Appendix F.

Brightwater SEPA Supplement Groundwater Evaluation

DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

Brightwater Regional Wastewater Treatment System

Technical Appendices

Brightwater
TREATMENT SYSTEM

King County

Appendix F

Brightwater SEPA Supplement Groundwater Evaluation

April 2005

Prepared for King County by
CH2M Hill

Alternative formats available upon request
by calling 206-684-1280 or 711 (TTY)

King County
Department of Natural Resources and Parks
Wastewater Treatment Division
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201 South Jackson Street
Seattle, WA 98104

Appendix F
Brightwater SEPA Supplement Groundwater Evaluation

F.1 Introduction

This memorandum presents the results from the groundwater flow and quality modeling work conducted to evaluate the potential groundwater impacts from three seismic event scenarios at the Brightwater facility. The scenarios, all based on the Phase 2 facility capacity of 54 MGD, are summarized below:

- **Scenario A:** 0.1 to 0.3 MG spill, representing 10 to 20 percent leakage, from broken pipes throughout the facility caused by strong ground shaking associated with the design level earthquake. The design level earthquake is based on a site-specific probabilistic seismic hazard analyses conducted in accordance with requirements of the 2003 International Building Code (IBC 2003), as discussed elsewhere in this SEPA document. Leaks from the influent and effluent pipelines near the facility side of the influent/effluent tunnel entrance bulkhead (0.6 MG, representing a worst case 100 percent leakage from the affected piping) were selected to represent this scenario because the tunnel entrance could be the closest contaminant source to Little Bear Creek.
- **Scenario B:** 0.44 MG spill from the influent/effluent lines caused by displacement along Lineament X at the tunnel location and, in addition, leakage from broken pipes throughout the facility caused by strong ground shaking (Scenario A).
- **Scenario C:** 9.4 MG spill from the aeration basins caused by displacement along an unknown fault assumed to run directly beneath the basins. In addition, leakage from broken pipes throughout the facility caused by strong ground shaking (Scenario A).

The remainder of this memorandum is organized as follows:

- Section 2 presents a summary of results by scenario for both the groundwater flow and groundwater quality modeling evaluations.
- Section 3 presents the details of the groundwater flow modeling evaluation that estimated the minimum time for contaminants to migrate from the assumed spill area through the subsurface and discharge into Little Bear Creek.
- Section 4 presents the details of the groundwater quality modeling evaluation that estimated the time for the initial and peak contaminant concentrations to arrive at Little Bear Creek.
- Section 5 presents references.

F.2 Summary of Results

F.2.1 Groundwater Scenario A

For groundwater Scenario A, with a facility capacity of 54 MGD, it is assumed that pipes would break between process units but that process tanks would not leak. The tanks are not expected to leak under this Scenario because structural design requirements for crack control under non-seismic loading exceed the levels of seismic induced loading; therefore, the only source of a wastewater spill is from the piping that connects the various process facilities.

The total volume of wastewater in all the connecting piping is 1.6 MG. A reasonable worst-case assumption based on observations from post-earthquake reconnaissance after past large seismic events would be that 10 to 20 percent of the wastewater would leak out, representing 0.1 to 0.3 MG.

Because the groundwater conditions will not likely change significantly between wet and dry periods, only one evaluation is presented below.

Figure F-1 shows the major piping between the proposed process units at Brightwater. Table F-1 summarizes the volumes of wastewater in the pipes. The assumed locations of the leaks and the maximum release volumes (assuming 100 percent failure in contrast to the more likely 10 to 20 percent) are as follows:

- The influent pipes (labeled 1 in Figure F-1) and effluent/reuse pipes (labeled 7 and 8) are assumed to break at the facility side of the influent/effluent tunnel entrance bulkhead located in the southeastern portion of the site, allowing about 0.6 MG of wastewater to enter the groundwater system at this location.
- The pipes between the primary effluent screen and aeration basin (2) are assumed to break at multiple locations, allowing about 0.3 MG of wastewater to enter the groundwater system in this area.
- The return activated sludge (RAS) pipes between the membrane and aeration basins (3) are assumed to break at multiple locations, allowing about 0.4 MG of wastewater to enter the groundwater system in this area.
- The mixed liquor (ML) pipe between the membrane and aeration basins (4) is assumed to break at multiple locations, allowing about 0.1 MG of wastewater to enter the groundwater system in this area.
- The membrane effluent pipes between the membrane basin and the membrane effluent box in the reclaimed water building (5 and 6) are assumed to break at multiple locations, allowing about 0.2 MG of wastewater to enter the groundwater system in this area.

Table F-1 Scenario A—Maximum Volume of Wastewater Spill if All Connection Pipes Break (Phase II 54 MGD)

	Connection Pipes	MG
1	Influent Pipes (66" INF & 48" INF) between Tunnel Bulkhead and Headworks	
	Maximum Total Vol. of Spill (MG)	0.2
2	48" PE pipes between Primary Effluent Screen and Aeration Basin	
	Maximum Total Vol. of Spill (MG)	0.3
3	RAS Pipes between Membrane Basin and Aeration Basin	
	Maximum Total Vol. of Spill (MG)	0.4
4	ML Pipe between Membrane Basin and Aeration Basin	
	Maximum Total Vol. of Spill (MG)	0.1
5	Membrane Effluent between Membrane Basin and Effluent Box in Reclaimed Water Bldg	
	Maximum Total Vol. of Spill (MG)	0.1
6	Membrane Effluent Pipes between Membrane Effluent Box and Effluent Collection Box	
	Maximum Total Vol. of Spill (MG)	0.1
7	78" PE between Membrane Effluent Collection Box and Tunnel Bulkhead	
	Maximum Total Vol. of Spill (MG)	0.3
8	27” Reuse Water Pipe between Membrane Effluent Box and Tunnel Bulkhead	
	Maximum Total Vol. of Spill (MG)	0.1
	When All Connection Pipes Break at the Same Time	
	Maximum **Total Vol. of Spill (MG)**	**1.6**

F.2.1.1 Groundwater Flow Model Results

The first part of the groundwater impact analysis of Scenario A involved an evaluation of the time that it would take for a spill from a pipe break to reach Little Bear Creek. Each area listed in Table F-1 was considered an independent source of infiltration. A leak at the facility side of the influent/effluent tunnel entrance bulkhead was selected to represent the worst case for Scenario A because the tunnel bulkhead would be the closest spill location to Little Bear Creek and therefore wastewater contaminants would reach the creek in the shortest time period. Computations were then performed to determine the minimum time that it would take for the wastewater to migrate through the underlying soil and seep into the creek. At the tunnel bulkhead, the volume of wastewater entering the groundwater was assumed to be 0.6 MG, representing the worst case, 100 percent loss from connection pipes 1, 7 and 8 in Table F-1.

The Groundwater Vistas/Modflow/Modpath model was run in particle tracking mode to determine the minimum time it would take for the most mobile of the contaminants in the spilled wastewater to travel from the influent/effluent tunnel bulkhead to Little Bear Creek. The model predicted time is about 4 years for the wastewater to travel to the creek. As noted above, at other locations the predicted time to reach Little Bear Creek is greater because of the greater distance from the location of the spill to the creek.

These results indicate that although the groundwater beneath the facility would be affected by the wastewater leakage from all the potential pipe leaks, based on the closest leak to the creek, there would be several years to remediate contaminated groundwater before it could reach the creek. These remediation activities could be conducted at locations where the leaks are observed during post-earthquake inspections of the piping systems. Moreover, because of the very low slow seepage of the wastewater into the relatively impermeable soil, there would be a wide window of time to pump the wastewater from the influent/effluent tunnel bulkhead area or any of the other potentially affected structures, minimizing impacts and future remediation time and costs.

F.2.1.2 Water Quality Model Results

The second part of the groundwater analysis of Scenario A evaluated the concentration of contaminants reaching Little Bear Creek in the event that a spill were to occur and no remediation of the migrating wastewater were performed. EPA's BioScreen model was used for this evaluation. As a reasonable worst case only dispersion attenuation of the contamination was assumed – adsorption or biological and chemical attenuation processes were not considered. Nitrate was selected as a representative wastewater contaminant. It is considered a reasonable worst-case constituent because it would only be naturally attenuated by dispersion. The BioScreen results show that nitrate would first reach Little Bear Creek in less than 5 years (consistent with the flow model results) but that the peak concentration entering Little Bear Creek would be about 11 mg/L at about 15 years, or less than 50 percent of its theoretical initial concentration. Thus, dispersion alone would significantly reduce the concentrations of contaminants that could possibly reach Little Bear Creek if unremediated.

Other contaminants that are affected by adsorption or biological and chemical changes would be attenuated to a greater extent. That is, their concentration reductions and years to peak concentrations would both be greater than for nitrate.

F.2.2 Groundwater Scenario B

For the groundwater Scenario B, with a facility capacity of 54 MGD, it is assumed that the tunnel and influent and effluent pipes within the tunnel would completely fail at Lineament X and that 0.44 MG of wastewater (0.2 MG of influent, 0.2 MG of effluent, and 0.04 MG of reclaimed water) would leak into the soil and groundwater. In addition, the connecting piping described in Scenario A would also leak.

Impacts to the groundwater and Little Bear Creek would be similar to those described above for Scenario A. As a worst case, Scenario B assumed that the wastewater and reclaimed water would enter the groundwater and flow towards Little Bear Creek.

However, groundwater could instead enter the tunnel and effluent pipe line and slowly flow towards the outfall. This alternative scenario was not considered worst case and was not evaluated further.

F.2.3 Groundwater Scenario C

For the groundwater Scenario C, with a facility capacity of 54 MGD, it is assumed that all the aeration basins would fail completely and that all of the 9.4 MG of liquid in the basins and the primary effluent pipes would immediately come in contact with the soil and groundwater system. In addition the connecting piping described in Scenario A would also leak.

The aeration basins were chosen to fail in this scenario because they represent the largest water holding tanks in the plant. To maximize the amount of wastewater entering the groundwater system, the underdrain system is also assumed to be plugged so no wastewater would diverted to the surface water system. Plugging of the underdrain system would likely results from the high percentage of solids in the aeration basin wastewater. There are also access manholes for the underdrain system that could be grouted closed following a seismic event, if wastewater were observed to be migrating through the underdrain system into Little Bear Creek. This capability offers an effective way of containing wastewater to the basin area, and would be part of the mitigation strategy in the unlikely event that such a failure were to occur.

F.2.3.1 Groundwater Flow Model Results

The groundwater flow model described in Scenario A was run in particle tracking mode to determine the minimum time it would take for any of the contaminants in the wastewater to travel from the aeration basins to Little Bear Creek. The time predicted by the model is about 12 years. As with Scenario A, there would be more than sufficient time to remediate the contaminated groundwater before it reaches the creek and to minimizing impacts, remediation time, and costs by pumping the wastewater out of the aeration basins and into the effluent system for discharge to Puget Sound.

F.2.3.2 Water Quality Model Results

As for Scenario A, EPA's BioScreen model was used to estimate the concentration of contaminants reaching Little Bear Creek in the event that a spill were to occur and no remediation of the migrating wastewater were performed. Nitrate was again selected as a representative wastewater contaminant from the aeration basins. The BioScreen results show that the first traces of nitrate would reach Little Bear Creek in about 15 years (consistent with the flow model results) but that the peak concentration entering Little Bear Creek would be about 25 mg/L in over 30 years, or about 50 percent of its assumed initial concentration. Thus, dispersion alone would significantly reduce the concentrations of contaminants that could possibly reach Little Bear Creek if the groundwater was unremediated.

Other contaminants affected by adsorption or biological and chemical changes would be attenuated naturally to a greater extent. That is, both their concentration reductions and years to peak concentrations would be greater than for nitrate.

F.3 Groundwater Flow Modeling

F.3.1 Introduction

Groundwater Vistas version 4.11, a groundwater model that incorporates MODFLOW – versions 88/96 and 2000 (a public source finite-difference model) and MODPATH (a public source particle tracking package for MODFLOW), was used to evaluate the potential impacts to groundwater. The model was used to predict groundwater flow patterns and velocities downgradient of the leaks associated with Scenarios A and C to estimate the minimum time it would take for contamination to migrate through the subsurface to Little Bear Creek. A separate evaluation of Scenario B was not conducted because the spill location and thus potential impacts are similar to Scenario A.

Each scenario included both steady state and transient simulations for the evaluation. The steady state simulations were carried out to calibrate model parameters so that the conceptual site model would more closely represent natural site conditions. The same models were then run under transient conditions to determine and evaluate the potential impacts to groundwater for each Scenario.

The hydrogeologic setting and, analytical approach, model input, and assumptions are discussed below.

F.3.2 Hydrogeologic Setting

The site is located in southern Snohomish County, WA, between State Routes 9 and 522 (Figure F-1). Local topography between State Routes 522 and 9 slopes from east to west. Groundwater flow at the site is from east to west, and Little Bear Creek is the local groundwater discharge area. Therefore, any contaminants entering the groundwater system would flow with the groundwater and ultimately discharge into Little Bear Creek. Because there are no groundwater users (i.e., regional or local water supply wells) between the facility and Little Bear Creek, the creek is the sole groundwater receptor.

There are three dominant geologic units at the site. These units are Vashon glacial recessional outwash (Qvrf); a combination of Vashon glacial diamicton (Qvd), Vashon till (Qvt), and Vashon lacustrine sediments (Qvlc), and the pre-glacial fluvial sediments comprising the Cross Valley Aquifer (Qpgf). Figure F-2 shows a plan view of the surficial geology, and Figure F-3 shows a schematic east-west geologic cross section through the site. Note: See Chapter 6 and Appendix 8 of the FEIS for a more complete discussion of the of the site geology and hydrogeology.

The subsurface conditions at the site are presented in a series of cross sections. Figure F-4 shows the locations of site specific cross sections. The facility structures cross sections are shown Figures F-5 and F-6. Geologic cross-sections from the Final Design Geotechnical Recommendations Report approximately aligned with the structures cross sections are shown in Figures F-7 through F-9.

F.3.3 Analytical Approach

The Groundwater Vistas (MODFLOW/MODPATH) model was constructed using geologic and hydrogeologic data derived from site subsurface investigations. A steady state simulation was performed to calibrate the model against existing site data. With boundary conditions held constant through time, model parameters of hydraulic conductivity (K), recharge (R), and evapotranspiration (ET) were calibrated such that the model-generated groundwater surface elevation matched existing field data. Three monitoring well locations where groundwater elevations have been documented over time were chosen as targets to carry out the model calibration (monitoring well FB-5, FB-7 and FB-16).

After running the steady state model, the difference between site-derived data and model-derived data at each location was evaluated using a simple statistical package. Once the residual values at each target location were less than 5 feet, the model was considered adequately calibrated and transient simulations were carried out.

A lake, with an initial head or stage equal to ground surface and having negligible lakebed thickness and sufficiently high hydraulic conductivity so as to not impede groundwater flow through the model layers, was used to simulate the leaks following a structural failure that would instantaneously introduce the entire volume of wastewater into the subsurface.

F.3.4 Assumptions and Input Data

General assumptions include:

- Groundwater inputs are instantaneous (a worst case assumption)
- Excepting the top layer, which has been constructed to closely represent the surface variations of the site, layers are of constant thickness
- Upgradient elevation is 310 feet, held constant from north-to-south (based on site water level data)

- Downgradient elevation is sloped from 250 feet at the north end of the site to 240 feet at the south end of the site (based on Little Bear Creek elevation data)
- The upgradient and downgradient boundaries serve as constant head boundaries (CHB's), where the upgradient CHB represents a constant groundwater elevation of 308 feet, and the downgradient CHB represents a groundwater elevation sloping from 239 feet at the North to 229 feet at the South

Model specific assumptions and input data are summarized in Table F-2.

F.3.5 Results

The estimated times for groundwater to travel from the leak source to Little Bear Creek are:

- Scenario A = about 4 years
- Scenario B not evaluated (similar to Scenario A)
- Scenario C = about 12 years

The modeling results are shown graphically through a series of model output screen shots. Figures F-10 through. F-13. summarize Scenario A, and F-14 though F-21 summarize Scenario C.

F.4 Groundwater Quality Modeling

F.4.1 Introduction

The EPA's BioScreen 1.4 model was used to evaluate the groundwater quality beneath the facility and the quality of the groundwater ultimately discharging into Little Bear Creek from spills of wastewater associated with Scenarios A and C (Scenario B impacts would be similar to A). The model was used to determine the changes over time in contaminant concentrations downgradient from leaks associated with each of the scenarios.

F.4.2 Modeling Parameters

The BioScreen 1.4 model has seven input fields (see Figure F-22—Scenario A Input Data). The seven input fields listed below control the model results (travel time and concentration from the source area):

1. Seepage velocity (groundwater flow velocity)
2. Dispersion (horizontal, vertical, and longitudinal plume expansion)

3. Adsorption (contaminant affinity to adhere to soil particles)
4. Biodegradation (contaminant breakdown due to natural attenuation)
5. General (model area dimensions and time elapsed since spill)
6. Source Data (dimensions of saturated source area; contaminant concentration; contaminant half-life)
7. Field Data (soil or groundwater samples that show contaminant concentrations at a distance from the source area)

F.4.2.1 Seepage Velocity

A value of 25.4 feet/year for seepage velocity was used in the BioScreen model to simulate travel time for a contaminant plume at the Brightwater site. This value was calculated using hydraulic conductivity (1.47×10^{-4} cm/sec), hydraulic gradient (5%), and porosity (0.3) values taken from the MODFLOW model of the site. Input values for MODFLOW are based on field data (pumping tests and geotechnical soil testing) from the Brightwater site.

F.4.2.2 Dispersion

A value of 800 feet for plume length (see section F.4.2.5) was used to estimate longitudinal, transverse, and vertical dispersivity. The plume length for Scenario A was set at 400 feet, the approximate distance from the influent/effluent tunnel entrance bulkhead to Little Bear Creek. Plume length, in the Brightwater Scenario C, is the distance from the west side of the aeration basin to Little Bear Creek.

F.4.2.3 Adsorption

The value of 1.0 for retardation was used in the model as a reasonable worst case. A retardation value of 1.0 means that contaminant migration is unaffected by adsorption processes in the subsurface.

F.4.2.4 Biodegradation

For this evaluation, a negligible biodegradation rate was assumed as a reasonable worst case (contaminant half-life of 500 years).

F.4.2.5 General

The Scenario A modeled area length is 400 feet long and 100 feet wide based on the influent/effluent tunnel footprint and distance to Little Bear Creek (Figure F-22). To assess the contaminant plume migrations, multiple simulation time lengths were modeled: 5 years, 10 years, 15 years, and 20 years.

The Scenario C modeled area length is 800 feet long and 900 feet wide based on the aeration basin footprint and distance to Little Bear Creek (Figure F-23). To assess the contaminant plume migrations, multiple simulation time lengths were modeled: 5 years, 10 years, 20 years, 30 years, 33 years, and 40 years.

F.4.2.6 Source Data

The source thickness of the modeled saturated zone is 50 feet. The width of the source zone is 100 feet (Scenario A) and 250 feet (Scenario C). The average concentration of the contaminants in the wastewater are shown in Table F-3. For Scenario A modeling purposes, a blended concentration of 30 mg/L was used (representing nitrate concentration). The total mass of nitrate in the spilled liquid (=100 kg) was estimated based on the contaminant concentration and total volume of the leak. For Scenario C, a concentration of 52 mg/L was used (representing nitrate concentration). The total mass of nitrate in the spilled liquid (=1,830 kg) was calculated using the contaminant concentration and total volume of the leak.

