REVISED GROUNDWATER FLOW MODEL
DUPONT WASHINGTON WORKS
WASHINGTON, WV

Date: January 2003

Project No.: 18983635
7423

DUPONT

CORPORATE REMEDIATION GROUP
An Alliance between
DuPont and URS Diamond

Barley Mill Plaza, Building 27
Wilmington, Delaware 19805

TABLE OF CONTENTS

TABLES

FIGURES

1.0 INTRODUCTION

A steady-state groundwater flow model was developed for the DuPont Washington Works facility (the site) in 1999. This model, which was completed as part of the RFI, was documented in the RCRA Facility Investigation Report (DuPont, 1999). The original groundwater flow model has been revised and expanded.

The primary objectives of the modeling work documented in this report included:

- Addressing EPA/ACOE comments on the previous groundwater flow model,
- Evaluating groundwater migration pathways at the site under current site and regional pumping conditions, and
- Predicting future groundwater migration pathways under various pumping scenarios.

Feedback was sought from experts with the U.S. Environmental Protection Agency (EPA), U.S. Army Corps of Engineers (ACOE), and U.S. Geological Survey during the redevelopment of the model. Meetings were held with these experts at key stages in model development including completion of the conceptual geologic model, following preliminary model calibration, and then after final model calibration in order to give the experts the opportunity to review the work completed at each stage and to solicit feedback.

The purpose of this report is to document the revised groundwater flow model for the DuPont Washington Works facility. The following sections describe the site setting, geology, and hydrogeology, and document the model set-up, calibration, and results.

2.0 SITE SETTING, GEOLOGY, AND HYDROGEOLOGY

2.1 Site Setting

The site is located on Washington Bottom in Washington, West Virginia. The location of the site and several surrounding properties are shown on Figure 1. The site, which is bounded on the north by the Ohio River, lies at the western (down-stream) end of Blennerhassett Island approximately between river miles 189 and 191. The DuPont site shares its southwestern boundary with another manufacturing facility operated by General Electric (GE).

2.2 Geology

The site lies within the Ohio River Valley and rests on Quaternary alluvial sediments that overly the Permian-aged Dunkard Group. The two predominant facies of the Ohio River alluvium that have been identified include coarse-grained Ohio River Alluvium (Pleistocene-aged glacial outwash deposits) and fine-grained Ohio River Alluvium (Holocene overbank deposits (Simard, 1989). The Pleistocene deposits consist primarily of coarse-grained sand and gravel while the Holocene deposits consist primary of interbedded and laminated silt, clay and fine-grained sand. Simard also identified three minor facies of the Ohio River Alluvium including tributary deposits (silt, sand and gravel), colluvial deposits (coarse sand, gravel, cobbles and boulders) and eolian sand and silt deposits. The Dunkard Group (bedrock) consists primarily of red and varicolored sandy shale; gray, green and brown sandstone; gray and light-gray siltstone; and minor beds of coal, claystone, black carbonaceous shale and limestone.

The facies of the Ohio River Alluvium formed in response to the glacial advances and retreats of the pre-, early- and late-Wisconsinan and were deposited as successive phases of aggradation and degradation of river valley alluvial materials. The coarse-grained Pleistocene alluvium was deposited as glacial outwash during the primary valley aggradation event following the glacial scouring of the valley into the bedrock floor. During the subsequent degredation and aggradation cycles of the Pleistocene, the glacial outwash sediments were partially removed, re-worked and then redeposited to a lower elevation than the previous cycle, thus forming a terrace. This process formed a series of Pleistocene-aged terrace surfaces within the Ohio River Valley. These surfaces were designated (youngest to oldest) as S4, S5, and S6 by Simard. With each subsequent degredation/aggradation cycle, additional fines were incorporated into the Pleistocene deposits due to continual influx of finer-grained fluvial sediments from tributaries of the Ohio River. As a result, the Pleistocene deposits become more highly re-worked and progressively finer-grained toward the center of the river valley, particularly in locations down-stream of significant tributaries (Simard, 1989). The total thickness of Pleistocene sediments at Washington Bottom ranges from about 80 feet beneath the highest Pleistocene terrace surfaces to about 15 feet beneath the current channel of the Ohio River.

The Pleistocene alluvial deposits are overlain by the finer-grained Holocene sediments. The silts, clays, and fine sands were deposited on the surface of the Pleistocene terraces as well as on a series of more recent floodplains, which formed in the center of the Ohio River Valley during the Holocene. The thickness of the Holocene sediments typically ranges from 5 to 15 feet over the Pleistocene terrace surfaces and 25 to 35 feet over the Holocene floodplains. Simard designated the Holocene floodplain surfaces as S1 through S3 and the modern floodplain of the Ohio River as S0. Figure 2, modified from Simard (1989), is a block diagram and idealized cross-section through the Ohio River valley depicting the complex set of Pleistocene terraces and Holocene floodplains which have formed in the valley.

Holocene floodplain surfaces and Pleistocene terrace surfaces were mapped using surface age and elevation data from Simard, 1989. A map of floodplain and terrace surfaces is shown in Figure 3. Individual floodplain and terrace surfaces were not differentiated. Due to damming of the river, the S0, S1, and S2 Holocene floodplain surfaces are now flooded along the reach of the Ohio River at Washington Bottom. The S3 surface remains above the current normal pool elevation of 582-ft. MSL. A thin strip of this surface remains on the south side of the river along Washington Bottom. More extensive expanses of this surface are present along the north side of the river at Little Hocking Water Association (WA), Blennerhassett Island, Shell Kraton, and Belpre. Additional expanses of this surface are present down-stream of Washington Bottom at Lubeck Public Service District (PSD). The remainder of the alluvial valley is occupied by the Pleistocene terrace surfaces.

A generalized north-south cross-section from the Little Hocking WA well field in Ohio, through the Ohio River and across the DuPont facility, is presented in Figure 4. This cross-section shows the floodplain and terrace surfaces, the Holocene silt and clay overbank deposits overlying the Pleistocene sand and gravel outwash deposits and the re-worked Pleistocene alluvium in the center of the river valley. The alluvial terrace deposits are underlain by a flat, river-scoured bedrock surface of the Dunkard Group that rises steeply and forms the valley walls to the North of Little Hocking Water Association and to the south of the DuPont facility (Figure 3).

2.3 Hydrogeology

Groundwater supplies in the region are obtained from the Dunkard Group bedrock and Ohio River alluvial terrace deposits. The saturated portion of the Ohio River alluvial terrace deposits comprise the principal regional aquifer used for water supply purposes. Production wells completed in this aquifer have been known to yield up to 500 gallons per minute (gpm) (Schultz, 1984). Based on these high yields, numerous industrial and commercial water supply companies obtain water from the alluvial aquifer.

The Holocene silts and clays support perched groundwater zones. Along the southern riverbank at the DuPont plant site on Washington Bottom, are seven monitoring wells that are completed in this perched groundwater zone. Groundwater elevations for these monitoring wells are typically 6 to 18 feet higher than elevations measured in monitoring wells completed in the underlying primary site water-table aquifer, which is significantly depressed as a results of pumping by DuPont and GE. During the February 2002 synoptic groundwater level event, groundwater elevations in the perched water table at the site ranged from 571.91 feet above mean sea level (MSL) to 582.09 feet MSL (Figure 5). Groundwater elevations in the underlying primary site water-table aquifer ranged from 558.24 to 566.61 feet MSL.

The Ohio River Alluvial Aquifer, which is the primary water-table aquifer in the area, occurs at a depth of about 60 to 70 feet below ground surface at the DuPont plant site. The saturated zone is approximately 30 to 40 feet thick, extending approximately to the surface of the underlying Dunkard Group bedrock. Numerous pumping tests have been completed in the alluvial aquifer in the Washington Bottom area as part of water supply investigations. The hydraulic conductivity of the alluvial aquifer in the area typically ranges from 100 to 300 ft./d. In contrast, the hydraulic conductivity of the underlying Dunkard Group bedrock aquifer is typically between 0.05 and 5 ft./d (see Section 4.3.1).

Natural recharge to the alluvial aquifer comes from various sources, including:

- Infiltration of precipitation falling directly on the alluvium
- Lateral movement of the river water through the alluvium
- Seepage from stream tributaries that discharge to the Ohio River
- Surface run-off from the outcrop areas of the Dunkard Group, which forms steep slopes adjacent to the uppermost Pleistocene terrace.

3.0 PRIMARY DATA SOURCES

Data was obtained from numerous sources for use in revising the Washington Works groundwater flow model. These sources and the nature of the data obtained from each source are summarized in Table 1 below.

Table 1. Primary Data Sources for the Groundwater Flow Model.

Data Source	Data Type(s)
DuPont Washington Works RCRA Facility Investigation Report, DuPont CRG, 1999	Well and soil boring logs Groundwater elevation data Aquifer testing results
Hydrogeologic Evaluation for Additional Water Supply from Blennerhassett Island, Leggette, Brashears & Graham, Inc., 1986	Well logs Aquifer testing results
Blennerhassett Island Water Supply Well Drilling and Test Pumping, Burgess & Niple, Ltd., 1988	Well logs Aquifer testing results Grain size analysis results
Washington Works Preliminary Hydrogeologic Assessment, DuPont, 1991	Well and soil boring logs Aquifer hydraulic conductivity data
RCRA Facility Investigation Report, Shell Kraton Plant, Belpre, Ohio, Shell Chemical Company, 1999	Well and soil boring logs Aquifer hydraulic conductivity data
Geologic History of the Lower Terraces and Floodplains of the Upper Ohio River Valley, West Virginia Geological Survey Open File Report 8903, Simard, 1989	Lithology, thickness, and depositional history of the Ohio River alluvial sediments Historical low water levels of the Ohio River Terrace ages and elevations
Aquifer-Characteristics Data for West Virginia, USGS Water-Resources Investigtions Report 01-4036, Kozar and Mathes, 2001	Aquifer hydraulic conductivity data Estimated recharge rates
Well Head Protection Plan, Little Hocking Water Association, 1996	Well logs Aquifer hydraulic conductivity data

Well Head Protection Area Survey, Lubeck Public Service District, 1998	Well logs Aquifer testing results
Geotechnical Boring Logs, Planned 892 Corridor, Burgess & Niple, 2001	Lithologic descriptions
Geotechnical Boring Logs, Planned Rt. 50 Corridor D over Ohio River and Blennerhassett Island, Michael Baker Jr., Inc., 2002	Lithologic descriptions
Ohio River Bathymetric Data, ACOE, 2002	Ohio River water depth and bed elevations
Monthly Operation Reports for Lubeck PSD, Little Hocking WA, and City of Belpre	Daily pumping rates
DuPont and Little Hocking Pumping Rate Data	Hourly or daily rates from days of synoptic water measurements
Well Logs from Shell and GE Sites	Lithologic descriptions
Synoptic Groundwater Levels from February 2, 2002 and August 21, 2002	Groundwater elevations at Lubeck, GE, DuPont plant, Blenn. Isle., Little Hocking, Shell

4.0 MODEL SET-UP

Groundwater flow in the Ohio River Alluvial Aquifer at the DuPont Washington Works facility and the surrounding area was simulated using United States Geological Survey's MODular Groundwater FLOW modeling code (MODFLOW, McDonald and Harbaugh, 1984). MODFLOW was selected because of its wide acceptance within the industry as well as its versatility in simulating various types of complex groundwater flow boundaries. The groundwater model was constructed and calibrated using Groundwater Vistas (v. 3.36), a graphical pre- and post-processor that interfaces with MODFLOW, published by Environmental Simulations, Inc. (ESI).

4.1 Model Domain and Discretization

The Washington Works Groundwater Model domain covers an area of 39.5 square miles, extending 41,568 feet east-west and 26,394 feet north-south. The origin of the finite difference grid is located at UTM Coordinates of 4,341,000 northing and 437,800 easting (UTM, NAD 27 meters). The finite difference model grid is shown on Figure 6.

The model domain was discretized as follows:

- 153 rows by 235 columns
- 3 layers
- 107,865 cells (69,705 active cells)
- Grid spacing: 25 m to 100 m (82 ft. to 328 ft.)

The Ohio River Alluvial Aquifer is represented in the model by layers 1 and 2, while the bedrock aquifer (minor aquifer) is simulated as layer 3. The vertical discretization and hydrostratigraphic units simulated in each layer is summarized in Table 2 below.

Table 2. Finite-Difference Grid Vertical Discretization.

Model Layer	Top Elevation (ft. above MSL)	Bottom Elevation (ft. above MSL)	Hydrostratigraphic Units Represented
Layer 1	Variable – based on topography	560	Fine-grained Holocene sediments Pleistocene Sands and Gravels Bedrock - Dunkard Group
Layer 2	560	535	Pleistocene Sands and Gravels Re-worked Pleistocene Sands and Gravels – main river channel Re-worked Pleistocene Sands and Gravels – Blennerhassett Island Bedrock - Dunkard Group
Layer 3	535	500	Bedrock - Dunkard Group

ASH020289

EID630717

The base of layer 1 is set at an elevation of 560 ft. above MSL throughout the model layer. This elevation corresponds approximately to the elevation of the contact between the fine-grained Holocene sediments and the underlying Pleistocene sand and gravel beneath the Holocene floodplains. The top of layer 2 coincides with the base of layer 1. The base of layer 2, which is also constant throughout the model, is set at an elevation of 535 ft. above MSL. This elevation corresponds approximately to the elevation of the contact between the Pleistocene sand and gravel and the underlying shales of the Dunkard Group (bedrock) within the river valley. These contact elevations are based on well and soil boring logs from the DuPont Washington Works plant site, Blennerhassett Island, and Little Hocking WA (Figure 4).

4.2 Boundary Conditions

Under normal stress conditions, the alluvial aquifer would be expected to discharge to the Ohio River with infiltration being the predominant source of recharge to the aquifer. Due to the high volume of groundwater pumping from the alluvial aquifer along this reach of the river, the Ohio River is the main source of recharge to the alluvium within the area of the model domain while infiltration is a secondary recharge source. Correspondingly, discharge of groundwater from the alluvial aquifer within the area of the model domain occurs primarily through the numerous industrial and pubic supply wells. Minor volumes of groundwater recharge and discharge to the alluvial aquifer along several minor surface water features.

The treatment of these boundary conditions in the groundwater flow model is described in the following sections. The model boundary conditions are shown in Figure 7.

4.2.1 No Flow Boundaries

Many of the cells within the model domain are set as inactive (no flow cells). These cells are in areas of the domain where the alluvium is absent and the low permeability shales of the bedrock are present exclusively. The area of bedrock immediately surrounding the alluvial aquifer, both adjacent and below the alluvium, is included as active cells within the model to discretely simulate recharge to the alluvial aquifer from the bedrock.

The area of active bedrock cells laterally surrounding the alluvial aquifer was delineated based on the estimated locations of groundwater divides within the bedrock aquifer. The locations of the divides were estimated from surface topography.

Additional no flow cells were assigned to the center of the Ohio River in model layer 1 where the river bed elevation was below the base of that layer (560 ft. MSL). River bed elevation in each model cell was interpolated from Ohio River bathymetric data (US ACOE, 2002)

4.2.2 Ohio River

The Ohio River is simulated in the model as a MODFLOW river boundary. River boundary cells were set within the model domain based on the current river channel width and riverbed elevation. The river boundary cells representing the Ohio River were assigned to either model layer 1 or 2, depending on the elevation of the riverbed at the center of each model cell. Where the river bed elevation was below the base of layer 1 (560 ft. MSL), the river boundary was assigned to layer 2 and the overlying cell in layer 1 was set as a no flow cell (inactive) as previously described.

