SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Florida Power and Light Turkey Point Monitoring

Annual Monitoring Report – August 2011

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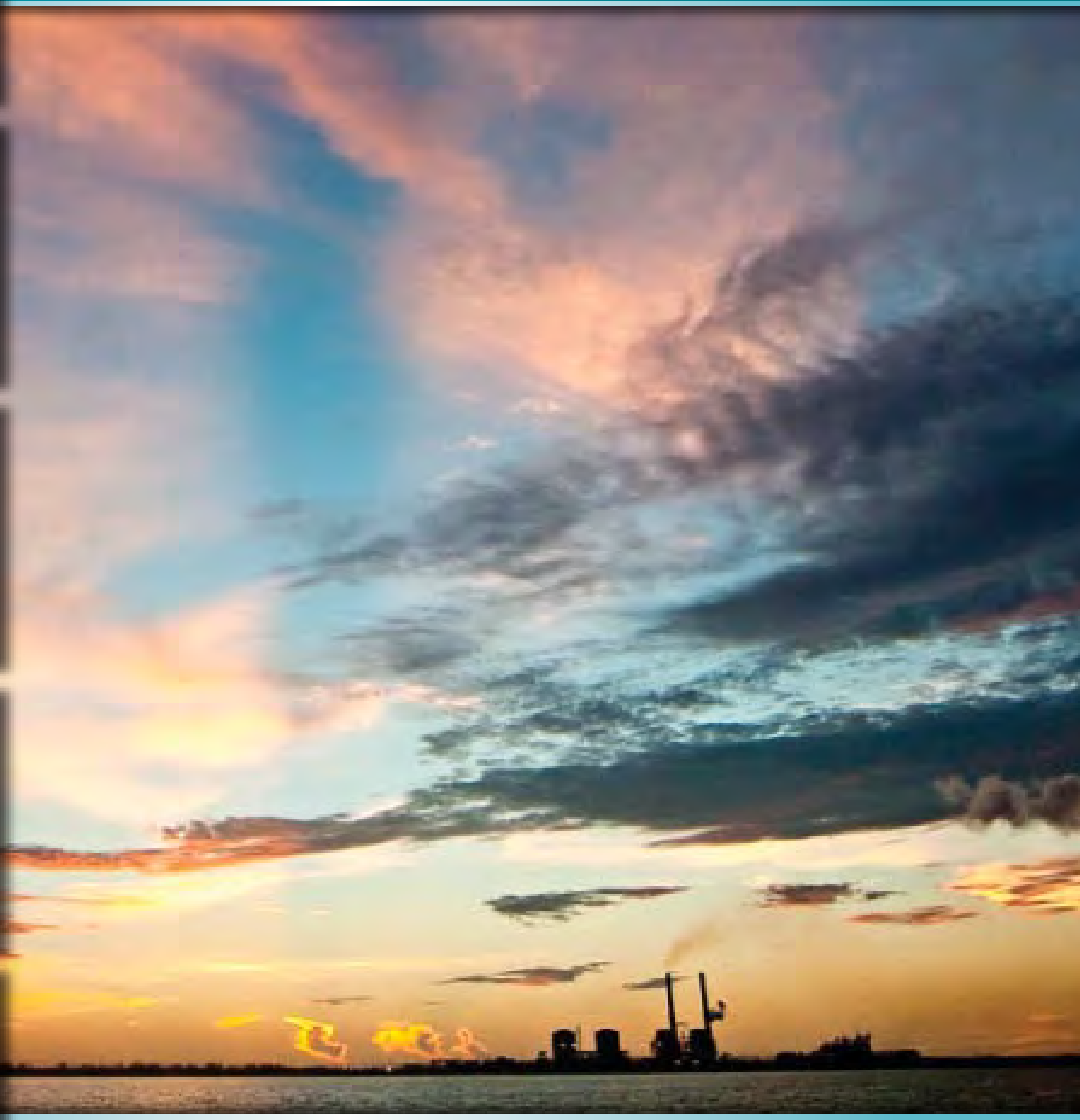
Turkey Point Plant

Annual Monitoring Report

Units 3 & 4 Uprate Project

August 2011



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EXECUTIVE SUMMARY

Florida Power & Light Company (FPL) has prepared an Annual Monitoring Report as a requirement of certification for the Turkey Point Units 3 and 4 Uprate Project. This report is prepared in accordance with the FPL Turkey Point Power Plant Groundwater, Surface Water and Ecological Monitoring Plan, referred to herein as the Monitoring Plan (October 2009). The Monitoring Plan requires the collection of groundwater, surface water, meteorological, flow and ecological data in and around the plant to establish baseline conditions, and to determine the horizontal and vertical effects and extent, if any, of the Cooling Canal System (CCS) water. The primary purpose of this Annual Monitoring Report is to summarize the monitoring efforts to date, to present and summarize the data, and to discuss the results from June 1, 2010, to May 31, 2011.

FPL installed an extensive monitoring network of 47 groundwater wells (42 new wells) and 20 surface water stations, along with automated meteorological stations, rainfall gauges and flow meters in the CCS and surrounding area. Most of the groundwater and surface water stations are automated and measure specific conductivity, salinity, and water levels, with data recorded at 15-minute intervals. Groundwater and surface water samples are collected across the vast network of stations every three months and analyzed for a broad suite of parameters. Water samples have also been collected from the shallow soils (referred to as porewater) at hundreds of locations and analyzed for a similar host of ions and isotopes. Ecological monitoring has been conducted in the mangroves, marsh and Biscayne Bay.

The preliminary results of the monitoring indicate that the parameters of most interest are those related to saltwater (chloride, sodium, specific conductance). Temperature is also of interest per the Conditions of Certification. However, the data collected thus far do not indicate any thermal influences to surface water and porewater. Further the temperature data indicates only one identified, localized and insignificant influence immediately adjacent to the CCS in groundwater. The surrounding ecology is also of interest per the Conditions of Certification; data collected to date do not show any impacts of plant operation.

Chloride concentration in normal seawater is around 19,600 milligrams per liter (mg/L); however, Biscayne Bay chloride levels can exceed 19,600 mg/L during dry periods but do not approach levels typically found in the CCS. Water in the CCS is hypersaline, with chloride levels typically in excess of 30,000 mg/L. In groundwater beneath Biscayne Bay, hypersaline conditions were detected at depth in the well cluster located off the southeast corner of the CCS. Groundwater in wells immediately to the west, north and south of the CCS also exhibited hypersalinity at depths greater than 30 feet below ground surface. These hypersaline conditions diminished with distance from the CCS. A shallow freshwater lens still exists west of the CCS. It is 15 to 20 feet deep from the surface and generally thickens towards the west. The western-most wells are fresh at all depths.

Based on these results, there is no evidence that the CCS is causing the westward movement of the saltwater intrusion line. Saltwater intrusion in the region preceded construction of the CCS. The extent of saltwater intrusion, as defined by the U.S. Geological Survey (USGS), varies from year to year but the landward extent which is west of Tallahassee Road is still similar to that reported in the 1950s. Saltwater intrusion is known to ebb and flow west and east depending on seasonal factors.

There are many factors which can cause saltwater intrusion including groundwater withdrawals, agricultural uses, mining, government water management practices, etc. A comprehensive regional model which takes into account all of the factors that may be contributing to this phenomena would be useful to better assess the causative factors for saltwater intrusion and the effect, if any, that the CCS has on saltwater intrusion. This model needs to account for density differences as well as the effect of groundwater withdrawals and surface and groundwater interactions by potentially responsible parties operating in the vicinity of FPL operations.

FPL and the Agencies successfully developed and agreed to a Monitoring Plan in October of 2009. The required components of the Monitoring Plan were implemented including but not limited to, installing the wells and monitoring equipment. FPL has also collected one year of quarterly data; submitted a semi-annual report; and is now submitting an annual report. The monitoring will continue in a phased manner as described in the Monitoring Plan. FPL and the Agencies will continue to collect data for one more year prior to the commencement of the certified Uprate and will continue to collect data after the Uprate. Completion of this data collection is a critical step if a regional model is to be developed and before any conclusions can be drawn from the data. Since the increase in temperature and salinity is expected to be minimal after the Uprate Project is implemented, there should be no presumption that the Project will cause any impact to the surrounding environment. The post-Uprate monitoring will help determine if there are any measurable impacts.

FPL will continue its monitoring protocol for chlorides, sodium specific conductivity, and a variety of other constituents including tritium, as described in the Monitoring Plan. Tritium is not a public health issue, particularly at the levels being analyzed which are far below drinking water standards. Tritium is being analyzed only as a potential tracer.

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LIST OF ACRONYMS

%	percent
≥	greater than or equal to
°C	degrees Celsius
µmols/m^2/sec	micromole per square meter per second
µS/cm	micro Siemens per centimeter
‰	parts per thousand
1x1	1-meter by 1-meter (subplot)
20x20	20-meter by 20-meter (plot)
5x5	5-meter by 5-meter (subplot)
ADFM	Acoustic Doppler Flow Meter
ADVM	Acoustic Doppler Velocity Meter
AFDW	ash-free dry weight
Agencies	South Florida Water Management District, the Florida Department of Environmental Protection, and Miami-Dade County Department of Environmental Resources Management
ANOVA	analysis of variance
Annual Monitoring Report	Florida Power & Light Company Turkey Point Plant Annual Monitoring Report for the Units 3 and 4 Uprate Project
AT100	Aqua TROLL® 100 (probe)
AT200	Aqua TROLL® 200 (probe)
B	bottom
Ba	barium
BBCA	Braun-Blanquet Cover Abundance
BBSW	Biscayne Bay Surface Water
BNP	Biscayne National Park

BTOC	below top of casing
C	carbon
$CaCO_3$	calcium carbonate
cc	cubic centimeter
CCS	cooling canal system
CCV	continuing calibration verification
CL	carapace length
cm	centimeter(s)
CO_2	carbon dioxide
CW	carapace width
D	deep
DERM	(Miami-Dade County) Department of Environmental Resources Management
D_f	freshwater density
DFA	Discriminant Function Analysis
DIC	dissolved inorganic carbon
DMA	dimethylamine
E & E	Ecology and Environment, Inc.
EDMS	Electronic Data Management System
e.g.	for example
EPA	(United States) Environmental Protection Agency
ETA	Mono-ehanolamine
F.A.C.	Florida Administrative Code
f/s	feet per second
FDEP	Florida Department of Environmental Protection
Fe	iron
FIU-WQM	Florida International University Water Quality Monitoring
FPL	Florida Power & Light Company
ft	foot/feet
ft/d	feet per day
FTT	Faunal Throw Trap
g/cm^3	grams per cubic centimeter

GIS	geographic information system
g/L	grams per liter
GPS	Global Positioning System
GW	groundwater
^3H	tritium
H_f	freshwater equivalent groundwater elevation
HCl	hydrocholoric acid
HCM	hydrological conceptual model
HSD	honestly significant difference
H_w	groundwater elevation
i.e.	that is
ICV	initial calibration verification
ID	Interceptor Ditch
K	potassium
km	kilometer
Li	lithium
LT500	Level TROLL® 500 (probe)
m	meter(s)
M	intermediate
MDL	method detection limit
MGD	million gallons per day
mg/kg	milligrams per kilogram
mg/L	milligram(s) per liter
mL	milliliter(s)
MLC	maximum likelihood classification
Monitoring Plan	Groundwater, Surface Water, and Ecological Monitoring Plan for the Florida Power & Light Company Turkey Point Nuclear Power Plant (2009)
M_P	measured pressure (psi)
MS	Microsoft
mS/cm	milliSiemens per centimeter
MSL	mean sea level

mV	millivolt(s)
NAVD 88	North American Vertical Datum of 1988
ND	Not Detected
NE	northeast
NIST	National Institute of Standards and Technology
NRC	Nuclear Regulatory Commission
NTU	nephelometric turbidity unit(s)
NW	northwest
ORP	oxidation reduction potential
PAR	photosynthetically active radiation
pCi/L	picocuries per liter
PPF	Photosynthetic Photon Flux
ppt	parts per thousand
PSU	practical salinity unit(s)
QA	quality assurance
QAPP	Quality Assurance Project Plan
R_L	reference water level
R_P	reference pressure (psi)
S	Shallow
SAV	submerged aquatic vegetation
SE	southeast
SFWMD	South Florida Water Management District
SG	specific gravity
SL	standard length
SW	surface water; *also* southwest
S_w	well screen midpoint elevation
T	top
TDS	total dissolved solids
TestAmerica	TestAmerica Laboratories, Inc.
TKN	total Kjeldahl nitrogen
TL	total length

TN	total nitrogen
TP	total phosphorus
TPGW	Turkey Point Groundwater
TPM-1	Turkey Point Meteorological Station
TPSWC	Turkey Point Surface Water Canal
TPSWCCS	Turkey Point Surface Water Cooling Canal System
TPSWID	Turkey Point Surface Water Interceptor Ditch
TTA	tolytriazole
USGS	United States Geological Survey
W_L	water level (feet NAVD 88)

1. INTRODUCTION

Florida Power & Light Company (FPL) is pleased to submit its first Annual Monitoring Report. This FPL Turkey Point Plant Annual Monitoring Report for the Units 3 and 4 Uprate Project (Annual Monitoring Report) is prepared in accordance with the FPL Turkey Point Power Plant Groundwater, Surface Water and Ecological Monitoring Plan, referred to herein as the Monitoring Plan (October 2009). The Monitoring Plan requires the collection of groundwater, surface water, meteorological, flow, and ecological data in and around the plant to establish baseline conditions and determine the horizontal and vertical effects and extent, if any, of the cooling canal system (CCS) water. The primary purpose of this Annual Monitoring Report is to summarize the monitoring efforts to date, present and summarize the data, and discuss results.

This Annual Monitoring Report covers data collected from June 1 2010, to May 31 2011. Data were collected in accordance with the FPL Quality Assurance Project Plan (QAPP [FPL August 2010]) and modifications as discussed with the appropriate agencies and updates to the QAPP (revision date pending). Any notable deviations are discussed herein.

1.1 Brief Overview of Automated Monitoring Network

FPL installed an extensive monitoring network to collect groundwater, surface water, meteorological, and hydrologic data at 15-minute intervals over a broad area surrounding Turkey Point. A brief overview of each is provided below and further discussion regarding the instrumentation, data collection, and results for the automated network is included in Section 2 of this report. Photographs of the automated stations are provided in the Semi-Annual Report for the project (submitted February 2011).

