PMTurkeyCOLPEm Resource

From: Franzone, Steve [Steve.Franzone@fpl.com]
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To: Franzone, Steve; Kugler, Andrew
Cc: Maher, William; Orthen, Richard; John Cunliffe; Comar, Manny
Subject: 2/24/11 Groundwater Presentation
Attachments: GWM_Presentation_24_Feb_2011_NRC.pdf

Andy,
I have attached the PDF of the Groundwater Model Update presentation.
Any questions, please call.

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"I like the dreams of the future better than the history of the past." Thomas Jefferson
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Groundwater Model Update

Turkey Point 6 & 7 Groundwater Modeling Team
February 24th 2011

Groundwater Model Update

- **Purpose:**
  - Summary of Rev 1 Groundwater Model Report:

    1. Model changes (relative to Rev. 0).
    2. Calibration and validation.
    3. Predictive simulations (and sensitivity analysis).

Groundwater Model Update: Reason for Model Update

- Interface with state and federal agencies identified additional data for review and incorporation into the model.
- Additional interaction with regional experts provided more detail on the hydrogeological conditions.
- To add agency specific assumptions to the model to increase model robustness.

Groundwater Model Update: Model Changes Compared to Revision 0

Conceptual Model

- Identification and incorporation of zones of higher hydraulic conductivity based on review of geological and geophysical data.
- Reinterpretation of the geology of Turkey Point plant property incorporating geophysical data and drilling information.
- Revised muck layer present throughout Biscayne Bay based on a literature review of sediment/rock type on the floor of Biscayne Bay.
- Incorporated two hydraulic conductivity zones within the Key Largo Limestone based on prior information.
- Recharge zones across the plant area have been delineated to represent post-construction conditions.
- The head drop across the circulating water pumps has been updated to the average value observed over the period of the pumping tests.
- All cooling canal depths have been updated to reflect actual conditions.

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Groundwater Model Update: Model Changes Compared to Revision 0

Numerical Model

- The base model used for calibration begins with all necessary layering for construction and post-construction simulations.
- The model layers are laterally continuous across the model domain. Previously, surface water features had been incised into layers, resulting in lateral discontinuity between some cells.
- The boundary condition used to represent Biscayne Bay has been updated from constant-head to general-head to account for resistance to flow through the bay floor.

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Groundwater Model Update: Model Changes Compared to Revision 0

Calibration and Validation

- Three pumping tests are now used in the model calibration phase; two of these tests were conducted in the Key Largo Limestone and one in the Fort Thompson Formation. In the previous revision of the model, two tests had been simulated.
- The model now includes a validation step, whereby an additional pumping test is simulated following the calibration phase.
- A range for the hydraulic conductivity anisotropy value of between 8:1 and 15:1 was used for the various hydrogeologic units. These values were determined during calibration and constrained by literature and field observations.

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Groundwater Model Update: Model Changes Compared to Revision 0

Predictive Runs

Construction

- Construction Groundwater Control: Grouting between the base of the excavation and base of the cut-off walls. Grouting simulated to estimate associated dewatering rates.

Operational

- Radial Collector Well System (RCW): Upper Higher Flow Zone and bottom of the Key Largo Limestone evaluated for placement of laterals.
- RCW: Flow into the laterals distributed non-linearly along its length to reflect the increase in flow closer to the caisson.

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Groundwater Model Update: Model Changes Compared to Revision 0

Sensitivity Analyses

Construction

- Construction Groundwater Control: Sensitivity analysis of hydraulic conductivity of grout plug and its affect on seepage rates into the base of the excavations for Units 6 & 7.

Operational

- RCW: Sensitivity analysis on Biscayne Bay general-head conductance to determine the origin of water to the radial collector wells and approach velocities to the bay floor.
- RCW: Sensitivity analysis on Biscayne Bay seasonal high and low water level to determine the origin of water to the radial collector wells and approach velocities to the bay floor.
- RCW: Sensitivity analysis on hydraulic conductivity of the Key Largo Limestone to determine the origin of water to the radial collector wells and approach velocities to the bay floor.

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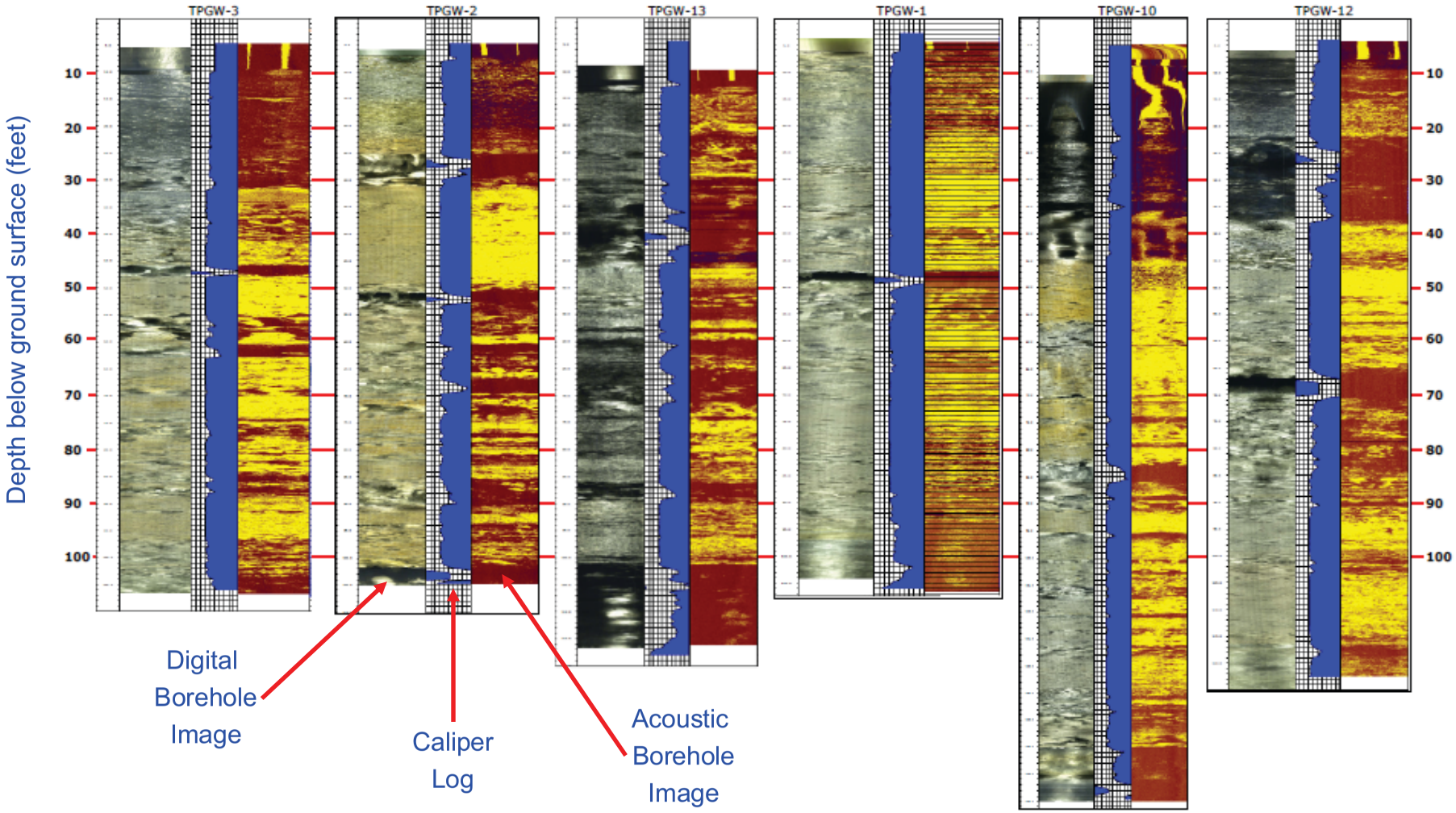
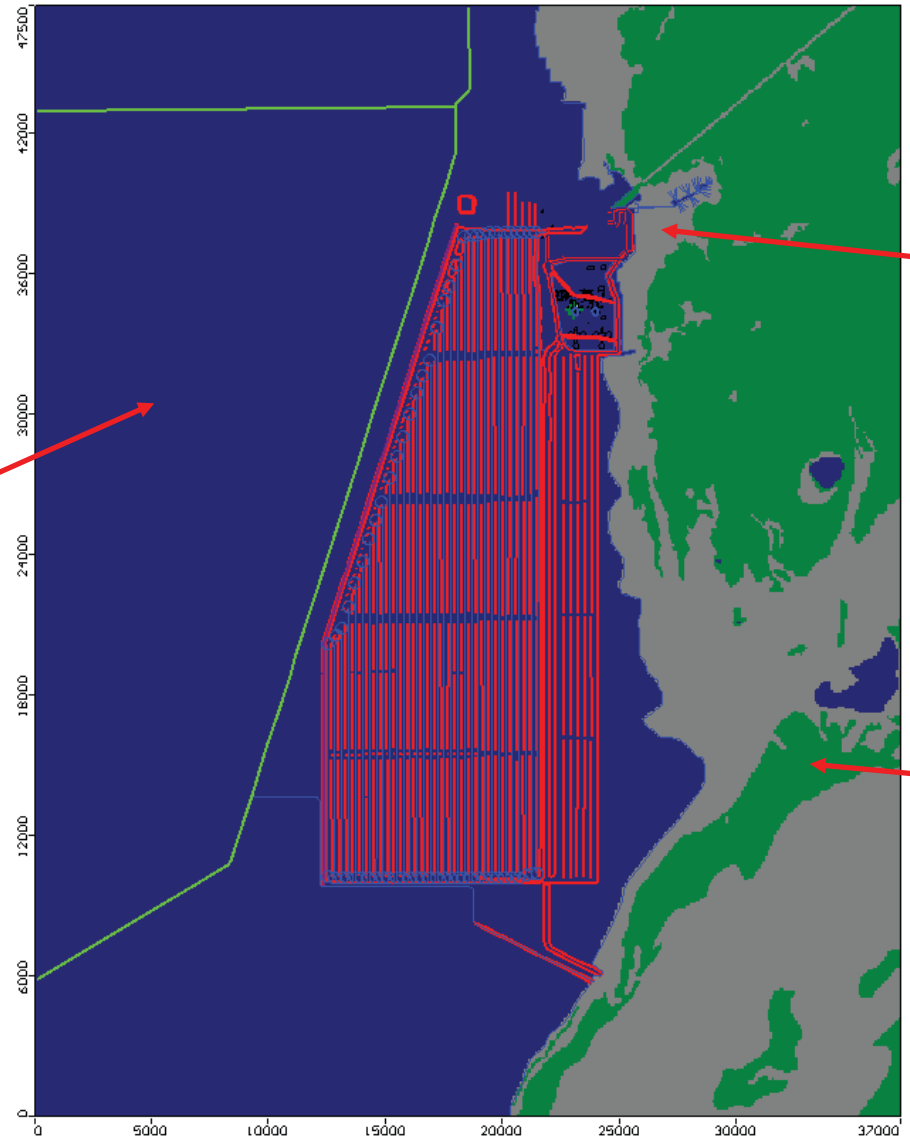
1. Model Changes Relative to Revision 0

Conceptual Model: Review Units 3 & 4 Uprate Monitoring Program to Assess Consistency with Model

Geophysical log data were reviewed for consistency with conceptual model.



