PMTurkeyCOLPEm Resource

From: Bryce, Robert W [rw.bryce@pnnl.gov]
Sent: Friday, September 30, 2011 12:14 PM
To: Kugler, Andrew
Cc: TurkeyCOL Resource
Subject: FW: Radial Collector Well Summary
Attachments: TP6-7_Radial_Collector_Well_Summary_Final.pdf

FYI

From: Thorne, Paul D
Sent: Thursday, September 29, 2011 4:06 PM
To: Melinda Lohmann; Gary L Patterson
Cc: Bryce, Robert W
Subject: Radial Collector Well Summary

Here is the latest FPL radial collector well document that I've seen.

And here is a link to the FPL model and some related info on the SCA site:
http://publicfiles.dep.state.fl.us/Siting/Outgoing/FPL_Turkey_Point/Units_6_7/Completeness/Plant_Associated_Facilities/4th_Round_Completeness/FPL%20Response_4thCompleteness/

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FPL TURKEY POINT UNITS 6 & 7
RADIAL COLLECTOR WELL SUMMARY

Submitted by:

Florida Power & Light Company
700 Universe Boulevard
Juno Beach, Florida 33408

February 2011

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FPL TURKEY POINT UNITS 6 & 7 PROJECT
RADIAL COLLECTOR WELLS

Preface

This paper presents a summary of information regarding the proposed backup water supply system (radial collector wells) associated with the FPL Turkey Point Units 6 & 7 Project (the Project). This information was previously submitted or submitted with the 4th Round Completeness responses. It is offered to assist the reader's understanding of the topic. The radial collector wells are a necessary system to provide the backup cooling water source for the new nuclear units and will supply water to dissipate heat from the nuclear electrical generating process. The wells will be used when reclaimed water, the primary source of cooling water, is not available in a quantity or quality needed to meet the Project's cooling water needs. The information in this paper is taken primarily from the Site Certification Application, Rev. 0 (June 2009) and Rev. 1 (May 2010) submitted under Florida's Power Plant Siting Act, and FPL's 1st, 2nd and 3rd Round Completeness Responses for Plant and non-Transmission Facilities (October 2009, April 2010, and July 2010) that address specific questions raised by the reviewing agencies. Information developed for the 4th Round of Completeness Responses (February 2011) is also included in this paper.

Introduction

An important consideration in developing a new nuclear power plant is the availability of adequate water to meet the cooling and process water requirements of the plant. Therefore, FPL conducted a systematic multiphase water supply alternatives study to identify, evaluate and select the best cooling water supply plan for Turkey Point Units 6 & 7 (HDR, 2007; HDR, 2008a; and HDR, 2008b). The study resulted in the following recommendations:

1. Reclaimed water from the Miami-Dade Water and Sewer Department (MDWASD) will be the primary supply of makeup water for the circulating water cooling system for Turkey Point Units 6 & 7.

2. When reclaimed water cannot supply sufficient quantity or quality of water needed for cooling, additional makeup water will be saltwater supplied from radial collector wells (backup source) that are recharged from the marine environment (Biscayne Bay).

The water source evaluation process involved a number of steps, including identification of potential sources, conceptual design and costs, and the development of screening criteria. A total of 16 potential sources were identified as primary cooling water sources (100 percent supply). Based on this analysis, the top-ranked alternatives were reclaimed water, the radial collector wells, the Boulder Zone of the Lower Floridan Aquifer, and a Card Sound Canal intake. After a further evaluation of conceptual engineering feasibility, reliability, environmental impacts, risks, cost, and designs, the Boulder Zone, the Lower Floridan and the Card Sound Canal Intake alternatives had the greatest cost, risk and/or uncertainty. Reclaimed water was determined to be technically and economically feasible and environmentally beneficial, and provided a reliable alternative water source. Radial collector wells were determined to provide a reliable backup water source with minimal environmental impact. As a result, reclaimed water from MDWASD was selected as the primary water source option, and radial collector wells were selected as the backup water supply option.

Reclaimed water use is a beneficial and cost-effective means of increasing the use of reclaimed water from Miami-Dade County and helps the County meet its reclaimed water compliance requirements. The use of reclaimed water will require an FPL reclaimed water treatment facility and associated pipelines from MDWASD facilities to Turkey Point Units 6 & 7 Site.

The location of the radial collector wells is presented in Figure 1. The radial collector wells will consist of 4 central caissons located on the Turkey Point peninsula. Up to 12 laterals will project from each of the caissons horizontally a distance of up to 900 ft beneath Biscayne Bay and be installed to a depth of approximately 25 to 40 ft below the Bay bottom. A conceptual design for a typical radial collector well is illustrated in Figure 2. Portions of the radial collector well laterals may extend beyond FPL property boundary onto sovereign submerged lands in the Biscayne Bay Aquatic Preserve. The laterals will not extend beneath Biscayne National Park (BNP). The wells will be designed, sited, constructed and operated to induce recharge from below Biscayne Bay. The area within which the radial collector wells will be located is shown in Figure 3.

The use and construction of radial collector wells have become much more common in the last decade in the U.S. and in other countries. This technology and the proposed construction methods are not new. Horizontal collector wells (radial wells) are the legacy of Leo Ranney, an Iowa engineer who developed the patented process in the 1920s. The patent for the process has expired, but the company continues operation today as Ranney® Collector Wells. Collector wells have become widely used, especially since the 1940s, for the purpose of inducing infiltration from surface water bodies into hydraulically-connected aquifer systems in order to develop moderate to high capacity water supplies. These systems may be applied for the purposes of supplying municipal drinking water, as well as for industrial power plant applications, such as process and cooling water. Radial collector wells function by taking advantage of the natural filtration process. This typically results in water lower in total suspended solids as compared to a surface water intake. Although collector wells are typically installed in sand and gravel aquifers along river banks, Ranney and others have drilling experience with geological formations similar to those found at and near the Turkey Point site.

FPL conducted a survey of existing radial collector well installations. While the survey did not capture all the radial collector well installations in the world, the examples demonstrate that radial collector wells of the size and type planned for the backup cooling water source for Turkey Point Units 6 & 7 can be constructed and operated. In the survey, 29 installations of radial collector wells were identified with a total capacity of 1,121 million gallon per day (MGD). Radial collector wells installations included in the survey ranged in size from 3 to 170 MGD, with an average capacity of about 44 MGD. The survey identified 5 installations for power plants including the Grand Gulf Nuclear Power Plant. A summary of the existing radial collector well installations found in the FPL survey are presented in Table 1 and include examples of seawater and freshwater installations. These radial collector well installations serve as examples of the successful use of this technology for the development of large capacity water supplies, such as required for Turkey Point Units 6 & 7.

Although the radial collector wells will be a backup cooling water source, FPL's assessment of impacts of radial collector well operation has assumed that the radial collector wells will operate 100 percent of the time, at full capacity, to provide a conservative assessment of potential impacts to Biscayne Bay and regional water resources. Since no adverse impacts have been identified under the 100 percent operation scenario, there is reasonable assurance that more limited radial collector well operation (only when reclaimed water is not available in sufficient quality or quantity) will not adversely impact water quality or aquatic systems in Biscayne Bay or harm regional water resources.

Nevertheless, in recognition of the backup nature and purpose of the radial collector wells, FPL has offered to accept a restriction on the use of this backup water supply based upon the Conditions of Certification established for FPL's West County Energy Center (WCEC). The WCEC condition provides an example of a recently-licensed power plant that uses reclaimed water as its primary water source. The WCEC condition allows withdrawals from the Floridan Aquifer for up to 90 days per calendar year as a temporary backup water supply source. A similar condition for Turkey Point Units 6 & 7 would allow operational reliability in the event that reclaimed water is not available. Since the radial collector wells will be used only as a backup water supply, these wells may not be operated at all during some years, other than for periodic testing and routine maintenance.

Location and Description of Radial Collector Wells

When FPL first considered the radial collector well concept, Card Sound was identified as a potential location for the system and source of water to recharge the wells. A radial collector well design concept was presented that could avoid impacts to freshwater inflows to the Bay by moving the laterals further offshore. The design concept called for the near shore sections of the radial collector well laterals to be cased. The remaining lengths of the radial wells would be screened to allow withdrawals of saltwater. The length of the cased well sections would limit withdrawals to areas far enough offshore to avoid interference with fresh groundwater. Since the design of the radial wells would prevent interception of freshwater, saltwater would be the water source. Using current technologies, the distance a lateral can be installed from a radial collector well caisson is approximately 900 ft. The Card Sound radial collector well option required the caissons to be installed along the coastline of the Sound. Except for a limited area of uplands adjacent to the Card Sound Canal mouth, the coastline is predominately wetlands. Therefore, the installation of the caissons and their footprint would result in unavoidable impact to coastal wetlands. The currently proposed location for the caissons on the Turkey Point peninsula (the landmass on FPL property that extends out into Biscayne Bay) was then selected because the caissons could be built in upland areas.

Figure 4 depicts survey information about the general area where the radial collector well laterals will be sited. The only portions of the system that will be constructed under the Biscayne Bay Aquatic Preserve boundaries are the outermost segments of the radial collector well laterals. The BNP boundary on the figure is based on the Judgment on Stipulation and Order of Vesting Title (BOT #30749 (4973)) that provides title of the subject lands to the United States of America and defines the boundary of BNP. It is anticipated that the laterals will extend from the four radial collection well caissons to the edge of the "area of potential submerged lands easement(s) for the radial collector well laterals" shown in the figure. It is anticipated that each well will have up to 12 laterals. The exact number and final locations will be determined during the post-certification detailed design phase.

There will be four radial collector wells [30,000 gallons per minute (gpm) capacity per well]. Three wells would meet the makeup water requirements for the circulating water systems; the fourth would act as a standby well. Two pumps (15,000 gpm capacity per pump) in each well caisson will transfer the saltwater to the circulating water systems via delivery pipelines to the Unit 6 & 7 Site. Each radial collector well will consist of a central reinforced concrete caisson extending below the ground level with laterals projecting from the caisson. The well laterals will be at a depth of approximately 25 to 40 ft and will be advanced from within the caissons horizontally a distance of up to 900 ft beneath Biscayne Bay. The radial collector well pumps will be located within the onshore caissons. The pumps are submersible and will be housed below ground level within the caissons.

Groundwater Modeling

A groundwater flow model for the Turkey Point Units 6 & 7 Project was developed to conservatively assess the potential impacts from the dewatering during construction and the operation of the radial collector wells. The groundwater model was developed using regional and site-specific hydrogeologic information for the Turkey Point Units 6 & 7 Site. Model simulations used several bounding conditions to conservatively calculate the maximum expected hydrologic and environmental impacts. As stated in the SCA, each caisson could have up to 12 laterals and the laterals may be up to 900 ft long. The model simulations use eight laterals per collector well, and the laterals are 700 ft long. This design configuration maximizes the flow per unit area of the aquifer, which in turn maximizes the calculated drawdown and the seabed approach velocity caused by pumping the radial collector wells. In addition, the radial collector well system will have four collector wells, each capable of providing one-third of the required flow. The model simulations use the three collector wells closest to the shoreline. This operational configuration maximizes the calculated impacts to the near shore areas west of the Bay. Finally, the laterals will be installed at a depth of approximately 25 to 40 ft below the bay. Within this zone, the model sensitivity analysis shows little sensitivity to the depth of the laterals. Nevertheless, the model simulations placed the laterals in the upper high flow zone located approximately 25 ft below the bay. This was done to ensure the lateral extent of the calculated area of influence and the calculated seabed velocities would be maximized. The steady-state, constant-density and three-dimensional groundwater model and the operational design configurations discussed above produce an environmentally conservative assessment of potential environmental impacts.