1.1.1 Groundwater

From February through June 2010, FPL installed 42 wells in 14 well clusters (TPGW-1 to TPGW-14) at and around Turkey Point (Figure 1.1-1). The locations were determined based on site conditions and extensive coordination among FPL and the SFWMD, the Florida Department of Environmental Protection (FDEP), and Miami-Dade County Department of Environmental Resources Management (DERM) (collectively described herein as the Agencies). The placement of station locations in Biscayne Bay also was coordinated with Biscayne National Park.

Three separate wells were installed at each location: a shallow well (S), an intermediate depth well (M), and a deep well (D). The borehole for the deep well was drilled first and down-hole geophysical methods were conducted to help determine high flow zones and other subsurface characteristics. Based on a collaborative effort among FPL, JLA Geoscience, and the SFWMD, screen depths were established with screen lengths varying from 2 to 6 feet based on site

conditions. Appendix A provides a brief summary of the well construction information and further details are provided in the Geology and Hydrology Report (JLA Geosciences, Inc. 2010).

Following well completion, the top of each well casing was surveyed and infrastructure (probes, telemetry, solar panels, and other elements) was installed to facilitate the collection of automated groundwater quality and stage data at 15-minute intervals. Most of the locations were re-surveyed in June 2011 to confirm the elevations (Appendix B). The measured water quality parameters include specific conductance and temperature. Salinity, density, and total dissolved solids (TDS) are calculated by the instrumentation based on the measured parameters. Groundwater data are remotely transmitted via telemetry each day and uploaded to an FPL electronic data management system (EDMS).

1.1.2 Surface Water

Per the Monitoring Plan and as shown on Figure 1.1-2, automated surface water stations were installed at the following locations:

- seven stations in the CCS;
- five stations in adjacent canals;
- three stations in the Interceptor Ditch; and
- five stations in Biscayne Bay.

Also a non-automated station was located in the CCS (TPSWCCS-8) and one in Card Sound Canal (TPSWC-6).

The locations of the monitoring stations were determined jointly with the Agencies and provide broad coverage of the key water bodies in the project area. Two additional stations (TPBBSW-10 and -14) were added at a later date to record stages in Biscayne Bay and are co-located with TPGW-10 and -14.

Surface water automated stations record water quality data using the same parameters as the groundwater stations. Stage data are recorded at all locations except four stations in Biscayne Bay that do not have the infrastructure to support stage recorders or a telemetry system (TPBBSW-1, TPBBSW-2, TPBBSW-4, and TPBBSW-5). The data at these four Biscayne Bay locations are retrieved manually at approximately six week intervals and downloaded into the database. Data from the other stations are transmitted via telemetry daily onto a secure server system and automatically uploaded into the FPL database.

1.1.3 Meteorological and Rainfall

One meteorological station that includes instrumentation to measure solar radiation, wind speed, wind direction, air temperature, relative humidity, and rainfall was installed near the center of the CCS (TPM-1). Four additional rainfall gauging stations were installed around the CCS. Data are collected at 15-minute intervals. Data from the meteorological station are uploaded daily into the database while the rainfall gauges are manually downloaded during routine site visits.

Seven rainfall collectors were installed around the CCS. Additionally, five evaporation pans have also been installed at various locations. Figure 1.1-3 illustrates the locations of the above-mentioned stations.

1.1.4 Hydrological

Acoustic Doppler Velocity Meters (ADVMs), otherwise known as index-velocity meters or flowmeters, were originally set up to determine flow in the CCS: near the power plant discharge into the CCS, the southern end of the CCS before the water enters the return canal of the CCS, and near the intake into the plant from the CCS. Data is currently being collected from two of the three stations via telemetry and automatically uploaded to the database (Figure 1.1-4).

1.1.5 Water Budget

An approach for the water budget, with input from the Agencies, has been developed for the CCS and is included in the Annual Report in Appendix L. The water budget results will be based on meteorological, hydrological, and water quality data.

1.2 Quarterly Sampling for Laboratory Analysis

The aforementioned monitoring network for groundwater and surface water supports the collection of water samples for laboratory analysis. The Monitoring Plan specifies samples must be collected from the 42 groundwater wells and the 20 surface water stations previously discussed. Samples also must be collected on a quarterly basis from one additional location on the Card Sound Road canal and at an anomalous location (area of possible cooler water) identified by the SFWMD in the CCS for the first quarterly event. The samples are analyzed for a variety of parameters including CCS tracer suite constituents, ions, trace elements, nutrients, TDS, and/or gross alpha, along with field parameters depending on the media and whether the effort was a quarterly or semi-annual event.

Further discussion of the analytical parameters, sample collection methods, and results is provided in Section 3 of this Annual Monitoring Report. The analytical data included in this report are based on four sampling events: June and early July 2010, September 2010, December 2010, and March 2011.

Samples also were collected at five existing wells as part of FPL's routine sampling for the Interceptor Ditch operation. Initially the timing of these sampling events was offset from the monitoring plan sampling events with samples being collected from historic wells L-3, L-5, G-21, G-28, and G-35 in October 2010 and January 2011. Based on discussions with the Agencies following the January 2011 sampling effort, FPL changed the Interceptor Ditch operation sampling to occur in the same month as the monitoring plan sampling. The most recent samples from L-3, L-5, G-21, G-28, and G-35 were collected in March 2011 and all the results are included in the Annual Monitoring Report.

1.3 Ecological Monitoring

The Monitoring Plan and QAPP outline an ecological monitoring program. Biotic components of interest include marsh vegetation in adjacent wetlands, mangroves, submersed aquatic vegetation, and benthic fauna in and adjacent to Biscayne Bay. Ecological monitoring efforts (setting up transects [Figure 1.3-1] and conducting ecological surveys) were initiated in October 2010 and completed in December 2010. Quarterly monitoring in the marsh/mangroves was conducted in February and May 2011. The semi-annual monitoring event for Biscayne Bay was originally scheduled for March 2011, but with Agency concurrence was shifted to April 2011. Information on the transect plot setups, sampling methods and materials, laboratory results, and general findings are included in Section 5 of this Annual Monitoring Report.

1.4 Broad-Scale Porewater Surveys

In accordance with the Monitoring Plan and through coordination with the Agencies, a broad-scale survey of porewater temperature and specific conductance was conducted in March 2010 (dry season) at over 200 locations in adjacent wetlands and Biscayne Bay. A second porewater temperature and specific conductance survey was conducted in August 2010 (wet season) at 100 locations in Biscayne Bay. Based on the initial temperature and specific conductance measurements, locations where porewater samples would be collected for tracer suite laboratory analysis were established. The wet season tracer suite sampling effort took place in October 2010 and the dry season sampling event was conducted in April 2011. As directed by the Agencies, the information will be included in a separate report (Initial Ecological Characterization Report) which will be initiated once all the wet and dry season results are available.

FIGURES

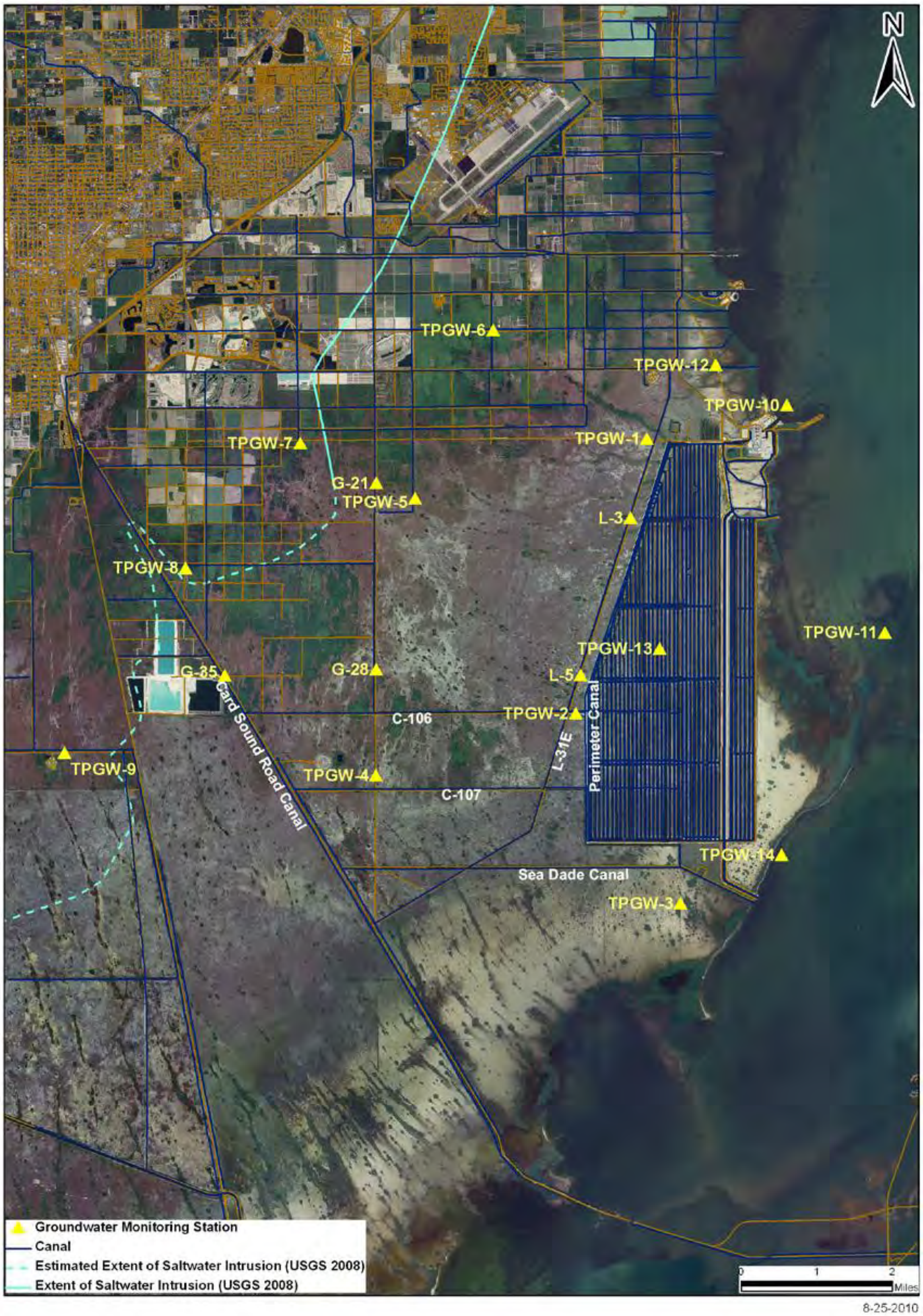

Figure 1.1-1. Locations of Groundwater Monitoring Stations.

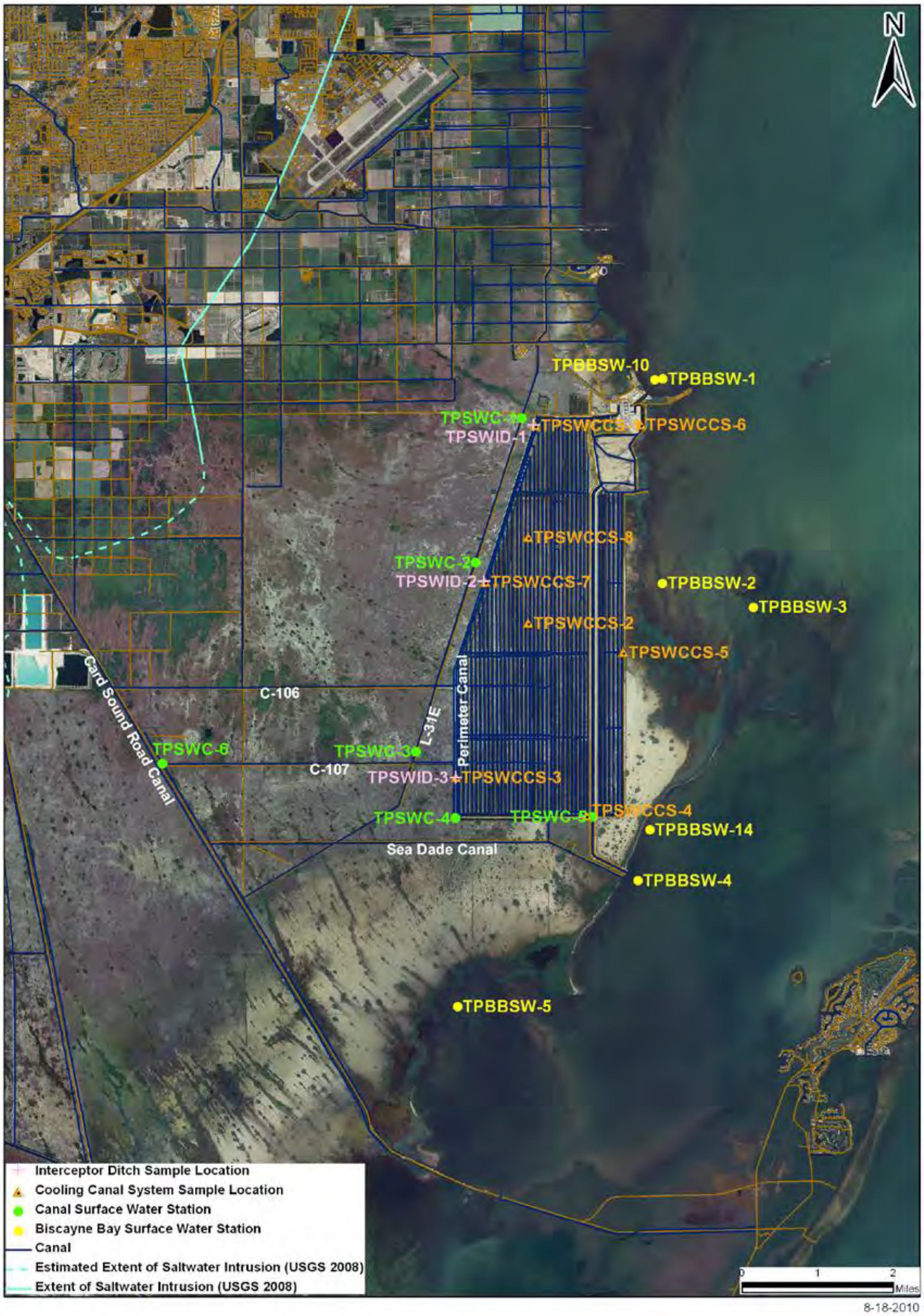

Figure 1.1-2. Locations of Surface Water Monitoring Stations.

