

# NOAA ARRA USVI Watershed Stabilization Project



## Coral Bay Watershed Management Project – Johnny Horn Trail Drainage Improvements



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

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This report described the projects undertaken in one of six subwatersheds in Coral Bay, St. John, USVI with \$1.5 million in 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). The U.S. Environmental Protection Agency (EPA) provided \$300,000 in funding to the Coral Bay Community Council (CBCC) under its Community Action for a Renewed Environment (CARE) program to provide the stormwater engineering expertise to provide the design portion of these projects and staff the CBCC Coral Bay Watershed Management Project. Local homeowners associations, the Virgin Islands government, and community volunteers have also provided more than \$400,000 in resources and worked cooperatively to achieve the project objective of reducing the stormwater sediment plumes entering Coral Bay, thereby improving water quality, ecological health, and stormwater management while minimizing future negative impacts associated with roadways and new construction.

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 Joseph Mina, P.E., Christopher Laude, P.E, Barry Devine, Ph.D., Sarah Gray, Ph.D., Blake Parker, and Sharon Coldren.

Photos provided by the Coral Bay Community Council.

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 fulltime to implement this project.

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.

## Executive Summary

The Johnny Horn Trail is a steep dirt road starting at the Emmaus Moravian Church and running uphill into a developing residential area alongside the Johnny Horn Ghut. Recent road maintenance has disrupted the natural drainage, funneling large amounts of stormwater and sediment down the road and directly into Coral Bay Harbor increasing water turbidity (Photo 1). **The goal of this project is to route water off the road and restore natural flows in the Johnny Horn Ghut; thereby, reducing sediment reaching Coral Bay by slowing velocities, promoting infiltration, and decreasing slopeside erosion.**

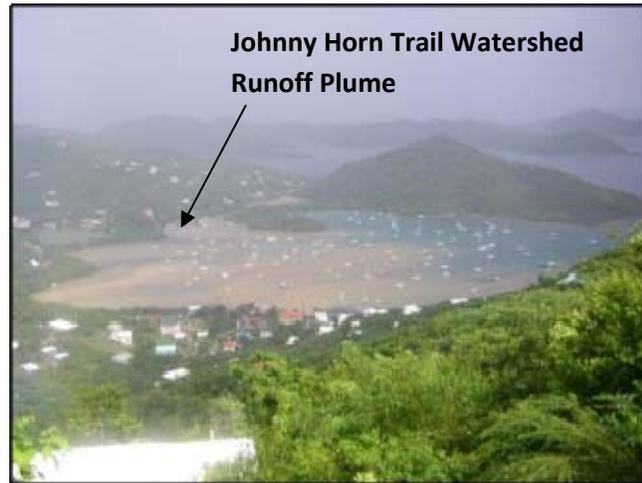


Photo 1: Plume into Coral Bay prior to drainage improvements.

In order to accomplish this goal, Joseph Mina, P.E., Coral Bay Community Council's (CBCC) first Stormwater Engineer, initially proposed berms, biofiltration/infiltration areas, a raingarden, trench and under drains, swales and step pools, and concrete roadside channels as described in the 2009 National Oceanic and Atmospheric Administration (NOAA) American Recovery and Reinvestment Act (ARRA) Coral Bay Workplan. Further investigation into the conditions of the ghut and the ability to fund the project as designed called for revised stormwater best management practices (BMPs). Ultimately, the second Stormwater Engineer, Christopher Laude, P.E. hired by CBCC after Mr. Mina left the island, designed a series of six concrete swale road crossings and two resized culverts. These can be seen in Figure 1, which details pre-existing and new stormwater structures, and other watershed features. Once installed, these swales helped to direct runoff into the ghut paralleling the road in the upper and middle portions of the watershed. The project also included the installation of a raingarden behind the fire station and adjacent to the elementary school in the lower watershed. The net effects are:

- 1) Reduced erosion of the unpaved road, since it has ceased to be a water path;
- 2) Elimination of waterflows across the church cemetery or along Route 10 and into the schoolyard;
- 3) Reduced ghut flow (observations during monitoring efforts of no runoff observed 10 out of 12 times) at the ghut outlet after construction due to infiltration along the ghut path; and,
- 4) Reduced sediment-laden water reaching Coral Bay, particularly during Tropical Storm Irene, based on observations of long-time Coral Bay residents.

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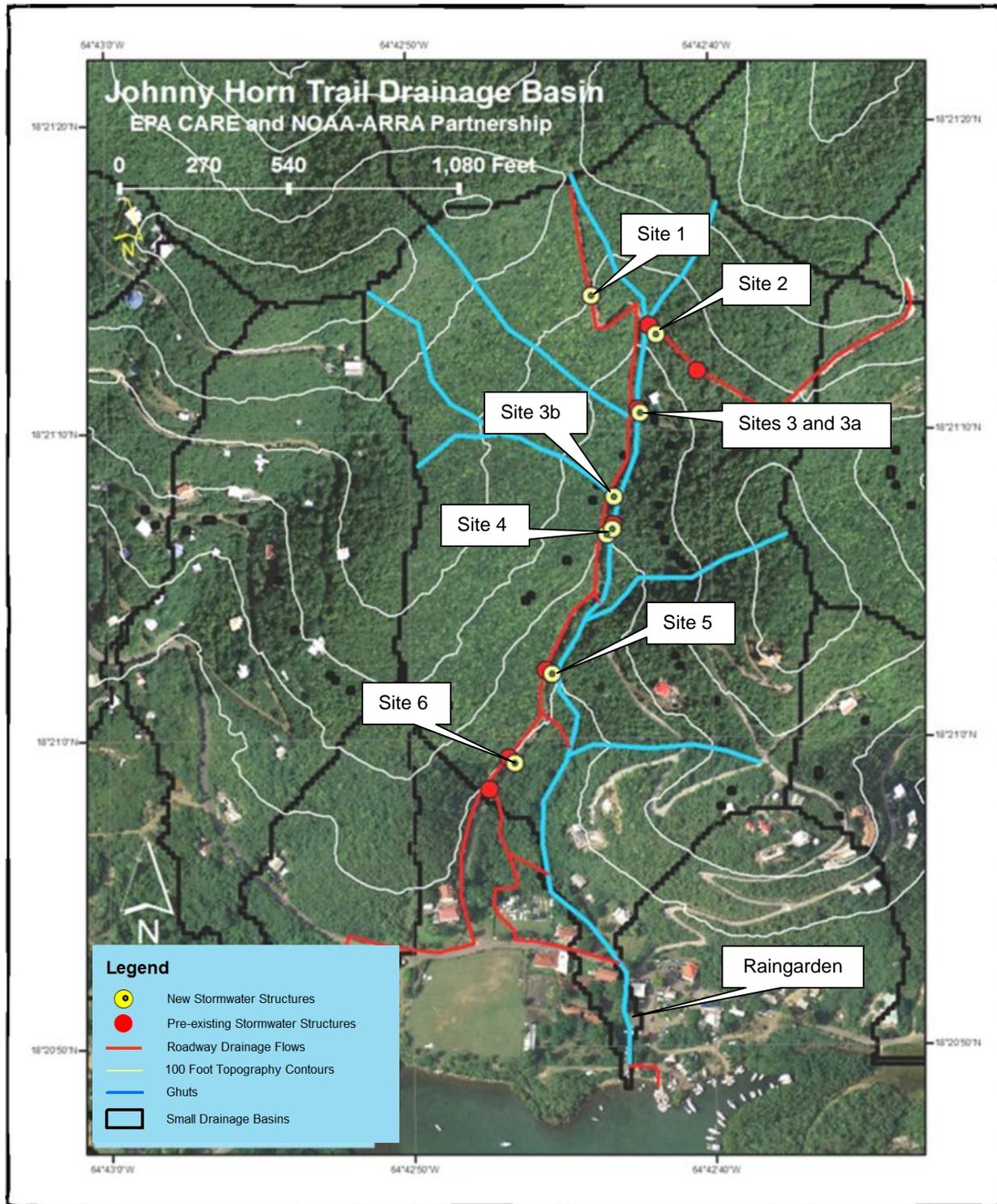


Figure 1: Johnny Horn Trail Drainage Basin and Watershed Features

## **1. Watershed Description**

The Johnny Horn Trail Watershed, named after the road bisecting the area, starts at the top of Base Hill, drains approximately 66 acres, and empties alongside the boat ramp/dock area into Coral Bay. Sheer slopes, highly erodible soils, and high water runoff volumes during rain events characterize the watershed. Water generated from the Johnny Horn Trail Watershed travels downhill primarily over the road and through a large gully that roughly parallels the road, flows behind a cemetery prior to continuing to a culvert under Route 10 across from the Guy Benjamin School, and then enters a short concrete channel that discharges to a grassed swale behind the firehouse.

The Johnny Horn Trail Road itself was mostly a grassy track in 2000, although it was a historic Danish road. As land above was subdivided and a few people began to build houses, private excavators began grading parts of the road. The Virgin Islands Department of Public Works (PW) constructed a drainage channel in the early 2000's on the east side of the dirt road to funnel water down the side of the road opposite the gully to address road washouts and reduce rutting. PW also paved the lower 200 yards (circa 2002). This road is the only access for nine residential properties, including two active home construction sites in the upper watershed. Route 10 crosses the lower watershed and provides access to the Emmaus Moravian Church and cemetery, Guy Benjamin School, and a number of other stores, shops, and establishments.

## **2. Problem Statement**

Local stakeholders identified several problems within the watershed in the Coral Bay Watershed Management Plan. First, the dirt public road in the mid- to upper watershed lacked appropriate water runoff controls, allowing water in the rough roadside swales on the uphill side to frequently cross the road causing existing fill-slopes on the downhill side of the road to wear away (Photos 2 & 3). Additionally, a new concrete subdivision road in the upper watershed has channeled flows into the Johnny Horn Trail Watershed instead of allowing them to naturally flow into a subgully and then into the adjacent Eden Watershed (Photo 4). At the bottom of the hill, next to the Emmaus Moravian Church, the asphalt roadway frequently functions as a waterway during larger storms. Finally, water in the gully overflows out of the gully and runs across the cemetery which then runs across Route 10 into a concrete swale in front of the school and into a system under and adjacent to the school yard. All these problems are increasing stormwater runoff amounts and velocities leading to roadway, cemetery, and school flooding, and ultimately highly visible amounts of dense, tan-colored, fine sediment deposition into Coral Bay's inner harbor (see Photos 5 & 6).



Photo 2: Upper Johnny Horn Trail roadside drainage erosion before the project.



Photo 3: Upper Johnny Horn Trail roadside drainage erosion before concrete swale installation.



Photo 4: Erosion from upper watershed concrete subdivision road before the project.



Photo 5: Runoff from lower paved section of Johnny Horn Trail before the project.



Photo 6: Runoff from Johnny Horn Trail before the project.

### 3. Background and Project Planning

Research has shown that as development increased in Coral Bay so has sedimentation of the bay, thereby threatening the health of the bay and its marine habitats (Devine et al. 2003). In order to reduce this threat, the partner agencies, CBCC, NOAA, the Virgin Islands Department of Planning and Natural Resources (DPNR), the U.S. Environmental Protection Agency (EPA), and the Virgin Islands Resource Conservation and Development Council (V.I. RC&D), have aggressively spent the last five years planning and implementing actions to reduce sediment loads in Coral Bay.

Starting 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 U.S. Virgin Islands. Upon publication of the WMP in 2008, CBCC applied for a \$300,000 EPA Community for a Renewed Environment (CARE) grant, and received it in early 2009 to begin implementation of the WMP as part of the overall Coral Bay Watershed Management Project. The primary goal of the EPA CARE grant was to implement *WMP Recommendation #1 – Provide direct, on-site technical*

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assistance to watershed residents, businesses, developers, and others implementing watershed recommendations. To help with this recommendation the WMP discussed five actions, two of which CBCC implemented as part of the EPA CARE grant:

- *Near-Term Action 1.1: Use EPA CARE grant as seed money to support a 1-2 year, full-time hydrologist/watershed manager for Coral Bay.*
- *Near-Term Action 1.4: DPNR and CBCC should consider providing resources needed to support new personnel (i.e. GIS, office basics, vehicle, etc.).*

In spring 2009, working through a local nonprofit partner, V.I. RC&D, CBCC secured \$1.5 million of NOAA ARRA grant funds. CBCC and V.I. RC&D used these funds to implement actions proposed in the [NOAA ARRA Coral Bay Workplan](#) prepared for the grant application, based on the expertise provided by the newly hired CBCC Stormwater Engineer (see Section 4.1). 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 the bay. These projects also implemented portions of *WMP Recommendation #3 - Evaluate and repair erosion and drainage problems that are threatening property, damaging infrastructure, or delivering excessive sediment loads to Coral Bay*. CBCC's website contains a [Project Overview](#) of the USVI Watershed Stabilization Project in Coral Bay and a description of the [Coral Bay Watershed Management Project](#).

In the NOAA ARRA Coral Bay Workplan, CBCC developed a list of watershed stabilization techniques appropriate for the Coral Bay environment (see Appendix A) and directly aimed at reducing sediment plumes to the bay. These were used to formulate the following goals for the Johnny Horn Trail Project:

1. Restore natural drainage flow patterns to the greatest extent possible (Strategy 1);
2. Slow down and retain water that reaches the valley floor (Strategy 2);
3. Reduce sediment entering Coral Bay at the mouth of the ghut (Strategy 3); and,
4. Correct failed stormwater devices (Strategy 4).

## **4. Project Implementation**

### **4.1 Project Design**

CBCC hired Joseph Mina, P.E. as its Stormwater Engineer in 2009 using the EPA CARE grant funds to provide design expertise and recommendations. Initially, he wrote a series of engineering design memos based on field conditions to help identify the key BMPs for local implementation. He also contributed significantly to writing the NOAA ARRA Coral Bay Workplan and prioritizing the detailed projects in it. The EPA CARE grant funded the engineering design phase, with the NOAA ARRA funding focused on the field engineering and inspection, permitting, construction bidding, and field construction phases. V.I. RC&D was directly responsible for the construction phases of the Coral Bay NOAA ARRA projects. For personal reasons, Mr. Mina had to leave CBCC's employment in June 2010 and CBCC hired Christopher Laude, P.E. to complete the design phase and implement the NOAA ARRA BMP projects over the following year.

Additionally, from 2008-2010 under another grant program, Rutgers New Jersey Agricultural Experiment Station conducted a study of, and developed recommendations for, installing a step pool/raingarden along the drainage channel behind the fire station. These recommendations were used by Mr. Laude in formulating the raingarden Scope of Work (August 2, 2010) used to contract, permit, and construct the project.

## **4.2 BMP Selection Process**

Mr. Mina initially divided the Johnny Horn Trail Watershed into four areas based on the type of terrain and type of beneficial stormwater management opportunities. The 2009 NOAA ARRA Coral Bay Workplan included these areas as described in Table 1. Mr. Mina refined and amplified the NOAA ARRA Coral Bay Workplan Proposed Actions in a series of design memos written in May and December 2009 after field surveys revealed the ability of the ghut to infiltrate water in the upper watershed; thereby reducing the need for large bioretention areas lower in the watershed and prioritizing trench drains (and other stormwater management devices) in the upper watershed. Mr. Mina fleshed out these recommendations in a final memo on March 31, 2010 changing two of the trench drains to pipe arches. By June 2010, Mr. Mina had drafted a Scope of Work & Details document changing the remaining trench drains to waterbars to reduce overall project costs. After Mr. Laude (replacement Stormwater Engineer) reviewed the Scope of Work and the project costs in July and August 2010 with the selected contractor, he deleted the expensive pipe arch and switched to a less expensive, but equally effective swale. Mr. Laude also replaced waterbars with swales to catch subghut flows from the upper hillside, redirecting these flows to the lower side of the road and the ghut. CBCC deemed the swales at \$9,500 more effective and self-cleaning than the waterbars at approximately \$3,000. Also with the elimination of the pipe arch, the swales could be paid for within the scope of the project providing an effective BMP that is easier to maintain than waterbars and cheaper than pipe arches.

For the raingarden, Rutgers New Jersey Agricultural Experiment Station's recommendations (March 2010) featured an off-line level depression on the right bank of the main channel for managing storm flows and infiltration. Mr. Laude expanded this design in August 2010 to double the raingarden size and place it within the existing drainage channel with rock rubble weirs at the entrance and exit of the BMP.

Tables 1 & 2 summarize the transition from actions proposed in the NOAA ARRA Coral Bay Workplan to the implemented actions by including dates for proposal, dates for construction, and any additional comments necessary. All engineering design documents have been included in Appendix A.

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Location	Proposed Action	Status	Comments
A-1- Repair area behind cemetery	Construction of a three-foot high, 300-foot long berm behind the cemetery; debris clearance; installation of a series of baffles & check dams; and, construction of a storm overflow spillway.	Cancelled (January 2011)	Landowner denied permission.
A-2- Biofiltration and Infiltration Area	Construction of a bio-filtration & infiltration area upstream of the Route 10 culvert crossing.	Cancelled (October 2009)	Landowner denied permission after seeing plan; wanted parking area instead so they went with PW recommendation to install a culvert.
A-3 - Raingarden	Construct the Rutgers University designed step pool/raingarden behind the Fire Station.	Revised (July 2010)	Original concept expanded during design to incorporate the reason for A-2.
A-4 - Roadwork & Uphill improvements	Repair fill-slope & landslide areas showing erosion & damage.	Cancelled (December 2009)	Conditions altered by PW and local residents.
Uphill Areas (Sites 1-6)	Install trench drains, underdrains, step pools, and concrete channels.	Upgraded to swales to allow quick removal of water flows from roadside channels into natural ghut. (July 2009 to August 2010)	Trench drains too expensive (costs \$40,000 vs. \$9,500 for a swale); focused all actions on enhancing infiltration potential of natural ghut.

Location	Implemented Action	Status	Comments
Site 1	Swale	Constructed (December 2010)	
Site 2	Concrete Swale & Paving	Constructed (January 2011)	
Site 3	Culvert	Constructed (January 2011)	
Site 3a	Concrete Swale	Constructed (January 2011)	
Site 3b	Concrete Swale	Constructed (January 2011)	
Site 4	Culvert	Constructed (September 2010)	
Site 5	Concrete Swale & Road Repair	Constructed (January 2011, completed August 2011)	
Site 6	Concrete Swale	Constructed (August 2011)	
Raingarden	Raingarden	Constructed (November 2010)	

### **4.3 Problems Encountered/Overcome**

The Johnny Horn Ghut flows mostly across private lands near public roads, thus several parties needed to be involved to implement solutions to the sedimentation problems caused by past human interventions in this watershed. For instance, to prepare for more waterflow straight into the ghut in the upper watershed, two undersized culverts under driveway crossings needed to be up-sized. Also, the planned sediment detention basin behind the cemetery was on land owned by the Moravian Church Conference. After a year and a half of discussions, no agreement was gained, partly because they wanted the project to invest in surveys and design

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before they gave conceptual approval, therefore this proposed action was cancelled and funds moved elsewhere.

Although initially enthusiastic, the homeowner where the bioretention “garden” was planned for the front yard, after seeing the design, did not want the proposed natural area. The homeowner preferred a proposal that PW had provided to place a large culvert at the driveway crossing and allow for a raised elevation and flat parking area for the restaurant on the adjacent property. The project shifted focus and funding to the proposed raingarden area 100 feet down the water path, doubling that BMP in size to increase infiltration.

Throughout the planning and construction period that spanned from 2009 to 2011, there was uncertainty regarding how much water would successfully infiltrate in the upper watershed because of this project; therefore, reducing flows in the lower watershed. This was partly because there were only trace amounts of rainfall from November 2010 to April 2011. When normal heavy rains began again, it became clear that the upper watershed improvements led to a very significant reduction in ghat flows at lower elevations, and when there was flow, it was not sediment laden based on eyewitness reports and photographic evidence. No flows were recorded for 10 out of 13 sampling events between April and November 2011, when other sampling stations within ½ mile were recording flows. Shortly after construction had started, Tropical Storm Otto arrived on October 6, 2010 depositing roughly 15 inches of rain in 24 hours, including a microburst. A tree fell down into the ghat below the project’s work, diverted water onto the dirt road, and washed it out. PW had the road regraded and installed a new dirt swale, which the NOAA ARRA Project subsequently added to the construction budget (#6 below) for paving, so all the water crossings were armored.

#### 4.4 Project Costs & Construction

After taking into consideration site conditions, BMP costs, and available project funds, the final BMPs implemented included six swales, two culverts, and a raingarden for a total cost of \$83,839.50. Table 3 details project cost elements for the implemented BMPs. Appendix A has detailed design drawings.

<b>Table 3: Johnny Horn Trail Project Costs</b>		
<i>Implemented BMPs</i>		
Road Site	Description	Total
1	Install Concrete Swale	\$3,500
2	Install Concrete Swale	\$9,500
3	Install 18' x 48" HDPE Pipe and Paving	\$17,350
3a	Install Concrete Swale	\$9,250
3b	Install Concrete Swale	\$9,250
4	Install 18' x 48" HDPE Pipe	\$5,100
5	Replace HDPE pipe with concrete swale and repair area. Install riprap on fill-slope.	\$9,250
6	Install Concrete Swale	\$9,250
<i>Total BMP Cost</i>		<b>\$72,450*</b>

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<b>Table 3: Johnny Horn Trail Project Costs (continued)</b>		
<i>Raingarden</i>		
	<b>Item</b>	<b>Total</b>
	1. Install Rock Rubble Weir	\$3,358
	2. Install Soil Berm	\$1,365
	3. Install Planting Materials	\$5,805
	4a. Planting Material Cost – Contractor	\$439.50
	4b. Planting Material Cost – Rutgers Grant**	\$984
	5. Maintenance of Plantings	\$2,438
	<i>Total Raingarden Cost</i>	\$14,389.50
* Contracting terms slightly reduced the total project cost to \$69,450.		
**Grey shading indicates another source of funding besides NOAA ARRA.		
Excavation of Raingarden area contributed by PW - value estimate \$3,000.		

