Sediment Management Plan For the Watersheds of Clearwater Harbor and Saint Joseph Sound

Prepared for:
Pinellas County
Department of Environment and Infrastructure

Prepared by:

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FORWARD

This document is provided in fulfillment of the Sediment Management task associated with the Comprehensive Conservation and Management Plan for Saint Joseph Sound and Clearwater Harbor; Contract No: 089-0222-P.

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EXECUTIVE SUMMARY

This document provides a Sediment Management Plan (SMP) to accompany the Comprehensive Conservation Management Plan (CCMP) for the watersheds of Clearwater Harbor and St. Joseph Sound. Collectively, this area is referred to in this document as the CHSJS. The CHSJS is located on the west-central coast of Florida, and includes much of northwestern Pinellas County.

Many of the surface water features in the CHSJS have undergone transformation from natural coastal stream systems to urban drainage networks. Although much of the CHSJS is relatively flat, there are areas with significant topographic relief including the coastal areas of northern Clearwater and Belleair Bluffs, and some reaches of Bee Branch and Curlew Creek. Urban land uses and steep stream channel slopes contribute to high rates of erosion and subsequent deposition in the watershed and estuary. Adverse impacts that may result from excess sedimentation include the following:

- property damage by undermining structures (foundations, bridge pilings, etc.) in the watershed,
- destruction of desirable habitat in stream channels,
- increased flooding potential by the reduction in channel flow capacity through deposition,
- impacts to natural resources in the estuary such as seagrass beds and benthic communities through physical smothering or reduction in water clarity,
- reduced circulation and nearshore flushing in the estuary and downstream channel reaches,
- introduction of contaminants into the environment,
- creation of hazards to navigation, and
- degradation of aesthetic values through accumulation of muck.

Erosion is a physical process that, under natural conditions, keeps stream channels dynamic and balanced. However, in a highly urbanized environment such as most of the CHSJS, alteration of the surface water system, referred to as hydro-modification, has resulted in excess erosion with subsequent adverse impacts to both freshwater and estuarine resources, as well as increased flooding potential. Although erosion management efforts have addressed individual water bodies in the CCMP area (e.g., Stevenson Creek, portions of Curlew Creek and others), a watershed-wide SMP will prove beneficial for the watershed, the receiving waters, and associated natural resources. Hydro-modification has resulted from efforts to move stormwater runoff off the landscape as quickly as possible. This is typically accomplished through any of the following actions:

- channelizing and straightening naturally meandering streams,
- filling stream floodplains,
- creating regular geometric channel cross sections and installing control structures,
- clearing vegetation from the channel,
- hardening and smoothing the channel with concrete, rip rap, gabions, etc., and
- replacing open channel streams with culverts.

The goal of the CHSJS SMP is to improve ecological function of coastal streams and the CHSJS estuary through a comprehensive assessment of watershed-based erosion sources and problems and the implementation of efficient and cost-effective solutions. The four objectives of the CHSJS SMP are listed below.

- Identify erosion/deposition problem areas in the watershed.
- Identify principal sources of sediment in the watershed.
- Assess potential issues from sediment contamination by metals.
- Identify cost-effective and efficient methods of managing sediment erosion and deposition.

It is noted that several of the freshwater streams in the CHSJS are on the State of Florida's list of Impaired Waters. The impaired water bodies include portions of Klosterman Creek (Innisbrook Canal), Bee Branch, Curlew Creek, Cedar Creek, and Stevenson Creek. Controlling sediment loading to these coastal streams will help improve overall water quality as well as the health of the receiving water estuaries

The Anclote River, located at the northern extreme of the CHSJS, is the largest freshwater tributary in the CHSJS. However, while the Anclote discharges into St. Joseph Sound, only a short length of the river is within Pinellas County. Therefore, the focus of this SMP is on the streams of the CHSJS other than the Anclote River. Further, issues related to coastal sediment erosion and deposition in coastal passes, channels, and the open bay estuarine waters of the CHSJS are discussed in the CCMP and are not addressed in this document.

The development of the CHSJS SMP included the following tasks:

- conducting a desktop evaluation to identify potential problem areas,
- completing field reconnaissance to identify areas of sediment erosion and accumulation,
- collecting sediment samples for laboratory analysis of grain size and metals content,
- reviewing and summarizing existing and proposed management plans and projects that address sediment management in the CHSJS, and
- developing recommendations to reduce adverse impacts from sediment erosion and deposition.

Results of the field investigation and desktop analysis suggested that all the streams assessed within the CHSJS are relatively small and are located in highly urbanized settings. These creeks have all been incorporated into urban stormwater drainage systems to varying degrees. Most reaches of the creeks examined have been channelized. There is generally modest topographic relief in the drainage areas and the stream channels have relatively low slopes, with exceptions as noted. Virtually no areas of high quality wetland habitat were observed associated with the creek channels. In-channel vegetation in most creek reaches is regularly cut back to maintain stormwater conveyance capacity. Significant shoaling of soft sand or fine-grained material was commonly observed. This type of sediment deposition can greatly reduce benthic and fisheries habitat value in the creeks. Many stream reaches are deeply incised with high steep banks, and are subject to bank erosion. Because the surrounding easements are so narrow, widening the channel to lower the bank slope and reduce erosion and bank slumping is rarely feasible.

Field observations suggested that the stream channels typically have a hard-packed sandy bottom covered with a layer of soft sand and silt that varies from one to four inches deep. A few sites had either a gravel channel bottom with little sand, or a clayey sand bottom. Channel sediments were comprised of sand, with very little silt/clay. Only one site, Spr3 on Spring Branch, had enough fine-grained material to be classified as "silty sand." The sampling sites were observed both before and after a rainfall event. In-stream shoals comprised of coarse sand tended to persist and accrete. Accumulations of fine-grained material tend to flush downstream during high flows.

Testing for metals enrichment showed that elevated levels of metals did occur in the tributary sediments, however, laboratory results indicated that the metal contamination was not at a level requiring action such as sediment removal. The sites with the most enriched metals were in Klosterman Creek, Bee Branch, Stevenson Creek, Spring Branch, and McKay Creek. No stream had more than one site with more than three of six tested metals enriched.

Recommendations were developed to address existing and potential future sediment-related problems in the CHSJS. In general, the main issues were channel bank erosion, sediment accumulation, and shoaling within the channels. As stated, options for stream restoration in CHSJS are limited because the channels are mainly contained within narrow parcels or easements. These slender corridors are not sufficiently wide to implement many typical stream restoration techniques such as channel widening or meandering, or lowering the bank slope. Therefore, based on this study, 10 site-specific projects were recommended to address sediment management in areas that do not have specific sediment management projects already in-place or planned. Additionally, recommendations were made to enhance stream reaches throughout the study area irrespective of existing projects. Recommended projects included the following:

- Maintenance dredging of fine-grained sediment at several locations including Curlew Creek (Jerry Branch south of Main Street and at Cypress Point Drive West) and McKay Creek (north of 134th Avenue near Ulmerton Road; south of 8th Avenue SW, and at Indian Rocks Road). Current maintenance activities could be expanded or enhanced to optimize fine-grained sediment removal from channels just prior to the beginning of the rainy season in mid – late June.

- Channel bed and bank stabilization was the focus of other recommended projects for Curlew Creek (downstream of County Rd. 1), Stevenson Creek (downstream of Bellevue Blvd.) and Bee Branch (near Belcher Rd. south of Nebraska Ave.). Erosion control for reaches of Curlew Creek and Bee Branch is currently an on-going effort for the County.

- Reducing sediment transport was recommended for one site on McKay Creek. This could be accomplished by the enhancement of an existing sediment sump at SW 8th Ave.

- Opportunities exist to enhance in-stream and stream bank habitat while stabilizing channel banks in several streams, in particular Curlew Creek (between St. Andrews Golf Course and County Rd. 1). "Soft" structural features may be strategically used to afford enhanced habitat for fish, benthos, and other wildlife including placement of snags and stop log, installation of root ball revetments or partial weirs, or placement of large rocks in or along the channel. In areas where the channel corridor is sufficiently wide, a littoral shelf or created wetlands may be employed

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1 Project Background

This document provides a Sediment Management Plan (SMP) for the watersheds of Clearwater Harbor and St. Joseph Sound to accompany the Comprehensive Conservation Management Plan (CCMP) for Clearwater Harbor and St. Joseph Sound. Collectively, this area is referred to in this document as the CHSJS. The CHSJS is located on the west-central coast of Florida, and includes much of northwestern Pinellas County. The CHSJS includes both estuarine waterbodies and their associated watersheds; however, the SMP is restricted to the watershed portions of the CHSJS. The project area has been delineated into three watersheds that make up the drainage basins for the three estuarine segments of the CHSJS (Figure 1-1) including:

- St. Joseph Sound (SJS);
- Clearwater Harbor North (CHN); and
- Clearwater Harbor South (CHS).

Erosion is a physical process that, under natural conditions, keeps stream channels dynamic and balanced. However, in a highly urbanized environment such as most of the CHSJS, alteration of the surface water system, referred to as hydromodification, has resulted in excess erosion with subsequent adverse impacts to both freshwater and estuarine resources, as well as increased flooding potential.

Sediment transport, or erosion, is caused by the movement of soil and rock particles by water. Factors that can affect the rate of erosion include channel slope, shape, and alignment; channel bed particle characteristics (density, grain size, organic content, etc.); and relative size of the contributing drainage basin. The inter-relationships between some of these features are illustrated in Figure 1-2.

One of the natural functions of a stream is to move sediment. In relatively unaltered systems the dynamic nature of sediment transport and accretion is in balance. However, alterations to natural surface water features, known as hydromodification, are usually conducted for the purpose of moving stormwater runoff off the landscape as quickly as feasible. This is usually accomplished through any of the following actions:

- channelizing and straightening naturally meandering streams,
- filling stream floodplains,
- creating regular geometric channel cross sections and installing control structures,
- clearing vegetation from the channel,
- hardening and smoothing the channel with concrete, rip rap, gabions, etc., and
- replacing open channel streams with culverts.

The above alterations are often accompanied by changes to the surrounding drainage areas that promote higher rates of stormwater runoff. These changes can include loss of natural vegetation including tree canopy, loss of on-site depressional storage, and increases in pavement and other impervious surfaces. The result is an imbalance in the relationships between the land, the water, sediment, and the biota.

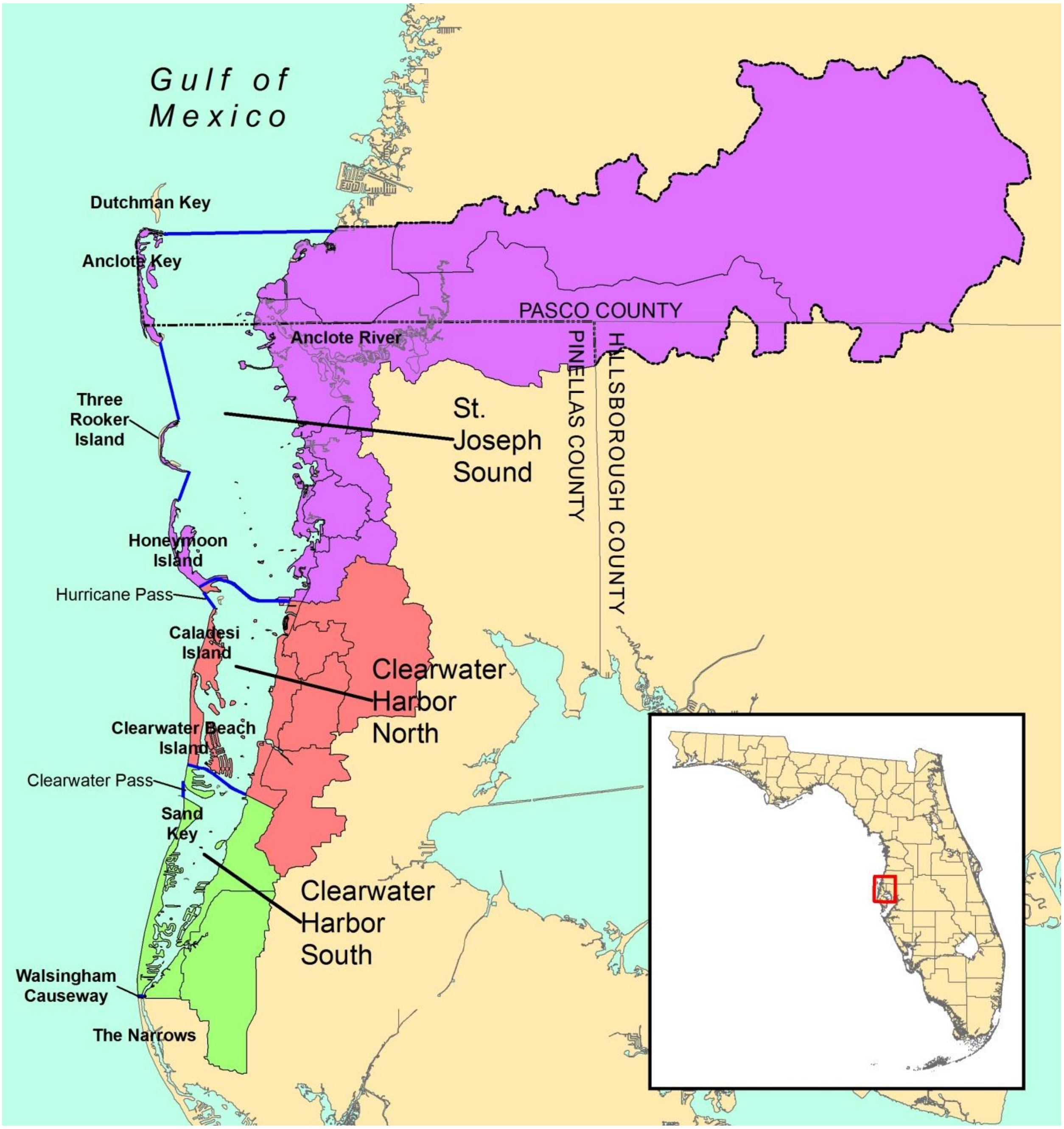

Figure 1-1. CHSJS location.

Many of the surface water features in the CHSJS have undergone the transformation from natural coastal stream systems to urban drainage networks.

Adverse impacts that may result from excess sedimentation include:

- property damage by undermining structures (foundations, bridge pilings, etc.) in the watershed;
- destruction of desirable habitat in stream channels;
- increased flooding potential by the reduction in channel flow capacity through deposition;

- impacts to natural resources in the estuary such as seagrass beds and benthic communities through physical smothering or reduction in water clarity;
- reduced circulation and nearshore flushing in the estuary and downstream channel reaches;
- introduction of contaminants into the environment;
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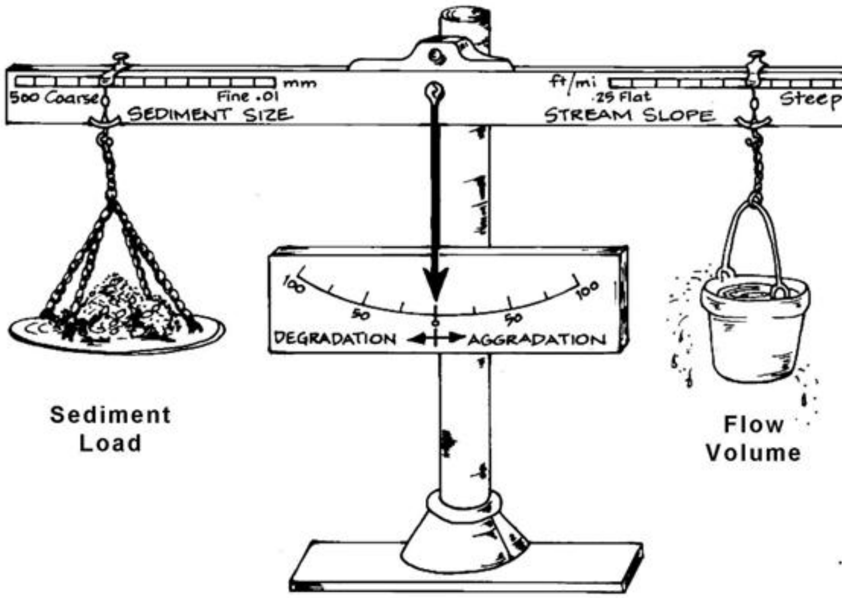


Figure 1-2. Schematic of Lane's Balance (Source: Lane, 1955).

Without proper stormwater management, a surface water system that has been subjected to the above alterations will subsequently generate higher water flow rates and velocities during runoff events. Because the rate of erosion is intimately tied to flow velocity, higher flows result in higher rates of sediment transport. Erosion management efforts have already addressed individual water bodies in the CHSJS (e.g., Stevenson Creek, portions of Curlew Creek and others). However, a comprehensive sediment management plan will prove beneficial for the watershed, the receiving waters, and associated natural resources.

It should also be noted that several of the freshwater streams in the CHSJS are on the State of Florida's list of Impaired Waters. The impaired water bodies include Klosterman Creek/Innisbrook Canal, Bee Branch, Curlew Creek, Cedar Creek, and Stevenson Creek. Controlling sediment loading to these creeks will help improve overall water quality as well as the health of the receiving water estuaries. Sediment characteristics in the CHSJS estuary are discussed in the CHSJS "State of the Resources Report" (Janicki Environmental, 2011) with respect to sediment quality and benthic habitats. The deposition of fine-grained mud and clay in the estuary is of special interest because pollutants such as organic compounds and petroleum products are more likely to sorb to these particles than coarser sand (MacDonald et al., 2004). Also, sediment that originates in the watershed is more likely to carry contaminants with it into the receiving water. Thus controlling sediments in the watershed is an effective step in limiting the opportunities for sediment contamination in the estuary.

2 Plan Goal and Objectives

The goal of the CHSJS Sediment Management Plan is to improve the ecological functions of coastal streams by mitigating excessive sediment erosion and accretion through a comprehensive assessment of erosion sources and problems, and the identification of efficient and cost-effective solutions.

The objectives of the CHSJS SMP are listed below:

- Identify erosion/deposition problem areas in the watershed;
- Identify principal sources of sediment in the watershed;
- Identify alternate methods of reducing erosion rates; and
- Evaluate and recommend methods to reduce impacts resulting from sediment erosion and deposition.

3 Methods

Tidal tributaries within the CHSJS were evaluated for issues relating to erosion, sediment accumulation, and sediment contamination. The evaluation included the following: a desktop assessment using geographic information system (GIS) - based aerial photography, topography, and soils data and other available information; field reconnaissance and sediment sampling for laboratory testing for grain size analysis and metals contamination; a review of existing management plans and projects, and the development of recommended projects. Each element of the investigation is described below and results for each waterbody are provided in the following chapters. Waterbodies in the CHSJS that were included in the SMP are shown in Table 3-1 and Figures 3-1, 3-2, and 3-3. The stream channel delineations were obtained from the Pinellas County Department of Environment and Infrastructure.

Table 3-1. Streams assessed for the CHSJS Sediment Management Plan.

Watershed	Tributary
St. Joseph Sound	
	Klosterman Creek
	Bee Branch
Clearwater Harbor North	
	Curlew Creek
	Cedar Creek
	Stevenson Creek
	Spring Branch
Clearwater Harbor South	
	McKay Creek

The Anclote River discharges to St. Joseph Sound and is the CHSJS's largest freshwater feature. However, almost all of the freshwater reaches of the river are in Pasco County, so the Anclote River was not assessed in this study.

3.1 Desktop Evaluation

A desktop evaluation was completed using GIS-based aerial photography and hydrographic, topographic, land use, and soils data. These data were used to:

- identify any visible signs of erosion or deposition in stream channels,
- find stream channel reaches with steep channel slopes,
- locate streams in areas of soil types that are more likely to erode, and
- identify likely sampling sites with respect to accessibility.

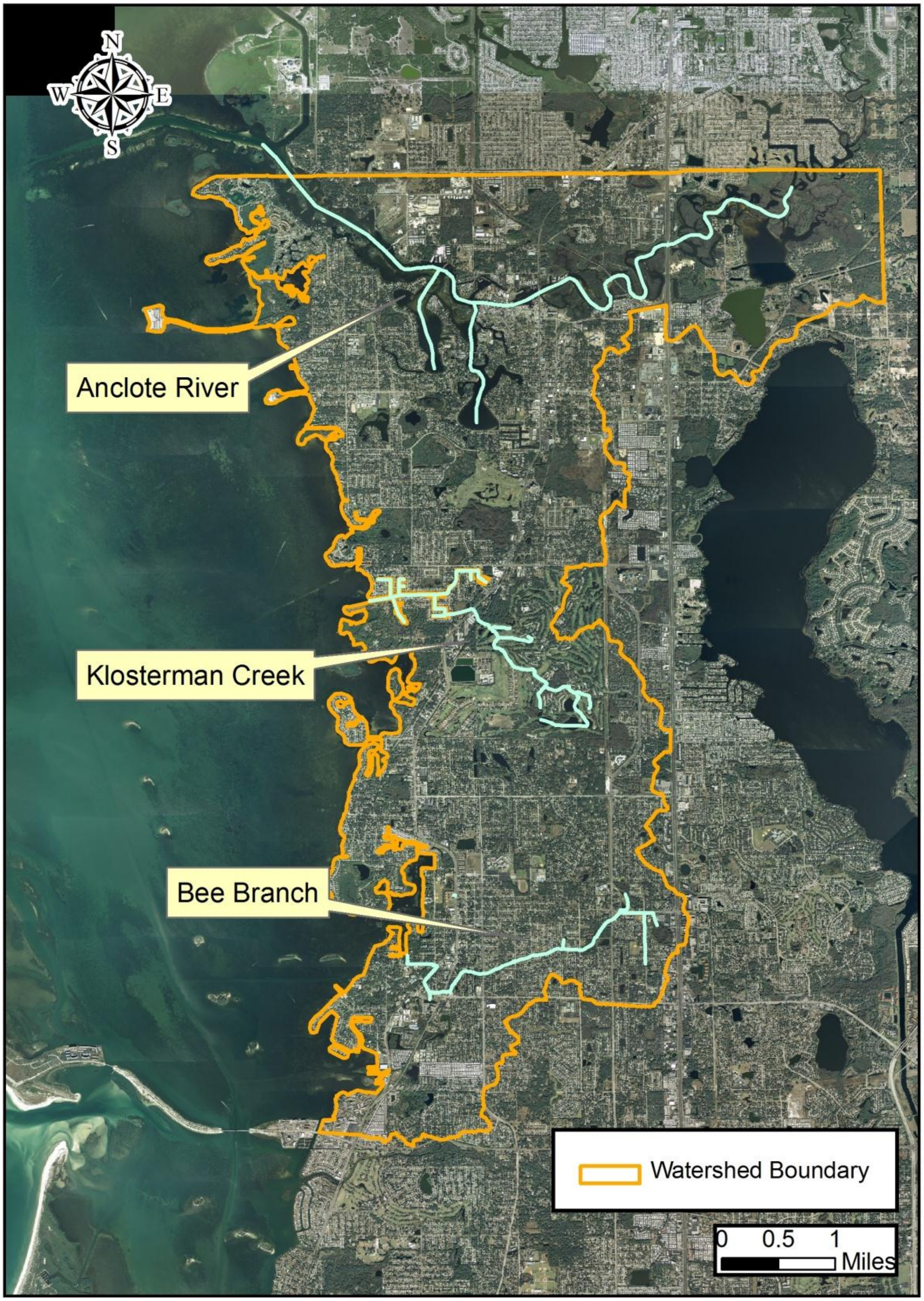


Figure 3-1. **Tidal streams in the St. Joseph Sound watershed. The Anclote River basin boundary is truncated and the river is not included in the Sediment Management Plan.**

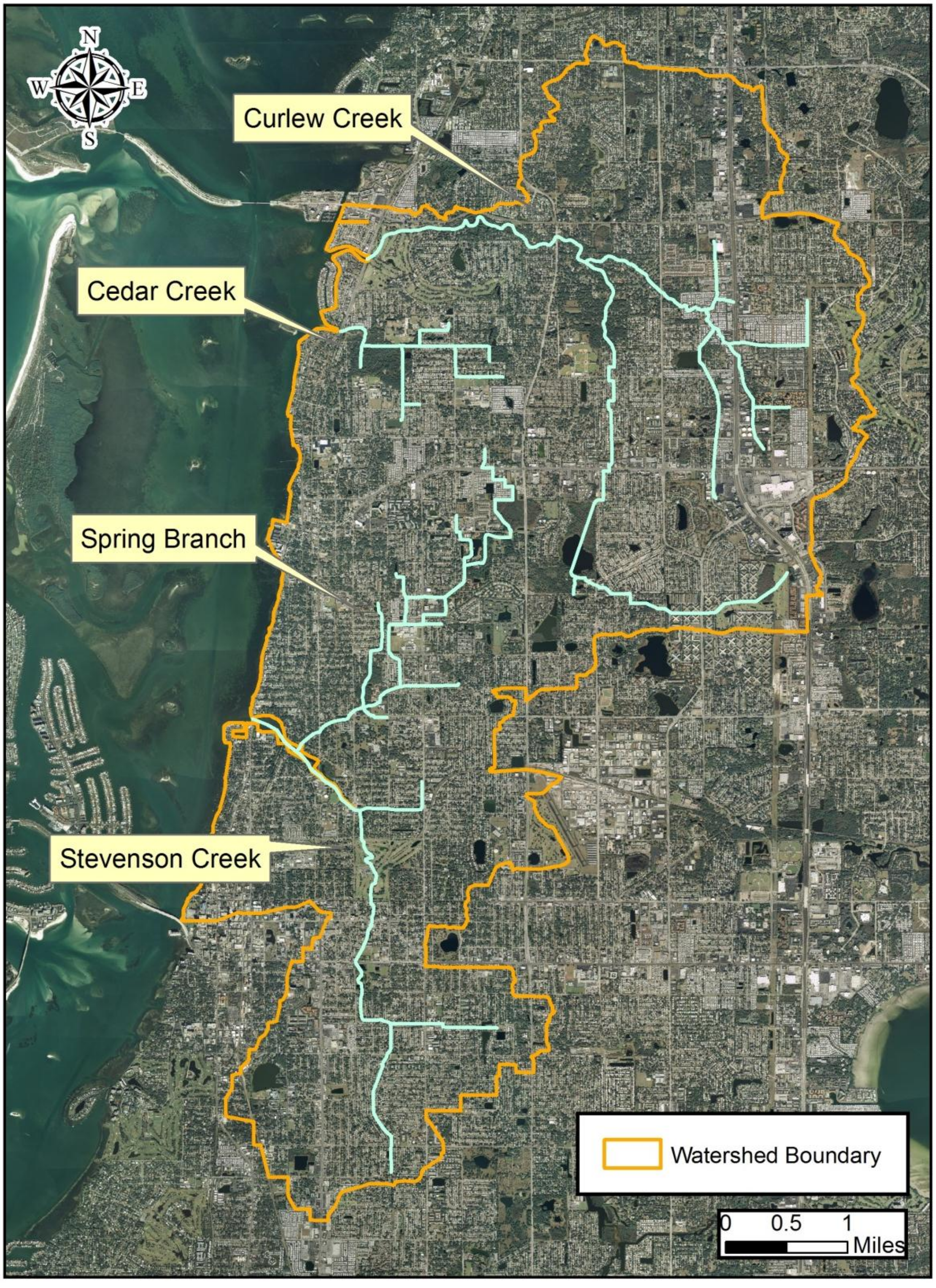


Figure 3-2. **Tidal streams in the Clearwater Harbor North watershed.**

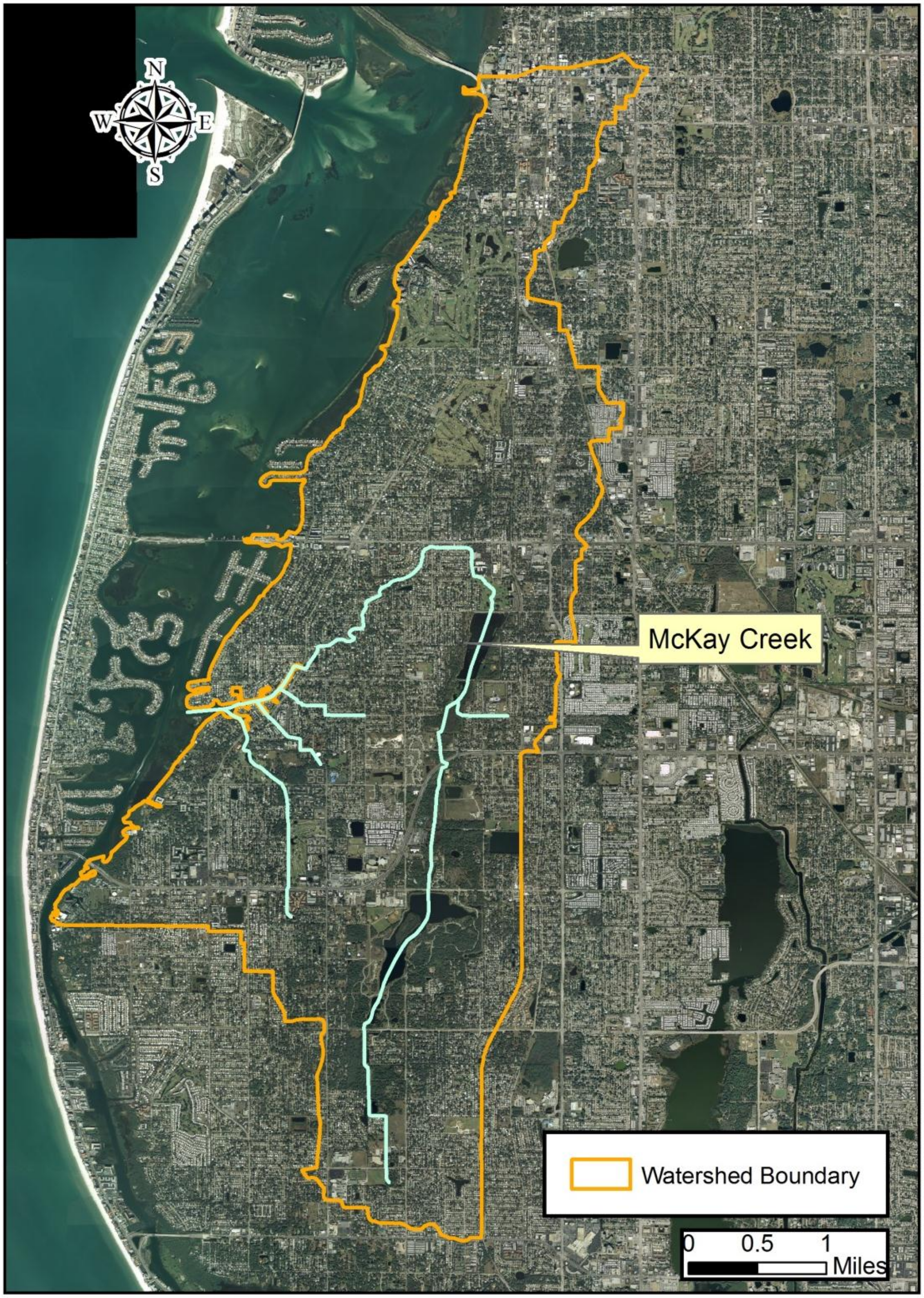


Figure 3-3. Tidal streams in Clearwater Harbor South watershed.

3.2 Field Reconnaissance

Field reconnaissance was conducted to obtain site-specific information for the CHSJS SMP. Recognizing that watershed-based sediment processes can affect habitats not only in the receiving water estuaries but also in the freshwater streams, an assessment of streams was completed to identify stream reaches that are subject to sediment erosion and deposition that may be detrimental to aquatic and littoral habitats. Both depositional areas and areas that may serve as sources of sediment export were examined. Field work includes:

- identification and documentation of existing and potential future problem areas,
- estimation of the unit volumes of fine-grained channel sediment at selected locations, and
- collection of sediment samples for laboratory analysis.

For this work the definition of "sediment" includes any substrate that would typically be transported by stream flow such as flocculent fine-grained and organic material; loose silt, sand, and shells; or other strata. The following methods were used to complete the field reconnaissance.

Field personnel visited each named tributary basin in the CHSJS to document stream channel conditions and to identify areas that are now subject to erosion or deposition, or that are likely to exhibit erosion or deposition problems in the future. Each site was photographed and the location documented using street maps, aerial photographs, and global positioning system (GPS) latitude-longitude coordinates. The field reconnaissance occurred June 8 - 9, and July 12 - 13, 2011. A total of 40 sites were inspected as follows.

- Klosterman Bayou/Creek – 3 sites
- Bee Branch – 4 sites
- Curlew Creek – 13 sites
- Cedar Creek – 4 sites
- Stevenson Creek – 5 sites
- Spring Branch – 4 sites
- McKay Creek – 7 sites

Site selection was confined to freshwater reaches of the streams, generally east of Alternate US 19. Sites were selected based on available access, however an attempt was made to locate sites approximately one-half mile apart on both the creeks' main stem and streams.

The "unit volume" of fine-grained sediments at each site was estimated. A unit volume is defined as the volume of fine-grained sediment per linear foot of channel, as measured at a single location, and is expressed here as cubic feet per linear foot (cu ft/lf) of channel. The unit volumes were calculated by multiplying the cross-sectional area of the sediment by the sediment layer depth, as illustrated in Figure 3-4. The purpose of obtaining the unit volume measurements was to provide a relative comparison of fine-grained sediment accumulation at specific locations. The information should be used to focus future engineering studies for the purpose of quantifying total volumes of material for dredging and removal.

Sediment depth at each location was measured on each side of the channel, providing access was possible. Sediment depth was measured by pushing a one-inch diameter PVC pipe into the channel bed until refusal. The pipe was marked with feet and fractions of feet. Three depth measurements were made and the results averaged for reporting. Channel dimensions (top of bank and toe of slope width) were measured using a tape measure and laser distance finder, or estimated as feasible. Inspection sites were spaced at approximate half-mile intervals or where access to the stream channel was feasible. Data were recorded manually on field data sheets and transferred to Microsoft Excel spreadsheets and Word documents.

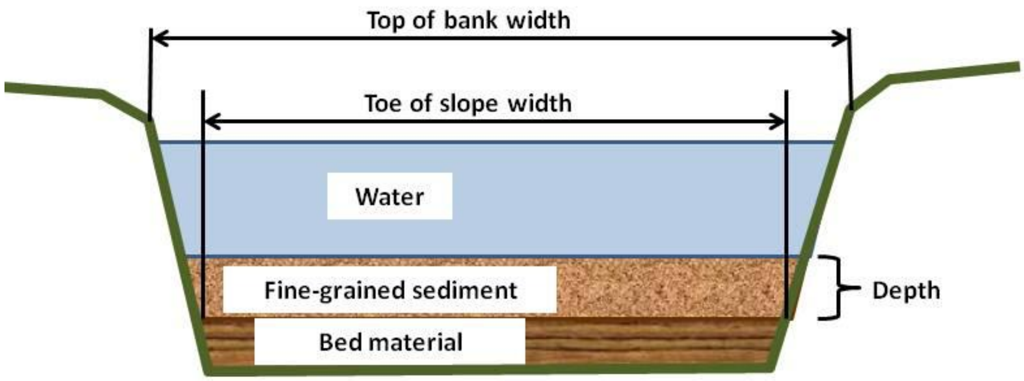


Figure 3-4. Conceptual schematic of stream cross section showing dimensions for fine-grained sediment unit volume measurements.

3.3 Laboratory Testing of Sediment Samples

Sediment samples to be analyzed for grain size and metals content were collected at eighteen sites. Samples were collected in 250 ml Thermo Scientific I-Chem Straight Sided HDPE Jars and stored in an iced cooler. Sediment was collected by submerging the jar in the top layer of sediment and capping the jar as soon as it filled to minimize the loss of fine-grained particles. At one site a seawall and deeper water required that a long-handled scoop be used to obtain the samples. Two jars of sediment were collected at each site – one for grain size analysis and the other for metals content.

Grain size analysis is useful to characterize the type of channel sediment (clayey fine grained, coarse or fine grained sand, organic muck, etc.) and metals analysis gives a general indication of the potential for sediment contamination. Metals often tend to sorb to fine grained sediments, especially clays, rather than stay in the water column.

Sample analysis was conducted by the Environmental Protection Commission of Hillsborough County (EPCHC) chemistry laboratory. Findings of the field investigation and laboratory analyses are provided below.

3.4 Summary of Existing Plans and Projects

All of the waterbodies within the CHSJS that were assessed for this work have previously been subject to studies or have had capital improvements completed to address sediment management issues. A literature review was conducted to identify stormwater and watershed management plans and studies relevant to sediment management, and capital projects that have been completed, are underway, or are planned. Individual plans, studies, and projects for each waterbody are summarized below. Sources of information include the following types and are summarized in Chapter 4 by waterbody.

- Existing stormwater and sediment management plans and studies (Stevenson Creek, City of Dunedin Drainage Master Plan, Pinellas County Stormwater Master Plan, etc.).
- County and municipality Capital Improvement Plans for drainage, erosion control, road and bridge improvement, and habitat restoration projects. Relevant projects for Curlew Creek, Stevenson Creek, Smith Bayou, and Bee Branch are listed in current CIPs.
- Local property owners in observed problem areas will be interviewed as feasible.

Documents that addressed sediment and drainage issues County-wide proved useful. Three of these are summarized below and specific recommendations contained in the documents are presented in section 4.0.

- **Pinellas County Master Drainage Plan (Pinellas County, 1988)**

A Master Drainage Plan (Plan) for the County was included in the County's 1988 Comprehensive Plan (Pinellas County 1998). Planned projects for each drainage basin in the County are provided but are dated. Stormwater standards include considerations for erosion control during and after construction. Identified priority basins in the CHSJS include the following streams: Cedar Creek, Curlew Creek, Klosterman Bayou, McKay Creek, Smith Bayou, Spring Branch, and Stevenson Creek.

- **Pinellas County Comprehensive Plan, Surface Water Management Element, (Pinellas County, 2008)**

The County Comprehensive Plan (Pinellas County 2008) provides guidance in stormwater management and erosion and sedimentation control. The plan includes goals, objectives, and policies for stormwater and sediment management, and lists surface water management improvements completed between 1997 and 2007. The only project in the CHSJS listed as completed during that period included improvements to Curlew Creek Channel A near SR580. Planned or scheduled future projects listed in the document include county-wide erosion control programs, and water body-specific projects which are described below.

- **Pinellas County Stormwater Governance Study (Pinellas County, 2011)**

The stormwater Governance Study (Pinellas County 2011) was completed for Pinellas County by Camp Dresser & McKee Inc. (CDM), Inc. with the support of URS Corporation Southern (URS) and Kurt Spitzer Associates Inc. (KSA). The study describes regulatory requirements for stormwater management including erosion control, assesses the County's current levels of service, considers potential activities to improve the level of service offered, and assesses possible funding options available to the County to pay for the current or expanded levels of service. The study also identifies stormwater programs, expenditures and budgets related to Fiscal Year 2011. Basin planning and Capital Improvement Program (CIP) funding were identified as the two areas most in need of enhancement. A review of County expenditures and budgets for FY 2006 - 2011 shows that during that period, most stormwater-based sediment management work in the CHSJS was focused on Smith Bayou/Bee Branch and Curlew Creek.

