BB&S TREATED LUMBER SITE

PREDESIGN INVESTIGATION

REPORT
GROUNDWATER FLOW/TRANSPORT MODELING AND TREATABILITY STUDY

February 2007

Site No. 1-52-123

Prepared for:

DIVISION OF ENVIRONMENTAL REMEDIATION
NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
625 BROADWAY, ALBANY, NY 12233-7012

Prepared by:

Iyer Environmental Group, PLLC
44 Rolling Hills Drive
Orchard Park, NY 14127

Submitted by:

Earth Tech Northeast, Inc.
40 British American Blvd.
Latham, NY 12110

REPORT

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Groundwater Flow/Transport Modeling & Treatability Study
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1.0 INTRODUCTION

The BB&S Treated Lumber site is a 10-acre site that was used by the BB&S Treated Lumber Corporation from 1979 to April 1996 to manufacture pressure treated wood for the construction industry. The site, located in a rural area in Speonk, NY, has a frame building where the wood treatment took place and a metal building for staging. Currently, the site is occupied by the Best Building and Supply Corporation, a wholesale lumber distribution yard with no on-site wood treatment.

Wood was pressure treated at the site by placing it in one of two 10,500-gallon, long horizontal cylinders which were closed off and filled with preservative (called CCA for chromate, copper and arsenate). The concentrated CCA solution contained 17% arsenic pentoxide, 9.25% copper oxide and 24.75% chromic acid. The cylinders were pressurized to 125-160 psi, forcing the preservative into the wood.

The compounds in the preservatives entered the soil and groundwater through concrete sumps inside the process building which collected excess preservative from the treatment area and the drip area where the wood was stacked for drying. A 330-gpm reverse osmosis system, installed and operated from 1987 to 1995 to treat contaminated groundwater, was not effective.

A Remedial Investigation (RI) was completed in June 1998, and the Record of Decision was issued in February 2000. The selected remedy calls for the ex-situ solidification and stabilization of contaminated soils, and the collection and treatment of groundwater. A pre-design investigation (PDI) was initiated by Earth Tech in 2005, and this groundwater flow/transport modeling and treatability study was performed to aid in the design of a remedial system for groundwater.

The objective of the groundwater modeling effort was to develop a better understanding of groundwater flow and contaminant transport, and to help optimize the plume containment design. A limited bench scale jar test is performed to evaluate the reduction and subsequent precipitation of hexavalent chromium in the aquifer and in an above ground treatment system.

2.0 HYDROGEOLOGIC SYSTEM

2.1 Regional Setting

The BB&S site is located on an island, with an elevation of 60 feet above mean sea level (amsl). The region has two main aquifers. USGS maps (included in Appendix A) show the Upper Glacial aquifer to be around 50 to 150 feet thick and the lower Magothy aquifer is 800 to 1000 feet thick. In some places, the two aquifers are separated by Gardiner's Clay, but this clay does not appear to be present in or around the site. Geologic cross-sections from the USGS maps are replotted in Figure 1. Both aquifers are permeable and productive, and made up mostly of sand and gravel. The Magothy is underlain by the Raritan formation.

Groundwater mostly occurs relatively deep, while rivers and streams are above the groundwater table (around 40 feet depth at the site) and serve as a source of recharge. Potentiometric surface is high in the center of the island and drops towards the ocean and bays. The USGS maps (Appendix A) show the groundwater table for the Upper Glacial aquifer in the vicinity of the site to be around 20' amsl, which is confirmed by measurements (17.1' to 21.5' amsl) at site monitoring wells during the RI and the PDI (see groundwater contour plots in Appendix B that were developed using SURFER and field water level measurements in Table 1).

The flow pattern is similar in both aquifers. Groundwater flows away from the center of the island and towards the ocean and bays. The aquifers are very conductive and hydraulic gradients are low, around 0.0017 for the Upper Glacial unit and 0.0008 for the Magothy based on calculations using USGS groundwater contours shown on Figure 1A.

Rivers start intersecting the groundwater table towards the ocean shore, where they serve as discharge locations. Recharge through infiltration of precipitation and surface water is the only source of fresh water, and the whole system is like a giant freshwater lens on top of salt water. In the center of the island, the Upper Glacial aquifer receives recharge from infiltration, and the Magothy receives flow from the Upper Glacial aquifer. Hydraulic head is significantly higher in the Upper Glacial aquifer than in the Magothy, creating a downward gradient. Farther down towards the discharge points along the shore line, the hydraulic gradient between the two aquifers diminishes. Close to the ocean, the hydraulic heads in both aquifers become very similar.

The region sees high recharge in undeveloped areas because of mostly sandy soils, with values ranging between 0.5 ft/yr (0.0014 ft/day) and 2 ft/yr (0.0055 ft/day). Several rivers and creeks flow from the high ground in the center of the island towards the ocean and the bay.

2.2 Groundwater Utilization

Groundwater is utilized throughout the region as the source of potable water. The 1998 RI Report (Malcolm Pirnie) notes two community water suppliers in the area, one serving a small community (Speonk Mobile Home Park) located within 2,000 feet south of the site, and the other a Suffolk County Water Authority (SCWA) well field approximately one mile southwest of the site. However, according to the SCWA, the County has been operating only the Old County Road well field, located about a mile southeast of the site. Recent information gathered by Earth Tech from the NYSDEC's Region 1 office shows five wells at this location with three wells operating at any time except for 1998 when four wells were used. The water supply wells appear to be screened in the Upper Glacial aquifer. Historical pumping data from the County well field is tabulated in Table 2 along with annual and five-year daily average pumping rates. For the purpose of this groundwater modeling effort, a total daily average pumping rate of 500 gpm (based on rates between 1990 and 2005 in Table 2) is used.

Also, there is a distribution of smaller residential wells around the region. The capacities range from 500 to 700 gpm. According to a USGS publication (included in Appendix A), individual wells in the Upper Glacial aquifer can yield as much a 1,700 gpm, while the Magothy formation yields as much as 2,200 gpm in a single well.

3.0 GROUNDWATER FLOW MODEL

3.1 Software – MODFLOW/MODPATH/MT3D/PEST

MODFLOW is the USGS's Modular Three-Dimensional Groundwater Flow Model. It is widely used because of its ability to simulate a wide variety of systems and its extensive publicly available documentation. MODPATH is a 3-D particle-tracking model that computes the path a particle takes in a steady-state or transient flow field over a given period of time. MT3D is a 3-D contaminant transport model that can simulate advection, dispersion, sink/source mixing, and chemical reactions of dissolved constituents in groundwater flow systems. VISUAL MODFLOW (version 4.2) developed by Waterloo Hydrogeologic is a professional version of 3D groundwater flow and contaminant transport modeling using MODFLOW-2000, MODPATH, MT3DMS AND RT3D (a 3-D multispecies reactive transport model). It also integrates WinPEST, a model-independent parameter estimator using nonlinear methods.

3.2 Model Domain

The model domain (see Figure 2) was selected such that the boundaries are far enough from the site to experience only negligible effects from stresses simulated at the site, like a pump and treat system. The USGS topographic map (reproduced on Figure 1A) is included as a background on all model output screens. Geologic cross-sections for this region from the USGS reference in Appendix A are reproduced in Figures 2B through 2E. The site appears to lie above the northern edge of the Gardiner's clay. Since no Gardiner's Clay was found in core samples from the site during the investigations, only the two water bearing zones (Upper Glacial and Magothy) are modeled without the Gardiner's Clay. The bottom of the Magothy (or the top of the Raritan unit) is the bottom of the model.

Groundwater in the study area flows south, from the water divide north of the site to the ocean. The north boundary is the location of the water divide in the Upper Glacial. The divide, a no-flow boundary, is located approximately 6,000 ft from the site. In the Magothy, hydraulic heads are specified along the northern boundary based on the USGS regional potentiometric surface map (constant head boundary). The south boundary in both aquifers is a line located approximately 6,000 ft from the site. It is a constant head boundary for which heads are specified based on the USGS regional potentiometric map.

The east and west boundaries are selected as flow lines, which go north-south. Flow lines are essentially identical in both aquifers. Flow lines selected as boundaries are located approximately 4,000 ft from the site on either side. Flow lines are no-flow boundaries.

3.3 Layering System and Finite-Difference Grid

The groundwater plume (see plots for chromium concentrations from the site investigation in Appendix C) is located in the Upper Glacial aquifer which is modeled with a 100 feet thickness down from the groundwater table. The Upper Glacial aquifer is modeled as three layers in order to capture the vertical migration of the plume and three-dimensional effects of the aquifer boundaries. Layer thicknesses for the first, second and the third (top down) are set at 25', 25' and 50' respectively (see Figures 3A and 3B). The Magothy is modeled as a single layer with a thickness of 900 feet (see Figure 3C).

MODFLOW requires the model domain to be divided into a grid system (see Figures 4A and 4B), with a finer grid (smaller spacing of around 25') in the vicinity of the plume and along the potential path of plume migration. Beyond the plume boundary, the grid spacing is increased progressively (not more than 1.5 times the inner consecutive grid) towards the outer limits of the model domain (maximum 600').

3.4 Hydrogeologic Units and Boundary Conditions

The model includes two water bearing geologic units – Upper Glacial and Magothy. The Upper Glacial aquifer is modeled as Layers 1, 2 and 3. Boundary conditions are the same in all three layers: no-flow along the water divide and along north-south flow lines, and constant head at the southern boundary (head value of 10 ft, based on regional USGS map).

The Magothy is modeled as one layer – Layer 4. The north boundary is specified along the line defining the water divide in the Upper Glacial aquifer. Because the location of the divide in the Magothy is somewhat different than in the Upper Glacial, this is not a no-flow boundary within Layer 4. Instead, it is modeled as a constant head boundary, where the heads are assigned based on the regional potentiometric surface maps. Heads along the north boundary are not uniform. The remaining boundaries in Layer 4 are the same as in the upper layers.

3.5 Cell Types

Cells inside the model domain are defined as variable-head cells. Heads in these cells are obtained as a solution to the problem. Heads at constant head boundaries are fixed, and do not vary during the solution.

Rivers (or streams) are modeled through the use of MODFLOW river cells. A river bottom, stage and conductance of river bed are specified. River cells exchange flow with the variable head cells according to a linear relationship, where the magnitude of flow is directly proportional to the differential between the river stage and the hydraulic head in the cell where the river section is located. The river bed conductance is the constant of proportionality. The flow direction – into the river from the model domain, or into the model domain from the river – is determined by the value of the head differential (river stage > head in the cell – flow out of the river, and vice versa). The magnitude of leakage from the river into the model domain is limited by the elevation of the river bed. Once the head in the variable cell containing the river segment falls below the river bed, the leakage reaches its maximum value and remains constant regardless of the head differential.

Groundwater extraction from the aquifers is modeled by means of MODFLOW well cells. An extraction well cell extracts a specified amount of water from the aquifer, regardless of all other factors, like hydraulic head in the cell. Similarly, an injection well injects a specified amount of water into the model domain.

3.6 Calibration

3.6.1 Parameters For Calibration

The parameters to be calibrated are the hydraulic conductivities of the aquifers (both vertical and horizontal) and recharge. Flow rates are not available; therefore, both parameters cannot be calibrated – one has to be assumed. For this site, recharge from precipitation and streams is assumed for each model calibration of the conductivities in the two aquifers. No information about the special distribution of properties is available; therefore, single values are assumed for the hydraulic conductivities of each aquifer.

Recharge is assumed (initially one value for the entire model area), and input into the model. The model is then calibrated for hydraulic conductivities. Initial calibration was performed by assigning conductivities manually to develop an understanding of the system's response to changes in parameter values. This is done for successive values of recharge from within the range determined to be realistic. The model calculated groundwater contour plots are compared visually against the USGS reference and values adjusted for subsequent runs.

3.6.2. Water Level Data for Calibration

The NYSDEC had requested that the model be calibrated against the SCWA's Groundwater Model which was developed using Dynflow. According to SCWA, the County model was calibrated using USGS water level data. The Dynflow model input data could not be directly imported into MODFLOW. So printed input data and output figures (included as Appendix D) were obtained from SWCA for possible use. Horizontal conductivity values used in the County model range from 10 to 250 ft/day for the Upper Glacial unit, and 2 to 125 ft/day for the Magothy. A single precipitation recharge rate of 1 MGD/sq.mi. (or 0.0048) is used for the entire County model region. The County model uses a relatively large grid spacing (4000' to 5,000') and covers the study area within 18 elements (the entire model has 1,143 elements). In comparison, the MODFLOW grid system (grid spacing of 25' at the site to 600' at the outer limits) in this modeling exercise uses a total of 35,866 cells to cover the model area including the site. The groundwater divide shown in the USGS map on Figure 2A (north of the site) for the Upper Glacial unit is not apparent in the County's model from the data provided. Water levels predicted by the SCWA model for this study area (see maps in Appendix D) show a more pronounced eastern groundwater flow direction largely as a result of its suitability for use as a regional model and not for localized applications. The County's groundwater model information is therefore used herein to make qualitative comparisons of values generated for the calibration parameters and predicted hydraulic heads.

Water level data for the calibration runs was developed for the Upper Glacial and Magothy units by using the individual USGS contours shown on Figure 1A and AutoCAD to generate data points all across the model area. The interpolated data was then imported into the Visual MODFLOW coordinate system. A few points, denoted as observation wells in MODFLOW, were chosen around the model area for comparison of water levels.

3.6.3 Manual Calibration

Initial manual calibration runs were made by varying conductivities for the Upper Glacial and the Magothy units. Groundwater contours from these runs were not similar in nature (heads and flow direction) to the USGS reference. First, it was realized that the northwest model region was artificially skewing the heads, possibly due to the shape of the boundary in that corner as modeled. So the model domain was revised as shown on Figure 5 (compare to Figure 3) to exclude this area. The geologic layers and their thicknesses were kept the same as shown on Figure 1.

The calibration runs were then repeated with varying conductivity values for the Upper Glacial and Magothy aquifers, and with and without the County supply wells (located southeast of the site) in operation. A recharge rate of 0.006 (the upper end of the range reported in the USGS reference in Appendix A) was used to keep the values of the conductivities for the two aquifers and their relative ratios reasonable. Groundwater contours from these runs are shown on Figure 6. The USGS contours on Figure 1A as well as site groundwater level measurements indicate a southerly groundwater flow direction. However, in Figure 6B, the model predicted drawdown by the supply wells skewed the groundwater contours such that the area west of the site had a southerly groundwater flow while the area east of the site had a southeasterly flow. This is addressed below.

In order to obtain groundwater contours similar to the USGS map, it became necessary to split the model region into three areas as shown on Figure 7 with different recharge rates. More manual calibration runs were made, this time varying the conductivity values and recharge rates in the three areas. Figures 8A through 8C show groundwater contours for the top layer (Layer 1) with the revised recharge rates applied. The calculated heads at the pre-selected data points are plotted on Figure 8D against observed heads interpolated from USGS data. The orientation of the model predicted groundwater contours more closely resembled the USGS contours on Figure 1A with a lower recharge rate (0.004 ft/day) for the upper western section (Area 3) compared to the upper eastern (Area 2) or the lower half (Area 1) of the model area (0.0065 ft/day). These recharge rates are within the range of reported values, and the resulting area weighted average recharge rate of 0.006 ft/day is slightly higher than the rate used in the SCWA groundwater model. The slightly higher recharge rate is allowable to account for any reinjection of potable water from the community back into the aquifer. At this time, it was deemed appropriate to use Visual MODFLOW's PEST routine to further refine the conductivity values.

3.6.4 PEST Calibration

Final calibration was performed using the PEST utility – a program that optimizes parameter values by minimizing the difference between the model-generated hydraulic heads and observed heads. Hydraulic conductivities obtained for different recharge values are then compared to the known regional values for each of the two aquifers. The most realistic combination is selected, taking into account both absolute values of the conductivities, and the relative values between the two aquifers.

The groundwater contours generated by MODFLOW after refinement of the conductivity values by PEST are shown on Figures 9A through 9C along with the calibrated and assumed parameter values. The model generated contours are similar to the USGS reference, and the heads on the site appear to be close to the groundwater levels measured at the site. The PEST refined conductivity values shown with the contour plots on Figure 9 are within the range of values reported in the literature as well as those listed in the SCWA's groundwater model input data (see Appendix D). The model calculated groundwater contours for Layer 1 on Figure 9A look nearly the same as those on Figure 8A because the horizontal conductivity values are very close in both figures. PEST run logs and records from the last PEST calibration run are included as Appendix E. Manual calculations (included as Appendix F) with site specific information were made to verify the model generated outputs. The comparison of calculated heads against observed heads (from USGS data) at pre-selected data points are shown on Figure 9D.

Model generated zone (water) budgets for groundwater flow are summarized in Table 3. Zone 2 is designated as a row of cells running east-west along the width (480 feet) of the site through MW-5. The model calculations show a recharge rate of 513,000 cf/day (or 0.0061 ft/day), and a total flux of 702,000 cf/day through the aquifer). Of this total, approximately 20,000 cf/day (or 100 gpm) is estimated to flow through a 480 feet width at the site.

3.7 Flow Simulation

Groundwater flow through the site was then simulated using the calibrated parameter values and taking into consideration groundwater extraction at the SCWA well field. Besides using MODFLOW for head contours, MODPATH is used to predict groundwater flow paths as shown on Figure 10. Particles inserted into the model domain within the plume are then tracked to their discharge point. The model shows groundwater to flow essentially to the south, following the gradient seen in the USGS maps with discharge to the ocean. The flow simulation on Figure 10 indicates that the pumping influence (modeled at 500 gpm) of the Suffolk County water supply system (shown as Well Field on Figure 10A) does not extend to the groundwater flow path from the site.

The model calculated flow paths in the east-west and north-south cross sectional views through the site (Figures 10B and 10C respectively) show that much of the flow in the Upper Glacial unit (upper three layers) occurs in the horizontal dimension, indicating that site contaminants did not migrate significantly downward into the Magothy.

3.8 Contaminant Plume

Contaminant (as hexavalent chromium) profiles were generated with the MT3DMS transport engine in Visual MODFLOW using the parameter values optimized from the PEST calibration. The model had to be used without the retardation factor since its use resulted in plume containment to the immediate vicinity of the source.

The transport module was run with a constant contaminant loading to the groundwater at the source for an initial period, and then continuing the transport model run for an additional period to simulate the overall duration of operation of the wood treatment and subsequent investigation of the site. Several variations were run to obtain concentrations within the site similar to values obtained during the RI. During the RI, the three extraction wells at the site were found to contain chromium at up to 9.7 mg/L, copper at 1.9 mg/L, and arsenic at 0.6 mg/L, with pH ranging from 5.2 to 6.6 and total dissolved solids from 72 to 160 mg/L. Recent metals data from the PDI for the site groundwater are tabulated in Table 4.

A groundwater pump and treat system was used in the 1990s, several years after the pressure treatment of wood began at the site. The treatment system was subsequently discontinued. This sequence of events seems responsible for the dual plume of chromium observed during the RI and the PDI (see Appendix C) – that is a relatively higher concentration plume near the source, and a diluted plume further downgradient from the site. Note that the shallow soils in the wood processing area still show chromium contamination, and its continued release can affect the plume dimensions. Model runs were made with and without this dual plume scenario, and with different values for porosity and dispersion coefficient.

The profiles presented in Figures 11A through 11C are based on model runs for a period of 4000 days (11 years), with a relatively high loading (equivalent to 0.1 lb/day of chromium) for the first 2000 days (5.5 years), followed by another 2000 days (5.5 years) with and without a lower loading (0.01 lb/day). The 11-year time frame was selected to simulate the operation of the pressure treatment process (mid to late 1980s) and subsequent remedial investigation work (late 1990s). The actual hexavalent chromium profile from 1997 (see also contour plots from the RI included in Appendix C) is shown in the background on these figures. The well field pumping rate was kept the same (500 gpm) in these simulations.

The MODFLOW predicted hexavalent chromium profiles indicate downgradient plume migration occurred in a southerly direction, and is not affected by the operation of the County well field located southeast of the site. This is consistent with the particle tracking groundwater flow simulations on Figure 10. To generate these profiles, the soil/water partition coefficient for hexavalent chromium was assumed to be zero (i.e. no retardation through soil adsorption). Model runs with non-zero values for the retardation factor for hexavalent chromium generated unrealistically short profiles with hexavalent chromium concentrated within one hundred feet from the source even with a newer version of the transport module (MT3DMS) in the Visual MODFLOW software package.

As seen on Figure 11A, the tip of the plume (0.01 ppm contour) is at a northing of 5,900 ft in 365 days, 5,300 ft in 1000 days and 4,400 ft in 2000 days. This translates into an average rate of 0.07 miles/year (or 3.6 years for every 0.25 miles) for the advancement of the plume. The effect of porosity and longitudinal dispersivity are illustrated by the profiles on Figures 11B and 11C. The plume gets moderately extended with an increase in the dispersivity or a decrease in the effective porosity. Figure 11D illustrates two scenarios. In the first case, contaminant loading at the site stops after the first half of the simulation period, and in the other, the loading continues at a much reduced rate through the second half of the simulation. The model predicted contaminant profile is used to develop a chart (Figure 11D) of contaminant concentration versus time at selected locations.

The model calculated profiles within the site boundary have the same general shape and relative distribution of contaminant concentrations as the chromium profile plotted from the 1997 RI groundwater data (Appendix C), and the relative concentrations at selected monitoring well locations also follow a pattern similar to actual observations. However, the exact history of the hexavalent chromium profile could not be matched with the model simulation since factors other than effective porosity and longitudinal dispersivity appear to have dictated the way the contaminant plume has evolved from the site and migrated downgradient. This includes the sequence of operations (including wood treatment and groundwater extraction and treatment) that have gone on at the plant site. However, the model generated profiles do explain the movement of the plume through the site and downgradient, and the hydrogeological parameters developed through the model can be used to simulate groundwater extraction options and predict the resulting contaminant profiles..

4 HYDRAULIC CONTAINMENT OF THE PLUME

4.1 Approach

Hydraulic containment and capture of the plume within the limits of the BB&S site was modeled using the particle tracking feature of the Visual MODFLOW package. One or more extraction wells are placed at appropriate locations in the plume, and particles are placed around the areas to be contained. Effective containment or capture occurs when the particles terminate in the extraction wells and do not leave the source area.

4.2 Simulations

Figures 12A through 12D show groundwater flow paths with one to two extraction wells and total extraction rates ranging from 12,000 ft^3/day (or 60 gpm) to 50,000 ft^3/day (or 260 gpm). The lowest flow rate was chosen based on calculations (see Appendix F) using the simplified flow equation (Q= KiA) which results in a groundwater flux rate of 72,600 gallons per day (or 50 gpm) across the width (280') of the plume in the Upper Glacial aquifer. The flow rate, number and well locations were adjusted to assess containment and capture options.

4.3 Containment and Capture

The widths of the actual chromium concentration profiles in Appendix C range from 150 ft to 280 ft. As shown on Figure 12A, the width of the capture zone calculated by the model is seen to be approximately 300 feet for an extraction well operated at 60 gpm. It increases to over 600 ft at 260 gpm. Based on the results of the model, a single extraction well operating at 60 gpm could just about intercept the cross-sectional width of the contaminant plume. Placement of the well at the downgradient site boundary with a higher flow rate (to account for variations in actual conditions from model assumptions) would fully intercept the plume and prevent further off-site contaminant migration.

Based on the model simulations shown on Figure 12, two wells, spaced apart along the axis of the plume, are needed to contain and capture the plume within the limits of the site. The extracted rate can be distributed equally between the multiple wells.

4.4 Contaminant Removal

MODFLOW simulation of groundwater extraction was performed to predict hexavalent chromium profiles within the site and the resulting contaminant removal. To perform these simulations, chromium data from the October 2005 PDI groundwater monitoring event (see Table 4) was imported into MODFLOW, which then created an interpolated plume of chromium contamination within the site as the starting point. The plume is bounded by MW-3 (north), MW-1 (east), MW-15 (west) and MW-16 (south), and has the highest chromium concentrations between monitoring well locations MW-5 and MW-10. The simulations assume no contaminant loading from the source area since the wood treatment operation does not exist and contaminated soils will be removed during site remediation. It will thus allow the establishment of a baseline from which qualitative projections can be made on cleanup durations under changing site conditions.

Model predicted groundwater contours for extraction rates of 120 and 240 gpm are shown on Figure 13A. Contaminant profiles generated with one and two extraction wells operating at a total flow of 120 gpm are shown on Figures 13B and 13C. Figure 13D shows simulated time plots of predicted chromium concentrations in the groundwater extracted at 60 to 260 gpm.

The model predicts a cleanup duration of the order of three years (see Figure 13D) with one well operating at 60 gpm at the downgradient site boundary. The continuing release of contaminants from the source area will extend the remediation time-frame. The use of two wells (at the source area and at the downgradient site boundary, with a combined higher flow than the minimum flow predicted by the model for plume capture) will ensure full interception of the plume and accelerate the remediation by targeting highly contaminated groundwater from the two areas along the axis of groundwater flow. Increasing the extraction rate to accelerate groundwater cleanup will entail higher capital expenditure but correspondingly reduced long-term operating costs.

5.0 CHEMICAL SPECIATION MODELING

Chemical speciation modeling was performed as part of this groundwater modeling and treatability study to render a better understanding of the redox reactions occurring between chromium and iron in groundwater and their dependence on the relative concentrations of the two metals.

5.1 Software – MINEQL

MINEQL is a computerized chemical equilibrium modeling system that can be used to perform calculations on low temperature (0-50^{o}C), low to moderate ionic strength (<0.5 M) aqueous systems. MINEQL is a data driven numerical program, and systems are created by selecting chemical components from a menu. The program scans a thermodynamic database and makes the calculations. MINEQL also provides tools to take control of reaction data, create a personal thermodynamic database, perform synthetic titrations and automatically process multiple samples (such as field data). MINEQL uses a thermodynamic database that contains the entire USEPA MINTEQA2 database plus data for chemical components that the EPA did not include; so all calculations produce results compatible with EPA specifications.

5.2 MINEQL Setup

Figure 14 shows the input screen for MINEQL with components (cations and anions) checked for groundwater at the site. Component concentrations are converted from mass to molar basis for model setup.

MINEQL develops a set of chemical species that are formed by a combination of the anions and cations like soluble complexes and insoluble precipitates (minerals included). The formation constants for these chemical species are extracted from the thermodynamic database that comes with the software. The input data tables in Appendix G (Table G-1A without redox reactions and Table G-1B with redox reactions) show all the components and the species associated with the groundwater system at the site.

The components (e.g. Na^{+}, Fe^{+2}, $CrO4^{-2}$, SO_4^{-}) are referred to as Type 1. Soluble complexes (e.g. $FeOH^{+}$, $HCrO4^{-1}$) are referred to as Type 2. Chemicals that can precipitate are initially placed under Type 5 (e.g. $Fe(OH)_3$, $Cr(OH)_3$). When MINEQL performs the equilibrium calculations, it checks the solution for saturation with respect to these Type 5 species, and if the solubility product is exceeded, the program precipitates the appropriate amount of the species and moves it into Type 4 (precipitated solids). The concentration of any component can be kept fixed (e.g. pH) by moving it to Type 3 and assigning it the fixed value. Components or species that are not to be considered in the computations are reassigned manually during the model setup. For this MINEQL simulation, species that have little or no effect on the chemical distribution were moved to Type 6 to minimize the number of iterations and speed up the run times.

5.3 Chemical Speciation

For the site, MINEQL simulations were performed with and without redox reactions under varying pH values (from 1.5 to 11.5 s.u.). For these runs, RI, PDI and Suffolk County water quality data were used to develop the list of chemical constituents. The highest concentration of the contaminants of concern were used to determine chemical speciation, including precipitation of metal hydroxides and oxidation/reduction of constituents like chromium, iron and copper.

Components like iron, chromium and copper exist in more than one valence state and can undergo oxidation/reduction reactions under appropriate conditions. Groundwater, with a lack of oxygen, is typically in a reducing state. Hence iron is commonly present as Fe^{+2} in groundwater. Chromium is added to the CCA preservative as chromate which is in a highly oxidative state. When the preservative enters the groundwater system, the chromate (Cr^{+6}) is subject to reduction to Cr^{+3} by iron which in turn gets oxidized to Fe^{+3}. The ferric iron is very insoluble in water while ferrous ion is relatively more soluble. Trivalent chromium also has a low solubility depending on the pH of the solution. The oxidation of iron and chromate reduction are generally slow (on the order of several years) processes under neutral pH conditions in the natural environment.

Chromate reduction is accelerated under acidic conditions. These phenomena, which affect the migration of chemicals in the groundwater environment, are simulated by MINEQL with appropriate input and setup.

Outputs from MINEQL are presented as tables in Appendix G. They include the distribution of chemical species of Cr, Fe, Cu and As at pH 6.5 (Tables G-2A and G-2B), and other tables that show the variations (molar concentrations and percent of total concentrations) by pH. The data is presented as concentrations in mg/L in Tables 5A (without redox) and 5B (with redox), and also graphically illustrated in Figures 15 and 16.

Groundwater at the site has pH values in the range of 5.5 to 6.5. Without redox reactions and in this pH range, MINEQL calculations show that all chromate, ferrous iron and arsenic should be in soluble forms at the range of concentrations observed for the site. Any chromium that is reduced to the trivalent form and any iron that is oxidized to the ferric ion will precipitate and adsorb onto the soil. While groundwater sampling and analysis for hexavalent chromium and ferrous iron can be reasonably accurate, the same cannot hold true for trivalent chromium or ferric iron. Total chromium results will tend to be elevated in turbid samples that are analyzed without filtration because of chromium precipitation in the aquifer.

When redox reactions are allowed, MINEQL calculations show all hexavalent chromium to be reduced to the trivalent form under all pH values, subject to the availability of a stoichiometric amount of ferrous iron. It should be noted that MINEQL calculates the distribution of chemical species under equilibrium conditions, and does not take into account reaction kinetics. Slow redox reactions will result in a distribution of species that is somewhat in between the concentrations shown in Tables 5A and 5B. It indicates the propensity of the reactants to proceed in a particular direction.

At the concentrations (less than 2 mg/L) observed in the groundwater, copper in either form is soluble at pH less 4 s.u. (see Table 5 and Figure 14B or 15B). The cupric ion (Cu^{+2}) remains more soluble than the cuprous ion (Cu^{+1}) at pH between 4 and 7.5 s.u. Above pH 7.5 s.u., both forms of copper will be precipitated in solution. Arsenic is observed in groundwater at the site at concentrations less than 3 mg/L. All of this arsenic will exist in solution with varying degrees of hydrolysis (see Table 5 and Figure 15B or 16B).

6.0 GROUNDWATER TREATABILITY STUDY

6.1 Field Testing

Groundwater was sampled from the monitoring wells during the PDI and tested in the field with field test kits for the heavy metals of concern. The data tabulated in Table 4 shows chromium ranging from less than 0.1 to 0.5 ppm. Iron concentrations were significantly higher in the RW wells (as high as 9 ppm) than in the MW wells.

6.2 Bench Scale Testing

Limited bench scale testing was performed to assess if existing conditions in the groundwater (i.e. relative iron and chromium concentrations) facilitate the reduction and subsequent precipitation of chromium. Besides iron, sodium bisulfite was also tested as an alternate for chromium reduction in the treatment process. Groundwater samples were obtained from three wells at the site based on the results of iron and chromium analysis during the PDI.

Photos of the test samples are shown on Figure 17. Samples were obtained from wells RW-1, RW-2, MW-5 and MW-10. Based on the initial characterization (see Table 7), bench tests were performed on three of the four samples (excluding MW-5). RW-2 represented a sample with high iron concentrations while MW-10 had the highest chromium concentration. There were significant variations in iron concentrations between the field measurements and in the test facility. This is most likely due to iron oxidation over time under aerobic conditions encountered when the groundwater is pumped and transported, and the resulting precipitation of the oxidized iron.

The groundwater samples were subject to redox reactions with sodium bisulfite and ferrous sulfate. Sulfuric acid was used to lower pH and sodium hydroxide was used to raise it. After mixing and final pH adjustment, an anionic polymer was added to each sample to facilitate flocculation of the precipitated solids (by mixing at a slow speed with jar test equipment) and then allowed to settle. The settled supernatant was sampled for chromium and iron.

The results are presented in Table 8. In Test A, the samples were treated separately with sodium bisulfite at pH 2 s.u. followed by a precipitation step at pH 9.5 s.u. This process is relatively more effective in chromium removal partly due to higher pH values needed for complete chromium precipitation. Test B was performed with just ferrous sulfate addition to reduce hexavalent chromium followed by pH adjustment to 10 s.u. to precipitate trivalent chromium. The stoichiometrically excess ferrous iron resulted in the removal of a greater percentage of chromium. Test C repeated Test A with sodium bisulfite reduction at pH 2.5 s.u. followed by precipitation at pH 10.2 s.u., but was not nearly as effective as Test B.

6.3 Treatment Alternatives

MINEQL calculations of equilibrium conditions at varying pH values show that the complete reduction of chromium in groundwater with iron is thermodynamically feasible. However, groundwater sampling and the treatability tests show the redox reaction to be rate limited by pH and the relative concentrations of iron and chromium. For an on-site treatment system, ferrous sulfate addition may be required (depending on iron concentration in the groundwater) in order to maintain excess iron to maximize the efficiency of chromium reduction. The excess iron will also coprecipitate copper (as shown by the MINEQL runs), and can remove arsenic from its soluble form through adsorption on to precipitated iron hydroxide.

7.0 SUMMARY

The following summarizes the results of this groundwater flow, transport and chemical equilibrium modeling.

7.1 Groundwater Flow

MODFLOW was used to simulate groundwater flow in a model domain extending 4,000 to 6,000 feet beyond the site boundaries in all directions. The model was calibrated to USGS heads and compared to the SCWA groundwater model. Results of the modeling show that groundwater moves south towards the ocean, and the pumping influence of the Suffolk County well field (located about a mile southeast of the site) does not extend to the contaminant plume at the site. The groundwater flow path, and hence contaminant migration, is predominantly in the Upper Glacial aquifer as predicted by MODFLOW.

7.2 Containment/Capture

The contaminant plume is up to 280 feet wide at the site, and model calculations indicate an average plume advancement rate of 0.07 miles/year. MODFLOW simulations using the transport engine MT3DMS (without retardation) indicate a radius of influence of around 300 ft for a well pumping at 60 gpm at the site. Results of the modeling indicate that the placement of a well at the downgradient site boundary would just about intercept the plume and prevent further off-site contaminant migration. The cleanup duration is predicted to be of the order of three years with one well. A higher rate than 60 gpm is recommended to ensure full capture of the plume and to account for actual conditions that may vary from the model assumptions. The remediation time frame can be significantly reduced with another well placed near the source area with a combined flow rate of around 120 gpm.

7.3 Groundwater Treatment

Computations using the MINEQL chemical equilibrium model indicate two factors contributing to the speciation of chromium in the groundwater. One is the reduction of hexavalent chromium by ferrous iron, which is a slow process and requires excess iron to be effective. Secondly, trivalent chromium, the reduced form, has a low solubility and tends to precipitate and adsorb onto soil soon thereafter. Hexavalent chromium, with its relatively high solubility, is very mobile as seen from the extent of the plume. Trivalent chromium becomes less mobile in its precipitated form. These redox and precipitation processes can be used to effectively treat contaminated groundwater at the site with the proper combination of reagent dosage and pH. Ferrous sulfate is the recommended chemical for chromium reduction since it is relatively more effective in chromium removal. Moreover, iron is already present in the groundwater at relatively high concentrations, and supplemental ferrous sulfate requirements may be minimal. The iron can also enhance copper removal by coprecipitation, and arsenic by adsorption onto the precipitated hydroxide.

BB&S Lumber Site Predesign Investigation
Groundwater Flow/Transport Modeling & Treatability Study

FIGURES

BB&S Lumber Site Predesign Investigation
Groundwater Flow/Transport Modeling & Treatability Study

TABLES

BB&S Lumber Site Predesign Investigation
Groundwater Flow/Transport Modeling & Treatability Study

APPENDICES

BB&S Lumber Site Predesign Investigation
Groundwater Flow/Transport Modeling & Treatability Study

APPENDIX A

USGS GEOLOGIC MAPS/REFERENCE

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APPENDIX B

SURFER PLOTS OF GROUNDWATER CONTOURS

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APPENDIX C

CHROMIUM PROFILE IN GROUNDWATER

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APPENDIX D

SCWA'S DYNFLOW MODEL INPUT/OUTPUT DATA

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APPENDIX E

PEST/MODFLOW CALIBRATION LOG/RUN RECORD

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APPENDIX F

CALCULATIONS/VERIFICATIONS FOR GROUNDWATER FLOW MODELING

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APPENDIX G

MINEQL CHEMICAL SPECIATION MODEL INPUT/OUTPUT

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Groundwater Flow/Transport Modeling & Treatability Study

APPENDICES

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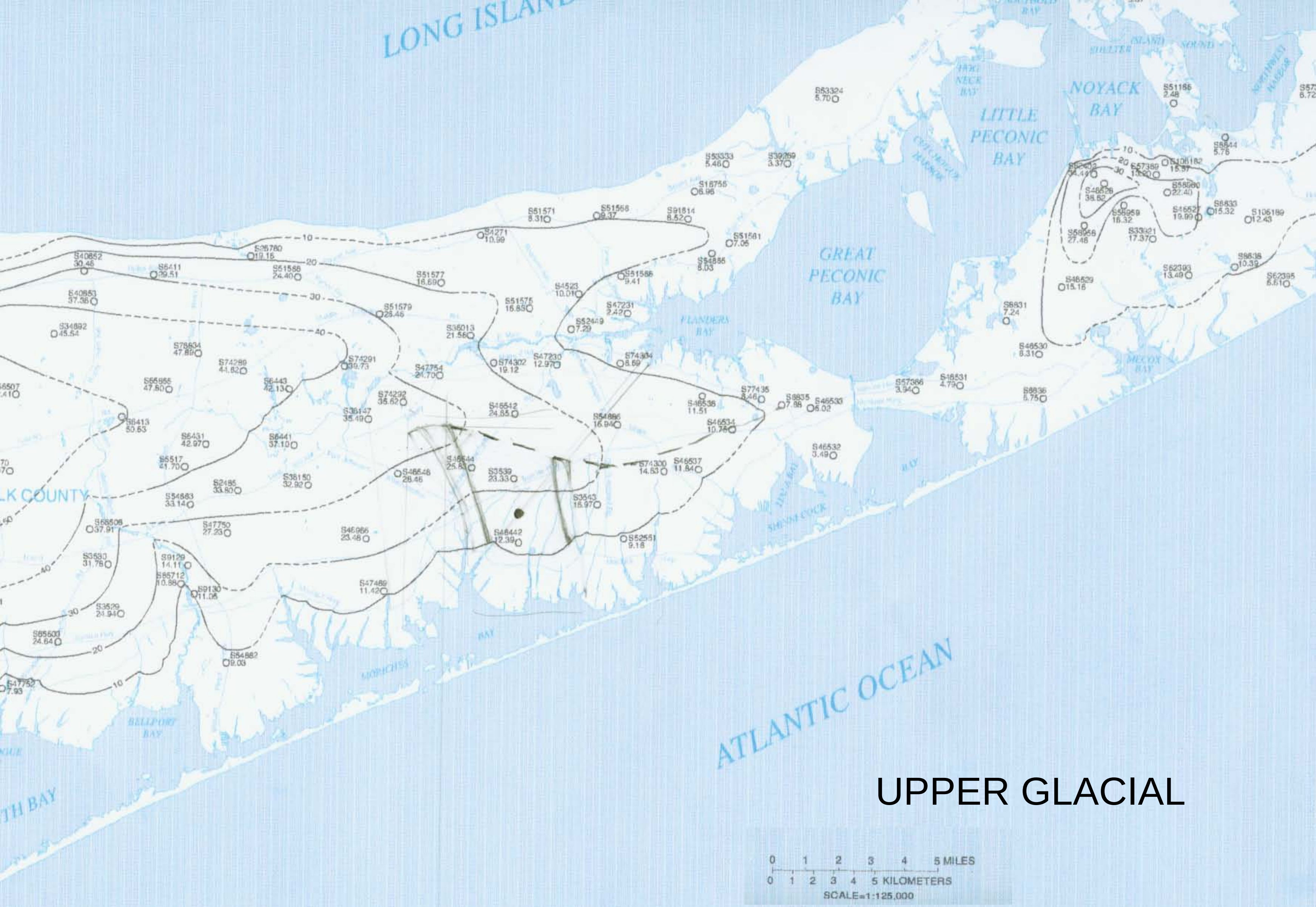
Groundwater Flow/Transport Modeling & Treatability Study

APPENDIX A

USGS GEOLOGIC MAPS/REFERENCE

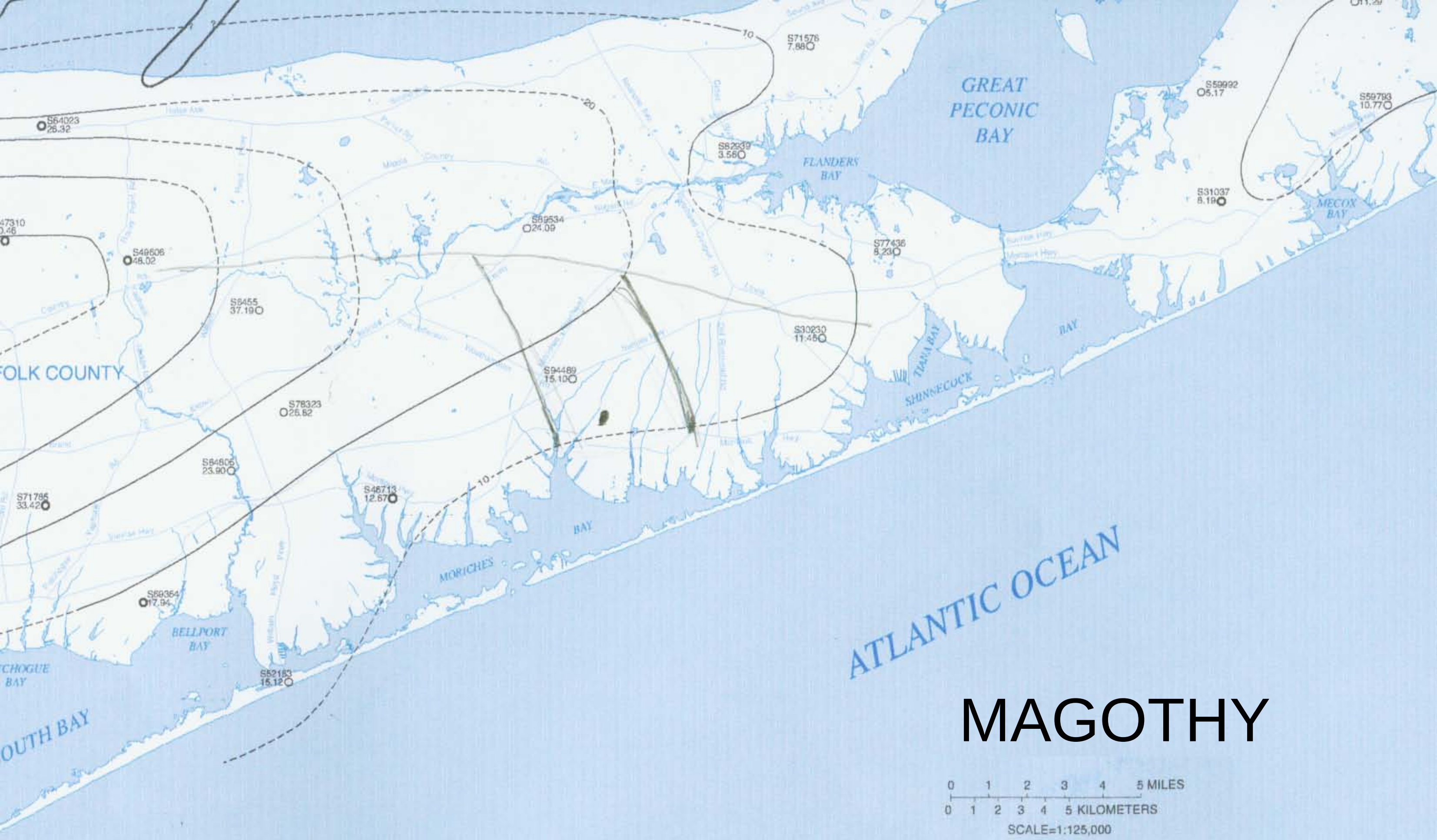


UPPER GLACIAL

EXPLANATION

S46549 24.16 ○ OBSERVATION WELL--Upper number is well number assigned by the New York State Department of Environmental Conservation; lower number is water-table altitude, in feet above or below (-) sea level.

—10 – – WATER-TABLE CONTOUR--Shows altitude of water table. Solid where approximately known; dashed where inferred. Contour interval 10 feet.



MAGOTHY

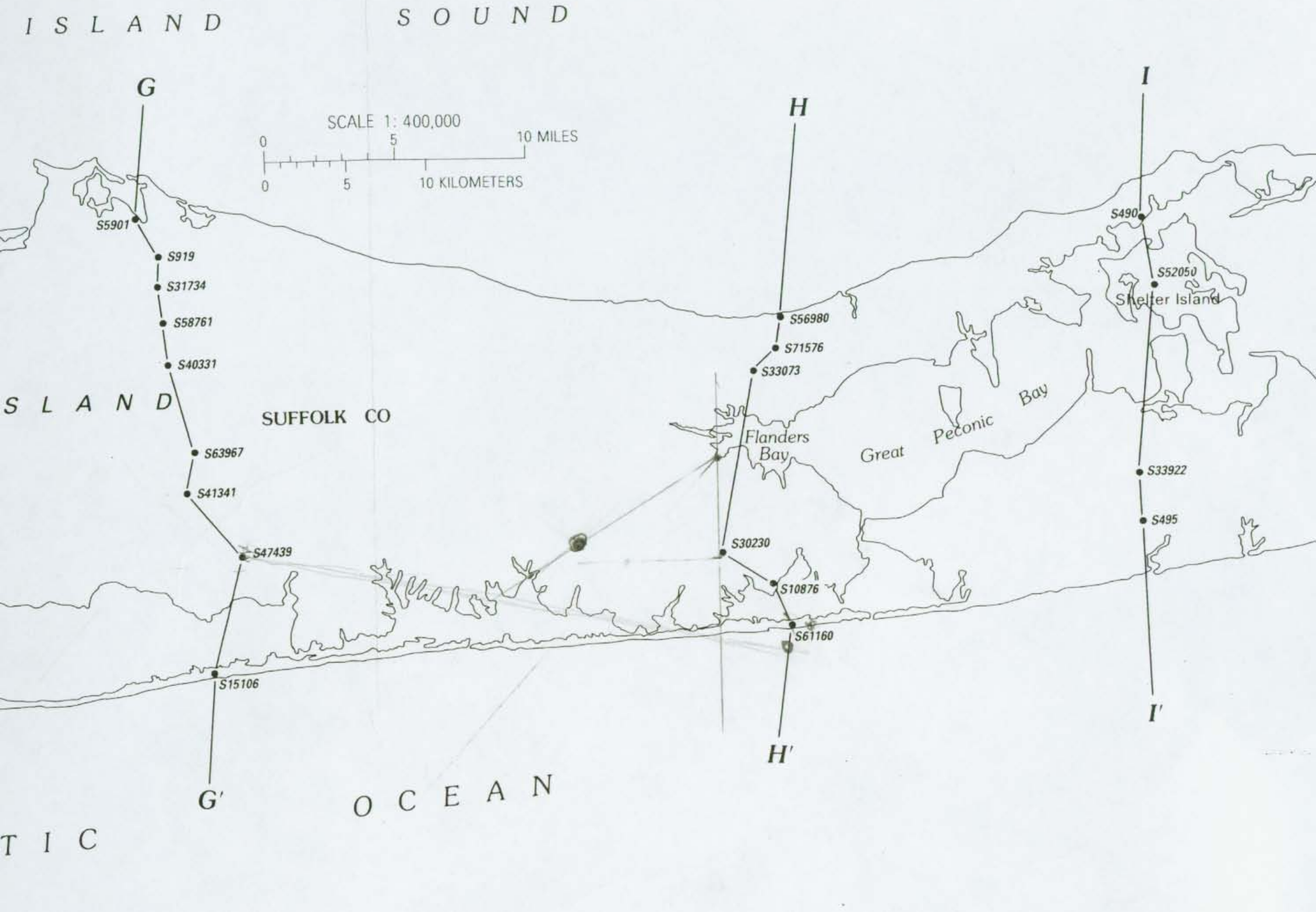
EXPLANATION

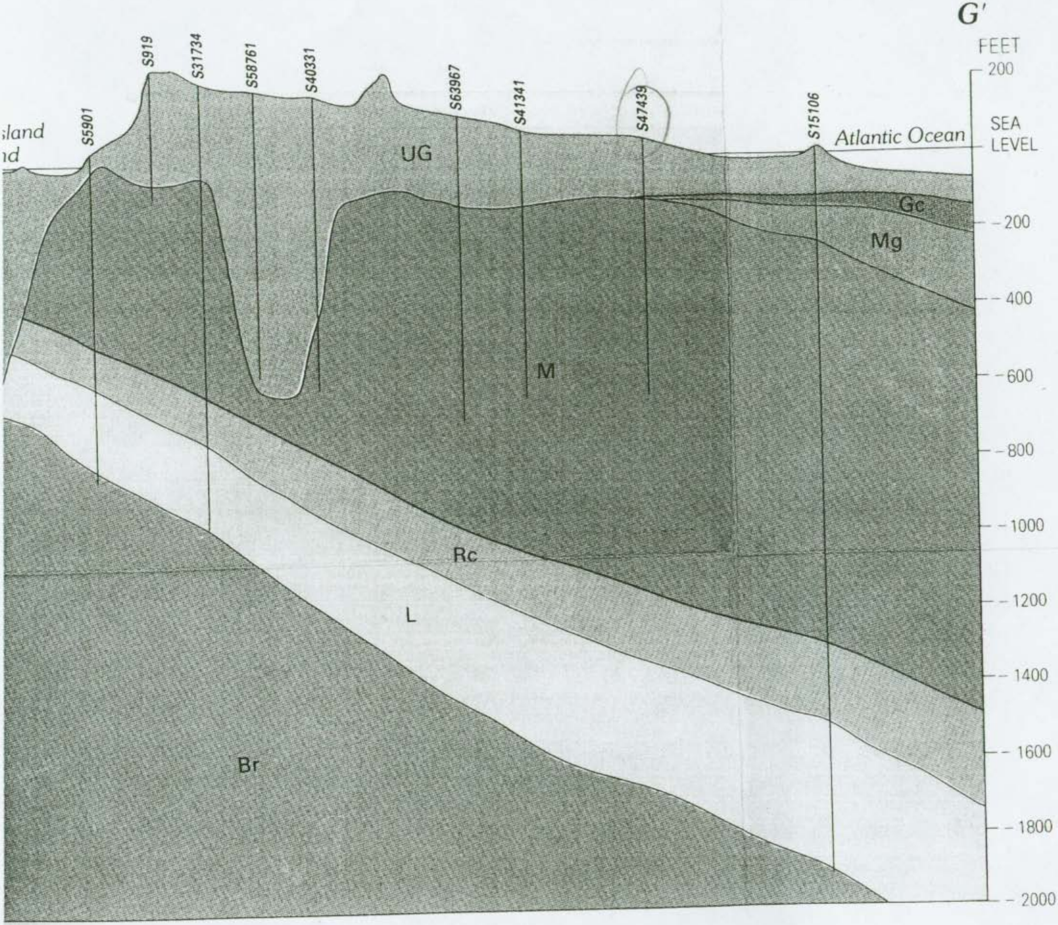
S32595 41.85 ○ S64023 26.32 ● OBSERVATION OR SUPPLY WELL-- Thin circle indicates observation well; thick circle indicates public or industrial supply well. Upper number is well number assigned by the New York State Department of Environmental Conservation; lower number is potentiometric-surface altitude, in feet above or below (-) sea level.

— 10 – – LINE OF EQUAL POTENTIOMETRIC-SURFACE ALTITUDE--Shows altitude at which the water level would have stood in tightly cased wells. Solid where approximately known; dashed where inferred. Contour interval 10 feet.

—— INFERRED LIMIT OF THE MAGOTHY AQUIFER

gineers, Coastal Engineering Research Center, Fort Belvoir, Va.,
–3.
Hydrogeologic framework of the New Jersey coastal plain: U.S.
Open-file Report 84–730, 61 p.

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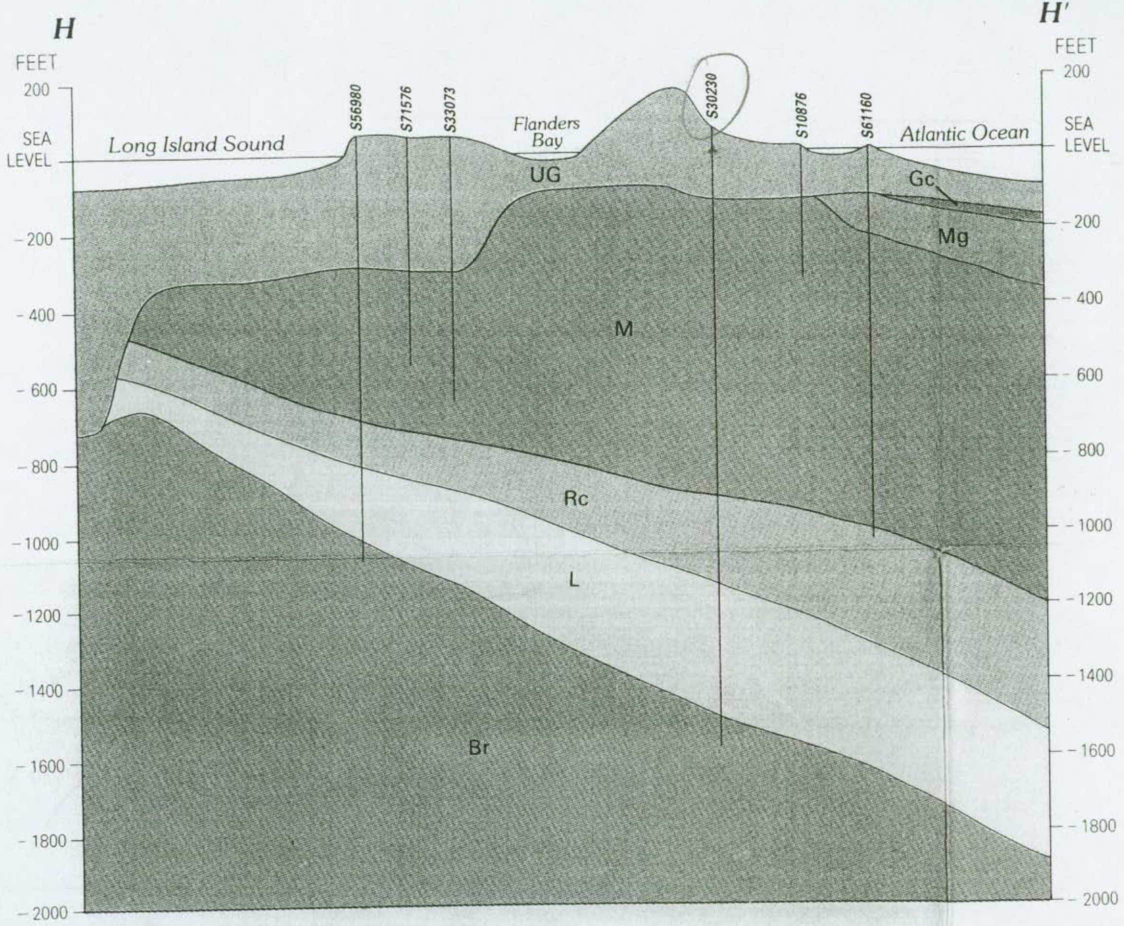
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S33073
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S30230
S10876
S61160
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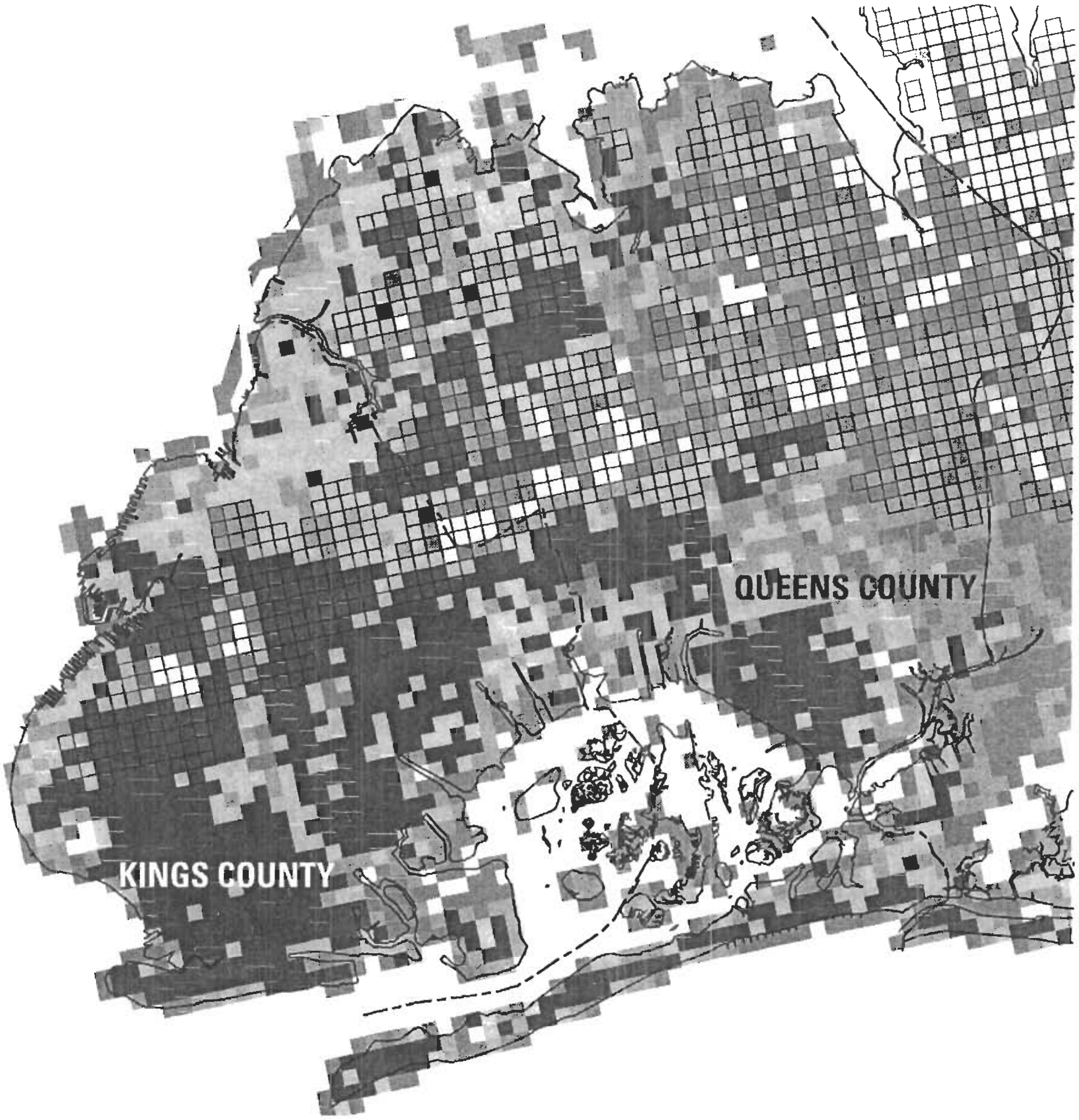
USGS
science for a changing world

UPPER GLACIAL

Simulation of Ground-Water Flow and Pumpage in Kings and Queens Counties, Long Island, New York

Prepared in cooperation with the New York City Department of Environmental Protection



U.S. Geological Survey
Water-Resources Investigations Report 98-4071

Environmental Protection, and John Isbister, Donald K. Cohen, and Joan Karn of Malcolm Pirnie, Inc. provided hydrologic data and interpretation that assisted in model development and map preparation. Sean Ahearn of Hunter College interpreted satellite imagery to estimate runoff in the study area. Suggestions for the manuscript were provided by H.T. Buxton and Angelo Kontis of the U.S. Geological Survey.

HYDROGEOLOGY

Development of the ground-water-flow model for this study required: (1) delineation of the aquifers and confining units (extent, thickness, and hydraulic characteristics), and (2) definition of hydrologic conditions, which include recharge from precipitation and lateral inflow of ground water, and discharge to streams, the shore, subsea saltwater bodies, and wells. These characteristics are described below.

Aquifers and Confining Units

Hydrogeologic units are distinguished on the basis of depositional history and water-bearing properties. The principal units in Kings and Queens Counties are described in table 1 and depicted in hydrogeologic sections in figure 2. Altitudes of the upper surfaces of the principal units (bedrock, Lloyd aquifer, Raritan confining unit, Magothy aquifer, Jameco aquifer, Gardiners Clay, and upper glacial aquifer) were interpreted from about 200 lithologic logs.

Vertical sections A-A′ and B-B′ (fig. 2) illustrate critical features of the hydrogeologic framework. Section A-A′ intersects an area where sediments of the Jameco aquifer were deposited by glacial meltwaters that were simultaneously eroding the Magothy surface. Jameco deposits near the southern shore are much thinner than the underlying Magothy deposits. Section B-B′ (fig. 2) intersects a major erosional channel that Soren (1978) interpreted to be an ancestral diversion of the Hudson River, trending north-south from Flushing Bay to the center of Queens. This channel has eroded through the Magothy aquifer into the Lloyd.

The hydraulic properties used in the model are those defined in the regional Long Island model (Buxton and Smolensky, in press). Horizontal hydraulic conductivity of the Jameco aquifer and outwash zone of upper glacial aquifer ranges from 200 to 300 ft/d; and that of the morainal zone ranges from 20 to 80 ft/d. Horizontal hydraulic conductivity of the Magothy and Lloyd aquifers ranges from 30 to 180 ft/d. The horizontal-to-vertical anisotropy of these deposits (table 1) is greater than that of the Jameco and upper glacial aquifers because the Magothy and Lloyd contain an abundance of discontinuous clay lenses.

Hydrologic Conditions

The body of fresh ground-water beneath Kings and Queens Counties is bounded on the top by the water table and on the bottom by relatively impermeable crystalline bedrock. The southern, western, and northern lateral boundaries of the freshwater are bodies of saline ground water and the saline tidal water that surround Long Island (fig. 1). Before development in Kings and Queens Counties, water entered the ground-water system as precipitation infiltrating to the water table and as underflow moving westward from Nassau County into Queens County. About 50 percent of the total precipitation that fell at that time infiltrated the soil and entered the water table; less than 5 percent ran off into surface-water bodies, and the remainder (45 percent) was lost through evapotranspiration. Ground water discharged from the system as base flow to streams whose channels intersected the water table, and along the shores and in offshore subsea regions. Water-budget data from a regional-model simulation of the predevelopment period (before 1900) is given in table 2.

Urbanization and pumping have altered the rate and distribution of discharge and recharge and have introduced new components in the water budget. Ground water discharges from all of the aquifers to wells, from the water-table aquifer to sewers, streams, and the shore, and from the confined aquifers to deep subsea regions. A comparison of water-budget data from regional-model simulations of the predevelopment period with those for the presumed steady-state period in 1983, when pumping in Queens by the Jamaica Water Supply Company (JWSC) was at its maximum, is given in table 2; pumping rates during the early 1990's averaged less than half of those of 1983, and 1991 water levels and gradients are generally intermediate between predevelopment values and 1983 values. Discharge and recharge components for 1991 are described below.

Discharge

The New York State Department of Environmental Conservation (NYSDEC) inventory of pumping wells during 1991 is given in Appendix A. In 1991, 24 Mgal/d was pumped in the Jamaica area of southeastern Queens County and about 180 Mgal/d was pumped in Nassau County. Most of the industrial and commercial pumping (27 Mgal/d) in Kings and western Queens Counties represents dewatering of subway tunnels and deep basements that are flooded as a result of water-table recovery since the cessation of public-supply pumping. The Metropolitan Transit Authority (MTA) is the largest industrial user of water; it withdraws more than 10 Mgal/d to dewater Brooklyn subway tunnels.

Ground water discharges to Long Island Sound and the Atlantic Ocean through the sea floor and is greatest near the shore, where vertical hydraulic gradients are largest. Discharge decreases rapidly offshore as the vertical hydraulic gradient decreases. Subsea discharges are discussed further on in the section on simulation of ground-water flow and pumpage.

The relation between ground water and streams affects flow patterns within the ground-water system. Gaining streams flow continually where their channels intersect the water table; in most streams, this intersection is continuous from the start of flow to the mouth. The location of the start of flow shifts with the water-table altitude; thus, the length of the stream varies seasonally. The rate of discharge to the stream channel is controlled by (1) the difference between the water table and the stream stage, (2) channel geometry, and (3) water-transmitting properties of the aquifer and streambed material. When the water table falls below the stream channel, the channel becomes dry. Ground-water discharge to streams (base flow) is the most readily measured type of natural discharge; base flows of nine Kings and Queens County streams that are now flowing were estimated for three periods of development on the basis of discharge measurements and through comparison of discharge measurements with water levels at wells adjacent to the streams. The resulting discharges are given in table 3. Many of the predevelopment stream channels in Kings and Queens have been filled and therefore are not listed in table 3.

Recharge

Recharge is calculated from the following equation:

$$\textit{Recharge} = \textit{Precipitation} - \textit{Evapotranspiration} - \textit{Runoff} + \textit{Artificial Returns} \qquad (1)$$

About half the long-term average precipitation (22 in/yr) was lost through evapotranspiration, leaving a potential recharge rate of about 1.1 $(\text{Mgal/d})/\text{mi}^2$. This corresponds to an application of 160 Mgal/d (table 2) to the regional model's predevelopment active area in Kings and Queens Counties. Runoff and artificial returns during the predevelopment period were negligible, and 160 Mgal/d represents total annual recharge.

Urbanization has caused runoff to increase, and the recharge estimated for 1983 from precipitation in Kings and Queens Counties is 78 Mgal/d (Buxton and Smolensky, in press), 49 percent of the predevelopment rate Nassau County uses an extensive system of recharge basins that capture storm runoff; this system roughly preserves the total predevelopment recharge rate, but not its distribution.

Artificial returns in Kings and Queens Counties are primarily from leakage from water-transmission mains and sewers; an estimated 460 Mgal/d is imported from upstate reservoirs (Odd Larson, New York City Department of Environmental Protection, oral commun., 1997) and flows through thousands of miles of supply lines. Artificial returns contributed an estimated 58 Mgal/d to the 1983 total annual recharge in Kings and Queens Counties (Buxton and Smolensky, in press).

Ground-Water Levels

Water levels measured at 24 wells in Kings County and 22 wells in Queens County in March 1993 were used to define the water-table altitude in the upper glacial aquifer (fig. 3A) and the potentiometric-surface altitude in the Magothy and Jameco aquifers (fig. 3B) and Lloyd aquifer (fig. 3C). A regional divide separating ground water that flows southward toward the Atlantic Ocean from water that flows northward to Long Island Sound or the East River trends east-west through northern Queens, then gradually turns southward through Brooklyn (figs. 3A and 5). Zones of low hydraulic conductivity and shallow depth to bedrock cause anomalously high water levels in some morainal

Table 1. Hydrologic units underlying Kings and Queens Counties, N.Y., and their water-bearing properties as represented by the Long Island regional model

[gal/min, gallons per minute; ft, feet; ft/d, feet per day. Modified from Doriski and Wilde-Katz, 1983. Modeled hydraulic properties from Buxton and Smolensky, in press]

System	Series	Age	Stratigraphic unit (hydrologic unit names are in parentheses)	Approximate range in thickness (feet)	Character	Water-bearing properties, modeled hydraulic conductivity, and anisotropy
QUATERNARY	Holocene	Post glacial	Holocene (recent) deposits (upper glacial aquifer)	0-40	Beach sand and gravel and dune sand, tan to white, black, brown, and gray bay-bottom deposits of clay and silt; artificial fill. Beach and dune deposits are mostly stratified and well sorted. Fill includes earth and rocks, concrete fragments, ashes, rubbish, and hydraulic fill.	Sandy beds of moderate to high permeability beneath barrier beaches, locally yield fresh or salty water from shallow depths. Clayey and silty beds beneath bays retard saltwater encroachment and confine underlying aquifers.
	Pleistocene	Wisconsinan	Upper Pleistocene deposits (upper glacial aquifer)	0-300	Till composed of clay, sand, gravel, and boulders, forms Harbor Hill and Ronkonkoma terminal moraines. Outwash consisting mainly of brown fine to coarse sand and gravel, stratified. Interbedded with clays.	Till is poorly permeable. Sand and gravel part of outwash highly permeable; yields of individual wells are as much as 1,700 gal/min. Specific capacities of wells as much as 109 gal/min per foot of drawdown. Water fresh except near shorelines. Horizontal hydraulic conductivity: 20-80 ft/d (moraine), 200-300 ft/d (outwash). Horizontal to vertical anisotropy is 10:1. Specific yield is 0.25 (moraine), 0.3 (outwash).
				0-40	Clay and silt, gray and grayish green; some lenses of sand and gravel. Contains shells, foraminifera, and peat. Altitude of top of unit about 20 ft below sea level. Interbedded with outwash in southern part of area.	Relatively impermeable confining unit. Retards saltwater encroachment in shallow depths. Confines water in underlying outwash deposits when present.
			unconformity			
		Sangamon interglaciation	Gardiners Clay	0-150	Clay and silt, grayish-green; some lenses of sand and gravel. Contains lignitic material, shells, glauconite, foraminifera, and diatoms. Interglacial deposit. Altitude of surface 50 ft or more below sea level.	Relatively impermeable confining layer above Jameco aquifer. Locally contains moderately to highly permeable sand and gravel lenses. Confines water in underlying Magothy aquifer. Vertical hydraulic conductivity is 0.001 - 0.0029 ft/d.
			unconformity			
		Illinoisan(?)	Jameco Gravel (Jameco aquifer)	0-200	Sand, coarse, granule to cobble gravel, generally dark brown and dark gray. A stream deposit in a valley cut in Matawan Group-Magothy Formation undifferentiated deposits. Buried valley of ancestral Hudson River.	Highly permeable. Yields as much as 1,500 gal/min to individual wells. Specific capacities as high as 135 gal/min per foot of drawdown. Contains water under artesian pressure. Water commonly has high iron content and is salty near shoreline. Horizontal hydraulic conductivity is 200-300 ft/d. Horizontal to vertical anisotropy is 10:1. Specific storage is 1 x 10^{-6} per ft.

