South Florida Engineering and Consulting LLC

Science and Technology Professional Services

C-51 Canal Sediment Trap Assessment

Work Order No: 4600004015-WO01 - PO NO: 950008188

Task 5. Final Project Report:

Prepared For:

South Florida Water Management District

January 26, 2021

Prepared By:
South Florida Engineering and Consulting LLC

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January 19, 2020

Mr. Garrido,
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Subject: Task 5 Final Project Report: C-51 Canal Sediment Trap Assessment (4600004015-WO01 - PO NO: 950008188)

Dear Mr. Garrido,

South Florida Engineering and Consulting LLC (SFEC) is pleased to submit the Final Project Report as the Task 5 deliverable for the above-referenced Work Order. This Final Report summarizes efforts to characterize soil contaminants and analyze the efficiency of the sediment trap during three categories of flow conditions. The report concludes with proposed recommendations for further consideration during the development of the Phase II of the C-51 Project follow up.

Respectfully,

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ATTACHMENTS:

(1) Final Project Report (1/19/2020)
(2) Excel Spreadsheet (C51 Sediment Trap Data.xlsx)

Executive Summary

This final project report documents all work performed under the C-51 Canal Sediment Trap Assessment (4600004015-WO01 - PO NO: 950008188) project and describes data collection, data analysis and the results of sediment trap characterization, and sediment load calculation to determine C-51 sediment trap efficiency during six pre-selected flow events. One objective of the C-51 project was to collect sediment samples from accumulated trap soils within the C-51 sediment trap to assess the presence of contaminants and their specific concentrations. Another major objective was to collect surface water canal samples and obtain analytical (i.e., total suspended solids; TSS) data to estimate sediment loading into and out of the sediment trap area in order to estimate sediment trap efficiency at three pre-selected and planned categories of flow rates, including Low flow ≤ 400-600 cfs; Moderate flow = 1,000-1,200 cfs; and High flow ≥ 1,400-1,600 cfs. Actual and final six flow events started on December 23, 2019 and concluded on October 29, 2020 and included three Low flow rates (570, 437, and 770 cfs), two Moderate flow rates (1,063 and 1,042 cfs), and one High flow rate (1,433 cfs), all measured at structure S-155.

Task 1 Report provided detailed descriptions of the project plans and literature review, while Task 2 Report documented assessing sampling of deposited material in the Sediment Trap (1 Event). The objective of Task 2 was to sample deposited sediment in the sediment trap, assess sediment depth along six transects, assess water depth, and characterize sediment contaminants through laboratory and subsequent data analysis. Bottom sediment samples were collected at six sites on November 4, 2019 at transects 119, 120, 122, 123, 124 and 125. Laboratory analysis results were delivered to the District Project Manager. Results of Task 2 for the six preselected transects indicated that measured water depths ranged between 8’ 8” and 18’ 0”, depth to bottom of sediment ranged between 13’ 1” and 26’ 11”, while sediment thickness varied between 4’ 0” and 8’ 11”. The laboratory analysis and sediment characterization from the four transects included analysis results for EPA 8270C and DOD Full Contaminant List, Wet Chemistry: 2540G Percent Solids (Dry weight), Semi-volatiles by GC Analysis Desc: EPA 8081 by GC L3 (EPA 8081 by GC L3), Analysis Desc: EPA 8082 PCBs (S), and other specific analytical results were documented in the Task 2 report (one event) and are summarized in Appendix A of this report.

Task 3 report of field data collection focused on two parts. The focus of the first part was to collect surface water samples, while the second part of the field data collection focused on stream gauging, both of which are needed to calculate sediment loads into and out of the C-51 Canal trap to determine trap efficiency. Water sample collections and stream gauging took place at the four pre-selected transects (B-1 through B-4).

Task 3 included stream gauging and surface water total suspended solids (TSS) sampling for sediment load calculations for a total of six flow events, while Task 4 summarized methods and results of inflow/outflow suspended sediment load calculations for the same pre-selected six flow events, including three Low flow; two Moderate flow, and one High flow events. Data collected during all six flow events included water samples at the preselected four transect locations for a total of 24 Total phosphorus (TP) (i.e., six flow events x 4 four transects = 6 x 4 x 1=24 values) and 168 TSS samples (6 flow events x 4 transects x 7 samples/transect). It should be noted that for all TP observed results in water column that were less than the minimum detection limits (i.e., reported as “u*”; below MDL) of a 0.005 mg L^{-1}, values were set to the half the MDL (i.e., 0.002 mg L^{-1}). Results of all TP data were similar to available data collected by the South Florida Water Management District (SFWMD) at S-155 structure. Similarly, TSS values reported as below MDL (u*) were set at 2 mg L^{-1} (half the MDL value). All measured values between the PQL and MDL (16.0 and 4.0 mg L^{-1}, respectively) were set to the reported value (i.e., 4i mg L^{-1} is set to 4 mg L^{-1}).

A total of six TSS mass balance budgets were developed representing each combination of flow values and surface water concentrations (TSS). The inflow (B-1, B-2, and B-3) and outflow (B-4) TSS loads were calculated and used to determine C-51 trap efficiency for all six flow events. Stream gauging was conducted at least three to six times at each transect (following standard methods). Yet only the average stream gauging flow data was used in sediment load calculations at

each of the four transects. Similarly, even though seven TSS samples were collected at each of the four transects, only the average of all seven values was used to represent a location for sediment load calculation into and out of the sediment trap.

Individual TSS values for all four transects and six flow events ranged between 4.2 and 39 mg L^{-1}, while TP values ranged between 0.018 and 0.087 mg L^{-1} (range = 0.069 mg L^{-1}) with a mean of 0.047 mg L^{-1} (±0.005 S.E.) Average stream gauging flow values at each of the four transects during all six flow events were 108 (±20.8 S.E.), 671 (±54.9 S.E.), 51 (± 8.2 S.E.), and 920 (±69.9 S.E.) cfs for transect B-1, B-2, B-3, and B-4, respectively. Flow values at S-155 and B-4 transect (representing flow downstream of sediment trap) were comparable and differ only by < 8% in five out of six flow events, and 16% during June 19, 2020 event. Water managers at SFWMD provided great support during all flow events and maintained the required flow for each event for at least four-six hours until all needed data were collected.

Sediment load into (load in = B-1 + B-2 + B-3) and out (load out = B-4) of the C-51 sediment trap were calculated by multiplying average flow by the average TSS concentrations at each transect (detailed calculations are presented in Chapter 3 of this report). This was done in three different ways, one by excluding values below MDL (TSS = null) for TSS, to calculate the average value for a transect, and two by using half the MDL (2 mg L^{-1}), when calculating average value for a transect. No statistically significant difference was found in the calculated TSS means between the aforementioned two methods to estimate sediment loads. The third method combined the use of half the MDL (2 mg L^{-1}) for TSS value below the minimum detection limits and flow proportional adjustment to maintain a net zero difference between inflow and out flow discharges. The third approach is the preferred method, as described in Chapter 4, and was used to evaluate C-51 canal trap efficiency.

Trap efficiency fluctuated between positive (i.e., sediment retention or no net sediment export) and negative sediment export (i.e., net sediment export) during the six flow events. Results indicated that trap efficiency decreased as flow increased, particularly for flow higher than 1,000 cfs. The highest trap efficiency was observed for flow range values between 459 and 588 cfs measured at Transect B-4 (or $Q_{S\text{-}155}$ = 437 & 571 cfs) respectively, while lowest trap efficiency was recorded at flow range of more than 1,000 cfs (e.g., $Q_{B\text{-}4}$ = 1,132, 1,143, and 1,460 cfs stream gauging measured flow events). Based on the low and high flow events efficiency results, it seems that a transition flow range existed between 750 to 900 cfs at the S-155 structure and may represent a change between positive (retention) and negative (export) trap efficiency.

Trap efficiency results provided a good summary of the relationship between flow event type (i.e., low, medium, high) and trap efficiency (% efficiency). For example, the highest three flows (i.e., $Q_{S\text{-}155}$ > 1,000 cfs) consistently showed a negative trap efficiency (i.e., sediment export) ranging between 3 and 42% while the low flow events (i.e., $Q_{S\text{-}155}$ < 571 cfs) achieved a positive trap efficiency (i.e., sediment retention) of 6 and 24%. Yet, at a somewhat "transition" flow event (i.e., $Q_{S\text{-}155}$ = 769 cfs) that fell between high and low flow measured values out of all six events, resulted in a modest negative efficiency (i.e., 18%); an interesting observation, that needs further investigation. The difference between stream gauging flow at B-4 and recorded flow at S-155 was less than 9% in five of the six flow events. Stream gauging flows at B-3 during some of the events were all negative and resulted in negative loads combined with high uncertainty in TSS measurements, which may provide a possible explanation as to why the estimated negative trap efficiency, in general. Some, of this discrepancy or unexpected results may also be attributed to variations in field conditions, human errors, changes in atmospheric conditions during data gathering, data manipulation, and changes in operations, among other factors.

In summary, sediment retention of 6 and 24% trap efficiency occurred at the two low flow events (i.e., $Q_{B\text{-}4}$ = 588 and 459 cfs), respectively as determined by the flow proportional adjustment third method (the three methods are described in details Chapter 4). However, sediment export of 11, 3, 18, 42% occurred during all high flow events ($Q_{S\text{-}155}$ = 1,068, 957, and 1,434 cfs) and transition flow (i.e., $Q_{S\text{-}155}$ = 769 cfs) as recorded at the S-155 structure. It should be noted that the highest estimated export of sediment from the C-51 trap (i.e., 42%) occurred during the highest flow event that took place on September 16, 2020 with a recorded flow rate of 1,434 cfs for S-155 structure.

Data analysis regarding trap efficiency for flows less than 850 cfs strongly suggest sediments retention, while flows higher the 850 cfs strongly suggest net sediments export out of the trap. Mainly two reasons that may have attributed and led to an inadequate steady state flow regime that definitely led to sediment retention, mostly uncertainty in the observed TSS values (i.e., values between MDL and PQL 4 to 16 mg L^{-1}) and high flow (Q) values that may include human errors and varying environmental conditions in the field. The large uncertainty associated with measured low TSS values (16> PQL>4.0 mg L^{-1}) is a major source of error. Furthermore, measured stream gauging flows also include variation of human error, field conditions, and changes in operations among other things. During all six flow events, the intent/target of this work, is that all load calculations and hence trap efficiency, are based on a "steady state" conditions; mainly flows that are the "large" number in sediment load calculations. While District's water managers did an excellent job to maintain the flow at the targeted values, other variables may have played a role to end up with imperfect steady state. For example, flow differences between observed transect B-4 and S-155 structure that might have been impacted by wind or by the fact relating to which part of the physical structure is used during an event, in addition to human errors. Transects B-1 and B-3 contributed much less to the overall mass balance compared to B-2 transect flow, yet at times a negative stream gauging flow values (an indication of extremely low/undetected flow), possibly a result of not meeting a full steady state condition, were also frequently observed at B-1 and B-3.

Results and experience gained during this work order led us to a better understanding of how prevailing conditions impact sediment mass balance and trap efficiency. This allows us to provide a set of recommendations to consider as a follow up and firm up the current work results and mainly seek additional information for the sole purpose of improving C-51 trap efficiency. The recommendations for the Phase II are summarized and divided into two major areas: 1) determination of a flow range at which sediments are retained in the trap, and 2) mimicking as practically as possible, the actual and real time S-155 structure operations (during wet/dry/storm season) to maximize trap efficiency, including the use of simulation models to provide additional options for improving trap efficiency.

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Chapter 1: Introduction

1.0 Project Background

In 2006, the South Florida Water Management District (SFWMD), Palm Beach County Department of Environmental Resources Management (PBC), and the City of West Palm Beach collaborated to design and construct a sediment trap on the C-51 canal. The objective was to intercept sediment load to the Lake Worth Lagoon through the S-155 structure. Construction of the C51 Canal Sediment Project began in May 2006 and ended in July 2007 removing approximately 101,500 cubic yards (CY) of muck from a 3,500 linear foot section of the C51 Canal. The canal was dredged about six feet deep (from around -12 ft depth to -18 ft and -20 ft. NGVD 29). The sediment trap is located between Forest Hill Blvd and the intersection of C-51 Canal and I-95 (Figure 1).

Palm Beach County Department of Environmental Resources Management, South Florida Water Management District and City of West Palm Beach retained Sea Diversified, Inc. to conduct hydrographic surveys of the C-51 Canal and the sediment trap from 2007 through 2010. Initial reference survey was conducted for the canal section, 1.5 miles, from Forest Hill Boulevard to the S-155 structure in 2007. In 2008, the survey limit was extended including the canal section from Forest Hill Boulevard to Southern Boulevard acquiring baseline for the reach. Both surveys were respective baselines that were compared to the 2008 and 2009 surveys of both reaches. The result of the four years' survey was presented by SDI in 1-ft contour maps color shaded with sediment gain/loss bathymetric changes. Tabular results of accumulation or loss of sediment for each year was presented for four reaches of A, B, C and D, Southern Boulevard to Summit (A), Summit Boulevard to Forest Hill Boulevard (B), sediment trap (C) and I-95 to structure S-155 (D).

2.0 Project Overview

The C-51 Sediment Trap project is part of restoration efforts included in the Lake Worth Lagoon Management Plan and the Comprehensive Everglades Restoration Plan. A Tri-party agreement was executed in January 2006 between Palm Beach County (PBC) Environmental Resources Management (ERM), SFWMD and the City of West Palm Beach. PBC agreed to construct the sediment trap, while the City provided land for material processing. SFWMD and PBC ERM cost-shared the project.

A 12-acre sediment trap was created in the canal to act as a "sump" to trap sediments before they are discharged to Lake Worth Lagoon (Figure 1). Construction was completed in 2007. Over 100,000 cubic yards of muck was hydraulically dredged from the C-51 Canal and transported through pipelines to settling ponds located adjacent to the West Palm Beach Golf Course. The muck was treated, then dewatered and dried to a cake-like consistency. It was trucked away for beneficial reuse as it was mixed with sand for use in landscaping for county parks and Florida Department of Transportation roadway projects.

Data from previous surveys show the trap is capturing sediments overtime. The trap is approximately 33% full currently; it has accumulated approximately 33,635 cubic yards since its construction 12 years ago; approximately 2,803 cubic yards per year.

3.0 Project Goals/Objectives

The goal of the current project under this Work Order (4600004015-WO01) is to conduct an in-depth data analysis of the sediment trap efficiency and to construct a mass balance, in terms of total suspended solids (TSS), to determine trap efficiency and to understand how the trap efficiency is affected by operating flow at structure S-155. A major goal of this project is also to collect sediment samples within the C-51 sediment trap to assess sediments for the presence of contaminants and their specific concentrations. Analyzing the efficiency of the sediment trap during three different categories of flow conditions is another major goal and therefore it is necessary to obtain analytical data from canal sampling to estimate sediment loading into and out of the sediment trap area. Sediment loads into and out of the trap were to be used to estimate sediment trap efficiency at three categories of planned flow rates, including Low flow = 100-300 cfs (i.e.,< 400cfs); Moderate flow = 1,000-1,200 cfs; and High flow > 1,600 cfs.

Figure 1 Location of C-51 Canal Sediment Trap

4.0 Project Report Organization

Chapter 2 describes in details field activities to sample accumulated sediment on the bottom of C-51 sediment trap and characterize sediment contaminants. Chapter 3 of the current report provides description of all field equipment used to collect samples required under this work order and how samples were collected, while Chapter 4 provides the results of all six-flow event in terms of water samples, sediment load into and out of the C-51 trap, and report on trap efficiency. Chapter 5 provides data analysis and the results of different methods to determine C-51 trap efficiency, analysis of field data, and recommends additional work on how to improve the trap efficiency. **Appendix A** summarizes literature review conducted under Task 1 of this project, characterization of accumulated sediments, while **Appendix B** includes all field notes, Letter of Acceptance (LOA) and Chain of Custody (COC), QA/QC, as well as all TSS nutrient concentrations observed at all four transects and for all six flow events.

Chapter 2: Field Activities and Characterization of Accumulated Sediment

1.0 Overview

As part of the C-51 Canal sediment assessment project, South Florida Engineering and Consulting (SFEC) collected sediment samples of deposited materials in the sediment trap, assessing sediment depth at sampling sites, assessing water depth, and characterize sediment contaminants through lab analysis. The objective of Task 2 was to sample deposited sediment at sites located along six transects (Figure 2) and to characterize sediment contaminants. In addition, Task 2 also included literature summary and Sampling methods, Laboratory analysis result (**Appendix A**).