Conceptual Model: Revise Biscayne Bay Sediment Layer



Offshore sediment

Onshore Muck

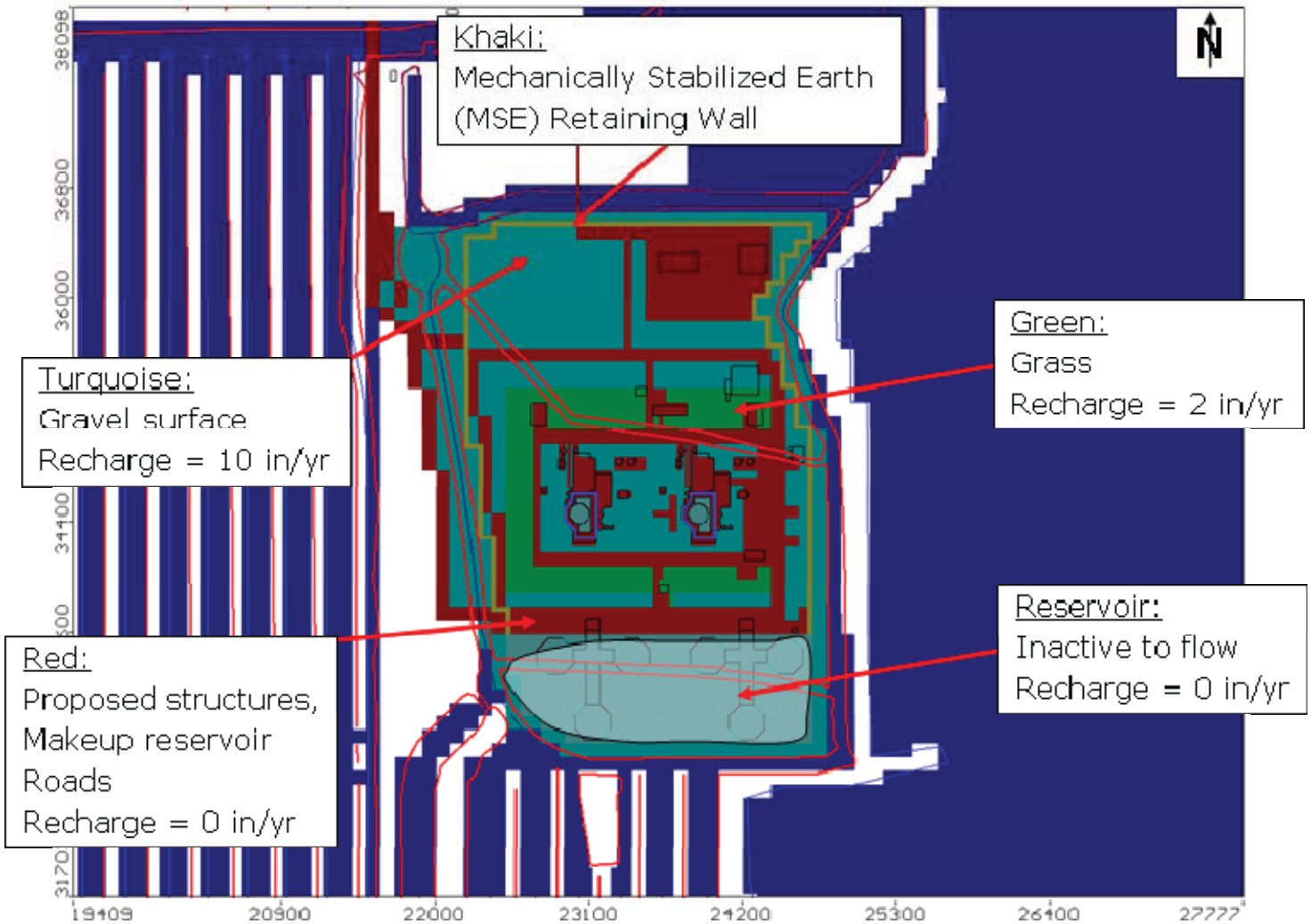
Miami Limestone

Conceptual Model: Key Largo Limestone Zonation

Key Largo Limestone (NE) (Blue)

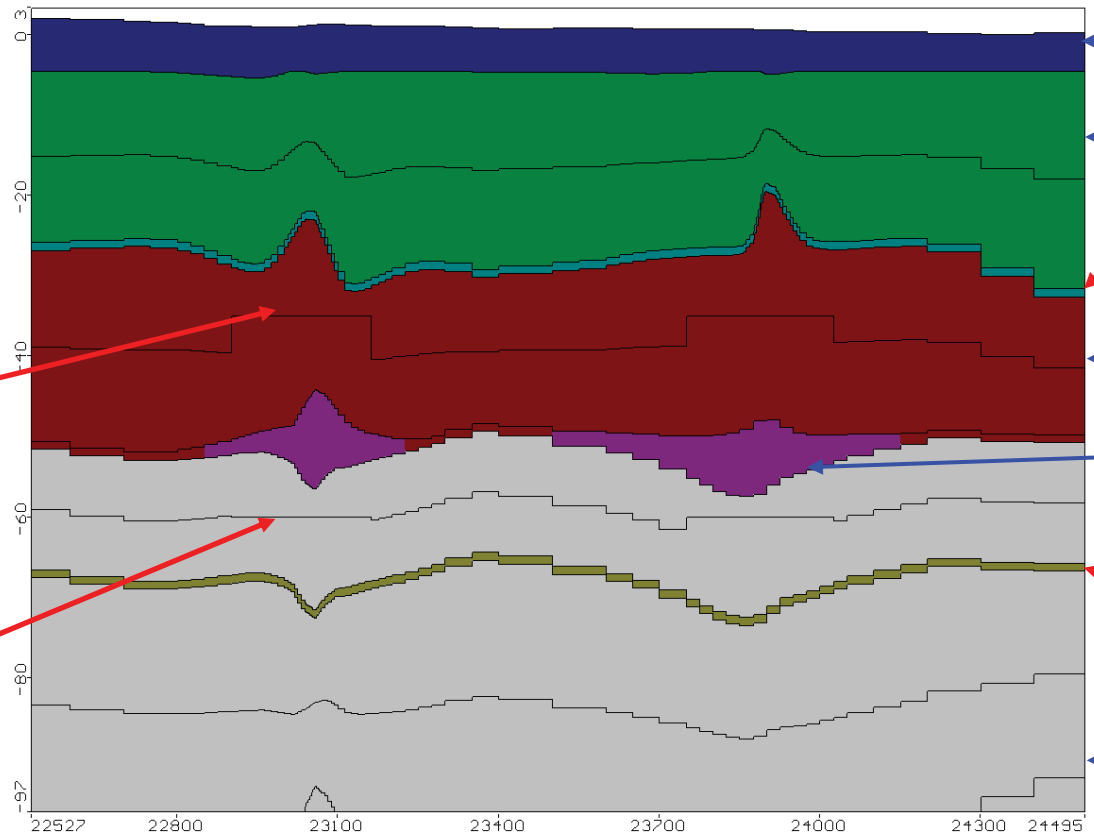
Key Largo Limestone (SW) (Red)

Conceptual Model: Refine Post-Construction Areas of Recharge



Numerical Model: Incorporate Zones of Higher Hydraulic Conductivity and Update Base Model Layering