Table 1. Hydrologic units underlying Kings and Queens Counties, N.Y., and their water-bearing properties as represented by the Long Island regional model—continued

System	Series	Age	Stratigraphic unit (hydrologic unit names are in parentheses)	Approximate range in thickness (feet)	Character	Water-bearing properties, modeled hydraulic conductivity, and anisotropy
QUATERNARY?	Pleistocene?	Illinoisan(?)	Reworked Matawan-Magothy channel deposits (upper glacial or Magothy aquifer)	0-260	Sand, fine to coarse, dark-gray and brown; gravel. Contains some thin beds of silt and clay.	Moderate to highly permeable. Provides an interconnection between Magothy aquifer and upper glacial aquifer where Gardiners Clay is absent.
			—unconformity—			
CRETACEOUS	Upper Cretaceous		Matawan Group-Magothy Formation, undifferentiated (Magothy aquifer)	0-500	Sand, fine to medium gray; interfingered with lenses of coarse sand, sandy clay, silt, and solid clay. Generally contains gravel in bottom 50 to 100 ft. Lignite and pyrite abundant.	Slightly to highly permeable. Individual wells yield as much as 2,200 gal/min. Specific capacities as high as 80 gal/min per foot of drawdown. Water mainly under artesian pressure; some wells in southern part of area flow. Water generally is of excellent quality except where contaminated by salty water, high iron concentrations, or by dissolved constituents associated with human activities. Horizontal hydraulic conductivity is 30-180 ft/d. Horizontal to vertical anisotropy is 100:1. Specific yield is 0.15. Specific storage is 1 x 10^{-6} per ft.
			—unconformity—			
			Raritan Formation Unnamed Clay Member (Raritan confining unit)	0-200	Clay, gray, white, and some red and purple; contains interbedded layers of sand and gravel. Lignite and pyrite occur widely throughout.	Relatively impermeable confining unit. Local lenses and layers of sand and gravel, moderate to high permeability. Vertical hydraulic conductivity is 0.001 ft/d.
			Raritan Formation Lloyd Sand Member (Lloyd aquifer)	0-300	Sand, fine to coarse, gray and white, and gravel; some lenses of solid sandy clay, and clayey sand. Thin beds of lignite locally.	Yields as much as 2,000 gal/min to individual wells. Specific capacities as high as 44 gal/min per foot of drawdown. Water under artesian pressure; some wells flow. Water of good quality except for high iron content. Horizontal hydraulic conductivity is 35-75 ft/d. Horizontal to vertical anisotropy is 10:1. Specific storage is 1 x 10^{-6} per ft.
			—unconformity—			
Paleozoic (or) Precambrian			Undifferentiated gneiss, schist, pegmatite (Bedrock)	--	Crystalline metamorphic and igneous rocks. Soft, clayey weathered zone at top, as thick as 100 ft.	Relatively impermeable. Contains water along joints and fault zones.

overlying units, as indicated by elevated heads beneath the confining units. As a result, the saltwater-freshwater interface beneath the confining unit is displaced seaward. The areas in which this upward discharge occurs are referred to as subsea-discharge boundaries.

The rate at which ground water discharges to subsea discharge boundaries depends on hydrologic conditions within the aquifer. These boundaries in the Kings-Queens model were treated in the same way as in the regional model (Buxton and Smolensky, in press) and are represented by constant heads along the upper surface of the confining units; this allows the rate of ground-water discharge to change as head within the system responds to natural or human-induced stresses. Under the assumption that the salty ground water is in hydrostatic equilibrium, the constant head (H) for each subsea-discharge boundary cell was calculated as:

$$H = z\frac{(\rho_s - \rho_f)}{\rho_f} \tag{4}$$

where

H is the constant head (L);

z is depth of the upper surface of the confining unit below sea level (L);

ρ_s is the density of saline ground water (ML^{-3}), and

ρ_f is the density of fresh ground water (ML^{-3}).

Pumpage

Locations of public-supply wells and industrial wells, taken from the 1991 NYSDEC inventory of pumping wells, are shown in figure 8. Pumped wells were represented in the model by constant-flux internal boundary conditions at cells corresponding to each well's location and screen-zone depth (Appendix A). Most wells that pump less than 0.5 Mgal/d are used for industrial purposes. Industrial pumping was estimated as the reported maximum yield per hour multiplied by 8 (to represent an 8-hour pumping period). Most wells that pump more than 0.5 Mgal/d are either public-supply wells (in Queens County) or subway-dewatering wells (in Kings County). The JWSC pumped an average of 24 Mgal/d for public supply in 1991. MTA subway-dewatering pumpage in 1991 is estimated to have been 10 Mgal/d. Proposed long-term dewatering strategy at the Nostrand and Newkirk stations (fig. 8) would increase the withdrawal rate of 3 Mgal/d to about 6 Mgal/d. This increased rate was included in hypothetical transient-state simulations for estimation of pumping-period durations.

Recharge

The spatial distribution of 1991 recharge was estimated through a geographic information system (GIS) in which map layers represent factors affecting precipitation, runoff, and artificial returns. Runoff was represented by classification of Systeme pour l'Observation de la Terre (SPOT) imagery (Sean Ahearn, Hunter College, written commun. 1996) that indicates the percentage of impervious surface area per model cell (fig. 9). Precipitation and leakage from sewer lines above the water table generally increase as land surface elevation increases; total recharge was augmented within a zone delineated by model cells with land surface 50 ft or greater above sea level (fig. 9).

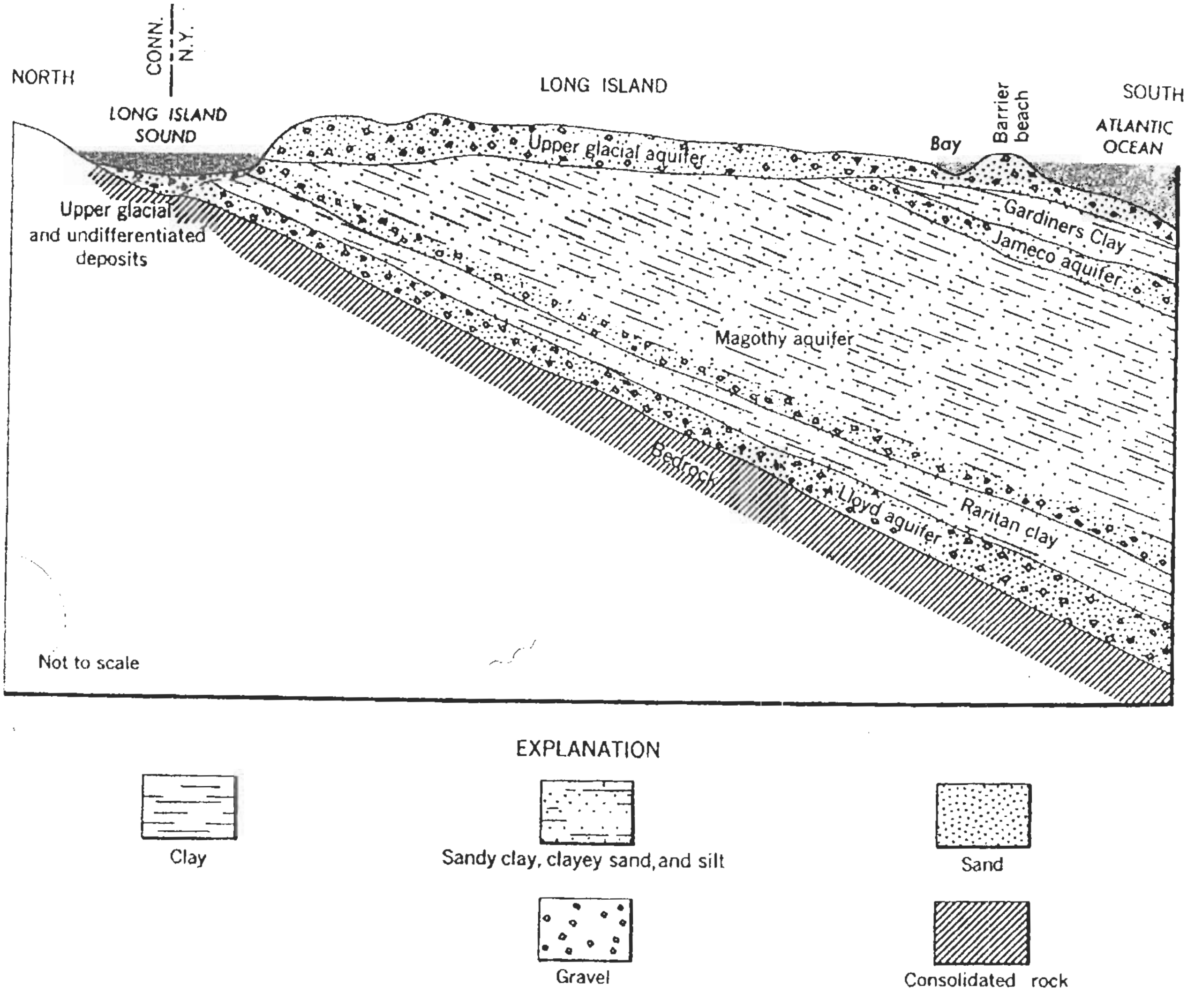
Annual recharge rates used in the refined Kings-Queens model area for the 1991 steady-state condition are shown in figure 10. Total recharge for the 1991 model was similar to that in the regional model for Kings and Queens Counties, although the distribution differed. Artificial returns were estimated to supplement recharge in Kings and Queens Counties by as much as 3 in/yr. Recharge values for Nassau County were taken directly from the regional model (Buxton and Smolensky, in press). In the pumping scenarios to be discussed, enhancement of recharge with surplus water from upstate reservoirs was simulated by injection at proposed wells and not included in the model recharge array.

Model Calibration and Sensitivity Analysis

Calibration of the refined model entailed adjustment of hydraulic property values and boundary conditions from the regional model in an attempt to improve the match between simulated heads and flows with measured heads and flows. Differences between the regional and refined models included (a) rate of recharge, which was calculated as described in the recharge section, (b) configuration of streams and shorelines, which were dependent on model grid discretization, (c) minor corrections to the vertical discretization and conductance values identified through GIS, and (d) rates and locations of pumping wells. Adjustments of hydraulic parameters during

LONG ISLAND GROUNDWATER[1]

Nassau and Suffolk Counties with close to 3 million people are completely dependent on groundwater for all of their freshwater needs. As a result the hydrology of Long Island has been extensively studied. Long Island is completely surrounded by salt water. New York City derives its water from upstate, but the supply is just adequate to provide the needs of the city. Thus the only source of freshwater on Long Island now or in the future is precipitation that becomes part of the groundwater system. Luckily an adequate supply of high quality freshwater is available if Long Island properly manages its water. Long Island's groundwater aquifer consists of a very large wedge of unconsolidated Cretaceous sands, gravels, silts and clay overlain by similar glacial sediments. This wedge of sediments feathers out to the north of the island and thickens to some 2000 feet at Fire Island. It comprises three major aquifers, an Upper Glacial aquifer at the top, the Magothy aquifer in the middle and a deep less accessible Lloyd aquifer lying just above the Paleozoic metamorphic basement rocks. There are two major confining units. The Pleistocene Gardiners Clay is found mainly on the southern part of the island and provides some restriction of flow between the Upper Glacial and the Magothy aquifers. The other confining unit is the Raritan confining unit which is quite thick and restricts the flow between the Lloyd and the Magothy aquifers.



Precipitation enters the groundwater system by infiltration through the porous soil at Long Island's surface. Due to the porous soil Long Island has an immature stream development, thus a relatively high percentage of wet

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[1] This summary is derived mainly from "Proceedings of the Conference on Water Quality on Long Island" sponsored by The Center for Regional Policy Studies and the Long Island Regional Planning Board held at the State University of New York at Stony Brook, January 26, 1993.

precipitation reaches the groundwater. The water moves laterally in the Upper Glacial aquifer to streams and shoreline or moves downward through the Upper Glacial aquifer to the lower units. Some of the water from the Magothy circulates downward and then flows upward toward the shoreline and then into the Long Island Sound or Atlantic Ocean. The rest mixes at depth with salt water under the Long Island Sound and Atlantic Ocean. A very small percentage of the water penetrates the Raritan confining unit and enters the Lloyd aguifer. The height of the water table and the location of the interface between the freshwater and saltwater at depth are transient and are affected by the extent of pumping and rainfall. Most streams on Long Island are effluent, that is they are fed by groundwater. If an area has too little rainfall or is pumped extensively, streams, lakes and ponds dry up.

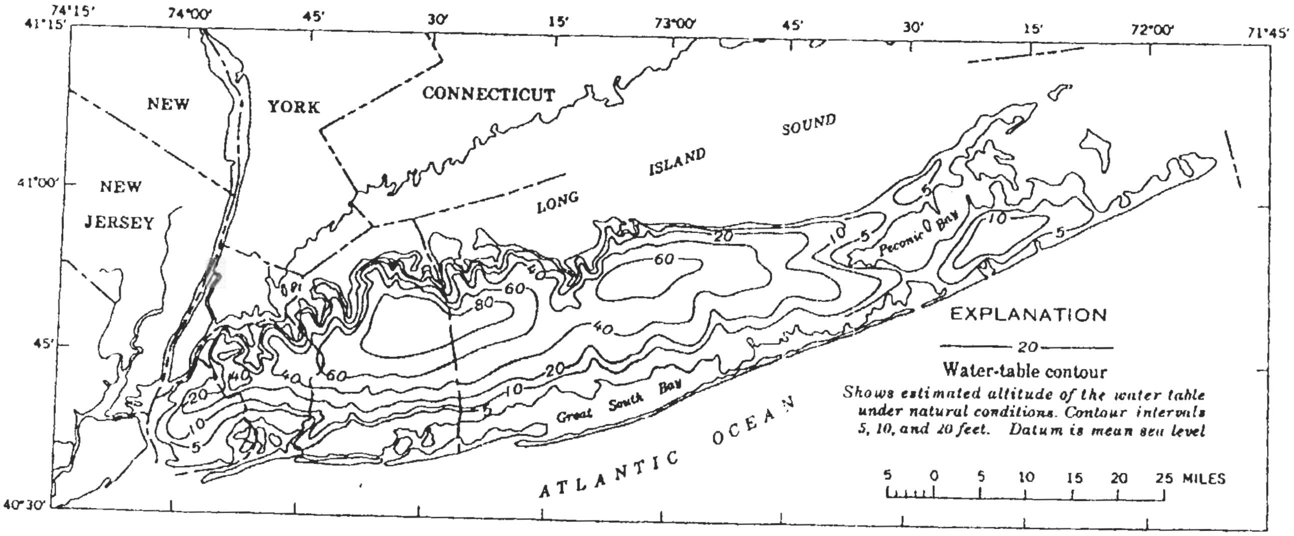


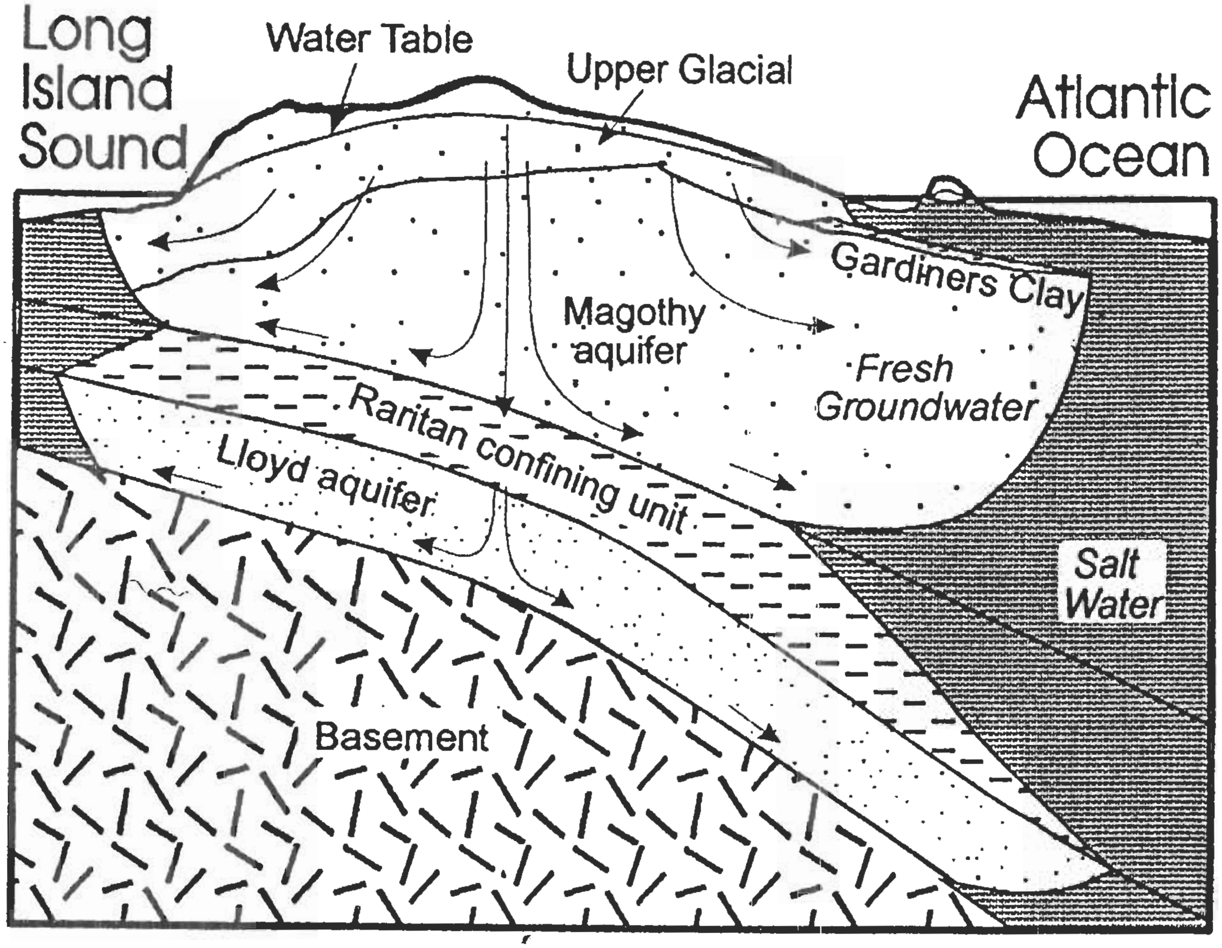
FIGURE 9.—Estimated average position of the water-table under natural conditions.

The major zone of recharge, especially to the Magothy and Lloyd aquifers, is along the center of the island where the water table is highest. The water system is a freshwater bubble surrounded by saltwater. There is no outside source of freshwater to the system. Recharge is not possible from the mainland. The only rocks on the mainland associated with Long Island are the impermeable basement rocks that crop out in New York to the west and Connecticut to the north. Long Island receives on average 44 inches of rain, or its equivalent in snow, per year distributed equally throughout the year, that is 3 to 4 inches per month. Approximately 50% of this rainfall is returned to the atmosphere as evapotranspiration. Each day 1,126 million gallons of water are recharged from precipitation. This is a dynamic system essentially at steady state, so an equal amount of water must be lost from the system as enters it. Before development 460 million gallons per day (MGD) were discharged through streams, 585 MGD along the shore, and 81 MGD at depth through the freshwater-saltwater interface. Of the recharge that entered Long Island's aquifer system 235 MGD would reach the base of the Magothy aquifer and 36 MGD would cross the Raritan confining unit and enter the Lloyd aquifer. The recharge of the Magothy and Lloyd Aquifers is dominantly at the groundwater divide near the center of the island.

The water is quite pure with about 50 mg/liter, or 50 ppm, of total dissolved solids, TDS. The water is, however, quite acid with a pH of 4.4 to 6.1, similar to that of the precipitation. As a result the water is quite corrosive. Due to the inert character of the minerals making up the aquifer, dominantly quartz sand, neither the concentration of TDS nor pH changes appreciably as the water travels through the aquifers.

The water travels relatively fast through the aquifer. Near surface the rate of flow may be about 300 feet per year. At depth the rate of flow may be one foot per year. The time necessary for the water to traverse the aquifer is indicated by the estimated age of water. At the top of the Magothy the water is about 10 years old. Near the center of the Magothy it is 100 years old. Near the base of the Magothy the water is some 500 years old. The Magothy is the source of much of our drinking water. Thus, in many places we are drinking water that fell on Long Island before it was extensively developed. Within the Lloyd aquifer the water is much more ancient. Near the groundwater divide the water is 1000 years old and as the freshwater-saltwater interface it is approached beneath the Atlantic Ocean the water is some 8000 years old.

MAGOTHY



The flow of water is dominantly to the north or to the south of the ground water divide along the center of the island west of William Floyd Highway. Therefore there is little east-west mixing of the groundwater. East of William Floyd Highway there is significant flow eastward associated with the Peconic River.

What affects the pattern and quantity of water that enters the system? Paving of recharge areas and pumping. In Nassau and Suffolk Counties there is an extensive system of recharge basins that collect water from storm sewers and recharge the system. Water is withdrawn through some 1000 wells for public supply, irrigation, commercial and industrial uses. We then redeposit some of this withdrawn water through septic tanks. Where there are major sewer systems the outflow water is generally discharged to the the Atlantic Ocean or Long Island Sound. Thus, little of this water is returned to the system. With irrigation a high percentage of the water is lost through evapotranspiration. During the 1980's wells pumped 366 MGD for public supply, 41 MGD for industrial and agricultural use, there was a loss of an additional 81 MGD due to increased runoff associated with development. Of the 489 MGD removed from the system, 249 MGD were returned to the system, for a net loss to the aquifer of 240 MGD.

The result of this excess withdrawal has been shrinkage of the freshwater bubble. This has resulted in:

saltwater incursion near the Nassau-Queens border,
reduction of the height of the water table in Jamaica to below sea level,
reduction of the height of the water table by some 20 feet in Nassau County,
the subsequent drying up of streams and lakes in Nassau County, and
the reduction of the height of the water table in Suffolk County by a few feet.

Nassau and Suffolk counties share the same aquifers but have different problems associated with the differences in population densities and times of development of the two counties.

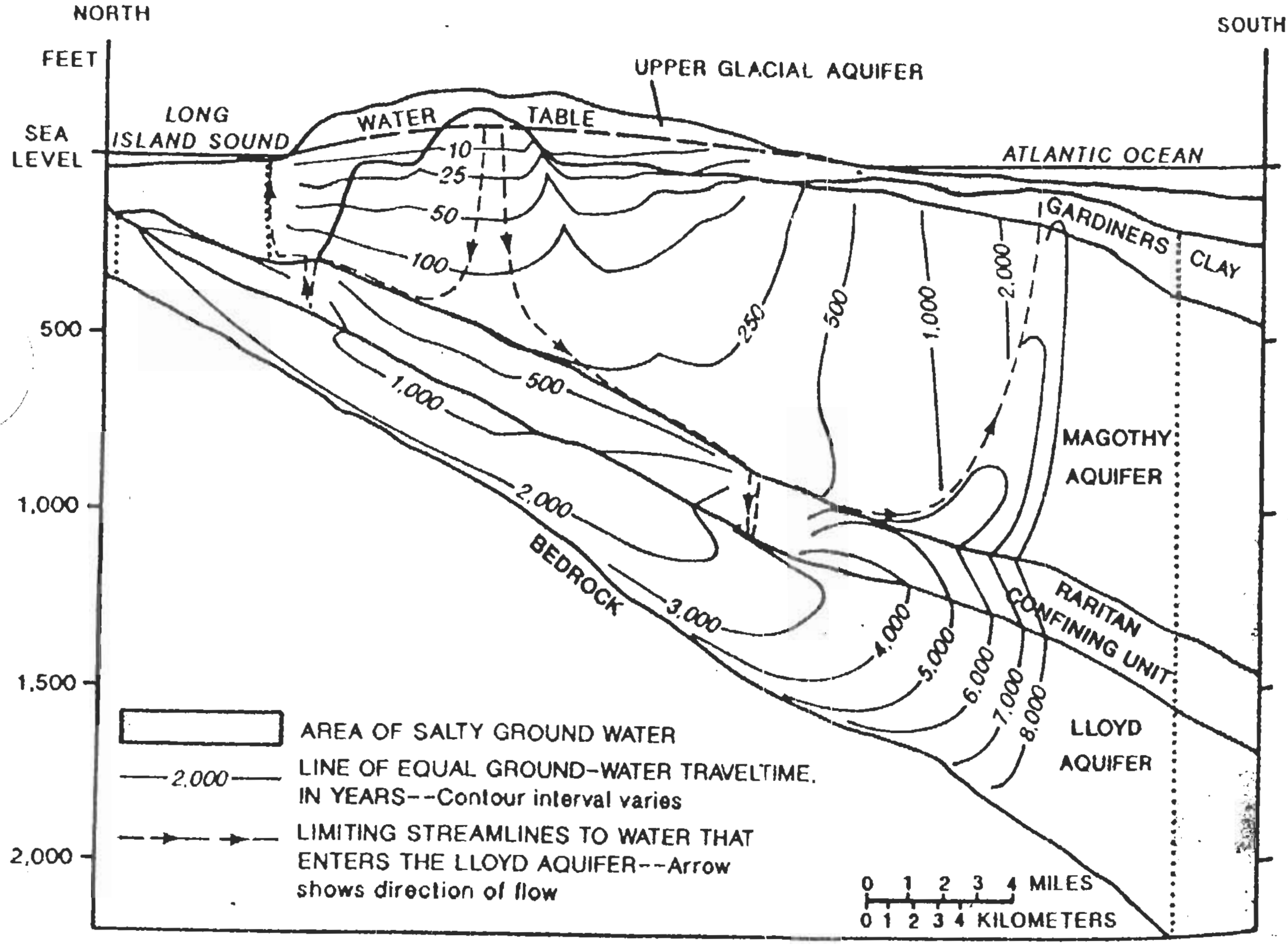


Fig. 8. Distribution of ground-water traveltime within modeled section.

Buxton & Modica

NASSAU COUNTY

Nassau County presently has a population of some 1.3 million people and an area of about 300 square miles. Precipitation provides 660 MGD of which 315 MGD is lost to evapo-transpiration and 15 MGD to direct runoff. Recharge into the groundwater system is 330 MGD. 180 MGD is pumped from the groundwater system, 40 is discharged through effluent streams, and 110 MGD is discharged underground. Consumptive use amounts to 180 MGD of which 140 MGD is lost through the sewer system, 34 MGD through sprinkling and 6 MGD through industrial-commercial use. Earlier when there was a projected population of 2.3 million people it was feared that Nassau County would not have enough water to serve its population. Nassau County did feasibility studies showing that it could take waste water, treat it and then recharge the aquifer. However, this would be very expensive and is now thought not necessary. This is because the population has stabilized or is decreasing and water conservation has reduced water use.

There was also a concern that salt water incursion would become a serious issue. This incursion appears to have stabilized and is a problem in only a few areas. The reasons for salt water incursion near Great Neck and along the south shore include the effects of pumping and the continuous sea level rise of about one foot per century.

Limits on the amount of water that can be pumped (caps) have been placed by New York State DEC in response to problems of saltwater incursion and the drying up of streams and lakes. Presently over 90% of Nassau County is served by sewers. Essentially 100% of the water in sewered areas is lost from the system. Three sewer disposal districts handle 140 MGD and this is discharged into surrounding saltwater bodies. This compares to 180 MGD of water that is pumped out of the system. Of the water pumped, 89% is from the Magothy, 5% is from the Upper Glacial and 6% is from the Lloyd aquifers. The 400 public supply wells are distributed evenly about the county.

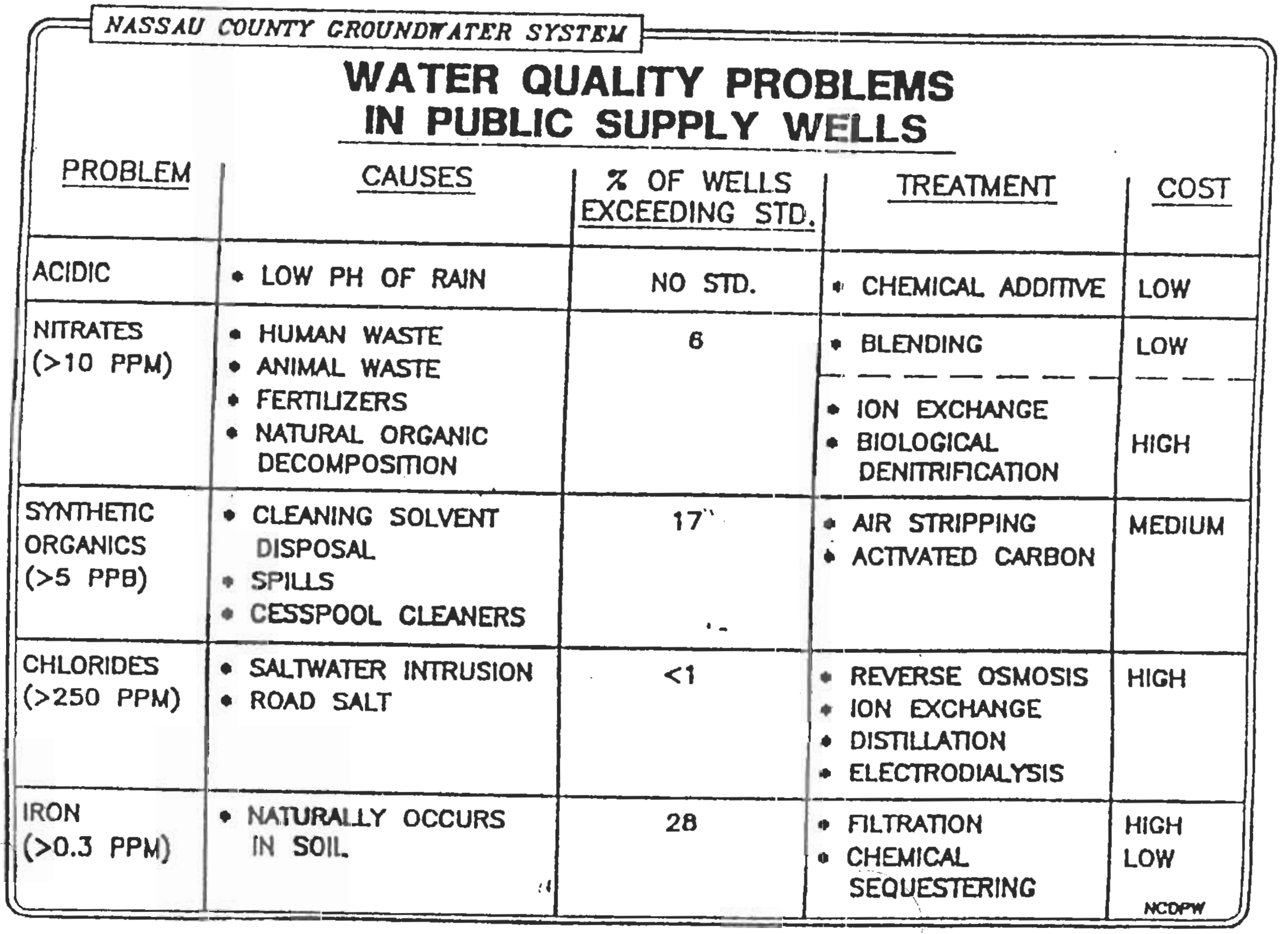
There are several water quality problems. The water is very acidic due to the low pH of rain. The water is neutralized by adding lime or caustic soda to prevent leaching of the pipes through which the water flows.

Another problem is nitrates. Six percent of the wells in Nassau exceed 10 mg per liter of nitrogen as nitrate that is the EPA minimum standard for drinking water. Such wells are either abandoned or the water from the well is blended with that from a well that has a lower nitrate concentration. It is generally thought that the nitrate contamination resulted from septic systems used prior to the installation of the sewer system. Since the installation of the sewer system the nitrate concentration of the Upper Glacial aquifer waters has decreased from 8 to 10 mg/liter to 3 to 4 mg/liter.

Synthetic organic compounds from cleaning solvents, cesspool cleaners, etc. affect 17% of the wells. Most of the contamination occurred prior to 1976 when testing first started because the contamination levels are remaining relatively constant. These organics in the water are treated by air stripping or passing the water over activated charcoal.

High chloride concentrations for some wells are the result of salt water incursion or road salt. This problem is too expensive to treat. When high chloride concentrations appear in a well pumping is stopped. If the freshwater replaces the salty water in a well, pumping may be restarted.

The last problem is high iron concentration from natural iron within the aquifer system. Twenty-eight percent of the wells need to be treated to reduce the iron concentration to below 0.3 milligrams per liter. This is done by filtering or chemically removing the iron.



NASSAU COUNTY GROUNDWATER SYSTEM

WATER QUALITY PROBLEMS IN PUBLIC SUPPLY WELLS

PROBLEM	CAUSES	% OF WELLS EXCEEDING STD.	TREATMENT	COST
ACIDIC	• LOW PH OF RAIN	NO STD.	• CHEMICAL ADDITIVE	LOW
NITRATES (>10 PPM)	• HUMAN WASTE • ANIMAL WASTE • FERTILIZERS • NATURAL ORGANIC DECOMPOSITION	6	• BLENDING	LOW
			• ION EXCHANGE • BIOLOGICAL DENITRIFICATION	HIGH
SYNTHETIC ORGANICS (>5 PPB)	• CLEANING SOLVENT DISPOSAL • SPILLS • CESSPOOL CLEANERS	17	• AIR STRIPPING • ACTIVATED CARBON	MEDIUM
CHLORIDES (>250 PPM)	• SALTWATER INTRUSION • ROAD SALT	<1	• REVERSE OSMOSIS • ION EXCHANGE • DISTILLATION • ELECTRODIALYSIS	HIGH
IRON (>0.3 PPM)	• NATURALLY OCCURS IN SOIL	28	• FILTRATION • CHEMICAL SEQUESTERING	HIGH LOW

NCDPW

SUFFOLK COUNTY

Suffolk County with an area of 884 square miles covers a much larger area than Nassau County, but the population of 1.4 million is similar to that of Nassau County with 1.3 million. The recharge in the area is 990 MGD. The total capacity of the aquifers underlying Suffolk County is about 70 trillion gallons. There are more than 600 public supply wells in Suffolk County. About 210 MGD are withdrawn by pumping with equal amounts coming from the Magothy and Upper Glacial. Most of this water is returned to the aquifer with consumptive loss estimated to be 95

MGD. The loss is through sewage systems, marine discharges and evapotranspiration associated with irrigation and lawn sprinkling.

Most of Suffolk County is not sewered. Instead most homes have septic tank systems that discharge their waste water back to the groundwater system. As a result a relatively small percentage of the recharge in Suffolk County is consumptively lost, about 10%, compared to 55% for Nassau County. The most serious problem when using septic tanks is the introduction of nitrates into the ground water. When sewage is discharged to a septic tank or cess pool, some nitrogen is lost as ammonia or nitrogen gases and about half is oxidized to nitrate. EPA standards limit nitrogen as nitrate concentrations to less than 10 mg per liter. If Suffolk County limits housing to one to two dwellings per acre, the nitrate standards should not be violated with the continued use of septic systems.

Pathogenic bacteria in septic systems generally die off as the water passes through the zone of aeration and into the zone of saturation. It is not clear that this is true for all viruses

As long as people do not dispose of organic compounds (paint thinners, petroleum products, grease cutters, and other household chemicals) through septic systems or pour it on the ground the water should not be contaminated by organic compounds.

In areas where the density increases to greater than two dwellings per acre, sewering will be required. The effluent from such systems could be discharged to the groundwater system and not to saltwater. While sewage systems can be built to produce effluent that meets drinking water standards, homeowner associations usually do not maintain such systems at a level to meet the standards.

Of the 600 public supply wells 48 have been taken out of service due to organic contamination. Most of this contamination was a result of earlier industrial disposal practices (gasoline and fuel storage areas, leaking underground storage tanks, dry cleaners, etc.). These practices have been severely limited by new health codes. Industries can no longer afford to dispose of their wastes improperly.

As in Nassau County high pH and iron are problems that must be treated before water can be distributed to the public.

Pine Barrens

The Pine Barrens in Suffolk County have been the focus of attention for the last few years. This is because they are the last large nearly undeveloped area on Long Island, consisting of some 100,000 acres. Also, because they are within the deep recharge zone of the Magothy aquifer. Due to the limited development in the Pine Barrens the ground water in this area is particularly pure. (Degradation of groundwater quality is inevitable wherever there are humans.) The present plan for the Pine Barrens is to retain a core of 50,000 acres of undeveloped land and have restricted development on the remaining 50,000 acres. The main reason for preserving the Pine Barrens would appear to be to preserve this special ecosystem. While the water is pure, extensive pumping would potentially harm the ecosystem by lowering the water table. Also, the high cost of pumping to developed areas would make use of this groundwater unfeasible for the foreseeable future.

SUMMARY OF CHARACTERISTICS OF LONG ISLANDS GROUNDWATER

Only source of water is precipitation
44 inches of rain per year
Daily average ppt is 1600 mgd
    780 is evapotranspiration
    820 enters hydrologic cycle
    340 mgd is stream runoff
    480 mgd enters groundwater
The 480 mgd groundwater is returned ocean
    340 mgd from glacial aquifer to groundwater fed streams
    140 mgd goes directly to salt water

Long Island groundwater is quite pure 50 mg/L of TDS 50 ppm. Purity oes not change as it travels through ground
    pH is 4.4 to 6.1, that means it is corrosive
    Fe sometimes exceeds 0.3 mg /L or 0.3 ppm

Concept of safe yield, that is the amount of water that should be removed from the aquifer is a societal decision.

Consumptive use results in
- lowering of water table
- decrease in streamflow
- lowering of potentiometric surface in deep aquifers
- intrusion of salt water

Contamination Ground Water Sources on Long Island
- Storm runoff into recharge basins
- Household sewage gets into groundwater through leaky pipes, cesspools and septic tanks
- Accidental spills and casual dumping
- Precipitation is now more acid (pH=4.5) and contains hydrocarbons and heavy metals
- Automotive wastes, road salts, pesticides and fertilizers

Characteristics of LI ground water
- Long Island is surrounded by salt water. No recharge of fresh water outside Long Island
- There is only one source of water which is rain or snow, which is relatively pure
- Relatively abundant rainfall average 44" per year
- Consistent rain all year, i.e. 3" to 4" per month
- Large section of porous sand with few aquicludes
- Thus, relatively rapid flow of water through section, 300 feet/y near surface less than 1 foot/y at depth.
- Flow is dominantly north-south west of William Floyd highway
    - i.e., in most developed area of Long Island, therefore there is little mixing of groundwater in the east-west direction
- Significant proportion of water used is recharged and re-used
- Recharge of Magothy and Lloyd only from near ground-water divide

BB&S Lumber Site Predesign Investigation
Groundwater Flow/Transport Modeling & Treatability Study

APPENDIX B

SURFER PLOTS OF GROUNDWATER CONTOURS

FIGURE B-1

BB7S TREATED LUMBER SITE
GROUNDWATER FLOW CONTOUR - August 1996

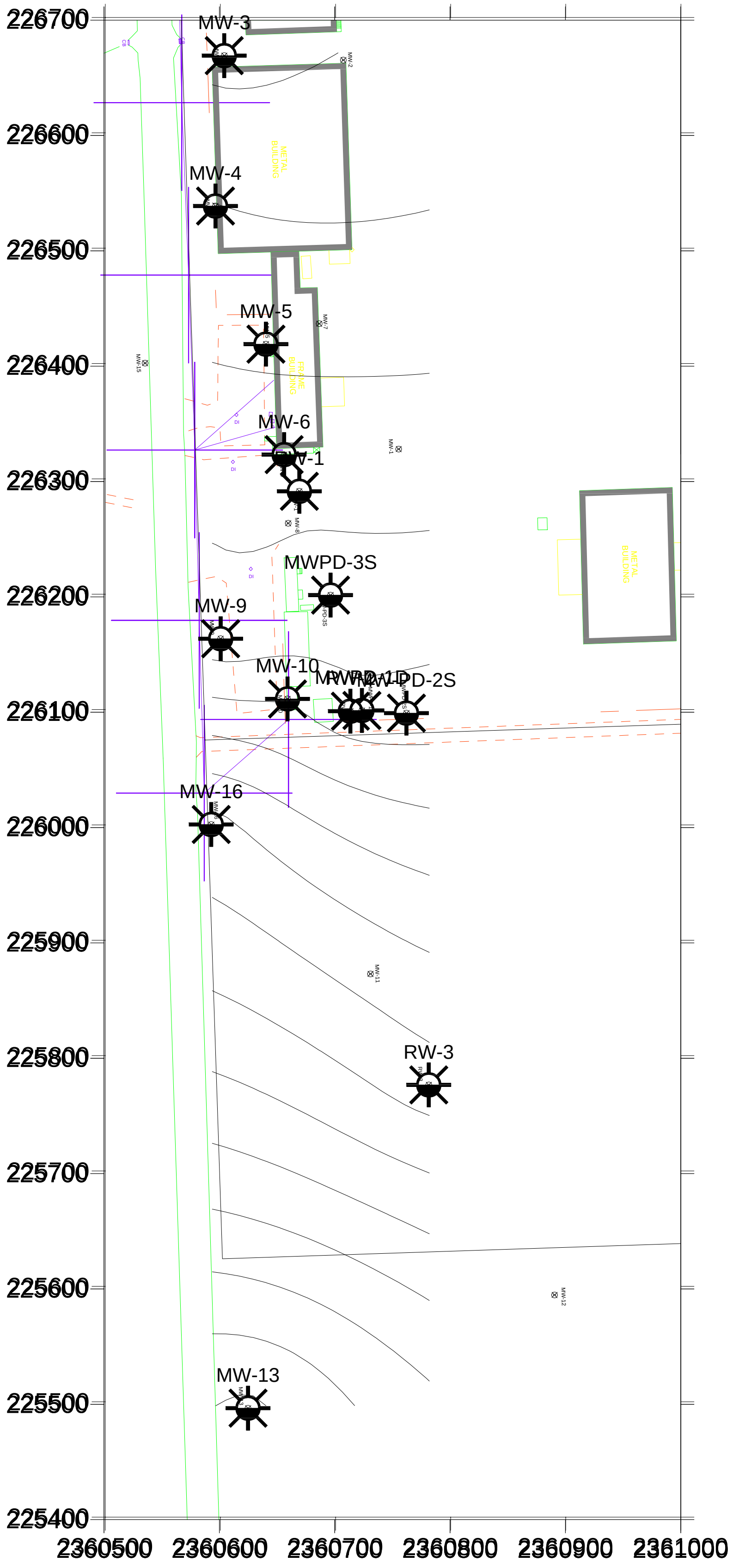


FIGURE B-2

BB7S TREATED LUMBER SITE
GROUNDWATER FLOW CONTOUR - October 2005

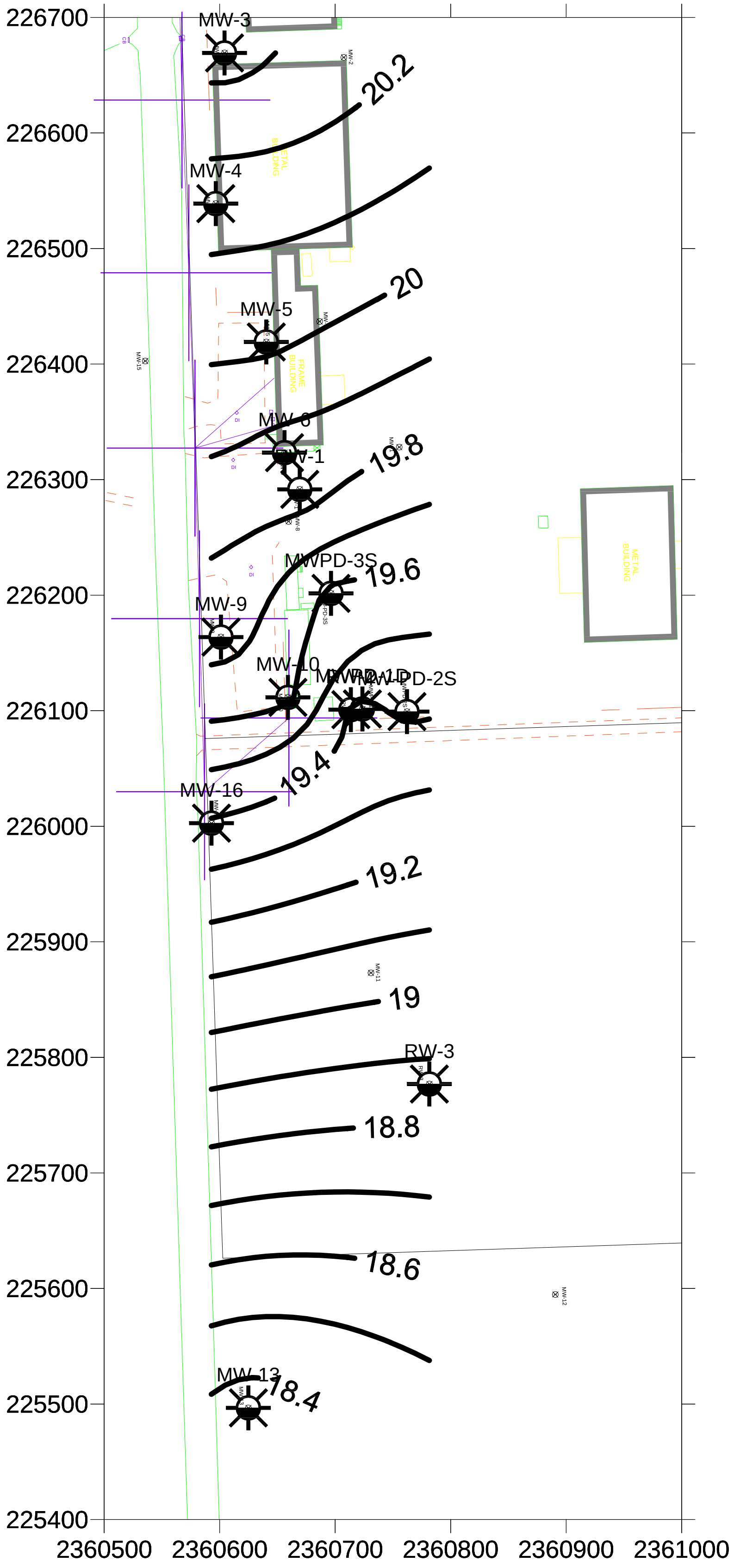
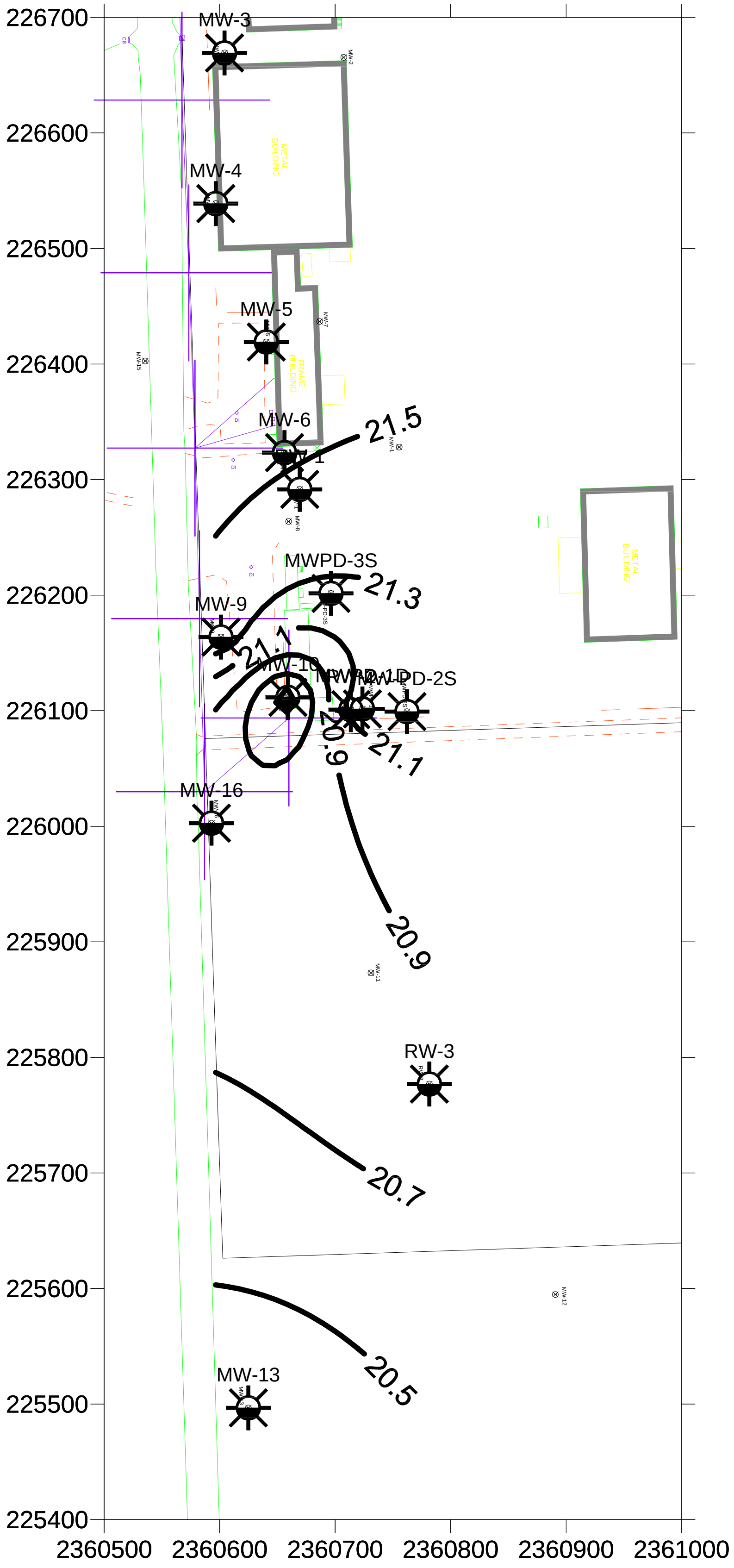


FIGURE B-3

BB7S TREATED LUMBER SITE
GROUNDWATER FLOW CONTOUR - February 2006



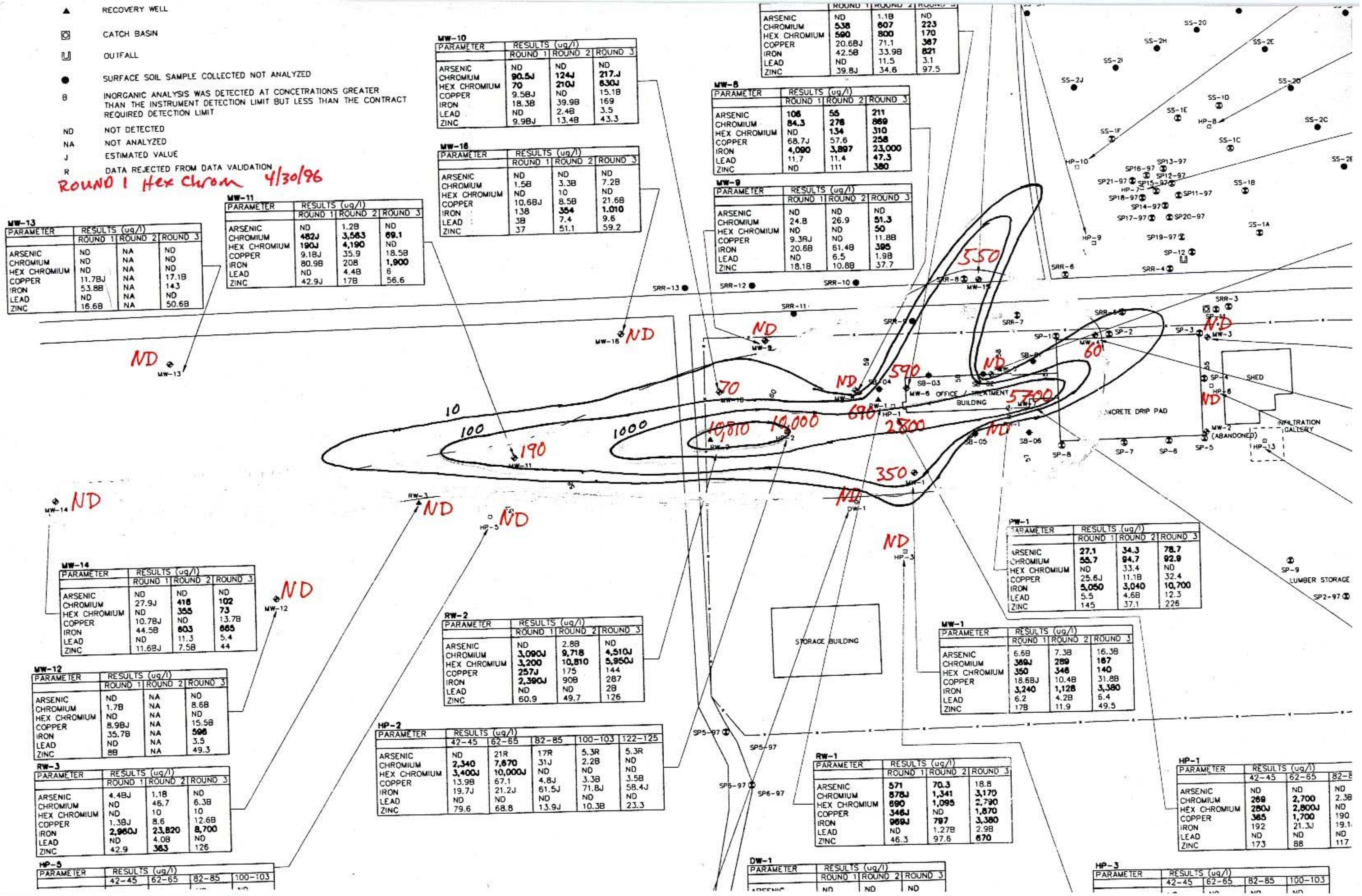
BB&S Lumber Site Predesign Investigation
Groundwater Flow/Transport Modeling & Treatability Study

APPENDIX C

CHROMIUM PROFILE IN GROUNDWATER

▲	RECOVERY WELL
▣	CATCH BASIN
⊔	OUTFALL
●	SURFACE SOIL SAMPLE COLLECTED NOT ANALYZED
B	INORGANIC ANALYSIS WAS DETECTED AT CONCETRATIONS GREATER THAN THE INSTRUMENT DETECTION LIMIT BUT LESS THAN THE CONTRACT REQUIRED DETECTION LIMIT
ND	NOT DETECTED
NA	NOT ANALYZED
J	ESTIMATED VALUE
R	DATA REJECTED FROM DATA VALIDATION

ROUND 1 Hex Chrom 4/30/96



	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	1.1B	ND
CHROMIUM	**538**	**607**	**223**
HEX CHROMIUM	**590**	**800**	**170**
COPPER	20.6BJ	71.1	**387**
IRON	42.5B	33.9B	**821**
LEAD	ND	11.5	3.1
ZINC	39.8J	34.6	97.5

MW-10

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	ND	ND
CHROMIUM	**90.5J**	**124J**	**217.J**
HEX CHROMIUM	**70**	**210J**	**630J**
COPPER	9.5BJ	ND	15.1B
IRON	18.3B	39.9B	169
LEAD	ND	2.4B	3.5
ZINC	9.9BJ	13.4B	43.3

MW-16

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	ND	ND
CHROMIUM	1.5B	3.3B	7.2B
HEX CHROMIUM	ND	10	ND
COPPER	10.6BJ	8.5B	21.6B
IRON	138	**354**	**1.010**
LEAD	3B	7.4	9.6
ZINC	37	51.1	59.2

MW-8

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	**106**	**55**	**211**
CHROMIUM	**84.3**	**276**	**869**
HEX CHROMIUM	ND	**134**	**310**
COPPER	68.7J	57.6	**258**
IRON	**4,090**	**3,897**	**23,000**
LEAD	11.7	11.4	**47.3**
ZINC	ND	111	**380**

MW-9

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	ND	ND
CHROMIUM	24.8	26.9	**51.3**
HEX CHROMIUM	ND	ND	**50**
COPPER	9.3RJ	ND	11.8B
IRON	20.6B	61.4B	**395**
LEAD	ND	6.5	1.9B
ZINC	18.1B	10.8B	37.7

MW-11

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	1.2B	ND
CHROMIUM	**482J**	**3,563**	**69.1**
HEX CHROMIUM	**190J**	**4,190**	ND
COPPER	9.1BJ	35.9	18.5B
IRON	80.9B	208	**1,900**
LEAD	ND	4.4B	6
ZINC	42.9J	17B	56.6

MW-13

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	NA	ND
CHROMIUM	ND	NA	ND
HEX CHROMIUM	ND	NA	ND
COPPER	11.7BJ	NA	17.1B
IRON	53.8B	NA	143
LEAD	ND	NA	ND
ZINC	16.6B	NA	50.6B

PW-1

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	**27.1**	**34.3**	**78.7**
CHROMIUM	**55.7**	**94.7**	**92.9**
HEX CHROMIUM	ND	33.4	ND
COPPER	25.6J	11.1B	32.4
IRON	**5,050**	**3,040**	**10,700**
LEAD	5.5	4.6B	12.3
ZINC	145	37.1	226

MW-14

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	ND	ND
CHROMIUM	27.9J	**416**	**102**
HEX CHROMIUM	ND	**355**	**73**
COPPER	10.7BJ	ND	13.7B
IRON	44.5B	**603**	**665**
LEAD	ND	11.3	5.4
ZINC	11.6BJ	7.5B	44

RW-2

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	2.8B	ND
CHROMIUM	**3,090J**	**9,718**	**4,510J**
HEX CHROMIUM	**3,200**	**10,810**	**5,950J**
COPPER	**257J**	175	144
IRON	**2,390J**	90B	287
LEAD	ND	ND	2B
ZINC	60.9	49.7	126

MW-1

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	6.6B	7.3B	16.3B
CHROMIUM	**369J**	**289**	**167**
HEX CHROMIUM	**350**	**346**	**140**
COPPER	18.6BJ	10.4B	31.8B
IRON	**3,240**	**1,128**	**3,380**
LEAD	6.2	4.2B	6.4
ZINC	17B	11.9	49.5

MW-12

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	NA	ND
CHROMIUM	1.7B	NA	8.6B
HEX CHROMIUM	ND	NA	ND
COPPER	8.9BJ	NA	15.5B
IRON	35.7B	NA	**596**
LEAD	ND	NA	3.5
ZINC	8B	NA	49.3

HP-2

PARAMETER	RESULTS (ug/l)				
	42-45	62-65	82-85	100-103	122-125
ARSENIC	ND	21R	17R	5.3R	5.3R
CHROMIUM	**2,340**	**7,670**	31J	2.2B	ND
HEX CHROMIUM	**3,400J**	**10,000J**	ND	ND	ND
COPPER	13.9B	67.1	4.8J	3.3B	3.5B
IRON	19.7J	21.2J	61.5J	71.8J	58.4J
LEAD	ND	ND	ND	ND	ND
ZINC	79.6	68.8	13.9J	10.3B	23.3

RW-1

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	**571**	**70.3**	18.8
CHROMIUM	**878J**	**1,341**	**3,170**
HEX CHROMIUM	**690**	**1,095**	**2,790**
COPPER	**346J**	ND	**1,870**
IRON	**969J**	**797**	**3,380**
LEAD	ND	1.27B	2.9B
ZINC	46.3	97.6	**670**

HP-1

PARAMETER	RESULTS (ug/l)		
	42-45	62-65	82-8
ARSENIC	ND	ND	ND
CHROMIUM	**269**	**2,700**	2.3B
HEX CHROMIUM	**280J**	**2,800J**	ND
COPPER	**385**	**1,700**	190
IRON	192	21.3J	19.1
LEAD	ND	ND	ND
ZINC	173	88	117

RW-3

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	4.4BJ	1.1B	ND
CHROMIUM	ND	46.7	6.3B
HEX CHROMIUM	ND	10	10
COPPER	1.3BJ	8.6	12.6B
IRON	**2,960J**	**23,820**	**8,700**
LEAD	ND	4.0B	ND
ZINC	42.9	**363**	126

HP-5

PARAMETER	RESULTS (ug/l)			
	42-45	62-65	82-85	100-103

DW-1

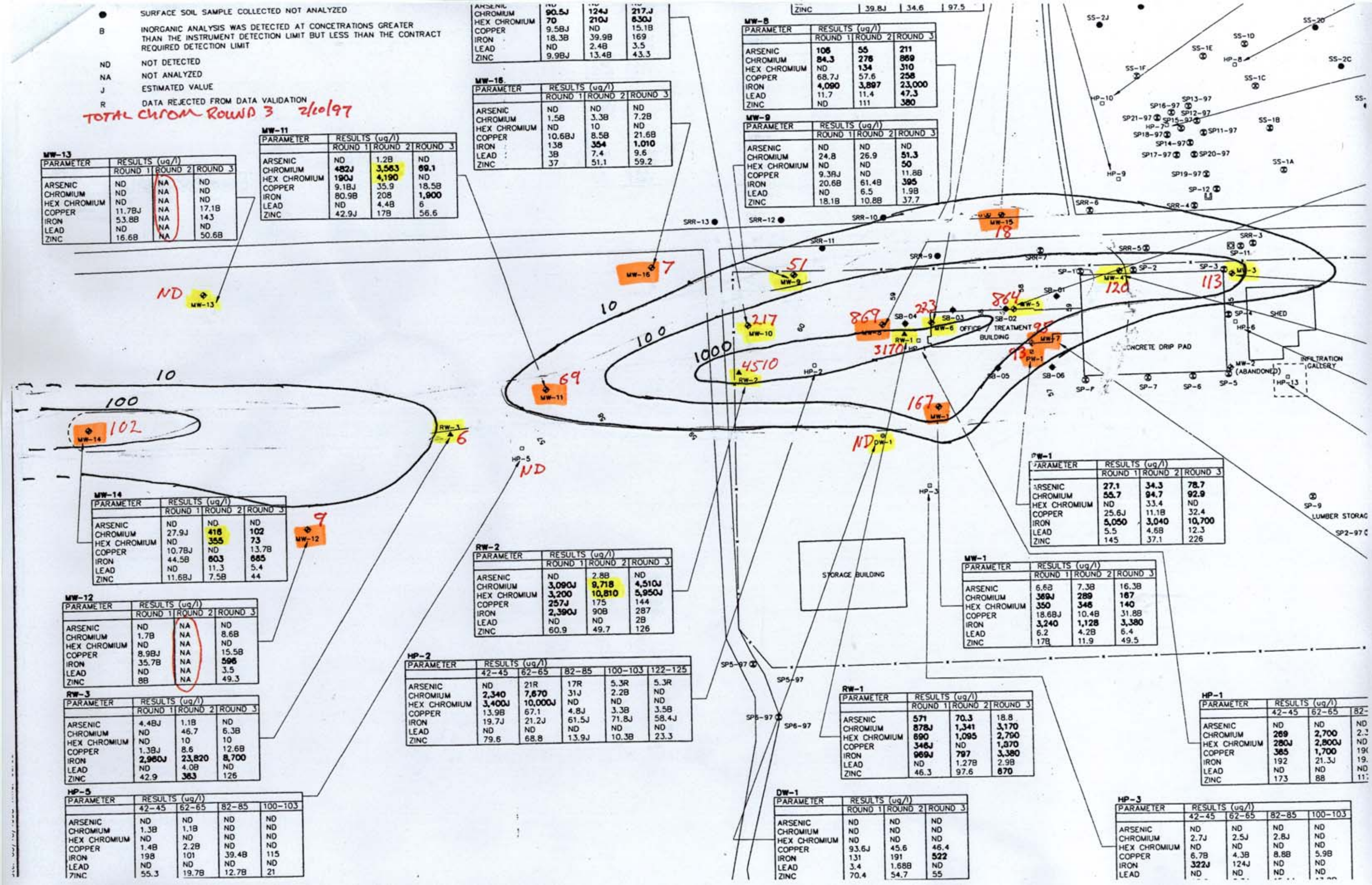
PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	ND	ND

HP-3

PARAMETER	RESULTS (ug/l)			
	42-45	62-65	82-85	100-103

●	SURFACE SOIL SAMPLE COLLECTED NOT ANALYZED
B	INORGANIC ANALYSIS WAS DETECTED AT CONCETRATIONS GREATER THAN THE INSTRUMENT DETECTION LIMIT BUT LESS THAN THE CONTRACT REQUIRED DETECTION LIMIT
ND	NOT DETECTED
NA	NOT ANALYZED
J	ESTIMATED VALUE
R	DATA REJECTED FROM DATA VALIDATION

TOTAL CHROM ROUND 3 2/10/97



ARSENIC			
CHROMIUM	90.5J	124J	217.J
HEX CHROMIUM	70	210J	630J
COPPER	9.5BJ	ND	15.1B
IRON	18.3B	39.9B	169
LEAD	ND	2.4B	3.5
ZINC	9.9BJ	13.4B	43.3

ZINC	39.8J	34.6	97.5

MW-13

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	NA	ND
CHROMIUM	ND	NA	ND
HEX CHROMIUM	ND	NA	ND
COPPER	11.7BJ	NA	17.1B
IRON	53.8B	NA	143
LEAD	ND	NA	ND
ZINC	16.6B	NA	50.6B

MW-11

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	1.2B	ND
CHROMIUM	482J	3,563	69.1
HEX CHROMIUM	190J	4,190	ND
COPPER	9.1BJ	35.9	18.5B
IRON	80.9B	208	1,900
LEAD	ND	4.4B	6
ZINC	42.9J	17B	56.6

MW-16

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	ND	ND
CHROMIUM	1.5B	3.3B	7.2B
HEX CHROMIUM	ND	10	ND
COPPER	10.6BJ	8.5B	21.6B
IRON	138	354	1.010
LEAD	3B	7.4	9.6
ZINC	37	51.1	59.2

MW-8

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	106	55	211
CHROMIUM	84.3	276	869
HEX CHROMIUM	ND	134	310
COPPER	68.7J	57.6	258
IRON	4,090	3,897	23,000
LEAD	11.7	11.4	47.3
ZINC	ND	111	380

MW-9

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	ND	ND
CHROMIUM	24.8	26.9	51.3
HEX CHROMIUM	ND	ND	50
COPPER	9.3RJ	ND	11.8B
IRON	20.6B	61.4B	395
LEAD	ND	6.5	1.9B
ZINC	18.1B	10.8B	37.7

PW-1

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	27.1	34.3	78.7
CHROMIUM	55.7	94.7	92.9
HEX CHROMIUM	ND	33.4	ND
COPPER	25.6J	11.1B	32.4
IRON	5,050	3,040	10,700
LEAD	5.5	4.6B	12.3
ZINC	145	37.1	226

MW-14

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	ND	ND
CHROMIUM	27.9J	416	102
HEX CHROMIUM	ND	355	73
COPPER	10.7BJ	ND	13.7B
IRON	44.5B	603	685
LEAD	ND	11.3	5.4
ZINC	11.6BJ	7.5B	44

