DOE/LX/07-2485&D1

Compilation of Meeting Summaries and White Papers (Fiscal Year 2022)

A Product of the Paducah Gaseous Diffusion Plant Site Groundwater Modeling Working Group

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A Product of the Paducah Gaseous Diffusion Plant Site Groundwater Modeling Working Group

Date Issued—January 2023

U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

Prepared by
FOUR RIVERS NUCLEAR PARTNERSHIP, LLC,
managing the
Deactivation and Remediation Project at the
Paducah Gaseous Diffusion Plant
under Contract DE-EM0004895

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ACRONYMS

EMP	environmental monitoring plan
EPA	U.S. Environmental Protection Agency
FY	fiscal year
KRCEE	Kentucky Research Consortium for Energy and the Environment
KY	Commonwealth of Kentucky
MMES	Martin Marietta Energy Systems, Inc.
MWG	Modeling Working Group
PGDP	Paducah Gaseous Diffusion Plant
TVA	Tennessee Valley Authority

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INTRODUCTION

The purpose of this document is to present the meeting summaries from the Paducah Site Groundwater Modeling Working Group (MWG) completed during fiscal year (FY) 2022. Activities for the MWG from September 2017 through July 2021 are documented in DOE/LX/07-2437&D1, DOE/LX/07-2451&D1, and DOE/LX/07-2475&D1. Notes from MWG meetings held in 2016 and in January and March 2017 are presented in Appendix A of *2016 Update of the Paducah Gaseous Diffusion Plant Sitewide Groundwater Flow Model*, DOE/LX/07-2415&D2/A1. The meeting summaries are provided for historical information to promote program consistency over time and facilitate succession planning. The meeting summaries include slides from the presentations provided during the FY 2022 meetings. The following meeting summaries are included in the appendices.

- October 6, 2021, Meeting Summary (Appendix A)
  - Attachment 1: Groundwater Elevation Data for TVA Wells Collected by KY on August 25, 2021
  - Attachment 2: 2020 Plume Map Document Summary
  - Attachment 3: 2022 EMP Schedule for Groundwater Strategy Project
  - Attachment 4: Precipitation and Ohio River State Data
  - Attachment 5: Presentation: 2016 Sitewide Paducah Groundwater Flow Model
- January 12, 2022, Meeting Summary (Appendix B)
  - Attachment 1: Groundwater Strategy Potentiometric Maps and Pressure Transducer Data
  - Attachment 2: Groundwater Elevation Data for TVA Wells Collected by KY on November 16, 2021
  - Attachment 3: 2022 Groundwater Strategy Project Planning Dates and EMP Schedule
  - Attachment 4: Precipitation and Ohio River Stage Data
  - Attachment 5: Presentation: Summary of EPA and KY Comments on the 2016 Sitewide Paducah Groundwater Flow Model
  - Attachment 6: Presentation: KRCEE Independent Review of the 2016 Sitewide Paducah Groundwater Flow Model
  - Attachment 7: McNairy Lithologic Technical Paper Annotated Outline
- April 6, 2022, Meeting Summary (Appendix C)
  - Attachment 1: Groundwater Strategy Potentiometric Map November 2021
  - Attachment 2: Groundwater Elevation Data for TVA Wells Collected by KY on February 23, 2022
  - Attachment 3: 2022 Groundwater Strategy Project Planning Dates and EMP Schedule
  - Attachment 4: Drone Information Provided by EPA Navassa, North Caroline Project
  - Attachment 5: McNairy Lithologic Technical Paper Outline
  - Attachment 6: Precipitation and Ohio River Stage Data
  - Attachment 7: Presentation: Summary of EPA and KY Comments to the 2016 Sitewide Paducah Groundwater Flow Model
- July 13, 2022, Meeting Summary (Appendix D)
  - Attachment 1: Groundwater Strategy Potentiometric Map February 2022
  - Attachment 2: Groundwater Elevation Data for TVA Wells Updated Datasets: August 2021, November 2021, and February 2022
  - Attachment 3: 2022 Groundwater Strategy Project Planning Dates and EMP Schedule
  - Attachment 4: Precipitation and Ohio River Stage Data
  - Attachment 5: Pages from: MMES 1995. *Final Report on Drive-Point Profiling of the Northwest Plume and Analysis of Related Data*, KY/ER-66R, April

Organizations and their affiliations that participate in the production of this document are the U.S. Department of Energy, the U.S. Environmental Protection Agency (EPA) Region 4, the

Commonwealth of Kentucky (KY) Energy and Environment Cabinet, the KY Radiation Health Branch, and the Tennessee Valley Authority (TVA).