The model also includes data collected during an aquifer performance test (APT) conducted on the Turkey Point peninsula, the location of the radial collector wells. FPL submitted the report entitled *Groundwater Model Development and Analysis: Units 6 & 7 Dewatering and Radial Collector Well Simulations, Rev. 0* (Bechtel Power Corporation, 2009) in October 2009. The groundwater model was subsequently revised to incorporate additional suggestions made by the reviewing agencies to refine and enhance the model. A description of the changes and the results of the revised model are presented in *Groundwater Model Development and Analysis: Units 6 & 7 Dewatering and Radial Collector Well*

Simulations, Rev. 1 (Bechtel Power Corporation, 2011) submitted in February 2011. This section provides a brief summary of the APT, groundwater model methodologies and results.

In order to further evaluate the use of a radial collector well system, an exploratory drilling and aquifer testing program was performed on the Turkey Point peninsula after planning, consultation with and review by local and state agencies. The APT program consisted of soil borings, rock/soil classification, water quality sampling, and monitoring well and test production well installation for the APT, and water quality sampling and analysis. Drilling was performed on the Turkey Point peninsula to assess the subsurface lithology and to install a test production well and monitoring wells for the APT. There were several goals of the APT. The first goal was to provide information on the potential yield of the shallow water bearing units beneath the Turkey Point peninsula that could potentially be utilized for a radial collector well system. The second goal was to provide data for an evaluation of the aquifer characteristics of this shallow permeable interval. The APT was also conducted to allow for an evaluation of potential short term water quality changes under pumping conditions. The final goal of the APT was to provide information for groundwater model calibration to assess the performance of operations of the radial collector wells.

The APT consisted of three phases: first, a background monitoring period beginning on February 11, 2009 and extending to April 3, 2009 to determine the natural water level fluctuations in the aquifer and surface water bodies, especially tidal influences from Biscayne Bay. Second, the step drawdown test was performed on the Turkey Point peninsula on April 4, 2009. The purpose of the step drawdown phase was to evaluate the well performance and to select the optimum pumping rate for the long-term phase (7-day duration) of the APT. Third, the 7-day constant rate test to be used in the calibration of the groundwater model was conducted during April 28, 2009 through May 4, 2009 at a rate of 7,100 gpm. Data collection prior to and during the aquifer test consisted of monitoring water levels, well discharge rates, and water quality sampling.

Based on the data obtained during the Turkey Point peninsula exploratory drilling and aquifer testing program, the proposed location for radial collector wells has suitable subsurface characteristics. Data collected from the APT and the hydraulic parameters derived from the test have been used to help conceptualize, calibrate and validate the Turkey Point groundwater model.

The model used to determine the potential impacts from the radial collector wells is a steady-state, constant-density, three-dimensional representation of the Biscayne Aquifer developed using the numerical code MODFLOW 2000 developed by the U.S. Geological Survey, as it is implemented in the user-interface software Visual MODFLOW developed by Schlumberger Water Services.

Hydrostratigraphic layer elevations are developed from geotechnical and geophysical logs for Units 6 & 7, pumping test wells from Turkey Point and Units 6 & 7, pumping wells from the Turkey Point plant property Upper Floridan Aquifer study, from historical borings and well logs from the Turkey Point plant property, and from logs for wells in the Florida Geological Survey Lithologic database.

Hydraulic conductivity values are based on results from three historical onsite pumping tests in the Biscayne aquifer, regional groundwater models that include Turkey Point within their domain, and onsite pumping tests at the location of proposed Units 6 & 7 and the proposed location of the radial collector wells on the Turkey Point peninsula.

The interaction between surface water and groundwater is simulated by including Biscayne Bay, the cooling water canals, L-31E Canal, Card Sound Canal, Florida City Canal and Model Land Canal (C-107) in the model. Spatially-variable groundwater recharge and evapotranspiration are considered based on USGS land use classification (Langevin, 2001).

Calibration was approached with a multi-faceted methodology. Initially, the response to three pumping tests was simulated by adjusting hydraulic conductivities of the various hydrostratigraphic units comprising the Biscayne aquifer. The conductance values of the various head-dependent boundary conditions were also primary calibration parameters. Following this phase, groundwater flow directions were compared to historical data, and a qualitative comparison of calculated groundwater flow between cooling water canals and groundwater beneath Biscayne Bay to results from pre-existing surface water modeling was performed. The model was then validated by simulating an additional different pumping test and comparing the modeled and observed drawdown values.

The groundwater model submitted in October 2009 for Turkey Point Units 6 & 7 (Bechtel Power Corporation, 2009) was revised based on agency comments to reflect the presence of laterally continuous secondary porosity zones (Bechtel Power Corporation, 2010). The upper flow zone is represented in the model as a thin (1 ft thick), continuous layer at the top of the Key Largo Limestone, while the lower flow zone is being represented as a thin (1 ft thick), continuous layer located 15 ft below the top of the Fort Thompson Formation. The hydraulic conductivities of these flow zones are established by model calibration, assuming that the laterally continuous secondary porosity zones are five times more conductive than the rest of the formation in which the laterally continuous secondary porosity zone is located. The revised model was calibrated and verified, then used to predict impacts of construction dewatering and radial collector well operation, and to assess the sensitivity of model predictions to key model parameters. The results are presented in *Groundwater Model Development and Analysis: Units 6 & 7 Dewatering and Radial Collector Well Simulations, Rev. 1* (Bechtel Power Corporation, 2011).

The results of the revised groundwater model determined that the radial collector wells will withdraw water from a saline aquifer that will be recharged from Biscayne Bay. The revised model indicates similar results as the prior model with regard to the source of water reporting to the radial collector well system: approximately 97.8 percent of the aquifer recharge will originate from boundaries representing Biscayne Bay, approximately 1.9 percent will originate from boundaries representing the cooling canal system and approximately 0.3 percent will be from boundaries representing precipitation onshore. The 0.3 percent from precipitation recharge represents a relatively small amount of water. Because precipitation is fresh water, it will tend to remain in the upper layers of the aquifer. Since the radial collector wells draw water at depth, the 0.3 percent is a conservative prediction of the water entering the radial collector wells. Furthermore, this 0.3 percent is of the same order of magnitude as the precision of the model water budget methodology. Therefore, the amount of fresh water drawn by the radial collector wells will be inconsequential and will not adversely impact the environment.

The steady state drawdown contour (i.e., cone of influence) of the radial collector wells is shown in Figure 5. This area is predominantly offshore, and groundwater in this area would have a salinity similar to that of seawater. Therefore, the subsurface area that is affected by the radial collector wells has a relatively constant density, and would not require adjustment of heads to account for variable density.

Hydrologic and Salinity Impacts of Radial Collector Well Operation

The results of the revised groundwater modeling provided in the report (Bechtel Power Corporation, 2010), entitled *Groundwater Model Development and Analysis: Units 6 & 7 Dewatering and Radial Collector Well Simulations, Rev 1,* demonstrates that pumping for backup cooling water supply from the radial collector well system will not significantly change the configuration of the hypersaline water under the cooling canal system.

The revised model indicates similar results as the prior model with regard to the source of water reporting to the radial collector well system: approximately 97.8 percent of the aquifer recharge will originate from boundaries representing Biscayne Bay, approximately 1.9 percent will originate from boundaries representing the cooling canal system and approximately 0.3 percent will be from boundaries representing precipitation onshore.

The revised groundwater modeling indicates that approximately 1.9 percent will be recharged from the area of the cooling canal system. Any hypersaline water drawn towards the radial collector well system will remain at depth within the salt water (G-III) aquifer due to the placement of the radial collector well laterals well below the seabed and due to its higher density relative to saltwater. Therefore, the withdrawals will not cause adverse impacts to groundwater or surface water.

As described below, salinity impact analyses of the radial collector wells shows that the potential effects of the withdrawal on the circulation and natural salinity within Biscayne Bay will not have an adverse impact on aquatic systems. The predicted highly localized salinity changes due to operation of the radial collector wells are well within the natural ranges in salinity currently experienced by aquatic life in Biscayne Bay.

A mixing chamber model (also referred to as a control volume analysis), was used to evaluate the potential impacts of the operation of the radial collector wells on the salinity regime of Biscayne Bay. The model is based on continuity of flow (including tidal flow), conservation of mass (i.e., conservation of solute or dissolved solids), steady-state conditions and uniform salinity concentrations within the specified control volume or mixing chamber. Using the data discussed above, the model was first calibrated to several salinity conditions by adjusting the model tidal exchange coefficient. Then, the model was run with the radial collector wells operating and the change in salinity induced by the radial collector wells withdrawal was determined. The model was run for two specified control volumes (i.e., two scenarios): Scenario 1 used a control volume based on a surface area of one square mile; Scenario 2 used a control volume based on a surface area of four square miles. The model control volumes are shown in Figure 6 to illustrate the two areas considered in this analysis relative to the Turkey Point peninsula where the radial collector wells will be located. While the area of each of the control volumes is important to the calculation, the exact shape of the control volume is not important.

The average salinity in Biscayne Bay near the Turkey Point peninsula is approximately 34 parts per thousand (ppt). During wet periods, the salinity in the Bay is typically below average; during dry periods, the salinity in the Bay is typically above average. The mixing chamber modeling results described below show that near the radial collector wells the water withdrawal will have a slight moderating effect on the salinity regime in the Bay. During the wet periods, the salinity near the radial collector wells will not be quite as low when the wells are operating. During the dry periods, the salinity near the radial collector wells will not be as high when the wells are operating. When the Bay is near its average salinity, the radial collector wells will have no measurable effect. This moderating effect will be small near the wells and undetectable approximately one mile from the center of pumping, or in any other part of Biscayne Bay.

To demonstrate this conclusion, salinity data from three water quality stations located in Biscayne Bay were evaluated (identified as Stations BB41, BISC122, BISC101 and BNP 12B). These stations were used to establish a salinity time history and probability distribution in the area of Turkey Point. Station BB41 is the closest SFWMD station to the Turkey Point plant with a long period of record (212 sampling events over 24 years, from 3/20/1979 to 3/5/2003). The station is located approximately 3 to 4 miles northeast of Turkey Point. The data set was obtained from the SFWMD DBHYDRO database.

Figure 7 shows the salinity time history and Figure 8 shows the salinity cumulative probability distribution at Station BB41. The black lines show the historical salinity in Biscayne Bay (i.e., salinity without the radial collector wells). The blue lines (Scenario 1 from the mixing chamber model) show the average predicted salinity within approximately 1/2 mile of the center of the collection area, with the radial collector wells operating at maximum capacity. The green lines (Scenario 2) show the average predicted salinity within approximately one mile of the center of the collection area with the radial collector wells operating at maximum capacity. At one mile, there is no measurable impact on salinity from operating the radial collector wells. This is illustrated by the fact that the green line (predicted) is almost completely covered by the black line (historical) in both figures. Near the average salinity (34 ppt), both lines are covered by the black line. This shows that the average salinity will not be significantly changed by operation of the radial collector wells.

