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San Jacinto River and Tributaries Sediment Removal and Sand Trap Development

Prepared for:

SAN JACINTO RIVER AUTHORITY

January 7th, 2022

Prepared by:

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EXECUTIVE SUMMARY

This conceptual design report was completed to support the San Jacinto River Authority's desire to explore the feasibility of implementing sediment trapping facilities, through a public private partnership, to remove sediments from the West Fork or East Fork San Jacinto River. The first step in this process was to identify regions prone to sediment deposition in the West Fork or East Fork and prioritize them. The methods and findings of this process were described in a memorandum titled "Preliminary Sediment Trapping Locations Memorandum" found in Appendix B. The highest prioritized sites were on the West Fork. The second step in this process was to measure the efficacy of the four highest priority sites (all on the West Fork) identified in the Preliminary Sediment Trapping Locations Memorandum. Efficacy results and recommendations are described in the "Sediment Trap Efficacy Study" found in Appendix A. The final step in this process is the development of the conceptual design criteria and approaches for potential sand trapping facilities and the development of recommendations for future potential implementation.

This report developed conceptual alternatives (a 10% design maturity) for the three highest priority regions identified in the Sediment Trap Efficacy Study. Each region, referred to as a facility, contained several opportunities to trap sediments, referred to as sediment traps. Eleven traps were identified and a conceptual alternative was developed for each. Seven of the evaluated traps are in-channel traps which would be built within the river's stream banks. The remaining four traps evaluated are out-of-channel traps which would be built alongside the river's terraces at a higher elevation. These conceptual alternatives were developed with limited site information, and it is expected these alternatives will be amended in future design phases. In addition to these alternatives, a bedload collector, a powered mechanical device which traps sediments and pumps them to the nearby shore was also introduced as another way of trapping sediments.

This report used sediment rating curves, created from USGS stream gage discharge and suspended sediment data, to predict the annual sediment load that is transported to the sediment traps. This value was estimated to be 42,198 cubic yards (CY) of sediment per year. The potential sediment trapping storage volume of all the evaluated traps of the recommended trap type (in-channel traps) was calculated as 14,120 CY, 71,290 CY and 84,220 CY respectively. The expected trapped sediment volume (169,630 CY) exceeds the annual sediment load volume transported by the West Fork. It would take approximately four years to fill these traps, assuming all the West Fork's annual sediment load is captured. This report recommends the potential volume be reduced and additional analysis be performed in future design phases to evaluate the appropriate amount of sediment to be removed. To create this potential sediment trapping storage volume for the in-channel traps, excavation will be required. Sediment transport models were developed to estimate the change in sediment transport capacity due to the channel modification.

It was estimated that the proposed conceptual alternatives could be permitted under a Nationwide Permit from the US Army Corps of Engineers (USACE), an Individual Permit, or may not be permissible. In order to determine which permit these activities could fall underneath, an ordinary high-water mark would need to be delineated. The permit type is the longest component of the implementation schedule which could range from 27 to 30 months assuming an individual permit is needed from the USACE. If a nationwide permit could be obtained the schedule should be much shorter. A hydraulic- analysis was completed for the conceptual designs of the traps to understand if the proposed conceptual alternatives cause unwanted rises in the 100-year return interval flood (calculated using Atlas 14 rainfall depths). Of the seven in-channel traps which were evaluated, six of them caused no rise, or resulted in lower water surface elevations under proposed conditions. Water surface elevations related to out-of-channel traps were not evaluated as part of this study.

A recommendation was made to further the design of two sediment trapping sites in the ST004 facility. The two recommended in-channel sediment traps within facility ST004 have a storage volume of 25,610 cubic yards and costs approximately $2.75 million to implement and would fill up on average, approximately two times a year. Therefore, would need frequent maintenance to restore their design storage volume.

Several other recommendations were made which included:

- Complete a geomorphic assessment as part of the preliminary design to evaluate how removal of sediments using sediment traps will impact downstream and upstream stability.
- Develop a sediment budget for the West Fork watershed including the region between the sediment traps and the West Fork's terminus with Lake Houston. Compare this volume of sediment to the volume that is anticipated to be removed by the traps. Compare the sediment load in the West Fork upstream of the traps to the volume that is anticipated to being captured by the traps.
- Since the perimeter for all in-channel sediment traps were drawn from aerial photography, conduct a topographic survey to map one-foot contours and to define the boundaries of established vegetation and other pertinent features as part of the preliminary design.

- If landowner is willing to pay for operating costs for bedload collector, consult with the US Army Corps of Engineers Engineering and Research Development unit who sponsored the bedload Mackinaw River Project to estimate production from a bedload collector.

- Adjust the width and depth of the proposed excavation for in-channel traps to balance the amount of potential storage volume with the cost to construct the trap.

- If changes to the conceptual width and depth of the in-channel traps are completed as part of preliminary design, the POWERSED/FLOWSED should be run to understand how the sediment trap's efficacy will be reduced over time as the sediment trap fills up. It is recommended that the modeling be run when the sediment trap is empty, half full and three quarters full.

- Develop a two-dimensional hydraulic analysis for the region around each in-channel trap to calculate shear stresses, velocities and percentage of the discharge which enters each trap. Develop a two-dimensional model around each off- channel trap to calculate the amount of discharge that is likely to enter the off-channel trap's conveyance channel.

- Add more cross-sections to the hydraulic model completed in the Sediment Trap Efficacy Study within the proposed work areas to improve the understanding of the proposed concepts and the 100-year water surface elevations resulting from their implementation.

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1.0 BACKGROUND

Two memoranda have been submitted as interim deliverables for the San Jacinto River Authority's (SJRA) San Jacinto River and Tributaries Sediment Removal and Sand Trap Development project. These deliverables identified locations to potentially trap sediment along the West Fork San Jacinto River and the East Fork San Jacinto River. These locations were referred to as sediment trap facilities. The potential sediment trap facilities were then prioritized, with the highest preference being assigned to facilities that offer the best opportunity to trap sediments and be maintained through a public-private partnership. The prioritization relied on estimates of the amount of sediment that could be trapped and the ease of which a private organization could remove the trapped sediment. Three sediment trap facilities (referred to as ST002, ST003 and ST004) were selected from the prioritization method.

This Conceptual Design Report (report) is the deliverable for Task 1107 in the San Jacinto River and Tributaries Sediment Removal and Sand Trap Development project scope of work between Freese & Nichols (FNI) and SJRA. The goal of this report is to recommend which of three potential sediment trap facilities should be included in a Preliminary Engineering Report (PER). The PER will include a preliminary (30%) design, identify environmental permitting requirements, create an implementation schedule, and develop an estimate of construction costs.

This report used the following criteria to recommend the continued design of several sediment traps which would be completed in the PER:

- Potential annual sediment load trapped at each facility
- Expected frequency and ease of maintenance for each facility
- Estimated impacts to water surface elevations in regions (at each trap and upstream) most likely to be affected by constructing each trap. Modeled the 100-year return interval flood (calculated using Atlas 14 rainfall depths)
- Potential reduction of sediment accumulation in downstream locations

2.0 CONCEPTUAL DESCRIPTION OF PROPOSED SEDIMENT TRAPS AND REGULATORY REQUIREMENTS

Three sediment trapping techniques were presented in the two preceding memorandums: in-channel sediment traps, out-of-channel sediment traps, and bedload collectors. In-channel and out-of-channel traps are passive approaches to trapping sediment while a bedload collector is an active trap. Active trapping requires electricity and supporting infrastructure at the trap while the former two alternatives do not. Sections 2.1 through 2.3 will describe each sediment trap type.

2.1 IN-CHANNEL SEDIMENT TRAP

Conceptual Description

An in-channel sediment trap is built within the river's stream banks. A trapezoidal channel is cut through a depositional feature (point bar or lateral bar) outside of the average daily river's stream bank and the material is removed as seen in **Figure 1** and **Figure 2.** The boundary of the constructed channel is then strengthened with rock, logs, and other bioengineering methods to create a hardened surface that is resistant to erosion and allows for excavation of sediment in consistent locations. Rocks are sized to be immobile during the design flood. Logs with rootwads are placed to redirect the highest velocity and resulting scour away from the base of rocks; gaps between rocks and logs will be backfilled with native material and topsoil then planted with live stakes. Bioengineering methods such as toe-wood and live stakes will be installed in the backfilled material and once established, will form a dense root system that provides substantially increased structural stability of the soils. Based on past project experience, it is expected this dense root system will be established before the logs with rootwads lose their structural integrity due to rot.

For purposes of this conceptual design report, the perimeter for all in-channel sediment traps was delineated from aerial photography. It is recommended that future preliminary design phases of the project include a topographical survey to develop one-foot contours which can be used to better define the boundaries of established vegetation and other pertinent features. In-channel trap parameters should be adjusted to maximize the traps' surface area while minimizing disturbance to established vegetation and undermining of steep banks.

Boulders would be used to increase the relative roughness in the trap. When river water laden with sediment enters the trap, the higher relative roughness will slow the water down, encouraging sediment deposition. The boulders would be arranged in clusters with five to seven boulders in each cluster, stacked next to and top of each other. Boulder clusters would be arranged in groups. The boulder clusters must be spaced within a group to avoid hydraulic conditions that would cause erosion and deformation of the channel perimeter. Therefore, the number of boulder clusters in a group depends on the trap's width. A group of boulder clusters would be located both near the end of the channel as well as approximately in the middle of the channel. **Table 1** presents a list of proposed materials and work items to be used in constructing an in-channel sediment trap.

The perimeter of in-channel traps will be lined with rocks and logs which will provide immediate strength to the trap's edges. The rocks and logs will be buried with topsoil which will then be planted using bioengineering and live stakes. Once the installed vegetation is established, its root density will provide long term strength to the trap. The combination of rocks, logs, topsoil and planting will be used along the entire perimeter. In regions where no established vegetation exists, the combination of rocks, etc. will be wider to create a thicker riparian zone because these regions are prone to faster velocities and higher shear stresses therefore are more prone to deformation due to erosion. More material in these regions will help prevent erosion damage. The long-term design goal of the perimeter will be a diverse riparian zone along the trap's edges whose roots will anchor the soil between the boulders forming a stable boundary.

For this report's conceptual design, the invert of the in-channel sediment trap is located approximately at the same elevation as the Ordinary High Water Mark (OHWM) of the river which is outside the average daily river's stream bank. The channel's invert elevation will determine how often sediment-laden water enters the trap. Because of this, its elevation is ultimately a management decision based on the desired maintenance frequency. A lower invert elevation will result in more deposition, leading to more frequent maintenance and a higher risk of an alternate channel forming through the trap.

Table 1: Description of materials and work items needed to build in-channel sediment trap

Work Item	Purpose	Units	Notes
Clearing and grubbing	Prepare access to sediment trap	Acre	Includes access to site and site preparation
Excavation	Used to remove material to create volume in the trap	CY	Determined per trap length and typical section
Rock Riprap	Used to strengthen perimeter alongside existing vegetation	Ton	Estimate maximum rock size to be 24”. Use TXDOT Rock Riprap 24”. Estimate 0.3 CY (0.50 tons) of Rock Riprap for every 1 linear foot
	Used to strengthen perimeter in gaps between existing vegetation	Ton	Estimate maximum rock size to be 24”. Use TXDOT Rock Riprap 24”. Estimate 1.7 CY (2.8 tons) of Rock Riprap for every 1 linear foot
	Boulder clusters to increase relative roughness and deposition	Ton	Estimate maximum rock size to be 36”. Use TXDOT Rock Riprap 36”. Boulder cluster will be 5’ wide by 5’ long and 5’ tall and contain approximately 8.5 tons of rock per cluster. Estimate one cluster for every 10 feet of the trap’s width
Logs	Used to strengthen perimeter and used to strengthen perimeter in gaps between vegetation	Each	Estimate 1 log for every 6 linear feet of perimeter to be strengthened
Bioengineering/Live Stakes	Used to strengthen perimeter and used to strengthen perimeter in gaps between vegetation. Once established, the root density will increase cohesive strength of material	EA	Utilize live stakes between rocks and logs. Estimate 2 live cuttings for every 1 linear feet of perimeter to be strengthened
Topsoil	Used to strengthen perimeter and used to strengthen perimeter in gaps between vegetation by increasing organic material which will aid growth for bioengineering plantings	SY	Estimate 0.2 SY for every 1 linear feet of perimeter to be strengthened

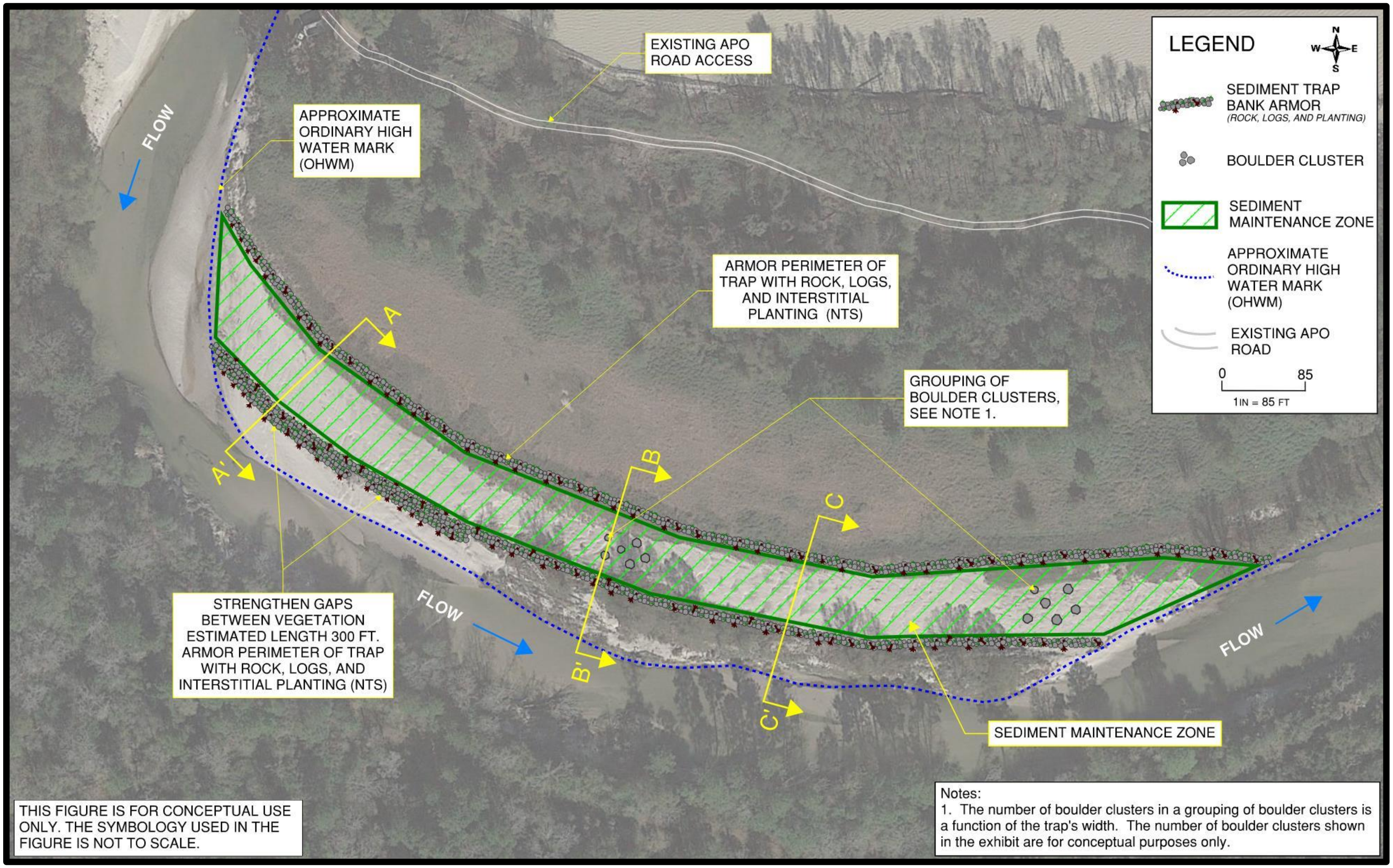

Figure 1: Plan View of Conceptual In-Channel Sediment Trap built within existing deposition bar deposits. Boulder clusters located throughout the sediment maintenance channel serve to slow flow and promote sediment deposition. A matrix of rock, logs, and vegetation armor the perimeter of the sediment maintenance channel.

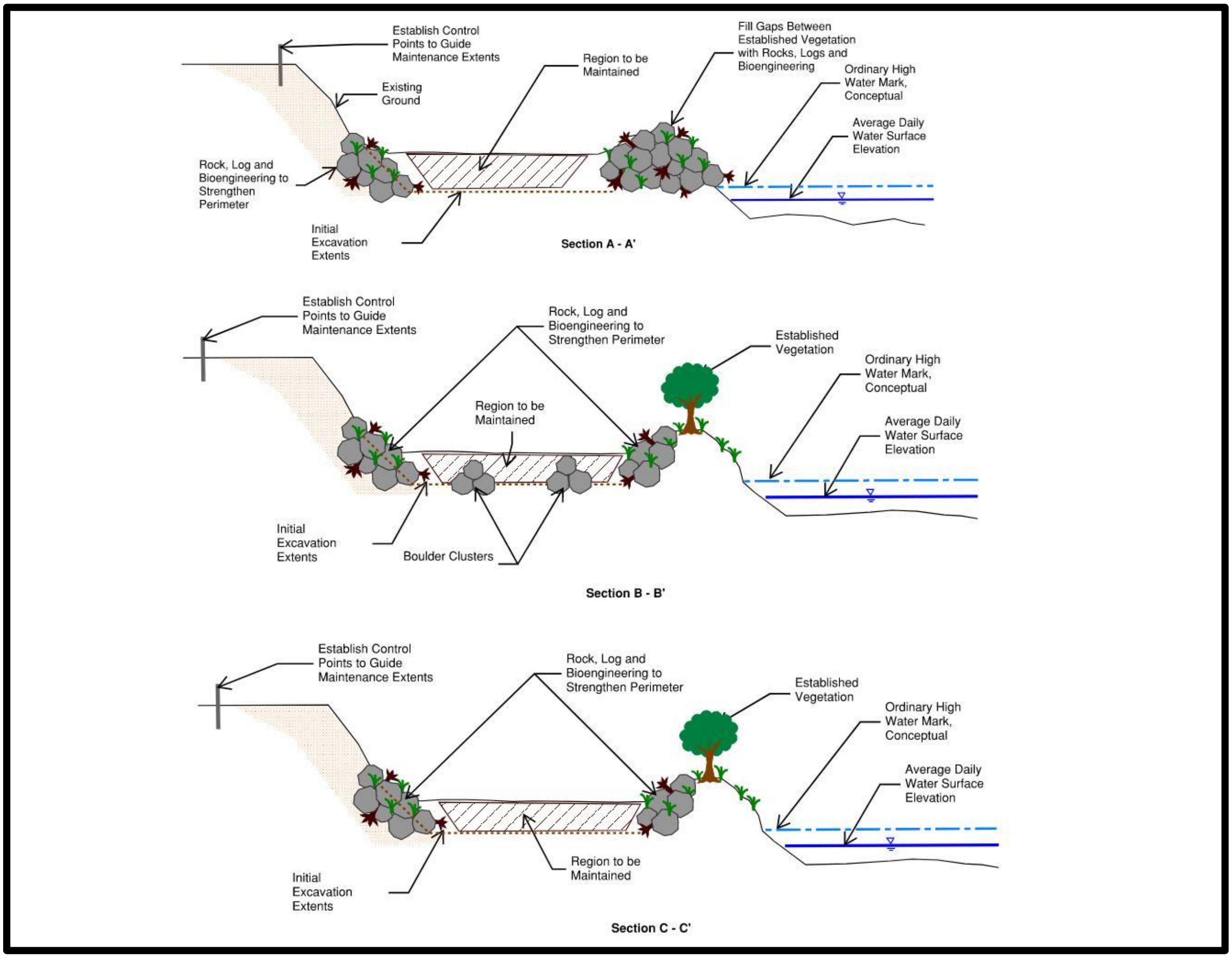

Figure 2: Conceptual sections for in-channel sediment trap illustrating the sediment maintenance zone located between the armored perimeter of the sediment trap. Section A-A' is for regions with no established vegetation on the riverward side of the trap, Section B-B' and Section C-C' are for regions with established vegetation.

It should be noted that in the preliminary design phase it may be determined that the construction of an armored perimeter and installation of boulder clusters within the point-bar is not required. In some systems, it is much more cost effective to simply "scalp" the point bar (lowering the point bar's surface elevation) with a slope of 10:1 or greater and allow the point bar to rebuild during subsequent flow events. This situation has specific design considerations and cannot be evaluated until detailed topographic, bathymetric, and vegetation survey is acquired. The concept for the in-channel trapping of sediments that does not require dredging hinges on utilizing a geomorphic location that is already depositional, such as the point bars presented in this conceptual report.

2.2 OUT-OF-CHANNEL SEDIMENT TRAP

Conceptual Description

An out-of-channel sediment trap is built alongside the river's terraces. The areas alongside a river's terraces are vertically much higher than the stream banks in which in-stream sediment traps are located. Therefore, sediment laden waters enter out-of-channel traps less frequently than in-channel traps. An out-of-channel sediment trap consists of a conveyance channel and a pit. The conveyance channel connects the river to the pit. A pit can be an existing pit at an APO site or where an APO operator intends to construct a new pit. When the river's water elevations exceed the bottom of the conveyance channel, sediment laden water will enter the channel, flow into the pit and deposit sediments. An example of a conveyance channel is shown in **Figure 3**. The conveyance channel features a low flow channel as seen in **Figure 4**. The low flow channel will guide sediment laden water to the pit along the centerline of the conveyance channel when the conveyance channel is first engaged and will help mitigate sediment deposition in the conveyance channel itself. The pits need to function similarly to stormwater offline basins which feature longer length to width ratios being desirable to increase the hydraulic residence time (HRT).

Its desirable that once sediment laden water enters the pit, the water's velocity approaches zero to encourage maximum sediment deposition. For this report's concept design, no exit channel was designed which achieves the near zero velocity condition in the pit. Once the floodwaters in the river recede, the water in the pit would evaporate. However, an exit channel can be designed to drain the pit quicker which would restore the pit's design storage volume faster. If an exit channel is designed, a hydraulic analysis should be completed to calculate the water velocities in the pit to ensure the desired sediment deposition conditions are created.

The invert elevation of the low flow channel within the conveyance channel will be guided by two criteria. The first criterion is the water surface elevation in the pit. This elevation, determined by the APO operator, must remain below the invert of the low flow channel to prevent water from flowing out of the pit and into the river and allow sediment-laden water to flow into the pit. The second criterion involves establishing the desired frequency at which sediment-laden river water enters the trap. The more frequently water enters the trap, the more frequently the trap will be filled with sediment and will need to be maintained by the APO operator. The sediment would deposit in the pit beginning at the conveyance channel's downstream edge and continue towards the center of the pit. Care will be needed in removing sediment from the trap to avoid damaging the rock armored channel edge.

The conveyance channel should be lined with a material that will not erode when the channel is full of water. Figure 3 and Figure 4 show the low flow channel being lined with rock and the remaining regions of the conveyance channel would be grass. Further analysis is needed to understand if the entire conveyance channel, including the low flow channel, could be lined with rock or if the entire conveyance channel can be lined with grass that grows through a biodegradable erosion control blanket. In this report, the conveyance channel's side slopes are 2 horizontal to 1 vertical. If more gradual side slopes are desired for maintaining the channel than the side slopes can be designed to be flatter. If the channel is lined with grass, the grass should be mowed to prevent the channel becoming overgrown which would obstruct the flow of water leading to sediment deposition in the channel. The conveyance channel should slope downhill to the pit, and the channel's downstream end should be armored with rock to protect its edge. If the upstream end of the conveyance channel is located on an eroding bank, then the sections of bank near the channel should also be armored with rock.

The ultimate configuration of the out-of-channel trap will be finalized based on operational goals and the sedimentology of the system.

Table 2 presents proposed materials and items of work to be used in construction of an out-of-channel sediment trap.

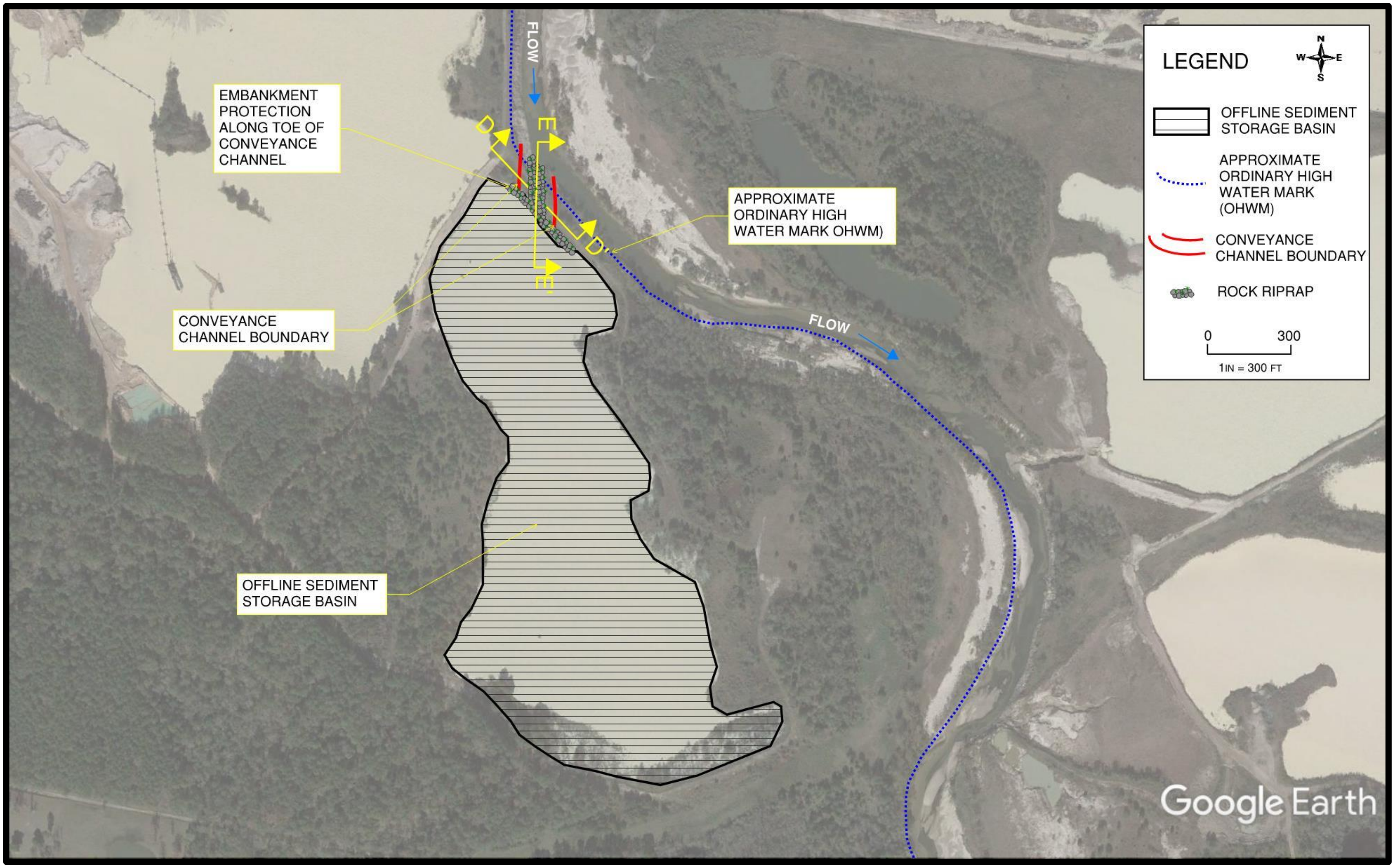

Figure 3: Conceptual plan view of an out-of-channel trap. The proposed conveyance channel serves to connect the channel to the offline sediment storage, where large flow events can access the storage basin and deposit excess sediment.

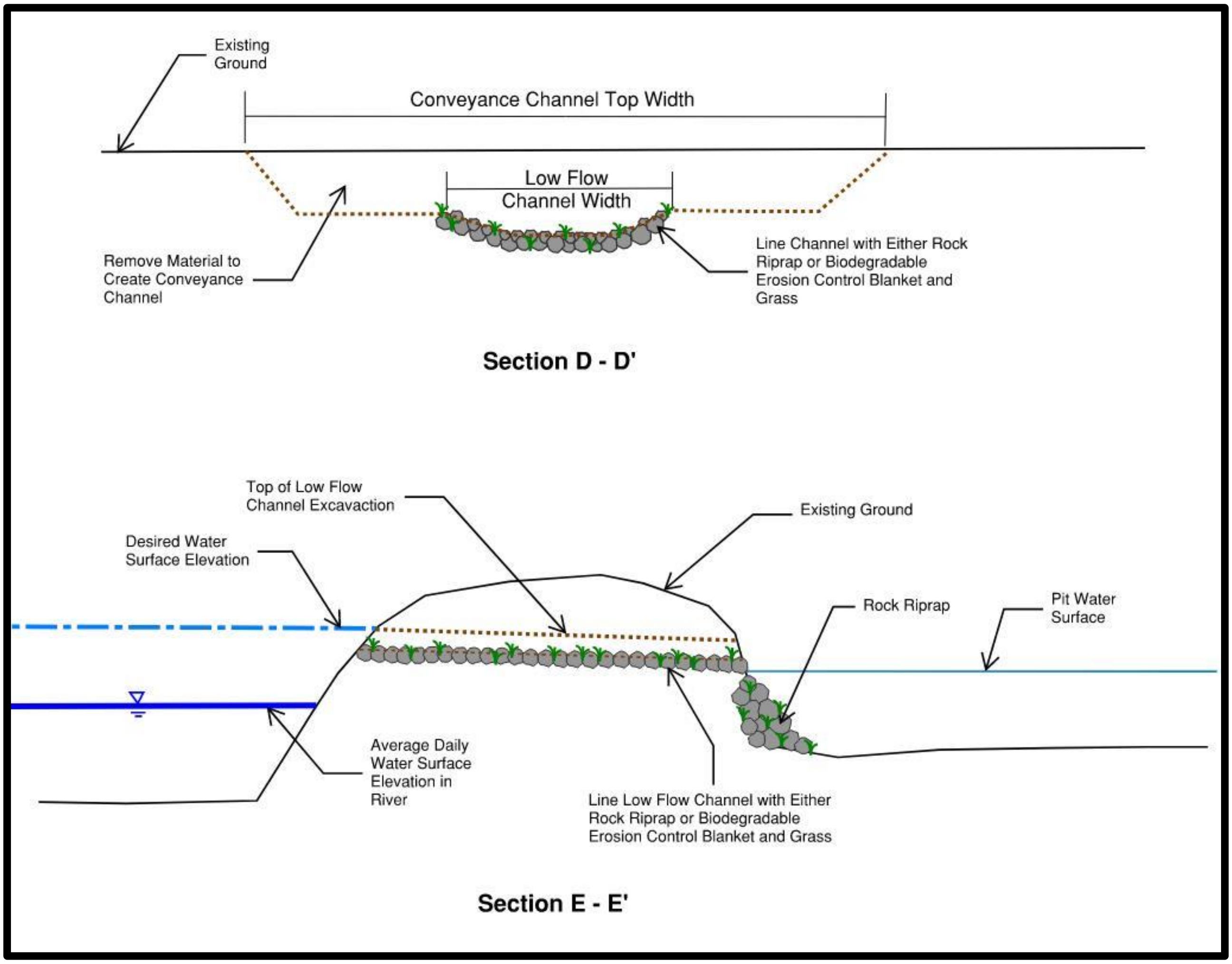

Figure 4: Conceptual section and profile for out-of-channel trap, illustrating the low flow channel connectivity to the offline sediment basin.

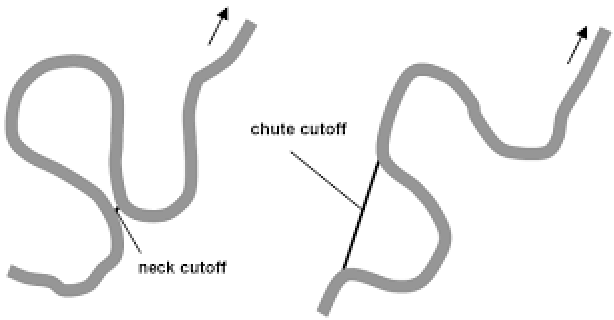

Figure 5: Avoid locating an off-channel sediment trap in a region where a neck cutoff or chute cutoff may form. Image from TWDB 2011.

An out-of-channel trap should not be located near an area where an avulsion is likely to form. An avulsion is a sudden change of a river alignment bisecting a curve (meander) in the river. **Figure 5** shows two scenarios where an avulsion may form inside a meander. An avulsion occurs in the image on the left in **Figure 5** when the land between the upstream and downstream regions of the meander is eroded resulting in the river bypassing the meander (referred to as a neck cutoff). The abandoned portion of the channel is known as an oxbow. If an off-channel trap is in a region where an oxbow may form due to an avulsion, it will not receive sediment laden water as designed.

The image on the right side of **Figure 5** shows an avulsion which occurs during flood conditions when river water overtops its banks and flows across the floodplain inside the meander. If the soils along this flow path are easily erodible, the flood waters will continue to remove them resulting in a chute cutoff. Therefore, if an off-channel trap is located inside of a meander bend which has a potential for a chute cutoff to form, the land between the pit and the river downstream should be lined with relatively non-erosive materials, such as native soils with established mature vegetation or with installed large rock.

Table 2: Description of materials and work items needed to build an out-of-channel sediment trap

Work Item	Purpose	Units	Notes
Clearing and grubbing	Clear area where conveyance channel will be built	Acre	
Excavation	Used to remove material to create conveyance channel	CY	Measured distance between river and upstream edge of pit and used for conveyance channel length. Assumed a typical section width with 2H:1V side slopes. For cost estimating, the maintained water surface elevations in existing pits were equal to the pits' water surface elevations when LiDAR was measured. Low flow channel's invert elevations set above these water surface elevations.
Erosion control blanket and grass	Used to line conveyance channel	SY	For cost estimating, assumed the conveyance channel will be designed so shear stresses do not exceed 6 pounds per square foot.
Rock riprap	Used to armor between downstream edge of conveyance channel and pit	Ton	Estimate maximum size to be 24 inch. Use TXDOT Rock Riprap 24 inch. Estimate 4.9 CY (8 tons) for every 1 linear foot of conveyance channel width. For estimating purposes, rock riprap was assumed to line the low flow channel and the downstream edge of the pit.
	Used to stabilize stream bank erosion.	Ton	Estimate maximum size to be 24 inch. Use TXDOT Rock Riprap 24 inch. Estimate 2 horizontal to 1 vertical slope. Volume and weight of rock riprap will vary and depend on length and height of stream bank that is to be protected.

2.3 BEDLOAD COLLECTOR

Conceptual Description

A bedload collector is a mechanical system, powered by a motor and electricity, which uses hydraulics to move the sediment from a riverbed and onto a conveyor belt or pipe which transports it to a sediment stockpile nearby. The system, shown in **Figure 6**, consists of a steel hopper which is placed along the bottom of the river. Sediment rolling along the river bottom falls into the hopper and is then pumped to a holding tank or a hopper where water is separated, and the remaining sediment is transported to a stockpile (**Figure 7**).

Optimal locations for bedload collectors exist in reaches of the river where sediment is in motion and where sediment is likely to be transported along the riverbed. The sediment load of the West Fork San Jacinto River is mostly sand (page 9 of the Sediment Trap Efficacy Study (Efficacy Study), Appendix A). The findings of this memorandum suggest that sand is suspended in water and moves along the river bottom in all three sediment trapping facility locations several times a year; possibly multiple times a month. Therefore, a bedload collector could be placed almost anywhere in a facility.

The ultimate location of the bedload collector will be driven more by the ability of the APO operator to maintain the bedload collector and its supporting infrastructure. Bedload collectors should not be located where there is a concern that the river alignment is migrating or has the potential to change due to an avulsion. This would shift the river and the transported sediment away from the bedload collector.

Figure 6: Image of bedload collector being installed. Note the open grate where bedload will fall into the trough below (Streamside 2020).

Figure 7: Image of supporting infrastructure to transport sediment and slurry from hopper to staging area (Streamside 2020).

Material Description

A document created by the US Army Corps of Engineers Engineer Research and Development Center describing the deployment of this technology in a riverine system (Mackinaw River in Illinois) has also been included in Appendix D. Materials include pipes, pumps, and collector units. The construction cost in Appendix C is for a single 30-foot bedload collector and is estimated to be approximately $2,078,000. This amount is for the design and installation cost for the collector. It does not include the cost for bringing utilities to the site, land acquisition, or permitting support. Streamside Technology LLC estimates the fixed annual operating costs and annual electricity cost will be $88,000. A 30-foot bedload collector was selected because it will stretch across a notable portion of the riverbed. It's assumed the rate sediment moving along the channel bed exceeds the rate the bedload collector collects sediments. Therefore, the bedload collector shouldn't be reduced unless the following are desired: lower implementation costs, lower rates of sediment capture, or lower operation and maintenance costs. Multiple bedload collectors could be used to increase the rate of sediment collection.

To determine the cost-effectiveness of using this technology at individual trap locations, it is recommended to first estimate the potential annual production load from a 30-foot bedload collector using the procedures in the Mackinaw River report in Appendix D which include a sediment rating curve analysis by installing a smaller version of the collector (4-foot) into the proposed region. Streamside estimates this to cost approximately $54,000 which includes site planning, deployment, recovery, and data analysis. This smaller version will collect bedload over a period of time. A bedload collection rating curve will then be created using hydrologic data from the nearest USGS stream gage and an annual production load calculated.

2.4 POTENTIAL REGULATORY REQUIREMENTS

A meeting with the US Army Corps of Engineers (USACE), FNI, SJRA and Harris County Flood Control District (HCFCD) was held on July 7, 2020. Meeting minutes are included in Appendix E. The purpose of the meeting was to coordinate with the USACE on the project and discuss what permits may be needed to implement sediment traps. It was determined at the meeting that the sediment trapping facilities are located within waters inside the Corps' jurisdictional area of the West Fork San Jacinto River, and therefore the construction and maintenance of the traps may be regulated under Section 404 of the U.S. Clean Water Act. In order to receive a permit under Section 404, a Texas state issued 401 certification is also required from the Texas Commission on Environmental Quality (TCEQ). There are several Section 404 Nationwide Permits (NWPs) that could potentially be used to permit the sediment traps. NWPs are general permits intended to simplify the permitting process. Each NWP has threshold limits of activity or triggering action(s) that if exceeded requires a pre-construction notification (PCN) to be submitted to the USACE or prohibits the NWP from being used. The shortest project schedule would be if the proposed work does not exceed the threshold requiring pre-construction notification because a review by the USACE is not needed. If an NWP cannot be used, an individual permit would be sought if the project is deemed permissible by the USACE.

The USACE could not determine at the meeting if the activities were permissible or not and therefore did not decide which permit the traps could be covered under or would need pre-construction notification. The USACE could decide on these topics once the USACE's jurisdictional boundary is determined and the design plans developed. These activities will be completed in the preliminary design (part of the Preliminary Engineering Report).

USACE's jurisdictional boundary is the Ordinary High Water Mark (OHWM) of the stream. Per 33-CFR 328.3e. The term "ordinary high water mark" means the "line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas." The OHWM needs to be identified by professionals in the field with expertise in applying this definition to delineate the OHWM. A conceptual OHWM was drawn in **Figure 8** and **Figure 9** based on the 33-CFR 328.3e criteria. If a sediment trap can be designed so that it is located outside of any jurisdictional area, i.e., above the OHWM and not in any adjacent special aquatic site, then it is possible that no authorization from the USACE would be required. It should be noted that any manmade channel or water body that extends the OHWM of a jurisdictional stream can itself be jurisdictional. Any proposed work (cut or fill) below the OHWM would be within the Corp's jurisdiction.

If the impacts below the OHWM, or in adjacent jurisdictional areas such as wetlands, exceed the allowable limits under any NWP, an individual permit (IP) would be required to authorize the activity. If an IP is required, the project schedule would be significantly longer than that for authorization under an NWP (either with or without pre-construction notification). An IP would also require proof that the preferred alternative is the least environmental damaging practicable alternative (LEDPA). The USACE can only permit the LEDPA.

Figure 8: Conceptual ordinary high water mark line drawn to illustrate an example of where the Corp's jurisdictional boundary may begin and end on a depositional feature.

Figure 9: Conceptual ordinary high water mark line drawn to illustrate an example of where the Corp's jurisdictional boundary may begin and end in a region of river with no depositional feature.

The OHWM along the subject reach of the San Jacinto River is highly variable in terms of width due to the presence of wide low-lying sandbars in some locations. These areas, while potential locations for the proposed sediment bedload collector or traps, could present permitting issues due to their location within areas subject to USACE regulation. Areas adjacent to the river that are above the OHWM would have fewer permitting issues due to the majority of all the site being in unregulated areas. These areas that are above the OHWM but also sufficiently low elevation to allow water exchange with the river during higher flow events as well as proximal to the river would provide the most suitable locations for in-channel traps or out-of-channel traps.

2.5 CONCEPTUAL LOCATIONS, COSTS AND IMPLEMENTATION STRATEGIES OF SEDIMENT TRAPS

2.5.1 ST002-Facility Trap Descriptions

Potential locations for two in-channel traps and one out-of-channel trap are located in ST002 and can be seen in Figure 1 through Figure 4 in Appendix F1. The potential storage volume for the two in-channel traps is 14,120 cubic yards as seen in **Table 3**. The out-of-channel trap potential storage volume is 548,496 cubic yards. The pit proposed for the off-channel trap appeared to be in use because the water is a chalky-white color which suggests recent activity has made the water turbid.

Table 3: Potential Storage Volume for the Three Traps at Facility ST002

Sediment Trap Name	Length (ft)	Bottom Width (ft)	Average Depth (ft)	Potential Storage Volume (CY)
ST002 01IC (In-Channel)	926	62	4	9,060
ST002 02IC (In-Channel)	723	57	3	5,060
				14,120
	Surface area of existing pit (acres)	**Average depth (ft)***		**Potential Storage Volume (CY)**
ST002 01OC Out-of- channel	34.0	10		548,496
* average depth is the depth between the operational water surface elevation and the bottom of the pit that would fill in with sediment.				

2.5.2 ST002-Implementation Costs

Table 4 shows the opinion of probable construct cost (OPCC) and the implementation cost for each trap within the facility. The cost for ST002 02OC also includes the stabilization of 150 feet of streambank by the pit as shown in **Figure 3**. The implementation cost is estimated to be thirty-three percent of the OPCC for each trap and this estimate includes the cost for surveying (easements and land acquisition support), permitting, preliminary engineering, preliminary design (PER), final design and construction supervision. Detailed cost estimates can be seen in Appendix G. The total cost for implementing the three traps at the ST002 facility would be $1.8 million. This cost is in 2020 US dollars and does not include an escalation factor. The cost of potential storage volume is seen in **Table 4** which was included for comparative purposes. The bulk of the construction costs for the in-channel traps is due to the amount of excavation required. It is recommended that the width and depth of the proposed excavation be assessed in final design to balance the amount of potential storage volume with the cost to construct the trap. That analysis may reveal that modifications to the concept are warranted, e.g., less hardening of the boundary of the trap or utilizing the excavation of existing point bars as lower cost trapping systems.

Table 4: Opinion of Probable Construction Cost and Implementation Costs at ST002

Work	Opinion of Probable Construction Cost	Implementation Cost	Subtotal	Potential Storage Volume (CY) (from table 6)	Cost of Potential Storage Volume ($/CY)
ST002 01IC (In-Channel)	$879,000	$291,000	$1,170,000	9,060	$129
ST002 02IC (In-Channel)	$304,000	$102,000	$406,000	5,060	$80
Subtotal			$1,576,000		
ST002 01OC (Out-of-channel)^	$176,000	$59,000	$235,000	548,496	$0.43
Total Cost			$1,811,000		
^Includes protecting streambank					

2.5.3 ST002-Implementation Strategy

There are two existing APO's within the ST002 potential sediment trapping facility site location: Hanson Aggregates and Liberty Materials. Before implementation it would be necessary to coordinate with these APOs to gain access to the property and to discuss potential private-public partnership arrangements to build and operate sediment trapping facilities within potential site location ST002.

Table 5 presents a conceptual implementation schedule and assumes all traps presented in the conceptual design will be built. Preliminary design will include the hydraulic modeling, surveying, Ordinary High-Water Mark delineation, and updated sediment transport modeling to adjust the sediment trap dimensions from this Conceptual Design Report. This schedule assumes permit acquisition will start at the sixty percent design level. The permit acquisition schedule assumes the proposed traps will require an individual permit from the USACE Section 404 Permit. If the proposed works can be permitted under an NWP, then the permitting process can be shortened significantly. Final design includes the time needed to complete final construction documents. It was assumed that advertisement, bid award, and construction can begin in the same quarter that the permit is obtained.

Table 5: Schedule to Implement Sediment Trap Facility ST002

	Year 1				Year 2				Year 3			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Preliminary Design	X	X	X									
Final Design			X	X	X							
Permit Acquisition				X	X	X	X	X				
Construction								X	X			

2.5.4 ST003-Facility Trap Description

Potential locations for two in-channel traps are located in ST003 and can be seen in Figure 5 through Figure 7 in Appendix F1**.** The potential storage volume for the two in-channel traps is 71,290 cubic yards as shown in **Table 6**.

Table 6: Potential Storage Volume for the two Traps at Facility ST003

Sediment Trap Name	Length (ft)	Bottom Width (ft)	Average Depth (ft)	Potential Storage Volume (CY)
ST003 01IC (In-Channel)	1,600	136	7	60,630
ST003 02IC (In-Channel)	1,190	119	2	10,660
Total				71,290

2.5.5 ST003-Implementation Costs

Table 7 shows the opinion of probable construct cost and the implementation cost for each trap within the facility. The implementation cost is estimated to be thirty-three percent of the OPCC for each trap and this estimate includes the cost for surveying (easements and land acquisition support), permitting, preliminary engineering, preliminary design (PER), final design and construction supervision. Detailed cost estimates can be seen in Appendix G. The total cost for implementing the two traps at the ST003 facility is $6.8 million. This cost is in 2020 US dollars and does not include an escalation factor. The cost of potential storage volume is seen in **Table 7** which was included for comparative purposes. The bulk of the construction costs for the in-channel traps is due to the amount of excavation required. It is recommended that the width and depth of the proposed excavation be assessed in final design to balance the amount of potential storage volume with the cost to construct the trap. That analysis may reveal that modifications to the concept are warranted, e.g., less hardening of the boundary of the trap or utilizing the excavation of existing point bars as lower cost trapping systems.

Table 7: Opinion of Probable Construction Cost and Implementation Costs at ST003

Work	Opinion of Probable Construction Cost	Implementation Cost	Subtotal	Potential Storage Volume (CY) (from table 6)	Cost of Potential Storage Volume ($/CY)
ST003 01IC (In-Channel)	$3,936,000	$1,300,000	$5,236,000	60,630	$86
ST003 02IC (In-Channel)	$1,200,000	$396,000	$1,596,000	10,660	$150
Total Cost			$6,832,000		

2.5.6 ST003- Implementation Strategy

Permission from one APO operator and one landowner is needed to implement two traps within the ST003 facility. Before implementation it would be necessary to coordinate with the APO operator to gain access to the property and to discuss potential private-public partnership arrangements to build and operate sediment trapping facilities within potential site location ST003. Montgomery Sand and Gravel runs the existing APO facilities on the right bank (southern shoreline at ST003 02IC). A purchase or lease agreement would be needed from a separate landowner to install ST003 01IC which is located on the left bank (northern shoreline). There is an access road to the river's right bank across the river from ST003 01IC which eliminates the need to build a new access road to the river (Figure 5 in Appendix F1).

Table 8 presents a conceptual schedule and assumes all traps presented in the conceptual design will be built. Preliminary design will include the hydraulic modeling, surveying, Ordinary High-Water Mark delineation, and updated sediment transport modeling to adjust the sediment trap dimensions from this Conceptual Design Report. This schedule assumes permit acquisition will start at the sixty percent design level. The permit acquisition schedule assumes the proposed traps will require an individual permit from the USACE Section 404 Permit. If the proposed works can be permitted under an NWP, then the permitting process can be shortened significantly. Permitting for this facility is expected to take longer than ST002 or ST004. There is no existing low water crossing that crosses the river from the existing access road from the right bank (southern shoreline) to the left bank where ST003 01IC will be installed. The need to construct a low water crossing may complicate permitting and increase permitting time. It was assumed it would take three additional months to permit a low water crossing. Final design includes the time needed to complete final construction documents. It was assumed that advertisement, bid award, and construction can begin in the same quarter that the permit is obtained.

Table 8: Schedule to Implement Sediment Trap Facility ST003

	Year 1				Year 2				Year 3			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Preliminary Design	■	■										
Final Design			■	■	■							
Permit Acquisition				■	■	■	■	■	■			
Construction									■	■		

2.5.7 ST004- Facility Trap Descriptions

Potential Locations for three in-channel traps and three out-of-channel traps are located in ST004 and can be seen in Figure 9 through Figure 15 in Appendix F1. The potential storage volume for the three in-channel traps is 84,220 cubic yards (**Table 9**). The ST004 01OC (out-of-channel) trap potential storage volume is 585,483 cubic yards. The out-of-channel traps, ST004 02OC and ST004 03OC, share the same potential storage volume, which has a volume of 1,755,060 cubic yards. Out-of-channel traps ST004-02OC and ST004-03OC could be built independent of each other even though they share the same potential storage volume. Building them together increases the volume of sediment that would flow into the pit. The pits proposed for off-channel traps appeared to be in use because the water is a chalky-white color which suggests recent activity has made the water turbid.

Table 9: Potential Storage Volume for the Three Traps at Facility ST004

<table>
<tr><th>Sediment Trap Name</th><th>Length (ft)</th><th>Bottom Width (ft)</th><th>Average Depth (ft)</th><th>Potential Storage Volume (CY)</th></tr>
<tr><td>ST004 01IC (In-Channel)</td><td>1,418</td><td>69</td><td>12</td><td>58,610</td></tr>
<tr><td>ST004 02IC (In-Channel)</td><td>1,102</td><td>24</td><td>7</td><td>10,850</td></tr>
<tr><td>ST004 03IC (In-Channel)</td><td>1,328</td><td>94</td><td>3</td><td>14,760</td></tr>
<tr><td colspan="4"></td><td>84,220</td></tr>
<tr><td colspan="5"></td></tr>
<tr><th></th><th>Surface area of existing pit (acres)</th><th>Average depth (ft)*</th><th></th><th>Potential Storage Volume (CY)</th></tr>
<tr><td>ST004 01OC (Out-of-channel)#</td><td>36.3</td><td>10</td><td></td><td>585,483</td></tr>
<tr><td>ST004 02OC (Out-of-channel)^</td><td rowspan="2">108.8</td><td rowspan="2">10</td><td></td><td rowspan="2">1,755,060</td></tr>
<tr><td>ST004 03OC (Out-of-channel)^</td><td></td></tr>
<tr><td colspan="5">* Assumed average storage depth which is the height between the operating water surface elevation and the bottom of the pit</td></tr>
<tr><td colspan="5">^ Share the same potential storage area</td></tr>
<tr><td colspan="5"># Includes 900 feet of streambank protection</td></tr>
</table>

2.5.8 ST004- Implementation Costs

Table 10 shows the opinion of probable construct cost and the implementation cost for each trap within the facility. It is assumed that trap ST004 02OC (out-of-channel) and ST004 03OC (out-of-channel) will both be constructed because they share the same storage area. Eroding streambanks were noted at site ST004 01OC and therefore need erosion protection. For estimating costs, it was assumed rock riprap would be used and extend sufficiently upstream and downstream to protect the conveyance channel.

The implementation cost is estimated to be thirty-three percent of the OPCC for each trap and this estimate includes the cost for surveying (easements and land acquisition support), permitting, preliminary engineering, preliminary design (PER), final design and construction supervision. Detailed cost estimates can be seen in Appendix G. The total cost for implementing the six traps at the ST004 facility is $5.97 million. This cost is in 2020 US dollars and does not include an escalation factor. The cost of potential storage volume is seen in **Table 10** which was included for comparative purposes. For the in-channel traps, ST004 01IC has the least cost of potential storage volume while ST004 03IC has the highest. The bulk of the construction costs for the in-channel traps is due to the amount of excavation required. It is recommended the width and depth of the proposed excavation be assessed in final design to balance the amount of potential storage volume with the cost to construct the trap. That analysis may reveal that modifications to the concept are warranted, e.g., less hardening of the boundary of the trap or utilizing the excavation of existing point bars as lower cost trapping systems.

Table 10: Opinion of Probable Construction Cost and Implementation Costs for ST004

Work	Opinion of Probable Construction Cost	Implementation Cost	Subtotal	Potential Storage Volume (CY) (table 9)	Cost of Potential Storage Volume ($/CY)
ST004 01IC (In-Channel)	$1,590,000	$525,000	$2,115,000	58,610	$36
ST004 02IC (In-Channel)	$804,000	$267,000	$1,071,000	10,850	$99
ST004 03IC (In-Channel)	$1,257,000	$416,000	$1,673,000	14,760	$113
Subtotal			$4,859,000		
ST004 01OC ^ (Out-of-channel)	$226,000	$75,000	$301,000	585,483	$0.51
ST004 02OC (Out-of-channel)	$226,600	$88,000	$354,000	1,755,060	$0.46
ST004 03OC (Out-of-channel)	$343,000	$114,000	$457,000		
Subtotal			$1,112,000		
Grand Total			$5,971,000		
^Includes protecting streambank					

2.5.9 ST004- Implementation Strategy

Permission from only one APO operator and one landowner agreement is needed to implement six traps within the ST004 facility. RGI Materials operates the existing APO facilities on both banks, and JR Development is the landowner. It appears both entities share ownership. Before implementation it would be necessary to coordinate with this APO to gain access to the property and to discuss potential private-public partnership arrangements to build and operate sediment trapping facilities within potential site location ST004.

Table 11 presents a conceptual schedule and assumes all traps presented in the conceptual design will be built. Preliminary design will include the hydraulic modeling, surveying, Ordinary High-Water Mark delineation and updated sediment transport modeling to adjust the sediment trap dimensions from this Conceptual Design Report. This schedule assumes permit acquisition will start at the sixty percent design level. The permit acquisition schedule assumes the proposed traps will require an individual permit from the USACE Section 404 Permit. If the proposed works can be permitted under an NWP, then the permitting process can be shortened significantly. Final design includes the time needed to collect survey information and complete preliminary engineering and final construction documents. It was assumed that advertisement, bid award, and construction can begin in the same quarter that the permit is obtained.

Table 11: Schedule to Implement Sediment Trap Facility ST004

	Year 1				Year 2				Year 3			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Preliminary Design												
Final Design												
Permit Acquisition												
Construction												

3.0 SEDIMENT TRAP EFFICIENCY

The conceptual sediment trap descriptions and feasibility analysis provided above focused on the potential type and number of traps at each siting location, as well as potential constraints and regulatory requirements that will need to be considered in the design of these systems. The following sections describe a basic analysis of the efficiency and potential production rates of the conceptual sediment traps, which is then used to estimate the cost-effectiveness of each trap. This information is useful from a planning perspective; however these analyses will need to be further refined during the design process as more detailed information becomes available, in order to make final determinations of trap dimensions and suitability.

The approach to calculate efficacy used a theoretical sediment transport capacity equation to calculate the transport capacity at the site of each trap under existing conditions. A theoretical sediment transport equation estimates an annual sediment load (reported in units of mass per time) that can be conveyed, i.e., transported through the site of each trap. It is an estimate because there is limited data about the actual sediment load upstream of each trap. With limited data, the estimate can be off by orders or even orders of magnitude from the actual annual sediment load. However, if the same theoretical sediment transport equation is used to calculate the annual sediment load under proposed conditions, i.e., when the trap is first built then the change to the annual sediment load that can be conveyed through the site of each trap can be determined by comparing existing conditions to proposed conditions. The annual sediment loads for the two conditions and the percent difference between the two was calculated. Sediment trap efficacy was equal to the percent difference. This percentage was then multiplied by the measured suspended sediment load in the river (at a USGS stream gage upstream) to predict the sediment volume that could deposit in or proximal to the trap. If the percent difference, i.e., efficacy exceeded 100% than the changes made due to the proposed activities could capture most if not all of the measured sediment load in the river.

3.1 SEDIMENT LOAD SIZE DISTRIBUTION

Particle size distribution of the transported sediment load was measured at each sediment trapping facility. This information was used to estimate the amount of sediment that would deposit in each sediment trap facility.

The measurement was obtained at a feature referred to as a point bar in each facility. A point bar is a region where sediments often deposit and is located on the inside of a meander bend. The particle size distribution sample was obtained using a handheld-hydraulic coring machine to extract a core from the point bar. The location where the core sample was obtained was roughly one-third of the sand bar's length from its downstream end. This is a location where point bar material is often a good representation of the sediment load size distribution. The core was drilled down to the layer of first refusal, a notable change in resistance to the driving forces of the coring machine. This elevation was assumed to be the riverbed bottom. The sample was then extracted, capped, and brought to a lab for testing. A core was obtained for each sediment trap facility. Detailed methodology for extracting the sample and measuring the particle size distribution is described in Appendix H.

The particle size distribution (PSD) of each sediment trap facility is shown in **Figure 11** and notable sediment size percentiles are shown in **Table 12.** The PSD for the three samples mostly fall within the sand fraction. The PSD at site ST002 does not contain any silts and clays and is roughly 95 percent sand. The D_{50} is a medium sand. The PSD for sites ST003 and ST004 is slightly finer than site ST002 and are still considered a medium sand. Larger (coarser) materials are easier to capture in an in-channel trap because they tend to be transported near the river bottom elevation where the in-channel traps are located. A medium sand is expected to deposit within the in-channel trap. It is recommended that during preliminary design and final design hydraulic modeling is used to calculate the hydraulic conditions that would result in the deposition of most of the size fractions in the bedload. Finer sands (smaller than 0.2 mm) usually are transported at a higher elevation in the river's water and therefore can be captured in out-of-channel traps since these traps' invert elevations are higher than in-channel traps'. The PSD in **Figure 10** show the finer sand percentages at facilities ST002 and ST004 (where out-of-channel traps are located) are 8% and 31% respectively. Therefore it's estimated the out-of-channel trap at ST004 may be more productive.

Table 12: Particle Size Distribution of Sediment Load in Three Facilities

	D15 (mm)	D50 (mm)	D84 (mm)
ST002	0.26	0.39	0.70
ST003	0.042*	0.24	0.50
ST004	0.028*	0.35	0.70
***extrapolated from curve**			

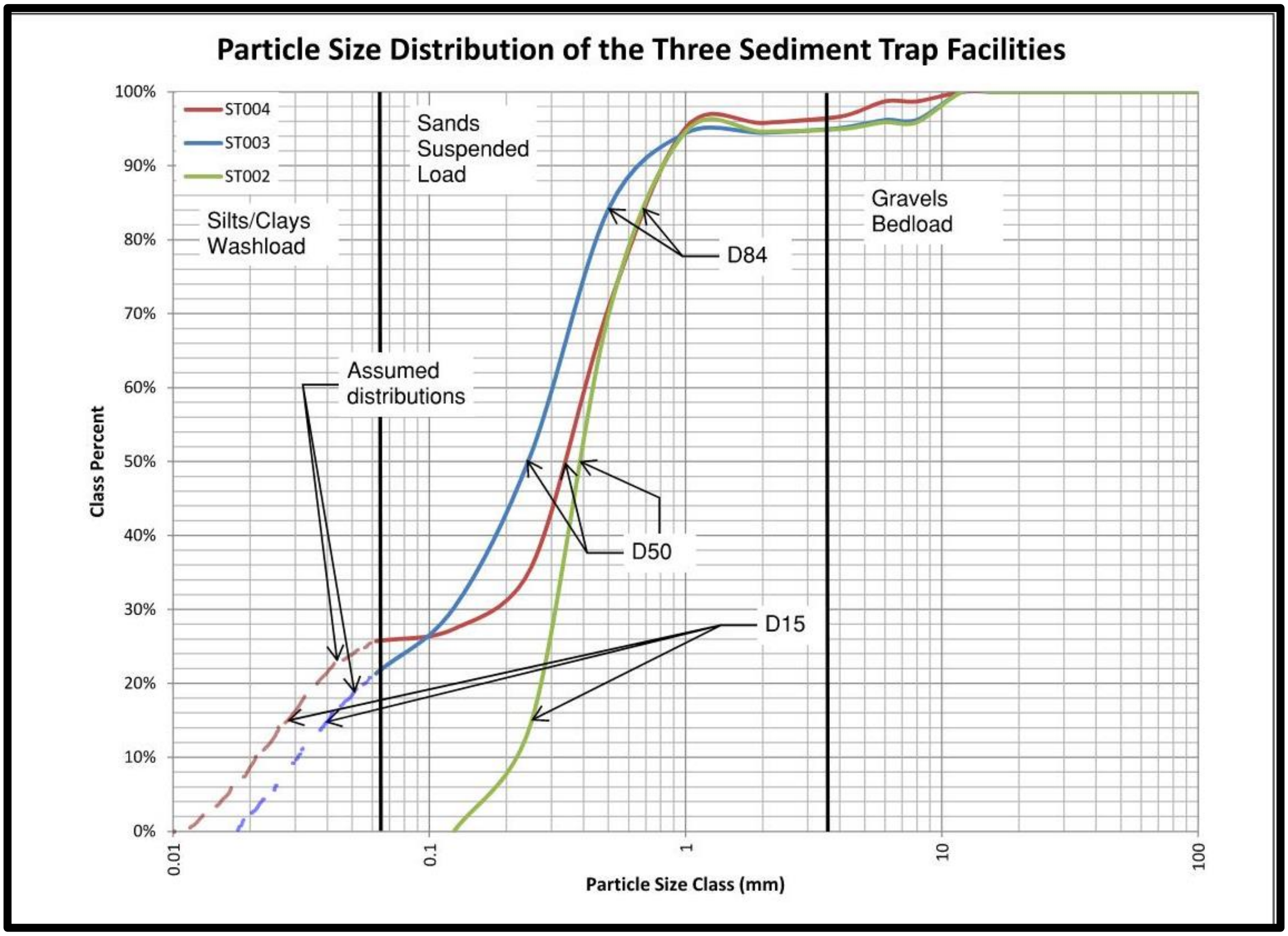

Figure 10: Particle size distribution of the three sediment trap facilities

3.2 HYDROLOGY

The flow duration curve developed from the USGS stream gage (USGS stream gage 08068090 near Porter, TX) in the Efficacy Study (Page 6 in Appendix A) is presented in **Figure 11**. The values from this curve were used to estimate the amount of sediment that would deposit in each sediment trap facility. The discharges from the flow duration curve used to make this estimate were translated using a method described in a report created by the United States Geological Survey (USGS 2006). This method used Equation 1 to adjust the flow duration curve's discharges from the USGS gage to each sediment trap facility. The drainage area for the USGS stream gage was obtained from the USGS website for the gage. A drainage area starting at the most downstream sediment trap in each sediment trap facility was delineated using LiDAR data.

$$\frac{Q_1}{Q_2} = K\frac{A_1}{A_2}^{\emptyset}$$

Equation 1

Where:

Q_1 Flow duration curve exceedance probability (10%,20%,30% etc.) discharge at sediment trap facility

Q_2 Flow duration curve exceedance probability (10%,20%,30%) at the USGS stream gage

A_1 is drainage area delineated for to the upstream most trap in each facility of interest

A_2 is drainage area at the USGS stream gage

K=single bias correction factor for flow duration curve exceedance probability (10%,20%,30% etc.) (USGS 2006 Table 4)

Θ= exponent for flow duration curve exceedance probability (10%,20%,30% etc.) (USGS 2006 Table 5)

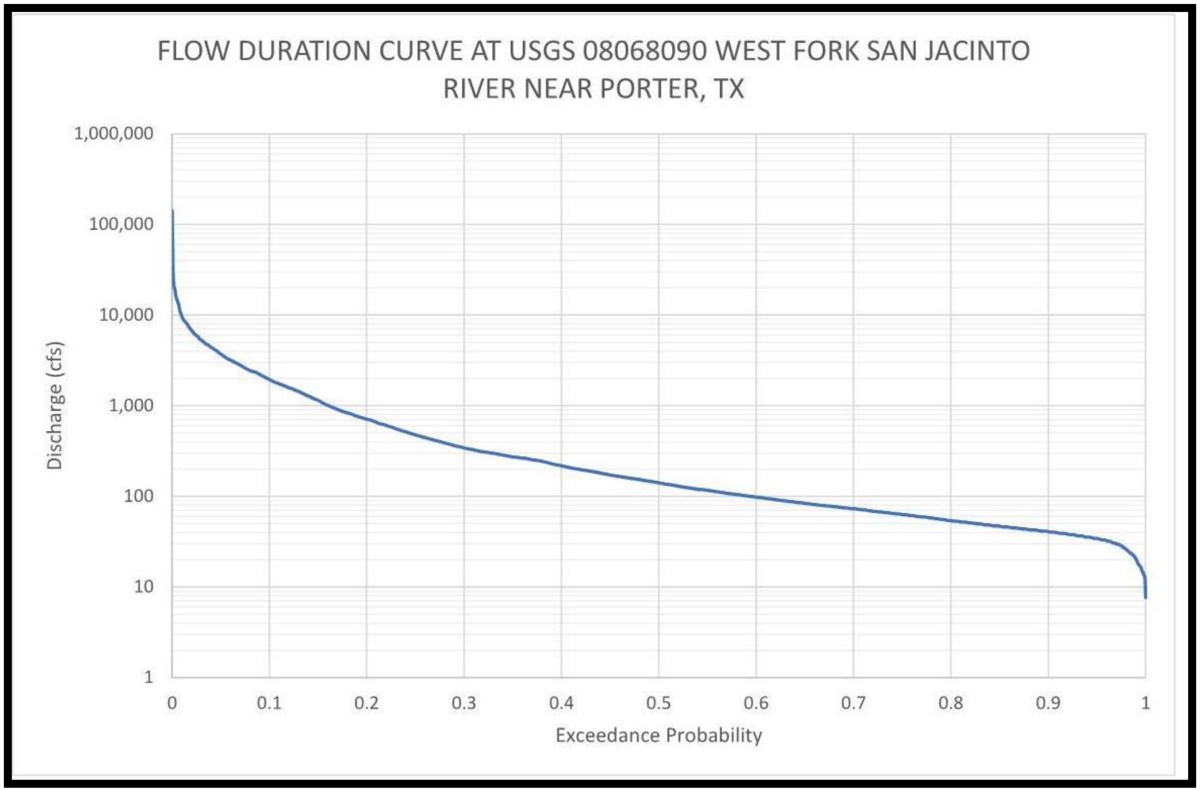

Figure 11: Flow duration curve used to estimate annual sediment loads in the sediment trap facilities

3.3 IN-CHANNEL TRAP EFFICACY

To predict in-channel trap efficacy, an analysis was conducted to calculate the change in the river's sediment transport capacity after implementing the proposed sediment traps at each location. The sediment transport capacity at each trap was calculated for existing conditions and then again under proposed conditions assuming the sediment trap was built per the conceptual design presented in this report. Sediment transport capacity is the ability of the river to transport its sediment load at a particular location on the river over time. Predicting sediment transport capacity can be accomplished in several ways, including through the use of regression equations, empirical data, physics-based equations, and hydrodynamic and morphodynamic models. A combination of the first three approaches is used within the FlowSED/PowerSED model developed by Rosgen (2006), which compares the relative ability of one cross-section to transport sediment over time with the ability of another section, based on differences or changes in their hydraulic geometry. This method has been shown to provide reasonable results with relatively few inputs, compared with other analytical approaches and sediment models, and thus is appropriate for planning-level estimates of sediment trap efficacy.

Fundamental to the use of the FlowSED/PowerSED model is an appropriate sediment rating curve. A sediment rating curve is the relationship of sediment transport and discharge for a given location on a river. Optimally this curve is made from discrete measurements of suspended and bedload sediment obtained across a range of low, moderate, and high discharges. When combined with a flow duration curve, the total amount of sediment transported over a given period of time can be calculated since the flow duration curve provides a percentage of time in which a given discharge, and thus an associated quantity of sediment, will occur.

In an attempt to increase the accuracy of predicting sediment transport capacity closer to that which could be obtained by actual measurements while still maintaining the low-cost associated with using analytical sediment transport equations, Rosgen (2006) proposed a method to develop and use reference sediment rating curves to predict bedload and suspended sediment transport and total sediment yield for a particular location on a river. To use this method, the reference sediment rating curve must be made dimensionless and “scaled” to the location on the river being studied. A commonly used reference sediment curve in the FLOWSED and POWERSED models is the Pagosa Curve, which was developed from an extensive sediment data set collected over several years on a river in Colorado. The Pagosa Curve has been compared with several rivers throughout the United States and has been shown to match closely with the measured values on many rivers (Rosgen, 2006). Furthermore, the curve has been shown to approximate the Parker Surface-based Bedload Equation, a physics-based approach to predict bedload transport (Hinton et al., 2012). Thus, it was deemed reasonable to use this reference curve to calculate the change in sediment transport capacity for this study.

To implement the FlowSED/PowerSED model, the dimensionless Pagosa Curve is scaled to the river being studied, using measured values of bedload and suspended sediment at the bankfull discharge for the study river location. Next, a locally developed flow duration curve is entered into the models along with the location’s cross-sectional geometry. The models will then calculate the unit stream power from the cross-section’s geometry across a range of discharges. From this, a relationship is then developed between discharge and unit stream power and the percent of time in which a given discharge, and thus an associated quantity of sediment, can be predicted using the locally developed flow duration curve. The process is repeated at another cross-section (or a modified version of the same cross-section) being used for comparison purposes. Thus, the model accounts for the changes in geometry that affect the ability to transport sediment at that location over time (sediment transport capacity), and predicts a total amount of deposition or degradation (measured in tons per year) of the river bed that may occur due to the change in geometry.

In this study, the PowerSED model was used to measure in-channel sediment trap efficacy through comparison of the change in the sediment transport capacity before and after construction of the in-channel sediment traps. In construction of the in-channel sediment traps, removal of material will alter the topography of the channel which in turn will alter unit stream power across a range of flows at that section. Thus the PowerSED results reflect the percent change in sediment transport capacity from pre-sediment trap conditions to post-sediment trap conditions. This percent change is the trap's efficacy. If the trap's efficacy exceeds 100%, then the trap could potentially capture most of the sediment being transported down the West Fork. The use of PowerSED in this study is to evaluate only the change in sediment transport capacity due to modifications made to topography from the excavation of the sediment traps. Therefore, the PowerSED model was only run for the region in a cross section between the tops of stream banks. A representative exhibit of this region is presented in Figure F28 of Appendix F1.

To run the PowerSED model, the following data was input into the model: bedload (lbs/sec) suspended sediment concentration (mg/L) and suspended sand (mg/L). The latter two inputs were obtained using suspended sediment concentrations (mg/L) and suspended sediment loads (tons/day) measured from the USGS station stream gage 08068000 upstream near Conroe, TX. The gage is located where interstate 45 crosses the river. The gage is located approximately 8.5 miles upstream of facility ST002 and has 187 discrete sediment samples from 1972 to 2011. It was assumed that the relationship between sediment concentration and discharge at this USGS stream gage was representative of the relationship between sediment concentration and discharge at the three sediment trap facilities. The data that created the sediment rating curve at the USGS stream gage is presented in **Figure 12**. The measured particle size distribution for each sediment trap facility, as described in Chapter 3.1, was then used to determine the percentage of bedload (particles coarser than 2.0mm), suspended sand (particles between 2.0 mm and 0.065mm) and washload (particles finer than 0.065mm) for each sediment trap facility.

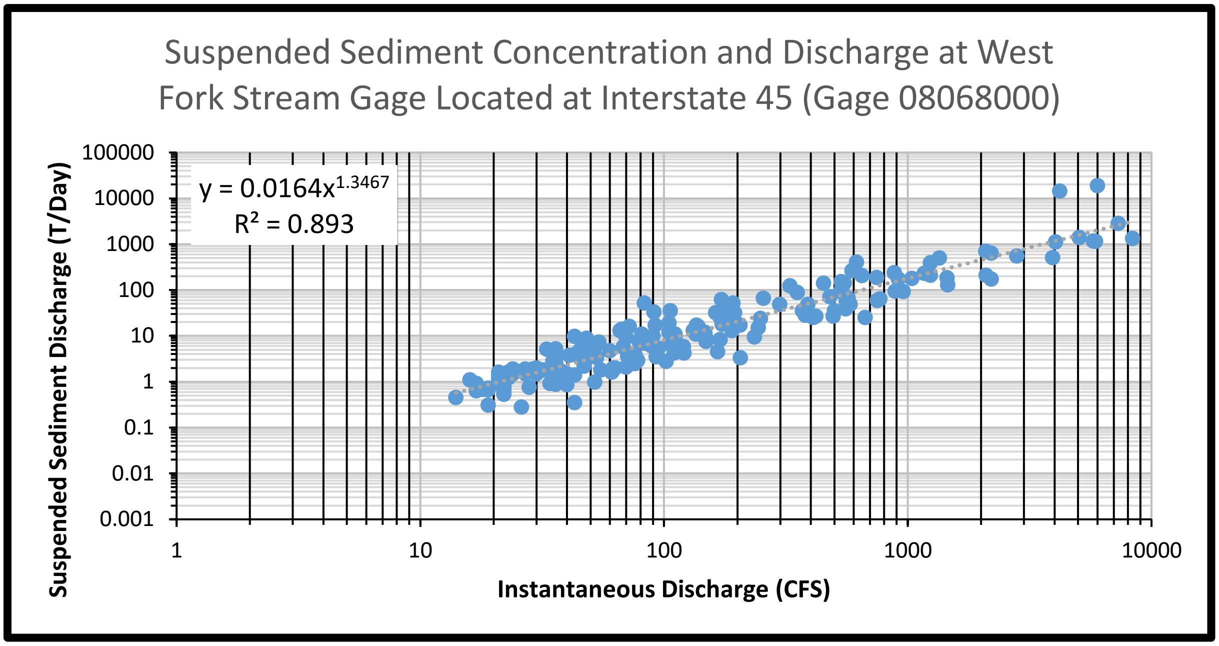

Figure 12: Plot of suspended sediment concentration and discharge used to predict annual sediment loads

The bankfull discharge used to develop the site-specific dimensionless sediment rating curves was calculated at a cross section where a bankfull indicator was observed using the embedded functionality in the FLOWSED/POWERSED models. During the field investigations described in the Sediment Trap Efficacy Study (Appendix A), bankfull elevations using bankfull indicators like the one called out in the image in **Figure 13** were measured using a laser level and mapped using a handheld GPS unit. There was a bankfull indicator for each sediment trap facility. The elevation measured in the field was then related to LiDAR using ESRI's ArcGIS program. The river discharge (flow coming down the river) which resulted in a water surface elevation that matched the bankfull elevation was then calculated using FLOWSED/POWERSED and used as the bankfull discharge.

The resulting bankfull discharge was then plotted on **Figure 12** to obtain the suspended sediment discharge measured in tons per day which was then converted to pounds per second. **Figure 10** shows that the percent of bed load within the sediment load (4 mm was considered the threshold between bedload and suspended load) for each sediment trap facility ranged from 5 percent to 6.5 percent. For this analysis, sediment finer than 0.065 mm was considered part of the washload (0 percent to 26 percent in **Figure 10**). A figure similar to **Figure 12** was plotted but used suspended sediment concentration (measured in mg/L) plotted on the dependent axis instead of suspended sediment discharge. The resulting bankfull discharge was then plotted on Figure F29 in Appendix F1 to obtain the suspended sediment concentration. **Table 13** shows data input for each sediment trap into the POWERSED/FLOWSED models.

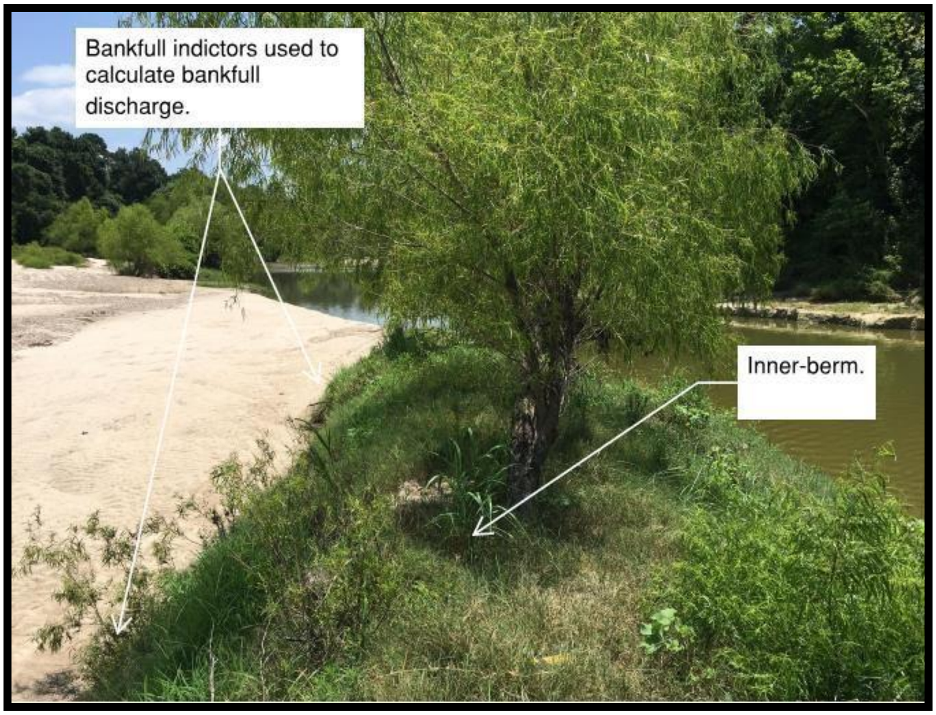

Figure 13: Image of a typical bankfull indicator at the point of inflection between the relatively flat surface of the sand bar and the steeper slope of the inner berm.

Table 13: Inputs Into POWERSED/FLOWSED Models

Facility	Bankfull Discharge (cfs)	Suspended Sediment Load (tons/day)	Bankfull Bedload (lbs/sec) (Percent of total load	Suspended Sediment Concentration (mg/L)	Suspended Sand Concentration (mg/L)(Percent of total load)
ST002	938	165.0	0.15 (4%)	65.8	55.8 (84%)
ST003	1,010	182.3	0.21 (5%)	67.6	38.5 (57%)
ST004	1,047	191.3	0.14 (3%)	68.5	41.6 (60%)

The models were run, and the theoretical sediment transport capacity for existing conditions (Column 3), proposed conditions (Column 4), and the change between the two conditions (Column 5) can be seen in **Table 14**. The values in Column 3 vary notably which is to be expected because an assumption was made when using the sediment data from the USGS stream gage near Conroe, TX in the FlowSED/PowerSED model to calculate sediment transport capacity. This approach assumed the relationship between sediment load and discharge at the USGS stream gage was the same relationship between sediment load and discharge at each location the model was run. However, it is reasonable to conclude each trap location's topography and local hydraulics are different than the USGS stream gage location's topography and local hydraulics therefore the calculated theoretical sediment load under existing conditions will be different at each trap location as shown in Column 3. As discussed in Chapter 3.0, a theoretical sediment transport capacity equation is an estimate of the actual annual sediment load (reported in units of mass per time) transported through the site of each trap and its value can be off by orders or even orders of magnitude from the actual annual sediment load. Therefore, the goal of calculating a theoretical sediment capacity is to compare this capacity under existing conditions and proposed conditions to calculate a percent change. The percent change is caused by the modifications in topography due to building each trap and therefore can be used to predict sediment trapping efficacy.