Base model includes layering for bottom of excavation and base of cut-off walls



Bottom of Excavation

Bottom of Cut-Off Walls

Muck

Miami Limestone

Upper Higher Flow Zone

Key Largo Limestone

Freshwater Limestone

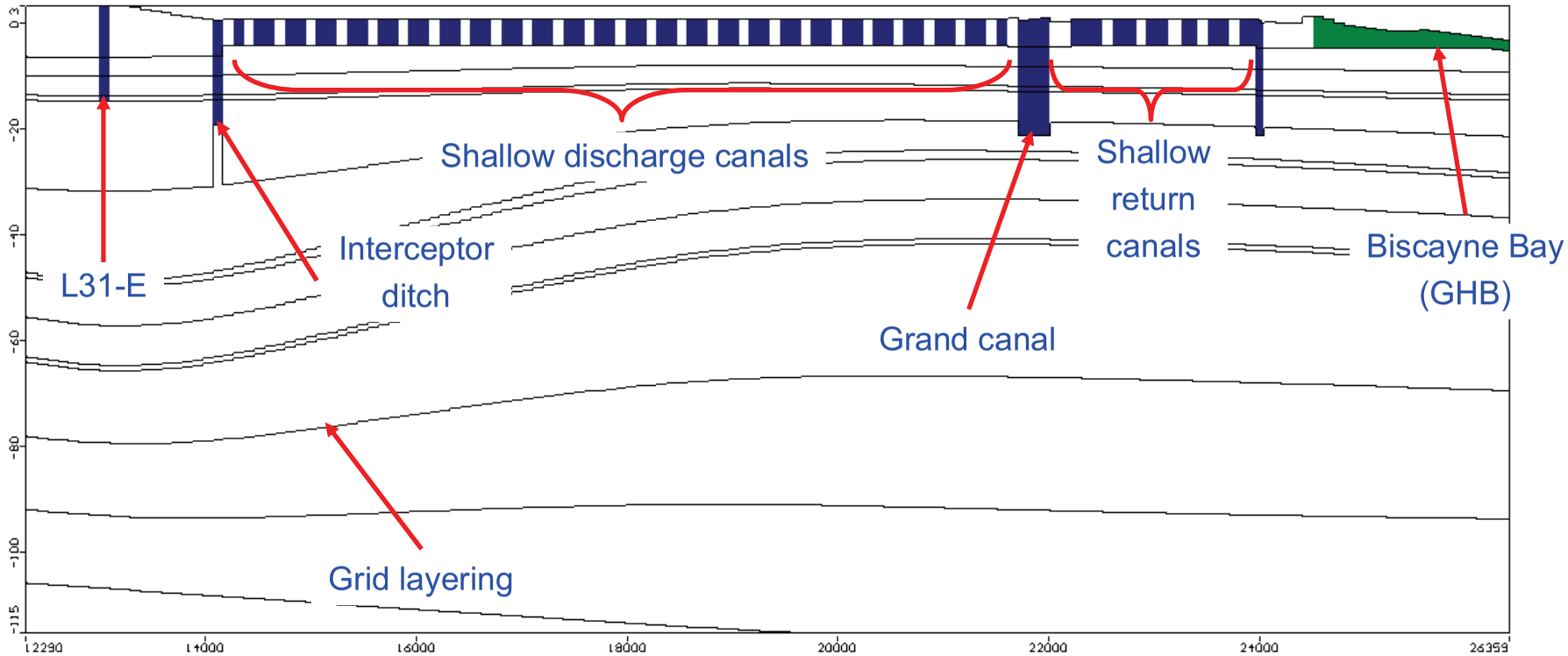
Lower Higher Flow Zone

Fort Thompson Fm.

- Cross section along row 214
- Vertical exaggeration = 15:1

Numerical Model: Laterally Continuous Model Layers Across Canals

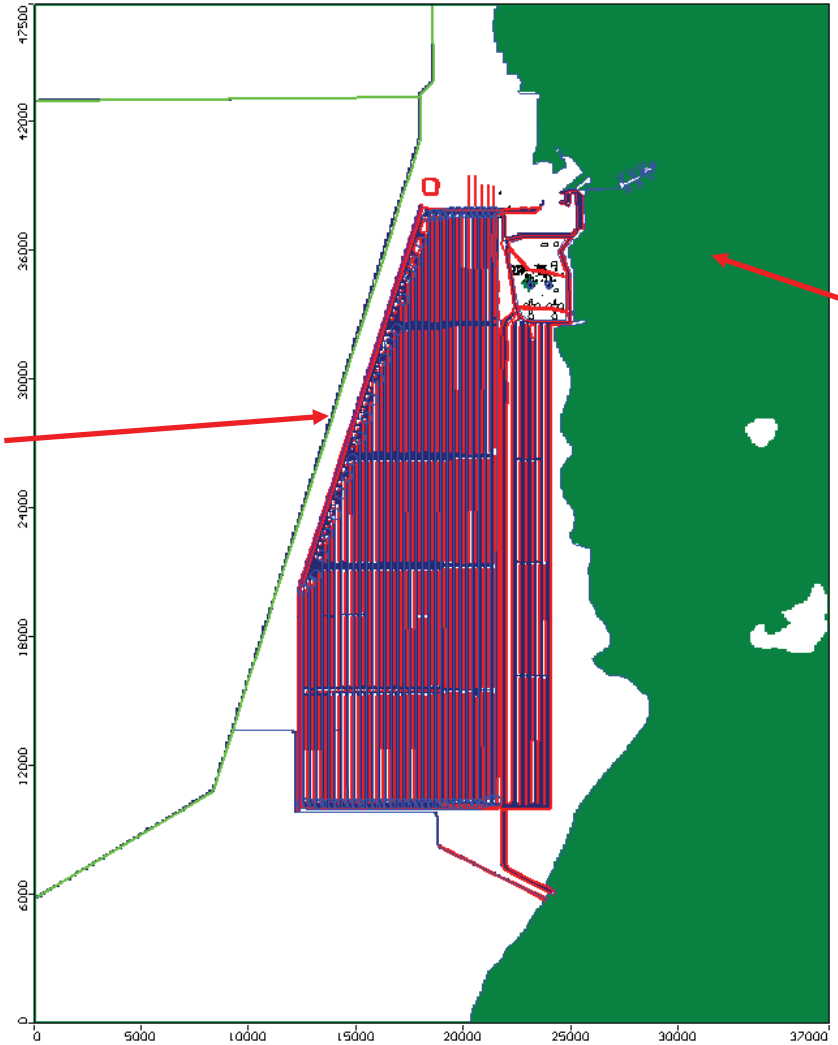
- **Canals no longer incise top of model layer one.**
- **RIV cells (blue color) now stacked upon one another in deep canals.**



- Cross section along row 326
- Vertical exaggeration = 50:1

Numerical Model: Boundary Conditions (general head vs. constant head vs. river cells)

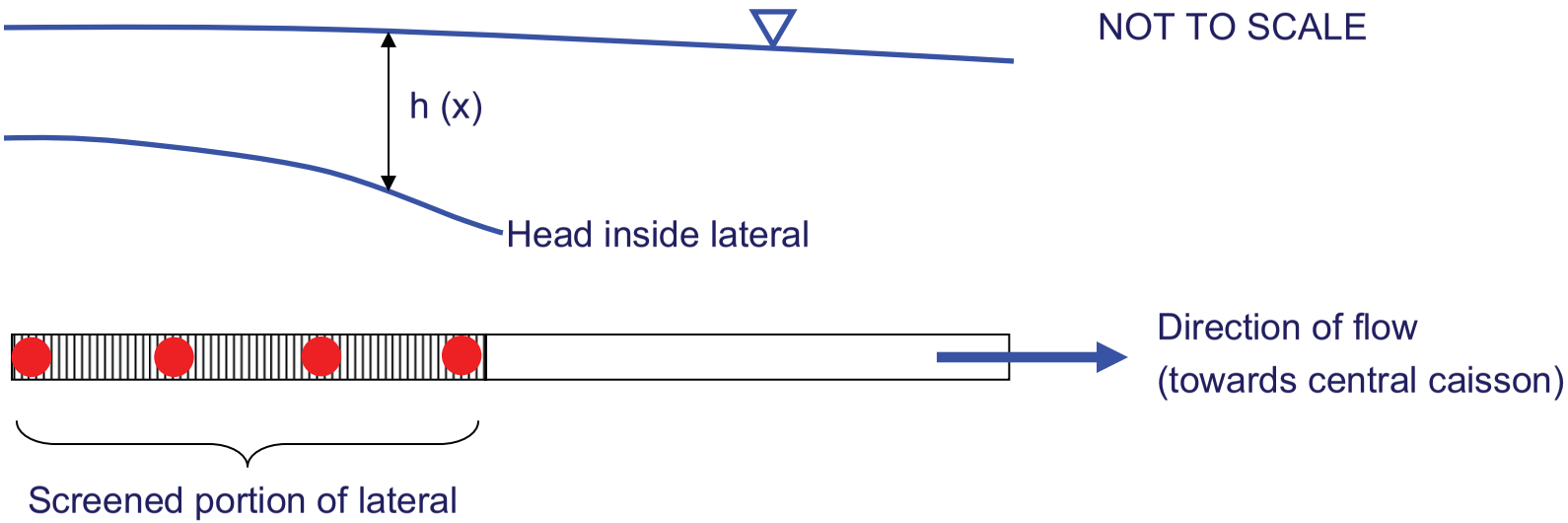
All canals now using river boundary condition. Tested using constant head cells but overestimate of flow from system.



General head boundary condition replaces constant head from previous revision.

Distribute Flow Non-Linearly Along Laterals

Head distribution inside lateral indicates that discharge is not distributed equally along lateral.



● Pumping well (WEL package) in numerical model.

Individual lateral previously modeled with four pumping wells of equal discharge (900 gpm). Incorporation of head variation redistributes pumping rates so that largest is closest to caisson and smallest is at furthest end of lateral.

2. Calibration & Validation

Calibration Approach

Establishment of Calibration Criteria

- Water levels: ARM < 1ft, RMS < 1ft, NRMS < 10%.
- Flows: Numerical mass balance, Md < 0.1%, match cooling canal system blowdown and makeup flows within an order of magnitude.

Calibration Simulations

- Calibration to PW-7L, PW-1, and PW-7U.
- Uniform hydraulic conductivity model provided poor calibration when three tests were modeled.
- Model fit improved by introduction of two hydraulic conductivity zones within the Key Largo Limestone (based on prior information).
- All three tests satisfactorily modeled with updated conceptual model.

Validation Simulation

- Calibrated model used to simulate PW-6U.

