF) will be capped.

Linkan Comment #02, Page 18

The presence of arsenic and antimony in the concentrates infers their presence in the tailings. Immobilization of these constituents in the final tailings and presumed exposed surfaces in the underground mine workings should be a priority. This is discussed in more detail in other comments.

Linkan Comment #03, Page 19

There appears to be adequate room for locating a runoff catchment basin.

Linkan Comment #04, Page 20

Complete geochemical characterization testing is a good idea, but it should also include a microbial testing component for the presence/ absence of acidophilic bacteria in the core samples collected from the site during the exploration program. Older samples should be tested prior to more-recent core samples.

Linkan Comment #05, Page 20

As revealed elsewhere in the PEA (Linkan Comment #06), the deposit contains high concentrations of pyrite and the tailings will exhibit a very fine grain size (Linkan Comment #01). Low dry stacked tailings permeability values notwithstanding, the tailings will likely be very geochemically reactive and prone to produce acid rock drainage (ARD). Amending the closure cover design to eliminate the low permeability geomembrane component is probably not a good plan.

Linkan Comment #06, Page 38

The presence of pyrite (FeS_2) and calcite ($CaCO_3$) in the ore constitute two end points on the ARD potential spectrum. The more calcite present in the mine waste, the less likely ARD will form. This would be confirmed in follow-up testing (Linkan Comment #04).

Linkan Comment #07, Page 39

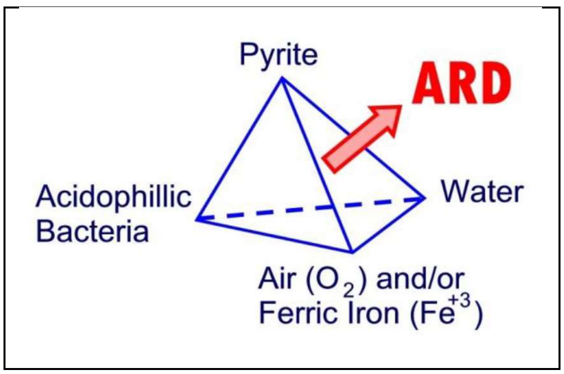
The level of pyrite in the ore (45% to 65%) will increase in the tailings when the minerals of value (chalcopyrite [Cu], galena [Pb], and sphalerite [Zn]) are recovered. By inspection, this elevated level of pyrite in the mine waste has an almost certain likelihood of generating ARD if mitigation measures (discussed elsewhere in the PEA) are not implemented. The arsenopyrite, tetrahedrite, and tennantite in the ore (and presumably the tailings) are potential sources of arsenic and antimony contamination. Mitigation measures are discussed elsewhere in the PEA.

Linkan Comment #08, Page 93

The smallest grain size distribution of the tailings sample used in this test was 325 mesh or 44 µm. Text in Section 1.4, Processing, states that regrinding to 14 µm would be necessary to produce a suitable lead concentrate. Vacuum filtration of 14 µm materials should be demonstrated. Vacuum filters with diatomaceous earth precoat are often used for very fine material.

Linkan Comment #09, Page 139

Backfilling the stopes with mine waste and tailings (Section 16.11.1) is a good idea. The technique should be called out as “co-disposal” which is the term commonly used. Surrounding coarser-grained mine development waste (which may or may not be acid generating) with tailings that presumably contain pyrite with a grain size of about 14 µm is an efficient use of space and geochemically sound as the moisture retention/field capacity of the tailings should keep the backfill moist (cutting off the oxygen supply leg of the ARD tetrahedron shown below) and have very low permeability.



Linkan Comment #10, Page 151

Table 17.2 includes sodium cyanide and multiple organic reagents such as xanthate (A325) used in the froth flotation circuit. The ultimate fate of these reagents should be discussed in the water treatment section. Are these reagents retained in the concentrates (which are shipped off site) or the tailings? It would be easy to add this information as an extra column or two in Table 17.2.

Linkan Comment #11, Page 156

This is a reasonable approach for collecting ARD. Materials above the liner might include a carbonate component to passively neutralize any ARD prior to its draining to the holding pond.

Linkan Comment #12, Page 157

The water management system (page 157) does not discuss the water quality requirements for process water. If all or some of the collected water is clean enough to be directly recycled without treatment, it could save treatment costs.

Linkan Comment #13, Page 157

Recommend that the proposed infiltration fields for excess water not be called septic fields…suggest Rapid Infiltration Basin (RIB).

Linkan Comment #14, Page 157

The WTP is designated to be designed for 120 gpm, and there does not seem to be adequate background for this number. On page 125 it says that the underground dewatering requirement is 1,420 m^3/day, or 260 gpm. On page 157 the text says, "the collected surface water, along with mine discharge water, is pumped to a raw water collection pond. This water is then treated through a water treatment facility". – this makes it seem that the WTP must be significantly larger than 120 gpm. Also, the WTP needs to be sized larger to "catch up" after rain events.

Linkan Comment #15, Page 158

Linkan's experience is that well mixed round reaction tanks followed by lamella or other type of clarifiers and then Microfiltration followed by RO gives a robust, system with consistent results.

Linkan Comment #16, Page 158

The RO reject is shown as going to "Waste/Concrete". RO reject disposal can be a severe problem, and this should be defined better.

Linkan Comment #17, Page 160

The tailings moisture will be controlled with pressure filtration, referencing Mine Paste, 2020. Did this test work use a tailing sample with a minimum grain size of 14 µm?

Linkan Comment #18, Page 161

The tailings volume is conservatively assumed to not include underground backfill.

Linkan Comment #19, Page 161

The design criteria need to include considerations for dust control. The very fine-grained dry stack tailings, even after moisture control, will quickly desiccate in dry weather and could pose a blowing dust problem. This could be managed with water sprays or a spray on water-based polymer which was discussed in Comment No.'s 9 and 10 in the Zoning Petition document.

Linkan Comment #20, Page 164

Over time, the grasses and shrubs will yield to a forest similar to the one surrounding the site. This is inevitable. The random soil layer for the root zone might be adjusted to accommodate for this.

Linkan Comment #21, Page 164

The contact water chemistry improvement timeline might be accelerated through the use of temporary sealants (see Linkan Comment #11 in the Rezoning Petition document) until the final cover is completed.

Linkan Comment #22, Page 177

Sequentially closing up to five TMF cells is a good plan; it provides an opportunity to adjust the closure of subsequent TMF cells based on the performance of earlier closure events.

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Jin, S., Fallgren, P. H., Morris, J. M., and Cooper, J. S. 2008. Source Treatment of Acid Mine Drainage at a Backfilled Coal Mine Using Remote Sensing and Biogeochemistry. Water Air Soil Poll. 188:205–212.

Gilbert, Christopher R., B. R. Furman, D.J. Feller-Kopman, and P. Haouzi. 2018. Description of Particle Size, Distribution, and Behavior of Talc Preparations Commercially Available Within the United States. Journal of Bronchology and Interventional Pulmonology, 2018 Jan;25(1):25-30. doi: 10.1097/LBR.0000000000000420.

END

MEMORANDUM

DATE: December 2, 2020

TO: Andrew Harley, SWCA

FROM: James J. Gusek and David A. Myers

SUBJECT: Wolfden Mining Rezoning Petition and Preliminary Economic Assessment Technical Review

REFERENCE NO.: 96.01_504a (addendum)

INTRODUCTION

At the request of SWCA, Linkan Engineering (Linkan) reviewed one additional document and one updated version of a previously reviewed document associated with the rezoning of a land parcel in Penobscot County, Maine for the development of an underground metal mine and its associated surface disturbances including a dry stack tailings facility. The Linkan review focused on technical issues related to the water treatment mitigation plans proposed:

- New Document - Ltr_Wolfden_Responce_AdInfoRequest.pdf
- Updated Document - Petition to Rezone Portion of Township 6, Range 6 Penobscot County, Maine for Development of an Underground Metallic Mineral Deposit, Revised June 30, 2020

Linkan's comments follow. Comments start at #23 as this is an addendum (addition) to the previously submitted Memorandum, same subject, dated NOV 24th, 2020, that ended with comment #22. References to the sections that pertain or connect with the reviewed document are provided for each comment.

Linkan has also provided a summary opinion on whether the information provided indicates that the mine is at least feasible for the purpose of rezoning to allow for detailed design and permitting to take place.

LINKAN'S COMMENTS TO: WOLFDEN RESPONSE INFO REQUEST

Linkan Comment #23, (Comment #7 Waste Disposal)

The process flow diagram is based on a packaged Suez treatment system using generic performance data. This package system is not optimized for the site specific water (not available yet) so there will be changes. Typically some type of solids removal step is in front of ultra-filtration (UF) process to optimize performance and reduce backwash volumes. Sludge levels could be high so more thought about sludge handling may be needed. Also a comment is made that the, "Reverse osmosis (RO) concentrate will flow to a storage tank for decant and solids removal." Some measure of additional treatment is needed for RO concentrate (brine) to precipitate. This is not included and not trivial.

Linkan Comment #24, (Comment 11 State Agency Review Comments, Answer 4 Streams and Wetlands)

The statement that, "The liner below and capping and closure of the TMF will prevent any leachate from infiltrating into the groundwater below" is a bold promise assuming industry standards. Liners and caps are almost never perfect so it is probably more correct to state that it will prevent <u>significant</u> infiltration. To say more than this would require justification about how this system is better than industry standard.

LINKAN'S COMMENTS TO: PETITION TO REZONE…, REVISED JUNE 30, 2020

On review of the text associated with Linkan's previous comments there is not any substantive changes that need to be made to the comments.

SUMMARY OPINION

Overall the documents were fairly well detailed for the expected level of project development. The rezoning requestor, Wolfden Mt. Chase LLC, has covered a fairly broad range of potential issues that will drive water treatment challenges during the active life of the project and after closure. We did not find any major category gaps in the documents.

There are many issues that still must be resolved based on more realistic water quality and flow rate predictions. This would include a more refined water treatment process that is specific to the site water (with a more definitive effluent quality), more details on how wastes will be handled (precipitates, sludges, brine, etc.), and a representative closure model that can be relied on. In this process we would assume that the issues we have discussed in our comments could be resolved.

In summary the documents that Linkan reviewed indicate that Wolfden Mt. Chase LLC, has covered the main categorical issues that will be faced with the water treatment aspects of the mining project. Both water treatment during active mining and source control measures for closure will not be trivial especially with the no impact goals stated for discharge. We believe these issues can be mitigated and the goals met if good planning, testing/proving, engineering, and execution is done behind adequate funding and good management. Thus the water treatment aspects of the project appear feasible for the purpose of rezoning.

END

ATTACHMENT 17

STATE OF MAINE
DEPARTMENT OF AGRICULTURE, CONSERVATION & FORESTRY
LAND USE PLANNING COMMISSION
22 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0022

JANET T. MILLS
GOVERNOR

AMANDA E. BEAL
COMMISSIONER

JUDY C. EAST
EXECUTIVE DIRECTOR

Memorandum

To: LUPC Commissioners

CC: Judy C. East, Executive Director
Jeremy Ouellette, Wolfden Mt. Chase LLC
Juliet T. Browne, Verrill Dana LLP

From: Stacie R. Beyer, Planning Manager

Date: October 7, 2021

Re: Wolfden Rezoning Petition, ZP 779, Wolfden Mt. Chase LLC, Pickett Mountain Metallic Mineral Mine, T6 R6 WELS

Background Information and Administrative History

On January 27, 2020, Wolfden Mt. Chase LLC (Wolfden) filed the first and second versions of its petition to rezone property the company owns in T6 R6 WELS to allow for the development of an underground metallic mineral mine at Pickett Mountain (the Petition). Since that time, Land Use Planning Commission (LUPC) staff have been working with Wolfden to obtain the information necessary for the Commission to make findings and conclusions on the Petition as required by State law and the Commission's rules. Key steps in the administrative history include:

- LUPC e-mail request for additional information, dated 1/30/2020, including a request for proper documentation for the notice of filing
- LUPC letter 1 requesting additional information, dated 3/6/2020
- LUPC letter 2 requesting additional information, dated 4/15/2020
- LUPC letter 3 requesting additional information, dated 5/27/2020
- Third version of the Petition, filed on 7/1/2020
- Wolfden letter requesting the Commission exclude from its review subjects addressed in the DEP's Chapter 200 Rules, dated 8/26/2020

- Commission acceptance of the Petition as complete for processing, 9/12/2020
- LUPC letter 4 requesting additional information, dated 9/12/2020
- LUPC letter 5 requesting additional information, dated 2/4/2021
- Commission staff generally held bi-weekly meetings with Wolfden, during which staff emphasized the need for Wolfden to ensure its next submission was internally consistent and presented credible evidence to support its arguments, 2/2021- 10/2021
- Fourth version of the Petition, filed on 9/1/2021.

Key Regulatory Criteria

- Chapter 12, Section 4, Requirements for Changes to a Subdistrict Boundary. "The Commission shall hold at least one public hearing on a petition for the D-PD Development Subdistrict designation in accordance with Chapter 5 of the Commission's Rules, *Rules for the Conduct of Public Hearings.*
- Chapter 10, Section 5, Burden of Proof. "In the case of any property owner or lessee who requests that the Commission place his/her land in a particular land use district, the burden of proof shall be defined as the burden of presenting sufficient evidence for the Commission to make affirmative findings as required by law or regulation."
- Chapter 4, Section 4.03(8)(b), Additional Information May Be Required. "…Even if an application or petition is accepted as complete for processing, the Commission may deny the application or petition for failure to provide information necessary to enable the Commission to make necessary findings under applicable review criteria."
- Chapter 4, Section 4.03(8)(c), Modification of Application. "If the applicant or petitioner (i) materially revises the application and the revised application requires new or supplemental review by the Commission … then the Commission may:

    (i) If there is insufficient time to make the findings and conclusions required by law within the deadlines set forth in 12 M.R.S.A. § 685-A(7-A) and § 685-B(2-B) and (3-A), deny the application;…"

- 12 M.R.S. § 685-A(7-A)(B)(4) states: "The commission must act to adopt or not to adopt proposed land use district standards, land use boundaries or land use maps within 90 days after the date of final closure of the public hearing."
- Chapter 4, Section 4.05(10)(a), Procedures and Time Limits for Issuing a Decision on a Petition to Adopt or Change a District Boundary, further clarifies the deadlines set forth in 12 M.R.S. § 685-A(7-A). It requires that: "[w]ithin 45 days after receipt of a petition for a change in a district boundary, the Commission shall schedule a public hearing or, if no hearing is held, set a final date by which comments on the petition may be submitted to the Commission."

Staff Analysis

LUPC staff have completed an initial review of the latest version of the Petition filed by Wolfden (the September 2021 Petition). Staff have identified 59 inconsistencies, errors, and failures to provide information requested in the LUPC's February 2021 letter (see attached spreadsheet). Wolfden itself recognizes that there are still inconsistencies in its Petition. A letter from Wolfden filed with the September 2021 Petition indicates:

> The document has been fully reviewed for consistency. Please note that given the size of and the amount of content within the Petition, it is anticipated that a few minor inconsistencies may still[ ]appear. Most material numeric values in the Petition are mentioned more than once, and so any single outlier that is not the same as all the others, should be overlooked.

In addition, staff have determined that Wolfden still must submit a significant amount of information to meet its burden of proving that the Petition meets the statutory and regulatory criteria for a zone change, and particularly those criteria related to soil suitability, best reasonably available location, and no undue adverse impact to water resources and fisheries.

LUPC staff have considered the history to date with Wolfden's Petition, the significant number of deficiencies in the September 2021 Petition, and the considerable amount of time required for Wolfden to respond to the last LUPC letter requesting additional information (nearly 7 months). Based on those factors, staff have determined it is highly unlikely that Wolfden will be able to provide the additional information needed to meet its burden of proof such that the Commission could make, within applicable statutory and regulatory deadlines, the findings and conclusions required by law to approve the Petition (Chapter 4, Sections 4.03(8)(b) and (c)).

Like prior versions of Wolfden's Petition, the September 2021 Petition contains numerous errors, inconsistencies, and omissions. As a result of these deficiencies, it is the staff's opinion that scheduling a public hearing on this Petition within the time required by the LUPC's rules (45 days) would not assist the Commission in reaching its decision. The state of the Petition is such that a hearing would need to focus on the Petition's numerous errors, inconsistencies, and omissions instead of a substantive review of the Petition relative to the criteria for the zoning decision. In addition, the Petition's numerous deficiencies will prevent review agencies (e.g., the Department of Environmental Protection, Department of Inland Fisheries and Wildlife, and Maine Natural Areas Program), from providing meaningful feedback on the September 2021 Petition. Under the current circumstances, continued review of this Petition places a significant burden on LUPC staff resources, which could be redirected to pending and new matters that will further the Commission's mission. For these reasons, LUPC staff believe that it is appropriate and necessary to request that the Commission direct staff to draft a denial of the Wolfden petition.

Staff Recommendation

Staff recommends the Commission direct staff to draft a denial of ZP 779 for the Commission's consideration at a future Commission meeting based on Wolfden's continued failure to provide sufficient information for the Commission to make necessary findings within the applicable deadlines, as required by Chapter 4 of the Commission's rules.

Attachment

Wolfden Rezoning Petition, Inconsistencies, Errors, and Omissions Worksheet

Exhibit #	Exhibit Name	Topic	Inconsistency, Error, or Omission	Comment
10	Surrounding Uses and Impacts	Water balance	The site water balance (Fig. 10-4, page 10-12) does not reflect the 20% increase in daily processing amount over the November 2020 petition (1,000 t/d to 1,200 t/d). The following values are the same (despite the change in units from the July 2020 petition to the September 2021 petition): total water from the tailings and concentrator system to the WTP, mine makeup water, and mine dewatering. Evidence of a well managed water collection and treatment system is critical in determining whether there will be no undue adverse impact on water resources.	
10	Surrounding Uses and Impacts	Water balance	Certain details of the water balance are not included on Figure 10-4. These details include water lost in the concentrates and tailings, makeup water from the TMF collection ponds going to the concentrator, precipitation on the TMF and collection ponds, evaporation from the TMF and collection ponds, and the process water conditioner.	
10	Surrounding Uses and Impacts	Water balance	There is an inconsistency between the Figure 10-4 water balance and the narrative on page 10-39. The figure shows 50.18 gpm of flow from impacted surfaces, where as page 10-29 indicates that flow would be 120 gpm.	
10	Surrounding Uses and Impacts	Water balance	On Figure 10-11, PDF p. 263, the red arrow indicating flow direction for the southern tailings collection pond is going the wrong direction and the green arrow for the IG labeled P20 is also going in the wrong direction. Same issueis found on Figure 2-2 and 2-3, PDF pages. 66 and 67.	
10	Surrounding Uses and Impacts	Water balance	There is no indication on Figures 2-2, 2-3 and 10-11 for how clean water gets to IG ID#9 north of the TMF.	
10	Surrounding Uses and Impacts	Water balance	Page 10-7 indicates the percent of water removed from the drainage basin is 1.6% and page 10-8 indicates 1.2%	
10	Surrounding Uses and Impacts	Winter/ spring operations	The petition does not provide a demonstration that snow and spring melt can be adequately managed on site, does not discuss how other northern mines handle winter/spring conditions on TMFs, and does not include specific climate comparisons requested (LUPC February 2021 letter, questions 33, 43, & 44).	
10	Surrounding Uses and Impacts	Winter/ spring operations	No basis was provided for Wolfden's conclusion that storage and disposal areas can accommodate winter storage of impacted snow, and no basis was provided for the projected volume and capacity needed for spring melt and spring runoff (LUPC February 2021 letter questions 43, 44, and 45).	

Exhibit #	Exhibit Name	Topic	Inconsistency, Error, or Omission	Comment
10	Surrounding Uses and Impacts	Storm events	No response was provided to the series of questions that LUPC posed in its February 2021 letter regarding storage of stormwater from a >500-year storm event in the mine shaft and the potential for groundwater impacts from that proposal (LUPC February 2021 letter, question 48).	
10	Surrounding Uses and Impacts	Water quantity	Table 1 and the table referenced as Table 10-12 appear to be missing from the petition (page 10-37). It looks like these tables could be critical pieces of information relating to the mounding study for the IGs. The table called 10-12 on page 10-40 relates to socioeconomic data not data on the IGs.	
10	Surrounding Uses and Impacts	Water quantity	Page 10-36 describing storwater drainage areas is confusing. The description of drainage areas first indicates that there is no change pre versus post development to DA 18 and does not include information on DA 13.1, 16.1, and DA 19 (also not shown on the associate map). Later, that page indicates that DA 13.1, 16.1, and DA 18 require water collection for treatment. The stormwater calculations are important to evaluate potential hydrologic impacts on downgradient wetlands and streams.	
10	Surrounding Uses and Impacts	Water quantity	The petition does not include distances from IGs to the nearest downgradient surface water body (LUPC February 2021 letter, question 14).	
10	Surrounding Uses and Impacts	Watewater treatment	LUPC outlined specific chemical constitents that may be present in the wastewater stream for the proposed operation and requested a specific demonstration that all of these constituents could be removed to background levels. There is no discussion in the Petition about non-metal species that carry a negative charge, nor other products and chemicals listed in the LUPC's February 2021 letter (question 17). The responses in Wolfen's September 1, 2021 letter for this line of questions conclude no direct discharges to surface waters, which doesn't relate to the constituents in nor the potential quality of the wastewater discharge. Also, DEP comments on potential limitations of using MetClear for water treatment were not addressed (MDEP comment H).	
10	Surrounding Uses and Impacts	Watewater treatment	There are inconsistencies in the design capacity for the WTP. Figure 10-4 indicates 146 gpm going to the treatment plant, Figure 10-6, page 10-16, indicates a 120 gpm design for the WTP, and the narrative on page 10-16 indicates the plant is designed for 200 gpm.	

Exhibit #	Exhibit Name	Topic	Inconsistency, Error, or Omission	Comment
10	Surrounding Uses and Impacts	Watewater treatment	The model for wastewater treatment provided on page 10-20 appears to contain some errors and inconsistencies: 1) the model input was run for a product flow of 100 gpm instead of the design flow for the proposed WTP (120 , 146 or 200 gpm?), and 2) the model was run with input values for sodium of 20 (mg/l?) and nitrate at 0.20 (mg/l?). It isn't clear why these numbers vary from the values provided for the Greens Creek Mine found in Table 10-5 on page 10-19 (11.2 mg/l and 3.43 mg/l respectively).	
10	Surrounding Uses and Impacts	Watewater treatment	The Suez letter dated 6/30/2020 regarding the performance of the WTP does not address molybdenum (LUPC February 2021 letter, question 17).	
10	Surrounding Uses and Impacts	Watewater treatment	LUPC's request for additional information to show there is sufficient space for onsite storage of sludge was not addressed (LUPC February 2021 letter, question 19)	
10	Surrounding Uses and Impacts	Watewater treatment	The Figure 10-5 reference appears to be incorrect (page 10-28). Figure 10-5 is a location map not data relating to zinc removal. The reference was likely intended to be Figure 10-7, Effects of Metclear2435 Addition on Zinc Removal.	
22	Soil Suitability	Soil suitability	The overburden thickness map, Figure 22-3, is missing from the petition (Technical Memorandum , May 21, 2021, ARC, PDF page 861). This is significant evidence to show whether soils are suitable for the proposal.	
22	Soil Suitability	Soil suitability	The soil suitability map does not include the entire area now proposed for rezoning, and there is no explanation as to why the prior map is sufficient.	
7	Site Plans	Soil suitability	The wetland delineation survey does not include the entire area now proposed for rezoning, and there is no explanation as to why the prior survey is sufficient.	
22	Soil Suitability	Soil suitability	The petition does not demonstrate that the costs of overcoming soil limitations are sufficiently covered in the PEA, particularly relating to the cost of bringing in a significant amount of fill to overcome shallow to bedrock and high water table limitations onsite, or for reclaiming the site, including removing all the fill to restore pre-development topgraphy. (LUPC February 2021, question 9).	Exhibit 22 indicates that a material balance has been generated and fill volumes calculated but these calculations and figures were not provided, and the exhibit indicates the volumes are well below anticipated fill requirements outlined in the PEA without a reference to where that information can be found and verified.

Exhibit #	Exhibit Name	Topic	Inconsistency, Error, or Omission	Comment
2	Project Description	Soil suitability	The Exhibit 2 figures do not include a cross section that shows how an above grade IG could be constructed and the diagrams do not include any fill material specifications.	
10	Surrounding Uses and Impacts	Number of employees	The total number of employees is projected to be 263 (Ex 9, Consistency with the CLUP, p. 207 of PDF) but 133 employees was used in the Socioeconomic Report. Also, 103 employees was used in the PEA.	The difference affects multiple aspects of economics and socioeconomics including total compensation, the job training program, ability to hire locally, and housing. It may also have implications for the preliminary economic assessment.
16	Fire, Police, and Ambulance	Number of employees	The support letter for fire and ambulance services references 60 employees. The Petition now proposes 263 employees.	Discussion of Policy 1 on page 9-4 of the petition (page 207 of the PDF) states that the total number of employees will be 263 (approx. 133 per day with two groups alternating a 7 day-on/7-day off schedule). This is a significant difference in scope and could have a substantial impact on service provisions. Additional input from providers is necesssary.
17	Education	Number of employees	The support letter for education services references 60 employees. The Petition now proposes 263 employees.	
2	Project Description	TMF	The Petition does not provide information on how Wolfden will achieve less post-closure leachate generation from the TMF than described in the EIS for the Greens Creek Mine Tailings Disposal Facility expansion (100 years) (LUPC February 2021 letter, question, 34).	
2	Project Description	TMF	The Petition does not provide sufficient evidence that the TMF is sized adequately. LUPC February 2021 letter, question 29. A statement that Wolfden checked the calculations isn't credible evidence. Given that the TMF size has been reduced significantly over time, evidence showing there is adequate space provided onsite for tailings disposal is needed.	
2	Project Description	TMF	TMF acreage is inconsistent- 54 acres (page 2-25 and PDF page 86), and 50.46 (page 7-1 and elsewhere).	
2	Project Description	TMF	The Petition does not include information on what factors could result in off-spec tailings and what mitigation measures could be put in place to overcome those factors (LUPC February 2021 letter, question 34).	

Exhibit #	Exhibit Name	Topic	Inconsistency, Error, or Omission	Comment
2	Project Description	TMF	Page 2-18 indicates that off-spec tailings will be placed within the TMF, desication will be readily enhanced by spreading the tailings to create a larger drying experience, and, once the adequate moisture content has been achieved, the tailings will be further dozed and compacted; while page 2-25 indicates off-spec tailings will be placed interior to the pile and subsequent lifts will not be placed on wet tailings untli drainage and compaction can occur.	
2	Project Description	TMF	The petition states that "once compacted, these tailings will not be subject to infiltration of water" on page 2-18. Several other places indicate that some infiltration will occur including page 2-23, which indicates "some infiltration is expected to report as tailings seepage..." and a run-off factor of 90% for the TMF.	
2	Project Description	TMF	Page 2-23 indicates that the TMF collection ponds would require 1.3M gallons for operation pond volume and 11.3M gallons to store a 500-yr storm event, indicating a pond size of 12.6M gallons would be required. However, the PEA indicates that only 10 M gallons are needed to store a 500-year storm event and the ponds would be sized for a total of 11.3M gallons.	
2	Project Description	Financial assurance	Groundwater pollution and the need for additional monitoring are not discussed in providing additional justification for the Financial Assurance Trust figure of $13.7 million used in the PEA, including relationship to MDEP's Chp. 200 rules on financial assurance (LUPC February 2021 letter, question 11).	
4	Notice of Filing	Public notice	Exhibit 4 is missing documentation on who was sent the public notice, when it was mailed, and the map and lot # for each property owner notified.	A public notice form was provided with updated information. Was a new public notice filed? If yes, we need new documentation. If not, the prior notice documentation (previously submitted on 1/28/20, under separate cover, should be in Exhibit 4).
10	Surrounding Uses and Impacts	Safety	The Petition, on page 10-18 indicates, "[g]iven that all residual chemicals are removed by the plant and specifically the RO system, no risk to workers using treated water as process water will be present due to the quality of the treatment water. Figure 10-4, page 10-12, shows that process water is pulled from the WTP before the RO unit, so would not be fully treated before reuse in the process, including reuse as mine water.	

Exhibit #	Exhibit Name	Topic	Inconsistency, Error, or Omission	Comment
10	Surrounding Uses and Impacts	Socioeconomic Report	The Socioeconomic Report does not contain the geographic location of existing businesses within the regional labor market area (table in socioeconomic report memo from rbouvier consulting, item 2a).	
10	Surrounding Uses and Impacts	Socioeconomic Report	The Socioeconomic Report does not contain an analysis of the economic impacts of transportation, including a description of the population and businesses along the transportation routes and a map of the transportation routes by phase (table in socioeconomic report memo from rbouvier consulting, items 1f, 3a, 3e).	
10	Surrounding Uses and Impacts	Socioeconomic Report	The Socioeconomic Report does not contain a breakdown of the number, occupational title, and type of jobs expected to be created in each phase of the project, nor a clear justification for the percentage of jobs reasonably expected to be local (table in socioeconomic report memo from rbouvier consulting, items 3a).	
10	Surrounding Uses and Impacts	Socioeconomic Report	The Socioeconomic Report does not contain a description of planned job training programs that includes the total number, intended audience, planned outreach to difficult to reach populations, transitional assistance for workers post-closure, and descriptions and outcomes of previous training programs (table in memo from rbouvier consulting, item 3b).	
10	Surrounding Uses and Impacts	Socioeconomic Report	The Socioeconomic Report does not include the extent to which consumables and services are sourced locally, a justification of assumptions, nor discussion of initiatives to increase local procurement (table in socioeconomic report memo from rbouvier consulting, items 3c & d). The report states that Wolfden estimated the portion of each expense line expected to be purchased from businesses within the economic region, but these percentages were not provided by category .	
10	Surrounding Uses and Impacts	Socioeconomic Report	The Socioeconomic Report does not address the use of economic incentives (table in socioeconomic report memo from rbouvier consulting, item 3f).	
10	Surrounding Uses and Impacts	Socioeconomic Report	The Socioeconomic Report does not include a plan to monitor the impacts of the project on local businesses, tourism, and recreation (table in socioeconomic report memo from rbouvier consulting, item 3g).	

Exhibit #	Exhibit Name	Topic	Inconsistency, Error, or Omission	Comment
3	Deed, Lease, Sales Contract, or Easement	D-PD boundaries	The legal description of the proposed subdistrict boundaries is not accurate or complete. The description references the total acreage of the proposed subdistrict inconsistently ("containing five hundred twenty-eight and twenty-three hundredths (645.96) acres." The description does not include the boundaries of the P-SL2 subdistricts that are now proposed to be excluded from the zone change. Also, the narrative in the legal description does not match the numerical coordinates provided. The narrative starts in the SW corner of the property but the corresponding points in the narrative start in the SE corner.	
2	Project Description	D-PD boundaries	Petition page 2-30 (as well as the Deed Sketches on PDF pg. 275) states the proposed rezoning area includes 646 contiguous acres. Elsewhere the acreage is listed as 600.1, including page 2-1.	LUPC staff recognize that the proposal, in places, removes the acreage for P-SL2 subdistricts from the rezone area, but it isn't clear throughout and not recommended by LUPC staff. Wolfden would have to submit additional information including a legal description and shape files for the P-SL2 subdistricts to remove them from the proposed subdistrict.
5	Land Division History	D-PD boundaries	The second map in Exhibit 5 states the area to be rezoned is 645 acres, which is inconsistent with other references to 600.1 acres.	
10	Surrounding Uses and Impacts	D-PD boundaries	Appendix A project drawings 1 & 2 show the proposed subdistrict as 528 acres, which is inconsistent with other references to the acreage of the subdistrict. The maps appear to be outdated.	
1	Directions and Locations	D-PD boundaries	The exhibit is missing a copy of our Land Use Guidance Map with the proposed subdistrict boundary shown.	There is one in the noise assessment, but the boundary is out of date.
2	Project Description	D-PD boundaries	Figure 2-22 does not show the existing subdistrict, the proposed P-SL2 subdistrict boundaries, nor proposed structures as the Petition narrative suggests.	
15	Harmonious Fit	Project description	There is no information in this exhibit, or elsewhere, that demonstrates the size of the employee parking is adequate for the number of employees. (LUPC February 2021, question 7).	
2	Project Description	Project description	The Petition does not contain a complete project description, nor a complete Preliminary Site Plan. Despite the indication in Wolfden's September 1 letter that Exhibit 7 includes all project components identified in the PEA, the project description, Preliminary Site Plan, and Table 7-1 do not include the mine rescue station, compressor station, cold storage building, surface water pump house, and waste oil depot.	