**Swale Construction**

Stormwater managers typically use swales to convey runoff in a desired direction. For instance, “cross-road” swales are used to channel runoff from one side of the road to the other into appropriate drainages. Concrete swales are typically used at sites where additional stabilization is necessary, such as a roadway. For the Johnny Horn Trail, the project used swales at several points in the watershed to direct water from the upslope side of the road across the road and back into the ghit instead of letting runoff continue down the roadside. Due to the steepness of the road, the swales are deeper and wider than usually constructed in order to retain the water within the swale.

Concrete swale construction (Photos 7-9) included two items: (1) installation of the swale across the roadway to redirect flows; and, (2) installation of fill-slope stabilization to protect the fill-slope from erosion. The six rebar-reinforced concrete swales were approximately 13-foot x 23-foot with a minimum of ½ inch per foot of slope across the bottom of the swale (see Figure 2 for design detail). In order to allow for one lane of continuous traffic use, the contractors constructed the swales in two panels taking approximately two work days each and several more days to cure prior to traffic use.



Photo 7: Swale construction.



Photo 8: Swale construction.



Photo 9: Swale construction.



### **Culvert Construction**

Culverts allow contractors to construct roadways over a drainage, and come in a variety of sizes, shapes, and materials depending upon drainage and road conditions. For the two Johnny Horn Trail driveways that cross the gully, it was determined 48-inch corrugated polymer pipe culverts should replace the existing 12-inch pipes. (Thirty-six inch pipes would have been sufficient; however, the larger size was available on island at a lower price and they would be harder to plug with debris.)

Culvert installation at Sites 3 & 4 (Photos 10 & 11) included excavating and shaping the gully bed for pipe placement, and then backfilling and stabilizing the driveway. During installation, it was important to place the culverts flush with the runoff channel so soil did not accumulate and plug the culvert. It was also important to ensure contractors placed rock on the upstream end and constructed rock aprons on the downstream end to avoid erosion by high velocity runoff entering and exiting the pipe.



Photo 10: Site 4 culvert installation.



Photo 11: Site 4 culvert installation.

### **Raingarden Construction**

Raingardens are planted depressions designed to retain water for ground absorption, reduce runoff velocity, and allow sediment to settle out; thereby, improving water quality. Contractors constructed the Johnny Horn Trail raingarden in the gully just before it enters Coral Bay to provide final “last chance” sediment reduction and water quality improvements. Creation of the approximately 12-foot by 50-foot raingarden/swale was a cooperative project supported by:

- Rutgers University Cooperative Extension – planning and \$1,000 subgrant funding to V.I. RC&D for plant purchases;
- DPNR – planning;
- EPA and NOAA – funding; and,
- PW - excavation.

After excavation by PW, a local contractor installed a rock rubble weir at the swale outlet, a soil berm around the excavation area, and geotextile mat in the planting areas. Finally, the

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contractor planted the site in three distinct areas (top of berm, berm side-slopes, and bottom areas) to account for different moisture levels. Plantings in bottom areas will be subject to periodic inundation of approximately six inches to two feet of water and must be able to handle dry seasons and times of no water (even during the rainy season) in the swale. Plantings on the berm side-slopes and top of berm must be able to tolerate drought and dry seasons, with occasional soil saturation. Table 4 lists the trees and plants placed in the raingarden.

<b>Table 4: Raingarden Plants</b>		
<b>Top of Berm</b>	<b>Berm Side-Slope</b>	<b>Bottom Area</b>
Coconut Palm	Local Lilies	Nut sedge
Royal Palm	Sea Grape	Elegant Sedge
Turpentine	Papaya	
White Frangipani	Banana	
Guavaberry		
Century Plant		
Pink Cedar Tree		

Construction of the raingarden took three weeks. During a six-month dry spell between construction and the beginning of the wet season in June, the contractor irrigated the site to ensure plant establishment. Additional plants, including lime and banana trees, were also planted in the raingarden since construction and planting, due to generous local donors. Photos 12-14 show the raingarden immediately, one month, and almost one year after installation.



Photo 12: Raingarden immediately after construction.



Photo 13: Raingarden one month after construction.



Photo 14: Raingarden 8 months after construction.

## 4.5 Achieved Results

Post-construction, Tropical Storm Irene passed through the area August 21-22, 2011 providing a good test of the Johnny Horn Trail drainage improvements. Photos 15-17 below depict better stormwater runoff management in the watershed. Stormwater BMPs now direct rainfall from the storm into the ghut high in the watershed where it has time to infiltrate before arriving at the lower watershed. This has led to less water on the roads and less-turbid water in the lower watershed. Attachment A shows the interpretive poster that highlights these achievements.



Photo 15: Site 3a swale after installation, performing during Tropical Storm Irene.



Photo 16: Site 6 swale after installation, performing during Tropical Storm Irene.



Photo 17: Site 3 swale after installation, performing during Tropical Storm Irene.

## 5. Sediment Reduction Monitoring

Dr. Barry Devine led a monitoring team (partially NOAA ARRA funded) that tracked turbidity in the watershed over a two-year period (September 2009 through November 2011). Dr. Devine used one primary sampling point at the bottom of the Johnny Horn Ghut for turbidity monitoring. Johnny Horn Trail Outlet sampling initially occurred where ghut flows entered the bay near the marine dock. Dr. Devine shifted this location approximately 40 yards to the west once the ghut flows were relocated back into the original ghut channel. The second sampling point was at the end of the marine dock and captured turbidity measurements from Johnny Horn Trail inflows as well as Flamingo Pond inflows. After analyzing the data, Dr. Devine's results showed the Johnny Horn Trail "drainage flow ran less often into the bay and the turbidity was markedly lower" after CBCC completed its drainage improvements in the watershed (Devine 2012).

## **6. Lessons Learned**

Removing water from roadside channels and returning it to the natural ghut system high in the watershed restored natural infiltration through ghut crevices in the hillside, virtually eliminating flows in the lower part of the watershed in many heavy, short rains. When water flowed, it was visibly less sediment laden, since it had not flowed along the dirt road.

Concrete swales across a steep dirt road, strategically placed to carry roadside water as well as subghut flows crossing the roadway, can effectively stabilize the drainage situation to reduce erosion and sedimentation, at a minimal cost (see project cost in Table 3). The swales must be deep enough to carry volumes of water across the road without overflowing. In this case, at least six to eight inches of usable depth was specified, which requires a broad, long concrete swale to ensure vehicle road clearance.

Swales are better than culverts because they cannot be readily blocked by small boulders eroding off the cut-slope hillside, and can be backhoe cleaned.

Swales need to be set on a diagonal, not with right angle turns, for the water to flow. Depths of swales should be as deep as possible, and have some "down pitch" so that they are less likely to fill with sediment.

There should be an emphasis on work done high in the watershed to assure natural drainage paths are used and respected. 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. This may not always be the case, and may not work in highly developed areas -- but was clearly seen in this subwatershed suite of projects.

## **7. Next Steps**

PW and private maintenance/improvement work on the Johnny Horn Trail during the last several years has established a deep, broad, roadside channel on the uphill side of the road and has pushed the roadbed closer to the ghut on the lower roadside. In some cases, the fill-slope is directly infringing on the natural ghut path. Now that the swales have removed the "need" for the deep roadside ditch, the whole roadway can be pushed back to the high side, stabilized with either paving or Geoweb®, and then the slope into the ghut needs to be re-naturalized. CBCC is currently working with PW on accomplishing these actions.

The two NOAA ARRA actions in this watershed that were cancelled (the sediment basin behind the cemetery and the bioretention area downstream in a resident's front yard) are still considered valuable additions. However, the other upstream BMPs were so successful in reducing both flow and sediment that these are deemed much lower priorities when compared to other Coral Bay Watershed needs based on an assessment by CBCC and other experts. However, the Moravian Church Conference of the Virgin Islands, which owns and provides stewardship for approximately 88 acres in this watershed, may still want to consider enhancing the natural sediment basin area behind their cemetery and implementing appropriate flood control measures that will drain the ball field.

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The Johnny Horn Trail is an old Danish road from the plantation days, with a 20 to 24 foot legal right of way, now acknowledged by PW as a public road. Currently, the usable road surface is one lane in most areas. Two narrow steep switchbacks, especially, need to be addressed from a roadway planning and engineering perspective, as well as a steep rocky stretch of road that is very unstable resulting in erosion. Routine grading does not last well, and the few resident homeowners pressure PW for an upgraded road. Standards for this roadway and each of its sections need to be established because the current PW requirement that PW roads be paved at a minimum of 16 feet wide - 18 to 20 feet preferred, is not feasible on all portions of this road without major excavation into the cut-slope. A discussion needs to be held with PW engineers and policy setters by CBCC and the residents to explore the basis for this standard and additional options, beyond continued frequent road grading.

Drainage along the dirt channel on the side road approaching the Johnny Horn Trail needs to be reduced by restoring natural flow patterns so that some of the water flow will be returned to the adjacent Eden Watershed. The private owners on the concrete subdivision road that diverts the natural ghut flow have shown an interest in installing a trench drain (or other device) to restore the flow, if they can get the appropriate professional advice. The original ghut path needs to be walked and reviewed to ensure that no newly constructed homes are in the path, prior to recommending/funding this solution.

The Seagrape Hill homeowners' association and the developer may need to address the flow of water on their roads across lower properties and into the Johnny Horn Ghut in its lower reaches, possibly by installing some energy dissipaters and level spreaders where the water leaves the concrete surfaces.

## **8. References**

Devine, Barry, Ph.D. 2012. *Virgin Islands NOAA-ARRA Monitoring Program Pre- and Post-Treatment Turbidity Monitoring Report Coral Bay Watershed.*

Devine, B., Brooks, G., and R. Nemeth. 2003. *Coral Bay Sediment Deposition and Reef Assessment Study.* State of the Bay, Final Project Report, Executive Summary. Submitted to VI DPNR Division of Environmental Protection MOA #NPS-01801.

# **Attachment A: Watershed Poster**

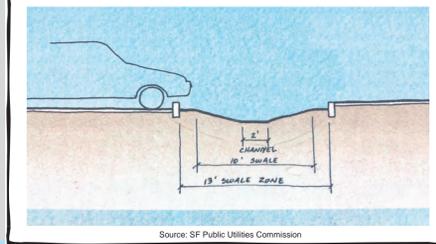


# JOHNNY HORN TRAIL

## WHAT IS HAPPENING HERE?

The Johnny Horn Trail is a steep dirt road which runs alongside the Emmaus Moravian Church into a developing residential area. Historically there have been large amounts of stormwater and sediment funneled directly into Coral Bay Harbor. The main problem at this site is that runoff is directed down a steeply sloping road. The road frequently functions as a channel during large storms. The goal is to install a series of concrete swales crossing the road to help manage and direct runoff into the ghat paralleling the road. This will also help reduce erosion while creating positive drainage. Removing the stormwater from the road and routing it to the natural ghat will greatly help in reducing sediment by slowing velocities, promoting infiltration, and decreasing slope side erosion.

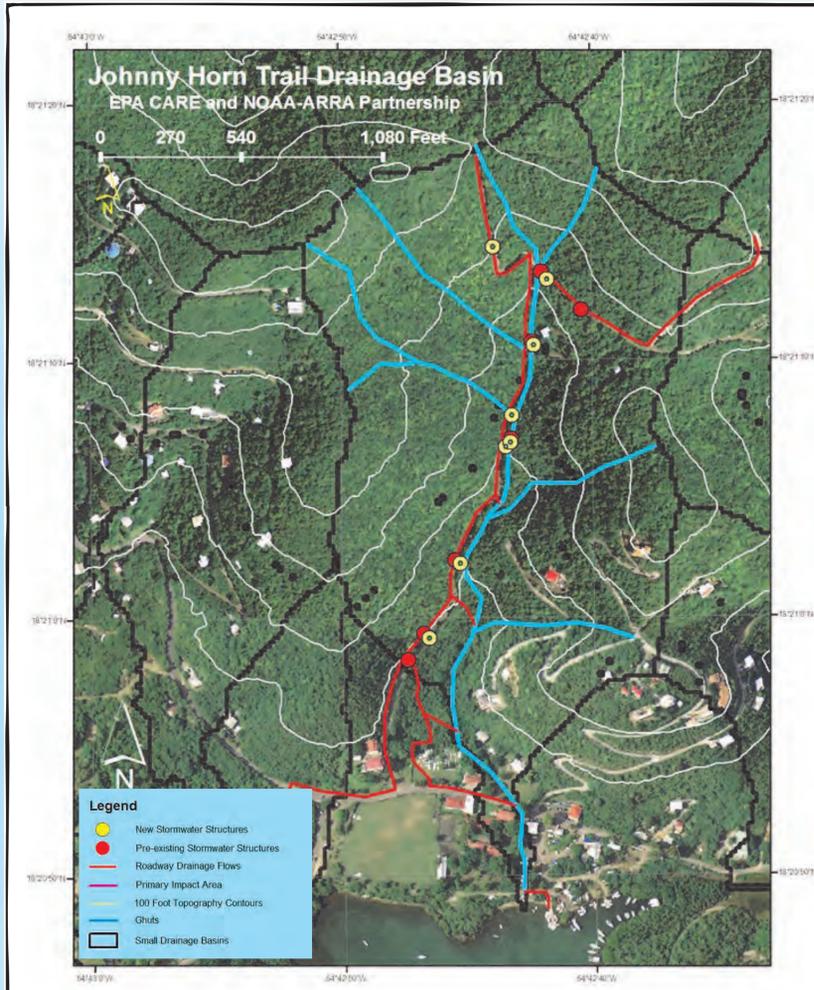
## TYPICAL SWALE CROSS SECTION



BEFORE & AFTER



IN CONSTRUCTION



## JOHNNY HORN TRAIL WATERSHED

Drainage from the Johnny Horn Trail watershed has a significant negative impact on the turbidity of inner Coral Bay Harbor. The natural drainage in the watershed has been disrupted by recent road construction and maintenance by track hoe. This map shows the Johnny Horn Trail area, sub-basins, natural drainage flow, pre-existing and new drainage structures. It also shows the old (red) and natural (blue) water routes.

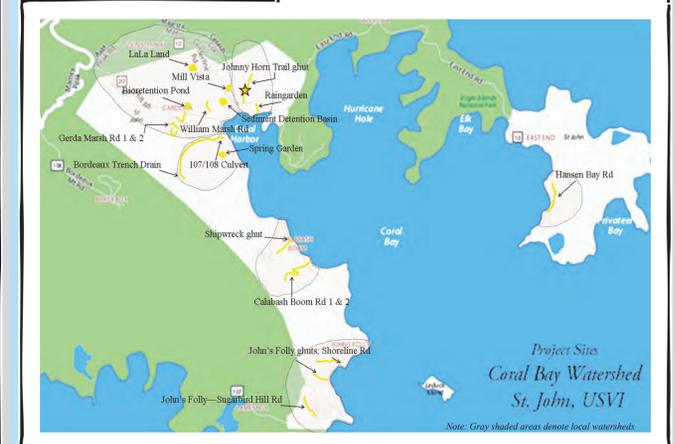


AFTER

## RESTORING NATURAL FLOW

Routing water off the road and restoring the natural flow into the main ghat is extremely important as it helps stormwater runoff infiltrate the ground, trap sediment, and reduce flooding of roadways, all while controlling the input source at the ocean.

## SITE LOCATIONS



WATERSHED SCALE GEOGRAPHIC INFORMATION SYSTEM (GIS) PLANNING TOOLS TARGETED WATER QUALITY MONITORING RESEARCH THAT HELPED IN SELECTING THE PRIORITY SITES FOR THESE SEDIMENT REDUCTION PROJECTS. FOLLOW-UP TERRESTRIAL AND MARINE SEDIMENT MONITORING WILL QUANTIFY AND DEMONSTRATE THE SUCCESS IN REDUCING SEDIMENT POLLUTION REACHING THE BAY.

## WHAT YOU CAN DO!

- ⇒ Vegetate bare slopes with native plants
- ⇒ Minimize use of pesticides & fertilizers
- ⇒ Clean up driveways, roadsides and gutters
- ⇒ Use cut brush to create berms on steep slopes
- ⇒ Eliminate muddy run-off water
- ⇒ Never dump anything down storm culverts or ghots
- ⇒ Properly dispose of oils, paints and chemicals
- ⇒ Do not disturb ghots for 30 feet from center of ghat
- ⇒ Preserve all trees
- ⇒ Pump and inspect your septic tank regularly
- ⇒ Notify DPNR if you notice a problem
- ⇒ DPNR permits are needed for using backhoes & trackhoes
- ⇒ Educate each other
- ⇒ Participate in community projects!

## PROTECTING COASTAL & CORAL REEF HABITATS BY REDUCING EROSION & SEDIMENTATION

THIS PROJECT IS ONE OF 18 IMPLEMENTED IN THE CORAL BAY WATERSHED WITH \$1.5 MILLION IN NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION FUNDING UNDER THE AMERICAN RECOVERY AND REINVESTMENT ACT OF 2009, AS PART OF THE \$2.7 MILLION USVI COASTAL HABITAT RESTORATION THROUGH WATERSHED STABILIZATION PROJECT TO REDUCE SEDIMENT LOADING RATES INTO THE COASTAL WATERS OF THREE USVI WATERSHEDS: CORAL BAY AND FISH BAY ON ST. JOHN AND EAST END BAY ON ST. CROIX. THE U.S. ENVIRONMENTAL PROTECTION AGENCY HAS PROVIDED FUNDING TO THE CORAL BAY COMMUNITY COUNCIL UNDER ITS COMMUNITY ACTION FOR A RENEWED ENVIRONMENT (CARE) PROGRAM TO SUPPORT THIS WORK. LOCAL HOMEOWNERS ASSOCIATIONS, THE VIRGIN ISLANDS GOVERNMENT AND COMMUNITY VOLUNTEERS HAVE ALSO PROVIDED RESOURCES AND WORKED COOPERATIVELY TO ACHIEVE THE PROJECT OBJECTIVE OF REDUCING THE STORMWATER SEDIMENT PLUMES ENTERING BEAUTIFUL BLUE CORAL BAY. THESE PROJECTS ARE ALSO PART OF IMPLEMENTING THE CORAL BAY WATERSHED MANAGEMENT PLAN THROUGH PUBLIC-PRIVATE PARTNERSHIPS TO IMPROVE WATER QUALITY, ECOLOGICAL HEALTH, AND STORMWATER MANAGEMENT WHILE MINIMIZING FUTURE IMPACTS ASSOCIATED WITH WATERSHED DEVELOPMENT.

### THANKS TO OUR LEAD PARTNERS!

CORAL BAY COMMUNITY COUNCIL (CBCC)  
VIRGIN ISLANDS RESOURCES CONSERVATION & DEVELOPMENT COUNCIL (VIRC&D)  
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)  
US ENVIRONMENTAL PROTECTION AGENCY (EPA)  
VIRGIN ISLANDS DEPT. OF PLANNING AND NATURAL RESOURCES (DPNR)  
VIRGIN ISLANDS DEPT. OF PUBLIC WORKS (DPW)  
COMMUNITY VOLUNTEERS AND HOMEOWNERS' ASSOCIATIONS

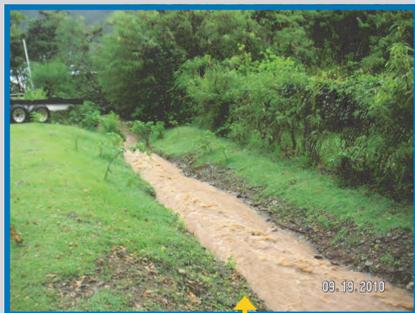
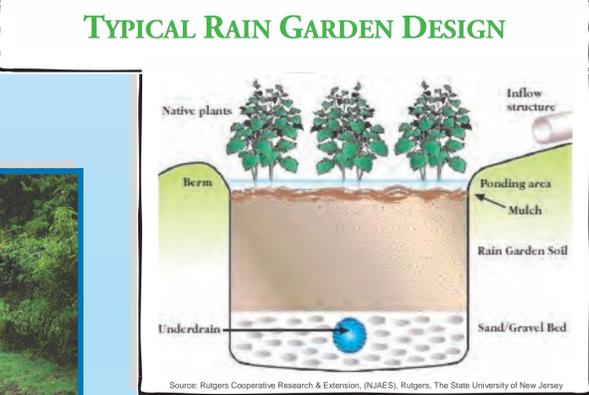
FOR MORE INFORMATION PLEASE CONTACT:  
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(340) 776-2099  
WWW.CORALBAYCOMMUNITYCOUNCIL.ORG



# GUY H. BENJAMIN RAIN GARDEN

**WHAT IS A RAIN GARDEN?**

A Rain Garden is a shallow constructed depression, planted with deep-rooted native plants and grasses. It's designed to slow, capture, and infiltrate rain and runoff from surfaces such as driveways, parking areas, or roads. Water typically drains within a day and filters into the surrounding soil. Native plants are drought-resistant, accustomed to local soils, and provide a niche for animals. The garden not only collects water but also any pollutants it carries such as sediment, oils, fertilizers, and pesticides. Rain Gardens are a beautiful and colorful way for communities to ease stormwater problems.