MW-12

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	NA	ND
CHROMIUM	1.7B	NA	8.6B
HEX CHROMIUM	ND	NA	ND
COPPER	8.9BJ	NA	15.5B
IRON	35.7B	NA	596
LEAD	ND	NA	3.5
ZINC	8B	NA	49.3

RW-3

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	4.4BJ	1.1B	ND
CHROMIUM	ND	46.7	6.3B
HEX CHROMIUM	ND	10	10
COPPER	1.3BJ	8.6	12.6B
IRON	2,960J	23,820	8,700
LEAD	ND	4.0B	ND
ZINC	42.9	383	126

HP-5

PARAMETER	RESULTS (ug/l)			
	42-45	62-65	82-85	100-103
ARSENIC	ND	ND	ND	ND
CHROMIUM	1.3B	1.1B	ND	ND
HEX CHROMIUM	ND	ND	ND	ND
COPPER	1.4B	2.2B	ND	ND
IRON	198	101	39.4B	115
LEAD	ND	ND	ND	ND
ZINC	55.3	19.7B	12.7B	21

RW-2

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	2.8B	ND
CHROMIUM	3,090J	9,718	4,510J
HEX CHROMIUM	3,200	10,810	5,950J
COPPER	257J	175	144
IRON	2,390J	90B	287
LEAD	ND	ND	2B
ZINC	60.9	49.7	126

HP-2

PARAMETER	RESULTS (ug/l)				
	42-45	62-65	82-85	100-103	122-125
ARSENIC	ND	21R	17R	5.3R	5.3R
CHROMIUM	2,340	7,670	31J	2.2B	ND
HEX CHROMIUM	3,400J	10,000J	ND	ND	ND
COPPER	13.9B	67.1	4.8J	3.3B	3.5B
IRON	19.7J	21.2J	61.5J	71.8J	58.4J
LEAD	ND	ND	ND	ND	ND
ZINC	79.6	68.8	13.9J	10.3B	23.3

MW-1

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	6.6B	7.3B	16.3B
CHROMIUM	369J	289	167
HEX CHROMIUM	350	346	140
COPPER	18.6BJ	10.4B	31.8B
IRON	3,240	1,128	3,380
LEAD	6.2	4.2B	6.4
ZINC	17B	11.9	49.5

RW-1

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	571	70.3	18.8
CHROMIUM	878J	1,341	3,170
HEX CHROMIUM	690	1,095	2,790
COPPER	346J	ND	1,370
IRON	969J	797	3,380
LEAD	ND	1.27B	2.9B
ZINC	46.3	97.6	670

DW-1

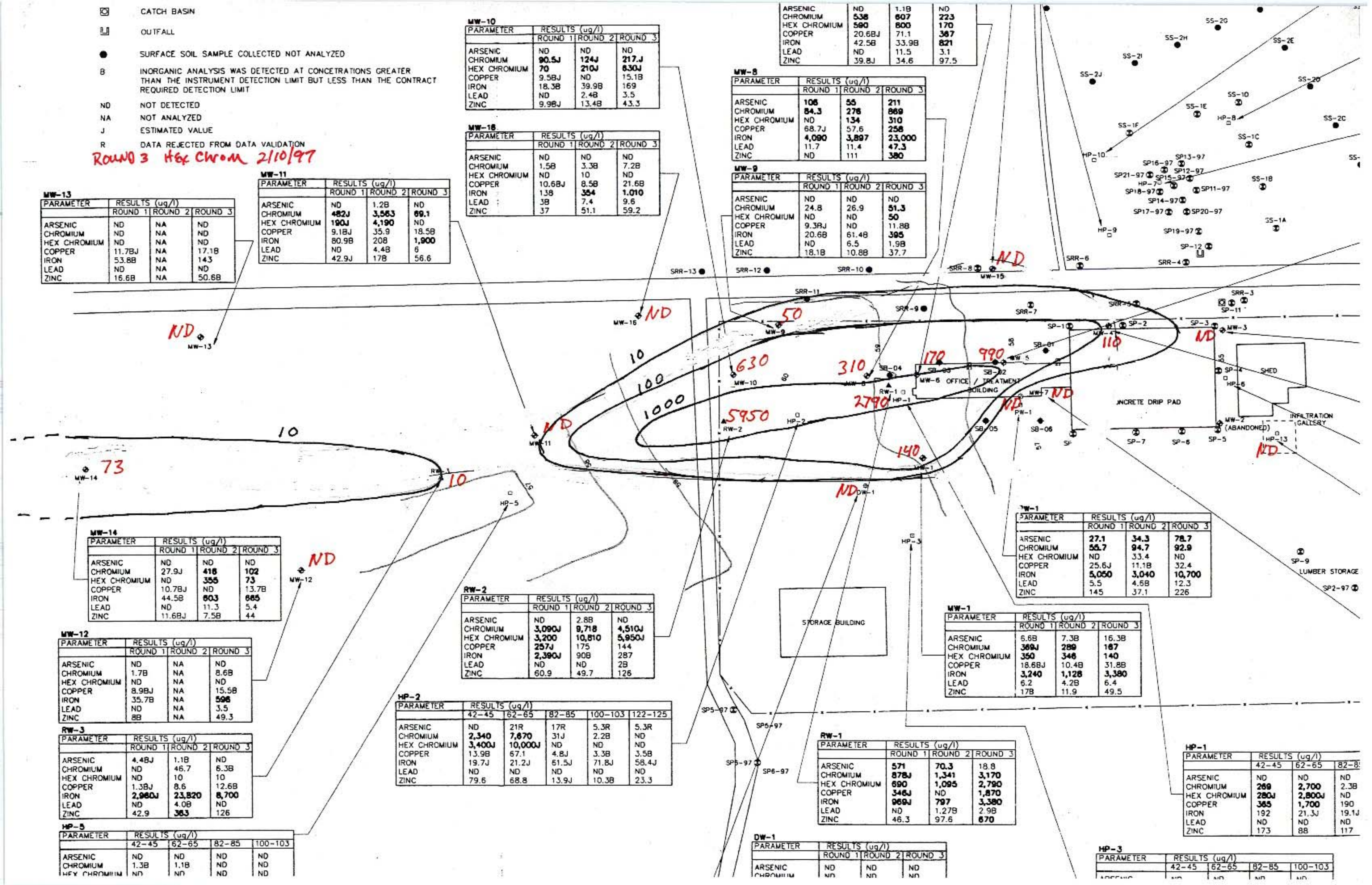
PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	ND	ND
CHROMIUM	ND	ND	ND
HEX CHROMIUM	ND	ND	ND
COPPER	93.6J	45.6	46.4
IRON	131	191	522
LEAD	3.4	1.68B	ND
ZINC	70.4	54.7	55

HP-1

PARAMETER	RESULTS (ug/l)		
	42-45	62-65	82-
ARSENIC	ND	ND	ND
CHROMIUM	269	2,700	2.
HEX CHROMIUM	280J	2,800J	ND
COPPER	365	1,700	19
IRON	192	21.3J	19.
LEAD	ND	ND	ND
ZINC	173	88	11

HP-3

PARAMETER	RESULTS (ug/l)			
	42-45	62-65	82-85	100-103
ARSENIC	ND	ND	ND	ND
CHROMIUM	2.7J	2.5J	2.8J	ND
HEX CHROMIUM	ND	ND	ND	ND
COPPER	6.7B	4.3B	8.8B	5.9B
IRON	322J	124J	ND	ND
LEAD	ND	ND	ND	ND



▣	CATCH BASIN
⊔	OUTFALL
●	SURFACE SOIL SAMPLE COLLECTED NOT ANALYZED
B	INORGANIC ANALYSIS WAS DETECTED AT CONCETRATIONS GREATER THAN THE INSTRUMENT DETECTION LIMIT BUT LESS THAN THE CONTRACT REQUIRED DETECTION LIMIT
ND	NOT DETECTED
NA	NOT ANALYZED
J	ESTIMATED VALUE
R	DATA REJECTED FROM DATA VALIDATION

ROUND 3 HEX CHROM 2/10/97

ARSENIC	ND	1.1B	ND
CHROMIUM	**538**	**607**	**223**
HEX CHROMIUM	**590**	**800**	**170**
COPPER	20.6BJ	71.1	**387**
IRON	42.5B	33.9B	**821**
LEAD	ND	11.5	3.1
ZINC	39.8J	34.6	97.5

MW-10

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	ND	ND
CHROMIUM	**90.5J**	**124J**	**217.J**
HEX CHROMIUM	**70**	**210J**	**630J**
COPPER	9.5BJ	ND	15.1B
IRON	18.3B	39.9B	169
LEAD	ND	2.4B	3.5
ZINC	9.9BJ	13.4B	43.3

MW-16

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	ND	ND
CHROMIUM	1.5B	3.3B	7.2B
HEX CHROMIUM	ND	10	ND
COPPER	10.6BJ	8.5B	21.6B
IRON	138	**354**	**1.010**
LEAD	3B	7.4	9.6
ZINC	37	51.1	59.2

MW-8

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	**106**	**55**	**211**
CHROMIUM	**84.3**	**276**	**869**
HEX CHROMIUM	ND	**134**	**310**
COPPER	68.7J	57.6	**258**
IRON	**4,090**	**3,897**	**23,000**
LEAD	11.7	11.4	**47.3**
ZINC	ND	111	**380**

MW-9

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	ND	ND
CHROMIUM	24.8	26.9	**51.3**
HEX CHROMIUM	ND	ND	**50**
COPPER	9.3BJ	ND	11.8B
IRON	20.6B	61.4B	**395**
LEAD	ND	6.5	1.9B
ZINC	18.1B	10.8B	37.7

MW-13

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	NA	ND
CHROMIUM	ND	NA	ND
HEX CHROMIUM	ND	NA	ND
COPPER	11.7BJ	NA	17.1B
IRON	53.8B	NA	143
LEAD	ND	NA	ND
ZINC	16.6B	NA	50.6B

MW-11

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	1.2B	ND
CHROMIUM	**482J**	**3,563**	**69.1**
HEX CHROMIUM	**190J**	**4,190**	ND
COPPER	9.1BJ	35.9	18.5B
IRON	80.9B	208	**1,900**
LEAD	ND	4.4B	6
ZINC	42.9J	17B	56.6

W-1

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	**27.1**	**34.3**	**78.7**
CHROMIUM	**55.7**	**94.7**	**92.9**
HEX CHROMIUM	ND	33.4	ND
COPPER	25.6J	11.1B	32.4
IRON	**5,050**	**3,040**	**10,700**
LEAD	5.5	4.6B	12.3
ZINC	145	37.1	226

MW-14

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	ND	ND
CHROMIUM	27.9J	**416**	**102**
HEX CHROMIUM	ND	**355**	**73**
COPPER	10.7BJ	ND	13.7B
IRON	44.5B	**603**	**685**
LEAD	ND	11.3	5.4
ZINC	11.6BJ	7.5B	44

RW-2

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	2.8B	ND
CHROMIUM	**3,090J**	**9,718**	**4,510J**
HEX CHROMIUM	**3,200**	**10,810**	**5,950J**
COPPER	**257J**	175	144
IRON	**2,390J**	90B	287
LEAD	ND	ND	2B
ZINC	60.9	49.7	126

MW-1

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	6.6B	7.3B	16.3B
CHROMIUM	**369J**	**289**	**167**
HEX CHROMIUM	**350**	**346**	**140**
COPPER	18.6BJ	10.4B	31.8B
IRON	**3,240**	**1,128**	**3,380**
LEAD	6.2	4.2B	6.4
ZINC	17B	11.9	49.5

MW-12

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	NA	ND
CHROMIUM	1.7B	NA	8.6B
HEX CHROMIUM	ND	NA	ND
COPPER	8.9BJ	NA	15.5B
IRON	35.7B	NA	**596**
LEAD	ND	NA	3.5
ZINC	8B	NA	49.3

HP-2

PARAMETER	RESULTS (ug/l)				
	42-45	62-65	82-85	100-103	122-125
ARSENIC	ND	21R	17R	5.3R	5.3R
CHROMIUM	**2,340**	**7,670**	31J	2.2B	ND
HEX CHROMIUM	**3,400J**	**10,000J**	ND	ND	ND
COPPER	13.9B	67.1	4.8J	3.3B	3.5B
IRON	19.7J	21.2J	61.5J	71.8J	58.4J
LEAD	ND	ND	ND	ND	ND
ZINC	79.6	68.8	13.9J	10.3B	23.3

RW-3

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	4.4BJ	1.1B	ND
CHROMIUM	ND	46.7	6.3B
HEX CHROMIUM	ND	10	10
COPPER	1.3BJ	8.6	12.6B
IRON	**2,960J**	**23,820**	**8,700**
LEAD	ND	4.0B	ND
ZINC	42.9	**383**	126

RW-1

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	**571**	**70.3**	18.8
CHROMIUM	**878J**	**1,341**	**3,170**
HEX CHROMIUM	**690**	**1,095**	**2,790**
COPPER	**346J**	ND	**1,870**
IRON	**969J**	**797**	**3,380**
LEAD	ND	1.27B	2.9B
ZINC	46.3	97.6	**670**

HP-1

PARAMETER	RESULTS (ug/l)		
	42-45	62-65	82-8
ARSENIC	ND	ND	ND
CHROMIUM	**269**	**2,700**	2.3B
HEX CHROMIUM	**280J**	**2,800J**	ND
COPPER	**365**	**1,700**	190
IRON	192	21.3J	19.1J
LEAD	ND	ND	ND
ZINC	173	88	117

HP-5

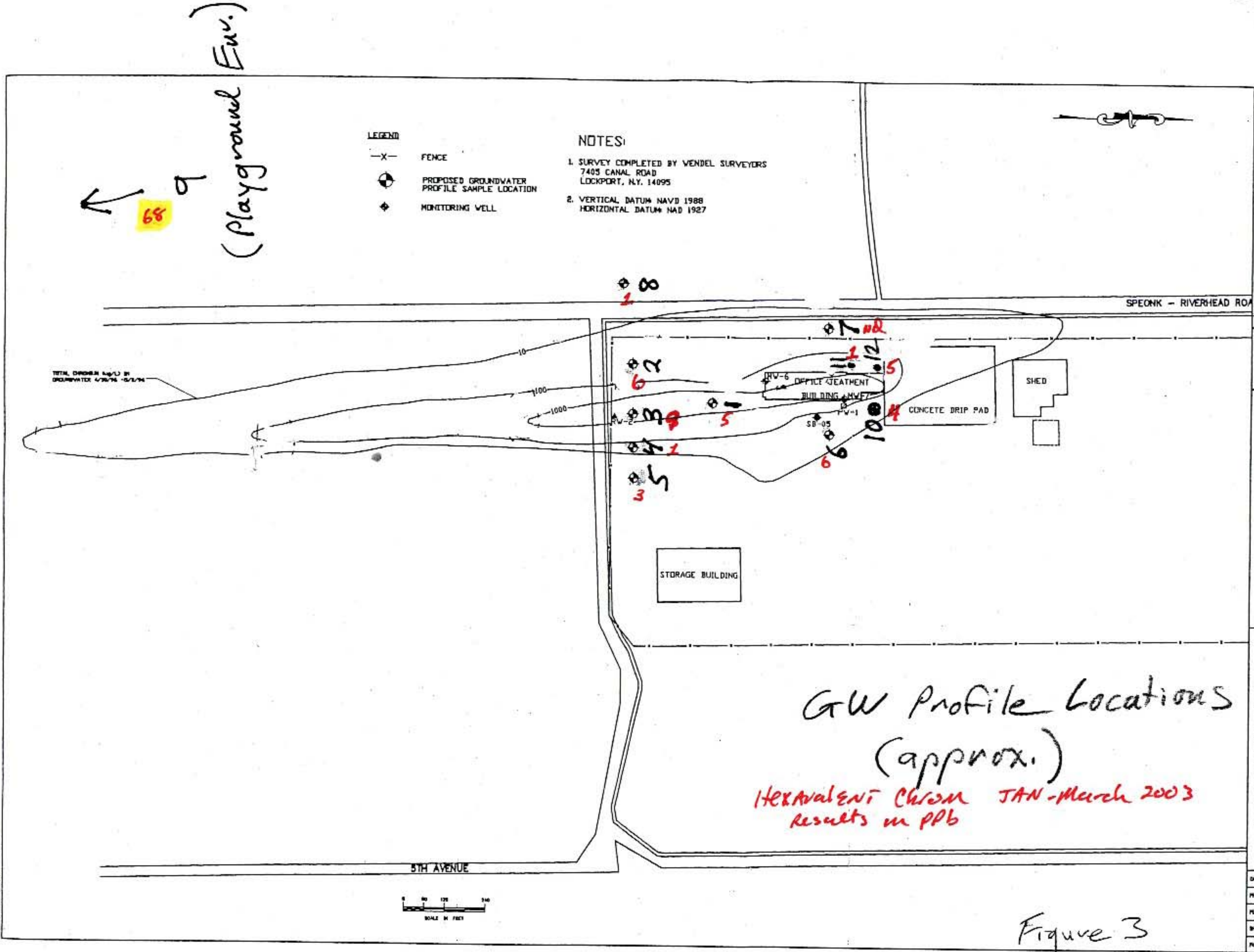
PARAMETER	RESULTS (ug/l)			
	42-45	62-65	82-85	100-103
ARSENIC	ND	ND	ND	ND
CHROMIUM	1.3B	1.1B	ND	ND
HEX CHROMIUM	ND	ND	ND	ND

DW-1

PARAMETER	RESULTS (ug/l)		
	ROUND 1	ROUND 2	ROUND 3
ARSENIC	ND	ND	ND
CHROMIUM	ND	ND	ND

HP-3

PARAMETER	RESULTS (ug/l)			
	42-45	62-65	82-85	100-103



LEGEND

—X— FENCE

⊕ PROPOSED GROUNDWATER PROFILE SAMPLE LOCATION

◆ MONITORING WELL

NOTES:

1. SURVEY COMPLETED BY WENDEL SURVEYORS
   7405 CANAL ROAD
   LOCKPORT, N.Y. 14095
2. VERTICAL DATUM NAVD 1988
   HORIZONTAL DATUM NAD 1927

GW Profile Locations
(approx.)

Hexavalent Chrom JAN-March 2003
Results in ppb

Figure 3

ALBANY, N.Y.

EARTH TECH
A tyco INTERNATIONAL LTD. COMPANY

BB&S TREATED LUMBER SITE
SPEONK, NEW YORK
NYSDEC SITE NO. 1-52-123

PROPOSED GROUNDWATER
PROFILE SAMPLE LOCATIONS

DATE	JANUARY 2001
PROJECT NO	42798
FILENAME	FIG-3.dwg
SHEET NO	1 of 1
FIGURE	3

BB&S Lumber Site Predesign Investigation
Groundwater Flow/Transport Modeling & Treatability Study

APPENDIX D

SCWA'S DYNFLOW MODEL INPUT/OUTPUT DATA

SCWA

SUFFOLK COUNTY WATER AUTHORITY

Timothy J. Hopkins
General Counsel

Administrative Offices: 4060 Sunrise Highway, Oakdale, NY 11769-0901
(631) 563-0236
Fax (631) 563-0370

October 3 , 2006

Dharmarajan R. Iyer, Ph.D., P.E.
Iyer Environmental Group, PLLC
44 Rolling Hills Drive
Orchard Park, NY 14127

Re: FOIL Request - County Groundwater Model Data
BB&S Lumber Site, Speonk-Riverhead Road, Southampton

Dear Mr. Iyer:

In response to the above mentioned correspondence, we are enclosing information which we believe will assist in your assessment of the BB and S site.

Page 1 – Site map taken from your e-mailed pdf file.

Page 2 – Geologic cross section through the model domain generated by the Suffolk County Groundwater model (aka SCGWM). The trend line of the section is shown by the dark black line in the inset map (lower right corner of page 2). The names of each stratigraphic unit shown in the cross section are listed in the legend in the lower left corner of page 2.

Pages 3 through 11 – map of the model domain area showing the water level (in ft. msl) in levels no. 1 through 9 of the SCGWM. Shown for reference in green is the model's finite element grid, with the actual head values printed at each node. You should be able to determine which nodes fit into your model domain. Also shown for reference are the major road (in red), coastline (in black) and surface hydrology (in blue).

The final four pages were taken from SCGWM input files, and contain all the information on the hydrogeologic properties of each unit in the SCGWM (in feet/ day units). Not all units are present in your model domain.

This information should allow you to calculate the flux through the model domain, as indicated in your September 15th letter. SCWA does not have electronic GIS coverages from the Suffolk County Department of Health Services (SCDHS) of all aquifer parameters for the SCGWM. You may wish to contact SCDHS directly for this information.

Very truly yours,

Kimberly Kennedy
Kimberly Kennedy
Assistant to General Counsel

Enc.

```
! ----------------------- DEFINE PROPERTIES ---------------------------

! MATERAIL PROPERTIES ARE ARRANGED IN THE FOLLOWING ORDER:
! Prop. #, Kx, Ky, Kz, Ss, Sy, Rechrge, Theta, Phi, Sp.Grav, Eff. Stress

! LLOYD AQUIFER
PROP
10, 35.0, 35.0, 3.5,0.000001,0.2500,0.0000,0.0000,0.0000,0.0000,0.0000

! RARITAN CLAY
PROP
20, 0.3, 0.3, 0.001,0.000001,0.2500,0.0000,0.0000,0.0000,0.0000,0.0000

! RARITAN CLAY NORTH
PROP
22, 3.0, 3.0, 0.02,0.000001,0.2500,0.0000,0.0000,0.0000,0.0000,0.0000

! PORT WASH CU
PROP
21, 2.5, 2.5, 0.025,0.000001,0.2500,0.0000,0.0000,0.0000,0.0000,0.0000

! BASAL MAGOTHY 125
PROP
30, 125.0, 125.0, 1.25,0.000001,0.2500,0.0000,0.0000,0.0000,0.0000,0.0000

! UPPER MAGOTHY CLAY
PROP
31, 2.5, 2.5, 0.02, 0.000001,0.2500,0.0000,0.0000,0.0000,0.0000,0.0000

! MAGOTHY BROWN CLAY
PROP
32, 2.0, 2.0, 0.02, 0.000001,0.2500,0.0000,0.0000,0.0000,0.0000,0.0000

! MIDDLE MAGOTHY 65
PROP
40, 65.0, 65.0, 1.0,0.000001,0.2500,0.0000,0.0000,0.0000,0.0000,0.0000

! UPPER MAGOTHY 35
PROP
```

```
41, 35.0, 35.0, 0.35,0.000001,0.2500,0.0000,0.0000,0.0000,0.0000,0.0000

! UPPER MAGOTHY 65
PROP
50, 65.0, 65.0, 1.0,0.000001,0.2500,0.0000,0.0000,0.0000,0.0000,0.0000

! MONMOUTH GROUP
PROP
52, 1.0, 1.0, 0.1, 0.000001,0.2500,0.1000,0.0000,0.0000,0.0000,0.0000,0.0000

! REWORKED MAGOTHY
PROP
60, 40.0, 40.0, 0.4,0.000001,0.2500,0.0000,0.0000,0.0000,0.0000,0.0000

! UPPER GLACIAL 250
PROP
61, 250.0, 250.0, 2.5, 0.000001,0.2500,0.0000,0.0000,0.0000,0.0000,0.0000

! UPPER GLACIAL 70
PROP
62, 70.0, 70.0, 0.7, 0.000001,0.2500,0.0000,0.0000,0.0000,0.0000,0.0000

! GARDINERS CLAY
PROP
63, 1.00, 1.00, 0.01,0.000001,0.2500,0.0000,0.0000,0.0000,0.0000,0.0000

! UPPER GLACIAL 10
! PROP
! 64, 10.0, 10.0, 1.0,0.000001,0.2500,0.0000,0.0000,0.0000,0.0000,0.0000

! UPPER GLACIAL 300
PROP
65, 300.0, 300.0, 30.0,0.000001,0.2500,0.0000,0.0000,0.0000,0.0000,0.0000

! UPPER GLACIAL 185
PROP
66, 185.0, 185.0, 18.5,0.000001,0.2500,0.0000,0.0000,0.0000,0.0000,0.0000

! REWORKED MAGOTHY 60
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PROP
67, 60.0, 60.0, 1.2,0.000001,0.2500,0.0000,0.0000,0.0000,0.0000,0.0000

! UG 275/27.5
PROP
68, 275.0, 275.0, 27.5,0.000001,0.2500,0.0000,0.0000,0.0000,0.0000,0.0000

! HH GRD MORAINE
PROP
71, 100.00, 100.00, 1.00,0.000001,0.2500,0.0000,0.0000,0.0000,0.0000,0.0000

! SMITHTOWN CLAY
PROP
72, 0.5, 0.5, 0.05,0.000001,0.25000,0.0000,0.0000,0.0000,0.0000,0.0000

! HH TRM MORAINE
PROP
73, 100.0, 100.0, 10.00,0.000001,0.25000, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0

! RON TRM MORAINE
PROP
74, 175.0, 175.0, 1.75,0.000001,0.25000, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0

! RON GRD MORAINE
PROP
75, 100.0, 100.0, 1.0,0.000001,0.25000, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0

! GLACIAL/MAGOTHY 110
PROP
76, 110.0, 110.0, 1.10,0.000001,0.25000, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0

! MANORVILLE CLAY
PROP
77, 20.0, 20.0, 2.00,0.000001,0.25000, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0

! MANHASSET NECK TILL
PROP
78, 5.0, 5.0, 0.5,0.000001,0.25000, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0
```
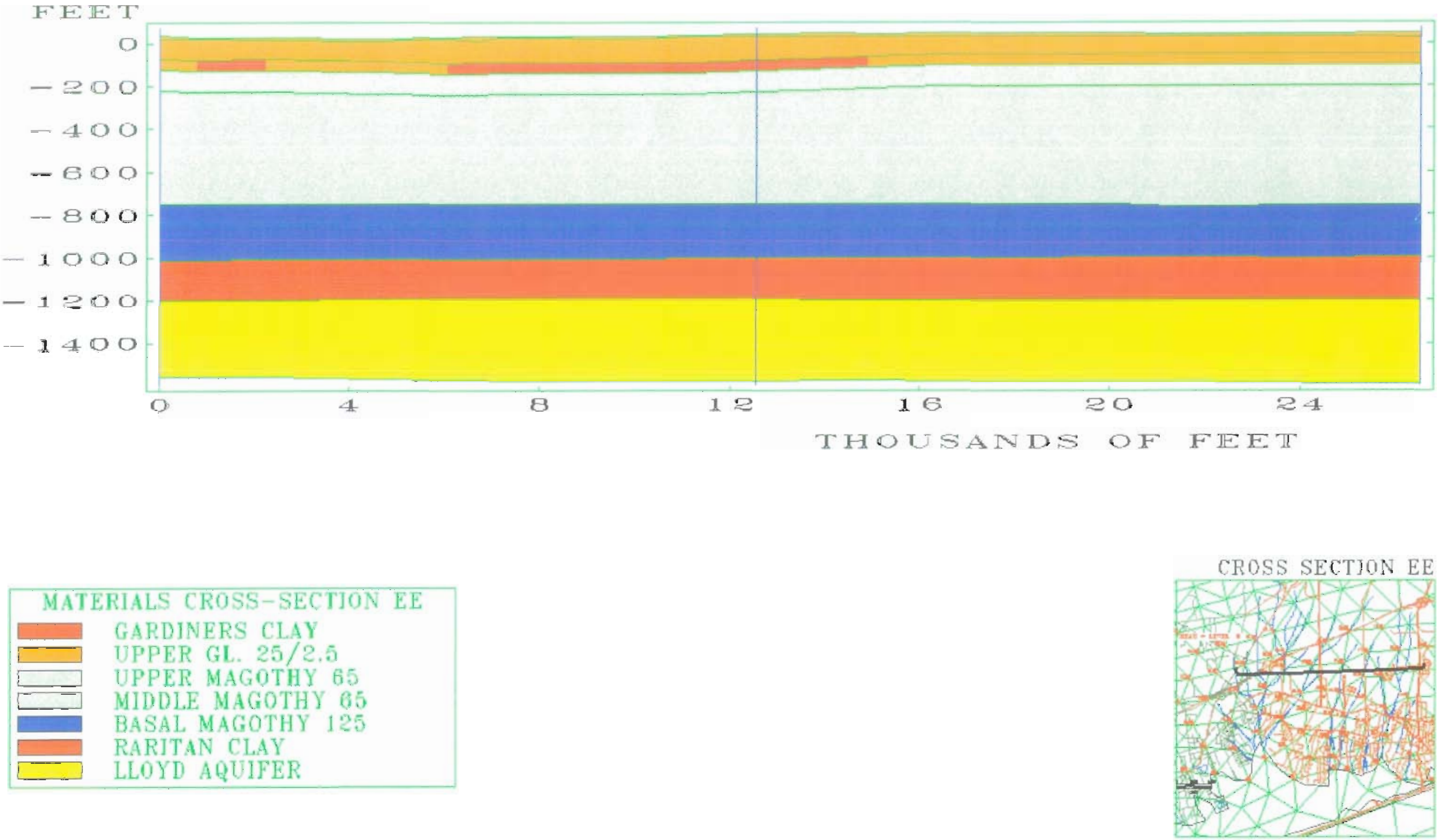
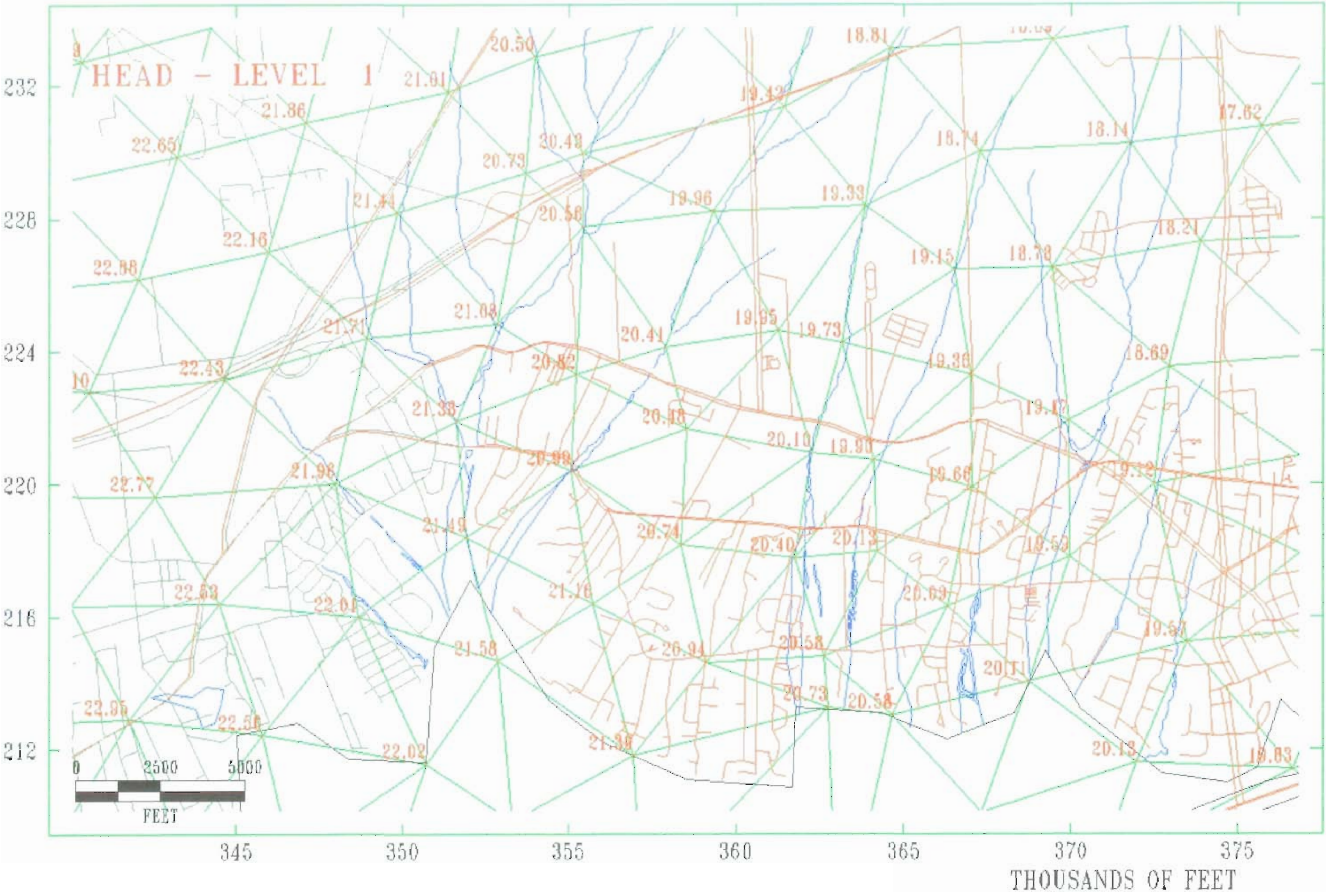
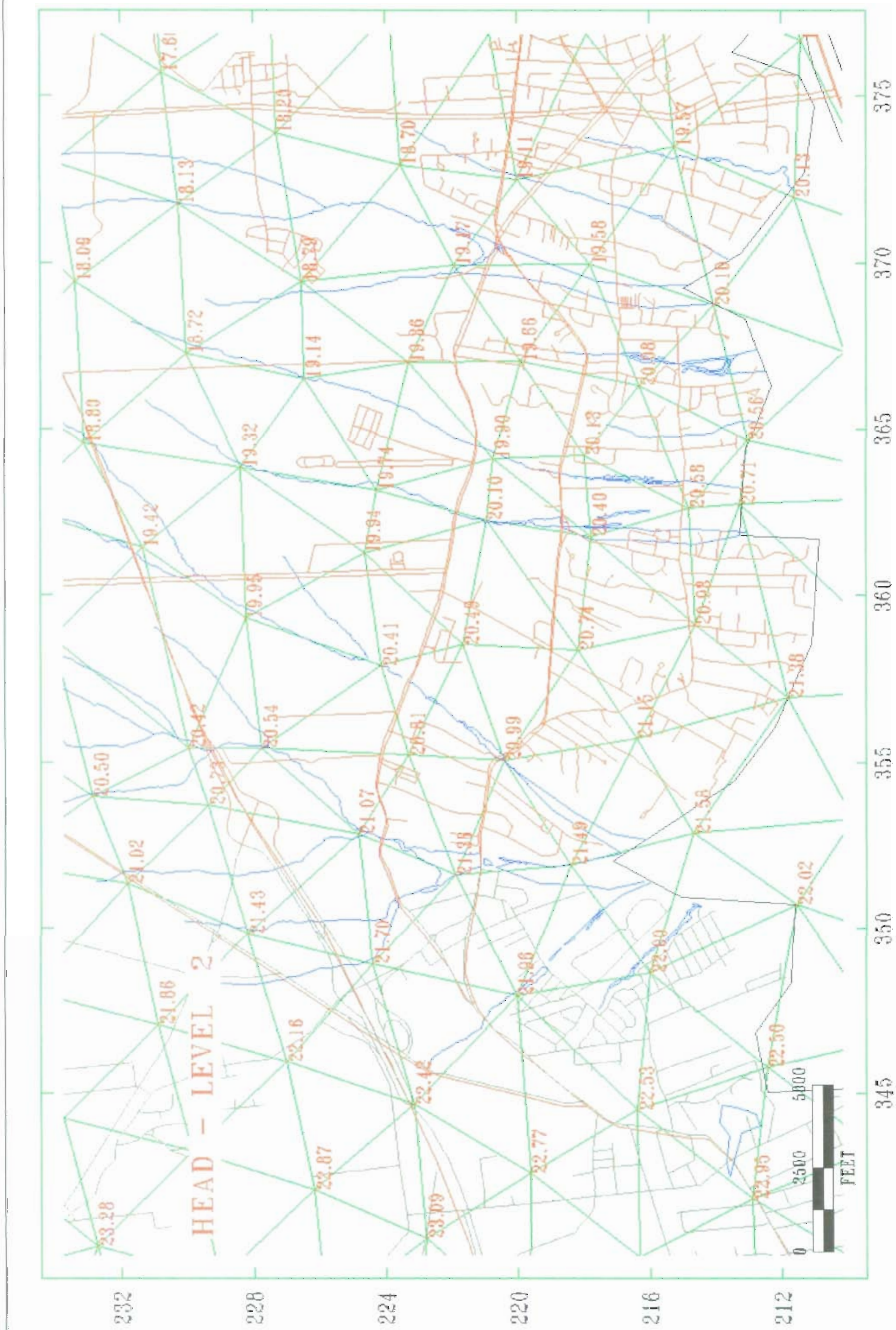
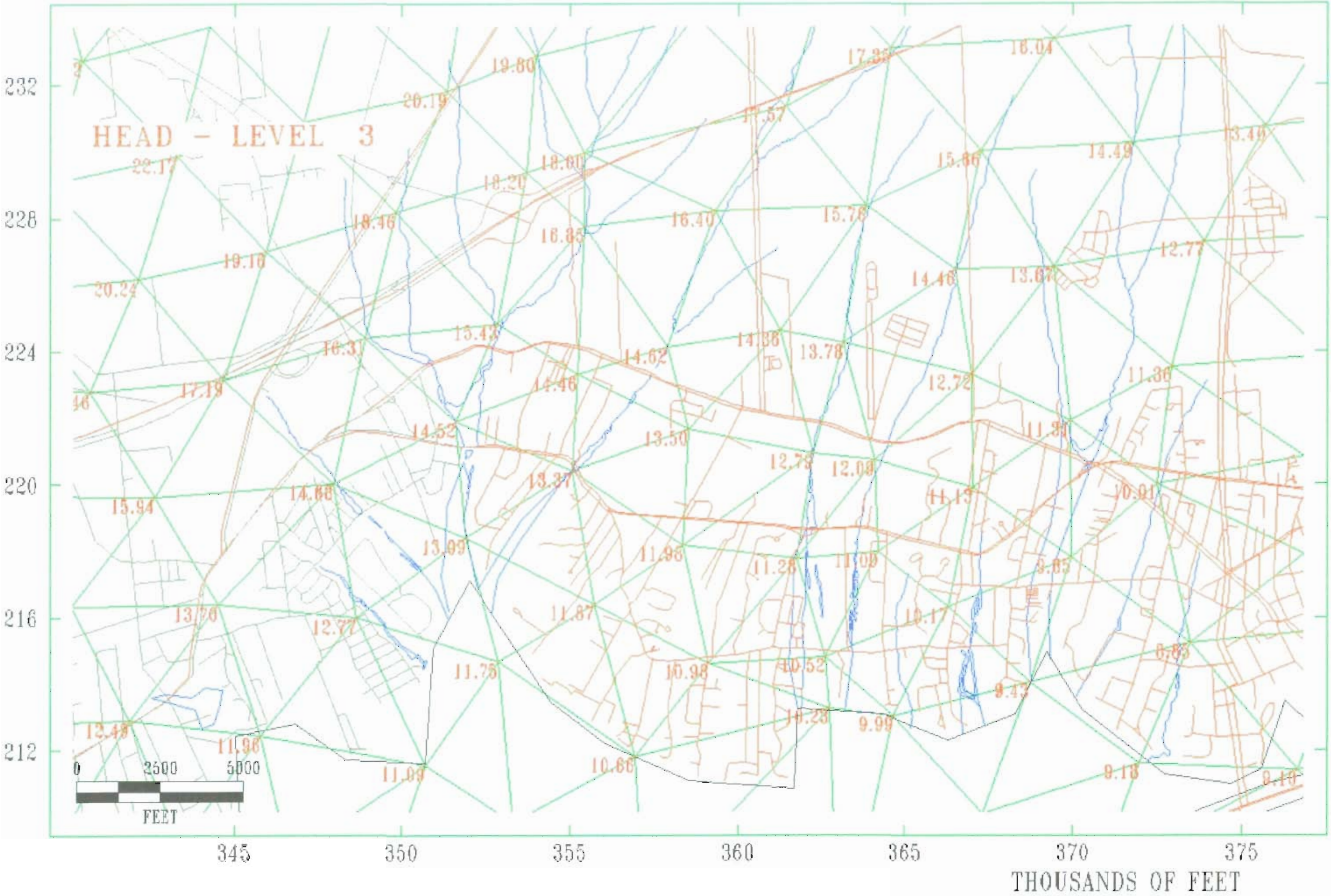

```
! TILL
PROP
80, 5.0, 5.0, 0.5,0.000001,0.25000, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0
```

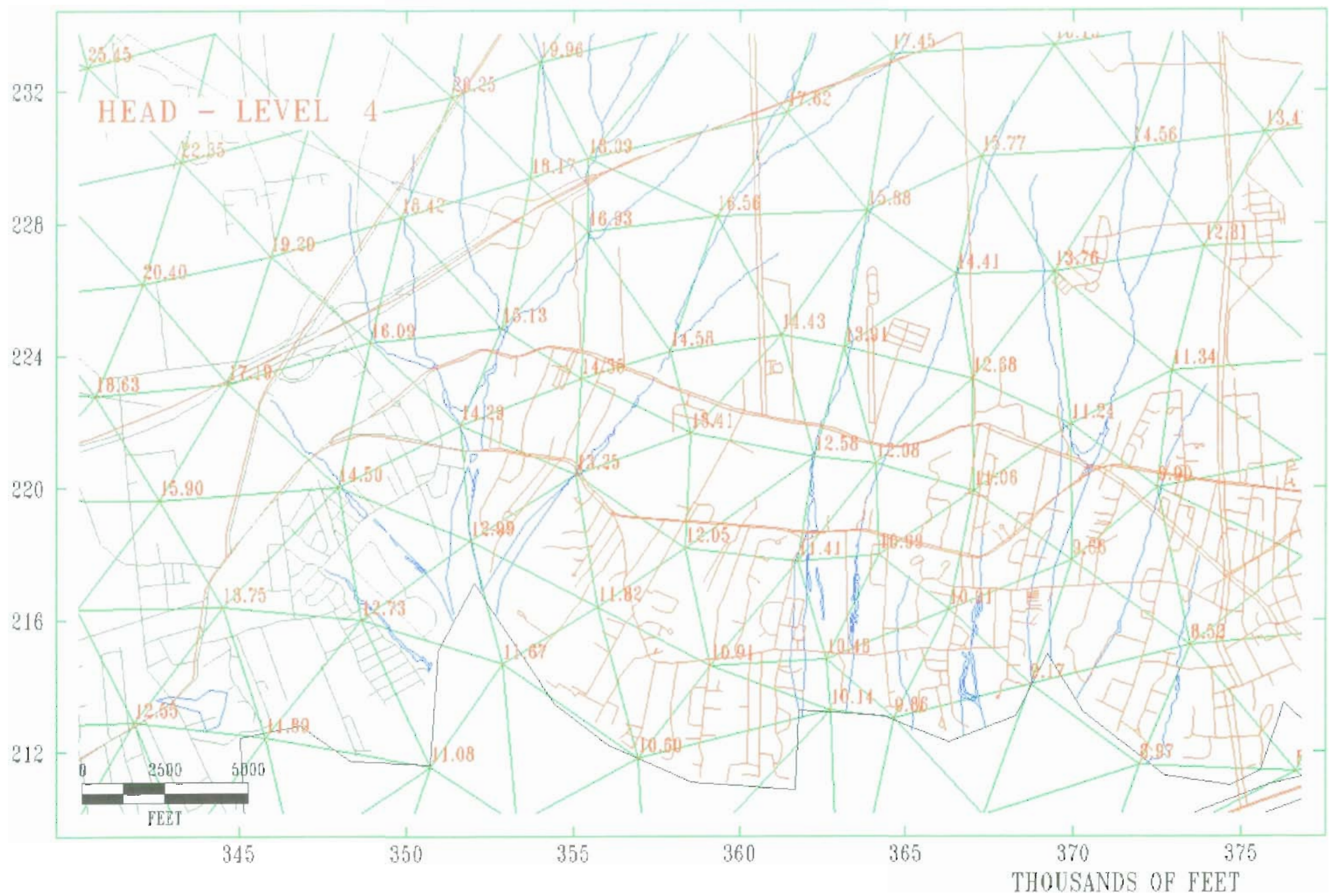

FEET
0
-200
-400
-600
-800
-1000
-1200
-1400
0
4
8
12
16
20
24
THOUSANDS OF FEET
MATERIALS CROSS-SECTION EE
GARDINERS CLAY
UPPER GL. 25/2.5
UPPER MAGOTHY 65
MIDDLE MAGOTHY 65
BASAL MAGOTHY 125
RARITAN CLAY
LLOYD AQUIFER
CROSS SECTION EE

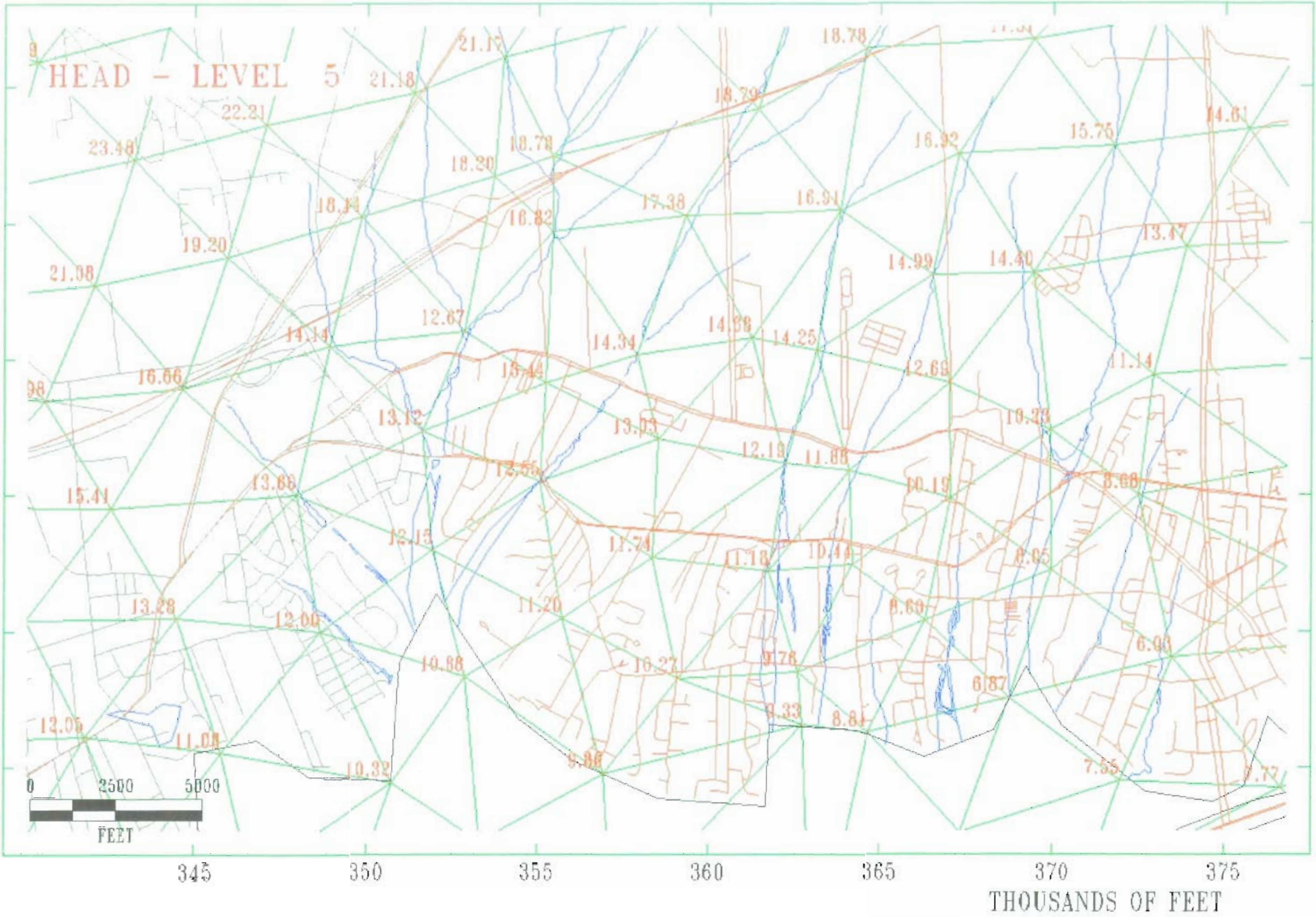

HEAD - LEVEL 1
232
228
224
220
216
212
345
350
355
360
365
370
375
THOUSANDS OF FEET
0
2500
5000
FEET
9
10
20.50
21.01
21.86
22.65
20.48
20.73
19.42
18.81
18.74
18.14
17.62
21.44
20.56
19.96
19.33
22.16
22.88
19.15
18.78
18.21
21.08
21.71
20.41
19.95
19.73
22.43
20.82
19.36
18.69
21.33
20.18
20.10
19.90
21.98
22.77
19.66
21.49
20.74
20.40
20.13
22.53
22.01
21.16
20.69
20.58
20.94
21.58
20.11
20.73
20.58
22.02
20.13

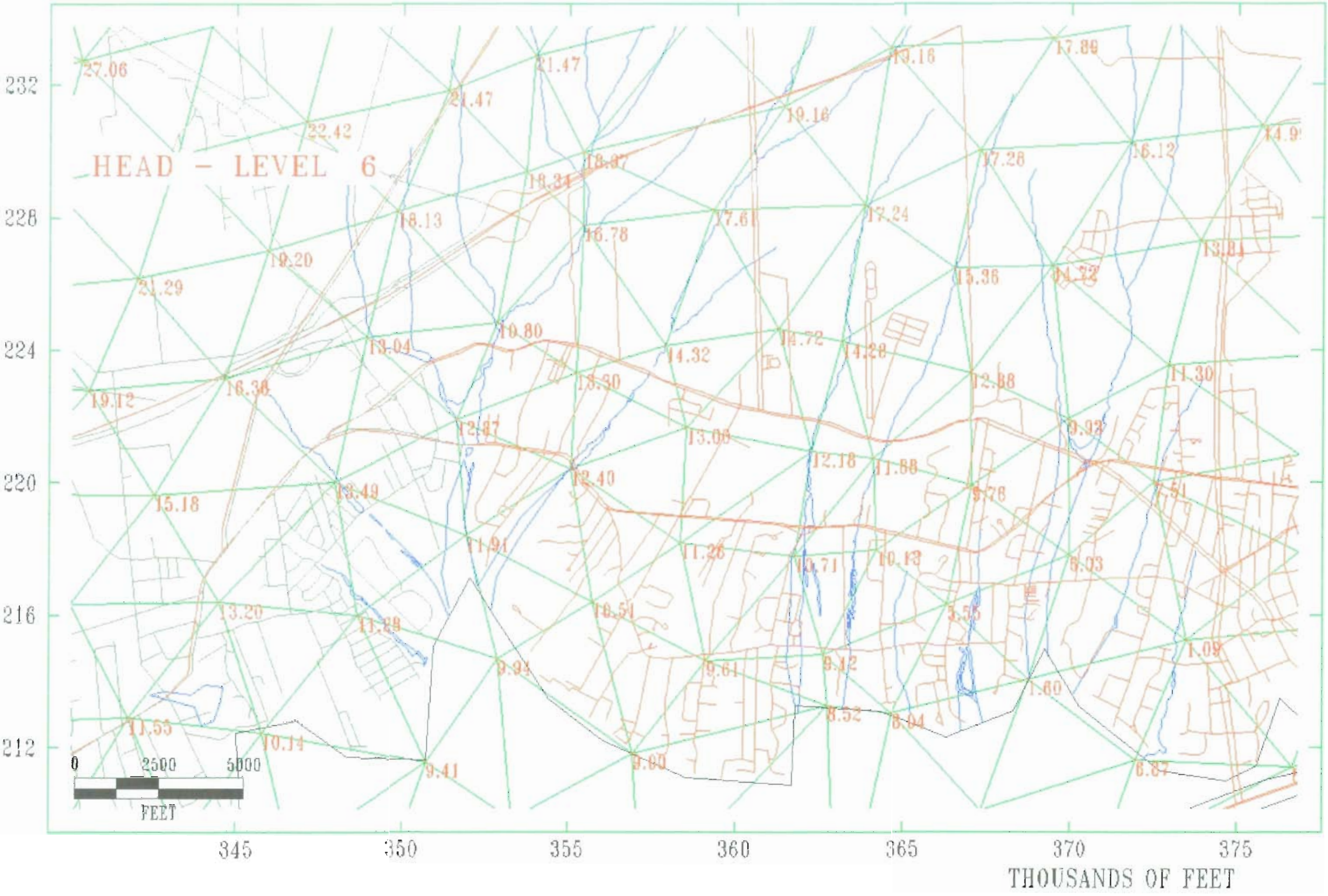


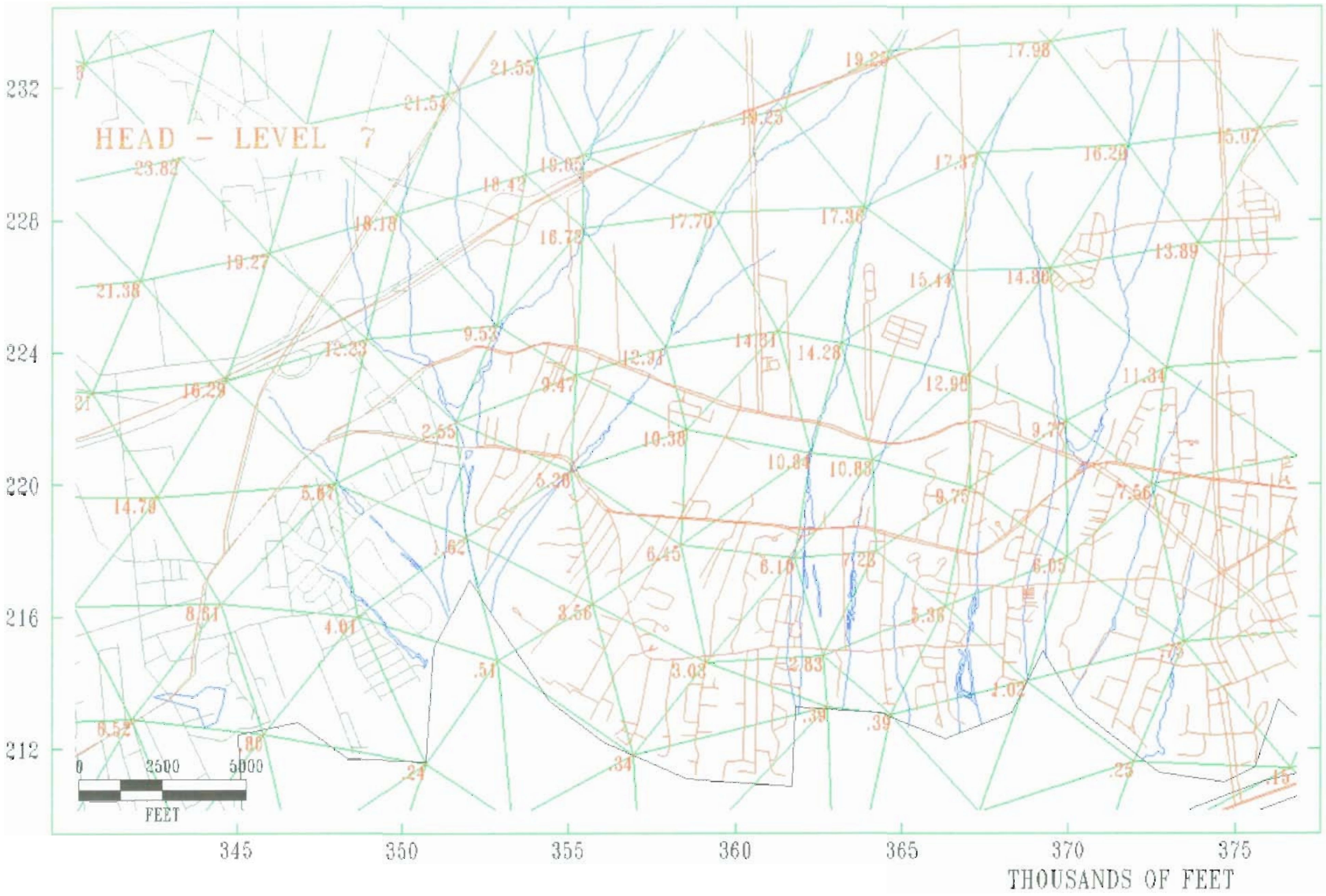
HEAD - LEVEL 2
THOUSANDS OF FEET
345
350
355
360
365
370
375
232
228
224
220
216
212
0
2500
5000
FEET
23.28
21.86
22.16
22.87
23.09
22.48
22.77
22.53
22.95
22.50
21.96
22.60
24.02
21.43
21.70
21.35
21.49
23.02
20.50
20.23
21.07
21.56
20.42
20.54
20.81
20.99
21.15
21.38
19.42
19.95
20.41
20.49
20.74
20.98
18.80
19.32
19.94
19.94
20.10
20.40
20.58
20.71
19.90
20.13
20.564
18.72
19.14
19.36
19.66
20.08
18.09
18.29
19.47
19.58
20.10
18.13
18.70
19.11
20.13
17.81
18.20
19.57

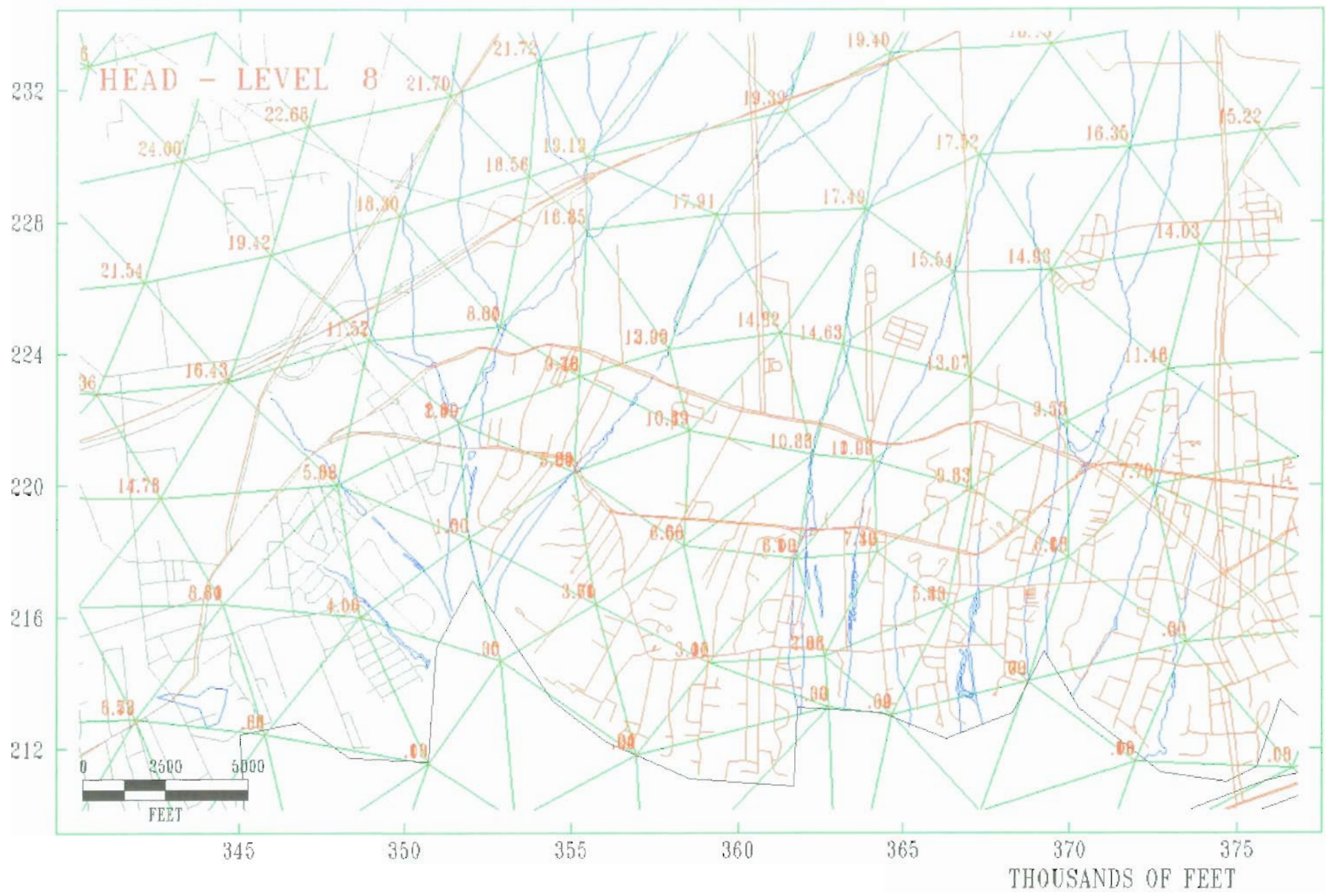
HEAD - LEVEL 3
19.80
20.19
22.17
17.35
16.04
17.57
18.00
18.20
15.86
14.49
13.49
18.46
16.85
16.40
15.76
12.77
19.10
20.24
14.46
13.67
15.43
16.31
14.36
13.78
14.62
17.19
14.46
12.72
11.36
14.52
13.50
11.39
12.78
12.09
13.37
14.68
15.94
11.13
10.01
13.09
11.98
11.28
11.09
9.85
13.70
12.77
11.87
10.17
11.75
10.98
10.52
8.83
9.43
12.48
11.96
10.23
9.99
11.09
10.66
9.18
9.10
0
2500
5000
FEET
232
228
224
220
216
212
345
350
355
360
365
370
375
THOUSANDS OF FEET


HEAD - LEVEL 4
25.45
20.25
19.96
17.45
22.35
17.62
18.03
18.17
15.77
14.56
13.4
18.42
16.93
16.56
15.88
12.81
19.20
20.40
14.41
13.76
15.13
14.43
16.09
14.58
13.91
17.10
14.36
12.68
11.34
18.63
14.29
13.41
11.24
12.58
12.08
13.25
14.50
11.06
9.90
15.90
12.99
12.05
11.41
10.99
9.68
18.75
11.82
10.91
12.73
10.91
10.48
11.67
8.52
9.17
10.14
9.86
12.55
11.89
11.08
10.60
8.97
0
2500
5000
FEET
232
228
224
220
216
212
345
350
355
360
365
370
375
THOUSANDS OF FEET


HEAD - LEVEL 5
232
228
224
220
216
212
345
350
355
360
365
370
375
THOUSANDS OF FEET
0
2500
5000
FEET
21.17
18.78
21.18
22.21
18.79
23.48
18.78
18.20
16.92
15.75
18.14
16.82
17.38
16.91
19.20
13.47
21.98
14.99
14.40
12.67
14.14
14.34
14.38
14.25
16.66
15.44
12.69
11.14
13.12
13.03
10.28
12.19
11.88
12.55
13.66
10.19
8.68
15.41
12.15
11.74
11.18
10.44
8.05
13.28
11.20
8.60
12.00
10.88
10.27
9.78
6.03
6.87
12.05
9.33
8.84
11.08
10.32
9.86
7.55


HEAD - LEVEL 6
27.06
21.47
21.47
22.42
19.16
19.16
17.89
18.37
18.34
17.28
16.12
14.9
18.13
16.78
17.61
17.24
19.20
21.29
15.36
14.72
13.84
10.80
13.04
14.72
14.32
14.28
16.38
19.12
13.30
12.88
11.30
12.87
13.00
9.93
12.18
11.88
12.40
13.49
15.18
9.76
7.51
11.91
11.26
10.71
10.13
6.03
13.20
10.51
11.28
3.55
9.94
9.61
9.12
1.09
1.60
11.55
10.14
8.52
8.04
9.41
9.00
6.87
232
228
224
220
216
212
0
2500
5000
FEET
345
350
355
360
365
370
375
THOUSANDS OF FEET


HEAD - LEVEL 7
8
21.55
17.98
19.23
21.54
19.25
23.82
19.05
17.37
16.29
15.07
18.42
18.18
17.70
17.36
16.75
13.89
19.27
21.38
15.44
14.80
9.53
12.23
14.31
14.28
12.37
16.29
9.47
12.98
11.34
21
2.55
10.38
9.77
10.84
10.88
5.20
5.67
9.75
7.56
14.79
1.62
6.45
7.23
6.10
6.05
3.56
8.61
4.01
5.36
.51
3.03
2.83
.75
1.02
6.52
.39
.39
.86
.24
.34
.25
.15
232
228
224
220
216
212
0
2500
5000
FEET
345
350
355
360
365
370
375
THOUSANDS OF FEET


HEAD - LEVEL 8
6
21.72
21.70
22.68
24.00
19.13
18.56
18.30
16.85
19.42
21.54
8.80
11.52
13.90
16.43
36
9.78
2.00
10.89
5.00
5.08
14.78
1.00
6.60
19.40
19.39
17.52
16.35
15.22
17.91
17.49
14.03
15.64
14.93
14.92
14.63
13.07
11.46
9.55
10.83
10.00
9.83
7.70
6.00
7.30
6.60
3.70
8.80
4.00
5.80
.00
3.00
2.06
.00
.00
.00
6.58
.00
.09
.04
.00
.09
0
2500
5000
FEET
232
228
224
220
216
212
345
350
355
360
365
370
375
THOUSANDS OF FEET

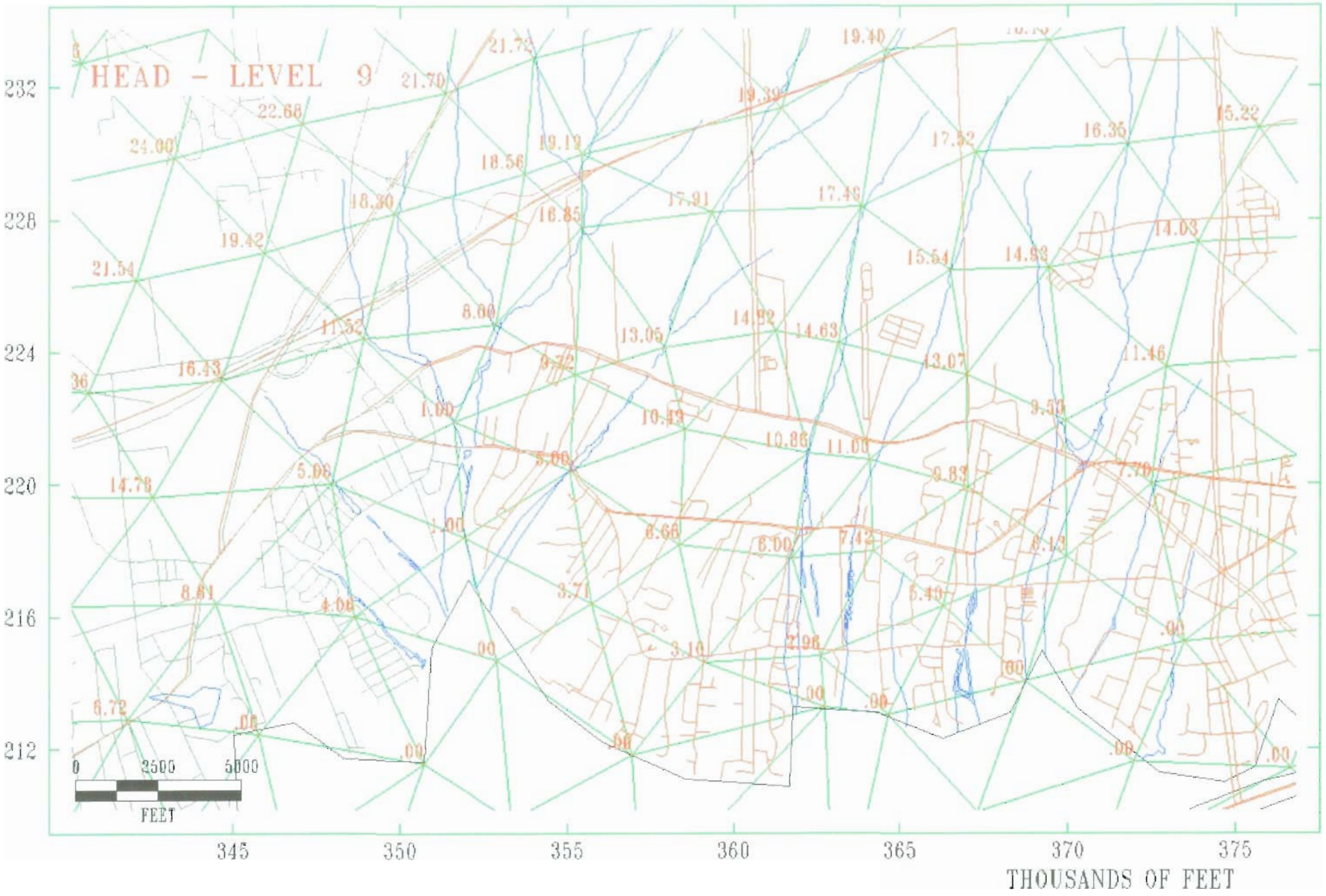

HEAD - LEVEL 9
21.72
19.40
21.70
19.39
22.68
15.22
24.00
19.19
18.56
17.52
16.35
18.30
17.91
17.46
16.85
19.42
14.03
15.54
14.93
21.54
8.00
14.92
14.63
11.52
13.05
16.43
9.72
13.07
11.46
36
1.00
10.49
9.53
10.86
11.00
5.00
5.00
9.83
7.70
14.78
1.00
6.66
6.00
7.42
8.13
8.81
3.71
4.00
5.40
3.10
2.96
.00
.00
.00
.00
.00
.00
.00
6.72
.00
.00
.00
.00
0
2500
5000
FEET
232
228
224
220
216
212
345
350
355
360
365
370
375
THOUSANDS OF FEET

Table 2-1

Hydraulic Conductivities (ft/day) used for the Calibrated Updated Model

Hydrogeologic Unit	Hydraulic Conductivity	
Lloyd Sand	K_h	40
	K_v	4.0
Raritan Clay	K_h	0.3-3.0 (1)
	K_v	0.0001 – 0.02 (1)
North Shore Aquifer	K_h	100
	K_v	10
North Shore Confining Unit	K_h	1.0
	K_v	0.005
Magothy Aquifer	K_h	10 – 125 (2)
	K_v	0.1 – 2.0 (2)
Jameco Gravel	K_h	175.0
	K_v	1.75
Gardiners 20-foot Clay	K_h	1.0 (3)
	K_v	0.01 (3)
Upper Glacial Aquifer	K_h	0.3 – 250 (4)
	K_v	0.0001 – 200 (4)

(1) High values represent more permeable zone in the north-northeast section of the model area.

