Restoration Strategies Regional Water Quality Plan – Science Plan for the Everglades Stormwater Treatment Areas:

Evaluation of the Influence of Canal Conveyance Features on Stormwater Treatment Area and Flow Equalization Basin Inflow and Outflow Total Phosphorus Concentrations

STA-1 Inflow Basin Canal Investigation Phase I Report

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EXECUTIVE SUMMARY

This report documents the Phase I study of the Stormwater Treatment Area 1 Inflow Basin Canal segment from S-5A to G-302. The objectives of this study are to determine, through detailed analyses of existing water quality and flow data, if total phosphorus concentrations change when conveyed along the canal. If the concentrations do change, another objective is to determine how much load has exported from the canal, or how much load has accumulated in the canal throughout the analysis period. Concentration based analyses, and a mass balance approach based on the different temporal scales in combination with statistical analysis tools was developed to address these objectives. The temporal scales investigated include instantaneously paired water quality sampling data; individual flow events; and monthly, wet/dry season, and annual analyses. The statistical analysis tools applied include descriptive statistics and boxplots, correlation, and regression analyses.

The various load-based analyses suggest that from S-5A to G-302, total phosphorus and particulate phosphorus loads were exported over the period analyzed. The results indicate that the canal acted as a total phosphorus source during the period from May 1, 2000 to April 30, 2013, exporting approximately 70 to 76 metric tons of total phosphorus. The mass balances for total phosphorus and phosphorus fractions also suggest the total phosphorus load exported from this canal system was mainly caused by the particulate phosphorus export.

The concentration-based analyses including the scatterplot matrix and the statistic tests (Wilcoxon Signed-Rank [WSR] test and t-test) of the water quality concentration changes and box plots associated with concentration change percentage (CCP), suggest that the canal appeared to act as TP and PP sources.

Storm event-based analyses suggested that, in general, when the water velocity increased to 0.8 ft/s or more, concentration increases from S-5A to G-302 were observed for TP. These results support the Restoration Strategies' goal of providing flow equalization basins upstream of the Everglades Stormwater Treatment Areas to reduce the frequency and duration of peak flow events.

Phase II is not recommended for this canal at this time because once the L-8 FEB is operational, peak flow rates into STA-1W are anticipated to reduce (magnitude and frequency) which in turn is expected to result in less potential for sediment transport/resuspension in this canal.

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CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

To address water quality concerns associated with existing flows to the Everglades Protection Area (EPA), the South Florida Water Management District (SFWMD or District), Florida Department of Environmental Protection (FDEP), and United States Environmental Protection Agency (USEPA) engaged in technical discussions starting in 2010. The primary objectives were to establish a Water Quality Based Effluent Limit (WQBEL) that would achieve compliance with the State of Florida's numeric total phosphorus (TP) criterion in the EPA and to identify a suite of additional water quality projects to work in conjunction with the existing Everglades Stormwater Treatment Areas (STAs) to meet the WQBEL. The Restoration Strategies Regional Water Quality Plan – Science Plan for the Everglades Stormwater Treatment Areas (Science Plan; SFWMD, 2013) is being implemented to investigate critical factors that influence phosphorus (P) treatment performance. It was developed in coordination with key state and federal agencies and experts and was designed to increase the understanding of factors that affect treatment performance; in particular, factors that affect performance at low TP concentrations [< 20 micrograms per liter (µg/L), or parts per billion (ppb)]. The findings from these studies are intended to be used to inform the design and operation of other Restoration Strategies projects, which will ultimately help improve the SFWMD's capabilities to manage TP in the STAs for achievement of the WQBEL.

Surface water TP concentrations have been observed to change along canal reaches between STA inflow pump stations and inflow structures at the upstream end of the STA flow-ways. Several mechanisms could drive these changes. Total suspended solids (TSS) are a component of stormwater and are present in STA inflow and outflow canals. Particulate and soluble P may sorb to suspended solids and settle in these canals. High flow velocities can induce sediment resuspension, resulting in elevated TP in inflow water or elevated TP in the outflow collection canals. During severe droughts, water levels in some canals are lowered to the extent that portions of the canal sediments are exposed. When reflooded, mineralized sediment P may be released to the overlying water column, which could also influence the water TP concentrations observed at the inflow and outflow structure sampling locations. Stagnant canal segments may allow excessive algal growth and settling of organic material that decomposes and removes dissolved oxygen. Anaerobic conditions at the sediment-flood water interface could trigger release of soluble P. Seepage of water into STA canals to or from adjacent water bodies might also be a contributing factor in changes in surface water TP concentration. All these factors may contribute to TP concentration changes along canals.

The Evaluation of the Influence of Canal Conveyance Features on STA and Flow Equalization Basin (FEB) Inflow and Outflow TP Concentrations Study (Canal Study) is a study in the Science Plan and that evaluating the P change in canals may help us meet the WQBELs. This study is being designed in two phases through desktop data analyses and field investigations. The objective of this study is to address if TP concentrations change when conveyed through STA inflow or outflow canals and, if so, what factors influence these changing concentrations. A mass balance approach based on different temporal scales combined with statistical analysis tools is developed to address these objectives. Grab samples collected at an upstream site were paired with samples collected at a downstream site by sample date over the period of record (POR). Scatterplot diagrams were used to look for trends. The Wilcoxon signed-rank (WSR) test and Seasonal Kendall Tau Trend test are the primary statistical methods used for the data analysis by using the statistical analysis tool SAS/STAT. For the mass balance approach, the temporal scales investigated include instantaneously paired water quality sampling data; individual flow events; and monthly, wet/dry season, and annual analyses. The potential influencing factors related to water quality changes as water travels from upstream to downstream were also evaluated. The water quality concentrations in grab samples were used in this particular analysis. The breakpoint flow and canal stage data were paired with water quality data based on the time of collection of each sample. Only paired data collected under flow conditions were used for these specific analyses. Water velocities in the canal were calculated based on flow, canal stage, and canal cross-section data. For each water quality parameter, three types of analyses were performed as follows: descriptive statistics and box plots, correlation analysis, and regression analysis.

This report summarizes the Phase I analyses conducted for the STA-1 Inflow Basin Canal segment from the S-5A Pump Station to the STA-1West (STA-1W) inflow structure G-302 (**Figure 1-1**).

1.2 STA-1 INFLOW BASIN CANAL SEGMENT FROM S-5A TO G-302

The STA-1 Inflow Basin is a 272-acre portion of northern Water Conservation Area (WCA)-1 near the S5A pump station that was leveled to form a basin that serves as storage and distribution for STA-1W and STA-1E (Abtew, 2005) (**Figure 1-1**). The STA-1 Inflow Basin Canal is the canal system located in this basin. The S-5A Pump Station, which provides flood control for the S-5A Basin, and the East Beach Water Control District through the S-5A Basin, is the major inflow structure to the STA-1 Inflow Basin Canal. S-5AS functions with S-5AE, S-5AW, and the S-5A Pump Station to route runoff from the L-8 Basin and make irrigation releases from WCA-1 to the L-10, L-12, L-8, and C-51 basins. The removal of stormwater runoff from the upstream basins is the primary function of the S-5A Pump Station. In addition to flood control for the S-5A tributary basin, the S-5A Pump Station is used to remove excess flows from the L-8 and C-51 basins as well as to convey excess water from Lake Okeechobee (when it is above its regulation schedule) to WCA-1. In some instances, the S-5A Pump Station is used to convey water from Lake Okeechobee to WCA-1 for the purpose of water supply for points downstream of the pump station. The S-5A Pump Station is located on the south side of State Road 80 and West Palm Beach Canal, approximately 20 miles west of West Palm Beach. The pump station is equipped with six diesel-powered pumps, each rated at 800 cubic feet per second (cfs) at a static head of 11.1 feet National Geodetic Vertical Datum of 1929 (ft NGVD), with a combined capacity of 4,800 cfs. It is the design intention that the majority of discharges from the S-5A Pump Station (up to nominal rate of 3,250 cfs) be directed to STA-1W through structure G-302. Discharge exceeding the capacity of STA-1W is directed to STA-1E through structure G-311.

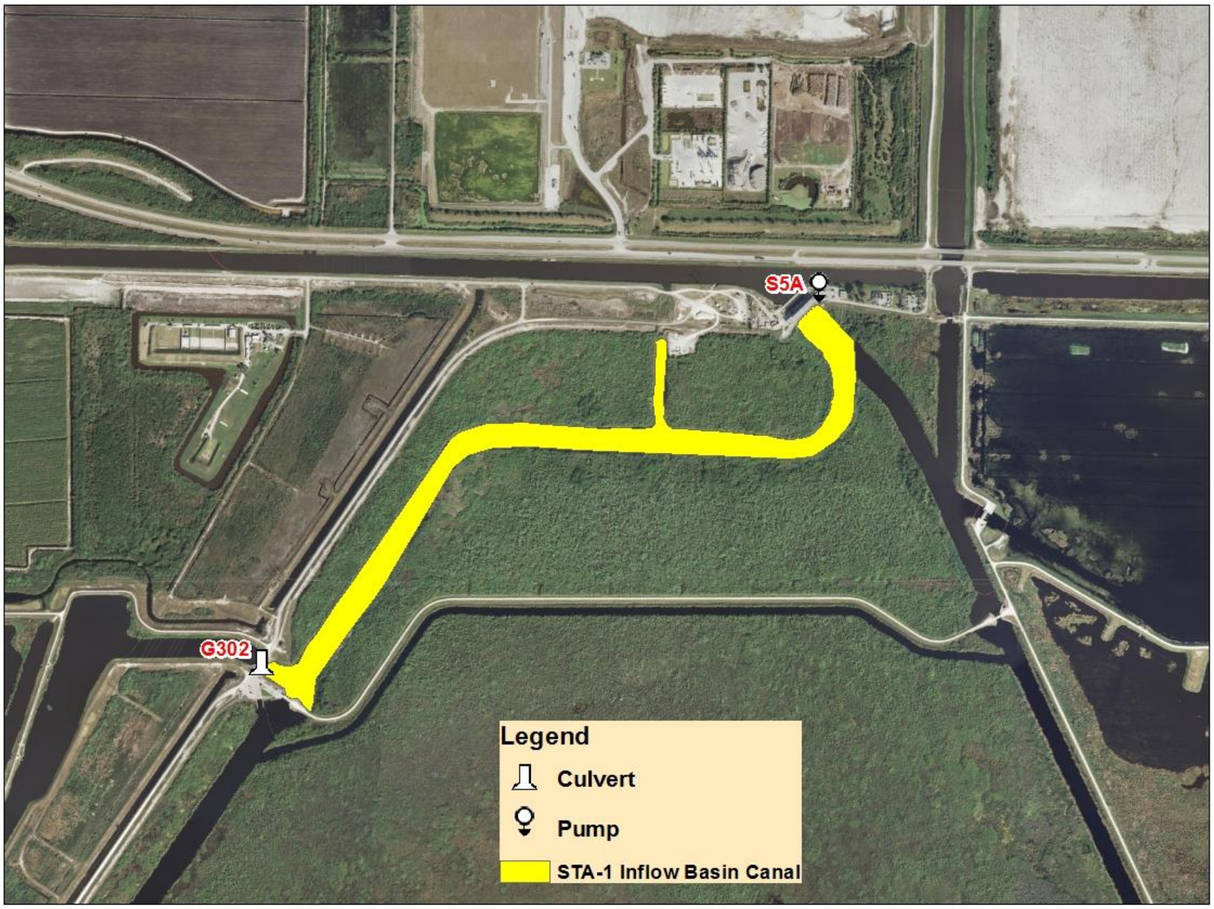


Figure 1-1. Map of the STA-1 Inflow Basin Canal between S-5A and G-302 showing other water control structures.

CHAPTER 2: STA-1 INFLOW BASIN CANAL WATER QUALITY CONCENTRATION DATA VARIABILITY AND TREND ANALYSES

Steven Hill, Hongying Zhao, Ph.D., P.E., and Tracey Piccone, P.E.

2.1 INTRODUCTION

This chapter summarizes statistical analyses conducted to quantify and characterize the relationship between upstream (S-5A) and downstream (G-302) water quality (WQ) concentrations along the STA-1 Inflow Basin Canal as summarized in **Table 2-1**. The WQ concentrations were evaluated to determine if (1) an overall trend is observed between upstream (S-5A) and downstream (G-302) WQ concentration data using a scatterplot, (2) WQ concentrations measured at S-5A and G-302 are different using statistical analyses, and (3) WQ concentration differences between S-5A and G-302 had a trend (increasing or decreasing) over the analysis period using statistical analyses. Background information on the STA-1 Inflow Basin Canal is presented in Chapter 1 of this report. The STA-1 Inflow Basin Canal segment from S-5A to G-302 is depicted in **Figure 1-1**.

Table 2-1. Water quality parameters analyzed in the STA-1 Inflow Basin Canal study.

Parameter	Unit	Test Number[1]
Phosphorus, Total as P (TP)	mg/L	25
Phosphorus, Soluble Reactive as P (SRP)	mg/L	23
Phosphorus , Total Dissolved as P (TDP)	mg/L	26
Phosphorus Particulate as P (PP) (calculated) [2]	mg/L	N/A
Phosphorus, Dissolved Organic as P (calculated) [3]	mg/L	N/A
Total Suspended Solids (TSS)	mg/L	16
Total Dissolved Chloride (CLD)	mg/L	32

[1] Numeric code used to identify individual tests within the District's Chemistry Laboratory, e.g., 25 = TPO_4 total phosphorus.

2.2 DATA PREPARATION AND STATISTICAL ANALYSES METHODS

WQ grab samples were collected, regardless of flow, first at the upstream site (S-5A) then at the downstream site (G-302). Concentration levels of TP, soluble reactive phosphorus (SRP), TSS, and total dissolved chloride (CLD) were measured while the concentration levels for particulate phosphorus (PP) and total dissolved phosphorus (TDP) were calculated in this study. Samples collected at the upstream site (S-5A) were paired with samples collected at the downstream site (G-302) by sample date over the POR. Scatterplot diagrams were used to look for trends. The WSR test and Seasonal Kendall Tau Trend test were the primary statistical methods used for the data analysis. A significance level of $\alpha = 0.05$ was used for all statistical analyses by using the statistical analysis tool SAS/STAT.

SCATTERPLOTS

A scatterplot is a simple diagram with X-Y axes used to display two variables of a data set. This simple tool was used to visually determine if any overall trend exists between the WQ concentration data measured at S-5A and G-302.

WILCOXON SIGNED-RANK TEST

The WSR test is a non-parametric (distribution-free) statistical procedure used to compare samples that are related (Sokal and Rohlf, 1973). It is an alternative to the paired t-test and is used when the paired differences (sample 1 - sample 2) are not normally distributed. The research hypothesis for the test is that the median difference is not zero. A statistically significant test result supports the research hypothesis and concludes that sample 1 and sample 2 data are statistically different.

In this study, the WSR test was used to test for statistically significant increases or decreases between upstream and downstream WQ parameters (as listed in **Table 2-1**) concentrations. This test was performed on the paired concentration differences (upstream-downstream). The median of the paired concentration differences (median difference) was used to quantify the difference in concentration between the upstream and downstream stations. The median difference was then tested for statistical significance with the WSR test. Statistical significance is indicated if the median of the paired differences is statistically greater or less than 0 at the specified significance level.

SEASONAL KENDALL TAU TREND TEST

The Seasonal Kendall Trend test is a non-parametric (distribution-free) statistical procedure used to detect trends in time series data (Reckhow et al., 1993). The test takes into account specified inherent seasonality and provides appropriate significance probabilities (p-values) in the presence of statistically significant autocorrelation (time correlated samples) in the data. The research hypothesis for the test is that the trend (slope) is not 0. A statistically significant result supports the research hypothesis and concludes that there is a trend in the time series data.

In this study, the Seasonal Kendall Tau Trend analysis was used to test for trends (increasing/ decreasing) in the upstream-downstream paired concentration differences over time by using monthly WQ parameter concentration data. Statistical significance of the trend is indicated if the tau statistic is statistically significant at the specified significance level.

2.3 RESULTS

SCATTERPLOTS

Observed trends for the WQ concentrations based on visual observations of the scatterplots are summarized below (see **Figures 2-1** through **2-7**, respectively):

- TP: Slightly higher TP concentrations at G-302 than at S-5A.
- DOP: No trend was observed.
- PP: Slightly higher PP concentrations at G-302 than at S-5A.
- TDP: No trend was observed.
- SRP: No trend was observed.
- TSS: Slightly higher TSS concentrations at G-302 than at S-5A.
- CLD: No trend was observed.

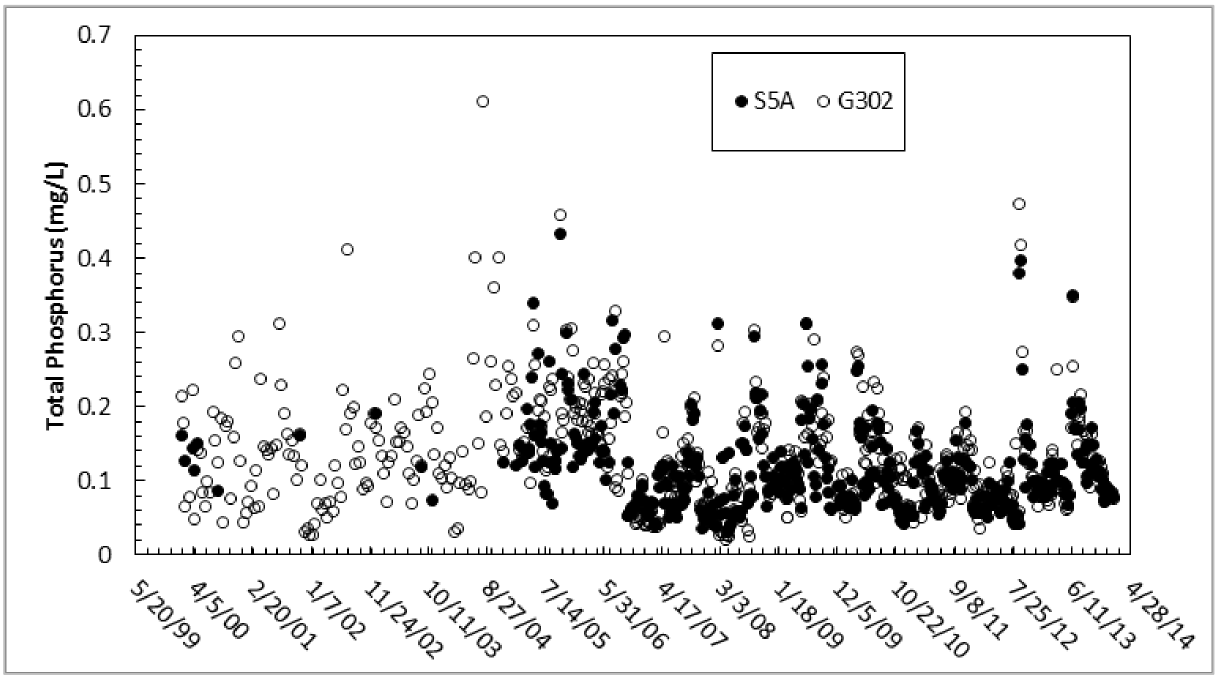


Figure 2-1. Total phosphorus concentration data at S-5A and G-302 versus time.

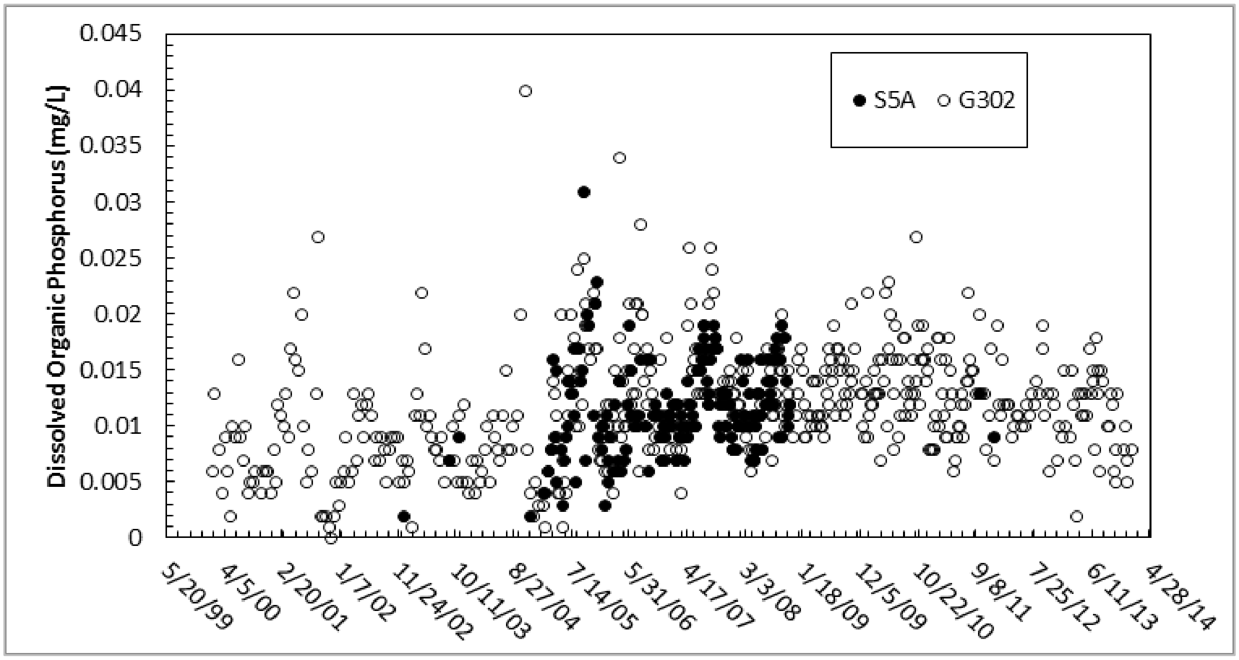


Figure 2-2. Dissolved organic phosphorus concentration data at S-5A and G-302 versus time.

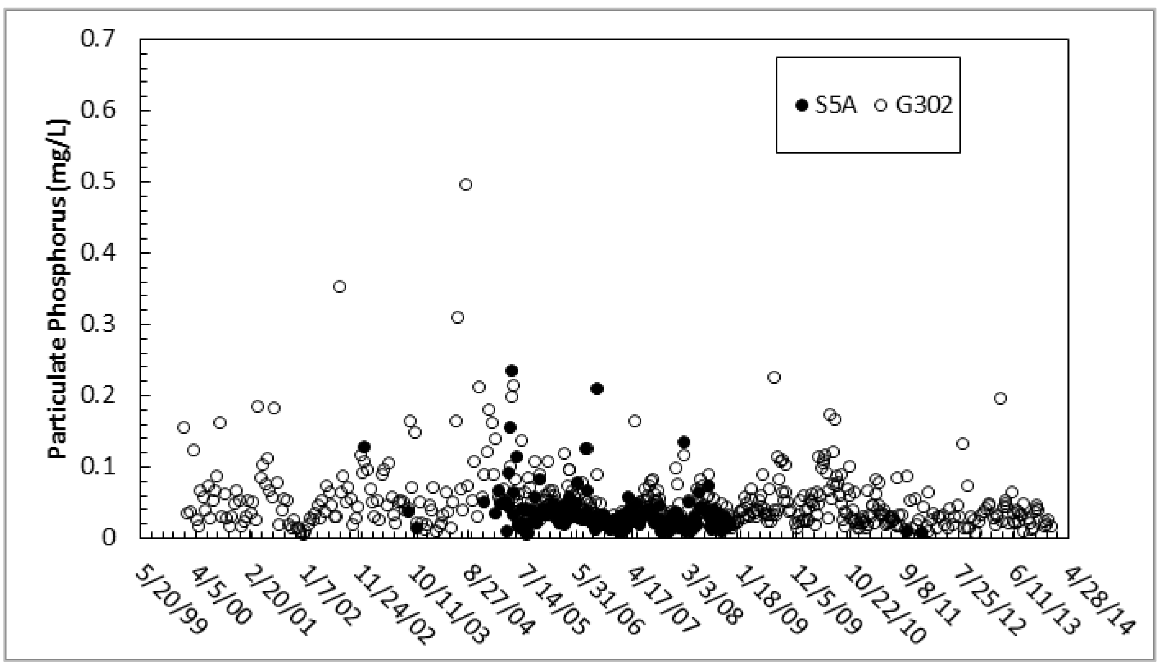


Figure 2-3. Particulate phosphorus concentration data at S-5A and G-302 versus time.

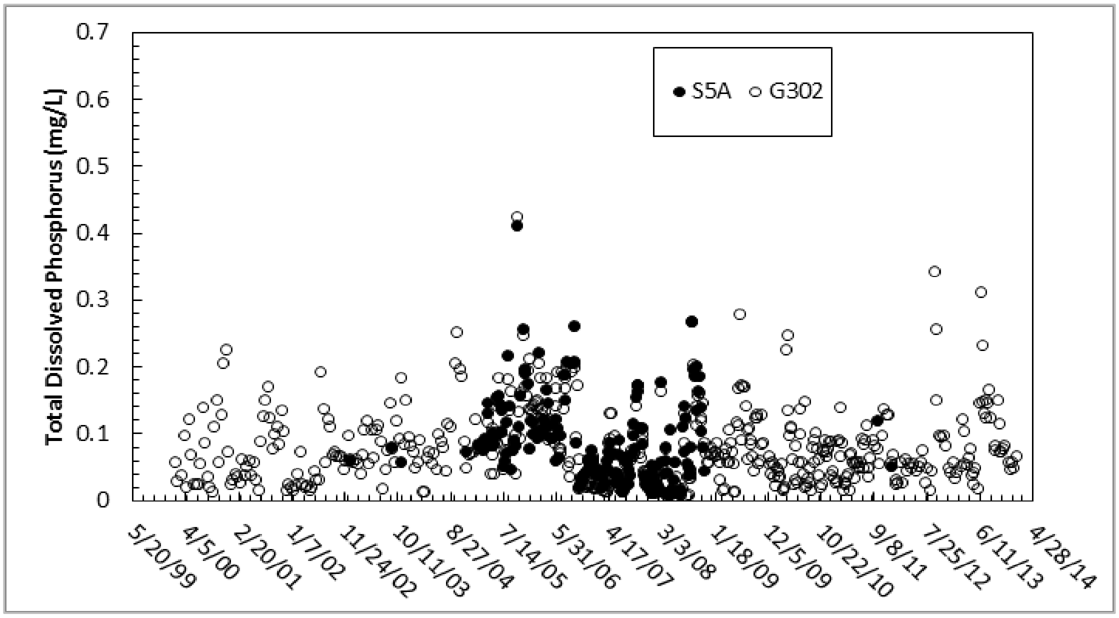


Figure 2-4. Total dissolved phosphorus concentration data at S-5A and G-302 versus time.

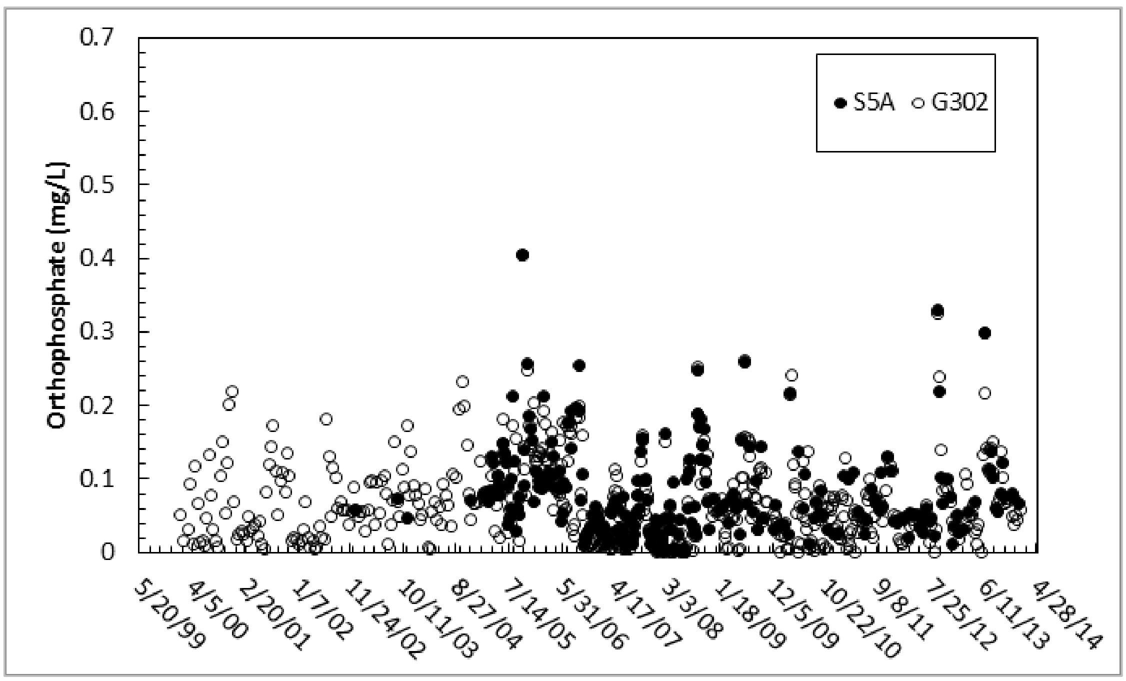


Figure 2-5. Soluble reactive phosphorus concentration data at S-5A and G-302 versus time.

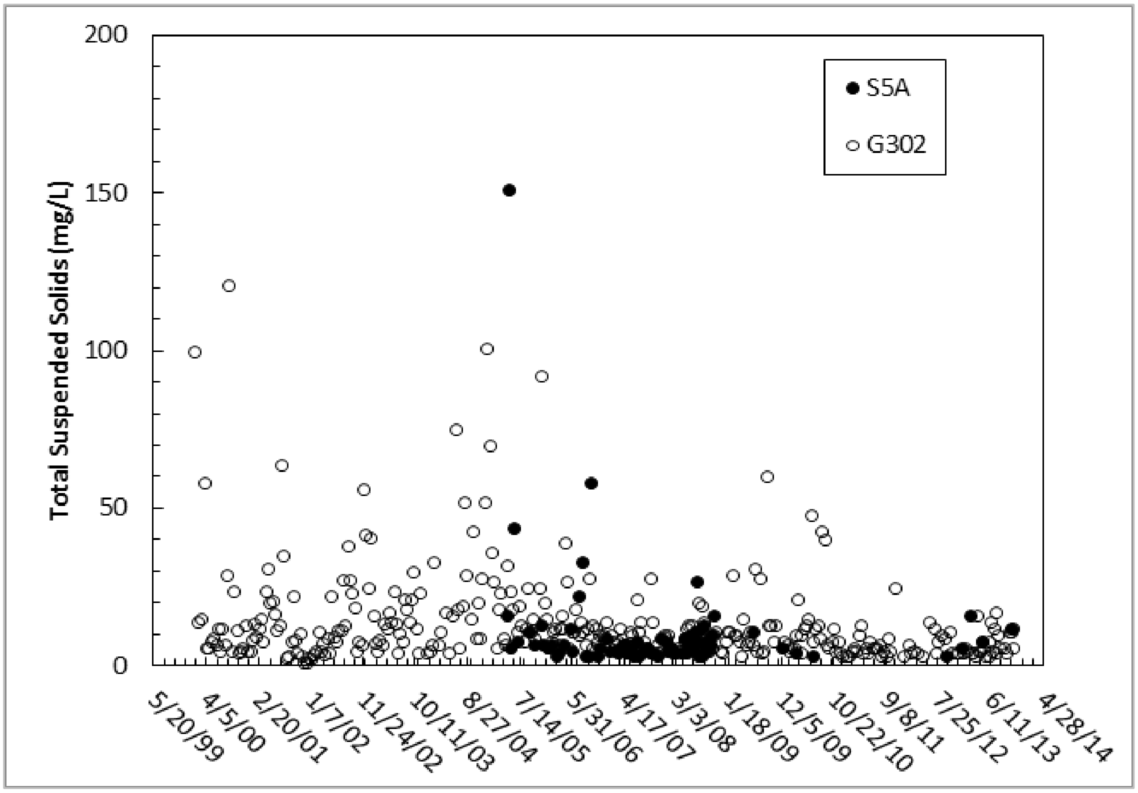


Figure 2-6. Total suspended solids concentration data at S-5A and G-302 versus time.

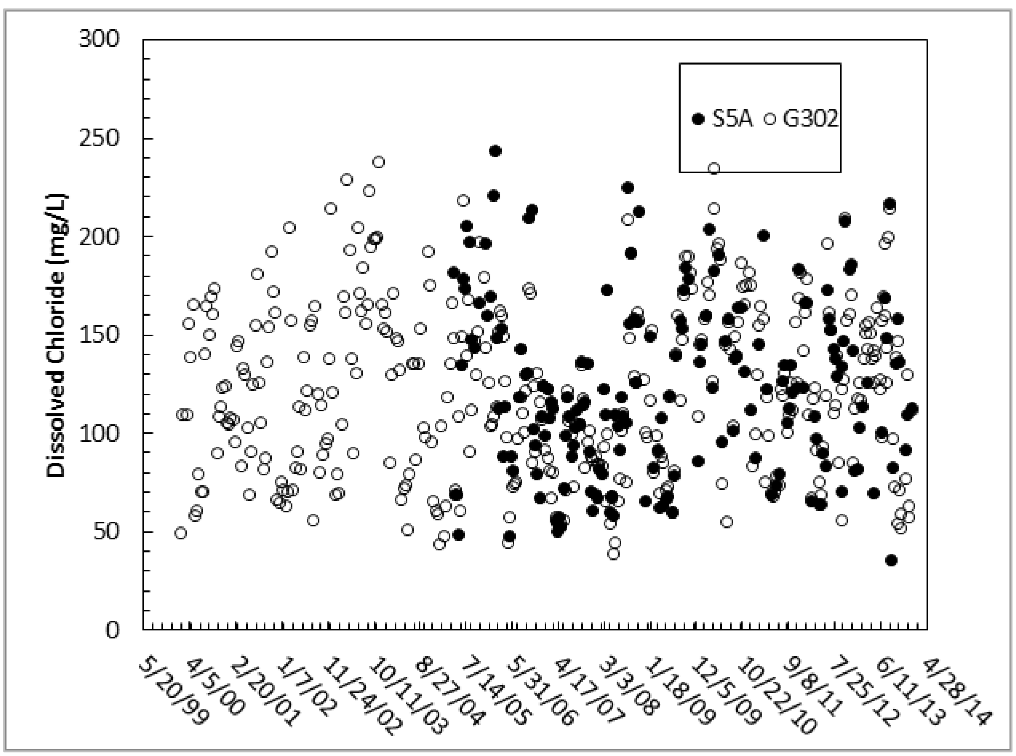


Figure 2-7. Total dissolved chloride concentration data at S-5A and G-302 versus time.

WILCOXON SIGNED-RANK TEST

The results of the WSR analyses for differences between upstream (S-5A) and downstream (G-302) WQ concentrations are presented in **Table 2-2** and summarized as follows:

- TP: Median concentrations at S-5A were 7 ppb lower than those at G-302; this difference is statistically significant (p-value < 0.0001).
- DOP: Median concentrations at S-5A were 1 ppb greater than those at G-302; this difference is statistically significant (p-value = 0.0003).
- PP: Median concentrations at S-5A were 9 ppb lower than those at G-302; this difference is statistically significant (p-value < 0.0001).
- TDP: Median concentrations at S-5A were 3 ppb greater than those at G-302; this difference is statistically significant (p-value = 0.0269).
- SRP: Median concentrations at S-5A were 5 ppb greater than those at G-302; this difference is statistically significant (p-value < 0.0001).
- TSS: Median concentrations at S-5A were 3,500 ppb lower than those at G-302; this difference is statistically significant (p-value = 0.0001).
- CLD: Median concentrations at S-5A were 700 ppb greater than those at G-302; this difference is not statistically significant (p-value = 0.2556).

Table 2-2. Wilcoxon Signed-Rank test statistics for upstream (S-5A) and downstream (G-302) sites.

Parameter	N	Median Upstream - Downstream Difference (ppb)	Upstream Station Comparison	Statistically Significant (α=0.05)	P-value
TP	447	-7	Lower	Yes	< 0.0001
DOP	171	1	Higher	Yes	0.0003
PP	175	-9	Lower	Yes	< 0.0001
TDP	177	3	Higher	Yes	0.0269
SRP	257	5	Higher	Yes	< 0.0001
TSS	42	-3,500	Lower	Yes	0.0001
CLD	143	700	Statistically no difference	No	0.2556

SEASONAL KENDALL TAU TREND TEST

The results of the Seasonal Kendall Tau Trend analyses of the upstream (S-5A) and downstream (G-302) WQ concentration differences are summarized below. **Appendix 2-1** of this appendix contains graphs of the concentration differences over time. The horizontal line at 0 on the y-axis aids in visualizing the distribution of the positive (upstream > downstream) and negative (upstream < downstream) differences. A linear trend line is provided to aid in visualizing the direction (increasing/decreasing) of the differences over time. For Seasonal Kendall Tau Trend Test, a minimum of 5 years of monthly data for monotonic trend analysis is suggested (Lettenmaier et al., 1982, Reckhow et al., 1993). In this study, only four years of data are available for TDP. This period may not be sufficient to ensure reliable results using a Seasonal Kendall Tau Trend Test, therefore the presented results need to be used cautiously. For DOP, PP, and TSS, more than 50% of data were missing for the analysis periods. Due to data scarcity, the statistical estimates for these parameters may be questionable and should be interpreted with caution. The estimates for these parameters are bolded and italicized in **Table 2-3**.

- TP: The difference between the concentrations at S-5A (upstream) and G-302 (downstream) increased at a rate of 0.3 ppb per year (ppb/year). This difference is not statistically significant (p-value = 0.7283).
- DOP: The difference between the concentrations at S-5A and G-302 was unchanged at a rate of 0.0 ppb/year. This difference is not statistically significant (p-value = 0.3761).
- PP: The difference between the concentrations at S-5A and G-302 increased at a rate of 0.8ppb/year. This difference is not statistically significant (p-value = 0.8666).
- SRP: The difference between the concentrations at S-5A and G-302 increased at a rate of 0.8 ppb/year. This difference is not statistically significant (p-value = 0.3123).
- TSS: The difference between the concentrations at S-5A and G-302 increased at a rate of 1.2 ppb/year. This difference is not statistically significant (p-value > 0.999).
- CLD: The difference between the concentrations at S-5A and G-302 decreased at a rate of 1.8 ppb/year. While this difference is statistically significant (p-value = 0.0339), this small change is of no practical importance considering that the CLD concentrations at S-5A ranged from 35,700 to 306,000 ppb during the period from May 1, 2000–April 30, 2013. In addition, this difference may represent analytical noise in the data.

Table 2-3 contains the statistics for the Seasonal Kendall Tau Trend analyses. In this table, note that DOP, PP, TDP, and TSS values (in bold and italicized) represent parameters with more than 50% of the data missing for the POR, respectively, and these estimates should be interpreted with caution.

Table 2-3. Seasonal Kendall Tau trend analysis of upstream (S-5A) and downstream (G-302) monthly flow-weighted mean concentration differences. [Note: Bold, italicized items represent parameters with >50% of data missing for the period of record; as such, these estimates should be interpreted with caution.]

Parameter	Number of Years	Number of Months	Months without Values	% Missing Months	Number of Months	Average annual difference	Sen's Trend Slope (ppb/year)	Slope P-value	Intercept
TP	15	180	63	35.00%	117	7.80	0.3	0.7283	-0.0080
DOP	***10***	***120***	***68***	***56.67%***	***52***	***5.20***	***0.0***	***0.3761***	***-0.0010***
PP	***10***	***120***	***68***	***56.67%***	***52***	***5.20***	***0.8***	***0.8666***	***-0.0146***
*TDP**	*4*	*48*	*2*	*4.17%*	*46*	*11.5*	*3*	*0.0286*	*0.0025*
SRP	12	144	38	26.39%	106	8.83	0.8	0.3123	0.0041
TSS	***8***	***96***	***69***	***71.88%***	***27***	***3.38***	***1.2***	***1.0000***	***-9.2500***
CLD	8	96	13	13.54%	83	10.38	-1.8	0.0339	8.6875

*Limited samples were used therefore results should be used with caution.

2.4 SUMMARY AND CONCLUSIONS

For TP, the concentration data scatterplot had slightly higher TP concentrations at G-302 than S-5A based on visual observations. This was confirmed by the WSR analysis, which suggests that the median TP concentrations at G-302 were 7 ppb higher than those at S-5A. This difference is statistically significant (p-value < 0.0001). Over the analysis period, Seasonal Kendall Tau Trend analyses indicated no statistically significant trend over time for the TP concentration differences (TP_S-5A - TP_G-302).

For SRP, the concentration data scatterplot had no obvious trend between G-302 and S-5A based on visual observations. However, the WSR analyses showed that SRP concentrations at G-302 were 5 ppb lower than those at S-5A. This difference is statistically significant (p-value < 0.0001). Over the analysis period, Seasonal Kendall Tau Trend analyses indicated no statistically significant trend over time for the SRP concentration difference (SRP_S-5A - SRP_G-302).

For TDP, the concentration data scatterplot had no obvious trend between G-302 and S-5A based on visual observations. However, the WSR analyses showed that TDP concentrations at S-5A were 3 ppb greater than those at G-302. This difference is statistically significant (p-value = 0.0269). For Seasonal Kendall Tau Trend analyses, over the analysis period, the results indicated a statistically significant (p-value = 0.0286) increasing trend over time for the TDP concentration difference (SRP_S-5A - SRP_G-302) at a rate of 3.0 ppb/year. However, these results may be questionable as only four years of data were available for this analysis.

For PP, the concentration data scatterplot had slightly higher PP concentrations at G-302 than S-5A based on visual observations. This was confirmed by the WSR analysis, which suggested that the concentrations at G-302 were 9 ppb higher than those at S-5A. This difference is statistically significant (p-value < 0.0001). Over the analysis period, Seasonal Kendall Tau Trend analyses indicated no statistically significant trend over time existed for the PP concentration difference (PP_S-5A - PP_G-302).

For DOP, the concentration data scatterplot had no obvious trend between G-302 and S-5A based on visual observations. However, the WSR analyses showed that DOP concentrations at G-302 were 1 ppb lower than those at S-5A. This difference is statistically significant (p-value = 0.0003). Over the analysis period, Seasonal Kendall Tau Trend analyses indicated no statistically significant trend over time for the DOP concentration difference (DOP_S-5A - DOP_G-302).

For TSS, the concentration data scatterplot had slightly higher TSS concentrations at G-302 than S-5A based on visual observations. This was confirmed by the WSR analysis, which suggested that the concentrations at S-5A were 3,500 ppb lower than those at G-302. This difference is statistically significant (p-value = 0.0001). Over the analysis period, Seasonal Kendall Tau Trend analyses indicated no statistically significant trend over time for the TSS concentration difference (TSS_S-5A - TSS_G-302).

For CLD, the concentration data scatterplot had no obvious trend between G-302 and S-5A based on visual observations. The WSR analyses also confirmed that no statistically significant difference in concentrations exists between G-302 and S-5A. Over the analysis period, Seasonal Kendall Tau Trend analyses indicated a statistically significant (p-value = 0.0339) decreasing trend over time for the CLD concentration difference (CLD_S-5A - CLD_G-302) at a rate of -1.8 ppb/year. While this difference is statistically significant (p-value = 0.0339), this small number is of no practical importance considering the large CLD concentrations range.

The following summarizes the overall findings from the concentration-based analyses for the STA-1 Inflow Basin Canal:

- Based on the scatterplots, an overall trend of slightly higher concentrations of TP, PP, and TSS at G-302 than at S-5A was observed. However, no trend was observed for SRP, TDP, DOP, and CLD.
- Based on the statistical analyses, TP, PP, and TSS had statistically significant higher concentrations at G-302 than at S-5A. The parameters showing statistically significant lower concentrations at G-302 than S-5A were DOP, TDP, and SRP. CLD showed no statistically significant difference.
- Also based on the statistical analyses, only the TDP concentration differences between S-5A and G-302 showed an increasing trend over the analysis period. However, only four years of data were available for this parameter, which is less than the minimum data requirement of five years. As such, this trend is questionable. The CLD showed a statistically significant decreasing trend, which is of no practical importance.
- In conclusion, the results of the above analyses suggest slightly higher concentrations at G-302 than at S-5A over time based on visual observations of the scatterplots. The canal is acting as a source of TP, PP, and TSS based on the WSR test.

The results from this chapter will be combined with the results from the analyses in the other chapters of this report to develop the overall conclusions and recommendations.

CHAPTER 3: STA-1 INFLOW BASIN CANAL SEDIMENTS AND TOTAL PHOSPHORUS ACCUMULATION EVALUATION BASED ON ANNUAL, MONTHLY AND SEASONAL MASS BALANCES

Hongying Zhao, Ph.D., P.E., and Tracey Piccone, P.E.

3.1 INTRODUCTION

This chapter summarizes annual, seasonal, and monthly mass balance analyses for the STA-1 Inflow Basin Canal for the following WQ parameters: TP, TDP, SRP, DOP, PP, TSS, and CLD. The mass balance analyses were conducted using the District's web-based Nutrient Load Program (NLP). Different concentration calculation modes within the NLP were used as appropriate. The load and sediment estimates based on the different calculation modes were evaluated for appropriateness and reasonableness, and the selected data was used to try to address the following five questions:

1. Is the canal a TP source or sink (qualitative assessment)?
2. What is the sediment accrual status in a canal based on the TSS load analysis (qualitative assessment)?
3. How much sediment (in metric tons) (based on the TSS load analysis) has been accumulated in a canal during the POR?
4. How much TP [in kilograms or metric tons (mt)] has been accumulated in a canal during the POR?
5. What is the source/sink status for other water quality parameters: TDP, SRP, CLD, PP, and DOP?

3.2 DATA ANALYSIS AND PRESENTATION

STA-1 INFLOW BASIN CANAL AND THE ASSOCIATED STRUCTURES

STA-1 Inflow Basin is a 272-acre portion of northern WCA-1 near the S-5A pump station that was levied to form a basin that serves as storage and distribution for STA-1W and STA-1E (Abtew, 2005) (**Figure 3.1**). The STA-1 Inflow Basin Canal is the canal system located in this basin. The S-5A Pump Station, which provides flood control for the S-5A Basin, and the East Beach Water Control District through the S-5A Basin, is the major inflow structure to the STA-1 Inflow Basin Canal. S-5AS functions with S-5AE, S-5AW, and the S-5A Pump Station to route runoff from the L-8 Basin and make irrigation releases from WCA-1 to the L-10, L-12, L-8, and C-51 basins. The removal of stormwater runoff from the upstream basins is the primary function of the S-5A Pump Station. In addition to flood control for the S-5A tributary basin, the S-5A Pump Station is used to remove excess flows from the L-8 and C-51 basins as well as to convey excess water from Lake Okeechobee (when it is above its regulation schedule) to WCA-1. In some instances, the S-5A Pump Station is used to convey water from Lake Okeechobee to WCA-1 for the purpose of water supply for points downstream of the pump station. S-5A Pump Station is located on the south side of State Road 80 and West Palm Beach Canal, approximately 20 miles west of West Palm Beach. The pump station is equipped with six diesel-powered pumps, each rated at 800 cfs at a static head of 11.1 ft NGVD, with a combined capacity of 4,800 cfs. It is the design intention that the majority of discharges from the S-5A Pump Station (up to nominal rate of 3,250 cfs) be directed to STA-1W through structure G-302. Discharge exceeding the capacity of STA-1W is directed to STA-1E through structure G-311.

Several structures associated with the STA-1 Inflow Basin Canal have multiple functions and can convey flow in two directions. The flow data are recorded as positive or negative to distinguish the direction of flow. For S-5AS, flows to the north are designated as outflows from the STA-1 Inflow Basin Canal and are shown as negative flows. Flows to the south are designated as inflows to the STA-1 Inflow Basin Canal and are expressed as positive flows. For G-311, flows to the west are designated as inflows to the STA-1 Inflow Basin Canal and are shown as negative flows; flows to the east are designated as outflows from the STA-1 Inflow Basin Canal and are shown as positive. Although the focus of the Canal Study is the canal segment from S-5A to G-302, for mass balance calculations, the other structures in this canal system, i.e., G-311, S-5AS, G-300, and G-301, were also included in the mass balance calculations.

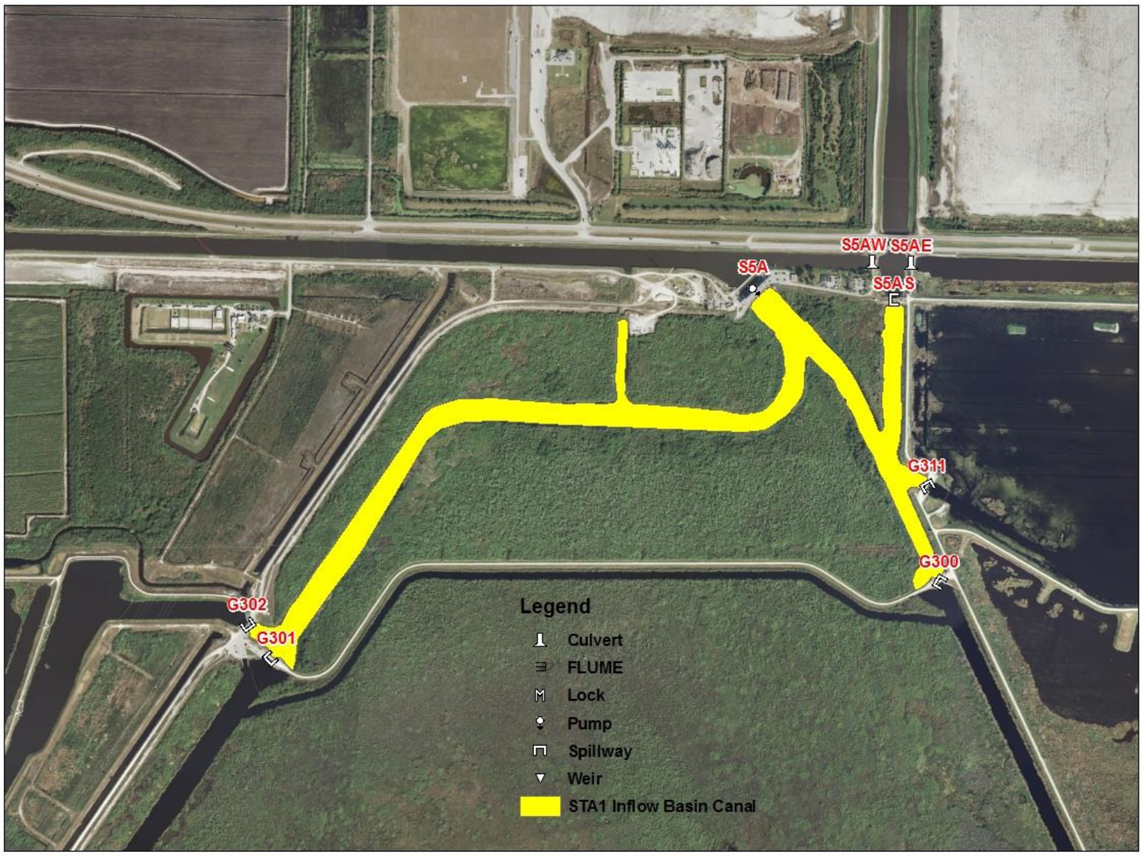


Figure 3-1. STA-1 Inflow Basin Canal and the associated structures

MASS BALANCE EQUATION

The basic mass balance equation is:

Inflow - Outflow = residual

where inflow and outflow are defined in **Table 3-1** based on the flow direction. The (+) and (-) symbols refer to the direction of flow as reported in DBHYDRO, and how it relates to flows into and out of the STA-1 Inflow Basin Canal. For S-5A and S-5AS, the positive flow data represent the flow entering the STA-1 Inflow Basin Canal and the negative flow data represent flow leaving the STA-1 Inflow Basin Canal. For G-300, G-301, G-311 and G-302, the negative flow data represent the flow entering the STA-1 Inflow Basin Canal and the positive flow data represent flow leaving the STA-1 Inflow Basin Canal.