Table 14 shows that the change in theoretical sediment transport capacity varies from 10% to over 600%. This means the sediment traps as conceptual designed impact the West Fork's ability to transport sediment. This will result in sediment depositing within a trap. The wide range of change was expected because the traps' dimensions vary. Since each trap's bottom elevation was proximally located to the average daily water surface elevation, a trap's bottom width and the resulting area that is frequently inundated are expected to influence sediment transport capacity. **Table 14** shows the change in sediment transport capacity (column 5) exceeds 100% in two traps (ST004-02IC and ST004-03IC), which suggests these traps by themselves could encourage deposition of most of the transported sediment in the West Fork.

To compare each trap's efficacy to the trap's excavated storage volume (i.e., the volume of material removed from excavating the trap), the portion of the West Fork's annual sediment load that could be trapped at each facility was calculated. This approach evaluated each trap in isolation and not as a cumulative effect. If multiple traps were built, the sediment load and the particle size distribution of the sediment load would be reduced and changed after each trap influencing the efficacy of the next trap.

The West Fork's annual sediment load was calculated from a relationship of measured sediment concentrations and discharge at the USGS station stream gage 08068000 upstream near Conroe, TX. The annual sediment load at this stream gage was calculated as part of the San Jacinto Regional Watershed Master Drainage Plan (SJMDP) in Appendix F and was 51,271 tons per year which was converted to cubic yards per year as show in Table I-1 in Appendix I. The PSD in **Figure 10** suggests the annual sediment load is mostly sand and it was assumed the load was well sorted, cohesionless, and has a density of 90 lbs/ft^3 which converts the annual sediment load to 42,198 cubic yards per year. The annual sediment load in cubic yards per year was then multiplied by each trap's efficacy (percentage) and is shown in Column 6 in **Table 14.** The excavated storage volume created by removing existing sediment to build each trap was copied from Tables 3, 6 and 9 and presented in Column 7 in **Table 14.**

The method using a theoretical sediment transport to calculate trapping efficacy was not used to predict depositional behavior under existing conditions. For example, the column 3 value in **Table 14** for ST004-03IC (16,966 tons/year) does not mean 40% of the annual sediment load measured at the USGS stream gage (51,271 tons/year, Table I-2) is being transported through the ST004-03IC location and 60% of the 51,271 tons/year is depositing.

Table 14 shows the cumulative change in sediment transport capacity (583,161 cubic yards) caused by the traps exceeds the West Fork's annual sediment load (42,198 cubic yards). This means the traps will encourage deposition of most if not all the river's sediment load. The cumulative excavated storage volume (Column 7) also exceeds the West Fork's annual sediment load. These findings suggest the designed storage volume can be reduced for all traps, or some traps can be eliminated altogether. For example, trap ST003-01IC has over 60,000 cubic yards of excavated storage volume yet only has an efficacy of 18%, the third least effective trap compared to trap ST002-01IC which has over 9,000 cubic yards with an efficacy of 68%. A comparison of potential storage volume to efficacy suggests ST003-01IC, ST004-01IC and ST003-02IC require relatively more excavation resulting in relatively lower efficacy and therefore can be eliminated. Sediment traps ST004-02IC, ST004-03IC and ST002-01IC have relatively larger efficacy for their respective storage volumes. One to two of these traps should be furthered to final design depending on which landowner participation. ST002-02IC requires less excavation to construct but also has less efficacy therefore it is a lower priority trap than ST004-02IC, ST004-03IC and ST002-01IC.

Trap efficacy was calculated assuming initial design conditions. Over time, traps fill in with sediments which will impact their efficacy. It is recommended these calculations be rerun during final design to calculate how the sediment trap's efficacy will be reduced over time as the sediment trap fills up. As the trap fills up, the cross-sectional topography will change reducing its ability to capture sediment when compared to initial design conditions. It is recommended the modeling be run for scenarios where 1) the trap has no sediment in it, 2) when it is half full, and 3) when it is three quarters full.

It is recommended that geomorphic assessment be completed as part of the final design to evaluate how removal of sediments using traps will impact downstream and upstream stability. There is a well-documented relationship between sediment transport and discharge, and when one part of the balance scale is changed, there is a response to the opposing part of the balance scale. The geomorphic assessment goal will be to identify what percentage of the annual sediment load can be removed without causing undesirable conditions downstream or upstream. It is also recommended that a two-dimensional hydraulic analysis be completed for the region around each trap to calculate shear stresses, velocities, and the percentage of discharge which enters the trap. The proposed traps are built in regions (meanders, i.e., curves in the river) which have velocity vectors that travel both longitudinally and laterally due to the secondary flow cells created by the meander. Further analysis of these velocity vectors will provide a better understanding which sediment sizes are likely to deposit within the trap, annual sediment load of the trap, and how frequently it will fill with sediment.

Table 14: Change in Sediment Transport Capacity Compared to Potential Storage Volume

1	2	3	4	5	6	7
Sediment Trap Facility	Sediment Trap	Existing Conditions	Proposed Conditions	Delta (% Change)	Volume of Annual Sediment Load^	Excavated Storage Volume*
		Tons/YR	Tons/Yr	Tons/Yr	Cubic Yards/YR	Cubic Yards
ST002	ST002-01IC (in-channel)	76,172	127,649	51,477 (68%)	28,518	9,060
	ST002-02IC (in-channel)	67,592	74,571	6,979 (10%)	4,357	5,060
				58,456	32,875	14,120
ST003	ST003-01IC (in-channel)	307,507	362,939	55,432 (18%)	7,607	60,630
	ST003-02IC (in-channel)	714,948	804,392	89,444 (13%)	5,279	10,660
				144,876	12,886	71,290
ST004	ST004-01IC (in-channel)	6,240	7,974	1,734 (28%)	11,726	58,610
	ST004-02IC (in-channel)	4,166	27,492	23,326 (560%)	236,274	10,850
	ST004-03IC (in-channel)	16,966	133,320	116,354 (686%)	289,399	14,760
Total				141,414	583,161	84,220
^ Percentage in column 5 multiplied by 42,198 cubic yards (Annual Sediment Load in West Fork)						
*From Tables 3, 6 and 9						

3.4 OUT-OF-CHANNEL TRAP EFFICACY

The approach described in Chapter 3.2 is not applicable for out-of-channel traps because this type of trap does not depend on the alteration of a cross-section's area to determine the ability to trap sediment. Therefore, the approach used in the San Jacinto Sediment Trap Efficacy Study (Appendix A) to evaluate out-of-channel trap efficacy was rerun using the measured sediment load particle size distribution presented previously in this report. This approach, referred to as sediment competency evaluation, calculates the ability of the river to move a sediment size percentile at discrete hydraulic events. This is important for out-of-channel traps since the greater the percentage of the sediment load that is in transport and in suspension, then the higher amount of sediment which can flow into the conveyance channel leading to out-of-channel traps.

The particle size distribution used in the Efficacy Study is presented in **Table 15** (in the row labeled "from STE Study in Appendix A"), along with the revised particle sizes from the PSD. The D_{15} and D_{50} are approximately the same but the D_{84} from the measured sediment is notably finer. The measured D_{84} is a coarse sand (0.63 mm) as opposed to a fine gravel.

Using the revised PSD, the critical shear stress calculations as explained on page 8 in Appendix A were rerun, and the results are shown in **Table 16**. The rerun calculations shown in **Table 16** show the shear stress required to mobilize D_{84} is much lower than what was calculated in the Efficacy Study. The critical shear stress values plotted in Appendix A's Figure 4 and Figure 5 were updated, and **Figure 14** and **Figure 15** show these updated values with the grain shear stress during several studied hydraulic conditions. The hydraulic conditions were modeled using the hydraulic model in the Efficacy Study at selected discharges from the flow duration curve at each facility. The shear stresses (grain and critical) are plotted for each discharge's exceedance probability.

A comparison between **Figure 14** and **Figure 15** and Appendix A's Figure 4 and Figure 5 shows that the D_{84} size percentile is in transport more frequently than found in the Efficacy Study. This means more of the sediment load is in transport and in suspension and thus is more likely to be captured by out-of-channel traps than what was shown in the Efficacy Study. These updated findings do not change the prioritization made in the Efficacy Study which found out-of-channel trapping efficacy is greater in facility ST002 than in facility ST004.

As part of final design, it is recommended that a two-dimensional hydraulic analysis be completed for the region around each out-of-channel trap to calculate the amount of discharge that is likely to enter the off-channel trap's conveyance channel. Once a discharge frequency curve is established for the conveyance channel, it can be used to compare to the discharge frequency curve and the sediment discharge frequency curve in the West Fork to estimate the amount of sediment which will flow through the conveyance channel into the trap.

Table 15: Measured Particle Sizes and Assumed Particle Sizes from Efficacy Study

	D15 (mm)	D50 (mm)	D84 (mm)
ST002	0.26	0.39	0.70
ST003	0.05*	0.24	0.50
ST004	0.08*	0.35	0.70
Average	0.13	0.33	0.63
From STE Study in Appendix A	0.13	0.25	5.23
***extrapolated from curve**			

Table 16: Critical Shear Stress Comparison

	D15 (lbs/sqft)		D50 (lbs/sqft)		D84 (lbs/sqft)	
Critical Shear Stress Method	Average from Table 15	From Table 2 in Appendix A	Average from Table 15	From Table 2 in Appendix A	Average from Table 15	From Table 2 in Appendix A
Miller 1977	0.00270	0.00270	0.00387	0.00453	0.07047	0.00689
Julien 2010	0.00471	0.00471	0.00412	0.00379	0.07969	0.00559

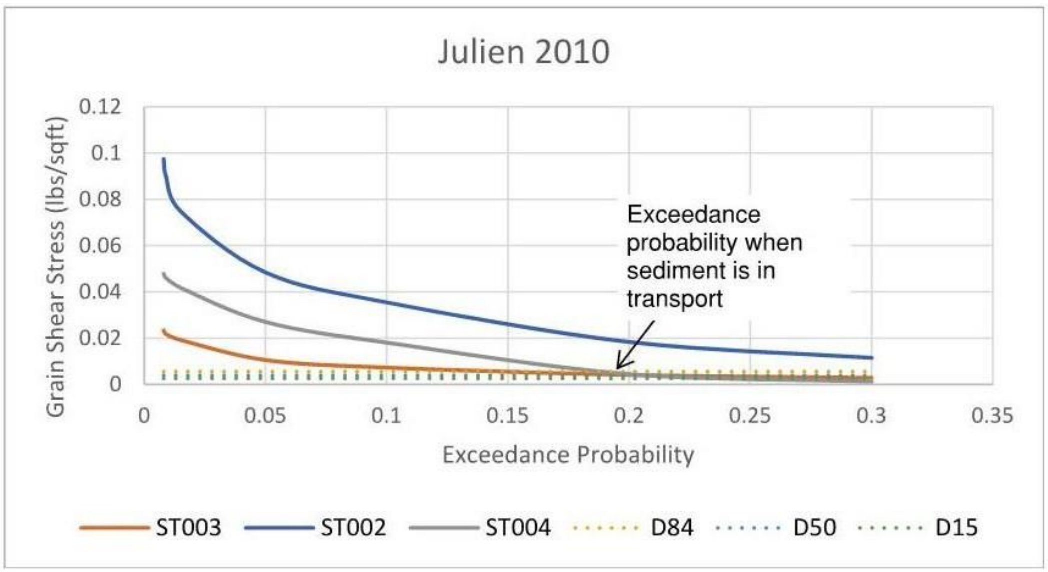

Figure 14: Critical shear stress (dashed line) and grain shear stress (solid line) for the most upstream trap at each facility

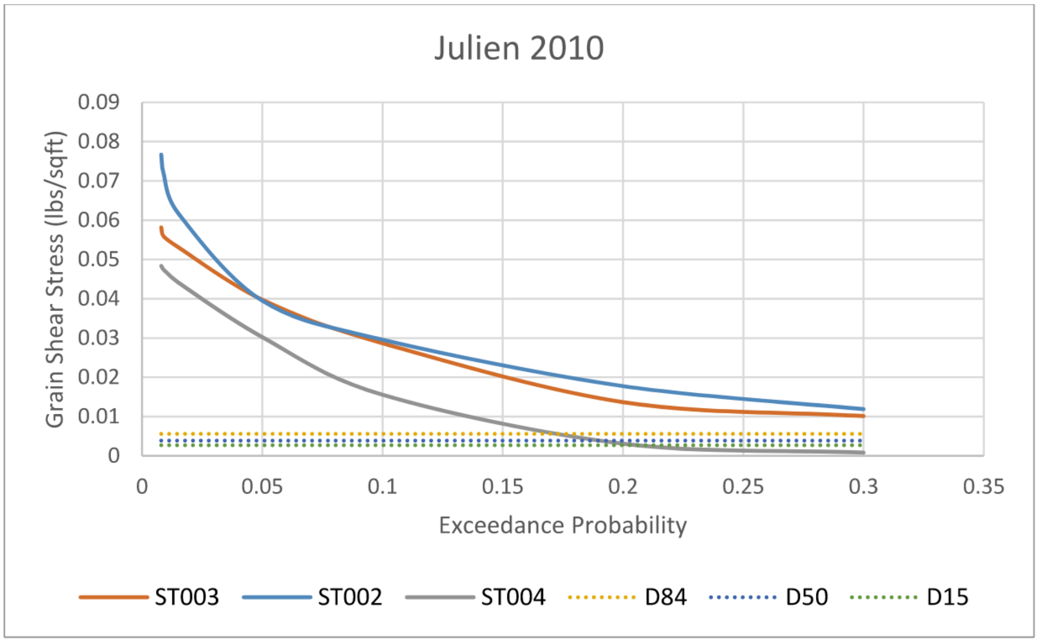

Figure 15: Critical shear stress (dashed line) and grain shear stress (solid line) for the most downstream trap at each facility

3.5 FACILTY COST COMPARISON AND EFFICACY SUMMARIZATION

Table 17 contains information that was used to prioritize in-channel traps: cost to implement, cost of potential storage volume and efficacy. If using efficacy as the sole metric to prioritize, the order would be ST004-03IC, ST004-02IC and ST002-01IC. If using cost to implement as the sole metric to prioritize, the order would be ST002-02IC, ST004-02IC and ST002-01IC. Since ST004-03IC and ST004-02IC are relatively inexpensive to implement with vastly higher efficacies than the others, they are recommended to be furthered into design as the highest priority in-channel traps. If the APO operator and landowner at ST004 are not willing to participate, ST002-01IC is recommended since it has the 3rd highest efficacy and is 3rd least expensive to implement

Per **Table 18**, the out-of-channel trap at ST002-01OC had the lowest implementation cost and lowest potential storage volume cost for out-of-channel traps. Per **Figure 14** and **Figure 15**, ST002-01OC is also the most effective in capturing sediments. If in-channel traps are infeasible or if additional storage is desired then it is recommended ST002-01OC be furthered into design. If coordination with only one APO operator and landowner is desired, then ST004-01OC can be pursued (due to its lower implementation costs) to complement the recommended in-channel traps at ST004. Out-of-channel traps ST004-02OC and ST004-03OC could be built independent of each other even though they share the same potential storage volume.

Table 17: Comparison of In-Channel Sediment Traps

Sediment Trap Name	Cost to Implement	Potential Storage Volume	Cost of Potential Storage Volume*	Efficacy^
	$	CY	$/CY	
ST002-01IC	1,170,000	9,060	129	68%
ST002-02IC	406,000	5,060	80	10%
ST003-01IC	5,236,000	60,630	86	18%
ST003-02IC	1,596,000	10,660	150	13%
ST004-01IC	2,115,000	58,610	36	28%
ST004-02IC	1,071,000	10,850	99	560%
ST004-03IC	1,673,000	14,760	113	686%
* From Tables 4,7,10				
^ From Table 14				

Table 18: Comparison of Out-of-Channel Sediment Traps

Sediment Trap Name	Cost to Implement	Potential Storage Volume	Cost of Potential Storage Volume *
	$	CY	$/CY
ST002-01OC	235,000	548,496	0.43
ST004-01OC	301,000	585,483	0.51
ST004-02OC	354,000	1,755,060	0.46
ST004-03OC	457,000		
*From Tables 4 and 10			

4.0 FLOOD WATER SURFACE ELEVATIONS

Each trap was modeled using the hydraulic model developed in the Efficacy Study (referred to as the Efficacy Study Model). This modeling effort was intended to estimate whether the proposed concept would cause a rise to the 100-year return interval flood (100-year flood) water surface elevations. The Efficacy Study Model utilized Atlas 14 rainfall data.

The Efficacy Study Model began with the hydraulic model that was developed as part of the San Jacinto Regional Watershed Master Drainage Plan (SJRWMDP) and was modified to study hydraulics during frequently occurring flow conditions as explained on pages six through 10 in the Efficacy Study in Appendix A. The 100-year flood discharge data (calculated using Atlas 14 rainfall depths) from the SJRWMDP model was extracted and used as boundary conditions in the Efficacy Study Model. The model was then run as the "Existing Conditions" model. A cross-section that cut through each trap was then selected from the RAS model. For each trap, a new geometry file was created by modifying the cross-section's geometry to reflect the proposed trap design described in Chapter 2.5 and presented in Figure 1 through Figure 15 in Appendix F1.

Table 19 is an abridged version of Table I-2 in Appendix I and lists the highest difference in water surface elevations for each trap's studied cross-sections.

All water surface elevations with the proposed traps (except ST002_01IC) are the same or slightly lower than under existing conditions. ST002_01IC resulted in an increase in water surface elevation of 0.24 feet, which is the largest increase in water surface elevation. The results of this modeling exercise suggest that most of the in-channel traps could be built and result in no rise in the 100-year water surface elevation. It is recommended that in preliminary engineering and final design additional cross-sections be added to the Efficacy Study Model within the proposed work area and the sections be updated to reflect their final design geometry.

Out-of-channel traps were not modeled as part of this study since in a one-dimensional hydraulic model, the conveyance channel from the river to the pond would be ineffective flow and thus not show a rise in the 100-year flood. If an out-of-channel trap is furthered in design, a two-dimensional model is recommended to be used to evaluate any potential rise in water surface elevation.

Table 19: Largest Difference in Water Surface Elevations (A (-) Number Means Lower)

Trap Name	Largest Difference in Water Surface Elevation (ft)
ST004_03IC	-0.01
ST004_02IC	-0.02
ST004_01IC	0.00
ST003_02IC	0.00
ST003_01IC	-0.06
ST002_02IC	0.00
ST002_01IC	0.24

5.0 DOWNSTREAM SEDIMENTATION MITIGATION

The findings of Chapter 3.4 suggest that sediment trapping will result in a reduction in the overall sediment load transported downstream. This could be beneficial to regions downstream where sediment deposition may be unwanted. Undesirable sediment deposition often occurs in regions where sediments have reduced the area available to convey water. This often occurs in regions near road crossings. During a flood, water normally conveyed through the bridge or culvert overtops the road crossing. Unwanted sediment deposition may also occur in regions of rivers and streams unencumbered by road crossings. For example, deposition can occur when there is a notable change in riverbed slope. Sediment deposition can also occur in large bodies of water, such as a lake, and reduce the storage capacity for storm runoff or at the mouth of a body of water such as a lake.

To evaluate the potential for sediment reduction downstream, the regions immediately downstream of each sediment trapping facility were evaluated to measure the current volume of deposition, estimate an annual deposition rate, and evaluate how the sediment trapped in the facilities will reduce the annual depositional rate in these regions.

A cross-section was cut through three depositional areas downstream of each facility. Depositional areas were identified and delineated as part of the Preliminary Sediment Trapping Locations Memorandum (Locations Memo). The Locations Memo identified depositional areas (as explained in detail on Page 2 in Appendix B) by comparing recently collected LiDAR topographic data to older LiDAR topographic data. Each cross-section was evaluated at areas within the cross section where recently collected LiDAR data (collected in 2018) was higher than the historic LiDAR data (collected in 2008). The evaluation was contained to areas within a cross-section where the change between the two data sources was more than likely due to alluvial processes (i.e., sediment deposition from the river) rather than anthropogenic activities, such as loss of material from APO facilities from breeches of APO ponds. The surface area was then measured between the two LiDAR topography data sources. After a visual inspection of each depositional area, the cross-section was cut across a representative section. The surface area of the representative section was then multiplied by length of each depositional area as shown in Figure 16 through Figure 18 in Appendix F1.

This evaluation does not account for sediment sources between the facility and the downstream region. It is recommended that any additional sediment budget analyses that may be performed as part of future phases of this project include the evaluation of sediment sources either from eroding stream banks or contributing tributaries downstream of the sediment trapping facilities.

The evaluated cross-sections are presented in Figure F19 through Figure F27 in Appendix F1 and a summary table presented in **Table 20**. The cross-section naming convention for this report used the sediment trap facility name upstream of the cross-sections as a prefix with a “DS” and the cross-section located closest to the facility was assigned an “01”. The sediment depositional volume at a cross section is referred to as the sediment depositional volume. The largest cumulative sediment deposition volume downstream of any facility was at ST002 DS (178,181, cubic yards). The largest volume in all the studied cross-sections was at ST002 DS 03 (110,213 cubic yards). The excavated storage volume in the traps (the amount of material excavated at the traps to initially build them) exceeds the cumulative sediment depositional volume in ST003 DS and ST004 DS in **Table 20**. The annual sediment depositional rate (**Table 21**) was calculated by dividing the cumulative sediment depositional volume by the number of years (10 years) between when the LiDAR data was collected. This was 3,724 cubic yards and 4,803 cubic yards per year for ST003 DS and ST004 DS respectively. The excavated storage volumes for traps at ST003 and ST004 were 71,120 cubic yards and 84,220 cubic yards which would provide approximately 20 years and 18 years of storage. It should be noted that the Hurricane Harvey flood event occurred during the time between LiDAR data sets. This flood event eroded, transported, and deposited more sediment than is normally deposited in any given year.

As discussed in Chapter 3.3 and presented in **Table 14**, modifications to the river corridor will cause some of the annual sediment load to deposit. In **Table 21**, the annual sediment load, calculated from the USGS stream gage on the West Fork, results in an estimate of an annual sediment load of 42,198 cubic yards at the stream gage. It was assumed the annual sediment load was approximately the same at each facility. This assumption does not account for sediment load being added to the West Fork between the gage and the facilities. It also does not account for the likely higher amounts of sediment transported during Hurricane Harvey. Therefore, the annual sediment depositional rates calculated at the cross sections in **Table 21** were likely higher than the normal annual sediment depositional rates meaning its unlikely 60% of the annual sediment load (26,347 cubic yard per year from **Table 21** divided by the annual sediment load of 42,198 cubic yards per year) deposited in these cross sections.

Per **Table 21** the sediment traps in ST002 would need to catch approximately 40% of the annual sediment load and be cleaned out annually to offset the annual rate of deposition immediately downstream. The traps at ST003 and ST004 would need to catch approximately 9% and 10% respectively. The annual sediment trapping rate for each facility far exceeds the annual sediment depositional rate. Therefore, each facility will have a direct impact on sediment deposition immediately downstream. Farther downstream from these facilities, the impacts will be less since more sediment will enter the West Fork from other sources as described above.

Table 20: Cross Section Sediment Depositional Volumes compared to Excavated Storage Volume

ST002		ST003		ST004	
Cross Section	Cross Section Sediment Depositional Volume (CY)	Cross Section	Sediment Depositional Volume (CY)	Cross Section	Sediment Depositional Volume (CY)
ST002 DS 01	25,909	ST003 DS 01	9,186	ST004 DS 01	12,278
ST002 DS 02	42,060	ST003 DS 02	22,171	ST004 DS 02	24,866
ST002 DS 03	110,213	ST003 DS 03	5,887	ST004 DS 03	10,900
Cumulative Sediment Depositional Volume	178,181	Cumulative Sediment Depositional Volume	37,244	Cumulative Sediment Depositional Volume	48,043
Cumulative Excavated Storage Volume in Each Facility*	14,120	Cumulative Excavated Storage Volume in Each Facility*	71,290	Cumulative Excavated Storage Volume in Each Facility*	84,220
***From Table 14**					

Table 21: Cumulative Sediment Depositional Volumes Compared to Annual Rate of Sediment Volume in West Fork

Facility Name	Cumulative Sediment Depositional Volume (CY)	Annual Rate of Sediment Deposition Over Ten Years (CY/yr)	Annual Rate of Sediment Deposition Over Ten Years (CY/yr)
ST002	178,181	17,819	40%
ST003	37,244	3,724	9%
ST004	48,043	4,804	10%
Total	263,448	26,347	

6.0RECOMMENDATIONS AND CONCLUSIONS

6.1 RECOMMENDATIONS

Chapter 3.3 through Chapter 3.4 discussed the comparison of facilities and the sediment traps within the facilities using an estimate of the trapped annual sediment volume, the cost to construct facilities, potential implementation strategies, and estimated impacts to flood water surface elevations. Chapter 3.5 summarized these findings.

The conceptual design in this study has more storage volume (i.e., volume of material removed due to excavating the traps) than the annual sediment load being transported by the West Fork, which means most of the studied facilities and their respective traps had the potential to store more sediment than the annual sediment load. Therefore, only one facility is needed and perhaps only one trap in a facility needs to be built.

In-channel sediment traps ST004-02IC and ST004-03IC were found to have a relatively larger efficacy (**Table 14**) and relatively lower implementation costs (**Table 17)**. It is recommended these concepts be shared with the landowner at Facility ST004. If the landowner and operator for Facility ST004 is unwilling to proceed then the next recommended in-channel trap is ST002-01IC. However, it should be noted that ST002 01IC is anticipated to cause a small increase in 100-year flood water surface elevation in the vicinity of the trap (**Table 19**). The proposed construction activities will need to comply with local floodplain development ordinances which do not allow any rise in the 100-year water surface elevation therefore this increase would have to be eliminated. It is recommended a mitigation strategy be evaluated before this trap be furthered into final design.

If the in-channel traps are infeasible or if additional storage is desired then it is recommended that out-of-channel traps should be furthered into design. Out-of-channel have unique design considerations that need to be further explored. Out-of-channel traps at facility ST002 were found to be more effective in capturing sediment (**Figure 15**) and had a lower overall implementation cost (**Table 18**). The following additional study elements are recommended as part of any potential future preliminary design efforts:

- Complete a geomorphic assessment as part of the preliminary design to evaluate how removal of sediments using sediment traps will impact downstream and upstream stability.
- Develop an annual sediment load for the West Fork including downstream of the trapping facilities using a stream gage which has sediment measurement and discharge data. There is such a gage at the Interstate 69 bridge over the West Fork. The bridge is located downstream of the West Fork's

confluence with Spring Creek and the West Fork's terminus with Lake Houston. Determine the total annual sediment load being transported to the Lake by the West Fork. Compare this sediment volume to the volume that is anticipated to being captured by the traps. Compare the sediment load in the West Fork upstream of the traps to the volume that is anticipated to being captured by the traps.

- Since the perimeter for all in-channel sediment traps were drawn from aerial photography, conduct a topographic survey to map one foot contours and to define the boundaries of established vegetation and other pertinent features as part of the preliminary design.
- If landowner is willing to pay for operating costs for bedload collector, consult with the US Army Corps of Engineers Engineering and Research Development unit who sponsored the bedload Mackinaw River Project to estimate production from a bedload collector.
- Adjust the width and depth of the proposed excavation for in-channel traps to balance the amount of potential storage volume with the cost to construct the trap.
- If changes to the conceptual width and depth of the in-channel traps are completed as part of preliminary design, the POWERSED/FLOWSED should be run to understand how the sediment trap's efficacy will be reduced over time as the sediment trap fills up. It is recommended that the modeling be run when the sediment trap is empty, half full and three quarters full.
- Develop a two-dimensional hydraulic analysis for the region around each in-channel trap to calculate shear stresses and velocities and develop a two-dimensional model around each out-of-channel trap to calculate the amount of discharge that is likely to enter the out-of-channel trap's conveyance channel.
- Add more cross-sections to the Efficacy Study Model within the proposed work areas to improve the understanding of the proposed concepts and the 100-year water surface elevations.

6.2 CONCLUSIONS

Conceptual alternatives were developed to investigate the feasibility and efficacy of removing sediment from the East Fork and West Fork San Jacinto River. Ultimately, three facilities on the West Fork were prioritized using remote and field collected data. These facilities were evaluated and conceptual alternatives for in-channel sediment trapping and out-of-channel sediment trapping were identified. The use of bedload collectors, a powered mechanical system to remove sediment, was also presented as an alternative to harvest sediment. A recommendation was made for two in-channel traps within the ST004 facility to be studied further as part of potential future preliminary design. The recommended traps at facility ST004 could harvest most of the West Fork's annual sediment load (**Table 14**, 42,198 cubic yards per year) if they are frequently maintained and would cost around $2.75 million to build (**Table 10)**. This study does not recommend all the West Fork's sediment load be harvested because it could cause unwanted instabilities downstream. Other trapping opportunities are a possibility if the two in-channel traps at ST004 cannot be implemented. The study recommends that in-channel traps be explored first for final design before out-of-channel traps due to the latter's complexity with design challenges, infrequency of inundation and permitting considerations. The study recommends a geomorphic evaluation to determine the appropriate amount of sediment to be removed each year.

It was also recommended to explore the productivity of bedload collectors by consulting with the US Army Corps of Engineer's Engineering Research and Development Division, who have used these systems in a riverine environment, and if a landowner is willing to pay for the operation and maintenance cost for this system. The findings from Chapter 5.0 suggest the traps can reduce, if not mitigate, sediment deposition immediately downstream of the facilities. Chapter 5.0 also suggests recommendations on how to evaluate sediment trapping as part of a larger sediment budget to evaluate its efficacy for regions further downstream.

7.0 REFERENCES

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Appendix A

San Jacinto River Sediment Trap Development: Sediment Trapping Efficacy Memorandum

TECHNICAL MEMORANDUM

FREESE AND NICHOLS

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TO: Matt Barrett, P.E., Division Engineer
San Jacinto River Authority

CC: Michael Reedy, P.E.

FROM: George Fowler, P.E.; S. Connor Kee, G.I.T.

SUBJECT: Sediment Trapping Efficacy Memorandum

PROJECT: SJ River Sediment Trap Development (SJR20297)

DATE: August 18, 2020

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INTRODUCTION

This memorandum is an interim deliverable in the San Jacinto River and Tributaries Sediment Removal and Sand Trap Development project (Sediment Trap Project), describing the efforts completed in Tasks 1103.2 through 1103.5 in the scope of work. This memo summarizes a preliminary evaluation of the sediment trapping efficacy of three sediment trapping facilities which were selected in the Sediment Trapping Locations Memo (dated June 15, 2020). A more detailed analysis of each facilities' sediment trapping efficacy will be completed to fulfill Task 1107. The deliverable in Task 1107 is the Conceptual Design Report.

The Sediment Trapping Locations Memo (Task 1102.6) described how these three facilities were located. These sites were chosen on the basis of:

- Potential sediment loads for each facility estimated using LiDAR data
- Proximity to Aggregate Production Operations (APO) that are actively mining
- Favorable site characteristics for trapping sediment

This memorandum (referred to as the Sediment Trapping Efficacy Memo) presents the work completed to develop the hydrology and hydraulics used to determine the frequency of which notable particle size fractions of the West Fork's sediment load will deposit in each sediment trap facility. This relationship is referred to as sediment competency. This approach calculates the ability of the West Fork to transport various sediment sizes at each of the three facilities. This calculation was completed for several discharges whose results were then plotted. The results for the sites were compared to one another to identify which of the three facilities had the least ability to transport the smallest sediment size. A facility located where the stream could transport the least sediment when compared to other facilities was deemed the facility with the highest sediment trapping efficacy because more of the sediment load would deposit than at the other facility locations.

BACKGROUND

The goal of the Sediment Trapping Project is to capture sediment through deposition. Deposition occurs naturally and is a function of the balance between the physical properties that transport sediment downstream and the physical properties that stop sediment movement. Sediment transport in a stream includes sediment rolling along the sedimentary bed that is too heavy to be lifted above it (referred to as bedload) and sediment in suspension within the turbulent flow of water (suspended sediment and washload) – (USACE 2003 and Biedenham and Thorne 2006). Washload typically consists of the smallest 10 percent of sediment size and deposits only in placid water. This Sediment Trapping Efficacy Memo will focus on bedload and suspended sediment, which fall out of the water more easily. The conditions that transport sediment and resist transport will be computed for each of the three selected facilities at several discharges. Preference will be given to facilities whose conditions favor sediment deposition (the forces that resist transport exceed those that transport sediment). It was assumed deposition will occur more frequently at these facilities and they will therefore be a more productive sediment trap.

Hydraulic Conditions for Sediment Transport

The force created by the hydraulic conditions is referred to as shear stress (a force, measured in weight per square area such as pounds per square foot). Shear stress which acts along a sediment grain is often referred to as applied shear stress or grain shear stress ((Julien 2010) (Wilcox 2001)) and will be called grain shear stress in this memorandum. Grain shear stress is calculated using water velocity, energy grade line slope and average water depth. These variables were calculated under seven studied hydraulic conditions using a US Army Corps of Engineers HEC-RAS hydraulic model developed for the San Jacinto Regional Watershed Master Drainage Plan (SJRWMDP). The discharge in each hydraulic condition modeling run varied from facility to facility therefore there was a unique grain shear stress for each facility.

Physical Properties to Resist Movement

The condition in which a sediment size begins to move and continues in transport is referred to as incipient motion. Incipient motion is critical in evaluating sediment management strategies (Ashiq and Doering 2006) such as sediment trapping. The physical conditions conducive to incipient motion are a function of sediment physical properties, physical properties of water and in the case of sand dominated river systems, fluidization of the riverbed (Holmes 2010). The resistance to movement of a sediment grain is mostly due to size and weight, as well as a sediment grain's size in relation to other sediment grainsizes around it (Wilcock and Crowe 2003, Li and Zhang 2019). Sediment physical properties include specific density, size and water properties include kinematic viscosity and specific density.

The physical force resisting sediment transport is referred to as critical shear stress. When grain shear stress is higher than the critical shear stress, incipient motion occurs. Each particle size has a critical shear stress. An estimated particle size distribution (PSD) of the bedload was developed and the same bedload PSD was used for each facility. Therefore, the critical shear stress for each studied sediment size was the same at each facility. Three sediment sizes are considered, the D_{50}, D_{84} and D_{15}, which are the median sediment size, the sediment size larger than 84 percent of the transported sediment and the sediment size larger than 15 percent of the transported sediment respectively. If the median sediment size (D_{50}) is being transported through the three sites, then it can be said "most" of the sediments in the bedload size distribution are being transported. The D_{84} and D_{15} represent sediment sizes that are notably bigger and notably smaller than the median sediment size.

Efficacy of Selected Sites

The grain shear stress produced at each discharge was compared to the critical shear stress for each sediment size at each of the selected locations for proposed sediment trapping. Preference would be given to a selected facility if grain shear stresses were more often less than the critical shear stress motion needed to move the three studied sediment sizes. This comparison assumes that the sediment sizes being studied are in motion when they reach a selected facility.

METHODOLOGY

Hydrology

The goal of this memorandum is to compare the efficacy of each facility in trapping sediment with preference given to facilities that are more prone to deposition. Deposition was calculated during hydraulic conditions which ranged from several times a month to once every two years. Mean and maximum daily discharge data were downloaded from USGS gage 08068090 (location shown in **Figure 1**) for the period of record (water year 1985 through water year 2019). Mean daily discharge data were available for the entire period of record, except for a gap between 1995 and 2001; and maximum daily discharge data were available from 2007 to 2016. For the time periods with both maximum daily and mean daily, maximum daily was divided by the mean daily to calculate a ratio, often referred to as a peaking factor. The average of all the ratios was calculated and then multiplied to all the mean daily discharges resulting in an "adjusted mean daily discharge", i.e. a mean daily discharge with a peaking factor. The average ratio of maximum daily discharge to mean was 1.18 while the 75th percentile of max-to-mean ratios was 1.22 (a 4% difference). Mean daily discharge values were adjusted using a factor of 1.18. Adjusted mean daily discharges were used to evaluate the frequency by which grain shear stress exceed critical shear stress.

Figure 1. USGS Gage Location

All the adjusted mean daily discharges (n=10,591) were organized from largest to smallest and an exceedance probability –in which a given flow is equaled or exceeded – was calculated for each value of daily mean discharge using the following equation (Weibull Plotting Position):

$$P = \left(\frac{M}{n+1}\right)$$

Where P is the exceedance probability, M is the rank of a given discharge (from highest to lowest), and n is the total number of records in the dataset. **Figure 2** shows the flow duration curve (FDC) which is a plot of the probability a particular discharge occurred during the data record. For example, 100 cubic feet per second (cfs) had an exceedance probability of approximately 0.5. Another way of phrasing this is 100 cfs occurred roughly half of the time in the data record (34 years). Another example is 1,800 cfs. This had an exceedance probability of 0.1 which means 10 percent of all flows in the data set are equal to or higher than this value. Large flood events such as Hurricane Harvey plot closer to the "0" value with very small exceedance values (0.001 or less) and occur once or twice in the data period. The data record is 34 years long and if an assumption was made that it is representative of the discharges occurring in any given year then 100 cfs or higher discharges would occur roughly half the time and 1,800 cfs or higher would occur 10 percent of the time, perhaps a couple times a year.

Seven plotting positions on the FDC were selected arbitrarily along the upper third of the curve (0.3, 0.2,0.1, 0.05, 0.015, 0.009 and 0.008). It was assumed that on the upper third of the curve a notable percentage of the sediment load would be moving. These are presented in **Table 1**. The largest selected discharge at 0.008 plotting position was 11,495 cfs. Often an annual percent chance exceedance figure is created to understand the annual percent chance a discharge will occur and the annual return interval (the reciprocal of the annual percent chance). An annual percent chance figure (**Figure A-1A**) was created from the annual peak discharges at the same USGS stream gage, using a regional skew of 0.1776044 and following Schedule 17C frequency analysis procedures using Weibull plotting positioning. The 11,495 cfs plots out to roughly 0.5 exceedance which is equivalent to a 2-year return interval. Another way of expressing this is the discharge occurs approximately once every two years. However, the annual percent chance exceedance only includes a single maximum discharge for each year in the data set used in the statistical analysis. This approach excludes other large discharges that occur in the year that may be of interest to further understand occurrence frequency. For example, if the three largest discharges in a year were 50,000 cfs, 20,000 cfs and 15,000 cfs, only the 50,000 cfs value would be included in the annual percent chance exceedance statistical analysis. For this study, the 20,000 cfs and 15,000 cfs are important because they exceed 11,495 cfs and are helpful in determining occurrence frequency.

A partial duration curve was developed to further explore how occurrence frequency. The partial duration curve was created by selecting a base-value and removing all adjusted average daily discharges beneath this base-value accounts . The base-value was arbitrarily selected from a plot of annual peak discharges (**Figure A-1B** in the appendix) at a discharge value (8,712 cfs) that appeared to occur most frequently on an annual basis (n=155). For this statistical analysis, it is desirable to remove discharges which occur during the same flood event, because they are not independent events. Therefore, consecutive days of adjusted average daily discharge were removed after selecting the maximum discharge which occurred during the consecutive days. The remaining discharges (n=46) were plotted using the Weibull plotting position and can be seen in **Figure A-2**. The 11,495 cfs discharge plots at an 0.6 exceedance which suggests this discharge may occur more frequently than once every two years.

Discharge (cfs)	FDC Exceedance Probability	Discharge (cfs)	FDC Exceedance Probability
11,495	0.008	1,947	0.1
10,411	0.009	709	0.2
8,192	0.015	342	0.3
3,718	0.05		

Table 1 : Selected Values From the FDC Curve

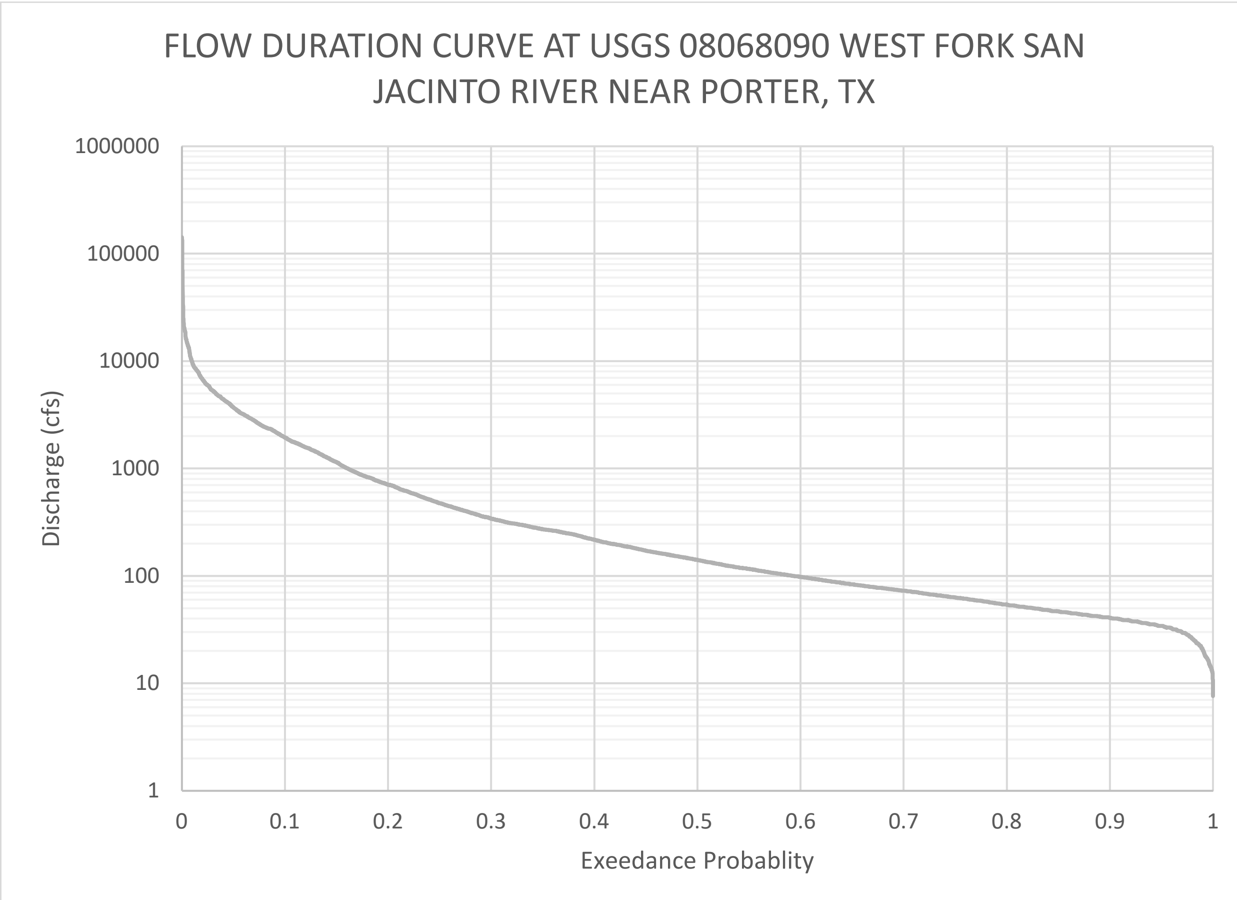

Figure 2. Flow Duration Curve

The HEC-RAS model (RAS model) created in the San Jacinto Regional Watershed Master Drainage Plan (SJRWMDP) was obtained, reviewed and truncated to include only the study area. The model's geometry file was reviewed and a cross section upstream of each of the three facilities was identified as shown in **Figure 3**. This RAS model was completed in an unsteady state flow condition which means water surface elevations and other hydraulic constituents were calculated at time intervals during a study period (seven days). The hydrograph for the smallest studied flood event in the SJRWMDP (the 2-year flood) was extracted for each of the three cross sections. The peak discharge from each hydrograph was selected. The peak discharge at section 263322 was divided by the largest studied discharge (11,495 cfs) from the flow duration curve presented in **Table 1.** The resulting ratio was used to create a synthetic hydrograph by multiplying the ratio by the discharge at each time interval:

$$Q_i = Q_j * (\frac{Q_{FDC}}{Q_{max}})$$

Q_i = the discharge at a time step in the hydrograph

Q_j = the discharge occurring in the 2-year flood hydrograph at a particular time step (cfs)

Q_{max} = the peak discharge from the 2-year flood hydrograph (cfs)

Q_{FDC} = a peak discharge value from **Table 1**

This was repeated for each discharge selected from the flow duration curve (in **Table 1**) for Q_{FDC} resulting in a unique hydrograph for each studied discharge at section 263322.

The peak discharge at section 235639 from the hydrograph for the smallest studied flood event in the SJRWMDP (the 2-year flood) was divided into the peak discharge for section 263322 from the SJRWMDP 2-year modeling run. The resulting ratio represented the increase in discharge from section 263322 to section 235639. This ratio was multiplied for each time interval for the seven day period resulting in a new hydrograph. This was repeated for each studied discharge in **Table 1** at section 235639**.** The same procedure was completed for section 210069. The peak discharges for the three sections can be seen in **Table A-1** in the Appendix**.**

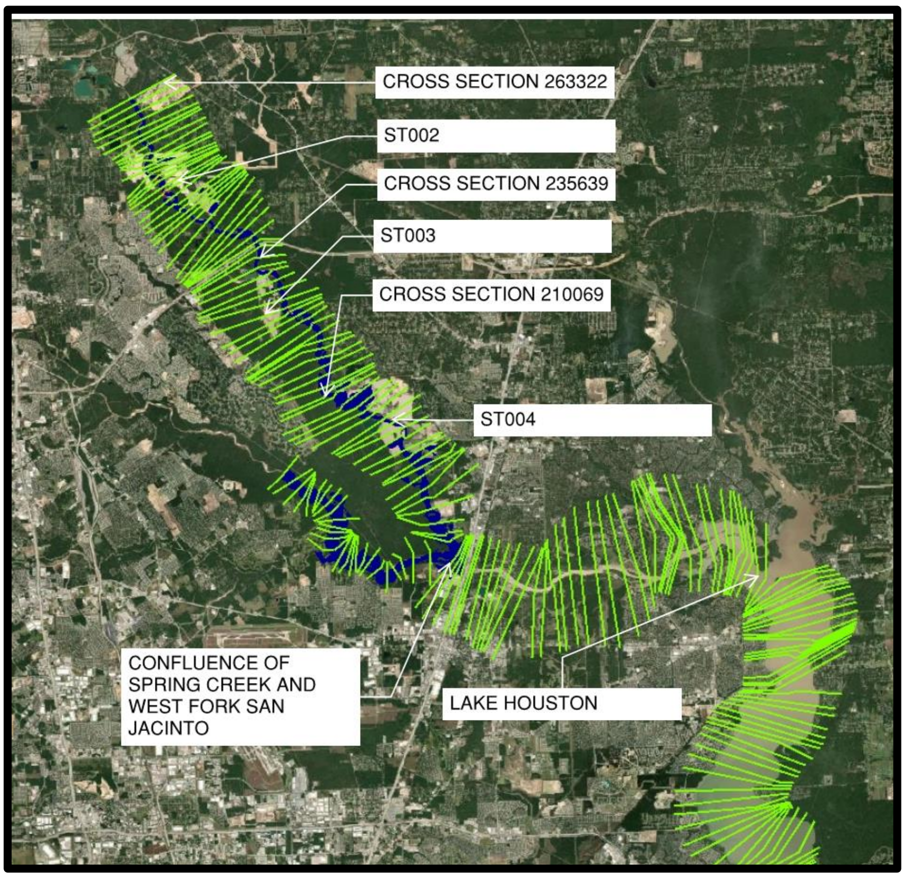

Figure 3. Cross Sections Used in Truncated HEC-RAS Model

The drainage areas for the USGS stream gage and cross section (263322) were measured and determined to be 962 mi^2 and 935 mi^2, respectively. The drainage area difference was small (2.8%) therefore it was assumed the flow duration curve created from gage was a reasonable approximation of the discharges at cross section 263322.

Determination of Critical Shear Stress

The force resistance to movement and transport is critical shear stress. Critical shear stress is calculated from a dimensionless critical shear stress by Equation 1. Two methods are presented to calculate dimensionless critical shear stress (Julien 2010 and Miller 1977) as shown in Equation 2 and Equation 3. The sediment size for the D_{50}, D_{84} and D_{15} were selected for study since the D_{50} is the median particle size in the West Fork's sediment load and the D_{84} and D_{15} are notable larger and smaller particle sizes in the sediment load respectively. A critical shear stress was calculated for each sediment size.

<u>Critical Shear Stress $(\tau)_c$ converted from SI units to Imperial units (pounds/square foot)</u>

Equation 1: $\tau_c = \tau *_c (\sigma_s - \sigma_w)\text{g}\rho\text{D}/47.88$

<u>Dimensionless Critical Shear Stress $(\tau *)_c$ converted from SI units to Imperial units (pounds/square foot)</u>

Equation 2: $\tau *_c = (0.105(S*)^{-0.3} + 0.045\, exp[-35(S*)^{-0.59}])$ (Miller 1977 presented in Wilcox et alt. 2009,)

Equation 3: $\tau *_c = (S_p(\sigma_s - \sigma_w)(g\theta D_{50}))$ (Julien 2010)

Where:

ρ_s= Specific density of sediment= 2.65

ρ_w= Specific density of water = 1.0

σ= density of water= 997 kg/m^3

v= kinematic viscosity= 0.00000114 m^2/sec

S_p= Shields Parameter =$0.3 * EXP\left(-\frac{d^*}{3}\right) + 0.06 * tan(\emptyset) * (1 - EXP(\frac{d^*}{20})$

d^*= dimensionless particle diameter= $D_{50}(g(\sigma_s - \sigma_w)/\mu^2)^\wedge 1/3$

S= dimensionless viscosity=* $= (g(\left(\frac{\sigma_s}{\sigma_w}\right) - 1) * D_{50}{}^\wedge 3)^\wedge 0.5/v$

The West Fork's sediment load's particle size distribution is mostly sand (HCFCD 2011). This was confirmed by field observations as presented by a representative image of a point bar (a sand bar located on the inside of a meander) in ST004 as seen in **Image 1 and Image 2**. A particle size distribution was then developed (**Figure A-3 in Appendix**) whose distribution was made of mostly moderate coarse sands with the largest particles being fine gravels. The values for D_{50}, D_{84} and D_{15} were obtained from **Figure A-3** and the critical shear stress was calculated for each value as shown in **Table 2**. The D_{15} critical shear stress for Julien 2010 was slightly higher than the D_{50}, which means most of the sediment in the moderate coarse sand size and finer will have roughly the same critical shear stress.

Image 1: Picture looking down at pit dug below the surface of a sand bar in ST004

Image 2: Looking downstream at the same sand bar in Image 1 in ST004

D	Size (mm)	Miller 1977	Julien 2010
D_{84}	5.23	0.07047	0.07969
D_{50}	0.250	0.00387	0.00412
D_{15}	0.13	0.00270	0.00471

Table 2 : Calculated Critical Shear Stress for Selected Particle Sizes

Determination of Grain Shear Stress

Equations 4 and 5 below are different methods for estimating grain shear stress caused by local hydraulics such as water depth, velocity and the slope of the energy grade line. Grain shear stress is the physical force to which moves sediment. Equations 4 and 5 were used to determine grain shear stress (τ') converted from SI units to Imperial units (pounds/square foot):

Equation 4: $\tau' = ((17 * U^{\frac{3}{2}} * (SD_{65})^{\frac{1}{4}}))/47.88$ (Wilcox et alt 2009)

Equation 5: $\tau' = ((d * (U/((\frac{2.3}{k}) * log\left(\frac{d}{Ks}\right) + 6.25))\text{^}2)/47.88$ (Julien 2010)

Where :

U= Depth averaged velocity (m/sec)

S=slope of channel

D_{50}=average particle size of channel bed (mm)

D_{65}=sixty-five percent particles are finer than (mm)

K= Von Karman's Constant= 0.41

*K_s= roughness height= 3.5*D_{84} (mm)*

d= mean flow depth (m)

In-channel sediment trap locations were identified in the Sediment Trapping Locations Memo from Task 1102.6. These features are located proximally vertically to the average daily water surface elevation. These features will be inundated frequently with sediment laden water, likely several times a year. Therefore, the cross sections occurring near the in-channel sediment traps are reasonable locations within each selected sediment trap facility to compare local hydraulic conditions that govern sediment transport and sediment deposition. A location map of all sediment trap features (in-channel and out of channel) and cross sections can be seen in **Figure A-4, Figure A-5 and Figure A-6** for ST002, ST003 and ST004 respectively.

The cross section closest to each in-channel sediment trap location (total of six in-channel sediment traps were located) was selected to calculate grain shear stress. The in-channel sediment trap locations and their cross sections were grouped. The most upstream cross sections in each site were grouped together (referred to as the upstream group) and the remaining three cross sections were organized into the downstream group. Equations 4 and Equation 5 were calculated for each cross section and results were obtained. Results from Equation 5 are presented in **Figure 4 and Figure 5** and results using Equation 4 are presented in **Figure A-7** and **Figure A-8**. **Figure 4 and Figure 5** was arbitrarily selected to include in the main body of the report.

Figure 4 and Figure 5 are used to evaluate if the grain shear stress is higher than the critical shear stress for each of the studied sediment sizes (D_{84}, D_{50}, D_{15}) for each of the seven studied discharges in **Table 1**. The flow exceedance probability (on the "X-axis" of the plot) was organized from less frequent (i.e. lower exceedance probability) to more frequent. If a continuous line (grain shear stress) is higher than a dashed line (critical shear stress) then the sediment size will be in transport. If a facility's continuous line intersects the dashed line at a lower flow exceedance level before another facility's continuous line intersects the same dashed line then the former facility transports the same sediment size less frequently than the comparative facility. This also means the former facility is potentially more prone to deposition.

In **Figure 4**, ST002's continuous line is higher than the other facilities. This means more of the sediment load will be in transport when compared to the other facilities. **Figure 4** also shows for facilities ST004 and ST003, the D_{50} critical shear stress is more than the grain shear stress at approximately the 0.2 exceedance probability. This means for roughly 80 percent of the discharges along the flow duration curve, most of the sediment load is not transported at ST004 and ST003. In **Figure 5** ST004 also appears to stop transporting the D_{50} at the 0.2 exceedance whereas most of the sediment load is still in transport at the other two facilities. The relationships of grain shear stress between the facilities in **Figure 4 and Figure 5** are similar to the plots found in **Figures A-7** and **A-8**. Stream power, a hydraulic constituent, often used by geomorphologists and engineers to describe the power of the river in moving sediment is presented **Figures A-9** and **A-10**. Stream power presented in these figures was extracted from the RAS model and is a vertical average of the stream power across a cross section and therefore is considered a less reliable predictor of the actual force acting along the stream bed. The findings when comparing grain shear stress to critical shear stress suggests ST004 and ST003 are more prone to deposition than ST002 because the grain shear stress is more frequently less than the critical shear stress. and potentially could be more productive in trapping sediments.

Figure 4 and Figure 5 show there are multiple locations where the grain shear stress (the force causing motion) of the D_{50} (the median particle size of the bedload) is less than the critical shear stress (the force resisting motion). This finding suggests most of the bedload will begin to deposit at a discharge that occurs roughly around the 0.2 exceedance probability. From the flow duration curve in **Figure 1**, the discharge occurring at the 0.2 exceedance is 700 cfs. Plotting 700 cfs on the percent chance exceedance in **Figure A-1A**, this discharge happens about 98% or roughly once a year. Plotting 700 cfs on **Figure A-1B** shows this discharge frequently occurs multiple times a year. The product of 0.2 and 10,591 days (the number of days discharge was recorded in the 34-year flow duration curve) is 2,118 days. This means the discharge of 700 cfs was equaled or exceeded 2,118 days in the record which is an average of 62 days per year. This is a beneficial finding for sediment trapping since this material potentially can be deposited in an in-channel trap multiple times a year.

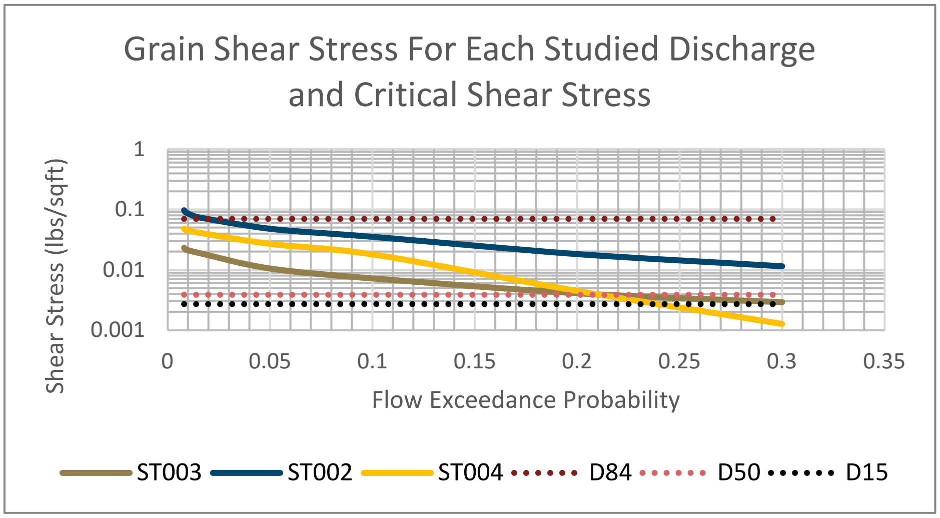

Figure 4 Comparison of Grain Shear Stress (Using Julien 2010) to Critical Shear Stress for Upstream Group

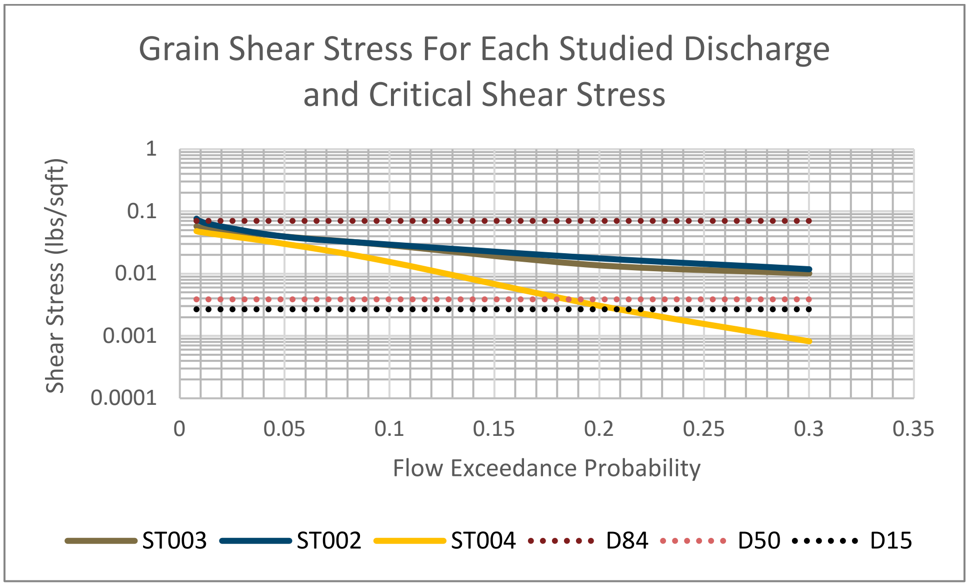

Figure 5 Comparison of Grain Shear Stress (Using Julien 2010) to Critical Shear Stress for Downstream Group

Water Surface Elevations and Out of Channel Sediment Traps

Out of channel sediment trap locations were also identified as part of the Sediment Trapping Locations Memo. These sediment trap opportunities work when sediment laden water enters a proximal Aggregate Production Operation (APO) pit, slows down and deposits it's sediment. The pit and the river are connected by a diversion channel which begins at the neighboring stream bank and continues to the pit. The diversion channel bottom elevation is established as a balance between priorities of establishing a desired frequency for sediment laden water entering the pit while also ensuring the river does not change alignment and sweep through the pit. **Figures 4, 5, A-7 and A-8** can also be used to estimate productivity of out of channel trap opportunities. It was assumed that the sediment load in the West Fork is well mixed meaning sediment will be distributed throughout the water column. It is well understood that coarser grains will generally stay along the bottom of the water column and finer grains along the top. For evaluating efficacy for out of channel sediment trap locations, this vertical distribution of sediment size is not important. Sediment size distribution will be important in making decisions about the type and location of sediment traps and will be included in the Conceptual Design Report (as discussed in this memorandum's introduction). If the continuous line in **Figures 4, 5, A-7 and A-8** is higher than the dashed line of the D_{50} this means most of the sediment load is in suspension. If a facility's continuous line intersects the dashed line of the D_{50} at a higher flow exceedance probability than the intersection of a comparative facility, this means most of the sediment load is in suspension more of the time at the former facility. This is a favorable condition for out of channel sediment trap locations. **Figure 4** suggests facility ST002 has more favorable conditions for out of channel sediment traps then the rest of the facilities.

These results need to be balanced with constructability and management decisions. The more frequently the out of channel trap is connected to sediment laden water from the river, the more frequent maintenance must occur. Establishing the desired frequency and the expected frequency sediment will enter the pit is therefore an APO management decision because it will establish the expected frequency the sediment will have to be removed. Once this management decision is made, a discharge can then be selected from the flow duration curve and a water surface elevation is then calculated. From a constructability perspective, preference is given to locations where the stream bank elevation is closer to the water surface elevation which occurs at the desired discharge because this will result in less excavation to build the diversion channel.

Locations of out of channel sediment traps are presented in **Figures A-4** through **A-6**. The nearest upstream cross section at each out of channel sediment trap was selected. Water surface elevations at each selected cross section from the RAS model are shown in **Figure A-11** through **A-14**. The elevations of the bank height and water surfaces of the four largest discharge events studied in this memorandum are presented in **Table 3** for comparison.

The difference between the bank height and water surface elevations is much smaller for ST004 than for ST002. The smallest elevation difference between water surface elevations and a proximal bank height is at facility ST004, cross section 197383. The difference between the bank elevation and water surface elevation occurring at the 0.05 exceedance (i.e. the water surface elevation in which 5 percent of the water surface elevations in the flow duration curve were higher than) was 11.4 feet. It is reasonable to expect that this water surface elevation would occur several times in a year. At the same location, the water surface elevation and bank elevation at the 0.009 exceedance (the 2-year annual return period discharge in the SJRWMDP) are 6.9 feet apart. These findings suggest that a preference be assigned to ST004 for off channel trapping with reasonable opportunities at cross section 19783. The next preference was assigned to cross section 280711 where the difference between bank height and water surface elevation at the 0.05 exceedance and the 0.009 exceedance was 14.3 feet and 9.1 feet respectively.

				Water Surface Elevations (difference with bank height)			
Facility	Cross Section	Trap Identification	Bank Elevation	0.008 FDC	0.009 FDC	0.015 FDC	0.05 FDC
ST002	259001	ST002_010C	98.0	82.0 (16.0)	81.4 (16.6)	80.2 (17.8)	76.1 (21.9)
ST004	208711	ST004_01C	71.0	61.9 (9.1)	61.3 (9.7)	60.5 (10.5)	56.7 (14.3)
	200293	ST004_02C	71.9	60.3 (11.6)	59.7 (12.2)	58.9 (13.0)	55.4 (16.5)
	197383	ST004_OC	66.3	59.4 (6.9)	58.8 (7.5)	58.1 (8.2)	54.9 (11.4)

Table 3: Comparison of Bank Elevations to Water Surface Elevations at the Four Highest Discharges (i.e. the Lowest Exceedance Probabilities)

RECOMMENDATIONS AND CONLCUSION

Recommendations

The efforts completed in this Sediment Trapping Efficacy Memorandum should be used to support the Conceptual Design Report (Task 1107.1). The values of the flow duration curve and the work to establish the hydrology and hydraulics in the RAS model can be used to calculate the annual volumetric sediment load being transported through each sediment trap facility under existing conditions. The annual sediment load is a function of the discharges on a flow duration curve, particle size distribution and channel geometry. The Conceptual Design Report will also include modifications to channel geometry in the regions where the in-channel sediment trap will be located. Sediment capacity calculations will be run under existing channel geometry and proposed channel geometry conditions. The difference between the existing annual sediment load and the proposed annual sediment load is the expected amount of sediment to stop moving due to the changes in channel geometry. This is the estimated annual sediment volume to deposit within the facility.

Sediment data has been collected upstream of each sediment trap facility. This data will calculate a particle size distribution of the sediment load to each facility. These results will inform estimates of how well mixed the sediment load in the water column (vertically) which is a key understanding for location sediment trap facilities and what type of trap is useful. For example, if most of the sediment is fine sands which are generally transported higher up in the water column, this would make traps that collect bedload along the bottom of the river less effective. This condition would make off channel sediment traps more effective because water flowing through the diversion channel which connects the river to the trap during the design discharge would be laden with sediment. These evaluations will be completed in the Conceptual Design Report which will be the deliverable in Work Task 1107.

Conclusion

A flow duration curve was developed and several discharges were run through a truncated HEC-RAS model that was originally developed as part of the San Jacinto Regional Watershed Master Drainage Plan (SJRWMDP). The results from this analysis suggest potential sediment trap facilities ST004 and ST003 may have higher efficacy in trapping sediment using in-channel sediment trapping than ST002. ST002 has more favorable hydraulic conditions than ST004 for out of channel sediment trapping but ST004 has shorter heights between calculated water surface elevations and the riverbank height separating the river from proximal APO pits. This is desirable condition because it would result in lower construction costs. ST003 has no identified out of channel sediment trapping opportunities. This preliminary evaluation of sediment trapping efficacy gives preference to facilities ST004 and ST003 over ST002 with a slight preference to ST004.

END OF MEMORANDUM

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Appendix

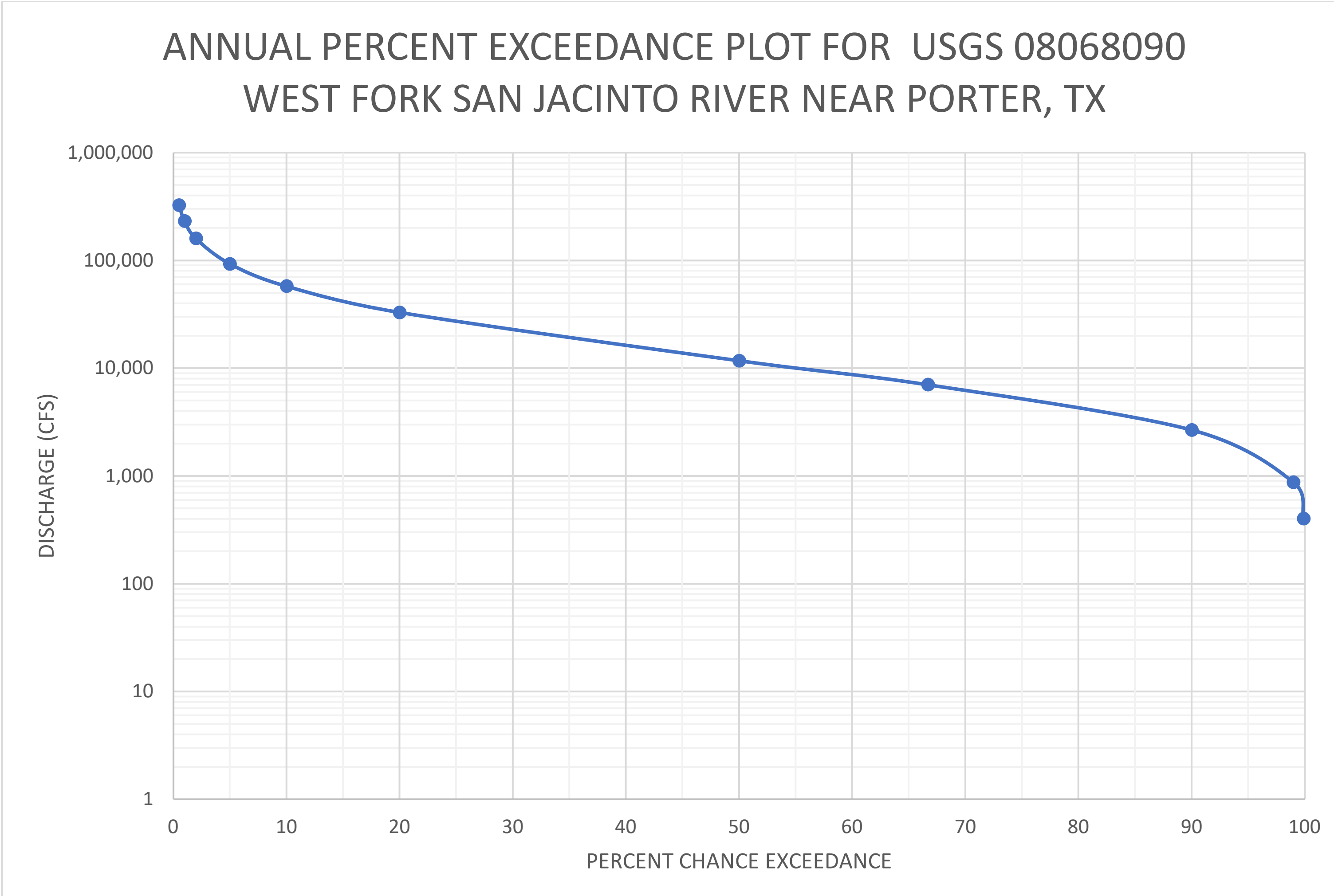

Figure A-1A. Plot of Percent Chance Exceedance of Discharges Using Schedule 17C Statistical Analysis of the Annual Peak Discharges at USGS gage site 08068090

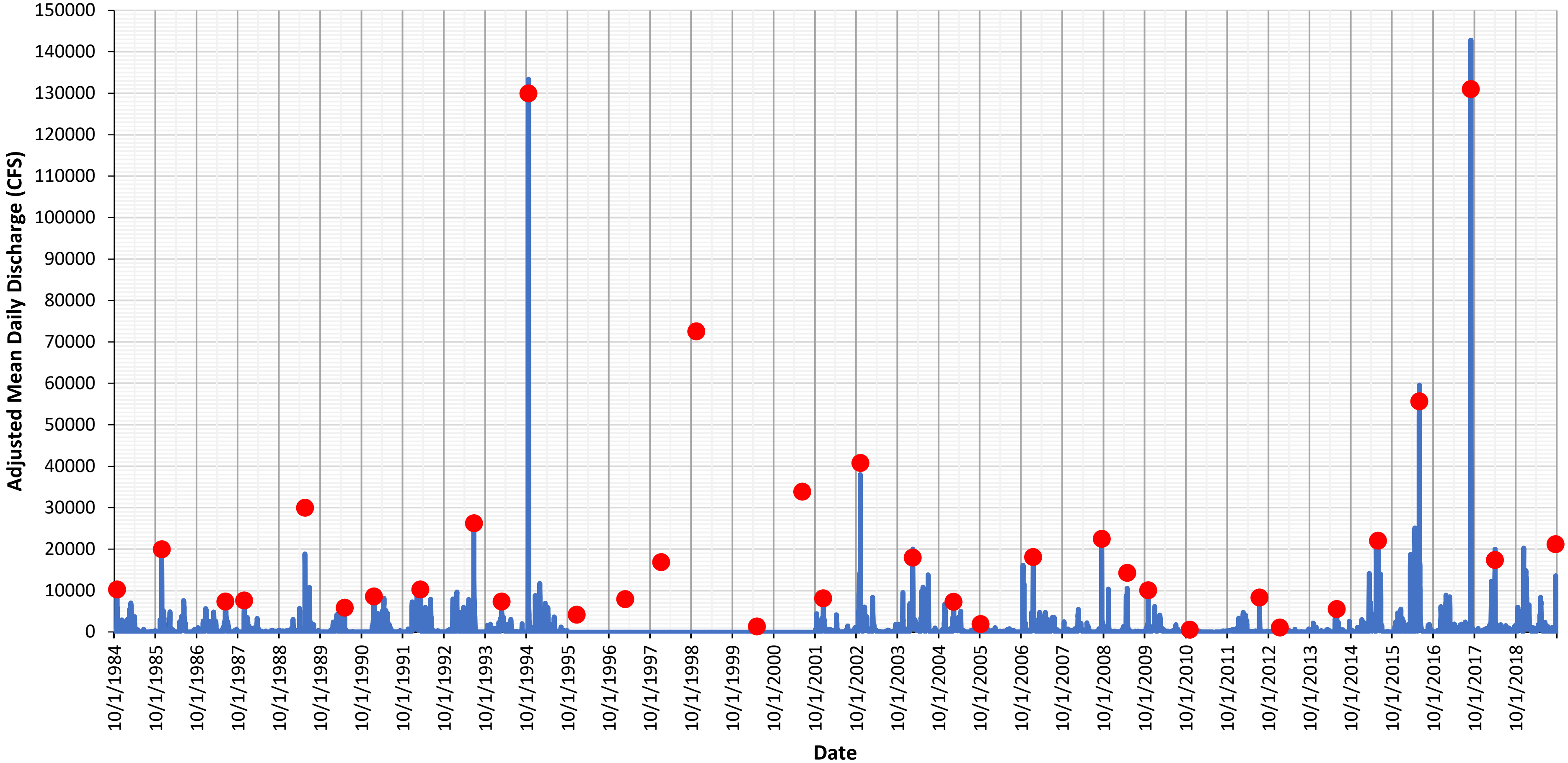

Figure A-1B. Plot of adjusted mean daily discharge through time at USGS gage site 08068090. Major vertical gridlines denote boundaries between water years. Red points represent annual peak flows.

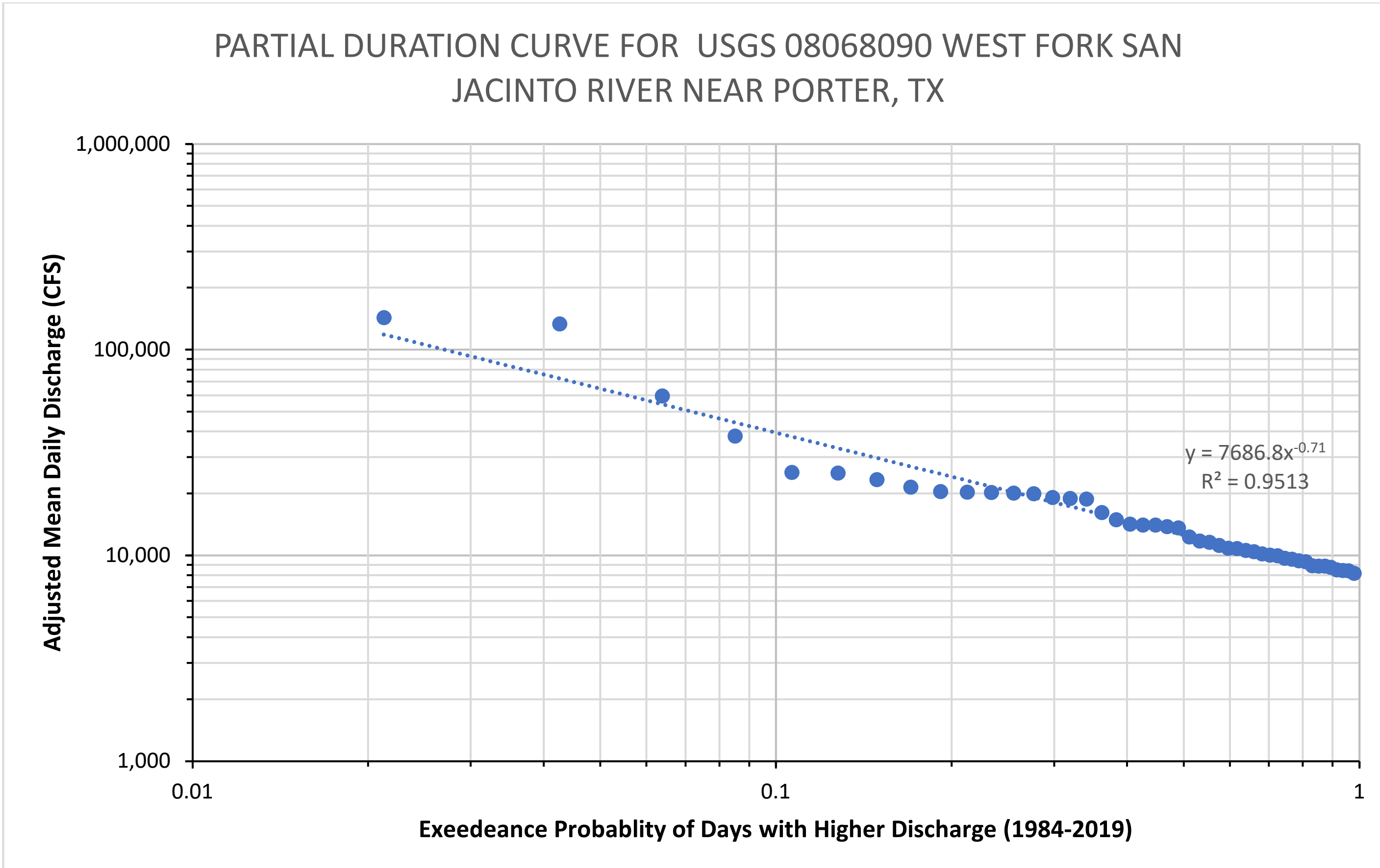

Figure A-2. Plot of adjusted mean daily discharge above a base value of 8,712 measured at USGS gage site 08068090. The trend line is a power function.

