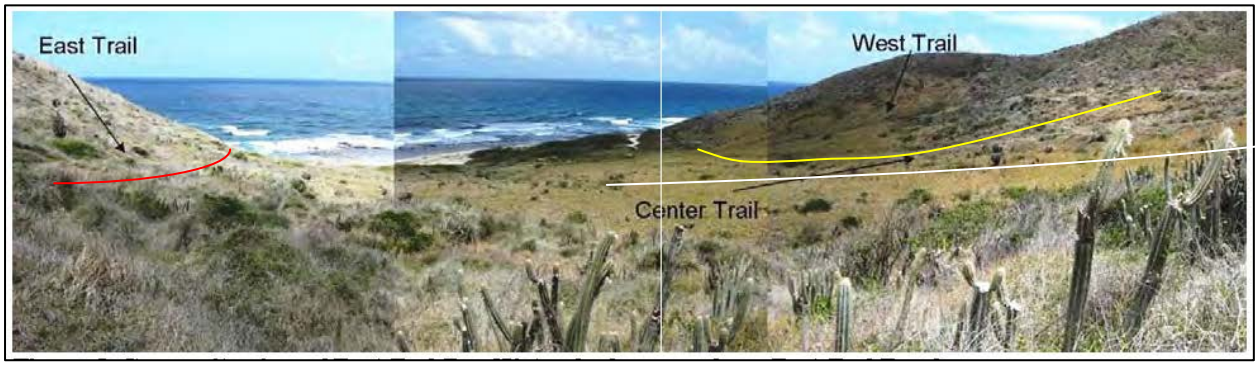
NOAA ARRA USVI Watershed Stabilization Project

Summary Report



National Oceanic and Atmospheric Administration
Virgin Islands Resource Conservation & Development Council
Coral Bay Community Council

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This report summarizes the $2.7 million USVI Watershed Stabilization Project undertaken with National Oceanic and Atmospheric Administration (NOAA) funding through the American Recovery and Reinvestment Act of 2009 (ARRA). There are nine reports in this series including this summary report:

- Coral Bay Watershed Management Project – Johnny Horn Trail Drainage Improvements
- Coral Bay Watershed Management Project – Hansen Bay Drainage Improvements
- Coral Bay Watershed Management Project – Lower Bordeaux Drainage Improvements
- Coral Bay Watershed Management Project – John's Folly Drainage Improvements
- Coral Bay Watershed Management Project – Calabash Boom Drainage Improvements
- Coral Bay Watershed Management Project – Carolina Valley Drainage Improvements
- Fish Bay, St. John Drainage Improvements
- East End Bay, St. Croix Erosion Repairs, Trail Construction, and Drainage Improvements
- NOAA ARRA USVI Watershed Stabilization Project Summary Report

The reports may be downloaded at: www.coralbaycommunitycouncil.org/VIRC-and-D.htm

Acknowledgements

Overall project management was provided by the Virgin Islands Resource & Development Council and its Board of Directors listed below:

President - Diane Capehart
Vice President - Olasee Davis
Secretary - Marcia Taylor
Treasurer - Dee Osinski (first year)/Olasee Davis
At Large member - Paul Devine

Work would not have been possible without the contributed countless volunteer hours, including the project's Principal Investigator Marcia Taylor who put a substantial amount of volunteer time into this project.

Work in Coral Bay would not have been possible without the Coral Bay Community Council, Inc., a 501(c)(3) organization, its volunteer Board members and many community volunteers. President and Executive Director, Sharon Coldren, spent three years as a volunteer working almost full time to implement this project. A $300,000 U.S. Environmental Protection Agency Community for a Renewed Environment grant supported the engineering designs in Coral Bay.

Work in the Fish Bay watershed would not have been possible without the Fish Bay Owners Association and particularly President Terry Piskho and board member Chuck Piskho. FBOA started the planning/design work on this project in 2002 with a small grant from VI DPNR, secured all necessary permits and began work on the road system using Association funding. Both Terry and Chuck visited the work sites daily and worked closely with the contractor to assure that the work was satisfactory to the Owners as well as the performance of the grant. They also secured funding from the Association to add to the Grant funds and successfully encouraged many homeowners to further the goals of the project by paving driveways and private roads.

Project management and project completion were facilitated by the technical expertise and project management skills of NOAA's Restoration Center, specifically staff members Daphne MacFarlan and Julia Royster.

Photos provided by CBCC, V.I. RC&D, and Greg Miller.

Executive Summary

In 2009, the National Oceanic and Atmospheric Administration (NOAA) released the *NOAA Coastal and Marine Habitat Restoration Project Grants under the American Recovery and Reinvestment Act* solicitation as a call for proposals that would "result in on-the-ground restoration of marine and coastal habitat … that are aligned with the objectives of the American Recovery and Reinvestment Act (ARRA)" (NOAA 2009). In the U.S. Virgin Islands (USVI), increased sedimentation and the associated decline of coral reefs is a critical environmental issue. The increasing rate of land development that has occurred throughout the USVI during the past several decades, combined with poor land use planning, sporadic regulation of development projects, and limited funding opportunities to implement effective mitigation strategies, continue to pose major environmental problems. Access to developed land is largely over a network of unpaved roads. These unpaved road systems have become both primary sources of sediment and primary drainage conveyances, effectively transporting sediment-laden runoff into sensitive coastal habitats.