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Calibration – Hydrogeologic Parameters

Hydrogeological Unit	Kh (cm/s)	Kv (cm/s)	Anisotropy Ratio
Offshore Sediment	3.5×10^{-2}	2.4×10^{-3}	15:1
Onshore Muck	4.4×10^{-3}	4.4×10^{-4}	10:1
Miami Limestone	8.8×10^{-2}	5.9×10^{-3}	15:1
Upper Higher Flow Zone	3.0×10^{1}	3.7×10^{0}	8:1
Key Largo Limestone SW	5.9×10^{0}	7.4×10^{-1}	8:1
Key Largo Limestone NE	1.0×10^{1}	1.3×10^{0}	8:1
Freshwater Limestone	3.4×10^{-5}	2.3×10^{-6}	15:1
Lower Higher Flow Zone	1.7×10^{0}	1.7×10^{-1}	10:1
Fort Thompson Formation	3.3×10^{-1}	3.3×10^{-2}	10:1
Tamiami Formation	2.8×10^{-4}	2.8×10^{-5}	10:1

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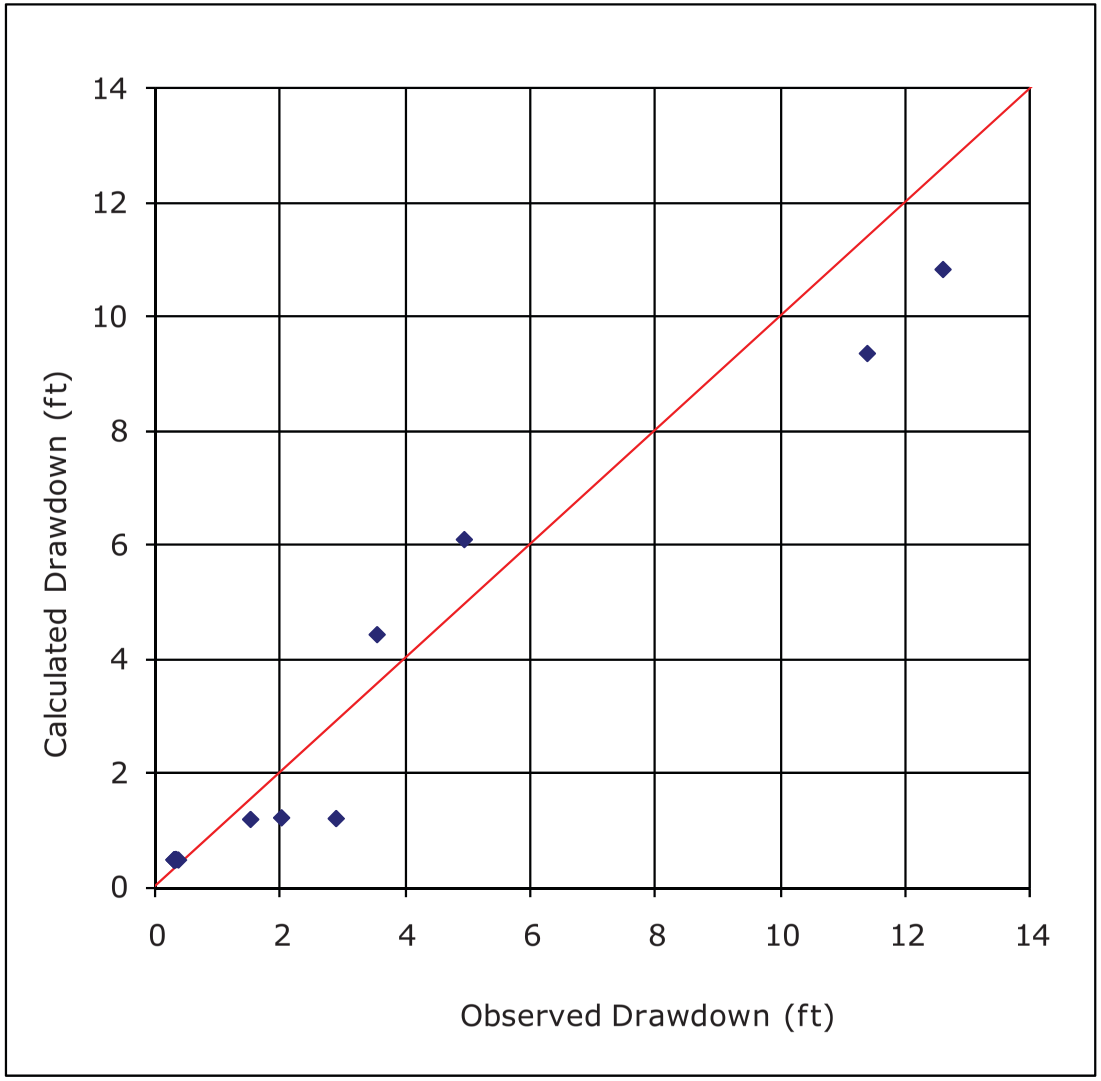
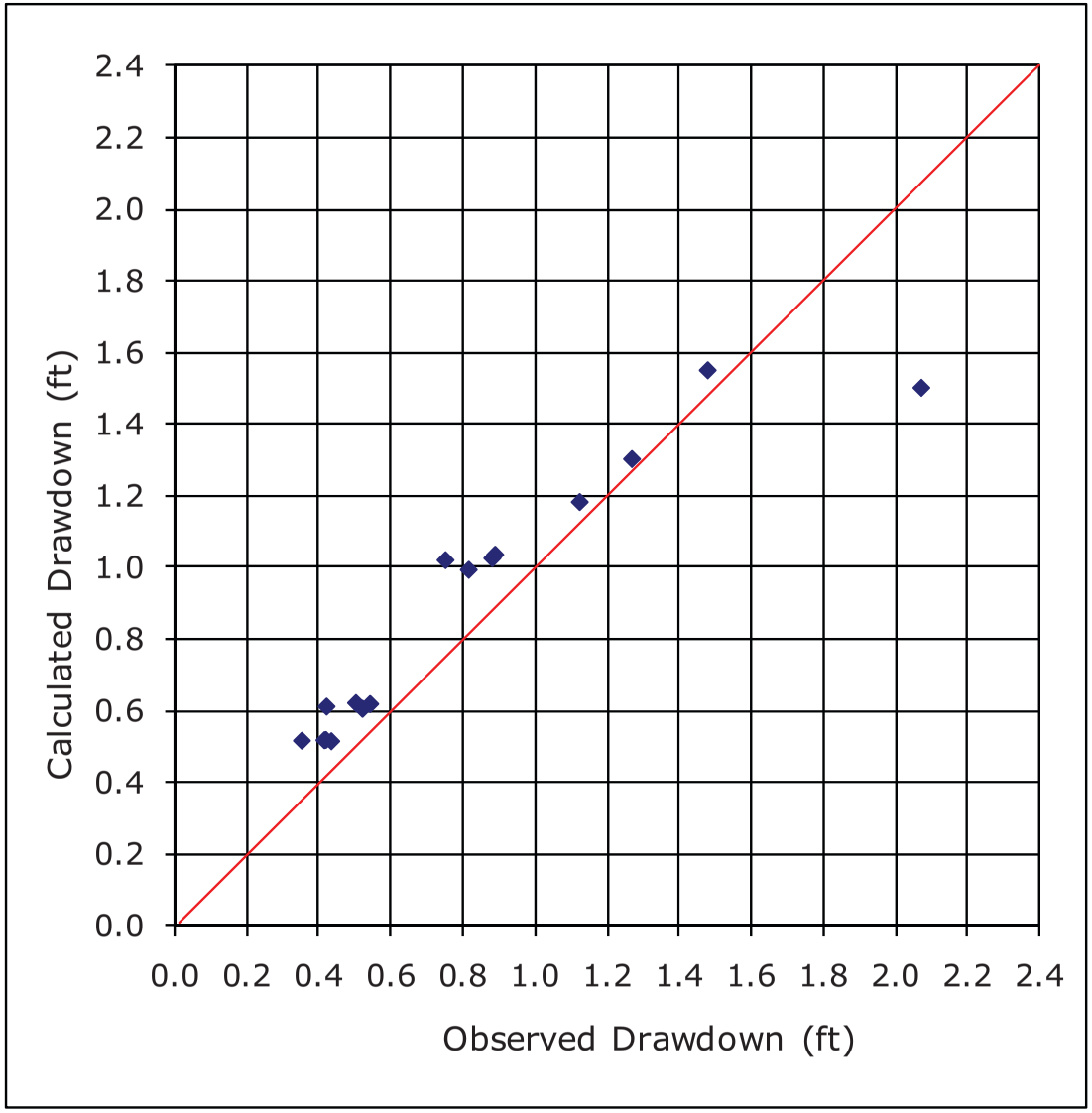
Calibration Statistics – PW-7L