The source half-life used in the model (a negligible rate) for nitrate was approximated using the total soluble mass in kilograms. Nitrate was selected as a representative wastewater contaminant. It is considered a reasonable worst-case constituent because it would not be attenuated by adsorption or biological and chemical changes and is only affected by dispersion.

Table F-3 Typical Wastewater Chemical Analysis

Major Constituents	Raw Influent (mg/L)	Aeration Basin (mg/L)	Membrane Effluent (mg/L)
Total Suspended Solids	180	8000	2
Volatile Suspended Solids	144	6350	0
Total Kjeldahl Nitrogen (TKN) as N	29.7	32	2
Ammonia as N	16	20	0
Nitrate as N*	0 (46)	0 (52*)	11
Total Phosphorous	6.4	7	5
Alkalinity-CaCO3	200	232	145
Hydrogen Sulfide	6	6	0
Biological Oxygen Demand (BOD)	185	135	1
Chemical Oxygen Demand (COD)	400	312	36

* Assumes all nitrogen species converted to nitrate

F.4.2.7 Field Data for Comparison

The BioScreen model was used in predictive mode (no spill yet), therefore there are no field data available at the Brightwater site.

F.4.3 BioScreen Results

After a spill, essentially all of the suspended solids and much of the Kjeldahl nitrogen, BOD_5, and COD would be filtered out in the first few feet of migration through the soil. It is likely that much of the nitrogen-containing constituents would be oxidized to nitrate before reaching Little Bear Creek, and because of the high clay content of the site soils, much of the phosphorous would likely be removed by anion exchange.

Scenario A model runs show in Figures F-24 through F-27 that a spill at the influent tunnel bulkhead would take about 5 years to first reach Little Bear Creek and that the peak concentration would arrive in about 15 years. However, the peak concentration would be about 11 mg/L or less than 50 percent of the initial assumed blended concentration due to dispersion.

Scenario B was not evaluated, results would be similar to Scenario A.

Scenario C model runs in Figures F-28 through F-33 show the results of a catastrophic failure of the aeration basin. The first trace amounts of contaminant would reach Little Bear Creek in about 15 years. Peak concentrations from the spill would take over 30 years to reach Little Bear Creek, however the concentration would by about 25 mg/L or 50 percent of the initial assumed concentration due to dispersion.

Other contaminants that are affected by adsorption or biological and chemical changes would be attenuated to a greater extent. That is, their concentration reductions and years to peak concentrations would both be greater than for nitrate.

F.5 References

Groundwater Vistas model, version 4.11

BioScreen Model, version 1.4. Users Manual and model available at EPA's website. http://www.epa.gov/ada/csmos/models/bioscrn.html.

CH2M HILL, Draft Report, Brightwater Regional Wastewater Treatment Plant, Final Design Geotechnical Recommendations Report. September 2004. Prepared for King County. (source for Figures F-7 through F-9).

Table F-2
Model Parameters for Seismic Scenarios A and C - Brightwater WWTP, Woodinville, WA

Layers = **9**
K Zones = **3**

K - representative geologic unit	ft/day	cm/sec	Layer(s)	Parameter Assumptions
Zone 1 - Qvd	0.50	0.00018	1-5, 6-8	isotropic
Zone 2 - Qvrf	1.00	0.00035	1-5	isotropic
Zone 3 - Qpgf	5.00	0.00176	9	isotropic

Bulk K = 0.58 0.00020466 **Note:** Average K calculated from two representative particle travel times and their corresponding hydraulic graidents, where particle tracks originated at the downgradient boundary of the aeration basins and terminated at the downgradient constant head boundary.

Porosity = 0.2 throughout all model layers

Layer #	Thickness (ft)	Geologic Unit	Parameter Assumptions
1	variable, but not less than approx. 5 feet	Qvrf, Qvd	heterogeneous (multiple zones of hydraulic conductivity)
2	2.0	Qvrf, Qvd	heterogeneous (multiple zones of hydraulic conductivity)
3	2.0	Qvrf, Qvd	heterogeneous (multiple zones of hydraulic conductivity)
4	2.0	Qvrf, Qvd	heterogeneous (multiple zones of hydraulic conductivity)
5	2.0	Qvrf, Qvd	heterogeneous (multiple zones of hydraulic conductivity)
6	2.0	Qvd	homogeneous, isotropic
7	2.0	Qvd	homogeneous, isotropic
8	40.0	Qvd	homogeneous, isotropic
9	30.0	Qpgf	homogeneous, isotropic

Recharge Rate =	0.002	ft/day	
Evapotranspiration Rate =	0.002	ft/day	w/ extinction depth of 5 feet

Stress Period (SP) Length =	365	days
No. of SP (steady state) =	1	
No. of SP (transient) =	30	
Time Step (TS) Length =	approx. 30	days
No. of TS within SP =	12	

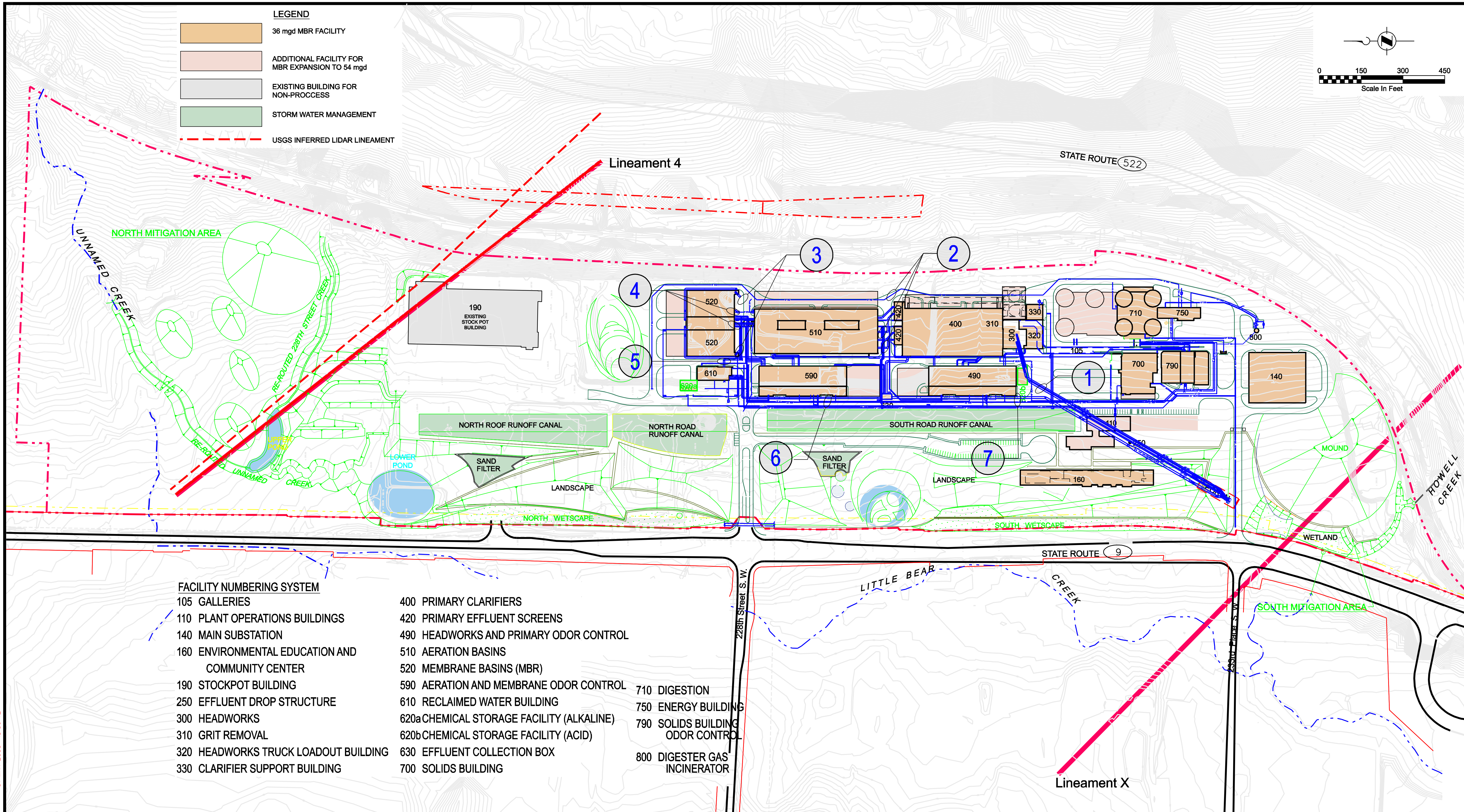

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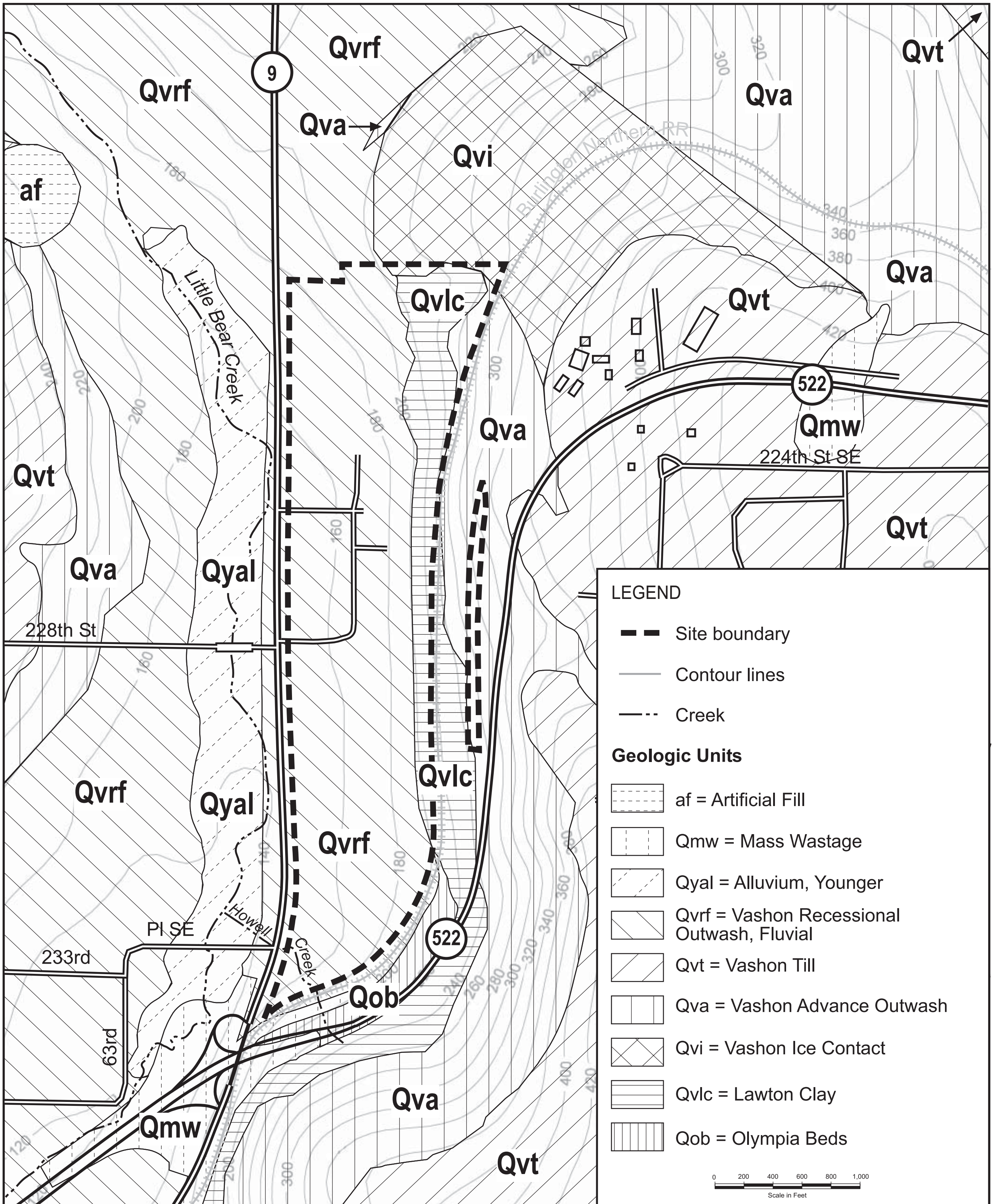
Figure F-1
Brightwater Treatment Plant
Consolidated Plant Layout with Lineament No. 4
SUPPLEMENTAL EIS

SEA NDM/188397



King County
Department of
Natural Resources and Parks
Wastewater Treatment Division

Data Sources: Minard, 1985; Seattle Geologic Mapping Project, 2003
File Name: 176493.03.06_E012005004SEA_Geology and GW TM • Fig F-2 R9 Prelim Surficial Geology B&W • 1/8/05 • lw/gr/lw/gm
Prepared by: CH2M HILL

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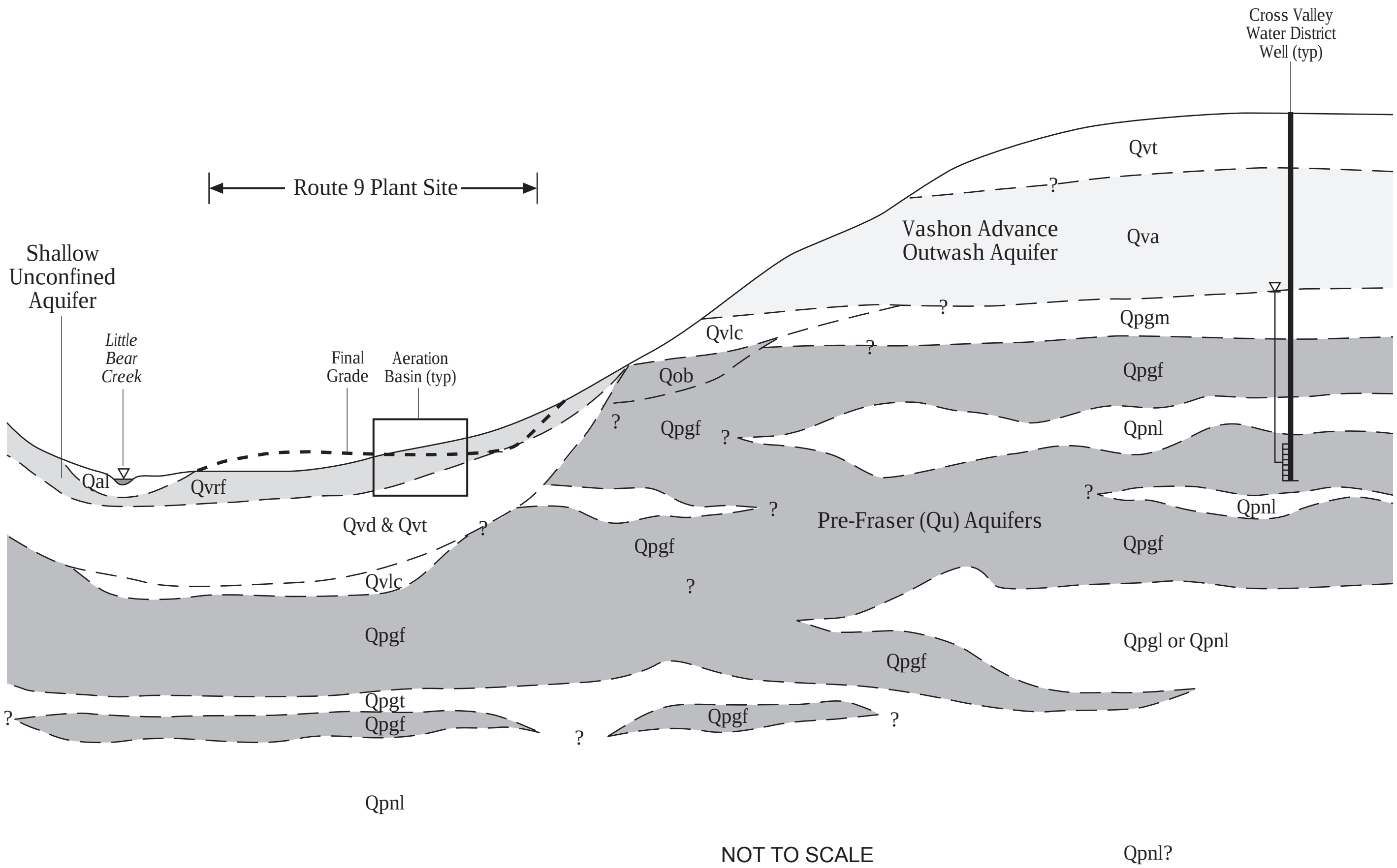
Figure F-2
Preliminary Surficial Geology – Route 9 Site

BRIGHTWATER REGIONAL WASTEWATER TREATMENT SYSTEM



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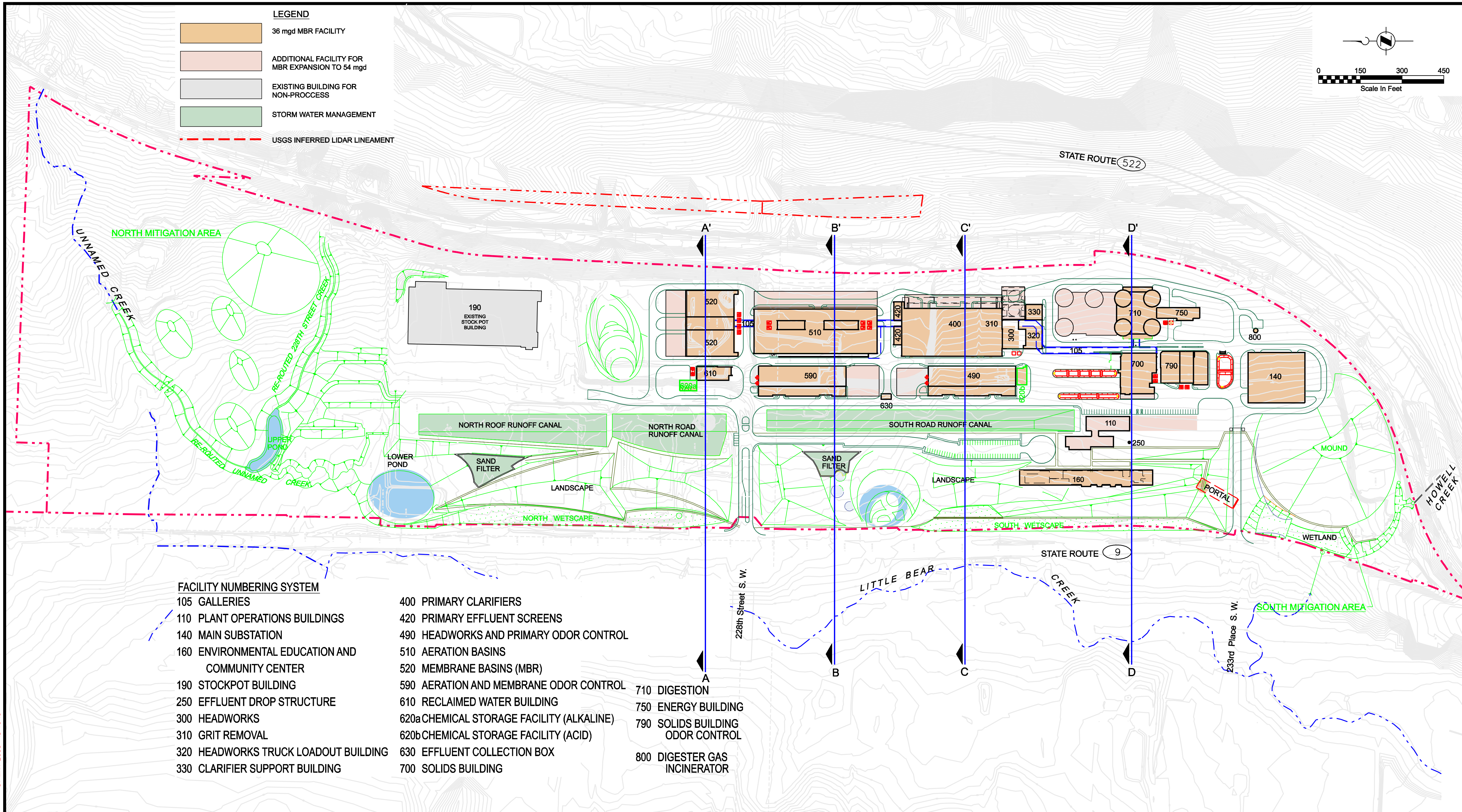
Prepared by: CH2M HILL
File Name: 157689.AP.EP.36.04_E012005004SEA • Fig F-3 Schematic Aquifer and Dewatering Section_Rt9 • 3/9/05 • dk

