

Climate Change Briefing

Bonner Bridge: Ensuring Connectivity and Resilience on North Carolina's Coastal Barrier Islands

This article discusses how the North Carolina Department of Transportation is incorporating a unique coastal monitoring approach and interagency collaborative process to ensure connectivity and future resilience on an ecologically and culturally sensitive stretch of barrier islands, as part of the decades-in-the-making Bonner Bridge replacement project.

North Carolina's system of coastal barrier islands, known as the Outer Banks, spans about 200 miles along the coast, separating the Currituck Sound, Albemarle Sound, and Pamlico Sound from the Atlantic Ocean. The islands are a popular destination for tourists and residents, offering wide stretches of ocean beaches, sound-side attractions, and a unique history including the Wright brothers' first flight at Kitty Hawk, infamous pirates such as Black Beard, and numerous shipwrecks that earned the region the nickname "graveyard of the Atlantic."



The Herbert C. Bonner Bridge spans Oregon Inlet, connecting Bodie Island and Hatteras Island. Photo: N.C. DOT

Barrier islands, by their nature, are constantly shifting. New islands are created when storms create inlets over narrow spits of land between the sound and the ocean - and these inlets are often filled back in by shifting sands as the islands continue to migrate in response to the forces of the ocean and the sound. In this dynamic environment, the North Carolina DOT faces ongoing challenges to maintain N.C. 12, the primary means of vehicular access for residents and tourists from the town of Corolla in the north, to Ocracoke Island in the south.

In 1963, N.C. DOT constructed the Herbert C. Bonner Bridge to span a major inlet south of Bodie Island created by a hurricane in the 1800s. The bridge was built to provide direct vehicular access between Bodie Island and Hatteras Island to the south, while also allowing vessels to navigate through the inlet. Subsequently, the inlet has tended to fill in and migrate to the south, requiring construction of a "terminal groin" structure in 1991 to stabilize the inlet south of the bridge. It also requires frequent dredging by the U.S. Army Corps of Engineers to maintain the navigation channel. As the bridge neared the end of its service life, N.C. DOT began the process of determining how best to replace the structure as well as maintain the vulnerable stretch of N.C. 12 south of the bridge to the village of Rodanthe.

Rodger Rochelle, Technical Services Administrator with N.C. DOT, described the Bonner Bridge project and its challenges at a session of the International Conference on Ecology and Transportation in September.

The project purpose, he said, was fairly straightforward: provide a replacement crossing that accommodates the Oregon Inlet channel which tends to migrate, and that is protected from shoreline movement south of the existing bridge within the Pea Island National Wildlife Refuge.

Complicating the National Environmental Policy Act review process, which began in 1990, was the fact that the project crosses the wildlife refuge and the Cape Hatteras National Seashore. The project area also includes historic resources including a former U.S. Coast Guard Station, an historic lifesaving station and an historic district in Rodanthe. In addition, the project area is home to several endangered species, including two species of shore birds and several species of sea turtles.

"It became apparent in this NEPA work as it evolved over the last couple of decades that the project is not just about replacing Bonner Bridge, but also addressing the needs along the entire 12 to 13-mile corridor," Rochelle said. And this must be done in a constantly changing coastal environment that is vulnerable to frequent and extreme storm events.

Planning and Environmental Considerations

Following many years of work among 13 different federal, state, and local agencies, a Record of Decision for the "Parallel Bridge Corridor with NC 12 Transportation Management Plan Alternative" was issued in December 2010. North Carolina uses an interagency "merger process" that integrates requirements under NEPA and Section 404 of the Clean Water Act. That process brings together all of the agencies with relevant jurisdiction and requires concurrence at several key decision points, including determining purpose and need, alternatives to be studied, bridge alignment, alternative selection, and avoidance and minimization.



The original Bonner Bridge, shown here, will be replaced with a more resilient parallel bridge. Photo: N.C. DOT

The selected alternative was construction of a parallel bridge corridor and consideration of future needs using the NC 12 Transportation Management Plan. This alternative has four general components:

- Construct a replacement Bonner Bridge, parallel to and west of the existing bridge, immediately. This is Phase 1 of the project. Due to the deteriorating condition of the bridge, it was imperative that N.C. DOT get this portion of the project moving immediately.
- Implement a coastal monitoring program between Oregon Inlet and Rodanthe to monitor conditions along NC 12 and determine when future phases of the project

should begin. This monitoring program began in 2011. This has led to identification of Bonner Bridge Phase 1, Phase 2a and Phase 2b.