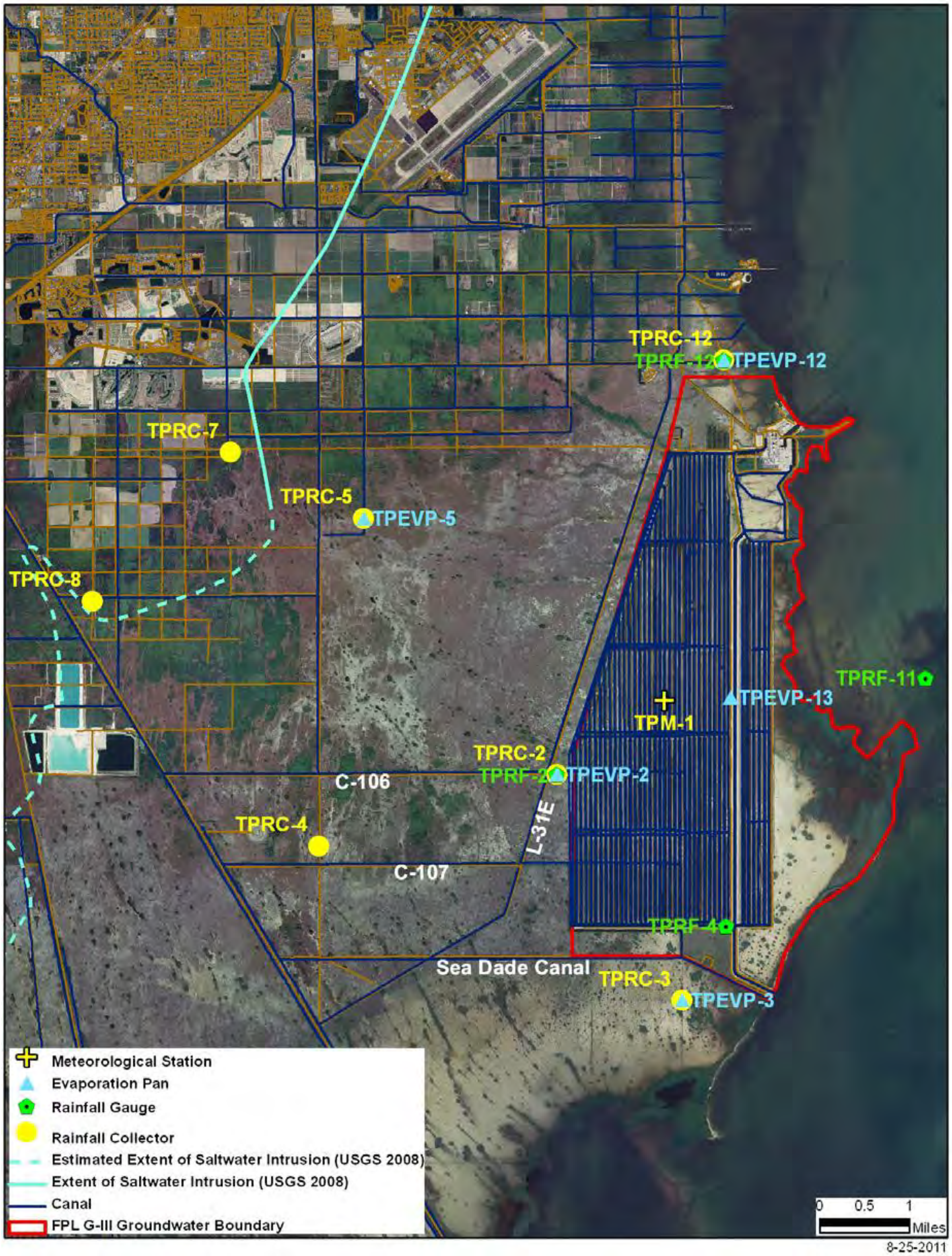

Figure 1.1-3. Locations of Meteorological Station, Rainfall Gauging Stations, Rainfall Collectors and Evaporation Pans.

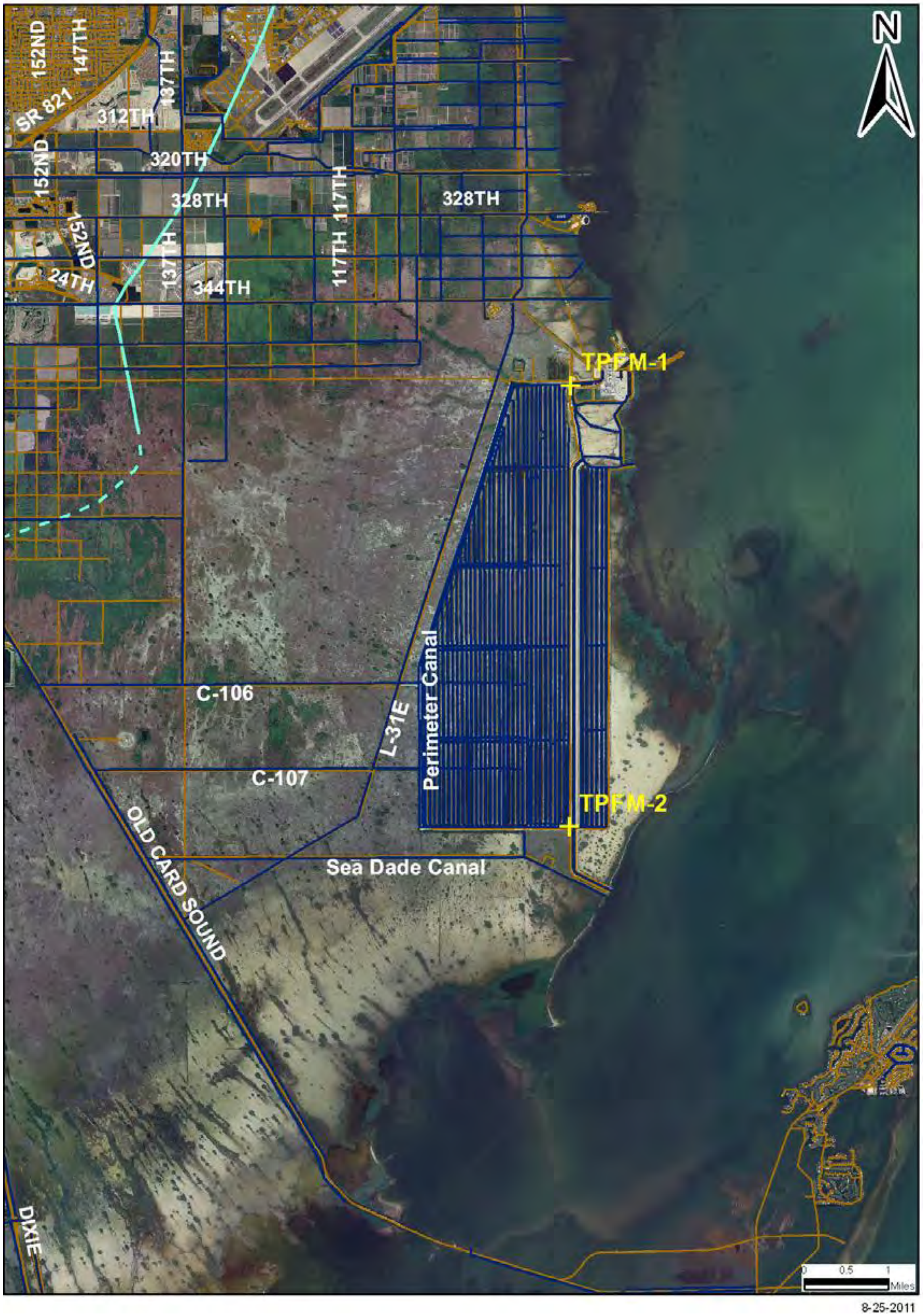

Figure 1.1-4. Flow Meter Locations in the CCS.

Figure 1.3-1. Ecological Transect Locations.

APPENDIX L:

WATER BUDGET

Water Budget

Tetra Tech GEO developed a draft model of the water and solute mass budget for the Turkey Point Plant Cooling Canal System (CCS). The purpose of this model is to quantify the volumes of water and mass of solute entering and exiting the CCS over a period of time. This analysis builds upon a prior study of the CCS water budget (Golder 2008) by revising methods of calculation for the various components of the CCS and by incorporating new hydrological, chemical, and meteorological data collected in and around the CCS between September 2010 and May 2011. This technical section describes the conceptual model of the CCS water budget, including a justification for the control volume upon which calculations are performed. Key calculations and preliminary results are provided to illustrate the components of the water budget model. All assumptions are clearly indicated. These calculations are performed in an Excel spreadsheet and included at the end of Appendix L. Since the approach to calculating the water budget has yet to be approved by the South Florida Water Management District, the Florida Department of Environmental Protection, and Miami-Dade County Department of Environmental Resources Management (Agencies) and further refinements to the assumptions or input parameters may be needed, the results are draft in nature and no conclusions should be drawn from them.

L.1 Conceptual Model

The first step in the modeling process is the development of a hydrological conceptual model (HCM). All data available for the site are assimilated in the HCM in a framework that facilitates the development of a quantitative model. Such data include information about the bathymetry of the CCS, Biscayne Bay, Interceptor Ditch (ID), and the South Florida Water Management District (SFWMD) L31-E Canal. The flows and the chemical characteristics of these water bodies and of the underlying groundwater are thoroughly monitored. These monitoring data are incorporated into the HCM and help to formulate a control volume that is primarily comprised of the CCS.

A control volume defines the entity being analyzed. The transfer of water and solutes within the control volume is not characterized. Rather the water and mass budget model focuses upon the transfer of water and solute into and out of the control volume. The control volume analyzed is comprised of the canals of the CCS and the adjacent ID. Raised earth berms between the individual canals are not considered as a part of the control volume. The base of the control volume is assumed to be the bottom of the ID and the cooling canals, whose elevation ranges from approximately -3 feet mean sea level (MSL) to approximately -30 feet MSL. This interpretation of the control volume was developed based upon the hydrological monitoring plan in place for the CCS. The components of the water budget model for this control volume are depicted on Figure L.1-1. On this figure, the L31-E Canal is red, the ID is green, discharge cooling canals are purple, return canals are dark blue, and Biscayne Bay is light blue.

Water level and quality are measured at seven stations throughout the CCS, three locations in the ID, three stations in L31-E Canal, two locations in other adjacent canals, five locations in Biscayne Bay (three of which measure water level), and 13 wells in the Biscayne Aquifer (at three depths each). These monitoring locations facilitate straightforward calculation of the components of water and solute transfer into and out of the proposed control volume:

- Surface water monitoring stations in the L31-E Canal and the ID permit a straightforward calculation of lateral seepage of water and solute between L31-E and the control volume;
- Surface water monitoring stations in the southernmost collector canal of the control volume and a monitoring station in a canal adjacent and parallel to the southern face of the control volume provide a means to calculate the seepage of water and solute through the southern face of the control volume;
- Surface water monitoring stations in the CCS return canals and in Biscayne Bay facilitate the calculation of seepage between Biscayne Bay and the control volume;
- Surface water monitoring stations in the CCS canals and a groundwater monitoring station beneath the CCS help to define water flow and solute transport through the bottom of the proposed control volume; and
- Meteorological stations in the CCS and immediately to the north and south provide data to calculate the loss of water from the control volume to evaporation and the gain of water to the control volume from precipitation.

The SFWMD proposed an alternative control volume that extends laterally from the west edge of the ID to the east edge of the return canals, from the north edge of the CCS to the south edge of the CCS, and vertically to the base of the Biscayne Aquifer. The primary difference between the control volume proposed by the SFWMD and the one described previously is with regard to the bottom of the control volume. The SFWMD control volume would eliminate calculation of seepage out of the bottom of the CCS and necessitate calculation of groundwater flow through vertical planes at the edges of the CCS and at the base of the Biscayne Aquifer. Tetra Tech GEO believes there are two significant problems with the SFWMD control volume. First, it requires computation of horizontal groundwater flow rates in a location that has complex horizontal and vertical flow patterns due to density differences set up by concentrations that vary from essentially fresh to hypersaline across an approximate 100-foot vertical interval. Tetra Tech GEO knows of no circumstance where this calculation has been made with any degree of accuracy using field data. Second, the SFWMD control volume does not optimally make use of the data collected as a part of the monitoring program. The monitoring program has numerous surface water stage and concentration measurement points within the CCS that can be used to compute flows based on the head difference between the CCS and groundwater beneath the CCS (that has essentially the same density as the surface water). The monitoring program is not optimized to compute horizontal groundwater flow at this location. This type of computation would require pairs of cluster wells at various locations along the ID or the L31-E Canal. Tetra Tech GEO believes it is more appropriate to characterize the transfer of water between the groundwater and the CCS using the data that have been collected as a part of the monitoring program.

L.2 Water Budget Calculations

As Figure L.1-1 depicts, the water budget for the proposed control volume is comprised of seepage (lateral through the sides and vertical through the bottom), blowdown (additional water pumped from other units to the CCS), precipitation (including runoff from earth berms between canals), and evaporation. Water pumped into and out of the CCS from Units 1 through 4 is also a component of inflow to and outflow from the control volume; however, these flows are assumed to be equal and have a net zero effect on the water and mass balances. Seepage to and from the control volume comprises a significant component of the water budget. The approach to calculating seepage to and from the control volume, as well as necessary assumptions, is provided below. Other means by which water is transferred (e.g., evaporation) are calculated in distinct manners and are discussed separately. Calculations were performed for a nine-month period from September 2010 through May 2011 in order to demonstrate the procedure for water budget calculation. Average flows into and out of the control volume were calculated for each day of this period. The average daily flows were summed to estimate the amount of water that enters or exits the control volume during each month and the entire nine-month period. These calculations are intended to demonstrate the methodology, provide preliminary results for assessment, and provide further insights into refinements to the methodology or assumptions. Since the methodology to calculate water budgets has yet to be approved by the Agencies and further refinements to the assumptions or input parameters may be needed, the results are draft in nature and no conclusions should be drawn from them.