Exhibit #	Exhibit Name	Topic	Inconsistency, Error, or Omission	Comment
2	Project Description	Project description	A complete list of underground facilities was not provided in Exhibit 2 (missing the maintenance shop, fuel stations, and water transfer stations and tanks). Detail drawings of several underground facilities were provided; however, they are not at a readable scale and detail drawings of the underground fuel stations, water transfer stations and tanks, and electrical substations were not provided.	
2	Project Description	Project description	The figures for soil fill are missing on pages 2.22 and 2.23.	
15	Harmonious Fit	Project description	The tallest building is stated as 85 feet (headframe), PDF page 708. However, two places, including the project description, indicate 80 feet, page 2-3 and page 7-1 (Table 7-1).	
10	Surrounding Uses and Impacts	Waste disposal	The Petition does not provide information on how waste products from the Process Water Conditioner will be disposed. (LUPC February 2021 letter, question 26). The LUPC expects the activated carbon will need to be replaced on a periodic basis.	
26	Development Plan	Development Plan	The Development Plan is incomplete. The document is missing the: •Purpose and scope •Legal boundaries of the subdistrict •Statement of the Petitioner's intentions with regard to future land divisions •Statement on any steps the petition will take to avoid or minimize the effects of the rezoning on existing uses and resources, and •Statement on any design requirements or standards that will ensure future development meets the purpose of the D-PD.	
3	Deed, Lease, Sales Contract, or Easement	TRI	A copy of the property deed nor the easement for road access and maintenance were not included in Exhibit 3.	
21	Site Access/Legal Right of Access	Legal access	The owner of the private road planned for site access between Rte 11 and Wolfden's property is not listed in Exhibit 21.	The road easement agreement was not submitted (see Ex. 3 omission).
24	Archaeological and Historical Resources	Archaeological resources	Exhibit 24, page 24-1, indicates that three potential stone tool sites are within the project area. As a result of the expanded project boundaries, ASA 4 is now also within the project area bringing the total to four.	

ATTACHMENT 18

ALERT

Cleanup costs climb at Beal Mountain as DEQ drops “bad actor” case against former Pegasus Gold executive

MICHAEL CAST
Jul 18, 2021

Doug Butori irrigates his ranch from German Gulch Creek, which has its headwaters at the base of the defunct Beal Mountain Mine near Anaconda.

The mine, closed over 20 years ago, still poses a threat to the water he relies on.

During a tour of the site with U.S. Forest Service personnel and members of the project’s technical working group Tuesday, Butori stood beside the mine’s leach pad, where cyanide once poured over ore to reveal gold, and summed up its legacy.

"You see horror stories like this, and the other mines that Pegasus had. I don’t think Pegasus did this state any good at all,” Butori said.

The open-pit cyanide heap leach mine stopped operating in 1997. A year later, Pegasus Gold Corporation went bankrupt, leaving behind inadequate reclamation bonds at its various Montana mines, costing taxpayers over 100 million since.

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The Beal Mountain Mine, once owned by Pegasus Gold Corporation, is now the site of an ongoing cleanup that's cost almost $25 million. The $6.2 million reclamation bond Pegasus left after its 1998 bankruptcy is long gone. German Gulch Creek flows from its base into Silver Bow Creek and the Clark Fork River, and those streams are still at risk of pollution from the mine.

Michael Cast, The Montana Standard

In 2003, the Forest Service entered into a settlement agreement with the Clark Fork Coalition conservation group to resolve a Clean Water Act lawsuit, thereby taking on responsibility to address the threat of a hazardous substance release at Beal Mountain.

The dike holding back the worst contaminants shows signs of geotechnical instability, and a failure would cause a devastating deluge into German Gulch, Silver Bow Creek and the Clark Fork River.

“If this thing ever breached, and that concentration went down the crick, it would hit me first, but it would hit all the way down," Butori said. “And all the cleanup would be for nothing.”

Selenium continues to drain into the creek from the mine, toxic to trout at low doses. Water is treated to prevent exceedances, but they still occur.

Pegasus would never get away with it today, Butori said. The mining method was banned in Montana by citizen initiative in 1998, and the law is now stricter on reclamation bonds.

Pegasus got away with plenty.

The Montana Department of Environmental Quality **on Wednesday dropped its “bad actor” lawsuit** to remove Hecla Mining Company’s president, Phillips Baker Jr., from Montana mining projects.

Baker was a top executive for Pegasus when it declared bankruptcy on the Zortman-Landusky gold mine on the edge of the Fort Belknap Indian Reservation, as well as operations at Beal Mountain and Basin Creek.

The Montana Legislature passed the Metal Mine Reclamation Act in 1989 and expanded it in 2001 after the Pegasus bankruptcy to prevent mining executives who haven't reimbursed the state for past cleanup efforts from receiving new mining permits.

In a press release Wednesday, the DEQ said bad actors cannot leave Montanans to foot their bills, yet the case wasn't pursued due to "complex procedural hurdles that complicate the case and potentially risk DEQ's ultimate goal of preventing bad actors from operating in Montana."

The suit was filed when Steve Bullock was still governor. DEQ attorney Sarah Clerget wrote that the election of Gov. Greg Gianforte and appointment of a new DEQ director prompted "a very careful look at the entire record of the case."

Hecla, under Baker's leadership, continues to move forward on two controversial copper and silver mines in the Cabinet Mountains near Libby and Noxon, which both Gianforte and U.S. Sen. Steve Daines have pushed for development.

The decision to withdraw the suit drew outrage from environmental groups and impacted Native American tribes. In a press release Wednesday, DEQ Director Chris Dorrington said new legislation is a better avenue to go after bad actors and outstanding cleanup funds.

"Changing the law is the best way to ensure it is clearer and easier to go after bad actors in the future," Dorrington said.

It isn't clear and easy now.

The DEQ this month ordered the company that currently owns the Montana Tunnels mine in Jefferson City, site of another former Pegasus operation, **to pay the $16.8 million bond owed and start reclamation.** If the company walks away and another mining company fails to step in, the DEQ gets stuck with the cleanup, $16.8 million short.

Meanwhile, the Pegasus legacy is on full display at Beal Mountain, where the U.S. Forest Service, with guidance from the various conservation groups and government agencies of the working group, is fighting with taxpayers' dollars to stop a mountain of contaminants from rushing downstream.

Money

Pegasus paid $6.2 million for the Beal Mountain cleanup, which has so far cost nearly $25 million. The state has paid $3 million and the Forest Service over $14 million.

The Forest Service estimated the cost of final closure at $40 million in 2010, but that's based on a plan which would likely fail to eliminate water treatment. Water treatment currently costs $350,000 per year and that cost is projected to increase with time.

The Forest Service is instead working on a new plan, which the agency hopes will prevent perpetual water treatment.

Sonny Thornborrow, project lead for the Forest Service, said the paramount risk is a major slope failure and contaminant release into the streams.

He said he’s optimistic that horizontal drilling, a method fine-tuned by mining companies, could be used to drain groundwater before it hits the most contaminated area, thereby taking weight off the unstable slope and ultimately reducing the amount of contaminated water to be treated.

Thornborrow said he believed it could be done — and that it needed to.

A company under Forest Service contract is drilling on a project at Hyalite Canyon south of Bozeman. Market research and 20 years of groundwater study around the Beal Mountain leach pad suggest something similar would work at Beal, he said.

Though it’s still in the planning stage, Thornborrow said the drilling project could start as early as 2023.

That would require more annual funding, however. The forest service vies for annual appropriations from Congress, and has so far received between $500,000 and $1.3 million a year.

Thornborrow ventured to speculate on the cost of the two- or three-year drilling project required.

“I think we would be looking at a few million dollars. So we're in the millions of dollars, not the tens of millions. So all things considered, that's probably within the realm of possibilities for a site like Beal," he said.

The next step is to form a precise plan, said Bob Wintergerst, the Forest Service’s regional environmental engineer for the project.

"We've been fortunate we've continued to get funding, but you need to have the model to say, ‘We are ready to take that big step and we need the big dollars.’ Because if you get big dollars, and you can't spend them then you basically failed," Wintergerst said.

It’s not to say they just hand those big dollars out. There are a lot of dead ends for Beal.

Great American Outdoors Act funds don’t necessarily fit, Wintergerst said, because the mine site is closed to the public.

He said he doubts Beal’s a fit for funds from the gigantic bipartisan infrastructure bill currently being debated either.

“It would be nice to say, okay, we need funding for legacy mines, and we need proper enforcement for current regulations that do the job of making sure they have enough money in their bonds to cover that,” he said. “But that’s out of my wheelhouse altogether.”

Instead, federal agencies compete for limited resources.

“Can the EPA step in? Yeah, but they’re in the same boat as we are. And the BLM. We’re all federal agencies, and a lot of the time funding is not there. Because if you look at the number of historic abandoned mines in Montana, it’s in the tens of thousands,” he said.

On Wednesday, a proposal advanced through the U.S. Senate’s Energy and Natural Resource Committee for a $3 billion grant program to reclaim abandoned hard-rock mines. Sen. Martin Heinrich (D-N.M.) wrote the bipartisan proposal with support from Daines.

The proposal has the support of environmental groups, including Trout Unlimited and Earthworks, both represented on Beal's working group, as well as the National Mining Association industry group.

Bonnie Gestring, northwest program director for Earthworks and a member of the Beal Mountain working group, said the legislation would appropriate more federal funds to abandoned mines, but stopped short of generating funds from the mining industry.

"Ultimately, we'd like to see legislation passed that generates a dedicated source of revenue to fund abandoned mine cleanup based on a royalty or reclamation fee on hardrock mining, similar to the coal program. Currently the hardrock mining industry does not pay a royalty for the minerals that are removed from federal lands," she said.

Legislators have submitted proposals to do so over the years, but they haven't passed.

Sonny Thornborrow on Tuesday describes the work so far and the work still to come at the Beal Mountain Mine site near Anaconda. Thornborrow, the project lead for the U.S. Forest Service, and the project's technical working group representing conservation groups and government agencies are working to clean up the mess left behind by Pegasus Gold Corporation.

Michael Cast, The Montana Standard

Up on Beal Mountain, Thornborrow told the group he worries about the early spring melt before the roads are clear, when groundwater's at the highest and the water treatment pumps are off. His team may have to think about plowing the roads to get in earlier, he said.

Pegasus ran the mine year-round.

“If you have enough people and equipment you can do it,” Thornborrow said. “It’s a lot different for a company versus us trying to plow in here every year. It’s a lot for us to take on.”

“Then you’ve got to worry about freezing, too,” Butori said of water treatment.

“Nothing up here’s easy,” Thornborrow responded, and the working group laughed.

Later, Butori reconsidered the issue.

“It’s nothing money can't fix," he said.

Fish eggs and earthquakes

At Beal the primary contaminant of concern is selenium. It’s getting into German Gulch, which feeds Silver Bow Creek and the Upper Clark Fork River.

The cleanup of the Clark Fork watershed is a separate, ongoing, roughly $1 billion investment, said Andrew Gorder, legal director for the Clark Fork Coalition conservation group.

The Atlantic Richfield Company, which owned the copper mining operations in Butte and Anaconda that polluted the watershed, is paying for much of the cleanup in Superfund settlements.

A contaminant release from Beal would further jeopardize a struggling ecosystem **where trout and even osprey populations are declining**.

Trevor Selch, water pollution biologist for Montana Fish, Wildlife and Parks, on the tour said German Gulch is the only known source of pure strain westslope cutthroat trout for Silver Bow Creek.

Selenium accumulates in fish eggs.

“They'll hatch normally, but when they start feeding off that selenium rich yolk sac is when you can see entire year classes wiped out," he said.

Pegasus built a pipeline to keep contaminants from the mine pit out of German Gulch. The Forest Service since rebuilt the system, but a buried valve broke in 2019 and water has since entered the creek during high flows.

Selenium exceedances occurred in German Gulch previously, but improved before the valve broken. For fish, the standard used for chronic concern is five micrograms per liter, and levels reached seven micrograms in June last year.

The valve will be repaired this year, Thornborrow said.

The Environmental Protection Agency set a lower national standard, 3.1 micrograms for rivers, but it isn’t yet used statewide in Montana.

The state and EPA approved the lower standard for the Kootenai River in northwest Montana, and a 0.8 microgram standard for the Koocanusa Reservoir that feeds it, because selenium from Canadian company Teck Resources Ltd.’s coal mines are killing the fish.

The trace amount of selenium now entering German Gulch is a real concern, but a major release of the leach pad at the containment dike would be catastrophic.

Thornborrow prioritized geotechnical research of the pit's highwall when he took over the project in 2019.

On Tuesday, he showed the working group why. One after another they stepped over a foot-high rift where the hillside is slowly creeping apart.

"That can go on like that for a long time. But when we're under maximum stress — high groundwater early in the spring, and no dewatering — if you get an earthquake on top of that, that's when you're going to have a failure of one of these parts," Thornborrow said.

It could happen directly along the fault where they stood, or in the weak clay layers nearby, he said.

"If one of those things fails, it causes the trigger in all the other parts of that slope, and that's when you get major movement," Thornborrow said.

Significant movement hasn't been observed in 20 or 30 years, Thornborrow said, but contractors started using light detection and ranging scans, or LIDAR, to map the area more precisely in the last couple years.

Understanding stability at the site will be key going forward with the new plan, Thornborrow said.

Then and now

John Fitzpatrick, the director of community and governmental affairs for Pegasus at the time, stood at the Beal Mountain pit in 1990.

“This may be the only mine in the world where the reclamation process began before the mining was finished,” he said.

On behalf of Pegasus, Fitzpatrick received a prestigious award of excellence from the Forest Service the year prior, in recognition of the company’s “commitment to developing an environmentally sound gold mine operation at the Beal Mountain Project.”

When the Forest Service took the project over from the bankruptcy trustee, the agency had to quickly build the reverse osmosis treatment system they use now. During construction, heavily contaminated water rose under the leach pad, hovering just below the critical level that would release it into German Gulch.

“We flipped the switch on just in the nick of time,” Thornborrow said.

Beal’s cleanup has been a long haul since, full of quick fixes, funding grabs, narrow misses, and occasional selenium exceedances.

The Forest Service inherited the building that houses the water treatment plant from the bankruptcy, and it’s a doozy. It becomes infested with mold and was struck by lightning. It’s a nightmare to clean the membranes from the tanks at the start of winter each year, when water leaks and freezes on the ground.

“This is just like a skating rink right here. And then some of that water is heated to help the cleaning process, so when you put that heated water in this cold steel box it's just condensation everywhere — it's pretty miserable,” Thornborrow said.

The situation will be rectified soon, he said. It was finally budgeted for.

Members of the technical working group for the Beal Mountain Mine site follow Sonny Thornborrow, project lead for the U.S. Forest Service, while he discusses geotechnical instability at the site Tuesday.

Michael Cast, The Montana Standard

The horizontal drilling solution is not a certainty. The concept is yet unproven on site, and members among the working group, including Gestring, are yet to rule out the possibility of a partial or full removal of a large waste rock area — an expensive undertaking.

But they're all in it together. Gestring commended the Forest Service on the job it has done so far. After all, the working group, local landowners and the agency are united in solving problems that affect everyone in the vast Upper Clark Fork watershed.

They're among the few to see the problems up close, they're making progress, but they're not out of the woods yet.

"Ignorance is bliss," Butori said. "There are plenty of people, if they saw what was happening, they would be very upset. The bottom line comes down to money. The bond put in place was not anywhere near enough to reclaim any of this stuff."

And while the former Pegasus executive continues to permit mines in Montana, the bankrupt company is nowhere to be found at Beal Mountain.

ATTACHMENT 19

PROJECTS

Wolfden Resources Corporation (WLF:TSXV) is a Canadian exploration and development compa
team that has a proven track record of precious and polymetallic deposit discoveries as well as mine
finance experience. The Company's mission is to create wealth for its stakeholders through the acqu
development of mineral deposits in an efficient and responsible manner.

Pickett Mountain, ME

Represents one of the highest-grade undeveloped massive sulphide deposits in North America.

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Rice Island, MB

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WOLFDEN'S PORTFOLIO OF PROJECTS INCLUDE:

Pickett Mountain, Maine USA

Rice Island Property, Manitoba

The Rice Island Ni-Cu-Co deposit is situated near infrastructure and the mining town of Snow Lake. 2015 to 2017 returned high-grade intersections of 12.4 metres grading 3.29% Ni, 1.32% Cu and 0.1 metres of 3.83% Ni, 1.33% Cu and 0.175% Co over 9.90 at the Main Zone. In addition a new discov referred to as the Lower Zone, returning 21.0 metres of 2.42% Ni, 1.28% Cu and 0.16% Co.

Nickel Island Property, Manitoba

The Property hosts known nickel-copper mineralization last explored by Inco Ltd. in the 1950's. Hist that time returned significant nickel-copper mineralization over a minimum strike length of one kilom highlights as 32.4 metres of 4.33% Ni over 4.50 metres and 1.18% Ni. Geological evidence suggest 'Kambalda-style' mineralization on the Property.

Tetagouche Property, New Brunswick

Located in the famous Bathurst Camp of northeastern New Brunswick, the Tetagouche Property (>2 contains 6 historic Pb-Zn-Cu-Ag massive sulphide deposits with excellent exploration upside. The P the bedrock source of numerous high-grade massive sulphide boulders that have traveled by glacial Property.

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COMPANY
Management and Directors
Strategy
Priorities
Corporate Governance
Careers

PROJECTS
Pickett Mountain, ME
Rice Island, MB
Nickel Island, MB

ATTACHMENT 20

High Country News

KNOW THE WEST

Summitville: an expensive lesson

Ray Ring | **Jan. 19, 1998** | *From the print edition*

Note: This article is a sidebar to this issue's feature story (https://www.hcn.org/issues/122/3876/view).

In mine reclamation, lessons are learned through failure. Nowhere has the failure been more spectacular than at the Summitville Gold Mine in southern Colorado.

The mine is being reclaimed now, but at a huge cost, borne almost entirely by people and companies that had nothing to do with the mine.

"This is the biggest mine reclamation paid for by Superfund," says Jim Hanley, the Environmental Protection Agency's project manager for the Summitville cleanup.

A Canadian company, Galactic Resources Ltd., ran the Summitville mine from the mid-1980s until 1992, when the company went bankrupt, leaving a cyanide heap-leach pond and other facilities that leaked pollution into the Alamosa River. The pollution killed fish and endangered farms that used the water for irrigation.

Galactic had posted a bond to help cover the cost of reclamation, but it didn't amount to much. Around the West, the bonding requirement varies from state to state. Colorado's Division of Minerals and Geology had required Galactic to post only $4.5 million. Worse, only $2.3 million was cash; the rest was in liens on the company's equipment.

So far, the cleanup has cost $120 million, with the total estimated to reach $150 million, not including lawyers' bills. Almost all the money has come from the Superfund, which is endowed mainly by fees on the oil and chemical industries.

At the mine, two adits that were draining have been plugged, waste piles have been capped, the pit has been backfilled, the tailings dam was enlarged, water treatment plants have been modernized and a new plant built - and still the site leaks some pollution. The cleanup continues.

Criminal charges have been pressed against two of the company's former executives, alleging violations of the Clean Water Act.

Meanwhile, the high-flying businessman who put the Summitville mine deal together and ran it for six years, Robert Friedland, denies responsibility and hasn't been charged. The criminal investigation continues, and EPA and the U.S. Department of Justice are pressing a civil court action against Friedland. Denver's Rocky Mountain News has dubbed Friedland the "King of Denial."

Friedland is famous for high-risk mining ventures, and continues to establish new mines in Canada, Africa and South America, some of which are reportedly earning him hundreds of millions of dollars.

"We'd like to get at least something from him" to help pay for the Summitville cleanup, says the EPA's Eleanor Dwight.

Learning the hard way, Colorado, whose agencies are also involved in the Summitville cleanup, has toughened its monitoring and bonding. The bond on a newer heap-leach mine near Cripple Creek has been set at a minimum of $40 million - all "real money," not liens - which, Hanley says, is "more realistic."

ATTACHMENT 21

January 18, 2023
File: 195602317

Attention: Tim Carr
Land Use Planning Commission
Department of Agriculture, Conservation, and Forestry
Harlow Building
18 Elkins Lane
Augusta, ME 04333

Dear Mr. Carr,

Reference: Wolfden Mount Chase LLC Application for Zone Change

On behalf of Wolfden Mount Chase LLC., Stantec Consulting Services is pleased to submit the attached Application for Zone Change for consideration of rezoning of approximately 374 acres in T6R6 WELS from General Management (M-GN) to Planned Development (D-PD). If rezoned and then ultimately approved by the Department of Environmental Protection under Maine's *Metallic Mineral Exploration, Advanced Exploration and Mining* regulations the rezone area would be used for development of an underground mining operation and associated structures. The purpose of the operation is to extract metallic ore that is rich in copper, lead, zinc, silver and gold. The proposed rezone area does not include facilities for ore concentration or tailings.

The document has been produced in a format that addresses the Land Use Planning Commission (LUPC) Chapter 10 and Chapter 12 regulations, including 27 Exhibits designed to provide the information that is required to support the proposed rezoning. In Table 2-2 of the Application, we have provided a matrix linking the applicable regulatory requirements to the relevant Application Exhibits.

Three hard copies are being submitted by hand delivery to your attention at Elkins Lane in Augusta. Please advise on how best to transmit an electronic copy compatible with State security and file size restrictions. In addition, hard copies are being posted via FedEx as follows:

- LUPC East Millinocket office – 1 copy;
- LUPC Ashland office – 2 copies; and
- Aroostook and Penobscot County Commissioners offices – 1 copy to each.

By separate transmittal Wolfden Mount Chase LLC is today submitting the Application fee ($14,350) and the Extraordinary Project Processing fee ($79,387.28).

Thank you for your attention to this submission. We look forward to working with the LUPC staff and Commission as you all undertake your review of these materials.

Respectfully yours,

Stantec Consulting Services Inc.

Brooke Barnes
Principal
Phone: 207 406 5461
Fax: 207 729 2715
brooke.barnes@stantec.com

Attachment: Application for Zone Change

c. Jeremy Ouellette, Wolfden Mount Chase LLC

EXECUTIVE SUMMARY

INTRODUCTION/LOCATION

Wolfden Mount Chase LLC is a wholly owned subsidiary of Wolfden Resources Corporation, a mining exploration and development company with specific interest in a high-grade poly-metallic mineral resource in T6 R6 WELS, Penobscot County, Maine, referred to as the Pickett Mountain deposit. The Pickett Mountain Project (Project) is a state-of-the-art proposal to mine zinc, lead, copper, silver and gold from this high-value deposit. These metals are used in a variety of applications such as cell phones, automobiles (including electric vehicles), electronics, low-carbon power generation, construction, and infrastructure. In 2017, Maine enacted the most stringent mining regulations in the nation. The Project will meet those requirements and showcase mining techniques that allow for responsible and safe extraction of metallic minerals that are key to our future.

This Application is part one of a two-step mining permit regulatory process. Part one requires rezoning the area of the underground mine from General Management (M-GN) to a Planned Development (D-PD) subdistrict. Part two is a full evaluation and permitting by the Department of Environmental Protection (DEP) under Maine's *Metallic Mineral Exploration, Advanced Exploration and Mining* regulations, Chapter 200. The purpose of the D-PD subdistrict is to allow a large-scale well-planned development that depends on a particular natural feature or location that is available at the site. To demonstrate the feasibility of the Project and compliance with applicable rezoning criteria, the Application includes data on the site and surrounding resources and uses, the anticipated economic impact of the Project, the processes and activities used in removal of metallic mineral ore from the site, the design of a water treatment facility to ensure that any discharges to groundwater will be at or below background levels, and other measures to ensure that the Project will not have an adverse impact on the environment or surrounding uses. The final design of the Project will occur after the required review and approval of baseline surveys by the DEP, with input from the public on the work plan for the surveys. Those baseline surveys are anticipated to occur over a period of two years.

A specific goal in the 2010 Comprehensive Land Use Plan (CLUP), which governs development in the unorganized and deorganized areas, is to "allow environmentally responsible exploration and mining of metallic and non-metallic mineral resources where there are not overriding, conflicting public values which require protection."[1] As described in the Application, the Project will not interfere with existing uses and will be operated in a manner fully protective of water and other natural resources. In addition to the significant indirect economic opportunities, it offers an estimated 272 high paying direct Project related jobs. It will also allow Maine to be a leader in showcasing responsible mining carried out in accordance with the strictest rules in the country, and in a manner consistent with the goals and policies of the CLUP and the rezoning requirements for a D-PD subdistrict.

[1] Comprehensive Land Use Plan, Chapter 1, Section 1.2.G, at p. 15.

2.5.3.1.2 Production Activities

The approach for mine production is to conduct underground mining with a decline and shaft to an estimated maximum depth of 2,700 feet. This will allow for underground haulage trucks and a hoist to carry rock to a surface staging pad, where waste rock will be segregated from ore. Ore will be trucked off-site to the concentrator facility. Rock of no value will be stored on the waste rock storage pad until it can be returned underground for backfill. A backfill plant located on the surface will be used to blend a binder with waste rock for backfilling mined excavations underground. Rock that is placed underground as backfill will be approved for use by MDEP. It is simply placed as rock fragments with or without the addition of binder (typically cement) to add strength.

Once productive areas in the mine are prepared, production miners will begin work with an estimate retrieval of ~1,322 tons (1,200 tonnes) per day of ore. The general sequence to be used during production activities will include:

- Blast hole drilling to place explosives for fragmentation of areas of mineralized ore;
- Blasting to fragment mineralized ore;
- Potential crushing and ore sorting if deemed economically viable;
- Haulage of ore and waste rock to the surface or other portions of the mine; and
- Backfilling of productive areas once fully excavated.

2.5.3.1.2 Backfilling and Source of Backfill Material

It is anticipated that voids created during the Project's mining activities can be back filled utilizing a combination of material removed as part of the mining process and off-site sources. Sargent Corporation (a Maine-based construction company) has reviewed the requirement for off-site material and has provided a conceptual borrow source identified in their proposal (see **Attachment 2-C)**. There is no intention of developing an on-site rock quarry for borrow rock material within the rezoned area of this application. Off-site material delivered to site for use as backfill will be delivered to the waste rock storage pad until it is consumed as backfill.

The addition of cement to the rock backfill as a binder provides improved strength to interior mine wall voids when multiple tunnels are located close to each other. The backfill plant is a batch mixing plant where cement is mixed in bulk with water and then blended with the rock backfill. When batches are complete, they are transported underground via low profile loaders and dumped into the void spaces that required Cemented Rock Fill (CRF). The Project plans to utilize reject water from the proposed water treatment plant for mixing of CRF or other concrete required for backfilling. See **Section 10.5.2 of Exhibit 10 – Surrounding Uses and Anticipated Impacts** for details on how this water will be utilized to support backfilling operations.

*The Project will provide for parking at the mine operations site and the transportation routes, described in **Exhibit 2 – Project Description,** would not adversely affect traffic circulation.*

c. Limiting the number and size of signs in order to prevent undue visual impacts or hazardous conditions.

The only signage visible to the public associated with the Project would be for transportation safety at the location where vehicles egress and exit from SR-11 to private roads.

Policy 2 Prevent the degradation of natural and cultural values resulting from cumulative impacts of incremental development.

The Project final design will be permitted through the MDEP, and efforts will be made to minimize impacts to the principal values of the jurisdiction, including avoidance and minimization of impacts to protected natural resources. Due to the location-specific nature of this mineral deposit, development of this Project will not result in incremental development.

9.3.3 Infrastructure

<u>CLUP Goal: Ensure that infrastructure improvements are well planned and do not have an adverse impact on the jurisdiction's principal values.</u>

The Project meets the CLUP's goal of ensuring that infrastructure improvements are well planned and do not have an adverse impact on the jurisdiction's principal values. These improvements will include upgrading existing gravel access roads located on private lands and the intersection of the private road with Route 11 for public safety purposes (see **Exhibit 21 – Public Roads).** The Project will also, separate from this application, establish a new power transmission service line to supply additional needed electrical power for the Project.

The power transmission route has been planned with Versant Power and would run from their substation located on Route 11, located approximately 0.6 miles south of downtown Patten, Maine. The transmission line would run north and northeast along Route 11 then follow the same gravel access road proposed for the mine for a total distance of approximately 11 miles. The access road upgrades to be considered in the design for the permit application submittal will be developed concurrently with the transmission line design. See **Exhibit 20 – Electricity and Communications.**

The Project is also consistent CLUP policies including the following items:

Policy 1 Consider the capacity of existing infrastructure and services to accommodate proposed development, as well as the costs associated with the provision of these services to proposed development.

It is Wolfden's objective that the primary workforce be employed locally from residents. This will require training for that work force since many unique skills are required of miners working underground. The mine will employ approximately 233 workers (employees and local contractors), composed of 91 shift the field include shallow bedrock conditions and areas with a seasonal high-water table. These soil limitations can be addressed through careful siting of Project infrastructure and use of site-appropriate engineering design and construction approaches. Further evaluation of soil conditions and the design of the Project's infrastructure will be part of the MDEP Chapter 200 permitting efforts. **Exhibit 23, Attachment 23-A Soil Suitability Evaluation for the Wolfden-Pickett Mountain Mine Rezoning Petition** further describes the analysis and results of desktop and field investigations. As noted in **Section 10.5.4**, during construction and operations phases of the Project, an Erosion Prevention and Sediment Control Plan will be utilized to control soil erosion and sedimentation. Through adherence to this Plan and consideration of the existing soil limitations, the Project does not anticipate any adverse impacts to soils.

10.5.1.2 Acid Rock Drainage

When mineralized rock is mined and processed, the surface area of exposed sulfide mineral increases along with the potential for acid generation. Undisturbed sulfide mineral deposits have limited exposed surfaces and, therefore, pose little threat to groundwater under natural, oxygen-limited conditions. Acid rock drainage occurs as a result of the oxidation and dissolution of sulfide bearing minerals and may generate low pH contact water. The Research Productivity Council Report (**Attachment 10-B)** details the results of analyzed rock samples from the Project Area and an assessment of the potential for existing rock to influence acid rock drainage from Project operations. Generally, non-mineralized rock outside of the Pickett Mountain mineral deposit (i.e., rock excavated during development) is non-acid generating and carries some neutralizing potential. Each sample collected greater than approximately 100 feet away from the mineral deposit had "Non-Acid Generating" results. Most of the infrastructure and mine development is planned in this area further than 100 feet from the mineral deposit for geotechnical considerations and this will significantly reduce the potential for acid rock drainage in contact waters. Three of the samples closest to the mineral deposit (bearing some sulfide minerals) were found to be potentially acid rock drainage producing, as expected.

Since the process leading to acid rock drainage requires the presence of both oxygen and water, as well as time, Wolfden will implement effective strategies to prevent acid generation into the design and operation of the mine. Within the Project Area, the potential sources of acid rock drainage are limited to mineralize rock from underground being temporarily stored on the surface. Although the mineral surface area remains small for broken rock material and the exposure of the rock material to water is short in duration before being removed from the mining site, the rock storage pads are designed within a water collection area. Rock pads will be lined to collect contact water from the material and then pumped to a storage pond and treated before being discharged (detailed further in **Section 10.5.2)**. This approach will remove potentially acid generating material and thereby remove the risk related to acid rock drainage.

10.5.2 Hydrology and Water Quality

The Project Area is characterized by relatively thin glacial deposits and overlying bedrock based on subsurface drilling conducted during Wolfden's mineral exploration activities. Except for the occasional rock outcrop or rock ridge, the entire Project Area is forested. Groundwater and surface water divides are expected to be controlled by topography and groundwater flow direction should mimic topography. **Figure**

The stormwater analysis completed by Wood (**Attachment 10-C**) has modeled anticipated seasonal volumes of precipitation in the Project Area that will need to be collected and stored in a Pre-Treatment Water Storage Pond (Pond). Water in contact with mineralized rock (ore, low grade ore, and waste rock) stored on lined pads will be collected in the Pond prior to treatment. The stormwater analysis also incorporates the need for additional collection and storage of 30 gallons per minute (gpm) of mine water (from mine dewatering) into the Pond. Pond sizing includes a contingency for increased runoff volume during a 500-year, 24-hour storm event in accordance with 06-096 Chapter 200: Metallic Mineral Exploration, Advanced Exploration and Mining. Based on current precipitation estimates and consideration for a 500-year storm event, the Pond volume was modeled to have a required capacity of approximately 6.87 million gallons with a minimum 2-foot freeboard. The conceptual location of the Pond and its approximate footprint of 3.25 acres is depicted on site plan drawings in **Exhibit 2 – Project Description.** Collected stormwater and mine water will be subsequently treated and tested at the Project's water treatment facility. Collected water will not be allowed to return to the natural environment prior to treatment.

