NOAA ARRA USVI Watershed Stabilization Project

Fish Bay, St. John
Drainage Improvements

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

Text taken directly from the NOAA ARRA Fish Bay Workplan written by:
Virgin Islands Resource Conservation and Development Council

Edited by:
Patricia Reed
Environmental Projects Manager
Coral Bay Community Council

March 31, 2012

This report describes the Fish Bay project undertaken with National Oceanic and Atmospheric Administration (NOAA) funding through the American Recovery and Reinvestment Act of 2009 (ARRA). These funds are part of the $2.7 million USVI Watershed Stabilization Project funds awarded to the Virgin Islands Resource Conservation & Development Council, Inc. (V.I. RC&D). There are nine reports in this series, describing the complete NOAA ARRA USVI Watershed Stabilization Project:

- 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

Acknowledgements

Based on work by the Virgin Islands Resource Conservation & Development Council and its Board Members (listed below) who provided overall project management.

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

Also, this project would not have been possible without the Fish Bay Homeowners Association.

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 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 home owner 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 Greg Miller.

Executive Summary

The Fish Bay Watershed has experienced significant development within the last 30 – 40 years, and this has induced a growth of the road network within the watershed. Previous research on St. John has shown that unpaved roads can erode at rates that are up to 10,000 times higher than erosion rates on undisturbed hillslopes (Ramos-Scharrón and MacDonald 2007a), and that they are currently a dominant source of the terrestrial sediment entering Fish Bay (Anderson and MacDonald 1998; Ramos-Scharrón 2004). **Therefore, the overarching theme of this project is to improve coral reef ecosystem condition in Fish Bay through an immediate and long-term reduction in sediment loading to the bay.**

In order to accomplish this objective, the Virgin Islands Resource Conservation and Development Council (V.I. RC&D) proposed the following actions in the 2009 National Oceanic and Atmospheric Administration (NOAA) American Recovery and Reinvestment Act (ARRA) Fish Bay Workplan as part of the third phase of work in Fish Bay:

- Paving roadways and ditches;
- Installing swales and a culvert; and,
- Stabilizing cuts with gabion baskets.

In addition to the work accomplished under the initial project, NOAA ARRA funding provided supplemental resources to cover increased project costs, expand the number of sites targeted, and expand project monitoring and evaluation. These funds were provided because of the quality and timeliness of the work being accomplished in the Fish Bay area. The Estate Fish Bay Owners' Association also provided money to add to the NOAA ARRA funding. Supplemental work included:

- Paving roadways;
- Installing concrete swales, riprap outlets, and headwalls; and,
- Ditch and culvert cleaning.

NOAA spent over $481,000 in Fish Bay as part of the USVI Watershed Stabilization Project. Figure 1 shows the location of both Phase 3 and supplemental proposed actions including road and ditch paving, installation of best management practices (BMPs), and work completed with supplemental funding.

The net effect of these actions is reduced road erosion and sediment loading into Fish Bay.