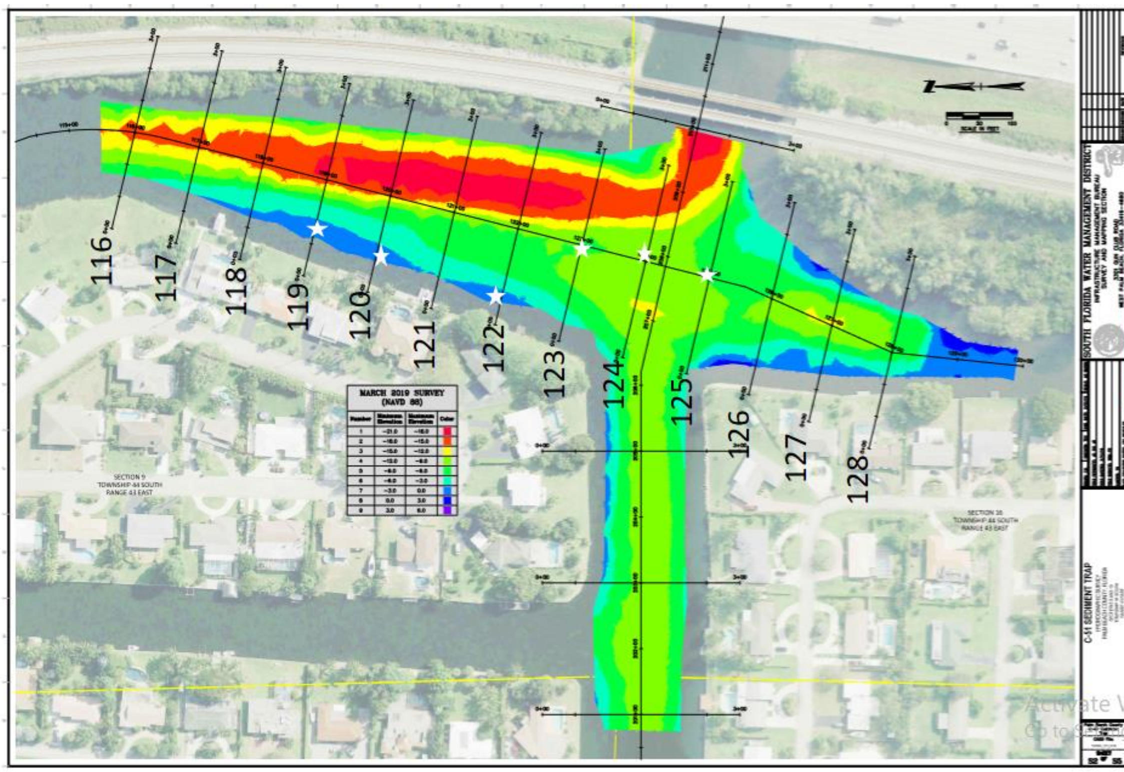


Figure 2 Bottom sediment sampling locations (white stars) at the six selected cross sections (119, 120, 122, 123, 124, and 125) to characterize soils for contaminants.

2.0 Bottom Sediment Sampling Sites

Bottom sediment samples were collected at six sites on November 4, 2019 at transects 119, 120, 122, 123, 124 and 125 (Figure 2). Sediment samples were submitted to Jupiter Environmental Laboratories (JEL) for analysis for the required parameters (Table 1). All samples were stored on ice and delivered for analysis within required sample hold times. Also, water depth to top of sediments from existing water level and total depth to bottom of sediment at all sampling sites was measured. Total Nitrogen analysis was outsourced to Florida-Spectrum Environmental Services by Jupiter Environmental Laboratories. Laboratory analysis from both laboratories is included in **Appendix A** of this report.

Table 1 Sediment parameters and analytical methods used.

Parameter	Method
OCCPs	EPA Method 8081
Eight RCRA Metals	EPA Method 6020
Copper	EPA Method 6020
Full List 8270 Semi-Volatiles	EPA Method 8270
PCB's By GC ECD SW846-8082	EPA Method 8082
Nitrogen (TN)	EPA Methods 300/351.4/SM4500
Phosphorus (TP)	EPA Methods 365.3
Total Organic Carbon in solids	EPA Method 9060 Mod

3.0 Sampling Procedure and Field Notes

The most downstream site cross-section 125 was accessed with a boat, sampling equipment and four staff members. Sampling was conducted from downstream to upstream cross-sections to avoid interference. First, the boat was moved to the coordinates of the location of the sampling site (Figure 2) using GPS and site coordinates was registered in the field notes. Water depth and sediment depth were measured. Sediment thickness was calculated as a difference of depth from water level to bottom of sediment and depth from water level to top of sediment as shown in the field notes (Table 3 & Figure 3). Water depth was measured using a 6.5-inch diameter weighed Secchi disk. By using the Secchi disk it was possible to consistently identify the top of the loose accumulated sediment. Water depth was measured two times and averaged. A 0.5-Inch copper pipe, 33-ft total length, was used to measure the depth to sand or sediment bottom. Three measurements were averaged at each site. Sediment thickness was calculated as the difference between depth to bottom of sediment and depth of water to top of sediment. Field notes are shown in Table 2.

Table 2 Sediment sampling field notes.

Site	Sample ID			Lat	Long	Water Depth	Depth to bottom of sediment	Sediment thickness	Time of Sampling
125	PG125_1	PG125_2	PG125_3	26°38'45.78"N	80° 04'12.02"W	16' 0"	23' 10"	7' 10"	9:41
124	PG124_1	PG124_2	PG124_3	26°38'46.97"N	80° 04'11.68"W	18' 0"	24' 11"	6' 11"	10:14
123	PG123_1	PG123_2	PG123_3	26°38'48.92"N	80° 04'10.98"W	18' 0"	26' 11"	8' 11"	11:00
122	PG122_1	PG122_2	PG122_3	26°38'49.59"N	80° 4'11.89"W	9' 8"	13' 8"	4' 0"	11:43
120	PG120_1	PG120_2	PG120_3	26°38'51.13"N	80° 4'11.57"W	8' 10'	13' 7"	4' 9"	12:09
119	PG119_1	PG119_2	PG119_3	26°38'51.66"N	80° 4'11.12"W	8' 8"	13' 1"	4' 5"	12:35

Figure 3 Sediment bottom gauge (Site 125).

Accumulated sediment was sampled upstream of the boat using the petite ponar sampling device (Figure 4). For better spatial characterization, three grab sediment samples were collected from the general area at a sampling site and dropped into a stainless-steel bucket. First sample was scooped with a stainless-steel scooper, before stirring the sediment in the stainless-steel bucket, and filled in the first sample bottle for semi-volatile analysis. Samples for semi-volatile analysis can be impacted by stirring. It is recommended that samples for semi-volatiles be collected before stirring. Bottle #2 and #3 were filled after mixing with a stainless-steel stirrer, for analysis of the remaining parameters listed in Table 1.

Table 3 Sediment sampling equipment.

Item	Description
1	Boat
2	Petit Ponar
3	Water depth gauge (marked nylon rope with flat weight)
4	Bottom of sediment depth gauge (four-piece on-site assembled marked metal pipe)
5	Stainless-steel bucket
6	Stainless-steel scoop
7	Stainless-steel stirrer
8	Sample bottles (18) and labels (Lab provided)
9	Fine Sharpe
10	Ice and cooler
11	GPS

Figure 4 Sediment sample being dropped in bucket from the ponar.

4.0 Sediment Samples Lab Analysis Results

At each sampling site (125, 124, 123, 122, 120, 119), three sample bottles were filled and labeled (Ex. PG125 1, PG125 2 and PG125 3). Bottle #1 was used for semi-volatile parameters, OCCPs and PCBs analysis. Bottle #2 was used for Total Nitrogen (TN) analysis. Bottle #3 was used for Total Phosphorus (TP), TOC and metals, including copper, analysis. Lab analysis for all parameters was done by Jupiter Environmental Laboratories except for TN. TN analysis was outsourced to Florida-Spectrum Environmental Services by Jupiter Environmental Laboratories. Laboratory analysis from both labs is attached. The first part of the report is from Jupiter Environmental Laboratories. Each bottle of sample has Lab ID and Sample ID in the lab report (**Appendix A)**. The second part of the lab report is from Florida-Spectrum Environmental Services for TN analytical results. The Lab ID is Client Sample ID in the TN report (**Appendix A**).

Chapter 3: Field Equipment and Field Data Collection

1.0 Overview

SFEC provided a review of the equipment proposed for field sampling in prior reports, including the equipment deployment method, and a review of equipment accuracy, and sampling method. Chapter 3 of the current report provides description of all equipment used to collect all samples required under this work order during all six flow events and describes how samples were collected in the field. Field data collection mainly focused on two parts: collect surface water samples and stream gauging. Both water sample collections and stream gauging took place at the four pre-selected transects (B-1, B-2, B-3, and B-4) depicted in Figure 5.

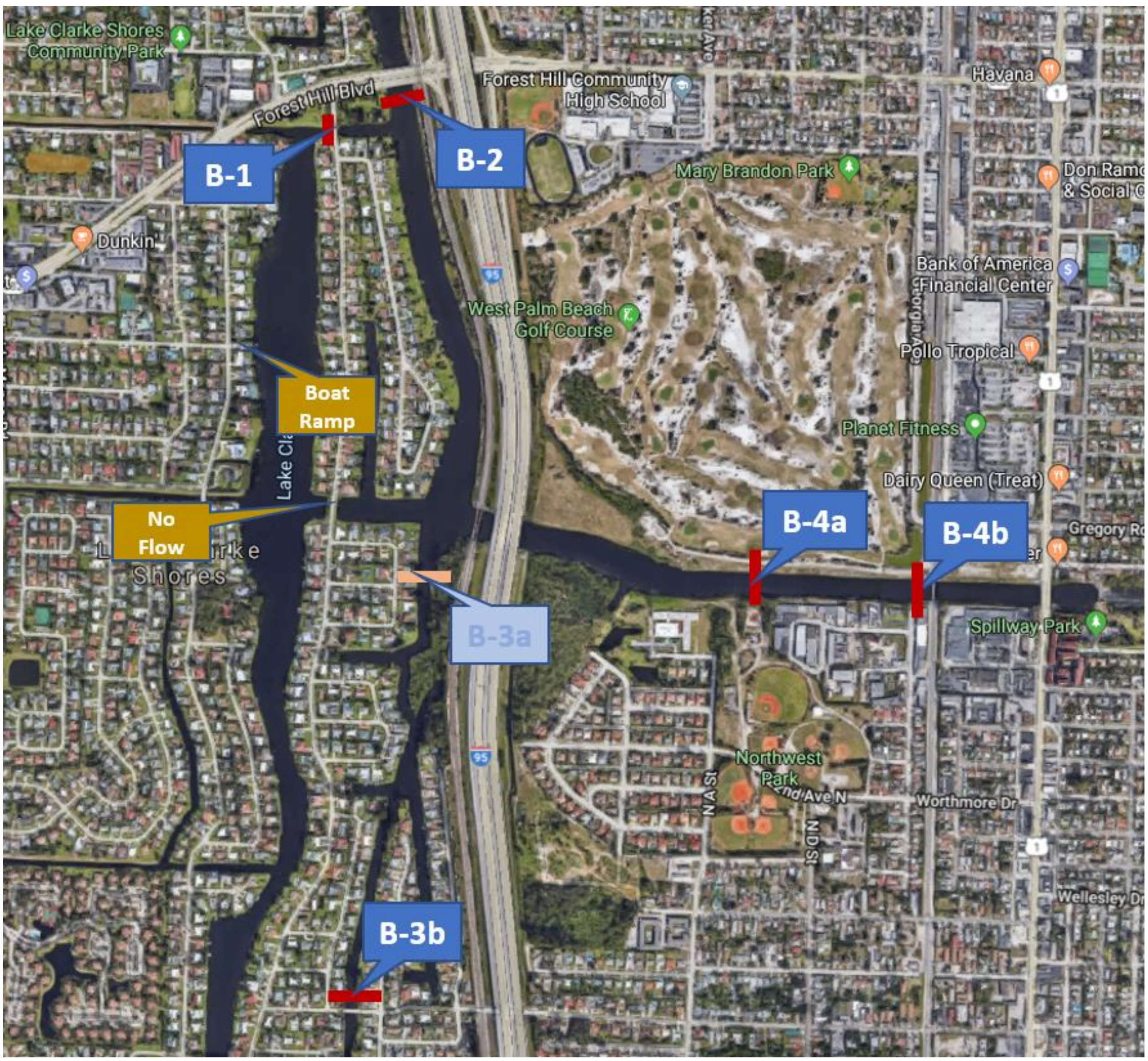


Figure 5 Location of all four transects where water sampling and stream gauging occurred. SFEC used a boat during the first flow event to sample the pre-selected transects (i.e., B-1, B-2, B-3, and B-4). Due to

Covid-19 and to save time and effort, SFEC sampled from alternative locations (bridges). B-3 went from a canal cross section just south of the C-51 to the bridge just upstream (at 17th avenue; B-3b). B-4 was a cross section West of the bridge and railroad (B-4a). The track is a few hundred meters West of the US-1 bridge. B-4 moved East of the US1 bridge (B-4b).

- **Conduct Stream Gauging:** SFEC used standard USGS stream gauging procedures for the determination of flow rates at the four selected C-51cross-sections as shown in Figure 5 to maintain consistency with previous structure rating and other stream gauging work conducted by the District in the canal. All stream gauging (Figure 6) data are described and included in Chapter 4 of this report.

- **Collect Surface Water Samples:** SFEC staff collected Total Suspended Solids (TSS) water samples at the same stream gauging locations (i.e., B-1, B-2, B-3, and B-4; Figure 5). Three vertical TSS water samples profiles were collected, using Nansen bottles to measure total suspended solids (TSS). First vertical profile (TSS) is located midway (center of canal) between the two canal banks of each transects at three water depths (surface=~1 ft, mid-depth, and ~1 ft above bottom; Figure 7). Second and third vertical profiles are located at a distance approximately 1/3 inward of the two canal banks, where TSS water samples were collected at two water depths (surface and mid depth Figure 7); a total of seven TSS water samples at each transect. Those seven TSS water samples collected at all four transects were used to develop TSS water cross-section profiles, for sediment load calculations, during all six flow events. For Covid-19 safety to SFEC staff, all sampling and stream gauging was done from bridges; B-3 site was pushed a bit back to 17th Avenue bridge and B-4 was pushed to the east to Railway bridge upstream of S-155 structure. All field notes regarding water sample collections are included in **Appendix B** of this report.

- **Laboratory Analysis:** All water samples collected at all four transects (Figure 5) were sent for laboratory analysis to determine TSS and TP concentrations. Letter of Acceptance (LOA), Station ID, and laboratory analysis results for both TSS and TP at all four transects are included in **Appendix B** of this report.

2.0 Field Activities

Field data collection is focused on two parts. The focus of the first part is to collect surface water samples, while the second part of the field data collection focuses on stream gauging. Both water sample collections and stream gauging took place at the four pre-selected transects (B-1, B-2, B-3, and B-4) as depicted in Figure 5. Coordinates for cross-sections where stream gauging and water sampling were conducted are listed in **Table 4**. Stream gauging and surface water sampling was conducted during six different predetermined flow events. Equipment for water quality sampling and stream gauging used for this project are listed in **Table 5**.

Table 4 Coordinates for sampling cross-sections.

Cross-Section	Latitude (North)	Longitude (West)
B-1	26 39 14.3	80 04 17.5
B-2	26 39 18.0	80 04 15.2
B-3	26 38 11.0	80 04 19.0
B-4	26 38 41.0	80 03 32.0

Table 5 Equipment for stream gauging and water sampling.

	Stream gauging and sampling equipment
1	Boat
2	ADCP and 16 backup batteries
3	Water depth measure (marked nylon rope with Secchi disk)
4	TSS sample bottles and labels (28)
5	TP sample bottles and labels (4 acidified)
6	Gloves
7	Van Dorn Sampler
8	Sampling Tray
9	Nalgene bucket
10	Fine Sharpe
11	Coolers with ice (2)
12	GPS
13	Rebars
14	Painter tape
15	Tag line Flagging

Six flow events were completed between December 23, 2019 and October 29, 2020. We thank the water managers for holding the flow fairly uniform during the period of stream gauging and water sampling. Sampling and stream gauging started around 8:00-09:00 AM and concluded at the last site approximately by 3:00 PM.

