TETRA TECH

Determination of Allocation of Costs for CCS Recovery and Improvement

December 21, 2016

Introduction

Florida Power & Light Company (FPL) will soon be operating a Recovery Well System (RWS) that is designed to extract 15 mgd of hypersaline water from the Biscayne Aquifer adjacent to the Turkey Point Cooling Canal System (CCS). The construction and operation of the RWS is required under the FDEP Consent Order and MDC DERM Consent Agreement for the purpose of: 1) retracting hypersaline groundwater that has migrated north and west of the G-III groundwater discharge zone, and 2) to contain hypersaline groundwater that occurs beneath the CCS within the northern and western CCS groundwater discharge boundaries. Because of the RWS' dual purpose, its cost should be allocated between the two regulatory objectives: recovery, which involves *retraction* hypersaline water from areas that are in violation of groundwater standards, and *containment* of hypersaline water within FPL property. In order to assess a potential allocation of costs of the dual RWS functions, Tetra Tech developed a groundwater modeling-based methodology that is predicated on delineating the proportion of the wells' function in hypersaline water retraction (recovery) and containment (capital improvement). The technical basis for the determination of cost allocation is summarized in this technical memorandum; and the resulting groundwater modeling-based projection of the allocation of costs between recovery and capital improvement is provided herein.

Background

In 2015, FPL and Miami Dade County (MDC) Department of Environmental Resource Management (DERM) agreed to a consent Agreement (CA) that stipulates the removal of hypersaline groundwater north and west of the CCS. As a requirement of this CA, FPL and Tetra Tech developed a regional, three-dimensional, density-dependent, groundwater flow and saltwater transport model of conditions in Biscayne Aquifer in the vicinity of the CCS (Tetra Tech, 2016a, b, c). The calibrated model was presented to and reviewed by MDC DERM, South Florida Water Management District (SFWMD), and Florida Department of Environmental Protection (FDEP). One of the primary objectives of the model was to identify/design a groundwater recovery well system (RWS) to intercept, capture, contain and retract the hypersaline plume north and west of the CCS. The selected alternative (alternative 3D) includes the operation of a series of ten groundwater extraction wells located along the west and northwest of the CCS (**Figure 1**). This MDC DERM-approved alternative was demonstrated to meet both the retraction and containment objectives of the CA. The permitting, construction and installation of these wells is currently in progress.

Because there are two separate objectives with which the RWS helps to meet, costs associated with implementing the RWS alternative can be allocated between:

1) Recovery: Costs associated with the retraction of hypersaline water west of the CCS; and

2) Capital Improvement: Costs associated with the containment of hypersaline CCS seepage and groundwater located on and beneath FPL property.

In order to evaluate an allocation of costs, Tetra Tech re-configured the groundwater flow and salt transport model to delineate and track the two different species of hypersaline water (retraction water and containment water) during a 20 year extraction period and quantify the proportion of these species that comprises the hypersaline water (recovery versus containment). This modeling procedure is described below.

Procedure

Introduction

The procedure for determining the allocation of costs for the operation of the RWS extraction wells includes groundwater and salt transport modeling and calculations with the associated salt transport model results. The key steps in the analysis are listed here and elaborated upon below.

1. Separate retraction and containment hypersaline waters into two distinct groundwater species based on location relative to the CCS;
2. Simulate 20-year operation of RWS extraction wells and the movement of hypersaline species with the groundwater model;
3. Calculate annual reductions in simulated retraction and containment hypersaline masses throughout the simulation;
4. Calculate the proportions of reduced retraction and containment hypersaline mass that constitute the total reduced hypersaline mass, for each year of the simulation;
5. Determine the 20-year average proportions of retraction and containment masses;

Model Setup (Steps 1 and 2)

The groundwater flow model presented to MDC, SFWMD, and FDEP was configured to simulate a single species of water (saltwater), though the model is capable of simulating multiples species. Tetra Tech leveraged this modeling capability to partition hypersaline water into two separate species, based on its location in the Biscayne Aquifer relative to the CCS. As shown in **Figure 2**:

- The retraction species is composed of hypersaline water located north and west of the CCS;
- The containment species is hypersaline water located within and beneath the CCS.