Therefore, the Virgin Islands Resource Conservation & Development Council (V.I. RC&D), the Coral Bay Community Council (CBCC), and other partners responded to NOAA's solicitation by submitting a proposal to conduct stormwater management work targeting sediment control in Coral Bay and Fish Bay, St. John, and East End Bay, St. Croix (see Figures 1 & 2 for project action areas). The USVI Watershed Stabilization Project, led by V.I. RC&D, received $2.7 million in NOAA ARRA funding to implement the proposed actions. Using these funds, the project partners constructed 126 best management practices (BMPs) targeting sediment source control and sediment cleanup. These BMPs ranged from paving roads to constructing sediment detention basins to trail closure. The net effects of these actions are:

- Reduced sediment loading to the targeted bays;
- Restored upland habitat;
- Beneficial effects on upland ghut habitats including more naturalized flows;
- Improved water quality;
- Increased public awareness about stormwater management, BMPs, and sedimentation; and,
- A reduced sediment threat to coastal and marine habitats.

In summary, this project reduced sediment loads at selected sites and served as a model of science-driven, community-based efforts to mitigate erosion problems that can be emulated in other parts of the USVI.

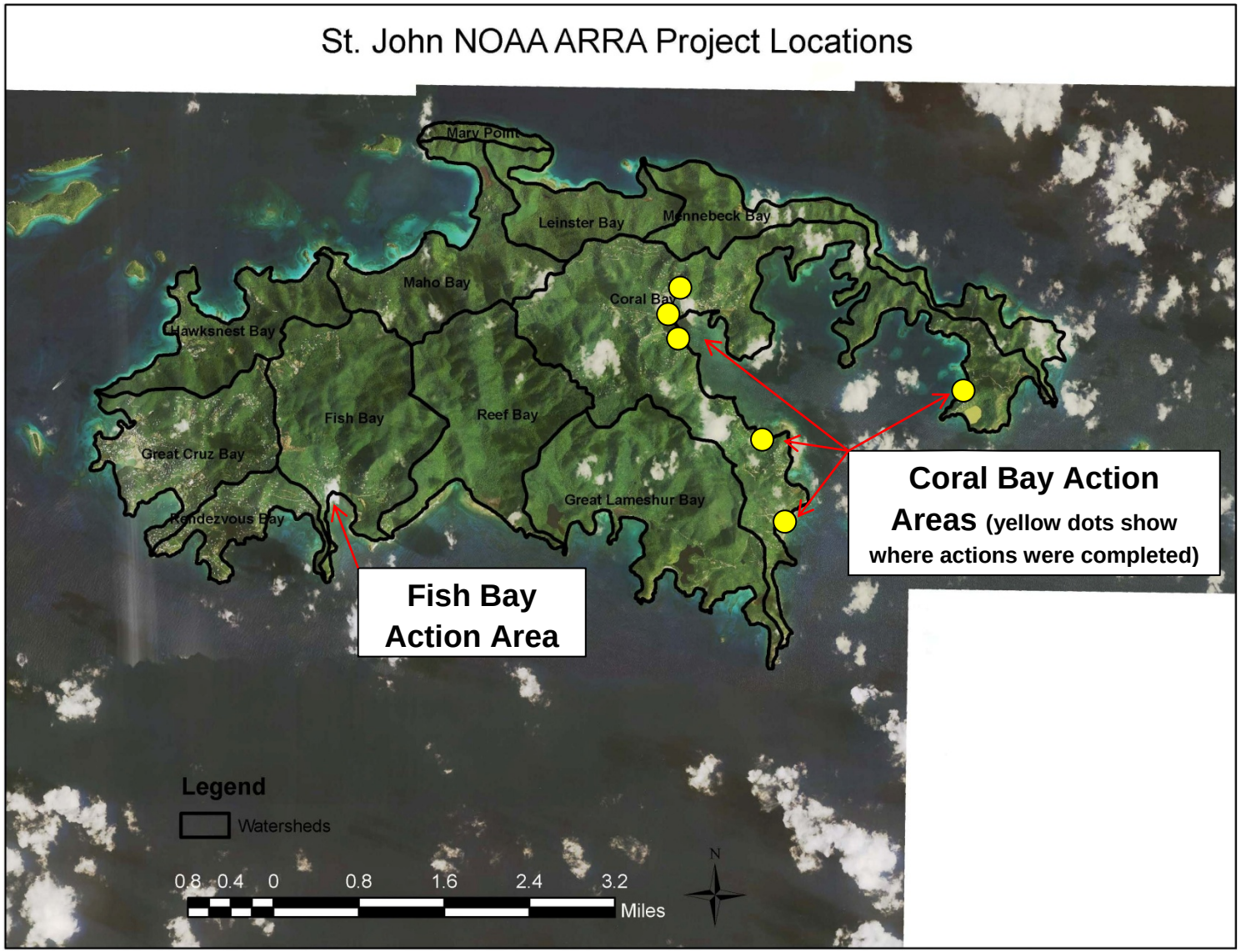

Figure 1: St. John NOAA ARRA Project Action Areas – Fish Bay and Coral Bay.