River boundaries allow the simulation of groundwater recharge or discharge on the basis of the gradient between the predicted groundwater head surrounding the river cell and the specified river stage elevation. The volumetric rate of groundwater flow across the boundary is governed by the hydraulic gradient between the groundwater head and the river stage and the hydraulic conductance of the riverbed material. The conductance of the riverbed is calculated for each river cell independently, according to the following formula:

$$C_{RIV} = KLW/M$$

Where:

C_{RIV} = hydraulic conductance of the river-aquifer interconnection

K = hydraulic conductivity of the riverbed material

L = length of the riverbed within the model cell

W = width of the riverbed within the model cell

M = thickness of the riverbed within the model cell

Because entire model cells are contained within the Ohio River, the length and width of the riverbed within each river boundary cell was taken to be the length and width of the model grid cell. The thickness of the riverbed was assumed to be 5 feet. The hydraulic conductivity of the riverbed material, which was adjusted during model calibration, varied depending upon the nature of the geologic materials that the river cell was founded upon (riverbed K for river cells overlying Holocene silt and clay were lower than those overlying Pleistocene sand and gravel). The final riverbed hydraulic conductivity values for river cells are summarized in Table 3 below.

Table 3. Riverbed Hydraulic Conductivity Values.

Geologic Materials Under Riverbed	Hydraulic Conductivity of Riverbed (ft./d)
Holocene alluvium – silt, clay, fine sand	0.1
Re-worked Pleistocene alluvium – sand, gravel, silt	0.3
Re-worked Pleistocene alluvium at west end of Blennerhassett Island	30

The normal pool elevation for this reach of the Ohio River in 582 ft. above MSL. River elevations measured at the Little Hocking WA and Shell Kraton plant on August 21, 2002 were 582.24 and 582.05, respectively. The river elevation should be higher at the Shell Kraton plant than at Little Hocking WA, which is down-stream, indicating that there is some error in one or both of these measurements. Therefore, the normal pool elevation of 582 ft above MSL was used as the river stage elevation in the groundwater flow model. A constant river elevation was used throughout the model domain (e.g., no stream fall was simulated) due to river damming, which has led to relatively insignificant change in river stage elevation within the model domain.

4.2.3 Minor Surface Water Features

Numerous minor surface water features occur within the bedrock outcrop areas as well as on the alluvial terrace surfaces within the model domain. The majority of these features are ephemeral streams in which the flow is limited primarily to storm water run-off. The stream reaches within the bedrock outcrop area are included in the model as MODFLOW drain boundaries.

This boundary type is appropriate for simulating the ephemeral streams in the bedrock areas, which are minor discharge points for the bedrock aquifer but do not contribute significant recharge. Drain boundaries allow the simulation of groundwater discharge on the basis of gradient between the predicted head surrounding the drain and the specified drain elevation (i.e., the surface water elevation). Similar to river boundaries described previously, the rate of flow across the boundary is governed by the hydraulic gradient between the surrounding groundwater head and the drain stage elevation and the hydraulic conductance of the drain bed material (streambed). Contrary to river boundaries, drain boundaries will not contribute positive flow into the model domain under inward gradient conditions (e.g., if the surrounding heads are lower than the specified boundary head). The drain elevation assigned to each drain boundary cell was based on the topographic elevation along the stream at the center of the cell. The drain conductance in each boundary cell was calculated using estimated stream dimensions (length, width and bed thickness) and the streambed hydraulic conductivity. A nominal streambed hydraulic conductivity of 1 ft. / d was used so as not restrict groundwater discharge along these boundaries.

Three perennial streams are present within the model domain. These streams include Sandy Creek near Lubeck PSD, an unnamed stream across the Ohio River from Lubeck, and an unnamed stream that flows through the Shell Kraton facility on the north side of the Ohio River near Blennerhassett Island. It is likely that each of these streams provides some recharge to the alluvial aquifer and has some influence on the local groundwater elevations. Therefore, these streams were simulated as MODFLOW river boundaries to allow for the simulation of this recharge component. The river boundary elevation in each cell was based on the topographic elevation along the stream. The stream conductance in each river boundary cell was calculated using estimated stream dimensions (length, width and bed thickness) and a streambed hydraulic conductivity of 0.1 ft. / d, which is appropriate for the Holocene streambed sediments.

4.2.4 Pumping Wells

A total of 50 industrial and public water supply wells are located within the model domain. These wells, which are shown on Figure 8, are located at the following sites:

- GE (14 wells)
- DuPont Washington Works Plant (13 wells)
- Blennerhassett Island (12 wells)
- Lubeck PSD (6 wells)
- Little Hocking WA (4 wells)
- City of Belpre (1 well)

Forty-four of these wells were actively pumping during the collection of synoptic groundwater elevation measurements used for model calibration. Therefore, pumping is simulated at these 44 wells in the groundwater flow model. The pumping wells, which are all completed in the lower portion of the alluvial aquifer, are simulated in layer 2 of the model.

In most cases, pumping rates (ft^3/d) used in the model were calculated from total daily flows on February 02, 2002 (day of synoptic groundwater level measurements), assuming continuous operation. The exception is pumping rates for Little Hocking WA wells, which were not pumping during the collection of synoptic groundwater levels on February 02. Additional groundwater level measurements were collected on August 21, 2002 while the Little Hocking pumping wells were active (See Section 5.1 Calibration Strategy). Therefore, pumping rates for these wells were calculated from hourly system flows on August 21, 2002.

The majority of the DuPont water supply wells are monitored individually, including the East Well Field wells (331 to 337), Blennerhassett Island wells (435 to 446) and the Ranney collector well. The pumping rates for these wells were calculated from the total daily flow of each well. Due to model convergence problems associated with model cells going dry around groups of closely-spaced pumping wells, the individual rates for the East Well Field wells were totaled and re-apportioned equally among the seven wells. The DuPont Ranney collector well, which includes the central well and 6 lateral collector wells (horizontal), was simulated in the model as 5 individual wells with the pumping rate apportioned equally between them. The location of the 5 wells used to simulate the Ranney collector was based on the actual orientation and length of the 5 lateral collectors.

Flow rates are not monitored at individual wells in the DuPont-Lubeck Well Field. Thus the total flow rate for the field was calculated from the total daily flow and apportioned equally among the 5 wells (DL-1 to DL-5).

Total system abstraction rates for the Lubeck PSD and the City of Belpre were obtained from Monthly Operation Reports for these supply systems, which were provided by the West Virginia Department of Environmental Protection or Ohio Environmental Protection Agency (OHEPA). The total system flow rate for each system was calculated from the total daily abstraction and apportioned equally between the pumping wells.

Hourly flow rates for Little Hocking WA were provided by OHEPA. Flow rates for the time of day during which groundwater levels were measured at Little Hocking were used in the model. The total flow rate for the system was apportioned equally between wells PW-1, PW-2, and PW-3, all of which were pumping when the groundwater levels were measured (August 21,2002).

Pumping rate data for GE was unavailable. Pumping rates for the GE wells were estimated from the "normal" operational pumping rates for individual wells, which were provided for the majority of the wells by GE. The actual pumping rates usually vary somewhat from the "normal" operation rates. Therefore, the pumping rates for several of the GE wells were adjusted during model calibration to roughly match the observed draw-downs.

The pumping rates used in the model are summarized in Table 4 below.

Table 4. Model Pumping Rates.

Site	Well ID	Pumping Rate on Feb 02, 2002 (gpm)	Model Pumping Rate (gpm)
Belpre	Well 1	697	697
Blennerhassett Island	435	465	465
Blennerhassett Island	436	485	485
Blennerhassett Island	437	442	442
Blennerhassett Island	438	297	297
Blennerhassett Island	439	489	489
Blennerhassett Island	440	409	409
Blennerhassett Island	441	323	323
Blennerhassett Island	442	236	236
Blennerhassett Island	443	414	414
Blennerhassett Island	444	444	444
Blennerhassett Island	445	417	417
Blennerhassett Island	446	0	0
DuPont Wash. Works Plant	331	159	165
DuPont Wash. Works Plant	332	69	165
DuPont Wash. Works Plant	333	203	165
DuPont Wash. Works Plant	334	247	165
DuPont Wash. Works Plant	335	147	165
DuPont Wash. Works Plant	336	84	165
DuPont Wash. Works Plant	337	247	165
DuPont Wash. Works Plant	DL-1	69	69
DuPont Wash. Works Plant	DL-2	69	69
DuPont Wash. Works Plant	DL-3	69	69
DuPont Wash. Works Plant	DL-4	69	69

DuPont Wash. Works Plant	DL-5	69	69
DuPont Wash. Works Plant	Gallery Well	0	0
DuPont Wash. Works Plant	Ranney Well 1	885	177
DuPont Wash. Works Plant	Ranney Well 2	--	177
DuPont Wash. Works Plant	Ranney Well 3	--	177
DuPont Wash. Works Plant	Ranney Well 4	--	177
DuPont Wash. Works Plant	Ranney Well 5	--	177
Little Hocking WA[1]	PW-1	287	287
Little Hocking WA[1]	PW-2	287	287
Little Hocking WA[1]	PW-3	287	287
Little Hocking WA[1]	PW-5	0	0
Lubeck PSD	PW-A	111	111
Lubeck PSD	PW-B	111	111
Lubeck PSD	PW-C	111	111
Lubeck PSD	PW-D	111	111
Lubeck PSD	PW-E	111	111
Lubeck PSD	PW-F	111	111
GE[2]	Well 3	200	200
GE[2]	Well 4	130	130
GE[2]	Well 5	0	0
GE[2]	Well 6	150	150
GE[2]	Well 7	NA	0
GE[2]	Well 8	150	150
GE[2]	Well 9	150	150
GE[2]	Well 10	NA	0
GE[2]	Well 11	NA	150
GE[2]	Well 12	60	60
GE[2]	Well 13	NA	100
GE[2]	Well 14	600	350
GE[2]	Well 15	500	350
GE[2]	Well 16	NA	0

1 - All pumping rates are based on measured daily flows from February 02, 2002 except for Little Hocking WA wells where August 21, 2002 hourly rates were used.
2 – Pumping rate data for GE wells was unavailable. Pumping rates for GE wells were estimated from design capacities and adjusted during model calibration.

4.3 Main Input Values

4.3.1 Hydraulic Conductivity

Distribution of hydraulic conductivity values used in the model was based on predicted sub-surface distribution of Holocene and Pleistocene aged alluvial sediments and depositional history of those sediments as described in Section 2.2 Site Geology. Model layer 1 was discretized vertically such that all fine-grained Holocene sediments occur within this model layer (See Section 4.1). The vertical discretization of model layer 2 was such that only the coarser grained Pleistocene sediments, which underlie the Holocene sediments and overlie the bedrock, occur within this model layer. The top of model layer 3 coincides with the estimated elevation of the top of the bedrock surface underlying the alluvium. Hydraulic conductivity zonation used in the model is shown in Figure 9.

The lateral distribution of hydraulic conductivity values in each model layer (zonation) reflects the predicted sub-surface distribution of alluvial sediments based on the terrace surface ages as previously described in Section 2.2. Areas of layer 1 that underlie Holocene aged floodplains in the central portion of the river valley were assigned hydraulic conductivity values appropriate for the silt and clay overbank deposits, which occur in the shallow sub-surface beneath the floodplains. Areas in both layer 1 and layer 2 underlying the higher Pliestocene-aged terraces were assigned conductivity values appropriate for the coarse sand and gravel glacial outwash deposits, which occur in the sub-surface in these areas. The areas of layer 2 beneath the existing Ohio River channel were assigned a lower conductivity than the surrounding Pleistocene sediments to account for the significant degree of re-working of the Pliestocene sediments and contribution of additional fines which has occurred in the center of the river valley. Hydraulic conductivity values assigned to model layer 3 were appropriate for the shales and sandstones of the Dunkard Group.

A range of appropriate hydraulic conductivity values was determined for each of the geologic units simulated in the flow model from available aquifer testing results and published literature values. Results from numerous aquifer pumping tests from water supply wells completed in the coarse-grained Pleistocene sand and gravels were considered in determining the appropriate range of values for these sediments. The appropriate range for the other geologic units (Holocene sediments, re-worked Pleistocene sediments, and bedrock) were estimated from published literature values. The conductivity value for each of the geologic units was adjusted during model calibration, but maintained within the range of conductivity values deemed appropriate for the unit. The range of appropriate hydraulic conductivity values for each geologic unit, the source of the conductivity data used, and the conductivity values assigned to each geologic unit in the groundwater flow model are presented in Table 5 below.

Table 5. Aquifer Hydraulic Conductivity Values.

Geologic Unit	Description	Range of K Values (ft./d.)				Model K Value (ft./d.)	Data Source(s)
		Number of Results	Min	Max	Geometric Mean		
Holocene Alluvial Sediments	Interbedded and laminated silt, clay, and fine sand	--	0.03	2.8	--	Kx,Ky = 1.0 Kv = 0.01	4
Pleistocene Alluvial Sediments	Coarse-grained sand and gravel	37	35	871	146	Kx,Ky = 300 Kv = 150	1, 2, 3, 6, 7, 8, 9
Pliestocene Sediments Underlying Blennerhassett Island	Coarse-grained sand and gravel	5	124	374	235	Kx,Ky = 200 Kv = 100	1, 6
Re-worked Pleistocene Alluvial Sediments	Interbedded sand and gravel with silt	--	2.8	284	--	Kx,Ky = 30 Kv = 3	4
Dunkard Group – Bedrock[1]	Interbedded shale and sandstone with minor limestone and coal beds	3	0.02	5.6	0.2	Kx,Ky = 0.1 Kv = 1×10^{-4}	5

Notes:

1. Results from Wood County only were used in the analysis. Hydraulic conductivity calculated from reported transmissivity and well depth.

Data Sources:

1. Burgess & Niple, Ltd., 1988
2. DuPont, 1991
3. DuPont CRG, 1999
4. Fetter, 1988
5. Kozar and Mathes, 2001
6. Leggette, Brashears & Graham, Inc., 1986
7. Little Hocking Water Association, 1996
8. Lubeck Public Service District, 1998
9. Shell, 1999

ASH020297

EID630725

4.3.2 Recharge

Distribution of recharge values used in the model was based on the predicted distribution of surficial soil types and thicknesses as described in Section 2.2 Site Geology. Pleistocene terraces, Holocene floodplains, and bedrock outcrop areas were assigned differing recharge rates to account for varying infiltration rates that would be anticipated in these areas due to differing soil types and thicknesses. An area of increased recharge was assigned along the outer edges of the Pleistocene terraces adjacent to the bedrock outcrop areas to account for increased infiltration of storm water run-off from the bedrock slopes in these areas. In addition, reduced recharge rates were assigned to large areas of impervious surface cover at the GE and DuPont plant sites. Recharge zonation used in the model is shown in Figure 10.

The recharge rates for the alluvial surfaces were based on estimates made by USGS (M. D. Kozar, oral communication). The rates for bedrock areas were estimated on the basis of topography and soil types present. A low infiltration rate was assigned to the bedrock areas to account for the steep slopes and low permeability of the surficial soils in these areas. Recharge rates were adjusted during model calibration. The rates used in the groundwater flow model are presented in Table 6 below.

Table 6. Model Recharge Rates.

Model Area	Recharge Rate (in. / yr.)
Holocene floodplains	4
Pleistocene terraces	8
Pleistocene terraces along bedrock outcrop	20
Bedrock and areas of impervious surface cover	0.1

5.0 GROUNDWATER MODEL CALIBRATION

5.1 Calibration Strategy

The steady-state groundwater flow model was calibrated against two sets of synoptic groundwater elevation measurements that were collected specifically for use in model calibration. The first set was collected on February 02, 2002. During this event, groundwater levels were measured in a total of 84 observation wells. Levels were measured at the following sites:

- DuPont Plant (44 wells)
- Blennerhassett Island (8 wells)
- Little Hocking WA (8 wells)
- Lubeck PSD (6 wells)
- GE Plant (13 wells)
- Shell Kraton Plant (5 wells)

It was determined that the pumping wells at Little Hocking WA were inactive at the time of measuring groundwater levels on February 02, 2002. Therefore, a second round of groundwater level measurements was made at the Little Hocking WA site on August 21, 2002 to obtain groundwater elevations for this site under active pumping conditions. Groundwater levels were also measured in selected wells at the DuPont Plant (15 wells) and the Shell Kraton Plant (1 well) for comparison between the two monitoring events.

