Hurricane Impact Assessment on Implemented BMP Projects in Guánica and Culebra Watersheds, Puerto Rico

FINAL REPORT

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1 PARTNERS AND COLLABORATORS FOR THIS PROJECT

Culebra Municipality

Punta del Viento Estates Homeowner Association (PPVSHA)

2 INTRODUCTION

The purpose of this report is to summarize damages observed in November at NOAA-funded restoration sites in Guánica and Culebra caused by Hurricanes Irma and Maria in September of 2017. Eight project sites were evaluated in Culebra, specifically in Punta del Viento, Zoní, Punta Soldado, Aeropuerto, Fulladosa, Townsite, Puerto Manglar, and Tamarindo with a two-phase project. Several sites were evaluated in the upper Guanica Bay watershed as well. Projects completed in these areas included the stabilization of a dirt road network, stormwater practices, among others. All of these projects have utilized green infrastructure practices to intercept stormwater runoff and utilize plants, soils, and natural processes to filter and reduce runoff pollution. This report includes a brief summary of pre and post-hurricane conditions (Section 3), as well as estimated repair costs (Section 4).

3 EVALUATION

3.1 PUNTA DEL VIENTO ESTATES

Several swales and Vetiver check dams were implemented as well as a series of raingardens and sediment traps downhill of the implemented road stabilization practices were implemented. The use of concrete crossing swales and underground drainage pipes was implemented to ensure proper conveyance of runoff to forested areas after passing through a series of treatments.

All the dirt road stabilized was regraded to the desired hydrological patterns, and runoff was conveyed into a continuous swale with check dams at intervals of approximately 25-30 ft., depending on the slope. The regrading process was conducted using a bulldozer, and soil was compacted with a 15-ton compacting roll. A series of concrete crossing swales was constructed to cross runoff from one side of the road to another into forested areas. Sediment traps were constructed to help filter stormwater that was causing erosion problems and discharging sediments. A rip-rap overflow was constructed with bigger 1-2 ft. stones to reduce energy of the water. The final segment of the road was paved with compacted gravel to reduce the sediments entering the raingarden that eventually drains to the Bay.

Figure 1. Stabilized road and check dams constructed at Punta del Viento prior to impact of hurricanes Irma and Maria.

Figure 2. Sediment trap constructed at Punta del Viento prior to impact of hurricanes Irma and Maria.

During the evaluation process, PDC identified that the previously stabilized dirt road had suffered erosion due to the rains associated with the storms. The photographs show the culverts formed by the water flowing over the dirt road (Figures 3-5). The sediment traps were in good conditions and found to have suffered minimal damage. The location of the sediment trap proved to be asserted as sediment eroded was transported and accumulated within the sediment trap.

Figure 3. Formation of ruts and false ditch on previously stabilized dirt road at Punta del Viento following impact of hurricanes Irma and Maria.

Figure 4. Erosion on previously stabilized dirt road at Punta del Viento following impact of hurricanes Irma and Maria.

Figure 5. Sediment trap conditions at Punta del Viento following impact of hurricanes Irma and Maria.

3.2 PUNTA SOLDADO

Project implementation in Punta Soldado included the stabilization and conditioning of approximately ½ mile of the main access dirt road and the creation of a permeable parking lot that helped to reduce sediment transport to the marine environment of Punta Soldado and Ensenada Malena. A series of 3 sediment trap system including rain gardens were constructed in the lowest part of the road where there used to be stagnant mud which vehicles crossed creating an ever-increasing sediment and erosion problem that periodically released sediments to the marine environment in Ensenada Malena. Implementation also included the delimitation of public access and critical habitat areas. PDC restored the coastal beach berm area with native vegetation barriers and delineated public access to the beach. This delineation was conducted by installing treated wooden posts and the reforestation with native vegetation. An elevated boardwalk was constructed for the public to access the beach without impacting restored vegetation buffers and sand dunes. In order to restore the coastal vegetated berm and buffer, we re-planted native species to coastal areas including Sea grapes (*Cocoloba uvifera*), Almácigo (*Bursera simaruba*) and Uverillo (*Coccoloba microstachya*) among other species (Figure 6-9).