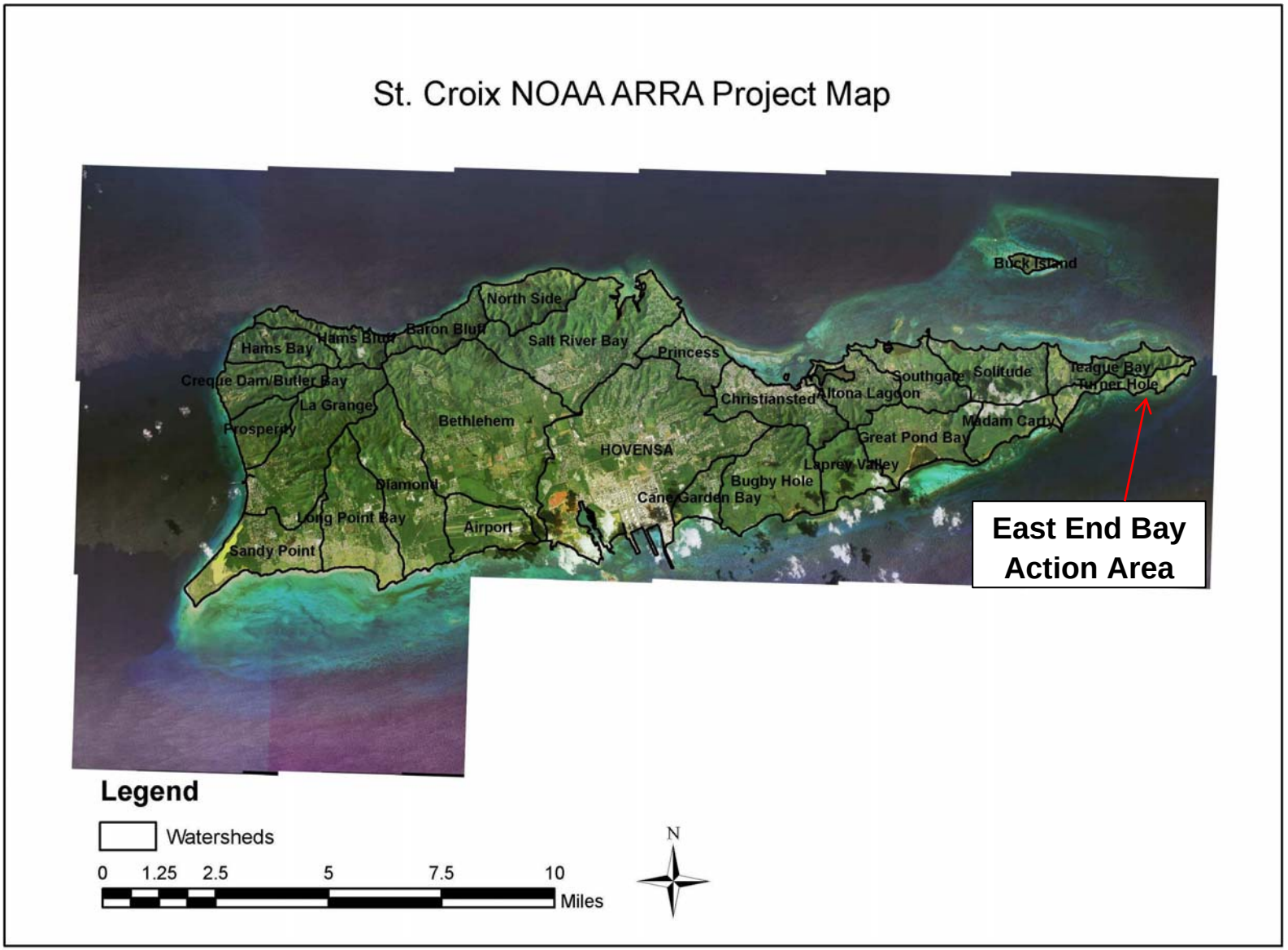

Figure 2: St. Croix NOAA ARRA Project Action Area – East End Bay.

1. Background and Project Planning

A three-decade decline in live coral reef cover in the Caribbean region has been associated with anthropogenic stresses occurring at a local level, including stresses related to excess delivery of land-based sediments (Gardner et al. 2003). In order to reduce stressors, the agencies and non-profit organizations discussed in the paragraphs below have spent the last decade planning and implementing actions to reduce sediment loads into Coral Bay, Fish Bay, and East End Bay.

In 2001, the Virgin Islands Department of Planning and Natural Resources (DPNR) developed a watershed-based management plan to improve the condition of Fish Bay. These activities led to the development of the Fish Bay Comprehensive Road Stabilization Plan (FBCRSP) under the guidance of the V.I. RC&D, DPNR, Island Resources Foundation, and the Estate Fish Bay Owners Association.

In 2002, in recognition of St. Croix East End's recreational and ecological value, DPNR Coastal Zone Management commissioned V.I. RC&D to develop a BMP implementation plan to mitigate erosion and sedimentation in the watershed. V.I. RC&D, using grant funds, hired the engineering firm Maguire Group, Inc. (Maguire) to inventory problem areas and develop erosion and sediment BMPs.

In 2003, Coral Bay residents formed the non-profit organization, CBCC, with the main environmental goal of reducing sediment-laden stormwater reaching the coral-fringed bay, by urging private and government actions. In 2007, NOAA funded the Coral Bay Watershed Management Plan (WMP) as a DPNR pilot watershed plan to provide a demonstration site for the whole USVI. Upon publication of the WMP in 2008, CBCC applied for a $300,000 U.S. Environmental Protection Agency Community for a Renewed Environment grant, and received it in early 2009 to begin implementation of the WMP as part of the overall Coral Bay Watershed Management Project.