The extent of seasonal variation in groundwater elevation between the two monitoring events was determined by comparing groundwater elevations from the two events from well MW-11 at the Shell Kraton Plant. This well was used fot the evaluation because it was the only well monitored during both events that was unlikely to be influenced by pumping activities DuPont and Little Hocking WA. The groundwater elevation decreased by 0.55 feet at MW-11 between the February and August monitoring events. This seasonal variation is likely to be insignificant relative the variation in groundwater elevation that occurs in response to changes in pumping rates within the model domain.

Given the small seasonal variation observed in groundwater elevation, the two sets of groundwater elevations were combined and used for model calibration targets (Figure 11). With the exception of those from Little Hocking WA, groundwater elevations from February 02, 2002 were used as the calibration targets in the model. The August 21, 2002 groundwater elevations from the Little Hocking WA site were used as model calibration targets in place of those from February in order to calibrate the model against groundwater elevations at this site under the influence of active pumping. Similarly, pumping rates from February 02, 2002 were used for all pumping wells other than those at Little Hocking WA where the August 21, 2002 rates were used instead (see Section 4.2.4 Pumping Wells).

5.2 Calibration Results

The results of the model calibration indicate that the groundwater flow model is accurately predicting the groundwater heads in areas where groundwater elevation data is available. The overall success of model calibration was measured in terms of the error (residual) between the observed (measured) groundwater elevation or head at each calibration target (observation well) and the head computed by the model at the target location. Calibration target residuals from the calibrated flow model along with a plot of observed versus calculated head are shown in Figure 12. The plot of observed versus computed heads shows a very good correlation between observed and computed head for a regional-scale groundwater flow model.

The success of model calibration can also be demonstrated through statistical analysis of the errors between observed and computed heads (target residuals). One particular measure is the overall residual error expressed as the percentage of the range in observed head, which is calculated as standard deviation of the residuals divided by the observed range in head. In this case, the standard deviation is 9.9% of the observed range. A result of 10% or less is generally considered to represent a good calibration. Table 7 below summarizes the results of the statistical analysis of the target residuals.

Table 7. Statistical Summary of Model Calibration Errors (Residuals).

Statistical Operation	Result
Residual Mean (ft.)	0.104
Residual Standard Deviation (ft.)	3.285
Sum of Squared Residuals (ft^2)	907.491
Absolute Residual Mean (ft.)	2.308
Minimum Residual (ft.)	-9.249
Maximum Residual (ft.)	12.060
Range in Observed Head (ft.)	33.350
Residual Standard Deviation / Range in Observed Head (ft./ft.)	0.099

6.0 MODEL RESULTS

6.1 Mass Balance

The total water balance (mass balance) of the groundwater flow model indicates very little error in the simulation. The total error (total inflow minus total outflow) is less than 0.01 percent. A summary of the mass balance for the groundwater flow model is shown in Table 8 below.

Table 8. Mass Balance Summary.

Component	In	Out
Storage	0	0
Constant Head	0	0
Wells	0	20,818,613
Drains	0	3,947
Recharge	4,343,758	0
River Leakage	17,581,300	1103300
Total	21,925,058	21,925,860
Absolute Error (In – Out)		-802
Percent Discrepancy		-0.0037

6.2 Current Pumping Conditions

The groundwater flow model is calibrated to observed groundwater elevations under the existing pumping conditions at sites within the model domain (as of February 02, 2002). The computed heads for the calibrated flow model for layers 1, 2 and 3 are shown in Figures 13, 14, and 15, respectively.

With the exception of local areas surrounding major pumping centers, the computed heads within the Pleistocene alluvium in layers 1 and 2 are approximately the same. Computed heads in the Holocene alluvium in layer 1 are slightly higher (less than 1 foot) than in the underlying Pleistocene alluvium. A slight downward gradient is predicted in most areas of the alluvial aquifer in response to pumping from model layer 2. Increased downward gradient is predicted in layer 2 locally around pumping centers.

A groundwater divide is predicted beneath the Ohio River in the Pleistocene alluvium (layer 2). A divide is predicted beneath the main channel and on either side of Blennerhassett Island. The divides separate the areas of significant draw-down centered

ASH020301

EID630729

at DuPont and GE, Blennerhassett Island, and Little Hocking WA from one another. Due to the presence of this divide, no groundwater migration pathway is predicted beneath river in the alluvial aquifer under the current pumping rates. The only exception is at the east end of Blennerhassett Island where the river has not incised as deeply into the underlying Pleistocene alluvium (the entire width of the river boundary remains in layer 1). At this location, a groundwater divide is absent in layer 2 and the cone of depression from Belpre extends southward across the river. Figure 14a shows the approximate extent of the capture zones associated with the DuPont and Little Hocking Pumping systems.

Computed heads in bedrock areas generally decrease from layer 1 to layer 3. An upward gradient from the bedrock to the overlying alluvial aquifer is predicted throughout most of the domain, with the highest gradient predicted near pumping centers. The highest predicted upward gradient is about 9 ft. at Blennerhassett Island.

A groundwater divide is not predicted in the bedrock aquifer beneath the Ohio River. Groundwater flow from Little Hocking WA to the DuPont and GE plant sites is predicted in the bedrock aquifer. However, the bedrock aquifer is simulated discretely in the model in order to provide recharge to the overlying alluvial aquifer. Groundwater elevations in the bedrock aquifer were not calibrated and therefore should be considered an approximation. Simplification of complex stratification of the bedrock aquifer may have resulted in inaccuracies in predicted groundwater elevations in the bedrock aquifer. This simplification has little or no effect on predictions of groundwater flow in alluvium.

The majority of the groundwater in the alluvial aquifer at the DuPont plant site is currently being captured by the on-site pumping activities. Some limited off-site groundwater migration may be occurring in the northwest corner of the DuPont plant site in response to pumping at GE wells 3 and 4.

6.3 No DuPont Pumping

A simulation was run to determine the influence that pumping activities at the DuPont plant and Blennerhassett Island are having on groundwater elevations at surrounding sites. To complete this simulation, pumping wells at the DuPont plant and at Blennerhassett Island were tuned-off while leaving all other pumping well rates as per the calibrated simulation. The predicted heads in model layer 2 for this scenario are shown in Figure 16.

The model predicts an increase in groundwater heads in the central areas of the DuPont and GE plant sites of approximately 15 and 9 ft., respectively. An increase of approximately 2 ft. is predicted at Lubeck PSD.

The model predicts no change in groundwater heads at Little Hocking WA, Shell Kraton, or Belpre would occur in response to cessation in pumping by DuPont. Conversely, this simulation suggests strongly that current pumping activities at the DuPont plant and Blennerhassett Island are not influencing groundwater heads at these sites.

ASH020302

EID630730

6.4 No GE Pumping

Similar to the previously described simulation, a simulation was run to investigate the influence that pumping activities at the GE plant are having on groundwater elevations at surrounding sites. To complete this simulation, pumping wells at the GE plant were tuned-off while leaving all other pumping well rates as per the calibrated simulation. The predicted heads in model layer 2 for this scenario are shown in Figure 17.

The model predicts an increase in groundwater heads in the central areas of the DuPont and GE plant sites of approximately 10 and 16 ft., respectively. An increase of approximately 3.5 ft. is predicted at Lubeck PSD.

Again, the model predicts no change in groundwater heads at Little Hocking WA would occur in response to cessation in pumping by GE.

6.5 No Pumping by DuPont or GE

The previous 2 simulations were combined to investigate the influence that pumping at Little Hocking WA would have on groundwater elevations at Washington Bottom if both DuPont and GE ceased pumping activities. To complete this simulation, pumping wells at the DuPont and GE plant sites were tuned-off while leaving all other pumping well rates as per the calibrated simulation. The predicted heads in model layer 2 for this scenario are shown in Figure 18.

The model predicts an increase in groundwater heads in the central areas of the DuPont and GE plant sites of approximately 22 and 24 ft., respectively, which is equivalent to the amount of draw-down. An increase of approximately 4 ft. is predicted at Lubeck PSD.

Again, the model predicts no change in groundwater heads at Little Hocking WA would occur in response to cessation in pumping by DuPont and GE. However, with no pumping on the south side of the Ohio River, the model predicts that the groundwater divide below the river would be overcome by pumping at Little Hocking WA and the capture zone for that site would extend across the river to the south.

6.6 No Little Hocking WA Pumping

A final simulation was run to determine the influence that pumping activities at the Little Hocking WA are having on groundwater elevations at surrounding sites. To complete this simulation, pumping wells at Little Hocking were tuned-off while leaving all other pumping well rates as per the calibrated simulation. The predicted heads in model layer 2 for this scenario are shown in Figure 19.

The model predicts an increase in groundwater heads in the central area of the Little Hocking well field of approximately 7-ft. An increase in groundwater elevation of about 0.5 ft. is predicted at the Shell Kraton site. No change in groundwater elevation is predicted at Belpre, Blennerhassett Island, the DuPont and GE plant sites, or at Lubeck PSD in response to cessation of pumping at Little Hocking.

Similar to the previous simulation, the model predicts that with no pumping on the north side of the Ohio River, the groundwater divide below the river would be overcome and the DuPont plant capture zone would extend across the river to the north.

7.0 SENSITIVITY ANALYSIS

A sensitivity analysis was completed to determine the sensitivity of the model to uncertainties in the primary input parameters including hydraulic conductivity, recharge, and river boundary conductance. This analysis involved perturbing the input value for a single input parameter by fixed increments and re-running the model. The overall calibration error from each of the sensitivity runs were then evaluated and compared to determine the relative sensitivity of the model to errors in each of the main input parameters.

For each input parameter, multiplication factors of 0.25, 0.75, 1.0, 1.25, and 1.5 were used in the sensitivity analysis.

The input values perturbed during the sensitivity analysis and the relative sensitivity of the model to each value are summarized in Table 9 below. Graphs of the absolute residual mean and mean change in computed head for each input parameter tested during the sensitivity analysis are shown in Figure 20.

The sensitivity analysis indicates that the model is most sensitive to uncertainties in the hydraulic conductivity value assigned to the re-worked Pleistocene alluvium beneath the Ohio River. The reduced conductivity of this unit serves to restrict the flow of groundwater beneath the river and thus strongly influences the response to pumping predicted by the model.

Table 9. Sensitivity Analysis Results.

Input Parameter	Geologic Unit or Area	Relative Model Sensitivity (ranked from 1 [highest] to 10 [lowest])
Hydraulic Conductivity	Holocene alluvium	7
	Pliestocene alluvium	2
	Pliestocene alluvium – Blennerhassett Island	6
	Re-worked Pliestocene alluvium	1
Recharge	Holocene floodplains	10
	Pleistocene terraces	4
	Pleistocene terraces along bedrock outcrop	5
River Boundary Conductance	Holocene alluvium	8
	Re-worked Pleistocene alluvium	3
	Re-worked Pleistocene alluvium at west end of Blennerhassett Island	9

8.0 MODEL CONCLUSIONS

The primary conclusions of the revised Washington Works Groundwater Flow Model are summarized as follows:

- The Ohio River is creating a groundwater divide within the Pleistocene sediments beneath the river. Due to the presence of this divide, no groundwater migration pathway is predicted beneath river in the alluvial aquifer under the current pumping rates at the various pumping centers simulated in the model.
- A groundwater divide is not predicted in the bedrock aquifer beneath the Ohio River. Groundwater flow from Little Hocking WA to the DuPont and GE plant sites is predicted in the bedrock aquifer. However, groundwater elevations in the bedrock aquifer were not calibrated and should be considered an approximation.
- The majority of the groundwater in the alluvial aquifer at the DuPont plant site is currently being captured by the on-site pumping activities. Some limited off-site groundwater migration may be occurring in the northwest corner of the DuPont plant site in response to pumping at GE wells 3 and 4.

9.0 REFERENCES

Michael Baker Jr., Inc. 2002. Geotechnical Boring Logs, Planned Rt. 50 Corridor D over Ohio River and Blennerhassett Island, unpublished.

Burgess & Niple, Ltd. 1988. *Blennerhassett Island Water Supply Well Drilling and Test Pumping*, unpublished report.

Burgess & Niple. 2001. Geotechnical Boring Logs, Planned 892 Corridor, unpublished.

DuPont, 1991. *Washington Works Preliminary Hydrogeologic Assessment*, unpublished report.

DuPont Corporate Remediation Group. 1999. *RCRA Facility Investigation Report, DuPont Washington Works, Washington, West Virginia*, unpublished report.

Fetter, C.W. 1988. *Applied Hydrogeology, Second Edition*. Macmillan Publishing Company, New York, New York, 592 p.

Leggette, Brashears & Graham, Inc. 1986. *Hydrogeologic Evaluation for Additional Water Supply from Blennerhassett Island*, unpublished report.

Kozar, M.D. and M.V. Mathes, 2001. *Aquifer-Characteristics Data for West Virginia.* Water-Resources Investigations Report 01-4036, United States Geological Survey, 74 p.

Little Hocking Water Association. 1996. *Well Head Protection Plan*, unpublished report.

Lubeck Public Service District. 1998. *Well Head Protection Area Survey*, unpublished report.

Shell Chemical Company, 1999, *RCRA Facility Investigation Report, Shell Kraton Plant, Belpre, Ohio*, unpublished report.

Simard, C.M. 1989. *Geologic History of the Lower Terraces and Floodplains of the Upper Ohio River Valley*, Open File Report 8903, West Virginia Geological Survey, 160 p.

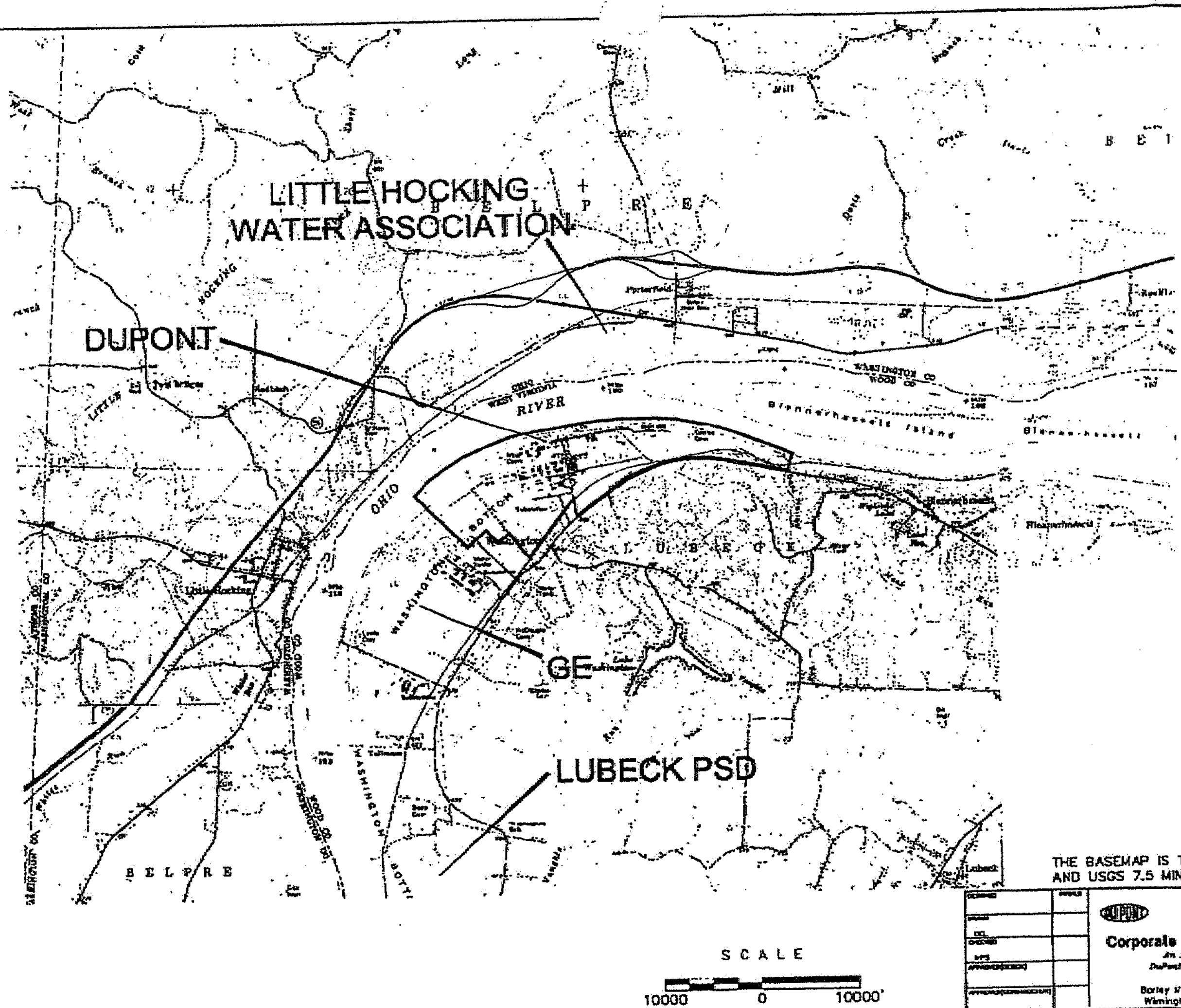
U.S. Army Corps of Engineers. 2002. Ohio River Bathymetric Data, survey date: July 2002, unpublished.