Table 3-1. STA-1 Inflow Basin Canal inflow and outflow water control structures.

Inflow	Outflow
S-5A (+)	S-5A (-)
G-300 (-)	G-300 (+)
G-301 (-)	G-301 (+)
S-5AS (+)	S-5AS (-)
G-311 (-)	G-311 (+)
G-302 (-)	G-302 (+)

Note: For S-5A and S-5AS, the positive flow data represent the flow entering the STA-1 Inflow Basin Canal and the negative flow data represent flow leaving the STA-1 Inflow Basin Canal.

For G-300, G-301, G-311 and G-302, the negative flow data represent the flow entering the STA-1 Inflow Basin Canal and the positive flow data represent flow leaving the STA-1 Inflow Basin Canal.

WATER QUALITY SAMPLING AND SURROGATES FOR MISSING DATA

Initially, the period selected for analysis for the water quality parameters list in **Table 2-1** was from May 1, 2000 to April 30, 2013. The final analysis period for the individual WQ parameters was adjusted based on data availability. In some cases, data at surrogate sites were used to fill in missing data, as described in this section. Different approaches were used for different sites and different operational modes based on comprehensive analysis of the available data and best professional judgment.

WQ sampling methods and beginning sampling dates for the STA-1 Inflow Basin Canal structures are summarized in **Tables 3-2** and **3-3**, respectively. G-311 operations started in June 2005 and WQ sampling started immediately after operation commenced. For G-300 and G-301, sampling of TDP, SRP, TSS, and CLD started around mid-2005. Outflow from G-300 and G-301 was mainly diversion of flows from S-5A. Inflows through G-300 and G-301 were mainly water supply deliveries and were sent north through S-5AS. As summarized in **Table 3-4**, during the period between May 1, 2000 and the first WQ sampling date, approximately 4% [82,000 acre-feet (ac-ft)] of flow was conveyed through structure G-301 was conveyed for water supply, and approximately 5% (102,000 ac-ft) of flow through structure G-301 was conveyed for flood control. At structure G-300, approximately 6% (119,000 ac-ft) of flow through this structure was conveyed for water supply during this period. This small percentage of flows was not sampled. A reasonable way to estimate WQ was applied and described below.

In order to quantify the load contribution from the small flows described above (4-6%), data surrogates were developed based on the following analyses. A regression analysis for TDP samples between G-302 and G-301 indicated a very good relationship with a coefficient of determination R^2 of 0.98. Based on the regression relationship, G-302 was used as a surrogate for G-301 for the period without sampling data (as G-302 is adjacent to G-301). Under the water supply flow scenario, for G-300, statistical descriptive analyses were conducted for the available sampling data series collected since 2005. The sample data varied within a small range for all water quality parameters during water supply mode (i.e., release of water from WCA-1 to water users in the adjacent basin); therefore, the mean values for TDP (19 ppb), SRP (10 ppb), TSS (6,067 ppb), and CLD (102,000 ppb) calculated from the sample data series were used for the associated load calculations. Under the flood control mode (i.e., movement of runoff from a tributary basin through a canal system), the sample data showed a relatively large variance. The mean values were not the best assumptions. However, it is reasonable to assume that the same rate of change that occurred between S-5A and G-301 occurred between S-5A and G-300, therefore, G-301 was used as a surrogate site.

For S-5AS, the sampling for TDP started around mid-2005. During the period from April 2000 to mid-2005, almost all the flows through S-5AS were Lake Okeechobee releases, which entered the system through S-5A and were then routed north via S-5AS leaving the canal system. To extrapolate the TDP concentration data, it was assumed that the TDP concentration data at S-5A and S-5AS were the same for the volume of water associated with the missing water quality data. For the purpose of this study, this assumption is thought to be reasonable as this water was not routed to G-302.

Table 3-2. Sampling methods for water quality parameters at study structures.

Parameter	S-5A	S-5AS	G-302	G-300	G-301	G-311
TP	auto/grab	grab	auto/grab	auto/grab	auto/grab	auto/grab
TSS	Grab	grab	grab	grab	grab	grab
SRP	Grab	grab	grab	grab	grab	grab
CLD	Grab	grab	grab	grab	grab	grab
TDP	Grab	grab	grab	grab	grab	grab

Table 3-3. Beginning sampling date for water quality parameters starting in Water Year 2000 (WY2000).

Structure	TP	TDP	SRP	TSS	CLD	Turbidity
S-5A	2/15//2000	2/15/2000	2/15/2000	2/28/2000	2/15/2000	2/15/2000
S-5AS	4/24/2000	1/28/2005	4/23/2000	4/23/2000	4/23/2000	1/23/2000
G-301	4/28/2000	3/13/2005	3/13/2005	7/19/2005	7/19/2005	-
G-302	2/7/2000	2/7/2000	2/7/2000	2/7/2000	2/7/2000	-
G-311	6/9/2005	5/4/2006	10/31/2005	5/4/2006	5/4/2006	-
G-300	5/3/2000	4/20/2005	4/20/2005	7/19/2005	7/19/2005	-

Table 3-4. Flow at water control structure from May 1, 2000 to April 30, 2005 relative to total flow for the STA-1 Inflow Basin Canal study.

Structure	Inflow (ac-ft)		Outflow (ac-ft)	
	Flow	Flow/Total Flow	Flow	Flow/Total Flow
S-5A	1,841,561	87.8%	0	0%
S-5AS	54,562	2.6%	263,434	13%
G-302	-	0%	1,598,306	77%
G-311	-	0%	0	0%
G-300	119,351	5.7%	102,301	5%
G-301	81,906	3.9%	113,222	5%
Total	2,097,380		2,077,262	

LOAD CALCULATION MODES

Load calculation modes M2, M3, and M5, as defined in the NLP, were used for this study. Preliminary results indicated that if no autosampler data were available, then the loads calculated by mode M3 and M5 were approximately the same. As TP is the only parameter collected by both autosamplers and grab samples, it is the only parameter that loads were calculated by all three modes. For all other water quality parameters, the loads were calculated only using modes M2 and M3.

- Mode 2 (M2): Use autosampler results first; if missing, then use grab sample results only on days with flow; extrapolate between missing values.
- Mode 3 (M3): Use autosampler results first; if missing, then use grab samples; extrapolate between missing values.
- Mode 5 (M5): Use grab sample results; use sample results if flow or no flow exists to extrapolate between missing values.

WET/DRY SEASON DEFINITION

In south Florida, the wet season generally starts in late May and ends in October. For consistency for this study, a fixed period of 6 months for wet/dry season was used. The following definition was used for the wet and dry seasons. Within each water year (i.e., May 1 to April 30), the wet season was defined as the six-month period from May 1 to October 31, and the dry season was defined as the six-month period from November 1 to April 30.

3.3 RESULTS

Table 3-5 summarizes POR mass balance results for various WQ parameters associated with the STA-1 Inflow Basin Canal. Preliminary conclusions based on the results are summarized below. The detailed annual, monthly, and wet/dry season analyses for these parameters are presented in subsequent sections.

- For each water quality parameter analyzed, the loads calculated from the NLP calculation modes M2 and M3 were relatively close. Therefore, for the monthly and seasonal analyses, only the results calculated by mode M3 are discussed.

Table 3-5. STA-1 Inflow Basin Canal mass balance summaries for the analysis period.

Parameter	Calculation Mode	Inflow to the Canal	Outflow from the Canal	Differences (in -out)	Difference/inflow (%)
Flow (ac-ft) (WY2001 to WY2013)	N/A	3,956,354	4,000,051	-43,698	-1.1%
TP (mt) (WY2001 to WY2013)	M2	797	872	-75.7	-9.5%
	M3	799	869	-70.0	-8.8%
	M5	833	822	11.2	1.3%
TDP (mt) (WY2001 to WY2007)	M2	360	355	5.3	1.5%
	M3/M5	359	343	15.7	4.4%
SRP (mt) (WY2001 to WY2013)	M2	511	491	19.6	3.8%
	M3/M5	506	478	28.0	5.5%
PP (mt) (WY2001 to WY2007)	M2	151	188	-36.8	-24.4%
	M3	147	196	-49.7	-33.9%
DOP (mt) (WY2001 to WY2007)	M2	29	33	-3.9	-13.6%
	M3	29	28	1.3	4.6%
TSS (mt) (WY2001 to WY2013)	M2	91,695	84,015	7680.0	8.4%
	M3/M5	87,749	78,818	8931.0	10.2%
CLD (mt) (WY2001 to WY2013)	M2	595,896	588,897	6999.0	1.2%
	M3/M5	614,876	597,360	17516.0	2.8%

- Good conservation of mass for flow, TDP, SRP, DOP, and CLD was observed from inflow to outflow structures with small percentages of difference compared to total inflows (most differences < 10%).
- CLD using both modes M2 and M3 were in close agreement with the flow mass balance. The mass balances for flow and CLD suggested all sources of water were accounted for in the evaluation. This also indicated that seepage may not be an important component of the canal water budget.
- The modes M2 and M3 TP mass balance results indicated a net TP load export over the analysis period from Water Year (WY) 2001 to WY2013, with a total of approximately 70 to 76 metric tons (mt). While the M5 results suggest a net loss of 11 metric tons, this mode ignores autosampler data and is therefore considered to be less reliable than M2 and M3.
- The PP mass balance results indicated a net PP load export over the analysis period from WY2001 to WY2007, with a total of approximately 37 to 50 metric tons.
- The TSS mass balance results indicated a net TSS load loss over the analysis period from WY2001 to WY2007, with a total of approximately 79,000 to 84,000 metric tons. As a result of the high variances in the TSS concentration data and inadequate sampling frequencies, there is relatively high uncertainty in the TSS load estimates.
- The mass balance for TDP and SRP indicated some load reduction from this canal system over time. In combining with the conclusion for PP, the mass balance for these P fractions suggested the TP load exported from this canal system was mainly caused by the PP export.
- Good conservation of mass for DOP indicated minor changes in this canal system over time.

FLOW

Annual Flow Analysis

Inflow volumes to the STA-1W Inflow Basin Canal for the period from WY2001–WY2013 averaged 304,335 ac-ft per year (**Table 3-6** and **Figure 3-2**), with an overall inflow volume of 3,956,354 ac-ft for the study period (**Table 3-6**). The average annual outflow volume was 307,696 ac-ft, with an overall outflow volume of 4,000,051 ac-ft from this canal system. The difference was approximately 1%. This small difference indicates a very good water budget balance. The inflow volume for WY2003 (660,998 ac-ft) accounted for 17% of the total inflow during the study period. High water levels in Lake Okeechobee during this year required the delivery of regulatory releases to the WCAs, with approximately 329,607 ac-ft sent to STA-1W for treatment prior to discharge to the Arthur R. Marshall Loxahatchee Wildlife Refuge (Refuge) (Goforth et al., 2004). The second highest inflow to STA-1W occurred in WY2005 when south Florida was impacted by multiple hurricanes.

Table 3-6. Annual total flow comparison for the STA-1 Inflow Basin Canal study, inflow versus outflow.

Water Year	Flow			
	Inflow	Outflow	Balance	Change percentage
	ac-ft	ac-ft	ac-ft	%
WY2001	268,301	266,940	1,360	0.5%
WY2002	330,003	333,129	-3,126	-0.9%
WY2003	660,998	664,299	-3,301	-0.5%
WY2004	352,881	365,315	-12,433	-3.5%
WY2005	486,304	447,579	38,724	8.0%
WY2006	216,169	226,428	-10,259	-4.7%
WY2007	249,949	266,188	-16,239	-6.5%
WY2008	251,344	293,019	-41,675	-16.6%
WY2009	278,709	282,201	-3,492	-1.3%
WY2010	294,771	288,871	5,900	2.0%
WY2011	157,828	151,006	6,822	4.3%
WY2012	148,227	145,072	3,155	2.1%
WY2013	260,869	270,005	-9,136	-3.5%
Total	3,956,354	4,000,051	-43,698	-1.1%
Average	304,335	307,696	-3,361	-1.1%
Min	148,227	145,072	-41,675	-16.6%
Max	660,998	664,299	38,724	8.0%

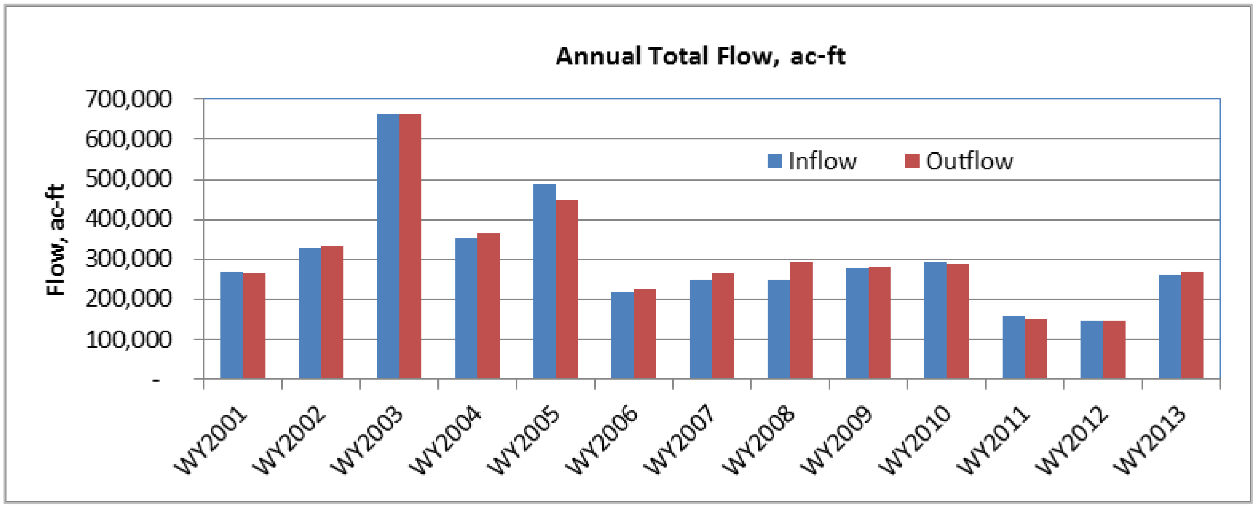


Figure 3-2. Annual total flow comparison for the STA-1 Inflow Basin Canal, inflow versus outflow.

Monthly and Seasonal Flow Analyses

Figure 3-3 shows the monthly average inflow and outflow volumes for the analysis period. The monthly comparison also indicated very good mass conservation. The average monthly inflow and outflow volumes were 25,361 and 25,641 ac-ft, respectively, with a difference of 1.1%. The two highest inflows and outflows occurred in the months of August and September. Approximately 35% of annual inflows and outflows occurred in these two months. The driest month was April when both inflow and outflow volumes were approximately 10,000 ac-ft, or only 3.5% of annual flow.

As indicated in **Figure 3-4**, the average wet/dry season inflow and outflow volumes also indicated very good mass balance. The two highest total inflow and outflow volumes during the wet season occurred in WY2003 and WY2005. For the dry season, the lowest inflow and outflow volumes occurred in WY2009, during the period from November 1, 2008–April 30, 2009. WY2009 was the year that south Florida experienced a severe drought with a temporary wet condition in the summer (Abtew et al., 2010).

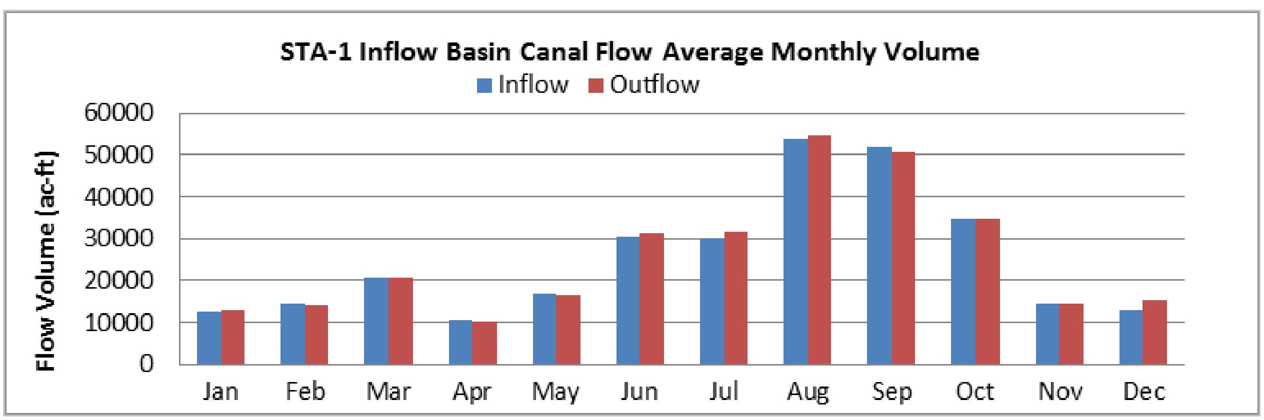


Figure 3-3. Monthly total flow comparison for the STA-1 Inflow Basin Canal, inflow versus outflow.

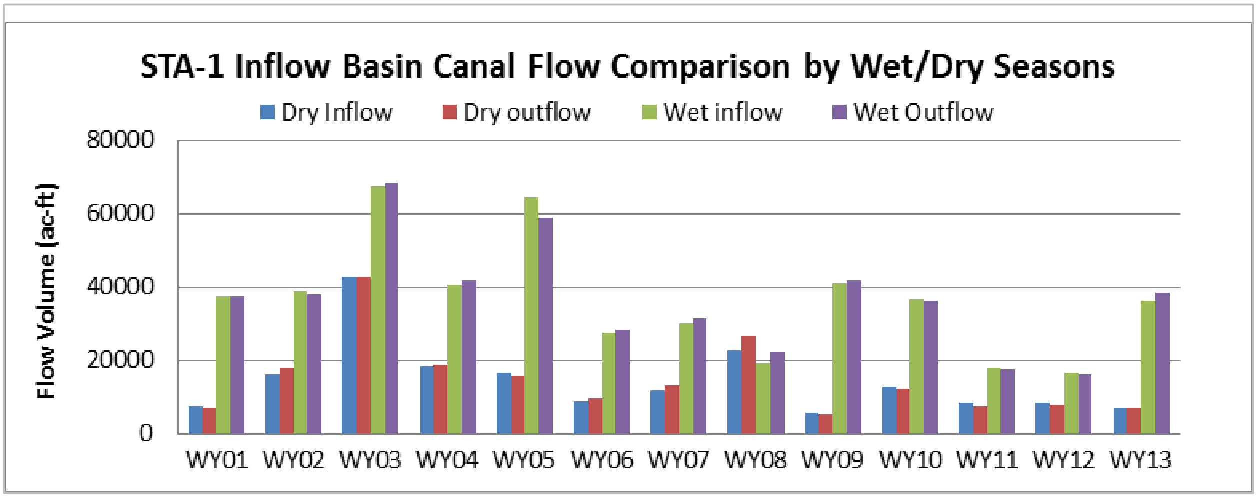


Figure 3-4. Seasonal total flow comparison for the STA-1 Inflow Basin Canal, inflow versus outflow.

TOTAL PHOSPHORUS

TP Annual Analyses

Three different NLP calculation modes were used and compared for the TP annual analyses. For all three modes (M2, M3, and M5), annual TP loads showed high variability during the analysis period (WY2001–WY2013), with substantially higher loads in WY2003 and WY2005 (**Figure 3-5**).

M2 Calculation Mode: Inflow TP loads calculated by mode M2 averaged 61.3 metric tons, with annual TP loads ranging from 22.2 metric tons in WY2012 to 139.6 metric tons in WY2005. From WY2001–WY2013, the analysis period, the outflow load from the canal was 872.4.0 metric tons of TP (**Table 3-7**), with WY2005 accounting for 16% of the total period. During WY2005, south Florida was impacted by heavy rainfall from hurricanes Frances and Jeanne. As a result, calculated inflow TP loads to the canal were two times larger than the long-term annual average value. Annual outflow TP loads were generally higher than the inflow TP loads and averaged a 5.8 metric tons increase From WY2001–WY2013, on average, the estimated annual outflow TP load increased by 10% compared to the annual inflow TP load to the canal system (61 metric tons). The TP load reductions were minor during two years, WY2003 (0.2%) and WY2005 (0.7%). For all other 11 water years in the analysis period, the TP load estimates indicate net increase annual export loads ranging from 0.2 metric tons in WY2013 to 19.2 metric tons in WY2002 and a net increase total export load of 75.7 metric tons.

M3 Calculation Mode: TP loads calculated by mode M3 were very close to those calculated by mode M2 (**Table 3-7**). Inflow TP loads averaged 61.5 metric tons, with annual loads ranging from 22.2 metric tons in WY2012 to 138.6 metric tons in WY2005. Outflow TP loads averaged 66.9 metric tons, with annual loads ranging from 24.2 metric tons in WY2012 to 135.0 metric tons in WY2005. The only year with an estimated TP load reduction was WY2005, with a value of 3.6 metric tons. For all other years in the analysis period, the load reduction estimates suggest that the canal acted as a TP source, with annual exported TP loads ranging from 0.4 metric tons in WY2003 to 18.9 metric tons in WY2002 and a total exported TP load of 70.0 metric tons.

Table 3-7. Annual total phosphorus (TP) load comparison for the STA-1 Inflow Basin Canal study, inflow versus outflow.

Water Year	TP (mode M2)				TP (mode M3)				TP (mode M5)			
	Inflow	Outflow	Balance	Change percentage	Inflow	Outflow	Balance	Change percentage	Inflow	Outflow	Balance	Change percentage
	mt	mt	mt	%	mt	mt	mt	%	mt	mt	mt	%
WY2001	35.2	42.6	-7.3	-20.8%	36.5	41.3	-4.7	-12.9%	42.2	41.3	0.9	2.1%
WY2002	38.4	57.6	-19.2	-50.0%	38.8	57.7	-18.9	-48.6%	56.8	57.7	-1.0	-1.7%
WY2003	125.2	124.9	0.3	0.2%	125.0	125.4	-0.4	-0.3%	133.9	125.4	8.5	6.3%
WY2004	55.6	61.2	-5.6	-10.1%	55.6	61.5	-5.9	-10.6%	61.1	60.1	1.0	1.7%
WY2005	139.6	138.6	1.0	0.7%	138.6	135.0	3.6	2.6%	159.9	148.2	11.7	7.3%
WY2006	58.4	60.2	-1.8	-3.1%	58.3	58.8	-0.5	-0.8%	54.6	57.2	-2.7	-4.9%
WY2007	58.6	73.0	-14.4	-24.6%	59.4	73.2	-13.8	-23.1%	59.1	56.6	2.5	4.2%
WY2008	33.7	41.1	-7.4	-22.1%	34.5	40.4	-5.9	-17.0%	31.4	35.0	-3.6	-11.5%
WY2009	66.8	74.3	-7.6	-11.3%	66.7	76.5	-9.8	-14.7%	68.1	62.8	5.3	7.8%
WY2010	68.3	78.6	-10.4	-15.2%	68.3	79.1	-10.8	-15.8%	63.2	65.5	-2.3	-3.6%
WY2011	25.3	26.4	-1.1	-4.3%	25.3	26.4	-1.1	-4.2%	21.4	23.9	-2.5	-11.6%
WY2012	22.2	24.2	-2.0	-8.8%	22.2	24.2	-2.0	-9.0%	19.9	21.5	-1.6	-8.2%
WY2013	69.5	69.7	-0.2	-0.3%	69.8	69.7	0.1	0.1%	61.7	66.8	-5.0	-8.2%
Total	796.7	872.4	-75.7	-9.5%	799.2	869.2	-70.0	-8.8%	833.1	821.9	11.2	1.3%
Average	61.3	67.1	-5.8	-9.5%	61.5	66.9	-5.4	-8.8%	64.1	63.2	0.9	1.3%

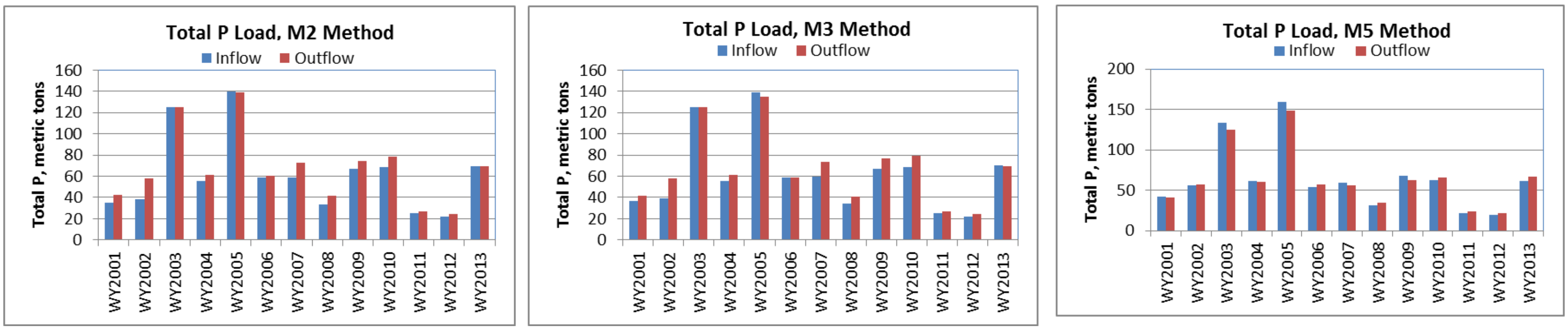


Figure 3-5. Annual total phosphorus (TP) load comparison by different calculation modes for the STA-1 Inflow Basin Canal study, inflow versus outflow.

M5 Calculation Mode: TP load reductions calculated using mode M5 were lower than the reductions calculated with modes M2 and M3, and suggest that the canal acted as a TP sink. Inflow TP loads from mode M5 averaged 64.1 metric tons, with annual inflow TP loads ranging from 19.9 metric tons in WY2012 to 159.9 metric tons in WY2005. From WY2001–WY2013, the canal received an estimated 833.1 metric tons of TP. Outflow TP loads were generally lower, averaging 63.2 metric tons, with annual loads ranging from 21.5 metric tons in WY2012 to 148.2 metric tons in WY2005. Using mode M5, the TP load that left the system over the analysis period was 821.9 metric tons, and the inflow and outflow loads were approximately equivalent, with an minor mean increase of 1.3%, or 0.9 metric tons (**Table 3-7**).

Summary: When samples were collected at adequate frequency, the loads calculated by modes M2 and M3 were similar. Mode M5 ignores autosampler data, which explains why the calculations were different from those produced by modes M2 and M3. It is likely that mode M5 introduced additional uncertainties because of the lack of autosampler data. For this reason, the results calculated by modes M2 and M3 are considered more appropriate for interpretation. In summary, the STA-1 Inflow Basin Canal acted as a TP source with total net exported loads of approximately 70.0 metric tons (mode M3) to 75.7 metric tons (mode M2) for the period analyzed.

TP Monthly and Seasonal Analyses

As stated previously, for the monthly and seasonal analyses, the M3 calculation mode was used for TP. The monthly data indicated that, on average, the highest TP loads occurred over the three months of the wet season (July, August, and September) (**Figure 3-6**). During the dry season months, the differences were very small, with a minor TP load reduction observed during February. Based on the seasonal data for the analysis period (**Figure 3-7**), TP outflow load increases were observed for 11 out of 13 years during the wet seasons. Very minor decreases were observed in WY06 and WY13. For the dry seasons, a comparison of the TP loads from the inflow and outflow structures showed small differences and included both TP load increases and decreases. The TP load increases during the wet season months of July, August, and September may be associated with high inflow volumes, increased water velocity due to the high flow rates, and reduced travel time. The results from the monthly and seasonal TP analyses were consistent with the results of the annual TP analyses showing this canal segment as a TP sources during the analysis period.

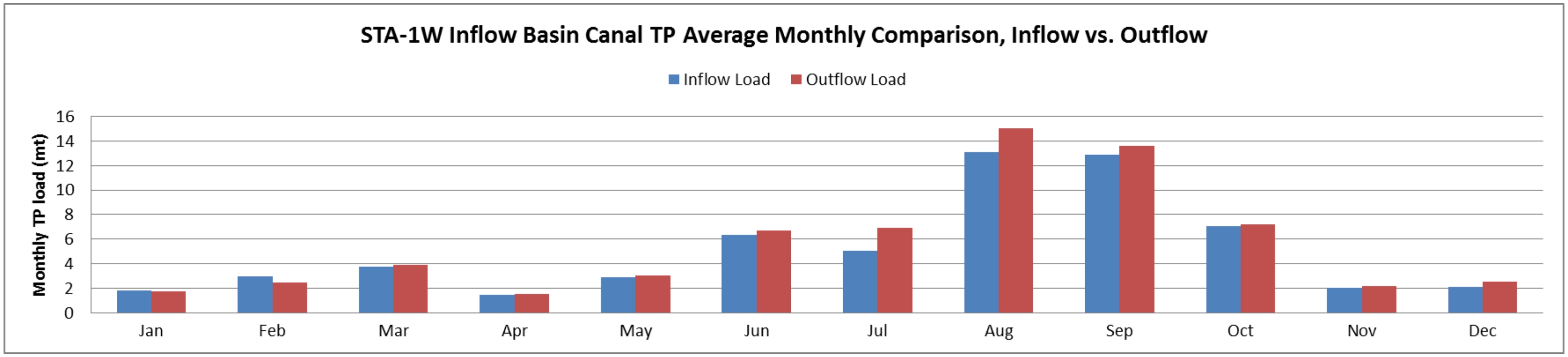


Figure 3-6. Average monthly total phosphorus (TP) load comparison for the STA-1 Inflow Basin Canal study, inflow versus outflow.

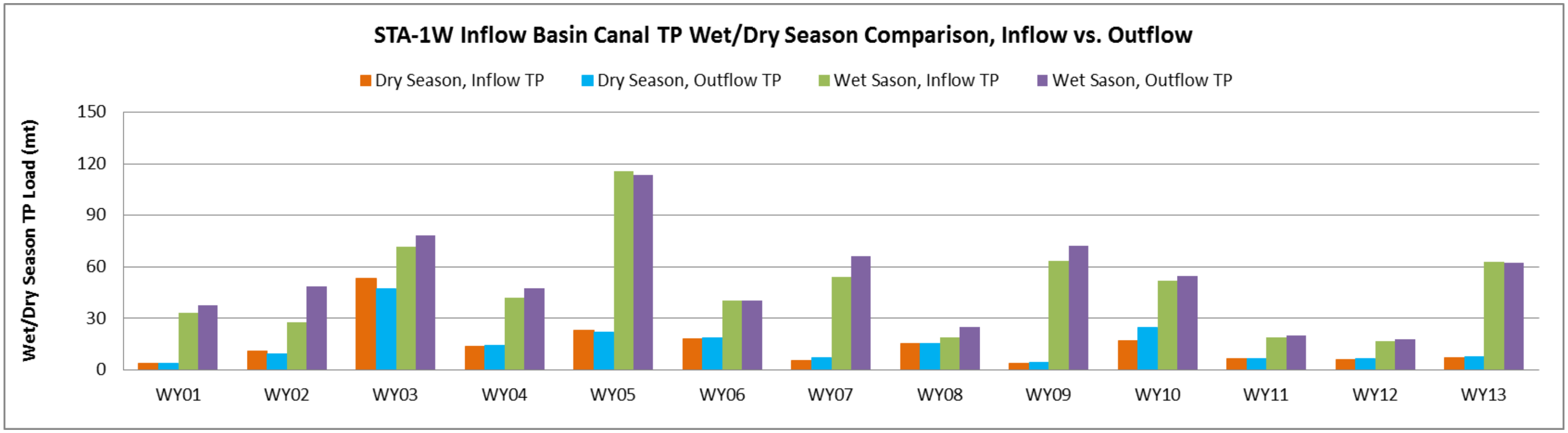


Figure 3-7. Seasonal total phosphorus (TP) load comparison for the STA-1 Inflow Basin Canal study, inflow versus outflow.

TOTAL DISSOLVED PHOSPHORUS

TDP Annual Analyses

The TDP loads for WY2001 to WY2013 were initially calculated using modes M2 and M3 for the period from WY2001–WY2013 (**Figure 3-8**). Further review of the data indicated only eight TDP samples were collected at S-5A for the period after November 8, 2008. Because this small number of water quality samples would not provide an accurate load estimate, water years after WY2007 were not included in further analyses.

Calculation Mode M2: Total inflow TDP load calculated using mode M2 for the analysis period from WY2001–WY2007 was 360.3 metric tons, which represents 71% of the inflow TP load for the same period (**Table 3-8**). Similar to TP, TDP loads were considerably higher during WY2003 and WY2005. Inflow TDP using mode M2 averaged 51.5 metric tons, with annual TDP loads ranging from 30.1 metric tons in WY2001 to 93.5 metric tons in WY2005. As indicated previously, in WY2005, south Florida was impacted by hurricanes Frances, Charley, and Jeanne, resulting in higher than normal canal inflow TDP loads. Outflow TDP loads were slightly lower than inflow loads with total loads of 354.7 metric tons, an average load of 50.7 metric tons, and with annual loads ranging from 28.4 metric tons in WY2001 to 85.4 metric tons in WY2005. During this period, the total TDP load decreased by 1.6%, or 5.6 metric tons in total, and averaged 0.8 metric tons ranging from -3.3 metric tons (increase) to 8.1 metric tons (decrease). The difference indicated some TDP load reduction over time.

Calculation Mode M3: TDP loads calculated using mode M3 were similar to those observed using mode M2 (**Table 3-8**). Inflow TDP loads averaged 51.3 metric tons, with annual loads ranging from 29.6 metric tons in WY2001 to 94.0 metric tons in WY2005. Outflow TDP loads averaged 49.0 metric tons, with annual loads ranging from 27.9 metric tons in WY2001 to 83.5 metric tons in WY2005. During this period, total TDP loads decreased by 4.4%, or 15.7 metric tons, and averaged 2.2 metric tons ranging from -3.9 metric tons (increase) to 10.5 metric tons (decrease). The difference indicated some TDP load reduction over time.

Summary: For TDP, based on the annual analysis of the data from WY2001 to WY2007, it is concluded that some TDP load reduction likely occurred for the STA-1 Inflow Basin Canal. SRP is the major component of TDP. The TDP settling is mainly due to SRP settling.

TDP Monthly and Seasonal Analyses

Based on the monthly data, the majority of inflow and outflow TDP loads generally occurred during the period from June to October. The differences between inflow and outflow monthly loads were very small throughout the year, with some TDP load reductions observed in September and some increases in July (**Figure 3-9**). Based on the seasonal data, a small reduction in TDP loads from the inflow to the outflow structures occurred during the wet seasons in most of the years (**Figure 3-10**). The only wet season TDP increase occurred in WY02 and WY03, with an approximate 9 metric tons difference. The results from the monthly and seasonal analyses indicate slight TDP reductions in September and the wet season.

Table 3-8. Annual total dissolved phosphorus (TDP) load comparison for the STA-1 Inflow Basin Canal study, inflow versus outflow.

Water Year	TDP (mode M2)				TDP (mode M3)			
	Inflow	Outflow	Balance	Change percentage	Inflow	Outflow	Balance	Change percentage
	mt	mt	mt	%	mt	mt	mt	%
WY2001	30.1	28.4	1.7	5.7%	29.6	27.9	1.7	5.7%
WY2002	38.5	41.8	-3.3	-8.6%	37.6	41.5	-3.9	-10.4%
WY2003	73.8	75.4	-1.6	-2.2%	73.7	72.7	1.1	1.4%
WY2004	39.8	39.1	0.7	1.9%	38.9	39.6	-0.8	-2.0%
WY2005	93.5	85.4	8.1	8.7%	94.0	83.5	10.5	11.2%
WY2006	40.4	40.4	0.0	0.0%	39.3	36.1	3.3	8.3%
WY2007	44.3	44.3	0.0	0.0%	45.7	41.9	3.8	8.2%
Total	360.3	354.7	5.6	1.6%	358.9	343.2	15.7	4.4%
Average	51.5	50.7	0.8	1.6%	51.3	49.0	2.2	3.2%
Min	30.1	28.4	-3.3	-8.6%	29.6	27.9	-3.9	-10.4%
Max	93.5	85.4	8.1	8.7%	94.0	83.5	10.5	11.2%

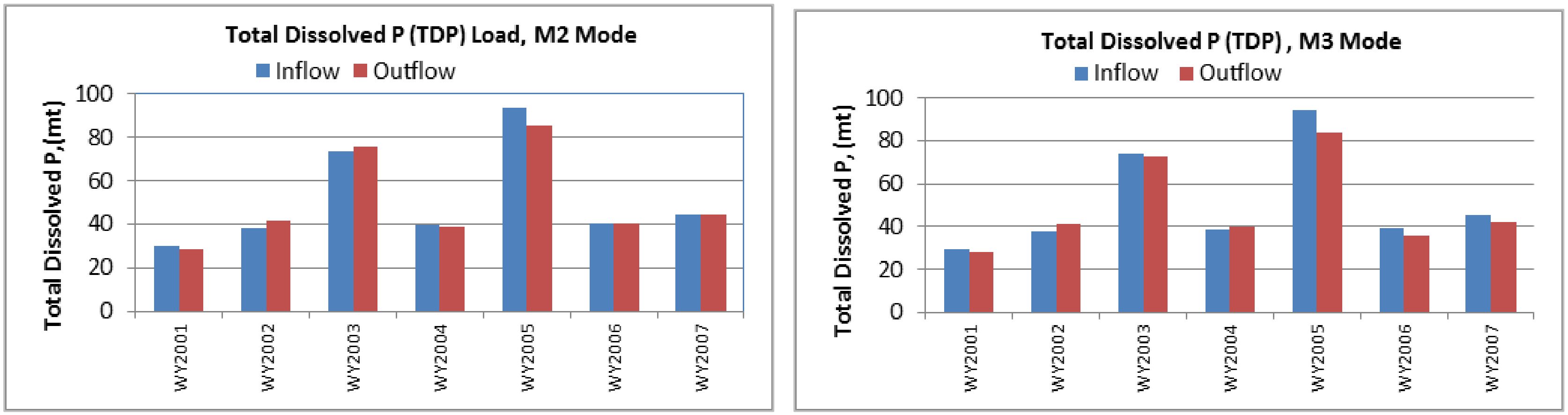


Figure 3-8. Annual total dissolved phosphorus (TDP) load comparison by different calculation modes (mode M2 top and mode M3 bottom) for the STA-1 Inflow Basin Canal study, inflow versus outflow.

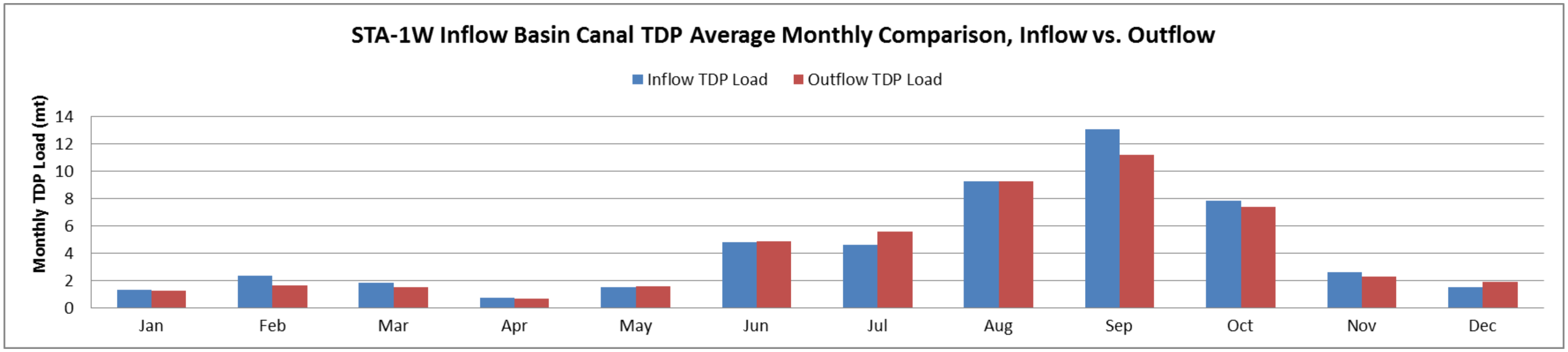


Figure 3-9. Average monthly total dissolved phosphorus (TDP) load comparison for the STA-1 Inflow Basin Canal study, inflow versus outflow.

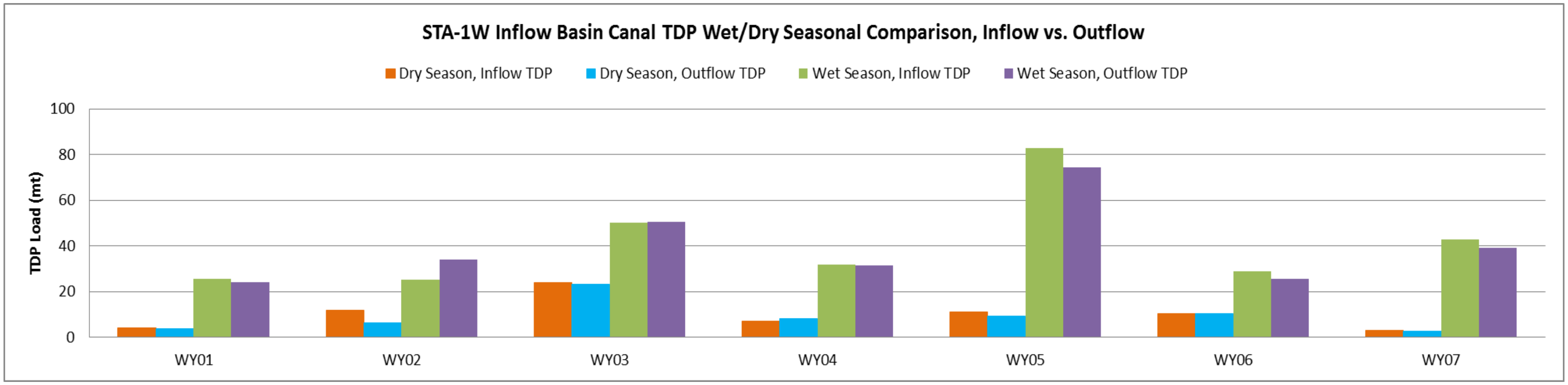


Figure 3-10. Seasonal total dissolved phosphorus (TDP) load comparison for the STA-1 Inflow Basin Canal study, inflow versus outflow.

PARTICULATE PHOSPHORUS

PP Annual Analyses

As PP is calculated as the difference between TP and TDP, the analysis of PP was limited to the same period as TDP (WY2001–WY2007).

Calculation Mode M2: The inflow PP load for WY2002 calculated using mode M2 was negative, which is not physically possible; therefore, WY2002 was excluded from analysis. The six years included in the analyses were WY2001 and WY2003–WY2007. Total inflow PP load calculated using mode M2 was 150.7 metric tons, which represents 32% of the inflow TP load for the same period (**Table 3-9**). This percentage was close to a value of 39% (at the STA-1W inflow structure, G302) calculated in a separate study by Chimney (2007). Annual PP loads showed high variability during the analysis period, with very high loads observed in WY2003 and WY2005 (**Figure 3-11**). Inflow PP calculated using mode M2 averaged 25.1 metric tons, with annual PP loads ranging between 5.1 metric tons in WY2001 to 51.4 metric tons in WY2003. During the analysis period, the outflow PP load from this canal was 187.5 metric tons (**Table 3-9**), with WY2003 and WY2005 accounting for 54% of total outflow PP in this period. As indicated previously, in WY2005, south Florida was impacted by hurricanes Frances and Jeanne, resulting in canal inflow PP loads that were approximately two times higher than the long-term annual average value. The only year showing a small PP increase was WY2003 with 1.9 metric tons. In five out of six years, outflow PP loads were higher than the inflow PP loads, with a total PP load increase of 36.8 metric tons. The results indicate that this canal system acted as a PP source, with exported PP loads ranging from 6.4 metric tons in WY2003 to 14.4 metric tons in WY2007 and an average of 6.1 metric tons.

Calculation Mode M3: Total PP loads calculated by mode M3 were very close to the values calculated by mode M2 (**Table 3-9**). During the analysis period, inflow PP loads averaged 25.4 metric tons, with annual loads ranging from 6.9 metric tons in WY2001 to 51.3 metric tons in WY2003. Outflow PP loads averaged 32.2 metric tons, with annual loads ranging from 13.3 metric tons in WY2001 to 52.7 metric tons in WY2003. During the analysis period, the canal acted as a PP source for all six years, with annual exported PP loads ranging from 1.4 metric tons in WY2003 to 17.5 metric tons in WY2007, an average of 6.9 metric tons and a total PP export of 41.2 metric tons.

Summary: On the basis of the above results, it is reasonable to conclude that the canal exported PP. Furthermore, as TDP showed insignificant change from the inflow to the outflow structures, the increase in PP is likely the main contributing source to the TP load increase.

PP Monthly and Seasonal Analyses

The highest inflow and outflow PP loads occurred during the wet season months from June to October. High monthly PP load increases from the inflow to outflow structures occurred during the months of July, August, and September, with average monthly PP exports of 1.8, 2.7, and 2.4 metric tons, respectively (**Figure 3-12**). The PP load differences between the inflow and outflow structures for the other months were relatively small. The results from the seasonal analysis were consistent with the results from the annual and monthly analyses (**Figure 3-13**). PP load increases from the inflow to the outflow structures occurred during all wet seasons. For the dry seasons, the PP load differences between the inflow and outflow structures were small except for WY2003, when the results indicated PP load reduction occurred from the inflow to the outflow structures. It is noted that for this water year, the net PP load increase in the wet season exceeded the net PP load reduction in the dry season.

On the basis of the annual, monthly, and seasonal analyses, it is reasonable to conclude that PP was exported from the STA-1 Inflow Basin Canal. High PP load export, especially during the wet season months may be associated with reduced travel time, increased water velocity, and high flow volumes typical of wet-season flow events.

Table 3-9. Annual particulate phosphorus (PP) comparison for the STA-1 Inflow Basin Canal study, inflow versus outflow.

Water Year	PP (mode M2)				PP (mode M3)			
	Inflow	Outflow	Balance	Change percentage	Inflow	Outflow	Balance	Change percentage
	Mt	mt	mt	%	mt	mt	mt	%
WY2001	5.1	14.1	-9.0	-176%	6.9	13.3	-6.4	-93%
WY2003	51.4	49.5	1.9	4%	51.3	52.7	-1.4	-3%
WY2004	15.8	22.1	-6.4	-40%	16.7	21.9	-5.1	-31%
WY2005	46.0	53.2	-7.1	-16%	44.6	51.5	-6.9	-15%
WY2006	18.0	19.8	-1.8	-10%	19.0	22.8	-3.8	-20%
WY2007	114.3	28.7	-14.4	-101%	13.7	31.3	-17.5	-127%
Total	150.7	187.5	-36.8	-24%	152.3	193.4	-41.2	-27%
Average	25.1	31.2	-6.1	-24%	25.4	32.2	-6.9	-27%
Min	5.1	14.1	-14.4	-176%	6.9	13.3	-17.5	-127.5%
Max	51.4	53.2	N/A	N/A	51.3	52.7	-1.4	-2.8%

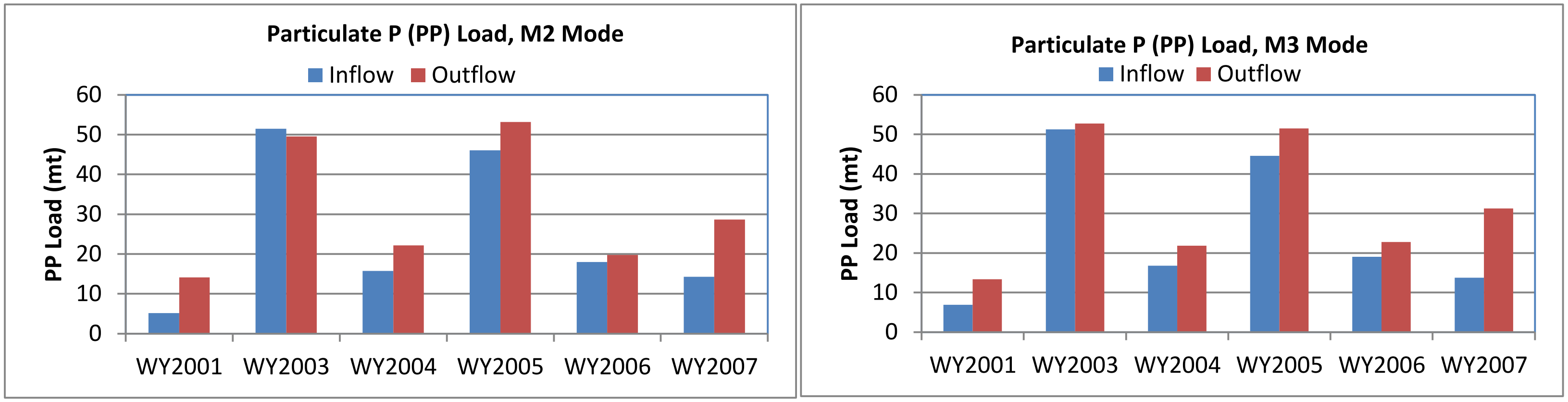


Figure 3-11. Annual particulate phosphorus (PP) load comparison by different calculation modes for the STA-1 Inflow Basin Canal study, inflow versus outflow.