In spring 2009, V.I. RC&D secured NOAA ARRA grant funds to implement actions proposed in the NOAA ARRA Coral Bay, Fish Bay, and East End Bay Workplans prepared for the grant application, based on work and expertise provided by the organizations discussed in the three paragraphs above. These NOAA ARRA funds allowed for the restoration of natural drainage functions and paving of roads in six subwatersheds in Coral Bay in order to eliminate or reduce the sediment-laden stormwater runoff plumes entering Coral Bay. They also allowed the Fish Bay partners to implement Phase 3 of the FBCRSP to reduce sediment loading in Fish Bay. (Phase 1 was implemented using Section 319(h) Non-Point Source funds and the homeowners provided funding for Phase 2.) Finally, the funds allowed for the creation of environmentally conscious recreation facilities in order to reduce the sediment-laden stormwater runoff entering East End Bay.

2. Project Summary

Land-based sources of pollution (LBSP) including terrestrial sediment have been identified at both Federal and local levels as high priority threats to coral reef ecosystem health. Due to the

significant and chronic impacts LBSP can have on coral reefs, NOAA's Coral Reef Conservation Program has identified LBSP as one of its three strategic program goals, acknowledging that land-based sources of pollution are a widespread stressor to USVI reefs that can be effectively managed locally through the application of watershed-based management actions including the installation of BMPs. LBSP were also highlighted as one of four targets in the USVI Local Action Strategies (latest revision - 2010) and the USVI Coral Reef Management Priorities (2005). Therefore, the overarching theme of the USVI Watershed Stabilization Project was to improve coastal ecosystems conditions in Coral Bay, Fish Bay, and East End Bay through a reduction in sediment loading to the bay.

Below is a brief summary of the issues and the work conducted under the NOAA ARRA grant in each action area. Detailed information can be found in the individual reports listed in the preface to this summary.

2.1 Implemented Actions

St. John: Coral Bay and Fish Bay

Studies have shown that steep slopes, highly erodible soils, and high runoff volumes, combined with a large percentage of dirt roads, active construction, and no existing stormwater management contribute to excessive sediment loading (CBCC and V.I. RC&D 2009). Research on St. John has also shown that unpaved roads can erode at rates that are up to 10,000 times higher than on undisturbed hillslopes (Ramos-Scharrón and MacDonald 2007). As such, for Coral Bay and Fish Bay the project partners focused on stormwater management improvements along roads and associated ghuts.

Actions proposed in the NOAA ARRA Fish Bay Workplan were based on the Fish Bay Comprehensive Road Stabilization Plan - Phase 3. These actions included paving roadways; installing concrete swales, riprap outlets, and headwalls; as well as, ditch and culvert cleaning. Of the 126 best management practices implemented during the course of this project, 21 actions were implemented in Fish Bay. In 2010 supplemental NOAA ARRA funding was competitively awarded to implement an additional 13 BMPs. These additional actions expanded the original scope of the work in Fish Bay and were utilized as demonstration projects to provide area residents and government officials with feedback on the implementation of conventional and alternative BMPs. that can be used to reduce the impact of erosion in Fish Bay by promoting use of the best BMPs for the area.

Actions proposed in the NOAA ARRA Coral Bay Workplan were located in six drainage basins (Johnny Horn Trail, Hansen Bay, Lower Bordeaux, John's Folly Bay, Calabash Boom, and Carolina Valley) identified by CBCC as having sediment issues requiring attention. The proposed actions were based on a list of watershed stabilization techniques appropriate for the Virgin Islands environment developed by CBCC's stormwater engineers. Project locations were selected based on CBCC announcing in March 2009 that it was applying for the NOAA ARRA grant and asking residents and homeowners associations to provide CBCC with information on erosion problems in their neighborhoods and an indication of their willingness to participate both as volunteers and financially in this project, if the grant was received. The actual project areas were selected for inclusion in the final grant proposal and workplan based on evaluation by the

CBCC stormwater engineer and each watershed's known contribution to bay sediment plumes that could be eliminated or reduced. Of the 126 best management practices implemented during the course of this project, 74 actions were implemented in Coral Bay. A portion of these actions were implemented as originally proposed in the NOAA ARRA Coral Bay Workplan. In addition, a portion of the actions were altered prior to implementation or not implemented at all for a variety of reasons, including identifying better solutions; insufficient funding for the design; and, unavailable or changed landowner permissions. All implemented actions are documented in Table 1 and the more detailed project reports.

St. Croix: East End Bay

East End Bay beach was accessible by four-wheel drive vehicles in the past, but by 2009 was only accessible on foot because of severe erosion. The most serious problems occurred along three trails that provided access from the public road to the beach: one down the center of the watershed, one down the west side, and one down the east side. All three trails typically have slopes of about 15%. Of these, the "East Trail" was used almost exclusively and was therefore the most severely eroded. The other two trails had fallen into disuse, which allowed for partial re-establishment of vegetation, and a reduction of erosion on these trails. However, more substantial slope stabilization, plant vegetation, and stormwater management activities were necessary. In addition, the most easily accessible beach is not a popular recreational area due to stoniness and heavy surf, but pedestrians frequently crossed this beach to access the more favored adjacent Isaac Bay beach. This pedestrian traffic flow frequently trampled sea turtle nesting sites in addition to contributing to trail erosion.