FIGURES

ASH020308

EID630736

FIGURES



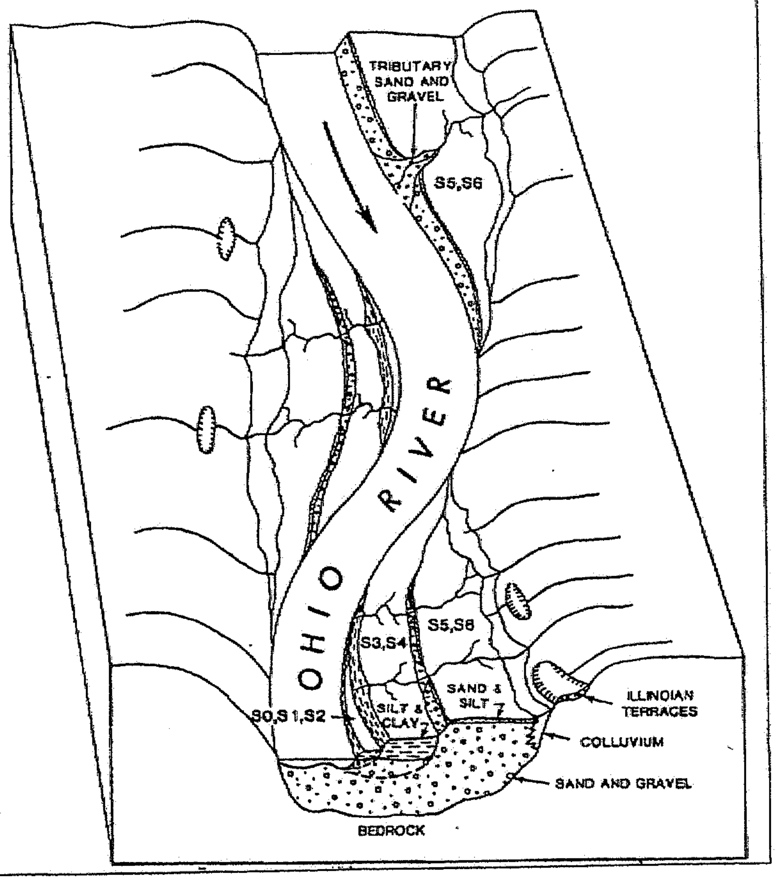
THE BASEMAP IS TAKEN FROM THE BELPRE, OH, LUBECK, WV AND USGS 7.5 MINUTE QUADRANGLE MAPS.

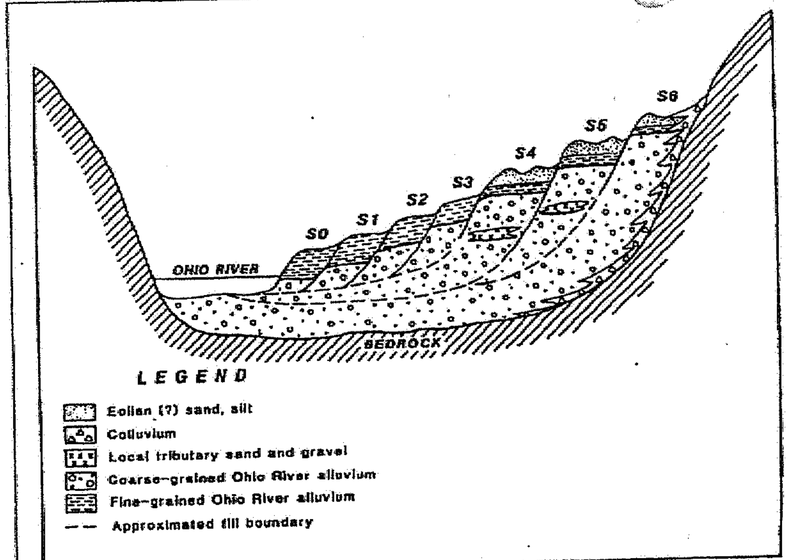
Corporate Remediation Group
An Alliance between DuPont and URS Diamond
Barley Mill Plaza, Building 27
Wilmington, Delaware 19805

SITE LOCATION MAP
DuPont Washington Works
Washington, West Virginia

ASH020310

EID630738





ILLUSTRATIONS TAKEN FROM SIMARD, 1989.

Corporate Remediation Group
An Alliance between DuPont and URS Diamond
Barley Mill Plaza, Building 27
Wilmington, Delaware 19805