Summary Statistics

ARM	0.69
RMS	0.97
NRMS	7.9 %
Md	0.0 %

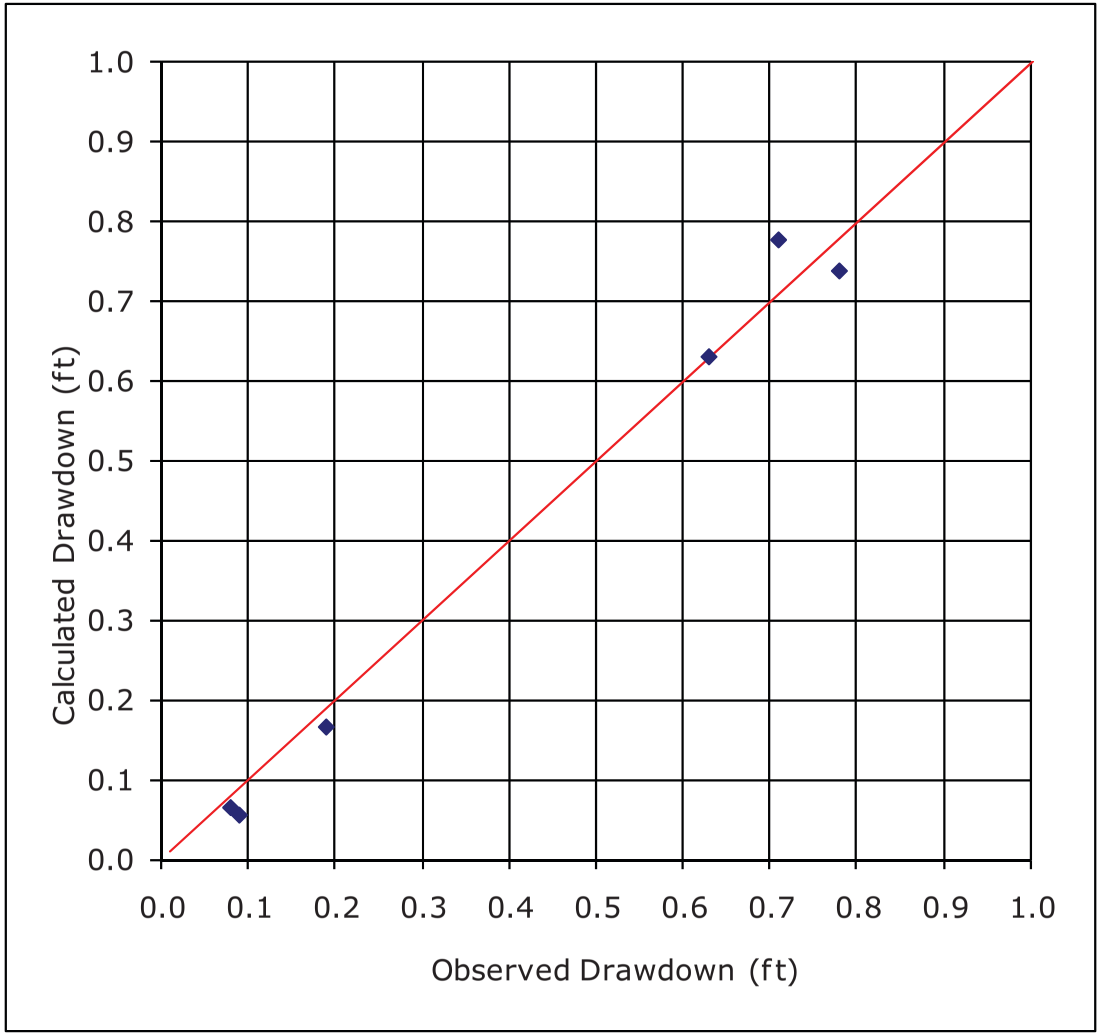
Calibration Statistics – PW-7U



Summary Statistics

ARM	0.15
RMS	0.19
NRMS	11.3 %
Md	0.0 %

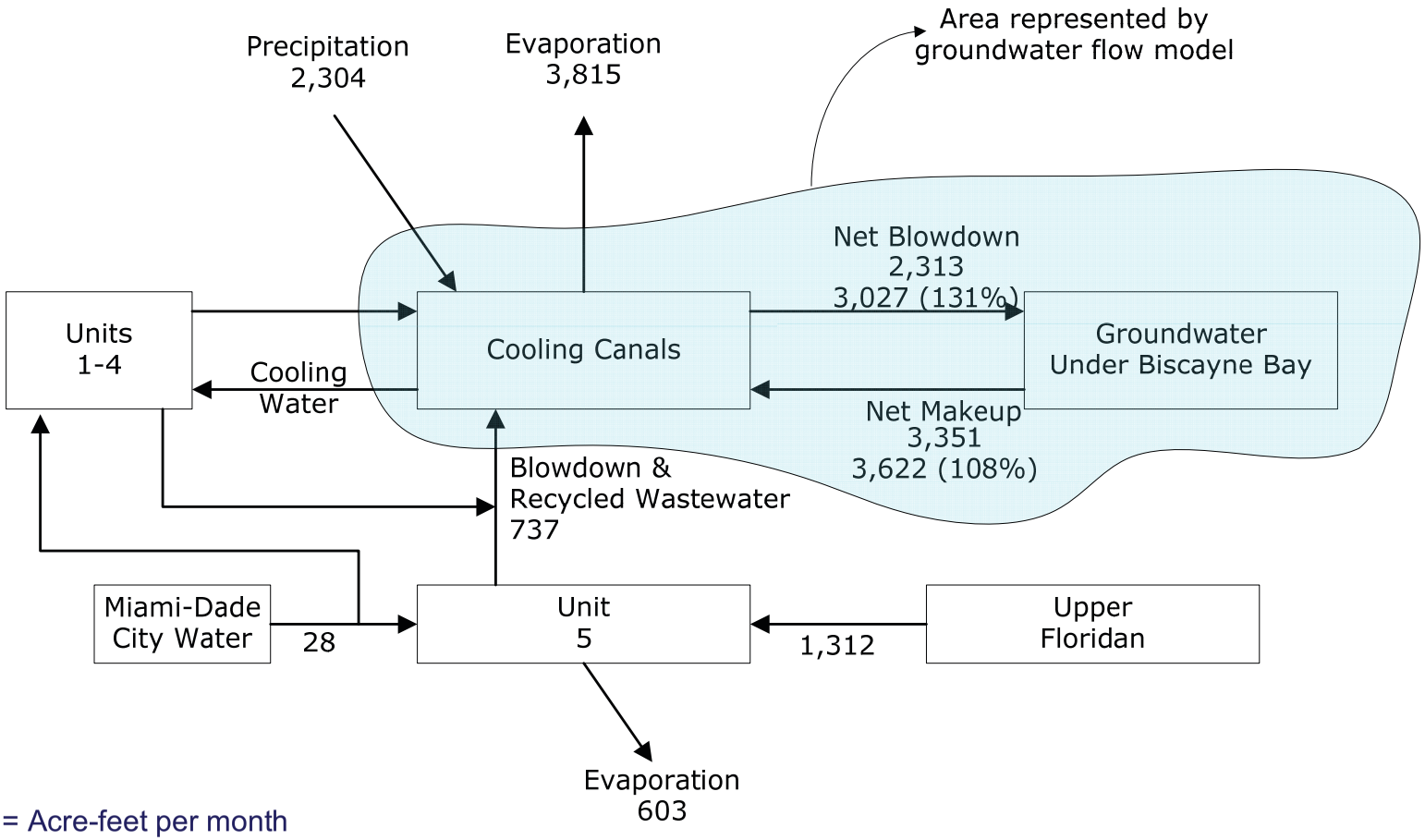
Calibration Statistics – PW-1



Summary Statistics

ARM	0.03
RMS	0.04
NRMS	5.3 %
Md	0.0 %

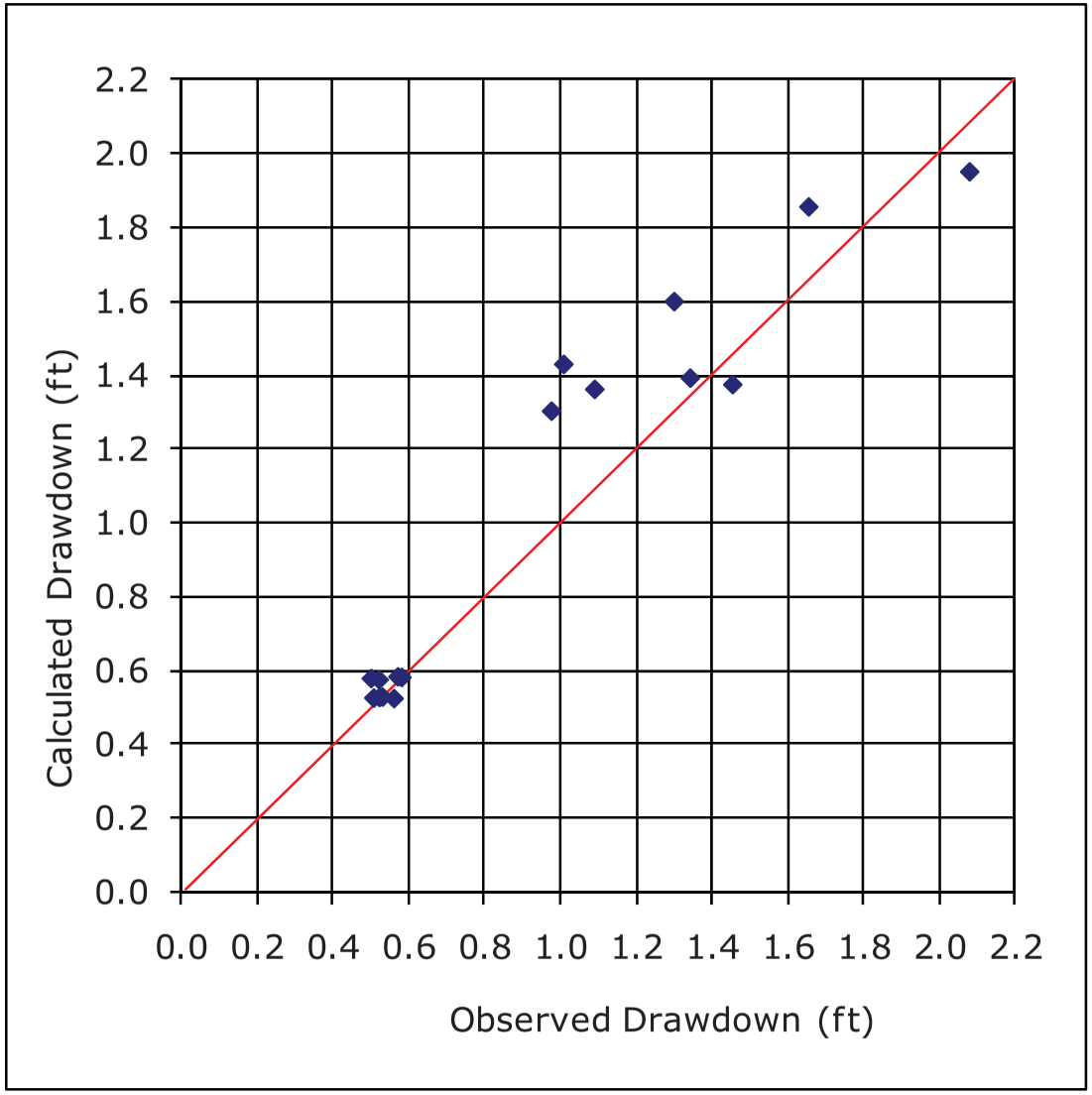
(Soft) Calibration Statistics – Water Balance



Units = Acre-feet per month

Water balance from Appendix 10.6 of the Uprate Project SCA and independent of numerical model