2.1 Stream Gauging:

As noted above, SFEC used standard USGS stream gauging procedures for the determination of flow rates at the four selected C-51cross-sections as shown in Figure 5 to maintain consistency with previous structure rating and other stream gauging work conducted by the District in the canal. All stream gauging data are included in Chapter 4 of this report.

Table 6 S-155 structure flow and dates for all six flow events.

Structure Flow	12/23/2019 (Q ft^3/s)	5/28/2020 (Q ft^3/s)	6/19/2020 (Q ft3/s)	9/11/2020 (Q ft^3/s)	9/16/2020 (Q ft^3/s)	10/29/2020 (Q ft^3/s)
S-155	571	1,068	958	769	1,434	437

SFEC coordinated closely with District operations and project manager during all six flow events. The low flow event occurred on December 23, 2019, September 11, 2020, and October 29, 2020 and the medium flow events were conducted on May 28, 2020 and June 19, 2020 with the high flow event on September 16, 2020 (Table 6). The project plan included three flow categories at the S-155 structure (Low, Moderate, and High). The originally planned flow rates were: High flow ≥ 1600 cfs, Moderate flow = 1,000-1,200 cfs, and Low flow = 100-300 cfs (i.e., < 400 cfs).

Stream gauging was conducted with StreamPro ADCP with Bluetooth USB adapter connection to a laptop. The StreamPro ADCP collects complete set of streamflow measurements in streams or canals Data is collected from a bridge (crossing the canal) or using a tagline depending on the flow rate and site accessibility. Data is conveniently acquired using a mobile device equipped with a highly intuitive user interface, WinRiver II Teledyne RD Instruments. Minimum cell size is 2 cm with up to 30 cells with an upgraded extended profiling range of up to 20 ft (Teledynmarine.com, Accessed January 3, 2020). Stream gauging was conducted at least three to six times at each transect. If successive results differed by greater than 5%, the transect was resampled (minimum N=3). All measured flow values were used as explained for method #3 in Chapter 4.

Figure 6 Stream gauging using a tag line at a Transect.

2.2 Surface Water Samples:

SFEC staff collected Total Suspended Solids (TSS) water samples at the same stream gauging locations (i.e., B-1, B-2, B-3, and B-4; Figure 5). A total of seven TSS water samples were collected at each transect (Figure 7). Those seven TSS water samples were used to develop TSS water cross-section profiles, for sediment load calculations, during all six flow events. All field notes regarding water sample collections are included in **Appendix B** of this report.

2.3 Laboratory Analysis:

Water samples collected at all four transects (Figure 1) were sent for laboratory analysis to determine TSS and TP concentrations. Letter of Acceptance (LOA), Station ID, and laboratory analysis results for both TSS and TP at all four transects are included in **Appendix B** of this report.

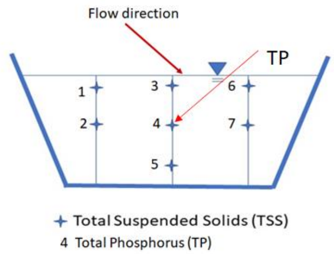


Figure 7 Total suspended solids sampling (TSS) locations lay-out in a cross-section, where velocity profile is measured; a total of seven (7) samples per transect. Sampling for TP is at sampling point #4. Water quality sampling schema is the same for all four-transect.

3.0 Water Quality Sampling Procedure

At the morning of every flow event, the necessary equipment for stream gauging and surface water sampling were assembled and transported to the site. For the first five events SFEC staff collected water samples at the four transects in the following order: B-1, B-2, B-3, and then B-4. At the last event, SFEC staff collected water samples starting at B-4 and followed by B-1, B-2 and finally B-3. Stream gauging started at B-4 and followed by B-1, B-2 and finally B-3 (Figure 5). Total canal depth at sampling point, sampling water depth and time of sampling were recorded. Figure 7 depicts sampling points for total suspended solids sampling (TSS) across each cross-section and sampling station for TP. A total of seven (7) samples were collected for TSS analysis at each cross-section at different points and depths in the canal using the Van Dorn grab sampler (SFWMD, 2017; Figure 8). One TP sample at each cross-section was collected at sampling point 4 (Figure 7). Samples were stored in respective sampling bottles provided by the lab. TP samples were collected in acidified bottles for sample preservation. All samples were stored on ice once collected. Sampling scheme depicted is the same for all four-stream gauging transects. Water samples were collected with Van Dorn grab sampler (Figure 8) at each sampling point.

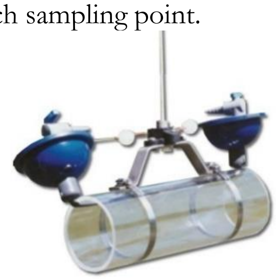


Figure 8 Van Dorn grab sampler.

Parameters and analytic methods are shown in Table 7. Twenty-eight TSS and four TP samples were submitted to Jupiter Environmental Laboratories (JEL) for analysis for the required parameters on each sample date. All samples were stored on ice and delivered for analysis within the required sample hold times. Detail lab results and lab QA/QC report are shown in **Appendix B**. Letter of Acceptance (LOA), Station ID, and laboratory analysis results for both TSS and TP at all four transects and all field notes regarding water sample collections are included in **Appendix B** of this report.

Table 7 Water quality parameters and analytical methods used.

Parameter	Method
TSS	SM 2540D
TP	EPA 365.3

Chapter 4: Data Analysis and Results

1.0 Overview

Chapter 4 of this report summarizes all field data collected under this work order and provides data analysis and the results of different methods used to determine C-51 trap efficiency for all six-flow events. Details of TSS sampling and stream gauging event are covered in Chapter 2 and 3 of this report. Calculations were made to determine sediment trap efficiency that combines all inflows into one (B-1 + B-2 + B-3) and determine how much of that sediment load is trapped based on the outflow sediment load (B-4). The results of load calculations using observed TSS values and measured stream gauging flows for all six preselected events are based on field-collected data+ between December 23, 2019 and October 29, 2020.

Summary of TSS water sample results, sediment load into and out of the C-51 trap at all transects (B-1, B-2, B-3, and B-4), and trap efficiency are presented herein. All six flow events represent three low flow (i.e., $Q_{S\text{-}155}$ = 571, 770, and 437 cfs), two medium flow (i.e., $Q_{S\text{-}155}$ = 1,068 and 958 cfs), and one high flow event (i.e., $Q_{S\text{-}155}$ = 1,434 cfs). Summary of the flow at S-155 and at transect B-4 (outflow) and dates of all six flow events are listed in Table 8. In general, we followed three methods to calculate TSS loads into and out of the C-51 sediment trap. The main reason for calculating sediment loads via three different methods was to ensure that we consider all possible scenarios that may impact sediment mass balance calculations. First method used average measured flows at the four selected transects and average TSS observed values at all transects but excluded all TSS values listed as "u*" to calculate sediment loads. In the second method, SFEC used average measured flows at the four selected transects and average TSS observed values at all transects but substituted half the TSS laboratory detection value of (MDL= 4) 2.0 mg L^{-1} for all TSS values listed as "u*" to calculate sediment loads. In the third method, SFEC adjusted average measured flows at the three selected transects by a percentage (i.e., flow proportional), based on that transect contributions of the total flow, to ensure that the difference between inflow and outflow discharges is zero (i.e., steady state flow conditions). This was also combined with TSS value of 2.0 mg L^{-1} for all TSS values listed as "u*" to calculate sediment loads and trap efficiency. Statistical tests (*t* test for significance) were used to investigate if there is a statistically significant differences among those methods, particularly for TSS concentrations; it seems that TSS measured values are more susceptible to wide range of uncertainty (MDL and PQL are 4 and 16 mg L^{-1}, respectively) and had more below detection values combined with extremely low concentrations. On the contrary, stream gauging data had less certainty compared to TSS, and therefore, method #3 was selected and used throughout the report to calculate sediment load and estimate the C-51 sediment trap efficiency.

Table 8 Comparison of upstream (inflow = B-1 + B-2 + B-3)) and downstream (outflow = B-4) flows for all stream gauging six events. Green cells represent low-flow events, Blue cell represent mid-range flow event, while No color cells represent high-flow event.

Flow gauging site	12/23/2019 (Q ft^3/s)	5/28/2020 (Q ft^3/s)	6/19/2020 (Q ft^3/s)	9/11/2020 (Q ft^3/s)	9/16/2020 (Q ft^3/s)	10/29/2020 (Q ft^3/s)
B-1+B-2+B-3	761.87	911.87	791.88	671.21	1,386.73	693.67
B-4	588.40	1,132.39	1,142.91	837.25	1,459.74	459.51
S-155	571.10	1,068.39	957.71	769.82	1434.16	437.54

2.0 Water Sampling Results

SFEC staff collected Total Suspended Solids (TSS) and Total Phosphorus (TP) Water Samples at the same stream gauging locations (i.e., B-1, B-2, B-3, and B-4; Figure 5). A total of seven TSS samples and one TP sample were taken at each of the four transects during all six flow events. Summary of stream gauging results from the four cross sections are listed in Table 8. Lab results of TSS samples at each of the seven sampling points in each cross section are listed in Table 9 and average TSS concentration is computed for load calculation, while Figure 9 summarizes TSS observed values in a box and whisker format.

2.1 Total Suspended Solids (TSS)

Summary of the lab results for TSS are listed in Table 9. EPA analytical Method SM 2540D was used to determine TSS concentrations in the water sample. In the JEL report, almost all TSS values are flagged with an "i" indicating the reported value is between the laboratory method detection limit (MDL) and the practical quantitation limit (PQL). SFWMD also have similar flag for S155 TSS data below the detection limit. Key Laboratory Definitions for Water Quality Samples: MDL (method detection limit), is the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix type containing the analyte. PQL (Practical Quantitation Limit): is the lowest level of measurement that can be reliably achieved during routine laboratory operating conditions within specified limits of precision and accuracy.

Table 9 Observed total suspended solids (TSS) concentrations at all selected four transects during all six-flow events. Yellow cells indicate substitution of 2 mg L^{-1} (half the minimum detection value for TSS) in place of below minimum detection level (u*), while clear cells indicate actual measured values.

12/23/2019							
B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1B1L1	5.30	1B2L1	6.00	1B3L1	5.30	1B4L1	2.00
2B1L1	4.00	2B2L1	5.20	2B3L1	4.60	2B4L1	7.40
3B1L1	4.40	3B2L1	4.40	3B3L1	4.50	3B4L1	4.50
4B1L1	4.30	4B2L1	7.00	4B3L1	4.60	4B4L1	4.90
5B1L1	4.40	5B2L1	5.60	5B3L1	5.20	5B4L1	4.50
6B1L1	4.70	6B2L1	4.60	6B3L1	4.30	6B4L1	4.50
7B1L1	4.00	7B2L1	6.00	7B3L1	4.20	7B4L1	5.10

5/28/2020							
B-1 (Sample ID)	**TSS (mg/L)**	**B-2 (Sample ID)**	**TSS (mg/L)**	**B-3 (Sample ID)**	**TSS (mg/L)**	**B-4 (Sample ID)**	**TSS (mg/L)**
1B1M1	2.00	1B2M1	6.50	1B3M1	6.70	1B4M1	8.10
2B1M1	2.00	2B2M1	7.70	2B3M1	23.00	2B4M1	7.20
3B1M1	4.60	3B2M1	4.80	3B3M1	7.70	3B4M1	5.90
4B1M1	4.50	4B2M1	5.00	4B3M1	7.00	4B4M1	5.30
5B1M1	4.70	5B2M1	4.70	5B3M1	7.80	5B4M1	7.90
6B1M1	4.50	6B2M1	5.40	6B3M1	8.00	6B4M1	5.10
7B1M1	4.40	7B2M1	5.10	7B3M1	25.00	7B4M1	6.00
6/19/2020							
B-1 (Sample ID)	**TSS (mg/L)**	**B-2 (Sample ID)**	**TSS (mg/L)**	**B-3 (Sample ID)**	**TSS (mg/L)**	**B-4 (Sample ID)**	**TSS (mg/L)**
1B1M2	5.80	1B2M2	6.40	1B3M2	6.20	1B4M2	5.00
2B1M2	5.20	2B2M2	6.20	2B3M2	7.40	2B4M2	6.10
3B1M2	5.40	3B2M2	4.10	3B3M2	6.60	3B4M2	5.20
4B1M2	5.40	4B2M2	4.90	4B3M2	6.90	4B4M2	6.70
5B1M2	5.00	5B2M2	13.00	5B3M2	7.00	5B4M2	8.70
6B1M2	5.80	6B2M2	4.80	6B3M2	6.40	6B4M2	6.10
7B1M2	2.00	7B2M2	4.80	7B3M2	7.40	7B4M2	6.40
9/11/2020							
B-1 (Sample ID)	**TSS (mg/L)**	**B-2 (Sample ID)**	**TSS (mg/L)**	**B-3b (Sample ID)**	**TSS (mg/L)**	**B-4b (Sample ID)**	**TSS (mg/L)**
1B1H1	4.20	1B2H1	4.60	1B3H1	6.80	1B4H1	5.40
2B1H1	4.20	2B2H1	5.00	2B3H1	8.60	2B4H1	6.80
3B1H1	5.00	3B2H1	4.60	3B3H1	7.00	3B4H1	5.00
4B1H1	4.80	4B2H1	5.60	4B3H1	7.40	4B4H1	5.60
5B1H1	5.20	5B2H1	5.80	5B3H1	6.60	5B4H1	7.60
6B1H1	5.40	6B2H1	4.40	6B3H1	6.80	6B4H1	6.80
7B1H1	5.20	7B2H1	5.20	7B3H1	6.20	7B4H1	6.80

9/16/2020							
B-1 (Sample ID)	**TSS (mg/L)**	**B-2 (Sample ID)**	**TSS (mg/L)**	**B-3 (Sample ID)**	**TSS (mg/L)**	**B-4 (Sample ID)**	**TSS (mg/L)**
1B1M2	5.20	1B2M2	4.00	1B3M2	6.60	1B4M2	4.20
2B1M2	5.00	2B2M2	7.60	2B3M2	7.80	2B4M2	5.00
3B1M2	5.00	3B2M2	2.00	3B3M2	8.40	3B4M2	4.20
4B1M2	4.80	4B2M2	5.60	4B3M2	8.80	4B4M2	6.00
5B1M2	4.20	5B2M2	11.00	5B3M2	8.00	5B4M2	37.00
6B1M2	4.60	6B2M2	4.40	6B3M2	7.80	6B4M2	4.80
7B1M2	4.60	7B2M2	4.00	7B3M2	7.80	7B4M2	5.60
10/29/2020							
B-1 (Sample ID)	**TSS (mg/L)**	**B-2 (Sample ID)**	**TSS (mg/L)**	**B-3 (Sample ID)**	**TSS (mg/L)**	**B-4 (Sample ID)**	**TSS (mg/L)**
1B1M2	4.40	1B2M2	2.00	1B3M2	2.00	1B4M2	2.00
2B1M2	2.00	2B2M2	4.00	2B3M2	2.00	2B4M2	2.00
3B1M2	4.20	3B2M2	2.00	3B3M2	2.00*	3B4M2	2.00
4B1M2	4.20	4B2M2	4.20	4B3M2	2.00	4B4M2	5.00
5B1M2	4.00	5B2M2	7.00	5B3M2	39.00	5B4M2	2.00*
6B1M2	2.00	6B2M2	2.00	6B3M2	2.00	6B4M2	2.00
7B1M2	2.00	7B2M2	4.60	7B3M2	2.00*	7B4M2	5.20

2.1.1 TSS data analysis results/presentation:

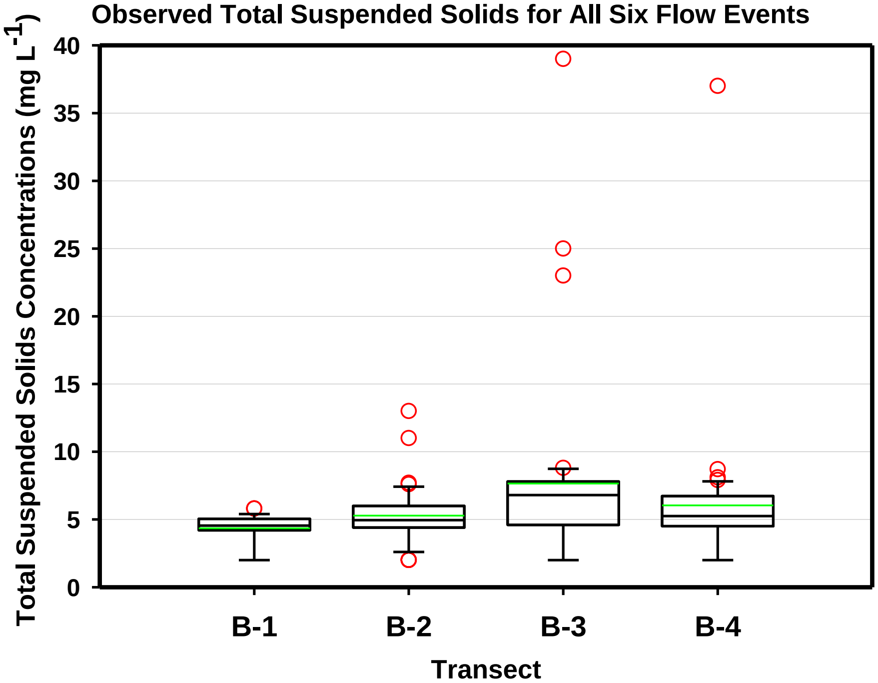
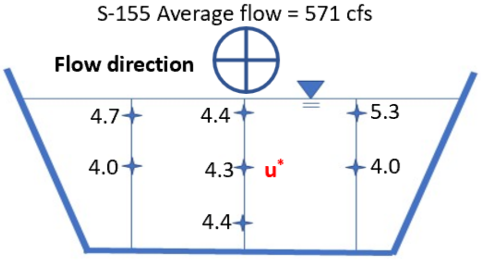


Figure 9 Observed total suspended solids at all four transects (average of seven observation per transect) and during all six flow events.