FDC Exceedance Probability	Discharge (cfs) At Cross Section 263322	Discharge (cfs) At Cross Section 235639	Discharge (cfs) At Cross Section 210069
0.004	15,688	17,437.81	17827
0.008	11,495	12,793	13,078
0.009	10,411	11,586	11,845
0.015	8,192	9,116	9,320
0.05	3,718	4,137	4,230
0.1	1,947	2,166	2,215
0.2	709	789	806
0.3	342	380	389

Table A-1. Peak Discharges Used to Create Hydrographs in the RAS Model

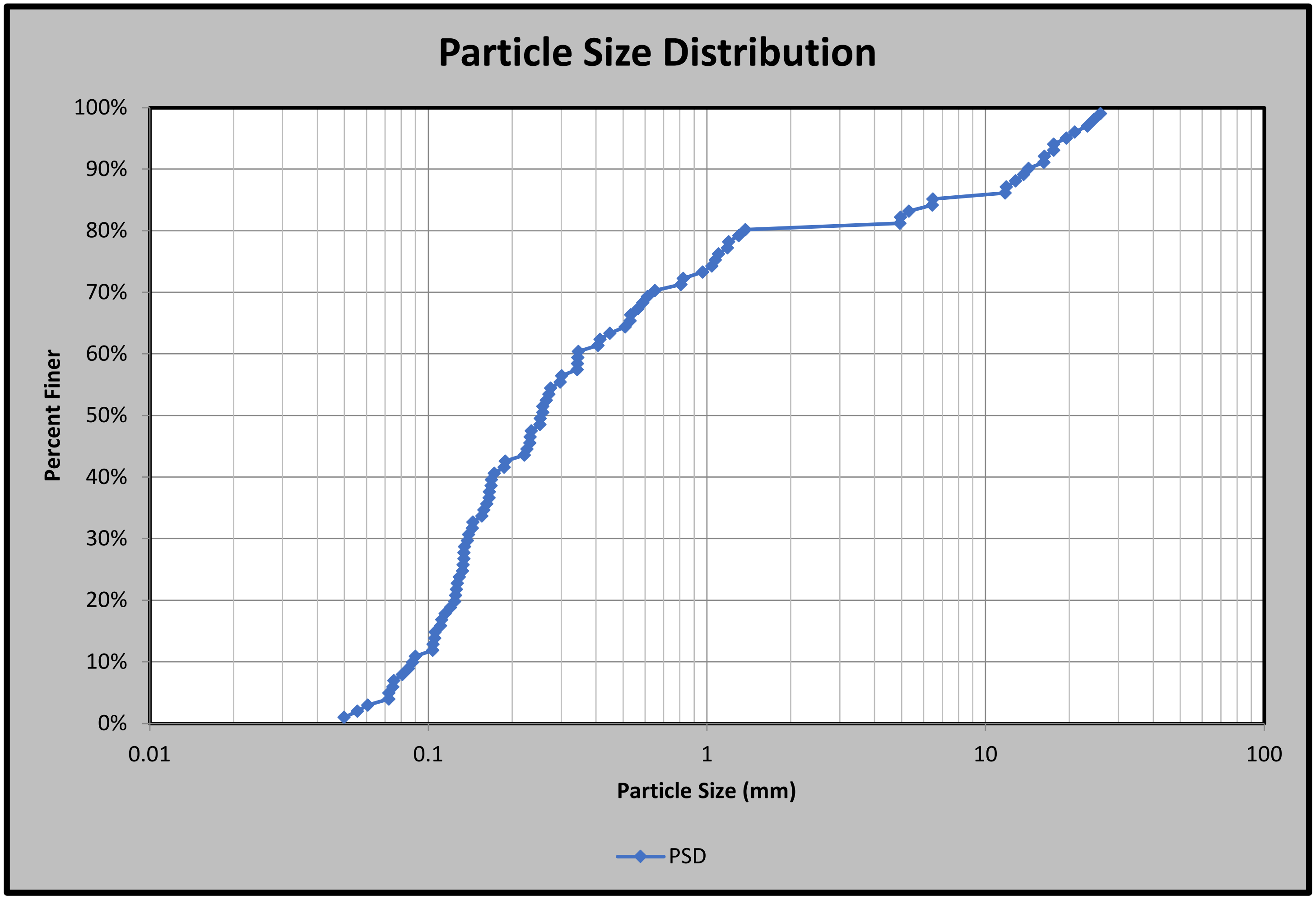

Figure A-3. Particle Size Distribution of Sediment Load At All Selected Sediment Trap Facilities

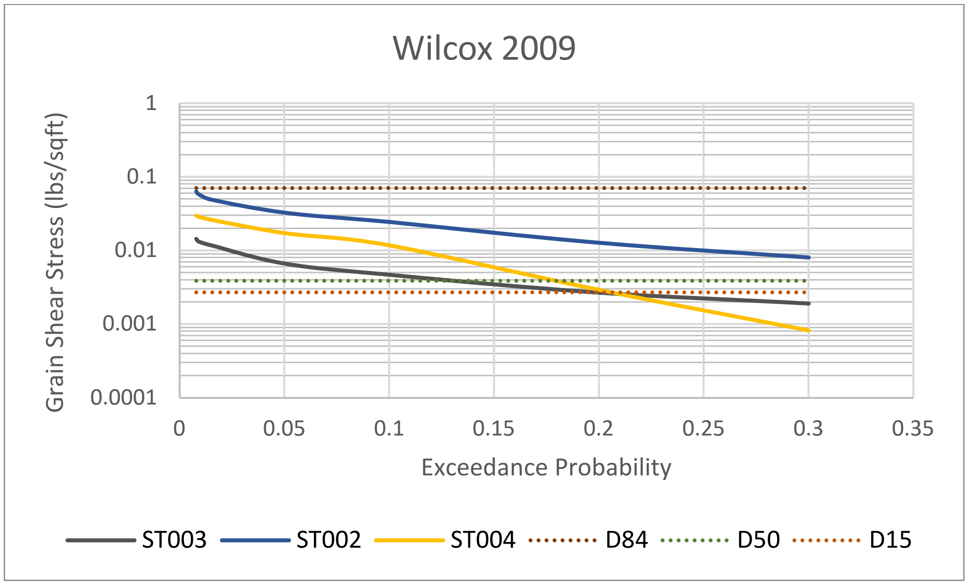

Figure A-7 Grain Shear Stress at Upstream Group

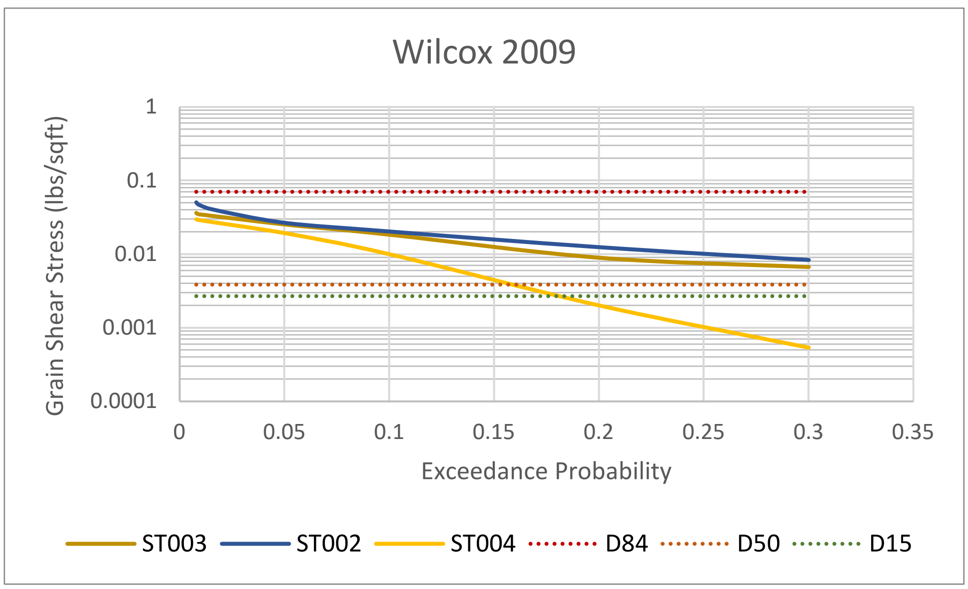

Figure A-8 Grain Shear Stress at Upstream Group

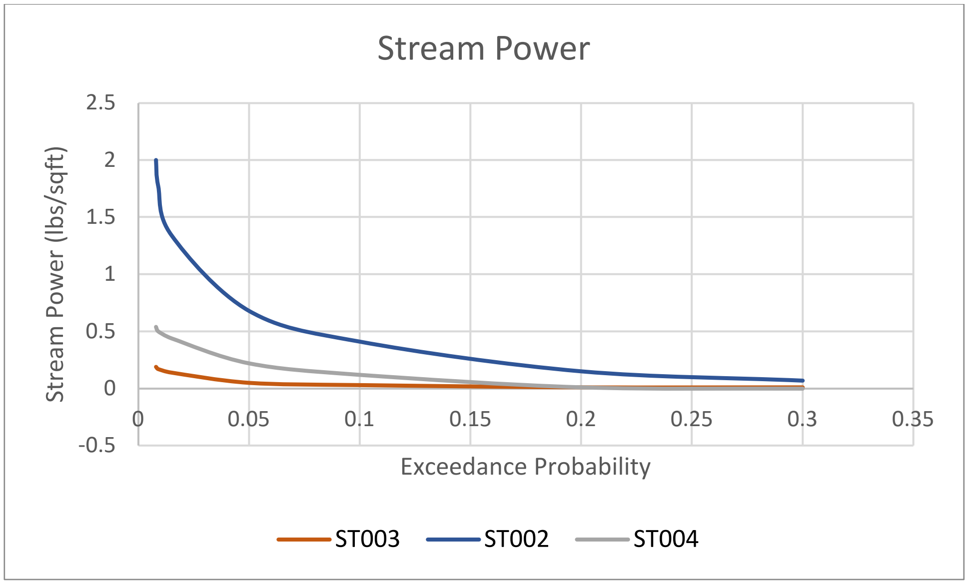

Figure A-9: Stream Power at Upstream Group

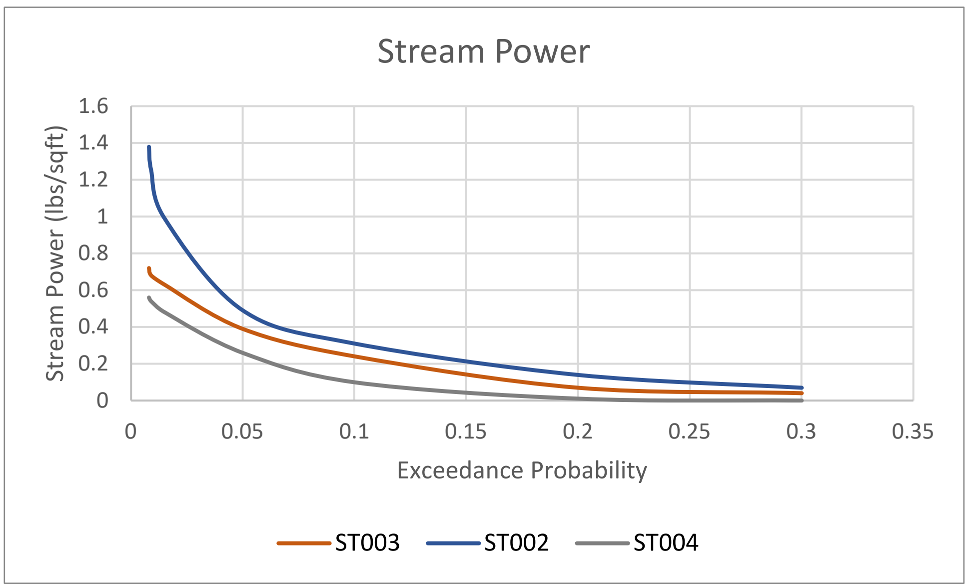

Figure A-10 Stream Power at Downstream Group

Appendix B

San Jacinto River Preliminary Sediment Trapping Location Memorandum

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TO:	Matt Barrett, P.E., Division Engineer San Jacinto River Authority
FROM:	George Fowler, P.E.; S. Connor Kee, G.I.T.
SUBJECT:	Preliminary Sediment Trapping Locations
PROJECT:	AU316288
DATE:	August 10, 2020
CC:	Michael Reedy, P.E.

STATE OF TEXAS
GEORGE DEFOREST FOWLER II
135438
LICENSED
PROFESSIONAL ENGINEER

FREESE AND NICHOLS, INC.
TEXAS REGISTERED
ENGINEERING FIRM
F-2144

INTRODUCTION

The purpose of this memorandum is to present the methodology used to recommend three sediment trapping locations for further study to determine the efficacy in capturing sediments, favorable characteristics for trapping sediment and a conceptual design for each location.

These three locations were selected from a list of potential sediment trapping locations along the West Fork San Jacinto River corridor and East Fork San Jacinto River corridor. The methods used to identify sediment trapping locations are outlined in the scope of work (project number SJRA 20297) and were discussed during meetings between Freese and Nichols, Inc. (FNI) and the San Jacinto River Authority (SJRA). This memorandum and the accompanying attachments serve as an interim deliverable for the San Jacinto River and Tributaries Sediment Removal and Sand Trap Development project.

BACKGROUND

The SJRA and the Harris County Flood Control District (HCFCD) have set a goal to reduce sediment loads that may deposit in the West Fork San Jacinto River by trapping sediments at strategic locations along the West Fork. Initial efforts to achieve this goal are focused along the mainstems of the West Fork and East Fork San Jacinto Rivers, which are the largest tributaries flowing into the lake. The purpose of this deliverable is to locate potential sites for sediment trapping facilities that will reduce sediment inputs into Lake Houston by removing trapped sediments.

These sites are located in regions where sediment deposition occurs naturally to take advantage of favorable hydraulic conditions for sediment trapping. The facilities will be designed so that trapped sediment can be removed to restore the original storage volume in each facility and allow continued sediment trapping. The concept is that the facilities will be maintained through a private-public partnership between SJRA and an existing Aggregate Production Operation (APO). To facilitate that, it is desirable to locate facilities where an APO can have easy access.

MEMO ORGANIZATION

This memo is organized in three sections. The first section describes the methodology used to identify ten sediment trapping facility locations within the East Fork river corridor and West Fork river corridor. The second section outlines how we selected four locations from the list of ten for additional study and site visits. The site visits were used to understand the physical attributes associated with these locations and to further assess the feasibility of these trapping facilities. The final section presents the methods and findings of the additional study and site visits and presents recommendations for three sediment trapping facilities to be further assessed as the overall study continues.

SELECTING THE TEN SEDIMENT TRAPPING FACILITIES

Methodology Summary

The general process used to identify potential sediment trapping facility sites was to:

1. Delineate areas of sediment deposition (referred to as depositional areas) along the East Fork and West Fork San Jacinto Rivers using LiDAR data and aerial imagery.
2. Select ten depositional areas (DA's) by ranking each delineated DA based on the cumulative volume of its depositional volume as well as depositional volumes of neighboring DAs. Define a sediment trapping facility around each selected DA.

Delineation of Aggradation Sites

Data Sources

Locating a sediment trapping facility in regions where sediment naturally deposits uses the natural dynamic of the river system to fill the sediment trap. Natural sediment deposition regions were delineated around a cluster of DAs. A sediment trapping facility will be located within a cluster of DAs to take advantage of natural processes and maximize the amount of sediment captured.

To delineate a DA, a comparison of recent and historical topographic conditions was completed using LiDAR data. These data are often organized by county and mapped during different years. Counties that had LiDAR data collected during the same measuring period were combined into a single file. The most recently collected LiDAR data set, representing 2018 conditions, covered most of the study area and was referred to as "recent LiDAR". LiDAR data measured before recent LiDAR, referred to as "historical LiDAR", had been collected at different times in different counties. **Table 1** lists the various LiDAR data sets used for historic LiDAR and their attributes as well as the attributes for the recent LiDAR.

Data Processing and Aggradation Site Delineation

The 2001, 2008, and 2018 LiDAR data for this study was all provided by HCFCD or downloaded from Texas Natural Resource Informational System (TNRIS). The 2018 LiDAR data was available for the entire watershed and the 2008 LiDAR for the mainstems in Montgomery County and parts of Liberty County. The 2001 data was only available for the portions of the mainstems in Harris County.

LiDAR data measures the vertical distance between a point on the earth and a reference vertical datum. The reference vertical datum is referred to as the geoid which represents average sea level. Average sea level changes over time (NOAA, 2020) requiring the geoid to be updated. LiDAR data used in this analysis was measured at different times from 2001 through 2018. The geoid had been updated during this time span. The geoids used in this study's LiDAR data measurements are listed in **Table B-1 in**

Appendix B. For comparative purposes, the two geoids (geoid99 and geoid12B) used for this study's LiDAR data measurements were checked at various locations throughout the West Fork and East Fork watersheds. Each geoid's elevation was obtained and compared at each location. Locations were selected near spatial boundaries of the measured LiDAR data and along road centerlines. Road centerlines were selected in case an adjustment was needed in the LiDAR. LiDAR precision at these locations was assumed to be the highest due to the lack of vegetation and lack of human activity that could change elevations. An adjustment would be needed if the difference between the geoids was large enough to be deemed unacceptable. The earlier data sources were measured using a different geoid than the more recent data. The differences in geoid were spot-checked around different points in the watershed and the differences were found to be between 1" and 4" (average 2.6 inches). The average difference was acceptable and therefore an adjustment in the LiDAR was not needed. Differences due to subsidence over this time period are also considered to be negligible for purposes of this study.

Once combined and organized, LiDAR data sets were clipped to subbasins and 100-year floodplains to assist with processing. The 100-year floodplains were obtained from the hydraulic modeling efforts in the San Jacinto Regional Watershed Master Drainage Plan (on-going in 2020) which used more recent topography and hydrologic data than had been used to create the effective floodplains. Additionally, the recent (2018) LiDAR data set was reduced to match the extent of the historical LiDAR data sets and subsequently resampled to account for differences in cell size.

Raster math was conducted using ArcGIS software to compare recent and historic topographic conditions. Historical LiDAR data was subtracted from the recent data set. In the resulting raster, positive values denote areas in which the recent LiDAR data has a greater elevation than historical data. These were areas of deposition. Conversely, negative values mark areas in which the recent LiDAR had a lower elevation than historical data, i.e. areas of degradation (referred to as erosion).

The resulting raster, in conjunction with aerial imagery, professional judgement, and knowledge of fluvial geomorphologic processes was used to designate DAs as polygons in ArcGIS. DAs were delineated from upstream to downstream. Delineation focused on areas experiencing at least two feet of aggradation between the historical and recent LiDAR data sets. Each DA was assigned a unique name for identification using a consistent format. For example, the most upstream DA delineated along the main stem of the West Fork San Jacinto River is identified as "WF001", where "WF" represents the West Fork San Jacinto River and "001" denotes the first aggradation site delineated along that river.

The surface area and the average elevation change within each DA were calculated for each DA. Since historical LiDAR data was measured in different years, the time lapse between historical LiDAR and recent LiDAR varied across the study area. To compare elevation changes of DAs from a region with one time lapse to a region with a different time lapse, an average annual depositional volume was computed by dividing the average elevational change by the time lapse between LiDAR data sets. Average elevational change for each DA covered by the 2001 data set were divided by 17 (2018 minus 2001), and average elevational change for each DA covered by the 2008 data set were divided by 10 (2018 minus 2008). The quotient was referred to as the average annual elevation change. The average annual elevational change for each DA was then multiplied by the surface area of each DA to calculate an average annual depositional volume. The time lapse for each of these analyses was relatively short, 10 years and 17 years. There have been notable flooding events during this stretch of time, most notably Hurricane Harvey. It is reasonable to expect larger amounts of erosion and deposition in response to such large flooding events than on any average year. Therefore, the average annual depositional volume and average annual erosional volumes (a calculation presented later in this memo) may be larger than the true average annual erosional volumes. It's recommended LiDAR be obtained again in the future, the same analysis run and an average annual volume calculated.

Identifying Ten Sediment Trapping Facilities

As a first step in selecting the ten sediment trapping facilities which the final three sediment trapping facilities would be chosen from, a GIS analysis was completed. A step by step protocol of selecting the ten facilities is presented in **Table B-2.** The analysis, for each depositional area (DA), measured the depositional volume of all DA's within a five-hundred-foot radius of each DA. This measurement was completed to understand the size of other DA's proximal to each DA which may be an indicator the DA is in a region prone to deposition. This "500-foot cumulative depositional volume" is Column 4 of **Table B-2**. The 500-foot cumulative volumes for all DA's were then organized from highest to lowest.

Since it's desirable that sediment trapping facilities be operated and maintained by an APO that actively mines sand, stone and other such materials, distance to active APO locations was used as the second selection method. The distance from the DA to the nearest boundary of an APO, was measured using ArcGIS. APO boundaries were established by inspecting a GIS shapefile provided by SJRA and visually inspecting a 2019 aerial photograph. A polygon was digitized around the ponds at each APO. The APO shapefile appeared to contain facilities that are being actively mined (**Image 1**) or have not been mined for some time (**Image 2**). **Image 1** shows an example of an active mine with little to no vegetation around and in between ponds and murky pond water. **Image 2** shows the vegetation area around and in between ponds, which is an identifying characteristic of a mine that is not being actively mined.

Image 1: Boundary (Red Polygon) Around Assumed Active APO

Image 2: Boundary (Red Polygon) Around Assumed Non-Active APO

A statistical analysis of the distance between DAs and APOs was completed. Based on discussions with SJRA, the 30th percentile distance was used as the threshold for the second selection metric. These distances are shown on Table 2.

The DAs with the highest 500-foot cumulative volume and whose distance to the nearest APO was shorter than the 30th percentile value were selected first. Aerial photography was used to determine whether the selected DA was part of a cluster of other DAs. A cluster was determined using professional judgement to delineate an upstream and downstream boundary where the distance between the selected DA and its neighboring DAs notably increases, signifying the end of the cluster. A cluster represents a region where sediment naturally deposits which is important since its advantageous to locate sediment trapping facilities in regions where natural conditions are favorable for trapping sediments.

The DA with the highest 500-foot cumulative depositional volume, and with a distance to an APO less than the 30th percentile was selected as one of the four most promising DAs. This was DA WF060. From the remaining DAs, the second DA was selected if it met these criteria:

- had the next highest 500-foot cumulative volume
- was within a distance to the nearest APO less than the 30th percentile value
- was not part of the delineated cluster that the already selected DA was in

The second selected DA was WF075. This selection process was repeated twice more until four DAs were selected (WF069 and WF079). The 5th selection was made from the list of DAs that hadn't been previously selected that had the highest remaining 500-foot cumulative depositional volume, regardless of its distance to an APO (WF093). The 6th, 7th and 8th selected DAs were selected from the remaining DAs beginning with the highest 500-foot cumulative depositional volume which met the 30th percentile value distance to APO threshold (WF092, WF044, WF026). The 9th selection and 10th selection were exclusively made from DAs on the East Fork using the same methodology of 500-foot cumulative depositional volume, clustering and APO proximity. These selected sites were EF022 and EF159. The ten DAs are presented below in **Table 1** and in detail in **Table 2** and will be prioritized in the following section. The clusters of DAs at each selected DA are shown in Figure 1 through Figure 10.

Table 1. Selected Ten Sediment Trapping Facilities

Selected DA	Associated DAs in Selected DA's Cluster	Figure	Selected DA	Associated DAs in Selected DA's Cluster	Figure
WF060	WF057 -WF067	1	WF092	WF091 -WF092	6
WF075	WF075 -WF074	2	WF044	WF043 -WF045	7
WF069	WF068 -WF070	3	WF026	WF023 -WF026	8
WF079	WF079 -WF086	4	EF022	EF020 -EF026	9
WF093	WF093 -WF100	5	EF161	EF154 -EF162	10

SELECTING FOUR SEDIMENT TRAPPING FACILITIES AND EVALUATING FAVORABLE CONDITIONS FOR TRAPPING SEDIMENTS

Methodology Summary

The previous section selected ten DAs and delineated the regional boundaries for the sediment trapping facilities associated with each selected DA using the boundaries of each selected DA's cluster. From this group of ten, four sediment trapping facilities were selected for further analysis to understand which sites have favorable characteristics for trapping sediments. The general processes used to select these sites were as follows

1. Select four sediment trapping facilities whose 500-foot cumulative depositional volume was the highest and whose distance to the most proximal APO was the shortest (as explained in the previous section).
2. Identify if the most proximal APO had active mining operations. Contact landowners whose land borders the selected sediment trapping facilities and obtain access to their property for site inspection.
3. If one of the selected four trapping facilities did not have an active APO or whose adjacent landowners were not available to grant access or did not grant access, select a replacement sediment trapping facility whose 500-foot cumulative depositional volume was the highest and whose distance to the most proximal APO was the shortest.

Selected Four Sediment Trapping Facilities

The four selected sediment trapping facility sites are presented below. They are arranged starting with the upstream most facility along the West Fork main stem and ending with the furthest downstream facility. A suggested sediment trapping facility name is presented in parenthesis. It was assumed that since the APO operator at each of the four selected facilities had granted land access to complete field visits to each facility (as discussed below) that they all had the same amount of willingness to participate in the maintenance of a sediment trap.

- WF044 (ST001)
- WF060 (ST002)
- WF075 (ST003)
- WF079 (ST004)

METHODS USED TO SELECT THREE SEDIMENT TRAPPING FACILITIES

Methodology Summary

The four selected sediment trapping facilities were further studied to determine which three sediment trapping facilities should studied be in greater detail as part of a future deliverable in this project. The selection of the three sediment trapping facilities was accomplished by:

- Characterizing potential upstream sediment sources
- Measuring existing potential sediment storage volume
- Looking for site conditions favorable for sediment trapping (windshield survey)

Each of the four sediment trapping facilities was reviewed using a desktop analysis and visited by a two-person team who were registered engineers with experience in sediment management strategies.

Estimating Upstream Sediment Sources

The depositional volume for all DAs upstream of each sediment trapping facility was used as an estimate of upstream sediment source volumes. Since this approach compared topographic data from two snapshots in time, it was assumed that only a percentage of the upstream sediment source volume deposited and this percentage was fixed regardless of location along the West Fork main stem. Therefore the higher the depositional volume, the higher the estimated upstream sediment sources which would flow into a sediment trap facility allowing for a comparison between each facility's potential to trap substantial amounts of sediment. Each facility was evaluated in isolation and this method did not evaluate how upstream facilities could reduce sediment volumes from reaching downstream facilities. This approach did not account for local hydraulics and sediment size to understand the relationship between depositional volume and upstream sediment volume. Local hydraulics and sediment size will be evaluated in subsequent steps in this project when data is collected from the field and hydraulic modeling is complete.

It was assumed that the depositional volume attributed to each DA was related to the amount of sediment being transported from upstream sources and can be used to characterize the upstream sediment supply. However, upstream sediment sources may exist without the presence of DAs. For example, topographic, geologic, and hydraulic conditions may prevent a DA from forming despite the presence of upstream sediment sources. A second technique was used to characterize upstream sediment sources. This technique involved measuring the movement of the river centerline over time. This technique's assumption is that a relatively large deviation distance indicates that the river has moved into a location formerly occupied by land, such as a stream bank. This movement results in the removal of the stream bank's material, which becomes a sediment source.

These two approaches were not used to estimate the load (volume) of upstream sediment sources, but rather were used to qualitatively compare potential upstream sediment sources, aiding in the selection of the three sediment trap facilities. A more detailed estimate of upstream sediment source volumes and prediction of sediment trapping efficacy will be completed after SJRA selects the three facilities.

Depositional Volume

To increase the understanding of potential sediment sources upstream of the four sediment trapping facilities, the methodology outlined above for delineating DAs was repeated along the first three miles of the two largest tributaries upstream of each of the four sediment trapping facilities. This began at the confluence of each tributary with the West Fork San Jacinto River and extended three miles upstream. Note, all of the four selected sites were located on the West Fork San Jacinto River. The two largest tributaries (by drainage area) upstream of the top four facilities are identical, meaning that no facility was located upstream of another facility's largest tributary. The two largest tributaries are Lake Creek and Crystal Creek. The methodology outlined above for delineating DAs was repeated along the first three miles of both tributaries. The depositional volume of all DAs upstream of each facility (West Fork, Lake Creek, and Crystal Creek) was totaled.

Erosional Volume

To increase the understanding of potential upstream sources, locations of potential sediment sources were mapped following a procedure similar to the one used to map aggradation locations. Areas of potential sediment sources (referred to as erosional areas or EAs) were delineated around regions where the more recent LiDAR data was lower than historical LiDAR. For example, if a portion of a stream bank measured by the historical LIDAR has been eroded by the river, that location will have a lower elevation when measured in the recent LiDAR. Erosion is a process which results in a sediment source.

The degradation value of -2 feet was used to constrain the delineation of EAs, focusing on areas experiencing at least 2 feet of degradation between the historical and recent LiDAR data sets. Each EA was assigned a unique name for identification using a consistent format similar to the DAs. "_Deg" was appended to the end of these unique names to identify them as EAs. The area of each EA, it's average elevation change, and its average erosional volume were calculated using similar methods used for the DAs. Each EA's average annual erosional volume was calculated by dividing the average elevation change by the time lapse between the mapped LiDAR.   The quotient was then multiplied by the surface area of each erosional area to calculate the average annual erosional volume. The measured erosional volume upstream of each facility (West Fork, Lake Creek and Crystal Creek) was totaled.

Stream Deviation Analysis

A stream deviation analysis was completed by FNI for the West Fork as part of the "Sediment Management Strategy for the West Fork San Jacinto River and Spring Creek" which was part of the "San Jacinto Watershed Drainage Plan" project, completed by FNI in 2020. (This study is in draft form as of June 2020.) A detailed methodology for this approach can be seen in **Appendix C** of the "Sediment Management Strategy for the West Fork San Jacinto River and Spring Creek". The results from this analysis were obtained and grouped for each sediment trapping facility. The amount of stream deviation along the West Fork was measured for each facility.

Additionally, lateral shifts in stream centerline alignment were also delineated along the first three miles of the Lake Creek and Crystal Creek tributaries to measure stream deviation in the two largest tributaries upstream of the sediment trapping facilities. Two stream centerlines were digitized following the methodology used for the West Fork using recent LiDAR data and historical LiDAR data.

Existing Potential Sediment Storage Volume

The goal of a sediment trapping facility is to capture sediments so they can be removed. Existing storage was selected as a criterion to characterize the available volume for sediment storage. The larger the existing storage, the less construction may be needed to achieve a targeted sediment storage volume.

A two-foot contour map was developed from recent LiDAR data for the West Fork mainstem and its adjacent floodplain in each of the four selected sediment facility. The surface area of each contour was then measured and a volume calculated at each contour. The volume was summarized and referred to as the existing potential storage volume. For comparative purposes, this measurement was completed for each contour elevation up to ten feet above the elevation at the downstream end of the proposed facility.

Favorable Site Conditions for Trapping Sediment (Windshield Survey)

The following characteristics were evaluated as potential criteria to determine the favorability of site conditions for a sediment trap at the four sediment trap facilities. The criteria are summarized in **Table 3.**

Table 3. Observed or Measured Site Conditions

Observation or Measurement	Explanation of Observation or Measurement
1	Opportunities where sediment laden river water could enter an existing pit at an APO. This is referred to as an "off-channel lateral" sediment trap. Determined from interviews with APO operators or a review of floodplain maps to compare APO pit locations with floodplain boundaries.
2	Bankfull height (a depth at which the most efficient discharge in moving sediment occurs) was measured using a laser level from river bottom to a bankfull indicator. A bankfull indicator was measured at a physical feature in the river where the following may have been observed: vegetative characteristics (e.g., location, presence, absence or destruction of terrestrial or aquatic vegetation) and physical characteristics (e.g., clear natural line impressed on a bank, scouring, shelving, or the presence of sediments, litter or debris). Bank heights were measured at a representative location where an APO pit was adjacent to the river using LiDAR. The height was measured from water surface in the river to the top of the riverbank. The river water depth was ranged from 0.5 feet to 1.5 feet in all locations and was added to the height from Lidar. To connect sediment laden water, bank heights between the river and adjacent APO pits will need to be lowered to at or just below bankfull height to encourage frequent sediment deposits. This understanding would be used to inform the design of an "off-channel lateral sediment trap."
3	Opportunities within an existing depositional feature to create "in-channel lateral" sediment trap. Optimal characteristics of a depositional feature for this approach will include established mature trees on the landward side and riverside of the feature. This suggests depositional feature within the tree region is stable due to established tree roots. An excavated channel within the tree region and parallel to river alignment could be completed. The bottom of the excavated channel would be near the average daily water surface elevation.
4	Signs of instability within a potential sediment trapping facility (eroding banks, vertical channel instabilities, debris loading, etc.) that may require stabilization to ensure a sediment trap works properly. This would involve construction in addition to the construction needed to build the trap.
5	Proximity to an existing access road. Long distances would increase the amount of construction needed to create access to allow for initial construction efforts and ongoing maintenance.

Proximity to Existing Access Roads

There are a variety of ways to trap sediment. Some methods require machinery and electricity to capture sediment and are referred to as active sediment trapping. Other methods are passive (i.e. no electricity or machinery needed to capture sediments). Active trapping and passive trapping both require access to the location where they will be built. This access may need to be maintained to continually harvest sediment. For this reason, proximity to an existing access road was considered a favorable criterion for a facility.

Favorable Hydraulic Conditions for Sediment Trapping

Sediment trapping can be parsed into two general categories, active sediment trapping and passive sediment trapping and their efficacy is partially determined by local hydraulic conditions. Active sediment trapping involves a machine that is usually aligned perpendicular to the river channel. The sediment falls into a trough. The sediment is then pulled through the trough into a pipe by a hydraulic screw and then pumped to shore. Optimal locations to install this machine are where sediment is likely to be moving along the channel bottom.

The second general category is passive sediment trapping and these can be parsed further into two sub-categories. Sub-categories are organized depending on the location and alignment of the structure that causes sediment to deposit within the trap. The first sub-category, referred to an "in-line trap", features a structure that extends across the river and is generally perpendicular to the river alignment. This structure can be impermeable like a dam or permeable like wood pilings that are spaced far enough apart that allow water to pass through them but cause the water to slow down. Optimal locations to install these structures are where sediment is likely to be moving along the channel bottom and where river water velocity is lowest.

The second sub-category of passive sediment traps is lateral traps. This sub-category contains two general approaches to trapping sediments: "in-channel traps" and "off-channel traps." In-channel traps are located between the two riverbanks, at locations where sediment may naturally deposit, such as a depositional area. The optimal characteristic of a depositional area which lends itself to an in-channel trap is the presence of mature vegetation (trees with a diameter at breast height greater than 3 inches) (Image 3). This mature vegetation anchors the soil, forming the boundary of the trap. In between the boundaries, existing sediment can be removed to an elevation near the average daily water surface. This will allow sediment to deposit in the excavated area in frequently occurring flood events. Additional armoring (large stones, large wood, bioengineering) should also be added to increase the protection of the trap's boundary. Therefore, proximity to existing access and presence of a depositional area with mature vegetation (as seen in Image 3) were used as criteria for identifying locations optimal for constructing sediment trapping facilities. Engineering evaluations (hydraulics) and geomorphic analysis (sediment transport, boundary condition modeling) should be completed to evaluate the size of the trap and how to protect its boundaries. These types of sediment traps also need favorable hydraulic conditions that are prone to sediment deposition.

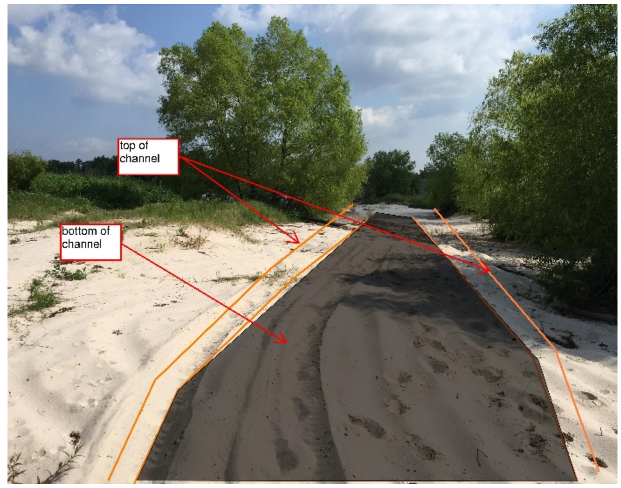


Image 3: Looking Downstream at a Vegetated Depositional Area with Mature Trees Along Its Boundary	Image 4: Looking Downstream at Conceptual "In-Channel Lateral Trap". The Dark Hatch is Where the Existing Sediment Would Be Excavated Creating Storage for Sediment to Deposit.

Since slower moving water does not have the physical properties to keep sediment suspended as well as fast moving water, depositional areas are an indicator of slower moving water. It was assumed that the hydraulic conditions were equally favorable at all four sediment trapping facilities for all categories and sub-categories of sediment trapping since the four sediment trapping facilities were selected based on their proximity to regions where sediment is naturally depositing. Therefore the presence of slower moving water was not used as a prioritization criterion. Favorable hydraulic conditions such as slower moving water will be studied in more detail later in this project.

Distance to Nearby APO Pits and Riverbank Height

Off-channel traps are located outside the riverbanks. These traps utilize existing APO pits to trap sediments. A notch is excavated into the riverbank starting from the riverbank's edge and a channel is excavated from the riverbank to the pit. The bottom elevation of the notch is set at an elevation that will allow sediment-laden floodwater to enter the pit. These pits are filled with water whose water surface should be slightly below the bottom elevation of the notch, forming a pond. When sediment laden floodwaters enter the pond, the water will slow and sediment will deposit. An outlet notch allows water to exit. Hydraulic modeling is needed to calculate the speed of water moving into and out of the pond. This will inform how the notches should be protected from erosion. Sediment transport calculations will inform the range of sediment sizes that may flow into the pond. The nearer the elevations of the entry and outfall notches are to the elevation of the river bottom; the more sediment is captured. Designs of such facilities must include measures to protect the river alignment from changing course and sweeping through the pit. It is recommended to begin the design process of off-channel traps by setting the bottom notch at the river discharge elevation which is the most efficient in moving sediment. This discharge is commonly referred to as the bankfull discharge. The height of water during the bankfull discharge is referred to as the bankfull height. The design of off-channel traps will determine whether notch bottom elevations should be adjusted higher or lower than the bankfull height.

For this study, the relationship between the bank height at proximal APO pits and bankfull height was used as a criterion. The smaller the difference between these two heights, the more favorable the site conditions are because less excavation will be needed to dig the notch bottom to the bankfull height. Another criterion used was the distance between the edge of riverbank and the APO. The shorter the distance, the less excavation will be needed. A third criterion was the presence or lack of mature vegetation (i.e. trees). The lack of vegetation would result in less clearing to construct the notches.

Presence of Instability

The final criterion used to evaluate the favorability of site conditions was the presence of instability within the potential sediment trap facility region. Instability, such as an eroding bank located on the same riverbank as the APO, may require additional resources to be spent to fix the instability. Since the location and method of trapping sediment was not known at this time, it was assumed any observed instability reflects less favorable site conditions.

A qualitative score was assigned to each facility after the windshield survey. A potential score included “Low,” “Moderate” or “High.” A high score was assigned to a facility where the observations and measurements appeared favorable for trapping sediments. A low score was assigned to a facility where notable construction would be needed to implement a sediment trap.

FINDINGS TO SELECT THREE SEDIMENT TRAPPING FACILITIES

Selecting Three Sediment Trap Facilities Using Potential Upstream Sediment Sources

Depositional Volume and Erosional Volume: General Summary of Findings for West Fork Mainstem and Tributaries

Sediment deposition was observed to commonly occur in the following locations throughout the study area:

- Insides of meander bends where point bars naturally form
- Areas where meander migration has led to point bar extension or new depositional features
- Mid-channel bars with established vegetation
- Side-bar deposition adjacent to APO sites

Larger DAs were typically observed downstream on the West Fork main stem and tributaries, which fits the geomorphic principle that sediment is commonly sourced from upstream extents of streams and deposition is more common in downstream reaches. On the West Fork in particular, the larger DAs were observed to be concentrated in the “transitional” and “depositional” zones of the river (classifications described in the “Sediment Management Strategy for the West Fork San Jacinto River and Spring Creek” report which was part of the “San Jacinto Watershed Drainage Plan”). In contrast, the upstream or “transport” zone of the river was observed to have far fewer DAs, and those that were delineated there were typically smaller compared to other sites along the river. **Table 4** presents average annual cumulative volume statistics of the two tributaries and of the West Fork which was completed in the above mentioned plan.

Table 4. Statistics for Average Annual Cumulative Volumes (ft^3)* in DAs by Stream

Stream Name (Drainage Area in mi^2)	Minimum	Maximum	Mean	Sum
West Fork San Jacinto River (540)**	798	311,500	52,033	5,255,385
Lake Creek (333)	3,639	22,433	10,712	117,841
Crystal Creek (48)	2,169	17,183	6,507	123,639

*Annualized, as described above in "Data Processing and Aggradation Site Delineation"
**Excludes the drainage area of Lake Conroe

Stream Deviation Analysis: General Summary of Findings for West Fork Mainstem and Tributaries

The distance between historic and recent stream centerlines of the two studied tributaries was quantified in ArcGIS to map regions of lateral stream instability to characterize upstream sediment sources. Overall, both tributaries exhibited minimal stream deviation change between 2018 and 2008, with over 90% of their lengths experiencing minimal to moderate change but less than 1% of their lengths experiencing severe adjustment. This is in contrast to the West Fork which has 29.8% of its mainstream length experiencing severe stream deviation. **Table 5** lists percentages of different stream deviation severity quantified along the West Fork and the two tributaries.

Table 5. Stream Deviation Severity Percentages Along West Fork San Jacinto River and Tributaries

Stream Deviation Severity	West Fork	Lake Creek	Crystal Creek
Minimal (< 30 ft)	38.8%	56.9%	90.6%
Moderate (30-60 ft)	18.2%	35.5%	6.1%
High (60-90 ft)	13.2%	6.7%	2.4%
Severe (> 90 ft)	29.8%	0.9%	0.9%

Selecting Three Sediment Trap Facilities: Potential Upstream Sediment Source Criteria

The four sediment trap facilities were organized from upstream to downstream in order and were assigned a numerical naming nomenclature starting with the most upstream facility. For comparative purposes, the depositional volume for all DAs upstream of each sediment trapping facility was totaled and divided by the river length upstream of each facility. This was also completed for erosional volume. The findings in **Table 6** and **Table 7** indicate that there is a decrease in erosional volume per foot of river (column 6 in Table 7) and an increase in depositional volume (column 6 in Table 6) between ST001 and ST004) in the downstream direction. This suggests the West Fork mainstem downstream of ST001 is more prone to sediment deposition. Therefore, preference should be given to the facilities downstream of ST001. In particular, preference should be given to ST004 and ST003 because in **Table 6**, their depositional volume per river foot is higher than the rest and preference should be given to ST002 since there is a notable jump in depositional volume per river foot measured in cubic feet per foot between ST001 and ST002. These findings suggest there is a higher tendency for sediment to be depositing in and between these facilities.

Stream deviation severity was comparable among the top four potential sediment trapping facilities. The proportion of minimal change to total stream length decreases in the downstream direction, with a decrease from 63% of the total stream length at ST001 to 51% of the total stream length at ST004. In contrast, the proportion of severe lateral change increases in the downstream direction, with an increase from 10% of the total stream length at ST001 to 17% of the total stream length at ST004. **Table 8** lists percentages of different stream deviation severity quantified at each sediment trapping facility. Per **Table 8**, ST004 has the greatest percentage of severe deviation, which suggests the greatest potential of upstream sediment sources and therefore should be prioritized. The criterion of potential upstream sediment sources suggest ST001 should be omitted from the final three facilities:

- ST001
- ✓ ST002
- ✓ ST003
- ✓ ST004

Table 6. Statistics for Depositional Volumes (ft^3) in Depositional Areas Upstream of Each Facility

Column Number	1	2	3	4	5	6
Sediment Trapping Facility ID (Included DAs)	Minimum	Maximum	Mean	Sum	River Length Upstream of Facility (ft)	CF/FT*
ST001 (WF043-WF050)	798	155,000	18,190	1,455,193	114,800	12.7
ST002 (WF057-WF067)	798	230,200	27,646	2,681,619	152,550	17.6
ST003 (WF074-WF075)	798	311,500	32,790	3,442,989	166,450	20.7
ST004 (WF079-WF086)	798	311,500	34,704	4,025,700	200,000	20.1
*Column 4 Divided by Column 5						

Table 7. Statistics for Erosional Volumes (ft^3) in Erosional Areas Upstream of Each Facility

Column Number	1	2	3	4	5	6
Sediment Trapping Facility ID (Downstream-most EA)	Minimum	Maximum	Mean	Sum	River Length Upstream of Facility (ft)	CF/FT*
ST001 (WF043-WF050)	1,787	307,719	43,025	2,022,163	114,800	17.6
ST002 (WF057-WF067)	1,787	307,719	42,706	2,263,394	152,550	14.8
ST003 (WF074-WF075)	1,787	307,719	42,520	2,381,097	166,450	14.3
ST004 (WF079-WF086)	1,787	307,719	45,374	2,767,818	200,000	13.8
*Column 4 Divided by Column 5						

Table 8. Stream Deviation Severity Percentages for Each Sediment Trapping Facility

Stream Deviation Severity	ST001	ST002	ST003	ST004
Minimal (< 30 ft)	63%	58%	56%	51%
Moderate (30-60 ft)	19%	21%	21%	20%
High (60-90 ft)	8%	10%	11%	12%
Severe (> 90 ft)	10%	11%	13%	17%

Selecting Three Sediment Trap Facilities Using Potential Sediment Storage Volume Criteria

Table 9 shows that the largest available sediment storage was measured at ST002 with 293.25 acre-feet of available storage. The smallest available storage was measured at ST001 with 9.38 acre-feet.

Table 9. Existing Available Sediment Storage

	ST001	ST002	ST003	ST004
Available Storage (Acre-ft)	9.38	293.25	35.36	20.51

Using the potential sediment storage volume criterion, ST001 is not recommended for the three final sites because it has the lowest available storage:

- ST001
- ✓ ST002
- ✓ ST003
- ✓ ST004

Selecting Three Sediment Trap Facilities Using Site Conditions Favorable to Trapping Sediment (Windshield Survey)

Each of the four facilities was visited and whenever possible, APO operators were interviewed to understand how floodwaters interact with their production facility and locations. Observations and measurements from each site visit are presented by facility in a table. Detailed explanation of the observation or measurement type can be found in **Table 3**. A figure for each facility was also created displaying observations and measurements. Facilities are organized by site name and include the cluster of DAs within the facility and the initial DA that identified the facility. A qualitative score was then assigned to each facility. The qualitative score is a reflection of all observations and measurements to summarize the favorability of a site in trapping sediments.

ST001: Findings

Table 10. Site ST001 Observations

Number	Observation or Measurement	Note
1	Opportunities for “off-channel lateral” sediment traps.	An average riparian buffer width of 100’ exists between stream bank top and APO. Area between riverbank and riparian buffer contains 20’ to 30’ tall trees
2	Bankfull height (BKFh) and adjacent bank height at APO Pit	Two BKFh measurements made: 11.5’ (upstream of Crystal Creek confluence) and 13.2’ (downstream of Crystal Creek confluence). Bank height Range: 20’ to 25’
3	Opportunities for “in-channel lateral” sediment traps.	One opportunity to build an in channel sediment trap observed
4	Signs of instability	No signs of eroding banks or headcuts
5	Proximity to an existing access road	Between 100’ to 200’ to road

ST001: Summary

One location for constructing an in-channel lateral sediment trap was observed as presented in **Figure 11**. There is a notable horizontal distance between the edge of the riverbank and the nearest APO pit. There are well established trees whose height varies between 20 feet and 30 feet. These trees would need to be cleared to allow connectivity to an off-channel lateral sediment trap. The disturbed site will also need to be stabilized. The bank height ranges between 20 feet and 25 feet. This is notably higher than the bankfull height which ranges between 11.5 feet and 13.2 feet. This would require considerable excavation of the bank to lower the bank elevation below the bankfull height to allow for regular connectivity between sediment laden floodwaters and pits.

Qualification Score: Low

ST002: Findings

Table 11. Site ST002 Observations

Number	Observation or Measurement	Note
1	Opportunities for “off-channel lateral” sediment traps.	One off-channel trap (west bank) Distance between edge of riverbank and proximal APO pit is between 25 feet and 50 feet on the west bank and 200 feet and 300 feet on east bank.
2	Bankfull height (BKFh) and adjacent bank height at APO Pit	Bank height between 20 feet and 25 feet. Bankfull height: 13.8 feet
3	Opportunities for “in-channel lateral” sediment traps.	Two in-channel trap opportunities were observed. These were on the west bank, opposite of the Liberty Material property.
4	Signs of instability	No eroding banks were observed within the sediment trap facility region. Note, there is a large gully formed at the nearest access road directly across the river from the top four depositional site.
5	Proximity to an existing access road	100 feet from edge of riverbank to road on eastern shore. No access road was observed on western shore due to lack of landowner access but a proximal road was observed from an aerial photo.

ST002: Summary

Two locations for constructing in-channel lateral sediment traps were observed as presented in **Figure 12.** There is a relatively longer horizontal distance between the edge of the riverbank and nearby APO pits on the east bank than on the west bank with the former generally lacking mature trees or vegetation and the latter having tall shrubs and short trees. The east shore would require more excavation than the west shore to build connectivity between the river and proximal pits since the distance between the edge of river is longer. The riverbank on the west shore and east shore would have to be lowered between seven to twelve feet to reach the bankfull height to build the connectivity that would allow sediment laden waters to enter the pits regularly. A large gully was observed on the eastern shore near the nearest access road, across the river from the top four depositional area as seen in Figure 12. This may have resulted from an avulsion (a failure) through one of the protective earthen barriers around an APO pit. This would need to be stabilized if one of the pits on the eastern shore would be used as an off-channel lateral trap. There appears to be short distances between existing access roads on the east side of the river (from observation) and from the west side of the river (from aerial photo).

Qualification Score: Moderate

ST003: Findings

Table 12. Site ST003 Observations

Number	Observation or Measurement	Note
1	Opportunities for "off-channel lateral" sediment traps.	No off-channel trap opportunity was identified given relatively tall bank heights and mature riparian canopy. Distance between riverbank and APO was between 50 feet and 100 feet
2	Bankfull height (BKFh) and adjacent bank height at APO Pit	Bank heights: 31 feet measured twice Bankfull height: Between 13.9 feet and 14.9 feet
3	Opportunities for "in-channel lateral" sediment traps.	One in-channel trap opportunity was observed and one in-channel trap has been built by APO operator .
4	Signs of instability	No signs of instability were observed
5	Proximity to an existing access road	Existing access roads lead to the riverbank

ST003: Summary

The distance between the edge of riverbank and nearby APO pits was between 50 feet and 100 feet. This region contained mature trees which ranged in height from 20 feet to 30 feet. The difference between bank height and bankfull height was between 17.1 feet and 16.1 feet which would require significant excavation depths to reach the notch bottom elevation. Therefore, no reasonable off-channel trap opportunity was identified.

Existing access roads extended to the riverbank suggesting access to construct a sediment trap and access to maintain will need less clearing and less additional resources to build.

This facility features an active "in-channel" lateral sediment trap located just downstream from bankfull 4 indicator (BKF4) in **Figure 13**. The APO operator excavated landward of the gradient boundary; a survey boundary used to define state land **(Figure 13**). Land between the gradient boundaries on a stream belongs to the state of Texas. This area was excavated before Hurricane Harvey (before 2017) and the APO operator reported that 65,000 tons of material was removed. The area was excavated after Hurricane Harvey (2018) and 55,000 tons of material was reportedly removed then.

No erosion was observed within 4,000 feet downstream of the active in channel sediment trap. A transverse bar had formed upstream of the active trap but no erosion was observed within 1,000 feet upstream of the trap.

Another in channel trap opportunity exists near the most downstream cross section on the eastern river shore.

Qualification Score: Moderate

ST004: Findings

Table 13. Site ST004 Observations

Number	Observation or Measurement	Note
1	Opportunities for "off-channel lateral" sediment traps.	There were three opportunities for off-channel traps identified by comparing bank heights using GIS data and from field observations. Distance between edge of riverbank to pits is between 25 feet and 50 feet.
2	Bankfull height (BKFh) and adjacent bank height at APO Pit	Bank height: Between 13 feet and 14 feet Bankfull height: Between 13.9 feet and 14.9 feet
3	Opportunities for "in-channel lateral" sediment traps.	Three opportunities for in-channel traps identified from field observations
4	Signs of instability	An eroding bank was observed on the western shore (right bank)
5	Proximity to an existing access road	Existing access roads are within 25 feet to 100 feet of the edge of the riverbank

ST004: Summary

There are multiple opportunities for off-channel lateral traps in ST004. The upstream opportunity is located on the eastern river shore (Figure 14). The bank height, between 13 feet and 14 feet, is at or about the same elevation as bankfull height (13.9 feet or 14.9 feet). The difference between these two heights is the smallest among the potential sediment trapping facilities. A second and third opportunity to connect floodwaters to APO pits is located downstream, near the downstream most cross section in Figure 14. This bank height is approximately 22 feet. The difference between bank height and bankfull height is relatively low compared to the other potential sediment trapping facilities. The distance between the edge of riverbank and APO is also shorter than the other three trapping sites, and the bank is generally devoid of vegetation.

Three in-channel lateral traps could also be reasonably built within ST004. Two are located on the same shore as the APO. The third is located on the western shore which does not have proximal existing access and therefore is less preferred. The upstream trap is near bankfull indicator 2 (BKF2) as seen in **Figure 14** and the downstream trap is near bankfull indicator 3 (BKF3). Access to the possible two in-channel lateral traps on the eastern shore is between 25 feet and 10 feet, and the bank is generally void of vegetation or has small shrubs.

Sediment trap facility ST004 features multiple opportunities to store sediment and has relatively lower amounts of required site work (excavation, clearing, etc.) than the other three facilities.

Qualification Score: High

RECOMMENDATIONS FOR THE THREE PRELIMINARY TRAPPING FACILIITES

Summary of Findings

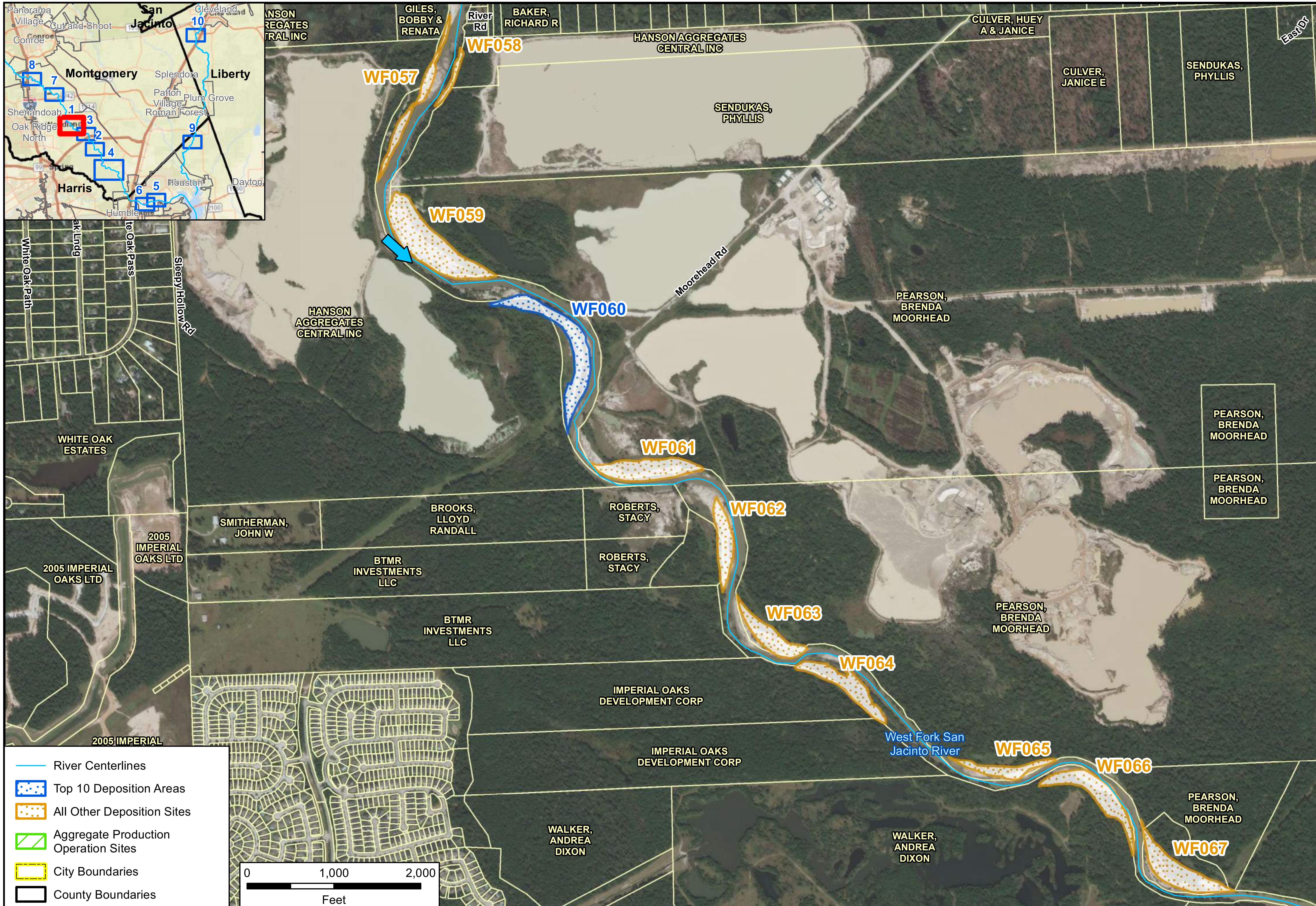
A desktop analysis was completed to identify ten regions within the West Fork San Jacinto River and the East Fork San Jacinto River where sediment appeared to deposit naturally. These regions were considered as potential sites for sediment trapping facilities. Four of these ten facilities were selected based on the volume of sediment deposited in the area and their proximity to an active Aggregate Production Operation (APO). A desktop analysis and field visit were then completed for each facility to determine which three of the four sites should be further studied to determine the efficacy of trapping sediment. Three of the four sites offered multiple opportunities to trap sediment with a varying degree of site conditions that influence sediment trap design and location, and these were recommended for further study.

Recommendations for the Three Sediment Trapping Facilities

The final three facilities recommended sites are ST002, ST003 and ST004 as seen in **Figure 12, Figure 13 and Figure 14.**

End of Memorandum

APPENDIX A - FIGURES



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DATE: June 2020
SCALE: 12,000
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San Jacinto River Authority
San Jacinto Watershed Study

Preliminary Sediment Trap Facility #1
San Jacinto Watershed

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817-735-7300

1

FIGURE

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Preliminary Sediment Trap Facility #2
San Jacinto Watershed

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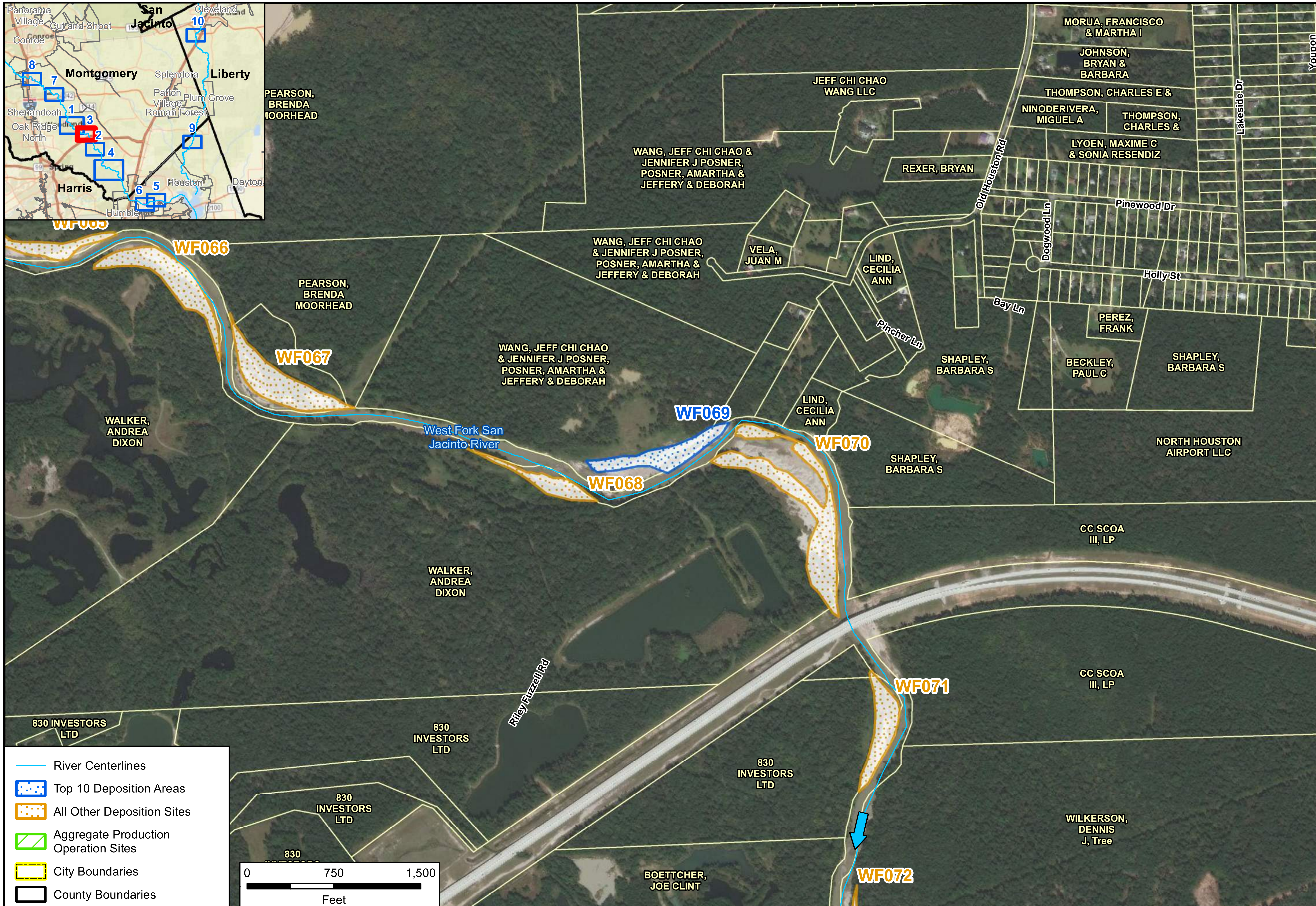
FIGURE



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Preliminary Sediment Trap Facility #3
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FIGURE

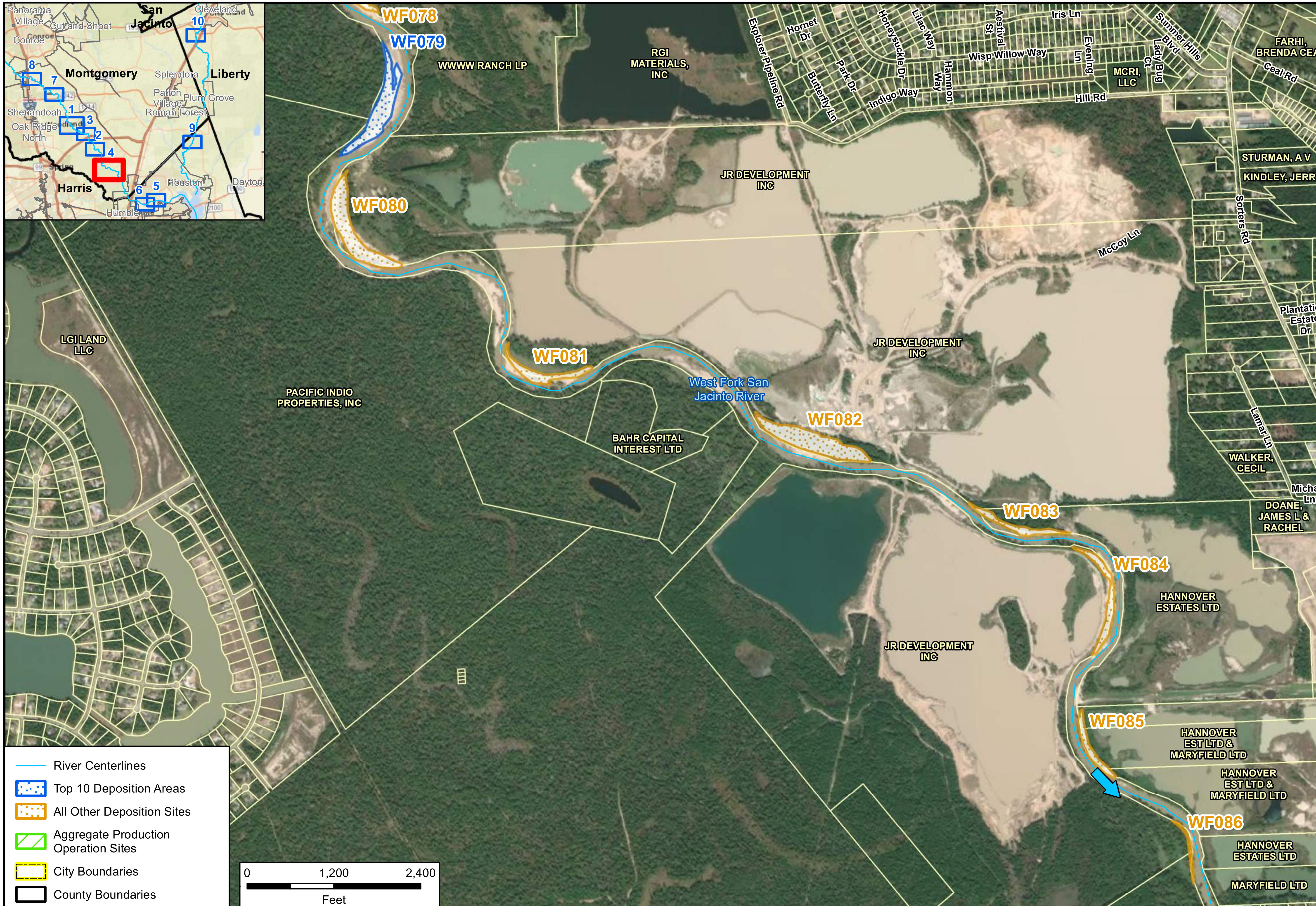

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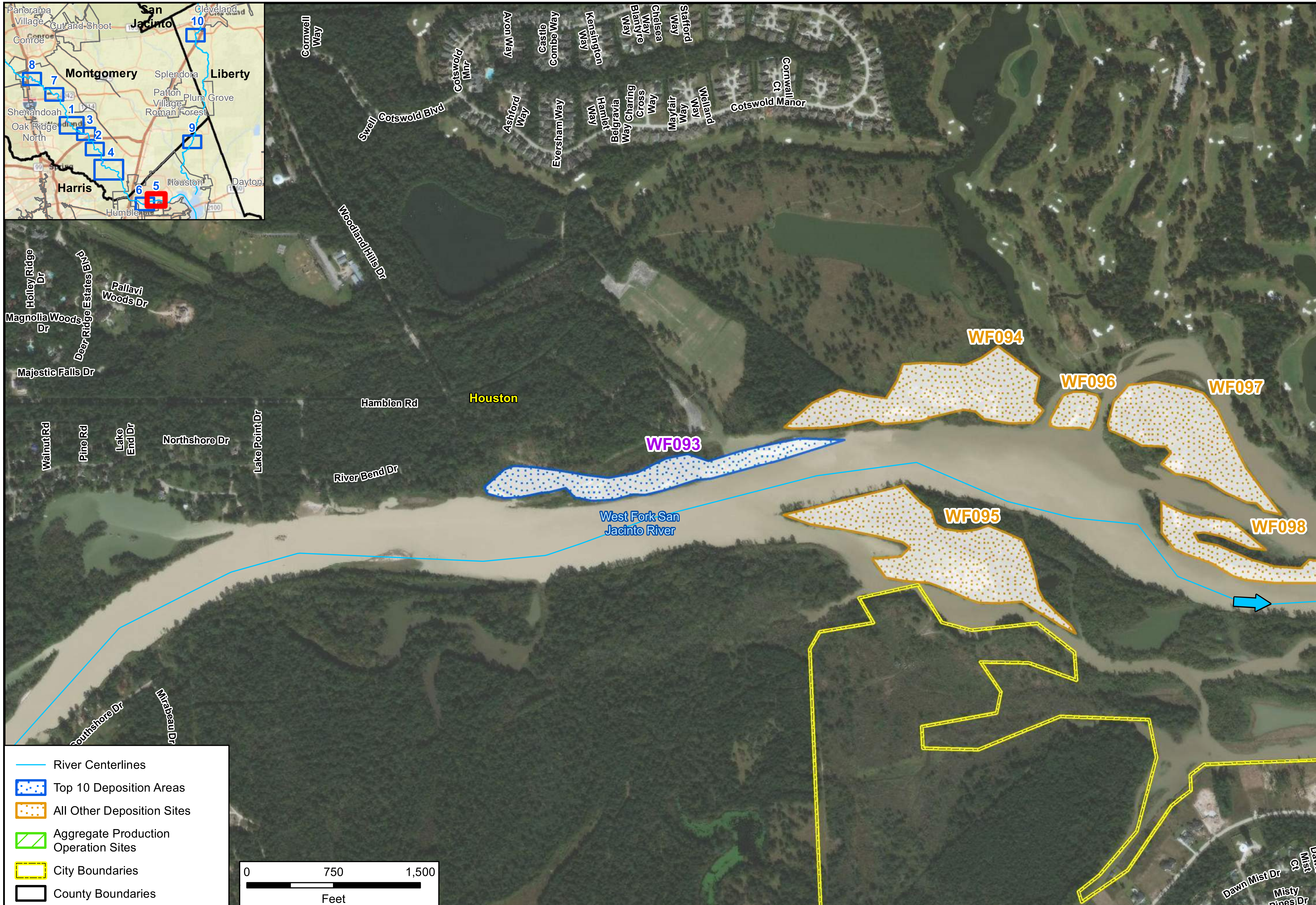
FIGURE
4



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Preliminary Sediment Trap Facility #5

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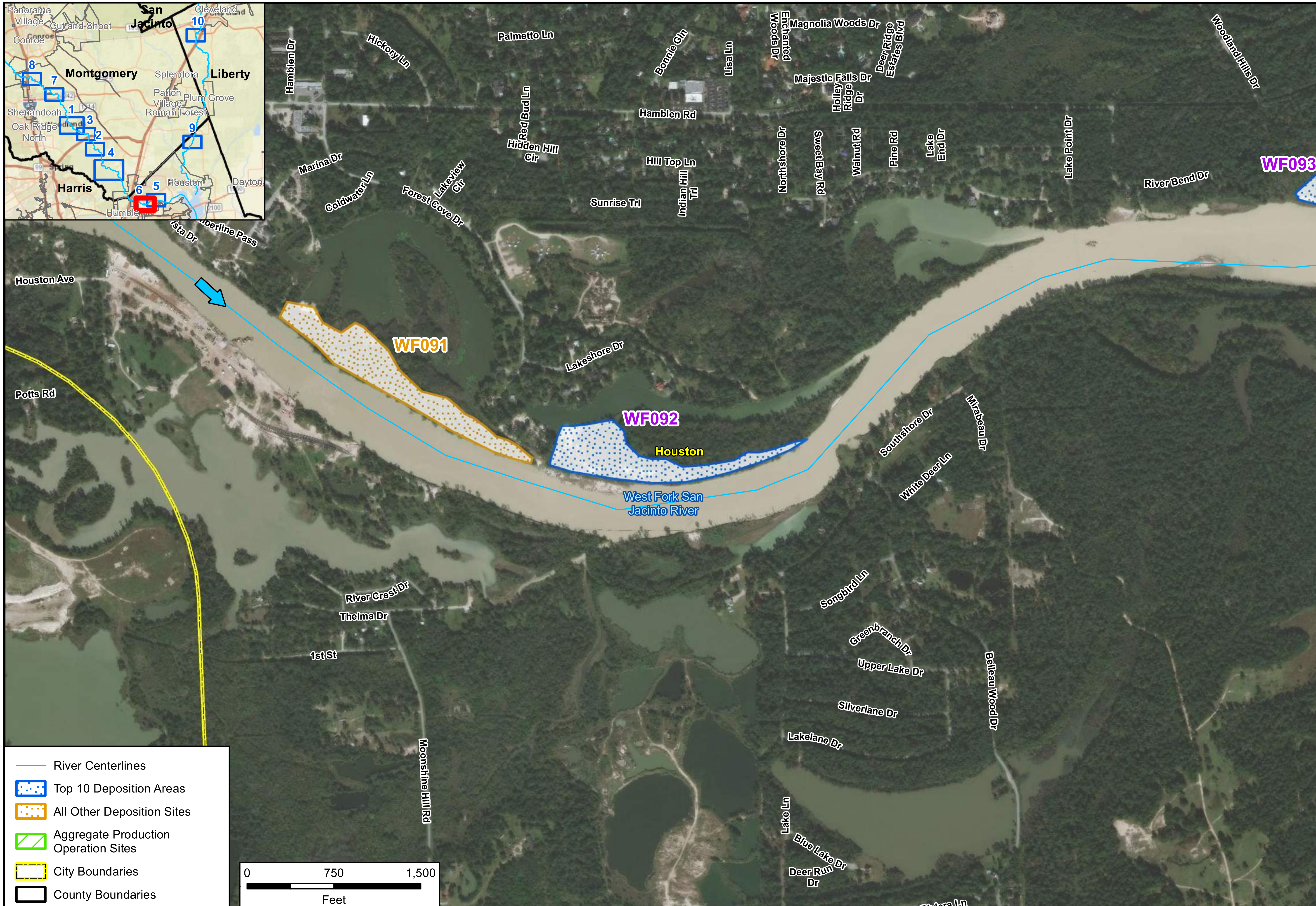
FIGURE



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Preliminary Sediment Trap Facility #6

San Jacinto Watershed

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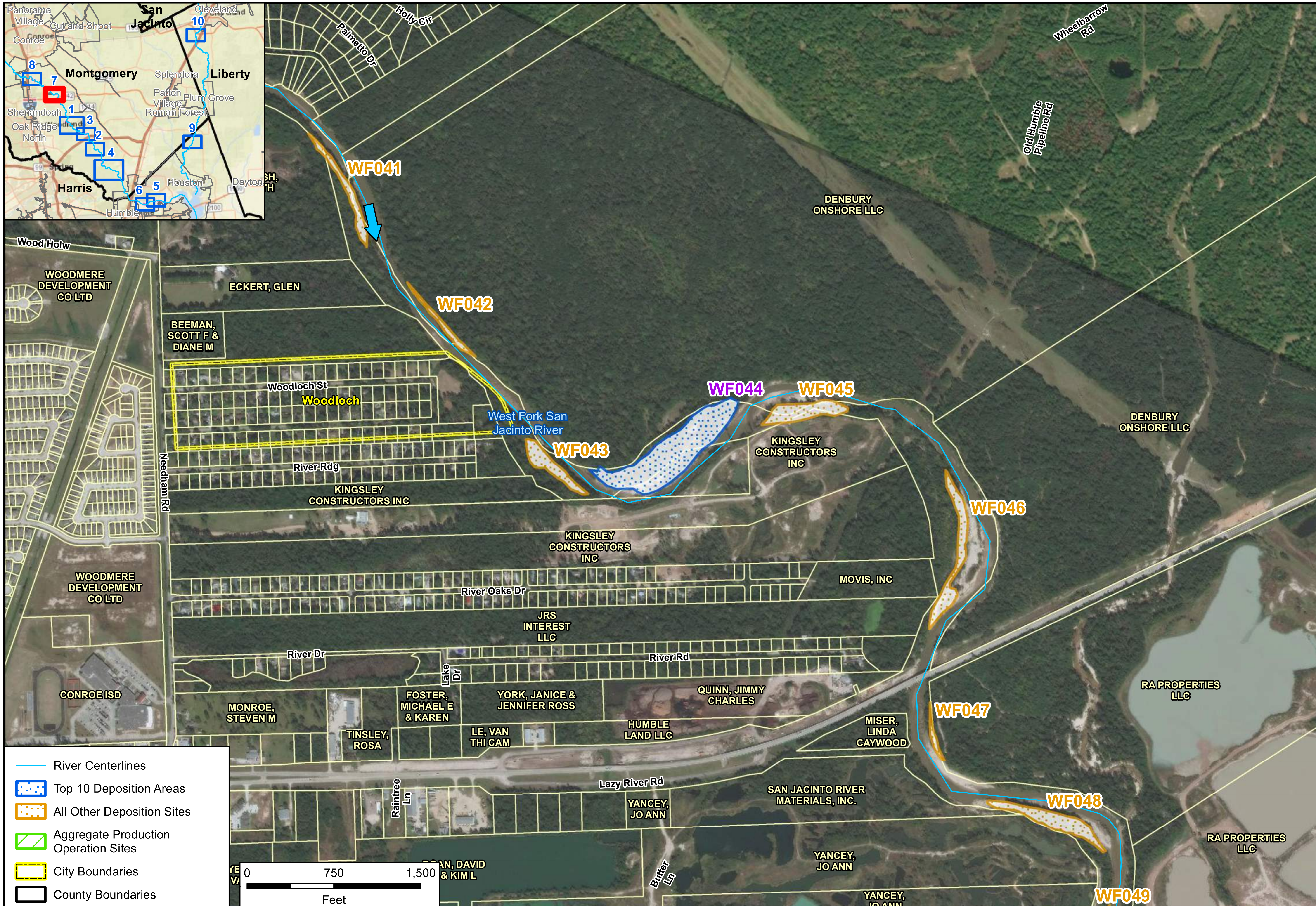
FIGURE



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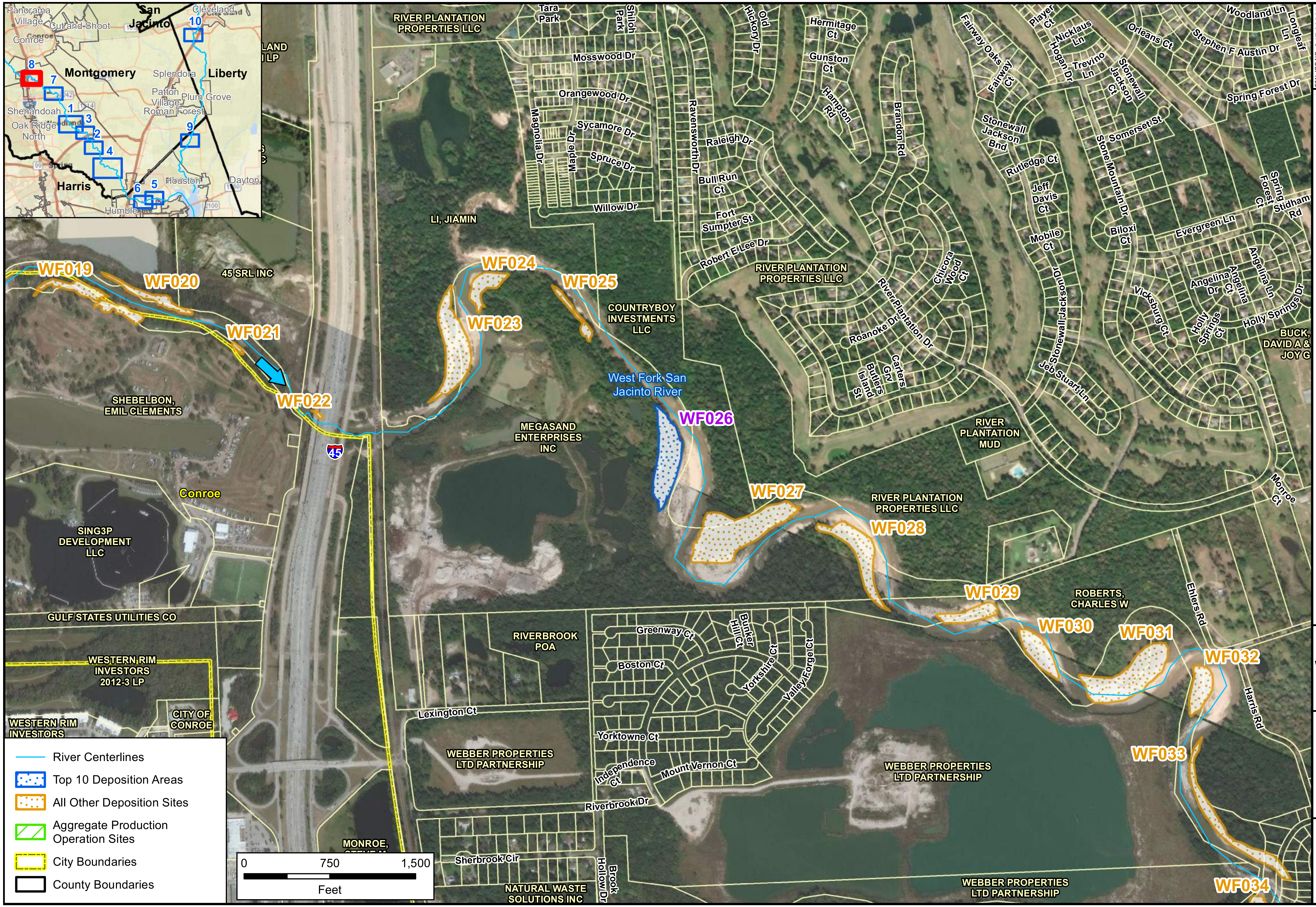
7