(2) Higher K_h values represent the coarser sediments found in the basal zone of the Magothy
High K_v values represent a coarser Magothy
found in northern sections of the model.

(3) The model layer represents a composite unit comprised of the Gardiners Clay, a thin layer of sandy upper glacial material, and the '20-foot' clay.

(4) Low values represent till and clay zones found in the northern sections of the model domain. Higher values represent upper glacial outwash.

BB&S Lumber Site Predesign Investigation
Groundwater Flow/Transport Modeling & Treatability Study

APPENDIX E

PEST/MODFLOW CALIBRATION LOG/RUN RECORD

PEST CALIBRATION
RUN 15 - LOG FILE

```
PEST Version 5.50. Watermark Numerical Computing.


PEST is running in Parameter Estimation mode.


PEST run record: case C:\0IEGPROJECTS\0BB&S SITE\GWMODEL\M14PEST1\M14PEST1
(See file C:\0IEGPROJECTS\0BB&S SITE\GWMODEL\M14PEST1\M14PEST1.REC for full details.)


Model command line:
"C:\vmodnt\dosmess.exe" 4195474 1101


Running model .....
   Sum of squared weighted residuals (ie phi) =   8.2340



OPTIMISATION ITERATION NO.        :    1
   Model calls so far             :    1
   Starting phi for this iteration:   8.2340

   Calculating Jacobian matrix: running model  4 times .....

       Lambda =   10.000     ----->
       running model .....
          Phi =   5.5349      (  0.672 of starting phi)

       Lambda =   5.0000     ----->
       running model .....
          Phi =   5.6535      (  0.687 of starting phi)

       Lambda =   20.000     ----->
       running model .....
          Phi =   5.7017      (  0.692 of starting phi)

   No more lambdas: phi rising
   Lowest phi this iteration:   5.5349

      Current parameter values                 Previous parameter values
```

```
      kx__1            157.900                kx__1            180.000
      kz__1            14.8835                kz__1            9.00000
      kx__2            45.4152                kx__2            80.0000
      kz__2           0.121995                kz__2           0.100000
   Maximum   factor change:  1.762     ["kx__2"]
   Maximum relative change: 0.6537     ["kz__1"]



OPTIMISATION ITERATION NO.        :    2
   Model calls so far             :    8
   Starting phi for this iteration:   5.5349

   Calculating Jacobian matrix: running model  4 times .....

       Lambda =   10.000     ----->
       running model .....
          Phi =   5.4493      (  0.985 of starting phi)

       Lambda =   5.0000     ----->
       running model .....
          Phi =   5.4634      (  0.987 of starting phi)

       Lambda =   20.000     ----->
       running model .....
          Phi =   5.4906      (  0.992 of starting phi)

   No more lambdas: phi rising
   Lowest phi this iteration:   5.4493
   Relative phi reduction between optimisation iterations less than 0.1000
   Switch to central derivatives calculation

      Current parameter values                 Previous parameter values
      kx__1            157.535                kx__1            157.900
      kz__1            12.6684                kz__1            14.8835
      kx__2            37.4350                kx__2            45.4152
      kz__2           0.128696                kz__2           0.121995
```

```
   Maximum   factor change:  1.213     ["kx__2"]
   Maximum relative change: 0.1757     ["kx__2"]



OPTIMISATION ITERATION NO.        :    3
   Model calls so far             :   15
   Starting phi for this iteration:   5.4493

   Calculating Jacobian matrix: running model  8 times .....

       Lambda =   10.000     ----->
       running model .....
          Phi =   36.306      (  6.662 times starting phi)

       Lambda =   5.0000     ----->
       running model .....
          Phi =   42.544      (  7.807 times starting phi)

       Lambda =   20.000     ----->
       running model .....
          Phi =   29.539      (  5.421 times starting phi)

       Lambda =   40.000     ----->
       running model .....
          Phi =   19.644      (  3.605 times starting phi)

       Lambda =   80.000     ----->
       running model .....
          Phi =   6.0566      (  1.111 times starting phi)

       Lambda =   160.00     ----->
       running model .....
          Phi =   5.3592      (  0.983 of starting phi)

       Lambda =   320.00     ----->
       running model .....
```

```
          Phi =   5.3600      (  0.984 of starting phi)

    No more lambdas: phi rising
    Lowest phi this iteration:   5.3592

       Current parameter values                 Previous parameter values
       kx__1            167.887                 kx__1             157.535
       kz__1            16.2271                 kz__1             12.6684
       kx__2            19.2731                 kx__2             37.4350
       kz__2           0.107406                 kz__2            0.128696
    Maximum   factor change:  1.942     ["kx__2"]
    Maximum relative change: 0.4852     ["kx__2"]



 OPTIMISATION ITERATION NO.        :    4
    Model calls so far             :   30
    Starting phi for this iteration:   5.3592

    Calculating Jacobian matrix: running model  8 times .....

        Lambda =   160.00     ----->
        running model .....
          Phi =   5.2236      (  0.975 of starting phi)

        Lambda =   80.000     ----->
        running model .....
          Phi =   5.2005      (  0.970 of starting phi)

    No more lambdas: relative phi reduction between lambdas less than 0.0200
    Lowest phi this iteration:   5.2005

       Current parameter values                 Previous parameter values
       kx__1            168.546                 kx__1             167.887
       kz__1            17.1719                 kz__1             16.2271
       kx__2            18.7364                 kx__2             19.2731
       kz__2           9.194381E-02             kz__2            0.107406
```

```
   Maximum   factor change:  1.168     ["kz__2"]
   Maximum relative change: 0.1440     ["kz__2"]



OPTIMISATION ITERATION NO.        :    5
   Model calls so far             :   40
   Starting phi for this iteration:   5.2005

   Calculating Jacobian matrix: running model  8 times .....

       Lambda =   40.000     ----->
       running model .....
          Phi =   5.1780      (  0.996 of starting phi)

       Lambda =   20.000     ----->
       running model .....
          Phi =   5.1907      (  0.998 of starting phi)

       Lambda =   80.000     ----->
       running model .....
          Phi =   5.1862      (  0.997 of starting phi)

   No more lambdas: phi rising
   Lowest phi this iteration:   5.1780

      Current parameter values                 Previous parameter values
      kx__1            172.967                 kx__1            168.546
      kz__1            21.1685                 kz__1            17.1719
      kx__2            18.8018                 kx__2            18.7364
      kz__2           7.624983E-02             kz__2           9.194381E-02
   Maximum   factor change:  1.233     ["kz__1"]
   Maximum relative change: 0.2327     ["kz__1"]



OPTIMISATION ITERATION NO.        :    6
   Model calls so far             :   51
```

```
   Starting phi for this iteration:   5.1780

   Calculating Jacobian matrix: running model  8 times .....

       Lambda =   40.000     ----->
       running model .....
          Phi =   5.2201      (  1.008 times starting phi)

       Lambda =   20.000     ----->
       running model .....
          Phi =   5.3394      (  1.031 times starting phi)

       Lambda =   80.000     ----->
       running model .....
          Phi =   5.1832      (  1.001 times starting phi)

   No more lambdas: relative phi reduction between lambdas less than 0.0200
   Lowest phi this iteration:   5.1832

      Current parameter values                 Previous parameter values
      kx__1            170.223                 kx__1            172.967
      kz__1            21.5210                 kz__1            21.1685
      kx__2            18.1946                 kx__2            18.8018
      kz__2           7.960842E-02             kz__2           7.624983E-02
   Maximum   factor change:  1.044     ["kz__2"]
   Maximum relative change: 4.4047E-02 ["kz__2"]

   Optimisation complete: the  3 lowest phi's are within a relative distance
                          of eachother of 1.000E-02
   Total model calls:   62

Recording run statistics .....

See file C:\0IEGPROJECTS\0BB&S SITE\GWMODEL\M14PEST1\M14PEST1.REC for full run details.
See file C:\0IEGPROJECTS\0BB&S SITE\GWMODEL\M14PEST1\M14PEST1.SEN for parameter sensitivities.
See file C:\0IEGPROJECTS\0BB&S SITE\GWMODEL\M14PEST1\M14PEST1.SEO for observation sensitivities.
```

```
See file C:\0IEGPROJECTS\0BB&S SITE\GWMODEL\M14PEST1\M14PEST1.RES for residuals.
```

PEST CALIBRATION
RUN 15 - RUN RECORD

```
EST RUN RECORD: CASE C:\0IEGPROJECTS\0BB&S SITE\GWMODEL\M14PEST1\M14PEST1



PEST run mode:-


   Parameter estimation mode



Case dimensions:-


   Number of parameters                 :    4
   Number of adjustable parameters      :    4
   Number of parameter groups           :    1
   Number of observations               :   16
   Number of prior estimates            :    0



Model command line(s):-


   "C:\vmodnt\dosmess.exe" 4195474 1101



Jacobian command line:-


   na



Model interface files:-


   Templates:
      M14PEST1.MF.TPL
   for model input files:
      M14PEST1.MF.PL

   (Parameter values written using single precision protocol.)
   (Decimal point always included.)

   Instruction files:
      M14PEST1.INH
   for reading model output files:
      M14PEST1.HOB



PEST-to-model message file:-


   na
```

```
Derivatives calculation:-

Param        Increment   Increment   Increment   Forward or   Multiplier  Method
group        type                    low bound   central      (central)   (central)
cndct        relative    2.0000E-02   none        switch        2.000     parabolic


Parameter definitions:-

Name         Trans-            Change       Initial        Lower          Upper
             formation         limit        value          bound          bound
kx__1        log               factor      180.000       1.000000E-15   1.000000E+29
kz__1        log               factor      9.00000       1.000000E-15   1.000000E+29
kx__2        log               factor      80.0000       1.000000E-15   1.000000E+29
kz__2        log               factor     0.100000       1.000000E-15   1.000000E+29

Name         Group          Scale         Offset        Model command number
kx__1        cndct         1.00000        0.00000            1
kz__1        cndct         1.00000        0.00000            1
kx__2        cndct         1.00000        0.00000            1
kz__2        cndct         1.00000        0.00000            1


Prior information:-

   No prior information supplied


Observations:-

Observation name    Observation       Weight       Group
 of000063            20.0000          1.000       hds.u2
 of000064            20.0000          1.000       hds.u2
 of000065            20.0000          1.000       hds.u2
 of000066            20.0000          1.000       hds.u2
 of000067            22.0000          1.000       hds.u2
 of000068            22.0000          1.000       hds.u2
 of000069            15.4000          1.000       hds.u2
 of000070            10.0000          1.000       hds.u2
 of000071            10.0000          1.000       hds.u2
 of000072            20.0000          1.000       hds.u2
 of000073            17.7000          1.000       hds.u2
 of000074            16.0000          1.000       hds.u2
 of000075            15.6000          1.000       hds.u2
```

```
 of000076            13.6000          1.000       hds.u2
 of000077            11.6000          1.000       hds.u2
 of000078            10.0000          1.000       hds.u2


Control settings:-

   Initial lambda                                               :  10.000
   Lambda adjustment factor                                     :  2.0000
   Sufficient new/old phi ratio per optimisation iteration      : 0.30000
   Limiting relative phi reduction between lambdas              : 2.00000E-02
   Maximum trial lambdas per iteration                          :  10

   Maximum  factor  parameter change (factor-limited changes)   :  10.000
   Maximum relative parameter change (relative-limited changes) :   na
   Fraction of initial parameter values used in computing
   change limit for near-zero parameters                        : 1.00000E-03

   Relative phi reduction below which to begin use of
   central derivatives                                          : 0.10000

   Relative phi reduction indicating convergence                : 0.10000E-01
   Number of phi values required within this range              :   3
   Maximum number of consecutive failures to lower phi          :   3
   Minimal relative parameter change indicating convergence     : 0.10000E-01
   Number of consecutive iterations with minimal param change   :   3
   Maximum number of optimisation iterations                    : 100



                            OPTIMISATION RECORD


INITIAL CONDITIONS:
   Sum of squared weighted residuals (ie phi) =   8.2340

      Current parameter values
      kx__1            180.000
      kz__1            9.00000
      kx__2            80.0000
      kz__2           0.100000


OPTIMISATION ITERATION NO.        :    1
   Model calls so far             :    1
   Starting phi for this iteration:   8.2340
```

```
       Lambda =   10.000     ----->
          Phi =   5.5349      (  0.672 of starting phi)

       Lambda =   5.0000     ----->
          Phi =   5.6535      (  0.687 of starting phi)

       Lambda =   20.000     ----->
          Phi =   5.7017      (  0.692 of starting phi)

   No more lambdas: phi rising
   Lowest phi this iteration:   5.5349

      Current parameter values                 Previous parameter values
      kx__1            157.900                 kx__1             180.000
      kz__1            14.8835                 kz__1             9.00000
      kx__2            45.4152                 kx__2             80.0000
      kz__2           0.121995                 kz__2            0.100000
   Maximum   factor change:  1.762     ["kx__2"]
   Maximum relative change: 0.6537     ["kz__1"]


OPTIMISATION ITERATION NO.        :    2
   Model calls so far             :    8
   Starting phi for this iteration:   5.5349


       Lambda =   10.000     ----->
          Phi =   5.4493      (  0.985 of starting phi)

       Lambda =   5.0000     ----->
          Phi =   5.4634      (  0.987 of starting phi)

       Lambda =   20.000     ----->
          Phi =   5.4906      (  0.992 of starting phi)

   No more lambdas: phi rising
   Lowest phi this iteration:   5.4493
   Relative phi reduction between optimisation iterations less than 0.1000
   Switch to central derivatives calculation

      Current parameter values                 Previous parameter values
      kx__1            157.535                 kx__1             157.900
      kz__1            12.6684                 kz__1             14.8835
      kx__2            37.4350                 kx__2             45.4152
```

```
      kz__2           0.128696                 kz__2            0.121995
   Maximum   factor change:  1.213     ["kx__2"]
   Maximum relative change: 0.1757     ["kx__2"]



OPTIMISATION ITERATION NO.        :    3
   Model calls so far             :   15
   Starting phi for this iteration:   5.4493



       Lambda =   10.000     ----->
          Phi =   36.306      (  6.662 times starting phi)

       Lambda =   5.0000     ----->
          Phi =   42.544      (  7.807 times starting phi)

       Lambda =   20.000     ----->
          Phi =   29.539      (  5.421 times starting phi)

       Lambda =   40.000     ----->
          Phi =   19.644      (  3.605 times starting phi)

       Lambda =   80.000     ----->
          Phi =   6.0566      (  1.111 times starting phi)

       Lambda =   160.00     ----->
          Phi =   5.3592      (  0.983 of starting phi)

       Lambda =   320.00     ----->
          Phi =   5.3600      (  0.984 of starting phi)

   No more lambdas: phi rising
   Lowest phi this iteration:   5.3592

      Current parameter values                 Previous parameter values
      kx__1            167.887                 kx__1             157.535
      kz__1            16.2271                 kz__1             12.6684
      kx__2            19.2731                 kx__2             37.4350
      kz__2           0.107406                 kz__2            0.128696
   Maximum   factor change:  1.942     ["kx__2"]
   Maximum relative change: 0.4852     ["kx__2"]



OPTIMISATION ITERATION NO.        :    4
   Model calls so far             :   30
   Starting phi for this iteration:   5.3592
```

```
       Lambda =   160.00     ----->
          Phi =   5.2236      (  0.975 of starting phi)

       Lambda =   80.000     ----->
          Phi =   5.2005      (  0.970 of starting phi)

   No more lambdas: relative phi reduction between lambdas less than 0.0200
   Lowest phi this iteration:   5.2005

      Current parameter values                 Previous parameter values
      kx__1            168.546                 kx__1             167.887
      kz__1            17.1719                 kz__1             16.2271
      kx__2            18.7364                 kx__2             19.2731
      kz__2           9.194381E-02             kz__2            0.107406
   Maximum   factor change:  1.168     ["kz__2"]
   Maximum relative change: 0.1440     ["kz__2"]


OPTIMISATION ITERATION NO.        :    5
   Model calls so far             :   40
   Starting phi for this iteration:   5.2005


       Lambda =   40.000     ----->
          Phi =   5.1780      (  0.996 of starting phi)

       Lambda =   20.000     ----->
          Phi =   5.1907      (  0.998 of starting phi)

       Lambda =   80.000     ----->
          Phi =   5.1862      (  0.997 of starting phi)

   No more lambdas: phi rising
   Lowest phi this iteration:   5.1780

      Current parameter values                 Previous parameter values
      kx__1            172.967                 kx__1             168.546
      kz__1            21.1685                 kz__1             17.1719
      kx__2            18.8018                 kx__2             18.7364
      kz__2           7.624983E-02             kz__2            9.194381E-02
   Maximum   factor change:  1.233     ["kz__1"]
   Maximum relative change: 0.2327     ["kz__1"]
```

```
OPTIMISATION ITERATION NO.        :    6
   Model calls so far             :   51
   Starting phi for this iteration:   5.1780


       Lambda =   40.000     ----->
          Phi =   5.2201      (  1.008 times starting phi)

       Lambda =   20.000     ----->
          Phi =   5.3394      (  1.031 times starting phi)

       Lambda =   80.000     ----->
          Phi =   5.1832      (  1.001 times starting phi)

   No more lambdas: relative phi reduction between lambdas less than 0.0200
   Lowest phi this iteration:   5.1832

      Current parameter values                 Previous parameter values
      kx__1            170.223                 kx__1             172.967
      kz__1            21.5210                 kz__1             21.1685
      kx__2            18.1946                 kx__2             18.8018
      kz__2           7.960842E-02             kz__2            7.624983E-02
   Maximum   factor change:  1.044     ["kz__2"]
   Maximum relative change: 4.4047E-02 ["kz__2"]

   Optimisation complete: the  3 lowest phi's are within a relative distance
                          of eachother of 1.000E-02
   Total model calls:   62


                            OPTIMISATION RESULTS


Parameters ----->

Parameter        Estimated         95% percent confidence limits
                 value             lower limit       upper limit
 kx__1           172.967            20.5265           1457.50
 kz__1           21.1685           6.170383E-15      7.262216E+16
 kx__2           18.8018           6.266934E-04       564084.
 kz__2          7.624983E-02       3.397548E-07       17112.4

Note: confidence limits provide only an indication of parameter uncertainty.
      They rely on a linearity assumption which  may not extend as far in
      parameter space as the confidence limits themselves - see PEST manual.
```

```
See file C:\0IEGPROJECTS\0BB&S SITE\GWMODEL\M14PEST1\M14PEST1.SEN for parameter sensitivities.



Observations ----->


Observation      Measured       Calculated     Residual       Weight     Group
                 value          value
 of000063        20.0000        20.2352      -0.235240        1.000      hds.u2
 of000064        20.0000        20.1920      -0.191960        1.000      hds.u2
 of000065        20.0000        20.0005      -5.100000E-04    1.000      hds.u2
 of000066        20.0000        19.7803       0.219730        1.000      hds.u2
 of000067        22.0000        21.3386       0.661440        1.000      hds.u2
 of000068        22.0000        21.5669       0.433060        1.000      hds.u2
 of000069        15.4000        16.2522      -0.852210        1.000      hds.u2
 of000070        10.0000        11.3583       -1.35831        1.000      hds.u2
 of000071        10.0000        11.0767       -1.07671        1.000      hds.u2
 of000072        20.0000        19.4141       0.585930        1.000      hds.u2
 of000073        17.7000        17.5850       0.114960        1.000      hds.u2
 of000074        16.0000        15.9248       7.515000E-02    1.000      hds.u2
 of000075        15.6000        15.5396       6.041000E-02    1.000      hds.u2
 of000076        13.6000        13.4364       0.163590        1.000      hds.u2
 of000077        11.6000        11.8163      -0.216250        1.000      hds.u2
 of000078        10.0000        10.4925      -0.492530        1.000      hds.u2

See file C:\0IEGPROJECTS\0BB&S SITE\GWMODEL\M14PEST1\M14PEST1.RES for more details of residuals in graph-ready format.

See file C:\0IEGPROJECTS\0BB&S SITE\GWMODEL\M14PEST1\M14PEST1.SEO for composite observation sensitivities.



Objective function ----->


  Sum of squared weighted residuals (ie phi)                =   5.178



Correlation Coefficient ----->


  Correlation coefficient                                   =  0.9954



Analysis of residuals ----->


  All residuals:-
     Number of residuals with non-zero weight               =    16
     Mean value of non-zero weighted residuals              = -0.1318
     Maximum weighted residual [observation "of000067"]     =  0.6614
     Minimum weighted residual [observation "of000070"]     =  -1.358
```

```
     Standard variance of weighted residuals                =  0.4315
     Standard error of weighted residuals                   =  0.6569

     Note: the above variance was obtained by dividing the objective
     function by the number of system degrees of freedom (ie. number of
     observations with non-zero weight plus number of prior information
     articles with non-zero weight minus the number of adjustable parameters.)
     If the degrees of freedom is negative the divisor becomes
     the number of observations with non-zero weight plus the number of
     prior information items with non-zero weight.



Parameter covariance matrix ----->

                kx__1        kz__1        kx__2        kz__2
kx__1          0.1805       2.8783E-02  -0.8223       -1.031
kz__1          2.8783E-02    50.83       -4.785       -2.663
kx__2         -0.8223       -4.785        4.222        4.919
kz__2          -1.031       -2.663        4.919        6.031



Parameter correlation coefficient matrix ----->

                kx__1        kz__1        kx__2        kz__2
kx__1           1.000       9.5035E-03  -0.9421      -0.9886
kz__1          9.5035E-03    1.000      -0.3267      -0.1521
kx__2         -0.9421      -0.3267        1.000       0.9748
kz__2         -0.9886      -0.1521       0.9748        1.000



Normalized eigenvectors of parameter covariance matrix ----->

              Vector_1     Vector_2     Vector_3     Vector_4
kx__1          0.9896      -4.5267E-02  -0.1361      -3.6795E-03
kz__1          1.1050E-02  -4.1442E-02   0.1209      -0.9917
kx__2          4.8402E-02  -0.7839       0.6096       0.1076
kz__2          0.1347       0.6179       0.7715       6.9744E-02



Eigenvalues ----->

               2.3098E-04   4.4391E-02    9.682        51.54
```

BB&S Lumber Site Predesign Investigation
Groundwater Flow/Transport Modeling & Treatability Study

APPENDIX F

CALCULATIONS/VERIFICATIONS FOR GROUNDWATER FLOW MODELING

IYER ENVIRONMENTAL GROUP, PLLC

Page 1 **of** 3

made By __________

PROJECT: BB&S Lumber – GW Flow/Transport Modeling

Checked By __________

SUBJECT: Manual Calculation/Verification

DATE 2/2/07

GRADIENT ACROSS SITE
(data from USGS map with contours on Figure 1)

Upper Glacial Unit:
Gradient i = 10’ across 6000’
= 10/6000 = 0.0017 ft/ft

Magothy:
i = 10’ across 12000’
= 10/12000 = 0.0008 ft/ft

GROUNDWATER FLOW THROUGH SITE

Flow Q = KiA = KiWD
Where K=conductivity, i= gradient; A= area; W=width; D=depth

Dimensions are from model area on Figure 4; conductivity from model calibration using PEST

Upper Glacial Unit:
K = 170 1/day; D=120’; W=280’; i = 0.0017

Q = 170 /d x 120’ x 280’ x 0.0017
= 9,700 cf/day = 72,600 gpd = 50 gpm

Magothy:
K = 87 1/day; W=280’; i = 0.0008;
calculate for a depth of 100’ (actual depth is 900’ to 1000’)

Q = 18.2 /d x 100’ x 280’ x 0.0008= 408 cf/day
= 3000 gpd = 2 gpm (for 100’ depth)

VELOCITY THROUGH SITE

Velocity V = Ki / η; Where η = effective porosity

Upper Glacial Unit:
V = (170 x 0.0017) / 0.1 = 2.89 ft/day for η =0.1
V = (170 x 0.0017) / 0.25 = 1.16 ft/day for η =0.25

Magothy:
V = (18.2 x 0.0008) / 0.1 = 0.15 ft/day for η =0.1
V = (18.2 x 0.0008) / 0.25= 0.06 ft/day for η =0.25

PLUME

Upper Glacial Unit: Groundwater characterization data show a plume length of around 9000', stretching from the source area inside the wood processing building. The duration of travel can be calculated using the plume length and velocity

Plume length = length / velocity
= 9000 / 2.89 = 3,300 days = 9 yrs (for η = 0.1)
= 9000 / 1.1 = 7,700 days = 21 yrs (for η = 0.25)

RECHARGE

Groundwater recharge occurs only from streams and rainfall in the model area because of the groundwater divide to the north. The model could not be calibrated well with a single precipitation recharge rate for the entire model area. The model area had to be spilt into three zones (see Figure 7 of the report) and recharge rates of 0.0065, 0.0065 and 0.004 ft/day for zones 1, 2 and 3 respectively provided with the best fit for the flow model along with appropriate assumptions for leakage from the streams. USGS documents indicate a range of 0.002 to 0.006 ft/day for the infiltration recharge rate, while the Suffolk County's DYNFLOW Model uses a regional average recharge rate of 1 MGD/sq.mi., or 0.005 ft/day.

Recharge from precipitation = infiltration rate x area

ZONE	INFILTRATION RATE	AREA	RECHARGE
1	0.0065 ft/day	50,300,000 sf	327,000 cf/day
2	0.0065 ft/day	20,900,000 sf	136,000 cf/day
3	0.0040 ft/day	12,500,000 sf	50,000 cf/day
TOTAL	**0.0061 ft/day**	**83,700,000 sf** (1,980 acres)	**513,000 cf/day**

From zone budget in the calibrated flow model for the area,
Leakage from the river = 89,000 cf/day

Therefore, total groundwater recharge = (513,000 + 89,000) = 602,000 cf/day

The quantities are needed such that PEST is able to match the USGS based groundwater contours for the upper glacial and Magothy layers with conductivities that are within the rage reported in the literature.

made By ______
PROJECT: BB&S Lumber – GW Flow/Transport Modeling **Checked By** ______

SUBJECT: Manual Calculation/Verification **DATE** **2/2/07**

RETARDATION FACTOR

$R = 1 + K_d \rho / \eta$; and $K_d = f_{oc}K_{oc}$
where K_d = adsorption (or distribution) coefficient of the chemical in soil/water;
ρ = bulk density; f_{oc} = fraction organic carbon; and
K_{oc} = organic carbon/water partition coefficient

According to Partition Coefficients for Metals in Surface Water, Soil and Waste, USEPA, 1999, Log K_{oc} (in L/Kg) ranges from -0.7 to 4.8 for to Cr(VI), and 1 to 4.8 for Cr(III) .
Thus, assuming ρ = 1.7 and f_{oc} = 0.00005 (or a 50 ppm organic content)

	Log K_{oc}	K_{oc}	R (for η = 0.25)	R (for η = 0.1)
Cr (VI)	-0.7 to 3.3	0.2 to 2000	1 to 1.7	1 to 2.7
Cr (III)	1 to 4.8	10 to 63000	1 to 22	1 to 55

APPENDIX G

MINEQL CHEMICAL SPECIATION MODEL INPUT/OUTPUT

TABLE G-1A

INPUT DATA FOR MINEQL RUN #05 WITHOUT REDOX

```
   Jun 28, 2006  10:33   MINEQL+ Header file for B05SCP.mdo


          $$$  INPUT DATA  $$$
ÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ
OPTIONS:  IADS= 0 IONIT=-1 IONPH= 0 IPHFX= 0 IPHA=  0
            IPHB= 0 ITITL= 0 IPCP=0 ICND=0
ÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ
                ELECTRONEUTRALITY NOT GUARANTEED
               TEMPERATURE  =  25.0 CELSIUS
                IONIC STRENGTH FIXED CONCENTRATION
                NO SURFACE MODEL USED
                      EPS =  1.0E-04
   ID           X     LOGX           T     COMPONENTS
    2   1.00D-20  -20.00   1.000E-18     H2O
    3   1.00D-07   -7.00   1.000E-18     H(+)
    9   3.89D-07   -6.41   3.900E-05     AsO3(3-)
   16   7.24D-06   -5.14   7.200E-04     Ca(2+)
   19   1.70D-05   -4.77   1.700E-03     Cl(-)
   26   9.55D-07   -6.02   9.600E-05     CrO4(2-)
   28   9.55D-07   -6.02   9.600E-05     Cr(OH)2(+)
   30   2.00D-07   -6.70   2.000E-05     Cu(2+)
   31   2.00D-07   -6.70   2.000E-05     Cu(+)
   32   3.63D-05   -4.44   3.600E-03     Fe(2+)
   33   3.63D-05   -4.44   3.600E-03     Fe(3+)
   38   7.76D-07   -6.11   7.700E-05     K(+)
   41   1.82D-06   -5.74   1.800E-04     Mg(2+)
   45   1.10D-05   -4.96   1.100E-03     Na(+)
   50   5.01D-06   -5.30   5.000E-04     NO3(-)
   68   3.09D-06   -5.51   3.100E-04     SO4(2-)

   ID    NAME                 LOGK      DELH      SPECIES:       TYPE I - COMPONENTS
     2 H2O                     .000        .000     H2O        1.0
     3 H(+)                    .000        .000     H(+)       1.0
     9 AsO3(3-)                .000        .000     AsO3(3-)   1.0
    16 Ca(2+)                  .000        .000     Ca(2+)     1.0
    19 Cl(-)                   .000        .000     Cl(-)      1.0
    26 CrO4(2-)                .000        .000     CrO4(2-)   1.0
    28 Cr(OH)2(+)              .000        .000     Cr(OH)2(+  1.0
    30 Cu(2+)                  .000        .000     Cu(2+)     1.0
    31 Cu(+)                   .000        .000     Cu(+)      1.0
    32 Fe(2+)                  .000        .000     Fe(2+)     1.0
    33 Fe(3+)                  .000        .000     Fe(3+)     1.0
```

TABLE G-1A

INPUT DATA FOR MINEQL RUN #05 WITHOUT REDOX

```
    38 K(+)                    .000        .000     K(+)       1.0
    41 Mg(2+)                  .000        .000     Mg(2+)     1.0
    45 Na(+)                   .000        .000     Na(+)      1.0
    50 NO3(-)                  .000        .000     NO3(-)     1.0
    68 SO4(2-)                 .000        .000     SO4(2-)    1.0

  ID    NAME                 LOGK      DELH      SPECIES:       TYPE II - COMPLEXES
  3800 OH-             (-1) -13.997      13.339     H2O        1.0   H(+)      -1.0
 11200 Cr+3            (+3)   9.569     -30.980     H2O       -2.0   H(+)       2.0   Cr(OH)2(+  1.0
 11300 Cr(OH)+2        (+2)   5.912     -18.621     H2O       -1.0   H(+)       1.0   Cr(OH)2(+  1.0
 11500 Cr(OH)4-        (-1) -17.819        .000     H2O        2.0   H(+)      -2.0   Cr(OH)2(+  1.0
 13200 Cu(OH)3-        (-1) -26.879        .000     H2O        3.0   H(+)      -3.0   Cu(2+)     1.0
 13300 Cu(OH)4-2       (-2) -39.980        .000     H2O        4.0   H(+)      -4.0   Cu(2+)     1.0
 13400 CuOH+           (+1)  -7.497       8.559     H2O        1.0   H(+)      -1.0   Cu(2+)     1.0
 13500 Cu(OH)2 (aq)         -16.194        .000     H2O        2.0   H(+)      -2.0   Cu(2+)     1.0
 13900 Fe(OH)3-        (-1) -28.991      30.218     H2O        3.0   H(+)      -3.0   Fe(2+)     1.0
 14000 Fe(OH)2 (aq)         -20.494      28.590     H2O        2.0   H(+)      -2.0   Fe(2+)     1.0
 14100 FeOH+           (+1)  -9.397      13.339     H2O        1.0   H(+)      -1.0   Fe(2+)     1.0
 14300 FeOH+2          (+2)  -2.187       9.993     H2O        1.0   H(+)      -1.0   Fe(3+)     1.0
 14400 Fe(OH)2+        (+1)  -4.594        .000     H2O        2.0   H(+)      -2.0   Fe(3+)     1.0
 14500 Fe2(OH)2+4      (+4)  -2.854      13.771     H2O        2.0   H(+)      -2.0   Fe(3+)     2.0
 14600 Fe(OH)3 (aq)         -12.560      24.809     H2O        3.0   H(+)      -3.0   Fe(3+)     1.0
 14700 Fe(OH)4-        (-1) -21.588        .000     H2O        4.0   H(+)      -4.0   Fe(3+)     1.0
 17900 MgOH+           (+1) -11.397      16.207     H2O        1.0   H(+)      -1.0   Mg(2+)     1.0
 26600 HAsO3-2         (-2)  13.414      -6.051     H(+)       1.0   AsO3(3-)   1.0
 26700 H3AsO3                34.744     -20.250     H(+)       3.0   AsO3(3-)   1.0
 26800 H2AsO3-         (-1)  25.454     -13.699     H(+)       2.0   AsO3(3-)   1.0
 26900 H4AsO3+         (+1)  34.439        .000     H(+)       4.0   AsO3(3-)   1.0
 33600 HCrO4-          (-1)   6.510        .478     H(+)       1.0   CrO4(2-)   1.0
 33700 H2CrO4 (aq)            6.419       9.321     H(+)       2.0   CrO4(2-)   1.0
 33900 CrO2-           (-1) -17.746        .000     H(+)      -2.0   Cr(OH)2(+  1.0

  ID    NAME                 LOGK      DELH      SPECIES:       TYPE III - FIXED SOLIDS (SPECIES)
196700 BRUCITE              -16.844      27.246     H2O        2.0   H(+)      -2.0   Mg(2+)     1.0
  3801 H2O (Solution)          .000        .000     H2O        1.0
175310 pH              (+1)   1.500        .000     H(+)       1.0

  ID    NAME                 LOGK      DELH      SPECIES:       TYPE V - DISSOLVED SOLIDS  (SUBJECT TO PRECIPITATION)
186700 LIME                 -32.699      46.346     H2O        1.0   H(+)      -2.0   Ca(2+)     1.0
191500 CrO3                   3.211       1.245     H2O       -1.0   H(+)       2.0   CrO4(2-)   1.0
191900 Cr2O3                  2.358      12.125     H2O       -1.0   H(+)      -2.0   Cr(OH)2(+  2.0
192100 Cr(OH)3               -1.335       7.115     H2O        1.0   H(+)      -1.0   Cr(OH)2(+  1.0
192500 Cu(OH)2               -8.674      13.485     H2O        2.0   H(+)      -2.0   Cu(2+)     1.0
193400 CUPRITE                1.406      29.642     H2O        1.0   H(+)      -2.0   Cu(+)      2.0
193700 Fe(OH)2              -13.564        .000     H2O        2.0   H(+)      -2.0   Fe(2+)     1.0
194500 FERRIHYDRITE          -3.191      17.537     H2O        3.0   H(+)      -3.0   Fe(3+)     1.0
196702 Mg(OH)2 (active)     -18.794        .000     H2O        2.0   H(+)      -2.0   Mg(2+)     1.0

  ID    NAME                 LOGK      DELH      SPECIES:       TYPE VI - SPECIES NOT CONSIDERED
  7300 CaOH+           (+1) -12.697      15.323     H2O        1.0   H(+)      -1.0   Ca(2+)     1.0
  8400 CrO3Cl-         (-1)   7.309        .000     H2O       -1.0   H(+)       2.0   Cl(-)      1.0   CrO4(2-)   1.0
```

TABLE G-1A

INPUT DATA FOR MINEQL RUN #05 WITHOUT REDOX

```
  8500 CrCl+2          (+2)   9.681     -24.766     H2O       -2.0   H(+)       2.0   Cl(-)      1.0   Cr(OH)2(+  1.0
  8600 CrCl2+          (+1)   8.658      -9.374     H2O       -2.0   H(+)       2.0   Cl(-)      2.0   Cr(OH)2(+  1.0
  8700 CrOHCl2 (aq)           2.963        .000     H2O       -1.0   H(+)       1.0   Cl(-)      2.0   Cr(OH)2(+  1.0
 10800 Cr2O7-2         (-2)  14.560      -3.585     H2O       -1.0   H(+)       2.0   CrO4(2-)   2.0
 11100 CrO3SO4-2       (-2)   8.994        .000     H2O       -1.0   H(+)       2.0   CrO4(2-)   1.0   SO4(2-)    1.0
 11400 Cr(OH)3 (aq)          -8.422        .000     H2O        1.0   H(+)      -1.0   Cr(OH)2(+  1.0
 12100 CrNO3+2         (+2)   8.209     -15.640     H2O       -2.0   H(+)       2.0   Cr(OH)2(+  1.0   NO3(-)     1.0
 12300 Cr2(OH)2(SO4)2 (aq)   17.929        .000     H2O       -2.0   H(+)       2.0   Cr(OH)2(+  2.0   SO4(2-)    2.0
 12400 Cr2(OH)2SO4+2   (+2)  16.155        .000     H2O       -2.0   H(+)       2.0   Cr(OH)2(+  2.0   SO4(2-)    1.0
 12500 CrSO4+          (+1)  12.937     -23.571     H2O       -2.0   H(+)       2.0   Cr(OH)2(+  1.0   SO4(2-)    1.0
 12700 CrOHSO4 (aq)           8.287        .000     H2O       -1.0   H(+)       1.0   Cr(OH)2(+  1.0   SO4(2-)    1.0
 13100 Cu2(OH)2+2      (+2) -10.594      18.313     H2O        2.0   H(+)      -2.0   Cu(2+)     2.0
 14800 Fe3(OH)4+5      (+5)  -6.288      15.593     H2O        4.0   H(+)      -4.0   Fe(3+)     3.0
 71901 CaNO3+          (+1)    .500      -1.291     Ca(2+)     1.0   NO3(-)     1.0
 72300 CaSO4 (aq)             2.360       1.697     Ca(2+)     1.0   SO4(2-)    1.0
 89000 CuCl3-          (-1)  -2.290      13.690     Cl(-)      3.0   Cu(2+)     1.0
 89100 CuCl2 (aq)             -.260      10.560     Cl(-)      2.0   Cu(2+)     1.0
 89200 CuCl4-2    1    (-2)  -4.590       7.780     Cl(-)      4.0   Cu(2+)     1.0
 89300 CuCl+           (+1)    .200       1.984     Cl(-)      1.0   Cu(2+)     1.0
 89400 CuCl2-          (-1)   5.420       -.420     Cl(-)      2.0   Cu(+)      1.0
 89401 CuCl (aq)              3.100        .000     Cl(-)      1.0   Cu(+)      1.0
 89500 CuCl3-2         (-2)   4.750        .260     Cl(-)      3.0   Cu(+)      1.0
 89600 FeCl            (+1)   -.200        .000     Cl(-)      1.0   Fe(2+)     1.0
 89700 FeCl2+          (+1)   2.130        .000     Cl(-)      2.0   Fe(3+)     1.0
 89800 FeCl3 (aq)             1.130        .000     Cl(-)      3.0   Fe(3+)     1.0
 89900 FeCl+2          (+2)   1.480       5.497     Cl(-)      1.0   Fe(3+)     1.0
102500 KCrO4-          (-1)    .570        .000     CrO4(2-)   1.0   K(+)       1.0
102600 NaCrO4-         (-1)    .696        .000     CrO4(2-)   1.0   Na(+)      1.0
104203 Cu(NO3)2 (aq)          -.400        .000     Cu(2+)     1.0   NO3(-)     2.0
104204 CuNO3+          (+1)    .500       -.980     Cu(2+)     1.0   NO3(-)     1.0
104800 CuSO4 (aq)             2.360       2.079     Cu(2+)     1.0   SO4(2-)    1.0
114900 FeSO4 (aq)             2.390       1.912     Fe(2+)     1.0   SO4(2-)    1.0
119901 FeNO3+2         (+2)   1.000      -8.843     Fe(3+)     1.0   NO3(-)     1.0
120400 FeSO4+          (+1)   4.050       5.975     Fe(3+)     1.0   SO4(2-)    1.0
120500 Fe(SO4)2-       (-1)   5.380       4.589     Fe(3+)     1.0   SO4(2-)    2.0
129700 KSO4-           (-1)    .850        .980     K(+)       1.0   SO4(2-)    1.0
133400 MgSO4 (aq)             2.260       1.386     Mg(2+)     1.0   SO4(2-)    1.0
141100 NaSO4-          (-1)    .730        .239     Na(+)      1.0   SO4(2-)    1.0
 43900 HSO4-           (-1)   1.990       5.258     H(+)       1.0   SO4(2-)    1.0
204000 ARSENOLITE           141.736     -95.330     H2O       -6.0   H(+)      12.0   AsO3(3-)   4.0
204100 CLAUDETITE           142.040     -94.290     H2O       -6.0   H(+)      12.0   AsO3(3-)   4.0
186800 PORTLANDITE          -22.804      30.741     H2O        2.0   H(+)      -2.0   Ca(2+)     1.0
189200 CrCl3                -15.114      28.939     H2O       -2.0   H(+)       2.0   Cl(-)      3.0   Cr(OH)2(+  1.0
189300 ATACAMITE             -7.391      22.330     H2O        3.0   H(+)      -3.0   Cl(-)      1.0   Cu(2+)     2.0
189400 Fe(OH)2.7Cl.3          3.040        .000     H2O        2.7   H(+)      -2.7   Cl(-)       .3   Fe(3+)     1.0
191600 K2Cr2O7               17.242     -19.300     H2O       -1.0   H(+)       2.0   CrO4(2-)   2.0   K(+)       2.0
191700 Na2Cr2O7               9.895      -5.305     H2O       -1.0   H(+)       2.0   CrO4(2-)   2.0   Na(+)      2.0
192000 Cr(OH)3 (am)            .750        .000     H2O        1.0   H(+)      -1.0   Cr(OH)2(+  1.0
192400 TENORITE              -7.644      15.504     H2O        1.0   H(+)      -2.0   Cu(2+)     1.0
192600 CUPRIC FERRITE        -5.988      50.241     H2O        4.0   H(+)      -8.0   Cu(2+)     1.0   Fe(3+)     2.0
193000 ANTLERITE             -8.788        .000     H2O        4.0   H(+)      -4.0   Cu(2+)     3.0   SO4(2-)    1.0
```

TABLE G-1A

INPUT DATA FOR MINEQL RUN #05 WITHOUT REDOX

```
192700 Cu2(OH)3NO3           -9.251      17.350     H2O        3.0   H(+)      -3.0   Cu(2+)     2.0   NO3(-)     1.0
193100 CuOCuSO4             -10.303      32.929     H2O        1.0   H(+)      -2.0   Cu(2+)     2.0   SO4(2-)    1.0
193200 BROCHANTITE          -15.222      48.485     H2O        6.0   H(+)      -6.0   Cu(2+)     4.0   SO4(2-)    1.0
193300 LANGITE              -17.489      39.567     H2O        7.0   H(+)      -6.0   Cu(2+)     4.0   SO4(2-)    1.0
193500 CUPROUS FERRITE        8.917       3.798     H2O        2.0   H(+)      -4.0   Cu(+)      1.0   Fe(3+)     1.0
193600 WUSTITE       -0.11) -11.688      24.842     H2O        1.0   H(+)      -2.0   Fe(2+)      .9
193800 MAGNETITE             -3.403      49.839     H2O        4.0   H(+)      -8.0   Fe(2+)     1.0   Fe(3+)     2.0
193900 Fe3(OH)8             -20.222        .000     H2O        8.0   H(+)      -8.0   Fe(2+)     1.0   Fe(3+)     2.0
194200 LEPIDOCROCITE         -1.371        .000     H2O        2.0   H(+)      -3.0   Fe(3+)     1.0
194300 GOETHITE               -.491      14.480     H2O        2.0   H(+)      -3.0   Fe(3+)     1.0
194400 HEMATITE               1.418      30.829     H2O        3.0   H(+)      -6.0   Fe(3+)     2.0
194600 MAGHEMITE             -6.386        .000     H2O        3.0   H(+)      -6.0   Fe(3+)     2.0
194700 K-JAROSITE            14.800      31.280     H2O        6.0   H(+)      -6.0   Fe(3+)     3.0   K(+)       1.0   SO4(2-)    2.0
194800 MAGNESIOFERRITE      -16.860      66.663     H2O        4.0   H(+)      -8.0   Fe(3+)     2.0   Mg(2+)     1.0
194900 Na-JAROSITE           11.200      36.180     H2O        6.0   H(+)      -6.0   Fe(3+)     3.0   Na(+)      1.0   SO4(2-)    2.0
195200 H-JAROSITE            12.100      55.150     H2O        7.0   H(+)      -5.0   Fe(3+)     3.0   SO4(2-)    2.0
196600 PERICLASE            -21.584      36.145     H2O        1.0   H(+)      -2.0   Mg(2+)     1.0
204700 GYPSUM                 4.610       -.239     H2O        2.0   Ca(2+)     1.0   SO4(2-)    1.0
206400 CHALCANTHITE           2.640      -1.440     H2O        5.0   Cu(2+)     1.0   SO4(2-)    1.0
206600 MELANTERITE            2.209      -4.900     H2O        7.0   Fe(2+)     1.0   SO4(2-)    1.0
207100 EPSOMITE               2.127      -2.763     H2O        7.0   Mg(2+)     1.0   SO4(2-)    1.0
207200 MIRABILITE             1.114     -18.987     H2O       10.0   Na(+)      2.0   SO4(2-)    1.0
211500 FeCr2O4               -7.200      33.556     H(+)      -4.0   Cr(OH)2(+  2.0   Fe(2+)     1.0
211600 MgCr2O4              -16.201      42.878     H(+)      -4.0   Cr(OH)2(+  2.0   Mg(2+)     1.0
219300 CaCrO4                 2.266       6.440     Ca(2+)     1.0   CrO4(2-)   1.0
219900 ANHYDRITE              4.360       1.721     Ca(2+)     1.0   SO4(2-)    1.0
221400 MELANOTHALLITE        -6.257      15.155     Cl(-)      2.0   Cu(2+)     1.0
221500 NANTOKITE              6.730     -10.197     Cl(-)      1.0   Cu(+)      1.0
221800 HALITE                -1.603       -.884     Cl(-)      1.0   Na(+)      1.0
225500 CuCrO4                 5.440        .000     CrO4(2-)   1.0   Cu(2+)     1.0
225700 K2CrO4                  .513      -4.367     CrO4(2-)   1.0   K(+)       2.0
225900 MgCrO4                -5.380      21.260     CrO4(2-)   1.0   Mg(2+)     1.0
226000 Na2CrO4               -2.930       4.692     CrO4(2-)   1.0   Na(+)      2.0
227000 CuSO4                 -2.939      17.457     Cu(2+)     1.0   SO4(2-)    1.0
227300 Cu2SO4                 1.950       4.560     Cu(+)      2.0   SO4(2-)    1.0
227700 Fe2(SO4)3              3.734      57.846     Fe(3+)     2.0   SO4(2-)    3.0
230200 THENARDITE             -.322       2.180     Na(+)      2.0   SO4(2-)    1.0
```

TABLE G-1B

INPUT DATA FOR MINEQL RUN #05 WITHOUT REDOX

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Jun 6, 2006  10:54   MINEQL+ Header file for BO6SCe.mdo

          $$$  INPUT DATA  $$$
ÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ
OPTIONS:  IADS= 0 IONIT=-1 IONPH= 0 IPHFX= 0 IPHA=  0
            IPHB= 0 ITITL= 0 IPCP=0 ICND=0
ÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ
                ELECTRONEUTRALITY NOT GUARANTEED
               TEMPERATURE  =  25.0 CELSIUS
                IONIC STRENGTH FIXED CONCENTRATION
                NO SURFACE MODEL USED
                      EPS =  1.0E-04
   ID          X    LOGX           T     COMPONENTS
    1   1.00D-20  -20.00   1.000E-18     e(-)
    2   1.00D-20  -20.00   1.000E-18     H2O
    3   1.00D-07   -7.00   1.000E-18     H(+)
    9   3.89D-07   -6.41   3.900E-05     AsO3(3-)
   16   7.24D-06   -5.14   7.200E-04     Ca(2+)
   19   1.70D-05   -4.77   1.700E-03     Cl(-)
   26   9.55D-07   -6.02   9.600E-05     CrO4(2-)
   28   9.55D-07   -6.02   9.600E-05     Cr(OH)2(+)
   30   2.00D-07   -6.70   2.000E-05     Cu(2+)
   31   2.00D-07   -6.70   2.000E-05     Cu(+)
   32   3.63D-05   -4.44   3.600E-03     Fe(2+)
   33   3.63D-05   -4.44   3.600E-03     Fe(3+)
   38   3.80D-07   -6.42   3.800E-05     K(+)
   41   1.82D-06   -5.74   1.800E-04     Mg(2+)
   45   1.10D-05   -4.96   1.100E-03     Na(+)
   50   5.01D-06   -5.30   5.000E-04     NO3(-)
   68   3.09D-06   -5.51   3.100E-04     SO4(2-)

   ID    NAME                 LOGK      DELH      SPECIES:       TYPE I - COMPONENTS
     68 SO4(2-)                 .000        .000     SO4(2-)    1.0
      2 H2O                     .000        .000     H2O        1.0
      3 H(+)                    .000        .000     H(+)       1.0
      9 AsO3(3-)                .000        .000     AsO3(3-)   1.0
     16 Ca(2+)                  .000        .000     Ca(2+)     1.0
     19 Cl(-)                   .000        .000     Cl(-)      1.0
     26 CrO4(2-)                .000        .000     CrO4(2-)   1.0
     28 Cr(OH)2(+)              .000        .000     Cr(OH)2(+  1.0
     30 Cu(2+)                  .000        .000     Cu(2+)     1.0
     31 Cu(+)                   .000        .000     Cu(+)      1.0
     32 Fe(2+)                  .000        .000     Fe(2+)     1.0
```

TABLE G-1B

INPUT DATA FOR MINEQL RUN #05 WITHOUT REDOX

```
    33 Fe(3+)                        .000          .000      Fe(3+)      1.0
    38 K(+)                          .000          .000      K(+)        1.0
    41 Mg(2+)                        .000          .000      Mg(2+)      1.0
    45 Na(+)                         .000          .000      Na(+)       1.0
    50 NO3(-)                        .000          .000      NO3(-)      1.0

ID    NAME                 LOGK      DELH      SPECIES:       TYPE II - COMPLEXES
 43900 HSO4-           (-1)   1.990       5.258     H(+)       1.0   SO4(2-)    1.0
  3800 OH-             (-1) -13.997      13.339     H2O        1.0   H(+)      -1.0
  7300 CaOH+           (+1) -12.697      15.323     H2O        1.0   H(+)      -1.0   Ca(2+)     1.0
 11200 Cr+3            (+3)   9.569     -30.980     H2O       -2.0   H(+)       2.0   Cr(OH)2(+  1.0
 11300 Cr(OH)+2        (+2)   5.912     -18.621     H2O       -1.0   H(+)       1.0   Cr(OH)2(+  1.0
 11400 Cr(OH)3 (aq)          -8.422        .000     H2O        1.0   H(+)      -1.0   Cr(OH)2(+  1.0
 13400 CuOH+           (+1)  -7.497       8.559     H2O        1.0   H(+)      -1.0   Cu(2+)     1.0
 13500 Cu(OH)2 (aq)         -16.194        .000     H2O        2.0   H(+)      -2.0   Cu(2+)     1.0
 13900 Fe(OH)3-        (-1) -28.991      30.218     H2O        3.0   H(+)      -3.0   Fe(2+)     1.0
 14000 Fe(OH)2 (aq)         -20.494      28.590     H2O        2.0   H(+)      -2.0   Fe(2+)     1.0
 14100 FeOH+           (+1)  -9.397      13.339     H2O        1.0   H(+)      -1.0   Fe(2+)     1.0
 14300 FeOH+2          (+2)  -2.187       9.993     H2O        1.0   H(+)      -1.0   Fe(3+)     1.0
 14400 Fe(OH)2+        (+1)  -4.594        .000     H2O        2.0   H(+)      -2.0   Fe(3+)     1.0
 14700 Fe(OH)4-        (-1) -21.588        .000     H2O        4.0   H(+)      -4.0   Fe(3+)     1.0
 17900 MgOH+           (+1) -11.397      16.207     H2O        1.0   H(+)      -1.0   Mg(2+)     1.0
 26600 HAsO3-2         (-2)  13.414      -6.051     H(+)       1.0   AsO3(3-)   1.0
 26700 H3AsO3                34.744     -20.250     H(+)       3.0   AsO3(3-)   1.0
 26800 H2AsO3-         (-1)  25.454     -13.699     H(+)       2.0   AsO3(3-)   1.0
 26900 H4AsO3+         (+1)  34.439        .000     H(+)       4.0   AsO3(3-)   1.0
 33600 HCrO4-          (-1)   6.510        .478     H(+)       1.0   CrO4(2-)   1.0
 33700 H2CrO4 (aq)            6.419       9.321     H(+)       2.0   CrO4(2-)   1.0
 33900 CrO2-           (-1) -17.746        .000     H(+)      -2.0   Cr(OH)2(+  1.0

  ID    NAME                 LOGK      DELH      SPECIES:       TYPE III - FIXED SOLIDS (Species)
  1100 Cr(OH)2+/CrO4-2       67.376     -24.618     e(-)       3.0   H2O       -2.0   H(+)       6.0   CrO4(2-)   1.0   Cr(OH)2(+ -1.0
  3400 Fe+2/Fe+3             13.032     -10.206     e(-)       1.0   Fe(2+)    -1.0   Fe(3+)     1.0
  3300 Cu+1/Cu+2              2.690       1.649     e(-)       1.0   Cu(2+)     1.0   Cu(+)     -1.0
  250001 pe             (-1)    .000        .000     e(-)       1.0
  175310 pH             (+1)   1.500        .000     H(+)       1.0
  3801 H2O (Solution)          .000        .000     H2O        1.0

  ID    NAME                 LOGK      DELH      SPECIES:       TYPE V - DISSOLVED SOLIDS (Subject to precipitation)
196702 Mg(OH)2 (active)     -18.794        .000     H2O        2.0   H(+)      -2.0   Mg(2+)     1.0
186700 LIME                 -32.699      46.346     H2O        1.0   H(+)      -2.0   Ca(2+)     1.0
191500 CrO3                   3.210       1.245     H2O       -1.0   H(+)       2.0   CrO4(2-)   1.0
191900 Cr2O3                  2.358      12.125     H2O       -1.0   H(+)      -2.0   Cr(OH)2(+  2.0
192000 Cr(OH)3 (am)            .750        .000     H2O        1.0   H(+)      -1.0   Cr(OH)2(+  1.0
192100 Cr(OH)3               -1.336       7.115     H2O        1.0   H(+)      -1.0   Cr(OH)2(+  1.0
192500 Cu(OH)2               -8.674      13.485     H2O        2.0   H(+)      -2.0   Cu(2+)     1.0
193400 CUPRITE                1.406      29.642     H2O        1.0   H(+)      -2.0   Cu(+)      2.0
193700 Fe(OH)2              -13.564        .000     H2O        2.0   H(+)      -2.0   Fe(2+)     1.0
194500 FERRIHYDRITE          -3.191      17.537     H2O        3.0   H(+)      -3.0   Fe(3+)     1.0

  ID    NAME                 LOGK      DELH      SPECIES:       TYPE VI - SPECIES NOT CONSIDERED
     1 e(-)                    .000        .000     e(-)       1.0
180800 Cu metal               8.756     -17.130     e(-)       1.0   Cu(+)      1.0
```

TABLE G-1B

INPUT DATA FOR MINEQL RUN #05 WITHOUT REDOX

```
174700 O2 (g)               -82.442     136.630     e(-)      -4.0   H2O        2.0   H(+)      -4.0
204000 ARSENOLITE           141.736     -95.330     H2O       -6.0   H(+)      12.0   AsO3(3-)   4.0
204100 CLAUDETITE           142.041     -94.290     H2O       -6.0   H(+)      12.0   AsO3(3-)   4.0
186800 PORTLANDITE          -22.804      30.741     H2O        2.0   H(+)      -2.0   Ca(2+)     1.0
189200 CrCl3                -15.114      28.939     H2O       -2.0   H(+)       2.0   Cl(-)      3.0   Cr(OH)2(+  1.0
189300 ATACAMITE             -7.391      22.330     H2O        3.0   H(+)      -3.0   Cl(-)      1.0   Cu(2+)     2.0
189400 Fe(OH)2.7Cl.3          3.040        .000     H2O        2.7   H(+)      -2.7   Cl(-)       .3   Fe(3+)     1.0
191600 K2Cr2O7               17.242     -19.300     H2O       -1.0   H(+)       2.0   CrO4(2-)   2.0   K(+)       2.0
191700 Na2Cr2O7               9.895      -5.305     H2O       -1.0   H(+)       2.0   CrO4(2-)   2.0   Na(+)      2.0
192400 TENORITE              -7.644      15.504     H2O        1.0   H(+)      -2.0   Cu(2+)     1.0
192600 CUPRIC FERRITE        -5.988      50.241     H2O        4.0   H(+)      -8.0   Cu(2+)     1.0   Fe(3+)     2.0
192700 Cu2(OH)3NO3           -9.251      17.350     H2O        3.0   H(+)      -3.0   Cu(2+)     2.0   NO3(-)     1.0
193000 ANTLERITE             -8.788        .000     H2O        4.0   H(+)      -4.0   Cu(2+)     3.0   SO4(2-)    1.0
193100 CuOCuSO4             -10.303      32.930     H2O        1.0   H(+)      -2.0   Cu(2+)     2.0   SO4(2-)    1.0
193200 BROCHANTITE          -15.222      48.485     H2O        6.0   H(+)      -6.0   Cu(2+)     4.0   SO4(2-)    1.0
193300 LANGITE              -17.489      39.567     H2O        7.0   H(+)      -6.0   Cu(2+)     4.0   SO4(2-)    1.0
193500 CUPROUS FERRITE        8.917       3.798     H2O        2.0   H(+)      -4.0   Cu(+)      1.0   Fe(3+)     1.0
193600 WUSTITE       -0.11) -11.688      24.842     H2O        1.0   H(+)      -2.0   Fe(2+)      .9
193800 MAGNETITE             -3.403      49.839     H2O        4.0   H(+)      -8.0   Fe(2+)     1.0   Fe(3+)     2.0
193900 Fe3(OH)8             -20.222        .000     H2O        8.0   H(+)      -8.0   Fe(2+)     1.0   Fe(3+)     2.0
194200 LEPIDOCROCITE         -1.371        .000     H2O        2.0   H(+)      -3.0   Fe(3+)     1.0
194300 GOETHITE               -.491      14.480     H2O        2.0   H(+)      -3.0   Fe(3+)     1.0
194400 HEMATITE               1.418      30.829     H2O        3.0   H(+)      -6.0   Fe(3+)     2.0
194600 MAGHEMITE             -6.386        .000     H2O        3.0   H(+)      -6.0   Fe(3+)     2.0
194700 K-JAROSITE            14.800      31.280     H2O        6.0   H(+)      -6.0   Fe(3+)     3.0   K(+)       1.0   SO4(2-)    2.0
194800 MAGNESIOFERRITE      -16.860      66.664     H2O        4.0   H(+)      -8.0   Fe(3+)     2.0   Mg(2+)     1.0
194900 Na-JAROSITE           11.200      36.180     H2O        6.0   H(+)      -6.0   Fe(3+)     3.0   Na(+)      1.0   SO4(2-)    2.0
195200 H-JAROSITE            12.100      55.150     H2O        7.0   H(+)      -5.0   Fe(3+)     3.0   SO4(2-)    2.0
196600 PERICLASE            -21.584      36.145     H2O        1.0   H(+)      -2.0   Mg(2+)     1.0
196700 BRUCITE              -16.844      27.246     H2O        2.0   H(+)      -2.0   Mg(2+)     1.0
204700 GYPSUM                 4.610       -.239     H2O        2.0   Ca(2+)     1.0   SO4(2-)    1.0
206400 CHALCANTHITE           2.640      -1.440     H2O        5.0   Cu(2+)     1.0   SO4(2-)    1.0
206600 MELANTERITE            2.209      -4.900     H2O        7.0   Fe(2+)     1.0   SO4(2-)    1.0
207100 EPSOMITE               2.126      -2.763     H2O        7.0   Mg(2+)     1.0   SO4(2-)    1.0
207200 MIRABILITE             1.114     -18.987     H2O       10.0   Na(+)      2.0   SO4(2-)    1.0
211500 FeCr2O4               -7.200      33.556     H(+)      -4.0   Cr(OH)2(+  2.0   Fe(2+)     1.0
211600 MgCr2O4              -16.201      42.878     H(+)      -4.0   Cr(OH)2(+  2.0   Mg(2+)     1.0
219300 CaCrO4                 2.266       6.440     Ca(2+)     1.0   CrO4(2-)   1.0
219900 ANHYDRITE              4.360       1.721     Ca(2+)     1.0   SO4(2-)    1.0
221400 MELANOTHALLITE        -6.257      15.155     Cl(-)      2.0   Cu(2+)     1.0
221500 NANTOKITE              6.730     -10.196     Cl(-)      1.0   Cu(+)      1.0
221800 HALITE                -1.602       -.884     Cl(-)      1.0   Na(+)      1.0
225500 CuCrO4                 5.440        .000     CrO4(2-)   1.0   Cu(2+)     1.0
225700 K2CrO4                  .513      -4.367     CrO4(2-)   1.0   K(+)       2.0
225900 MgCrO4                -5.380      21.260     CrO4(2-)   1.0   Mg(2+)     1.0
226000 Na2CrO4               -2.930       4.692     CrO4(2-)   1.0   Na(+)      2.0
227000 CuSO4                 -2.940      17.457     Cu(2+)     1.0   SO4(2-)    1.0
227300 Cu2SO4                 1.950       4.560     Cu(+)      2.0   SO4(2-)    1.0
227700 Fe2(SO4)3              3.734      57.846     Fe(3+)     2.0   SO4(2-)    3.0
230200 THENARDITE             -.322       2.180     Na(+)      2.0   SO4(2-)    1.0
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TABLE G-2A

BB&S LUMBER SITE - PREDESIGN INVESTIGATION
CHEMICAL SPECIES DISTRIBUTION WITHOUT REDOX
MINEQL RUN #05 at pH = 6.5 s.u.

COMPONENTS	Type	CONCENTRATION (moles/L)
AsO3(3-) (as As)	1	3.90E-05
Ca(2+)	1	7.20E-04
Cl(-)	1	1.70E-03
CrO4(2-)	1	9.60E-05
Cr(OH)2(+)	1	9.60E-05
Cu(2+)	1	2.00E-05
Cu(+)	1	2.00E-05
Fe(2+)	1	3.60E-03
Fe(3+)	1	3.60E-03
K(+)	1	3.80E-05
Mg(2+)	1	1.80E-04
Na(+)	1	1.10E-03
NO3(-)	1	5.00E-04
SO4(2-)	1	3.10E-04

COMPONENTS/SPECIES	Type	CONCENTRATION (moles/L)	LogK	% of Total	Matrix
HEXAVALENT CHROMIUM					
CrO4(2-)	1	0.0000574	0	59.8	
HCrO4-	2	0.0000386	6.27	40.2	
H2CrO4 (aq)	2	8.6E-12	6.05	0	
CrO3	5	--	2.85		
TOTAL CrO4(2-)		0.000096		100	SOLUTION
TRIVALENT CHROMIUM					
Cr(OH)2(+)	1	2.41E-08	0	0	
Cr+3	2	2.74E-11	9.93	0	
Cr(OH)+2	2	9.48E-09	6.03	0	
Cr(OH)4-	2	3.66E-13	-17.7	0	
CrO2-	2	4.32E-13	-17.62	0	
Cr(OH)3	5	--	-1.34		
TOTAL Cr(OH)2(+)		3.36E-08		0	
Cr2O3	4	0.000048	2.36	100	SOLUTION
FERRIC IRON (+3)					
Fe(3+)	1	1.74E-16	0	0	
FeOH+2 (+2)	2	1.77E-12	-2.43	0	
Fe(OH)2+ (+1)	2	1.44E-08	-4.96	0	
Fe(OH)4- (-1)	2	1.46E-12	-21.83	0	
TOTAL Fe(3+)		1.48E-08		0	SOLUTION
FERRIHYDRITE	4	0.0036	-3.56	100	SOLID

TABLE G-2A

BB&S LUMBER SITE - PREDESIGN INVESTIGATION
CHEMICAL SPECIES DISTRIBUTION WITHOUT REDOX
MINEQL RUN #05 at pH = 6.5 s.u.

		FERROUS IRON (+2)			
Fe(2+)	1	0.0036	0	99.9	
Fe(OH)3-	2	7.62E-13	-28.99	0	
Fe(OH)2 (aq)	2	6.58E-11	-20.62	0	
FeOH+	2	0.00000299	-9.52	0	
Fe(OH)2	5	--	-13.69		
TOTAL Fe(2+)	7	0.0036		100	SOLUTION
		COPPER (+2)			
Cu(2+)	1	0.0000188	0	93.8	
CuOH+	2	0.00000124	-7.62	6.2	
Cu(OH)2 (aq)	2	6.84E-09	-16.32	0	
Cu(OH)2	5		-8.8		
TOTAL Cu(2+)		0.00002		100	SOLUTION
		COPPER (+1)			
Cu(+)	1	7.21E-08	0	0	
TOTAL Cu(+)		7.21E-08		0.4	SOLUTION
CUPRITE	4	0.00000996	1.41	99.6	SOLID
		ARSENIC			
AsO3(3-)	1	7.85E-20	0	0	
HAsO3-2	2	3.19E-13	13.05	0	
H3AsO3	2	0.0000389	34.01	99.8	
H2AsO3-	2	7.26E-08	24.84	0	
H4AsO3+	2	7.02E-12	33.71	0	
TOTAL AsO3(3-)		0.000039		100	SOLUTION

NOTE: Type 1 = component; Type 2 = dissolved complex; Type 3 = fixed concentration
Type 4 = solids precipitated; Type 5 = subject to precipitation; Type 6 = not considered

TABLE G-2B

BB&S LUMBER SITE - PREDESIGN INVESTIGATION
CHEMICAL SPECIES DISTRIBUTION WITHOUT REDOX
MINEQL RUN #06 at pH = 6.5 s.u.