The time history plot for monitoring station BISC 122 is provided in Figure 9 and the cumulative probability plot is shown in Figure 10. Using salinity data from this station, the average salinity for Scenario 1 (within about ½ mile of Turkey Point) will increase approximately 0.17 psu or 0.5 percent. The maximum salinity would decrease by 0.25 psu and the minimum salinity would increase by 0.88 psu. For Scenario 2 (about one mile from Turkey Point), the average salinity would increase by only 0.04 psu or 0.1 percent. The maximum salinity would decrease by 0.06 psu and the minimum salinity would increase by 0.22 psu.

Station BISC101 is located about 2.5 miles directly north of the Turkey Point peninsula (i.e., Northeast of Homestead Bayfront Park). This station is located in the near-shore area north of Homestead Bayfront Park, where significant freshwater enters the Bay from the drainage canals. This station has a different salinity regime from BB41 and BISC122. Station BISC101 was evaluated to determine the potential impacts of the radial collector wells, assuming the salinity regime in the area of BISC101 is representative of the radial collector well area. A similar moderating effect is observed; but because the salinity regime is lower at this station (median salinity 28 ppt (or psu), minimum salinities 13 ppt or psu), the potential impact of the radial collector wells on salinity would be somewhat greater. At a distance of one mile from the wells, there is no significant difference. Within 0.5 mile of the wells, the median or average salinity increases by only about 1 ppt. The mean absolute difference in the salinity within 0.5 mile of the wells is less than 5 percent. This change in salinity would have no adverse impact on the estuarine biota that is already acclimated to a salinity variation between 13 ppt and 40 ppt.

An additional salinity analysis was conducted with salinity data from Site 12B of the Biscayne Bay Salinity Monitoring Network provided to FPL by Biscayne National Park. The data was collected, verified and validated by Biscayne National Park. The site is a bottom station located about one mile east of the Turkey Point peninsula. The period of record is from May 7, 2004 to December 31, 2009. The data were recorded on 15-minute intervals. The average salinity at this station for the period of record was 33.02 psu. The median value was 33.23 psu. The minimum and maximum weekly average salinity values were 24.63 psu and 40.83 psu, respectively. The salinity impact analysis was performed using weekly average values calculated from this data set. Weekly average values were used in the salinity impact analysis because this interval is reasonable and appropriate considering the estimated flushing time (several days to more than a week) for the Bay volume contained within the radial collector wells area of influence. Figure 11 shows the time history salinity plot without the radial collector wells and two scenarios with the radial collector wells operating. Scenario 1 uses a control volume with a radius of approximately ½ mile. Scenario 2 uses a control volume with approximately one mile radius. Figure 12 shows the cumulative probability plot without the radial collector wells and with the radial collector wells operating. The average and median salinity value increases by only approximately 0.1 psu (0.3 percent) within ½ mile of the radial collector wells (Scenario 1) and by less than 0.02 psu (0.06 percent) within one mile (scenario 2). These salinity impact analyses from multiple stations demonstrate that operation of the radial collector wells will have no adverse impact on salinity levels in Biscayne Bay and the change in salinity would have no adverse impact on the estuarine biota that is already acclimated to a salinity variation between 13 ppt and 40 ppt.

Ecological Impacts of Radial Collector Well Operation

The results of the ground water model were used to determine seabed velocity induced by the radial collector wells. The revised modeling analysis is discussed in the report entitled *Groundwater Model Development and Analysis: Units 6 & 7 Dewatering and Radial Collector Well Simulations, Rev. 1* (Bechtel Power Corporation, 2011). Based on the results of the Turkey Point APT and the groundwater modeling (Bechtel Power Corporation, 2011), the average tidal groundwater fluxes (oscillatory flow) are calculated to be less than 0.1 ft/day, while the average induced flux velocity directly above the radial collector wells will be less than 1.73 ft/day (6.2×10^{-4} cm/sec). To put this in perspective, a one-foot wind wave on Biscayne Bay in five to six feet of water can induce a velocity of approximately 1 ft/sec near the Bay bottom. This is about five orders of magnitude greater than the velocity induced by the radial collector wells. Consequently, natural mixing and dispersion processes in the water above the seabed will be the dominant factor in the movement of planktonic organisms.

There are a number of epibenthic macroinvertebrate and vertebrate species that utilize the seagrass beds of Biscayne Bay, including the area under which the proposed radial collector well laterals will be located. Recent trawl sampling conducted by EAI in the vicinity of the Turkey Point Plant documented a total of 74 taxa of fish over a one year period (EAI, 2009a). A total of nine species comprised over 75 percent of all individuals collected. They included pinfish (*Lagodon rhomboids*; 19.6%), bluestriped grunt (*Haemulon sciurus*; 12.6%), silver jenny (*Eucinostomus gula*; 12.3%), white grunt (*Haemulon plumierii*; 11.6%) fringed pipefish (*Anarchopterus criniger*; 6.9%), scrawled cowfish (*Acanthostracion quadricornis*; 4.1%), gulf toadfish (*Opsanus beta*; 3.7%), gray snapper (*Lutjanus griseus*; 3.3%), and planehead filefish (*Stephanolepis hispida*: 3.3%). Only pinfish exceeded one specimen per 100 m of bottom trawled.

The principal macroinvertebrates captured were shrimp within the genus *Farfantepenaeus*, primarily pink shrimp (*F. duorarum*). They comprised nearly 75% of the total shellfish captured. Other invertebrates captured included spiny lobster (*Panulirus argus*), blue crabs (*Callinectes sapidus*) and other related species within the genus *Callinectes*, and white shrimp (*Litopenaeus setiferus*). Stone crab (*Menippe mercenaria*), rock shrimp (*Sicyonia typica*), and brown shrimp (*Farfantepenaeus aztecus*) were only rarely captured. The catch per unit effort for pink shrimp was only 2.4 individuals per 100 m trawled.

All of the fish and invertebrates captured are highly motile and thus are able to enter and exit the area over time. These organisms are well adapted to living in areas like Biscayne Bay with relatively swift currents associated with tidal exchange and wind and wave-driven shallow-water turbulence. There is no likelihood that these organisms would be affected by the very minor through-substrate velocity changes projected for the radial collector well system.

Most families of fishes likely to spawn in the vicinity of seagrass beds are broadcast spawners producing buoyant eggs with oil globules. Buoyancy increases as both water temperatures and salinity increases. Thus, the warm saline conditions that characterize the shallow water environments along the western edge of Biscayne Bay and Card Sound produce conditions that ensure fish eggs remain suspended in the water column until hatching. The anticipated through-substrate velocities projected for the radial collector well system are predicted to have no effect on these buoyant eggs.

The few fish species that lay demersal eggs attach the eggs to hard bottom, vegetation, or other substrates. The attachment would render them immune to any slight velocity changes associated with the radial collector well system. Demersal fish eggs also tend to have longer embryonic development and the eggs are tended by the parents. The larvae hatch at a more developed stage than pelagic spawned species and thus are immediately capable of sustained swimming.

The EPA, in developing the Clean Water Act Section 316(b) rule for cooling water intakes at new facilities, and after reviewing numerous studies, determined that a through-screen velocity of 0.5 ft/sec was best technology available for minimizing impacts of impingement on fish and shellfish [40 CFR 125.84(b)(2)]. Although the radial collector wells are not subject to the 316(b) rule, for purposes of comparison, the seabed velocity induced by the radial collector wells will be at least four orders of magnitude less than the velocity accepted by the EPA for intakes subject to 316(b). Furthermore, as discussed previously, common wind waves on Biscayne Bay will induce bottom velocities that are five orders of magnitude greater than the velocity induced by the radial collector wells. Consequently, natural mixing and dispersion processes in the water above the seabed will dominate; and pelagic organisms, eggs, and larvae will not have an opportunity to settle, or be entrained onto the seabed.

Operation of the radial collector wells is not anticipated to result in adverse effects upon seagrasses. Seagrasses have low nutrient requirements and are able to recycle nutrients efficiently, so that they are strong competitors under low nutrient levels (Koch, 2001; Armitage et al., 2005). *Thalassia testudinum* is dominant species of seagrass in the area, and is more tolerant of low phosphorus environments as compared to other species such as *Halodule wrightii*.

Chapin (1980, 1988) indicated that plants in nutrient-poor environments have several effective strategies to overcome periods of nutrient stress, such as luxury consumption of nutrients, reduced growth rates, increased leaf longevity, reduced leaching, and nutrient uptake by leaves. Often, one or more of these strategies co-occur with nutrient resorption (Chapin 1980; Li et al., 1992; Reich et al., 1992). Stapel and Hemminga (1997) measured nutrient resorption efficiency in seagrasses up to 28 percent for nitrogen and 51 percent for phosphorus. The plants may optimize their leaf uptake capacity according to the relative nutrient availability in the water column and the porewater (Stapel et al. 1996). Additionally, the downward advection of surface water through the sediments during operation of the radial collector wells may transport more organic matter from the sediment surface than would typically occur due to normal settling processes, which may provide a larger pool of organic matter for diagenetic processes that regenerate nutrients.

An increase in anaerobic respiration, a condition associated with low oxygen, can result in an increase of hydrogen sulfide in the sediment porewater (Goodman et al, 1995). Seagrass health is compromised by anoxia and sulfide concentration in the rhizosphere (Terrados et al., 1999; Duarte et al., 2005). Oxygen released by seagrass roots may prevent the development of anoxic conditions and exposure of the seagrass rhizospheres to toxic metabolites (Marba and Duarte, 2001). The vertical flux of surface water resulting from operation of the radial collector wells is anticipated to increase oxygen concentrations within the porewater, thus increasing redox potential and reducing potential for deleterious effects related to sulfides. Due to the shallow, well-mixed surface waters of the Bay, it is unlikely that operation of the radial collector wells would result in any alteration in temperature within the rhizosphere.

Based on the analyses performed, the radial collector wells will not be detrimental to Comprehensive Everglades Restoration Project (CERP) objectives. The radial collector wells will withdraw water from a saline aquifer that is recharged almost entirely from the Bay. There are no significant sources of fresh water in this part of the Bay. As demonstrated by the salinity impact analysis, the effect of the radial collector wells is to slightly moderate extreme salinity fluctuations that are known to exist in Biscayne Bay. The potential impacts conservatively model the radial collector wells as if they were operated full-time, 365 days a year. However, it is expected that this backup supply would be required, on an infrequent basis, during periods when reclaimed water is not available in sufficient quality or quantity.

The Biscayne Bay Coastal Wetland (BBCW) projects have an objective to return salinity levels in Biscayne Bay to more natural conditions. As mentioned above, one of the goals is to lower salinities along the shoreline. However, this is not the only consideration. It is also widely recognized that cumulative urban development and channelization of the drainage basins around Biscayne Bay have increased variability in freshwater flow to the Bay. More freshwater enters the Bay in rapid response to storm events and less enters the Bay as a steady base flow. The increased temporal variability in the freshwater inflow causes a corresponding increased variability in the Bay salinity, especially near the shoreline. Also, based on the annual average salinity near the Turkey Point peninsula and research conducted in Biscayne Bay [Stalker, (2008)], the water in the area of the Turkey Point Peninsula contains less than one percent freshwater from groundwater sources. The source of freshwater flows into the Bay primarily through canals located north of Homestead Bayfront Park.