FIGURE



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Preliminary Sediment Trap Facility #8
San Jacinto Watershed

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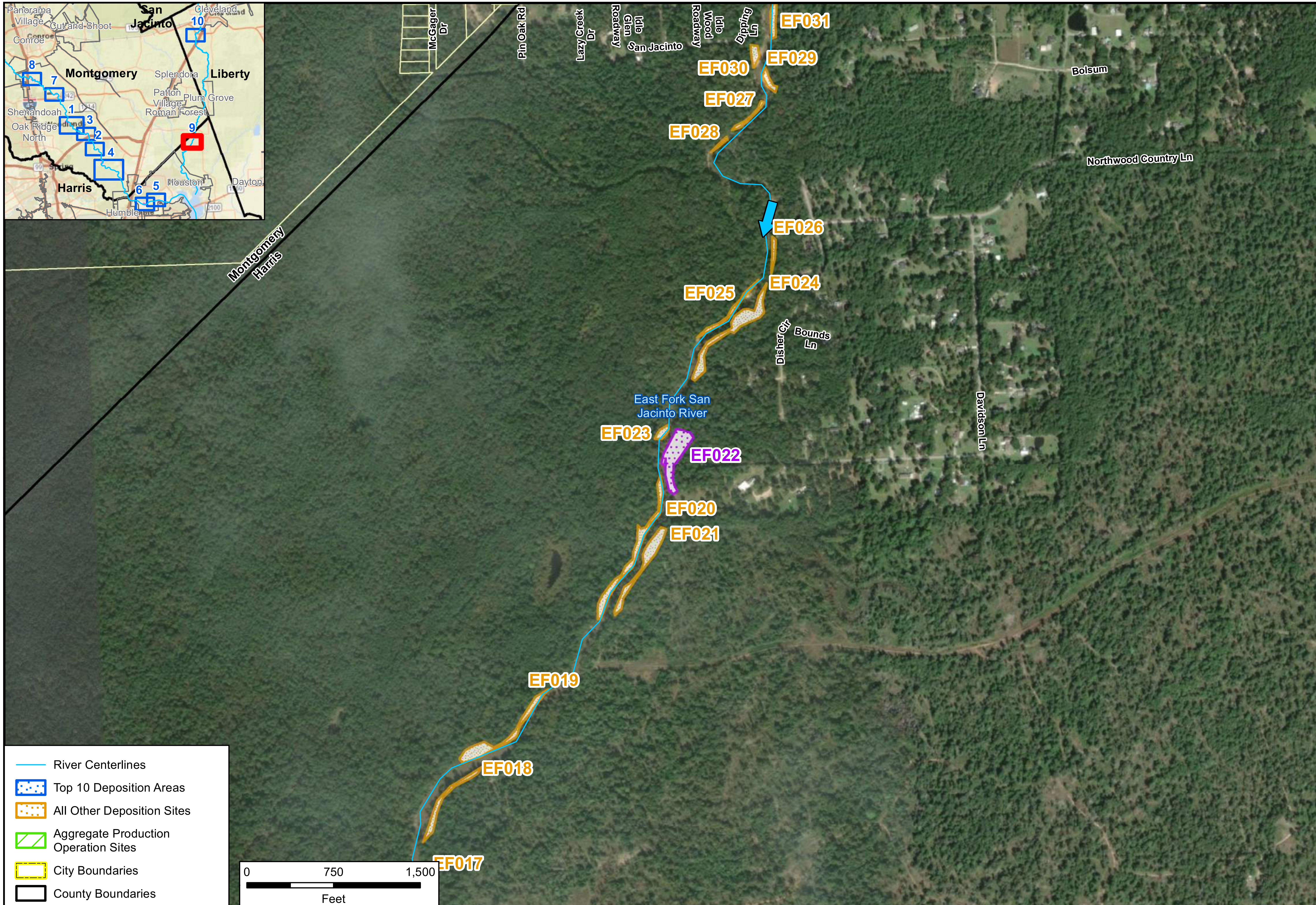
8
FIGURE



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San Jacinto Watershed

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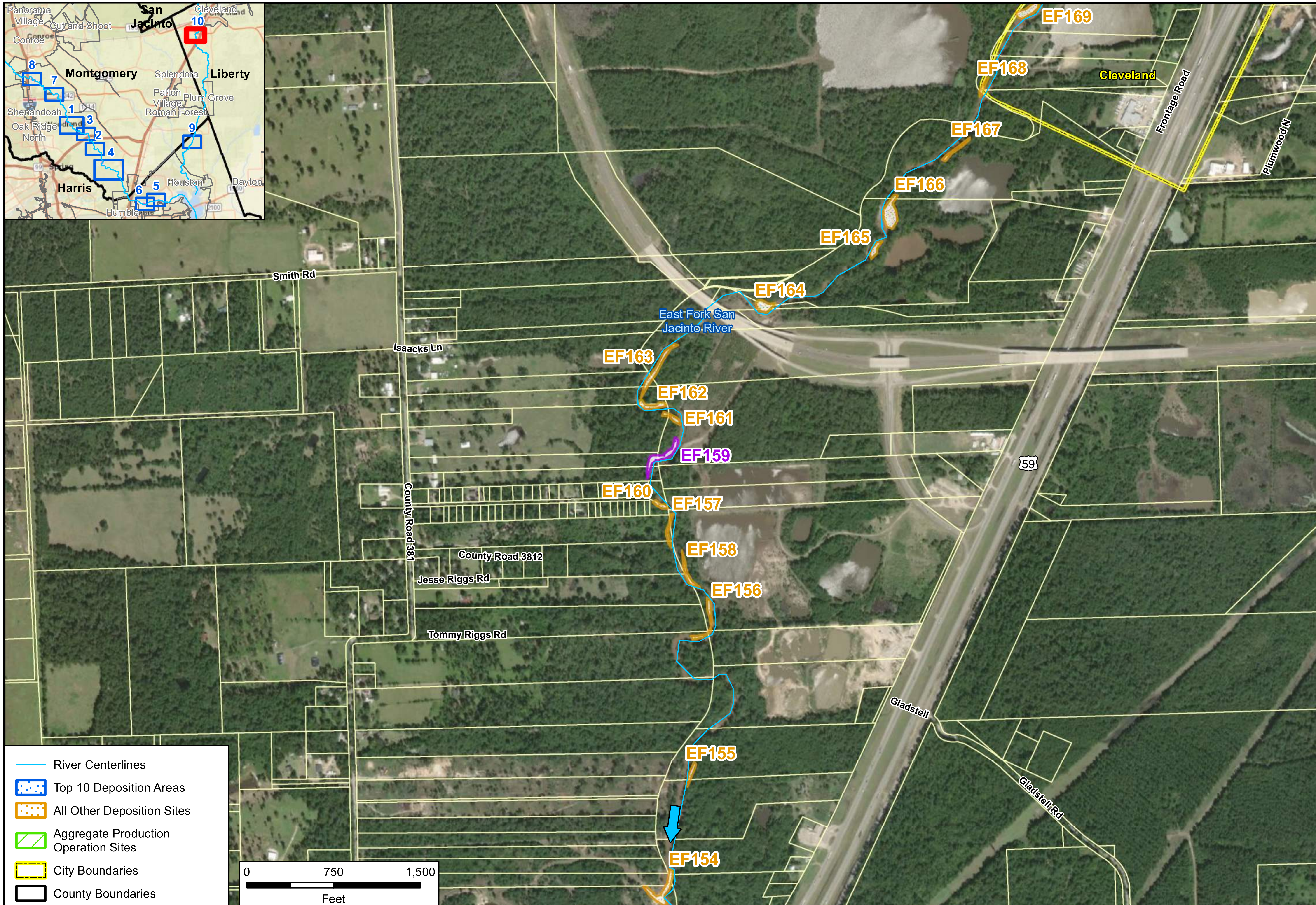
9

FIGURE



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San Jacinto Watershed

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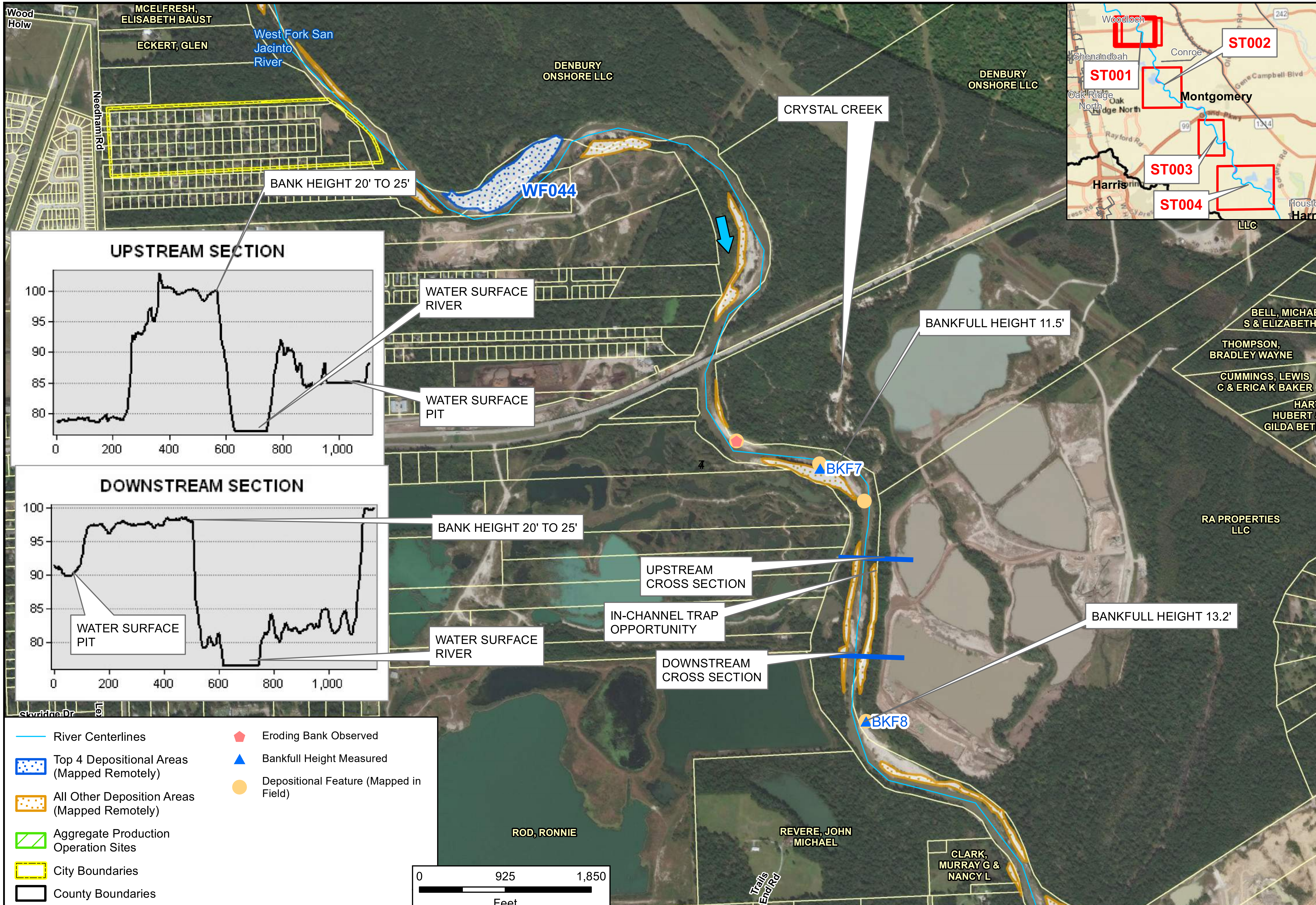
10

FIGURE



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Preliminary Sediment Trap Facility ST001
San Jacinto Watershed

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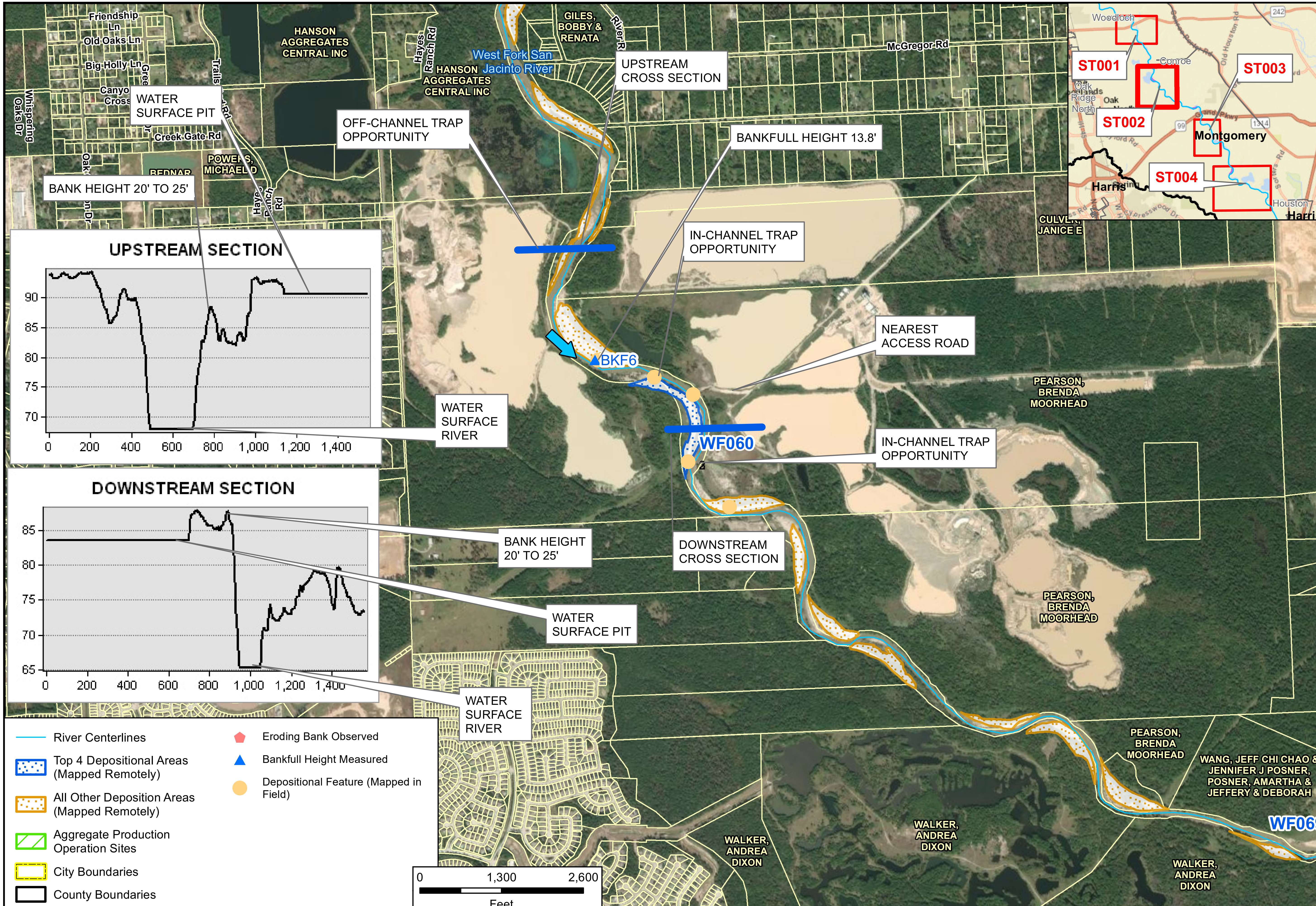
FIGURE



San Jacinto River Authority
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Preliminary Sediment Trap Facility ST002
San Jacinto Watershed

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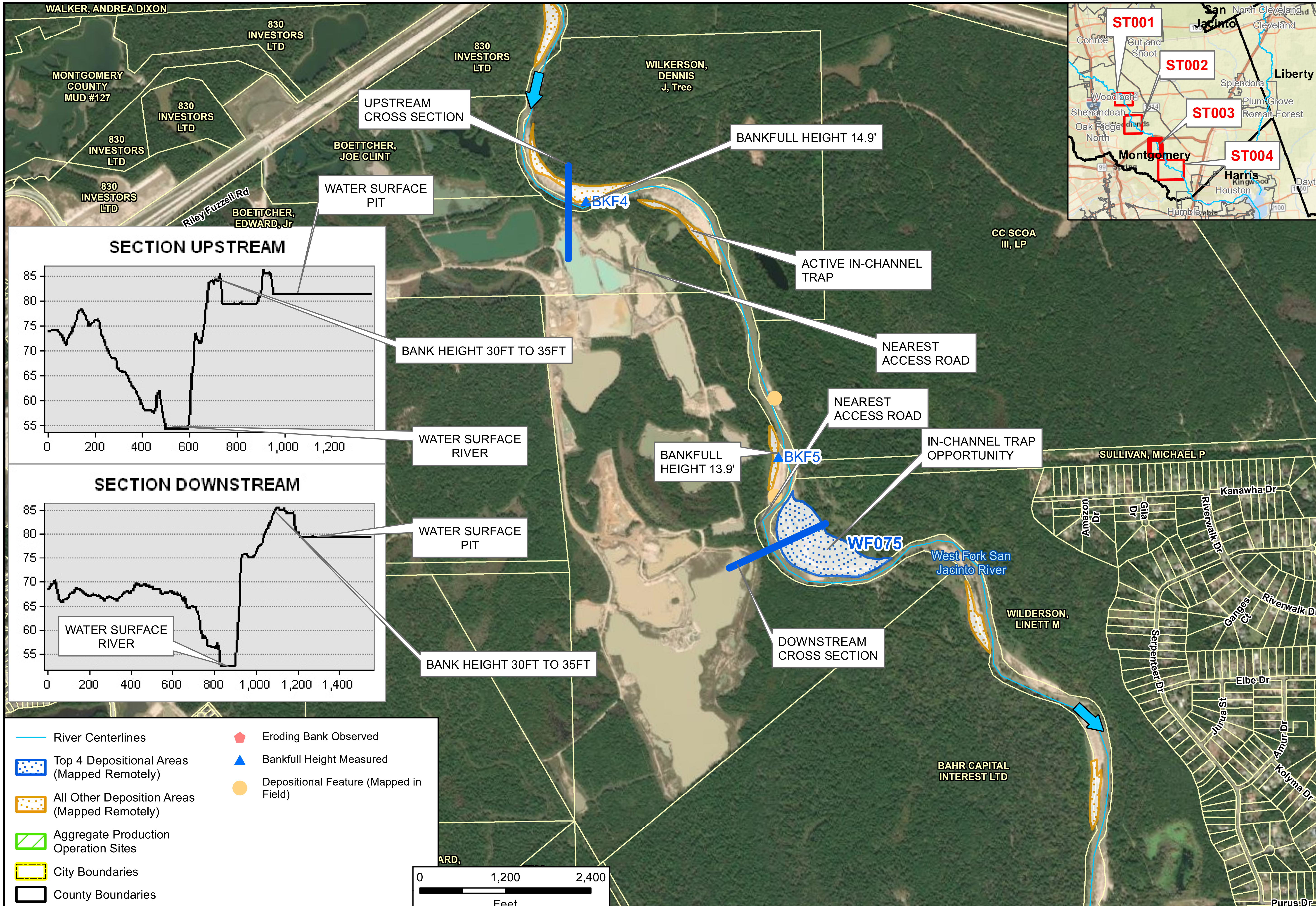
FIGURE



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Preliminary Sediment Trap Facility ST003
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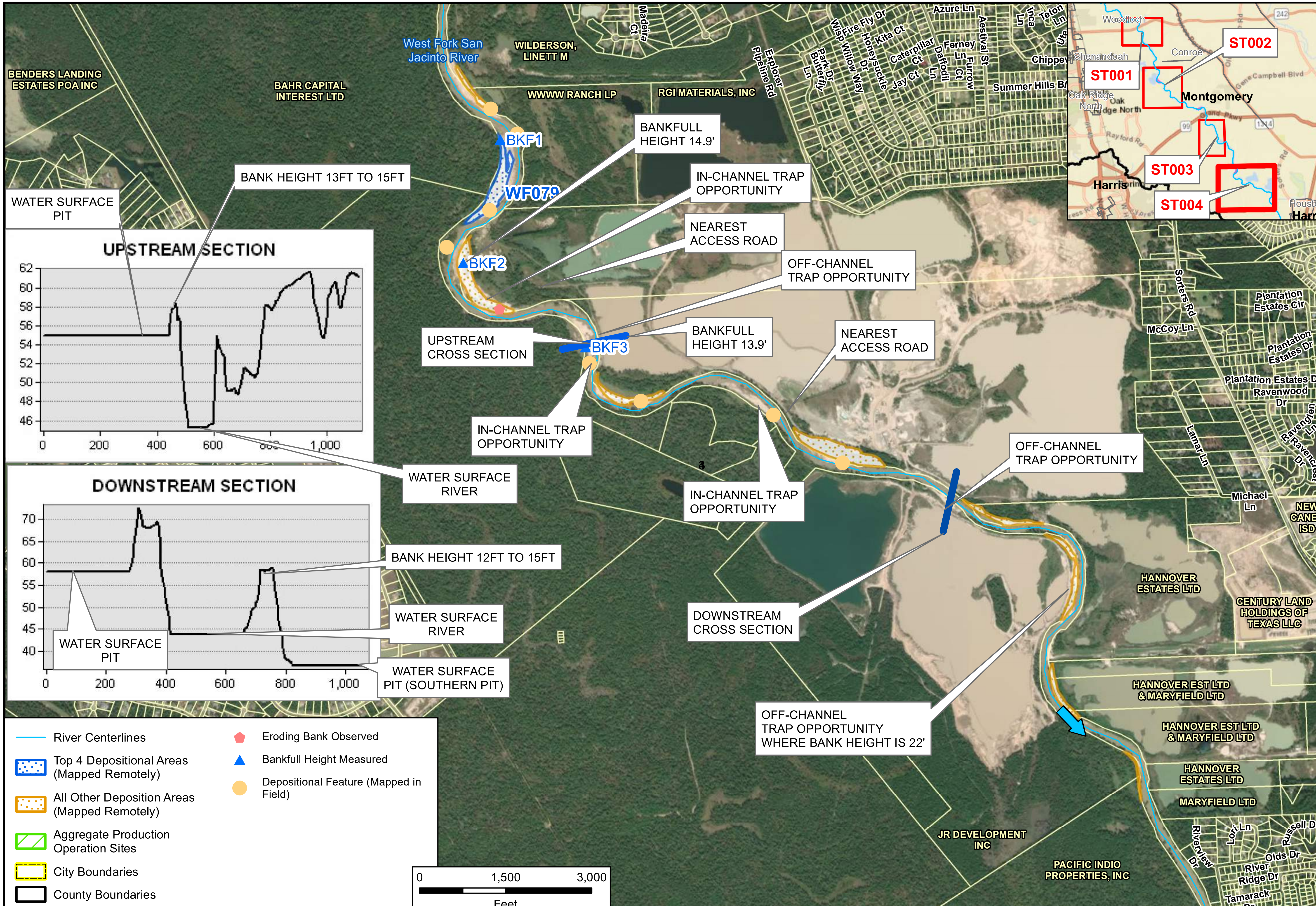
FIGURE



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San Jacinto River Authority
San Jacinto Watershed Study

Preliminary Sediment Trap Facility ST004
San Jacinto Watershed

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FIGURE
14

APPENDIX B - TABLES

Table B-1. Geoids Used in LiDAR Analysis and Elevation Comparison

Location ID	Latitude	Longitude	Geoid 99 Elevation (meters)	Geoid 12B Elevation (meters)	Elevation Difference (meters)	Elevation Difference (feet)	Elevation Difference (inches)
EF002	95.0793	30.36444	27.392	27.421	0.029	0.095	1.14
EF004	95.0967	30.23148	27.368	27.401	0.033	0.108	1.3
EF005	95.1868	30.19814	27.37	27.419	0.049	0.161	1.93
EF009	95.0933	30.00972	27.281	27.354	0.073	0.24	2.87
WF003	95.2071	30.00969	-27.321	-27.409	0.088	0.289	3.46
WF006	95.5612	30.34613	-27.422	-27.497	0.075	0.246	2.95
WF008	95.5374	30.22505	-27.45	-27.553	0.103	0.338	4.06
WF010	95.3698	30.06706	-27.37	-27.457	0.087	0.285	3.43
Average							2.64

TABLE B-2

Title:	Prioritization Table for Preliminary Sediment Trapping Facility Location
Date:	5/14/2020
By:	GDF

1. The top ten sites will include at least two sites on the East Fork
2. The top four sites do not need to include any sites on the East Fork
3. To select the top four sites
    - a. Select a depositional area whose values in Column 4 exceed 90th Percentile (Column 6) and whose value in Column 8 is less than 30th percentile (Column 10)
    - b. Note proximal depositional areas to selected depositional area from 3.a in Column 11
    - c. If a depositional area meets criteria 3.a but has already been included in Column 11, omit
    - d. Continue steps 3.a through 3.c until four depositional areas have been selected
    - e. The top four sites will have an orange hatch
4. To select the remaining four sites from the West Fork to be in the top ten sites
    - a. Select any remaining depositional area whose value in Column 4 is within the top ten of the highest values (Column 5) regardless of distance to an APO
    - b. Note proximal depositional areas to the selected area in 4.a in Column 12
    - c. If a depositional area meets criteria 4.a but has already been included in Column 12, omit
    - d. Once 4.c is comlete, select a depositional area whose values in Column 4 exceed 90th Percentile (Column 6) and whose value in Column 8 is less than 30th percentile (Column 10)
    - e. Note proximal depositional areas to the selected area in 4.d in Column 12
    - f. If a depositional area meets criteria 4.d but has already been included in Column 12, omit
    - g. The remaining four sites will have a blue hatch
5. To select the two sites from the East Fork to be in the top ten sites
    - a. Select a depositional area in the East Fork with the highest value in Column 4 and whose value in Column 8 is less than 30th percentile (Column 10)
    - b. Select a depositional area in the East Fork with the highest value in Column 4

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12	Column 13	Column 14
Depositional Identification	Average Cumulative Volume	Cumulitive Volume of All Depositional Areas Within 500 feet (Cubic Yards)	Cumulitive Volume of This DA and All Depositional Areas Within 500 Feet (Column 2 plus Column 3)	Rank of Column 4	Does the Cumulitive Volume of This DA and All DA Within 500 Feet Exceed the 90th Percentile	Distance to Nearest APO (feet)	Rank: Distance to Nearest APO	Is the distance to the Nearest APO Less Than the 20th Percentile	Is the distance to the Nearest APO Less Than the 30th Percentile	Shares APO With the Following Depositional Areas Within a Preliminary Sediment Trapping Facility (Final Four Sites)	Grouped with Other Depositional Areas (Remaining Six Sites)	Total Average Cumulative Volume Depositional Areas within Column 10	Total Average Cumulative Volume Depositional Areas within Column 11
WF093	138,300	372,800	511,100	1	Yes	6,034	169	No	No		WF093 through WF100		979,300
WF098	81,896	372,309	454,205	2	Yes	11,046	199	No	No		WF093 through WF100		
WF060	128,700	315,837	444,537	3	Yes	190	23	Yes	Yes	WF057 through WF067		1,053,500	
WF057	56,626	369,006	425,632	4	Yes	166	19	Yes	Yes	WF057 through WF067			
WF059	230,200	185,326	415,526	5	Yes	202	25	Yes	Yes	WF057 through WF067			
WF095	215,100	138,300	353,400	6	Yes	8,084	179	No	No		WF093 through WF100		
WF075	311,500	29,347	340,847	7	Yes	430	46	Yes	Yes	WF075 and WF074		340,900	
WF074	29,347	311,500	340,847	7	Yes	954	86	No	Yes	WF075 and WF074			
WF096	25,491	303,700	329,191	9	Yes	10,492	193	No	No		WF093 through WF100		
WF094	157,700	163,791	321,491	10	Yes	8,461	183	No	No		WF093 through WF100		
WF099	214,800	93,405	308,205	11	Yes	12,601	203	No	No		WF093 through WF100		
WF100	11,509	296,696	308,205	12	Yes	12,658	204	No	No		WF093 through WF100		
WF061	85,637	192,690	278,327	13	Yes	523	53	Yes	Yes	WF057 through WF067			
WF069	71,860	202,175	274,035	14	Yes	722	68	No	Yes	WF068 through WF070			274,100
WF079	80,973	191,322	272,295	15	Yes	626	61	No	Yes	WF079 thorugh WF086			272,300
WF097	146,000	107,387	253,387	16	Yes	10,947	197	No	No		WF093 through WF099		
WF080	170,600	80,973	251,573	17	Yes	730	69	No	Yes	WF079 thorugh WF086			
WF027	122,000	121,927	243,927	18	Yes	1,076	90	No	No		WF027 through WF033		
WF070	169,400	71,860	241,260	19	Yes	211	27	Yes	Yes	WF068 through WF070			
WF092	115,300	112,800	228,100	20	Yes	950	84	No	Yes		WF091 through WF092		228,100
WF091	112,800	115,300	228,100	20	Yes	1,270	95	No	No		WF091 through WF092		
WF066	70,569	143,274	213,844	22	Yes	379	42	Yes	Yes	WF057 through WF067			
WF044	155,000	54,598	209,598	23	Yes	517	52	Yes	Yes		WF043 through WF045		209,600
WF062	63,990	131,684	195,674	24	Yes	913	82	No	Yes	WF057 through WF067			
WF026	69,434	122,000	191,434	25	Yes	624	60	No	Yes		WF023 through WF026		166,300
WF028	52,493	136,610	189,103	26	Yes	532	54	Yes	Yes				
WF045	33,302	155,000	188,302	27	Yes	80	4	Yes	Yes				
WF067	109,500	70,569	180,069	28	Yes	731	70	No	Yes				
WF056	122,700	56,626	179,326	29	Yes	1,040	88	No	No				
WF043	21,295	155,000	176,295	30	Yes	1,370	100	No	No				
WF032	43,185	118,377	161,562	31	Yes	586	58	Yes	Yes				
WF101	158,100	0	158,100	32	No	23,897	233	No	No				
WF063	46,048	106,483	152,531	33	Yes	873	78	No	Yes				
WF031	81,683	63,937	145,619	34	Yes	151	15	Yes	Yes				
WF053	67,712	57,772	125,484	35	Yes	139	14	Yes	Yes				
WF051	51,409	74,075	125,484	35	Yes	578	57	Yes	Yes				
WF052	6,363	119,121	125,484	37	Yes	1,214	93	No	No				
WF082	119,000	0	119,000	38	No	352	40	Yes	Yes				
WF030	20,751	96,293	117,044	39	Yes	265	33	Yes	Yes				
WF049	36,312	80,719	117,032	40	Yes	131	13	Yes	Yes				
WF034	31,331	82,735	114,065	41	Yes	876	79	No	Yes				
WF033	36,694	74,516	111,210	42	Yes	458	50	Yes	Yes				
WF068	32,775	71,860	104,635	43	Yes	857	77	No	Yes				
WF065	33,774	70,569	104,344	44	Yes	403	43	Yes	Yes				
WF078	20,722	80,973	101,695	45	Yes	2,274	116	No	No				
WF024	14,069	82,775	96,844	46	Yes	434	48	Yes	Yes				
WF054	47,518	47,081	94,599	47	Yes	1,852	106	No	No				
WF055	47,081	47,518	94,599	47	Yes	2,107	111	No	No				
WF035	46,040	46,667	92,707	49	Yes	1,233	94	No	No				
WF023	75,249	14,069	89,319	50	Yes	221	29	Yes	Yes				
WF064	42,493	46,048	88,541	51	Yes	664	62	No	Yes				
WF072	65,401	23,060	88,460	52	Yes	410	44	Yes	Yes				
WF073	23,060	65,401	88,460	52	Yes	4	1	Yes	Yes				
WF029	14,610	73,244	87,854	54	Yes	237	30	Yes	Yes				
WF048	43,298	36,312	79,611	55	Yes	211	26	Yes	Yes				
WF084	46,556	29,201	75,757	56	Yes	164	17	Yes	Yes				
WF083	29,201	46,556	75,757	56	Yes	189	22	Yes	Yes				

Depositional Identification	Average Cumulative Volume	Cumulitive Volume of All Depositional Areas Within 500 feet (Cubic Yards)	Cumulitive Volume of This DA and All Depositional Areas Within 500 Feet (Column 2 plus Column 3)	Rank of Column 4	Does the Cumulitive Volume of This DA and All DA Within 500 Feet Exceed the 90th Percentile	Distance to Nearest APO (feet)	Rank: Distance to Nearest APO	Is the distance to the Nearest APO Less Than the 20th Percentile	Is the distance to the Nearest APO Less Than the 30th Percentile	Shares APO With the Following Depositional Areas Within a Preliminary Sediment Trapping Facility (Final Four Sites)	Grouped with Other Depositional Areas (Remaining Six Sites)	Total Average Cumulative Volume Depositional Areas within Column 10	Total Average Cumulative Volume Depositional Areas within Column 11
EF022	18,556	55,612	74,168	58	Yes	33,721	262	No	No		EF020 through EF026		147,700
WF050	37,421	36,312	73,733	59	Yes	335	39	Yes	Yes				
WF058	16,106	56,626	72,732	60	Yes	430	47	Yes	Yes				
WF036	15,336	54,552	69,889	61	Yes	1,851	105	No	No				
EF023	2,475	59,174	61,649	62	Yes	33,710	261	No	No				
WF071	58,027	0	58,027	63	No	850	76	No	Yes				
EF020	19,503	33,550	53,052	64	Yes	34,146	263	No	No				
WF090	51,151	0	51,151	65	No	1,034	87	No	Yes				
EF021	12,519	38,059	50,578	66	Yes	34,579	264	No	No				
EF024	21,115	27,889	49,004	67	Yes	32,312	260	No	No				
EF012	14,935	24,660	39,595	68	Yes	40,207	278	No	No				
WF041	24,873	11,011	35,884	69	Yes	4,000	141	No	No				
WF042	11,011	24,873	35,884	69	Yes	2,779	126	No	No				
EF013	14,210	19,675	33,885	71	Yes	39,586	277	No	No				
WF089	32,634	0	32,634	72	No	282	36	Yes	Yes				
WF046	31,909	0	31,909	73	No	719	67	No	Yes				
WF077	31,542	0	31,542	74	No	4,652	154	No	No				
WF076	30,555	0	30,555	75	No	2,977	128	No	No				
EF034	6,680	23,727	30,407	76	Yes	28,515	247	No	No				
WF020	12,017	18,201	30,218	77	Yes	111	9	Yes	Yes				
EF018	7,481	22,708	30,189	78	Yes	36,988	270	No	No				
WF040	16,582	12,829	29,411	79	Yes	4,801	157	No	No				
WF039	12,829	16,582	29,411	79	Yes	4,356	150	No	No				
WF081	28,860	0	28,860	81	No	116	10	Yes	Yes				
WF019	16,152	12,017	28,169	82	Yes	269	34	Yes	Yes				
EF032	8,367	19,658	28,026	83	Yes	29,083	250	No	No				
EF025	4,021	23,952	27,973	84	Yes	32,298	259	No	No				
EF026	2,836	25,137	27,973	84	Yes	31,907	258	No	No				
WF018	27,890	0	27,890	86	No	819	74	No	Yes				
EF011	10,449	17,001	27,451	87	Yes	41,223	279	No	No				
EF068	6,381	20,723	27,104	88	Yes	15,007	212	No	No				
EF179	25,527	0	25,527	89	No	97	5	Yes	Yes				
EF065	6,371	19,098	25,470	90	Yes	15,417	214	No	No				
EF047	1,728	23,414	25,142	91	Yes	24,040	234	No	No				
EF046	4,278	20,864	25,142	92	Yes	24,261	235	No	No				
EF061	2,885	21,361	24,246	93	Yes	16,902	217	No	No				
EF035	4,650	19,546	24,195	94	Yes	28,751	249	No	No				
WF037	8,512	15,336	23,849	95	Yes	2,324	118	No	No				
EF058	7,810	15,942	23,752	96	Yes	17,511	220	No	No				
EF045	5,341	18,347	23,688	97	Yes	25,166	237	No	No				
EF014	4,740	17,800	22,540	98	Yes	39,301	276	No	No				
EF036	10,710	11,465	22,175	99	Yes	28,042	246	No	No				
EF016	6,711	15,394	22,105	100	Yes	38,094	274	No	No				
EF017	4,324	17,781	22,105	101	Yes	37,954	271	No	No				
WF016	4,225	17,521	21,746	102	Yes	4,180	146	No	No				
WF025	7,526	14,069	21,595	103	Yes	357	41	Yes	Yes				
EF033	4,498	16,847	21,345	104	Yes	29,391	251	No	No				
EF038	2,709	18,310	21,019	105	Yes	27,429	243	No	No				
EF031	3,830	17,077	20,908	106	Yes	29,920	253	No	No				
EF048	11,019	9,683	20,702	107	Yes	23,536	231	No	No				
WF085	20,301	0	20,301	108	No	99	6	Yes	Yes				
EF069	3,283	16,973	20,256	109	Yes	14,365	210	No	No				
EF044	8,117	11,347	19,464	110	Yes	24,572	236	No	No				
EF015	3,590	15,774	19,364	111	Yes	38,866	275	No	No				
WF015	8,916	10,418	19,334	112	Yes	4,757	156	No	No				
EF019	11,674	7,481	19,154	113	Yes	36,183	268	No	No				
EF056	5,785	13,179	18,963	114	Yes	18,299	222	No	No				
EF064	6,279	12,553	18,832	115	Yes	15,858	215	No	No				
EF049	3,677	14,931	18,608	116	Yes	23,402	230	No	No				
EF185	18,482	0	18,482	117	No	2,937	127	No	No				
EF153	1,428	17,037	18,465	118	Yes	2,230	115	No	No				
EF059	2,708	15,260	17,968	119	Yes	17,244	219	No	No				
EF060	2,476	15,492	17,968	119	Yes	17,655	221	No	No				
EF062	2,089	15,879	17,968	121	Yes	17,005	218	No	No				
EF037	2,076	15,582	17,658	122	Yes	27,877	244	No	No				
EF159	5,600	12,007	17,607	123	Yes	436	49	Yes	Yes				
EF067	7,927	9,664	17,591	124	Yes	14,601	211	No	No				
EF183	5,684	11,490	17,174	125	Yes	1,618	103	No	No				
EF063	3,297	12,650	15,947	126	Yes	16,068	216	No	No				
EF066	3,142	12,752	15,894	127	Yes	15,270	213	No	No				
EF042	2,759	12,813	15,571	128	Yes	25,763	240	No	No				
EF043	4,410	11,161	15,571	129	Yes	25,348	238	No	No				
EF041	3,062	12,509	15,571	129	Yes	25,545	239	No	No				
WF013	8,471	6,729	15,200	131	Yes	8,186	180	No	No				
WF012	6,729	8,471	15,200	131	Yes	8,759	185	No	No				
WF014	6,193	8,916	15,108	133	Yes	5,292	161	No	No				
EF010	2,067	12,585	14,652	134	Yes	41,618	280	No	No				
EF055	3,174	11,310	14,484	135	Yes	19,100	224	No	No				
EF057	2,194	12,290	14,484	135	Yes	18,852	223	No	No				
EF163	5,237	8,948	14,185	137	Yes	952	85	No	Yes				

Depositional Identification	Average Cumulative Volume	Cumulitive Volume of All Depositional Areas Within 500 feet (Cubic Yards)	Cumulitive Volume of This DA and All Depositional Areas Within 500 Feet (Column 2 plus Column 3)	Rank of Column 4	Does the Cumulitive Volume of This DA and All DA Within 500 Feet Exceed the 90th Percentile	Distance to Nearest APO (feet)	Rank: Distance to Nearest APO	Is the distance to the Nearest APO Less Than the 20th Percentile	Is the distance to the Nearest APO Less Than the 30th Percentile	Shares APO With the Following Depositional Areas Within a Preliminary Sediment Trapping Facility (Final Four Sites)	Grouped with Other Depositional Areas (Remaining Six Sites)	Total Average Cumulative Volume Depositional Areas within Column 10	Total Average Cumulative Volume Depositional Areas within Column 11
EF161	1,444	12,741	14,185	137	Yes	553	55	Yes	Yes		EF156 Through EF0162		19,000
EF162	1,904	12,281	14,185	139	Yes	752	71	No	Yes				
EF184	8,384	5,684	14,067	140	Yes	2,176	113	No	No				
WF021	2,048	12,017	14,065	141	Yes	886	81	No	Yes				
EF148	6,206	7,571	13,777	142	Yes	2,726	124	No	No				
EF176	4,729	8,809	13,538	143	Yes	697	63	No	Yes				
EF052	5,798	7,660	13,458	144	Yes	20,643	227	No	No				
EF053	4,018	9,130	13,147	145	Yes	20,026	226	No	No				
WF017	8,605	4,225	12,830	146	Yes	3,297	132	No	No				
EF054	3,332	9,386	12,718	147	Yes	19,465	225	No	No				
EF149	2,406	9,943	12,349	148	Yes	3,243	131	No	No				
EF078	7,459	4,871	12,330	149	Yes	10,545	195	No	No				
EF152	1,678	10,040	11,718	150	Yes	2,612	122	No	No				
EF166	8,065	3,432	11,498	151	Yes	913	83	No	Yes				
EF167	2,039	9,338	11,377	152	Yes	470	51	Yes	Yes				
EF077	3,615	7,459	11,074	153	Yes	11,022	198	No	No				
EF178	6,253	4,729	10,983	154	Yes	572	56	Yes	Yes				
EF080	1,256	9,718	10,973	155	Yes	10,207	190	No	No				
EF187	3,270	7,667	10,937	156	Yes	1,976	109	No	No				
EF006	10,877	0	10,877	157	No	44,195	284	No	No				
EF157	2,410	8,374	10,784	158	Yes	220	28	Yes	Yes				
EF160	1,012	9,772	10,784	159	Yes	263	32	Yes	Yes				
EF150	2,059	8,612	10,671	160	Yes	3,488	135	No	No				
EF154	6,857	3,725	10,581	161	Yes	1,671	104	No	No				
EF151	2,296	8,285	10,581	161	Yes	2,041	110	No	No				
EF170	5,226	5,163	10,389	163	Yes	273	35	Yes	Yes				
WF087	7,695	2,690	10,385	164	Yes	613	59	No	Yes				
WF088	2,690	7,695	10,385	164	Yes	300	37	Yes	Yes				
EF040	2,164	8,145	10,309	166	Yes	27,187	242	No	No				
EF073	1,463	8,434	9,896	167	Yes	13,346	206	No	No				
EF030	2,262	7,587	9,850	168	Yes	30,342	254	No	No				
EF029	1,950	7,900	9,850	168	Yes	30,502	255	No	No				
EF144	1,322	8,476	9,798	170	Yes	5,567	163	No	No				
EF143	1,149	8,649	9,798	171	Yes	5,600	164	No	No				
EF165	1,393	8,065	9,458	172	Yes	1,304	97	No	No				
EF051	3,642	5,798	9,440	173	Yes	21,278	228	No	No				
EF169	3,926	5,226	9,152	174	Yes	195	24	Yes	Yes				
EF071	2,183	6,701	8,884	175	Yes	13,664	208	No	No				
EF182	3,106	5,684	8,790	176	Yes	1,161	92	No	No				
EF002	6,206	2,147	8,353	177	No	48,367	288	No	No				
EF003	2,147	6,206	8,353	177	Yes	47,539	287	No	No				
EF039	3,360	4,873	8,233	179	Yes	26,841	241	No	No				
EF098	1,525	6,660	8,185	180	Yes	2,616	123	No	No				
EF097	1,173	7,012	8,185	181	Yes	2,726	125	No	No				
EF070	2,666	5,466	8,132	182	Yes	14,015	209	No	No				
WF007	7,979	0	7,979	183	No	29,862	252	No	No				
EF082	3,935	3,913	7,848	184	Yes	7,772	176	No	No				
EF081	2,590	5,258	7,848	184	Yes	8,380	182	No	No				
EF083	1,324	6,524	7,848	186	Yes	8,005	178	No	No				
EF158	1,763	5,841	7,604	187	Yes	127	12	Yes	Yes				
EF050	3,913	3,677	7,589	188	Yes	22,691	229	No	No				
WF038	7,424	0	7,424	189	No	3,217	130	No	No				
EF075	3,678	3,709	7,387	190	Yes	12,669	205	No	No				
EF177	2,556	4,729	7,285	191	Yes	1,046	89	No	No				
EF145	4,670	2,471	7,140	192	Yes	5,094	159	No	No				
EF186	3,868	3,270	7,138	193	Yes	2,366	120	No	No				
EF188	3,799	3,270	7,069	194	Yes	1,479	102	No	No				
EF027	1,807	4,936	6,743	195	Yes	30,792	256	No	No				
EF171	1,238	5,226	6,464	196	Yes	105	8	Yes	Yes				
EF141	2,657	3,756	6,413	197	Yes	5,190	160	No	No				
EF072	2,573	3,646	6,218	198	Yes	13,622	207	No	No				
EF095	1,384	4,731	6,115	199	Yes	2,443	121	No	No				
EF096	2,032	4,082	6,115	200	Yes	2,188	114	No	No				
EF174	6,017	0	6,017	201	No	167	21	Yes	Yes				
EF074	2,246	3,678	5,924	202	Yes	12,501	202	No	No				
WF004	1,313	4,603	5,916	203	Yes	36,014	267	No	No				
WF003	3,805	2,111	5,916	204	No	36,367	269	No	No				
WF005	798	5,118	5,916	205	Yes	35,856	266	No	No				
EF009	2,136	3,739	5,875	206	Yes	41,940	281	No	No				
WF047	5,539	0	5,539	207	No	797	73	No	Yes				
EF140	1,158	4,214	5,371	208	Yes	4,297	148	No	No				
EF139	2,929	2,402	5,331	209	Yes	3,613	138	No	No				
EF181	3,388	1,814	5,201	210	No	314	38	Yes	Yes				
EF180	1,814	3,388	5,201	210	Yes	66	2	Yes	Yes				
EF142	1,285	3,815	5,100	212	Yes	4,612	153	No	No				
WF010	5,081	0	5,081	213	No	23,887	232	No	No				
WF011	4,964	0	4,964	214	No	11,323	200	No	No				
WF001	2,586	2,187	4,772	215	Yes	38,075	273	No	No				
WF002	2,187	2,586	4,772	215	Yes	38,021	272	No	No				
EF099	2,071	2,698	4,769	217	Yes	3,081	129	No	No				

Depositional Identification	Average Cumulative Volume	Cumulitive Volume of All Depositional Areas Within 500 feet (Cubic Yards)	Cumulitive Volume of This DA and All Depositional Areas Within 500 Feet (Column 2 plus Column 3)	Rank of Column 4	Does the Cumulitive Volume of This DA and All DA Within 500 Feet Exceed the 90th Percentile	Distance to Nearest APO (feet)	Rank: Distance to Nearest APO	Is the distance to the Nearest APO Less Than the 20th Percentile	Is the distance to the Nearest APO Less Than the 30th Percentile	Shares APO With the Following Depositional Areas Within a Preliminary Sediment Trapping Facility (Final Four Sites)	Grouped with Other Depositional Areas (Remaining Six Sites)	Total Average Cumulative Volume Depositional Areas within Column 10	Total Average Cumulative Volume Depositional Areas within Column 11
EF126	920	3,815	4,734	218	Yes	4,095	144	No	No				
EF127	459	4,143	4,602	219	Yes	3,823	140	No	No				
EF173	4,415	0	4,415	220	No	68	3	Yes	Yes				
WF086	4,401	0	4,401	221	No	241	31	Yes	Yes				
EF086	3,190	1,127	4,317	222	No	4,091	143	No	No				
EF087	1,127	3,190	4,317	222	Yes	3,507	136	No	No				
EF084	2,464	1,829	4,293	224	No	6,346	170	No	No				
EF085	1,829	2,464	4,293	224	Yes	6,618	171	No	No				
EF106	859	3,369	4,228	226	Yes	5,844	166	No	No				
EF107	605	3,623	4,228	227	Yes	5,865	167	No	No				
EF105	1,856	2,372	4,228	228	Yes	5,682	165	No	No				
EF108	908	3,320	4,228	229	Yes	5,937	168	No	No				
EF156	2,420	1,763	4,182	230	No	167	20	Yes	Yes				
EF138	1,244	2,929	4,173	231	Yes	3,370	134	No	No				
EF114	721	3,391	4,112	232	Yes	10,713	196	No	No				
EF125	1,402	2,595	3,997	233	Yes	4,331	149	No	No				
EF113	1,788	2,191	3,979	234	Yes	10,370	192	No	No				
EF008	1,673	2,136	3,808	235	No	42,094	282	No	No				
EF110	517	3,237	3,754	236	Yes	8,360	181	No	No				
EF100	1,368	2,314	3,682	237	Yes	4,167	145	No	No				
EF120	174	3,438	3,611	238	Yes	7,363	174	No	No				
EF124	1,216	2,321	3,537	239	Yes	4,696	155	No	No				
EF134	2,973	563	3,536	240	No	844	75	No	Yes				
EF135	563	2,973	3,536	240	Yes	1,364	99	No	No				
WF008	3,528	0	3,528	242	No	28,524	248	No	No				
EF079	2,259	1,256	3,514	243	No	9,702	188	No	No				
EF007	3,455	0	3,455	244	No	42,740	283	No	No				
EF005	1,704	1,679	3,383	245	No	45,059	285	No	No				
EF004	1,679	1,704	3,383	245	No	45,620	286	No	No				
EF168	1,273	2,039	3,312	247	No	164	18	Yes	Yes				
EF122	1,464	1,834	3,298	248	No	7,007	173	No	No				
EF121	1,660	1,638	3,298	249	No	6,741	172	No	No				
EF112	1,470	1,788	3,258	250	No	10,249	191	No	No				
EF128	738	2,463	3,200	251	Yes	3,542	137	No	No				
EF115	1,603	1,514	3,117	252	No	10,530	194	No	No				
EF103	1,644	1,368	3,012	253	No	4,473	151	No	No				
EF001	2,710	0	2,710	254	No	49,409	289	No	No				
EF175	2,670	0	2,670	255	No	704	64	No	Yes				
EF028	724	1,807	2,531	256	No	31,169	257	No	No				
WF006	2,511	0	2,511	257	No	35,028	265	No	No				
EF118	1,287	1,219	2,505	258	No	8,689	184	No	No				
EF117	1,219	1,287	2,505	258	No	8,995	187	No	No				
EF164	2,469	0	2,469	260	No	1,353	98	No	No				
EF146	1,698	722	2,420	261	No	4,284	147	No	No				
EF147	722	1,698	2,420	261	No	4,559	152	No	No				
EF116	793	1,603	2,396	263	No	10,031	189	No	No				
EF129	1,084	1,197	2,281	264	No	3,304	133	No	No				
EF109	1,655	517	2,172	265	No	7,832	177	No	No				
EF090	1,366	805	2,172	266	No	412	45	Yes	Yes				
EF089	805	1,366	2,172	266	No	712	66	No	Yes				
EF076	2,115	0	2,115	268	No	11,782	201	No	No				
EF111	1,582	517	2,099	269	No	8,911	186	No	No				
EF102	359	1,679	2,038	270	No	4,053	142	No	No				
EF101	311	1,727	2,038	271	No	3,782	139	No	No				
EF092	2,029	0	2,029	272	No	156	16	Yes	Yes				
EF172	1,792	0	1,792	273	No	126	11	Yes	Yes				
EF155	1,579	0	1,579	274	No	877	80	No	Yes				
EF133	1,510	0	1,510	275	No	100	7	Yes	Yes				
EF094	789	637	1,426	276	No	1,276	96	No	No				
EF093	637	789	1,426	276	No	1,418	101	No	No				
EF137	1,286	0	1,286	278	No	2,341	119	No	No				
EF130	998	249	1,248	279	No	2,139	112	No	No				
EF131	249	998	1,248	279	No	1,936	108	No	No				
WF022	1,175	0	1,175	281	No	708	65	No	Yes				
EF088	1,134	0	1,134	282	No	2,282	117	No	No				
EF091	1,103	0	1,103	283	No	760	72	No	Yes				
EF136	936	0	936	284	No	1,898	107	No	No				
WF009	829	0	829	285	No	27,919	245	No	No				
EF132	801	0	801	286	No	1,095	91	No	No				
EF123	789	0	789	287	No	5,434	162	No	No				
EF104	612	0	612	288	No	4,874	158	No	No				
EF119	313	174	487	289	No	7,609	175	No	No				

Appendix C

Bedload Collector Implementation Cost,

San Jacinto Sand Study **Riverine Sediment Bedload Collector System** **Preliminary Cost Estimate**					
RIVERINE 30' HIGH CAPACITY BEDLOAD COLLECTOR SYSTEM INSTALLATION HAS (75 TPH Maximum)	Qty	Unit	$ / unit	Subtotal	Section Total
Mob/Demob & Install/Commission	1	ea	$177,535.00	$177,535.00	
Collector System Components Mob (Shipping)	1	ea	$22,465.00	$22,465.00	
Pre-Installation/Post-Installation Survey	1	ea	$4,000.00	$4,000.00	
FIXED RIVERNE COLLECTOR SYSTEM COMPONENTS					
30-ft High Capacity Riverine Bedload Collector Unit W/O Deck Wash	1	ea	$325,000.00	$325,000.00	
Submersible MVLH4 Pumps (Inject - 50 hp)	1	ea	$56,959.00	$56,959.00	
Submersible MVLH4 Pumps (Suction - 75 hp)	1	ea	$90,000.00	$90,000.00	
Control Valves	9	ea	$1,400.00	$12,600.00	
Check Valves	1	ea	$2,200.00	$2,200.00	
DEWATER, SEPERATOR, & STACKER PLANT COMPONENTS 75 TPH Maximum					
Dewater/Separator Plant w/ 36inch Screw and 1500 gal Tank	1	ea	$360,746.00	$360,746.00	
Stacker Plant 24" x 60'	1	ea	$72,340.00	$72,340.00	
SCADA / Controls	1	ea	$208,500.00	$208,500.00	
Remote Access Interface	1	ea	$32,600.00	$32,600.00	
San Jacinto Bedload Collector Equipment - SubTotal					**$1,364,945.00**
CONTINGENCY FOR IMPLEMENTATION					
10% Contingency of $1,364,945	1	ea	$136,494.50	$136,494.50	**$136,494.50**
ENGINEERING & DESIGN					
Streamside Engineeering, Testing and support	1	ea	$166,854.00	$166,854.00	
Engineering & Design (Installation & Monitoring)	1	ea	$170,000.00	$170,000.00	
San Jacinto - SubTotal E&D					**$336,854.00**
PERFORMANCE & VALIDATION OPTION ITEMS					
Density meters	1	ea	$40,000.00	$40,000.00	
Third Party Evaluation, Validation & Documentation	1	ea	$200,000.00	$200,000.00	
San Jacinto - Performance & Validation Options					**$240,000.00**
TOTAL COST FOR EQUIPMENT, EQUIPMENT DESIGN, ENGINEERING, DELIVERY, INSTALLATION OVERSITE					**$2,078,293.50**
Delivery			**16 to 18 weeks**		

Appendix D

Background Report for Bedload Collector in Mackinaw River, Illinois

Mackinaw River Bedload Sediment Collector

Authority for the Dredging of the Illinois Waterway.

The formal authorization for the U. S. Army Corps of Engineers to operate and maintain the nine-foot channel for navigation in the Illinois Waterway (Chicago River, Chicago Sanitary and Ship Canal, Calumet Sag Channel, Des Plaines River and the Illinois River) was given in the Rivers and Harbors Act of 1927, as modified by the Rivers and Harbors Act of 1930, and as further modified by the Rivers and Harbors Act of 1935.

The Need

A method other than hydraulic or mechanical dredging is needed to remove sediment from the Illinois River that is deposited by the Mackinaw River on a continuous basis.

The Current Situation

The Mackinaw River is located within the confines of the Rock Island District Corps of Engineers, flowing thru mid-central Illinois, draining an area of 1,136 square miles and running 129.7 miles in length. It runs thru what was a glacial outwash plain of the Wisconsin Period. In doing so it transports material ranging from fine to course sand and small gravel ranging in size from an eighth -of-an-inch to three-quarter-inch. The Mackinaw empties into the Illinois River just below Pekins, Illinois at River Mile 147.9, forming a delta made up of this material which requires dredging on an at least yearly basis.

Hydraulic dredging of the Mackinaw delta started in earnest in 1941 when 48,000 cubic yards of material was removed and place on the bank line. Since that time the delta has been dredged 55 times with quantities of material ranging from 2,000 cubic yards to 254,000 cubic yards with the average being 50,000 cubic yards of the approximant 2,300,000 cubic yards removed. This makes the Mackinaw delta the most chronically dredged site on the entire Illinois Waterway. This past season alone the cost of the work was $970,000 for the removal of 90,000 cubic yards (2014) or $10.78 a cubic yard. Not included in these figures is the amount of material removed in the next dredge cut immediately downstream, Kingston Mines, which over the past 68 years has required the removal of 1,100,000 cubic yards of material.

Since 1996, the majority of the dredged material has been placed upland behind a flood control levee. This site was constructed at the time with a 30 year life expectancy. The site has since received 700,000 cubic yards to date and is at 85% capacity instead of the 66% originally anticipated. This will require the construction of a new placement site for the dredged material with or without the installation of an automatic removal system. It is proposed to construct the new placement site alongside the Mackinaw River itself for efficient economic placement.

The Potential Solution and Test

While the construction of the new placement site is a foregone conclusion, a new method of “dredging” is also being considered. In 2010 it was brought to the Districts’ Channel Maintenance Section’s attention that Streamside Technology, LLC, had developed a Streamside Systems® Sediment Removal (or harvesting) system that extracts sediment bed load. The system operates on the principle that sediment in the bedload can be trapped by gravity and removed at the natural rate of transport, instead of episodically.

How the System Works

The removal system consists of the in-stream collector, slurry pump and pipeline, and a sediment dispersal system (e.g., conveyor). The collector is a steel hopper that is placed on the bottom along a sediment transport pathway. Figure 1 shows a photograph of a bedload collector being installed in Fountain Creek in Pueblo, Colorado, to demonstrate this technology's potential to alleviate the need for dredging by lowering the downstream grade to reduce flooding and ultimately reduce sediment deposition as far downstream as John Martin Reservoir, a USACE managed lake (Thomas et al. in preparation). This technology uses the energy of the water flow to move bedload sediment up the collector's ramp (left shallower sloped-side of the collector in Figure 1) that subsequently falls into the hopper because of its density. Grating over the hopper keeps large rock, wood debris, man-made litter and aquatic life out of the collector (see Figure 2). As the sediment fills the hopper it is pumped via slurry pump and pipeline to a dewatering or placement site.

Figure 1. Installation of a 30 ft. collector.

Figure 2. Sediment Collector installed in Fountain Creek, Pueblo, Colorado.

The system can either be operated in an open or closed cycle. In the open cycle, water is drawn into the collector manifold from across the grate, since the area of the grate is much greater than the area of the manifold orifices, velocity across the grate is very small (<1 ft./s), even though velocity at the manifold is large enough to transport sediment. In the closed cycle, the slurry is discharged into a holding tank and separated from the water, and then the water is returned to the opposite side of the manifold so that water is drawn from the holding tank instead of across the grate; advantages of the closed cycle include near-zero impingement velocity (reducing potential for clogging) on the hopper grate, near-zero entrainment of aquatic organisms, and greatly reduced consumptive water loss.

Bedload can either be stored in the hopper and pumped out intermittently, or can be pumped continuously during high flows or storm events. Collectors are installed in various scenarios for multiple purposes. The collector’s relative elevation to the water body’s bottom is determined by its intended function (e.g., as a grade control structure to reduce dredging or for sand and gravel excavation for commercial purposes).

Slurry transported out the hopper via dredge pump can be handled in a variety of ways such as being deposited directly from the pipeline discharge into a placement area, or being dewatered in some manner for subsequent use. At Fountain Creek the slurry was discharged into a bin at the base of the screw separator, which separates and drops the coarse sediment onto the stacker (Figure 3) and the sediment is stockpiled at the stacker until it can be trucked away.

Figure 3. Archimedes screw (sand washer) separator (left) and stacker (right).

Mackinaw River Bedload Collector Evaluation Study

Our Channel Maintenance Section (OD-T) contacted the Corps' Engineer Research and Development Center (ERDC) in Vicksburg, Mississippi about the possibility of conducting a study to evaluate this technology's applicability in the Mackinaw. ERDC's funding was provided by the Navigation Systems Research Program. The following section describes this study and its results.

Sediment sampling

Sediment samples were collected by MVR and ERDC personnel 20 May 2013 with a push corer, grab sampler, and jars from subaqueous and sub-aerial locations (e.g., point bars and bank) along the Mackinaw and Illinois Rivers (illustrated in Figure 4). These samples were analyzed by MVR for grain size distribution and visual classification as per the Unified Soils classification System (USCS). These data were used to establish the range of sediments that could be expected to be encountered by the bedload collector for design purposes, and for use in generating a sediment rating and load curve for the Mackinaw River.

Bedload Collector Prototype Trials

During 22, 23, and 24 July 2013, two prototype bedload collectors (2 foot and 4 foot wide respectively as shown in figure 5) were deployed in the Mackinaw River delta by MVR and ERDC personnel to demonstrate this technology's proof of concept, as well as to collect data to estimate preliminary sediment recovery rates of a full-sized bedload collector system. Figure 6 shows the 4 foot collector with grate removed to view the sediment collection hopper and suction port. After a collector was placed on the river bottom in a crater to optimize its elevation, its suction port was connected to a trash pump's suction side via a 2 inch diameter non-collapsible suction hose. The trash pump's discharge was then connected to a sediment settling tank via another 2 inch diameter hose (see Figure 7).

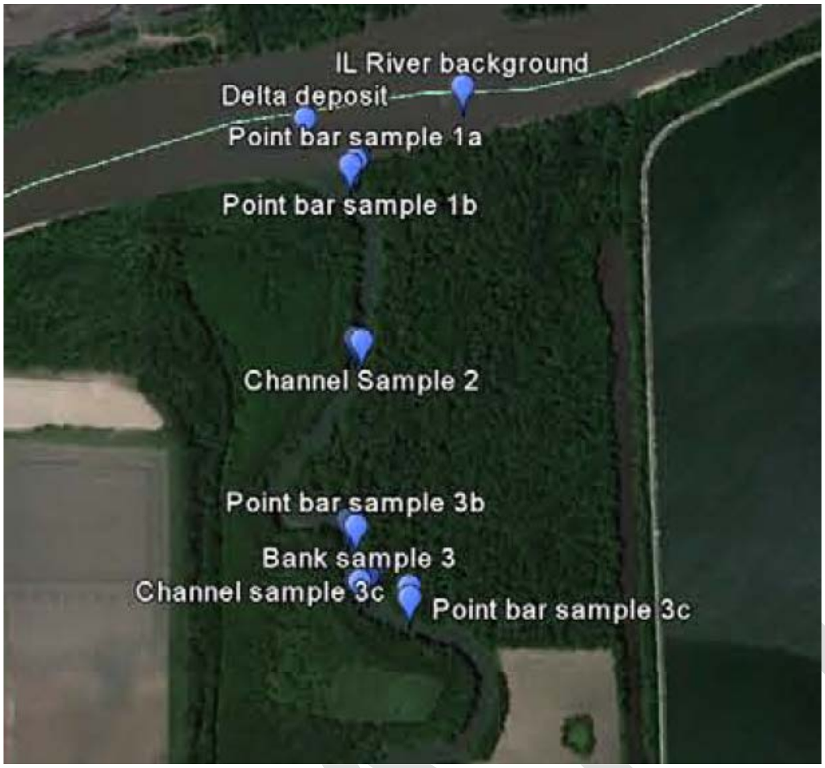


Figure 4. Sediment sampling locations

Figure 5. Two and four foot-wide collectors used in the Mackinaw River Study

Figure 6. Four foot collector with grate off to show hopper, hopper suction port, and pipeline fitting

Figure 7. Pump and settling tank assembly

When the pump was turned on, sediment in the collector's hopper was entrained and transported through the pump as a slurry and subsequently deposited in the settling tank. The sand and gravel's relatively higher density caused it to settle to the bottom of the tower while carrier water was discharged as an overflow from a separate port at the top of the tank. Sediment was removed from the bottom of the settling tank through a ball valve-controlled port. As the sediment flowed through the ball valve, it was collected in filter cloth bag that allowed water to drain out from the mixture (see Figure 8). The bedload collector hopper was pumped out as empty as possible before separate trials were initiated. After running for an allotted time, pumping ceased and sediment volume measured.

Figure 8. Harvested sediment being retrieved in a filter cloth bag from settling tank

The first day was spent mobilizing equipment to the site, deploying the 2 foot collector relatively near the boat (where the boats davit could be used to lower and raise the collector), setting up the pump/settling tank assembly, and conducting several successful proof-of-concept trials before the entire system had to be disassembled and demobilized from the site. On the second day, the 4 foot collector was mobilized to the site and, based on experience gained the first day with the relatively smaller lighter 2 foot collector, it was decided to deploy the 4 foot collector as close to the Mackinaw River's centerline as possible on the delta. But, due to the fact that it had to be placed manually, the 400 pound collector could only be placed off centerline on the shallow water delta in the location as indicated in Figure 9 (man in water with lifejacket is standing by the 4 foot collector), and this consumed the majority of the second day such that only 2 production trials were completed before the pump/settling tank had to be de-mobilized from the site. Due to the difficulty experienced (labor and time) in placing the 4 foot collector, it was decided to leave the collector in place over night and marked by buoys. On the third day, the pump/settling tank assembly was re-mobilized back to the site, and 4 production trials were conducted before all the bedload collector equipment had to be demobilized from the site.

Figure 9. Man (in water) standing next to 4 foot bedload collector on Mackinaw River delta.

Evaluation Study Results and Discussion

Sediment Classifications and Grain size Distributions

The results of laboratory analyses of the sediment samples collected from the study site are presented in Appendix A (visual classification and grain size distribution ratios and curves). These sediment samples were predominantly coarse-grained ranging in composition from coarse gravel to fine sand with an average of 13.5% fraction minus #200 finer by weight.

4 Foot Bedload Collector Production Trials

Results of the 4 foot production trials are listed in Table 1. Sediment was initially collected and volume measured in 5 (US) gallon buckets (as shown in Figure 8, and close-up of harvested sediment in Figure 10), then converted to cubic feet and yards.

Figure 10. Goal of the project, a mixture of harvested fine and course sand and small gravel in this bucket!

Trials 1 through 5 were conducted and time and volume of sediment recorded. These values were used as the basis (assuming a constant excavation rate) to calculate hourly production rates that varied from 0.1 to 0.23 yd^3/hr. and daily production rates (2.38 to 5.53 yd^3/24hr). The average hourly production rate from these 5 trials was 0.16 yd^3/hr., or a daily production rate of 3.95 yd^3/24hr. For some of the trials, run time was varied to try to optimize the total number of trials (given the limited amount of operating time) that could be conducted. It was observed that a significant amount of blinding was occurring on the grate due to the larger sized gravel (see Figure 11) (FIND OUT GRATE SIZE 3/4 inch?), so three trials were conducted with the grate removed and the average production rates increased to 0.18 yd^3/hr. (4.32 yd^3/24hr).

Table 1. Production data for bedload collector trials and calculated values for 30 foot collector

			Measured 4 Ft Collector Production						Calculated 30 Ft Collector Production		
Trial	Time Minutes	Volume Gallons	Volume ft^3	roductio ft3/min	Volume yd^3	Production yd^3/min	Production yd^3/hr	Daily Production yd^3/24hr	Production 30 footer yd^3/hr	Production 30 footer yd^3 per 24hr	Production 30 footer yd^3 per year
1	15	6.0	0.80	0.05	0.030	0.002	0.12	2.85	0.89	21	7,807
2	30	20.0	2.67	0.09	0.099	0.003	0.20	4.75	1.49	36	13,012
3	30	13.0	1.74	0.06	0.064	0.002	0.13	3.09	0.97	23	8,457
4	24.5	19.0	2.54	0.10	0.094	0.004	0.23	5.53	1.73	41	15,136
5	30	10.0	1.34	0.04	0.050	0.002	0.10	2.38	0.74	18	6,506
6 grate off	4.5	2.0	0.27	0.06	0.010	0.002	0.13	3.17	0.99	24	8,674
7 grate off	8.93	6.0	0.80	0.09	0.030	0.003	0.20	4.79	1.50	36	13,114
8 grate off	14.16	10.0	1.34	0.09	0.050	0.003	0.21	5.04	1.57	38	13,783

Figure 11. Gravel and sand blinding across top of 4 foot collector grate

Assuming a linear function, the production rate of a 30 ft long collector would equal the production of a 4 ft collector multiplied by a factor of 7.5. Table 1 lists the calculated production rates of a 30 ft collector using this rationale. The average yearly production rate (based on the average calculated from all 8 trials of the 4 ft collector) of a 30 foot collector would be 10,811 yd^3/year. If four 30 ft collectors were installed to span the breath of the Mackinaw River (i.e., a total collector length of 120 ft), their collective production rate would be approximately 43,240 yd^3/year.

The bedload collector can only harvest sediment at the rate that the flowing water feeds it. Every river's discharge changes constantly, or, in Heraclitus words, "you can't step into the same river twice." Bedload transport rates, given sufficient sediment supply, are a function of river flow (or discharge). The production values listed in Table 1 are based on the Mackinaw River's flow rates on 23 and 24 July 2013, only 2 out of 365 days a year. To gain a relative appreciation of the Mackinaw River's discharge variability, the flow (as measured near Green Valley 17.3 miles above the mouth of the Mackinaw River confluence) for the year 2013 is plotted in Figure 12 and specific values listed in Table 2. Flow rates for 23 and 24 July 2013 are 291 and 275 cubic feet per second (CFS) respectively on a falling river for that year. The mean CFS values for August thru December are 128 to 78 CFS respectively, so any collector production rate would be decreased for that duration. But when looking at the average flow rates for January through June (343 to 3,090 CFS respectively), a bedload collector's production rate would be increased, especially at the 18,200 CFS measured on 20 April 2013!

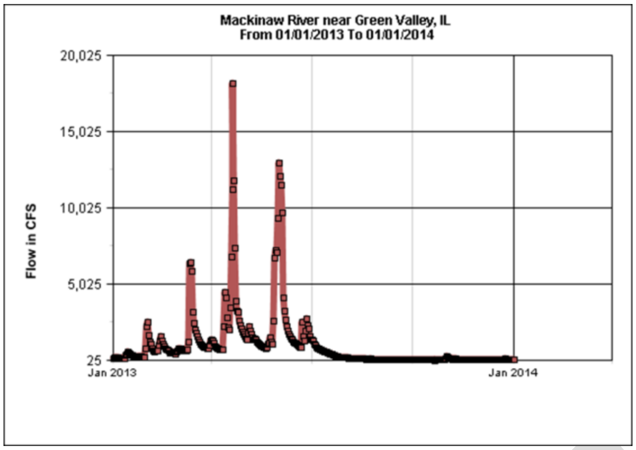


Figure 12. Plot of flow rates of Mackinaw River for 2013 (http://rivergages.mvr.usace.army.mil/WaterControl/new/layout.cfm

Table 2. 2013 Mackinaw River flow (cubic feet per second)

Mackinaw River near Green Valley, IL
Gage Zero - 477.10 Ft. NGVD29
Record High Stage - 28.29 Ft. (09/16/1993)
River Mile - 17.3 miles above the mouth of the Mackinaw River
Location of Gage -

Located in Tazewell County, IL. on the right bank downstream side of the Towerline Road bridge, 3.9 miles northeast of Green Valley, 2.5 miles east of State Highway 29, 5.8 miles south of Peken and 10.2 miles north of U.S. Highway 136.

For official flow data, please visit the USGS website listed in the Additional Links for this station.

This gage is funded by the U.S. Army Corps of Engineers (Rock Island District) and operated by the USGS Illinois Water Science Center.

2013 Flow (CFS)

Day	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT	NOV	DEC
1	176	2550	814	1300	1620	13000	1370	192	77	38	291	75
2	192	1650	726	1130	1460	12100	1300	190	77	37	190	73
3	155	1240	767	964	1390	11500	1110	179	75	37	152	73
4	212	1060	726	856	1800	9740	984	176	73	53	127	71
5	190	809	686	804	2230	4130	890	181	73	52	109	71
6	145	682	695	767	1990	3230	828	176	71	52	104	71
7	165	596	677	753	1740	2690	767	168	69	50	168	73
8	135	638	617	731	1550	2270	717	158	69	46	124	71
9	129	686	691	708	1400	1970	699	155	67	43	114	71
10	121	660	1200	691	1440	1760	669	147	69	41	104	71
11	165	1010	6410	2250	1390	1600	634	152	71	38	97	71
12	375	1340	6420	4460	1260	1480	604	137	67	37	88	73
13	445	1560	5850	4130	1150	1360	583	140	71	40	88	67
14	563	1310	3190	2790	1070	1240	555	132	67	38	86	67
15	510	1110	2450	2190	1020	1140	518	124	67	37	83	65
16	411	944	2050	2030	974	1150	487	119	69	37	77	67
17	383	809	1790	3490	924	1090	471	114	71	37	75	65
18	393	740	1570	6820	905	1020	445	111	67	37	79	65
19	307	695	1390	11200	847	959	404	106	67	38	81	63
20	281	634	1240	18200	818	905	368	104	75	38	77	61
21	247	522	1120	11800	847	856	334	99	81	35	79	67
22	226	526	1000	7400	1110	2510	314	99	69	37	81	79
23	266	510	929	3910	1170	1610	291	109	38	38	81	102
24	266	567	871	3230	1490	1290	275	99	40	46	88	168
25	212	530	875	3170	1210	1950	253	90	40	67	83	90
26	298	471	880	2630	1110	2760	235	90	37	63	79	88
27	195	559	809	2290	2610	2320	232	86	37	63	81	92
28	187	673	800	2070	6730	2070	229	86	38	63	79	88
29	215		984	1910	7280	1620	209	83	41	61	81	81
30	832		1290	1760	7090	1380	195	81	52	63	77	95
31	2250		1390		9380		218	81		124		86
MIN	121	471	617	691	818	856	195	81	37	35	75	61
MAX	2250	2550	6420	18200	9380	13000	1370	192	81	124	291	168
MEAN	343	896	1642	3548	2161	3090	554	128	63	48	104	78

To provide a more quantitative understanding of the Mackinaw River's flow impact to a bedload collector's production rate, sediment rating and load curves were formulated by the ERDC coastal and Hydraulics Laboratory for the bed material load in the Mackinaw River. The calculated curves are intended to define the sediment yield at the mouth of the river for sediment harvesting with a sediment collector.

Defining the sediment load and rating curves (SRC) required a series of steps (for more detailed information on the development of these SRC, please refer to Appendix B). First, appropriate site specific data were necessary that included hydrodynamic, bed material gradation, basic cross-sectional data, and general site knowledge. Initially, all the available data were collected and inventoried to define the missing data, then missing data were estimated. Second, normal depth computations were performed with hydrodynamic and cross-section data. Normal depth establishes the free surface at a cross-section for uniform flow conditions, and is required to pass a specific flow given the resistance coefficient. Third, using the collected, calculated, and estimated data from the previous steps, selection of the most useful sediment transport functions was made. Sediment transport functions were formulated based on regime, regression, probabilistic, and deterministic approaches. Finally, after running a series of sediment transport functions, dissemination of the calculated data was conducted to select the most appropriate function to define the SRC. The selected sediment transport functions were used to bracket the sediment flux. Once the SRC was generated, a flow sequence was processed through the SRC to determine the temporal supply of sediment at a given location.

Figure 13 shows the selected sediment rating curve by size class in milligrams/Liter. Each color band on the curve represents the total concentration for the bed material load in its respective size class. The accumulation of all size classes represents the total bed material load at the cross-section for each flow (note that the bed load is a portion of the bed material load). Likewise, Figure 14 shows the sediment load curve in tons/day. From these curves, the total daily bed material load and concentration were estimated for a given flow. Using the period of record, the average daily load is 4,200 tons/day and the average annual load is 1,500,000 tons/year. Using an approximate conversion value of 2,916 lbs. per yd^3 of dry sand and gravel, these values convert to an average daily load of 2,880 yd^3/day and average annual load of 1,029,000 yd^3/year. When the average Mackinaw River discharge value from July 23 and 24 July 2013 flows (283 CFS) is applied to the SCR in Figure 14, the corresponding capacity value is 140 tons/day (or 96 yd^3/day). This value of shows relatively good agreement to the calculated sediment harvesting value of 119 yd^3/day of a 120 ft long bedload collector system (based on the 4 ft collector trials in Mackinaw River flows on 23 and 24 July 2014).

In tests of the system in Colorado, it was noted that "the collectors have a high capture efficiency and therefore reflect the actual bedload transport rate of the targeted sediment sizes." And as with the Colorado demonstration, these tests also had the same results in removing "fine, medium, and coarse sand, and fine to medium gravel." Silts and very fine sand were also removed but were not apparent to the naked eye. It was also observed that small Shad of 1 inch in length were not bothered by the collectors when they passed over them. Use of the results from the 4 ft collector trials and the SRC will facilitate detailed design optimization of a bedload collector system to achieve system requirements.