Figure F-3
Schematic Geologic Section – Route 9 Site

BRIGHTWATER REGIONAL WASTEWATER TREATMENT SYSTEM



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Wastewater Treatment Division

Figure F-4
Brightwater Treatment Plant
Cross Section Locations
SUPPLEMENTAL EIS

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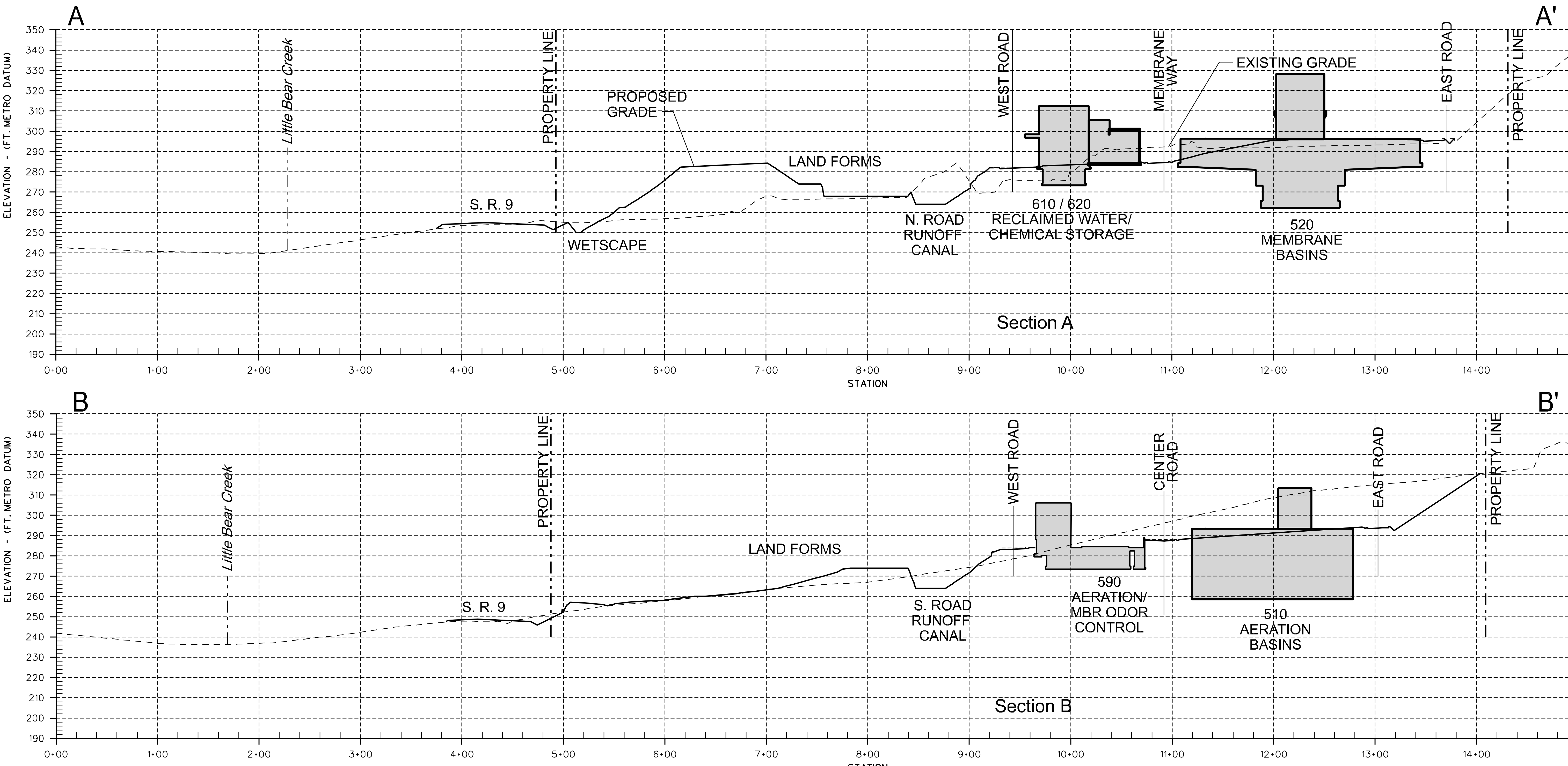

NOTE:
ELEVATIONS ARE IN METRO DATUM.
TO CONVERT TO NAVD 88 FROM METRO DATUM
SUBTRACT 96.28 FEET FROM METRO DATUM

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Division

Figure F-5
Brightwater Treatment Plant
Site Cross Sections A-A' and B-B'
SUPPLEMENTAL EIS

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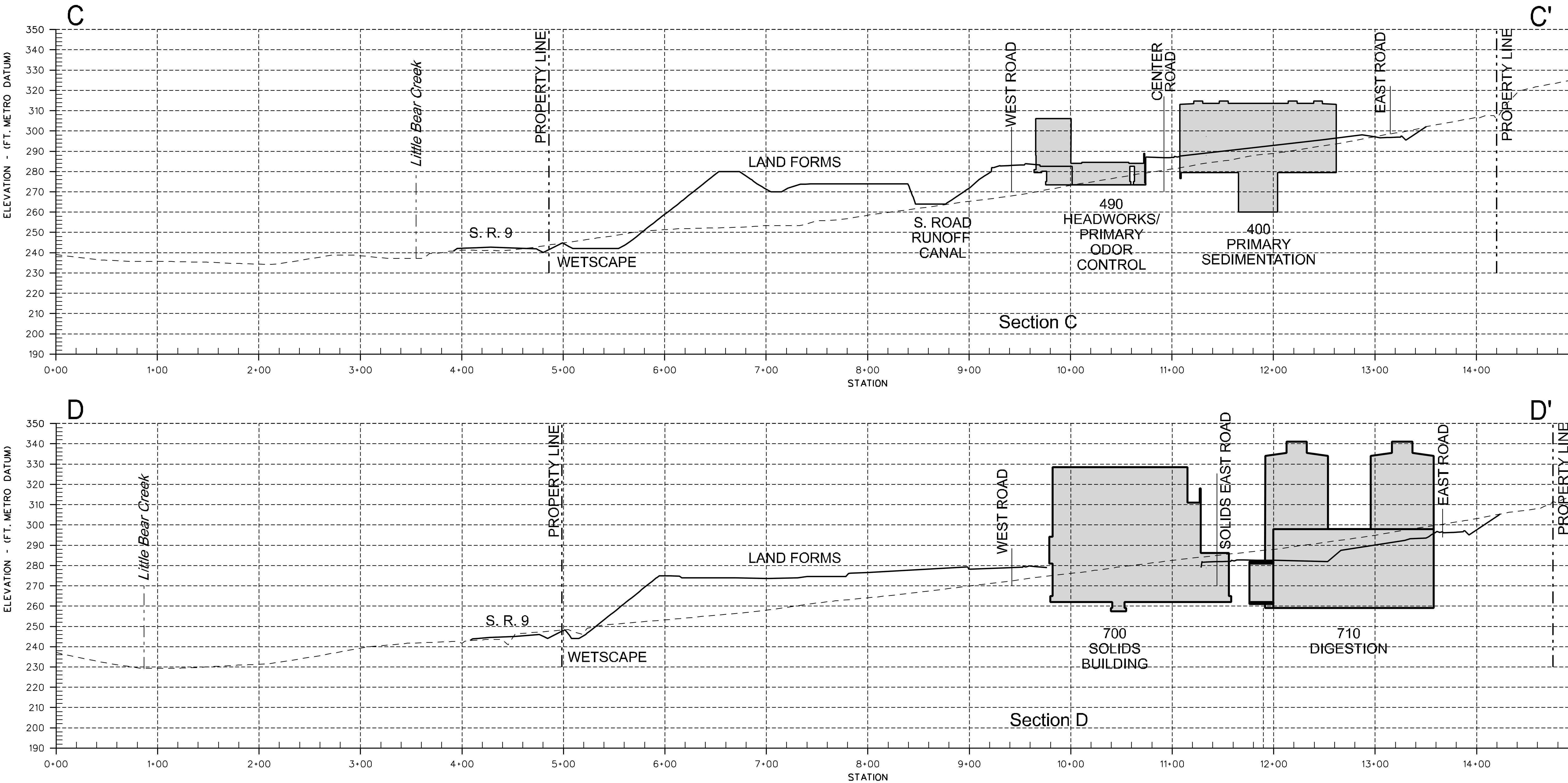

NOTE:
ELEVATIONS ARE IN METRO DATUM.
TO CONVERT TO NAVD 88 FROM METRO DATUM
SUBTRACT 96.28 FEET FROM METRO DATUM

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Figure F-6
Brightwater Treatment Plant
Site Cross Sections C-C' and D-D'
SUPPLEMENTAL EIS

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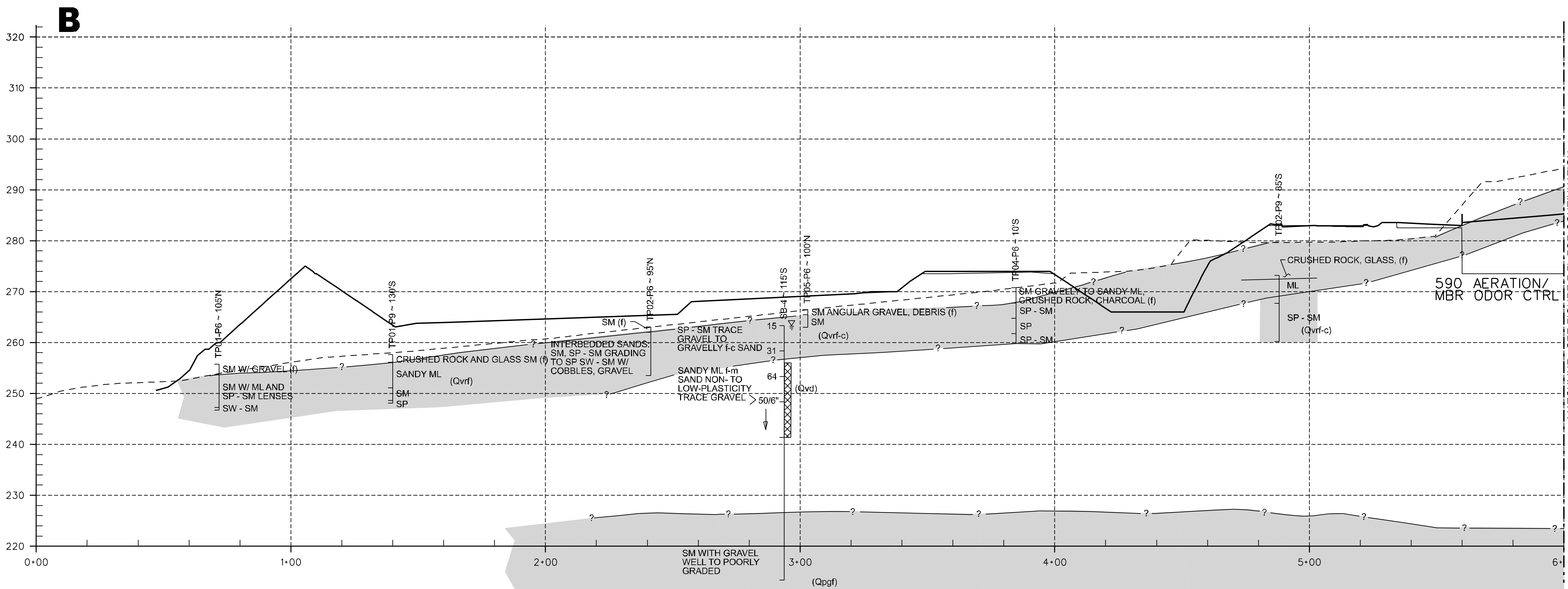

NOTES:

1. TEST PITS AND BORINGS ARE LOCATED IN PLAN FROM SURVEY LATE 2001 AND MAY 2003, WITH METRO DATUM. SITE PLAN IS PRELIMINARY AS OF JULY 2004, AND IS NOT FOR CONSTRUCTION.
2. SEE FIGURE 2-2A FOR LEGENDS AND ABBREVIATIONS.
3. SUBSURFACE INTERPRETATIONS HAVE BEEN MADE BETWEEN BORINGS FOR THE PURPOSE OF DESIGN ONLY. LOCAL SUBSURFACE CONDITIONS WILL VARY. SEE TEXT FOR FULL LIMITATIONS.

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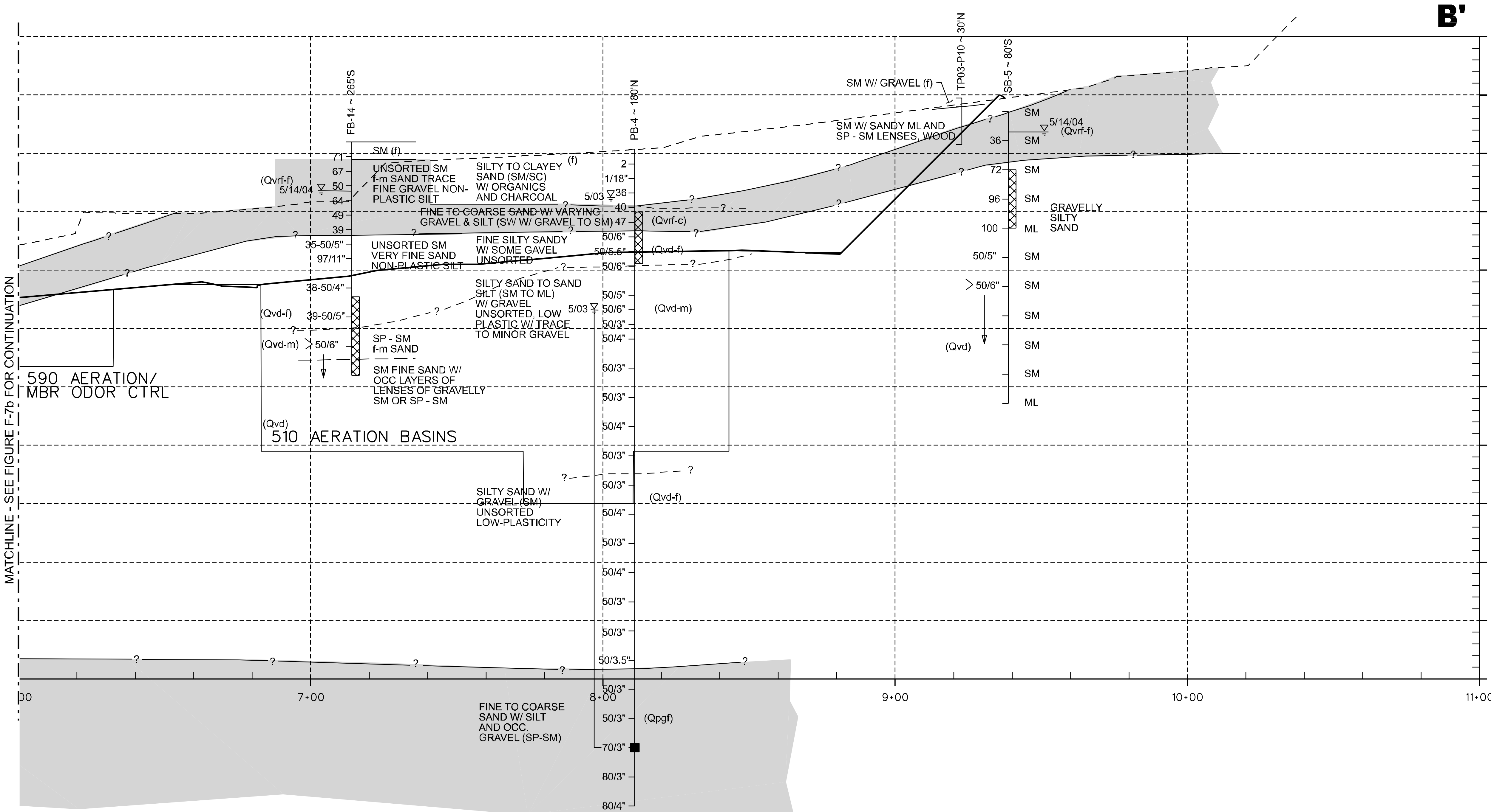
Figure F-7a
Brightwater Treatment Plant
Site Cross Section B-B' (West)
SUPPLEMENTAL EIS



NOTES:

1. TEST PITS AND BORINGS ARE LOCATED IN PLAN FROM SURVEY LATE 2001 AND MAY 2003, WITH METRO DATUM. SITE PLAN IS PRELIMINARY AS OF JULY 2004, AND IS NOT FOR CONSTRUCTION.

2. SEE FIGURE 2-2A FOR LEGENDS AND ABBREVIATIONS.

3. SUBSURFACE INTERPRETATIONS HAVE BEEN MADE BETWEEN BORINGS FOR THE PURPOSE OF DESIGN ONLY. LOCAL SUBSURFACE CONDITIONS WILL VARY. SEE TEXT FOR FULL LIMITATIONS.