All other hypersaline groundwater not located within these zones, as well as less-than-hypersaline water throughout the entire model domain, is specified as a third and separate species. Since FPL is primarily interested in costs associated with recovery and containment of hypersaline groundwater alone, calculations of mass for this third species were not performed as a part of the cost allocation analysis. The separation of hypersaline water into species facilitated the definition of initial water quality conditions as three distinct saltwater species plumes (retraction, containment, and other) and provided a means to track the movement of each species throughout the Biscayne Aquifer during the model simulation.

A 20-year predictive simulation of the operation of the RWS alternative (alternative 3D) was constructed using the most recent calibrated model properties (Tetra Tech, 2016c) and observed hydrologic stresses that occurred over the 5-year timeframe from 2011 through 2015 (repeated 4 times to constitute a 20-year simulation).

The movement of the three species of saline groundwater (retraction, containment, and other) throughout the aquifer (particularly movement toward the extraction wells, as broadly illustrated in **Figure 3**) was simulated over the 20-year timeframe, and the annual changes in the amount of hypersaline mass remaining in the aquifer (as compared to the initial masses) were calculated. It is important to note that the movement and amount of hypersaline mass throughout time were calculated for the shallow and intermediate portions of the aquifer (model layers 1 through 9). Model layers 10 and 11 were omitted from hypersaline mass calculations due to uncertainties in hydraulic parameters in the deepest portion of the aquifer along the southwestern border of the CCS. Currently, there is a relative paucity of hydrogeologic data for the deepest portions of the aquifer and the model's representation of the known extent of the hypersaline water at depth does not correlate well with actual data. Likewise, the model appears to under-simulate the extraction well influence in the bottom two layers of the model. As more information becomes available (e.g. geologic data from the installation of the RWS extraction wells), the model will be updated and these uncertainties resolved. These new geologic data will confirm either: 1) what the model is currently representing -- that the lower two layers have low permeability and are not part of the Biscayne Aquifer (the MDC CA only requires retraction in the Biscayne Aquifer), or 2) the permeability of the lower two layers are reflective of the Biscayne Aquifer, in which case the lower two layers will respond in similar fashion as the upper 9 layers. Accordingly, it is believed that changes in hypersaline mass for model layers 1 through 9, where the model best simulates past and current conditions, are reflective of hypersaline mass changes throughout the entire depth of the Biscayne Aquifer and provide an effective basis for determining cost allocation.

Annual Species Mass Reductions (Steps 3)

At the conclusion of each year of the simulation, the total masses of hypersaline water for the retraction and containment species in the Biscayne Aquifer were calculated. Using these calculated annual hypersaline mass estimates, the annual reduction in hypersaline retraction and containment masses were calculated. These reductions in hypersaline mass were attributed to the operation the RWS extraction wells.

Mass Reduction Proportions (Steps 4 and 5)

For each year, the simulated *total* hypersaline mass eliminated from the aquifer is the sum of the eliminated retraction and containment masses. The proportions of retracted and contained hypersaline mass that constitute the total eliminated hypersaline mass can be readily calculated. The average of these proportions over the 20-year simulation timeframe can then be used to inform the allocation of costs between recovery (retraction proportion) and capital improvement (containment proportion). The results of the model simulation, hypersaline mass calculations, and cost allocation analyses are discussed below.

Results

At the conclusion of the model simulation, the annual reductions in hypersaline mass for the two species were tabulated. These hypersaline mass reductions are plotted in **Figure 4**. The changes in the composition of hypersaline mass reductions vary annually, and are initially dominated by retraction mass. Over time, however, the percentage of the containment benefit achieved become dominant as the retraction hypersaline mass to the west and north of the CCS is fully removed after approximately 11 years. This is more clearly reflected in the plot of the proportions of reduced hypersaline mass in **Figure 5**. By year 12 of the simulated timeframe, 100% of the eliminated hypersaline mass is containment mass. On average, over 20-year, 83% of the reduced hypersaline mass is containment mass (17% is retraction mass). Analogously, it is reasonable to allocate 83% of the cost of implementing RWS alternative 3D to capital improvement, and 17% to recovery.

