Non-Scope A 11

CONESTOGA-ROVERS & ASSOCIATES

651 Colby Drive, Waterloo, Ontario, Canada N2V 1C2
Telephone: (519) 884-0510 Fax: (519) 884-0525
www.CRAworld.com

MEMORANDUM

TO:	Jim Gosnell and Al Haeger/Exelon	REF. NO.:	016841-37
FROM:	Phil Harvey/Hongze Gao/Nicholas Fitzpatrick/ev/30	DATE:	March 6, 2007
RE:	**Evaluation on Impacts of Private Well Pumping and Ponded Surface Water on Groundwater Flow Exelon Generation Company, LLC Braidwood Station, Braceville, Illinois**		

This memorandum provides the assessment results of a capture zone analysis for three private water wells located along Smiley Road. This memorandum also presents an evaluation of the impact of historically ponded water (containing tritium) near the private homes. These analyses are being performed to determine whether private wells could have intercepted tritiated water resulting from a spill in the Fall of 2000 from vacuum breaker 2 (0CW136).

The three water wells are located on Smiley Road, just southwest corner of the Exelon Pond; they are owned by James, Keca, and Phelps, respectively and shown on Figure 1. Although only two of these residences existed in 2000 (current Phelps and James homes), all three are considered for conservatism. Two areas of historically ponded water containing tritium were evaluated. The first is a ditch along Smiley Road (Figure 2) and the second is the low grassy area east of the residential properties (Figure 3). Flooding of these areas is documented by photographs that Exelon took as they responded to the event.

1.0 METHODS

CRA employed the existing three-dimensional (3D) groundwater flow model that was developed by CRA (August 2006) and further calibrated under a transient pumping condition (CRA, December 2006). The model was used to evaluate both the private well capture zones and the potential impacts of the tritiated ponded water.

The capture zone analysis associated with the three private wells was carried out through groundwater particle tracking, and an analytical capture zone width calculation. The particle tracking program MODPATH (Pollock, 1994) was applied to conduct the particle tracking. MODPATH uses the groundwater flow field simulated by the MODFLOW-2000, as used in the existing 3D groundwater flow model, to calculate particle pathways through the simulated groundwater flow field based on advective processes.

The graphical user interface (GUI) Groundwater Vistas (Rumbaugh, 2005) was employed to provide pre- and post-processing for the numerical flow model.

N/11

2.0 CAPTURE ZONE CALCULATIONS FOR THE PRIVATE WATER WELLS

A typical single family home water usage is estimated to be 45 to 90 gallons per day (GPD) per person (Metcalf and Eddy, 1991). In order to use a conservatively high estimate of water usage it was assumed that each resident used 100 GPD and that each house had four residents totaling 400 GPD per house. The analysis made no allowance for lawn sprinkling or other outdoor watering since the spill occurred in October and November. The groundwater flow model (MODFLOW) was run under a state-state condition.

A line of particles was released from an area upgradient of the three private wells, and forward particle tracking was simulated under the steady-state pumping condition. The pathlines originated from the upgradient area and the simulated groundwater elevation contours are presented on Figure 1.

An analytical capture zone calculation was also performed using the Todd Equation (1976). Based on Todd, the capture zone width at the infinite location upgradient of the pumping well under a steady state condition is expressed as:

$$L_Y = 2Y_L = Q/(2Kbi)$$

where,

> L_y is the upstream inflow zone (limits of groundwater entering the pumping well), or capture zone width at the infinite upstream distance (L);
> Q is the discharge rate (L^3/T);
> K is the hydraulic conductivity of the aquifer (L/T);
> b is the aquifer thickness (L);
> i is the groundwater hydraulic gradient.

The capture zone width at the line of the extraction well is $L_Y/2$, or Y_L.

The parameters for this capture zone calculation are presented in Table 1. As a result, the capture zone width of each individual private well is only 2.0 ft. The hand calculation result suggests that the simulation results from the 3D model are reasonable.

It can be concluded, based on the 3D numerical and the analytical solution, that the pumping of these three private wells does not have any discernible impact on the local groundwater flow due to the insignificant pumping of groundwater. The groundwater flow pathlines and the capture zone calculation results demonstrate that the capture zone of each individual well is very small with the three wells barely capturing any cross-gradient water. Also, their capture zones do not reach any part of the current observed tritium plume (Figure 1) associated with the Vacuum Breakers 2 and 3, under the simulated condition, since the limit of the plume is over 350 feet east of the nearest private water well.

3.0 EVALUATION OF HISTORICALLY PONDED AREAS OF SURFACE WATER

Two scenarios were simulated of the historically ponded water containing tritium. As a worst case, it is assumed that the ponded surface water can fully saturate the soil above the water table. The system configurations and the simulated results are presented in the following sections.

3.1 Scenario 1 Configuration and 3D Numerical Model Results - Ditch along Smiley Road

Scenario 1 (ditch along Smiley Road) has a 2-ft wide and about 1000-ft long infiltration gallery to simulate the ponded surface water observed in the ditch along the south side of Smiley Road as a result of the water leak from VB-2 in the Fall of 2000 (Figure 2). The ponded water is assumed to occur for 30 consecutive days with a stable water level of 598 ft AMSL (which is about 1 ft above the ground surface).

The Smiley Road ditch was simulated as river cells in the model. The river stage was set to be 598 ft AMSL and the riverbed bottom was set to be 596 ft AMSL. The river conductance was calculated by the model using a hydraulic conductivity of 77.8 ft/day for river bedding material.

To obtain the results, eight model observation points were used aligned perpendicular to the infiltration trench as shown on Figure 2 with distances of 50 ft, 100 ft, 150 ft, 200 ft, 250 ft, 300 ft, 400 ft, and 500 ft away from the Smiley Road ditch through the property of Phelps.

The transient model simulated groundwater elevations and groundwater elevation increases (with respect to the initial groundwater elevation at the corresponding locations) due to the impact of the ponded water in the ditch are presented on Figures 4 and 5, respectively.

Figures 4 and 5 demonstrate that the ponded water in the ditch would likely cause a groundwater elevation increase, and that the system would not reach a steady-state condition even at the end of the 30-day period. The figures also show that the closer one is to the ditch, the more groundwater levels will increase.