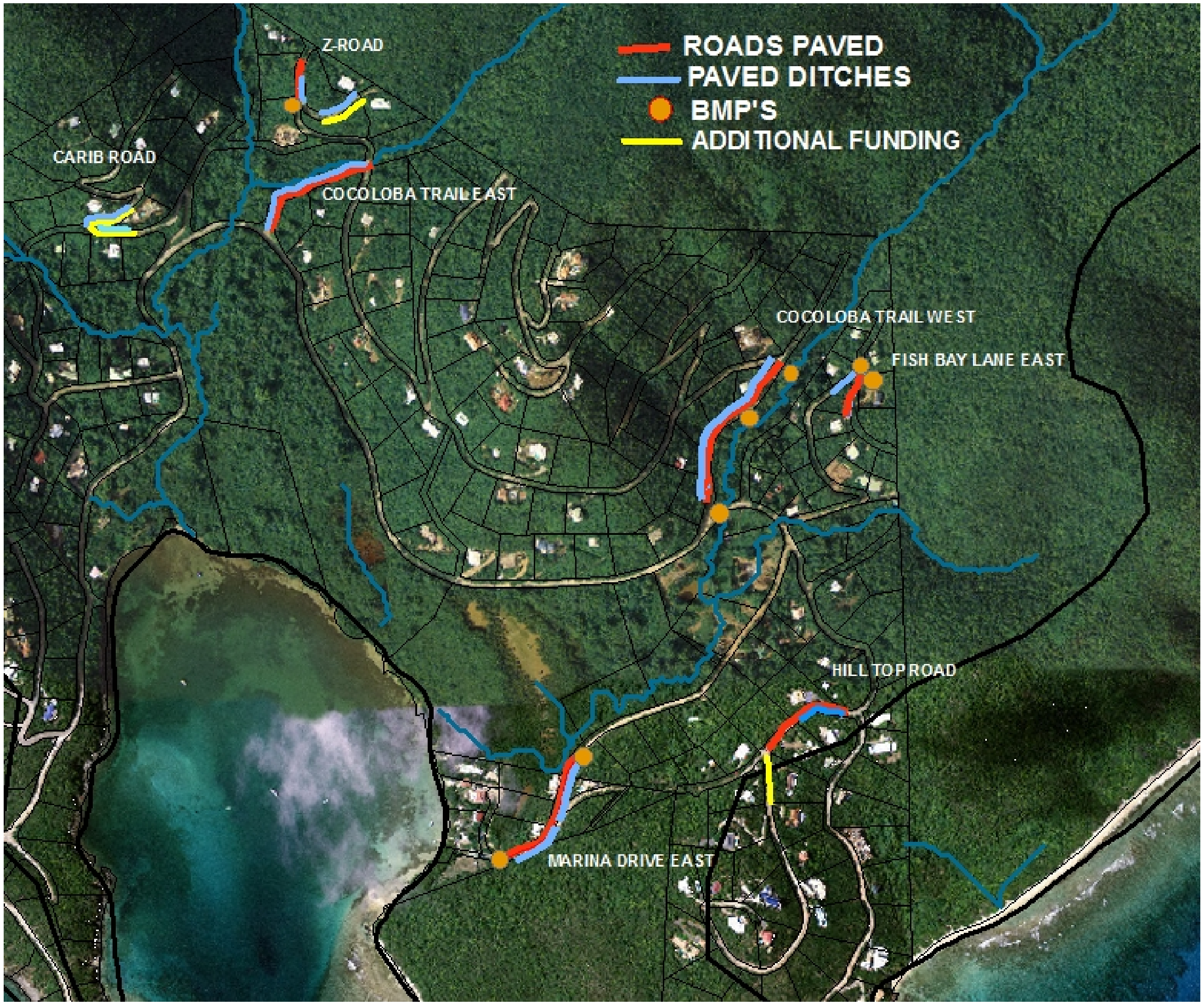


Figure 1: Fish Bay Drainage Improvements Phase 3 and Supplemental Work

1. Watershed Description

The Fish Bay Watershed encompasses a 6.0 square kilometer (km^2) (1,480 acres) area that drains towards a well-enclosed bay on the south shore of St. John (Photos 1 & 2). Slopes are generally very steep; just over half of the watershed has slopes exceeding 30% (16 degrees). The watershed is composed of two main drainages known as the Main Fish Bay Ghut and the Little Fish Bay Ghut. The Main Fish Bay Ghut and its Battery Ghut tributary drain more than half of the watershed as these ghuts extend towards the higher elevations (~280 meters) on the northernmost portions of the watershed. These ghuts are ephemeral with the exception being a spring-fed section on the upper Main Fish Bay Ghut. Runoff from the two main ghuts, and thus sediment delivery into Fish Bay, only lasts for periods extending from hours to several weeks because of moderate to high intensity rainfall events following wet periods (Ramos-Scharrón, 2004).

Photo 1: Fish Bay Watershed looking southeast.

Photo 2: Fish Bay Watershed looking southwest.

Based on a generalized map, 4.0 km^2, or 67% of the watershed, is managed by the Virgin Islands National Park (VINP), and with the exception of a few privately owned in-holdings, there is very little development on the areas within VINP. All other areas have experienced significant development within the last 30 – 40 years, and this has induced a growth of the road network within the watershed. Between 1971 and 2000, the road network (including public access roads and private driveways) in the Fish Bay Watershed nearly tripled in length from 8.3 km to 22 km, and this translates into a growth rate of about 0.5 km of new roads every year. Currently there are 27.8 km of roads within the Fish Bay Watershed, and 47% or 12.9 km of these roads are unpaved. The growth rate of the road network over the last six years translates to a doubling of the long-term trend to approximately 1.0 km of new roads every year, and it shows no sign of slowing down.

About 37% of all unpaved roads in the Fish Bay Watershed are actively used by traffic and they are graded at least once every two years (‘graded’), while an equal amount is actively used but not frequently graded (‘ungraded’). About 27% of all unpaved roads are only rarely used by traffic and experience no maintenance activity (‘abandoned’). Sediment production data collected from different areas of St. John between 1998 and 2000 demonstrated that graded roads had the highest erosion rates, and that ungraded and abandoned roads had erosion rates that were on average only 40% and 6% relative to graded roads, respectively (Ramos-Scharrón and MacDonald 2005).

2. Problem Statement

The fast pace of land development that has occurred throughout the U.S. Virgin Islands in the past several decades has resulted in increased sediment yield rates into coastal waters (Photo 3) and this has had detrimental effects on the quality of its marine resources (Jeffrey et al. 2005). Fish Bay exemplifies the type of impact that high rates of unchecked land-based erosion may have on marine habitats. The poor quality of the marine environment in Fish Bay (>51% of macroalgae cover, <15% of coral cover, high sedimentation rates, high water turbidity, and sediment-laden salt ponds) is in sharp contrast to other nearby bays along the southern shore of St. John (Beets et al. 1986; Hubbard et al. 1987; Nemeth et al. 2001). Experts agree that increased erosion associated with the unpaved road network and land development occurring in the Fish Bay Watershed is responsible for its deteriorated condition.

Photo 3: Sediment plume in Fish Bay.