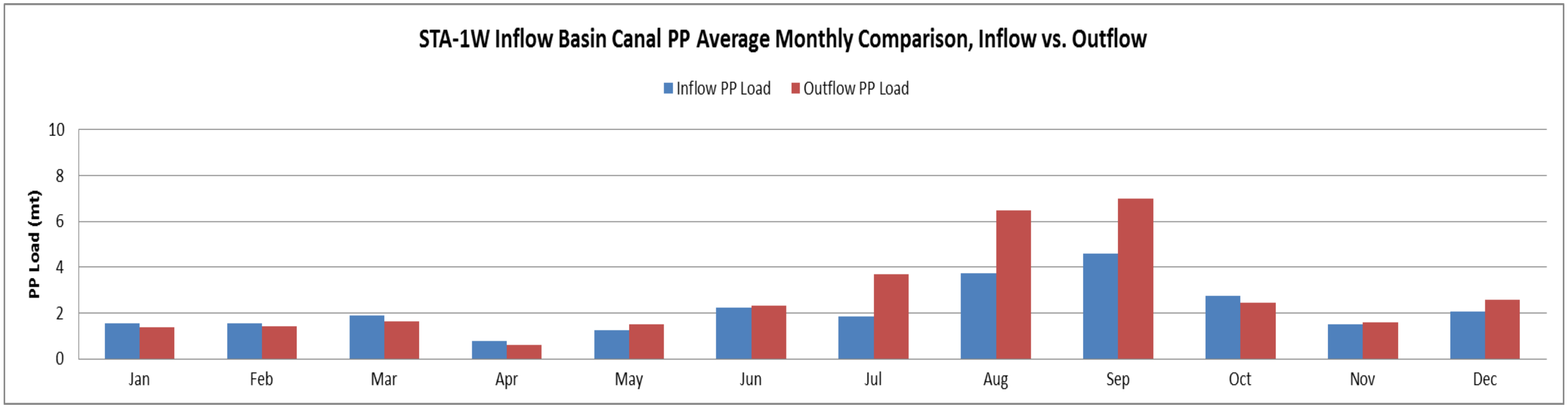


Figure 3-12. Average monthly particulate phosphorus (PP) load comparison for the STA-1 Inflow Basin Canal study, inflow versus outflow.

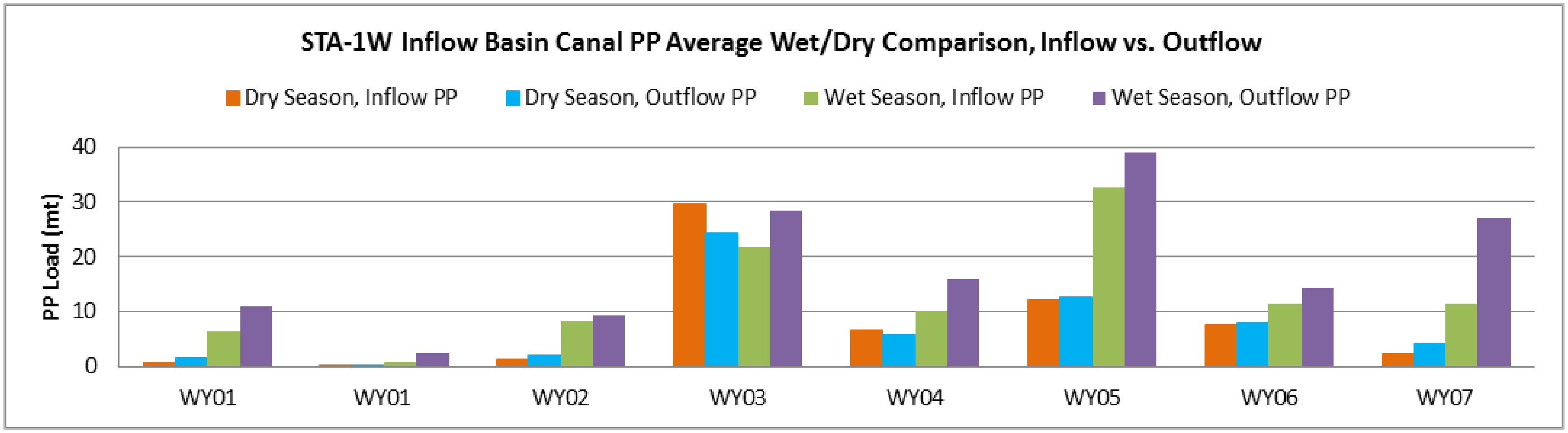


Figure 3-13. Seasonal particulate phosphorus (PP) load comparison for the STA-1 Inflow Basin Canal study, inflow versus outflow.

SOLUBLE REACTIVE PHOSPHORUS

SRP Annual Analyses

Calculation Mode M2: Canal inflow SRP load calculated using mode M2 for the period WY2001 to WY2013 represented 64% of the canal inflow TP load for the same period (**Table 3-10**) and 92% of the canal inflow TDP load for the period of WY2001 to WY2007. The percentage of SRP/TDP was close to the ratio (92%) calculated by Chimney at the STA-1W inflow structure G-302 (2007) while the ratio of SRP/TP was higher than 56% calculated by Chimney at the STA-1W inflow structure G-302 (2007). Similar to the TDP fraction, inflow SRP loads were high in WY2003 and WY2005 (**Figure 3-14**). Inflow SRP load averaged 39.3 metric tons, with annual SRP loads ranging from 10.7 metric tons in WY2011 to 85.6 metric tons in WY2005. During the period from WY2001 to WY2013, the outflow SRP load from the canal was 491.3 metric tons. As indicated previously, in WY2005, south Florida was impacted by hurricanes Frances and Jeanne, resulting in higher than normal canal inflow SRP loads. Outflow SRP loads averaged 37.8 metric tons, with loads ranging from 12.1 metric tons in WY2011 to 79.4 metric tons in WY2005. From WY2001 to WY2013, the SRP loads decreased from the inflow to outflow structures by a small percentage (3.8%) or 19.6 metric tons, equating to an average annual decrease of 1.5 metric tons. This amount of reduction may indicate some minor SRP removal occurred.

Calculation Mode M3: The SRP loads calculated using mode M3 were similar to load estimates obtained using mode M2 (**Table 3-10**). Inflow SRP averaged 39.0 metric tons, with SRP loads ranging from 12.2 metric tons in WY2011 to 85.4 metric tons in WY2005. During the analysis period (WY2001–WY2013), the outflow SRP load from this canal was 478.4 metric tons (**Table 3-10**). Outflow SRP loads averaged 36.8 metric tons, with annual outflow SRP loads ranging from 11.6 metric tons in WY2011 to 77.9 metric tons in WY2005. From WY2001 to WY2013, the SRP loads decreased from the inflow to outflow structures by a small percentage (5.5%) or 28.0 metric tons, equating to an average annual reduction of 2.2 metric tons. For 11 of 13 years, reductions were observed, which may indicate the canal acted as an SRP sink with minor SRP removal occurring.

Summary: On the basis of the annual analyses, it is concluded that the STA-1Inflow Basin Canal likely performed as an SRP sink over the period analyzed.

SRP Monthly and Seasonal Analyses

Based on the monthly data, the majority of canal SRP inflow and outflow loads occurred during the wet season months (June to October) and accounted for approximately 77% of annual inflow and outflow SRP loads. Monthly differences between inflows and outflows were small, with slight reductions in 8 out of 12 months (**Figure 3-15**). Based on the seasonal data, in 9 out of 13 years, the wet seasons showed minor SRP load reductions, while very small SRP load increases and decreases occurred fairly evenly in the dry seasons (**Figure 3-16**). These results indicate that overall, a slight SRP reduction occurred in the STA-1 Inflow Basin Canal from the inflow to outflow structures. The SRP load increase in July may be associated with reduced travel time and increased water velocity in the canal (**Figure 3-15**). The results of the seasonal analyses match the results of the monthly and annual analyses.

Table 3-10. Annual soluble reactive phosphorus (SRP) load comparison for the STA-1 Inflow Basin Canal study, inflow versus outflow.

Water Year	SRP (mode M2)				SRP (mode M3/M5)			
	Inflow	Outflow	Balance	Change percentage	Inflow	Outflow	Balance	Change percentage
	mt	mt	mt	%	mt	mt	mt	%
WY2001	25.8	24.7	1.1	4.2%	25.5	23.7	1.8	7.1%
WY2002	35.2	38.5	-3.3	-9.5%	34.8	38.4	-3.6	-10.2%
WY2003	68.9	68.9	-0.1	-0.1%	69.1	65.9	3.2	4.6%
WY2004	36.4	35.6	0.8	2.2%	35.5	36.4	-0.9	-2.5%
WY2005	85.6	79.4	6.2	7.3%	85.4	77.9	7.5	8.8%
WY2006	38.7	35.	3.2	8.2%	37.1	34.9	2.2	6.0%
WY2007	40.8	39.2	1.7	4.0%	42.2	38.2	4.1	9.6%
WY2008	16.5	18.5	-2.1	-12.5%	17.5	16.8	0.6	3.7%
WY2009	44.8	42.8	2.0	4.5%	44.8	44.0	0.7	1.6%
WY2010	50.0	42.8	7.2	14.4%	46.4	42.2	4.2	9.1%
WY2011	10.7	12.1	-1.4	-12.8%	12.2	11.6	0.6	4.7%
WY2012	13.2	14.2	-1.0	-7.2%	13.8	11.6	2.1	15.5%
WY2013	44.4	39.2	5.2	11.8%	42.0	36.7	5.3	12.7%
Total	510.9	491.3	19.6	3.8%	506.4	478.4	28.0	5.5%
Average	39.3	37.8	1.5	3.8%	39.0	36.8	2.2	5.5%
Min	10.7	12.1	-3.3	-12.8%	12.2	11.6	-3.6	-10.2%
Max	85.6	79.4	7.2	14.4%	85.4	77.9	7.5	15.5%

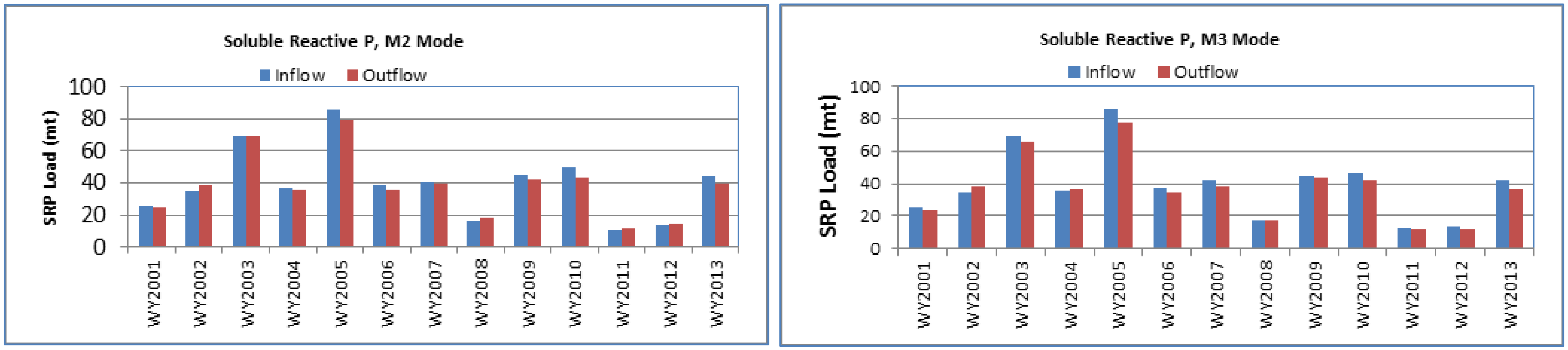


Figure 3-14. Annual soluble reactive phosphorus (SRP) soluble reactive phosphorus load comparison by different calculation modes for the STA-1 Inflow Basin Canal study, inflow versus outflow.

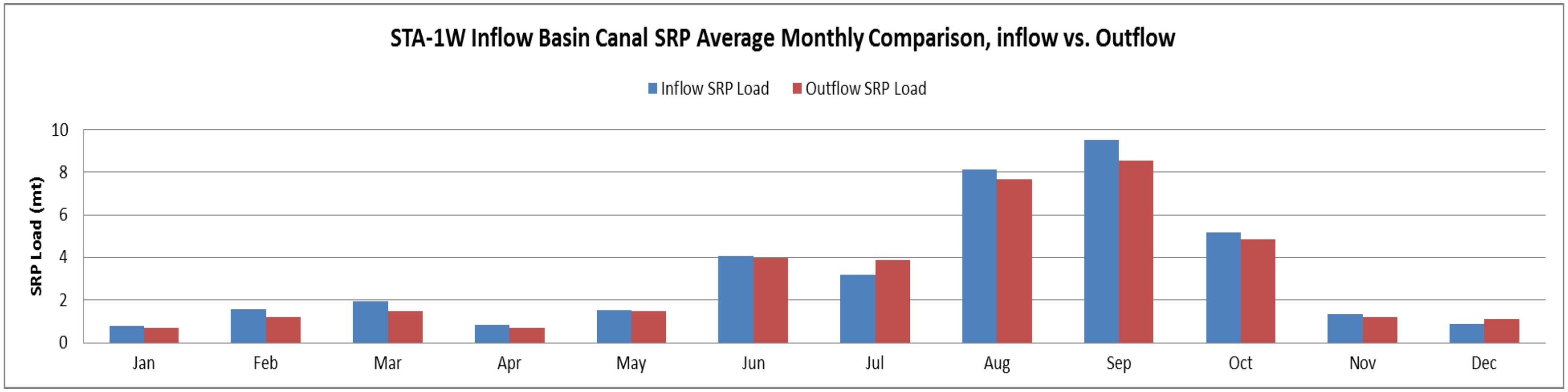


Figure 3-15. Average monthly soluble reactive phosphorus (SRP) load comparison for the STA-1 Inflow Basin Canal study, inflow versus outflow.

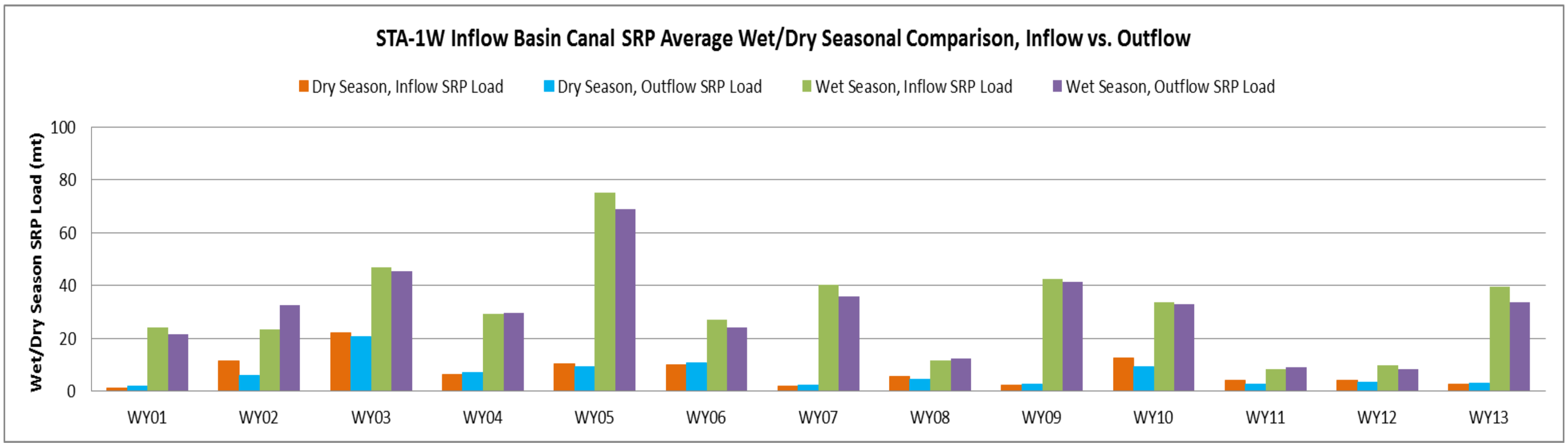


Figure 3-16. Seasonal soluble reactive phosphorus (SRP) soluble reactive phosphorus load comparison for the STA-1 Inflow Basin Canal study, inflow versus outflow.

DISSOLVED ORGANIC PHOSPHORUS

DOP Annual Analyses

As DOP is calculated as the difference between TDP and SRP, analysis of DOP was limited to the same period as TDP (WY2001–WY2007).

Calculation Mode M2: Canal inflow DOP mass calculated using mode M2 represented 8% of the inflow TDP load and 6% of TP load for the analysis period. Both ratios, DOP/TDP and DOP/TP, were relatively small and were equivalent to the ratios calculated by Chimney at G302 (2007). Canal inflow DOP loads averaged 4.1 metric tons, with annual loads ranging from 1.7 metric tons in WY2006 to 7.9 metric tons in WY2005 (**Table 3-11**). The canal outflow DOP load for the analysis period was 32.9 metric tons. Canal outflow DOP loads averaged 4.7 metric tons, with annual loads ranging from 3.3 metric tons in WY2002 to 6.5 metric tons in WY2003. From WY2001 to WY2007, the total DOP load increased by 14% (3.9 metric tons) from the canal inflow to the outflow structures.

Calculation Mode M3: The canal inflow DOP loads calculated using mode M3 averaged 4.2 metric tons (**Table 3-11**). The canal received a total DOP load of 29.1 metric tons, with most of the load occurring during the period from WY2003 to WY2005 (**Figure 3-17**). Outflow DOP loads averaged 4.0 metric tons. In contrast to the results from mode M2, the total DOP load calculated using mode M3 showed a decrease of 4.5% (1.3 metric tons) from the canal inflow to the outflow structures for the analysis period (WY2001–WY2007) (**Table 3-11**). Since both TDP and SRP only grab samples were available for TDP and SRP and the DOP was calculated by TDP-SRP, Mode M3 should provide a more reliable estimate.

Summary: Due to the small proportion of DOP, the calculation method for DOP (TDP minus SRP), the data uncertainties associated with both TDP and SRP, and the differences in the algorithms of each mode the source/sink status of DOP is inconclusive for the STA-1 Inflow Basin Canal. The overall calculated ratio of DOP/TP was approximately 6%.

DOP Monthly and Seasonal Analyses

Relatively large average monthly DOP load differences from inflow to outflow structures were observed during the months of June through October, with June, July, and October showing DOP load increases and August and September showing DOP load decreases (**Figure 3-18**). The load differences for other months were comparatively small. The results from the seasonal analysis were consistent with the results from the annual and monthly analyses (**Figure 3-19**). For the dry seasons, the load differences were relatively small. DOP load differences were relatively high during the wet seasons likely as a result of high flow volumes typical for wet season flow events. Similar to the findings of the annual analyses, the source/sink status in terms of DOP is inconclusive for the STA-1 Inflow Basin Canal.

Table 3-11. Annual dissolved organic phosphorus (DOP) load comparison for the STA-1 Inflow Basin Canal study, inflow versus outflow.

Water Year	DOP (mode M2)				DOP (mode M3)			
	Inflow	Outflow	Balance	Change percentage	Inflow	Outflow	Balance	Change percentage
	mt	mt	mt	%	mt	mt	mt	%
WY2001	4.3	3.7	0.6	14.2%	4.1	4.2	-0.1	-2.8%
WY2002	3.3	3.3	0.0	0.9%	2.8	3.1	-0.3	-12.4%
WY2003	4.9	6.5	-1.6	-32.2%	4.6	6.7	-2.1	-45.8%
WY2004	3.4	3.5	-0.1	-1.8%	3.3	3.2	0.1	3.6%
WY2005	7.9	6.0	1.9	23.7%	8.6	5.6	3.0	35.2%
WY2006	1.7	4.9	-3.2	-183.2%	2.2	1.2	1.1	47.6%
WY2007	3.4	5.1	-1.7	-48.2%	3.4	3.8	-0.3	-9.1%
Total	29.0	32.9	-3.9	-13.6%	29.1	27.8	1.3	4.5%
Average	4.1	4.7	-0.6	-13.6%	4.2	4.0	0.2	4.5%
Min	1.7	3.3	N/A	N/A	2.2	1.2	-2.1	-95.8%
Max	7.9	6.5	1.9	23.7%	8.6	6.7	N/A	N/A

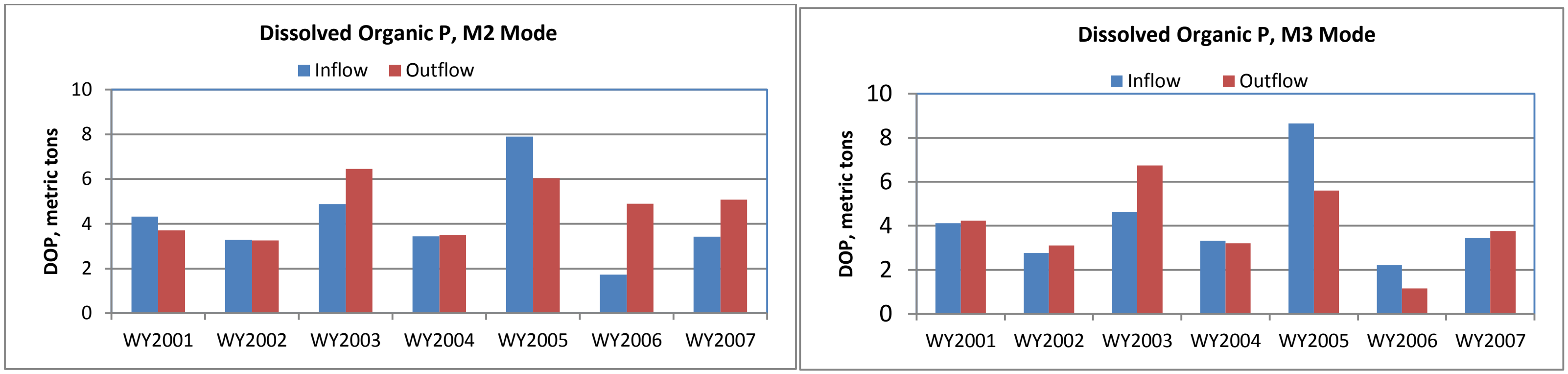


Figure 3-17. Annual dissolved organic phosphorus (DOP) load comparison by different calculation modes for the STA-1 Inflow Basin Canal study, inflow versus outflow.

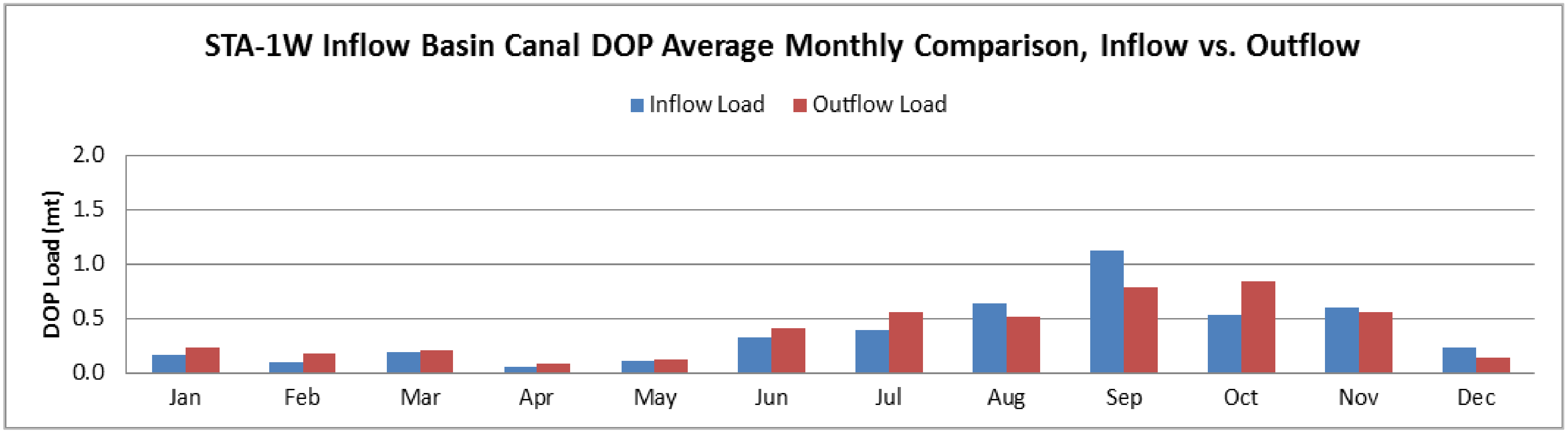


Figure 3-18. Average monthly dissolved organic phosphorus (DOP) load comparison for the STA-1 Inflow Basin Canal study, inflow versus outflow.

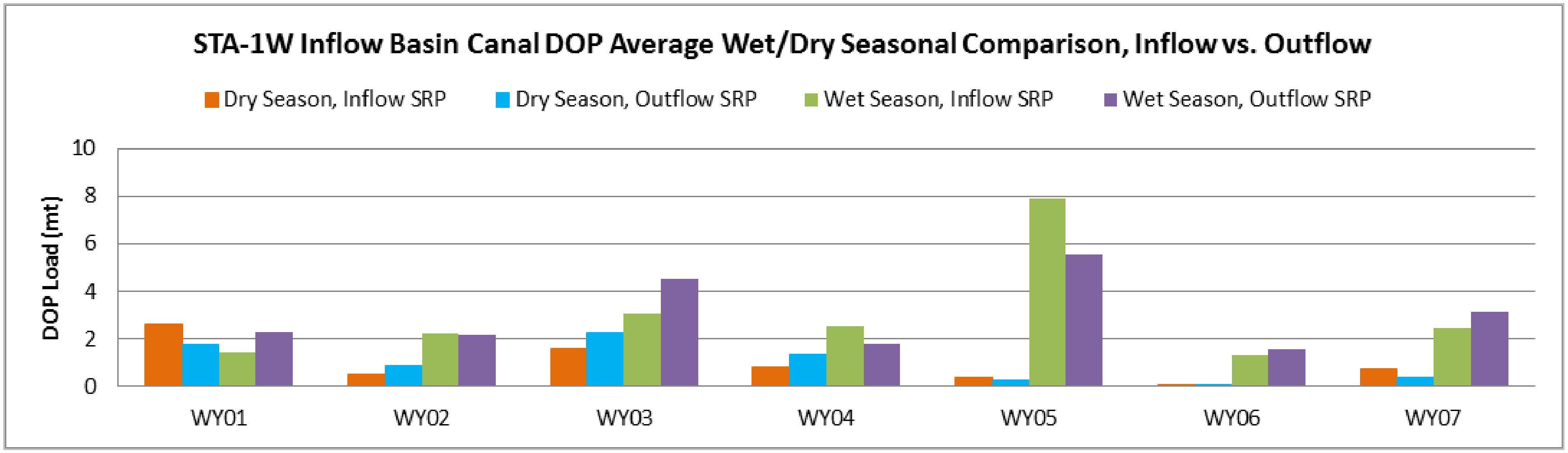


Figure 3-19. Seasonal dissolved organic phosphorus (DOP) load comparison for the STA-1 Inflow Basin Canal study, inflow versus outflow.

TOTAL DISSOLVED CHLORIDE

CLD Annual Analyses

The analysis period for CLD is between WY2001 to WY2013.

Calculation Mode M2: Inflow CLD loads calculated using mode M2 averaged 45,838 metric tons, with annual CLD loads ranging from 17,871 metric tons in WY2012 to 93,427 metric tons in WY2003 (**Table 3-12**). Outflow CLD loads averaged 45,300 metric tons with annual loads ranging from 19,971 metric tons in WY2012 to 96,907 metric tons in WY2003. The total period of analysis CLD load reduction was very small (1.2%), which indicates good mass balance from the inflow to outflow structures.

Calculation Mode M3: The CLD loads calculated using mode M3 were similar to those obtained using mode M2 (**Table 3-12**). Inflow CLD loads averaged 47,298 metric tons, with annual loads ranging from 19,320 metric tons in WY2012 to 96,274 metric tons in WY2003. Outflow CLD loads averaged 45,951 metric tons, with annual loads ranging from 19,812 metric tons in WY2012 to 97,915 metric tons in WY2003. The total CLD load reduction using mode M3 was small (2.8%), although slightly higher than the result obtained using mode M2.

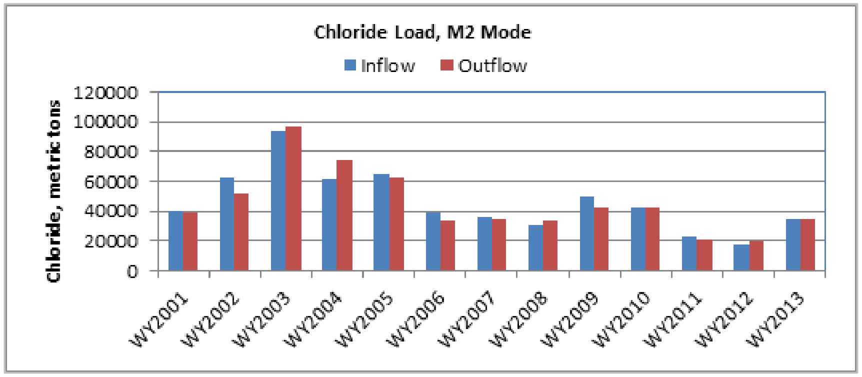
Summary: Good mass conservation of CLD by both modes M2 and M3 (**Figure 3-20**) is in agreement with the flow mass conservation for the canal. As indicated by James (2012), the CLD budget can be used as a semi-independent check on the accuracy of the water budget. The good mass conservation in both flow and CLD suggests that (1) all sources of water were accounted for, (2) estimates of net inflow (inflow-outflow) matched closely the net change of volumes within the canal segment over time, and (3) seepage was not a significant source for this segment of the canal.

CLD Monthly and Seasonal Analyses

The majority of CLD inflow and outflow loads occurred during the wet season months, accounting for approximately 70% of the annual CLD inflow and outflow loads. Monthly differences between inflow and outflow loads were very small for most months (**Figure 3-21**). On a seasonal basis, the wet seasons showed minor CLD load decreases for 9 out of 13 years, while only minor CLD load increases and decreases occurred during most dry seasons (**Figure 3-22**). The increases and decreases likely offset each other as suggested by the annual analyses results, which depicted good conservation of CLD for the analysis period.

Table 3-12. Annual total dissolved chloride (CLD) load comparison for the STA-1 Inflow Basin Canal study, Inflow versus outflow.

Water Year	CLD (mode M2)				CLD (mode M3)			
	Inflow	Outflow	Balance	Change percentage	Inflow	Outflow	Balance	Change percentage
	mt	mt	mt	%	mt	mt	mt	%
WY2001	40,146	38,848	1,299	3.2%	41,226	38,468	2,757	6.7%
WY2002	62,908	51,652	11,255	17.9%	63,774	51,786	11,988	18.8%
WY2003	93,427	96,907	-3,480	-3.7%	96,274	97,915	-1,641	-1.7%
WY2004	61,589	74,189	-12,600	-20.5%	66,920	74,057	-7,137	-10.7%
WY2005	64,525	63,141	1,385	2.1%	65,729	63,359	2,370	3.6%
WY2006	39,186	34,165	5,020	12.8%	40,683	39,119	1,564	3.8%
WY2007	35,594	35,374	220	0.6%	35,364	35,311	53	0.1%
WY2008	30,954	33,408	-2,455	-7.9%	29,809	31,608	-1,799	-6.0%
WY2009	49,605	42,849	6,756	13.6%	49,688	44,273	5,415	10.9%
WY2010	41,912	42,494	-582	-1.4%	44,836	43,850	985	2.2%
WY2011	22,936	20,955	1,980	8.6%	25,456	22,661	2,795	11.0%
WY2012	17,871	19,971	-2,100	-11.8%	19,320	19,812	-492	-2.5%
WY2013	35,244	34,944	299	0.8%	35,798	35,148	651	1.8%
Total	595,896	588,897	6,998	1.2%	614,876	597,367	17,509	2.8%
Average	45,838	45,300	538	1.2%	47,298	45,951	1,347	2.8%
Min	17,871	19,971	-12,600	-20.5%	19,320	19,812	-7,137	-10.7%
Max	93,427	96,907	11,255	17.9%	96,274	97,915	11,988	18.8%



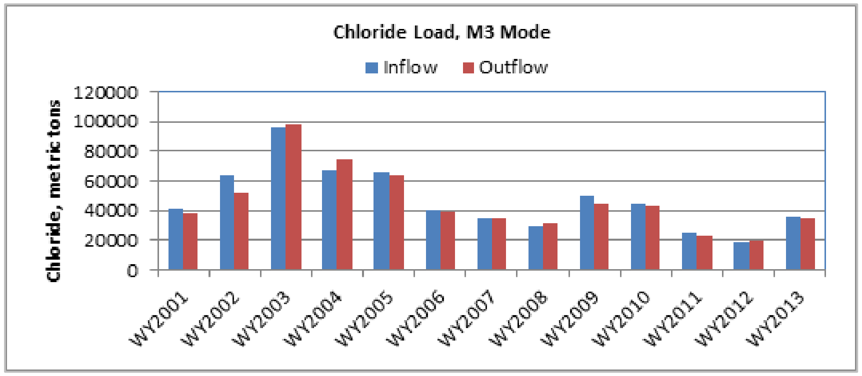


Figure 3-20. Annual total dissolved chloride (CLD) load comparison by different calculation modes for the STA-1 Inflow Basin Canal study, inflow versus outflow.

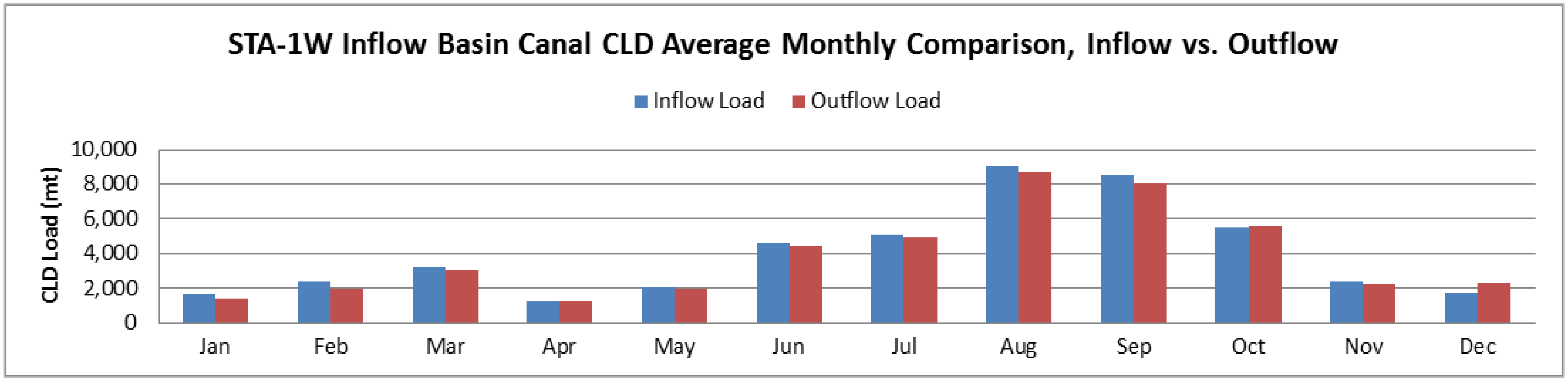


Figure 3-21. Average monthly total dissolved chloride (CLD) load comparison for the STA-1 Inflow Basin Canal study, inflow versus outflow.

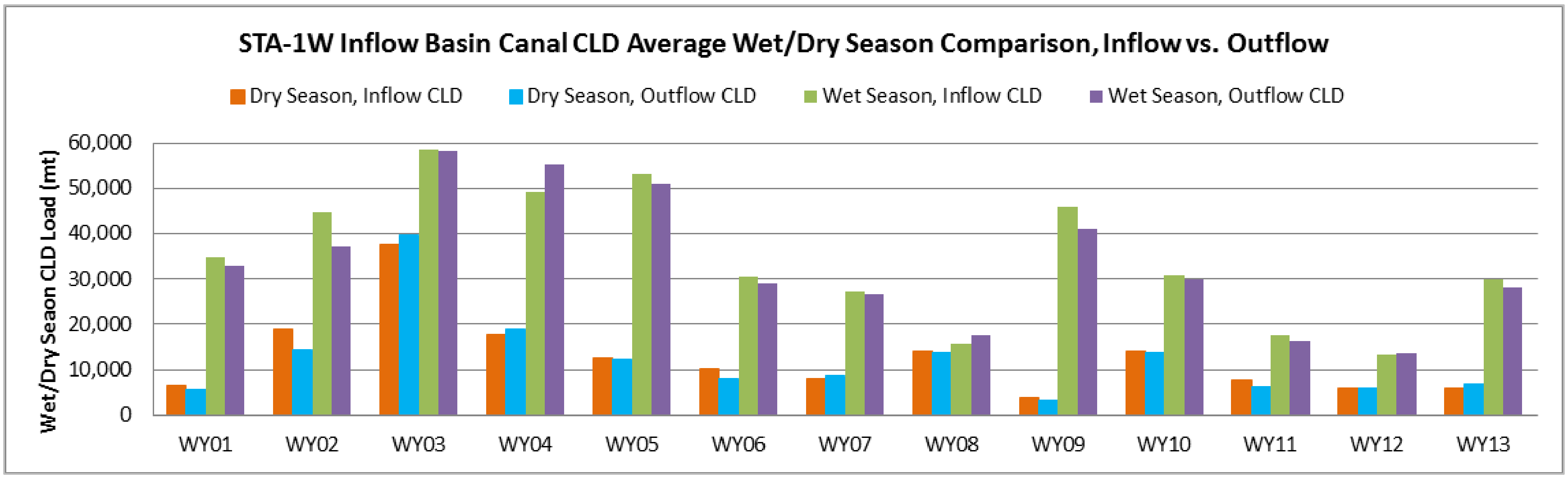


Figure 3-22. Seasonal total dissolved chloride (CLD) load comparison for the STA-1 Inflow Basin Canal study, inflow versus outflow.

TOTAL SUSPENDED SOLIDS

TSS Annual Analyses

While the TSS at G-302 were measured at a relatively constant frequency, at the S-5A site, TSS was collected in grab samples only and at various frequencies ranging from biweekly to quarterly. TSS concentrations were highly variable, ranging from 3,000 ppb during no-flow or low-flow events to 85,000 ppb during high-flow events. In particular, during the period from July 31, 2004 to September 17, 2004, three samples were collected with values of 19,000 ppb, 85,000 ppb, and 28,000 ppb, the ratio between the maximum and the minimum and values is 450%. Inadequate TSS data and high variability in TSS concentrations resulted in high uncertainties in the TSS load calculations and questionable and inconclusive results. To expand the TSS concentration data set, regression analyses were conducted. The independent variables selected were turbidity and conductivity measured at S-5A, PP calculated for S-5A, and TSS measured at G-302. Three regression analyses [TSS versus PP], [TSS versus conductivity], and [S-5A TSS versus G-302 TSS] failed to produce a relationship with satisfactory R^2. The best regression relationship was developed between TSS and turbidity at S-5A, with an R^2 of 0.74 using 265 data pairs. The resulting regression equation is as follows:

$$TSS = 0.9825 * Turb + 0.9926$$

where TSS is the TSS at S-5A in mg/L and Turb is the turbidity measured at S5A in nephelometric turbidity units (NTU).

The TSS concentration data set which was expanded by adding 143 data points using the above regression equation was used for the TSS load calculations.

<u>Calculation Mode M2</u>: TSS analyses calculated using mode M2 indicated that the canal performed as a sink over the analysis period of WY2001 to WY2013 (**Table 3-13**). Inflow TSS loads using mode M2 averaged 7,053 metric tons, with more than 50% of the load occurring in WY2003 and WY2005. High inflow TSS during WY2003 may have been the result of very high inflow volumes including 329,607 ac-ft of Lake Okeechobee regulatory releases that were sent to STA-1W for treatment prior to discharge to the Refuge. High inflow TSS loads during WY2005 (24,112 metric tons) resulted from high inflow volumes associated with hurricanes Frances and Jeanne (**Figure 3-23**). Outflow TSS loads during the analysis period averaged 6,463 metric tons, with approximately 53% occurring in WY2003 and WY2005. The total POR TSS load decrease from the inflow to outflow structures was 7,679 metric tons, representing approximately 8% of the inflow TSS load. The annual TSS load differences suggest that from WY2003 to WY2007 the canal acted as a TSS sink and, from WY2008 to WY2013, the canal was a TSS source. One possible explanation is that the high inflow volumes in WY2003 and WY2005 resulted in substantial TSS accumulation in the canal bottom (approximately 16,000 metric tons) and, once the accumulation reached a critical level, the canal changed from a TSS sink to a source.

<u>Calculation Mode M3</u>: The results calculated using mode M3 were similar to the results using mode M2 (**Table 3-14**). Inflow TSS loads using mode M3 averaged 6,750 metric tons per year, with more than 50% of the load occurring in WY2003 and WY2005. Outflow TSS loads during the analysis period averaged 6,063 metric tons per year, with approximately 42% occurring in WY2003 and WY2005 (**Figure 3-24**). From WY2001 to WY2013, the STA-1 Inflow Basin Canal imported 8,589 metric tons of TSS, representing approximately 10% of the inflow TSS to the canal during this period. Similar to the mode M2 results, the results using mode M3 also suggest that from WY2003 to WY2007 the canal acted as a TSS sink and, from WY2008 to WY2013, the canal was a TSS source.

Table 3-13. Annual total suspended solids (TSS) load comparison for the STA-1 Inflow Basin Canal study, inflow versus outflow.

Water Year	TSS (mode M2)				TSS (mode M3)			
	Inflow	Outflow	Balance	Changing Rate	Inflow	Outflow	Balance	Changing Rate
	mt	mt	mt	%	mt	mt	mt	%
WY2001	4,909	5,788	-879	-18%	6,110	4,827	1,283	21%
WY2002	5,790	5,824	-35	-1%	4,558	5,733	-1,176	-26%
WY2003	24,954	16,233	8,721	35%	24,209	16,004	8,205	34%
WY2004	7,843	7,070	773	10%	6,228	6,928	-700	-11%
WY2005	24,112	16,983	7,130	30%	21,438	16,451	4,987	23%
WY2006	6,779	5,620	1,159	17%	6,113	4,694	1,419	23%
WY2007	3,871	3,519	352	9%	3,700	3,906	-206	-6%
WY2008	1,573	4,144	-2571	-163%	1,519	3,715	-2,196	-154%
WY2009	6,645	4,761	1,884	28%	6,764	4,099	2665	39%
WY2010	2,398	5,650	-3,252	-136%	3,339	5,299	-1,960	-59%
WY2011	742	3,886	-3,144	-424%	1,102	3,646	-2,544	-237%
WY2012	550	1,964	-1,414	-257%	949	1,532	-583	-96%
WY2013	1,529	2,574	-1045	-68%	1,720	1,983	-264	-19%
Total	91,695	84,015	7,679	8%	87,749	78,818	8,931	10.2%
Average	7,053	6,463	591	8%	6,750	6,063	687	10.2%
Min	550	1,964	-3,252	-424%	949	1,532	-2,544	-237.3%
Max	24,954	16,983	8,721	35%	24,209	1,6451	N/A	N/A

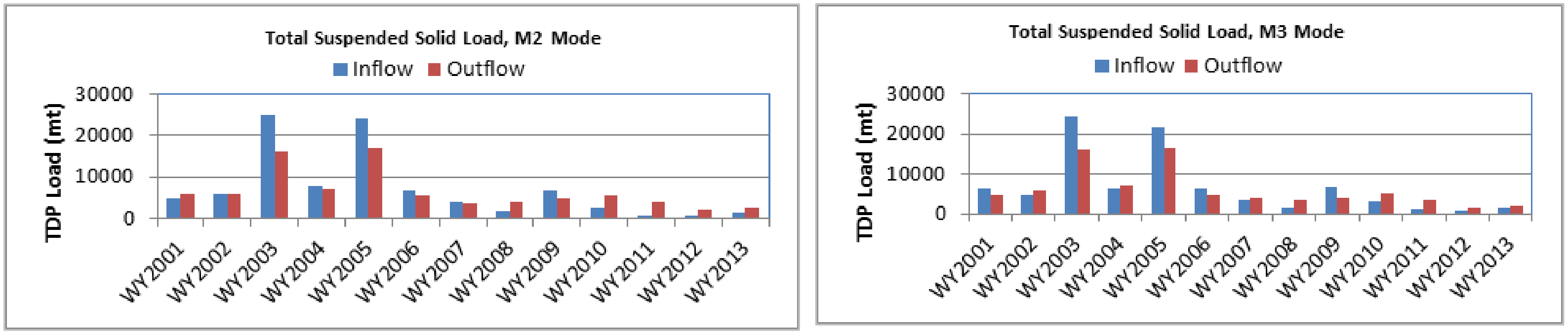


Figure 3-23. Annual total suspended solids (TSS) comparison by different calculation modes for the STA-1 Inflow Basin Canal study, inflow versus outflow.

Summary: Among all the water quality variables analyzed for the STA-1 Inflow Basin Canal, TSS concentration data showed the highest variability. Inadequate TSS data and large variations in TSS concentrations resulted in high uncertainties in the TSS load calculations and questionable and inconclusive results. To expand the TSS concentration data set, regression analyses were conducted, and the results used to develop POR TSS load estimates. The resulting annual analyses suggest that from WY2003 to WY2007 the canal acted as a TSS sink and, from WY2008 to WY2013, the canal was a TSS source. One possible explanation is that the high inflow volumes in WY2003 and WY2005 resulted in substantial TSS accumulation in the canal bottom (approximately 16,000 metric tons) and, that once the accumulation reached a critical level, the canal changed from a TSS sink to source.

TSS Monthly and Seasonal Analyses

A monthly TSS decrease from the canal inflow to outflow structures occurred in 9 out of 12 months. The monthly results are consistent with the annual results showing more frequent occurrences of TSS settling. For the dry season months, the differences between inflow loads and outflow loads were relatively small. The months showing a TSS load increase were April, July, and November, and the highest TSS difference occurred in July with an average of 2,600 metric tons (**Figure 3-24**). The seasonal analyses suggest that from WY2003 to WY2007 the canal generally acted as a TSS sink except the very minor TSS increase in WY2004 and, from WY2008 to WY2013, the canal generally was a TSS source (**Figure 3-25**).

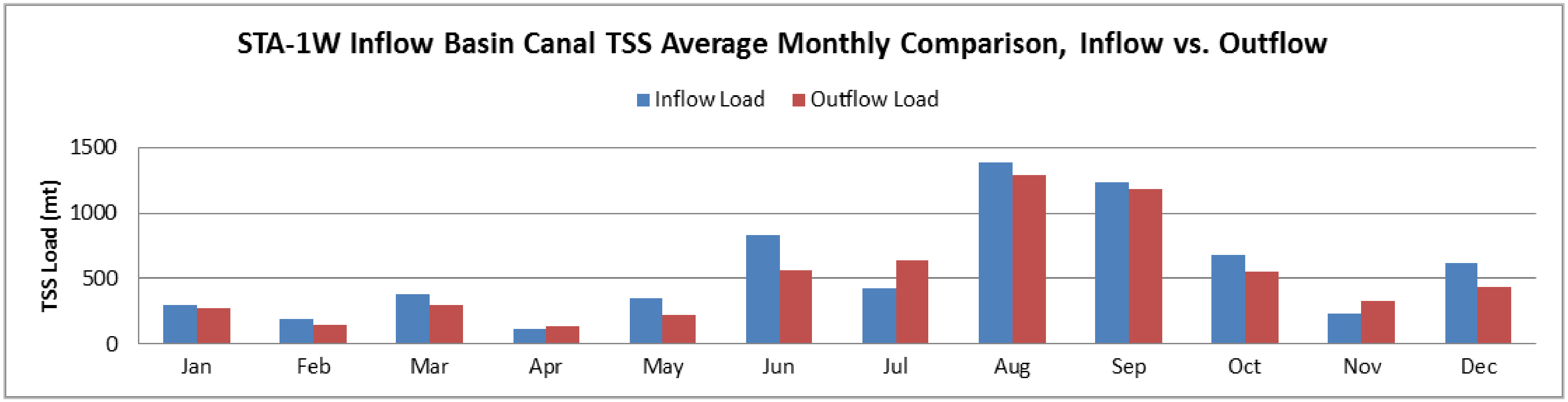


Figure 3-24. Average monthly total suspended solids (TSS) load comparison for the STA-1 Inflow Basin Canal study, inflow versus outflow.

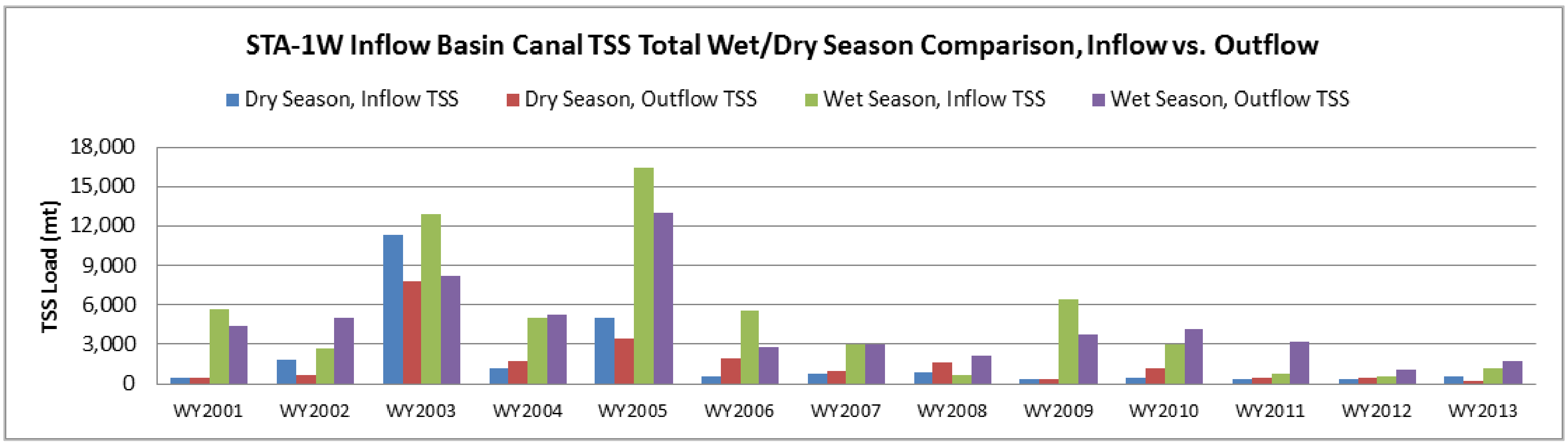


Figure 3-25. Seasonal total suspended solids (TSS) load comparison for the STA-1 Inflow Basin Canal study, inflow versus outflow.