Groundwater Movement Toward Private Water Wells

Particles were released along the ditch to evaluate how far the particles south of the ditch would travel in the 30-day period. As shown on Figure 6, the pathlines are very short indicating tritium in the ponded ditch would only be limited to the immediate vicinity after the 30-day groundwater mounding period. Specifically, the model predicts a travel distance of only 15-20 feet away from the ponded ditch in 30 days (Figure 6).

3.2 Scenario 2 Configuration and 3D Numerical Model Results - Ponded Surface Water South of Smiley Road and East of Private Water Wells

Scenario 2 (ponded water east of private water wells) simulated the ponded surface water of about 480 ft by 480 ft in size located to the east of the residential properties and south of Smiley Road which resulted from the VB-2 leak (Figure 3) that occurred in 2000. The ponded water is assumed to remain for 30 days with a stable water level of 599 ft AMSL (which is about 1 ft above the ground surface). Similarly, the river package with a river stage of 599 ft AMSL and a riverbed bottom of 597 ft AMSL was used to simulate the surface water infiltration.

Similar to Scenario 1, eight model observation points were used aligned perpendicular to the infiltration pond as shown on Figure 3 with distances of 50 ft, 100 ft, 150 ft, 200 ft, 250 ft, 300 ft, 400 ft ,and 500 ft away from the infiltration pond through the three private properties.

The transient model simulated groundwater elevations and groundwater elevation increases due to the impact of the ponded water are presented on Figures 7 and 8, respectively.

Figures 7 and 8 demonstrate that the ponded water would likely cause a groundwater elevation increase, and that the system would not reach a steady-state condition at the end of the 30-day period. The figures also show that the closer one is to the ponded water, the more groundwater levels will increase.

<u>Groundwater Movement Toward Private Water Wells</u>

Particles were released along the western edge of the ponded area to evaluate how far the particles in the ponded area would travel in the 30-day period toward the residential area. As shown on Figure 9, the pathlines are very short indicating tritium in the ponded area would only be limited to the immediate vicinity after the 30-day groundwater mounding period. Specifically, the model predicts a travel distance of only 20-25 feet away from the ponded area in 30 days (Figure 9).

3.3 Conclusion With Regard To Surface Water Ponding

Based on the above 3D transient groundwater flow model simulations for the two scenarios and the associated particle tracking results, it can be concluded that while the 30-day period of surface water ponding would likely cause groundwater elevation increases in the vicinity of ponded areas, tritium in the ponded areas could not travel far away from the ponded areas and therefore could not have impacted the local private wells. Since all standing water was removed upon discovery, the driving force for continued migration toward the private wells was removed immediately after the analyzed 30-day period. Normal ground water movement would have then been adequate to sweep any tritium laced water north and away from the residences.

REFERENCES

CRA, August 2006. Groundwater Flow and Tritium Transport Modeling, Braidwood Generation Station, Braceville, Illinois, Report prepared by Conestoga-Rovers & Associates, for Exelon Generation Company, LLC.

CRA, September 2006. Hydrogeologic Investigation Report, Fleetwide Assessment, Braidwood Generation Station, Braceville, Illinois, Report prepared by Conestoga-Rovers & Associates, for Exelon Generation Company, LLC.

CRA, December 2006. Transient Groundwater Flow Model Calibration and Transport Model, Scenario Update, Memorandum (#25) prepared by Conestoga-Rovers & Associates, for Exelon Generation Company, LLC.

Metcalf & Eddy, Inc., 1991. Wastewater Engineering, Treatment, Disposal, and Reuse, Third Edition", McGraw-Hill, Inc., New York.

Pollock, D. W., 1994. User's Guide for MODPATH/MODPATH-PLOT, Version 3: A Particle Tracking Post-Processing Package for MODFLOW, the U.S. Geological Survey Finite-Difference Ground-Water Flow Model, United States Geological Survey Open-File Report 94-464, Reston, Virginia.

Rumbaugh, J. O., 2005. Guide to Using Groundwater Vistas, Version 4.19, Environmental Simulations Inc., Herndon, Virginia.

Todd, D. K., 1976 . Groundwater Hydrology, Second Edition, John Wiley & Sons, pp. 122-123.

TABLE 1

PRIVATE WELL CAPTURE ZONE HAND CALCULATION

Pumping Rate[1] *GPD*	*Hydraulic Conductivity*[2] *ft/day*	*Aquifer Thickness*[3] *ft*	*Hydraulic Gradient*[4] *-*	*Capture Zone Width* *ft*
400	77.8	25	0.007	2.0

Notes:

1. Assumed household water usage in gallons per day.
2. 3D groundwater flow model calibrated value (CRA, August 2006).
3. Average saturated aquifer thickness.
4. CRA, Fleetwide Report (September 2006).

