Aquatic Connectivity Through Climate-Ready Infrastructure

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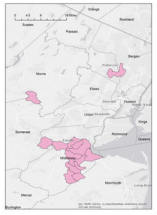
Introduction

Restoring aquatic connectivity removes barriers, providing more habitat for fish and other wildlife that migrate up and downstream as part of their lifecycle. This is especially critical for anadromous fish species that are already vulnerable due to climate change and fishing pressure. While aquatic connectivity has been studied in coastal New Jersey's watersheds with respect to dams, the effectiveness of aquatic passage at road-stream crossing infrastructure is less certain. Undersized culverts affect hydrology, sediment transport, and water quality, and cost money to replace and maintain. This assessment combines an evaluation of aquatic connectivity with one of hydrologic issues that can lead to erosion and flooding. The resulting prioritization is being shared with stakeholders to advance planning and capital projects that will replace problematic crossings with climate-ready, connectivity-friendly versions.

Methods

Aquatic Connectivity Assessments: All road-stream crossings were assessed using the methodology of the North Atlantic Aquatic Connectivity Collaborative (NAACC). NAACC has developed a training program, monitoring protocols, and a public database for all results.[1] The NAACC assessments include such data as infrastructure dimensions, condition, material, barriers to passage, constriction, scour and other streamflow data. The major output was a predicted Aquatic Organism Passage (AOP) score, which indicated the severity of the crossing as a barrier to aquatic life. Most of the field assessments in this study were completed in partnerships with environmental organizations or university students.

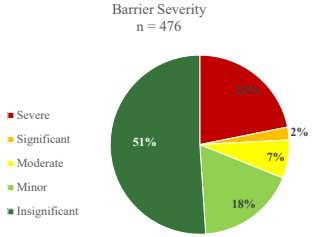
Hydraulic Capacity Modeling: We predicted the capacity of each road-stream crossing using Cornell University's hydraulic capacity GIS model, developed by the Water Resources Institute.[2] The model uses culvert measurements from the NAACC field surveys, along with a digital elevation model[3], streamflow data[4] and precipitation data[5]. The model estimated the maximum storm interval that each culvert could withstand without causing flooding and erosion. This model also accounted for future precipitation scenarios due to climate change, by increasing the precipitation by 15%. This conceptual-level analysis was designed specifically for the prioritization of infrastructure restoration or replacement projects. Note that the model did not work with every crossing type, for example crossings that were very large or had asymmetrical inlets and outlets. However, most culverts could be modeled.



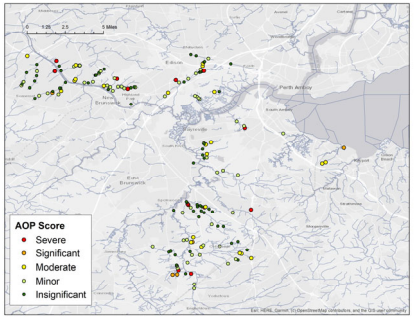
Study Subwatersheds

Results

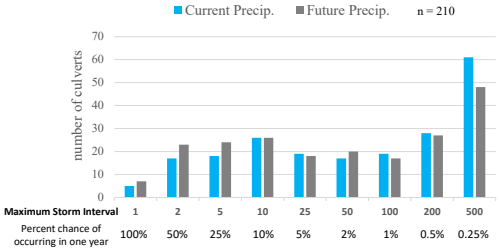
Aquatic Organism Passage



More than half of the crossings surveyed were passable for aquatic life. There was no relationship between AOP score and position in the watershed.

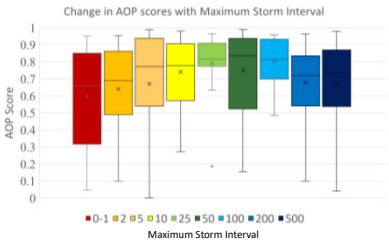


Hydrologic Model



The maximum storm interval represents the storm event for which anything larger fills up the culvert capacity causing flooded roads and erosion. For example, a capacity for a 50-year storm event is predicted to flood twice a year and a 1-year storm event floods with each rainstorm.

Alignment between AOP and Hydraulic Results



Other Findings

- 14% of road-stream crossing structures were found to be in "poor" condition, indicated by crumbling concrete, rusted out or warped metal, or in some cases collapse.
- 21% of structures had some dry passage that may be suitable for crossing use by terrestrial species.
- There was no correlation between road size and the AOP or Hydraulic Analysis scores.

Discussion

The data presented here is a prioritization analysis that can help determine appropriate next steps for coastal resiliency planners, fisheries managers, and the transportation sector. Fact-sheets are available for each subwatershed assessed.

- While 22% of crossings are severe barriers for aquatic life, those crossings are typically not the best candidates for restoration or replacement as most of them are streams buried under houses or even whole neighborhoods. The significant or moderate barriers can be prioritized for restoration.
- Around 40% of the culverts assessed have a capacity of a 25-year storm event or less - these are all undersized. Field observers noticed many instances of eroded banks, which will only get worse with the heavier precipitation predicted.
- We expected that undersized crossings would coincide with crossings with low AOP scores. But we found little correlation between the two datasets and crossings of any size were just as likely to be a barrier for aquatic passage.
- There were opportunities for restoration of road-stream crossings in each the watersheds assessed, including some that only needed maintenance. Field observers also found quite a few "ghost crossings," historic infrastructure that no longer functions as a road but still blocks streamflow.

References

1. More information about NAACC: https://streamcontinuity.org/
2. More information about the Cornell Culvert Model: https://cals.cornell.edu/water-resources-institute
3. NJ Department of Environmental Protection, Statewide10-ft. Digital Elevation Model.
4. Geological Survey (U.S.). National Hydrography Dataset. Reston, Va.: U.S. Dept. of the Interior, U.S. Geological Survey, 2004.
5. NOAA Precipitation Frequency Data Server.

Acknowledgments

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