Figure 6. Reforestation event located at Punta Soldado prior to hurricanes Irma and Maria.

Figure 7. Permeable parking located at Punta Soldado prior to hurricanes Irma and Maria.

Figure 8. Permeable parking located at Punta Soldado prior to hurricanes Irma and Maria.

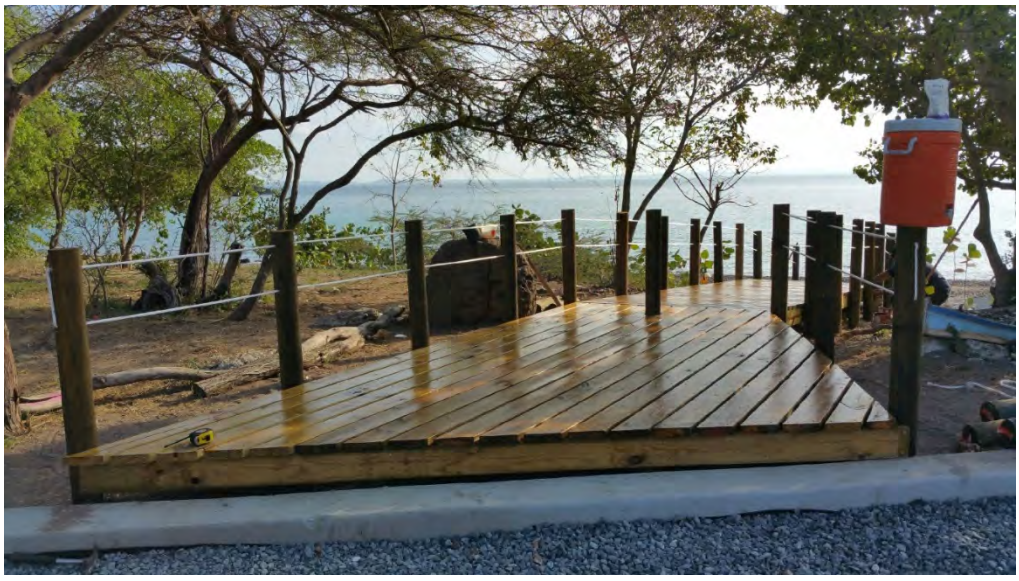

Figure 9. Public access boardwalk located at Punta Soldado prior to hurricanes Irma and Maria.

During the evaluation process at Punta Soldado, PDC identified that the stabilized dirt road had suffered greatly. The rains and water flowing caused serious erosion on the road. The photographs shown below are of the ditches formed by the water flowing over the dirt road. Wooden posts used for delimitation of public access and critical habitat areas were also damaged and require replacements. The restored coastal beach berm area with native vegetation barriers has been overgrown by weeds, limiting the healthy growth of the planted native trees. The elevated boardwalk constructed showed minimal damages, with some posts needing to be replaced (Figures 10-14).

Figure 10. Previously stabilized road located at Punta Soldado showing damages following hurricanes Irma and Maria.

Figure 11. Previously stabilized road located at Punta Soldado showing overgrowth of vegetation following hurricanes Irma and Maria.

Figure 12. Delimited public area located at Punta Soldado showing overgrowth of vegetation and debris following hurricanes Irma and Maria.

Figure 13. Previously stabilized road located at Punta Soldado showing damages following hurricanes Irma and Maria.

Figure 14. Permeable parking area located at Punta Soldado showing damages following hurricanes Irma and Maria.

3.3 PUERTO MANGLAR

Work completed consisted of stabilizing the access road and parking area by regrading and compaction. Sediment control practices included installing silt fences and planting Vetiver grass to redirect runoff to forested areas. A series of swales and check dams were installed to direct part of the runoff from the main access roads to a sediment trap. The parking area and all the road segments that run parallel to the wetland system were then paved with gravel after the installation of geotextile to serve as a filtration system.