Location	B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1	1B1L1	5.30	1B2L1	6.00	1B3L1	5.30	1B4L1	u*
2	2B1L1	4.00	2B2L1	5.20	2B3L1	4.60	2B4L1	7.40
3	3B1L1	4.40	3B2L1	4.40	3B3L1	4.50	3B4L1	4.50
4	4B1L1	4.30	4B2L1	7.00	4B3L1	4.60	4B4L1	4.90
5	5B1L1	4.40	5B2L1	5.60	5B3L1	5.20	5B4L1	4.50
6	6B1L1	4.70	6B2L1	4.60	6B3L1	4.30	6B4L1	4.50
7	7B1L1	4.00	7B2L1	6.00	7B3L1	4.20	7B4L1	5.10
Average		4.44		5.54		4.67		5.15
Center	TP_4B1L1	u*	TP_4B2L1	u*	TP_4B3L1	u*	TP_4B4L1	u*

S-155 Average flow = 571 cfs

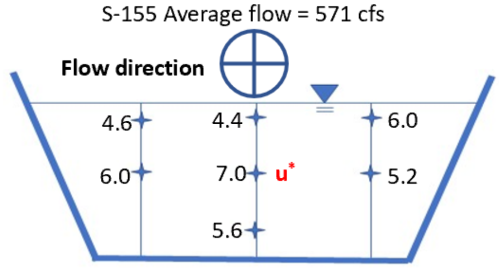


Total Suspended Solids (TSS)

Total Phosphorus (TP)
12/23/2019
Transect B-1

Location	B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1	1B1L1	5.30	1B2L1	6.00	1B3L1	5.30	1B4L1	u*
2	2B1L1	4.00	2B2L1	5.20	2B3L1	4.60	2B4L1	7.40
3	3B1L1	4.40	3B2L1	4.40	3B3L1	4.50	3B4L1	4.50
4	4B1L1	4.30	4B2L1	7.00	4B3L1	4.60	4B4L1	4.90
5	5B1L1	4.40	5B2L1	5.60	5B3L1	5.20	5B4L1	4.50
6	6B1L1	4.70	6B2L1	4.60	6B3L1	4.30	6B4L1	4.50
7	7B1L1	4.00	7B2L1	6.00	7B3L1	4.20	7B4L1	5.10
Average		4.44		5.54		4.67		5.15
Center	TP_4B1L1	u*	TP_4B2L1	u*	TP_4B3L1	u*	TP_4B4L1	u*

S-155 Average flow = 571 cfs

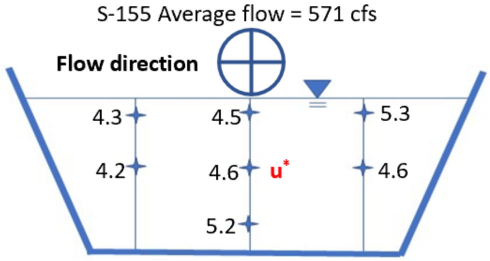


Total Suspended Solids (TSS)

Total Phosphorus (TP)
12/23/2019
Transect B-2

Location	B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1	1B1L1	5.30	1B2L1	6.00	1B3L1	5.30	1B4L1	u*
2	2B1L1	4.00	2B2L1	5.20	2B3L1	4.60	2B4L1	7.40
3	3B1L1	4.40	3B2L1	4.40	3B3L1	4.50	3B4L1	4.50
4	4B1L1	4.30	4B2L1	7.00	4B3L1	4.60	4B4L1	4.90
5	5B1L1	4.40	5B2L1	5.60	5B3L1	5.20	5B4L1	4.50
6	6B1L1	4.70	6B2L1	4.60	6B3L1	4.30	6B4L1	4.50
7	7B1L1	4.00	7B2L1	6.00	7B3L1	4.20	7B4L1	5.10
Average		4.44		5.54		4.67		5.15
Center	TP_4B1L1	u*	TP_4B2L1	u*	TP_4B3L1	u*	TP_4B4L1	u*

S-155 Average flow = 571 cfs

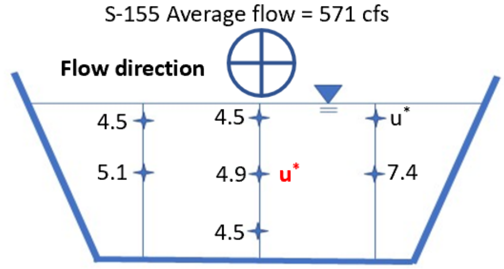


Total Suspended Solids (TSS)

Total Phosphorus (TP)
12/23/2019
Transect B-3

Location	B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1	1B1L1	5.30	1B2L1	6.00	1B3L1	5.30	1B4L1	u*
2	2B1L1	4.00	2B2L1	5.20	2B3L1	4.60	2B4L1	7.40
3	3B1L1	4.40	3B2L1	4.40	3B3L1	4.50	3B4L1	4.50
4	4B1L1	4.30	4B2L1	7.00	4B3L1	4.60	4B4L1	4.90
5	5B1L1	4.40	5B2L1	5.60	5B3L1	5.20	5B4L1	4.50
6	6B1L1	4.70	6B2L1	4.60	6B3L1	4.30	6B4L1	4.50
7	7B1L1	4.00	7B2L1	6.00	7B3L1	4.20	7B4L1	5.10
Average		4.44		5.54		4.67		5.15
Center	TP_4B1L1	u*	TP_4B2L1	u*	TP_4B3L1	u*	TP_4B4L1	u*

S-155 Average flow = 571 cfs

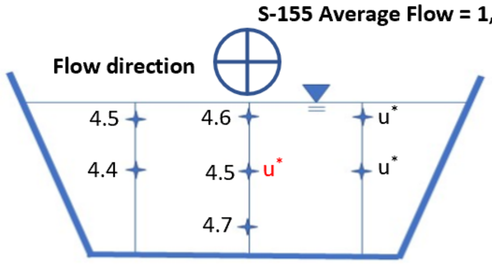


Total Suspended Solids (TSS)

Total Phosphorus (TP)
12/23/2019
Transect B-4

Location	B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1	1B1M1	u	1B2M1	6.50	1B3M1	6.70	1B4M1	8.10
2	2B1M1	u	2B2M1	7.70	2B3M1	23.00	2B4M1	7.20
3	3B1M1	4.60	3B2M1	4.80	3B3M1	7.70	3B4M1	5.90
4	4B1M1	4.50	4B2M1	5.00	4B3M1	7.00	4B4M1	5.30
5	5B1M1	4.70	5B2M1	4.70	5B3M1	7.80	5B4M1	7.90
6	6B1M1	4.50	6B2M1	5.40	6B3M1	8.00	6B4M1	5.10
7	7B1M1	4.40	7B2M1	5.10	7B3M1	25.00	7B4M1	6.00
Average		4.54	Average	5.60	Average	12.17	Average	6.50
Center	TP_4B1M1	u*	TP_4B2M1	u*	TP_4B3M1	u*	TP_4B4M1	u*

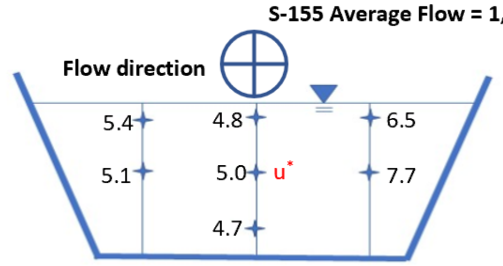
S-155 Average Flow = 1,063 cfs



Total Suspended Solids (TSS)
Total Phosphorus (TP)
05/28/2020
Transect B-1

Location	B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1	1B1M1	u	1B2M1	6.50	1B3M1	6.70	1B4M1	8.10
2	2B1M1	u	2B2M1	7.70	2B3M1	23.00	2B4M1	7.20
3	3B1M1	4.60	3B2M1	4.80	3B3M1	7.70	3B4M1	5.90
4	4B1M1	4.50	4B2M1	5.00	4B3M1	7.00	4B4M1	5.30
5	5B1M1	4.70	5B2M1	4.70	5B3M1	7.80	5B4M1	7.90
6	6B1M1	4.50	6B2M1	5.40	6B3M1	8.00	6B4M1	5.10
7	7B1M1	4.40	7B2M1	5.10	7B3M1	25.00	7B4M1	6.00
Average		4.54	Average	5.60	Average	12.17	Average	6.50
Center	TP_4B1M1	u*	TP_4B2M1	u*	TP_4B3M1	u*	TP_4B4M1	u*

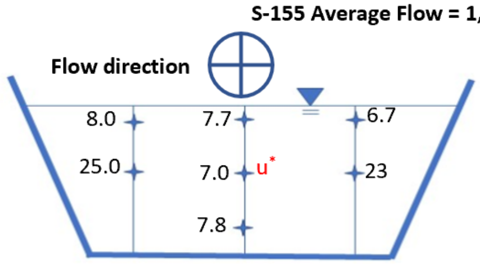
S-155 Average Flow = 1,063 cfs



Total Suspended Solids (TSS)
Total Phosphorus (TP)
05/28/2020
Transect B-2

Location	B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1	1B1M1	u	1B2M1	6.50	1B3M1	6.70	1B4M1	8.10
2	2B1M1	u	2B2M1	7.70	2B3M1	23.00	2B4M1	7.20
3	3B1M1	4.60	3B2M1	4.80	3B3M1	7.70	3B4M1	5.90
4	4B1M1	4.50	4B2M1	5.00	4B3M1	7.00	4B4M1	5.30
5	5B1M1	4.70	5B2M1	4.70	5B3M1	7.80	5B4M1	7.90
6	6B1M1	4.50	6B2M1	5.40	6B3M1	8.00	6B4M1	5.10
7	7B1M1	4.40	7B2M1	5.10	7B3M1	25.00	7B4M1	6.00
Average		4.54	Average	5.60	Average	12.17	Average	6.50
Center	TP_4B1M1	u*	TP_4B2M1	u*	TP_4B3M1	u*	TP_4B4M1	u*

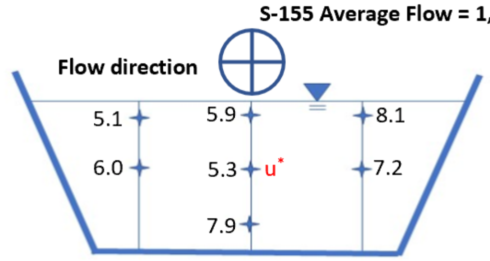
S-155 Average Flow = 1,063 cfs



Total Suspended Solids (TSS)
Total Phosphorus (TP)
05/28/2020
Transect B-3

Location	B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1	1B1M1	u	1B2M1	6.50	1B3M1	6.70	1B4M1	8.10
2	2B1M1	u	2B2M1	7.70	2B3M1	23.00	2B4M1	7.20
3	3B1M1	4.60	3B2M1	4.80	3B3M1	7.70	3B4M1	5.90
4	4B1M1	4.50	4B2M1	5.00	4B3M1	7.00	4B4M1	5.30
5	5B1M1	4.70	5B2M1	4.70	5B3M1	7.80	5B4M1	7.90
6	6B1M1	4.50	6B2M1	5.40	6B3M1	8.00	6B4M1	5.10
7	7B1M1	4.40	7B2M1	5.10	7B3M1	25.00	7B4M1	6.00
Average		4.54	Average	5.60	Average	12.17	Average	6.50
Center	TP_4B1M1	u*	TP_4B2M1	u*	TP_4B3M1	u*	TP_4B4M1	u*

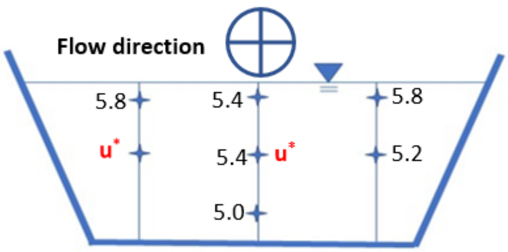
S-155 Average Flow = 1,063 cfs



Total Suspended Solids (TSS)
Total Phosphorus (TP)
05/28/2020
Transect B-4

Location	B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1	1B1M2	5.80	1B2M2	6.40	1B3M2	6.20	1B4M2	5.00
2	2B1M2	5.20	2B2M2	6.20	2B3M2	7.40	2B4M2	6.10
3	3B1M2	5.40	3B2M2	4.10	3B3M2	6.60	3B4M2	5.20
4	4B1M2	5.40	4B2M2	4.90	4B3M2	6.90	4B4M2	6.70
5	5B1M2	5.00	5B2M2	13.00	5B3M2	7.00	5B4M2	8.70
6	6B1M2	5.80	6B2M2	4.80	6B3M2	6.40	6B4M2	6.10
7	7B1M2	u*	7B2M2	4.80	7B3M2	7.40	7B4M2	6.40
Average		5.43		6.31		6.84		6.31
Center	TP_4B1M2	u*	TP_4B2M2	u*	TP_4B3M2	0.02	TP_4B4M2	u*

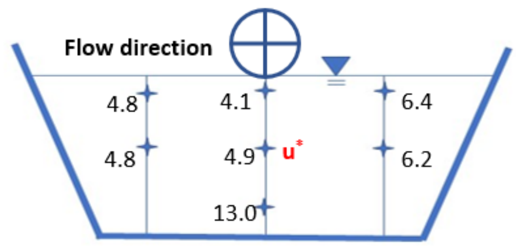
S-155 Average Flow = 958 cfs



Total Suspended Solids (TSS)
Total Phosphorus (TP)
06/19/2020
Transect B-1

Location	B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1	1B1M2	5.80	1B2M2	6.40	1B3M2	6.20	1B4M2	5.00
2	2B1M2	5.20	2B2M2	6.20	2B3M2	7.40	2B4M2	6.10
3	3B1M2	5.40	3B2M2	4.10	3B3M2	6.60	3B4M2	5.20
4	4B1M2	5.40	4B2M2	4.90	4B3M2	6.90	4B4M2	6.70
5	5B1M2	5.00	5B2M2	13.00	5B3M2	7.00	5B4M2	8.70
6	6B1M2	5.80	6B2M2	4.80	6B3M2	6.40	6B4M2	6.10
7	7B1M2	u*	7B2M2	4.80	7B3M2	7.40	7B4M2	6.40
Average		5.43		6.31		6.84		6.31
Center	TP_4B1M2	u*	TP_4B2M2	u*	TP_4B3M2	0.02	TP_4B4M2	u*