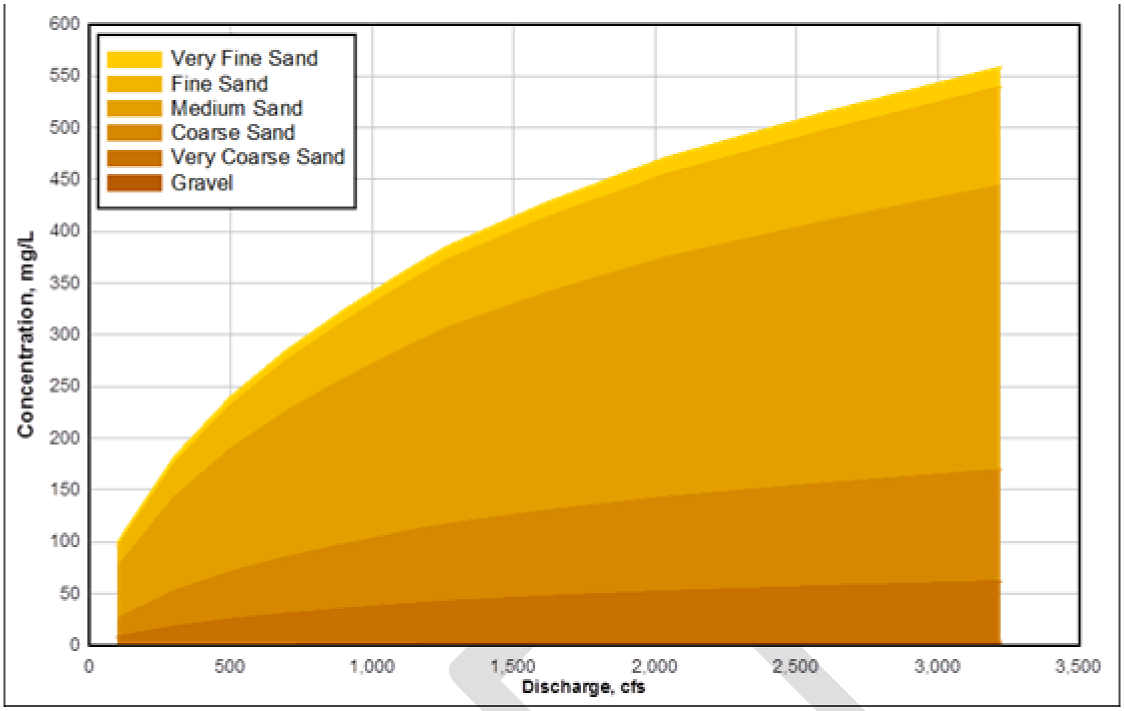


Figure 13. Sediment rating curve by size class

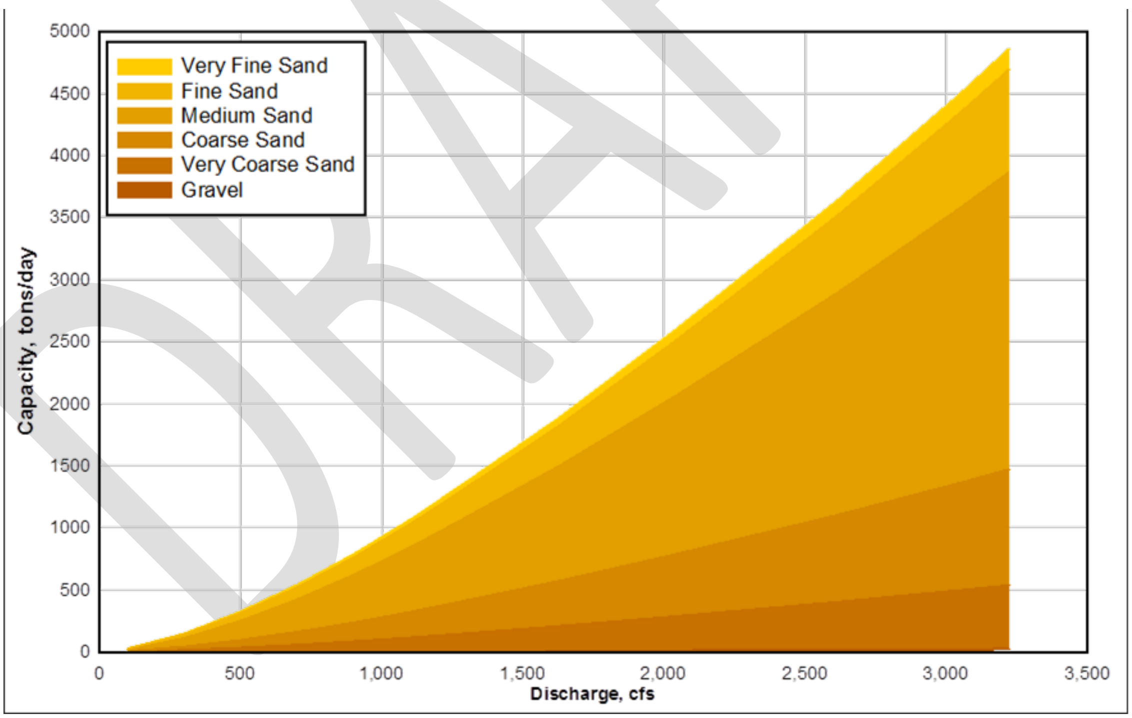


Figure 14. Sediment load curve by size class

Preliminary Mackinaw River Bedload Collector Design

When such a system is installed in the Mackinaw River, OD-T has identified two possible locations for the equipment to be located. In both instances power lines will have to be run to the site selected. At that site OD-T proposes the installation of four 30 foot collectors placed between concrete abutment walls; a pump station located above the 448.00 foot elevation (MSL 29) to keep it above flood waters; the plumbing necessary to remove the sediment from the river, connected to the pump; and from the pump a conveyor system to cross over the main stem flood control levee allowing for the placement of the material in the confined placement site. Instead of the use of a large conveyor system, there is the possibility of going directly thru the levee with the plumbing to a smaller conveyor within the site.

While the system removes sediment it will not remove fish (of any size), leaves, twigs, branches, trees or man-made litter, leaving clean material in the placement site. This would be a big help in marketing the material for beneficial use as local sand and gravel companies have told the Corps in the past that they are not interested in our material, as it is now dredged, due to the content of wood debris, and trash that they would have to remove.

Operational Requirements upon Installation

Once the system is in place and operational, it will be necessary to move the material around the site in order to make room for continued placement by the system. This may be accomplished by having an end-loader or bulldozer moving the material (either Corps or Contractor), or finding a beneficial user who would be interested in a long term agreement to remove the material.

Using the figure of 90,000 cubic yards of material for one year (the amount dredged in 2014), the system would remove on average 10.3 cubic yards of material per hour year round. Possibly a more complex conveyor system which is automatic and movable, similar to a field irrigation system, could be designed to move the material throughout the site thereby requiring less end-loader or bulldozer work.

Anticipated Results

With the installation and operation of the Streamside Sediment Collector, within two years the District should be able to either eliminate or greatly reduce the need for dredging at the mouth of the Mackinaw River thereby allowing the dredge to concentrate on other dredging needs.

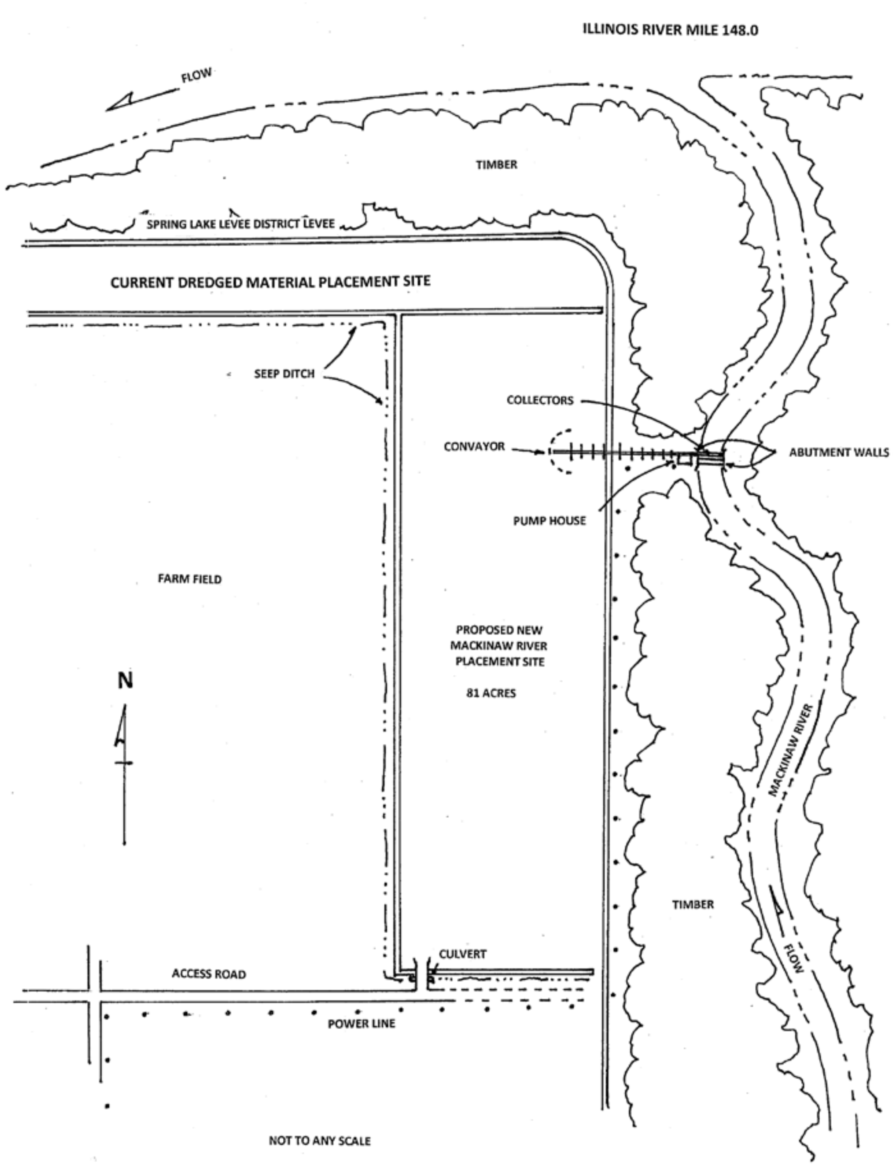
Other Potential Uses Within the District

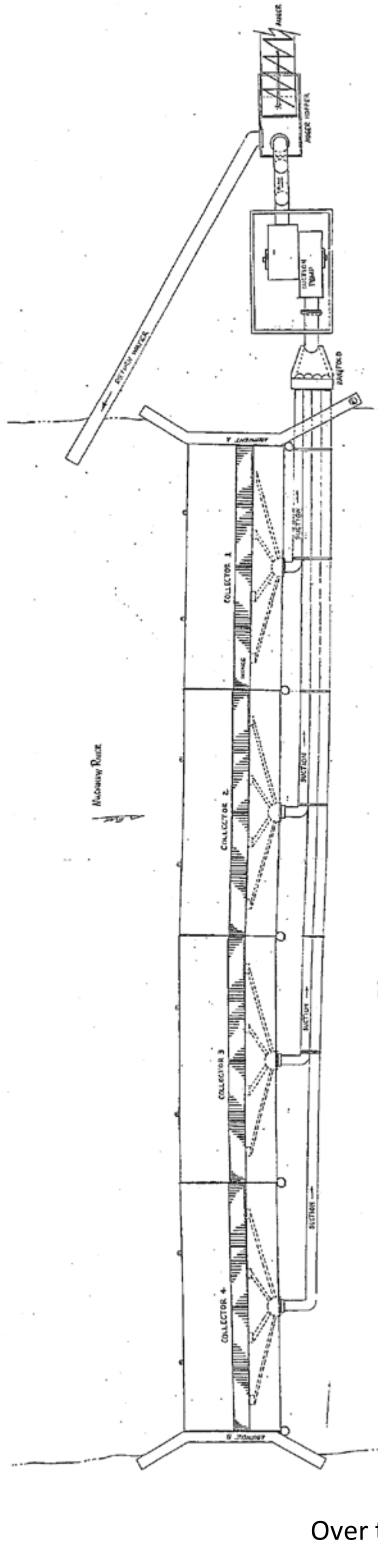
Upon the success of this system, other similar installations could be located in the Sangamon River just above Beardstown, Senachwine Creek at Chillicothe, Blue Creek at Spring Bay and in the Kankakee River, all of these on the Illinois River. The same systems could be used on the Maquoketa River Ecosystem Restoration, the Wapsipinicon River Ecosystem, The Rock River Ecosystem, the Iowa River Ecosystem, as well as on the Fabius River and Des Moines River, all located on the Mississippi River. The potential uses are almost limitless for dredging and ecosystem restorations.

Sediment Collector Diagrams and Proposed Set Up in the Mackinaw

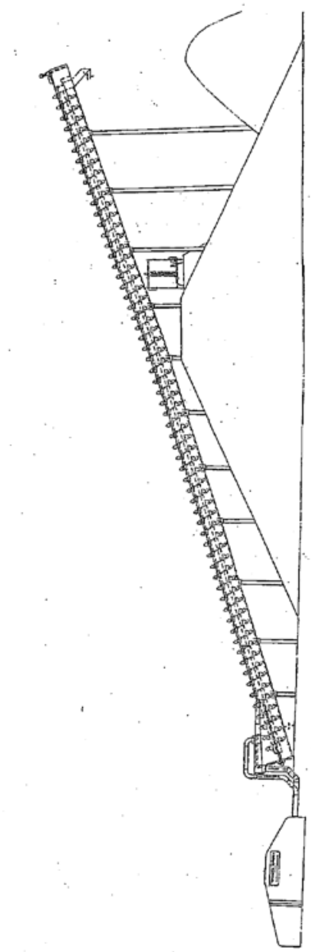
The following diagrams and site plan is only representative of what the possible installation of the Streamside System might look like under operational conditions. These are for information value only and does not necessarily show what the final configuration or location will look like.

Site Location Map – Mackinaw River Delta, Tazewell County, Illinois





Plan View With Four 30 Foot Collectors

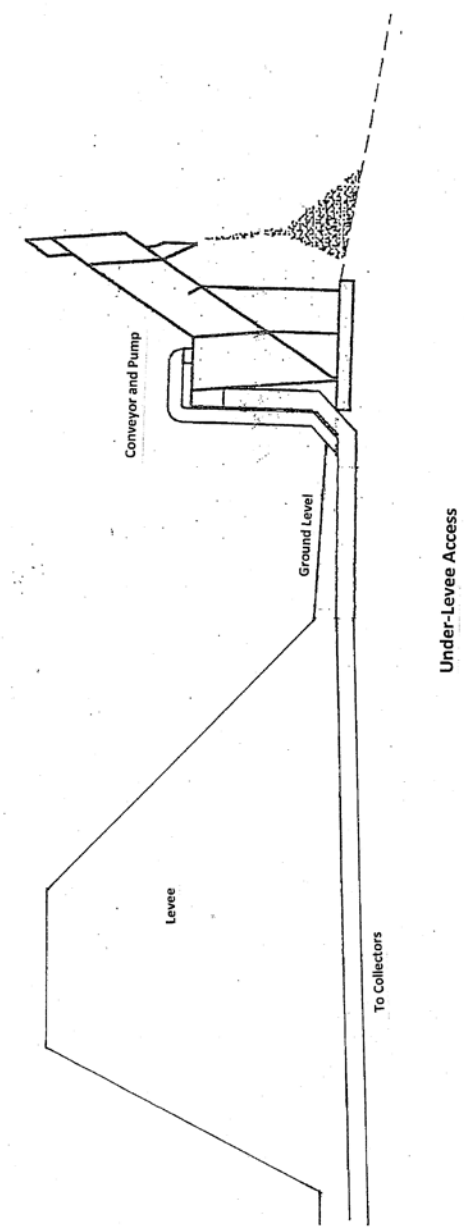


Side View Showing the Conveyor Over the Levee (The Collectors Have Been Rotated 90* for Ease of Viewing

Over the Levee Placement

Possible Under-Levee Access

The possibility of using directional boring under the flood control levee is also a potential method of accessing the placement site. This would reduce the cost that would be required by a conveyor passing over the top of the levee. The boring would be under, not thru, the levee, in the existing natural soil. It will be necessary to use Bentonite to fill in around the pipe(s) to insure no seepage from the river or the placement site. At least one control valve will need to be installed on the riverward side of the levee to close off the pipe(s) in the event of extreme high water occurrences.



Some of the diagrams in this paper have made use of parts of the drawings originally shown in the project plans entitled ***FOUINTAN CREEK; BEDLOAD MONITORING PHASE 1****,* which were put together for the City of Pueblo, Colorado, in the **Fountain Creek Sediment Removal, Final Plans**.

Streamside Technology, LLC, can be reached at 7440 Township Road 95, Findlay, Ohio, 45840 or by e-mailing www.streamsidetechnologyllc.com, or by calling 419-423-1290.

References

Thomas, C., McArthur, J. A. D., Braatz, and T.L. Welp, (in preparation). "Sediment Management Methods to Reduce Dredging: Part 2, Sediment Collector Technology," *DOER Technical Notes Collection* (ERDC TN-DOER-T ?), U.S. Army Engineer Research and Development Center, Vicksburg, MS. *www.wes.army.mil/el/dots/doer*

Appendix A: Sediment Sample Grain size Analyses and Visual Classification

MACKINAW AND ILLINOIS RIVERS
SEDIMENT COLLECTOR STUDY

GRAIN SIZE ANALYSIS OF SEDIMENT SAMPLES

SAMPLES COLLECTED: 20-May-13

Percent Finer by Weight

	SAMPLE NUMBERS:	MR-1	MR-1a	MR-1a(Dup)	MR-1b	MR-2a	MR-2b
	1 1/2"						100.0%
S	3/4"	100.0%				100.0%	100.0%
I	3/8"	95.0%	100.0%	100.0%	100.0%	96.9%	99.3%
E	#4	84.9%	96.7%	98.7%	99.8%	87.0%	90.3%
V	#10	73.0%	92.4%	94.7%	99.6%	80.3%	81.0%
E	#16	60.3%	86.8%	89.1%	99.4%	76.5%	77.8%
	#30	34.1%	72.1%	74.3%	99.3%	65.0%	74.6%
S	#40	19.5%	59.5%	60.4%	99.1%	47.2%	66.8%
I	#50	10.4%	25.3%	25.7%	98.5%	21.5%	25.6%
Z	#70	6.9%	4.9%	5.4%	86.0%	11.0%	8.2%
E	#100	5.8%	2.6%	2.9%	48.1%	7.9%	5.7%
S	#200	5.3%	2.2%	2.5%	13.4%	6.6%	5.0%
	CLASSIFICATION:	SP-SC, CLAYEY GRAVELLY COARSE TO FINE SAND	SP, MEDIUM TO FINE SAND, TRACE GRAVEL	SP, MEDIUM TO FINE SAND	SC, CLAYEY SAND	SP-SC, CLAYEY GRAVELLY MEDIUM TO FINE SAND	SP-SC, CLAYEY MEDIUM TO FINE SAND WITH GRAVEL

Notes:

1. Visual classification of soil is in accordance with "The Unified Soils Classification System (USCS)".
2. Laboratory testing was performed in accordance with EM 1110-2-1906, dated 30 Nov 70, revised 1 May 80 and 20 Aug 86.
All samples were oven dried at 110 degrees centigrade. Sample designated (dup) is a duplicate sample.

MACKINAW AND ILLINOIS RIVERS
SEDIMENT COLLECTOR STUDY

GRAIN SIZE ANALYSIS OF SEDIMENT SAMPLES

SAMPLES COLLECTED: 20-May-13

Percent Finer by Weight

	SAMPLE NUMBERS:	MR-3bc	MR-3bp	MR-3ap	MR-3ac	MR-3	MR-3cp	MR-3cc
	1 1/2"							100.0%
S	3/4"	100.0%	100.0%	100.0%	100.0%			96.7%
I	3/8"	88.9%	99.8%	80.7%	98.3%	100.0%		94.6%
E	#4	72.2%	99.2%	55.2%	95.6%	99.8%	100.0%	89.2%
V	#10	47.9%	97.0%	35.4%	93.8%	99.6%	99.8%	69.2%
E	#16	31.1%	95.4%	27.4%	92.1%	99.4%	99.4%	47.6%
	#30	14.0%	93.7%	17.3%	87.4%	98.4%	97.9%	17.9%
S	#40	11.2%	92.2%	12.4%	78.1%	96.9%	92.7%	7.4%
I	#50	9.2%	85.5%	9.7%	35.0%	94.8%	62.2%	2.7%
Z	#70	6.3%	61.2%	8.1%	10.4%	92.3%	31.9%	0.8%
E	#100	5.1%	40.9%	7.0%	6.7%	88.9%	23.1%	0.4%
S	#200	4.5%	24.4%	6.3%	5.2%	79.1%	19.2%	0.3%
	CLASSIFICATION:	SP, GRAVELLY COARSE TO MED SAND	SC, CLAYEY SAND	SP-SC, CLAYEY GRAVELLY COARSE TO MED SAND	SP-SC, CLAYEY MEDIUM TO FINE SAND, TRACE GRAVEL	SC, CLAYEY SAND	SC, CLAYEY SAND	SP, GRAVELLY COARSE TO MED SAND

Notes:

1. Visual classification of soil is in accordance with "The Unified Soils Classification System (USCS)".
2. Laboratory testing was performed in accordance with EM 1110-2-1906, dated 30 Nov 70, revised 1 May 80 and 20 Aug 86.
All samples were oven dried at 110 degrees centigrade. Sample designated (dup) is a duplicate sample.

MACKINAW AND ILLINOIS RIVERS
SEDIMENT COLLECTOR STUDY

GRAIN SIZE ANALYSIS OF SEDIMENT SAMPLES

SAMPLES COLLECTED: 20-May-13

Percent Finer by Weight

SAMPLE NUMBERS:		MR-4a	MR-4b	BANK SAMPLE				
	1 1/2"							
S	3/4"		100.0%	100.0%				
I	3/8"	100.0%	96.6%	97.1%				
E	#4	99.9%	77.2%	95.2%				
V	#10	97.5%	52.2%	92.4%				
E	#16	89.1%	44.1%	90.4%				
	#30	64.5%	37.5%	84.9%				
S	#40	48.7%	34.4%	77.9%				
I	#50	33.1%	29.7%	66.2%				
Z	#70	7.2%	7.9%	53.7%				
E	#100	1.7%	1.9%	45.9%				
S	#200	0.9%	1.1%	35.6%				
	CLASSIFICATION:	SP, MEDIUM TO FINE SAND	SP, GRAVELLY COARSE TO FINE SAND	SC, CLAYEY SAND, TRACE GRAVEL				

Notes:

1. Visual classification of soil is in accordance with "The Unified Soils Classification System (USCS)".
2. Laboratory testing was performed in accordance with EM 1110-2-1906, dated 30 Nov 70, revised 1 May 80 and 20 Aug 86.

MACKINAW AND ILLINOIS RIVERS
SEDIMENT COLLECTOR STUDY

GRAIN SIZE ANALYSIS OF SEDIMENT SAMPLES

SAMPLES COLLECTED: 20-May-13

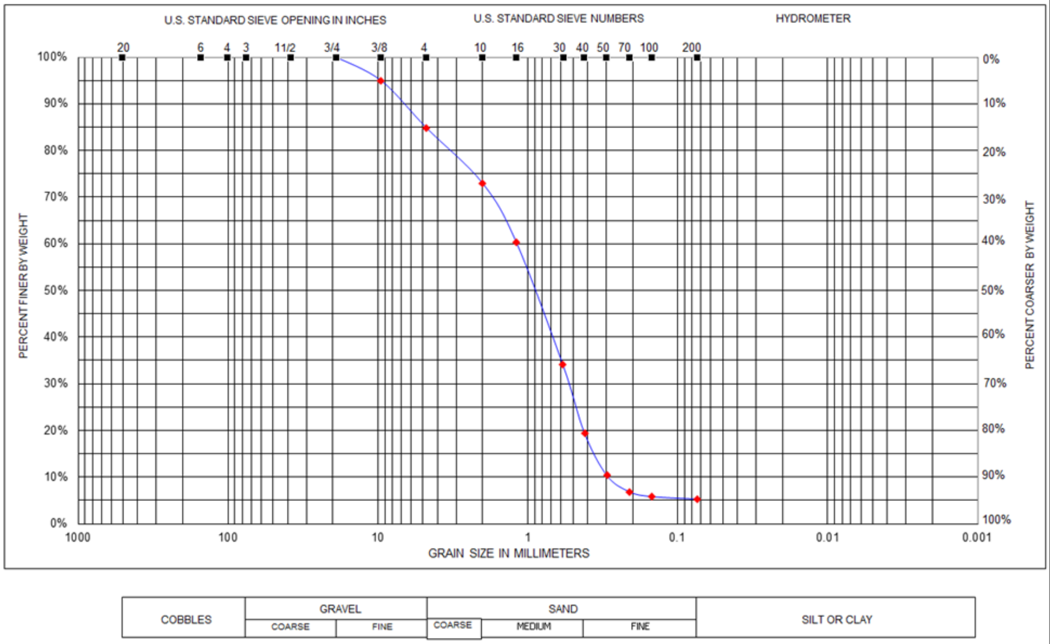
Percent Finer by Weight

SAMPLE NUMBERS:		IR-1	IR-2	IR-3				
	1 1/2"							
S	3/4"	100.0%	100.0%	100.0%				
I	3/8"	96.4%	99.2%	92.8%				
E	#4	88.3%	96.0%	82.1%				
V	#10	79.4%	90.8%	70.3%				
E	#16	70.7%	84.4%	63.3%				
	#30	54.9%	59.6%	43.5%				
S	#40	39.7%	27.0%	25.6%				
I	#50	15.6%	7.6%	13.4%				
Z	#70	3.0%	2.3%	8.1%				
E	#100	1.6%	1.2%	6.5%				
S	#200	1.1%	0.4%	5.6%				
	CLASSIFICATION:	SP, GRAVELLY MEDIUM TO FINE SAND	SP, MEDIUM TO FINE SAND, TRACE GRAVEL	SP-SC, CLAYEY GRAVELLY COARSE TO FINE SAND				

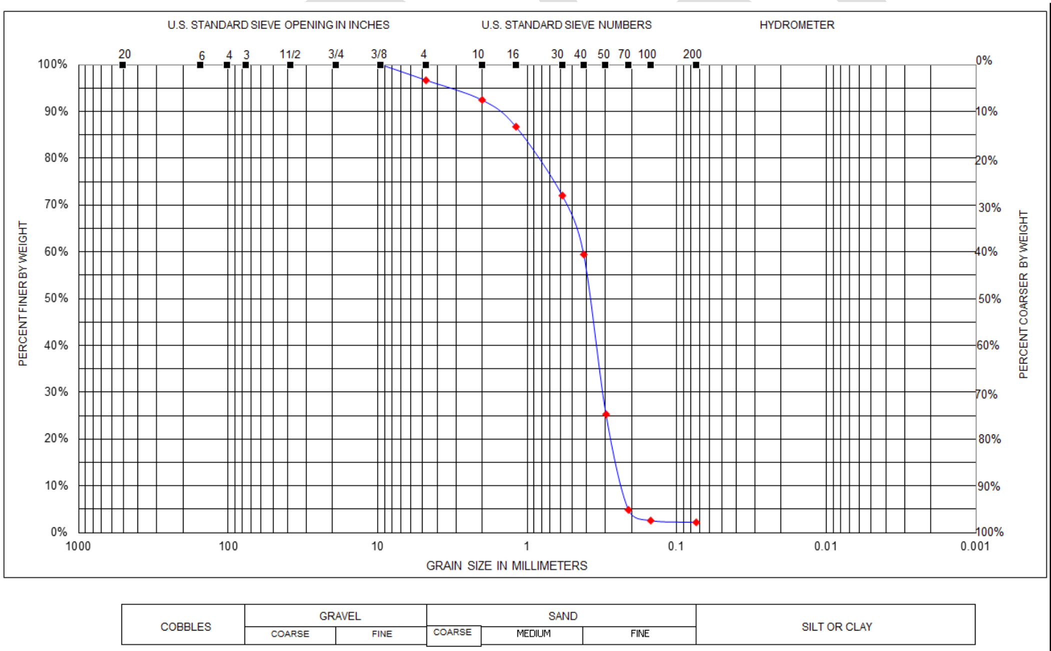
Notes:

1. Visual classification of soil is in accordance with "The Unified Soils Classification System (USCS)".
2. Laboratory testing was performed in accordance with EM 1110-2-1906, dated 30 Nov 70, revised 1 May 80 and 20 Aug 86.

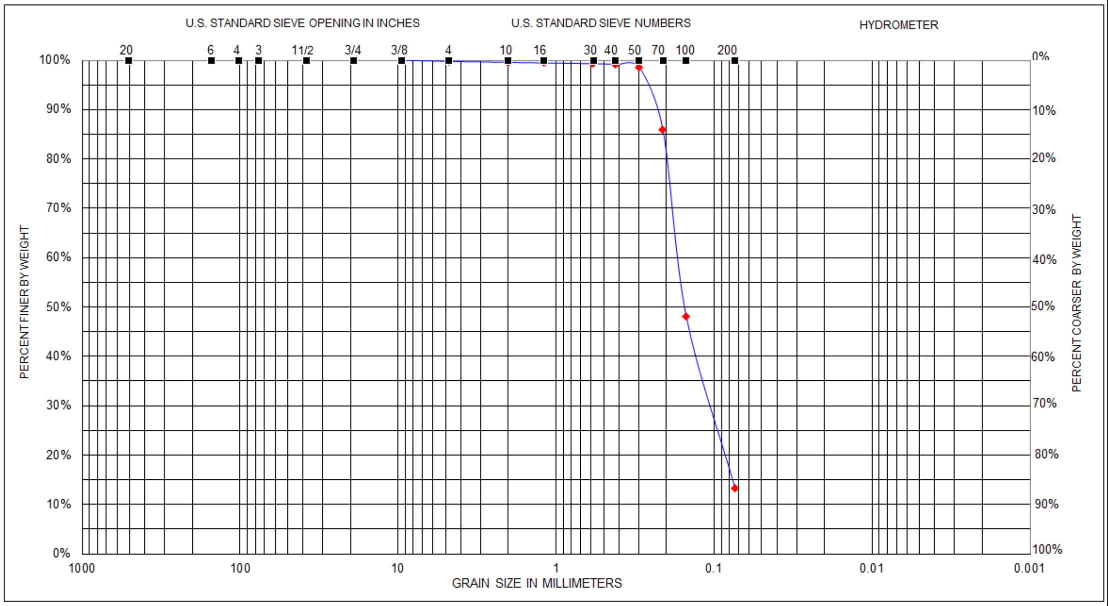
All samples were oven dried at 110 degrees centigrade. Sample designated (dup) is a duplicate sample.



Sample No.	Elev or Depth	Classification	Color	D_{10}	-#200	Project:	MACKINAW AND ILLINOIS RIVERS
MR-1		SP-SC, CLAYEY GRAVELLY COARSE TO FINE SAND	BR	0.30	5.3%		SEDIMENT COLLECTOR STUDY
						Area:	
		(THIN CLAYEY LAYERS IN SAMPLE)				Boring No.:	
						Date:	20-May-13

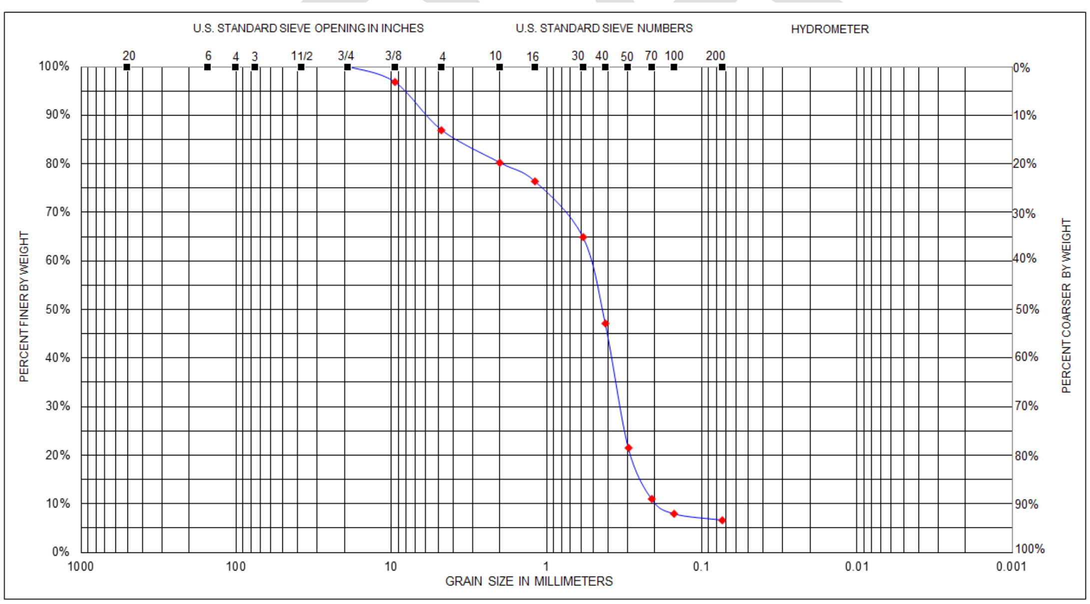


Sample No.	Elev or Depth	Classification	Color	D_{10}	-#200	Project:	MACKINAW AND ILLINOIS RIVERS
MR-1a		SP, MEDIUM TO FINE SAND, TRACE GRAVEL	BR	0.23	2.2%		SEDIMENT COLLECTOR STUDY
						Area:	
						Boring No.:	
						Date:	20-May-13



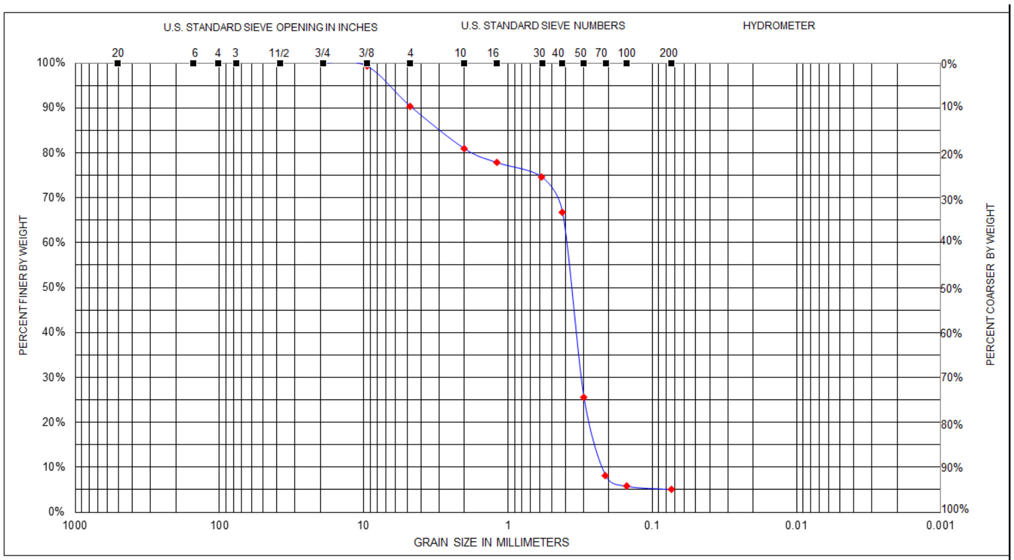
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev or Depth	Classification	Color	D_{10}	-#200	Project:	MACKINAW AND ILLINOIS RIVERS
MR-1b		SC, CLAYEY SAND	BR		13.4%		SEDIMENT COLLECTOR STUDY
						Area:	
		(ORGANICS - LEAVES, TWIGS)				Boring No.:	
						Date:	20-May-13



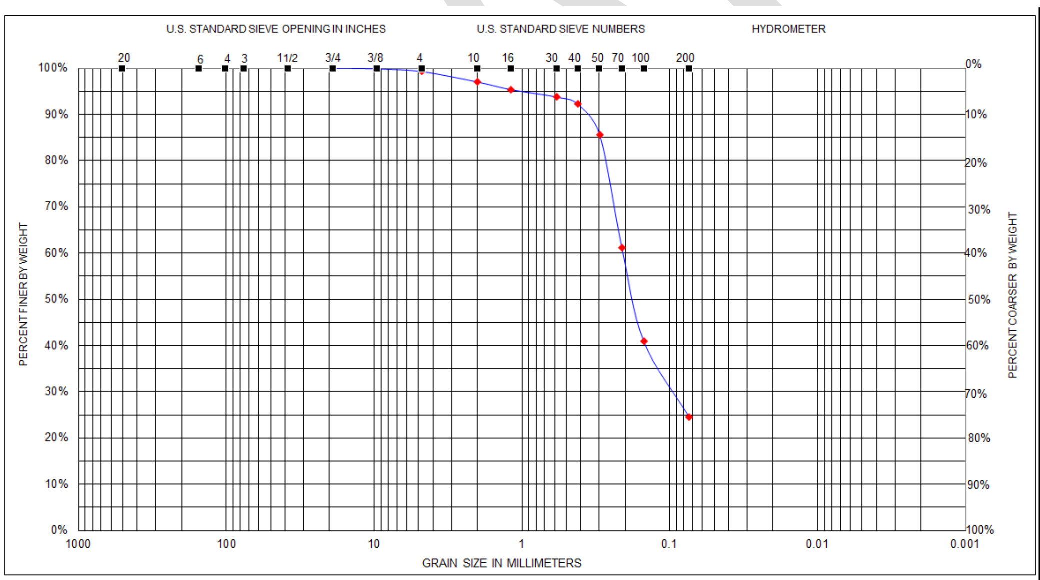
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev or Depth	Classification	Color	D_{10}	-#200	Project:	MACKINAW AND ILLINOIS RIVERS
MR-2a		SP-SC, CLAYEY GRAVELLY MEDIUM TO FINE SAND	BR	0.20	6.6%		SEDIMENT COLLECTOR STUDY
						Area:	
		(THIN CLAY LAYER TOP OF SAND SAMPLE)				Boring No.:	
						Date:	20-May-13



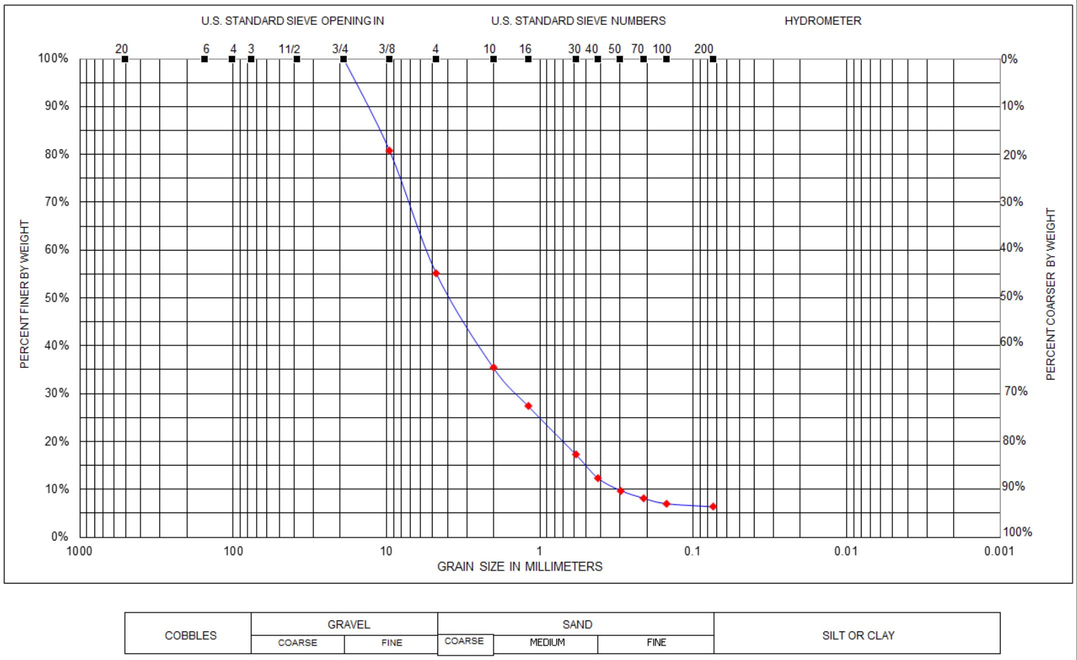
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev or Depth	Classification	Color	D_{10}	-#200	Project:	MACKINAW AND ILLINOIS RIVERS
MR-2b		SP-SC, CLAYEY MEDIUM TO FINE SAND WITH GRAVEL	BR	0.23	5.0%		SEDIMENT COLLECTOR STUDY
						Area:	
						Boring No.:	
						Date:	20-May-13

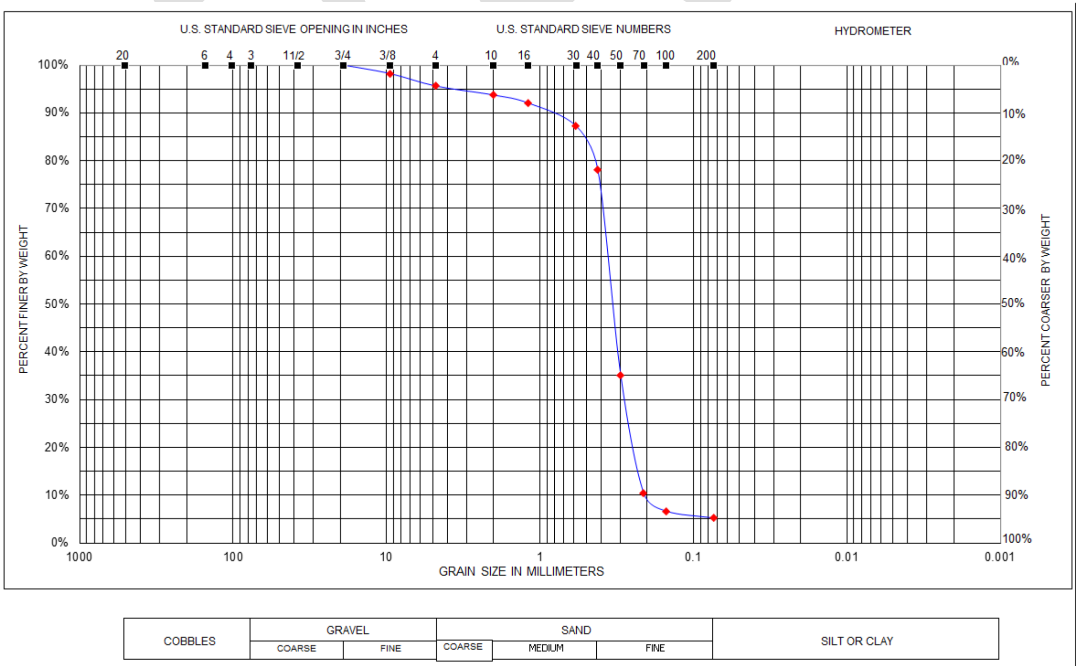


COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

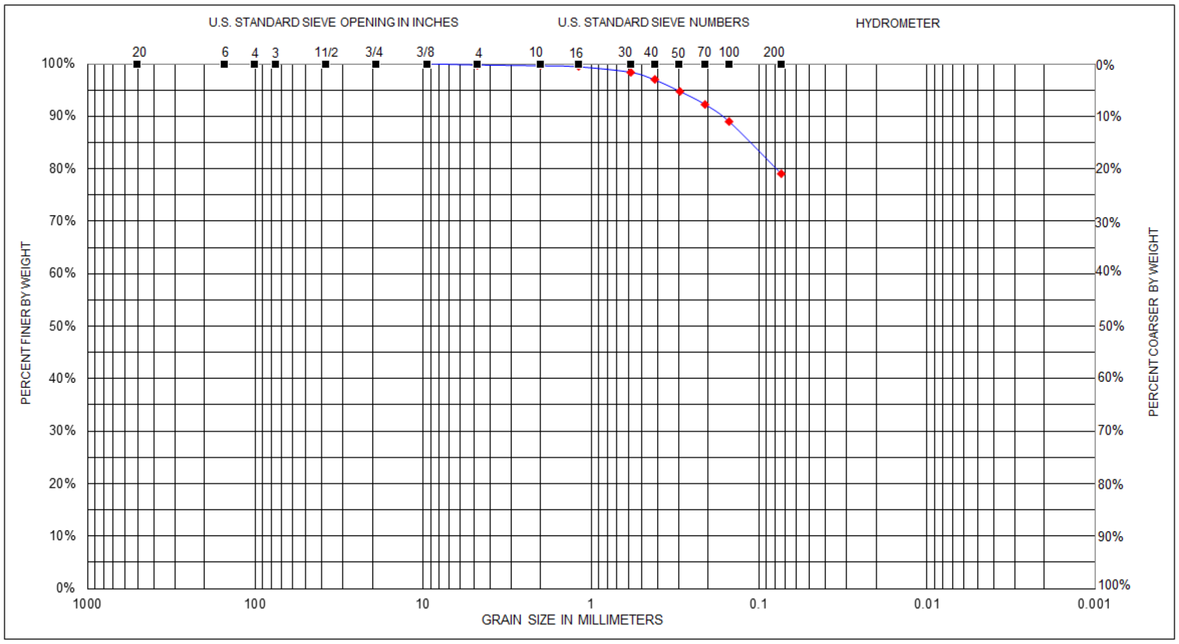
Sample No.	Elev or Depth	Classification	Color	D_{10}	-#200	Project:	MACKINAW AND ILLINOIS RIVERS
MR-3bp		SC, CLAYEY SAND	BR		24.4%		SEDIMENT COLLECTOR STUDY
						Area:	
		(ORGANICS - WOOD, LEAVES, TWIGS)				Boring No.:	
						Date:	20-May-13



Sample No.	Elev or Depth	Classification	Color	D_{10}	-#200	Project:	MACKINAW AND ILLINOIS RIVERS
MR-3ap		SP-SC, CLAYEY GRAVELLY COARSE TO MED SAND	BR	0.30	6.3%		SEDIMENT COLLECTOR STUDY
						Area:	
		(SOFT CLAY LAYER ON TOP OF SAND SAMPLE)				Boring No.:	
						Date:	20-May-13

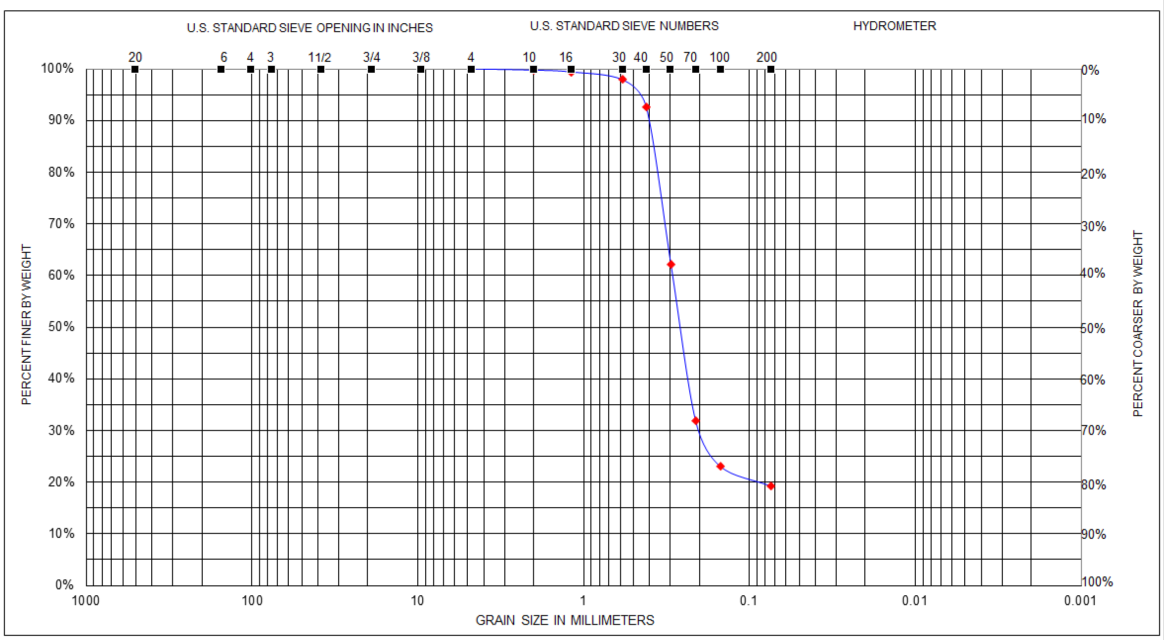


Sample No.	Elev or Depth	Classification	Color	D_{10}	-#200	Project:	MACKINAW AND ILLINOIS RIVERS
MR-3ac		SP-SC, CLAYEY MEDIUM TO FINE SAND, TRACE GRAVEL	BR	0.21	5.2%		SEDIMENT COLLECTOR STUDY
						Area:	
		(SOFT CLAY LAYER ON TOP OF SAND SAMPLE)				Boring No.:	
						Date:	20-May-13



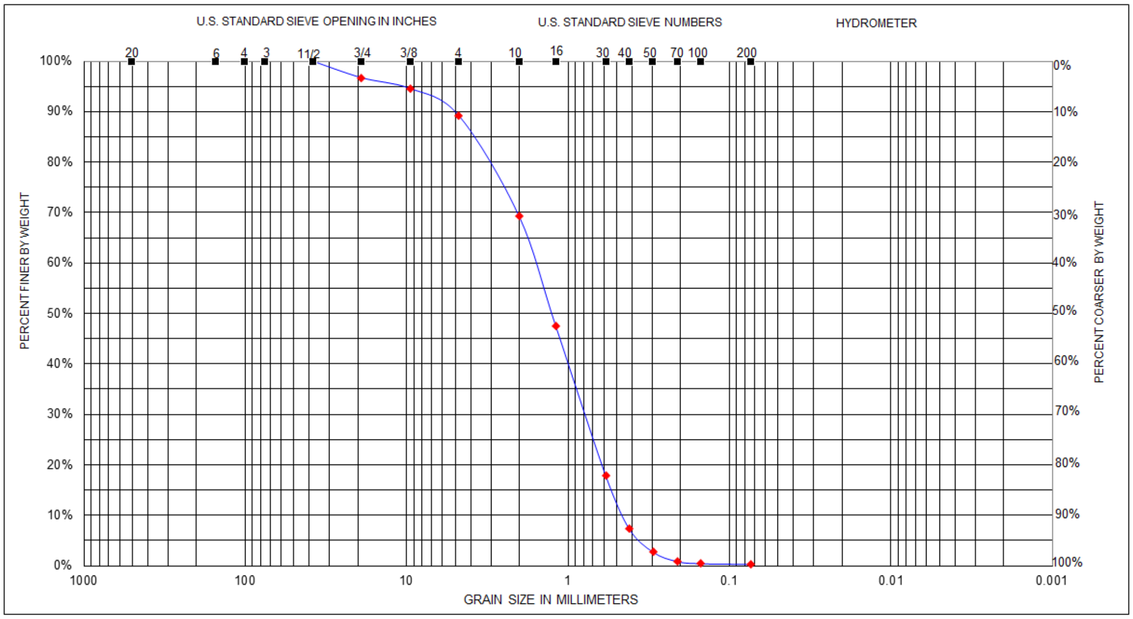
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev or Depth	Classification	Color	D_{10}	-#200	Project:	MACKINAW AND ILLINOIS RIVERS
MR-3		SC, CLAYEY SAND	BR		79.1%		SEDIMENT COLLECTOR STUDY
						Area:	
		(SOME ORGANIC MATERIAL PRESENT)				Boring No.:	
						Date:	20-May-13



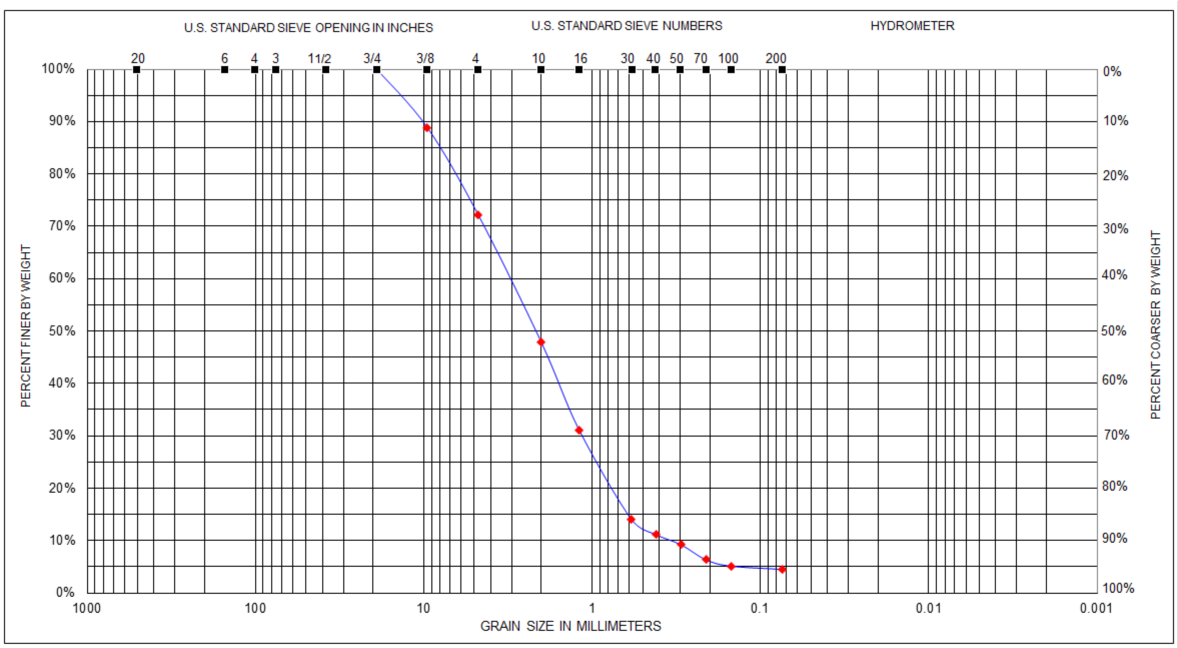
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev or Depth	Classification	Color	D_{10}	-#200	Project:	MACKINAW AND ILLINOIS RIVERS
MR-3cp		SC, CLAYEY SAND	BR		19.2%		SEDIMENT COLLECTOR STUDY
						Area:	
						Boring No.:	
						Date:	20-May-13



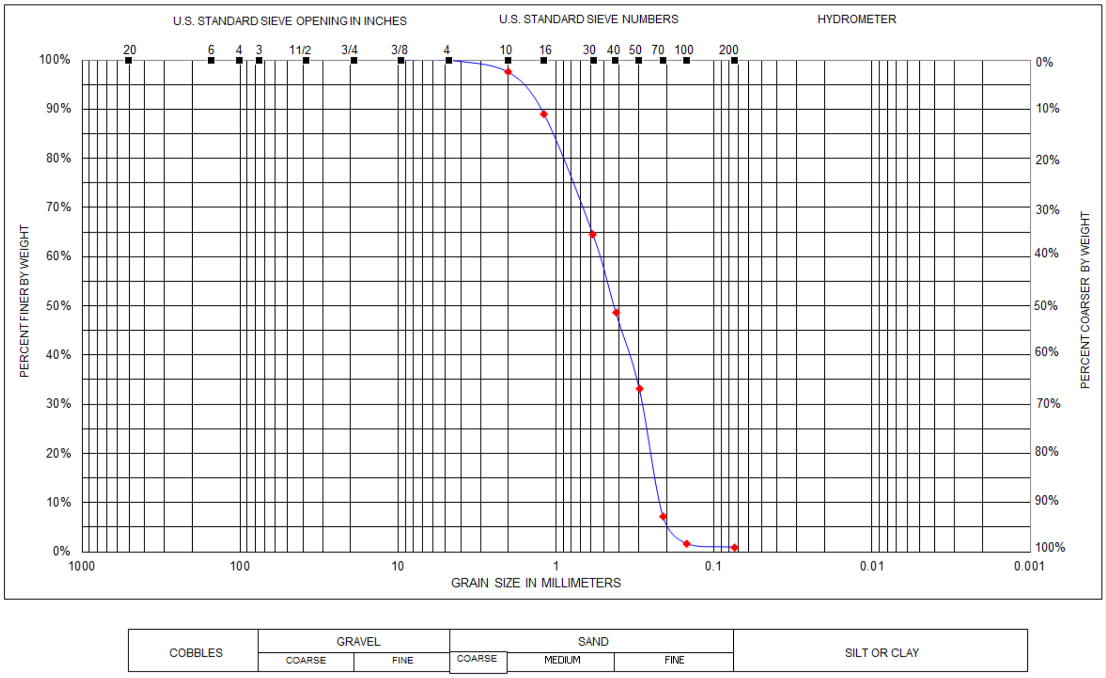
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev or Depth	Classification	Color	D_{10}	-#200	Project:	MACKINAW AND ILLINOIS RIVERS
MR-3cc		SP, GRAVELLY COARSE TO MED SAND	BR	0.36	0.3%		SEDIMENT COLLECTOR STUDY
						Area:	
						Boring No.:	
						Date:	20-May-13

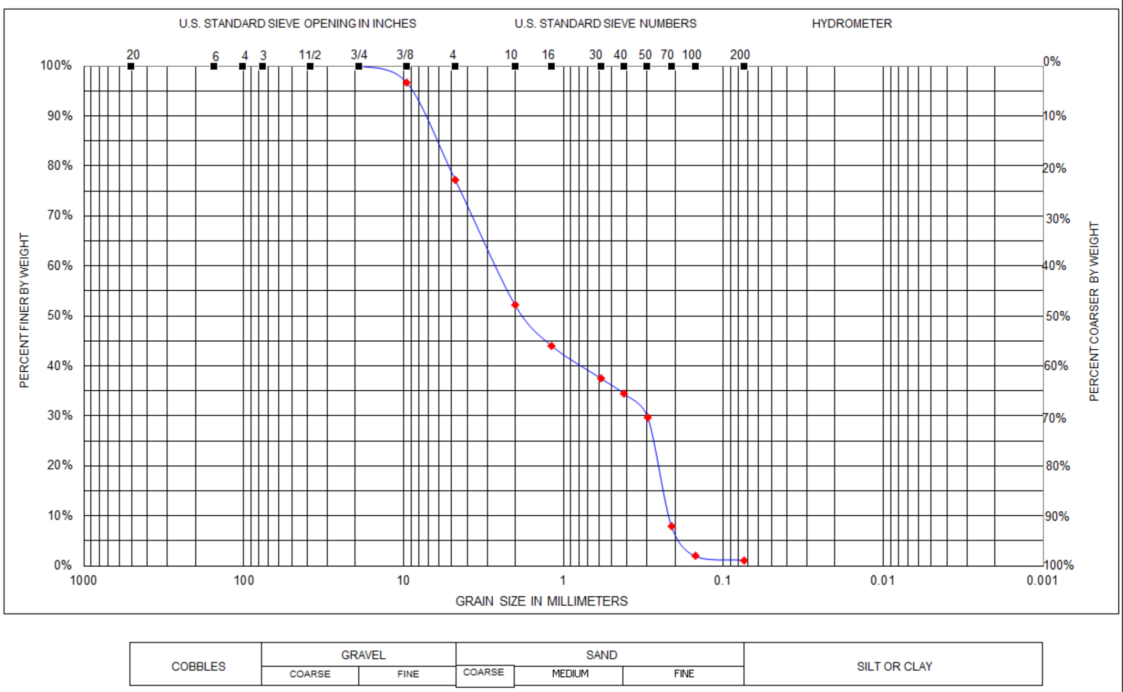


COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev or Depth	Classification	Color	D_{10}	-#200	Project:	MACKINAW AND ILLINOIS RIVERS
MR-3bc		SP, GRAVELLY COARSE TO MED SAND	BR	0.30	4.5%		SEDIMENT COLLECTOR STUDY
						Area:	
		(SOFT CLAY LAYER ON TOP OF SAND SAMPLE)				Boring No.:	
						Date:	20-May-13



Sample No.	Elev or Depth	Classification	Color	D_{10}	-#200	Project:	MACKINAW AND ILLINOIS RIVERS
MR-4a		SP, MEDIUM TO FINE SAND	BR	0.22	0.9%		SEDIMENT COLLECTOR STUDY
						Area:	
						Boring No.:	
						Date:	20-May-13



Sample No.	Elev or Depth	Classification	Color	D_{10}	-#200	Project:	MACKINAW AND ILLINOIS RIVERS
MR-4b		SP, GRAVELLY COARSE TO FINE SAND	BR	0.22	1.1%		SEDIMENT COLLECTOR STUDY
						Area:	
						Boring No.:	
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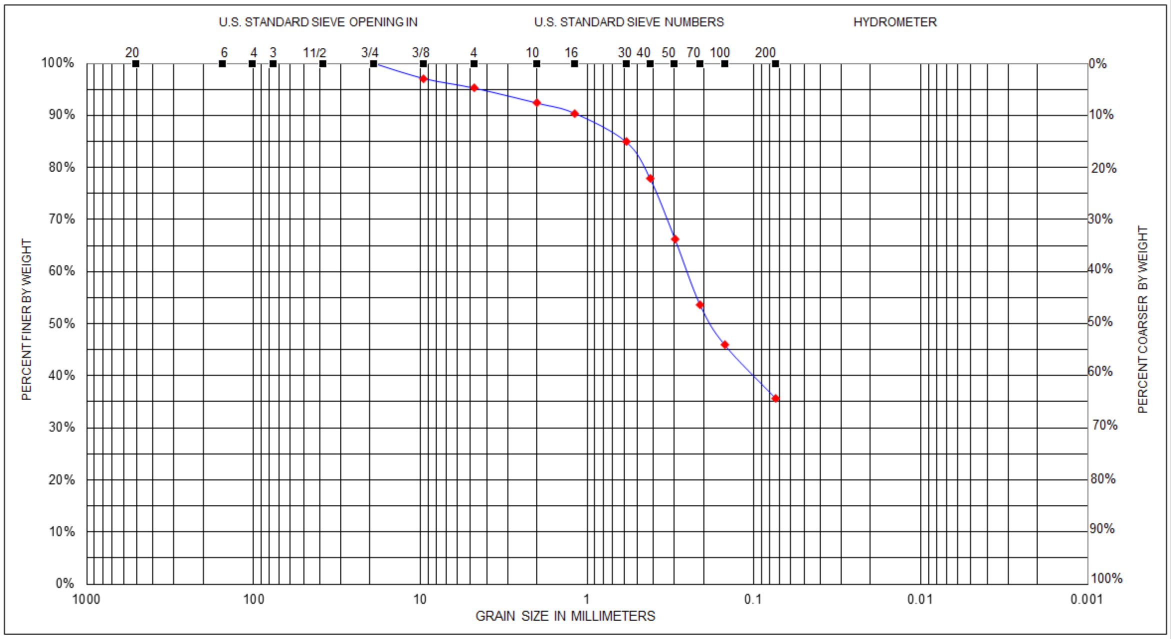
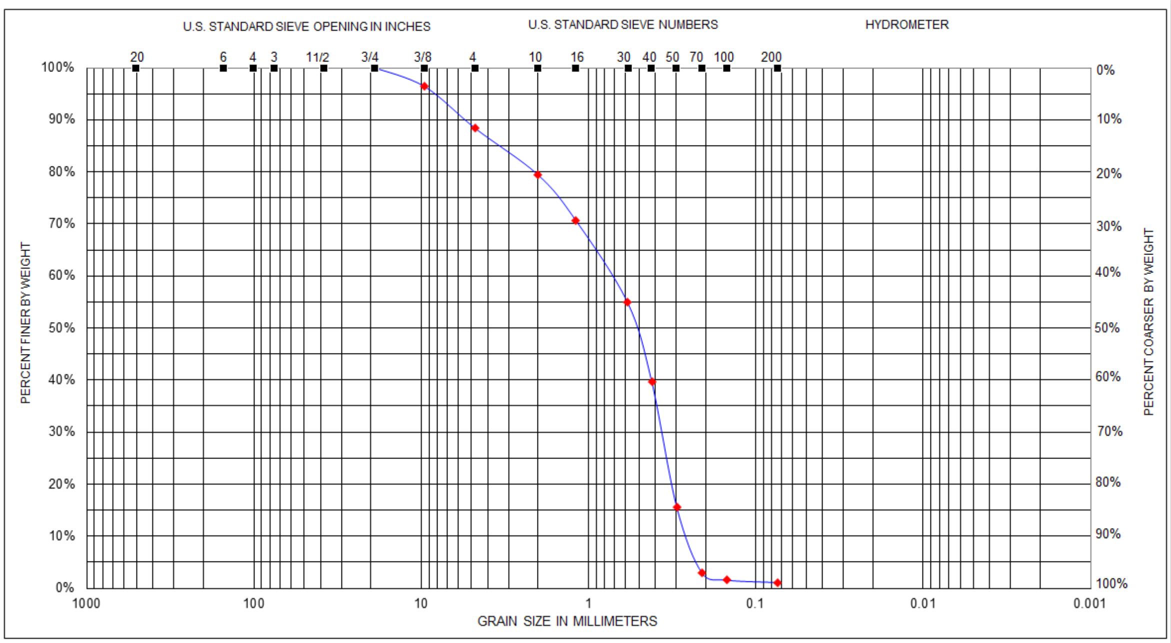


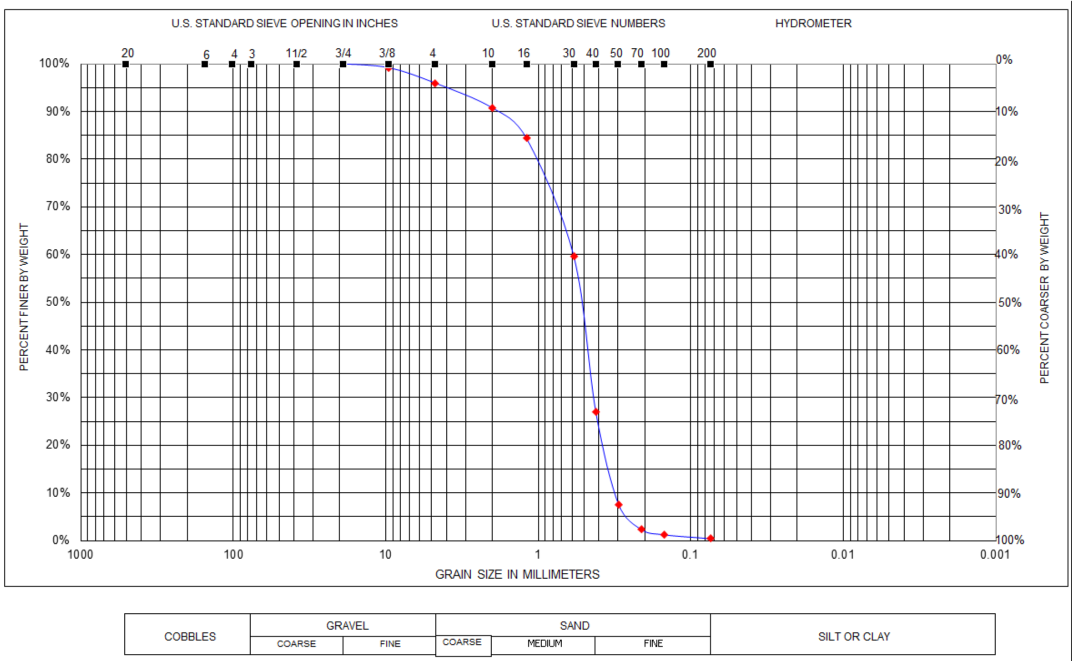
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev or Depth	Classification	Color	D_{10}	-#200	Project:	MACKINAW AND ILLINOIS RIVERS
BANK SAMPLE		SC, CLAYEY SAND, TRACE GRAVEL	BR		35.6%		SEDIMENT COLLECTOR STUDY
						Area:	
						Boring No.:	
						Date:	20-May-13

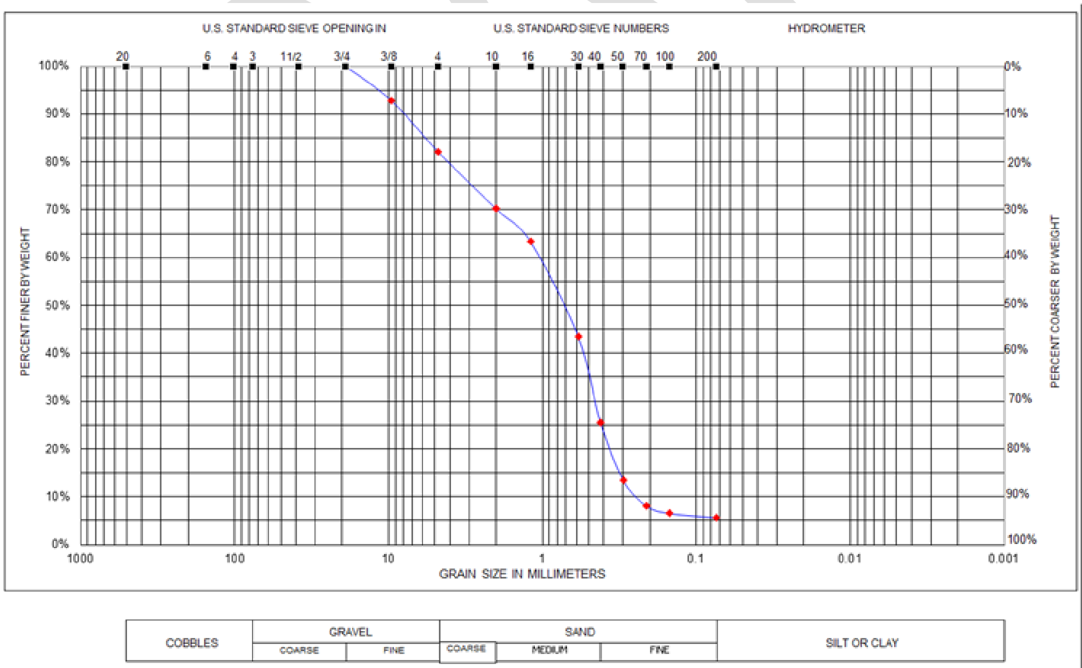


COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev or Depth	Classification	Color	D_{10}	-#200	Project:	MACKINAW AND ILLINOIS RIVERS
IR-1		SP, GRAVELLY MEDIUM TO FINE SAND	BR	0.25	1.1%		SEDIMENT COLLECTOR STUDY
						Area:	
						Boring No.:	
						Date:	20-May-13



Sample No.	Elev or Depth	Classification	Color	D_{10}	-#200	Project:	MACKINAW AND ILLINOIS RIVERS
IR-2		SP, MEDIUM TO FINE SAND, TRACE GRAVEL	BR	0.31	0.4%		SEDIMENT COLLECTOR STUDY
						Area:	
						Boring No.:	
						Date:	20-May-13



Sample No.	Elev or Depth	Classification	Color	D_{10}	-#200	Project:	MACKINAW AND ILLINOIS RIVERS
IR-3		SP-SC, CLAYEY GRAVELLY COARSE TO FINE SAND	BR	0.23	5.6%		SEDIMENT COLLECTOR STUDY
						Area:	
						Boring No.:	
						Date:	20-May-13

US Army Corps of Engineers®

Generation of a Sediment Rating and Load Curve Demonstrated at the Mackinaw River Confluence

by Jeremy A. Sharp and Ronald E. Heath

PURPOSE: This Coastal and Hydraulics Engineering Technical Note (CHETN) contains a description of the process to formulate sediment rating and load curves for the bed material load in the Mackinaw River. The calculated curves are intended to define the sediment yield at the mouth of the river for sediment harvesting with a sediment collector.

INTRODUCTION: The approach and data requirements described below are applicable for the generation of sediment concentration and sediment load rating curves (SRC) in a sand bed system. The SRC is a set of two complementary curves that define the sediment capacity and concentration at a given flow for a specific system. The SRC is necessary for defining sediment load for a sediment budget, a numerical model, or other sediment related field investigation.

Defining the SRC requires a series of steps. First, appropriate site specific data are necessary. The data must include hydrodynamic, bed material gradation, basic cross-sectional data, and general site knowledge. Initially, all available data are collected and inventoried to define the missing data. Missing data may need to be estimated. Second, normal depth computations are performed with hydrodynamic and cross-section data. Normal depth establishes the free surface at a cross-section for uniform flow conditions, and is required to pass a specific flow given the resistance coefficient (Sturm 2001). Third, using the collected, calculated, and estimated data from the previous steps, selection of the most useful sediment transport functions is made. Sediment transport functions are typically formulated based on regime, regression, probabilistic, and deterministic approaches. Finally, after running a series of sediment transport functions, dissemination of the calculated data is conducted to select the most appropriate function to define the SRC. The selected sediment transport functions are used to bracket the sediment flux. Once the SRC is generated, a flow sequence can be processed through the SRC to determine the temporal supply of sediment at a given location.

BACKGROUND: The mouth of the Mackinaw River was selected as the demonstration site for this process. The confluence of the Mackinaw River and the Illinois River is four miles west of Pekin, Illinois. The Mackinaw River produces a shoal in the Illinois River that impinges on the navigation channel. The sediment deposition forms a natural delta that if not removed via dredging, would encroach on the channel. However, the sediment has the potential for beneficial use. The Streamside Systems' Bedload Monitoring Collector (Lipscomb et al 2005) is one model of a stationary sediment harvester that is capable of collecting sediment bed material before it enters the Illinois River. In order to estimate the removal rate for the system, the sediment load must be defined. The SRC provides a means to determine the available volume of bed material sediment available for harvesting and the peak delivery rates.

DATA REQUIRMENTS: Discussed here are two forms of data, collected and calculated, necessary to formulate the SRC. Collected data usually include hydrodynamic, bed gradation, and bathymetric data that are site specific. Calculated or estimated data are necessary to fill in the gaps to formulate the SRC. At this demonstration site, the calculated data include watershed adjustment computations, flood flow frequency analysis, and normal depth computations. These data are calculated using the collected data. Once compiled, collected, computed, and estimated data are used congruently to formulate the SRC and calculate the transport potential.

Hydrodynamic data were derived from the USGS Mackinaw River near Green Valley streamflow gaging (USGS station ID 05568000). The station has 90 years of record, including stage and discharge. It is ideal to have a long (at least 20 years) period of record. This provides the means to calculate the flood flow frequency curve. Additional collected data are the bed samples that were graded to formulate bed gradation curves. The bed gradation curves describe the material that is available in the system for transport (see Figure 1). From all the bed samples, at the cross-section of interest, an average bed gradation curve was calculated (Figure 1). If there is a large spread in the bed samples then a sensitivity test by varying the bed gradation should be performed. The sensitivity test can be performed using the standard deviation. However, the standard deviation needs to bracket both the high and low end of the gradation spread, which it does in this case (see Figure 1). The three curves can then be simulated to determine the variability in sediment flux with gradation. Here it was deemed unnecessary because the bed gradations were all within half of the magnitude of the spread. A finer sample would be more mobile, thus requiring special consideration eg flocculation. Finally, the bathymetric data were taken in the field using soundings and adjusted to pool elevation. For the Mackinaw River, the horizontal projection is State Plane, NAD 1983, Illinois West – 1202 U.S. Survey Feet, and the Vertical Datum is NGVD 1929. The gage zero for the near Green Valley stream flow gaging station (USGS station ID 05568000) is 477.10 feet. From the soundings and gage zero the elevation of the bed was calculated along with the channel slope (see Figure 2). These three pieces of information are imperative for the construction of an SRC.

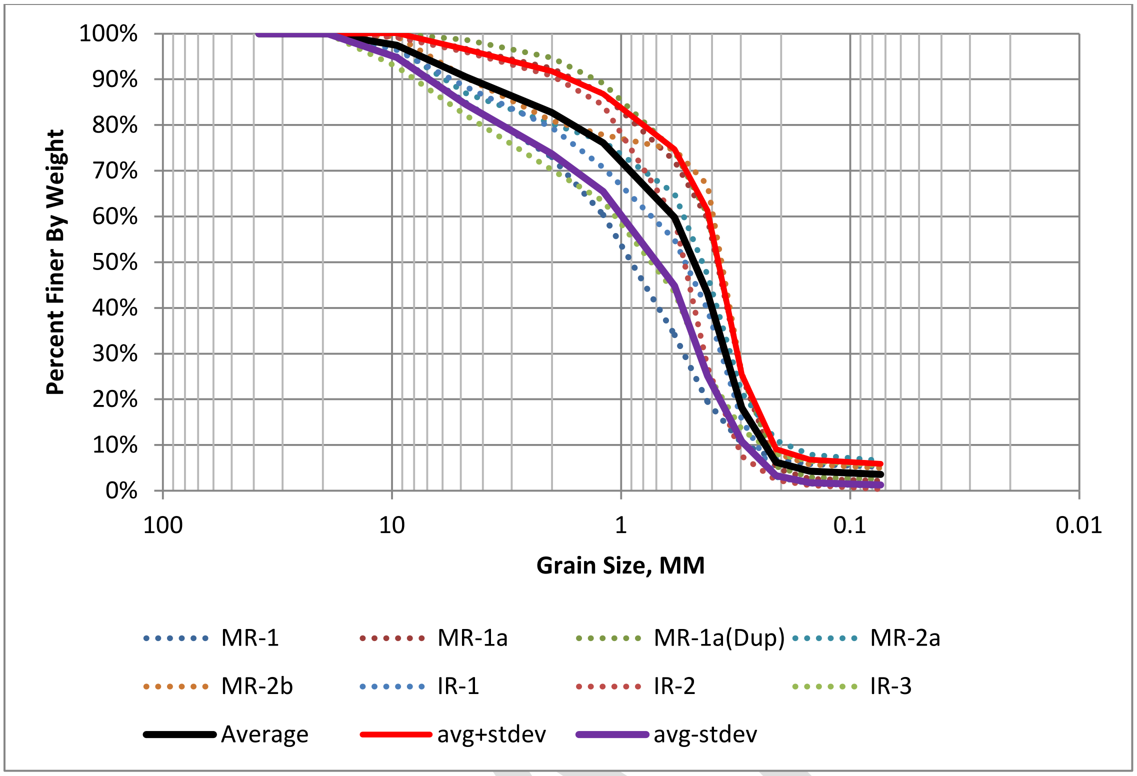


Figure 1. Bed sample gradations at the mouth of the Mackinaw River.

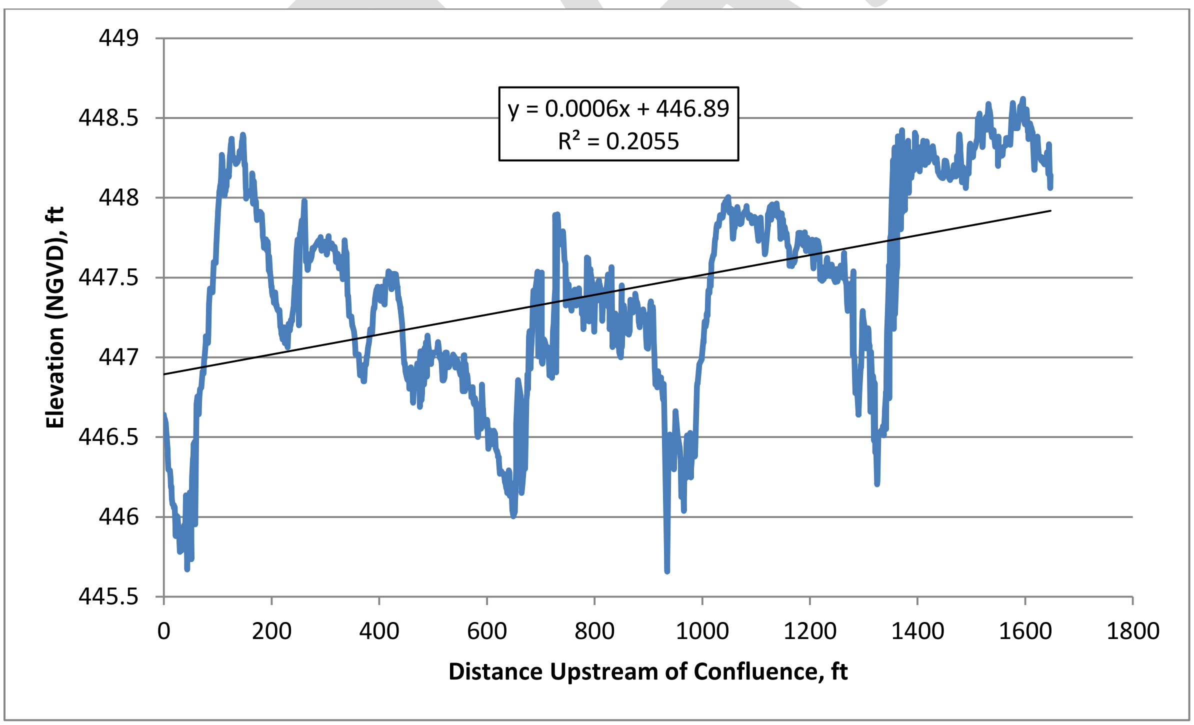


Figure 2. Estimated Mackinaw River channel slope from the confluence with the Illinois River based on bathymetry data

Calculated and/or estimated data for the SRC includes the total watershed discharge, the flood flow frequency analysis, and the normal depth computation. The total watershed discharge must be estimated if there is not a streamflow gaging station at the watershed outlet. In this case, there is not a streamflow gaging station at the watershed outlet. The near Green Valley streamflow gaging station (drainage area of 1,073 miles^2) encompasses 94 percent of the total Mackinaw River watershed (drainage area of 1,138 miles^2). Assuming the lower 6 percent of the watershed produces the same ratio of discharge in the river per watershed area, one can assume that the discharge can be scaled up to estimate the discharge at the watershed outlet using equation 1.

$$Q_{streamgage}/A_{streamgage} = Q_{watershed}/A_{watershed} \qquad (1)$$

where $Q_{streamgage}$ is the discharge at the streamflow gaging station at each frequency interval, $A_{streamgage}$ is the watershed area at the streamflow gaging station, $Q_{watershed}$ is the discharge at the watershed outlet at each frequency interval (to be computed), and $A_{watershed}$ is the total watershed area. The total watershed discharge value was used for the study.