The general equation for seepage flow employed in the water budget analysis is:

$$Q = C \times \Delta \boldsymbol{h} \qquad (1)$$

where:

Q ≡ Volumetric flow, $[L^3/T]$

Δh ≡ Head gradient between control volume and external source/sink, [L]

C ≡ Conductance of the media between the control volume and the external source/sink with which it is transferring water, $[L^2/T]$

$$C = \frac{K * A}{D} \qquad (2)$$

where:

K ≡ Hydraulic conductivity of the media through which water flows, [L/T]

A ≡ Area of the face of the control volume through which water flows, [L^2]

D ≡ Distance water flows between the external source/sink and the control volume, [L]

In accordance with widely accepted modeling convention, flow into the control volume is positive (+) and flow out of the control volume is negative (-). Calculated flows are reported in 10 million gallons per day (mgd).

The mass flux into or out of the control volume is calculated by multiplying the volumetric flow by the salinity of the body of water from which the water is flowing. Salinity was monitored at all groundwater and surface water stations employed in the ensuing calculations and was reported in practical salinity units (PSU), which is equivalent to grams per liter (g/L). Calculated mass fluxes are reported in thousands of pounds per day (lb x 1000/day).

The data monitoring locations, seepage face dimensions (where relevant), additional equations, and assumptions that support the estimation of the individual components of the water budget for the control volume are discussed below. Draft results of water and mass budgets for the entire nine-month period are discussed in Section L-4 and provided at the end of this appendix.

L.2.1 Seepage to/from the L31-E Canal (Western Seepage)

Three surface water monitoring stations measure the water levels and salinities in the L31-E Canal (TPSWC-1, TPSWC-2, and TPSWC-3). Three corresponding stations (at similar longitudes) measure water levels and salinities in the ID (TPSWID-1, TPSWID-2, and TPSWID-3). The locations of these monitoring stations are plotted on Figure L.2-1.

Using data recorded at these monitoring stations, the seepage through the west face of the control volume was calculated. In order to calculate this seepage, the western face of the control volume was subdivided into two sub-faces (Figure L.2-1). For this calculation, the following assumptions were made and seepage face dimensions were estimated:

- TPSWC-1, TPSWC-2, and TPSWC-3 were used to interpolate water levels and salinity along the L-31E;
- TPSWID-1, TPSWID-2, and TPSWID-3 were used to interpolate water levels and salinity along the ID;
- The northernmost section of the west seepage face is approximately 18,800 feet long; the southernmost section of the west seepage face is approximately 10,200 feet long;
- Along the northernmost section of the west seepage face, L31-E and the ID are separated by approximately 950 feet; the average separation between the two canals in the southernmost portion is approximately 2,434 feet; and
- The elevation of the base of the ID is approximately -20 feet MSL.

The subdivision of seepage through the west face of the control volume is based on the orientation of the L31-E Canal. The conductance of and seepage through each of the sub-faces were calculated using Equations (1) and (2). The resulting component of the water budget is presented in Table L.2-1. Mass budget estimates for this seepage face were calculated by multiplying the salinities in the sources of water by the calculated flow (Table L.2-2). For instance, where the flow was to be calculated into the control volume, the salinity of L-31E would be multiplied by the calculated flow to derive the mass flux of this budget component.

L.2.2 Southern Seepage

Seepage through the south face of the proposed control volume is primarily driven by the water levels in the southern end of the CCS and in the canal adjacent to the southern edge of the control volume. One monitoring station records water levels and salinity in the southern end of the CCS (TPSWCCS-4). Likewise, one monitoring station measures water levels and salinity in the adjacent canal (TPSWC-4). These monitoring stations are plotted on Figure L.2-2.

Using observed data recorded at these monitoring stations, the seepage through the south face of the control volume was calculated. For this calculation, the following assumptions were made and seepage face dimensions were estimated:

- Water levels and salinities measured in TPSWC-4 are representative of the southern external canal;
- Water levels and salinities measured in TPSWCCS-4 are representative of the southern CCS collector canal;
- The depth of the southern CCS Canal is assumed to be that at TPSWCCS-4, where the canal bottom is an approximate elevation of -22 feet MSL; and
- The length of the seepage face is approximately 9,300 feet.

The southern external canal is 155 feet south of and parallel to the bottom edge of the CCS.

The application of data observed at TPSWC-4 to the entire southern canal was necessitated by the absence of other monitoring stations in this external canal. Likewise, TPSWCCS-4 is, by far, the most proximate and relevant monitoring station to the seepage face. The conductance for this seepage face was calculated using Equation (2). The flow through this seepage face was subsequently calculated by Equation (1) using water level differences between the two monitoring stations. The calculation flow associated with this component of the water budget is provided in Table L.2-1. Salinities of the source water were multiplied by the calculated flows in order to estimate the solute mass flux and total mass through this seepage face (Table L.2-2).

L.2.3 Eastern Seepage

Seepage through the eastern face is assumed to flow into the control volume from Biscayne Bay or out of the control volume into Biscayne Bay. In order to calculate this seepage, the eastern face of the control volume was subdivided into two sub-faces (Figure L.2-3). Canal depths at these two locations and stage variation within the CCS necessitated the subdivision of the eastern seepage face. The elevation of the canal bottom at TPSWCCS-5 is approximately -22 feet MSL; the elevation of the canal bottom in the vicinity of TPSWCCS-6 is lower (approximately -30 feet MSL). Water characteristics in Biscayne Bay are observed at a number of monitoring stations along the seepage face; the monitoring station at which data were accurately measured during the 14-day analysis period was TPBBSW-3.

Using observed water levels from these three monitoring stations, the seepage through the east face of the control volume was calculated. For this calculation, the following assumptions were made and seepage face dimensions were estimated:

- TPSWCCS-5 water levels and salinities effectively reflect conditions in the return canal adjacent to the southernmost seepage sub-face;
- TPSWCCS-6 water levels and salinities effectively reflect conditions in the return canal adjacent to the northernmost seepage sub-face (TPSWCCS-5 salinity employed when data were not available for TPSWCCS-6);
- Reliable water levels at TPSWCCS-6 were not available for most of September 2010 and all of April and May 2011; water levels during these times were estimated from the measurements at TPSWCCS-5 by adding the average difference in water levels between the two sensors to TPSWCCS-6;
- TPBBSW-3 water levels and salinities are representative of Biscayne Bay along the eastern seepage face of the return canals;
- TPBBSW-10 water levels and salinities are representative of Biscayne Bay along the intake canal seepage face (water level and salinity measurements at TPBBSW-3 and -4 were employed when data were not available for TPBBSW-10);
- The average elevation of the canal bottom along the southernmost seepage sub-face is assumed to be -22.5 feet MSL (elevation at TPSWCCS-5);
- Interval-valued bathymetric data defines a range of depths below water for the northernmost seepage sub-face between 20 and 40 feet. Based on these data, an approximate elevation of the canal bottom was defined to be -30 feet MSL;
- The length of the southernmost seepage sub-face is approximately 22,500 feet; and
- The length of the northernmost seepage sub-face is approximately 8,340 feet.

The conductance for this seepage face was calculated using Equation (2). The flow through this seepage face was subsequently calculated by Equation (1) using water level differences between each of the two monitoring stations in the control volume and the Biscayne Bay monitoring station. The calculation of flow associated with this component of the water budget is provided in Table L.2-1. Salinities of the source water were multiplied by the calculated flows in order to estimate the solute mass flux and total mass through this seepage face (Table L.2-2).

L.2.4 Northern Face Seepage

Seepage through the northern face of the control volume (Figure L.2-4) is defined by the difference in water levels between the northernmost discharge canal of the CCS and shallow groundwater levels to the north of the control volume. TPSWCCS-1 is the monitoring station most proximate to the northern seepage face. Groundwater levels were interpolated along a transect that is parallel to the northern edge of the CCS, starts at a point with the same latitude as TPGW-12 and same longitude at TPSWCCS-1, intersects TPGW-12, and terminates at a point with the same latitude at TPGW-12 and the same longitude as plant outflow meter TPFM-1. Groundwater levels along this transect were interpolated based on data recorded at shallow monitoring wells TPGW-6, TPGW-10, and TPGW-12.

Using observed water levels from the CCS monitoring station and interpolated shallow groundwater levels along the transect (depicted on Figure L.2-4) the seepage through the north face of the control volume was calculated. For this calculation, the following assumptions were made and seepage face dimensions estimated:

- Water levels and salinities measured in TPSWCCS-1 applied to the entire north canal of the control volume (TPSWCCS-7 data were used when TPSWCCS-1 data were not reliable);
- A hydraulic gradient was calculated along a straight line between TPGW-6 and TPGW-12; this gradient was employed to estimate groundwater levels along the transect west of TPGW-12;
- A hydraulic gradient was calculated along a straight line between TPGW-12 and TPGW-10; the gradient was employed to estimate groundwater levels along the transect east of TPGW-12;
- The salinity at TPGW-12 was assumed to apply across the length of the transect;
- Length of the seepage face is the lateral distance between TPSWCCS-1 and TPFM-1;
- The distance between the northern edge of the CCS and the transect is the difference between the latitudes of TPGW-12 and TPFM-1; and
- Based on bathymetry data, the elevation of the bottom of the CCS varied from -10 to -25 feet MSL along the northern canal.

The conductance for this seepage face was calculated using Equation (2). The flow through this seepage face was subsequently calculated by Equation (1) using water level differences between the monitoring station in the control volume and interpolated shallow groundwater levels along the transect. The calculation of flow associated with this component of the water budget is provided in Table L.2-1. Salinities of the source water were multiplied by the calculated flows in order to estimate the solute mass flux and total mass through this seepage face (Table L.2-2).

L.2.5 Bottom Seepage

The calculation of flow through the bottom of the control volume employed monitoring data from four shallow groundwater wells located beneath and adjacent to the control volume (TPGW-13, TPGW-1, TPGW-3, and TPGW-11) and four monitoring stations in the CCS (TPSWCCS-1, TPSWCCS-2, TPSWCCS-4, and TPSWCCS-5). For this calculation, the control volume was subdivided into four zones (Figure L.2-5), based on the locations of the CCS monitoring stations and the conceptualization of bottom seepage to and from the control volume (primarily downward flow in the northern and middle portions of the discharge cooling canals; primarily upward flow in the return canals). The seepage through each zone of the control volume was calculated; bottom seepage was calculated by summing the flows through the four zones.

Surface water levels and salinity for each zone were defined to be those measured at the monitoring station within the zone (e.g., water levels and salinity observed at TPSWCCS-1 were applied to Zone A; TPSWCCS-2 to Zone B; TPSWCCS-4 to Zone C; and TPSWCCS-5 to Zone D). In general, water levels decreased from Zone A to Zone D. Groundwater levels beneath each zone were defined based upon proximate groundwater monitoring stations (Zone A: TPGW-1; Zone B: TPGW-13; Zone C: TPGW-3; and Zone D: TPGW-10). Groundwater salinity flowing into Zones A, B, and C was assumed to be that observed at TPGW-13; groundwater flowing into Zone D was assumed to have salinity similar to TPGW-10. The thickness of the seepage face varied amongst the zones, since the approximate average elevation of canal bottoms for each zone varied (as approximated from bathymetric survey data).

The calculation of seepage through the bottom of the control was predicated on the following simplifying assumptions:

- Groundwater levels beneath each zone are reflected by the groundwater levels at underlying or proximate monitoring wells, as described above;
- Groundwater salinity at shallow well TPGW-13 is representative of the water quality beneath Zones A, B, and C; groundwater quality of TPGW-10 is assumed to be more representative of the groundwater flowing into much of the return canals;
- The elevation of the canal bottom as representative for each zone was interpreted from bathymetric survey data and assumed to be constant throughout the zone;
- The surface water level and salinity observed at a monitoring station within each zone was applied to the entire zone, as described above; and

- Water levels employed in the seepage flow calculation were not adjusted for density; however, consideration will be made for future calculations to account for density differences at points where concentration differences exist (e.g., TPGW-10).

Based on these assumptions, the conductance of, and flows through, the four zones were calculated using Equations (2) and (1), respectively. The calculated flow is provided in Table L.2-1. Mass flux was calculated by multiplying the volumetric flow by the salinity of the source (Table L.2-2).

L.2.6 Evaporation

The estimation of evaporative loss from the control volume is a unique case of evaporation from a surface water body due to the elevated heat of water entering the CCS from the FPL Turkey Point power plant and the variability of salinity of water in the control volume. The elevated heat of water has the general effect of increasing evaporative loss, whereas salinity is inversely proportional to the rate of evaporation (Salhotra et al. 1985).

Numerous approaches for estimating evaporation have been developed; they generally fall into two categories: energy balance methods and Dalton Law methods. The former method is widely applied to surface water bodies in spite of being a "costly and time-consuming method" (Mosner and Aulenbach 2003). This approach to calculating evaporative losses requires calculation of individual components of energy flux into and out of the control volume due to solar radiation, surface water, groundwater, and precipitation. Evaporative loss is then indirectly estimated as the difference between net energy flux from the control volume and the sum of the individual calculated energy flux components (Lensky et al. 2005; Mosner and Aulenbach 2003). This indirect approach can necessitate the detailed measurement of solar radiation, fraction of penetrating solar radiation, brine mass, and cloud cover, and can be unreliable for water bodies with elevated temperatures (Leppanen and Harbeck 1960; Bowen 1926).

The Dalton Law approach, on the other hand, relies upon an understanding of the vapor pressure gradient between the surface water and the overlying air, as well as the wind speed above the surface water. Use of this method is limited in practice since wind speed is often the least known parameter in evaporation estimation (Lensky et al. 2005).