The old parking lot that was utilized by visitors was located on the terrestrial maritime zone, and motor vehicles had direct access to the beach area. As part of this project, this area was closed with boulder rocks to ensure soil stabilization and vegetation recovery. The new parking area was developed using green infrastructure techniques to help with the sediment load reduction process. The parking, as well as all the flat sections of the dirt road, was designed to capture and infiltrate rainwater and runoff from the adjacent hillsides into the subsoil. Parking was also regraded and designed to convey the excess runoff produced in larger storm events into a rain garden system without directly discharging into the mangrove and subsequently into the marine environment.

The salt flat wetland area was restored by removing the piles of sediment that had accumulated from the adjacent road and parking areas. This sediment accumulation was preventing natural hydrological flow patterns of tidal process. After the sediment was removed and natural hydrologic conditions were reestablished, we reforested the area with mangroves and other coastal forest. A wooden boardwalk was constructed to provide

pedestrian access while protecting the surrounding restored area. Hydroseeding was used to stabilize remaining bare soil areas of the restored site (See Figures 15 to 16).

Figure 15. Stabilized site at Puerto del Manglar prior to hurricanes Irma and Maria.

Figure 16. Stabilized site at Puerto del Manglar prior to hurricanes Irma and Maria.

Damages observed at Puerto del Manglar was of structural and vegetative damages. The previously stabilized road is in need of resurfacing and clearing the accumulated debris. Areas with vegetative cover will requiere replanting of several trees and clearing those that were uprooted by the force of the storms. The affected areas are showing signs of water flowing through and accumulating at the dirt road as before instead of being redirected with the help of the green infrastructure constructed by PDC (Figures 17 and 18).

Figure 17. Damages suffered at stabilized site at Puerto del Manglar following hurricanes Irma and Maria.

Figure 18. Damages suffered at stabilized site at Puerto del Manglar following hurricanes Irma and Maria.

3.4 AEROPUERTO

Within the Aeropuerto subwatershed, the implementation work included the biofilter parking area by the airport runway and the road stabilization, two sediment traps and hydroseeding and planting in the nearby landfill. Prior to stabilization, in most parts of the dirt road networks, runoff was flowing down the center of the road causing erosive forces to transport sediments into the nearshore environment.

The parking area was encountering serious problems of erosion and sedimentation that were mainly associated with runoff generated from the dirt parking lot and the uncontrolled vehicular and pedestrian transit. This infrastructure was in a critical state of disrepair with rutting and small undesirable watercourses conveying runoff and sediment to the subwatershed. The lack of proper planning and management of erosion and sediment led to an increase in contamination with land-based sources of pollution including sediments and motor vehicle associated contaminants. Implementation for the parking area consisted in the creation of a biofilter parking that allows the sediment to be contained and to infiltrate most of the rain water avoiding its transport with flowing water. The constructed parking area was done at a slight angle to allow water flow to reach the drainage swale. The stone that was laid in the parking lot was selected to promote infiltration and reduce surface water flows causing erosion during rainy periods. The stone was slightly compacted to both maintain a safe walking surface and infiltration in the area (Figures 19-21).

Figure 19. BMPs constructed at the Aeropuerto site prior to hurricanes Irma and Maria.

Figure 20. Sedimentation pond constructed at the Aeropuerto site prior to hurricanes Irma and Maria.

Figure 21. Hydroseeding at the Aeropuerto site prior to hurricanes Irma and Maria.

The Aeropuerto site BMP work implemented by PDC suffered mostly vegetation damage. It was estimated that 65% of the hydroseeding work previously performed during the implementation phase was damaged and required remediation. Structural damage encountered includes the washing away of areas that had been previously stabilized with gravel stones allowing once again for the runoff to erode away the sediments in the path of water flow (Figure 22).

Figure 22. Damages suffered at stabilized site at Aeropuerto following hurricanes Irma and Maria.

3.5 ZONI

The problems identified in Zoní beach were mainly associated with runoff generated from the dirt parking lot and the unpaved road network that provides vehicular access to areas adjacent to the beach. Existing infrastructure was in a critical state of disrepair with rutting and small undesirable watercourses conveying runoff and sediment down to Zoní Beach. The dirt parking lot covered approximately 500 m² and vehicles had direct access to the permanent vegetation areas of the beach.