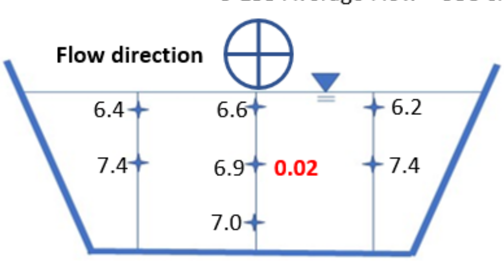
S-155 Average Flow = 958 cfs



Total Suspended Solids (TSS)
Total Phosphorus (TP)
06/19/2020
Transect B-2

Location	B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1	1B1M2	5.80	1B2M2	6.40	1B3M2	6.20	1B4M2	5.00
2	2B1M2	5.20	2B2M2	6.20	2B3M2	7.40	2B4M2	6.10
3	3B1M2	5.40	3B2M2	4.10	3B3M2	6.60	3B4M2	5.20
4	4B1M2	5.40	4B2M2	4.90	4B3M2	6.90	4B4M2	6.70
5	5B1M2	5.00	5B2M2	13.00	5B3M2	7.00	5B4M2	8.70
6	6B1M2	5.80	6B2M2	4.80	6B3M2	6.40	6B4M2	6.10
7	7B1M2	u*	7B2M2	4.80	7B3M2	7.40	7B4M2	6.40
Average		5.43		6.31		6.84		6.31
Center	TP_4B1M2	u*	TP_4B2M2	u*	TP_4B3M2	0.02	TP_4B4M2	u*

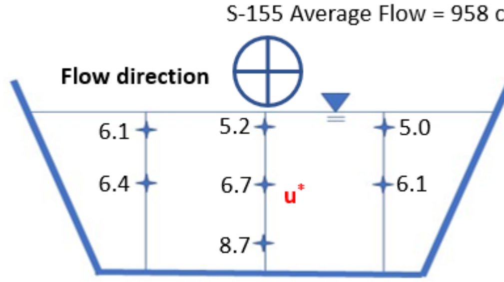
S-155 Average Flow = 958 cfs



Total Suspended Solids (TSS)
Total Phosphorus (TP)
06/19/2020
Transect B-3

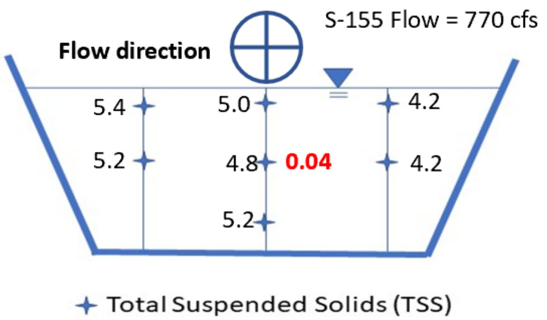
Location	B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1	1B1M2	5.80	1B2M2	6.40	1B3M2	6.20	1B4M2	5.00
2	2B1M2	5.20	2B2M2	6.20	2B3M2	7.40	2B4M2	6.10
3	3B1M2	5.40	3B2M2	4.10	3B3M2	6.60	3B4M2	5.20
4	4B1M2	5.40	4B2M2	4.90	4B3M2	6.90	4B4M2	6.70
5	5B1M2	5.00	5B2M2	13.00	5B3M2	7.00	5B4M2	8.70
6	6B1M2	5.80	6B2M2	4.80	6B3M2	6.40	6B4M2	6.10
7	7B1M2	u*	7B2M2	4.80	7B3M2	7.40	7B4M2	6.40
Average		5.43		6.31		6.84		6.31
Center	TP_4B1M2	u*	TP_4B2M2	u*	TP_4B3M2	0.02	TP_4B4M2	u*

S-155 Average Flow = 958 cfs



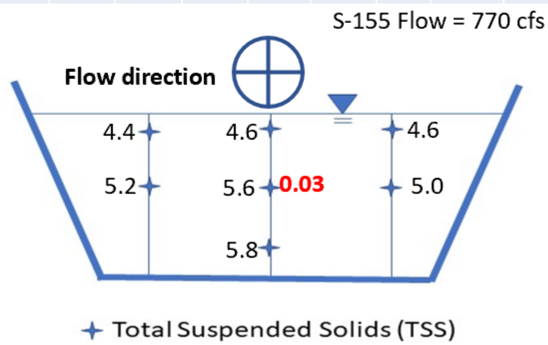
Total Suspended Solids (TSS)
Total Phosphorus (TP)
06/19/2020
Transect B-4

location	B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1	1B1H1	4.20	1B2H1	4.60	1B3H1	6.80	1B4H1	5.40
2	2B1H1	4.20	2B2H1	5.00	2B3H1	8.60	2B4H1	6.80
3	3B1H1	5.00	3B2H1	4.60	3B3H1	7.00	3B4H1	5.00
4	4B1H1	4.80	4B2H1	5.60	4B3H1	7.40	4B4H1	5.60
5	5B1H1	5.20	5B2H1	5.80	5B3H1	6.60	5B4H1	7.60
6	6B1H1	5.40	6B2H1	4.40	6B3H1	6.80	6B4H1	6.80
7	7B1H1	5.20	7B2H1	5.20	7B3H1	6.20	7B4H1	6.80
Average		4.86		5.03		7.06		6.29
Center	TPB1H1	0.04		0.03		u*		0.04



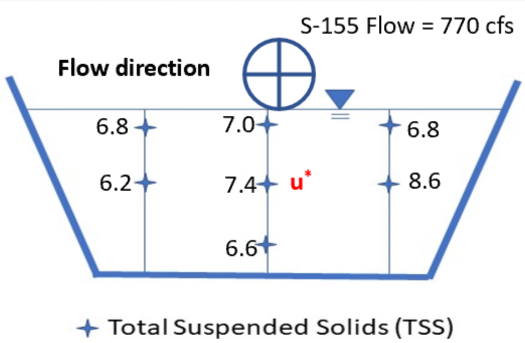
Total Phosphorus (TP)
09/11/2020
Transect B-1

location	B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1	1B1H1	4.20	1B2H1	4.60	1B3H1	6.80	1B4H1	5.40
2	2B1H1	4.20	2B2H1	5.00	2B3H1	8.60	2B4H1	6.80
3	3B1H1	5.00	3B2H1	4.60	3B3H1	7.00	3B4H1	5.00
4	4B1H1	4.80	4B2H1	5.60	4B3H1	7.40	4B4H1	5.60
5	5B1H1	5.20	5B2H1	5.80	5B3H1	6.60	5B4H1	7.60
6	6B1H1	5.40	6B2H1	4.40	6B3H1	6.80	6B4H1	6.80
7	7B1H1	5.20	7B2H1	5.20	7B3H1	6.20	7B4H1	6.80
Average		4.86		5.03		7.06		6.29
Center	TPB1H1	0.04		0.03		u*		0.04



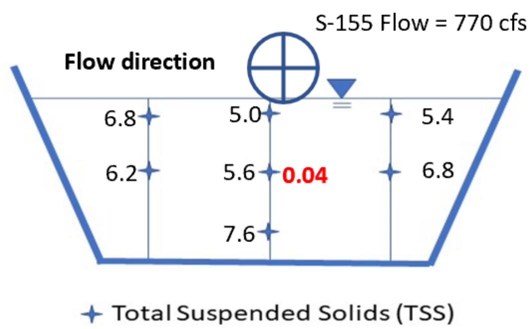
Total Phosphorus (TP)
09/11/2020
Transect B-2

location	B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1	1B1H1	4.20	1B2H1	4.60	1B3H1	6.80	1B4H1	5.40
2	2B1H1	4.20	2B2H1	5.00	2B3H1	8.60	2B4H1	6.80
3	3B1H1	5.00	3B2H1	4.60	3B3H1	7.00	3B4H1	5.00
4	4B1H1	4.80	4B2H1	5.60	4B3H1	7.40	4B4H1	5.60
5	5B1H1	5.20	5B2H1	5.80	5B3H1	6.60	5B4H1	7.60
6	6B1H1	5.40	6B2H1	4.40	6B3H1	6.80	6B4H1	6.80
7	7B1H1	5.20	7B2H1	5.20	7B3H1	6.20	7B4H1	6.80
Average		4.86		5.03		7.06		6.29
Center	TPB1H1	0.04		0.03		u*		0.04



Total Phosphorus (TP)
09/11/2020
Transect B-3

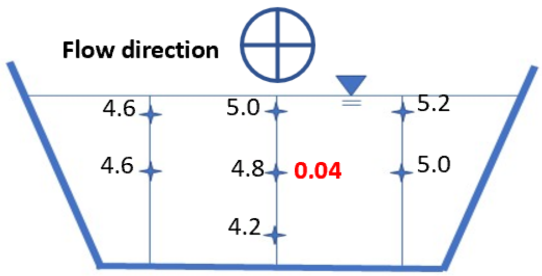
location	B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1	1B1H1	4.20	1B2H1	4.60	1B3H1	6.80	1B4H1	5.40
2	2B1H1	4.20	2B2H1	5.00	2B3H1	8.60	2B4H1	6.80
3	3B1H1	5.00	3B2H1	4.60	3B3H1	7.00	3B4H1	5.00
4	4B1H1	4.80	4B2H1	5.60	4B3H1	7.40	4B4H1	5.60
5	5B1H1	5.20	5B2H1	5.80	5B3H1	6.60	5B4H1	7.60
6	6B1H1	5.40	6B2H1	4.40	6B3H1	6.80	6B4H1	6.80
7	7B1H1	5.20	7B2H1	5.20	7B3H1	6.20	7B4H1	6.80
Average		4.86		5.03		7.06		6.29
Center	TPB1H1	0.04		0.03		u*		0.04



Total Phosphorus (TP)
09/11/2020
Transect B-4

Location	B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1	1B1M2	5.20	1B2M2	4.00	1B3M2	6.60	1B4M2	4.20
2	2B1M2	5.00	2B2M2	7.60	2B3M2	7.80	2B4M2	5.00
3	3B1M2	5.00	3B2M2	u*	3B3M2	8.40	3B4M2	4.20
4	4B1M2	4.80	4B2M2	5.60	4B3M2	8.80	4B4M2	6.00
5	5B1M2	4.20	5B2M2	11.00	5B3M2	8.00	5B4M2	37.00
6	6B1M2	4.60	6B2M2	4.40	6B3M2	7.80	6B4M2	4.80
7	7B1M2	4.60	7B2M2	4.00	7B3M2	7.80	7B4M2	5.60
Average		4.77		6.10		7.89		9.54
Center		0.043		0.033		0.062		0.034

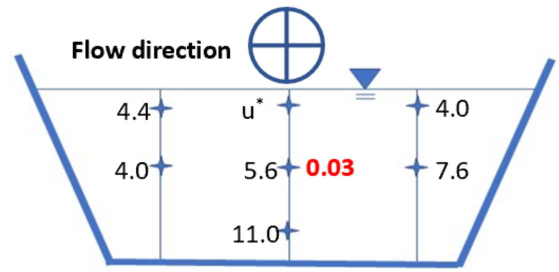
S-155 Flow Average = 1,433 cfs



Total Suspended Solids (TSS)
Total Phosphorus (TP)
09/16/2020
Transect B-1

Location	B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1	1B1M2	5.20	1B2M2	4.00	1B3M2	6.60	1B4M2	4.20
2	2B1M2	5.00	2B2M2	7.60	2B3M2	7.80	2B4M2	5.00
3	3B1M2	5.00	3B2M2	u*	3B3M2	8.40	3B4M2	4.20
4	4B1M2	4.80	4B2M2	5.60	4B3M2	8.80	4B4M2	6.00
5	5B1M2	4.20	5B2M2	11.00	5B3M2	8.00	5B4M2	37.00
6	6B1M2	4.60	6B2M2	4.40	6B3M2	7.80	6B4M2	4.80
7	7B1M2	4.60	7B2M2	4.00	7B3M2	7.80	7B4M2	5.60
Average		4.77		6.10		7.89		9.54
Center		0.043		0.033		0.062		0.034

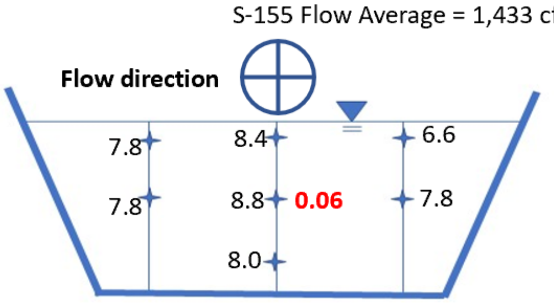
S-155 Flow Average = 1,433 cfs



Total Suspended Solids (TSS)
Total Phosphorus (TP)
09/16/2020
Transect B-2

Location	B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1	1B1M2	5.20	1B2M2	4.00	1B3M2	6.60	1B4M2	4.20
2	2B1M2	5.00	2B2M2	7.60	2B3M2	7.80	2B4M2	5.00
3	3B1M2	5.00	3B2M2	u*	3B3M2	8.40	3B4M2	4.20
4	4B1M2	4.80	4B2M2	5.60	4B3M2	8.80	4B4M2	6.00
5	5B1M2	4.20	5B2M2	11.00	5B3M2	8.00	5B4M2	37.00
6	6B1M2	4.60	6B2M2	4.40	6B3M2	7.80	6B4M2	4.80
7	7B1M2	4.60	7B2M2	4.00	7B3M2	7.80	7B4M2	5.60
Average		4.77		6.10		7.89		9.54
Center		0.043		0.033		0.062		0.034

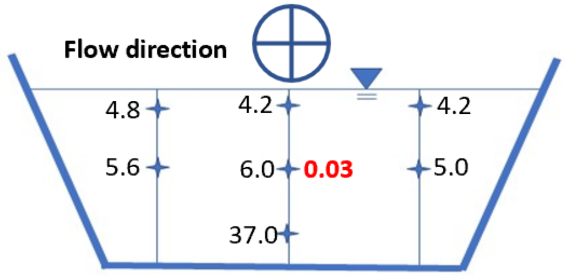
S-155 Flow Average = 1,433 cfs



Total Suspended Solids (TSS)
Total Phosphorus (TP)
09/16/2020
Transect B-3

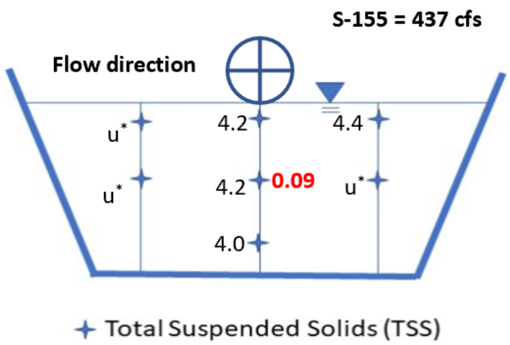
Location	B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1	1B1M2	5.20	1B2M2	4.00	1B3M2	6.60	1B4M2	4.20
2	2B1M2	5.00	2B2M2	7.60	2B3M2	7.80	2B4M2	5.00
3	3B1M2	5.00	3B2M2	u*	3B3M2	8.40	3B4M2	4.20
4	4B1M2	4.80	4B2M2	5.60	4B3M2	8.80	4B4M2	6.00
5	5B1M2	4.20	5B2M2	11.00	5B3M2	8.00	5B4M2	37.00
6	6B1M2	4.60	6B2M2	4.40	6B3M2	7.80	6B4M2	4.80
7	7B1M2	4.60	7B2M2	4.00	7B3M2	7.80	7B4M2	5.60
Average		4.77		6.10		7.89		9.54
Center		0.043		0.033		0.062		0.034

S-155 Flow Average = 1,433 cfs



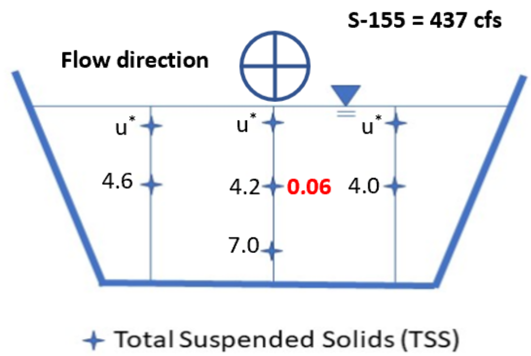
Total Suspended Solids (TSS)
Total Phosphorus (TP)
09/16/2020
Transect B-4

Location	B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1	1B1M2	4.40	1B2M2	2.00	1B3M2	2.00	1B4M2	2.00
2	2B1M2	2.00	2B2M2	4.00	2B3M2	2.00	2B4M2	2.00
3	3B1M2	4.20	3B2M2	2.00	3B3M2	2.00	3B4M2	2.00
4	4B1M2	4.20	4B2M2	4.20	4B3M2	2.00	4B4M2	5.00
5	5B1M2	4.00	5B2M2	7.00	5B3M2	39.00	5B4M2	2.00
6	6B1M2	2.00	6B2M2	2.00	6B3M2	2.00	6B4M2	2.00
7	7B1M2	2.00	7B2M2	4.60	7B3M2	2.00	7B4M2	5.20
Average		3.26		3.69		7.29		2.89
Center	TP_4B1L2	0.09	TP_4B2L2	0.06	TP_4B3L2	0.05	TP_4B4L2	0.07