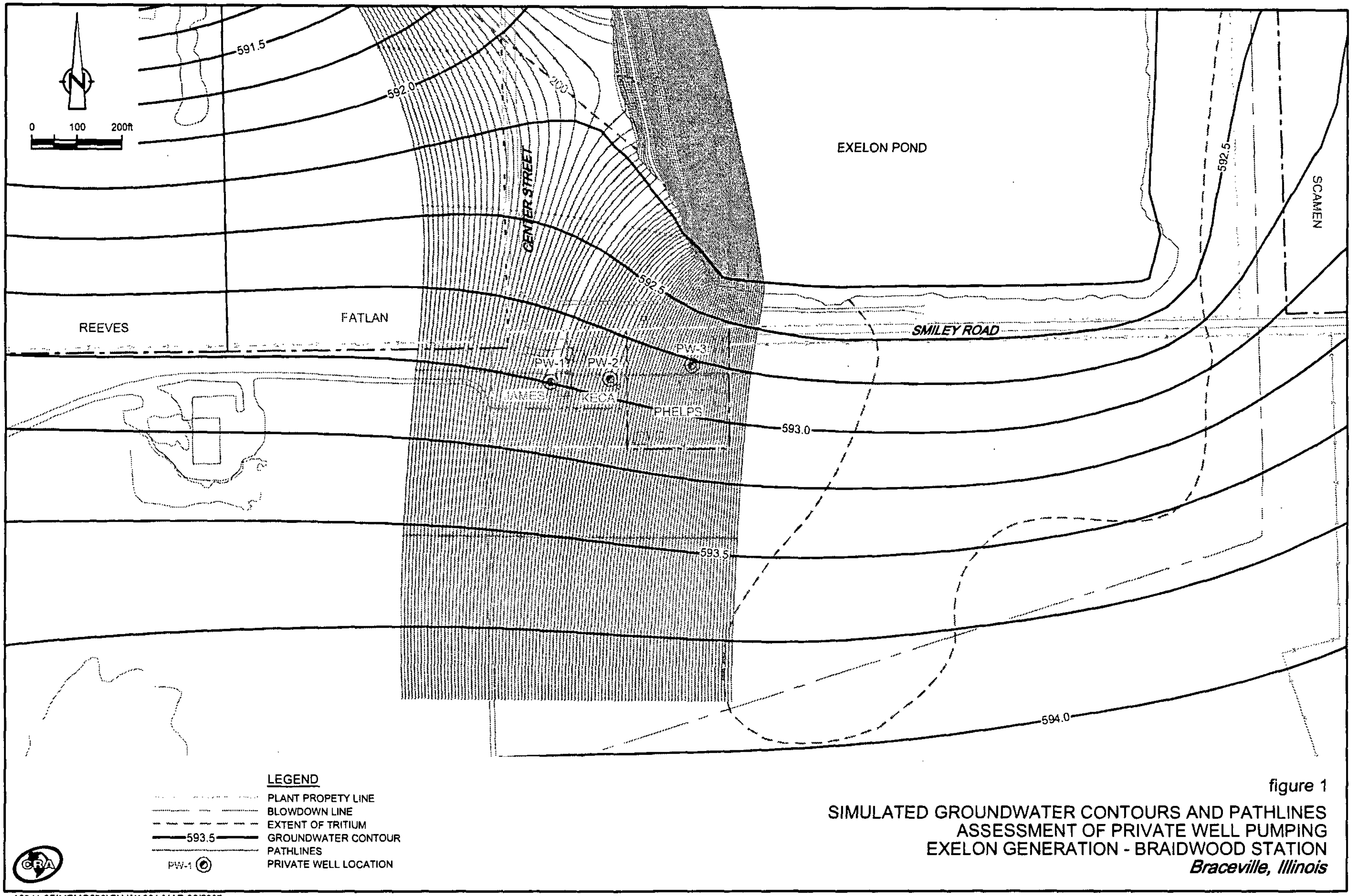
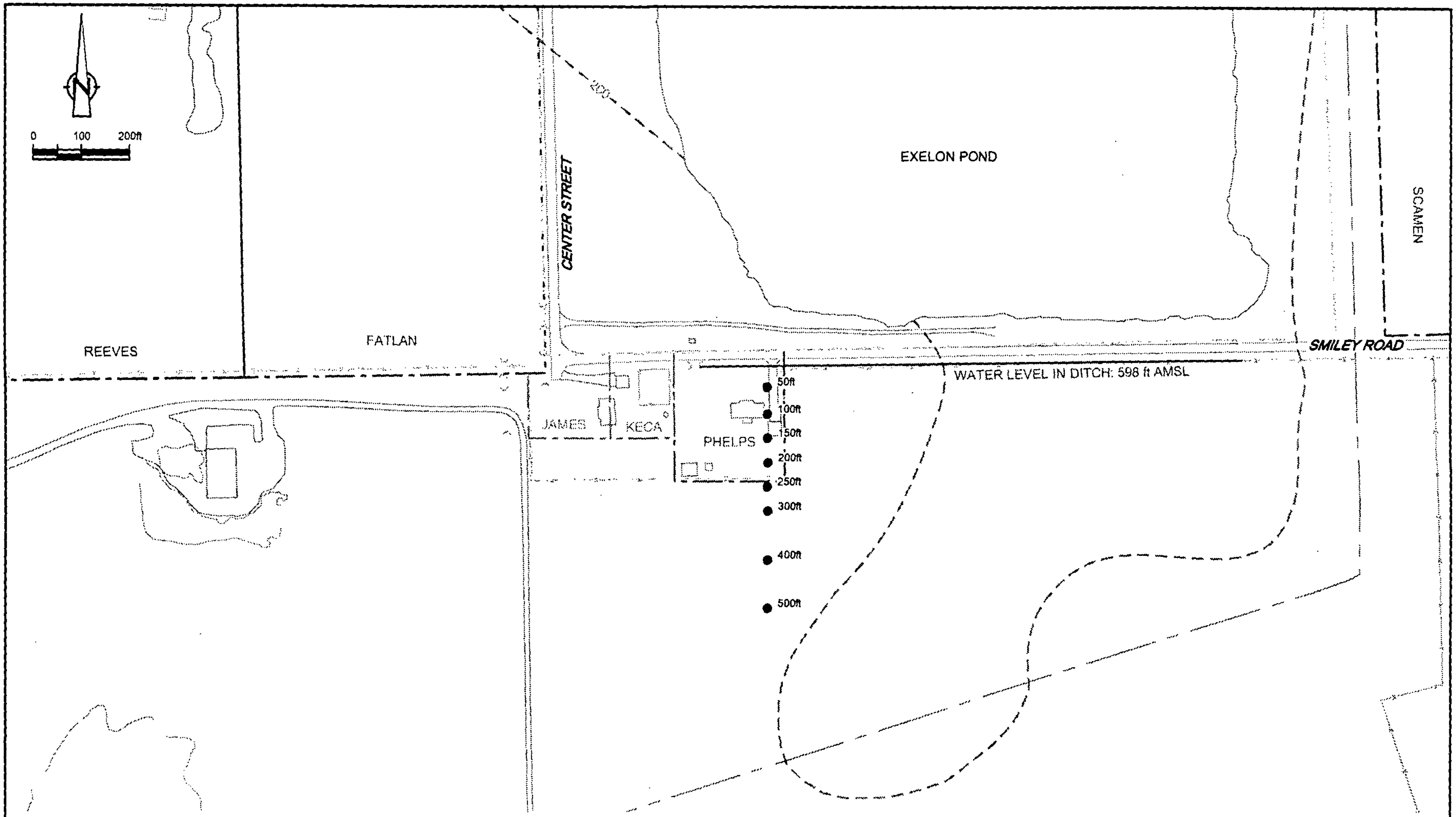


figure 1

SIMULATED GROUNDWATER CONTOURS AND PATHLINES
ASSESSMENT OF PRIVATE WELL PUMPING
EXELON GENERATION - BRAIDWOOD STATION
Braceville, Illinois