The stabilization of the dirt road significantly reduced the amount of flow and the velocity of water and sediment sent downhill. Restoration work at this site consisted of diverting runoff water to forested areas in 4 to 6 segmented locations. To stabilize this section of road, we installed dirt swales, thus reducing flow and diverting water to adjoining forested areas. In order to reduce runoff and dissipate its energy, water was conveyed to intercepts at 3 locations on both sides of the road that break up flow paths and reduce concentrated flow of runoff over the parking lot. The excess runoff will be forced to a riprap and Vetiver swale built parallel to the south side of the road to take water off the road and it will end in a wider concrete bio-filter system with built-in large stones that promote sheet flow towards the sediment trap after passing through several lines of Vetiver grass.

A Rain Garden/Sediment Trap system (Figure 23) was designed to help filter storm water that was discharged to Zoní Beach. The entire filtration process consists in three filtration chambers, a Rain garden and a permeable parking system. This practice was designed to treat residual runoff coming from the dirt and access roads that could not be addressed

with stabilization practices discussed in the previous sections. Water is conveyed to the sediment trap by a concrete swale.

Figure 23. Sediment pond/rain garden at Zoni prior to hurricanes Irma and Maria.

The stabilized parking area consisted of approximately 500 m². The parking area was developed using the best available technology to help in the sediment load reduction process. Parking was constructed with multiple layer base confined with a 1' concrete curb composed of; (1) geo-mebrane support (2) gabion with pebble stones as base, this allows support and drainage, (3) filter fabric, this eliminate the possibility of contamination of the base with sediment, and (4) a Geo-Cell with ¼" gravel infill, this will allow vehicle support and drainage of all stormwater (Figure 24).

Figure 24. Parking area at Zoni prior to hurricanes Irma and Maria.

A small elevated boardwalk was constructed for the public to access the beach without impacting vegetation and sand dunes. This area was closed to vehicular access by the installing wood poles and it has a defined pedestrian access area to the beach. This is accompanied by signage with educational information and rules to be followed by users (Figure 25). In order to restore the coastal vegetated berm and buffer, we re-planted the area with coastal native species. A total of approximately 300 native trees were planted with active collaboration of local groups and volunteers.

Damages encountered following the hurricanes Irma and Maria at Zoni were described as mostly vegetative damages with approximately 85% of areas needing recovery, while over one third of the structural components need repairs. Of the structural repairs needed, the parking area and delimitation need attention, while the boardwalk requires minimal repairs (Figures 26-27).

Figure 25. Elevated boardwalk and area delimitation at Zoni prior to hurricanes Irma and Maria

Figure 26. Structural and vegetation damages suffered at Zoni parking area following hurricanes Irma and Maria.

Figure 27. Structural and vegetation damages suffered at Zoni following hurricanes Irma and Maria.

3.6 TOWN SITE

The Town site is located in a small subwatershed that drains to the Lobina Channel. Most of the access roads in the area are paved except for a road that goes to the main potable water reservoir in the top of the hill. This dirt road is very steep and served as the major source of sediment laden runoff to the Lobina Channel. It was identified as a priority due to extensive sediment transport from a dirt road and conveyance of stormwater runoff in a small eroding channel out to the Lobina Channel.

A series of components were constructed to increase the effectiveness of the conservation practices implemented and help reduce sediment transport to the Lobina channel and the nearshore reefs. A total of three rain gardens/sediment traps were

constructed (Figure 28). The project resulted in over 150 native trees and 1000 Vetiver plants being planted to help stabilize conveyances and re-establish native vegetation. Cross swales and a series of check dams with riprap and Vetiver were established to redirect runoff to the rain gardens and reduce the energy of the water (Figure 29). An infiltration gallery was created to address runoff from an uncontrolled drainage are from the overflow of the water reservoir tank.

Figure 28. Sediment trap at Town site prior to hurricanes Irma and Maria.

Figure 29. Check dam at Town site prior to hurricanes Irma and Maria.

Damages in the Town site include road stabilization and vegetative loss. It is evident that sediment has been transported by runoff following the storm events of 2017. Deep grooves can be observed from the photographs taken at the implementation Town sites. Repairs are needed to prevent further impact of the Lobina Channel with sediment laden runoff (Figures 30 and 31).