Collected stormwater and mine water will be fed to the onsite water treatment plant at a calculated maximum rate of 200gpm and treated using a multistage approach. First, pre-treatment via ultrafiltration (UF) will occur to remove suspended solids and other particles down to 0.1 micron in size. Second, reverse osmosis (RO) membranes will be employed to remove remaining chemical constituents down to their atomic radii in size. RO can effectively remove contaminants from water and can produce pure water containing only water molecules. The use of UF and RO is well-established and used across multiple industries. Treatment plant reject water (i.e., water not meeting quality standards) will either be returned to the treatment plant for another round of UF and RO of or used by mine operations as a concrete mix for backfilling areas of completed excavation as a physically and chemically stable mixture. Untreated or contaminated water will not be allowed to return to the natural environment. Through this approach, the Project will satisfy Maine Chapter 200 and Title 38, Chapter 3 wastewater discharge requirements. The Water Treatment Scoping Study (**Attachment 10-D)** provides more background and literature on how UF and RO technology works along with details on the conceptual design of the treatment system presenting the various steps and anticipated treatment volumes.

After water has been treated by UF and RO and tested, WRAs will allow for treated and tested water infiltration back into the natural environment. The WRAs will be positioned upgradient of both wetlands and streams so that existing hydrology (replenishment of shallow or perched groundwater) is maintained (see **Attachment 10-E**). Based on the current available information, a combination of spray irrigation and snowmaking (WRSs) placed over the WRAs will provide suitable conditions to return treated water at the Project Area while maintaining wetland and stream hydrology at the site. Using these technologies, and application rates typical of similar projects at similar sites, it is currently estimated that the Project will require between 15 and 29 acres of land required for recharge. There are at least 60 acres of available area for WRAs that could be utilized for treated water disposition within the 374 acres proposed for rezoning. For the purposes of visualization, the Conceptual Site Plan displays an example footprint of 22 acres (the mean anticipated required area). The final size and locations of WRAs will be determined once detailed soil studies have been completed.

Human sewage generated from the underground mine operations will be contained to Portable Toilets (Porta Potties). These will be on contract basis and managed through replacement of filled facilities with clean facilities by the supplier. Grey and black waters generated from the surface facilities will drain to a typical state approved septic system located on the site down gradient of the building infrastructure and potable water supply. Sewage management is further discussed in **Exhibit 24 – Sewage Water/Wastewater Disposal**. No adverse impacts to hydrology and water quality are anticipated from the management of the Project's wastewater.

10.5.3 Aquifers

The Project Area is not located near a high yield sand and gravel aquifer nor a high yield bedrock aquifer. A medium yield sand and gravel aquifer has been mapped along the north shore of Pleasant Lake (approximately 1.5 miles from the Project Area) with indicated yields >/= 10 gpm. The yield of the residential well on the south side of Pleasant Lake is reported as >/= 8 gpm. It is assumed that all seasonal residencies have private water supplies (wells), though this has not been confirmed. There are no other known private or public water supplies within a 3-mile radius of the site. **Figure 10-4** depicts these features in addition to inferred surface water divides and groundwater flow direction in the vicinity of the Project Area.

The Project's water treatment approach (see **Section 10.5.2.1**) is designed to treat mine process and stormwater and remove chemicals to meet background levels prior to its return to the natural environment. Treatment of water will occur through a combination of ultrafiltration and reverse osmosis. Additionally, the control of volume and location of these water releases will be designed to maintain existing rates of flow and percolation through the Project area's existing soils. As a result, the Project does not anticipate any adverse impacts to the quantity or quality of water received by local aquifers.

10.5.4 Wetlands/Streams/Waterbodies

Within 3 miles of the Project Area, the U.S. Fish and Wildlife Service (USFWS) has mapped wetlands in T6R6 WELS as a part of the National Wetlands Inventory dataset. LUPC Land Use Guidance Maps have incorporated National Wetlands Inventory mapped wetlands and are displayed in **Exhibit 6, Figure 6-1**. Within the Project Area, a formal delineation of wetlands, streams, and potential vernal pools (PVPs) in the Project Area was completed in June 2022 to supplement previous delineation efforts. Twenty-nine wetlands, 27 watercourses, and PVPs were identified during these surveys. Further information on the delineated wetlands, PVPs, vernal pools previously delineated, and representative photographs are in **Exhibit 6, Attachment 6-A Wetland and Watercourse Delineation and Potential Vernal Pool Survey Report**. The eastern shoreline of Upper Shin Pond, Pleasant Lake, Mud Lake, Huntley Duck Pond, Pickett Mountain Pond, Grass Pond, Tote Road Pond, Bear Mountain Pond, Hale Pond, and Green Pond are located within 3 miles of the Project Area (**Figure 10-1).**

Mine infrastructure in the Project Area will be sited at least 75 feet away from delineated wetlands, streams, PVPs, and vernal pools to avoid direct impacts to these resources during construction and mine operations. An Erosion Prevention and Sediment Control Plan will be developed for the Project to provide a strategy for controlling soil erosion and sedimentation during and after construction. This plan will incorporate the standards and specifications for erosion prevention for development projects contained in

ECONOMIC ASSESSMENT OF THE PROPOSED PICKETT MINE PROJECT

In February 2021, Wolfden Mt. Chase LLC (Wolfden) retained Stepwise Data Research, an economic consulting firm based in Yarmouth, Maine, to provide a comprehensive socioeconomic analysis of Wolfden's proposed Pickett Mine Project (Project) proposed for T6 R6 in northern Penobscot County. This analysis is intended to meet the requirements of the Land Use Planning Commission (LUPC) specific to rezoning for Mining and Level C Mineral Exploration Activities in Chapter 12 of the LUPC Rules and as further informed by previous consultation with LUPC staff and LUPC's third-party economic expert. Section 1 of this report provides baseline statistics on the current socioeconomic conditions of the region surrounding the proposed Project. Section 2 quantifies the economic impact of the proposed Project in terms of jobs, earnings, and output. Because the Project's economic impact will be felt regionally, this section reports the economic impact for the entire Project, including both the mine located in T6 R6 and the concentrator and tailings facility which will be located in at a remote location. Section 3 provides a qualitative assessment of several other potential economic impacts related to the Project's operations. Section 4 is a detailed appendix including baseline economic statistics and a description of the methodology used for the economic impact analysis.

1. Socioeconomic Conditions of the Pickett Mine Project Region

Key Findings

This section of the report presents information on the current socioeconomic conditions of the region surrounding the Project. The statistics reveal a sparsely populated region with limited economic activity and an aging population. Local wages trail the state average by 20-30% and poverty rates exceed the state average, particularly among children. In a place that once led Maine's manufacturing sector, the percentage of jobs in this field now trails the state average. The decline of the former Great Northern Paper mills in Millinocket and East Millinocket, which once employed thousands, has clearly hurt the local economy and no other large businesses have located here to take their place.

Data Sources

Most of the statistics in this section of the report come from the U.S. Census Bureau's American Community Survey and are five-year estimates for 2016-2020. Results from the 2020 Census are utilized for demographic data. Except for the decennial census, five-year estimates are the most reliable source of detailed information on communities with populations under 65,000. Combining five years of survey results reduces the margins of error for statistics on small populations, while creating a more current snapshot of socioeconomic conditions than provided by the decennial censuses. Estimates for labor market areas (explained below) are aggregations of estimates for the municipalities and unorganized territories located within them. Where appropriate, these aggregations are weighted averages that account for the varying size and composition of the communities within each labor market area (LMA). See appendices for additional notes and data sources.

Table 2
Acid Base Accounting Results on Wolfden Samples

Sample ID	Paste pH	Total Sulfur	Sulfate† (as S)	Sulfide	Carbon Total Inorganic	Carbon Total	Acid Production Potential	Neutralizing Potential pH 8.3	Net NP pH 8.3	NP/AP
		%	%	%	%	%	Kg $CaCO_3$/tonne			
ABA-001	9.5	0.124	0.009	0.114	0.15	0.21	3.8	17.4	13.6	4.6
ABA-002	9.4	0.021	0.005	0.016	< 0.01	< 0.01	0.5	5.5	5.0	11.0
ABA-003	8.3	2.70	0.008	2.69	< 0.01	< 0.01	84.1	1.7	-82.4	0.0
ABA-004	9.7	0.262	0.002	0.260	< 0.01	0.02	8.1	3.7	-4.4	0.5
ABA-005	9.7	0.085	0.002	0.083	0.05	0.07	2.6	8.5	5.9	3.3
ABA-006	8.9	0.926	0.003	0.923	0.05	0.08	28.8	7.7	-21.2	0.3
ABA-007	9.3	0.005	0.003	0.002	0.01	0.04	0.1	8.2	8.1	131

† Acid soluble, non-volatile sulfur species (sulfate (as S)).
Sulfide was determined as the difference between Total Sulfur and Sulfate (as S).

The Total Inorganic Carbon analyses seen in Table 2 indicated that the inorganic carbon content was low over all 7 samples (ranging from <0.01 % to 0.15 % in the Wolfden samples). In addition, the Total Sulfur contents of the 7 samples were also relatively low (see Table 2), ranging from 0.005 % to 2.70 % in the ABA-003 sample.

As seen from Table 2, four of the Wolfden samples obtained positive Net Neutralizing Potential values with NP/AP ratio values (ratio between Neutralizing Potential and Acid Production Potential) above 2.0. This indicated that these specific samples were not net acid producers. On three of the Wolfden samples the Net Neutralizing Potential values were negative, and the NP/AP ratio was less than 1.0, indicating that these were potentially acid producing. These samples were as follows:

- ABA-003
- ABA-004
- ABA-006

It is recommended that a specialized consultant be contacted for the full MEND Report 1.20.1 analysis and interpretation prior to follow up with the regulatory agent.

Multi-Element Assay of Solids Results

Whole rock analyses as well as ICP multi-element analyses were conducted with the results reported in Table 3 to Table 4.

conditions and develop stormwater controls. HydroCAD® by Applied Microcomputer Systems, Inc, a stormwater modeling software which uses the TR-20 method, combined with the standard hydraulic equations, was used to for development and evaluation of the stormwater models and drainage systems.

The design for the collection, storage and treatment of surface water runoff from the identified mine facilities is based on the following design parameters and assumptions:

Pre-Treatment Pond Sizing:

- Peak Pond Storage Design Storm: Total runoff volume from a 500-year, 24-hour storm event in accordance with 06-096 Chapter 200: Metallic Mineral Exploration, Advanced Exploration and Mining. Using precipitation data taken from NOAA Atlas 14, Volume 10, Version 3, the 500-year, 24-hour is 7.82 inches of precipitation for the mine site (Attachment 2).
- Mine Dewatering: A base water flow of 30 gallons per minute (gpm) from dewatering the mine is included in the total volume of water to be collected and stored for treatment. Seepage of bedrock water as well as the use of water during the mining process, necessitates constant mine dewatering. Although engineering/hydrologic studies have not been conducted to quantify flow rates required to keep the working areas of the mine in a dewatered state, it is currently estimated based on similar site experience and the likelihood of low transmissivity bedrock at depth, that these “seepage “flows are likely to be on the order of 30 gallons per minute (gpm) long term.
- For the Pre-Treatment Water Storage Pond sizing it is assumed that no discharge from the pond for treatment occurs during the design storm event.
- A minimum 2-foot freeboard from the stored water elevation to the top of the pond berm/embankment was used for calculating the required Pre-Treatment Water Storage Pond volume.

Peak Monthly Treatment Volume:

- Average Monthly Precipitation: Average monthly precipitation data was obtained for Patten, Maine from the U.S. Climate Data website (Attachment 3). The monthly precipitation was input into the HydroCAD® model to get an estimated monthly runoff volume.
- The monthly runoff volume was adjusted using an estimated factor for seasonal temperature affects to account for ice and snow precipitation that buildups in the winter months and then melts in the early spring months. The temperature/seasonal adjustment factors were estimated by reviewing historical mean daily discharge data for a gauge located on the Seboeis River located approximately 8.5 miles west of the mine site (Attachment 4). The discharge data shows a significant increase in stream flow for the months of April and May.
- The estimated monthly runoff volume for the months of April and May were increased by a temperature/seasonal adjustment factor of 2.3 and 1.6, respectively to provide an estimated typical peak monthly runoff volume for treatment.
- The monthly runoff volume includes the 30-gpm mine dewatering volume.

3.0 RESULTS

The HydroCAD® model provides the following results for the Pre-Treatment Pond storage volume and the typical monthly treatment volumes:

Pre-Treatment Pond Storage:

Water Treatment Plant Waste Water Management

The proposed treatment plant will produce, at peak flow, 5 USGPM of wastewater which will be directed to the Pre-Treatment Water Storage Pond within the Pickett Mountain Site. Wastewater will be stored until backfill production commences and will then be used to prepare cement to be utilized for backfill placement underground as a means of ground stabilization. Annual water treatment requirements for the Pickett Mountain Site are projected to be 43.73 million gallons which equates to an average water treatment plant permeate production rate of 83.2 USGPM (utilizing 365 days per year plant operation) during production. Wastewater production from the plant at this treatment rate will be 2.13 USGPM or 3,072 US gallons per day based on the Wood PLC Engineering study cited above.

Backfill production is based on the use of cemented rock fill with an anticipated fill placement rate of 6.6 tons per day of rock placement and 5% cement binder content. Daily water requirements for cement preparation are estimated to be 6,340 US gallons. Daily wastewater production from the UF RO plant is projected to be 3,072 US gallons. This means that all wastewater generated from the RO plant can be used for cement production during production.

Reagent Use and Final Disposition

Various chemical reagents are employed to treat the various membrane systems for scale and deposit control as well as required periodic cleaning. While cleaning frequency can't be determined until the plant is in actual operation MWS's experience with UF RO plants treating similar quality water indicates that cleaning frequency will likely be less than monthly and more likely quarterly for first stage UF and first and second stage RO. Cleaning frequency for the brine recover UF (UF 2) and RO will be slightly more frequent due to the nature of the water being treated at this stage of the process however anticipated frequency would still be not more than monthly. All chemicals are applied to the influent side of the UF and RO system and therefore report to the wastewater side of the process. In all cases, the reagents do not represent a hazard for downstream use of wastewater in the Pickett Mountain operations. The anticipated maximum consumption of reagents that will be utilized in operation of the plant are outlined below in Table 6.

Typically, mining projects are funded through a combination of project debt and equity. For small mining companies, the equity portion of the project financing is usually raised through several share issuances as the project completes the principal milestones as those listed above, such as the 1) full Feasibility Study with a positive outcome; 2) mine permitting approvals; 3) approval of a project debt facility with a lead financial arranger; and 4) positive results from any ongoing exploration that indicate the potential for additional resources. Project debt facilities are provided by lenders who are sophisticated and experienced with the mining sector. Wolfden's management and board members have experience in all facets of mine project financings as founders and executives of other junior and senior public mining companies, in challenging locations.

Wolfden's two largest shareholders (Kinross and Altius) are larger mining companies with the excess financial capacity to finance the construction of the Project. Kinross is considered to be one of the largest international gold mining companies and the owner of the Fort Knox mining operation in Alaska. Altius, is a primarily a royalty company that participates in project financing and share ownership of companies with high quality assets. As the company progresses through the permitting process, it is likely to become more attractive to other larger producing mining companies with a focus on North American high-grade mineral deposits. In summary, financing for the project will take place through a combination of equity raises, short term and long-term debt facilities or a joint venture with a larger producer. The PEA (**Attachment 14-A**) demonstrates the financial viability of the project.

14.4 FINANCIAL ASSURANCE TRUST FUND

Unlike other forms of development, the Chapter 200 rules provide additional protection and ensure that funds are available to fully reclaim the site and address any corrective action. Specifically, Chapter 200 requires the applicant to provide financial assurance in an amount sufficient to cover the cost for the DEP to administer and hire a third-party to implement all necessary investigation, monitoring, closure, post-closure, treatment, remediation, corrective action, reclamation, operation and maintenance activities under the environmental protection, reclamation and closure plan, including the cost to respond to a worst-case catastrophic mining event or failure (06-096 CMR 200 4.17). The form and the amount of the financial assurance must be reviewed by an independent third-party expert, and Wolfden must deposit the required financial assurance in a trust fund (the "Financial Assurance Trust Fund") prior to issuance of a Chapter 200 permit. (06-096 CMR 200 4.17.D) The financial assurance requirements ensure that the mine facilities in T6 R6 will be fully reclaimed, and that there are sufficient funds to cover any corrective action, irrespective of Wolfden's financial strength and without taking into account operating revenue.

The PEA (**Attachment 14-A**) takes into account the requirements to establish the Financial Assurance Trust Fund, in an amount sufficient to cover both the mine in T6 R6 as well as the processing and tailing facilities that will be located outside of T6 R6. That analysis demonstrates that the financial assurance trust fund does not adversely impact the financial practicability of the project.

A summary of the expected parameters used for the financial analysis is presented in Table 1.6.

TABLE 1.6
CASHFLOW MODEL INPUT PARAMETERS

		Average Mill Head Grade:	Payability	Average Long Term Pricing
Undiluted Mineral Resources ~50/50 Indicate & Inferred	4,471,000 tonnes at grades of 9.51 % zinc, 1.23% copper, 3.77% lead, .88 g/t gold and 98.67 g/t silver			
Estimated Mining Dilution	10% at 0 grade			
Projected Mining Recovery	85%			
Zinc %		8.56	0.85	$ 1.15
Copper %		1.11	0.95	$ 3.00
Lead %		3.40	0.95	$ 1.00
Gold g/t		88.80	0.95	$ 1,500
Silver g/t		0.79	0.93	$ 18.00
Pre Production Capital, incl Working Capital	$ US 147.4 million			
Total Sustaining Capital	$ US 100 million			
Financial Assurance Trust: Reclamation & Closure	$ US 13.7 million			
Royalties	None			
Estimated Operating Costs ($/Tonne)	$ US 93.08 /tonne			
Life of Mine	9.7 years			

1.9 Sensitivity Analysis

Sensitivity analyses were performed for metal prices, capital expenditures, operating costs, mined grades, smelter charges, and recoveries with ranges up to 20% positive and negative variations. The project is most sensitive to changes in metals prices and reasonably sensitive to changes in all the other variables.

The NPV and IRR sensitivities to variations in key parameters are depicted graphically in Figure 1.2 and Figure 1.3. The IRR is most sensitive to variations in metal prices and mined grades and less sensitive to capital and operating costs.

TABLE 21.8
PROJECT SUSTAINING CAPITAL REQUIREMENTS

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
Underground Development	$15,533,815	$15,236,152	$9,381,831	$8,453,491	$8,535,734	$4,734,586	$1,468,628	$1,468,628	$1,174,903
Mine Facilities and Equipment	$4,417,577	$1,794,115	$809,788						
Mine Equipment Leasing and Remanufacturing	$3,175,078	$3,175,078	$3,175,078	$2,187,648	$2,187,648		$1,376,923		
Tailings Storage Facility	$247,860	$1,226,081	$1,629,618	$1,226,081	$1,629,618	$1,226,081	$1,629,618	$1,226,081	$1,629,618
	$23,374,330	$21,431,426	$14,996,316	$11,867,220	$12,353,001	$5,960,667	$4,475,169	$2,694,709	$2,804,521
Total Sustaining Capital	**$99,957,359**								

The tailings storage facility is planned to be constructed in phases, with five roughly equal-sized cells constructed sequentially and progressively reclaimed after each cell is completed. The construction and reclamation costs have been split evenly in 5 phases for this cost estimate; however, realistically, these costs would be greater for initial construction and final closure, and less during the intervening years of operation.

21.1.11 Financial Assurance Trust – Reclamation and Closure Costs

The Financial Assurance Trust fund, required by MEDEP, is included as capital cost in Year (-2). The total cost for the Financial Assurance Trust used in the PEA is $13,684,557. This considers a present value from future costs at a discount rate of 2% based on standard federal rates and does not include any salvage value for assets at closure.

The reclamation and closure costs include the cost for the closure of the last remaining TMF cell is $1,226,081 (SLR). As outlined in Section 21.0, the cost for the closure of all other TMF cells is included in the TMF capital cost line item. The cost for building demolition, remaining mine backfill, and site grading/re-vegetation was developed by AMPL, and is estimated at $2,200,000, $600,000, and $978,393, respectively. The total reclamation and closure cost (approximately $5,000,000) for these elements will be paid for through salvage income following the cessation of mining. Salvage income is expected to be in the range of $5,200,000. The income for the salvage component of mine closure and reclamation has not been included as part of the financial analysis in this PEA; therefore ,the cost for reclamation, which will be funded by the revenue stream, was not included as a line item cost. The salvage revenue should be factored and reflected in the next technical study – preliminary feasibility study.

21.2 Operating Cost Estimates

21.2.1 Basis for Estimates

Operating costs are based on U.S. and other country normal prices from suppliers and other similar type projects, for consumables and parts. The cost of power is based on online posted rates for the State of Maine.

Critical operating cost components are based on the following costs:

- The diesel fuel price is assumed to be US$0.80/litre.
- The electrical power cost is assumed to be US$0.085 per kWh.

Labour costs for the operating period are based on the manpower schedules presented for each department and the associated labour costs. The costs include a burden component of approximately

25.0 Interpretation and Conclusions

The Pickett Mountain deposit is a typical volcanogenic massive sulphide deposit, with upper quartile grades. The deposit lies near the top of a variably altered, generally fragmental, felsic volcanic sequence with evidence of at least two periods of hydrothermal activity and base metal deposition. Two lenses of massive sulphide, West and East Lenses, comprise the Mineral Resource. The two sulphide lenses are separated by a short strike length zone of Z-folding, which results in a 50m to 80m horizontal displacement where fold-repetition of the massive sulphide lenses have been observed.

In addition to the East and West Lenses, a high-grade lens of footwall massive sulphide mineralisation (FW Zone) was discovered, approximately 150mstratigraphically below the East Lens. Interpretation of geology indicates that this FW Zone can traced along strike and is open both along strike and up plunge. More testing of this horizon is required.

This PEA has identified a diluted mineral resource of 4.2 million tonnes at 8.56% Zn, 1.11% Cu, 3.4% Pb, 0.79 g/t Au, and 88.8 g/t Ag. This resource is comprised of 50% Indicated Resources and 50% Inferred Resources. It should be noted that the Inferred Mineral Resources are considered too speculative geologically to have economic considerations applied to them that would enable them to be categorised as Mineral Reserves. Therefore, there is no guarantee that the economic projections contained in this PEA would be realised.

The deposit would be mined by underground mining methods with metals extracted in a processing plant custom built for the purpose. The mine site infrastructure facilities would be minimised but include a processing plant, small surface shop, warehouse, office complex, water treatment facility, dry stack tailings facility, and transformer and power distribution. Water for the project is assumed for this study to be provided from a well(s) near to the Project, initially, then mainly recycled within the project site.

The mine would operate at 432,000 tonnes per annum and produce $1.36 billion in cash flow during the life of the mine.

Based on the study results, the conclusions of AMPL are:

1. The project provides positive returns based on the parameters and metal prices used in this study and should be developed further with the aim of bringing the deposit to production.

2. The proposed project would be considered a small- to medium-sized underground mining operation, which can be developed for production at a reasonable cost in a near-term horizon, provided regulatory approval and permits are acquired.

3. The mined grade of potentially economic mineralisation is an important variable for the success of the operation as are operating costs. Operating management efforts during mine production must be focused on these parameters.

4. The scoping level test work has indicated that a sequential flotation process will produce marketable-grade copper, lead, and zinc concentrates. Arsenic and antimony levels were high in copper concentrates produced in open-cycle and locked-cycle tests. Additional geo-metallurgical test work will provide additional information on the impurities in the marketable-grade copper concentrate to determine if penalties need to be paid. In addition, blending of ores from different areas in the mine will keep impurities (As/Sb) below penalty levels.

21.5.2 Ore and Concentrate Transport Traffic

Ore trucks will be 32,000-pound (empty truck weight) semi-tractor trailer dump trucks, with a loaded weight of 80,000 pounds (48,000-pound payload). The mine will generate approximately 55 round trips per day between the mine and the concentrator/TMF. Shipping of ore via trucks will only occur during daytime hours with a preference to utilize private roads. Concentrate transport trucks going to market will have similar empty and loaded weights to the ore haul trucks. The TMF will generate approximately 11 round trips per day by trucks travelling to and from market on public roads.

21.6 SUFFICIENCY OF EXISTING ROADS

21.6.1 Private Roads

Existing private gravel roads are currently in good condition and have been well maintained for logging operations conducted on and around the Project Area. Appendix B of **Attachment 21-A** details the results of the field assessment completed by Wood engineers to assess the adequacy of the existing private roads for mine-related vehicles. Engineers determined that with a few routine improvements the roads will function adequately for the Project.

21.6.2 Public Roads

Route 11 and SR-158 are the two primary public roads that ore trucks may travel on between the mine and concentrator/TMF, and for concentrate transport. Route 11 is characterized by rolling hills ranging in elevation from approximately 485 to 955 feet MSL. Posted speed limits on Route 11 ranges from 50 MPH to 35 MPH. SR-158 has gradual slope from approximately 542 to 490 from west to east with a posted speed limit of 35 MPH. Each road typically has an approximate 11 feet wide travel lane with 3-foot shoulder in both directions. Some portions of both Route 11 and SR-158 have three lanes. Roads are in good to fair condition and include several bridge crossings; and intersections along state routes have good turning radiuses.

Average Annual Daily Traffic (AADT) presented on the MDOT website ranged from 620-2848 along Route 11 and 3090 AADT for SR-158 in 2021. Eight crashes were reported from 2018-2021 along Route 11 and the short section of SR-158 to access ramps at I-95, according to MDOT Crash Portal. The Level of Service is A (light & free flowing) on all state roads within the route. State roads allow for up to 88,000 lbs for 5 axel configurations of unconsolidated rock material. The increase in ore truck, commuter vehicles, delivery vehicle and concentrate truck trips per day as noted in **Attachment 21-A** is minor compared to current volumes and well within existing capacity of public roads to be utilized for the mine operations.

21.7 IMPROVEMENTS TO PRIVATE AND PUBLIC ROADS

21.7.1 Private Roads

To support safe travel of additional traffic, road widths will be expanded to meet MDOT Standards along with some additional clearing of up to 10’ on each side of the roadway in areas where visibility is constricted.

facility and then trucks carrying the mineral concentrate to the US – Canadian border, the level of additional traffic, potential impacts and potential improvements to promote safety. The proposed route is dependent on the final locations where the ore processing will occur as well as where the mineral concentrate will be shipped for further processing (smelting) in Canada. These processing locations have not been finalized and therefore the proposed routes could be subject to change.

2.1 TRANSPORTATION NEED

The proposed mining activity has an anticipated mill feed rate of 1,200 tonnes/day (2,645,547 lbs.) that will require shipment for processing and concentrating at an offsite facility. Typical tractor trailer tare weights (empty weight including driver and fuel) vary and range from 26,000 to 37,000 lbs. Using an average of 32,000 lbs. tare weight allows 48,000 lbs. for cargo; requiring approximately 55 ore shipments per day. With anticipated metal recoveries, total concentrate yields will be approximately 192 tonnes/day (423,288 lbs.) of concentrate for shipment for smelting. Using an average of 32,000 lbs. tare weight allows 48,000 lbs. for cargo; requiring approximately 11 concentrate shipments per day.

Roads within the area will also be used for employee travel to and from the mine site as well as all supply vehicles and contractors.

2.2 POTENTIAL TRANSPORTATION ROUTE OPTION DESCRIPTIONS

Three potential proposed ore processing locations are being considered, including a location in Hersey (Hersey Option), a location in Patten (Patten Option), and a location in Stacyville (Stacyville Option). The ore processing facility location will be selected at a later date, however the transportation routes for the ore rock and mineral concentrate haul trucks for the three potential locations are discussed below. The proposed truck route consists of gravel roads on private property from the Pickett Mountain site to public roads that include rural town and rural state highways, and a US Interstate Highway (See **Figures 21-1 and 21-2 in Attachment A** for traffic routes for each option).

Hersey Option:

From the Mine Site, ore rock trucks will travel on private gravel roads to Maine (ME) State Route 11 (ME SR-11), hence south-southwest to Hersey to an ore processing and concentrator facility. The location of the ore processing facility in Hersey is still to be determined. Trucks carrying mineral concentrate from the process facility will continue to travel south on ME SR-11 to ME SR-159 in Patten. Trucks carrying mineral concentrate will travel east on ME SR-159 to an access ramp to I-95 in Island Falls traveling northeast to Houlton and the Canadian-US border and proceed to the Canadian National Highway in Woodstock New Brunswick (see **Attachment A Figure 21-1** for this traffic route). These roads are more specifically described below:

- Approximately 4.4 miles of gravel roads (consisting of an unnamed road, Pleasant Lake Road, Bear Mountain Road, and Hale Pond Road). Elevations from the Pickett Mountain site to Maine (ME) state route (SR)-11 drop from approximately 1205 to 852 feet mean sea level (MSL) from west to east.
  - Existing gravel roads are currently in good condition, and well maintained for logging operations conducted on and around the property. An agreement is in place with land owning neighbors to allow right of way using this set of gravel roads outside of the Wolfden property boundary. Confirmation of the right of way is in the form of a letter within this

ATTACHMENT 22

S242

REPORT 80701/1

OPINION OF TECHNICAL AND ECONOMIC ASPECTS OF WASTE MANAGEMENT BALD MOUNTAIN PROJECT

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AUGUST 1990

8.0 MINE WATER TREATMENT AND DISCHARGE ALTERNATIVES

8.1 Introduction

From the preliminary water balance calculations presented in a report by Barr Engineering Co., 1987, the average daily flow of mine water requiring treatment was estimated at 35 USgpm. The report indicated that the estimate could increase by an order of magnitude. A more recent study by Barr Engineering Co. concluded that, under "average" precipitation conditions, an excess of approximately 106 gallons per minute would occur in the tailings impoundment during operation (Barr Engineering Co., 1988). Due to the potential variability in the mine water flows, further flow estimates have been generated through development of a tailings impoundment water balance, as described in Section 7.0. The results obtained from the water balance calculations indicate a significant increase in the anticipated excess mine water flow. The recalculated excess mine water flows after year 3 of operation, under average precipitation conditions, range from 294 to 720 USgpm with an annual mean of 490 USgpm at 70% recycle of process water, to 92 to 363 USgpm with a mean of 180 USgpm at 90% recycle. The increase in mine water flows has a dramatic impact on the cost and viability of the proposed discharge and treatment options. It may be possible to achieve discharge requirements to between 0 and 260 USgpm at 90% recycle of mill water and enhanced evaporation of 100 USgpm. However, further analysis is necessary to validate these calculations.

With regards to discharge of treated mine water, two scenarios have been advanced. The first involves discharge of treated mine water into either Bald Mountain Brook or an upper reach of Clayton Stream. The second scenario involves land application of treated mine water through spray irrigation. Both the brook and stream are classified Class A according to the State of Maine water quality regulations. According to surveys conducted by Woodward-Clyde Consultants (1982) and Normandeau Associates (1990), both potential surface water receiving systems contain well established invertebrate and reproducing brook trout populations. The water quality of the local surface and groundwater are excellent, with very low levels of metals, hardness, dissolved solids, and nutrients noted in a study conducted by Woodward-Clyde Consultants (1982).

8.2 Surface Water Discharge

Due to the sensitivity of the fishery and the low background levels of hardness and metals, instream criteria associated with the surface waters are very stringent. The State of Maine recently promulgated numerical water quality criteria based on values presented in the USEPA Gold Book (USEPA, 1986) and a hardness of 20 mg/l as $CaCO_3$. The values presented in Table 8.1 are taken from an earlier report prepared by Normandeau Associates, 1990. The numerical criteria are very low, particularly in the case of silver, copper, cadmium, mercury, lead, and zinc.