For the control volume, wind speeds are measured at 15-minute intervals at meteorological station TPM-1 (Figure L.2-6) and at one-hour intervals north and south of the control volume. As such, the Dalton Law approach is employed herein to estimate the rate of evaporative loss, E, from the control volume. The general form of the equation is:

$$E = f(W) \cdot \{\beta \cdot e_{sat}(T_S) - \psi \cdot e_{sat}(T_A)\} \text{ [L/T]} \quad (3)$$

where

$f(W)$ ≡ wind function; W is wind speed, [L/T]

$\beta \equiv$ coefficient of water activity

$e(T) \equiv$ saturation vapor pressure [$M/(LT^2)$]

T_S, $T_A \equiv$ temperature of surface water and air, respectively [°C]

$\psi \equiv$ relative humidity [%]

The wind function, f(W), is an empirically derived formula that uses wind speed at 2 meters above the surface to quantify the effect of air convection above the water surface on the rate of evaporation. The thermal loading of the FPL power plant can increase forced convection at the north end of the control volume. Approaches to explicitly consider free and forced convection are available (Adams et al. 1990), though they are tailored to estimating energy lost due to evaporation rather than water lost due to evaporation. Though free and forced convection are not explicitly characterized herein, the wind function employed in these calculations was derived for heated cooling water and is given by the following equation:

$$f(W) = 0.301 + 0.113 \cdot W \tag{4}$$

where wind is measured in meters per second (m/s) (Williams and Tomasko 2009).

The coefficient of water activity, β, varies in the range [0, 1] and is intended to account for the reduced evaporation from saline water bodies. It decreases with increasing salinity; at salinity levels in the CCS, β does not vary significantly (Salhotra et al. 1985) and is conservatively assumed to be 0.9.

The saturation vapor pressure relationship used in these calculations accounts for elevated water saturation gradients that result from heated water and provides reliable estimates of saturation vapor pressure for temperatures up to 40 degrees Celsius (°C) (Jobson and Schoelhamer 1987):

$$e_{sat}(T) = \exp\left(52.4185 - \frac{6788.6}{T - 273.16} - 5.0016 \cdot \ln(T + 273.16)\right). \tag{5}$$

Temperature of surface water at monitoring stations TPSWCCS-1, TPSWCCS-2, TPSWCCS-4, and TPSWCCS-5 were used in the calculation. Air temperature and relative humidity are measured at meteorological station TPM-1 and were used in the calculation.

In order to estimate evaporative loss, the control volume was subdivided into four zones. Zone 1 covers the northern area of the discharge canals; wind speeds applied to this zone are measured north of the control volume and water temperatures are measured at TPSWCCS-1. Zone 2 covers the middle area of the discharge canals; wind speeds applied to this zone are measured at TPM-1 and water temperatures are measured at TPSWCCS-2. Zone 3 covers the south area of the discharge canals; wind speeds applied to this zone are measured south of the control volume and water temperatures are measured at TPSWCCS-4. Zone 4 covers the return canals; wind speeds applied to this zone are measured at TPM-1 and water temperatures are measured at TPSWCCS-5.

Additional assumptions made in order to estimate evaporative flux include:

- The air temperature and relative humidity measured at TPM-1 are applicable to the entire control volume;
- Wind speeds north and south of the control volume were measured at 10 meters above ground surface; an empirical relationship between wind speed and elevation was used to estimate wind speeds at 2 meters above ground surface at these stations; and
- Wind speeds employed in evaporative loss calculations were daily averaged values.

Calculated water flow from the control volume due to evaporation is provided in Table L.2-1. No solute mass is lost from the control volume to evaporation.

L.2.7 Precipitation

Precipitation is measured at the site at meteorological station TPM-1 every 15 minutes. Precipitation-based flow into the control volume is simply the sum of measured rainfall occurring during the period of analysis, which is assumed constant over the control volume. Quantities of water entering the control volume due to precipitation are provided in Table L.2-1. No solute enters the control volume through the precipitation. Runoff into the control volume from earth berms between canals is assumed to be 50% of precipitation that falls on the berms.

L.2.8 Blowdown

Blowdown refers to water added to the control volume from a number of sources: the Unit 5 cooling tower (originally Floridan water), Miami-Dade wastewater, and Units 1 through 4. Flow from blowdown into the control volume is assumed to be a constant 7.8 MGD; this is an approximate value employed in a previous study of the CCS water balance (Golder 2008). Since the blowdown water is comprised of partially evaporated Floridan Aquifer water (from the Unit 5 cooling towers), wastewater and hyper-saline water from Units 1 through 4, the salinity of this water is assumed to be equal to 25% of seawater, 8.75 g/L.

L.3 Storage

The gain/loss of water and solute mass within the control volume during some period of time results in a change in the control volume's water and solute mass storage. Increased water storage, for instance, occurs when more water enters the control volume than exits. Storage, then, can be estimated by summing all of the components of the water (and solute mass) budgets. When the net flow is positive (into the control volume) during a specified period of time, the storage of control volume increases. Conversely, a net negative (out of the control volume) flow implies a decrease in storage during a specified time period.

Another manner in which a change in storage can be estimated relies on direct measurements of water levels and salinities within the control volume. A change in water level within the control

volume can be calculated as a difference between water levels at the beginning and end of a specified time period. The product of this change in water levels and the surface area of the control volume provide an estimate of the change in the volume of water contained in the control volume during that period of time. Because the sides of the cooling canals slope away from berms, the surface area of the control volume changes with water level. Thus, this method of calculating the change in storage due to changes in water level requires fairly detailed information on canal side slope. As such, estimates of storage changes derived from this method are used as validation of water balance results (see Section L4.4).

L.4 Results

The individual components of the water budget were calculated for each month from September 2010 through May 2011, as well as for the collective nine-month period. The latter draft results are summarized in Table L.4-1. The modeled net flow of water, as calculated by the summing the components of the water budget is denoted as the "Modeled Change in CCS Storage" was calculated to be an average outflow of 4.1 MGD. This modeled nine-month net loss of water was achieved by calibrating the flow budget model to the nine individual monthly changes in storage. This was achieved by adjusting the hydraulic conductivities of the hydrogeological units surrounding the control volume. The horizontal hydraulic conductivities laterally adjacent to the control volume were calibrated to be approximately 20 feet per day (ft/d). The calibrated vertical conductivities beneath the control volume ranged from 2 to 10.3 ft/d. The higher vertical conductivity corresponds to the material beneath the return canals; it is assumed that the deepest return canals intersect a high flow zone underlying the muck and Miami limestone. A vertical conductivity of 10.3 ft/d reflects an average hydraulic conductivity weighted by the degree to which portions of the seepage face intersect muck, Miami limestone and the high flow zone. These values are consistent with the hydraulic parameters calibrated by Bechtel (2011) in their model of Units 6 and 7 for the muck (K_h = 12.5 ft/d) and Miami limestone K_v =16.7 ft/d).

The drop in average water levels in the CCS was 0.47 foot over the nine-month period, which indicates an average net loss of 2.63 MGD in water over that time period (denoted as measured change in CCS storage in Table L.4-1. The modeled nine-month change in storage matches this measured value quite well. All results are draft and further refinement may be necessary. Some of the input parameters or assumptions may be changed as more data are collected and a better understanding of the hydrogeological system is obtained.

The modeled daily change in storage in the control volume can be calculated by summing all components of the water budget for each day of the modeled period. These daily net flows can be converted to daily changes in the average CCS water level by dividing the surface area of the control volume. The daily modeled changes in water level can be compared to the actually average measured water level in the CCS to validate the conceptual model. This comparison is shown on Figure L.4-1, where it is evident that the model matches measured surface water levels very well. Because the water level in the CCS was not explicitly employed in the calibration of the flow budget model, the ability of the calibrated model to effectively match observed water levels in the CCS over the nine-month period is a validation of the conceptual model and methodology employed herein.

The associated mass budget for the control volume is calculated in a manner analogous to the water budget. As mentioned previously for each component of the budget analysis, the mass flux associated with each component of the water budget is calculated by multiplying the concentration of the source water by the calculated volumetric flow. The resulting estimates of mass flux are summed to produce a net flow of mass into or out of the control volume. These draft estimates for the nine-month period are presented in Table L.2-2. Results for the monthly water and mass balances are provided in Tables L4.4-1 through L4.4-18.

Based upon the analyses presented herein it is clear that the conceptualization of the control volume at the cooling canals and the interceptor ditch is appropriate; moreover, the efficacy of approach described herein for calculating flow into and out of the control volume can potentially produce reasonable estimates of the overall water balance. The next step is to obtain concurrence on the methodology with the Agencies and to determine if further refinement to some of the input parameters or assumptions is needed. The computation and analysis of the CCS water budget will extend over a continuous period of at least two years. These subsequent results will be more appropriate for comparison to other data for verification purposes.

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TABLES

Table L.2-1. Water Budget for 9-Month Period (September 2010 through May 2011)

Water Budget Component		Flow (MGD)	Volume (gal x 10^6)
Into CCS	W. Seepage	*0.02*	*5.81*
	E. Seepage	0.37	100.83
	N. Seepage	*0.00*	*0.00*
	S. Seepage	*0.10*	*27.19*
	Bot Seepage	41.98	11461.22
	Precipitation and Runoff	22.15	6046.16
	Evaporation	0.00	0.00
	Blowdown	7.80	2129.40
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total In:	***72.42***	***19770.61***
Out of CCS	W. Seepage	*0.00*	*-0.07*
	E. Seepage	-0.10	-26.99
	N. Seepage	*0.00*	*-0.39*
	S. Seepage	*0.00*	*-0.08*
	Bot Seepage	-22.47	-6135.65
	Precipitation and Runoff	0.00	0.00
	Evaporation	-53.95	-14729.43
	Blowdown	0.00	0.00
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total Out:	***-76.53***	***-20892.60***
Modeled Change in CCS Storage:		***-4.11***	***-1121.99***

Note: Italicized terms calculated with qualified water level data

Table L.2-2. Solute Mass Budget for 9-Month Period (September 2010 through May 2011)

Mass Budget Component		lb/day (x1000)	Mass (lb x 1000)
Into CCS	W. Seepage	*0.14*	*37.55*
	E. Seepage	*111.24*	*30368.73*
	N. Seepage	*0.00*	*0.34*
	S. Seepage	*17.48*	*4773.27*
	Bot Seepage	*12813.38*	*3498051.70*
	Precipitation and Runoff	0.00	0.00
	Evaporation	0.00	0.00
	Blowdown	569.57	155493.66
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total In:	***13511.81***	***3688725.26***
Out of CCS	W. Seepage	*-3.08*	*-839.94*
	E. Seepage	*-38.43*	*-10490.35*
	N. Seepage	*-0.60*	*-162.92*
	S. Seepage	*-0.12*	*-31.40*
	Bot Seepage	-9542.52	-2605108.63
	Precipitation and Runoff	0.00	0.00
	Evaporation	0.00	0.00
	Blowdown	0.00	0.00
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total Out:	***-9584.74***	***-2616633.24***
Modeled Change in CCS Storage:		***3927.08***	***1072092.02***

*Italicized terms calculated with qualified water level and water quality data

Table L.4-1. Water Budget for September 2010

Water Budget Component		Flow (MGD)	Volume (gal x 10^6)
Into CCS	W. Seepage	*0.02*	*0.48*
	E. Seepage	0.19	5.80
	N. Seepage	0.00	0.00
	S. Seepage	*0.10*	*3.13*
	Bot Seepage	21.36	640.82
	Precipitation and Runoff	86.27	2588.12
	Evaporation	0.00	0.00
	Blowdown	7.80	234.00
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total In:	***115.74***	***3472.35***
Out of CCS	W. Seepage	*0.00*	*0.00*
	E. Seepage	-0.13	-3.91
	N. Seepage	0.00	-0.01
	S. Seepage	*0.00*	*0.00*
	Bot Seepage	-16.20	-485.99
	Precipitation and Runoff	0.00	0.00
	Evaporation	-66.64	-1999.27
	Blowdown	0.00	0.00
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total Out:	***-82.97***	***-2489.19***
Modeled Change in CCS Storage:		***32.77***	***983.16***

Note: Italicized terms calculated with qualified water level data.

Table L.4-2. Solute Mass Budget for September 2010

Mass Budget Component		lb/day (x1000)	Mass (lb x 1000)
Into CCS	W. Seepage	*0.03*	*1.00*
	E. Seepage	43.04	1291.09
	N. Seepage	0.00	0.15
	S. Seepage	*4.29*	*128.68*
	Bot Seepage	7821.84	234655.18
	Precipitation and Runoff	0.00	0.00
	Evaporation	0.00	0.00
	Blowdown	569.57	17087.22
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total In:	***8438.78***	***253163.31***
Out of CCS	W. Seepage	*0.00*	*0.00*
	E. Seepage	-52.55	-1576.64
	N. Seepage	-0.16	-4.92
	S. Seepage	*0.00*	*0.00*
	Bot Seepage	-6574.94	-197248.07
	Precipitation and Runoff	0.00	0.00
	Evaporation	0.00	0.00
	Blowdown	0.00	0.00
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total Out:	***-6627.65***	***-198829.62***
Modeled Change in CCS Storage:		***1811.12***	***54333.69***

Note: Italicized terms calculated with qualified water level and water quality data.

Table L.4-3. Water Budget for October 2010

Water Budget Component		Flow (MGD)	Volume (gal x 10^6)
Into CCS	W. Seepage	*0.01*	*0.17*
	E. Seepage	0.01	0.46
	N. Seepage	0.00	0.00
	S. Seepage	*0.08*	*2.53*
	Bot Seepage	23.57	730.55
	Precipitation and Runoff	14.38	445.81
	Evaporation	0.00	0.00
	Blowdown	7.80	241.80
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total In:	***45.85***	***1421.32***
Out of CCS	W. Seepage	*0.00*	*-0.01*
	E. Seepage	-0.49	-15.12
	N. Seepage	0.00	-0.03
	S. Seepage	*0.00*	*-0.05*
	Bot Seepage	-44.02	-1364.53
	Precipitation and Runoff	0.00	0.00
	Evaporation	-47.44	-1470.78
	Blowdown	0.00	0.00
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total Out:	***-91.95***	***-2850.52***
Modeled Change in CCS Storage:		***-46.10***	***-1429.19***

Note: Italicized terms calculated with qualified water level data.