Figure 30. Damages suffered at the Town site following hurricanes Irma and Maria.

Figure 31. Damages suffered at the Town site following hurricanes Irma and Maria.

3.7 FULLADOSA

The Fulladosa site represents a location draining to Ensenada Honda, a bay recognized as critical habitat due to prevalence and abundance of seagrass beds and coral reefs. At this site there is an increasing sediment plume that is severely impacting seagrass communities. The Fulladosa site is composed of a municipal dirt road system. This dirt road is very steep, and it is one of the major sources of sediment runoff to Ensenada Honda.

Figure 32. Road stabilization work at Fulladosa prior to hurricanes Irma and Maria.

Approximately ½ mile of dirt road was stabilized to reduce sediment transport to the marine environment of Ensenada Honda. Prior to stabilization of the dirt road, run off was running through the center of the road causing erosion forces to drag sediments to the marine environment. The road was regraded, and runoff was conveyed into a continuous swale that runs parallel to the road. The check dams were constructed using 8-12 inch stones to reduce the energy of the water and to hold some of the sediment resulting from the dirt road. The swale discharges runoff into a series of sediment traps and then to forested areas (Figures 32 and 33).

Additionally, a series of 2 sediment trap systems were constructed. The sediment ponds were designed to trap most of the core particulates and the overflow discharges through a

cascade composed of combine boulders and smaller stones and various lines of Vetiver grass before entering a forested area in its way to the dry channel (Figure 34).

Figure 33. Road stabilization work at Fulladosa prior to hurricanes Irma and Maria.

Figure 34. Sediment trap system constructed at Fulladosa prior to hurricanes Irma and Maria.

Damages identified during the evaluation process include erosion of the previously stabilized road due to the rains associated with the storms. The photographs show the culverts formed by the water flowing over the dirt road (Figures 35-37). The sediment traps were in good conditions and found to have suffered minimal damage. Vegetation and debris require attention as the site is overgrown with invasive grasses and weeds.

Figure 35. Damages suffered at the Fulladosa site following hurricanes Irma and Maria.

Figure 36. Damages suffered at the Fulladosa site following hurricanes Irma and Maria.

Figure 37. Damages suffered at the Fulladosa site following hurricanes Irma and Maria.

3.8 TAMARINDO

The problems identified in Tamarindo were mainly associated with runoff generated from an exposed dirt turnaround and the extensive areas of unpaved road in areas that drain directly to the Marine Reserve. Existing infrastructure was in a critical state of disrepair with rutting and small undesirable watercourses conveying runoff and sediment down to Tamarindo Beach. This was causing bank erosion that was yielding considerable amounts of sediments directly to coral reef communities. In order to reduce runoff and dissipate its energy, we rehabilitated culvert drainages with riprap and Vetiver swales built parallel to both sides of the road.

Figure 38. Road stabilization work at Tamarindo prior to hurricanes Irma and Maria.

The implementation of these practices will promote sheet flow towards a series of sediment trap system built with stones after passing through several lines of Vetiver grass with gabion stones (Figure 6). Further, water was conveyed to intercepts at 3 locations. On both sides of the road, we broke up flow paths and reduced concentrated flow over the road, thus converging flows to areas of treatment. Upon finalizing the rehabilitation, we covered most of the exposed soil with a mixture of different sizes of gravel to allow compaction. Dirt turnaround stabilization, the conservation practices implemented to stabilize this site were composed of a series of check dams and bio swales with the

combination of excavation of 2 to 4 inches of soil and replacing it with a mixture of different size gravel (¼ – 1 ¼ inch). Gravel was also compacted with a 16-ton compacting roller.

A sediment trap system was designed to help filter storm water that was causing erosion problems and discharging sediments to Tamarindo Beach. The entire filtration process consists of three stabilization ponds. This practice was designed to lower the erosive force of water, treat residual runoff coming from the road and divert water to forested areas. Water is conveyed to the sediment traps trough gabion stone and Vetiver grass swales.

Figure 39. Sediment trap system work at Tamarindo prior to hurricanes Irma and Maria.