- Develop a Refuge Vulnerability Study to determine what sections of the refuge are most susceptible to damage from coastal conditions and storm events. N.C. DOT is working with the U.S. Fish and Wildlife Service on this study, with some elements underway as part of the coastal monitoring program.
- Use the NEPA/Section 404 Merger Process to study and select the alternatives for future phases. Following Hurricane Irene in 2011, N.C. DOT began work on Phase 2a and 2b of the project, to address the two sites damaged by the hurricane.

Legal Challenge

Shortly after the ROD was issued, a lawsuit was filed by environmental groups challenging the alternative selected for the project, the NEPA process, and the analysis conducted for potential impacts to the refuge under Section 4(f) of the Department of Transportation Act.

In an interview, former N.C. DOT project manager and now consultant Beth Smyre, said the environmental groups were pushing for a 17-mile bridge alternative that would be constructed entirely in Pamlico Sound, which they believed would have less environmental impact on the refuge. N.C. DOT, however, could not afford the cost of building such a structure all at once.

Although N.C. DOT and the Federal Highway Administration won the legal challenge regarding the adequacy of its NEPA document, the court found that the agencies' analysis under 4(f) needed to be reevaluated.

Following the court ruling, both sides of the lawsuit were able to come together and focus on what both wanted to get out of it, Smyre said. Ultimately, the two sides reached a settlement in which the DOT agreed to study the concept of other bridges or bridge extensions that could be worked out over time in phases. This approach would allow DOT to proceed with the most critical areas immediately, replacing Bonner Bridge with a shorter span as originally proposed, then doing a "jug handle" shaped bridge alternative in Rodanthe. This southern span would extend the roadway into Pamlico Sound from Rodanthe spanning several miles north, and reconnect N.C. 12 to the original highway easement in Pea Island National Wildlife Refuge. This alternative could be further expanded in the sound in later phases as needed and as dictated by the Transportation Management Plan.

Ensuring Resiliency

Smyre said the question of resiliency "has come up quite a bit because we've had to think about what this island is going to look like in 50 years."

The agency has to provide a safe and reliable facility - it could be a bridge, it could be a road, it could be a ferry service - to get people on and off the island. "How do we figure out how to design something that's going to last 50 years recognizing that it's sitting on a strip of land that's changing?" she asked.

In considering alternatives, Smyre said that the agency used the best data possible to make its decision, including coastal analyses and shoreline forecasts, to figure out where the ocean will be and whether there will be any changes on the sound side of the island.

Working with researchers at N.C. State University, the DOT is analyzing how the island is changing from month to month and doing a regression analysis to forecast what it's going to look like, Smyre said.

"We have tried to get the best data that we can and use the best science we can to figure out what alternatives should look like and where they should be located," she said. At the same time the agency recognized that "one storm could change everything" in terms of determining where the next phase will be. This is what happened in 2011, when Hurricane Irene hit.

Hurricane Irene struck NC as a Category 1 storm, moving through Pamlico Sound and causing extensive flooding on Hatteras Island. The storm caused the island to breach in two places within the study area: within the Pea Island National Wildlife Refuge and in northern Rodanthe.



In 2011, Hurricane Irene breached NC 12 in several spots, cutting off access near Rodanthe. Photo: N.C.DOT

This section of roadway was repaired by installing a temporary 660-foot Mabey bridge (which consists of a number of pre-assembled modular steel bridge units) over the main breach and filling in the smaller channels on either side. This allowed the breach to continue to function as

an inlet and evolve naturally, while maintaining the transportation corridor. An interim bridge will be constructed as Phase 2a of the Bonner Bridge Project, and the jug handle solution in the area connecting Rodanthe will be constructed as Phase 2b of the project.

Smyre said the Transportation Management Plan allows N.C. DOT to determine additional future phases of the project based on data gathered from the ongoing monitoring efforts and in collaboration with all agencies involved in the merger process. Adding to this concept, the parties to the lawsuit agreed that N.C. DOT would at least consider options that would adjust the original alignment in favor of adding additional spans to the sound-side bridge.

Design and Construction Considerations

Smyre said the agency used the results of coastal monitoring to help determine the appropriate height of the Bonner Bridge deck. The agency based its decision on an analysis of storm surge

and storm events - including approximately the last 60 storms, as well as a range of climate change scenarios, with an additional buffer on top of that.