TABLE 8.1
Selected EPA "Gold Book" Water Quality Criteria* Versus Detection Limits Reported By Woodward-Clyde Consultants(1982) and USGS(1989).
(After Normandeau Associates Inc., 1990)

PARAMETER	ACUTE TOXICITY LIMIT mg/l	CHRONIC TOXICITY LIMIT mg/l	REPORTED DETECTION LIMIT RANGES mg/l
Ag	0.00025	0.00012	0.001-0.10
Al	0.950	0.200	0.09-0.10
As	0.390	0.190	0.001-0.005
Cd	0.0006	0.0003	0.0001-0.005
CN	0.022	0.005	0.010-0.060
Cr VI	0.016	0.011	0.001-0.010
Cu	0.004	0.003	0.001-0.005
Hg	0.002	0.000012	0.0002-0.060
Ni	0.363	0.040	0.001-0.005
Pb	0.011	0.0004	0.001-0.005
Zn	0.030	0.027	0.001-0.010

*Assumes hardness of 20 mg/L

Assuming a mean flow in Bald Mountain Brook of about 335 USgpm, an annual mean low flow for upper Clayton Stream of about 1,800 USgpm, and mean average annual discharge flows ranging from 225 to 598 USgpm, depending upon the degree of recycle, the estimated dilution factors range between 0.5 and 1.5 in Bald Mountain Brook and between 3 and 8 in Clayton Stream. Through development of a more detailed site water balance and application of a controlled hydrograph release system, the dilution factor could increase significantly. In conjunction with dilution, completion of a site specific analysis could yield alternative instream criteria greater than the background water quality, but still protective of the local ecosystem.

The anticipated increase in mine water flows limits the available dilution significantly, and discharge to Bald Mountain Brook is not a viable option under present conditions. Discharge into upper Clayton Stream would require very high levels of treatment efficiency, even though there is increased dilution. It is not probable that the proposed treatment systems (as discussed in Section 8.4) would provide an effluent of acceptable quality to allow discharge into either the stream or the brook, unless reduced instream criteria can be obtained. Development and acceptance of site specific criteria may still not yield achievable end-of-pipe effluent limitations, due to the limited dilution.

The controlled hydrograph release approach involves discharge of treated mine water at such a rate as to maintain a specified minimum dilution based on continuously gauged stream flows. Precedence for the approach in the State of Maine is not known at this time. The approach is utilized in conjunction with industrial discharges in other states (i.e., South Carolina). The surface water discharge option into Clayton Stream is probable only if the above conditions of reduced instream standards can be satisfied and the approach is accepted by the State. The site specific approach will involve additional studies including further stream surveys and specific toxicity tests. At a minimum there would be a requirement for modification of existing instream criteria, development and acceptance of a controlled hydrography release system to maximize dilution, implementation of advanced or tertiary mine water treatment, and adherence to a stringent mine water balance. A detailed engineering and a scientific study would be necessary to verify the validity of these approaches.

8.3 The Land Application Option

The second discharge option involves land application of treated mine water through spray irrigation as discussed by Barr Engineering, 1987. Through a detailed study of the land application option it has been determined that suitable soils exist for percolation of the mine water (Woodard and Curran Inc., 1989). Treatment of the mine water prior to application would be required. The results of the geochemical evaluation included in the study indicates that the cation exchange capacity of the soil could supply the sorption necessary to remove the residual constituents and minimize the potential for groundwater contamination, the primary concern associated with land application. Of secondary concern is the accumulation of undesirable levels of constituents in the native vegetation.

There is precedent for land application of both industrial and municipal wastewaters in the State of Maine. However, the characteristics of the mine water are different from those of other wastewaters and more detailed evaluations of chemical and physical attenuation mechanisms are needed. With regards to land application of treated mine waters, there are permitted and operating systems existing in other states, such as Montana.

The success of the land application option is related to the effluent criteria established by the State of Maine and the volume of mine water requiring disposal. The Barr Engineering report suggested either drinking water standards or background water quality as possible effluent standards. From a review of the anticipated mine water characteristics, it is not probable that treatment to background levels is achievable. Treatment to drinking water standards is not acceptable since the aquatic life criteria are more stringent for several of the parameters of concern.

The preferred approach is to establish effluent limitations on the basis of probable soil attenuation and protection of groundwater. At this point in time, the acceptability of the approach and the probable selection of effluent limitations have not been addressed with the State of Maine.

If the land application approach proves viable based upon derivation of suitable effluent limitations, it would be necessary to provide storage for treated or untreated mine water for up to six or seven months. Storage of untreated mine water would dictate a significant increase in the capacity of the treatment system, since the total volume of mine water must be treated and discharged in about 50% of the time. Based upon the estimated range of daily mine water flows (i.e., 92 to 720 USgpm), the volume of storage required ranges from 20 to 190 million gallons. This approach would require storage capacity within the tailings impoundment or construction of a large lined mine water holding pond.

Another detailed assessment of required and available surface area for land application must be undertaken, since the required acreage would increase significantly due to the anticipated increase in mine water flows. However, unless a significant reduction in anticipated mine water flows is realized, land application is probably not a viable discharge option.

8.4 Selection of Preferred Mine Water Treatment Options

Based on anticipated effluent requirements employing either drinking water standards or background water quality, several treatment options have been postulated by Barr Engineering, 1987. The options included lime treatment, either alone or in combination with filtration, reverse osmosis, or ion exchange. Based on the original anticipated mine water flow of 35 USgpm, the capital costs of the system ranged from $1.8 to 3.1 million. The anticipated annual operating costs ranged from $240,000 to $410,000. These costs are very high compared with the anticipated untreated mine water flows.

However, the water balance calculations indicate that mine water flows requiring discharge could increase to between 200 and 720 USgpm. Conventional treatment including cyanide oxidation and metals precipitation using pH adjustment and flocculent addition would increase the anticipated capital costs to $5,000,000 or more. The annual operating costs could reach $1,000,000. A comparison of approximate costs and effectiveness of treatment for conventional and advanced treatment technologies is illustrated in Table 8.2. For example, this level of treatment using proven technology could achieve a copper effluent value of about 0.10 mg/L. Assuming an instream copper criteria of 0.003 mg/L taken from Table 8.1, a dilution factor of 33 is needed. At the anticipated discharge volumes, the required dilution is not available. A significant relaxation in stream standards or an alternative discharge point far downstream is needed.

Application of advanced technologies beyond the conventional treatment involving either filtration and reverse osmosis or filtration and ion exchange could produce an effluent copper of about 0.05 mg/L. At a minimum, the increased capital costs would be about $1,000,000 to $2,000,000. The annual operating costs would increase by an additional $200,000 to $400,000. The required dilution for copper to reach an instream concentration of 0.003 mg/L would still remain about 16, which is not achievable unless a discharge point far downstream is utilized. A downstream discharge point would require the installation of a pipeline which may need to be buried.

TABLE 8.2
Comparison of Costs and Effectiveness of Different Treatment Technologies
For Illustrative Purposes Only

Level of Technology	Approximate Costs Capital	Operating	Effluent Copper (mg/L)	Required Dilution
Conventional	$5,000,000	$1,000,000	0.1	33
Advanced	$6,000,000	$1,400,000	0.05	16

The example using copper demonstrates the extreme difficulty and cost in achieving acceptable effluent quality for discharge, under the proposed mine plan. Similar or increased difficulties will be encountered for the metals silver, mercury, lead, cadmium, zinc, and nickel. These metals are of primary concern with regard to both treatment and toxicity. No significant advantage with regards to treatment efficiency is achieved through the use of advanced technologies.

For discharge of treated mine water to be a viable option, more reasonable effluent limitations must be obtained, in conjunction with a decrease in the anticipated mine water flows. In the case of the surface water discharge option, the effluent limitations would be derived from a site specific waste load allocation. In the case of land application, the effluent limitations would be based on considerations of potential groundwater impacts. For example, effluent limitations based on the BAT standards for the Ore Mining and Dressing Industry are achievable and acceptable. Effluent limitations based on either background water quality or the present aquatic life standards, in conjunction with required treatment of elevated mine water flows constitute a probable fatal flaw.

In the event that more reasonable effluent limitations are obtained along with a more favorable mine water balance, a treatment system based on conventional processes is possible. In this case, the treatment system would combine chemical oxidation and precipitation possibly followed by filtration. Reverse osmosis or ion exchange would not be necessary. These latter processes are not preferred due to expense, complexity, and the problems associated with brine or regeneration solutions. The side streams produced from these processes contain very high concentrations of dissolved constituents which can not be continuously disposed of in the tailings impoundment. A mine water treatment system based on the advanced processes is not practical or justifiable. Several operational problems could be encountered during the life of the mine.

In the case of conventional treatment, chemical precipitation would convert the metals to the insoluble hydroxides which could be disposed of in the impoundment along with the tailings. As long as the pH of the solids remains elevated, significant dissolution of the metals would not occur. The capital and operating costs for conventional treatment would be lower relative to the advanced or tertiary treatment options. In addition, conventional treatment processes, such as hydrogen peroxide oxidation for cyanide and lime precipitation for metals, are well known.

One additional area requiring discussion involves the need for increased design capacity for treatment of contaminated seepage in the event of failure of the liner. Based on preliminary hydrological calculations, the potential flow of groundwater which could be contaminated through failure of the liner is about 200 USgpm. Increasing the capacity of the treatment system would not only increase the cost of treatment, but further reduces the viability of both the surface water and land application discharge options.

In the case of the surface water discharge option, the degree of available dilution is reduced and a significant increase in treatment performance is required to meet the instream criteria. In the case of land application, the available storage capacity for untreated mine water is increased dramatically as is the area needed for irrigation. It is not probable that suitable land application area is available to accommodate a combined seepage and mine water flow in the range of 400 to 900 USgpm. Further analysis of this potential fatal flaw is necessary prior to making a final decision.

8.5 Conclusions

Based on a review of the available documents, there are several areas related to the mine water management and treatment systems which may result in a fatal flaw. It is not probable, based upon the current conditions, that either the surface water discharge or land application option are viable based upon the expected treatment cost and efficiency needed to achieve either background surface water quality or aquatic life criteria. In the case of a surface water discharge the available dilution is minimal, while in the case of land application the required surface area and storage volume are excessive. It is not probable that any available conventional or advanced treatment process can achieve background water quality.

In order to allow treatment and discharge of mine water to maintain the internal water balance, alternative site specific effluent criteria must be derived and accepted, along with a significant reduction in the expected mine water flows. The allowable mine water volumes and quality must be determined through further evaluations. Based upon a non-quantitative assessment, a reduction of 50% or greater in the anticipated mine water flow is needed.

The preferred approach would utilize either a controlled hydrograph release in conjunction with site specific criteria and conventional treatment, or land application using conventional treatment and effluent limitations base upon standards similar to the BAT regulations. In both cases significant reductions in the mine water volumes must be realized.

ATTACHMENT 23

EPA
United States
Environmental Protection
Agency

REFERENCE GUIDE
to Treatment Technologies for Mining-Influenced Water

March 2014
EPA 542-R-14-001

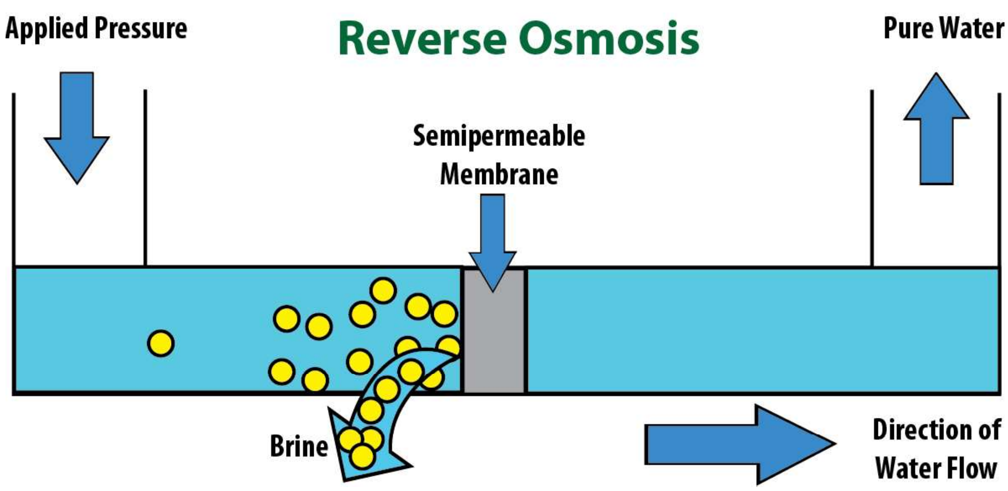
U.S. Environmental Protection Agency
Office of Superfund Remediation and Technology Innovation

Technology: Reverse Osmosis

Technology Description

Reverse osmosis is the pressure-driven separation of contaminants through a semi-permeable membrane that allows water to pass through while retaining contaminants. The dissolved ions are retained in a concentrated brine solution that requires management or disposal (Figure 11). Reverse osmosis is a proven method to demineralize acid mine drainage. However, it does require significant construction and operating costs.

Figure 11: Diagram of Simplified Reverse Osmosis Technology



Constituents Treated

Reverse osmosis can be used to remove metals, total dissolved solids, and sulfate from MIW.

Operations

Reverse osmosis involves a semipermeable membrane through which almost pure water is removed from a concentrated input solution by applying pressure, leaving a more highly concentrated brine solution. The membrane is the primary component of a reverse osmosis system. Durable membranes resistant to chemical and microbial agents that retain structural stability over long operating periods are essential. Pre-treatment is necessary to prevent membrane fouling, particularly if the water contains elevated levels of hardness (i.e., calcium or magnesium) or total suspended solids. With pre-treatment and routine maintenance, membranes typically last two to five years.[81]

[81] CH2M Hill, 2010.

The brine produced is typically 20 to 30 percent of the influent flow in a single system, depending on influent water quality. The process produces a concentrated waste stream that must be disposed of properly. Various disposal options are available. However, the concentrated waste stream is typically disposed of through evaporation, deep well injection or ocean discharge.

Reverse osmosis has been used successfully to treat MIW at several sites. At the Barrick Richmond Hill Mine near Lead, South Dakota, reverse osmosis polishes selenium from mine water after pre-treatment for iron reduction and precipitation. The reverse osmosis unit is operated at pressures of 250 pounds per square inch and greater.[82] As of 2005, filtration pre-treatment was required to remove total suspended solids. During winter months, water is heated to prevent crystallization caused by depressed salt solubilities. Additionally, a softening plant is under consideration for treating gypsum scaling resulting from elevated calcium concentrations.

At a historic former gold mine in California, reverse osmosis treated impounded water as an emergency measure to prevent impounded water from affecting a drinking water reservoir below the mine.[83] Trailer-mounted reverse osmosis systems were leased along with pre-filtration and manganese removal columns. The system flow was greater than 100 gpm and the system operated for about four months. The system operated at about 40 percent selenium recovery due to the high total dissolved solids in the influent water. The brine was then returned to the initial impoundment. Selenium concentrations were reduced from about 60 μg/L to less than 5 μg/L. The system operated until levels in the impoundment were reduced to acceptable levels.

Reverse osmosis is also in use at the Kennecott South site, which is located in the Salt Lake Valley, east-southeast of Copperton, Utah.[84] The Bingham Canyon Water Treatment Plant (BCWTP), built as part of the site's remedy, is located in operable unit (OU) 2. Reverse osmosis is being used as the primary technology for addressing total dissolved solids- and sulfate-impacted ground water.

The BCWTP has two reverse osmosis treatment racks that treat 3,200 gpm with total dissolved solids concentrations of about 2,000 mg/L and a sulfate concentration of 1,200 mg/L.[85] The quality of the feed water and regular cleaning has extended the system's lifespan to about six years.

[82] Microbial Technologies, 2005.
[83] Golder, 2009.
[84] ITRC, 2010.
[85] ITRC, 2010.

Figure 12: Two Reverse Osmosis Treatment Racks at the BCWTP

Image Source: http://www.itrcweb.org/miningwaste-guidance/cs48_kennecott_south.htm.

Long-Term Maintenance

Frequent membrane monitoring and maintenance are required to ensure the effective operation of a reverse osmosis system. With pre-treatment and the performance of routine maintenance, membranes typically last two to five years. If membranes become fouled due to lack of pre-treatment or water chemistry, or when they reach the end of their effective lifespan, proper waste disposal is required. Following the performance of a waste determination, proper waste disposal is required consistent with a waste determination.

To minimize viscosity effects that inhibit performance, water temperature controls may be needed at low and high temperatures. Adjustment to pH and the addition of antiscalant to prevent membrane fouling may also be required.[86] Brine concentrates generated during the reverse osmosis process must either be treated or further concentrated for proper disposal. The treated stream may also require pH and total dissolved solids buffering prior to discharge to receiving waters to meet regulatory requirements.

System Limitations

The primary constraint is the need for high operating pressure and associated energy and costs to push the water through the membrane to remove high levels of total dissolved solids. The technology is not practical above 10,000 mg/L total dissolved solids.[87]

[86] CH2M Hill, 2010.
[87] CH2M Hill, 2010.

Pre-treatment and chemical additions are required to reduce membrane scaling and fouling. Scale-forming ions will irreversibly foul the membranes and create selenium removal issues by allowing leakage. Disposal of brine solution is also required. In addition, low ionic-strength effluent lowers hardness and alkalinity in receiving streams, which can increase susceptibility of aquatic biota to metals toxicity.

Costs

Reverse osmosis typically requires high capital costs for the purchase, installation and operation of the membrane system. For a 1-million-gpd system, the total installed cost is estimated at $42.9 million (2013 USD).[88] Annual operation and maintenance costs for the same system are estimated at $3.2 million (2013 USD). Management and disposal of the brine solution that is generated can require higher operating costs. In arid climates, atmospheric evaporation may offer a technique for removing water in the brine solution followed by appropriate solid waste disposal. For locations where atmospheric evaporation is not feasible, thermal treatment may be needed.

The total cost for the BCWTP was about $16.1 million (2013 USD).[89] Total yearly operation and maintenance costs (40 percent of these costs represent labor and 24-hour maintenance) for the BCWTP are about $1.3 million (2013 USD). These capital and yearly operation and maintenance costs include energy requirements, but do not reflect the costs associated with extraction wells, feed pipelines, disposal infrastructure and off-site disposal.

According to Golder Associates, the capacity of a permanent reverse osmosis facility used to treat waste rock leachate was 60 gpm and included an evaporator for brine management. The capital cost of the system was estimated at $5.6 million (2013 USD).[90] The operation and maintenance cost was estimated at $19.28 (2013 USD) per 1,000 gallons of water treated.

Effectiveness

The BCWTP at the Kennecott South site has consistently seen permeate reduction efficiencies of 71 to 72 percent.[91] Between June 2006 and May 2009, total dissolved solids removal efficiencies at the BCWTP averaged 98.9 percent. Between 2007 and 2009, product water also consistently complied with all applicable State of Utah primary and secondary drinking water standards. Product water continues to remain in compliance with permit limitations established by the State of Utah's Division of Drinking Water.

[88] CH2M Hill, 2010.
[89] ITRC, 2010.
[90] Golder, 2009.
[91] ITRC, 2010.

At the Barrick Richmond Hill Mine, reverse osmosis concentrates selenium from mine water after treatment by iron reduction and precipitation. Selenium is reduced from 22 µg/L to 12 µg/L to about 2 µg/L at flows of 200 gpm.[92]

Reverse osmosis systems have been demonstrated at full scale to remove selenium (selenate or selenite) to less than 5 µg/L and to remove 90 to 98 percent of total dissolved solids.[93] At a historic former gold mine in California, reverse osmosis was used to treat impounded water for reduction of selenium from about 60 µg/L to less than 5 µg/L, with a flow rate of greater than 100 gpm.

[92] Golder, 2009.
[93] Golder, 2009.

ATTACHMENT 24

Mine Drainage

ACTIVE

By Water Resources Mission Area February 28, 2019

As settlers traveled west and mined the American landscape, thousands of new mines were created over the centuries and then abandoned. Now, these long forgotten remnants of a bygone area still haunt us, as their operations left behind materials and rock exposures that can be easily eroded and carried downstream. The USGS helps track the sources of acidic mine drainage and helps land managers develop better mitigation strategies.

BACKGROUND

Mine drainage refers to any surface water or groundwater that drains from an active or abandoned mining operation. Mine drainage can be high-quality similar to natural waters or contaminated by leftover materials. Polluted mine drainage can be extremely acidic and is often laden with high concentrations of toxic, heavy metals. In general, the more acidic the water, the more likely it is to be harmful to living organisms.

Mine drainage forms from a chemical reaction between water and rocks containing sulfur-bearing minerals. The resulting waters become rich in sulfuric acid and dissolved iron. As the iron settles out of the water, it can form red, orange, or yellow sediments in the bottom of streams. The acidic runoff further dissolves heavy metals such as copper, lead, mercury into groundwater or surface water. The rate and degree by which acid-mine drainage proceeds can be increased by the action of certain bacteria.

Sources/Usage: Public Domain.

Acid mine drainage can change the color of a stream into red or orange.

THE CHEMISTRY OF MINE DRAINAGE

Because the chemistry of water samples can rapidly change if removed from the mine, many mine drainage measurements are made in the field. The first measurement typically looks at acidity, which is reported as pH. A *neutral* pH has a value of 7. Any sample that reads below a pH of 7 is characterized as being *acidic*. Anything greater than 7 is described as being *basic*. The more acidic the water is, the better it is at eroding mining slag, rocks, and other materials. The water then transports the contaminated mine materials to nearby rivers before eventually depositing the materials downstream. Some mine drainage has been seen to have pH in the 2.5-4 range[1].

Another water-quality parameter that is useful for characterizing water quality of acid mine drainage is specific conductance. Conductance is a measurement of the electrical conductivity in a water sample and is a indicator of what's dissolved in a liquid. It is also very inexpensive to measure, unlike testing for metals and other pollutants. Different substances will affect the conductance of water, allowing scientists to use changes in conductance as an indicator of changes of whatever is in the water - in this case the amount of contaminants coming from the mine.

Sources/Usage: Public Domain.

Sampling acid mine drainage residuals in Elk County, Pennsylvania. The USGS has pioneered a new use for these residuals that are currently a disposal challenge, using them to filter phosphorus from agricultural and municipal wastewaters. (Credit: Philip Sibrell, USGS)

RELATED USGS RESEARCH

- USGS Mine Drainage Activities
- Contamination associated with active and abandoned hard-rock mining
- USGS Central Mineral Resources team

ATTACHMENT 25

Petition to Rezone Portion of Township 6, Range 6 Penobscot County, Maine for Development of an Underground Metallic Mineral Deposit

Prepared by:

Wolfden Mt. Chase LLC

Submitted to:

Maine Land Use Planning Commission

Date: Sept 1, 2021

2.2.3.5 Tailings Management

The tailings will contain some iron sulfides and other metallic sulfide minerals and are therefore managed accordingly to mitigate acid generation and leaching. Tailings are produced through the floatation process and are pumped in a slurry to be dewatered via a pressure filter and then deposited on a dry stack tailings management facility (TMF). The filtered tailings will be transported by truck to the TMF where they are spread, stacked and compacted by a dozer. All water generated by the dewatering pressure filter process is recycled and pumped back to the concentrator for reuse in the process circuit. The dewatered tailings have a low moisture content (~15-17% by mass) and is expected that no supernatant pond will form, nor will precipitation penetrate deeply as they are compacted in the TMF. Responsible Mining Solutions (RMS) was commissioned to analyze a Pickett Mountain tailings sample with respect to dewatering through thickening, vacuum filtration and pressure filtration. The tailings material filters well despite the fine grind size. The pressure filtration produced compact and dry friable cakes ranging from 12-7-17.6% residual moisture. The full analysis report is shown in **Attachment B – Ground Ore Characterization Dewatering, Rheology, Testing Campaign**

Rainfall on the TMF is expected and the run-off is collected. All TMF water will be captured in two lined collection ponds located at the north and south edges of the TMF. Water from the lined TMF collection ponds will be pumped back to the concentrator for reuse in the processing circuit and any excess water will be pumped to the water treatment plant to be treated for reuse or discharged to the environment (better than or equal to background water quality) via the infiltration system. The dewatered tailings will exit the concentrator plant via conveyor onto a storage pad with 24 hours of capacity. The tailings will be loaded and hauled via 35 or 40 tonne articulated trucks or conveyor to the TMF. The expected 1000 tonnes of tailings per day, will require 1.0 to 1.5 truckloads of haulage to the TMF per hour depending on the size of the truck. Once or twice per shift, the truck operator will spend up to one hour with a dozer and roller compactor to grade and compact the tailings. The expected cycle time to the farthest area of the TMF is under 7 hours while the closest will be 4 hours. This allows more than sufficient time for haulage, grading and compacting in a 10-hour work shift.

Sub-aerial (dry stacked) tailings are the only above ground tailings management method allowed under the MDEP Chapter 200 rules for Group A and Group B mine waste. The sub-aerial TMF will be designed in accordance with requirements (including a composite liner and leachate collection) of Chapter 200 Subchapter 5 Section 21 Mine Waste Unit Design Standards. Leachate ponds that collect water that encounters tailings are also governed by these standards. TMF ground slopes of 20% to 30% may be used for dry stack tailings. The maximum height of the TMF cells when completed at Pickett Mt. are not expected to exceed 22 feet above the ridgeline elevation. However, based on geotechnical stability of the closed TMF, the engineering limit is 55 feet.

Once compacted, these tailings will not be subject to infiltration of water and intrusion of atmospheric oxygen which will mitigate the oxidation of sulfide minerals. Management of dry stacked tailings placed within a lined containment facility, that is progressively closed during mine operation will control leaching of metals and provide long-term protection to water resources (groundwater and surface water). The TMF would be designed with run-on controls to prevent contact with surface water run-off. During the operating period of the dry stacked tailings facility, contact water (precipitation) is actively managed. Tailing's solids that require placement during which time off-specified moisture values will be placed within the tailings facility and allowed to naturally desiccate and or shed water within the containment facility. Desiccation is readily enhanced by spreading the tailings with a dozer to create a larger drying exposure; this enlarged area is still relatively small within the tailings facility, given the relatively low throughput rate of the operation. Once the adequate moisture content has been reached, the tailings will be further dozed and compacted to the requisite values.

Winter operations will be handled similarly to non-winter operations except in the case of heavy snowfall or rain/ice events for both safety reasons and deposition/placement. Since the tailings will be desaturated coming from the pressure filter operations, placement via dozing and compaction can continue. Freezing conditions will thus not have detrimental impact on the normal filtration and placement operations. If non-specified tailings with some excess moisture is placed, these can be stored for up to several months if needed, since the throughput is relatively small; once normal operations resume with low moisture content, the temporary contained tailings can be incorporated into the operations. It is anticipated that an area of 4 acres is sufficient to store the winter season of tailings temporarily if consistent freezing conditions occur resulting in the inability to manage tailings through standard management processes.

Tailings (rock byproduct) is the remaining processed rock that did not float into a valuable concentrate. The conceptual design developed for the PEA (**Exhibit 13 - Attachment B**) was focused on confirming the availability of adequate space to accommodate the proposed tailings storage facility (TMF) and support planning for geotechnical subsurface investigations and geotechnical and rheological testing of processed ore (tailings).

Management and disposal of the mill tailings in a filter-cake consistency was selected to minimize risks related to the physical stability of the tailings and satisfy the MDEP Chapter 200 Metallic Mineral Exploration, Advanced Exploration, and Mining regulations set by the Maine Department of Environmental Protection. A slight reconfiguration to the original conceptual TMF footprint was made for the PEA in order to satisfy wetland and groundwater protection issues. Future design stages will be focused on optimizing the layout (within the same location), staging, and development of the TMF within the proposed footprint.

Some metallurgical testing has been completed to try and separate tailings further into a high Sulphur content portion and low Sulphur content portion. This would mean that sulphides and residual metals would be even further removed from the low Sulphur content portion resulting is a few additional options for management. These theoretical options are:

- Sell high Sulphur content portion as fuel for smelting leaving only the low Sulphur content portion for on-site TMF storage
- Store the high Sulphur content portion in the center of the TMF and surround it in the low Sulphur content portion resulting in further protection from leaching and acid generation.

Until more detailed metallurgical test work has been completed, it is not possible to confirm if a high Sulphur and low Sulphur tailings could be generated via additional floatation. The tailings TMF design, however, is conservative and accounts for the highest possible potential risk. The tailings material is pressure filtered to remove majority of associated water and then transported, placed and compacted on an engineered Tailings Management Facility (TMF) in order to prevent potential adverse impacts to the environment. The TMF design has been completed by SLR Consulting. Key Project design criteria, assumed for the TMF, are summarized as follows:

- **Life of Mine** (Commercial Production): 9 years (10-15 total project life)
- **Mined Tonnes**: 4,100,000 tonnes (4,520,000 tons)
- **Tailings Produced**: 3,280,000 tonnes (3,620,000 tons)
- **No Underground Tailings Backfill**
- **Dam Classification**: Significant (CDA, 2013)
- **Environmental Design Flood**: 500-year 24-hour storm (7.8 inches)
- **Inflow Design Flood**: 1,000-year 24-hour storm (8.5 in)
- **Contact Water Containment**: composite liner system with leachate collection system
- **Contact Water Drainage**: maximum 1 ft head above containment system liner

- **Seepage Control Measures**: collection pond with water reused by mine/concentrator or treated and discharged
- **Closure Cover**: composite liner system with drainage layer and soil cover for vegetation growth

The TMF is comprised of the following design components:

- Containment system, consisting of a composite liner system, to minimise the seepage to the environment.
- Perimeter berms to provide containment of the tailings.
- Collection Pond to store excess contact water.
- Collection Ditches to convey contact water to the Collection Pond; and
- Surface Water Ditches to convey fresh, or non-contact water, around the TMF.

The design and operation of a filter cake disposal facility is dependent on tailings to the specified consistency, (i.e., filtering to near optimum moisture content to allow for placement and compaction). Additional rework of the tailings may be necessary to achieve the optimum moisture content and design dry density.

Figure 2-1 (Exhibit 2 - Attachment A) identifies the location of the TMF and appurtenant structures.

Surface disposal of filter-cake tailings is a relatively new approach introduced by the mining industry and adopted commonly in the recent decade to optimize the costs and minimize risks associated with tailings dams. However, the technology is well developed from the use of filtered and paste (dewatered) tailings as an underground mine backfilling method. Dewatered tailings have also been used successfully at various mines for surface disposal or tailings, including mines with a similar climate and production rate to Pickett Mountain:

- Myra Fall, BC, Canada – 3,600 tons per day, deposited as a paste consistency (pumped), with a cemented paste liner to reduce seepage and the risk of tailings rush-in to the underground mine. Available reports do not indicate the presence of a geomembrane liner or planned geomembrane cover. The publicly available records do not indicate any groundwater impacts have occurred.

- Minto Mine, Yukon, Canada – 3,800 tons per day, deposited as a compacted filter cake. The reports indicate the TMF (Tailings Management Facility) has no liner. A proposed 1m soil cover is planned for closure. The publicly available records do not indicate any groundwater impacts have occurred.

- Greens Creek, Alaska, USA – 750 tons per day, deposited as a filter-cake on surface and as underground backfill, the TMF includes a geomembrane liner under part of the tailings area and the collection ponds are lined and a soil cover will be placed for closure. Some zones of saturation in the TMF have been reported but these have been managed within compliance. The facility is reported to be performing within environmental compliance guidelines, despite only having a partial tailings liner. Surface and groundwater water quality is reportedly within geochemical predictions developed during mine permitting and the facility is performance is satisfactory. Pickett Mountain will be constructed using a fully engineered liner system throughout the entire footprint of the tailings facility compared to the Greens Creek semi lined facility. This will give Pickett Mountain an even more positive result related to ground water impact.

Figure 2-18: Hecla's Greens Creek in Alaska Tailings Management Images Between 2004 and 2017

Generally, filter tailings stacks have been shown to be safe and reliable and the noted case studies along with numerous examples with higher production rates or varying climates provide a reference framework for identifying and addressing design challenges. In essence, the system of mechanical dewatering is designed to produce a waste that can be managed safely. The Pickett Mountain TMF will have full composite basal liner and a composite closure cover that encapsulates the tailings and inhibits infiltration.

A further example of similar tailings deposition is Cerro Lindo (Peru) shown in **Figure 2-19**. Although the climate in Peru is drier than in Maine, the concept is the same. Sub-aerial tailings are currently used in other cold regions including Alaska, Minnesota and Canada. In most cases in cold weather climates, the tailings are progressively covered to optimize water treatment and reduce the remaining area requiring closure during final reclamation. The MDEP regulations require a cover system of permeability equal to the liner system which has specific maximum permeability requirements.