Validation Statistics – PW-6U

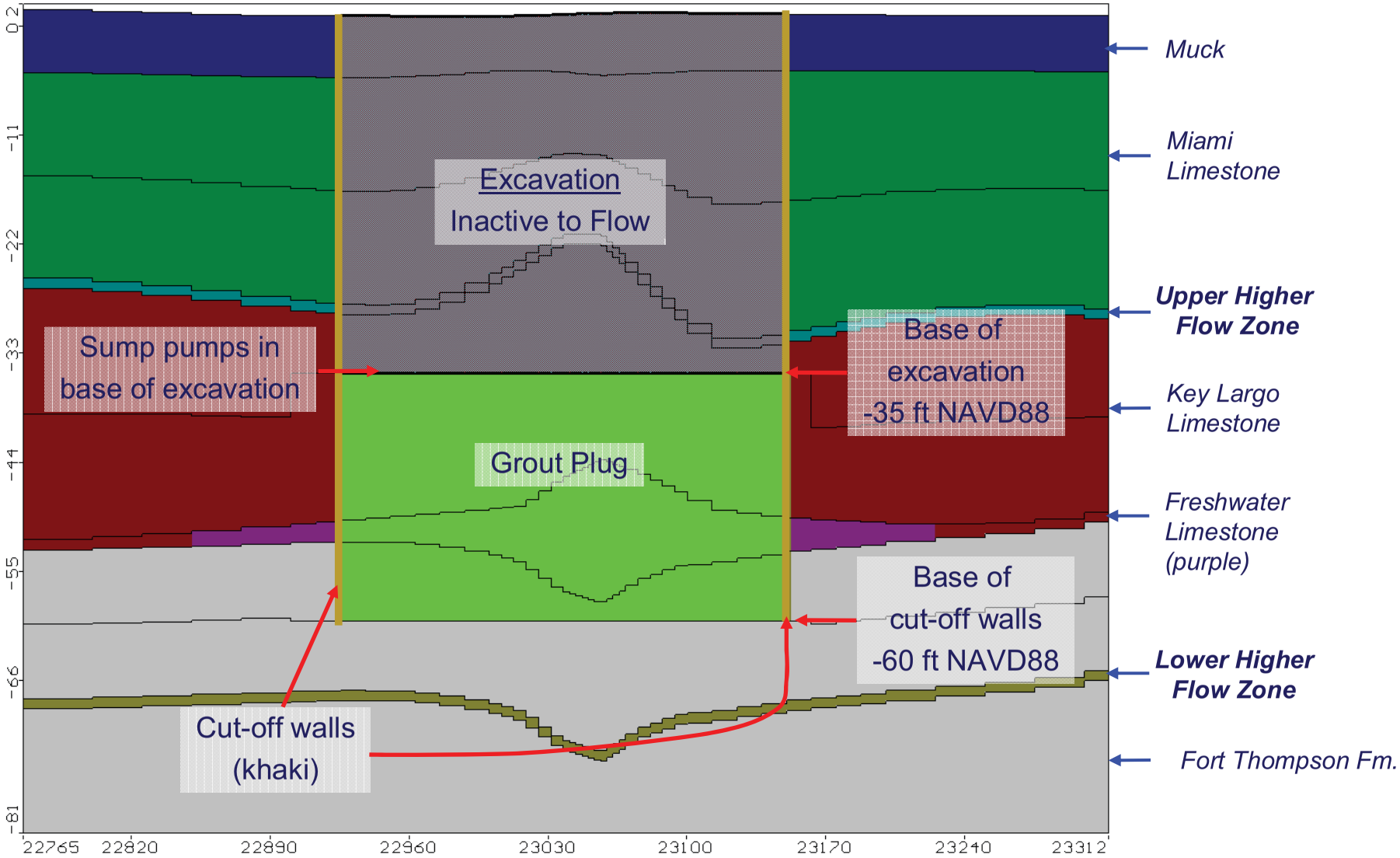


Summary Statistics

ARM	0.12
RMS	0.18
NRMS	11.4 %
Md	0.0 %

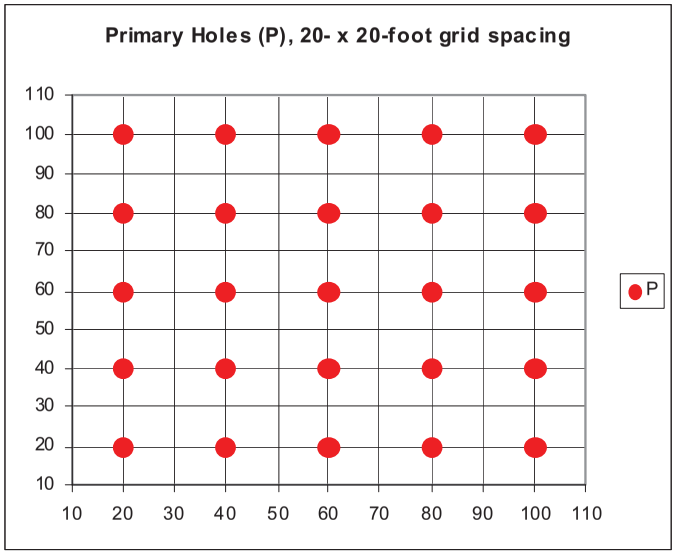
3. Predictive Simulations

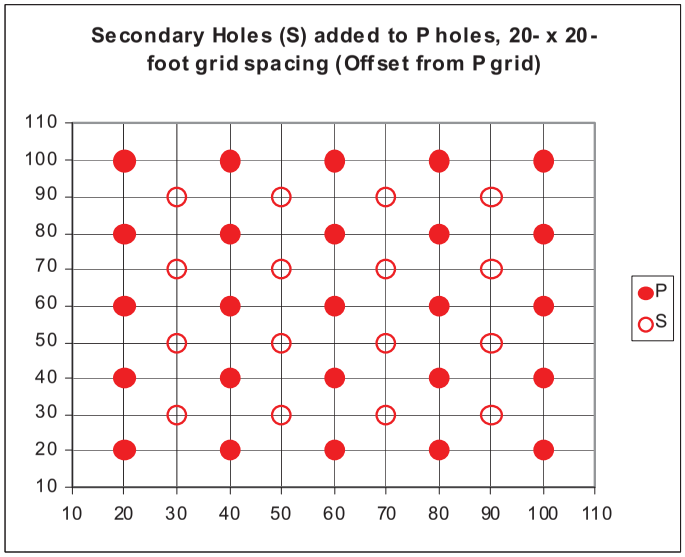
Grouting Simulation Setup

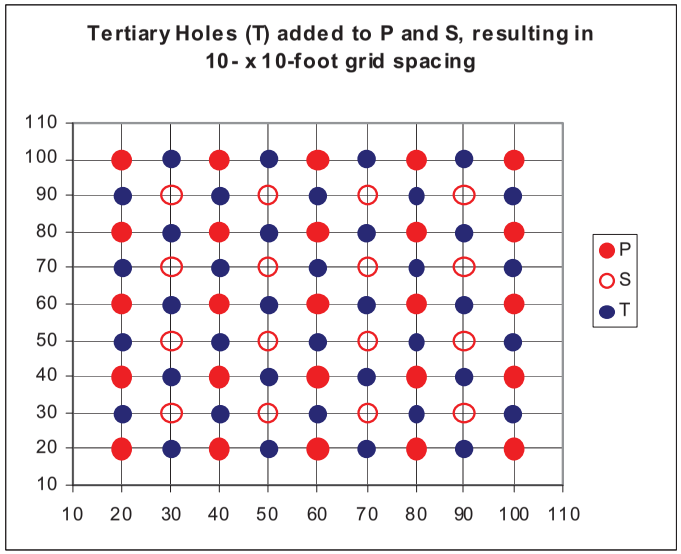


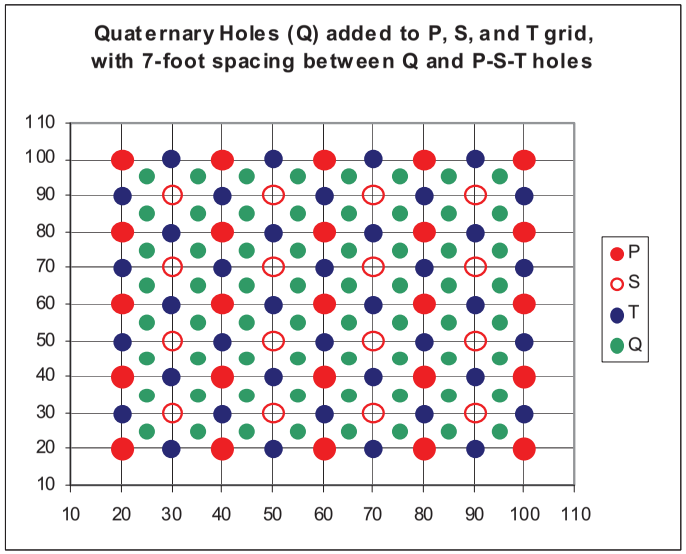
Cut-off walls extended to top of model domain for illustration only.