The salinity impact analysis shows that operation of the radial collector wells will have no significant adverse impact on the average salinity in the Bay. Salinity changes attributable to the radial collector wells (changes that are calculable, but not likely measureable), tend to moderate the extreme salinity variations. Because the radial collector wells reduce the salinity extremes, they tend to move the system back toward the more natural salinity condition that existed before development. In addition, USACE modeling of the BBCW projects shows that the area around the Turkey Point peninsula will not be influenced by these projects (USACE, 2010). As a result, the radial collector wells would not be inconsistent with BBCW or CERP goals.

Construction of the Radial Collector Wells

The existing road to the Turkey Point peninsula will be used for construction of the radial collector wells and no widening of the existing access road to the Turkey Point peninsula is proposed. Although all details regarding construction equipment staging area(s) are not available at this time, it is FPL's intent to limit the staging area(s) to impacted areas. Construction laydown areas for the Turkey Point Units 6 & 7 Site and the radial collector wells are illustrated on Figure 13.

The caissons for the radial collector wells will be initially constructed on the upland areas of the Turkey Point peninsula. The laterals will then be directionally drilled from the caissons approximately 25 to 40 ft below Biscayne Bay. The drilling technology envisioned for the radial collector wells is a conventional rotary-type horizontal drilling method whereby the drilling fluid consists of formation water.

The drilling would occur from a position inside the concrete caisson that would be maintained in a dewatered condition. This would place the drilling equipment below sea level and use the natural head in the formation (and Bay) to push the drilling water (and cuttings) back toward the caisson where the drilling water and cuttings would be managed to handle the water and spoils generated. This reverse-flow scenario will maintain control of the drilling water within the drill bore and within the caisson, precluding "frac-outs" as the water in the formation would be drawn into the bore hole rather than pushed out by head pressure into the surrounding formation.[1]

Dewatering effluent will be routed to the existing industrial wastewater facility to avoid any discharge to surrounding surface waters or wetlands. The solid *in situ* materials (i.e., drill cuttings), if suitable, will be reused for fill; if not suitable for fill, the solid material will be placed in the spoils areas, which are located within the industrial wastewater facility. The radial collector well caissons will be installed within previously filled upland areas of the Turkey Point peninsula, surrounded by silt fencing prior to construction to avoid erosion/turbidity impacts to nearby surface waters. FPL will utilize BMPs during construction of the radial collector wells to isolate the construction area with turbidity curtains, silt screens, or other erosion and turbidity control measures, as appropriate.

The radial collector well site is only a few feet above high tide [ground surface elevations are typically 2.5 ft to 4.5 ft NAVD 88 (North America Vertical Datum of 1988)]. While it is not subject to submergence during seasonal high tide, it could be submerged during a significant storm event. FPL will take appropriate and necessary steps to protect nearby waters from turbidity and nutrient runoff during construction of the radial collector wells and associated pipelines. Sheet pile barriers are under consideration, along with the other best management practice (BMP) technologies.

Terrestrial systems within the radial collector wells area, the laydown area and associated delivery pipelines are limited to uplands previously filled with limerock aggregate. These areas do not contain unique wildlife species and are not considered important wildlife habitats because of their disturbed nature. No significant adverse impacts to terrestrial wildlife resources in these areas are expected as a result of construction of the radial collector wells and installation of the associated delivery pipelines.

The delivery pipelines from the radial collector wells will require excavation on the Turkey Point peninsula and the existing berm east of the plant area. Approximately 14 acres will be temporarily

[1] A typical type of horizontal directional drilling, but which will not be used for the radial collector wells, uses a viscous drilling fluid (mud) to help maintain the bore hole and collect cuttings, and transport the cuttings for removal from the bore hole. Because of the nature of the directional drilling setup, the hole is managed from grade level and allows the mud to maintain head during the drilling operation. If and when a fracture or solution channel is encountered during drilling there is a tendency to lose drilling fluids which can cause the drilling mud to enter the formation and or to travel to openings where this fluid could enter the surface water (e.g. Bay). This occurrence is termed "frac-out" and the head maintained during drilling forces the mud out into the openings and possibly into the surface water body.

disturbed during the construction of the wells and the delivery pipelines, including an area for laydown. Approximately 3 acres of wetlands will be temporarily impacted during pipeline installation; these areas will be restored.

During the construction of the radial collector well caissons and the delivery pipelines, the surface water flow will temporarily change in the immediate vicinity. Unused excavated material will be placed in designated spoils areas. Sedimentation barriers or other appropriate methods will be installed to limit potential impacts to surface water bodies. Temporary traps with a controlled stormwater release structure will be installed as necessary to detain sediment-laden runoff from disturbed areas. When construction activities are complete, the drainage will be restored to preconstruction conditions.

No impacts to aquatic systems are expected as a result of the radial collector well caissons on the Turkey Point peninsula. Construction of the delivery pipelines from the radial collector wells to the Site will result in temporary impact to approximately three acres of mangrove wetlands during the radial collector well delivery pipeline installation. These temporarily impacted areas will be restored *in situ*. The co-location of the radial collector well delivery pipeline with the existing previously impacted roadway from the Turkey Point peninsula to the Site minimizes the amount of additional clearing required for construction and reduces impacts to adjacent wetlands.

Efforts to avoid and minimize mangrove wetlands adjacent to the radial collector wells include location of the caissons within previously-filled upland areas of the peninsula and co-location of the delivery pipeline with the existing access roadway. Adjacent areas will be protected through use of BMPs to isolate the construction area with silt screens, turbidity curtains, or other erosion and turbidity control measures. These BMPs will be designed to prevent discharge of sediments or turbid water during construction, including during storm events.

Following installation, the delivery pipeline trench will be backfilled with soil to original topographic grade and the area will be allowed to naturally re-vegetate. The upper layer of the soil horizon associated with the delivery pipeline trench will be scraped and placed in a spoils bank, segregated from the spoils resulting from the further excavation of the trench. The upper layer of the soil horizon will be replaced and the grading restored to allow natural revegetation of the temporarily impacted work area from the native seed bank.

As necessary, FPL will control exotic species of vegetation within the restored areas through manual removal and/or herbicide application. The pipeline restoration areas will be monitored to document vegetative succession and extent of exotic species of vegetation, in accordance with FDEP vegetative restoration success criteria. If regeneration of the native vegetative community from the seed bank is not successful, FPL will conduct supplemental plantings of native species to restore the temporarily impacted areas.

Some dewatering will be required for the construction of the radial collector well caissons and the removal of water generated while drilling the laterals. Areas requiring dewatering will be isolated using sheet pile technology or equivalent. The amount of dewatering will be based on the final engineering/construction means and methods selected during final design. However, the amount of dewatering effluent generated will be small compared to the hydraulic capacity of the industrial wastewater facility. Dewatering effluent produced during construction of the radial collector well laterals will be collected in the caissons and pumped to a temporary sedimentation basin. After sedimentation, dewatering effluent from construction of the radial collector wells will be routed to the existing industrial wastewater facility. Thus for dewatering quantities from the construction of the radial collector wells there will be no adverse impact on the industrial wastewater facility.

Maintenance of the Radial Collector Wells

Pump Maintenance Testing

The pumps associated with the radial collector wells will normally not be operated since the radial collector wells are a backup cooling water supply. As a result, periodic testing will be necessary to determine the operability of each pump and identify maintenance requirements for each pump. The periodic testing schedule will include monthly, quarterly and annual pump testing. The total duration of testing in an annual period is approximately 8 hours (480 minutes) per year for each pump when the radial collector wells are not operated as a backup supply. If the radial collector wells are operated as the backup supply in any annual period, the amount of periodic testing will be adjusted according to the radial collector well operation and the periodic testing schedule.

Well Maintenance

Maintenance for the radial collector wells, consisting primarily of cleaning the laterals, will be scheduled once the system becomes operational. FPL will develop a program to monitor radial collector well performance. The performance monitoring program will be used to determine the frequency of cleaning and maintenance. The monitoring criteria to be measured will include, at a minimum, flow rate, water temperature, static and pumping water levels, and ground water differentials. Typically radial collector well laterals need cleaning every 5-10 years; however, some have operated for 40-plus years with no upkeep required. Water quality, geologic formations, and frequency of use are key determinants for the timing of maintenance and/or cleaning activities. Lower utilization generally leads to longer intervals between required maintenance. As the radial collector wells are proposed as a back-up water source to the reclaimed water supply, the current expectation is that cleaning will be infrequent.

Multiple chemical and physical methods have been developed for cleaning radial collector well laterals. There is no plan at this time to use chemicals to clean the well laterals. FPL expects to use physical methods to clean, if necessary, the well laterals. Three common physical methods that may be used, individually or in succession, to maintain well laterals are:

1. A high-pressure rotating water jet blaster that is hydraulically projected at a prescribed rate into each lateral well screen;
2. A mechanical packer/surge block device which surges water or air in isolated sections of the laterals; and
3. A bore blast where a small quantity of nitrogen is used to create a pressure pulse down the length of the lateral.

All three options remove obstructions to flow located in the interior of the laterals, with all water and solids flowing into the caisson. The solids are separated from the water, removed from the caisson, and deposited in the designated spoils location within the industrial wastewater facility or at an approved off-site disposal facility. The water will remain in the caissons as makeup cooling water.

Following installation of the radial collector well delivery pipeline, no maintenance is required, nor is any requirement for repair of the radial collector well delivery pipeline anticipated. If any disturbance of the restored areas becomes necessary, the areas will be returned to the pre-disturbance condition to avoid any loss of wetland function.

Monitoring and Conditions of Certification

While the Project is not anticipated to cause adverse impacts to aquatic systems in Biscayne Bay as a result of the operation of the radial collector wells as a backup cooling water supply, FPL anticipates that monitoring may be required to confirm the analyses presented in the SCA and the completeness responses. FPL will work with the appropriate agencies to develop appropriate monitoring conditions based on expected Project impacts to Biscayne Bay.

Summary

The radial collector wells are a necessary backup cooling water source for the proposed new nuclear units. The wells will be used when reclaimed water, the primary source of cooling water, is not available in a quantity or quality needed to meet the Project's cooling water needs. Considerable amounts of data and analyses have been developed for the radial collector wells that lead to the following conclusions.

1. Radial collector wells were selected for the backup cooling water supply based on an evaluation of 16 potential water source alternatives.
2. Radial collector wells have been successfully used worldwide for the development of large capacity water supplies.
3. Location of the radial collector well caissons on the upland portion of the Turkey Point peninsula minimizes potential impacts to wetland areas.
4. A groundwater model was developed using regional and site specific geologic information. The model also includes data collected during an APT conducted on the Turkey Point peninsula at the location of the radial collector wells. This groundwater model was calibrated using aquifer pumping test results and sensitivity analyses performed to validate predictions.
5. The results of the revised groundwater model determined that the radial collector wells will withdraw water from a saline aquifer that will be recharged from Biscayne Bay. This is demonstrated by revised groundwater model that shows: approximately 97.8 percent of the aquifer recharge will originate from boundaries representing Biscayne Bay, approximately 1.9 percent will originate from boundaries representing the cooling canal system and approximately 0.3 percent will be from boundaries representing precipitation onshore.
6. Analyses of multiple sampling stations in Biscayne Bay shows that the potential effects of the withdrawal from the radial collector wells on the circulation and natural salinity within Biscayne Bay will not have an adverse impact on aquatic systems. The predicted highly localized salinity changes are well within the natural ranges experienced by aquatic life in Biscayne Bay.
7. The through-substrate velocity is not anticipated to have adverse impacts on highly motile fish and invertebrates, planktonic organisms or seagrasses.
8. Based on the analyses performed, the radial collector wells will neither be detrimental to CERP objectives nor to BBCW projects.
9. The assessment of impacts was based on assumed continuous operation of the radial collector wells. However, FPL is prepared to accept a restriction for the radial collector wells as a backup water supply based on the approach taken for other recent power plants using reclaimed water as their primary water supply source.