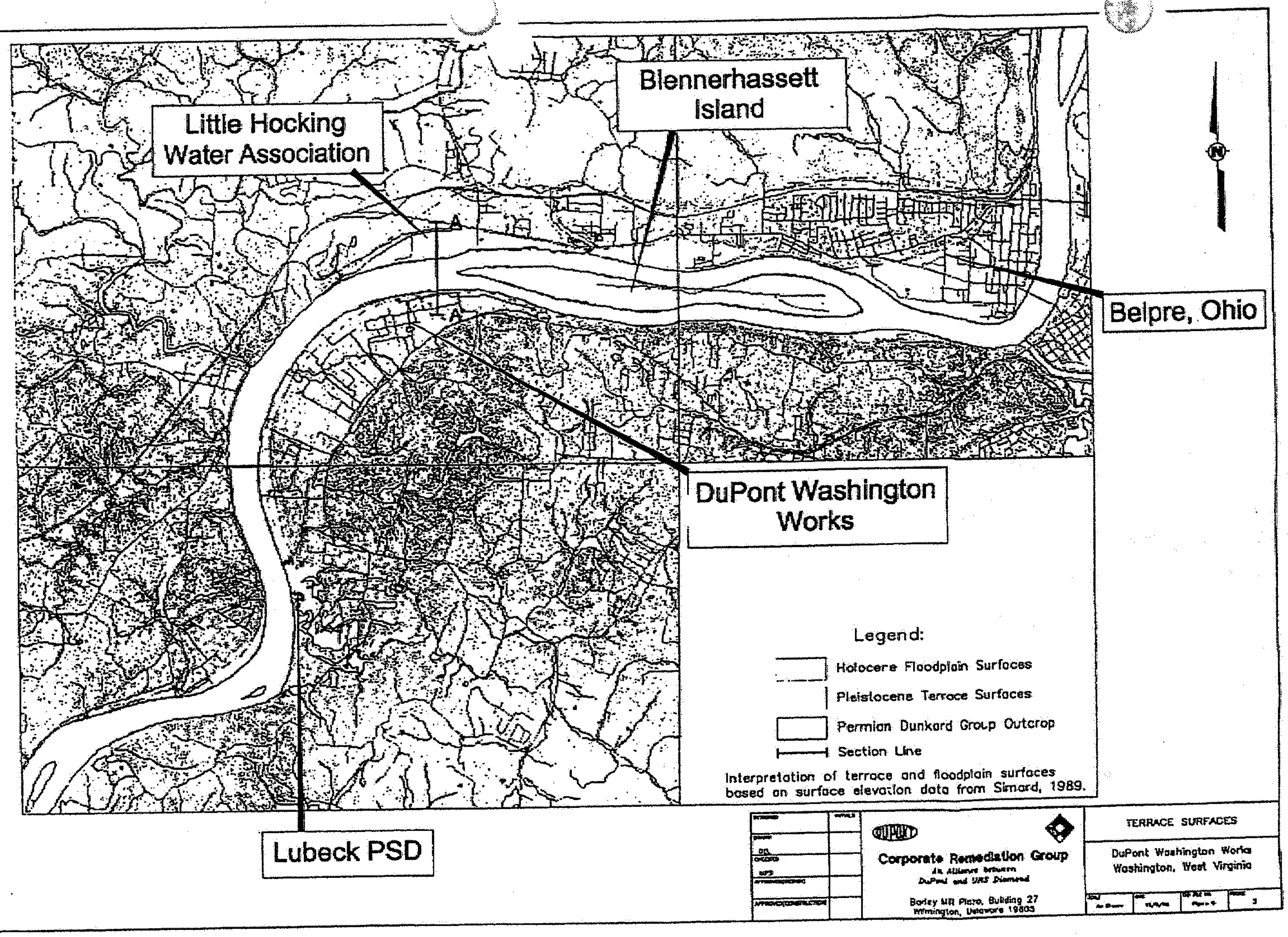
IDEALIZED OHIO RIVER VALLEY CROSS-SECTION AND BLOCK DIAGRAM

DuPont Washington Works
Washington, West Virginia

Figure 4

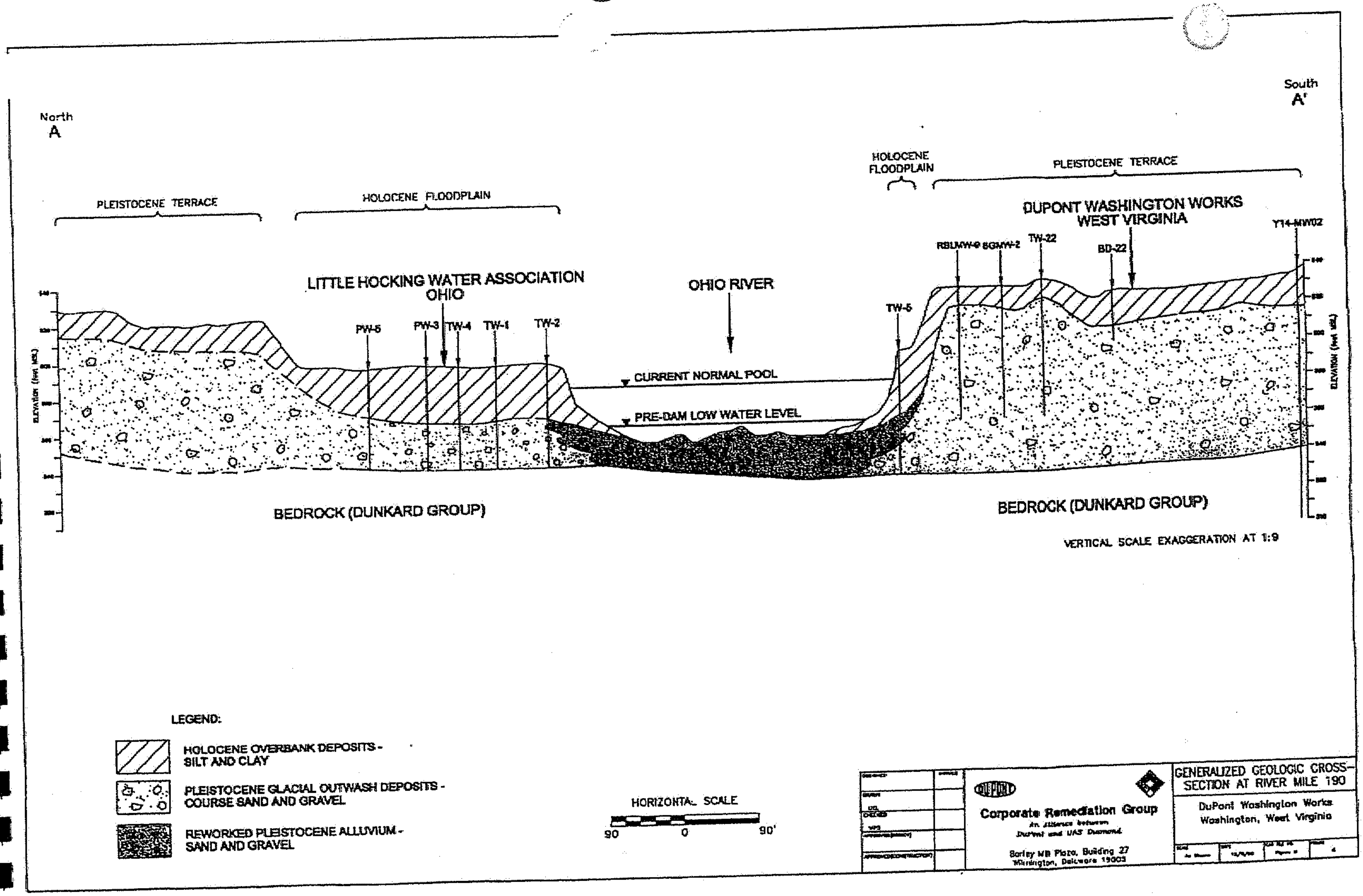
ASH020311

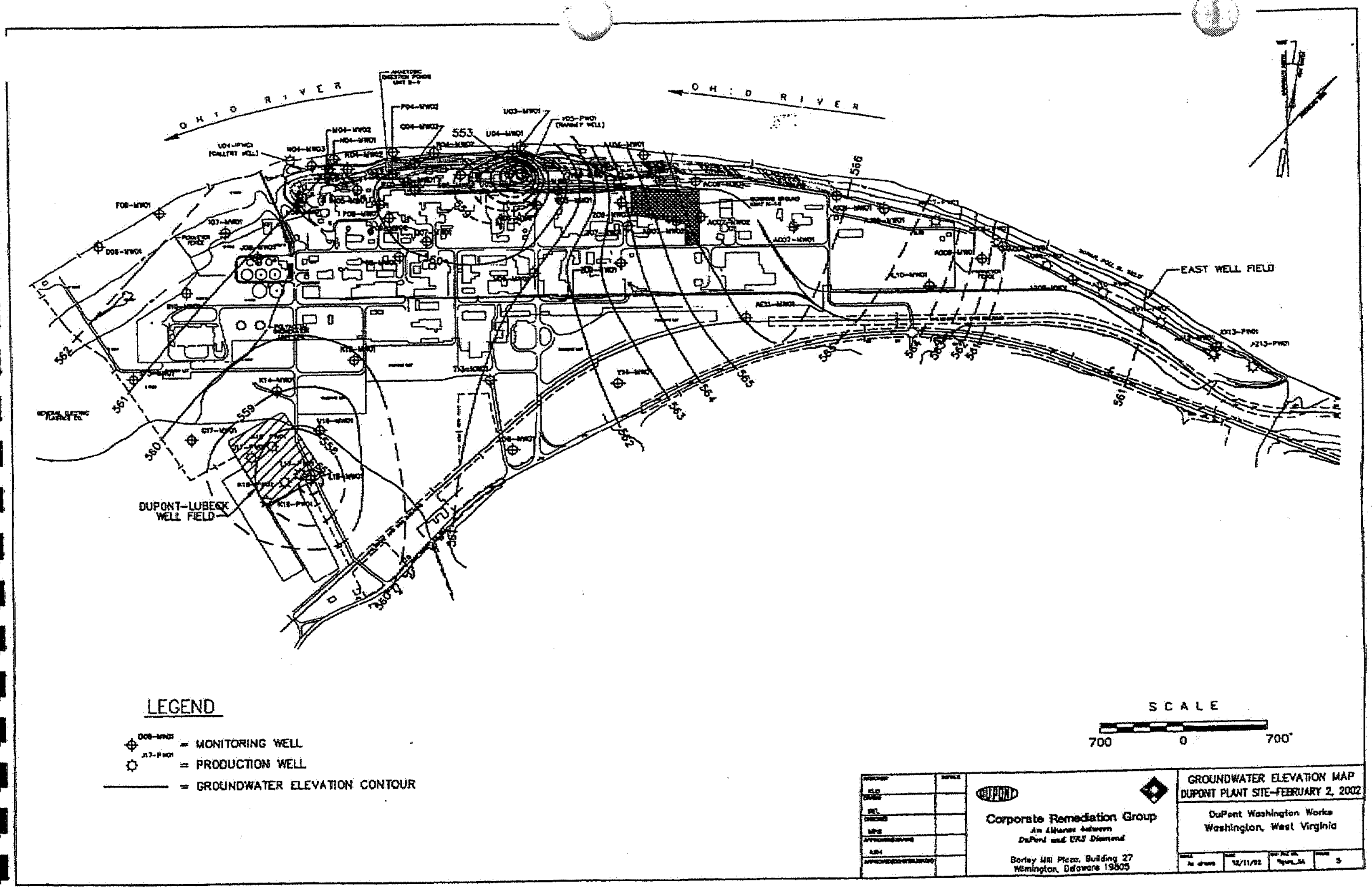
EID630739



ASH020312

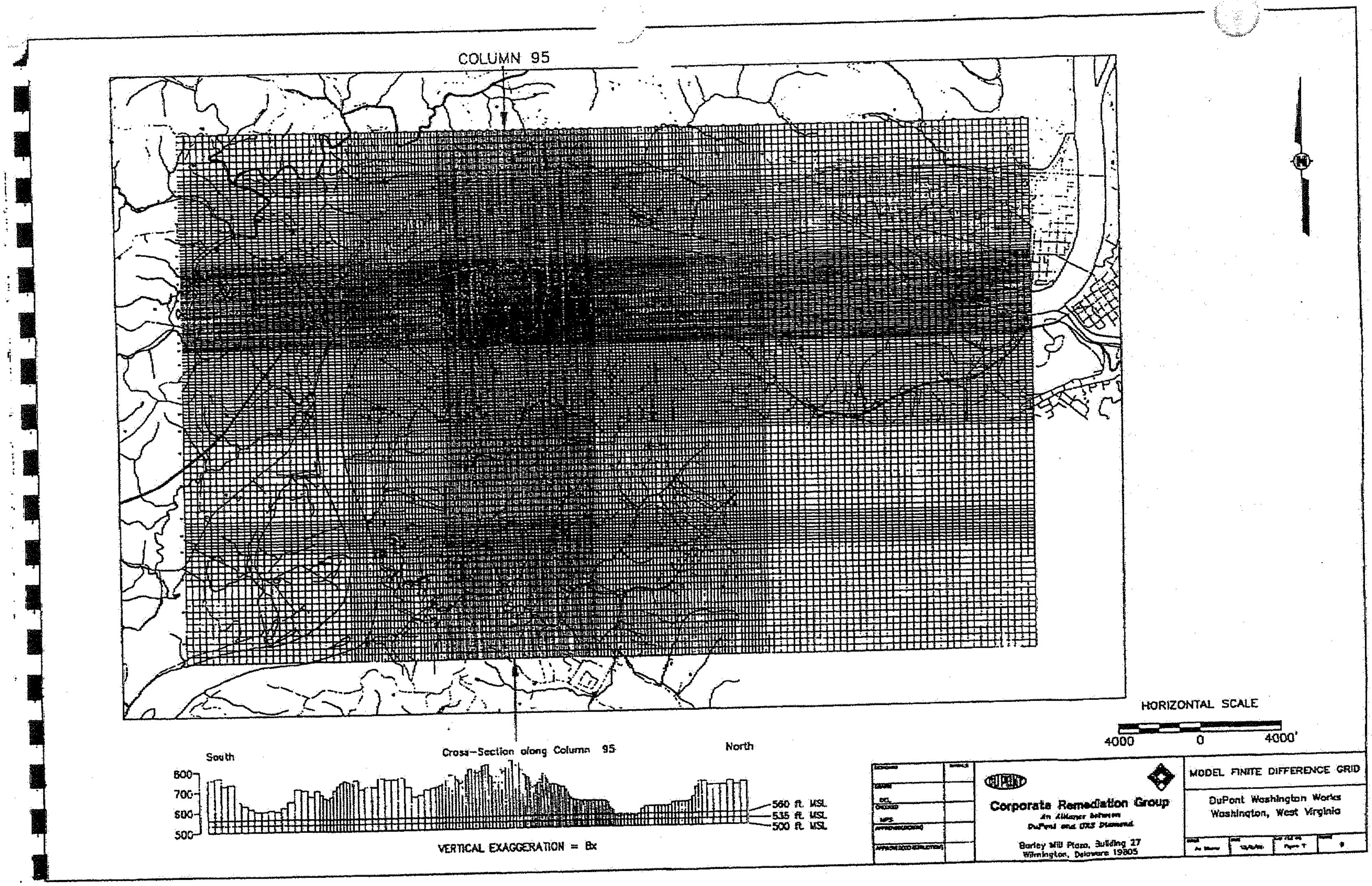
EID630740


North
A
South
A'
PLEISTOCENE TERRACE
HOLOCENE FLOODPLAIN
HOLOCENE FLOODPLAIN
PLEISTOCENE TERRACE
LITTLE HOCKING WATER ASSOCIATION OHIO
OHIO RIVER
DUPONT WASHINGTON WORKS WEST VIRGINIA
PW-5
PW-3
TW-4
TW-1
TW-2
TW-5
RBLMW-9
BGMW-2
TW-22
BD-22
Y14-MW02
CURRENT NORMAL POOL
PRE-DAM LOW WATER LEVEL
BEDROCK (DUNKARD GROUP)
BEDROCK (DUNKARD GROUP)
VERTICAL SCALE EXAGGERATION AT 1:9
LEGEND:
HOLOCENE OVERBANK DEPOSITS - SILT AND CLAY
PLEISTOCENE GLACIAL OUTWASH DEPOSITS - COURSE SAND AND GRAVEL
REWORKED PLEISTOCENE ALLUVIUM - SAND AND GRAVEL
HORIZONTAL SCALE
90
0
90'
Corporate Remediation Group
An Alliance between DuPont and URS Diamond
Barley Mill Plaza, Building 27
Wilmington, Delaware 19805
GENERALIZED GEOLOGIC CROSS-SECTION AT RIVER MILE 190
DuPont Washington Works
Washington, West Virginia



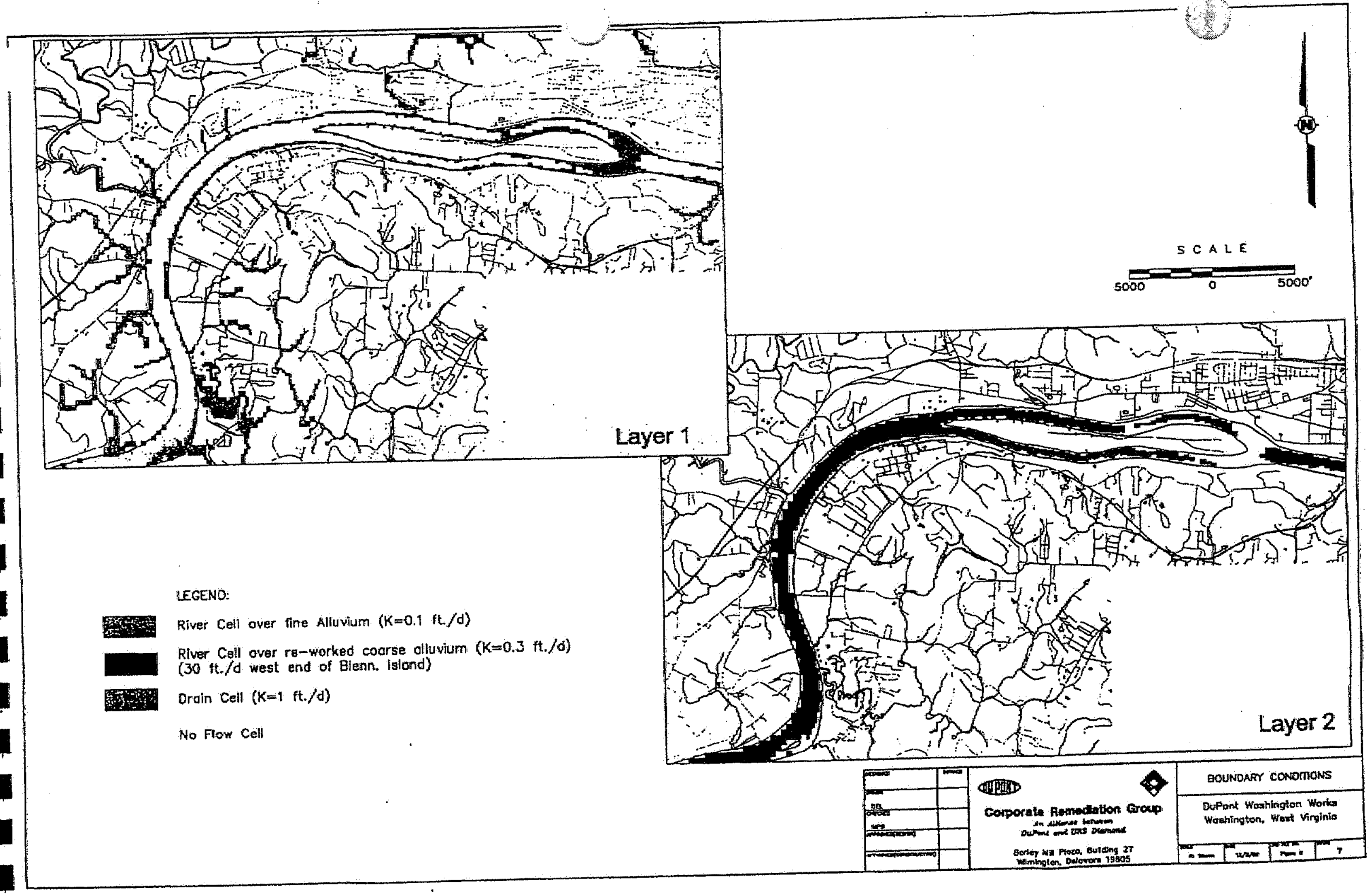
ASH020314

EID630742



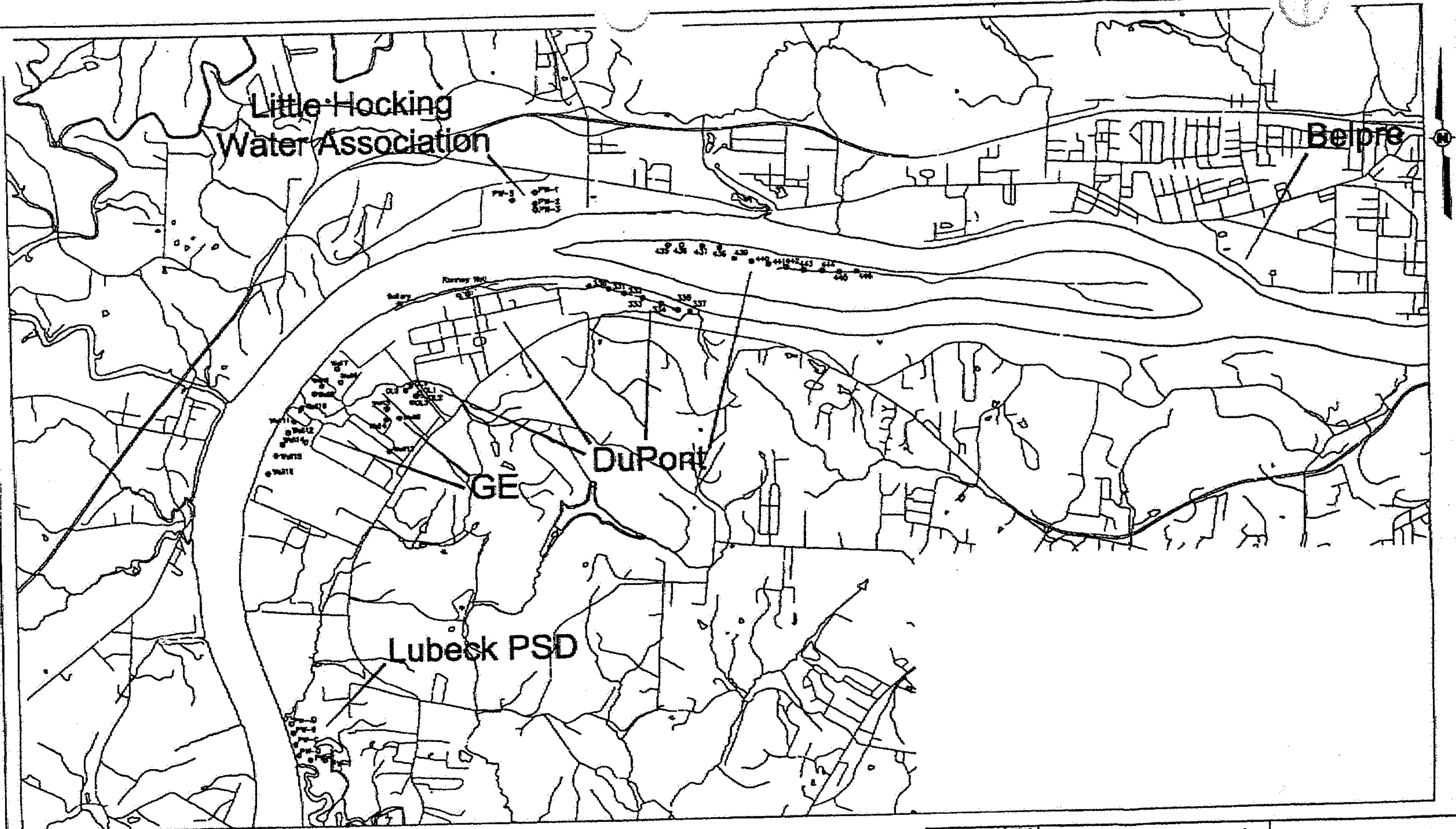
ASH020315

EID630743



ASH020316

EID630744



Site	Total (gpm)
DuPont (exc. Gallery)	6804
GE (estimated)	1750
Little Hocking (August 21, 2002)	860
Lubeck	664
Belpre	697