3.4 SUMMARY AND CONCLUSIONS

The flow average annual difference between S-5A and G302 was approximately 1% of the average S-5A annual flow. This small difference indicates a very good water budget balance.

For all the water quality parameters (TP, SRP, TDP, PP, DOP, TSS, and CLD) analyzed, the annual/monthly/seasonal mass balance analyses suggest that from S-5A to G-302, TP and PP loads were exported over the period analyzed. The results suggest that this canal behaved as a TP source during the period from WY2001 to WY2013 (May 1, 2000–April 30, 2013), exporting approximately 70 to 76 metric tons of TP. Approximately 37 to 41 metric tons of PP may have been exported from this canal system during the period from WY2001 to WY2007 (May 1, 2000–April 30, 2007). In combination with the mass balances for other P fractions, the results also suggest that the TP load exported from this canal system was in the form of PP. The results indicated that the canal acted as a sink for SRP and TDP during the period analyzed. The annual mass balance suggests that approximately 20 to 28 metric tons of SRP was sequestered in this canal system during the WY2001–WY2013 period and that 5.6 to 15.7 metric tons TDP was removed in this canal during the WY2001–WY2007 period.

The annual mass balance suggests this canal acted as a sink for TSS. Approximately 591 to 687 metric tons of TSS settled in this canal system during the period analyzed. Among all the water quality variables analyzed, TSS concentration data showed the highest variability. Inadequate TSS data and large variations in TSS concentrations resulted in high uncertainties in the TSS load calculations and questionable and inconclusive results.

For DOP, due to the small proportion of DOP, the calculation method (TDP - SRP), the data uncertainties associated with both TDP and SRP, and the assumptions inherent in the calculations, the source/sink status in terms of DOP is inconclusive for this canal. The percentage of DOP/TP (approximately 6%) was relatively small. The small percentage indicates the removal/flux of DOP was not a major contributing source of the TP export.

The results from the CLD annual/monthly/seasonal mass balance analyses demonstrate good mass conservation and insignificant removal/flux of CLD from S-5A to G-302.

The results from this chapter will be combined with the results from the analyses in the other chapters of this report to develop the overall conclusions and recommendatio

CHAPTER 4: STA-1 INFLOW BASIN CANAL FLOW EVENT-BASED MASS BALANCES FOR TOTAL PHOSPHORUS AND OTHER WATER QUALITY PARAMETERS

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4.1 INTRODUCTION

This chapter summarizes the flow event-based mass balance analyses for the STA-1 Inflow Basin Canal for the WQ parameters listed in **Table 2-1** described in the Supporting Information for Canal Evaluations Report (Zhao, et al., 2015), load calculation modes M2, M3, and M5 as defined in the NLP were used for this study. Preliminary results indicated that if no autosampler data were available, the loads calculated by modes M3 and M5 were the same. As TP is the only parameter collected by both autosamplers and grab samples, TP is the only parameter that loads were calculated by all three modes. For all other water quality parameters, the loads were calculated only by modes M2 and M3.

Background information on the STA-1 Inflow Basin Canal is presented in the Chapter 1 of this report. The STA-1 Inflow Basin Canal segment from S-5A to G-302 is depicted in **Figure 1-1**.

4.2 DATA ANALYSIS AND PRESENTATION

For the STA-1 Inflow Basin Canal, the basic mass balance equation is as follows:

Inflow - Outflow = Residual

where Inflow and Outflow are defined in **Table 3-1** based on the flow direction. The plus symbol indicates positive flow and the negative symbol indicates negative flow. Absolute values were used in the calculations.

For each water quality parameter, the load change Percentage (*LCP*) is defined as

$$LCP = \frac{Load_{in} - Load_{out}}{Load_{in}} \; X \; 100\%$$

A combination of descriptive statistics and exploratory graphical techniques was employed to assess the change of each water quality parameter from the inflow structure S-5A to the outflow structure G-302 that occurred during discrete flow events.

4.3 RESULTS

FLOW EVENT ANALYSES

The S-5A pumping station is equipped with six pumps each rated 800 cfs at a static head of 11.1 ft NGVD, with a combined capacity of 4,800 cfs. Daily flow data for the S-5A Pump Station from May 1, 2005 to April 30, 2013 were analyzed. The daily flow rate calculation is influenced by the pumping rate (a result of the number of pumps running) and pumping duration. For example, at the S-5A an 800 cubic feet per second (cfs) daily flow rate can be achieved in several ways: two 800 cfs pumps running for 12 hours or one 800 cfs pump running for 24 hours. For these analyses, flow events were categorized by the total daily flow rate, not the number of pumps that were pumping. The number of days that the S-5A Pump Station pumped at different rates is summarized in **Table 4-1**, and a daily pumping rate frequency analysis for the S-5A Pump Station is shown in **Figure 4-1**.

Table 4-1. Summary of S-5A Pump Station daily flow rates during the STA-1 Inflow Basin Canal study.

S-5A Daily Flow Rate (cfs)	# Days	Percentage
4000 < Q	25	0.5%
3200 < Q ≤ 4000	25	0.5%
2400 < Q ≤ 3200	95	2.0%
1600 < Q ≤ 2400	168	3.5%
800 < Q ≤ 1600	361	7.6%
0 < Q ≤ 800	1,265	26.6%
Q = 0	2,809	59.2%

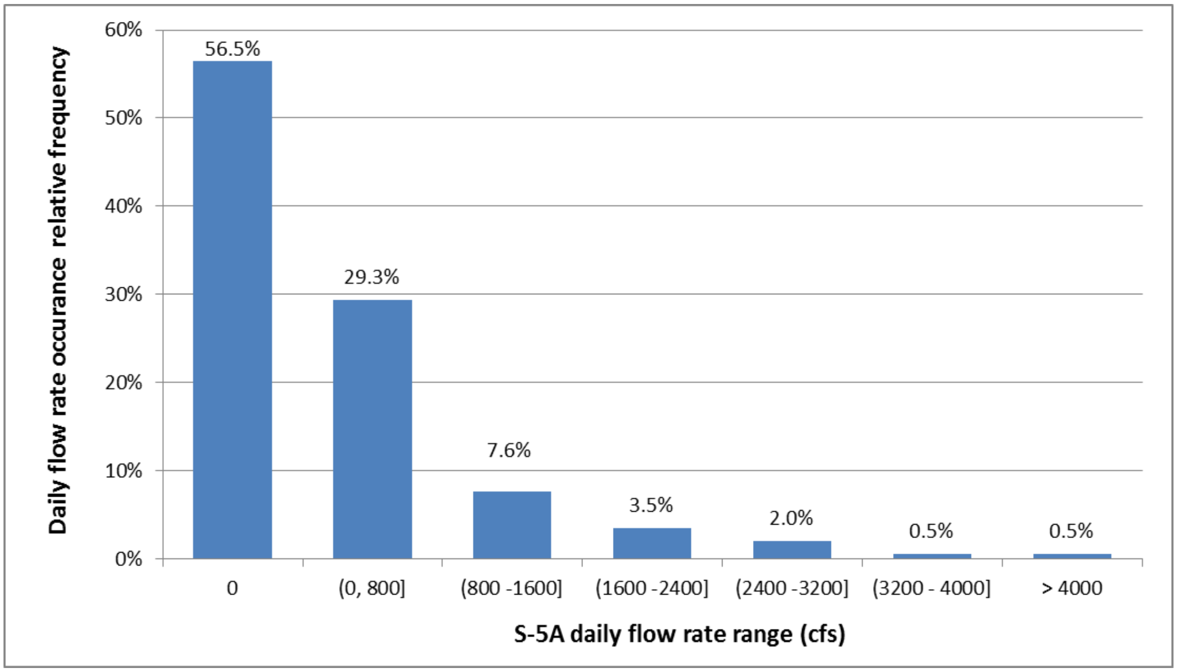


Figure 4-1. S-5A Pump Station daily-pumping rate frequency analysis during the STA-1 Inflow Basin Canal study.

A flow event can be characterized by a hydrograph showing the rate of flow versus time at specific locations. A typical hydrograph includes a rising limb, a recession limb, and peak discharge. **Figure 4-2** depicts a typical flow event at S-5A and G-302. Daily flow data from May 1, 2000 to April 30, 2013 were reviewed, focusing on the canal segment from S-5A to G-302. Flow events were selected only if S-5A was pumping and G-302 was open. If other structures along the canal reach were open during those events (i.e., G-300, G-301 G-311, or S-5AS), then those flow volumes were subtracted from the S-5A flows. Flow events when the S-5A Pump Station was used to convey water from Lake Okeechobee to WCA-1 through G-300 or G-301 for the purpose of water supply were eliminated from the analysis. As a result, a total of 175 flow events was selected for analysis.

Appendix 4-1 summarizes the flow events analyzed in this study. The event hydrographs plot inflow at S-5A minus outflow at G300 + G301 + G311 + S-5AS versus outflow at G-302. For the selected flow events, the majority of flows were conveyed to G-302, while relatively small proportion of flows was directed to the other structures as circumstances required. The hydrographs show good agreement between flow measured at the two structures, which indicates very good mass conservation. Due to the short travel distance (approximately 1.2 miles) and limited storage in the STA-1 Inflow Basin Canal from S-5A to G-302, the travel time from S-5A to G-302 is generally short (i.e., 1 to 2 hours). The peak flow rate attenuation was also minimal.

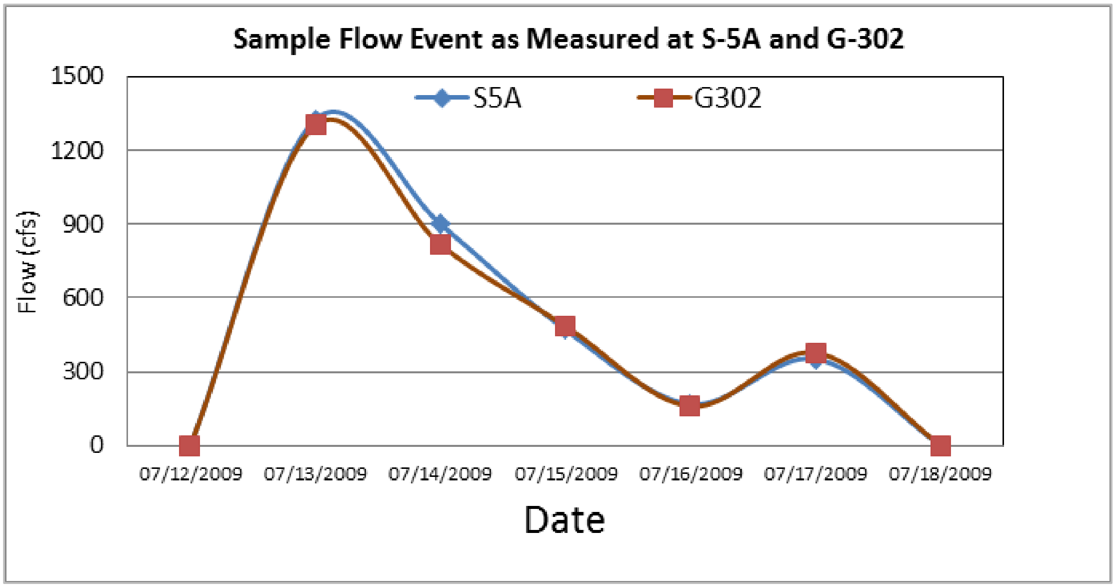


Figure 4-2. Hydrograph of a typical flow event at S-5A and G-302.

Overall, water budgets for the selected flow events showed equivalent inflow and outflow water volumes (**Appendix 4-2**). The flow events observed at the inflow structure (S-5A) were reproduced in the downstream structures (i.e., flow rates and shape of hydrograph). The mass balance analysis further verified the well-balanced inflow and outflow data (**Appendix 4-1** and **4-2**). For the 175 flow events, the average volume difference percentage between inflow and outflow structures is approximately -2.0%. This indicates that there was little impact from other water budget components, such as seepage, rain, and evapotranspiration (ET) that were not included in the analyses.

EVENT BASED WATER QUALITY ANALYSES

Total Phosphorus

For the TP analyses, flow events were further evaluated based on the availability of sampling data. Some flow events were eliminated due to inadequate (i.e., prolonged flow event with only one grab sample) or missing TP data. A total of 134 flow events was kept for further evaluation.

1. For the 134 flow events, auto and/or grab WQ samples were collected at S-5A and G-302. The calculated total TP mass for each event by modes M2 and M3 were similar, while the TP loads calculated by mode M5 showed some differences (**Appendix 4-2**). For some events, the discrepancy was mainly caused by the difference between the auto and grab sample TP concentrations. For example, the autosampler data collected on October 30, 2001 was 92 ppb, while the grab sample was 155 ppb; on November 6, 2001, the autosampler data was 99 ppb, while the grab sample was 303 ppb. The event-based results using modes M2 and M3 are consistent with the results from annual, monthly, and seasonal analyses (i.e., suggest canal behaved as a TP source). Mode M5 ignores the autosampler data in the calculation, which doesn't take advantage of all the available data; therefore, this mode is not recommended.
2. For the 134 flow events analyzed, the number of events and percentages showing net TP load increase from S-5A to G-302 by the different load calculation modes M2, M3, and M5 were 101 (75%), 101 (75%), and 80 (60%), respectively. The descriptive statistical analyses also showed a TP load increase of 19% by mode M2, 18% by mode M3, and 11% by mode M5 from S-5A to G-302, respectively. Both

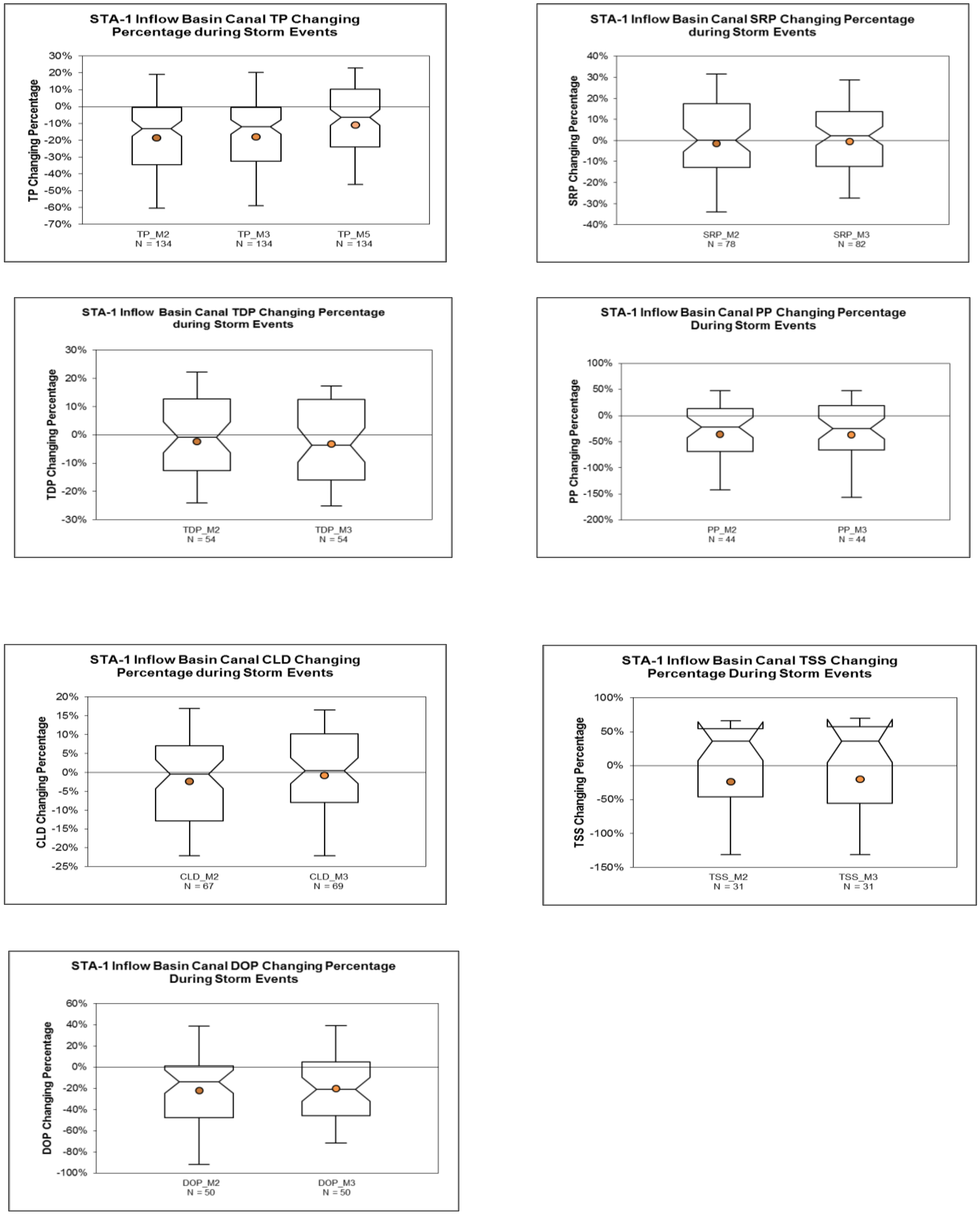
average and median values for all three calculation modes showed negative values for the inflow-to-outflow load change percentages (**Appendix 4-2**), which indicated that TP load generally increased from S-5A to G-302.

3. The box plot (**Figure 4-3**) showed the average TP rate of change during the flow events as a negative value. The TP box plot also shows that for modes M2 and M3, 75% of all inflow-to-outflow load change values were negative and that more than 50% of load change values for mode M5 were negative indicating increased outflow TP load compared to the inflow TP load. The box plot suggests the TP loads leaving the STA-1 Inflow Basin canal via G-302 were higher than the TP loads entering the STA-1 Inflow Basin from S-5A.

The increased TP load from S-5A to G-302 suggests that when S-5A was pumping, it may have stirred up the sediments, resulting in increased TP concentration at the outflow structures, mainly G-302, and the short travel distance from S-5A to G-302 likely did not allow sufficient time for settling of TP.

Soluble Reactive Phosphorus

1. For the SRP analyses, 78 flow events for modes M2 and 82 events for mode M3 were selected for further analysis, as these flow events were well sampled. The excluded events included those occurrences when either the majority of flows were routed north via S-5AS (i.e., water supply mode) or when no samples were collected at either S-5A or G-302, or both structures.
2. For SRP, only grab samples were collected at the inflow and outflow structures. No meaningful differences were observed in the calculations for modes M2 and M3 (**Appendix 4-2**).
3. For the 78 flow events analyzed by Mode M2, the percentages of events showing net SRP load increase from S-5A to G-302 by different load calculation modes M2 and M3 were approximately 49% and 46%, respectively. The descriptive statistical analysis indicated small average load rates of change of -1.5% by mode M2 and -0.5% by mode M3, and small or median load rates of change of -0.1% by mode M2 and 2.1% by mode M3 (**Appendix 4-2**). Both average and median values for the calculation modes were less than 3%. The box plot (**Figure 4-3**) shows the average and median SRP load rates of change were close to zero, indicating a small rate of change from S-5A to G-302.
4. While both mean and median values of SRP load rates of change were close to zero, the net load difference indicated overall SRP settling based on the event-based analysis result.



Note: Description of box plots: top and bottom of box = 75th and 25th percentiles, respectively; mid-line in box = median; ends of whiskers = 10th and 90th percentiles, respectively; solid circles = mean values.

Figure 4-3. Event-based load changing percentage for different water quality variables

Total Dissolved Phosphorus

1. For TDP analyses, 54 flow events were selected for further analysis, as these events were well sampled for TDP. Events excluded were the occurrences when either major flows were not routed through the canal to G-302 or no samples were collected at either S-5A or G-302, or at both structures. The TDP routine sampling at S-5A has been suspended since November 2008; therefore, no flow events were selected since that time.
2. For TDP, only grab samples were collected at the inflow and outflow structures. The comparison was made between the calculations by modes M2 and M3, which indicates small differences (**Appendix 4-2**).
3. For the 54 flow events analyzed, the percentages of events showing net TDP load increase from S-5A to G-302 by different load calculation modes M2 and M3 were approximately 54% and 56%, respectively. The descriptive statistical analysis indicated an small average TDP load rate of change of -2.3% by mode M2 and -3.3% by mode M3 (**Appendix 4-2**). The median values for the two calculation modes were less than 1% each. The box plot (**Figure 4-3**) shows the average TDP load rates of change by modes M2 and M3 were close to zero, which indicates little rate of change from S-5A to the outflow structure.
4. While both mean and median values of TDP load rates of change were close to zero, the net load difference indicated overall TDP settling based on the event-based analysis results. SRP is the major component of TDP. The TDP settling is mainly due to SRP settling.

Particulate Phosphorus

1. As PP is calculated as TP minus TDP, the same 54 flow events selected for TDP were initially selected. Ten flow events were further excluded, as the calculated PP loads were negative, which is not physically possible.
2. The PP value and the PP rates of change calculated by modes M2 and M3 were similar (**Appendix 4-2**).
3. For the 44 flow events analyzed, the percentages of events showing net PP load increase from S-5A to G-302 by different load calculation modes M2 and M3 were approximately 61% and 57%, respectively. For all the 44 flow events, under mode 2, the total PP load increase from S-5A to G-302 was 13%, under mode 3, the increase was 15%. The event based average PP load change percentages from S-5A to G-302 were -36% by mode M2 and -37% by mode M3. The event-based median PP load change percentages from S-5A to G-302 were -22% by mode M2 and -24% by mode M3 (**Appendix 4-2**) Both average and median values for the two calculation modes produced negative values. This indicates that PP load, on average, increased from S-5A to G-302. The box plot (**Figure 4-3**) also indicates that the majority of PP loads leaving the STA-1 Inflow Basin Canal via G-302 were higher than the PP loads entering the canal from S-5A.
4. When S-5A was pumping, it may have resuspended accrued canal sediments, resulting in increased PP concentration at the outflow structures, mainly G-302, and the short travel distance from S-5A to G-302 likely did not allow sufficient time for settling of PP. Both factors likely contributed to the increased PP load at G-302.

Dissolved Organic Phosphorus

1. As DOP is calculated as TDP minus SRP, the same 54 flow events selected for TDP were initially selected. Four flow events were further excluded, as the calculated DOP loads were negative, which is not physically possible.
2. The DOP values and the DOP rates of change calculated by the two calculation modes [TDP_{M2} - SRP_{M2}] and [TDP_{M3} - SRP_{M3}] were similar (**Appendix 4-2**).
3. For the 50 flow events analyzed, the percentages of events showing net DOP load increase from S-5A to G-302 by different load calculation modes M2 and M3 were approximately 70% and 66%, respectively. The average and median rates of change for both calculation modes produced negative values. The event-based average rates of change from S-5A to G-302 were -22% by mode M2 and -20% by mode M3 (**Appendix 4-2**). For the median DOP load change percentage from S-5A to G-302, the values were -14% by mode M2 and -21% by mode M3, respectively. The box plot (**Figure 4-3**) shows the average DOP load change percentage during the flow events as a negative value. This suggests that, on average, the outflow DOP load was higher than the inflow DOP load.
4. The results suggest DOP increases from S-5A to G-302, which may be explained by the short travel distance that does not allow sufficient time for DOP to break down or precipitate. The percentage of DOP/TP, approximately 6%, was relatively small. This small percentage indicates that DOP was not a major contributing source of the TP differences from the inflow to outflow sites.

Total Suspended Solids

1. For the TSS analyses, 31 events were selected for further analyses as TSS grab samples were collected during these flow events.
2. For the 31 flow events analyzed, the average TSS load rates of change were negative (-24% by mode M2 and -20% by mode M3; **Appendix 4-2**). In contrast, the median values had opposite results, with a value of 36% for both modes M2 and M3. The positive median values indicated TSS reductions from the S-5A to G-302 structures. The box plot shows the average values were skewed by high negative change percentages from some storm events (**Figure 4-3**). In this case, the median values better represent the overall trend. For the 31 flow events, 68% of the events showed positive rates of change.
3. Based on the median values, the event-based analyses showed that TSS decreased from S-5A to G-302, which indicated TSS settling in the canal. The event-based result is in agreement with the annual and monthly-based mass balances.
4. Large variations in TSS concentration samples and insufficient samples resulted in uncertainties in the TSS load calculation. For example, for the event from July 31, 2004 to September 17, 2004, three samples had values of 19,000 ppb, 85,000 ppb, and 28,000 ppb, with approximately a 450% of variation among these three samples. Theoretically, due to the short travel time from S-5A to G-302, the samples collected on the same day would capture the dynamics of a flow event. However, for the 31 flow events selected for TSS analyses, not all the samples could be paired. For this event, while 85,000 ppb at S-5A was sampled on August 10, 2004, the sample collected at G-302 was on August 19, 2004. For TSS, insufficient sampling data and different sampling schedules resulted in limited paired sampling data. As a result, the TSS load for individual storm events could not be estimated accurately. The resulting uncertainties carried forward to the annual and monthly mass balances could be larger (also, see Section 6.6 of this report).

Total Dissolved Chloride

1. For total dissolved chloride (CLD), 67 flow events for mode M2 and 69 events for mode M3 were selected for further analyses, as these events were well sampled. The reason for the different number of well-sampled events relates to the way grab sample data is used in the different modes.

2. For CLD, only grab samples were collected at the inflow and outflow structures. The total inflow/outflow CLD loads calculated by modes M2 and M3 were similar to each other (**Appendix 4-2**).
3. Overall, the flow event-based mass balance showed equivalent inflow and outflow CLD loads (**Appendix 4-2**). The box plots (**Figure 4-3**) show that the average and median CLD load rates of change were close to zero, which indicates a small rate of change from S-5A to G-302 (**Figure 4-3**). The descriptive statistical analysis further verified the well-balanced inflow and outflow CLD load data. For the selected flow events, the average CLD load difference percentage between inflow and outflow was approximately -2% by mode M2 and -1% by mode M3; the median CLD load difference percentage between inflow and outflow was approximately -0.5% by mode M2 and -0.4% by mode M3 (**Appendix 4-2**). This indicates an insignificant change from S-5A to G-302; these small values could also be associated with random measurement error in the data.

4.4 SUMMARY AND CONCLUSIONS

Based on the findings of the flow event-based analyses, conclusions are summarized below:

- Overall, the water budget showed equivalent inflow and outflow volumes. The flow events observed at the inflow structure (S-5A) were reproduced (i.e., flow rates and shape of hydrograph) in the downstream structures.
- As all the events selected for analyses were sampled, the results from calculation modes M2 and M3 were similar for all the parameters analyzed.
- For DOP and CLD, the overall rates of change from S-5A to G-302 were relatively small and probably insignificant. This indicated little loss of mass from S-5A to G-302.
- For SRP and TDP, the overall rates of change from S-5A to G-302 were relatively small and probably insignificant. However, the net load reductions indicated settling from S-5A to G-302. SRP is the major component of TDP. The TDP settling is mainly due to SRP settling.
- The parameters showing an increased concentration from S-5A to G-302 were TP and PP. For the 134 events analyzed for TP, approximately 75% of events showed a net increase in TP load. The average TP rate of change was approximately -20%. For the 44 events selected for PP, approximately 62% of events showed a net increase in PP load. The average PP rate of change was approximately -36% while the rate of PP change based on the median value was approximately -23%.
- For the 31 flow events analyzed for TSS, the average TSS load rates of change were negative (-24% by mode M2 and -20% by mode M3). In contrast, the median values showed opposite results with a value of 36% for both modes M2 and M3. The positive median values indicated TSS reductions/settling from the S-5A to G-302 structures. The box plots (**Figure 4-3**) show that the average values were skewed by high negative change percentages associated with some storm events. In this case, the median values are a more representative of the overall trend. However, for TSS, large variations in TSS concentration samples, insufficient sampling data, and different sampling schedules resulted in limited paired sampling data. As a result, the TSS load estimate for individual storm events could not be estimated accurately. The resulting uncertainties carried forward to the annual and monthly mass balances could also be large.
- The flow event-based evaluation indicated the main contributing component for the TP increase from S-5A to G-302 is PP.

The results from this chapter will be combined with the results from the analyses in the other chapters of this report to develop the overall conclusions and recommendations.

CHAPTER 5: EVALUATION OF THE POTENTIAL INFLUENCING FACTORS RELATED TO WATER QUALITY CHANGES IN THE STA-1 INFLOW BASIN CANAL

Hongying Zhao, Ph.D., P.E., and Tracey Piccone, P.E.

5.1 INTRODUCTION

This chapter summarizes the evaluation of the potential influencing factors related to water quality changes as water travels from S-5A to G-302 in the STA-1 Inflow Basin Canal. The water quality parameters included in the analyses are shown in **Table 4-1**. The potential influencing factors evaluated are water velocity and canal stage. The water quality concentrations in grab samples collected at S-5A and G-302 were used in the analyses. Data mining from DBHYDRO and canal topographic survey was conducted. Flow and water quality data were downloaded from DBHYDRO. The breakpoint flow and canal stage data were retrieved by the District's Flow Program. Breakpoint data is the name given to fine time resolution data (the time step varies, but generally in minutes) collected by the District. The canal cross-section data used in this study are from the 2013 survey of the STA-1 Inflow Basin Canal conducted by the District (SFWMD, 2013). Flow and canal stage data were paired with water quality data based on the time of collection of each sample. Only paired data collected under flow conditions were used for analyses. Water velocities in the canal were calculated based on flow, canal stage, and canal cross-section data. Paired water quality samples were collected from S-5A and G-302 on the same day; most sample times were only 1 to 2 hours apart. The matched flow and canal stage data were measured within 15 minutes of the grab sample collection times.

For each water quality parameter, three types of analyses were performed: descriptive statistics (and box plots), correlation analysis, and regression analysis. Interpretation of each of the analyses is provided.

Background information on the STA-1 Inflow Basin Canal is presented in Chapter 1 of this report. The STA-1 Inflow Basin Canal segment from S-5A to G-302 is depicted in **Figure 1-1**.

5.2 DATA PREPARATION AND METHODS

For this portion of the STA-1 Inflow Basin Canal study, the dependent variable is the concentration change percentage (CCP) from S-5A to G-302 defined as follows:

$$Concentration\ Change\ Percentage\ (CCP) = \frac{Conc_{S5A} - Conc_{G302}}{Conc_{S5A}}\ X\ 100\%$$

A positive CCP indicates a concentration decrease from S-5A to G-302 and a negative CCP indicates a concentration increase from S-5A to G-302.

Breakpoint flow and canal stage data for the S-5A Pump Station for the period of January 1, 2000 to April 30, 2014 were retrieved using the Flow Program. For G-302, 740,291 breakpoint flow and headwater stage data records were retrieved. For S-5A, 1,216,629 breakpoint flow and tailwater stage data records were retrieved. Breakpoint flow data at S-5A were not linearly distributed between 0 and 4,800 cfs. A review of the historical S-5A non-zero flow breakpoint data indicates groupings of flow in the ranges of 800 to 1,000 cfs, 1,600 to 1,800 cfs, and 2,400 to 2,600 cfs, corresponding to the operation of 1 pump, 2 pumps, 3 pumps, or more (**Figure 5-1**). In **Figure 5-1**, the number labeled above the bar represents the number of hours pumped for each flow range. To investigate the responses of WQ parameters to different operational regimes, a blocking technique was applied to subdivide the flow data into different groups with the intent to quantify the relationships for TP, SRP, TDP, PP, DOP, TSS, and CLD as well as other canal physical features and hydraulic data, i.e., stage, flow, and velocities. Data were analyzed in four flow scenarios as defined below:

Scenario I: 0 cfs < $Q_{S5A} \leq$ 1,000 cfs [average water velocity: 0.4 feet per second (ft/s)]

Scenario II: 1,000 cfs < $Q_{S5A} \leq$ 1,800 cfs (average water velocity: 0.7 ft/s)

Scenario III: Q_{S5A} > 1,800 cfs (average water velocity: 1.0 ft/s)

Scenario IV: All flows included

For TSS and CLD, only Scenario IV was analyzed due to limited sample sizes.

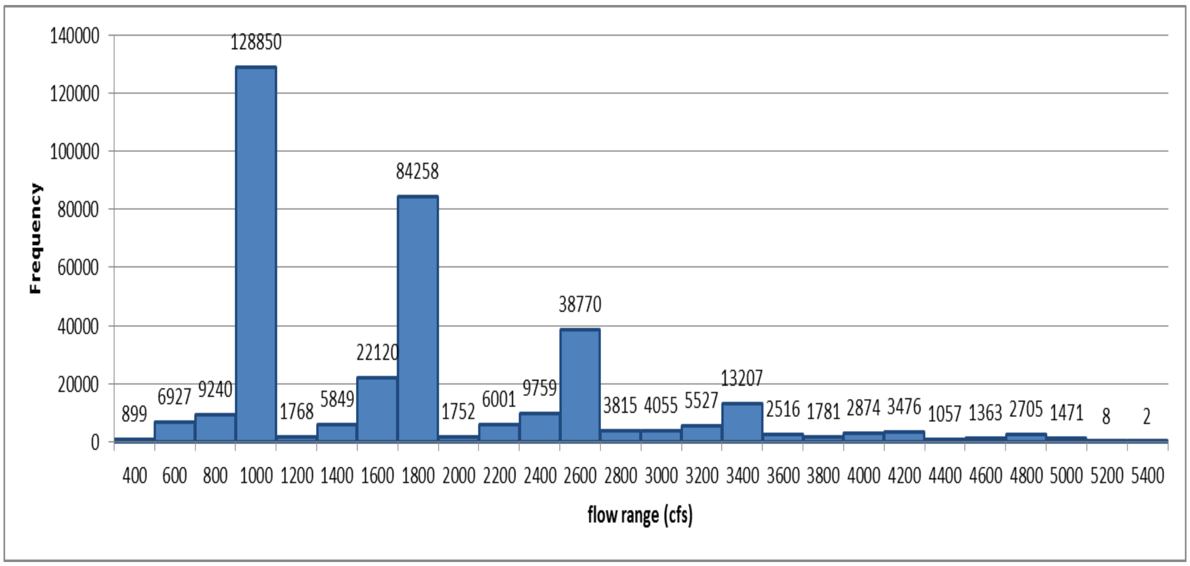


Figure 5-1. S-5A breakpoint flow data for the STA-1 Inflow Basin Canal study.

First, the water quality data at S-5A and G-302 were paired by sampling dates. Next, a spreadsheet was developed to match the breakpoint flow and canal stage data with the water quality data by sampling time. Correspondingly, the velocities were calculated based on the stage-area relationships at Cross-Section 5 (**Figure 5-2**) using matched flow and canal stage data. **Table 5-1** below summarizes the sample size of each paired grab sample data set for the different WQ parameters under each flow scenario. Due to the different sampling frequencies and schedules at S-5A and G-302, the sample sizes of paired data are very small even though more than 15 years of data (January 1, 2000–April 30, 2014) were scrutinized.

Table 5-1. Number of observations analyzed under different flow scenarios for the STA-1 Inflow Basin Canal study.

Flow Scenario	TP	SRP	TDP	PP	DOP	TSS	CLD
Scenario I	29	19	17	17	16	N/A	N/A
Scenario II	36	26	19	19	18	N/A	N/A
Scenario III	23	17	8	4	7	N/A	N/A
Scenario IV	88	62	44	40	41	11	28

A detailed cross-section survey along the STA-1 Inflow Basin Canal was conducted in 2013 by the District (SFWMD, 2013). The stage-area relationships were developed at five locations (see **Figure 5-2** and **Table 5-2**). The stage-area relationship at Cross-Section 1 was used to calculate water velocity in the canal, as this cross-section is representative of the entire canal segment from S-5A to G-302 and is located close to the G-302 structure. **Equation 5-1** was used to calculate the velocity. Additional information on the STA-1 Inflow Basin Canal survey and cross-sections is presented in **Appendix 5-1**.

$$V = \frac{Q}{A} \qquad 5\text{-}1$$

where Q is the breakpoint flow data in cfs, A is the cross-section area in square feet (ft^2) corresponding to the stage at the same moment the flow was measured at cross-section 1.

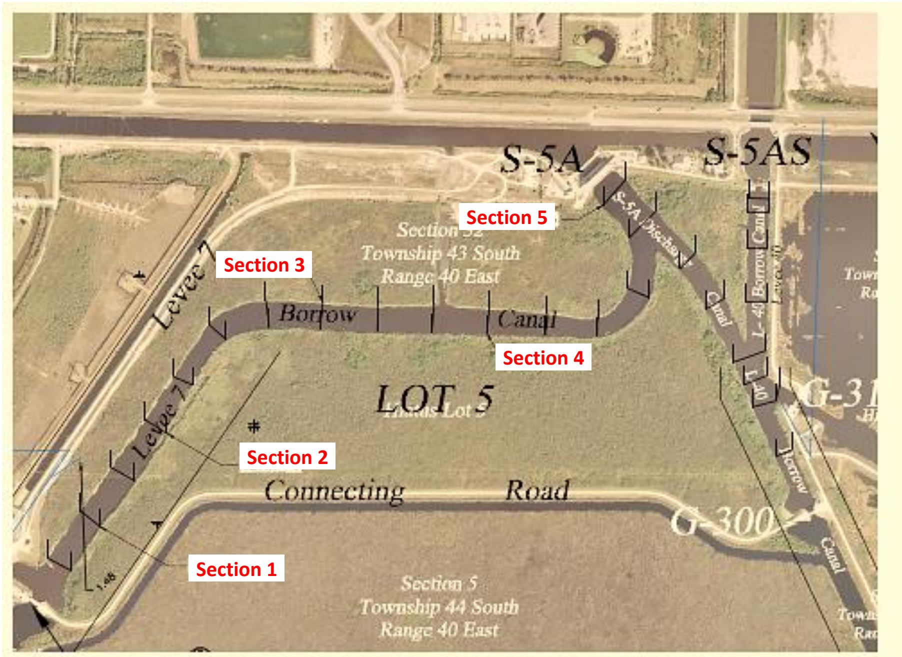


Figure 5-2. Cross-section survey diagram for the STA-1 Inflow Basin Canal.

Table 5-2. Stage-area relationship for five cross-sections in the STA-1 Inflow Basin Canal from S-5A to G-302.

Canal Stage (ft NGVD)	Cross-Section 1 (ft^2)	Cross-Section 2 (ft^2)	Cross-Section 3 (ft^2)	Cross-Section 4 (ft^2)	Cross-Section 5 (ft^2)
11.0	1106.78	971.07	928.71	829.08	2707.98
11.5	1202.37	1052.38	1021.62	918.82	2836.45
12.0	1301.17	1138.58	1118.13	1011.68	2967.83
12.5	1403.18	1228.58	1217.86	1107.74	3102.41
13.0	1508.42	1322.55	1320.81	1207.02	3240.21
13.5	1616.87	1430.15	1426.97	1309.51	3381.22
14.0	1728.54	1540.54	1536.35	1415.22	3525.44
14.5	1843.42	1654.15	1648.95	1524.15	3672.89
15.0	1961.52	1770.98	1764.76	1636.30	3823.55
15.5	2082.84	1891.02	1883.79	1751.66	3977.42
16.0	2207.37	2014.28	2006.04	1870.24	4134.52
16.5	2335.12	2140.75	2131.50	1992.03	4294.83
17.0	2466.08	2270.44	2260.18	2117.04	4458.35
17.5	2600.26	2403.35	2392.07	2245.27	4625.09
18.0	2737.66	2539.47	2527.18	2376.71	4795.05

For each parameter and each flow scenario, three types of analyses were conducted:

1. Descriptive statistics and box plots to characterize overall distributions
2. Correlation analysis to evaluate the statistical relationships among different parameters
3. Regression analysis to identify the potential factors that influence CCP

Velocity can be a critical factor in evaluating nutrient transport. A velocity is determined by the flow rate and the cross-section area corresponding to the stage at the moment the flow was measured. High velocity can be observed at both high flow and low flow conditions. In this study, the blocking technique was also applied to subdivide the data into two groups, velocity lower than 0.8 ft/s and velocity equal to or higher than 0.8 ft/s. The percentage showing WQ increase from S5A to G302 for each group were summarized.

DESCRIPTIVE STATISTICS AND BOX PLOTS

In descriptive statistics, a box plot is a simple and convenient way of graphically depicting groups of numerical data through their quartiles. Box plots display variation in samples of a statistical population without making any assumptions of the underlying statistical distribution. Box plots are non-parametric. The spacing between the different parts of the box indicate the degree of dispersion (spread) and skewness in the data, and show outliers.

CORRELATION ANALYSIS

The Spearman and Pearson correlation analyses were used to quantify the strength of association between upstream and downstream station concentrations for each WQ variable [SAS/STAT User's Guide 9.3 (2011)]. Correlation coefficients can range between -1 and 1. The closer the correlation is to 1 or -1, the stronger the relationship. The Pearson correlation measures strength of the linear relationship, whereas the Spearman correlation measures the strength of any monotonic, one directional relationship. Due to the violation of distributional assumptions (based on tests for normality, linearity, and equal variance) required for the Pearson correlation, the Spearman correlation p-value was used to determine statistical significance because these assumptions are not a requirement for its validity.

Table 5-3. Dancey and Reidy's (2014) categorization of the strength of correlation coefficients.

Values of the Correlation Coefficient (Absolute Value)	Strength of Correlation
1	perfect
0.7 – 0.9	strong
0.4 – 0.6	moderate
0.1 – 0.3	weak
0	zero

REGRESSION ANALYSIS

Regression analysis is a statistical process for estimating the relationships among variables. In regression analysis, the ratio of the explained variation to the total variation is called the coefficient of determination, or r^2. The coefficient of determination measures the proportion of the variability of the dependent variable that is "explained" by the independent variables.

A SAS program with the stepwise method (maximum r-squared improvement option) was selected. This stepwise method is a modification of the forward-selection technique and differs in that variables already in the model do not necessarily stay there. As in the forward-selection method, variables are added one by one to the model, and the F statistic for a variable to be added must be significant at the established selection level. After a variable is added, however, the stepwise method looks at all the variables already included in the model and deletes any variable that does not produce an F statistic significant at the selection level. Only after this check is made and the necessary deletions accomplished, can another variable be added to the model. The stepwise process ends when none of the variables outside the model has an F statistic significant at the selection level and every variable in the model is significant at the selection level, or when the variable to be added to the model is the one just deleted from it. This technique also seeks to maximize the model r^2 value as it adds and removes variables from the regression model. It sequentially picks the best 1-variable model, best 2-variable model, ending with the best n-variable model in which each n-variable model has the highest r^2 value and all the independent variables make a statistically significant contribution to the model. Regression analyses based on the stepwise method were performed for all the flow scenarios with CCP as the dependent variable and stage, velocity, and WQ measured at S5A as the potential independent variables. Since WQ measured at S-5A and G-302 are highly correlated, only one of them could be included in the regression analyses. For these analyses, the S-5A WQ data were included as one of the independent variables. A 0.15 significance level was used for entry in the model.

5.3 RESULTS

TOTAL PHOSPHORUS

Descriptive Statistics

The descriptive statistics and box plots for the TP concentrations at S-5A and G-302 are presented in **Figure 5-3** and **Appendix 5-2**. For the period from January 1, 2000 to April 30, 2014, 88 paired data points were extracted (**Table 5-3**). In all four flow scenarios, as indicated by the descriptive statistics, TP concentration increases from S-5A to G-302 were observed. The average CCPs for different flow scenarios were -3% for Scenario I, -14% for Scenario II, and -12% for Scenario III. The overall TP CCP with all 88 data pairs included (Scenario IV) was -10%.

The box plot for Scenario I indicates that when flow was less than 1,000 cfs, the TP concentration increase from S-5A to G-302 was relatively small. For Scenarios II and III, when flows were larger than 1,000 cfs, equivalent to two or more pumps on at S-5A, the TP concentration increase from S-5A to G-302 was larger. For Scenarios II and III, the median, mean, and approximately 70% of data demonstrated a TP concentration increase when water traveled from S-5A to G-302, with a CCPs of -12 and -10%, respectively.

Inspection of TP CCPs indicates (**Table 5-4**) that when the water velocity was less than 0.8 ft/s, 59% of the data showed TP concentration increases from S-5A to G-302. When the water velocity increased to 0.8 ft/s or above, 75% of the data showed TP concentration increases from S-5A to G-302.

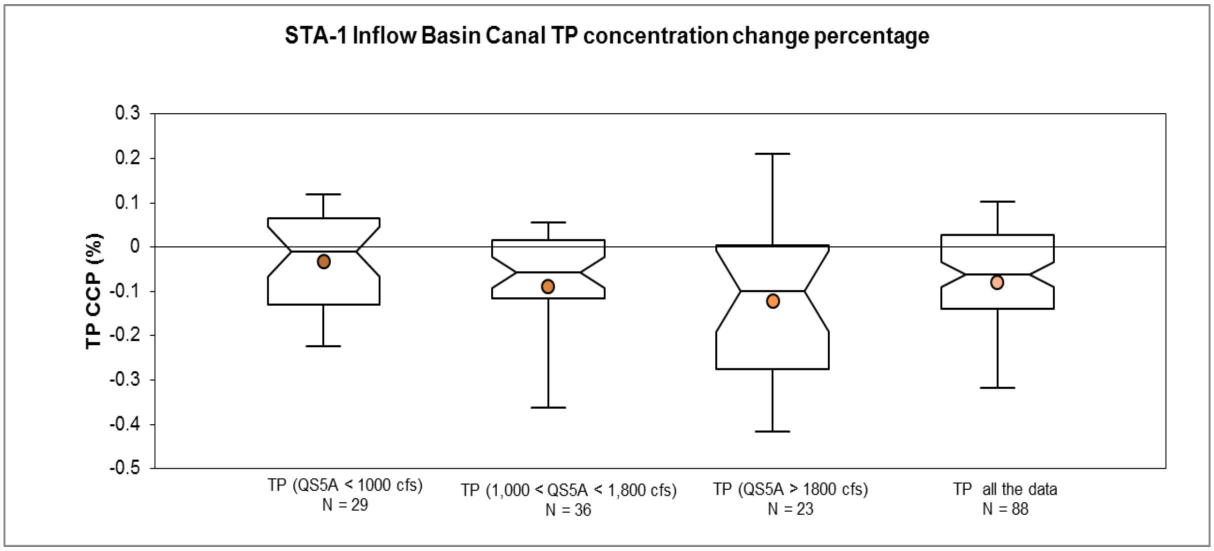


Figure 5-3. STA-1 Inflow Basin Canal total phosphorus Concentration change percentage box plots.

Table 5-4. STA-1 Inflow Basin Canal Velocity Frequency Analyses

Parameter	Percentage of Data Pairs Showing Velocity Less than 0.80 ft/s	Percentage of Data Pairs Showing Velocity Larger than or Equal to 0.80 ft/s
TP	59% (56)	75% (32)
SRP	33% (40)	45% (22)
TDP	34% (33)	60% (11)
PP	82% (39)	100% (1)
DOP	47% (30)	36% (11)
TSS	40% (5)	100% (6)
CLD	36% (11)	41% (17)

*The number in the parenthesis denotes the size of data pairs used in the analysis.

Correlation Analysis

In all four flow scenarios, even though the correlation relationships between the TP CCPs and water velocities are not statistically significant, negative correlation relationships can be observed (**Appendix 5-3**). This could suggest that when the water velocity was high, the TP CCPs decrease from S-5A to G-302. The correlation analyses detected statistically significant strong positive correlation relationships between S5A_TP and G302_TP (r = 0.96, 0.84, 0.89, and 0.89, respectively) with all the p-values less than 0.001.

Scenario III included 23 paired observations (**Table 5-1**). The Spearman correlation and the p-value matrix indicate a statistically significant positive correlation relationship between S5A_TP and TP CCP.

Regression Analysis

Table 5-5 summarizes the regression analysis results for TP. For Scenario II, no variable met the 0.15 significance level for entry in the model. For Scenario I, TP met the significance level and was entered in the model with an r^2 of 0.09. For Scenario III, the variables that met the significance level and were entered in the model were S5A_TP, water velocity, and canal stage with an r^2 of 0.49. For Scenario IV, the variable that met the significance level and was entered in the model was canal stage with an r^2 of 0.11. Although these variables entered the model with statistically significant levels, the proportion of the variability in TP CCP that can be explained by the independent variables is small. A common factor that entered all three models and contributed most to the proportion of the variability is S5A_TP.

Scenario I (r^2= 0.09): $TP\ CCP = -0.26 + 1.30 \cdot S5A\_TP$

Scenario III (r^2= 0.49): $TP\ CCP = 1.27 - 0.092 \cdot Stage + 2.16 \cdot S5A\_TP - 0.33 \cdot Velocity$

Scenario IV (r^2= 0.11): $TP\ CCP = -0.25 + 0.99 \cdot S5A\_TP$

Table 5-5. Independent variable(s) selected by the stepwise regression analyses.

	Scenario I	**Scenario II**	**Scenario III**	**Scenario IV**
TP CCP	S5A_TP (0.09)	X	S5A_TP, velocity, stage	S5A_TP
SRP CCP	stage	X	X	velocity
TDP CCP	stage, velocity	X	X	X
PP CCP	S5A_PP	X	stage	S5A_PP
DOP CCP	velocity	S5A_DOP, velocity, stage	S5A_DOP, velocity	X
TSS CCP	N/A	N/A	N/A	S5A_TSS
CLD CCP	N/A	N/A	N/A	X

Summary

In summary, the concentrations at S-5A and G-302 are highly correlated. Negative correlation relationships between TP Concentration change percentage and water velocity suggests when the velocities are high, the TP concentration change percentages decrease from S-5A to G-302. The matched data pair indicates a more frequent TP concentration increase from S5A to G-302 as velocities are higher than 0.8 ft/s. The relatively high water velocity can be a contributing factor to the TP concentration increase as it reduces the time for TP to settle out of the water column and also results in relatively high sheer forces along the bottom and sides of the canal. When a flow is higher than 1,800 cfs, the TP CCP can be related to the independent variables of S5A_TP, water velocity, and canal stage with an r^2 of 0.49.