Along the coast line at Tamarindo Beach, PDC led the efforts to stabilize a parking area, delimited the public access, stabilized with planting native tree species and construct 2 bio-filter areas. Several of these initiatives included the assistance of volunteers and the Municipality of Culebra (Figure 40).

Figure 40. Coastal stabilization work at Tamarindo prior to hurricanes Irma and Maria.

Damages as a result of the impact of hurricanes Irma and Maria at Tamarindo were found to be 100% structural and 100% vegetative. This level of damage should receive priority attention in comparison to the other Culebra implementation sites. During the post-hurricane evaluation, PDC found severe erosion of the previously stabilized road due to the rains associated with the storms. The photographs below show the formation of deep ditches formed by the water flowing over the road. Vegetation was also overgrown and covering the BMP structures put in place during project implementation. Implementation for the coastal stabilization work was also severely impacted and in need of repairs (Figures 41-44).

Figure 41. Damages suffered at the Tamarindo site following hurricanes Irma and Maria.

Figure 42. Damages suffered at the Tamarindo site following hurricanes Irma and Maria.

Figure 43. Damages suffered at the coastal Tamarindo site following hurricanes Irma and Maria.

Figure 44. Damages suffered at the coastal Tamarindo site following hurricanes Irma and Maria.

3.9 GUANICA

The primary goal of this project was to stabilize bare soils in the upper watershed farms to reduce sediment loads to the Guánica Bay with the goal to protect and build resilience of coral reef ecosystems in this priority area. Prior to stabilization of portions of the dirt road, runoff was running through the center of the road causing erosion forces to transport sediments into our watershed water resources. After completing the installation of temporary sediment and erosion control measures, PDC stabilized dirt roads in three coffee farms by installing BMPs such as check dams and sediment traps. Dirt roads were stabilized to reduce sediment transport to the GB/RL watershed.

Installed BMPs included sediment traps, check dams, swales, regrading, rip raps and paving with granulate fill material and compacting. Approximately 1.7 miles (using ArcGIS tools) of dirt road was stabilized in all three farms to reduce sediment transport to the GB/RL watershed and eventually the marine environment. All the dirt road stabilized was regraded toward the inside of the hillside and runoff was conveyed into a continuous swale with check dams at intervals of approximately 25 ft. Grading activities were a bit challenging do to the fact that these roads have been bulldozed so many times in the past decades that the hydrologic conditions desired by the regrading process are very difficult to achieve. Another challenge was that side banks on the roads have vertical slopes and while conducting works part of the slopes falls into the road again. Also, during rain events landslides occur damaging work completed.

Check dams were implemented in combination with a continuous swale along the inner side of the road (Figure 45). It was almost impossible to cut flow patterns in the swale and

get runoff out to forested areas because of the presence of high banks on both sides of the road in many cases and in other instances because of active farmlands that couldn't get affected by the runoff. For this reason, we decided to intersect flow in the continuous swale with the check dams at intervals of approximately 25 to 30 feet depending on the slope.

Figure 45. Implemented check dams in combination with a continuous swale prior to hurricanes Irma and Maria.

A series of sediment traps were constructed to help filter storm water that was causing erosion problems and discharging sediments. The traps were formed by excavating an area across a low portion of drainage swale and berms were constructed and compacted with the small compacting roll. After compacting, the sediment traps where covered with 2-8 in stones to prevent erosion from the berms and the bottom was punched through with the backhoe to promote infiltration and vetiver half-moons were planted to help trap sediment and promote infiltration and evapotranspiration (Figure 46). A rip-rap overflow was constructed with bigger 1-2 feet stones to reduce energy of the water. In other areas, we

used rip-rap in existing water ways and it offered an easy-to-use method for decreasing water velocity and protecting slopes from erosion (Figure 47).

In this effort, we used vetiver on check dams, sediment traps, rip-rap and on stabilizing soil banks on the side of the dirt road system we have worked on. In combination with other practices such as using proper size stones, it has demonstrated to be the most cost-effective technique we have implemented.

Figure 46. Implemented sediment trap prior to hurricanes Irma and Maria.

