Atlantic Richfield Company

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February 8, 2019

Jessica LaClair
Project Manager
New York State Department of Environmental Conservation
Division of Environmental Remediation
625 Broadway, 12th Floor
Albany, New York 12233-7016

RE: Pre-Design Investigation Data Summary Report Amendment
Former Anaconda Plant (a.k.a. Harbor at Hastings Site) Site No. 3-60-022
Hastings-On-Hudson, New York

Dear Ms. LaClair:

Please find attached a supplement to Appendix B of the Preliminary Design Report submitted by Arcadis of New York, Inc. (Arcadis) in November 2017 as requested by the New York State Department of Environmental Conservation (NYSDEC) in its response letter to that report dated March 13, 2018. This supplement provides the current groundwater model for the Harbor at Hastings (Former Anaconda Wire & Cable Plant Site) Site located at 1 River Street, Hastings-on-Hudson, New York (Site).

Arcadis, on behalf of Atlantic Richfield Company (ARC), updated the steady-state numerical groundwater flow model previously developed for the Site (Haley and Aldrich 2016). Once updated, this numerical groundwater flow model was used in preparing the Preliminary Design (PD) to evaluate the two sheet pile wall options within the Hudson River, the purpose of which is to provide containment and allow for the potential recovery of liquid polyvinyl chlorinated biphenyl dense non-aqueous phase liquid (PCB DNAPL) offshore of the northwest corner of the Site (Northwest Extension Area [NEA]). The model results will be used to design a gate within the NEA to alleviate potential mounding of groundwater behind the sheet pile wall.

If you have any questions or comments on this submittal, please feel free to contact me at 832-619-5825.

Sincerely,

Paul G. Johnson
Operations Project Manager

Enclosure

cc: Francis Frobel, Hastings-On-Hudson
Mark Chertok, Hastings-On-Hudson
Karl Coplan, Pace/Riverkeeper
File

ecc: Maureen Schuck, New York State Department of Health
Jacquelyn Nealon, New York State Department of Health
Kevin Farrar, New York State Department of Environmental Conservation
John Armitage, New York State Department of Environmental Conservation
Benjamin Conlon, Esq. New York State Department of Environmental Conservation, Office of General Counsel
Jim Lucari, BP
Michael Daneker, Arnold & Porter
Martha Gopal, Sovereign Consulting Inc.

APPENDIX B SUPPLEMENT TO PRELIMINARY DESIGN REPORT (NOVEMBER 2017)

GROUNDWATER MODEL: 2017 UPDATE AND REMEDIAL SCENARIO ANALYSIS FOR HARBOR-AT-HASTINGS SITE

Harbor at Hastings Site
(Former Anaconda Wire & Cable Plant Site)
Hastings-On-Hudson, New York
NYSDEC Site #3-60-022

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FIGURES

ACRONYMS AND ABBREVIATIONS

ARC	Atlantic Richfield Company
Arcadis	Arcadis of New York, Inc.
cm/sec	centimeter per second
DNAPL	dense non-aqueous phase liquid
gpm	gallons per minute
NAVD88	North American Vertical Datum of 1988
NEA	Northwest Extension Area
PCB	polychlorinated biphenyl
RSS	residual sum of squares
Site	Harbor at Hastings Site (Former Anaconda Wire & Cable Plant Site)
USGS	United States Geological Survey

1 INTRODUCTION AND OBJECTIVE

Arcadis of New York, Inc. (Arcadis), on behalf of Atlantic Richfield Company (ARC), has updated the steady-state numerical groundwater flow model previously developed (Haley and Aldrich 2016) for the Harbor at Hastings (Former Anaconda Wire & Cable Plant Site) Site located at 1 River Street, Hastings-on-Hudson, New York (Site) (Figure 1). Once updated, this numerical groundwater flow model was used in preparing the Preliminary Design (PD) to evaluate the two sheet pile wall options within the Hudson River, the purpose of which is to provide containment and allow for the potential recovery of liquid polyvinyl chlorinated biphenyl dense non-aqueous phase liquid (PCB DNAPL) offshore of the northwest corner of the Site (Northwest Extension Area [NEA]). The model results will be used to design a gate within the NEA to alleviate potential mounding of groundwater behind the sheet pile wall.

This model update was not provided in the Preliminary Design Report (Arcadis, November 2017) and serves as a supplement to Appendix B of that document.

2 GROUNDWATER FLOW MODEL UPDATES

Prior to performing the two sheet pile analyses, Arcadis updated the previously developed (Haley and Aldrich 2016) three-dimensional MODFLOW groundwater flow model. This update consisted of expanding the groundwater flow model to the west into the Hudson River and including shore structures that restrict groundwater flow. The model was then recalibrated to the most recent Sitewide groundwater levels collected (July 1, 2014). Sensitivity analyses were performed to evaluate the sensitivity of horizontal and vertical hydraulic conductivity on model calibration.

Specifically, this effort included the following updates:

- Expanded/adjusted the active model domain (i.e., finite-difference grid) to the west to accommodate the NEA;
- Adjusted boundary conditions assigned to the Hudson River to more accurately reflect current conditions;
- Modified the hydraulic conductivity and applied recharge distributions to better reflect recent observed Site conditions (through 2017); and
- Recalibration of the model using recent Sitewide groundwater level data.

Details of the groundwater model update and sheet pile wall evaluation are discussed below.

2.1 Expanded Model Domain

The existing model (Haley and Aldrich 2016) covered an area of approximately 378 acres with an overall orientation due north, approximately parallel to the primary direction of groundwater flow (west towards the Hudson River). Three model layers were used to represent unconfined flow in the surficial overburden deposits (Haley and Aldrich 2016). The finite-difference grid for the updated model remains oriented due north, but was expanded westward such that boundary effects would not be observed in the NEA. The updated finite-difference grid now covers an area of approximately 523 acres and consists of 215 columns, 452 rows, and 3 layers for a total of 291,540 model cells. Note that the original model was composed of 115 columns, 444 rows, and 3 layers for a total of 153,180 model cells. Figure 2 compares the two model extents. The updated model grid retains the variable spacing of the original model with refined cell dimensions near the Site (10 feet by 10 feet) and larger cells near the model boundaries (Figure 3).

2.2 Boundary Condition Update

Boundary conditions in the existing model included constant head boundaries (representing the Hudson River), no flow boundaries, general head boundaries, and drains (Haley and Aldrich 2016). These boundary conditions were retained from the existing model, but were updated accordingly. Constant head boundaries were updated using United States Geological Survey (USGS) stream gauge data for the Hudson River. Changes to the constant head boundaries were also made to accommodate the expanded finite-difference grid. Horizontal flow barriers to account for shore structures that restrict groundwater flow were added to the model. Lastly, the position of no flow boundaries was adjusted to accommodate the refined finite-difference grid. The revised boundary conditions are shown on Figure 4.

2.3 Hydraulic Conductivity and Recharge Refinement

The hydraulic conductivity distribution was modified as part of the model verification/re-calibration process based on two data sources: 1) Site-specific geologic cross-sections and boring logs; and 2) New York State Museum Surficial Geology (New York State Museum 2017). These sources were used as a guide to assign updated hydraulic conductivity values during model re-calibration (Figure 5). This updated distribution is similar to the distribution assigned in the original model (Haley and Aldrich 2016).

Also, as part of model verification/re-calibration, recharge within permeable areas of the model was decreased from 7.0 inches per year to 5.98 inches per year based on data from 2014 (Figure 6).

2.4 Flow Model Recalibration

Re-calibration of the updated groundwater flow model was evaluated via a statistical analysis of model residuals, defined as the difference between field-observed and model-simulated groundwater elevations. Positive residuals indicate that simulated hydraulic heads are lower than field-observed values and negative residual values indicate model-simulated values greater than field-observed values. The primary objective of model calibration is to minimize the model residuals for a given set of calibration targets.

Residual statistics for the selected July 1, 2014 mean tide water-level calibration targets (Table 1) present a minimum residual of -1.17 feet with a maximum of 1.56 feet. Updated calibration results are presented graphically in a scatter plot of simulated versus observed head values shown on Figure 7 and indicate that model-simulated water levels are generally consistent with field-measured values. Some outliers are present, and are generally associated with areas of the Site where there is large topographical relief.

Residual statistics are also presented on Figure 7. The standard deviation divided by the range of observed heads (scaled residual standard deviation) is used to assess the overall model fit as adjusted for scaling effects (Anderson and Woessner, 1992). For this parameter, a result of approximately 10 to 15 percent (%) is considered to be the goal for model calibration. As shown on Figure 7, the scaled residual standard deviation is approximately 13.6%, indicating a relatively high degree of calibration. Additionally, the absolute residual mean, representing the average of the absolute value of the residuals is 0.45 feet. The absolute residual mean should be close to zero, indicating a well-calibrated model.

As a part of the evaluation of the updated calibration, a simulated potentiometric surface map was prepared for the Site to ensure that simulated groundwater flow patterns are reasonable and to illustrate the spatial distribution of model residuals. Figure 8 indicates that, based on simulated groundwater elevation contours, the model generally reflects observed groundwater flow patterns. Groundwater generally flows toward the Hudson River to the west. The spatial distribution of model errors (Figure 8) indicates minimal over-predicted spatial bias, indicated by blue circles. As discussed earlier, calibration statistics indicate a high degree of calibration was achieved and that the updated steady-state groundwater flow model adequately simulates Site groundwater flow conditions.