SOLUBLE REACTIVE PHOSPHORUS

Descriptive Statistics

The descriptive statistics and box plots for the SRP concentrations at S-5A and G-302 are shown in **Figure 5-4** and **Appendix 5-2**. For the period from January 1, 2000 to April 30, 2014, 62 paired SRP observations were extracted. As indicated by the descriptive statistics for Scenario I, the small positive mean and median CCP values suggests minimal removal of SRP from S-5A to G-302. For all four flow scenarios, the frequencies of negative CCPs were less than 50%.

A simple analysis between water velocity and SRP CCP (**Table 5-4**) indicates a 33% TP concentration increase from S-5A to G-302 when the water velocities were less than 0.8 ft/s. When the velocities increased to 0.8 ft/s or above, this percentage was 45%. This suggests more than a 50% occurrence of SRP concentration decreasing from S-5A to G-302. Low water velocities could be a contributing factor to SRP removal.

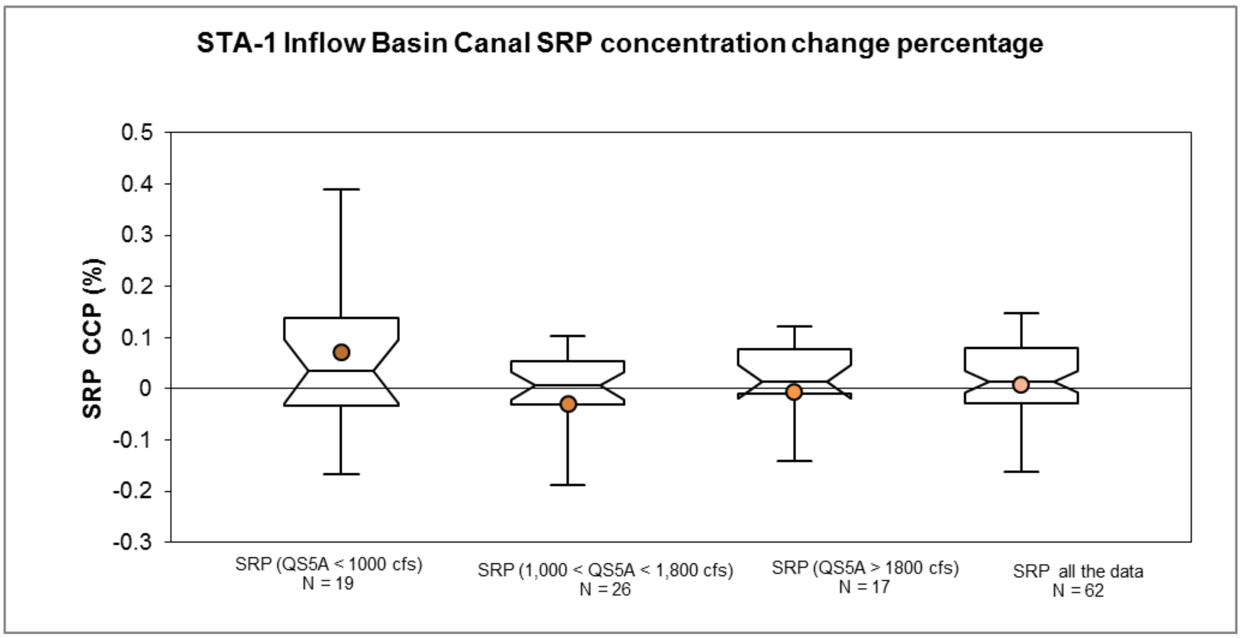


Figure 5-4. STA-1 Inflow Basin Canal soluble reactive phosphorus concentration change percentage box plots.

Correlation Analysis

For Scenario I (flow less than 1,000 cfs), the correlation analysis (**Appendix 5-3**) detected a moderate correlation relationship between SRP CCP and canal stage ($r = 0.64$).

Under the other three flow scenarios, the mean and median CCPs were close to zero (**Appendix 5-2**). This suggests that there were little SRP concentration changes from S-5A to G-302. The District implements a regular canal maintenance program, and routine field observations indicate that this segment of canal is very well maintained, with little vegetation within the canal. This also helps explain the small SRP CCP from S-5A to G-302 under relatively high flow scenarios (higher than 1,000 cfs) (**Figure 5-4**). Under all four flow scenarios, S5A_SRP and G302_SRP were strongly correlated ($r = 0.91$, 0.99, 0.98, and 0.97, respectively), with p-values less than 0.001 (**Appendix 5-3**).

Regression Analysis

The stepwise regression analyses produced only one one-variable regression equation listed below. This relationship indicates that when the canal stage was high and flow rate was relatively low, some SRP removal occurred.

Scenario I (r^2 = 0.24, p = 0.003): $SRP\ CCP = -1.79 + 0.13 \cdot stage$

Table 5-5 summarizes the regression analysis results. For Scenarios II and III, no variable met the 0.15 significance levels for entry into the model. For Scenario IV, the variable that met the significance level and was entered in the model was water velocity with an r^2 of 0.04. This very small r^2 value indicates that almost none of the variability in SRP CCP can be explained by water velocity.

Summary

In summary, the concentrations at S-5A and G-302 are highly correlated. The matched SRP concentration data pairs indicate a more frequent SRP concentration decrease from S-5A to G-302. The correlation analyses suggest SRP removal could occur when flows are less than 1,000 cfs and the canal stages are relatively high.

TOTAL DISSOLVED PHOSPHORUS

Descriptive Statistics

The descriptive statistics and box plots for the TDP concentrations at S-5A and G-302 are shown in **Figure 5-5** and **Appendix 5-2**. For the period from January 1, 2000 to April 30, 2014, 44 paired TDP observations were extracted. Based on the box plots for Scenario I (flow less than 1,000 cfs) and Scenario II (flow between 1,000 cfs and 1,800 cfs), a slight TDP concentration reduction was observed, as the mean and median SRP CCPs were positive. This may be explained by the relatively low water velocity. For Scenario III, the mean and median values were close to zero, which indicates little TDP concentration change from S-5A to G-302.

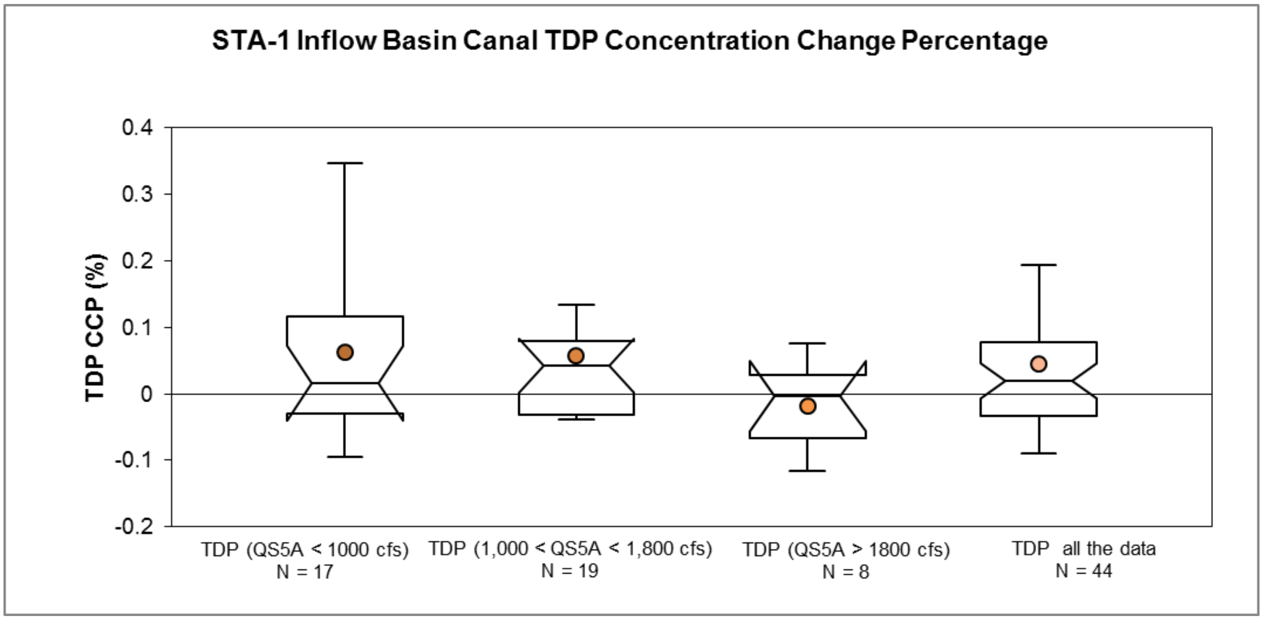


Figure 5-5. STA-1 Inflow Basin Canal total dissolved phosphorus concentration change percentage box plots.

A simple analysis between water velocity and TDP CCP (**Table 5-4**) indicates a 34% TDP concentration increase from S-5A to G-302 when water velocities were less than 0.8 ft/s. The TDP concentration increase from S-5A to G-302 was 60% when water velocities increased to 0.8 ft/s or above. These suggest low water velocities might contribute to TDP removal.

Correlation Analysis

For Scenario I (flow less than 1,000 cfs), the correlation analysis (**Appendix 5-3**) indicates a moderate negative correlation relationship between the TDP CCP and water velocity (r = -0.56 and p-value = 0.02). The correlation analysis matrix also indicates a moderate positive correlation relationship between the TDP Concentration change percentage and canal stage (r = 0.50 and p-value = 0.04). Under Scenario III (average water velocity of 0.8 ft/s), the TDP CCP and water velocity are also negatively correlated with an r of -0.69 and a p-value of 0.06. Under all four flow scenarios, S5A_TDP and G302_TDP are strongly correlated (r = 0.95, 0.97, 0.98, and 0.98, respectively), with p-values less than 0.001.

Regression Analysis

Table 5-5 summarizes the regression analysis results. For Scenario I, the variables met the significance level and were entered in the model were canal stage and water velocity with an r^2 of 0.41. The proportions of the variability in the TDP change percentage can be explained by the canal stage and water velocities are only 0.26 and 0.16, respectively. In this flow scenario, the average canal stage was 14.30 ft NGVD. The positive coefficient of canal stage indicates the higher the canal stage, the higher TDP concentration reduction from S-5A to G-302. This relationship was observed only when water velocity was relatively low. For Scenarios II, III, and IV, no variable met the 0.15 significance levels for entry in the model.

Scenario I (r^2 = 0.41): $TDP\ CCP = -1.07 + 0.088 \cdot Stage - 0.45 \cdot Velocity$

Summary

In summary, the concentrations at S-5A and G-302 are highly correlated. The matched data pairs indicate a more frequent TDP concentration decrease from S-5A to G-302 when the water velocities are relatively small. For Scenario I, flow less than 1,000 cfs, the variables that met the significance level and were entered in the model were canal stage and water velocity with an r^2 of 0.41.The relatively low water velocity and high canal stage could be contributing factors to the TDP concentration changes along the canal.

PARTICULATE PHOSPHORUS

Descriptive Statistics

The descriptive statistics and box plots for the PP concentrations at S-5A and G-302 are shown in **Figure 5-6** and **Appendix 5-2**. For the period from January 1, 2000 to April 30, 2014, 40 paired observations were extracted. The descriptive statistics from all four flow scenarios indicate PP concentration increases from S-5A to G-302. The average increase percentages for different flow scenarios were -36% for Scenario I (flow less than 1,000 cfs), -43% for Scenario II (flow between 1,000 cfs and 1,800 cfs), and -16% for Scenario III (flow higher than 1,800 cfs). The overall average increase percentage for all the data was -37%. The relatively low PP increase percentages for Scenario III may be explained by high pumping rates during sampling. Only four data pairs were extracted for Scenario III. Under this flow scenario, even though the flows were the highest, the PP concentrations measured at S-5A were low. The flow during the sampling event on August 28, 2008 was 2,507 cfs, which occurred during the period of Tropical Storm Fay, however, the measured PP concentration at S-5A and G-302 were only 27 and 34 ppb, respectively. S-5A had been pumping since August 18, 2008. The daily flow rates varied between 2,500 cfs and 4,400 cfs for nine days prior to the sampling date on August 28, 2008. One possible explanation for the low PP concentrations is that any accrued sediments already had been flushed out of the canal and were not captured by the grab samples at S-5A and G-302.

Based on the box plots (**Figure 5-6**) for all flow scenarios, PP concentration increases were observed since the mean and median concentration change percentages are all negative and almost all the paired samples showed PP concentration increase from S-5A to G-302. The water velocities for Scenario II and III averaged 0.7 ft/s and 1.0 ft/s, respectively. It is likely that the relatively high water velocities reduced the time for PP to settle out of the water column and also resulted in high scouring forces stirring up the sediments.

A simple analysis between water velocity and PP CCP (**Table 5-4**) suggests that when the water velocity was less than 0.8 ft/s, 82% of the data showed PP concentration increase from S-5A to G-302. There was only one occurrence for water velocity higher than 0.8 ft/s, which also showed a PP increase from S-5A to G-302.

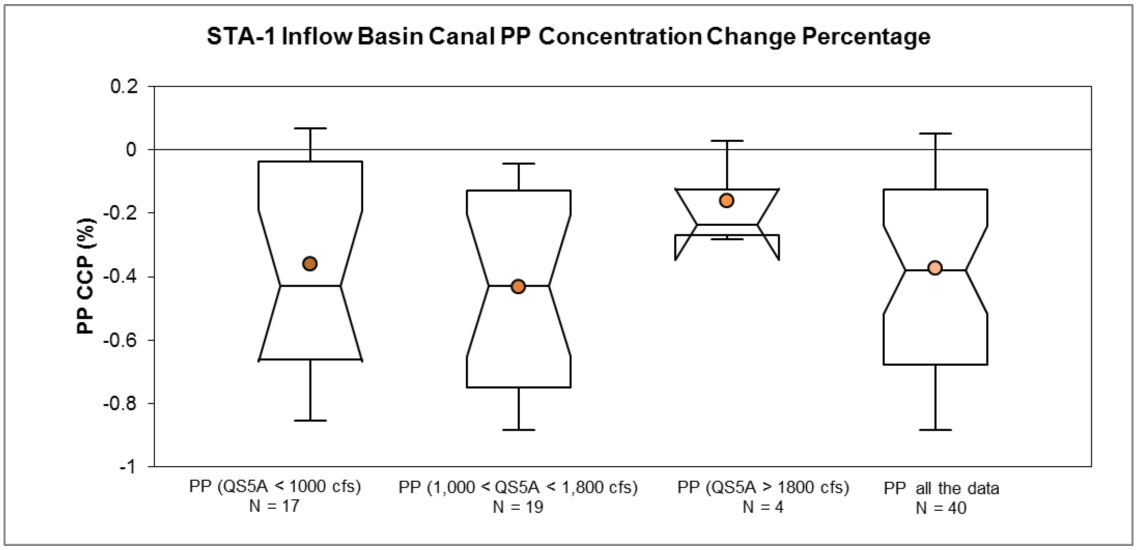


Figure 5-6. STA-1 Inflow Basin Canal particulate phosphorus concentration change percentage box plots.

Correlation Analysis

The correlation analysis matrix (**Appendix 5-3**) indicates a moderate to strong positive correlation relationship between S5A_PP and G302_PP (r = 0.54, 0.88, 0.99, and 0.79 respectively), with p-values less than 0.001.

Regression Analysis

Table 5-5 summarizes the regression analysis results. A high S-5A PP concentration resulted in a high PP concentration at G-302. No statistically significant relationship was observed for PP CCPs and water velocity even though the PP concentrations increased under all flow scenarios. Even though a significant regression relationship is observed in Scenario IV between S5A_PP and the PP **CCP**, only four samples were included in this analysis. This regression relationship is not considered meaningful.

Summary

In summary, the PP concentrations at S-5A and G-302 are highly correlated. Even though no statistically significant relationship can be observed in the PP rates of change and water velocity, the PP concentrations increase from S-5A to G-302 under all flow scenarios. The matched data pairs also indicate a high frequent occurrence of PP concentration increase from S-5A to G-302 under different flow and water velocity regions. The short travel distance most likely will not allow sufficient time for PP to settle.

DISSOLVED ORGANIC PHOSPHORUS

Descriptive Statistics

Descriptive statistics for DOP concentrations at S-5A and G-302 are shown in **Figure 5-7** and **Appendix 5-2**. DOP is a calculated value (TDP - SRP); therefore, uncertainties in the TDP and SRP data will impact the accuracy of the DOP values. In addition, the proportion of DOP concentration in the water column was small for the inflow to this canal. The ratios of DOP/TDP and DOP/TP are 8% and 6%, respectively. A previous study by Chimney (2007) indicated for STA-1W inflow, the average DOP accounted for only 5% of TP, which can be considered an insignificant portion. For the period from January 1, 2000 to April 30, 2014, 41 paired data were extracted. In all four flow scenarios, as indicated by the descriptive statistics, a DOP concentration increase from S-5A to G-302 can be observed. The average increase percentages for different flow scenarios were 15% for Scenario I (flow less than 1,000 cfs), 27% for Scenario II (flow between 1,000 cfs and 1,800 cfs), and 15% for Scenario III (flow higher than 1,800 cfs). The overall increase percentage with all the data pairs included (Scenario IV) was 20%. However, the median values suggest no change (i.e., the values were close to zero) in all four flow scenarios. The average values were impacted by some high negative CCPs.

Based on the box plots for all flow scenarios, a DOP increase is suggested since the mean and median change percentages were all negative and almost all the paired samples showed a DOP concentration increase from S-5A to G-302 (**Figure 5-7**). It is likely the short travel time from S-5A to G-302 contributes to the changes in DOP along the canal.

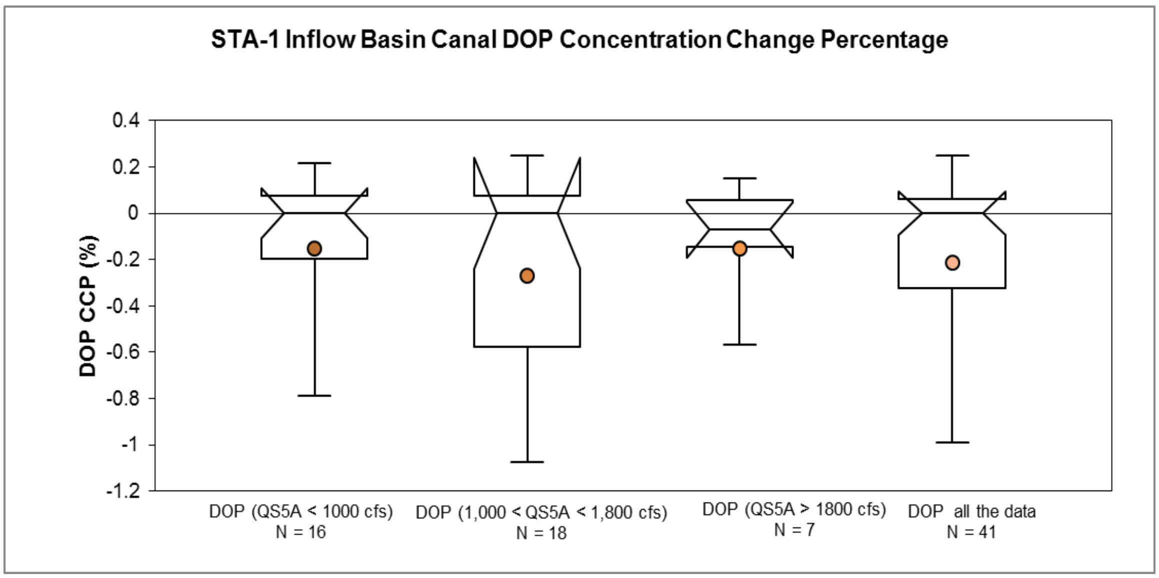


Figure 5-7. STA-1 Inflow Basin Canal dissolved organic phosphorus concentration change percentage box plots.

A simple analysis between water velocity and DOP CCP (**Table 5-4**) indicates that when the water velocity was less than 0.8 ft/s, 46% of the data showed DOP concentration increase from S-5A to G-302. The occurrence of DOP concentration increase from S-5A to G-302 was 36% when the water velocity increased to 0.8 ft/s or above. This indicates DOP removal for most of the data pairs. These percentages do not suggest that increased water velocities result in increased DOP concentration.

Correlation Analysis

For all four flow scenarios (**Appendix 5-3**), under scenarios II and IV, the DOP CCPs are significantly related to S5A_DOP. In Scenarios I and IV, the correlation between S5A_DOP and G302_DOP is statistically significant. With all the data included (Scenario IV), the moderate correlation between DOP change percentage and S5A_DOP ($r = 0.53$, p-value < 0.001) and weak correlation between DOP CCP and G302_DOP are statistically significant ($r = -0.31$, p-value = 0.05).

Regression Analysis

Table 5-5 summarizes the regression analysis results. For Scenario I, the variable that met the significance level and was entered in the model was water velocity with an r^2 of 0.23. For Scenario II, the variables that met the significance level and were entered in the model were S5A_DOP, water velocity, and canal stage with an r^2 of 0.81. For Scenario III, the variables that met the significance level and were entered in the model were S5A_DOP and canal stage with an r^2 of 0.91. For Scenario IV, no variables met the significance level and were entered in the model. Although these variables are statistically significant, the proportion of the variability in the CCP that can be explained by the independent variables is small.

Scenario I (r^2 = 0.23): $DOP\ CCP = -0.56 + 1.57 \cdot velocity$

Scenario II (r^2 = 0.81): $DOP\ CCP = -6.85 + 0.32 \cdot Stage + 61.45 \cdot S5A_{DOP} + 1.14 \cdot Velocity$

Scenario III (r^2 = 0.91): $DOP\ CCP = 1.64 + 0.32 \cdot Stage - 406.36 \cdot S5A_{DOP} + 4.86 \cdot Velocity$

Summary

In summary, different analyses produced different results for the DOP Concentration change percentage from S-5A to G-302. No DOP CCP increase or decrease can be concluded. DOP is a calculated value (TDP - SRP), therefore, uncertainties in both TDP and SRP data could impact the accuracy of the DOP values. In addition, the DOP concentration in the water column was very small. With a ratio of 8% for DOP/TDP (8%) and 6% for DOP/TP, DOP can be considered as a minor TP component.

TOTAL SUSPENDED SOLIDS

Descriptive Statistics

The descriptive statistics and box plots for the TSS concentrations at S-5A and G-302 are shown in **Figure 5-8** and **Appendix 5-2**. For the period from January 1, 2000 to April 30, 2014, 11 paired observations under flow conditions were extracted (note that the size of this data sample is relatively small). As indicated by the descriptive statistics and box plots, the mean (119% increase) and median (58%) suggest an increased TSS concentration from S-5A to G-302. For the 11 paired samples, 8 out of 11 (73%) of the calculated CCPs were negative. This also suggests a TSS concentration increase from S-5A to G-302. This trend is consistent with the observations of PP and TP.

For the 3 paired observations showing a TSS concentration reduction from S-5A to G-302, the water velocities were lower than 0.5 ft/s. For 7 paired observations showing a TSS concentration increase from S-5A to G-302, the average water velocity was 0.9 ft /s (0.78 to 1.06 ft/s). However, the samples collected on December 26, 2006 were an exception. During this occurrence, the water velocity was 0.3 ft/s, while the TSS concentration showed a 56% increase. Also during this occurrence, the canal stage was very low, with a value of 13.63 ft NGVD. It is likely that the drought condition experienced during WY2007 contributed to the high TSS increase percentage during a low water velocity and low canal stage condition. It should also be noted that the Everglades STAs received relatively low inflows during the WY2007 regional drought.

A simple analysis between water velocity and TSS CCP (**Table 5-4**) suggests that when the water velocity was less than 0.8 ft/s (five data pairs), two data pairs (40%) showed TSS concentration increases from S-5A to G-302. When the water velocity was higher than 0.8 ft/s, all six data pairs (100%) showed TSS increases from S-5A to G-302.

Correlation Analysis

For Scenario IV (**Appendix 5-3**), the scenario with all the paired data, the correlation analysis matrix indicates strong correlations between the TSS CCP and G302_TSS (r = -0.61, p-value = 0.04) and S5A_TSS (r = 0.77, p-value = 0.006). Even though the p-value was 0.1, a moderate negative correlation relationship between TSS CCP and water velocity was observed (r = -0.57). This suggests that a high water velocity could have resulted in a high TSS concentration increase percentage from S-5A to G-302. It is likely that the relatively high water velocities reduced the time for TSS to settle out of the water column and also resulted in high scouring forces stirring up the sediments.

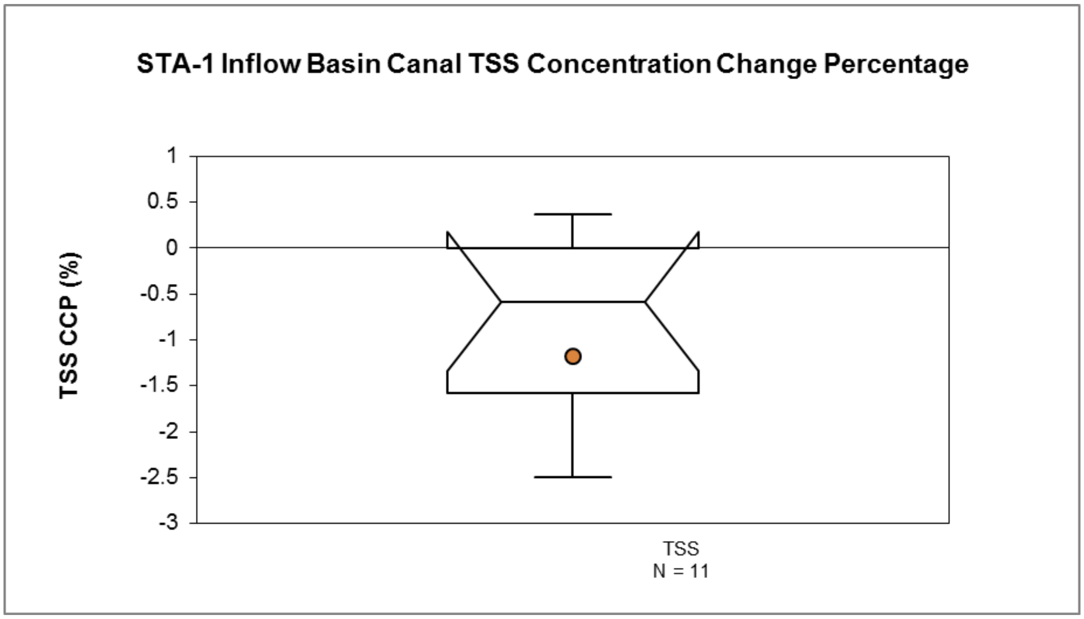


Figure 5-8. STA-1 Inflow Basin Canal total suspended solids concentration change percentage box plot.

Regression Analysis

Table 5-5 summarizes the regression analysis results. For Scenario IV, the variable that met the significance level and was entered in the model was S5A_TSS, with an r^2 of 0.50. This indicates that 50% of the variation in the TSS change percentage can be explained by the variation in S5A_TSS. Only 11 pairs of data were included in the analysis. Such a small data set may not adequately characterize what happened in the field during the study period and that due to the limitation of the data, this regression model may be of little practical use.

TSS CCP = -4.0919 + 0.35 X S5A_TSS

While the seasonal monthly and annual analysis results show TSS load reductions from S-5A to G-302 (**Appendix 2-1**), the paired data analyses indicate TSS concentration increases when the water velocity was higher than 0.8 ft/s. Except CLD, among all other water quality variables analyzed for the STA-1 Inflow Basin Canal, TSS concentration data demonstrate the highest variability.

Summary

In summary, the matched data pairs suggest when the water velocity are higher than 0.8 ft/s, TSS concentrations increase from S-5A to G-302. Even though the p-value was 0.1, a moderate negative correlation relationship between TSS Concentration change percentage and water velocity was observed (r = -0.57). This also suggests that a high water velocity could result in a higher TSS concentration increase from S-5A to G-302.

TOTAL DISSOLVED CHLORIDE

Descriptive Statistics

The descriptive statistics and box plots for the CLD concentrations at S-5A and G-302 are shown in **Figure 5-9** and **Appendix 5-2**. For CLD, for the period from January 1, 2000 to April 30, 2014, 28 paired data were extracted. Based on the descriptive statistics and box plots for the 28 paired samples, the median Concentration change percentage was zero, while the mean was a small positive number of 4%. The small change percentages indicate the minor CLD concentration difference between G-302 and S-5A.

A simple analysis between water velocity and CLD CCP (**Table 5-4**) indicates that when the water velocity was less than 0.8 ft/s, approximately 36% of the data showed CLD concentration increase from S-5A to G-302. The occurrence of CLD concentration increase from S-5A to G-302 was 41% when the water velocity increased to 0.8 ft/s or above. This data suggests that minor CLD removal might have occurred.

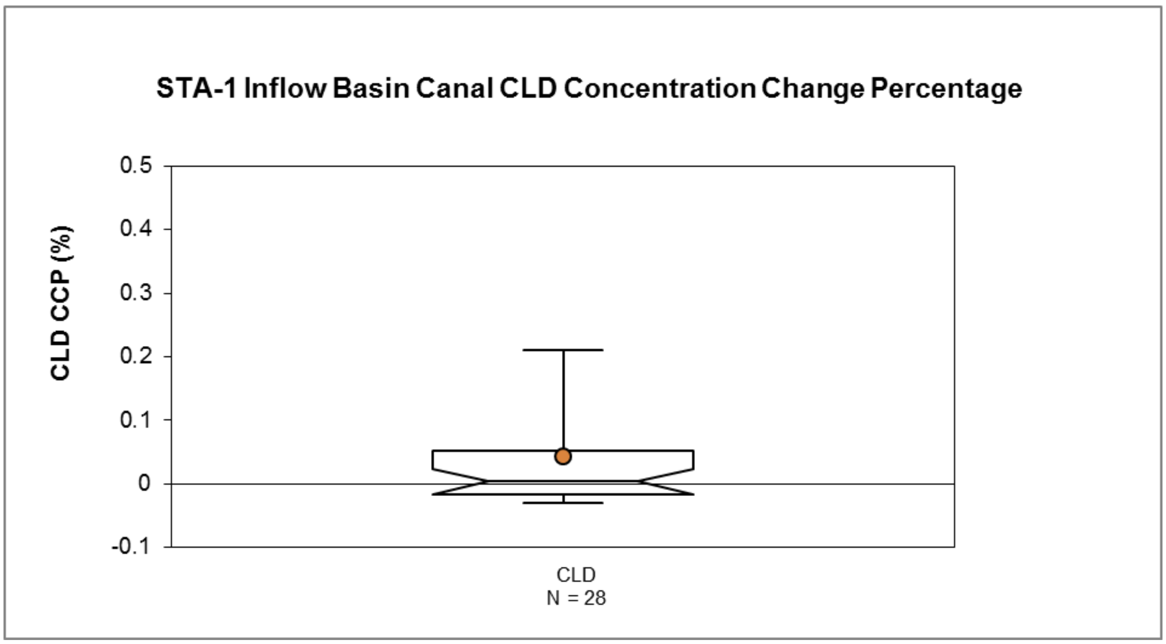


Figure 5-9. STA-1 Inflow Basin Canal dissolved chloride concentration change percentage box plot.

Correlation Analysis

Due to the small sample size, only Scenario IV was analyzed. Correlation analysis (**Appendix 5-3**) indicates a strong correlation relationship between S5A_CLD and G302_CLD (r = 0.92 and P < 0.001). No other significant correlation relationship was detected.

Regression Analysis

Table 5-5 summarizes the regression analysis results. No variable met the 0.15 significance level for being entered in the regression model. As CLD is a component that does not easily settle out of the water column, the stable CLD concentrations from S-5A to G-302 may indicate the minimal impact from other water sources, such as seepage.

Summary

In summary, the matched data pairs indicate a more frequent CLD concentration decrease from S-5A to G-302. The CLD concentration change percentage is not highly related to the canal physical characteristics and hydraulic parameters included in this study.

5.4 SUMMARY AND CONCLUSIONS

For all the water quality parameters (TP, SRP, TDP, PP, DOP, TSS, and CLD) analyzed, the concentrations at S-5A and G-302 are significantly correlated.

When water velocity increased to 0.8 ft/s or above, concentration increases from S-5A to G-302 were observed for TP and TSS. PP concentration increases from S-5A to G-302 were observed in different water velocity regions.

Given the relatively low flow rates (less than 1,000 cfs) and high canal stages, more frequent SRP and TDP concentration decreases from S-5A to G-302 were observed. The relatively low water velocities and high canal stage, and associated increased travel time, may be the contributing factors to the SRP and TDP concentration removal.

For CLD and DOP, no statistically significant relationship was observed between the change percentage and water velocity, canal stage, and CLD concentration. The DOP concentration in the water column was very small, with a ratio of approximately 6% for DOP/TP. Typically, DOP can be considered as an insignificant portion of the TP component. CLD mass conservation was very well maintained between S-5A and G-302.

The velocity-based results support the Restoration Strategies goal of providing FEBs upstream of the Everglades STAs to attenuate the peak flow rate, reduce the high flow frequency, and minimize the duration of high flow conditions. The results from this chapter will be combined with the results from the analyses in the other chapters of this report to develop the overall conclusions and recommendations.

CHAPTER 6: RESULTS

In this Phase I study, the STA-1 Inflow Basin Canal segment from S-5A to G-302 was investigated through detailed analyses of existing water quality and flow data to determine if TP concentrations change when conveyed along the canal (i.e., evaluate whether canal acts as a TP source or sink) and, if TP concentrations do change, determine how much sediment and TP were exported from the canal, or how much TP has accumulated in the canal throughout the analysis period. In support of the TP and TSS analysis, the same analyses were applied to other water quality parameters (SRP, TDP, PP, DOP, TSS, and CLD). A mass balance approach based on different temporal scales in combination with statistical analysis tools was developed to address these objectives. The temporal scales investigated include instantaneously paired water quality sampling data; individual flow events; and monthly, wet/dry season, and annual analyses. This chapter summarizes the results from different analyses.

6.1 TOTAL PHOSPHORUS

Total phosphorus (TP) data were analyzed for the period from WY2001 to WY2013 (May 1, 2000–April 30, 2013). The results from the TP concentration data variability analyses, annual/monthly/ seasonal mass balance analyses, and event-based mass balance analyses are consistent. All these analyses demonstrate increased TP concentration and load from S-5A to G-302. The WSR test suggests that the TP concentrations at G-302 were 7 ppb higher than TP concentrations at S-5A. This difference is statistically significant (p-value < 0.0001). For the 134 storm events analyzed, approximately 75% of events showed increased TP loads and concentrations from S-5A to G-302. These results indicate that this canal acted as a TP source over the period analyzed. It is estimated that approximately 70 to 76 metric tons of TP may have been exported from this canal system.

The TP concentrations at S-5A and G-302 are highly correlated (0.96, 0.85, 0.89, and 0.89 for Scenario I, II, III, and IV). The negative correlation relationships between TP concentration change percentage and water velocity suggests that when the velocity was high, the TP concentration change percentages decreased from S-5A to G-302. The paired t-test analyses indicates more frequent TP concentration increases from S-5A to G-302 given velocities higher than 0.8 ft/s. The relatively high water velocity could be a contributing factor to TP concentration increases, as it reduced the time for TP to settle out of the water column and results in relatively high sheer forces along the bottom and sides of the canal that can scour and resuspend sediment. When flow was higher than 1,800 cfs, the TP concentration change percentages can be related to the independent variables S5A_TP, water velocity, and canal stage, with an R^2 of 0.49.

6.2 SOLUBLE REACTIVE PHOSPHORUS

SRP (or orthophosphate) data were analyzed for the period from May 1, 2000 to April 30, 2013. The results from the SRP concentration data variability analyses and annual/monthly/seasonal mass balance analyses suggest slight SRP reduction from S-5A to G-302. The WSR analysis indicates that the SRP concentrations at G-302 were 5 ppb lower than the SRP concentrations at S-5A. This difference is statistically significant (p-value < 0.0001). The annual mass balance suggests approximately 20 to 28 metric tons of SRP was sequestered in this canal system during the study period. Although the event-based evaluation shows a minor change percentage from S-5A to G-302 given the calculated negative average rate of change and positive median rate of change, the event-based SRP net load difference suggests SRP removal of approximately 17 to 19 metric tons. The selected events for SRP analyses account for approximately 70% of flows occurring during the study period. These results suggest that this canal acted as an SRP sink over the study period.

The SRP concentrations at S-5A and G-302 are highly correlated with r of higher than 0.91 for all scenarios. The matched SRP concentration data pairs indicate more frequent SRP concentration decreases from S-5A to G-302. The regression analyses indicate SRP removal can occur given less than 1,000 cfs of flow and relatively high canal stages.

6.3 TOTAL DISSOLVED PHOSPHORUS

TDP data were analyzed for the period from May 1, 2000 to April 30, 2007, based on data availability. The results from the concentration data variability analyses and annual/monthly/seasonal mass balance analyses are consistent. These analyses indicate relatively small TDP concentration and load decreases from S-5A to G-302. The WSR analysis showed that the TDP concentrations at G-302 were 3 ppb lower than TDP concentrations at S-5A. This difference is statistically significant (p-value = 0.0269). The results from annual/monthly/seasonal mass balance analyses suggest a small TDP load reduction with an overall decrease of 5.6 to 15.7 metric tons. Although the event-based analyses (54 storm events were analyzed) produced negative average and median TDP concentration change percentages (from -1 to -4%), which imply TDP concentration increases from S-5A to G-302, the event-based TDP net load differences actually suggests TDP removal of approximately 12 to 13 metric tons. The selected events for TDP analyses account for approximately 60% of flows occurring during the study period. These results suggest that this canal acted as a TDP sink during the period analyzed.

The TDP concentrations at S-5A and G-302 are highly correlated (0.95, 0.97, 0.98, and 0.98). The matched data pairs indicate that more frequent TDP concentrations decreased from S-5A to G-302 when the velocities were relatively small. When flow was less than 1,000 cfs, the TDP concentration change percentages are related to the variables, canal stage and water velocity, with an r^2 of 0.41.The relatively low water velocity and high canal stage may be the contributing factors to the TDP concentration reduction as they result in increased travel time.

6.4 PARTICULATE PHOSPHORUS

PP data were analyzed for the period from May 1, 2000 to April 30, 2007, based on data availability. The results from the PP concentration data variability analyses, annual/monthly/seasonal mass balance analyses, and event-based mass balance analyses are all consistent. These analyses indicate increased PP concentrations and loads from S-5A to G-302. The WSR analysis suggests the PP concentrations at G-302 were 9 ppb higher than PP concentrations at S-5A. This difference is statistically significant (p-value < 0.0001). For the 44 storm events analyzed, the descriptive analyses suggest an increased PP load from S-5A to G-302, with an approximate average PP load change percentage of -36% and median PP change percentage of -22%. These results suggest that this canal acted as a PP source over the period analyzed. During the study period, approximately 37 to 41 metric tons of PP may have been exported from this canal system.

The PP concentrations at S-5A and G-302 are highly correlated with a correlation coefficient of 0.79 when all the data pair included. Although no statistically significant relationship was observed between the PP rates of change and water velocity, the PP concentration increases from S-5A to G-302 were observed consistently under all flow scenarios, and the matched data pairs also indicate high frequency of PP concentration increases from S-5A to G-302 under different flow and water velocity regimes. The short distance travelled most likely does not allow sufficient time for PP to settle out of the water column.

6.5 DISSOLVED ORGANIC PHOSPHORUS

DOP data were analyzed for the period from May 1, 2000 to April 30, 2007, based on data availability. DOP is a calculated value (TDP - SRP). Therefore, uncertainties in both TDP and SRP data could impact the accuracy of the DOP values. In addition, the DOP concentration in the water column was very small with a mean value of approximately 10 ppb and a ratio of 8% for DOP/TDP and 6% for DOP/TP. Generally, DOP was as a minor component of TP. Inadequate DOP data, large uncertainties in DOP concentrations data, and small DOP concentrations in the water column resulted in inconclusive results. The results from the concentration data variability analyses, annual/monthly/seasonal mass balance analyses, and event-based mass balance analyses were not conclusive whether DOP was sequestered within or exported from the canal on a net basis.

6.6 TOTAL SUSPENDED SOLIDS

TSS data were analyzed for the period from May 1, 2000 to April 30, 2013. Among all the water quality variables analyzed for the STA-1 Inflow Basin Canal, the TSS concentration data showed the highest variability. Results from the concentration data variability analyses, annual/monthly/seasonal mass balance analyses, and the event-based mass balance analyses had discrepancies. The WSR analysis suggests that the TSS concentrations at G-302 were 3,500 ppb higher than TSS concentrations at S-5A. This difference is statistically significant (p-value < 0.0001). The annual mass balance showed different results, with approximately 591 to 687 metric tons of TSS settling in this canal system. For the 31 flow events analyzed, the average TSS load rate of change and median TSS load rate of change indicate different results. The average rates of change were negative, indicating TSS load increases from S-5A to G-302. In contrast, the median values had different results, with a value of 36%, indicating TSS load decreases from S-5A to G-302. Inadequate TSS data and large variations in TSS concentrations resulted in high uncertainties in the TSS load calculations and inconclusive results as to whether this canal acted as a source or sink of TSS over the period analyzed.

A simple analysis between the water velocity and TSS concentration change percentage suggests that when the water velocity was less than 0.8 ft/s (five data pairs), two data pairs showed TSS concentration increased from S-5A to G-302. All six data pairs with water velocities higher than 0.8 ft/s showed TSS concentration increased from S-5A to G-302. Although the p-value was 0.1, a moderately negative correlation relationship between TSS concentration change percentage and water velocity was observed (r = -0.57). This suggests that a high water velocity could result in a higher TSS concentration increase from S-5A to G-302.

6.7 TOTAL DISSOLVED CHLORIDE

CLD data were analyzed for the period from May 1, 2000 to April 30, 2013. The results from the CLD concentration data variability analyses, annual/monthly/seasonal mass balance analyses, and event-based mass balance analyses are in general agreement, indicating good CLD mass conservation from S-5A to G-302. The WSR analysis suggests no significant CLD concentration changes from S-5A to G-302. The flow event-based mass balance also indicates equivalent inflow and outflow CLD loads. For the selected flow events, the average CLD load change percentage between inflow and outflow was approximately -2 to -1%, and the median CLD load change percentage between inflow and outflow was approximately -0.5 to -0.4%. This indicates insignificant concentration change from S-5A to G-302. Annual mass balance analyses also demonstrate very minor difference from S-5A to G-302. Good mass conservation of CLD is in agreement with the water balance for the canal segment from S-5A to G-302. The good agreement in both water and CLD budgets suggests that seepage was not an important source of inflow to this canal.

No statistically significant relationship was observed between the CLD rates of change and water velocity, canal stage, and CLD concentrations at S-5A. No independent variable met the 0.15 significance level to be included in the regression model.

6.8 RESULTS SUMMARY

For all the water quality parameters (TP, SRP, TDP, PP, DOP, TSS, and CLD) analyzed, the concentrations at S-5A and G-302 are significantly correlated. The various analyses showed that from S-5A to G-302, a net increase in TP and PP loads over the period analyzed, and that PP and TP concentrations increased as well. These findings suggest that this canal acted as a net TP source during the 13-year period (May 1, 2000–April 30, 2013), exporting approximately 70 to 76 metric tons of TP. The mass balances for TP and P fractions also suggest the TP load exported from this canal system was mainly PP. Phase II studies are needed to better understand the specific source of the TP load.

Storm event-based analyses suggested that, in general, when the water velocity increased to 0.8 ft/s or more, concentration increases from S-5A to G-302 were observed for TP and TSS. PP concentration increases from S-5A to G-302 were observed under different water velocity regimes. These results support the Restoration Strategies goal of providing FEBs upstream of the STAs to reduce the frequency and duration of peak flow events.

CHAPTER 7: RECOMMENDATIONS

The STA-1 Inflow Basin Canal Phase I study results support the Restoration Strategies' goal of providing flow equalization basins upstream of the Everglades Stormwater Treatment Areas to reduce the frequency and duration of peak flow events. Phase II is not recommended for this canal at this time because once the L-8 FEB is operational, peak flow rates into STA-1W are anticipated to reduce (magnitude and frequency) which in turn is expected to result in less potential for sediment transport/resuspension in this canal. If in the future it is decided to proceed with Phase II, the following preliminary recommendations are provided in this section. These recommendations should be re-evaluated if and when it is decided to proceed with the Phase II study of this canal.

TOPOGRAPHIC SURVEY

A detailed cross-section survey along the STA-1 Inflow Basin Canal was conducted in 2013 by the District (SFWMD, 2013). Therefore, no topographic survey is recommended at this time.

SEDIMENT CORE SAMPLING

Samples of the existing sediments are recommended within this 6,300-foot long canal segment. It is proposed that at each selected cross-sections, the depth of the sediment layer will be measured by appropriate means and methods. Multiple measurements at each cross-section are required to allow good estimate of the sediment volumes within the entire canal. At a minimum, four sediment cores will be collected approximately within the middle portion of each cross-section. The cores will not be collected at the canal toe of the slope. The sediment cores will be at least 30-centimeters deep where practical [bedrock may limit penetration of the core to allow identification of the unconsolidated (floc layer) and consolidated (sediment/soil) layers] for physical and chemical analysis. For three of the four cores collected, the floc layer will be separated and the remaining core samples will be sectioned in intervals to allow a good understanding of the sediment chemical and physical and hydraulic characteristics. The fourth core will remain intact for separate laboratory analysis.

SEDIMENT LABORATORY ANALYSES

It is proposed that the floc layers, sediment core sections, and the fourth intact core will be tested for physical and chemical characteristics, as summarized below.

Physical Laboratory Test

Visual observation of the floc layer, sectioned sediment cores, and fourth core will be performed prior to any test. The physical characterization for the floc layer, sectioned sediment cores, and fourth core will be analyzed for the following parameters: bulk density, ash-free dry weight, organic content, and water content measurements.

Chemical Laboratory Test

For the floc layers and sectioned sediment cores, the chemical parameters to be analyzed include TP, SRP, TDP, total carbon, total calcium, and total nitrogen.

The chemical characterization of the fourth intact core will include the parameters summarized below. The sediment analytical results will be compared to the defined values outlined in Chapter 62-777, Florida Administrative Code, as specified for the Soil Cleanup Target Levels (SCTL) for direct exposure and the SCTL limits for leachability based on groundwater and surface water.

- Arsenic barium
- Cadmium
- Lead
- Selenium
- Silver
- Mercury (Total) by cold vapor atomic absorption spectrometry
- TP
- Total recoverable petroleum hydrocarbons
- Organochlorine pesticides

Canal TP and Sediment Accrual Estimate Refinement

Subsequently, it is proposed that the canal TP and sediment accrual status and volumes developed during Phase I will be reevaluated and refined based on the sediment depth measurement, core sampling, and laboratory testing results.