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Table 1. Examples of Existing Radial Collector Wells Installations

Location	Capacity (MGD)	Water Source	Comments
Sur, Oman	53	Seawater	Reverse Osmosis Desalination Plant
Salina Cruz, Mexico	14	Seawater	Pemex Refinery
Almeria, Spain	15	Seawater	Reverse Osmosis Desalination Plant (installed 2001)
Cartagena I, Spain	17	Seawater	Reverse Osmosis Desalination Plant (installed 2001)
Javea-Alicante, Spain	7	Seawater	Reverse Osmosis Desalination Plant (2002)
Fukuoka, Japan	13	Seawater	Reverse Osmosis Desalination Plant (2005)
Alicante II, Spain	10	Seawater	Reverse Osmosis Desalination Plant (2009)
Charlestown, Idaho	100	Freshwater	Indiana Army Ammunition Plant (installed 1940-41)
Belgrade, Serbia	170	Freshwater	Belgrade Water Works and Sewerage
Marysville, Washington	10	Freshwater	
Boardman, Oregon	9	Freshwater	
Carmichael, California	8	Freshwater	
Santa Rosa, California	110	Freshwater	Sonoma Co. Water Agency (1957 first well installed)
Kansas City, Kansas	50	Freshwater	Board of Public Utilities; two wells
Louisville, Kentucky	80	Freshwater	Louisville Water Company; 5 wells
Grand Gulf, Mississippi	40	Freshwater	Entergy Nuclear Power Plant, 25+ years operation
Prince George, British Columbia	75	Freshwater	Municipal system (1972 first well installed)
Newport, Indiana	90	Freshwater	Newport Army Ammunition Plant (1940-41 first well installed)
Minnesota	90	Freshwater	Gopher Army Ammunition Plant
Carolina, Puerto Rico	3	Freshwater	
Boise, Idaho	3	Freshwater	United Water Idaho
Vernal, Utah	10	Freshwater	Bonanza Power Plant
W. Terre Haute, Indiana	7	Freshwater	Mirant Sugar Creek Power Plant
Evansville, Indiana	10	Freshwater	Vectren A.B. Brown Power Plant
Port of St. Helens, Oregon	15	Freshwater	Port Westward ethanol plant
Beloit, Wisconsin	7	Freshwater	Calpine Riverside Power Plant
Lake Havasu, Arizona	25	Freshwater	Lake Havasu City
Kansas City, Kansas	30	Freshwater	Johnson County Water District; additional 50 MGD planned
Umatilla/Irrigon, Oregon	50	Freshwater	Umatilla and Irrigon Steelhead Hatcheries

Source: FPL. 2009. Examples of Existing Radial Collector Well Installations and Permitting Summary, Memorandum.

1,750 0 1,750 Feet

LEGEND

- Turkey Point Plant Property
- Turkey Point Units 6 & 7 Site
- Associated Non-Linear Facilities

REFERENCES

1. Imagery, Miami-Dade County, 2007.
2. Original Figure 1.4-1 Provided in SCA Chapter 1 as Figure # 1.4-1.

PROJECT

TURKEY POINT UNITS 6 & 7 PROJECT

TITLE

SITE AND ASSOCIATED NON-LINEAR FACILITIES ON TURKEY POINT PLANT PROPERTY

FPL

FILE No. 09387652C070

REV. 0

PLOT DATE 12/1/2010

FIGURE 1

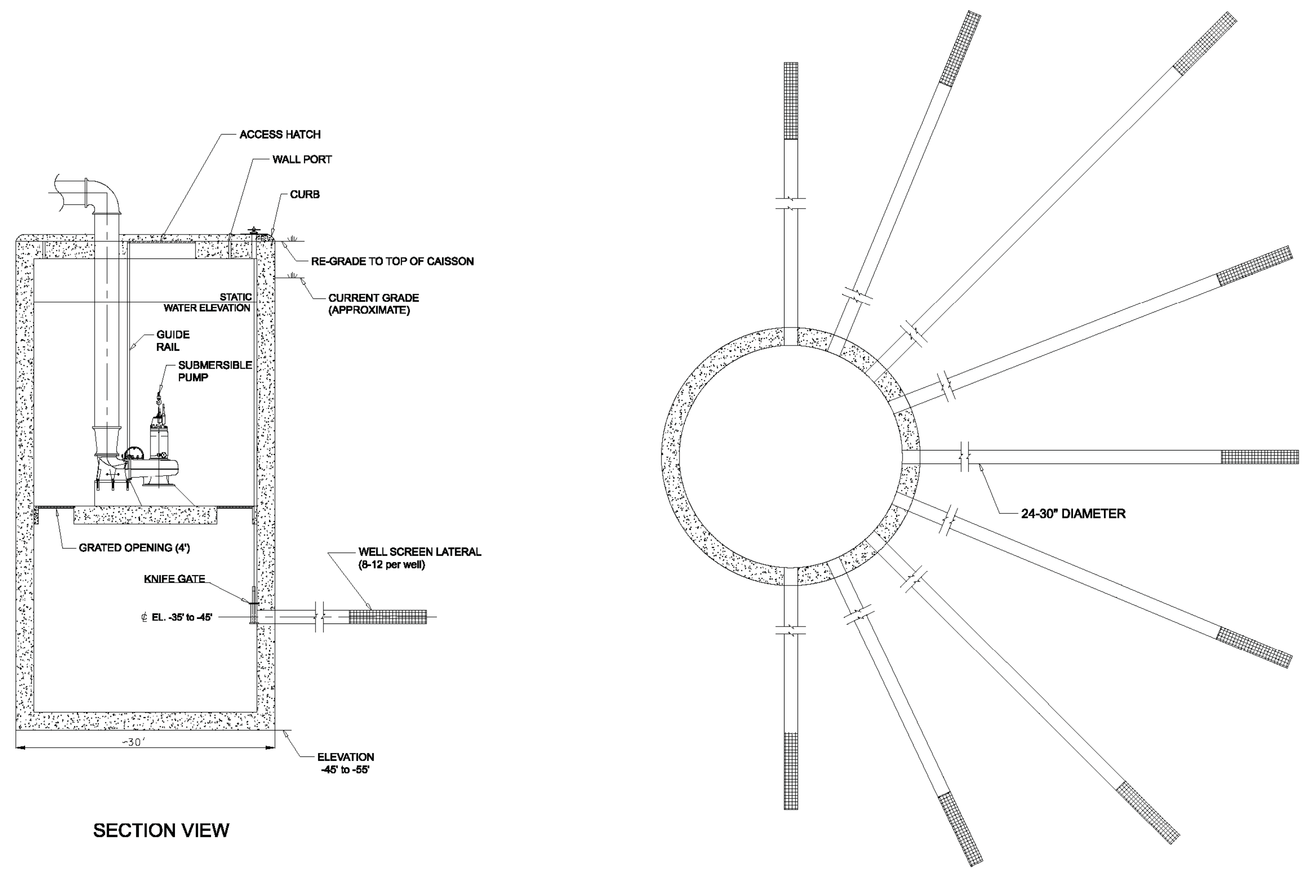
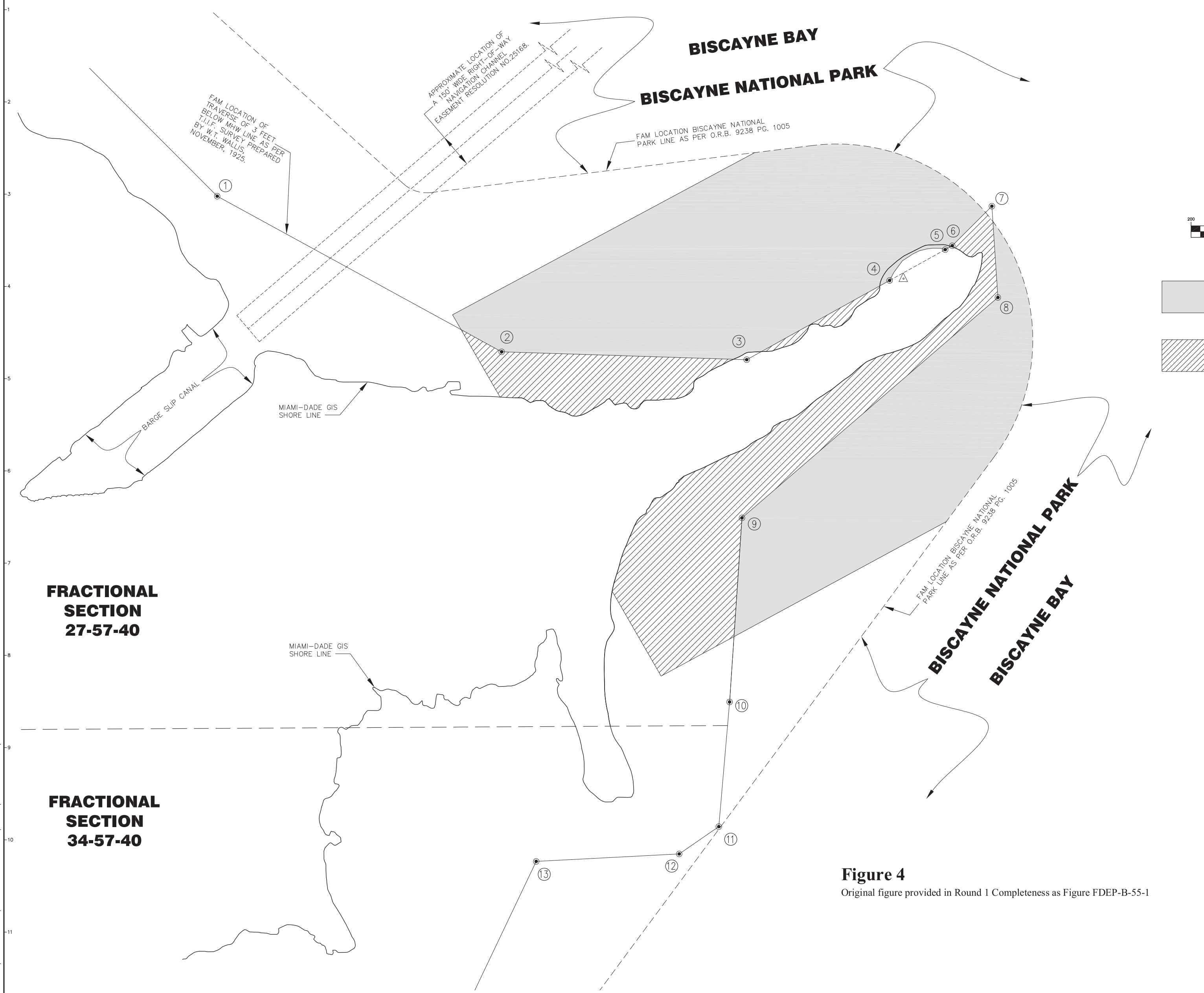