Whereas Figures 4 and 5 represent Tetra Tech's professional opinion to focus the analysis on model layers 1 through 9, the consideration of all model layers (model layers 1 through 11) is a possible alternative interpretation of model results. Figures 6 and 7 provide the outcome of this alternative interpretation of model results. **Figure 6** shows reductions in containment and retraction mass in all model layers (layers 1 to 11). The general trend in mass reductions is very similar to that shown in **Figure 4** for model layers 1 through 9, yet some retraction mass is removed from the model layers 10 and 11 throughout the 20-year timeframe. This is further reflected in **Figure 7**, which plots the proportions of reduced hypersaline mass in model layers 1 through 11. Unlike in model layers 1 through 9 (**Figure 5**), where retraction mass is eliminated by year 12, the elimination of retraction mass from layers 10 and 11 occurs throughout the 20-year operation of the RWS wells. The 20-year average proportions of reduced mass (**Figure 7**), when mass reductions in all model layers are evaluated, are 74% containment mass and 26% retraction mass. Based on these results, up to 26% of the RWS implementation costs could be allocated to recovery and 74% could be allocated to capital improvement.

References

Tetra Tech, 2016a, Application of Parameter Estimation Techniques to Simulation of Remedial Alternatives at the FPL Turkey Point Cooling Canal System, Technical Memorandum provided to Florida Power & Light, July 14, 2016.

Tetra Tech, 2016b, Addendum to Regional Biscayne Aquifer Model Report (Tetra Tech, 2016), Technical Memorandum provided to Florida Power & Light, October 12, 2016.

Tetra Tech, 2016c, Biscayne Aquifer Groundwater Flow and Transport Model: Heterogeneous Hydraulic Conductivity Analyses, and addendum to the July 2016 modeling report, Technical Memorandum provided to Florida Power & Light, December 2, 2016 (submitted for FPL review).