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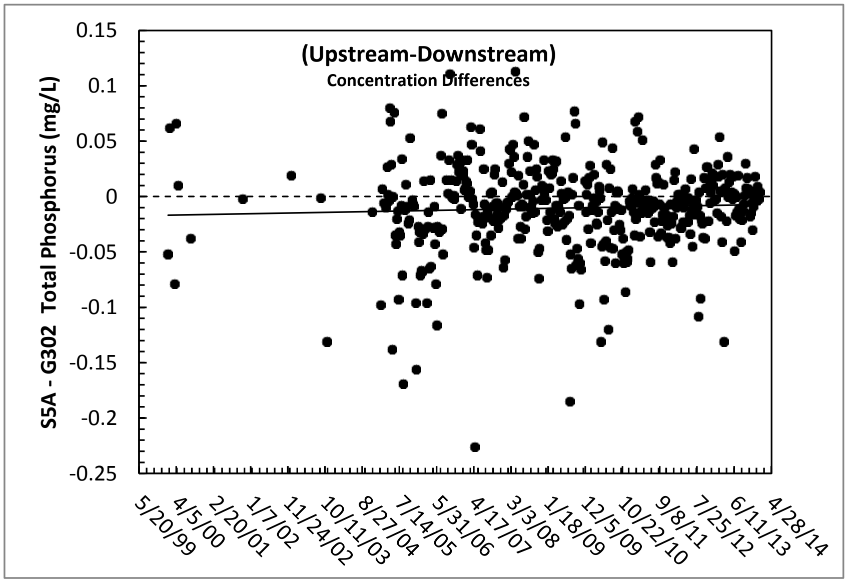
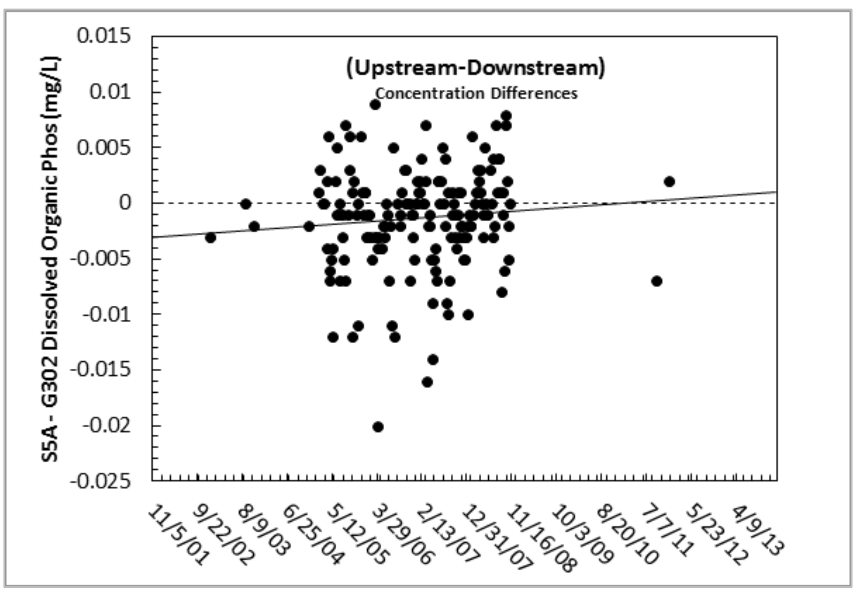
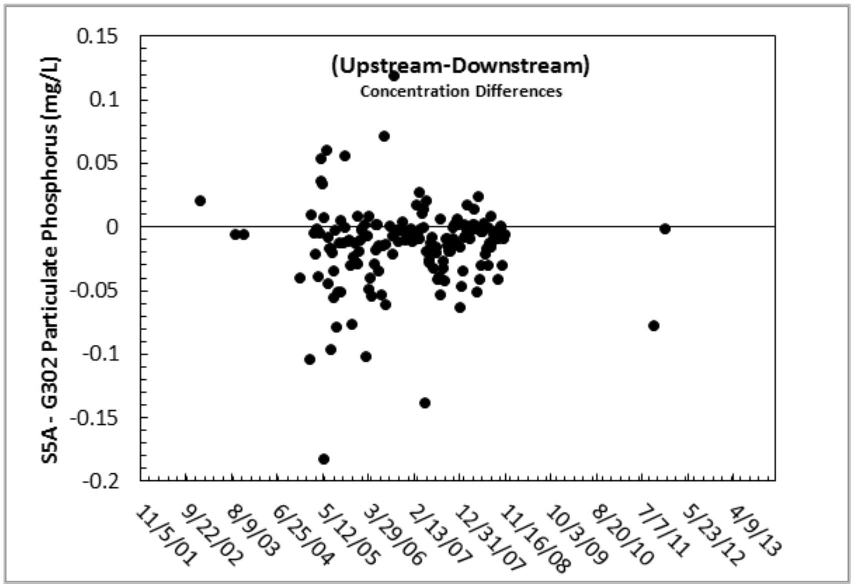
APPENDIX 2-1

Trend Plots: Upstream-Downstream Differences versus Time







(Upstream-Downstream)
Concentration Differences
S5A - G302 Particulate Phosphorus (mg/L)
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
11/5/01
9/22/02
8/9/03
6/25/04
5/12/05
3/29/06
2/13/07
12/31/07
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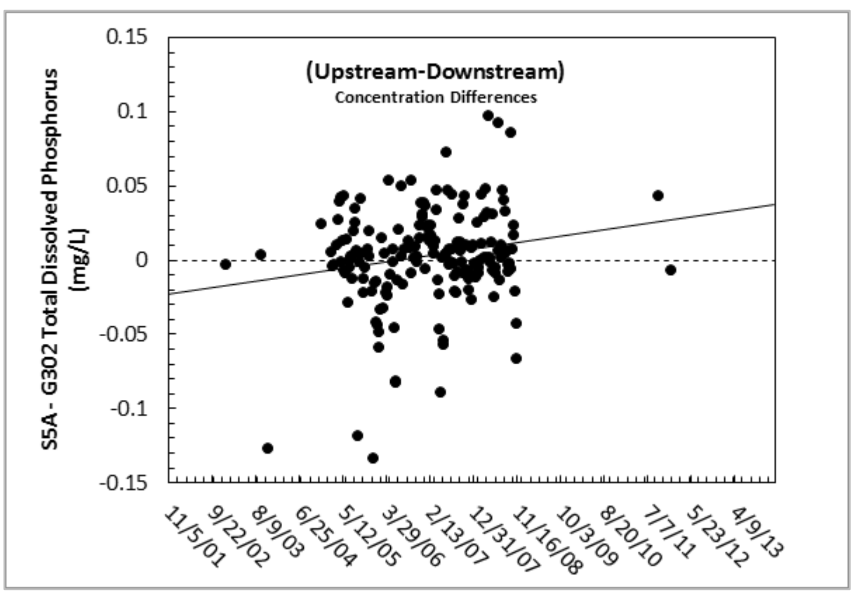
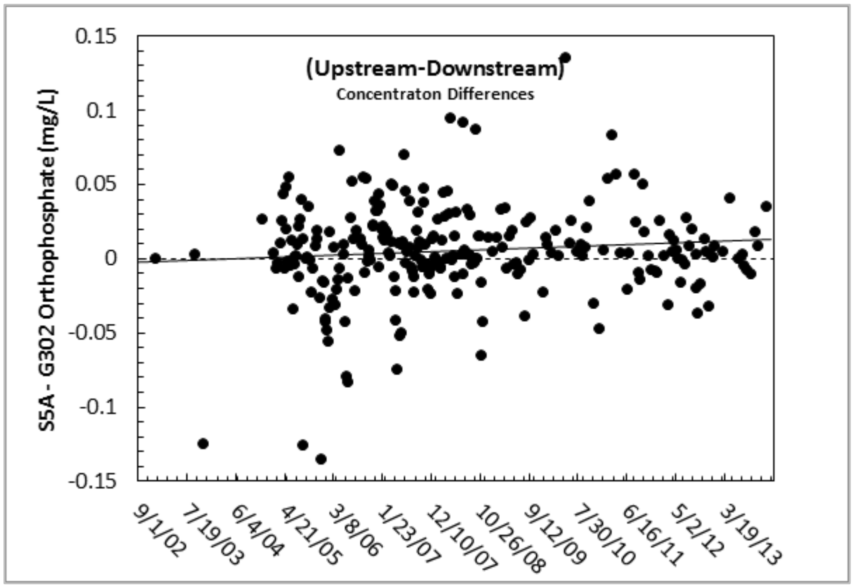
7/7/11
5/23/12
4/9/13



(Upstream-Downstream)
Concentration Differences
S5A - G302 Total Dissolved Phosphorus (mg/L)
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
11/5/01
9/22/02
8/9/03
6/25/04
5/12/05
3/29/06
2/13/07
12/31/07
11/16/08
10/3/09
8/20/10
7/7/11
5/23/12
4/9/13


(Upstream-Downstream)
Concentraton Differences
S5A - G302 Orthophosphate (mg/L)
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
9/1/02
7/19/03
6/4/04
4/21/05
3/8/06
1/23/07
12/10/07
10/26/08
9/12/09
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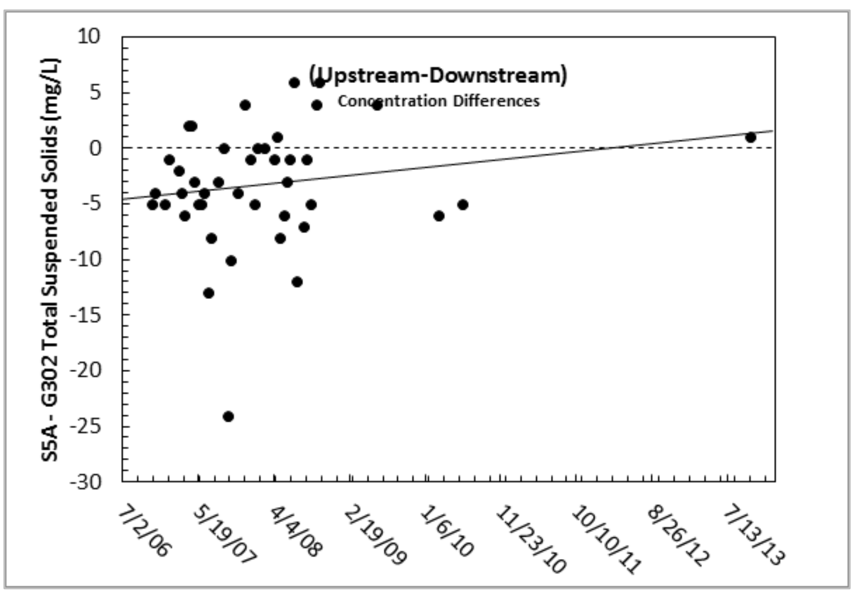
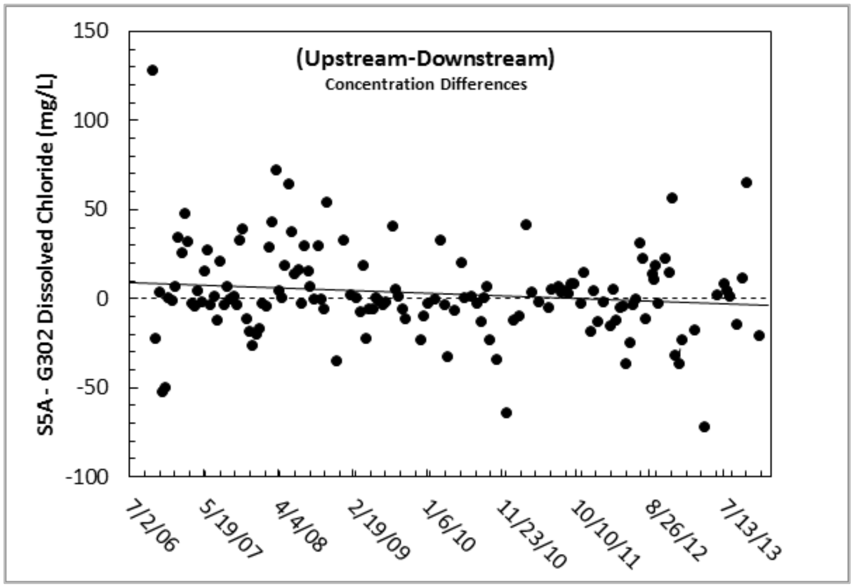
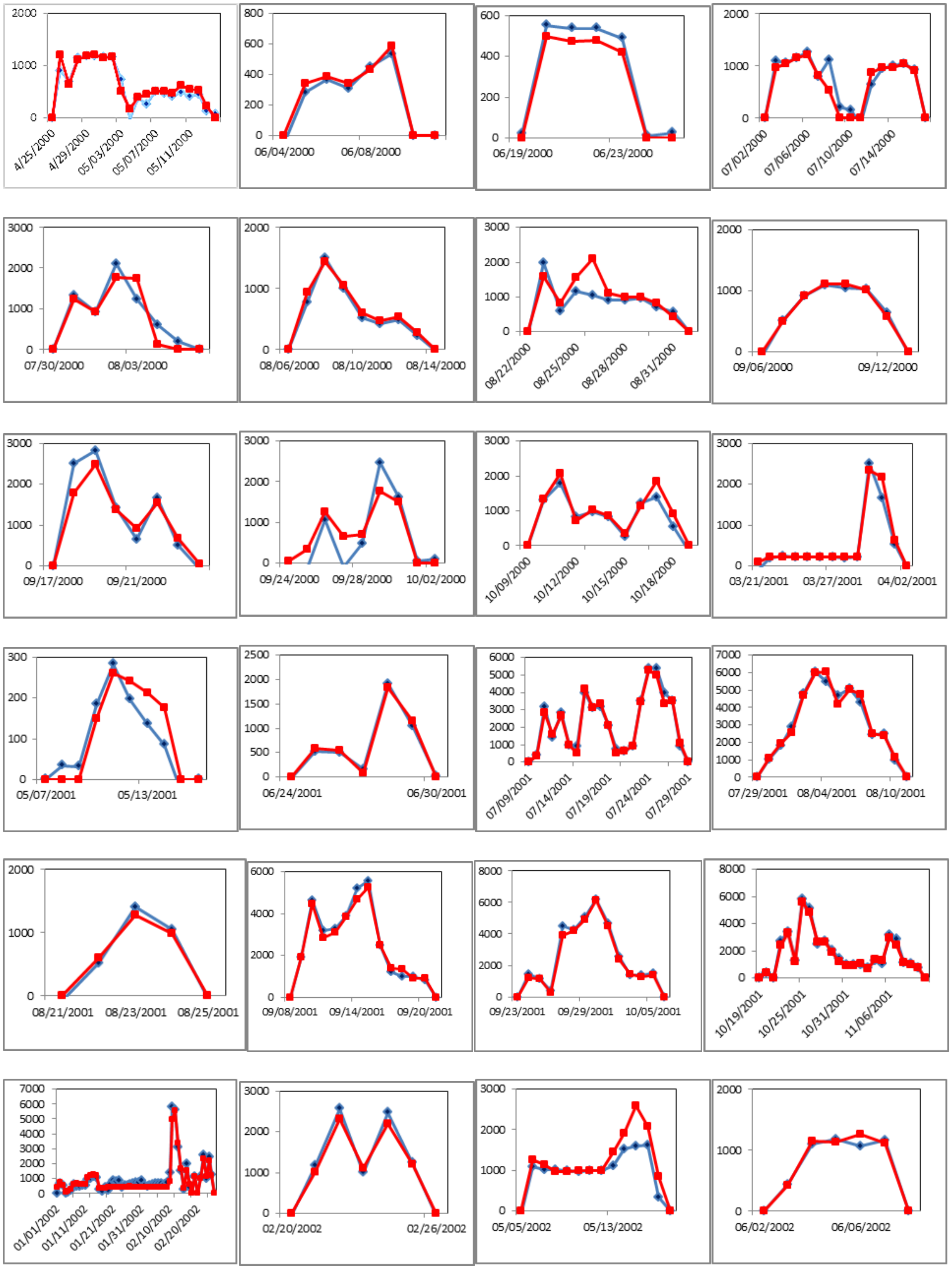
6/16/11
5/2/12
3/19/13


(Upstream-Downstream)
Concentration Differences
S5A - G302 Total Suspended Solids (mg/L)
10
5
0
-5
-10
-15
-20
-25
-30
7/2/06
5/19/07
4/4/08
2/19/09
1/6/10
11/23/10
10/10/11
8/26/12
7/13/13


(Upstream-Downstream)
Concentration Differences
S5A - G302 Dissolved Chloride (mg/L)
150
100
50
0
-50
-100
7/2/06
5/19/07
4/4/08
2/19/09
1/6/10
11/23/10
10/10/11
8/26/12
7/13/13

APPENDIX 4-1: FLOW EVENT HYDROGRAPHS

(Y: flow (cfs); X: date)



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06/19/2000
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07/06/2000
07/10/2000
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01/21/2002
01/31/2002
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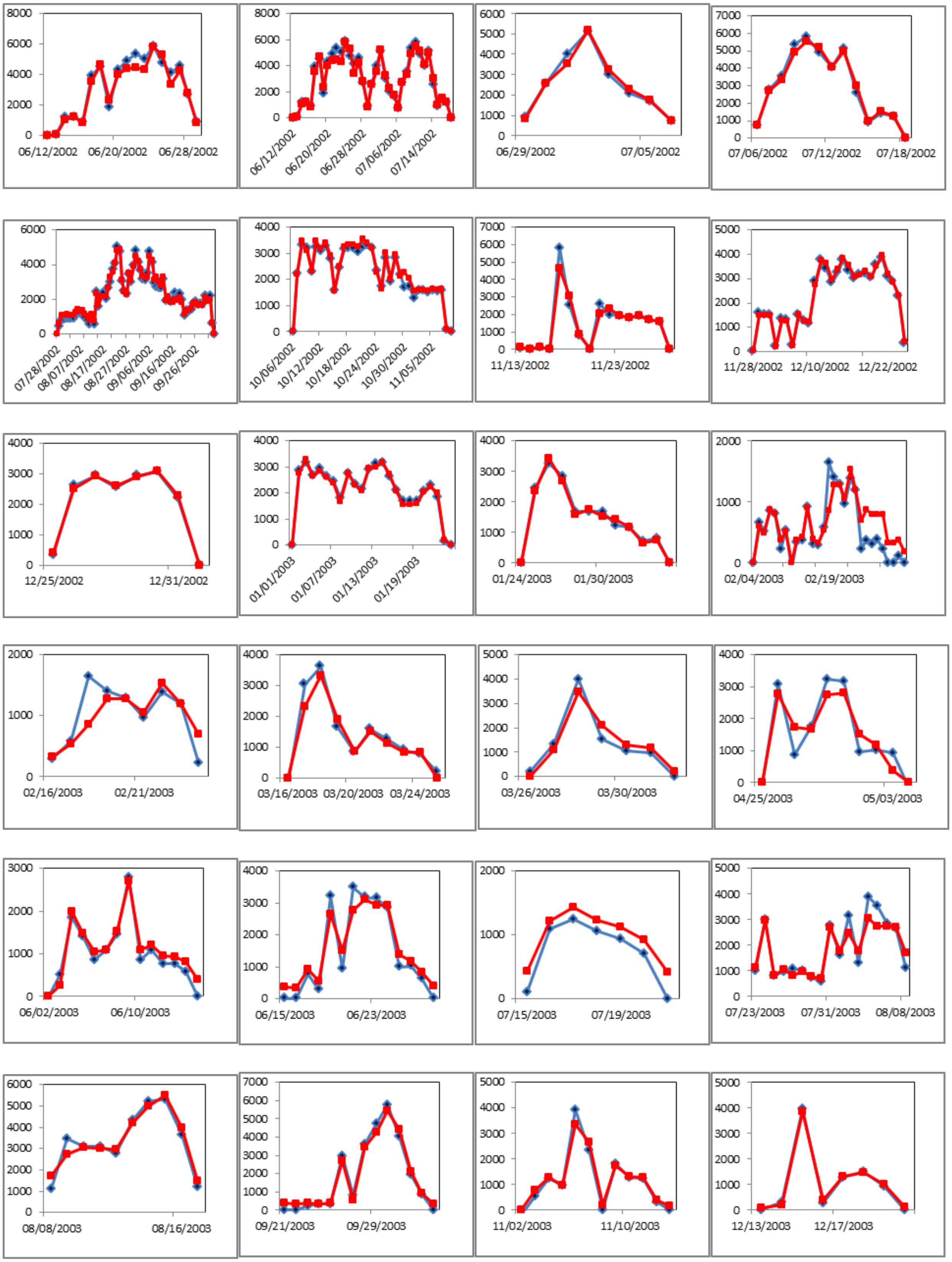
02/20/2002
02/26/2002
05/05/2002
05/13/2002
06/02/2002
06/06/2002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06/29/2002 07/05/2002
0 1000 2000 3000 4000 5000 6000 7000
07/06/2002 07/12/2002 07/18/2002
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07/28/2002 08/07/2002 08/17/2002 08/27/2002 09/06/2002 09/16/2002 09/26/2002
0 1000 2000 3000 4000
10/06/2002 10/12/2002 10/18/2002 10/24/2002 10/30/2002 11/05/2002
0 1000 2000 3000 4000 5000 6000 7000
11/13/2002 11/23/2002
0 1000 2000 3000 4000 5000
11/28/2002 12/10/2002 12/22/2002
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0 1000 2000 3000 4000
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07/23/2003 07/31/2003 08/08/2003
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08/08/2003 08/16/2003
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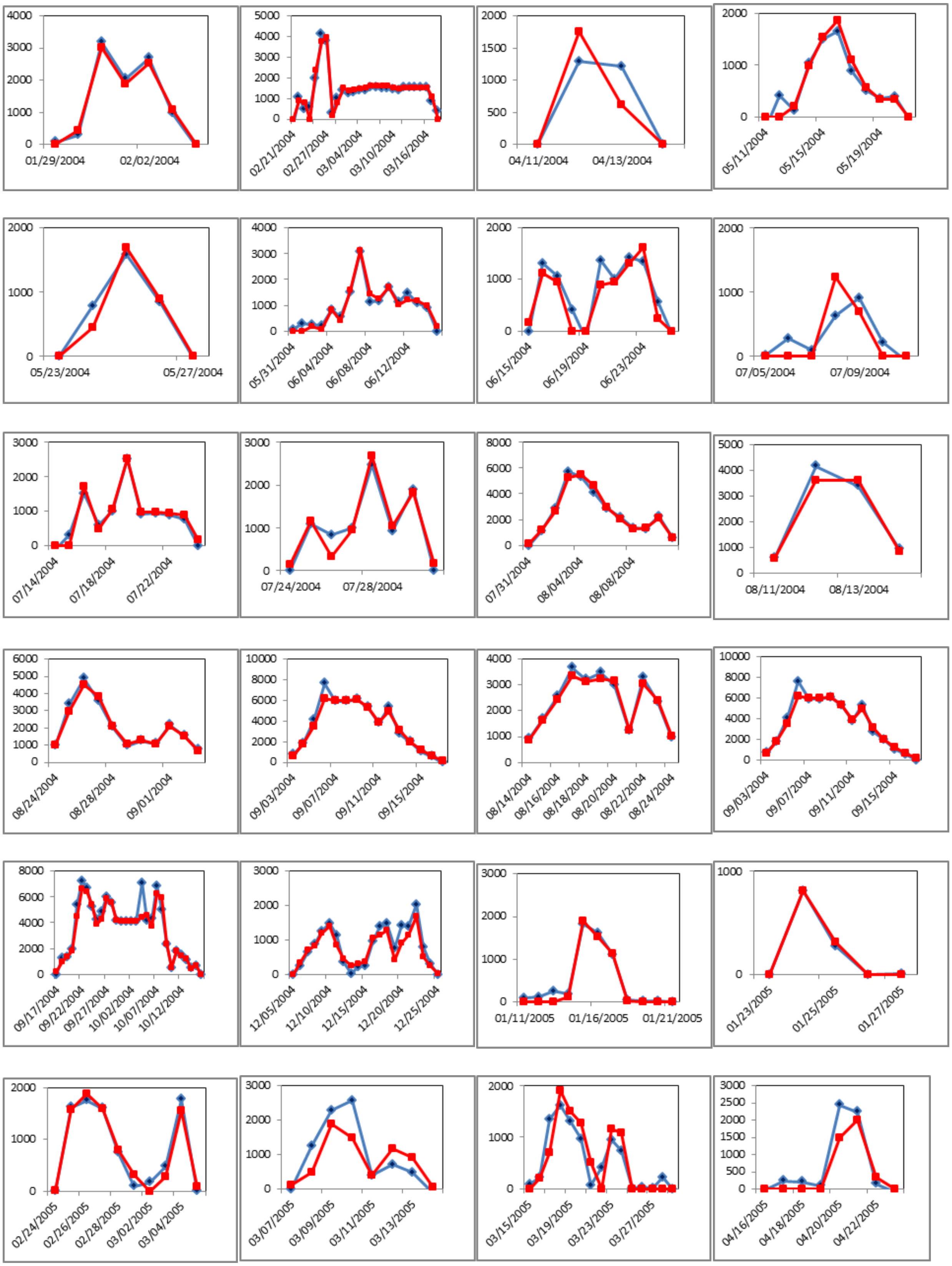
12/13/2003 12/17/2003



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02/21/2004 02/27/2004 03/04/2004 03/10/2004 03/16/2004
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04/11/2004 04/13/2004
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2000 1000 0
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06/15/2004 06/19/2004 06/23/2004
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08/24/2004 08/28/2004 09/01/2004
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4000 3000 2000 1000 0
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09/03/2004 09/07/2004 09/11/2004 09/15/2004
8000 6000 4000 2000 0
09/17/2004 09/22/2004 09/27/2004 10/02/2004 10/07/2004 10/12/2004
3000 2000 1000 0
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01/23/2005 01/25/2005 01/27/2005
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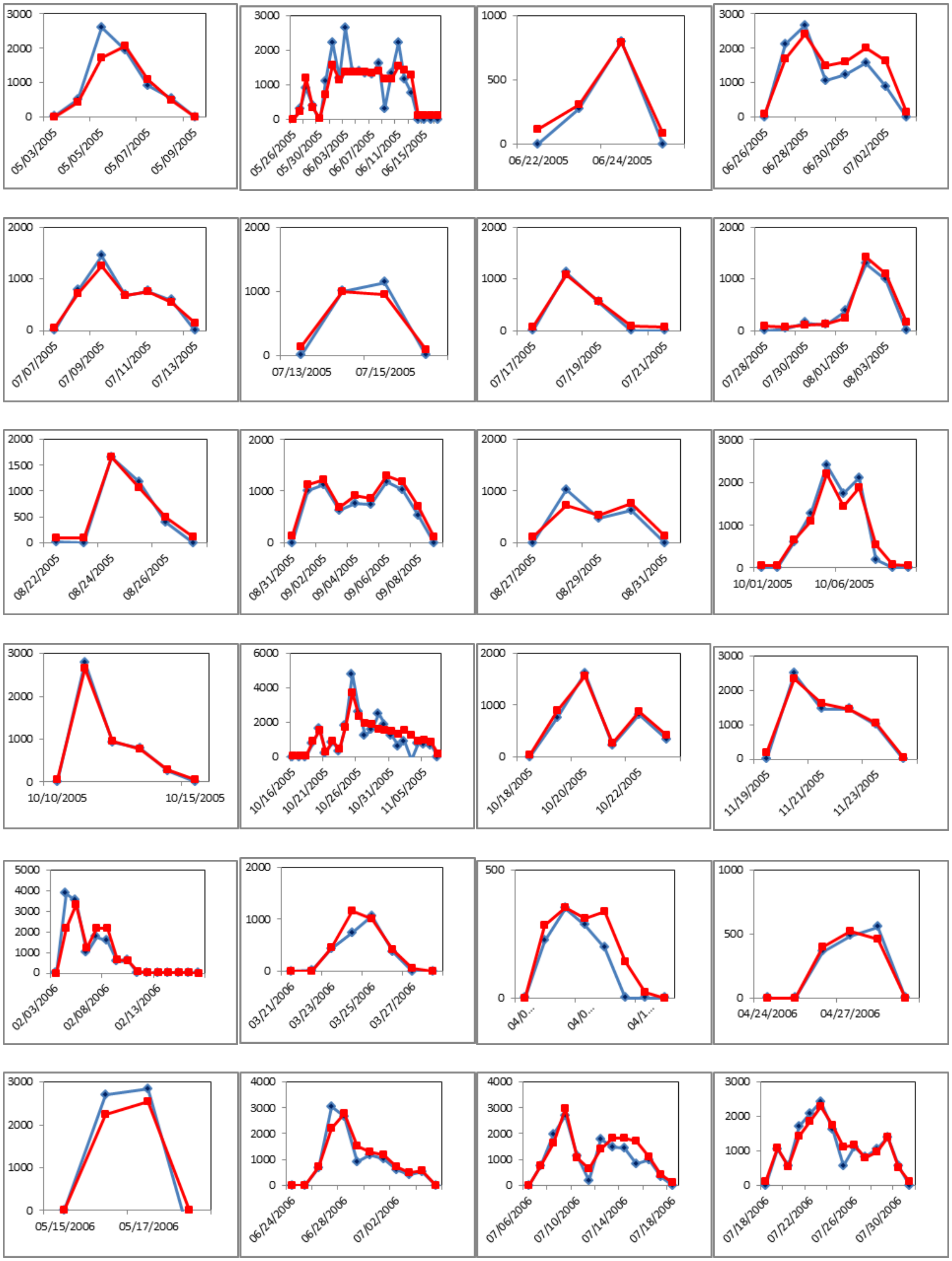
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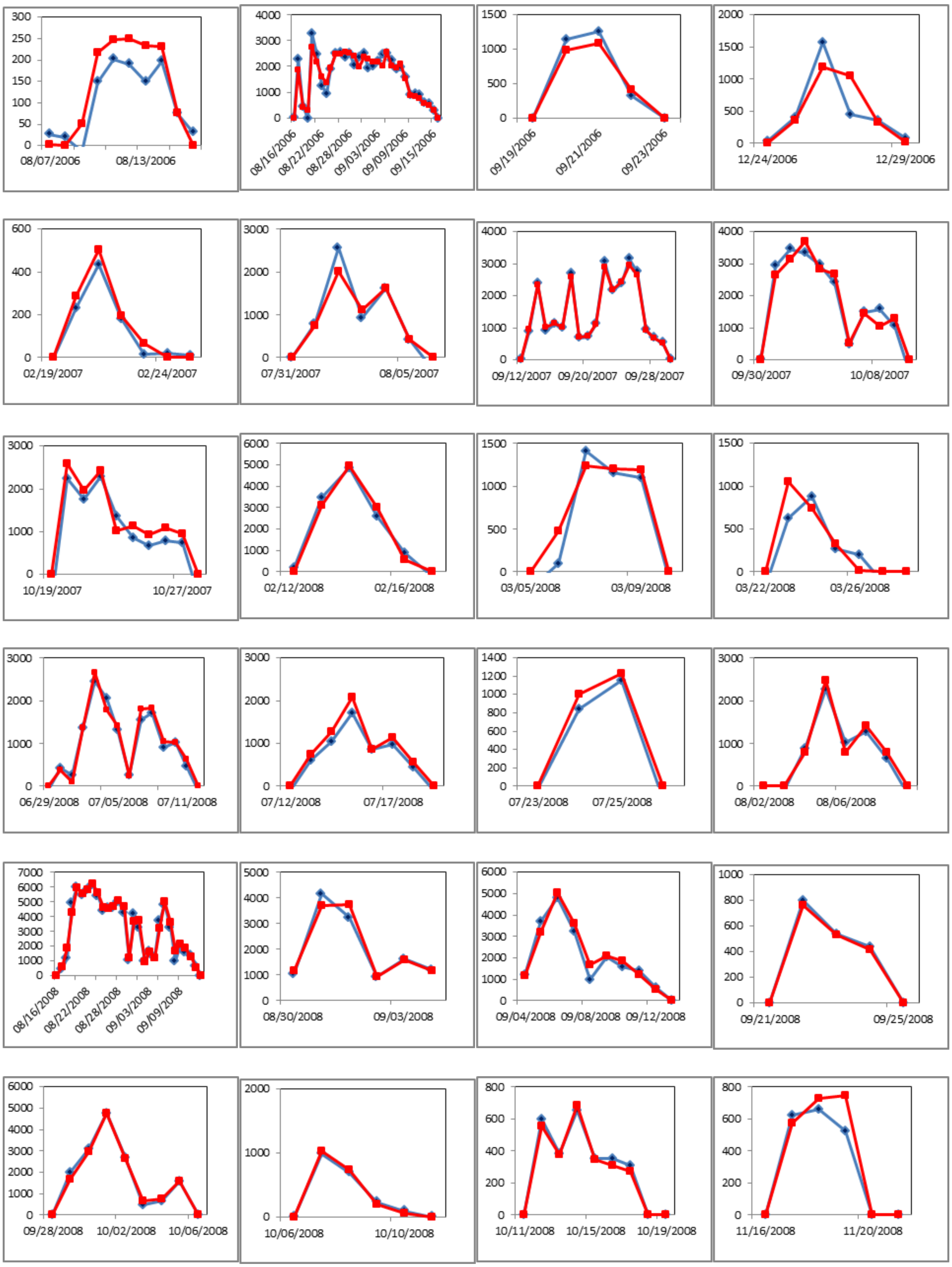

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09/19/2006 09/21/2006 09/23/2006
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03/05/2008 03/09/2008
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07/12/2008 07/17/2008
07/23/2008 07/25/2008
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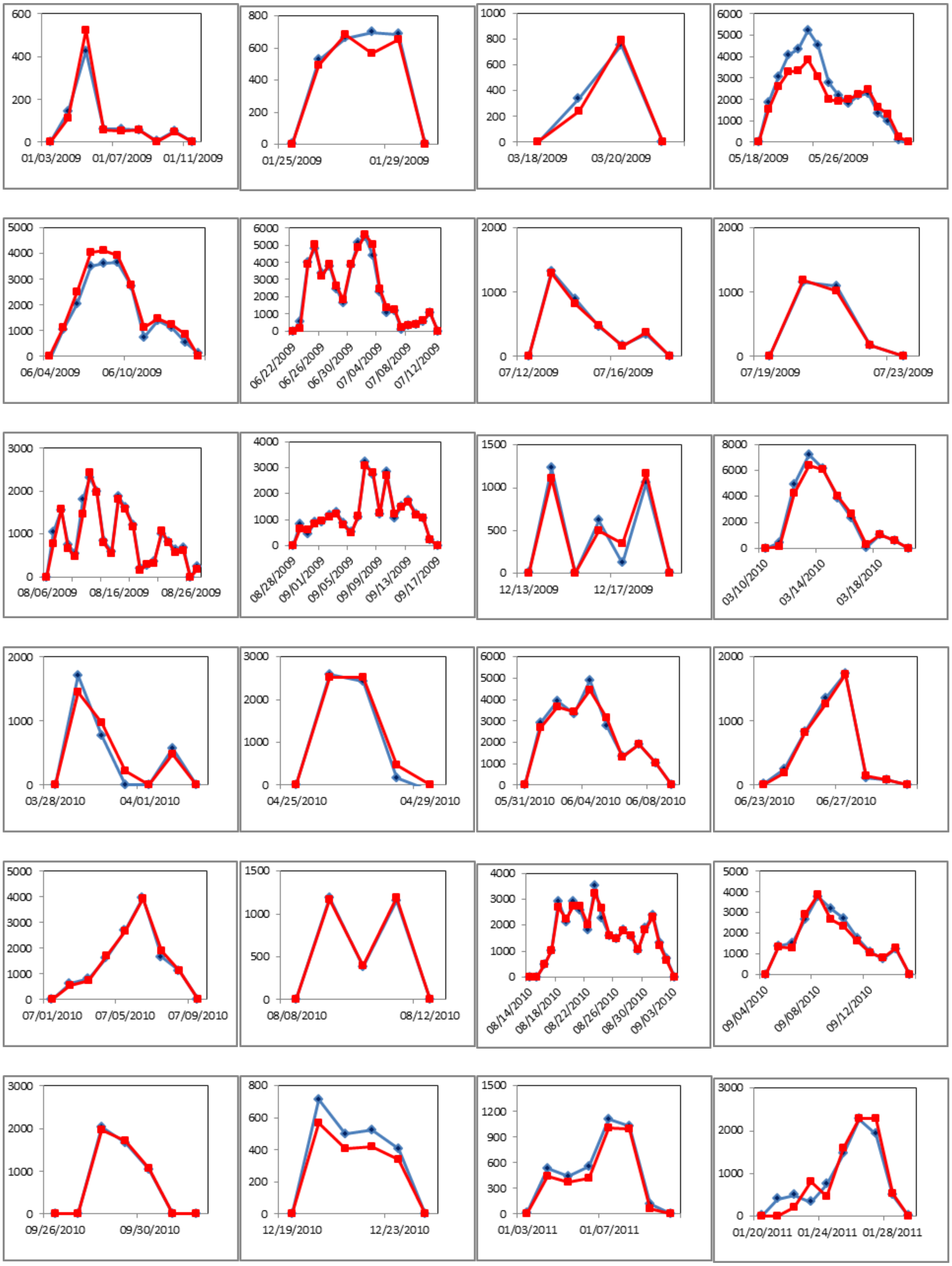

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01/25/2009 01/29/2009
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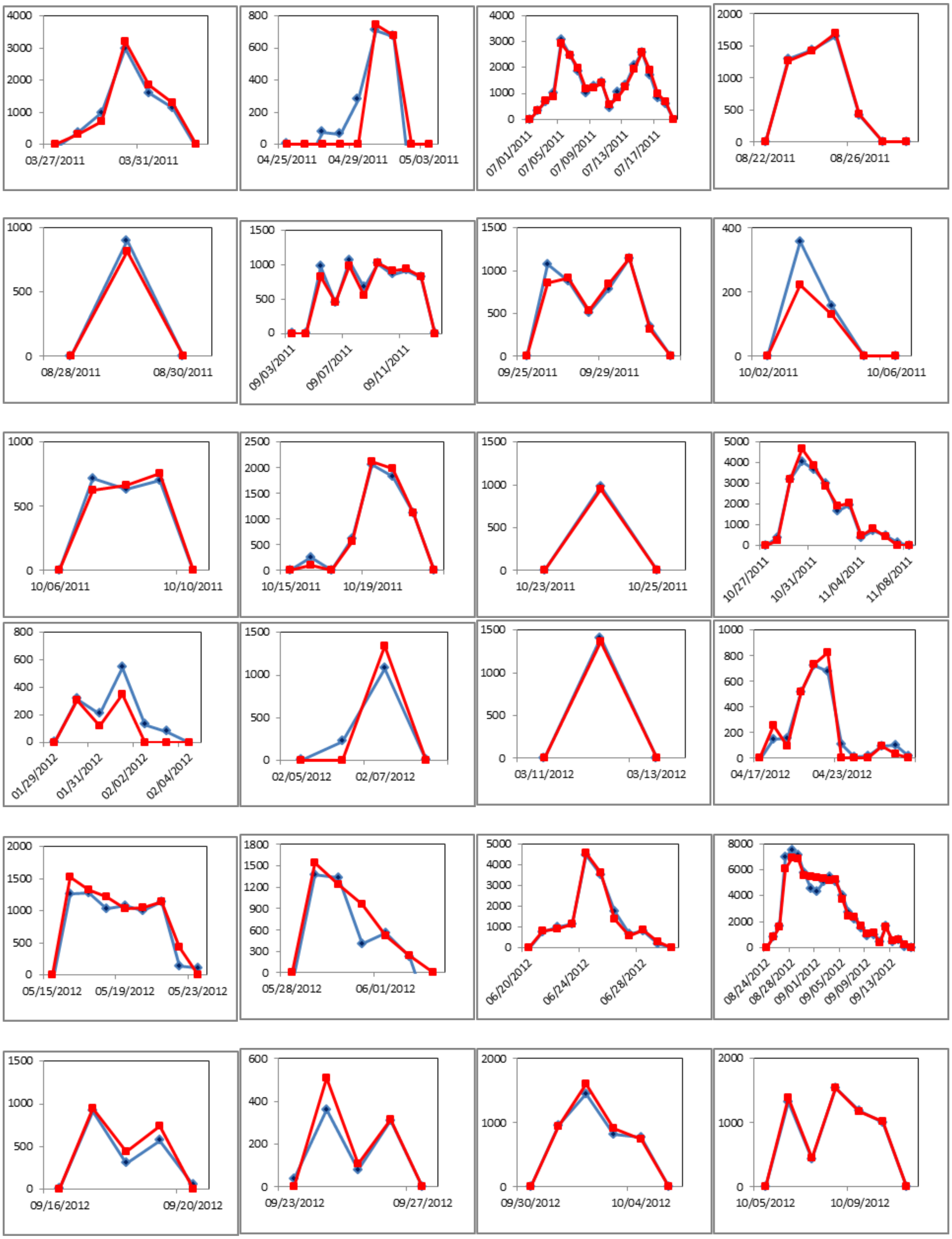
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500
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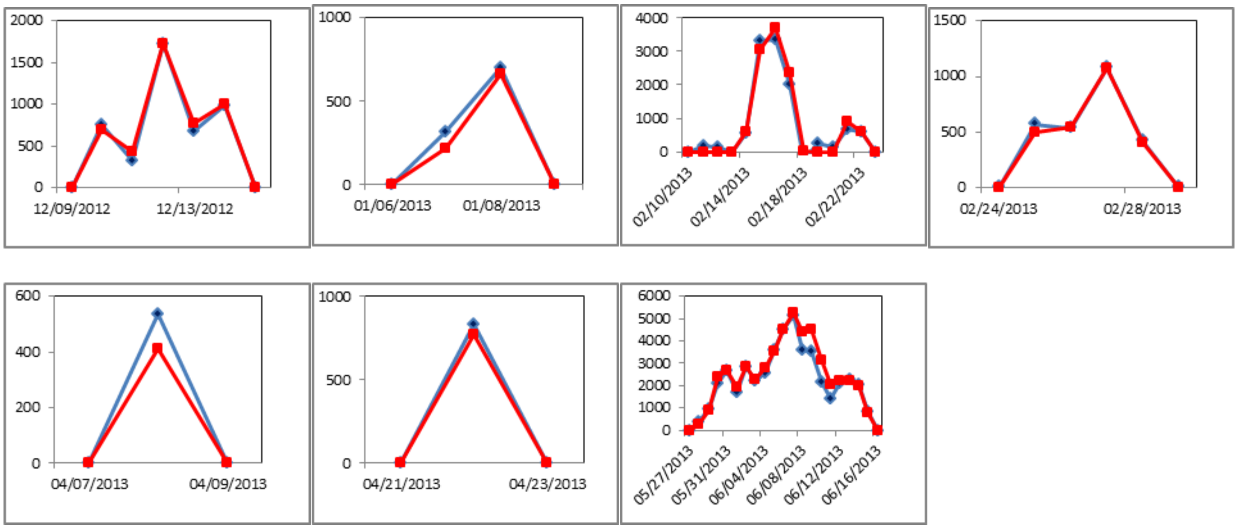
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06/04/2013
06/08/2013
06/12/2013
06/16/2013

APPENDIX 4-2: EVENT-BASED MASS BALANCE

Appendix 4-2: STA-1 Inflow Basin Canal Event Based Flow and TP Mass Balance																		
Start Date	End Date	Volume (ac-ft)				TP (mt) -- M2				TP (mt) -- M3				TP (mt) -- M5				
		in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in
07/02/2000	07/17/2000	11,315	10,475	841	7.4%	1.4	2.4	-1.1	-77%	1.4	2.1	-0.7	-53%	2.5	2.1	0.3	14%
07/30/2000	08/06/2000	6,424	5,805	619	9.6%	0.6	1.0	-0.4	-56%	0.6	1.0	-0.4	-56%	0.8	1.0	-0.2	-23%
08/06/2000	08/14/2000	4,949	5,318	-369	-7.5%	0.4	0.9	-0.5	-133%	0.4	0.9	-0.5	-133%	0.5	0.9	-0.4	-69%
09/06/2000	09/13/2000	5,179	5,234	-55	-1.1%	0.7	1.2	-0.4	-56%	0.7	0.5	0.2	26%	0.7	0.5	0.2	26%
09/17/2000	09/24/2000	9,587	8,858	730	7.6%	2.2	1.9	0.3	13%	2.2	1.9	0.3	14%	2.2	1.9	0.3	14%
09/24/2000	10/02/2000	5,546	6,301	-754	-13.6%	1.3	1.1	0.1	10%	1.3	1.4	-0.1	-10%	1.2	1.4	-0.2	-19%
10/09/2000	10/19/2000	9,017	10,256	-1239	-13.7%	2.0	1.2	0.9	42%	2.0	1.4	0.6	29%	2.4	1.4	1.0	41%
06/24/2001	06/30/2001	4,208	4,240	-32	-0.8%	1.1	0.8	0.2	20%	1.1	0.8	0.2	21%	1.0	0.8	0.2	18%
07/09/2001	07/29/2001	47,187	45,493	1694	3.6%	8.1	14.6	-6.5	-80%	8.1	14.6	-6.5	-80%	9.9	14.6	-4.7	-47%
07/29/2001	08/11/2001	42,078	42,341	-263	-0.6%	5.2	10.5	-5.3	-101%	5.2	10.5	-5.3	-101%	8.5	10.5	-2.0	-23%
09/08/2001	09/21/2001	34,228	33,158	1070	3.1%	3.1	6.0	-2.9	-95%	3.1	6.0	-2.9	-95%	6.3	6.0	0.2	4%
09/23/2001	10/05/2001	34,468	32,711	1757	5.1%	2.8	5.6	-2.8	-103%	2.8	5.6	-2.8	-103%	5.2	5.6	-0.4	-8%
10/19/2001	11/11/2001	42,846	40,741	2104	4.9%	4.6	7.0	-2.4	-53%	4.6	7.2	-2.6	-57%	9.4	7.2	2.2	24%
05/05/2002	05/18/2002	13,213	16,225	-3012	-22.8%	1.7	2.4	-0.8	-46%	1.7	2.2	-0.5	-30%	1.8	2.2	-0.4	-23%
06/02/2002	06/08/2002	4,943	5,066	-124	-2.5%	0.6	0.8	-0.2	-27%	0.5	0.6	0.0	-6%	0.5	0.6	-0.1	-13%
06/12/2002	07/18/2002	113,641	110,283	3358	3.0%	23.5	26.3	-2.8	-12%	23.5	26.1	-2.6	-11%	28.9	26.1	2.9	10%
07/28/2002	10/04/2002	150,551	152,529	-1978	-1.3%	27.5	29.8	-2.2	-8%	27.5	30.7	-3.2	-11%	28.6	30.7	-2.1	-7%
10/06/2002	11/09/2002	78,194	81,020	-2826	-3.6%	9.9	9.9	0.0	0%	9.9	9.7	0.3	3%	10.1	9.7	0.4	4%
11/28/2002	12/25/2002	63,016	64,294	-1278	-2.0%	12.6	14.5	-1.9	-15%	12.6	14.5	-1.9	-15%	16.0	14.5	1.5	9%
12/25/2002	01/01/2003	16,667	16,803	-136	-0.8%	3.4	3.5	-0.1	-3%	3.4	3.5	-0.1	-3%	3.3	3.5	-0.2	-5%
01/24/2003	02/04/2003	17,562	17,301	261	1.5%	3.9	2.7	1.2	31%	3.9	2.7	1.2	31.4%	3.0	2.7	0.3	11%
03/16/2003	03/25/2003	13,695	12,797	898	6.6%	4.0	2.1	1.9	47.0%	4.0	2.2	1.8	44%	4.1	2.2	1.9	46%
03/26/2003	04/01/2003	9,138	9,346	-208	-2.3%	2.7	1.6	1.1	40%	2.7	2.2	0.5	20%	1.6	2.2	-0.5	-34%
04/25/2003	05/04/2003	14,916	14,840	76	0.5%	3.9	2.8	1.0	27%	3.9	2.8	1.0	27%	4.5	2.8	1.7	37%
06/02/2003	06/15/2003	14,105	15,515	-1410	-10.0%	1.5	2.8	-1.3	-90%	1.5	2.9	-1.4	-95%	1.6	2.9	-1.3	-78%
06/15/2003	06/28/2003	20,525	21,932	-1407	-6.9%	2.7	3.2	-0.6	-21%	2.7	3.2	-0.6	-21%	3.5	3.2	0.3	7%
07/15/2003	07/21/2003	5,183	6,782	-1599	-30.8%	0.6	0.8	-0.2	-39%	0.6	0.8	-0.2	-39%	0.7	0.8	-0.1	-9%

Appendix 4-2: STA-1 Inflow Basin Canal Event Based Flow and TP Mass Balance

Start Date	End Date	Volume (ac-ft)				TP (mt) -- M2				TP (mt) -- M3				TP (mt) -- M5			
		in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in
07/22/2003	09/11/2003	119,776	119,777	-1	0.0%	22.1	22.7	-0.6	-3%	22.1	22.7	-0.6	-3%	26.2	22.7	3.5	13%
07/23/2003	08/08/2003	32,271	30,953	1318	4.1%	5.6	4.8	0.8	14%	5.6	4.8	0.8	14%	7.3	4.8	2.5	34%
08/08/2003	08/17/2003	33,370	33,707	-336	-1.0%	6.6	7.0	-0.4	-6%	6.6	7.0	-0.4	-6%	8.2	7.0	1.2	15%
09/21/2003	10/04/2003	25,765	26,208	-442	-1.7%	5.4	6.5	-1.1	-21%	5.4	6.5	-1.1	-21%	6.7	6.5	0.2	3%
11/02/2003	11/13/2003	13,613	14,158	-546	-4.0%	2.4	2.4	0.0	1%	2.4	2.4	0.0	1%	2.8	2.7	0.1	3%
12/13/2003	12/20/2003	8,313	8,557	-244	-2.9%	1.4	1.2	0.2	12%	1.4	1.2	0.2	12%	0.7	1.1	-0.4	-63%
01/29/2004	02/04/2004	9,183	8,966	217	2.4%	1.6	1.4	0.2	13%	1.6	1.4	0.2	13%	1.0	1.4	-0.4	-42%
04/11/2004	04/14/2004	2,518	2,383	135	5.4%	0.5	0.4	0.1	12%	0.5	0.4	0.1	12%	0.5	0.4	0.1	16%
05/11/2004	05/21/2004	6,673	6,956	-283	-4.2%	0.6	0.9	-0.3	-47%	0.6	0.9	-0.3	-47%	0.7	0.8	-0.1	-17%
05/23/2004	05/27/2004	3,205	3,035	169	5.3%	0.3	0.3	0.0	-10%	0.3	0.3	0.0	-10%	0.3	0.4	0.0	-10%
05/31/2004	06/15/2004	15,422	15,143	279	1.8%	3.8	3.0	0.8	22%	3.8	3.0	0.8	22%	3.4	4.9	-1.4	-42%
06/15/2004	06/25/2004	8,295	7,250	1045	12.6%	1.6	1.3	0.3	16%	1.6	1.3	0.3	16%	1.9	3.3	-1.4	-77%
07/05/2004	07/11/2004	2,098	1,928	170	8.1%	0.3	0.4	-0.2	-70%	0.3	0.4	-0.2	-70%	0.5	0.4	0.2	31%
07/14/2004	07/24/2004	9,253	9,691	-438	-4.7%	1.1	1.4	-0.3	-30%	1.1	1.4	-0.3	-30%	0.9	1.3	-0.4	-47%
07/24/2004	07/31/2004	8,246	8,331	-85	-1.0%	1.3	1.8	-0.5	-35%	1.3	1.8	-0.5	-35%	1.0	3.4	-2.4	-241%
07/31/2004	08/11/2004	29,786	29,805	-20	-0.1%	12.9	13.2	-0.3	-2%	12.9	13.2	-0.3	-2%	13.8	20.1	-6.3	-45%
08/11/2004	08/14/2004	9,023	8,705	318	3.5%	1.2	2.5	-1.3	-108%	1.2	2.5	-1.3	-108%	6.8	4.1	2.7	40%
08/14/2004	08/24/2004	26,224	25,574	650	2.5%	3.5	5.9	-2.5	-72%	3.5	5.9	-2.5	-72%	8.0	7.1	0.9	11%
08/24/2004	09/03/2004	22,453	22,173	281	1.3%	4.6	6.8	-2.2	-47%	4.6	6.8	-2.2	-47%	4.4	5.8	-1.4	-31%
09/03/2004	09/17/2004	52,983	51,409	1574	3.0%	19.5	20.1	-0.6	-3%	19.5	20.1	-0.6	-3%	22.8	15.6	7.2	32%
09/17/2004	10/16/2004	106,245	100,744	5502	5.2%	37.3	34.7	2.6	7%	37.3	34.7	2.6	7%	41.0	39.6	1.5	4%
01/11/2005	01/21/2005	5,382	4,741	641	11.9%	1.3	1.3	0.0	-3%	1.3	1.3	0.0	-3%	1.0	1.3	-0.3	-30%
02/24/2005	03/05/2005	8,208	8,140	68	0.8%	1.7	1.6	0.0	3%	1.7	1.6	0.0	3%	1.5	1.4	0.1	10%
03/07/2005	03/14/2005	7,562	6,426	1136	15.0%	2.1	1.2	0.9	42%	2.1	1.2	0.9	42%	2.6	1.1	1.4	56%
03/15/2005	03/29/2005	8,043	8,376	-333	-4.1%	2.6	2.0	0.5	20%	2.6	2.0	0.5	20%	1.5	1.6	-0.1	-5%
05/03/2005	05/09/2005	6,527	5,768	759	11.6%	1.8	1.2	0.7	36%	1.8	1.2	0.7	36%	2.5	2.1	0.4	15%
05/26/2005	06/17/2005	21,487	20,445	1042	4.8%	5.2	5.2	0.1	2%	5.2	5.2	0.1	2%	5.8	5.1	0.7	12%