Therefore, a variety of best management practices were implemented throughout the East End Bay Watershed. Actions proposed in the NOAA ARRA East End Bay Workplan were based on the work by Maguire discussed in Section 1. Actions were implemented as stated in the NOAA ARRA East End Bay Workplan with minor changes made in the field (e.g. enlarging a parking area). Implemented actions included trail closure and stabilization, parking area stabilization, trail clearing, and installation of trail drainage structures, a viewing platform, and beach stairs. Of the 126 best management practices implemented during the course of this project, 18 actions were implemented in East End Bay. Implemented actions are documented in Table 1 and the more detailed project reports.

2.2 Selected Best Management Practices

As documented in Table 1 and discussed briefly in Section 2.1, a wide variety of BMPs were used to help reduce sediment loads. These BMPs focused on targeting the source of sediment (e.g. trail erosion) and trying to prevent or reduce its generation in the first place (e.g. getting water back into the proper drainage and off unpaved roads). If the project partners were unable to reduce sediment at the source, then BMPs were selected that would provide methods to remove sediment from stormwater (e.g. sediment detention basins) once sediment transport had begun. The majority of the implemented BMPs (75%) were implemented to provide sediment source control.

Table 1: Project Best Management Practices Summary

		Sediment Source Control						Sediment Cleanup						Various	
	# BMPs	**Cross-Road Swale**	**Waterbar**	**Culvert**	**Trench Drain**	**Roadside Drainage Swale**	**Paving Segment**	**Bioretention Pond**	**Sediment Detention Basin**	**Raingarden**	**Check Dams**	**Step Pools**	**Plunge Pool**	**Other**	**Retaining Wall**
Coral Bay															
Johnny Horn Trail	10	6		2			1			1					
Hansen Bay	3	1				1	1								
Lower Bordeaux	7	1			1	1								4	
John's Folly Bay	9	3				2	1				1		1	1	
Calabash Boom	27		9			3	4				3	7		1	
Carolina Valley	18	2	1	2		5	3	1	1					3	
Fish Bay															
Fish Bay	34	7		1		10	12							3	1
East End Bay															
East End Bay	18													17	1
Totals	126	20	10	5	1	22	22	1	1	1	4	7	1	29	2

2.3 Restoration and Other Project Benefits

The USVI Watershed Stabilization Project logged 1 acre of restored upland habitat. The majority of this habitat constitutes roadside or trail areas that were seeded after disturbance. Over 11 acres of upland habitat benefited from this project. These areas are typically ghuts that now receive more naturalized and less sediment-laden flows. It should be pointed out that the completion of the USVI Watershed Stabilization Project also reduced the threat of land-based pollution to bay habitats. Final project metrics will be posted in a final edition in June 2012.

3. Project Costs

Table 2 presents total direct construction costs for each action area and indirect costs including project management costs, permitting, engineering, and monitoring paid for using NOAA ARRA funds. These costs do not reflect extra funds contributed by local homeowners associations, volunteer labor provided by these associations for activities extending beyond project actions, any work provided by Virgin Island government agencies such as the Department of Public Works (PW), V.I. RC&D and CBCC's volunteer project management activities, and CBCC's EPA-grant-funded stormwater engineer.

Table 2: Total NOAA ARRA Funding

Action Area	Total Cost
Johnny Horn Trail, Coral Bay, St. John	$86,839
Hansen Bay, Coral Bay, St. John	$166,181
Lower Bordeaux, Coral Bay, St. John	$120,422
John's Folly, Coral Bay, St. John	$96,890
Calabash Boom, Coral Bay, St. John	$185,926
Carolina, Coral Bay, St. John	$374,213
Fish Bay, St. John	$481,396
East End Bay, St. Croix	$244,076
Total Construction Cost	$1,755,943
Indirect Project Costs (Project Management, Permitting, Engineering, & Monitoring)	$944,057
Total Costs	$2,700,000

Table 3 presents the range of costs for various types of construction activities such as paving, swale installation, etc. These costs were generated based on the final project totals where unit costs could be derived from project billing information. These costs are for comparison purposes only.

Table 3: Cost Ranges for Construction Activities		
Activity	**Unit**	**Cost Range[1]**
Cross-Road Concrete Swale	Each	$3,500-$14,000
Culvert installation – simple HDPE to Aluminum Pipe Arch	Each	$5,000-$35,000
Excavation	Linear Foot	$4-$65
Paving - various	Square Foot	$12-$20
Paving – roadway	Linear Foot (various widths)	$113-$216
Paving – curb, gutter, drainage channel	Linear Foot (various widths)	$12-$90
Retaining Wall – boulder wall and gabion basket	Linear Foot	$130-$297
Rock Weir	Each	$3,400-$14,500
Step Pool and Check Dam	Each	$360-$2,000
Trench Drain	Each	$45,000
Waterbar	Each	$2,000-$2,500
[1]The range of costs is often dependent upon square footage/linear footage of each activity and location (some areas required longer travel times; therefore, material costs were higher). Culvert costs were dependent upon the type of culvert installed and the need for inlets/outlets.		

4. Sediment Reduction Monitoring

Researchers conducted sediment and turbidity monitoring at terrestrial sites within all three watersheds. Marine sediment monitoring occurred in the Coral Bay Watershed. Details on these monitoring efforts and their relation to the eight work areas can be found in the individual reports listed in the preface to this summary.