Rochelle said the bridge at the southern end of Oregon Inlet is designed at about 22 feet in elevation, providing enough space to accommodate typical tidal and wave type action during a hurricane. "But it's also designed in a way that is almost sacrificial, that is to say, that if the inlet does breach behind the existing terminal groin and the need arises to bridge further to the south that we would be able to remove a portion of that southern terminus and continue to extend the bridge further to the south to cross that additional breach that may or may not occur."

In addition, Rochelle described challenges the agency faces with bridge construction and construction access. The constantly shifting sands during the Nor'easter season or during a Hurricane event pose challenges for construction, and the agency also faces the need to keep the navigation channel open for the region's vital fishing industry.

The new bridge will provide a much wider section at navigational height to accommodate the movement of the channel and reduce the need for dredging by the Army Corps of Engineers.

Rochelle said the inlet is a very challenging environment because of the velocity of the water and among the heaviest salt concentrations of any area of the U.S. The existing structure has suffered serious corrosion, he said, and the new structure will include numerous concrete admixtures for the design to ensure a 100-year service life. It also will include thousands of tons of stainless steel rebar in the foundations of the bridge.

To address scour, "the challenge in construction is putting in foundations that are approaching 150 feet in length in this environment so that the bridge can survive for the next 100 years," Rochelle said. Numerous flume studies were developed in the laboratory to predict what that scour will look like based on the exact foundation design that is proposed, he added.

Demolition of the existing 2.5-mile bridge is also a concern. The agency has worked with the National Marine Fisheries Service to develop a plan for depositing clean material from the existing bridge to create an artificial reef offshore.

Lessons Learned

Smyre pointed to several lessons learned as a result of the project, but noted that it was a unique case because of the unique environment of the Outer Banks.

"We've learned about pulling in the information we can and figuring out which things we need to consider when trying to design and locate an alternative," Smyre said.

The agency is learning a lot from the ongoing monitoring program and has created a trusting relationship with the resource agencies. Data gathering includes biological data collected by N.C. DOT staff as well as coastal engineering reports developed by N.C. State University, based on aerial photography conducted every other month by the DOT.

A big lesson was the importance of the collaborative process with other agencies, Smyre said. In addition to the design and location considerations, the project incorporates a range of mitigation actions for potential impacts to endangered species and historic resources. She urged other DOTs faced with this type of project to get the resource agencies involved early in the process.

"It took a lot of time, and a lot of meetings, but that trust developed over time," she said. Smyre attributed this success to the interagency merger process and spending time with the other agencies in one-on-one meetings.

Regarding the lawsuit, Rochelle said "the mixed ruling really brought the parties together to discuss what this corridor will look like in the future."

The parties discussed "how to look at this corridor in a manner that doesn't preclude us from eventually ending up with more bridging in the sound. So the southern terminus of the Oregon inlet bridge is designed such that we can extend it in the future. The northern terminus of the bridge in Rodanthe will be designed so we can extend that in the future as needed. So eventually you may end up with more or longer bridges in Pamlico Sound but right now we're addressing the needs as they arise."

Cost concerns also have been an ongoing issue. Rochelle noted that the original bridge was built for \$4 million, and the new bridge will cost \$240 million. Meanwhile, since 1990, N.C. DOT has spent \$60 million to maintain the structure.

The phased approach allows the department take a more conservative approach that takes into account ongoing financial constraints.



This section of N.C. 12 north of the village of Rodanthe has been washed out numerous times by hurricanes and Nor'easters. Long-term plans will avoid reconstruction of this section of roadway in favor of a "jug handle" bridge to the west, built into Pamlico Sound from Rodanthe spanning several miles north, and reconnecting N.C. 12 to the original highway easement in Pea Island National Wildlife Refuge. The N.C. 12 Transportation Management Plan will allow N.C. DOT to consider abandoning additional segments of the original N.C. 12 right-of-way in smaller segments, including the possibility of extending the "jug handle" span in the sound further north or extending the Oregon Inlet bridge further south. Ultimately, this phased approach allows the DOT to make changes as needed or deemed appropriate by ongoing monitoring. This may eventually result in more or longer bridges in the sound connecting Rodanthe to the Bonner Bridge span.

Construction of the Bonner Bridge replacement is expected to begin in the spring of 2016.

More information on the multi-phase Bonner Bridge project, including the NEPA documents, the settlement agreement, and an animation of the bridge construction, is available on the project website at <http://www.ncdot.gov/projects/bonnerbridgereplace/>.

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