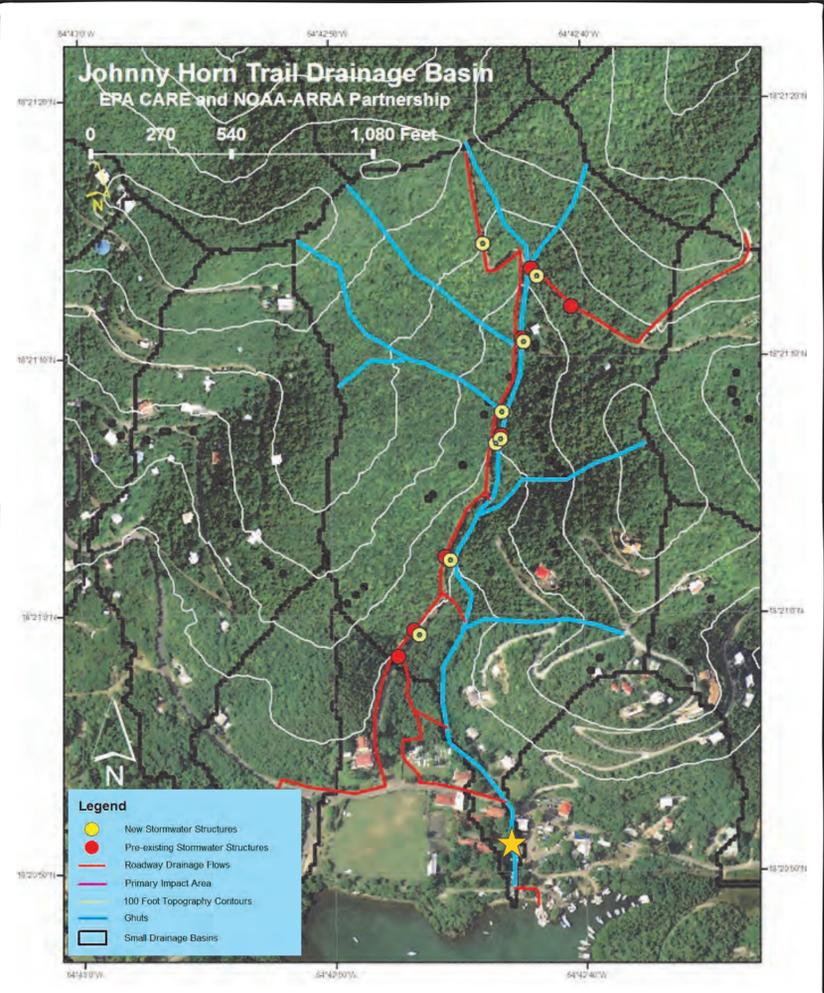
**BEFORE**



**DURING CONSTRUCTION**



**AFTER**



**JOHNNY HORN TRAIL WATERSHED**

Drainage from the Johnny Horn Trail watershed has a significant negative impact on the turbidity of inner Coral Bay Harbor. The natural drainage in the watershed has been disrupted by recent road construction and maintenance by track hoe. This map shows the Johnny Horn Trail area, sub-basins, natural drainage flow, and pre-existing and new drainage structures.

- NATIVE PLANTS**
- These plants are native to St. John and found within the Rain Garden:
- Coconut Palm
  - Royal Palm
  - Local Lilies
  - Turpentine
  - White Frangipani
  - Seagrape
  - Guavaberry
  - Elegant Sedge
  - Nutsedge
  - Papaya Tree
  - Banana Tree
  - Century plant
  - Pink Cedar Tree



WATERSHED SCALE GEOGRAPHIC INFORMATION SYSTEM (GIS) PLANNING TOOLS TARGETED WATER QUALITY MONITORING RESEARCH THAT HELPED IN SELECTING THE PRIORITY SITES FOR THESE SEDIMENT REDUCTION PROJECTS. FOLLOW-UP TERRESTRIAL AND MARINE SEDIMENT MONITORING WILL QUANTIFY AND DEMONSTRATE THE SUCCESS IN REDUCING SEDIMENT POLLUTION REACHING THE BAY.

- WHAT YOU CAN DO!**
- ⇒ Vegetate bare slopes with native plants
  - ⇒ Minimize use of pesticides & fertilizers
  - ⇒ Clean up driveways, roadsides and gutters
  - ⇒ Use cut brush to create berms on steep slopes
  - ⇒ Eliminate muddy run-off water
  - ⇒ Never dump anything down storm culverts or ghots
  - ⇒ Properly dispose of oils, paints and chemicals
  - ⇒ Do not disturb ghots for 30 feet from center of ghot
  - ⇒ Preserve all trees
  - ⇒ Pump and inspect your septic tank regularly
  - ⇒ Notify DPNR if you notice a problem
  - ⇒ DPNR permits are needed for using backhoes & trackhoes
  - ⇒ Educate each other
  - ⇒ Participate in community projects!

## PROTECTING COASTAL & CORAL REEF HABITATS BY REDUCING EROSION & SEDIMENTATION

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 VIRGIN ISLANDS DEPT. OF PUBLIC WORKS (DPW)  
 GUY H. BENJAMIN ELEMENTARY SCHOOL  
 COMMUNITY VOLUNTEERS AND HOMEOWNERS' ASSOCIATIONS

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# **Appendix A: Engineering Designs & Drawings**

# CORAL BAY COMMUNITY COUNCIL, INC.

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## **Coral Bay Projects Design Guidance**

### *Strategies Appropriate for Coral Bay Environment*

By: Joseph Mina, P.E.

1. Many natural drainage flows have been disturbed by construction and other man-made activities. A primary method of addressing water quality exiting the watershed into the bay will be to restore natural drainage flow patterns to the greatest extent possible both in intermittent drainage swales and ghuts and restoring sheet flow over steep slopes where possible. This will be accomplished primarily by:

a. Redirecting drainage from channels and redirecting the large areas of upslope water intercepted along many roads and construction sites and distribute that water using level spreaders, bioretention/infiltration devices and/or rock aprons or similar means to recreate the natural sheet flow, reduce velocity and improved percolation into soil.

i. Regrade roadbeds to direct flows to appropriate outflow devices where feasible, and add additional paving or permanent structures as appropriate to make preferred patterns of flow permanent.

ii. Add shallow vegetated swales, and detention areas with rocks and naturalized vegetation where possible to reduce velocity and promote infiltration.

iii. Install trench drains across driveways and roads into rain gardens, infiltration trenches, localized water collection systems for irrigation, or other appropriate devices.

b. Eliminate deep excavated unlined ditches which are common to many of the dirt roads in order to slow velocities and reduce amount of sediment produced by erosion. Check dams, bioretention swales, and underground stone trenches with perforated pipe will be installed where appropriate.

c. Reduce the length water travels in roadside swales by directing flow from roadways into devices often. Preferably at each switchback at a minimum by incorporating drywells, rain gardens and infiltration chambers using locally available materials and native species.

2. Retain and slow down water that reaches valley floor in larger scale regional detention/retention basins with Best Management Practices installed including forebays, infiltration cells and bioretention pond areas:

a. Devices will utilize native plantings and species where possible and available to mimic local Caribbean seasonal flow dry ghut conditions to promote both stormwater quality and to provide wildlife and riparian habitat restoration.

b. Sediment deposition retention area, cleaned regularly, with reuse of sediment material as gravel, topsoil, building sand, etc.

3. Provide “Last Chance” effort to reduce sediment entering sea at ends of ghuts and drainage ways immediately adjacent to where the flows enter the ocean.

a. Install devices just upstream of exit to the ocean from ghuts including:

i. Combination of weirs, pre-manufactured sediment retention chambers and/or small bioretention areas with local rock rip-rap aprons and multi-step natural rock retention step pools.

ii. Baffles and check dams where ghut is large enough.

iii. Construct and maintain natural “Caribbean Berm” (usually created by wave action and sand deposition) where water enters ocean in each area to provide natural sediment protection. Protection against mosquitoes and parasites in sitting water with guppies)

b. Slow, redirect and/or restore gut flow within 300 yards of ocean by installing the following where appropriate and feasible:

i. Re-vegetate gut outflow areas.

ii. Rock weirs, ghut slope and embankment protection including erosion control blankets, concrete cable mats or other manufactured devices to reduce erosion.

c. Install in-line biofiltration areas and flow spreading devices to slow velocities and provide opportunities for sediment to drop out and naturalized vegetation to reduce pollutant loading in the runoff.

4. Correction of failed devices, culverts, water routing by installing any appropriate Best Management Practices to attempt to solve some past poor choices of storm water management, or areas where no thought was given to management.

**June 2009**

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## Engineering Recommendation Memo A Series of Observations & Preliminary Recommendations

### CBCC Engineering Recommendation Memo #5

**From:** Joseph A. Mina, P.E.

**Date:** May 15, 2009

**Subject Property:** Coral Bay

**Specific Issue:** Plumes of Sediment Laden Runoff in Multiple Locations – The Creek behind Skinny Legs

There are four primary areas where plumes of sediment laden water flow into the bay as a result of improper erosion and sediment pollution control in the various watersheds. These are Johnson Bay, Coral Bay at Voyages, Coral Bay at Kings Hill Road, and The Creek behind Skinny Legs. Due to the large amount of photos, these four areas will be the subject of four Engineering Recommendation Memos. This is the last of the four memos on this topic. The summary paragraphs below are repeated from ERM#2 for ease of reference.

#### **Summary**

On May 4, 2009 there was a substantial rainfall event that, according to various sources, dropped between 10 to 12 inches of rain on Cruz Bay. By my observations of the storm event's intensities in both Coral Bay and Cruz Bay, I estimate that between 8 and 10 inches fell in Coral Bay. During the event, I performed numerous site visits and took many photos.

It should be noted that in general, during an event of this magnitude, it is almost impossible to manage the runoff, and most BMP's seek to control the first 1" to 1.5" of runoff from a drainage area, or the 3" rain event. While I am still making a decision on which rain event to choose for our future BMP designs, I do know the devices will not manage this type of storm but only serve to pass larger events through safely after controlling the first 1" to 1.5" of runoff. It also needs to be noted that my estimates are prevalent throughout the memo. These are based on my personal observations of the intensities and reports from others describing the type of rain falling. At this time, there is no scientific measurement of these amounts, just a "best guess" based on professional experience.

During the early portion of my observations (prior to 8AM) few of the ghuts were actually flowing, and much of the runoff observed watershed-wide was clearly the result of impervious surfaces, construction activities, or runoff from existing roadways that acted as channels and decreased the initial runoff Times of Concentration. The Ghuts began to run between 8:30 and 10AM depending on the upstream watershed characteristics. This supports my "first flush" theory that the initial 1.5" of runoff is clearly the real culprit in the spiking amounts of sediment laden waters entering the bay.

#### **Creek Behind Skinny Legs Plume**

During this storm event, I did not personally view the plume in this area due to the high intensity of the rainfall while I was in this area. I did have the opportunity to see the numerous flows across Route 10 from Johnny Horn Trail, and Sea Grape Hill that contribute to the pollution in this area. Water flows down Johnny Horn Trail directly, and in a ghat that runs behind the cemetery. Specific issues regarding Sea Grape Hill and Johnny Horn Trail will be the subject of future Engineering Recommendation Memos. A summary of each contributing watershed is given for background information:

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## Engineering Recommendation Memo A Series of Observations & Preliminary Recommendations

### Sea Grape Hill

The water from Sea Grape Hill comes down the hill and runs partially into a culvert which simply passes it under the road down Sea Grape Hill, and partially down the road and out into Rt. 10. Ultimately both flows go into the concrete roadside swale along Rt. 10. The swale runs the water down Rt. 10 where it crosses the road in front of Mr. Guy Benjamin's house and runs overland at the end and enters the mangroves there. These flows are relatively clean but need management which will be outlined in a future Engineering Recommendation Memo.



Flow in the road and  
Into Culvert under road



Flow out of submerged culvert  
Culvert outlet is below grade



Flow runs out on to Rt. 10



Ultimate discharge from road into  
end of creek and mangroves

### Johnny Horn Trail

Water generated from the Johnny Horn Trail watershed travels down the hill primarily over the road and through a large Ghut roughly parallels the road and flows behind the cemetery prior continuing to a culvert under the road across from the Guy Benjamin School and then enters a concrete channel which discharges to a grassed swale behind the firehouse. An initial analysis of the problems shows that water in the ghut jumps out of the ghut and runs across the cemetery. Water from the cemetery runs across Rt. 10, into a concrete swale in front of the school and into a system under the school yard that eventually discharges it behind the school onto the basketball courts. All of these flows are fairly sediment laden, and are not provided with any treatment. This is the primary source of the Creek Plume.



Views of runoff in Rt. 10 from Johnny Horn Trail

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## Engineering Recommendation Memo A Series of Observations & Preliminary Recommendations



Flows coming out of cemetery



Flow at end of gully  
Behind Donkey Diner



Flow entering culvert across Rt. 10



Flow exiting culvert under Rt. 10  
Into concrete channel



Concrete channel ends at bridge visible  
in distance

### Recommended Action

- A previous study of the flows to this area indicated that the installation of a step pool system below the bridge after the concrete swale would help mitigate some of the problem. It is recommended that the step pool system be installed.
- Additional improvements within the concrete swale could help remove some sediment. Installation of baffles to channel the flow through a longer flow path would assist the step pool system in performing the removal.
- Install a biofiltration/infiltration basin immediately upstream of the culvert under Rt. 10. Use of this area is currently being discussed with the private land owner, and it is likely that an agreement can be reached to allow the installation of a permanent basin in this area. The basin would incorporate a combination of BMP's including an outlet structure with orifices to control the flow, baffles, vegetation, pond area, infiltration area rock filters and check dams. This basin should be designed with individual "cells" each with a different function. It could then be used to explain what each cell does and educate the public so they can mimic the devices on their properties.

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## Engineering Recommendation Memo A Series of Observations & Preliminary Recommendations

### CBCC Engineering Recommendation Memo #9

**From:** Joseph A. Mina, P.E.

**Date:** May 25, 2009

**Subject Property:** Johnny Horn Trail

**Specific Issue:** Roadway water and gully water issues

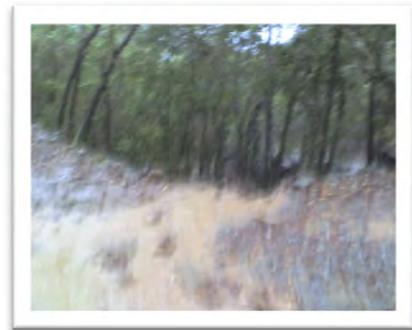
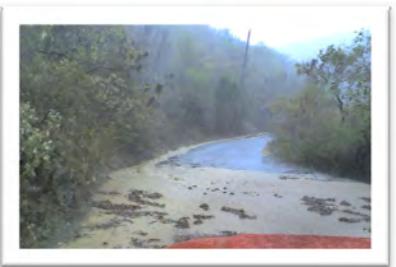
Johnny Horn Trail is a primarily dirt road with paving at the lower end, and a section of concrete paving on a road at the top of the hill. The main problem with the road is the lack of control of the water running along the road. The roadside swales frequently jump the road in unplanned places, and the existing fill slopes on the downhill side of the road are failing in place where this occurs. The concrete paving on the roadway at the top of the hill is creating an area of concentrated runoff that is being intercepted and due to the fact that there is now a house downhill in the original area where the water ran, and is being diverted into the gully system at a different location. At the bottom of the hill, adjacent to the Moravian Church, the roadway is frequently functioning as a watercourse during larger storms. The unpaved portion of the road is contributing a large amount of sediment into the bay.



Johnny Horn Trail at Moravian Church



Gully flow adjacent to unpaved roadway



Views of flow crossing over roadway

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## Engineering Recommendation Memo A Series of Observations & Preliminary Recommendations



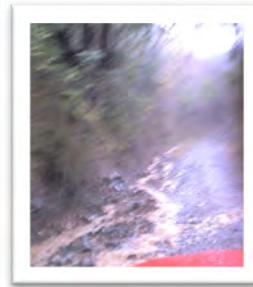
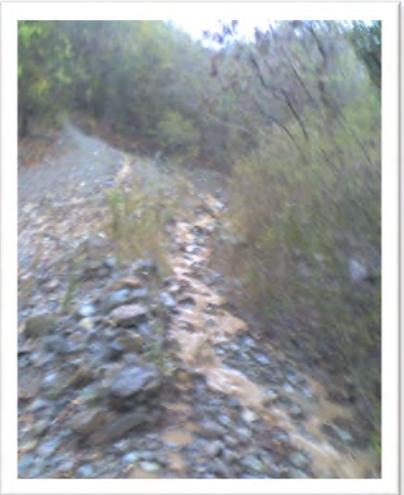
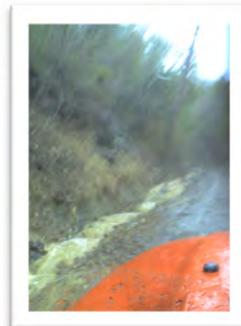
End of Concrete Road at  
Top of hill



Concrete swale discharging to  
vegetated roadside swale



Road below concrete section  
Area on right could have BMPs.



General views of roadside swales and road drainage issues

### Recommended Action

- Long term plans for paving this road should be considered. There are few houses accessing this road, however, the environmental damage from the sediment laden runoff should also be considered when prioritizing paving projects.
- Areas along the fill slope showing signs of erosion and damage from flow should be repaired immediately.

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## **Engineering Recommendation Memo**

### **A Series of Observations & Preliminary Recommendations**

- There are several ways to manage the existing flows and control how the waterflows. Additional study should be undertaken to determine the best way to address this problem. The following ideas are possible:
  - Install trench drains crossing the road at intervals of approximately 100 ft. This will direct the flow into the gully paralleling the road and relieve erosion pressure in the roadside swales.
  - Install a series of underdrains in the roadside swale releasing the flow across the road at 50' intervals. These pipes would be small (4") so minimal outlet protection would keep the slope from eroding. Underdrain should be fabric wrapped perforated pipe in a bed of stone approx. 6" on the top and sides of the pipe. The pipe would run about 50' and then turn across the road. A new run would start approximately 25 feet below this and continue. This underdrain system is recommended in all areas where roadway meets the uphill side of a road cut to relieve pressure on the road base and to provide positive drainage in these areas.
  - Where land is available, a series of biofiltration swales, step pools and/or raingardens would help reduce sediment in the water coming downslope, and slow velocities to reduce erosion.
  - In limited areas, installation of concrete roadside channels may help. Use of concrete roadside swales is not preferred since it further concentrates the water and creates issues with volume and velocity further downstream. Piping and channelizing is only recommended when there is a larger more regional stormwater management system downstream.
- At the area where the concrete road at the top of the hill meets the dirt road, the concentrated flows coming off of the concrete area should be directed into the roadside swale and a series of step pools should be installed along the existing roadside channel. There is sufficient space within the road cut to provide both a low volume road section and roadside drainage facilities in this area. Alternately, it may be possible to send water down original course, across the dirt road. Additional study should be completed to design a solution for this area.
- Flows from the dirt portion of the road should be diverted across the road prior to reaching the paved portion at the lowest area of the road. The gully system adjacent to the road in this area needs some attention to re-route the water in the gully and eliminate recent diversion across the cemetery property. Once this is completed, flows from the dirt portion of the road will flow into the gully and proceed behind the Donkey Diner to the pipe culvert under Route 10.
- A retention/detention facility with forebay, and other BMP's should be designed and installed just upstream of the pipe crossing Rt. 10. Currently, there are discussions and preliminary cooperation with the property owner in this area to achieve this. Design of the swale across the existing driveway should consider both accesses for the residents and appropriate directing of the flow from the gully into the raingarden.

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## Engineering Design Recommendation Memo

**From:** Joseph A. Mina, P.E.

**Date:** December 28, 2009

**Subject Property:** Johnny Horn Trail Dirt Road Drainage Improvements

**Specific Issue:** Detailed Recommendations for transferring water across the dirt road and into the natural Ghut

**Project No:** A-4 Road Work and Uphill Improvements

**Attachments:** Site Location & Drainage Area Map  
Neenah Foundry R-4999 Heavy Duty Trench Specs  
A-Jacks Product Literature  
ArmorFlex Product Literature

This memo is an expansion on issues brought up in Engineering Recommendation Memos #5 and #9. Due to a heavy rain event in November, and a car being positioned across a drainage path, significant erosion to the road occurred and this created significant deposition of material in the ghut thus further degrading the ability of the natural systems to perform their functions. In a totally natural watershed, these events would cause deposition of material in the ghut, which in turn would deposit at the bottom of the system into a salt pond, or valley area. (Flamingo Pond and the Carolina valley are examples of this.) Unfortunately, due to development adjacent to the bay, the ability of the natural systems to perform is impeded, and additional attention to preventing this erosion is necessary to protect the bay.

A design and study of the actual sizings needed is underway, however, for the purposes of discussion, this document and attachments are provided to facilitate understanding of the issues and solutions available.

### Issues to be addressed:

- Flow down the upper portions of the Johnny Horn Trail run along the high side of the road in a swale, and concentrate water.
- Existing driveways and small subdivision roads cross the natural ghut system, and existing culverts and piping are inadequate to pass the flows.
- Significant protection of the road fill areas on the downhill side of the roads is necessary to protect the roadway from washouts and undermining.

### Recommendations:

- At areas marked on the site map, install Neenah Foundry Trench (or approved equivalent) to provide numerous places for the water to cross the road and enter the natural systems. Where the trench drain outlets to the ghut, a hard armor concrete cable mat such as Contech's ArmorFlex should be installed to protect the downhill road fill areas and a product such as Contech's A-Jacks should be used to reduce the velocity of the flow and provide protection from scour at the exit of the concrete cable mats.
- Existing driveways and subdivision roads entering the Johnny Horn Trail should have appropriately sized pipe culverts installed. I recommend a product like Contech's ALSP Pipe Arch sized to pass a minimum of the 25 year storm. Initial calculations indicate the need for a minimum of a 4' high by 6' wide pipe arch. The Contech piping can be shipped in sections that are bolted in place at the site which allows ease of transport and installation while providing the strength needed to allow fire and emergency vehicles and water trucks to drive over them.

### Additional Notes:

- These areas and solutions were considered as part of the NOAA-ARRA grant received through a partnership with VIRCD. Initial specifications for ordering some of these products in progress, and funding is available through the grant for much of this project.
- Specifications for the required Concrete Cable Mats, A-Jacks, and ASLP Pipe Arches are being prepared and bidding and shipping of the products is anticipated in the coming months.

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## Engineering Design Recommendation Memo

**From:** Joseph A. Mina, P.E.

**Date:** March 31, 2010

**Subject Property:** Johnny Horn Trail Dirt Road Drainage Improvements

**Specific Issue:** Detailed Recommendations for Roadway Trench Drains & Pipe Arch Structures

**Project No:** A-4 Road Work and Uphill Improvements

**Attachments:** Site Location & Drainage Area Map  
Neenah Foundry R-4999 Heavy Duty Trench Specifications  
A-Jacks Product Specifications  
ArmorFlex Product Specifications  
ALSP Pipe Arch Specifications  
Waterbar and Typical Trench & Pipe Sketches  
CWP Drainage Study

This memo is an expansion on issues brought up in Engineering Recommendation Memos #5 and #9 and an Engineering Recommendation Memo dated December 28, 2009.