3 GROUNDWATER FLOW MODEL SENSITIVITY ANALYSES

Sensitivity analyses were performed on all the parameters and boundary conditions adjusted during the calibration process: horizontal hydraulic conductivity, vertical hydraulic conductivity, and aerial recharge. The sensitivity analyses focused on quantitative calibration metrics, residual sum of squares (RSS), and residual mean. These metrics were assessed to determine when the model calibration could no longer be significantly improved (the RSS was low and the residual mean was close to zero), and whether the changes in a model parameter have a large or small effect on the model calibration. The results of the sensitivity analyses are discussed below.

3.1 Horizontal Hydraulic Conductivity

The horizontal hydraulic conductivity zonations and the values within each zone are summarized on Figure 5. Figure 9 presents the results of the sensitivity analysis of horizontal hydraulic conductivity with respect to RSS. Figure 10 presents the results of the sensitivity analysis of horizontal hydraulic conductivity with respect to residual mean. The use of a multiplier allows assessment of proportional changes in a parameter on the model calibration. For example, a multiplier of 2.0 is twice the calibrated value and a value of 0.5 is one-half the calibrated value. The greater the change in the RSS, the more sensitive a model is to that parameter. Zones 2 (fill) and 5 (basal sand) are the most sensitive. All other zones are relatively insensitive. The minimum RSS value during the sensitivity analysis was obtained from the calibration value (multiplier of 1). Similarly, the residual mean is closest to zero using the values obtained from the calibration.

3.2 Vertical Hydraulic Conductivity

The horizontal hydraulic conductivity zonations and the values within each zone are summarized on Figure 5. Figure 11 presents the results of the sensitivity analysis of vertical hydraulic conductivity with respect to RSS. Figure 12 presents the results of the sensitivity analysis of vertical hydraulic conductivity with respect to residual mean. All zones are relatively insensitive with respect to RSS and residual mean.

3.3 Recharge

The recharge zonations and the values within each zone are summarized on Figure 6. Figure 13 presents the results of the sensitivity analysis of recharge with respect to RSS. Figure 14 presents the results of the sensitivity analysis of recharge with respect to residual mean. Recharge is a relatively sensitive parameter, with small changes to the simulated recharge yielding large changes in the RSS. The minimum RSS value during the sensitivity analysis was obtained from the calibration value (multiplier of 1). Similarly, the residual mean is closest to zero using the values obtained from the calibration.

4 SHEET PILE WALL EVALUATION

To support Site remedial strategy, the updated flow model was utilized to evaluate the two sheet pile wall options within the Hudson River to provide containment and allow for the potential recovery of liquid PCB DNAPL offshore of the northwest corner of the Site NEA. Two scenarios were evaluated and are shown on Figure 15:

- Scenario 1 – NEA Bulkhead (Partially Enclosed); bulkhead along the Hudson River Shoreline; and
- Scenario 2 – NEA Bulkhead (Fully Enclosed); bulkhead encloses the NEA.

The NEA bulkheads for each scenario were simulated as horizontal flow barriers and assigned hydraulic conductivity values of 1e-8 centimeters per second (cm/s). The NEA bulkheads were simulated in model layers 1 and 2 (fill and marine silt). All other shoreline structures along the NEA were assumed excavated. The fill within the NEA was assigned a hydraulic conductivity value of 1 cm/s.

The groundwater elevation, flow rate, and flow direction for the two scenarios were evaluated under mean, high, and low tide conditions. MODFLOW was used to simulate the groundwater elevation under each of the three flow conditions (low, mean, and high tide), and MODPATH (Pollock 1989)—which utilizes flow terms and velocities computed by MODFLOW, was used to generate the flow paths and travel times for each of the flow conditions, as shown on Figures 16 and 17. The flow rate noted on the figures was evaluated using a mass balance approach for model layer 1 (Fill).

Figure 16 shows the modeling results for Scenario 1 (Partially Enclosed). The model results indicated that the principle groundwater flow direction is to the northeast and to the southwest. The peak groundwater elevation within the NEA along the bulkhead under mean, high, and low tides is 1.5, 3 and -0.5 feet North American Vertical Datum of 1988 (NAVD 88), respectively. The flow out of the NEA under mean, high, and low tides is 1.68, 1.48, and 1.80 gallons per minute (gpm), respectively. To alleviate potential groundwater mounding along the bulkhead, and across the NEA, any gate within the NEA bulkhead would need to allow those flow rates (at a minimum) to pass through. The final placement of the gate within the NEA will be analyzed in the final design.

Figure 17 shows the modeling results for Scenario 2 (Fully Enclosed). Groundwater elevations for mean, high, and low tides exceed the top elevation of the NEA (approximately 6 feet NAVD 88), indicating overtopping in all directions would be expected without the use of a gate. The principal groundwater flow direction is to the northwest towards the Hudson River. The flow out of the NEA under mean, high, and low tides is 1.62, 1.47, and 1.73 gpm, respectively. Any gate within the NEA would need to accept those flow rates at a minimum. As with Scenario 1, the final placement of the gate within the NEA will be analyzed in the final design.

5 SUMMARY AND CONCLUSIONS

The primary objective of this model effort was to evaluate the two sheet pile wall options within the Hudson River designed to provide containment and allow for the potential recovery of liquid PCB DNAPL offshore of the northwest corner of the Site NEA. The model was re-calibrated using July 1, 2014 mean tide water-level data collected from 19 monitoring wells distributed throughout the area. Following recalibration of the groundwater flow model and a sensitivity analysis, two bulkhead alignments were analyzed under mean, high, and low tidal conditions. The groundwater flow within the NEA ranged from 1.47 to 1.80 gpm. A gate designed to alleviate potential mounding will need to accept those rates at a minimum. The final placement of the gate and bulkhead design will be analyzed in the final design.

6 REFERENCES

Anderson, M., and W. Woessner. 1992. Applied Groundwater Modeling Simulation of Flow and Advective Transport, Academic Press.

Haley and Aldrich. 2016. Report on Hastings Tidal Modeling Hudson, New York.

McDonald, M. G., and A. W. Harbaugh, 1988. A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model, Techniques of Water-Resources Investigations, Book 6, Chapter A1. U. S. Geological Survey. Reston, Virginia.

New York State Museum. 2017. Surficial Geology Shape Files. http://www.nysm.nysed.gov/research-collections/geology/gis.

Pollock, D. 1989. Documentation of Computer Programs to Compute and Display Pathlines Using Results for the U.S. Geological Survey Modular Three-Dimensional Finite-Difference Ground-Water Flow Model. U.S. Geological Survey Open File Report 89-381. Reston, Virginia.

TABLE

Table 1
July 1, 2014 Mean Tide Water Level Targets and Residuals
NYSDEC Site #3-60-022
1 River Street
Hastings-on-Hudson, New York
Groundwater Model

Well ID	Easting (NY East NAD 83)	Northing (NY East NAD 83)	Layer	July 1, 2014 Mean Tide Observed Water Level (ft NAVD 88)	Simulated Water Level (ft NAVD 88)	Residual (ft)
MW-09	661647	788360	1	1.11	0.63	0.48
PDMW-07	661498	786034	1	1.04	0.59	0.45
PDMW-10	661678	786500	1	0.94	1.10	-0.16
PDMW-12	661529	787926	1	0.85	0.98	-0.13
PDMW-16S	661901	786030	1	3.80	2.25	1.55
PDMW-18S	661920	787313	1	2.40	2.40	0.00
PDMW-20S	661894	787640	1	2.32	3.49	-1.17
PDMW-21S	661700	786023	1	1.24	1.34	-0.10
PDMW-22S	661686	786956	1	1.13	1.02	0.11
PDMW-23S	661706	787521	1	1.12	1.10	0.02
PDMW-24S	661721	788203	1	1.22	1.40	-0.18
PDMW-26S	661763	788201	1	1.27	1.59	-0.32
RW-03	661511	787696	1	1.14	0.36	0.78
PDMW-16D	661902	786035	3	5.07	4.37	0.70
PDMW-17D	661867	786781	3	5.36	4.41	0.95
PDMW-18D	661913	787313	3	4.29	4.37	-0.08
PDMW-25D	661658	787243	3	4.16	4.38	-0.22
MW-13A	661616	787837	3	3.74	4.35	-0.61
MW-15A	661626	788332	3	3.77	4.33	-0.56

Residual Statistics	
Residual Mean (ft)	0.080
Residual Std. Deviation (ft)	0.61
Sum of Squares (ft^2)	7.16
Number of Observations	19
Range in Observations (ft)	4.51
Scaled Residual Std. Deviation	13.61%

Notes and Abbreviations
ft = feet
NAD 83 = North American Datum of 1983
NAVD 88 = North American Vertical Datum of 1988

FIGURES

NYSDEC SITE #3-60-022
1 RIVER STREET
HASTINGS-ON-HUDSON, NEW YORK
GROUNDWATER MODEL

SITE LOCATION

ARCADIS Design & Consultancy for natural and built assets

FIGURE
1

Legend

Haley and Aldrich Model Extents

Arcadis Model Extents (this report)