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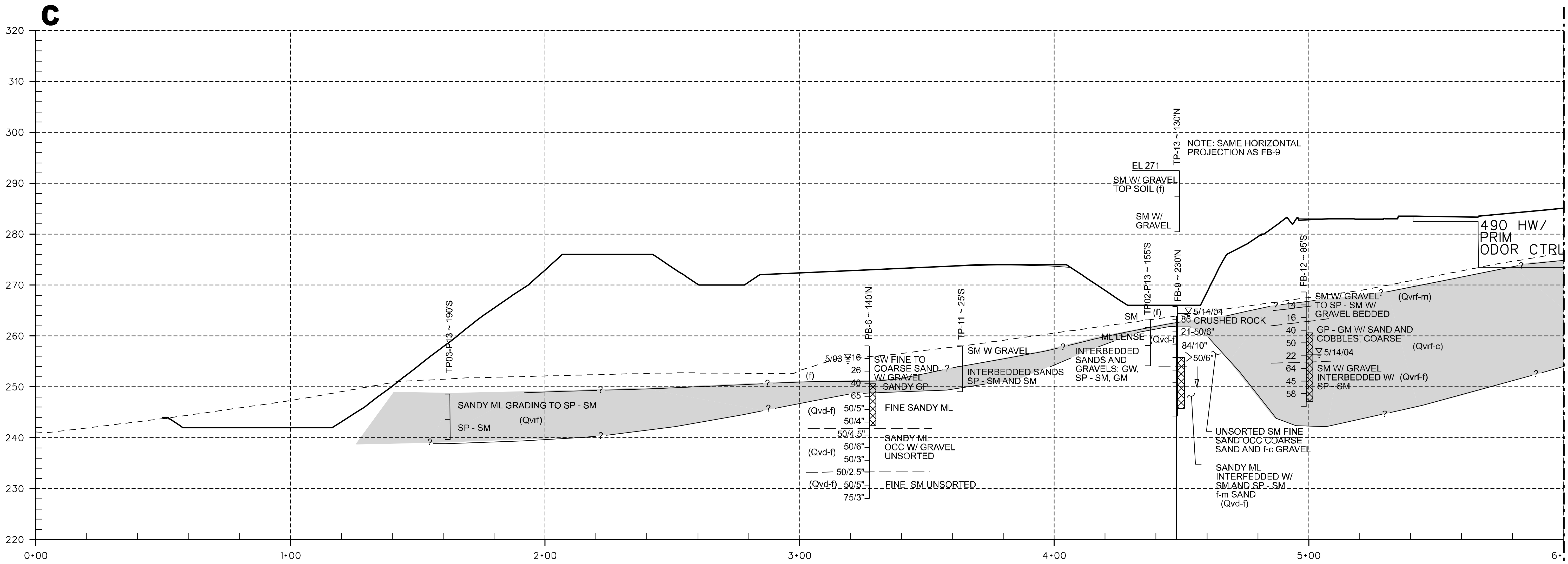
Figure F-7b
Brightwater Treatment Plant
Site Cross Section B-B' (East)
SUPPLEMENTAL EIS

SEA NDM/188397



NOTES:

1. TEST PITS AND BORINGS ARE LOCATED IN PLAN FROM SURVEY LATE 2001 AND MAY 2003, WITH METRO DATUM. SITE PLAN IS PRELIMINARY AS OF JULY 2004, AND IS NOT FOR CONSTRUCTION.
2. SEE FIGURE 2-2A FOR LEGENDS AND ABBREVIATIONS.
3. SUBSURFACE INTERPRETATIONS HAVE BEEN MADE BETWEEN BORINGS FOR THE PURPOSE OF DESIGN ONLY. LOCAL SUBSURFACE CONDITIONS WILL VARY. SEE TEXT FOR FULL LIMITATIONS.

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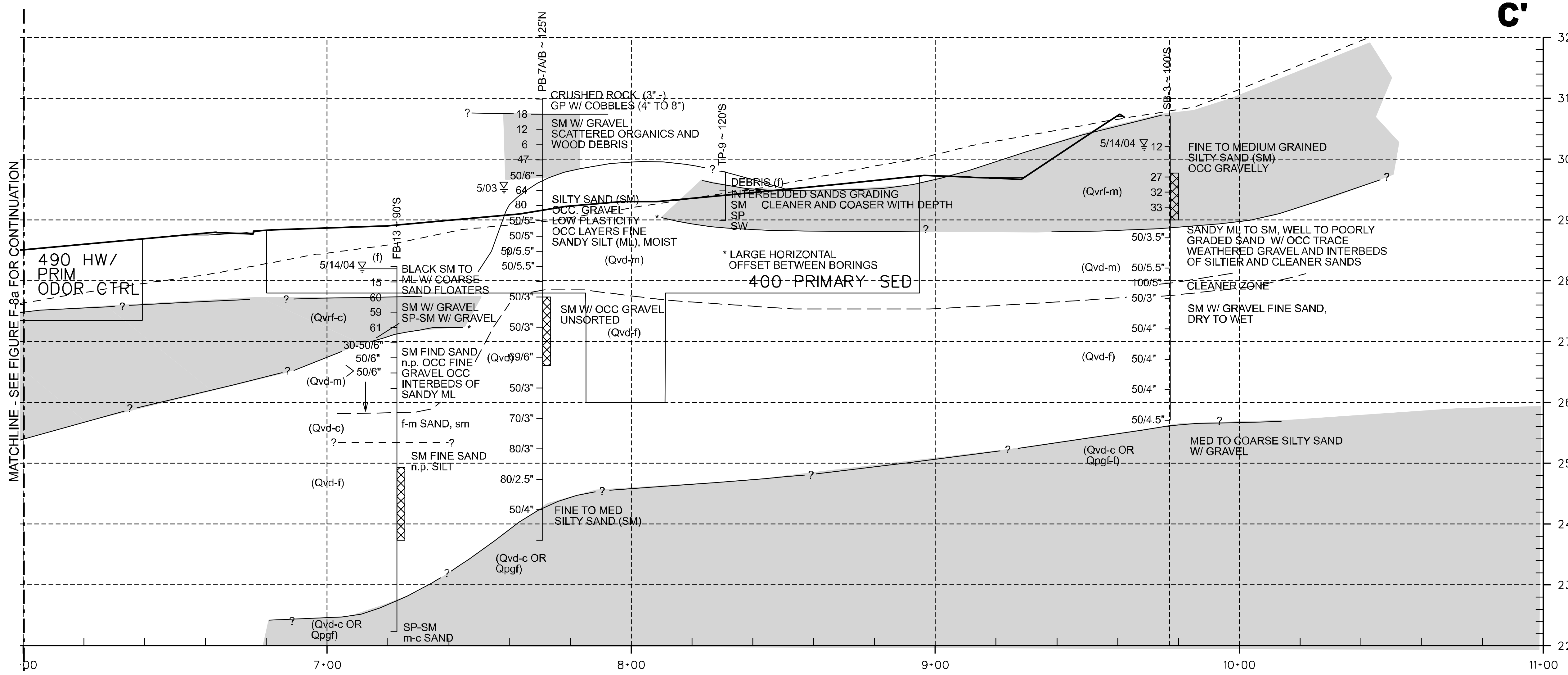
Figure F-8a

Brightwater Treatment Plant
Site Cross Section C-C' (West)
SUPPLEMENTAL EIS



NOTES:

1. TEST PITS AND BORINGS ARE LOCATED IN PLAN FROM SURVEY LATE 2001 AND MAY 2003, WITH METRO DATUM. SITE PLAN IS PRELIMINARY AS OF JULY 2004, AND IS NOT FOR CONSTRUCTION.
2. SEE FIGURE 2-2A FOR LEGENDS AND ABBREVIATIONS.
3. SUBSURFACE INTERPRETATIONS HAVE BEEN MADE BETWEEN BORINGS FOR THE PURPOSE OF DESIGN ONLY. LOCAL SUBSURFACE CONDITIONS WILL VARY. SEE TEXT FOR FULL LIMITATIONS.

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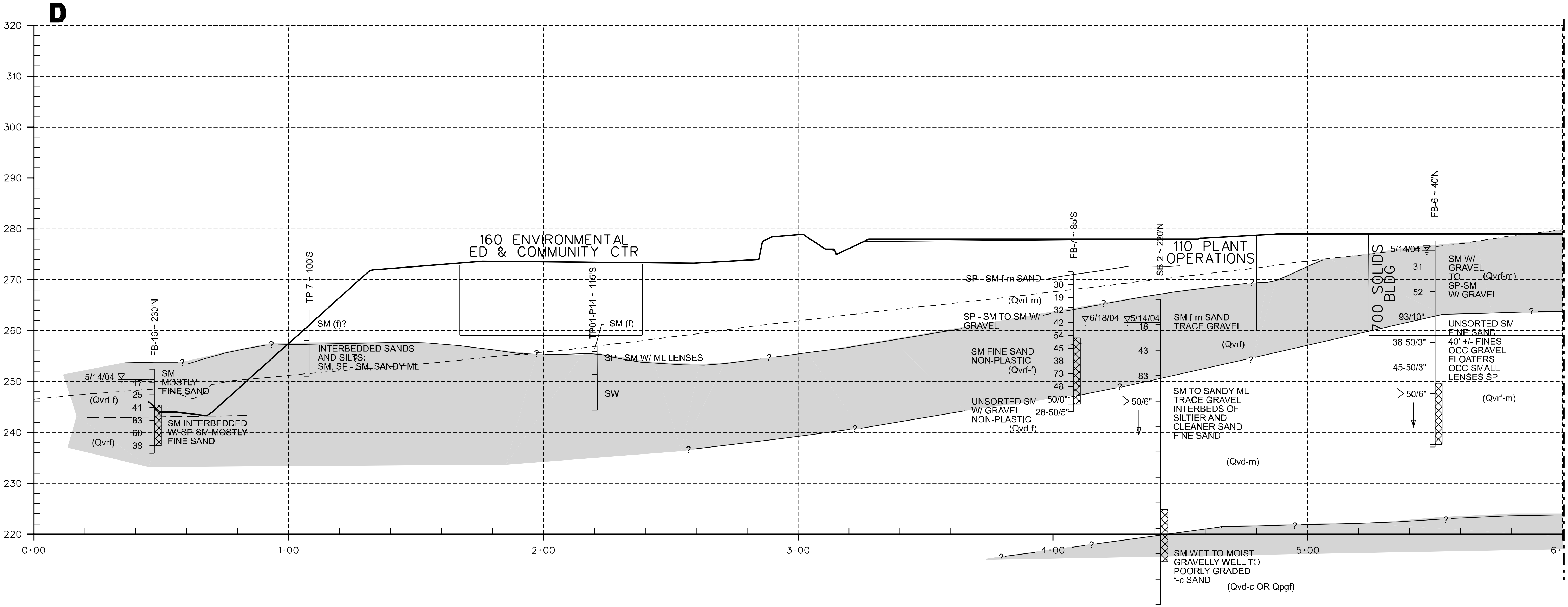
Division

Figure F-8b

Brightwater Treatment Plant
Site Cross Section C-C' (East)
SUPPLEMENTAL EIS



NOTES:

1. TEST PITS AND BORINGS ARE LOCATED IN PLAN FROM SURVEY LATE 2001 AND MAY 2003, WITH METRO DATUM. SITE PLAN IS PRELIMINARY AS OF JULY 2004, AND IS NOT FOR CONSTRUCTION.

2. SEE FIGURE 2-2A FOR LEGENDS AND ABBREVIATIONS.

3. SUBSURFACE INTERPRETATIONS HAVE BEEN MADE BETWEEN BORINGS FOR THE PURPOSE OF DESIGN ONLY. LOCAL SUBSURFACE CONDITIONS WILL VARY. SEE TEXT FOR FULL LIMITATIONS.

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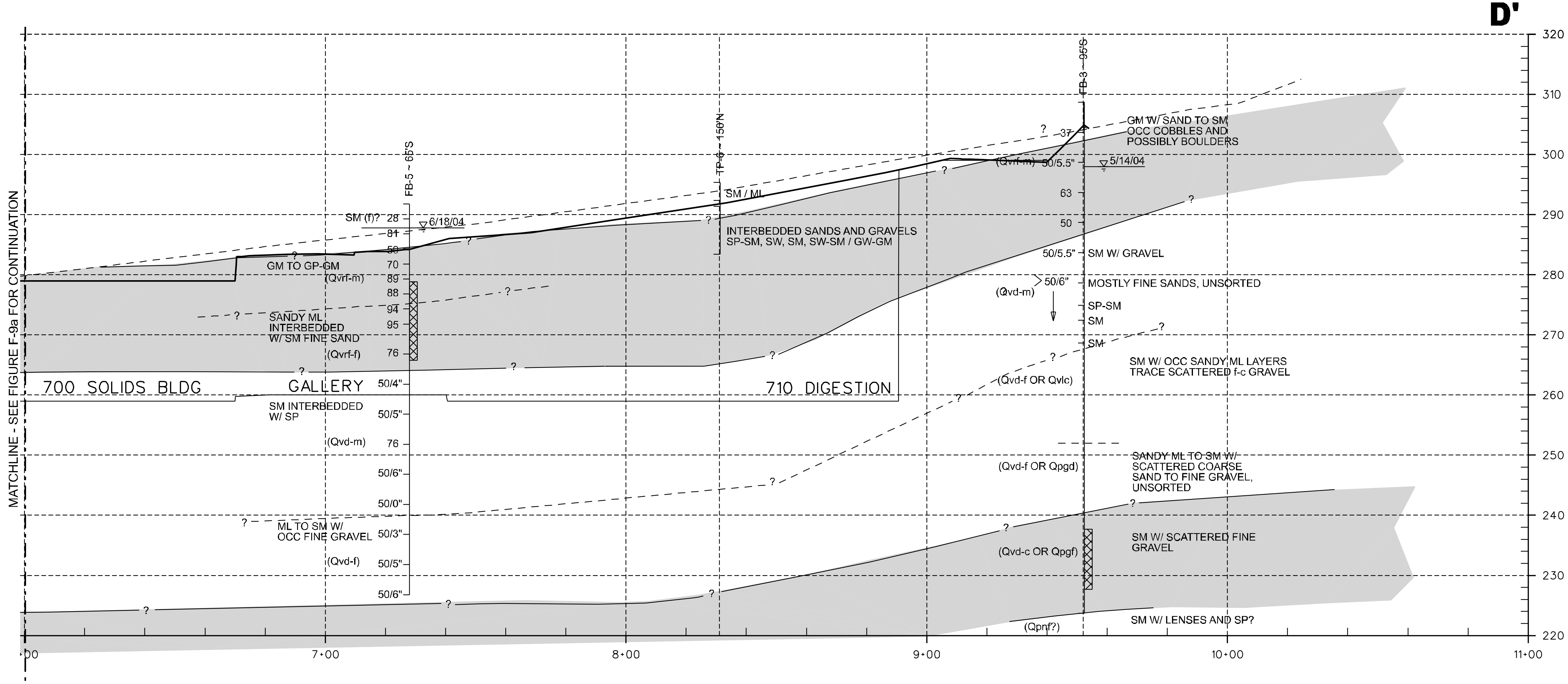
Figure F-9a

Brightwater Treatment Plant
Site Cross Section D-D' (West)

SUPPLEMENTAL EIS

SEA NDM/188397



PROFILE F

NOTES:

1. TEST PITS AND BORINGS ARE LOCATED IN PLAN FROM SURVEY LATE 2001 AND MAY 2003, WITH METRO DATUM. SITE PLAN IS PRELIMINARY AS OF JULY 2004, AND IS NOT FOR CONSTRUCTION.
2. SEE FIGURE 2-2A FOR LEGENDS AND ABBREVIATIONS.
3. SUBSURFACE INTERPRETATIONS HAVE BEEN MADE BETWEEN BORINGS FOR THE PURPOSE OF DESIGN ONLY. LOCAL SUBSURFACE CONDITIONS WILL VARY. SEE TEXT FOR FULL LIMITATIONS.

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Figure F-9b

Brightwater Treatment Plant
Site Cross Section D-D' (East)
SUPPLEMENTAL EIS

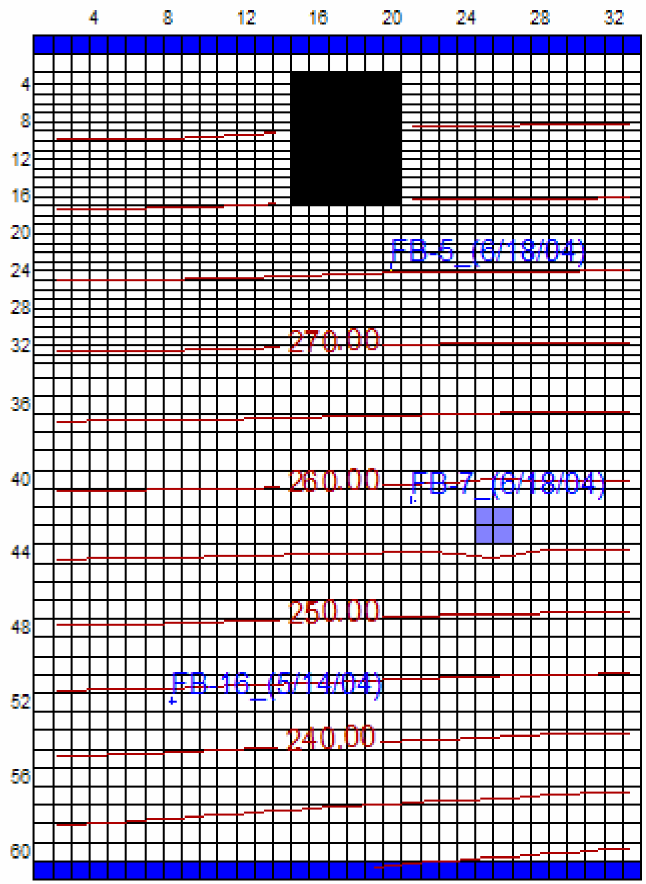


Figure F-10: Scenario A – Plan view of model grid after transient simulation. Blue cells are lake boundary cells, used to define an initial water elevation in the location of the influent/effluent portal, then allowed to equilibrate with surrounding cells over time during the transient simulation. Groundwater elevation contours at t = 10 years.

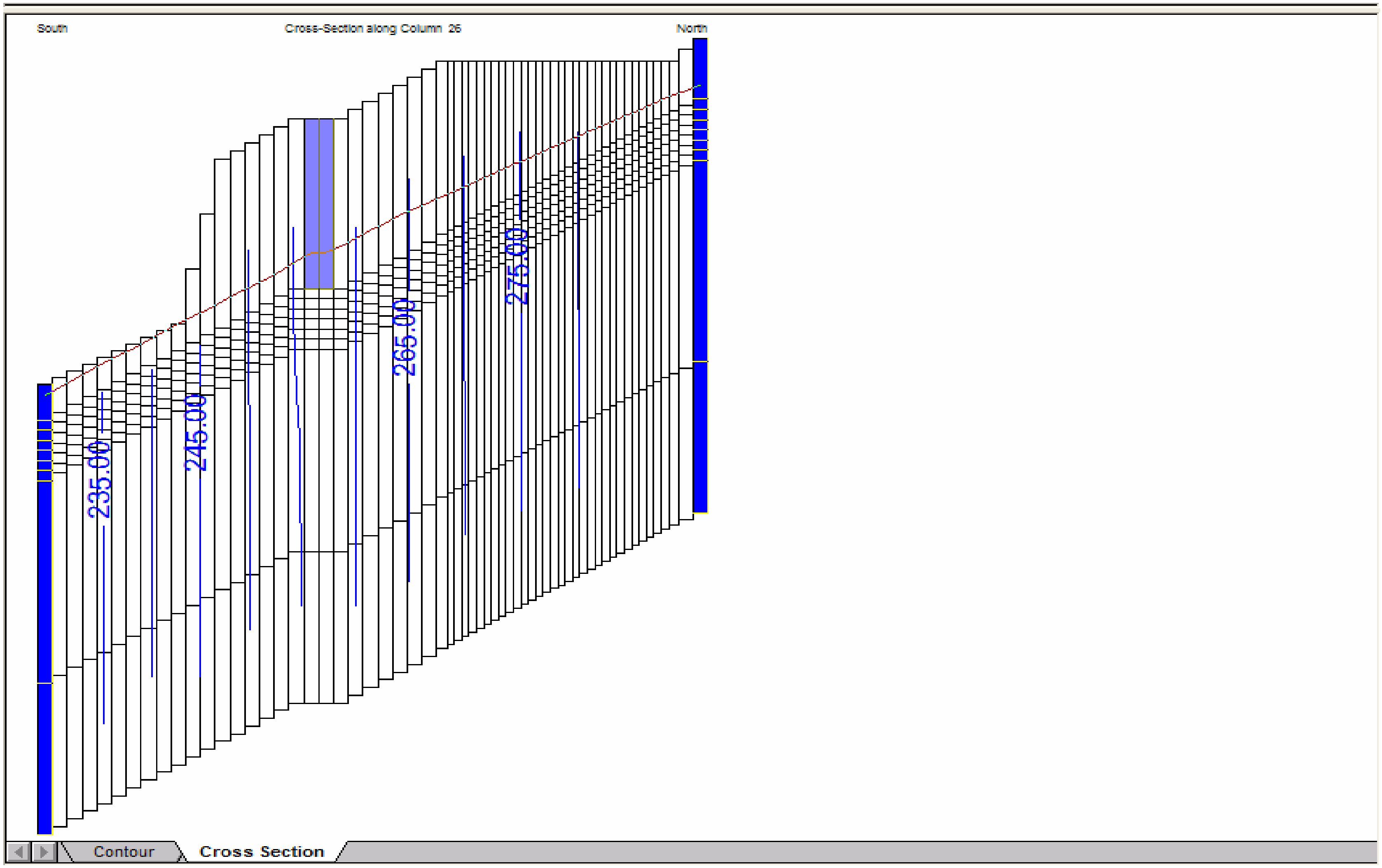


Figure F-11: Scenario A – Cross section of model after transient simulation. Cross section in location of influent/effluent portal (near cross section D-D′ from Figure F-4). Groundwater elevation contours at t = 10 years.