Two main factors currently control the poor water quality conditions in Fish Bay. First, the Fish Bay Watershed has experienced a fast pace of development over the last three decades contributing to the sediment output originating from the Main Fish Bay Ghut that has created a depositional delta extending seaward towards the deeper sections of Fish Bay. This sediment is commonly re-incorporated into the water column during high wave energy periods and is responsible for the poor water quality of Fish Bay during dry conditions.

Secondly, the Fish Bay Watershed contains different types of active sediment sources that influence the marine environment. Among the types of land use practices that are considered to be important sediment sources in the Fish Bay Watershed are land clearing and vegetation removal associated with home construction, a rock crushing and construction material storage site on the upper portions of the Fish Bay Watershed, and activities associated with road construction and maintenance (Photo 4).

Photo 4: Sediment sources in Fish Bay including land clearing, construction materials storage, and unpaved roads.

Photo 5: Unpaved road in Estate Fish Bay.

Previous research on St. John has shown that unpaved roads (Photo 5) can erode at rates that are up to 10,000 times higher than erosion rates on undisturbed hillslopes (Ramos-Scharrón and MacDonald 2007a), and that they are currently a dominant source of the terrestrial sediment entering Fish Bay (Anderson and MacDonald 1998; Ramos-Scharrón 2004). The application of a GIS-based erosion model (Ramos-Scharrón and MacDonald 2007b) estimated that the average sediment load into Fish Bay, based on the condition of the unpaved road network in 1999, was about 275 tons per year, and this was seven times higher than rates observed from natural, undeveloped sites. Unpaved roads accounted for 85% of the total estimated sediment yield (234 tons per year).

3. Background and Project Planning

A three-decade long 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 this stressor, the partner agencies: NOAA, the Virgin Islands Department of Planning and Natural Resources (DPNR), V.I. RC&D, Island Resources Foundation (IRF), and the Estate Fish Bay Owners' Association (EFBOA) have spent the last decade planning and implementing actions to reduce sediment loads into Fish Bay.

In spring 2009, V.I. RC&D secured NOAA ARRA grant funds to implement actions proposed in the NOAA ARRA Fish Bay Workplan prepared for the grant application, based on expertise provided by IRF and Colorado State University (see Section 4.1). These NOAA ARRA funds allowed the partners to continue implementing BMPs to reduce sediment loading in Fish Bay.

4. Project Implementation

4.1 Project Design

In 2001, 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, IRF, and EFBOA (Hodge et al. 2001; Lamphear 2003). The road stabilization plan was developed based on more than 10 years of research done on the Fish Bay Watershed by IRF and Colorado State University. The FBCRSP was structured in phases and it addressed erosion problems exclusively at the lower portions of the Fish Bay Watershed in what is known as Estate Fish Bay.

Phase 1 identified specific sites that needed immediate action to reduce erosion and sedimentation going into Fish Bay. Phase 2 addressed stabilization of the main road servicing the Estate Fish Bay area (i.e., Marina Drive). Phase 1 was implemented using funds from 319(h) Non-point source of pollution grants distributed locally by DPNR as well as homeowner association funds, and Phase 2 has been mostly completed at the homeowners' expense (~$500,000).

In 2001, the estimated sediment yield into Fish Bay was 276 tons per year and this is about 6.5 times higher than the expected sediment delivery rate under natural conditions (Ramos-Scharrón and MacDonald 2007a). Actions related to the road rehabilitation plan resulted in paving 1.6 km of roads and they appear to have decreased the estimated annual yields by approximately 45 tons per year (Ramos-Scharrón et al. 2007). However, new unpaved roads and driveways constructed between 2001 and 2006 have largely negated the benefits of previous actions and current sediment yield rates have again increased to an estimated 280 tons per year (Ramos-Scharrón et al. 2007). In fact, the rate of new road development between 2001 and 2007 (1.0 km of new roads per year) seems to have increased relative to the 0.5 km per year estimated between 1971 and 2001. A series of projects funded by grants from the Gulf of Mexico Foundation, the National Fish and Wildlife Foundation, and the U.S. Fish and Wildlife Service between 2006 and 2007 provided limited funds to do additional road improvements within the Fish Bay Watershed and these resulted in a reduction of approximately 20 tons of sediment per year compared to pre-construction (Ramos-Scharrón et al. 2009).

Phase 3 of the Fish Bay Comprehensive Road Rehabilitation Plan addressed the final stabilization required, but yet to be completed, to improve the roadways in an environmentally sound manner to reduce erosion and sedimentation in the Fish Bay Watershed area. This phase became the NOAA ARRA Fish Bay Workplan, which included road and roadside drainage channel paving, swale and culvert installation, and slope stabilization. In 2010, V.I. RC&D sought funding for supplemental work in Fish Bay to cover increased costs of implementing the NOAA ARRA Fish Bay Workplan, work at additional sites, and expanded monitoring efforts.