Figure 2
Typical Radical Collector Well Conceptual Design
Rev. 0
Source: Golder, 2008.
Original figure provided in SCA Chapter 4 as Figure 4.5-2.
0838-7584

Figure 3
Potential Area of Radial Collector Well Laterals
Rev. 0
Original figure provided in SCA Chapter 4 as Figure 4.5-3.
0838-7584

TURKEY POINT DETAIL



FROM POINT TO POINT	BEARING AND DISTANCE
1 TO 2	S61°23'00"E 1405.80' (BY DEED) S61°19'12"E 1405.80' (Calculated)
2 TO 3	S88°13'00"E 1063.26' (BY DEED) S88°09'12"E 1063.26' (Calculated)
3 TO 4	N60°59'48"E 708.44' (Calculated)
4 TO 5	N60°59'48"E 275.79' (Calculated)
5 TO 6	N60°59'48"E 34.82' (Calculated)
6 TO 7	N45°00'00"E 242.88' (BY DEED) N45°03'48"E 242.88' (Calculated)
7 TO 8	S03°49'00"E 396.66' (BY DEED) S03°45'12"E 396.66' (Calculated)
8 TO 9	S49°12'00"W 1464.54' (BY DEED) S49°15'48"W 1464.54' (Calculated)
9 TO 10	S03°47'00"W 799.92' (BY DEED) S03°50'48"W 799.92' (Calculated)
10 TO 11	S04°53'00"W 542.52' (BY DEED) S04°56'48"W 542.52' (Calculated)
11 TO 12	S55°18'00"W 208.56'(BY DEED) S55°21'48"W 208.56' (Calculated)
12 TO 13	S86°57'00"W 621.06' (BY DEED) S87°00'48"W 621.06' (Calculated)

POINT NUMBER	NORTH	EAST
1	402,494.5109	722,019.4073
2	401,819.8439	723,252.7353
3	401,785.5812	724,315.4432
4	402,129.0740	724,935.0346
5	402,262.7921	725,176.2350
6	402,279.6740	725,206.6866
7	402,451.2262	725,378.6183
8	402,055.4170	725,404.5844
9	401,099.6818	724,294.8783
10	400,301.5639	724,241.2149
11	399,761.0645	724,194.4346
12	399,642.5251	724,022.8372
13	399,610.1653	723,402.6208

3 RM 3 FOUND
TRIANGULATION POINT
LATITUDE: 25°26'19.61926" (NAD 83)
LONGITUDE= 080°19'04.749000" (NAD 83)
COORDINATES
N 402136.8770 (NAD 27)
E 724995.2940 (NAD 27)

Figure 4
Original figure provided in Round 1 Completeness as Figure FDEP-B-55-1

FORD, ARMENTEROS & MANUCY, INC.
1950 N.W. 94th AVENUE, 2nd FLOOR
DORAL, FLORIDA 33172
PH. (305) 477-6472
FAX (305) 470-2805
L.B. No. 6557

RECORD OF REVISION

No.	DATE	DESCRIPTION	BY	APP.

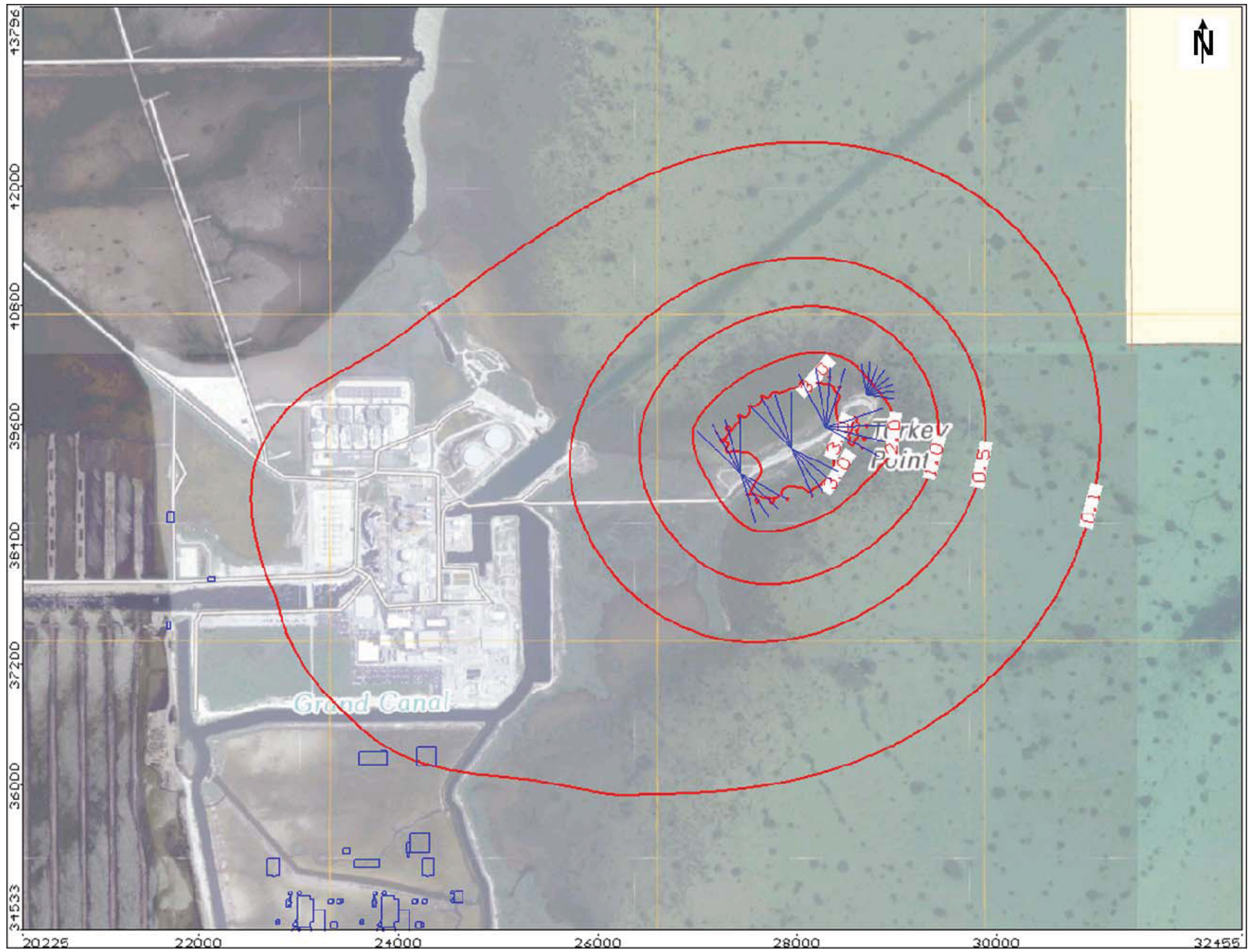
TURKEY POINT DETAIL

TYPE OF PROJECT: EXHIBIT
SHEET NAME: EXHIBIT
CLIENT: "FLORIDA POWER & LIGHT COMPANY"
CLIENT ADDRESS: 700 UNIVERSE BOULEVARD JUNO BEACH, FLORIDA
PROJECT LOCATION: SECTIONS 33 AND 34, TOWNSHIP 57 SOUTH, RANGE 40 EAST, MIAMI-DADE COUNTY, FLORIDA.

SCALE: 1" = 200'
DRAWN BY: R.RODRIGUEZ
DWG. CHECKED BY: O.A.
QUALITY CONTROL:
DATE: SEPTEMBER 29, 2009.
PROJECT No. 08-023-5807
SHEET: 1 OF 1 SHEETS

CAD FILE:Q:\FORD COMPANIES\ENGINEERING & SURVEYING\SURVEY\SKETCH AND LEGAL\08-023-5807.DWG

Figure 5 RCW Drawdown within the Pumped Layer (Upper Higher Flow Zone)



Note: Thin red line = 0.1, 0.5, 1.0, 2.0, and 3.0 foot drawdown contours. Light yellow portion in top right is where aerial imagery is not available. Approximate elevation of Upper Higher Flow Zone underneath Turkey Point Peninsula is -22 ft NAVD 88.

LEGEND

- Center of Collection Area
- Scenario 1 = 1 Square Mile
- Scenario 2 = 4 Square Miles

NOTES

Scenario 1
- The change in the average salinity is 0.36 percent.
- The mean absolute percent difference in the salinity is 1.47 percent.

Scenario 2
- The change in the average salinity is 0.09 percent.
- The mean absolute percent difference in the salinity is 0.37 percent