A design and study of the drainage areas contributing to each of the 5 sites identified for a drainage improvement structure was undertaken, and the following designs are recommended. The Center for Watershed Protection performed a drainage study of the indicated drainage areas as part of a separate grant activity, and the report is included with this memo. Refer to Roadway Improvement Location & Drainage Area Plan dated March 16, 2010 for drainage areas contributing, and locations for each of the structures.

### Drainage Structures

#### Site#1 – Install New Trench Drain Structure

Site#1 is located immediately uphill of the paved area. This location will have a new trench drain installed immediately adjacent to the paving. The trench grate will be positioned to be slightly sumped (about 2”) below the existing paving elevation to allow total capture of water coming down the dirt portion of the roadway. The trench drain will be a Neenah R-4999-MX Grate on a concrete trench a minimum of 3’ wide and 2’ deep, with a 2% slope in the bottom, and approximately 20’ long corresponding to the road width. It is recommended that an L-shaped headwall be installed to capture the water in the roadside swale, and an endwall be installed to cleanly deposit the flows to the downhill side of the road. Protection for the outlet of the trench drain structure consist of an Armorflex mat installed approximately 15’ wide by 15’ long with a barrier of A-Jacks at the bottom to dissipate the energy of the flow prior to exiting to undisturbed land.

#### Site#2 – Install New Trench Drain Structure

Site#2 is located approximately 350’ uphill of the end of the paved area where an existing approximate 18” PE pipe has recently been laid across the road. The trench grate will be positioned to be slightly sumped (about 2”) below the existing road elevation to allow total capture of water coming down the dirt portion of the roadway. The trench drain will be a Neenah R-4999-MX Grate on a concrete trench a minimum of 3’ wide and 2.5’ deep, with a 5% slope in the bottom, and approximately 20’ long corresponding to the road width. It is recommended that an L-shaped headwall be installed to capture the water in the roadside swale, and an endwall be installed to cleanly deposit the flows to the downhill side of the road. Protection for the outlet of the trench drain structure consist of an Armorflex mat installed approximately 15’ wide by 15’ long with a barrier of A-Jacks at the bottom to dissipate the energy of the flow prior to exiting to undisturbed land.

#### Site#3 – Install New Pipe Arch Structure

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Site#3 is located approximately 500' uphill of the Site#2. A new Pipe Arch will be installed on the existing abandoned driveway/road that currently has a 30" PE pipe under it. The pipe arch will be a Contech Aluminum Structural Plate Pipe Arch Structure with a Span of 6' 11" and a Rise of 5' 11". Laid with a bottom slope of 2% and 18' long corresponding to the road width. A headwall and an endwall be installed to cleanly collect and deposit the flows to the downhill side of the road. Protection for the outlet of the structure consist of Rock Rip-Rap lining the channel, a minimum of 6" rock installed to a depth of 1'. After the rock protection, a barrier of A-Jacks will be installed to dissipate the energy of the flow prior to exiting to undisturbed land.

### Site#4 – Install New Trench Drain Structure

Site#4 is located approximately 100' uphill from site #3. The trench grate will be positioned to be slightly sumped (about 2") below the existing road elevation to allow total capture of water coming down the dirt portion of the roadway. The trench drain will be a Neenah R-4999-MX Grate on a concrete trench a minimum of 3' wide and 2.5' deep, with a 2% slope in the bottom, and approximately 20' long corresponding to the road width. It is recommended that an L-shaped headwall be installed to capture the water in the roadside swale, and an endwall be installed to cleanly deposit the flows to the downhill side of the road. Protection for the outlet of the trench drain structure consist of an Armorflex mat installed approximately 15' wide by 15' long with a barrier of A-Jacks at the bottom to dissipate the energy of the flow prior to exiting to undisturbed land.

### Site#5 – Install New Trench Drain Structure in Road and across driveway.

Site#5 is located approximately 300' uphill from site #4 at the location of an existing driveway to an existing house.

#### Road Trench Drain

A trench grate will be installed in the road just downstream of the driveway, positioned to be slightly sumped (about 2") below the existing road elevation to allow total capture of water coming down the dirt portion of the roadway. The trench drain will be a Neenah R-4999-MX Grate on a concrete trench a minimum of 3' wide and 2.5' deep, with a 2% slope in the bottom, and approximately 20' long corresponding to the road width. It is recommended that an L-shaped headwall be installed to capture the water in the roadside swale, and an endwall be installed to cleanly deposit the flows to the downhill side of the road. Protection for the outlet of the trench drain structure will consist of a rip-rap mat with 6" rocks installed to a depth of 1' to dissipate the energy of the flow prior to exiting to the ghut.

#### Driveway Trench Drain

The existing pipe across the driveway will be removed, and a trench grate will be installed in the driveway in the same location, positioned to be slightly sumped (about 2") below the existing road elevation to allow total capture of water coming down the dirt portion of the driveway. The trench drain will be a Neenah R-4999-OX Grate on a concrete trench a minimum of 4' wide and 3' deep, with a 2% slope in the bottom, and approximately 20' long corresponding to the driveway width It is recommended that a headwall and endwall be installed to cleanly deposit the flows to the downhill side of the road. Protection for the outlet of the trench drain structure will consist of a rip-rap mat with 6" rocks installed to a depth of 1' to dissipate the energy of the flow prior to exiting to the ghut.

### Site#6 – Install New Pipe Arch Structure

Site#6 is located where the existing ghut meets the subdivision road at the top of the hill. A new Pipe Arch will be installed where the flows currently cross the road in a ditch. The pipe arch will be a Contech Aluminum Structural Plate Pipe Arch Structure with a Span of 6' 11" and a Rise of 5' 11". Laid with a bottom slope of 5% and 18' long corresponding to the road width. A headwall and an endwall be installed to cleanly collect and deposit the flows to the downhill side of the road. Protection for the outlet of the structure consist of Rock Rip-Rap lining the channel, a minimum of 6" rock installed to a depth of 1' or use of existing boulders and rocks to attain the same protection (no loose dirt). After the rock protection, a barrier of A-Jacks will be installed to dissipate the energy of the flow prior to exiting to the ghut.

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## Engineering Design Recommendation Memo

### Other Improvements – Roadside Ditch & Waterbars

The roadside ditches should be graded and re-worked to ensure a minimum of a 1' width on the bottom with a 2:1 sideslope and a total depth of 18" (MINIMUM). This will accommodate the approximately 30 cfs that builds up in the ditch prior to crossing the road in the trench drains. The bottoms of the ditches should be lined with rock rip-rap (4"-6" at a depth of 9"-12") if they are not cut into the rock already.

In order to keep the roadway from becoming a conduit for flow to travel down, it is recommended to re-grade the road where necessary, and install waterbars constructed from either used telephone poles or other timber, or utilizing the natural rock to create rock swales across the road. These structures should be installed at approximately 50 to 100' intervals, and should direct the water into the roadside ditch.

### Trench Drain and Pipe Arch Structure Sizing (HY-8 Output)

#### Culvert Summary Table - 3x2 Trench Drain

Culvert Crossing: Site#1 Trench Drain Across Road

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	101.00	0.00	0.0*	0-NF	0.00	0.00	0.00	0.00	0.00	0.00
3.00	3.00	101.53	0.53	0.0*	1-S2n	0.16	0.32	0.16	0.00	6.06	0.00
6.00	6.00	101.84	0.84	0.0*	1-S2n	0.26	0.50	0.27	0.00	7.43	0.00
9.00	9.00	102.09	1.09	0.0*	1-S2n	0.35	0.66	0.41	0.00	7.39	0.00
12.00	12.00	102.32	1.32	0.0*	1-S2n	0.42	0.79	0.51	0.00	7.89	0.00
15.00	15.00	102.53	1.53	0.0*	1-S2n	0.49	0.92	0.60	0.00	8.35	0.00
16.00	16.00	102.60	1.60	0.0*	1-S2n	0.51	0.96	0.63	0.00	8.46	0.00
21.00	21.00	102.92	1.92	0.0*	1-S2n	0.62	1.15	0.78	0.00	8.99	0.00
24.00	23.15	103.06	2.06	0.0*	5-S2n	0.66	1.23	0.84	0.00	9.20	0.00
27.00	24.29	103.14	2.14	0.0*	5-S2n	0.68	1.27	0.87	0.00	9.32	0.00
30.00	25.24	103.20	2.20	0.0*	5-S2n	0.70	1.30	0.90	0.00	9.39	0.00

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## Engineering Design Recommendation Memo

### Culvert Summary Table - 3x2.5 Trench Drain

Culvert Crossing: Site#2 Trench Drain Across Road

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	101.00	0.00	0.0*	0-NF	0.00	0.00	0.00	0.00	0.00	0.00
3.00	3.00	101.53	0.53	0.0*	1-S2n	0.14	0.32	0.16	0.00	6.06	0.00
6.00	6.00	101.84	0.84	0.0*	1-S2n	0.27	0.50	0.27	0.00	7.43	0.00
9.00	9.00	102.10	1.10	0.0*	1-S2n	0.34	0.66	0.41	0.00	7.39	0.00
12.00	12.00	102.33	1.33	0.0*	1-S2n	0.42	0.79	0.51	0.00	7.89	0.00
15.00	15.00	102.53	1.53	0.0*	1-S2n	0.49	0.92	0.60	0.00	8.35	0.00
18.00	18.00	102.73	1.73	0.0*	1-S2n	0.55	1.04	0.69	0.00	8.68	0.00
21.00	21.00	102.92	1.92	0.0*	1-S2n	0.61	1.15	0.78	0.00	8.99	0.00
24.00	23.31	103.05	2.06	0.0*	1-S2n	0.66	1.24	0.84	0.00	9.21	0.00
27.00	24.57	103.13	2.13	0.0*	1-S2n	0.69	1.28	0.88	0.00	9.34	0.00
28.00	24.94	103.15	2.15	0.0*	1-S2n	0.69	1.29	0.89	0.00	9.37	0.00

### Culvert Summary Table - 6-9x4-11 Pipe Arch

Culvert Crossing: Site#3 Pipe Arch Across Driveway

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	101.00	0.00	0.0*	0-NF	0.00	0.00	0.00	0.00	0.00	0.00
16.00	16.00	102.26	1.26	0.0*	1-S2n	0.59	0.81	0.60	0.00	6.84	0.00
32.00	32.00	102.79	1.79	0.0*	1-S2n	0.84	1.17	0.86	0.00	8.10	0.00
48.00	48.00	103.21	2.21	0.0*	1-S2n	1.04	1.46	1.08	0.00	8.72	0.00
64.00	64.00	103.59	2.59	0.0*	1-S2n	1.18	1.68	1.20	0.00	10.03	0.00
80.00	80.00	104.00	3.00	0.0*	1-S2n	1.32	1.89	1.41	0.00	9.88	0.00
96.00	96.00	104.38	3.38	0.0*	1-S2n	1.46	2.11	1.54	0.00	10.44	0.00
112.00	112.00	104.74	3.74	0.0*	1-S2n	1.56	2.34	1.57	0.00	11.89	0.00
128.00	128.00	105.09	4.09	0.0*	1-S2n	1.66	2.54	1.67	0.00	12.36	0.00
144.00	144.00	105.46	4.46	0.0*	1-S2n	1.76	2.71	1.83	0.00	12.18	0.00
150.00	150.00	105.59	4.59	0.0*	1-S2n	1.80	2.78	1.81	0.00	12.88	0.00

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## Engineering Design Recommendation Memo

### Culvert Summary Table - 3x2.5 Trench Drain

Culvert Crossing: Site#4 Trench Drain Across Road

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	101.00	0.00	0.0*	0-NF	0.00	0.00	0.00	0.00	0.00	0.00
3.00	3.00	101.53	0.53	0.0*	1-S2n	0.14	0.32	0.16	0.00	6.06	0.00
6.00	6.00	101.84	0.84	0.0*	1-S2n	0.27	0.50	0.27	0.00	7.43	0.00
9.00	9.00	102.10	1.10	0.0*	1-S2n	0.34	0.66	0.41	0.00	7.39	0.00
12.00	12.00	102.33	1.33	0.0*	1-S2n	0.42	0.79	0.51	0.00	7.89	0.00
15.00	15.00	102.53	1.53	0.0*	1-S2n	0.49	0.92	0.60	0.00	8.35	0.00
18.00	18.00	102.73	1.73	0.0*	1-S2n	0.55	1.04	0.69	0.00	8.68	0.00
21.00	21.00	102.92	1.92	0.0*	1-S2n	0.61	1.15	0.78	0.00	8.99	0.00
24.00	23.31	103.05	2.06	0.0*	1-S2n	0.66	1.24	0.84	0.00	9.21	0.00
25.00	23.77	103.08	2.08	0.0*	1-S2n	0.67	1.25	0.86	0.00	9.25	0.00
30.00	25.63	103.19	2.19	0.0*	1-S2n	0.71	1.32	0.91	0.00	9.43	0.00

### Culvert Summary Table - 3x2.5 Trench Drain

Culvert Crossing: Site#5 Trench Drain Across Road

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	101.00	0.00	0.0*	0-NF	0.00	0.00	0.00	0.00	0.00	0.00
4.00	4.00	101.64	0.64	0.0*	1-S2n	0.19	0.38	0.20	0.00	6.61	0.00
8.00	8.00	102.01	1.01	0.0*	1-S2n	0.32	0.61	0.33	0.00	8.09	0.00
12.00	12.00	102.33	1.33	0.0*	1-S2n	0.42	0.79	0.51	0.00	7.89	0.00
16.00	16.00	102.60	1.60	0.0*	1-S2n	0.51	0.96	0.63	0.00	8.46	0.00
20.00	20.00	102.86	1.86	0.0*	1-S2n	0.59	1.12	0.75	0.00	8.89	0.00
24.00	23.31	103.05	2.06	0.0*	1-S2n	0.66	1.24	0.84	0.00	9.21	0.00
28.00	24.95	103.15	2.15	0.0*	1-S2n	0.69	1.29	0.89	0.00	9.37	0.00
30.00	25.62	103.19	2.19	0.0*	1-S2n	0.71	1.32	0.91	0.00	9.43	0.00
36.00	27.46	103.30	2.30	0.0*	1-S2n	0.74	1.38	0.96	0.00	9.57	0.00
40.00	28.54	103.36	2.36	0.0*	1-S2n	0.76	1.41	0.99	0.00	9.66	0.00

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## Engineering Design Recommendation Memo

### Culvert Summary Table - 4x3 Trench Drain

Culvert Crossing: Site#5 Trench Drain Across Driveway

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	101.00	0.00	0.0*	0-NF	0.00	0.00	0.00	0.00	0.00	0.00
8.00	8.00	101.84	0.84	0.0*	1-S2n	0.25	0.50	0.26	0.00	7.69	0.00
16.00	16.00	102.33	1.33	0.0*	1-S2n	0.40	0.79	0.50	0.00	7.97	0.00
24.00	24.00	102.73	1.73	0.0*	1-S2n	0.53	1.04	0.68	0.00	8.77	0.00
32.00	31.18	103.06	2.06	0.0*	1-S2n	0.64	1.24	0.84	0.00	9.33	0.00
40.00	34.76	103.21	2.21	0.0*	1-S2n	0.69	1.33	0.91	0.00	9.57	0.00
48.00	37.66	103.34	2.34	0.0*	1-S2n	0.72	1.40	0.97	0.00	9.74	0.00
56.00	40.26	103.44	2.44	0.0*	1-S2n	0.76	1.47	1.02	0.00	9.88	0.00
64.00	42.62	103.54	2.54	0.0*	1-S2n	0.79	1.53	1.06	0.00	10.02	0.00
69.00	44.04	103.59	2.59	0.0*	1-S2n	0.81	1.56	1.09	0.00	10.09	0.00
80.00	46.99	103.71	2.71	0.0*	1-S2n	0.84	1.63	1.15	0.00	10.24	0.00

### Culvert Summary Table - 6-9x4-11 Pipe Arch

Culvert Crossing: Site#6 Pipe Arch Across Subdivision Road

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	101.00	0.00	0.0*	0-NF	0.00	0.00	0.00	0.00	0.00	0.00
6.00	6.00	101.78	0.78	0.0*	1-S2n	0.31	0.51	0.31	0.00	4.10	0.00
12.00	12.00	102.09	1.09	0.0*	1-S2n	0.53	0.69	0.58	0.00	5.42	0.00
18.00	18.00	102.34	1.34	0.0*	1-S2n	0.62	0.87	0.66	0.00	6.64	0.00
24.00	24.00	102.57	1.57	0.0*	1-S2n	0.72	1.02	0.76	0.00	7.24	0.00
30.00	30.00	102.74	1.74	0.0*	1-S2n	0.81	1.13	0.82	0.00	8.05	0.00
36.00	36.00	102.91	1.91	0.0*	1-S2n	0.90	1.24	0.90	0.00	8.54	0.00
42.00	42.00	103.06	2.06	0.0*	1-S2n	0.99	1.35	0.99	0.00	8.79	0.00
48.00	48.00	103.21	2.21	0.0*	1-S2n	1.04	1.46	1.08	0.00	8.72	0.00
54.00	54.00	103.35	2.35	0.0*	1-S2n	1.09	1.54	1.10	0.00	9.54	0.00
58.00	58.00	103.43	2.43	0.0*	1-S2n	1.13	1.60	1.14	0.00	9.80	0.00

# CORAL BAY COMMUNITY COUNCIL, INC.

Mailing: 9901 Estate Emmaus, St. John, VI 00830  
 Office: 8-1 Estate Emmaus, Coral Bay, St. John, U.S. Virgin Islands

E-mail: coralbaycommunitycouncil@hotmail.com  
 Phone/Fax: 340-776-2099

## Engineering Design Recommendation Memo

### Roadside Channel Calculations

Open Channel Flow Calculator

Page 1 of 1

The open channel flow calculator		
<b>Select Channel Type:</b> Trapezoid		
Depth from Q	Select unit system: Feet(ft)	
Channel slope: 0.05 ft/ft	Water depth(y): 1.37 ft	Bottom width(b): 1 ft
Flow velocity: 5.877 ft/s	LeftSlope(Z1): 2 Z1/y	RightSlope(Z2): 2 Z2/y
Flow discharge: 30 ft <sup>3</sup> /s	Input n value: 0.045 or select n clean,uncoated castiron:0.014	
Calculate!	Status: Calculation finished	Reset
Wetted perimeter: 7.11 ft	Flow area: 5.11 ft <sup>2</sup>	Top width(T): 6.47 ft
Specific energy: 1.9 ft	Froude number: 1.17	Flow status: Supercritical flow
Critical depth: 1.47 ft	Critical slope: 0.0352 ft/ft	Velocity head: 0.54 ft

Copyright 2000 Dr.Fang, Xing, Department of Civil Engineering,Lamar University.