NEA Bulkhead Alignment

N

Scale in feet

0 500 1,000

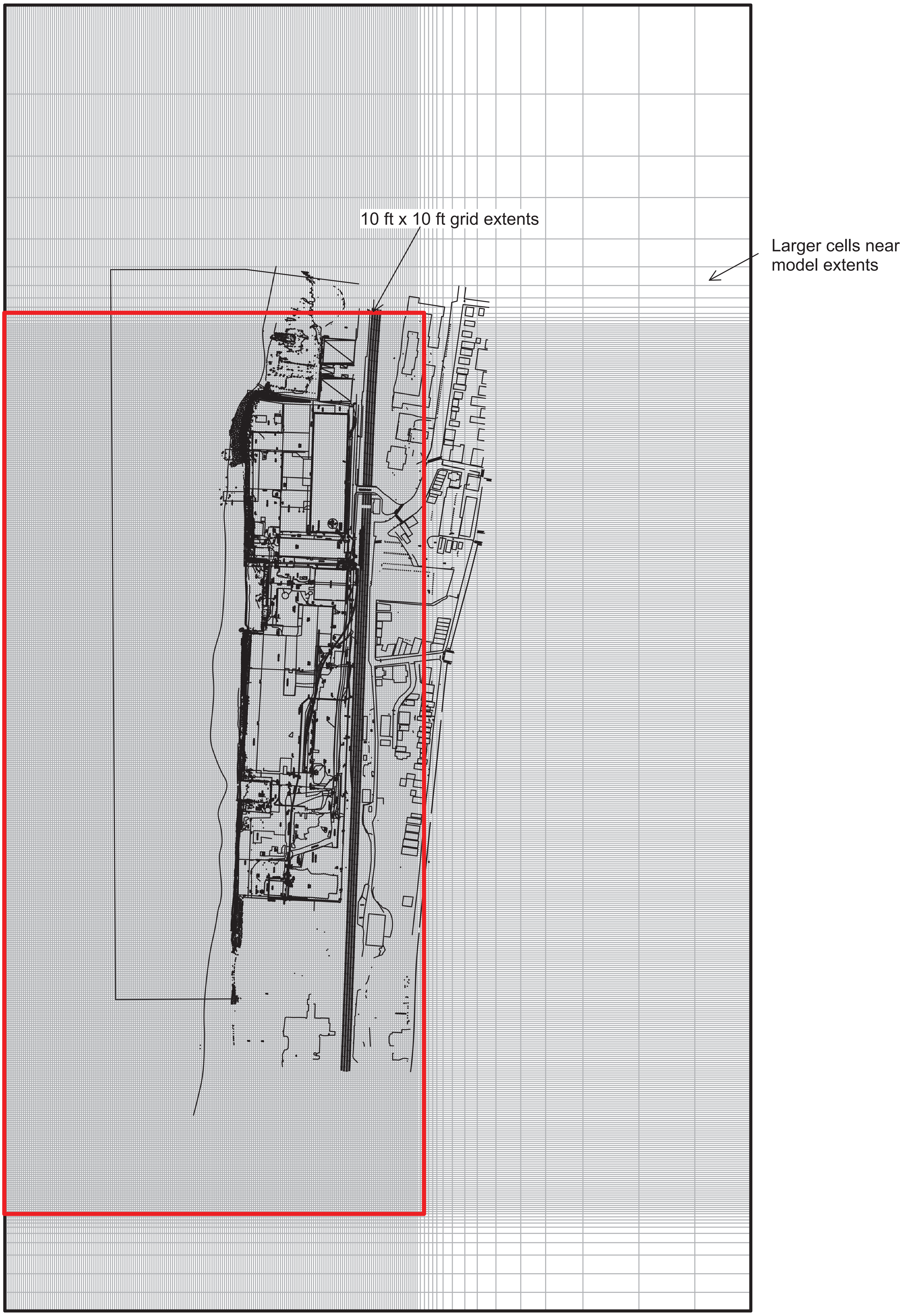
Basemap from the USGS
https://viewer.nationalmap.gov/basic/#productSearch

NYSDEC SITE #3-60-022
1 RIVER STREET
HASTINGS-ON-HUDSON, NEW YORK
GROUNDWATER MODEL

MODEL EXTENTS COMPARISON

ARCADIS Design & Consultancy for natural and built assets

FIGURE
2



Legend

Finite Difference Grid Cell

10 ft x 10 ft Grid Extents

Arcadis Model Extents (this report)

N

Scale in feet

0 500 1,000

NYSDEC SITE #3-60-022
1 RIVER STREET
HASTINGS-ON-HUDSON, NEW YORK
GROUNDWATER MODEL

FINITE DIFFERENCE GRID

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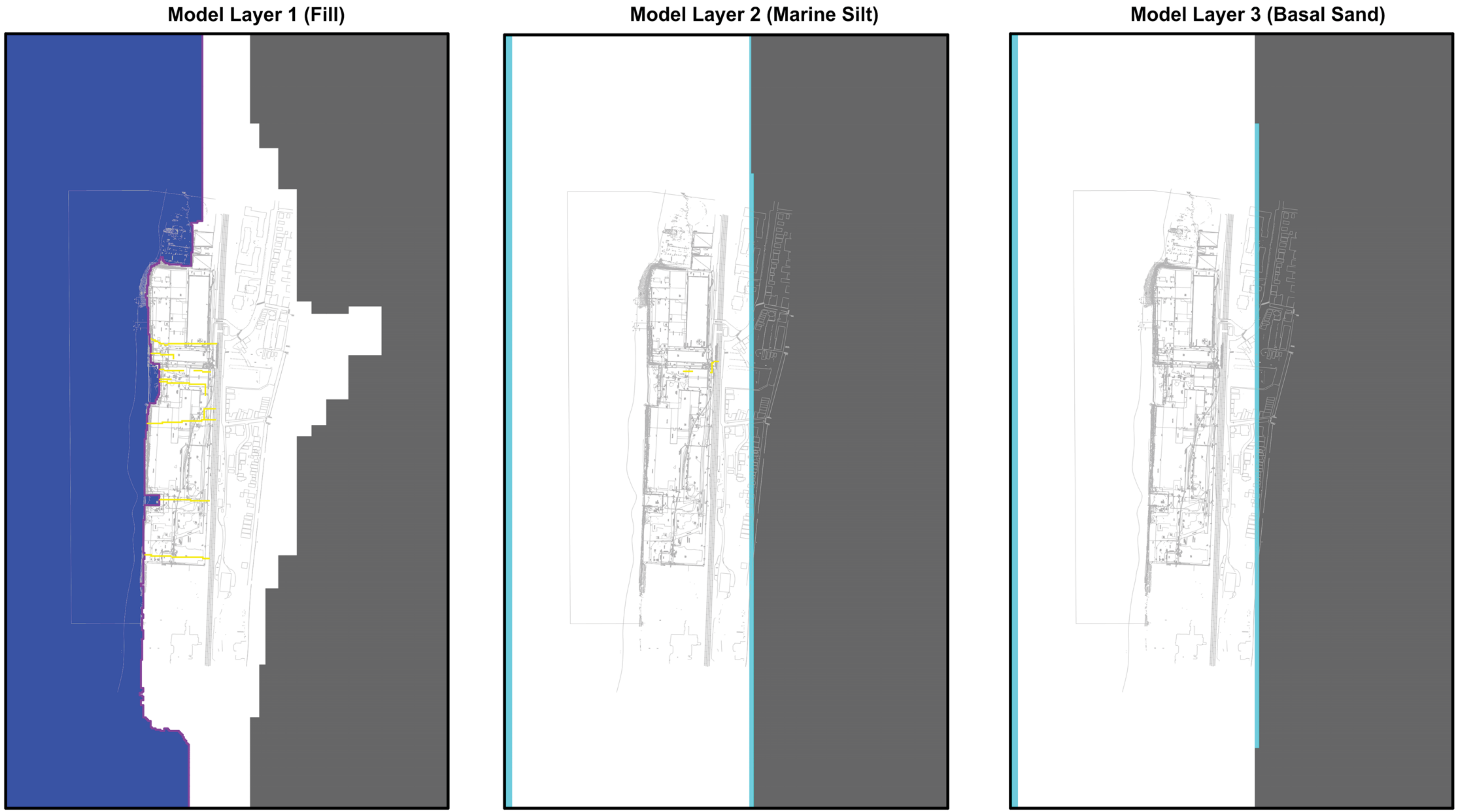
FIGURE 3



N

Legend

- Constant Head Boundary
- No-Flow Boundary
- Horizontal Flow Barrier
- General Head Boundary
- Drain Boundary