Throughout FY 2021 and FY 2022, quarterly synoptic water level measurement events were conducted and potentiometric maps for the site were generated and discussed as part of the quarterly Paducah Site Groundwater MWG meetings. The following potentiometric maps are included in Appendix E.

- February 2021
- May 2021
- August 2021
- November 2021
- February 2022
- May 2022
- August 2022

During FY 2022, the Paducah Site Groundwater MWG participated in the development of three white papers by reviewing and providing input for those papers. The white papers include the following:

- *Evaluation of Anthropogenic Recharge Associated with the Process Buildings in Support of the Sitewide Groundwater Flow Model, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, FRNP-RPT-0224. The Paducah Site Groundwater MWG undertook the development of this white paper in response to an uncertainty regarding the quantity of induced groundwater infiltration derived from roof drain system leaks of process buildings at the Paducah Gaseous Diffusion Plant (PGDP)—identified in the *2016 Update of the Paducah Gaseous Diffusion Plant Sitewide Groundwater Flow Model*, DOE/LX/07-2415&D2/A1. The white paper presents process building construction information and a tiered approach to assess the current formation of a seasonal reservoir in the gravel sub-slab layer of the process buildings, should further investigation be determined necessary. The white paper concludes that the thin, compacted nature of the gravel layer beneath the floor slab of all four process buildings limits the significance of variable saturation within the gravel layer. The white paper also provides an outline for a graded approach for potential future field studies, based on the anticipated uncertainty in a future groundwater flow model update, and the need for further investigation to assess the amount of groundwater infiltration related to roof drain system leaks of process buildings.

  The Paducah Site Groundwater MWG was provided the draft white paper on February 15, 2022. The group provided comments on March 24, 2022, and the comments were discussed during the April 6, 2022, meeting. The final paper was provided to the Paducah Site Groundwater MWG on July 19, 2022, and a copy of the paper is included as Appendix F.

- *Detailed Correlations between Lithologic Units in the McNairy Formation across the Paducah Gaseous Diffusion Plant*, FRNP-RPT-0249. This paper was prepared to be consistent with and to satisfy a requirement in the Memorandum of Agreement for resolution of informal dispute concerning the 2018 Five-Year Review. This paper will be formally issued, following issuance of the *Remedial Investigation/Feasibility Study Report for the C-400 Complex Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2474&D1.

  This paper provides a review of the available lithologic information for PGDP and assesses the presence and displacement of faulting within the McNairy Formation. Based on the review of the lithologic information, no evidence of faulting is apparent from the correlation of soil borings; however, this paper concludes that the deep PGDP soil borings with available lithologic logs are spaced too far apart to identify the occurrence of faults with offsets of approximately 25 ft or less within the

McNairy Formation. The closely-spaced soil borings of the C-400 Complex Operable Unit remedial investigation did not identify faulting within the upper McNairy Formation.

The Paducah Site Groundwater MWG was provided the draft paper on June 30, 2022. The group provided comments on June 28, 2022, and August 1, 2022. The Paducah Site Groundwater MWG comments will be reflected in the final paper, which is to be issued in FY 2023.

- *Evaluation of the 2016 Groundwater Model with Updated Reference Point Elevations for the Groundwater Monitoring Network at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, FRNP-RPT-0234. This white paper was developed to assess the impacts of updated reference measuring point elevations on the model calibration and the 2016 sitewide groundwater model results. The paper concludes that the overall model calibration, which used updated water level targets, would not have changed substantively and that the findings and conclusions, based on the 2016 model results, remain valid.