4.2 BMP Selection Process

The NOAA ARRA road rehabilitation workplan for the Fish Bay Watershed addressed erosion issues along 0.9 km of roads that were estimated to contribute a total of 30 tons of sediment into Fish Bay every year. The general plan (as documented in Table 1) included providing surface protection to the unpaved road in the form of pavement at the lowermost portions of the Fish Bay Watershed. The plan also included improving road drainage conditions (i.e., stormflow management) in the form of paved inside ditches, cemented swales, and a culvert. In addition, unstable cut-slopes were to be secured with gabion baskets. Activities were concentrated at seven different sites throughout the watershed. The original plans were carried from proposal to implementation without changes. Table 1 summarizes these plans including proposal and construction dates, and additional necessary comments. All engineering design documents have been included in Appendix A.

A 2010 supplemental proposal included the BMPs summarized in Table 2. These actions were used as demonstrations to provide area residents and government officials with information on conventional and alternative BMPs that can be used to reduce the impact of erosion in the bay.

Table 1: Workplan Proposed and Implemented Actions (Designed 2009)			
Location	**Proposed/Implemented Actions (see Comments)**	**Status**	**Comments**
Z-Road (Site #1-Parcel 318)	Roadway and ditch paving and installation of two concrete swales.	Revised and constructed (Early 2010)	Site #1 was not paved due to home construction at the abutting property. An alternate section of Z road was paved and one concrete swale was constructed. Another homeowner funded an additional 100 feet of pavement.
Cocoloba Trail West (Site #2-Parcel 312)	Roadway and ditching paving.	Constructed (Early 2010)	The project was constructed as planned and the EFBOA funded an additional lane of pavement on the first section of Cocoloba Trail.
Marine Drive End-West (Site #3-Parcel 301)	Roadway and ditch paving and installation of a concrete swale.	Constructed (Early 2010)	Roadway and ditches were paved as planned. Abutting homeowners provided funding to install a trench drain in place of the proposed concrete swale which significantly reduced outlet velocities.
Marina Drive End-East (Site #6-Parcel 301)	Roadway and ditch paving and installation of a concrete swale.	Constructed (Early 2010)	Constructed as planned.
Fish Bay Lane East (Site #7-Parcel 307 & 308)	Roadway and ditch paving, installation of a concrete swale and culvert, and gabion basket cut stabilization.	Constructed (Early 2010)	Constructed as planned.
Hilltop Road (Site #8-Parcel 302)	Roadway and ditch paving.	Constructed (Early 2010)	Constructed as planned.
Cocoloba Trail East (Site #9-Parcel 309)	Roadway and ditch paving and installation of two concrete swales.	Constructed (Early 2010)	Constructed as planned.

Table 2: Supplemental Workplan Proposed and Implemented Actions (Designed 2010)			
Location	**Proposed/Implemented Actions**	**Status**	**Comments**
Z Road, lower section	Paving 85 feet of one lane roadway.	Constructed (Mid 2010)	
Z Road upper section	Paving 200 feet with concrete swale.	Constructed (Mid 2010)	
Caribe Lane	Paving 130 feet with concrete swale.	Constructed (Mid 2010)	
Coccoloba Trail East, south end	Paving 50 feet of roadway.	Constructed (Mid 2010)	This action was taken to make the entrance to Coccoloba Trail East 2 lanes.
Coccoloba Trail East, north end	Constructing concrete swale and stone rip rap outlet.	Constructed (Mid 2010)	
Marina Drive	Cleaning ditches and culverts and constructing head walls.	Constructed (Mid 2010)	
Hilltop Road	Paving 300 feet of roadway and constructing 200 feet of concrete swale.	Constructed (Mid 2010)	

4.3 Problems Encountered/Overcome

The project went smoothly with the contractor completing exceptionally good work. Because of this, many abutting property owners hired the contractor to pave their driveways, which was beneficial to the goals of the project.

Photo 6: Z Road before construction.

4.4 Project Costs & Construction

After taking into consideration site conditions, BMP costs, and available project funds, the final BMPs implemented included paving road segments and ditches, installing swales and culverts, and constructing gabion basket cut stabilization for a total cost of $481,396. The sections below provide a more detailed description of construction quantities and activities. Appendix A has detailed design drawings.

Photo 7: Marina Drive before construction.

Construction Quantities

The following bullets summarize the amount of construction at each site including supplemental work. Figure 1 shows the location of each road.

- **Z-Road (Photo 6):** Work at this site included paving 777 feet of road surface, and improving road drainage with a 492-foot long paved ditch and a concrete swale.
- **Caribe Lane:** Work at this site included paving 130 feet of road surface.
- **Cocoloba Trail West:** Work at this site included paving 541 feet of road surface, and improving road drainage with a 541-foot long paved ditch and incorporating it with two already installed cemented swales and a broad-based swale at the bottom of the segment.
- **Marina Drive End-West:** Work at this site included paving of road surface, and improving road drainage with a 302-foot long paved ditch and a trench drain.

Photo 8: Road cut-slope needing stabilization.

- **Marina Drive End–East (Photo 7):** Work at this site included paving 328 feet of road surface, and improving road drainage with a 328-foot long paved ditch and a new cemented swale.

- **Fish Bay Lane East:** Work at this site included paving 197 feet of road surface, and improving road drainage with a 197-foot long paved ditch and a new swale and culvert. A 98-foot long portion of the road cut-slope (Photo 8) was also secured with gabion baskets.
- **Hilltop Road:** Work at this site included paving 628 feet of road surface, and improving road drainage with 528 feet of paved ditch.
- **Cocoloba Trail East:** Work at this site included paving 850 feet of road surface, and improving road drainage with an 800-foot long paved ditch and three swales plus a riprap swale outlet.