16841-37(MEMO030)GN-WA001 MAR 06/2007



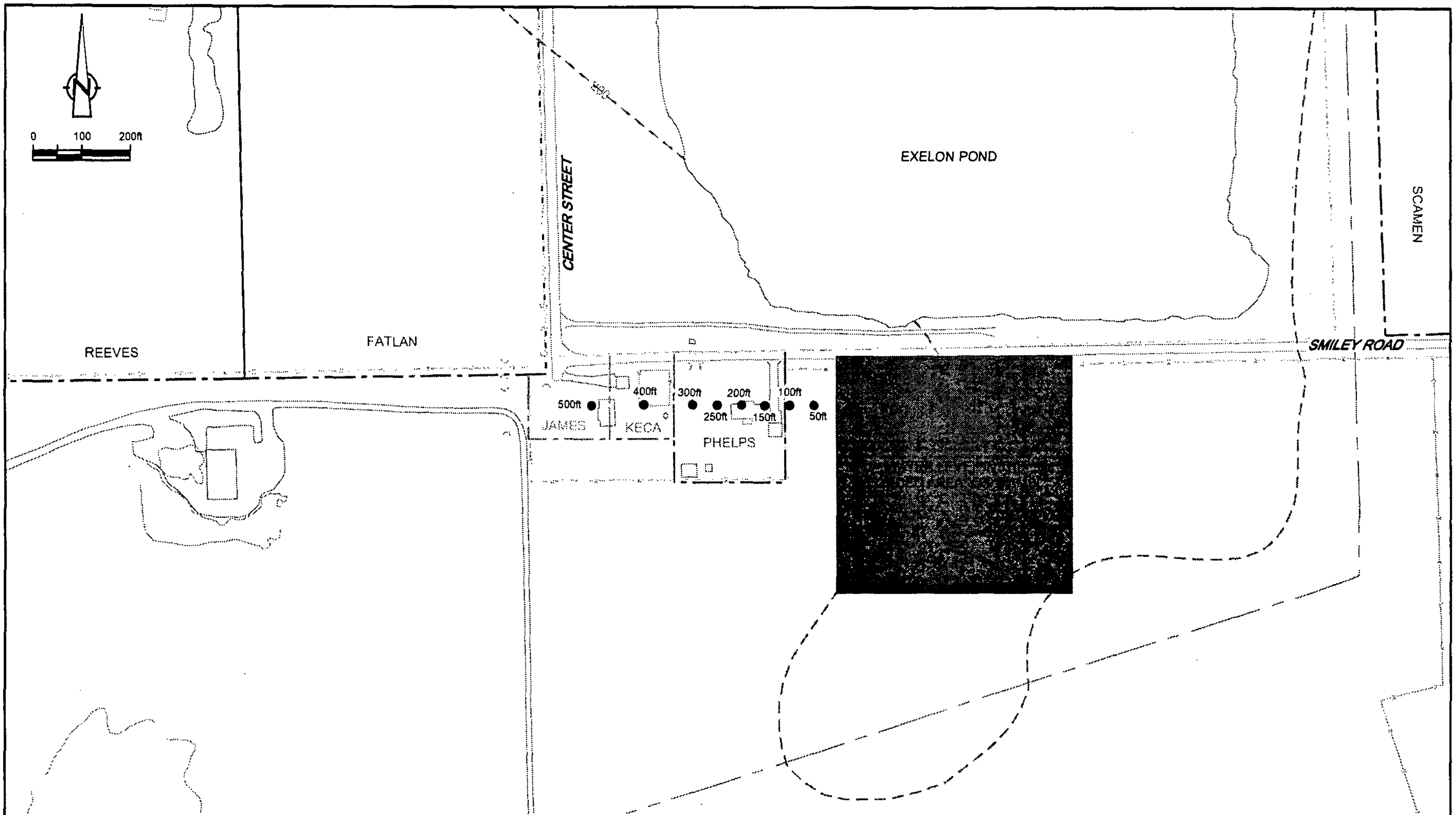
LEGEND

- PLANT PROPETY LINE
- BLOWDOWN LINE
- EXTENT OF TRITIUM
- PONDED DITCH
- ● 50ft OBSERVATION LOCATION

figure 2

SCENARIO 1: PONDED DITCH LOCATION AND MODEL OBSERVATION POINTS
ASSESSMENT OF PONDED WATER IMPACT TO PRIVATE WELLS
EXELON GENERATION - BRAIDWOOD STATION
Braceville, Illinois

16841-37(MEMO030)GN-WA002 MAR 06/2007



LEGEND

PLANT PROPETY LINE

BLOWDOWN LINE

EXTENT OF TRITIUM

● 50ft OBSERVATION LOCATION

PONDED AREA

figure 3

SCENARIO 2: PONDED AREA LOCATION AND MODEL OBSERVATION POINTS
ASSESSMENT OF PONDED WATER IMPACT TO PRIVATE WELLS
EXELON GENERATION - BRAIDWOOD STATION
Braceville, Illinois