Scale in feet

0 800 1,600

NYSDEC SITE #3-60-022
1 RIVER STREET
HASTINGS-ON-HUDSON, NEW YORK

GROUNDWATER MODEL

SIMULATED BOUNDARY CONDITIONS

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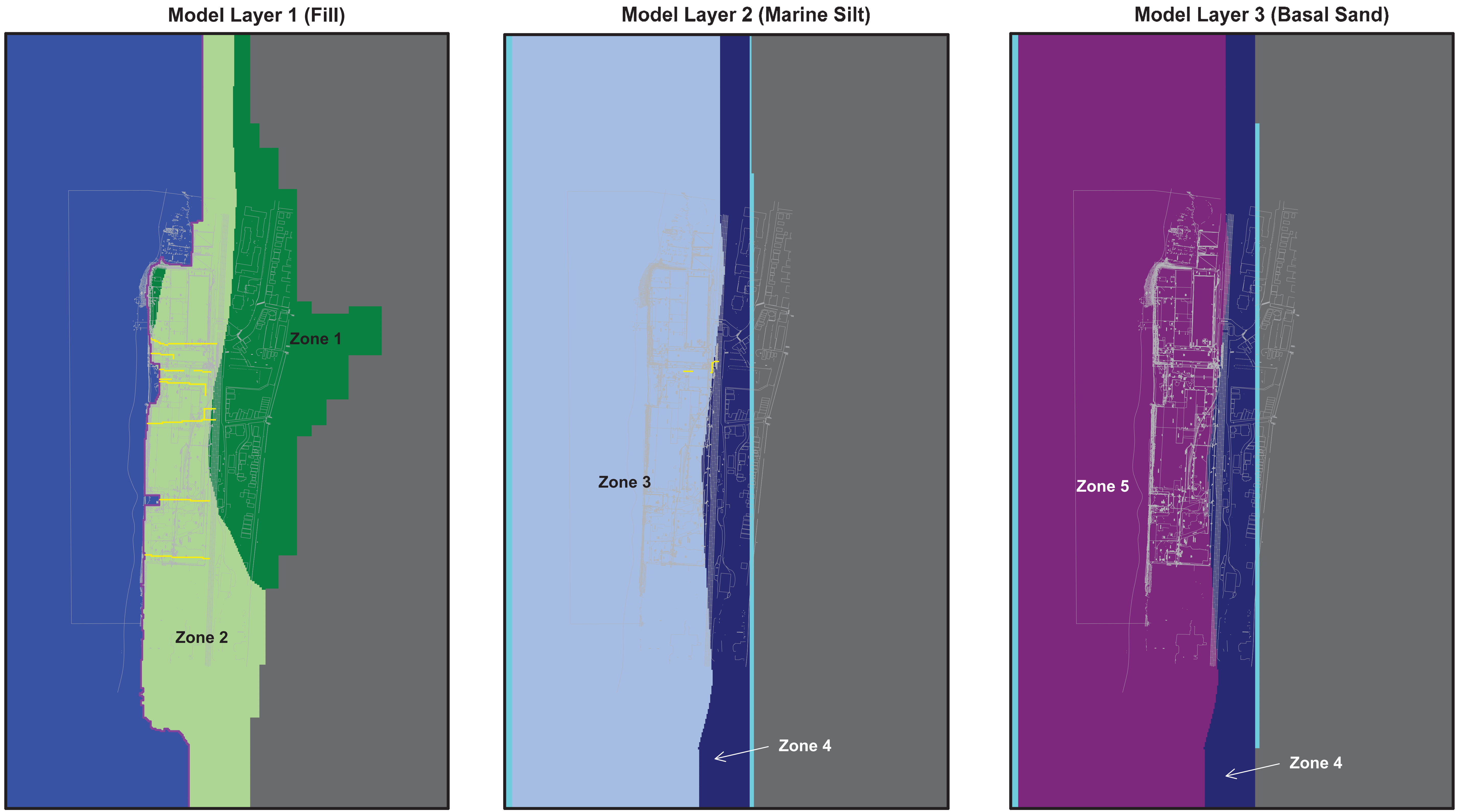
FIGURE
4



Legend

- Constant Head Boundary
- No-Flow Boundary
- Horizontal Flow Barrier
- General Head Boundary
- Drain Boundary
- Zone 1 = 0.83 : 0.05
- Zone 2 = 10.0 : 0.40
- Zone 3 = 0.008 : 0.001
- Zone 4 = 0.006 : 0.001
- Zone 5 = 9.85 : 0.4

*Horizontal hydraulic conductivity : vertical hydraulic conductivity (feet per day)

Scale in feet: 0 800 1,600

N

NYSDEC SITE #3-60-022
1 RIVER STREET
HASTINGS-ON-HUDSON, NEW YORK
GROUNDWATER MODEL

SIMULATED HYDRAULIC CONDUCTIVITY DISTRIBUTION

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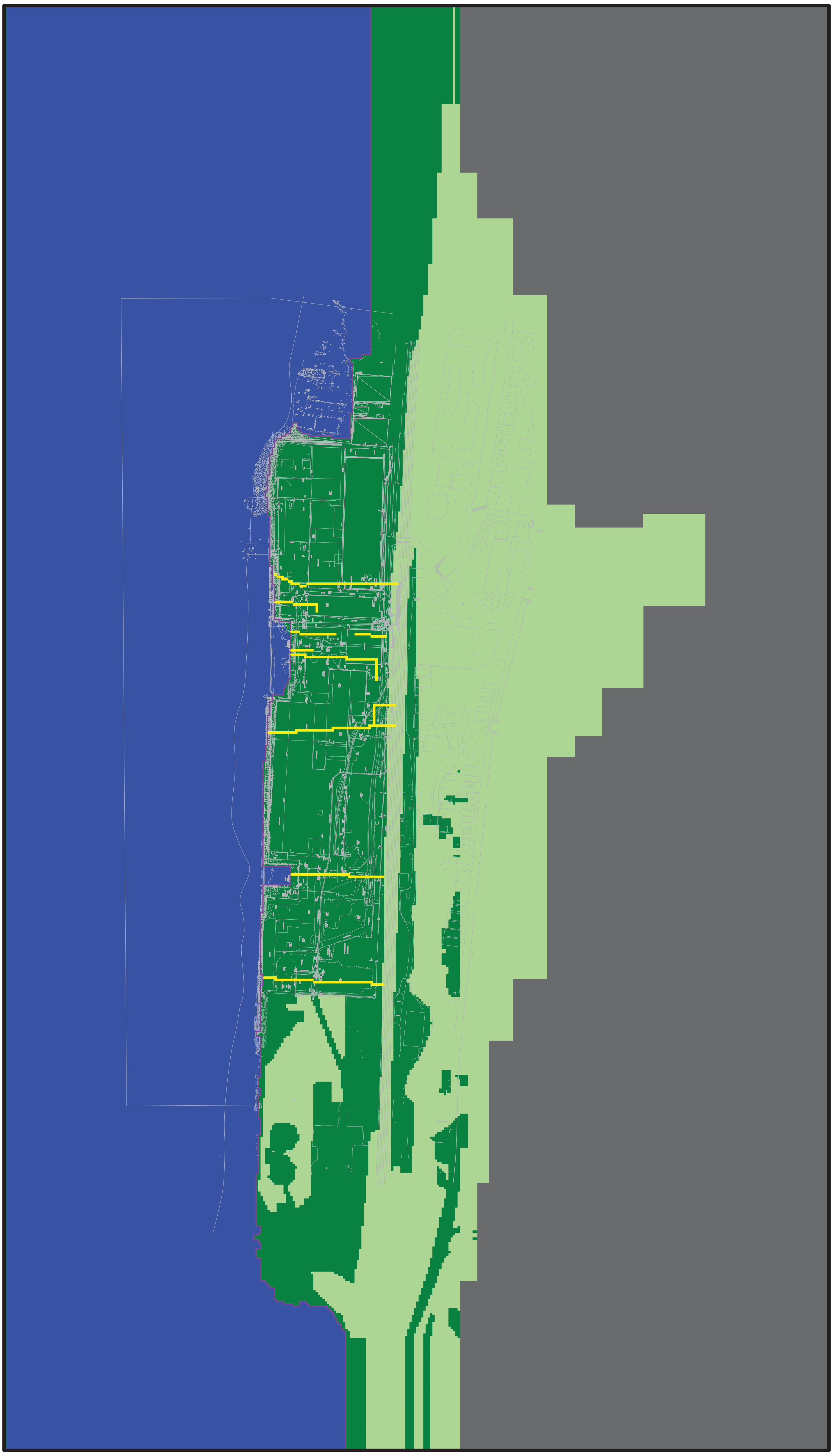
FIGURE 5



Legend

- Constant Head Boundary
- No-Flow Boundary
- Horizontal Flow Barrier
- Drain Boundary
- Zone 1 = 5.98 in/yr
- Zone 2 = 0 in/yr
  (Based on impermeable surfaces)

N

Scale in feet

0 500 1,000

NYSDEC SITE #3-60-022
1 RIVER STREET
HASTINGS-ON-HUDSON, NEW YORK
GROUNDWATER MODEL

SIMULATED RECHARGE DISTRIBUTION

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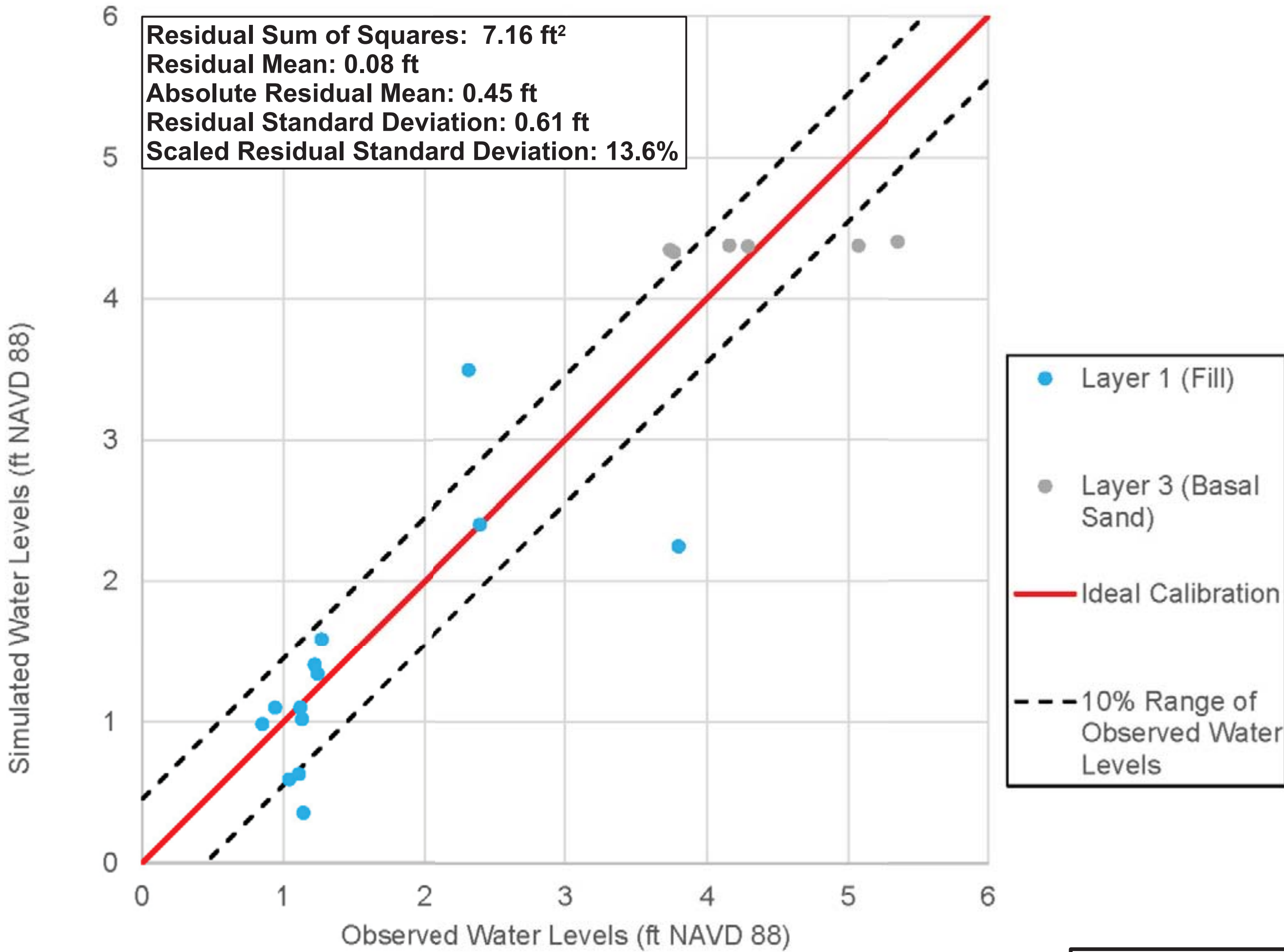
FIGURE
6