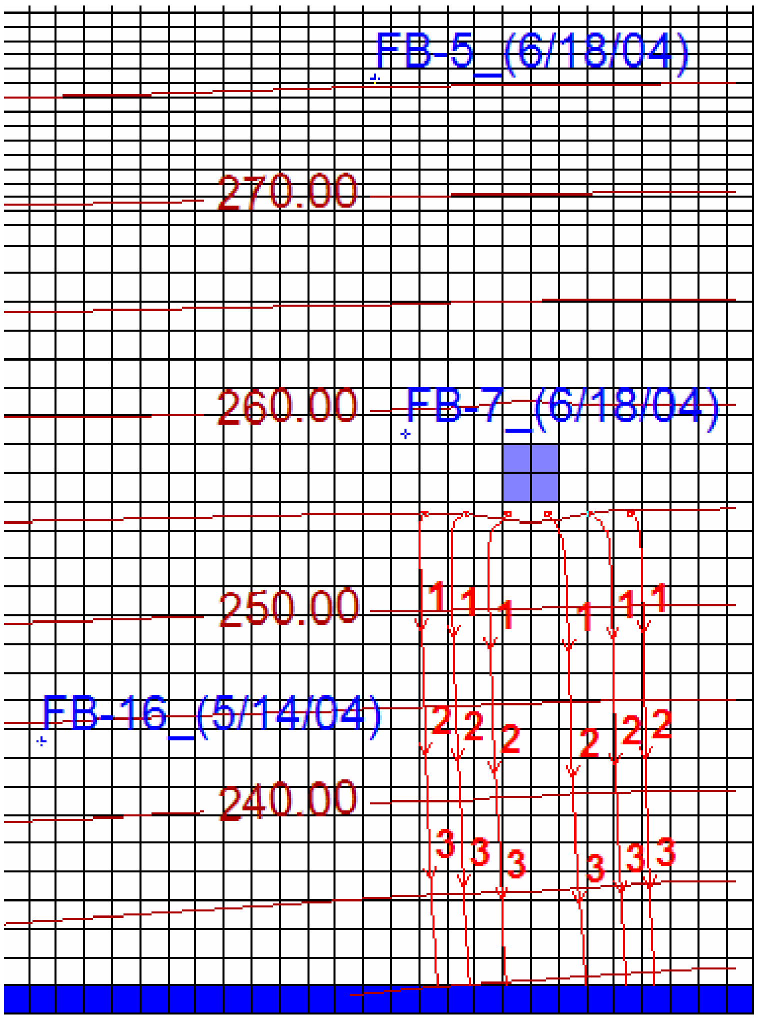


Figure F-12: Scenario A – Plan view of model grid after transient simulation. Particle lines (red lines) generated using MODPATH during 10-year transient simulation (red numbers indicate travel time, in years, of a conservative particle traveling along the line from its origin). Groundwater elevation contours at t = 10 years.

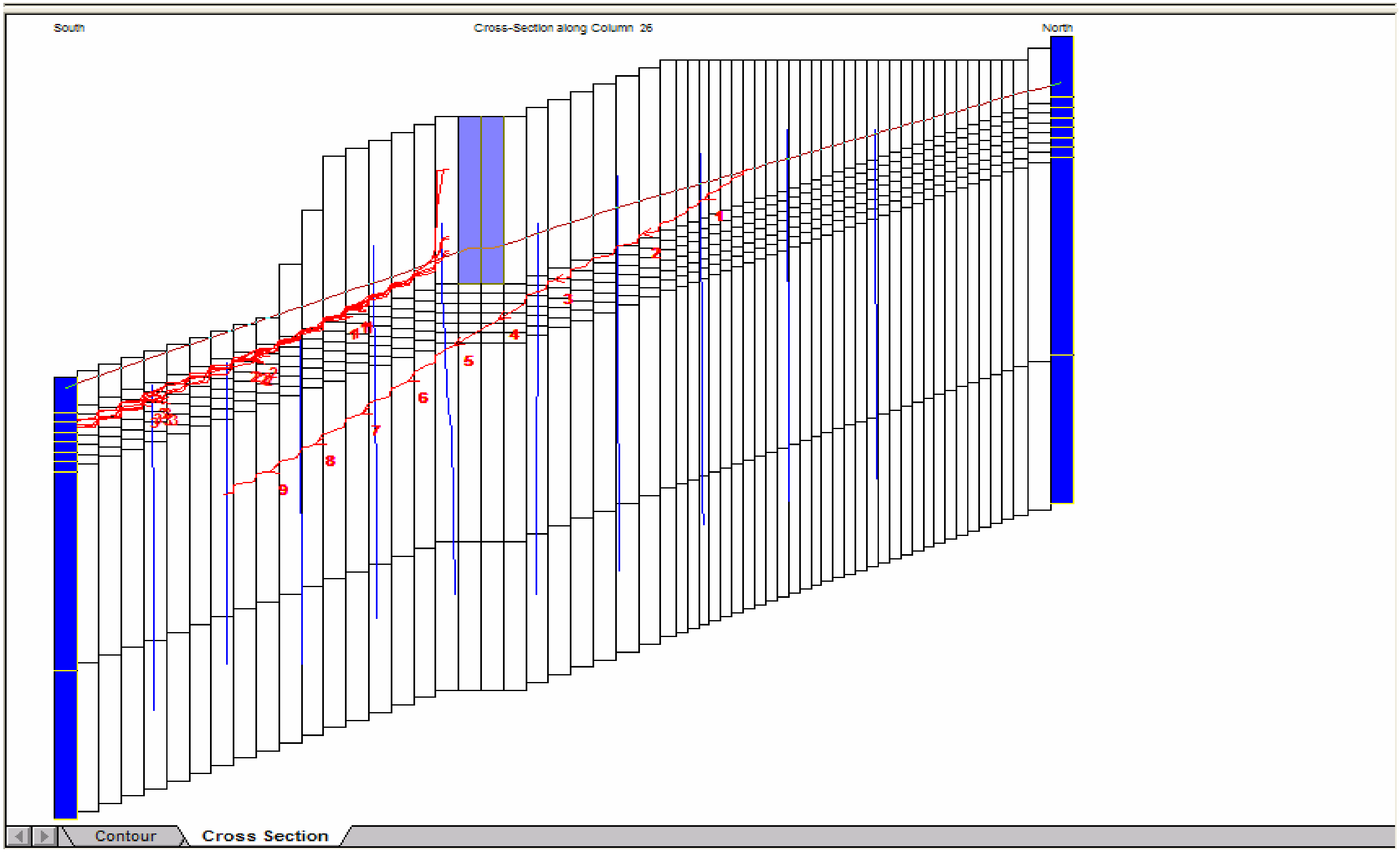


Figure F-13: Scenario A – Cross section of model after transient simulation. Cross section of model in location of influent/effluent portal. Particle lines (red lines) generated using MODPATH during 10-year transient simulation (red numbers indicate travel time, in years, of a conservative particle traveling along the line from its origin). Groundwater elevation contours at t = 10 years. Under the model conditions, the shortest particle travel time is approximately 4 years.

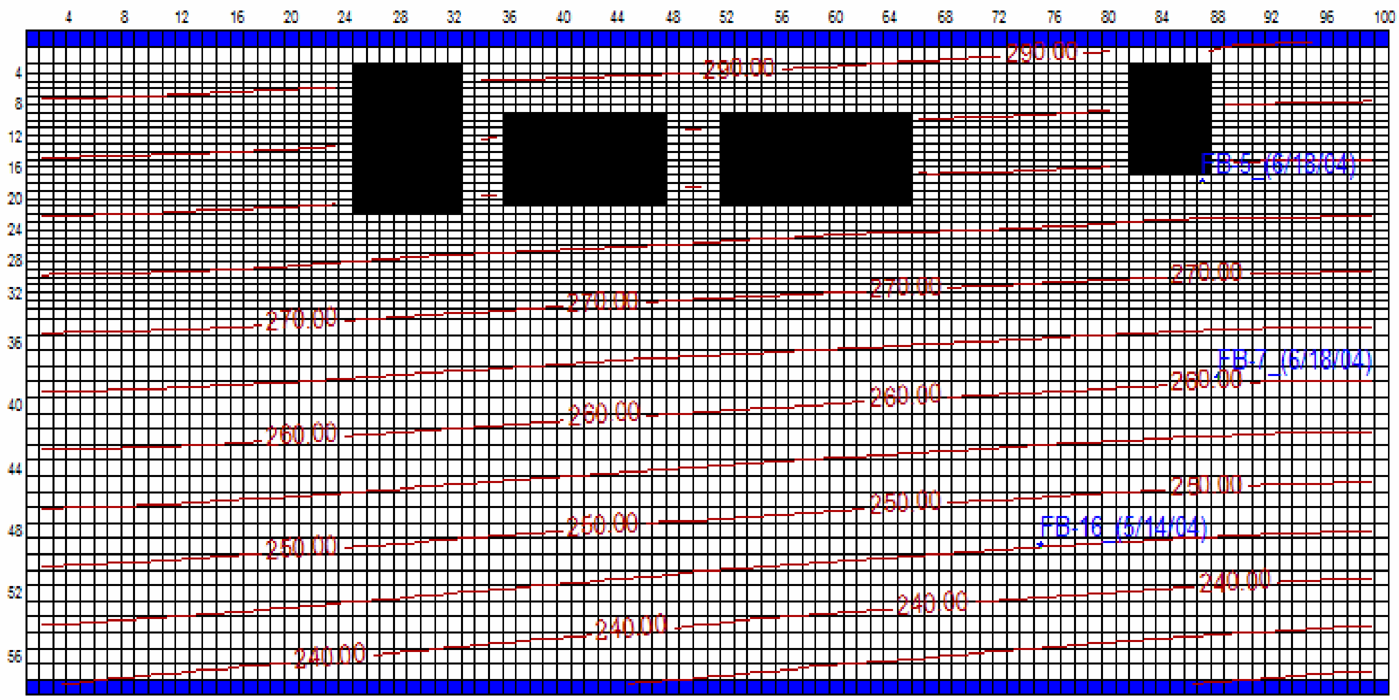


Figure F-14: Scenario C - Plan view of model grid after steady state simulation. Groundwater elevation contours at t = 1 year. Dark cells in rows 1 and 58 are constant head boundary cells representative of upgradient and downgradient constant head boundary conditions. Dark cells within grid are no-flow boundary cells representative of impermeable subsurface structures.

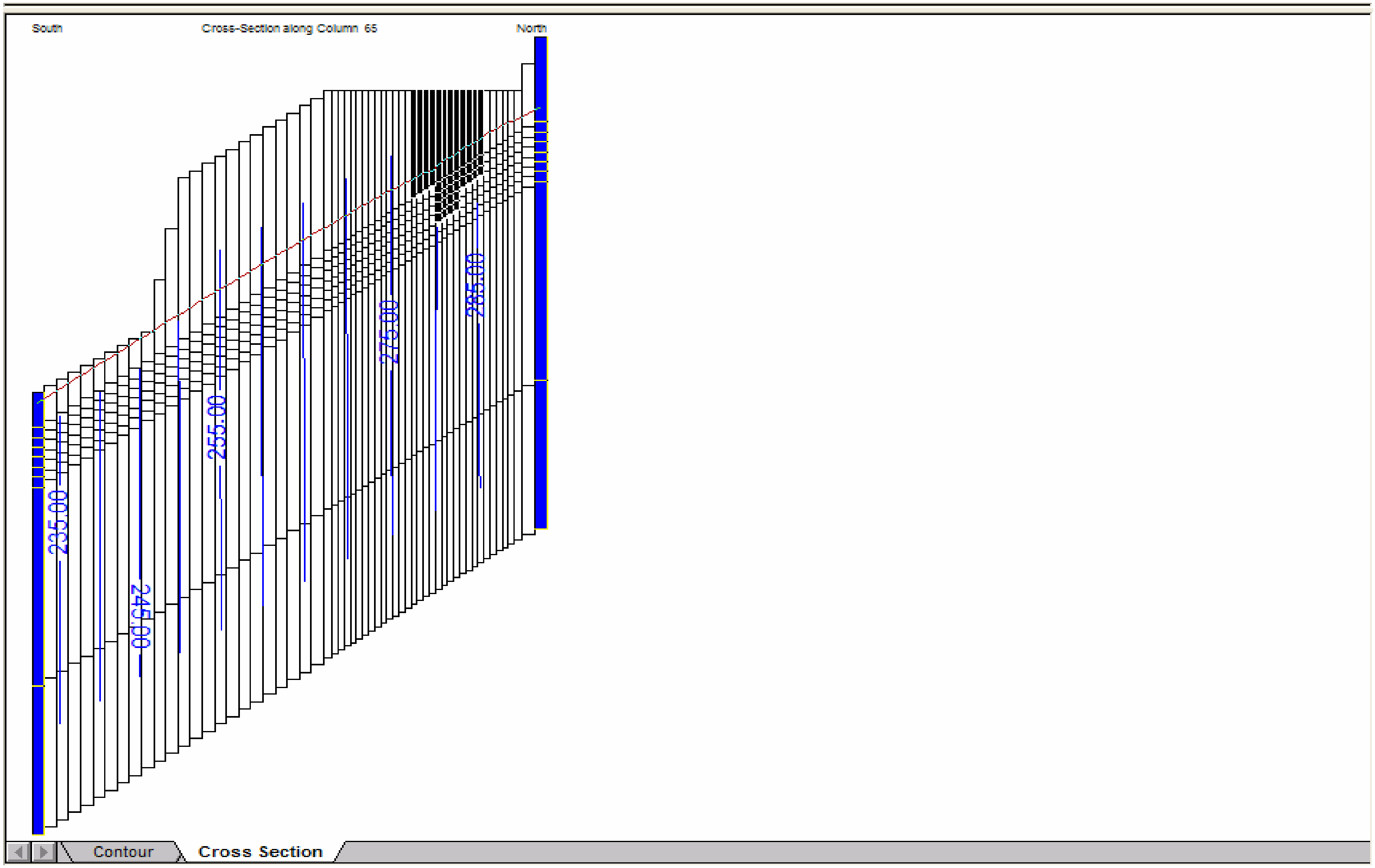


Figure F-15: Scenario C - Cross section of model after steady state simulation. Groundwater elevation contours at t = 1 year. Cross section in location of cross section C-C' from Figure F-4.

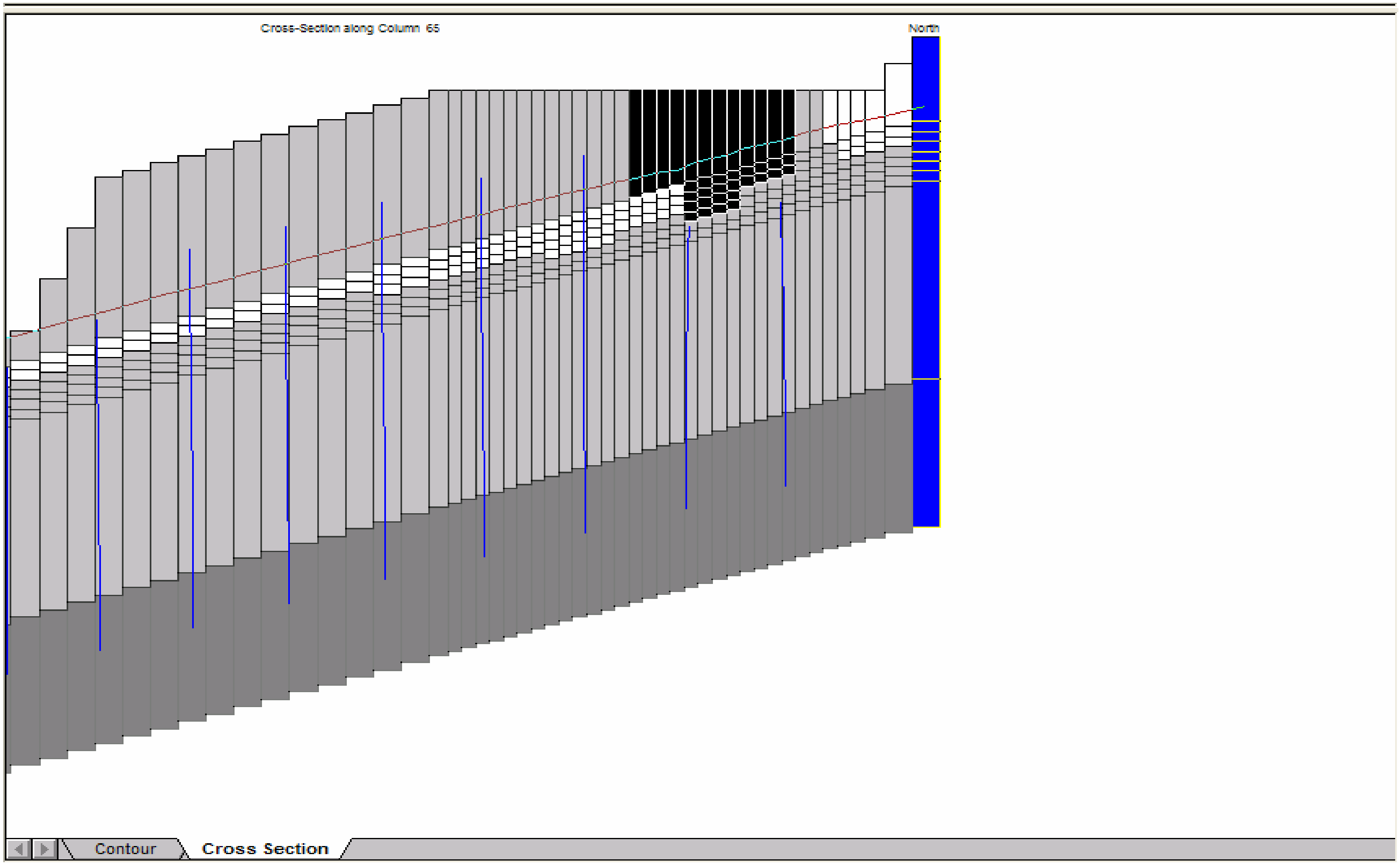


Figure F-16: Scenario C - Cross section of model in location of cross section C-C' from Figure F-4. Colors represent zones of different hydraulic conductivity that have been used also to represent the dominant geologic units. White represents Qvrf, light gray represents Qvd, and dark gray represents Qpgf.