16841-37(MEMO030)GN-WA003 MAR 06/2007

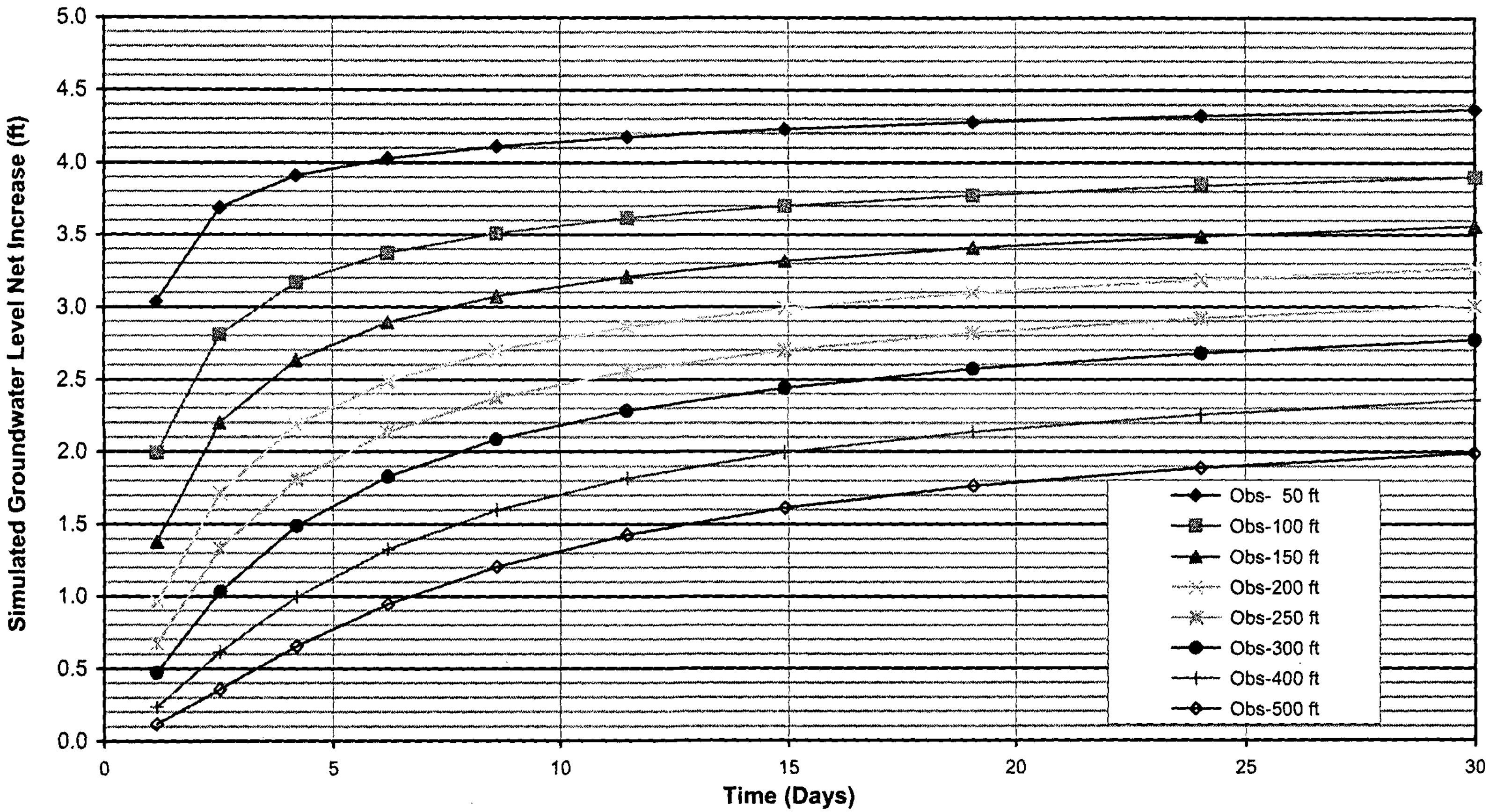


figure 4
SCENARIO 1: SIMULATED GROUNDWATER LEVEL INCREASE VS. TIME
3D NUMERICAL TRANSIENT SIMULATION RESULT
EXELON GENERATION - BRAIDWOOD STATION
Braceville, Illinois

016841-37(MEMO30) GN-WA-HYD (N:\HEG\16841\3DMODEL\FLOW\FlowForWCFP\Output-Plots\16841-37(Memo030)-Fig4.xls) FEB 2007

