

Emergency Relief Program

Resilience Case Study – Hawai‘i

Incorporating Resilience through Bridge Replacement and Rehabilitation

Between April 13 and April 15, 2018, the island of Kaua‘i in the State of Hawai‘i experienced a record amount of rainfall, nearly 50 inches total, causing severe flooding and landslides along Kūhiō Highway (State Route 56 and 560). Three historic one-lane, load-restricted bridges along Route 560, Wai‘oli, Waikoko, and Waipā, often referred to as the 3W bridges, were damaged. The bridges all experienced scour at the footings and abutments and damage due to debris buildup.

The stretch of Route 560 where the 3W bridges are located is a vital route that connects Hā‘ena to Hanalei, and is the only way to reach these communities located on the north shore of the island. Additionally, tourists utilize Route 560 to access Hā‘ena State Park and the trailhead to hike to the Hono O Nā Pali Natural Reserve Area and Nā Pali Coast State Wilderness Park. Starting on April 14, 2018, Route 560 was fully closed from Waikoko to Wainiha and only re-opened for limited emergency access in late April. During that time, boats and helicopters were used to transport people to and from the cut-off region. Limited access to local traffic was restored in early May 2018.

In the immediate aftermath of the storm, the Hawai‘i Department of Transportation (HDOT) in coordination with several State, county, and Federal agencies removed debris and performed emergency repairs along Kūhiō Highway. In early May 2018, the Federal Highway Administration (FHWA) approved \$8 million in quick release Emergency Relief (ER) Program funding for work to restore access to the route. Across many locations, HDOT installed several thousand soil nails to stabilize slopes and soil nail walls to retain material. Also, as part of temporary repairs, the 3W bridges were stabilized by installing piles and braces.



Figure 1: Side view of the historic Waipā Bridge illustrating the damage caused by the historic rainfall event in April 2018. Source: HDOT

Project Snapshot

Location: Kaua‘i, Hawai‘i

Date of ER Event: April 2018

Nature of Event: Heavy rainfall

Assets Impacted: Wai‘oli, Waikoko, and Waipā Bridges

Cost of Resilience Improvements: \$31 million

Type of Improvement: Replacement of the Waikoko and Waipā Bridges to current standards and rehabilitation and strengthening the Wai‘oli Bridge

Lead agency: Hawai‘i Department of Transportation

Other agencies involved: Federal Highway Administration, Hawai‘i Division



Resilience Features

Utilizing funding from FHWA's ER program, HDOT ultimately decided to replace the Waikoko and Waipā bridges and rehabilitate and strengthen the Wai'oli bridge to improve long-term resilience. Several factors influenced HDOT's decision:

- **Extent of the damage:** HDOT determined that the severity of the damage to the Waikoko and Waipā bridges and the ongoing deterioration of these bridges necessitated replacement. However, inspections and testing indicated that rehabilitating the Wai'oli bridge was feasible. For the Wai'oli bridge, HDOT removed and refurbished the existing unsound concrete and corroded rebar. The newly rehabilitated parts of the structure were then wrapped with fiberglass reinforced plastic (FRP) to strengthen the bridge.
- **Likelihood of future storms and impacts to the community:** According to the U.S. Global Change Research Program's [4th National Climate Assessment](#), while overall rainfall has been declining in Hawai'i for decades, extreme rainfall events that result in increased runoff, erosion, and flooding have become more common over the past 50 years. Given the potential threat of future storms, HDOT determined that if the bridges were repaired in place, the 3Ws would be more susceptible to flooding, which would likely result in bridge closures. Restricted access to and from the northwest part of the island can significantly affect the local community, impede evacuation efforts, and restrict access to goods, social services, jobs, etc.