  The Paducah Site Groundwater MWG was provided the draft paper on February 23, 2022. The group provided responses to the paper on May 3, 2022, and May 4, 2022, which did not result in any changes to the paper. The paper was incorporated into the 2016 sitewide groundwater modeling report (DOE/LX/07-2415&D2/A1), dated June 2022. The final version of the paper was provided as Appendix E of the 2016 Groundwater Flow Model document.

The white paper, *Comparison of Regional Groundwater Flow Pre- and Post-Construction and Operation of Olmsted Locks and Dam*, FRNP-RPT-0260, is currently under development and will be provided to the Paducah Site Groundwater MWG in FY 2023 for input. The paper provides a comparison of synoptic groundwater level measurements (i.e., synoptic events), precipitation records, and Ohio River elevations collected from September 2013 through February 2022, and is reflective of the pre- and post-construction and operation periods of the Olmsted Locks and Dam. The evaluation presented in the paper is intended to be used for consideration when the Paducah Site groundwater model is updated.

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APPENDIX A

GROUNDWATER MODELING WORKING GROUP MEETING SUMMARY—OCTOBER 6, 2021

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ACRONYMS[1]

AIP	agreement in principle
amsl	above mean sea level
BC	Bayou Creek
CB	colloidal borescope
CCR	coal combustion residual
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CRS	comment response summary
CSM	conceptual site model
DNAPL	dense nonaqueous-phase liquid
DOE	U.S. Department of Energy
DQO	data quality objective
DTW	depth to water
EMP	environmental monitoring plan
EPA	U.S. Environmental Protection Agency
ETAS	Enterprise Technical Assistance Services, Inc.
EW	extraction well
FRNP	Four Rivers Nuclear Partnership, LLC
FS	feasibility study
FY	fiscal year
GIS	geographic information system
GW	groundwater
GWSP	groundwater strategy project
KRCEE	Kentucky Research Consortium for Energy and the Environment
KY	Commonwealth of Kentucky
LBC	Little Bayou Creek
LBCSP	Little Bayou Creek seep
MCL	maximum concentration limit
MW	monitoring well
MWG	Modeling Working Group
NGVD	National Geodetic Vertical Datum
OREIS	Oak Ridge Environmental Information System
OU	operable unit
PEGASIS	PPPO Environmental Geographic Analytical Spatial Information System
PEST	parameter estimation
PGDP	Paducah Gaseous Diffusion Plant
P-QAPP	programmatic quality assurance project plan
PT	pressure transducer
PVC	polyvinyl chloride
PZ	piezometer
Q	quarter
RFP	request for proposal
RGA	Regional Gravel Aquifer
RI	remedial investigation
RMS	root mean squared
RMSE	root mean square error
SS	special storage

[1] Acronym list was not part of the original meeting summaries.

SWMU	solid waste management unit
TBD	to be determined
TIC	top of inner casing
TOC	top of casing
TVA	Tennessee Valley Authority
UCRS	upper continental recharge system
VI	vapor intrusion
WDA	waste disposal alternative

Paducah Site Groundwater Modeling Working Group
Meeting Summary—October 6, 2021

MWG Attendees:

DOE
Rich Bonczek ✓
Dave Dollins ✓

ETAS
Martin Clauberg ✓
Bruce Stearns ✓
Tracy Taylor ✓

KRCEE
Steve Hampson ✓

TVA
Tabitha Ester ✓
Anna Fisher ✓
Dominic Norman ✓

EPA
Noman Ahsanuzzaman ✓
Ben Bentkowski
Eva Davis ✓
Mac McRae
Victor Weeks ✓

Kentucky
Brian Begley ✓
Stephanie Brock
Nathan Garner ✓
Brian Lainhart
Bart Schaffer
Chris Travis ✓

FRNP
Austin Buckhalter
Bryan Clayton
Lisa Crabtree
Ken Davis ✓
Rob Flynn
Bruce Ford
Stefanie Fountain ✓
LeAnne Garner
Bruce Meadows ✓
Todd Powers
Joe Tarantino ✓
Denise Tripp ✓
Alexis Wiltfong ✓

Original meeting agenda items are provided in followed by meeting notes; the meeting notes are provided in italics with action items noted in green.

