Background

Modeling results are most useful to the Project Team if they allow direct comparison of specific metrics identified to evaluate the degree to which competing structure sizes and design alternatives meet predefined performance objectives. Crossing performance objectives fall into structural, ecological, and other categories as needed based on site specifics. For the ecological performance category, achieving upstream wetland resilience for the service life of the structure is often the highest priority. Wetland resilience requires the upstream wetland to experience unrestricted tidal flow and drainage so natural processes (such as marsh surface accretion) allow the wetland to keep pace with sea level rise over the coming decades. Primary indicators of unrestricted tidal flow are synchrony in upstream and downstream high and low tide elevations and timing during the highest tides of the year, including storm tides.

To evaluate whether proposed design alternatives meet these objectives, best practices for most tidal crossings include the use of at least 1-D modeling methods that allow bi-directional, unsteady flow simulation for application in tidal environments. One example is the US Army Corps of Engineers' software package HEC-RAS (such as version 5.0.7). Modeling procedures rely on previously collected data from continuous water level monitoring up and downstream of the crossing and bathymetric and terrain elevation surveys. These facilitate the development of upstream tidal volume calculations and provide hydrographs and supporting data for simulated water level elevations associated with different design alternatives during the specified design tides. For ecological considerations, design tides typically represent the Highest Annual Tide or Highest Astronomical Tide under present conditions and those projected at the conclusion of the structure's expected service life, which includes integration of sea level rise. For considerations related to roadway height and crossing stability under flood conditions, storm surge predictions are added to the simulations.

At sites with no constraints on upsizing the crossing structure, modeled simulations of tide elevations corresponding to each design alternative under review should clearly indicate the likelihood of synchrony in the timing and elevation of high and low tides during the established design tides. In these analyses, a comparison is conducted between modeling simulations of 1) upstream tides with the proposed structure in place and 2) unrestricted tides represented by either downstream conditions or those associated with no structure in place. These simulations are run under present conditions and those projected for the conclusion of the structure's expected service life.

Recommended Modeling and Alternatives Evaluation Products

1. Model Calibration - superimposed hydrographs of observed and modeled conditions, an error analysis, and a brief discussion to describe model fit.

2. Alternatives Evaluation/Analysis - Each analysis below should consider at least two sizing alternatives, but preferably more. These consist of the present crossing and 1-2 larger configurations. Each alternative is evaluated in the context of specified design tides, typically:

    - Present Highest Astronomical Tide, plus upstream storm event inflow
    - Future (typical year is 2100) Highest Astronomical Tide, plus upstream storm event inflow. Tide elevations are calculated based on the CoastWise risk-based sea level rise scenario selection process.

    a. Structure resiliency considerations - These influence the height of the embankment and possibly the size of the structure, to ensure crossing resilience and level of service objectives are met. Consider potential upstream flood magnitudes, high tide levels, and coastal storm conditions, including consideration of storm surge for present and future sea levels.

    b. Ecological Data Products - At least one of the design alternatives should meet wetland resilience performance objectives such as high tide-low tide synchrony up and downstream of the crossing and other ecological criteria like aquatic organism passage (AOP) for identified target species.

i. Hydrograph Plots and Data - Provide superimposed upstream hydrographs and supporting data for tidal water level elevations associated with each crossing alternative and without. Hydrographs should include local tidal datums (e.g. MLW, MHW, MHHW, HAsT). For the present conditions data plot, the range or average of selected wetland surface elevations outside of the channel should be indicated. For salt marshes, horizontal lines representing the range and average high marsh plain elevation is most useful to understand the near-term influence of crossing designs on marsh hydroperiod.

ii. Tide Synchrony Evaluation - Provide a comparison of upstream high tide and low tide elevations and the timing of each associated with 1) the proposed structure in place and 2) either no structure in place or the immediate downstream tide. Results of these comparisons can be provided in tabular or graphic format.

iii. Hydraulic Head Differential - Identify the timing and amount the largest difference between upstream-downstream water levels during the running tide.

iv. Aquatic Organism Passage - Provide estimates of in-structure current velocities to allow assessment of AOP objectives.

c. Mapping - for each alternative, map the extent of upstream tidal inundation under present and projected design tides. Include map annotations representing locations of low-lying infrastructure, resource uses, or other relevant low-lying features vulnerable to undesired flooding.

d. Contextual Design Drawings - provide cross section and profile drawings of the alternatives. Drawings should include:

v. Relevant structural elevations such as inverts, top of the structure, and roadbed
vi. Tidal datum elevations (discussed above) for each design tide
vii. Present streambed elevations

e. Other Discussion - this can include topics such as potential for head-cutting or other concerns.