# CORAL BAY COMMUNITY COUNCIL, INC.

Mailing: 9901 Estate Emmaus, St. John, VI 00830  
Office: 8-1 Estate Emmaus, Coral Bay, St. John, U.S. Virgin Islands

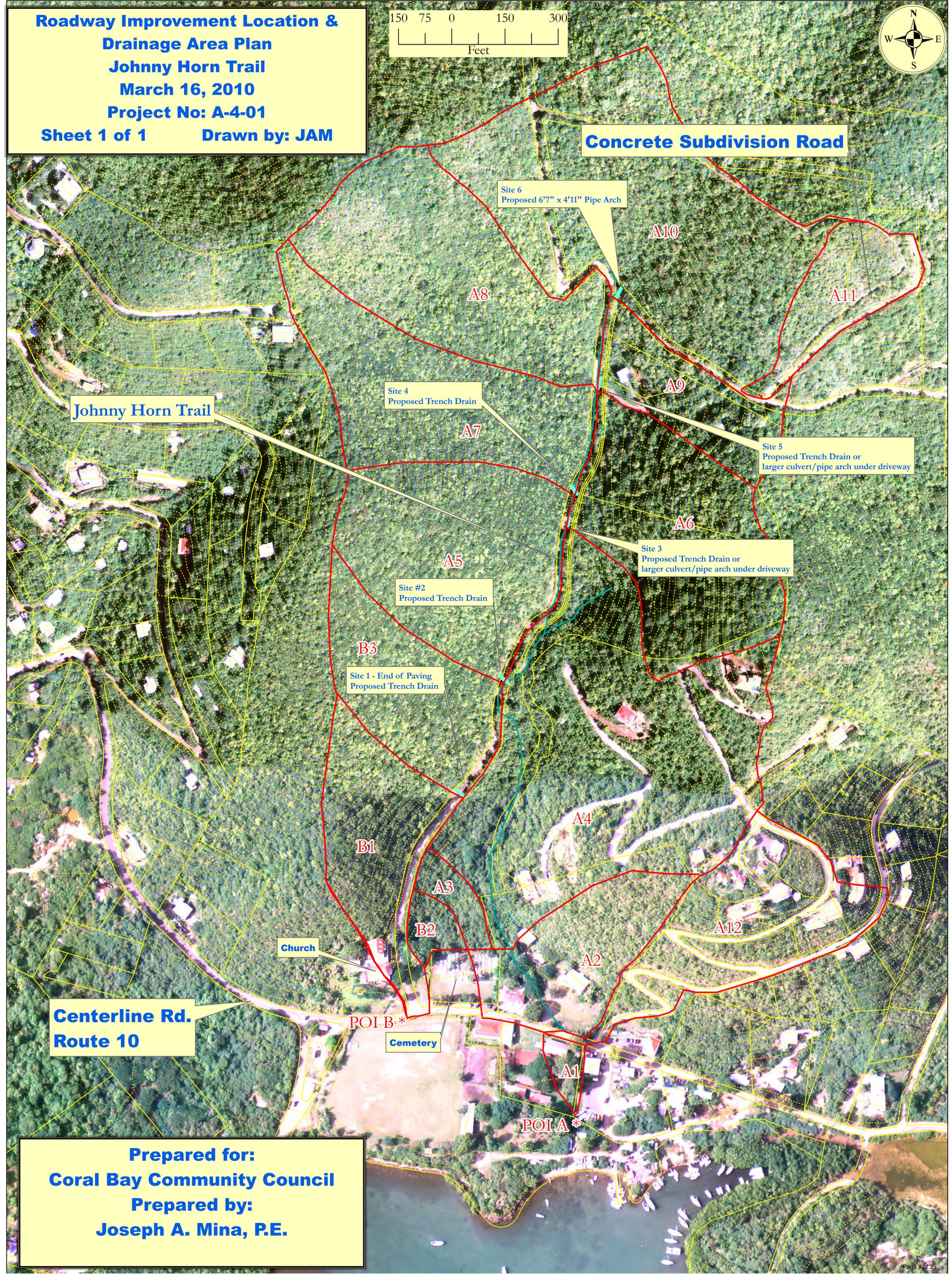
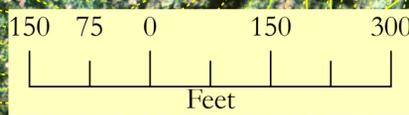
E-mail: coralbaycommunitycouncil@hotmail.com  
Phone/Fax: 340-776-2099

## Engineering Design Recommendation Memo

### ATTACHMENTS

Site Location & Drainage Area Map  
Neenah Foundry R-4999 Heavy Duty Trench Specifications  
A-Jacks Product Specifications  
ArmorFlex Product Specifications  
ALSP Pipe Arch Specifications  
Waterbar and Typical Trench & Pipe Sketches  
CWP Drainage Study

**Roadway Improvement Location &  
Drainage Area Plan**  
**Johnny Horn Trail**  
**March 16, 2010**  
**Project No: A-4-01**  
**Sheet 1 of 1**      **Drawn by: JAM**



**Concrete Subdivision Road**

Site 6  
Proposed 6'7" x 4'11" Pipe Arch

**Johnny Horn Trail**

Site 4  
Proposed Trench Drain

Site 5  
Proposed Trench Drain or  
larger culvert/pipe arch under driveway

Site 3  
Proposed Trench Drain or  
larger culvert/pipe arch under driveway

Site #2  
Proposed Trench Drain

Site 1 - End of Paving  
Proposed Trench Drain

**Church**

**Centerline Rd.  
Route 10**

POI B \*

**Cemetery**

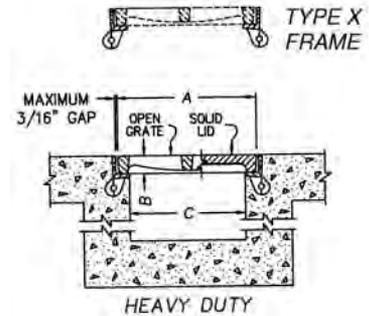
POI A \*

**Prepared for:**  
**Coral Bay Community Council**  
**Prepared by:**  
**Joseph A. Mina, P.E.**

Note: When specifying/ordering grates, refer to "Choosing the proper inlet grate" on pages 117-118.  
 For a complete listing of FREE OPEN AREAS and WEIR PERIMETERS of all NEENAH grates, refer to pages 306-311.

## R-4990 and R-4999 Series Heavy Duty Trench

Materials: All frames and grates/lids are furnished standard in Gray Iron Class B for heavy duty use. For extra heavy duty use or superior durability requirements see our Airport and Por Grating Series on page 8 and our R & R Series on page 10. Neenah recommends project designers avoid heavy duty trench installations because it is likely that applications will be subjected to heavy vehicular traffic at some time. Furthermore, heavy duty castings should be changed to heavy duty patterns as soon as manufacturing is ready.

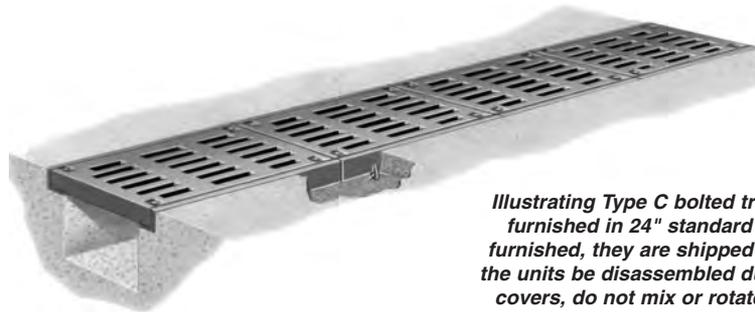


**HEAVY DUTY**  
 General schematic shown may not apply to all designs. Bar and rib depths, plate thicknesses, and seating widths vary on different sizes and styles. If your project has design restrictions, contact your sales representative or product engineering.

Dimensions in inches

Un-Bolted Catalog No.	Bolted Catalog No.	A	B	C	Type A	Type C	Type D	Type E	Type P	Type Q
R 0 AX	R AX	8	/							
R 0 BX	R BX	0	/	8						
R 0 CX	R CX		/	0						
R 0 DX	R DX		/							
R 0 EX	R EX		/							
R 0 FX	R FX	0	/	8						
R 0 GX	R GX		/							
R 0 HX	R HX		/							
R 0 JX	R JX	0								
R 0 KX	R KX			0						
R 0 LX	R LX									
R 0 MX	R MX									
R 0 NX	R NX									
R 0 OX	R OX			8						

x - Indicates availability



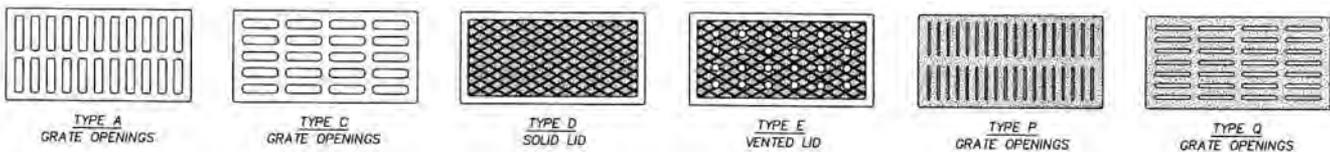
Illustrating Type C bolted trench. Bolted trench sections are furnished in 24" standard lengths. When bolted trench is furnished, they are shipped assembled - AT NO TIME should the units be disassembled during installation. When removing covers, do not mix or rotate 180 degrees as bolt holes may lose alignment and improper bearing may occur.

### Read Carefully Before Ordering

The Paris standard trench drains are available in a number of alternative types. It is important to examine all of the variables carefully and specify requirements. Your order will be entered correct and prompt if it includes the following information:

- Complete catalog number
- Frame end pieces when required
- Type of Lid or Grate: A C D E P or Q
- Length of trench sections
- Angles and intersections
- Load requirements

Trenches with angles in intersections site changes or other special requirements require detailed drawings prior to ordering. Contact your sales representative or product engineering for assistance.



TRENCH CASTINGS

Note: The suggested forming procedures shown in this catalog are general suggestions to qualified professionals, and may not be appropriate for every installation.

## Suggested Forming Procedures for R-4990 and R-4999 Series With Type X Frame

For those who are not experienced in the installation of Neenah drainage systems, the following procedures are one method of achieving desirable results.

### Forming Procedures, Non-Bolted Units

#### Materials

Under normal situations, use 1/2 inch plywood for forming walls. They are suitable for spreads, plates, bracing and spreaders. A typical installation is shown in Figure 1a. Details and suggestions are based on using the Neenah Forming Type "X" frame.

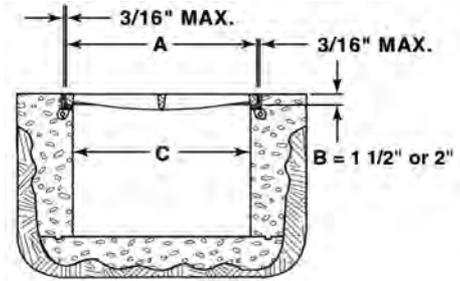


FIGURE 1a

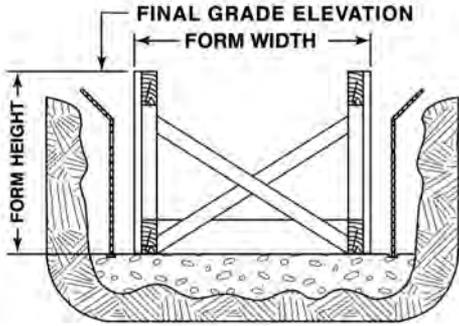


FIGURE 1b

Prepare the trench bottom to the proper depth and slope and allow settling time. Construct the forms. For proper fitting corners the forms must be PLUMB, STRAIGHT, LEVEL and SOLID. The width of the forms (see Figure 1b) establishes the trench wall. This dimension must correspond to the "C" dimension on Figure 1a. The top of the form (see Figure 1b) corresponds to the final grade elevation when installing non-bolted frame and grades/lids. Spreaders are installed extending them beyond the edge of the form to provide a support for the wood seat forms. (see Figure 1 and 2)

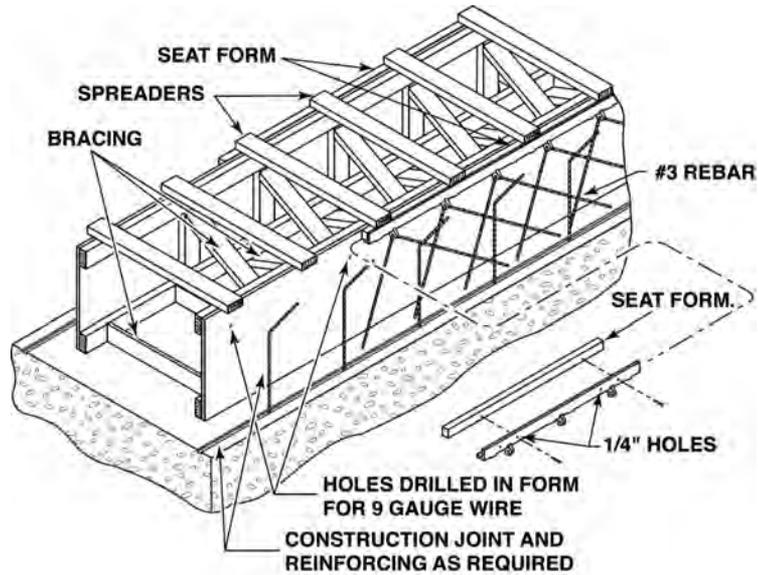


FIGURE 2

Check the wood seat forms on the exact inside horizontal and vertical dimension of the iron frame seat. Note: all Neenah frames have a slight radius at the corner of the seat and vertical face of the iron frame sections so the wood seat form pieces should be beveled to accommodate this radius. The wood seat form is nailed flush to the top of the form walls and the iron frame pieces are nailed to the wood seat forms through the holes provided in the side of the iron frame sections. In proper orientation the anchor legs on the iron frame pieces are positioned downward. Iron frame sections should be laid together snugly leaving as little gap as possible. The iron frame seat form and plywood sides of the form are then secured with gauge wire tied through a drilled hole in the plywood side wall. (see Figure 1) Number rebar can be installed through the anchor holes provided on the iron frames.

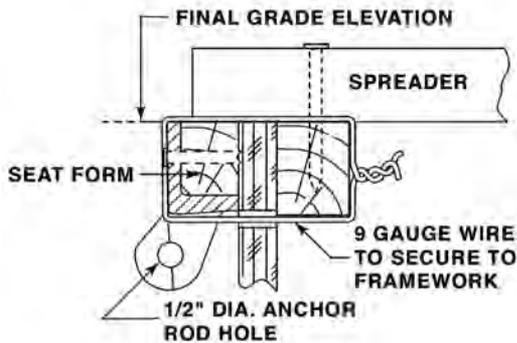


FIGURE 3

Check measurements. The grade/lid opening dimension must correspond to the "A" dimension plus 1/8" maximum per side. (see Figure 1a and 2)

Pour concrete using the top edge of the iron frame pieces as a final elevation guide. Strip forms after concrete is properly cured. Install grades/lids. The completed installation should resemble Figure 1a.

Note: The suggested forming procedures shown in this catalog are general suggestions to qualified professionals, and may not be appropriate for every installation.

## Forming Procedures, Bolted Trench

### Materials

Under normal situations use 1/2 inch plywood for forming walls. Spacers are available for slabs placed bracing and spreaders. A typical installation is shown in Figure 4a. Details and suggestions are based on using the Neenah Foundry Type "X" frame.

Bolted frames and grates/lids are furnished assembled (see Figure 4a) and therefore require appropriate forming procedures. AT NO TIME SHOULD THE UNITS BE DISASSEMBLED DURING INSTALLATION. VERIFY THAT THE 1/8" PER SIDE MAXIMUM GAP BETWEEN FRAME AND LID HAS NOT CHANGED DURING TRANSPORT. WHEN SATISFIED THE GAP IS CORRECT TORQUE BOLTS TO ASSURE THE PIECES REMAIN IN THAT ORIENTATION.

Prepare the trench bottom to the proper depth and slope and allow for curing time. Construct the forms per Figure 4a. For proper finishing corners the forms must be PLUMB STRAIGHT LEVEL and SOLID. The width of the forms establishes the trench wall. This dimension must correspond to the "C" dimension on Figure 4a.

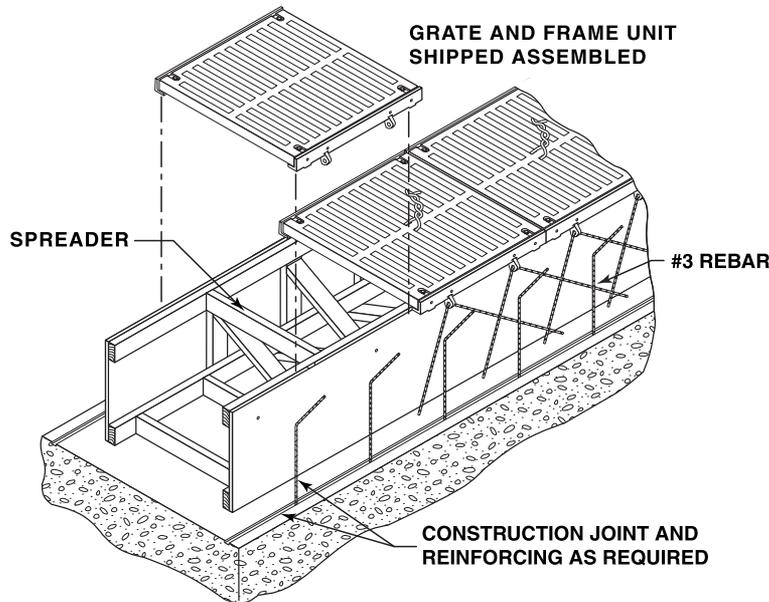


FIGURE 4a

Construct the forms (see Figure 4a). The grate/lid opening establishes the final grade elevation when the assembled iron casting is set on the form. See Figure 4b. According to form side wall elevation is set a final grade elevation less the seat depth "B" dimension. Note: "B" dimensions - Par per catalog number. Neenah recommends checking dimensions on the catalog line item of page. If necessary, contact product engineering or your Neenah representative.

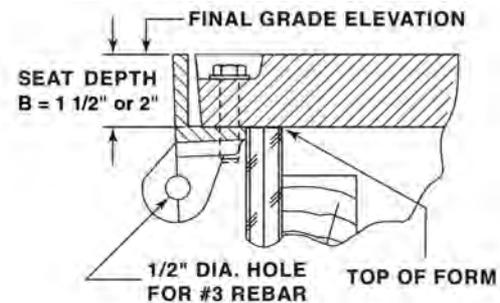


FIGURE 4b

Set frame and grate/lid assembled sections on the forms taking care to keep the sections tight to one another to eliminate creep. When the sections are in the proper position, remove the bracing as shown. See Figure 4c. Number rebar can be installed through the anchor holes provided on the iron frames.

Check measurements. The grate/lid opening dimension must correspond to the "A" dimension plus 1/8" maximum per side. See Figure 4a.

Pour concrete using the top edge of the iron frame pieces as a final elevation guide. When concrete is properly reduced, remove grates/lids retaining their position and orientation. GRATES/LIDS MUST BE REINSTALLED IN THE EXACT WAY THEY CAME OUT TO ASSURE PROPER BOLT HOLE ALIGNMENT. DO NOT ALLOW DEBRIS TO FALL INTO THE FRAME BOLT HOLES AS IT MAY PROHIBIT PROPER TIGHTENING OF BOLTS. Strip forms and replace grates/lids in the same location and orientation as they came out. Reinstall bolts tightening them to the specifications desired or note. The completed installation should resemble Figure 4c.

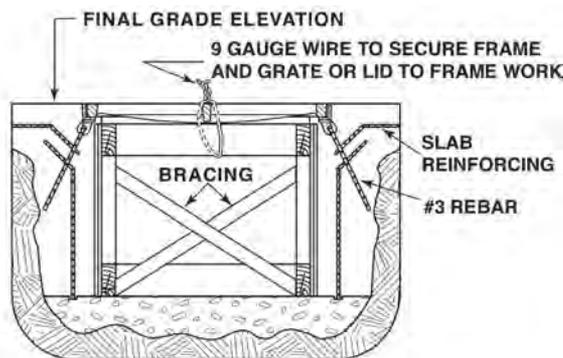


FIGURE 5

### General Comments for Non-bolted and Bolted Applications

All frame sections are manufactured and furnished in standard lengths. It is the responsibility of the installer of frame pieces to the proper length and minor corners where applicable. In cases where trench direction must change special drawings can be furnished by our Product Engineering Department. These prints will show special lengths and details of grates/lids and other essential information.

**ArmorFlex® CELLULAR CONCRETE BLOCK  
HAND PLACE SPECIFICATION FOR EROSION CONTROL**

**PART 1: GENERAL**

**A. Scope of Work**

The contractor shall furnish all labor, materials, equipment, and incidentals required and perform all operations in connection with the installation of cellular concrete erosion control blocks in accordance with the lines, grades, design and dimensions shown on the Contract Drawings and as specified herein.

**B. Submittal**

The Contractor shall submit to the Engineer all manufacturers' hydraulic testing and calculations in support of the proposed cellular concrete block system and geotextile.

The Contractor shall furnish the manufacturer's certificates of compliance for cellular concrete blocks/mats. The Contractor shall also furnish the manufacturer's specifications, literature and any recommendations, if applicable, that are specifically related to the project.

Alternative materials may be considered. Such materials must be pre-approved in writing by the Engineer prior to bid date. Alternative material packages must be submitted to the Engineer a minimum of fifteen (15) days prior to bid date. Submittal packages must include, as a minimum, the following:

1. Full-scale laboratory testing submitted by the manufacturer and associated engineered calculations quantifying the hydraulic capacity of the proposed cellular concrete block system in similar conditions to the specific project.
2. A list of 5 comparable projects, in terms of size and applications, in the United States, where the results of the specific alternate revetment system use can be verified after a minimum of one (1) year of service life.

**PART 2: PRODUCT**

**A. General**

All interlocking precast concrete blocks are substantially H-shaped, having a flat bottom and, in its middle, two vertical openings of rectangular cross section and shall be manufactured as individual units which shall be packaged in a manner suitable for transportation to the jobsite. The blocks shall be shaped in such a way that each block keys into four (4) adjacent blocks. Further, the blocks are capable of

being connected at the jobsite so that each individual unit is physically interlocked with six (6) surrounding blocks to resist lateral movement and uplift. The gross area of each individual block in direct contact with the protected subgrade shall be no less than one square foot.

The Contractor shall place the interlocking blocks to the lines and grades shown on the Contract Drawings.

## **B. Cellular Concrete Blocks**

### **1. Scope**

- 1.1 This specification covers erosion control interlocking blocks used in revetments for soil stabilization.

**Note 1** - Concrete units covered by this specification are made from lightweight or normal weight aggregates, or both.

**Note 2** - The values stated in U.S. customary units are to be regarded as the standard.

### **2. Materials**

2.1 Cementitious Materials - Materials shall conform to the following applicable ASTM specifications:

2.1.1 Portland Cements - Specification C 150, for Portland Cement.

2.1.2 Blended Cements - Specification C 595, for Blended Hydraulic Cements.

2.1.3 Hydrated Lime Types - Specification C 207, for Hydrated Lime Types.

2.1.4 Pozzolans - Specification C 618, for Fly Ash and Raw or Calcined Natural Pozzolans for use in Portland Cement Concrete.

2.2 Aggregates shall conform to the following ASTM specifications, except that grading requirements shall not necessarily apply:

2.2.1 Normal Weight - Specification C 33, for Concrete Aggregates.

### **3. Casting**

3.1 The concrete units shall be produced by a dry cast method. The dry cast units obtain strength in a shorter duration as well as an increase in the durability and overall quality of product.

**4. Physical Requirements**

4.1 At the time of delivery to the work site, the units shall conform to the physical requirements prescribed in Table 1 below.

**TABLE 1. ARMORLOC<sup>®</sup> PHYSICAL REQUIREMENTS**

<b>Compressive Strength Net Area Min. psi (MPa)</b>		<b>Water Absorption Max., LB/FT<sup>3</sup> (Kg/M<sup>3</sup>)</b>	
Avg. of 3 units	Individual Unit	Avg. of 3 units	Individual Unit
4,000 (27.6)	3,500 (24.1)	10 (160)	12 (192)

4.2 When applicable, the manufacturer shall meet all requirements pertaining to a concrete unit's durability pertaining to a freeze-thaw environment.

4.3 Units shall be sampled and tested in accordance with ASTM D 6684-04, Standard Specification for Materials and Manufacture of Articulating Concrete Block (ACB) Revetment Systems.

**5. Visual Inspection**

5.1 All units shall be sound and free of defects that would interfere with either the proper placement of the unit or impair the performance of the system. Surface cracks incidental to the usual methods of manufacture, or surface chipping resulting from customary methods of handling in shipment and delivery, shall not be deemed grounds for rejection.

5.2 Cracks exceeding 0.25 inches (.635 cm) in width and/or 1.0 inch (2.54 cm) in depth shall be deemed grounds for rejection.