3.5 Identification of Recommended Projects

Based on the desktop analysis, the field reconnaissance and laboratory testing, and the review of existing management plans and projects, existing and potential erosion and deposition problem areas were identified and mapped. Some areas are spatially limited, such as a pipe or channel outfall, while some problem conditions extend over an entire channel reach. Potential methods of reducing sediment transport and deposition were then identified. Because of site conditions and other factors, there was often only one potentially feasible recommendation for any given site. The following factors were considered in developing the alternatives:

- effectiveness in sediment management,
- cost,
- permittability,
- responsible entity,
- public acceptance, and
- secondary effects or benefits (habitat, flooding relief, etc.).

Best Management Practices (BMPs) to reduce erosion and deposition were developed based on common practice, a review of relevant literature, and each sites' characteristics (Rosgen and Silvey, 1996; Schueler and Brown, 2004). Alternatives that were considered include but were not limited to:

- bank stabilization (vegetation, filter fabrics, soil amendments, gabions, hardening, etc.);
- re-routing flows through channel realignment or control structures;
- sediment sumps (in-line or off-line);
- in-line weirs;
- source control (street sweeping, etc.) and
- initiate or change maintenance practices.

4 Results

This section provides the results of the investigation of each of the CHSJS streams shown in Table 3-1. A summary of the desktop analysis, field reconnaissance, and the results of the laboratory analysis of sediment samples for grain size and metals content is reviewed. Additionally, existing management plans, studies and projects addressing sediment management in the CHSJS are described. A detailed description of all field sites including geographic coordinates is presented in Appendix A

4.1 Klosterman Bayou/Creek

Klosterman Bayou is a coastal embayment of St. Joseph Sound. A small (2.5 mile) stream extends east and south of the bayou draining residential and golf course areas. The stream is tidally influenced near the sound, and originates in a cypress swamp in the Innisbrook Resort. The stream appears to have been dredged over much of its length and is incorporated into the Innisbrook golf course drainage system.

4.1.1 Field Reconnaissance

Three field sites on Klosterman Creek were documented. Sites sampled for sediment depth and/or laboratory testing are shown in Figure 4-1.

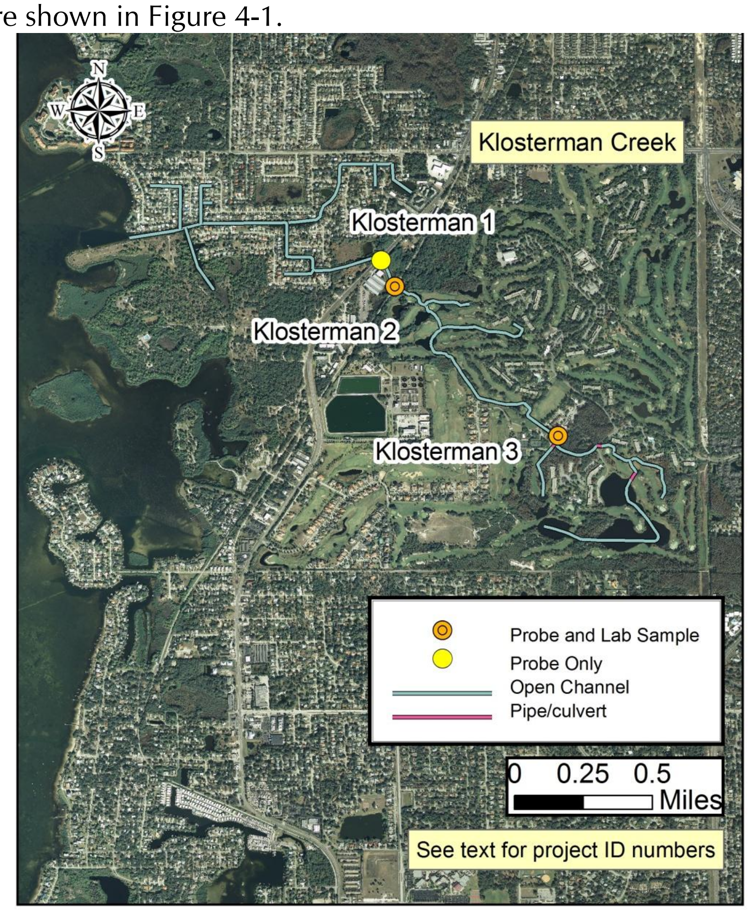


Figure 4-1. Location of stream sampling sites – Klosterman Creek.

Site "Klosterman 1" is located just upstream of the stream crossing at Alternate US 19 (Figure 4-2). The reach is tidally influenced and has very little topographic relief. Water quality data indicate that the stream is brackish from its mouth to upstream of US 19 at the discharge point of the Innisbrook Resort lake system (Pinellas County, 2010; FDEP, 2008a). Much of the upstream drainage area is contained within the Innisbrook Resort water management system and very high flows at this site are not expected. The sediment probe was used to estimate fine-grained material and loose soft sand layers. Loose sediment layer depths ranged from 6 to 12 inches at the site.

Figure 4-2. Site Klosterman 1 looking upstream.

Site Klosterman 2 (Figures 4-3 and 4-4) is located just upstream of the Pinellas Trail approximate 0.1 mile upstream of Alternate US 19. The terrain is relatively flat and the channel slope is low.

Figure 4-3. Site Klosterman 2 looking downstream.

Figure 4-3 shows the stream downstream of the trail. The stream reach is tidal and supports mangroves along the banks. Figure 4-4 shows the upstream reach to be overgrown, with significant amounts of detritus in the channel. However only a thin (1-inch) layer of silty/mucky sand sediment was observed. Although the channel banks were overgrown it appeared that the channel had been excavated at one time.

Figure 4-4. Site Klosterman 2 looking upstream.

The site was visited during a long dry period and there was minimal flow in the channel. The channel terminated approximately 0.5 miles upstream at a golf course pond at the Innisbrook Resort.

Site Klosterman 3 was on the Innisbrook Resort grounds near the stream headwaters. The stream was channelized with grassed side slopes (Figures 4-5 and 4-6). Soft sand with fine-grained material had accumulated to a depth of 10 inches upstream of the road crossing and had shoaled to 14 inches deep downstream of the Old Post Road culvert. Although potential issues with sediment accumulation were noted, the stream was on private property and its maintenance may not be a County responsibility

The "unit volume" of fine-grained sediment at each field site was estimated and is presented in Appendix B. A unit volume is defined as the volume of fine-grained sediment per linear foot of channel (ft^3/ft), as measured at a single location and is discussed in section 3.2. Downstream site Klosterman 1 had an estimated unit volume of 9.0 ft^3/ft, Klosterman 2 had a unit volume of 1.3 ft^3/ft, and Kosterman 3 had the highest unit volume with 10.0 ft^3/ft.

Figure 4-5. **Site Klosterman 3 looking downstream.**

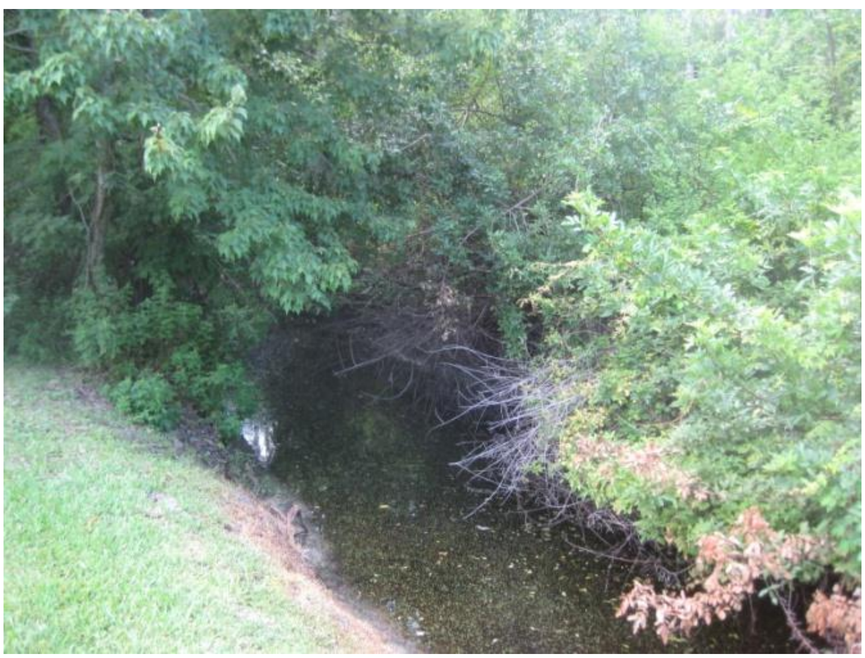


Figure 4-6. **Site Klosterman 3 looking upstream.**

4.1.2 Results of Laboratory Testing

The following summarizes the results of the laboratory analyses that were conducted on sediment samples taken at sites Klosterman 2 and 3. Analyses included determination of percent silt and clay (collectively known as fines) and metals concentrations. Additional information and numeric results for the sediment analyses are presented in Appendix C.

To be classified as a silty sand or clayey sand soil, sediment must contain at least 12% fines (FDOT, 2011). None of the Klosterman Creek sites had sufficient fines content to be classified as silty or clayey sand. In general the samples had low fines content, with samples from sites Klosterman 2 and 3 having 2.0% and 0.7% fines, respectively.

The relative potential for adverse impacts resulting from contaminants such as metals in sediments can be assessed using the Effects Level Approach (ELA) (MacDonald et al., 2003). The ELA uses empirically-derived ranges of contaminant concentrations to determine the likelihood of sediment contaminants causing adverse effects to benthic (sediment-dwelling) and water-dependent organisms and humans. Metal concentrations in the sediment were compared to derived values for the Threshold Effects Concentration (TEC) (the lower value) and the Probable Effects Concentration (PEC).

A review of the sediment metal concentrations show that cadmium at all sites was above the TEC (the lower value) but below the PEC. No other exceedances of the TECs were observed. Because the cadmium values were closer to the TEC than the PEC it can be concluded that severe adverse impacts to benthos from metal contamination at the sites sampled are not likely.

Another method of assessing the conditions of sediment quality is to examine the metals concentrations relative to a normalizing agent, in this case aluminum. By comparing the concentrations of a metal to the agent ranges of the two metals similar to concentrations representing non-enriched levels can be developed. Metal concentrations falling outside (above) the range have a greater probability of being enriched by anthropogenic sources. Site Klosterman 2 showed signs of metals enrichment for cadmium, lead, and nickel. Site Klosterman 3 had elevated levels of cadmium, copper, lead, and nickel. Although these metals may be present in higher concentrations than under natural conditions, the test provides no evidence of toxicity.

4.1.3 Summary of Existing Plans, Studies, and Projects

This section includes a summary of existing sediment management plans, studies, and capital improvement projects that have been proposed or completed for Klosterman Creek. Information was identified from agency web sites, the CHSJS Working Group (2010) bibliography, Tampa Bay Regional Planning Council (2006) and other sources. Additional information and numeric results for the sediment metals analyses are presented in Appendix C.

<u>Plans and Studies</u>

- **Klosterman Bayou/Joe's Creek Nutrient Source Evaluation (2010)**

This study was undertaken by Environmental Research and Design, Inc. for Pinellas County in response to the proposed nutrient TMDL for Klosterman Bayou (Pinellas County, 2010). The study's purpose was to evaluate nutrient loadings to Klosterman Bayou and Joe's Creek and to recommend methods of reducing current levels. The one recommendation relevant to sediment management in the CHSJS was to isolate Innisbrook Resort golf course ponds from other water bodies to prevent outflows except during very high rainfall events (Table 4-1 and Figure 4-1). The primary purpose of this would be to retain nutrients but it could also prove detrimental to sediment management. The lakes can be expected to act as sediment sumps, and letting the stream bypass the lakes could increase sediment loading to the estuary from the headwaters.

Table 4-1. Existing or proposed sediment management projects in the Klosterman Creek Basin.	
Project ID	**Project**
1	Isolate golf course lakes from stormwater management system

- **Joe's Creek Klosterman Bayou Total Maximum Daily Load (TMDL) for Dissolved Oxygen and Nutrients**

Florida Department of Environmental Protection (FDEP) published a TMDL for the tidal reach of Klosterman Bayou for dissolved oxygen and nutrients (FDEP, 2008a). Although sediment was not a focus of the report, the effects of sediment oxygen demand (SOD) on dissolved oxygen levels in estuarine surface waters were included in the assessment. The potential relative importance of SOD in the findings of impairment was not discussed.

Figure 4-7. Plans, studies, and capital projects for Klosterman Creek.

Capital Projects

No completed or proposed public capital projects to address sediment management were identified for Klosterman Bayou/Canal. Much of the stream is on private land and is the land owner's maintenance responsibility.

4.1.4 Conclusions and Recommendations

Conclusions and recommendations for Klosterman Creek are contained in section 5.0. No new site-specific projects are recommended for this stream but general recommendations presented in section 5.0 are applicable.

4.2 Bee Branch

Bee Branch originates near US 19 and Nebraska Avenue in Palm Harbor and travels to the southwest to the Sound. The drainage area contains some of the most significant topographic relief in the watershed. The channel elevation is approximately 65 feet NGVD at its headwaters and 10 feet NGVD near Alternate US 19. The channel length is approximately one mile, resulting in a stream channel slope of about 1 percent, significantly higher than the other streams in the CHSJS. Also, the creek corridor is comprised of Taveres fine sand which is noted in the Natural Resources Conservation Service (NRCS) Soil Survey for Pinellas County (USDA, 2006) as being structurally unstable and subject to cave-ins of embankments. Given the steep channel slope and unstable soils, Bee Branch is likely a significant source of sediment that is ultimately deposited downstream.

4.2.1 Field Reconnaissance

Sediment at four sites on Bee Branch was examined. Sites sampled for sediment depth and/or laboratory testing are shown in Figure 4-8.

Site Bee 1 is the most upstream site, and is located just west of Belcher Road south of Nebraska Ave. Loose silty sand sediment was observed to be approximately 6 inches deep, with significant shoaling as shown in Figure 4-9. Bank undercutting suggests high flow velocities.

Site Bee 2 is located at the 19th Street crossing south of Mary's Meadow Lane. Gabions have been installed on the channel bed, but not banks, upstream and downstream of the box culvert under 19th Street. Sand shoaling downstream of the road crossing (Figure 4-10) averaged about 7 inches deep, with apparent high fine-grained material content. This upper reach of the creek is not as steep as farther downstream, and channel morphometry indicates modest flow velocities.

Site Bee 3 is farther downstream at the 15th Street crossing, south of Ohio Avenue and north of Tampa Road. A review of a topographic map indicates that the reach downstream of site Bee 3 has a steeper slope than upstream, which would lead to higher in-stream velocities and higher erosion rates. Figure 4-11 shows the steep highly-incised channel banks. Only a thin spotty layer of loose soft sand, about 3 inches, was observed with most of the channel covered in rock and rubble. The relative lack of loose sediment and bank erosion indicates that stream flow likely reaches velocities sufficient to scour loose material and transport it downstream. The reach upstream at 15th Street was somewhat incised (Figure 4-12) but not to the extent seen in the downstream reach.

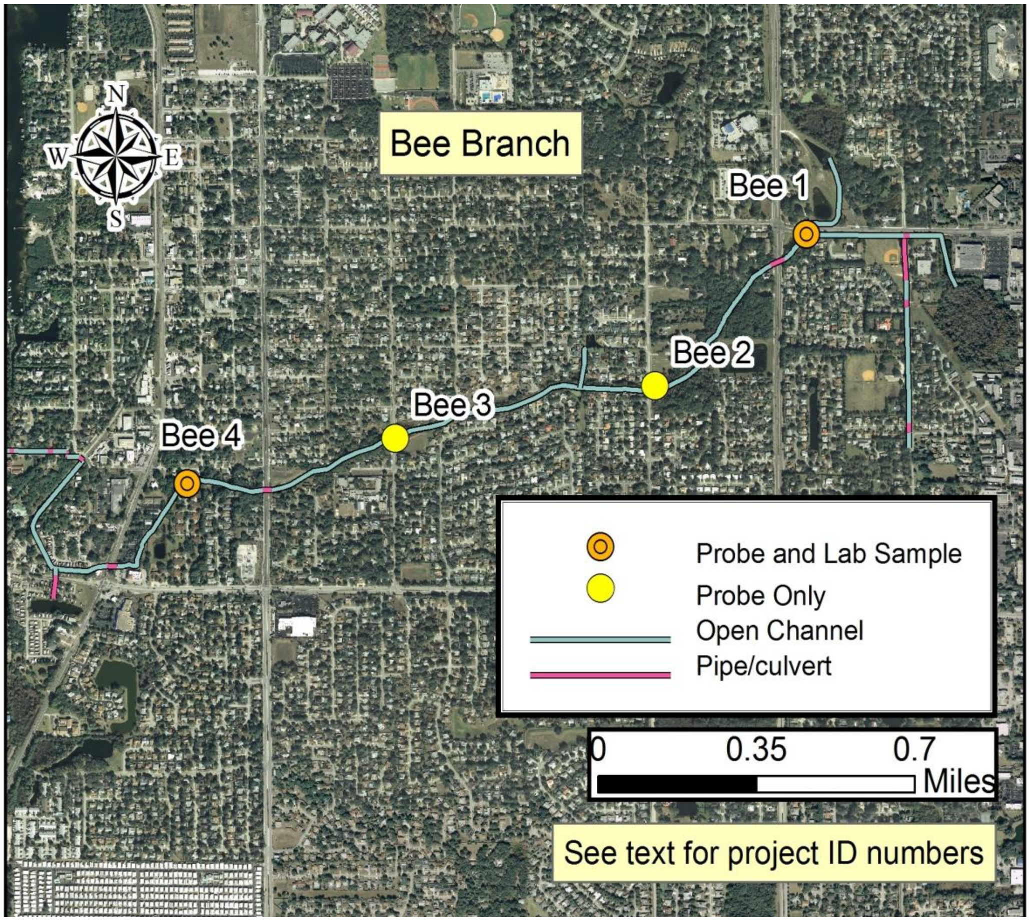


Figure 4-8. **Location of tributary sampling sites –Bee Branch.**

Figure 4-9. **Site Bee 1 looking downstream.**

Figure 4-10. Site Bee 2 looking downstream.

Figure 4-11. Site Bee 3 looking downstream.

Figure 4-12. Site Bee 3 looking upstream.

Site Bee 4 is located at the downstream end of the steep portion of the creek, at Hidden Brook Drive north of Tampa Road. Figure 4-13 shows that the channel is incised but the vegetated banks indicate that bank erosion is not as high as upstream where the banks are bare in many areas. Soft sand shoals are evident at the site, indicating that flow velocities are likely not as high as upstream, allowing sediment to accumulate.

Figure 4-13. Site Bee 4 looking downstream.

The unit volume of fine-grained sediment at each field site was estimated and is presented in Appendix B. A unit volume is defined as the volume of fine-grained sediment per linear foot of channel (ft^3/ft), as measured at a single location and is discussed in section 3.2. Upstream site Bee 1 had a unit volume estimate of 4.0 (ft^3/ft), Bee 2 had a unit volume of 8.8 ft^3/ft, Bee 3 had 3.8 ft^3/ft, and Bee 4 had 5.0 ft^3/ft.

4.2.2 Results of Laboratory Testing

The following summarizes the results of the laboratory analyses that were conducted on sediment samples taken at sites Bee 1 and 4. Analyses included determination of percent silt and clay (collectively known as fines) and metals concentrations. To be classified as a silty sand or clayey sand soil, sediment must contain at least 12% fines (FDOT, 2011). None of the Bee Branch sites had sufficient fines content to be classified as silty sand.

In general the samples had very low fines content, with samples from sites Bee 1 and 4 having 0.2% and 0.6% fines, respectively. Additional information and numeric results of the sediment analyses are presented in Appendix C.

The relative potential for adverse impacts resulting from contaminants in sediments can be assessed using the Effects Level Approach (ELA) (MacDonald et al., 2003). The ELA uses empirically-derived ranges of contaminant concentrations to determine the likelihood of sediment contaminants causing adverse effects to benthic (sediment-dwelling) and water-dependent organisms and humans. Metal concentrations in the sediment were compared to derived values for the threshold effects concentration (TEC) (the lower value) and the probable effects concentration (PEC).

A review of the sediment metals concentration shows that cadmium at all sites was above the TEC (the lower value) but below the PEC. No other exceedances of the TECs were observed. Because the cadmium values are closer to the TEC than the PEC it can be concluded that severe adverse impacts to benthos from metal contamination at the sites sampled is not likely.

Another method of assessing the conditions of sediment quality is to examine the metals concentrations relative to a normalizing agent, in this case aluminum. By comparing the concentrations of a metal to the agent ranges of the two metals similar to concentrations representing non-enriched levels can be developed. Metal concentrations falling outside (above) the range have a greater probability of being enriched by anthropogenic sources.

Both sites Bee 1 and 4 showed signs of metals enrichment for cadmium, lead, and nickel. Site Bee 4 also had enriched chromium. Although these metals may be present in higher concentrations than under natural conditions, the test provides no evidence of toxicity. Additional information and numeric results of the sediment metals testing are presented in Appendix C.

4.2.3 Summary of Existing Plans, Studies, and Projects

This section includes a summary of existing sediment management plans, studies, and capital improvement projects that have been proposed or completed for Bee Branch.

Plans and Studies

No stormwater or sediment management plans or studies specific to Bee Branch were identified. However erosion and sedimentation is an issue for this water body and has been addressed in the Pinellas County Master Drainage Plan (1988), Pinellas County Surface Water Management Element, Comprehensive Plan (2008), and Pinellas County Stormwater Governance Study (2011) as referenced above.

Capital Projects

- **Bee Branch Drainage Improvements (Channel Stabilization)**

Pinellas County and Southwest Florida Water Management District (SWFWMD) are cooperating to provide channel stabilization improvements to Bee Branch (SWFWMD, 2009). Projects include expanding the channel cross section, installing gabions to prevent erosion, and installing transverse weirs to slow flow velocities (Pinellas County, 2011). The project phases are described below and shown in Table 4-2 and Figure 4-14.

Table 4-2. Existing or proposed sediment management projects in the Bee Branch/Sutherland Bayou Basins.

Project ID	Project
2	Sutherland Bayou: Pop Stansell Stormwater Treatment and Habitat
3	Channel improvements and sediment basin CR1 – 14th St
4	Channel improvements 15th St to 19th St
5	Channel improvements 14th St to 15th St

- Phase IA (channel improvements CR1 – 14th St) was constructed FY 08-09. ;
- Phase IB (sediment basin on 14th St) will be constructed FY11-12. (ID 3);
- Phase II (channel improvements 15th St to 19th St) will be constructed FY 11-12. (ID 4); and
- Phase III (channel improvements 14th St to 15th St) will be constructed FY 14 (ID 5).

- **Sutherland Bayou: Pop Stansell Stormwater Treatment and Habitat (ID 2)**

Pop Stansell Park, owned by Pinellas County, is a 4.5-acre parcel of coastal property located in Palm Harbor in northwest Pinellas County. The park fronts Sutherland Bayou with marine access to St. Joseph Sound. Extensive public use of the property has resulted in erosion of soils. Stormwater, potentially influenced by this public use, has flowed relatively untreated into Sutherland Bayou.

In this cooperative project between Pinellas County and SWFWMD, habitat restoration will be achieved through the removal of exotic vegetation and planting of native species (Pinellas County, 2009). This native vegetation will also be planted in an existing ditch to eliminate soil erosion, filter pollutants, provide wildlife habitat and prevent undesirable public access to sensitive restored habitat. Water quality will be improved on-site through construction of a stormwater detention pond. The project was mostly funded in 2006.

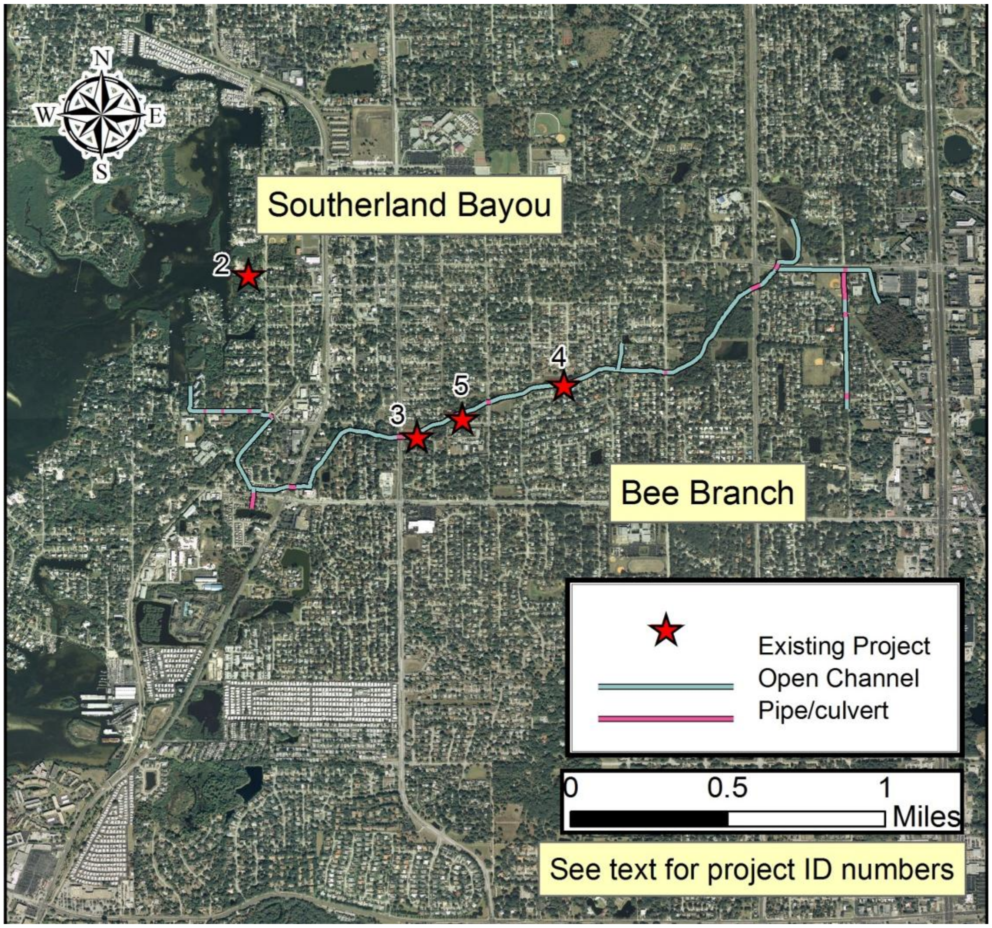


Figure 4-14. **Plans, studies, and capital projects for and Bee Branch and Sutherland Bayou.**

4.2.4 Conclusions and Recommendations

Conclusions and recommendations for Bee Branch are contained in section 5.0. One site-specific channel stabilization project is recommended for this stream and general recommendations presented in section 5.0 are applicable.

4.3 Curlew Creek

The mouth of Curlew Creek is just south of CR 586 (Curlew Road). The creek is the one of the larger in the CHSJS, and extends east past Belcher Road. A branch of the creek, Jerry Branch, continues south to Jerry Lake south of Main Street (CR 580). Curlew Creek has in general a milder slope than Bee Branch.

4.3.1 Field Reconnaissance

Sediment at 13 sites on Curlew Creek and its tributaries was examined. Sites sampled for sediment depth and/or laboratory testing are shown in Figure 4-15.

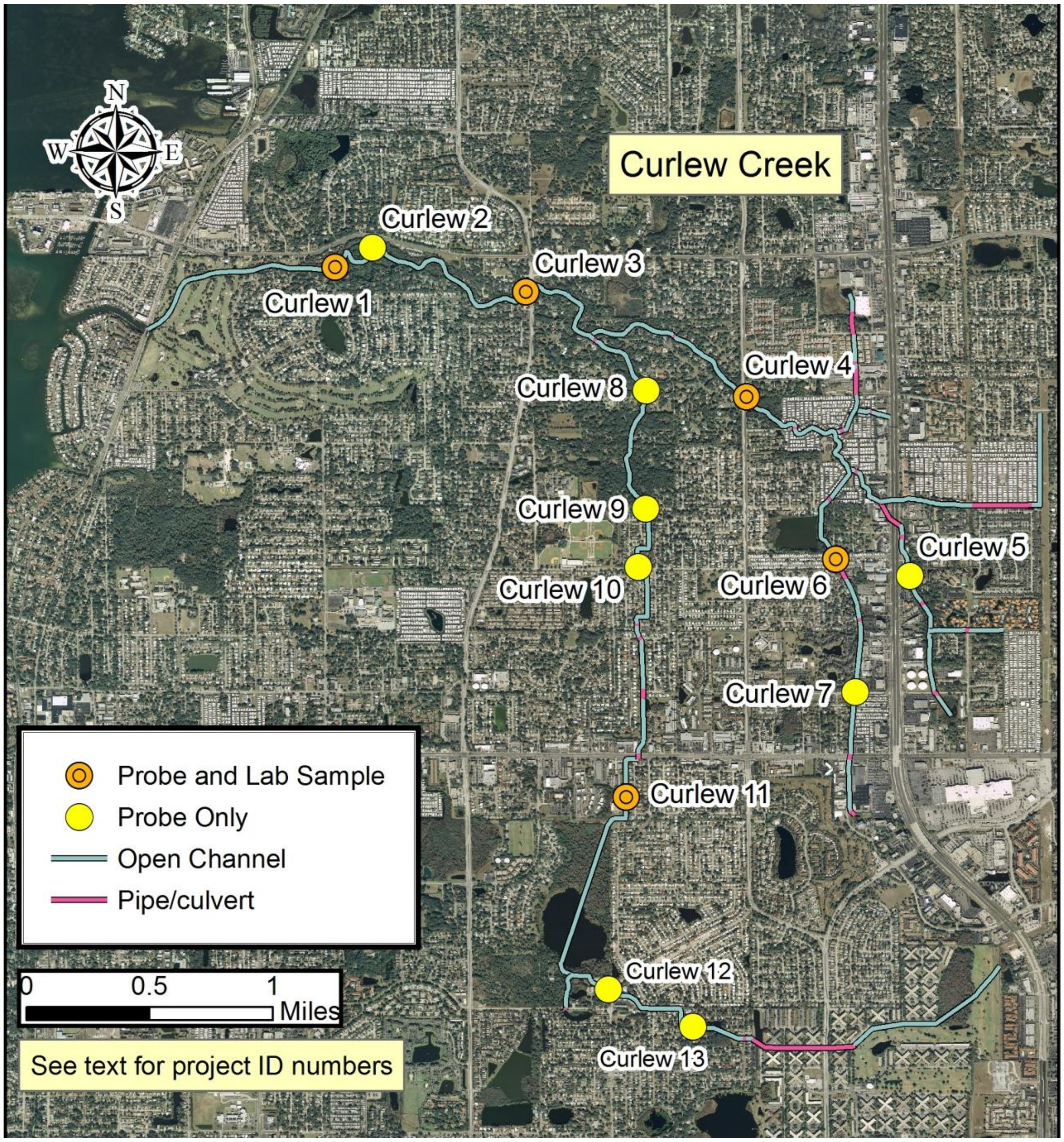


Figure 4-15. Location of stream sampling sites – Curlew Creek.

Site Curlew 1 is located north of Weybridge Lane in Fairway Estates. This site has retained some floodplain and has a shallow channel slope. Figure 4-16 shows sand shoaling that has occurred in the channel. Site Curlew 1 is the most downstream site investigated and appears to be representative of the reach from Curlew Creek Park downstream to the St. Andrews Links Golf Course, where tidal action becomes a driving force. Shoals tend to accumulated on the inside of a bend in the channel, but the shoal shown in Figure 4-16 has grown along a straight reach of the creek. The channel bottom was generally sandy with only 2 – 3 inches of loose sand in non-shoaling areas.

Site Curlew 2 is located in Curlew Creek Park about 0.2 miles upstream of Curlew 1. The channel is sinuous but the bed material is similar to that at Curlew 1(about 2 – 3 inches of loose sand). There was virtually no fine-grained sediment visible in the channel. Figure 4-17 shows unstable loose sand banks, making this area susceptible to bank erosion.

Figure 4-16. Site Curlew 1 looking downstream.

Figure 4-17. Site Curlew 2 looking downstream.

Site Curlew 3 is approximately 0.7 miles upstream of Curlew 2, 100 feet downstream of County Road 1. The channel is narrower than downstream reaches but the bed material appeared to be similar to Curlew 2, with about 2 inches of soft sand. Figure 4-18 shows tree damage caused by bank erosion. Figure 4-19 illustrates overbank shoaling at a residential lot caused by recent high flows in the stream.

Figure 4-18. **Site Curlew 3 looking downstream showing tree downed during high flows.**

Figure 4-19. **Site Curlew 3 - overbank shoaling after high flows.**

Site Curlew 4 is located at Belcher Road south of Ranchette Lane. Figure 4-20, looking upstream, shows filled land to the south of the channel. This elevated land is a berm for a stormwater retention pond that was constructed in association with County Road 1 improvements. It is likely that the relatively steep south channel bank contributes material to the creek during rainfall events. Downstream, the bottom was generally clean with 2 – 3 inches of loose sand. Patches of fine-grained material and bottom algae were observed, but no major accumulations were noted.

Figure 4-20. Site Curlew 4 looking upstream.

Site Curlew 5 is on the main stem at Estancia Blvd east of US 19. The channel was overgrown and had a sand bottom with 2 – 3 inches of loose sand. Figure 4-21 shows site conditions.

Figure 4-21. Site Curlew 5 looking downstream.

Site Curlew 6 is west of US 19 in Birch Court in the Silk Oak Trailer Park (Figure 4-22). The channel bottom is bare clean sand with some rocks with some shoaling and 3 – 4 inches of loose sand.

Figure 4-22. Site Curlew 6 looking upstream.

Site Curlew 7 is west of US 19 and north of Evans Road (Figure 4-23). The channel bottom was composed of coarse sand with silt and about 2 inches of loose sand. There is substantial debris in the channel, which receives runoff from an adjacent shopping center parking lot.

Figure 4-23. Site Curlew 7 looking downstream.

Site Curlew 8 is located on Brady Drive east of County Road 1 and is on Jerry Branch, a tributary of Curlew Creek. This is at one of the reaches within the Curlew Creek system with a higher channel slope. Figures 4-24 shows fairly incised banks.

Figure 4-24. Site Curlew 8 looking upstream.

The bottom channel was packed sand with virtually no loose surficial sand. Given the local topography and incised channel banks, this area is a potential sediment source, although not as significant as Bee Branch. Targeting this reach, with Bee Branch, seems a reasonable approach in identifying management practices to reduce the effects of excess sediment transport.

Site Curlew 9 is located at Laurelwood Lane west of Belcher Road. The channel is lined with gabions and is 7 – 8 feet deep as shown in Figure 4-25. There was mainly gravel on the gabion channel bottom.

Figure 4-25. Site Curlew 9 looking upstream.

Site Curlew 10 is located at Solon east of Cottonwood Terrace. The channel is lined with gabions as shown in Figure 4-26, however there was a 3 – 4 inch layer of loose sand on the bottom at this site.

Figure 4-26. Site Curlew 10 looking downstream.

Site Curlew 11 is on Jerry Branch located south of Main Street and east of Creek Park Drive, and is shown in Figure 4-27. The west bank was maintained but the east bank was thickly overgrown. The channel bottom was composed of thick mucky fine-grained material. The 8 – 10 inch thick layer gave off sulfur smell and profuse bubbles when probed. There was limited bank erosion.

Figure 4-27. Site Curlew 11 looking upstream.

Site Curlew 12 is located at Greenbriar Blvd north of Virginia Ave. Gabions on the east bank are shown downstream in Figure 4-28. Upstream of the bridge both sides of the channel are lined with gabions (Figure 4-29). The upstream channel bottom was relatively clean but downstream a 2 – 4 inch layer of loose sand was observed.

Figure 4-28. Site Curlew 12 looking downstream.

Figure 4-29. Site Curlew 12 looking upstream.

Site Curlew 13 is located east of Cypress Point Drive West, south of Cypress Point Drive North, about 0.4 miles west of Belcher Road. As seen in Figures 4-30, the north bank was overgrown but the steep south grass bank was typically maintained with spotty bank erosion evident. A sand layer with black fine-grained material about 3 inches thick was encountered.

Figure 4-30. Site Curlew 13 looking downstream.

The "unit volume" of fine-grained sediment at each field site was estimated and is presented in Appendix B. A unit volume is defined as the volume of fine-grained sediment per linear foot of channel (ft^3/ft), as measured at a single location and is discussed in section 3.2. Unit volume values ranged from 0.0 (ft^3/ft) at site Curlew9 (gravel on gabion channel bed) to 15 (ft^3/ft) at Curlew 11, a site with muck that released gas bubbles probed. Typical values were 2.5 to 5.0 (ft^3/ft), as shown in Appendix B.

4.3.2 Results of Laboratory Testing

The following summarizes the results of the laboratory analyses that were conducted on sediment samples taken at sites Curlew 1, 3, 4, 6, and 11. Analyses included determination of percent silt and clay (collectively known as fines) and metals concentrations. Additional information and numeric results of the sediment analyses are presented in Appendix C.

To be classified as a silty sand or clayey sand soil, sediment must contain at least 12% fines (FDOT, 2011). None of the Klosterman Creek sites had sufficient fines content to be classified as silty sand. In general the samples had very low fines, with samples from sites Curlew 1, 3, 4, 6, and 11 having fines contents of 0.7%, 0.5%, 0.6%, 0.6%, and 1.0%, respectively.

The relative potential for adverse impacts resulting from contaminants in sediments can be assessed using the Effects Level Approach (ELA) (MacDonald et al., 2003). The ELA uses empirically-derived ranges of contaminant concentrations to determine the likelihood of sediment contaminants causing adverse effects to benthic (sediment-dwelling) and water-dependent organisms and humans. Metal concentrations in the sediment were compared to derived values for the threshold effects concentration (TEC) (the lower value) and the probable effects concentration (PEC).

A review of the sediment metals concentration shows that cadmium at all sites was above the TEC (the lower value) but below the PEC. No other exceedances of the TECs were observed. Because the cadmium values are closer to the TEC than the PEC it can be concluded that severe adverse impacts to benthos from metal contamination at the sites sampled is not likely.

Another method of assessing the conditions of sediment quality is to examine the metals concentrations relative to a normalizing agent, in this case aluminum. By comparing the concentrations of a metal to the agent ranges of the two metals similar to concentrations representing non-enriched levels can be developed. Metal concentrations falling outside (above) the range have a greater probability of being enriched by anthropogenic sources.

All sites showed signs of metals enrichment for cadmium. Curlew sites 1, 3, 4, and 6 were also enriched with lead, and sites 3, 4, and 6 were enriched for nickel. Although these metals may be present in higher concentrations than under natural conditions, the test provides no evidence of toxicity. Additional information and numeric results of the sediment metals testing are presented in Appendix C.

4.3.3 Summary of Existing Plans, Studies, and Projects

This section includes a summary of existing sediment management plans, studies, and capital improvement projects that have been proposed or completed for Bee Branch.

Plans and Studies

Existing or proposed sediment management plans and capital projects for the Curlew Creek basin are summarized below. The project locations are listed by Project ID number in Table 4-3 and are shown on Figure 4-31.

Table 4-3. Existing or proposed sediment management projects in the Curlew Creek Basin.