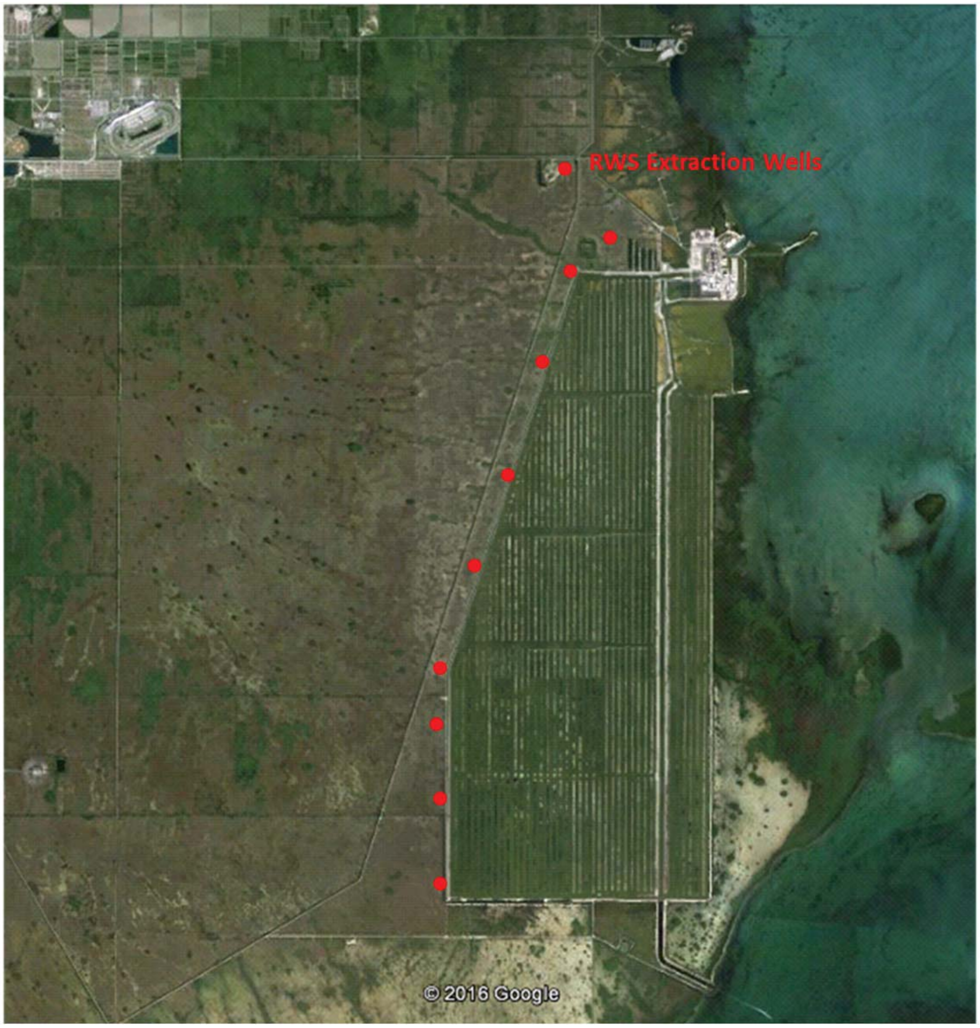

Figure 1. Approximate location of extraction wells associated with the selected RWS alternative

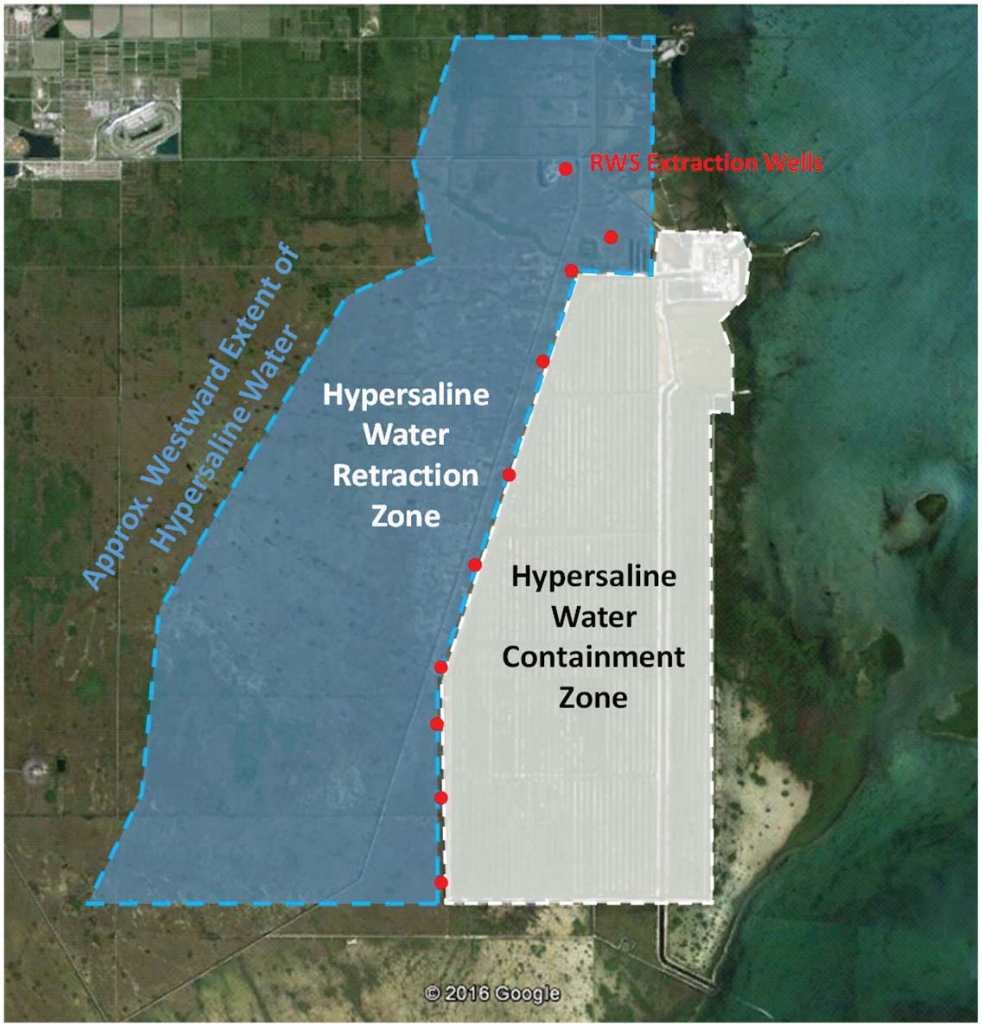

Figure 2. Approximate groundwater zones that partition hypersaline water into the retraction and containment species