Construction Activities

<u>Paving</u>

Hard surfacing of the roadbed consisted of grading (Photos 9 & 10) then 5-inch concrete pavement reinforced with woven wire fabric, known locally as “roadmesh” (Photos 11-14). Twelve-inch stone was used to protect swale outfalls from eroding and to dissipate the energy of the falling water. Larger stones were used if available and equipment operators could position them properly.

Photo 9: Z-Road during grading.

Photo 10: Z-Road during grading.

Photo 11: Z-Road during forming and paving.

Photo 12: Marina Drive during paving.

Photo 13: Marina Drive ditch paving.

Photo 14: Marina Drive during paving.

Gabion Basket Cut Stabilization

Gabion basket cut-slope stabilization utilized two rows of 3’x3’x6’ and/or 3’x3’x9’ baskets to prevent slope failure. This part of the project required the first row of baskets to be keyed into the trench and slope (Photos 15-17). The second row of baskets was placed on top of the first row, so that the contractor could gradually fill in with earth behind them (Photo 18).

Photo 15: Cut-slope stabilization gabion basket installation.

Photo 16: Cut-slope stabilization gabion basket stone installation.

Photo 17: Cut-slope stabilization gabion basket installation.

Photo 18: Completed cut-slope stabilization gabion basket installation.

4.5 Achieved Results

For a total project cost of $481,396 (including supplemental funds), roadway and ditch paving, installation of swales and a culvert, and stabilizing an area with gabion baskets allowed V.I. RC&D to reduce road erosion; thus reducing sediment discharged into Fish Bay. Photograph 18 above and Photos 19-22 below depict the completed project that will decrease the potential for erosion and reduce sediment loading.

Photo 19: Completed Z-Road paving.

Photo 20: Completed Z-Road paving and concrete ditch and swale.

Photo 21: Completed Marina Drive paving.

Photo 22: Completed Marina Drive paving and trench drain.

5. Sediment Reduction Monitoring

Dr. Carlos Ramos-Scharron and his team evaluated the effects of road paving and other drainage improvement activities on the rate of sediment flowing into Fish Bay. Results from these activities will be available in mid- to late 2012.

6. Lessons Learned

Having approved plans in place allowed this project to be completed very quickly relative to the rest of the grant projects.

Federal funds through this grant stimulated private contributions allowing additional construction.

7. Next Steps

The project partners have identified the following next steps for the Fish Bay Watershed:

- Secure funding to pave the remaining unpaved roads; and,
- Encourage enforcement of regulations on industrial uses of properties located on the upper end of the watershed.

Also, even though the erosion control work conducted in Fish Bay under the NOAA ARRA USVI Watershed Stabilization Project focused on the unpaved road network, project partners recognize the potential importance of other land use activities (home construction land clearing and vegetation removal and rock crushing and onsite construction material storage) in delivering sediment into Fish Bay. While individual home-site development might not appear to contribute large quantities of sediment, its importance for watershed-scale sediment yields should not be ignored given that this type of activity has been and is constantly occurring within the Fish Bay Watershed. Therefore, all homeowners should be encouraged to pave or plant all exposed soil on their property.

8. References

Anderson DM and MacDonald LH. 1998. *Modeling road surface sediment production using a vector geographic information system.* Earth Surface Processes and Landforms 23: 95–107.

Beets J, Lewand L, Zullo ES. 1986. *Marine community descriptions and maps of bays within the Virgin Islands National Park/Biosphere reserve*. Biosphere Reserve Research Report No. 2, VIRMC/NPS, 118 p.

Gardner TA, Cote IM, Gill JA, Grant A, Watkinson, AR, 2003. *Longterm region-wide declines in Caribbean corals.* Science 301: 958–960.

Hodge, Janice D., Bill Rohring, Dayle Barry, Earl Haase, Rudy G. O'Reilly, Jr., Henry Smith, Edward Towle, and Julie Wright. 2001*. Fish Bay Watershed Management Plan, St. John, U.S. Virgin Islands,V.I.* Department of Planning & Natural Resources Coastal Zone Management Program, pp 88.

Hubbard DK, Stump JD, Carter B. 1987. *Sedimentation and reef development in Hawksnest, Fish and Reef Bays, St. John, U.S. Virgin Islands.* Virgin Islands Resources Management Cooperative, Biosphere Reserve Research Report no. 21. St. Thomas, USVI, 99 p.

Jeffrey CFG, Anlauf U, Beets J, Caseau S, Coles W, Friedlander AM, Herzlieb S, Hillis-Star Z, Kendall M, Mayor V, Miller J, Nemeth R, Rogers C, Toller W. 2005. *The state of coral reef ecosystems of the U.S. Virgin Islands*. In: Waddell JE (ed.), The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States. NOAA Technical Memorandum NOS NCCOS 11. NOAA/NCCOS Center for Coastal Monitoring and Assessment's Biogeography Team, Silver Springs, MD, pp. 45-83.