REFERENCES

1. Original Figure Provided in SCA Chapter 6 as Figure 6.1.3-1

1,400 700 0 1,400 Feet

PROJECT
TURKEY POINT UNITS 6 & 7
PROJECT

TITLE
CONTROL VOLUMES FOR
SALINITY ANALYSIS

FPL

FILE No. 09387652C071
REV. 0
PLOT DATE 12/3/2010

FIGURE 6

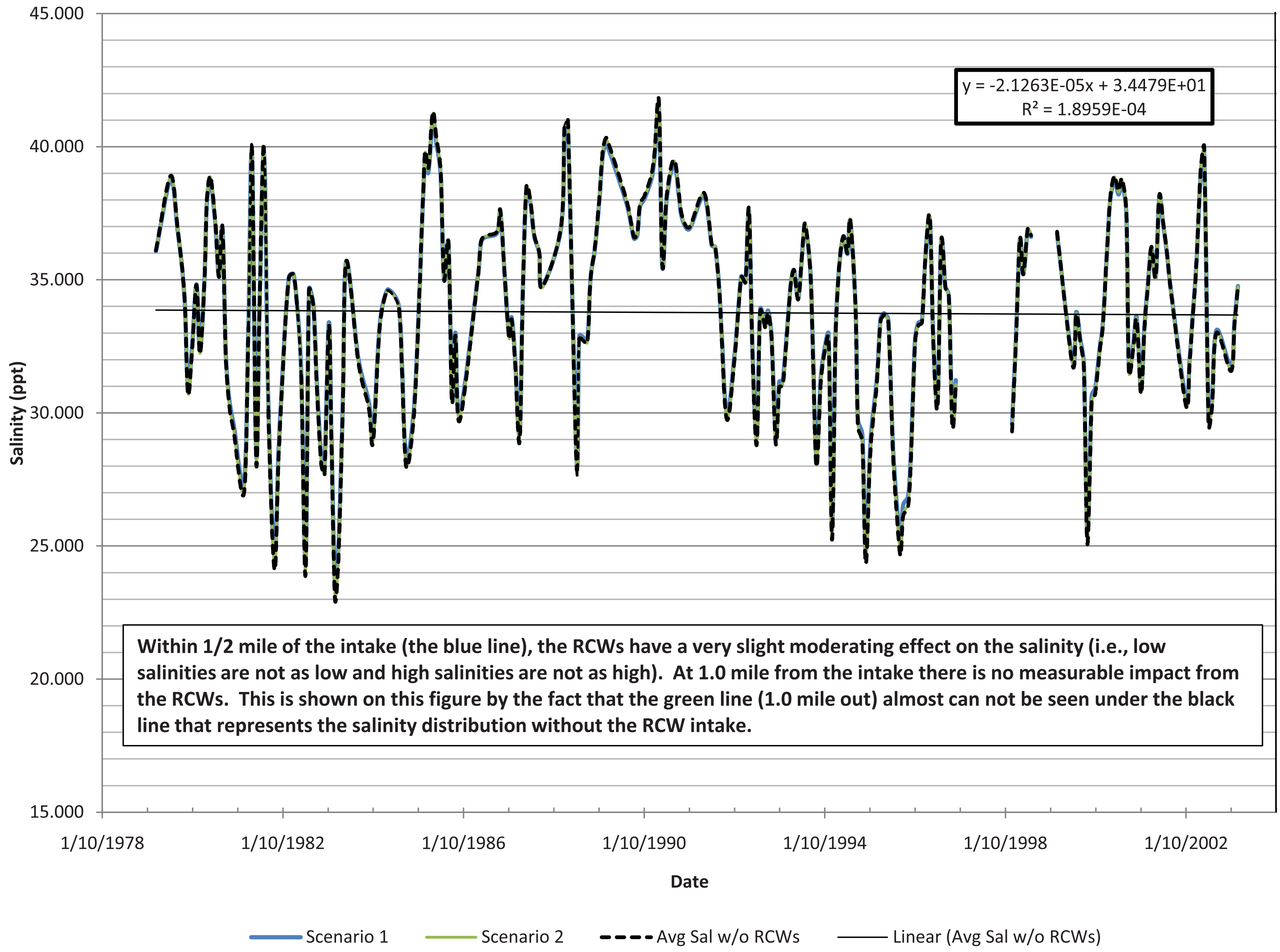


Figure 7: Salinity Time History in Biscayne Bay With and Without RCWs for Station BB41

Original figure provided in Round 1 Completeness as Figure 3 to Attachment SFWMD-B-63a

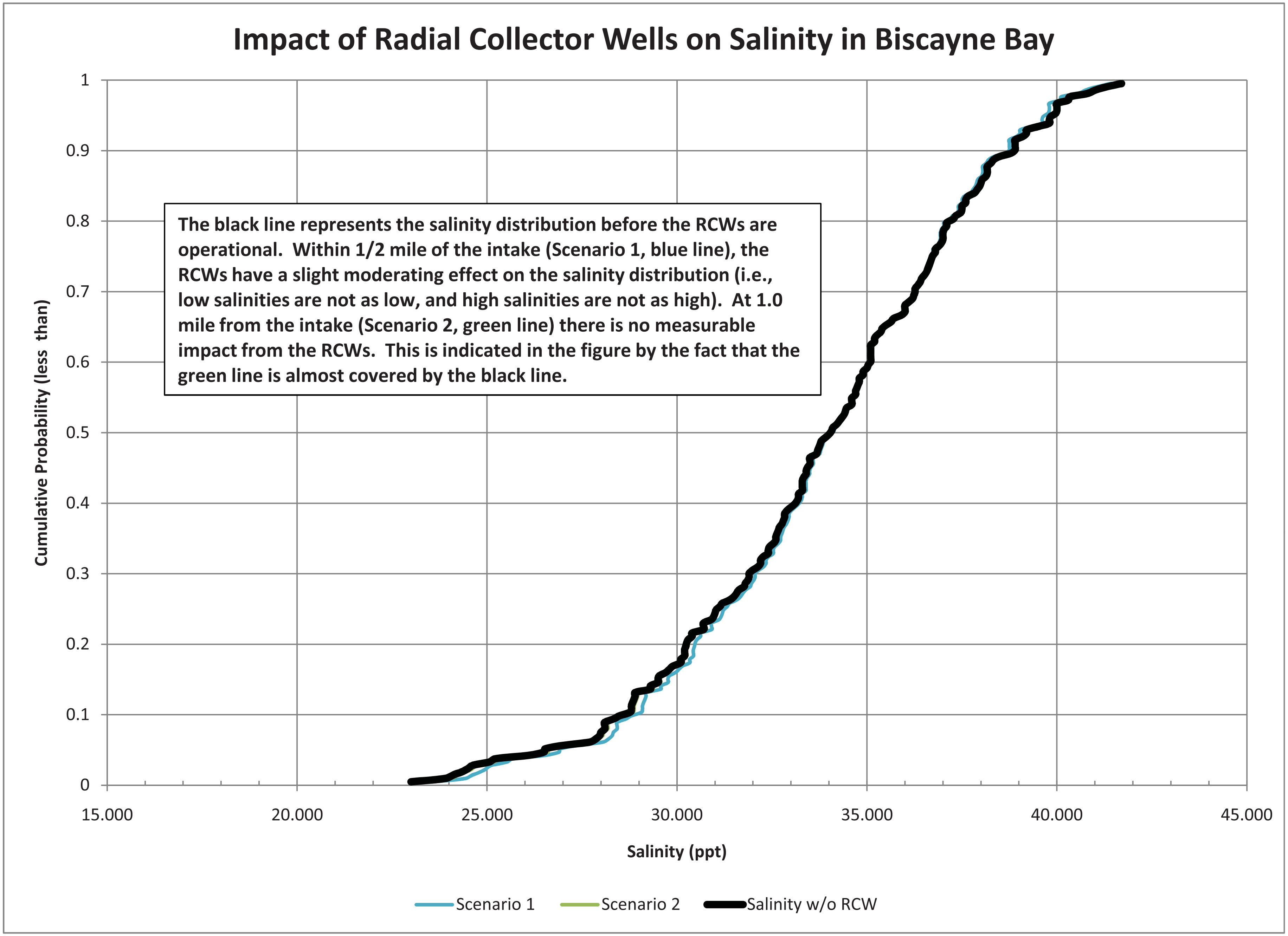


Figure 8. Salinity Probability Distributions in Biscayne Bay with and without RCWs for Station BB41

Original figure provided in Round 1 Completeness as Figure 2 to Attachment SFWMD-B-63a

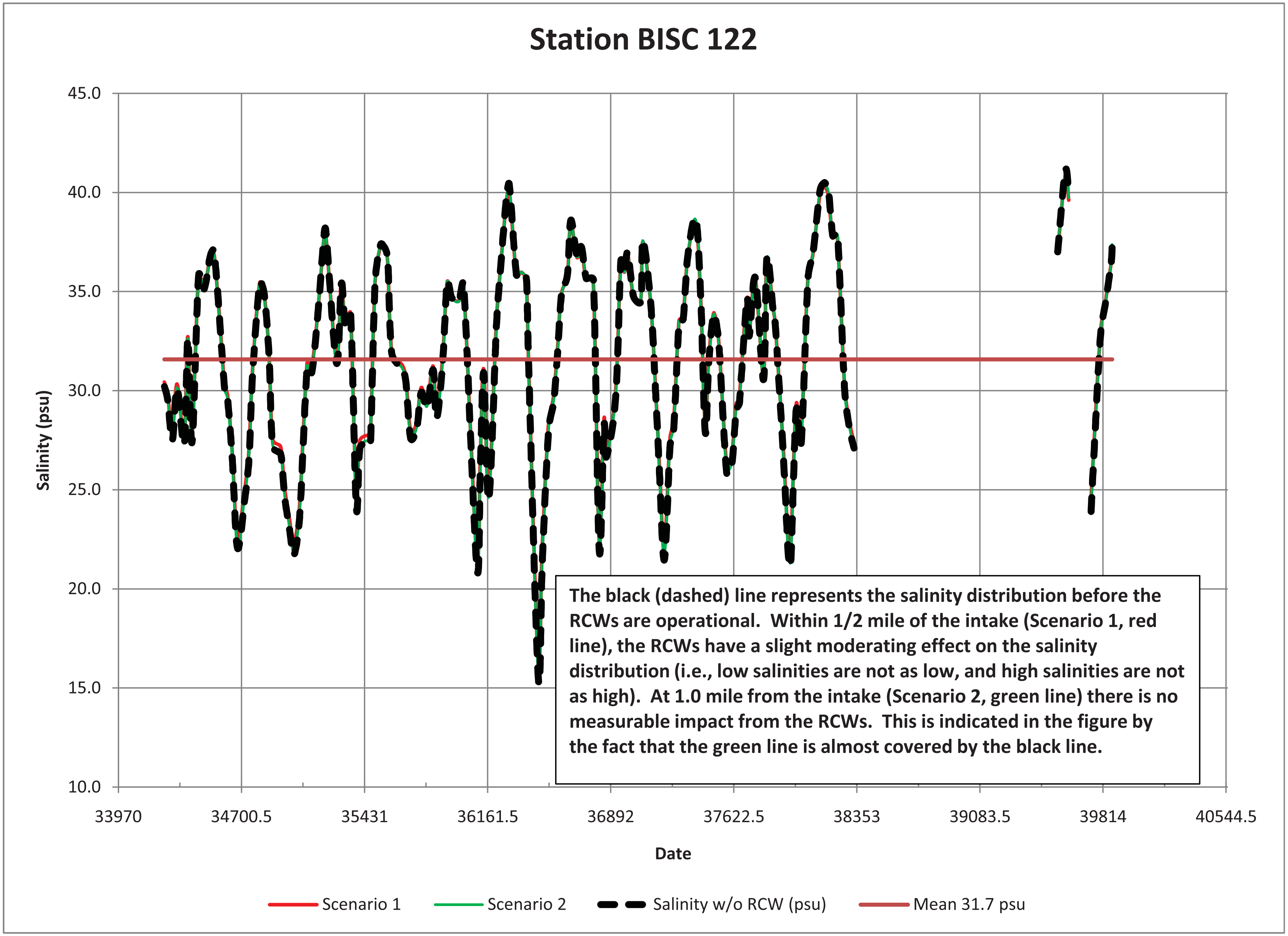


Figure 9. Salinity Time History in Biscayne Bay with and without radial collector wells for Station BISC122