NYSDEC SITE #3-60-022
1 RIVER STREET
HASTINGS-ON-HUDSON, NEW YORK
GROUNDWATER MODEL

CALIBRATION SCATTER PLOT
MEAN TIDE

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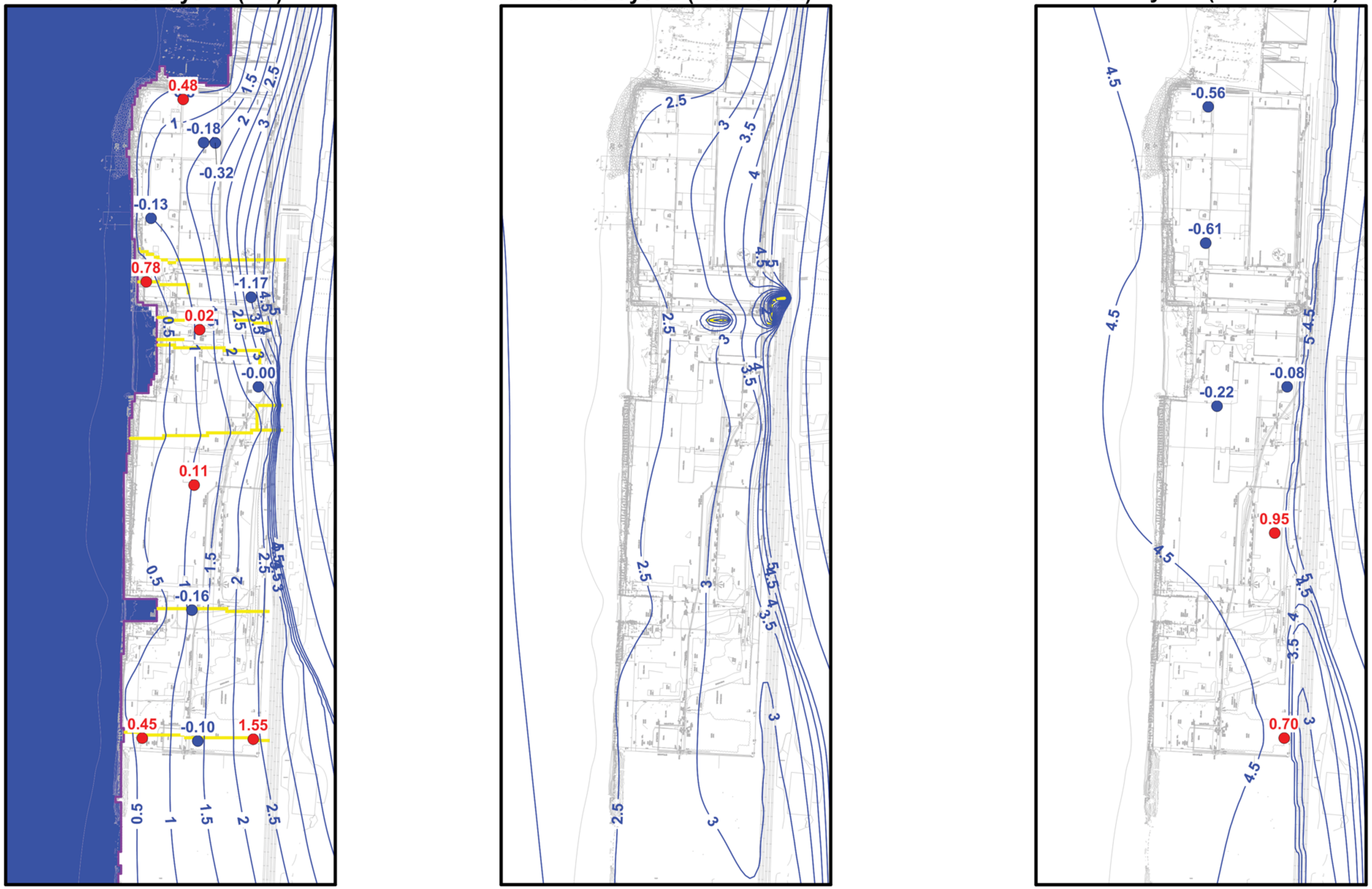
FIGURE
7

Model Layer 1 (Fill) **Model Layer 2 (Marine Silt)** **Model Layer 3 (Basal Sand)**



N

Scale in feet

0 400 800

Legend

Constant Head Boundary

Horizontal Flow Barrier

Drain Boundary

Simulated Groundwater Elevation (ft NAVD88)

-0.1 0.1 Residual (ft)
(Residual = Observed Water Level - Simulated Water Level)

*Blue circles represent over simulation (simulated water levels are greater than observed water levels).
Red circles represent under simulation (simulated water levels are less than observed water levels).
**Contour intervals are non-uniform for clarity.

NYSDEC SITE #3-60-022
1 RIVER STREET
HASTINGS-ON-HUDSON, NEW YORK

GROUNDWATER MODEL

SIMULATED GROUNDWATER CONTOURS AND RESIDUALS – MEAN TIDE

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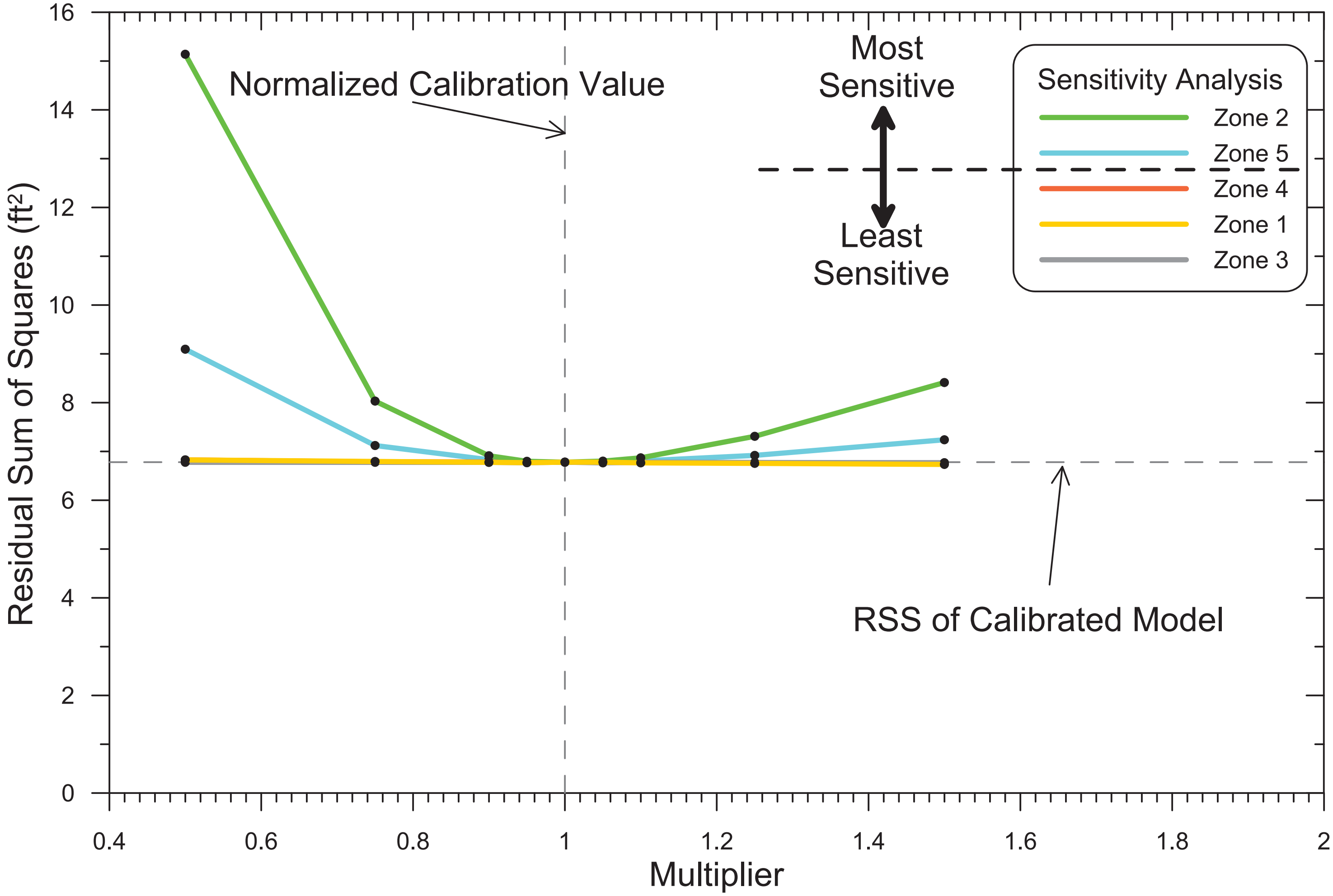
FIGURE 8