Lamphear, Steve. 2003. *Fish Bay Comprehensive Road Stabilization Plan.* Produced for V.I. Department of Planning & Natural Resources Coastal Zone Management Program.

Nemeth RS, LH MacDonald, CE Ramos-Scharrón. 2001. *Delivery, deposition, and effects of land-based sediments on corals in St. John, U.S. Virgin Islands.* Report to the Water Resources Research Institute, Univ. of the Virgin Islands, Project No. VI99-02, 24 p.

Ramos-Scharrón, C.E., 2004. *Measuring and predicting erosion and sediment yields on St. John, U.S Virgin Islands.* Ph.D. Dissertation, Department of Geosciences, Colorado State University, Fort Collins, CO.

Ramos-Scharrón CE, MacDonald LH, 2007a. *Measurement and prediction of erosion rates from natural and anthropogenic sources of sediment in St. John, U.S. Virgin Islands.* Catena Special Issue-Soil water erosion on rural areas. 71: 250-266.

Ramos-Scharrón CE, MacDonald LH. 2007b. *Development and application of a GIS-based sediment budget model.* Journal of Environmental Management. 84: 157-172.

Ramos-Scharrón, Carlos E. and Lee H. MacDonald, 2005. *Measurement and prediction of sediment production from unpaved roads, St John, US Virgin Islands.* Earth Surface Processes and Landforms 30, pp.1283–1304.

Ramos-Scharrón CE, Lindsay K, Bacle JP. 2007. *Fish Bay Watershed assessment-Recommendations for an erosion control program.* Submitted to the Gulf of Mexico Foundation and the National Fish & Wildlife Foundation.

Ramos-Scharrón CE, Lindsay K, Bacle JP. 2009. *Erosion control strategy for the Fish Bay Watershed*. Final Project Report, US Fish and Wildlife. 32 p.

Appendix A: Engineering Designs & Drawings

5.2 Design details

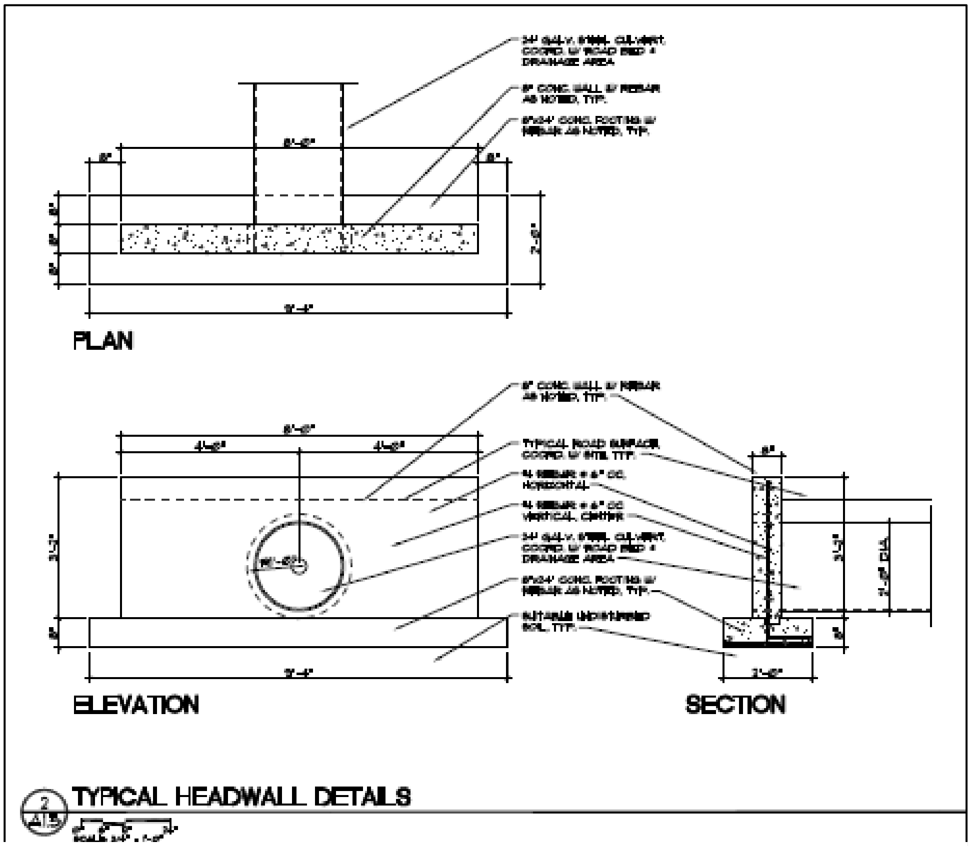


Figure 21. Typical culvert headwall design for road rehabilitation work in the Fish Bay Watershed.