Project ID	Project
6	Dredging at mouth of creek
7	Sago Court channel and bank stabilization
8	County Road 1 channel and bank stabilization
9	Channel A off-line detention pond
10	Saddle Hill North channel and bank stabilization
11	Spanish Oaks Stream flow diversion
12	Doral Village channel stabilization
13	Channel A Gabions
14	Oak Creek Drive channel stabilization
15	Lynnwood Court, Indian Creek bank stabilization
16	Brady Road channel stabilization
17	Channel B gabion installation

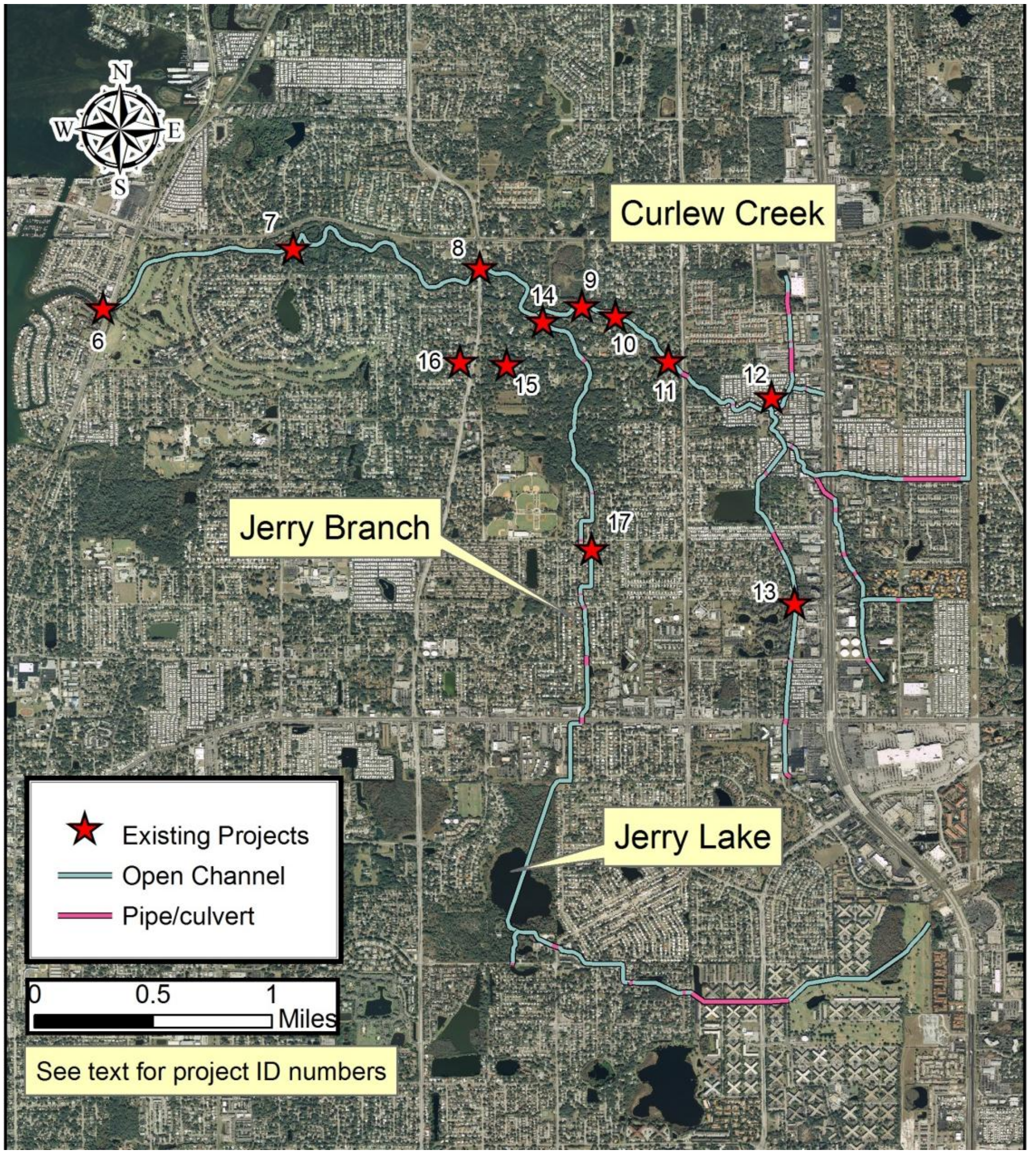


Figure 4-31. **Plans, studies, and capital projects for Curlew Creek.**

- **City of Dunedin Drainage Master Plan (2003) and City of Dunedin Comprehensive Plan Support Services Element and Conservation/Coastal Zone Element (2008a and b)**

The City's Drainage Master Plan addresses portions of Curlew Creek, Cedar Creek, and Spring Branch that are in City jurisdiction. Several capital projects recommended in the plan have been constructed. It was recognized in the City's Master Drainage Plan and Comprehensive plan that stormwater-related erosion and siltation result in challenges for flood control, navigation, and recreation, especially in areas near the mouths of Curlew Creek and Cedar Creek. City records show that almost 45,000 cubic yards of sediment were dredged from the mouth of Curlew Creek between 1968 and 1998. The City's stormwater system was inventoried and a series of infrastructure improvements were recommended in the Master Drainage Plan and included in the City Comprehensive Plan. Recommendations relevant to sediment management in the Curlew Creek basin included:

- Curlew Creek Channel A - Various improvements including off-line detention (ID 9), detention ponds, and bank stabilization are proposed. Detention will lower peak flows in the creek and reduce flow velocities. Bank stabilization will reduce scour and erosion. Priority areas included North Saddle Hill Bridge and Cross Creek Way Bridge (ID 10), CR 1 crossing (ID 8), and north of Sago Court (ID 7). On-going work throughout the City includes installation of pollution control boxes (baffle boxes or sediment traps) at eight pipe outfalls greater than 36″, and installation of skimmers with sumps at 45 pipe outfalls less than 36″ diameter. Sites include Curlew Creek at Weybridge Lane and at Sturbridge Court. Some of these units have been installed.

- Curlew Creek Channel B – Proposed improvements include installation of gabions for channel bank stabilization from Copper Kettle Lane to Laurelwood Lane (ID 17). Bank stabilization was also proposed for bridges at Laurelwood Lane, west of Lynnwood Court, and Indian Creek Court (ID 15). Other channel stabilization projects include Brady Road (ID 16) and Oak Creek Drive (ID 14).

- Mouth of Curlew Creek (ID 6) – Sediment is periodically dredged from the mouth of the creek to improve navigation and free flow of water.

- **Curlew Creek Fluvial Geomorphology and Natural Channel Design (2006)**

Pinellas County retained consultants AMEC-BCI, Inc. to examine erosion problems on Curlew Creek Channel A and develop erosion control measures. Erosion and depositional areas were identified. Recommendations included installing road crossing structures that do not promote deposition of sediment, using bank stabilization techniques such as riprap and bioengineering methods, purchasing land parcels with high risk of erosion, and installation of streamflow control structures.

Capital Projects

- **Curlew Creek Channel A Improvements**

Pinellas County, City of Dunedin, City of Clearwater, and SWFWMD have all participated in improvements to Curlew Creek for water quality and sediment management.

- Past funded projects include the Spanish Oaks diversion project (ID 11) that included an off-line storage area. Stream flow is diverted to a pond to reduce flooding, bank erosion, and downstream transport of sediment.

- Current capital projects on Curlew Creek Channel A include channel improvements between Republic Drive and Belcher Road (ID 13), improvements at SR580 (included in the County's FY2005 CIP, as was a watershed management plan for Curlew Creek), and in Doral Village (ID 12). Measures for erosion control include culvert replacement, gabion installation, and other bank stabilization measures, and are funded for FY 11-12.

- Periodic maintenance dredging of tidal channel segments.

4.3.4 Conclusions and Recommendations

Conclusions and recommendations for Curlew Creek are contained in section 5.0. Three channel stabilization/habitat enhancement projects and two sediment removal projects are recommended for this stream and general recommendations presented in section 5.0 are applicable.

4.4 Cedar Creek

Cedar Creek is a small multi-channel creek within the City of Dunedin. Much of it has been channelized for drainage purposes and stabilized using gabions or other structures. However, restoration efforts are attempting to return some of the natural features of the channel and floodplain. The City has developed a restoration plan for Cedar Creek, and several projects sponsored by the City, Pinellas County, and/or the Southwest Florida Water Management District have provided for channel stabilization, habitat restoration, and flood protection in the Cedar Creek system. The creek runs through the City-owned Hammock Park and discharges to the Sound about one mile south of Curlew Road.

4.4.1 Field Reconnaissance

Sediment at four sites was examined. Sites sampled for sediment depth and/or laboratory testing are shown in Figure 4-32.

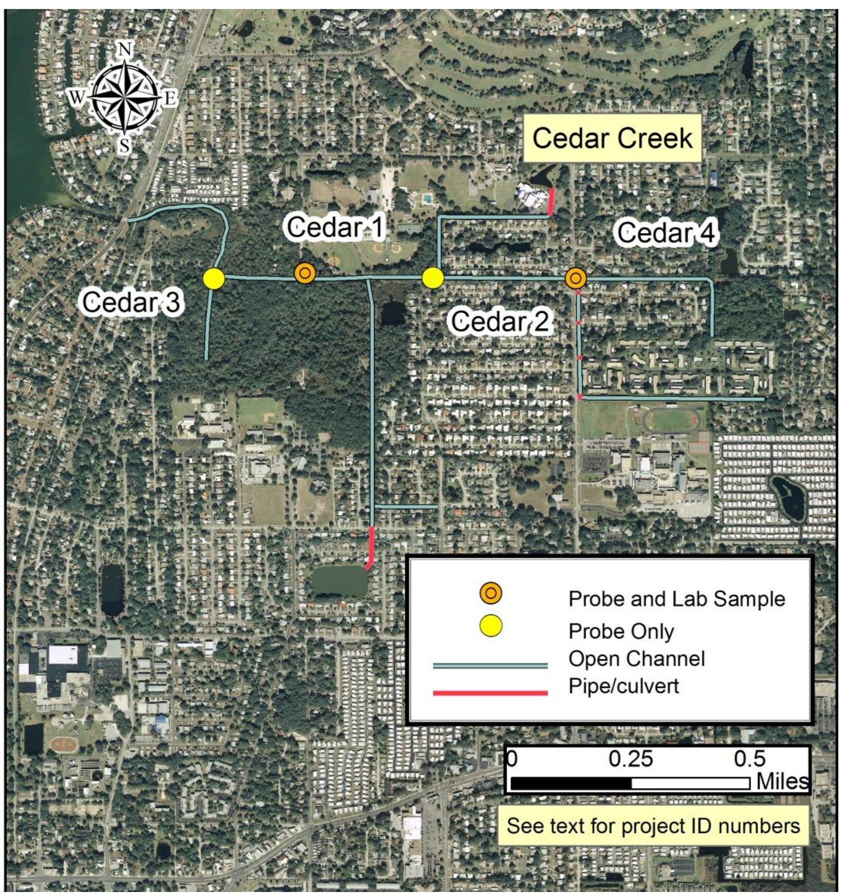


Figure 4-32. Location of stream sampling sites – Cedar Creek.

Site Cedar 1 is located in the park at the south end of Harvard Avenue, near Pinellas County water quality monitoring site 9-2. Figure 4-33 shows the channel to have shallow banks and to be relatively clear of fine-grained debris. A layer of loose sand approximately 2 – 4 inches deep was observed. The terrain is fairly flat and the channel has minimal slope.

Figure 4-33. Site Cedar 1 looking upstream.

Site Cedar 2 is located west of Pinehurst at the end of Jackmar Road, near Pinellas County water quality monitoring site 9-3. Figure 4-34 shows that the channel is lined with gabions constructed to control channel erosion. Minimal loose sediment was observed at the site.

Figure 4-34. Site Cedar 2 looking upstream.

Site Cedar 3 is located in the park at Sugarberry Trail (Figure 4-35). There was substantial detritus in the shallow banked creek channel with a thin film of fine-grained silt on the bottom.

Figure 4-35. Site Cedar 3 looking upstream.

Site Cedar 4 is the most upstream site, located at the Pinehurst Road crossing (Figure 4-36). Although the channel is lined with gabions there is still sand shoaling evident.

Figure 4-36. Site Cedar 4 looking upstream.

The unit volume of fine-grained sediment at each field site was estimated and is presented in Appendix B. A unit volume is defined as the volume of fine-grained sediment per linear foot of channel (ft^3/ft), as measured at a single location and is discussed in section 3.2. Downstream site Cedar 1 had an estimated unit volume of 7.5 ft^3/ft, Cedar 2 had a unit volume of 0.0 ft^3/ft, (gabion channel bottom), Cedar 3 had 2.0 ft^3/ft, and Cedar 4 had 2.0 ft^3/ft.

4.4.2 Results of Laboratory Testing

The following summarizes the results of the laboratory analyses that were conducted on sediment samples taken at sites Cedar 1 and 4. Analyses included determination of percent silt and clay (collectively known as fines) and metals concentrations. Additional information and numeric results of the sediment analyses are presented in Appendix C.

To be classified as a silty sand or clayey sand soil, sediment must contain at least 12% fines (FDOT, 2011). None of the Cedar Creek sites had sufficient fines content to be classified as silty sand. In general the samples had very low fines content, with samples from sites Cedar 1 and 4 having 0.6% and 0.7% fines, respectively.

The relative potential for adverse impacts resulting from contaminants in sediments can be assessed using the Effects Level Approach (ELA) (MacDonald et al., 2003). The ELA uses empirically-derived ranges of contaminant concentrations to determine the likelihood of sediment contaminants causing adverse effects to benthic (sediment-dwelling) and water-dependent organisms and humans. Metal concentrations in the sediment were compared to derived values for the threshold effects concentration (TEC) (the lower value) and the probable effects concentration (PEC). A review of the sediment metals concentration shows that cadmium at all sites was above the TEC (the lower value) but below the PEC. No other exceedances of the TECs were observed. Because the cadmium values are closer to the TEC than the PEC it can be concluded that severe adverse impacts to benthos from metal contamination at the sites sampled is not likely.

Another method of assessing the conditions of sediment quality is to examine the metals concentrations relative to a normalizing agent, in this case aluminum. By comparing the concentrations of a metal to the agent ranges of the two metals similar to concentrations representing non-enriched levels can be developed. Metal concentrations falling outside (above) the range have a greater probability of being enriched by anthropogenic sources. Both sites Cedar 1 and 4 showed signs of metals enrichment for cadmium, lead, and nickel. Although these metals may be present in higher concentrations than under natural conditions, the test provides no evidence of toxicity. Additional information and numeric results of the sediment metals testing are presented in Appendix C.

4.4.3 Summary of Existing Plans, Studies, and Projects

<u>**Plans and Studies**</u>

- **City of Dunedin Drainage Master Plan (2003) and City of Dunedin Comprehensive Plan Support Services Element and Conservation/Coastal Zone Element (2008a and b)**

The City's Drainage Master Plan addresses Cedar Creek and other streams that are in City jurisdiction. Recommendations for sediment management in the Cedar Creek basin included:

➢ At St. Catherine Drive East (ID 20) - realign and stabilize channel. Also the Hammock Park Restoration project (ID 18) will help stabilize waterways and reduce sediment transport. On-going work throughout the City includes installation of pollution control boxes (baffle boxes or sediment traps) at eight pipe outfalls greater than 36″, and installation of skimmers with sumps at 45 pipe outfalls less than 36″ diameter. Sites include Cedar Creek at Alternate US 19. Some of these units have been installed.

Table 4-4. Existing or proposed sediment management projects in the Cedar Creek Basin.

Project ID	Project
18	Hammock Park Restoration projects
19	Cedar Creek Restoration projects
20	St. Catherine Drive channel re-alignment and stabilization
21	Dunedin High School channel bank stabilization

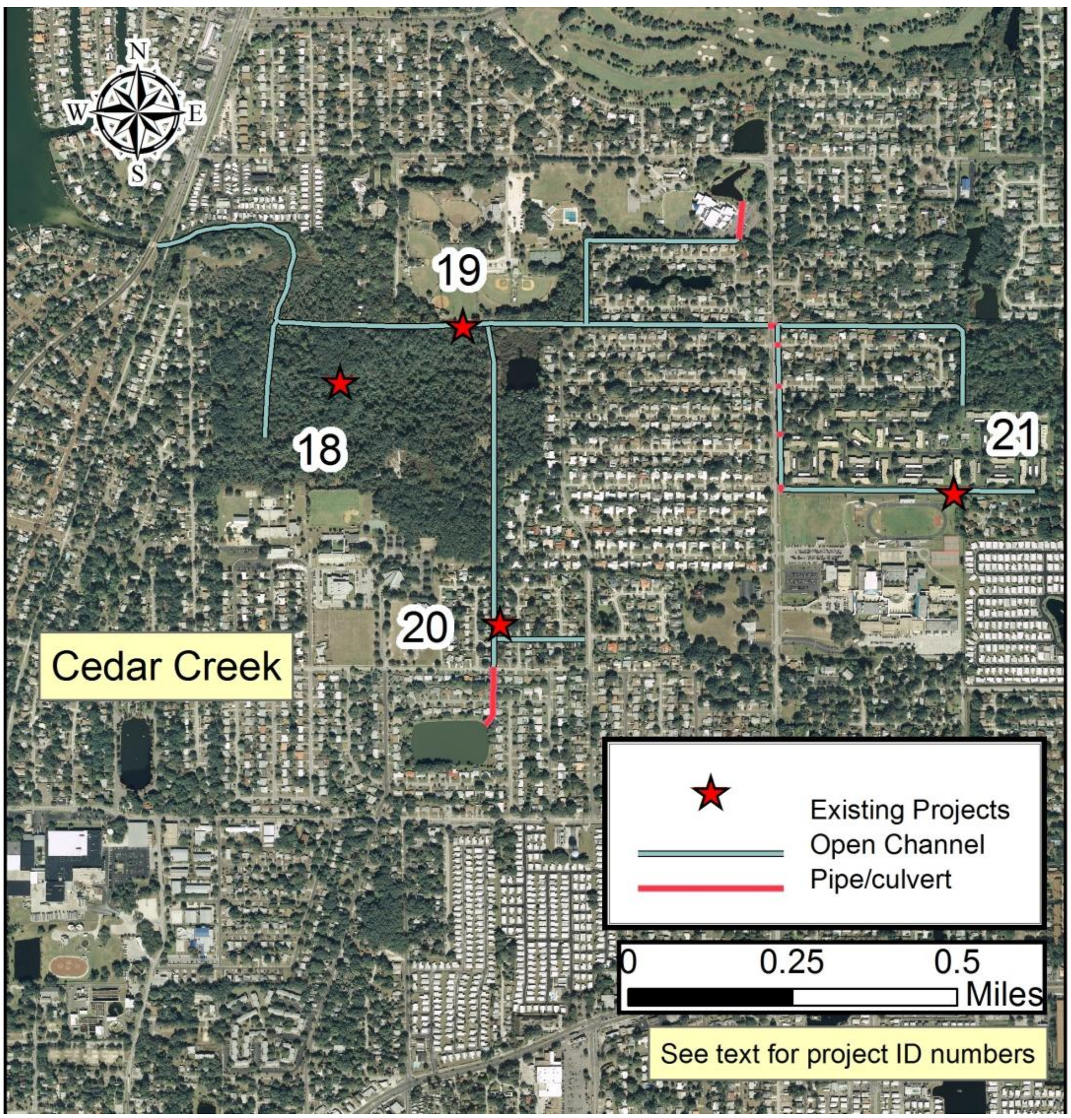


Figure 4-37. Plans, studies, and capital projects for Cedar Creek.

- **Cedar Creek Restoration Plan (2006) (ID 19)**

This plan was developed by the City of Dunedin to reduce flooding, reduce channel erosion, and re-hydrate part of Hammock Park (St. Petersburg Times, 2008). Projects, some of which have been implemented as noted below, include:

  - Dredging Cedar Creek outfall
  - Installing pollution control structures at stormwater pipe outfalls
  - Remove fill and riprap from the channel
  - Rehydrate Hammock Park
  - Enhance Lake Suemar
  - Install bank protection in Channel C
  - Lake Sperry enhancements

<u>Capital Projects</u>

- **Lake Suemar Water Quality Enhancements**

This element of the Cedar Creek Restoration Plan is a cooperative project between the City of Dunedin and SWFWMD that includes the reconfiguration of Lake Suemar for enhancement of water quality entering Cedar Creek (and ultimately St. Joseph Sound). The project provides additional retention and treatment capacity for portions of the flows from the nearby channels.

Also, by constructing a water level control structure in the conveyance channel, along with overflow pipes and berms, normal flows are diverted for treatment within Lake Suemar. The reconfigured Lake Suemar serves to collect sediment and provide treatment across a littoral shelf to enhance the quality of water. Treated water is released back for discharge into Cedar Creek. The project, an element of the Cedar Creek Restoration Plan described above, was completed in 2010.

- **Stormwater Filter Systems**

This is a cooperative project between the City of Dunedin and SWFWMD, and includes installation of three CDS-type filtration units at the discharge of existing pipes to remove sediment and pollutants from runoff prior to its entering Lake Sperry. The project is an element of the Cedar Creek Restoration Plan. The project is an element of the City of Dunedin's Cedar Creek Restoration Plan and received funding in 2010.

- **Lake Sperry Filter System**

This cooperative project between the City of Dunedin and SWFWMD includes installation of a baffle box filtration system with exfiltration pipes to remove sediment and pollutants from runoff prior to entering Lake Sperry. The project is an element of the City of Dunedin's Cedar Creek Restoration Plan and received funding in 2010.

- **Maintenance Dredging at Creek Mouth**

The City of Dunedin (Dunedin, 2011) funds maintenance dredging of the main channel downstream of Alternate US 19 due to the accumulation of sediments that impede navigation.

- **Bank Stabilization at Dunedin High School (ID 21)**

This project was funded in the City of Dunedin's 2008 CIP budget and included measures for reducing bank erosion in Cedar Creek.

4.4.4 Conclusions and Recommendations

Conclusions and recommendations for Cedar Creek are contained in section 5.0. No new site-specific channel stabilization project is recommended for this stream but general recommendations presented in section 5.0 are applicable.

4.5 Stevenson Creek

Stevenson Creek shares many of the features of the other creeks – it is in a highly urbanized drainage area, and it has been largely ditched and maintained for flood protection. Stevenson Creek originates in the City of Largo and flows north over 4 miles to the City of Clearwater, discharging into Clearwater Harbor North south of Sunset Point Road. Stevenson Creek is not steep, but rather runs along the base of the Penholoway Terrace, an ancient shoreline geomorphic feature. It is the terrace that forms the relatively steep bluffs along the coast in Clearwater and Bellaire Bluffs.

4.5.1 Field Reconnaissance

Sediment at five sites on Stevenson Creek was examined. Sites sampled for sediment depth and/or laboratory testing are shown in Figure 4-38.

Site Stevenson 1 is the farthest upstream, located at Bellevue Boulevard near South Evergreen Avenue. The channel was piped upstream of the site. The channel downstream had a gravel bed but did have a sandy shoal as shown in Figure 4-39. The downstream reach is subject to significant bank erosion. Local residents have had to use rip rap and rubble debris to slow erosion near homes.

Site Stevenson 2 is located at the Lakeview Road bridge west of Hillcrest Drive. A large sand shoal had developed under the bridge as shown in Figure 4-40. The reach is channelized with a sediment layer of approximately 5 inches of loose sandy silt and patchy fine-grained sediment (Figure 4-41). Although sediment transport is evident it is likely of nearby origin, as a stormwater in-line pond about 0.7 miles upstream of this site should act as sediment sump for material originating farther upstream.

Site Stevenson 3 is located at Drew Street east of Betty Lane (Figure 4-42). The channel is concrete-lined both north and south of the bridge but there was an average of 3 inches of silty and mucky sand on the channel bottom. This reach receives high volumes of runoff from downtown Clearwater.

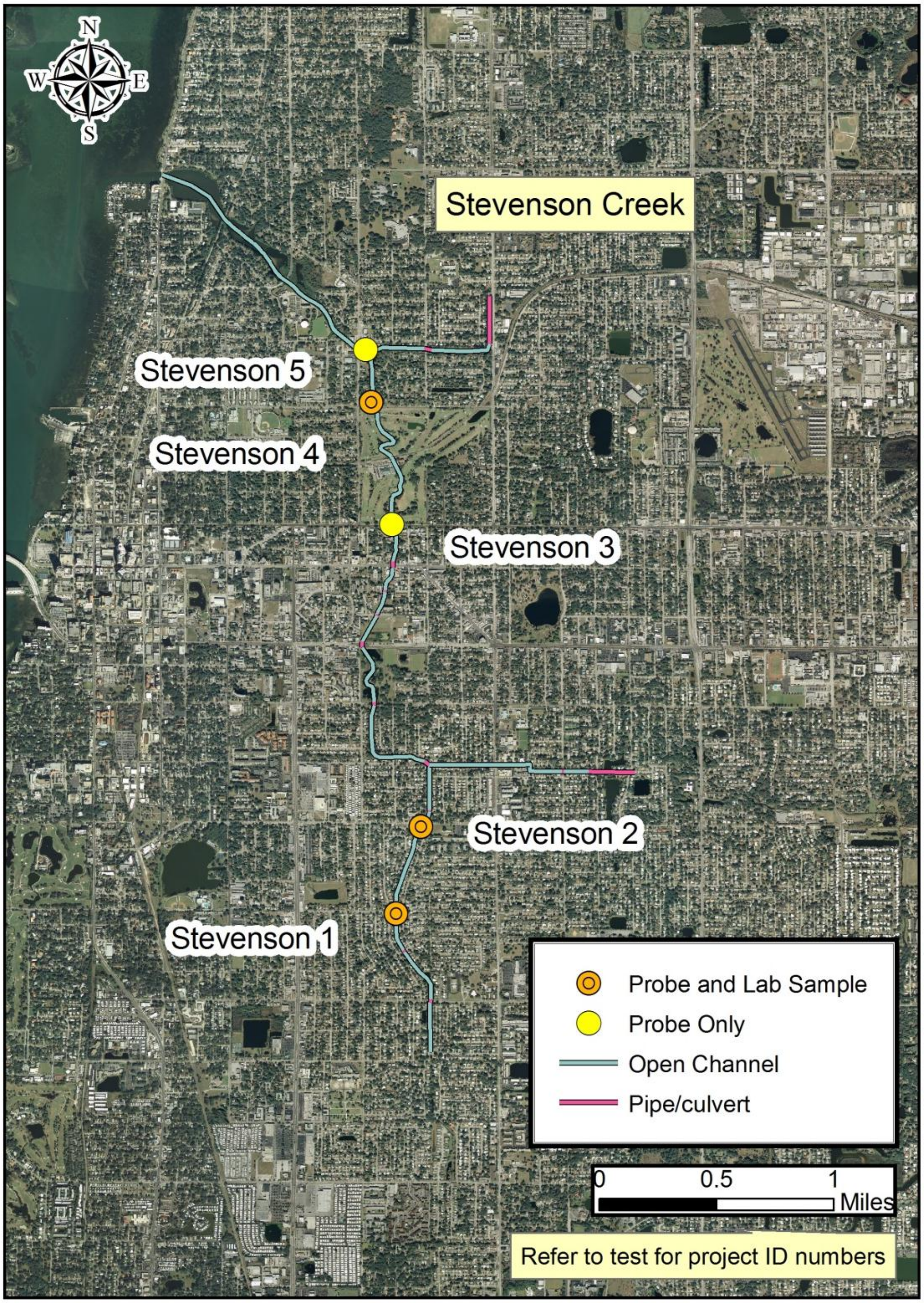


Figure 4-38. Location of stream sampling sites – Stevenson Creek.

Figure 4-39. Site Stevenson 1 looking downstream.

Figure 4-40. Site Stevenson 2 sand shoal under Lakeview Road bridge.

Figure 4-41. Site Stevenson 2 looking upstream.

Figure 4-42. Site Stevenson 3 looking downstream.

Site Stevenson 4 is located north of the Palmetto Street crossing, east of Betty Lane. The channel has seawalls on both sides but sediment accumulation on the east side has promoted the establishment of cattails and other vegetation as shown in Figure 4-43. A soft sand bottom approximately 4 inches thick was measured off the west seawall.

Figure 4-43. Site Stevenson 4 looking upstream.

Site Stevenson 5 is located east of Betty Lane and south of Overlea Street, at a wide area of the channel where the main stem is joined by a tributary from the east. The channel widens, and significant sandy shoals were observed as shown in Figures 4-44.

Figure 4-44. Site Stevenson 5 looking upstream (SE).

The "unit volume" of fine-grained sediment at each field site was estimated and is presented in Appendix B. A unit volume is defined as the volume of fine-grained sediment per linear foot of channel (ft^3/ft), as measured at a single location and is discussed in section 3.2. Upstream site Stevenson 1 had a unit volume estimate of 0.0 ft^3/ft (gravel bed with minimal silt), Stevenson 2 had a unit volume of 3.3 ft^3/ft, Stevenson 3 had 2.5 ft^3/ft, Stevenson 4 had 10.0 ft^3/ft, and Stevenson 5 had 20.0 ft^3/ft.

4.5.2 Results of Laboratory Testing

The following summarizes the results of the laboratory analyses that were conducted on sediment samples taken at sites Stevenson 2 and Stevenson 4. Analyses included determination of percent silt and clay (collectively known as fines) and metals concentrations. Additional information and numeric results of the sediment analyses are presented in Appendix C.

To be classified as a silty sand or clayey sand soil, sediment must contain at least 12% fines (FDOT, 2011). Samples from sites Stevenson 2 and Stevenson 4 both had 0.7%. These values were among the lowest of all samples

The relative potential for adverse impacts resulting from contaminants in sediments can be assessed using the Effects Level Approach (ELA) (MacDonald et al., 2003). The ELA uses empirically-derived ranges of contaminant concentrations to determine the likelihood of sediment contaminants causing adverse effects to benthic (sediment-dwelling) and water-dependent organisms and humans. Metal concentrations in the sediment were compared to derived values for the threshold effects concentration (TEC) (the lower value) and the probable effects concentration (PEC).

A review of the sediment metals concentration shows that cadmium at all sites was above the TEC (the lower value) but below the PEC. No other exceedances of the TECs were observed. Because the cadmium values are closer to the TEC than the PEC it can be concluded that severe adverse impacts to benthos from metal contamination at the sites sampled is not likely.

Another method of assessing the conditions of sediment quality is to examine the metals concentrations relative to a normalizing agent, in this case aluminum. By comparing the concentrations of a metal to the agent ranges of the two metals similar to concentrations representing non-enriched levels can be developed. Metal concentrations falling outside (above) the range have a greater probability of being enriched by anthropogenic sources.

Site Stevenson 2 showed signs of metals enrichment for cadmium, copper, lead, and nickel. Site Stevenson 4 had enriched cadmium, lead, and nickel. Although these metals may be present in higher concentrations than under natural conditions, the test provides no evidence of toxicity. Additional information and numeric results of the sediment metals testing are presented in Appendix C.

4.5.3 Summary of Existing Plans, Studies, and Projects

Management plans, studies, and capital projects for Stevenson Creek are summarized below. Projects are listed in Table 4-5 and shown on Figure 4-45.

Table 4-5. Existing or proposed sediment management projects in the Stevenson Creek Basin.	
Project ID	**Project**
22	Dredging/restoration at the mouth of the creek
23	Palmetto St. sediment sump
24	Glen Oaks stormwater management facility
25	Upper creek channel stabilization
26	Jeffords St. retention pond

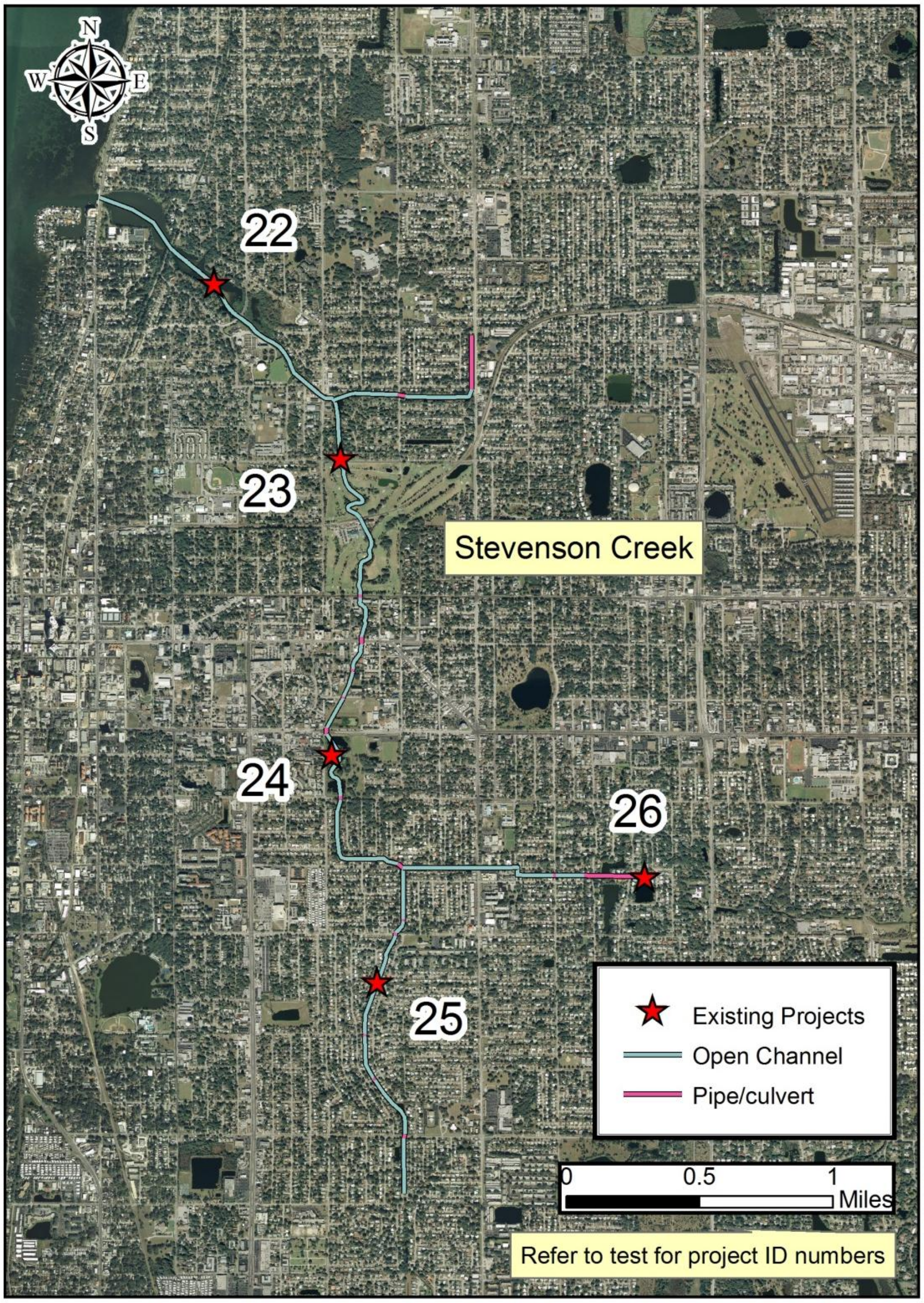


Figure 4-45. Plans, studies, and capital projects for Stevenson Creek.

Plans and Studies

- **Stevenson Creek Watershed Management Plan (SCWMP) (2001)**

The SCWMP (City of Clearwater, 2001) was developed by a team consisting of the City of Clearwater, Parsons Engineering Science, Inc., SWFWMD, Pinellas County, and US Army Corps of Engineers (ACOE). The SCWMP addressed surface water quality, flood control, habitat protection and enhancement, and erosion control. A series of alternative Best Management Practices (BMPs) were developed to address each of the management objectives. Erosion control and sediment management BMPs that scored the highest in the priority ranking in the SCWMP include the following. Spring Branch was integral to the Stevenson Creek system in the analysis. Although the Glen Oaks Stormwater Detention Facility had only moderate scores for erosion control it was the highest ranked overall, and has been completed.

- Project 3A - Glen Oaks (ID 24) is a regional stormwater treatment facility consisting of five treatment areas totaling 21 acres. The site provides both flood protection and pollutant removal. The stormwater ponds also act as sediment sumps and reduce downstream loads.

- Project 2A – Palmetto Street Sediment Sump (ID 23). A weir would be constructed across the Stevenson Creek channel north of Palmetto Street to capture suspended sediment. This would compliment an existing sediment sump south of Palmetto that is maintained but still fills with sediment.

- Project 4B – Upper Stevenson Creek Stabilization (ID 25). Channel stabilization in the upper basin is necessary because of significant bank erosion, especially in the reach between Lakeview Road and Bellvue Boulevard. It is recommended to either conduct isolated fixes of problem areas as they occur, using geotextiles or gabions, or to re-configure the entire channel reach with a narrow deeper center lined with gabions and less steep higher side slopes.

- Project 7C – Jeffords Street/Barry Road Detention Pond (ID 26). In conjunction with the construction of a detention pond with wetland plantings, 500 linear feet of open ditch were proposed to be piped to eliminate bank erosion in this reach. The pipes would be constructed under a shallow swale.

- **Stevenson Creek Estuary Restoration Plan (2003) (ID 22)**

A study was completed by the US Army Corps of Engineers (COE) (2003) to develop an ecological restoration plan for downstream reaches of Stevenson Creek. The recommended plan included dredging muck from the creek channel between Fort Harrison Avenue and the Pinellas Trail to a depth of -5.5 feet NGVD, dredging muck from the creek channel between the Pinellas Trail and Douglas Avenue to a depth of -4.5 feet NGVD, and planting 3.2 acres of mangroves along the creek banks at two locations. Removing the muck will prevent sediment loading to the estuary, and the mangroves will help to trap sediment and reduce future loadings.

- **City of Clearwater Floodplain Management Plan (2009a), Comprehensive Plan Stormwater Management Element (2008), and Stormwater Management System Policy (2007)**

The City's stormwater management strategy includes maintaining channels to prevent property damage from erosion or flooding from sediment accumulation in channels. Standards, level of service, and policies are detailed but no specific projects are referenced.

<u>**Capital Projects**</u>

- **Stevenson Creek: Muck Dredging Project**

As an outcome of the ACOE Stevenson Creek Estuary Restoration Plan (COE, 2003) the City of Clearwater contracted with a private dredger to remove 95,000 cubic yards of muck from the downstream creek channel (Clearwater, 2009b). In October 2010 the contractor stopped work after a spill from Clearwater's Marshall Street Sewage Treatment Plant (St. Petersburg Times, 2010, 2011). The work was recently scheduled for completion in 2012.

- **Stevenson Creek Stormwater Improvements**

This is a cooperative project between the City of Clearwater and SWFWMD. It includes providing additional storage for stormwater runoff to reduce flooding and channel erosion in Stevenson Creek. Sites include Palmetto Street, Glen Oaks, and Lake Bellevue. All these projects are recommendations of the Stevenson Creek Watershed Management Plan as listed above (Clearwater, 2010).

4.5.4 Conclusions and Recommendations

Conclusions and recommendations for Stevenson Creek are contained in section 5.0. One new site-specific bank stabilization project is recommended for this stream but general recommendations presented in section 5.0 are applicable.

4.6 Spring Branch

Spring Branch is a tributary to Stevenson Creek, converging with the main stem near the creek mouth. The channel slope is moderate in the lower reach, however upstream of Sunset Point Road the surrounding terrain flattens. The creek is incorporated into a trailer park drainage system in southern Dunedin, and then continues farther east and north.

4.6.1 Field Reconnaissance

Sediment at four sites on Spring Branch was examined. Sites are shown in Figure 5-46.