Calibrated Hydraulic Conductivity Values

Zone 2 - 10.0 ft/day
Zone 5 - 9.8 ft/day

Zone 4 - 0.006 ft/day
Zone 1 - 0.83 ft/day
Zone 3 - 0.008 ft/day

Most Sensitive

Least Sensitive

NYSDEC SITE #3-60-022
1 RIVER STREET
HASTINGS-ON-HUDSON, NEW YORK
GROUNDWATER MODEL

HORIZONTAL HYDRAULIC CONDUCTIVITY SENSITIVITY ANALYSES (RSS)

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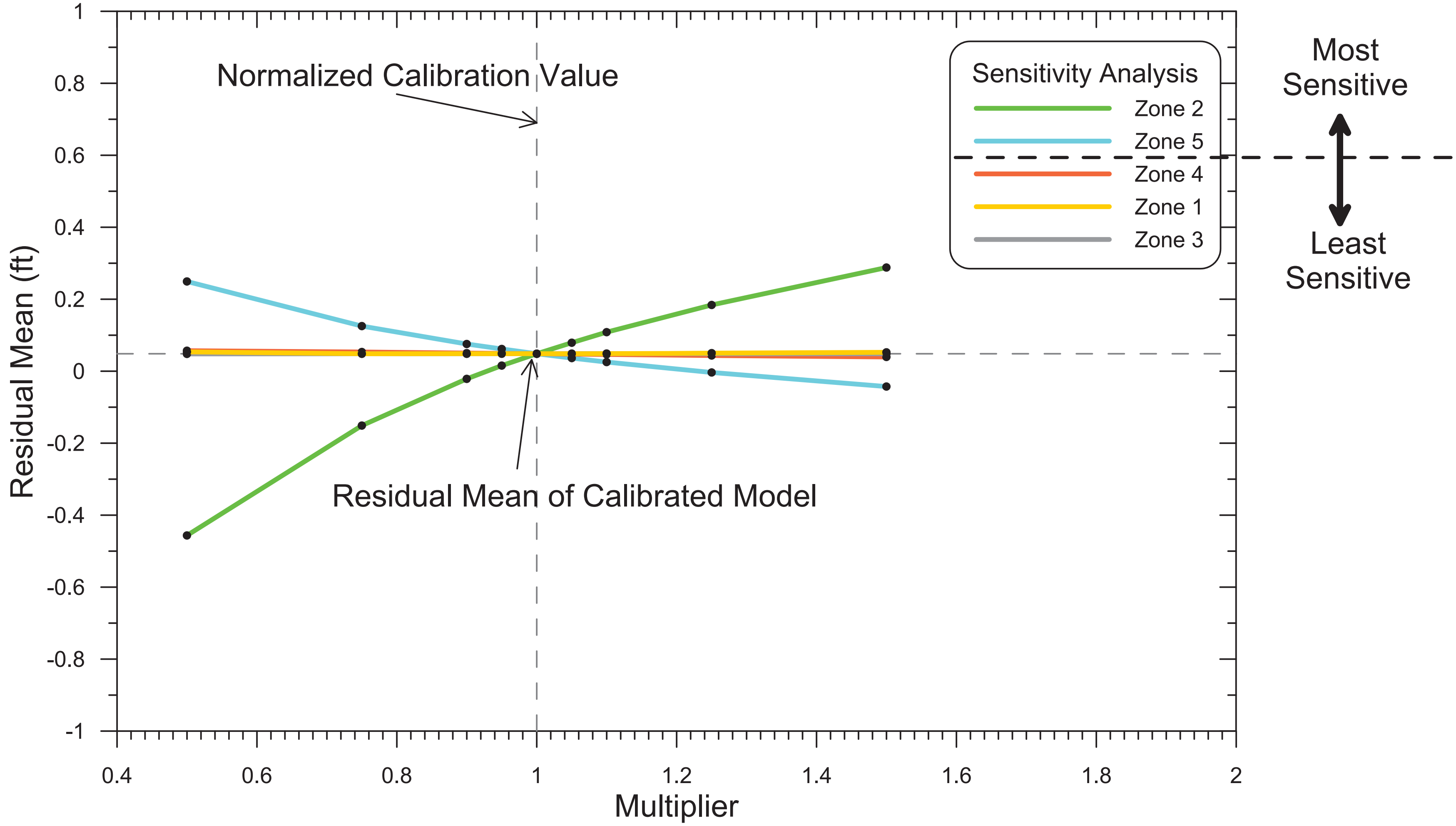
FIGURE 9



Calibrated Hydraulic Conductivity Values

Most Sensitive

Zone 2 - 10.0 ft/day
Zone 5 - 9.8 ft/day

Zone 4 - 0.006 ft/day
Zone 1 - 0.83 ft/day
Zone 3 - 0.008 ft/day

Least Sensitive

NYSDEC SITE #3-60-022
1 RIVER STREET
HASTINGS-ON-HUDSON, NEW YORK
GROUNDWATER MODEL

HORIZONTAL HYDRAULIC CONDUCTIVITY SENSITIVITY ANALYSES (RESIDUAL MEAN)

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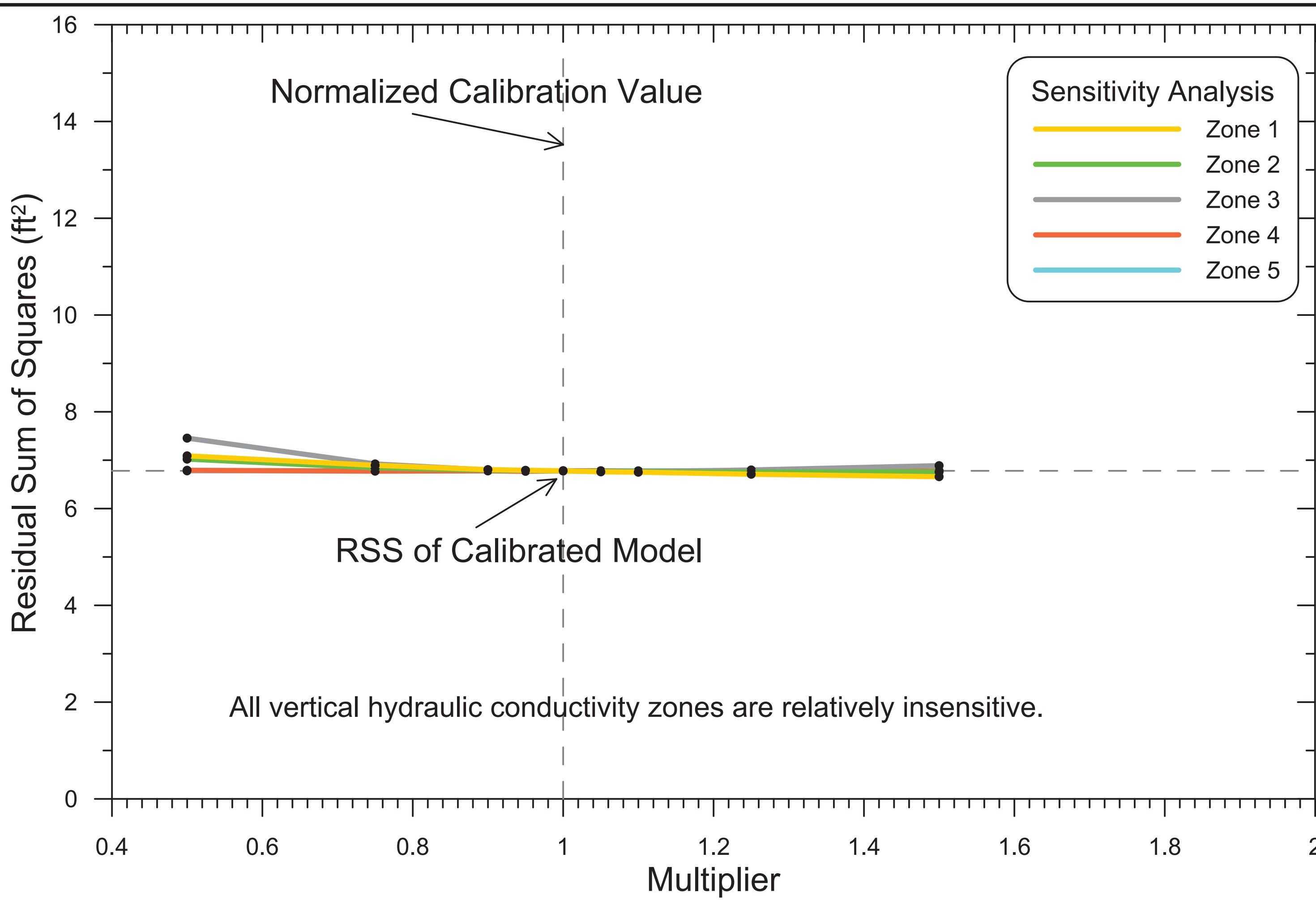
FIGURE 10



Calibrated Hydraulic Conductivity Values

Zone 1 - 0.05 ft/day
Zone 2 -0.40 ft/day
Zone 3 - 0.001 ft/day
Zone 4 - 0.001 ft/day
Zone 5 - 0.40 ft/day