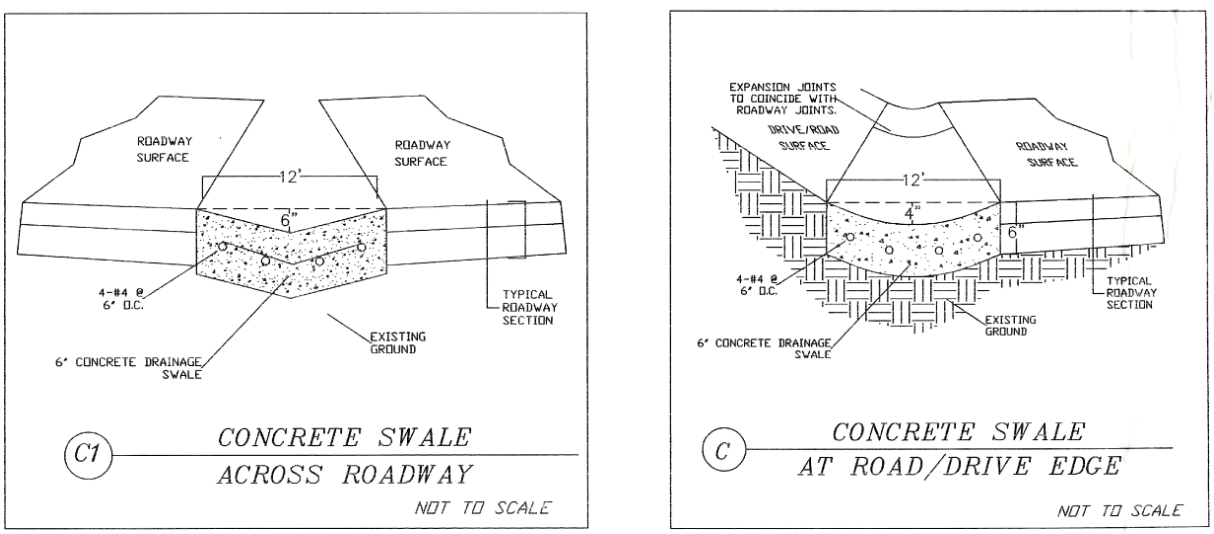


Figure 22. Typical cemented swale design for road rehabilitation work in the Fish Bay Watershed.

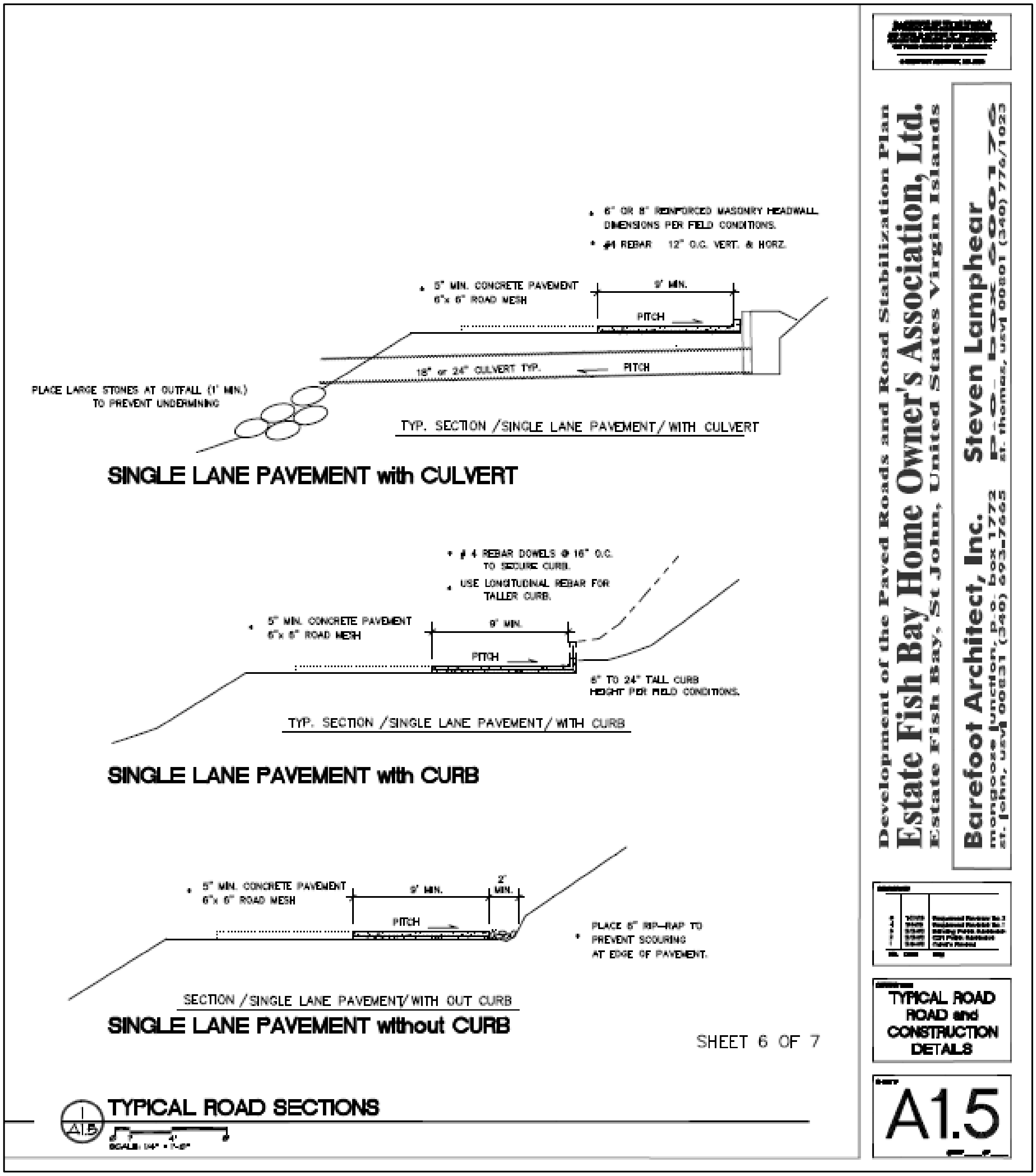
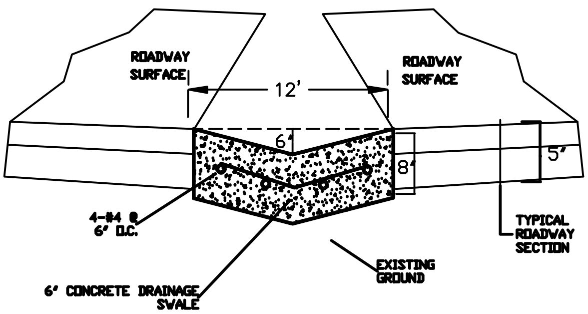