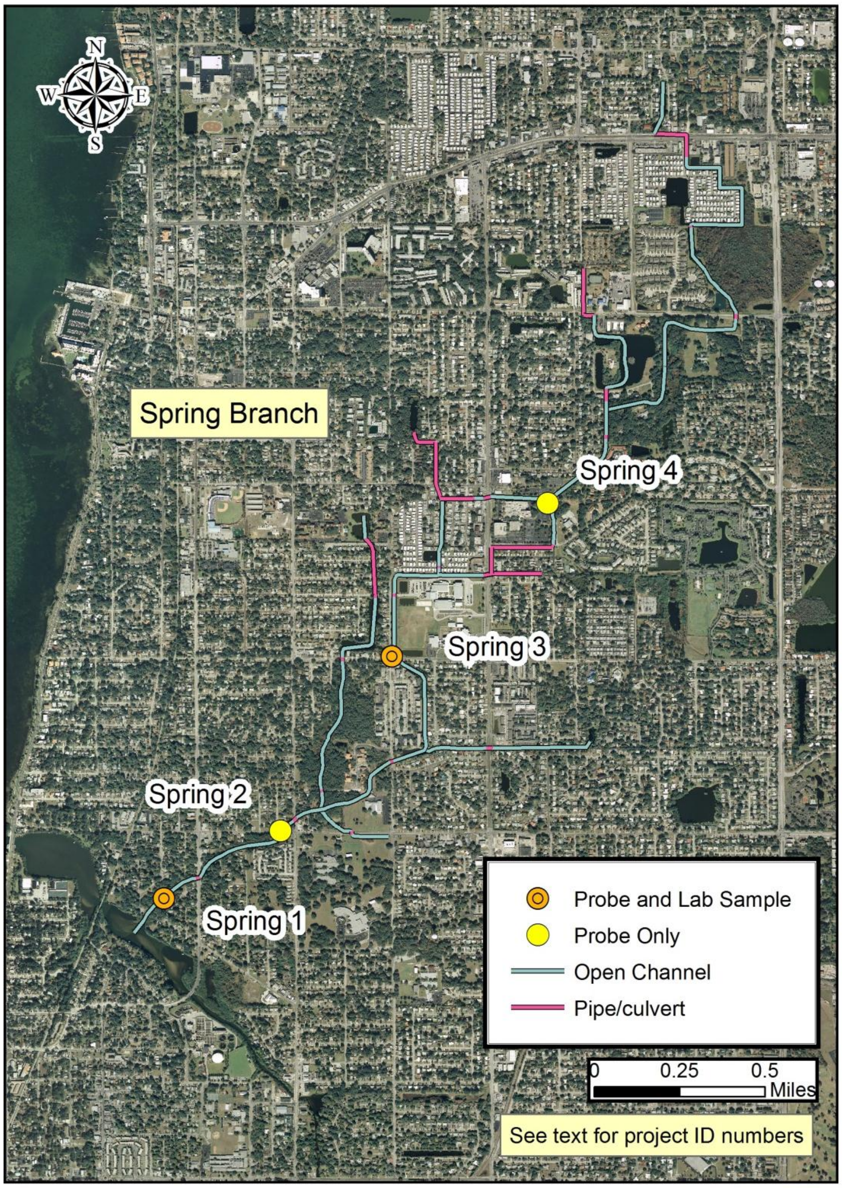


Figure 4-46. **Location of stream sampling sites – Spring Branch.**

Site Spring Branch 1 is located at the Overbrook Avenue crossing near the stream mouth. The creek is tidal with shallow banks at this location and had a loose sand layer with substantial fine-grained content about 4 inches thick, as shown in Figure 4-47.

Site Spring Branch 2 is located at the Sunset Point crossing west of Betty Lane, shown in Figure 4-48. The site is located near Pinellas County water monitoring site 15-04. A section of the upstream channel is concrete-lined. The downstream reach has a gravel bed with minimal sediment.

Site Spring Branch 3 is located north of Union Street west of the Dunedin Middle School. The channel is a shallow drainage swale with grassed banks with a thin layer of silty sand in the channel bed as shown in Figure 4-49. Water was stagnant at the time of inspection.

Figure 4-47. Site Spring Branch 1 looking upstream.

Figure 4-48. Site Spring Branch 2 looking upstream.

Figure 4-49. **Site Spring Branch 3 looking upstream.**

North of the school the creek is incorporated into a trailer park drainage system, and then continues farther east and north. Spring Branch 4 is the farthest upstream site visited, located east of Patricia Avenue and south of Cedarwood Drive (Figure 4-50). The channel is prismatic with a commonly observed trapezoidal configuration. Although the steep side slopes were grassed, isolated bank slumping was observed. The bottom contained algae mats and 1 – 2 inches of soft sand.

Figure 4-50. **Site Spring Branch 4 looking downstream.**

The "unit volume" of fine-grained sediment at each field site was estimated and is presented in Appendix B. A unit volume is defined as the volume of fine-grained sediment per linear foot of channel (ft^3/ft), as measured at a single location and is discussed in section 3.2. Downstream site Spring 1 had a unit volume estimate of 10.0 ft^3/ft, Spring 2 had a unit volume of 0.0 ft^3/ft (gravel bed with minimal silt), Spring 3 had 11.3 ft^3/ft, and Spring 4 had 1.0 (ft^3/ft).

4.6.2 Results of Laboratory Testing

The following summarizes the results of the laboratory analyses that were conducted on sediment samples taken at sites Spring 1 and Spring 3. Analyses included determination of percent silt and clay (collectively known as fines) and metals concentrations. Additional information and numeric results of the sediment analyses are presented in Appendix C. To be classified as a silty sand or clayey sand soil, sediment must contain at least 12% fines (FDOT, 2011). Samples from sites Spring 1 and Spring 3 had 6.4% and 13.1% fines, respectively. Site Spring 3 was the only site tested with sufficient fines content to be classified as silty sand.

The relative potential for adverse impacts resulting from contaminants in sediments can be assessed using the Effects Level Approach (ELA) (MacDonald et al., 2003). The ELA uses empirically-derived ranges of contaminant concentrations to determine the likelihood of sediment contaminants causing adverse effects to benthic (sediment-dwelling) and water-dependent organisms and humans. Metal concentrations in the sediment were compared to derived values for the threshold effects concentration (TEC) (the lower value) and the probable effects concentration (PEC).

A review of the sediment metals concentration shows that cadmium at all sites was above the TEC (the lower value) but below the PEC. No other exceedances of the TECs were observed. Because the cadmium values are closer to the TEC than the PEC it can be concluded that severe adverse impacts to benthos from metal contamination at the sites sampled is not likely.

Another method of assessing the conditions of sediment quality is to examine the metals concentrations relative to a normalizing agent, in this case aluminum. By comparing the concentrations of a metal to the agent ranges of the two metals similar to concentrations representing non-enriched levels can be developed. Metal concentrations falling outside (above) the range have a greater probability of being enriched by anthropogenic sources.

Both sites Spring 1 and 3 showed signs of metals enrichment for cadmium and copper. Site Spring 1also had enriched lead and nickel and site Spring 3 had enriched zinc. Although these metals may be present in higher concentrations than under natural conditions, the test provides no evidence of toxicity. Additional information and numeric results of the sediment metals testing are presented in Appendix C.

4.6.3 Summary of Existing Plans, Studies, and Projects

Management plans, studies, and capital projects for Spring Branch are summarized below. The projects focus on channel stability mainly through the use of gabions. Portions of Spring Branch are within either the City of Clearwater or the City of Dunedin

Plans and Studies

- **Stevenson Creek Watershed Management Plan (SCWMP) (2001)**

The SCWMP (City of Clearwater, 2001) included both Stevenson Creek and Spring Branch. Recommended projects to address sediment management in the Spring Branch basin included the following and are shown in Table 4-6 and Figure 4-51.

> - Project 1A.1 – Spring Branch Conveyance Enhancements (Lower Portion) (ID 28). This project includes widening approximately 700 linear feet of Spring Branch channel downstream of Kings Highway. The center of the channel would be deeper and lined with gabions of littoral plantings, as appropriate. The upper side slopes would be made less steep and planted for stability.
>
> - Project 1F – Spring Branch Stabilization, Union Street to Byram Pond (ID 27). Existing irregular and steep channel banks would be re-shaped. A narrow center channel would have vertical gabions or sheet pile retaining walls, and the upper banks would have geotextile covered with sod for stabilization.

Table 4-6. Existing or proposed sediment management projects in the Spring Branch Basin.

Project ID	Project
27	Union St. to Byram Pond channel stabilization
28	Lower channel improvements
29	Tooke's Lake to Lyndhurst St. ditch paver installation
30	Ohio Ave to San Christopher gabions installation

- **City of Dunedin Drainage Master Plan (2003) and City of Dunedin Comprehensive Plan Support Services Element and Conservation/Coastal Zone Element (2008a and b)**

The City's Drainage Master Plan addresses portions of Spring Branch that are within the City's jurisdiction. Recommendations relevant to sediment management in the Spring Branch basin included:

> - Spring Branch Channel A – Proposed improvements include installation of gabions for channel bank stabilization from Ohio Avenue to San Christopher Drive (ID 30). Also installation of concrete ditch pavers from Tooke's Lake to Lyndhurst St. extension (ID 29).

Capital Projects

- **Spring Branch Stormwater Improvements**

Capital projects are recommendations of either the SCWMP or the City of Dunedin Drainage Master Plan and are listed in Table 4-6 and shown on Figure 4-51. Recommended projects include providing additional storage for stormwater runoff, increasing channel conveyance, and adding erosion protection on Spring Branch channel banks to reduce flooding and channel erosion.

Figure 4-51. **Plans, studies, and capital projects for Spring Branch.**

4.6.4 Conclusions and Recommendations

Conclusions and recommendations for Spring Branch are contained in section 5.0. No new site-specific projects are recommended for this stream but general recommendations presented in section 5.0 are applicable.

4.7 McKay Creek

McKay Creek is the southernmost tributary in the CHSJS. It originates in Seminole west of Lake Seminole at an unnamed lake south of 86th Ave North, and flows to the north. The seven mile long creek makes a 180-degree bend and flows back to the south to discharge to Clearwater Harbor South. The creek has a tidal reach that includes dredged residential canals at Harbor Hills. The extent of tidal influence on McKay Creek's water level extends upstream of site McKay 6 at 8th Ave SW and Hickory Drive. However, salinity monitoring at the 20th Street crossing south of West Bay Drive shows the stream to be freshwater at that location. EPA (2012) delineates the tidal extent of McKay Creek as extending slightly upstream of site McKay 6. Another feature of McKay Creek is the surface water storage volume contained in Taylor Lake and Walsingham Reservoir. The lakes are in-line (stream flow passes through the lakes), and act as sediment sumps, with suspended materials settling to the lake bottom as current velocity slow when stream flow enters the lakes.

4.7.1 Field Reconnaissance

Sediment at seven sites on McKay Creek was examined. Sites sampled for sediment depth and/or laboratory testing are shown in Figure 4-52.

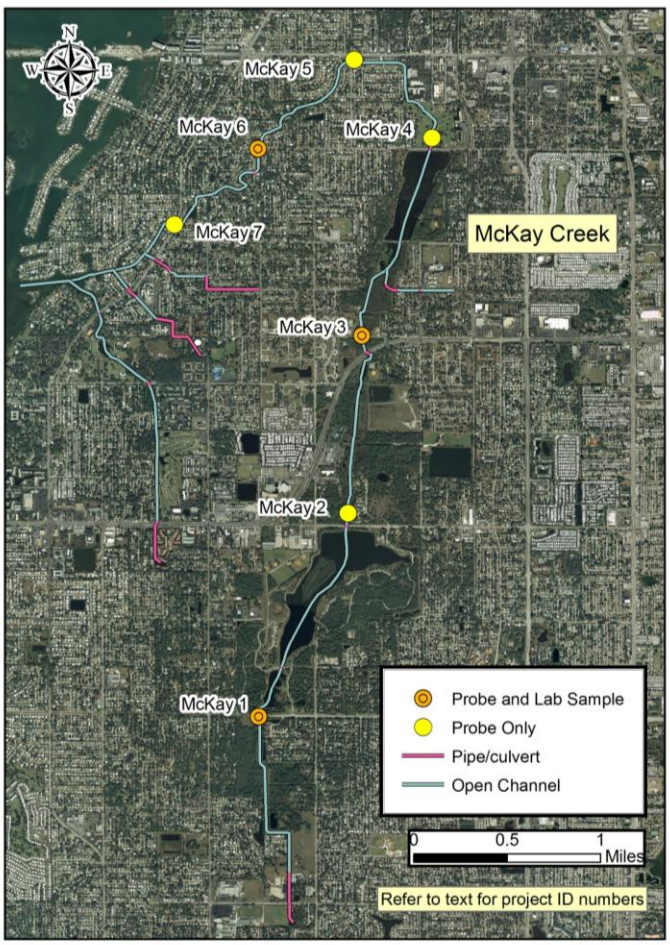


Figure 4-52. Location of stream sampling sites – McKay Creek.

Site McKay 1 is the most upstream site visited and is located at the crossing at 102nd Avenue. As shown in Figure 4-53 the channel south of 102nd Avenue has been dredged and is maintained. The depth of loose sand at the site averaged 6 inches. The channel bottom was relatively clean with only patchy silty and fine-grained material visible.

Figure 4-53. **Site McKay 1 looking downstream.**

In contrast, the channel south (upstream) of 102nd Avenue is much narrower and the channel sides are not so well maintained (Figure 4-54).

Figure 4-54. **Site McKay 1 looking upstream.**

Site McKay 2 is located in Heritage Park north of Walsingham Road. The creek is open water (Walsingham Reservoir) between 102nd Street and Walsingham Road. The site, which is near Pinellas County water quality monitoring site 27-10, is shown in Figure 4-55. Just upstream of the site the channel is very overgrown and had a loose sand layer with substantial fine-grained material measured to be 6 – 10 inches thick. It is likely that much of the sediment at this site is of local origin, as the upstream reservoir acts as a sediment sump.

Figure 4-55. Site McKay 2 looking downstream.

Site McKay 3 is located north of 134th Avenue and west of 121St Street. As seen in Figure 4-56 the channel is maintained with a shallow grassy bank on the west side and is overgrown on the east bank. This reach had a significant fine-grained muck layer averaging 18 to 20 inches at the site. The water surface was covered with duckweed and abundant trash.

Water was stagnant during the site visit. However, during high flows this reach could contribute a significant sediment load downstream. A second inspection of this site after substantial rain proved this correct, and only a sand layer remained where the thickest fine-grained muck had been.

Site McKay 4 is located north of 8th Avenue SW at Pine Crest Golf Course. The channel has grassy banks and crosses the golf course (Figure 4-57). A weir at the site retains water and presumably sediment upstream, as shown in Figure 4-58. Loose sand was approximately 2 inches deep below the weir and 3 inches deep above it.

Site McKay 5 is located at the 20th Street crossing south of West Bay Drive (Figure 4-59), near Pinellas County water quality monitoring site 27-09. Data indicate that the site is freshwater with salinity averaging 0.3 ppt. Whether the tide levels affect the water level in the stream at this location is unknown. This site marks the location of the channel as it turns to flow back to the south. The channel has concrete lining adjacent to the bridge and is otherwise is incised with vegetated banks. The grass growing along the edges of the channel bottom supports a fine-grained layer approximately 4 inches deep. The clean channel center has a sand and gravel bottom and minimal fine sediment was observed. This reach is narrower than several upstream reaches so flow velocities must be high at the site, leading to the scour and transport of fine grained sediments.

Figure 4-56. Site McKay 3 looking downstream.

Figure 4-57. Site McKay 4 looking downstream.

Figure 4-58. **Site McKay 4 looking upstream.**

Figure 4-59. **Site McKay 5 looking downstream.**

Site McKay 6 is located downstream of 8th Avenue SW east of Hickory Drive and is near the US Geological Survey stream gaging station #02309110. A review of water level records from the site shows a strong tidal signal, with daily fluctuations of up to one foot. The channel has been widened and currently serves as an in-line sediment sump. Large shoals of silty and muddy sand were observed, as shown in Figure 4-60. Numerous birds appeared to be feeding at the site.

Figure 4-60. **Site McKay 6 looking downstream at sediment sump.**

Site McKay 7 is the most downstream site and is located at Indian Rocks Road. The channel is tidal and had sea walls on both sides as shown in Figure 4-61. Deep (24 inches) black anoxic fine-grained muck was observed along the seawall.

Figure 4-61. **Site McKay 7 looking upstream.**

The "unit volume" of fine-grained sediment at each field site was estimated and is presented in Appendix B. A unit volume is defined as the volume of fine-grained sediment per linear foot of channel (ft^3/ft), as measured at a single location and is discussed in section 3.2. Site McKay1 had an estimated unit volume of 15.0 ft^3/ft, McKay 2 had a unit volume of 20.0 ft^3/ft, McKay 3 had 28.5 ft^3/ft, McKay 4 had 1.0 ft^3/ft, McKay 5 had 0.5 ft^3/ft, McKay 6 had 5.5 ft^3/ft, and McKay 7 had 70.0 ft^3/ft. These values include the highest measured unit volumes for any stream. The highest, 70 ft^3/ft, was taken at the estuarine site but all the high values are a function of both channel width and sediment depth.

4.7.2 Results of Laboratory Testing

The following summarizes the results of the laboratory analyses that were conducted on sediment samples taken at sites McKay 1, McKay 3, and McKay 6. Analyses included determination of percent silt and clay (collectively known as fines) and metals concentrations. To be classified as a silty sand or clayey sand soil, sediment must contain at least 12% fines (FDOT, 2011). Samples from sites McKay 1, McKay 3, and McKay 6 had relatively low fines contents of 2.6%, 0.8%, and 2.6%, respectively.

The relative potential for adverse impacts resulting from contaminants in sediments can be assessed using the Effects Level Approach (ELA) (MacDonald et al., 2003). The ELA uses empirically-derived ranges of contaminant concentrations to determine the likelihood of sediment contaminants causing adverse effects to benthic (sediment-dwelling) and water-dependent organisms and humans. Metal concentrations in the sediment were compared to derived values for the threshold effects concentration (TEC) (the lower value) and the probable effects concentration (PEC).

A review of the sediment metals concentration shows that cadmium at all sites was above the TEC (the lower value) but below the PEC. No other exceedances of the TECs were observed. Because the cadmium values are closer to the TEC than the PEC it can be concluded that severe adverse impacts to benthos from metal contamination at the sites sampled is not likely.

Another method of assessing the conditions of sediment quality is to examine the metals concentrations relative to a normalizing agent, in this case aluminum. By comparing the concentrations of a metal to the agent ranges of the two metals similar to concentrations representing non-enriched levels can be developed. Metal concentrations falling outside (above) the range have a greater probability of being enriched by anthropogenic sources.

Site McKay 1 showed signs of metals enrichment for copper only. Site McKay 3 showed signs of metals enrichment for cadmium, copper, lead, nickel, and zinc. Site McKay 6 showed signs of metals enrichment for cadmium and lead. Although these metals may be present in higher concentrations than under natural conditions, the test provides no evidence of toxicity. Additional information and numeric results of the sediment metals analyses are presented in Appendix C.

4.7.3 Summary of Existing Plans, Studies, and Projects

Management plans, studies, and capital projects for McKay Creek are summarized below. Projects are listed in Table 4-7 and shown on Figure 4-62.

Table 4-7. Existing or proposed sediment management projects in the McKay Creek Basin.	
Project ID	**Project**
31	Pocahontas Drive tributary channel stabilization
32	8th Ave sediment sump
33	Twin Lakes tributary sediment sump and improvements
34	Alcove Creek tributary channel stabilization
35	Walsingham Rd to Ulmerton Rd channel improvements

Figure 4-62. **Plans, studies, and capital projects for McKay Creek.**

Plans and Studies

- **McKay Creek Watershed Management Plan (scheduled 2012)**

Pinellas County and cooperator City of Largo recently obtained a grant from SWFWMD for the development of a comprehensive watershed management plan for the McKay Creek watershed beginning in 2012. This evaluation will take approximately 30 months to complete. The evaluation will recommend specific implementation strategies to address:

- management of water levels in the two reservoirs,
- conveyance improvements to reduce flooding and erosion problems, and
- improvements to water quality in McKay Creek, Taylor Lake, and the Walsingham Reservoir.

- **City of Largo Public Works Element, Stormwater Sub-element**

The City's Comprehensive Plan provides guidance in stormwater management, erosion, and sedimentation control. The plan includes goals, objectives, and policies for stormwater and sediment management, and calls for the development of a City-wide Watershed Management Plan. No new or proposed projects are included.

Capital Projects

- **McKay Creek Tributary Improvements – Indian Rocks Drive to Pocahontas Drive (ID 31)**

The purpose of this City of Largo Capital Improvement Project is to reduce channel erosion and improve conveyance in a ditch that is tributary to McKay Creek by clearing and regrading the channel. It is funded for construction in 2015.

- **McKay Creek: 8th Avenue SW Sediment Sump (ID 32)**

The County constructed and maintains a sediment sump south of 8th Avenue SW at Arbor Lane. The sump is a widened reach of the creek and regularly fills with sediment, requiring dredging.

- **McKay Creek: - Tributary Retrofit - Twin Lakes (ID 33)**

This cooperative project between the City of Largo (2010) and SWFWMD includes reconstruction on an upland cut ditch to reduce erosion and nutrient loadings. This project will mitigate sediment pollution through bank stabilization and the installation of a sediment trap. The ditch in its existing configuration is filled with invasive vegetation and has unstable banks that are subject to collapse and erosion. The ditch is approximately 900 feet in length and located between Barlow Lane to the west, Twin Lakes Drive to the east, Sunset Drive to the north and Bluffs Drive to the south. The ditch serves an upstream watershed of approximately 155 acres consisting of largely untreated residential and commercial land uses. The ditch discharges to McKay Creek - a State of Florida Impaired Waterbody - upstream of an existing sediment sump in the main channel. Nutrient and suspended solid removal will be enhanced through the installation of native vegetation and construction of a series of cascading weirs to create littoral and wet detention zones. As of August 2010 the project was in preliminary design.

- **McKay Creek Tributary Improvements – Alcove Creek (ID 34)**

The purpose of this City of Largo Capital Improvement Project is to reduce channel erosion and improve conveyance in a ditch that is tributary to McKay Creek. It will entail reconstruction of a ditch channel between Edna Street and West Bay Drive Mobile Home Park and will be funded after 2015.

- **McKay Creek: Channel Improvements – Walsingham Road to Ulmerton Road (ID 35)**

These unidentified improvements were completed between 1997 and 2007, as listed in the Pinellas County Comprehensive Plan.

4.7.4 Conclusions and Recommendations

Conclusions and recommendations for McKay Creek are contained in section 5.0. One new site-specific maintenance project is recommended for this stream and general recommendations presented in section 5.0 are applicable.

5 Findings and Recommendations

The following synthesizes the results of this sediment management investigation including the review of existing information, completion of desktop analysis, field investigation, and laboratory analysis. Some findings can be generalized to the entire CHSJS, and some are waterbody-specific.

Recommendations are also presented below. Some apply to all or several waterbodies and some to specific creeks or individual reaches.

5.1 Findings

General

- All the creeks examined are relatively small and are located in highly urbanized settings.

- There is generally modest topographic relief in the drainage areas and the stream channels have relatively low slopes.

- The creeks have all been incorporated into the urban stormwater drainage system. Large portions or all of the creeks examined have been channelized and are regularly maintained.

- With the exception of downstream Curlew Creek and Hammock Park in the Cedar Creek basin, virtually no significant areas of wetland or upland habitat were observed associated with the creek channels and floodplains.

- Significant shoaling of soft sand or fine-grained material was commonly observed. This type of sediment deposition can greatly reduce benthos and fisheries habitat value in the creeks, as well as reduce flood water conveyance capacity.

- In-channel vegetation in most creek reaches is regularly cut back to maintain conveyance capacity.

- In-stream sedimentation was observed before and after high rainfall. In-stream shoals comprised of sand tended to persist and accrete. Accumulations of fine-grained material tended to flush downstream during high flows.

- One of the most commonly observed features in the streams was eroded channel banks. Conditions ranged from isolated small gullies to large-scale slope failure. The eroded material enters the creek channel and is then transported downstream to accumulate in the channel or wash into the estuary. Erosion occurred via two mechanisms. The most common was for the bank sides to wash out due to direct rainfall and runoff flow over the top of the bank. The other method of erosion was undercutting at the toe of the bank slope. In this case the bottom of the slope is removed allowing the upper bank material to slough down. Undercutting is typically caused by high flow velocities in the channel.

  Bank erosion is difficult to remedy in many situations. Most observed stream reaches in the CHSJS have been channelized to trapezoidal cross sections and are deeply incised with high steep banks. The channels are frequently within drainage easements, rights-of-way, or narrow publicly-owned parcels. The narrow parcel configuration limits the maximum top of bank width of the channel, so it is often not feasible to reduce the grade of the bank slope. Also, channel banks are predominantly comprised of relatively loose, fine-grained sand with little cohesive strength which also promotes washouts.

- Options for riparian habitat restoration are also limited because of the narrow drainage easements and parcels. These slender corridors are not sufficient to implement many typical stream restoration techniques such as channel widening or meandering, or lowering the bank slope.

- The creek channels typically had a hard packed sandy bottom covered with a layer of soft silty sand the varied from one to four inches deep. A few sites had either a gravel channel bottom with little sand or a clayey sand bottom.

- Channel sediments were comprised of sand, with very little silt/clay. Only one site, Spr3 on Spring Branch, had enough fine-grained material (13.1%) to be classified as "silty sand." Sediment samples were taken soon after a large rain event which may have washed much of the fine-grained material downstream.

- Testing for metals enrichment by comparing metal concentration with aluminum concentration (normalizing) showed that elevated levels of metals did occur in the tributary sediments. The sites with the most enriched metals were in Klosterman Creek, Bee Branch, Stevenson Creek, Spring Branch, and McKay Creek. No creek had more than one site with more than three of six tested metals enriched, as follows:

    - Four enriched: Klosterman 3, Bee 4, Stevenson 2, Spring 1, McKay 3
    - Three enriched: Klosterman 2, Bee 1, Curlew 1, Curlew 3, Curlew 4, Cedar 1, Stevenson 4
    - Two enriched: Curlew 6, Cedar 4, McKay 1, McKay 6
    - One enriched: Curlew 11, Spring 3

  The metals most commonly observed to be at potentially-enriched levels included cadmium (all 18 samples), lead (15 samples), and nickel (14 samples). Copper, zinc, and chromium had 6, 2, and 1 enriched samples, respectively.

- Examining the sediment metals data for exceedances of biological thresholds concentrations (threshold effects concentrations – TEC and probable effects concentration – PEC) revealed that cadmium at all sites was above the TEC (the lower value) but below the PEC. No other exceedances of the TECs were observed. Because the cadmium values are closer to the TEC than the PEC it can be concluded that severe adverse impacts to benthos from metal contamination at the sites sampled is not likely.

- The highest unit volumes were at sites McKay 7 (downstream reach), McKay 3 (middle reach), and Stevenson 5 (downstream reach). Site Curlew 11, which is relatively upstream in the basin, also had a relatively large unit volume. The accumulation of fine-grained sediment is a function of a site's location with respect to sources of sediment, so downstream sites may be expected to show signs of sediment deposition to a greater extent than upstream sites. However, sediment accumulation is also a function of local conditions such as channel slope, vegetative cover, and other features, so upstream sites may be subject to excess sediment deposition as well.

The purpose of obtaining the unit volume measurements was to provide a relative comparison of fine-grained sediment accumulation at specific locations. The information should be used to focus future engineering studies for the purpose of quantifying total volumes of material for dredging and removal. Typically, an engineering study would include surveyed cross sections, and a detailed estimate of sediment based on multiple unit volume measurements over a reach length. Given the dynamic nature and sensitivity to local conditions of sediment transport mechanisms, it is unreasonable to expect that a single unit volume estimate would be applicable to a channel reach of several hundred or more feet. Also, it must be remembered that sediment in a channel moves downstream whenever the flow velocity is high enough to suspend the particles. Thus the volumes shown in the appendix, which were taken at the end of a prolonged dry period, are likely very different from volumes calculated based on sediment depth measurements following a high rain event.

Klosterman Creek

- The Klosterman Creek basin has the lowest percent coverage of impervious surface of any of the streams.

- Except for a short downstream tidal reach the creek is entirely within the Innisbrook Resort. The stream is integrated into the on-site golf course surface water management system.

- Excess sediment was observed at the Old Post Road Bridge in the form of silty sand and fine-grained sediment shoaling. However based on the area's general appearance it is likely that Innisbrook Resort staff routinely maintain the channel. That portion of the stream that is on private land is the land owner's responsibility to maintain, but no adverse downstream effects were noted.

Bee Branch

- The Bee Branch basin has significant topographic relief and the stream channel, especially the middle reaches, has the steepest channel slope of any of the streams examined. Also the steepest stream reaches are located in soil type Tavares fine sand which is highly erodible.

- The middle stream reaches were deeply incised and exhibited significant bed scour and bank erosion. Sand and silt had been washed away exposing a rocky bed.

- The stream's downstream reach had significant shoaling of silty sand material.

- The County and SWFWMD are cooperating to address some of the erosion and deposition issues for Bee Branch through capital improvement projects.

Curlew Creek

- The Curlew Creek basin is the largest system in the CHSJS. The basin is highly urbanized.
- Significant portions of the downstream and middle reaches of the creek have wooded floodplains remaining. The tree canopy moderates water temperature and provides habitat benefits.
- Downstream and mid-stream channels consist of fine soft sand. Unprotected banks are subject to significant erosion.
- Significant areas of sandy shoals were observed in the downstream reach.
- Over-bank shoaling was observed along the creek just downstream of County Road 1.
- Sediment deposition at the mouth of the creek is an on-going issue and has required periodic dredging.
- Gabions have been used for channel stabilization in some middle and upper creek reaches. The gabions do prevent channel erosion but do not reduce the downstream transport of transient sediment loads originating upstream. Habitat values are minimal.
- The entire reach between US 19 and County Road 1 which included Sites 1, 2, and 3 exhibited significant sediment transport. Shoaling both in the channel and outside the banks was observed. Sediment is carried downstream to the creek mouth.

Cedar Creek

- Cedar Creek is a small urban water body. It passes through Hammock Park, a City of Dunedin park with one of the largest undeveloped wooded areas in the CHSJS.
- Significant lengths of Cedar Creek have been lined with gabions.
- The Cedar Creek Restoration Plan is being implemented by the City of Dunedin, cooperating with SWFWMD. The Plan includes rehydration of Hammock Park, channel stabilization, lake enhancements and wetland creation, and on-going dredging of sediment at the mouth of the creek.

Stevenson Creek

- The Stevenson Creek basin is the second largest in the CHSJS. It is located in a highly urbanized setting including downtown Clearwater.
- Significant accumulation of fine-grained muck is evident in the downstream-most estuarine reach. The muck and its removal are an on-going issue.
- The channel at the headwaters of the Creek (Site Stevenson 1 at Bellevue Blvd) had marked channel erosion. Local residents have used rip rap to limit bank decay near homes.

- The City of Clearwater and cooperator SWFWMD are implementing recommendations of the Stevenson Creek Watershed Management Plan, which include a regional stormwater management facility (Glen Oak), lake enhancements, and creek tributary channel restoration.

Spring Branch

- Spring Branch is a small urban stream. It had the most diversity in sediment characteristics, with a gravel bed at the mid-stream site Spring 2 and clayey sand at upstream site Spring 4.

McKay Creek

- McKay Creek is the southernmost creek in the CHSJS. Its drainage basin is highly urbanized with little topographic relief.

- In-stream sediments generally had higher silt content than other creeks.

- An in-line sediment sump is current in use, located at 8th Avenue. The sump is periodically dredged of accumulated sediment which was observed to have a high fine-grained material content.

5.2 Recommendations

The following are recommended actions designed to reduce ecological impacts from excessive sediment movement. As noted above, bank erosion can cause habitat degradation by removing stable substrate, and sediment deposition can smother channel bottoms, covering benthic organisms.

5.2.1 General

Existing Plans and Projects

The top priority recommendation is that existing management plan recommendations and capital improvement projects continue to be funded and implemented as scheduled. Effective sediment management will reduce flooding risk, maintain what habitat remains, and protect public and private property. Also, priority should be given to enforcement of the County's National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit requirements regarding erosion control.

Operations and Maintenance (O&M)

O&M work to keep the County's surface water management system operating is a major effort and has a current annual budget of over $15 million. Although the primary objective of O&M is to keep ditches, creeks, retention ponds, and control structures at their design capacities, the methods used can greatly affect the physical stability of ditch and creek channels. O&M crew training should include teaching methods of protecting channel banks while ensuring adequate conveyance for stormwater. A few examples are listed below, and others are included in the Pinellas County Land Development Code Sections 154-72 and -73.

- Use of mechanical equipment (e.g., long-arm scoops) to clear sediment from channel beds to avoid disturbance of banks by crews trampling vegetation.
- Leaving a vegetative cover on channel bottoms and not exposed bare dirt or sand.
- Keeping records of observed erosion or sedimentation to share with design engineers.
- Minimize use of herbicide in channels.

The following recommendations are intended to address areas within the CHSJS that are not addressed by existing plans or capital projects. Some projects recommend stream bank stabilization techniques to reduce bank erosion. As discussed in the report, one of the greatest challenges for reducing excess sediment transport is to reduce erosion of channel banks and bed incising. This is especially an issue in situations where the channel and/or watershed has been altered through human activity, and where the bed material is composed of noncohesive sandy material. Both these conditions exist to a moderate-to-high degree in most of the CHSJS streams. Additionally, the land parcels and drainage easement containing the tributary channels is usually quite narrow, 60 feet or less, so any alteration to the channel must retain its one-dimensional morphometry.

However, there have been many investigations completed regarding methods to stabilize stream channels and restore some of their natural functions, including Brown (2000), Schueler and Brown (2004), Doll et al. (2003), FISRWG (1998), Fischenich (2001), Rosgen and Silvey (1996), TVA (undated), USDA (2007, 1996), and FDEP (2008b), among many others. A selection of stabilization methods is provided in Appendix E and should be used to select specific alternatives when the extent of a project implementation is determined.

5.2.2 Recommended Projects

Site-specific conceptual projects to address observed problem areas in the streams have been developed and are listed in Table 5-1.

Projects 1 through 4: Fine-grained Sediment Removal

It was observed that significant fine-grained sediment accumulation that had developed during periods of low flow in some creek reaches was flushed downstream during high stream flow. To most effectively remove fine-grained sediments, upstream areas where accumulation is most likely should be identified and maintenance dredging of those areas should be scheduled for the end of the dry season (May – early June), before regular rains begin. Maintenance dredging is recommended to remove fine-grained material accumulation at the following sites and others as appropriate. Note that abundant fine-grained sediment was observed at site McKay 6 south of 8th Avenue as well as the sites below. However, the site is an existing sediment sump and is already maintained so it is not listed below.

Table 5-1. Recommended sediment management projects for CHSJS streams.			
Project Number	**Project Description**	**Project Site/Location**	**Latitude/ Longitude**
1	Fine-grained sediment removal	Site Curlew 11: Curlew Creek/Jerry Branch south of Main St.	28.017 -82.754
2	Fine-grained sediment removal	Curlew 13: Curlew Creek east of Cypress Point Dr. West	28.004 -82.750
3	Fine-grained sediment removal	McKay 3: McKay Creek at 134th Ave. north of Ulmerton Rd.	27.895 -82.808
4	Fine-grained sediment removal	McKay 7: McKay Creek east of Indian Rocks Rd.	27.904 -82.823
5	Channel stabilization and habitat enhancement	Curlew 1&2: Curlew Creek between St. Andrews Golf Course and County Rd. 1	28.048 -82.771
6	Channel reconfiguration and habitat enhancement	Curlew 3: Curlew Creek downstream of County Rd. 1	28.047 -82.760
7	Sediment transport and habitat enhancement	McKay 6: sediment sump at SW 8th Ave	27.909 -82.816
8	Channel reconfiguration and habitat enhancement	Curlew 8: Curlew Creek/Jerry Branch at Brady Dr. east of County Rd. 1	28.041 -82.753
9	Channel bank stabilization	Stevenson 1: Stevenson Creek downstream of Bellevue Blvd.	27.944 -82.781
10	Channel bank stabilization	Bee 1: Bee Branch south of Nebraska Ave.	28.079 -82.747

Project 1

Location - Curlew Creek site Curlew 11, Jerry Branch south of Main Street (Figure 5-1)

Objective – Remove accumulated fine-grained sediment from creek channel before it is washed downstream.

Description - This recommended project includes a channel reach approximately 400 feet north of Main Street and approximately 1500 feet south of Main Street just north of Jerry Lake. Only surface layer of sediment would be removed, maintaining design channel dimensions.

Land Ownership - The channel is within a 50-foot wide parcel owned by the City of Dunedin. The site parcel map from the Pinellas County Property Appraiser web site is shown in Appendix D.

Relative cost – The action involves regular maintenance activities, coordinated to visit the sites at the end of the dry season, so no new costs would be incurred.

Lead Entity – City of Dunedin

Issues – Turbidity curtains would be required downstream of the dredging.

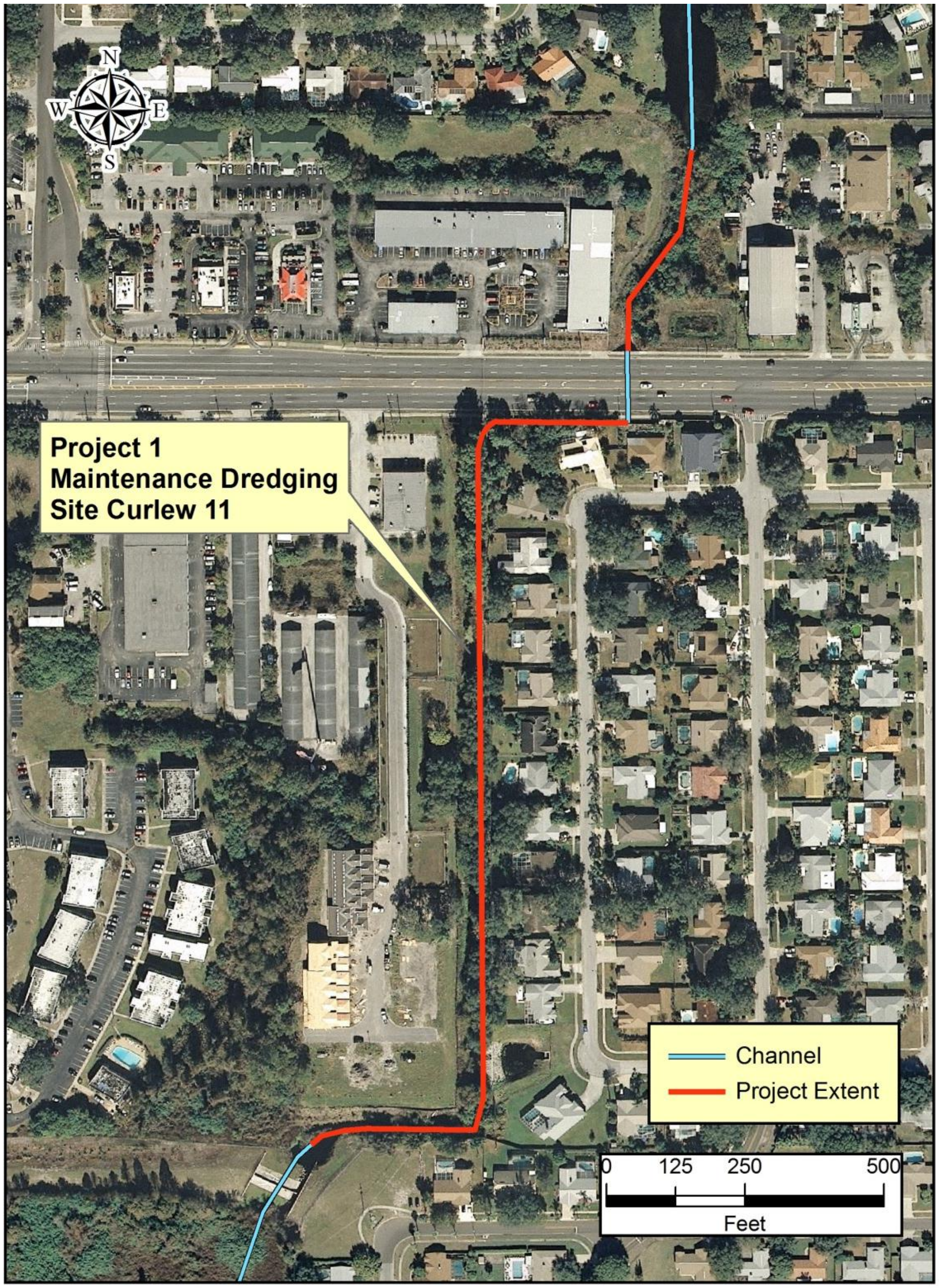


Figure 5-1. Project 1 at Site Curlew 1.