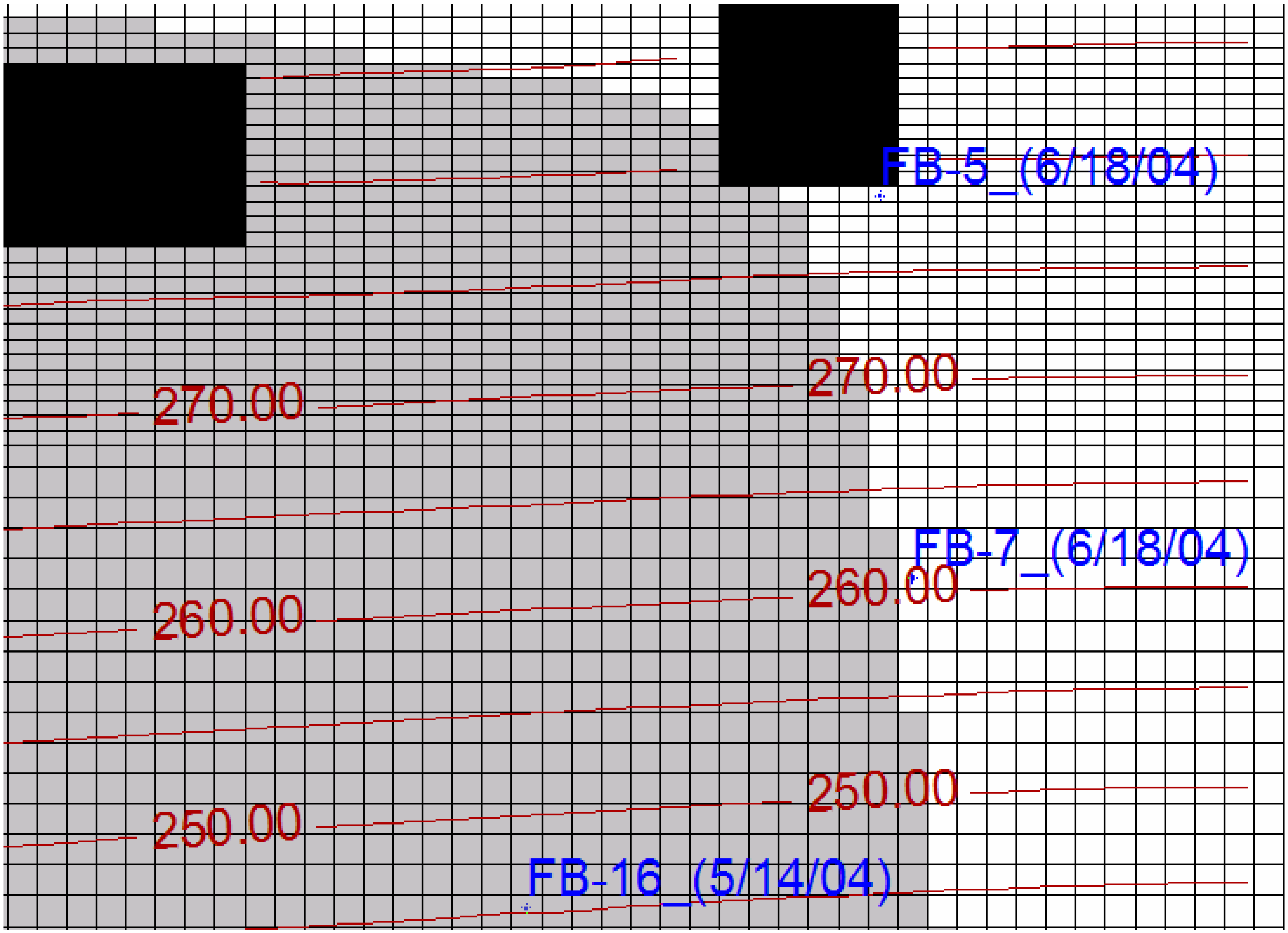


Figure F-17: Scenario C - Steady state target locations (blue dots) used to calibrate model (site boring ID listed with date of water level measurement in parentheses).

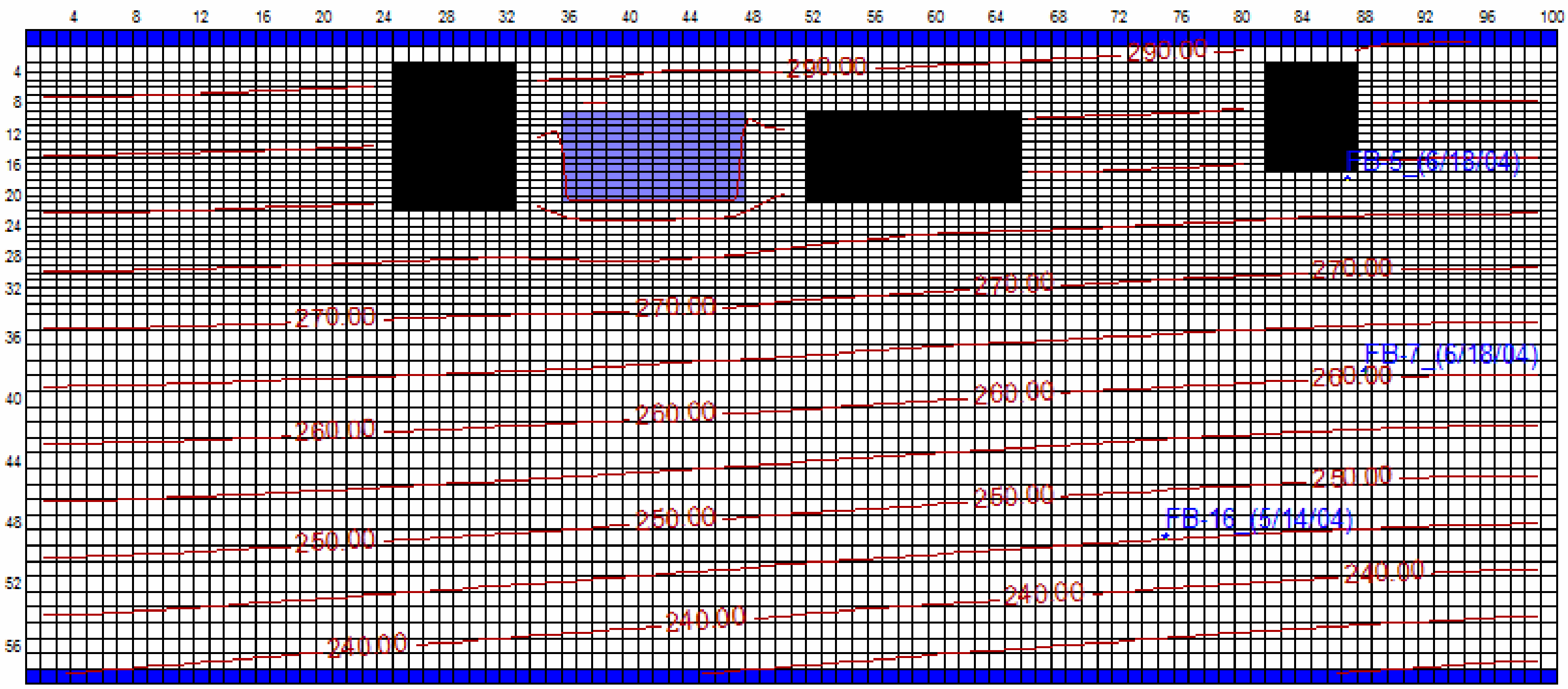


Figure F-18: Scenario C - Plan view of model grid after transient simulation. Groundwater elevation contours at t = 30 years. Blue cells are lake boundary cells, used to define an initial water elevation in the location of the aeration basins, then allowed to equilibrate with surrounding cells over time during the transient simulation.

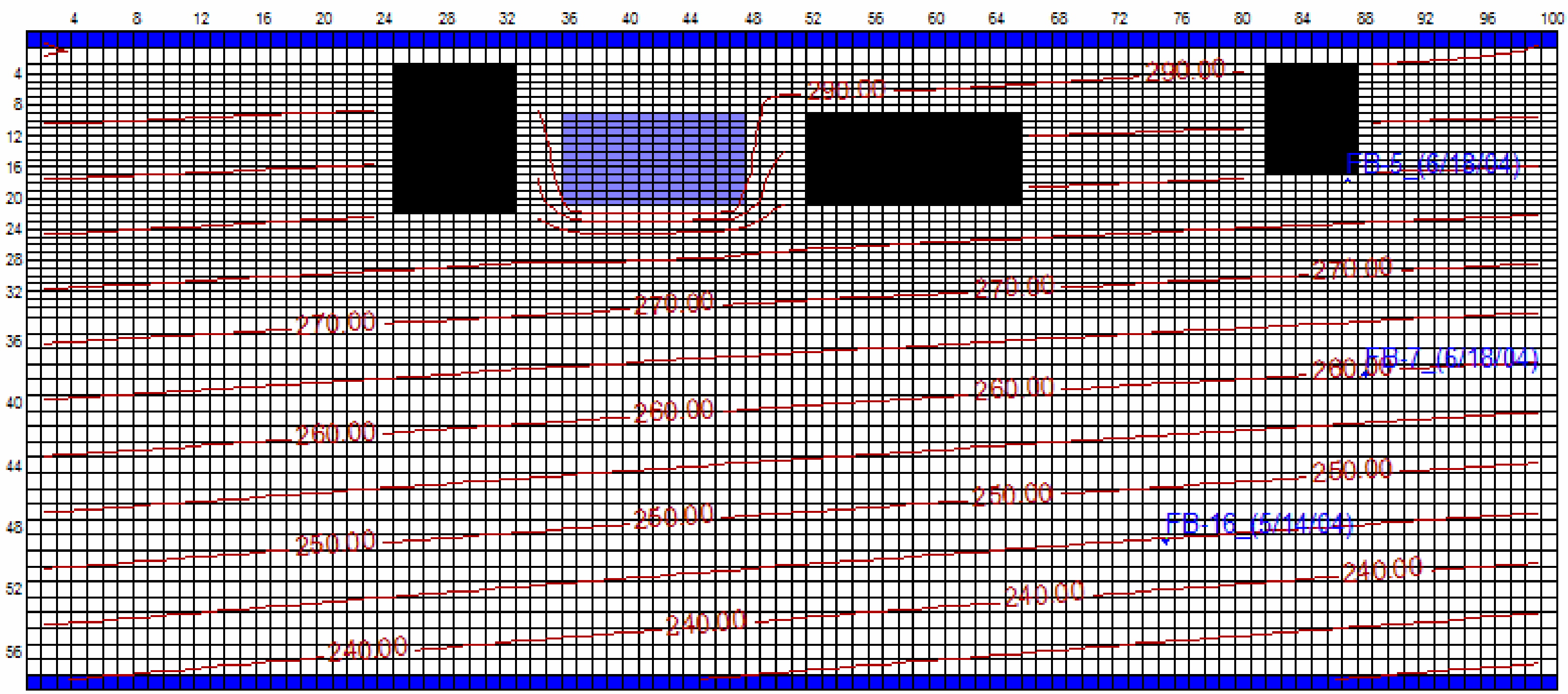


Figure F-19: Scenario C - Plan view of model grid after transient simulation. Groundwater elevation contours at t = 1 month (365/12 days).

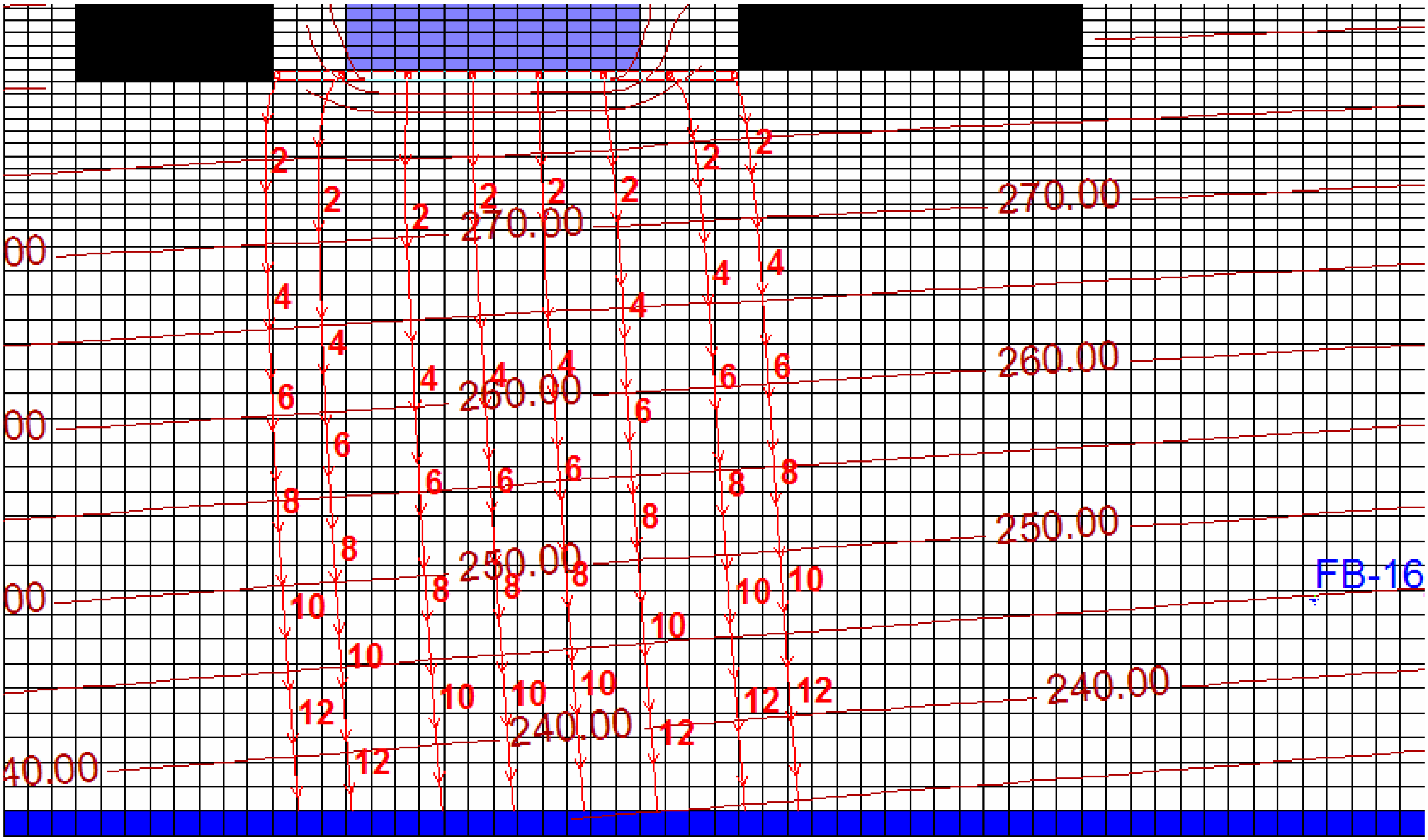


Figure F-20: Scenario C - Plan view of model grid after transient simulation. Particle lines (red lines) generated using MODPATH during 30-year transient simulation (red numbers indicate travel time, in years, of a conservative particle traveling along the line from its origin). Under the model conditions, the shortest particle travel time is approximately 11.5 years.