(in moles/liter)

COMPONENTS	**Type**	**CONCENTRATION** (moles/L)
AsO3(3-) (as As)	1	3.90E-05
Ca(2+)	1	7.20E-04
Cl(-)	1	1.70E-03
CrO4(2-)	1	9.60E-05
Cr(OH)2(+)	1	9.60E-05
Cu(2+)	1	2.00E-05
Cu(+)	1	2.00E-05
Fe(2+)	1	3.60E-03
Fe(3+)	1	3.60E-03
K(+)	1	3.80E-05
Mg(2+)	1	1.80E-04
Na(+)	1	1.10E-03
NO3(-)	1	5.00E-04
SO4(2-)	1	3.10E-04

COMPONENTS/SPECIES	**Type**	**CONCENTRATION** (moles/L)	**LogK**	**% of Total**	**Matrix**
HEXAVALENT CHROMIUM					
CrO4(2-)	1	2.35E-36	0	59.8	
HCrO4-	2	1.58E-36	6.27	40.2	
H2CrO4 (aq)	2	3.52E-43	6.05	0	
Cr(OH)2+/CrO4-2	3	--	66.64		
CrO3	5	--	2.84		
TOTAL CrO4(2-)		3.93E-36		100	SOLUTION
TRIVALENT CHROMIUM					
Cr(OH)2(+)	1	2.41E-08	0	0	
Cr+3	2	2.74E-11	9.93	0	
Cr(OH)+2	2	9.48E-09	6.03	0	
Cr(OH)3 (aq)	2	2.51E-10	-8.42	0	
CrO2-	2	4.32E-13	-17.62	0	
Cr(OH)2+/CrO4-2	3	--	66.64		
Cr(OH)3 (am)	5	--	0.75		
Cr(OH)3	5	--	-1.34		
TOTAL Cr(OH)2(+)		3.39E-08		0	SOLUTION
Cr2O3	4	0.000096	2.36	100	SOLID
FERRIC IRON (+3)					
Fe(3+)	1	1.74E-16	0	0	
FeOH+2	2	1.77E-12	-2.43	0	
Fe(OH)2+	2	1.44E-08	-4.96	0	
Fe(OH)4-	2	1.46E-12	-21.83	0	
Fe+2/Fe+3	3	--	12.67		
TOTAL Fe(3+)		1.44E-08		0	SOLUTION
FERRIHYDRITE	4	0.00639	-3.56	100	SOLID

TABLE G-2B

BB&S LUMBER SITE - PREDESIGN INVESTIGATION
CHEMICAL SPECIES DISTRIBUTION WITHOUT REDOX
MINEQL RUN #06 at pH = 6.5 s.u.

(in moles/liter)

		FERROUS IRON (+2)			
Fe(2+)	1	0.000805	0	99.9	
Fe(OH)3-	2	1.71E-13	-28.99	0	
Fe(OH)2 (aq)	2	1.47E-11	-20.62	0	
FeOH+)	2	0.00000067	-9.52	0	
Fe+2/Fe+3	3	--	12.67		
Fe(OH)2	5	--	-13.69		
TOTAL Fe(2+)	7	0.000806		100	SOLUTION
		COPPER (+2)			
Cu(2+)	1	2.58E-10	0	93.8	
CuOH+	2	1.71E-11	-7.62	6.2	
Cu(OH)2 (aq)	2	9.42E-14	-16.32	0	
Cu+1/Cu+2	3	--	2.45		
Cu(OH)2	5	--	-8.8		
TOTAL Cu(2+)		2.75E-10		100	SOLUTION
		COPPER (+1)			
Cu(+)	1	7.21E-08	0	0	
Cu+1/Cu+2	3	--	2.45		
TOTAL Cu(+)	7	7.21E-08		0.2	SOLUTION
CUPRITE	4	0.00002	1.41	99.8	SOLID
		ARSENIC			
AsO3(3-)	1	7.85E-20	0	0	
HAsO3-2	2	3.19E-13	13.05	0	
H3AsO3	2	0.0000389	34.01	99.8	
H2AsO3-	2	7.26E-08	24.84	0	
H4AsO3+	2	7.02E-12	33.71	0	
TOTAL AsO3(3-)		0.000039		100	SOLUTION

NOTE: Type 1 = component; Type 2 = dissolved complex; Type 3 = fixed concentration
Type 4 = solids precipitated; Type 5 = subject to precipitation; Type 6 = not considered

TABLE G-3A

BB&S LUMBER SITE - PREDESIGN INVESTIGATION

CHEMICAL SPECIES DISTRIBUTION WITHOUT REDOX

(MINEQL RUN #05; concentration in moles/L)

COMPONENT/	pH (s.u.)										
SPECIES	**1.5**	**2.5**	**3.5**	**4.5**	**5.5**	**6.5**	**7.5**	**8.5**	**9.5**	**10.5**	**11.5**
HEXAVALENT CHROMIUM											
1:CrO4(2-)	1.4E-09	1.4E-08	1.4E-07	1.4E-06	1.2E-05	5.7E-05	9.0E-05	9.5E-05	9.6E-05	9.6E-05	9.6E-05
2:HCrO4-	9.4E-05	9.6E-05	9.6E-05	9.5E-05	8.4E-05	3.9E-05	6.0E-06	6.4E-07	6.4E-08	6.5E-09	6.5E-10
2:H2CrO4 (aq)	2.1E-06	2.1E-07	2.1E-08	2.1E-09	1.9E-10	8.6E-12	1.4E-13	1.4E-15	1.4E-17	1.4E-19	1.4E-21
TOTAL CrO4(2-)	9.6E-05	9.6E-05	9.6E-05	9.6E-05	9.6E-05	9.6E-05	9.6E-05	9.6E-05	9.6E-05	9.6E-05	9.6E-05
TRIVALENT CHROMIUM											
1.Cr(OH)2(+)	8.4E-12	8.2E-10	6.3E-08	1.9E-06	2.4E-07	2.4E-08	2.4E-09	2.4E-10	2.4E-11	2.4E-12	2.4E-13
2:Cr+3	9.6E-05	9.3E-05	7.1E-05	2.1E-05	2.7E-08	2.7E-11	2.7E-14	2.7E-17	2.7E-20	2.7E-23	2.7E-26
2:Cr(OH)+2	3.3E-07	3.2E-06	2.5E-05	7.3E-05	9.5E-07	9.5E-09	9.5E-11	9.5E-13	9.5E-15	9.5E-17	9.5E-19
S:Cr2O3					4.7E-05	4.8E-05	4.8E-05	4.8E-05	4.8E-05	4.8E-05	4.8E-05
TOTAL Cr(OH)2(+)	9.6E-05	9.6E-05	9.6E-05	9.6E-05	1.2E-06	3.4E-08	2.5E-09	3.2E-10	8.2E-10	8.0E-09	8.0E-08
FERRIC IRON (+3)											
1:Fe(3+)	3.2E-03	1.7E-04	1.7E-07	1.7E-10	1.7E-13	1.7E-16	1.7E-19	1.7E-22	1.7E-25	1.7E-28	1.7E-31
2:FeOH+2	3.3E-04	1.8E-04	1.8E-06	1.8E-08	1.8E-10	1.8E-12	1.8E-14	1.8E-16	1.8E-18	1.8E-20	1.8E-22
2:Fe(OH)2+	2.7E-05	1.4E-04	1.4E-05	1.4E-06	1.4E-07	1.4E-08	1.4E-09	1.4E-10	1.4E-11	1.4E-12	1.4E-13
S:FERRIHYDRITE		3.1E-03	3.6E-03	3.6E-03	3.6E-03	3.6E-03	3.6E-03	3.6E-03	3.6E-03	3.6E-03	3.6E-03
TOTAL Fe(3+)	3.6E-03	5.0E-04	1.6E-05	1.5E-06	1.4E-07	1.5E-08	1.9E-09	7.2E-10	1.9E-09	1.5E-08	1.5E-07
FERROUS IRON (+2)											
1:Fe(2+)	3.6E-03	3.6E-03	3.6E-03	3.6E-03	3.6E-03	3.6E-03	3.6E-03	6.4E-04	6.4E-06	6.4E-08	6.4E-10
2:Fe(OH)3-	7.6E-28	7.6E-25	7.6E-22	7.6E-19	7.6E-16	7.6E-13	7.6E-10	1.4E-07	1.4E-06	1.4E-05	1.4E-04
2:FeOH+	3.0E-11	3.0E-10	3.0E-09	3.0E-08	3.0E-07	3.0E-06	3.0E-05	5.3E-05	5.3E-06	5.3E-07	5.3E-08
S:Fe(OH)2								2.9E-03	3.6E-03	3.6E-03	3.5E-03
TOTAL Fe(2+)	3.6E-03	3.6E-03	3.6E-03	3.6E-03	3.6E-03	3.6E-03	3.6E-03	7.0E-04	1.3E-05	1.4E-05	1.4E-04
COPPER (+2)											
1:Cu(2+)	2.0E-05	2.0E-05	2.0E-05	2.0E-05	2.0E-05	1.9E-05	8.3E-07	8.3E-09	8.3E-11	8.3E-13	8.3E-15
2:Cu(OH)3-	5.5E-28	5.5E-25	5.5E-22	5.5E-19	5.5E-16	5.1E-13	2.3E-11	2.3E-10	2.3E-09	2.3E-08	2.3E-07
2:CuOH+	1.3E-11	1.3E-10	1.3E-09	1.3E-08	1.3E-07	1.2E-06	5.5E-07	5.5E-08	5.5E-09	5.5E-10	5.5E-11
S:Cu(OH)2							1.9E-05	2.0E-05	2.0E-05	2.0E-05	2.0E-05
TOTAL Cu(2+)	2.0E-05	2.0E-05	2.0E-05	2.0E-05	2.0E-05	2.0E-05	1.4E-06	9.3E-08	3.8E-08	5.4E-08	2.7E-07
COPPER (+1)											
1:Cu(+)	2.0E-05	2.0E-05	2.0E-05	7.2E-06	7.2E-07	7.2E-08	7.2E-09	7.2E-10	7.2E-11	7.2E-12	7.2E-13
S:CUPRITE				6.4E-06	9.6E-06	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05
TOTAL Cu(+)	2.0E-05	2.0E-05	2.0E-05	7.2E-06	7.2E-07	7.2E-08	7.2E-09	7.2E-10	7.2E-11	7.2E-12	7.2E-13
ARSENIC											
2:HAsO3-2	3.1E-23	3.2E-21	3.2E-19	3.2E-17	3.2E-15	3.2E-13	3.1E-11	2.7E-09	1.1E-07	1.6E-06	1.2E-05
2:H3AsO3	3.8E-05	3.9E-05	3.9E-05	3.9E-05	3.9E-05	3.9E-05	3.8E-05	3.3E-05	1.4E-05	1.9E-06	1.4E-07
2:H2AsO3-	7.2E-13	7.3E-12	7.3E-11	7.3E-10	7.3E-09	7.3E-08	7.1E-07	6.1E-06	2.5E-05	3.6E-05	2.7E-05
2:H4AsO3+	6.9E-07	7.0E-08	7.0E-09	7.0E-10	7.0E-11	7.0E-12	6.9E-13	5.9E-14	2.5E-15	3.4E-17	2.6E-19
TOTAL AsO3(3-)	3.9E-05	3.9E-05	3.9E-05	3.9E-05	3.9E-05	3.9E-05	3.9E-05	3.9E-05	3.9E-05	3.9E-05	3.9E-05

NOTE: Type 1 = component; Type 2 = dissolved complex; Type S = solids phase

TABLE G-3B

BB&S LUMBER SITE - PREDESIGN INVESTIGATION
CHEMICAL SPECIES DISTRIBUTION WITH REDOX

(MINEQL RUN #06; concentration in moles/L)

COMPONENT/	**pH (s.u.)**										
SPECIES	**1.5**	**2.5**	**3.5**	**4.5**	**5.5**	**6.5**	**7.5**	**8.5**	**9.5**	**10.5**	**11.5**
HEXAVALENT CHROMIUM											
1:CrO4(2-)	2E-69	2E-61	1E-53	2E-46	2E-41	2E-36	2E-31	2E-26	2E-21	2E-16	2E-11
2:HCrO4-	1E-64	1E-57	8E-51	2E-44	2E-40	2E-36	2E-32	2E-28	2E-24	2E-20	2E-16
2:H2CrO4	2E-66	2E-60	2E-54	4E-49	4E-46	4E-43	4E-40	4E-37	4E-34	4E-31	4E-28
TOTAL CrO4(2-)	1E-64	1E-57	8E-51	2E-44	2E-40	4E-36	3E-31	2E-26	2E-21	2E-16	2E-11
TRIVALENT CHROMIUM											
1:Cr(OH)2(+)	2E-11	2E-09	1E-07	2E-06	2E-07	2E-08	2E-09	2E-10	2E-11	2E-12	2E-13
2:Cr+3	0.0002	0.0002	0.0001	3E-05	3E-08	3E-11	3E-14	3E-17	3E-20	3E-23	3E-26
2:Cr(OH)+2	7E-07	6E-06	5E-05	9E-05	9E-07	9E-09	9E-11	9E-13	9E-15	9E-17	9E-19
S:Cr2O3				3E-05	1E-04	1E-04	1E-04	1E-04	1E-04	1E-04	1E-04
TOTAL Cr(OH)2(+)	0.0002	0.0002	0.0002	0.0001	1E-06	3E-08	3E-09	5E-10	7E-10	5E-09	4E-08
FERRIC IRON (+3)											
1:Fe(3+)	2E-15	2E-15	2E-15	2E-15	2E-15	2E-16	2E-19	2E-22	2E-25	2E-28	2E-31
2:FeOH+2	2E-16	2E-15	2E-14	2E-13	2E-12	2E-12	2E-14	2E-16	2E-18	2E-20	2E-22
2:Fe(OH)2+	1E-17	1E-15	1E-13	1E-11	1E-09	1E-08	1E-09	1E-10	1E-11	1E-12	1E-13
S:FERRIHYDRITE						0.0064	0.0072	0.0072	0.0072	0.0072	0.0072
TOTAL Fe(3+)	2E-15	4E-15	1E-13	1E-11	1E-09	1E-08	1E-09	3E-10	1E-09	1E-08	1E-07
FERROUS IRON (+2)											
1:Fe(2+)	0.0072	0.0072	0.0072	0.0072	0.0072	0.0008	8E-07	8E-10	8E-13	8E-16	8E-19
2:Fe(OH)3-	6E-11	6E-10	6E-09	6E-08	6E-07	7E-07	7E-09	7E-11	7E-13	7E-15	7E-17
2:FeOH+	1E-11	1E-09	1E-07	1E-05	0.0011	0.0139	0.002	0.0003	4E-05	6E-06	8E-07
TOTAL Fe(2+)	0.0072	0.0072	0.0072	0.0072	0.0072	0.0008	8E-07	9E-10	2E-12	2E-13	2E-13
COPPER (+2)											
1:Cu(2+)	1E-07	1E-07	1E-07	3E-08	3E-09	3E-10	3E-11	3E-12	3E-13	3E-14	3E-15
2:CuOH+	9E-14	9E-13	9E-12	2E-11	2E-11	2E-11	2E-11	2E-11	2E-11	2E-11	2E-11
2:Cu(OH)2 (aq)	5E-21	5E-19	5E-17	9E-16	9E-15	9E-14	9E-13	9E-12	9E-11	9E-10	9E-09
TOTAL Cu(2+)	1E-07	1E-07	1E-07	3E-08	3E-09	3E-10	4E-11	3E-11	1E-10	1E-09	9E-09
COPPER (+1)											
1:Cu(+)	4E-05	4E-05	4E-05	7E-06	7E-07	7E-08	7E-09	7E-10	7E-11	7E-12	7E-13
S:CUPRITE				2E-05	2E-05	2E-05	2E-05	2E-05	2E-05	2E-05	2E-05
TOTAL Cu(+)	4E-05	4E-05	4E-05	7E-06	7E-07	7E-08	7E-09	7E-10	7E-11	7E-12	7E-13
ARSENIC											
2:HAsO3-2	3E-23	3E-21	3E-19	3E-17	3E-15	3E-13	3E-11	3E-09	1E-07	2E-06	1E-05
2:H3AsO3	4E-05	4E-05	4E-05	4E-05	4E-05	4E-05	4E-05	3E-05	1E-05	2E-06	1E-07
2:H2AsO3-	7E-13	7E-12	7E-11	7E-10	7E-09	7E-08	7E-07	6E-06	3E-05	4E-05	3E-05
TOTAL AsO3(3-)	4E-05	4E-05	4E-05	4E-05	4E-05	4E-05	4E-05	4E-05	4E-05	4E-05	4E-05

NOTE: Type 1 = component; Type 2 = dissolved complex; Type S = solids phase

TABLE G-4A

BB&S LUMBER SITE - PREDESIGN INVESTIGATION
CHEMICAL SPECIES DISTRIBUTION WITHOUT REDOX

(MINEQL RUN #05; concentration in moles/L)

COMPONENT/ SPECIES	pH (s.u.)										
	1.5	**2.5**	**3.5**	**4.5**	**5.5**	**6.5**	**7.5**	**8.5**	**9.5**	**10.5**	**11.5**
HEXAVALENT CHROMIUM											
1:CrO4(2-)	0	0	0	1.5	13	59.8	93.7	99.3	99.9	100	100
2:HCrO4-	97.8	99.8	99.8	98.5	87	40.2	6.3	0	0	0	0
2:H2CrO4	2.2	0	0	0	0	0	0	0	0	0	0
TOTAL CrO4(2-)	100	100	100	100	100	100	100	100	100	100	100
TRIVALENT CHROMIUM											
1.Cr(OH)2(+)	0	0	0	1.9	0	0	0	0	0	0	0
2:Cr+3	99.7	96.7	74.3	22	0	0	0	0	0	0	0
2:Cr(OH)+2	0	3.3	25.7	76	0	0	0	0	0	0	0
S:Cr2O3	0	0	0	0	98.7	100	100	100	100	100	99.9
TOTAL Cr(OH)2(+)	100	100	100	100	1.3	0	0	0	0	0	0.1
FERRIC IRON (+3)											
1:Fe(3+)	89.5	4.8	0	0	0	0	0	0	0	0	0
2:FeOH+2	9.1	4.9	0	0	0	0	0	0	0	0	0
2:Fe(OH)2+	0	4	0	0	0	0	0	0	0	0	0
S:FERRIHYDRITE	0	86.3	99.6	100	100	100	100	100	100	100	100
TOTAL Fe(3+)	100	14	0.5	0	0	0	0	0	0	0	0
FERROUS IRON (+2)											
1:Fe(2+)	100	100	100	100	100	99.9	99.2	17.8	0	0	0
2:Fe(OH)3-	0	0	0	0	0	0	0	0	0	0	3.8
2:FeOH+	0	0	0	0	0	0	0	1.5	0	0	0
S:Fe(OH)2	0	0	0	0	0	0	0	80.7	99.6	99.6	96.2
TOTAL Fe(2+)	100	100	100	100	100	100	100	19.3	0.4	0.4	3.8
COPPER (+2)											
1:Cu(2+)	100	100	100	99.9	99.3	93.8	4.1	0	0	0	0
2:Cu(OH)3-	0	0	0	0	0	0	0	0	0	0	1.1
2:CuOH+	0	0	0	0	0	6.2	2.7	0	0	0	0
S:Cu(OH)2	0	0	0	0	0	0	93	99.5	99.8	99.7	98.7
TOTAL Cu(2+)	100	100	100	100	100	100	7	0.5	0.2	0.3	1.3
COPPER (+1)											
1:Cu(+)	100	100	100	36	3.6	0	0	0	0	0	0
S:CUPRITE	0	0	0	64	96.4	99.6	100	100	100	100	100
TOTAL Cu(+)	100	100	100	36	3.6	0.4	0	0	0	0	0
ARSENIC											
2:HAsO3-2	0	0	0	0	0	0	0	0	0	4	30.2
2:H3AsO3	98.2	99.8	100	100	100	99.8	98.2	84.3	34.8	4.9	0
2:H2AsO3-	0	0	0	0	0	0	1.8	15.7	64.9	91.1	68.7
2:H4AsO3+	1.8	0	0	0	0	0	0	0	0	0	0
TOTAL AsO3(3-)	100	100	100	100	100	100	100	100	100	100	100

NOTE: Type 1 = component; Type 2 = dissolved complex; Type S = solids phase

TABLE G-4B

BB&S LUMBER SITE - PREDESIGN INVESTIGATION
CHEMICAL SPECIES DISTRIBUTION WITH REDOX

(MINEQL RUN #06; concentration in moles/L)

COMPONENT/	pH (s.u.)										
SPECIES	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5
HEXAVALENT CHROMIUM											
1:CrO4(2-)	0	0	0	2	13	60	94	99	100	100	100
2:HCrO4-	98	100	100	99	87	40	6	0	0	0	0
2:H2CrO4	2	0	0	0	0	0	0	0	0	0	0
TOTAL CrO4(2-)	100	100	100	100	100	100	100	100	100	100	100
TRIVALENT CHROMIUM											
1.Cr(OH)2(+)	0	0	0	1.3	0	0	0	0	0	0	0
2:Cr+3	99.7	96.7	74.3	14.3	0	0	0	0	0	0	0
2:Cr(OH)+2	0	3.3	25.7	49.4	0	0	0	0	0	0	0
S:Cr2O3	0	0	0	35.1	99.4	100	100	100	100	100	100
TOTAL Cr(OH)2(+)	100	100	100	64.9	0.6	0	0	0	0	0	0
FERRIC IRON (+3)											
1:Fe(3+)	90.1	35.1	1.1	0	0	0	0	0	0	0	0
2:FeOH+2	9.2	35.8	10.8	1.2	0	0	0	0	0	0	0
2:Fe(OH)2+	0	29.1	88.1	98.8	99.9	0	0	0	0	0	0
S:FERRIHYDRITE	0	0	0	0	0	100	100	100	100	100	100
TOTAL Fe(3+)	100	100	100	100	100	0	0	0	0	0	0
FERROUS IRON (+2)											
1:Fe(2+)	100	100	100	100	100	99.9	99.2	92.3	48.5	0	0
2:Fe(OH)3-	0	0	0	0	0	0	0	0	10.3	95	99.9
2:FeOH+	0	0	0	0	0	0	0	7.7	40.3	3.7	0
TOTAL Fe(2+)	100	100	100	100	100	100	100	100	100	100	100
COPPER (+2)											
1:Cu(2+)	100	100	100	99.9	99.3	93.8	58.9	8.9	0	0	0
2:CuOH+	0	0	0	0	0	6.2	38.9	58.7	15.3	1.8	0
2:Cu(OH)2 (aq)	0	0	0	0	0	0	2.2	32.4	84.5	98.2	99.8
TOTAL Cu(2+)	100	100	100	100	100	100	100	100	100	100	100
COPPER (+1)											
1:Cu(+)	100	100	100	18	1.8	0	0	0	0	0	0
S:CUPRITE	0	0	0	82	98.2	99.8	100	100	100	100	100
TOTAL Cu(+)	100	100	100	18	1.8	0.2	0	0	0	0	0
ARSENIC											
2:HAsO3-2	0	0	0	0	0	0	0	0	0	4	30.2
2:H3AsO3	98.2	99.8	100	100	100	99.8	98.2	84.3	34.8	4.9	0
2:H2AsO3-	0	0	0	0	0	0	1.8	15.7	64.9	91.1	68.7
2:H4AsO3+	1.8	0	0	0	0	0	0	0	0	0	0
7:TOTAL AsO3(3-)	100	100	100	100	100	100	100	100	100	100	100

NOTE: Type 1 = component; Type 2 = dissolved complex; Type S = solids phase

BB&S Lumber Site Predesign Investigation
Groundwater Flow/Transport Modeling & Treatability Study

TABLES

TABLE 1
Summary of Well Parameters/Groundwater Elevation
BB&S LUMBER SITE

Well ID	WORLD COORDINATES		MODFLOW COORDINATES		GROUND ELEVATION (ft amsl)	WELL DEPTH (from TOR) (ft)	Measuring Point Elevation (TOR) (ft amsl)	GROUNDWATER ELEVATION (ft amsl)						Depth to GW (ft)	Groundwater Elev. (ft)
	NORTHING (ft)	EASTING (ft)	NORTHING (ft)	EASTING (ft)				May-96	Aug-96	Feb-05	Aug-05	Oct-05	Nov-05	Feb-06	
MW-1	226328.1	2360755.5	6080	8430		52.50									
MW-2	227619.1	2360534.0	6420	8385	ABANDONED										
MW-3	226669.3	2360604.3	6415	8280	54.90	68.75	57.19	18.64	19.93	18.28	19.79	20.34	21.15		
MW-4	226538.9	2360596.7	6290	8260	59.00	69.90	60.20	18.53	19.80	18.11	19.65	20.14	21.03	38.53	21.67
MW-5	226419.1	2360640.4	6180	8310		69.23	59.63	18.36	19.72	17.87	19.61	20.02	20.95	38.04	21.59
MW-6	226323.3	2360656.2	6070	8325	59.80	69.90	61.07	18.21	19.65	17.89	19.46	19.86	20.85		
MW-7	226436.9	2360686.6	6200	8360		77.60									
MW-8	226263.8	2360659.7	6015	8335		67.20									
MW-9	226163.8	2360601.1	5915	8270	61.60	59.10	61.89	18.03	19.57	17.63	19.41	19.74	20.80	40.43	21.46
MW-10	226111.6	2360659.1	5870	8330	61.50	58.10	61.88	18.05	19.41	17.80	19.28	19.62	20.70	41.49	20.39
MW-11	225873.1	2360731.0	5630	8400		77.40									
MW-12	225594.8	2360890.6	5350	8555		77.02									
MW-13	225496.6	2360624.9	5250	8290		71.00	58.44	17.47	18.28	17.11	18.23	18.35	19.69	38.08	20.36
MW-14	225342.1	2360774.4	5095	8450		75.05									
MW-15	226402.7	2360535.6	6160	8200		77.24									
MW-16	226002.7	2360593.0	5750	8260	60.20	77.60	60.06	18.24	19.07	17.94	19.04	19.39	20.59		
RW-1	226291.6	2360669.3	6045	8330	60.20	100.00	62.39		19.61		19.43	19.85			
RW-2	226100.9	2360713.6	5855	8380	61.10	103.28	63.04		19.47		19.04	19.39	20.49	41.87	21.17
RW-3	225776.9	2360781.6	5530	8455	58.20	102.14	60.37		18.96		18.72	18.86	20.14	39.52	20.85
OW-GATE	224383.2	2360693.9	4140	8360	52.90		52.38				16.87	16.74	18.36	33.36	19.02
MWPD-1D	226101.5	2360723.6	5855	8400	60.80		63.34					19.38	21.47		
MW-PD-2S	226099.2	2360762.2	5855	8425	60.70		63.53					19.42	20.50		
MWPD-3S	226201.5	2360696.4	5955	8360	61.20		61.14					19.58	20.62		
GWPD-1	225882.8	2360750.8			57.85										
HP-10	226526.1	2360394.5													
HP-13	226734.3	2360710.2													
HP-7	226600.0	2360420.3													
HP-8	226678.9	2360351.7													
HP-9	226543.0	2360481.3													

Note: RW-3 and RW-1 measuring points are top of metal casing

TABLE 2

BB&S Treated Lumber Site Rre-Design Investigation

OLD COUNTRY RD WELL FIELD PUMPING RECORDS

(1985 to 2005)

Year	I.D. of Wells Pumped	Total Annual Gallons Pumped	Average GPD Pumped for Year	Average GPM Pumped for Year	Average GPM Pumped for Duration
1985	1, 2, 3	140,302,000	384,389	267	Years 1985 - 1990 **270** GPM
1986	1, 2, 3	137,700,000	377,260	262	
1987	1, 2, 3	166,100,000	455,068	316	
1988	1, 2, 3	155,104,000	424,942	295	
1989	1, 2, 3	99,215,000	271,822	189	
1990	1, 2, 3	153,994,000	421,901	293	
1991	1, 2, 3	126,955,000	347,822	242	Years 1991 - 1995 **336** GPM
1992	1, 2, 3	141,966,000	388,948	270	
1993	1, 2, 3	90,677,000	248,430	173	
1994	1, 2, 3	246,614,000	675,655	469	
1995	1, 2, 3	277,867,000	761,279	529	
1996	1, 2, 3	227,701,000	623,838	433	Years 1996 - 2000 **565** GPM
1997	1, 2, 3	310,419,000	850,463	591	
1998	1, 2, 3, 4	395,273,000	1,082,940	752	
1999	1A, 1, 4	297,990,000	816,411	567	
2000	1A, 1, 4	254,652,000	697,677	484	
2001	1A, 1, 4	124,910,000	342,219	238	Years 2001 - 2005 **404** GPM
2002	1A, 1, 4	209,680,000	574,466	399	
2003	1A, 1, 4	205,510,000	563,041	391	
2004	1A, 1, 4	320,300,000	877,534	609	
2005	1A, 1, 4	202,494,000	554,778	385	
ALL YEARS	**max**	395,273,000	1,082,940	752	
	min	90,677,000	248,430	173	
	avg.	204,067,762	559,090	388	

Well	Total Depth (ft)	Aquifer	Capacity (gpm)
1A	185 ft	Glacial	1000
1	76	Glacial	200
2	69	Glacial	225
3	161	Glacial	700
4	160	Glacial	1300

TABLE 3
BB&S LUMBER PRE-DESIGN INVESTIGATION
GROUNDWATER FLOW SIMULATION – ZONE BUDGETS

PEST CALIBRATION RUN 14

CONDUCTIVITIES (CALIBRATED)
Layers 1, 2 & 3: Kxy = 170; Kz = 21.5 ft/day; Layer 4: Kxy = 18.2; Kz = 0.08 ft/day

RECHARGE (ASSUMED)
Zone 1 = 0.0065 (ft/day); Zone 2 = 0.0065 (ft/day); Zone 3 = 0.0040 (ft/day)

SCWA WELL FIELD (ASSUMED): 500 GPM

ZONE 1

INFLOW	***OUTFLOW***
Storage = 0.00 ft^3/day	Storage = 0.00 ft^3/day
Constant Head = 80312.00 ft^3/day	Constant Head = 579500.00 ft^3/day
Wells = 0.00 ft^3/day	Wells = 96000.00 ft^3/day
Drains = 0.00 ft^3/day	Drains = 0.00 ft^3/day
Recharge = 512830.00 ft^3/day	Recharge = 0.00 ft^3/day
ET = 0.00 ft^3/day	ET = 0.00 ft^3/day
River Leakage = 88944.00 ft^3/day	River Leakage = 8454.80 ft^3/day
Stream Leakage = 0.00 ft^3/day	Stream Leakage = 0.00 ft^3/day
Surface Leakage = 0.00 ft^3/day	Surface Leakage = 0.00 ft^3/day
General-Head = 0.00 ft^3/day	General-Head = 0.00 ft^3/day
Zone 2 to 1 = 19670.00 ft^3/day	Zone 1 to 2 = 19374.00 ft^3/day
Total IN = 701750.00 ft^3/day	Total OUT = 703330.00 ft^3/day

ZONE 2

INFLOW	***OUTFLOW***
Storage = 0.00 ft^3/day	Storage = 0.00 ft^3/day
Constant Head = 0.00 ft^3/day	Constant Head = 0.00 ft^3/day
Wells = 0.00 ft^3/day	Wells = 0.00 ft^3/day
Drains = 0.00 ft^3/day	Drains = 0.00 ft^3/day
Recharge = 95.35 ft^3/day	Recharge = 0.00 ft^3/day
ET = 0.00 ft^3/day	ET = 0.00 ft^3/day
River Leakage = 200.00 ft^3/day	River Leakage = 0.00 ft^3/day
Stream Leakage = 0.00 ft^3/day	Stream Leakage = 0.00 ft^3/day
Surface Leakage = 0.00 ft^3/day	Surface Leakage = 0.00 ft^3/day
General-Head = 0.00 ft^3/day	General-Head = 0.00 ft^3/day
Zone 1 to 2 = 19374.00 ft^3/day	Zone 2 to 1 = 19670.00 ft^3/day
Total IN = 19669.00 ft^3/day	Total OUT = 19670.00 ft^3/day

TABLE 4
Groundwater Analytical Results - October 2005

Sample I.D.	Arsenic			Copper			Iron			Total Chromium			Hexavalent Chromium		
	GWS* 25ppb			GWS* 200ppb			GWS* 300ppb			GWS* 50ppb			GWS* 0.05ppm		
	total	%Diss	dissolved	total	%Diss	dissolved	total		dissolved	total	%Diss	dissolved	total	%Diss	dissolved
MWPD-2S	3.1	0%	nd	nd		nd	337	0%	nd	11.8	0%	nd	nd		nd
MWPD-3S	478	86%	410	34.5	26%	9	860	3%	29.2	207	100%	208	0.24	96%	0.23
MWPD-1D	3.6	0%	nd	nd		nd	5120	0%	nd	23.2	0%	nd	nd		nd
MW-3	nd		nd	nd		nd	nd		nd	nd	0%	nd	nd		nd
MW-4	30	69%	20.7	2.6	81%	2.1	139	33%	46	42.5	85%	36.1	0.04	75%	0.03
MW-5	4.1	100%	4.1	nd		nd	411	41%	170	567	106%	601	0.76	96%	0.73
MW-6	nd		nd	35.6	99%	35.2	nd		nd	401	103%	413	0.43	102%	0.44
MW-9	2.8	0%	nd	3.5	66%	2.3	49.6	0%	nd	83.5	89%	74.7	0.08	0%	nd
MW-10	nd		nd	nd		nd	119	0%	nd	549	98%	538	0.61	0%	nd
MW-13	2.8	100%	2.8	1.1	0%	nd	41	46%	18.7	11	96%	10.6	nd		nd
MW-16 -*-	2.8	179%	5	nd		nd	nd	>>>	1910	16.7	189%	31.5	0.04	200%	0.08
RW-2	2.8	100%	2.8	49.9	0%	nd	28600	61%	17500	765	0%	nd	nd		nd
X-1	nd		nd	56.8	0%	nd	31300	48%	15100	978	0%	nd	nd		nd
RW-3	nd		nd	nd		nd	93200	85%	78900	46.7	0%	nd	nd		nd
OW-GATE	nd		nd	2.9	76%	2.2	127	0%	nd	nd	0%	nd	nd		nd
GWPD-1	nd		- -	- -		- -	- -		- -	389		- -	nd		- -
SBPD-158-GW1	437		- -	386		- -	35200		- -	771		- -	nd		- -
DUP-4	412		- -	383		- -	33300		- -	732		- -	nd		- -

	Arsenic			Copper			Iron			Total CR			Hex CR		
	Total **(mg/kg)**	% Extracted	SPLP **(ug/L)**	Total **(mg/kg)**		SPLP **(ug/L)**	Total **(mg/kg)**		SPLP **(ug/L)**	Total **(mg/kg)**		SPLP **(ug/L)**	Total **(mg/kg)**		SPLP **(mg/L)**
SBPD-158(23-24)	233	94%	11000	463	111%	25600	330	1%	197	25	61%	757	NA		0.22
SBPD-158(30-34)	43.8	64%	1400	110	98%	5410	601	3%	760	12.1	47%	286	NA		0.01
DUP-3	41.1	62%	1270	95.5	103%	4930	451	3%	713	10.2	52%	263	NA		0.01
SBPD-158(38-39)	44.7	48%	1080	265	96%	12700	544	3%	897	8.9	33%	146	NA		0.01

NOTE: %extracted assumes 50 gms of soil mixed with 1000 ml of SPLP leachate

TABLE 5A

BB&S LUMBER SITE - PREDESIGN INVESTIGATION
CHEMICAL SPECIES DISTRIBUTION WITHOUT REDOX

(MINEQL RUN #06; concentration in mg/L)

COMPONENT/	**pH (s.u.)**										
SPECIES	**1.5**	**2.5**	**3.5**	**4.5**	**5.5**	**6.5**	**7.5**	**8.5**	**9.5**	**10.5**	**11.5**
HEXAVALENT CHROMIUM (Initial 5 mg/L)											
1:CrO4(2-)	0.0	0.0	0.0	0.1	0.6	3.0	4.7	5.0	5.0	5.0	5.0
2:HCrO4-	4.9	5.0	5.0	4.9	4.3	2.0	0.3	0.0	0.0	0.0	0.0
2:H2CrO4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL CrO4(2-)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
TRIVALENT CHROMIUM (Initial 5 mg/L)											
1:Cr(OH)2(+)	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2:Cr+3	5.0	4.8	3.7	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2:Cr(OH)+2	0.0	0.2	1.3	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S:Cr2O3	0.0	0.0	0.0	0.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5
TOTAL Cr(OH)2(+)	5.0	5.0	5.0	5.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
FERRIC IRON (+3) (Initial 200 mg/L)											
1:Fe(3+)	179.7	9.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2:FeOH+2	18.4	9.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2:Fe(OH)2+	1.5	8.0	0.8	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL Fe(3+)	200.9	28.0	0.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S:FERRIHYDRITE	0.0	172.4	199.8	200.9	200.9	200.9	200.9	200.9	200.9	200.9	200.9
FERROUS IRON (+2) (Initial 200 mg/L)											
1:Fe(2+)	200.9	200.9	200.9	200.9	200.9	200.9	199.2	35.8	0.4	0.0	0.0
2:Fe(OH)3-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.8	7.6
2:FeOH+	0.0	0.0	0.0	0.0	0.0	0.2	1.7	3.0	0.3	0.0	0.0
TOTAL Fe(2+)	200.9	200.9	200.9	200.9	200.9	200.9	200.9	38.8	0.7	0.8	7.6
S:Fe(OH)2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	161.8	200.3	200.3	193.1
COPPER (+2) (Initial 1.3 mg/L)											
1:Cu(2+)	1.3	1.3	1.3	1.3	1.3	1.2	0.1	0.0	0.0	0.0	0.0
2:Cu(OH)3-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2:CuOH+	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
TOTAL Cu(2+)	1.3	1.3	1.3	1.3	1.3	1.3	0.1	0.0	0.0	0.0	0.0
S:Cu(OH)2	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.3	1.3	1.3	1.3
COPPER (+1) (Initial 1.3 mg/L)											
1:Cu(+)	1.3	1.3	1.3	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL Cu(+)	1.3	1.3	1.3	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S:CUPRITE	0.0	0.0	0.0	0.4	0.6	0.6	0.6	0.6	0.6	0.6	0.6
ARSENIC (Initial 2.9 mg/L)											
2:HAsO3-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.9
2:H3AsO3	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.5	1.0	0.1	0.0
2:H2AsO3-	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.5	1.9	2.7	2.0
2:H4AsO3+	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL AsO3(3-)	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9

NOTE: Type 1 = component; Type 2 = dissolved complex; Type S = solids phase

TABLE 5B

BB&S LUMBER SITE - PREDESIGN INVESTIGATION
CHEMICAL SPECIES DISTRIBUTION WITH REDOX

(MINEQL RUN #06; concentration in mg/L)

COMPONENT/	**pH (s.u.)**										
SPECIES	**1.5**	**2.5**	**3.5**	**4.5**	**5.5**	**6.5**	**7.5**	**8.5**	**9.5**	**10.5**	**11.5**
HEXAVALENT CHROMIUM (Initial 5 mg/L)											
1:CrO4(2-)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2:HCrO4-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2:H2CrO4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL CrO4(2-)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TRIVALENT CHROMIUM (Initial 5 mg/L)											
1:Cr(OH)2(+)	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2:Cr+3	9.9	9.7	7.4	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2:Cr(OH)+2	0.0	0.3	2.6	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL Cr(OH)2(+)	10.0	10.0	10.0	6.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0
S:Cr2O3	*0.0*	*0.0*	*0.0*	*1.8*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*
FERRIC IRON (+3) (Initial 200 mg/L)											
1:Fe(3+)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2:FeOH+2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2:Fe(OH)2+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL Fe(3+)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S:FERRIHYDRITE	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*356.6*	*401.8*	*401.8*	*401.8*	*401.8*	*401.8*
FERROUS IRON (+2) (Initial 200 mg/L)											
1:Fe(2+)	401.8	401.8	401.8	401.8	401.8	44.9	0.0	0.0	0.0	0.0	0.0
2:Fe(OH)3-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2:FeOH+	0.0	0.0	0.0	0.6	61.9	775.6	109.4	15.4	2.2	0.3	0.0
TOTAL Fe(2+)	401.8	401.8	401.8	401.8	401.8	45.0	0.0	0.0	0.0	0.0	0.0
COPPER (+2) (Initial 1.3 mg/L)											
1:Cu(2+)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2:CuOH+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2:Cu(OH)2 (aq)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL Cu(2+)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COPPER (+1) (Initial 1.3 mg/L)											
1:Cu(+)	2.5	2.5	2.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL Cu(+)	2.5	2.5	2.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S:CUPRITE	0.0	0.0	0.0	1.0	1.2	1.3	1.3	1.3	1.3	1.3	1.3
ARSENIC (Initial 2.9 mg/L)											
2:HAsO3-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.9
2:H3AsO3	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.5	1.0	0.1	0.0
2:H2AsO3-	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.5	1.9	2.7	2.0
TOTAL AsO3(3-)	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9

NOTE: Type 1 = component; Type 2 = dissolved complex; Type S = solids phase

TABLE 6
BB&S SITE PRE-DESIGN STUDY

SITE TESTING OF WELLS

SAMPLE	MW-3	MW-6	MW-10	MW PD-1D	RW-2	MW-2S	MW-16	MWPD-3S	RW-3	OW GATE	MW-13	MW-4
ph strip	7.0	6.5	6.0	6.0	6.0	5.5	6.5	6.5	6.5	5.0	6.0	5.5
Chromium strip	0.50	0.25	0.50	<0.1	0.25	<0.1	0.01	0.50	0.50	0.25	0.50	0.25
Ferrous	0.0	<0.5	0.0	0.0	0.0	0.0	0.0	0.0	9.0	0.0	0.0	0.0
Ferric	0.0	<0.5	0.0	<0.5	4.0	0.5	1.0	4.0	> Range	1.0	<0.5	0.0
3645 Chromium	0.00	0.45	0.10	0.04	0.10	0.05	0.03	0.03	0 .01 / 0.03	0.00	0.02	0.13
3668 FE	0.29	0.12	0.28	> Range	> Range	0.83 / 1.20	1.60	8.89	> Range	0.61	0.05	0.36
3640 CU	0.09	0.04	0.07	0.08	0.39 / 0.62	0.07	0.07	0.03	2.06	0.04	0.01	0.02
3646 CU	0.00	0.01	0.00	0.00	0.52	0.03	0.00	0.02	0.74	0.00	0.27	0.10
Arsenic	<0.005	<0.005	<0.005	0.005	<0.005	0.005	0.01	0.1	0.005	0.005	0.005	0.1

Wednesday ------------------------->

Thursday ---------------------- >

NOTES:

1) All concentrations are in mg/L; pH is in standard units.
2) Colorimeter was powered by generator which was moved to each well location, interrupting testing process. Also, could only be powered by 110 volt adapter as battery would not take a charge. During testing generator hesitated several times.
3) Distilled water tested and recorded as 0.12 ppm
4) Second test Performed
5) Arsenic samples were run after attempts made to raise sample temperatures to 77F, from 50 - 55 F, (i.e. placing in direct sunshine and placing inside clothing.)
6) Chromium strip pad, right out from sealed packaging with an off-white ivory tint. No strip produced a pronounced coloring.
7) Chromium 3645 Conversion - 2.23x to ppm Chremate, 3.12x to ppm Sodium Chromate
8) Sample RW-3 diluted 3:1 for ferrous and 5:1 for ferric.
9) Testing Done - Tuesday (PM) to Thursday, 18, 19, and 20, October 2005

TABLE 7

BB&S SITE PRE-DESIGN STUDY

GROUNDWATER TREATABILITY TESTING

A. Characterization in the Field

WELL	WATER LEVEL	SAMPLE DEPTH	ORP	Ph	TDS	T	SP	Fe+2	Fe+3
RW-2	41.87	50	0.053	5.8	116	12.4	242	4	4
RW-1	--	80	0	6.3	72	11.4	130	12	28
MW-5	41.49	53	151	5.7	169	9.3	334	<0.5	2
MW-10			154	5.73	83	12.4	164		

B. Chemicals

CHEMICALS	%
$FeS0_4$	20
$NaHSO_3$	38
NaOH	50
H_2SO_4	20
Polymer Anionic	0.25

C. Characterization in the Test Facility

WELL	WATER LEVEL	SAMPLE DEPTH	TDS	Cr^{+6} (ppb)	Cr^T (ppb)	Fe^{+2} (ppb)	Fe^T (ppb)	pH	T^o C
RW-2	41.87	50	42	130	410	4500	7700	6.1	16.3
MW-10	--	--	125	290	600	ND	ND	5.86	16.7
RW-1	--	--	55	100	200	ND	ND	6.3	17.9

TABLE 8

BB&S SITE PRE-DESIGN STUDY

GROUNDWATER TREATABILITY TESTING - RESULTS

Test A

WELL	WATER LEVEL	SAMPLE DEPTH	pH	5% H_2SO_4 (ml)	pH	1% $NaHSO_3$ (ml)	5% NaOH (ml)	pH (s.u.)	Cr^{+6} (ppb)	Cr^T (ppb)	Fe^T (ppb)
RW-1	--	--	7.3		2	1	3.6	9.5	140	620	110
RW-2	41.87	50	5.2	3	2.5						
				6	2.2						
				8	2	1	3.5	9.5	170	940	4830
MW-10				3	2.5						
				6	2.2						
	--	--	5.8	8.5	2	1	3.7	9.5	260	3300	340

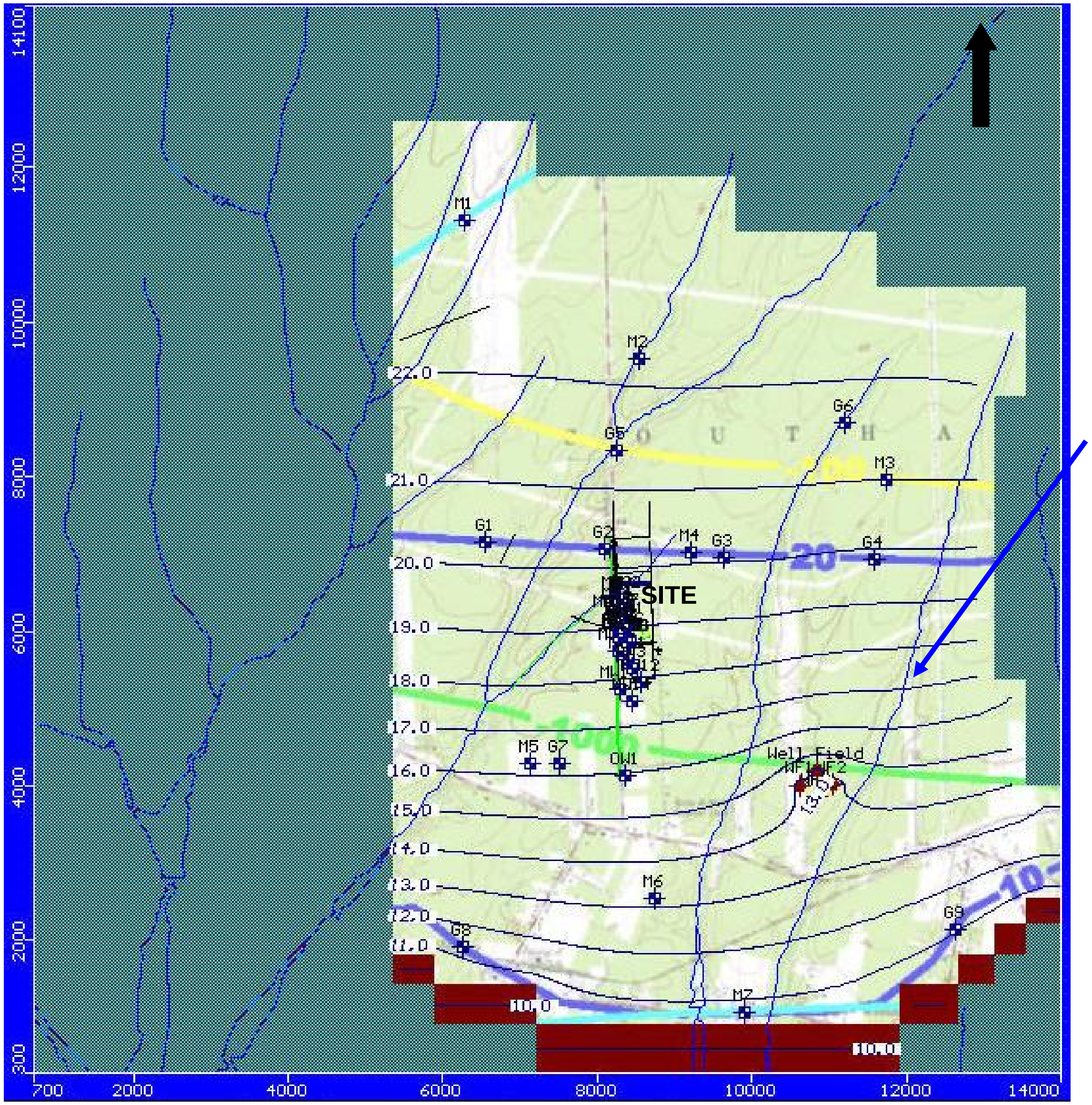
WELL	WATER LEVEL	SAMPLE DEPTH	pH	NaOH	pH	1% $FeSO_4$ (ml)	5% NaOH (ml)	pH (s.u.)	Cr^{+6} (ppb)	Cr^+ (ppb)	Fe (ppb)
RW-1			6.5	0.3	7.5	1	0.5	9.5	120	800	1110
RW-2	41.87	50	5.2	0.4	7.5	1	0.5	9.5	160	350	690
MW-10	--	--	6.7	0.4	7.5	3	0.7	9.5	130	830	2620

Test B

WELL	WATER LEVEL	SAMPLE DEPTH	pH (s.u.)	1% $FeSO_4$ (ml)	pH (s.u.)	5% NaOH (ml)	pH (s.u.)	Cr^{+6} (ppb)	Cr^T (ppb)	Fe (ppb)
RW-1	--	--	6.3	10	6.3	1.5	10	90	40	1720
RW-2	41.87	50	6.1	20	6.26	1.25	10	120	90	280
MW-10	--	--	5.86	30	6.45		10	40	70	1170

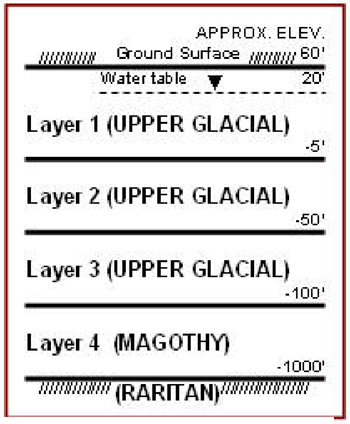
Test C

WELL	WATER LEVEL	SAMPLE DEPTH	pH (s.u.)	5% H_2SO_4 (ml)	pH (s.u.)	1% $NaHSO_3$ (ml)	5% NaOH (ml)	pH (s.u.)	Fe (ppb)	Cr^{+6} (ppb)	Cr^T (ppb)
RW-1	--	--	6.7	2.5	2.5	2	1.5	10.2	670	80	80
RW-2	41.87	50	5.81	2	2.5	2	1.5	10.1	113	120	110
MW-10	--	--	5.71	2.5	2.5	2	1.5	10.1	170	120	330



CONDUCTIVITIES (CALIBRATED)
Layers 1, 2 & 3:
Kxy = 170; Kz = 21.5 ft/day
Layer 4:
Kxy = 18.2; Kz = 0.08 ft/day
RECHARGE (ASSUMED)
Zone 1 = 0.0065 (ft/day)
Zone 2 = 0.0065 (ft/day)
Zone 3 = 0.0040 (ft/day)
SCWA WELL FIELD (ASSUMED)
500 GPM

Model Calculated
GROUNDWATER CONTOURS
for Layer 3

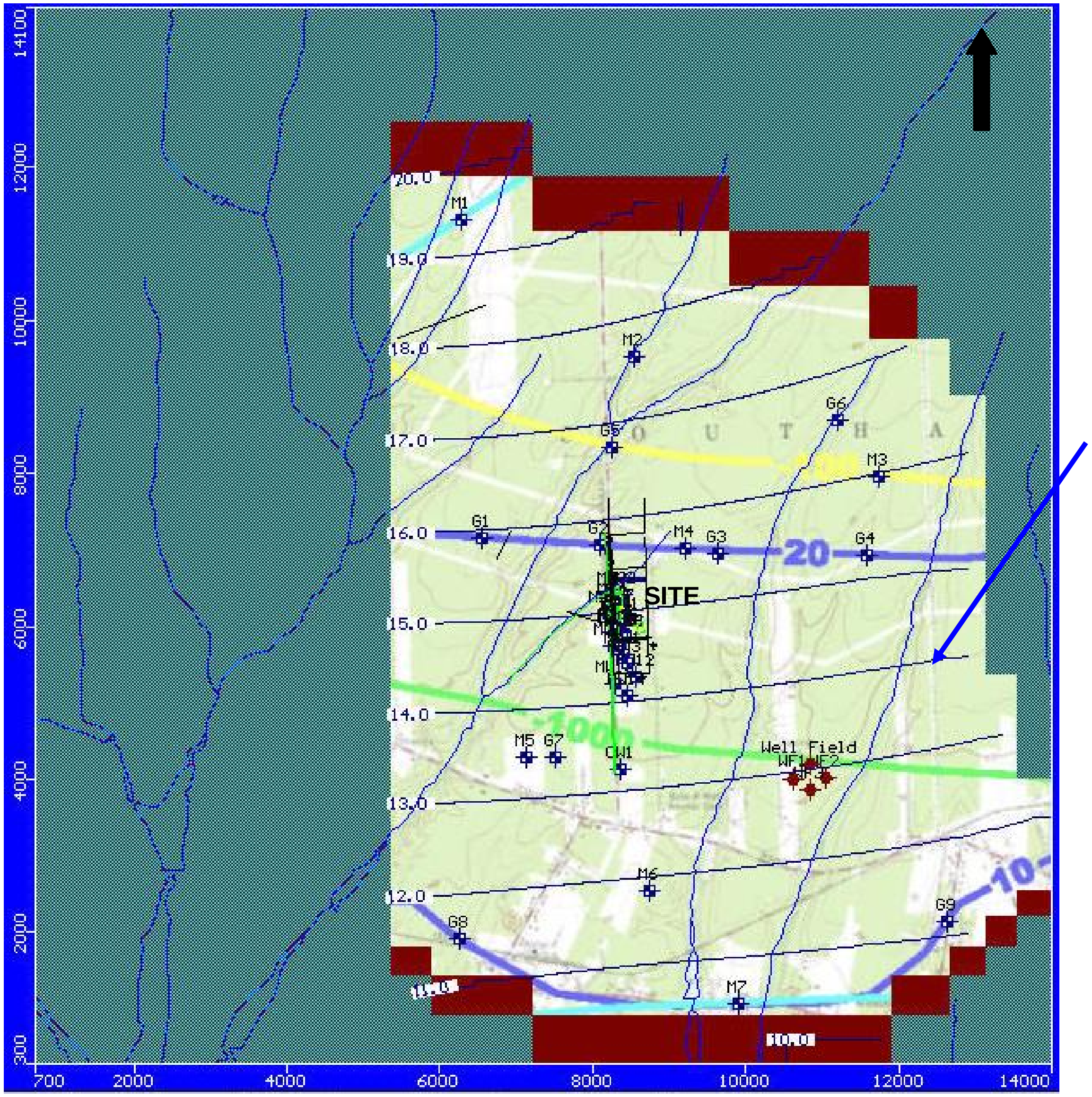


CONTOURS
— GEOLOGIC UNIT – GARDINER'S CLAY
— GEOLOGIC UNIT – MAGOTHY
— GEOLOGIC UNIT – RARITAN
— WATER TABLE – MAGOTHY
— WATER TABLE – UPPER GLACIAL

BB&S - MODFLOW SCREENS
GROUNDWATER CONTOURS FROM PEST CALIBRATION RUN 15
LAYER 3

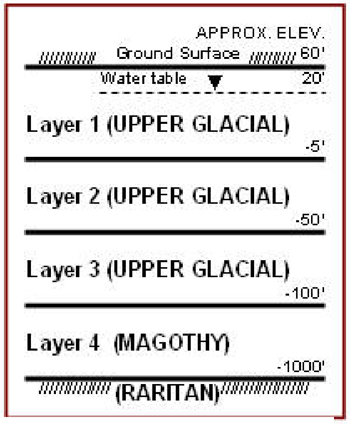
FIGURE 9B

IEG



CONDUCTIVITIES (CALIBRATED)
Layers 1, 2 & 3:
Kxy = 170; Kz = 21.5 ft/day
Layer 4:
Kxy = 18.2; Kz = 0.08 ft/day
RECHARGE (ASSUMED)
Zone 1 = 0.0065 (ft/day)
Zone 2 = 0.0065 (ft/day)
Zone 3 = 0.0040 (ft/day)
SCWA WELL FIELD (ASSUMED)
500 GPM

Model Calculated
GROUNDWATER CONTOURS
for Layer 4

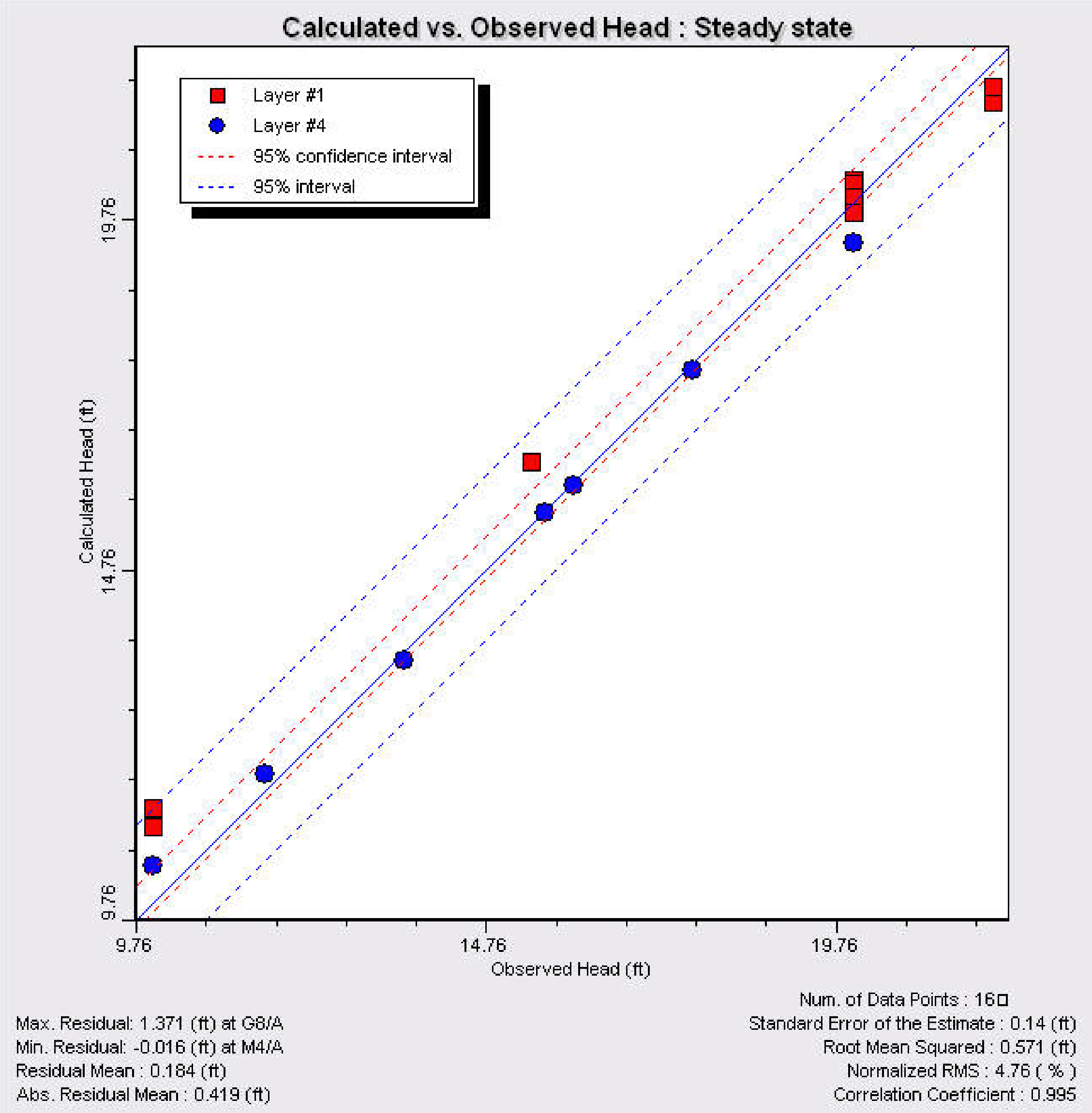


CONTOURS
🟥 GEOLOGIC UNIT – GARDINER'S CLAY
🟨 GEOLOGIC UNIT – MAGOTHY
🟩 GEOLOGIC UNIT – RARITAN
🟦 WATER TABLE – MAGOTHY
🟦 WATER TABLE – UPPER GLACIAL

BB&S - MODFLOW SCREENS
GROUNDWATER CONTOURS FROM PEST CALIBRATION RUN 15
LAYER 4

FIGURE 9C

IEG



Max. Residual: 1.371 (ft) at G8/A
Min. Residual: -0.016 (ft) at M4/A
Residual Mean : 0.184 (ft)
Abs. Residual Mean : 0.419 (ft)

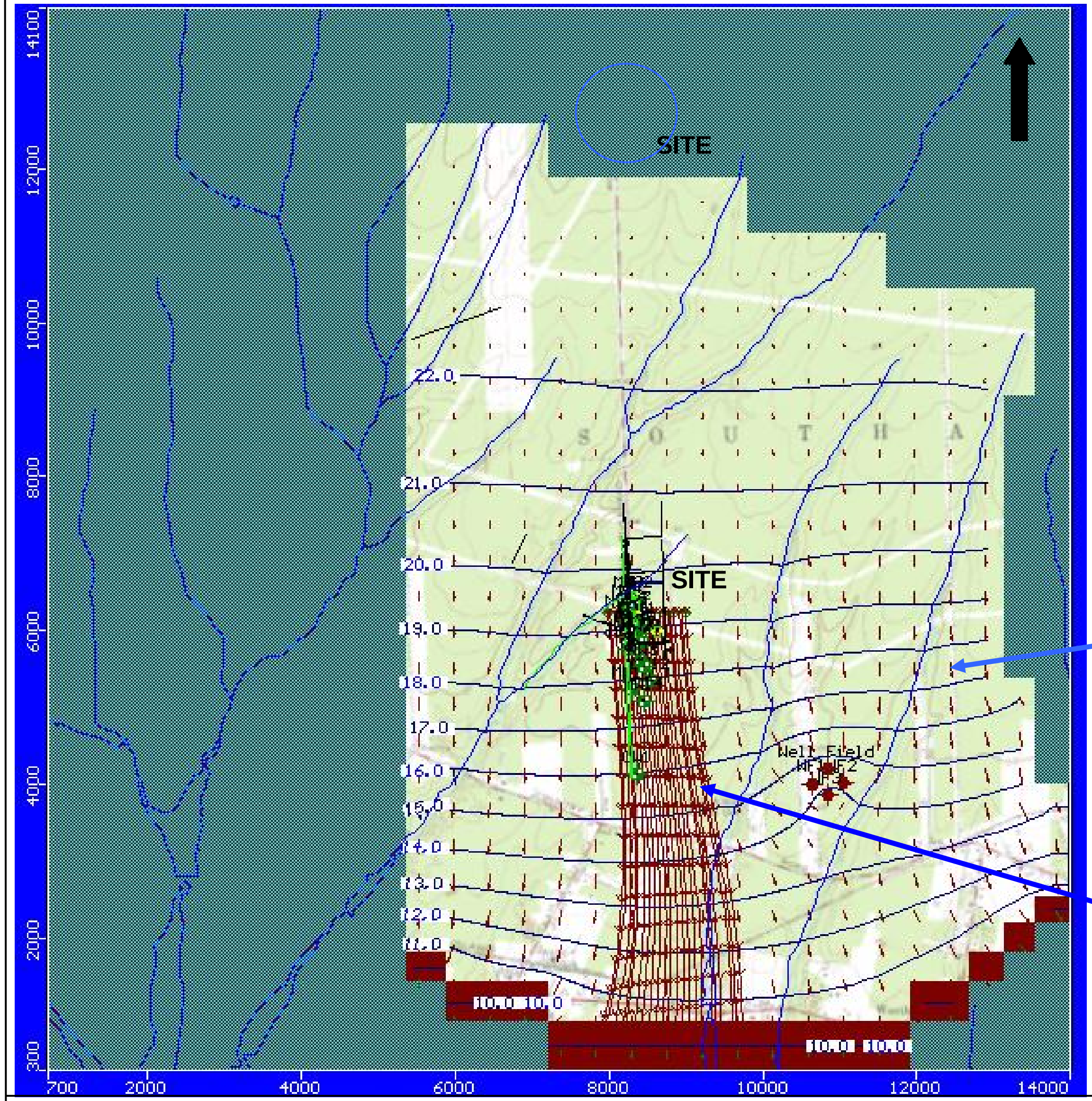
Num. of Data Points : 16
Standard Error of the Estimate : 0.14 (ft)
Root Mean Squared : 0.571 (ft)
Normalized RMS : 4.76 (%)
Correlation Coefficient : 0.995

CONDUCTIVITIES (CALIBRATED)
Layers 1, 2 & 3:
Kxy = 170; Kz = 21.5 ft/day
Layer 4:
Kxy = 18.2; Kz = 0.08 ft/day
RECHARGE (ASSUMED)
Zone 1 = 0.0065 (ft/day)
Zone 2 = 0.0065 (ft/day)
Zone 3 = 0.0040 (ft/day)
SCWA WELL FIELD (ASSUMED)
500 GPM

BB&S - MODFLOW SCREENS
COMPARISION OF CALCULATED VS OBSERVED HEADS
PEST CALIBRATION RUN 15

FIGURE 9D

IEG



CONDUCTIVITIES (CALIBRATED)
Layers 1, 2 & 3:
Kxy = 170; Kz = 21.5 ft/day
Layer 4:
Kxy = 18.2; Kz = 0.08 ft/day
RECHARGE (ASSUMED)
Zone 1 = 0.0065 (ft/day)
Zone 2 = 0.0065 (ft/day)
Zone 3 = 0.0040 (ft/day)
SCWA WELL FIELD (ASSUMED)
500 GPM

GROUNDWATER FLOW VECTORS

MODEL CALCULATED GROUNDWATER FLOW PATHS

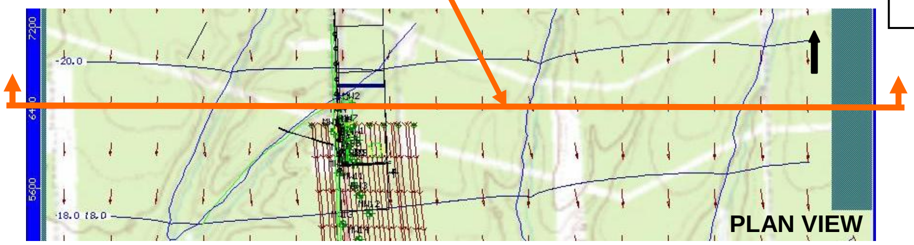
BB&S - MODFLOW SCREENS
MODEL CALCULATED GROUNDWATER FLOW PATH
PLAN VIEW – LAYER 1