4.1 Terrestrial

For terrestrial monitoring, Dr. Barry Devine led a monitoring team that tracked turbidity in the Coral Bay Watershed over a two-year period (September 2009 through November 2011) at over 30 sites (10 reliably). Although a longer post-construction monitoring period is necessary, his early results show that at two of his long-term sites there is a reduction in number of events and level of runoff turbidity meaning there has been a reduction in sediment entering the bay (Devine 2012). Additionally,

> "[k]nowledgeable staff who were gathering these multiple samples were witness to lower volumes of runoff, less roadway drainage, smaller, fewer or absent plumes in the bay, and [clear waters in the bay in a shorter timeframe]. The largest contributor at King['s] Hill was stopped almost completely by a retention pond and other sites were running clear where recent samples were not. Many neighbors, live-aboard residents, sailors, and volunteers all contributed anecdotes of cleaner bay water" (Devine 2012).

Dr. Carlos Ramos-Scharron and his team took "daily observations of [the King's Hill Road bioretention] pond water levels and sporadic measurements on the amount of sediment that have settled to the bottom of the pond" (Ramos-Scharron et al. 2012b). These measurements, in combination with the monitoring of rainfall rates, were used to evaluate the volumetric capacity of the pond and determine the effectiveness of the pond at reducing sediment loads. Dr. Ramos-Scharron concluded that:

> "The total mass of sediment retained by the pond during the monitoring period (15-Oct-10 to 19-Aug-11) was roughly 58 tons. Adjusted for rainfall this translates into a sediment delivery rate of 86.5 tons yr-1 and this is the estimated amount of sediment that otherwise would be reaching Coral Bay if the [King's Hill] Detention Pond would not have been constructed" (Ramos-Scharron et al. 2012b).

Dr. Ramos-Scharron also conducted terrestrial sediment monitoring of unpaved roads and trails in Coral Bay, Fish Bay, and East End Bay. His results for nine sites in Fish Bay and five sites in Coral Bay will be available in mid to late 2012. In East End Bay, Dr. Ramos-Scharron and his team evaluated the effects of trail restoration activities on the rate of sediment production by surface erosion along the East End trails from July 2009 until November 2011. From the monitoring data collected at 10 sites, he concluded trail erosion rates are higher than undisturbed conditions and that vegetation cover and slope are key factors controlling the erosion rate (Ramos-Scharron et al. 2012a). He also noted that "the long-term effect of the trail restoration work at East End Bay is likely to have reduced the amount of sediment delivered into the marine environment" (Ramos-Scharron et al. 2012a).

4.2 Marine

Dr. Sarah Gray, University of San Diego, and her team (partially NOAA ARRA funded) conducted marine sediment and water quality monitoring in Coral Bay from July 2007 to early March 2012. She selected 11 main sites throughout Coral Bay: three in Hurricane Hole to capture sediment coming off an undisturbed watershed; two offshore reef areas; and, the other six sites were along the developed Coral Bay shoreline. Her results showed:

> "Total and terrigenous sediment accumulation was generally higher below the steepest and most developed watersheds (such as Shipwreck [TC-3B] and Coral Harbor [TC-5, TC-8]) than below the [less] developed watersheds (such as [Little Plantation]) for equivalent environments. … Finally, total sedimentation accumulation rates below all ARRA mitigated watersheds (North Mangrove [TC-5], South Mangrove [TC-8], Shipwreck Shore [TC-3B]) were lower during the fall of 2011, which was the post-mitigation period compared to 2010. But these 2011 accumulation rates do not appear to be measurably lower than they were pre-mitigation during the fall rainy season of 2009" (Gray 2012).

There were two factors that will require further study in order to generate more information from this data: (1) a determination of how the 2010 rainfall season (historically high) affected sediment measurements and its effect on any comparative analysis; and, (2) further monitoring to construct a complete post-construction dataset (the last construction was completed in December 2011).

5. Lessons Learned

Each action conducted by the project partners provided unique successes and challenges. The challenges are documented here as lessons learned so that future efforts can take advantage of this valuable knowledge gained. There are four types of lessons listed below: Monitoring and

Metrics, Land Use Planning and Regulatory Enforcement, Project Planning & Funding, and BMP Design. **Key points are in Bold**. The text following the bold type provides supporting information and/or examples. For additional detail, please see the eight individual project reports in the series available at the CBCC website.

BMP DESIGN LESSONS

- **Cutting-edge stormwater BMP engineering design expertise is essential.**

- **Ghuts naturally infiltrate stormwater astoundingly well.** Removing water from roadside channels and returning it to the natural ghut system high in the watershed restores natural infiltration through ghut crevices into the hillside, virtually eliminating flows in the lower parts of the watershed in many heavy, short rains.

- **Waterbar or cross-road swale installations extend the useful life of unpaved road surfaces by reducing rutting and erosion on the road.** Moving water off road surfaces and into roadside drainage channels means the graded sections last longer, between regradings because water flows are not making eroding channels down road surfaces, for a longer period of time – perhaps two years, rather than one.

- **Concrete cross-road swales work well on steep roads (where waterbars won't work as well) to carry larger volumes of water across the road**. Individual waterbars carry small volumes of water.

- **Concrete cross-road swales are better than culverts,** because they cannot be readily blocked by small boulders eroding off the steep hillsides and are easily cleaned.

- **Swales need to be set on a diagonal, not with right angle turns for the water flow.** Depths of swales should be as deep as possible, and have some "down pitch" so that they are less inclined to fill with sediment. For instance, waterbars and swales need to be sufficiently angled to be self-cleaning. Also, grading and paving should have an exaggerated slope to encourage proper drainage, particularly during localized, short-lived heavy rains.