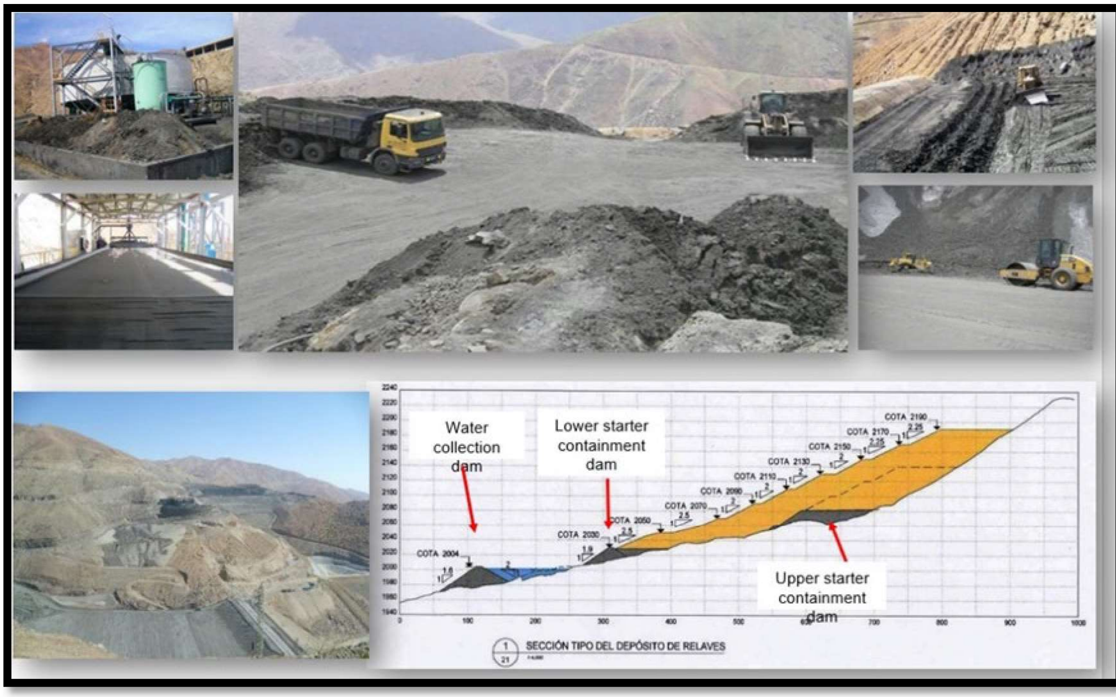


Figure 2-19 Cerro Lindo Moist Cake Disposal (1:2 Slope)

Tailings Base Grade and Containment System

The base or foundation of the TMF will generally follow the natural topography of the ground surface, sloping from the topographic divide downwards to the Collection Pond in the north. The topographic ridge features two small crowns (approximately 6 ft tall) that will need to be regraded to provide positive internal drainage to the Collection Pond on the north and south side of the TMF.

A containment system is required by MEDEP Chapter 200 mining regulation (Maine, 2017) consisting of a composite liner and drainage layer. Contact water collected above the composite liner will gravity drain to the Collection Ditches and ultimately the Collection Ponds. Contact water will be recirculated to the concentrator. Minimal contact water in excess of the concentrator requirement will be directed for water treatment and discharge.

- The containment system is comprised of the following components, from bottom to top:
- ft minimum thick low permeability soil fill (permeability less than 1×10^{-6} centimetres per second (cm/s));
- 60 mil High Density Polyethylene (HDPE) geomembrane; and
- 2 ft minimum thick Drainage Collection Layer.

The containment system is required to also ensure that the contact water head does not exceed 1 ft above the HDPE liner. To satisfy this condition, a series of perforated, corrugated polyethylene (PCPE) drainage pipes will be installed within the free draining Drainage Collection Layer.

The relatively uniform subgrade and HDPE liner configuration is important for gravity drainage to the collection ponds. In addition, this configuration essentially eliminates potential stability concerns related to the low interfacial friction angle between the geomembrane and the underlying compacted soil liner.

Tailings Perimeter Berm and Ditch

A 3 ft to 10 ft high perimeter berm will be provided along the toe of the TMF. The berm will be used for anchoring the geomembrane liner and for creating a Collection Ditch for contact water collection along the tailing's perimeter. The height of the perimeter berm will be a function of the length of the tailings slope. The south side of the TMF is situated on flat ground and will have a minimum berm height of 3 feet, while the north side of the TMF is situated on a slope and will have a maximum height of 10 feet.

Filtered tailings will be placed up to the perimeter berm, maintaining a minimum 3 ft deep ditch between the filtered tailings and berm slopes. The grade of the ditch will follow the natural topography. Grading will be required on the topographic divide through a grading plan that ensures a minimum 1% slope that drains toward the east side then turning and draining downhill south to the Collection Pond. Borrow from the cut of the two crowns can be used to regrade the lower areas in between. If insufficient soils depth is found while cutting the two crowns, then imported borrow material will be used for grading the lower areas.

The perimeter berm will be notched at the low point in the TMF to allow drainage from the TMF to the Collection Ponds.

Tailings Drainage Collection Ponds

Contact water from precipitation and tailings seepage will drain into the perimeter Collection Ditch system, which ultimately drains to the Collection Pond on the north and south side of the TMF.

The Collection Ponds are sized to contain a total of 11.3M gallons, which is the anticipated run-off from an Environmental Design Flood (EDF) in addition to the maximum operating level. SLR sized the Collection Pond based on the following:

- SLR assumed a maximum operating pond volume of 1.3M gallons for a tailing's facility of this size and with progressive reclamation potentially reducing the quantity of contact water generated. The filtered tailings are relatively dry with an estimated gravimetric moisture content of about 18% which SLR expects to result in very little free water to drain out. Rainfall is expected to be the main source of contact water, and some infiltration is expected to report as tailings seepage.
- The EDF criterion for the Project is defined as the 500-yr 24-hr. event required by MDEP Chapter 200 mining regulations. SLR calculated an EDF volume of 11.3M gallons to be stored in the Collection Ponds based on a the lined TMF footprint area of 50.5 acres, a 500-yr 24-hr. event of 7.8 inches and a run-off factor of 90%.

SLR assumed that the containment berms for the Collection Pond will be constructed by placing and compacting soils excavated from within the Collection Pond footprint. The Collection Pond will be constructed with a similar containment system as the TMF to prevent solution seeping into the groundwater, and is comprised of the following components, from bottom to top:

- ft minimum thick low permeability soil fill (permeability less than 1×10^{-6} cm/s)
- 60 mil HDPE geomembrane

A spillway equipped with a rip rap protected channel and energy dissipation downstream of the south side of the pond will prevent overtopping and will be sized to safely pass the IDF event, defined as the 1,000-year 24-hour event. The water discharged by the spillway will drain overland north to Pleasant Lake or south to Pickett Mountain Pond. In the event of such a major storm, rainwater would be pumped directly into the mine in order to prevent usage of the spillway. If an event of this nature were to occur and the mine workings flooded, this would degrade the installed ground support and would cause a series of reconditioning work to regain access to those workings after the mine was dewatered. Any electrical motors would be disconnected and brough to safe and dry elevation prior to allowing water to fill up the mine working therefore, not major concerns on electrical components would be realized. However, electrical cabling would likely be submerged. Submerged and dried electrical cable is tested for safe use and if testing fails then the cables are replaced along with replacing all of the damaged or impacted ground support.

Additional Considerations for Collection Ponds

The collection ponds are provided at the perimeter of the facility to collect tailings seepage and surface runoff. Collected water would be pumped to the process plant for use as make-up water. The collection ponds are geomembrane lined to inhibit outward seepage.

Unlike "infiltration ponds" which require an adequate depth of well-drained soils for infiltration (e.g. septic wastewater ponds) the collection ponds will be created using a combination of excavation, berm construction, and/or engineered fill to create the required storage volume and protect groundwater. The design considerations will include the depth or thickness of overburden, the depth to groundwater, and risk issues.

Figure 2-20 shows schematic pond construction concepts that will be considered at the design stage:

- Bermed
- Partially excavated
- Engineered fill

Detailed site reconnaissance and geotechnical investigations will be carried out at the design stage to optimize the configuration of the ponds.

Figure 2-20: Alternative Collection Pond Design Concepts

Operational Controls & Monitoring

Filter-cake tailings that are produced according to (future) design specifications and placed and -compacted at the design moisture content that will provide a configuration and geometry that are stable. With a proper engineering design, concurrent reclamation, and operating procedures, minimal wind and water erosion impacts are anticipated.

The hydraulic conductivity of the compacted tailings is expected to be low due to the particle size distribution based on precedent global experience. Infiltration into the tailings mass should occur at a very low rate during and following placement of the tailings. Piezometers will be placed throughout the TMF to record the phreatic level data and confirm operational performance according to the design intent.

Wet or off-specification tailings may be produced in the plant during periods of filtration plant upset or malfunction. During these periods, the tailings will be placed interior to the pile to avoid potential complications with slope stability. Subsequent lifts will not be placed on wet tailings until drainage and compaction occur. This is to avoid creating a hydraulic gradient that could saturate the underlying tailings. Wet tailings storage locations will be rotated periodically to comply with the design intent.

Progressive reclamation and geomembrane cover placement will limit infiltration further, minimize operational controls required to avoid runoff erosion of tailings placed on the slopes and eliminate tailings dusting concerns.

Tailings Stability and Risk

Compaction requirements typically vary throughout the facility depending on the design requirements. Roller compaction is typically specified to achieve the target density values required to satisfy stability requirements if earthquake resistance is a concern, or steep slope inclinations are required to achieve the required storage volume. Precedent data on stability and seismic loading resistance is available for the Cerro Lindo Mine which was subjected to strong earthquake loading. Lara and Leon (2011) highlights how the properly place filtered tailings did not liquefy or deform in any significant manner during strong earthquake motions (Richter magnitude 7). Uncompacted filtered tailings in an upset disposal area suffered only incremental movements (i.e. cyclic mobility) but did not liquefy and flow. The Cerro Lindo case study provides a strong case record for filter-cake tailings stack stability.

At Pickett Mountain the seismic risk is low and there is adequate space to use shallow external slopes selected to satisfy post-closure aesthetic considerations. The PEA (**Exhibit 13 – Attachment B**) concept has external slopes of 4 horizontal (H) to 1 vertical (V), which are flatter than required for stability, even considering the limits of the geomembrane-soil interfacial friction angle. Stepped steeper slopes of say 3H:1V, for example, are common for closure covers on tailings facilities and landfills. Dozer track-packing is likely sufficient to meet the design intent, however roller compaction for the Pickett Mountain is planned to densify in order to inhibit infiltration of runoff and reduce erosion by storm runoff and wind (i.e. dusting). Roller compaction serves to further increase the target density in order to support the construction equipment, maximize density and storage capacity, and reduce the hydraulic conductivity.

The basis for sizing the TMF includes placement and compaction of the tailings in a lined storage facility. Tailings will be dewatered by thickening to approximately 60 to 63% solids by mass (mass solids/total mass) followed by pressure filtration to approximately 83 to 85% solids with approximately 15 to 17% moisture content by mass. Based on a specific gravity of 3.25 and a compacted void ratio of 0.6 (volume voids / volume solids), SLR estimated the filtered tailings density to be 125 pounds per cubic foot.

The TMF size in the PEA had an average height of about 22 ft above the ridgeline based on 4.5 million tons of tailings over a 54-acre footprint, and tailings dry density of 125 pcf. At the design stage the configuration and geometry of the final TMF geometry will be determined to meet post-closure land use and aesthetic values agreed through the approvals and consultation. Potential areas of lateral expansion are available for optimization and identified with hatched lines in **Figure 2-1.**

Figure 2-21 is a schematic cross section of the tailing's facility. There is no pond on the surface of the tailings. Perimeter berms and ditches will direct seepage and surface runoff to the collection ponds for pumping to the concentrator and mine for processing reuse.

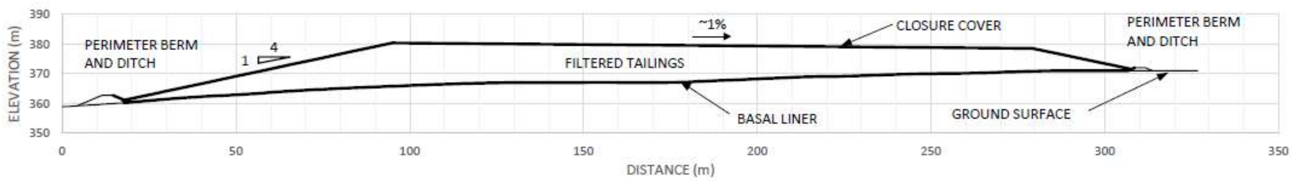


Figure 2-21 – Longitudinal Section Through The Tailings Management Facility

2.2.3.6 Security

Security for the project site will be managed through a series of installed physical barriers as well as a 24-hour active-duty security contract. Physical barriers will be inclusive of fencing and gates around restricted access locations such as but not limited to, ponds, material storage areas, high voltage electrical areas and any openings to underground. Additional fixed barricades will be locations at any known access to the proposed project site at the rezoned boundary. In addition, signs restricting passage will be posted along the perimeter of the rezoned boundary to ensure that people approaching the site are notified of the restriction. Guard house and gate will be located at the east boundary of the property and main access. Any person or vehicle entering or exiting the project site will need approval and documenting by the security team and systems prior to entry or exit. The fixed barricades as well as guard house are identified on **Figure 2-1** .

2.2.4 Phase 4 – Reclamation/Remediation

2.2.4.1 Reclamation/Remediation Strategy

The overall design and operational strategy at Pickett Mountain are to limit and maintain a small environmental footprint and thereby limit potential impacts throughout all phases of the project. For example, as the project generates tailings from production, they will be placed and capped in an estimated 5 tailings cells over the life of the project, such that a completed cell will be closed and reclaimed while the next cell is in use. Closure of the first cell will be completed after it has been filled to design capacity. Cell 2 will be constructed in conjunction with this timeframe to ensure continued operation of the concentrator facility. Cell 3 will be developed prior to cell 2 closure. Closure of each cell will consist of a similar process which will spread the closure and reclamation over the life of the project, rather than at the end. The ongoing closure can be monitored and adjusted to monitor effectiveness, maximize operational efficiency, and continuously improve on designs and operations.

Upon completion of the project, final reclamation activities will take place. These activities will be based on a previously engineered and approved reclamation plan required by the mining application.

The majority of the required reclamation work will be completed by a skilled workforce from the state and include:

ATTACHMENT 26

Wolfden Resources Corporation

Consolidated Financial Statements
(Stated in Canadian Dollars)

For the years ended December 31, 2022 and 2021

Grant Thornton

Independent auditor's report

Grant Thornton LLP
11th Floor
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Toronto, ON
M5H 3T4

T +1 416 366 0100
F +1 416 360 4949

To the Shareholders of Wolfden Resources Corporation

Opinion

We have audited the consolidated financial statements of Wolfden Resources Corporation and its subsidiaries (the "Company"), which comprise the consolidated statements of financial position as at December 31, 2022 and 2021 and the consolidated statements of loss and comprehensive loss, consolidated statements of changes in equity and consolidated statements of cash flows for the years then ended, and notes to the consolidated financial statements, including a summary of significant accounting policies.

In our opinion, the accompanying consolidated financial statements present fairly, in all material respects, the consolidated financial position of the Company as at December 31, 2022 and 2021, and its consolidated financial performance and its consolidated cash flows for the years then ended in accordance with International Financial Reporting Standards (IFRS).

Basis for Opinion

We conducted our audit in accordance with Canadian generally accepted auditing standards. Our responsibilities under those standards are further described in the *Auditor's Responsibilities for the Audit of the Consolidated Financial Statements* section of our report. We are independent of the Company in accordance with the ethical requirements that are relevant to our audit of the consolidated financial statements in Canada, and we have fulfilled our other ethical responsibilities in accordance with these requirements. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our opinion.

Material Uncertainty Related to Going Concern

We draw attention to Note 1 in the consolidated financial statements, which indicates that the Company has no source of operating cash flows, has not yet achieved profitable production, and has accumulated losses of $40,834,518 as at December 31, 2022. This condition, along with the matters set forth in Note 1, indicate the existence of a material uncertainty that may cast significant doubt about the Company's ability to continue as a going concern. Our opinion is not modified in respect of this matter.

Key Audit Matters

Key audit matters are those matters that, in our professional judgement, were of most significance in our audit of the consolidated financial statements of the current period. These matters were addressed in the context of our audit of the consolidated financial statements as a whole, and in forming our opinion thereon, and we do not provide a separate opinion on these matters.

Except for the matter described in the *Material Uncertainty Related to Going Concern* section, we have determined that there are no other key audit matters to communicate in our auditor's report.

Information Other than the Consolidated Financial Statements and Auditor's Report Thereon

Management is responsible for the other information. The other information comprises the Management Discussion and Analysis but does not include the consolidated financial statements and our auditor's report thereon.

Our opinion on the consolidated financial statements does not cover the other information and we do not express any form of assurance conclusion thereon.

In connection with our audit of the consolidated financial statements, our responsibility is to read the other information and, in doing so, consider whether the other information is materially inconsistent with the consolidated financial statements or our knowledge obtained in the audit or otherwise appears to be materially misstated.

If, based on the work we have performed, we conclude that there is a material misstatement of this other information, we are required to report that fact. We have nothing to report in this regard.

Responsibilities of Management and Those Charged with Governance for the Consolidated Financial Statements

Management is responsible for the preparation and fair presentation of the consolidated financial statements in accordance with IFRS, and for such internal control as management determines is necessary to enable the preparation of consolidated financial statements that are free from material misstatement, whether due to fraud or error.

In preparing the consolidated financial statements, management is responsible for assessing the Company's ability to continue as a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of accounting unless management either intends to liquidate the Company or to cease operations, or has no realistic alternative but to do so.

Those charged with governance are responsible for overseeing the Company's financial reporting process.

Auditor's Responsibilities for the Audit of the Consolidated Financial Statements

Our objectives are to obtain reasonable assurance about whether the consolidated financial statements as a whole are free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our opinion. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with Canadian generally accepted auditing standards will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these consolidated financial statements.

As part of an audit in accordance with Canadian generally accepted auditing standards, we exercise professional judgment and maintain professional skepticism throughout the audit. We also:

- Identify and assess the risks of material misstatement of the consolidated financial statements, whether due to fraud or error, design and perform audit procedures responsive to those risks, and obtain audit evidence that is sufficient and appropriate to provide a basis for our opinion. The risk of not detecting a material misstatement resulting from fraud is higher than for one resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations, or the override of internal control.

- Obtain an understanding of internal control relevant to the audit in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the Company's internal control.
- Evaluate the appropriateness of accounting policies used and the reasonableness of accounting estimates and related disclosures made by management.
- Conclude on the appropriateness of management's use of the going concern basis of accounting and, based on the audit evidence obtained, whether a material uncertainty exists related to events or conditions that may cast significant doubt on the Company's ability to continue as a going concern. If we conclude that a material uncertainty exists, we are required to draw attention in our auditor's report to the related disclosures in the consolidated financial statements or, if such disclosures are inadequate, to modify our opinion. Our conclusions are based on the audit evidence obtained up to the date of our auditor's report. However, future events or conditions may cause the Company to cease to continue as a going concern.
- Evaluate the overall presentation, structure and content of the consolidated financial statements, including the disclosures, and whether the consolidated financial statements represent the underlying transactions and events in a manner that achieves fair presentation.
- Obtain sufficient appropriate audit evidence regarding the financial information of the entities or business activities within the Group to express an opinion on the consolidated financial statements. We are responsible for the direction, supervision and performance of the group audit. We remain solely responsible for our audit opinion.

We communicate with those charged with governance regarding, among other matters, the planned scope and timing of the audit and significant audit findings, including any significant deficiencies in internal control that we identify during our audit.

We also provide those charged with governance with a statement that we have complied with relevant ethical requirements regarding independence, and to communicate with them all relationships and other matters that may reasonably be thought to bear on our independence, and where applicable, related safeguards.

From the matters communicated with those charged with governance, we determine those matters that were of most significance in the audit of the [consolidated] financial statements of the current period and are therefore the key audit matters. We describe these matters in our auditor’s report unless law or regulation precludes public disclosure about the matter or when, in extremely rare circumstances, we determine that a matter should not be communicated in our report because of the adverse consequences of doing so would reasonably be expected to outweigh the public interest benefits of such communication.

The engagement partner on the audit resulting in this independent auditor's report is Mark Irwin.

Grant Thornton LLP

Toronto, Canada
April 28, 2023

Chartered Professional Accountants
Licensed Public Accountants

WOLFDEN

(Incorporated under the laws of Ontario)

CONSOLIDATED STATEMENTS OF FINANCIAL POSITION

(Stated in Canadian Dollars)

As at	December 31, 2022 $	December 31, 2021 $
ASSETS		
Current assets		
Cash and cash equivalents	**3,511,011**	3,229,005
Amounts receivable *[note 5]*	**134,134**	60,552
Prepaid expenses	**17,535**	12,579
Total current assets	**3,662,680**	3,302,135
Non-current assets		
Equipment *[note 6]*	**550**	745
Total assets	**3,663,230**	3,302,880
LIABILITIES		
Current liabilities		
Accounts payable and accrued liabilities	**568,795**	232,843
Total current liabilities	**568,795**	232,843
EQUITY		
Share capital *[note 8]*	**41,865,575**	39,331,498
Equity settled employee benefits *[note 8]*	**2,350,593**	2,082,236
Other comprehensive loss	**(287,216)**	(196,519)
Deficit	**(40,834,518)**	(38,147,178)
Total equity	**3,094,434**	3,070,037
Total liabilities and equity	**3,663,230**	3,302,880

Going concern [note 1]
Subsequent event [note 17]
See accompanying notes to the consolidated financial statements

These consolidated financial statements are authorized for issue by the Board of Directors on April 27, 2023 and they are signed on the Corporation's behalf by:

"Ron Little"
Director

"John Seaman"
Director

WOLFDEN

(Incorporated under the laws of Ontario)

CONSOLIDATED STATEMENTS OF LOSS AND COMPREHENSIVE LOSS

(Stated in Canadian Dollars)

	For the year ended December 31	
	2022	**2021**
	$	**$**
EXPENSES		
Depreciation *[note 6]*	**195**	265
Exchange loss/(gain)	**(201,272)**	(51,653)
Exploration and evaluation expenses *[note 7]*	**2,953,698**	3,238,735
Flow through interest penalty	**1,853**	492
General and administrative expenses	**1,007,158**	1,198,768
Professional fees	**74,390**	82,567
Share-based payments *[note 8]*	**405,849**	544,022
Loss before the following	**(4,241,871)**	(5,013,196)
INCOME		
Investment income	**2,965**	6,398
Flow-through renunciation	**-**	139,500
Other income *[note 13]*	**1,515,500**	233,316
Loss before income taxes	**(2,723,405)**	(4,633,983)
Income tax expense (recovery) *[note 12]*	**(36,065)**	-
Loss for the year	**(2,687,340)**	(4,633,983)
Cumulative translation adjustment	**(90,697)**	(27,358)
Total comprehensive loss for year	**(2,778,037)**	(4,661,341)
Basic and diluted loss per share *[note 9]*	**(0.02)**	(0.03)

See accompanying notes to the consolidated financial statements

(Incorporated under the laws of Ontario)

CONSOLIDATED STATEMENTS OF CASH FLOWS

(Stated in Canadian Dollars)

	For the year ended December 31	
	2022 **$**	2021 $
OPERATING ACTIVITIES		
Loss for the year	**(2,687,340)**	(4,633.983)
Depreciation	**195**	265
Share based payments	**405,849**	544,022
Changes in non-cash working capital related to operations		
Amounts receivable	**(71,286)**	(46,630)
Prepaid expenses	**(4,893)**	1,082
Accounts payable and accrued liabilities	**325,265**	(222,994)
Cash used in operating activities	**(2,032,210)**	(4,358,238)
INVESTMENT ACTIVITIES	**-**	-
FINANCING ACTIVITIES		
Proceeds from shares issued in private placements	**2,299,985**	6,552,500
Proceeds from the exercise of stock options	**96,600**	89,700
Cash provided by financing activities	**2,396,585**	6,642,200
Increase (Decrease) in cash and cash equivalents during year	**364,375**	2,283,962
Cash and cash equivalents, beginning of year	**3,229,005**	972,401
Effect of foreign exchange on cash and cash equivalents	**(82,369)**	(27,358)
Cash and cash equivalents, end of year	**3,511,011**	3,229,005

See accompanying notes to the consolidated financial statements

WOLFDEN

(Incorporated under the laws of Ontario)

CONSOLIDATED STATEMENTS OF CHANGES IN EQUITY

(Stated in Canadian Dollars)

	Share Capital		Reserves			
Issued and outstanding:	Number of Shares	Share Capital	Equity Settled Employee Benefits	Foreign exchange differences	Deficit	Total Equity
Balance as at December 31, 2020	**130,844,086**	**32,377,150**	**1,850,244**	**(169,062)**	**(33,513,176)**	**545,156**
Share based payments *[note 8]*	-	-	544,022	-	-	544,022
Private Placement #1	6,250,000	2,000,000	-	-	-	2,000,000
Private Placement #2	1,550,000	480,500	-	-	-	480,500
Private Placement #3	12,725,000	4,072,000	-	-	-	4,072,000
Restricted share units *[note 8]*	759,584	231,673	(231,673)	-	-	-
Exercise of stock options *[note 8]*	690,000	170,175	(80,475)	-	-	89,700
Cumulative translation adjustment	-	-	118	(27,457)	(19)	(27,358)
Loss for the year	-	-	-	-	(4,633,983)	(4,633,983)
Balance as at December 31, 2021	152,818,670	39,331,498	2,082,236	(196,519)	(38,147,178)	3,070,037
Share based payments *[note 8]*	-	-	405,849	-	-	405,849
Private Placement	10,952,310	2,299,985	-	-	-	2,299,985
Restricted share units *[note 8]*	356,668	78,467	(78,467)	-	-	-
Exercise of stock options [*note 8*]	690,000	155,625	(59,025)	-	-	96,600
Cumulative translation adjustment	-	-	-	(90,697)	-	(90,697)
Loss for the year	-	-	-	-	(2,687,340)	(2,637,340)
Balance as at December 31, 2022	**164,817,648**	**41,865,575**	**2,350,593**	**(287,216)**	**(40,834,518)**	**3,094,434**

See accompanying notes to the consolidated financial statements

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

For the years ended December 31, 2022 and 2021
(Stated in Canadian Dollars)

1. NATURE OF BUSINESS

Wolfden Resources Corporation (the "Corporation" or "Wolfden") was incorporated under the laws of the Province of Ontario on August 12, 2009. The principal business activity of the Corporation is the acquisition, exploration and development of mineral properties in Canada and the United States (see note 7 for locations). The office address of the Corporation is 1100 Russell Street, Unit 5 Thunder Bay, Ontario, P7B 5N2.

Going concern

The Corporation, being in the exploration stage, is subject to risks and challenges similar to companies in a comparable stage of development. These risks include the challenges of securing adequate capital for exploration, development and operational risks inherent in the mining industry, global economics, health concerns and metal price volatility and there is no assurance management will be successful in its endeavors. At December 31, 2022, the Corporation has no ongoing source of operating cash flows but has raised $2,299,985 through private placement of shares. The Corporation incurred a net loss of $2,687,340, for the year ended December 31, 2022, (net loss of $4,633,983 for the year ended December 31, 2021) and has accumulated a deficit of $40,834,518 (December 31, 2021 - $38,147,178) since the inception of the Corporation. As at December 31, 2022, the Corporation had working capital of $3,093,885 (December 31, 2021 – $3,069,295). The Corporation’s ability to continue as a going concern is largely dependent upon its ability to raise additional capital to continue the development of its mineral properties. Management attempts to raise additional capital whenever favorable market conditions exist (see Note 17, Subsequent Events).

Although the Corporation to date has been successful in raising sufficient funds with its strategic investors and the capital markets to advance its projects, the capital markets continue to be volatile and are largely out of the Corporation’s control, and therefore, there remains material uncertainties that cast significant doubt on the Corporation's ability to continue as a going concern. It is not possible to predict whether financing efforts will be successful or if the Corporation will attain profitable levels of operation. These financial statements do not include any adjustments to the carrying values of assets and liabilities and the reported expenses and statement of loss and comprehensive loss classification that would be necessary should the Corporation be unable to continue as a going concern. These adjustments could be material.

2. SIGNIFICANT ACCOUNTING POLICIES

Basis of Presentation

These consolidated financial statements have been prepared in accordance with International Financial Reporting Standards ("IFRS") issued by the International Accounting Standards Board ("IASB") and interpretations of the IFRS Interpretations Committee ("IFRIC").

The consolidated financial statements of the Corporation for the period ended December 31, 2022 were approved and authorized by the Board of Directors on April 27, 2023.

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

For the years ended December 31, 2022 and 2021
(Stated in Canadian Dollars)

Basis of consolidation

The Corporation's consolidated financial statements consolidate those of its subsidiaries. The Corporation's subsidiaries are:

	Percentage of ownership	Jurisdiction	Principal activity
Wolfden Resources Canada Inc.	100%	Canada	Mineral exploration
Wolfden USA Inc.	100%	United States	Mineral exploration
Wolfden Mt. Chase LLC	100%	United States	Mineral exploration
Wolfden Big Silver LLC	100%	United States	Mineral exploration

All transactions and balances between the Corporation and its subsidiaries are eliminated on consolidation, including unrealized gains and losses on transactions between the companies.

Foreign currency translation

The consolidated financial statements are presented in Canadian dollars (CAD), which is also the functional currency of the Corporation, as well as its subsidiary Wolfden Resources Canada Inc. The functional currency of the Corporation's subsidiaries, Wolfden USA Inc, Wolfden Mt. Chase LLC, and Wolfden Big Silver LLC is U.S. dollars (USD).

Foreign currency transactions are translated into the functional currency of the respective Corporation, using the exchange rates prevailing at the dates of the transactions (spot exchange rate). Foreign exchange gains and losses resulting from the settlement of such transactions and from the remeasurement of monetary items at year-end exchange rates are recognized in profit or loss.

In the Corporation's consolidated financial statements, all assets, liabilities and transactions of the Corporations' subsidiary are translated into CAD upon consolidation. On consolidation, assets and liabilities have been translated into CAD at the closing rate at the reporting date. Income and expenses have been translated into the Corporation's presentation currency at the average rate over the reporting period. Exchange differences are charged/credited to other comprehensive income and recognized in the currency translation reserve in equity. On disposal of a foreign operation the cumulative translation differences recognized in equity are reclassified to profit or loss and recognized as part of the gain or loss on disposal.

Financial instruments

Financial instruments are measured on initial recognition at fair value, plus, in the case of financial instruments other than those classified as fair value through profit or loss ("FVTPL"), directly attributable transaction costs. Financial instruments are recognized when the Corporation become party to the contracts that gives rise to them and are classified as amortized cost, fair value through profit or loss or fair value through other comprehensive income, as appropriate. The Corporation considers whether a contract contains an embedded derivative when the entity first becomes a party to it. The embedded derivatives are separated from the host contract if the host contract is not measured at fair value through profit or loss and when the economic characteristics and risks are not closely related.to those of the host contract. Reassessment only occurs if there is a change in the terms of the contract that significantly modifies the cash flows that would otherwise be required.

<u>Financial assets at FVTPL</u>

Financial assets at FVTPL include financial assets held for trading and financial assets not designated upon initial recognition as amortized cost or fair value through other comprehensive income ("FVOCI"). A financial asset is classified in this category principally for the purpose of selling in the short term, or if so designated by management.

Transaction costs are expensed as incurred. On initial recognition, a financial asset that otherwise meets the requirements to be measured at amortized cost or FVOCI may be irrevocably designated as FVTPL if doing so eliminates or significantly reduces an accounting mismatch that would otherwise arise. Financial assets measured at FVTPL are measured at fair value with changes in fair value recognized in the consolidated statements of operations.

Financial assets at FVOCI

On initial recognition of an equity investment that is not held for trading, an irrevocable election is available to measure the investment at fair value upon initial recognition plus directly attributable transaction costs and at each period end, changes in fair value are recognized in other comprehensive income ("OCI") with no reclassification to the consolidated statements of earnings. The election is available on an investment-by-investment basis. Investments in equity securities, where the Corporation cannot exert significant influence, are designated as financial assets at FVOCI.