1. Call for Issues from Groundwater Modeling Working Group (MWG) Members

No comments were received to the July 14, 2021, Meeting Summary (sent to participants on 8/2/2021). This summary will be considered final.

No comments were received to the July 14, 2021 Meeting Summary. The meeting summary is now final.

2. FY 2022 Work Plan/Schedule

Activity	Date
~~Quarterly Meeting (October/FY22Q1)~~	~~10/6/2021~~
MWG Concurs with FY 2022 Work Plan/Schedule	11/5/2021
Submit Draft Meeting Summaries and White Papers Compilation (FY21)	11/15/2021
MWG Provide Comments on Draft Compilation of Meeting Summaries and White Papers (FY21)	11/30/2021
Submit Final Meeting Summaries and White Papers Compilation (FY21)	12/21/2021
Quarterly Meeting (January/FY22Q2)	1/12/2022
Submit Draft Large Building PZ White Paper to MWG	1/12/2022
MWG Review Draft Large Building PZ White Paper	2/16/2022
Submit Draft Survey White Paper 2 to MWG	3/3/2022
Quarterly Meeting (April/FY22Q3)	4/6/2022
Submit Final Large Building PZ White Paper to EPA and KY	4/15/2022
Quarterly Meeting (July/FY22Q4)	7/13/2022
Submit Draft McNairy Lithologic Technical Paper to MWG	8/11/2022

Activity	Date
MWG Meeting to Discuss Draft McNairy Lithologic Technical Paper	8/24/2022
MWG Provide Comments on Draft McNairy Lithologic Technical Paper	9/12/2022

Color code for schedules:

Due date	Quarterly meeting
Submittal date	Concurrence/acknowledgement date

The Proposed FY 2022 Work Plan/Schedule will be revised to reflect new dates for the Large Building PZ White Paper and the Survey White Paper 2. The revised dates will be provided to the group once they are finalized

b. FY 2023 Activities

Activity	Date
Quarterly Meeting (October/FY23Q1)	10/5/2022
Submit Final McNairy Lithologic Technical Paper to EPA and KY	11/7/2022

These activities and dates are provided for advance planning.

3. Update on Water Levels

Synoptic water level events are being collected quarterly, and since the last meeting (July 14, 2021) a synoptic event occurred on August 23-26, 2021. Groundwater elevation data is in the process of being reviewed and will be discussed with the MWG at the FY2022/Q2 (January) meeting.

Groundwater elevation data for TVA wells collected by KY occurred on August 25, 2021 and is included as Attachment 1.

There was no discussion by the group specific to water levels. Several items regarding the TVA sheet pile wall construction were discussed; refer to Summary Item 11, Projects on the "Watch Topics" List, TVA Changes section for more information.

4. 2020 Plume Map Document

The document *Trichloroethene and Technetium-99 Groundwater Contamination in the Regional Gravel Aquifer for Calendar Year 2020 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (referred to as the Plume Map Document) was issued on August 9, 2021. A summary of the document is included in Attachment 2.

*The addition of the 1,930 pCi/L isocontour to the Tc-99 figures was discussed by the group. Attachment 2 references the 1,930 pCi/L as (DOE 2020). This reference was mistakenly relayed to the MWG as (DOE 2020) in Attachment 2 and was discussed during the meeting as the derived concentration standard based on the 2021 DOE-STD-1196 (*Derived Concentration Technical Standard*) under DOE Order 458.1. As described in the 2020 Plume Map Document, the correct reference for the derived concentration standard of 1,930 pCi/L is Table A.9 in the* Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Volume 1. Human Health*, DOE/LX/07-0107&D2/R12V1 (DOE 2021) and the 2011 DOE-STD-1196, where 1,930 pCi/L represents the derived concentration standard corresponding to standards for public consumption of drinking water that equate to an effective dose of 4 mrem/year. DOE-STD-1196 was updated in 2021 (https://www.standards.doe.gov/standards-documents/1100/1196-astd-2021/@@images/file). As noted in the 2021 standard, "some dose coefficients and [derived concentration standards] have moderately significant changes as a result of the improved dosimetry and updated population*

distribution in the Standard…" The revised dose coefficients and derived concentration standards will be reviewed as part of the 2022 update to the Risk Methods Document and will be discussed with the Risk Assessment Working Group.