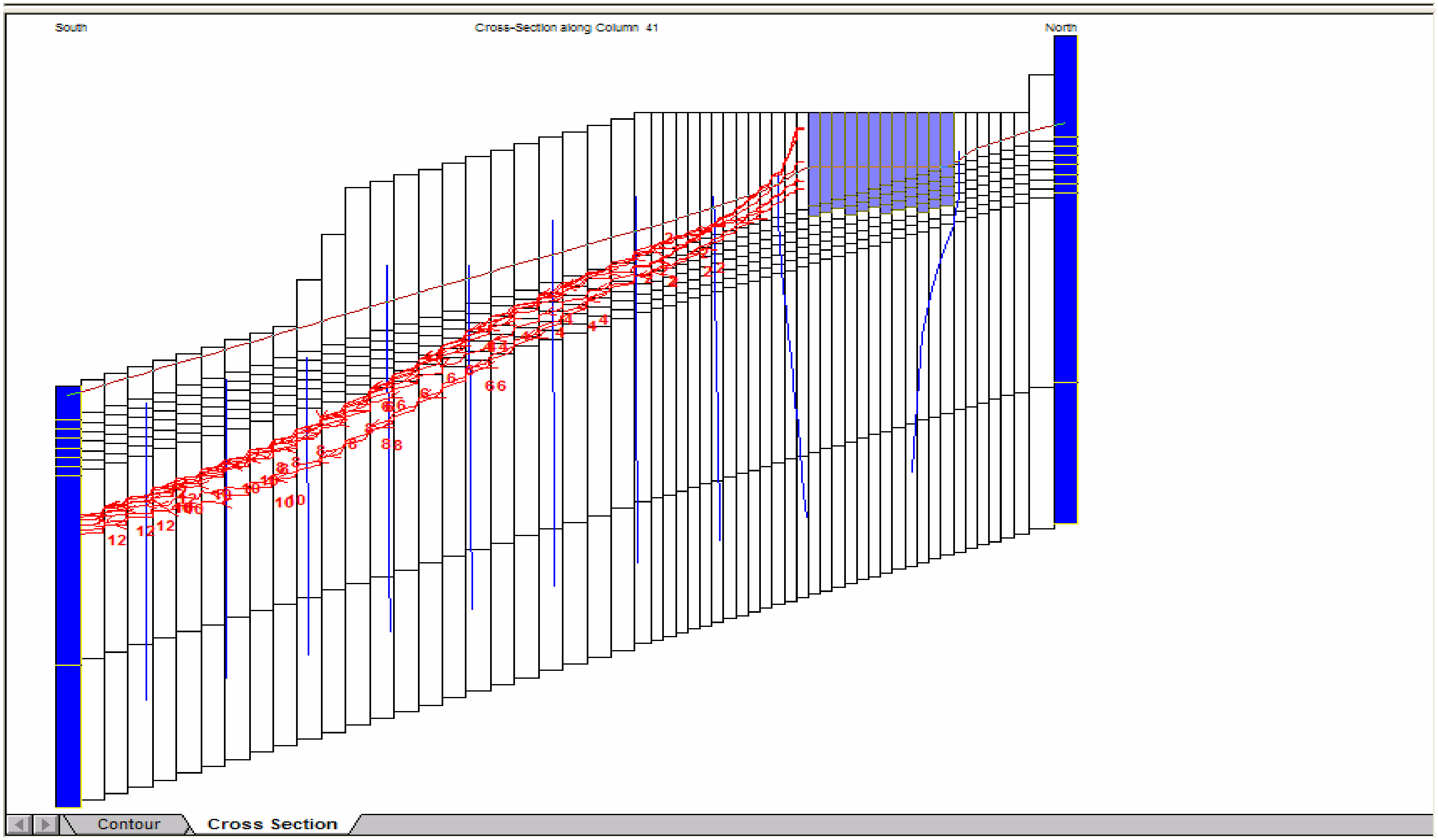
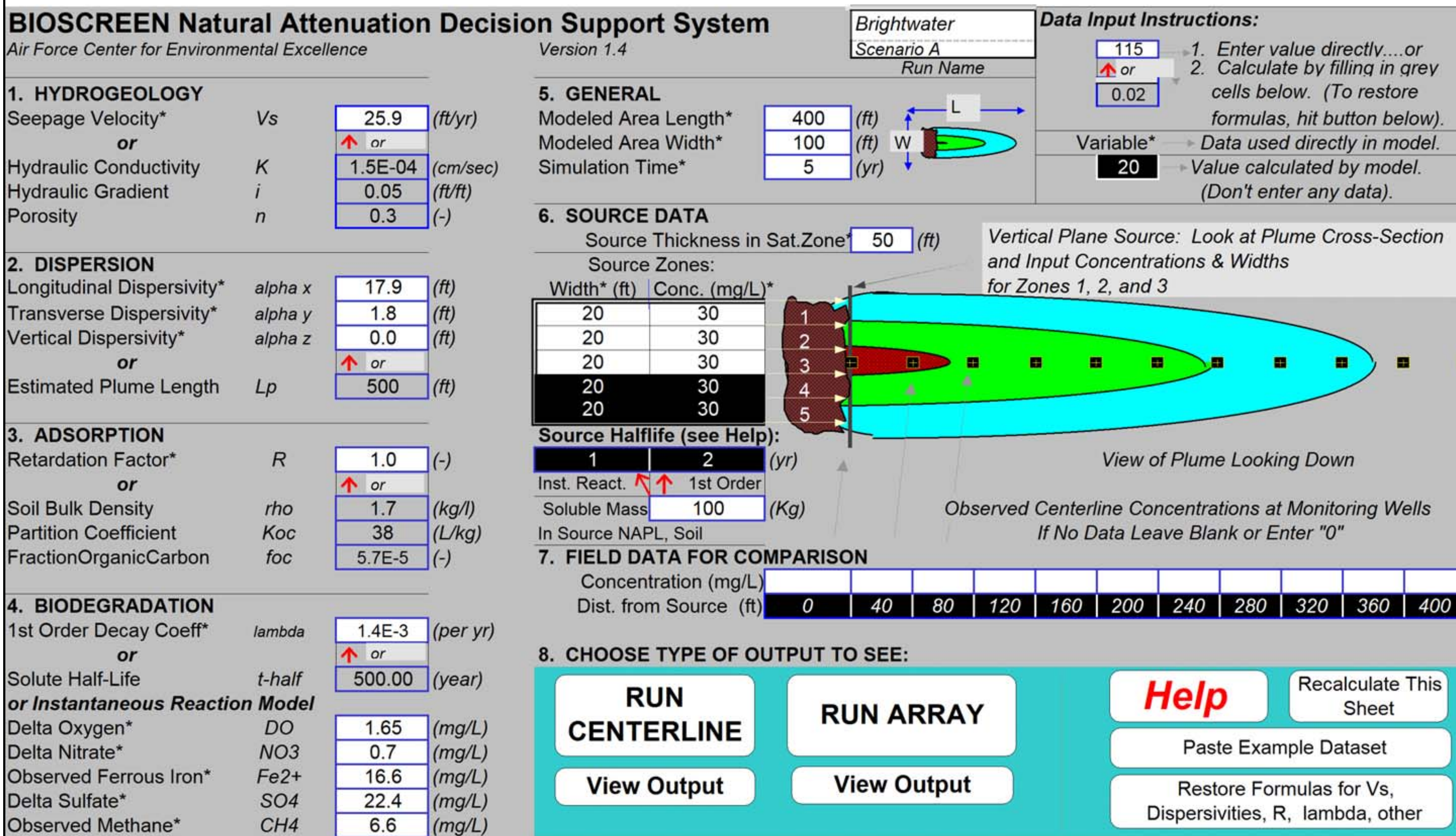


Figure F-21: Scenario C - Cross section of model after transient simulation. Cross section of model in location of cross section B-B' from Figure F-4. Particle lines (red lines) generated using MODPATH during 30-year transient simulation (red numbers indicate travel time, in years, of a conservative particle traveling along the line from its origin). Groundwater elevation contours at t = 1 year.



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File Name: 157689.AP.EP.36.04_E012005003SEA • Brightwater Supplemental EIS • Fig 22 BioscreenEval_Input• 1/08/05 • gm

Figure 22

Scenario A - Bioscreen Water Quality Model Results Groundwater Evaluation

BRIGHTWATER SUPPLEMENTAL EIS

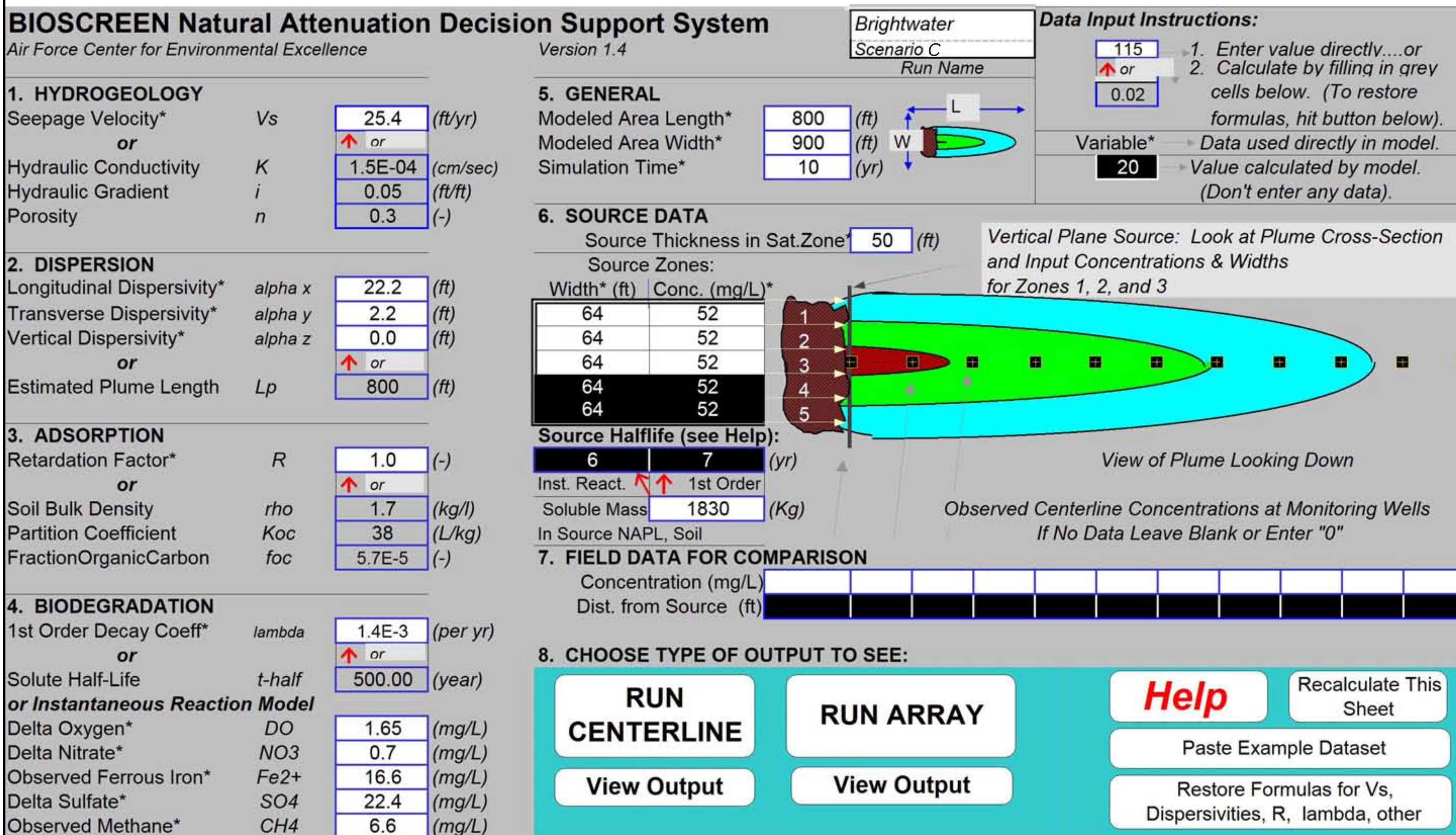


Figure 23

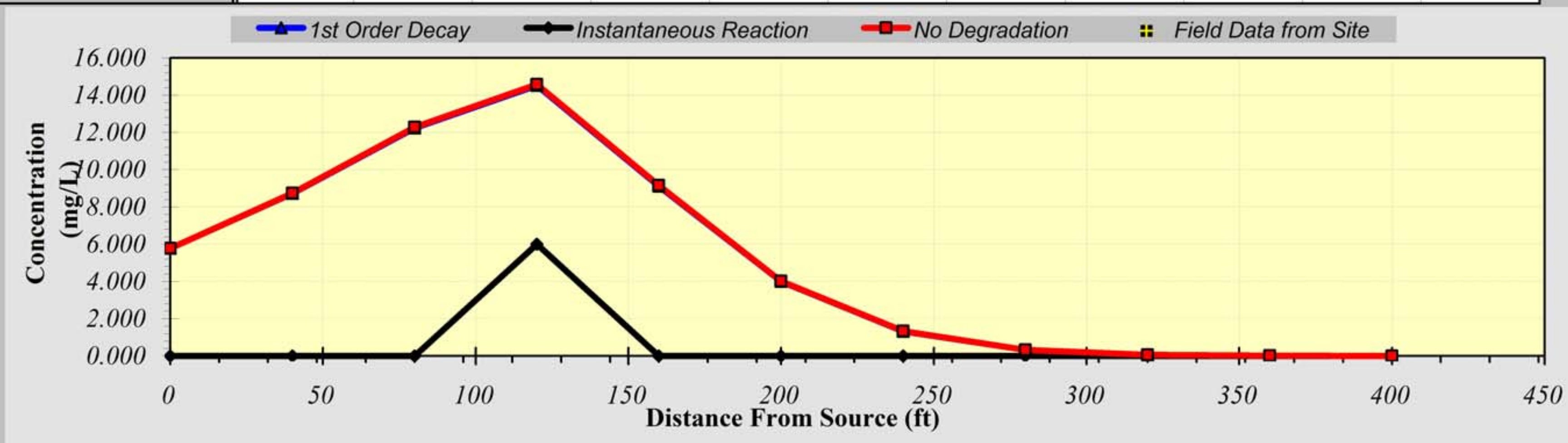
Scenario C - Bioscreen Water Quality Model Results Groundwater Evaluation

BRIGHTWATER SUPPLEMENTAL EIS

NITRATE CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

Distance from Source (ft)

TYPE OF MODEL	0	40	80	120	160	200	240	280	320	360	400
No Degradation	5.779	8.735	12.276	14.575	9.157	4.022	1.330	0.325	0.058	0.008	0.001
1st Order Decay	5.779	8.722	12.241	14.519	9.116	4.002	1.323	0.323	0.058	0.007	0.001
Inst. Reaction	0.000	0.000	0.000	6.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site											



Calculate Animation

Time: 5 Years

Return to Input

Recalculate This Sheet

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File Name: 157689.AP.EP.36.04_E12005003SEA • Brightwater Supplemental EIS • Fig 24 BioscreenEval 5years • 1/08/05 • gm

Figure 24

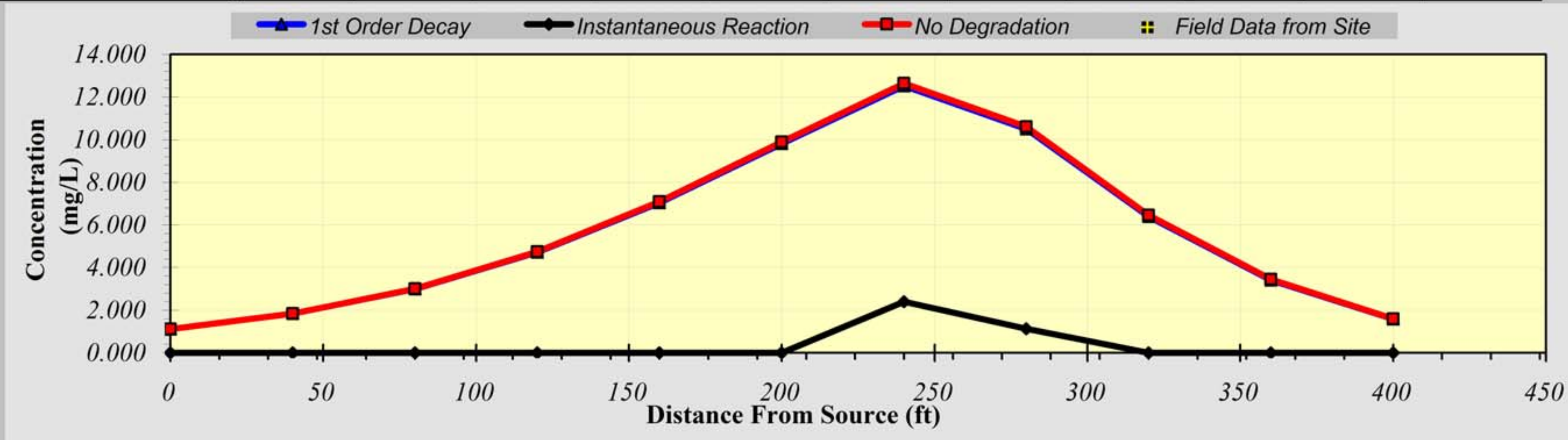
Scenario A - Bioscreen Water Quality Model Results Groundwater Evaluation

BRIGHTWATER SUPPLEMENTAL EIS

NITRATE CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

Distance from Source (ft)

TYPE OF MODEL	0	40	80	120	160	200	240	280	320	360	400
No Degradation	1.113	1.841	3.008	4.742	7.092	9.892	12.638	10.601	6.458	3.449	1.600
1st Order Decay	1.113	1.838	2.997	4.715	7.041	9.810	12.520	10.494	6.389	3.410	1.582
Inst. Reaction	0.000	0.000	0.000	0.000	0.000	0.000	2.403	1.123	0.000	0.000	0.000
Field Data from Site											



Calculate Animation

Time:

10 Years

Return to Input

Recalculate This Sheet

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File Name: 157689.AP.EP.36.04_E012005003SEASEA • Brightwater Supplemental EIS • Fig 25 BioscreenEval 10years • 1/08/05 • gm

Figure 25

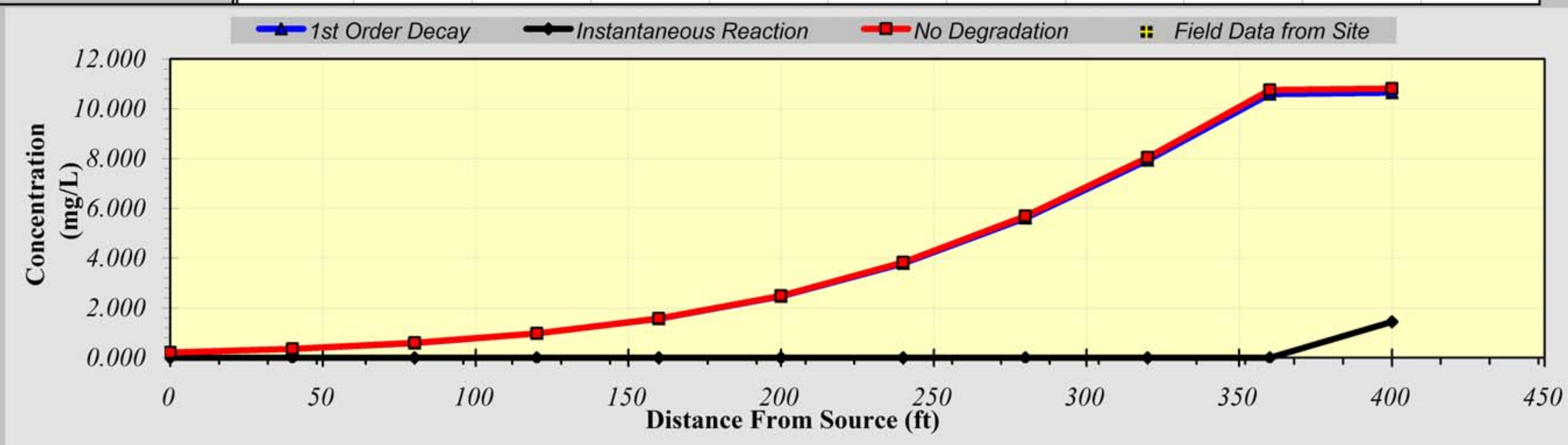
Scenario A - Bioscreen Water Quality Model Results Groundwater Evaluation

BRIGHTWATER SUPPLEMENTAL EIS

NITRATE CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

Distance from Source (ft)

TYPE OF MODEL	0	40	80	120	160	200	240	280	320	360	400
No Degradation	0.214	0.358	0.597	0.979	1.578	2.494	3.835	5.688	8.049	10.751	10.816
1st Order Decay	0.214	0.358	0.594	0.973	1.565	2.469	3.791	5.614	7.936	10.588	10.644
Inst. Reaction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.443
Field Data from Site											



Calculate Animation

Time: 15 Years

Return to Input

Recalculate This Sheet

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File Name: 157689.AP.EP.36.04_E012005003SEA • Brightwater Supplemental EIS •
Fig 26 BioscreenEval 20years • 1/08/05 • gm

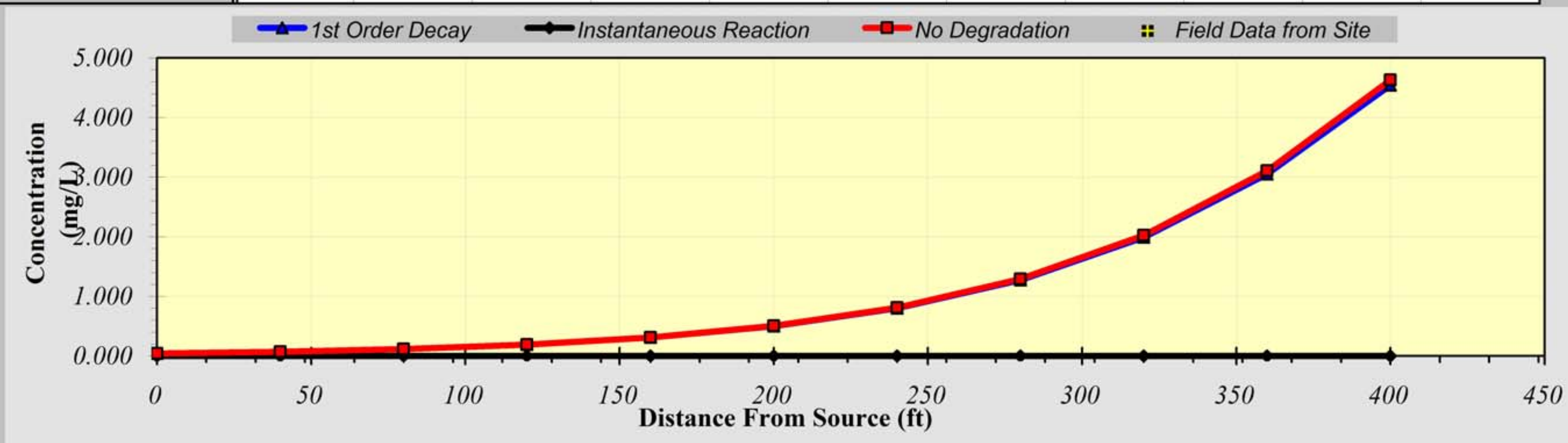
Figure 26

Scenario A - Bioscreen Water Quality Model Results Groundwater Evaluation

BRIGHTWATER SUPPLEMENTAL EIS

NITRATE CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	*Distance from Source (ft)* 0	40	80	120	160	200	240	280	320	360	400
No Degradation	0.041	0.069	0.115	0.191	0.311	0.505	0.812	1.292	2.024	3.105	4.629
1st Order Decay	0.041	0.069	0.115	0.189	0.309	0.500	0.802	1.273	1.992	3.051	4.541
Inst. Reaction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site											