Financial assets at amortized cost

A financial asset is measured at amortized cost if it is held within a business model whose objective is to hold assets to collect contractual cash flows and its contractual terms give rise on specified dates to cash flows that are solely payments of principal and interest on the principal amount outstanding, and is not designated as FVTPL. Financial assets classified as amortized cost are measured subsequent to initial recognition at amortized cost using the effective interest method. Cash and cash equivalents and amounts receivable are classified as and measured at amortized cost.

Financial liabilities

Financial liabilities are classified as measured at amortized cost or FVTPL. A financial liability is classified as FVTPL if it is classified as held-for-trading, it is a derivative or it is designated as such on initial recognition. Financial liabilities at FVTPL are measured at fair value and net gains and losses, including any interest expense, are recognized in profit or loss. Other financial liabilities are subsequently measured at amortized cost using the effective interest method. Gains and losses are recognized in net earnings when the liabilities are derecognized as well as through the amortization process. Borrowing liabilities are classified as current liabilities unless the Corporation has an unconditional right to defer settlement of the liability for at least 12 months after the statement of financial position date. Accounts payable and accrued liabilities are classified as and measured at amortized cost.

Derivative instruments

Derivative instruments, including embedded derivatives, are measured at fair value on initial recognition and at each subsequent reporting period. Any gains or losses arising from changes in fair value on derivatives are recorded in net earnings.

Fair values

The fair value of quoted investments is determined by reference to market prices at the close of business on the statement of financial position date. Where there is no active market, fair value is determined using valuation techniques. These include using recent arm's length market transactions; reference to the current market value of another instrument that is substantially the same; discounted cash flow analysis; and, pricing models.

Financial instruments that are measured at fair value subsequent to initial recognition are grouped into a hierarchy based on the degree to which the fair value is observable as follows:

Level 1 fair value measurements are quoted prices (unadjusted) in active markets for identical assets or liabilities;

Level 2 fair value measurements are those derived from inputs other than quoted prices included within Level 1 that are observable for the asset or liability either directly (i.e. as prices) or indirectly (i.e. derived from prices); and

Level 3 fair value measurements are those derived from valuation techniques that include inputs for the asset or liability that are not based on observable market data (unobservable inputs).

Impairment of financial assets

At each balance sheet date, on a forward-looking basis, the Corporation assesses the expected credit losses associated with its financial assets carried at amortized cost and FVOCI. The impairment methodology applied depends on whether there has been a significant increase in credit risk. The impairment model does not apply to investment in equity instruments. The expected credit losses are required to be measured through a loss allowance at an amount equal to the 12- month expected credit losses (expected credit losses that result from those default events on the financial instrument that are possible within 12 months after the reporting date) or full lifetime expected credit losses (expected credit losses that result from all possible default events over the life of the financial instrument). A loss allowance for full lifetime expected credit losses is required for a financial instrument if the credit risk of that financial instrument has increased significantly since initial recognition.

Derecognition of financial assets and liabilities

A financial asset is derecognised when either the rights to receive cash flows from the asset have expired or the Corporation has transferred its rights to receive cash flows from the asset or has assumed an obligation to pay the received cash flows in full without material delay to a third party. If neither the rights to receive cash flows from the asset have expired nor the Corporation has transferred its rights to receive cash flows from the asset, the Corporation will assess whether it has relinquished control of the asset or not. If the Corporation does not control the asset then derecognition is appropriate.

A financial liability is derecognised when the associated obligation is discharged or canceled or expires. When an existing financial liability is replaced by another from the same lender on substantially different terms, or the terms of an existing liability are substantially modified, such an exchange or modification is treated as the derecognition of the original liability and the recognition of a new liability. The difference in the respective carrying amounts is recognised in net earnings.

Exploration and Evaluation

The Corporation is in the process of exploring its mineral properties and chooses to expense acquisition costs for property rights. Mineral property acquisition costs include the cash consideration given, direct legal costs incurred for the acquisition, and issuance of shares for mineral property interests. Where the Corporation has entered into an option agreement for the acquisition of an interest in a mineral property which provides for periodic payments, such amounts unpaid are not recorded as a liability since they are payable entirely at the Corporation's discretion.

The Corporation has adopted the policy of expensing exploration costs and periodic maintenance costs incurred prior to the determination that a property has economically recoverable reserves.

Equipment and leaseholds

Equipment and leaseholds are stated at historical cost less accumulated depreciation and any provision for impairment in value. Cost includes the purchase price, any directly attributable costs of bringing the asset to the location and condition necessary for it to be capable of operating in the manner intended by management, and the present value of the estimated costs of decommissioning and restoration, if applicable. Costs relating to major upgrades are included in equipment and leaseholds if it is probable that future economic benefits associated with the expenditure will flow to the Corporation.

Depreciation on equipment is recognized on a declining balance basis to write down the cost or valuation less estimated residual value of equipment. Depreciation on leaseholds is recognized on the straight-line basis over the term of the lease, which is 5 years. The rates generally applicable are:

Computer equipment	30%
Vehicles	30%
Leaseholds	Straight line over term

Material residual value estimates and estimates of useful life are updated as required, but at least annually.

Gains or losses arising on the disposal of equipment are determined as the difference between the disposal proceeds and the carrying amount of the equipment and are recognized in profit or loss within 'other income' or 'other expenses'.

Cash and cash equivalents

Cash and cash equivalents comprise cash on hand and demand deposits, together with other short-term, highly liquid investments that are readily convertible into known amounts of cash and which are subject to an insignificant risk of changes in value.

Impairment of non-financial assets

At each financial position reporting date, the carrying amounts of the Corporation's non-financial assets are reviewed to determine whether there is any indication that those assets are impaired. If any such indication exists, the recoverable amount of the asset is estimated in order to determine the extent of the impairment, if any. The recoverable amount is the higher of fair value less costs to sell and value in use. Fair value is determined as the amount that would be obtained from the sale of the asset in an arm's length transaction between knowledgeable and willing parties. In assessing value in use, the estimated future cash flows are discounted to their present value using a pre-tax discount rate that reflects current market assessments of the time value of money and the risks specific to the asset. If the recoverable amount of an asset is estimated to be less than its carrying amount, the carrying amount of the asset is reduced to its recoverable amount and the impairment loss is recognized in the profit or loss for the period. For an asset that does not generate largely independent cash inflows, the recoverable amount is determined for the cash generating unit to which the assets belong.

When an impairment loss subsequently reverses, the carrying amount of the asset (or cash-generating unit) is increased to the revised estimate of its recoverable amount, but so that the increased carrying amount does not exceed the carrying amount that would have been determined had no impairment loss been recognized for the asset (or cash-generating unit) in prior years. A reversal of an impairment loss is recognized immediately in profit or loss.

Share capital

Share capital represents the fair value of consideration received. Equity instruments are contracts that give a residual interest in the net assets of the Corporation. Financial instruments issued by the Corporation are classified as equity only to the extent that they do not meet the definition of a financial liability or financial asset. The Corporation's common shares, reserves, share options and share warrants are classified as equity instruments.

Incremental costs directly attributable to the issue of new shares, options or warrants are shown in equity as a deduction, net of tax, from the proceeds.

The Corporation periodically issues units to investors consisting of common shares and warrants in non-brokered private placements. Each whole warrant issued entitles the holder to acquire a common share of the Corporation, at a fixed Canadian dollar price over a specified term. These warrants are not transferable from the original investor to a new investor. The Corporation's investor warrants are equity instruments and not financial liabilities or financial obligations. Accordingly, gross investor proceeds received from the issuance of units are accounted for as an increase in share capital. No separate valuation (i.e. "bifurcation") of investor warrants is made for accounting purposes at the time of issuance or at any time thereafter.

When investor or other warrants are exercised, the proceeds received are added to share capital. When investor or other warrants expire unexercised, no accounting entry is recorded.

Share-based payment transactions

The Corporation has two share-based compensation plans: The Share Option Plan and Restricted Share Unit plan, as noted below, and as further discussed in Note 8 of these consolidated financial statements.

All goods and services received in exchange for the grant of any share-based payment are measured at their fair values. Where employees are rewarded using share-based payments, the fair values of employees' services are determined indirectly by reference to the fair value of the equity instruments granted. This fair value is determined at the grant date.

Share Option Plan

Stock options are equity-settled share-based compensation awards. The fair value of stock options at the grant date is estimated using the Black-Scholes option pricing model. Compensation expense is recognized over the stock option vesting period based on the number of units estimated to vest. Vesting periods range from immediate to five years. This expense is recognized as share-based compensation expense with a corresponding increase in contributed surplus. When options are exercised, the proceeds received by the Corporation, together with the amount in contributed surplus, are credited to common shares.

If vesting periods or other vesting conditions apply, the expense is allocated over the vesting period, based on the best available estimate of the number of share options expected to vest. Non-market vesting conditions are included in assumptions about the number of options that are expected to become exercisable. Estimates are subsequently revised if there is any indication that the number of share options expected to vest differs from previous estimates. Any cumulative adjustment prior to vesting is recognized in the current period. No adjustment is made to any expense recognized in prior periods if share options ultimately exercised are less than that estimated on vesting.

Restricted Share Unit Plan

Restricted share units ("RSU") are granted to eligible members of the Board of Directors, eligible employees and eligible contractors. The RSUs are settled in cash or equity at the option of the Corporation. The RSUs vest subject to an RSU award letter but no later than December 31, of the third calendar year following the service year determined based on date of grant. The RSUs granted are accounted for under the equity method as they expected to be settled in equity.

Income taxes

Tax expense recognized in profit or loss comprises the sum of deferred tax and current tax not recognized in other comprehensive income or directly in equity.

Current income tax assets and/or liabilities comprise those obligations to, or claims from, fiscal authorities relating to the current or prior reporting periods, that are unpaid at the reporting date. Current tax is payable on taxable profit, which differs from profit or loss in the financial statements. Calculation of current tax expense is based on tax rates and tax laws that have been enacted or substantively enacted by the end of the reporting period.

Deferred income taxes are calculated using the liability method on temporary differences between the carrying amounts of assets and liabilities and their tax bases. However, deferred tax is not provided on the initial recognition of goodwill, or on the initial recognition of an asset or liability unless the related transaction is a business combination or affects tax or accounting profit. Deferred tax on temporary differences associated with investments in subsidiaries and joint ventures is not provided if reversal of these temporary differences can be controlled by the Corporation and it is probable that reversal will not occur in the foreseeable future.

Deferred tax assets and liabilities are calculated, without discounting, at tax rates that are expected to apply to their respective period of realization, provided they are enacted or substantively enacted by the end of the reporting period. Deferred tax liabilities are always provided for in full.

Deferred tax assets are recognized to the extent that it is probable that they will be able to be utilised against future taxable income. To the extent that the Corporation does not consider it probable that a future tax asset will be recovered, it provides a valuation allowance against the excess.

Deferred tax assets and liabilities are offset only when the Corporation has a right and intention to offset current tax assets and liabilities from the same taxation authority.

Changes in deferred tax assets or liabilities are recognized as a component of taxable income or expense in profit or loss, except where they relate to items that are recognized in other comprehensive income or directly in equity, in which case the related deferred tax is also recognized in other comprehensive income or equity, respectively.

Provisions

Provisions are recognized when the Corporation has a present obligation (legal or constructive) as a result of a past event, it is probable that an outflow of resources will be required to settle the obligation and a reliable estimate can be made of the amount of the obligation. The amount recognized as a provision is the best estimate of the consideration required to settle the present obligation at the end of the reporting period. If the effect of the time value of money is material, provisions are determined by discounting the expected future cash flows at a pre-tax rate that reflects current market assessments of the time value of money and, where appropriate, the risks specific to the liability. Where discounting is used, the increase in the provision due to the passage of time is recognized as a finance cost. Contingent liabilities are not recognized in the financial statements, if not estimable and probable, and are disclosed in notes to the financial information unless their occurrence is remote. Contingent assets are not recognized in the financial statements, but are disclosed in the notes if their recovery is deemed probable.

Environmental rehabilitation provision

Provisions for environmental rehabilitation are made in respect of the estimated future costs of closure and restoration and for environmental rehabilitation costs (which include the dismantling and demolition of infrastructure, removal of residual materials and remediation of disturbed areas) in the accounting period when the related environmental disturbance occurs. The provision is discounted using a pre-tax rate, and the unwinding of the discount is included in finance costs. At the time of establishing the provision, a corresponding asset is capitalized and is depreciated over future production from the mining property to which it relates. The provision is reviewed on an annual basis for changes in cost estimates, discount rates and operating lives. Changes to estimated future costs are recognized in the statement of financial position by adjusting the rehabilitation asset and liability. If, for mature mines, the revised mine assets net of rehabilitation provisions exceeds the carrying value, that portion of the increase is charged directly to expenses. For closed sites, changes to estimated costs are recognized immediately in the profit and loss.

Loss per share

The Corporation presents basic and diluted loss per share data for its common shares, calculated by dividing the loss attributable to common shareholders of the Corporation by the weighted average number of common shares outstanding during the period. Diluted loss per share is determined by adjusting the profit or loss attributable to common shareholders and the weighted average number of common shares outstanding for the effects of all dilutive potential common shares.

Interest

Interest income and expenses are reported on an accrual basis using the effective interest method.

Operating expenses

Operating expenses are recognized in profit or loss upon utilization of the service or at the date of their origin.

Segment reporting

An operating segment is a component of an entity (i) that engages in business activities from which it may earn revenues and incur expenses (including revenues and expenses relating to transactions with other components of the same entity), (ii) whose operating results are regularly reviewed by the entity's management, and (iii) for which discrete financial information is available. The Corporation's operating segments are its separately identifiable exploration and evaluation properties [See note 4 & note 7].

Significant accounting judgements and estimates

In the application of the Corporation's accounting policies, which are described in Note 2 of the audited consolidated financial statements for the year ending December 31, 2022, management is required to make judgements, estimates and assumptions about the carrying amounts of assets and liabilities that are not readily apparent from other sources. The estimates and associated assumptions are based on historical experience and other factors that are considered to be relevant. Actual results may differ from these estimates.

Significant estimates

The preparation of these financial statements requires management to make estimates and assumptions that affect the reported amounts of assets and liabilities at the date of the financial statements and reported amounts of expenses during the reporting period. Actual outcomes could differ from these estimates. The financial statements include estimates, which by their nature are uncertain. The impacts of such estimates are pervasive throughout the consolidated financial statements and may require accounting adjustments based on future occurrences. Revisions to accounting estimates are recognized in the period in which the estimate is revised, and the revision affects both current and future periods. Significant estimates include:

i. the inputs used in accounting for share purchase option expense in the statement of loss and comprehensive loss;

ii. the provision for income taxes which is included in the statements of income and comprehensive income and composition of deferred income tax assets and liabilities included in the statement of financial position which have not yet been confirmed by the taxation authorities, and

iii. the estimated useful lives of equipment and leaseholds which are included in the statement of financial position and the related depreciation included in the statement of loss and comprehensive loss.

Flow through shares

Under Canadian income tax legislation, a company is permitted to issue flow through shares whereby the company agrees to incur qualifying expenditures and renounce the related income tax deductions to the investors. The Corporation allocates the proceeds from the issuance of these shares between the offering of shares and the sale of tax benefits. The allocation is made based on the difference between the quoted price of the shares and the amount the investor pays for the shares. A deferred flow through premium liability is recognized for the difference. The liability is reversed though other income in the income statement. The spending also gives rise to a deferred tax timing difference between the carrying value and tax value of the qualifying expenditure.

Government grants

Government grants are recorded as other income when there is reasonable assurance that the Company has complied with and will continue to comply with, all necessary conditions to obtain the grants. These grants are used to reduce the related exploration expenditures.

Timber sales

The Company engages with third parties for sale of its Royalty on timber. The proceeds from these sales have been recorded as other income.

Functional currency

Management uses its judgement to determine the functional currency that most faithfully represents the economic effects of the underlying transactions, events and conditions. As part of this approach, management gives priority to indicators like the currency that mainly influences costs and the currency in which those costs will be settled and the currency in which funds from financing activities are generated. Management also assesses the degree of autonomy the foreign operation has with respect to operating activities.

3. RECENT ACCOUNTING PRONOUNCEMENTS

There have been no new standards and interpretations adopted since the release of the Company's financial statements for the year ended December 31, 2022.

New standards and interpretations not yet adopted

Disclosure of Accounting Policies (Amendments to IAS 1)

The IASB has issued amendments to IAS 1 *Presentation of Financial Statements* which require entities to disclose their "material" accounting policy information rather than their "significant" accounting policies. The amendments explain that accounting policy information is material if omitting, misstating or obscuring that information could reasonably be expected to influence decisions that the primary users of the financial statements make on the basis of those financial statements. The amendments also clarify that accounting policy information may be material because of its nature, even if the related amounts are immaterial. This amendment is effective for annual periods beginning on or after January 1, 2023. Earlier application is permitted. The extent of the impact of adoption of these amendments has not yet been determined.

Definition of Accounting Estimates (Amendments to IAS 8)

The IASB has issued amendments to IAS 8 *Accounting Policies, Changes in Accounting Estimates and Errors* which introduce a definition of accounting estimates and provide other clarifications to help entities distinguish accounting policies from accounting estimates. Under the amendments, accounting estimates are defined as "monetary amounts in financial statements that are subject to measurement uncertainty". The amendments also emphasize that a change in an accounting estimate that results from new information or new developments is not an error correction, and that changes in an input or a measurement technique used to develop an accounting estimate are considered changes in accounting estimates if those changes in an input or measurement technique are not the result of an error correction. This amendment is effective for annual periods beginning on or after January 1, 2023. Earlier application is permitted. The extent of the impact of adoption of these amendments has not yet been determined.

Deferred Tax related to Assets and Liabilities arising from a Single Transaction (Amendments to IFRS 1 and IAS 12)

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

For the years ended December 31, 2022 and 2021
(Stated in Canadian Dollars)

The IASB has issued amendments to IFRS 1 *First-time Adoption of International Financial Reporting Standards* and IAS 12 *Income Taxes* which clarify that the initial recognition exemption set out in IAS 12 does not apply to transactions that give rise to equal taxable and deductible temporary differences. The aim of the amendments is to reduce diversity in the reporting of deferred tax on leases and decommissioning obligations. This amendment is effective for annual periods beginning on or after January 1, 2023. Earlier application is permitted. The extent of the impact of adoption of this amendment has not yet been determined.

Classification of Liabilities as Current or Non-Current (Amendments to IAS 1)

The IASB has published *Classification of Liabilities as Current or Non-Current (Amendments to IAS 1)* which clarifiesthe guidance on whether a liability should be classified as either current or non-current. The amendments:

i. clarify that the classification of liabilities as current or non-current should only be based on rights that are in place "at the end of the reporting period"

ii. clarify that classification is unaffected by expectations about whether an entity will exercise its right to defer settlement of a liability

iii. make clear that settlement includes transfers to the counterparty of cash, equity instruments, other assets or services that result in extinguishment of the liability.

iv. This amendment is effective for annual periods beginning on or after January 1, 2024. Earlier application is permitted. The extent of the impact of adoption of this amendment has not yet been determined.

4. SEGMENTED INFORMATION

The Corporation's significant segments are represented by its separately identifiable exploration and evaluation properties (see note 7 for disclosure by property). The Corporation also operates in two distinct geographic areas. The Canadian operations are managed from the Corporation's head office in Thunder Bay. The U.S. operations are managed from an office in Maine.

For the year ended December 31, 2022

	Canada $	USA $	Total $
Segmented Assets	2,757,217	906,013	**3,663,230**
Segmented Liabilities	290,248	278,547	**568,795**
Operating activities			
Depreciation	195	-	**195**
Exchange loss	(114,365)	(86,907)	**(201,272)**
Exploration and evaluation expenses	1,605,301	1,348,397	**2,953,698**
Flow-through interest penalty	1,853	-	**1,853**
General and administrative	705,447	299,861	**1,005,308**
Professional fees	75,046	1,194	**76,240**
Share-based payments	405,849	-	**405,849**
Income tax expense	32,909	(68,974)	**(36,065)**
Total	**2,712,235**	**1,493,570**	**4,205,805**
Other items	246,021	1,272,444	1,518,465
Loss for the year	**(2,466,214)**	**(221,127)**	**(2,687,340)**

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

For the years ended December 31, 2022 and 2021
(Stated in Canadian Dollars)

For the year ended December 31, 2021

	Canada $	USA $	Total $
Segmented Assets	2,266,023	1,036,857	**3,302,880**
Segmented Liabilities	139,621	93,222	**232,843**
Operating activities			
Depreciation	265	-	265
Exchange loss	(44,783)	(6,869)	(51,653)
Exploration and evaluation expenses	1,284,869	1,953,866	3,238,735
Flow-through interest penalty	492	-	492
General and administrative	793,574	405,194	1,198,768
Professional fees	82,567	-	82,567
Share-based payments	509,130	34,893	544,022
Total	**2,626,113**	**2,387,084**	**5,013,196**
Other items	378,294	920	379,214
Loss for the year	**(2,247,819)**	**(2,386,164)**	**(4,633,983)**

5. AMOUNTS RECEIVABLE

For the years ended December 31, 2022 and 2021

	2022 $	2021 $
Recoverable taxes (i)	**134,134**	60,552

(i) Recoverable taxes include Canadian harmonized sales tax receivable, refund for overpayment of flow through taxes and a balance of income tax overpayment for 2020.

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

For the years ended December 31, 2022 and 2021
(Stated in Canadian Dollars)

6. EQUIPMENT

	Computer Equipment $
Cost	
Balance, December 31, 2021	13,120
Balance, December 31, 2022	**13,120**
Accumulated depreciation	
Balance, January 1, 2021	12,110
Depreciation for the year	265
Balance, December 31, 2021	12,375
Depreciation for the year	195
Balance, December 31, 2022	**12,570**
Carrying amounts	
December 31, 2021	745
December 31, 2022	**550**

7. EXPLORATION AND EVALUATION

For the year ended December 31, 2022

	Manitoba Nickel	Pickett Mountain	Teta-gouche	Big Silver	Total for 2022	Total to date from inception
Analysis	-	27,915	14,487	-	**42,402**	998,784
Geological	71,123	32,215	22,338	30,333	**156,008**	3,800,437
Geophysical	74,440	-	47,715	107,437	**229,591**	3,237,891
Geochemical	27,188	1,570	30,468	57,189	**116,414**	454,005
Travel	58,755	43,088	12,455	12,434	**126,732**	880,933
Drilling	944,541	888	780	3,883	**950,091**	8,786,919
Property Work	-	16,123	175,008	-	**191,131**	1,013,828
Ops Support	5,375	17,441	21,095	37,212	**81,124**	605,585
Administration	5,533	832	9,242	-	**15,607**	767,729
General expense	5,599	399	19,232	196	**25,426**	60,200
Site Acquisition costs	50,000	-	-	-	**50,000**	167,837
Mine Permitting expense	10,000	959,169	-	-	**969,169**	1,239,858
Total Exploration	1,252,553	1,099,641	352,821	248,684	**2,953,698**	22,014,009
Other costs	-	-	-	-	**-**	21,133,497
Total	1,252,553	1,099,641	352,821	248,684	**2,953,698**	43,147,506

(Stated in Canadian Dollars)

For the year ended December 31, 2021

	Manitoba Nickel	Pickett Mountain	Teta-gouche	Big Silver	Total for 2021	Total to date from inception
Analysis	581	102,776	13,978	8,522	**125,857**	956,382
Geological	205,300	204,650	117,859	31,070	**558,879**	3,644,429
Geophysical	147,903	1,006	99,210	92,272	**340,391**	3,008,300
Geochemical	50	-	25,158	28,674	**53,883**	337,591
Travel	8,246	54,185	11,248	25,751	**99,429**	754,201
Drilling	292,610	860,815	210,888	7,649	**1,371,960**	7,836,828
Property Work	-	14,190	27,055	61,072	**102,317**	822,697
Ops Support	12,586	89,208	41,941	18,468	**162,203**	524,461
Administration	-	-	516	-	**516**	752,122
General expense	750	17,403	13,992	2,630	**34,774**	34,774
Site Acquisition costs	55,000	-	-	62,837	**117,837**	117,837
Mine Permitting expense	-	270,689	-	-	**270,689**	270,689
Total Exploration	723,025	1,614,922	561,844	338,944	**3,238,735**	19,060,312
Other costs	-	-	-	-	**-**	21,133,497
Total	723,025	1,614,922	561,844	338,944	**3,238,735**	40,193,809

Mineral property acquisitions and agreements

Maine, U.S.A.

Pickett Mountain Property

On November 16, 2017, the Corporation acquired a 100% interest in the Pickett Mountain Property (the “Property”), located in Penobscot County, northern Maine, U.S.A for a cash purchase price of $11,292,055 (US$8.5 million) (the “Acquisition”).

To fund the acquisition of the Property, the Corporation entered into a Royalty Agreement that granted a 1.35% gross sales royalty on the Property to Altius Resources Inc. (“Altius”), a wholly owned subsidiary of Altius Minerals Corporation, for cash consideration of $7,663,800 (US$6,000,000) and completed a non-brokered private placement (the "Offering") of 20,200,000 subscription receipts ("Subscription Receipts") at a price of $0.25 per Subscription Receipt for gross proceeds of $5,050,000, with Altius subscribing for 14,200,000 Subscription Receipts. The subscription receipts were converted into 14,200,000 common shares of the Corporation.

Pursuant to the Royalty Agreement, Altius has the option to purchase an additional 0.50% gross sales royalty at any time before the first anniversary of commercial production for US$7,500,000. In addition, the Corporation granted Altius certain rights to convert the Pickett Mountain Royalty to equity under certain terms, or to exchange the royalty for a similar royalty on the Corporation's Orvan Brook property. Furthermore, the Corporation agreed to use its best efforts to sell or transfer the timber from the project for gross proceeds of US$5,000,000 or such other amount as agreed to by Wolfden and Altius, acting reasonably (the "Timber Proceeds"). Wolfden is required to pay Altius 20% of the Timber Proceeds. These terms as shown were amended from the original agreement on October 7, 2020.

On January 22, 2020, the Corporation secured up to US$4.5 million in non-dilutive funding by selling-forward $5 million worth of timber from its Pickett Mountain Property. Under the terms of the agreement the Corporation received

US$3 million and is entitled to receive an additional US$1.5 million between the 4th and 5th anniversary of the agreement. The timber company has the right to harvest US$5 million of timber from the property over 5 years. For the year ended December 31, 2020, the Corporation recorded net timber sales proceeds of $3,140,880 (US$ 2,400,000), that are net of 20% (US$600,000) that was passed onto to Altius as per the Royalty Agreement (2019 - $252,326). The entire amount of the proceeds was recognized as no further performance obligation is required by the Corporation. These funds are not being placed in escrow and have been included in the working capital of the Corporation.

Pursuant to the Royalty Agreement, Altius has a conversion right and exchange right. The Call Right, which related to Altius's call option on the Timber Rights, was eliminated in the October 7, 2020 amendment of the Royalty Agreement as a direct result of the Corporations January 22, 2020 $4.5 million timber sale agreement which by effect, eliminated the possibility for any potential call option on those Timber Rights. Each or the other two rights are valid and are summarized below.

Conversion Right

At any time after November 14, 2023, Altius will have the right to convert the Pickett Mountain Royalty, in accordance with the terms of the Royalty Agreement, to cash or Common Shares, or a combination thereof (the "Conversion Right"). Upon the exercise of the Conversion Right, the Common Share consideration to be received by Altius will be equal to the lesser of: (a) the number of Common Shares that is equal in Royalty Value; and (b) the number of Common Shares that does not exceed 19.99% of all outstanding Common Shares on a partially diluted basis. The remaining balance of the Royalty Value is to be paid to Altius in cash. Under the Royalty Agreement, "Royalty Value" means an amount equal to the aggregate of: (i) all amounts paid by Altius to Wolfden (including the purchase price consideration paid by Altius) in respect of the Pickett Mountain Royalty, minus (ii) all timber Proceeds received by Altius, minus (iii) all other payments received by Altius in respect of the Pickett Mountain Royalty. The Common Share conversion price is the greater of: (i) $0.05 per Common Share; and (ii) the volume weighted average trading price of the Common Shares on the TSXV (or any other principal exchange on which the Common Shares are trading) for the twenty consecutive trading days immediately preceding the date of the exercise of the Conversion Right. Upon the exercise of the Conversion Right and satisfaction of the payment thereof by Wolfden, any remaining Escrowed Proceeds will be released to Wolfden.

Exchange Right

Under the Royalty Agreement, Altius has the right to exchange the Pickett Mountain Royalty to a gross sales royalty in respect of the Orvan Brook property, which will be calculated and payable on the same terms as the terms of the Pickett Mountain Royalty in effect on the date of exchange, mutatis mutandis.

During the period ending September 30, 2019, Altius and Wolfden agreed to an amendment to their Offering and Subscription Agreements, dated November 14, 2017 whereby during any period when the common shares of Wolfden are trading on the Toronto Stock Exchange Venture Exchange at a volume-weighted average trading price of not less than $0.60 per common share for at least 20 consecutive trading days, it will, upon written request by Wolfden during such period, exercise its warrants. Altius currently holds 7,100,000 Wolfden common share purchase warrants priced at $0.35 per share with a termination date of November 15, 2022.

Timber Agreements

On January 22, 2020, the Corporation secured up to US$4.5 million in non-dilutive funding for its exploration projects by selling-forward timber from its wholly owned Pickett Mountain Zn-Pb-Cu-Ag-Au Project in Maine, USA. Under the terms of a 5 year stumpage agreement with a privately owned Maine timber company, the Corporation received US$3 million upon closing and is entitled to receive an additional US$1.5 million between the 4th and 5th anniversary of the agreement. The timber company has the right to harvest US$5 million of timber from the property over 5 years. In addition, the timber company also granted Wolfden an option to earn a 100% interest (less an NSR) in the mineral rights of the property that adjoins Pickett Mountain as well as long-term road access rights for the current forest road used to reach the Pickett Mountain deposit from the state highway #11. As part of the Altius Royalty agreement on

Pickett Mt., dated November 2017 and as amended on October 7, 2020 and on February 8, 2022, Altius and the Corporation executed an amendment to their Pickett Mountain Royalty Agreement where Altius increased its royalty for the payment of US$1 million to the Corporation on signing. As per the terms of the agreement, Altius will receive the next US$1.2 million in net timber revenues and thereafter increases its future timber royalties from 20% to 30%. The 30% royalty will also apply to any revenue generated from the sale of any timber related carbon credits from the Property.

Other properties, Maine USA

On April 6, 2019, the Corporation's U.S. subsidiary entered into a mineral rights earn-in agreement on a property located in Maine, U.S.A. The agreement called first and second year lease payments of $25,000 USD, both of which have been paid.

On November 30, 2020, the Corporation's U.S. subsidiary entered into a mineral rights earn-in agreement on a property in Maine referred to as the Big Silver Project. The agreement called for a first-year payment of $50,000 which has been paid. The Corporation is assessing the project, including the positive results of its 2021 and 2022 programs and the potential economic impact of a new town ordinance that would restrict commercial mining of this project in the future. .

New Brunswick, Canada

Tetagouche Property

On January 6, 2014, the Corporation closed a definitive purchase agreement (the ""Agreement"") to acquire a large strategic land package (the ""Property"") situated in the Bathurst Mining Camp and surrounding area in northeastern New Brunswick. Wolfden acquired the Property from 8100896 Canada Inc., a wholly owned subsidiary of GeoVenCap Inc. (the "Vendor"). Pursuant to the terms of the Agreement, the Corporation purchased all of the Vendor's right, title and interest to and in the Property for cash consideration of $125,000 and 571,428 common shares of Corporation (the "Consideration Shares") having a value of $100,000. The Consideration Shares were subject to a four month hold period under applicable securities laws in Canada.

Orvan Brook Property

On January 3, 2017, the Corporation acquired through claim staking the Orvan Brook property located in the Bathurst Mining Camp, west of the town of Bathurst, New Brunswick. Orvan Brook is included under the Tetagouche Properties.

Clarence Stream Property Agreements

On August 2, 2016, the Corporation entered into a definitive option agreement with 2520885 Ontario Inc. and Galway Metals Inc., whereby Galway could earn a 100% interest in the property, located in southwestern New Brunswick.