Appendix 4-2: STA-1 Inflow Basin Canal Event Based Flow and TP Mass Balance

Start Date	End Date	Volume (ac-ft)				TP (mt) -- M2				TP (mt) -- M3				TP (mt) -- M5			
		in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in
06/22/2005	06/25/2005	1,077	1,306	-230	-21.3%	0.2	0.3	-0.1	-53%	0.2	0.3	-0.1	-53%	0.2	0.3	-0.1	-37%
06/26/2005	07/03/2005	9,465	11,021	-1556	-16.4%	1.3	2.0	-0.6	-47%	1.3	2.0	-0.6	-47%	1.5	2.0	-0.5	-33%
07/07/2005	07/13/2005	4,231	4,177	55	1.3%	0.6	0.7	0.0	-7%	0.6	0.7	0.0	-7%	0.5	0.8	-0.3	-73%
07/13/2005	07/16/2005	2,140	2,206	-66	-3.1%	0.3	0.3	-0.1	-26%	0.3	0.3	-0.1	-26%	0.2	0.3	-0.1	-44%
07/17/2005	07/20/2005	1,677	1,822	-144	-8.6%	0.2	0.2	-0.1	-51%	0.2	0.2	-0.1	-51%	0.2	0.3	-0.1	-53%
08/22/2005	08/27/2005	3,255	3,518	-263	-8.1%	0.5	0.8	-0.3	-60%	0.5	0.8	-0.3	-60%	0.4	0.8	-0.4	-121%
08/27/2005	08/31/2005	2,120	2,233	-113	-5.4%	0.3	0.5	-0.2	-68%	0.3	0.5	-0.2	-68%	0.3	0.4	-0.1	-52%
08/31/2005	09/09/2005	6,988	8,199	-1211	-17.3%	1.0	1.4	-0.4	-37%	1.0	1.4	-0.4	-37%	1.1	1.2	-0.2	-18%
10/01/2005	10/10/2005	8,328	8,059	269	3.2%	1.9	2.3	-0.4	-24%	1.9	2.3	-0.4	-24%	1.9	2.0	-0.1	-8%
10/10/2005	10/15/2005	4,793	4,765	28	0.6%	1.1	1.1	0.0	-1%	1.1	1.1	0.0	-1%	1.3	1.1	0.2	17%
10/16/2005	11/07/2005	25,038	27,342	-2304	-9.2%	9.3	8.3	1.1	11%	9.3	8.3	1.1	11%	7.5	8.4	-0.8	-11%
10/18/2005	10/23/2005	3,771	4,022	-251	-6.7%	1.1	1.1	0.0	-3%	1.1	1.1	0.0	-3%	0.9	0.9	0.0	-4%
11/19/2005	11/24/2005	6,381	6,737	-356	-5.6%	2.0	2.5	-0.4	-22%	2.0	2.5	-0.4	-22%	1.7	1.8	-0.1	-8%
02/03/2006	02/17/2006	12,869	12,583	286	2.2%	5.4	5.2	0.3	5%	5.4	5.2	0.3	5%	3.2	3.3	-0.1	-4%
03/21/2006	03/28/2006	2,621	3,077	-456	-17.4%	0.8	1.1	-0.3	-38%	0.8	1.1	-0.3	-38%	0.5	0.7	-0.2	-36%
04/04/2006	04/11/2006	1,059	1,462	-403	-38.1%	0.2	0.4	-0.2	-69%	0.2	0.4	-0.2	-69%	0.3	0.4	-0.1	-35%
04/24/2006	04/29/2006	1,403	1,388	15	1.1%	0.2	0.3	-0.1	-34%	0.2	0.3	-0.1	-34%	0.2	0.3	0.0	-21%
05/15/2006	05/18/2006	4,957	4,770	187	3.8%	1.8	1.5	0.3	14%	1.8	1.5	0.3	14%	1.0	1.2	-0.2	-17%
06/24/2006	07/05/2006	11,041	11,400	-359	-3.3%	3.8	4.9	-1.1	-29%	3.8	4.9	-1.1	-29%	5.0	3.1	1.9	38%
07/06/2006	07/18/2006	13,582	15,386	-1804	-13.3%	4.3	5.7	-1.4	-31%	4.3	5.7	-1.4	-31%	4.6	4.2	0.4	8%
07/18/2006	07/31/2006	14,935	15,068	-133	-0.9%	3.5	5.5	-1.9	-55%	3.5	5.4	-1.8	-52%	4.3	5.0	-0.7	-16%
08/16/2006	09/16/2006	52,529	51,544	985	1.9%	16.9	19.7	-2.7	-16%	16.9	19.7	-2.7	-16%	16.2	13.6	2.6	16%
09/19/2006	09/23/2006	2,718	2,481	237	8.7%	1.2	0.8	0.4	37%	1.2	0.8	0.4	37%	1.0	0.6	0.4	41%
07/31/2007	08/06/2007	6,046	5,902	144	2.4%	1.0	1.2	-0.2	-18%	1.0	1.2	-0.2	-18%	0.5	0.9	-0.4	-69%
09/12/2007	09/30/2007	27,114	27,025	89	0.3%	5.3	6.2	-0.9	-16%	5.3	6.2	-0.9	-16%	5.9	6.2	-0.3	-5%
06/17/2008	07/12/2008	19,824	19,349	475	2.4%	3.6	4.1	-0.5	-13%	3.6	4.1	-0.5	-13%	3.7	3.7	-0.1	-2%
08/16/2008	09/13/2008	88,776	90,845	-2070	-2.3%	32.3	35.8	-3.5	-11%	32.3	35.8	-3.5	-11%	31.9	24.2	7.7	24%

Appendix 4-2: STA-1 Inflow Basin Canal Event Based Flow and TP Mass Balance

Start Date	End Date	Volume (ac-ft)				TP (mt) -- M2				TP (mt) -- M3				TP (mt) -- M5			
		in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in
09/21/2008	09/25/2008	1,786	1,721	65	3.6%	0.4	0.5	-0.1	-32%	0.4	0.5	-0.1	-32%	0.4	0.4	0.0	-3%
09/28/2008	10/06/2008	15,340	15,082	258	1.7%	3.3	3.6	-0.3	-10%	3.3	3.6	-0.3	-10%	3.7	3.5	0.2	6%
10/06/2008	10/11/2008	2,027	2,064	-37	-1.8%	0.4	0.5	-0.1	-26%	0.4	0.5	-0.1	-26%	0.5	0.5	0.0	6%
10/11/2008	10/19/2008	2,651	2,547	103	3.9%	0.4	0.6	-0.2	-39%	0.4	0.6	-0.2	-39%	0.6	0.5	0.1	13%
11/16/2008	11/21/2008	1,802	2,043	-242	-13.4%	0.1	0.3	-0.1	-117%	0.1	0.3	-0.1	-117%	0.2	0.2	-0.1	-38%
01/25/2009	01/30/2009	2,565	2,393	173	6.7%	0.3	0.4	-0.1	-22%	0.3	0.4	-0.1	-22%	0.4	0.3	0.1	14%
03/18/2009	03/21/2009	1,090	1,037	53	4.9%	0.1	0.1	0.0	-13%	0.1	0.1	0.0	-13%	0.1	0.2	0.0	-14%
05/18/2009	06/02/2009	36,641	31,416	5225	14.3%	10.3	9.4	0.8	8%	10.3	9.4	0.8	8%	8.5	7.8	0.7	8%
06/04/2009	06/15/2009	20,565	23,260	-2695	-13.1%	6.0	8.1	-2.1	-35%	6.0	8.1	-2.1	-35%	6.4	7.3	-0.9	-14%
06/22/2009	07/12/2009	46,430	47,614	-1183	-2.5%	10.6	11.5	-0.9	-8%	10.6	11.5	-0.9	-8%	9.7	11.2	-1.5	-16%
07/12/2009	07/18/2009	3,220	3,143	77	2.4%	0.5	0.7	-0.2	-31%	0.5	0.7	-0.2	-31%	0.7	0.7	0.0	-6%
07/19/2009	07/23/2009	2,427	2,392	35	1.5%	0.3	0.4	-0.1	-25%	0.3	0.4	-0.1	-25%	0.4	0.7	-0.4	-100%
08/06/2009	08/27/2009	20,373	19,311	1062	5.2%	3.5	4.6	-1.1	-32%	3.5	4.6	-1.1	-32%	3.9	4.0	-0.1	-2%
08/28/2009	09/17/2009	24,873	24,365	508	2.0%	5.8	5.6	0.2	4%	5.8	5.6	0.2	4%	7.0	5.5	1.5	21%
12/13/2009	12/19/2009	3,021	3,143	-122	-4.1%	0.5	0.6	-0.1	-14%	0.5	0.6	-0.1	-14%	0.3	0.3	0.0	-2%
03/10/2010	03/20/2010	26,739	25,490	1249	4.7%	7.7	12.3	-4.6	-61%	7.7	12.3	-4.6	-61%	4.6	5.3	-0.7	-15%
03/28/2010	04/03/2010	3,079	3,136	-57	-1.9%	0.7	0.9	-0.2	-32%	0.7	0.9	-0.2	-32%	0.8	0.8	0.0	0%
04/25/2010	05/01/2010	5,029	5,508	-479	-9.5%	0.7	1.0	-0.4	-54%	0.7	1.0	-0.4	-54%	0.5	0.9	-0.3	-59%
05/31/2010	06/09/2010	22,192	21,586	606	2.7%	5.1	5.1	0.0	-1%	5.1	5.1	0.0	-1%	4.1	4.2	-0.1	-3%
06/23/2010	06/30/2010	4,413	4,234	179	4.0%	0.6	0.6	0.0	-1%	0.6	0.6	0.0	-1%	0.6	0.7	-0.1	-18%
07/01/2010	07/09/2010	12,527	12,655	-128	-1.0%	2.2	2.5	-0.2	-11%	2.2	2.5	-0.2	-11%	2.6	3.2	-0.6	-23%
08/08/2010	08/12/2010	2,734	2,748	-14	-0.5%	0.5	0.5	0.0	-7%	0.5	0.5	0.0	-7%	0.3	0.4	-0.1	-29%
08/14/2010	09/03/2010	33,537	33,443	94	0.3%	5.8	6.1	-0.3	-6%	5.8	6.1	-0.3	-6%	4.7	5.9	-1.2	-25%
09/04/2010	09/15/2010	20,037	19,085	952	4.7%	2.9	3.3	-0.4	-15%	2.9	3.3	-0.4	-15%	2.6	2.4	0.2	9%
09/26/2010	10/02/2010	4,760	4,740	20	0.4%	0.4	0.5	-0.1	-25%	0.4	0.5	-0.1	-25%	0.4	0.6	-0.2	-34%
12/19/2010	12/24/2010	2,153	1,740	413	19.2%	0.1	0.2	0.0	-8%	0.1	0.2	0.0	-8%	0.2	0.1	0.0	13%
01/03/2011	01/10/2011	3,787	3,305	482	12.7%	0.3	0.3	0.0	8%	0.3	0.3	0.0	8%	0.3	0.3	0.0	5%

Appendix 4-2: STA-1 Inflow Basin Canal Event Based Flow and TP Mass Balance																	
Start Date	End Date	Volume (ac-ft)				TP (mt) -- M2				TP (mt) -- M3				TP (mt) -- M5			
		in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in
01/20/2011	01/29/2011	8,129	8,196	-66	-0.8%	1.3	1.3	0.0	-1%	1.3	1.3	0.0	-1%	1.0	1.2	-0.2	-21%
03/27/2011	04/02/2011	6,990	7,398	-408	-5.8%	1.5	1.8	-0.3	-18%	1.5	1.8	-0.3	-18%	0.7	1.0	-0.3	-35%
04/27/2011	05/25/2011	5,424	4,642	782	14.4%	0.5	0.5	0.0	-2%	0.5	0.5	0.0	-2%	0.6	0.5	0.1	13%
07/01/2011	07/19/2011	23,780	23,840	-60	-0.3%	3.3	3.8	-0.5	-16%	3.3	3.8	-0.5	-16%	3.2	3.4	-0.2	-7%
08/22/2011	08/28/2011	4799.8	4823.6	-23.8	-0.5%	0.7	0.8	-0.1	-13%	0.7	0.8	-0.1	-13%	0.6	0.7	-0.1	-21%
08/28/2011	08/30/2011	899.5	820.5	79.0	8.8%	0.1	0.1	0.0	-2%	0.1	0.1	0.0	-2%	0.1	0.1	0.0	19%
09/03/2011	09/13/2011	6743.7	6527.7	215.9	3.2%	1.0	1.1	-0.1	-8%	1.0	1.1	-0.1	-8%	1.0	0.9	0.1	12%
09/25/2011	10/02/2011	4744.8	4616.8	128.0	2.7%	0.6	0.6	0.0	8%	0.6	0.6	0.0	8%	0.6	0.7	-0.1	-16%
10/06/2011	10/10/2011	2056.6	2047.3	9.3	0.5%	0.3	0.3	0.0	-10%	0.3	0.3	0.0	-10%	0.2	0.2	0.0	4%
10/15/2011	10/22/2011	5917.2	5886.5	30.6	0.5%	0.9	1.0	-0.1	-10%	0.9	1.0	-0.1	-10%	0.8	0.9	-0.1	-11%
10/23/2011	10/25/2011	985.8	944.1	41.6	4.2%	0.1	0.2	0.0	-5%	0.1	0.2	0.0	-5%	0.2	0.2	0.0	-8%
10/27/2011	11/08/2011	19550.9	20391.9	-841.0	-4.3%	5.2	5.6	-0.4	-8%	5.2	5.6	-0.4	-8%	4.0	4.7	-0.7	-17%
01/29/2012	02/04/2012	1264.4	772.7	491.7	38.9%	0.1	0.1	0.0	29%	0.1	0.1	0.0	29%	0.1	0.1	0.0	32%
02/05/2012	02/08/2012	1302.5	1336.1	-33.6	-2.6%	0.1	0.2	-0.1	-51%	0.1	0.2	-0.1	-51%	0.1	0.1	0.0	-6%
03/11/2012	03/13/2012	1414.3	1367.0	47.3	3.3%	0.2	0.2	-0.1	-35%	0.2	0.2	-0.1	-35%	0.2	0.2	0.0	-24%
04/17/2012	04/28/2012	2579.2	2559.7	19.6	0.8%	0.3	0.3	0.0	-15%	0.3	0.3	0.0	-15%	0.3	0.3	0.0	2%
08/24/2012	09/16/2012	69955.2	70150.4	-195.3	-0.3%	34.3	34.8	-0.5	-2%	34.3	34.8	-0.5	-2%	31.8	36.3	-4.5	-14%
09/16/2012	09/20/2012	1838.9	2129.4	-290.5	-15.8%	0.4	0.5	-0.1	-26%	0.4	0.5	-0.1	-26%	0.3	0.4	-0.1	-42%
09/23/2012	09/27/2012	791.5	934.2	-142.7	-18.0%	0.1	0.2	0.0	-24%	0.1	0.2	0.0	-24%	0.1	0.2	0.0	-10%
09/30/2012	10/05/2012	4017.2	4197.9	-180.7	-4.5%	0.7	0.5	0.2	28%	0.7	0.5	0.2	28%	0.5	0.7	-0.2	-33%
10/05/2012	10/11/2012	5489.7	5560.7	-71.0	-1.3%	1.1	0.7	0.4	33%	1.1	0.7	0.4	33%	1.1	1.1	0.0	2%
12/09/2012	12/15/2012	4471.2	4642.4	-171.2	-3.8%	0.6	0.7	-0.1	-17%	0.6	0.7	-0.1	-17%	0.5	0.5	0.1	10%
01/06/2013	01/09/2013	1024.9	886.3	138.6	13.5%	0.1	0.1	0.0	-6%	0.1	0.1	0.0	-6%	0.1	0.1	0.0	10%
02/10/2013	02/23/2013	10973.2	11152.9	-179.7	-1.6%	2.3	2.7	-0.4	-16%	2.3	2.7	-0.4	-16%	1.5	1.7	-0.2	-15%
02/24/2013	03/01/2013	2603.6	2541.4	62.2	2.4%	0.4	0.4	-0.1	-15%	0.4	0.4	-0.1	-15%	0.3	0.4	-0.1	-25%
04/21/2013	04/23/2013	835.7	770.7	65.0	7.8%	0.1	0.1	0.0	-3%	0.1	0.1	0.0	-3%	0.1	0.1	0.0	8%
Average					-0.4%				-18.7%				-18.1%				-11.0%

Appendix 4-2: STA-1 Inflow Basin Canal Event Based Flow and TP Mass Balance																	
Start Date	End Date	Volume (ac-ft)				TP (mt) -- M2				TP (mt) -- M3				TP (mt) -- M5			
		in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in
Median					0.4%				-13.1%				-12.1%				-6.4%

Appendix 4-2: STA-1 Inflow Basin Canal Event Based Flow and SRP Mass Balance													
Start Date	End Date	Volume (ac-ft)				SRP (mt) -- M2				SRP (mt) -- M3			
		in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in
09/08/2001	09/21/2001	34,228	33,158	1070	3.1%	5.75	3.25	2.50	43%	5.73	3.25	2.48	43%
09/23/2001	10/05/2001	34,468	32,711	1757	5.1%	3.27	4.35	-1.08	-33%	3.24	4.35	-1.11	-34%
10/19/2001	11/11/2001	42,846	40,741	2104	4.9%	8.52	5.77	2.75	32%	8.52	5.99	2.53	30%
06/02/2002	06/08/2002	4,943	5,066	-124	-2.5%	0.27	0.37	-0.10	-37%	0.27	0.13	0.14	52%
06/12/2002	07/18/2002	113,641	110,283	3358	3.0%	18.38	20.30	-1.92	-10%	18.38	18.40	-0.01	0%
07/28/2002	10/04/2002	150,551	152,529	-1978	-1.3%	16.18	15.50	0.69	4%	16.18	15.20	0.99	6%
10/06/2002	11/09/2002	78,194	81,020	-2826	-3.6%	5.72	5.94	-0.22	-4%	5.72	5.85	-0.13	-2%
11/28/2002	12/25/2002	63,016	64,294	-1278	-2.0%	5.59	5.96	-0.38	-7%	5.59	5.96	-0.38	-7%
01/24/2003	02/04/2003	17,562	17,301	261	1.5%	1.16	1.21	-0.04	-4%	1.21	1.21	0.00	0%
03/16/2003	03/25/2003	13,695	12,797	898	6.6%	2.12	1.45	0.66	31%	2.09	1.49	0.60	29%
04/25/2003	05/04/2003	14,916	14,840	76	0.5%	1.32	1.66	-0.34	-26%	1.32	1.64	-0.32	-24%
06/02/2003	06/15/2003	14,105	15,515	-1410	-10.0%	1.09	2.00	-0.91	-84%	1.09	1.98	-0.89	-82%
06/15/2003	06/28/2003	20,525	21,932	-1407	-6.9%	2.27	2.32	-0.05	-2%	2.22	2.32	-0.10	-4%
07/22/2003	09/11/2003	119,776	119,777	-1	0.0%	16.93	15.19	1.74	10%	16.56	15.19	1.37	8%
07/23/2003	08/08/2003	32,271	30,953	1318	4.1%	4.02	2.59	1.43	36%	3.66	2.59	1.06	29%
09/21/2003	10/04/2003	25,765	26,208	-442	-1.7%	4.36	3.52	0.84	19%	3.96	3.52	0.44	11%
11/02/2003	11/13/2003	13,613	14,158	-546	-4.0%	1.49	1.43	0.06	4%	1.49	1.78	-0.29	-19%
01/29/2004	02/04/2004	9,183	8,966	217	2.4%	0.72	0.58	0.14	20%	0.72	0.57	0.15	21%
04/11/2004	04/14/2004	2,518	2,383	135	5.4%	0.16	0.21	-0.04	-28%	0.16	0.20	-0.04	-27%
05/11/2004	05/21/2004	6,673	6,956	-283	-4.2%	0.30	0.51	-0.22	-73%	0.33	0.51	-0.18	-54%
05/23/2004	05/27/2004	3,205	3,035	169	5.3%	0.17	0.16	0.01	8%	0.17	0.16	0.01	8%
05/31/2004	06/15/2004	15,422	15,143	279	1.8%	1.55	1.64	-0.09	-6%	1.55	1.64	-0.09	-6%
06/15/2004	06/25/2004	8,295	7,250	1045	12.6%	0.70	0.75	-0.05	-7%	0.70	0.75	-0.05	-7%
07/05/2004	07/11/2004	2,098	1,928	170	8.1%	0.10	0.16	-0.05	-49%	0.10	0.16	-0.05	-49%
07/14/2004	07/24/2004	9,253	9,691	-438	-4.7%	0.46	0.51	-0.06	-12%	0.46	0.51	-0.06	-12%
07/24/2004	07/31/2004	8,246	8,331	-85	-1.0%	0.57	0.72	-0.15	-26%	0.57	0.72	-0.15	-26%
07/31/2004	08/11/2004	29,786	29,805	-20	-0.1%	3.18	3.78	-0.61	-19%	3.18	3.78	-0.61	-19%
08/14/2004	08/24/2004	26,224	25,574	650	2.5%	4.14	3.39	0.75	18%	4.14	3.39	0.75	18%

Appendix 4-2: STA-1 Inflow Basin Canal Event Based Flow and SRP Mass Balance													
Start Date	End Date	Volume (ac-ft)				SRP (mt) -- M2				SRP (mt) -- M3			
		in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in
09/03/2004	09/17/2004	52,983	51,409	1574	3.0%	15.47	11.11	4.36	28%	15.47	11.11	4.36	28%
09/17/2004	10/16/2004	106,245	100,744	5502	5.2%	23.24	27.36	-4.12	-18%	23.24	27.36	-4.12	-18%
01/11/2005	01/21/2005	5,382	4,741	641	11.9%	0.44	0.67	-0.24	-54%	0.55	0.67	-0.13	-23%
02/24/2005	03/05/2005	8,208	8,140	68	0.8%	0.73	0.78	-0.04	-6%	0.80	0.76	0.04	5%
03/15/2005	03/29/2005	8,043	8,376	-333	-4.1%	1.06	0.78	0.28	26%	1.06	0.84	0.22	21%
05/03/2005	05/09/2005	6,527	5,768	759	11.6%	0.82	0.76	0.06	7%	0.82	0.67	0.15	18%
05/26/2005	06/17/2005	21,487	20,445	1042	4.8%	3.81	3.92	-0.11	-3%	3.81	3.83	-0.02	-1%
06/26/2005	07/03/2005	9,465	11,021	-1556	-16.4%	1.13	1.23	-0.10	-8%	1.11	1.23	-0.11	-10%
07/07/2005	07/13/2005	4,231	4,177	55	1.3%	0.32	0.21	0.11	34%	0.22	0.21	0.01	4%
07/13/2005	07/16/2005	2,140	2,206	-66	-3.1%	0.13	0.16	-0.03	-22%	0.13	0.16	-0.03	-20%
08/31/2005	09/09/2005	6,988	8,199	-1211	-17.3%	0.60	0.69	-0.09	-15%	0.60	0.69	-0.09	-15%
10/01/2005	10/10/2005	8,328	8,059	269	3.2%	1.35	1.52	-0.17	-12%	1.35	1.52	-0.17	-12%
10/10/2005	10/15/2005	4,793	4,765	28	0.6%	0.77	0.82	-0.04	-6%	0.77	0.82	-0.04	-6%
10/16/2005	11/07/2005	25038	27342	-2304	-0.09	6.55	5.77	0.78	12%	6.53	5.77	0.76	12%
10/18/2005	10/23/2005	3,771	4,022	-251	-6.7%	0.80	0.45	0.35	44%	0.80	0.45	0.35	44%
11/19/2005	11/24/2005	6,381	6,737	-356	-5.6%	1.28	1.20	0.08	6%	1.24	1.19	0.05	4%
02/03/2006	02/17/2006	12,869	12,583	286	2.2%	3.35	2.64	0.71	21%	2.56	2.64	-0.08	-3%
03/21/2006	03/28/2006	2,621	3,077	-456	-17.4%	0.31	0.40	-0.09	-29%	0.34	0.47	-0.13	-38%
04/24/2006	04/29/2006	1,403	1,388	15	1.1%	0.16	0.15	0.01	6%	0.15	0.15	0.01	5%
05/15/2006	05/18/2006	4,957	4,770	187	3.8%	0.65	0.63	0.02	4%	0.65	0.81	-0.16	-25%
06/24/2006	07/05/2006	11,041	11,400	-359	-3.3%	3.04	2.38	0.66	22%	2.90	2.17	0.73	25%
07/06/2006	07/18/2006	13,582	15,386	-1804	-13.3%	3.08	3.15	-0.07	-2%	2.95	2.92	0.03	1%
07/18/2006	07/31/2006	14,935	15,068	-133	-0.9%	3.12	3.07	0.04	1%	3.09	3.02	0.08	2%
08/16/2006	09/16/2006	52,529	51,544	985	1.9%	13.34	10.90	2.44	18%	14.18	10.90	3.28	23%
09/19/2006	09/23/2006	2,718	2,481	237	8.7%	0.28	0.27	0.01	4%	0.28	0.27	0.01	2%
07/31/2007	08/06/2007	6,046	5,902	144	2.4%	0.10	0.15	-0.06	-61%	0.11	0.18	-0.06	-57%
09/12/2007	09/30/2007	27,114	27,025	89	0.3%	4.32	4.07	0.25	6%	4.32	4.07	0.25	6%
06/17/2008	07/12/2008	19,824	19,349	475	2.4%	2.01	2.00	0.01	1%	2.01	1.65	0.36	18%

Appendix 4-2: STA-1 Inflow Basin Canal Event Based Flow and SRP Mass Balance														
Start Date	**End Date**	**Volume (ac-ft)**				**SRP (mt) -- M2**				**SRP (mt) -- M3**			
		in	**out**	**in-out**	**(in-out)/in**	**in**	**out**	**in-out**	**(in-out)/in**	**in**	**out**	**in-out**	**(in-out)/in**
08/16/2008	09/13/2008	88,776	90,845	-2070	-2.3%	22.42	18.52	3.90	17%	22.42	18.52	3.91	17%
09/21/2008	09/25/2008	1,786	1,721	65	3.6%	0.28	0.28	0.00	0%	0.29	0.26	0.03	11%
09/28/2008	10/06/2008	15,340	15,082	258	1.7%	2.56	2.69	-0.13	-5%	2.56	2.69	-0.13	-5%
10/06/2008	10/11/2008	2,027	2,064	-37	-1.8%	0.35	0.39	-0.03	-10%	0.35	0.39	-0.03	-10%
10/11/2008	10/19/2008	2,651	2,547	103	3.9%	0.44	0.37	0.06	15%	0.44	0.37	0.06	14%
03/18/2009	03/21/2009	1,090	1,037	53	4.9%	0.10	0.08	0.02	17%	0.10	0.08	0.02	19%
05/18/2009	06/02/2009	36,641	31,416	5225	14.3%	6.43	5.06	1.37	21%	5.29	4.81	0.48	9%
06/04/2009	06/15/2009	20565	23260	-2695	-13.1%	6.03	6.86	-0.83	-14%	6.03	5.74	0.30	5%
06/22/2009	07/12/2009	46430	47614	-1183	-2.5%	5.63	7.87	-2.23	-40%	5.63	7.87	-2.24	-40%
08/06/2009	08/27/2009	20373	19311	1062	5.2%	2.54	1.81	0.73	29%	1.99	1.81	0.18	9%
03/10/2010	03/20/2010	26739	25490	1249	4.7%	6.93	3.06	3.87	56%	5.31	3.06	2.25	42%
08/08/2010	08/12/2010	2734	2748	-14	-0.5%	0.17	0.12	0.06	32%	0.17	0.12	0.06	32%
08/14/2010	09/03/2010	33537	33443	94	0.3%	2.70	2.38	0.32	12%	2.70	2.38	0.32	12%
09/04/2010	09/15/2010	20037	19085	952	4.7%	1.34	1.49	-0.16	-12%	1.47	1.49	-0.02	-1%
04/27/2011	05/25/2011	5424	4642	782	14.4%	0.32	0.26	0.05	17%	0.34	0.26	0.09	25%
09/03/2011	09/13/2011	6744	6528	216	3.2%	0.49	0.55	-0.06	-13%	0.57	0.55	0.02	4%
10/27/2011	11/08/2011	19551	20392	-841	-4.3%	3.15	3.21	-0.07	-2%	3.13	3.20	-0.07	-2%
08/24/2012	09/16/2012	69955	70150	-195	-0.3%	25.20	25.18	0.01	0%	23.95	21.30	2.66	11%
09/16/2012	09/20/2012	1839	2129	-291	-15.8%	0.23	0.36	-0.13	-55%	0.23	0.36	-0.13	-55%
09/30/2012	10/05/2012	4017	4198	-181	-4.5%	0.33	0.43	-0.10	-30%	0.35	0.44	-0.09	-27%
12/09/2012	12/15/2012	4471	4642	-171	-3.8%	0.20	0.18	0.02	9%	0.22	0.20	0.01	6%
01/06/2013	01/09/2013	1025	886	139	13.5%	0.04	0.02	0.01	38%	0.04	0.02	0.01	37%
06/26/2005	07/03/2005	9,465	11,021	-1556	-16.4%					1.11	1.23	-0.11	-10%
08/28/2009	09/17/2009	24,873	24,365	508	2.0%					2.34	2.55	-0.21	-9%
05/31/2010	06/09/2010	22,192	21,586	606	2.7%					1.96	2.27	-0.31	-16%
02/05/2012	02/08/2012	1302.5	1336.1	-33.6	-2.6%					0.08	0.07	0.00	6%
Average					0.0%				-1.5%				-0.5%
Median					0.9%				0.1%				2.1%

Appendix 4-2: STA-1 Inflow Basin Canal Event Based Flow and TDP Mass Balance													
Start Date	End Date	Volume (ac-ft)				TDP (mt) -- M2				TDP (mt) -- M3			
		in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in
09/08/2001	09/21/2001	34,228	33,158	1070	3.1%	6.1	3.8	2.3	38%	6.0	3.8	2.3	38%
09/23/2001	10/05/2001	34,468	32,711	1757	5.1%	3.8	4.4	-0.7	-17%	3.7	4.4	-0.8	-21%
10/19/2001	11/11/2001	42,846	40,741	2104	4.9%	9.0	5.8	3.1	35%	8.9	6.0	2.9	32%
06/12/2002	07/18/2002	113,641	110,283	3358	3.0%	19.1	21.6	-2.5	-13%	19.1	19.7	-0.7	-3%
07/28/2002	10/04/2002	150,551	152,529	-1978	-1.3%	17.4	16.9	0.4	3%	17.4	16.6	0.7	4%
10/06/2002	11/09/2002	78,194	81,020	-2826	-3.6%	6.4	6.8	-0.5	-7%	6.4	6.7	-0.4	-6%
11/28/2002	12/25/2002	63,016	64,294	-1278	-2.0%	5.8	6.4	-0.6	-11%	5.8	6.4	-0.6	-11%
03/16/2003	03/25/2003	13,695	12,797	898	6.6%	2.3	1.6	0.6	28%	2.2	1.7	0.5	24%
04/25/2003	05/04/2003	14,916	14,840	76	0.5%	1.4	1.9	-0.4	-29%	1.4	1.8	-0.4	-28%
06/02/2003	06/15/2003	14,105	15,515	-1410	-10.0%	1.2	2.2	-0.9	-77%	1.2	2.1	-0.9	-75%
06/15/2003	06/28/2003	20,525	21,932	-1407	-6.9%	2.6	2.5	0.1	2%	2.5	2.5	0.0	0%
07/22/2003	09/11/2003	119,776	119,777	-1	0.0%	17.8	15.5	2.3	13%	17.4	15.5	1.9	11%
09/21/2003	10/04/2003	25,765	26,208	-442	-1.7%	4.8	3.7	1.0	22%	4.4	3.7	0.6	14%
11/02/2003	11/13/2003	13,613	14,158	-546	-4.0%	1.6	1.5	0.1	3%	1.6	1.9	-0.3	-20%
01/29/2004	02/04/2004	9,183	8,966	217	2.4%	0.8	0.7	0.1	13%	0.8	0.6	0.1	14%
04/11/2004	04/14/2004	2,518	2,383	135	5.4%	0.2	0.2	0.0	-20%	0.2	0.2	0.0	-19%
05/11/2004	05/21/2004	6,673	6,956	-283	-4.2%	0.4	0.6	-0.2	-65%	0.4	0.6	-0.2	-49%
05/23/2004	05/27/2004	3,205	3,035	169	5.3%	0.2	0.2	0.0	4%	0.2	0.2	0.0	4%
05/31/2004	06/15/2004	15,422	15,143	279	1.8%	1.7	1.8	-0.1	-5%	1.7	1.8	-0.1	-4%
06/15/2004	06/25/2004	8,295	7,250	1045	12.6%	0.8	0.8	-0.1	-7%	0.8	0.8	0.0	-5%
07/14/2004	07/24/2004	9,253	9,691	-438	-4.7%	0.5	0.6	-0.1	-17%	0.5	0.6	-0.1	-17%
07/31/2004	08/11/2004	29,786	29,805	-20	-0.1%	3.4	4.1	-0.7	-22%	3.4	4.1	-0.7	-22%
08/14/2004	08/24/2004	26,224	25,574	650	2.5%	4.3	3.7	0.6	13%	4.3	3.7	0.6	13%
09/03/2004	09/17/2004	52,983	51,409	1574	3.0%	17.7	11.8	5.9	33%	17.7	11.8	5.9	33%
09/17/2004	10/16/2004	106,245	100,744	5502	5.2%	24.5	29.1	-4.7	-19%	24.5	29.1	-4.7	-19%
02/24/2005	03/05/2005	8,208	8,140	68	0.8%	0.7	0.8	0.0	-6%	0.7	0.8	0.0	-6%
03/15/2005	03/29/2005	8,043	8,376	-333	-4.1%	1.1	0.9	0.3	23%	1.1	0.9	0.2	18%
05/03/2005	05/09/2005	6,527	5,768	759	11.6%	0.8	0.8	0.0	4%	0.8	0.7	0.1	13%

Appendix 4-2: STA-1 Inflow Basin Canal Event Based Flow and TDP Mass Balance													
Start Date	**End Date**	**Volume (ac-ft)**				**TDP (mt) -- M2**				**TDP (mt) -- M3**			
		in	**out**	**in-out**	**(in-out)/in**	**in**	**out**	**in-out**	**(in-out)/in**	**in**	**out**	**in-out**	**(in-out)/in**
05/26/2005	06/17/2005	21,487	20,445	1042	4.8%	4.0	4.1	0.0	-1%	4.0	4.0	0.1	1%
06/26/2005	07/03/2005	9,465	11,021	-1556	-16.4%	1.3	1.4	-0.1	-10%	1.3	1.4	-0.1	-12%
07/07/2005	07/13/2005	4,231	4,177	55	1.3%	0.4	0.3	0.1	22%	0.3	0.3	0.0	-5%
07/13/2005	07/16/2005	2,140	2,206	-66	-3.1%	0.2	0.2	0.0	-20%	0.2	0.2	0.0	-18%
08/31/2005	09/09/2005	6,988	8,199	-1211	-17.3%	0.7	0.8	-0.1	-14%	0.7	0.8	-0.1	-14%
10/01/2005	10/10/2005	8,328	8,059	269	3.2%	1.5	1.7	-0.2	-11%	1.5	1.7	-0.2	-11%
10/10/2005	10/15/2005	4,793	4,765	28	0.6%	0.9	0.9	0.0	-4%	0.9	0.9	0.0	-4%
10/16/2005	11/07/2005	25,038	27,342	-2304	-9.2%	6.8	6.0	0.8	11%	6.8	6.0	0.7	11%
11/19/2005	11/24/2005	6,381	6,737	-356	-5.6%	1.4	1.3	0.0	0%	1.4	1.3	0.0	1%
02/03/2006	02/17/2006	12,869	12,583	286	2.2%	3.5	2.8	0.7	20%	2.7	2.8	-0.1	-4%
03/21/2006	03/28/2006	2,621	3,077	-456	-17.4%	0.3	0.5	-0.1	-34%	0.4	0.5	-0.1	-40%
04/24/2006	04/29/2006	1,403	1,388	15	1.1%	0.2	0.2	0.0	2%	0.2	0.2	0.0	0%
05/15/2006	05/18/2006	4,957	4,770	187	3.8%	0.7	0.7	0.0	-1%	0.7	0.9	-0.2	-25%
06/24/2006	07/05/2006	11,041	11,400	-359	-3.3%	3.2	2.7	0.6	17%	3.1	2.4	0.6	21%
07/06/2006	07/18/2006	13,582	15,386	-1804	-13.3%	3.3	3.5	-0.3	-8%	3.1	3.2	-0.1	-4%
07/18/2006	07/31/2006	14,935	15,068	-133	-0.9%	3.4	3.4	0.0	-1%	3.3	3.4	0.0	0%
08/19/2006	09/16/2006	49,757	49,292	465	0.9%	13.4	11.6	1.8	13%	13.9	11.6	2.3	16%
09/19/2006	09/23/2006	2,718	2,481	237	8.7%	0.3	0.3	0.0	5%	0.3	0.3	0.0	4%
07/31/2007	08/06/2007	6,046	5,902	144	2.4%	0.2	0.3	-0.1	-35%	0.2	0.3	-0.1	-38%
09/12/2007	09/30/2007	27,114	27,025	89	0.3%	4.9	4.6	0.3	5%	4.9	4.6	0.3	5%
06/17/2008	07/12/2008	19,824	19,349	475	2.4%	2.3	2.4	0.0	-1%	2.3	2.0	0.4	16%
08/16/2008	09/13/2008	88,776	90,845	-2070	-2.3%	24.1	20.2	3.9	16%	24.15	20.23	3.92	16%
09/21/2008	09/25/2008	1,786	1,721	65	3.6%	0.3	0.3	0.0	-1%	0.32	0.29	0.03	9%
09/28/2008	10/06/2008	15,340	15,082	258	1.7%	2.8	2.9	-0.1	-5%	2.76	2.91	-0.15	-5%
10/06/2008	10/11/2008	2,027	2,064	-37	-1.8%	0.3	0.4	-0.1	-25%	0.33	0.41	-0.08	-25%
10/11/2008	10/19/2008	2,651	2,547	103	3.9%	0.5	0.4	0.1	16%	0.48	0.41	0.07	15%
Average					-0.3%				-2.3%				-3.3%
Median					0.9%				-0.8%				-3.6%

Appendix 4-2: STA-1 Inflow Basin Canal Event Based Flow and PP Mass Balance													
Start Date	End Date	Volume (ac-ft)				PP (mt) -- M2				PP (mt) -- M3			
		in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in
06/12/2002	07/18/2002	113,641	110,283	3358	3.0%	4.4	4.7	-0.3	-6%	4.4	6.4	-1.9	-44%
07/28/2002	10/04/2002	150,551	152,529	-1978	-1.3%	10.2	12.8	-2.6	-26%	10.2	14.1	-3.9	-38%
10/06/2002	11/09/2002	78,194	81,020	-2826	-3.6%	3.6	3.1	0.5	13%	3.6	3.0	0.6	18%
11/28/2002	12/25/2002	63,016	64,294	-1278	-2.0%	6.8	8.1	-1.2	-18%	6.8	8.1	-1.2	-18%
03/16/2003	03/25/2003	13,695	12,797	898	6.6%	1.7	0.5	1.3	72%	1.8	0.5	1.2	70%
04/25/2003	05/04/2003	14,916	14,840	76	0.5%	2.4	1.0	1.5	60%	2.4	1.0	1.4	59%
06/02/2003	06/15/2003	14,105	15,515	-1410	-10.0%	0.3	0.6	-0.4	-152%	0.3	0.7	-0.5	-188%
07/22/2003	09/11/2003	119,776	119,777	-1	0.0%	4.2	7.2	-2.9	-69%	4.6	7.2	-2.5	-55%
11/02/2003	11/13/2003	13,613	14,158	-546	-4.0%	0.9	0.9	0.0	-4%	0.9	0.5	0.3	39%
01/29/2004	02/04/2004	9,183	8,966	217	2.4%	0.9	0.8	0.1	13%	0.9	0.8	0.1	12%
04/11/2004	04/14/2004	2,518	2,383	135	5.4%	0.3	0.2	0.1	33%	0.3	0.2	0.1	32%
05/11/2004	05/21/2004	6,673	6,956	-283	-4.2%	0.2	0.3	-0.1	-21%	0.2	0.3	-0.1	-43%
05/23/2004	05/27/2004	3,205	3,035	169	5.3%	0.1	0.2	0.0	-31%	0.1	0.2	0.0	-31%
05/31/2004	06/15/2004	15,422	15,143	279	1.8%	2.1	1.2	0.9	44%	2.1	1.2	0.9	43%
06/15/2004	06/25/2004	8,295	7,250	1045	12.6%	0.8	0.5	0.3	39%	0.8	0.5	0.3	38%
07/14/2004	07/24/2004	9,253	9,691	-438	-4.7%	0.5	0.8	-0.2	-44%	0.5	0.8	-0.2	-44%
07/31/2004	08/11/2004	29,786	29,805	-20	-0.1%	9.6	9.1	0.5	5%	9.6	9.1	0.5	5%
09/17/2004	10/16/2004	106,245	100,744	5502	5.2%	12.9	5.6	7.3	56%	12.9	5.6	7.2	56%
02/24/2005	03/05/2005	8,208	8,140	68	0.8%	0.9	0.9	0.1	10%	0.9	0.9	0.1	10%
03/15/2005	03/29/2005	8,043	8,376	-333	-4.1%	1.4	1.2	0.3	18%	1.4	1.1	0.3	22%
05/03/2005	05/09/2005	6,527	5,768	759	11.6%	1.0	0.4	0.6	63%	1.0	0.4	0.5	55%
05/26/2005	06/17/2005	21,487	20,445	1042	4.8%	1.2	1.1	0.1	9%	1.2	1.2	0.0	2%
07/07/2005	07/13/2005	4,231	4,177	55	1.3%	0.2	0.3	-0.1	-59%	0.3	0.3	0.0	-8%
07/13/2005	07/16/2005	2,140	2,206	-66	-3.1%	0.1	0.1	0.0	-37%	0.1	0.1	0.0	-41%
08/31/2005	09/09/2005	6,988	8,199	-1211	-17.3%	0.3	0.5	-0.3	-95%	0.3	0.5	-0.3	-95%
10/01/2005	10/10/2005	8,328	8,059	269	3.2%	0.3	0.6	-0.3	-81%	0.3	0.6	-0.3	-81%
10/10/2005	10/15/2005	4,793	4,765	28	0.6%	0.2	0.2	0.0	13%	0.2	0.2	0.0	13%

Appendix 4-2: STA-1 Inflow Basin Canal Event Based Flow and PP Mass Balance													
Start Date	End Date	Volume (ac-ft)				PP (mt) -- M2				PP (mt) -- M3			
		in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in
10/16/2005	11/07/2005	25,038	27,342	-2304	-9.2%	2.6	2.3	0.3	12%	2.6	2.3	0.3	12%
11/19/2005	11/24/2005	6,381	6,737	-356	-5.6%	0.7	1.1	-0.5	-69%	0.7	1.1	-0.5	-69%
02/03/2006	02/17/2006	12,869	12,583	286	2.2%	1.9	2.4	-0.4	-23%	2.7	2.4	0.4	14%
03/21/2006	03/28/2006	2,621	3,077	-456	-17.4%	0.4	0.6	-0.2	-41%	0.4	0.5	-0.1	-37%
04/24/2006	04/29/2006	1,403	1,388	15	1.1%	0.1	0.1	-0.1	-149%	0.1	0.1	-0.1	-139%
05/15/2006	05/18/2006	4,957	4,770	187	3.8%	1.0	0.8	0.3	25%	1.0	0.6	0.4	41%
06/24/2006	07/05/2006	11,041	11,400	-359	-3.3%	0.6	2.2	-1.6	-289%	0.7	2.4	-1.7	-244%
07/06/2006	07/18/2006	13,582	15,386	-1804	-13.3%	1.1	2.2	-1.1	-103%	1.2	2.4	-1.2	-103%
08/16/2006	09/16/2006	52,529	51,544	985	1.9%	3.6	8.1	-4.5	-127%	3.1	8.1	-5.0	-164%
09/19/2006	09/23/2006	2,718	2,481	237	8.7%	0.9	0.4	0.4	49%	0.9	0.4	0.4	50%
07/31/2007	08/06/2007	6,046	5,902	144	2.4%	0.8	0.9	-0.1	-13%	0.8	0.9	-0.1	-12%
09/12/2007	09/30/2007	27,114	27,025	89	0.3%	0.4	1.5	-1.1	-294%	0.4	1.5	-1.1	-294%
06/17/2008	07/12/2008	19,824	19,349	475	2.4%	1.3	1.7	-0.5	-35%	1.3	2.1	-0.8	-65%
08/16/2008	09/13/2008	88,776	90,845	-2070	-2.3%	8.2	15.6	-7.4	-90%	8.2	15.6	-7.4	-90%
09/21/2008	09/25/2008	1,786	1,721	65	3.6%	0.1	0.2	-0.1	-165%	0.1	0.2	-0.2	-231%
09/28/2008	10/06/2008	15,340	15,082	258	1.7%	0.5	0.7	-0.2	-34%	0.5	0.7	-0.2	-34%
10/06/2008	10/11/2008	2,027	2,064	-37	-1.8%	0.0	0.0	0.0	-31%	0.0	0.0	0.0	-31%
Average					-0.3%				-36%				-37%
Median					0.7%				-22%				-24%

Appendix 4-2: STA-1 Inflow Basin Canal Event Based Flow and DOP Mass Balance														
Start Date	End Date	Volume (ac-ft)				DOP (mt) -- M2				DOP (mt) -- M3				
		in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in	
09/08/2001	09/21/2001	34,228	33,158	1070	3.1%	0.31	0.52	-0.21	-66%	0.31	0.52	-0.20	-65%	
09/23/2001	10/05/2001	34,468	32,711	1757	5.1%	0.50	0.08	0.42	84%	0.43	0.08	0.35	81%	
10/19/2001	11/11/2001	42,846	40,741	2104	4.9%	0.43	0.07	0.36	85%	0.43	0.06	0.37	87%	
06/12/2002	07/18/2002	113,641	110,283	3358	3.0%	0.67	1.28	-0.61	-90%	0.67	1.32	-0.64	-96%	
07/28/2002	10/04/2002	150,551	152,529	-1978	-1.3%	1.18	1.43	-0.25	-21%	1.18	1.44	-0.26	-22%	
10/06/2002	11/09/2002	78,194	81,020	-2826	-3.6%	0.64	0.88	-0.24	-38%	0.64	0.89	-0.25	-40%	
11/28/2002	12/25/2002	63,016	64,294	-1278	-2.0%	0.23	0.48	-0.25	-108%	0.23	0.48	-0.25	-108%	
03/16/2003	03/25/2003	13,695	12,797	898	6.6%	0.14	0.18	-0.04	-29%	0.12	0.19	-0.07	-57%	
04/25/2003	05/04/2003	14,916	14,840	76	0.5%	0.12	0.20	-0.08	-69%	0.12	0.20	-0.08	-70%	
06/02/2003	06/15/2003	14,105	15,515	-1410	-10.0%	0.13	0.16	-0.03	-21%	0.13	0.16	-0.03	-22%	
06/15/2003	06/28/2003	20,525	21,932	-1407	-6.9%	0.32	0.22	0.10	33%	0.31	0.22	0.10	31%	
07/22/2003	09/11/2003	119,776	119,777	-1	0.0%	0.87	0.35	0.52	60%	0.88	0.35	0.52	60%	
09/21/2003	10/04/2003	25,765	26,208	-442	-1.7%	0.43	0.23	0.20	46%	0.40	0.23	0.17	43%	
11/02/2003	11/13/2003	13,613	14,158	-546	-4.0%	0.08	0.09	0.00	-6%	0.08	0.11	-0.03	-34%	
01/29/2004	02/04/2004	9,183	8,966	217	2.4%	0.03	0.08	-0.05	-155%	0.03	0.07	-0.04	-150%	
04/11/2004	04/14/2004	2,518	2,383	135	5.4%	0.02	0.01	0.01	38%	0.02	0.01	0.01	37%	
05/11/2004	05/21/2004	6,673	6,956	-283	-4.2%	0.06	0.08	-0.01	-22%	0.06	0.08	-0.01	-20%	
05/23/2004	05/27/2004	3,205	3,035	169	5.3%	0.02	0.03	-0.01	-24%	0.02	0.03	-0.01	-24%	
05/31/2004	06/15/2004	15,422	15,143	279	1.8%	0.14	0.14	0.00	3%	0.16	0.14	0.02	15%	
06/15/2004	06/25/2004	8,295	7,250	1045	12.6%	0.08	0.09	-0.01	-10%	0.10	0.09	0.01	6%	
07/14/2004	07/24/2004	9,253	9,691	-438	-4.7%	0.08	0.11	-0.03	-44%	0.08	0.11	-0.03	-44%	
07/31/2004	08/11/2004	29,786	29,805	-20	-0.1%	0.18	0.30	-0.12	-64%	0.18	0.30	-0.12	-64%	
08/14/2004	08/24/2004	26,224	25,574	650	2.5%	0.13	0.31	-0.18	-138%	0.13	0.31	-0.18	-138%	
09/03/2004	09/17/2004	52,983	51,409	1574	3.0%	2.26	0.68	1.58	70%	2.26	0.68	1.58	70%	
09/17/2004	10/16/2004	106,245	100,744	5502	5.2%	1.22	1.77	-0.56	-46%	1.22	1.77	-0.56	-46%	
03/15/2005	03/29/2005	8,043	8,376	-333	-4.1%	0.08	0.09	-0.01	-14%	0.08	0.10	-0.02	-19%	
05/26/2005	06/17/2005	21,487	20,445	1042	4.8%	0.21	0.13	0.07	36%	0.20	0.12	0.08	39%	
06/26/2005	07/03/2005	9,465	11,021	-1556	-16.4%	0.16	0.20	-0.04	-22%	0.16	0.20	-0.04	-22%	