Table L.4-4. Solute Mass Budget for October 2010

Mass Budget Component		lb/day (x1000)	Mass (lb x 1000)
Into CCS	W. Seepage	*0.01*	*0.32*
	E. Seepage	2.99	92.54
	N. Seepage	0.01	0.20
	S. Seepage	*0.29*	*9.01*
	Bot Seepage	10880.30	337289.23
	Precipitation and Runoff	0.00	0.00
	Evaporation	0.00	0.00
	Blowdown	569.57	17656.79
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total In:	***11453.16***	***355048.09***
Out of CCS	W. Seepage	*-2.29*	*-71.12*
	E. Seepage	-188.55	-5844.97
	N. Seepage	-0.36	-11.10
	S. Seepage	*-0.60*	*-18.74*
	Bot Seepage	-16746.44	-519139.56
	Precipitation and Runoff	0.00	0.00
	Evaporation	0.00	0.00
	Blowdown	0.00	0.00
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total Out:	***-16938.24***	***-525085.48***
Modeled Change in CCS Storage:		***-5485.08***	***-170037.40***

Note: Italicized terms calculated with qualified water level and water quality data

Table L.4-5. Water Budget for November 2010

Water Budget Component		Flow (MGD)	Volume (gal x 10^6)
Into CCS	W. Seepage	*0.01*	*0.16*
	E. Seepage	0.10	2.91
	N. Seepage	0.00	0.00
	S. Seepage	*0.07*	*2.13*
	Bot Seepage	22.02	660.55
	Precipitation and Runoff	35.20	1056.09
	Evaporation	0.00	0.00
	Blowdown	7.80	234.00
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total In:	***65.19***	***1955.84***
Out of CCS	W. Seepage	*0.00*	*-0.07*
	E. Seepage	-0.15	-4.74
	N. Seepage	0.00	-0.03
	S. Seepage	*0.00*	*-0.03*
	Bot Seepage	-18.73	-599.39
	Precipitation and Runoff	0.00	0.00
	Evaporation	-43.43	-1389.85
	Blowdown	0.00	0.00
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total Out:	***-62.32***	***-1994.11***
Modeled Change in CCS Storage:		**2.88**	**-38.27**

Note: Italicized terms calculated with qualified water level data

Table L.4-6. Solute Mass Budget for November 2010

Mass Budget Component		lb/day (x1000)	Mass (lb x 1000)
Into CCS	W. Seepage	*0.01*	*0.40*
	E. Seepage	*22.80*	*684.03*
	N. Seepage	0.00	0.00
	S. Seepage	*2.56*	*76.87*
	Bot Seepage	8277.89	248336.68
	Precipitation and Runoff	0.00	0.00
	Evaporation	0.00	0.00
	Blowdown	569.57	17087.22
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total In:	***8872.84***	***266185.21***
Out of CCS	W. Seepage	*-24.03*	*-768.83*
	E. Seepage	*-55.57*	*-1778.17*
	N. Seepage	-0.39	-12.38
	S. Seepage	*-0.33*	*-10.47*
	Bot Seepage	-6983.16	-223461.05
	Precipitation and Runoff	0.00	0.00
	Evaporation	0.00	0.00
	Blowdown	0.00	0.00
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total Out:	***-7063.47***	***-226030.90***
Modeled Change in CCS Storage:		***1809.37***	***40154.31***

Note: Italicized terms calculated with qualified water level and water quality data.

Table L.4-7. Water Budget for December 2010

Water Budget Component		Flow (MGD)	Volume (gal x 10^6)
Into CCS	W. Seepage	*0.02*	*0.55*
	E. Seepage	0.37	11.33
	N. Seepage	0.00	0.00
	S. Seepage	*0.06*	*1.99*
	Bot Seepage	29.87	926.02
	Precipitation and Runoff	3.32	102.86
	Evaporation	0.00	0.00
	Blowdown	7.80	241.80
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total In:	***41.44***	***1284.56***
Out of CCS	W. Seepage	*0.00*	*0.00*
	E. Seepage	-0.01	-0.23
	N. Seepage	0.00	-0.05
	S. Seepage	*0.00*	*-0.01*
	Bot Seepage	-9.03	-279.96
	Precipitation and Runoff	0.00	0.00
	Evaporation	-43.93	-1361.79
	Blowdown	0.00	0.00
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total Out:	***-52.97***	***-1642.04***
Modeled Change in CCS Storage:		***-11.53***	***-357.47***

Note: Italicized terms calculated with qualified water level data.

Table L.4-8. Solute Mass Budget for December 2010

Mass Budget Component		lb/day (x1000)	Mass (lb x 1000)
Into CCS	W. Seepage	*0.06*	*1.99*
	E. Seepage	*94.74*	*2936.88*
	N. Seepage	0.00	0.00
	S. Seepage	*12.13*	*376.02*
	Bot Seepage	8630.42	267542.91
	Precipitation and Runoff	0.00	0.00
	Evaporation	0.00	0.00
	Blowdown	569.57	17656.79
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total In:	***9306.92***	***288514.59***
Out of CCS	W. Seepage	*0.00*	*0.00*
	E. Seepage	*-2.66*	*-82.52*
	N. Seepage	-0.61	-18.99
	S. Seepage	*-0.07*	*-2.19*
	Bot Seepage	-3328.07	-103170.04
	Precipitation and Runoff	0.00	0.00
	Evaporation	0.00	0.00
	Blowdown	0.00	0.00
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total Out:	***-3331.41***	***-103273.74***
Modeled Change in CCS Storage:		***5975.51***	***185240.85***

Note: Italicized terms calculated with qualified water level and water quality data

Table L.4-9. Water Budget for January 2011

Water Budget Component		Flow (MGD)	Volume (gal x 10^6)
Into CCS	W. Seepage	*0.04*	*1.15*
	E. Seepage	0.21	6.63
	N. Seepage	*0.00*	*0.00*
	S. Seepage	*0.06*	*1.72*
	Bot Seepage	27.98	867.53
	Precipitation and Runoff	21.83	676.87
	Evaporation	0.00	0.00
	Blowdown	7.80	241.80
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total In:	***57.93***	***1795.70***
Out of CCS	W. Seepage	*0.00*	*0.00*
	E. Seepage	-0.08	-2.58
	N. Seepage	*0.00*	*-0.06*
	S. Seepage	*0.00*	*0.00*
	Bot Seepage	-16.98	-526.27
	Precipitation and Runoff	0.00	0.00
	Evaporation	-44.30	-1373.28
	Blowdown	0.00	0.00
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total Out:	***-61.36***	***-1902.19***
Modeled Change in CCS Storage:		***-3.44***	***-106.49***

Note: Italicized terms calculated with qualified water level data.

Table L.4-10. Solute Mass Budget for January 2011

Mass Budget Component		lb/day (x1000)	Mass (lb x 1000)
Into CCS	W. Seepage	*0.14*	*4.40*
	E. Seepage	*58.01*	*1798.46*
	N. Seepage	*0.00*	*0.00*
	S. Seepage	*10.33*	*320.33*
	Bot Seepage	*8589.96*	*266288.64*
	Precipitation and Runoff	0.00	0.00
	Evaporation	0.00	0.00
	Blowdown	569.57	17656.79
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total In:	***9228.02***	***286068.61***
Out of CCS	W. Seepage	*0.00*	*0.00*
	E. Seepage	*-32.96*	*-1021.74*
	N. Seepage	*-0.72*	*-22.45*
	S. Seepage	*0.00*	*0.00*
	Bot Seepage	*-6807.13*	*-211021.15*
	Precipitation and Runoff	0.00	0.00
	Evaporation	0.00	0.00
	Blowdown	0.00	0.00
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total Out:	***-6840.82***	***-212065.33***
Modeled Change in CCS Storage:		***2387.20***	***74003.27***

Note: Italicized terms calculated with qualified water level and water quality data.

Table L.4-11. Water Budget for February 2011

Water Budget Component		Flow (MGD)	Volume (gal x 10^6)
Into CCS	W. Seepage	0.03	0.74
	E. Seepage	0.50	14.10
	N. Seepage	0.00	0.00
	S. Seepage	0.11	3.14
	Bot Seepage	50.30	1408.34
	Precipitation and Runoff	1.62	45.29
	Evaporation	0.00	0.00
	Blowdown	7.80	218.40
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total In:	**60.36**	**1690.01**
Out of CCS	W. Seepage	0.00	0.00
	E. Seepage	-0.01	-0.22
	N. Seepage	0.00	-0.06
	S. Seepage	0.00	0.00
	Bot Seepage	-15.57	-435.82
	Precipitation and Runoff	0.00	0.00
	Evaporation	-53.95	-1510.52
	Blowdown	0.00	0.00
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total Out:	**-69.52**	**-1946.61**
Modeled Change in CCS Storage:		**-9.16**	**-256.60**

Note: Italicized terms calculated with qualified water level data.

Table L.4-12. Solute Mass Budget for February 2011

Mass Budget Component		lb/day (x1000)	Mass (lb x 1000)
Into CCS	W. Seepage	0.09	2.53
	E. Seepage	*134.37*	*3762.32*
	N. Seepage	0.00	0.00
	S. Seepage	18.79	526.14
	Bot Seepage	*14099.83*	*394795.13*
	Precipitation and Runoff	0.00	0.00
	Evaporation	0.00	0.00
	Blowdown	569.57	15948.07
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total In:	***14822.65***	***415034.18***
Out of CCS	W. Seepage	*0.00*	*0.00*
	E. Seepage	*-3.38*	*-94.60*
	N. Seepage	-0.91	-25.34
	S. Seepage	0.00	0.00
	Bot Seepage	*-7158.47*	*-200437.06*
	Precipitation and Runoff	0.00	0.00
	Evaporation	0.00	0.00
	Blowdown	0.00	0.00
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total Out:	***-7162.75***	***-200557.00***
Modeled Change in CCS Storage:		***7659.90***	***214477.18***

Note: Italicized terms calculated with qualified water level and water quality data.

Table L.4-13. Water Budget for March 2011

Water Budget Component		Flow (MGD)	Volume (gal x 10^6)
Into CCS	W. Seepage	0.03	0.92
	E. Seepage	0.42	12.89
	N. Seepage	0.00	0.00
	S. Seepage	0.12	3.81
	Bot Seepage	51.32	1590.78
	Precipitation and Runoff	10.17	315.31
	Evaporation	0.00	0.00
	Blowdown	7.80	241.80
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total In:	**69.86**	**2165.51**
Out of CCS	W. Seepage	0.00	0.00
	E. Seepage	-0.01	-0.19
	N. Seepage	0.00	-0.04
	S. Seepage	0.00	0.00
	Bot Seepage	-18.94	-587.17
	Precipitation and Runoff	0.00	0.00
	Evaporation	-56.54	-1752.71
	Blowdown	0.00	0.00
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total Out:	**-75.49**	**-2340.10**
Modeled Change in CCS Storage:		**-5.63**	**-174.59**

Note: Italicized terms calculated with qualified water level data.

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Table L.4-14. Solute Mass Budget for March 2011

Mass Budget Component		lb/day (x1000)	Mass (lb x 1000)
Into CCS	W. Seepage	0.15	4.74
	E. Seepage	*124.60*	*3862.63*
	N. Seepage	0.00	0.00
	S. Seepage	25.02	775.76
	Bot Seepage	*14392.83*	*446177.58*
	Precipitation and Runoff	0.00	0.00
	Evaporation	0.00	0.00
	Blowdown	569.57	17656.79
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total In:	***15112.18***	***468477.50***
Out of CCS	W. Seepage	*0.00*	*0.00*
	E. Seepage	*-2.96*	*-91.71*
	N. Seepage	-0.56	-17.33
	S. Seepage	0.00	0.00
	Bot Seepage	*-8999.72*	*-278991.46*
	Precipitation and Runoff	0.00	0.00
	Evaporation	0.00	0.00
	Blowdown	0.00	0.00
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total Out:	***-9003.24***	***-279100.50***
Modeled Change in CCS Storage:		***6108.94***	***189377.00***

Note: Italicized terms calculated with qualified water level and water quality data.

Table L.4-15. Water Budget for April 2011

Water Budget Component		Flow (MGD)	Volume (gal x 10^6)
Into CCS	W. Seepage	0.02	0.70
	E. Seepage	0.59	17.60
	N. Seepage	0.00	0.00
	S. Seepage	0.15	4.38
	Bot Seepage	62.49	1874.77
	Precipitation and Runoff	11.82	354.65
	Evaporation	0.00	0.00
	Blowdown	7.80	234.00
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total In:	**82.87**	**2486.10**
Out of CCS	W. Seepage	0.00	0.00
	E. Seepage	0.00	0.00
	N. Seepage	0.00	-0.04
	S. Seepage	0.00	0.00
	Bot Seepage	-18.20	-546.08
	Precipitation and Runoff	0.00	0.00
	Evaporation	-59.37	-1780.97
	Blowdown	0.00	0.00
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total Out:	**-77.57**	**-2327.09**
Modeled Change in CCS Storage:		**5.30**	**159.01**

Note: Italicized terms calculated with qualified water level data.

Table L.4-16. Solute Mass Budget for April 2011

Mass Budget Component		lb/day (x1000)	Mass (lb x 1000)
Into CCS	W. Seepage	0.17	5.04
	E. Seepage	187.62	5628.56
	N. Seepage	0.00	0.00
	S. Seepage	35.65	1069.44
	Bot Seepage	17591.62	527748.48
	Precipitation and Runoff	0.00	0.00
	Evaporation	0.00	0.00
	Blowdown	569.57	17087.22
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total In:	**18384.62**	**551538.74**
Out of CCS	W. Seepage	0.00	0.00
	E. Seepage	0.00	0.00
	N. Seepage	-0.56	-16.69
	S. Seepage	0.00	0.00
	Bot Seepage	-8201.93	-246057.87
	Precipitation and Runoff	0.00	0.00
	Evaporation	0.00	0.00
	Blowdown	0.00	0.00
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total Out:	**-8202.49**	**-246074.56**
Modeled Change in CCS Storage:		**10182.14**	**305464.18**

Note: Italicized terms calculated with qualified water level and water quality data.