As per the terms of the agreement, and as of July 9, 2019 Galway successfully completed exploration expenditures and made cash payments to Wolfden totaling $3,250,000 to earn a 100% interest in the property less a 1% Net Smelter Return Royalty held by Wolfden that can purchased at any time for the sum of $2,000,000.

Brunswick No. 6 West Property

On April 29, 2015, the Corporation acquired, by claim staking, the Brunswick No. 6 West property (the "Property). The wholly owned Property is located southwest of the City of Bathurst, in the heart of the Bathurst Mining Camp.

Manitoba Nickel Properties, Canada

Rice Island Property

On September 15, 2015, the Corporation acquired a 100% interest in the Rice Island nickel-copper deposit situated on the Rice Island property (the "Property") through claim staking. The Property is located in west-central Manitoba at Wekusko Lake, just east of the Snow Lake concentrator complex owned by Hudbay Minerals Inc.

During the fourth quarter of 2015, a Notice of Dispute (the "Notice") was filed with the Province of Manitoba with respect to the Rice Island, Manitoba claims. Specifically, the Notice states that an individual (the "Disputant") has taken the position that one of the claims recorded in favour of Wolfden is invalid due to the existence of the Disputant's claims on the land prior to Wolfden's staking of the claim. Wolfden has responded to the Notice and is confident that it has clear and legal title to the subject claim as confirmed by the issuing of the recording certificate by the Manitoba Mining Recorder. This matter was brought to a resolution in conjunction with the signing of the Rice Island Tie-On Property ("RITOP") agreement described below. On September 21, 2016, the Corporation entered into an option agreement to expand the Rice Island property by earning a 100% interest in the Rice Island Tie-On Property, located adjacent to Wolfden's existing Rice Island property. Under terms of the option agreement with the Vendor, to earn a 100% interest in the RITOP, the Corporation must make cash payments totaling $250,000 and issue 500,000 common shares of Wolfden annually over a five year period, on or before the anniversary date of the signing of the agreement. A $25,000 cash payment and the issuance of 100,000 common shares was completed on signing. In addition, the Corporation must incur $1,000,000 in exploration expenditures over the same five year period including $100,000 in the first year. As at December 31, 2019, the exploration commitments have been completed and, in 2021 the cash annual cash payments to earn into the project were completed. Starting in September 2022, an annual cash payment of $50,000 as an advance royalty payment, shall be paid to a maximum of $250,000. Under an amendment to the agreement, the first payment was deferred and paid in January 2023.

Upon earning a 100% interest in the RITOP, the Vendor retains a 2.5% Net Smelter Royalty on the RITOP as well as on the Rice Island property; of which, Wolfden can purchase 1.5% of the Net Smelter Royalty for the sum of $1,500,000 (0.5% increments at $500,000 per each increment) for each of the properties. Wolfden also retains the right of first refusal on the remaining 1.0% Net Smelter Royalty held by the Vendor for each of the RITOP and Rice Island property.

8. SHARE CAPITAL AND RESERVES

i. Authorized

The Corporation is authorized to issue an unlimited number of common shares.

ii. Details of share issuances

2022

Private Placement

On December 16, 2022, the Corporation completed a non-brokered (no agent) private placement of 10,952,310 Common shares of the Corporation at a price of $0.21 per Common Share for gross proceeds of $2,299,985.

2021

Private Placement # 1

On January 27, 2021, the Corporation completed a non-brokered (no agent) private placement of 6,250,000 common shares of the Corporation at a price of $0.32 per Common Share with Altius Mineral Corporation (“Altius”) and Kinross

(Stated in Canadian Dollars)

Gold Corporation("Kinross") for gross proceeds of $2,000,000("the Offering"). Altius now holds approximately 12.6% and Kinross holds approximately 11.4% of the issued and outstanding shares of the Corporation.

Private Placement # 2

On February 24, 2021, the Corporation completed a non-brokered (no agent) private placement of 1,550,000 common shares of the Corporation that are "flow through shares" within the meaning in the Income Tax Act (Canada) at a price of $0.40 per Common Share for gross proceeds of $620,000. The proceeds from the financing ($620,000) were allocated between share capital ($480,500) and flow-through liability ($139,500) using residual method. All flow-through expenditures were completed during the year.

Private Placement # 3

On March 30, 2021, the Corporation completed a non-brokered (no agent) private placement of 12,725,000 unit of the Corporation at a price of $0.32 per unit for gross proceeds of $4,072,000. Each unit is comprised of one common share of the Corporation (a "Common Share") and one half of a common share purchase warrant of the Corporation (each whole warrant, a "Warrant"). Each whole purchase warrant can be converted in one common share of the Corporation at a price of $0.45 for two years, subject to acceleration in certain circumstances. No purchase value was allocated to the warrants.

iii. Warrants

The following table reflects the continuity of warrants as at December 31, 2022:

Expiry Date	Exercise Price	2022 Opening Balance	Warrants Issued	Warrants Exercised	Warrants Expired	2022 Closing Balance
	$	#	#	#	#	#
November 15, 2022	0.35	10,100,000	-	-	(10,100,000)	**-**
January 15, 2023	0.61	375,000	-	-	-	**375,000**
March 30,2023	0.45	6,362,500	-	-	-	**6,362,500**
Total		16,837,500	-	-	(10,100,000)	**6,737,500**
Weighted average exercise price		0.39	-	-	0.35	**0.46**

The following table reflects the continuity of warrants as at December 31, 2021:

Expiry Date	Exercise Price	2021 Opening Balance	Warrants Issued	Warrants Exercised	Warrants Expired	2021 Closing Balance
	$	#	#	#	#	#
November 15, 2022	0.35	10,100,000	-	-	-	10,100,000
January 15, 2023	0.61	375,000	-	-	-	375,000
March 30, 2023	0.45	-	6,362,500	-	-	6,362,500
Total		10,475,000	6,362,500	-	-	16,837,500
Weighted average exercise price		0.35	0.45	-	-	0.39

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

For the years ended December 31, 2022 and 2021
(Stated in Canadian Dollars)

iv. Share purchase option compensation plan

Share-based payments consists of the following amounts:

	For the year ended	
Share Based Payments	**2022** **$**	2021 $
Share purchase Options	**393,813**	462,220
Restricted Share Units (RSU's)	**12,036**	81,802
Total	**405,849**	544,022

The Corporation has a share incentive plan (the "Plan"), which is restricted to directors, officers, key employees and consultants of the Corporation. The number of common shares subject to options granted under the Plan (and under all other management options and employee stock purchase plans including RSU's) is limited to 10% in the aggregate and 5% with respect to any one optionee of the number of issued and outstanding common shares of the Corporation at the date of the grant of the option. Options issued under the Plan may be exercised during a period determined by the Board of Directors which cannot exceed ten years.

The following table reflects the stock options outstanding as at December 31, 2022:

Expiry Date	**Exercise Price**	**2022 Opening Balance**	**Granted**	**Exercised**	**Expired/ Cancelled**	**2022 Closing Balance**
	$	**#**	**#**	**#**	**#**	**#**
March 9, 2022	0.75	1,000,000	-	-	(1,000,000)	**-**
July 20, 2022	0.14	690,000	-	(690,000)	-	**-**
December 29, 2022	0.53	600,000	-	-	(600,000)	**-**
July 10, 2023	0.30	2,390,000	-	-	-	**2,390,000**
April 29, 2024	0.30	530,000	-	-	-	**530,000**
June 26, 2024	0.20	200,000	-	-	-	**200,000**
September 1, 2024	0.20	200,000	-	-	-	**200,000**
July 13, 2025	0.20	200,000	-	-	-	**200,000**
February 4, 2026	0.32	1,750,000	-	-	-	**1,750,000**
April 27, 2026	0.32	200,000	-	-	-	**200,000**
September 1, 2027	0.25		3,155,000			**3,155,000**
Total		7,760,000	3,155,000	(690,000)	(1,600,000)	**8,625,000**
Weighted Average exercise price		0.36	0.25	0.14	0.67	**0.28**

(Stated in Canadian Dollars)

The following table reflects the stock options outstanding as at December 31, 2021:

Expiry Date	Exercise Price	2021 Opening Balance	Granted	Exercised	Expired/ Cancelled	2021 Closing Balance
	$	#	#	#	#	#
March 09, 2022	0.75	1,080,000	-	-	(80,000)	**1,000,000**
August 18, 2021	0.13	710,000	-	(690,000)	(20,000)	**-**
July 20, 2022	0.14	710,000	-	-	(20,000)	**690,000**
December 29, 2022	0.53	600,000	-	-	-	**600,000**
July 10, 2023	0.30	2,390,000	-	-	-	**2,390,000**
April 29, 2024	0.30	600,000	-	-	(70,000)	**530,000**
June 26, 2024	0.20	200,000	-	-	-	**200,000**
September 1, 2024	0.20	200,000	-	-	-	**200,000**
July 13, 2025	0.20	200,000	-	-	-	**200,000**
February 04, 2026	0.32	-	1,750,000	-	-	**1,750,000**
April 27, 2026	0.32	-	200,000	-	-	**200,000**
Total		6,690,000	1,950,000	*(690,000)	(190,000)	**7,760,000**
Weighted Average exercise price		0.34	0.32	0.13	0.45	**0.36**

The Corporation applies the fair value method of accounting for all stock based compensation awards. During the year 3,155,000 stock options were granted, out of which 3,055,000 vested immediately and related compensation of $ 393,813 was recorded (2021 -$10,077 was recorded as compensation for the July 17, 2025 options that vested during the period, $409,459 for the February 4, 2026 options that vested during the period and $42,684 for the April 27,2026 options that vested during the period). As of December 31, 2022, there were 100,000 unvested stock options (December 31, 2021 - 0 unvested stock options).

* 690,000 options were exercised during the year with a weighted average share price of $0.14 (December 31, 2021 - 690,000 options were exercised during the year with a weighted average share price of $0.13). The Corporation credited $155,625 to the share capital in respect of the 690,000 shares issued (December 31, 2021 – credited $170,175 to share capital in respect of 690,000 shares issued).

** The weighted average remaining life of the outstanding stock options is 2.33 years (December 31, 2021 – 2.03 years).

For purposes of the options granted, the fair value of each option was estimated on the date of grant using the Black-Scholes option pricing model, with the following assumptions:

	2022	2021
Risk-free interest rate	**0.95%- 3.23%**	0.48%- 0.95%
Annualized volatility	**86.87%**	113.91% - 85.15%
Expected dividend	**Nil**	Nil
Expected option life	**5 years**	5 years
Forfeiture rate	**Nil**	Nil

(Stated in Canadian Dollars)

v. Restricted Share Units

1,070,000 Restricted Share Units ("RSUs") were issued in 2020 under the restricted share unit plan of the Corporation. The RSUs vest equally over a three year period, vesting on August 31 2020, April 29, 2021 and April 29, 2022. Each RSU has the same value as one Wolfden Resources Corporation common share. Additional, 1,208,750 Restricted Share Units ("RSUs") were issued under the restricted share unit plan of the Corporation in 2019. The RSUs vest equally over a three year period, vesting on June 26, 2019, April 29, 2020 and April 29, 2021.The RSUs are expected to be settled in equity and are therefore accounted for as equity instruments.

A share based payment expense of $12,036 ($81,802 for December 31, 2021) was recorded for the year ended December 31, 2022. During the year, 356,668 shares vested at $0.22 per share and the Corporation credited $78,467 to share capital in respect of the shares issued. As at December 31, 2022, there were no RSU's outstanding (December 31, 2021 – 356,668). The RSU's may be converted into common shares of the Corporation, at the option of the Corporation.

9. LOSS PER SHARE

Both the basic and diluted earnings per share have been calculated using the loss attributable to shareholders of the Corporation as the numerator. No adjustments to loss were necessary in 2022 or 2021.

For the year ended December 31

	2022	**2021**
Numerator: Loss for the year	**(2,637,341)**	**(4,633,983)**
Denominator: Weighted average number of common shares	**164,817,648**	**152,818,670**
Basic and diluted loss per share	**(0.02)**	**(0.03)**

10. RELATED PARTY TRANSACTIONS

The Corporation's related parties include key management personnel and entities over which they have control or significant influence as described below. There were no related party transactions in 2022.

Key management personnel remuneration includes the following amounts:

For the years ended December 31	**2022** **$**	**2021** **$**
Salary and wages	**429,921**	420,033
Share-based payments	**376,116**	297,406
Other compensation	**28,630**	21,658
Directors' fees	**72,861**	81,100
Total	**907,528**	820,197

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

For the years ended December 31, 2022 and 2021
(Stated in Canadian Dollars)

11. COMMITMENTS

Flow-through Renunciation

On February 24, 2021, the Corporation completed a flow-through financing to raise $620,000. The Corporation renounced 100% of the flow-through raised at year end. The Corporation had until February 1, 2022 to incur expenditures before monthly interest charges begin to accrue on unspent funds. Interest charges incurred by the Corporation as a result of this income tax legislation are charges to income in the period incurred. The Corporation incurred more than $620,000 in the flow-through eligible exploration expenses prior to December 31, 2021.

12. INCOME TAX EXPENSE

(a) The Corporation's income tax expense differs from the amount computed by applying the combined federal and provincial income tax rates to loss before income taxes as a result of the following:

	2022 $	2021 $
Loss for the year	**(2,687,340)**	(4,633,983)
Statutory rates	**26.50%**	26.50 %
Income tax recovery computed at statutory rates	**(712,145)**	(1,228,006)
Increase in deferred tax assets not recognized	**-**	1,067,205
Non-deductible items	**9,061**	131,465
Effect of change in tax rates	**699,391**	65,702
Change in estimates	**(38,000)**	-
Income tax expense (recovery)	**(38,000)**	0

(b) Deferred tax assets not recognized

Management believes that it is not likely to be sufficient taxable profits in the next few years to allow the benefit of the following deferred tax assets to be utilized:

	2022 $	2021 $
Non - capital losses	**5,188,383**	4,912,045
Common share issue costs	**-**	951
Equipment and leaseholds	**33,863**	33,812
Exploration and evaluation	**5,389,205**	4,651,698
Deferred tax assets not recognized	**10,611,452**	9,598,506
Unused operating tax losses expiring 2030 to 2041	**14,494,264**	14,369,659
Unused operating tax losses with indefinite expiration	**5,628,356**	4,645,848
Deductible temporary differences	**21,864,469**	18,985,183
Total unused operating tax losses	**41,987,089**	38,000,690

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

For the years ended December 31, 2022 and 2021
(Stated in Canadian Dollars)

13. OTHER INCOME

Other income for the year ended December 31, 2022 includes the sale of any increased timber and renewable energy royalty on the Pickett Mt. Project to Altius in addition to the receipt of exploration incentive grants received from the Manitoba Mineral Development Fund and the Government of New Brunswick. The amount of each grant will be deducted from the the total eligible exploration costs, for the related project, that can used in the future to offset any taxable income, taxable gains or eligible flow through flow expenditures.

	2022 **$**	2021 $
CEBA Loan	**-**	20,000
Manitoba Mineral Development Fund	**207,000**	115,000
Government of New Brunswick Grant	**36,900**	12,000
Wolfden USA Inc. 2018 Tax Refund	**-**	81,694
Proceeds from Timber Sales from Pickett Mt. project	**1,267,430**	-
Other Items	**4,170**	4,622
Total Other Income	**1,515,500**	233,316

14. FINANCIAL INSTRUMENTS AND RELATED RISKS

The Corporation's operations include the acquisition and exploration of mineral properties in Canada. The Corporation examines the various financial risks to which it is exposed and assesses the impact and likelihood of occurrence. These risks may include credit risk, liquidity risk, currency risk, interest rate risk and other risks. Where material, these risks are reviewed and monitored by the Board of Directors.

Credit risk

Counterparty credit risk is the risk that the financial benefits of contracts with a specific counterparty will be lost if a counterparty defaults on its obligations under the contract. This includes any cash amounts owed to the Corporation by those counterparties, less any amounts owed to the counterparty by the Corporation where a legal right of offset exists and also includes the fair values of contracts with individual counterparties which are recorded in the financial statements.

Trade credit risk

The Corporation closely monitors its financial assets and does not have any significant concentration of trade credit risk. The historical level of defaults is negligible and, as a result, the credit risk associated with trade receivables is considered to be negligible. Accounts receivable is made up of recoverable taxes which is deemed collectable and minimal risk.

Liquidity risk

Liquidity risk is the risk that the Corporation will not be able to meet its financial obligations as they fall due. The Corporation manages liquidity risk through the management of its capital structure.

Accounts payable and accrued liabilities are due within the current operating period.

Interest rate risk

Interest rate risk is the risk that the fair value or future cash flows of a financial instrument will fluctuate because of changes in market interest rates. The risk that the Corporation will realize a significant loss as a result of a decline in the fair market value is limited as the Corporation holds all of its funds in cash and guaranteed investment certificates.

Currency risk

The Corporation is exposed to the financial risk related to the fluctuation of foreign exchange rates. The functional and reporting currency of the Corporation is the Canadian dollar; however, it has operations located in the United States, and as such is subject to fluctuations in that currency. Changes in the currency exchange rates between the Canadian dollar relative to the US dollar could have an effect on the Corporation's results of operations, financial position or cash flows. The Corporation has not hedged its exposure to currency fluctuations.

The Corporation does not invest in derivatives to mitigate these risks.

15. MANAGEMENT OF CAPITAL RISK

The Corporation manages its common shares, stock options and warrants as capital, that as at December 31, 2022 totaled $ 44,216,168 (2021 - $41,413,734). The Corporation's objectives when managing capital are to safeguard the Corporation's ability to continue as a going concern in order to pursue the exploration of its mineral properties and to maintain a flexible capital structure which optimizes the costs of capital at an acceptable risk.

The Corporation manages the capital structure and makes adjustments to it in light of changes in economic conditions and the risk characteristics of the underlying assets. To maintain or adjust the capital structure, the Corporation may attempt to issue new shares and acquire or dispose of mineral properties.

In order to maximize ongoing exploration efforts, the Corporation does not pay out dividends. The Corporation's investment policy is to invest its short-term excess cash in highly liquid short-term interest-bearing investments with short-term maturities, selected with regard to the expected timing of expenditures from continuing operations.

16. COVID 19

The spread of COVID-19 has severely impacted many local economies around the globe. In many countries, including Canada and the United States, businesses are being forced to cease or limit operations for long or indefinite periods of time. Global stock markets have also experienced great volatility and a significant weakening. Governments and central banks have responded with monetary and fiscal interventions to stabilize economic conditions.

The Corporation has been monitoring the COVID-19 outbreak since March 2020 and the potential impact at all of its operations and has put measures in place to ensure the wellness of all of its employees and surrounding communities where the Corporation works while continuing to operate. Field work programs and the field work personnel were adjusted. Programs in Manitoba were deferred due to localized outbreaks, and programs in Maine experienced some delays and cost increases due to cross border travel restrictions and requirements.

17. SUBSEQUENT EVENT

On March 9, 2023, the Corporation reached an agreement with Advance Lithium Corp (“Advance Lithium”). Advance Lithium acquired a 100% interest in the Tetagouche project in the Bathurst Mining Camp of New Brunswick. Upon closing, Advance Lithium will issue to Wolfden 19.9% of its current 83,520,000 issued and outstanding shares. In addition, the Corporation shall spend $3 million and make additional payments in cash or shares totalling $750,000. Wolfden shall retain up to a 2% Net Smelter Return on all claims subject to a buy back option of 1% NSR for $2 million to Advance Lithium. Wolfden shall have first rights of refusal with respect to any claims that are sold, dropped or transferred and a right to an Advance Lithium board seat so long as it maintains a 10% shareholding in the Corporation. Some terms of the agreement remain subject to regulatory approval.

ATTACHMENT 27

Wolfden Resources Corporation

Consolidated Financial Statements
(Stated in Canadian Dollars)

For the three months ended March 31, 2023 and 2022

WOLFDEN RESOURCES CORPORATION

WOLFDEN

NOTICE TO SHAREHOLDERS
FOR THE THREE MONTHS ENDED MARCH 31, 2023
MANAGEMENT'S RESPONSIBILITY FOR FINANCIAL REPORTING

The accompanying unaudited condensed consolidated interim financial statements of Wolfden Resources Corporation were prepared by management in accordance with International Financial Reporting Standards ('IFRS"). Only changes in accounting policies have been disclosed in these unaudited condensed consolidated interim financial statements. Management acknowledges responsibility for the preparation and presentation of the unaudited condensed consolidated interim financial statements, including responsibility for significant accounting judgments and estimates and the choice of accounting principles and methods that are appropriate to the Corporation's circumstances.

Management has established processes, which are in place to provide them sufficient knowledge to support management representations that they have exercised reasonable diligence that (i) the unaudited condensed consolidated interim financial statements do not contain any untrue statement of material fact or omit to state a material fact required to be stated or that is necessary to make a statement not misleading in light of the circumstances under which it is made, as of the date of and for the periods presented by the unaudited condensed consolidated interim financial statements and (ii) the unaudited condensed consolidated interim financial statements fairly present in all material respects the financial position, results of operations and cash flows of the Corporation, as of the date of and for the periods presented by the unaudited condensed consolidated interim financial statements.

The Board of Directors is responsible for reviewing and approving the unaudited condensed consolidated interim financial statements together with other financial information of the Corporation and for ensuring that management fulfills its financial reporting responsibilities. An Audit Committee assists the Board of Directors in fulfilling this responsibility. The Audit Committee meets with management to review the financial reporting process and the unaudited condensed consolidated interim financial statements together with other financial information of the Corporation. The Audit Committee reports its findings to the Board of Directors for its consideration in approving the unaudited condensed consolidated interim financial statements together with other financial information of the Corporation for issuance to the shareholders.

Management recognizes its responsibility for conducting the Corporation's affairs in compliance with established financial standards, and applicable laws and regulations, and for maintaining proper standards of conduct for its activities.

WOLFDEN

(Incorporated under the laws of Ontario)

CONSOLIDATED STATEMENTS OF FINANCIAL POSITION

(Stated in Canadian Dollars)

As at	March 31, 2023 $	December 31, 2022 $
ASSETS		
Current assets		
Cash and cash equivalents	**2,661,481**	3,511,011
Amounts receivable *[note 5]*	**121,427**	134,134
Prepaid expenses	**7,742**	17,535
Total current assets	**2,790,649**	3,662,680
Non-current assets		
Equipment *[note 6]*	**510**	550
Total assets	**2,791,159**	3,663,230
LIABILITIES		
Current liabilities		
Accounts payable and accrued liabilities	**129,011**	568,795
Total current liabilities	**129,011**	568,795
EQUITY		
Share capital *[note 8]*	**41,865,575**	41,865,575
Equity settled employee benefits *[note 8]*	**2,353,738**	2,350,593
Other comprehensive loss	**(283,707)**	(287,216)
Deficit	**(41,273,458)**	(40,834,518)
Total equity	**2,662,147**	3,094,434
Total liabilities and equity	**2,791,159**	3,663,230

Going concern [note 1]
Subsequent event [note 16]
See accompanying notes to the consolidated financial statements

These consolidated financial statements are authorized for issue by the Board of Directors on May 24, 2023 and they are signed on the Corporation's behalf by:

"Ron Little"
Director

"John Seaman"
Director

WOLFDEN

(Incorporated under the laws of Ontario)

CONSOLIDATED STATEMENTS OF LOSS AND COMPREHENSIVE LOSS

(Stated in Canadian Dollars)

	For the three months ended March 31,	
	2023	2022
	$	$
EXPENSES		
Depreciation *[note 6]*	**40**	55
Exchange loss/(gain)	**2,746**	68,944
Exploration and evaluation expenses *[note 7]*	**220,979**	1,442,669
General and administrative expenses	**218,682**	251,849
Professional fees	**17,391**	19,428
Share-based payments *[note 8]*	**3,181**	9,103
Loss before the following	**(463,018)**	(1,792,048)
INCOME		
Investment income	**9,077**	1,910
Other income *[note 12]*	**15,000**	1,285,430
Loss before income taxes	**(438,940)**	(1,287,340)
Income tax expense (recovery)	**-**	(68,877)
Loss for the year	**(438,940)**	(435,831)
Exchange differences related to foreign operations	**3,509**	29,090
Total comprehensive loss for year	**(435,431)**	(406,741)
Basic and diluted loss per share *[note 9]*	**(0.00)**	(0.00)

See accompanying notes to the consolidated financial statements

WOLFDEN

(Incorporated under the laws of Ontario)

CONSOLIDATED STATEMENTS OF CASH FLOWS

(Stated in Canadian Dollars)

	For the three months ended March 31,	
	2023	2022
	$	$
OPERATING ACTIVITIES		
Loss for the year to date	**(438,940)**	(435,831)
Depreciation	**40**	55
Share based payments	**3,181**	9,103
Income tax recovery	**-**	(68,877)
Changes in non-cash working capital related to operations		
Accounts receivable	**12,707**	(7,240)
Prepaid expenses	**9,793**	10,115
Accounts payable and accrued liabilities	**(439,821)**	518,177
Cash used in operating activities	**(853,040)**	25,502
INVESTMENT ACTIVITIES		
Cash provided by investment activities	**-**	-
FINANCING ACTIVITIES		
Cash provided by financing activities	**-**	**-**
Increase (Decrease) in cash and cash equivalents during year	**(853,040)**	25,502
Cash and cash equivalents, beginning of year	**3,511,011**	3,229,005
Effect of foreign exchange on cash and cash equivalents	**3,509**	29,090
Cash and cash equivalents, end of year	**2,661,481**	3,283,597

See accompanying notes to the consolidated financial statements

WOLFDEN
(Incorporated under the laws of Ontario)

CONSOLIDATED STATEMENTS OF CHANGES IN EQUITY
(Stated in Canadian Dollars)

	Share Capital		Reserves			
Issued and outstanding:	Number of Shares	Share Capital	Equity Settled Employee Benefits	Foreign exchange differences	Surplus/(Deficit)	Total Equity
Balance as at December 31, 2021	**152,818,670**	**39,331,498**	**2,082,236**	**(196,519)**	**(38,147,178)**	**3,070,037**
Share based payments [note 8]	-	-	9,103	-	-	9,103
Cummulative translation adjustment	-	-	-	29,090	-	29,090
Loss and comprehensive loss for the period	-	-	-	-	(435,830)	(435,830)
Balance as at March 31, 2022	**152,818,670**	**39,331,498**	**2,091,339**	**(167,429)**	**(38,583,008)**	**2,672,400**
Share based payments *[note 8]*	-	-	396,746	-	-	88,431
Restricted stock units	356,668	78,467	(78,467)	-	-	-
Private placement	10,952,310	2,299,985	-	-	-	2,299,985
Exercise of stock options	690,000	155,625	(59,025)	-	-	96,600
Cummulative translation adjustment	-	-	-	(119,787)	-	(119,787)
Loss and comprehensive loss for the year	-	-	-	-	(2,251,510)	(2,251,510)
Balance as at December 31, 2022	**164,817,648**	**41,865,575**	**2,350,593**	**(287,216)**	**(40,834,518)**	**3,094,434**
Share-based payments [note 8]	-	-	3,181	-	-	3,181
Cummulative translation adjustment	-	-	(37)	3,509	-	3,472
Loss and comprehensive loss for the year	-	-	-	-	(438,940)	(438,940)
Balance as at March 31, 2023	**164,817,648**	**41,865,575**	**2,353,738**	**(283,707)**	**(41,273,458)**	**2,662,147**

See accompanying notes to the consolidated financial statements

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

For the three months ended March 31, 2023 and 2022
(Stated in Canadian Dollars)

1. NATURE OF BUSINESS

Wolfden Resources Corporation (the "Corporation" or "Wolfden") was incorporated under the laws of the Province of Ontario on August 12, 2009. The principal business activity of the Corporation is the acquisition, exploration and development of mineral properties that it believes contain mineralization that will be economically recoverable in the future. The office address of the Corporation is 1100 Russell Street, Unit 5 Thunder Bay, Ontario, P7B 5N2.

Going concern

The Corporation, being in the exploration stage, is subject to risks and challenges similar to companies in a comparable stage of development. These risks include the challenges of securing adequate capital for exploration, development and operational risks inherent in the mining industry, global economics, health concerns and metal price volatility and there is no assurance management will be successful in its endeavors. At March 31, 2023, the Corporation has no ongoing source of operating cash flows but has raised $2,299,985 through private placement of shares in the previous fiscal year and $1,267,430 from the sale of an additional timber royalty in the same period. The Corporation incurred a net loss of $438,940 for the three months ended March 31, 2023, (net loss of $435,831 for the three months ended March 31, 2022) and has accumulated a deficit of $41,273,458 (December 31, 2022 - $40,834,518) since the inception of the Corporation. As at March 31, 2023, the Corporation had working capital of $2,661,638 (December 31, 2022 – $3,093,885). The Corporation’s ability to continue as a going concern is largely dependent upon its ability to raise additional capital to continue the development of its mineral properties. Management attempts to raise additional capital whenever favorable market conditions exist.

Although the Corporation to date has been successful in raising sufficient funds with its strategic investors and the capital markets to advance its projects, the capital markets continue to be volatile and are largely out of the Corporation’s control, and therefore, there remains material uncertainties that cast significant doubt on the Corporation's ability to continue as a going concern. It is not possible to predict whether financing efforts will be successful or if the Corporation will attain profitable levels of operation. These financial statements do not include any adjustments to the carrying values of assets and liabilities and the reported expenses and statement of loss and comprehensive loss classification that would be necessary should the Corporation be unable to continue as a going concern. These adjustments could be material.

2. SIGNIFICANT ACCOUNTING POLICIES

Basis of Presentation

These consolidated financial statements have been prepared in accordance with International Financial Reporting Standards ("IFRS") issued by the International Accounting Standards Board ("IASB") and interpretations of the IFRS Interpretations Committee ("IFRIC").

The consolidated financial statements of the Corporation for the three months ended March 31, 2023, were approved and authorized by the Board of Directors on *May 24, 2023*.

Basis of consolidation

The Corporation's consolidated financial statements consolidate those of its subsidiaries. The Corporation's subsidiaries are:

	Percentage of ownership	Jurisdiction	Principal activity
Wolfden Resources Canada Inc.	100%	Canada	Mineral exploration
Wolfden USA Inc.	100%	United States	Mineral exploration
Wolfden Mt. Chase LLC	100%	United States	Mineral exploration
Wolfden Big Silver LLC	100%	United States	Mineral exploration

All transactions and balances between the Corporation and its subsidiaries are eliminated on consolidation, including unrealized gains and losses on transactions between the companies.

Foreign currency translation

The consolidated financial statements are presented in Canadian dollars (CAD), which is also the functional currency of the Corporation, as well as its subsidiary Wolfden Resources Canada Inc. The functional currency of the Corporation's subsidiaries, Wolfden USA Inc, Wolfden Mt. Chase LLC, and Wolfden Big Silver LLC is U.S. dollars (USD).

Foreign currency transactions are translated into the functional currency of the respective Corporation, using the exchange rates prevailing at the dates of the transactions (spot exchange rate). Foreign exchange gains and losses resulting from the settlement of such transactions and from the remeasurement of monetary items at year-end exchange rates are recognized in profit or loss.

In the Corporation's consolidated financial statements, all assets, liabilities and transactions of the Corporations' subsidiary are translated into CAD upon consolidation. On consolidation, assets and liabilities have been translated into CAD at the closing rate at the reporting date. Income and expenses have been translated into the Corporation's presentation currency at the average rate over the reporting period. Exchange differences are charged/credited to other comprehensive income and recognized in the currency translation reserve in equity. On disposal of a foreign operation the cumulative translation differences recognized in equity are reclassified to profit or loss and recognized as part of the gain or loss on disposal.

Significant accounting judgements and estimates

In the application of the Corporation's accounting policies, which are described in Note 2 of the audited consolidated financial statements for the year ending December 31, 2022, management is required to make judgements, estimates and assumptions about the carrying amounts of assets and liabilities that are not readily apparent from other sources. The estimates and associated assumptions are based on historical experience and other factors that are considered to be relevant. Actual results may differ from these estimates.