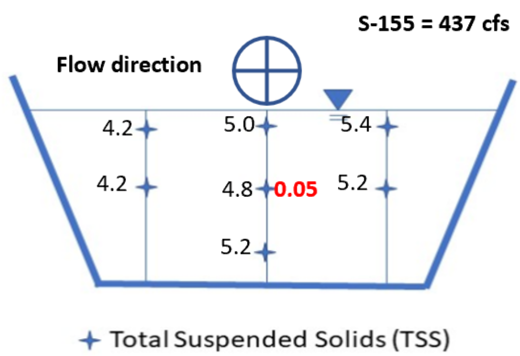
Total Phosphorus (TP)
10/29/2020
Transect B-1

Location	B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1	1B1M2	4.40	1B2M2	2.00	1B3M2	2.00	1B4M2	2.00
2	2B1M2	2.00	2B2M2	4.00	2B3M2	2.00	2B4M2	2.00
3	3B1M2	4.20	3B2M2	2.00	3B3M2	2.00	3B4M2	2.00
4	4B1M2	4.20	4B2M2	4.20	4B3M2	2.00	4B4M2	5.00
5	5B1M2	4.00	5B2M2	7.00	5B3M2	39.00	5B4M2	2.00
6	6B1M2	2.00	6B2M2	2.00	6B3M2	2.00	6B4M2	2.00
7	7B1M2	2.00	7B2M2	4.60	7B3M2	2.00	7B4M2	5.20
Average		3.26		3.69		7.29		2.89
Center	TP_4B1L2	0.09	TP_4B2L2	0.06	TP_4B3L2	0.05	TP_4B4L2	0.07



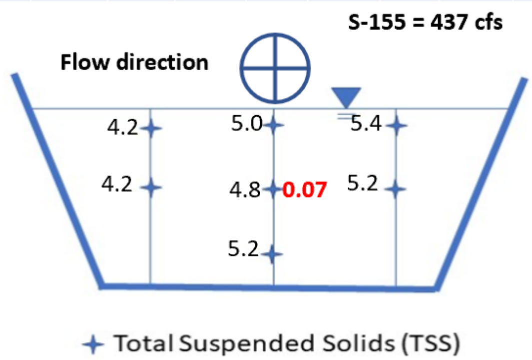
Total Phosphorus (TP)
10/29/2020
Transect B-2

Location	B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1	1B1M2	4.40	1B2M2	2.00	1B3M2	2.00	1B4M2	2.00
2	2B1M2	2.00	2B2M2	4.00	2B3M2	2.00	2B4M2	2.00
3	3B1M2	4.20	3B2M2	2.00	3B3M2	2.00	3B4M2	2.00
4	4B1M2	4.20	4B2M2	4.20	4B3M2	2.00	4B4M2	5.00
5	5B1M2	4.00	5B2M2	7.00	5B3M2	39.00	5B4M2	2.00
6	6B1M2	2.00	6B2M2	2.00	6B3M2	2.00	6B4M2	2.00
7	7B1M2	2.00	7B2M2	4.60	7B3M2	2.00	7B4M2	5.20
Average		3.26		3.69		7.29		2.89
Center	TP_4B1L2	0.09	TP_4B2L2	0.06	TP_4B3L2	0.05	TP_4B4L2	0.07



Total Phosphorus (TP)
10/29/2020
Transect B-3

Location	B-1 (Sample ID)	TSS (mg/L)	B-2 (Sample ID)	TSS (mg/L)	B-3 (Sample ID)	TSS (mg/L)	B-4 (Sample ID)	TSS (mg/L)
1	1B1M2	4.40	1B2M2	2.00	1B3M2	2.00	1B4M2	2.00
2	2B1M2	2.00	2B2M2	4.00	2B3M2	2.00	2B4M2	2.00
3	3B1M2	4.20	3B2M2	2.00	3B3M2	2.00	3B4M2	2.00
4	4B1M2	4.20	4B2M2	4.20	4B3M2	2.00	4B4M2	5.00
5	5B1M2	4.00	5B2M2	7.00	5B3M2	39.00	5B4M2	2.00
6	6B1M2	2.00	6B2M2	2.00	6B3M2	2.00	6B4M2	2.00
7	7B1M2	2.00	7B2M2	4.60	7B3M2	2.00	7B4M2	5.20
Average		3.26		3.69		7.29		2.89
Center	TP_4B1L2	0.09	TP_4B2L2	0.06	TP_4B3L2	0.05	TP_4B4L2	0.07



Total Phosphorus (TP)
10/29/2020
Transect B-4

Figure 10 Total Suspended Solids (TSS) values at each of the four transects for all six flow events. Average S-155 Flow is from DBHydro 64865 during the measurement time.

2.1.2 Statistical Test Results for TSS:

A *t* test was conducted on the average observed TSS from all transects and all six flow events. The difference between were created by substituting a null or a 2 mg L^{-1} value in place of u* as reported from the analytical results (Table 8). Results of the t-test revealed that the difference in the median values between the two groups is not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference ($P = 0.483$). T test analysis were conducted using SigmaPlot statistical package (SigmaPlot Version 14.5). *t* test statistical results are summarized below.

Normality Test (Shapiro-Wilk): **Failed** ($P < 0.050$)

Mann-Whitney Rank Sum Test

Group	**N**	**Missing**	**Median**	**25%**	**75%**
Average 1	24	0	5.570	4.883	6.755
Average 2	24	0	5.525	4.678	6.755

Mann-Whitney U Statistic= 254.000
Yates continuity correction option not applied to calculations.
T = 622.000 n(small)= 24 n(big)= 24 ($P = 0.483$)

T-test results of no significant difference further confirm the fact that using average TSS concentrations after substituting half the MDL (i.e., 2 mg L^{-1}) instead of a "null" value did not impact or affect the final sediment loads and the calculated trap efficiency.

Table 10 Descriptive Statistic for Total Suspended Sediments (TSS) at all four transects and during all six flow events.

TSS	Size	Mean	Std Dev	Std. Error	C.I. of Mean	Range	Max	Min	Median	0.25	0.75
Average 1[1]	24	7.43	6.957	1.420	2.938	34.80	39.00	4.20	5.57	4.88	6.76
Average 2[2]	24	5.83	2.045	0.417	0.864	9.28	12.17	2.90	5.53	4.68	6.76

[1] = substituting null values for u*
[2] = substituting 2 mg L^{-1} value for u*

2.1.3 Evaluation of TSS concentrations lab results at the four cross-sections

The TSS concentrations in this study are comparable to the past ten years of monthly TSS concentration observations at S-155 structure as reported in SFWMD water quality database, DBHYRO (Figure 11). The blank values in Figure 11are data tagged as "u*" in DBHYDRO which means under detection limit (MDL) of 3 mg L^{-1} for the lab that analyzed the samples for the SFWMD. There were 107 monthly TSS data at S-155 with mean of 4.62 mg·L^{-1}, minimum of 3 mg·L^{-1} (MDL) and maximum of 8 mg L^{-1}.

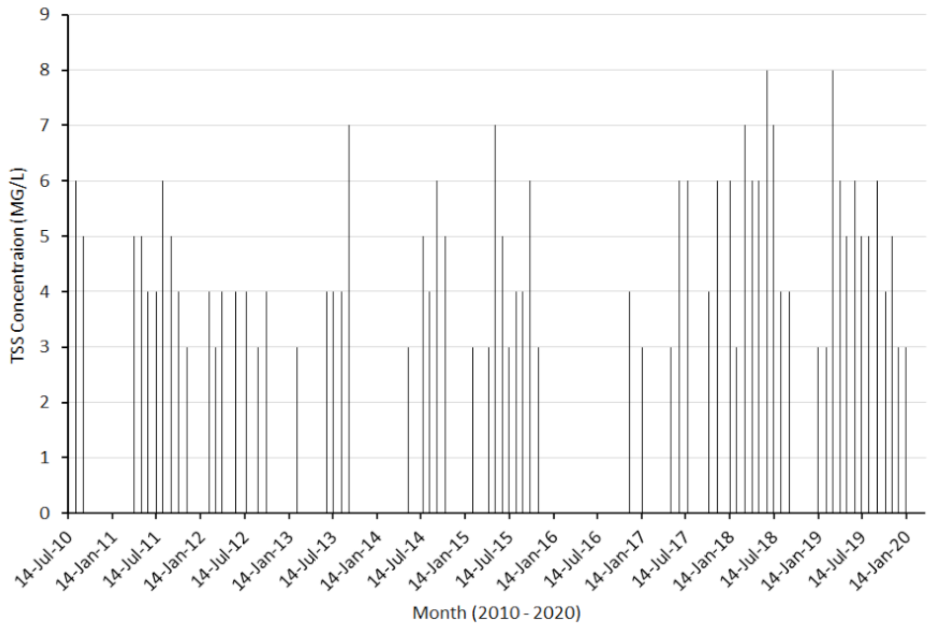


Figure 11 Monthly TSS concentrations at S155 from DBHYDRO (2010 to 2020).

2.2 Total Phosphorus Data and Evaluation of lab results at the four cross-sections

Summary of the lab results for TP are listed in Table 11, and EPA analytical Method EPA 365.3 was used to determine TP concentrations in the water sample. In the JEL report, TP values are flagged with a "u*" when the reported value is below the laboratory method detection limit (MDL). SFWMD also have similar flag for S-155 TP data below the detection limit. The lab results for TP analysis at each of the four locations (B-1, B-2, B-3 and B-4) and all six flow events (Table 11) came back with a mean of 0.047 and a range of 0.069 mg-L^{-1} (Table 10). Summary statistics for TP are listed in Table 12. Monthly TP data at S-155 structure from 2010 to 2019 was extracted from DBHYDRO. Observation of TP data shows that 25% of monthly values are below the lab detection limit of 0.005 mg L^{-1}.

Table 11 Observed Total phosphorus (TP) concentrations at all four transects during all six flow events. Observed TP below detection limits (u*) were replaced with 0.005 mg L^{-1}) in all calculations.

Date	B-1	B-2	B-3	B-4
12/23/2019	u*[1]	u*	u*	u*
5/28/2020	u*	u*	u*	u*
6/19/2020	u*	u*	0.018	u*
9/11/2020	0.037	0.033	u*	0.043
9/16/2020	0.043	0.033	0.062	0.034
10/29/2020	0.087	0.062	0.048	0.066

[1] = u* is the lab minimum detection limit (MDL) = 0.005 mg L^{-1}.

Table 12 Total Phosphorus summary statistics at all four transects and for all six flow events.

Total Phosphorus	Size	Mean	Std Dev	Std. Error	C.I. of Mean	Range	Max	Min	Median
	16	0.047	0.019	0.005	0.012	0.069	0.087	0.005	0.043

2.3 Stream Gauging Flow Data

All measured stream gauging flow values at all four transects and for all six flow events are listed in Table 13. Measured stream gauging flows at Transect B-4 closely matched with S-155 observations at the same time (< 8%) with the exception of one flow event (-16%) during 06/19/2020. Table 14 lists average stream gauging flow values, TSS measured values, the difference in flow (%) between observed structure flow and stream gauging values (i.e., $Q_{S-155} – Q_{B-4}$), sediment loads and trap efficiency at all four transects for all six flow events, including time duration to complete flow measurements per event. The sum of upstream flows (B-1, B-2, B-3) and downstream flows (B-4) are also listed in Table 14., which provide an indication of how close the event was to mimic steady state flow conditions.

Figure 12 and Figure 13 provide a clear picture of stream gauging at all four transects for all six flow events. For example, Figure 12 clearly illustrates that B-2 (part of the inflow to the C-51 trap) and B-4 (the outflow for the sediment trap) are the major contributor of flow and that B-1 and B-3 contributed minimum flow, and hence the total mass balance regarding trap efficiency. Furthermore, Figure 12 and Figure 13 of the measured cress-section areas during stream gauging at all four transects (average of three to seven runs per transect) and during all six-flow events, further confirms that B-1 and B-3 are minimum contributors, compared to B-2 and B-4, for mass balance calculations and trap efficiency.

Descriptive statistics of flow measurements for all transects and during all flow six events are summarized in **Table 13**. Minimum measured mean flows were observed at Transect B-3 (51 cfs) followed by transect B-1 108 cfs), while the highest mean flow was observed at B-4 (920 cfs) and followed by Transect B-2 (671 cfs). Results of the *t*-test indicated that the difference in the median values of between the two groups (B-2 vs. B-4) is greater than would be expected by chance; there is a statistically significant difference ($P = 0.010$). Similarly, the difference in the mean values of the two groups (B-1 vs. B-3) is greater than would be expected by chance; there is a statistically significant difference between the input groups ($P = 0.014$).

Table 13 Descriptive statistics of stream gauging flow values at all four transects during all sic flow events.

Transect	Size	Mean	Std Dev	Std. Error	Max	Min	Median
B-1 Q1 (ft^3/s)	37	108.21	122.985	20.8	329.42	-137.94	106.76
B-2 Q2 (ft^3/s)	34	670.63	279.961	54.9	1168.92	221.71	584.69
B-3 Q3 (ft^3/s)	36	51.34	46.416	8.2	123.28	-10.52	50.73
B-4 Q4 (ft^3/s)	34	920.50	349.443	69.9	1502.29	454.39	899.25

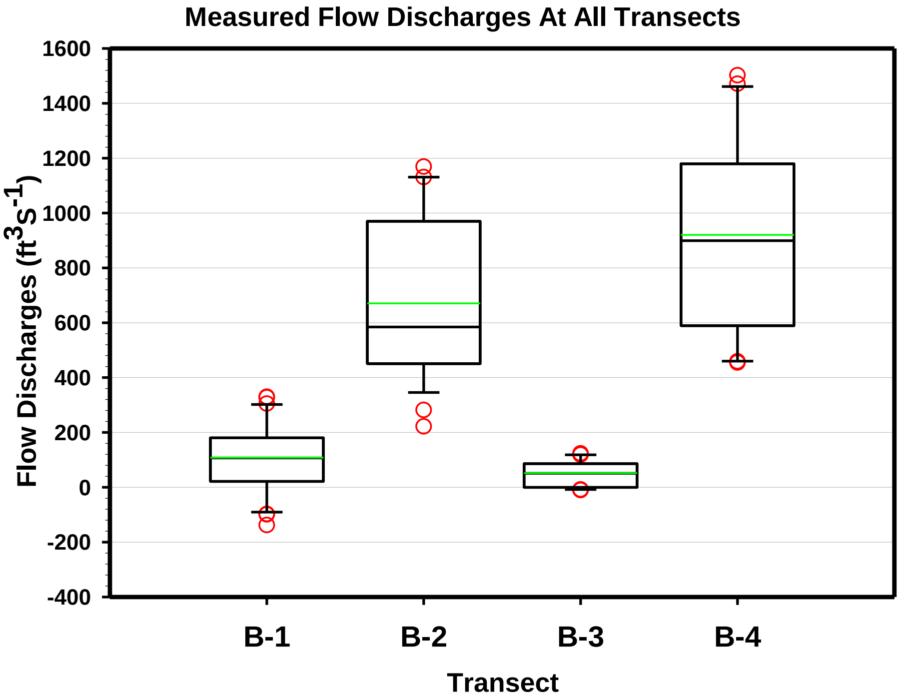


Figure 12 Measured stream gauging flows at all four transects (average of three to seven runs per transect) and during all six flow events. Green line represents mean value.

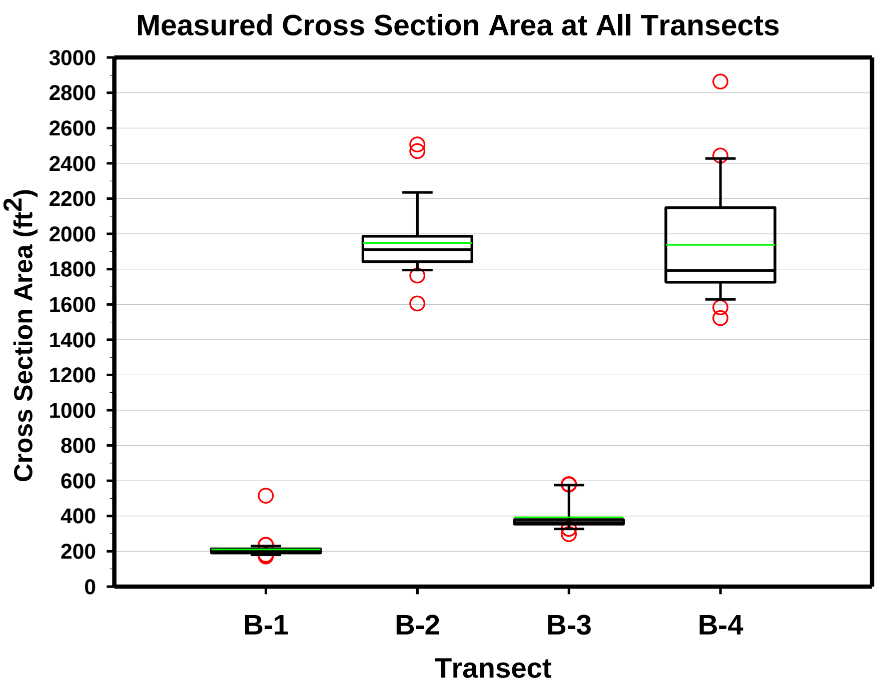


Figure 13 Measured cress-section areas during stream gauging at all four transects (average of three to seven runs per transect) and during all six flow events. Green line represents mean value.