The flood flow frequency curve was computed using the recommended guidelines in Bulletin #17B (IACWD 1982). Here, the Log Pearson Type III method was applied. The frequency curve at the near Green Valley stream gage (non-adjusted) and at the watershed confluence (adjusted) are shown in the flood flow frequency curve (Figure 3). In this system there is a small flow difference between the two curves because the near Green Valley stream gage captures 94 percent of the total watershed area. In other systems the difference could be significant, thereby drastically altering the transport behavior of the system. Total flow delivered to the point of interest must be accounted for correctly in order to reduce error in the SRC computation.

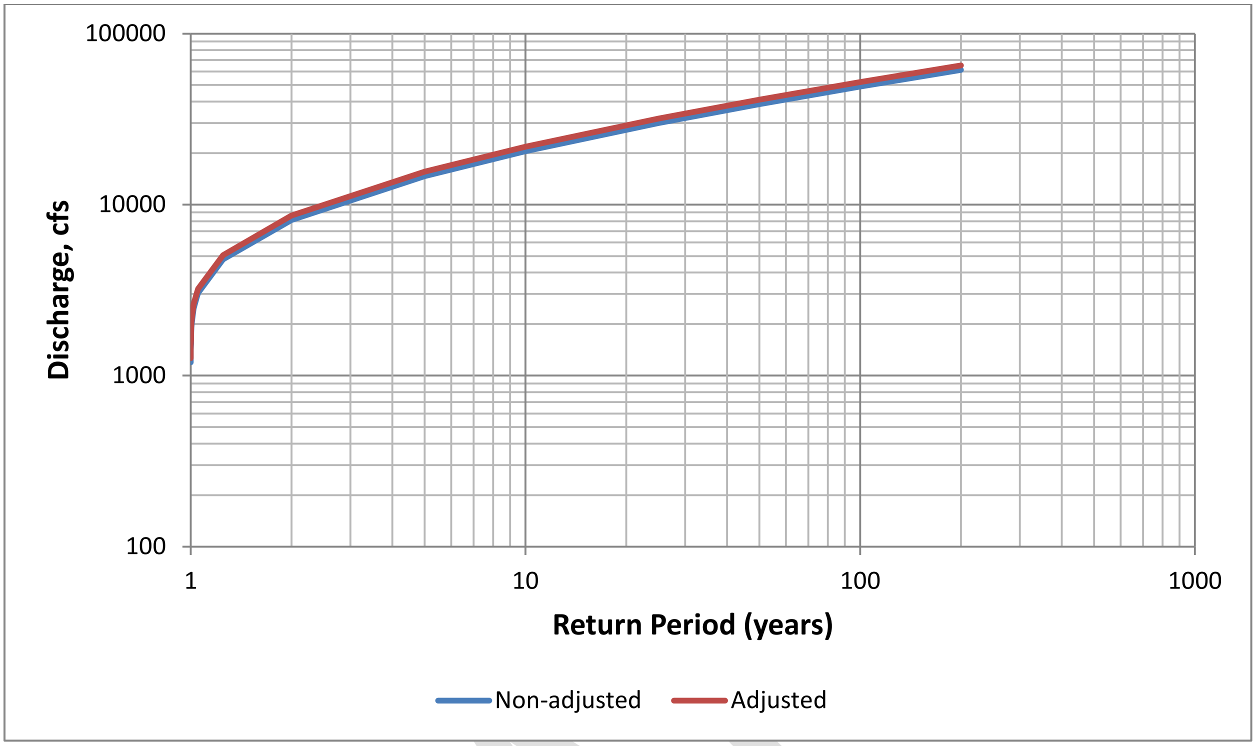


Figure 3. 1922-2011 flood flow frequency curves for the Mackinaw River near Green Valley gage (Non-adjusted) and the entire Mackinaw River watershed (Adjusted).

Normal depth computations were computed with the Hydraulic Design Package for Channels (SAM) (USACE 2003). The normal depth is commonly computed with one of five uniform flow equations: Manning, Keulegan, Strickler, Limerinos, or Brownlie Bed Roughness (USACE 2003). It can also be computed using one of five Soil Conservation Service equations (USACE 2003). Careful consideration should be given to each method prior to use of any of the equations, see EM 1601 chapter 5 for additional information (USACE 1994). Here the Soil Conservation Service equations are not applicable (USACE 2003), but the uniform flow equations are useable for the system. The Brownlie equation is specifically formulated for transitioning from upper and lower regime flow (Brownlie 1983), a condition that is not occurring in this system. The Limerinos equation was formulated for course sand to cobble where the roughness is a function of the grain size class of the 84 percent passing (Limerinos 1970). While the roughness height is relatively significant for the Linerinos and Keulegan equations, it does not account for bed form losses. The remaining three equations are applicable for this location. For this effort the Manning Equation was implemented since it provided a mean range of the three functions (Figure 4).

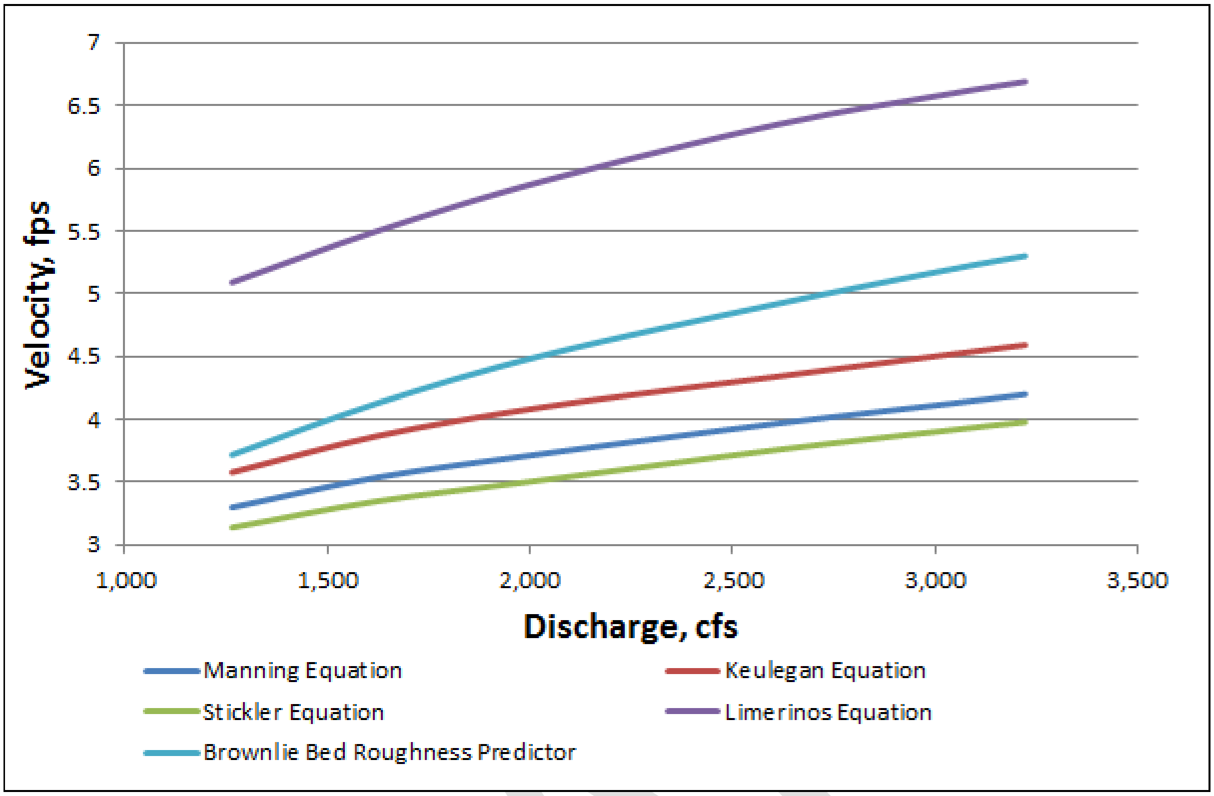


Figure 4. Results from five uniform flow equation used to compute normal depth.

TRANSPORT FUNCTION: Sediment transport functions are applicable for non-cohesive beds, which are defined as beds with less than 10 percent cohesive material. However, the transport functions should be carefully selected as they are heavily site dependent. Furthermore, the functions at best "serve as guides to planning and usually the engineer is forced to rely strongly on experience and judgment in such work" (Vanoni 2006). SAM.aid is available within SAM to aid in the selection of the transport function. Typically; grain size class, slope, velocity, width, and depth are considered when selecting a function. Ideally, the three most appropriate functions should be used for comparison when estimating an SRC.

The goal with using multiple transport functions is to obtain a reasonable agreement between the selected functions. Reasonable agreement is defined as +/- 50 percent relative to the other calculated curves. If all three are in reasonable agreement, then any of the three can be used. Likewise, it is recommended that if two of the three are in agreement then one of the two can be selected. However, transport functions may not be applicable if no two of the three selected equations are within reasonable agreement. If there are not two functions within reasonable agreement with one another, then an alternative means should be taken to measure the SRC. This may require a long-term field collection effort, which may be costly and time intensive.

Even with reasonable agreement between transport functions it is possible to have an incorrect convergence. A fundamental understanding of sediment transport theory, transport functions, and how these related to the specific site are necessary to best define the sediment load in a system. If there is insufficient agreement between the transport functions and additional data collection is planned, it is recommended to collect isokinetic depth integrated suspended samples across a cross-section at a few flows and compare the cross-section averaged observations to the computed concentration rating curve. Guidance for collecting samples can be found in Edwards and Glysson (1999). While this method accounts for the suspended load, it does not consider the bed load. However, the modified Einstein method (Colby and Hembree 1955, Einstein 1950,USBR 1955, and USBR 1966) can be used to estimate the bedload. The modified Einstein approach would give an indication to the correct magnitude of the transport capacity.

The first transport function that was applied for the Mackinaw River was the Toffaleti-Schoklistsch. This function is a combination function of Toffaleti (Toffaleti 1963, Toffaleti 1968, and Toffaleti 1969) and Schoklistsch (Schoklitsch 1934) for sand and gravel bed streams. Both functions are applied for the computation by grain size. The Toffaleti (Toffaleti 1963, Toffaleti 1968, and Toffaleti 1969) portion of the function is used to compute the suspended load. Bed load is computed with both functions, with the higher of the two being used. The second equation that was applied was the Laursen Copeland (Copeland and Thomas 1989) and is a modification of the Laursen equation (Laursen 1958). This equation was modified for a broader grain size where it was extended into the larger gravel range. Finally, the third equation implemented was Yang (Yang 1973, and Yang 1979). Yang initially was based on a single grain size but was later extended for multiple grain sizes (Yang 1979). All three equations were viable options for the Mackinaw River confluence.

The concentration comparison shown in Figure 5 includes the results of the three functions along with the +/- standard deviation of the Yang equation. Two of the three, Yang and Toffaleti-Schoklistsch, show the closest agreement with an average variation of 11.6 percent. While the Laursen Copeland average variation from that of Yang is 79.8 percent. Thus, the values from the Laursen Copeland equation were not considered. The Yang equation was selected as the SRC. Figure 6 shows the sediment rating curve by size class in milligrams/Liter. Each color band on the curve represents the total concentration for the bed material load in its respective size class. The accumulation of all size classes represents the total bed material load at the cross-section for each flow (note that the bed load is a portion of the bed material load). Likewise, Figure 7 shows the sediment load curve in tons/day. From these curves, the total daily bed material load and concentration can be estimated for a given flow. Using the period of record, the average daily load is 4,200 tons/day and the average annual load is 1,500,000 tons/year. Therefore, based on these two curves, an appropriate stream side sediment collector can be sized and optimized for sediment harvesting.

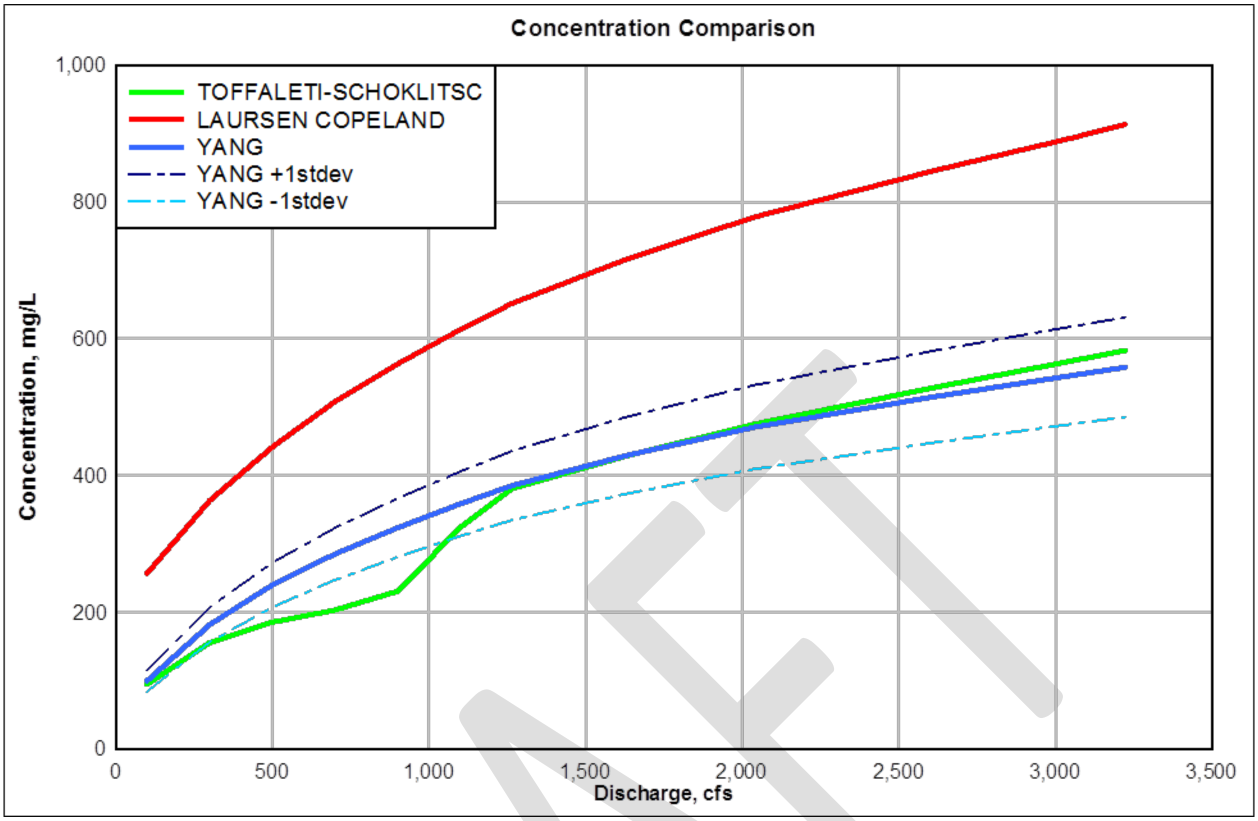


Figure 5. Concentration comparison for three selected functions.

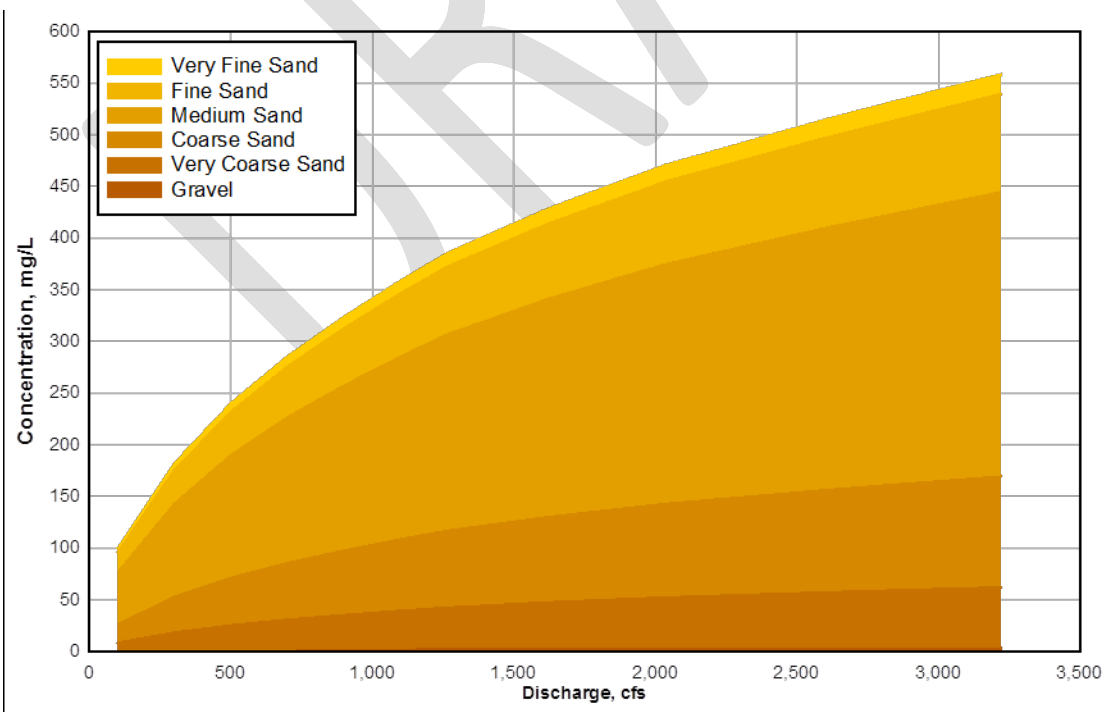


Figure 6. Sediment rating curve by size class for the Yang equation.

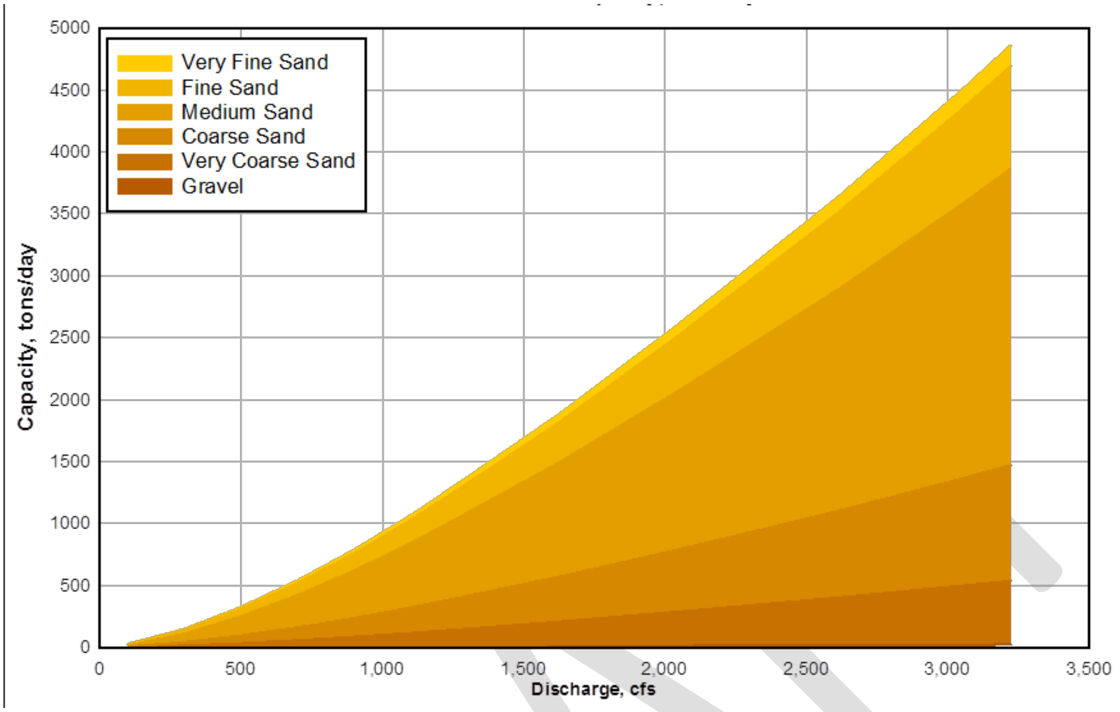


Figure 7 Sediment load curve by size class for the Yang equation

ADDITIONAL INFORMATION: This Technical Note was prepared by Jeremy A. Sharp and Ronnie Heath, Research Hydraulic Engineers at the Coastal and Hydraulics Laboratory (CHL), U.S. Army Engineer Research and Development Center. Questions about this CHETN can be addressed to Mr. Sharp (601-634-4212; Jeremy.A.Sharp@usace.army.mil.).

This Technical Note should be cited as follows:

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Appendix E

Meeting Minutes With US Army Corps of Engineers.

MEETING MINUTES

Innovative approaches
Practical results
Outstanding service

PROJECT:	Sand Trap Conceptual Design
NAME OF MEETING:	Sand Trap Conceptual Design Status Meeting
RECORDED BY:	Cory Stull, Mike Reedy
DATE:	July 7, 2020
LOCATION:	Webex Conference Call
DATE SENT FOR APPROVAL:	July 15, 2020
DATE FINALIZED:	
ATTENDEES:	Briana Gallagher, Coraggio Maglio, Kristi McMilian, Chris Haring, Lisa Mairs, Ryan Schwartzengraber, George Fowler, Cory Stull, Tim Dellapenna, David May, Chuck Gilman, Robert Mrse, Michael Garske

The following reflects our understanding of the items discussed during the subject meeting. If you do not notify us within five working days, we will assume that you are in agreement with our understanding.

ITEM	DESCRIPTION	PRESENTER
1.	1) High profile sediment issue after Hurricane Harvey a) Interest in reducing sediment loading into Lake Houston	Coraggio Maglio
2.	1) Looked at locations for opportunities to remove sediments a) Watershed overview 2) Project Overview i) Narrowed down 700 square mile watershed to a number of sites and identify top sites ii) Used LiDAR to guide identification of locations 2001, 2008, 2018 iii) Used data comparison to identify areas of aggregation and deposition iv) Came up with average elevation change, multiplied times area, came up with volume v) Identified individual sites, then summarized proximal sediment deposition (within 500’ buffer) to identify groupings/cumulative deposition vi) Compared cumulative volumes of grouped areas vii) Discussed table of identified sites and project scoring 3) Project Development i) First look at cumulative depositional volume ii) Looked at proximity to APOs to leverage public/private partnerships to manage/maintain the sand trapping facilities iii) Question: Comparative purposes for volume?	George Fowler

ITEM	DESCRIPTION	PRESENTER
	(1) Discussed process to assess elevation differences iv) Top 10 sites prone to deposition (1) Ranked 1-10 (2) Top 4 were top sites for efficacy potential using cumulative volume and proximity to APOs	
3.	1) Discussion on what permitting may be needed to implement these trapping facilities a) Question on requirements, b) Online resources for potential permitting hurdles	All
4.	1) After top 4 sites were developed, selected 3 to perform sediment transport modeling and conceptual design of trapping solutions a) Identified which sites were most prone to deposition and which sites had best potential for trapping b) Identified erosion upstream of the sites as a proxy for potential maximum loading at the site	George Fowler
5.	1) Approaches to trapping sediment (George Fowler) a) In-channel sediment trapping i) Good approach since it can fill in with sediment regularly (closer to normal river WSEL) – higher production b) Off-channel sediment trap i) Uses offline/adjacent APO pit ii) Set notch at effective discharge/channel-forming flow of river iii) Higher elevation, less-frequent engaging of facility c) Question (Chris Haring) i) How long would sediment traps be effective? ii) What does the maintenance look like? iii) What are costs? d) Currently in the process of looking at the sediment transport competency – what we would expect from each site (George Fowler) i) Will look at annual loading expectations	All
6.	1) Question (Chris Haring) – If traps are strategically located, how does cutting off sediment supply affect the channel downstream? Don't want to cause more erosion downstream by sediment removal a) Discussions on Lane's relationship (All)	

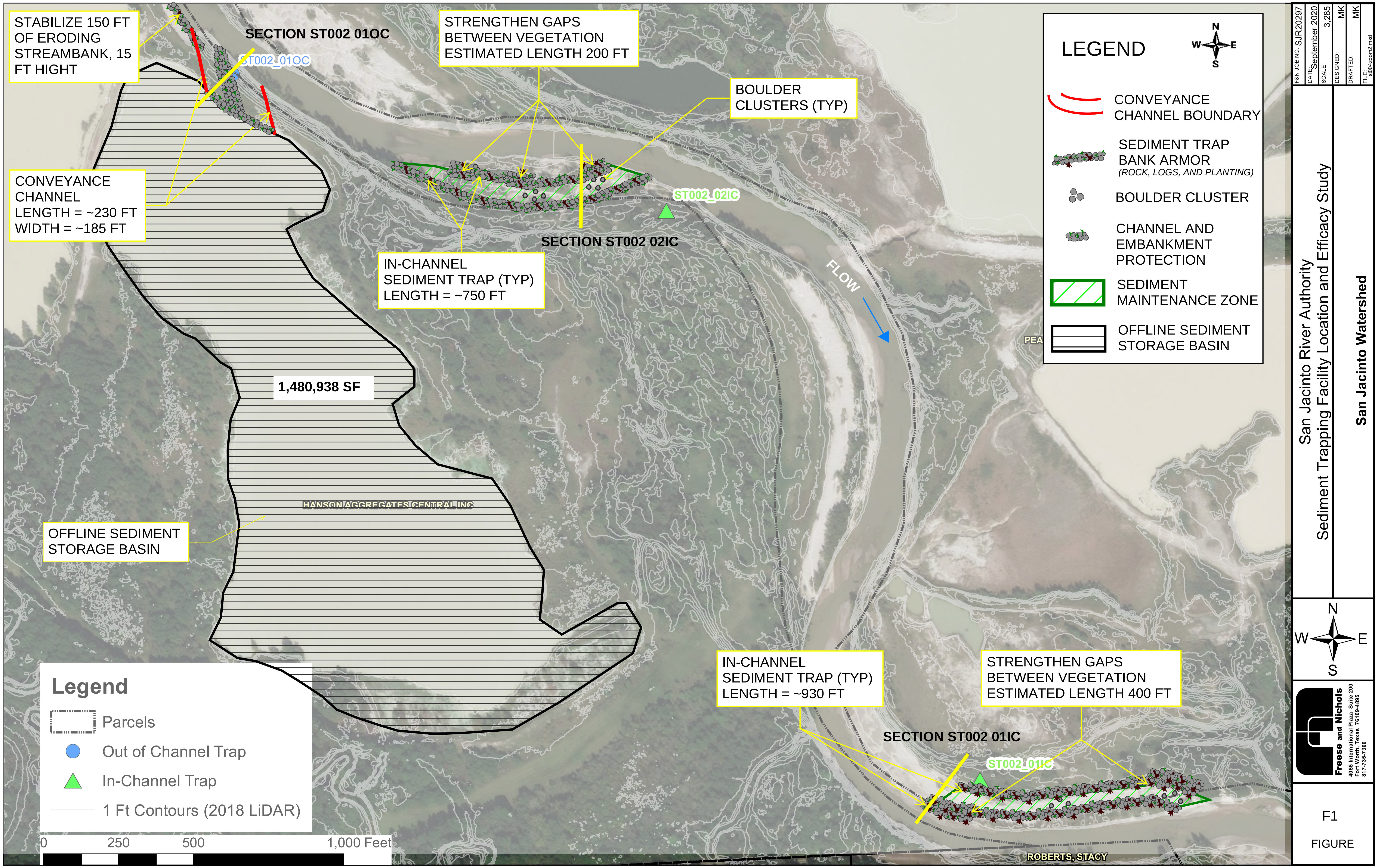
ITEM	DESCRIPTION	PRESENTER
	b) Part of the analysis – what is the potential for total volumetric load, what percentage is expected to be removed c) Have come up with percentage of load expected to be removed – if 5% is removed, what is expected river response? d) Targeting to remove a relatively low percentage so we don't tip the scale by removing too much sediment. e) Have annual loading curves for the West Fork – can use as a guide to compare to total storage created at trapping facilities, then determine percentage	
7.	1) Permitting a) Question – if civil works funded (Kristi McMillan) i) Not CW funded, just locally funded, locally sponsored ii) Will need a USACE regulatory permit to perform any fill/excavation within river itself (Section 404 – federal) iii) Any in-stream structures iv) Not sure how state legislature could bypass 404 requirements v) Need stage TCEQ Section 401 Permit b) 404 and 401 tied together i) Can't receive a 404 unless a 401 is in place, and vice-versa Would need to look at drawings to be able to determine what kind of permits would be required ii) TPW iii) Endangered Species	All
8.	1) Question on if navigable/non-navigable a) Not applicable, all of San Jacinto is jurisdictional under 404 (Kristi McMillan) b) River is perennial, not ephemeral	All
9.	1) Question on time to move through regulatory permitting a) Depends on impacts b) Large impacts, large time c) Depends on public comments received d) Public interest review e) Depends how long it may take to respond to comments f) Need to mitigate impacts	(Kristi McMillan)
10.	1) Question (David May) – were other alternatives evaluated? a) TWDB report form 2000 that looked at contributing area b) 45% of sediment load into Lake Houston came from Cypress Creek, Cypress and Spring contributed 60%	All

ITEM	DESCRIPTION	PRESENTER
	c) USACE has seen a lot of success in stabilizing the source as compared to higher cost, higher maintenance dredging and sediment trapping d) Stabilization should be explored as a supplemental concept e) Can FNI recreate the sediment load calculations done in 2000? f) SJRA and HCFCD have sought out funding from TDWB to complete a regional sediment management plan. The application is pending.	
11.	1) Project Goal was to identify P3 opportunities (Briana Gallagher) a) Limited on what can be done on Spring and Cypress b) Most activities SJRA can take on have to be through grants c) No APOs in Spring Creek watershed 2) Example (David May) – Mississippi – Delta Headwaters project a) Watershed-level stabilization, grade control, bank stabilization b) May be a good model for long-term solution c) Digging out sediment over next 20 years may not slow sediment loading 3) Degradational tendencies in Spring and Cypress 4) Regulatory (Kristi McMillan) a) What is need and purpose? i. The proposal needs to truly achieve the goal (i.e., reducing sediment loading into the Lake) The permit application needs to demonstrate that the proposed alternative is better than other alternatives at achieving the goal. If the Corps does not believe the proposed work achieves the goal better than other alternatives, then it cannot issue a permit. The goal of the project must be thoughtfully worded and the proposed activity's ability to achieve the goal clearly stated. ii. Will look to see if alternatives meet need and purpose 5) If current proposal shows to be less likely to reduce sediment than alternative, then will it be permitted? (Briana Gallagher) a) Needs to show LEDPA 6) SJRA is currently exploring a regional sediment management solution (includes Spring and Cypress Creek) that would look at other options 7) USACE has a regional sediment management (RSM) Program to encourage partnerships with other entities (David May) 8) Many ways USACE can interface with SJRA to identify opportunities to work together on sediment management (Coraggio Maglio)	All

ITEM	DESCRIPTION	PRESENTER
	9) David May to send additional resources to SJRA	
12.	1) Impetus for this project came from state legislature 2) Wanted to explore and identify opportunities for sediment trapping	Briana Gallagher
13.	1) USACE has various technologies for sediment collection a) Bedload collector b) Have 2 year study on this c) ERDC has been researching d) USACE has techniques to do demonstration projects e) Can provide info	Chris May

Appendix F

Figures F1 through F29



STABILIZE 150 FT OF ERODING STREAMBANK, 15 FT HIGHT
SECTION ST002 01OC
ST002_01OC
STRENGTHEN GAPS BETWEEN VEGETATION ESTIMATED LENGTH 200 FT
BOULDER CLUSTERS (TYP)
CONVEYANCE CHANNEL LENGTH = ~230 FT WIDTH = ~185 FT
ST002_02IC
SECTION ST002 02IC
IN-CHANNEL SEDIMENT TRAP (TYP) LENGTH = ~750 FT
FLOW
1,480,938 SF
HANSON AGGREGATES CENTRAL INC
OFFLINE SEDIMENT STORAGE BASIN
IN-CHANNEL SEDIMENT TRAP (TYP) LENGTH = ~930 FT
STRENGTHEN GAPS BETWEEN VEGETATION ESTIMATED LENGTH 400 FT
SECTION ST002 01IC
ST002_01IC
ROBERTS, STACY
LEGEND
N
S
W
E
CONVEYANCE CHANNEL BOUNDARY
SEDIMENT TRAP BANK ARMOR
(ROCK, LOGS, AND PLANTING)
BOULDER CLUSTER
CHANNEL AND EMBANKMENT PROTECTION
SEDIMENT MAINTENANCE ZONE
OFFLINE SEDIMENT STORAGE BASIN
Legend
Parcels
Out of Channel Trap
In-Channel Trap
1 Ft Contours (2018 LiDAR)
0
250
500
1,000 Feet
F&N JOB NO. SJR20297
DATE: September 2020
SCALE: 3,285
DESIGNED: MK
DRAFTED: MK
San Jacinto River Authority
Sediment Trapping Facility Location and Efficacy Study
San Jacinto Watershed
Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300
F1
FIGURE

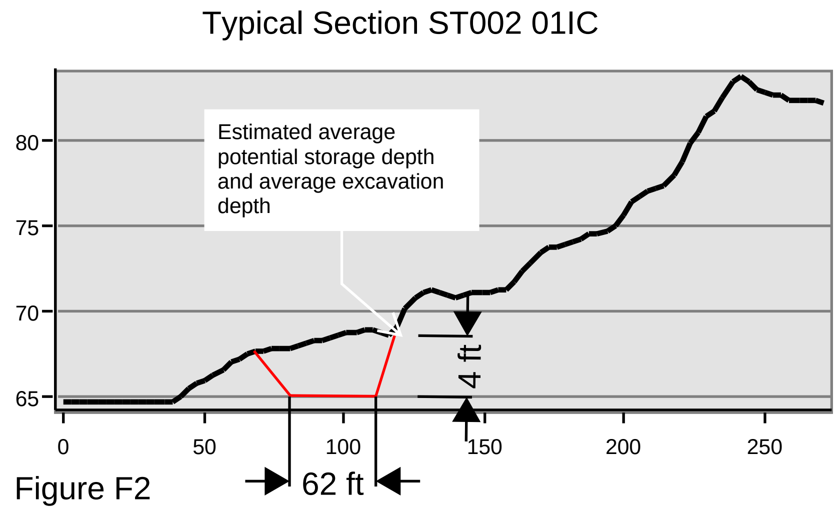
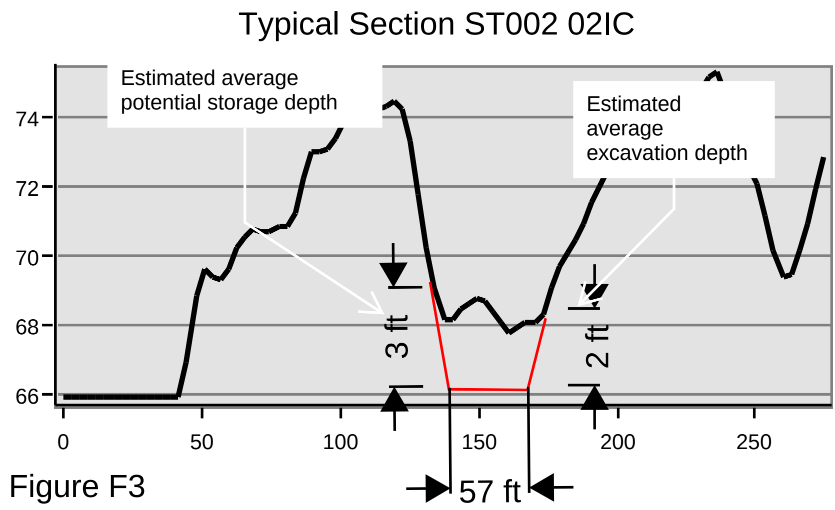

Typical Section ST002 01IC
Estimated average potential storage depth and average excavation depth
80
75
70
65
0
50
100
150
200
250
4 ft
62 ft

Figure F2



Typical Section ST002 02IC
Estimated average potential storage depth
Estimated average excavation depth
74
72
70
68
66
3 ft
2 ft
0
50
100
150
200
250
57 ft

Figure F3

Typical Section ST002 01OC

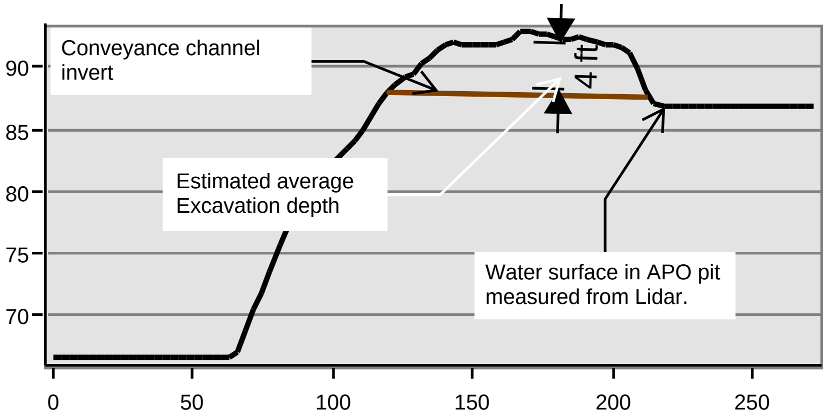
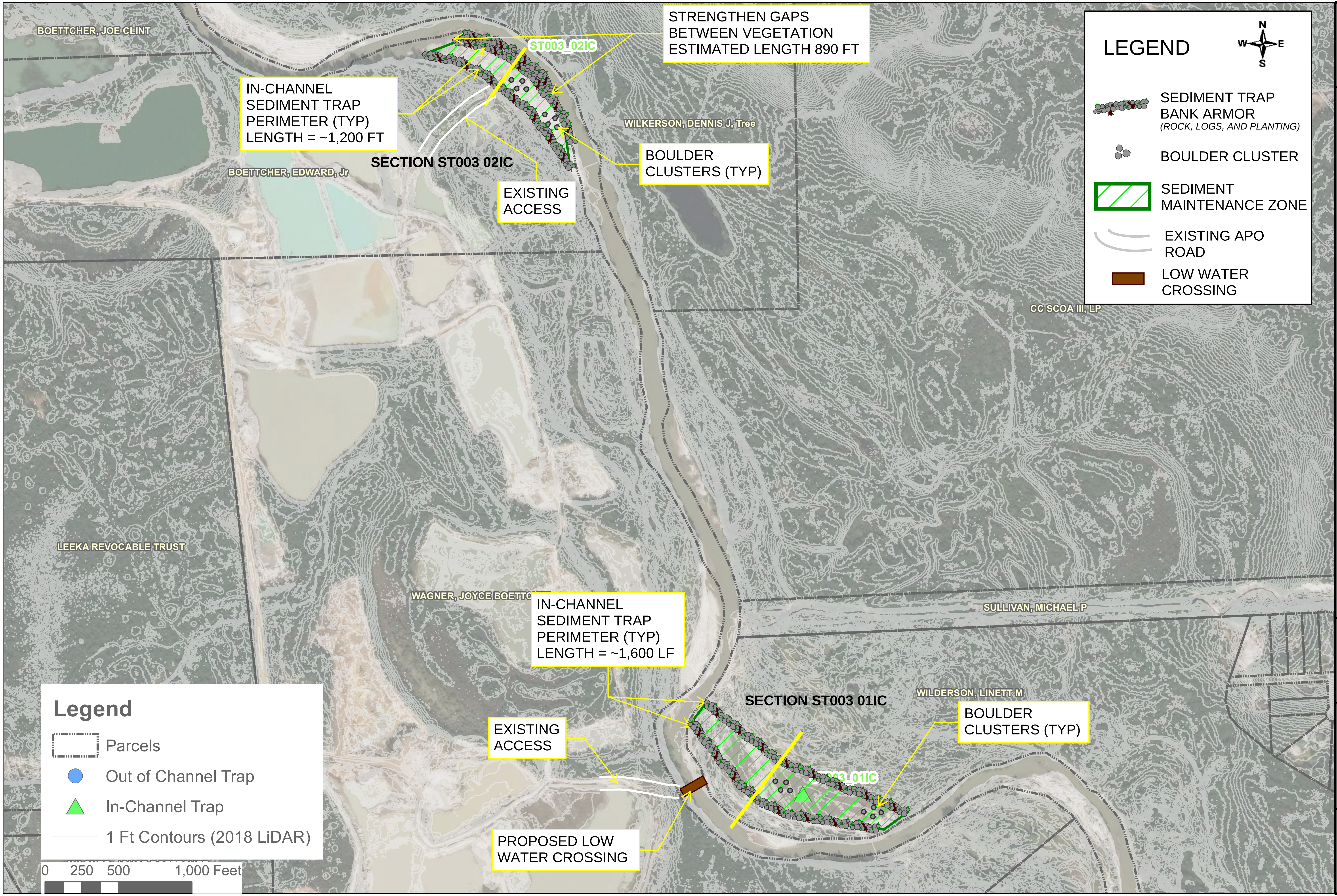


Figure F4



F&N JOB NO. SJR20297
DATE: September 2020
SCALE: 6,930
DESIGNED: MK
DRAFTED: MK
FILE: st002.mxd

San Jacinto River Authority
Sediment Trapping Facility Location and Efficacy Study

San Jacinto Watershed

N
W E
S

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F5

FIGURE

Typical Section ST003 01IC

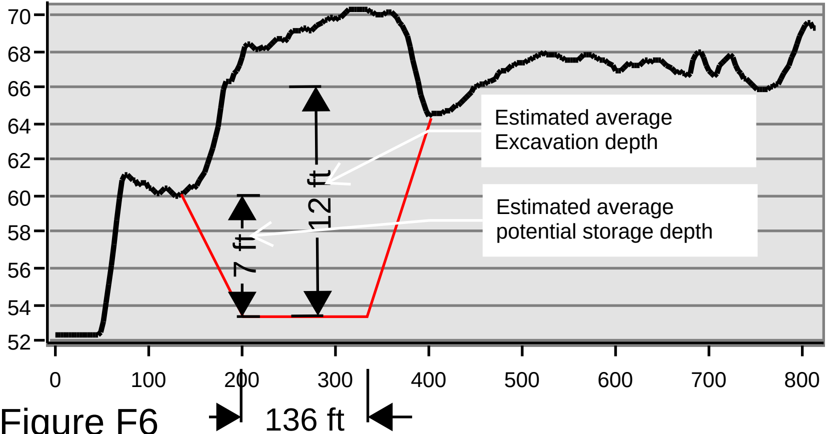


Figure F6

Typical Section ST003 02IC

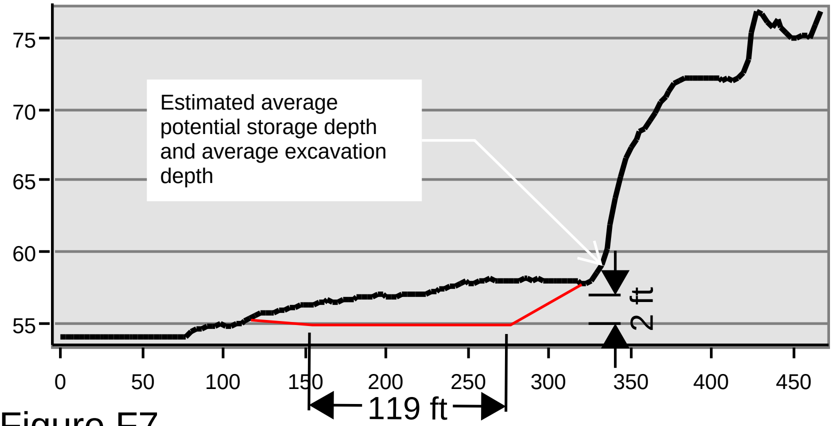
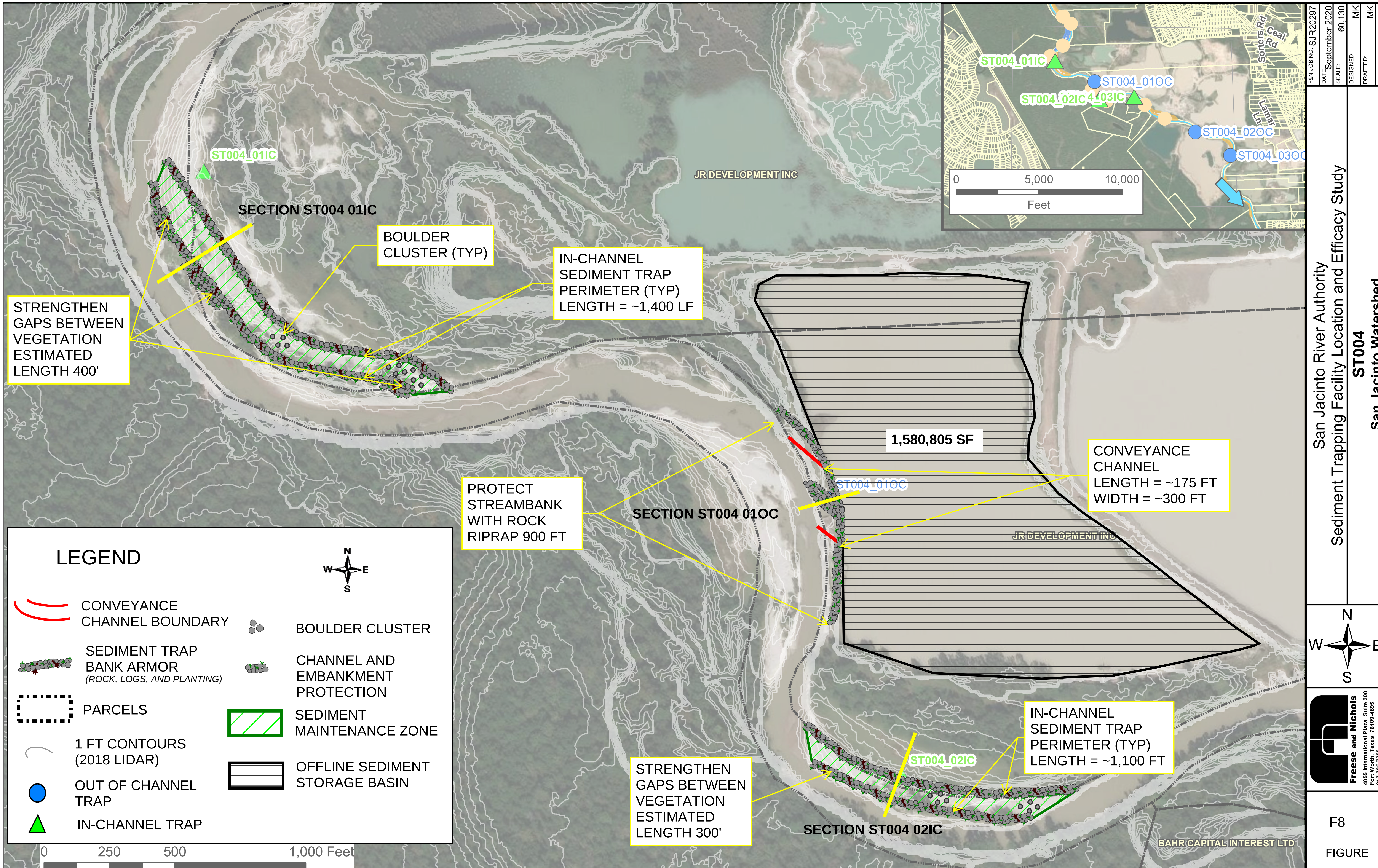
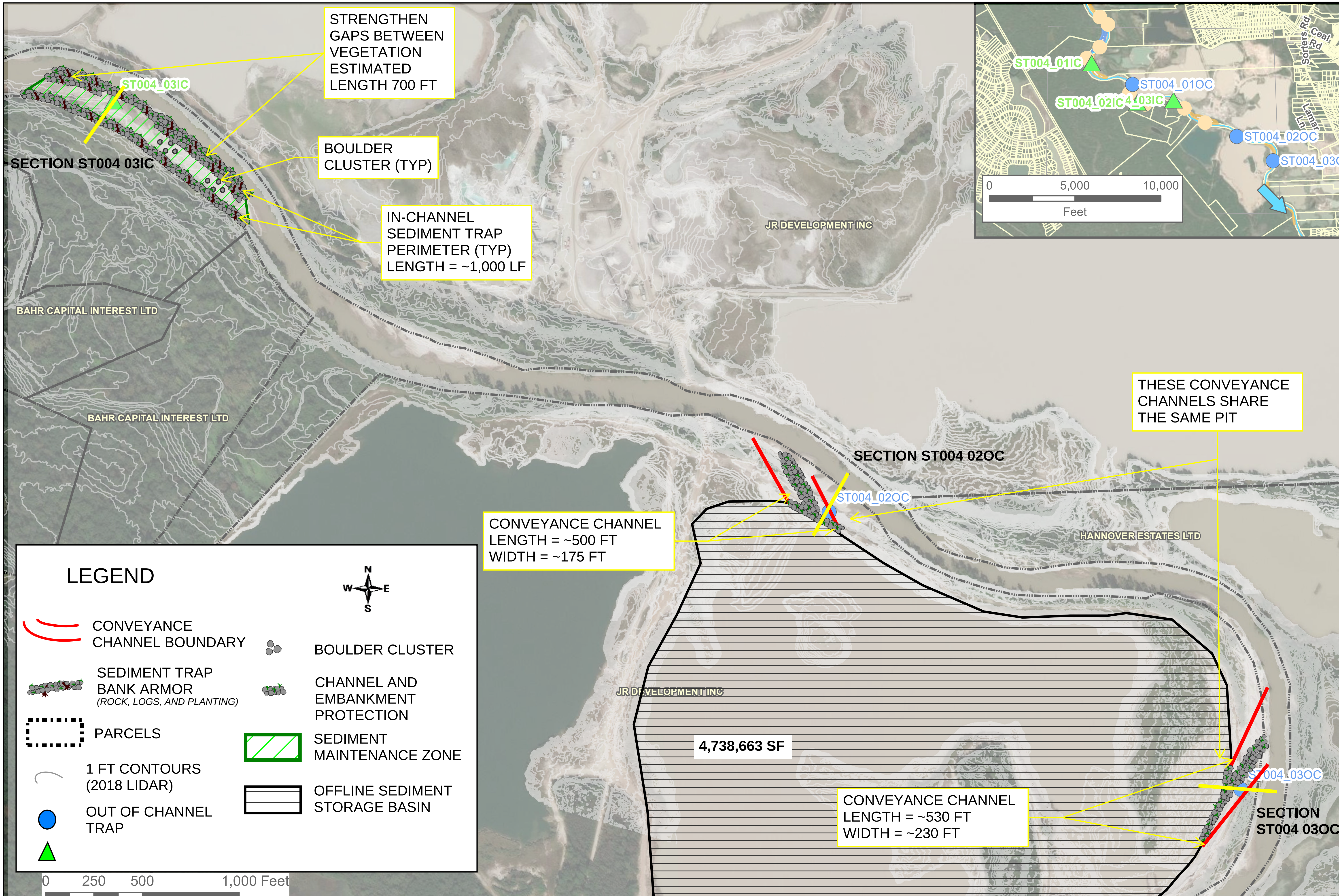


Figure F7



ST004_01IC
SECTION ST004 01IC
BOULDER CLUSTER (TYP)
IN-CHANNEL SEDIMENT TRAP PERIMETER (TYP) LENGTH = ~1,400 LF
STRENGTHEN GAPS BETWEEN VEGETATION ESTIMATED LENGTH 400'
JR DEVELOPMENT INC
1,580,805 SF
CONVEYANCE CHANNEL LENGTH = ~175 FT WIDTH = ~300 FT
ST004_01OC
SECTION ST004 01OC
PROTECT STREAMBANK WITH ROCK RIPRAP 900 FT
JR DEVELOPMENT INC
IN-CHANNEL SEDIMENT TRAP PERIMETER (TYP) LENGTH = ~1,100 FT
ST004_02IC
STRENGTHEN GAPS BETWEEN VEGETATION ESTIMATED LENGTH 300'
SECTION ST004 02IC
BAHR CAPITAL INTEREST LTD
LEGEND
CONVEYANCE CHANNEL BOUNDARY
SEDIMENT TRAP BANK ARMOR (ROCK, LOGS, AND PLANTING)
PARCELS
1 FT CONTOURS (2018 LIDAR)
OUT OF CHANNEL TRAP
IN-CHANNEL TRAP
BOULDER CLUSTER
CHANNEL AND EMBANKMENT PROTECTION
SEDIMENT MAINTENANCE ZONE
OFFLINE SEDIMENT STORAGE BASIN
N S E W
0 250 500 1,000 Feet
ST004_01IC
ST004_01OC
ST004_02IC
4_03IC
ST004_02OC
ST004_03OC
Sorters Rd
Ceal Rd
Lamar
0 5,000 10,000
Feet
F&N JOB NO: SJR20297
DATE: September 2020
SCALE: 60,130
DESIGNED: MK
DRAFTED: MK
FILE: st004zoom.mxd
San Jacinto River Authority
Sediment Trapping Facility Location and Efficacy Study
ST004
San Jacinto Watershed
N W E S
Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300
F8
FIGURE



F&N JOB NO.	SJR20297
DATE:	September 2020
SCALE:	60,130
DESIGNED:	MK
DRAFTED:	MK
FILE:	st004zoom2.mxd

San Jacinto River Authority
Sediment Trapping Facility Location and Efficacy Study

ST004
San Jacinto Watershed

N
W E
S

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F9
FIGURE

Typical Section ST004 1C

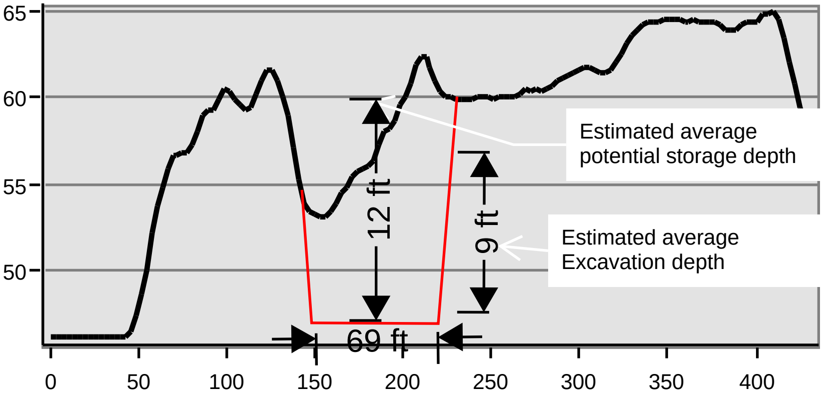
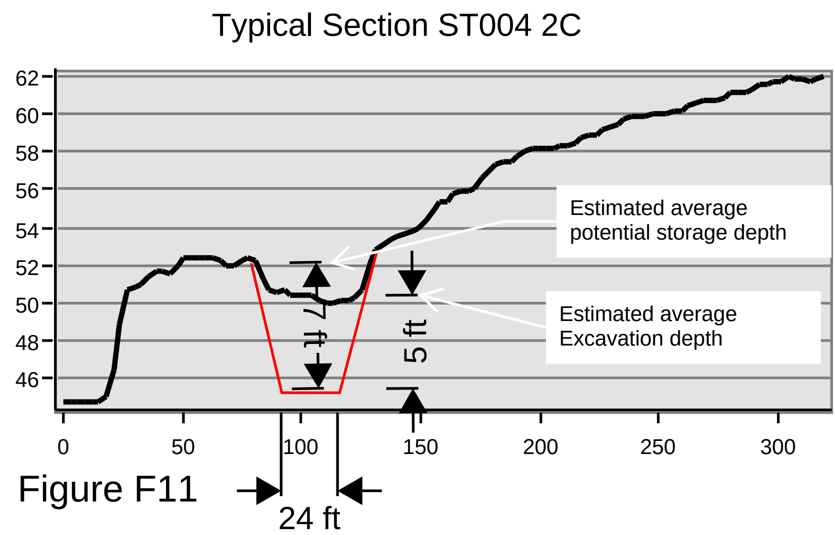


Figure F10



Typical Section ST004 2C
62
60
58
56
54
52
50
48
46
0
50
100
150
200
250
300
Estimated average potential storage depth
Estimated average Excavation depth
7 ft
5 ft
24 ft

Figure F11

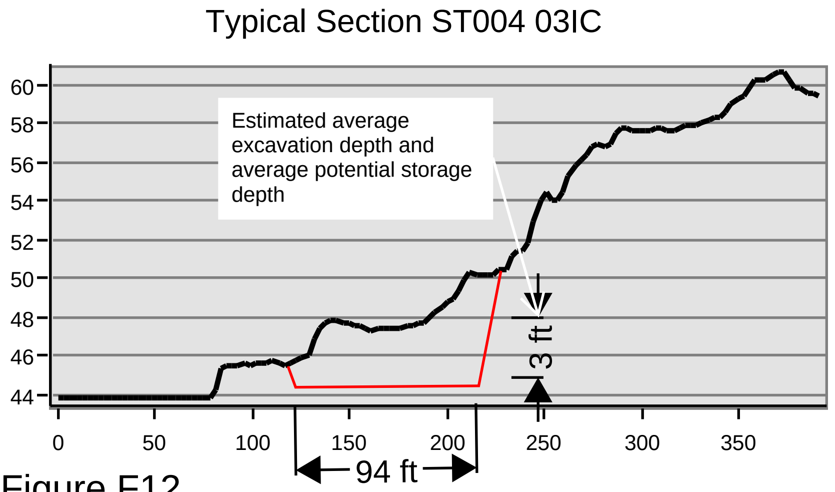
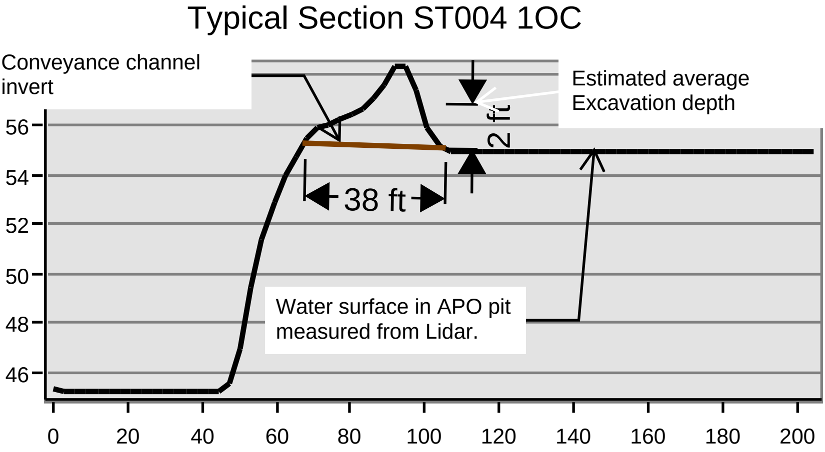
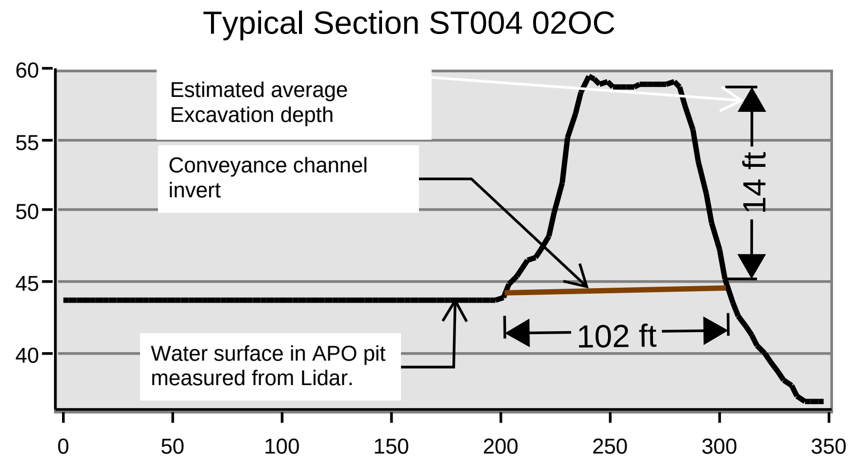

Typical Section ST004 03IC
Estimated average excavation depth and average potential storage depth
60
58
56
54
52
50
48
46
44
0
50
100
150
200
250
300
350
3 ft
94 ft

Figure F12



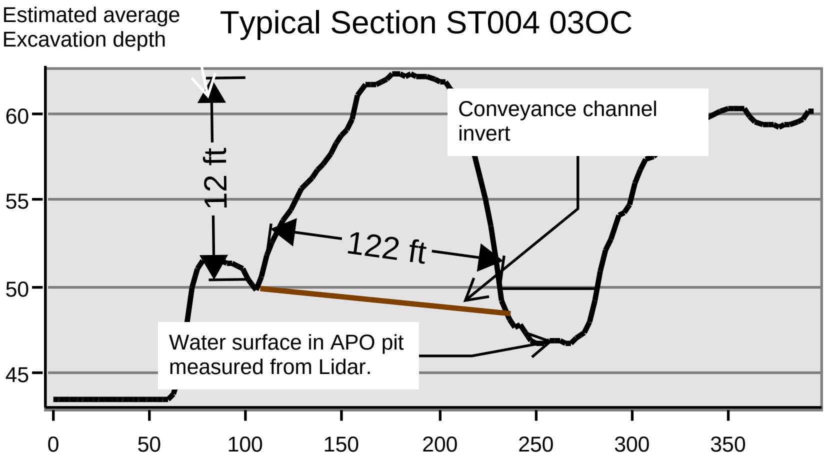
Typical Section ST004 1OC
Conveyance channel invert
Estimated average Excavation depth
2 ft
38 ft
Water surface in APO pit measured from Lidar.
56
54
52
50
48
46
0
20
40
60
80
100
120
140
160
180
200

Figure F13



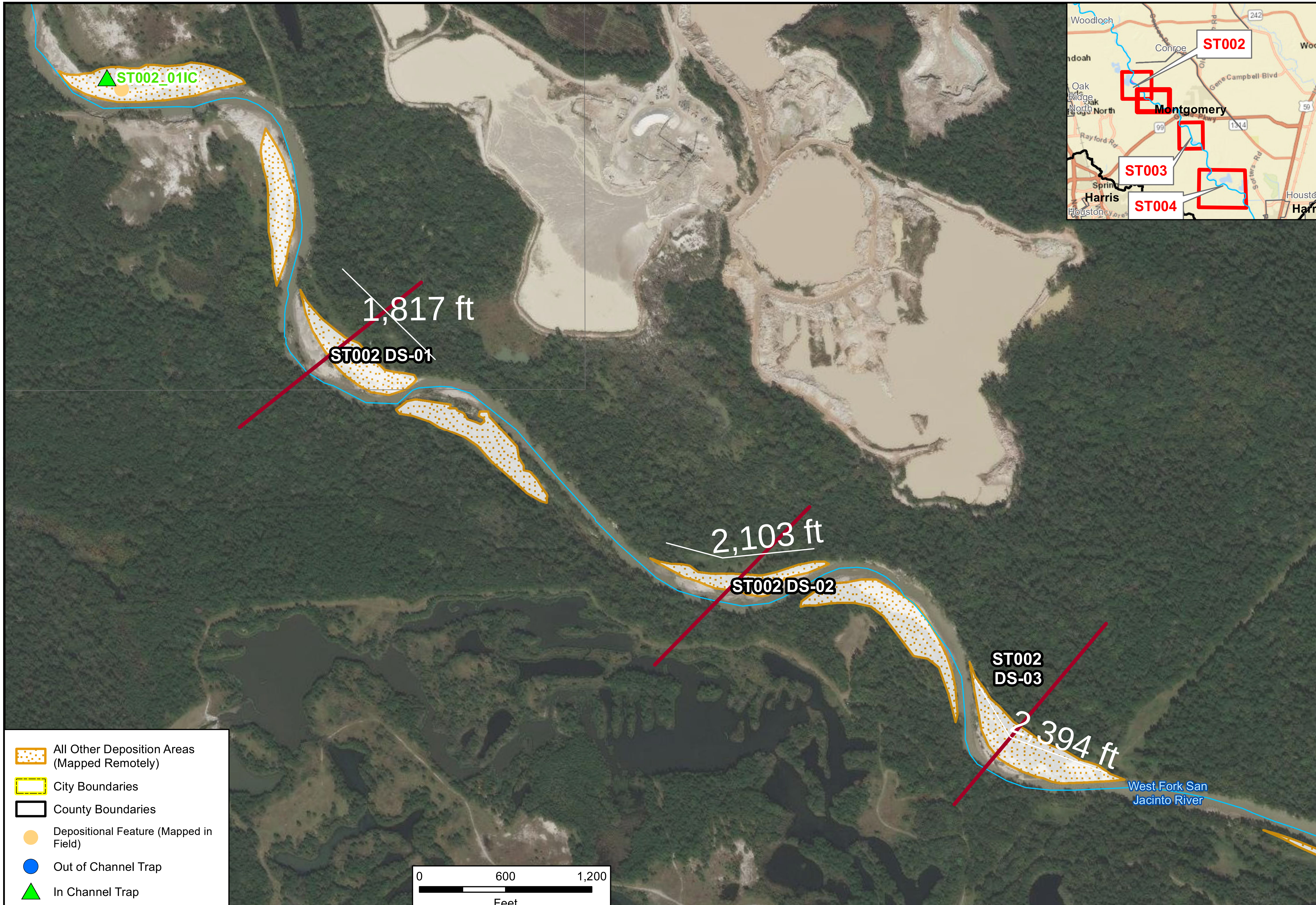
Typical Section ST004 02OC
Estimated average Excavation depth
Conveyance channel invert
Water surface in APO pit measured from Lidar.
14 ft
102 ft
60
55
50
45
40
0
50
100
150
200
250
300
350

Figure F14



Estimated average
Excavation depth
Typical Section ST004 03OC
12 ft
122 ft
Conveyance channel
invert
Water surface in APO pit
measured from Lidar.
60
55
50
45
0
50
100
150
200
250
300
350

Figure F15



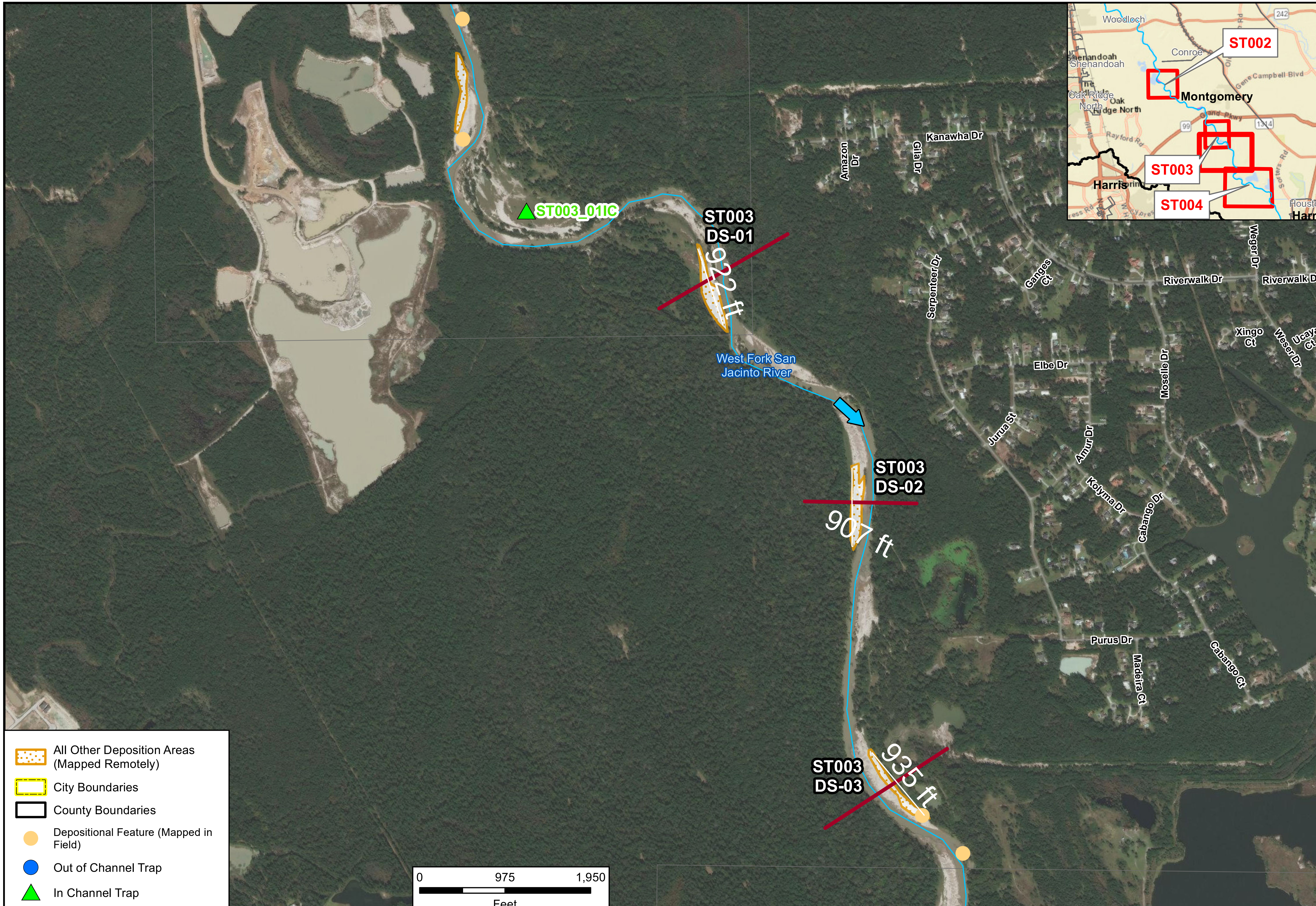
San Jacinto River Authority
Sediment Trapping Facility Conceptual Design Report

ST002
DOWNSTREAM SEDIMENT BENEFITS

F&N JOB NO.: SJR20297
DATE: September 2020
SCALE: 7,244
DESIGNED: MK
DRAFTED: MK
FILE: ST002 DS Sediment Benefits.mxd

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

F16
FIGURE



San Jacinto River Authority
Sediment Trapping Facility Conceptual Design Report

ST003
DOWNSTREAM SEDIMENT BENEFITS

F&N JOB NO. SJR20297
DATE: September 2020
SCALE: 11,881
DESIGNED: MK
DRAFTED: MK
FILE: ST003 DS Sediment Benefits.mxd

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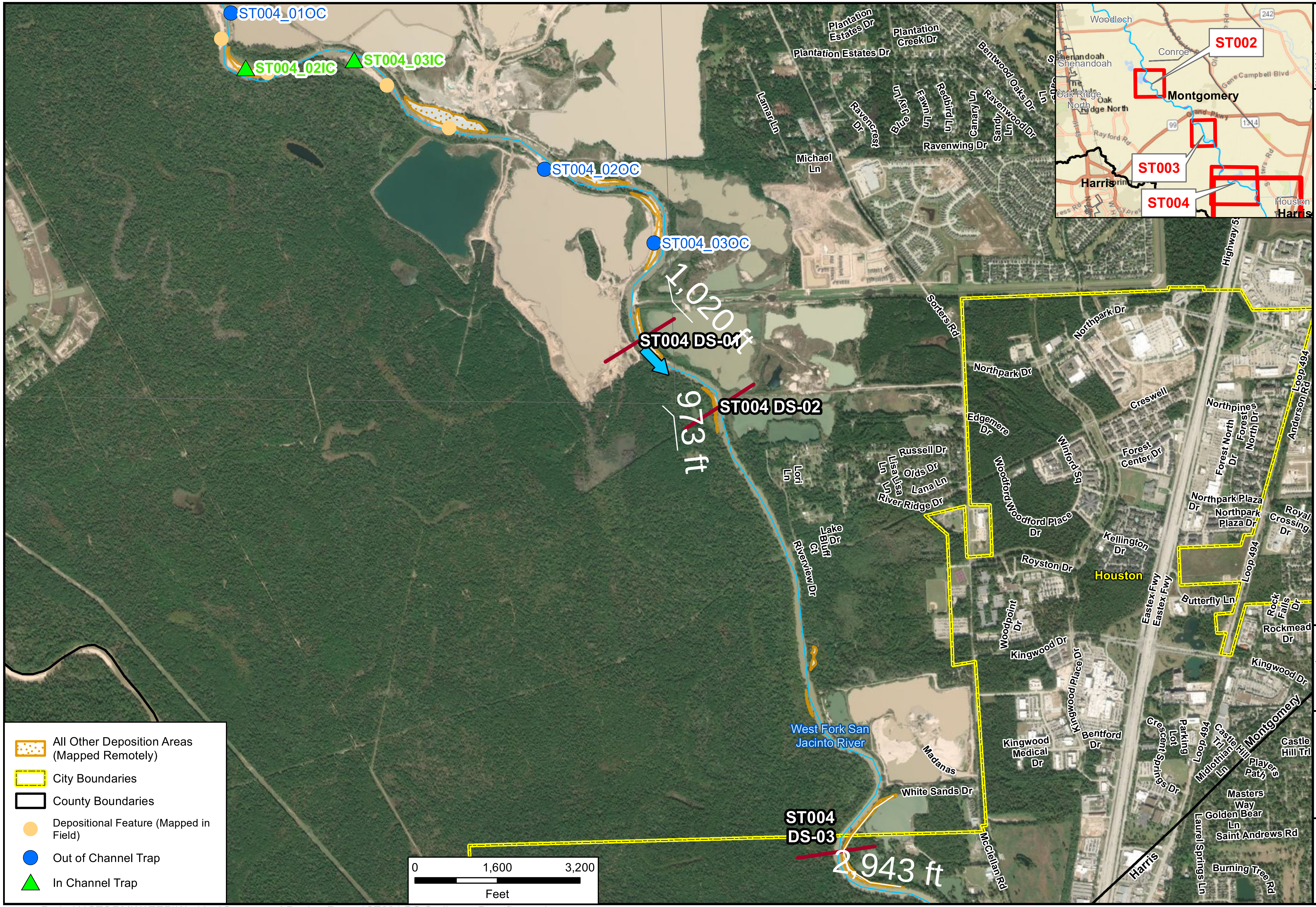
F17
FIGURE

Document Path: H:\STORMWATER\Working\Conceptual Design Report\ST003 DS Sediment Benefits.mxd



San Jacinto River Authority
Sediment Trapping Facility Conceptual Design Report
ST004
DOWNSTREAM SEDIMENT BENEFITS

F&N JOB NO. SJR20297
DATE: September 2020
SCALE: 19,976
DESIGNED: MK
DRAFTED: MK
FILE: ST004 DS Sediment Benefits.mxd

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Fort Worth, Texas 76109-4895
817-735-7300

F18
FIGURE

Document Path: H:\STORMWATER\Working\Conceptual Design Report\ST004 DS Sediment Benefits.mxd

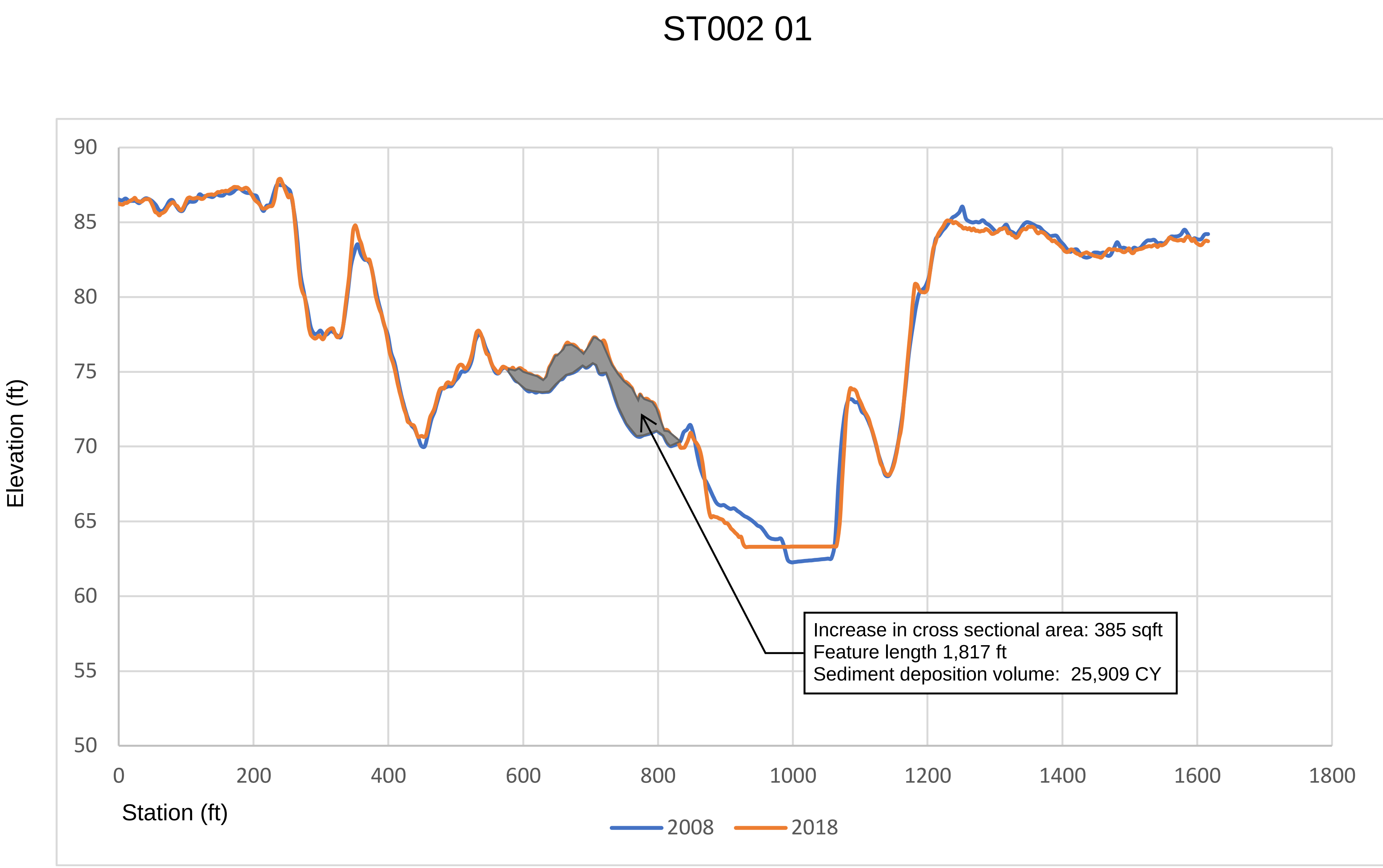

ST002 01
90
85
80
75
70
65
60
55
50
Elevation (ft)
0
200
400
600
800
1000
1200
1400
1600
1800
Station (ft)
2008
2018
Increase in cross sectional area: 385 sqft
Feature length 1,817 ft
Sediment deposition volume: 25,909 CY