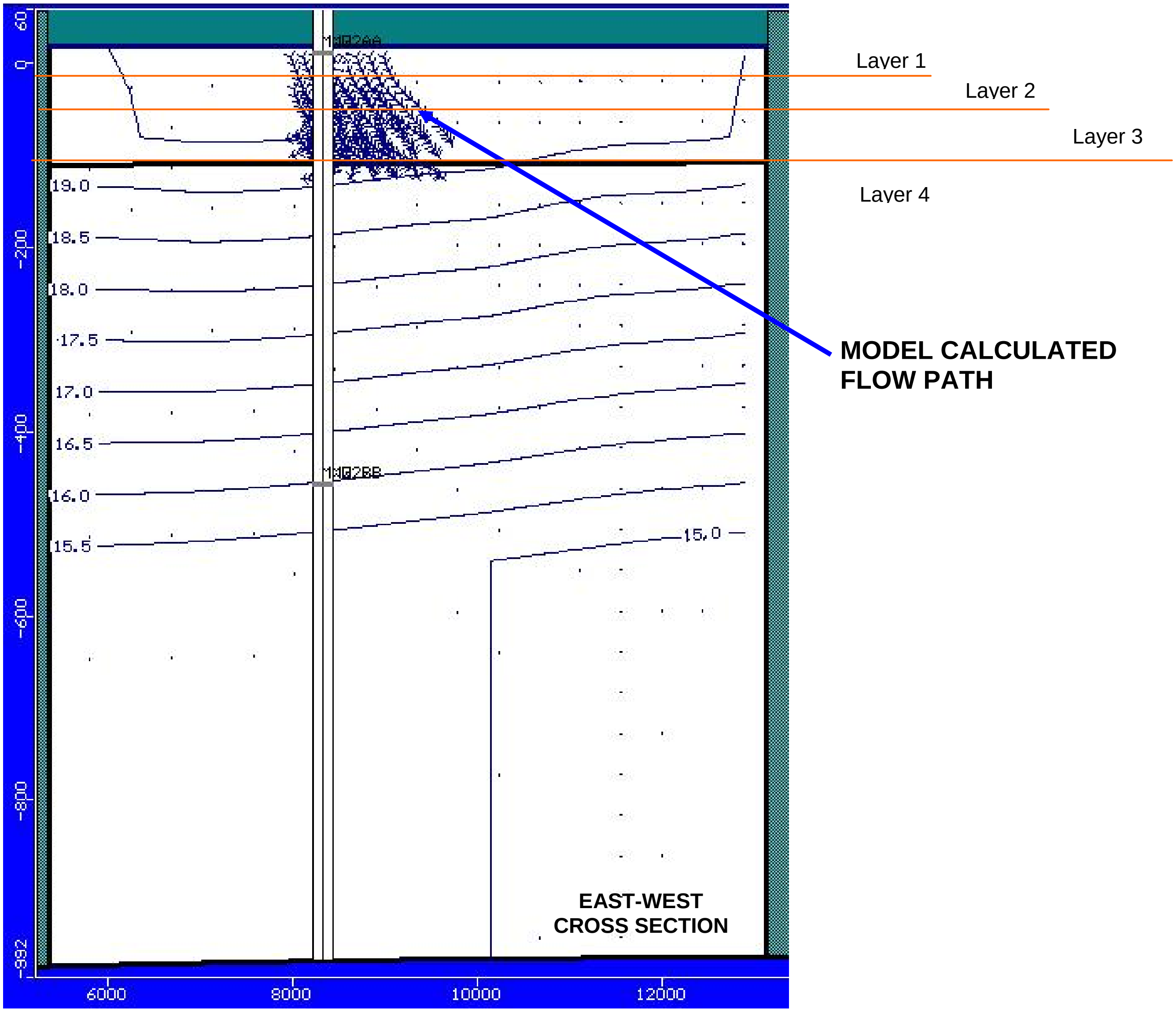
FIGURE 10A

IEG

CONDUCTIVITIES (CALIBRATED)
Layers 1, 2 & 3:
Kxy = 170; Kz = 21.5 ft/day
Layer 4:
Kxy = 18.2; Kz = 0.08 ft/day
RECHARGE (ASSUMED)
Zone 1 = 0.0065 (ft/day)
Zone 2 = 0.0065 (ft/day)
Zone 3 = 0.0040 (ft/day)
SCWA WELL FIELD (ASSUMED)
500 GPM

LOCATION OF CROSS SECTION
at Model Row 53; Northing 6414





MODEL CALCULATED FLOW PATH

EAST-WEST CROSS SECTION

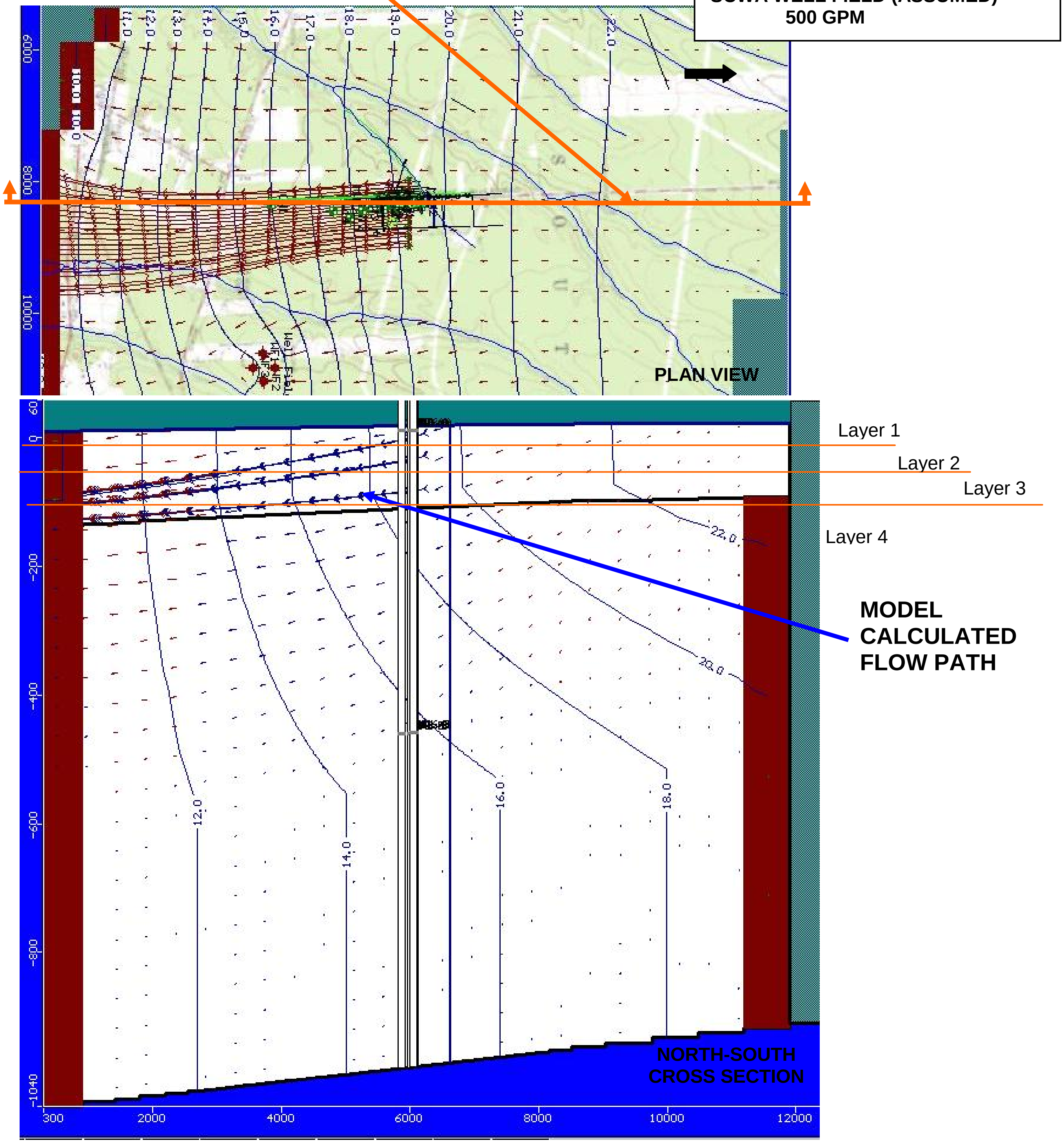
BB&S - MODFLOW SCREENS
MODEL CALCULATED GROUNDWATER FLOW PATH
EAST-WEST CROSS SECTION

FIGURE 10B

IEG

CONDUCTIVITIES (CALIBRATED)
Layers 1, 2 & 3:
Kxy = 170; Kz = 21.5 ft/day
Layer 4:
Kxy = 18.2; Kz = 0.08 ft/day
RECHARGE (ASSUMED)
Zone 1 = 0.0065 (ft/day)
Zone 2 = 0.0065 (ft/day)
Zone 3 = 0.0040 (ft/day)
SCWA WELL FIELD (ASSUMED)
500 GPM

LOCATION OF CROSS SECTION
at Model Column 116; Easting 8342

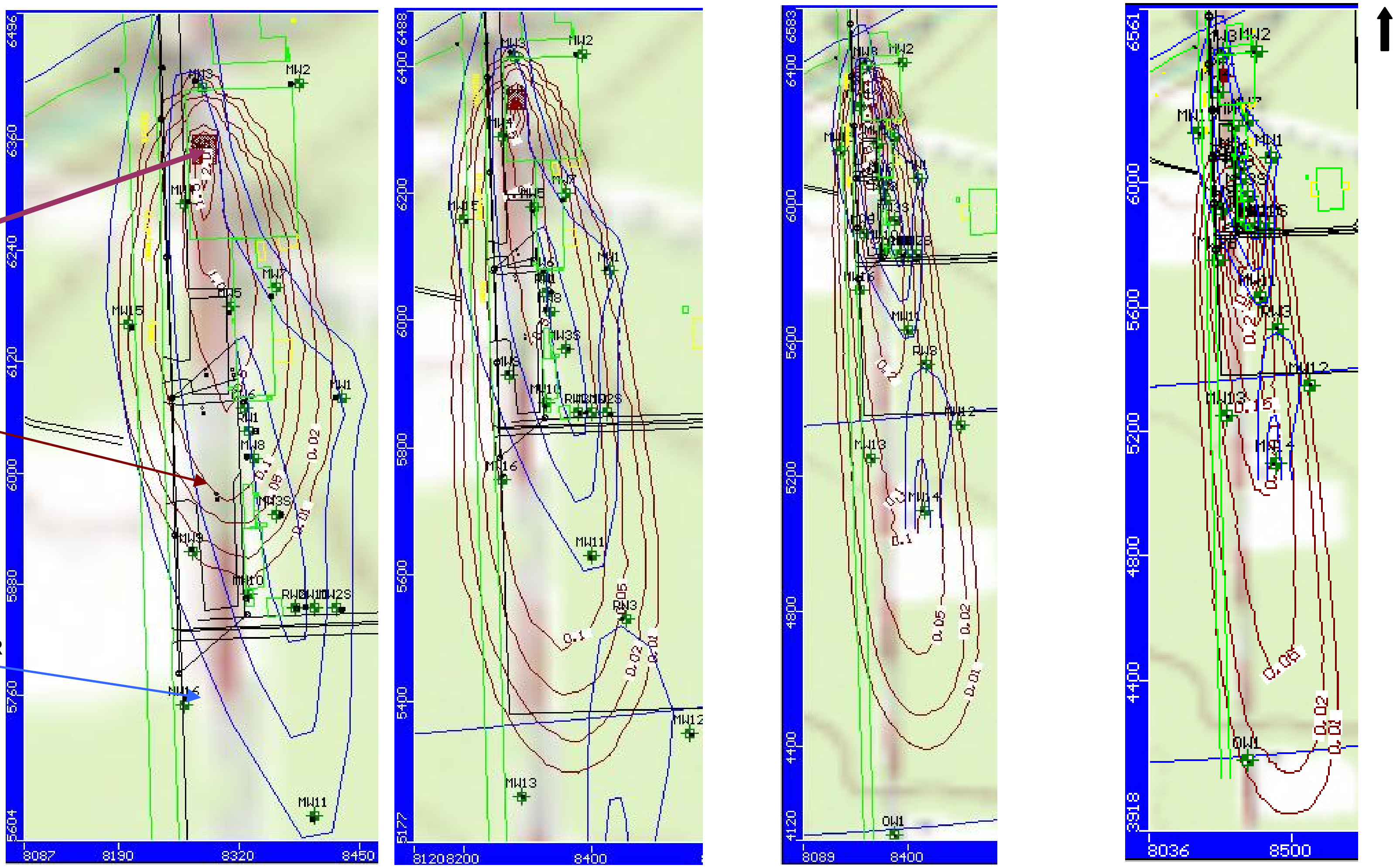


MODEL CALCULATED FLOW PATH

BB&S - MODFLOW SCREENS
MODEL CALCULATED GROUNDWATER FLOW PATH NORTH-SOUTH CROSS-SECTION

FIGURE 10C

IEG



SOURCE

MODFLOW PREDICTED CONTOUR FOR HEXAVALENT CHROMIUM

ACTUAL 1997 CONTOUR FOR HEXAVALENT CHROMIUM

AT 365 DAYS

AT 1000 DAYS

AT 2000 DAYS

AT 2500 DAYS

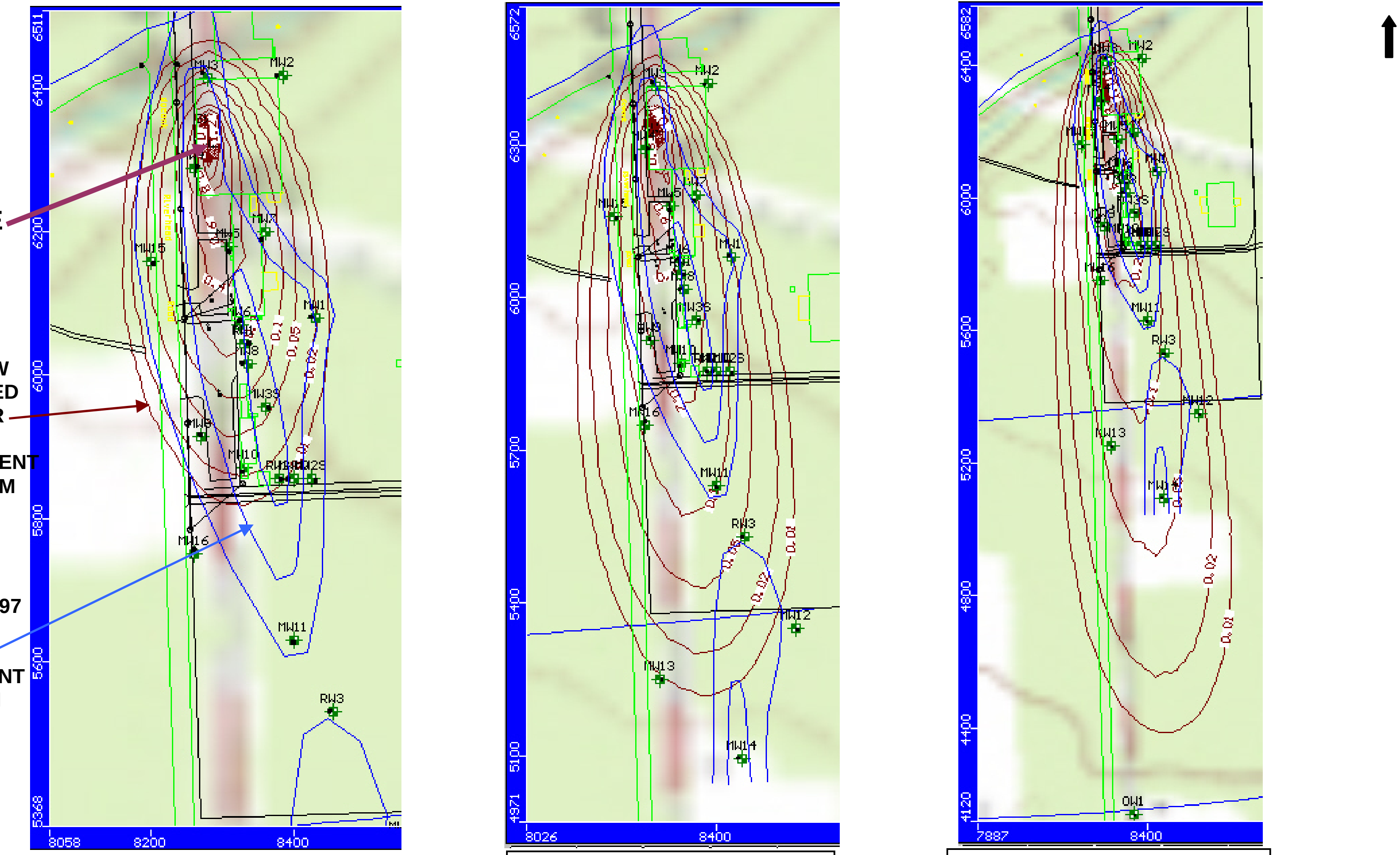
EFFECTIVE POROSITY = 0.30; LONGITUDINAL DISPERSIVITY = 15; SCWA WELL FIELD AT 500 GPM

SOURCE: 0.1 LB/DAY FOR FIRST 2000 DAYS; TOTAL SIMULATION = 4000 DAYS

BB&S - MODFLOW SCREENS
MODEL PREDICTED CONTAMINANT PROFILE
(SIMULATION RUN 29A)

FIGURE 11A

IEG



SOURCE

MODFLOW PREDICTED CONTOUR FOR HEXAVALENT CHROMIUM

ACTUAL 1997 CONTOUR FOR HEXAVALENT CHROMIUM

AT 365 DAYS

AT 1000 DAYS

AT 2000 DAYS

EFFECTIVE POROSITY = 0.30; LONGITUDINAL DISPERSIVITY = 25 FT; SCWA WELL FIELD AT 500 GPM
SOURCE: 0.1 LB/DAY FOR FIRST 2000 DAYS; TOTAL SIMULATION = 4000 DAYS

BB&S - MODFLOW SCREENS
MODEL PREDICTED CONTAMINANT PROFILE
(SIMULATION RUN 30)

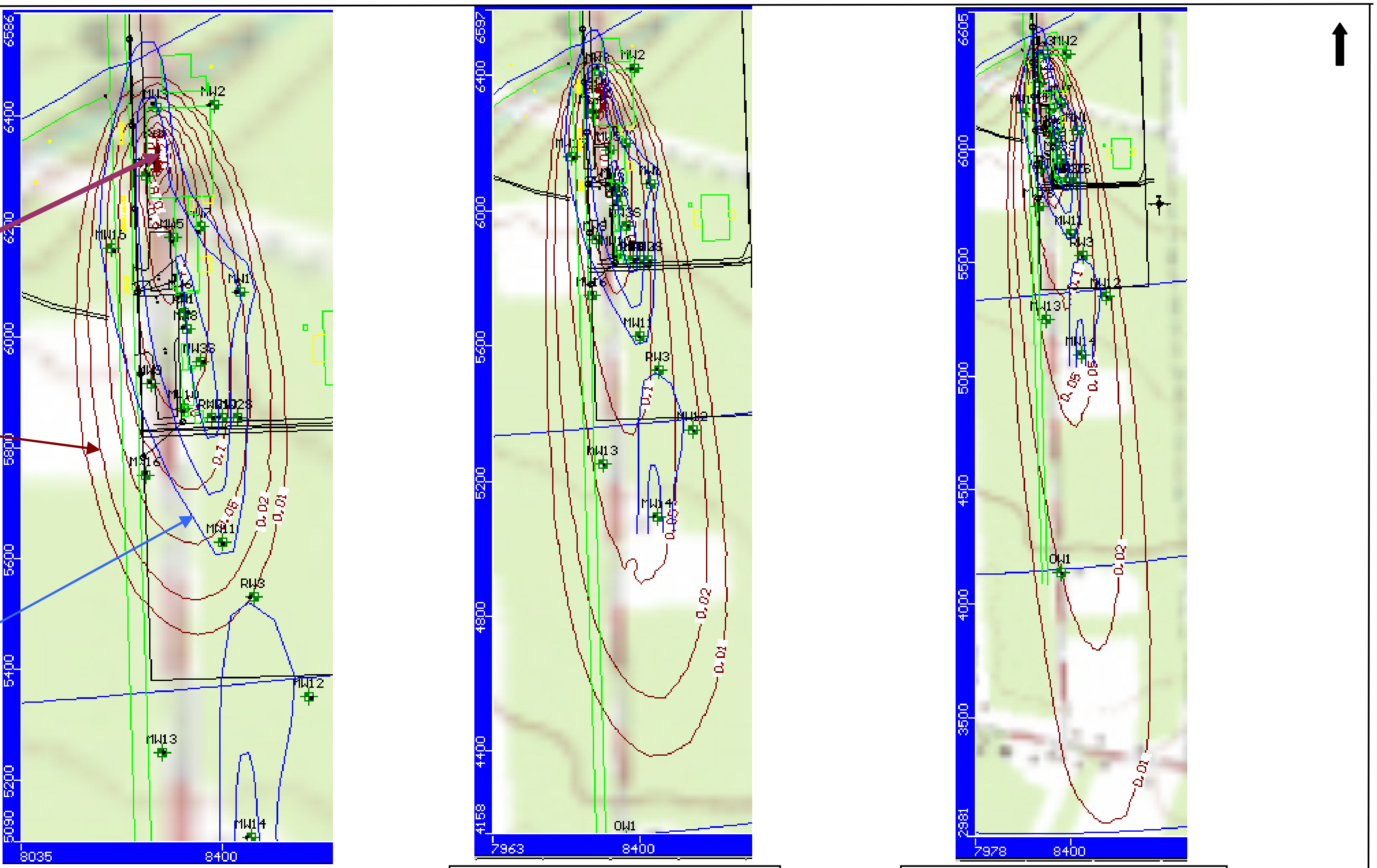
FIGURE 11B

IEG

SOURCE

MODFLOW PREDICTED CONTOUR FOR HEXAVALENT CHROMIUM

ACTUAL 1997 CONTOUR FOR HEXAVALENT CHROMIUM



AT 365 DAYS

AT 1000 DAYS

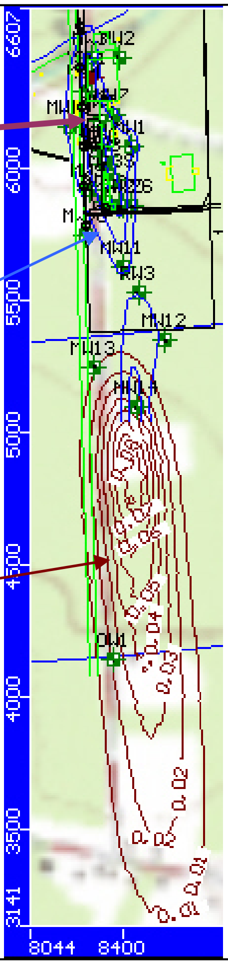
AT 2000 DAYS

EFFECTIVE POROSITY = 0.15; LONGITUDINAL DISPERSIVITY = 10 FT; SCWA WELL FIELD AT 500 GPM
SOURCE: 0.1 LB/DAY FOR FIRST 2000 DAYS; TOTAL SIMULATION = 4000 DAYS

BB&S - MODFLOW SCREENS
MODEL PREDICTED CONTAMINANT PROFILE
(SIMULATION RUN 31)

FIGURE 11C

IEG

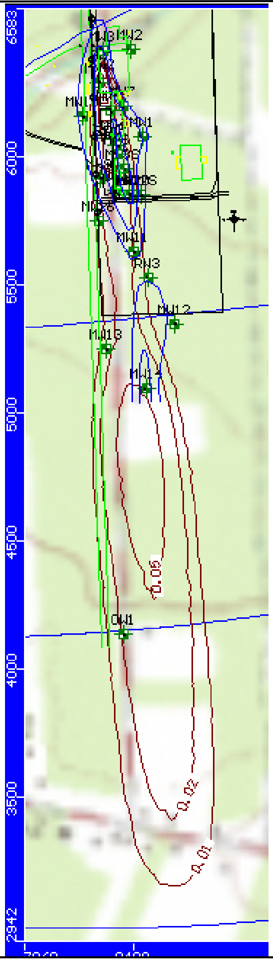


SOURCE

ACTUAL 1996
CONTOUR FOR
HEXAVALENT
CHROMIUM

MODFLOW
PREDICTED
CONTOUR
FOR
HEXAVALENT
CHROMIUM

AT 3500 DAYS;
0.1 LB/DAY FOR FIRST 2000 DAYS
NO LOADING FOR SECOND 2000 DAYS



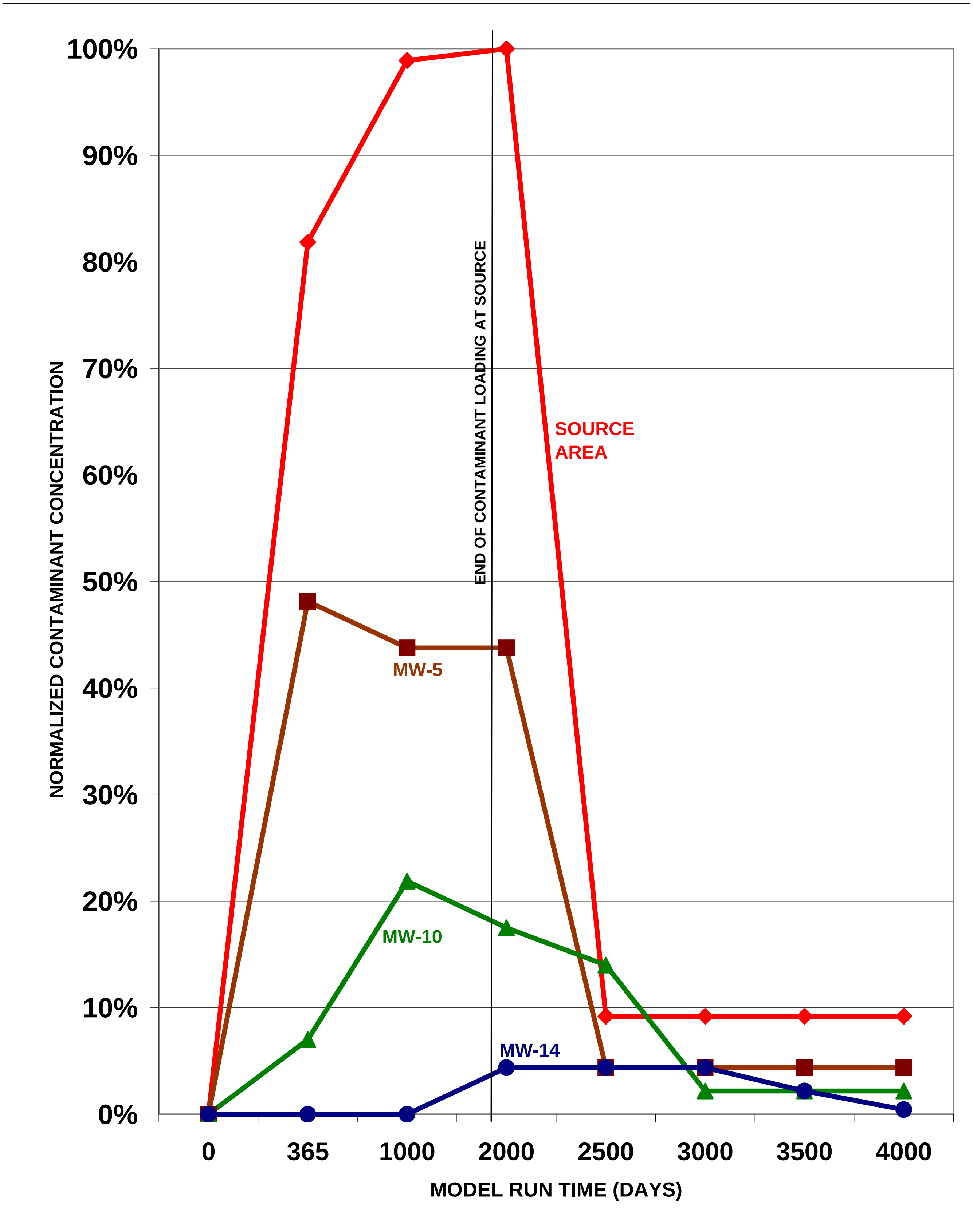
AT 3500 DAYS;
0.1 LB/DAY FOR FIRST 2000 DAYS
0.01 LB/DAY FOR SECOND 2000 DAYS

EFFECTIVE POROSITY = 0.30; LONGITUDINAL DISPERSIVITY = 15; SCWA WELL FIELD AT 500 GPM
SOURCE LOADING VARIES; TOTAL SIMULATION = 4000 DAYS

BB&S - MODFLOW SCREENS
MODEL PREDICTED CONTAMINANT PROFILE
(SIMULATION RUNS 29A&B)

FIGURE 11D

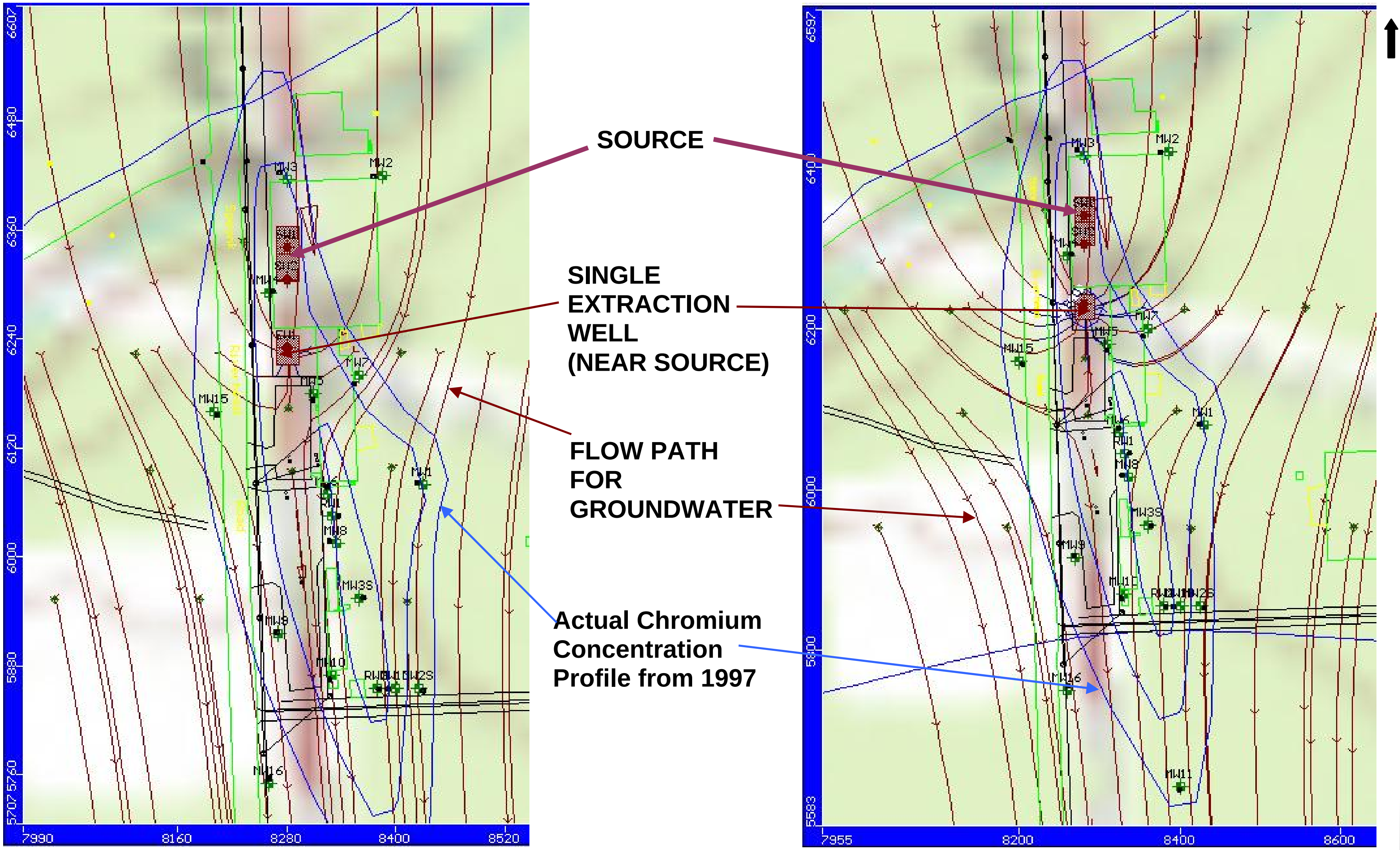
IEG



MODEL PREDICTED CONTAMINANT PROFILE
NORMALIZED CONCENTRATION AT SELECTED LOCATIONS
(Expressed as Percent of Maximum Predicted Concentration at Source)

FIGURE 11E

IEG



SOURCE

SINGLE EXTRACTION WELL (NEAR SOURCE)

FLOW PATH FOR GROUNDWATER

Actual Chromium Concentration Profile from 1997

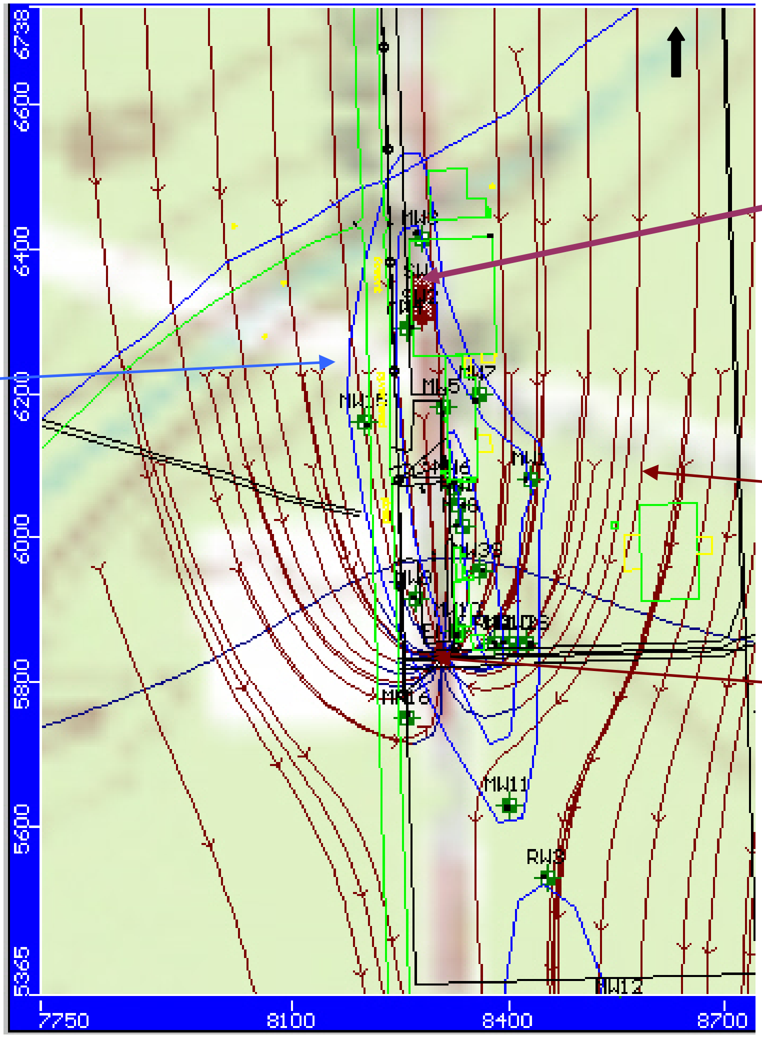
EXTRACTION RATE: 12,000 FT^3/DAY (or 60 GPM)

EXTRACTION RATE: 25,000 FT^3/DAY (or 120 GPM)

GROUNDWATER FLOW PATHS WITH EXTRACTION EXTRACTION WELL NEAR SOURCE

FIGURE 12A

IEG



Actual Chromium Concentration Profile from 1996

SOURCE

FLOW PATH FOR GROUNDWATER

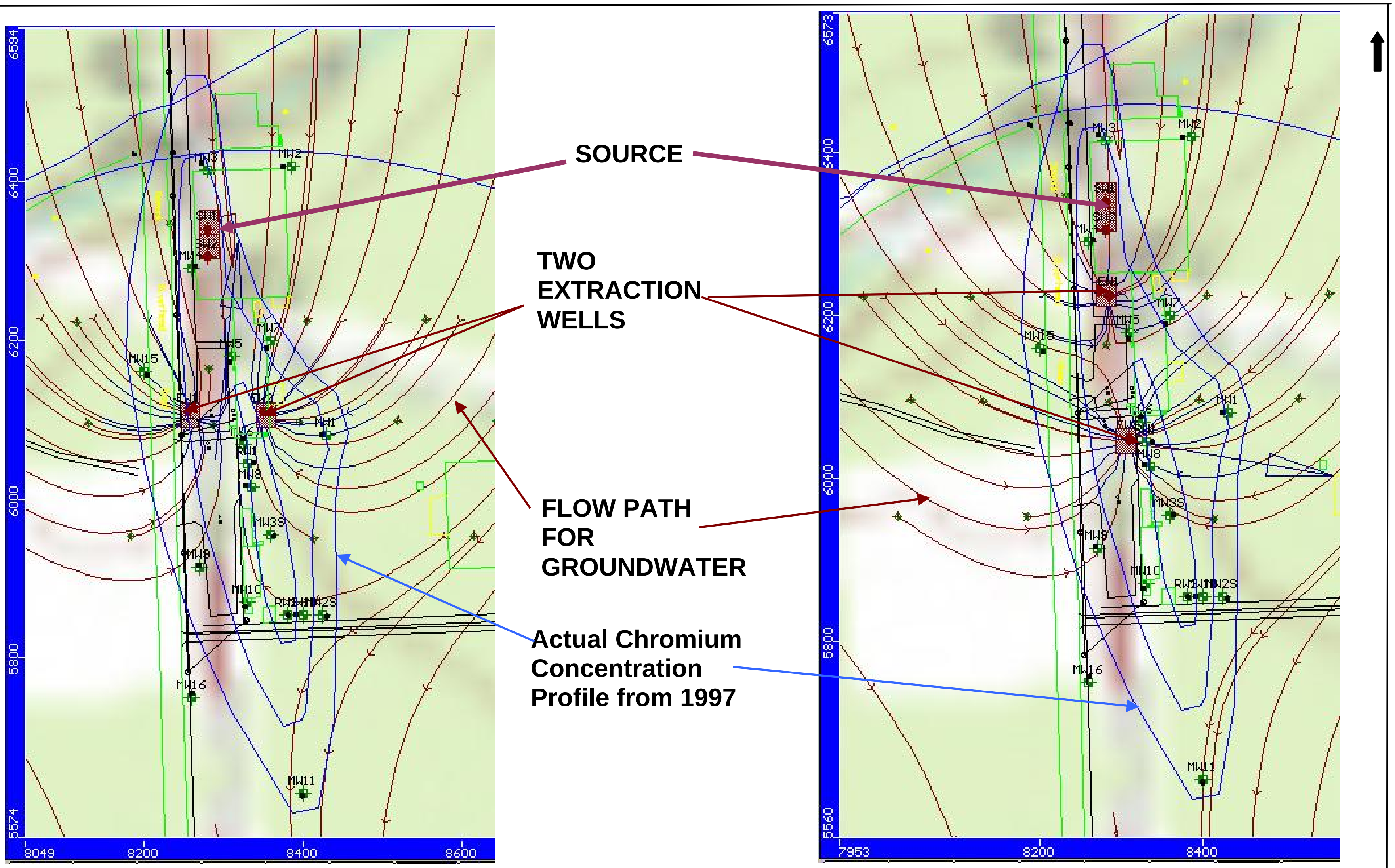
SINGLE EXTRACTION WELL (SOUTH OF SOURCE)

EXTRACTION RATE
25,000 FT^3/DAY (or 120 GPM)

GROUNDWATER FLOW PATHS WITH EXTRACTION EXTRACTION WELL AT DOWNGRADIENT BOUNDARY

FIGURE 12B

IEG



SOURCE

TWO EXTRACTION WELLS

FLOW PATH FOR GROUNDWATER

Actual Chromium Concentration Profile from 1997

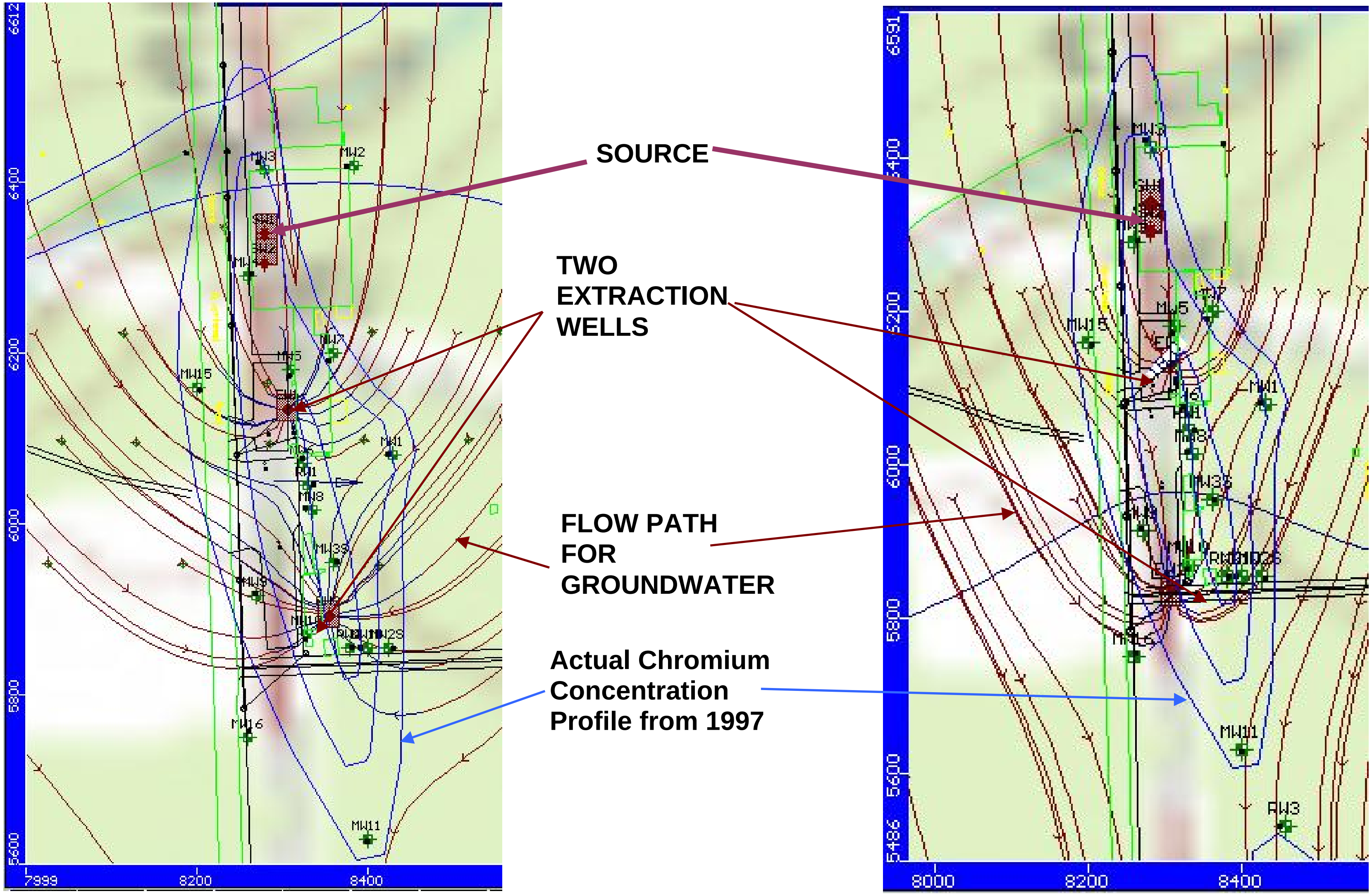
TOTAL EXTRACTION RATE: 50,000 FT^3/DAY (or 260 GPM)

TOTAL EXTRACTION RATE: 50,000 FT^3/DAY (or 260 GPM)

GROUNDWATER FLOW PATHS WITH EXTRACTION
TWO EXTRACTION WELLS NEAR SOURCE

FIGURE 12C

IEG



SOURCE

TWO
EXTRACTION
WELLS

FLOW PATH
FOR
GROUNDWATER

Actual Chromium
Concentration
Profile from 1997

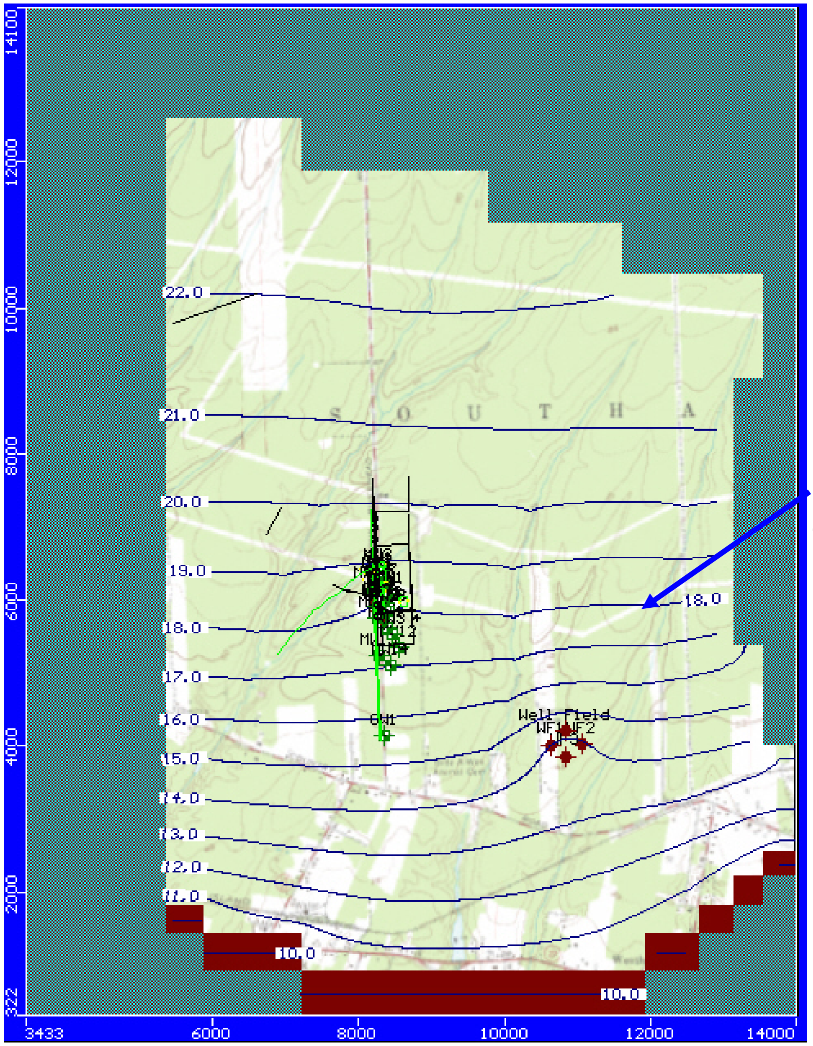
TOTAL EXTRACTION RATE: 50,000 FT^3/DAY (or 260 GPM)

TOTAL EXTRACTION RATE: 25,000 FT^3/DAY (or 120 GPM)

GROUNDWATER FLOW PATHS WITH EXTRACTION
TWO EXTRACTION WELLS NEAR SOURCE AND DOWNGRADIENT

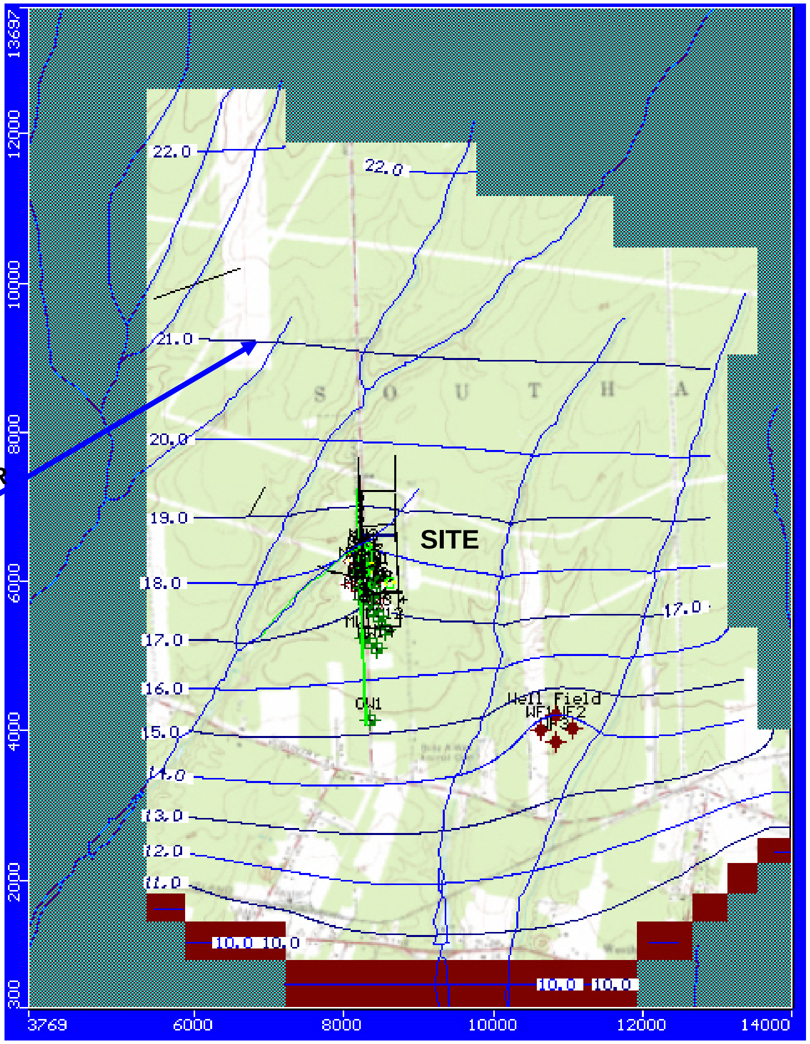
FIGURE 12D

IEG



TWO EXTRACTION WELLS ON SITE (RUN 38)
TOTAL 25,000 FT^3/DAY (120 GPM)

Model
Calculated
GROUNDWATER
CONTOURS
for Layer 1



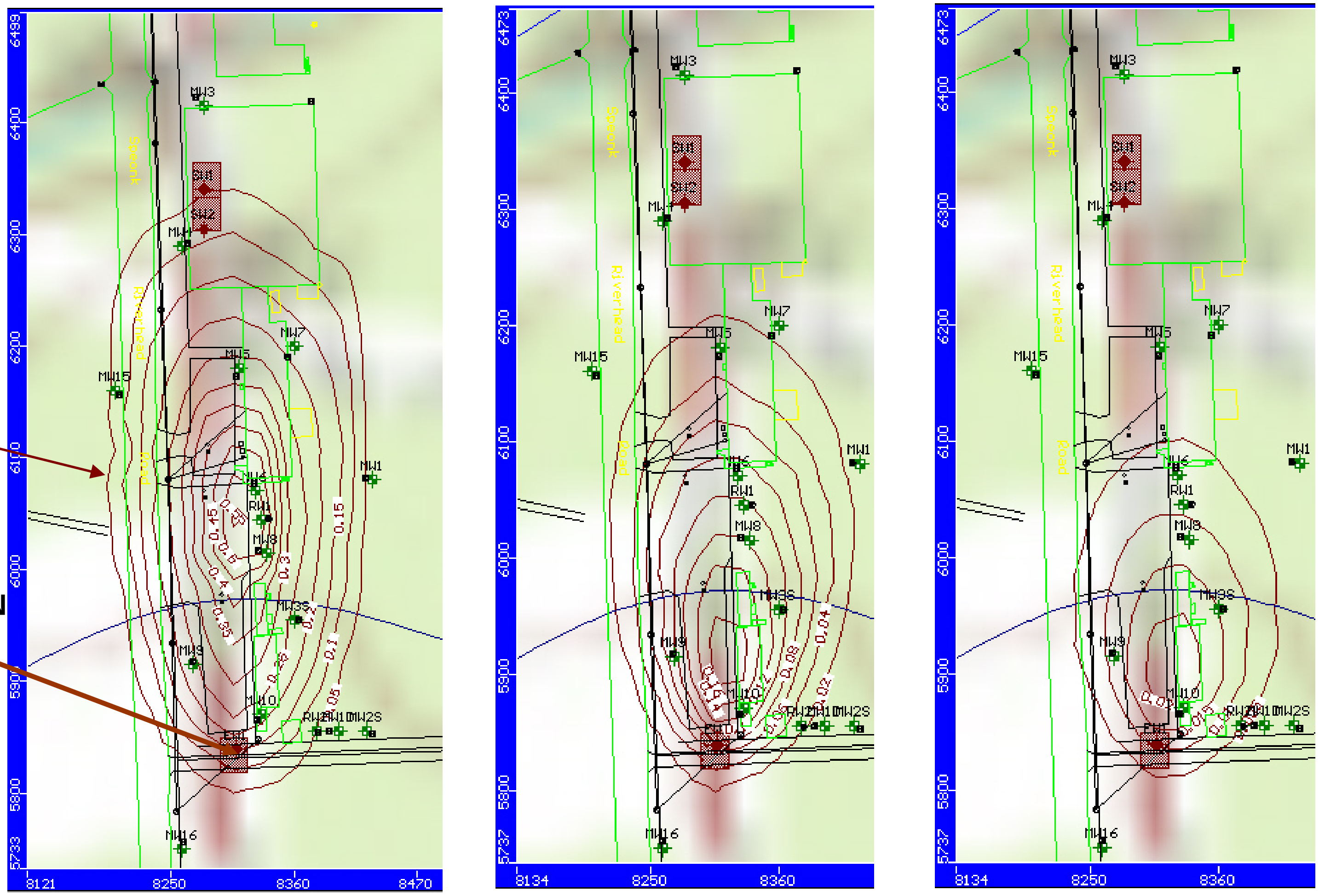
TWO EXTRACTION WELLS ON SITE (RUN 38)
TOTAL 50,000 FT^3/DAY (240 GPM)

NOTE: SEE FIGURE 10A FOR VALUES OF CONDUCTIVITIES, RECHARGE AND SCWA WELL FIELD PUMPING RATE

MODEL PREDICTIONS WITH EXTRACTION WELLS GROUNDWATER CONTOURS IN LAYER 1

FIGURE 13A

IEG



MODFLOW PREDICTED CONTOUR FOR HEXAVALENT CHROMIUM

EXTRACTION WELL

AT 100 DAYS

AT 300 DAYS

AT 500 DAYS

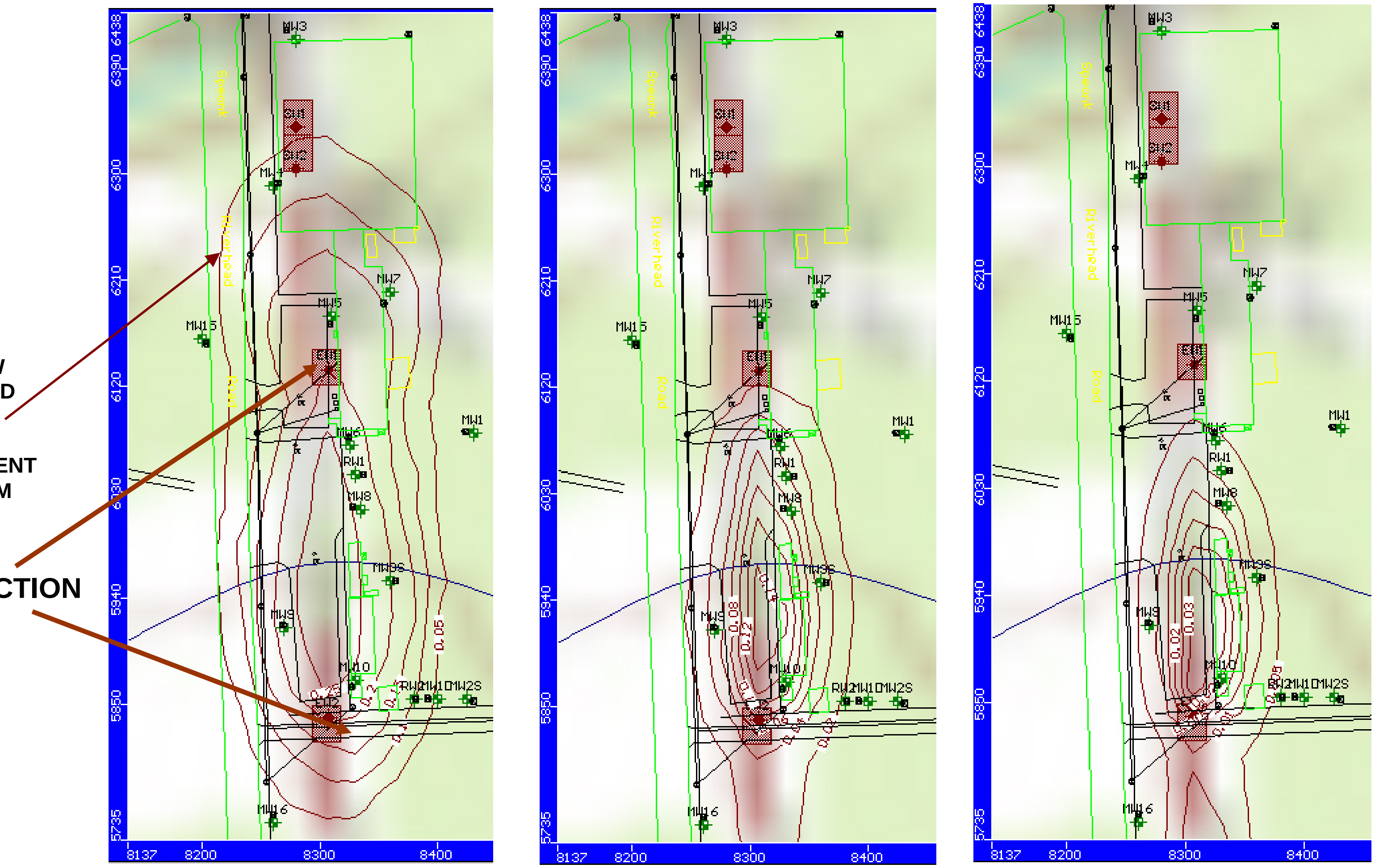
MODEL PREDICTIONS WITH EXTRACTION WELLS CONTAMINANT PROFILE WITH ONE WELL AT 120 GPM

FIGURE 13B

IEG

MODFLOW PREDICTED CONTOUR FOR HEXAVALENT CHROMIUM

EXTRACTION WELLS



AT 100 DAYS

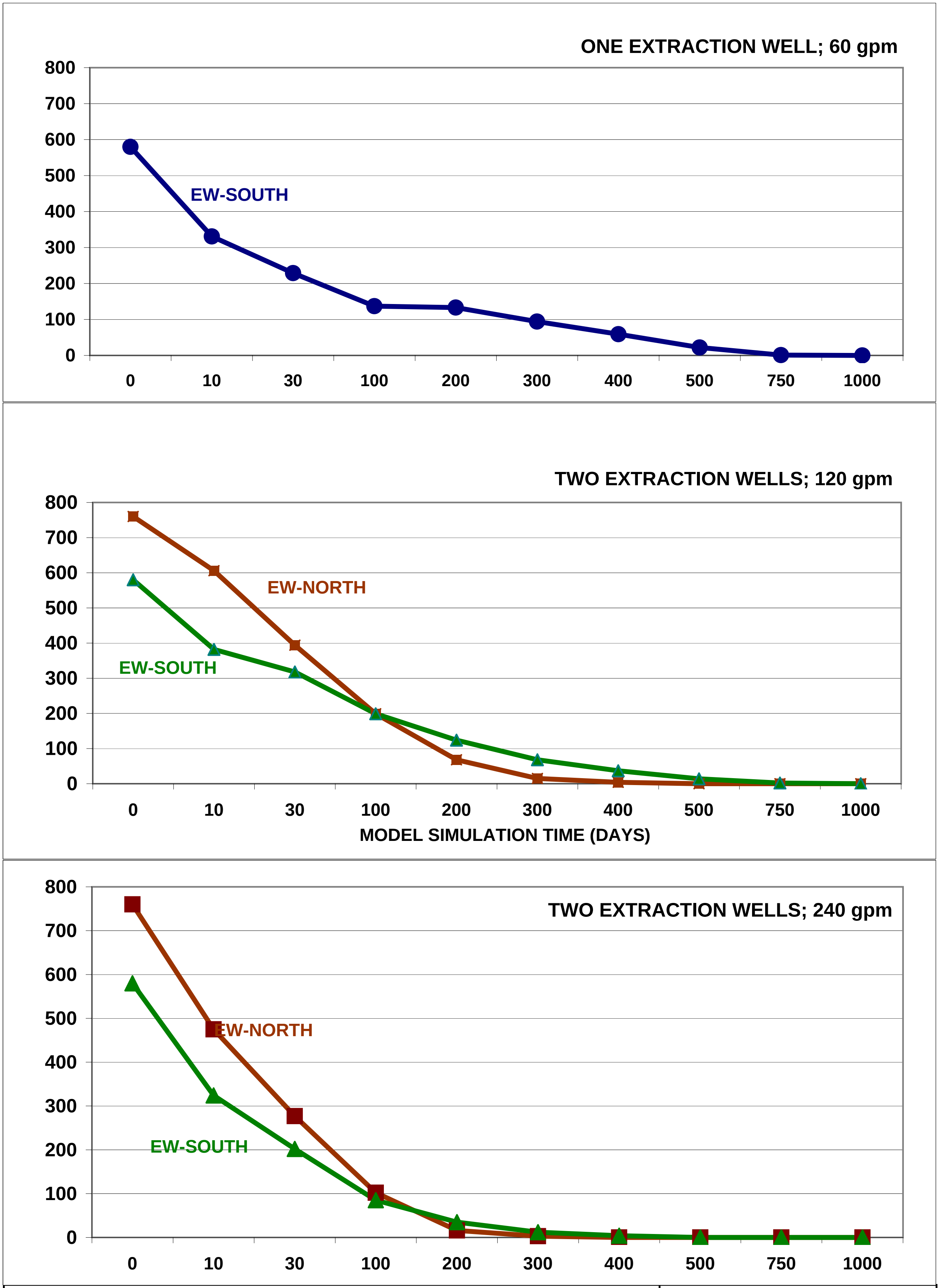
AT 300 DAYS

AT 500 DAYS

MODEL PREDICTIONS WITH EXTRACTION WELLS CONTAMINANT PROFILE WITH TWO WELLS AT 120 GPM

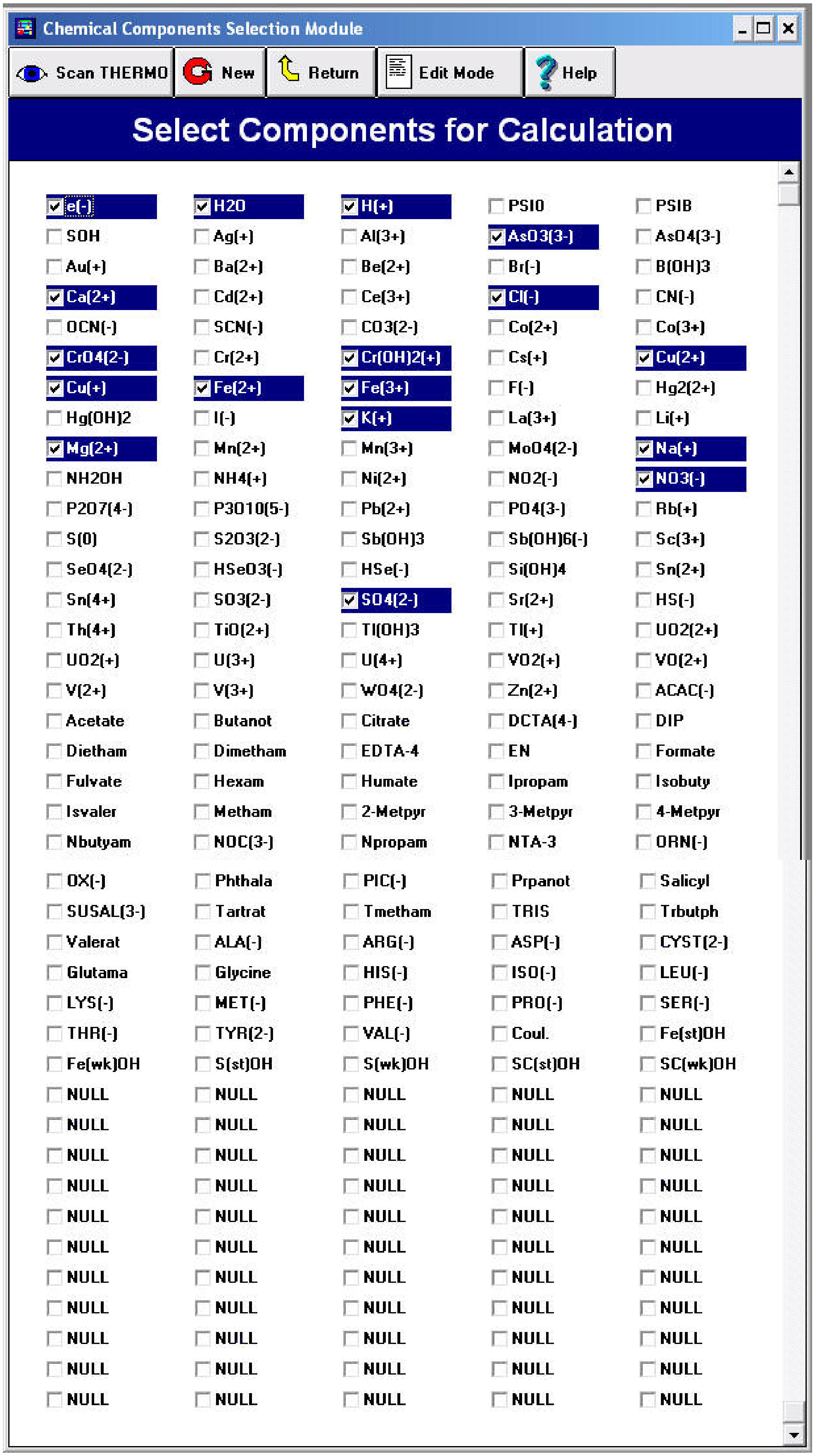
FIGURE 13C

IEG



MODEL PREDICTIONS WITH EXTRACTION WELLS CHROMIUM CONCENTRATION IN EXTRACTION WELLS	**FIGURE 13D** IEG

FIGURE 14
BB&S LUMBER SITE
MINEQL CHEMICAL SPECIATION MODEL
INPUT SCREEN FOR COMPONENTS



☑ e(-)	☑ H2O	☑ H(+)	☐ PSIO	☐ PSIB
☐ SOH	☐ Ag(+)	☐ Al(3+)	☑ AsO3(3-)	☐ AsO4(3-)
☐ Au(+)	☐ Ba(2+)	☐ Be(2+)	☐ Br(-)	☐ B(OH)3
☑ Ca(2+)	☐ Cd(2+)	☐ Ce(3+)	☑ Cl(-)	☐ CN(-)
☐ OCN(-)	☐ SCN(-)	☐ CO3(2-)	☐ Co(2+)	☐ Co(3+)
☑ CrO4(2-)	☐ Cr(2+)	☑ Cr(OH)2(+)	☐ Cs(+)	☑ Cu(2+)
☑ Cu(+)	☑ Fe(2+)	☑ Fe(3+)	☐ F(-)	☐ Hg2(2+)
☐ Hg(OH)2	☐ I(-)	☑ K(+)	☐ La(3+)	☐ Li(+)
☑ Mg(2+)	☐ Mn(2+)	☐ Mn(3+)	☐ MoO4(2-)	☑ Na(+)
☐ NH2OH	☐ NH4(+)	☐ Ni(2+)	☐ NO2(-)	☑ NO3(-)
☐ P2O7(4-)	☐ P3O10(5-)	☐ Pb(2+)	☐ PO4(3-)	☐ Rb(+)
☐ S(0)	☐ S2O3(2-)	☐ Sb(OH)3	☐ Sb(OH)6(-)	☐ Sc(3+)
☐ SeO4(2-)	☐ HSeO3(-)	☐ HSe(-)	☐ Si(OH)4	☐ Sn(2+)
☐ Sn(4+)	☐ SO3(2-)	☑ SO4(2-)	☐ Sr(2+)	☐ HS(-)
☐ Th(4+)	☐ TiO(2+)	☐ Tl(OH)3	☐ Tl(+)	☐ UO2(2+)
☐ UO2(+)	☐ U(3+)	☐ U(4+)	☐ VO2(+)	☐ VO(2+)
☐ V(2+)	☐ V(3+)	☐ WO4(2-)	☐ Zn(2+)	☐ ACAC(-)
☐ Acetate	☐ Butanot	☐ Citrate	☐ DCTA(4-)	☐ DIP
☐ Dietham	☐ Dimetham	☐ EDTA-4	☐ EN	☐ Formate
☐ Fulvate	☐ Hexam	☐ Humate	☐ Ipropam	☐ Isobuty
☐ Isvaler	☐ Metham	☐ 2-Metpyr	☐ 3-Metpyr	☐ 4-Metpyr
☐ Nbutyam	☐ NOC(3-)	☐ Npropam	☐ NTA-3	☐ ORN(-)
☐ OX(-)	☐ Phthala	☐ PIC(-)	☐ Prpanot	☐ Salicyl
☐ SUSAL(3-)	☐ Tartrat	☐ Tmetham	☐ TRIS	☐ Trbutph
☐ Valerat	☐ ALA(-)	☐ ARG(-)	☐ ASP(-)	☐ CYST(2-)
☐ Glutama	☐ Glycine	☐ HIS(-)	☐ ISO(-)	☐ LEU(-)
☐ LYS(-)	☐ MET(-)	☐ PHE(-)	☐ PRO(-)	☐ SER(-)
☐ THR(-)	☐ TYR(2-)	☐ VAL(-)	☐ Coul.	☐ Fe(st)OH
☐ Fe(wk)OH	☐ S(st)OH	☐ S(wk)OH	☐ SC(st)OH	☐ SC(wk)OH
☐ NULL	☐ NULL	☐ NULL	☐ NULL	☐ NULL
☐ NULL	☐ NULL	☐ NULL	☐ NULL	☐ NULL
☐ NULL	☐ NULL	☐ NULL	☐ NULL	☐ NULL
☐ NULL	☐ NULL	☐ NULL	☐ NULL	☐ NULL
☐ NULL	☐ NULL	☐ NULL	☐ NULL	☐ NULL
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☐ NULL	☐ NULL	☐ NULL	☐ NULL	☐ NULL
☐ NULL	☐ NULL	☐ NULL	☐ NULL	☐ NULL
☐ NULL	☐ NULL	☐ NULL	☐ NULL	☐ NULL