The group specifically discussed the TCE trends at MW354. This location is part of the Groundwater Strategy Project Activity #1 discussed below.

DOE provided an update on the EarthCon contract and evaluation; these are now planned for next calendar year following the completion of the C-400 remedial investigation.

5. Update on Paducah Site Groundwater Strategy

The Groundwater Strategy Project (GWSP) schedule from the EMP is included as Attachment 3. In this schedule, "Month 1" is September 2020. Data has been collected for Months 1-12 (September-August).

Datasets from September 2020-August 2021, and also including the January 2020-March 2020 datasets, are being reviewed; inconclusive datasets were reviewed against DQOs to understand if additional testing is indicated for FY2022.

Field data collection planned for FY 2022, including any additional testing associated with FY 2021 data collection, will be included in the FY2022 EMP.

FRNP continues to coordinate with KY on the AIP monitoring wells sampling schedule.

Activity	Activity Description	FY 2021 Scope	FY 2022 Scope
1	TCE Extent West of PGDP (SW Plume)	Water level/colloidal borescope investigation	Continue field data collection at select wells Desktop study: Evaluate data collected in 2020/2021 for potential additional monitoring well installation
2	TCE Extent East of PGDP (Downgradient NE Plume)	Water level/colloidal borescope investigation	Review data and prepare map(s)
3	North Extent of PGDP TCE plumes (Impacts to Ohio River)	None	Desktop study: Develop/revise conceptual site model
4	Nature and Extent of Dissolved-Phase Contaminants Currently Contributed by Little Bayou Creek Seeps	None	Quarterly walkdowns with seep sampling (if seeps are identified) Desktop study: Review of historical seep and water level data
5	Nature and Extent of Dissolved-Phase Contaminants Other than TCE and Tc-99	None	Desktop study: Develop/revise conceptual site model, review/summary of analytical data
6	Capture Efficiency of NW Plume Extraction Wells	None	Desktop study: Develop/revise conceptual site model, optimize extraction well pump rates and pump depths

Activity	Activity Description	FY 2021 Scope	FY 2022 Scope
7	TCE Extent and Trends in East Side of Downgradient NW Plume	None	Two rounds of CB testing in MW98, MW135, and MW200 Desktop study: Evaluate data collected in 2020/2021 for potential additional monitoring well installation
8	TCE Extent and Trends in West Side of Downgradient NE Plume	Water level/colloidal borescope investigation	Two rounds of CB testing in monitoring well MW193 Desktop study: Evaluate data collected in 2020/2021 for potential additional monitoring well installation
9	RGA Dissolved-phase and DNAPL Contaminant Impacts to the McNairy Formation	None	Review data from C-400 Remedial Investigation
10	Characterize Underflow from the Terrace Area	None	Desktop study: Develop/revise conceptual site model
11	Expansion of GW Monitoring Network	None	Desktop study: Develop/revise conceptual site model, review of EarthCon evaluation (if available), obtain and review TVA groundwater data
12	Water Balance Study	None	Perform walkdown along areas of interest to identify potential sampling and/or gauging locations Desktop study: Documentation of the ongoing utility optimization program, compilation of available information regarding the chronology of roof drain repairs, expanded assessment of the water supply and storm water systems, and review of outfall data
13	Continuous RGA Water Level Monitoring	Water level/colloidal borescope investigation	Reporting
14	Synoptic Water Level Events	Field synoptic water level measurements	Continue quarterly synoptic water level measurements (add new C-400 MWs)
15	Water Level Divide Study	Water level/colloidal borescope investigation	Perform two rounds of CB measurements at MW525, MW526, MW527, MW529, and MW155, MW156, MW178, MW341
16	Hydraulic Conductivity	None	Post-FY2022 Activity
17	Monitoring Well Survey Study	Well elevation survey Survey White Paper 1	Survey White Paper 2
18	Groundwater Chemical Trend Evaluation	Review existing groundwater analytical data	Review existing groundwater analytical data
19	TCE Degradation Rates	None	Desktop study: Develop/revise conceptual site model, review of available data