NYSDEC SITE #3-60-022
1 RIVER STREET
HASTINGS-ON-HUDSON, NEW YORK
GROUNDWATER MODEL

VERTICAL HYDRAULIC CONDUCTIVITY SENSITIVITY ANALYSES (RSS)

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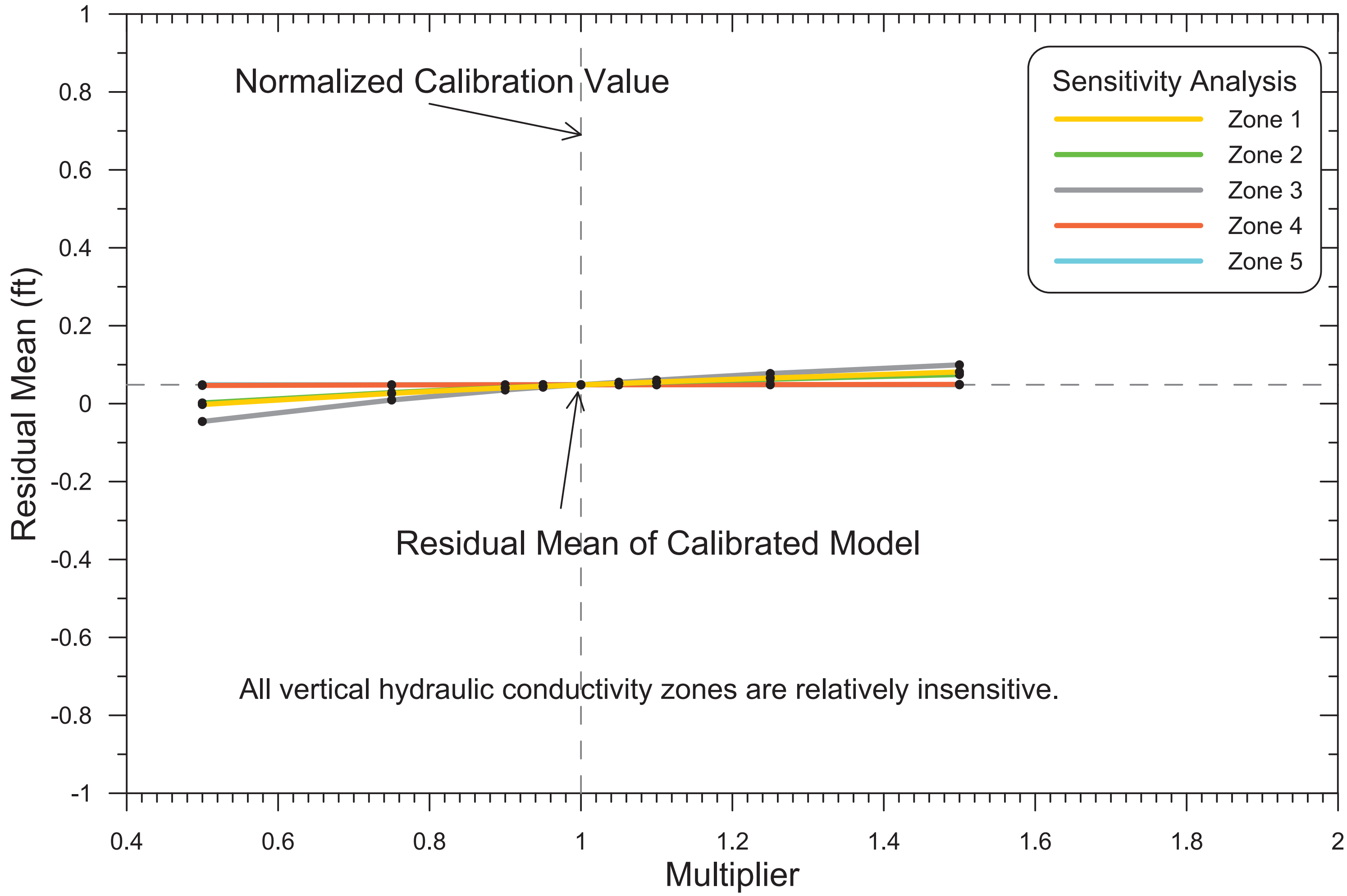
FIGURE
11



Calibrated Hydraulic Conductivity Values

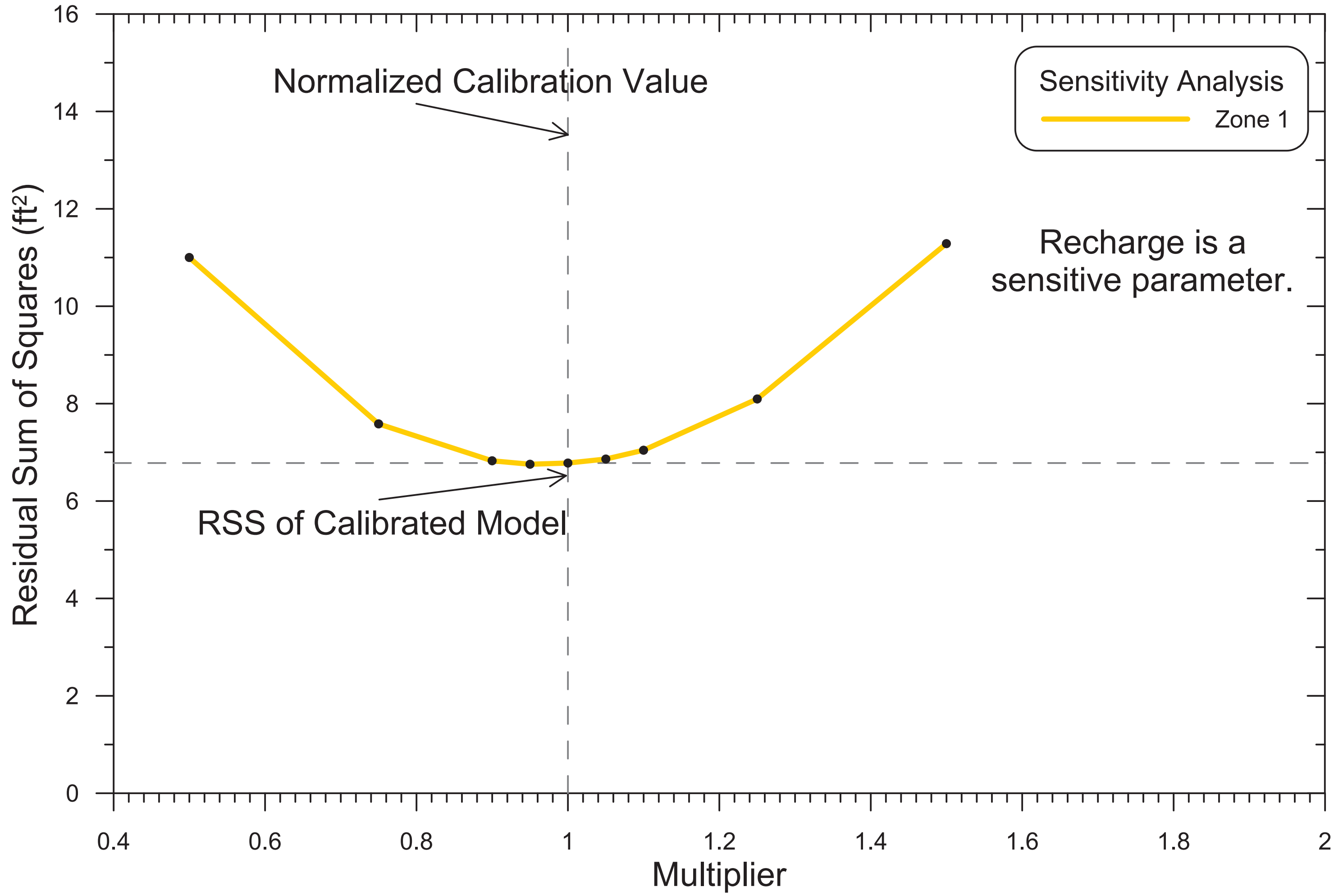
Zone 1 - 0.05 ft/day
Zone 2 -0.40 ft/day
Zone 3 - 0.001 ft/day
Zone 4 - 0.001 ft/day
Zone 5 - 0.40 ft/day

NYSDEC SITE #3-60-022
1 RIVER STREET
HASTINGS-ON-HUDSON, NEW YORK
GROUNDWATER MODEL

VERTICAL HYDRAULIC CONDUCTIVITY SENSITIVITY ANALYSES (RESIDUAL MEAN)