Calculate Animation

Time: 20 Years

Return to Input

Recalculate This Sheet

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Wastewater Treatment Division

File Name: 157689.AP.EP.36.04_E012005003SEA • Brightwater Supplemental EIS • Fig 27 BioscreenEval 30years • 1/08/05 • gm

Figure 27

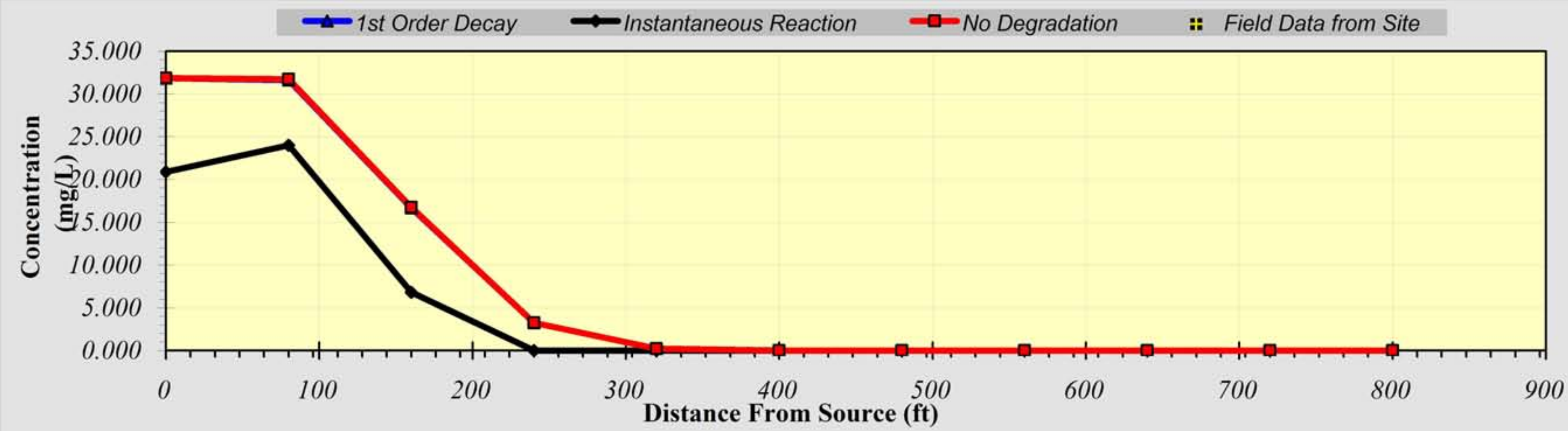
Scenario A - Bioscreen Water Quality Model Results Groundwater Evaluation

BRIGHTWATER SUPPLEMENTAL EIS

NITRATE CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

Distance from Source (ft)

TYPE OF MODEL	0	80	160	240	320	400	480	560	640	720	800
No Degradation	31.850	31.720	16.741	3.256	0.240	0.006	0.000	0.000	0.000	0.000	0.000
1st Order Decay	31.850	31.640	16.670	3.240	0.238	0.006	0.000	0.000	0.000	0.000	0.000
Inst. Reaction	20.901	24.018	6.802	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site											



Calculate Animation

Time:

5 Years

Return to Input

Recalculate This Sheet

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File Name: 157689.AP.EP.36.04_E12005003SEA • Brightwater Supplemental EIS • Fig 28 BioscreenEval 5years • 1/08/05 • gm

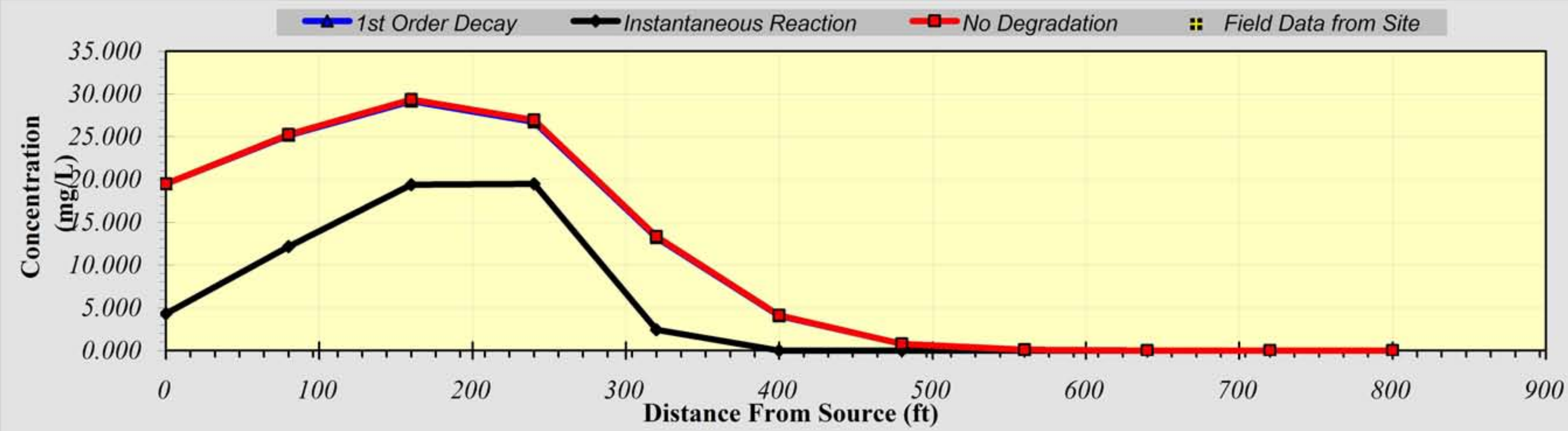
Figure 28

Scenario C - Bioscreen Water Quality Model Results Groundwater Evaluation

BRIGHTWATER SUPPLEMENTAL EIS

NITRATE CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	80	160	240	320	400	480	560	640	720	800
No Degradation	19.508	25.257	29.353	26.965	13.344	4.114	0.783	0.089	0.006	0.000	0.000
1st Order Decay	19.508	25.162	29.153	26.724	13.207	4.068	0.774	0.088	0.006	0.000	0.000
Inst. Reaction	4.311	12.163	19.384	19.495	2.448	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site											



Calculate Animation

Time:

10 Years

Return to Input

Recalculate This Sheet

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Natural Resources and Parks
Wastewater Treatment Division

File Name: 157689.AP.EP.36.04_E012005003SEASEA • Brightwater Supplemental EIS • Fig 29 BioscreenEval 10years • 1/08/05 • gm

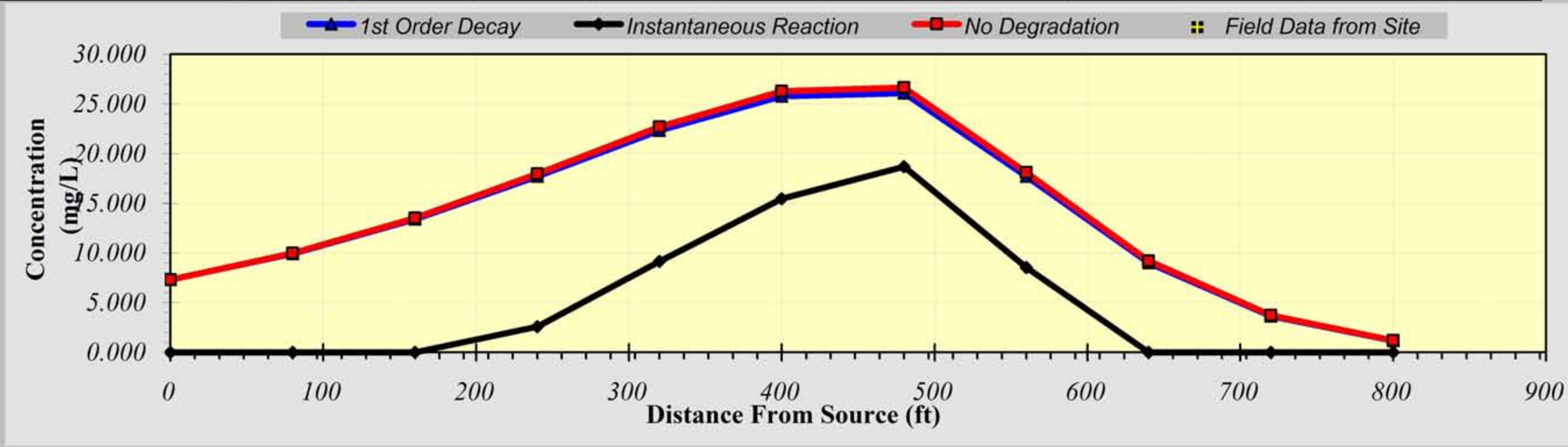
Figure 29

Scenario C - Bioscreen Water Quality Model Results Groundwater Evaluation

BRIGHTWATER SUPPLEMENTAL EIS

NITRATE CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	*Distance from Source (ft)* 0	80	160	240	320	400	480	560	640	720	800
No Degradation	7.318	9.980	13.523	17.947	22.695	26.271	26.634	18.101	9.210	3.734	1.187
1st Order Decay	7.318	9.936	13.407	17.724	22.337	25.787	26.089	17.704	8.998	3.645	1.158
Inst. Reaction	0.000	0.000	0.000	2.585	9.154	15.446	18.672	8.546	0.000	0.000	0.000
Field Data from Site											



Calculate Animation

Time:

20 Years

Return to Input

Recalculate This Sheet

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Wastewater Treatment Division

File Name: 157689.AP.EP.36.04_E012005003SEA • Brightwater Supplemental EIS •
Fig 30 BioscreenEval 20years • 1/08/05 • gm

Figure 30

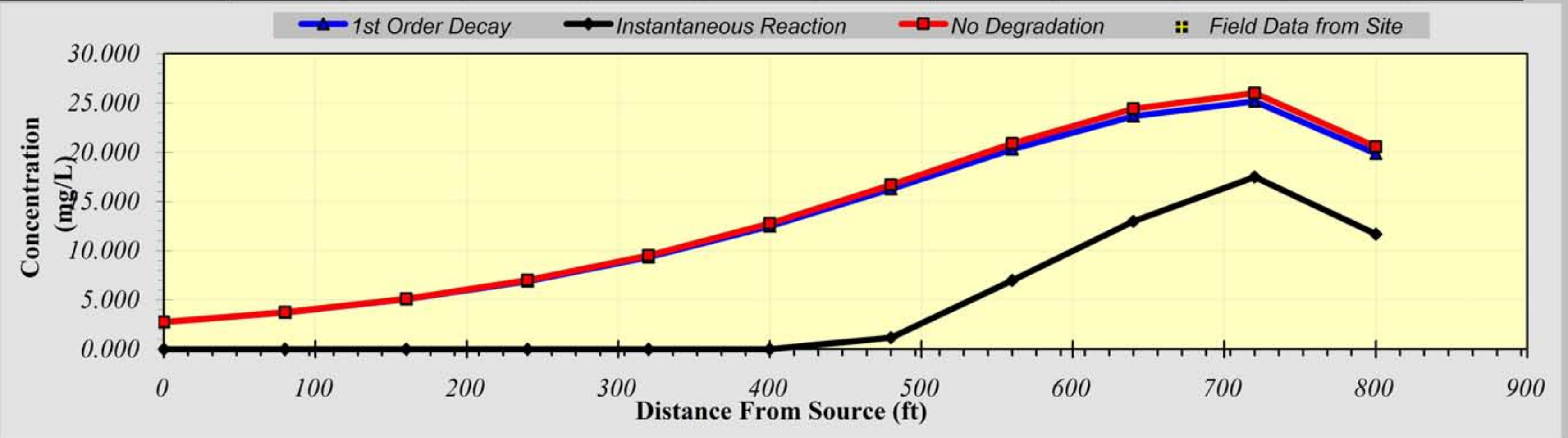
Scenario C - Bioscreen Water Quality Model Results Groundwater Evaluation

BRIGHTWATER SUPPLEMENTAL EIS

NITRATE CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

Distance from Source (ft)

TYPE OF MODEL	0	80	160	240	320	400	480	560	640	720	800
No Degradation	2.745	3.752	5.127	6.994	9.499	12.748	16.684	20.879	24.404	26.004	20.554
1st Order Decay	2.745	3.736	5.082	6.903	9.335	12.478	16.271	20.299	23.664	25.164	19.859
Inst. Reaction	0.000	0.000	0.000	0.000	0.000	0.000	1.179	6.987	12.971	17.494	11.690
Field Data from Site											



Calculate Animation

Time:
30 Years

Return to Input

Recalculate This Sheet

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Department of
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Wastewater Treatment Division

File Name: 157689.AP.EP.36.04_E012005003SEA • Brightwater Supplemental EIS • Fig 31 BioscreenEval 30years • 1/08/05 • gm

Figure 31

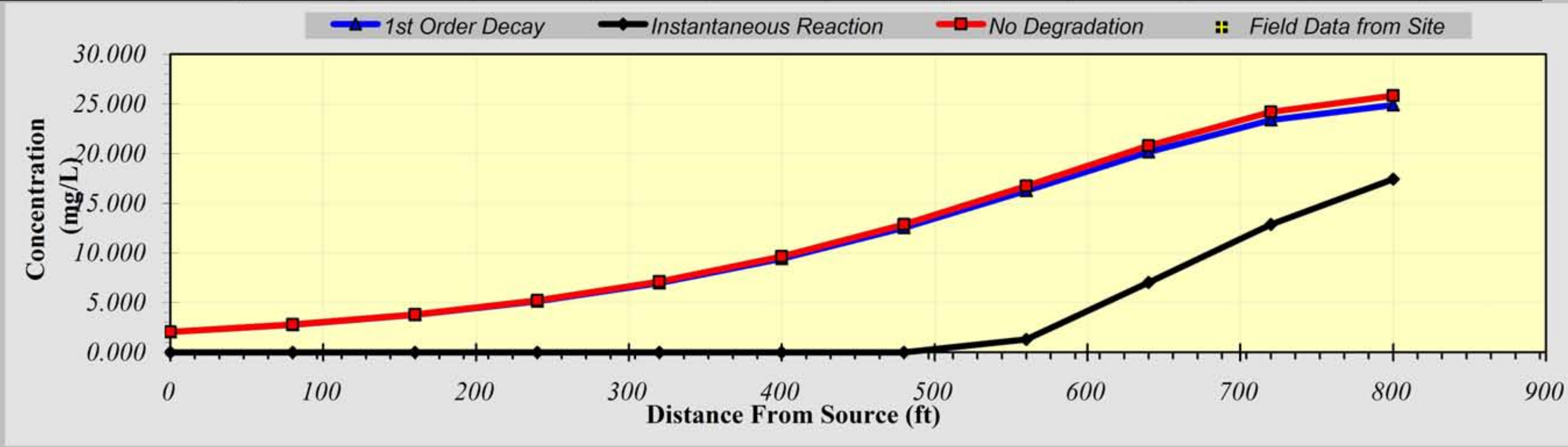
Scenario C - Bioscreen Water Quality Model Results Groundwater Evaluation

BRIGHTWATER SUPPLEMENTAL EIS

NITRATE CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

Distance from Source (ft)

TYPE OF MODEL	0	80	160	240	320	400	480	560	640	720	800
No Degradation	2.046	2.796	3.822	5.220	7.114	9.637	12.874	16.739	20.803	24.202	25.818
1st Order Decay	2.046	2.784	3.788	5.151	6.990	9.430	12.549	16.258	20.144	23.377	24.888
Inst. Reaction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.315	7.021	12.886	17.431
Field Data from Site											



Calculate Animation

Time: 33 Years

Return to Input

Recalculate This Sheet

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File Name: 157689.AP.EP.36.04_E012005003SEA • Brightwater Supplemental EIS •
Fig 32 BioscreenEval 33years • 1/08/05 • gm

Figure 32

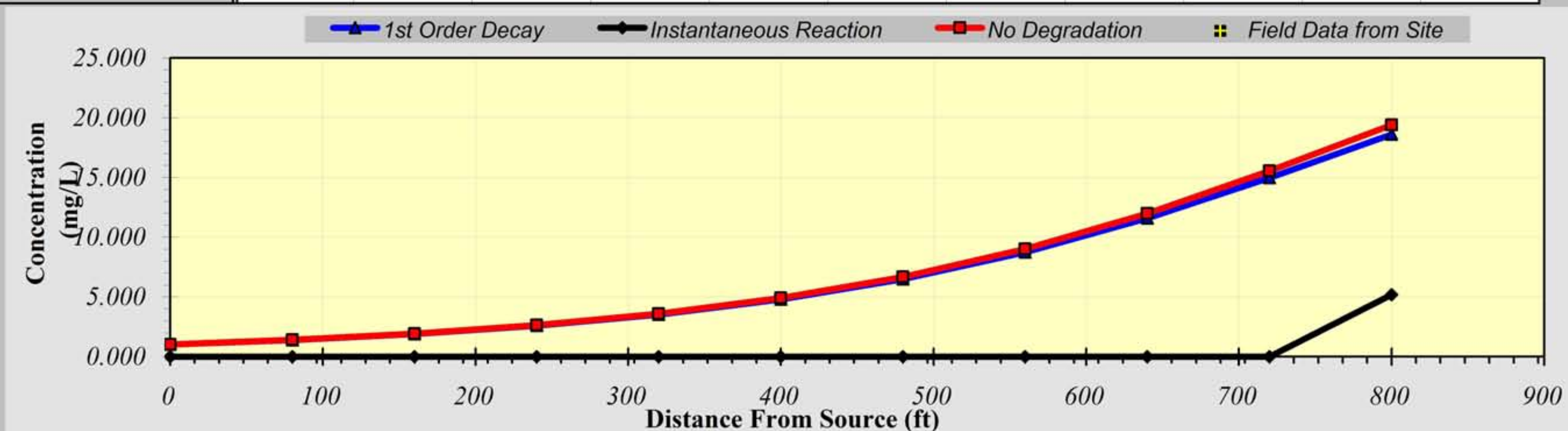
Scenario C - Bioscreen Water Quality Model Results Groundwater Evaluation

BRIGHTWATER SUPPLEMENTAL EIS

NITRATE CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

Distance from Source (ft)

TYPE OF MODEL	0	80	160	240	320	400	480	560	640	720	800
No Degradation	1.030	1.408	1.924	2.630	3.594	4.904	6.671	9.009	11.988	15.550	19.387
1st Order Decay	1.030	1.402	1.907	2.596	3.531	4.798	6.498	8.739	11.585	14.975	18.615
Inst. Reaction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5.201
Field Data from Site											



Calculate Animation

Time:

40 Years

Return to Input

Recalculate This Sheet

Figure 33

Scenario C - Bioscreen Water Quality Model Results Groundwater Evaluation