Figure 47. Implemented rip rap with Vetiver prior to hurricanes Irma and Maria.

The previously implemented BMPs in the upper Guanica Bay watershed were seriously impacted by hurricane Maria in September 2017. As a result of the amount and duration of rain, mayor landslides occurred at the farms targeted during project implementation. Large quantities of runoff were reported and responsible for damaging the check dams, swales, sediment traps and stabilized roads. In the photographs below, it is evident that these BMPs require immediate restoration in order to return them to optimum conditions and allow the continued runoff and sedimentation control impacting the lower Guanica Bay watershed (Figures 48-50).

Figure 48. Damages suffered at Guánica Bay watershed site following hurricane Maria.

Figure 49. Damages suffered at Guanica Bay watershed site following hurricane Maria.

Figure 50. Damages suffered at Guánica Bay watershed site following hurricane Maria.

4 ESTIMATED REPAIR COSTS

PDC estimated a percentage of structural and vegetative damage to each of the practices evaluated. These percentages were used to estimate repair costs based on the original cost of construction. Table 1 summarizes original project costs, % damage for structural and vegetative components of the project, and total estimated repair cost. Tables 2 and 3 provide estimates of repair costs to various structural or vegetative components, respectively. These estimates are derived from the % assessed damages applied to original costs (i.e., not based on a repair design plan). These estimates were used to support post-hurricane repair funding requests for NOAA.

Table 1. Summary of Original Project Cost, Damages, and Repair Estimates

Project	Subwatershed	Funding Source	Original Project Costs	% Structural	% Structural Damages	% Vegetative	% Vegetative Damages	Total Repair Costs
Dirt Road Stabilization in Coffee Farms (private)	Guánica -Luchetti	NOAA CRCP Domestic Grant	$75,400	75%	65%	25%	85%	$77,407.53
Dirt Road Stabilization	Manzanillo, Aeropuerto, Puerto del Manglar, Fulladosa, Culebra Town	NOAA CRCP	$279,314	75%	25%	25%	75%	$139,831.57
Hydroseeding	Guánica- Luchetti	NOAA CRCP	$122,000	0%	0%	100%	85%	$103,700.00
Hydroseeding	Guánica- Luchetti	NOAA CRCP	$127,000	0%	0%	100%	95%	$120,650.00
Hydroseeding	Aeropuerto	NFWF CRC	$20,000	0%	0%	100%	65%	$13,000.00
Dirt Road Stabilization	Manzanillo, Aeropuerto, Puerto del Manglar	NOAA OHC	$146,000	75%	25%	25%	75%	$73,091.25
Puerto Manglar Coastal Stabilization	Puerto del Manglar	NOAA CRCP/RC	$20,000	95%	25%	5%	25%	$8,182.50
Punta Soldado Coastal Stabilization	Malena, Puerto del Manglar	NOAA CRCP Domestic Grant	$69,704	95%	80%	5%	95%	$91,779.26
Jaboncillo Coastal Stabilization	Guanica Coast	NFWF CRC (CRCP)	$77,985	95%	25%	5%	25%	$31,905.61
Zoni Coastal Stabilization	Zoní	NOAA CRCP	$59,210	95%	35%	5%	85%	$35,394.26
Tamarindo Coastal Stabilization	Tamarindo	NOAA CRCP	$71,476	95%	100%	5%	100%	$116,970.47
Tree Nursery Construction	Guánica -Yauco Town	NFWF CRC	$77,985	100%	35%	0%	0%	$45,582.23
Total NOAA Funds Invested			$1,146,074					**$857,494.68**