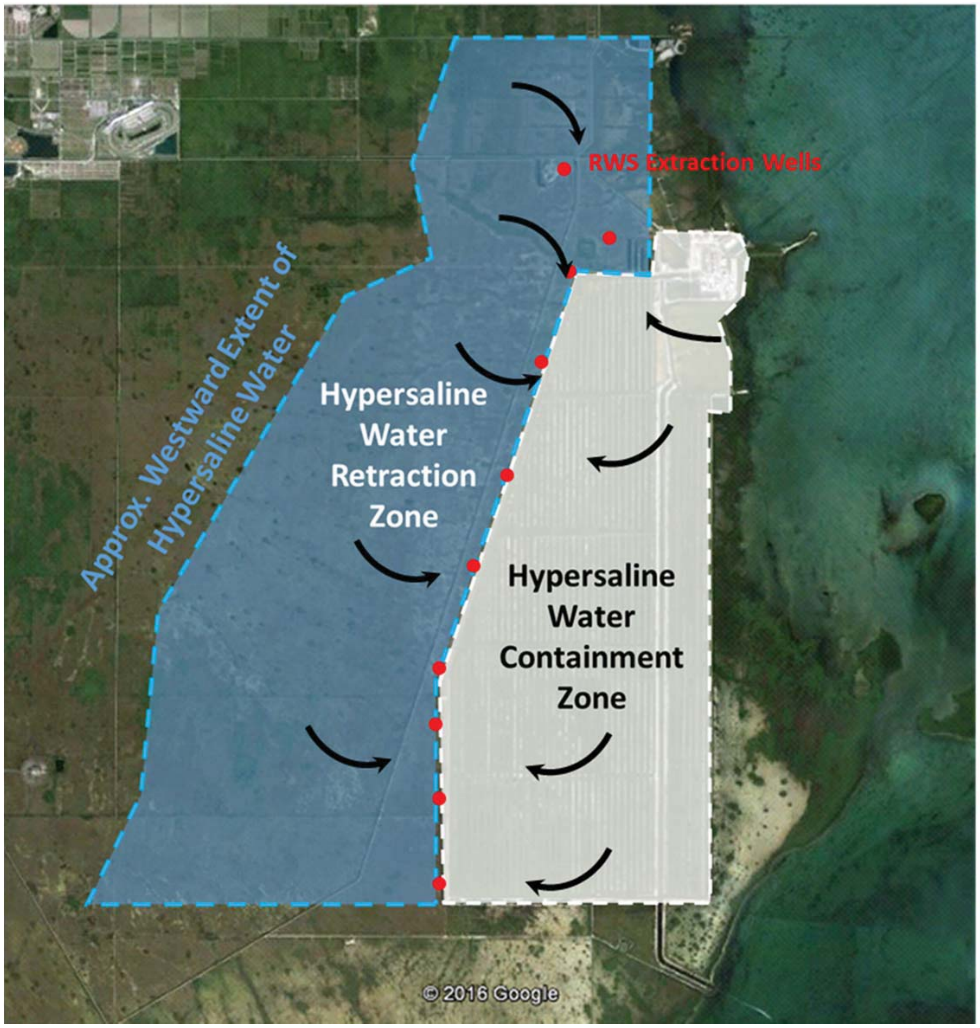

Figure 3. General movement of retraction and containment hypersaline groundwater to the RWS alternative 3D extraction wells

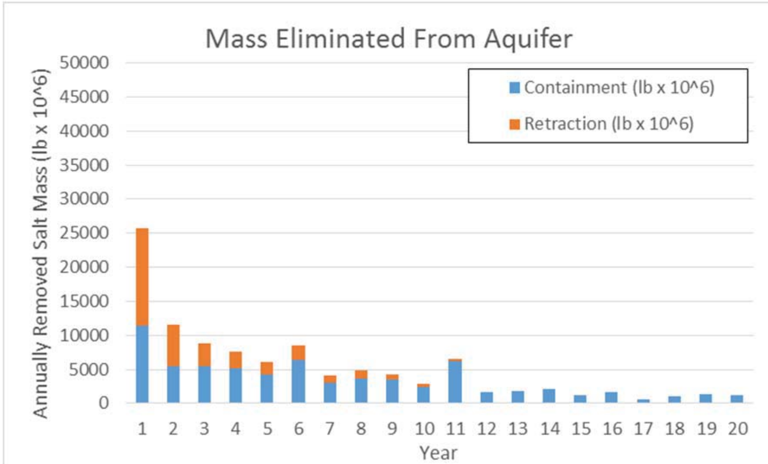

Figure 4. Containment and retraction mass reductions in the Biscayne Aquifer in each year of the model simulation (layers 1 through 9 evaluated)