Figure 23. Typical road cross-section design for road rehabilitation work in the Fish Bay Watershed.



CONCRETE SWALE

ACROSS ROADWAY

NOT TO SCALE

NOTES

1. IT IS THE INTENT OF THIS PROJECT TO GRADE THE EXISTING ROADWAY, INSTALL PAVEMENT AND SWALES CONDUITS DOING THE MINIMUM POSSIBLE DISTURBANCE TO THE EXISTING SLOPES AND PLANT GROWTH.

2. IN AREAS SUSCEPTIBLE TO EROSION WHICH ARE TO BE DISTURBED SILT FENCING SHALL BE INSTALLED PRIOR TO ANY EARTH WORK OPERATIONS AND MAINTAINED THROUGHOUT THE DURATION OF THE PROJECT.

3. ALL EDGES OF PAVEMENT WILL BE BACKFILLED WITH AVAILABLE SOIL

4. ALL FILL AREAS ARE TO BE COMPACTED TO 95% COMPACTION IN 12" LIFTS.

5. CULVERTS SHALL BE CONSTRUCTED PER MANUFACTURERS RECOMMENDATIONS. EXTREME CARE SHALL BE TAKEN TO ASSURE THAT BACKFILLING IS COMPACTED TO 95% COMPACTION IN MAXIMUM 8" LIFTS.

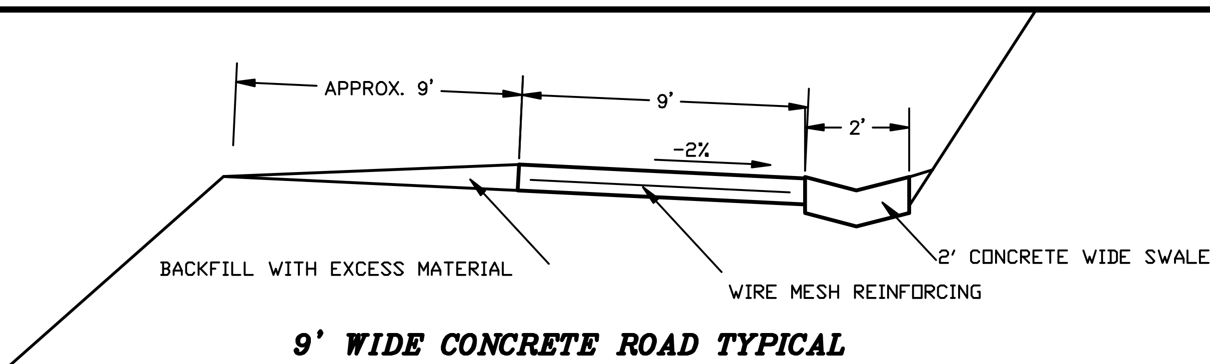
6. CONCRETE ROAD PAVING IS TO HAVE A LONGITUDINAL JOINT AT THE EDGE OF ROAD/DITCH

7. CONCRETE ROAD PAVING IS TO HAVE A TRANSVERSE JOINT EVERY TEN FEET ALONG THE ROADWAY.

8. CONCRETE ROADWAY STEEPER THAN 10% SHALL HAVE A TEXTURED SURFACE

9. ALL CONCRETE CROSS SWALES SHALL BE GRADED AT THE INLET AND OUT LET ENDS TO PROVIDE FREE FLOW OF WATER IN AND OUT

10. ALL CONSTRUCTION SHALL COMPLY WITH V.I. GOVERNMENT STANDARDS AND FP 2004.



9' WIDE CONCRETE ROAD TYPICAL WITH 2' DRAINAGE SWALE

ESTATE FISH BAY HOMEOWNERS ASSOC.
ERONSION CONTROL PROJECT

SCALE: NA	EFBHA
DATE: 11-1-2009	ROAD DETAILS
FILE: X.X.	
JOB NO.: X.X.	