All measured stream gauging raw flow values at all four transects and for all six flow events are listed in Table 14. Measured stream gauging flows at Transect B-4 closely matched with S-155 observations at the same time (i.e., difference = (Q_{B-4} - Q_{S-155} /Q_{S-155}) and < 8%) with the exception of one flow event during 06/19/2020 (difference = 16%). Table 14 lists average stream gauging flow values and the difference in flow (%) between observed structure flow and stream gauging values at all four transects for all six flow events, including time duration to complete flow measurements per event. The sum of upstream flows (B-1, B-2, B-3) and downstream flows (B-4) are also listed in Table 14, which provide an indication of how close the event was to selected planned flow and to mimic steady state conditions. (Qavg-S155)/S155

2.4 Inflow/Outflow Suspended Sediment Load (Six events)

As described in Chapter 3, water sediment samples (TSS) collected at the proposed stream gauging sites were combined with measured flow velocity at all four transects (B-1, B-2, B-3, and B-4) to calculate suspended sediment loads for a total of six events. As follow, SFEC conduct inflow/outflow sediment load calculations at the proposed four flow locations (Figure 5) for all six flow events, using stream gauging and TSS water samples data collected in the field during those flow events. All sediment load calculation results were documented and summarized in table format provided in the work plans and previous reports (Tasks 3 and 4) submitted to the District.

2.4.1 Sediment Load Calculation Methods and Results

Sediment transport along a canal reach is composed of incoming sediment load, settling sediment or accretion within the reach and resuspension of sediment or erosion in the reach. The mass balance of sediment transport within a canal reach (Figure 8**)** is expressed by **Equation 1**. Similar model is applied in DECOMP study in L-67C Canal (Saunders et al., 2019).

$$\Delta S = S_{in} - S_{out} - S_s + S_r \qquad (1)$$

Where ΔS is net change in sediment mass in the canal reach, S_{in} is incoming sediment load, S_{out} is sediment load leaving the reach, S_s is settling sediment (accretion) within the reach, and S_r is resuspended or eroded sediment load. When ΔS is positive, there is net accretion and when it is negative there is net resuspension or erosion. No change indicates balance in inflow and outflow or accretion and resuspension.

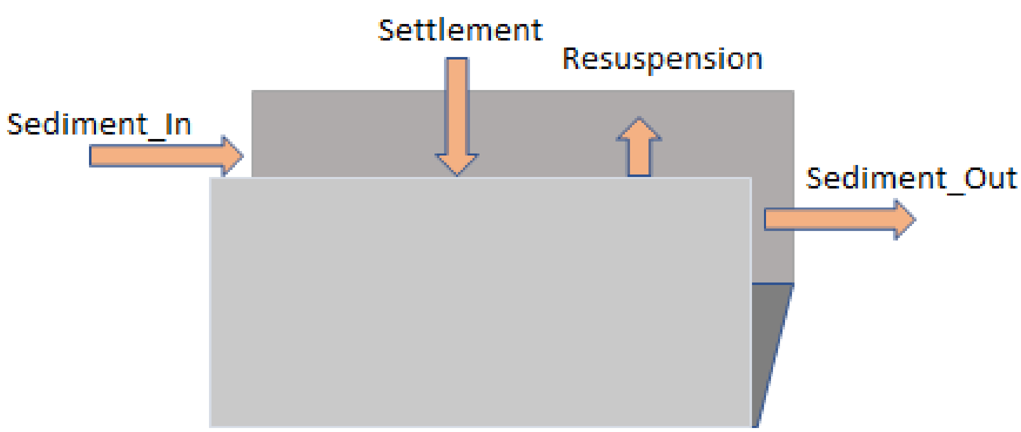


Figure 14 Sediment transport through a canal reach.

Inflow and outflow suspended load calculation is performed based on USGS method (Eq. 2), Gray and Simoes (2008).

$$Q_s = Q_w\, C_s\, \mathrm{k} \qquad (2)$$

Where Q_s suspended sediment discharge in tons per day; Q_w is water discharge in cfs and C_s is sediment concentration in mg L^{-1} and k is a coefficient based on the unit measurement of water discharge that assumes a given specific weight for sediment that depends on flow rate that assumes a specific weight of 2.65 for sediment, and equals 0.0027 in inch-pound units, or 0.0864 in SI units (Gray and Simoes, 2008). Based on observation of the sediment at the bottom of the C-51 sediment trap, organic silt specific weight of 1.75 is used in this analysis. Organic silt unit weight ranges from 87 to 131 lb/ft^3 ((http://www.geotechnicalinfo.com/soil_unit_weight.html). To calculate specific weight, the average unit weight, 109 lb/ft^3 was divided by 62.4 lb/ft^3, which is the unit weight of water. With specific weight of 1.75, k is correct to 0.00178 as calculated by Equation 3 and applied in Equation 2 to give Equation 4.

$$k = \frac{0.0027 \text{ x } 1.75}{2.65} = 0.00178 \qquad (3)$$

$$Q_s = 0.00178\, Q_w\, C_s \qquad (4)$$

2.4.2 Load Calculation Results:

Equation 5 was used to calculate sediment loads into and out of the C-51 trap during all six stream gauging events (Table 14). Average flow values and TSS concentrations listed in Table 14 were used to calculate inflow and outflow loads and estimate trap efficiency for all six events. By comparing inflow load into the sediment trap (B-1+B-2+B-3) with outflow load from the sediment trap (B-4), trap efficiency in percentage is computed by Eq. 3. Average TSS concentrations at a transects, calculated either by substituting a null value or 2 mg L^{-1} to represent all "i" and "u" observations, did not have any significant impacts on inflow/outflow loads and hence trap efficiency for all six flow events. In addition, no difference was observed in calculated trap efficiency using the straight average stream gauging flow values or by adjusting measured flow values to ensure that inflow equal outflow value (i.e., steady state conditions prevailed).

$$Trap\ Efficiency = \frac{((\mathrm{B{-}1{+}B{-}2{+}B{-}3})_{\mathrm{Loadin}} - B4_{\mathrm{Loadout}})}{(\mathrm{B{-}1{+}B{-}2{+}B{-}3})_{\mathrm{Loadin}}} \qquad (5)$$

Table 14 provides a complete listing of TSS loads into and out of C-51 Canal trap. Trap efficiency is also included for all six events in Table 14**.** The third method is used to calculate trap efficiency was based on flow adjustment to ensure net discharge flow is zero (net Q = B-1+B-2+B-3 - B-4 = 0.0) and hence, steady state conditions prevailed during each event.

In summary, C-51 trap retained 0.31- and 2.36-tons day^{-1} (trap efficiency = -6 and -24%) were achieved for low flows (i.e., $Q_{S\text{-}155}$ = 571 and 437 cfs, respectively). However, C-51 trap exported 1.46, 0.38, 1.67-, and 10.36-tons day^{-1} of sediments (trap efficiency = 11, 3, 18, and 42%) during high flow events (i.e., $Q_{S\text{-}155}$ = 1,068, 958, 769, and 1,434 cfs). It should be noted that highest export or trap efficiency value of 42% was achieved during the highest flow ($Q_{S\text{-}155}$ = 1,434 cfs) recorded event at structure S-155.

Table 14 results provide a good summary of the relationship between flow type (low, medium, high) and trap efficiency. For example, the highest three flows (i.e., Q > 1,000cfs) consistently showed a negative trap efficiency (i.e., net sediment export) ranging between 3 and 42%. On the contrary, the low flow events (i.e., Q_{B-4} < 571 cfs) achieved a positive trap efficiency (i.e., sediment retention). Yet, at a somewhat "transition" flow (i.e., Q_{B-4} = 770 cfs) that fell between high and low flow values out of all six events, resulted in sediment export at a medium trap sediment efficiency range (i.e., 18%); an interesting observation, that needs further investigation. The difference between stream gauging flow at B-4 and flow at S-155 was less than 8% in five out of the six flow events, while the highest disagreement of flows of 19% occurred during June 19, 2020 (Table 14). At some instance (5/28/2020), stream gauging flow results at B-1, for example, were all negative (Table 13), an indication of very-slow or undetected flow.

Figure 12 and Figure 13 illustrate the difference in cross-sectional area where stream gauging took place. Those figures also and indicated that measured flows at B-1 and B-3 and cross-sectional area values at those transects are the lowest among all stream gauging locations. Table 14 also shows that B-1 and B-3 average measured flow are the lowest of all four transects.

The stream gauging value of 770 cfs at transect B-4 is somewhat falls between higher flow values (i.e., 1,000 cfs) and low flow values (< 600 cfs) conducted under this work order and provide a clue relating to when trap efficiency switch from exporting sediment to retaining sediment within the C-51 trap. Therefore, it is one of SFEC's recommendation to conduct additional flow event monitoring at a flow values somewhere between 650-800 cfs to determine in a more precise way the top flow discharges at S-155 where trap efficiency remains positive (i.e., sediment retention).

Low flow sampling events (i.e., Q_{S-155} = 571 and 437 cfs) showed positive (i.e., sediment retention) in the trap as shown in Table 14. It is also clear that as flow increased from 437 to 571 cfs, sediment retention decreased from 24% down to 6% (Table 14**;** Figure 15). However, it is unclear, at this time, if the results for the flow event (9/11/2020) value (Q_{S-155} = 770 cfs) follow the same rule of higher flow leads to lower sediment retention. The fact that the C-51 trap exported more (18%) during the 770 cfs flow event compared to 957and 1,068 cfs medium flow events exporting 3 and 11%, respectively on 6/19/2020 and 5/28, 2020, is puzzling and need further evaluation.

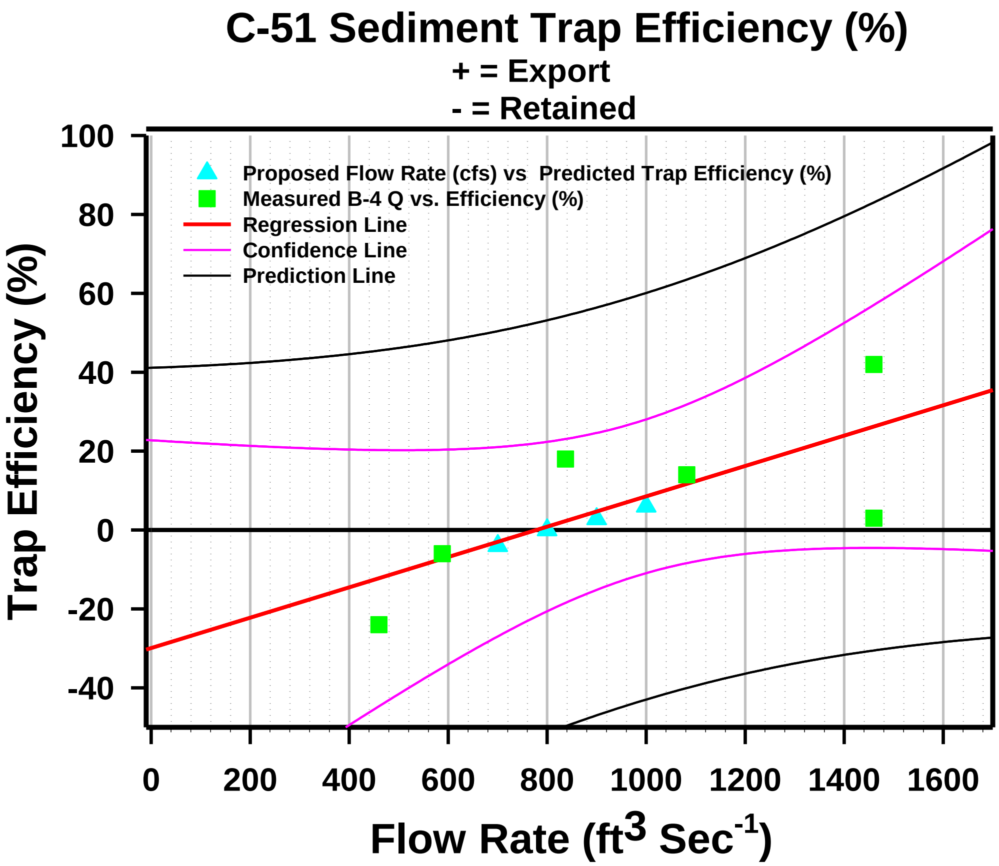


Figure 15. C-15 Canal Trap efficiency for all six flow events (solid green box symbols). Proposed flow rate and expected trap efficiency (solid blue triangle symbol) based on regression analysis.

Table 14 Stream gauging data at all four transects (i.e., B-1, B-2, B-3 and B-4) during all six flow events.

12/23/2019	B-1 (ft^3/s)	Total Area ft^2	Time Started	B-2 (ft^3/s)	Total Area ft^2	Time Started	B-3 (ft^3/s)	Total Area ft^2	Time Started	B1+B2+B3	B-4 (ft^3/s)	Total Area ft^2	Time Started
1	329.42	196.83	11:45:41	416.18	1815.98	12:29:27	84.79	579.65	16:45:28		587.88	2417.03	14:58:53
2	327.51	188.11	11:48:46	453.86	1866.21	12:40:13	85.89	578.44	16:54:03		591.17	2442.97	15:10:35
3	299.61	191.12	11:51:40	440.23	1839.19	12:50:49	89.91	571.83	16:55:27		614.76	2357.3	15:19:22
4	304.52	187.55	11:54:27	372.96	1845.76	13:00:00	79.07	572.4	16:59:35		559.81	2395.52	15:57:15
5				281.39	1817.38	13:11:41	71.44	576.76	17:05:34				
6				221.71	1837.52	13:21:45							
Average =	315.26			364.39			82.22			761.87	588.40	$Q_{B\text{-}4}$-$Q_{S\text{-}155/QS\text{-}155}$ =	3%
Percent Contributing Flow B1/(B1+B2+B3) =	41%			48%			11%			100%			
Weighted Flow	243.48			281.42			63.50			588.40			
TSS =	4.44 (mg/L)			5.54 (mg/L)			4.67 (mg/L)				4.70 (mg/L)		Efficiency
TSS =	1.93 (Tons/days)			2.78 (Tons/days)			0.53 (Tons/days)			5.23	4.92 (Tons/days)		6%
Net Export =											0.31 (Tons/days)		Retention
	B1+B2+B3 = 761.87 B1+B2+B3-B4 = 173.47 Difference = 23%			DBKey = 64865 S-155 Flow 571.10 cfs			DBKey = 64864 S-155A Flow - cfs				DBKey = 90754 S5AE Flow 11.28 cfs		
5/28/2020	B-1 (ft^3/s)	Total Area ft^2	Time Started	B-2 (ft^3/s)	Total Area ft^2	Time Started	B-3 (ft^3/s)	Total Area ft^2	Time Started	B1+B2+B3	B-4 (ft^3/s)	Total Area ft^2	Time Started
1	21.33	226.48	9:38:46	998.88	2079.19	11:35:01	18.86	359.28	15:54:16		1267.20	2218.92	14:15:10
2	-22.04	513.83	9:55:35	993.44	2053.12	11:48:35	11.44	363.54	13:03:14		1018.55	1905.6	14:23:29
3	-99.16	188.97	10:51:21	962.15	2009.80	12:01:46	-6.04	296.50	13:09:35		1150.20	2078.16	14:40:49
4	-86.20	187.22	10:59:08	952.75	2063.47	12:15:40	7.98	354.20	13:16:59		1093.63	2022.62	14:51:43
5	-97.75	190.52	11:03:52				-6.32	422.26	13:27:50				
6	-137.94	169.10	11:11:06				6.22	351.57	13:33:40				
Average =	(70.29)			976.80			5.36			911.87	1,132.39	$Q_{B\text{-}4}$-$Q_{S\text{-}155/QS\text{-}155}$ =	6%
Percent Contributing Flow B1/(B1+B2+B3) =	-8%			107%			1%			100%			
Weighted Flow	-87.29			1213.03			6.65			1,132.39			
TSS =	3.81 (mg/L)			5.60 (mg/L)			12.17 (mg/L)				6.50 (mg/L)		Efficiency
TSS =	-0.59 (Tons/day)			12.09 (Tons/day)			0.14 (Tons/day)			11.64	13.10 (Tons/day)		-11%
Net Export =											-1.46 (Tons/day)		Export
	B1+B2+B3 = 911.87 B1+B2+B3-B4 = -220.53 Difference = -24%			DBKey = 64865 S-155 Flow 1,068.39 cfs			DBKey = 64864 S-155A Flow 644.28 cfs				DBKey = 90754 S5AE Flow 352.79 cfs		