- **With small volumes of water, step pools and check dams catch sediment well**. The sediment must be removed at regular intervals by PW, HOAs, or neighboring residents. The sediment can be useful topsoil.

- **With larger volumes of water, sediment retention ponds and detention basins can act as very effective retrofits to help mitigate bad development practices taking place upstream and on the surrounding hills.** Ponds that retain water also provide naturalized habitat areas, promote the growth of fruit trees, and provide a source of water for livestock and wild creatures.

- **During retrofit road paving projects, prioritize paving switchbacks to stabilize and permanently direct water flow in the most desirable directions.** The water can be directed either off the road into neighboring ghuts, if available, or directed to curve down with the paving to a preferred flow area below. Understanding existing and natural waterflow patterns at a site is critical. Intentionally making a determination about future waterflows before any paving is essential.

- **Geoweb® cellular confinement system seems to be an effective stabilizer of unpaved roads.** CBCC is investigating the longevity and cost-effectiveness of this technique.

PROJECT PLANNING & FUNDING LESSONS

- **Outreach, education, and project transparency are essential for any successful effort.** NGO and government cooperation with community residents – including education, pre-planning, partnership building, implementation, and evaluation – ensures strategic coordination to complete the project, and sets the stage for follow-on efforts.

- **Community participation in selecting, designing, and implementing projects is essential for developing the ownership that leads to sustaining maintenance, and encourages actions for future projects.**

- **By having the grant funding commitment focused on reducing sediment plumes into the bay, rather than being focused on a particular BMP implementation at a particular site, more effective long-term solutions were found.** The project management strategies employed by CBCC's engineers in Coral Bay showed the value of extending the search for solutions to bay plume problems into locations higher up in the watershed, at the same time being aware of solutions (BMPs) that could be implemented downstream near the shoreline. In principle, one should be able to do both. However, with limited financial resources and limited time, having the flexibility to move the BMPs actually implemented to other places in the watershed allowed the contractors to provide higher quality solutions. Solving some waterflow issues relied on the flexibility of the project to change BMP strategies/solutions and locations midstream. This also had the benefit of managing greater stormwater volumes.

- **Permit and bid a longer BMP list, then refine, once prices are received.** The project partners realized early on that the best strategy was to bid out a long list. Then, once the bids were in, they could be reviewed and project managers could choose the elements that created the most cost-effective mix of BMPs and optimized the greatest reduction of sediment now, and then recommend "follow-on" actions for completion by residents willing to add funds and by PW to enhance the overall impact to the area.

- **Problems encountered (and presented) by one landowner can perhaps most effectively be solved by BMP work done on another property owner's land.** The second property owner may not be experiencing any "problem" from the waterflows and

thus often has no incentive to make any monetary investment. Also, we need to recognize the impact of the historic management strategy of "get the water off my land as quickly as possible." This strategy often leads to water being unnaturally channeled.

- **In addition to shoreline sediment mitigation efforts, there should be an emphasis on work done high in the watershed to assure natural drainage paths are used and respected.** If more detailed engineering evaluations are funded upstream, above the presenting "problem areas," the nature of the problems and solutions may change. In some cases, this can eliminate the need for BMPs near the bottom of the drainage area that are intended to correct problems that started uphill.

- **Funding often dictates both public and private stormwater management efforts.** For instance, PW faces a constant funding challenge to complete "visible" feet of new paving with limited funds, as opposed to investing in "hidden" stormwater management features. We need to be sure everyone in government decision-making (the Governor, Legislators, Commissioners, etc.) understand the importance of funding stormwater controls when road paving. Developers and HOAs face the same funding decision factors.

- **Homeowners Associations and residents will step forward with significant dollars if they can respond to an engineering plan that incorporates their perceived concerns and has their input.** The long informal process of encouraging homeowners associations to be formed, asking for input and participation, and letting them know more work can be done in their neighborhoods if they contribute "real dollars" has generally had a positive result in increasing the total amount of work that could be done. Asking upfront in a grant process for matching fund contributions is unlikely to yield secured funds. Residents are generally reluctant to commit actual dollars until (1) the construction will happen in the next two weeks; and, (2) they can see the plans, review them, and talk to the engineer and each other.

- **Any project doing stormwater management must be constantly vigilant about other parties making alterations that change stormwater flow patterns in the same area.** Awareness of construction activities in the watershed is a critical part of careful project oversight and management.

MONITORING & METRICS LESSONS

- **To quantitatively evaluate the success of this type of project, appropriate monitoring plans and timelines are necessary.** Monitoring included as part of the USVI Watershed Stabilization Project was conducted by researchers who had expertise in conducting sediment studies in the USVI. These scientists extended their existing studies into areas where the USVI Watershed Stabilization Project was being implemented. However, in several cases, due to weather data availability, permitting, construction timelines, and landowner permissions, the timing of these studies were not always able to directly monitor the actual impact of the project work in the reduction of

land-based sources of pollution. Stronger linkages between monitoring efforts and on-the-ground activities are recommended, as well as the collection of baseline data to ensure the impact of restoration projects can be fully quantified. Also, strong communication between researchers and project managers, project engineers, and other onsite personnel is critical to better monitoring efforts.