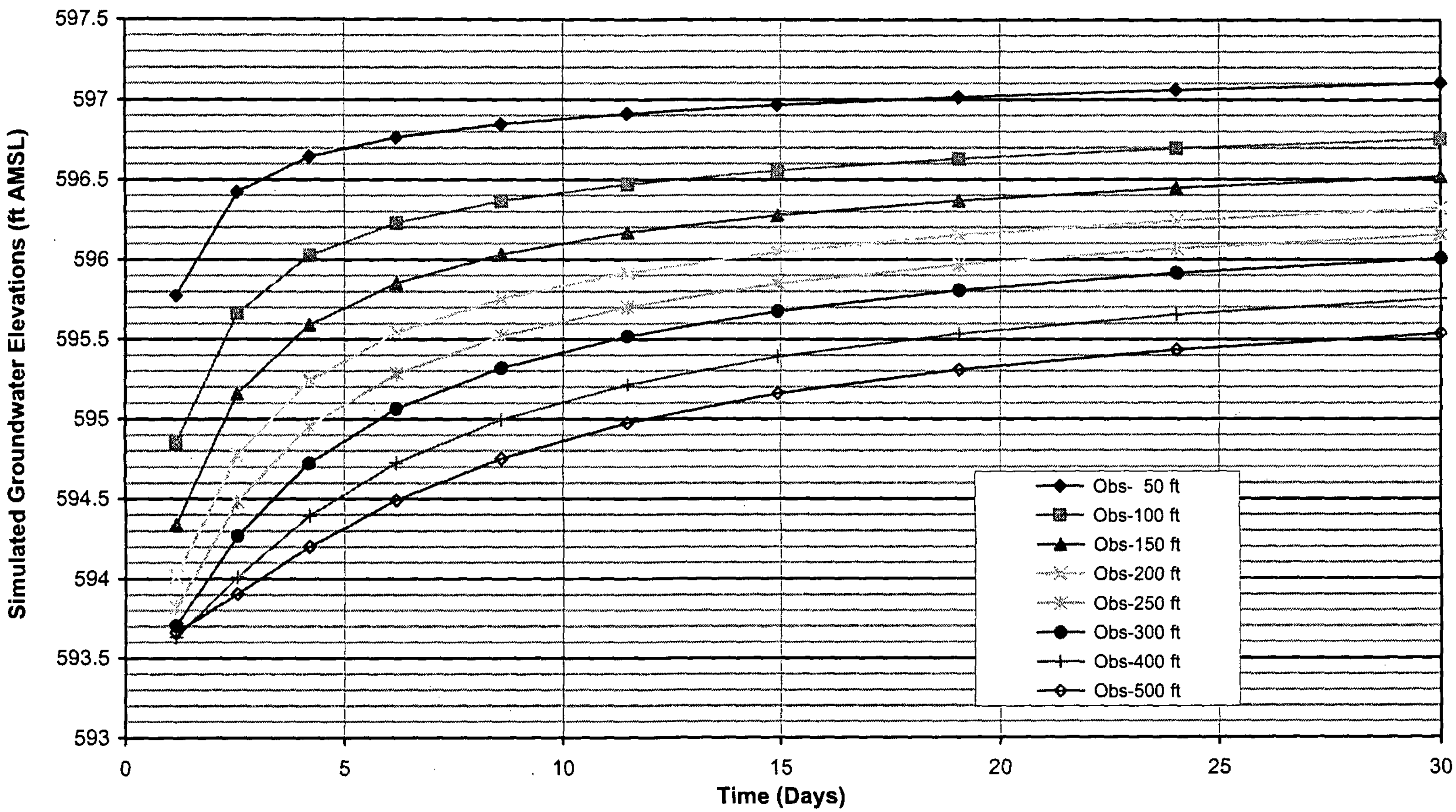


figure 5

SCENARIO 1: SIMULATED GROUNDWATER ELEVATION VS. TIME

3D NUMERICAL TRANSIENT SIMULATION RESULT

EXELON GENERATION - BRAIDWOOD STATION

Braceville, Illinois

016841-37(MEMO30) GN-WA-HYD (N:\HEG\16841\3DMODEL\FLOW\FlowForWCFP\Output-Plots\16841-37(Memo30)-Fig5.xls) FEB 2007

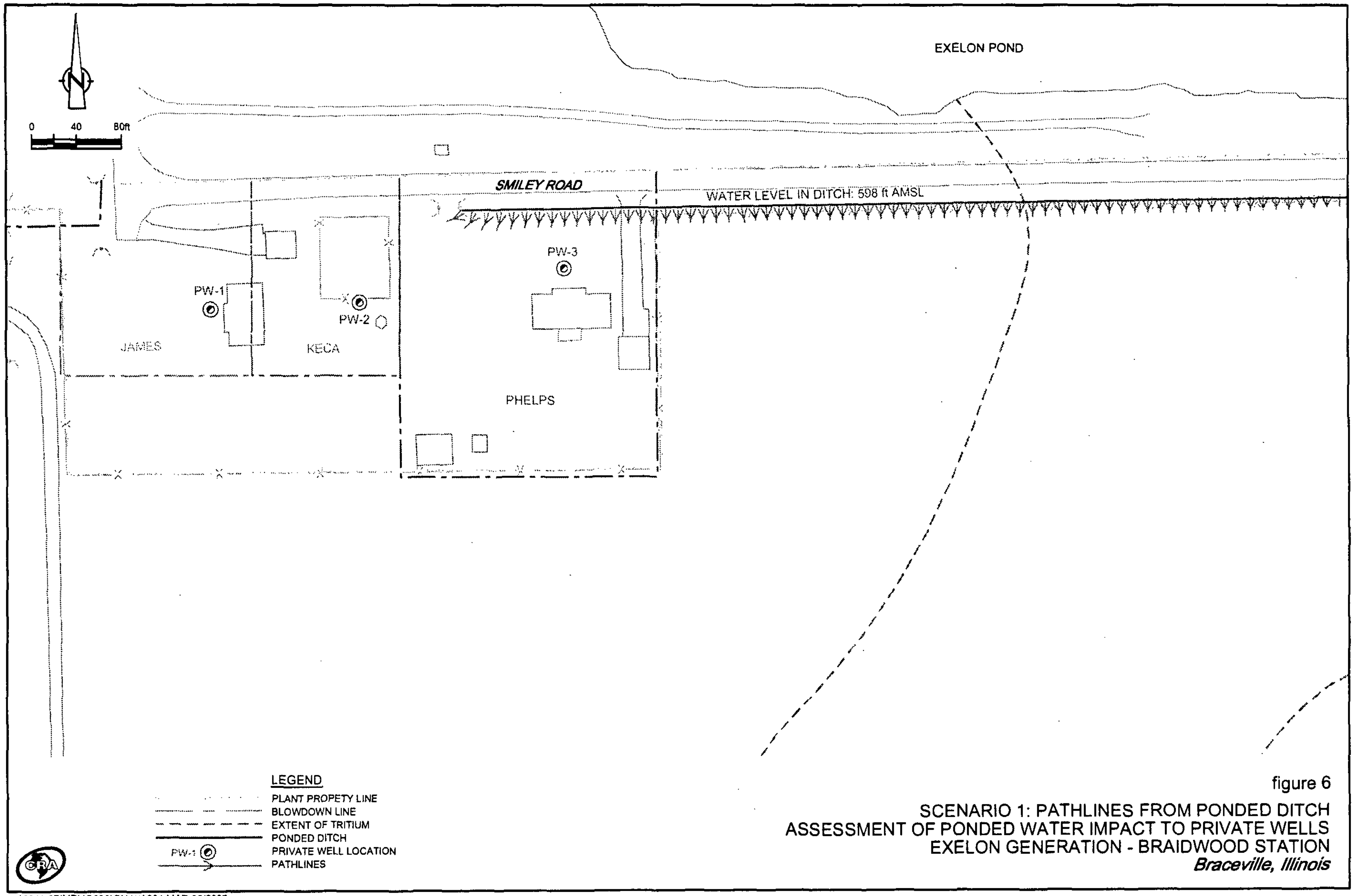


figure 6

SCENARIO 1: PATHLINES FROM PONDED DITCH
ASSESSMENT OF PONDED WATER IMPACT TO PRIVATE WELLS
EXELON GENERATION - BRAIDWOOD STATION
Braceville, Illinois