Table L.4-17. Water Budget for May 2011

Water Budget Component		Flow (MGD)	Volume (gal x 10^6)
Into CCS	W. Seepage	0.03	0.94
	E. Seepage	0.94	29.10
	N. Seepage	0.00	0.00
	S. Seepage	0.14	4.37
	Bot Seepage	89.09	2761.85
	Precipitation and Runoff	14.88	461.16
	Evaporation	0.00	0.00
	Blowdown	7.80	241.80
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total In:	**112.88**	**3499.22**
Out of CCS	W. Seepage	0.00	0.00
	E. Seepage	0.00	0.00
	N. Seepage	0.00	-0.07
	S. Seepage	0.00	0.00
	Bot Seepage	-42.27	-1310.43
	Precipitation and Runoff	0.00	0.00
	Evaporation	-67.43	-2090.25
	Blowdown	0.00	0.00
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total Out:	**-109.70**	**-3400.75**
Modeled Change in CCS Storage:		**3.18**	**98.46**

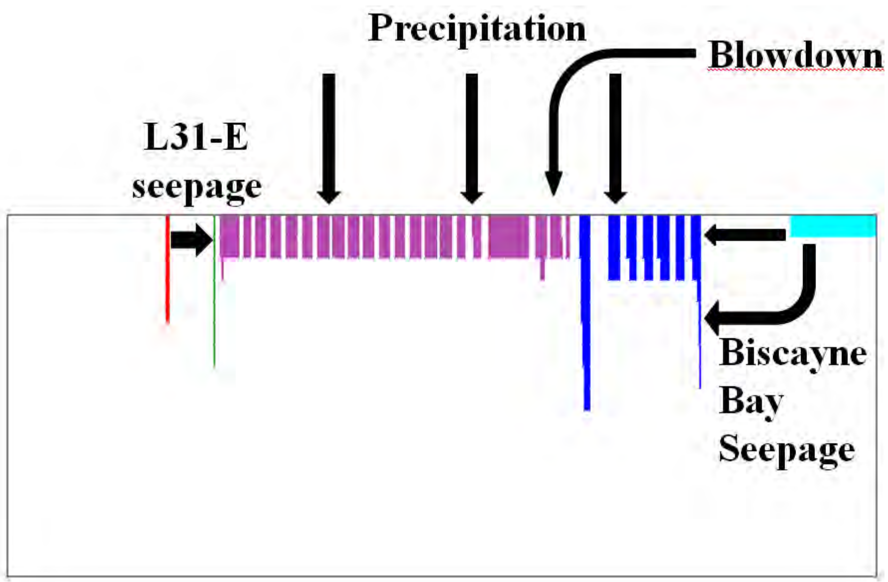
Note: Italicized terms calculated with qualified water level data.

Table L.4-18. Solute Mass Budget for May 2011

Mass Budget Component		lb/day (x1000)	Mass (lb x 1000)
Into CCS	W. Seepage	0.55	17.14
	E. Seepage	332.65	10312.22
	N. Seepage	0.00	0.00
	S. Seepage	48.10	1491.03
	Bot Seepage	25007.03	775217.86
	Precipitation and Runoff	0.00	0.00
	Evaporation	0.00	0.00
	Blowdown	569.57	17656.79
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total In:	**25957.90**	**804695.04**
Out of CCS	W. Seepage	0.00	0.00
	E. Seepage	0.00	0.00
	N. Seepage	-1.09	-33.73
	S. Seepage	0.00	0.00
	Bot Seepage	-20180.08	-625582.37
	Precipitation and Runoff	0.00	0.00
	Evaporation	0.00	0.00
	Blowdown	0.00	0.00
	Plant Outflow	Equal to Intake	
	Plant Intake	Equal to Outflow	
	Total Out:	**-20181.16**	**-625616.10**
Modeled Change in CCS Storage:		**5776.74**	**179078.93**

Note: Italicized terms calculated with qualified water level and water quality data.

FIGURES



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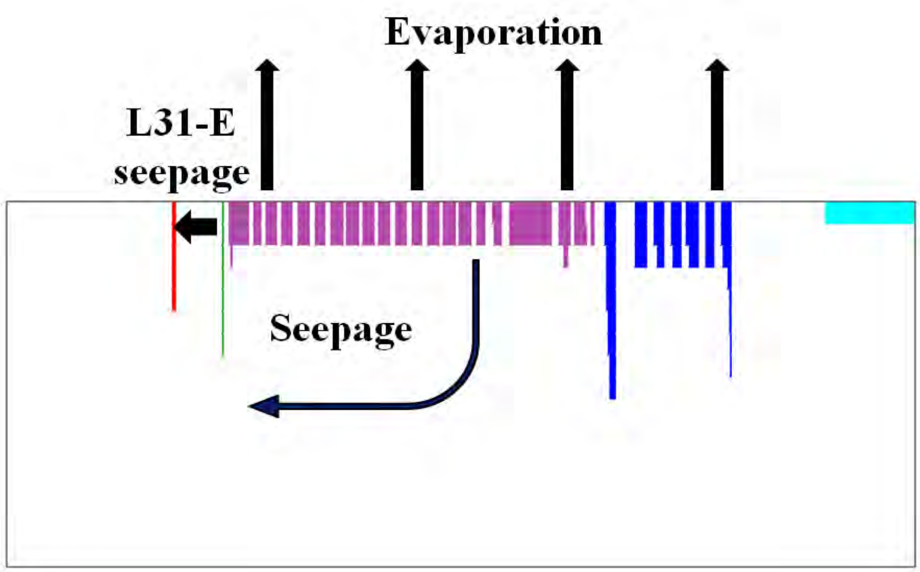

(B)

Figure L.1-1. Flow (A) into and (B) out of the Proposed Control Volume, Shown in Cross-Section.

Figure L.2-1. Locations of L31-E and ID monitoring Stations; Conceptualized Seepage from L31-E into the ID is Shown.

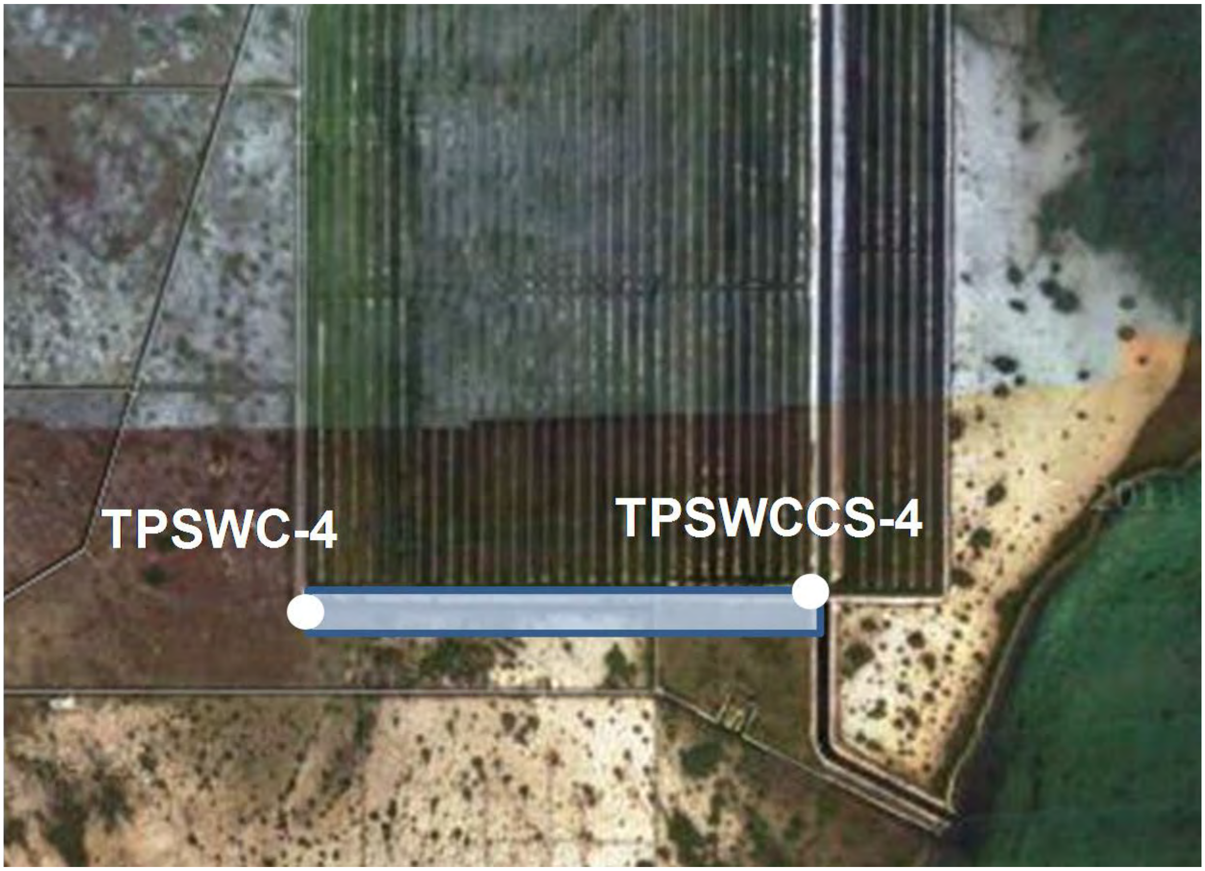

Figure L.2-2. Locations of TPSWCCS-4 and TPSWC-4 Monitoring Stations; Conceptualized Seepage from Southern Collector Canal into the CCS is Shown.

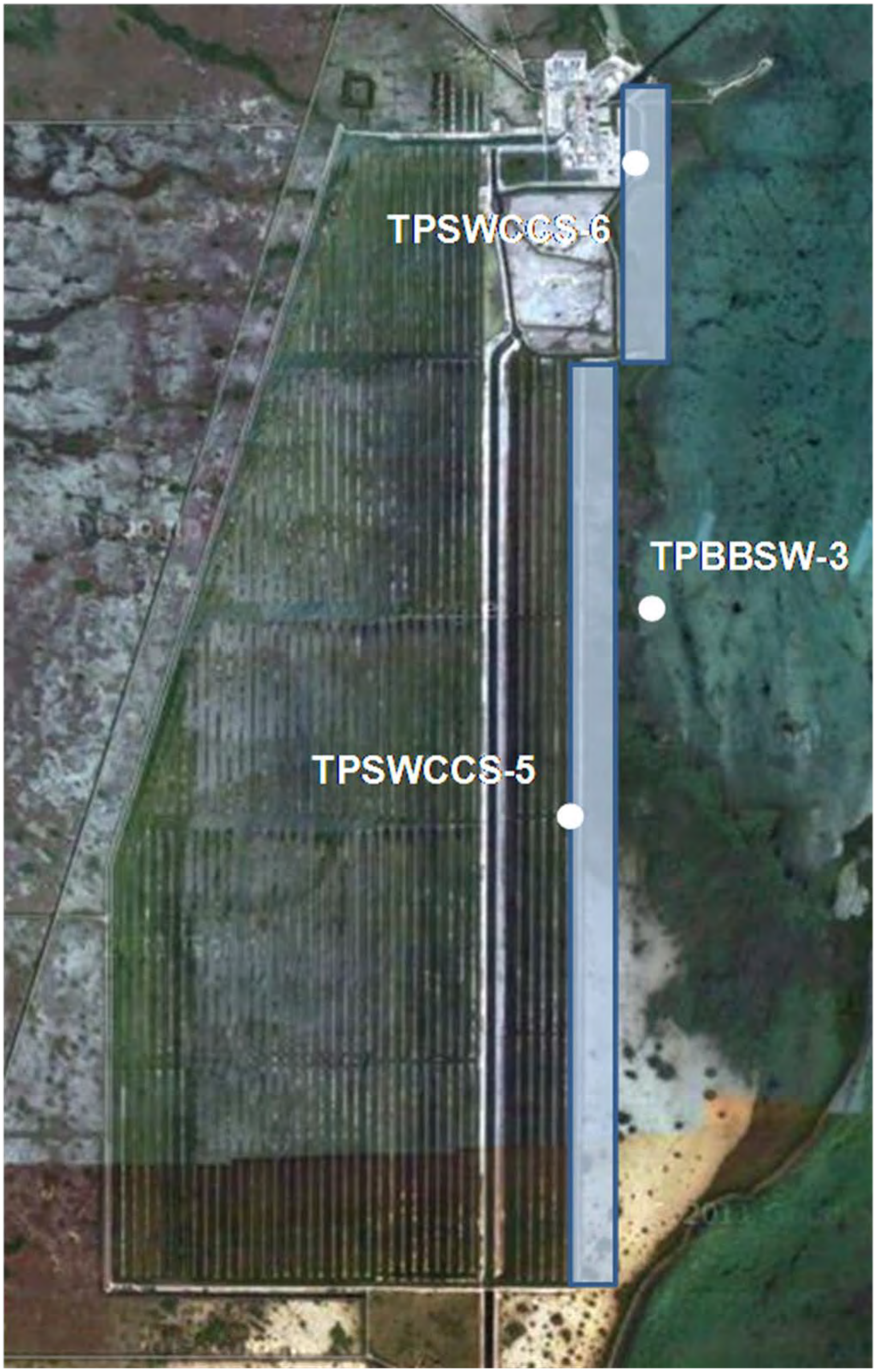

Figure L.2-3. Locations of TPSWCCS-5, TPSWCCS-6 and TPBBSW-3 Monitoring Stations; Conceptualized Seepage from Biscayne Bay into the CCS is Shown.