6/19/2020	B-1 (ft^3/s)	Total Area ft^2	Time Started	B-2 (ft^3/s)	Total Area ft^2	Time Started	B-3 (ft^3/s)	Total Area ft^2	Time Started	B1+B2+B3	B-4 (ft^3/s)	Total Area ft^2	Time Started
1	93.58	216.67	9:31:00	674.65	1889.07	11:43:41	108.70	360.49	13:13:06		1208.93	1688.29	14:37:10
2	92.60	213.65	9:37:45	396.76	1900.84	12:01:03	117.07	356.07	13:19:42		1104.25	1804.15	14:48:39
3	106.76	212.99	9:45:15	511.71	1912.85	12:16:09	89.38	362.61	13:27:33		1115.56	1659.82	15:02:06
4	122.08	220.82	9:51:51	525.77	1762.43	12:33:25	118.87	353.73	13:33:03				
5	237.32	206.86	11:16:13				123.28	358.86	13:38:54				
6	258.65	211.65	11:20:46				119.68	351.8	13:43:41				
Average =	151.83			527.22			112.83			791.88	1,142.91	$Q_{B\text{-}4}$-$Q_{S\text{-}155/QS\text{-}155}$ =	19%
Percent Contributing Flow B1/(B1+B2+B3) =	19%			67%			14%			100%			
Weighted Flow	219.13			760.93			162.85			1,142.91			
TSS =	4.94 (mg/L)			6.31 (mg/L)			6.84 (mg/L)				6.31 (mg/L)		Efficiency
TSS =	1.93 (Tons/day)			8.55 (Tons/day)			1.98 (Tons/day)			12.46	12.85 (Tons/day)		-3%
Net Export =											-0.38 (Tons/day)		Export
B1+B2+B3 = 791.88				DBKey = 64865			DBKey = 64864				DBKey = 90754		
B1+B2+B3-B4 = -351.03				S-155 Flow			S-155A Flow				S5AE Flow		
Difference = -44%	DBKey =			957.71 cfs			54.37 cfs				- cfs		
9/11/2020	B-1 (ft^3/s)	Total Area ft^2	Time Started	B-2 (ft^3/s)	Total Area ft^2	Time Started	B-3 (ft^3/s)	Total Area ft^2	Time Started	B1+B2+B3	B-4 (ft^3/s)	Total Area ft^2	Time Started
1	2.01	220.68	9:58:18	559.95	1963.92	10:52:29	38.56	374.44	12:09:28		693.55	1521.73	13:53:36
2	39.45	205.73	10:04:37	641.95	1941.75	11:06:45	50.29	364.07	12:15:37		998.10	1867.86	14:00:21
3	30.16	204.45	10:10:27	588.63	1958.26	11:19:09	47.85	375.91	12:20:54		858.39	1718.26	14:08:57
4	26.91	190.30	10:14:23	635.31	1604.11	11:29:44	51.17	359.33	12:26:23		899.25	2862.29	14:16:24
5	4.31	206.51	10:20:13				46.69	368.8	12:32:36		735.08	1582.08	14:22:25
6	4.20	190.75	10:24:35								839.15	1670.52	14:34:17
Average =	17.84			606.46			46.91			671.21	837.25	$Q_{B\text{-}4}$-$Q_{S\text{-}155/QS\text{-}155}$ =	9%
Percent Contributing Flow B1/(B1+B2+B3) =	3%			90%			7%			100%			
Weighted Flow	22.25			756.48			58.52			837.25			
TSS =	4.86 (mg/L)			5.03 (mg/L)			7.06 (mg/L)				6.29 (mg/L)		Efficiency
TSS =	0.19 (Tons/day)			6.77 (Tons/day)			0.74 (Tons/day)			7.70	9.37 (Tons/day)		-18%
Net Export =											-1.67 (Tons/day)		Export
B1+B2+B3 = 671.21				DBKey = 64865			DBKey = 64864				DBKey = 90754		
B1+B2+B3-B4 = -166.04				S-155 Flow			S-155A Flow				S5AE Flow		
Difference = -25%				769.82 cfs			401.82 cfs				275.69 cfs		

9/16/2020	B-1 (ft^3/s)	Total Area ft^2	Time Started	B-2 (ft^3/s)	Total Area ft^2	Time Started	B-3 (ft^3/s)	Total Area ft^2	Time Started	B1+B2+B3	B-4 (ft^3/s)	Total Area ft^2	Time Started
1	228.52	178.80	9:28:25	1168.92	1907.95	10:24:16	83.13	341.61	12:02:15		1471.10	1774.79	13:26:37
2	196.00	180.63	9:33:10	1030.55	1910.80	10:41:26	84.69	325.89	12:08:48		1502.29	1792.31	13:35:28
3	179.72	193.27	9:37:42	1130.92	1876.54	11:02:02	85.74	326.39	12:14:38		1454.55	1766.34	13:45:19
4	170.68	197.49	9:41:42	1130.95	1941.36	11:18:36	79.88	326.92	12:19:57		1411.03	1734.29	13:55:24
5	173.15	207.61	9:47:42										
6	180.14	200.46	9:54:21										
Average =	188.03			1,115.33			83.36			1,386.73	1,459.74	Q_{B-4}-$Q_{S-155/QS-155}$ =	2%
Percent Contributing Flow B1/(B1+B2+B3) =	14%			80%			6%			100%			
Weighted Flow	197.93			1,174.06			87.75			1,459.74			
TSS =	4.77 (mg/L)			5.51 (mg/L)			7.89 (mg/L)				9.54 (mg/L)		Efficiency
TSS =	1.68 (Tons/day)			11.52 (Tons/day)			1.23 (Tons/day)			14.44	24.80 (Tons/day)		-42%
Net Export =											-10.36 (Tons/day)		Export
	B1+B2+B3 = 1386.73 B1+B2+B3-B4 = -73.01 Difference = -5%			DBKey = 64865 S-155 Flow 1,434.16 cfs			DBKey = 64864 S-155A Flow 886.23 cfs				DBKey = 90754 S5AE Flow 534.40 cfs		

10/29/2020	B-1 (ft^3/s)	Total Area ft^2	Time Started	B-2 (ft^3/s)	Total Area ft^2	Time Started	B-3 (ft^3/s)	Total Area ft^2	Time Started	B1+B2+B3	B-4 (ft^3/s)	Total Area ft^2	Time Started
1	131.09	205.14	9:58:31	640.18	2468.21	11:04:52	-7.17	380.75	12:24:04		458.49	1821.6	13:31:41
2	144.65	206.39	10:04:03	580.75	2506.00	11:20:45	-9.43	384.64	12:32:06		460.65	1782.78	13:42:21
3	86.91	175.28	10:09:13	575.81	1935.53	11:37:51	-7.31	374.64	12:39:57		454.39	1771.27	13:49:43
4	123.95	236.05	10:25:32	549.96	2557.85	11:50:50	-2.54	367.93	12:46:37		464.49	1783.67	13:56:03
5	118.06	234.41	10:31:12				-10.52	364.08	12:55:07				
6	103.30	201.05	10:38:57				-8.37	359.44	0.542800926				
7	93.94	217.90	10:44:16										
Average =	114.56			586.67			(7.56)			693.67	459.51	Q_{B-4}-$Q_{S-155/QS-155}$ =	5%
Percent Contributing Flow B1/(B1+B2+B3) =	17%			85%			-1%			100%			
Weighted Flow	75.88			388.63			-5.01			459.51			
TSS =	3.26 (mg/L)			3.69 (mg/L)			7.29 (mg/L)				2.89 (mg/L)		Efficiency
TSS =	0.44 (Tons/day)			2.55 (Tons/day)			-0.06 (Tons/day)			2.92	2.36 (Tons/day)		24%
Net Export =											0.56 (Tons/day)		Retention
	B1+B2+B3 = 693.67 B1+B2+B3-B4 = 234.17 Difference = 34%			DBKey = 64865 S-155 Flow 437.54 cfs			DBKey = 64864 S-155A Flow 311.09 cfs				DBKey = 90754 S5AE Flow 1,103.33 cfs		

Chapter 5: Summary, Conclusions and Recommendations

1.0 Introduction

Chapter 5 provides a summary of the analysis of field data results and the different methods used to determine C-51 trap efficiency. In addition, Chapter 5 provides further recommendation, after gaining much valuable information regarding stream gauging and sediment water sampling that led to calculate trap efficiency. Lessons learned from the current project will be used to refine additional field data collection and data analysis to provide recommendations to help increase sedimentation (sediment trap efficiency) and minimize sediment transport from trap to downstream.

As part of the C-51 Canal sediment assessment project, South Florida Engineering and Consulting (SFEC) collected sediment samples of deposited materials in the sediment trap, assessing sediment depth at sampling sites, assessing water depth, and characterize sediment contaminants through lab analysis. The objective of Task 2 was to sample deposited sediment at sites located along six transects (Figure 2) and to characterize sediment contaminants. In addition, literature summary and sampling of sediment accumulated in the sediment trap including, mapping of sample locations, sampling methods, Laboratory analysis results were provided in separate report (**Appendix A**).

SFEC also provided a review of the equipment used for field sampling in prior reports, including the equipment deployment method, and a review of equipment accuracy, and sampling method. Chapter 3 of the current report provides description of all equipment used to collect all samples required under this work order during all six flow events and describes how samples were collected in the field. Field data collection mainly focused on two parts: collect surface water samples and stream gauging. Both water sample collections and stream gauging took place at the four pre-selected transects (B-1, B-2, B-3, and B-4).

2.0 Summary and Conclusions

Summary of the field data collection and analysis to estimate C-51 canal sediment trap efficiency may be stated as follow: as inflow increases, sediment export increases at higher flow ranges ($Q_{S\text{-}155}$ > 1,000 cfs). Results of SFEC field data analysis collected at the four pre-selected transects and during the six flow events, narrowed down the aforementioned statement and added quantitative limits to describe high and low flow conditions/values. Data analysis indicated that flow below 600 cfs generally led to sediment retention in the C-51 Canal trap. Furthermore, flow discharges at the S-155 structure with higher flow ranges ($Q_{S\text{-}155}$ > 1,000 cfs) led to sediment export from the C-51 Canal trap. Following those guidelines will minimize sediment export out of the trap.

Minimizing sediment discharge while maintaining flood protection is critical to the District. Field monitoring and data analysis provided no specific answer as to: what is the highest discharge flow value at S-155 that would maintain positive trap efficiency? During flood protection operations, flows are likely to be higher than 1,000 cfs. Hence, determining the maximum flow rate at which trap efficiency remains positive will provide operators with specific guidance that maximizes both operational flexibilities, improve sediment trap efficiency, and benefits to water quality.

3.0 Recommendations for Consideration for Phase II C-51 Sediment Trap Study

In this section SFEC is providing an overview of tasks for Phase II that would lead to practical structure operation during flood protection events and further improve C-51 trap efficiency. During the course of the current work order, SFEC gained more experience, inside knowledge, and insights that will be deployed to enhance and improve the next steps to improve the C-51 canal trap efficiency. For example, the time allotted for conducting the field work necessary to collect the intended data needs to be extended, particularly for low flow range (e.g., $Q_{S\text{-}155}$ = 500-800 cfs) to ensure that steady state conditions are prevailing (e.g., six or more hours of S-155 operation to produce the required flow). Furthermore, it is also recommended to gather information at S-155A and S5AE, which may not only impact the intended steady state conditions, where field data are collected, but also may be a source of a different sediment type and may introduce uncertainty in the measured TSS values.

Sampling and laboratory analysis:

1. TSS observation is an issue, should we use a surrogate (e.g., turbidity) to calculate trap efficiency? (maybe difficult given lots of other factors can affect turbidity. Using half the detection limit during non-detects is the current approach. We will consult with the lab to see if they can run a lower MDL).
2. Increase number of bottom/benthic TSS samples to compare to surface and mid water depth samples. Current sampling regime only includes one bottom sample per transect. Most high TSS values were observed at or near bottom and mid-depth.
3. It is also critical to measure surface water TN concentration; Lake Worth Lagoon is brackish water.
4. Estuarine conditions: Contribution of freshwater macrophytes relative to marine and estuarine vegetation. Survey vegetation before and after structure operations.

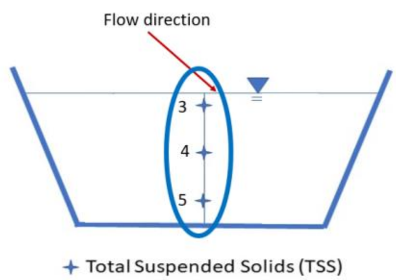
Determine flow rate range at which sediments are retained in the trap:

5. Additional field measurements are needed to verify and support results from this study. It is critical for SFWMD structure operations to determine (with more certainty) the flow range at S-155 required to maintain a "net" zero sediment export: (i.e., sediment retention); conduct at least three flow events ranging between 650-850 cfs. Steady flow is utmost needed for those scenarios; run and maintain those flow for extended period of time; at least six hours, no negative flows at any transects. It is important to note that Phase I results are based on a handful of events and hence there is low statistical power. Additional monitoring will provide greater power and likely greater detail regarding trap efficiency at varying flow rates.
6. The District plans to conduct another survey of the trap around April 2021, which could be used to verify and/or add to the findings of this study.

Mimic as practically as possible, the actual and real time S-155 structure operations (during wet/dry/storm season) to maximize trap efficiency, including the use of simulation models to provide additional options for improving trap efficiency.

7. Conduct grain size analysis at four locations within the sediment trap.
8. Use grain size analysis to conduct "modeling scenarios, including "unplugging" of culverts to determine optimum combined operation protocol and unplugging scenarios to increase trap efficiency.

9. First Flush Sampling: Collect TSS water samples, take pictures of floating vegetation, right before the start of a flow event at S-155 structure. (before and after comparison to capture flush and steady flow condition). In addition, collect bottom sediment grab samples at two upstream locations of S-155 and conduct grain size analysis to examine available sediment for resuspension at the outset of the structure operation.
10. Develop a relationship of stage and flow at S-155, that combined with flow-weighted TSS measurements at S-155, may reliably predict the dynamic trap efficiency and the total trap efficiency for each flood control event. Mass balance results of the newly developed relationship shall be checked against annual, or more frequent, survey of accumulated volume of sediment, and sediment analysis, in the trap. Data required to develop this approach shall include a stepwise fashion sampling event to mimic gate-flow operation. Incremental flow combined with measuring TSS at two locations (i.e., B-2 and B-4). This proposed event covers a wide range of flow conditions (e.g., 300 – 2,000 cfs) and flow increments as follow: 300, 400, 700, 1000, 1500, 2000 cfs. Stream gauging will take place at B-2, while DBHydro flow at S-155 will be used for dynamic load calculations. TSS water samples shall be collected concurrently at B2 and B4 for every flow increment; a total of 15 TSS samples collected at B2 and B4 in the following manner: Three vertical (center) as indicated below and repeated five times prior to increasing S-155 structure discharge to the next flow value as described.



11. Conduct sampling after gate closure to evaluate settling rate and perhaps particle size. This can be done in combination with a continuous monitoring scenario to evaluate pre flow conditions, flow conditions (variable or steady state) and post flow conditions.
12. Conduct upstream and downstream sampling and compare overall vs. basin contributions.
13. Conduct field measurements during variable operations capturing seasonal variation in sediment loads and source (ie. TSS vs. macrophyte/vegetation contributions).
14. Variable operations: characterize no flow, initial high flow and maintenance flow loads.
15. Characterize settling in trap: high, medium and low flow conditions and sampling over several hours to track settling (component of 10 above or separately).

6. References

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