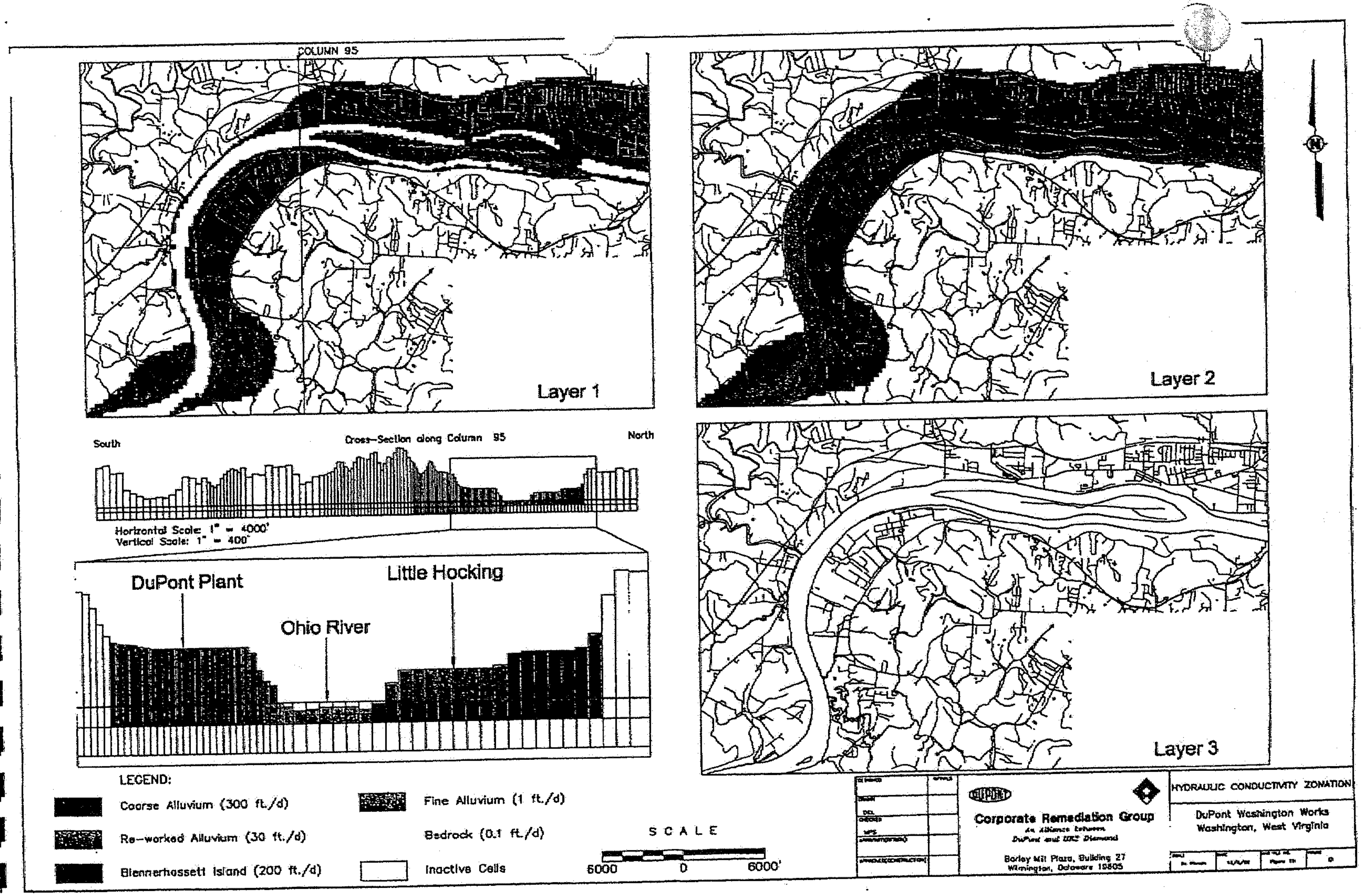
SCALE
2600 0 2600'

DUPONT
Corporate Remediation Group
An Alliance between DuPont and URS Diamond
Barley Mill Plaza, Building 27
Wilmington, Delaware 19805

MODEL PUMPING WELL LOCATIONS
DuPont Washington Works
Washington, West Virginia

ASH020317

EID630745



ASH020318

EID630746

LEGEND:

- Holocene Alluvium (4 in./yr.)
- Pleistocene Alluvium (8 in./yr.)
- Alluvium at bedrock outcrop (20 in./yr.)
- Bedrock/Impervious Cover (0.1 in./yr.)
- Inactive Cells

SCALE

3000 0 3000'

Corporate Remediation Group
An Alliance between DuPont and URS Diamond
Barley Mill Plaza, Building 27
Wilmington, Delaware 19805

RECHARGE ZONATION

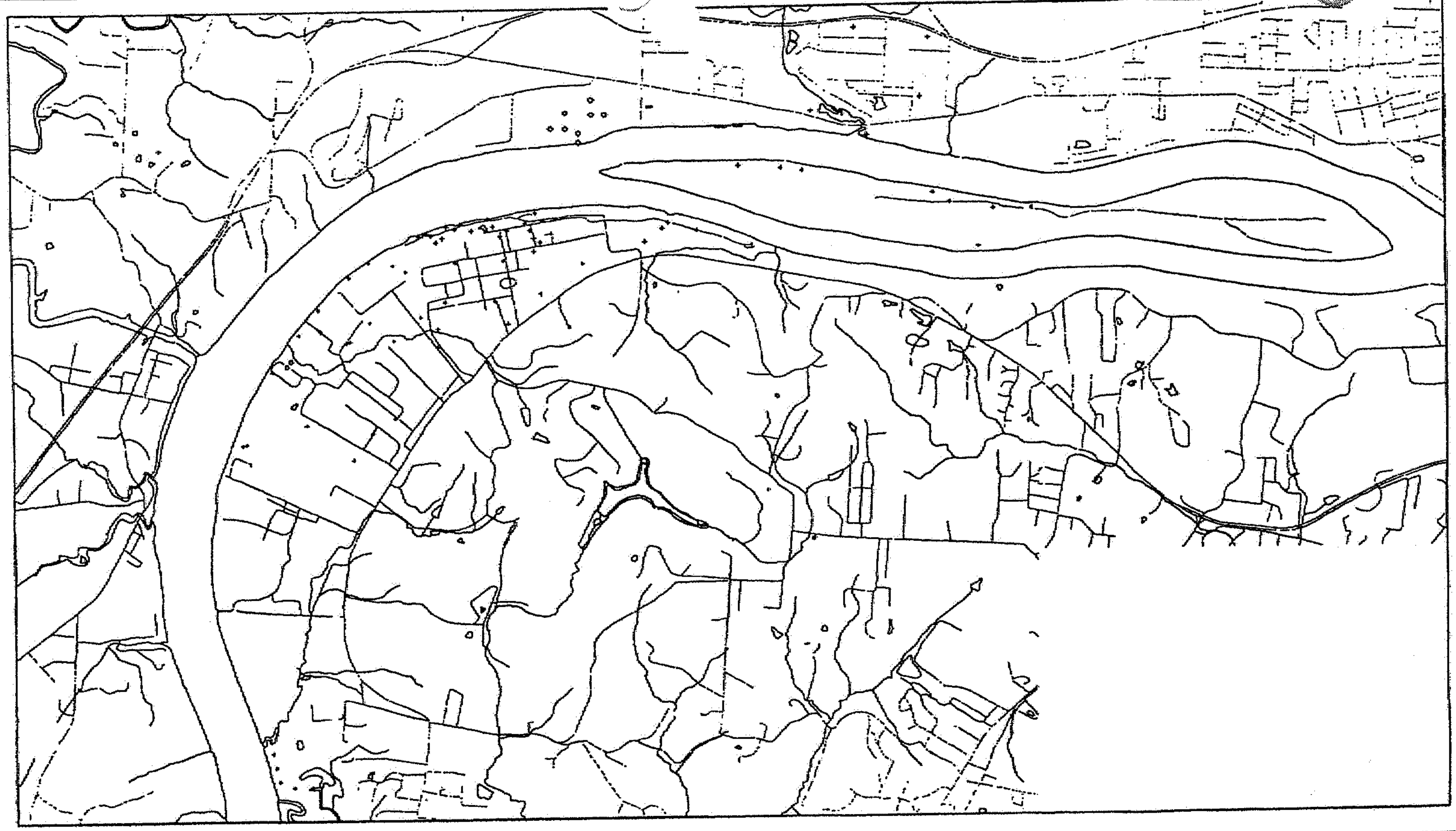
DuPont Washington Works
Washington, West Virginia

Figure 11

10

ASH020319

EID630747



LEGEND:
- + CALIBRATION TARGET – LAYER 1 – FEBRUARY 2, 2002
- + CALIBRATION TARGET – LAYER 2 – FEBRUARY 2, 2002
- ◇ CALIBRATION TARGET – LAYER 2 – AUGUST 21, 2002

SCALE

2200 0 2200'

DUPONT

Corporate Remediation Group

An Alliance between DuPont and URS Diamond

Barley Mill Plaza, Building 27
Wilmington, Delaware 19805

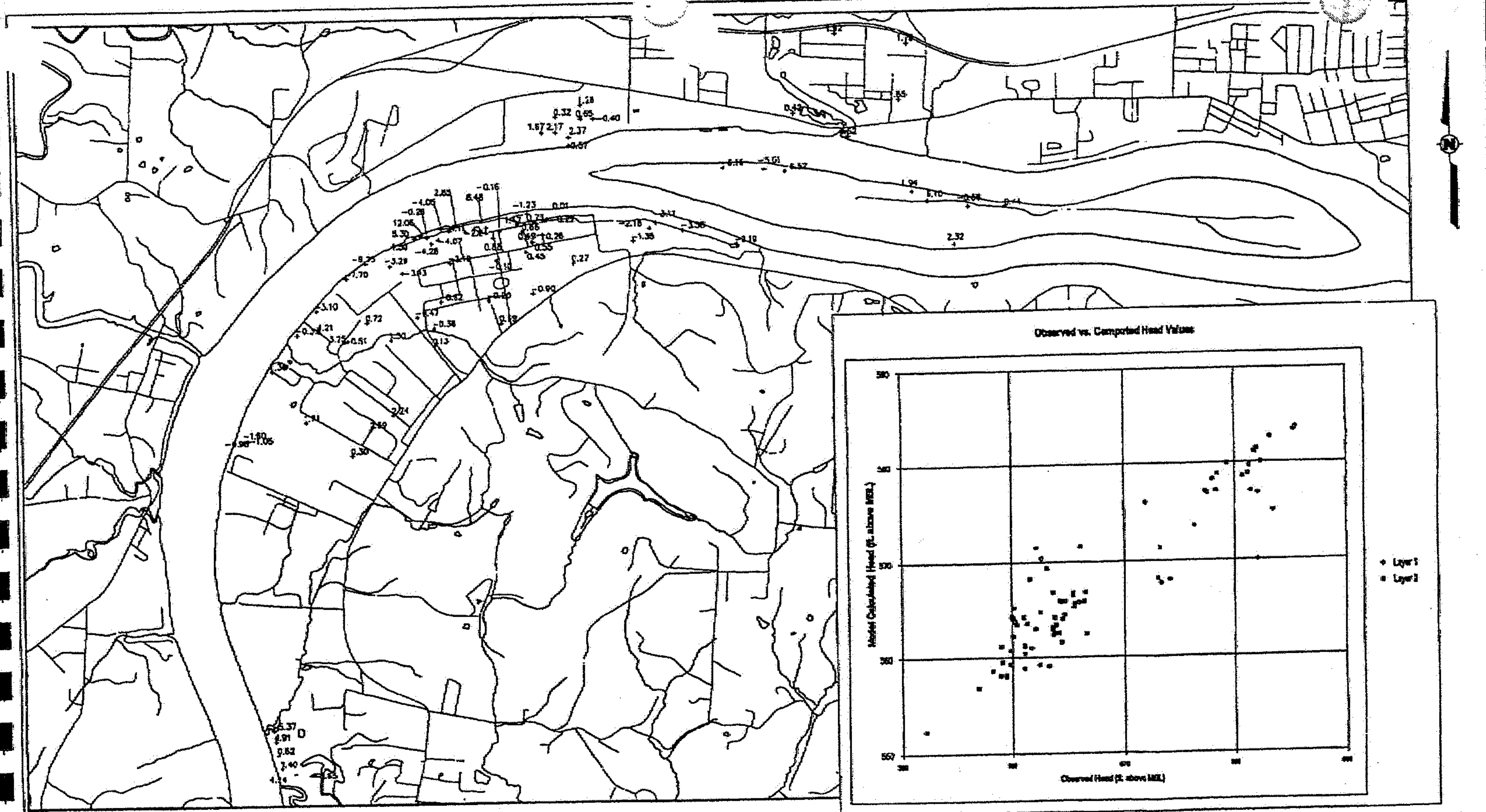
SYNOPTIC WATER LEVEL MEASUREMENT LOCATIONS

DuPont Washington Works
Washington, West Virginia

11

ASH020320

EID630748



Calibration Error Statistical Summary

Residual Mean	0.104
Residual Standard Deviation	3.285
Sum of Squares	907.491
Absolute Residual Mean	2.308
Minimum Residual	−9.249
Maximum Residual	12.080
Range in Observed Head	33.350
Standard Dev./Obs Range	0.099

LEGEND:

LAYER 1 TARGET LOCATION AND RESIDUAL

LAYER 2 TARGET LOCATION AND RESIDUAL

SCALE

2200 0 2200'