- **During evaluation and analysis of monitoring data, researchers determined that the lack of local pre-existing baseline data was an impediment, as was the limited post-construction monitoring conducted.** Pre-existing baseline data, such as localized rainfall amounts on a drainage basin scale, were not available. Therefore, conclusions derived from monitoring data were limited. Additionally, because of the short post-construction monitoring period and the lack of solid start and stop dates for the construction of each aspect of the project, limited conclusions could be made regarding when and if projects became effective. Understanding data needs and associated data limitations prior to the development of a monitoring plan is essential.

- **In retrospect, the informal use of photo-monitoring and citizen observations provided the most insightful post-construction assessments of individual BMP effectiveness. Project partners did use this tool, although without a formal plan.** Post-storm photo-documentation of Coral Bay turbidity conditions in ghuts, on roadways, and in the bay turned out to be the most illustrative way to demonstrate pre- and post-construction conditions on a “real-time” basis. It is recommended that future monitoring efforts, if intended to evaluate project success as a metric, take on a more coordinated and formalized approach. This could include a centralized data repository, enhanced equipment (webcams and automatic time-series cameras) and handheld photography, perhaps to be linked with rain data and saturation conditions.

- **Set realistic, measurable metrics during proposal development and ensure the funded proposal includes metrics that will capture the significant impact of the project in a meaningful way for both the funding agency and the award recipient.** Metrics should help measure and represent the progress, accomplishments, and impact of the project. Examples of potential metrics include, but are not limited to, restored acreage, the number of BMPs implemented, the number of watershed management plan actions completed, the number of linear feet paved, the tons of sediment prevented from entering the marine environment, or the number of education opportunities provided.

LAND USE PLANNING & REGULATORY ENFORCEMENT LESSONS

- **Land Subdivisions should not be authorized without deference to land contours and retaining natural drainage.** Many subdivision areas in the Coral Bay Watershed were subdivided seemingly without deference to land contours and drainage patterns, causing future unavoidable erosion problems. They were simply drawn on surveys to maximize the number of saleable lots decades ago, mostly in the 60s and 70s. The only government records available are plain subdivision surveys and deeds that contain only the simplest boilerplate and no reference to road or drainage maintenance or common

subdivision lot owner responsibilities. More recent subdivisions within the last decade also have shown little or no deference to land contours or drainage, although none were included in this project.

- **Land subdivisions and private road right of ways should not be authorized without perpetual deeded responsibility for construction and maintenance of roads and stormwater controls; including bonding of original construction and required homeowners associations.** Additional Virgin Islands legislation needs to be explored.

- **There is a need for diligent DPNR enforcement of all Clean Water Act standards,** including Territorial Pollutant Discharge Elimination System regulations, within building permitting processes. The activity of discharging water (pollutants) from construction sites is a federally regulated activity, delegated to DPNR. To be effective, there may also be a need for a special stormwater management authority or similar governing body that authorizes all construction projects with the potential to change stormwater flows, and has funding available to make priority retrofit corrections.

- **Effective stormwater management BMPs will most often cross property lines.** Governmental/NGO coordinationl/involvement is therefore appropriate.

6. Next Steps

As demonstrated by the visible project results in redirecting stormwater flows and reducing sediment reaching the bay, and the initial sediment monitoring results discussed in Section 4, progress has been made towards reducing sediment loads to Coral Bay, Fish Bay, and East End Bay. However, more still needs to be accomplished in these bays and throughout the USVI by the federal and territorial governments, local non-profits, and landowners to reduce sediment loads. The list below outlines some of the key next steps. For details, see the eight individual project reports in the series.

- Continue to promote project lessons learned throughout the Virgin Islands to strengthen future restoration efforts and continually develop and refine best management practices.

- Continue BMP implementation by pursuing additional grant funds and encouraging action by community members.

- Continue water quality monitoring to build a sufficient dataset for analysis of post-construction turbidity levels.

- Continue marine habitat data collection to build a sufficient dataset for analysis and monitoring.

- Update existing watershed management plans at least every 5 years, and draft new plans for watersheds without any management document.

- Perform ghut restoration in areas affected by altered drainage patterns due to residential development and road construction.

- Perform ghut revegetation efforts in areas where prior ghut maintenance has removed the vegetation. Ensure that ghuts remain in a vegetated state.

- During watershed management planning, identify areas suitable for installation of sediment retention ponds and detention basins as these devices provide very effective sediment reduction.

- During watershed management planning, identify areas where natural ghut flows need restoration.

- Resources need to be made available so that proper road widths, appropriate road layouts, and suitable stormwater management are an integral part of the planning/design process at all levels from the landowner to the V.I. Government.

- The V.I. Government needs to encourage education on and enforce ghut conservation regulations so that homes and roads are constructed with ghuts in mind.

- Stormwater devices need to be designed based on USVI conditions. For instance, culvert inlet grates often clog with vegetation and small rocks. Modified designs would prevent this and require less maintenance.

- A stormwater BMP maintenance schedule should be coordinated with local landowners, Public Works, and other responsible parties to ensure devices continue to function properly.

- Project partners need to continue to consider ways to capture more fine sediment along a ghut path before it reaches the ocean, including experimenting with the use of landscaping stream-restoration techniques. The V.I. Government needs practical solutions to resolve road ownership issues, so unclear ownership (and thus no signed landowner permission document) is not a barrier to performing BMP actions.

- Encourage enforcement of regulations related to the control of land-based sources of pollution.

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