Figure F19

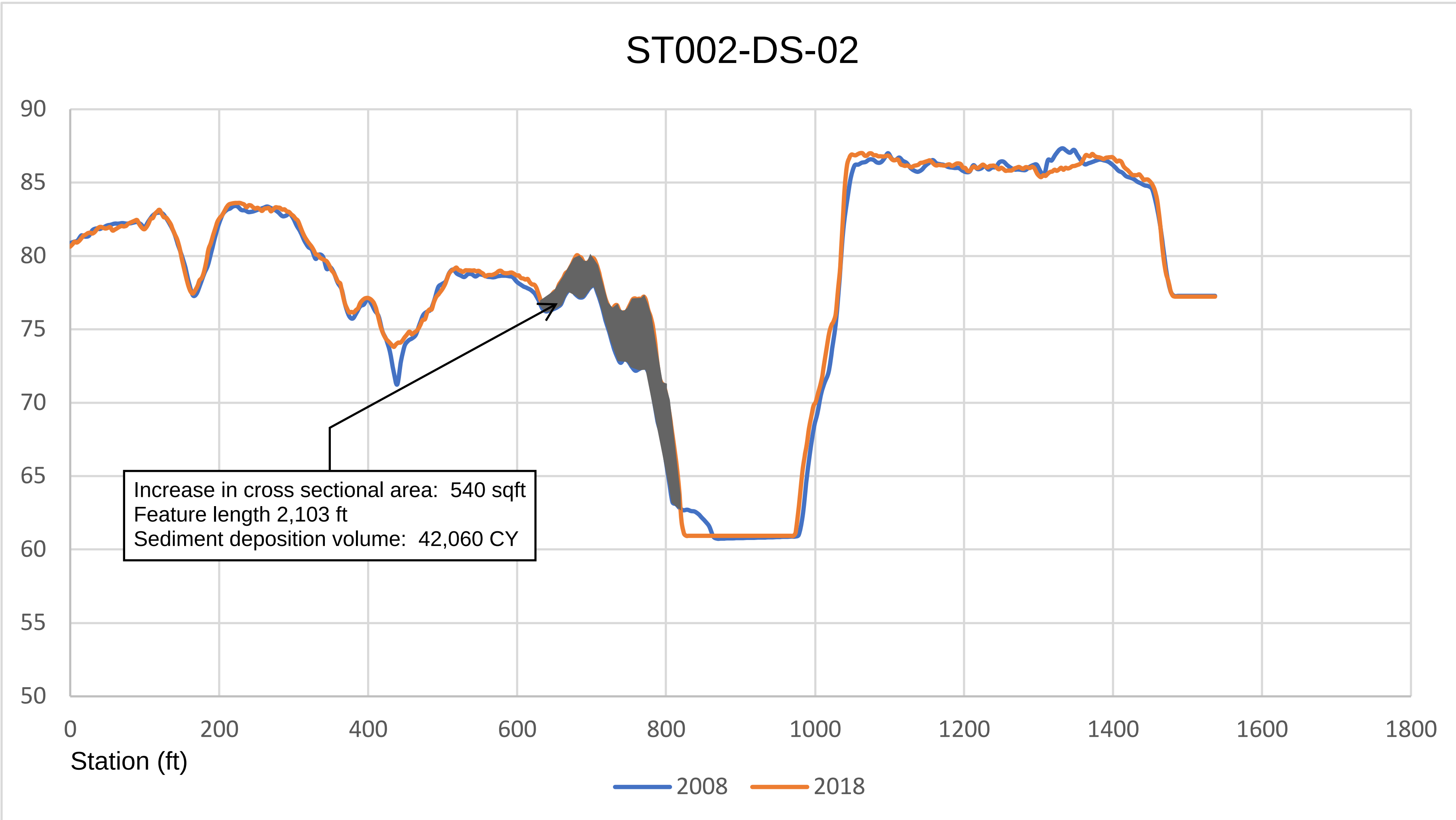

ST002-DS-02
Elevation (ft)
90
85
80
75
70
65
60
55
50
0
200
400
600
800
1000
1200
1400
1600
1800
Station (ft)
2008
2018
Increase in cross sectional area: 540 sqft
Feature length 2,103 ft
Sediment deposition volume: 42,060 CY

Figure F20

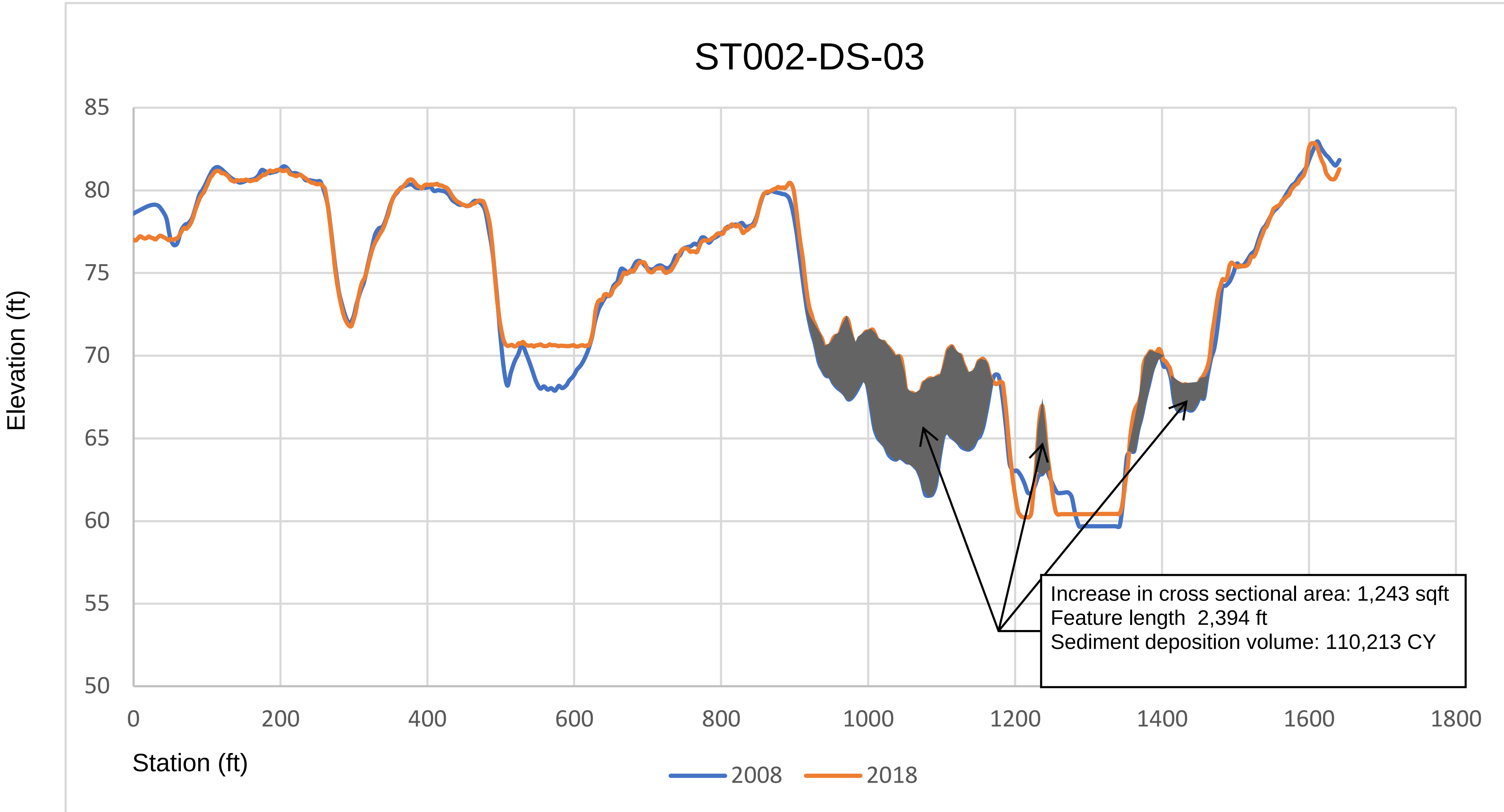

ST002-DS-03
85
80
75
70
65
60
55
50
0
200
400
600
800
1000
1200
1400
1600
1800
Elevation (ft)
Station (ft)
2008
2018
Increase in cross sectional area: 1,243 sqft
Feature length 2,394 ft
Sediment deposition volume: 110,213 CY

Figure F21

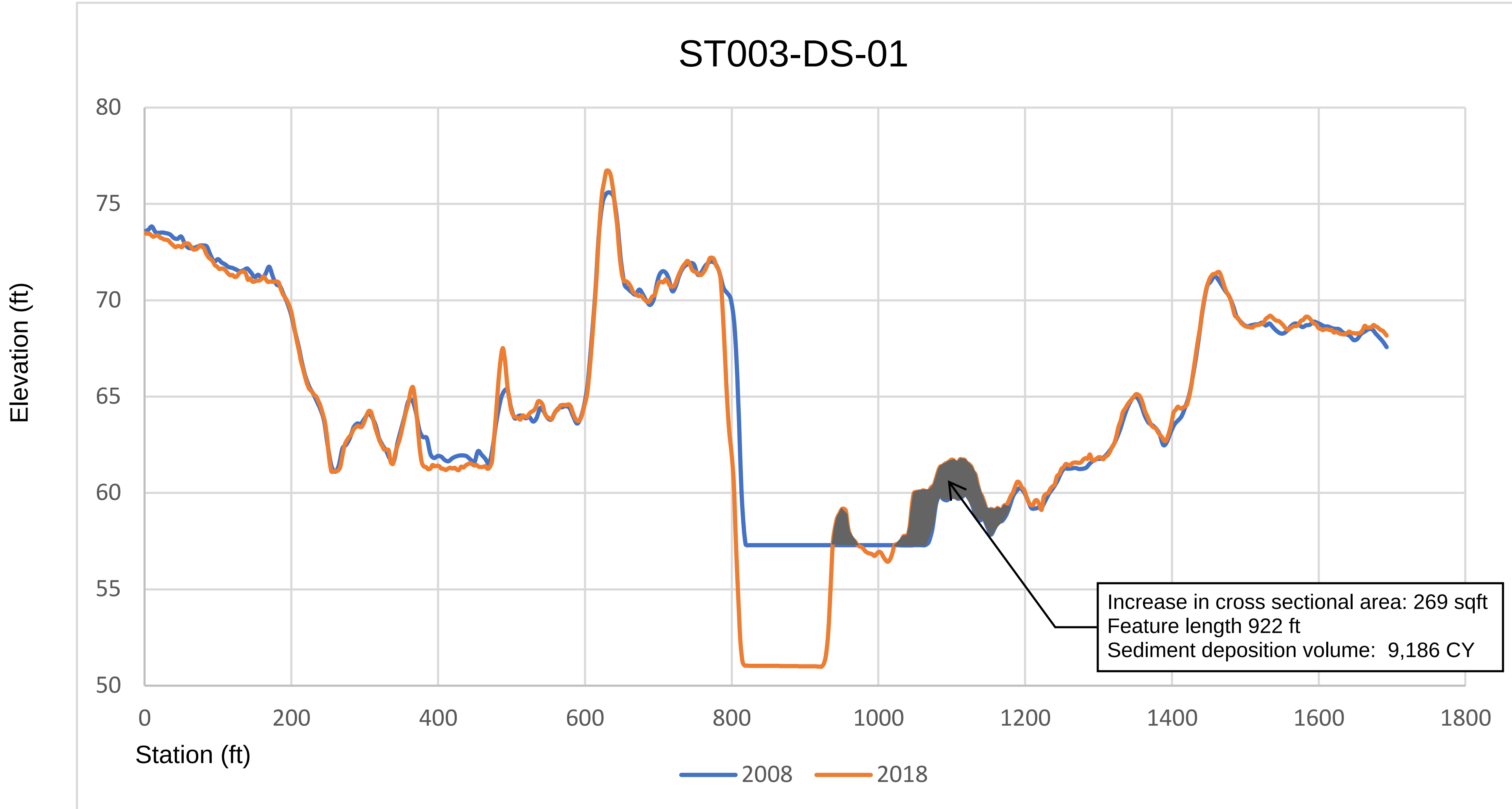
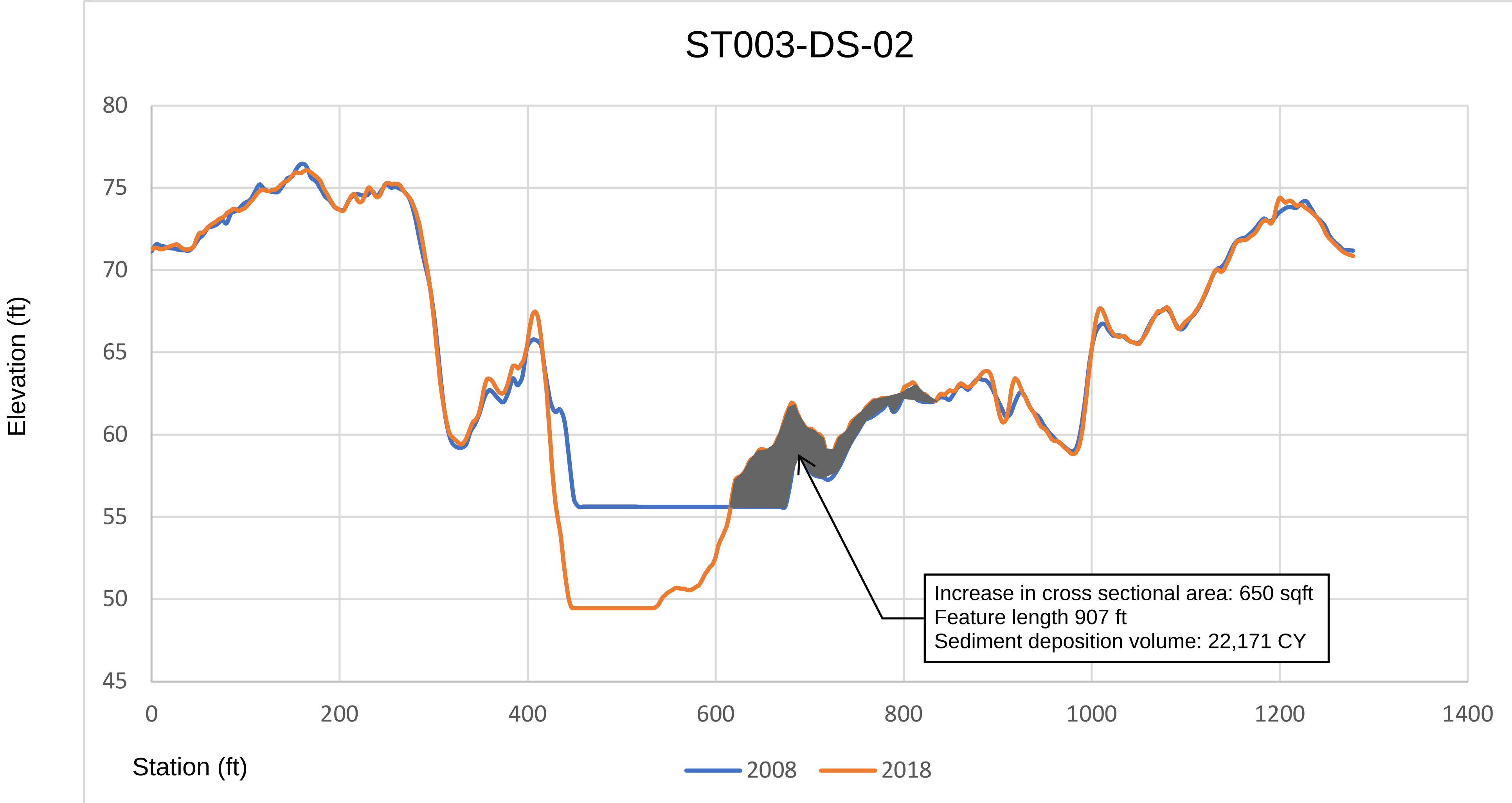

ST003-DS-01
Elevation (ft)
80
75
70
65
60
55
50
0
200
400
600
800
1000
1200
1400
1600
1800
Station (ft)
Increase in cross sectional area: 269 sqft
Feature length 922 ft
Sediment deposition volume: 9,186 CY
2008
2018

Figure F22



ST003-DS-02
Elevation (ft)
80
75
70
65
60
55
50
45
0
200
400
600
800
1000
1200
1400
Station (ft)
2008
2018
Increase in cross sectional area: 650 sqft
Feature length 907 ft
Sediment deposition volume: 22,171 CY

Figure F23

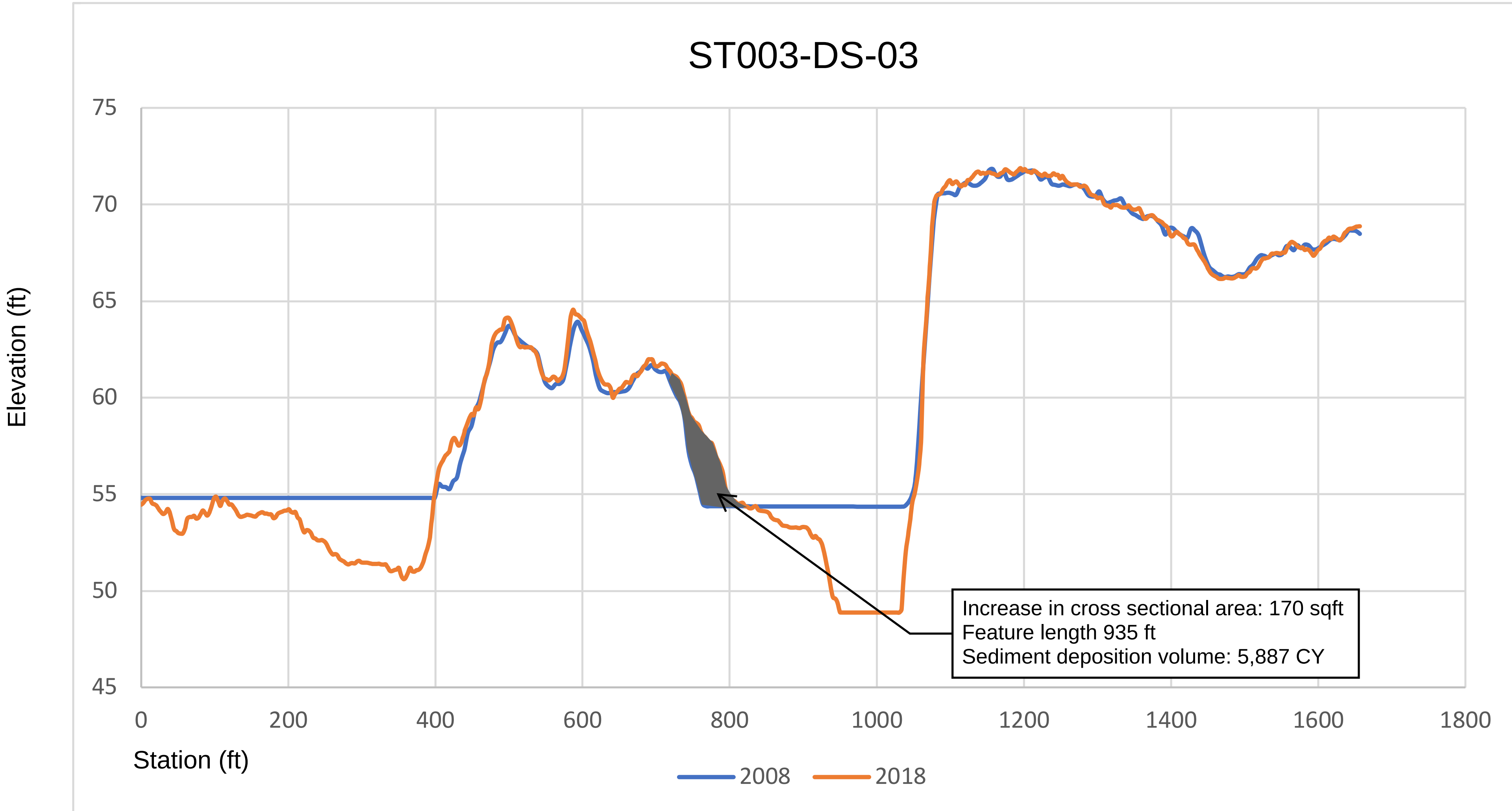

ST003-DS-03
Elevation (ft)
75
70
65
60
55
50
45
0
200
400
600
800
1000
1200
1400
1600
1800
Station (ft)
Increase in cross sectional area: 170 sqft
Feature length 935 ft
Sediment deposition volume: 5,887 CY
2008
2018

Figure F24

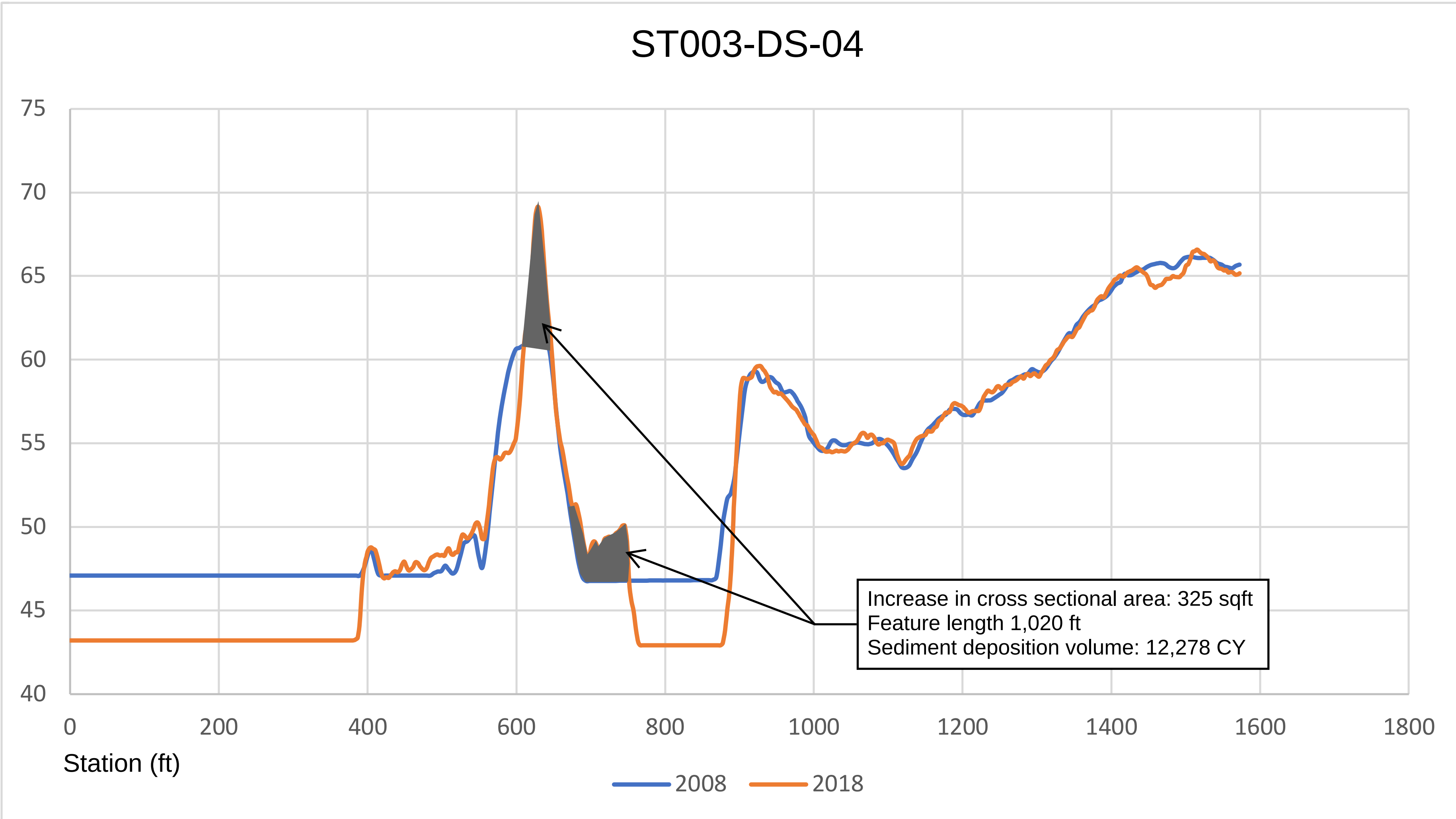
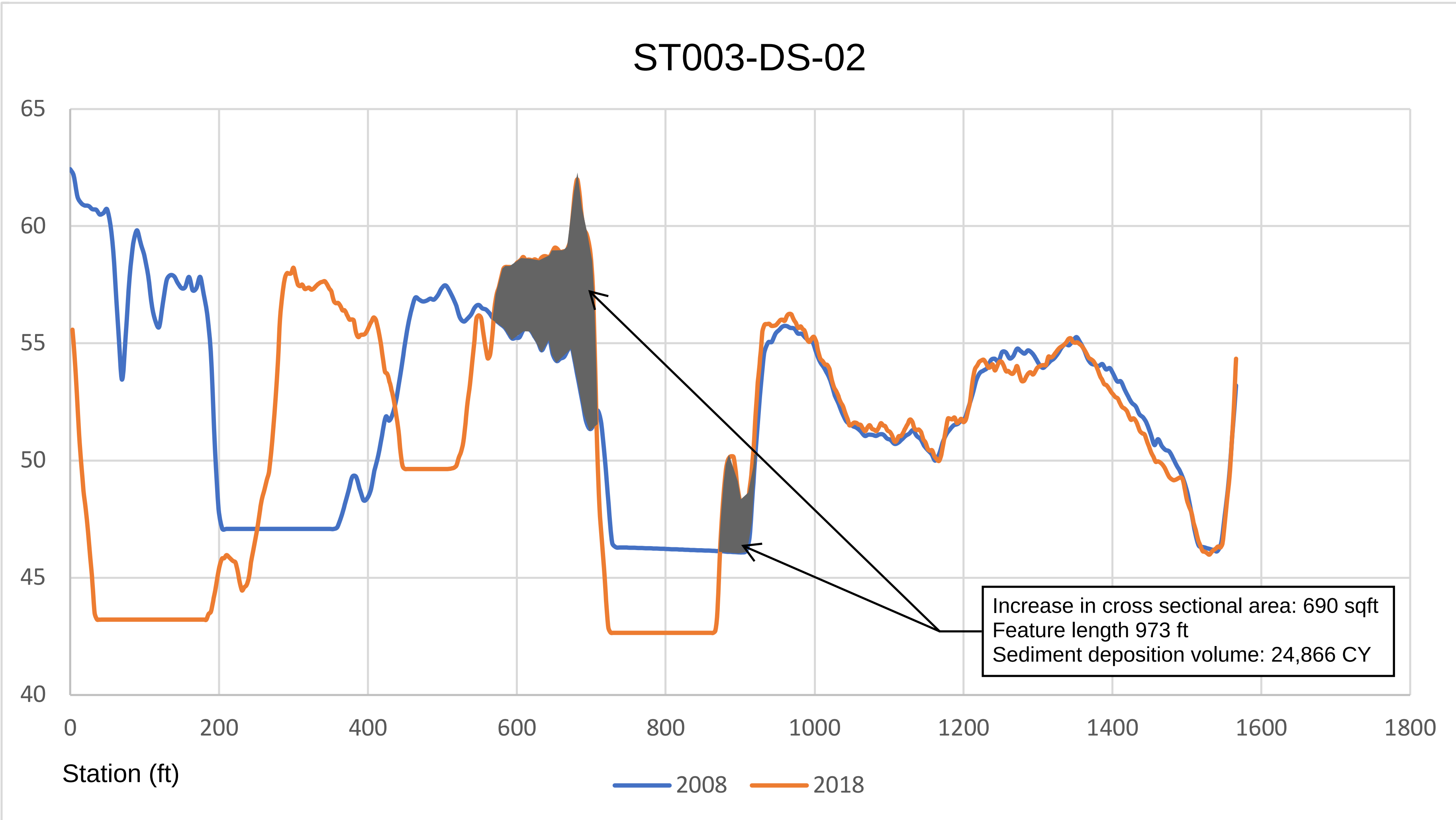
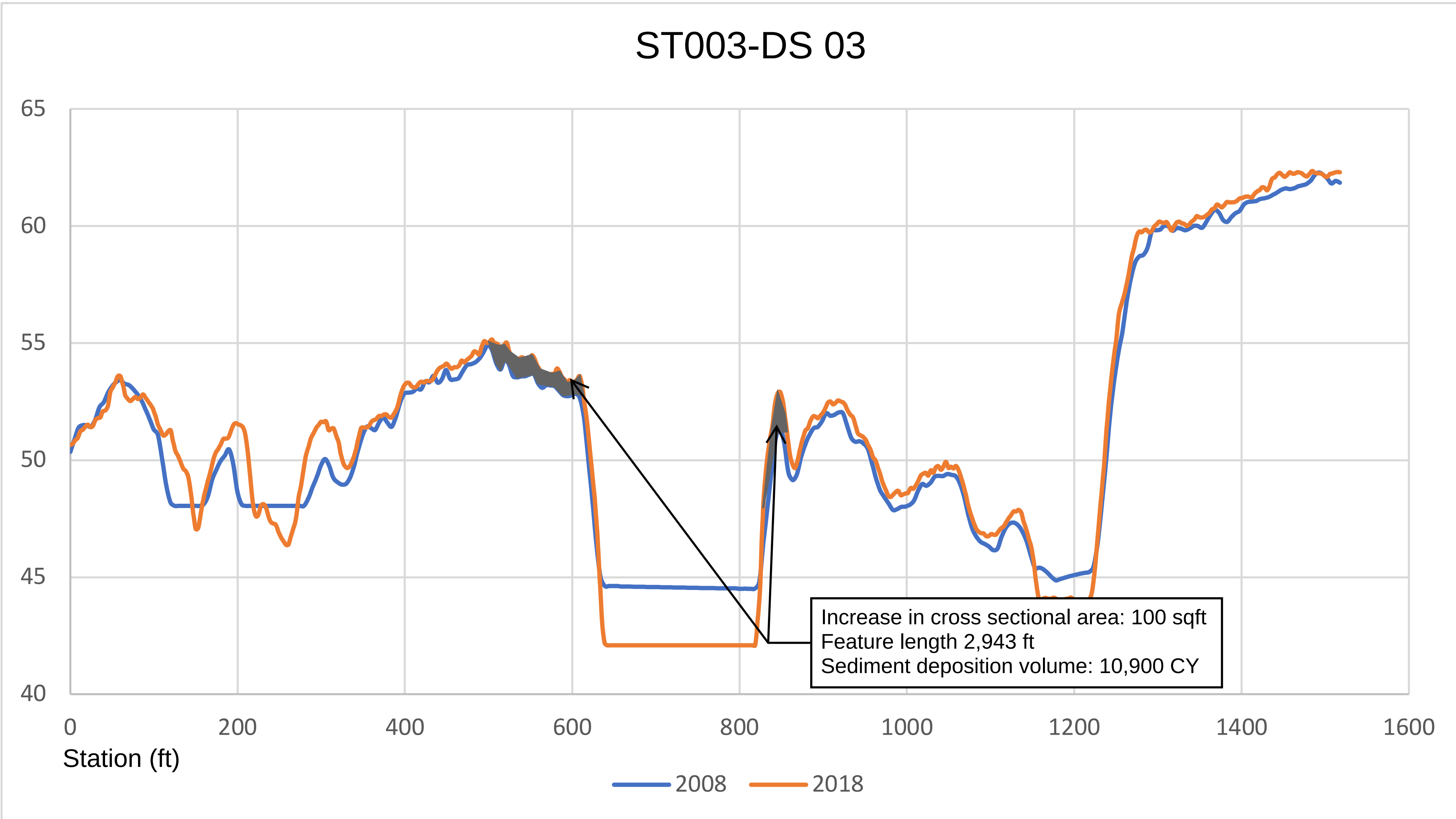

ST003-DS-04
Elevation (ft)
75
70
65
60
55
50
45
40
0
200
400
600
800
1000
1200
1400
1600
1800
Station (ft)
2008
2018
Increase in cross sectional area: 325 sqft
Feature length 1,020 ft
Sediment deposition volume: 12,278 CY

Figure F25



ST003-DS-02
Elevation (ft)
65
60
55
50
45
40
0
200
400
600
800
1000
1200
1400
1600
1800
Station (ft)
2008
2018
Increase in cross sectional area: 690 sqft
Feature length 973 ft
Sediment deposition volume: 24,866 CY

Figure F26



ST003-DS 03
Elevation (ft)
65
60
55
50
45
40
0
200
400
600
800
1000
1200
1400
1600
Station (ft)
Increase in cross sectional area: 100 sqft
Feature length 2,943 ft
Sediment deposition volume: 10,900 CY
2008
2018

Figure F27

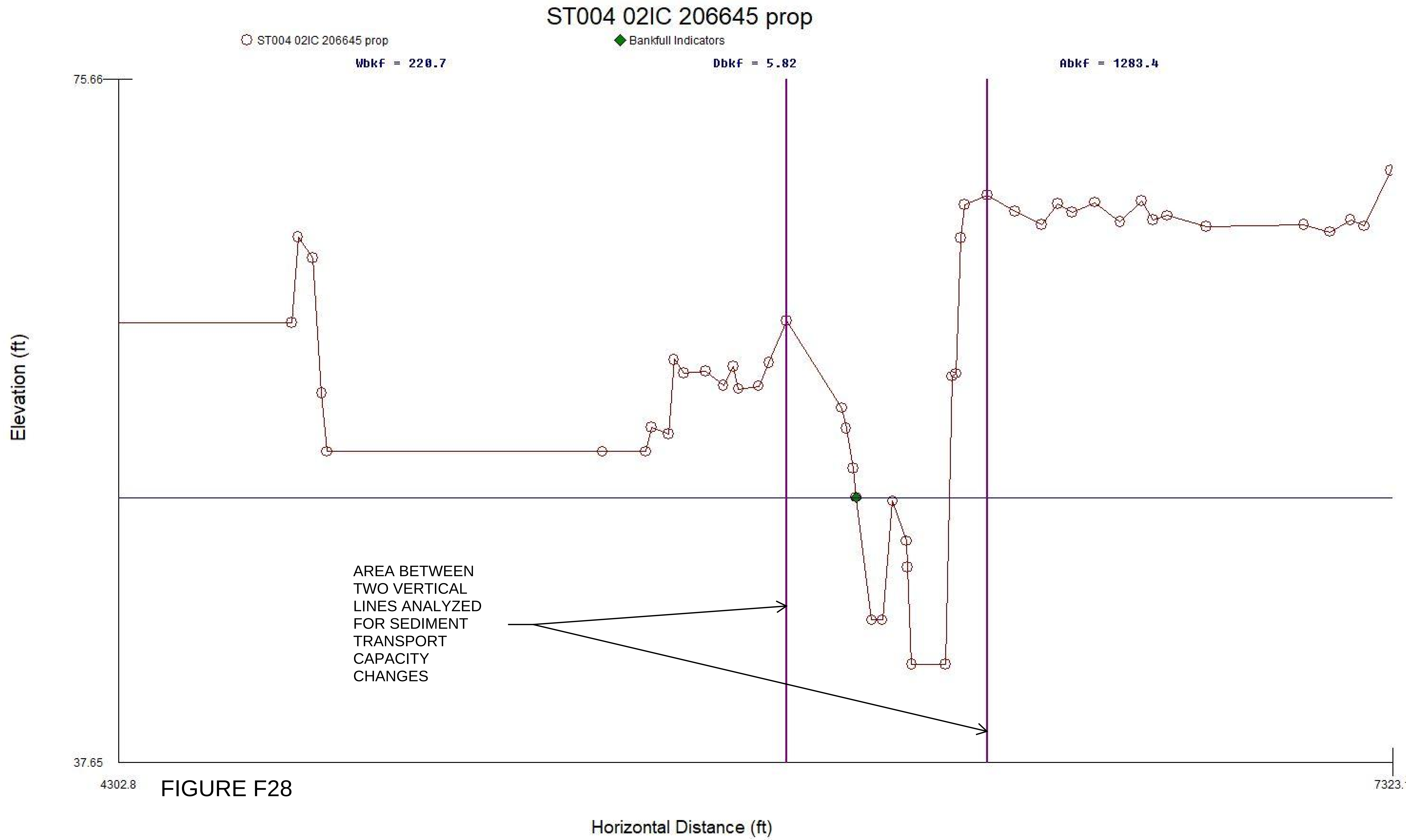

ST004 02IC 206645 prop
ST004 02IC 206645 prop
Bankfull Indicators
Wbkf = 220.7
Dbkf = 5.82
Abkf = 1283.4
75.66
37.65
4302.8
7323.1
Elevation (ft)
Horizontal Distance (ft)
AREA BETWEEN TWO VERTICAL LINES ANALYZED FOR SEDIMENT TRANSPORT CAPACITY CHANGES

FIGURE F28

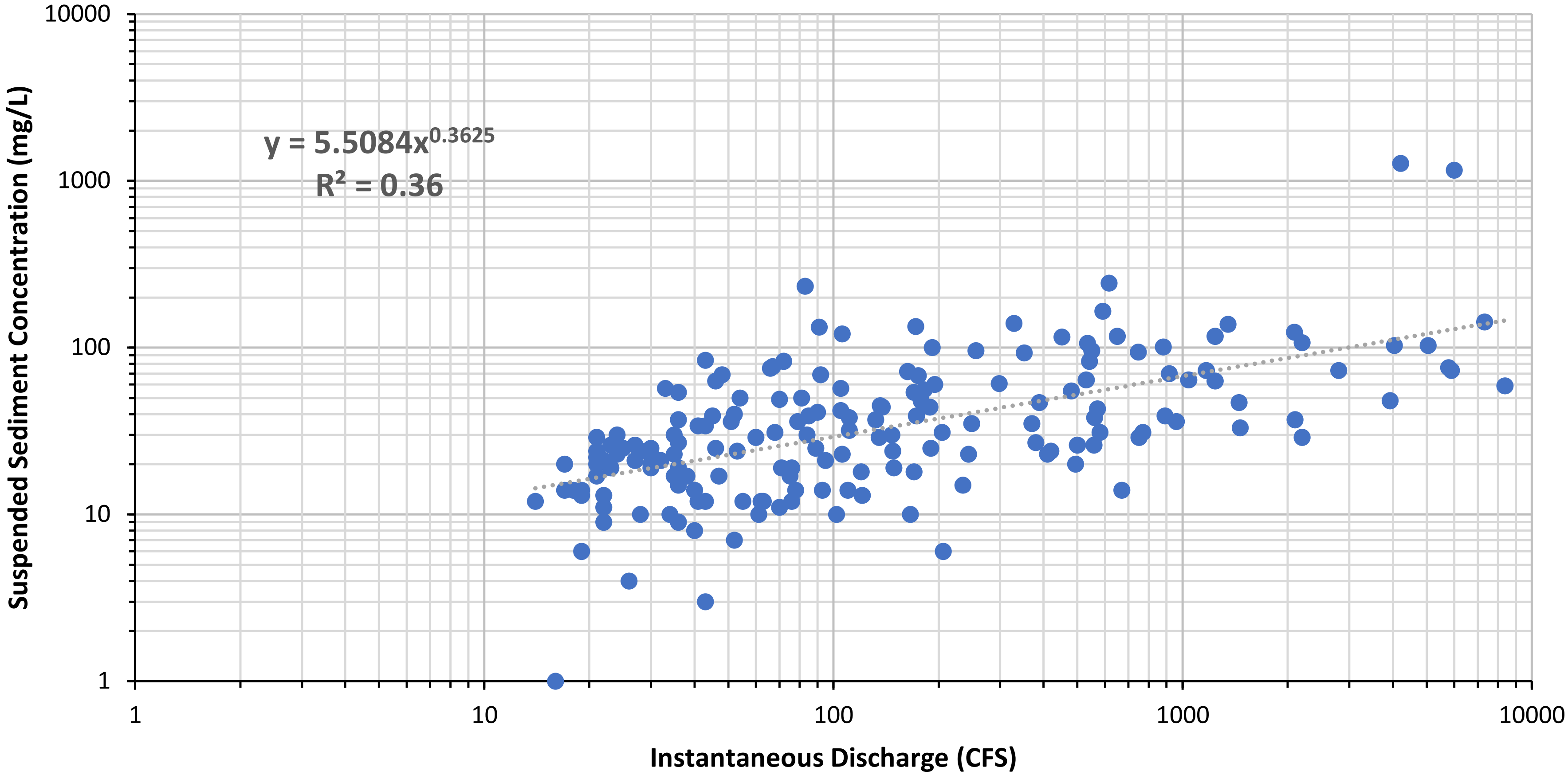

y = 5.5084x^0.3625
R² = 0.36
10000
1000
100
10
1
Suspended Sediment Concentration (mg/L)
1
10
100
1000
10000
Instantaneous Discharge (CFS)

FIGURE F29

Appendix G

Opinion of Probable Construction Costs

Innovative approaches
Practical results
Outstanding service

SEDIMENT TRAP FACILITY ST002-01IC (In-channel)
OPINION OF PROBABLE PROJECT COST

PROJECT NAME	San Jacinto River and Tributaries Sediment Removal and Sand Trap Development	DATE	2/24/2021
CLIENT	San Jacinto River Authority	GROUP	1149
% SUBMITTAL	Conceptual Plan:	PM	George Fowler

ESTIMATED BY	QC CHECKED BY	FNI PROJECT NUMBER
GDF	JG	SJR200297

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
OPINION OF PROBABLE CONSTRUCTION COST					
1	CLEARING AND GRUBBING	1.7	AC	$ 20,000.00	$ 34,000
2	EXCAVATION (CHANNEL)*	11,318	CY	$ 18.00	$ 203,720
3	TXDOT PROTECTION RIPRAP STONE 24" *	1,130	TON	$ 165.00	$ 186,450
4	TXDOT PROTECTION RIPRAP STONE 36"*	105	TON	$ 225.00	$ 23,625
5	12" TO 14" LOGS WITH/WITHOUT ROOTWADS 12' LONG	155	EA	$ 325.00	$ 50,375
6	FURNISHING AND PLACING TOPSOIL (4")*	371	SY	$ 4.00	$ 1,484
7	LIVE STAKES	690	EA	$ 4.00	$ 2,760
8	EROSION AND SEDIMENT CONTROL	1	LS	$ 17,180.00	$ 17,180
9	CARE OF WATER	1	LS	$ 25,979.70	$ 25,980
*	STANDARD TXDOT BID ITEM. UNIT PRICE FROM STATEWIDE				
	AUGUST REPORT OF AVERAGE LOW BID ITEMS				
	ALL OTHER ITEMS ARE SPECIALTY BID TIEM WITH UNIT PRICES				
	BASED ON PROFESSIONAL JUDGEMENT				
		SUBTOTAL			$ 545,574
		CONTINGENCY		30%	$ 163,672
		SUBTOTAL			$ 709,246
		MOBILIZATION		5%	$ 35,462
		SUBTOTAL			$ 744,708
		OH&P		18%	$ 134,047
OPINION OF PROBABLE CONSTRUCTION COST (2020 COSTS):					**$ 879,000**
FINAL DESIGN, BIDDING, CONSTRUCTION PHASE SERVICES					
	ENGINEERING (FINAL DESIGN SERVICES) (30% of OPCC)	1	LS	$ 264,000.00	$ 264,000
	ENGINEERING: CONSTRUCTION PHASE SERVICES(3% of OPCC)	1	LS	$ 27,000.00	$ 27,000
OPINION OF PROBABLE TOTAL PROJECT COST (2020 COSTS):					**$ 1,170,000**
COST ESCALATION FACTOR				2.1%	$ 24,570
OPINION OF PROBABLE TOTAL PROJECT COST (2021 COSTS):					**$ 1,195,000**

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NOTES:

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SEDIMENT TRAP FACILITY ST002-2IC (In-channel)
OPINION OF PROBABLE PROJECT COST

PROJECT NAME	San Jacinto River and Tributaries Sediment Removal and Sand Trap Development	DATE	2/24/2021
CLIENT	San Jacinto River Authority	GROUP	1149
% SUBMITTAL	Conceptual Plan:	PM	George Fowler

ESTIMATED BY	QC CHECKED BY	FNI PROJECT NUMBER
GDF	JG	SJR200297

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
OPINION OF PROBABLE CONSTRUCTION COST					
1	CLEARING AND GRUBBING	1.1	AC	$ 20,000.00	$ 22,000
2	EXCAVATION (CHANNEL)*	3,267	CY	$ 18.00	$ 58,804
3	TXDOT PROTECTION RIPRAP STONE 24" *	882	TON	$ 30.00	$ 26,460
4	TXDOT PROTECTION RIPRAP STONE 36"*	97	TON	$ 165.00	$ 16,005
5	12" TO 14" LOGS WITH/WITHOUT ROOTWADS 12' LONG	121	EA	$ 325.00	$ 39,325
6	FURNISHING AND PLACING TOPSOIL (4")*	290	SY	$ 3.00	$ 870
7	LIVE STAKES	690	EA	$ 4.00	$ 2,760
8	EROSION AND SEDIMENT CONTROL	1	LS	$ 13,214.00	$ 13,214
9	CARE OF WATER	1	LS	$ 8,971.90	$ 8,972
*	STANDARD TXDOT BID ITEM. UNIT PRICE FROM STATEWIDE				
	AUGUST REPORT OF AVERAGE LOW BID ITEMS				
	ALL OTHER ITEMS ARE SPECIALTY BID TIEM WITH UNIT PRICES				
	BASED ON PROFESSIONAL JUDGEMENT				
		SUBTOTAL			$ 188,410
		CONTINGENCY		30%	$ 56,523
		SUBTOTAL			$ 244,933
		MOBILIZATION		5%	$ 12,247
		SUBTOTAL			$ 257,180
		OH&P		18%	$ 46,292
OPINION OF PROBABLE CONSTRUCTION COST (2020 COSTS):					**$ 304,000**
FINAL DESIGN, BIDDING, CONSTRUCTION PHASE SERVICES					
	ENGINEERING (FINAL DESIGN SERVICES) (25% of OPCC)	1	LS	$ 92,000.00	$ 92,000
	ENGINEERING: CONSTRUCTION PHASE SERVICES(3% of OPCC)	1	LS	$ 10,000.00	$ 10,000
OPINION OF PROBABLE TOTAL PROJECT COST (2020 COSTS):					**$ 406,000**
COST ESCALATION FACTOR				2.1%	$ 8,526
OPINION OF PROBABLE TOTAL PROJECT COST (2021 COSTS):					**$ 415,000**

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NOTES:

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SEDIMENT TRAP FACILITY ST002-1OC (Out-of-channel)
OPINION OF PROBABLE PROJECT COST

PROJECT NAME	San Jacinto River and Tributaries Sediment Removal and Sand Trap Development	DATE	2/24/2021
CLIENT	San Jacinto River Authority	GROUP	1149
% SUBMITTAL	Conceptual Plan:	PM	George Fowler

ESTIMATED BY	QC CHECKED BY	FNI PROJECT NUMBER
GDF	JG	SJR200297

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
OPINION OF PROBABLE CONSTRUCTION COST					
1	CLEARING AND GRUBBING	1	AC	$ 20,000.00	$ 20,000
2	EXCAVATION (CHANNEL)*	2,522	CY	$ 18.00	$ 45,397
3	SOIL RETENTION BLANKETS (CL 2) (TY E) *	5,099	SY	$ 2.00	$ 10,198
4	TXDOT PROTECTION RIPRAP STONE 24"*	202	TON	$ 165.00	$ 33,330
5	EROSION AND SEDIMENT CONTROL	1	LS	$ 165.00	$ 165
*	STANDARD TXDOT BID ITEM. UNIT PRICE FROM STATEWIDE				
	AUGUST REPORT OF AVERAGE LOW BID ITEMS				
	ALL OTHER ITEMS ARE SPECIALTY BID TIEM WITH UNIT PRICES				
	BASED ON PROFESSIONAL JUDGEMENT				
		SUBTOTAL			$ 109,090
		CONTINGENCY^		30%	$ 32,727
		SUBTOTAL			$ 141,817
		MOBILIZATION		5%	$ 7,091
		SUBTOTAL			$ 148,908
		OH&P		18%	$ 26,803
OPINION OF PROBABLE CONSTRUCTION COST (2020 COSTS):					**$ 176,000**
FINAL DESIGN, BIDDING, CONSTRUCTION PHASE SERVICES					
	ENGINEERING (FINAL DESIGN SERVICES) (30% of OPCC)	1	LS	$ 53,000.00	$ 53,000
	ENGINEERING: CONSTRUCTION PHASE SERVICES(3% of OPCC)	1	LS	$ 6,000.00	$ 6,000
OPINION OF PROBABLE TOTAL PROJECT COST (2020 COSTS):					**$ 235,000**
COST ESCALATION FACTOR				2.1%	$ 4,935
OPINION OF PROBABLE TOTAL PROJECT COST (2021 COSTS):					**$ 240,000**

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SEDIMENT TRAP FACILITY ST003-01IC (In-channel)
OPINION OF PROBABLE PROJECT COST

PROJECT NAME	San Jacinto River and Tributaries Sediment Removal and Sand Trap Development	DATE	2/24/2021
CLIENT	San Jacinto River Authority	GROUP	1149
% SUBMITTAL	Conceptual Plan:	PM	George Fowler

ESTIMATED BY	QC CHECKED BY	FNI PROJECT NUMBER
GDF	JG	SJR200297

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
OPINION OF PROBABLE CONSTRUCTION COST					
1	CLEARING AND GRUBBING	7	AC	$ 20,000.00	$ 132,000
2	EXCAVATION (CHANNEL)*	94,579	CY	$ 18.00	$ 1,702,428
3	TXDOT PROTECTION RIPRAP STONE 24" *	1,902	TON	$ 165.00	$ 313,830
4	TXDOT PROTECTION RIPRAP STONE 36"*	230	TON	$ 225.00	$ 51,750
5	12" TO 14" LOGS WITH/WITHOUT ROOTWADS 12' LONG	260	EA	$ 325.00	$ 84,500
6	FURNISHING AND PLACING TOPSOIL (4")*	624	SY	$ 4.00	$ 2,496
7	LIVE STAKES	690	EA	$ 2.50	$ 1,725
8	EROSION AND SEDIMENT CONTROL	1	LS	$ 38,015.00	$ 38,015
9	CARE OF WATER	1	LS	$ 116,337.20	$ 116,337
*	STANDARD TXDOT BID ITEM. UNIT PRICE FROM STATEWIDE				
	AUGUST REPORT OF AVERAGE LOW BID ITEMS				
	ALL OTHER ITEMS ARE SPECIALTY BID TIEM WITH UNIT PRICES				
	BASED ON PROFESSIONAL JUDGEMENT				
		SUBTOTAL			$ 2,443,081
		CONTINGENCY		30%	$ 732,924
		SUBTOTAL			$ 3,176,006
		MOBILIZATION		5%	$ 158,800
		SUBTOTAL			$ 3,334,806
		OH&P		18%	$ 600,265
OPINION OF PROBABLE CONSTRUCTION COST (2020 COSTS):					**$ 3,936,000**
FINAL DESIGN, BIDDING, CONSTRUCTION PHASE SERVICES					
	ENGINEERING (FINAL DESIGN SERVICES) (25% of OPCC)	1	LS	$ 1,181,000.00	$ 1,181,000
	ENGINEERING: CONSTRUCTION PHASE SERVICES(3% of OPCC)	1	LS	$ 119,000.00	$ 119,000
OPINION OF PROBABLE TOTAL PROJECT COST (2020 COSTS):					**$ 5,236,000**
COST ESCALATION FACTOR				2.1%	$ 109,956
OPINION OF PROBABLE TOTAL PROJECT COST (2021 COSTS):					**$ 5,346,000**

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SEDIMENT TRAP FACILITY ST003-02IC (In-channel)
OPINION OF PROBABLE PROJECT COST

PROJECT NAME	San Jacinto River and Tributaries Sediment Removal and Sand Trap Development	DATE	2/24/2021
CLIENT	San Jacinto River Authority	GROUP	1149
% SUBMITTAL	Conceptual Plan:	PM	George Fowler

ESTIMATED BY	QC CHECKED BY	FNI PROJECT NUMBER
GDF		SJR200297

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
OPINION OF PROBABLE CONSTRUCTION COST					
1	CLEARING AND GRUBBING	3.5	AC	$ 20,000.00	$ 70,000
2	EXCAVATION (CHANNEL)*	14,412	CY	$ 18.00	$ 259,420
3	TXDOT PROTECTION RIPRAP STONE 24" *	1,452	TON	$ 165.00	$ 239,580
4	TXDOT PROTECTION RIPRAP STONE 36"*	201	TON	$ 225.00	$ 45,225
5	12" TO 14" LOGS WITH/WITHOUT ROOTWADS 12' LONG	199	EA	$ 325.00	$ 64,675
6	FURNISHING AND PLACING TOPSOIL (4")*	476	SY	$ 4.00	$ 1,904
7	LIVE STAKES	690	EA	$ 2.50	$ 1,725
8	EROSION AND SEDIMENT CONTROL	1	LS	$ 26,710.00	$ 26,710
9	CARE OF WATER	1	LS	$ 35,461.95	$ 35,462
*	STANDARD TXDOT BID ITEM. UNIT PRICE FROM STATEWIDE				
	AUGUST REPORT OF AVERAGE LOW BID ITEMS				
	ALL OTHER ITEMS ARE SPECIALTY BID TIEM WITH UNIT PRICES				
	BASED ON PROFESSIONAL JUDGEMENT				
		SUBTOTAL			$ 744,701
		CONTINGENCY		30%	$ 223,410
		SUBTOTAL			$ 968,111
		MOBILIZATION		5%	$ 48,406
		SUBTOTAL			$ 1,016,517
		OH&P		18%	$ 182,973
OPINION OF PROBABLE CONSTRUCTION COST (2020 COSTS):					**$ 1,200,000**
FINAL DESIGN, BIDDING, CONSTRUCTION PHASE SERVICES					
	ENGINEERING (FINAL DESIGN SERVICES) (30% of OPCC)	1	LS	$ 360,000.00	$ 360,000
	ENGINEERING: CONSTRUCTION PHASE SERVICES(3% of OPCC)	1	LS	$ 36,000.00	$ 36,000
OPINION OF PROBABLE TOTAL PROJECT COST (2020 COSTS):					**$ 1,596,000**
COST ESCALATION FACTOR				2.1%	$ 33,516
OPINION OF PROBABLE TOTAL PROJECT COST (2021 COSTS):					**$ 1,630,000**

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NOTES:

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SEDIMENT TRAP FACILITY ST004-01IC (In-channel)
OPINION OF PROBABLE PROJECT COST

PROJECT NAME	San Jacinto River and Tributaries Sediment Removal and Sand Trap Development	DATE	2/24/2021
CLIENT	San Jacinto River Authority	GROUP	1149
% SUBMITTAL	Conceptual Plan:	PM	George Fowler

ESTIMATED BY	QC CHECKED BY	FNI PROJECT NUMBER
GDF	JG	SJR200297

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
OPINION OF PROBABLE CONSTRUCTION COST					
1	CLEARING AND GRUBBING	3.4	AC	$ 20,000.00	$ 68,000
2	EXCAVATION (CHANNEL)*	38,050	CY	$ 18.00	$ 684,894
4	TXDOT PROTECTION RIPRAP STONE 36"*	117	TON	$ 225.00	$ 26,325
5	12" TO 14" LOGS WITH/WITHOUT ROOTWADS 12' LONG	237	EA	$ 325.00	$ 77,025
6	FURNISHING AND PLACING TOPSOIL (4")*	568	SY	$ 3.00	$ 1,704
7	LIVE STAKES	690	EA	$ 4.00	$ 2,760
8	EROSION AND SEDIMENT CONTROL	1	LS	$ 27,166.00	$ 27,166
9	CARE OF WATER	1	LS	$ 46,988.70	$ 46,989
*	STANDARD TXDOT BID ITEM. UNIT PRICE FROM STATEWIDE				
	AUGUST REPORT OF AVERAGE LOW BID ITEMS				
	ALL OTHER ITEMS ARE SPECIALTY BID TIEM WITH UNIT PRICES				
	BASED ON PROFESSIONAL JUDGEMENT				
		SUBTOTAL			$ 986,763
		CONTINGENCY		30%	$ 296,029
		SUBTOTAL			$ 1,282,792
		MOBILIZATION		5%	$ 64,140
		SUBTOTAL			$ 1,346,931
		OH&P		18%	$ 242,448
OPINION OF PROBABLE CONSTRUCTION COST (2020 COSTS):					**$ 1,590,000**
FINAL DESIGN, BIDDING, CONSTRUCTION PHASE SERVICES					
	ENGINEERING (FINAL DESIGN SERVICES) (30% of OPCC)	1	LS	$ 477,000.00	$ 477,000
	ENGINEERING: CONSTRUCTION PHASE SERVICES(3% of OPCC)	1	LS	$ 48,000.00	$ 48,000
OPINION OF PROBABLE TOTAL PROJECT COST (2020 COSTS):					**$ 2,115,000**
COST ESCALATION FACTOR				2.1%	$ 44,415
OPINION OF PROBABLE TOTAL PROJECT COST (2021 COSTS):					**$ 2,160,000**

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SEDIMENT TRAP FACILITY ST004-02IC (In-channel)
OPINION OF PROBABLE PROJECT COST

PROJECT NAME	San Jacinto River and Tributaries Sediment Removal and Sand Trap Development	DATE	2/24/2021
CLIENT	San Jacinto River Authority	GROUP	1149
% SUBMITTAL	Conceptual Plan:	PM	George Fowler

ESTIMATED BY	QC CHECKED BY	FNI PROJECT NUMBER
GDF	JG	SJR200297

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
OPINION OF PROBABLE CONSTRUCTION COST					
1	CLEARING AND GRUBBING	1.1	AC	$ 20,000.00	$ 22,000
2	EXCAVATION (CHANNEL)*	7,857	CY	$ 18.00	$ 141,423
3	TXDOT PROTECTION RIPRAP STONE 24" *	1,344	TON	$ 165.00	$ 221,760
4	TXDOT PROTECTION RIPRAP STONE 36"*	41	TON	$ 225.00	$ 9,225
5	12" TO 14" LOGS WITH/WITHOUT ROOTWADS 12' LONG	184	EA	$ 325.00	$ 59,800
6	FURNISHING AND PLACING TOPSOIL (4")*	441	SY	$ 3.00	$ 1,323
7	LIVE STAKES	690	EA	$ 4.00	$ 2,760
8	EROSION AND SEDIMENT CONTROL	1	LS	$ 17,001.00	$ 17,001
9	CARE OF WATER	1	LS	$ 23,764.62	$ 23,765
*	STANDARD TXDOT BID ITEM. UNIT PRICE FROM STATEWIDE				
	AUGUST REPORT OF AVERAGE LOW BID ITEMS				
	ALL OTHER ITEMS ARE SPECIALTY BID TIEM WITH UNIT PRICES				
	BASED ON PROFESSIONAL JUDGEMENT				
			SUBTOTAL		$ 499,057
			CONTINGENCY	30%	$ 149,717
			SUBTOTAL		$ 648,774
			MOBILIZATION	5%	$ 32,439
			SUBTOTAL		$ 681,213
			OH&P	18%	$ 122,618
OPINION OF PROBABLE CONSTRUCTION COST (2020 COSTS):					**$ 804,000**
FINAL DESIGN, BIDDING, CONSTRUCTION PHASE SERVICES					
	ENGINEERING (FINAL DESIGN SERVICES) (30% of OPCC)	1	LS	$ 242,000.00	$ 242,000
	ENGINEERING: CONSTRUCTION PHASE SERVICES(3% of OPCC)	1	LS	$ 25,000.00	$ 25,000
OPINION OF PROBABLE TOTAL PROJECT COST (2020 COSTS):					**$ 1,071,000**
COST ESCALATION FACTOR				2.1%	$ 22,491
OPINION OF PROBABLE TOTAL PROJECT COST (2021 COSTS):					**$ 1,094,000**

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SEDIMENT TRAP FACILITY ST004-03IC (In-channel)
OPINION OF PROBABLE PROJECT COST

PROJECT NAME	San Jacinto River and Tributaries Sediment Removal and Sand Trap Development	DATE	2/24/2021
CLIENT	San Jacinto River Authority	GROUP	1149
% SUBMITTAL	Conceptual Plan:	PM	George Fowler

ESTIMATED BY	QC CHECKED BY	FNI PROJECT NUMBER
GDF	JG	SJR200297

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
OPINION OF PROBABLE CONSTRUCTION COST					
1	CLEARING AND GRUBBING	3	AC	$ 20,000.00	$ 64,000
2	EXCAVATION (CHANNEL)*	15,124	CY	$ 18.00	$ 272,240
3	TXDOT PROTECTION RIPRAP STONE 24" *	1,620	TON	$ 165.00	$ 267,300
4	TXDOT PROTECTION RIPRAP STONE 36"*	159	TON	$ 225.00	$ 35,775
5	12" TO 14" LOGS WITH/WITHOUT ROOTWADS 12' LONG	222	EA	$ 325.00	$ 72,150
6	FURNISHING AND PLACING TOPSOIL (4")*	532	SY	$ 3.00	$ 1,596
7	LIVE STAKES	690	EA	$ 4.00	$ 2,760
8	EROSION AND SEDIMENT CONTROL	1	LS	$ 27,166.00	$ 27,166
9	CARE OF WATER	1	LS	$ 37,149.35	$ 37,149
*	STANDARD TXDOT BID ITEM. UNIT PRICE FROM STATEWIDE				
	AUGUST REPORT OF AVERAGE LOW BID ITEMS				
	ALL OTHER ITEMS ARE SPECIALTY BID TIEM WITH UNIT PRICES				
	BASED ON PROFESSIONAL JUDGEMENT				
		SUBTOTAL			$ 780,136
		CONTINGENCY		30%	$ 234,041
		SUBTOTAL			$ 1,014,177
		MOBILIZATION		5%	$ 50,709
		SUBTOTAL			$ 1,064,886
		OH&P		18%	$ 191,680
OPINION OF PROBABLE CONSTRUCTION COST (2020 COSTS):					**$ 1,257,000**
FINAL DESIGN, BIDDING, CONSTRUCTION PHASE SERVICES					
	ENGINEERING (FINAL DESIGN SERVICES) (30% of OPCC)	1	LS	$ 378,000.00	$ 378,000
	ENGINEERING: CONSTRUCTION PHASE SERVICES(3% of OPCC)	1	LS	$ 38,000.00	$ 38,000
OPINION OF PROBABLE TOTAL PROJECT COST (2020 COSTS):					**$ 1,673,000**
COST ESCALATION FACTOR				2.1%	$ 35,133
OPINION OF PROBABLE TOTAL PROJECT COST (2021 COSTS):					**$ 1,709,000**

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SEDIMENT TRAP FACILITY ST004-01OC (Out-of-channel)
OPINION OF PROBABLE PROJECT COST

PROJECT NAME	San Jacinto River and Tributaries Sediment Removal and Sand Trap Development	DATE	2/24/2021
CLIENT	San Jacinto River Authority	GROUP	1149
% SUBMITTAL	Conceptual Plan:	PM	George Fowler

ESTIMATED BY	QC CHECKED BY	FNI PROJECT NUMBER
GDF	JG	SJR200297

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
OPINION OF PROBABLE CONSTRUCTION COST					
1	CLEARING AND GRUBBING	0.3	AC	$ 20,000.00	$ 6,000
2	EXCAVATION (CHANNEL)*	481	CY	$ 18.00	$ 8,653
3	SOIL RETENTION BLANKETS (CL 2) (TY E) *	1,442	SY	$ 2.00	$ 2,884
4	TXDOT PROTECTION RIPRAP STONE 24"*	569	TON	$ 165.00	$ 93,885
5	EROSION AND SEDIMENT CONTROL	1	LS	$ 22,027.00	$ 22,027
6	CARE OF WATER	1	LS	$ 6,672.47	$ 6,672
*	STANDARD TXDOT BID ITEM. UNIT PRICE FROM STATEWIDE				
	AUGUST REPORT OF AVERAGE LOW BID ITEMS				
	ALL OTHER ITEMS ARE SPECIALTY BID TIEM WITH UNIT PRICES				
	BASED ON PROFESSIONAL JUDGEMENT				

SUBTOTAL		$ 140,122
CONTINGENCY^	30%	$ 42,037
SUBTOTAL		$ 182,158
MOBILIZATION	5%	$ 9,108
SUBTOTAL		$ 191,266
OH&P	18%	$ 34,428

OPINION OF PROBABLE CONSTRUCTION COST (2020 COSTS): $ 226,000

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
FINAL DESIGN, BIDDING, CONSTRUCTION PHASE SERVICES					
	ENGINEERING (FINAL DESIGN SERVICES) (30% of OPCC)	1	LS	$ 68,000.00	$ 68,000
	ENGINEERING: CONSTRUCTION PHASE SERVICES(3% of OPCC)	1	LS	$ 7,000.00	$ 7,000

OPINION OF PROBABLE TOTAL PROJECT COST (2020 COSTS): $ 301,000

COST ESCALATION FACTOR	2.1%	$ 6,321
OPINION OF PROBABLE TOTAL PROJECT COST (2021 COSTS):		**$ 308,000**

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SEDIMENT TRAP FACILITY ST004-02OC (Out-of-channel)
OPINION OF PROBABLE PROJECT COST

PROJECT NAME	San Jacinto River and Tributaries Sediment Removal and Sand Trap Development	DATE	2/24/2021
CLIENT	San Jacinto River Authority	GROUP	1149
% SUBMITTAL	Conceptual Plan:	PM	George Fowler

ESTIMATED BY	QC CHECKED BY	FNI PROJECT NUMBER
GDF	JG	SJR200297

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
OPINION OF PROBABLE CONSTRUCTION COST					
1	CLEARING AND GRUBBING	0.5	AC	$ 20,000.00	$ 10,000
2	EXCAVATION (CHANNEL)*	6,511	CY	$ 18.00	$ 117,189
3	SOIL RETENTION BLANKETS (CL 2) (TY E) *	2,752	SY	$ 2.00	$ 5,504
4	TXDOT PROTECTION RIPRAP STONE 24"*	93	TON	$ 165.00	$ 15,345
5	EROSION AND SEDIMENT CONTROL	1	LS	$ 8,907.00	$ 8,907
6	CARE OF WATER	1	LS	$ 7,847.27	$ 7,847
*	STANDARD TXDOT BID ITEM. UNIT PRICE FROM STATEWIDE				
	AUGUST REPORT OF AVERAGE LOW BID ITEMS				
	ALL OTHER ITEMS ARE SPECIALTY BID TIEM WITH UNIT PRICES				
	BASED ON PROFESSIONAL JUDGEMENT				
		SUBTOTAL			$ 164,793
		CONTINGENCY^		30%	$ 49,438
		SUBTOTAL			$ 214,230
		MOBILIZATION		5%	$ 10,712
		SUBTOTAL			$ 224,942
		OH&P		18%	$ 40,490
OPINION OF PROBABLE CONSTRUCTION COST (2020 COSTS):					**$ 266,000**
FINAL DESIGN, BIDDING, CONSTRUCTION PHASE SERVICES					
	ENGINEERING (FINAL DESIGN SERVICES) (30% of OPCC)	1	LS	$ 80,000.00	$ 80,000
	ENGINEERING: CONSTRUCTION PHASE SERVICES(3% of OPCC)	1	LS	$ 8,000.00	$ 8,000
OPINION OF PROBABLE TOTAL PROJECT COST (2020 COSTS):					**$ 354,000**
COST ESCALATION FACTOR				2.1%	$ 7,434
OPINION OF PROBABLE TOTAL PROJECT COST (2021 COSTS):					**$ 362,000**

The Engineer has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable costs provided herein are based on the information known to Engineer at this time and represent only the Engineer's judgment as a design professional familiar with the construction industry. The Engineer cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from its opinions of probable costs.

NOTES:

1. FNI OPCC classified as an AACE Class 5 Estimate with accuracy range of -20% to + 50%.
2. Final Design, Bidding, and Construction Phase Services also includes anticipated costs associated with Surveying (including land acquisition or easements), Geotech, and Permitting

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SEDIMENT TRAP FACILITY ST004-03OC (Out-of-channel)

OPINION OF PROBABLE PROJECT COST

PROJECT NAME	San Jacinto River and Tributaries Sediment Removal and Sand Trap Development	DATE	2/24/2021
CLIENT	San Jacinto River Authority	GROUP	1149
% SUBMITTAL	Conceptual Plan:	PM	George Fowler

ESTIMATED BY	QC CHECKED BY	FNI PROJECT NUMBER
GDF	JG	SJR200297

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
OPINION OF PROBABLE CONSTRUCTION COST					
1	CLEARING AND GRUBBING	0.8	AC	$ 20,000.00	$ 16,000
2	EXCAVATION (CHANNEL)*	8,821	CY	$ 18.00	$ 158,776
3	SOIL RETENTION BLANKETS (CL 2) (TY E) *	3,871	SY	$ 2.00	$ 7,742
4	TXDOT PROTECTION RIPRAP STONE 24"*	121	TON	$ 165.00	$ 19,965
5	EROSION AND SEDIMENT CONTROL	1	LS	$ 10,124.15	$ 10,124
*	STANDARD TXDOT BID ITEM. UNIT PRICE FROM STATEWIDE				
	AUGUST REPORT OF AVERAGE LOW BID ITEMS				
	ALL OTHER ITEMS ARE SPECIALTY BID TIEM WITH UNIT PRICES				
	BASED ON PROFESSIONAL JUDGEMENT				
		SUBTOTAL			$ 212,607
		CONTINGENCY^		30%	$ 63,782
		SUBTOTAL			$ 276,389
		MOBILIZATION		5%	$ 13,819
		SUBTOTAL			$ 290,209
		OH&P		18%	$ 52,238
OPINION OF PROBABLE CONSTRUCTION COST (2020 COSTS):					**$ 343,000**
FINAL DESIGN, BIDDING, CONSTRUCTION PHASE SERVICES					
	ENGINEERING (FINAL DESIGN SERVICES) (30% of OPCC)	1	LS	$ 103,000.00	$ 103,000
	ENGINEERING: CONSTRUCTION PHASE SERVICES(3% of OPCC)	1	LS	$ 11,000.00	$ 11,000
OPINION OF PROBABLE TOTAL PROJECT COST (2020 COSTS):					**$ 457,000**
COST ESCALATION FACTOR				2.1%	$ 9,597
OPINION OF PROBABLE TOTAL PROJECT COST (2021 COSTS):					**$ 467,000**

The Engineer has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable costs provided herein are based on the information known to Engineer at this time and represent only the Engineer's judgment as a design professional familiar with the construction industry. The Engineer cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from its opinions of probable costs.

NOTES:

1 FNI OPCC classified as an AACE Class 5 Estimate with accuracy range of -20% to + 50%.

2 Final Design, Bidding, and Construction Phase Services also includes anticipated costs associated with Surveying (including land acquisition or easements), Geotech, and Permitting

Appendix H

Sediment Investigation Report Completed By Texas A&M University

Pebble Count Analyses of Sediment Cores from the San Jacinto River banks-

Dr. Timothy M. Dellapenna[1], Assoc. Prof. of Marine Science

Dr. Peng Lin[1], Research Scientist

Christena Hoelscher[1],

Nicholas Wellbrock[1]

[1]Department of Marine and Environmental Sciences

Texas A&M University-Galveston Campus

1. General Summary

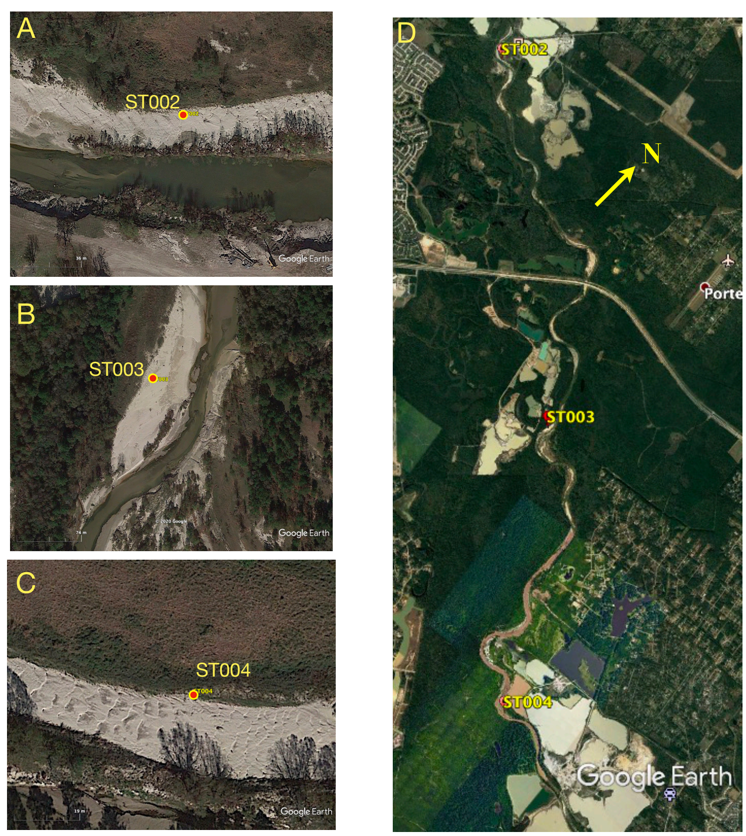
This report documents the methods used, the core locations and the results of the analyses of the requested analyses. Three core sites were selected by the project team and vibra-cores were collected at each site between of July 1-20 and laboratory analyses followed through the remainder of July and August.

Table 1. Core Locations

Site	Lat (DD)	Long (DD)
ST004	30.08469 ° W	95.30523° N
ST002	30.16059 ° W	95.37306 ° N
ST003	30.12105 ° W	95.32824 ° N

1.1. Site Description

Core locations were provided by George Fowler and are reported in Table 1. Each core was collected from the modern river channel bank proximal to the vegetation line (Fig. 1)



location of all cores along the San Jacinto River.

2. Materials and methods

2.1. Core Collection and Handling

Core sites were accessed using a rented Utility Terrain Vehicle (UTV). Cores were collected using a 7.6 cm diameter aluminum barrels through the combination of an Oztech vibra-corer and a gasoline powered fence post driver. Cores were extracted from the river banks using a 3-ton farm jack. Upon recovering the core, the top of the core barrel was cut a few centimeters above the top of the sediment surface and flourofoam was inserted into the core top so that it rested just above the sediment surface, the flourofoam was cut flush with the top of the core barrel and then the top and bottom of the core was sealed with a core cap and electrical tape, and the caps and core barrels were labeled appropriately and transported back to the lab.

Upon return the lab, each core barrel was cut axially using electric shears and a wire was drawn across the sediment to split the core in half. Each core was digitally photographed and x-rayed. Using the combination of the x-radiographs and core photographs, a sample plan was developed for each core.

Figure 2. A) Pile driver being used to drive in core barrel at ST003 site B) Pile driving being driven in, with vibra-corer on ground next to student and UTV in background.

For plutonium (Pu) analysis, 1 cm thick subsamples were collected every 10 cm, beginning at a depth of 10 cm depth, to the top of the clay layer or the bottom of the core, if no clay layer was present. Each sample was placed in a weighing dish and dried overnight at 60 ºC, weighted and placed in a sealed plastic bag for further analyses.

Each core consists of a series of decimeters thick layers, the base of each deposit was clearly demarcated by a gravel deposit (Fig. X). Cores ST003 and ST004 had clay layers at the base of the core, marking the base of the flood bank deposit. Although three cores were recovered from the ST002 site, none of the cores were able to reach the clay layer, so the most complete of the cores was used and the other two were discarded. The interval within the core for each flood deposit was determined based on x-radiograph and visual observations and each deposit was extracted from the core barrel, placed in a container and homogenized. These intervals are listed in Table 2. A subsample was removed from each interval for grain size analyses (Appendix A).

2.2. X-radiography

X-radiographs were taken of all of the split core halves at an energy level of 64 kV and exposure time of 1.6 mAS with a portable Medison X-ray source and a Varian PaxScan® Amorphous Silicon Digital Imager. X-radiographs were imported to Photoshop for tone adjustments and Powerpoint for display. The tones of the image in the x-radiograph result from the density of the material being x-rayed. In this report, more dense objects appear as lighter tones, so, clay dominated sediment will appear lighter than sand, gravel or pebbles.

2.3. Determination of grain size distributions

2.3.1. Sand/Sil/Clay Analyses

Samples were run through a 2 mm sieve to separate sand from coarser fractions. The coarser than sand fraction was set aside for sieve analyses, described below. For the sand and finer fraction (< 2 mm), samples were homogenized in 0.05 M sodium metaphosphate solution prior to the determination of the grain size distribution (63 µm to 2 mm, 4 µm to 63 µm and 0.01 µm to 4 µm) using a Malvern Mastersizer 2000 particle analyzer. This device separates the grain sizes (from clay to sand-sized particles) using laser diffraction.

2.3.2. Coarse Size Fraction Analyses

Table 2. Udden Wentworth Scale of Grain Size Fractions

φ scale	**Size range (metric)**	**Size range (approx. inches)**	**Aggregate name (Wentworth class)**
<−8	>256 mm	>10.1 in	Boulder
−6 to −8	64–256 mm	2.5–10.1 in	Cobble
−5 to −6	32–64 mm	1.26–2.5 in	Very coarse gravel
−4 to −5	16–32 mm	0.63–1.26 in	Coarse gravel
−3 to −4	8–16 mm	0.31–0.63 in	Medium gravel
−2 to −3	4–8 mm	0.157–0.31 in	Fine gravel
−1 to −2	2–4 mm	0.079–0.157 in	Very fine gravel
0 to −1	1–2 mm	0.039–0.079 in	Very coarse sand
1 to 0	0.5–1 mm	0.020–0.039 in	Coarse sand
2 to 1	0.25–0.5 mm	0.010–0.020 in	Medium sand
3 to 2	125–250 µm	0.0049–0.010 in	Fine sand
4 to 3	62.5–125 µm	0.0025–0.0049 in	Very fine sand
8 to 4	3.9–62.5 µm	0.00015–0.0025 in	Silt
10 to 8	0.98–3.9 µm	3.8×10^{-5}–0.00015 in	Clay

The coarser than sand size fraction (>2 mm) are unable to go through the Malvern Mastersizer 2000 particle analyzer. Consequently, these samples were sieved through a sieve stack using 90 mm, 31.5 mm, 16 mm, 8 mm, 4 mm, and 2 mm sieves. Each fraction not passing the respective sieve was carefully removed and placed in a pre-weighed tin, dried and weighed.