<u>Significant estimates</u>

The preparation of these financial statements requires management to make estimates and assumptions that affect the reported amounts of assets and liabilities at the date of the financial statements and reported amounts of expenses during the reporting period. Actual outcomes could differ from these estimates. The financial statements include estimates, which by their nature are uncertain. The impacts of such estimates are pervasive throughout the consolidated financial statements and may require accounting adjustments based on future occurrences. Revisions to accounting estimates are recognized in the period in which the estimate is revised, and the revision affects both current and future periods. Significant estimates include:

i. the inputs used in accounting for share purchase option expense in the statement of loss and comprehensive loss;

ii. the provision for income taxes which is included in the statements of income and comprehensive income and composition of deferred income tax assets and liabilities included in the statement of financial position which have not yet been confirmed by the taxation authorities, and

iii. the estimated useful lives of equipment and leaseholds which are included in the statement of financial position and the related depreciation included in the statement of loss and comprehensive loss.

Government grants

Government grants are recorded as other income when there is reasonable assurance that the Company has complied with and will continue to comply with, all necessary conditions to obtain the grants. These grants are used to reduce the related exploration expenditures.

Timber sales

The Company engages with third parties for sale of its Royalty on timber. The proceeds from these sales have been recorded as other income.

Functional currency

Management uses its judgement to determine the functional currency that most faithfully represents the economic effects of the underlying transactions, events and conditions. As part of this approach, management gives priority to indicators like the currency that mainly influences costs and the currency in which those costs will be settled and the currency in which funds from financing activities are generated. Management also assesses the degree of autonomy the foreign operation has with respect to operating activities.

3. RECENT ACCOUNTING PRONOUNCEMENTS

There have been no new standards and interpretations adopted since the release of the Company's financial statements for the year ended December 31, 2022.

New standards and interpretations not yet adopted

Disclosure of Accounting Policies (Amendments to IAS 1)

The IASB has issued amendments to IAS 1 *Presentation of Financial Statements* which require entities to disclose their "material" accounting policy information rather than their "significant" accounting policies. The amendments explain that accounting policy information is material if omitting, misstating or obscuring that information could reasonably be expected to influence decisions that the primary users of the financial statements make on the basis of those financial statements. The amendments also clarify that accounting policy information may be material because of its nature, even if the related amounts are immaterial. This amendment is effective for annual periods beginning on or after January 1, 2023. Earlier application is permitted. The extent of the impact of adoption of these amendments has not yet been determined.

Definition of Accounting Estimates (Amendments to IAS 8)

The IASB has issued amendments to IAS 8 *Accounting Policies, Changes in Accounting Estimates and Errors* which introduce a definition of accounting estimates and provide other clarifications to help entities distinguish accounting policies from accounting estimates. Under the amendments, accounting estimates are defined as "monetary amounts in financial statements that are subject to measurement uncertainty". The amendments also emphasize that a change in an accounting estimate that results from new information or new developments is not an error correction, and that changes in an input or a measurement technique used to develop an accounting estimate are considered changes in accounting estimates if those changes in an input or measurement technique are not the result of an error correction. This amendment is effective for annual periods beginning on or after January 1, 2023. Earlier application is permitted. The extent of the impact of adoption of these amendments has not yet been determined.

Deferred Tax related to Assets and Liabilities arising from a Single Transaction (Amendments to IFRS 1 and IAS 12)
The IASB has issued amendments to IFRS 1 *First-time Adoption of International Financial Reporting Standards* and IAS 12 *Income Taxes* which clarify that the initial recognition exemption set out in IAS 12 does not apply to transactions that give rise to equal taxable and deductible temporary differences. The aim of the amendments is to reduce diversity in the reporting of deferred tax on leases and decommissioning obligations. This amendment is effective for annual periods beginning on or after January 1, 2023. Earlier application is permitted. The extent of the impact of adoption of this amendment has not yet been determined.

Classification of Liabilities as Current or Non-Current (Amendments to IAS 1)

The IASB has published *Classification of Liabilities as Current or Non-Current (Amendments to IAS 1)* which clarifies the guidance on whether a liability should be classified as either current or non-current. The amendments:

i. clarify that the classification of liabilities as current or non-current should only be based on rights that are in place "at the end of the reporting period"

ii. clarify that classification is unaffected by expectations about whether an entity will exercise its right to defer settlement of a liability

iii. make clear that settlement includes transfers to the counterparty of cash, equity instruments, other assets or services that result in extinguishment of the liability.

iv. This amendment is effective for annual periods beginning on or after January 1, 2024. Earlier application is permitted. The extent of the impact of adoption of this amendment has not yet been determined.

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS
For the three months ended March 31, 2023 and 2022
(Stated in Canadian Dollars)

4. SEGMENTED INFORMATION

The Corporation's significant segments are represented by its separately identifiable exploration and evaluation properties (see note 7 for disclosure by property). The Corporation also operates in two distinct geographic areas. The Canadian operations are managed from the Corporation's head office in Canada. The U.S. operations are managed from an office in Maine.

For the three months ended March 31, 2023

	Canada $	USA $	Total $
Segmented Assets	2,316,714	474,444	**2,791,159**
Segmented Liabilities	74,748	54,264	**129,011**
Operating activities			
Depreciation	40	-	40
Exchange loss	609	2,137	2,746
Exploration and evaluation expenses	59,473	161,505	220,979
General and administrative	133,191	85,491	218,682
Professional fees	17,391	-	17,391
Share-based payments	-	3,181	3,181
Total	**210,704**	**252,314**	**463,018**
Other items	23,906	172	24,077
Loss for the year	**(186,798)**	**(252,142)**	**(438,940)**

For the three months ended March 31, 2022

	Canada $	USA $	Total $
Segmented Assets	2,517,434	906,110	**3,423,545**
Segmented Liabilities	635,083	116,062	**751,145**
Operating activities			
Depreciation	55	-	55
Exchange loss	(49,332)	(19,612)	(68,944)
Exploration and evaluation expenses	1,091,009	351,660	1,442,669
General and administrative	167,333	84,516	251,849
Professional fees	19,428	-	19,428
Share-based payments	9,103	-	9,103
Income tax expense	-	68,877	68,877
Total	**1,237,596**	**485,440**	**1,723,036**
Other items	1,287,022	184	1,287,206
Loss for the year	**(49,426)**	**(485,256)**	**(435,831)**

(Stated in Canadian Dollars)

5. AMOUNTS RECEIVABLE

For the three months ended March 31,2023 and 2022.)

	2023 $	2022 $
Recoverable taxes (i)	**121,427**	134,134

(i) Recoverable taxes include Canadian harmonized sales tax and income tax receivable .

6. EQUIPMENT

	Computer Equipment $	Total $
Cost		
Balance, January 01, 2022	13,120	13,120
Balance, December 31, 2022	13,120	13,120
Balance, March 31, 2023	**13,120**	**13,120**
Accumulated depreciation		
Balance, January 01, 2022	12,375	12,375
Depreciation for the period	195	195
Balance, December 31, 2022	12,570	12,570
Depreciation for the period	40	40
Balance, March 31, 2023	**12,610**	**12,610**
Carrying amounts		
December 31, 2022	550	550
March 31, 2023	**510**	**510**

7. EXPLORATION AND EVALUATION

For the three months ended 31st March, 2023

	Manitoba Nickel	Pickett Mountain	Teta-Gouche	Big Silver & Other	Total for Period	Total inception to date
Analysis	-	-	-	-	-	**998,784**
Geological	26,616	3,365	5,883	-	35,864	**3,836,301**
Geophysical	9,631	-	-	-	9,631	**3,247,523**
Geochemical	-	-	-	-	-	**454,005**
Travel	1,794	14,164	340	-	16,928	**897,232**
Drilling	-	-	-	-	-	**8,786,919**
Property Work	-	-	12,530	-	12,530	**1,026,358**
Ops Support	-	5,686	970	2,435	9,091	**614,676**
Administration	-	-	1,710	-	1,710	**829,639**
Development	-	135,855	-	-	135,855	**1,543,551**
Total Exploration	38,041	159,070	21,432	2,435	220,979	**22,234,988**
Other costs	-	-	-	-	-	**21,133,497**
Total	38,041	159,070	21,432	2,435	220,979	**43,368,485**

(Stated in Canadian Dollars)

For the three months ended March 31, 2022

	Manitoba Nickel	Pickett Mountain	Teta-Gouche	Big Silver & Other	Total for Period	Total inception to date
Analysis	-	-	8,151	-	8,151	**964,533**
Geological	42,463	16,274	4,695	18,704	82,135	**3,726,564**
Geophysical	15,000	-	36,129	107,437	158,566	**3,166,866**
Geochemical	240	-	4,764	57,189	62,192	**399,783**
Travel	16,058	7,236	-	10,280	33,574	**787,775**
Drilling	920,922	-	103	-	921,025	**8,757,853**
Property Work	-	858	33,555	-	34,413	**857,110**
Ops Support	5,000	5,452	600	25,457	36,509	**560,970**
Administration	1,500-	-	1,830	-	3,330	**790,226**
Development	-	102,774	-	-	102,774	**491,300**
Total Exploration	1,001,182	132,594	89,827	219,066	1,442,669	**20,502,980**
Other costs	-	-	-	-	-	**21,133,497**
Total	1,001,182	132,594	89,827	219,066	1,442,669	**41,636,477**

Mineral property acquisitions and agreements

Maine, U.S.A.

Pickett Mountain Property

On November 16, 2017, the Corporation acquired a 100% interest in the Pickett Mountain Property (the “Property”), located in Penobscot County, northern Maine, U.S.A for a cash purchase price of $11,292,055 (US$8.5 million) (the “Acquisition”).

To fund the acquisition of the Property, the Corporation entered into a Royalty Agreement that granted a 1.35% gross sales royalty on the Property to Altius Resources Inc. (“Altius”), a wholly owned subsidiary of Altius Minerals Corporation, for cash consideration of $7,663,800 (US$6,000,000) and completed a non-brokered private placement (the "Offering") of 20,200,000 subscription receipts ("Subscription Receipts") at a price of $0.25 per Subscription Receipt for gross proceeds of $5,050,000, with Altius subscribing for 14,200,000 Subscription Receipts. The subscription receipts were converted into 14,200,000 common shares of the Corporation.

Pursuant to the Royalty Agreement, Altius has the option to purchase an additional 0.50% gross sales royalty at any time before the first anniversary of commercial production for US$7,500,000. In addition, the Corporation granted Altius certain rights to convert the Pickett Mountain Royalty to equity under certain terms, or to exchange the royalty for a similar royalty on the Corporation's Orvan Brook property. Furthermore, the Corporation agreed to use its best efforts to sell or transfer the timber from the project for gross proceeds of US$5,000,000 or such other amount as agreed to by Wolfden and Altius, acting reasonably (the "Timber Proceeds"). Wolfden is required to pay Altius 20% of the Timber Proceeds. These terms as shown were amended from the original agreement on October 7, 2020.

On January 22, 2020, the Corporation secured up to US$4.5 million in non-dilutive funding by selling-forward $5 million worth of timber from its Pickett Mountain Property. Under the terms of the agreement the Corporation received US$3 million and is entitled to receive an additional US$1.5 million between the 4th and 5th anniversary of the agreement. The timber company has the right to harvest US$5 million of timber from the property over 5 years. For the year ended December 31, 2020, the Corporation recorded net timber sales proceeds of $3,140,880 (US$ 2,400,000), that are net of 20% (US$600,000) that was passed onto Altius as per the Royalty Agreement (2019 - $252,326). The entire amount of the proceeds was recognized as no further performance obligation is required by the Corporation. These funds are not being placed in escrow and have been included in the working capital of the Corporation

Pursuant to the Royalty Agreement, Altius has a conversion right and exchange right. The Call Right, which related to Altius's call option on the Timber Rights, was eliminated in the October 7, 2020 amendment of the Royalty Agreement as a direct result of the Corporations January 22, 2020 $4.5 million timber sale agreement which by effect, eliminated the possibility for any potential call option on those Timber Rights. Each or the other two rights are valid and are summarized below.

Conversion Right

At any time after November 14, 2023, Altius will have the right to convert the Pickett Mountain Royalty, in accordance with the terms of the Royalty Agreement, to cash or Common Shares, or a combination thereof (the "Conversion Right"). Upon the exercise of the Conversion Right, the Common Share consideration to be received by Altius will be equal to the lesser of: (a) the number of Common Shares that is equal in Royalty Value; and (b) the number of Common Shares that does not exceed 19.99% of all outstanding Common Shares on a partially diluted basis. The remaining balance of the Royalty Value is to be paid to Altius in cash. Under the Royalty Agreement, "Royalty Value" means an amount equal to the aggregate of: (i) all amounts paid by Altius to Wolfden (including the purchase price consideration paid by Altius) in respect of the Pickett Mountain Royalty, minus (ii) all timber Proceeds received by Altius, minus (iii) all other payments received by Altius in respect of the Pickett Mountain Royalty. The Common Share conversion price is the greater of: (i) $0.05 per Common Share; and (ii) the volume weighted average trading price of the Common Shares on the TSXV (or any other principal exchange on which the Common Shares are trading) for the twenty consecutive trading days immediately preceding the date of the exercise of the Conversion Right. Upon the exercise of the Conversion Right and satisfaction of the payment thereof by Wolfden, any remaining Escrowed Proceeds will be released to Wolfden.

Exchange Right

Under the Royalty Agreement, Altius has the right to exchange the Pickett Mountain Royalty to a gross sales royalty in respect of the Orvan Brook property, which will be calculated and payable on the same terms as the terms of the Pickett Mountain Royalty in effect on the date of exchange, mutatis mutandis.

During the period ending September 30, 2019, Altius and Wolfden agreed to an amendment to their Offering and Subscription Agreements, dated November 14, 2017 whereby during any period when the common shares of Wolfden are trading on the Toronto Stock Exchange Venture Exchange at a volume-weighted average trading price of not less than $0.60 per common share for at least 20 consecutive trading days, it will, upon written request by Wolfden during such period, exercise its warrants. Altius currently holds 7,100,000 Wolfden common share purchase warrants priced at $0.35 per share with a termination date of November 15, 2022.

Timber Agreements

On January 22, 2020, the Corporation secured up to US$4.5 million in non-dilutive funding for its exploration projects by selling-forward timber from its wholly owned Pickett Mountain Zn-Pb-Cu-Ag-Au Project in Maine, USA. Under the terms of a 5 year stumpage agreement with a privately owned Maine timber company, the Corporation received US$3 million upon closing and is entitled to receive an additional US$1.5 million between the 4th and 5th anniversary of the agreement. The timber company has the right to harvest US$5 million of timber from the property over 5 years. In addition, the timber company also granted Wolfden an option to earn a 100% interest (less an NSR) in the mineral rights of the property that adjoins Pickett Mountain as well as long-term road access rights for the current forest road used to reach the Pickett Mountain deposit from the state highway #11. As part of the Altius Royalty agreement on Pickett Mt., dated November 2017 and as amended on October 7, 2020 and on February 8, 2022, Altius and the Corporation executed an amendment to their Pickett Mountain Royalty Agreement where Altius increased its royalty for the payment of US$1 million to the Corporation on signing. As per the terms of the agreement, Altius will receive the next US$1.2 million in net timber revenues and thereafter increases its future timber royalties from 20% to 30%. The 30% royalty will also apply to any revenue generated from the sale of any timber related carbon credits from the Property.

Other properties, Maine USA

On April 6, 2019, the Corporation's U.S. subsidiary entered into a mineral rights earn-in agreement on a property located in Maine, U.S.A. The agreement called first and second year lease payments of $25,000 USD, both of which have been paid.

On November 30, 2020, the Corporation's U.S. subsidiary entered into a mineral rights earn-in agreement on a property in Maine referred to as the Big Silver Project. The agreement called for a first-year payment of $50,000 which has been paid. The Corporation is assessing the project including the positive results of its 2021 and 2022 programs and the potential economic impact of a new town ordinance that would restrict commercial mining of this project in the future.

New Brunswick, Canada

Tetagouche Property

On January 6, 2014, the Corporation closed a definitive purchase agreement (the ""Agreement"") to acquire a large strategic land package (the ""Property"") situated in the Bathurst Mining Camp and surrounding area in northeastern New Brunswick. Wolfden acquired the Property from 8100896 Canada Inc., a wholly owned subsidiary of GeoVenCap Inc. (the "Vendor"). Pursuant to the terms of the Agreement, the Corporation purchased all of the Vendor's right, title and interest to and in the Property for cash consideration of $125,000 and 571,428 common shares of Corporation (the "Consideration Shares") having a value of $100,000. The Consideration Shares were subject to a four month hold period under applicable securities laws in Canada.

Orvan Brook Property

On January 3, 2017, the Corporation acquired through claim staking the Orvan Brook property located in the Bathurst Mining Camp, west of the town of Bathurst, New Brunswick. Orvan Brook is included under the Tetagouche Properties.

Clarence Stream Property Agreements

On August 2, 2016, the Corporation entered into a definitive option agreement with 2520885 Ontario Inc. and Galway Metals Inc., whereby Galway could earn a 100% interest in the property, located in southwestern New Brunswick.

As per the terms of the agreement, and as of July 9, 2019, Galway successfully completed exploration expenditures and made cash payments to Wolfden totaling $3,250,000 to earn a 100% interest in the property less a 1% Net Smelter Return Royalty held by Wolfden that can purchased at any time for the sum of $2,000,000.

Brunswick No. 6 West Property

On April 29, 2015, the Corporation acquired, by claim staking, the Brunswick No. 6 West property (the "Property). The wholly owned Property is located southwest of the City of Bathurst, in the heart of the Bathurst Mining Camp.

Manitoba, Canada

Rice Island Property

On September 15, 2015, the Corporation acquired a 100% interest in the Rice Island nickel-copper deposit situated on the Rice Island property (the "Property") through claim staking. The Property is located in west-central Manitoba at Wekusko Lake, just east of the Snow Lake concentrator complex owned by Hudbay Minerals Inc.

During the fourth quarter of 2015, a Notice of Dispute (the "Notice") was filed with the Province of Manitoba with respect to the Rice Island, Manitoba claims. Specifically, the Notice states that an individual (the "Disputant") has taken the position that one of the claims recorded in favour of Wolfden is invalid due to the existence of the Disputant's claims on the land prior to Wolfden's staking of the claim. Wolfden has responded to the Notice and is confident that it has clear and legal title to the subject claim as confirmed by the issuing of the recording certificate by the Manitoba Mining Recorder. This matter was brought to a resolution in conjunction with the signing of the Rice Island Tie-On Property ("RITOP") agreement described below. On September 21, 2016, the Corporation entered into an option agreement to expand the Rice Island property by earning a 100% interest in the Rice Island Tie-On Property, located adjacent to Wolfden's existing Rice Island property. Under terms of the option agreement with the Vendor, to earn a 100% interest in the RITOP, the Corporation must make cash payments totaling $250,000 and issue 500,000 common shares of Wolfden annually over a five-year period, on or before the anniversary date of the signing of the agreement. A $25,000 cash payment and the issuance of 100,000 common shares was completed on signing. In addition, the Corporation must incur $1,000,000 in exploration expenditures over the same five-year period including $100,000 in the first year. As at December 31, 2019, the exploration commitments have been completed and, in 2021 the cash annual cash payments to earn into the project were completed. Starting in September 2022, an annual cash payment of $50,000 as an advance royalty payment, shall be paid to a maximum of $250,000. Under an amendment to the agreement, the first payment was deferred and paid in January 2023.

Upon earning a 100% interest in the RITOP, the Vendor retains a 2.5% Net Smelter Royalty on the RITOP as well as on the Rice Island property; of which, Wolfden can purchase 1.5% of the Net Smelter Royalty for the sum of $1,500,000 (0.5% increments at $500,000 per each increment) for each of the properties. Wolfden also retains the right of first refusal on the remaining 1.0% Net Smelter Royalty held by the Vendor for each of the RITOP and Rice Island property.

(Stated in Canadian Dollars)

8. SHARE CAPITAL AND RESERVES

i. Authorized

The Corporation is authorized to issue an unlimited number of common shares.

ii. Details of share issuances

2022 Private Placement

On December 16, 2022, the Corporation completed a non-brokered (no agent) private placement of 10,952,310 Common shares of the Corporation at a price of $0.21 per Common Share for gross proceeds of $2,299,985.

iii. Warrants

The following table reflects the continuity of warrants as at March 31, 2023

Expiry Date	Exercise Price	2023 Opening Balance	Warrants Issued	Warrants Exercised	Warrants Expired	2023 Closing Balance
	$	#	#	#	#	#
January 15, 2023	0.61	375,000	-	-	(375,000)	**-**
March 30,2023	0.45	6,362,500		-	(6,362,500)	**-**
Total		6,737,500	-	-	(6,737,500)	**-**
Weighted average exercise price		0.46	-	-	-	-

The following table reflects the continuity of warrants as at December 31, 2022:

Expiry Date	Exercise Price	2022 Opening Balance	Warrants Issued	Warrants Exercised	Warrants Expired	2022 Closing Balance
	$	#	#	#	#	#
November 15, 2022	0.35	10,100,000	-	-	(10,100,000)	**-**
January 15, 2023	0.61	375,000	-	-	-	**375,000**
March 30,2023	0.45	6,362,500	-	-	-	**6,362,500**
Total		16,837,500	-	-	(10,100,000)	**6,737,500**
Weighted average exercise price		0.39	-	-	0.35	**0.46**

iv. Share purchase option compensation plan

Share-based payments consists of the following amounts:

	For the period ended March 31,	
Share Based Payments	**2023**	2022
	$	$
Share purchase Options	**3,181**	-
Restricted Share Units (RSU's)	**-**	9,103
Total	**3,181**	9,103

The Corporation has a share incentive plan (the "Plan"), which is restricted to directors, officers, key employees and consultants of the Corporation. The number of common shares subject to options granted under the Plan (and under all other management options and employee stock purchase plans including RSU's) is limited to 10% in the aggregate and 5% with respect to any one optionee of the number of issued and outstanding common shares of the Corporation at the date of the grant of the option. Options issued under the Plan may be exercised during a period determined by the Board of Directors which cannot exceed ten years.

(Stated in Canadian Dollars)

The following table reflects the stock options outstanding as at March 31, 2023:

Expiry Date	Exercise Price	2023 Opening Balance	Granted	Exercised	Expired/ Cancelled	Mar 31, 2023 Closing Balance
	$	#	#	#	#	#
July 10, 2023	0.30	**2,390,000**	-	-	-	**2,390,000**
April 29, 2024	0.30	**530,000**	-	-	-	**530,000**
June 26, 2024	0.20	**200,000**	-	-	-	**200,000**
September 1, 2024	0.20	**200,000**	-	-	-	**200,000**
July 13, 2025	0.20	**200,000**	-	-	-	**200,000**
February 4,2026	0.32	**1,750,000**	-	-	-	**1,750,000**
April 27, 2026	0.32	**200,000**	-	-	-	**200,000**
September 1, 2027	0.25	**3,155,000**	-	-	-	**3,155,000**
Total		**8,625,000**	-	-	-	**8,625,000**
Weighted Average exercise price		0.28	-	-	-	**0.28**

The following table reflects the stock options outstanding as at December 31, 2022:

Expiry Date	Exercise Price	2022 Opening Balance	Granted	Exercised	Expired/ Cancelled	Dec 31, 2022 Closing Balance
	$	#	#	#	#	#
March 9, 2022	0.75	1,000,000	-	-	(1,000,000)	**-**
July 20, 2022	0.14	690,000	-	(690,000)	-	**-**
December 29, 2022	0.53	600,000	-	-	(600,000)	**-**
July 10, 2023	0.30	2,390,000	-	-	-	2,390,000
April 29, 2024	0.30	530,000	-	-	-	530,000
June 26, 2024	0.20	200,000	-	-	-	200,000
September 1, 2024	0.20	200,000	-	-	-	200,000
July 13, 2025	0.20	200,000	-	-	-	200,000
February 4, 2026	0.32	1,750,000	-	-	-	1,750,000
April 27, 2026	0.32	200,000	-	-	-	200,000
September 1, 2027	0.25		3,155,000			3,155,000
Total		7,760,000	3,155,000	(690,000)	(1,600,000)	8,625,000
Weighted Average exercise price		0.36	0.25	0.14	0.67	0.28

The Corporation applies the fair value method of accounting for all stock-based compensation awards. During the period ending March 31, 2023, a compensation expense of $3,181 was recorded (March 31, 2022 -$0 was recorded). As of March 31, 2023, there were 100,000 unvested stock options (December 31, 2022 -100,000 unvested stock options).

* No options were exercised during the period (December 31, 2022 - 690,000 options were exercised during the year with a weighted average share price of $0.14).

** The weighted average remaining life of the outstanding stock options is 2.08 year (December 31, 2022 – 2.33 years).

The Corporation currently estimates the forfeiture rate to be nil.

(Stated in Canadian Dollars)

v. Restricted Share Units

1,070,000 Restricted Share Units ("RSUs") were issued in 2020 under the restricted share unit plan of the Corporation. The RSUs vest equally over a three-year period, vesting on August 31, 2020, April 29, 2021, and April 29, 2022. Each RSU has the same value as one Wolfden Resources Corporation common share. Additional, 1,208,750 Restricted Share Units ("RSUs") were issued under the restricted share unit plan of the Corporation in 2019. The RSUs vest equally over a three-year period, vesting on June 26, 2019, April 29, 2020, and April 29, 2021.The RSUs are expected to be settled in equity and are therefore accounted for as equity instruments. The RSU's may be converted into common shares of the Corporation, at the option of the Corporation.

As of March 31, 2023, there were no outstanding RSU's (March 31, 2022 – 356,668). As such no share-based payment expense was recorded as of March 31, 2023 ($9,103 for March 31, 2022).

9. LOSS PER SHARE

Both the basic and diluted earnings per share have been calculated using the loss attributable to shareholders of the Corporation as the numerator. No adjustments to loss were necessary in 2023 or 2022.

For the three months ended March 31,

	2023	2022
Numerator: Loss for the year	**(438,940)**	(435,831)
Denominator: Weighted average number of common shares	**164,817,648**	152,818,670
Basic and diluted loss per share	**(0.00)**	(0.00)

10. RELATED PARTY TRANSACTIONS

The Corporation's related parties include key management personnel and entities over which they have control or significant influence as described below. There were no related party transactions.

Key management personnel remuneration includes the following amounts:

For the three months ended March 31,	**2023** **$**	2022 $
Salary and wages	**117,038**	100,730
Share-based payments	**-**	9,103
Other compensation	**3,518**	8,514
Directors fees	**17,848**	17,875
Total	**136,222**	136,222

11. COMMITMENTS

There are no commitments to disclose.

12. OTHER INCOME

Other income for the three-month period ended March 31,2023 includes a $15,000 grant received from the Government of New Brunswick (March 31, 2022- $18,000) and during the same period in 2022, the Corporation received $1,267,430 (USD $1,000,000) from the sale of timber royalty related to Pickett Mt. project in Maine which was included in Other Income on the financial statements.

13. FINANCIAL INSTRUMENTS AND RELATED RISKS

The Corporation's operations include the acquisition and exploration of mineral properties in Canada. The Corporation examines the various financial risks to which it is exposed and assesses the impact and likelihood of occurrence. These risks may include credit risk, liquidity risk, currency risk, interest rate risk and other risks. Where material, these risks are reviewed and monitored by the Board of Directors.

Credit risk

Counterparty credit risk is the risk that the financial benefits of contracts with a specific counterparty will be lost if a counterparty defaults on its obligations under the contract. This includes any cash amounts owed to the Corporation by those counterparties, less any amounts owed to the counterparty by the Corporation where a legal right of offset exists and also includes the fair values of contracts with individual counterparties which are recorded in the financial statements.

Trade credit risk: The Company closely monitors its financial assets and does not have any significant concentration of trade credit risk. The historical level of defaults is negligible and, as a result, the credit risk associated with trade receivables is considered to be negligible. Accounts receivable is made up of recoverable taxes which is deemed collectable and minimal risk.

Liquidity risk

Liquidity risk is the risk that the Corporation will not be able to meet its financial obligations as they fall due. The Corporation manages liquidity risk through the management of its capital structure.

Accounts payable and accrued liabilities are due within the current operating period.

Interest rate risk

Interest rate risk is the risk that the fair value or future cash flows of a financial instrument will fluctuate because of changes in market interest rates. The risk that the Corporation will realize a significant loss as a result of a decline in the fair market value is limited as the Corporation holds all of its funds in cash and guaranteed investment certificates.

Currency risk

The Corporation is exposed to the financial risk related to the fluctuation of foreign exchange rates. The functional and reporting currency of the Corporation is the Canadian dollar; however, it has operations located in the United States, and as such is subject to fluctuations in that currency. Changes in the currency exchange rates between the Canadian dollar relative to the US dollar could have an effect on the Corporation's results of operations, financial position or cash flows. The Corporation has not hedged its exposure to currency fluctuations.

The Corporation does not invest in derivatives to mitigate these risks.

14. MANAGEMENT OF CAPITAL RISK

The Corporation manages its common shares, stock options and warrants as capital, that as at March 31, 2023 totaled $ 44,219,313 (2022 - $44,216,168). The Corporation's objectives when managing capital are to safeguard the Corporation's ability to continue as a going concern in order to pursue the exploration of its mineral properties and to maintain a flexible capital structure which optimizes the costs of capital at an acceptable risk.

The Corporation manages the capital structure and makes adjustment to it in light of changes in economic conditions and the risk characteristics of the underlying assets. To maintain or adjust the capital structure, the Corporation may attempt to issue new shares and acquire or dispose of mineral properties.

In order to maximize ongoing exploration efforts, the Corporation does not pay out dividends. The Corporation's investment policy is to invest its short-term excess cash in highly liquid short-term interest-bearing investments with short-term maturities, selected with regard to the expected timing of expenditures from continuing operations.

15. COVID-19

The spread of COVID-19 has severely impacted many local economies around the globe. In many countries, including Canada and the United States, businesses are being forced to cease or limit operations for long or indefinite periods of time. Global stock markets have also experienced great volatility and a significant weakening. Governments and central banks have responded with monetary and fiscal interventions to stabilize economic conditions.

The Corporation has been monitoring the COVID-19 outbreak since March 2020 and the potential impact at all of its operations and has put measures in place to ensure the wellness of all of its employees and surrounding communities where the Corporation works while continuing to operate. Field work programs and the field work personnel were adjusted. Programs in Manitoba were deferred to due to localized outbreaks, and programs in Maine experienced some delays and cost increases due to cross border travel restrictions and requirements.

16. SUBSEQUENT EVENT

On May 4, 2023 the Corporation announced that it has granted a total of 2,480,000 options to purchase common shares of the Company to certain directors, officers, employees and consultants pursuant to the Company's Share Incentive Plan. Such options have an exercise price of $0.21 per common share and expire on May 3, 2028.

ATTACHMENT 28

S&P 500	Dow 30	Nasdaq	Russell 2000	Crude Oil	Gold
4,335.59	34,093.95	13,249.43	1,786.60	89.64	1,941.1
-66.61 (-1.51%)	-346.93 (-1.01%)	-219.70 (-1.63%)	-23.50 (-1.30%)	-0.02 (-0.02%)	-26.00 (-1

Wolfden Resources Corporation (WLFFF)

Other OTC - Other OTC Delayed Price. Currency in USD

Quote Lookup

0.0800 0.0000 (0.00%)

As of 11:04AM EDT. Market open.

Summary Company Insights Chart Conversations Statistics Historical Data Profile Financials Analysis Options Holders Sustainability

1d 5d 1m 6m YTD 1y 5y Max Full screen

Trade prices are not sourced from all markets

Chart Events

Neutral *pattern detected*

View all chart patterns

Performance Outlook

Short Term 2W - 6W	Mid Term 6W - 9M	Long Term 9M+

Previous Close	0.0800
Open	0.0800
Bid	0.0000 x 0
Ask	0.0000 x 0
Day's Range	0.0800 - 0.0800
52 Week Range	0.0120 - 0.2600
Volume	139,500
Avg. Volume	10,120

Market Cap	13.185M
Beta (5Y Monthly)	0.45
PE Ratio (TTM)	N/A
EPS (TTM)	-0.0200
Earnings Date	Nov 23, 2023 - Nov 27, 2023
Forward Dividend & Yield	N/A (N/A)
Ex-Dividend Date	N/A
1y Target Est	N/A

Fair Value

Related Research

XX.XX

View details

N/A

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ACCESSWIRE

Wolfden Announces Public Hearing Date for Pickett Project Rezoning

Wolfden Resources Corporation(WLF.V) ("Wolfden" or the "Company") is pleased to announce that the Maine Land Use Planning Commission…

ACCESSWIRE

Wolfden Reports Progress Update on Pickett Rezoning Application

Wolfden Resources Corporation(WLF.V) ("Wolfden" or the "Company") is pleased to announce that the Maine Land Use Planning Commission…

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