Corporate Remediation Group

An Alliance between DuPont and URS Diamond

Barley Mill Plaza, Building 27
Wilmington, Delaware 19805

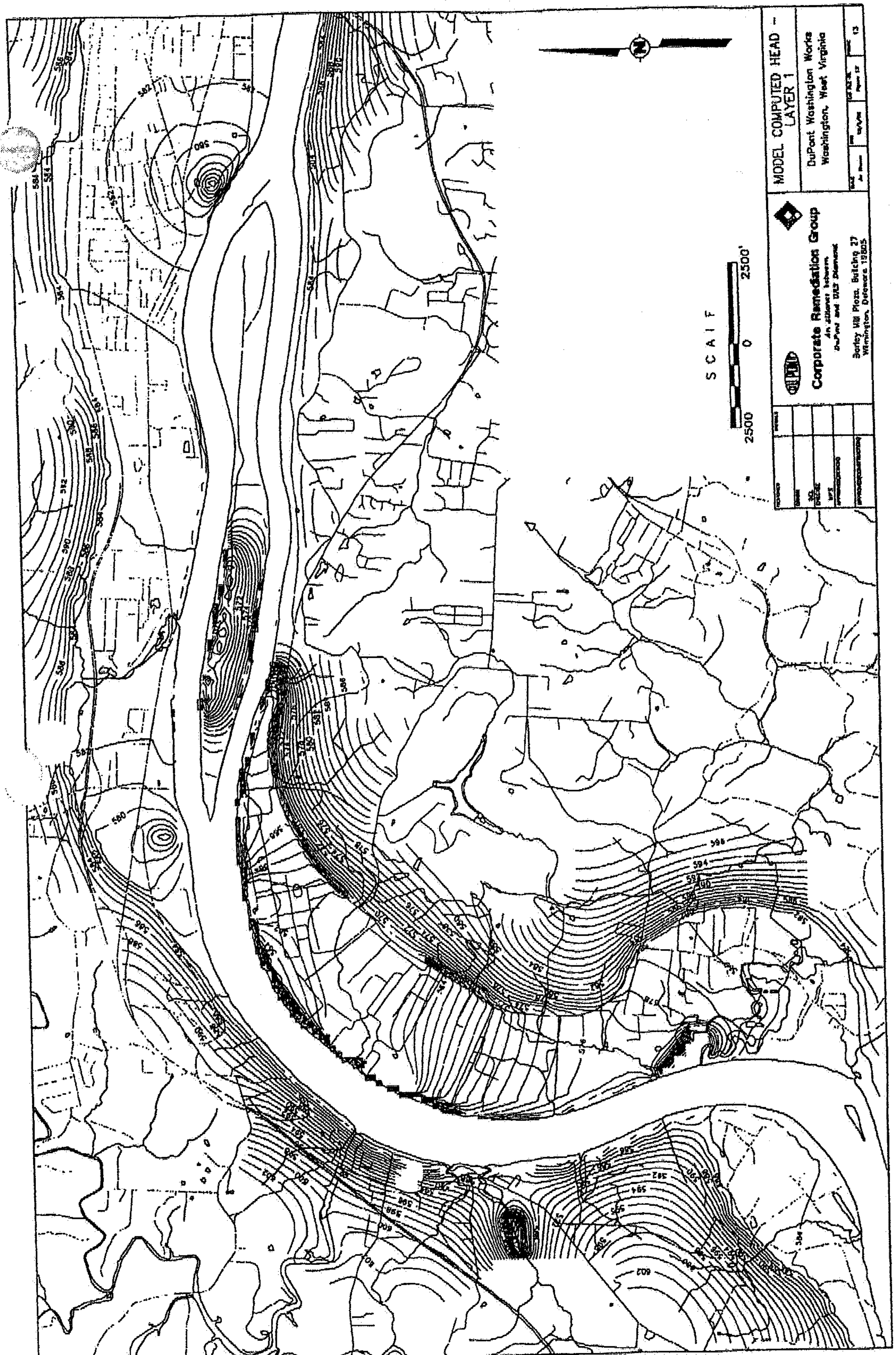
MODEL CALIBRATION RESULTS

DuPont Washington Works
Washington, West Virginia

13

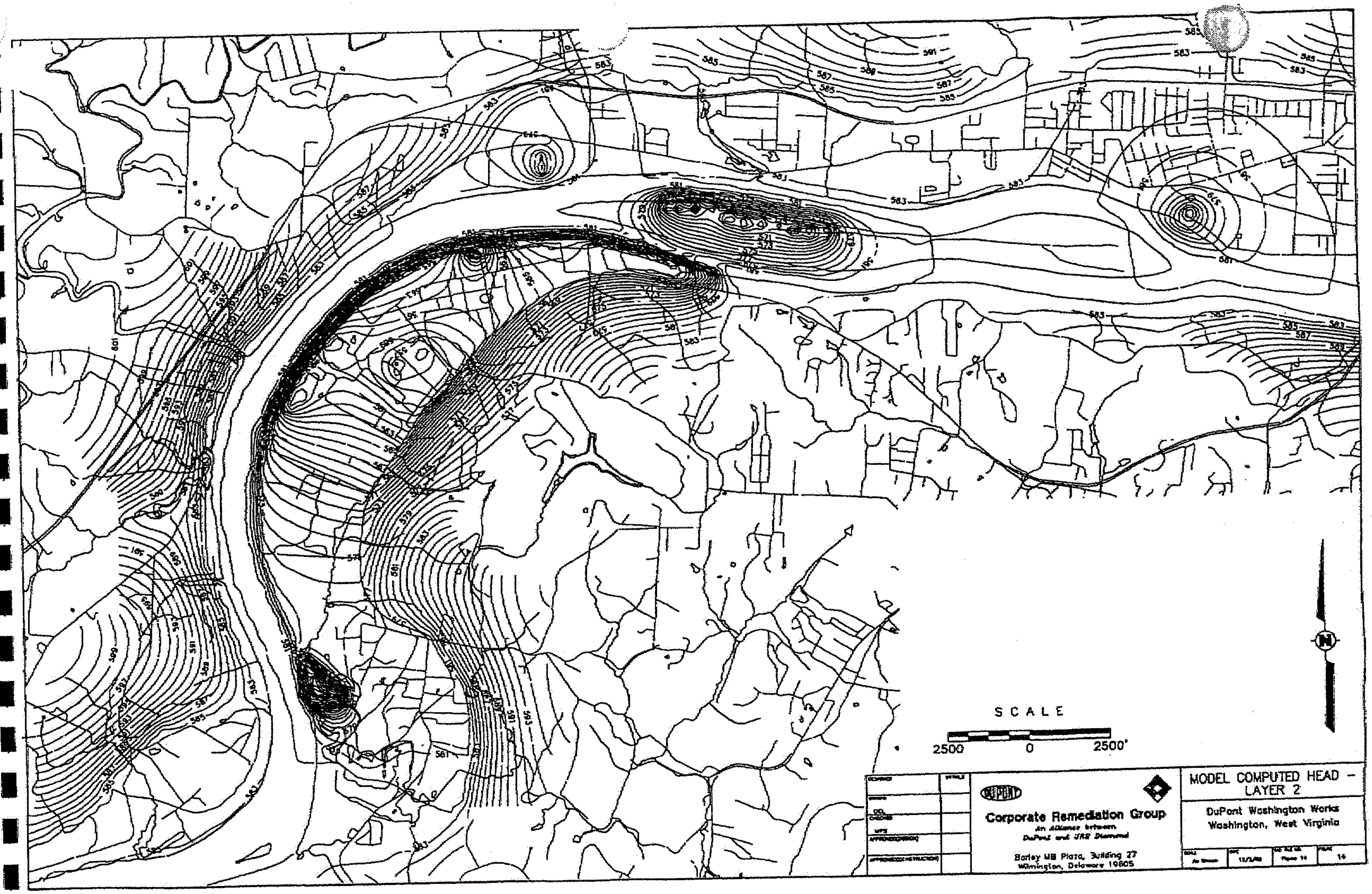
ASH020321

EID630749



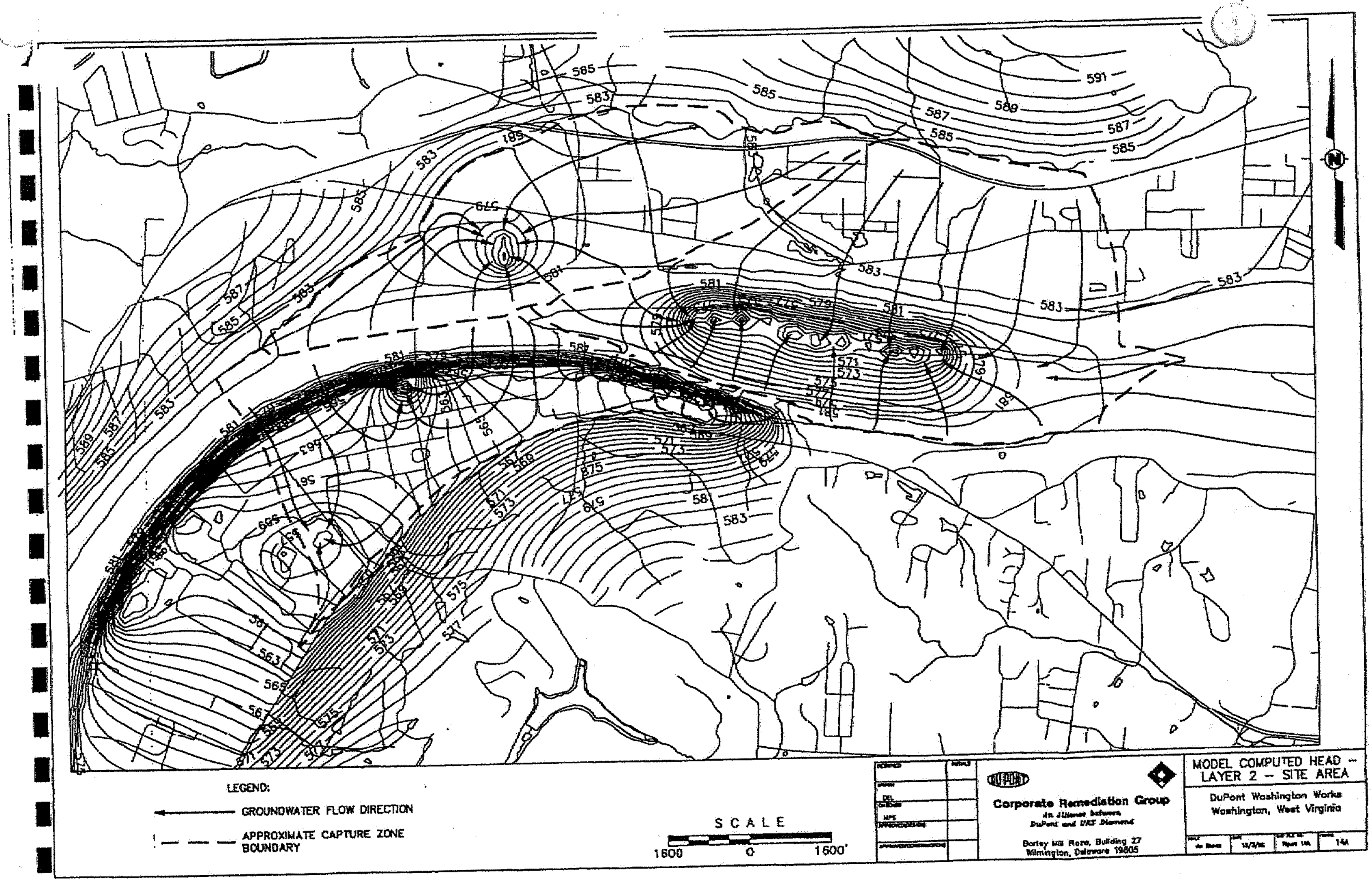
ASH020322

EID630750



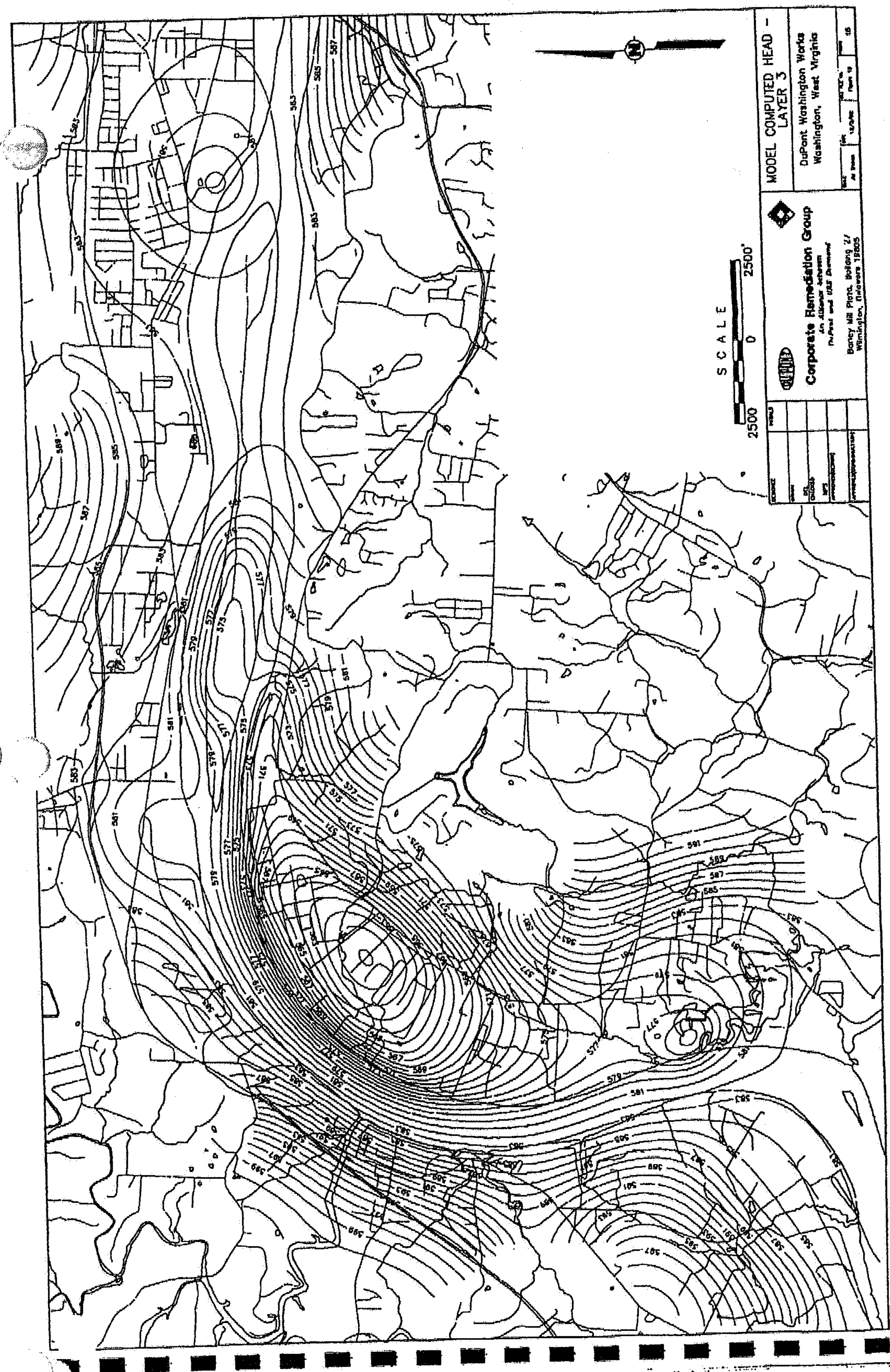
ASH020323

EID630751



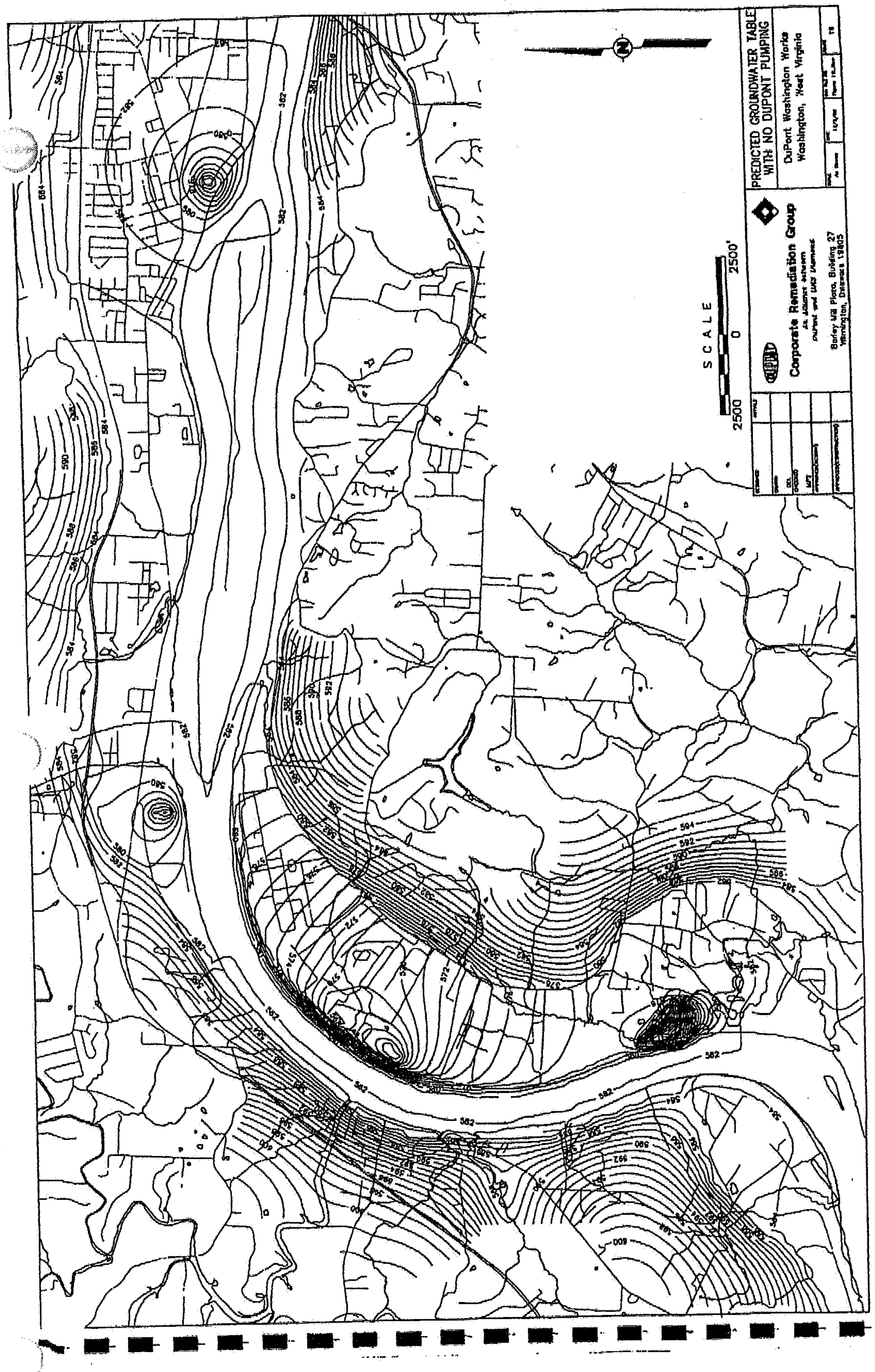
ASH020324

EID630752



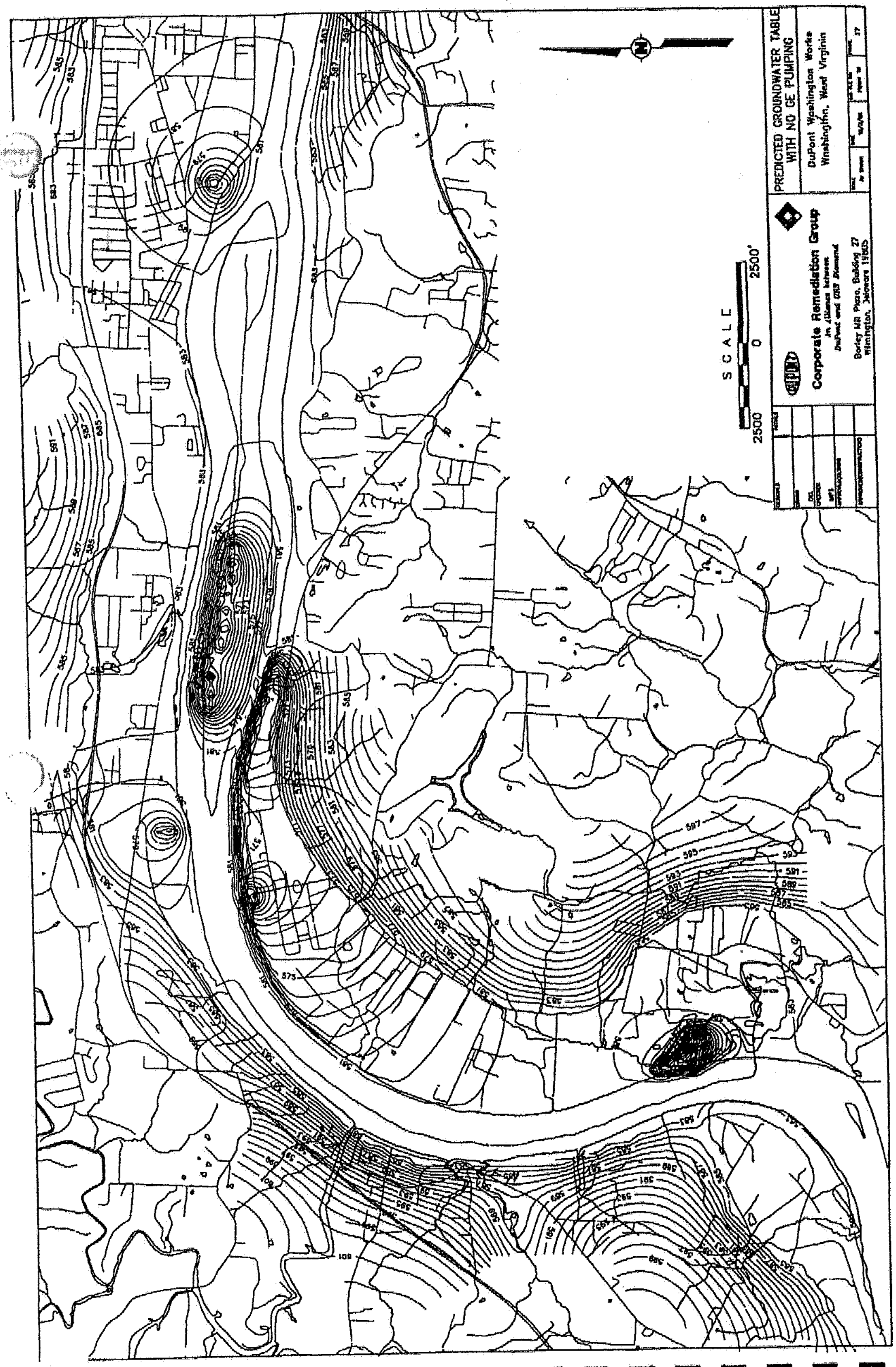
ASH020325

EID630753



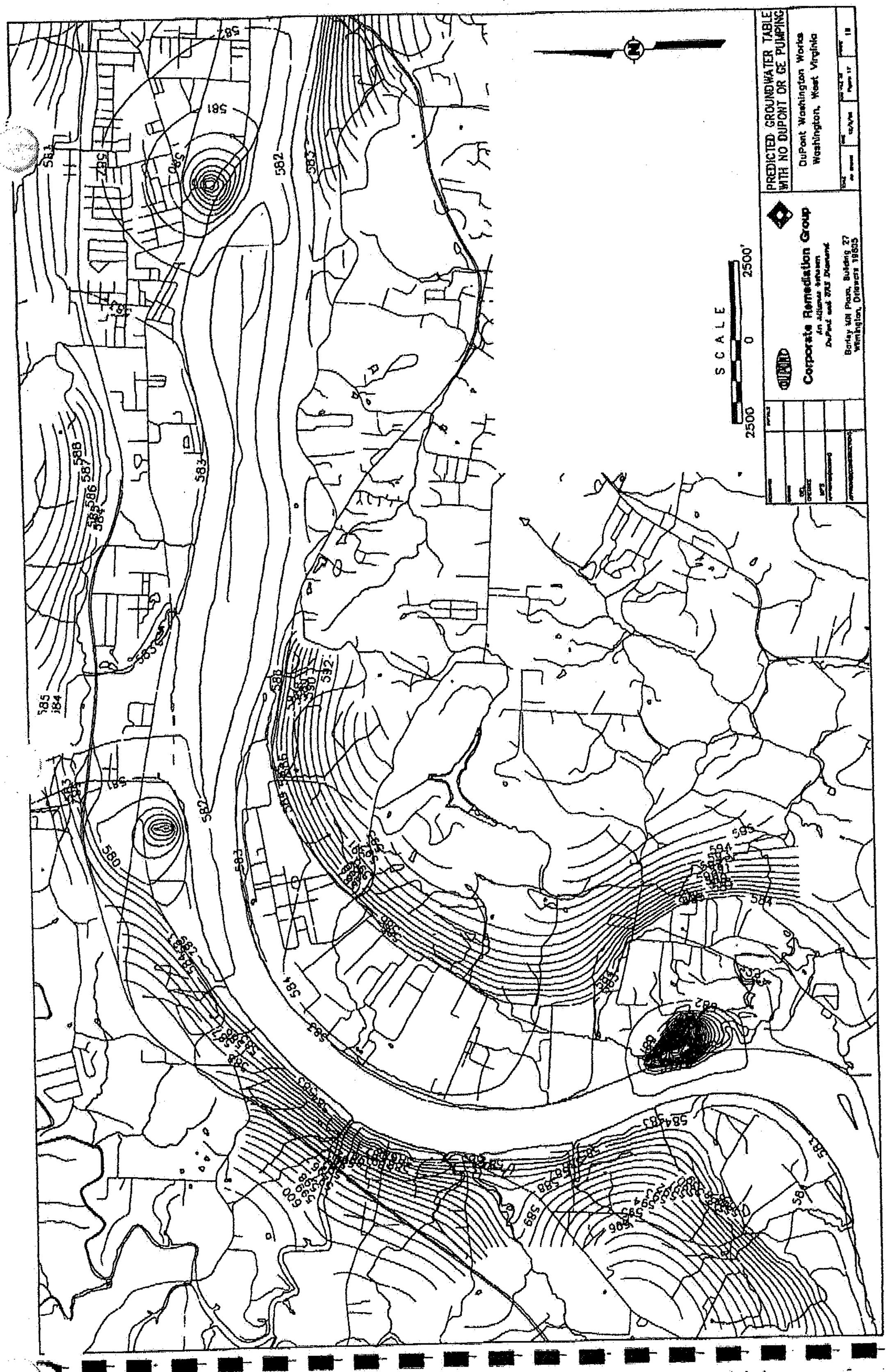
ASH020326

EID630754



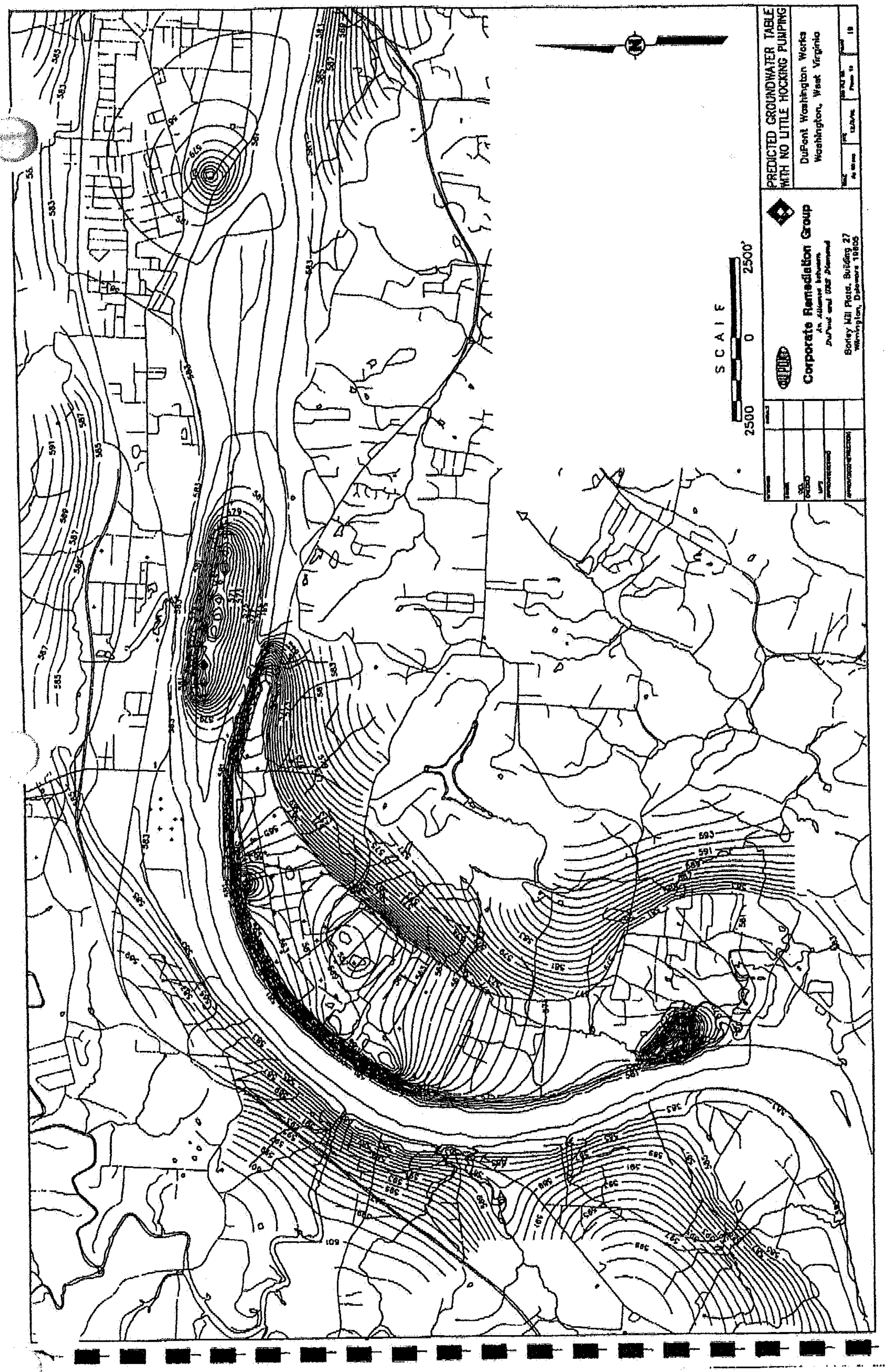
ASH020327

EID630755



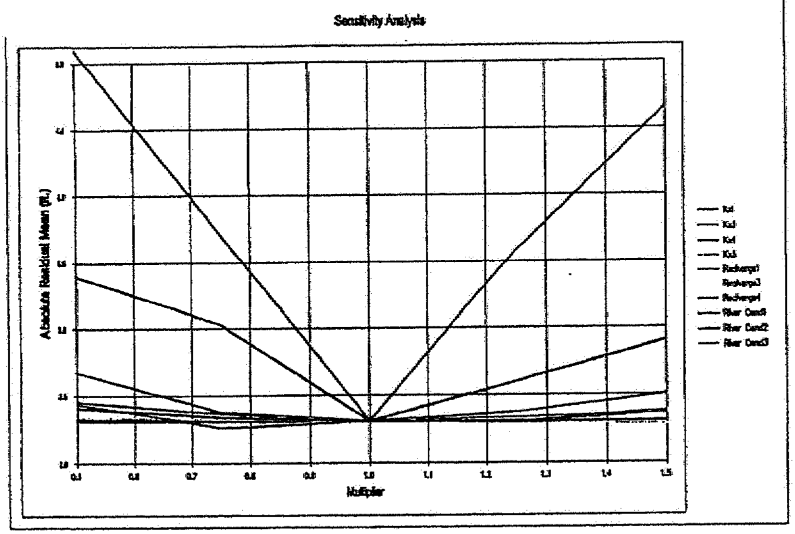
ASH020328

EID630756



ASH020329