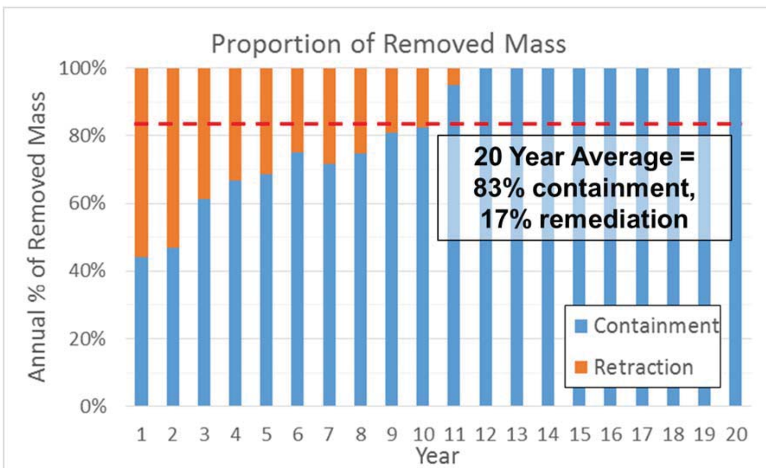

Figure 5. Proportions of containment and retraction mass reductions in Biscayne Aquifer in each year of the model simulation (layers 1 through 9 evaluated)

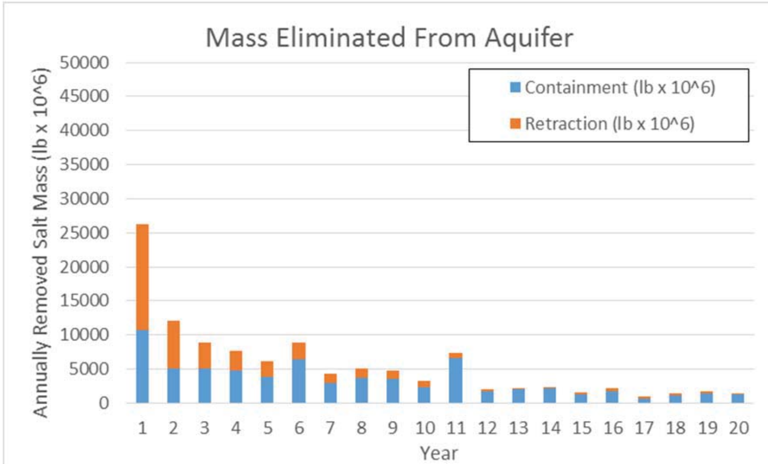

Figure 6. Containment and retraction mass reductions in the Biscayne Aquifer in each year of the model simulation (layers 1 through 11 evaluated)

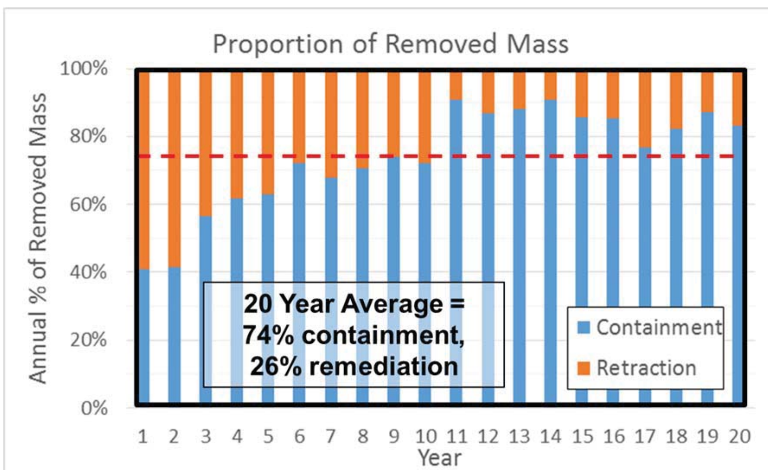

Figure 7. Proportions of containment and retraction mass reductions in Biscayne Aquifer in each year of the model simulation (layers 1 through 11 evaluated)