FIGURE 15A
BB&S LUMBER SITE - PREDESIGN INVESTIGATION
CHEMICAL SPECIES DISTRIBUTION WITHOUT REDOX
(MINEQL #RUN 05)

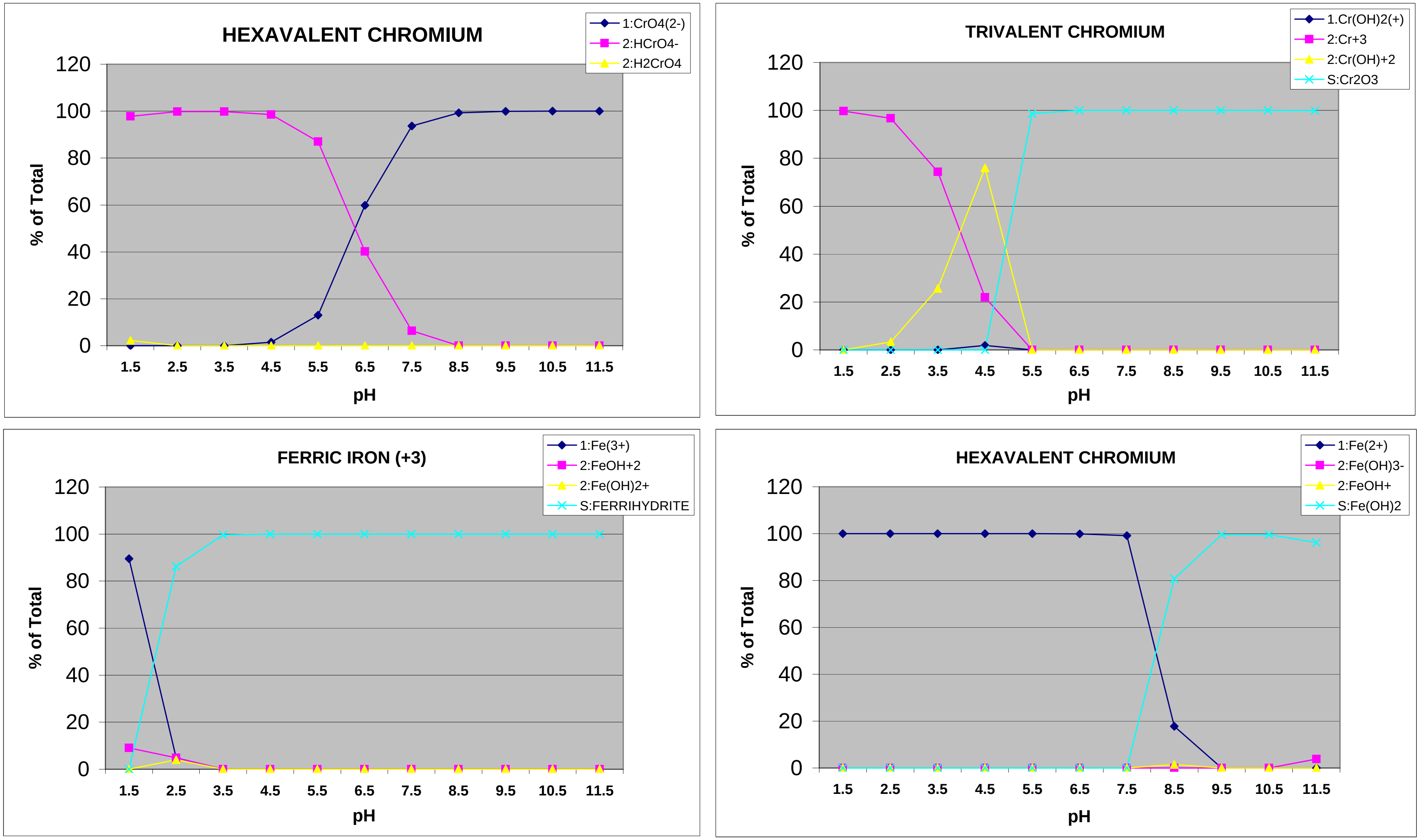


FIGURE 15B
BB&S LUMBER SITE - PREDESIGN INVESTIGATION
CHEMICAL SPECIES DISTRIBUTION WITHOUT REDOX

(MINEQL RUN #05)

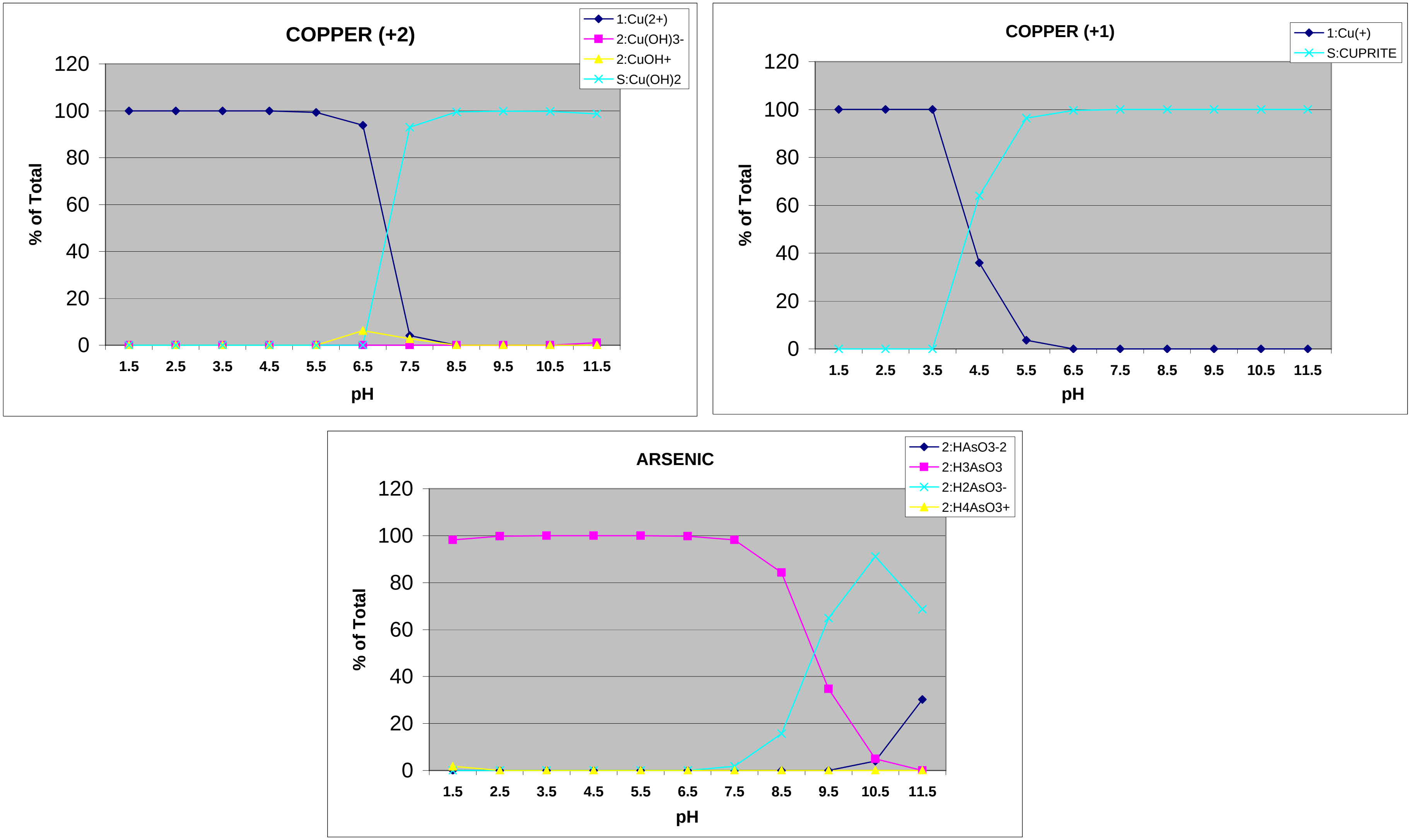


FIGURE 16A
BB&S LUMBER SITE - PREDESIGN INVESTIGATION
CHEMICAL SPECIES DISTRIBUTION WITH REDOX
(MINEQL RUN #06)

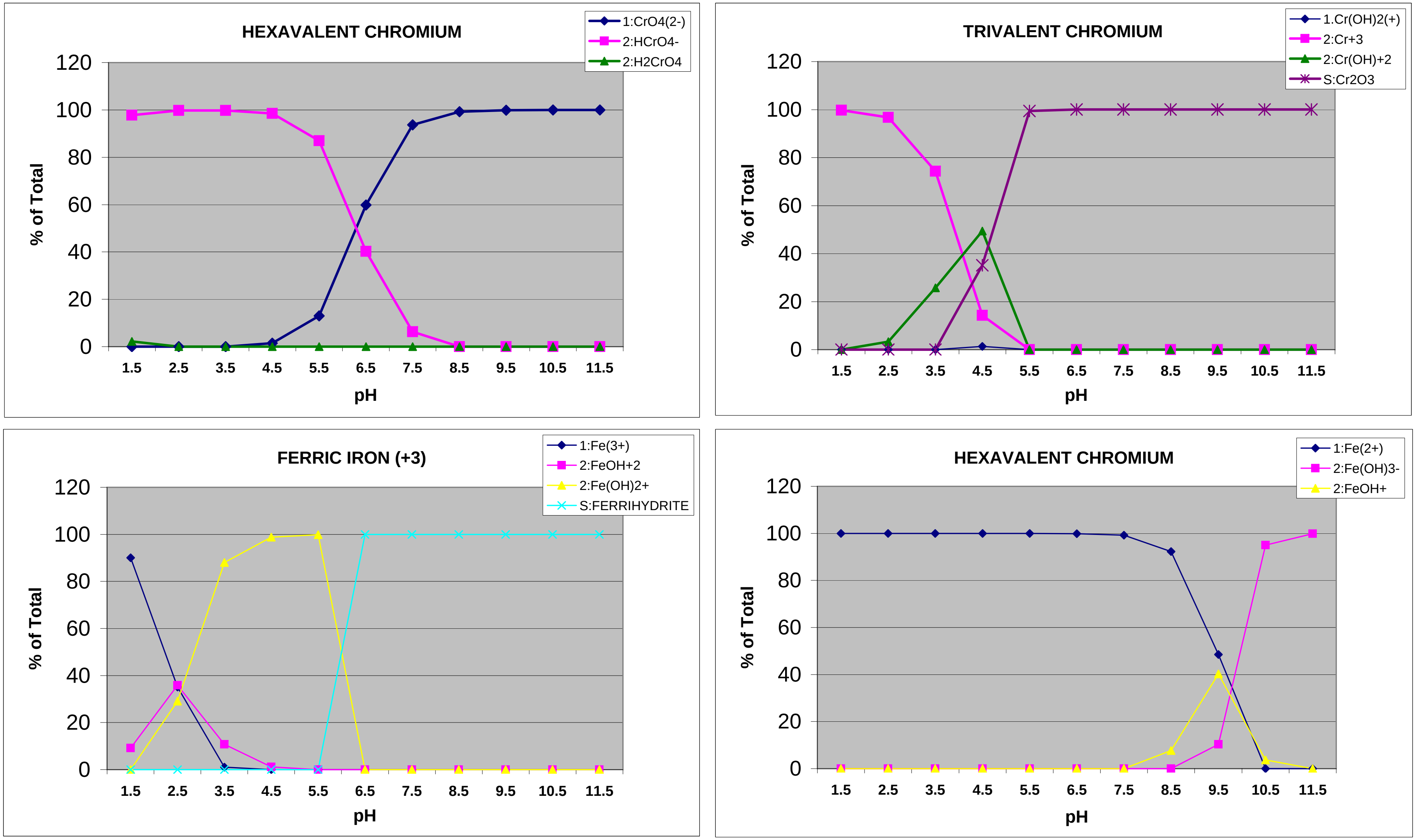
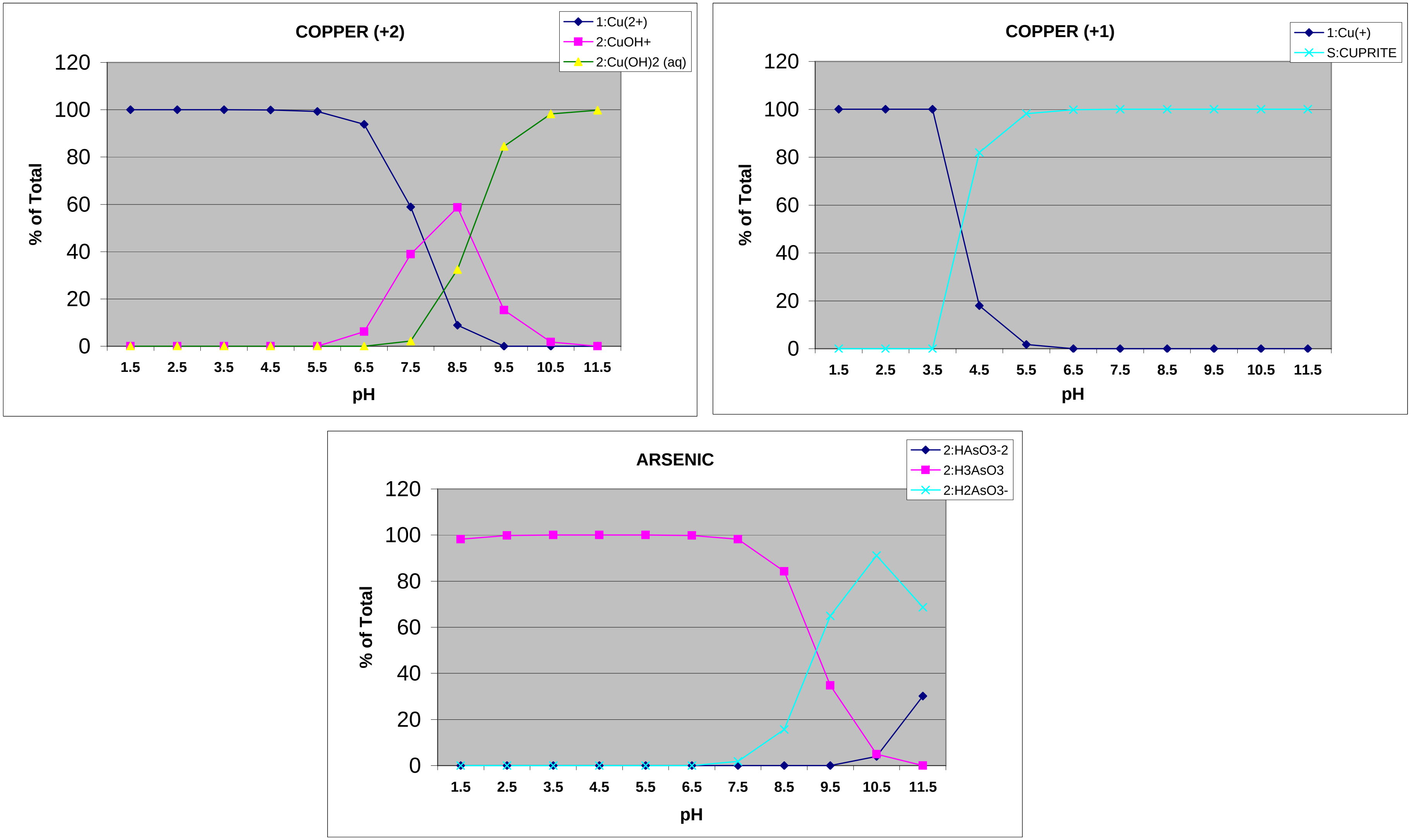


FIGURE 16B
BB&S LUMBER SITE - PREDESIGN INVESTIGATION
CHEMICAL SPECIES DISTRIBUTION WITH REDOX
(MINEQL RUN #06)



Goundwater Samples

Samples in Jars for Testing

Mixed with Reagents for Redox

Precipitation/Flocculation Step

Settling Step

After Settling

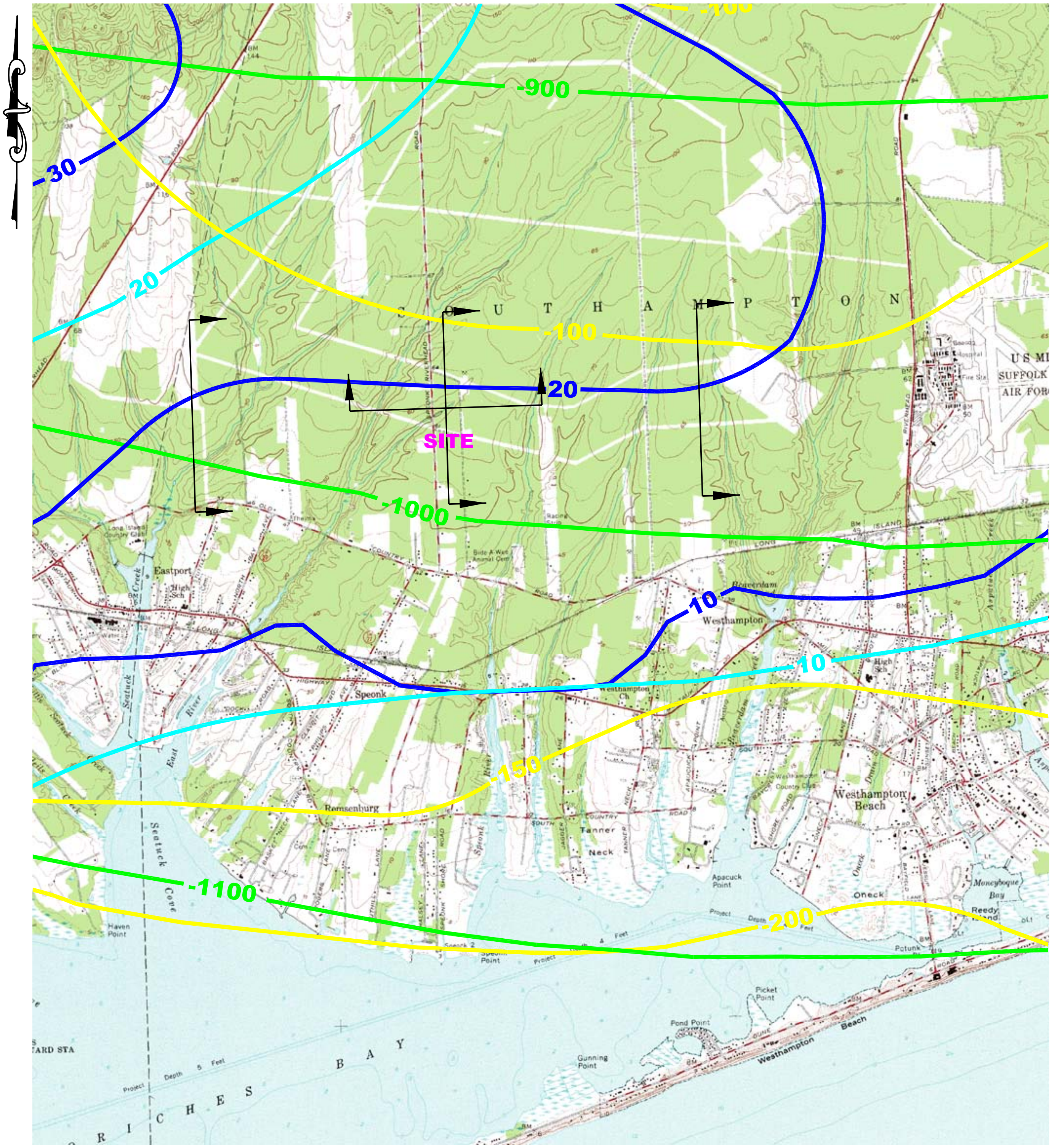
BB&S LUMBER SITE PRE-DESIGN STUDY
GROUNDWATER TREATABILITY TEST PHOTOS

FIGURE 17

IEG

FIGURES

IEG\LONG ISLAND\LONG ISLAND.dwg



LEGEND

SOURCE: MAP AND CONTOURS FROM USGS

🟨	GEOLOGIC UNIT – MAGOTHY
🟩	GEOLOGIC UNIT – RARITAN
🟦	WATER TABLE – MAGOTHY
🟦	WATER TABLE – UPPER GLACIAL

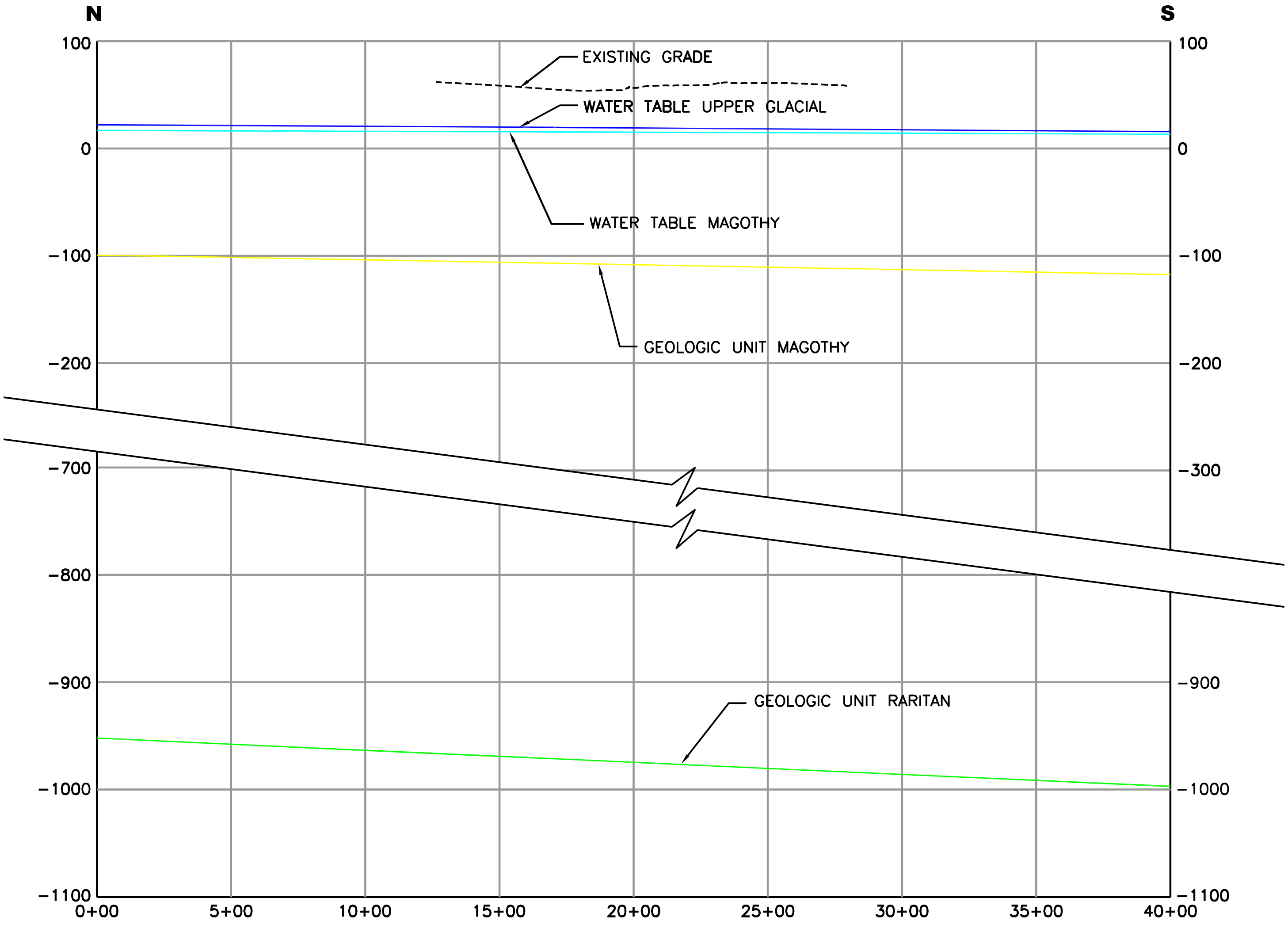
4000' 0 4000'

SCALE: 1"= 4000'

IYER ENVIRONMENTAL GROUP

GEOLOGIC UNITS, WATER TABLES AND CROSS-SECTION LOCATIONS

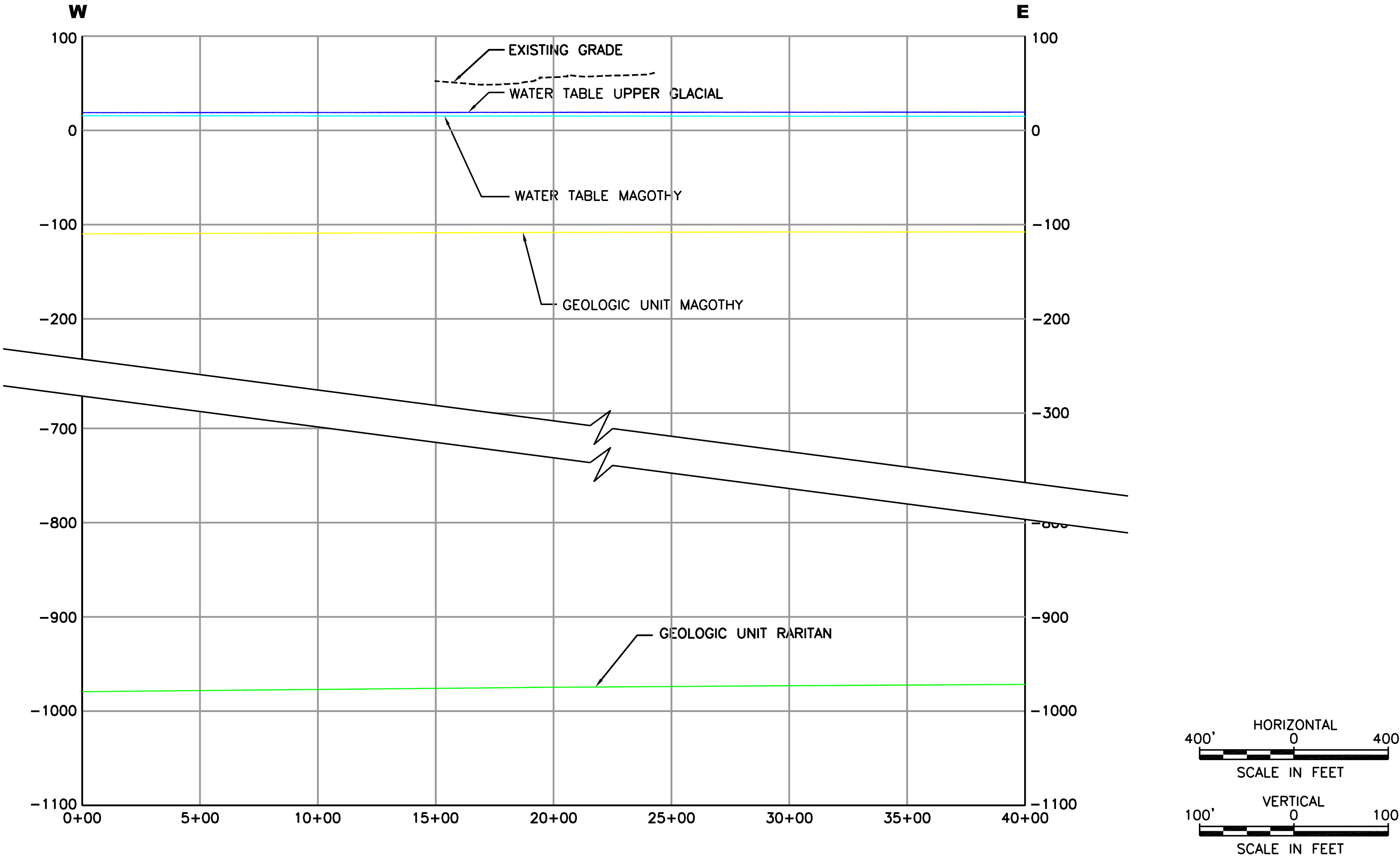
FIGURE 1A



IYER ENVIRONMENTAL GROUP

LONG ISLAND - GEOLOGICAL CROSS SECTION (THROUGH THE SITE)

FIGURE 1B

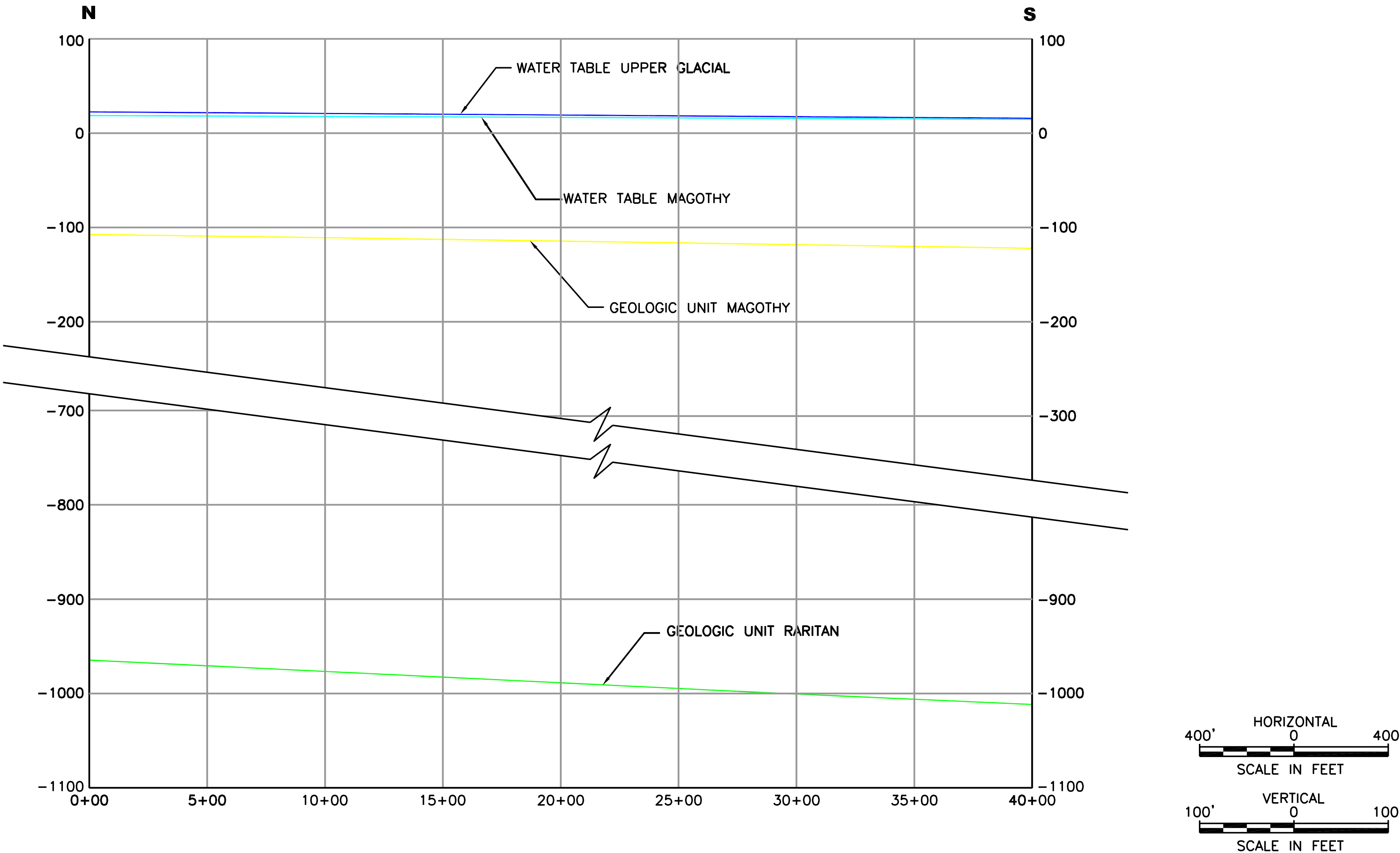


IEG IYER ENVIRONMENTAL GROUP

LONG ISLAND - GEOLOGICAL CROSS SECTION
(THROUGH THE SITE)

FIGURE 1C

IEG\LONG ISLAND\SECTIONS.dwg 6/10/06

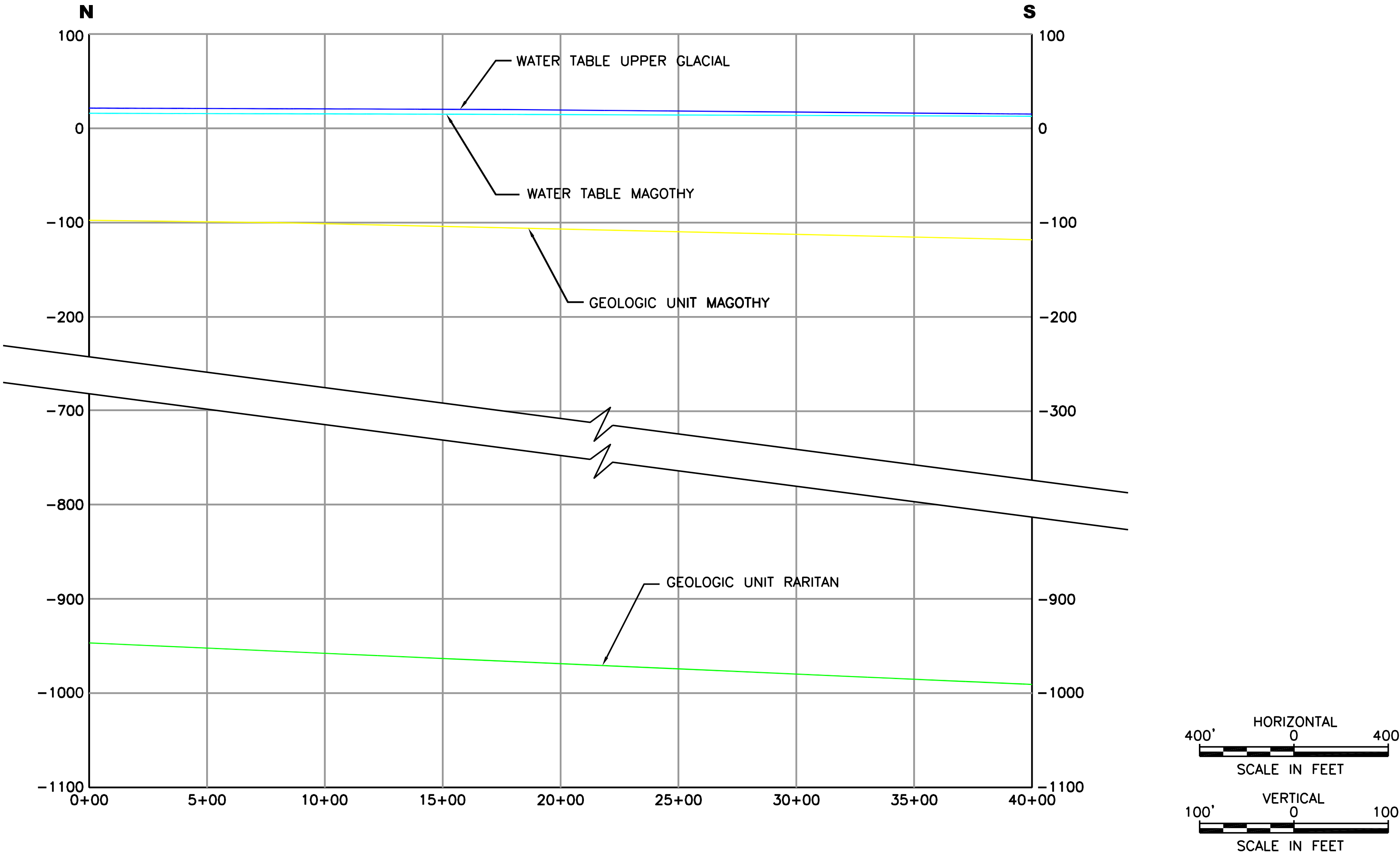


IEG IYER ENVIRONMENTAL GROUP

LONG ISLAND - GEOLOGICAL CROSS SECTION
(1-MILE EAST OF SITE)

FIGURE 1D

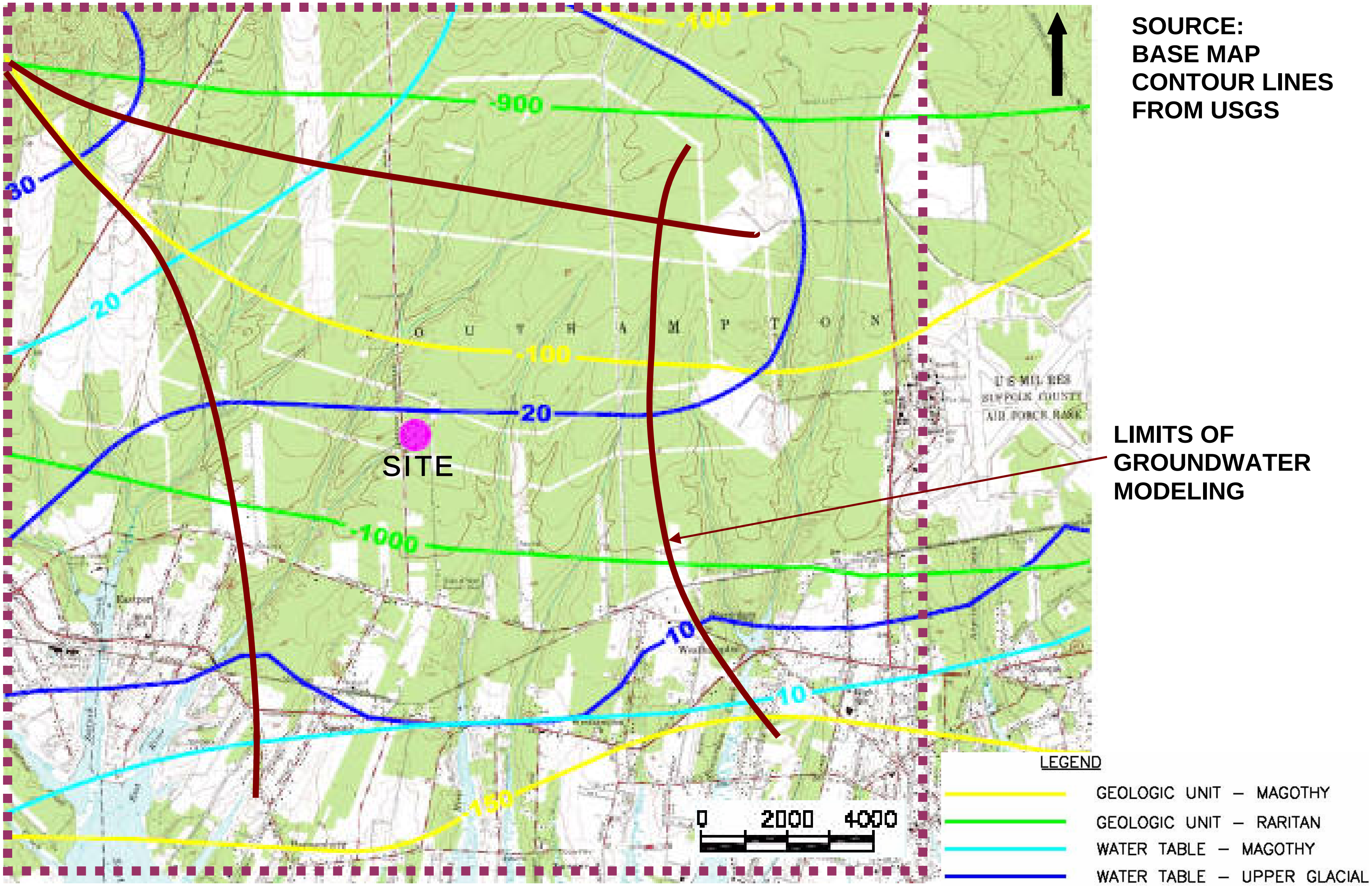
IEG\LONG ISLAND\SECTIONS.dwg 6/10/06



IYER ENVIRONMENTAL GROUP

LONG ISLAND - GEOLOGICAL CROSS SECTION (1-MILE WEST OF SITE)

FIGURE 1E



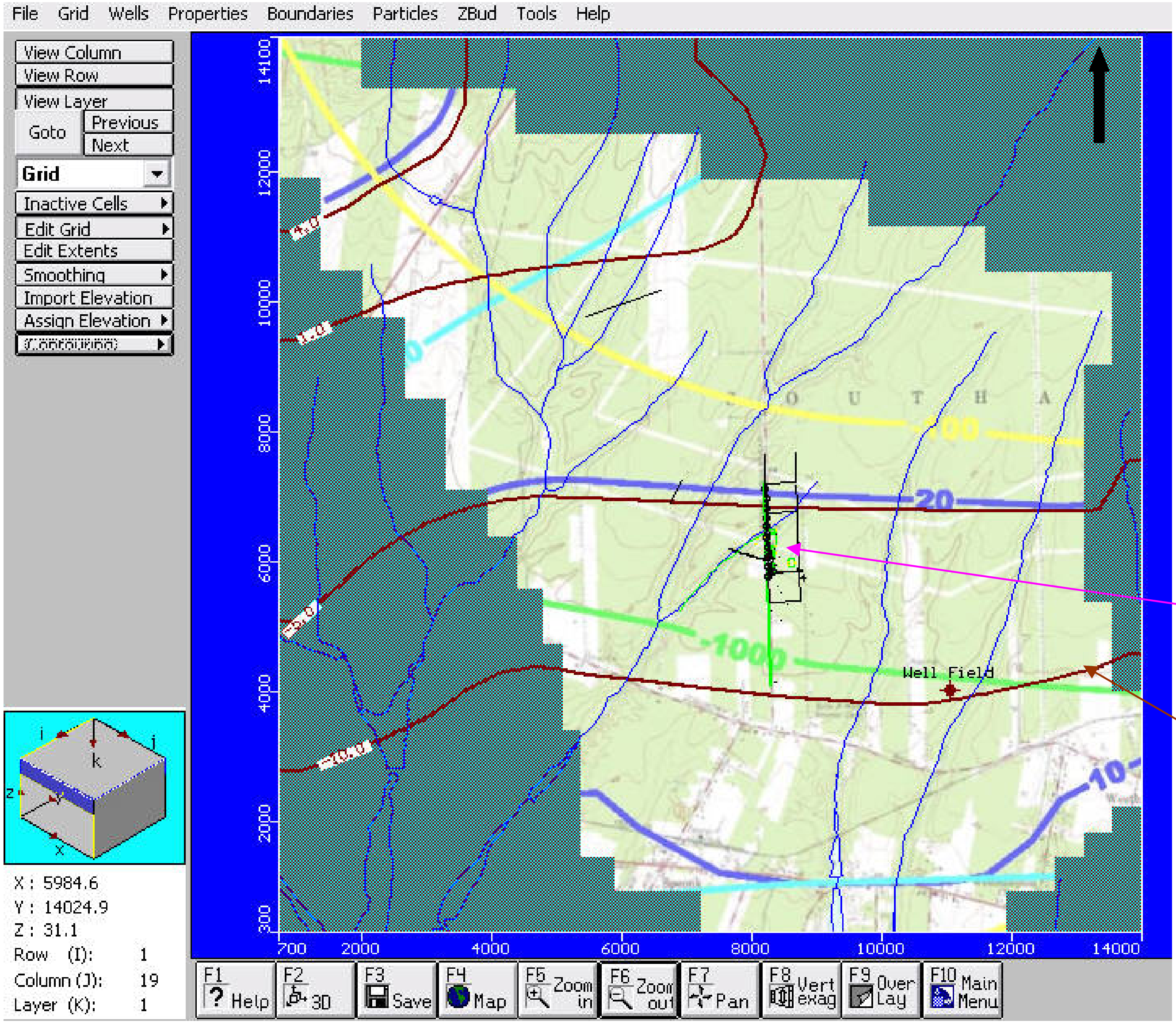
SOURCE:
BASE MAP
CONTOUR LINES
FROM USGS

LIMITS OF
GROUNDWATER
MODELING

BB&S - MODFLOW SCREENS
GROUNDWATER CONTOUR/INITIAL MODEL LIMITS

FIGURE 2

IEG



X : 5984.6

Y : 14024.9

Z : 31.1

Row (I): 1

Column (J): 19

Layer (K): 1

SITE

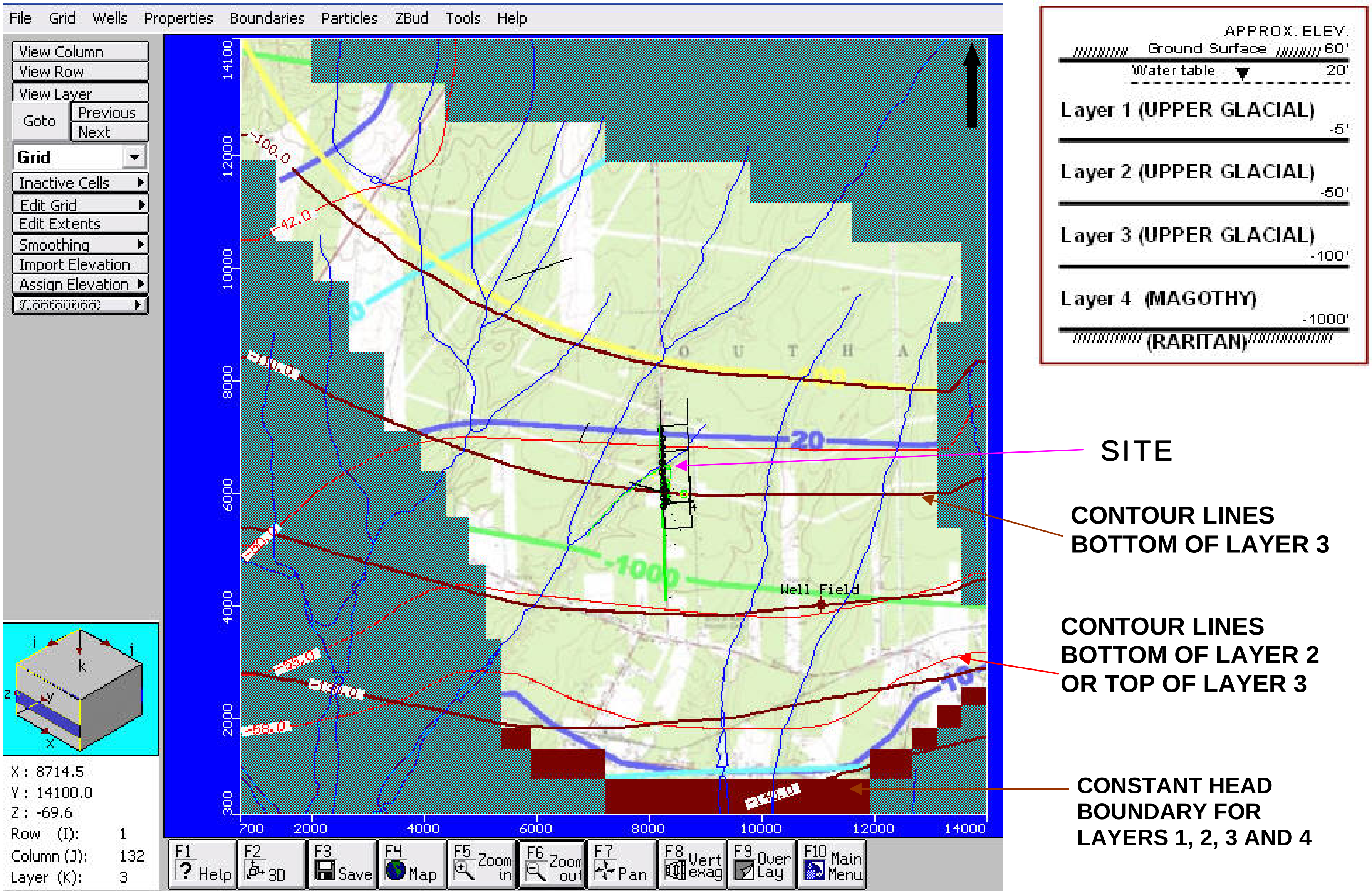
MODEL CONTOUR LINES BOTTOM OF LAYER 1

Note: See Figure 1 for details on USGS base map and contour lines for geologic units and groundwater

BB&S - MODFLOW SCREENS
INITIAL MODEL AREA SHOWING LAYER 1

FIGURE 3A

IEG



X : 8714.5
Y : 14100.0
Z : -69.6
Row (I): 1
Column (J): 132
Layer (K): 3

SITE

CONTOUR LINES
BOTTOM OF LAYER 3

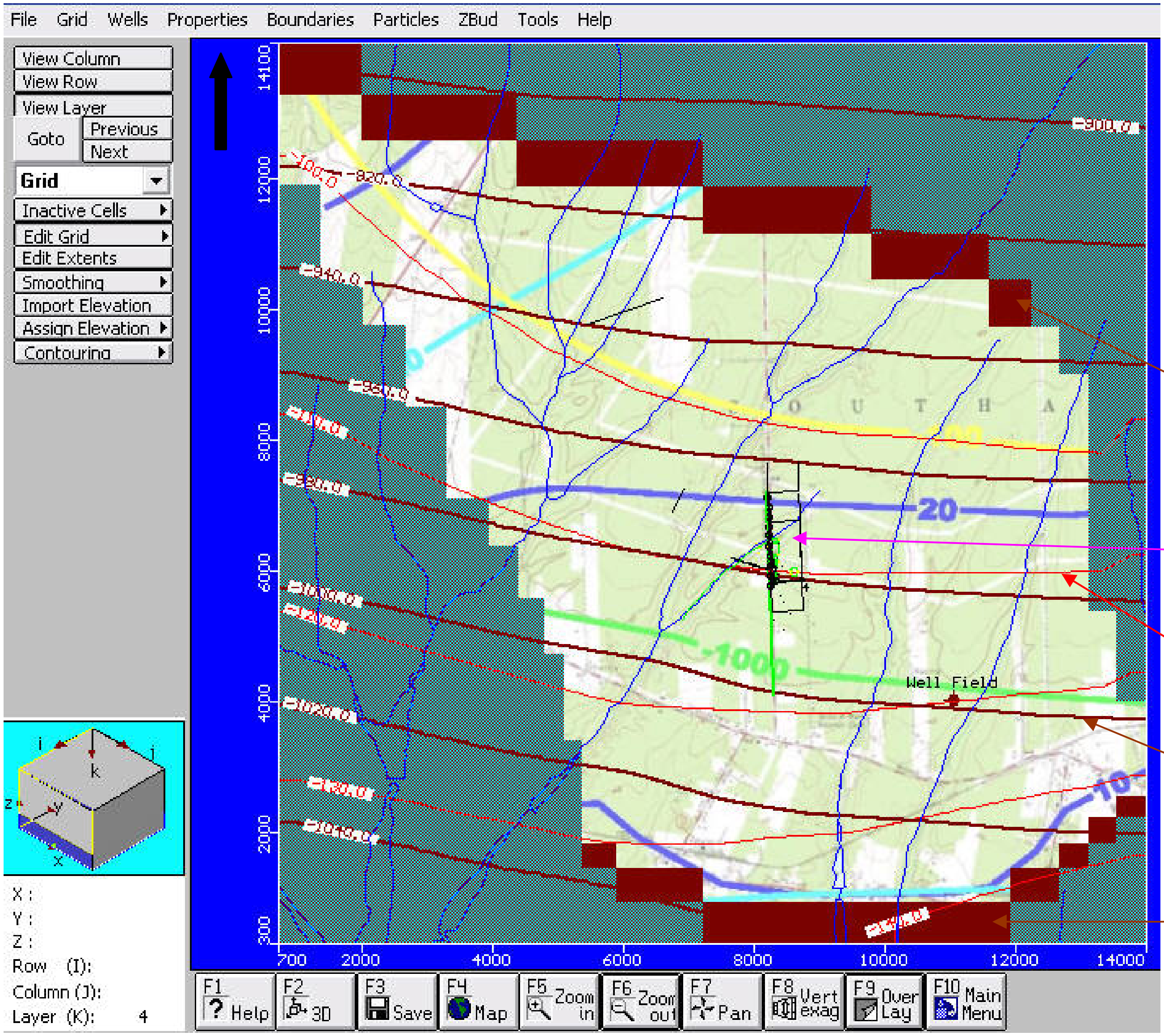
CONTOUR LINES
BOTTOM OF LAYER 2
OR TOP OF LAYER 3

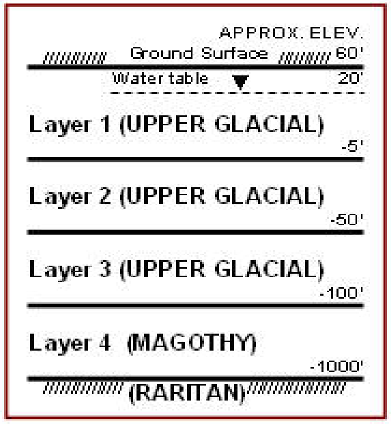
CONSTANT HEAD
BOUNDARY FOR
LAYERS 1, 2, 3 AND 4

BB&S - MODFLOW SCREENS
INITIAL MODEL AREA SHOWING LAYER 3

FIGURE 3B

IEG





CONSTANT HEAD BOUNDARY FOR LAYERS 1, 2 AND 3 (NOT FOR LAYER 4)

SITE

CONTOUR BOTTOM OF LAYER 2 OR TOP OF LAYER 3

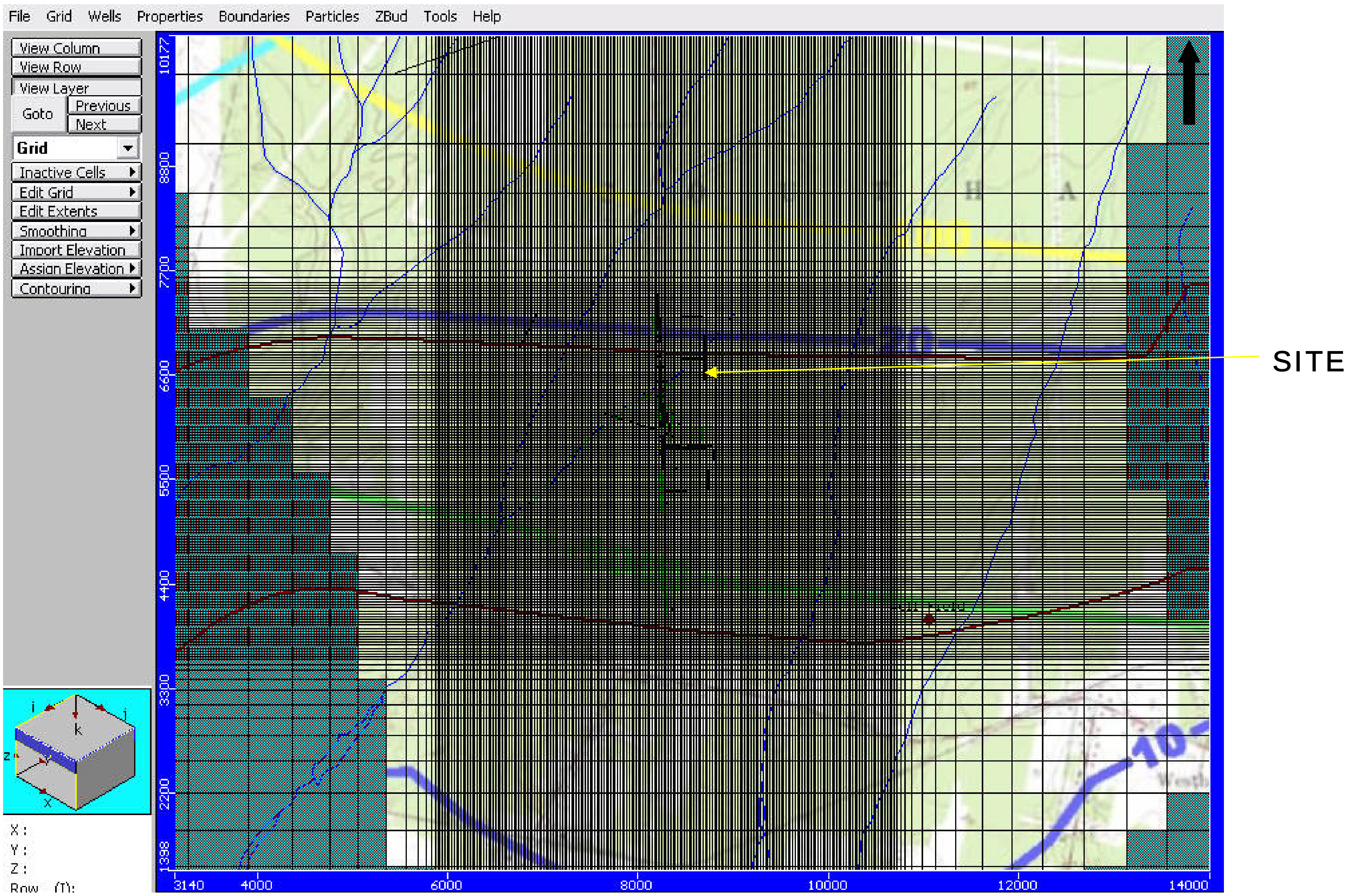
CONTOUR BOTTOM OF LAYER 4

CONSTANT HEAD BOUNDARY FOR LAYERS 1, 2, 3 AND 4

BB&S - MODFLOW SCREENS
INITIAL MODEL AREA SHOWING LAYER 4

FIGURE 3C

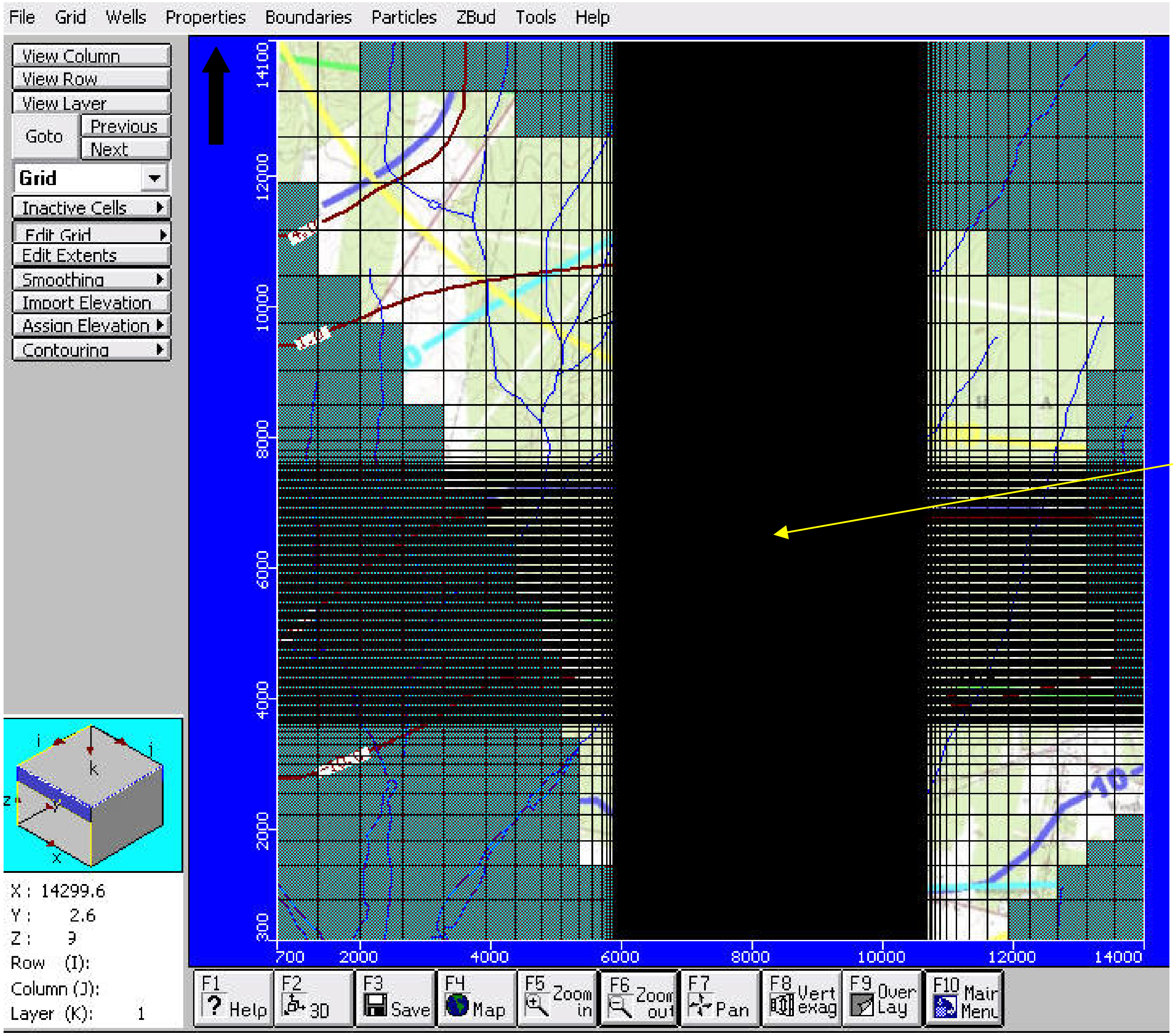
IEG



BB&S - MODFLOW SCREENS
GRID SPACING AROUND SITE

FIGURE 4A

IEG



X : 14299.6
Y : 2.6
Z : 9
Row (I):
Column (J):
Layer (K): 1

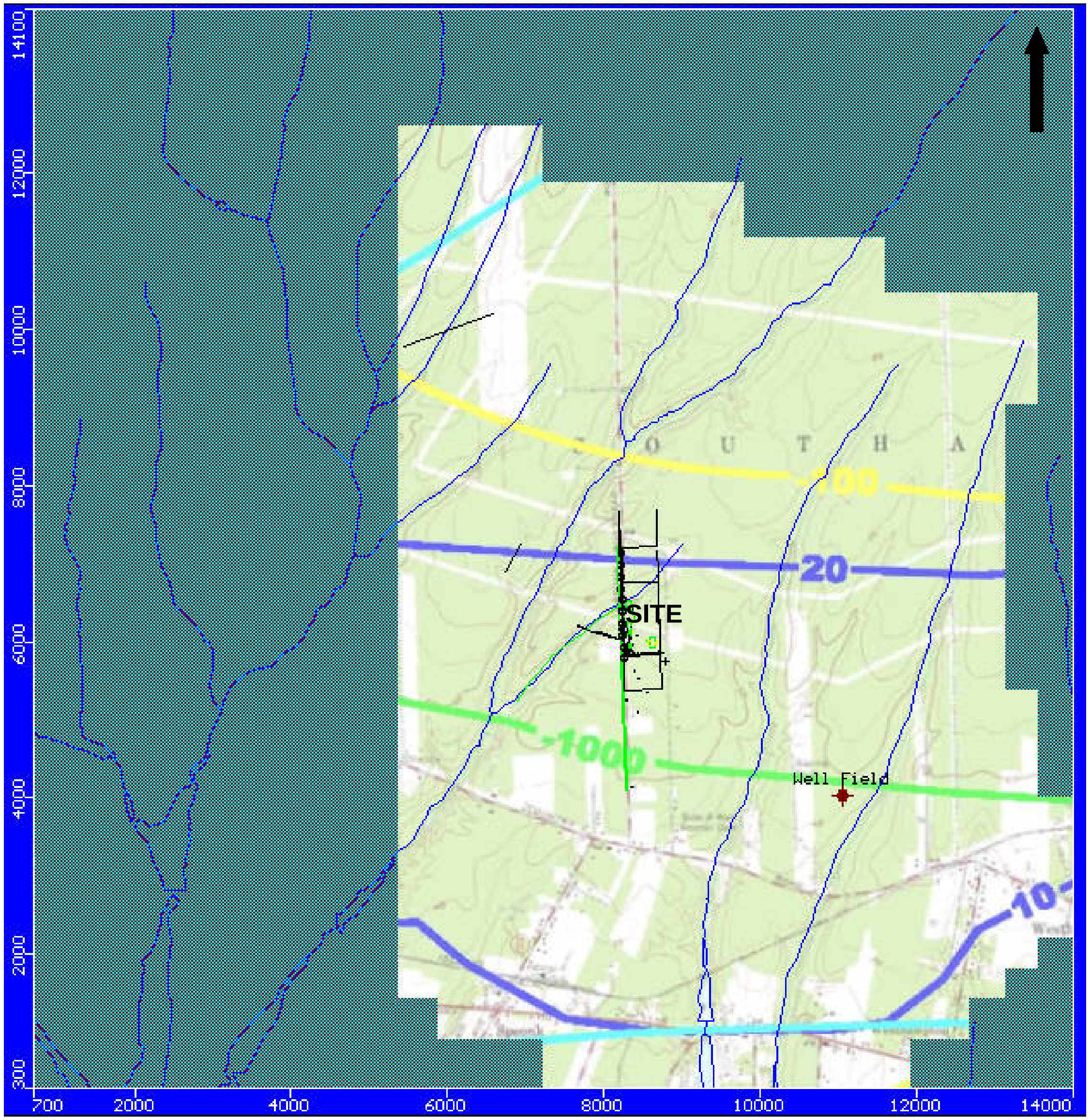
SITE

NOTE:
GRID SPACING STARTS AT 25 FT WITHIN THE SITE AND GRADUALLY INCREASES TO 600 FT AT THE MODEL BOUNDARIES

BB&S - MODFLOW SCREENS
GRID SPACING FOR ENTIRE MODEL AREA

FIGURE 4B

IEG



LEGEND

━ GEOLOGIC UNIT – MAGOTHY

━ GEOLOGIC UNIT – RARITAN

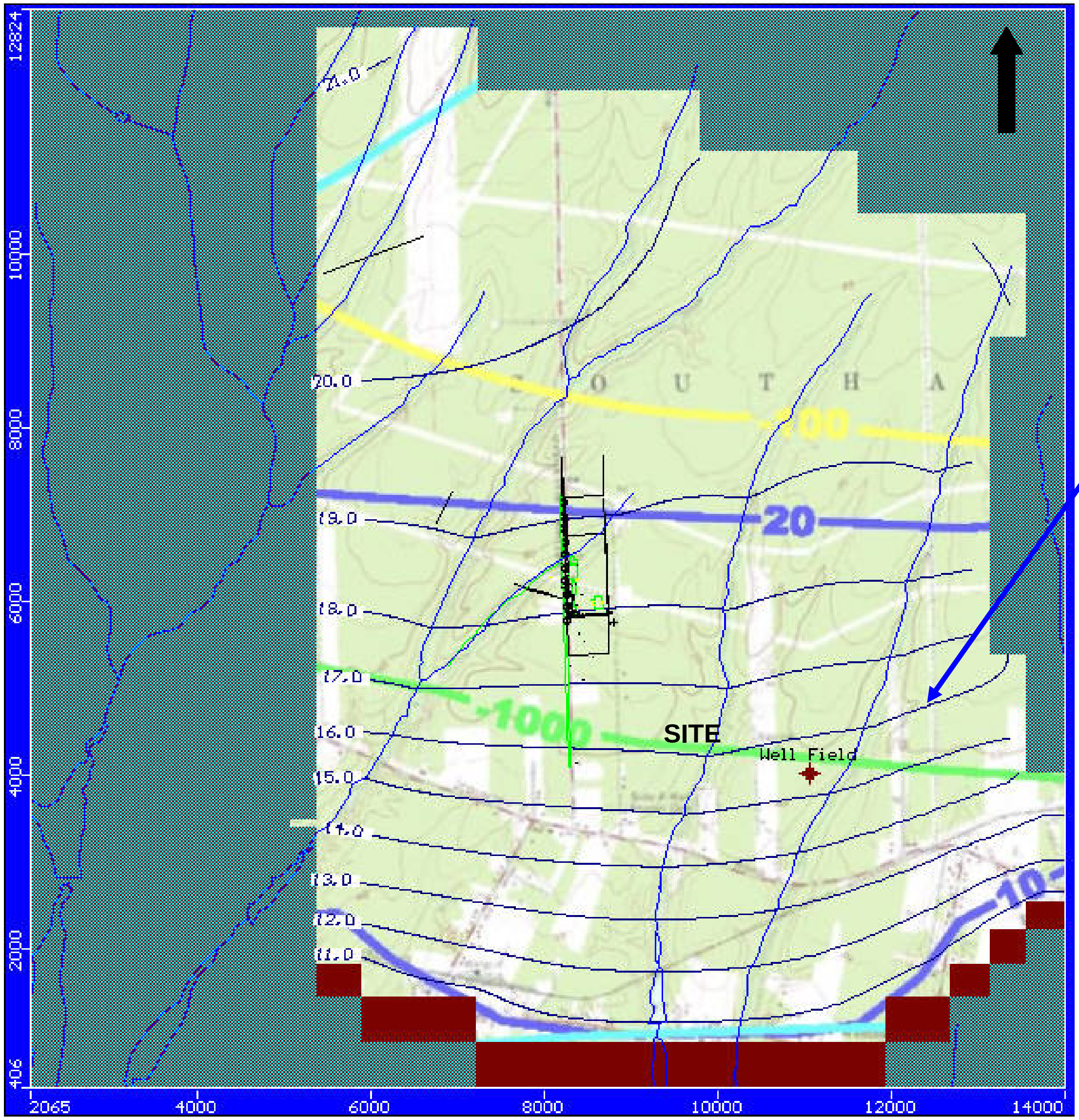
━ WATER TABLE – MAGOTHY

━ WATER TABLE – UPPER GLACIAL

BB&S - MODFLOW SCREENS
REVISED MODEL AREA FOR CALIBRATION

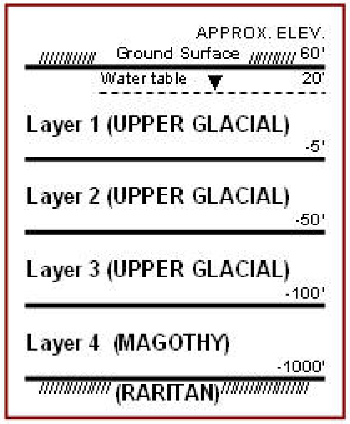
FIGURE 5

IEG



CONDUCTIVITIES
Layers 1, 2 & 3:
Kxy = 100; Kz = 10 ft/day
Layer 4:
Kxy = 20; Kz = 2 ft/day
RECHARGE
0.006 ft/day (all zones)
SCWA WELL FIELD
0 GPM