The resilience improvements incorporated as part of the 3W bridges project included:

- **Updating the 3W bridges to current load requirements.** Due to load restricted bridges along Kūhiō Highway, initial recovery operations relied on smaller trucks to carry debris, and HDOT was limited in the type of equipment that could access repair sites. These limitations contributed to delays in reopening the roadway. To aid in ongoing repairs and to facilitate recovery and relief efforts for future storms, the Waikoko and Waipā bridges were designed and built to current HDOT Bridge Design Criteria, including meeting HDOT current load standards of 20 tons. As part of its rehabilitation, the Wai'oli bridge was also fortified to increase its load capacity. The previous bridges were restricted to eight tons. The improved load capacity enabled access to the area for larger construction vehicles and equipment to access the area as well as delivery of heavy materials to complete revetment walls designed to prevent future slope failure at roadway stabilization areas. The increased load capacity will also help to reduce overall construction costs, limit closures, and expedite repair and reconstruction efforts along the corridor.
- **Constructing the Waipā and Waikoko bridges to conform with current hydraulic design standards.** HDOT constructed the Waipā bridge to meet the State's current hydraulic design standards and in doing so, improved the performance and resilience of the bridge in addressing scour. The Waikoko bridge, known locally as the "broken bridge," had previously been damaged and partially repaired, resulting in reduced hydraulic capacity. By following current hydraulic design standards, the replacement of the Waikoko bridge allowed for larger stream flows.



Figure 2: Aerial view of the rehabilitated Wai'oli bridge. Source: HDOT



Other Project Development Considerations and Lessons Learned

Although Route 560 between Waikoko to Wainiha was fully opened to traffic starting in June 2019, construction on the 3W bridges continued through early 2020. Construction delays and intermittent roadway and bridge closures created challenges for the local community and substantially hampered access within and to the north shore. To ensure local stakeholders and visitors received up-to-date information, HDOT conducted ongoing engagement throughout recovery and construction to provide regular updates via meetings, weekly emails, social media messages, website posts, and direct outreach to residents.

Community members and local advocacy groups also expressed concern that replacing the historic, one-lane Waipā and Waikoko bridges and rehabilitating the Wai'oli bridge would affect the corridor's historically rural character. In accordance with section 106 of the National Historic Preservation Act of 1966, FHWA and HDOT conducted a consultation process with historic preservation organizations as well as community-based organizations regarding the impact on these historic properties. These organizations included Hanalei Roads Committee, Historic Hawai'i Foundation, Hanalei Watershed Hui, Waikoko 'Ohana, Hui Ho'omalu I Ka 'Āina, and the Konoiki Restoration Project. Stemming from this engagement, FHWA and HDOT developed a memorandum of agreement (MOA) to minimize and mitigate effects and lay out specific stipulations for the repair and cleanup work along the roadway, replacement of the Waipā and Waikoko bridges, and rehabilitation of the Wai'oli bridge. In particular, the design for the new Waipā and Waikoko bridges required that these low traffic volume facilities remain one lane (with a 12-foot roadway and one-foot shoulders on each side), retain the existing alignment and view sheds, and include railings similar to the old 3W bridges. The MOA also stated that the design for the new Waipā and Waikoko bridges would conform to the guidelines recommended by the Kūhiō Highway Historic Roadway Corridor Plan. An innovative feature that was negotiated between the parties was the inclusion of non-mountable curbs to act as a bridge girder, allow for pedestrian access, and improve roadway safety and traffic flow by providing additional space for emergency vehicle access.

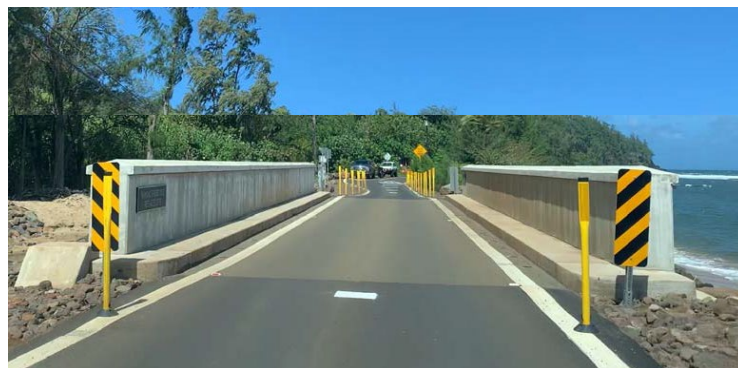


Figure 3: Completed Waikoko bridge with roadway striping and non-mountable curbs. Source: HDOT

Key Takeaways

Since the new Waipā and Waikoko bridges were installed and the Wai'oli bridge was rehabilitated, several severe storms have passed through the area with no damage reported. The 3W bridges project serves as a helpful example to other agencies of how rebuilding to meet current load requirements and hydraulic design standards can improve resilience to flooding events.

Contact Information

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