Project 2

Location – Curlew Creek site Curlew 13 at Cypress Point Drive west of Belcher Road (Figure 5-2)

Objective - Remove accumulated fine-grained sediment from creek channel before it is washed downstream.

Description - A channel reach 1800 feet long between Cypress Point Drive East and Cypress Point Drive West is recommended for maintenance dredging. Only surface layer of sediment would be removed, maintaining design channel dimensions.

Land Ownership – No publicly-owned land, easements, or rights-of-way at the site were identified from interactive maps at the County Property Appraisers Office web site. The site parcel map from the Pinellas County Property Appraiser web site is shown in Appendix D.

Relative cost – The action involves regular maintenance activities, coordinated to visit the sites at the end of the dry season, so no new costs would be incurred.

Lead Entity – Pinellas County

Issues – Turbidity curtains would be required downstream of the dredging

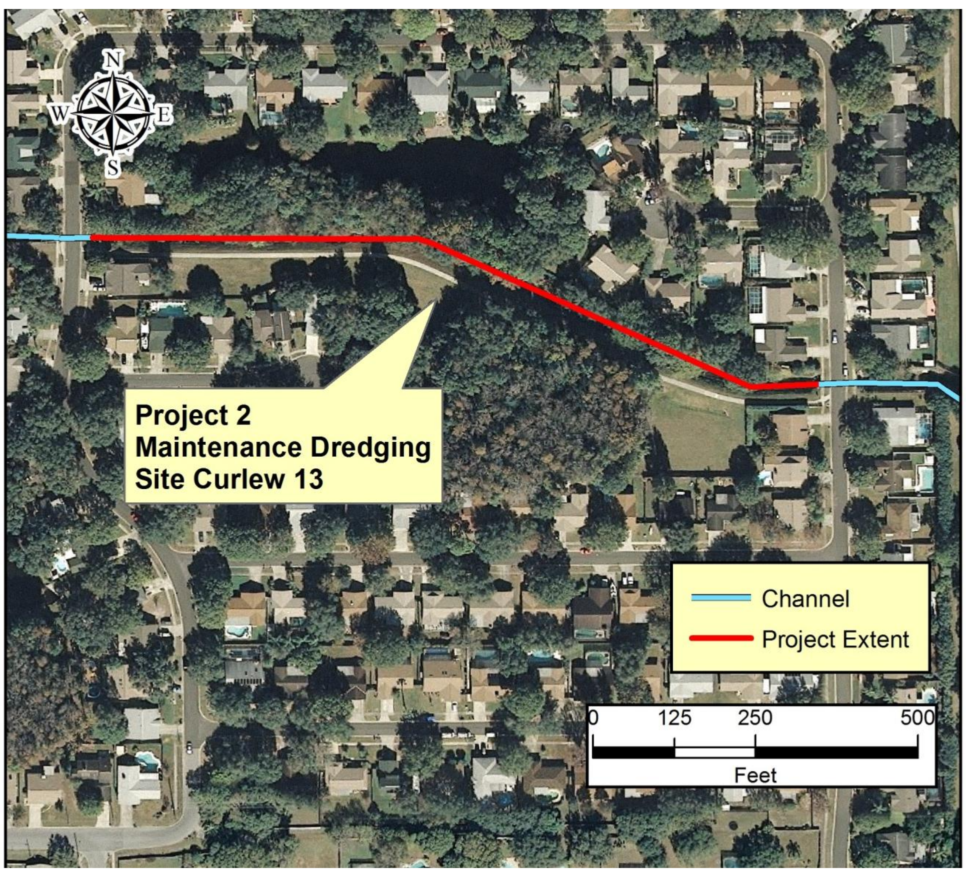


Figure 5-2. Project 2 at site Curlew 13.

Project 3

Location - McKay Creek site McKay 3 north of 134th Ave near Ulmerton Rd (Figure 5-3)

Objective - Remove accumulated fine-grained sediment from creek channel before it is washed downstream.

Description - The recommended project begins at Ulmerton Rd in the south and includes a 2400-foot reach north to the south end of Taylor Lake. Only surface layer of sediment would be removed, maintaining design channel dimensions.

Land Ownership – The channel is totally within land owned by Pinellas County. The site parcel map from the Pinellas County Property Appraiser web site is shown in Appendix D.

Relative cost – The action involves regular maintenance activities, coordinated to visit the sites at the end of the dry season, so no new costs would be incurred.

Lead Entity – Pinellas County

Issues – Turbidity curtains would be required downstream of the dredging.

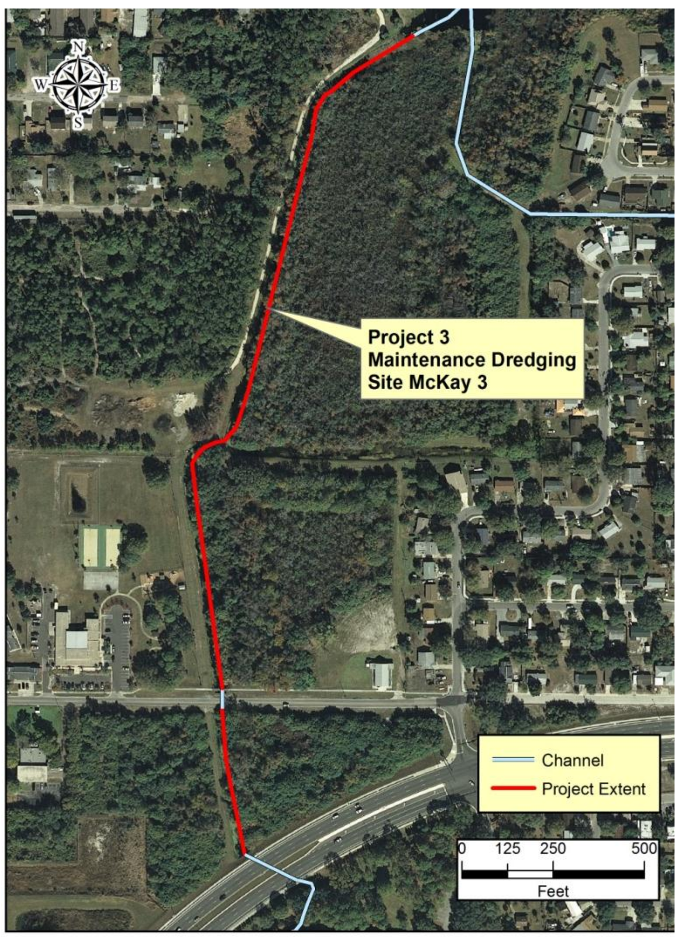


Figure 5-3. Project 3 at Site McKay 3.

Project 4

Location - McKay Creek site McKay 7 at Indian Rocks Road (Figure 5-4)

Objective - Remove accumulated fine-grained sediment from creek channel before it is washed downstream.

Description - This recommended project begins at Indian Rocks Road and includes the channel and widened channel upstream of the bridge, about 2500 feet downstream of the existing sediment sump at 8th Ave. Only surface layer of sediment would be removed, maintaining design channel dimensions.

Land Ownership – No publicly-owned land, easements, or rights of-way at the site were identified from interactive maps at the County Property Appraisers Office web site. The east side of the site is within the City of Largo, the west side is in unincorporated Pinellas County. The site parcel map from the Pinellas County Property Appraiser web site is shown in Appendix D.

Relative cost – The action involves regular maintenance activities, coordinated to visit the sites at the end of the dry season, so no new costs would be incurred.

Responsible Entity – Pinellas County, City of Largo

Issues – Turbidity curtains would be required downstream of the dredging. Environmental permitting would be necessary.

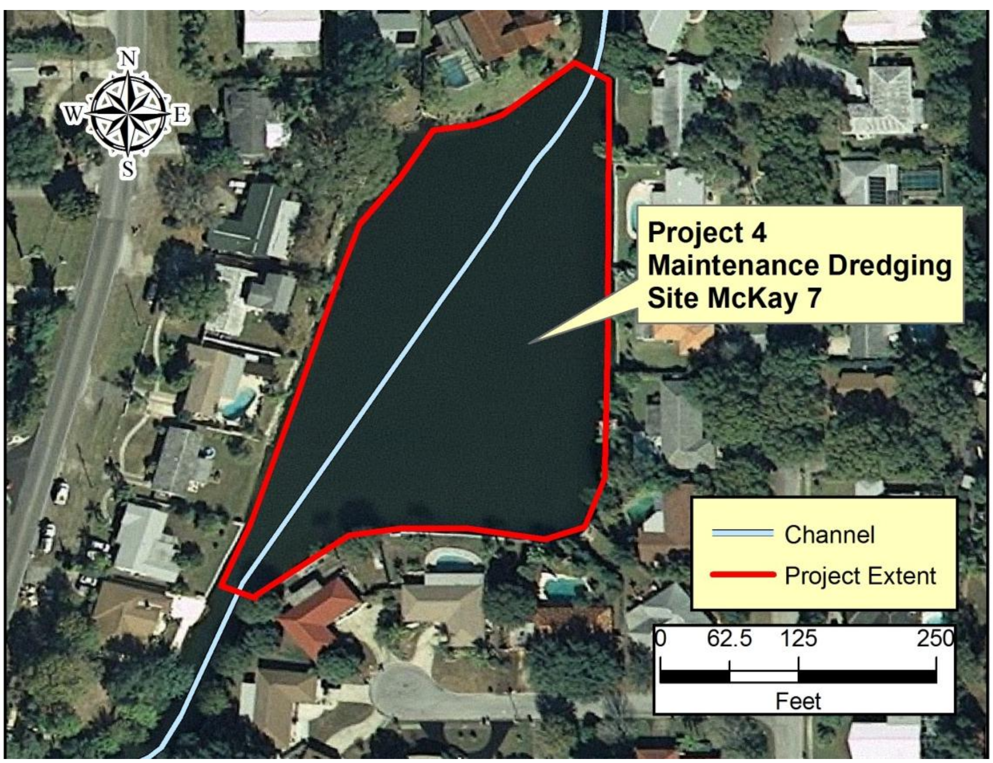


Figure 5-4. **Project 4 at site McKay 7.**

Project 5

Location – Lower Curlew Creek

Objectives – Provide habitat in-stream enhancement and channel bank stabilization, and reduce downstream sediment transport.

Description – Opportunities exist to enhance in-stream habitat and stabilize channel banks in lower Curlew Creek (Figure 5-5). Target areas include much of the main stem of Curlew Creek downstream of County Road 1 to the north end of St. Andrews Links Golf Course, a distance of about 6100 feet. Structural habitat including the following may be strategically placed within the channel to afford enhanced habitat for fish, benthos, and other wildlife. Sediment transport will be reduced due to lower stream flow velocities. Site-specific placement of any of these alternatives should include hydrologic modeling and engineering analysis that is beyond the scope of this work. Habitat enhancement options include:

- snags;
- stop log;
- coir fiber log placement;
- root ball revetments;
- partial weirs; and
- placement of large rocks.

Land Ownership – The entire reach is either within land owned by the City of Dunedin, a drainage easement, or drainage right-of-way, as shown on the County Property Appraiser web site parcel map. The site parcel map from the Pinellas County Property Appraiser web site is shown in Appendix D.

Relative cost – Costs would depend on the magnitude of enhancements desired. If any large-scale work is anticipated then flow modeling and engineering analysis would be required and the cost would be relatively high. If a more modest program in initiated without the modeling and engineering analysis then costs would be relatively low to moderate.

Lead Entity – City of Dunedin

Issues – Environmental permitting will be required. Structures must withstand high flows and not increase flood potential.

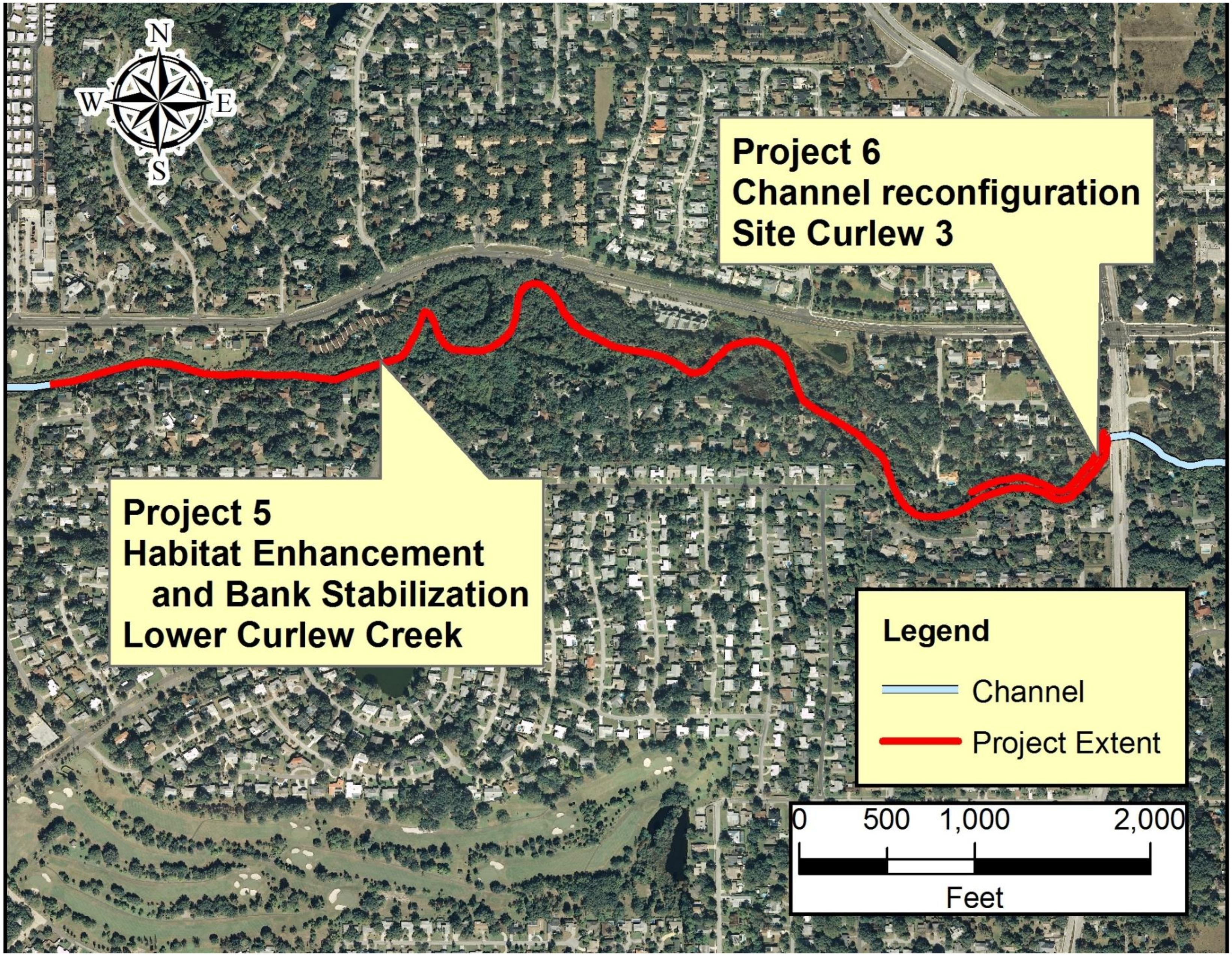


Figure 5-5. Project 5 in Lower Curlew Creek and Project 6 at site Curlew 3 (County Rd 1).

Project 6

Location – Curlew Creek site Curlew 3 west of CR1, shown in Figure 5-5 above.

Objectives – Provide habitat in-stream habitat enhancement and channel reconfiguration to reduce sediment transport.

Description - Overbank shoaling and tree damage from bank erosion was observed in Curlew Creek just downstream of County Road 1 in the vicinity of site Curlew 3. The configuration of the channel at this location may be appropriate for channel reconfiguration and widening. A variety of channel cross section designs are available that would stabilize the channel and allow a larger flow path to lower flow velocities and reduce sediment transport.

Land Ownership – The entire reach is within City of Dunedin drainage easements or drainage rights-of-way, as shown on the County Property Appraiser web site parcel map. The site parcel map from the Pinellas County Property Appraiser web site is shown in Appendix D.

Relative cost – Costs would depend on the magnitude of enhancements desired, however, channel configuration will require stream flow modeling and engineering design for the earthwork and stabilization measures. It is anticipated that the channel banks would remain soft, with no gabions or other hardening. Costs would be moderate to high for an effective, structurally sound channel reconstruction.

Lead Entity – City of Dunedin

Issues – Environmental permitting will be required. Channel configuration must withstand high flows and not increase flood potential.

Project 7

Location – Sediment Sump at site McKay 6, SW 8th Ave and Hickory Dr. (Figure 5-6).

Objectives – Provide habitat enhancement and channel bank stabilization, and reduce downstream sediment transport.

Description – Opportunities exist to enhance habitat and reduce sediment transport in lower McKay Creek (Figure 5-6). The subject site now acts as a sediment sump, but only by virtue of stream flow velocity slowing in the widened channel. Excess sediment is currently dredged from the water body, but the material is not confined to a portion of the site, making effective dredging operations difficult. Additionally, the site is entirely open water surrounded by private yards on the east side and a public grassed open space on the west side.

Both this issues could be addressed by transforming the water body into a multi-cell system. The upstream cell would remain deeper open water and would serve as the sediment sump. A berm constructed across the site would act to contain the sediment in a more confined space, making dredging more efficient. The berm could be constructed to be structurally sound during all flow events, with a spillway to allow high flows to pass.

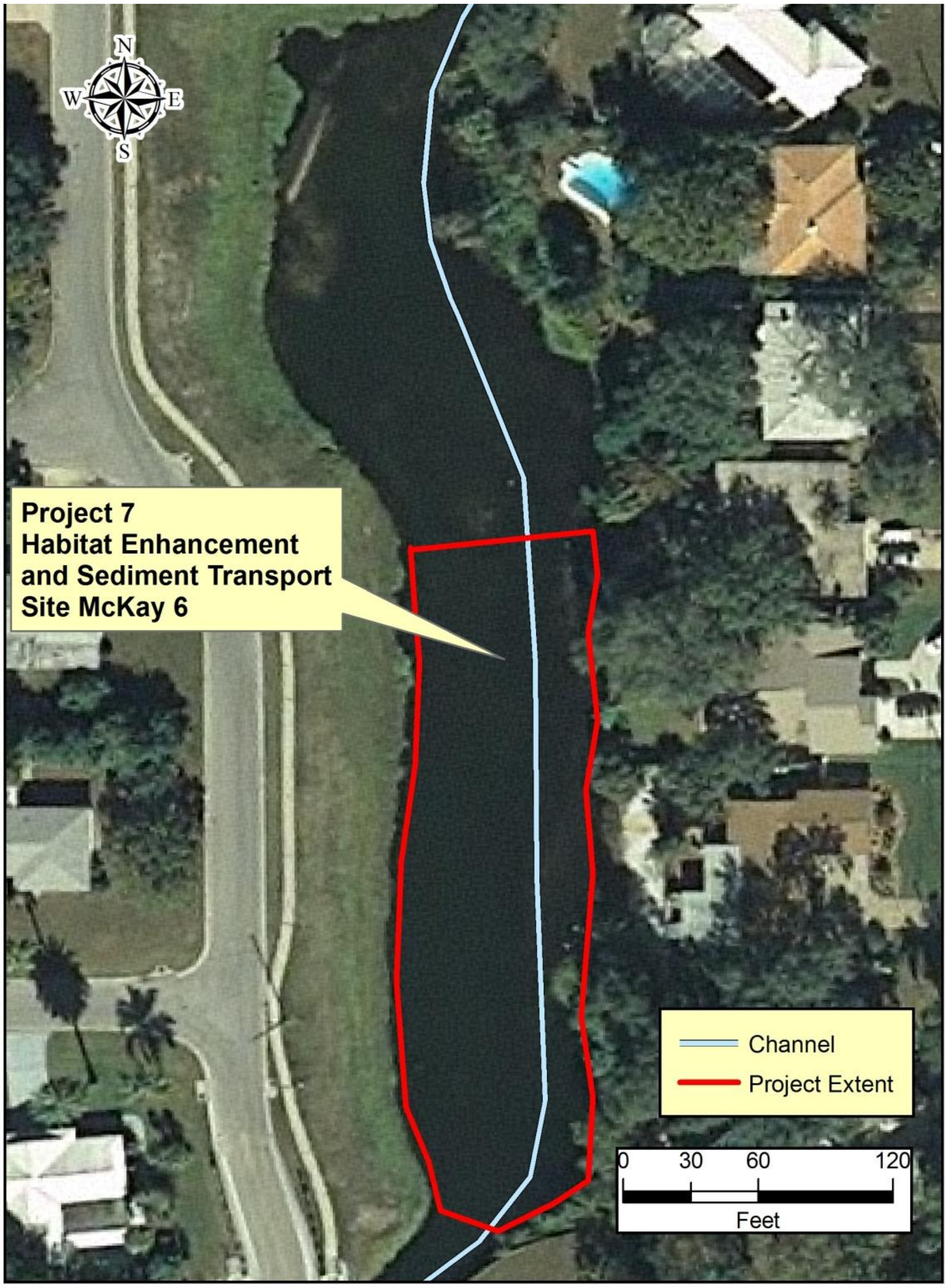


Figure 5-6. **Project 7 at site McKay 6.**

Habitat enhancements could include vegetating the berm, and making the downstream portion of the site a series of wetlands with interconnecting flow paths. A high flow channel would be maintained to convey flood waters. Woody plants could be planted along the bank or on built-up hammocks within the water body. Deeper pools would provide fish and bethic refugia.

Land Ownership – The west side of the project site is within land owned by Pinellas County and the east side is in private ownership, as shown on the County Property Appraiser web site parcel map. The site parcel map from the Pinellas County Property Appraiser web site is shown in Appendix D.

Relative cost – Costs would depend on the magnitude of enhancements desired. Stream flow modeling and engineering analysis and design would be required and the cost would be relatively high. Construction costs would include use of heavy equipment for earth moving and structure placement, and manual labor for plantings.

Lead Entity – Pinellas County

Issues – Environmental permitting will be required. Structures must withstand high flows and not increase flood potential. High flows must be accommodated without damage to enhancements. Also, surrounding residents should be included in the process.

Project 8

Objectives – Provide in-stream habitat enhancement and channel bank stabilization to reduce sediment transport.

Location – This recommended project is at Curlew Creek site Curlew 8, located on Brady Drive east of County Road 1 on Jerry Branch (Figure 5-7).

Description - Opportunities exist to enhance in-stream habitat and stabilize channel banks in this reach that extends from Brady Drive downstream to County Road 1. The channel slope is steeper than adjoining reaches and channel banks are steep. Introducing natural bank stabilization measures could reduce this site's potential as a source of sediment by slowing flow velocities, as well as improve aquatic and benthic habitat. Stream is well-shaded with vegetated banks. Structural habitat including the following may be strategically placed within the channel to afford enhanced habitat for fish, benthos, and other wildlife. Site-specific placement of any of these alternatives should include hydrologic modeling and engineering analysis that is beyond the scope of this work. Habitat enhancement options include:

- snags;
- stop log;
- coir fiber log placement;
- root ball revetments;
- partial weirs; and
- placement of large rocks.

Land Ownership – The entire reach is within privately-owned lands. No drainage easements or rights-of way were identified on the County Property Appraiser web site parcel map. The site parcel map from the Pinellas County Property Appraiser web site is shown in Appendix D.

Relative cost – Costs would depend on the magnitude of enhancements desired. If any large-scale work is anticipated then flow modeling and engineering analysis would be required and the cost would be relatively high. If a more modest program in initiated without the modeling and engineering analysis then costs would be relatively low to moderate.

Lead Entity – City of Dunedin

Issues – Environmental permitting will be required. Structures must withstand high flows and not increase flood potential.

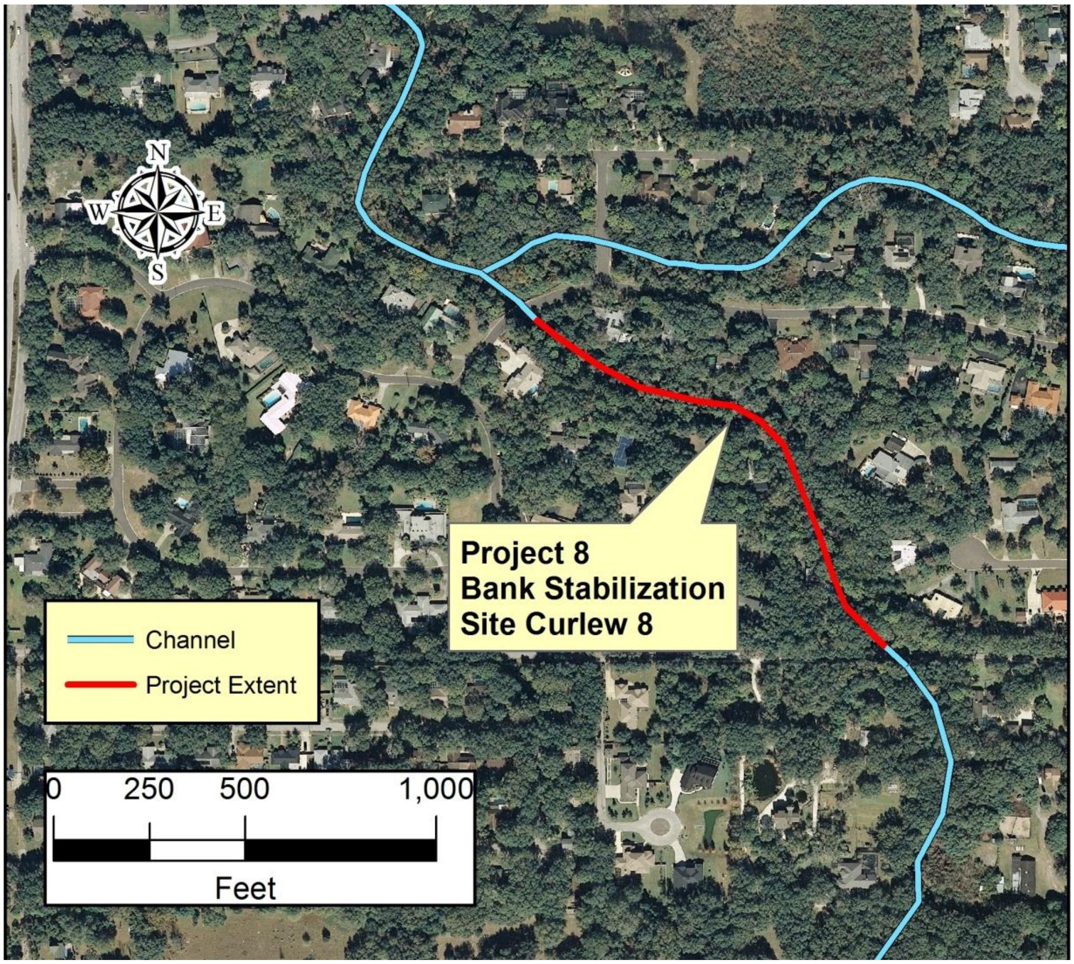


Figure 5-7. **Project 8 at site Curlew 8.**

Project 9

Objective – Reduce bank erosion and risk of damage to residential structures.

Location - Upper Stevenson Creek (site Stevenson 1) downstream of Bellevue Blvd. (Figure 5-8)

Description – Significant bank erosion has occurred in the reach of Stevenson Creek downstream of Bellevue Blvd, as discussed in Chapter 5. Channel stabilization measures should be used to reduce bank erosion along the reach from Bellevue downstream to Lakeview Road, a distance of about 2000 feet. Riprap is a reasonable alternative to gabions in this application. Although the entire reach was not accessible it appears that portions of the reach are relatively stable, and that stabilization treatments would occur on an as-needed basis.

Land Ownership – The entire reach is within privately-owned lands. No drainage easements or rights-of way were identified on the County Property Appraiser web site parcel map. The site parcel map from the Pinellas County Property Appraiser web site is shown in Appendix D.

Relative cost – Work involved would include clearing existing debris from the banks, smoothing the banks, and the manual placement of rip rap in the channel. Costs are expected to be moderate to relatively high for the benefit.

Lead Entity – City of Clearwater

Issues – Environmental permitting will be required. Structures must withstand high flows and not increase flood potential. Most of the site is not accessible to power equipment and permission from residents would be needed to access the channel.

Figure 5-8. Project 9 at site Stevenson 1.

Project 10

Objective – reduce sediment transport and bank erosion.

Location - Bee Branch site Bee 1, located near Belcher Road south of Nebraska Ave. (Figure 5-9).

Description - Shoaling and bank erosion were observed at this site, which is in an area not affected by the County's current capital projects. Although several stormwater ponds are located nearby, these appear to be designed to capture roadway or residential runoff and not intercept stream flow. The reach is bounded by undeveloped oak woods. Although preservation of the trees is desired, it may be feasible to widen or meander the channel to slow flows and reduce sediment transport. Alternate channel sections should account for tree protection.

Land Ownership – The upstream-most reach, about 300 feet east of Belcher Road, is on land owned by Pinellas County. The entire 2200-foot reach west of Belcher Road is within privately-owned lands. No drainage easements or rights-of way were identified on the County Property Appraiser web site parcel map. The site parcel map from the Pinellas County Property Appraiser web site is shown in Appendix D.

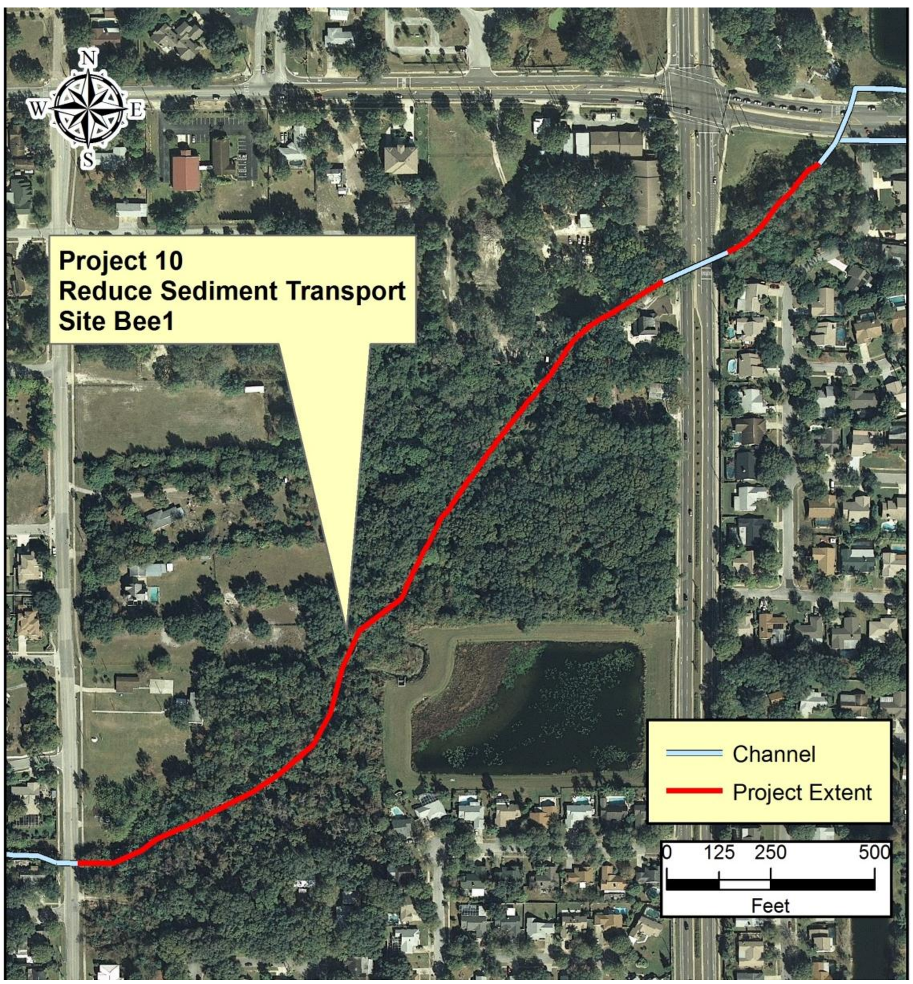


Figure 5-9. Project 10 at site Bee 1.

Relative cost – Work involved would include clearing existing debris from the banks, smoothing the banks, and the manual placement of rip rap in the channel. Costs are expected to be moderate to relatively high for the benefit.

Lead Entity – Pinellas County

Issues – Environmental permitting will be required. Structures must withstand high flows and not increase flood potential. The site is wooded and tree protection would be a factor.

5.2.3 Project Ranking

The objectives of this Sediment Management Plan are to identify problem areas for erosion and sediment accumulation, especially as related to potential ecological degradation of existing riparian habitats in freshwater streams in the CHSJS, and to recommend potential methods to reduce observed or potential adverse impacts from those areas. Sediment related issues identified through previous work were summarized in Chapter 4. The physical characteristics of freshwater streams at selected locations were summarized in Chapters 5, 6, and 7.1, and potential management activities to ameliorate sediment problems were described above.

Ranking Criteria

In this section the ten potential sediment management projects were compared and ranked based on a variety of factors. The overall purpose of the projects is to reduce erosion, protect in-stream habitats from sediment-related impacts, and to reduce excess sediment transport, especially fine-grained sediments, downstream to the receiving water estuaries. All the projects are in the public interest, and are consistent with the missions and priorities of Pinellas County, local municipalities, SWFWMD, and other stakeholders.

Given that all the projects cannot be implemented simultaneously, it was necessary to prioritize the projects based on comparable evaluation criteria and a ranking matrix. This process assists managers in utilizing limited resources most effectively. The criteria are rated based on the relative merits of each project, and issues that would complicate project implementation. In each category the projects were scored on a qualitative scale of 1 to 5, with 1 being the least beneficial and 5 the most.

- **Stabilize channel banks –** One of the most commonly observed conditions in the streams was eroded channel banks. Conditions ranged from isolated small washouts to large-scale slope failure. Recommended actions that have the highest potential for minimizing slope erosion received a 5 with lower scores given for less effective or smaller scale measures.

- **Reduce sediment transport –** Once in the channel flow path, eroded material from the channel banks, as well as scoured channel bottom sediment, is subject to being washed downstream. Excess sediment transport can affect downstream areas physically through smothering benthic habitats, and through water quality impacts resulting from reduced water clarity and the accumulation of sediment-borne contaminants. Reducing flow velocities and installing obstacles for sediment movement in channels can reduce the transport of the material. Projects anticipated to be most effective in achieving reductions in sediment transport are scored highest.

- **Enhance riparian habitat –** Stable substrate in a creek channel promotes ecological diversity. Many of the creek reaches are now for all purposes ditches and the potential for re-introducing a sustainable benthic or pelagic community is limited. However some channel reaches may benefit from the placement of habitat-enhancing materials as discussed above. Those projects with the most potential for improving habitat conditions in the streams through the addition of suitable substrate or by protection from adverse impacts are scored highest.

- **Reduce property damage potential -** Channel-side structures and landscaping can be impacted through flooding or erosion. Although no active property damage was observed, there were sites where, if unchecked, future damage may well occur. Projects that are anticipated to be most effective in reducing the threat of property damage through flooding or erosion are ranked highest in this category.

- **Cost –** Developing formal cost estimates for the potential projects is beyond the scope of this investigation. However the projects were compared on a relative basis. Some of the projects are flexible in the scale on which they could be implemented. In these cases a general cost to benefit determination was made for the purpose of scoring.

- **Permitting issues –** Most of the projects are proposed in channel reaches with little ecological value and no major projected hurdles to permitting in-stream work. However, some projects must be developed and constructed in a manner that is sensitive to nearby wetlands or forested areas. These latter projects are scored lower.

- **Public acceptance –** There are several factors that may affect the public's view of projects such as these. Likely the most important factor is the perceived inconvenience that the project will have on homeowners in terms of construction noise, traffic disruption, etc. Another factor is the perception of the level of environmental benefit/degradation that a project would provide. For example widening a channelized stream to provide a floodplain is a benefit, but if the effort would require clearing a stand of grandfather oaks the public opinion may be much reduced. Also, public concern regarding expenditures of public funds may negatively impact any project no matter what its benefits or detriments.

- **Land ownership and access –** Project implementation is in general much simpler is no privately-held land is involved. Work on private land required the owner's consent as well as legal documents for temporary easements and access, etc. Also, the physical ease of access to a site is a factor in ease of implementation. If access restricts power equipment then manual labor will be necessary. Project sites on public land and with physical features conducive to easy access are ranked higher.

The scores in each category for each project were determined and ranked. No weighting factors were used, so all scoring categories have equal weight. Projects were assessed individually and not in groups. All projects are independent of others, that is, no project needs another to be implemented for it to be implemented.

When reviewing the scoring of the projects it is important to remember that the scores are not on absolute terms, but relative to other listed projects. For example the costs of Projects 5 and 6 are listed as "1" or high cost. This only indicates that Projects 5 and 6 are likely to cost more for implementation than .projects with a cost score of 1 – 4.

Ranking Results

Table 5-2 presents the results of the ranking based on the above criteria. The following provides a summary of individual project scores.

The three inland sediment removal projects (projects numbers 1, 2 and 3) scored highest. This was a result of high scores for reducing sediment transport, relatively low cost, projected ease of permitting, general public acceptance, and land ownership (public). Projects for channel reconfiguration and bank stabilization generally ranked in the middle, due to higher cost and greater permitting effort. The lowest ranked project (number 4) - sediment removal in McKay Creek at Indian Rocks Rd (site McKay 7) had low values for erosion benefits and land ownership, as the entire site is privately owned.

Table 5-2. Prioritization of recommended sediment management projects for CHSJS area streams.