Model Calculated GROUNDWATER CONTOURS for Layer 1



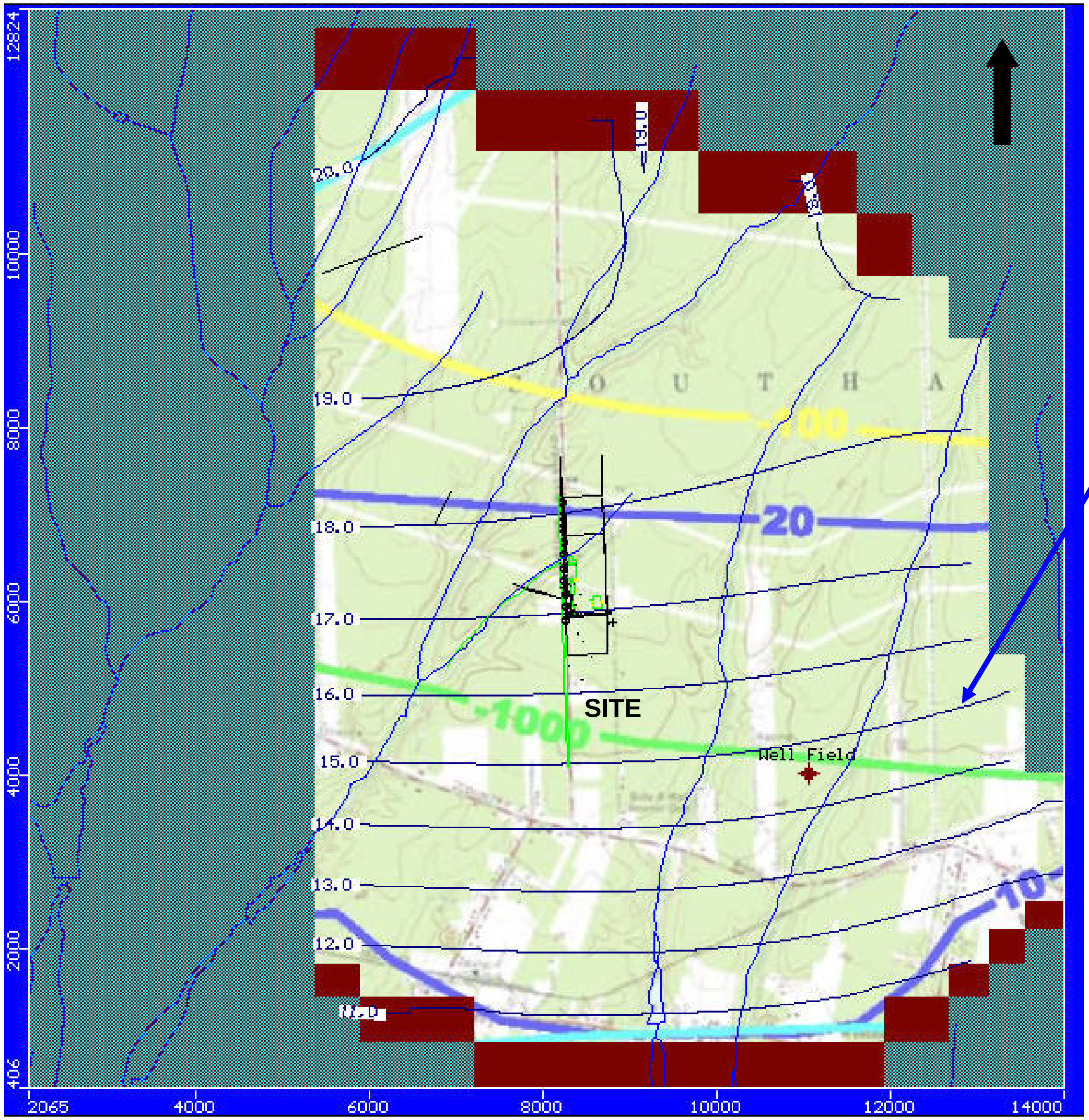
CONTOURS
🟥 GEOLOGIC UNIT – GARDINER'S CLAY
🟨 GEOLOGIC UNIT – MAGOTHY
🟩 GEOLOGIC UNIT – RARITAN
🟦 WATER TABLE – MAGOTHY
🟦 WATER TABLE – UPPER GLACIAL

NOTE: GROUNDWATER CONTOURS FOR LAYERS 2 AND 3 ARE SIMILAR TO LAYER 1 EXCEPT FOR RIVER/STREAM EFFECT

BB&S - MODFLOW SCREENS
GROUNDWATER CONTOURS FROM MANUAL CALIBRATION RUN 6
(LAYER 1)

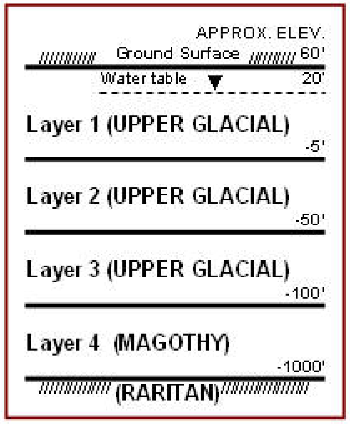
FIGURE 6A

IEG



CONDUCTIVITIES
Layers 1, 2 & 3:
Kxy = 100; Kz = 10 ft/day
Layer 4:
Kxy = 20; Kz = 2 ft/day
RECHARGE
0.006 ft/day (all zones)
SCWA WELL FIELD
0 GPM

Model Calculated GROUNDWATER CONTOURS for Layer 4

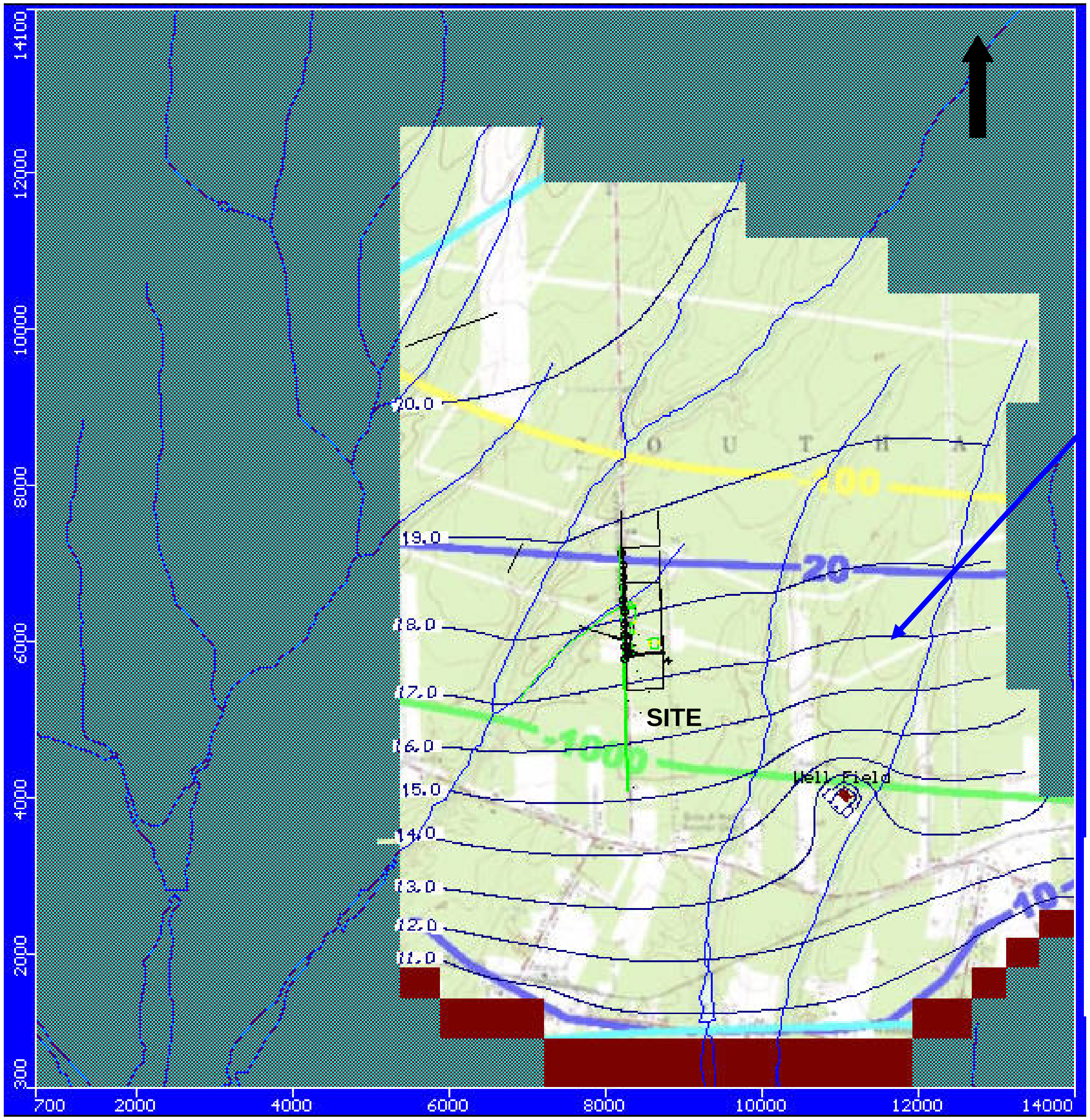


CONTOURS	
━	GEOLOGIC UNIT – GARDINER'S CLAY
━	GEOLOGIC UNIT – MAGOTHY
━	GEOLOGIC UNIT – RARITAN
━	WATER TABLE – MAGOTHY
━	WATER TABLE – UPPER GLACIAL

BB&S - MODFLOW SCREENS
GROUNDWATER CONTOURS FROM MANUAL CALIBRATION RUN 6
(LAYER 4)

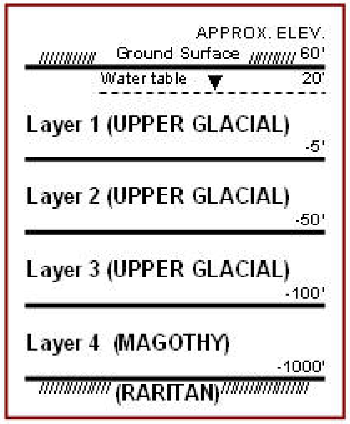
FIGURE 6A

IEG



CONDUCTIVITIES
Layers 1, 2 & 3:
Kxy = 100; Kz = 10 ft/day
Layer 4:
Kxy = 20; Kz = 2 ft/day
RECHARGE
0.006 ft/day (all zones)
SCWA WELL FIELD
500 GPM

Model Calculated GROUNDWATER CONTOURS for Layer 1



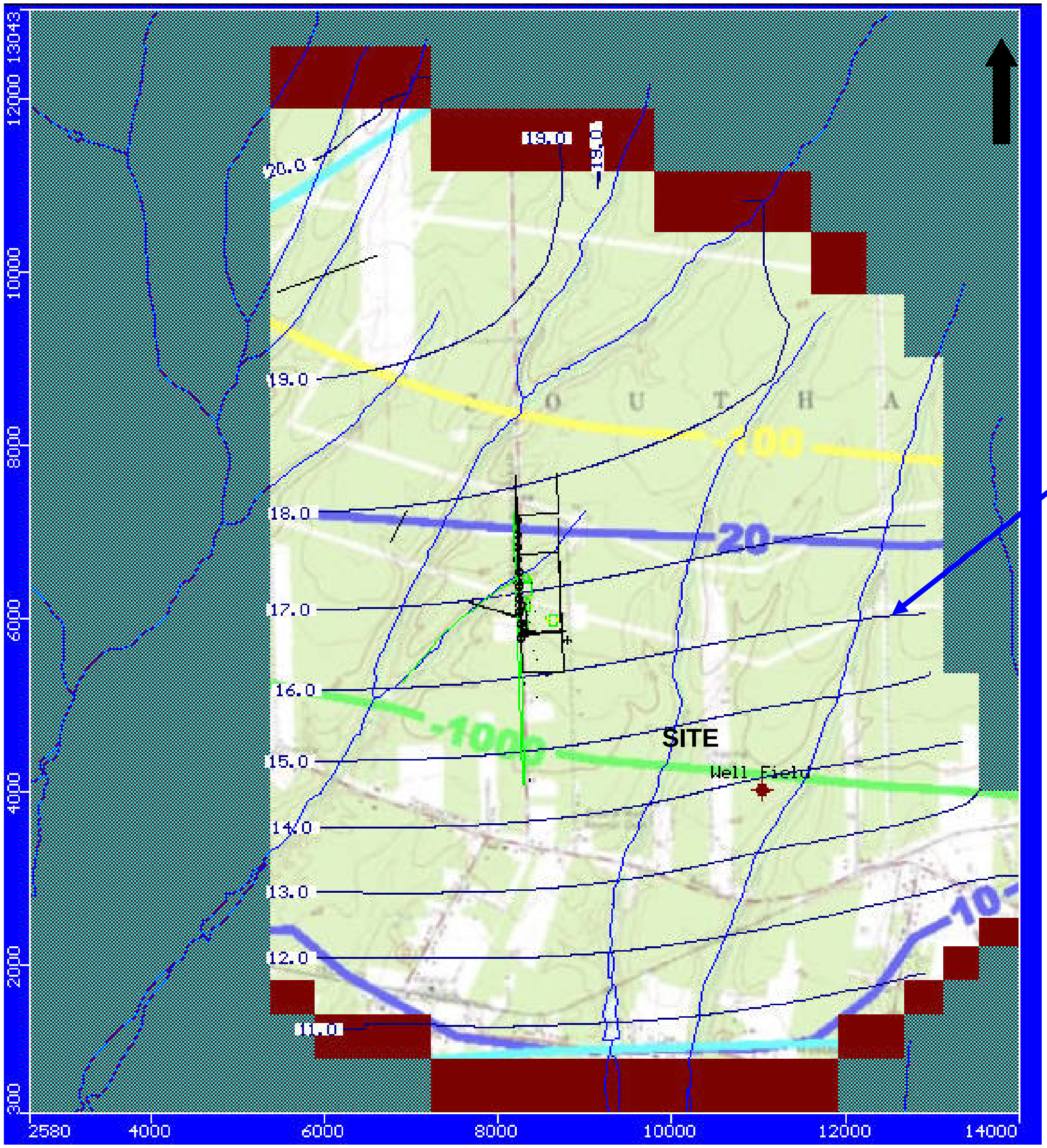
CONTOURS	
🟥	GEOLOGIC UNIT – GARDINER'S CLAY
🟨	GEOLOGIC UNIT – MAGOTHY
🟩	GEOLOGIC UNIT – RARITAN
🟦	WATER TABLE – MAGOTHY
🟦	WATER TABLE – UPPER GLACIAL

NOTE: GROUNDWATER CONTOURS FOR LAYERS 2 AND 3 ARE SIMILAR TO LAYER 1 EXCEPT FOR RIVER/STREAM EFFECT

BB&S - MODFLOW SCREENS
GROUNDWATER CONTOURS FROM MANUAL CALIBRATION RUN 7
(LAYER 1)

FIGURE 6B

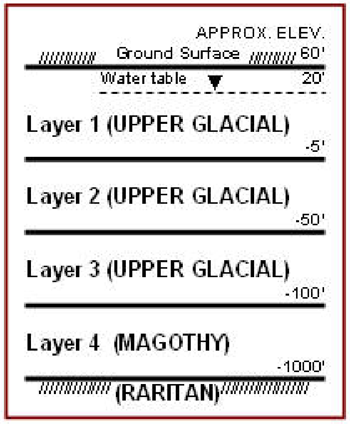
IEG



CONDITIVITIES

CONDUCTIVITIES
Layers 1, 2 & 3:
Kxy = 100; Kz = 10 ft/day
Layer 4:
Kxy = 20; Kz = 2 ft/day
RECHARGE
0.006 ft/day (all zones)
SCWA WELL FIELD
500 GPM

Model Calculated GROUNDWATER CONTOURS for Layer 4



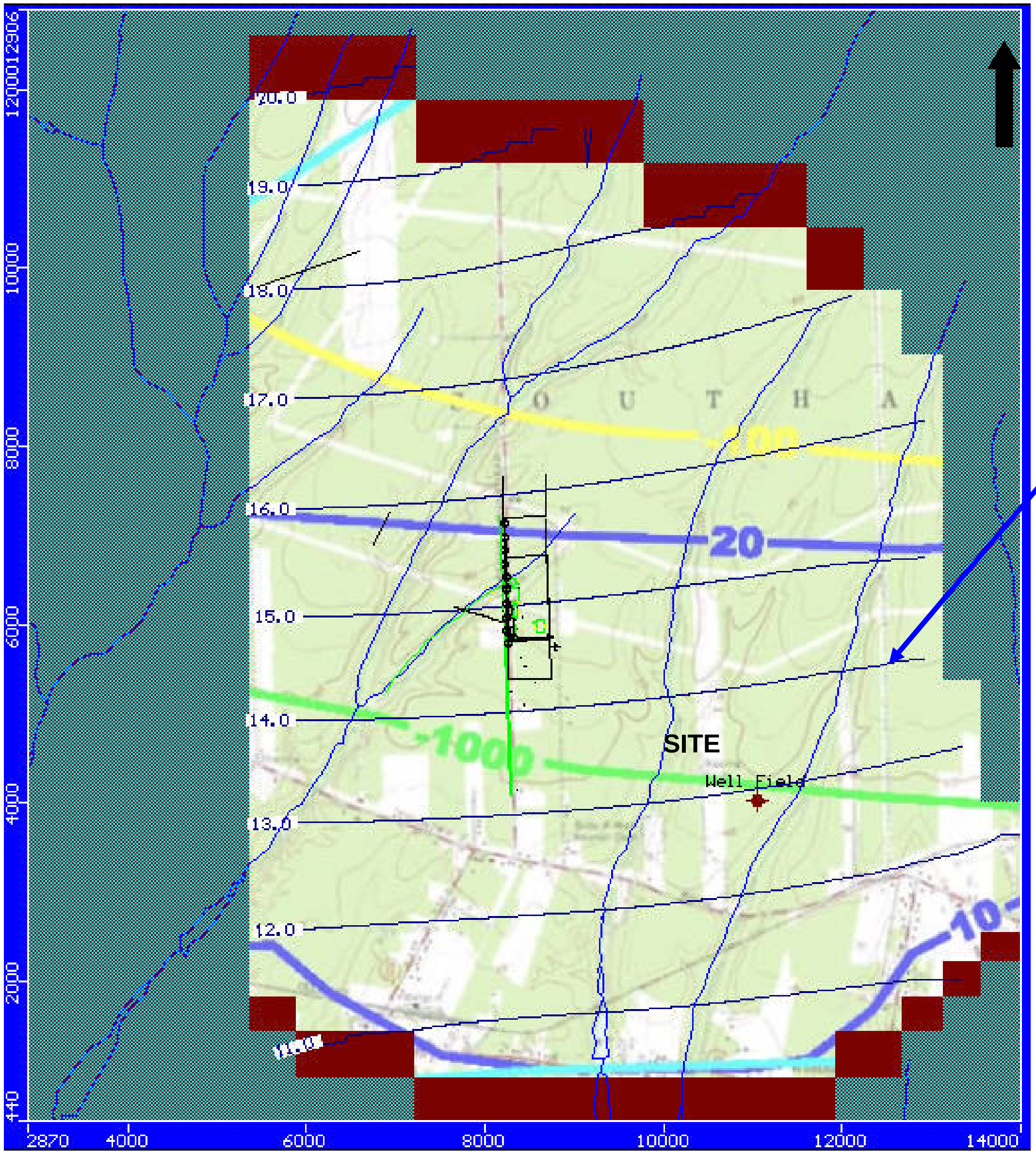
CONTOURS	
🟥	GEOLOGIC UNIT – GARDINER'S CLAY
🟨	GEOLOGIC UNIT – MAGOTHY
🟩	GEOLOGIC UNIT – RARITAN
🟦	WATER TABLE – MAGOTHY
🟦	WATER TABLE – UPPER GLACIAL

NOTE: GROUNDWATER CONTOURS FOR LAYERS 2 AND 3 ARE SIMILAR TO LAYER 1 EXCEPT FOR RIVER/STREAM EFFECT

BB&S - MODFLOW SCREENS
GROUNDWATER CONTOURS FROM MANUAL CALIBRATION RUN 7
(LAYER 4)

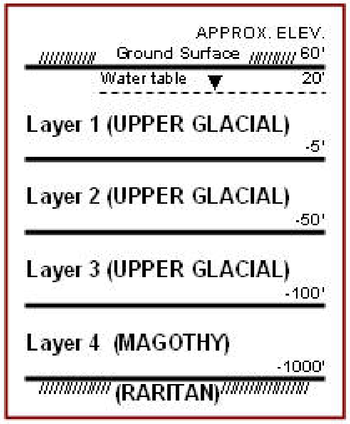
FIGURE 6B

IEG



CONDUCTIVITIES
Layers 1, 2 & 3:
Kxy = 300; Kz =30 ft/day
Layer 4:
Kxy = 100; Kz = 10 ft/day
RECHARGE
0.006 ft/day (all zones)
SCWA WELL FIELD
0 GPM

Model Calculated GROUNDWATER CONTOURS for Layer 4



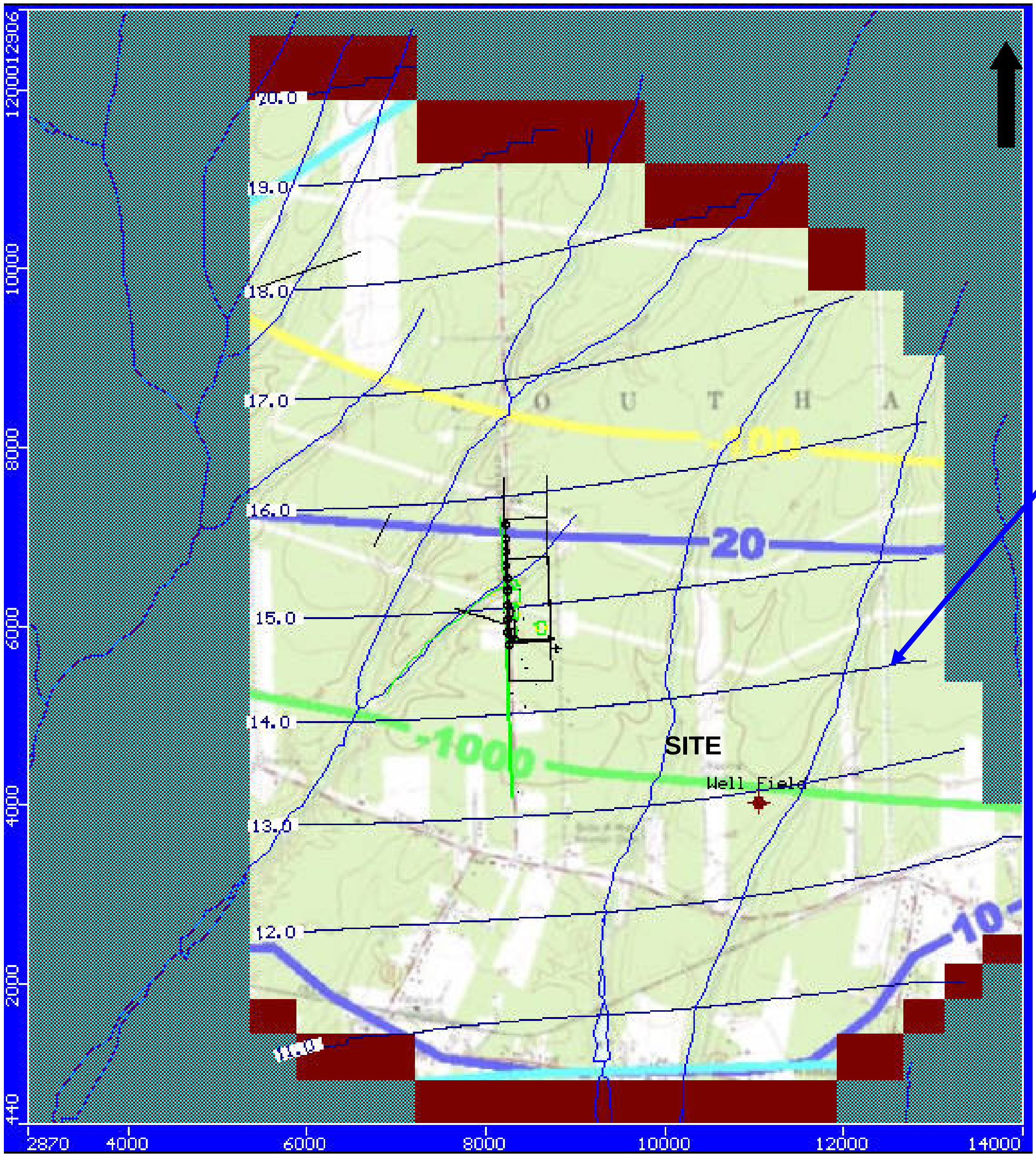
CONTOURS	
🟥	GEOLOGIC UNIT – GARDINER'S CLAY
🟨	GEOLOGIC UNIT – MAGOTHY
🟩	GEOLOGIC UNIT – RARITAN
🟦	WATER TABLE – MAGOTHY
🟦	WATER TABLE – UPPER GLACIAL

NOTE: GROUNDWATER CONTOURS FOR LAYERS 2 AND 3 ARE SIMILAR TO LAYER 1 EXCEPT FOR RIVER/STREAM EFFECT

BB&S - MODFLOW SCREENS
GROUNDWATER CONTOURS FROM MANUAL CALIBRATION RUN 8
(LAYER 4)

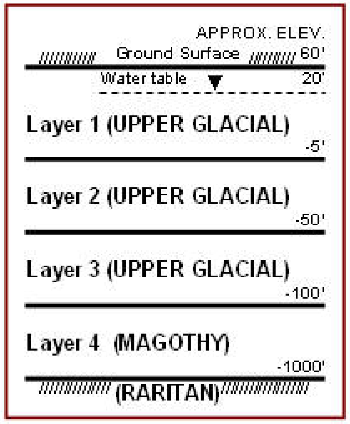
FIGURE 6C

IEG



CONDUCTIVITIES
Layers 1, 2 & 3:
Kxy = 300; Kz =30 ft/day
Layer 4:
Kxy = 100; Kz = 10 ft/day
RECHARGE
0.006 ft/day (all zones)
SCWA WELL FIELD
0 GPM

Model Calculated GROUNDWATER CONTOURS for Layer 4



CONTOURS

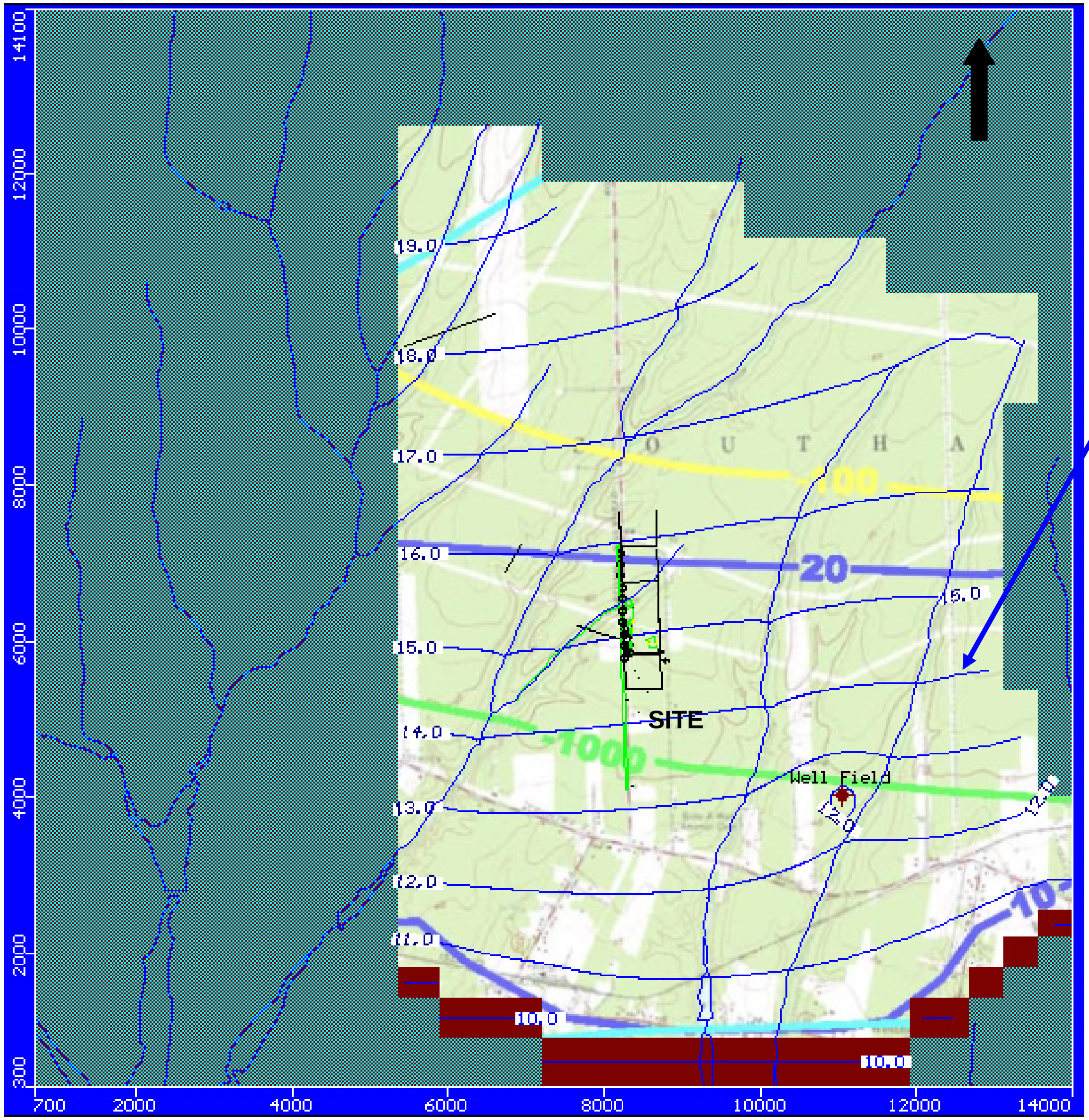
🟥 GEOLOGIC UNIT – GARDINER'S CLAY
🟨 GEOLOGIC UNIT – MAGOTHY
🟩 GEOLOGIC UNIT – RARITAN
🟦 WATER TABLE – MAGOTHY
🟦 WATER TABLE – UPPER GLACIAL

NOTE: GROUNDWATER CONTOURS FOR LAYERS 2 AND 3 ARE SIMILAR TO LAYER 1 EXCEPT FOR RIVER/STREAM EFFECT

BB&S - MODFLOW SCREENS
GROUNDWATER CONTOURS FROM MANUAL CALIBRATION RUN 8
(LAYER 4)

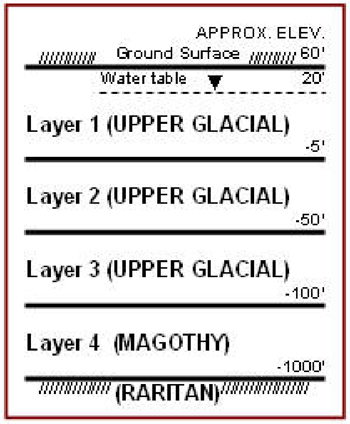
FIGURE 6C

IEG



CONDUCTIVITIES
Layers 1, 2 & 3:
Kxy = 300; Kz =320 ft/day
Layer 4:
Kxy = 100; Kz = 10 ft/day
RECHARGE
0.006 ft/day (all zones)
SCWA WELL FIELD
500 GPM

Model Calculated GROUNDWATER CONTOURS for Layer 1



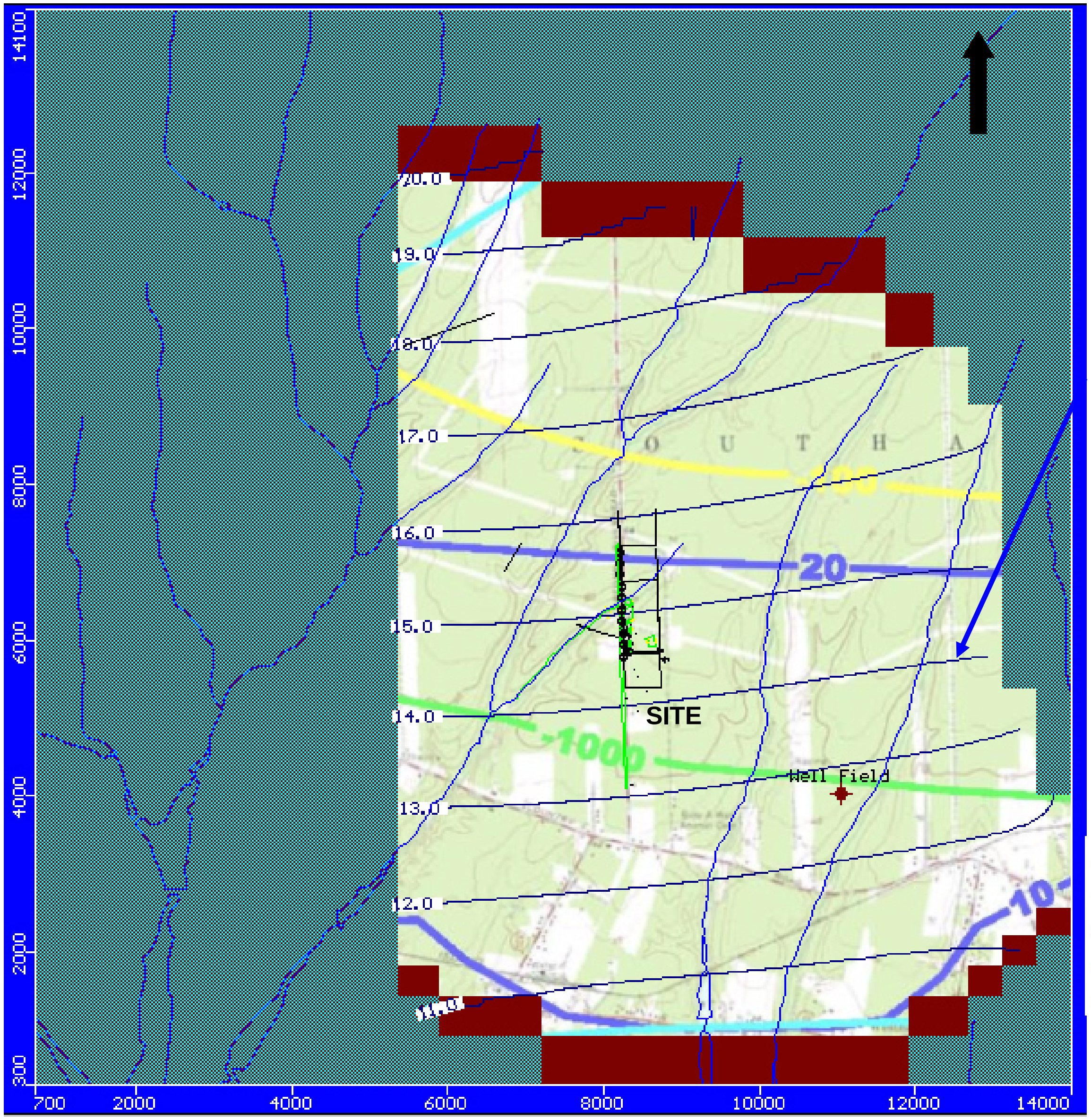
CONTOURS	
🟥	GEOLOGIC UNIT – GARDINER'S CLAY
🟨	GEOLOGIC UNIT – MAGOTHY
🟩	GEOLOGIC UNIT – RARITAN
🟦	WATER TABLE – MAGOTHY
🟦	WATER TABLE – UPPER GLACIAL

NOTE: GROUNDWATER CONTOURS FOR LAYERS 2 AND 3 ARE SIMILAR TO LAYER 1 EXCEPT FOR RIVER/STREAM EFFECT

BB&S - MODFLOW SCREENS
GROUNDWATER CONTOURS FROM MANUAL CALIBRATION RUN 9
(LAYER 1)

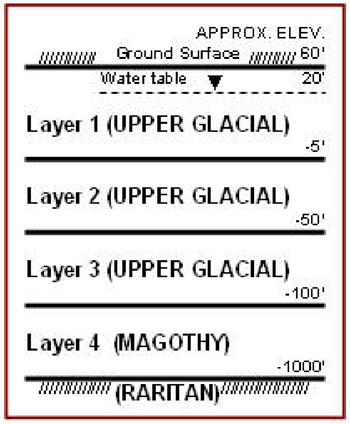
FIGURE 6D

IEG



CONDUCTIVITIES
Layers 1, 2 & 3:
Kxy = 300; Kz =30 ft/day
Layer 4:
Kxy = 100; Kz = 10 ft/day
RECHARGE
0.006 ft/day (all zones)
SCWA WELL FIELD
500 GPM

Model Calculated GROUNDWATER CONTOURS for Layer 4



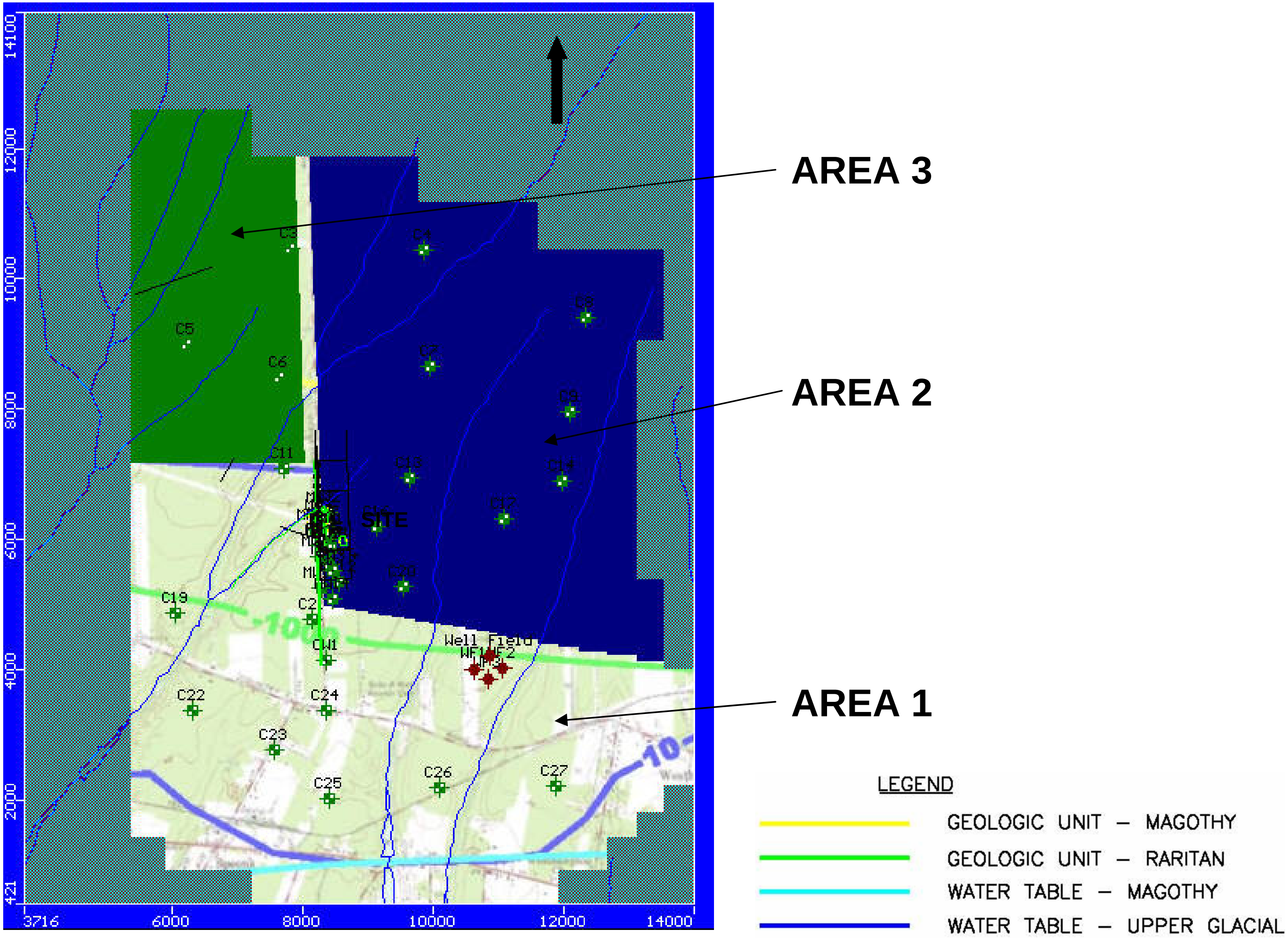
CONTOURS
🟥 GEOLOGIC UNIT – GARDINER'S CLAY
🟨 GEOLOGIC UNIT – MAGOTHY
🟩 GEOLOGIC UNIT – RARITAN
🟦 WATER TABLE – MAGOTHY
🟦 WATER TABLE – UPPER GLACIAL

NOTE: GROUNDWATER CONTOURS FOR LAYERS 2 AND 3 ARE SIMILAR TO LAYER 1 EXCEPT FOR RIVER/STREAM EFFECT

BB&S - MODFLOW SCREENS
GROUNDWATER CONTOURS FROM MANUAL CALIBRATION RUN 9
(LAYER 4)

FIGURE 6D

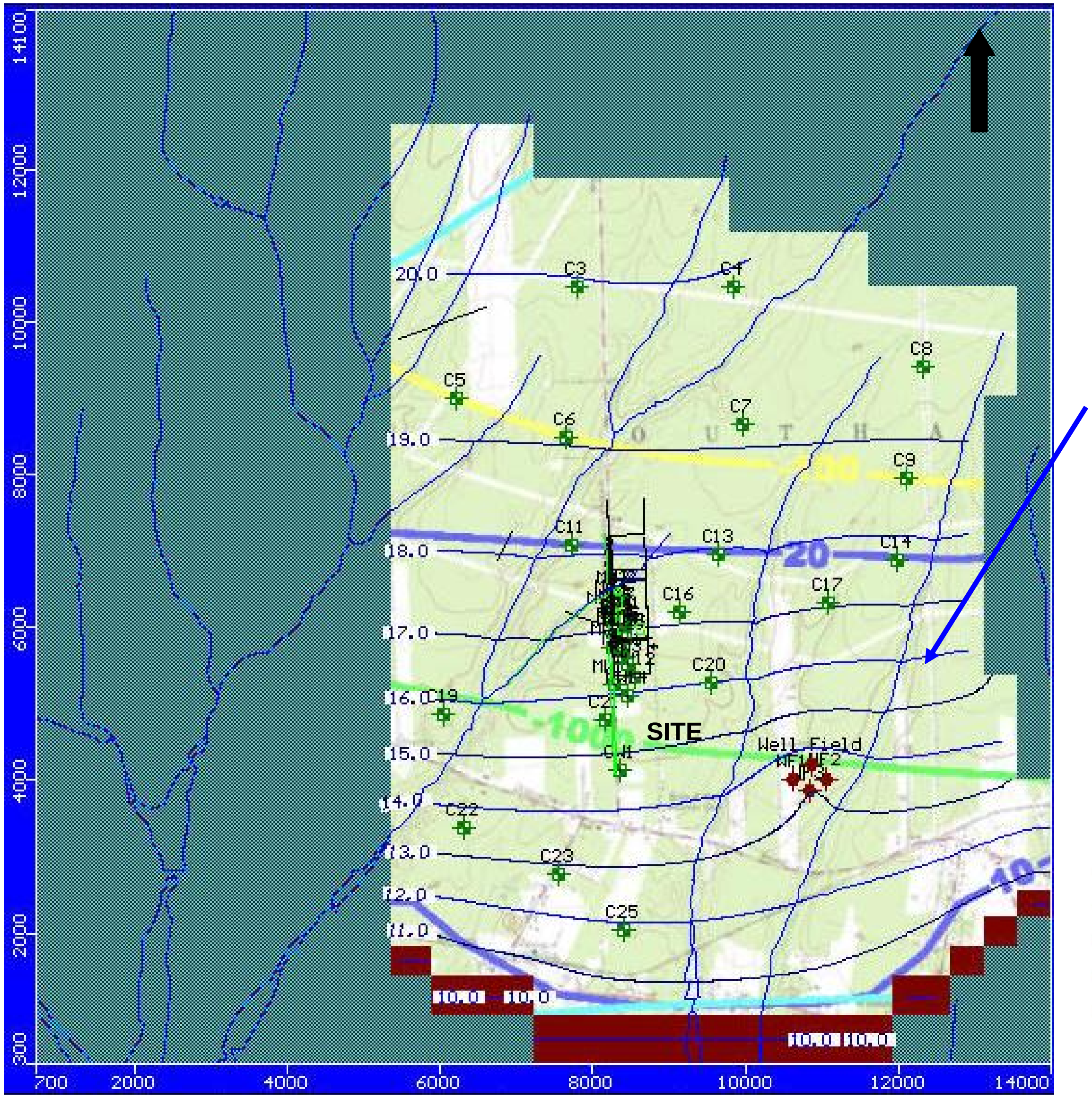
IEG



BB&S - MODFLOW SCREENS
MODEL AREAS FOR RECHARGE RATES

FIGURE 7

IEG



CONDUCTIVITIES

Layers 1, 2 & 3:

Kxy = 200; Kz = 20 ft/day

Layer 4:

Kxy = 30; Kz = 0.3 ft/day

RECHARGE (ft/day)

Zone 1 = 0.0065

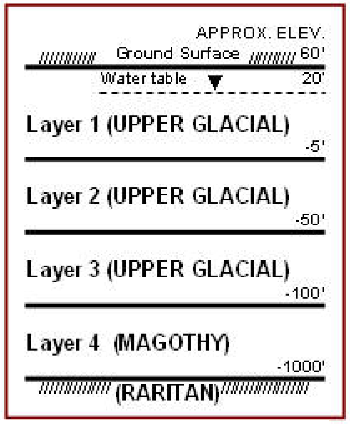
Zone 2 = 0.0065

Zone 3 = 0.0040

SCWA WELL FIELD

500 GPM

Model Calculated GROUNDWATER CONTOURS for Layer 1



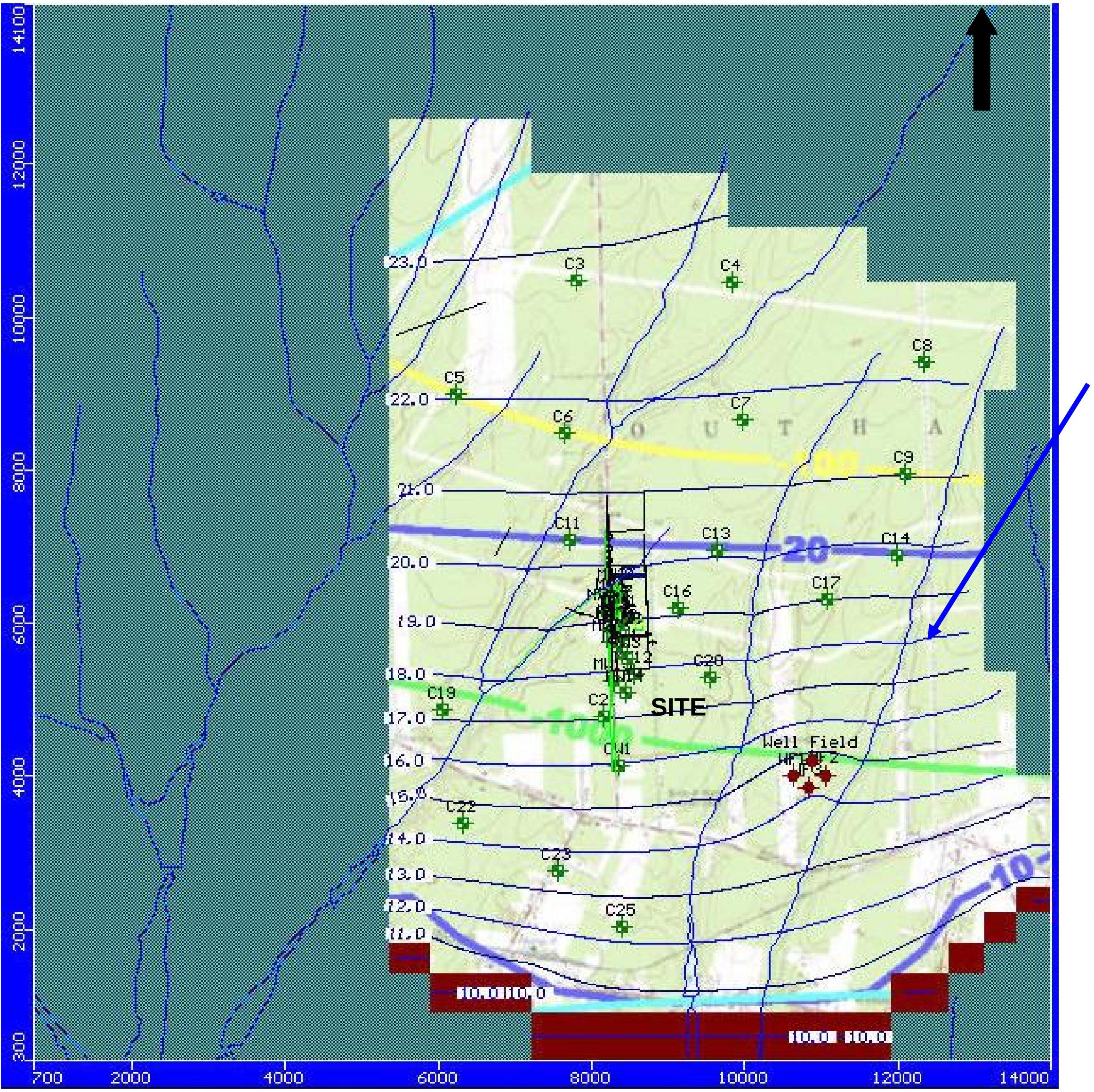
CONTOURS	
🟥	GEOLOGIC UNIT – GARDINER'S CLAY
🟨	GEOLOGIC UNIT – MAGOTHY
🟩	GEOLOGIC UNIT – RARITAN
🟦	WATER TABLE – MAGOTHY
🟦	WATER TABLE – UPPER GLACIAL

NOTE: GROUNDWATER CONTOURS FOR LAYERS 2 AND 3 ARE SIMILAR TO LAYER 1 EXCEPT FOR RIVER/STREAM EFFECT

BB&S - MODFLOW SCREENS
GROUNDWATER CONTOURS FROM MANUAL CALIBRATION
RUN 16

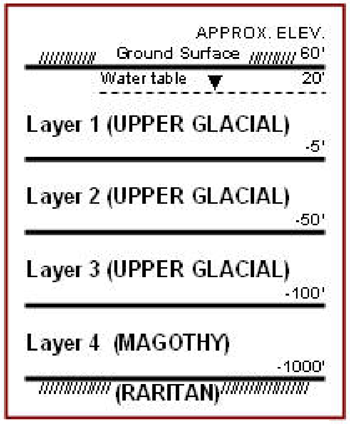
FIGURE 8A

IEG



CONDUCTIVITIES
Layers 1, 2 & 3:
Kxy = 182; Kz = 8.7 ft/day
Layer 4:
Kxy = 30; Kz = 0.1 ft/day
RECHARGE (ft/day)
Zone 1 = 0.0065
Zone 2 = 0.0070
Zone 3 = 0.0055
SCWA WELL FIELD
500 GPM

Model Calculated
GROUNDWATER CONTOURS
for Layer 1



CONTOURS

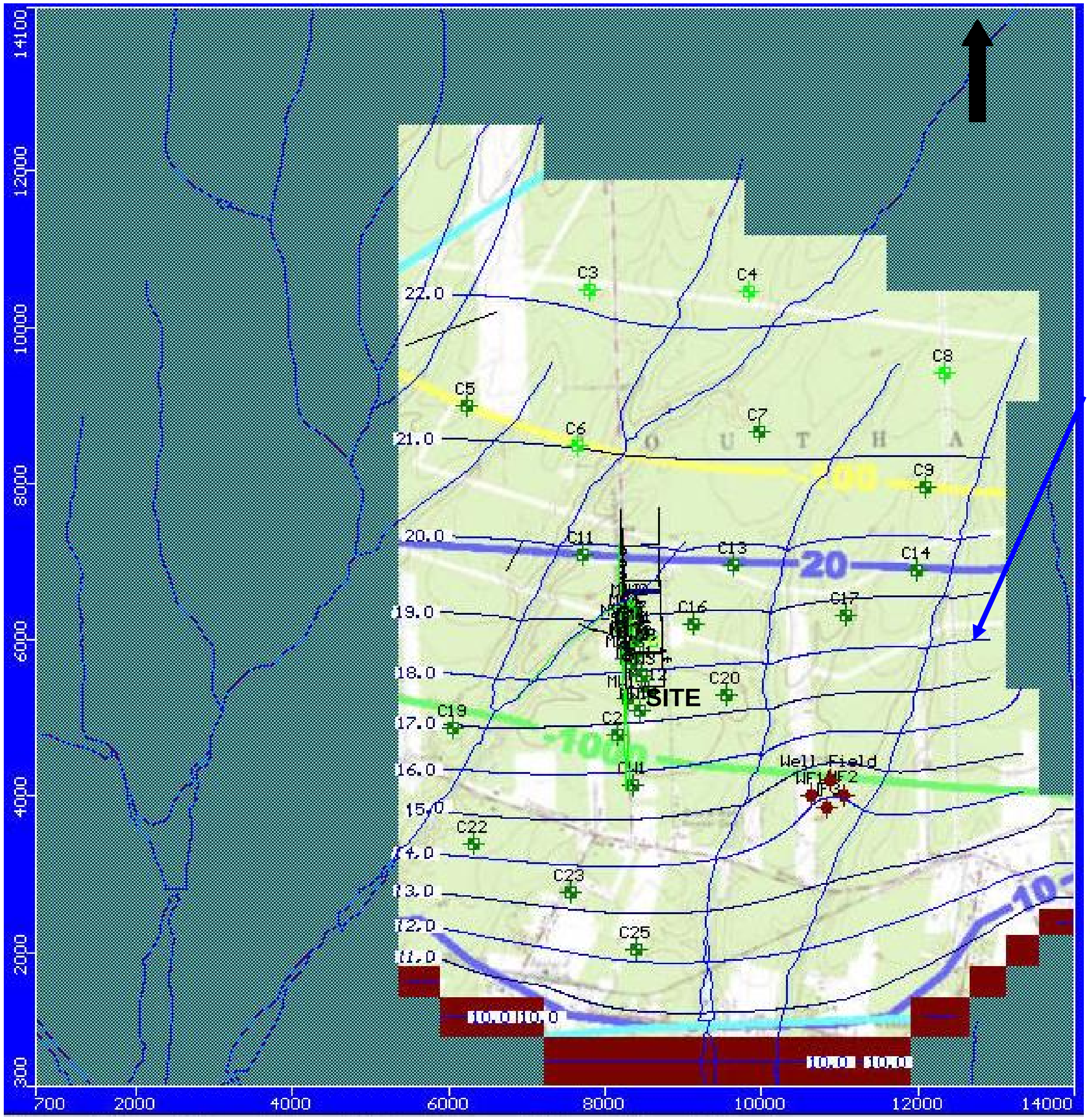
🟥	GEOLOGIC UNIT – GARDINER'S CLAY
🟨	GEOLOGIC UNIT – MAGOTHY
🟩	GEOLOGIC UNIT – RARITAN
🟦	WATER TABLE – MAGOTHY
🟦	WATER TABLE – UPPER GLACIAL

NOTE: GROUNDWATER CONTOURS FOR LAYERS 2 AND 3 ARE SIMILAR TO LAYER 1 EXCEPT FOR RIVER/STREAM EFFECT

BB&S - MODFLOW SCREENS
GROUNDWATER CONTOURS FROM MANUAL CALIBRATION
RUN 18

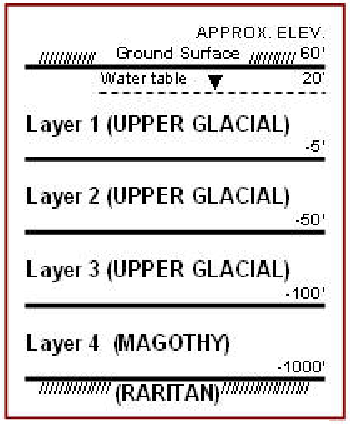
FIGURE 8B

IEG



CONDUCTIVITIES
Layers 1, 2 & 3:
Kxy = 187; Kz = 15 ft/day
Layer 4:
Kxy = 30; Kz = 0.1 ft/day
RECHARGE (ft/day)
Zone 1 = 0.0065
Zone 2 = 0.0070
Zone 3 = 0.0040
SCWA WELL FIELD
500 GPM

Model Calculated GROUNDWATER CONTOURS for Layer 1



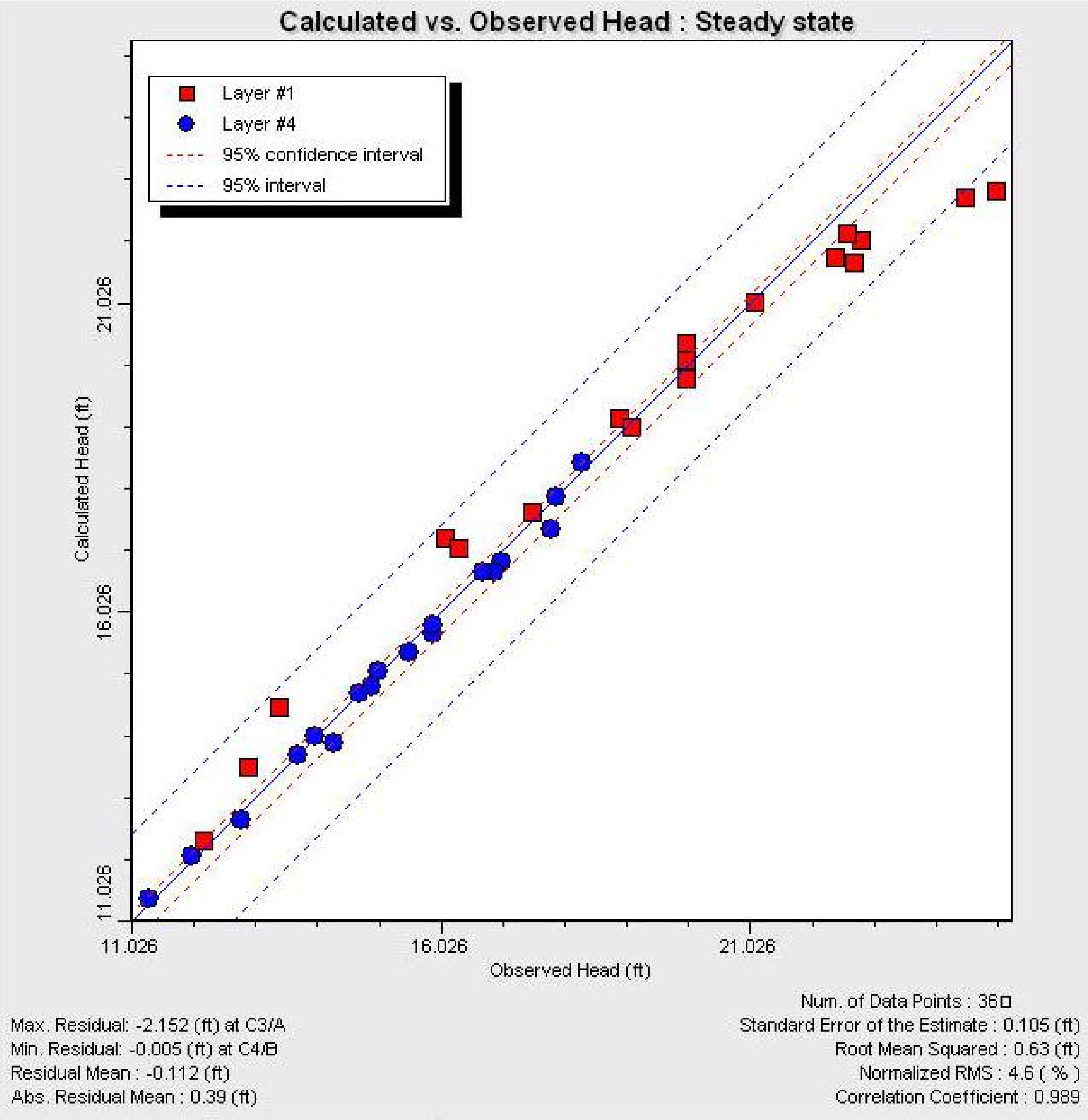
CONTOURS
🟥 GEOLOGIC UNIT – GARDINER'S CLAY
🟨 GEOLOGIC UNIT – MAGOTHY
🟩 GEOLOGIC UNIT – RARITAN
🟦 WATER TABLE – MAGOTHY
🟦 WATER TABLE – UPPER GLACIAL

NOTE: GROUNDWATER CONTOURS FOR LAYERS 2 AND 3 ARE SIMILAR TO LAYER 1 EXCEPT FOR RIVER/STREAM EFFECT

BB&S - MODFLOW SCREENS
GROUNDWATER CONTOURS FROM MANUAL CALIBRATION
RUN 20

FIGURE 8C

IEG



Num. of Data Points : 36□

Max. Residual: -2.152 (ft) at C3/A
Min. Residual: -0.005 (ft) at C4/B
Residual Mean : -0.112 (ft)
Abs. Residual Mean : 0.39 (ft)

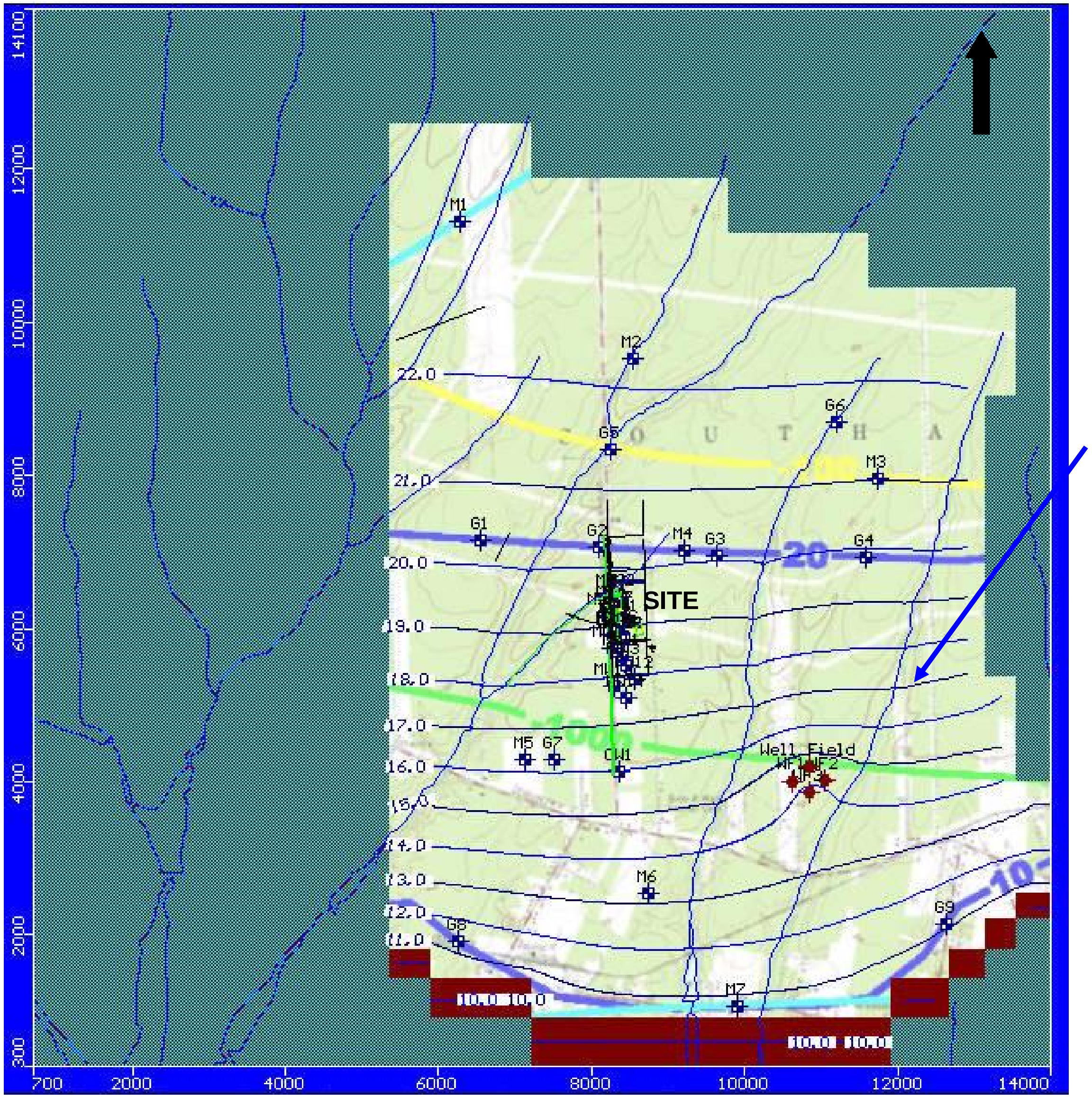
Standard Error of the Estimate : 0.105 (ft)
Root Mean Squared : 0.63 (ft)
Normalized RMS : 4.6 (%)
Correlation Coefficient : 0.989

CONDUCTIVITIES
Layers 1, 2 & 3:
Kxy = 187; Kz = 15 ft/day
Layer 4:
Kxy = 30; Kz = 0.1 ft/day
RECHARGE (ft/day)
Zone 1 = 0.0065
Zone 2 = 0.0070
Zone 3 = 0.0040
SCWA WELL FIELD
500 GPM

BB&S - MODFLOW SCREENS
COMPARISION OF CALCULATED VS OBSERVED HEADS
MANUAL CALIBRATION RUN 20

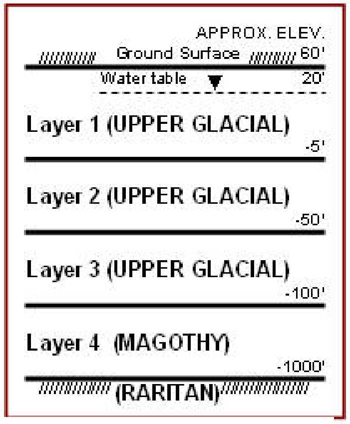
FIGURE 8D

IEG



CONDUCTIVITIES (CALIBRATED)
Layers 1, 2 & 3:
Kxy = 170; Kz = 21.5 ft/day
Layer 4:
Kxy = 18.2; Kz = 0.08 ft/day
RECHARGE (ASSUMED)
Zone 1 = 0.0065 (ft/day)
Zone 2 = 0.0065 (ft/day)
Zone 3 = 0.0040 (ft/day)
SCWA WELL FIELD (ASSUMED)
500 GPM

Model Calculated GROUNDWATER CONTOURS for Layer 1



CONTOURS

🟥	GEOLOGIC UNIT – GARDINER'S CLAY
🟨	GEOLOGIC UNIT – MAGOTHY
🟩	GEOLOGIC UNIT – RARITAN
🟦	WATER TABLE – MAGOTHY
🟦	WATER TABLE – UPPER GLACIAL

BB&S - MODFLOW SCREENS
GROUNDWATER CONTOURS FROM PEST CALIBRATION RUN 15
LAYER 1

FIGURE 9A

IEG