ARCADIS Design & Consultancy for natural and built assets

FIGURE
12



Calibrated Recharge Value

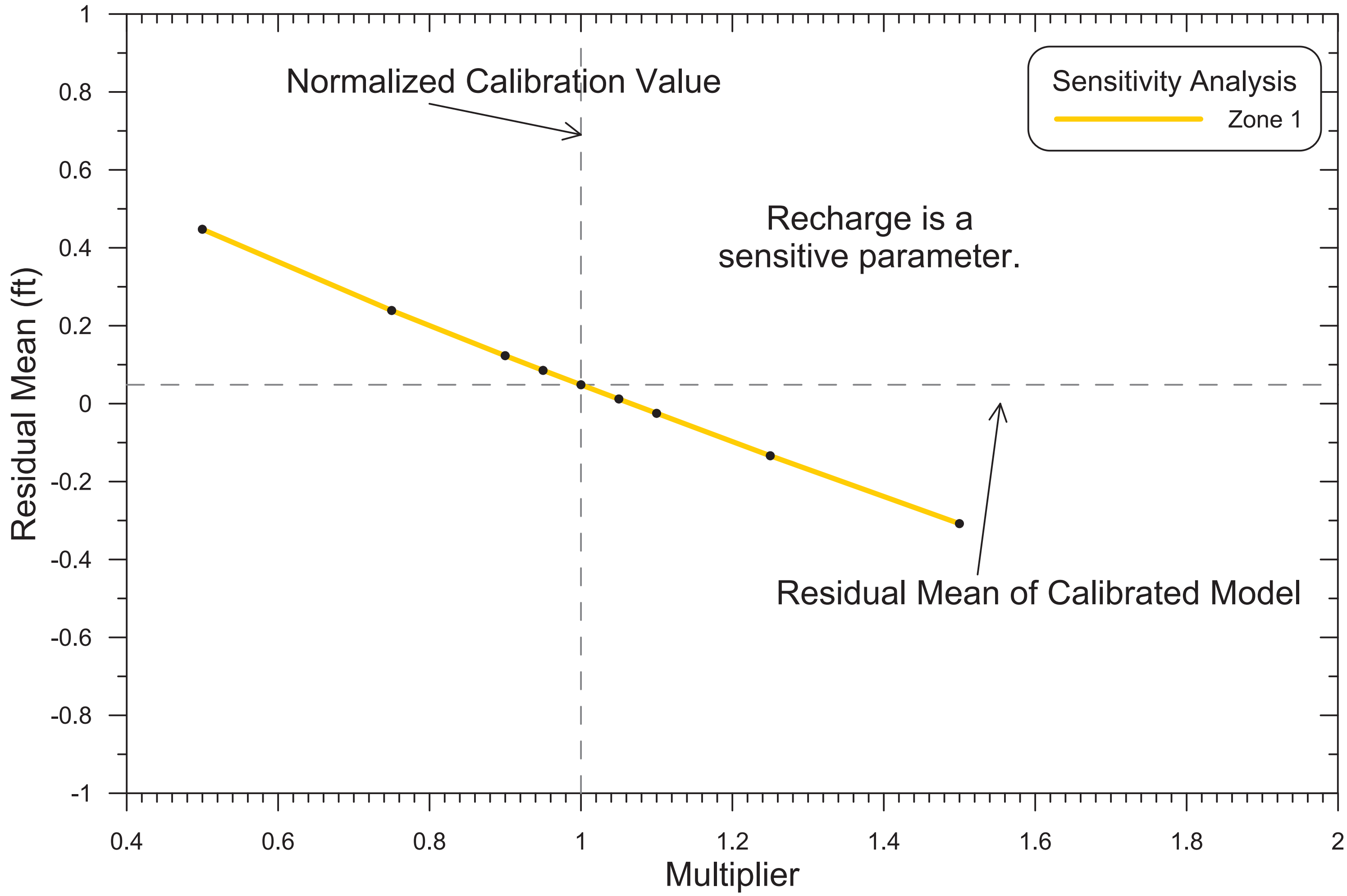
Zone 1 - 5.98 in/yr

NYSDEC SITE #3-60-022
1 RIVER STREET
HASTINGS-ON-HUDSON, NEW YORK
GROUNDWATER MODEL

RECHARGE SENSITIVITY ANALYSES (RSS)

ARCADIS Design & Consultancy for natural and built assets

FIGURE
13



Calibrated Recharge Value

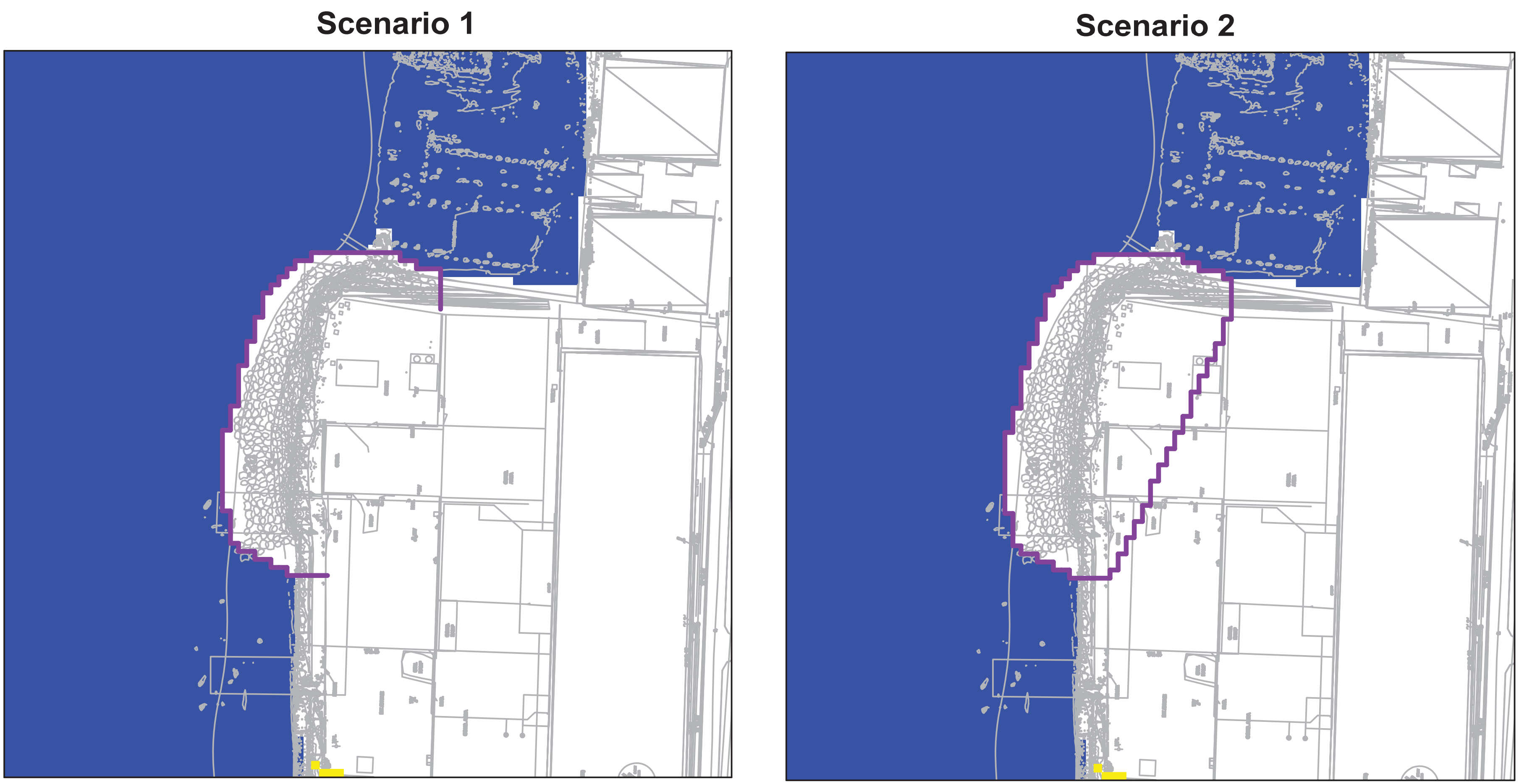
Zone 1 - 5.98 in/yr

NYSDEC SITE #3-60-022
1 RIVER STREET
HASTINGS-ON-HUDSON, NEW YORK
GROUNDWATER MODEL

RECHARGE SENSITIVITY ANALYSES (RESIDUAL MEAN)

ARCADIS Design & Consultancy for natural and built assets

FIGURE
14



Legend

Constant Head Boundary

Horizontal Flow Barrier (Hydraulic conductivity = 1e-8 cm/s)

Drain Boundary

*The hydraulic conductivity of fill within the NEA is 1 cm/s.

N

Scale in feet

0 200 400

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GROUNDWATER MODEL

REMEDIAL SCENARIO LAYOUT

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FIGURE
15

Mean Tide

Inflow to NEA = 1.68 gpm
Outflow from NEA = 1.68 gpm

High Tide

Inflow to NEA = 1.48 gpm
Outflow from NEA = 1.48 gpm

Low Tide

Inflow to NEA = 1.80 gpm
Outflow from NEA = 1.80 gpm

N

Scale in feet

0 200 400

Legend

- Constant Head Boundary
- Horizontal Flow Barrier
- Drain Boundary
- Simulated Groundwater Elevation (ft NAVD88)
- Simulated Particle Pathlines (travel time shown from particle origin every year; maximum travel time of 30 years)

*Mean tide = 0.22 ft NAVD 88
**High tide = 2.31 ft NAVD 88
***Low tide = -1.84 ft NAVD 88
****Inflow and outflow within NEA was calculated using a water balance within the NEA.

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GROUNDWATER MODEL

SCENARIO 1 - SIMULATED GROUNDWATER ELEVATION AND PATHLINES

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FIGURE 16

Mean Tide

Inflow to NEA = 1.62 gpm
Outflow from NEA = 1.62 gpm

High Tide

Inflow to NEA = 1.47 gpm
Outflow from NEA = 1.47 gpm

Low Tide

Inflow to NEA = 1.73 gpm
Outflow from NEA = 1.73 gpm

N

Scale in feet

0 200 400

Legend

- Constant Head Boundary
- Horizontal Flow Barrier
- Drain Boundary
- Simulated Groundwater Elevation (ft NAVD88)
- Simulated Particle Pathlines (travel time shown from particle origin every year; maximum travel time of 30 years)

*Mean tide = 0.22 ft NAVD 88
**High tide = 2.31 ft NAVD 88
***Low tide = -1.84 ft NAVD 88
****Inflow and outflow within NEA was calculated using a water balance within the NEA.

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GROUNDWATER MODEL

SCENARIO 2 - SIMULATED GROUNDWATER ELEVATION AND PATHLINES

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FIGURE
17

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