16841-37(MEMO030)GN-WA004 MAR 06/2007

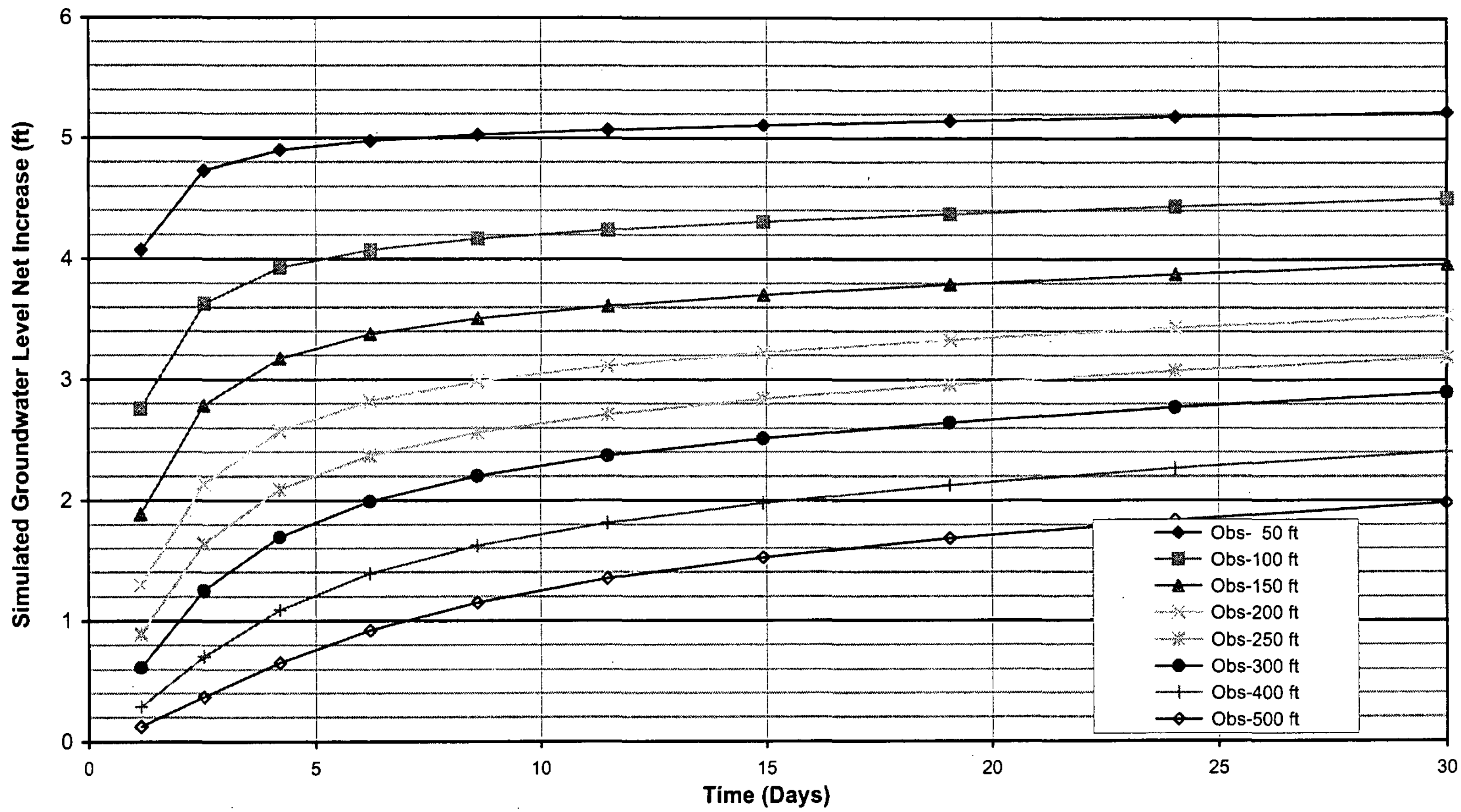


figure 7

SCENARIO 2: SIMULATED GROUNDWATER LEVEL INCREASE VS. TIME
3D NUMERICAL TRANSIENT SIMULATION RESULT
EXELON GENERATION - BRAIDWOOD STATION
Braceville, Illinois

016841-37(MEMO30) GN-WA-HYD (N:\HEG\16841\3DMODEL\FLOW\FlowForWCFP\Output-Plots\16841-37(Memo30)-Fig7.xls) FEB 2007