Appendix 4-2: STA-1 Inflow Basin Canal Event Based Flow and DOP Mass Balance													
Start Date	End Date	Volume (ac-ft)				DOP (mt) -- M2				DOP (mt) -- M3			
		in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in
07/07/2005	07/13/2005	4,231	4,177	55	1.3%	0.07	0.09	-0.02	-30%	0.07	0.09	-0.02	-33%
07/13/2005	07/16/2005	2,140	2,206	-66	-3.1%	0.03	0.04	0.00	-12%	0.03	0.04	0.00	-13%
08/31/2005	09/09/2005	6,988	8,199	-1211	-17.3%	0.12	0.14	-0.01	-10%	0.12	0.14	-0.01	-10%
10/01/2005	10/10/2005	8,328	8,059	269	3.2%	0.19	0.19	0.00	1%	0.19	0.19	0.00	1%
10/10/2005	10/15/2005	4,793	4,765	28	0.6%	0.11	0.10	0.01	10%	0.11	0.10	0.01	10%
10/16/2005	11/07/2005	25,038	27,342	-2304	-9.2%	0.22	0.25	-0.03	-13%	0.23	0.25	-0.02	-10%
11/19/2005	11/24/2005	6,381	6,737	-356	-5.6%	0.07	0.14	-0.07	-107%	0.11	0.15	-0.04	-41%
02/03/2006	02/17/2006	12,869	12,583	286	2.2%	0.14	0.15	-0.01	-4%	0.11	0.15	-0.04	-31%
03/21/2006	03/28/2006	2,621	3,077	-456	-17.4%	0.03	0.05	-0.02	-90%	0.03	0.04	-0.02	-61%
04/24/2006	04/29/2006	1,403	1,388	15	1.1%	0.01	0.02	-0.01	-65%	0.01	0.02	-0.01	-61%
05/15/2006	05/18/2006	4,957	4,770	187	3.8%	0.07	0.10	-0.03	-48%	0.07	0.08	-0.01	-22%
06/24/2006	07/05/2006	11,041	11,400	-359	-3.3%	0.19	0.29	-0.11	-57%	0.18	0.27	-0.09	-52%
07/06/2006	07/18/2006	13,582	15,386	-1804	-13.3%	0.18	0.37	-0.19	-107%	0.17	0.33	-0.15	-88%
07/18/2006	07/31/2006	14,935	15,068	-133	-0.9%	0.25	0.34	-0.08	-33%	0.25	0.33	-0.09	-35%
09/19/2006	09/23/2006	2,718	2,481	237	8.7%	0.05	0.04	0.01	14%	0.05	0.04	0.01	16%
07/31/2007	08/06/2007	6,046	5,902	144	2.4%	0.10	0.12	-0.01	-11%	0.10	0.12	-0.02	-17%
09/12/2007	09/30/2007	27,114	27,025	89	0.3%	0.58	0.57	0.01	1%	0.58	0.57	0.01	1%
06/17/2008	07/12/2008	19,824	19,349	475	2.4%	0.34	0.37	-0.03	-8%	0.34	0.34	0.00	1%
08/16/2008	09/13/2008	88,776	90,845	-2069.7	0.0	1.73	1.72	0.01	1%	1.73	1.72	0.01	1%
09/21/2008	09/25/2008	1,786	1,721	64.6	0.0	0.03	0.03	0.00	-7%	0.03	0.03	0.00	-11%
09/28/2008	10/06/2008	15,340	15,082	258.0	0.0	0.20	0.21	-0.01	-7%	0.20	0.21	-0.01	-7%
10/11/2008	10/19/2008	2,651	2,547	103.5	0.0	0.05	0.04	0.01	25%	0.05	0.04	0.01	23%
Average					-1%				-22%				-20%
Median					1%				-14%				-21%

Appendix 4-2: STA-1 Inflow Basin Canal Event Based Flow and TSS Mass Balance

Start Date	End Date	Volume (ac-ft)				TSS (mt) -- M2				TSS (mt) -- M3			
		in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in
07/02/2000	07/17/2000	11,315	10,475	841	7.4%	434	148	286	66%	434	127	307	71%
07/09/2001	07/29/2001	47,187	45,493	1,694	3.6%	503	2,516	-2,013	-400%	503	2,516	-2,014	-401%
07/29/2001	08/11/2001	42,078	42,341	-263	-0.6%	905	580	324	36%	816	580	235	29%
09/08/2001	09/21/2001	34,228	33,158	1,070	3.1%	417	665	-248	-60%	369	665	-296	-80%
10/19/2001	11/11/2001	42,846	40,741	2,104	4.9%	1,330	418	912	69%	1,320	401	919	70%
05/05/2002	05/18/2002	13,213	16,225	-3,012	-22.8%	100	428	-328	-328%	100	359	-259	-260%
06/12/2002	07/18/2002	113,641	110,283	3,358	3.0%	5,401	1,549	3,852	71%	5,401	1,581	3,821	71%
07/28/2002	10/04/2002	150,551	152,529	-1,978	-1.3%	4,149	5,079	-930	-22%	4,149	5,139	-990	-24%
10/06/2002	11/09/2002	78,194	81,020	-2,826	-3.6%	1,845	871	974	53%	1,845	742	1,104	60%
11/28/2002	12/25/2002	63,016	64,294	-1,278	-2.0%	5,896	2,937	2,959	50%	5,896	2,937	2,959	50%
06/02/2003	06/15/2003	14,105	15,515	-1,410	-10.0%	192	254	-63	-33%	192	294	-103	-54%
06/15/2003	06/28/2003	20,525	21,932	-1,407	-6.9%	460	177	283	61%	460	177	283	61%
07/22/2003	09/11/2003	119,776	119,777	-1	0.0%	3,434	2,576	857	25%	3,433	2,576	857	25%
07/31/2004	09/03/2004	85,033	83,795	1,238	1.5%	4,718	3,710	1,009	21%	4,718	3,710	1,009	21%
09/03/2004	09/17/2004	52,983	51,409	1,574	3.0%	1,917	1,152	765	40%	1,917	1,152	765	40%
09/17/2004	10/16/2004	106,245	100,744	5,502	5.2%	6,137	3,913	2,224	36%	6,137	3,913	2,224	36%
03/15/2005	03/29/2005	8,043	8,376	-333	-4.1%	377	230	147	39%	374	206	167	45%
05/26/2005	06/17/2005	21,487	20,445	1,042	4.8%	993	110	883	89%	993	189	804	81%

Appendix 4-2: STA-1 Inflow Basin Canal Event Based Flow and TSS Mass Balance														
Start Date	End Date	Volume (ac-ft)				TSS (mt) -- M2				TSS (mt) -- M3			
		in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in
08/24/2005	09/09/2005	12,358	13,531	-1,172	-9.5%	192	348	-156	-81%	192	348	-156	-81%
09/26/2005	10/15/2005	14,622	14,693	-71	-0.5%	129	212	-83	-64%	135	212	-77	-58%
07/06/2006	07/18/2006	13,582	15,386	-1,804	-13.3%	416	254	161	39%	416	221	195	47%
07/18/2006	07/31/2006	14,935	15,068	-133	-0.9%	552	240	312	56%	552	244	308	56%
08/16/2006	09/16/2006	52,529	51,544	985	1.9%	378	875	-497	-131%	378	875	-497	-131%
09/12/2007	09/30/2007	27,114	27,025	89	0.3%	134	834	-699	-520%	140	769	-629	-448%
06/17/2008	07/12/2008	19,824	19,349	475	2.4%	412	465	-53	-13%	412	309	103	25%
08/16/2008	09/13/2008	88,776	90,845	-2,070	-2.3%	3,144	1,316	1,828	58%	3,144	1,299	1,845	59%
09/28/2008	10/06/2008	15,340	15,082	258	1.7%	274	117	157	57%	274	113	161	59%
10/11/2008	10/19/2008	2,651	2,547	103	3.9%	57	30	26	47%	56	30	25	46%
05/18/2009	06/25/2009	66,227	63,959	2,268	3.4%	617	989	-372	-60%	607	964	-357	-59%
12/09/2009	12/23/2009	5,025	4,720	305	6.1%	27	25	2	8%	27	34	-7	-26%
12/09/2012	12/15/2012	4,471	4,642	-171	-3.8%	34	19	15	45%	35	18	17	49%
Average					-0.8%				-24.0%				-20.0%
Mean					0.3%				36.2%				36.2%

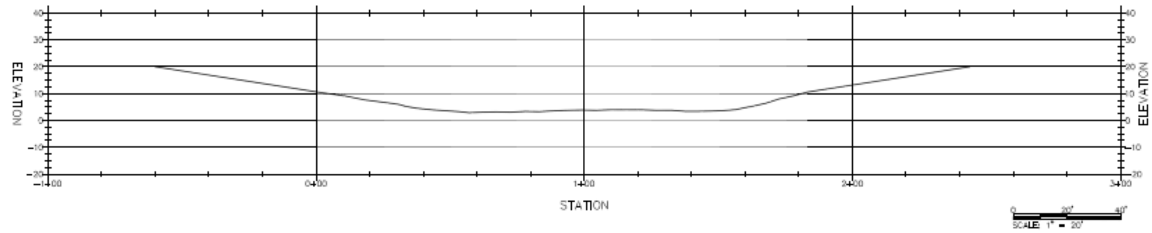
Appendix 4-2: STA-1 Inflow Basin Canal Event Based Flow and CLD Mass Balance													
Start Date	End Date	Volume (ac-ft)				CLD (mt) -- M2				CLD (mt) -- M3			
		in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in
07/02/2000	07/17/2000	11,315	10,475	841	7.4%	1,545	1,787	-241	-16%	1,545	1,606	-60	-4%
07/09/2001	07/29/2001	47,187	45,493	1694	3.6%	9,029	8,192	836	9%	9,181	8,192	989	11%
07/29/2001	08/11/2001	42,078	42,341	-263	-0.6%	8,162	5,803	2,359	29%	7,701	5,803	1,898	25%
09/08/2001	09/21/2001	34,228	33,158	1070	3.1%	6,856	4,758	2,098	31%	6,853	4,758	2,095	31%
09/23/2001	10/05/2001	34,468	32,711	1757	5.1%	6,163	6,066	97	2%	6,338	6,066	272	4%
10/19/2001	11/11/2001	42,846	40,741	2104	4.9%	10,502	8,576	1,926	18%	10,507	8,871	1,636	16%
05/05/2002	05/18/2002	13,213	16,225	-3012	-22.8%	1,443	1,758	-315	-22%	1,446	1,805	-359	-25%
06/12/2002	07/18/2002	113,641	110,283	3358	3.0%	22,067	18,373	3,694	17%	22,067	18,305	3,763	17%
07/28/2002	10/04/2002	150,551	152,529	-1978	-1.3%	20,045	22,186	-2,141	-11%	20,045	22,398	-2,353	-12%
10/06/2002	11/09/2002	78,194	81,020	-2826	-3.6%	7,698	9,580	-1,882	-24%	7,698	9,481	-1,783	-23%
11/28/2002	12/25/2002	63,016	64,294	-1278	-2.0%	10,691	13,574	-2,883	-27%	10,691	13,574	-2,883	-27%
06/02/2003	06/15/2003	14,105	15,515	-1410	-10.0%	2,830	3,819	-989	-35%	2,830	3,588	-757	-27%
06/15/2003	06/28/2003	20,525	21,932	-1407	-6.9%	3,777	4,855	-1,078	-29%	4,007	4,855	-849	-21%
07/22/2003	09/11/2003	119,776	119,777	-1	0.0%	21,851	26,211	-4,360	-20%	22,224	26,211	-3,987	-18%
07/23/2003	08/08/2003	32,271	30,953	1318	4.1%	6,324	6,251	73	1%	6,695	6,251	444	7%
01/29/2004	02/04/2004	9,183	8,966	217	2.4%	1,249	1,447	-199	-16%	1,249	1,405	-156	-13%
05/11/2004	05/21/2004	6,673	6,956	-283	-4.2%	444	602	-159	-36%	451	602	-152	-34%
05/31/2004	06/15/2004	15,422	15,143	279	1.8%	1,245	1,526	-281	-23%	1,489	1,526	-37	-2%
06/15/2004	06/25/2004	8,295	7,250	1045	12.6%	947	1,088	-141	-15%	1,132	1,088	44	4%
07/14/2004	07/24/2004	9,253	9,691	-438	-4.7%	976	1,148	-172	-18%	976	1,148	-172	-18%
07/31/2004	08/11/2004	29,786	29,805	-20	-0.1%	5,838	4,929	909	16%	5,838	4,929	909	16%
07/31/2004	09/03/2004	85,033	83,795	1238	1.5%	16,537	14,541	1,996	12%	16,537	14,541	1,996	12%
09/03/2004	09/17/2004	52,983	51,409	1574	3.0%	5,950	7,254	-1,305	-22%	5,950	7,254	-1,305	-22%
09/17/2004	10/16/2004	106,245	100,744	5502	5.2%	13,238	14,663	-1,425	-11%	13,898	14,663	-764	-5%
01/11/2005	01/21/2005	5,382	4,741	641	11.9%	551	538	13	2%	452	538	-86	-19%
02/24/2005	03/05/2005	8,208	8,140	68	0.8%	1,308	1,185	122	9%	764	1,058	-294	-38%
03/15/2005	03/29/2005	8,043	8,376	-333	-4.1%	1,569	1,410	159	10%	1,569	1,474	95	6%
05/26/2005	06/17/2005	21,487	20,445	1042	4.8%	3,631	3,867	-236	-6%	3,812	3,277	535	14%

Appendix 4-2: STA-1 Inflow Basin Canal Event Based Flow and CLD Mass Balance													
Start Date	End Date	Volume (ac-ft)				CLD (mt) -- M2				CLD (mt) -- M3			
		in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in	in	out	in-out	(in-out)/in
07/07/2005	07/16/2005	6,371	6,235	136	2.1%	1,565	1,145	421	27%	1,567	1,145	422	27%
08/24/2005	09/09/2005	12,358	13,531	-1172	-9.5%	2,155	2,318	-163	-8%	2,138	2,318	-180	-8%
08/31/2005	09/09/2005	6,988	8,199	-1211	-17.3%	1,219	1,444	-226	-19%	1,219	1,444	-226	-19%
09/26/2005	10/15/2005	14,622	14,693	-71	-0.5%	3,081	3,211	-130	-4%	3,059	3,211	-152	-5%
10/10/2005	11/07/2005	29,831	32,107	-2275	-7.6%	7,072	7,492	-420	-6%	7,171	7,492	-320	-4%
02/03/2006	02/17/2006	12,869	12,583	286	2.2%	2,385	1,954	432	18%	2,709	1,954	756	28%
07/06/2006	07/18/2006	13,582	15,386	-1804	-13.3%	1,907	2,093	-186	-10%	1,907	2,023	-116	-6%
07/18/2006	07/31/2006	14,935	15,068	-133	-0.9%	2,529	2,160	369	15%	2,529	2,168	362	14%
08/16/2006	09/16/2006	52,529	51,544	985	1.9%	8,686	8,047	639	7%	8,686	8,048	638	7%
09/12/2007	09/30/2007	27,114	27,025	89	0.3%	4,416	4,340	76	2%	4,332	4,290	42	1%
06/17/2008	07/12/2008	19,824	19,349	475	2.4%	2,792	2,641	151	5%	2,761	2,520	241	9%
08/16/2008	09/13/2008	88,776	90,845	-2070	-2.3%	19,018	19,111	-93	0%	19,018	18,939	79	0%
09/28/2008	10/06/2008	15,340	15,082	258	1.7%	2,452	2,414	38	2%	2,452	2,372	80	3%
10/11/2008	10/19/2008	2,651	2,547	103	3.9%	503	498	5	1%	508	498	10	2%
11/16/2008	11/21/2008	1,802	2,043	-242	-13.4%	314	363	-49	-16%	485	343	142	29%
03/18/2009	03/21/2009	1,090	1,037	53	4.9%	88	90	-2	-3%	88	91	-3	-3%
05/18/2009	06/25/2009	66,227	63,959	2268	3.4%	7,740	7,461	279	4%	7,386	7,081	306	4%
06/22/2009	07/12/2009	46,430	47,614	-1183	-2.5%	5,853	6,167	-313	-5%	5,854	6,174	-320	-5%
08/06/2009	08/26/2009	20,118	19,137	980	4.9%	3,800	3,243	557	15%	3,881	3,243	638	16%
08/28/2009	09/17/2009	24,873	24,365	508	2.0%	5,321	5,330	-8	0%	5,419	5,330	89	2%
12/09/2009	12/23/2009	5,025	4,720	305	6.1%	550	642	-92	-17%	705	754	-49	-7%
03/10/2010	03/20/2010	26,739	25,490	1249	4.7%	4,036	3,972	64	2%	4,890	4,388	501	10%
05/31/2010	06/09/2010	22,192	21,586	606	2.7%	2,639	1,944	695	26%	2,930	2,413	517	18%
08/08/2010	08/12/2010	2,734	2,748	-14	-0.5%	352	364	-11	-3%	352	364	-11	-3%
08/14/2010	09/03/2010	33,537	33,443	94	0.3%	5,566	5,921	-355	-6%	5,566	5,921	-355	-6%
09/04/2010	09/15/2010	20,037	19,085	952	4.7%	3,447	3,272	175	5%	3,558	3,347	211	6%
01/03/2011	01/10/2011	3,787	3,305	482	12.7%	537	535	3	1%	425	390	35	8%
04/27/2011	05/02/2011	1,501	1,428	74	4.9%	170	168	2	1%	136	129	7	5%

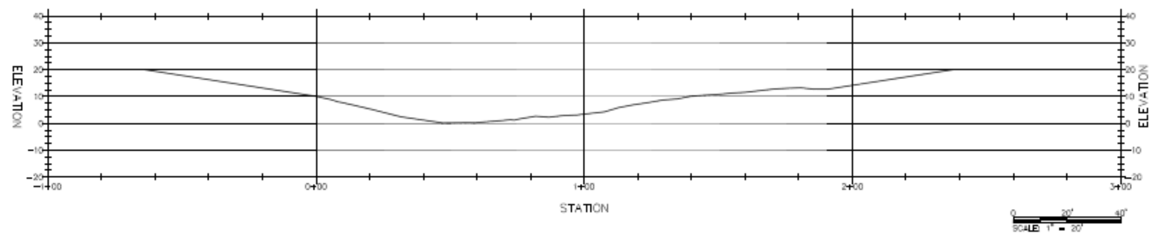
Appendix 4-2: STA-1 Inflow Basin Canal Event Based Flow and CLD Mass Balance													
Start Date	**End Date**	**Volume (ac-ft)**				**CLD (mt) -- M2**				**CLD (mt) -- M3**			
		in	**out**	**in-out**	**(in-out)/in**	**in**	**out**	**in-out**	**(in-out)/in**	**in**	**out**	**in-out**	**(in-out)/in**
08/22/2011	08/28/2011	4,800	4,824	-24	-0.5%	634	672	-38	-6%	634	609	24	4%
08/28/2011	08/30/2011	900	820	79	8.8%	121	113	8	7%	121	106	15	12%
09/03/2011	09/13/2011	6,744	6,528	216	3.2%	946	888	58	6%	977	913	64	7%
09/25/2011	10/05/2011	5,259	4,969	290	5.5%	776	685	92	12%	812	714	99	12%
10/23/2011	10/25/2011	986	944	42	4.2%	150	143	7	5%	150	165	-15	-10%
10/27/2011	11/08/2011	19,551	20,392	-841	-4.3%	2,972	3,171	-198	-7%	3,099	3,281	-182	-6%
08/24/2012	09/16/2012	69,955	70,150	-195	-0.3%	7,282	6,022	1,260	17%	7,418	6,202	1,216	16%
09/16/2012	09/20/2012	1,839	2,129	-291	-15.8%	342	350	-8	-2%	342	350	-8	-2%
09/30/2012	10/05/2012	4,017	4,198	-181	-4.5%	1,022	1,072	-49	-5%	1,025	1,061	-37	-4%
12/09/2012	12/15/2012	4,471	4,642	-171	-3.8%	460	653	-193	-42%	451	651	-200	-44%
01/06/2013	01/09/2013	1,025	886	139	13.5%	130	137	-7	-5%	130	137	-6	-5%
02/05/2012	02/08/2012	1,303	1,336	-34	-2.6%					109	117	-9	-8%
04/17/2012	04/28/2012	2,579	2,560	20	0.8%					236	246	-10	-4%
Average					0.2%				-2.4%				-0.8%
Median					1.7%				-0.5%				0.4%

APPENDIX 5-1: STA-1 INFLOW BASIN CANAL SURVEY AND CROSS-SECTIONS

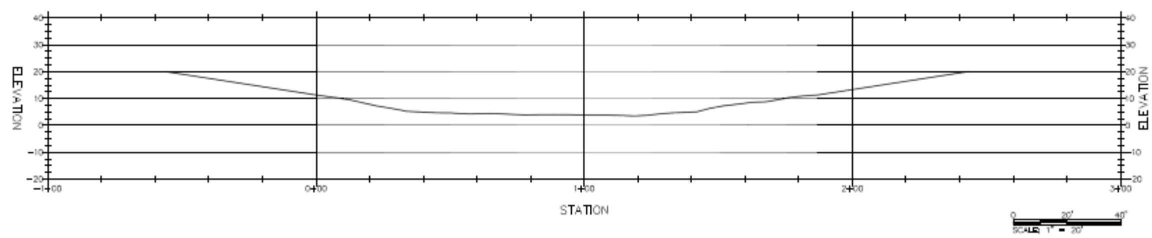
SECTION 1



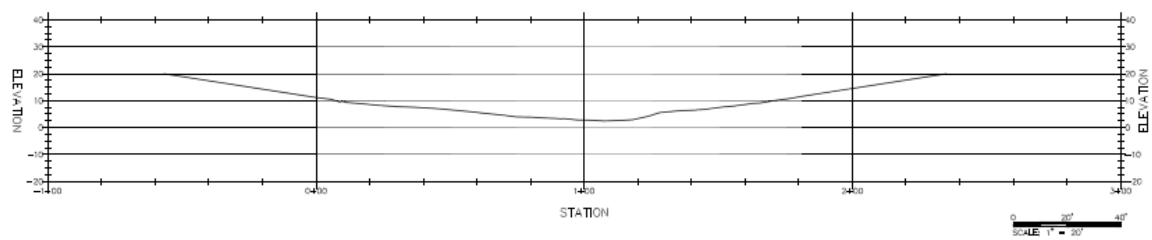
SECTION 2



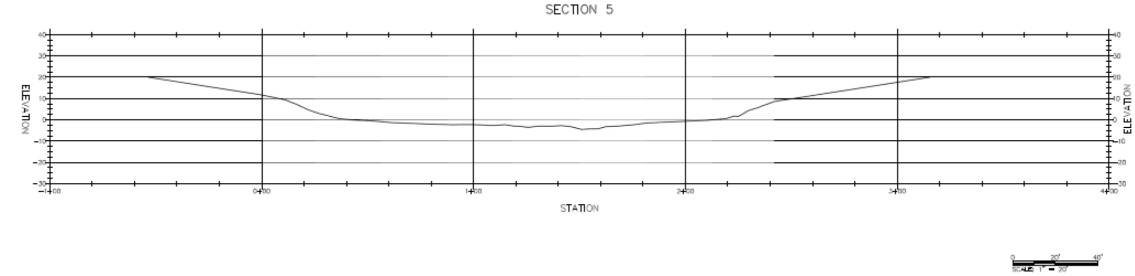
SECTION 3



SECTION 4



SECTION 5



APPENDIX 5-2: DESCRIPTIVE STATISTICS SUMMARY

	Variable	N	Mean	Std Dev	Median	Minimum	Maximum
			TP				
Scenario I	TP CCP	29	-0.03	0.14	-0.01	-0.33	0.22
	Stage (ft, NGVD)	29	14.63	0.99	14.39	13.01	16.98
	S5A_TP (ppb)	29	0.14	0.06	0.13	0.06	0.30
	G302_TP (ppb)	29	0.15	0.06	0.14	0.07	0.30
	Velocity (ft/s)	29	0.36	0.22	0.39	0.06	0.91
Scenario II	TP CCP	36	-0.14	0.28	-0.06	-1.35	0.21
	Stage (ft, NGVD)	36	15.57	0.88	15.50	13.19	17.49
	S5A_TP (ppb)	36	0.17	0.07	0.16	0.07	0.44
	G302_TP (ppb)	36	0.18	0.07	0.17	0.08	0.46
	Velocity (ft/s)	36	0.64	0.24	0.58	0.27	1.04
Scenario III	TP CCP	23	-0.12	0.23	-0.10	-0.55	0.37
	Stage (ft, NGVD)	23	16.18	0.90	15.99	15.02	19.10
	S5A_TP (ppb)	23	0.19	0.09	0.18	0.06	0.40
	G302_TP (ppb)	23	0.20	0.09	0.18	0.10	0.47
	Velocity (ft/s)	23	0.93	0.23	0.97	0.37	1.34
Scenario IV	TP CCP	88	-0.10	0.23	-0.06	-1.35	0.33
	Stage (ft, NGVD)	88	15.42	1.10	15.37	13.01	19.10
	S5A_TP (ppb)	88	0.17	0.08	0.15	0.06	0.44
	G302_TP (ppb)	88	0.18	0.08	0.17	0.07	0.47
	Velocity (ft/s)	88	0.63	0.31	0.53	0.06	1.34
			SRP				
Scenario I	SRP CCP	19	0.07	0.21	0.03	-0.25	0.56
	Stage (ft, NGVD)	19	14.35	0.82	14.16	13.01	16.20
	S5A_SRP (ppb)	19	0.11	0.06	0.09	0.01	0.26
	G302_SRP (ppb)	19	0.10	0.06	0.08	0.01	0.25
	Velocity (ft/s)	19	0.30	0.20	0.29	0.06	0.89
Scenario II	SRP CCP	26	-0.03	0.17	0.01	-0.67	0.14
	Stage (ft, NGVD)	26	15.51	0.97	15.32	13.19	17.49
	S5A_SRP (ppb)	26	0.14	0.08	0.13	0.01	0.41
	G302_SRP (ppb)	26	0.14	0.08	0.13	0.02	0.41
	Velocity (ft/s)	26	0.67	0.25	0.70	0.27	1.04

	Variable	N	Mean	Std Dev	Median	Minimum	Maximum
SRP							
Scenario III	SRP CCP	17	-0.01	0.16	0.01	-0.54	0.20
	Stage (ft, NGVD)	17	16.29	0.73	16.27	15.02	17.91
	S5A_SRP (ppb)	17	0.13	0.09	0.11	0.03	0.33
	G302_SRP (ppb)	17	0.13	0.09	0.11	0.03	0.33
	Velocity (ft/s)	17	0.84	0.25	0.88	0.28	1.17
Scenario IV	SRP CCP	62	0.01	0.18	0.01	-0.67	0.56
	Stage (ft, NGVD)	62	15.37	1.14	15.29	13.01	17.91
	S5A_SRP (ppb)	62	0.13	0.08	0.11	0.01	0.41
	G302_SRP (ppb)	62	0.12	0.08	0.11	0.01	0.41
	Velocity (ft/s)	62	0.60	0.32	0.53	0.06	1.17
TDP							
Scenario I	TDP CCP	17	0.06	0.17	0.02	-0.19	0.42
	Stage (ft, NGVD)	17	14.30	0.85	14.08	13.01	16.20
	S5A_TDP (ppb)	17	0.13	0.06	0.11	0.02	0.26
	G302_TDP (ppb)	17	0.12	0.06	0.09	0.03	0.25
	Velocity (ft/s)	17	0.25	0.14	0.23	0.06	0.48
Scenario II	TDP CCP	19	0.06	0.22	0.04	-0.38	0.84
	Stage (ft, NGVD)	19	15.44	1.09	15.29	13.19	17.49
	S5A_TDP (ppb)	19	0.14	0.09	0.14	0.03	0.41
	G302_TDP (ppb)	19	0.14	0.10	0.14	0.01	0.43
	Velocity (ft/s)	17	0.65	0.26	0.65	0.27	1.01
Scenario III	TDP CCP	8	-0.02	0.09	0.00	-0.17	0.10
	Stage (ft, NGVD)	8	16.46	0.52	16.55	15.49	16.94
	S5A_TDP (ppb)	8	0.14	0.07	0.13	0.08	0.27
	G302_TDP (ppb)	8	0.14	0.06	0.13	0.08	0.27
	Velocity (ft/s)	8	0.72	0.29	0.81	0.28	1.11
Scenario IV	TDP CCP	44	0.05	0.18	0.02	-0.38	0.84
	Stage (ft, NGVD)	44	15.19	1.20	15.24	13.01	17.49
	S5A_TDP (ppb)	44	0.14	0.08	0.13	0.02	0.41
	G302_TDP (ppb)	44	0.13	0.08	0.13	0.01	0.43
	Velocity (ft/s)	44	0.51	0.31	0.45	0.06	1.11

	Variable	N	Mean	Std Dev	Median	Minimum	Maximum
			PP				
Scenario I	PP CCP	17	-0.36	0.43	-0.43	-0.94	0.67
	Stage (ft, NGVD)	17	14.30	0.85	14.08	13.01	16.20
	S5A_PP (ppb)	17	0.04	0.02	0.04	0.01	0.09
	G302_PP (ppb)	17	0.05	0.02	0.05	0.02	0.10
	Velocity (ft/s)	17	0.25	0.14	0.23	0.06	0.48
Scenario II	PP CCP	19	-0.43	0.34	-0.43	-0.91	0.16
	Stage (ft, NGVD)	19	15.44	1.09	15.29	13.19	17.49
	S5A_PP (ppb)	19	0.04	0.03	0.03	0.01	0.13
	G302_PP (ppb)	19	0.05	0.03	0.04	0.02	0.13
	Velocity (ft/s)	19	0.68	0.26	0.78	0.27	1.01
Scenario III	PP CCP	4	-0.16	0.20	-0.23	-0.29	0.13
	Stage (ft, NGVD)	4	16.19	0.61	16.19	15.49	16.92
	S5A_PP (ppb)	4	0.07	0.05	0.06	0.03	0.14
	G302_PP (ppb)	4	0.07	0.04	0.07	0.03	0.12
	Velocity (ft/s)	4	0.93	0.15	0.92	0.79	1.11
Scenario IV	PP CCP	40	-0.37	0.37	-0.38	-0.94	0.67
	Stage (ft, NGVD)	40	15.03	1.15	15.17	13.01	17.49
	S5A_PP (ppb)	40	0.04	0.03	0.03	0.01	0.14
	G302_PP (ppb)	40	0.05	0.03	0.04	0.02	0.13
	Velocity (ft/s)	40	0.53	0.32	0.46	0.06	1.11
			DOP				
Scenario I	DOP CCP	16	-0.15	0.48	0.00	-1.43	0.45
	Stage (ft, NGVD)	16	14.33	0.87	14.12	13.01	16.20
	S5A_DOP (ppb)	16	0.01	0.01	0.01	0.00	0.02
	G302_DOP (ppb)	16	0.01	0.01	0.01	0.00	0.03
	Velocity (ft/s)	16	0.26	0.15	0.26	0.06	0.48
Scenario II	DOP CCP	18	-0.27	0.60	0.00	-1.71	0.39
	Stage (ft, NGVD)	18	15.42	1.11	15.24	13.19	17.49
	S5A_DOP (ppb)	18	0.01	0.00	0.01	0.00	0.02
	G302_DOP (ppb)	18	0.01	0.01	0.01	0.01	0.03
	Velocity (ft/s)	18	0.67	0.26	0.71	0.27	0.97

	Variable	N	Mean	Std Dev	Median	Minimum	Maximum
			DOP				
Scenario III	DOP CCP	7	-0.15	0.45	-0.07	-1.10	0.29
	Stage (ft, NGVD)	7	16.48	0.56	16.71	15.49	16.94
	S5A_DOP (ppb)	7	0.01	0.00	0.01	0.01	0.02
	G302_DOP (ppb)	7	0.02	0.00	0.02	0.01	0.02
	Velocity (ft/s)	7	0.75	0.31	0.83	0.28	1.11
Scenario IV	DOP CCP	41	-0.20	0.52	0.00	-1.71	0.45
	Stage (ft, NGVD)	41	15.18	1.21	15.19	13.01	17.49
	S5A_DOP (ppb)	41	0.01	0.00	0.01	0.00	0.02
	G302_DOP (ppb)	41	0.01	0.01	0.02	0.00	0.03
	Velocity (ft/s)	41	0.52	0.31	0.45	0.06	1.11
			TSS				
Scenario IV	TSS CCP	11	-1.19	1.84	-0.58	-6.00	0.40
	Stage (ft, NGVD)	11	15.05	0.72	15.18	13.63	16.18
	S5A_TSS (ppb)	11	8.27	3.69	9.00	3.00	13.00
	G302_TSS (ppb)	11	13.73	6.56	14.00	6.00	28.00
	Velocity (ft/s)	11	0.74	0.27	0.89	0.30	1.06
			CLD				
Scenario IV	CLD CCP	28	0.04	0.12	0.00	-0.14	0.48
	Stage (ft, NGVD)	28	15.54	0.88	15.44	13.63	17.91
	S5A_TSS (ppb)	28	132.83	38.41	130.00	60.00	225.00
	G302_TSS (ppb)	28	127.67	42.40	126.00	56.30	210.00
	Velocity (ft/s)	28	0.80	0.25	0.89	0.30	1.17

APPENDIX 5-3: STA-1 INFLOW BASIN CANAL CORRELATION ANALYSIS SUMMARY

	Variable	Variable	N	Spearman Correlation	Spearman P-value	Statistically Significant (a = 0.05)	Pearson Correlation
TP							
Scenario I	TP CCP	stage	29	0.07	0.7	No	0.03
	TP CCP	S5A_TP	29	0.29	0.13	No	0.36
	TP CCP	G302_TP	29	0.09	0.66	No	0.07
	TP CCP	velocity	29	-0.14	0.47	No	-0.02
	Stage	S5A_TP	29	0.05	0.79	No	0.03
	stage	G302_TP	29	0.06	0.76	No	0.05
	stage	velocity	29	0.08	0.66	No	0.08
	S5A_TP	G302_TP	29	0.96	<0.001	Yes	0.94
	S5A_TP	velocity	29	-0.23	0.22	No	-0.2
	G302_TP	velocity	29	-0.23	0.23	No	-0.16
Scenario II	TP CCP	stage	36	0.07	0.70	No	0.09
	TP CCP	S5A_TP	36	0.39	0.02	yes	0.36
	TP CCP	G302_TP	36	-0.04	0.82	No	-0.14
	TP CCP	velocity	36	-0.16	0.37	No	0.05
	Stage	S5A_TP	36	-0.01	0.95	No	-0.25
	stage	G302_TP	36	-0.09	0.62	No	-0.30
	stage	velocity	36	-0.43	0.01	Yes	-0.37
	S5A_TP	G302_TP	36	0.84	<0.0001	Yes	0.92
	S5A_TP	velocity	36	-0.34	0.04	Yes	-0.37
	G302_TP	velocity	36	-0.37	0.03	Yes	-0.40
Scenario III	TP CCP	stage	23	0.38	0.06	No	0.23
	TP CCP	S5A_TP	23	0.68	<0.001	Yes	0.59
	TP CCP	G302_TP	23	0.37	0.06	No	0.18
	TP CCP	velocity	23	-0.10	0.63	No	-0.17
	Stage	S5A_TP	23	0.55	0.00	No	0.65
	stage	G302_TP	23	0.41	0.04	No	0.66
	stage	velocity	23	-0.07	0.74	No	-0.05
	S5A_TP	G302_TP	23	0.89	<0.001	Yes	0.88
	S5A_TP	velocity	23	0.12	0.55	No	0.13
	G302_TP	velocity	23	0.17	0.42	No	0.29

	Variable	Variable	N	Spearman Correlation	Spearman P-value	Statistically Significant (a = 0.05)	Pearson Correlation
TP							
Scenario IV	TP CCP	stage	88	0.05	0.61	No	0.03
	TP CCP	S5A_TP	88	0.40	<0.001	Yes	0.33
	TP CCP	G302_TP	88	0.02	0.85	No	-0.02
	TP CCP	velocity	88	-0.14	0.2	No	-0.05
	Stage	S5A_TP	88	0.24	0.02	No	0.27
	stage	G302_TP	88	0.23	0.03	Yes	0.27
	stage	velocity	88	0.27	0.01	Yes	0.32
	S5A_TP	G302_TP	88	0.89	<0.001	Yes	0.92
	S5A_TP	velocity	88	0.03	0.8	No	0.08
	G302_TP	velocity	88	0.07	0.53	No	0.12
SRP							
Scenario I	SRP CCP	stage	19	0.64	0.003	Yes	0.49
	SRP CCP	S5A_SRP	19	-0.01	0.97	No	0.11
	SRP CCP	G302_SRP	19	-0.26	0.28	No	-0.22
	SRP CCP	velocity	19	-0.3	0.21	No	-0.22
	Stage	S5A_SRP	19	0.06	0.79	No	0.08
	stage	G302_SRP	19	-0.11	0.66	No	-0.11
	stage	velocity	19	-0.08	0.74	No	-0.07
	S5A_SRP	G302_SRP	19	0.91	<0.001	Yes	0.93
	S5A_SRP	velocity	19	-0.28	0.24	No	-0.28
	G302_SRP	velocity	19	-0.08	0.74	No	-0.15
Scenario II	SRP CCP	stage	26	-0.07	0.72	No	-0.12
	SRP CCP	S5A_SRP	26	0.002	0.99	No	0.25
	SRP CCP	G302_SRP	26	-0.09	0.65	No	0.16
	SRP CCP	velocity	26	0.08	0.7	No	0.1
	Stage	S5A_SRP	26	0.04	0.86	No	-0.22
	stage	G302_SRP	26	0.06	0.75	No	-0.22
	stage	velocity	26	-0.38	0.05	Yes	-0.37
	S5A_SRP	G302_SRP	26	0.99	<0.001	Yes	0.99
	S5A_SRP	velocity	26	-0.53	0.005	Yes	-0.53
	G302_SRP	velocity	26	-0.53	0.005	Yes	-0.53

	Variable	Variable	N	Spearman Correlation	Spearman P-value	Statistically Significant (a = 0.05)	Pearson Correlation
SRP							
Scenario III	SRP CCP	stage	17	-0.27	0.3	No	-0.18
	SRP CCP	S5A_SRP	17	0.09	0.73	No	0.21
	SRP CCP	G302_SRP	17	-0.05	0.86	No	0.14
	SRP CCP	velocity	17	-0.33	0.19	No	-0.29
	Stage	S5A_SRP	17	0.68	0.003	No	0.67
	stage	G302_SRP	17	0.73	<0.001	Yes	0.69
	stage	velocity	17	-0.2	0.44	No	-0.32
	S5A_SRP	G302_SRP	17	0.98	<0.001	Yes	1
	S5A_SRP	velocity	17	-0.22	0.4	No	-0.1
	G302_SRP	velocity	17	-0.2	0.44	No	-0.06
Scenario IV	SRP CCP	stage	62	0.005	0.97	No	-0.07
	SRP CCP	S5A_SRP	62	0.03	0.81	No	0.15
	SRP CCP	G302_SRP	62	-0.15	0.25	No	-0.006
	SRP CCP	velocity	62	-0.15	0.23	No	-0.21
	Stage	S5A_SRP	62	0.19	0.13	No	0.15
	stage	G302_SRP	62	0.22	0.08	No	0.15
	stage	velocity	62	0.28	0.03	Yes	0.29
	S5A_SRP	G302_SRP	62	0.97	<0.001	Yes	0.98
	S5A_SRP	velocity	62	-0.24	0.06	No	-0.15
	G302_SRP	velocity	62	-0.14	0.27	No	-0.09
TDP							
Scenario I	TDP CCP	stage	17	0.5	0.04	Yes	0.51
	TDP CCP	S5A_TDP	17	0.02	0.93	No	0.06
	TDP CCP	G302_TDP	17	-0.2	0.44	No	-0.25
	TDP CCP	velocity	17	-0.56	0.02	No	-0.49
	Stage	S5A_TDP	17	0.13	0.63	No	0.1
	stage	G302_TDP	17	-0.06	0.82	No	-0.08
	stage	velocity	17	-0.2	0.45	No	-0.19
	S5A_TDP	G302_TDP	17	0.95	<0.001	Yes	0.94
	S5A_TDP	velocity	17	-0.12	0.65	No	-0.14
	G302_TDP	velocity	17	0.03	0.9	No	0.06

	Variable	Variable	N	Spearman Correlation	Spearman P-value	Statistically Significant (a = 0.05)	Pearson Correlation
TDP							
Scenario II	TDP CCP	stage	19	0.31	0.19	No	0.15
	TDP CCP	S5A_TDP	19	-0.25	0.3	No	-0.17
	TDP CCP	G302_TDP	19	-0.43	0.07	No	-0.28
	TDP CCP	velocity	19	0.18	0.51	No	0.33
	Stage	S5A_TDP	19	-0.05	0.85	No	-0.25
	stage	G302_TDP	19	-0.13	0.6	No	-0.3
	stage	velocity	19	-0.29	0.25	No	-0.37
	S5A_TDP	G302_TDP	19	0.97	<0.001	Yes	0.99
	S5A_TDP	velocity	19	-0.41	0.1	No	-0.42
	G302_TDP	velocity	19	-0.39	0.12	No	-0.42
Scenario III	TDP CCP	stage	8	0.33	0.42	No	0.35
	TDP CCP	S5A_TDP	8	0.55	0.16	No	0.54
	TDP CCP	G302_TDP	8	0.45	0.26	No	0.42
	TDP CCP	velocity	8	-0.69	0.06	No	-0.54
	Stage	S5A_TDP	8	0.57	0.14	No	0.44
	stage	G302_TDP	8	0.6	0.12	No	0.41
	stage	velocity	8	-0.36	0.39	No	-0.4
	S5A_TDP	G302_TDP	8	0.98	<0.001	Yes	0.99
	S5A_TDP	velocity	8	-0.19	0.65	No	0.01
	G302_TDP	velocity	8	-0.14	0.74	No	0.09
Scenario IV	TDP CCP	stage	44	0.23	0.13	No	0.11
	TDP CCP	S5A_TDP	44	0.04	0.82	No	-0.05
	TDP CCP	G302_TDP	44	-0.15	0.34	No	-0.23
	TDP CCP	velocity	44	-0.25	0.1	No	-0.07
	Stage	S5A_TDP	44	0.12	0.44	No	0.002
	stage	G302_TDP	44	0.08	0.6	No	-0.04
	stage	velocity	44	0.32	0.04	Yes	0.27
	S5A_TDP	G302_TDP	44	0.98	<0.001	Yes	0.98
	S5A_TDP	velocity	44	-0.07	0.67	No	-0.07
	G302_TDP	velocity	44	0.01	0.93	No	-0.02

	Variable	Variable	N	Spearman Correlation	Spearman P-value	Statistically Significant (a = 0.05)	Pearson Correlation
PP							
Scenario I	PP CCP	stage	17	-0.28	0.29	No	-0.21
	PP CCP	S5A_PP	17	0.29	0.26	No	0.49
	PP CCP	G302_PP	17	-0.47	0.06	No	-0.41
	PP CCP	velocity	17	0.19	0.48	No	-0.18
	Stage	S5A_PP	17	-0.09	0.73	No	-0.07
	stage	G302_PP	17	0.27	0.3	No	0.25
	stage	velocity	17	-0.17	0.52	No	-0.81
	S5A_PP	G302_PP	17	0.54	0.02	Yes	0.47
	S5A_PP	velocity	17	-0.47	0.06	No	-0.06
	G302_PP	velocity	17	-0.49	0.05	No	0.06
Scenario II	PP CCP	stage	19	-0.15	0.53	No	-0.11
	PP CCP	S5A_PP	19	0.18	0.45	No	0.33
	PP CCP	G302_PP	19	-0.21	0.4	No	-0.15
	PP CCP	velocity	19	0.02	0.93	No	0.09
	Stage	S5A_PP	19	-0.35	0.14	No	-0.35
	stage	G302_PP	19	-0.39	0.1	No	-0.3
	stage	velocity	19	-0.22	0.36	No	-0.77
	S5A_PP	G302_PP	19	0.88	<0.001	Yes	0.83
	S5A_PP	velocity	19	0.22	0.37	No	0.16
	G302_PP	velocity	19	0.22	0.38	No	0.22
Scenario III	PP CCP	stage	4	0.8	0.2	No	0.83
	PP CCP	S5A_PP	4	0.8	0.2	No	0.95
	PP CCP	G302_PP	4	0.8	0.2	No	0.84
	PP CCP	velocity	4	0.6	0.4	No	0.09
	Stage	S5A_PP	4	0.4	0.6	No	0.66
	stage	G302_PP	4	0.4	0.6	No	0.5
	stage	velocity	4	0	1	No	-0.1
	S5A_PP	G302_PP	4	1	<0.001	Yes	0.97
	S5A_PP	velocity	4	0.8	0.2	No	0.37
	G302_PP	velocity	4	0.8	0.2	No	0.58

	Variable	Variable	N	Spearman Correlation	Spearman P-value	Statistically Significant (a = 0.05)	Pearson Correlation
PP							
Scenario IV	PP CCP	stage	40	-0.06	0.71	No	-0.08
	PP CCP	S5A_PP	40	0.32	0.04	Yes	0.44
	PP CCP	G302_PP	40	-0.19	0.24	No	-0.13
	PP CCP	velocity	40	0.11	0.5	No	0.11
	Stage	S5A_PP	40	-0.13	0.42	No	-0.01
	stage	G302_PP	40	0.005	0.98	No	0.05
	stage	velocity	40	0.38	0.02	No	0.37
	S5A_PP	G302_PP	40	0.79	<0.001	Yes	0.78
	S5A_PP	velocity	40	-0.03	0.85	No	0.34
	G302_PP	velocity	40	0.03	0.87	No	0.32
DOP							
Scenario I	DOP CCP	stage	16	-0.35	0.18	No	-0.22
	DOP CCP	S5A_DOP	16	0.58	0.02	No	0.46
	DOP CCP	G302_DOP	16	0.01	0.96	No	-0.39
	DOP CCP	velocity	16	0.37	0.16	No	0.48
	Stage	S5A_DOP	16	-0.33	0.2	No	-0.33
	stage	G302_DOP	16	-0.17	0.52	No	-0.04
	stage	velocity	16	-0.21	0.44	No	-0.21
	S5A_DOP	G302_DOP	16	0.79	<0.001	Yes	0.59
	S5A_DOP	velocity	16	0.4	0.13	No	0.41
	G302_DOP	velocity	16	0.23	0.38	No	-0.01
Scenario II	DOP CCP	stage	18	0.47	0.049	Yes	0.60
	DOP CCP	S5A_DOP	18	0.64	0.004	Yes	0.71
	DOP CCP	G302_DOP	18	-0.43	0.07	No	-0.23
	DOP CCP	velocity	18	0.39	0.11	No	0.23
	Stage	S5A_DOP	18	0.46	0.05	Yes	0.43
	stage	G302_DOP	18	-0.09	0.72	No	-0.08
	stage	velocity	18	-0.29	0.25	No	-0.41
	S5A_DOP	G302_DOP	18	0.26	0.3	No	0.41
	S5A_DOP	velocity	18	0.06	0.82	No	-0.01
	G302_DOP	velocity	18	-0.32	0.19	No	0.97

	Variable	Variable	N	Spearman Correlation	Spearman P-value	Statistically Significant (a = 0.05)	Pearson Correlation
DOP							
Scenario III	DOP CCP	stage	7	-0.09	0.85	No	-0.18
	DOP CCP	S5A_DOP	7	0.17	0.72	No	0.2
	DOP CCP	G302_DOP	7	-0.73	0.06	No	-0.75
	DOP CCP	velocity	7	-0.02	0.97	No	0.29
	Stage	S5A_DOP	7	-0.19	0.69	No	-0.23
	stage	G302_DOP	7	0.17	0.72	No	-0.04
	stage	velocity	7	-0.43	0.33	No	-0.47
	S5A_DOP	G302_DOP	7	0.21	0.65	No	0.5
	S5A_DOP	velocity	7	0.89	0.007	Yes	0.94
	G302_DOP	velocity	7	0.39	0.38	No	0.4
Scenario IV	DOP CCP	stage	41	0.08	0.6	No	0.19
	DOP CCP	S5A_DOP	41	0.53	<0.001	Yes	0.55
	DOP CCP	G302_DOP	41	-0.31	0.05	Yes	-0.34
	DOP CCP	velocity	41	0.16	0.32	No	0.16
	Stage	S5A_DOP	41	0.04	0.83	No	0.07
	stage	G302_DOP	41	-0.002	0.99	No	<0.001
	stage	velocity	41	0.28	0.08	No	0.23
	S5A_DOP	G302_DOP	41	0.51	<0.001	Yes	0.51
	S5A_DOP	velocity	41	0.23	0.14	No	0.19
	G302_DOP	velocity	41	0.12	0.46	No	-0.01
TSS							
Scenario IV	TSS CCP	stage	11	0.44	0.18	No	0.37
	TSS CCP	S5A_TSS	11	0.77	0.006	Yes	0.71
	TSS CCP	G302_TSS	11	-0.61	0.04	No	-0.76
	TSS CCP	velocity	11	-0.53	0.1	No	-0.36
	Stage	S5A_TSS	11	0.2	0.55	No	0.23
	stage	G302_TSS	11	-0.53	0.09	No	-0.44
	stage	velocity	11	0.27	0.42	No	0.17
	S5A_TSS	G302_TSS	11	-0.06	0.85	No	-0.17
	S5A_TSS	velocity	11	-0.2	0.55	No	-0.4
	G302_TSS	velocity	11	0.32	0.33	No	0.33

	Variable	Variable	N	Spearman Correlation	Spearman P-value	Statistically Significant (a = 0.05)	Pearson Correlation
CLD							
Scenario I	CLD CCP	stage	28	0.034	0.86	No	0.05
	CLD CCP	S5A_CLD	28	0.035	0.86	No	-0.15
	CLD CCP	G302_CLD	28	-0.24	0.23	No	-0.5
	CLD CCP	velocity	28	-0.16	0.4	No	-0.15
	Stage	S5A_CLD	28	-0.13	0.5	No	-0.18
	stage	G302_CLD	28	-0.07	0.71	No	-0.15
	stage	velocity	28	0.11	0.57	No	0.12
	S5A_CLD	G302_CLD	28	0.92	<0.001	Yes	0.93
	S5A_CLD	velocity	28	0.02	0.91	No	0.11
	G302_CLD	velocity	28	0.12	0.53	No	0.18