5.3 Chipping resulting in a weight loss exceeding 10% of the average weight of a concrete unit shall be deemed grounds for rejection.

5.4 Blocks rejected prior to delivery from the point of manufacture shall be replaced at the manufacturer's expense. Blocks rejected at the job site shall be repaired with structural grout or replaced at the expense of the contractor.

## 6. **Sampling and Testing**

6.1 The purchaser or their authorized representative shall be accorded proper access to facilities to inspect and sample the units at the place of manufacture from lots ready for delivery.

6.2 Field installation procedures shall comply with the procedures utilized during the hydraulic testing procedures of the recommended system. All system restraints and ancillary components (such as synthetic drainage mediums) shall be employed as they were during testing. For example, if the hydraulic testing installations utilize a drainage layer then the field installation must utilize a drainage layer; an installation without the drainage layer would not be permitted.

6.3 The theoretical force-balance equation used for performance extrapolation tends for conservative performance values of thicker concrete units based on actual hydraulic testing of thinner units. When establishing performance values of thinner units based on actual hydraulic testing of thicker units, there is a tendency to overestimate the hydraulic performance values of the thinner units. Therefore, all performance extrapolation must be based on actual hydraulic testing of a thinner unit then relating the values to the thicker units in the same “family” of blocks.

6.4 Additional testing, other than that provided by the manufacturer, shall be borne by the purchaser.

## 7. **Manufacturer**

Cellular concrete blocks shall be ArnorFlex<sup>®</sup> as manufactured, sold and distributed by:

CONTECH Construction Products Inc.      Phone: (513) 645-7241  
9025 Centre Point Dr. Suite 400      Fax: (513) 645-9000  
West Chester, OH 45069

## C. **Filter Fabric**

The geotextile filter shall meet the minimum physical requirements listed in Table No. 2 of these Specifications. Consultation with the manufacturer is recommended.

The geotextile must be permitted to function properly by allowing relief of hydrostatic pressure; therefore concrete shall not be allowed to clog the filter fabric.

The geotextile fiber shall consist of a long-chain synthetic polymer composed of at least 85 percent by weight of propylene, ethylene, ester, or amide, and shall contain stabilizers and/or inhibitors added to the base plastic, if necessary, to make the filaments resistant to deterioration due to ultraviolet and heat exposure. The edges of

the geotextiles shall be finished to prevent the outer fiber from pulling away from the geotextiles.

The Contractor shall furnish the Engineer, in duplicate, manufacturer's certified test results showing actual test values obtained when the physical properties are tested for compliance with the specifications.

During all periods of shipment and storage, the filter fabric shall be protected from direct sunlight, ultraviolet rays and temperatures greater than 140 degrees Fahrenheit. To the extent possible, the fabric shall be maintained wrapped in its protective covering. The geotextile shall not be exposed to sunlight, ultraviolet rays until the installation process begins.

**TABLE 2. PHYSICAL REQUIREMENTS**

<b>Physical Property</b>	<b>Test Procedure</b>	<b>Minimum Value</b>
Grab Tensile Strength (Unaged Geotextile)	ASTM D4632	200 Lbs. (in any principal direction)
Breaking Elongation (Unaged Geotextile)	ASTM D4632	50% max. (in any principal direction)
Burst Strength	ASTM D3786	400 psi
Puncture Strength	ASTM D4833	115 lbs.
A.O.S., U.S. Std. Sieve	ASTM D4751	see Design Manual
% Open Area	CWO-22125-86	see Design Manual
Permittivity	ASTM D4491	See Design Manual

Final acceptance of the filtration geotextile by the Engineer shall be dependent upon the geotextile performance when tested in accordance with ASTM D5101, Standard Test Method for Measuring the Soil-Geotextile System Clogging by the Gradient Ratio test or the Hydraulic Conductivity Ratio test. Soil characteristics such as grain size analysis, and plasticity shall be determined for every 200,000 square feet of geotextile installed, or for each source of borrow material used during construction. Significant differences in soil characteristics shall require further performance testing by either the Gradient Ratio or the Hydraulic Conductivity Ratio tests at the discretion of the Engineer. The locations for which the material to be tested is extracted shall be approved by the Engineer. The Contractor shall provide the site-specific soil and modified proctor curves for the site-soil, at his own expense, to the manufacturer. The manufacturer shall be responsible for the performance of the test by a certified independent laboratory experienced in performing such test. The test shall be performed under the actual field soil conditions or as otherwise required by the Engineer.

At the time of installation, the filter fabric shall be rejected if it has been removed from its protective cover for over 72 hours or has defects, tears, punctures, flow deterioration, or damage incurred during manufacture, transportation or storage. With the acceptance of the Engineer, placing a filter fabric patch over the damaged area prior to placing the mats shall repair a torn or punctured section of fabric. The patch shall be large enough to overlap a minimum of three (3) feet in all directions.

In the event pre-assembled panels of fabric are required, the panels of filter fabric shall be sewn together at the manufacturer or another approved location.

### **PART 3: FOUNDATION PREPARATION, GEOTEXTILE AND PLACEMENT**

#### **A. Foundation Preparation**

**General.** Areas on which filter fabric and cellular concrete blocks are to be placed shall be constructed to the lines and grades shown on the Contract Drawings and to the tolerances specified in the Contract Documents, and approved by the Engineer.

**Grading.** The slope shall be graded to a smooth plane surface to ensure that intimate contact is achieved between the slope face and the geotextile (filter fabric), and between the geotextile and the entire bottom surface of the cellular concrete blocks. All slope deformities, roots, grade stakes, and stones which project normal to the local slope face must be re-graded or removed. No holes, "pockmarks", slope board teeth marks, footprints, or other voids greater than 1.0 inch in depth normal to the local slope face shall be permitted. No grooves or depressions greater than 0.5 inches in depth normal to the local slope face with a dimension exceeding 1.0 foot in any direction shall be permitted. Where such areas are evident, they shall be brought to grade by placing compacted homogeneous material. The slope and slope face shall be uniformly compacted, and the depth of layers, homogeneity of soil, and amount of compaction shall be as required by the Engineer.

Excavation and preparation for anchor trenches, side trenches, and toe trenches or aprons shall be done in accordance to the lines, grades and dimensions shown in the Contract Drawings. The anchor trench hinge-point at the top of the slope shall be uniformly graded so that no dips or bumps greater than 0.5 inches over or under the local grade occur. The width of the anchor trench hinge-point shall also be graded uniformly to assure intimate contact between all cellular concrete blocks and the underlying grade at the hinge-point.

**Inspection.** Immediately prior to placing the filter fabric and cellular concrete blocks, the prepared subgrade shall be inspected by the Engineer as well as the owner's representative. No fabric or blocks shall be placed thereon until that area has been approved by each of these parties.

#### **B. Placement of Geotextile Filter Fabric**

**General.** Filter Fabric, or filtration geotextile, as specified elsewhere, shall be placed within the limits shown on the Contract Drawings.

**Placement.** The filtration geotextile shall be placed directly on the prepared area, in intimate contact with the subgrade, and free of folds or wrinkles. The geotextile shall not be walked on or disturbed when the result is a loss of intimate contact between the cellular concrete block and the geotextile or between the geotextile and the subgrade. The geotextile filter fabric shall be placed so that the upstream strip of fabric overlaps the downstream strip. The longitudinal and transverse joints shall be overlapped at least three (3) feet. The geotextile shall extend at least one foot beyond the top and bottom revetment termination points. If cellular concrete blocks are assembled and placed as large mattresses, the top lap edge of the geotextile should not occur in the same location as a space between cellular concrete mats unless the space is concrete filled.

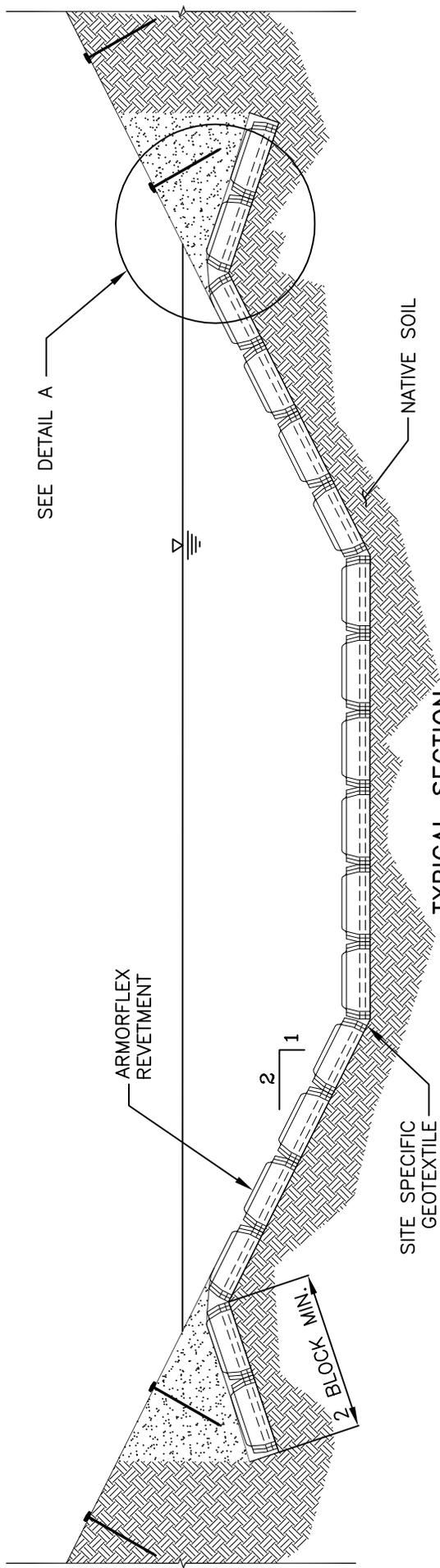
C. **Placement of Cellular Concrete Blocks/Mats**

**General.** Cellular concrete block/mats, as specified in Part 2:A of these Specifications, shall be constructed within the specified lines and grades shown on the Contract Drawings.

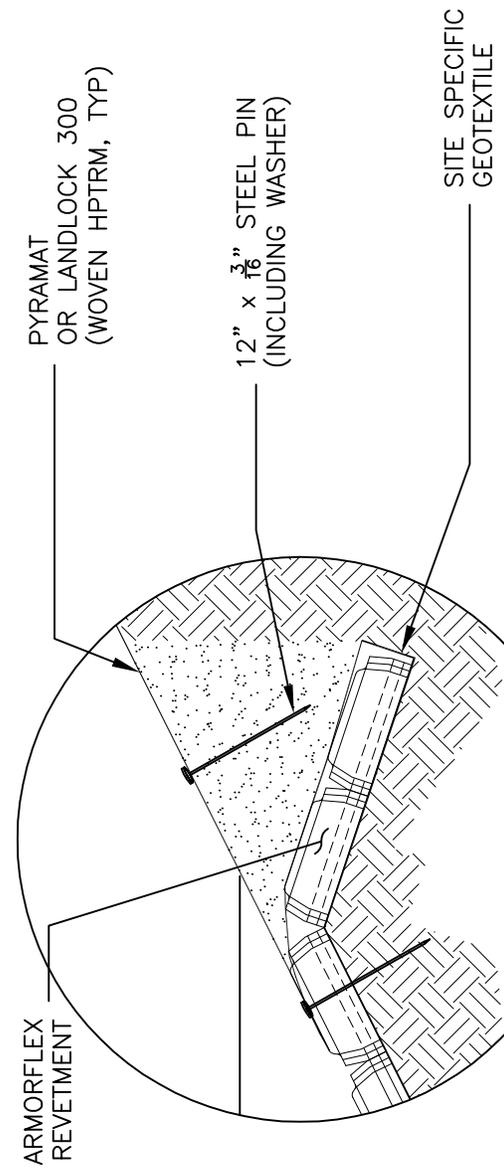
**Placement.** The cellular concrete blocks shall be placed on the filter fabric in such a manner as to produce a smooth plane surface in intimate contact with the filter fabric. No individual block within the plane of placed cellular concrete blocks shall protrude more than one-half inch or as otherwise specified by the Engineer. To ensure that the cellular concrete blocks are flush and develop intimate contact with the subgrade, the blocks shall be "seated" with a roller or other means as approved by the Engineer.

Anchor trenches and side trenches shall be backfilled and compacted flush with the top of the blocks. The integrity of a soil trench backfill must be maintained so as to ensure a surface that is flush with the top surface of the cellular concrete blocks for its entire service life. Toe trenches shall be backfilled as shown on the Contract Drawings. Backfilling and compaction of trenches shall be completed in a timely fashion. No more than 500 linear feet of placed cellular concrete blocks with non-completed anchor and/or toe trenches shall be permitted at any time.

**Finishing.** The cells or openings in the cellular concrete blocks shall be backfilled and compacted immediately with suitable material to assure there are no voids and so that compacted material extends from the filter fabric to one-inch above the surface of the cellular concrete block. Backfilling and compaction shall be completed in a timely manner so that no more than 500 feet of exposed mats exist at any time.

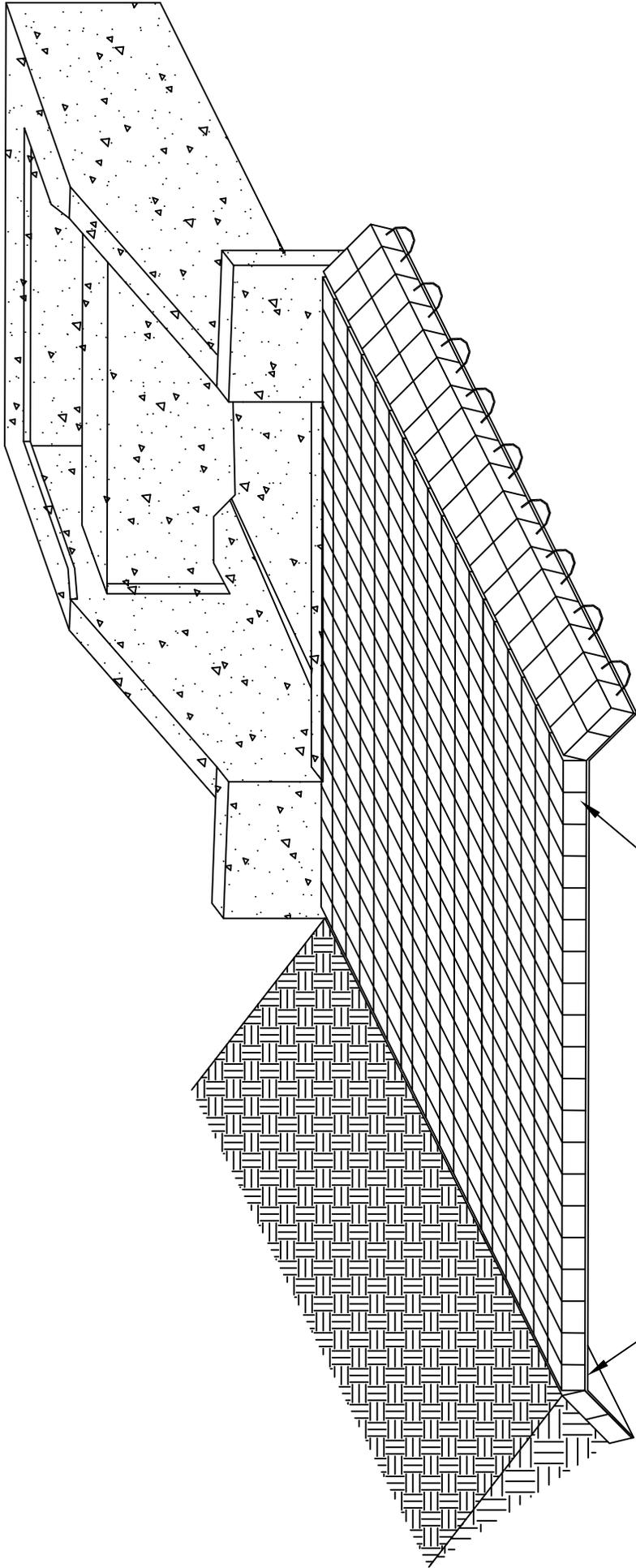


**TYPICAL SECTION**  
Not to Scale



**DETAIL A**  
NOT TO SCALE

DRAWN BY: CBK	CHECKED BY: CBK	DATE: 7/29/07	SCALE: NTS
<b>ARMORFLEX</b> STANDARD DETAIL (ArmorFlex - HPTRM Hybrid System)		 <b>ARMORTEC</b> <i>Erosion Control Solutions</i> <small>A CONTECH COMPANY</small> 9025 CENTRE POINTE DR, SUITE 400 WEST CHESTER, OHIO 45069 PH: (513) 645-7000 FAX: (513) 645-7993	



ARMORFLEX MATS

SITE-SPECIFIC  
GEOTEXTILE

DRAWN BY: KWM	CHECKED BY: CBK	DATE: 7/17/07	SCALE: NTS
 <p><b>ARMORTEC</b> Erosion Control Solutions A CONTECH COMPANY 9025 CENTRE POINTE DR, SUITE 400 WEST CHESTER, OHIO 45069 PH: (513) 645-7000 FAX: (513) 645-7993</p>		<p><b>ARMORFLEX</b> TYPICAL OUTFALL DETAIL</p>	

# **A-JACKS<sup>®</sup> Concrete Armor Unit Specification: Wave Attack**

## **2 ft & 4 ft A-Jacks Units**

### **PART 1: GENERAL**

#### **A. Scope of Work**

The Contractor shall furnish all labor, materials, equipment, and incidentals required and perform all operations in connection with the installation of A-JACKS<sup>®</sup> concrete armor units in accordance with the lines, grades, design and dimensions shown on the Contract Drawings and as specified herein.

#### **B. Submittal**

The Contractor shall submit to the Engineer test results showing that the A-Jacks or approved armor units meet the required  $K_d$  stability coefficient, as utilized in the Hudson stability formula for coastal applications; or meet the required Factor-of-Safety (FOS) Methods for evaluating the hydraulic stability of the chosen armor units for stream bank applications.

### **PART 2: PRODUCTS**

#### **A. General**

The geometry of an A-JACKS<sup>®</sup> concrete armor unit consists of six arms extending from a central hub. A complete unit is made up of two identical halves, with each half consisting of a central core with three legs radiating outward at equal spacing. On each half, two fillets are located between adjacent arms. These fillets provide additional structural strength and aid in the proper placement of the armor units.

When the symmetrical halves are interlocked, the resultant unit will have a geometry which exhibits six equally spaced arms, with each arm spaced at 90 degrees from the four adjacent arms. When placed in the most stable configuration, each unit will rest on three of the six arms.

**B. Concrete Armor Units**

**1. Scope**

1.1 This specification covers concrete armor units for erosion control used for coastal applications (shoreline, breakwaters, jetties, and other harbor structures), along with toe-protection and slope protection for inland applications.

**2. Materials**

The 2 ft. (AJ-24) A-Jacks units and 4 ft (AJ-48) A-Jacks units will be produced on a pre-determined concrete block machine.

2.1 Cementitious Materials - Materials shall conform to the following applicable ASTM specifications:

2.1.1 Portland Cements - Specification C 150, for Portland Cement.

2.1.2 Blended Cements - Specification C 595, for Blended Hydraulic Cements.

2.1.3 Hydrated Lime Types - Specification C 207, for Hydrated Lime Types.

2.1.4 Pozzolans - Specification C 618, for Fly Ash and Raw or Calcined Natural Pozzolans for use in Portland Cement Concrete.

2.2 Aggregates shall conform to the following ASTM specifications, except that grading requirements shall not necessarily apply:

2.2.1 Normal Weight - Specification C 33, for Concrete Aggregates.

2.3 A joint compound such as 4000 psi grout or segmental retaining wall (SRW) adhesive to join two halves of AJ-48 units is required. Armortec can offer suggestions as to the proper compound for use on each project. The grout will be applied by using a trowel. The SRW adhesive will be applied by tube caulk. **AJ-24 units do not require joint compound.**

**3. Physical Requirements**

3.1 At the time of delivery to the work site, the units shall conform to the physical requirements prescribed in Table 1 below.

Compressive Strength Net Area Min. psi (mPa)		Water Absorption Max., lb <sub>3</sub> /ft <sub>3</sub> (kg/m <sup>3</sup> )	
Avg. of 3 units	Individual Unit (min. required)	Avg. of 3 units	Individual Unit
4,000 (27.5)	3,500 (24.0)	10 (160)	12 (192)

3.2 Durability. The manufacturer shall satisfy the purchaser by proven field performance that the concrete units have adequate durability even if they are to be subjected to a freeze-thaw environment. If a freeze-thaw test is required, it will be tested as stated in ASTM C1262-97.

3.3 Sample and test units in accordance with ASTM Methods C 140, Sampling and Testing Concrete Masonry Units.

**4. Visual Inspection**

4.1 All units shall be sound and free of defects that would interfere with the proper placing of the unit or impair the strength or permanence of the construction. Minor surface cracks incidental to the usual methods of manufacture, or surface chipping resulting from customary methods of handling in shipment and delivery, shall not be deemed grounds for rejection.

4.2 Broken units shall not be repaired or used in the matrix assembly.

**5. Sampling and Testing**

5.1 The purchaser or his authorized representative shall be accorded proper access to facilities to inspect and sample the units at the place of manufacture from lots ready for delivery.

**6. A. Performance Specifications –Coastal applications**

6.1.a. To minimize the time and cost for installation, the armor unit should be able to meet the specified design conditions with the placement of a single layer of armor units.