Project Number	Project Description	Project Location	Bank Erosion	Sediment Transport	Habitat	Property Damage	Cost	Permitting	Public Acceptance	Land Ownership, Access	Average Score	Rank
1	Fine-grained sediment removal	Curlew Creek/Jerry Branch south of Main St.	1	4	2	1	5	5	4	5	3.375	1
2	Fine-grained sediment removal	Curlew Creek at Cypress Point Dr.	1	4	2	1	5	5	3	5	3.250	2
3	Fine-grained sediment removal	McKay Creek north of 134th Ave	1	4	2	1	4	4	4	5	3.125	3
4	Fine-grained sediment removal	McKay Creek east of Indian Rocks Rd.	1	3	2	1	4	3	3	1	2.250	10
5	Channel stabilization and habitat enhancement	Lower Curlew Creek downstream of County Road 1	4	2	5	2	1	2	3	3	2.750	7
6	Channel reconfiguration and habitat enhancement	Curlew Creek west of CR 1	5	1	5	4	1	2	2	3	2.875	4 (tie)
7	Sediment transport, habitat enhancement	Sediment sump at SW 8th Ave, site McKay 6	1	5	4	1	2	2	3	1	2.375	8 (tie)
8	Channel reconfiguration and habitat enhancement	Curlew Creek/Jerry Branch at Brady Dr. east of CR 1	5	3	4	2	3	2	3	1	2.875	4(tie)
9	Channel bank stabilization	Stevenson Creek downstream of Bellevue Blvd.	5	2	1	4	3	3	4	1	2.875	4(tie)
10	Channel bank stabilization	Bee Branch south of Nebraska Ave.	4	5	1	1	2	2	2	2	2.375	8 (tie)

Note: High scores are more desirable.

6 References

Batley, G.E. and W.A. Maher. 2001. The Development and Application of ANVECC and ARMCANZ Sediment Quality Guidelines. Australian Journal of Toxicology. 7: 81-92.

Brown, K. 2000. Urban Stream Restoration Practices: An initial Assessment. The Center for Watershed Protection. Elliot City, MD

Carvalho, A, S.J. Schropp, G.M. Sloane, T.P. Biernacki, and T.L. Seall. 2002. Development of an Interpretive Tool for Assessment of Metal Enrichment in Florida Freshwater Sediment. Prepared by Taylor Engineering and Florida Department of Environmental Protection. Tallahassee, FL.

Clearwater, City of. 2001. Stevenson Creek Watershed Management Plan. Prepared by Parsons Engineering Science. Tampa, FL.

Clearwater, City of. 2007. Stormwater Management System Policy. Departments of Engineering and Public Services. Clearwater, FL.

Clearwater, City of. 2008. Comprehensive Plan Stormwater Management Element. Clearwater, FL.

Clearwater, City of. 2009. Floodplain Management Plan. Prepared by City of Clearwater Engineering Department. Clearwater, FL.

Clearwater, City of. 2009. Stevenson Creek Estuary Restoration Project - Engineering Department Project Summary. Clearwater, FL.

Clearwater, City of. 2010. 2010 – 2011 Annual Operating and Capital Improvement Budget. Clearwater, FL.

Clearwater Harbor/St. Joseph Sound Working Group. 2010. Bibliography. Clearwater, FL.

Cummings, V., S. Thrush, J. Hewitt, A. Norkko, and S. Pickmere. 2003. Terrestrial deposits on intertidal sandflats: sediment characteristics as indicators of habitat suitability for recolonising macrofauna. Marine Ecology Progress Series. 253: 39-54.

Denton, G.R. W., L.P. Concepcion, H.G. Siegrist, D.T. Vann, H.R. Rick, and B.G. Bearden. 2001. Contaminant Assessment of Surface Sediments from Tanapag Lagoon, Saipan. University of Guam Water and Environmental Research Institute of the Western Pacific. Mangilao, Guam.

Doll, B.A., G.L. Grabow, K.R. Hall, J. Halley, W.A. Harman, G.D. Jennings and D.E. Wise. 2003. Stream Restoration: A Natural Channel Design Handbook. North Carolina Stream Restoration Institute, NC State University. 128 pp.

Dunedin, City of. 2003. Master Drainage Plan: Final Report for the City of Dunedin. Prepared by Tampa Bay Engineering. Clearwater.

Dunedin, City of. 2006. Cedar Creek Restoration Plan. Prepared by the Department of Public Works and Utilities. Dunedin, FL.

Dunedin, City of. 2008a. Comprehensive Plan Support Services Element – Stormwater. Prepared by Department of Public Works and Utilities. Dunedin, FL.

Dunedin, City of. 2008b. Comprehensive Plan Conservation and Coastal Zone Element – Stormwater. Prepared by Planning and Development Department. Dunedin, FL.

Dunedin, City of. 2011. Hutchens, D. Personal Communication to Melissa Harrison, Pinellas County Department of Environment and Infrastructure regarding City of Dunedin's dredging plans. Dunedin, FL.

Federal Interagency Stream Restoration Working Group (FISRWG). 2001. Stream Corridor Restoration: Principles, Processes, and Practices - Revised. National Technical Information Service. Springfield, VA.

Florida Department of Environmental Protection (FDEP). 2008a. Dissolved Oxygen and Nutrient TMDL for the Klosterman Bayou Tidal Segment, WBID 1508. Tallahassee, FL.

Florida Department of Environmental Protection (FDEP). 2008b. Florida Stormwater Erosion and Sedimentation Control Inspector's Manual. Prepared by the Nonpoint Source Management Section. Tallahassee, FL.

Florida Department of Transportation (FDOT). 2011. Soil and Foundations Handbook. Tallahassee, FL.

Fischenich, J.C. 2001. Technologies for Urban Stream Restoration and Watershed Management. Ecosystem Management and Restoration. May, 2001.

Ingersoll, C.G., T. Dillon, and R.G. Biddinger (Eds.). 1997. Methodological uncertainty in sediment ecological risk assessment. *In*: Ecological Risk Assessments of Contaminated Sediment. SETAC Special Publication Series. SETAC Press. Pensacola, FL. 389 pp.

Janicki Environmental, Inc. 2011. State of the Resource Report for Clearwater Harbor and St. Joseph Sound. Prepared for Pinellas County Department of Environmental Management. Clearwater, FL.

Lane, E.W. 1955. The importance of fluvial morphology in hydraulic engineering. American Society of Civil Engineering. Proceeding 81. Paper 745. pp. 1-17.

Largo, City of. 2009. City of Largo Comprehensive Plan Public Works Element, Stormwater Sub-element. Largo, FL.

Largo, City of. 2010. 2010 Capital Improvements Program. Largo, FL.

Long, E.R. and L.G. Morgan. 1991. The potential for biological effects of sediment-sorbed contaminants tested in the National Status and Trends Program. NOAA Tech. Memo NOS OMA 52. National Oceanic and Atmospheric Administration. Washington, D.D.

MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. Archives of Environmental Contamination and Toxicology 39: 20-31.

MacDonald, D.D. and C.G. Ingersoll. 2002. A Guidance Manual to Support the Assessment of Contaminated Sediments in Freshwater Ecosystems. Prepared for United States Environmental Protection Agency Great Lakes National Program Office. Chicago, IL.

MacDonald, D.D., C.G. Ingersoll, D.E. Smorong, R.A. Lindskoog, G. Sloane and T. Biernacki. 2003. Development and Evaluation of Numerical Sediment Quality Assessment Guidelines for Florida Inland Waters. Prepared for Florida Department of Environmental Protection. Tallahassee, FL.

MacDonald, D.D., R.S. Carr, D. Eckenrod, H. Greening, S. Grabe, C.G. Ingersoll, S. Janicki, T. Janicki, R.A. Lindskoog, E.R. Long, R. Pribble, G. Sloane, and D.E. Smorong. 2004. Development, Evaluation, and Application of Sediment Quality Targets for Assessing and Managing Contaminated Sediments in Tampa Bay, Florida. Archives of Environmental Contamination and Toxicology 46: 147-161.

Nagpal, N.K., L.W. Pommen, and L.G. Swain. 2006. A Compendium of Working Water Quality Guidelines for British Columbia. British Columbia Ministry of Environment, Environmental Protection Division.

Pinellas County. 1988. Master Drainage Plan. Prepared by Pinellas County Engineering Department. Clearwater, FL.

Pinellas County. 2008. Surface Water Management Element of the Pinellas County Comprehensive Plan. Prepared by: Pinellas County Planning Department. Clearwater, FL.

Pinellas County. 2009. Pop Stansell Stormwater Treatment & Habitat Restoration Environmental Assessment. Prepared by Pinellas County Department of Environmental Management. Clearwater, FL.

Pinellas County. 2010. Klosterman Bayou and Joe's Creek Nutrient Source Evaluation. Prepared for Department of Environmental Management. Prepared by Environmental Research & Design, Inc., Orlando, FL.

Pinellas County. 2011. FY2011 Operating and Capital Budget. Clearwater, FL.

Pinellas County. 2011. Stormwater Governance Study. Prepared by Camp Dresser McKee, Inc. Tampa, FL

Pinellas County Board of County Commissioners (PCBOCC). 2011. Stormwater Issues in Pinellas County. Presentation at Board of County Commissioners Work Session. May 31, 2011.

Poppe, L.J., A.H. Eliason, J.J. Fredericks, R.R. Rendigs, D. Blackwood, and C.F. Polloni. 2000. USGS East-Coast Sediment Analysis: Procedures, Database, and Georeferenced Displays. Chapter 1: Grain-Size Analysis of Marine Sediments: Methodology And Data Processing. U.S. Geological Survey Open-File Report 00-358. Woods Hole MA.

Raforth, R.L., D.K. Norman, and A. Johnson. 2002. Second Screening Investigation of Water and Sediment Quality in Creeks in Ten Washington Mining Districts, with Emphasis on Metals. Washington State Department of Ecology. Yakima, WA.

Ralston, N.V.C., J. Unrine, and D. Wallschläger. Undated. Biogeochemistry and Analysis of Selenium and its Species. Prepared for North American Metals Council. Washington, D.C.

Robbins, J.A., C.W. Holmes, R. Halley, M. Bothner, E. Shinn, J. Graney, G. Keeler, M. Tenbrink, K.A. Orlandini, and D. Rudnick. 2000. Time-average fluxes of lead and fallout radionuclides to sediments in Florida Bay, Florida, USA. Journal of Geophysical Research. 105: 28,805–28,821.

Rosgen, D. and H.L. Silvey. 1996. Applied River Morphology. Wildland Hydrology Publishing. Pagosa Springs, CO.

Schropp, S.J. and H.L. Windom. 1988. A Guide to the Interpretation of Metal Concentrations in Estuarine Sediments. Prepared for Florida Department of Environmental Regulation. Tallahassee, FL.

St. Petersburg Times. 2008. Dunedin will create a dam to restore part of Hammock Park. Prepared by Theresa Blackwell, Times Staff Writer. St. Petersburg, FL.

St. Petersburg Times. 2010. Dispute puts cleanup of Clearwater's Stevenson Creek on hold. Prepared by Mike Brassfield, Times Staff Writer. St. Petersburg, FL.

St. Petersburg Times. 2011. Damaged sewer line spills wastewater into McKay Creek. St. Petersburg, FL.

Schueler, T. R. 1997. Impact of Suspended and Deposited Sediment. Watershed Protection Techniques. 2(3): 443-444.

Schueler, T.R. and K. Brown. 2004. Urban Stream Repair Practices. Urban Watershed Restoration Manual No. 4. Center for Watershed Protection. Ellicott City, MD

Southwest Florida Water Management District (SWFWMD). 2009. Pinellas – Anclote River Basin Projects 2010. Brooksville, FL.

Tampa Bay Regional Planning Council (TBRPC). 2006. Local Mitigation Strategy Accomplishments. St. Petersburg, FL.

Tennessee Valley Authority (TVA). Undated. Using Stabilization Techniques. Riparian Restoration Fact Sheet Series No. 8. Knoxville, TN.
http://www.tva.com/river/landandshore/stabilization/stabilization.htm

US Army Corps of Engineers (COE). 2003. Stevenson Creek Aquatic Ecosystem Restoration. Section 206 Ecosystem Restoration Report. Jacksonville, FL.

U.S. Department of Agriculture (USDA). 2006. Soil Survey for Pinellas County, Florida. Prepared by Natural Resources Conservation Service. Washington, D.C.

U.S. Department of Agriculture (USDA). 2007. Part 654 Stream Restoration Design - National Engineering Handbook Chapter 4 Stream Restoration Design Process. Prepared by Natural Resources Conservation Service. Washington, D.C.

U.S. Department of Agriculture (USDA). 1996. Part 650 - National Engineering Field Handbook Chapter 16 Streambank and Shoreline Protection. Prepared by Natural Resources Conservation Service (NRCS). Washington, D.C.

U.S. Environmental Protection Agency (EPA). 2012. Proposed Total Maximum Daily Load for Fecal Coliform in McKay Creek WBID 1633B. January 2012, Atlanta, GA.

U.S. Environmental Protection Agency (EPA). 1992. Catalog Documentation EMAP-Estuaries Program Level Database 1992 Virginian Province Sediment Grain Composition Data. Washington, D.C.

APPENDIX A

LIST OF FIELD SITES

List of CHSJS Field Investigation Sites						
Watershed	**Waterbody**	**Site ID**	**Location**	**Lat-dec degree**	**Lon-dec degree**	**Lab Sample**
St. Joseph Sound	Klosterman Creek	Klosterman 1	Abridge at Alternate US 19	28.117	-82.765	
St. Joseph Sound	Klosterman Creek	Klosterman 2	At Pinellas Trail, 0.1 mile E of Alt US 19	28.116	-82.764	X
St. Joseph Sound	Klosterman Creek	Klosterman 3	Innisbrook Resort, at Old Post Rd	28.108	-82.756	X
St. Joseph Sound	Bee Branch	Bee 1	S of Nebraska Ave, W of Belcher Rd	28.079	-82.747	X
St. Joseph Sound	Bee Branch	Bee 2	19th St, S of Mary's Meadow Lane	28.074	-82.751	
St. Joseph Sound	Bee Branch	Bee 3	15th St, N of Tampa Rd	28.073	-82.760	
St. Joseph Sound	Bee Branch	Bee 4	Hidden Brook Dr, N of Tampa Rd	28.071	-82.766	X
Clearwater Harbor North	Curlew Creek	Curlew 1	N of Sago Ct, E of Weybridge Ln	28.048	-82.771	X
Clearwater Harbor North	Curlew Creek	Curlew 2	Curlew Creek Park	28.049	-82.769	
Clearwater Harbor North	Curlew Creek	Curlew 3	W of County Road 1, S of Winding Creek Rd	28.047	-82.760	X
Clearwater Harbor North	Curlew Creek	Curlew 4	Belcher Rd, S of Ranchette Dr	28.040	-82.747	X
Clearwater Harbor North	Curlew Creek	Curlew 5	S of Estancia Blvd, E of US 19	28.03	-82.737	
Clearwater Harbor North	Curlew Creek	Curlew 6	Birch Ct, W of US19	28.031	-82.742	X
Clearwater Harbor North	Curlew Creek	Curlew 7	N of Evans Rd, W of US 19	28.023	-82.741	
Clearwater Harbor North	Curlew Creek	Curlew 8	Bradey Dr, E of County Road 1	28.041	-82.753	
Clearwater Harbor North	Curlew Creek	Curlew 9	Laurelwood Ln, W of Belcher Rd	28.034	-82.752	
Clearwater Harbor North	Curlew Creek	Curlew 10	Solon Ave, E of Cottonwood Ter	28.031	-82.753	
Clearwater Harbor North	Curlew Creek	Curlew 11	S of Main St, E of Creek Park Dr	28.017	-82.754	X
Clearwater Harbor North	Curlew Creek	Curlew 12	Greenbriar Blvd, N of Virginia Ave	28.006	-82.755	

Clearwater Harbor North	Curlew Creek	Curlew 13	E of West Cypress Pt Dr, S of North Cypress Pt Dr	28.004	-82.750	
Clearwater Harbor North	Cedar Creek	Cedar 1	Hammock Park foot bridge, S end Harvard Ave	28.034	-82.780	X
Clearwater Harbor North	Cedar Creek	Cedar 2	At Patricia Ave N of Jackmar Rd	28.034	-82.776	
Clearwater Harbor North	Cedar Creek	Cedar 3	Hammock Park Sugarberry Trail East	28.034	-82.783	
Clearwater Harbor North	Cedar Creek	Cedar 4	At Pinehurst Rd	28.034	-82.772	X
Clearwater Harbor North	Stevenson Creek	Stevenson 1	Bellevue Blvd E of S Evergreen Ave	27.944	-82.781	
Clearwater Harbor North	Stevenson Creek	Stevenson 2	Lakeview Rd W of Hillcrest Dr	27.950	-82.780	X
Clearwater Harbor North	Stevenson Creek	Stevenson 3	At Drew St, E of Betty Ln	27.968	-82.782	
Clearwater Harbor North	Stevenson Creek	Stevenson 4	N of Palmetto St, E of Betty Ln	27.976	-82.783	X
Clearwater Harbor North	Stevenson Creek	Stevenson 5	E of Betty Ln, S of Overlea St	27.979	-82.783	
Clearwater Harbor North	Spring Branch	Spring 1	At Overbrook Ave	27.987	-82.789	X
Clearwater Harbor North	Spring Branch	Spring 2	Sunset Point Rd, W of Betty Ln	27.990	-82.784	
Clearwater Harbor North	Spring Branch	Spring 3	Azalea (New York) Ave, N of Union St	27.998	-82.780	X
Clearwater Harbor North	Spring Branch	Spring 4	E of Patricia Ave, S of Cedarwood Dr	28.004	-82.773	
Clearwater Harbor South	McKay Creek	McKay 1	S of 102nd Ave, W of 125th St	27.865	-82.816	X
Clearwater Harbor South	McKay Creek	McKay 2	In Heritage Park N of Walsingham Rd	27.881	-82.809	
Clearwater Harbor South	McKay Creek	McKay 3	N of 134th Ave, W of 121st St	27.895	-82.808	X
Clearwater Harbor South	McKay Creek	McKay 4	N of NW 8th Ave at Pine Crest Golf Course	27.910	-82.803	
Clearwater Harbor South	McKay Creek	McKay 5	S of West Bay Dr at 20th St	27.916	-82.809	
Clearwater Harbor South	McKay Creek	McKay 6	At SW 8th Ave and Hickory Dr	27.909	-82.816	X
Clearwater Harbor South	McKay Creek	McKay 7	At Indian Rocks Rd	27.904	-82.823	

APPENDIX B

SEDIMENT UNIT VOLUME CALCULATIONS

Sediment Unit Volume Calculations				
Site Name	**Bottom Width (ft)**	**Sediment Depth (ft)**	**Sed. Unit Volume (cu ft/lf)**	**On-site Observation**
Klosterman 1	12	0.75	9.0	soft sand
Klosterman 2	15	0.08	1.3	detritus, little silt
Klosterman 3	10	1.00	10.0	fine-grained muck
Bee 1	8	0.50	4.0	patchy soft sand, shoaling
Bee 2	15	0.58	8.8	shoaling below bridge
Bee 3	15	0.25	3.8	patchy sed, rocky bed, bank erosion
Bee 4	10	0.50	5.0	soft sand, shoaling
Curlew 1	30	0.25	7.5	soft sand
Curlew 2	15	0.17	2.5	soft sand
Curlew 3	15	0.17	2.5	soft clean sand
Curlew 4	20	0.25	5.0	soft sand
Curlew 5	15	0.25	3.8	soft sand
Curlew 6	10	0.33	3.3	clean soft sand
Curlew 7	15	0.17	2.5	coarse soft sand
Curlew 8	12	0.25	3.0	soft sand
Curlew 9	20	0.00	0.0	gravel on gabion bed
Curlew 10	30	0.33	10.0	soft sand
Curlew 11	20	0.75	15.0	fine-grained muck, bubbles when
Curlew 12	8	0.25	2.0	soft sand
Curlew 13	15	0.25	3.8	soft sand
Cedar 1	30	0.25	7.5	soft sand
Cedar 2	10	0.00	0.0	gabion bottom, no sed
Cedar 3	12	0.08	1.0	detritus, little silt
Cedar 4	12	0.17	2.0	gabions, patchy soft sand
Stevenson 1	5	0.00	0.0	gravel bed, no sediment
Stevenson 2	8	0.42	3.3	soft sand
Stevenson 3	10	0.25	2.5	soft sand, emergent veg
Stevenson 4	30	0.33	10.0	soft sand, shoaling
Stevenson 5	40	0.50	20.0	soft sand, at wide bend in channel
Spring 1	30	0.33	10.0	soft sand
Spring 2	6	0.00	0.0	minimal silt, gravel bed
Spring 3	30	0.38	11.3	soft sand
Spring 4	6	0.17	1.0	clayey silt, bank erosion
McKay 1	30	0.50	15.0	clean soft sand
McKay 2	30	0.67	20.0	very soft sand and fine-grained
McKay 3	18	1.58	28.5	fine-grained muck, duckweed
McKay 4	6	0.17	1.0	soft sand, algae
McKay 5	6	0.08	0.5	gravel bottom, little sed
McKay 6	12	0.46	5.5	very soft sand w/ fine-grained muck; up stream of existing sediment sump
McKay 7	35	2.00	70.0	fine-grained muck - sulfur smell

APPENDIX C

LABORATORY ANALYSIS OF SEDIMENT GRAIN SIZE AND METALS CONTENT

Results of Laboratory Analyses

The following summarizes the results of the laboratory analyses that were conducted on sediment samples taken from 18 stream sites, listed in Appendix A. Analyses included determination of percent silt and clay (fines) and metals concentrations.

Grain Size Analysis

Grain size is the single most important physical property of sediment. Grain size governs sediment transport and deposition behavior, determines structural stability under load, influences kinetic reactions and the relationships between fine-grained particles and contaminants; and affects the movement of subsurface fluids (Poppe et al,. 2000). Therefore, having information about sediment grain size allows presumptions to be made regarding how the sediment behaves and what management actions are best suited to particular sediment attributes.

For the purposes of this management plan, the most important single grain size feature is the percent silt and clay (collectively known as fines) in the sediment composition. Stream channels in the CHSJS freshwater streams are primarily composed of sand, although some fines and organic detritus exist in varying amounts. The fines content of sediment is important to habitats and in-stream biota for several reasons. The lighter fines are more easily eroded and can cause instability of channel banks. The eroded fines can also be deposited in lower energy areas and smother benthic organisms and habitats in both the channel, and the receiving water (Cummings et al., 2003; Scheuler, 1997).

Geochemically, water-borne contaminants including metals and organic compounds are much more prone to sorb to fine grained sediments, especially clays and accumulate in those layers (Carvalho, 2002; Schropp, 1988). This process is further discussed below.

Sediment samples were analyzed at the Environmental Protection Commission of Hillsborough County's (EPCHC) Tampa laboratory. Sample collection methods are described in Chapter 3 above. EPCHC defines the silt-clay (fines) fraction of soil and sediment as all particles 63 micrometers (μm) diameter and smaller. This follows the standards of ISO 14688 – Geotechnical Investigation and Testing, rather than the Unified Soil Classification System (USCS) which includes particles up to 75 μm in the fines fraction. The EPCHC grain size analysis followed the USEPA EMAP protocol (EPA, 1992). The amount of silt and clay in a sample is expressed as a dry weight percent. To be classified as a silty sand or clayey sand soil, sediment must contain at least 12 % fines (FDOT, 2011). Table 6-1 shows the analysis results.

As can be seen in Table C-1, only one sample, Spr3 on upper Spring Branch, qualified as silty sand with 13.1 % fines. In general the samples had low fines content, with only six of the 18 samples having over one percent fines. Sites with lower percent silt content include the two Bee Branch sites. The downstream site, BB4 had just 0.6% silt.

As noted in Chapter 4.2 Bee Branch had the highest channel slope of any of the streams visited. The higher slope will result in higher flow velocities which will tend to transport more fine-grained sediment downstream that flatter channels. Site BB4 was in a stream reach closer to the coast, and was not as steep as the upstream reaches. Site BB1, farther upstream, had a steeper slope, and had sediment with just 0.2% fines content.

Table C-1. Silt/clay content of CHSJS stream sediments.	
Site/Sample ID	**% Silt/Clay**
Klo2	2.0
Klo3	0.7
BB1	0.2
BB4	0.6
Cur1	0.7
Cur3	0.5
Cur4	0.6
Cur6	0.6
Cur11	1.0
Ced1	0.6
Ced4	0.7
Spr1	6.4
Spr3	13.1
Ste2	0.7
Ste4	0.7
McK1	2.6
McK3	0.8
McK6	2.6

It should be noted that the sediment samples were taken a few days after a large rain event that raised creek flows to out-of-bank proportions in some areas. It is believed that this high flow event flushed the channels of light, easily transported silt. Corresponding observations were made during the site visits. The initial visits to probe the depth of surficial soft sediments occurred before the rain event during a prolonged dry period. During those site visits, soft silty sediment layers up to a foot deep were observed at some locations. These silt layers were generally not present or not as thick at the time of sample collection after the rain. This shows the importance of proper timing of maintenance dredging of channels, which should remove accumulated silt layers before they are flushed in the receiving water.

Chemical Analysis (Metals)

The sediment samples were also analyzed for metals content. Metals, as well as other contaminants such as organic compounds that enter a water body, are more likely to attach (sorb) to sediment grains than remain in solution. These chemicals of potential concern (COPC) have special affinity to fine grained particles due to their physical and electrical properties.

Sediments contaminated with COPCs are an environmental concern for several reasons. Contaminated sediments can be chronically or acutely toxic to sediment-dwelling organisms and fish. Also, some COPCs in the sediments are taken up by benthic organisms through a process called bioaccumulation. When larger predators consume the contaminated prey, the pollutants are accumulated in the predators' bodies. Subsequent predators at higher levels of the food web receive heightened doses of COPCs through a process called biomagnification (Ingersoll *et al.* 1997; MacDonald et al., 2002; 2000).

COPCs can accumulate in the sediment, which then acts as a reservoir. COPCs in sediments can reach several times the concentrations of water-borne contaminants, and can re-enter the water column due to physical disturbance or chemical or environmental conditions where they are more easily accessed by biota. Thus, contaminated sediments can cause adverse effects to benthic organisms, fish, birds, and mammals – as well as humans - through several pathways (Carvalho et al, 2002). Metals that were evaluated included those shown in Table C-2.

Table C-2. Metals assayed in CHSJS sediment samples.	
Aluminum	Antimony
Arsenic	Cadmium
Chromium	Copper
Iron	Lead
Manganese	Nickel
Selenium	Silver
Tin	Zinc

All sediment chemistry samples were analyzed by EPCHC. The sediment metal samples were processed using a total digestion method with hydrofluoric acid using a CEM MARS Xpress microwave digester. Analysis was performed on a Perkin Elmer Optima 2000 Optical Emission Spectrometer according to EPA Method 200.7. The results of the laboratory analysis are shown in Table C-3.

Four metals (antimony, arsenic, silver, and tin) were below the detection limits in all samples. In general, the sites with higher concentrations included Spring Branch site Spr 3 and McKay Creek site McK1, although no extreme "hot spots" were noted. Sites with generally lower concentrations included the upstream Innisbrook Canal site Klo3 and the upstream Bee Branch site BB1.

Contamination Assessment – Effects Level Approach

The relative potential for adverse impacts resulting from contaminants in sediments can be assessed using the Effects Level Approach (ELA) (MacDonald et al., 2003). The ELA uses empirically-derived ranges of contaminant concentrations to determine the likelihood of sediment contaminants causing adverse effects to benthic (sediment-dwelling) and aquatic-dependent organisms and humans.

Threshold Effects Concentrations (TECs) identify the concentrations of sediment-associated contaminants below which adverse effects on sediment-dwelling organisms are unlikely to occur. Probable Effects Concentrations (PECs) identify the concentrations of sediment-associated contaminants above which adverse effects on sediment-dwelling organisms are likely to occur. This approach was first developed in Florida for estuarine sediments in Tampa Bay (MacDonald et al., 2004) and was later used to develop TECs and PECs for Florida freshwater sediments (MacDonald et al., 2002; 2003). TECs and PECs for sediment-dwelling organisms in freshwater are shown in Table C-3. Local guidelines for metals are not available for aquatic-dependent organisms or humans.

Table C-3. CHSJS tributary freshwater sediment metals concentrations (mg/kg dry weight).														
Site	**Aluminum**	**Antimony**	**Arsenic**	**Cadmium**	**Chromium**	**Copper**	**Iron**	**Lead**	**Manganese**	**Nickel**	**Selenium**	**Silver**	**Tin**	**Zinc**
Klo2	1938	BDL	BDL	1.97	5.16	3.03	637	11.96	13.40	4.61	9.68	BDL	BDL	7.10
Klo3	483	BDL	BDL	1.85	2.54	11.74	430	12.15	8.70	4.42	9.26	BDL	BDL	4.84
BB1	514	BDL	BDL	1.99	3.70	0.59	189	11.63	5.78	4.62	9.51	BDL	BDL	2.77
BB4	727	BDL	BDL	2.00	6.55	0.79	770	12.24	23.10	4.31	10.00	BDL	BDL	4.56
Cur1	3190	BDL	BDL	1.91	8.74	2.51	1152	14.07	11.93	5.09	11.55	BDL	BDL	12.75
Cur3	882	BDL	BDL	2.10	3.77	0.87	347	12.00	5.70	4.33	9.21	BDL	BDL	3.42
Cur4	702	BDL	BDL	1.82	2.96	0.72	348	12.54	4.42	4.60	10.16	BDL	BDL	4.74
Cur6	690	BDL	BDL	1.76	2.10	1.19	250	10.20	2.91	4.43	12.21	BDL	BDL	7.61
Cur11	3311	BDL	BDL	1.74	7.74	2.16	747	7.15	8.41	4.89	11.18	BDL	BDL	7.82
Ced1	700	BDL	BDL	1.84	4.30	0.63	735	10.70	27.07	4.36	9.63	BDL	BDL	5.52
Ced4	1369	BDL	BDL	1.90	3.92	1.45	723	9.83	6.72	4.35	7.52	BDL	BDL	15.35
Spr1	2543	BDL	BDL	2.05	10.3	4.15	1221	16.71	18.21	4.98	10.81	BDL	BDL	17.5
Spr3	8885	BDL	BDL	2.01	23.77	17.21	3101	9.55	33.51	5.74	16.81	BDL	BDL	64.36
Ste2	1115	BDL	BDL	1.46	2.48	3.69	349	14.28	3.37	4.78	11.14	BDL	BDL	13.89
Ste4	1433	BDL	BDL	1.88	3.39	1.99	326	11.84	2.91	4.77	9.37	BDL	BDL	7.97
McK1	7427	BDL	BDL	1.77	12.39	13.84	1611	15.82	6.22	5.46	12.49	BDL	BDL	40.68
McK3	1149	BDL	BDL	2.07	4.23	5.03	758	16.72	10.08	5.15	11.18	BDL	BDL	23.52
McK6	3357	BDL	BDL	1.93	8.16	7.02	1311	13.37	14.39	4.74	13.88	BDL	BDL	27.89
Sediment Quality Guidelines														
TEC	NG	NG	9.8	1.0	43	32	NG	36	NG	23	NG	1.0	NG	120
PEC	NG	NG	33	5.0	110	150	NG	130	NG	49	NG	2.2	NG	460
SQG(1)											2			
TEC(2)		2												
PEC(2)		25												
SEL(1)							40,000							
ERM	58,000													
TEC(3)									460					
SEL(2)									1100					
LC													0.1-5	

Notes for Table C-3:

TEC = Threshold Effects Concentration for freshwater sediment-dwelling organisms (McDonald et al., 2000)
PEC = Probable Effects Concentration for freshwater sediment-dwelling organisms (McDonald et al., 2000)
NG = No Florida PEL or TEL guideline is provided.
SQG(1) = Sediment Quality Guideline (Ralston et al., undated) "…appropriate for prevention of bioaccumulation in food chains."
PEC, TEC (2) (Long et al., 1991)
SEL (1) = Severe Effects Level; ERM = Effects Range Medium (Raforth et al., 2002)
TEC (3), SEL (2) (Nagpal et al, 2006)
LC = Light Contamination (Denton et al., 2001)
BDL = Below Detection Limit

A review of the data show that cadmium at all sites was above the TEC (the lower value) but below the PEC. No other exceedances of the TECs were observed. Because the cadmium values are closer to the TEC than the PEC it can be concluded that severe adverse impacts to benthos from metal contamination at the sites sampled are not likely. Cadmium (Cd) concentrations in "clean" freshwater Florida sediments were assessed by Carvalho et al., (2002) and shown to be generally between 0.01 and 0.1 mg/kg (ppm), so the results from the CHSJS streams, all of which are within an urban environment, are somewhat elevated above natural background levels.

One interesting feature of the results is that the Cd levels are within a very tight range for all samples, varying by only 30%, and if the lowest value is discarded, by only 17%. This despite samples having been collected over a wide range of conditions. One potential explanation is that atmospheric deposition is a major source of Cd. Some types of manufacturing and metal-working operations, as well as the burning of fossil fuels, release Cd into the atmosphere. Coal and oil-powered power plants, and motor vehicles contribute significant amounts of Cd into the atmosphere nation-wide. Given the urban nature of the CHSJS it is quite possible that a relatively even distribution of atmospheric Cd caused the consistent results.

MacDonald et al. (2000) did not develop TELs and PELs for all the metals that were tested, including aluminum, antimony, iron, manganese, selenium, and tin. A review of sediment assessment guideline literature revealed other contaminant range values for those chemicals, as shown in Table 6-2. Sources and comments for the other values are included following the table (Batley and Maher, 2001), (Ingersall et al., 1997).

It must be noted that MacDonald et al.'s (2000) TEL and PEL values apply to adverse impacts to sediment-dwelling organisms, not pelagic species or humans. Some of the other values are appropriate for different applications, as noted. For example, SQG(1) for selenium was stated to be a value appropriate to prevent bioaccumulation in the food web (Ralston et al., undated), a very different purpose than MacDonald et al.'s (2000) TELS and PELs.

Contamination Assessment – Metals to Aluminum Ratio

Another method of assessing the conditions of sediment quality is to examine the metals concentrations relative to a normalizing agent. This technique has been used to identify concentration ranges for naturally occurring metals in Florida estuaries and coastal waters (Schropp and Windom, 1988), and the state's freshwaters (Carvalho et al., 2002). By comparing the concentrations of a metal to the agent, in this case aluminum, ranges of the two metals similar to concentrations representing non-enriched levels can be developed. Metal concentrations falling outside (above) the range have a greater probability of being enriched by anthropogenic sources. This methodology helps determine whether metals in Florida freshwater sediments exceed expected natural concentrations. It provides a means to account for the natural variability of metals in some of Florida's freshwater systems and to determine whether sediment is metal enriched.

Carvalho et al., (2002) developed a spreadsheet-based tool based on the work of Schropp and Windom (1988) and adjusted for freshwater. The tool is based on the relatively constant relationships between metals and the reference element aluminum in natural sediments. "Clean" lake, stream, and spring sediments from north and central Florida were sampled to provide the background (natural) reference concentrations. Metal/aluminum linear regressions were used to predict the range of natural conditions. Subsequently, metal concentrations from other freshwater sediments can be compared to the predictive limits to determine whether the metal concentrations exceed expected natural ranges (Carvalho et al., 2002). The tool assesses cadmium, chromium, copper, lead, nickel, and zinc for enrichment with respect to aluminum.

Two cautions should be noted when using this interpretive tool. First, if a sample value is outside the 95% confidence boundaries it does not guarantee that the sediment metal content is enriched. Even some of the "clean" samples fall outside the confidence limits. The second note is that Schropp et al., (1998) recommends not using this technique with single sample values but only with the averaged results of replicate samples. Therefore, the results discussed below should be taken as potential evidence but non-definitive regarding the level of metal enrichment in CHSJS tributary sediments. Additional sampling at sites with the single samples suggesting potential metal enrichment should be completed prior to a final determination of a site's metal enrichment.

Figures C-1 through C-6 show plots of the 95% confidence intervals for metals from "clean" sediments and aluminum used as the normalizing element, with the CHSJS tributary sample concentrations superimposed. Metals ratios falling above the upper limit of the confidence limit suggest enrichment.

Figure C-1 generally corresponds with the Cd TEC/PEC analysis discussed above. All samples are at or above the upper confidence limit of natural sediment concentrations. As stated above, Cd in clean Florida freshwater sediments is typically below 1 mg/kg (ppm), so the observed values, all near 2 mg/kg, are clearly enriched. Also as noted above, atmospheric sources may be a major cause of the higher values.

Figure C-2 indicates that chromium is not enriched, as all but one sample are within the confidence limits and the sample BB4 is very close to the upper boundary. Copper concentrations are shown in Figure C-3. Most are within the confidence limits but six samples, including all three McKay Creek samples, are above the upper boundary. The upstream Klosterman Bayou site Klo3 is the farthest outside the confidence interval. The McKay Creek sites have high silt/clay content relative to other samples, although the fines content is not high in absolute terms.

The lead-(Pb)-aluminum relationships in Figure C-4 show elevated lead concentrations. All but two of the samples are above the upper confidence limit, and the lead values are relatively tightly grouped. Like Cd, Pb has historically been introduced into the environment via atmospheric deposition. Although the trend in lead deposition has been downward for the past decades, residual, or legacy, concentrations may persist in sediments for decades due to sediment's reservoir effect (Robbins et al., 2000).

Figure C-5 shows nickel (Ni)-aluminum relationships to be similar to Cd-aluminum in that the Nickel concentrations are all within a narrow band. All but five sites show evidence of enrichment. Atmospheric deposition is a significant source of Ni, mainly from burning fossil fuels which may explain the uniform concentrations. Figure C-6 shows zinc-aluminum relationships. All but one sample (McK3) is within the confidence limits.

The following summarizes the total number of potentially enriched metals of the six tested for each site. In should be noted that no tributary had more than one site with over three enriched metals. In other words, the highest metal concentrations were a site-specific phenomenon, and were not associated with an entire waterbody. No sites had no unenriched metals.

Four enriched: Klosterman 3, Bee 4, Stevenson 2, Spring 1, McKay 3
Three enriched: Klosterman 2, Bee 1, Curlew 1, Curlew 3, Curlew 4, Cedar 1, Stevenson 4
Two enriched: Curlew 6, Cedar 4, McKay 1, McKay 6
One enriched: Curlew 11, Spring 3

The number of enriched samples for each metal are as follows, for the 18 sites: Cd: 18 sites (all), Cr: 1 site, Cu: 6 sites, Pb:15 sites, Ni: 14 sites, and Zn: 2 sites.