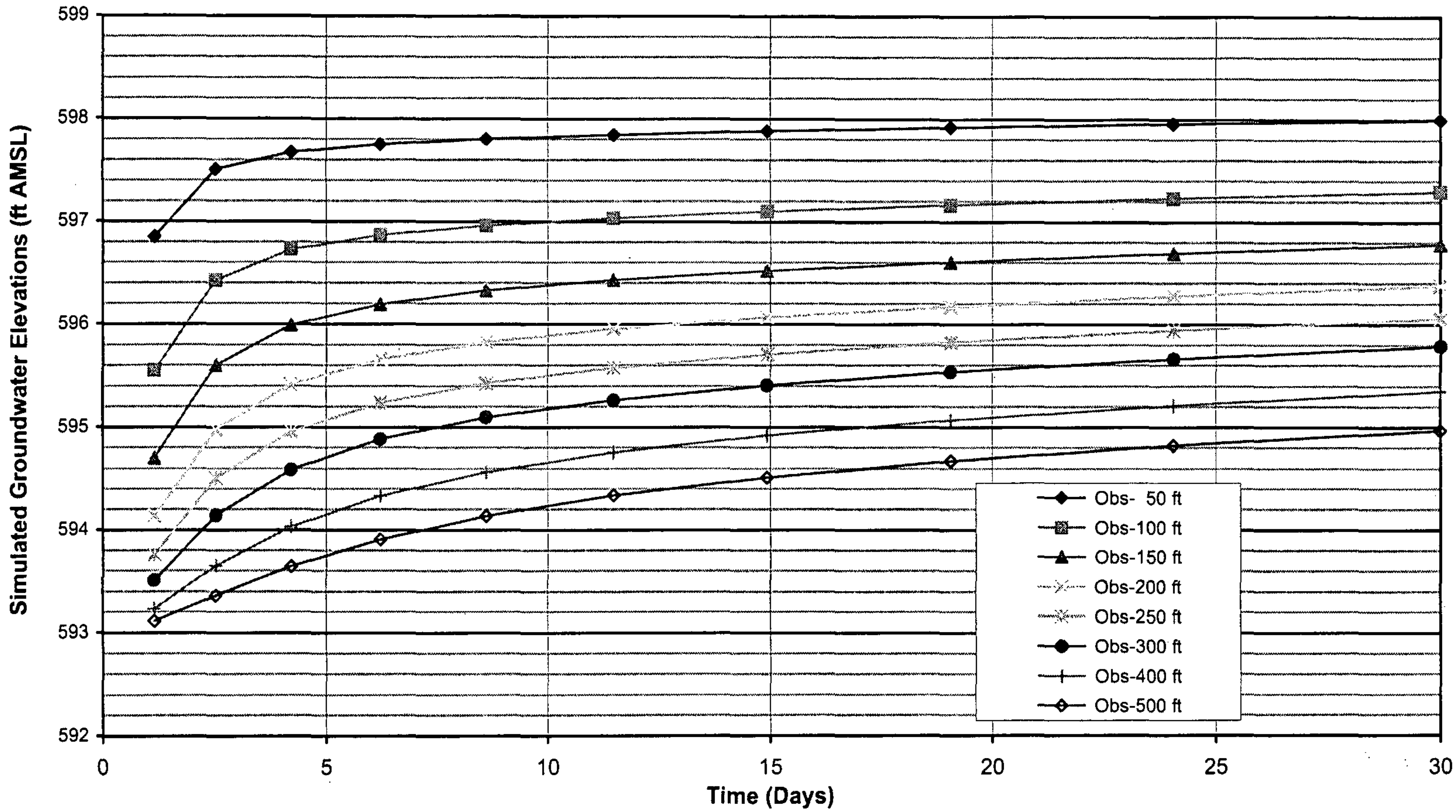


figure 8

SCENARIO 2: SIMULATED GROUNDWATER ELEVATION VS. TIME
3D NUMERICAL TRANSIENT SIMULATION RESULT
EXELON GENERATION - BRAIDWOOD STATION
Braceville, Illinois

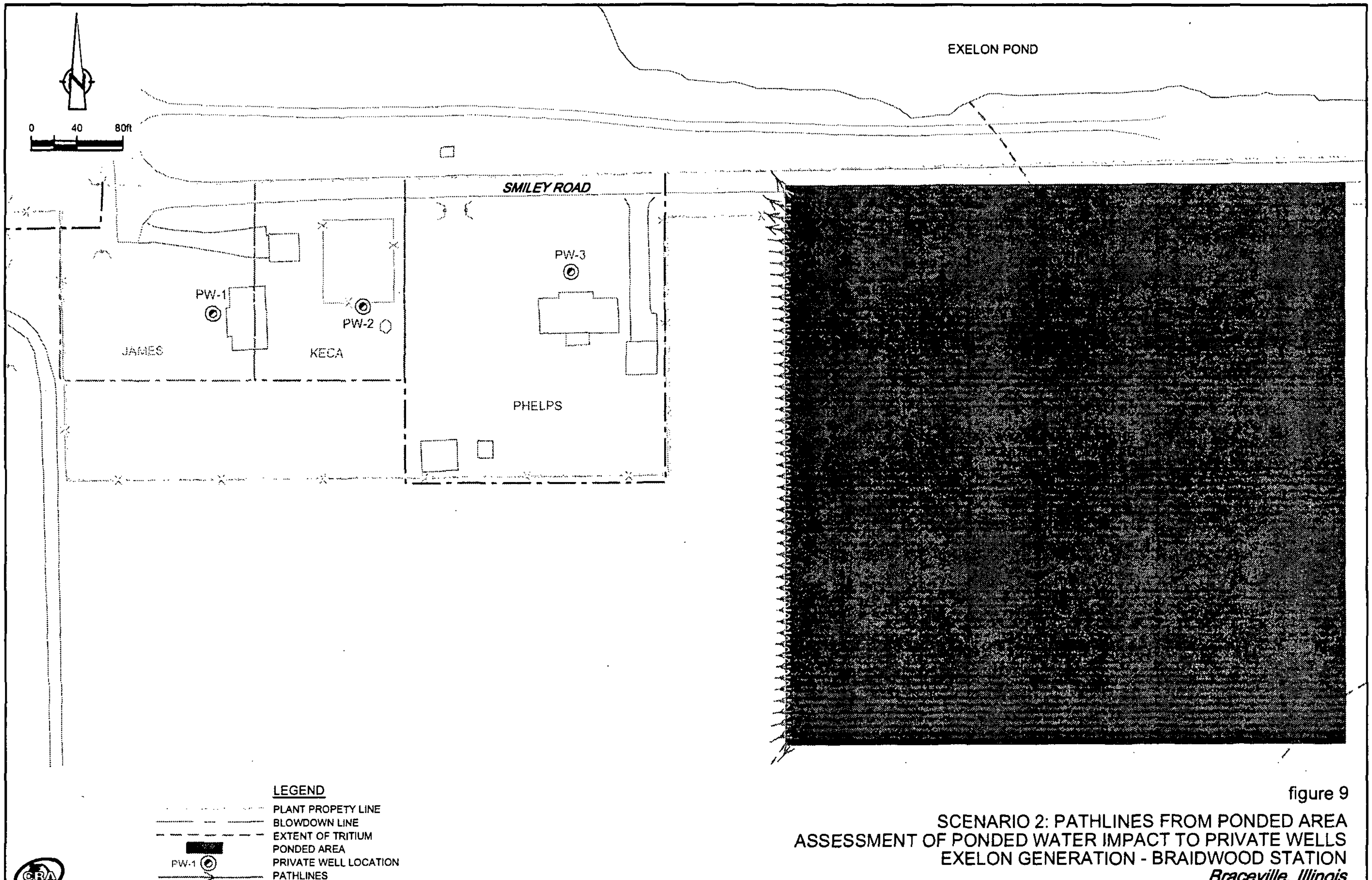


figure 9

SCENARIO 2: PATHLINES FROM PONDED AREA
ASSESSMENT OF PONDED WATER IMPACT TO PRIVATE WELLS
EXELON GENERATION - BRAIDWOOD STATION
Braceville, Illinois

16841-37(MEMO030)GN-WA005 MAR 06/2007