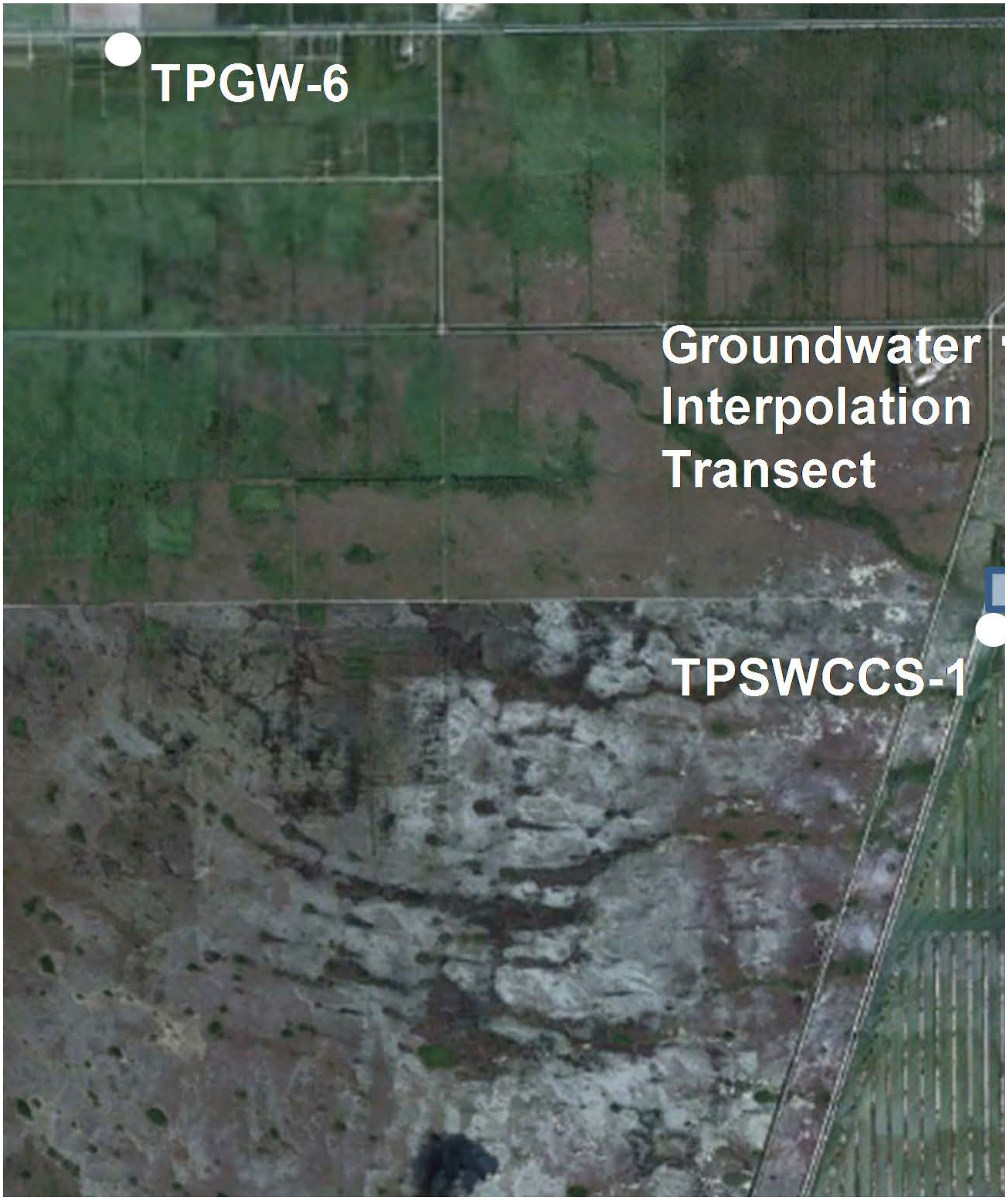

Figure L.2-4. Locations of TPGW-6, TPGW-10, and TPGW-12 Shallow Groundwater Monitoring Stations, TPSWCCS-1 Surface Water Monitoring Station, and TPFM-1 Plant Outflow Meter; Conceptualized Seepage from the CCS into the Shallow Groundwater is Shown.

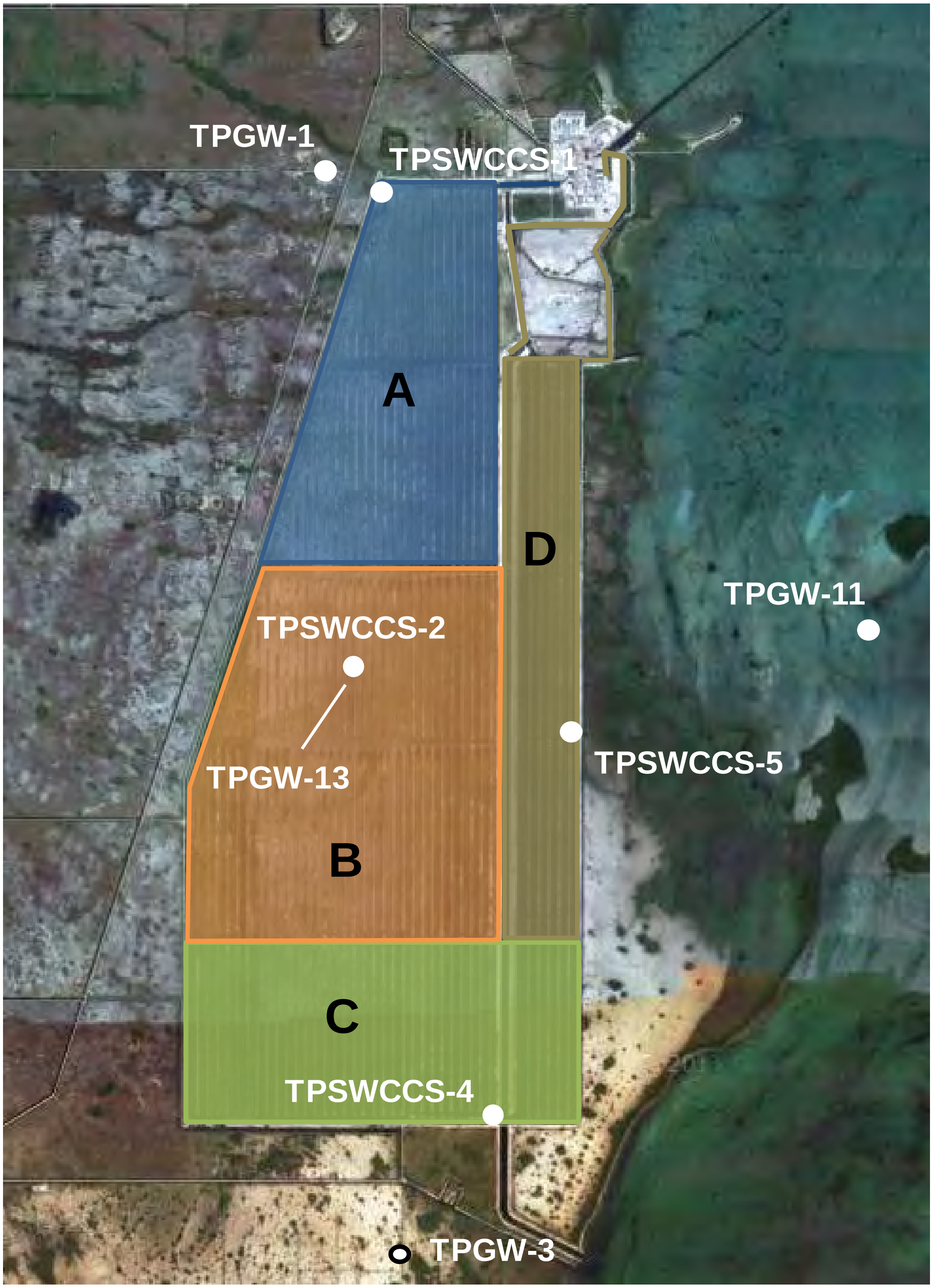

Figure L.2-5. Locations of TPGW and TPSWCCS Monitoring Stations And Four Zones that Subdivide the Control Volume (Zone A Extends Eastward along the Northern Canal to Plant Outflow, Zone D Extends North to the Plant Intake).

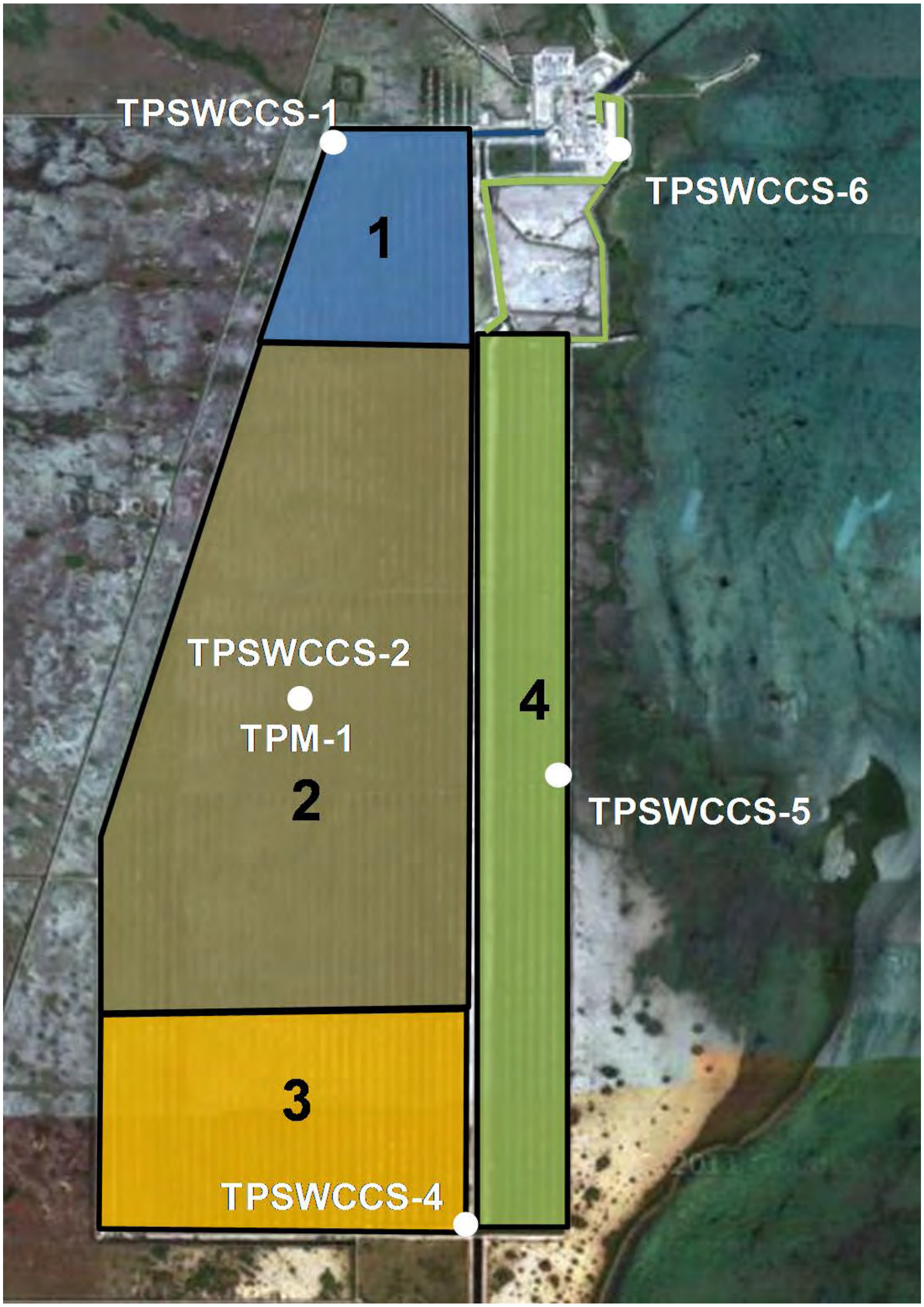

Figure L.2-6. Locations of CCS Monitoring Stations, Meteorological Station TPM-1 and Four Zones that Subdivide the Control Volume (Zone 1 Extends Eastward along the Northern Canal to Plant Outflow, Zone 4 Extends North to the Plant Intake).

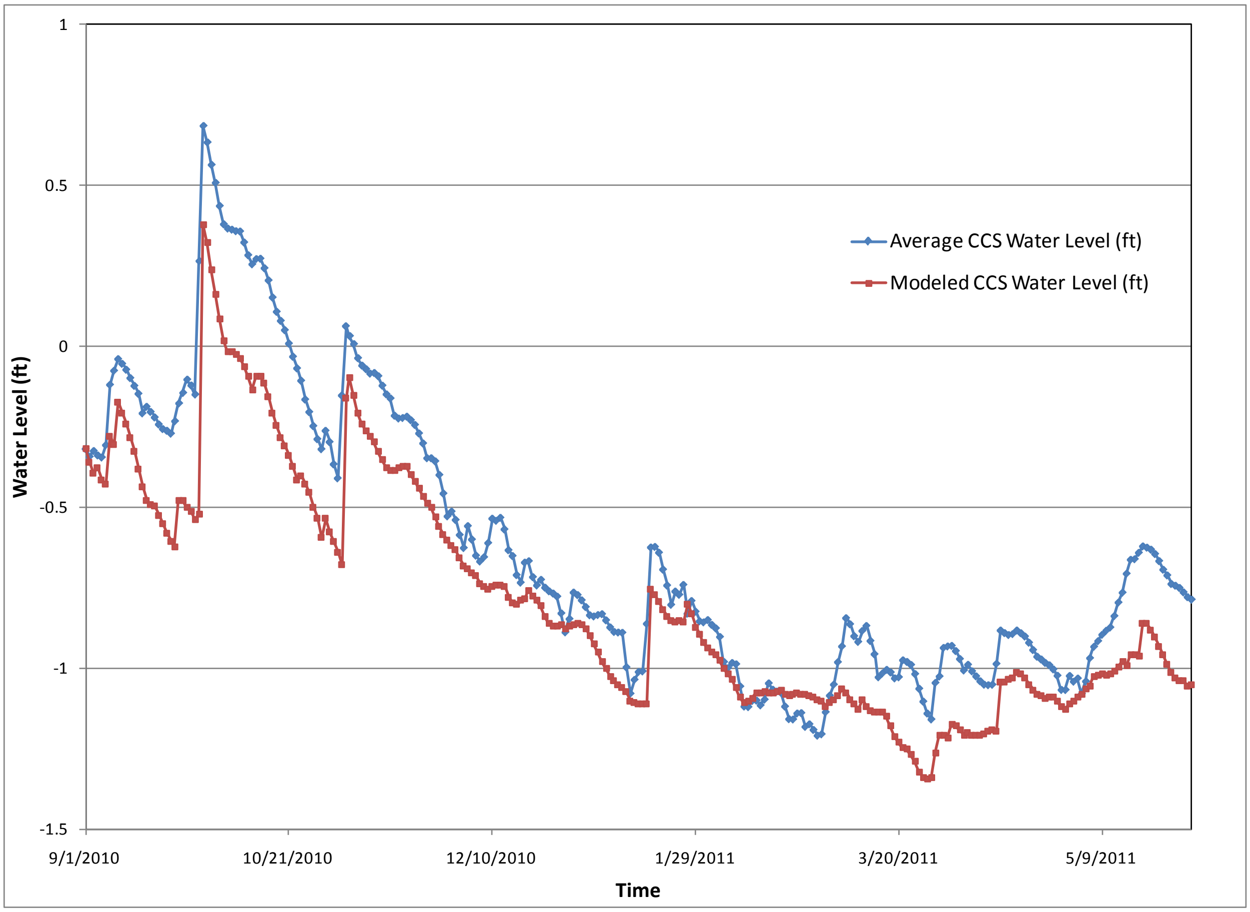

Figure L.4-1. Modeled versus Measured Average Water Levels in the CCS over the 9-Month Period; Used as Validation of the Conceptual Model.