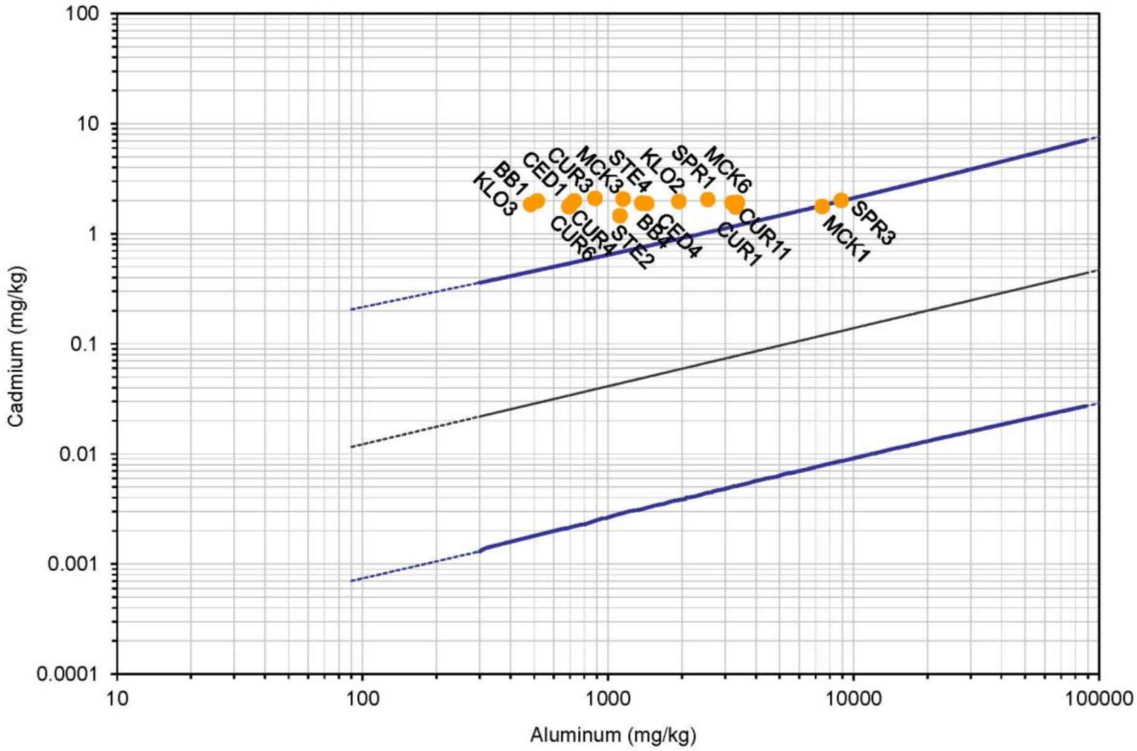


Figure C-1. **Plot of cadmium vs aluminum concentrations for CHSJS streams with 95% confidence interval for unenriched sediments.**

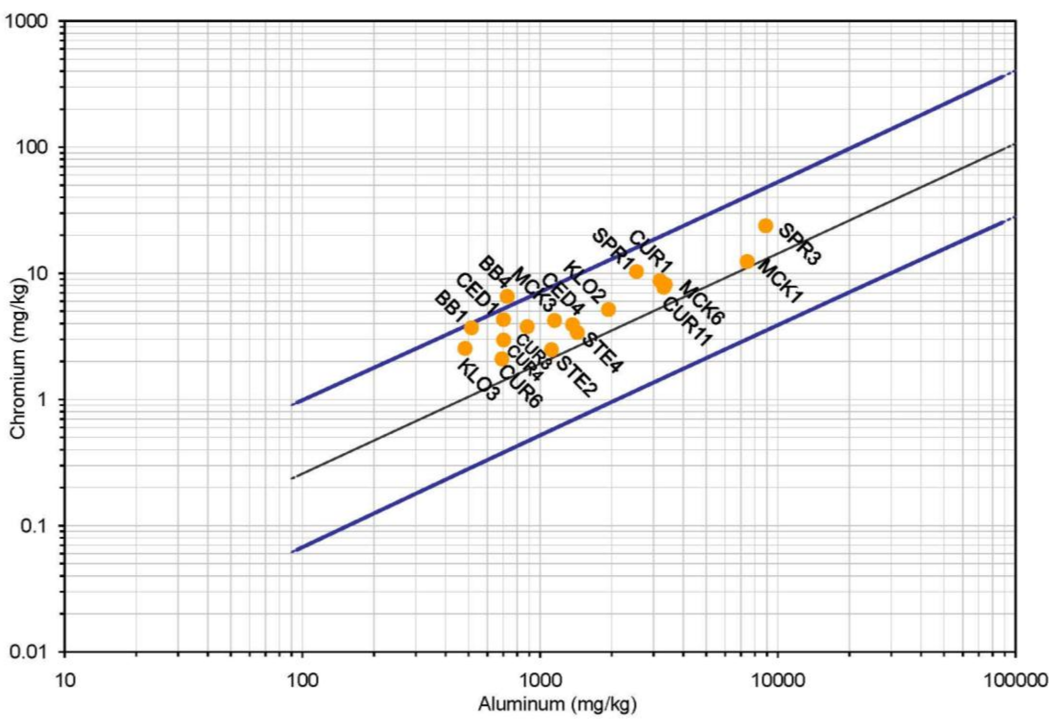


Figure C-2. **Plot of chromium vs aluminum concentrations for CHSJS streams with 95% confidence interval for unenriched sediments.**

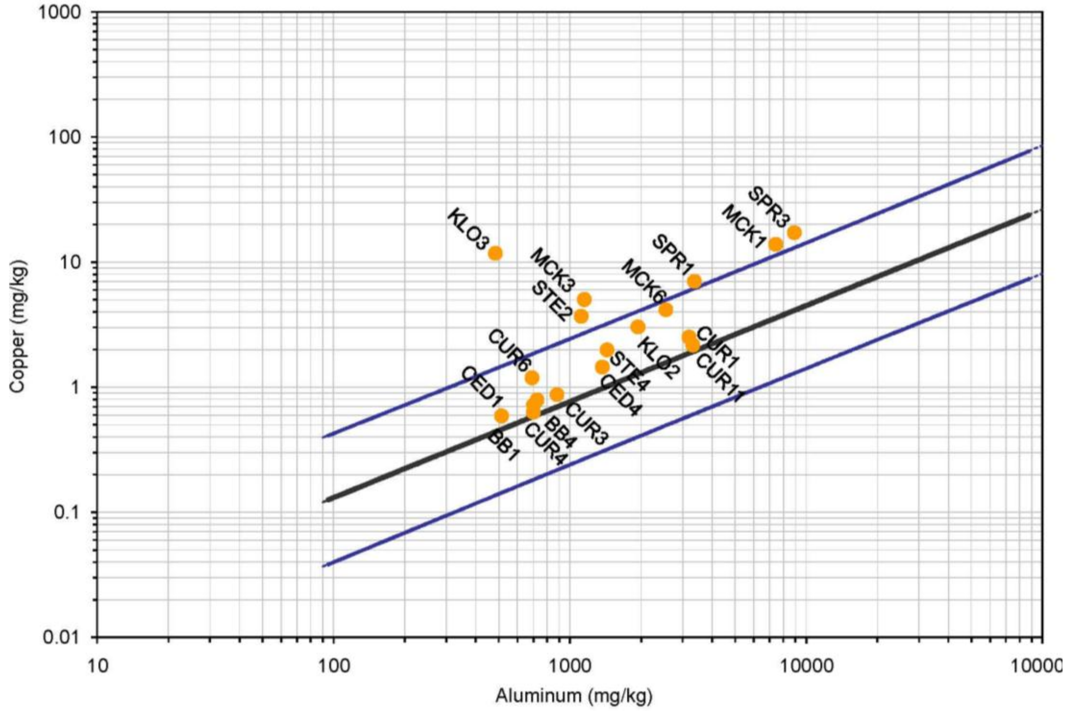


Figure C-3. Plot of copper vs aluminum concentrations for CHSJS streams with 95% confidence interval for unenriched sediments.

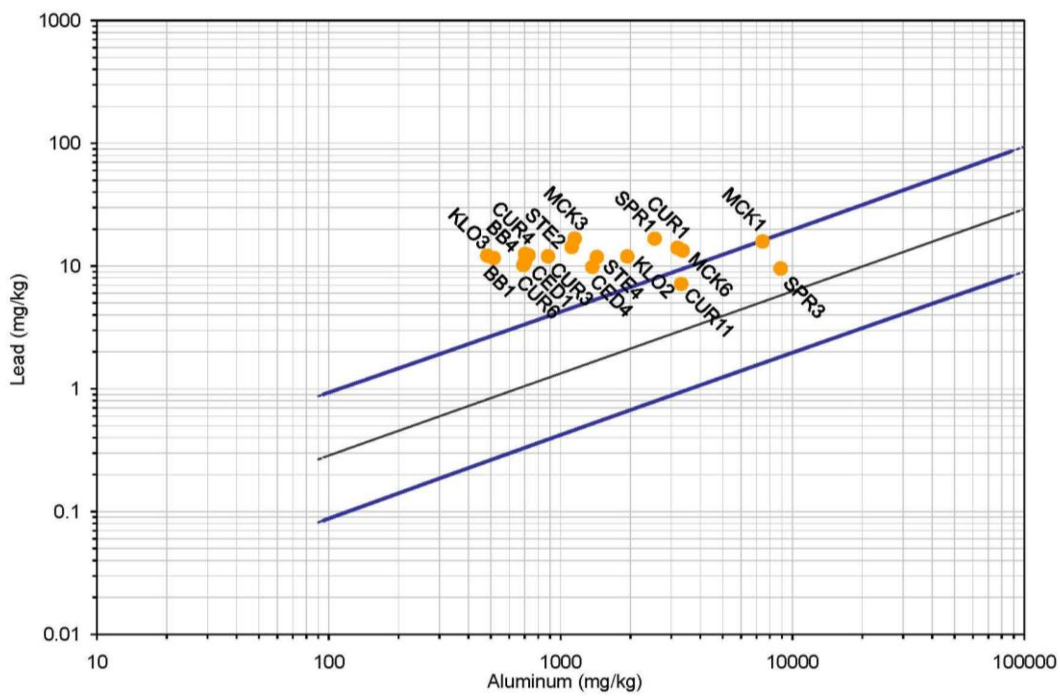


Figure C-4. Plot of lead vs aluminum concentrations for CHSJS streams with 95% confidence interval for unenriched sediments.

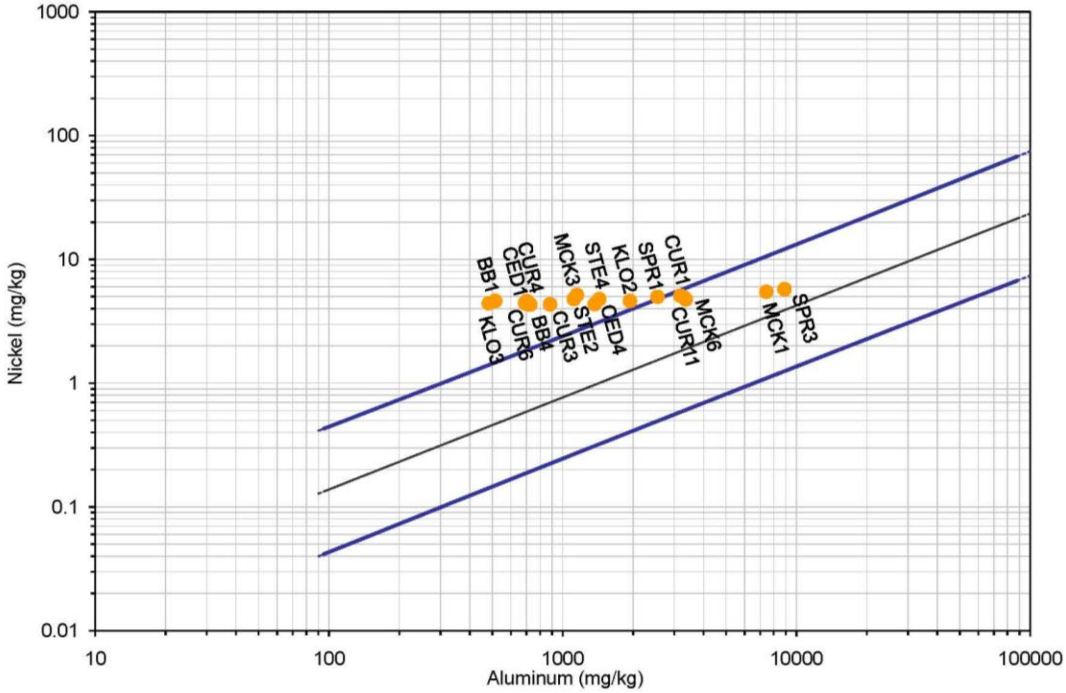


Figure C-5. **Plot of nickel vs aluminum concentrations for CHSJS streams with 95% confidence interval for unenriched sediments.**

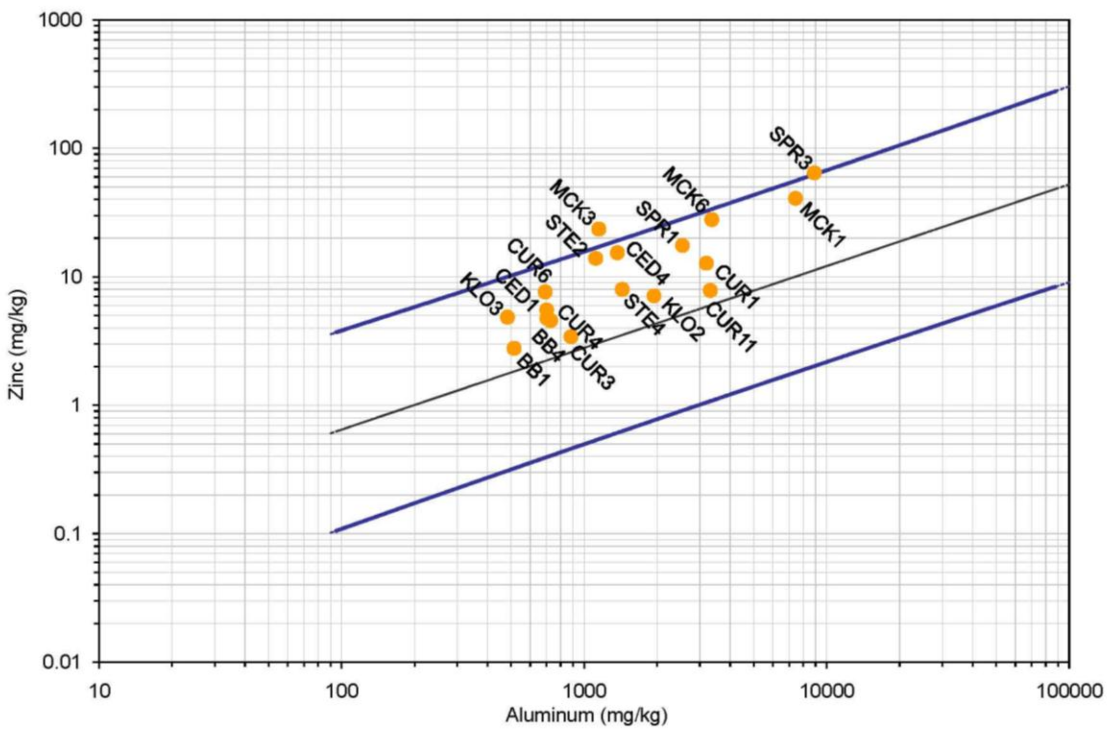
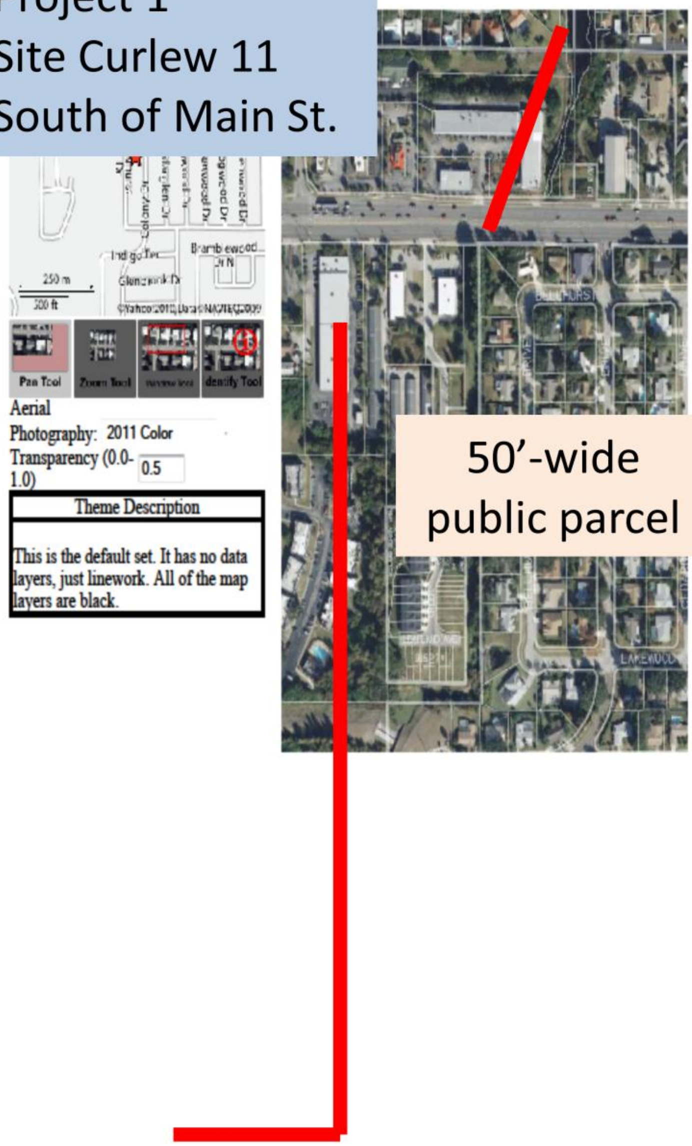


Figure C-6. **Plot of zinc vs aluminum concentrations for CHSJS streams with 95% confidence interval for unenriched sediments.**

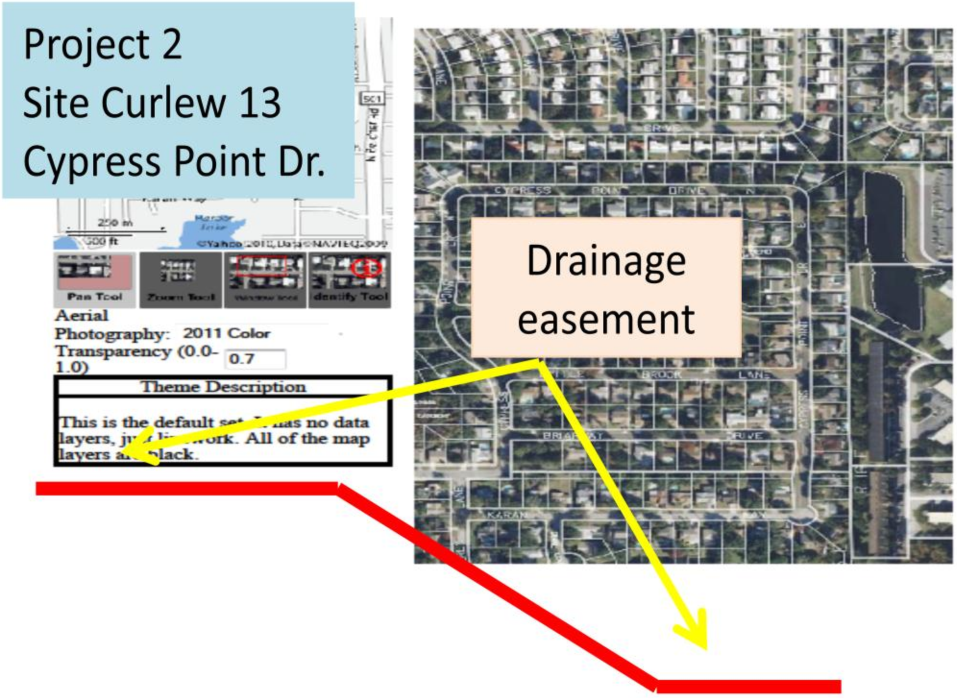
APPENDIX D

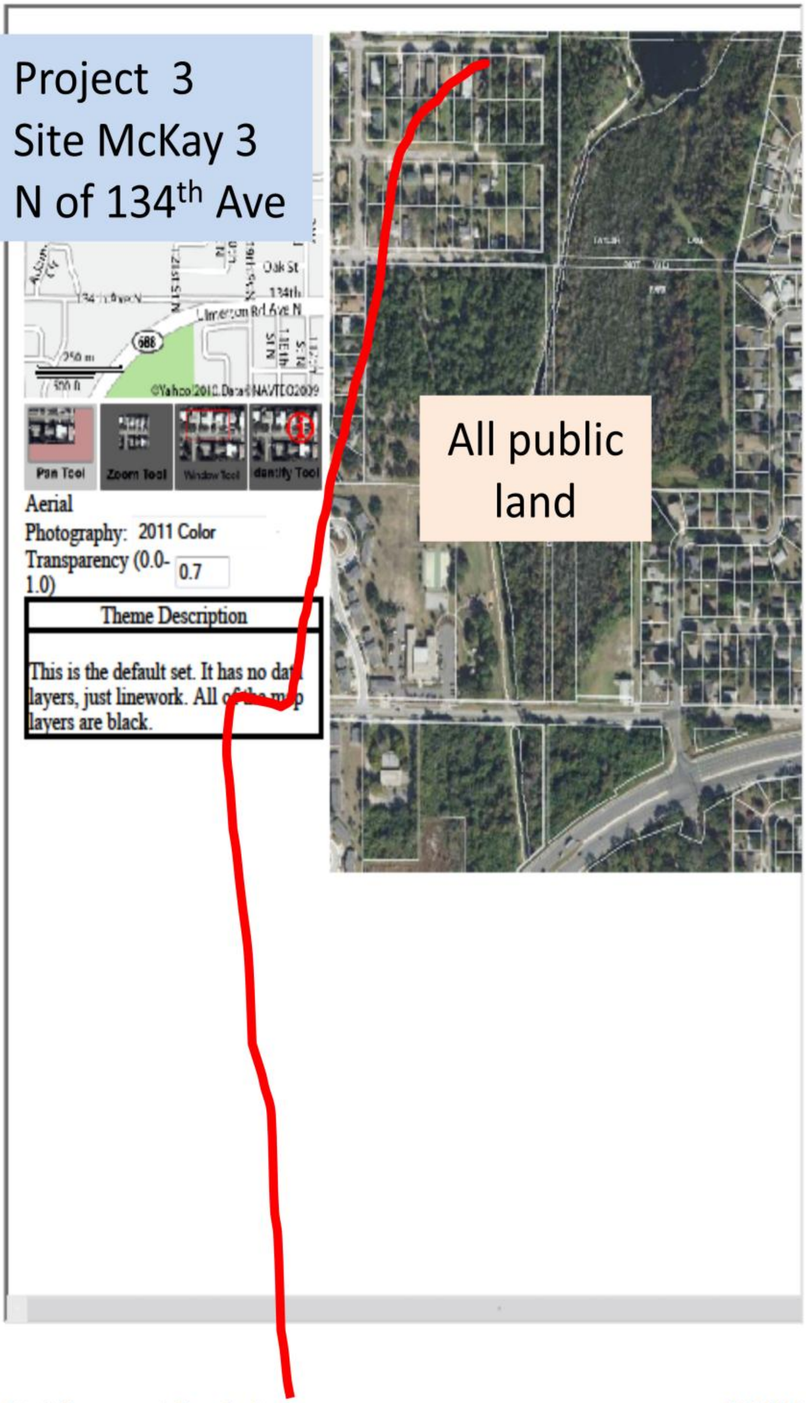
PINELLAS COUNTY PROPERTY APPRAISER WEBSITE PARCEL MAPS FOR RECOMMENDED PROJECTS

Project 1
Site Curlew 11
South of Main St.



50'-wide
public parcel


Project 2
Site Curlew 13
Cypress Point Dr.
Pan Tool
Zoom Tool
Identify Tool
Aerial Photography: 2011 Color
Transparency (0.0-1.0) 0.7
Theme Description
This is the default set. It has no data layers, just linework. All of the map layers are black.
Drainage easement
CYPRESS POINT DRIVE
BROOK LANE
BRIARWOOD DRIVE
KARAN


Project 3
Site McKay 3
N of 134th Ave
All public land
Oak St
Pan Tool
Zoom Tool
Aerial
Photography: 2011 Color
Transparency (0.0-1.0) 0.7
Theme Description
This is the default set. It has no data layers, just linework. All of the map layers are black.

Project 4
Site McKay 7
East of Indian Rocks
Beach Rd

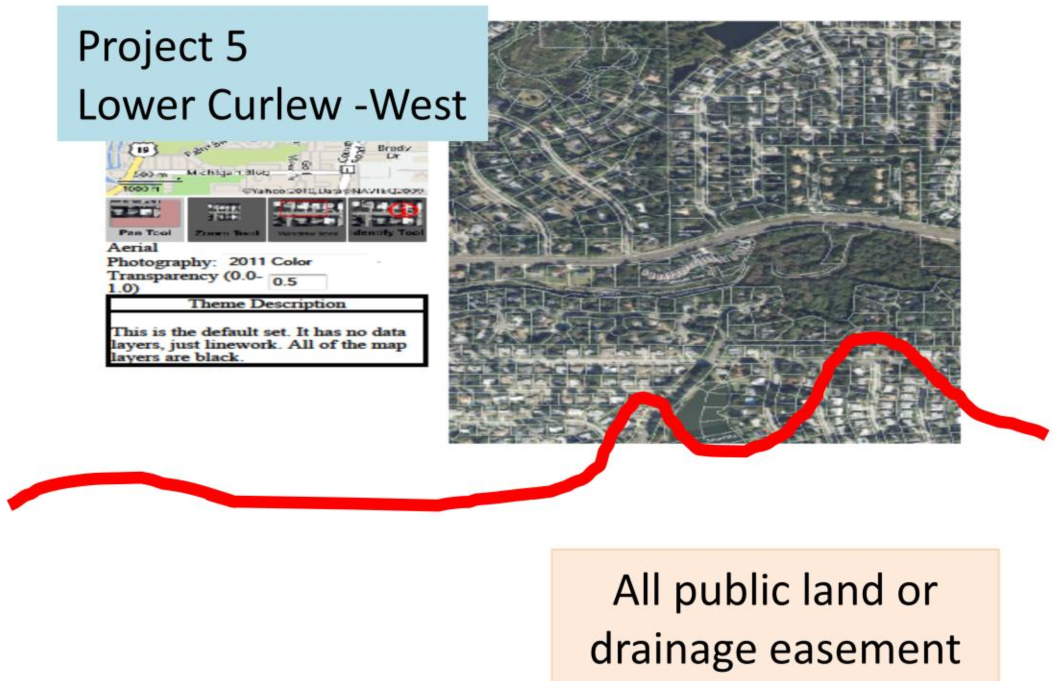
Aerial Photography: 2011 Color
Transparency (0.0-1.0) 0.5

Theme Description
This is the default set. It has no data layers, just linework. All of the map layers are black.

All private land

Welcome to VDB on the Web

Page 1 of 1

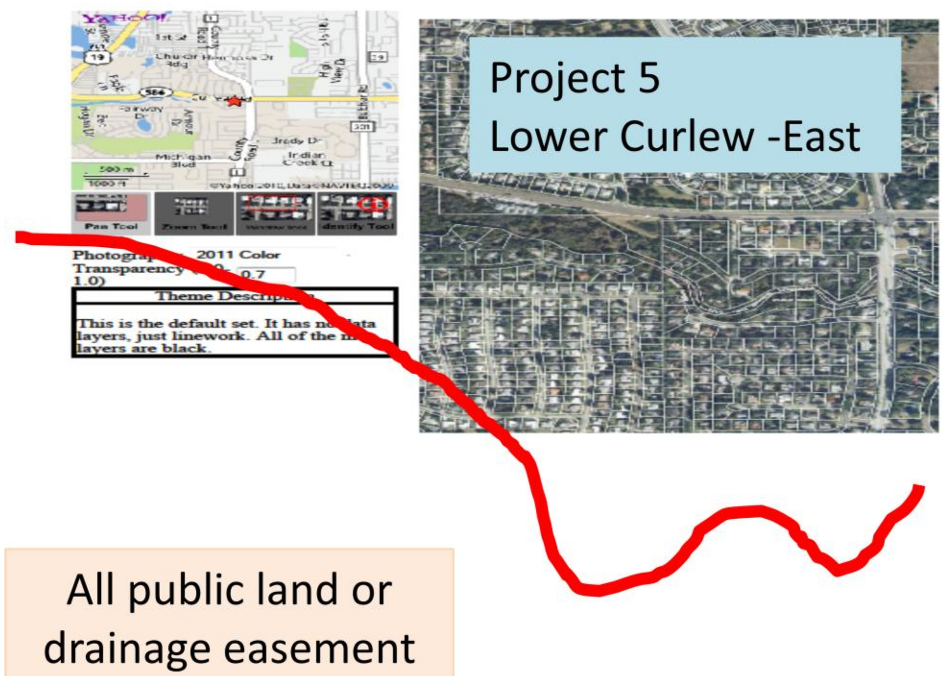


http://vdb.pcpao.org/vdb.php

8/18/2011

Welcome to VDB on the Web

Page 1 of 1



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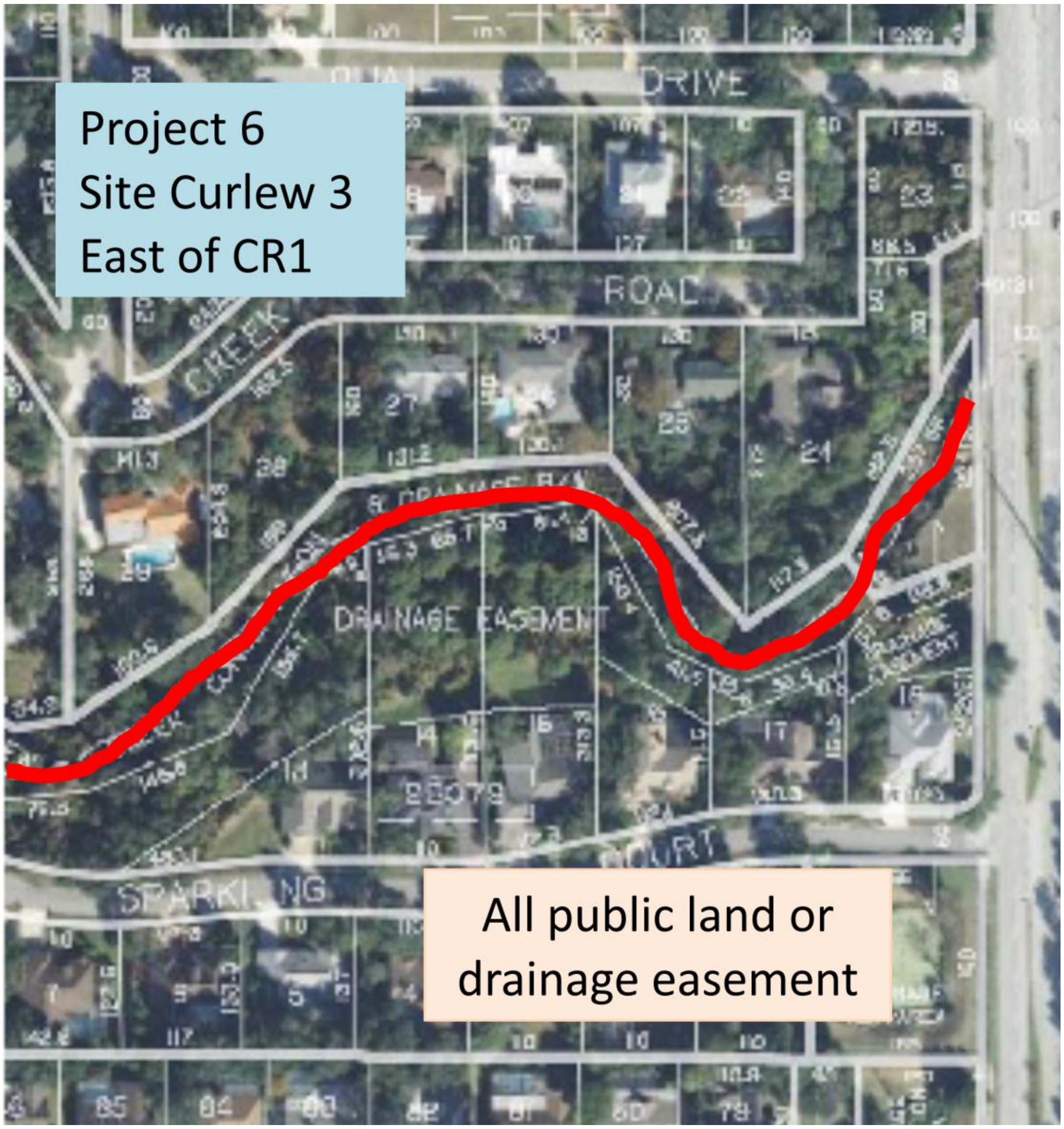
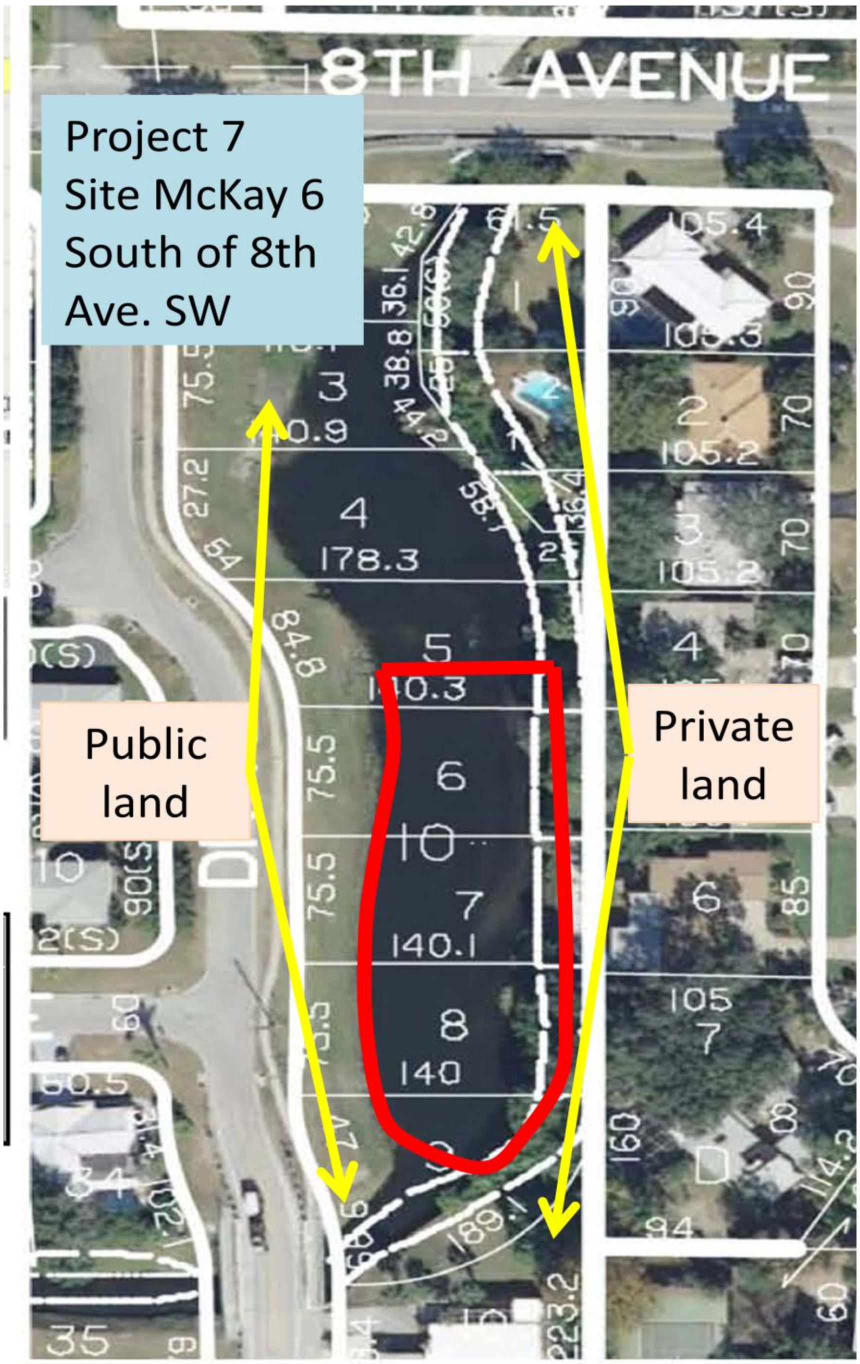
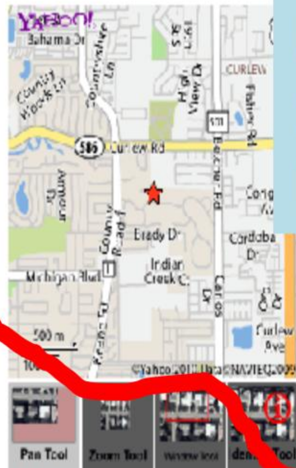
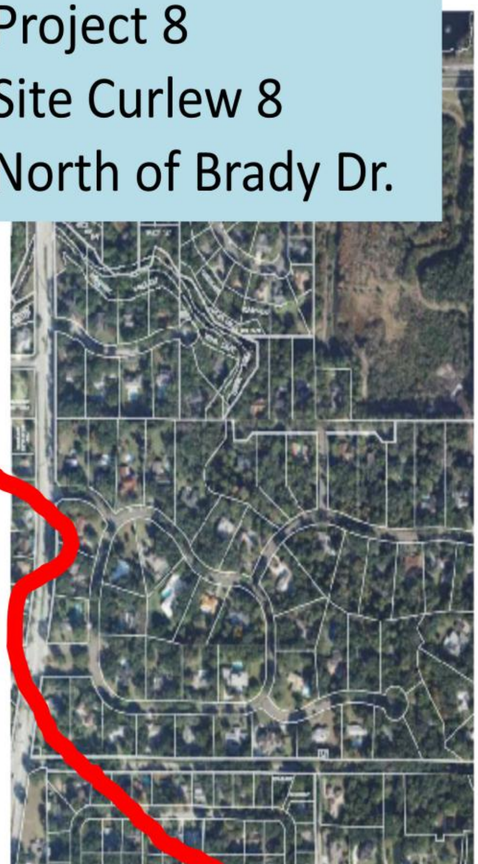
8/18/2011


Project 6
Site Curlew 3
East of CR1
All public land or
drainage easement
QUAIL
DRIVE
ROAD
CREEK
DRAINAGE EASEMENT
SPARKLING
COURT


8TH AVENUE
Project 7
Site McKay 6
South of 8th
Ave. SW
Public
land
Private
land

Project 8
Site Curlew 8
North of Brady Dr.



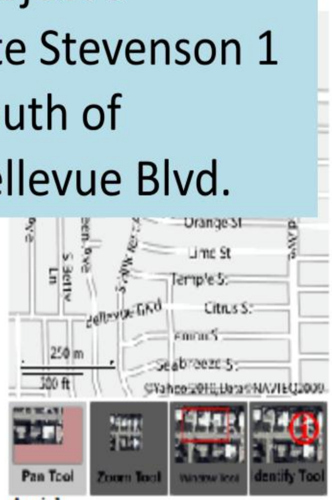


Aerial
Photography: 2011 Color
Transparency (0.0-1.0) 0.7

Theme Description
This is the default set. It has no data layers, just linework. All of the map layers are black.

All private land

Project 9
Site Stevenson 1
South of
Bellevue Blvd.