EID630757



KEY:

Kx1 = Pleistocene Alluvium

Kx2 = Holocene Alluvium

Kx4 = Re-worked Pleistocene Alluvium

Kx5 = Blennerhassett Island Pleistocene Alluvium

Recharge1 = Pleistocene Terrace Surfaces

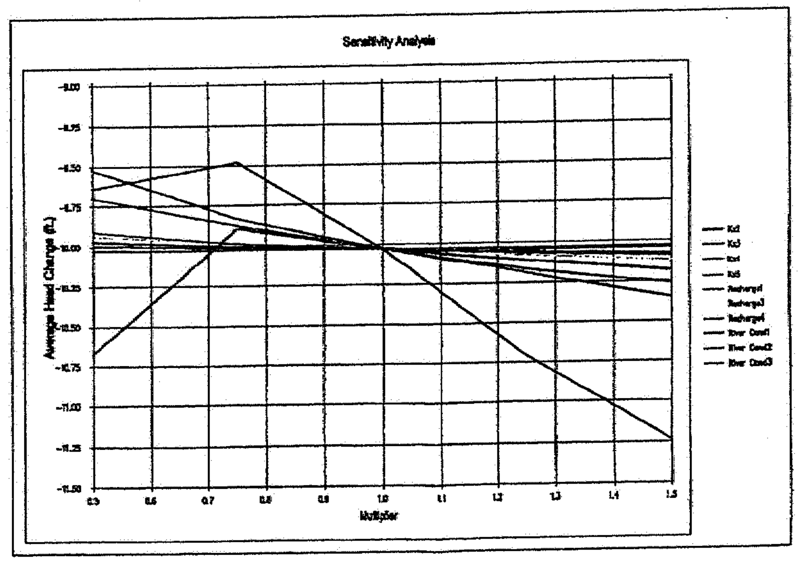
Recharge3 = Holocene Floodplain Surfaces

Recharge4 = Pleistocene Terrace Surfaces Along Bedrock Outcrop

River Cond1 = Riverbed over Holocene Alluvium

River Cond2 = Riverbed over Pleistocene Alluvium

River Cond3 = Riverbed over Pleistocene Alluvium at West End of Blennerhassett Island



DuPont

Corporate Remediation Group

An Alliance between DuPont and URS Diamond

Barley Mill Plaza, Building 27
Wilmington, Delaware 19805

SENSITIVITY ANALYSIS RESULTS

DuPont Washington Works
Washington, West Virginia

ASH020330

EID630758