Original figure provided in Round 2A Completeness as Figure 2SFWMD-B-60(58)-1

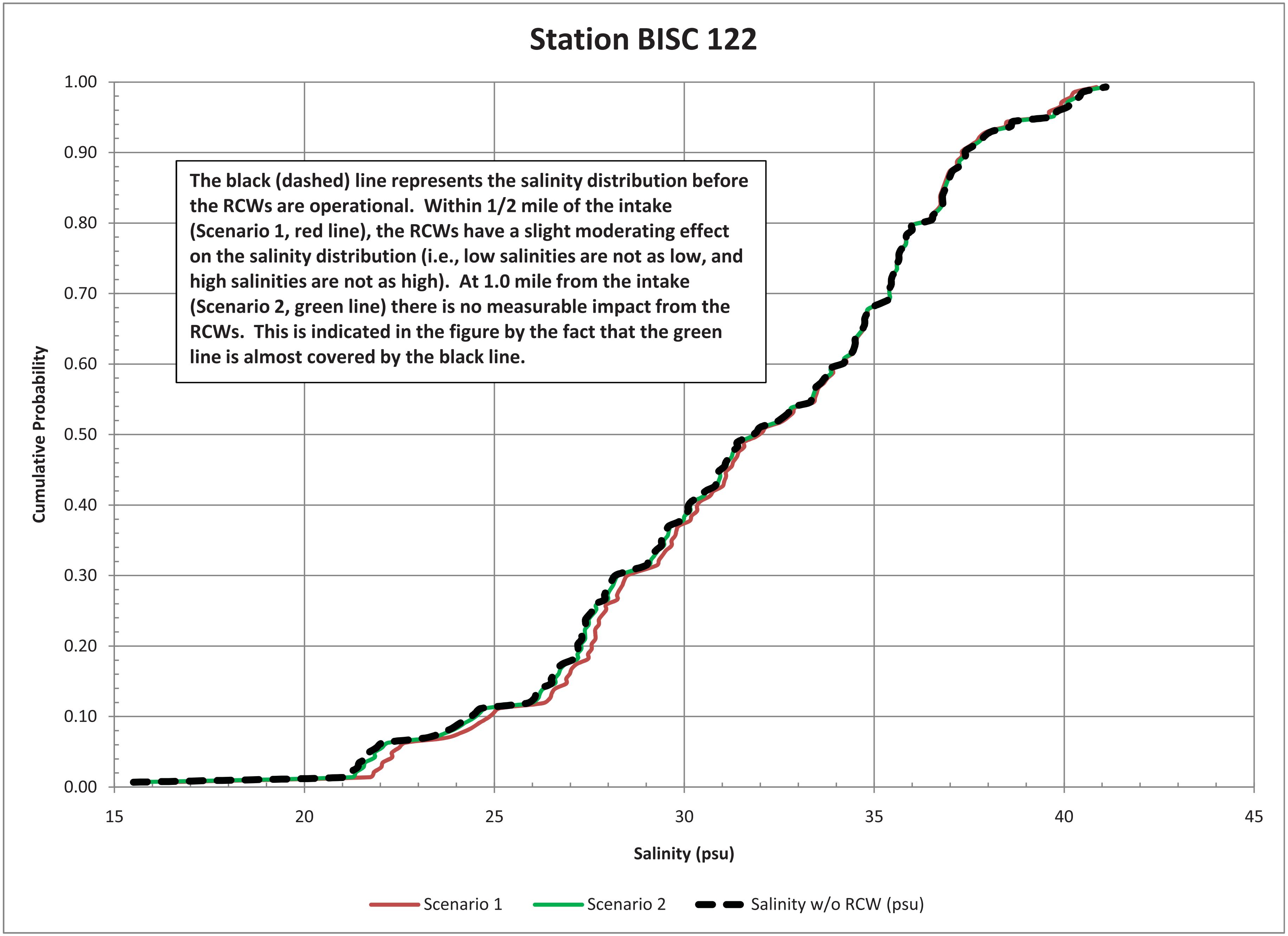


Figure 10. Salinity Probability Distributions in Biscayne Bay with and without radial collector wells for Station BISC122

Original figure provided in Round 2A Completeness as Figure 2SFWMD-B-60(58)-2

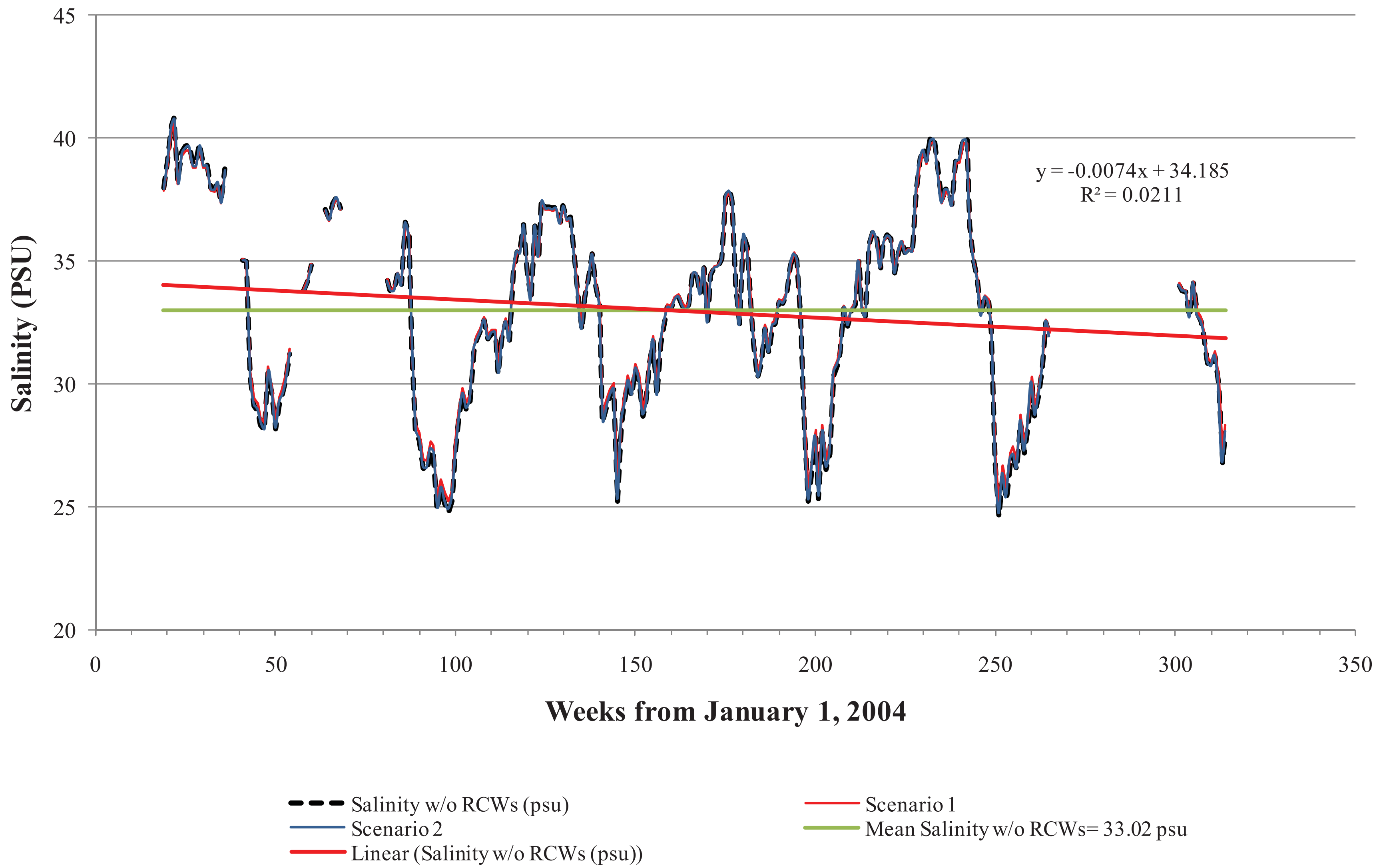


Figure 11
Time History Plot – BNP Site 12 Bottom – Weekly Average Salinity, 2004-2009

Original figure provided in Round 3 Completeness as Figure 3FDEP-VI(CAMA)-6-1

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Source: Golder, 2010.

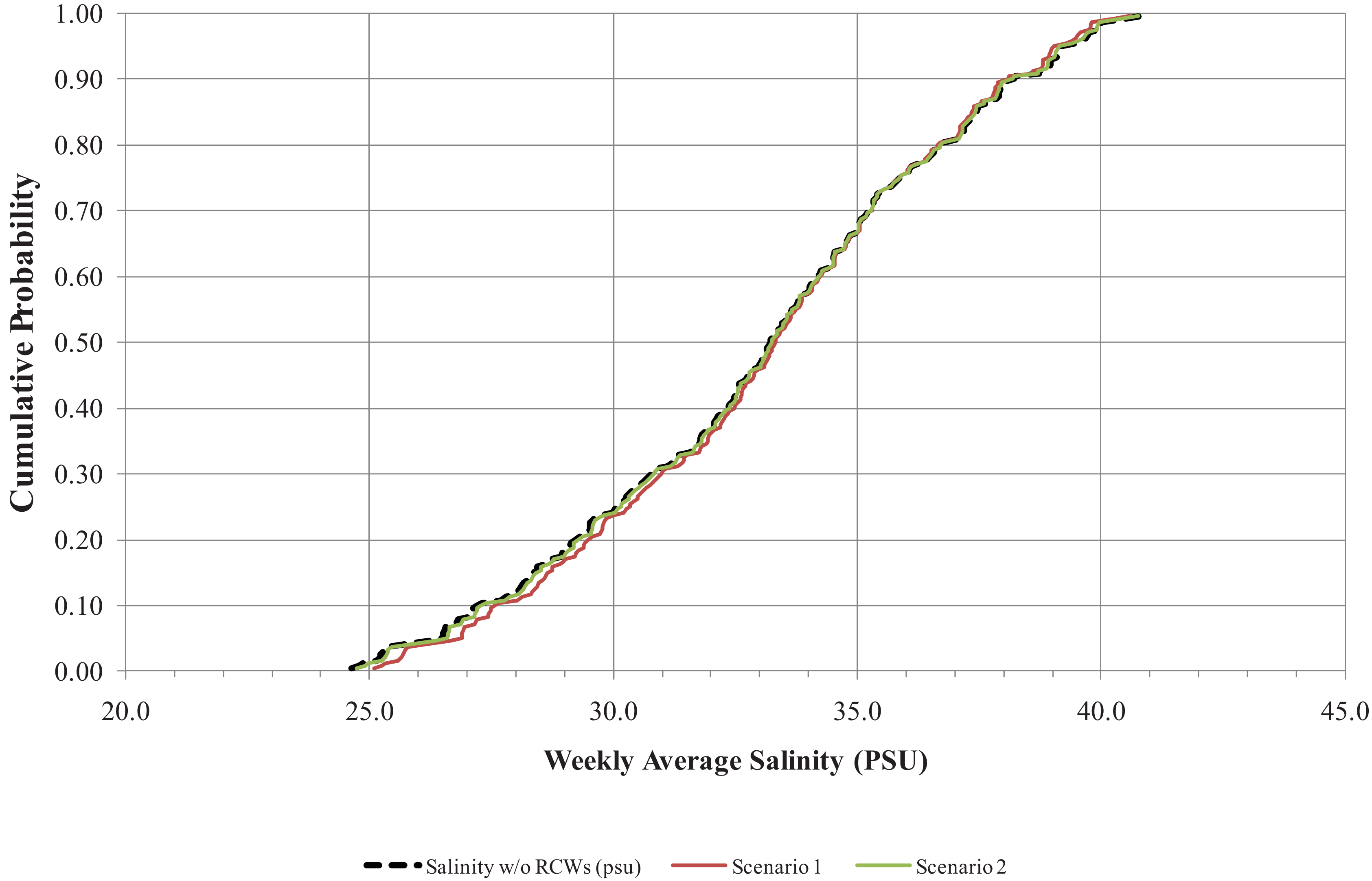

Figure 12
Cumulative Probability of Salinity – BNP Site 12 Bottom

Original figure provided in Round 3 Completeness as Figure 3FDEP-VI(CAMA)-6-2

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Source: Golder, 2010.

LEGEND

Turkey Point Units 6 & 7 Site

Construction Laydown Areas

REFERENCES

1. Original Figure Provided in SCA RAI Response to FDEP as Figure II-B-49

PROJECT

TURKEY POINT UNITS 6 & 7
PROJECT

TITLE

CONSTRUCTION LAYDOWN AREAS

FPL

FILE No. 09387652C072

REV. 0

PLOT DATE 12/3/2010

FIGURE 13