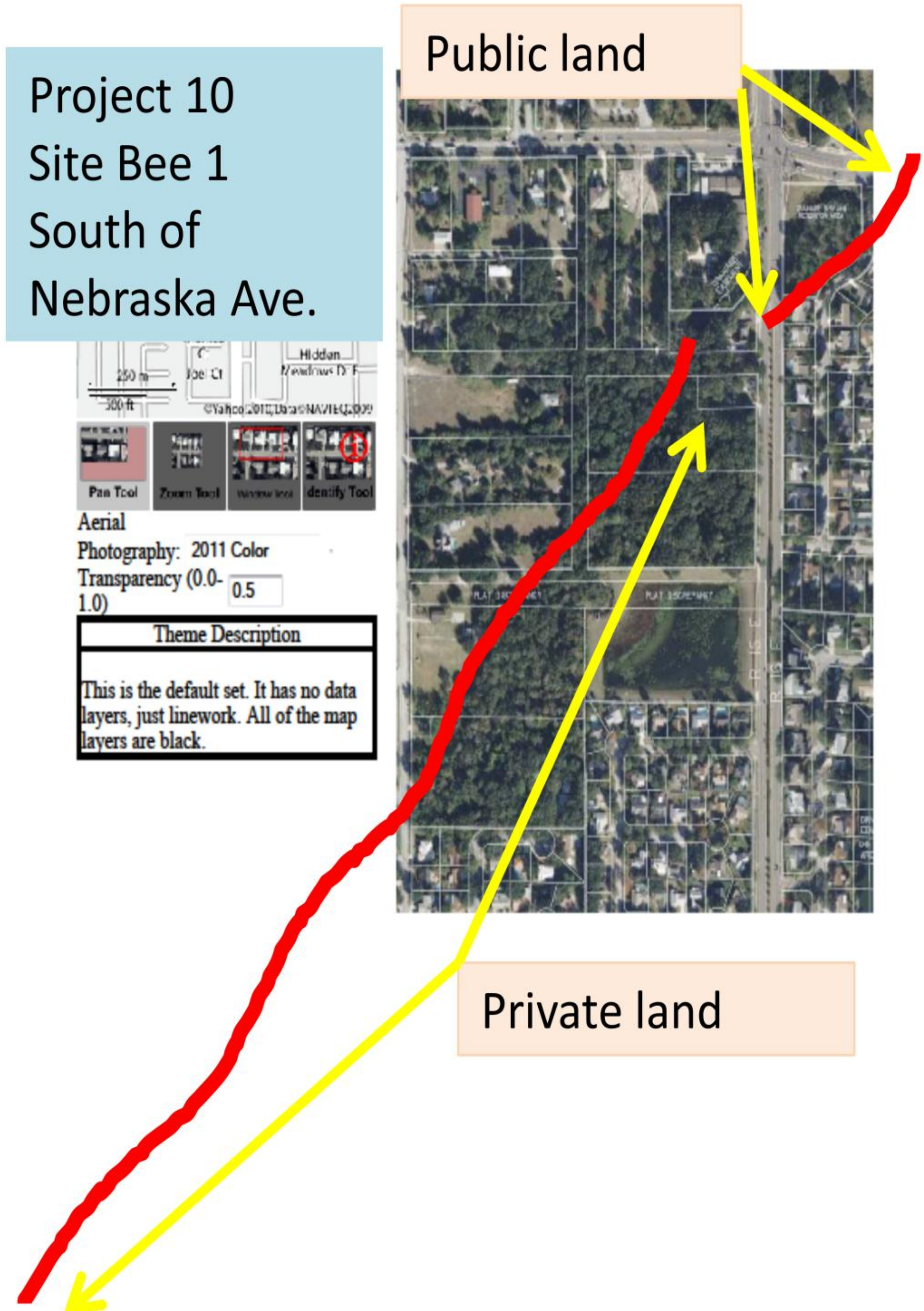
Aerial Photography: 2011 Color

Transparency (0.0-1.0) 0.5

Theme Description
This is the default set. It has no data layers, just linework. All of the map layers are black.

All private land

Appendix D


Project 10
Site Bee 1
South of
Nebraska Ave.
Public land
Private land
Hidden
Meadows Dr
Pan Tool
Zoom Tool
Identify Tool
Aerial
Photography: 2011 Color
Transparency (0.0-1.0) 0.5
Theme Description
This is the default set. It has no data layers, just linework. All of the map layers are black.

Appendix D

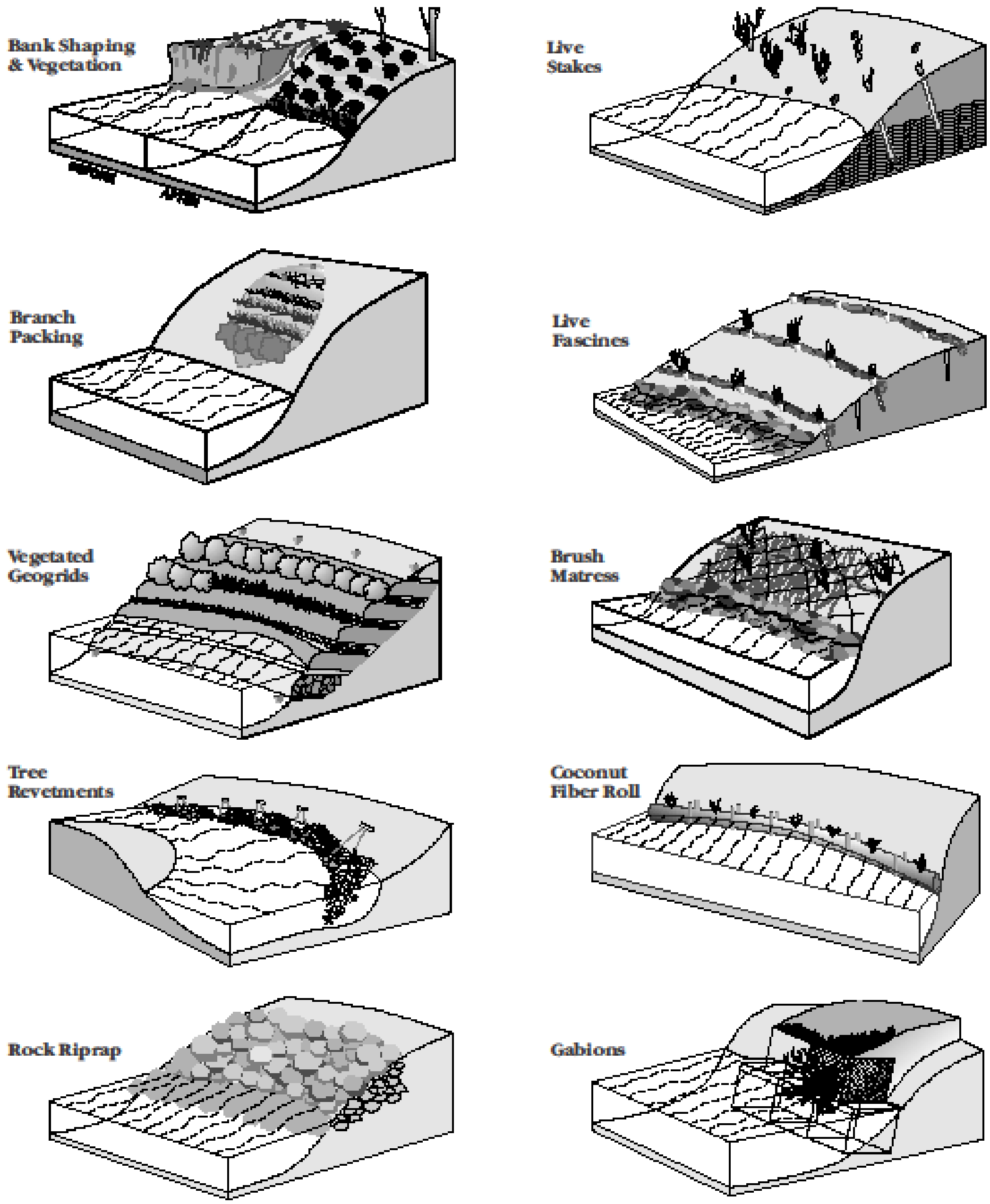
APPENDIX E

ALTERNATIVES FOR CHANNEL STABILIZATION

Stabilization Techniques

Treatment	Description	Costs	Equipment Required	Stabilization Purposes			Comments
				Toe protection	Upper bank protection	Runoff control	
Preparation Bank shaping	Removal of soil to reduce the slope of very steep banks to a more stable angle.	Moderate to high	Hand tools or power machinery	Used in conjunction with other techniques			Stabilization techniques can be more successful with a stable slope.
Live Plantings Vegetation	Trees, shrubs and other vegetation used to stabilize banks.	Low	Hand tools or light power machinery	✓	✓	✓	May require protection from flowing water (stakes, erosion control matting) during root establishment.
Live stakes	Branches of rootable plants inserted into the bank.	Low	Hand tools		✓		A flexible technique with many applications.
Branch packing	Live branch cuttings incorporated into compacted soil.	Moderate	Hand tools		✓	✓	Used to fill depressions in soil.
Live fascines	Bundles of live branch cuttings that are buried into the bank and staked in place.	Moderate	Hand tools		✓	✓	Enhances conditions for colonization with native vegetation; often used with other bioengineering techniques and vegetative plantings.
Bioengineering Vegetated geogrids	Alternating layers of live branch cuttings and compacted soil layers wrapped in geotextile fabric to rebuild and vegetate eroded banks.	High	Hand tools	✓	✓	✓	Can be installed for steeper and higher slopes; useful in restoring outside bends where erosion is a problem.
Brush mattress	Live branch cuttings covering entire stream bank and secured in place.	Moderate to high	Hand tools		✓	✓	Provides immediate complete cover and long-term stabilization.
Tree revetments	Rows of cut trees (usually cedar trees) anchored to the toe of the bank.	Low	Hand tools or light power machinery	✓			Often used as toe protection with other bioengineering techniques.
Coconut fiber roll	Flexible "logs" made from coconut hull fibers, staked at the toe of the bank.	Moderate	Hand tools	✓			Used in conjunction with native plants to trap sediment and encourage plant growth.
Hard armoring Rock riprap	Large stones along the slope of a bank to stabilize the soil.	Moderate to high	Light to heavy power machinery	✓	✓	✓	Requires good design and construction.
Gabions	Wire baskets filled with rocks.	High to very high	Light to heavy power machinery	✓	✓	✓	Can reduce or eliminate the need for bank sloping by creating a vertical wall.

From: TVA. Undated. Using Stabilization Techniques. Riparian Restoration Fact Sheet Series No. 8. http://www.tva.com/river/landandshore/stabilization/stabilization.htm



Illustrations were adapted with permission from "Stream Corridor Restoration: Principles, Processes, and Practices," by the Federal Interagency Stream Restoration Working Group

From: TVA. Undated. Using Stabilization techniques. Riparian Restoration Fact Sheet Series No. 8

http://www.tva.com/river/landandshore/stabilization/stabilization.htm

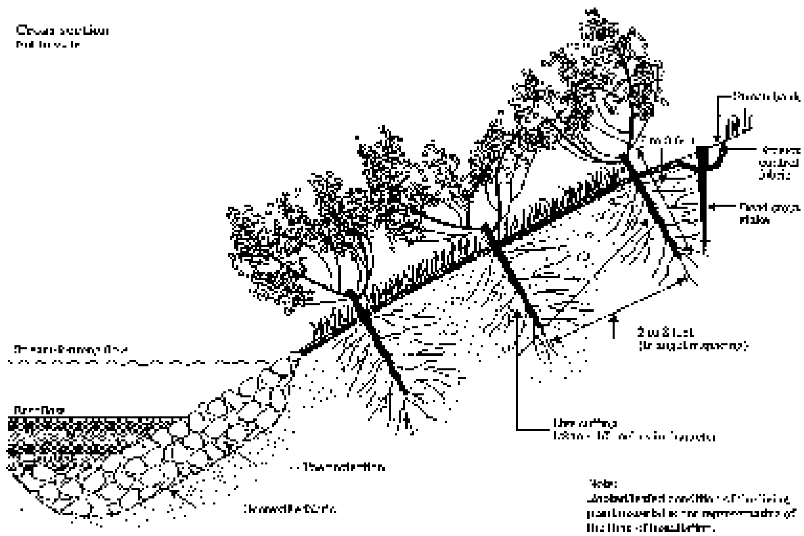
Soil Bioengineering Systems

Some of the most common and useful soil bioengineering systems for restoration and protection of streambanks and shorelines are described in the following sections.

Live Staking

Live stakes are living, woody plant cuttings capable of rooted when inserted into the banks. These stakes, commonly willow species, can root and grow into shrubs that overtime will stabilize the streambank or shoreline and provide riparian habitat.

Figure 1. Live stake details



NRCS Engineering Field Handbook (210-vi-EFH, December 1996)

Live Fascines (Fascine Rolls/Wattles)

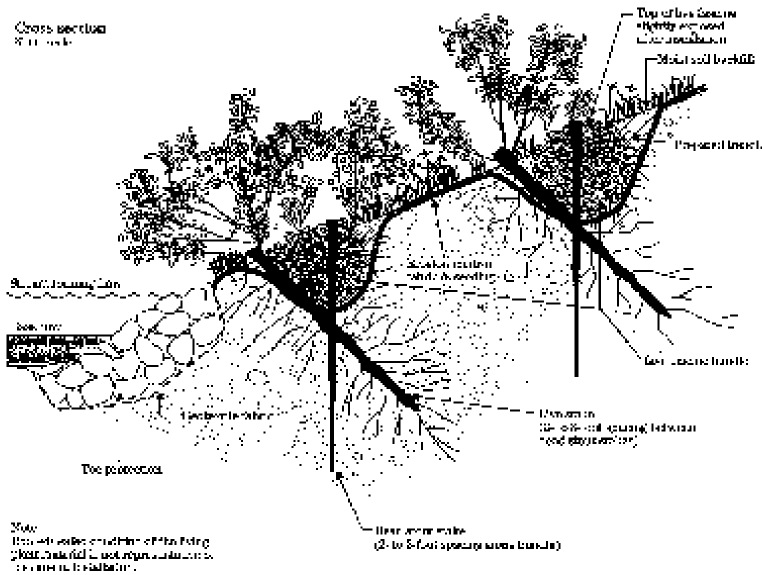
Live facines are bound bundles of live branch cuttings that are buried onto the bank and staked into place along the slope contour. Willow branches are the most commonly used for this method.

Figure 2. Live fascine details

NRCS Engineering Field Handbook (210-vi-EFH, December 1996)

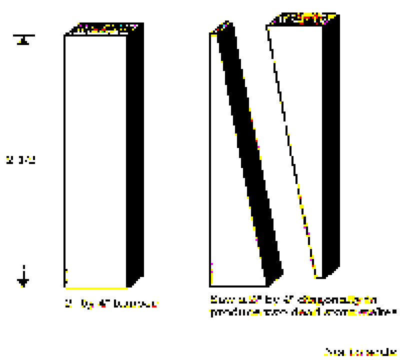
From: NRCS Engineering Field Handbook, 1996.

Figure 3. Live fascine details



NRCS Engineering Field Handbook (210-vi-EFH, December 1996)

Figure 4. Preparation of a dead stout stake



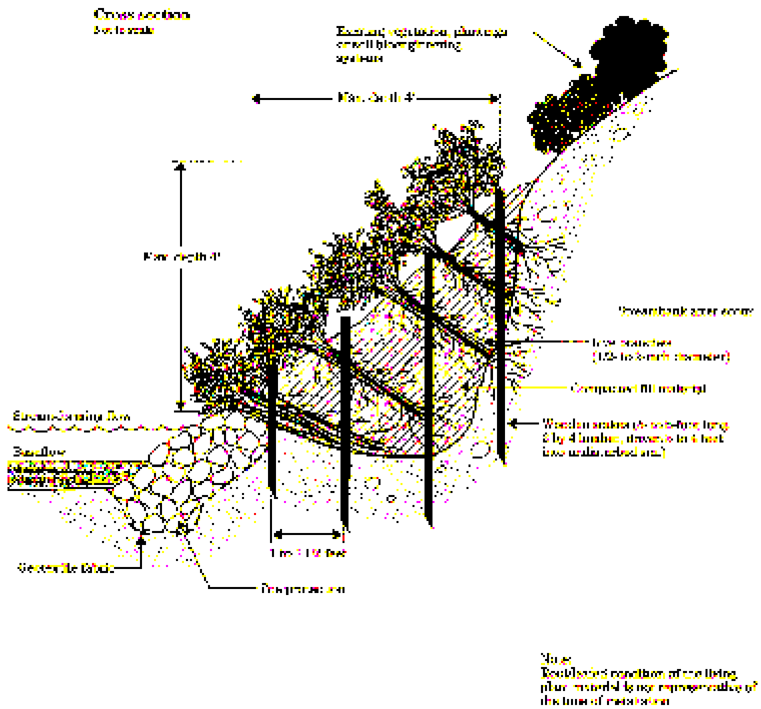
NRCS Engineering Field Handbook (210-vi-EFH, December 1996)

From: NRCS Engineering Field Handbook, 1996.

Branchpacking

Branchpacking is the process of incorporating alternating layers of live branch cuttings and compacted soils into a hole, gully or slump. This method is used to fill in depressions along the streambank or shoreline.

Figure 5. Branchpacking details



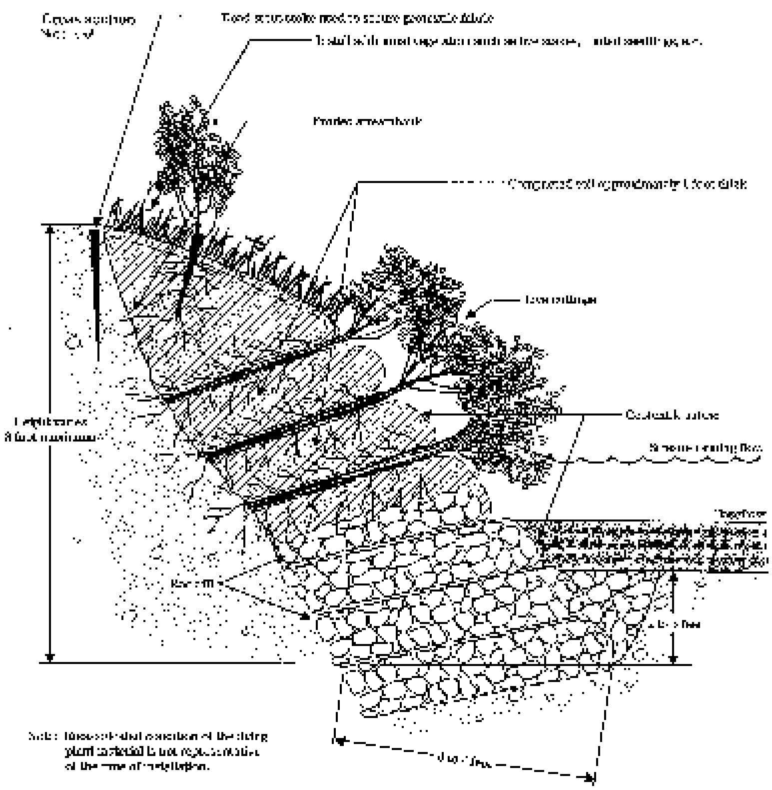
NRCS Engineering Field Handbook (210-vi-EFH, December 1996)

From: NRCS Engineering Field Handbook, 1996.

Vegetated Geogrid

Vegetated geogrids are similar to branchpacking except that natural or synthetic geotextile materials are wrapped around each soil lift between the layers of live branch cuttings.

Figure 6. Vegetated geogrid details

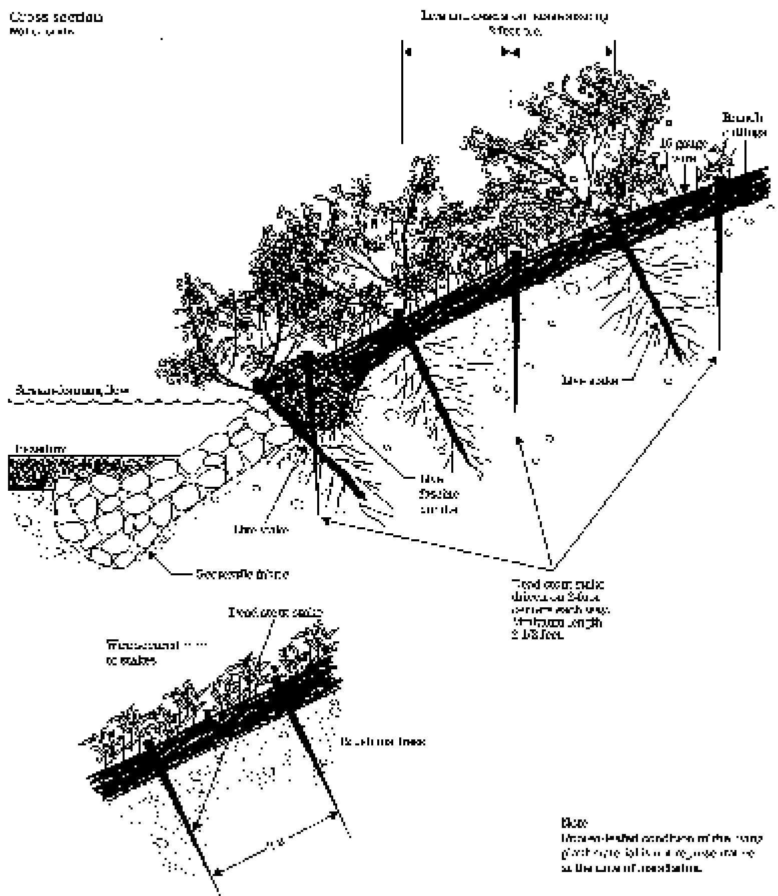


From: NRCS Engineering Field Handbook, 1996.

Brushmattress

A brushmattress system consists of live branch cuttings, live stakes, and live fascines installed to cover and stabilize the entire streambank/shoreline and secured in place. This method is installed above the normal stream flow and provides immediate protective coverage of the bank.

Figure 7. Brushmattress details



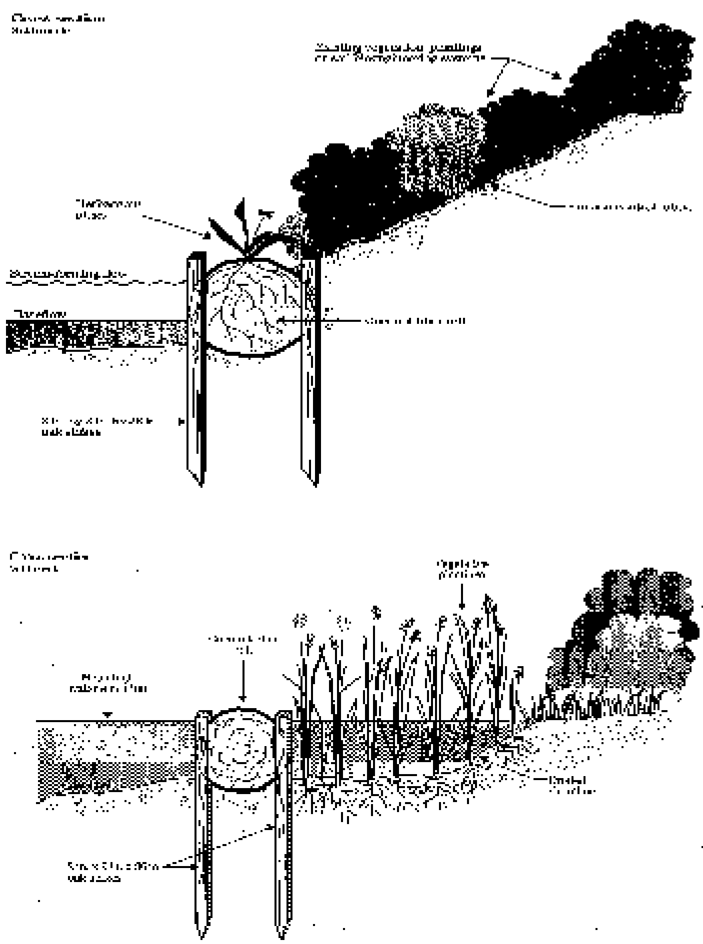
NRCS Engineering Field Handbook (210-vi-EFH, December 1996)

From: NRCS Engineering Field Handbook, 1996.

Coconut Fiber Roll

A coconut fiber roll is a flexible "log" made from coconut hull fibers, staked at the toe of the bank. The technique is often used in conjunction with native plants to trap sediment and encourage plant growth.

Figure 8. Coconut fiber rolls detail

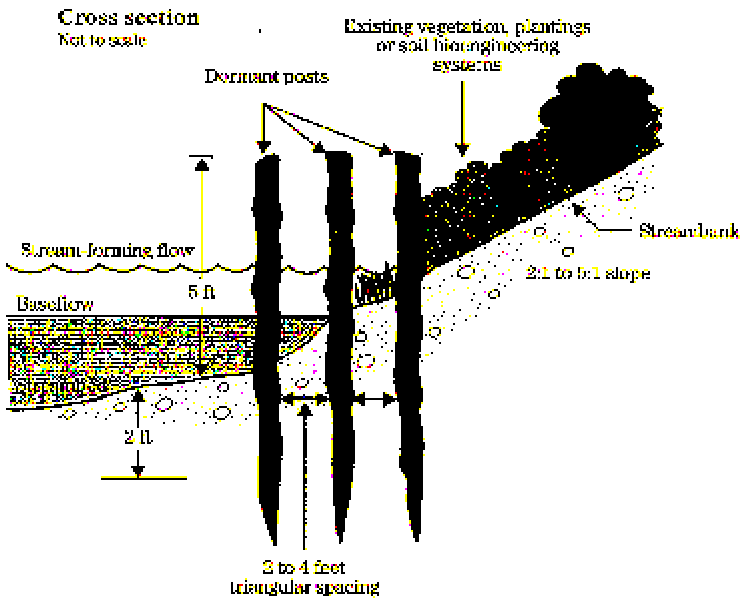


From: NRCS Engineering Field Handbook, 1996.

Dormant Post Plantings (Live Posts)

Dormant post plantings form a permeable revetment that is constructed from rootable vegetative material placed along streambanks in a square or triangular pattern.

Figure 9. Dormant post details



NRCS Engineering Field Handbook (210-vi-EFH, December 1996)

Acceptable Practices

Integrated Bioengineering Practices

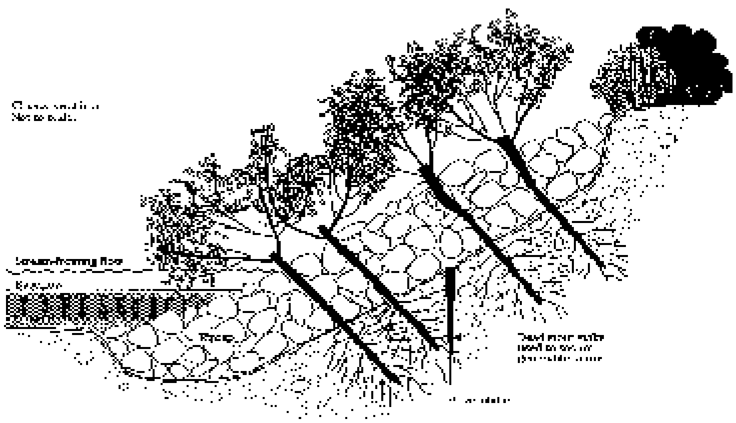
Acceptable stabilization methods are integrated bioengineering with one or more structural component useful in areas with higher velocity flows and/or wave action. This is most often appropriate at the "toe" of the bank or shoreline to prevent additional bank slumping. Structural components should be minimal and only used when necessary to ensure long-term success of the stabilization efforts.

Joint Planting

Joint planting or vegetated riprap involves tamping live stakes into joints or open spaces in rocks that have been placed on a slope. Vegetation, especially deep rooting species, planted above and immediately behind the rock will greatly increase the stability of the slope

From: NRCS Engineering Field Handbook, 1996.

Figure 10. Joint planting details

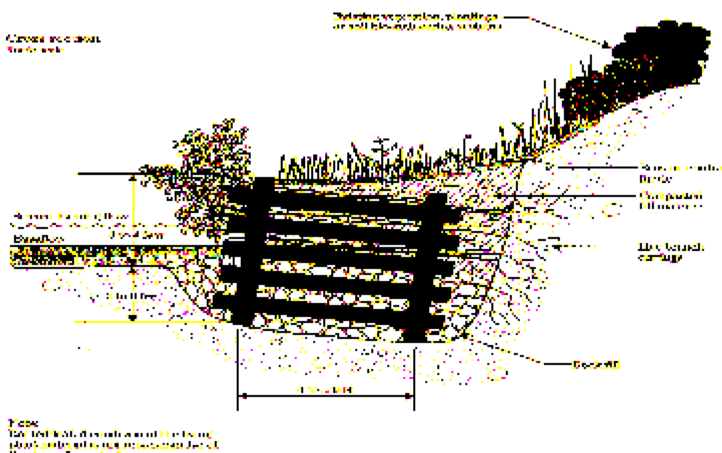


NRCS Engineering Field Handbook (210-vi-EFH, December 1996)

Live Cribwall

A live cribwall is a box-like structure with a framework of logs or timbers, rock and live cuttings that can protect eroding streambanks or shorelines. Once live cuttings become established, mature vegetation gradually takes over the structural functions of the logs or timbers.

Figure 11. Live cribwall details



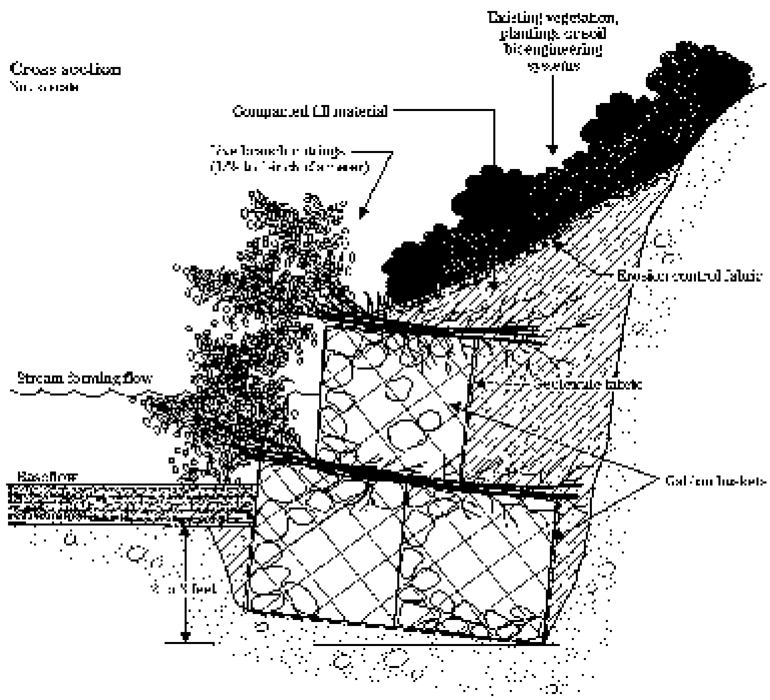
NRCS Engineering Field Handbook (210-vi-EFH, December 1996)

From: NRCS Engineering Field Handbook, 1996.

Vegetated Rock Gabions

Gabion baskets are rectangular containers fabricated from a heavily galvanized steel wire or triple twisted hexagonal mesh. These empty gabions are placed in position, wired to adjoining gabions, filled with stones, and then wired shut. Vegetation is incorporated into rock gabions by placing live branches on each consecutive layer between the rock filled baskets.

Figure 12. Vegetated gabion details



Note:
Rooted/leafed condition of the living plant material is not representative of the time of installation.

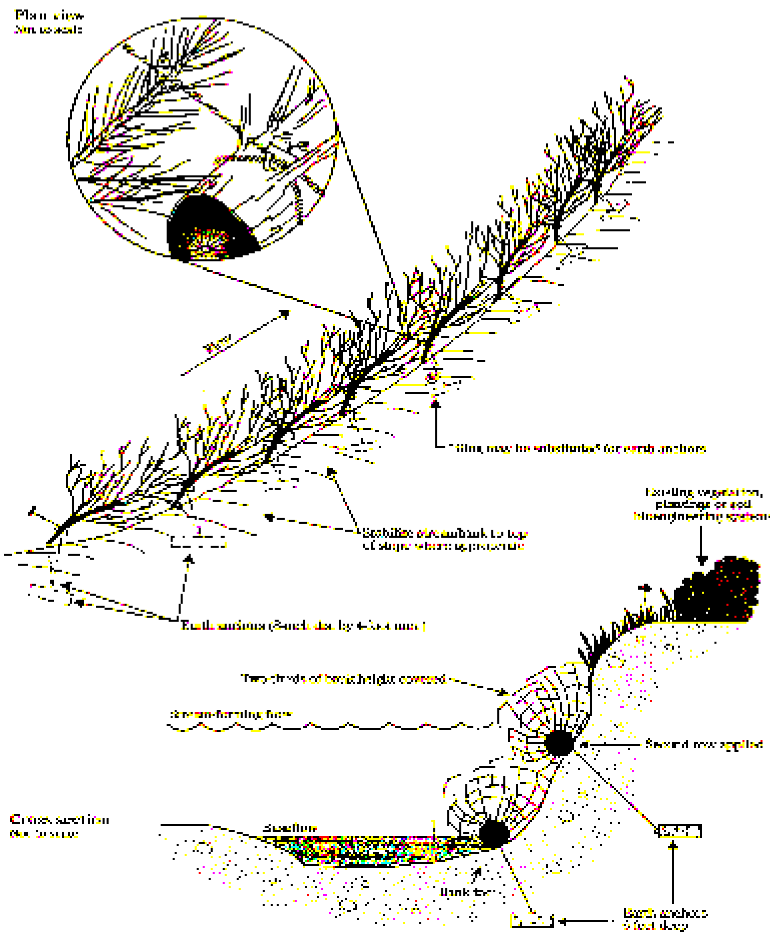
NRCS Engineering Field Handbook (210-vi-EFH, December 1996)

From: NRCS Engineering Field Handbook, 1996.

Tree Revetments

Tree revetments are rows of cut trees anchored to the toe of the bank. This is a low cost method, often used for toe protection with other bioengineering techniques.

Figure 13. Tree revetment details



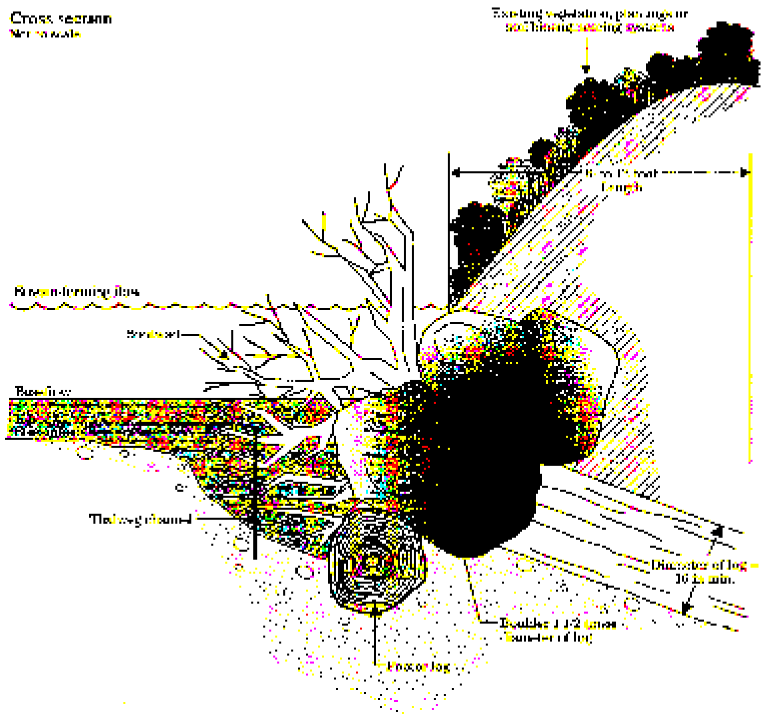
NRCS Engineering Field Handbook (210-vi-EFH, December 1996)

From: NRCS Engineering Field Handbook, 1996.

Log, Rootwad, and Boulder Revetments

These revetments are systems composed of logs, rootwads, and boulders selectively placed in and on streambanks.

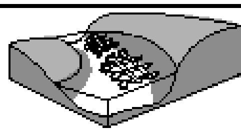
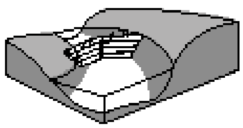
Figure 14. Log, rootwad, and boulder revetment details



NRCS Engineering Field Handbook (210-vi-EFH, December 1996)

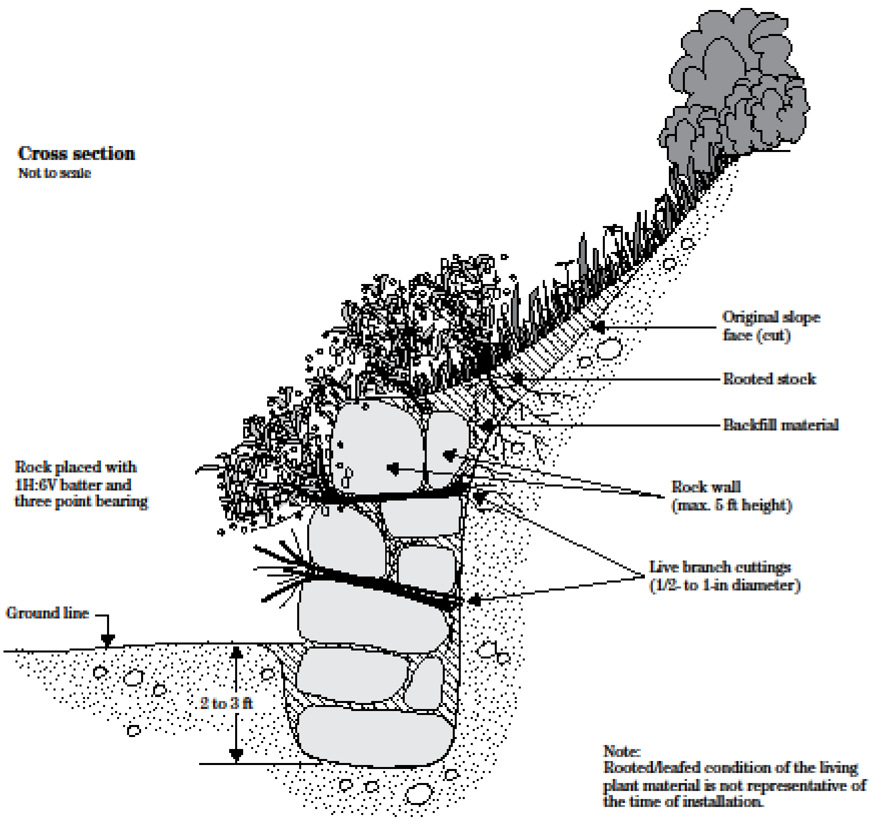
From: NRCS Engineering Field Handbook, 1996.

Table TS14J–3 Classification of large wood instream structures

Configuration	Sketch	Description	Strengths	References
Engineered logjams		Intermittent structures built by stacking whole trees and logs in crisscross arrangements	Emulates natural formations. Creates diverse physical conditions, traps additional debris	Abbe, Montgomery, and Petroff (1997); Shields, Morin, and Cooper (2004)
Log vanes		Single logs secured to bed protruding from bank and angled upstream. Also called log bendway weir	Low-cost, minimally intrusive	Derrick (1997); D'Aoust and Millar (2000)
Log weirs		Weirs spanning small streams comprised of one or more large logs	Creates pool habitat	Hilderbrand et al. 1998; Flosi et al. (1998)
Rootwads		Logs buried in bank with rootwads protruding into channel	Protects low banks, provides scour pools with woody cover	
Tree revetments or roughness logs		Whole trees placed along bank parallel to current. Trees are overlapped (shingled) and securely anchored	Deflects high flows and shear from outer banks; may induce sediment deposition and halt erosion	Cramer et al. (2002)
Toe logs		One or two rows of logs running parallel to current and secured to bank toe. Gravel fill may be placed immediately behind logs	Temporary toe protection	Cramer et al. (2002)

From: NRCS Engineering Field Handbook, 2007.

Figure TS14M–2 Vegetated rock wall details



From: NRCS Engineering Field Handbook, 2007.

Appendix E