Table 2. Summary of Structural Component Repair Costs

Project	Subwatershed	Estimated Structural Material Costs	General Labor Structural Costs	Heavy Equipment Structural Rental	Project Management and Coordination	Project Design and Engineering	Estimated Total Structural Costs
Dirt Road Stabilization in Coffee Farms (private)	Guánica -Luchetti	$ 36,758	$ 5,514	$7,351.50	$4,410.90	$7,351.50	$61,385.03
Dirt Road Stabilization	Manzanillo, Aeropuerto, Puerto del Manglar, Fulladosa, Culebra Town	$ 52,371	$ 7,856	$10,474.28	$6,284.57	$10,474.28	$87,460.20
Hydroseeding	Guánica- Luchetti	$ -	$ -	$0.00	$0.00	$0.00	$0.00
Hydroseeding	Guánica- Luchetti	$ -	$ -	$0.00	$0.00	$0.00	$0.00
Hydroseeding	Aeropuerto	$ -	$ -	$0.00	$0.00	$0.00	$0.00
Dirt Road Stabilization	Manzanillo, Aeropuerto, Puerto del Manglar	$ 27,375	$ 4,106	$5,475.00	$3,285.00	$5,475.00	$45,716.25
Puerto Manglar Coastal Stabilization	Puerto del Manglar	$ 4,750	$ 713	$950.00	$570.00	$950.00	$7,932.50
Punta Soldado Coastal Stabilization	Malena, Puerto del Manglar	$ 52,975	$ 7,946	$10,595.01	$6,357.00	$10,595.01	$88,468.32
Jaboncillo Coastal Stabilization	Guanica Coast	$ 18,521	$ 2,778	$3,704.29	$2,222.57	$3,704.29	$30,930.80
Zoni Coastal Stabilization	Zoní	$ 19,687	$ 2,953	$3,937.47	$2,362.48	$3,937.47	$32,877.83
Tamarindo Coastal Stabilization	Tamarindo	$ 67,902	$ 10,185	$13,580.44	$8,148.26	$13,580.44	$113,396.67
Tree Nursery Construction	Guánica -Yauco Town	$ 27,295	$ 4,094	$5,458.95	$3,275.37	$5,458.95	$45,582.23
Total NOAA Funds Invested		$ 307,635	$ 46,145	$61,526.93	$36,916.16	$61,526.93	**$513,749.83**

Table 3. Summary of Vegetative Component Repair Costs

Project	Subwatershed	Estimated Vegetative Material Costs	General Labor Structural Costs	Heavy Equipment Rental	Project Management & Coordination	Project Design and Engineering	Estimated Total Veg Costs
Dirt Road Stabilization in Coffee Farms (private)	Guánica -Luchetti	$ 11,216	$ 1,602	$ 1,602	$801.13	$801.13	$16,022.50
Dirt Road Stabilization	Manzanillo, Aeropuerto, Puerto del Manglar, Fulladosa, Culebra Town	$ 36,660	$ 5,237	$ 5,237	$2,618.57	$2,618.57	$52,371.38
Hydroseeding	Guánica- Luchetti	$ 72,590	$ 10,370	$ 10,370	$5,185.00	$5,185.00	$103,700.00
Hydroseeding	Guánica- Luchetti	$ 84,455	$ 12,065	$ 12,065	$6,032.50	$6,032.50	$120,650.00
Hydroseeding	Aeropuerto	$ 9,100	$ 1,300	$ 1,300	$650.00	$650.00	$13,000.00
Dirt Road Stabilization	Manzanillo, Aeropuerto, Puerto del Manglar	$ 19,163	$ 2,738	$ 2,738	$1,368.75	$1,368.75	$27,375.00
Puerto Manglar Coastal Stabilization	Puerto del Manglar	$ 175	$ 25	$ 25	$12.50	$12.50	$250.00
Punta Soldado Coastal Stabilization	Malena, Puerto del Manglar	$ 2,318	$ 331	$ 331	$165.55	$165.55	$3,310.94
Jaboncillo Coastal Stabilization	Guanica Coast	$ 682	$ 97	$ 97	$48.74	$48.74	$974.81
Zoni Coastal Stabilization	Zoní	$ 1,761	$ 252	$ 252	$125.82	$125.82	$2,516.43
Tamarindo Coastal Stabilization	Tamarindo	$ 2,502	$ 357	$ 357	$178.69	$178.69	$3,573.80
Tree Nursery Construction	Guánica -Yauco Town	$ -	$ -	$ -	$0.00	$0.00	$0.00
Total NOAA Funds Invested		$ 240,621	$ 34,374	$34,374.49	$17,187.24	$17,187.24	**$343,744.85**