Based on the bulk dry weight and the dry weight in each size-section, the grain size distribution can be calculated in terms of weight percentage. Together with the results from the Malvern Mastersizer analyzer, the grain size distribution among >90 mm, 31.5 – 90 mm, 16 – 31.5 mm, 8 – 16 mm, 4 – 8 mm, 2 – 4 mm, 63 µm – 2 mm, 4 – 63 µm and 0.01 – 4 µm was estimated for three sediment cores and reported in Appendix A. These size fractions follow the Udden-Wentworth Scale (Table 2).

2.4. Determination of ^{239,240}Pu activity concentration

^{239,240}Pu activities were determined by alpha-spectroscopy (Lin et al., 2017). Briefly, a known activity of ^{242}Pu was spiked to trace the yield of ^{239,240}Pu during the extraction steps. The samples were oven-dried, then heated at 600 ºC overnight in a ceramic crucible. The resulting ash fraction was then digested in Teflon tubes overnight in concentrated HNO_3 and HCl (1:1) at 85ºC. The remaining solid residual fraction was collected by centrifugation and discarded, and the supernatant was further evaporated to incipient dryness. To convert all Pu ions to Pu(IV), a $FeSO_4 \cdot 7H_2O$ (0.2 g/mL) solution, followed by 0.25 g of $NaNO_2$, were added to each sample to achieve a final volume of 3 mL for each sample. Samples were then passed through an UTEVA column (Cat. # UT-C50-A, Eichrom, USA) to separate Pu from other alpha-emitting radionuclides (e.g., ^{238}U, ^{241}Am). After washing the column with an 8 M HNO_3 solution, the Pu was eluted using freshly-prepared 0.02 M $NH_2OH \cdot HCl$/0.02 M ascorbic acid in 2 M HNO_3. The Pu-containing eluent was evaporated and re-constituted in 0.4 M $(NH_4)_2SO_4$ (pH~2.6) for electroplating onto a stainless steel planchet at 0.6 Amps current for 2 hr. Sample-bearing planchets were then analyzed via alpha spectroscopy for at least one week.

3. Results

3.1. Core Descriptions and sediment size distributions

3.1.1. Surface intervals

For each core, the upper 5.8 cm (2. inches) was removed and analyzed seperately. (Note, 5.8 cm was used rather than 5.08 cm (2.28 inches) due to a typing error when this sample interval was communicated to the lab workers, however the 0.28 cm extra would not affect results in any appreciable manner). Fig. 3 shows the pie charts associated with the grain size distributions. Appendix X contains the tabular version of this data.

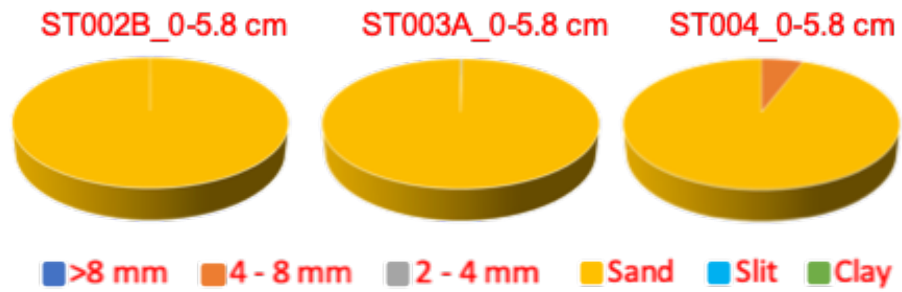


Fig. 3. Grain size distribution for 0-5.8 cm sections in three cores at St. Jacinto River

As the pie charts indicate, all of the sediment within the surface interval was sand dominated, with no silt or clay. The surface interval for Core ST002B was 100% sand, Core ST003A contained 99.78% sand and 0.22% in the size fraction between 2-4 mm. The surface interval for Core ST004 contains 94.20% sand and 5.80% gravel in the size fraction between 4.0-8.0 mm. A complete tabulation of the grain size data is provided in Appendix A.

3.1.2. Core Analyses

The color photographs and x-radiographs are shown in Appendix B. The selection of sample intervals were based on the identificaiton of flood beds. The base of each flood deposit was demarcated by the presence of a gravel layer, which would have been the first grains to have been deposited during a flood event. The demarcation of the base of the each flood layer was based off of observations from both the core photographs as well as the x-radiographs. Each sample interval is marked on each core section and the grain size distributions are shown in the pie chart next to each sampled interval. A complete summary of the size distributions for each interval is provided in Appendix A. It should be noted here that >90 mm, 31.5-90 mm and 16-31.5 mm sized particles were all undetected for each of the three cores. Therefore, the grain size distribution among >8 mm, 4 – 8 mm, 2 – 4 mm, 63 μm – 2 mm (Sand), 4 – 63 μm (Slit) and 0.01 – 4 μm (Clay) are reported here.

For ST002B core, there is no clay layer, and 0-52 cm (gravel layer), 52-87 cm (flood layer) and 87 cm to the bottom of the core were sampled, respectively, for grain size distributions. Generally, both 0-5.8 cm and 0-52 cm layers are all composed by sand-size particles (63 μm – 2 mm, 100%). In comparison, although sand-size is still the main grain size for both 52-87 cm (87% as sand) and 87-161 cm (91% as sand) sections of ST002B core, these two layers contain pebble-sizes, consist of 11% >8 mm particles, 1.4% 4-8 mm and 0.4% 2-4 mm particles in 52-87 cm section, and 5.6% >8mm particles, 2.3% 4-8 mm and 0.9% 2-4 mm particles in 87-161 cm section.

For ST003A core, a clay layer is found beginning from ~131 cm. Three intervals within the clay layer were sampled for grain size analysis, among which 132-133 cm section has the highest abundance of sand (52%), compared with other two sections (30% at 168-169 cm and 37% at 201-202 cm). 36% of 132-133 cm section, 47% of 168-169 cm section and 43% of 201-202 cm section are composed of silt (4-63 μm), while the clay faction (0.01-4 μm) makes up 12% of 132-133 cm, 23% of 168-169 cm and 20% of 201-202 cm sections of ST003A core, respectively. For <131 cm layer, they are mostly composed of sand (63 μm – 2 mm) , with >99% at 0-5.8 cm section, 92% at 0-30 cm, 88% at 30-63 cm, 92% at 63-84 cm, 95% at 84-103 cm and 82% at 103-131 cm, respectively. >8 mm pebble-size fraction has the second highest abundance in these layers, e.g., 11% at 30-63 cm and 13% at 103-131 cm. The 4-8 mm and 2-4 mm pebble size fraction provide minor contribution at 0-5.8 cm, 0-30 cm and 30-63 cm sections of ST003A core (<1%), but contribute to 1-3% of the majority of the size fraction at 63-84 cm, 84-103 cm and 103-131 cm sections (e.g., 3.3% as 4-8 mm and 2% as 2-4 mm pebbles at 103-131 cm section).

The top of the clay layer in ST004 core is at 126 cm as shown in Appendix B, and two sections of the clay layer were collected for grain size anlaysis. For 132-133 cm section, slit (4-63 μm) is the predominant size fraction (58%), followed by the clay (37%) and sand (5%). Similarly, 174-175 cm section also has high abundance of silt (54%), with 17% as sand and 29% as clay. For the graval layer and flood layer of ST004 core, all the sampled sections are mostly composed by sand, like ST002B and ST003A core, e.g., 94% as sand at 0-5.8 cm and 98% as sand at both 0-34 cm and 94-126 cm sections. Pebbles compose <5% of the majority of the size fraction for most of the sections of ST004, except 77-94 section containing 6%, 7% and 3% of the majority of the size fraction at >8 mm, 4-8 mm and 2-4 mm pebble-size fraction, respectively. For 0-5.8 cm section of ST004 core, 4-8 mm size is the only grain size range of the pebble, making up about 6% of the size fraction in the surface of ST004 core.

3.2. Pebble Count Analyses

The grain size data was also formated for the Wolman Pebble Count technique (Wolman, 1954; Bevenger, 1995). Although the analyses was not performed by us, the cummulative size distribution graphs and histograms were prepared for these analyses and are reported in Appendix C.

3.3. Plutonium

Every 10 cm from the surface to the top of the clay layer or the bottom of the core were sampled for Pu analysis. However, the ^{239,240}Pu activity concentrations are all lower than detection limit for both ST003A and ST004 cores, probably due to the lack of any clay fraction. Sand has a weak adsorption capbility for the radionuclides. In comparison, weak ^{239,240}Pu signals are detected at some sections of the ST002B core, with 0.51 ± 0.23 dpm/kg at 10-11 cm, 0.80 ± 0.31 dpm/kg at 50-51 cm and 0.38 ± 0.22 dpm/kg at 60-61 cm, respectively. At the writing of this report, a re-analyses of cores for ^{239,240}Pu is currently be conducted, with a large sample size being used. It take about 2 weeks for the full analyses to be conducted and the reporting of this will be provided in the next iteration of this report

4. References Cited

Bevenger, G.S., 1995. *A pebble count procedure for assessing watershed cumulative effects* (Vol. 319). US Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Lin, P., Xu, C., Zhang, S., Fujitake, N., Kaplan, K.I., Yeager, C.M., Sugiyama, Y., Schwehr, K.A., Santschi, P.H., 2017. Plutonium partitioning behavior to humic acids from widely varying soils is related to carboxyl-containing organic compounds. Environ. Sci. Technol. 51, 11742-11751.

Wolman, M. G. (1954). “A method of sampling coarse river-bed material.” *Trans., Am. Geophys. Union*, 35(6), 951–956.

APPENDIX A

Percent Sediment Size Distributions by Major Size Class Passing Through Respective Sieve

Sample Name	%Clay	%Silt	%Sand	%2mm	%4 mm	%8 mm	%16. mm	%31.5 mm	%90 mm
ST002 0-5.8 cm	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00
ST002 0-52 cm	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00
ST002 52-87 cm	0.00	0.00	87.35	0.44	1.37	10.85	0.00	0.00	0.00
ST002 87-161 cm	0.00	0.00	91.17	0.90	2.31	5.62	0.00	0.00	0.00

Sample Name	%Clay	%Silt	%Sand	%2mm	%4 mm	%8 mm	%16. mm	%31.5 mm	%90 mm
ST003A 0-5.8 cm	0.00	0.00	99.78	0.22	0.00	0.00	0.00	0.00	0.00
ST003A 0-30 cm	0.00	0.00	92.43	0.30	0.15	7.12	0.00	0.00	0.00
ST003A 30-63 cm	0.00	0.00	88.18	0.31	0.55	10.96	0.00	0.00	0.00
ST003A 63-84 cm	0.00	0.00	92.46	1.13	3.05	3.35	0.00	0.00	0.00
ST003A 84-103 cm	0.00	0.00	95.27	1.58	3.15	0.00	0.00	0.00	0.00
ST003A 103-131 cm	0.00	0.00	82.16	1.97	3.27	12.60	0.00	0.00	0.00
ST003A 168-169 cm	23.28	46.68	30.04	0.00	0.00	0.00	0.00	0.00	0.00
ST003A 132-133 cm	11.62	35.84	52.54	0.00	0.00	0.00	0.00	0.00	0.00

Sample Name	%Clay	%Silt	%Sand	%2mm	%4 mm	%8 mm	%16. mm	%31.5 mm	%90 mm
ST004 0-5.8 cm	0.00	0.00	94.20	0.00	5.80	0.00	0.00	0.00	0.00
ST004 0-34 cm	0.00	0.14	98.83	1.03	0.00	0.00	0.00	0.00	0.00
ST004 34-77 cm	0.00	0.00	95.51	1.15	0.99	2.35	0.00	0.00	0.00
ST004 77-94 cm	0.00	0.00	83.73	2.80	6.90	6.57	0.00	0.00	0.00
ST004 94-126 cm	0.00	0.00	98.19	0.88	0.93	0.00	0.00	0.00	0.00
ST004 132-133 cm	36.69	58.04	5.27	0.00	0.00	0.00	0.00	0.00	0.00
ST004 174-175 cm	29.27	53.68	17.05	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX B

Core Photos, X-radiographs and Grainsize Pie Charts

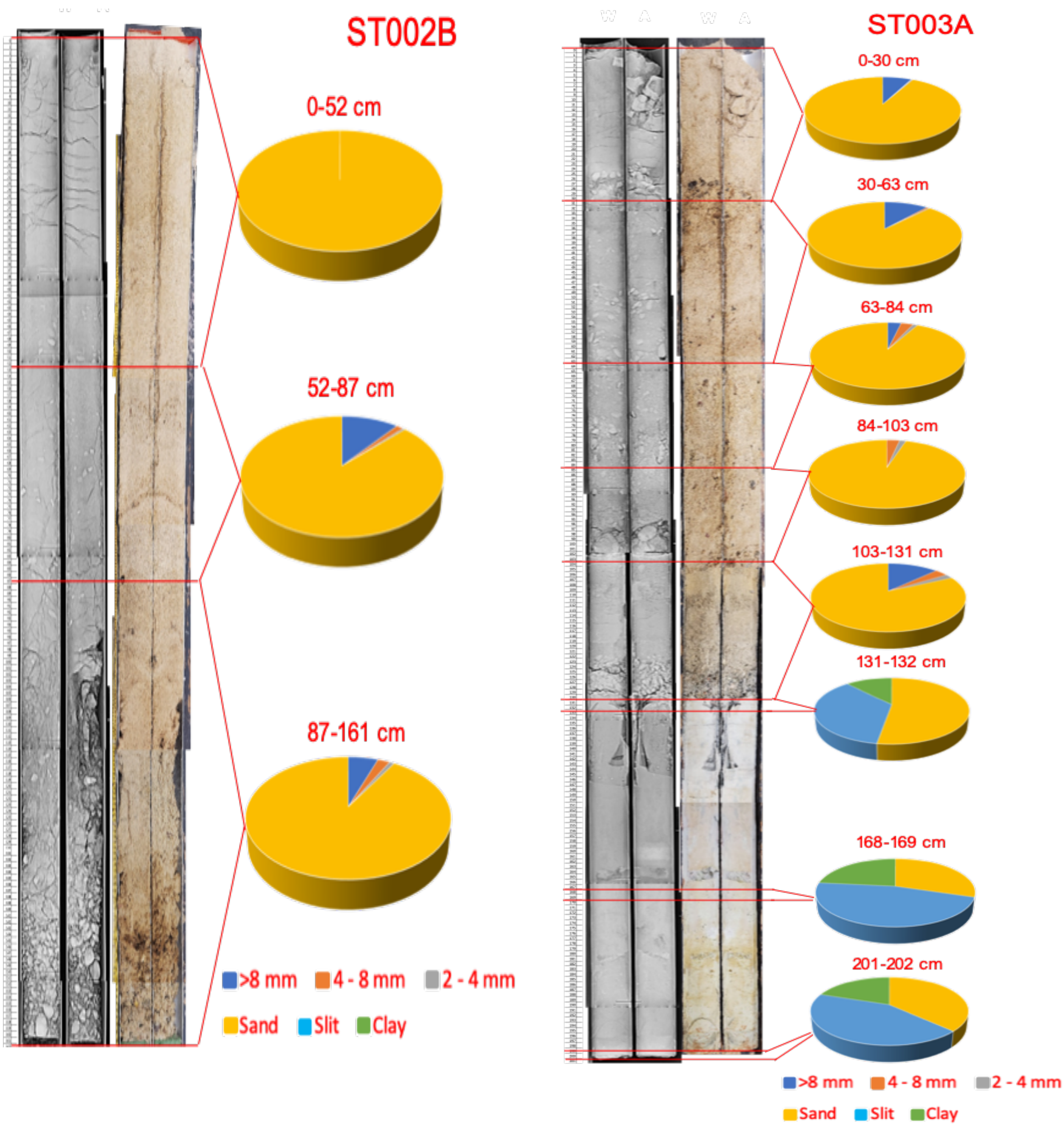


Figure 4. Color photo and X-ray graph of three cores at St. Jacinto River, as well as the corresponding grain size distribution in different sections for Cores ST002B and ST003A.

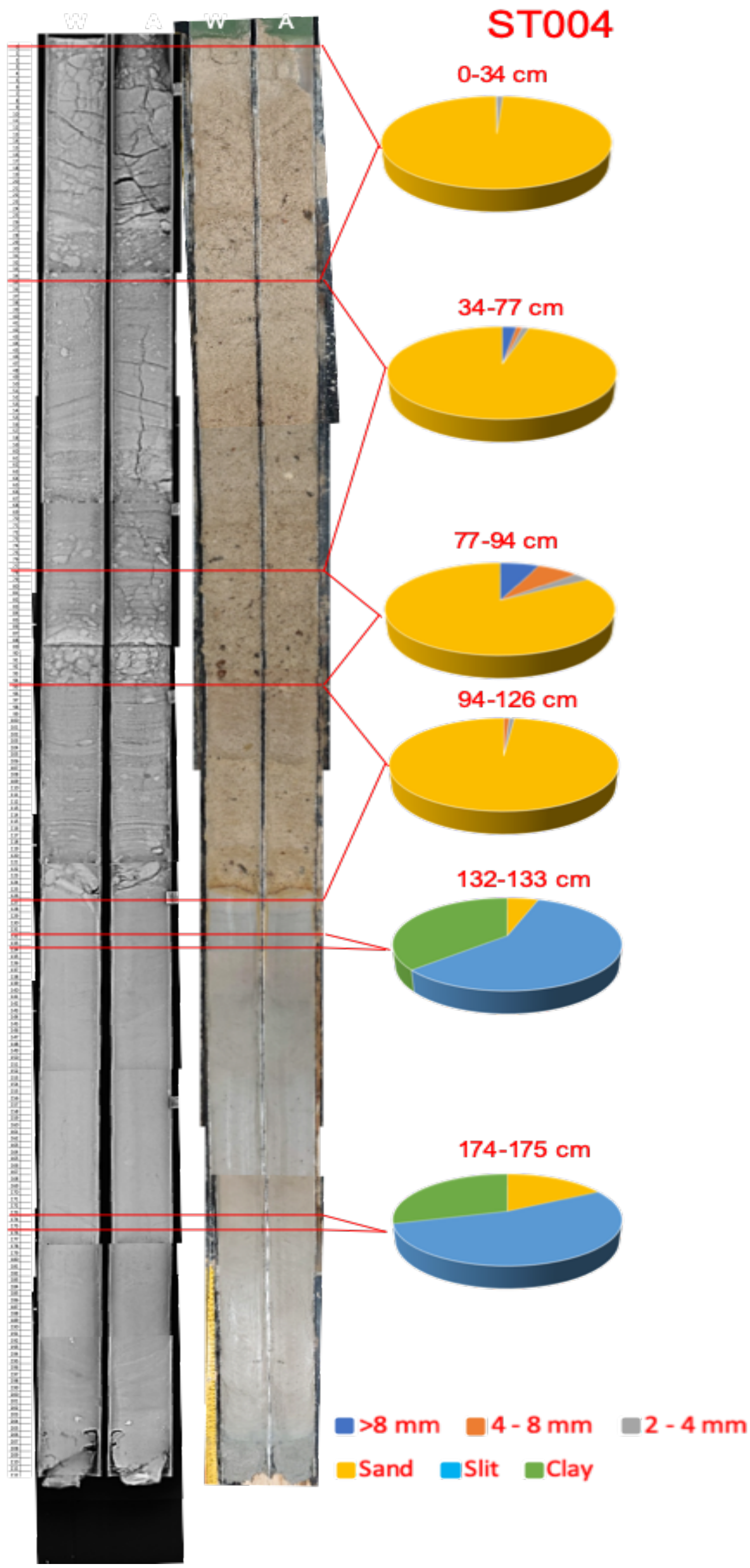


Figure 4. Color photo and X-ray graph of three cores at St. Jacinto River, as well as the corresponding grain size distribution in different sections for Cores ST004.

APPENDIX C

Pebble Count Graphs

Core ST002B

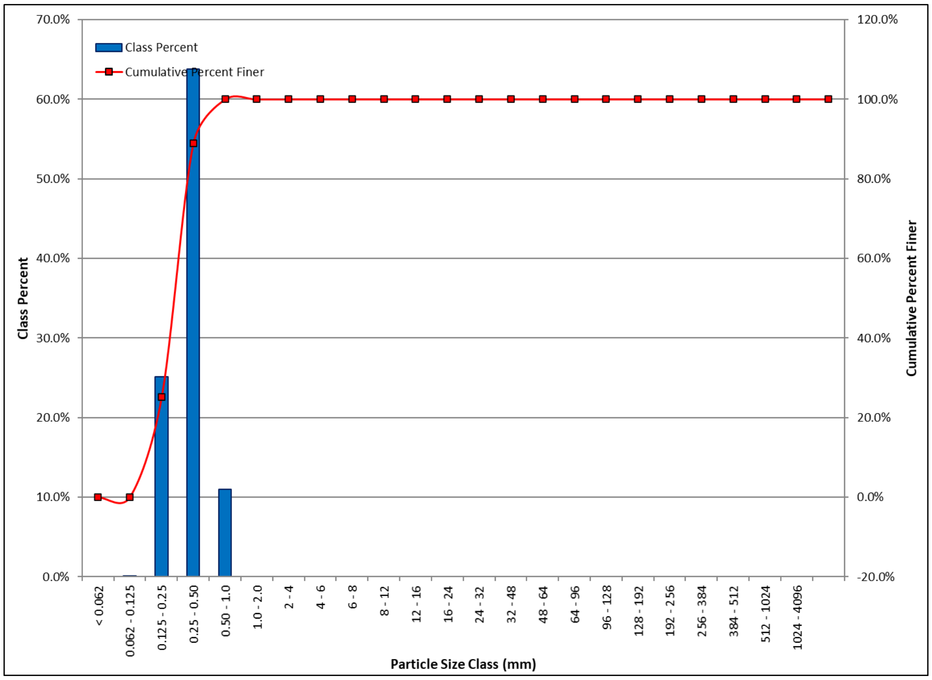


Figure 1- ST002 0-5.8cm

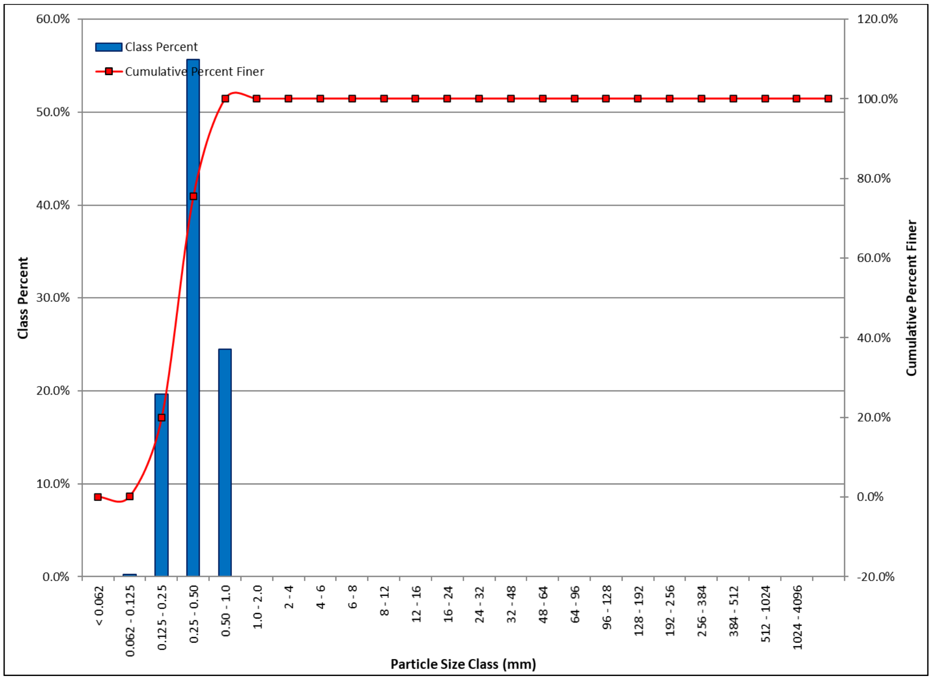


Figure 2- ST002 0-52 cm

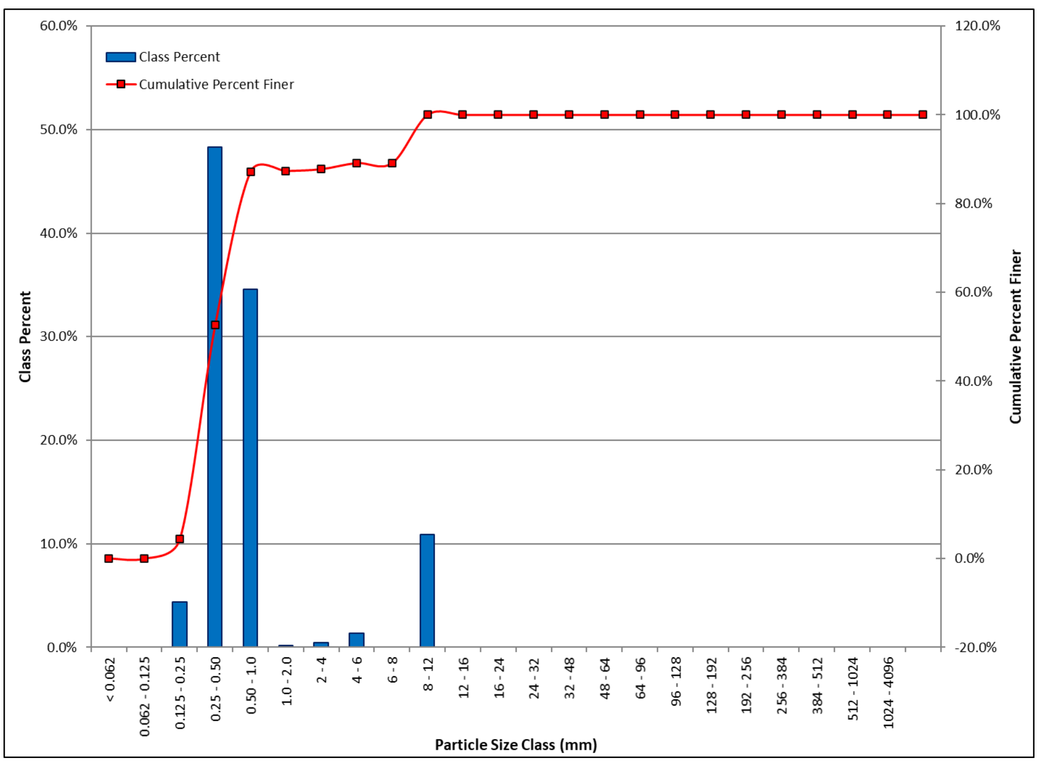


Figure 3- ST002 52-87 cm

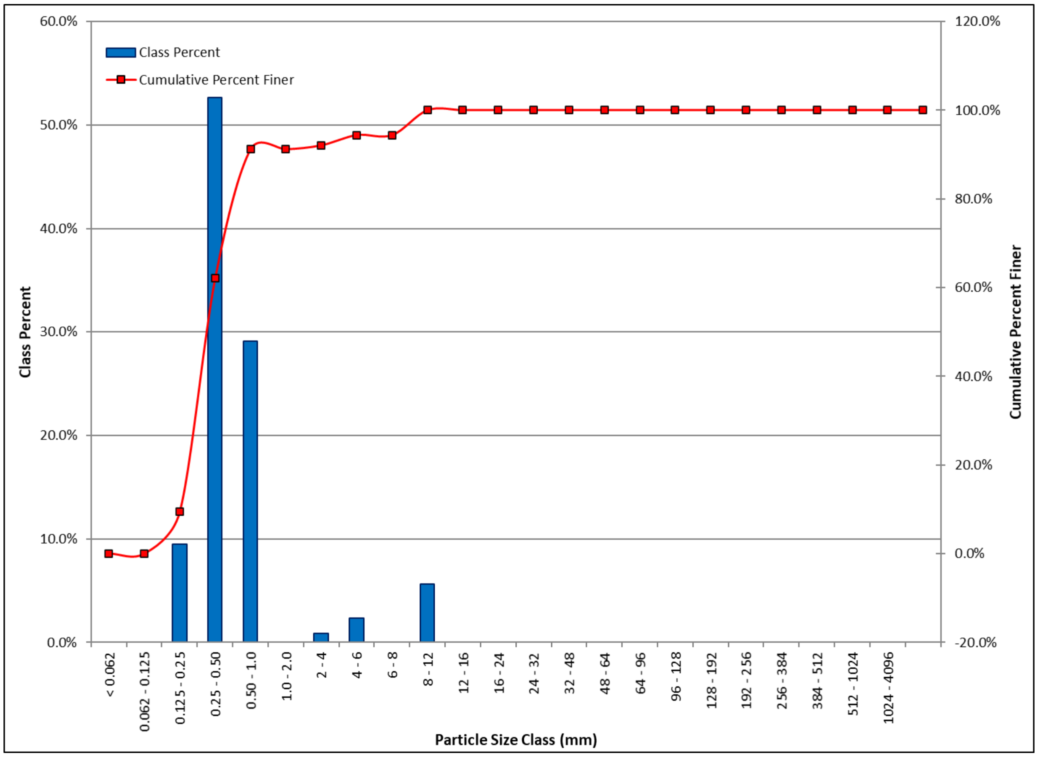


Figure 4- ST002 87- 161 cm

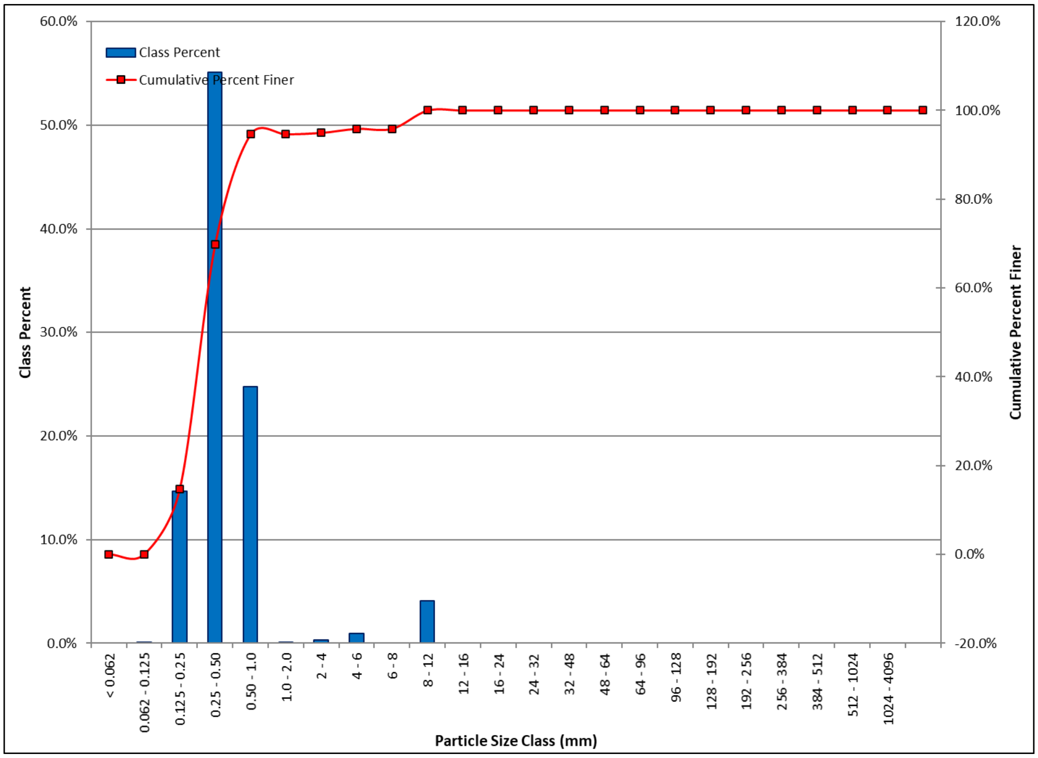


Figure 5- ST002 Cumulative

Core ST003A

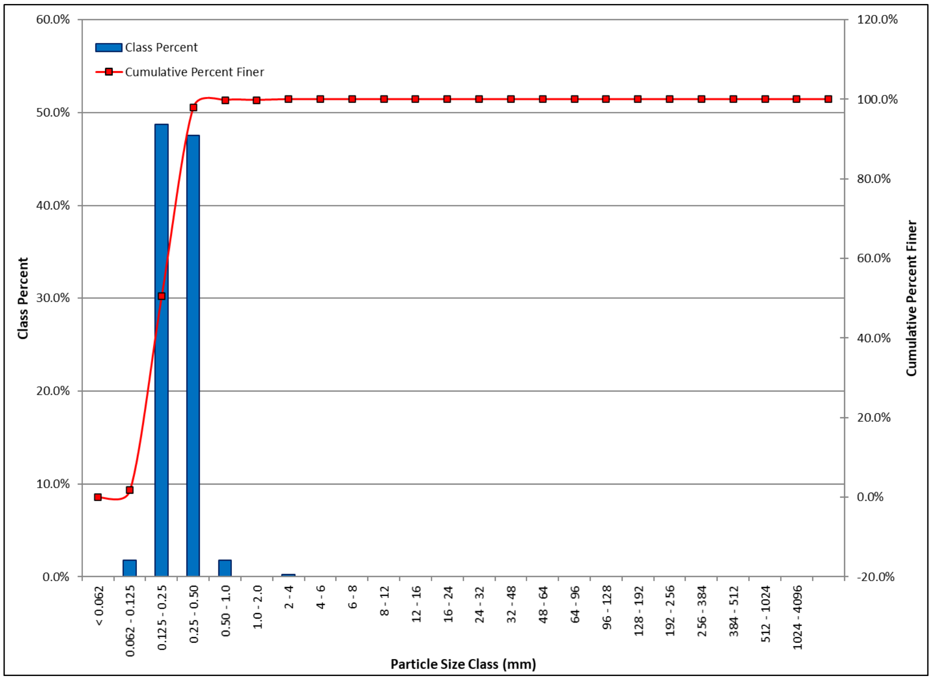


Figure 6- ST003 0-5.8 cm

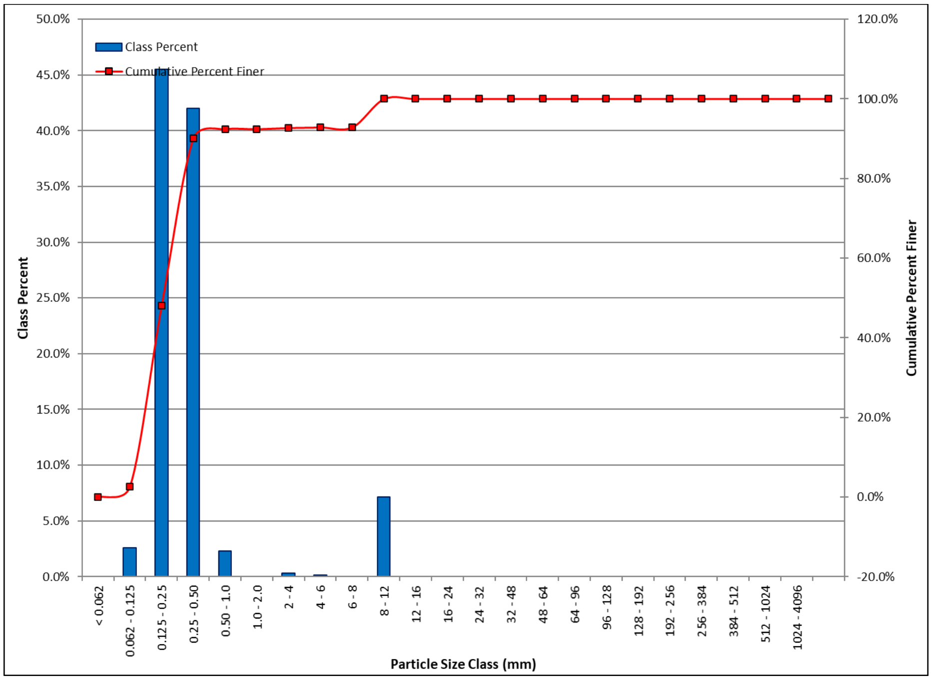


Figure 7- ST003 0-30 cm

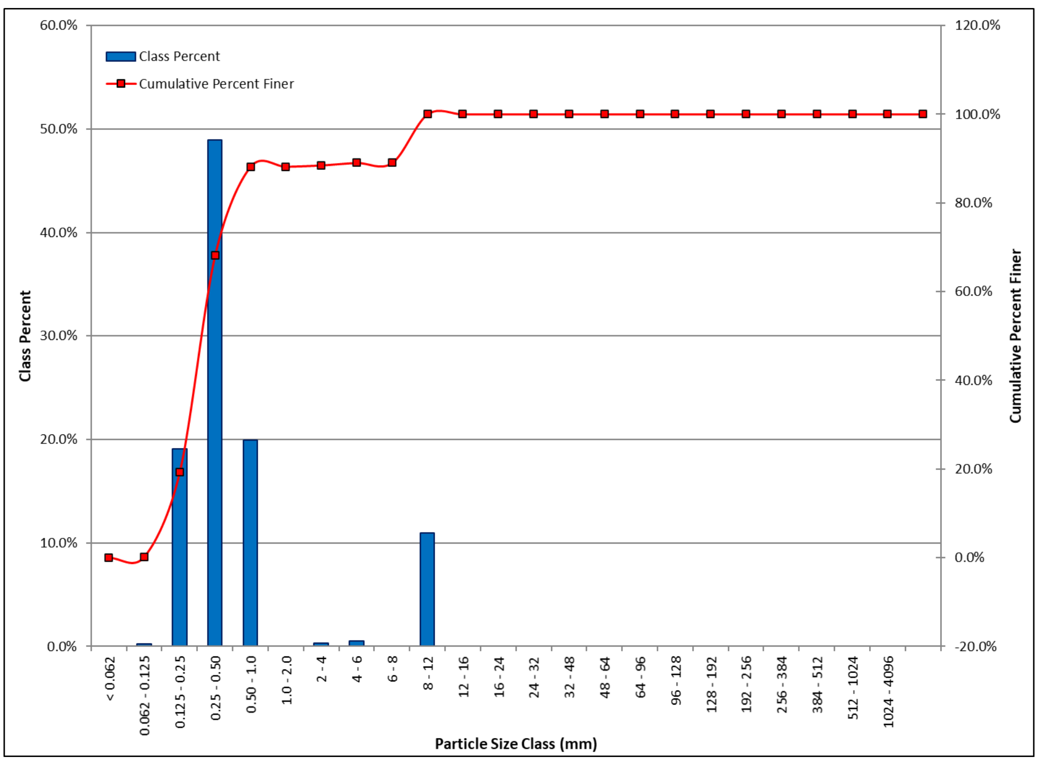


Figure 8- ST003 30-63 cm

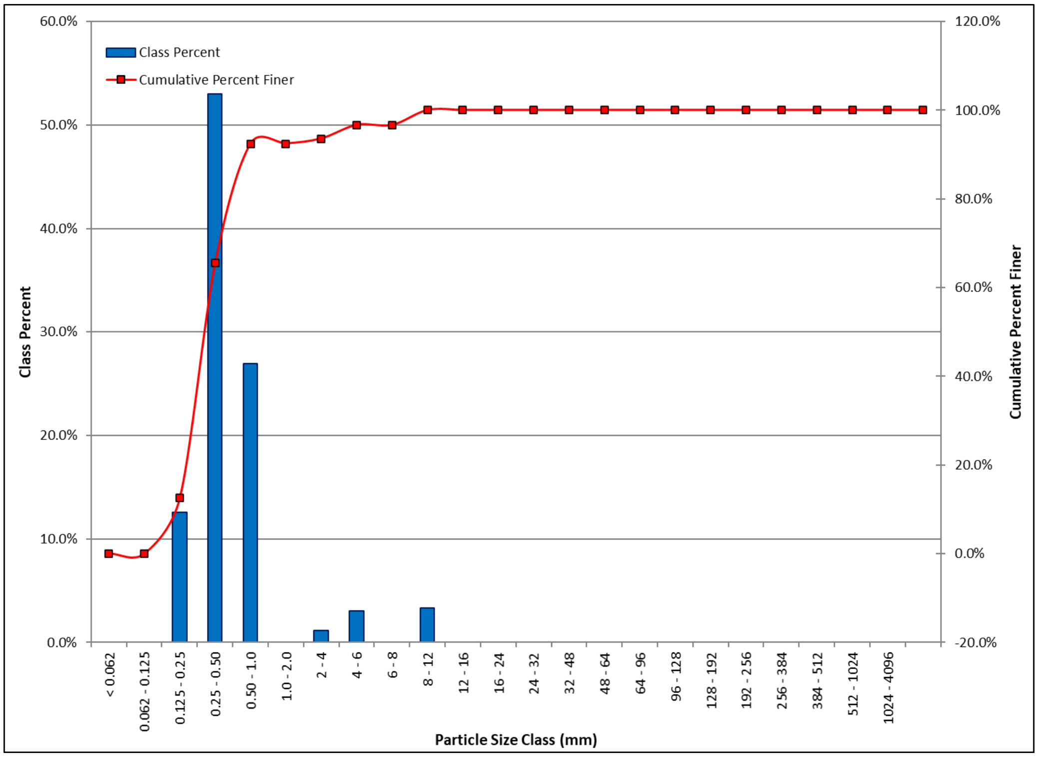


Figure 9- ST003 63-84 cm

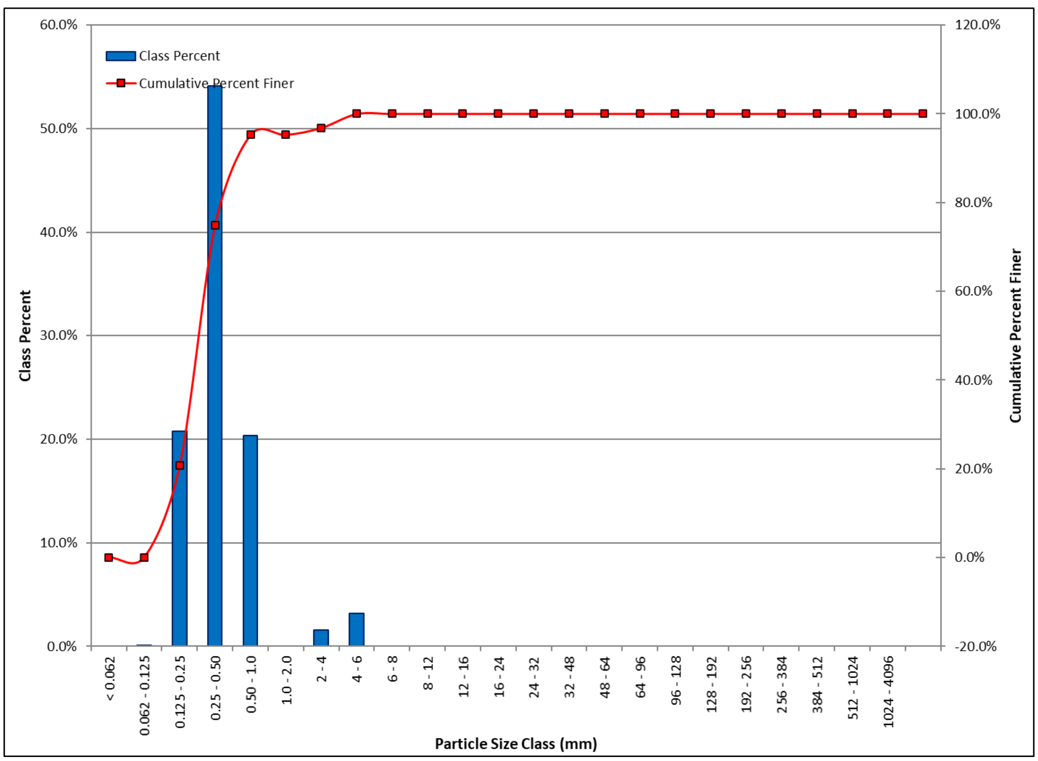


Figure 10- ST003 84-103 cm

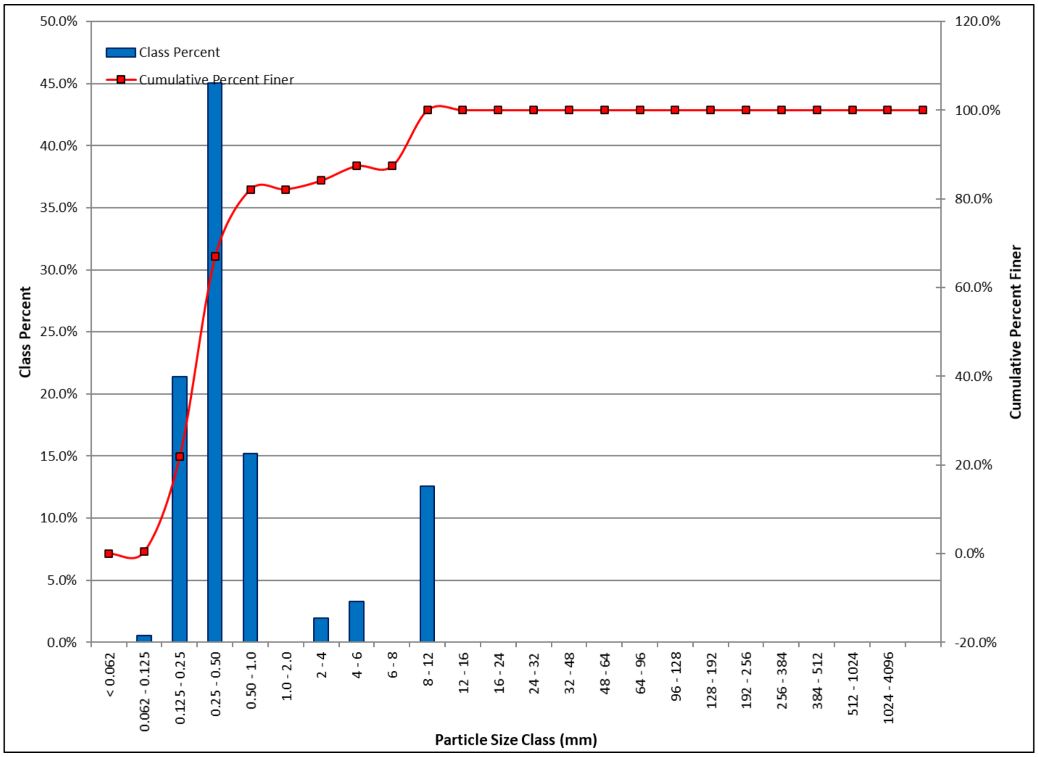


Figure 11- ST003 103-131 cm

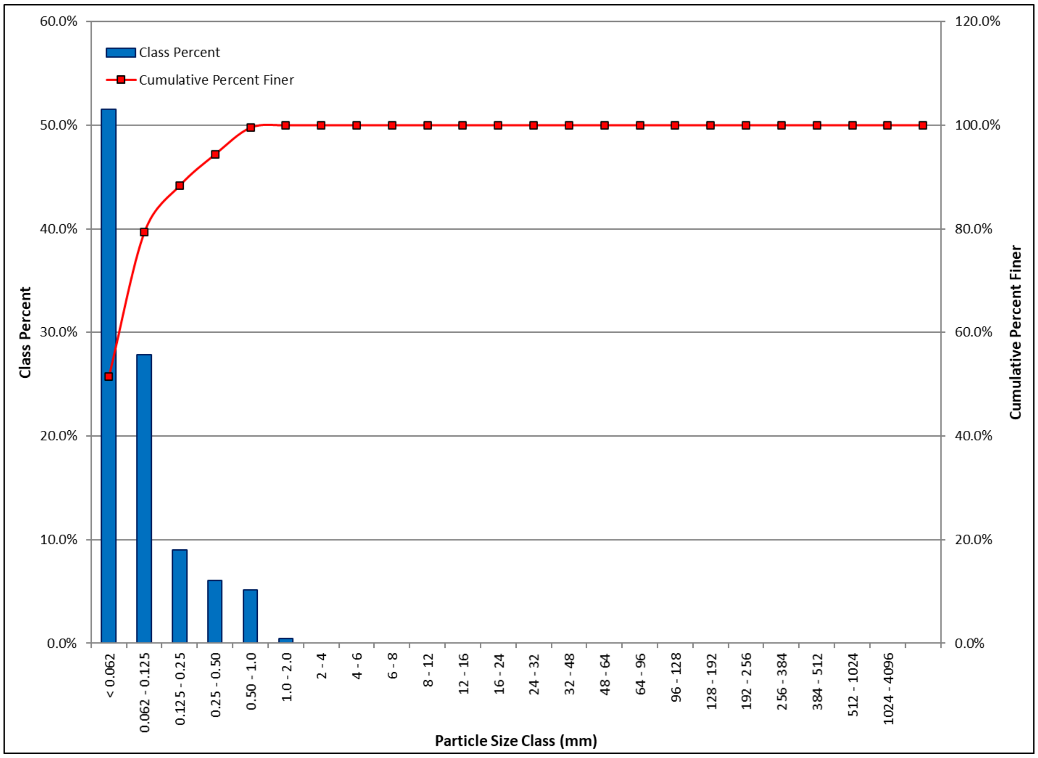


Figure 12- ST003 132-133 cm

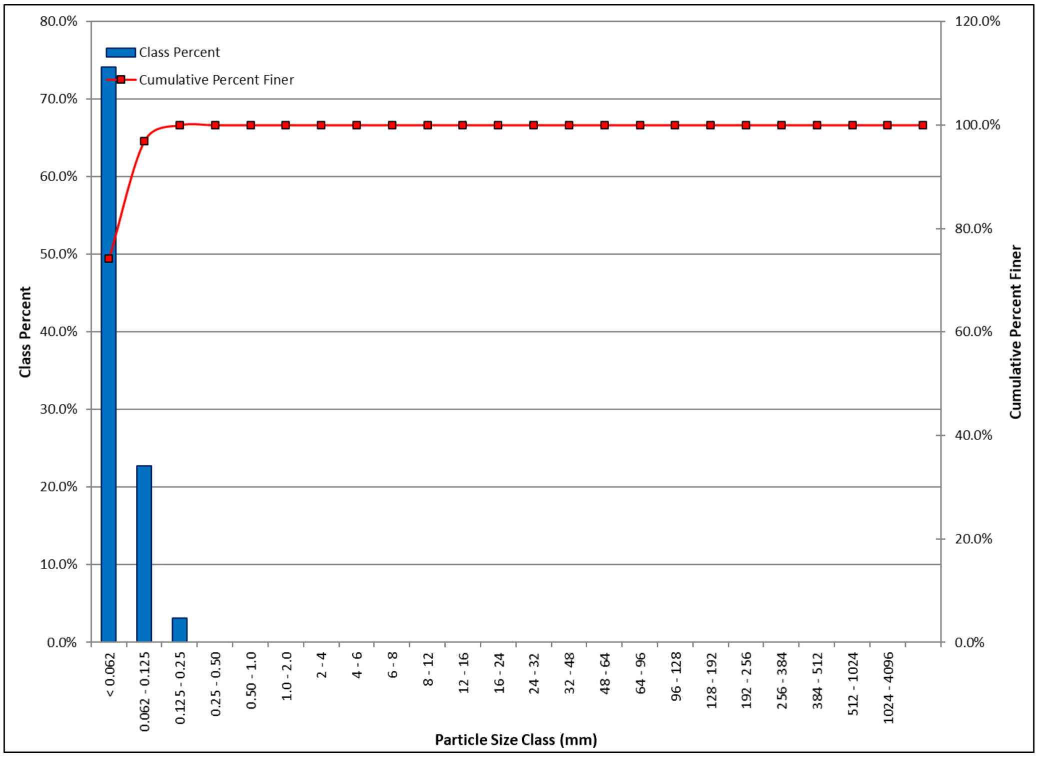


Figure 13- ST003 168-169 cm

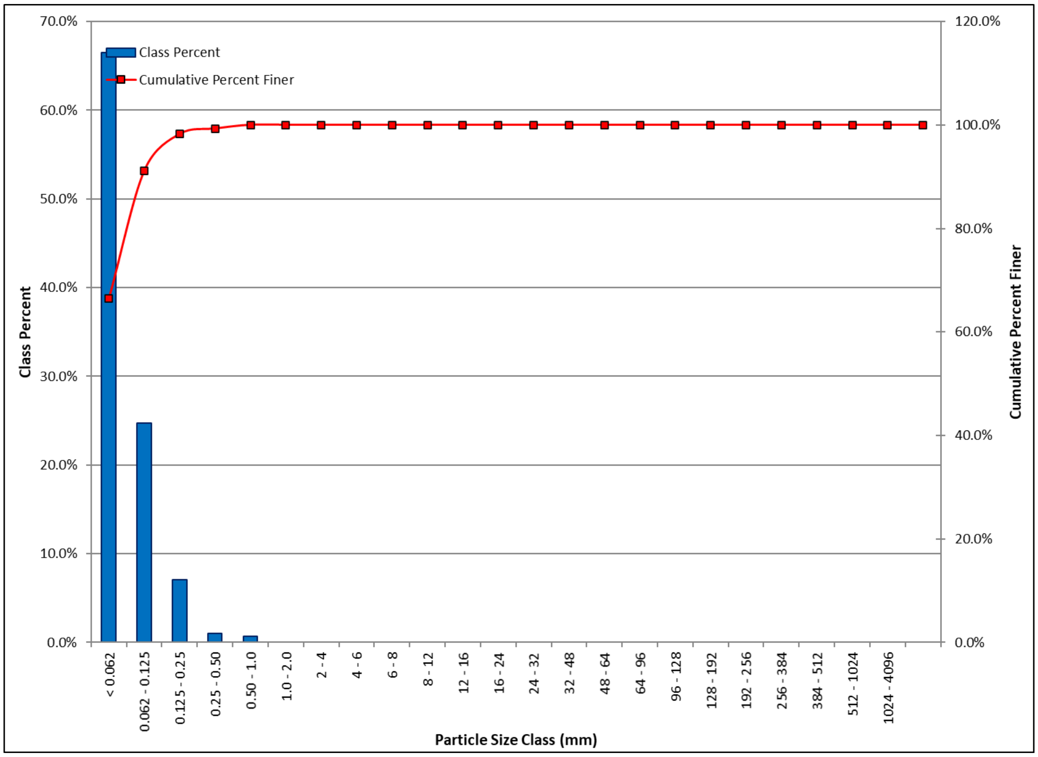


Figure 14- ST003 201-202 cm

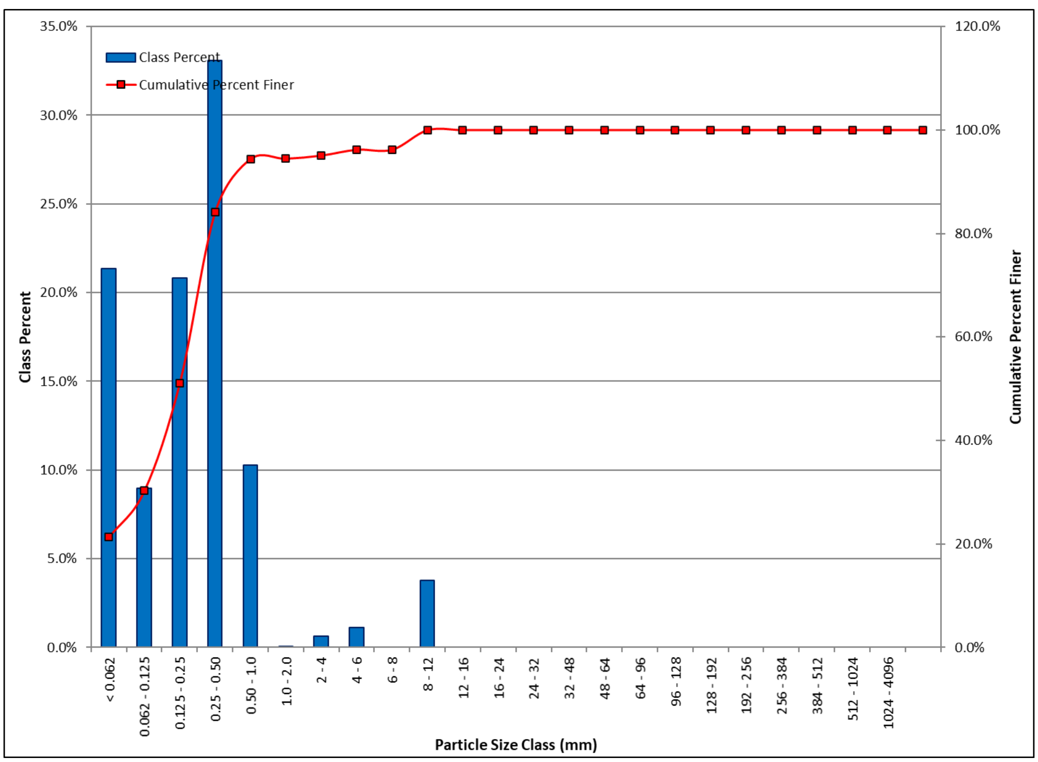


Figure 15- ST003 Cumulative

Core ST004

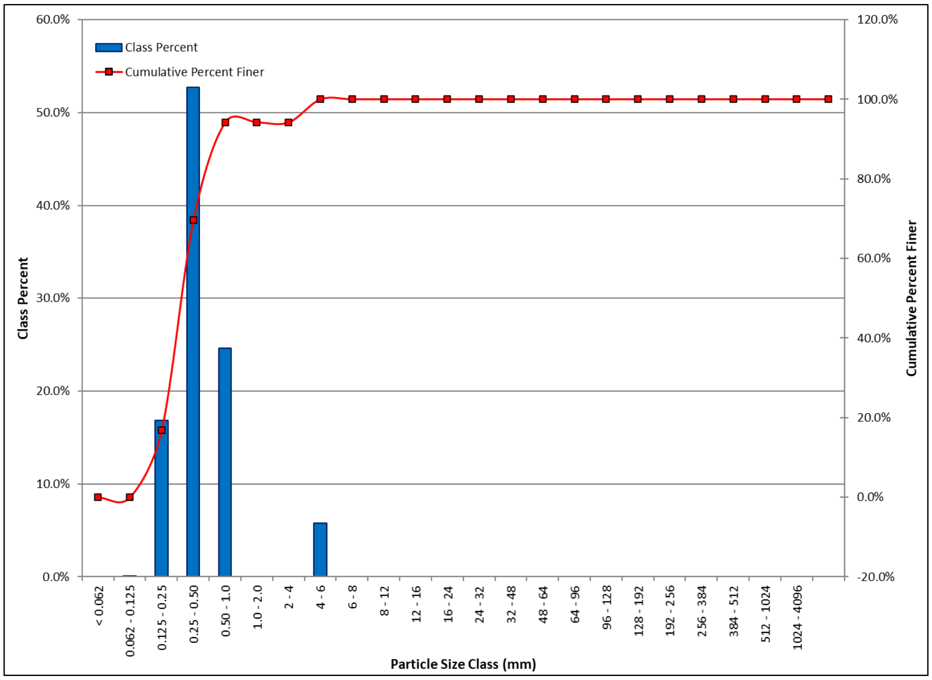


Figure 16- ST004 0-5.8 cm

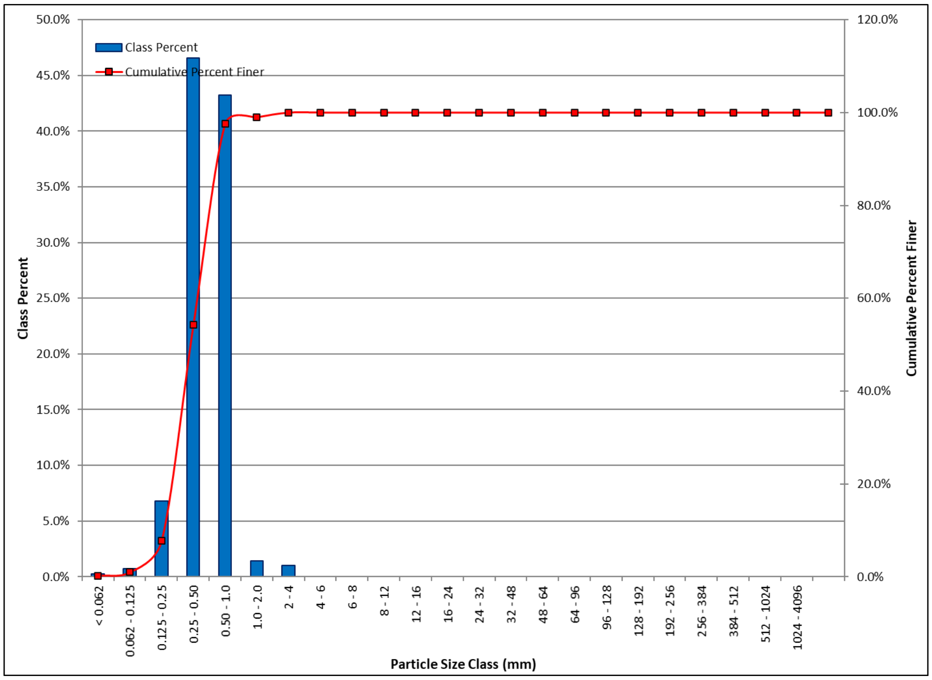


Figure 17- ST004 0-34 cm

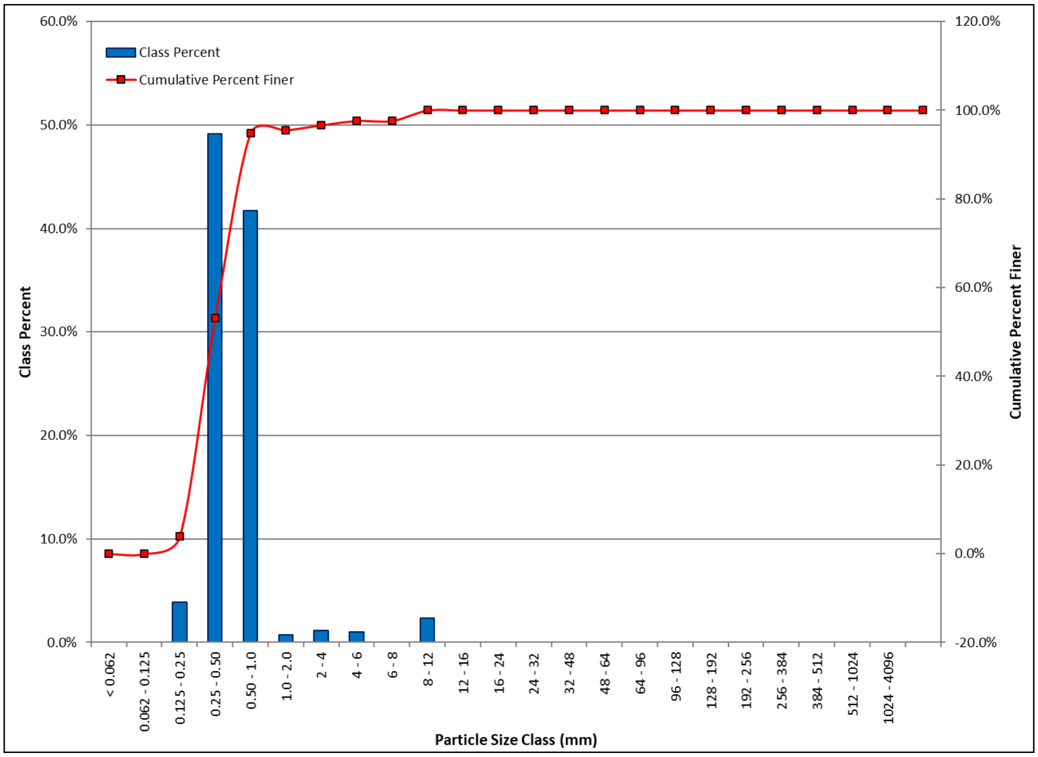


Figure 18- ST004 34-77 cm

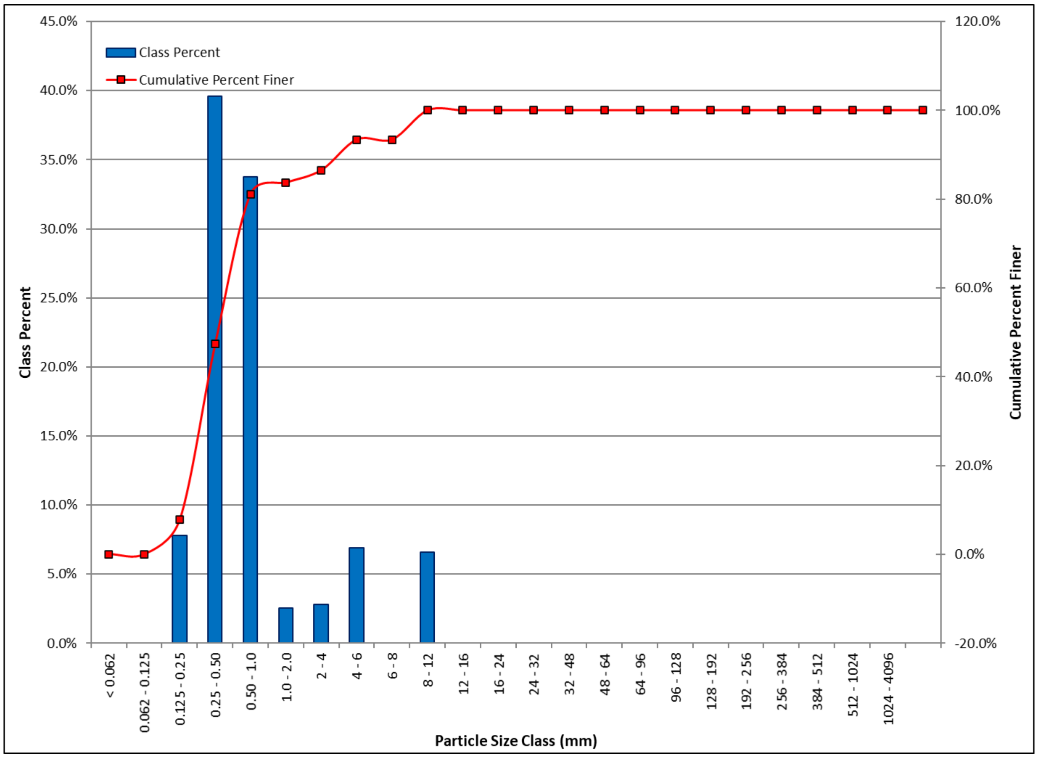


Figure 19- ST004 77-94 cm

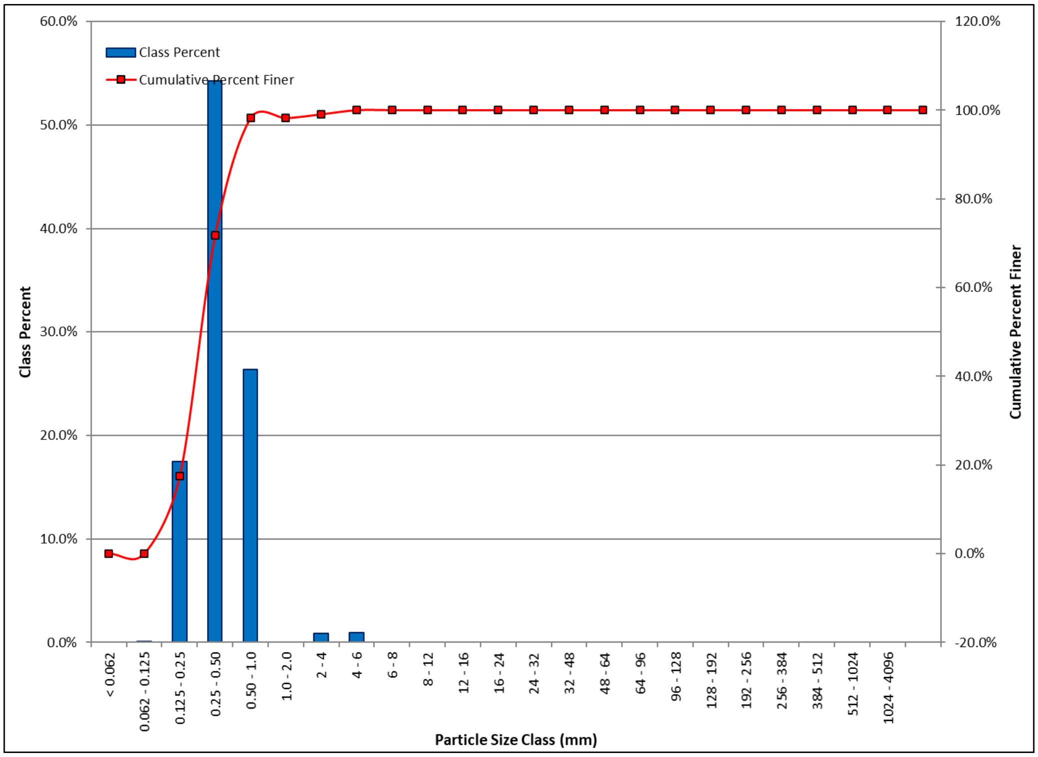


Figure 20- ST004 94-126 cm

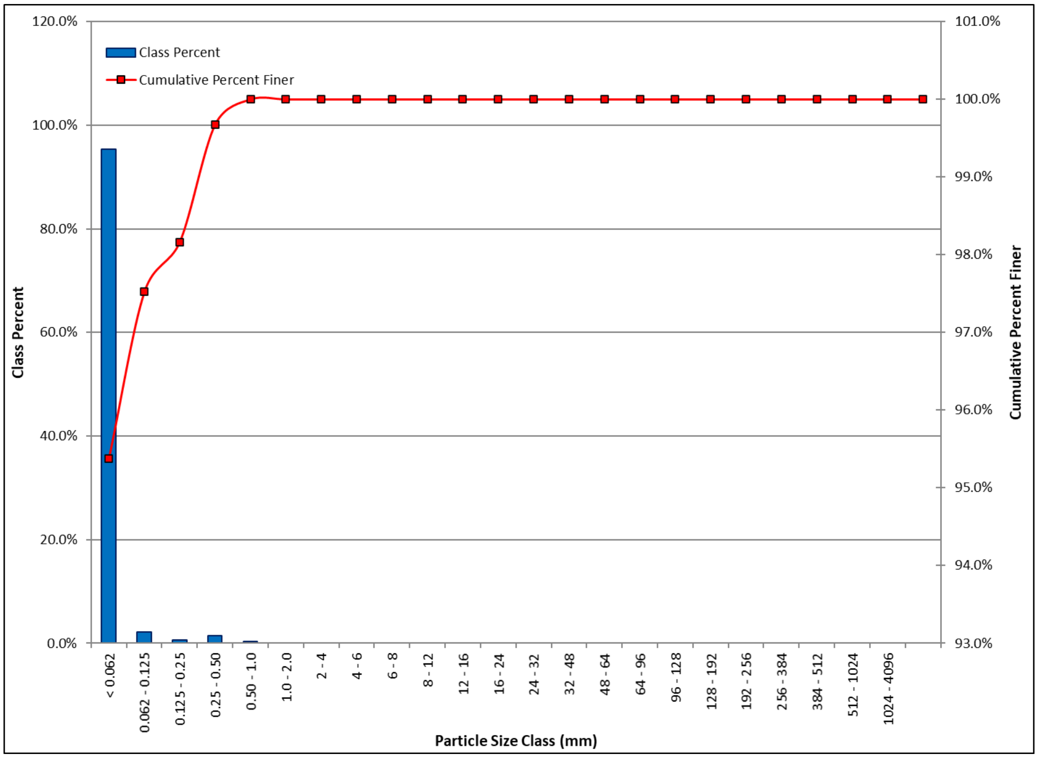


Figure 21- ST004 132-133 cm

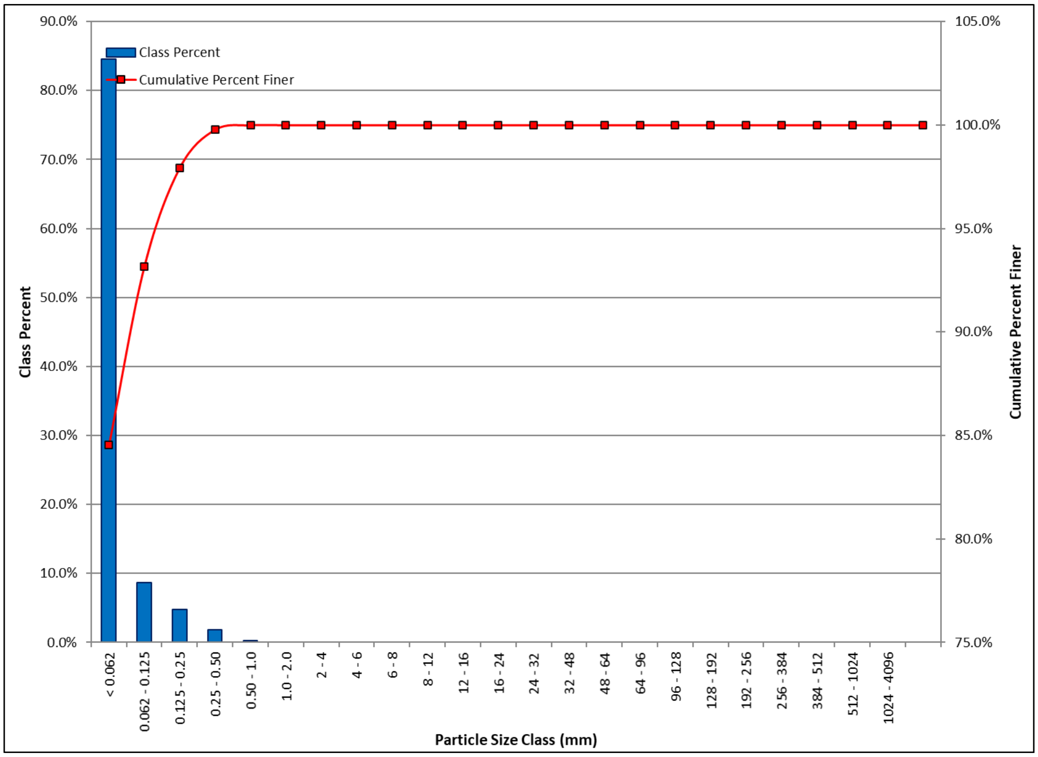


Figure 22- ST004 174-175 cm

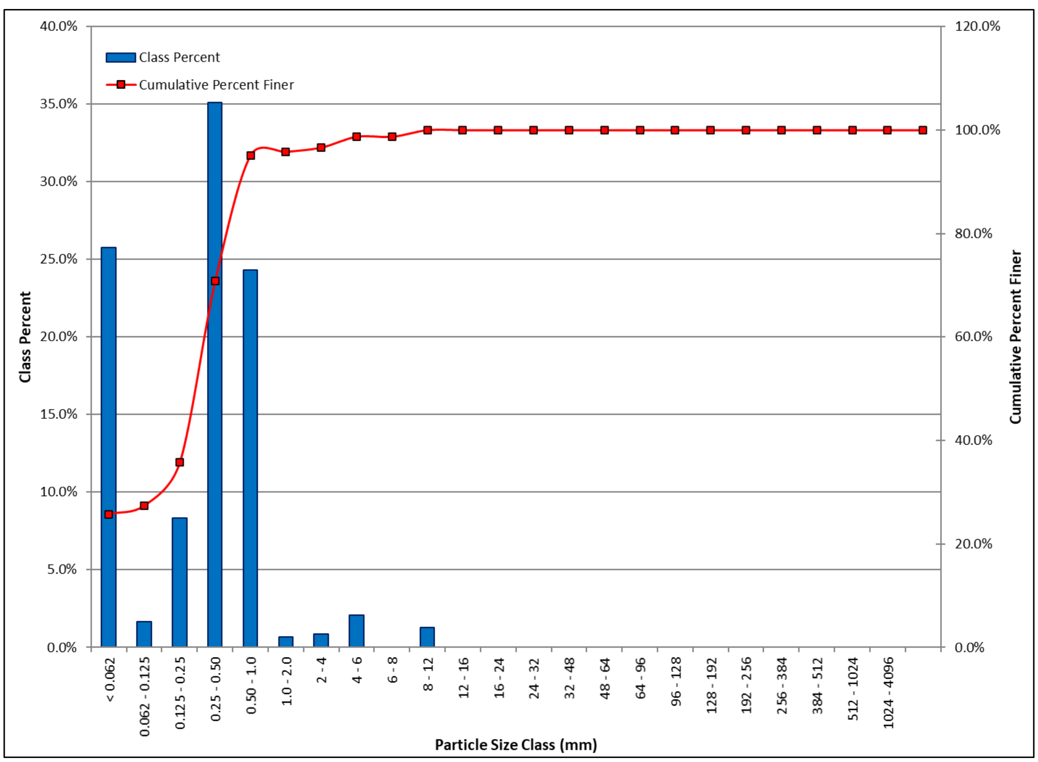


Figure 23- ST004 Cumulative

Appendix I

Tables I-1 through I-2

Table I-1: Annual Sediment Volume in West Fork San Jacinto River from USGS Stream Gage at Conroe, TX (USGS 08068000)

Normalized Occurrence (%)			Daily Discharge per Occurrence (CFS)	Suspended Sediment Load (T/Day)			
Occurrence Range	Occurrence Increment	Average Occurrence		Load per Occurrence Flow*	Load per Occurrence Flow**	Increment of Load per Occurrence*	Increment of Load per Occurrence**
0.0-0.1	0.1	0.05	34,800	31,483	21,428	31.5	21.4
0.1-0.3	0.2	0.2	16,800	11,980	8,037	24.0	16.1
0.3-0.5	0.2	0.4	11,700	7,413	4,937	14.8	9.9
0.5-1.0	0.5	0.75	8,240	4,656	3,079	23.3	15.4
1-2	1	1.5	5,410	2,664	1,747	26.6	17.5
2-4	2	3	3,540	1,518	987	30.4	19.7
4-8	4	6	2,040	731	470	29.2	18.8
8-15	7	11.5	975	274	174	19.2	12.2
15-25	10	20	396	83	52	8.3	5.2
25-35	10	30	198	33	20	3.3	2.0
35-45	10	40	114	16	10	1.6	1.0
45-55	10	50	75	9	5	0.9	0.5
55-65	10	60	52	6	3	0.6	0.3
65-75	10	70	38	4	2	0.4	0.2
75-85	10	80	28	2	1	0.2	0.1
85-95	10	90	20	1.6	0.9	0.16	0.1
95-100	5	97.5	11	0.7	0.4	0.04	0.0
			Total Sediment Load (T/Day):	60,875	40,954	214.5	140.5
					Total Sediment Load (T/Year):	78,278	51,271

* Pre-1974 Sediment [T/Day] = 0.0297*(Flow [CFS])^1.3267

** Post-1974 Sediment [T/Day] = 0.0164*(Flow [CFS])^1.3467

Table I-2: Summary Table of HEC-RAS Water Surface Elevations

Trap	Cross Section Through Trap	Existing Water Surface Elevation (ft)	Proposed Water Surface Elevation (ft)	Difference (ft)	Cross Section Upstream of trap	Existing Water Surface Elevation (ft)	Proposed Water Surface Elevation (ft)	Difference (ft)
ST004 01IC	211138	79.9	79.89	-0.01	213648	80.42	80.41	-0.01-
ST004 02IC	206645	78.64	78.63	-0.01	208711	79.25	79.23	-0.02
ST004 03IC	204075	78.27	78.27	0	206645	78.64	78.64	0
ST003 021C	231966	89.29	89.29	0	234194	89.98	89.98	0
ST003 011C	225570	85.88	85.85	-0.03	227966	86.77	86.71	-0.06
ST002 02IC	257047	99.17	99.17	0	257749	99.48	99.48	0
ST002 01IC	254048	97.56	97.8	0.24	254747	97.91	98.15	0.24