6.2.a. Armor units should be sized for hydraulic stability under the specified wave conditions. The size and weight of an armor unit that is hydraulically stable for a given design wave condition and structure slope should be estimated using the Hudson formula:

$$W = \frac{(\gamma_{cc} H^3)}{K_D (\gamma_{cc} / \gamma_w - 1)^3 m} \qquad M = \frac{\rho_{cc} H^3}{K_D (\rho_{cc} / \rho_w - 1)^3 m}$$

where:

- $M$  = weight of median size armor unit ( kg )
- $W$  = weight of median size armor unit ( lb )
- $\gamma_{cc}$  = armor unit weight (N/m<sup>3</sup> or lb/ft<sup>3</sup>)
- $H$  = wave height (m or ft)
- $K_D$  = armor unit stability coefficient corresponding to “no damage” condition (defined actually as minimum acceptable damage expressed as a percent of armor unit rocking or displacement)
- $\gamma_w$  = unit weight of water
- $m$  = structure slope angle

6.2.c. Armor units may be user specified utilizing the default values below:

<b>Default Values for Hudson Equation</b>		
<b>Variable</b>	<b>English Units</b>	<b>Metric Units</b>
Hudson Coefficient	$K_D = 20$ (Random) $K_D = 50$ (Uniform)	$K_D = 20$ (Random) $K_D = 50$ (Uniform)
Concrete Density	$\gamma_{cc} = 135$ lb/ft <sup>3</sup> (dry cast)	$\rho_{cc} = 2,165$ kg/m <sup>3</sup> (dry cast)
Water Density	$\gamma_w = 64$ lb/ft <sup>3</sup> (Seawater) $\gamma_w = 62.4$ lb/ft <sup>3</sup> (Freshwater)	$\rho_w = 1026$ kg/m <sup>3</sup> (Seawater) $\rho_w = 1000$ kg/m <sup>3</sup> (Freshwater)

To reduce the size of the structure, the armor unit should have a minimum  $K_D$  value of 20 as defined in the above Hudson formula for the specified structural slope.

**7. Expense of Tests**

Additional testing, other than that provided by the manufacturer, shall be borne by the purchaser.

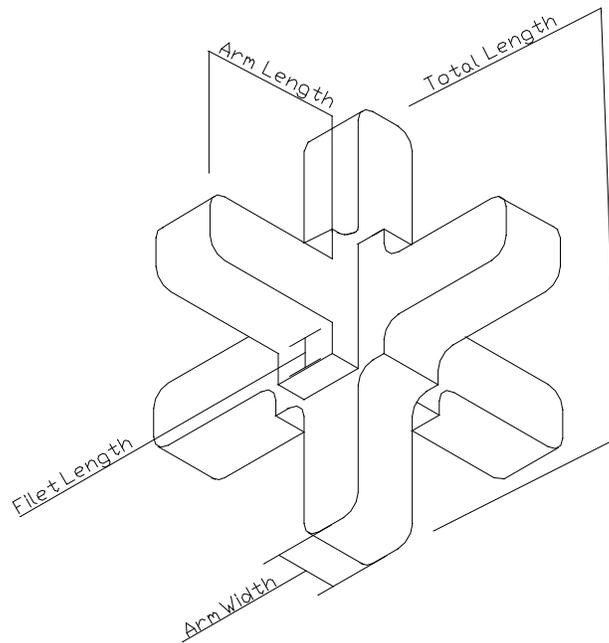
**8. Manufacturer**

A-JACKS<sup>®</sup> units are manufactured and sold by:

ARMORTEC (A Contech Company)  
 9025 Centre Point Drive  
 Suite 400  
 West Chester, OH 45069  
 Phone: 1-513-645-7000  
 Fax: 1-513-645-7993

The A-JACKS<sup>®</sup> concrete system shall have the following nominal characteristics:

<b>A-JACKS Model</b>	<b>Total Length in (cm)</b>	<b>Arm Length in (cm)</b>	<b>Fillet Length in (cm)</b>	<b>Arm Width in (cm)</b>	<b>Volume ft<sup>3</sup> (m<sup>3</sup>)</b>	<b>Weight lbs (kg)</b>
AJ-24	24 (60.96)	4.00 (10.16)	1.84 (4.67)	3.68 (9.35)	.56 (.016)	78 (35)
AJ-48	48 (121.92)	7.36 (18.69)	3.68 (9.34)	7.36 (18.69)	4.49 (.127)	629 (285)

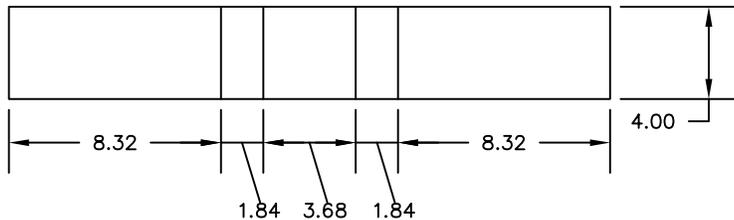


**Consultation.** The manufacturer of the cellular concrete blocks shall provide design and construction advice during the design and initial installation phases of the project when required.

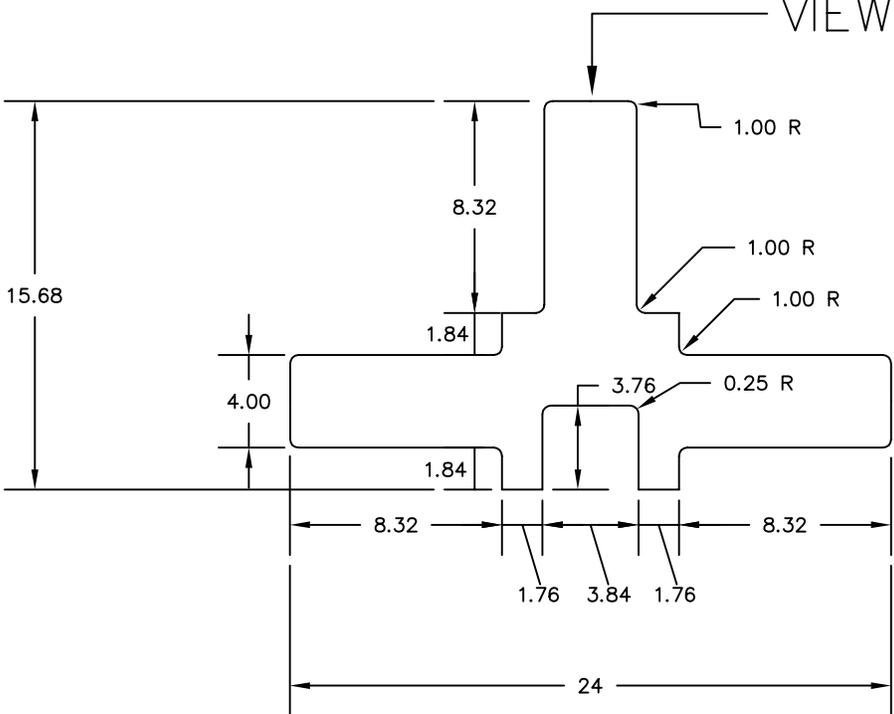
**TABLE 3. STANDARD SIZES OF ARMORFLEX® BLOCKS**

CLASS	TYPE	BLOCK WEIGHT		BLOCK SIZE			OPEN AREA %
		Lbs (kg)	Lbs./Sq.ft. (kg/m <sup>2</sup> )	Length inches (cm)	Width inches (cm)	Height inches (cm)	
30S	Open	31-36 (14-16)	32-37 (152-176)	13.0 (33.0)	11.6 (29.5)	4.75 (12.1)	20
50S	Open	45-52 (20-24)	45-53 (220-254)	13.0 (33.0)	11.6 (29.5)	6.0 (15.2)	20
45S	Closed	39-45 (18-20)	40-45 (191-220)	13.0 (33.0)	11.6 (29.5)	4.75 (12.1)	10
55S	Closed	53-61 (24-28)	54-62 (259-298)	13.0 (33.0)	11.6 (29.5)	6.0 (15.2)	10
40	Open	62-71	35-40	17.4	15.5	4.75	20
50	Open	81-94 (37-43)	46-53 (396-460)	17.4 (44.2)	15.5 (39.4)	6.0 (15.2)	20
70	Open	120-138 (55-63)	68-78 (587-675)	17.4 (44.2)	15.5 (39.4)	9.0 (22.9)	20
45	Closed	78-89	43-50	17.4	15.5	4.75	10
55FT	Closed	94-108 (43-49)	53-61 (460-528)	17.4 (44.2)	15.5 (39.4)	6.0 (15.2)	10
75	Closed	120-138 (55-63)	68-78 (587-675)	17.4 (44.2)	15.5 (39.4)	7.5 (19.1)	10
85	Closed	145-167 (66-76)	82-95 (709-817)	17.4 (44.2)	15.5 (39.4)	9.0 (22.9)	10
40L	Open	95-111 (43-51)	35-41 (303-347)	17.4 (44.2)	23.6 (59.9)	4.75 (12.1)	20
70L	Open	181-211 (82-96)	68-78 (587-675)	17.4 (44.2)	23.6 (59.9)	9.0 (22.9)	20
45L	Closed	113-132 (51-60)	43-50 (382-435)	17.4 (44.2)	23.6 (59.9)	4.75 (12.1)	10
85L	Closed	219-254 (100-116)	82-95 (709-817)	17.4 (44.2)	23.6 (59.9)	9.0 (22.9)	10

# VIEW A



# VIEW A



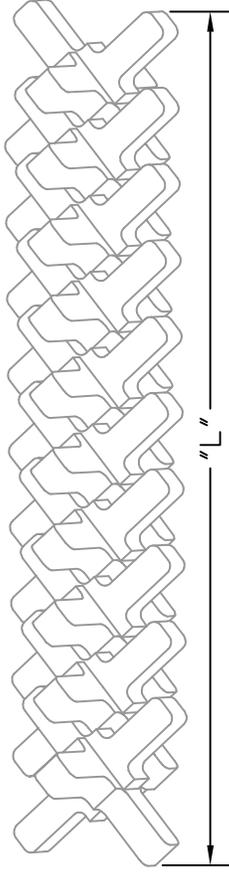
ALL DIMENSIONS IN INCHES

DRAWN BY: KWM	CHECKED BY: CBK	DATE: 7/20/07	SCALE: NTS
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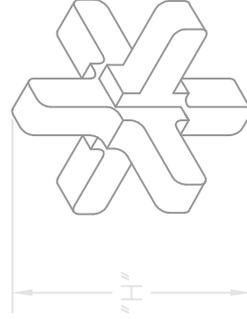
24" A-JACKS  
STANDARD DETAIL  
(Dimensions)

**ARMORTEC**  
Erosion Control Solutions  
A CONTECH COMPANY  
9025 CENTRE POINTE DR, SUITE 400  
WEST CHESTER, OHIO 45069  
PH: (513) 645-7000 FAX: (513) 645-7993

A-JACKS UNITS



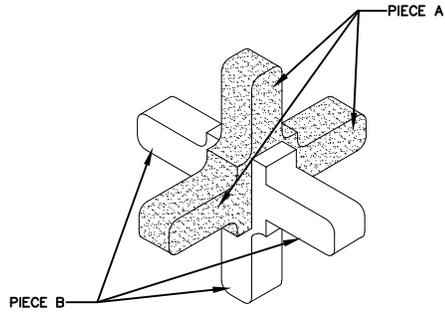
A-JACKS PLACEMENT: PROFILE  
(NOT TO SCALE)



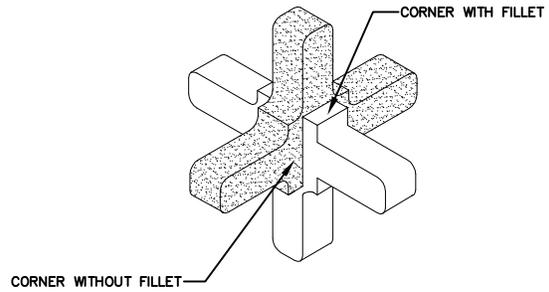
A-JACKS UNITS: COVERAGE EXAMPLES			
SIZE "H"	"L" LENGTH (ft.)	# OF UNITS	COVERAGE PER UNIT*
24"	15'-0"	15	1'-0"
48"	16'-0"	8	2'-0"
72"	15'-0"	5	3'-0"
96"	16'-0"	4	4'-0"
120"	20'-0"	4	5'-0"
*DEPENDS ON TIGHTNESS OF PLACEMENT			

DRAWN BY: KWM	CHECKED BY: CBK	DATE: 12/1/08	SCALE: NTS
<p><b>A-JACKS</b> <b>STANDARD DETAIL</b> (Installed Dimensions)</p>		<p><b>ARMORTEC</b> Erosion Control Solutions A CONTECH COMPANY 9025 CENTRE POINTE DR, SUITE 400 WEST CHESTER, OHIO 45389 PH: (513) 645-7000 FAX: (513) 645-7993</p>	

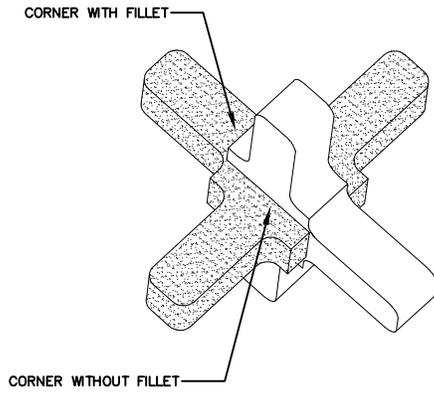
1. IDENTIFY A-Jacks COMPONENTS.



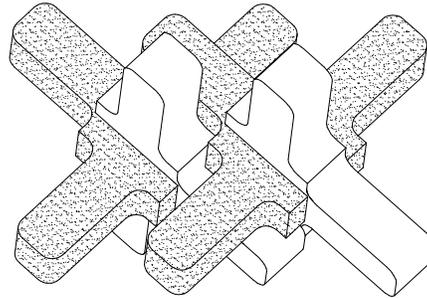
2. IDENTIFY CORNERS WITH AND WITHOUT FILLETS.



3. PROPER ROTATION OF A-Jacks.



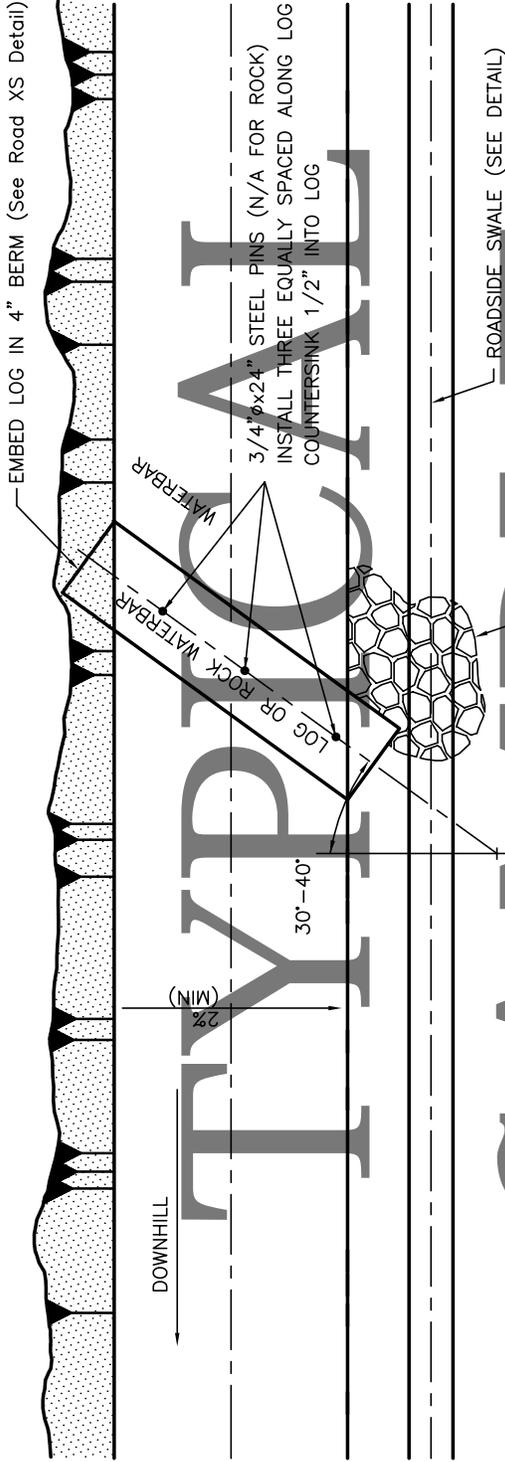
4. ALIGN ALL A-Jacks IN SAME DIRECTION. CORNERS WITHOUT FILLET MUST LINE UP.



DRAWN BY: KWM	CHECKED BY: CBK	DATE: 7/21/07	SCALE: NTS
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**A-JACKS  
STANDARD DETAIL  
(Construction)**

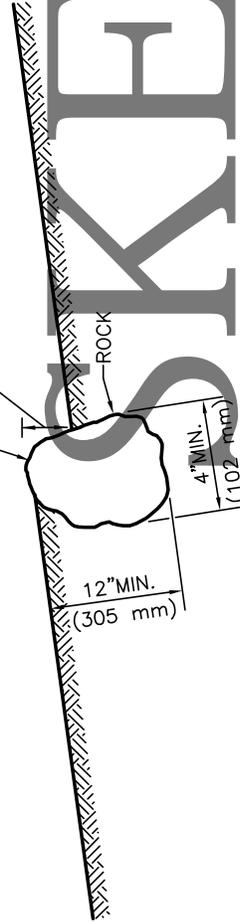




**PLAN**

USE NATURAL ROCK OUTCROPS  
OR BEDROCK EXCAVATED AS

1 1/2" (MIN) - 3" Max REVEAL



**PROFILE FOR LOG**

**PROFILE FOR ROCK**

Prepared by:  
**JAM Engineering Associates LLC**  
Suzanne Water  $\infty$  Civil Engineering  $\infty$  Planning  
1912 Koffel Rd.  
Hatfield, PA 19440  
215-920-2985  
www.jam-engineering.com

**Plan & Profile Views  
Waterbar Installation  
Calabash Boom Road**

Date: 03-25-10

Project No: D-001-09

Drawn By: J.A.M. Checked: J.A.M.

Sheet 7 of 7

Prepared for:  
**Coral Bay Community Council**  
- CBCC is a 501(c)(3) nonprofit organization -  
8-1 Emmaus  
St. John, VI  
340-776-2099  
cbcc@coralbaycommunitycouncil.com

Shipping Address:  
9901 Emmaus  
St. John, VI 00830  
www.jam-engineering.com

Install 26' long ALSP Pipe Arch  
6'-9" x 4'11"  
(15" minimum cover)  
(or approved equivalent)  
per manufacturers specifications

Proposed 8' long  
Concrete Endwall  
(see profile view for details)

Modify & sump roadside swale  
to direct water to pipe arch.

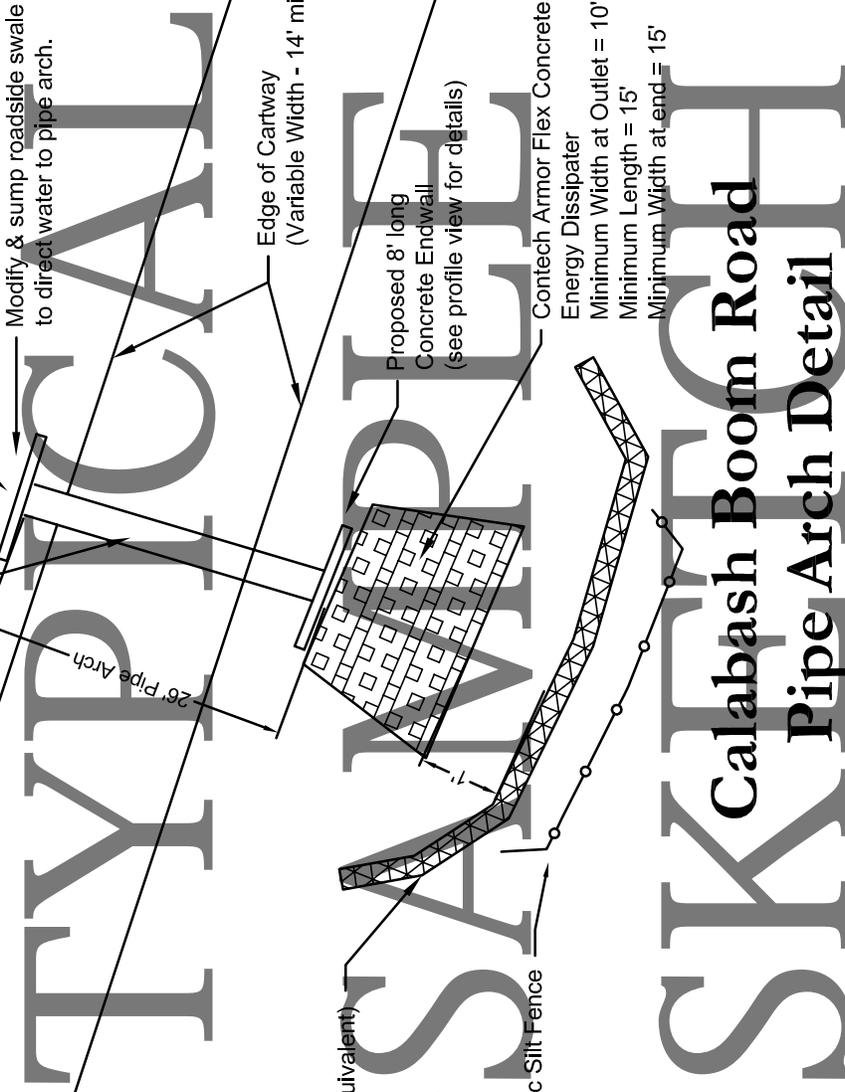
Edge of Cartway  
(Variable Width - 14' min)

Proposed 8' long  
Concrete Endwall  
(see profile view for details)

Contech A-Jacks (or approved equivalent)  
Energy Dissipater Hand Placed  
Minimum Length = 20'  
Turn last 5' of edges 45% towards  
outlet structure

18" Filter Fabric Silt Fence  
(See Detail)

Contech Armor Flex Concrete Cable Mat (or approved equivalent)  
Energy Dissipater  
Minimum Width at Outlet = 10'  
Minimum Length = 15'  
Minimum Width at end = 15'



# Calabash Boom Road Pipe Arch Detail

## Plan View

(N.T.S.)