Grouting Methodology

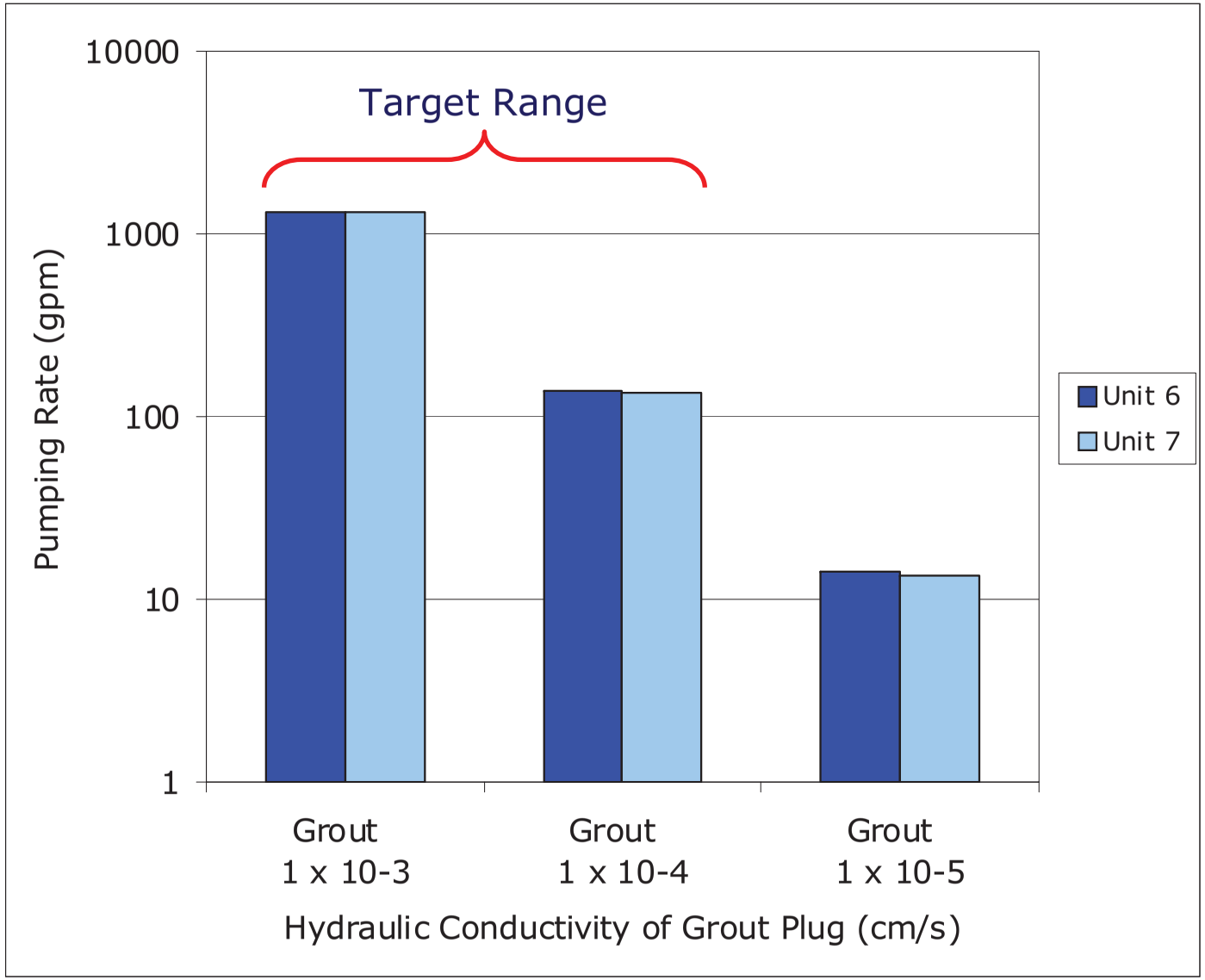




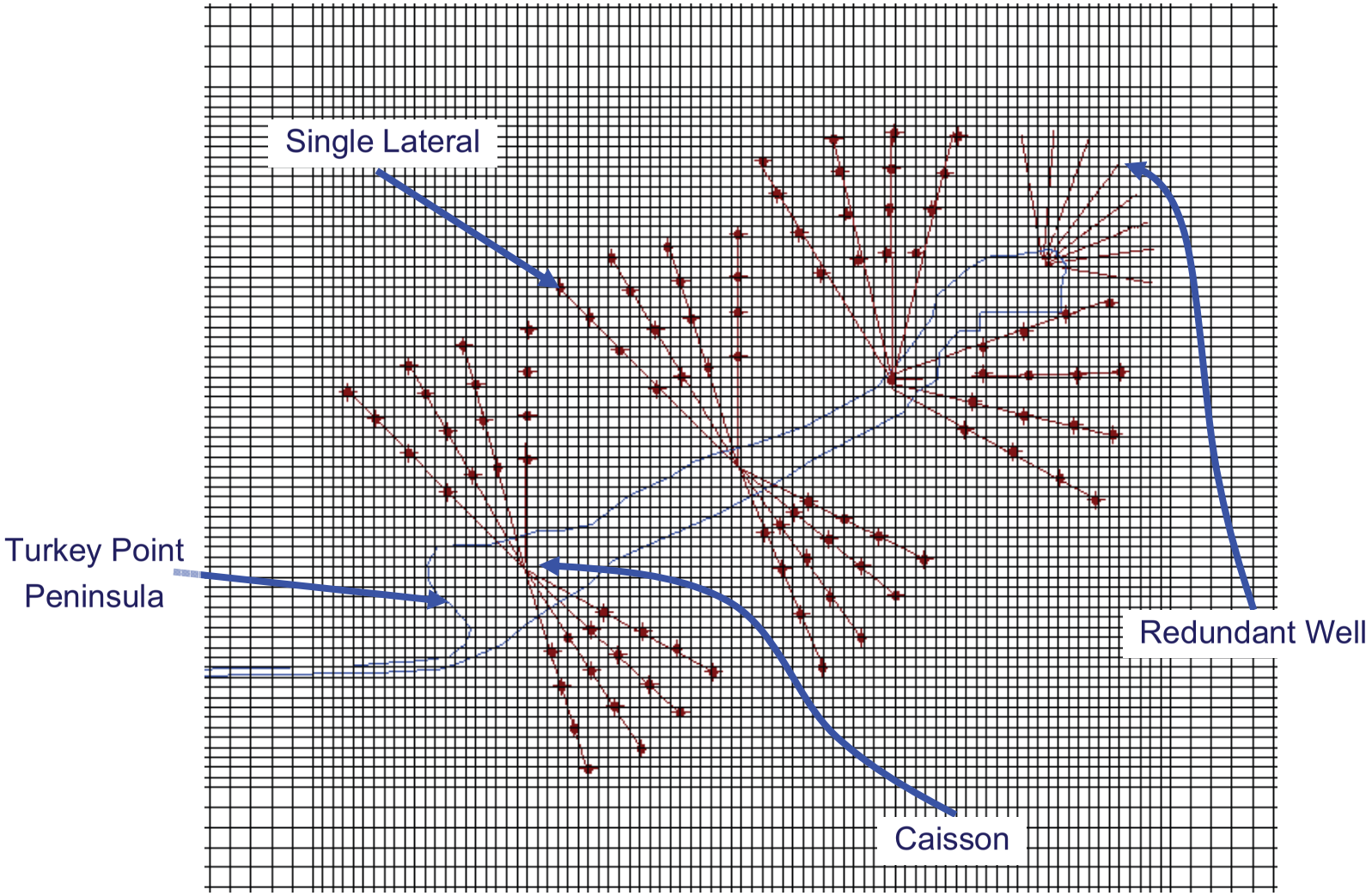




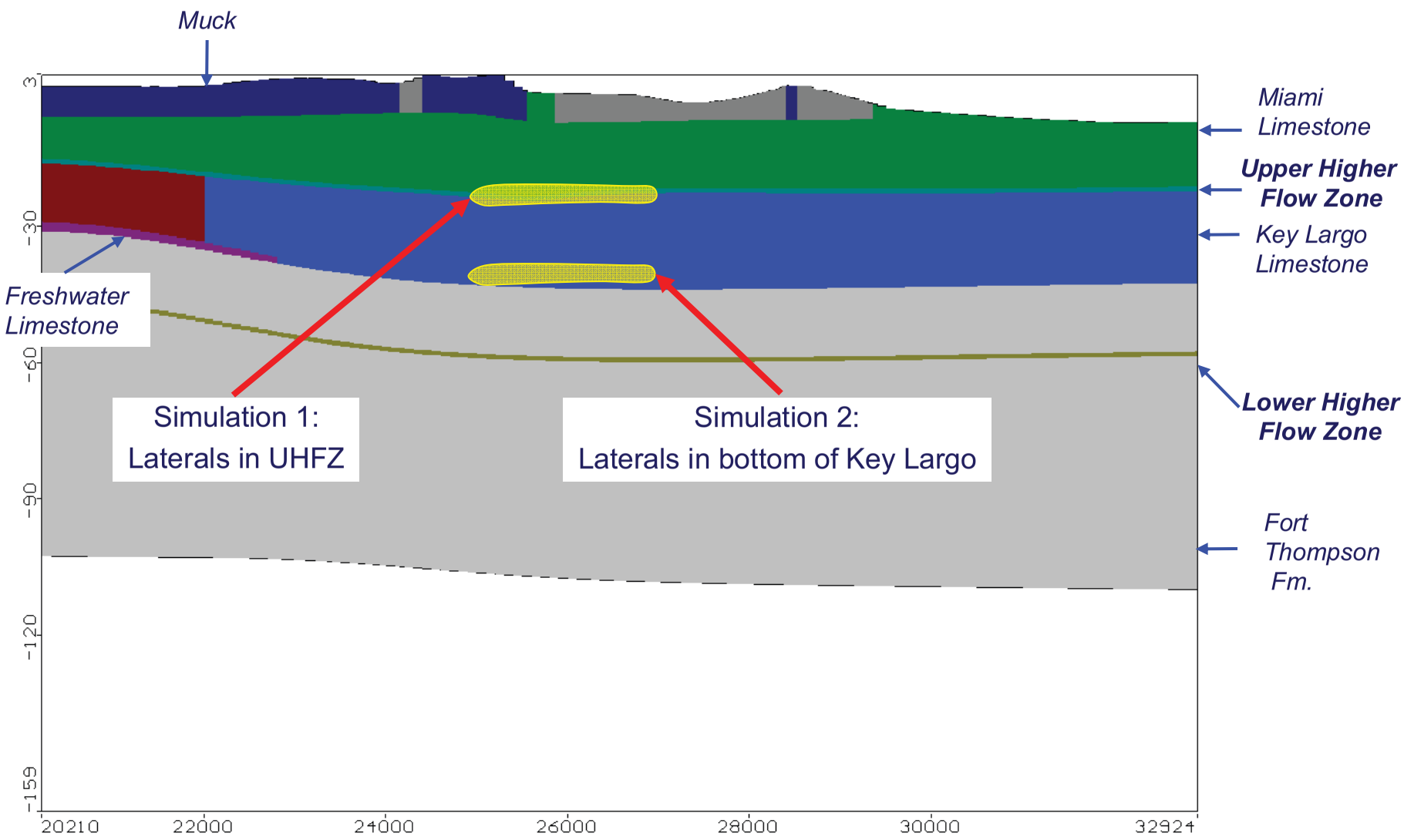
Dewatering & Grouting Results



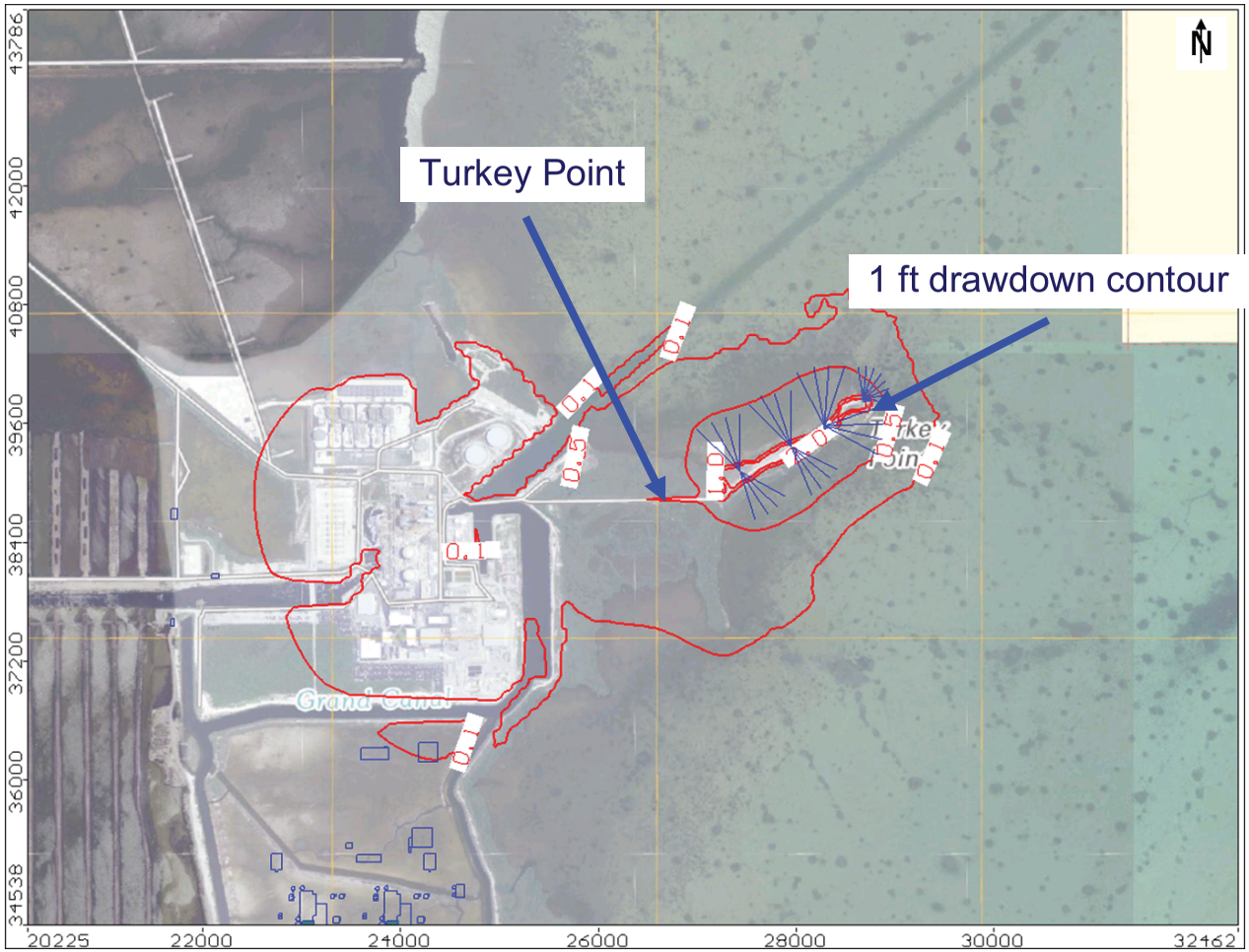
Radial Collector Well Model Setup



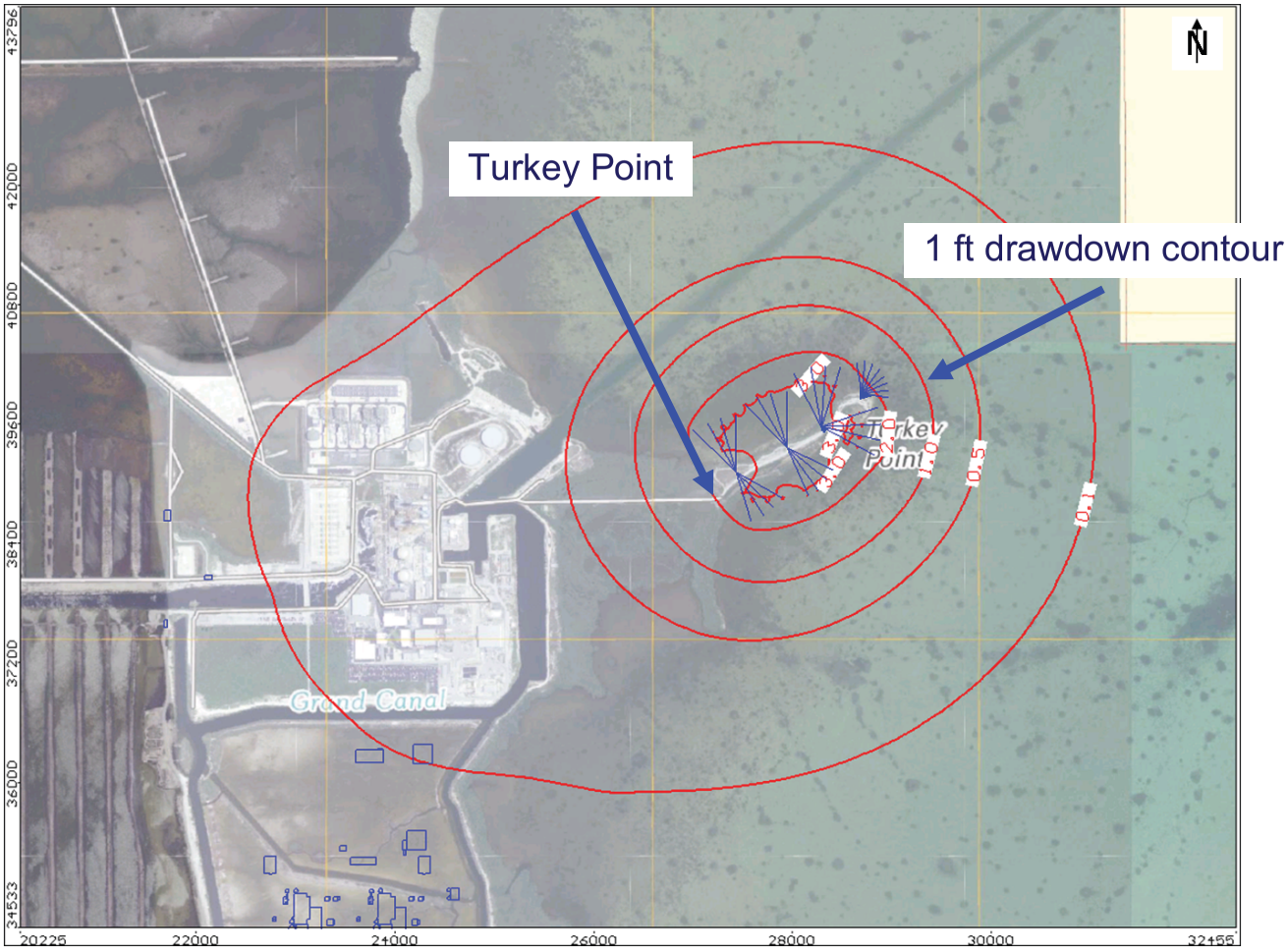
Radial Collector Well Setup



Radial Collector Well Results
Laterals in UHFZ
Drawdown in Muck & Off-Shore Sediment (Layer 1)



Radial Collector Well Results
Laterals in UHFZ
Drawdown in UHFZ (Layer 4)



Radial Collector Well Results
Approach Velocity / Water Origin

Upper Higher Flow Zone

Approach Velocities

- Entire RCW Catchment: 2.6 x 10^{-5} cm/s (8.5 x 10^{-7} ft/s) [Preliminary Value]
- Immediate RCW Area: 5.2 x 10^{-4} cm/s (1.7 x 10^{-5} ft/s)
- Single RCW Lateral: 6.2 x 10^{-4} cm/s (2.0 x 10^{-5} ft/s)

Water Origin

- Biscayne Bay >97%, CCS >2%, Other <1% [Preliminary Value]

Key Largo

Approach Velocities

- Entire RCW Catchment: 2.6 x 10^{-5} cm/s (8.5 x 10^{-7} ft/s) [Preliminary Value]
- Immediate RCW Area: 5.1 x 10^{-4} cm/s (1.7 x 10^{-5} ft/s)
- Single RCW Lateral: 6.1 x 10^{-4} cm/s (2.0 x 10^{-5} ft/s)

Water Origin

- Biscayne Bay >97%, CCS >2%, Other <1% [Preliminary Value]

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Radial Collector Well Results
Sensitivity Analyses

- Upper Higher Flow Zone selected as base case for RCW simulations. Sensitivity analyses conducted to determine variation in approach velocity / RCW water origin as a result of:
  1. Placement of laterals at base of Key Largo Limestone.
  2. Seasonal high and low water level in Biscayne Bay.
  3. Doubling and halving vertical hydraulic conductivity in Biscayne Bay.
  4. Assigning single value of hydraulic conductivity to Key Largo Limestone (all blue or all red – see slide 12).
- These simulations demonstrate minimal change in approach velocity and RCW flow percentages compared to base case.

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Summary

- The groundwater model was revised to incorporate additional data and ongoing input.
- Model robustness improved by review process and incorporation of comments.
- Updated model demonstrates reduction in construction dewatering rate by implementation of grouting program.
- RCW simulations demonstrate consistency of model results (approach velocity, flow origin, drawdown) to depth of laterals, conductance of bay floor, seasonal variations in Biscayne Bay water level, and hydraulic conductivity of Key Largo Limestone.
- The conclusions from the model have not changed significantly between the Rev 0 and Rev 1 reports.

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