Prepared by:  
**JAM Engineering Associates LLC**  
*Sustainable ∞ Civil Engineering ∞ Planning*  
Address: 1912 Koffel Rd.  
Hatfield, PA 19440  
215-920-2985  
Company Address: 9901 Emmaus  
St. John, VI 00830  
www.jam-engineering.com

**Plan & Profile Views  
Pipe Arch Installation  
Calabash Boom Road**

Date: 03-24-10
Project No: D-001-10
Drawn: J.A.M. Checked: J.A.M.
Sheet 4 of 7

Prepared for:  
**Coral Bay Community Council**  
*- CBCC is a 501(c)(3) nonprofit organization -*  
Address: 9901 Emmaus  
St. John, VI 00830  
340-776-2099    cbcc@coralbaycommunitycouncil.com



Install Neenah R-4999 Series Heavy Duty Trench with Type C Grate (or approved equivalent) per manufacturers specifications

Install 2' x 4' Concrete Box Inlet with grate raised up on 2" legs.

Modify Roadside Swale to direct water to inlet and Trench

Existing Concrete Roadside Swale

Existing Edge of Concrete

Contech A-Jacks (or approved equivalent) Energy Dissipater Hand Placed Minimum Length = 20' Turn last 5' of edges 45% towards outlet structure

Proposed 6' long Concrete Endwall (see profile view for details)

18" Filter Fabric Silt Fence (See Detail)

Contech Armor Flex Concrete Cable Mat (or approved equivalent) Energy Dissipater Minimum Width at Outlet = 10' Minimum Length = 15' Minimum Width at end = 15'

# Bordeaux Mountain Road (Rt. 108)

## Site #3 - Upper Ghut Detail

### Plan View

(N.T.S.)

Prepared for:  
**Coral Bay Community Council**  
*- CBCC is a 501(c)(3) nonprofit organization -*  
 Physical Address:  
 8-1 Emmaus  
 St. John, VI  
 340-776-2099      cbcc@coralbaycommunitycouncil.com

Date: 03-15-10

Project No: B1&2-09

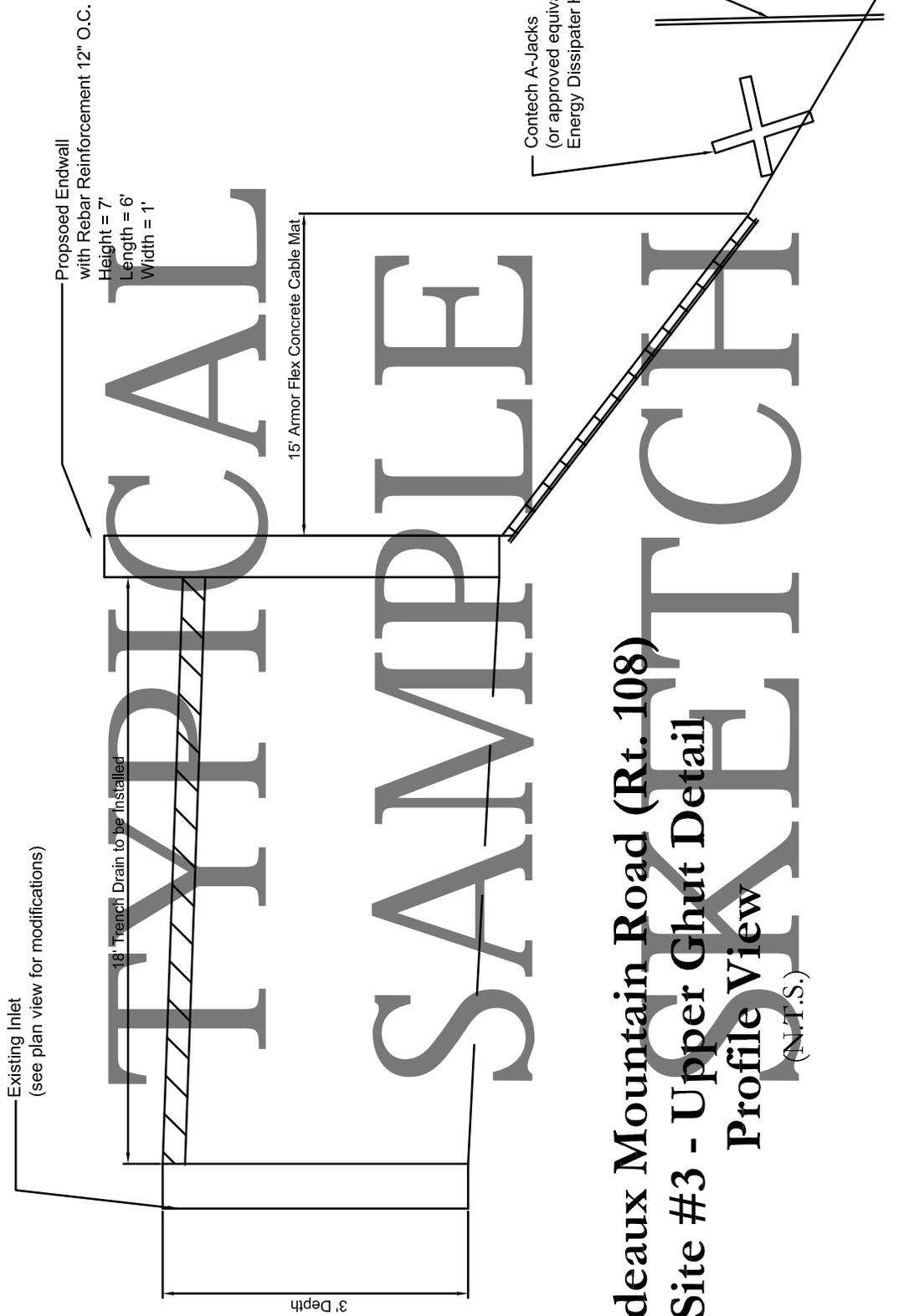
Drawn By: J.A.M.      Checked: J.A.M.

Sheet 2 of 3

Plan & Profile Views  
 Trench Drain Improvements  
 Bordeaux Mountain Road

Prepared by:  
**JAM Engineering Associates LLC**  
*Stormwater ∞ Civil Engineering ∞ Planning*  
 Address:  
 1912 Koffel Rd.  
 Hatfield, PA 19440  
 215-920-2985

Company Name, Address:  
 9901 Emmaus  
 St. John, VI 00830  
 www.jam-engineering.com



**Bordeaux Mountain Road (Rt. 108)**  
**Site #3 - Upper Gully Detail**  
**Profile View**  
 (N.T.S.)

Prepared by:  
**JAM Engineering Associates LLC**  
*Stormwater ∞ Civil Engineering ∞ Planning*  
 1912 Koffel Rd.  
 Hatfield, PA 19440  
 215-920-2985  
 www.jam-engineering.com

**Plan & Profile Views**  
**Trench Drain Improvements**  
**Bordeaux Mountain Road**

Date: 03-15-10  
 Project No: B1&2-09  
 Designer: J.A.M. Checked: J.A.M.  
 Sheet 3 of 3

Prepared for:  
**Coral Bay Community Council**  
*- CBCC is a 501(c)(3) nonprofit organization -*  
 8-1 Emmaus  
 St. John, VI  
 340-776-2099  
 cbcc@coralbaycommunitycouncil.com

# Johnny Horn Trail



Robinson Projection  
Central Meridian: -60.00



**Johnny Horn Trail  
Drainage Improvements Plan  
June 14, 2010**

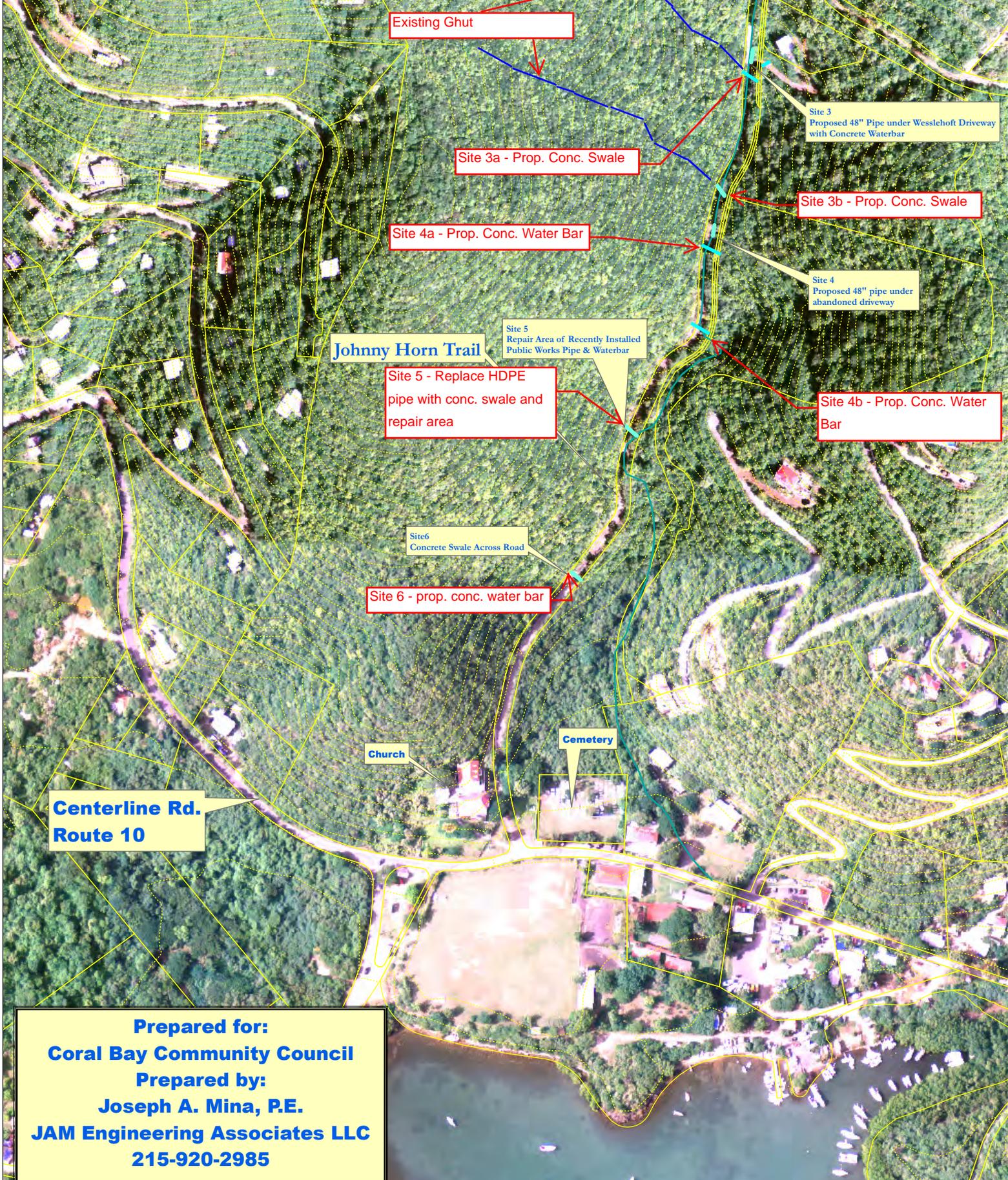
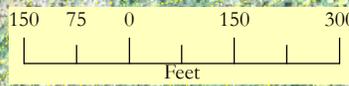
**Project No: A-004-10**

**Sheet 1 of 1**

**Drawn by: JAM**

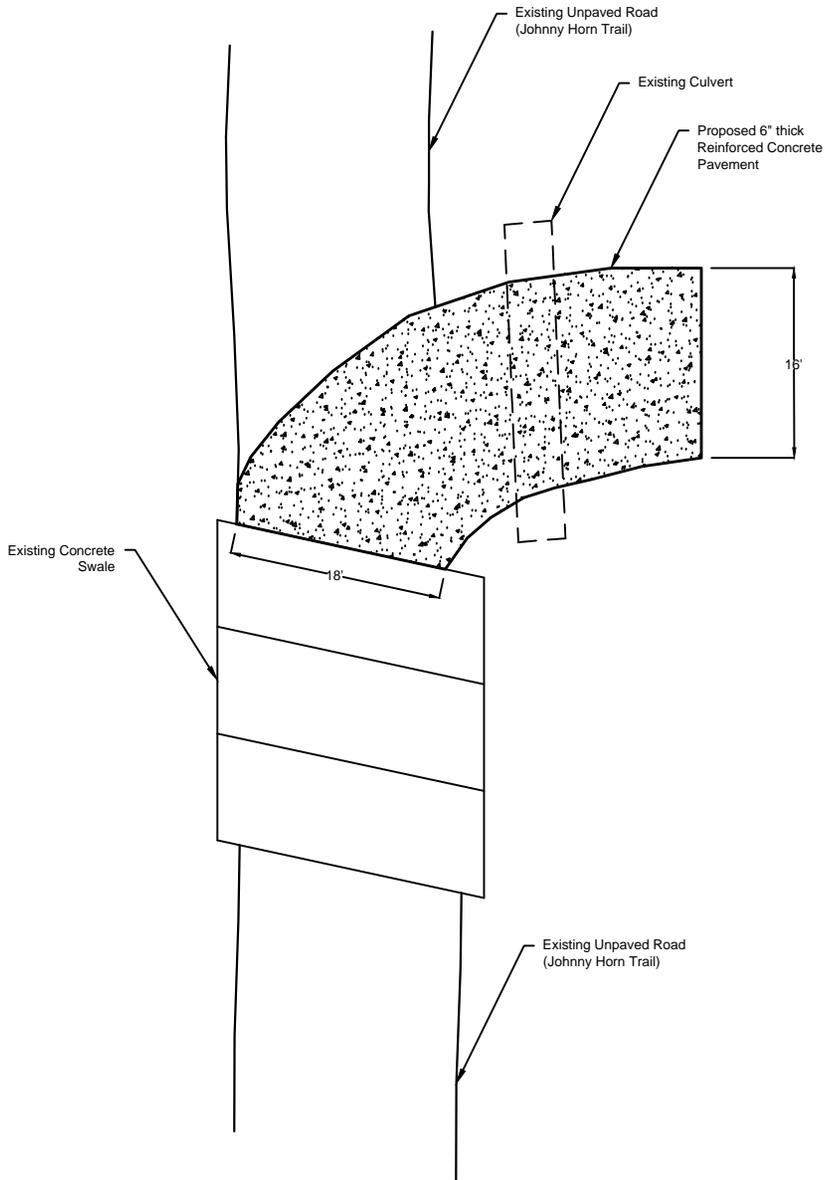
Rev: 8/14/2010

Rev. by: CSL

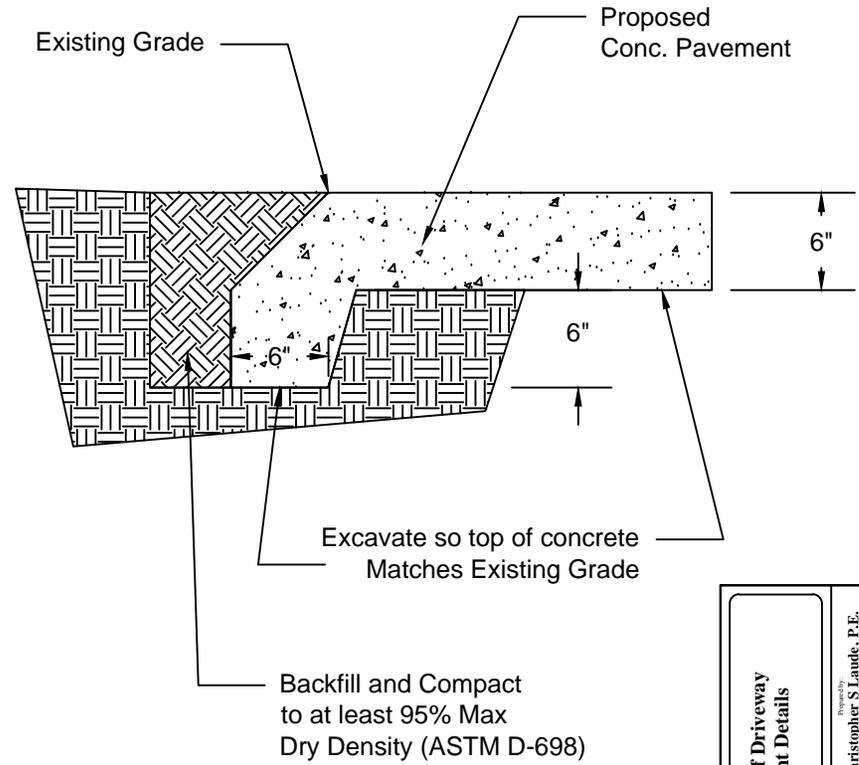


**Prepared for:  
Coral Bay Community Council  
Prepared by:  
Joseph A. Mina, P.E.  
JAM Engineering Associates LLC  
215-920-2985**

# Plan View



# X-Section/Profile View



<b>Drainage Improvements</b> <b>Johnny Horn Trail</b> <b>Coral Bay, St. John, USVI</b>	Prepared by: <b>Coral Bay Community Council</b> <small>CRIC for 100% EOP approval/representation</small> 9901 Emmaus St. John, VI	Project No.: AD	Date: 05/17/2011
	Prepared by: <b>Christopher S Laude, P.E.</b> <small>Stormwater &amp; Civil &amp; Planning</small> 9901 Emmaus St. John, VI	Sheet 1 of 1	Project No.: AD
<b>Wesselhoff Driveway</b> <b>Pavement Details</b>		Project No.: AD	Date: 05/17/2011
Not To Scale		Project No.: AD	Date: 05/17/2011

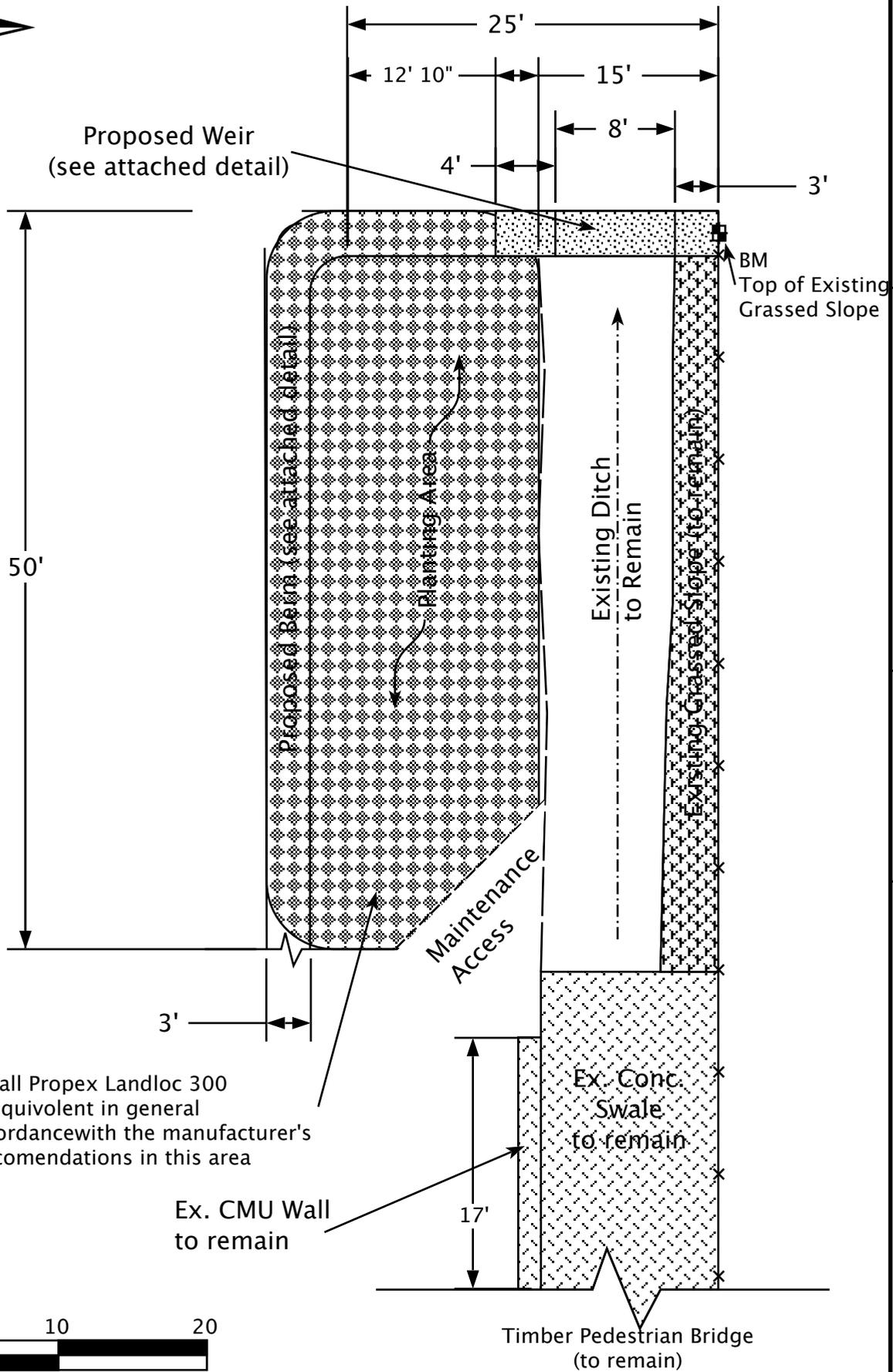


Approximate area  
for concrete paving  
at Wesselhoff  
driveway -  
contiguous with  
existing concrete  
swale.

04/11/2011



Proposed Weir  
(see attached detail)



Install Propex Landloc 300  
or equivalent in general  
accordance with the manufacturer's  
recommendations in this area

Ex. CMU Wall  
to remain



Prepared by:

Christopher S. Laude, PE  
9901 Emmaus  
St John, USVI 00830  
910-612-5990

Project:

Rain Garden Plan  
Johnny Horn Trail  
St John, USVI

Date: 07-27-2010

Project #: B1&2-09

Sheet:

**Coral Bay Community Council, Inc.**

Physical Address:  
8-1 Emmaus  
St John, VI 00830  
340-776-2099

Mailing Address:  
9901 Emmaus  
St John, VI 00830  
CBCC@CoralBayCommunityCouncil.org

-a 501(c)(3) nonprofit organization-