The group discussed the overall objectives for the GWSP:

Develop a groundwater strategy that closes out various issues for the site:

- *Change status of two Environmental Indicator Performance Measures to "Yes"*
  - *Human exposure under control*
  - *Groundwater migration under control*
- *Resolution of data needs*
- *Groundwater Modeling Working Group (MWG) recommended maintenance and updates*

The project objectives and draft schedule were originally discussed during the April 10, 2019 MWG meeting and included in the Compilation of Meeting Summaries and White Papers (2019–July 2020) (DOE/LX/07-2451&D1). The GWSP is a multi-year plan with near-term (0-3 years) activities and longer-term (beyond 3 years) activities planned. The specific timing and scope of each activity are developed by DOE based on data collected in the prior year(s).

The group discussed the relationship between the GWSP and the C-400 OU Remedial Investigation. These projects are separate, but where activities overlap they are coordinated and the relevant information obtained from the remedial investigation will be incorporated into the GWSP.

The group specifically discussed Activity 4: KY advised that seeps may not be able to be observed during quarterly walkdown, specifically during periods where the Ohio River is elevated above normal pool and where the seeps are not accessible or visible due to the Ohio River backing up into the creek KY recommended instead coordinating the walkdowns with precipitation and river stage forecasts. Stream gauging is not planned for FY 2022 due to the ongoing construction of the TVA sheet pile wall and the intent to observe the system for any changes resulting from the presence of the wall. KY suggested that the walkdowns be adjusted to account for fluctuations in the Ohio River stage.

6. Discussion on Installation of Piezometers …Associated with Several of the Large Process Buildings

Preliminary information to be collected for the "Installation of piezometers …associated with several of the large process buildings…." white paper will benefit from the information learned during the vapor intrusion (VI) project. The D1 VI Work Plan was finalized in December 2020 and field sample collection occurred February 22, 2021 through March 9, 2021. The D1 VI Report was submitted to EPA and KY in September 2021.

The schedule for this white paper has been revised as shown below to allow for integration of VI Report information into the white paper, as appropriate.

Activity	Target Start	Target Finish
~~Quarterly Meeting (October/FY21Q1)~~		~~10/7/2020~~
~~Develop Outline for Large Building PZ White Paper~~	~~10/14/2020~~	~~12/11/2020~~
~~Provide Large Building PZ White Paper Outline to MWG~~		~~12/11/2020~~
~~MWG Review Large Building PZ White Paper Outline~~	~~12/11/2020~~	~~1/13/2021~~
~~Quarterly Meeting (January/FY21Q2)~~		~~1/13/2021~~
~~Revise Outline for Large Building PZ White Paper Based on MWG Discussions~~	~~1/13/2021~~	~~1/28/2021~~

Activity	Target Start	Target Finish
~~VI Field Sampling / Laboratory Analysis / Validation~~	~~Feb 21~~	~~Apr 21~~
~~Quarterly Meeting (April/FY21Q3)~~		~~4/7/2021~~
~~Quarterly Meeting (July/FY21Q4)~~		~~7/14/2021~~
Develop Draft Large Building PZ White Paper	9/1/2021	1/12/2022
Quarterly Meeting (October/FY22Q1)		10/6/2021
Submit Draft Large Building PZ White Paper to MWG		1/12/2022
Quarterly Meeting (January/FY22Q2)		1/12/2022
MWG Review and Provide Comments on Draft Large Building PZ White Paper	1/23/2022	2/16/2022
MWG Meeting to Discuss Draft Large Building PZ White Paper		TBD
Revise Draft Large Building PZ White Paper	2/17/2022	4/15/2022
Submit Final Large Building PZ White Paper to EPA and KY		4/15/2022

Items shown in strikeout text are completed.

The draft annotated outline was included in the January 13, 2021 MWG meeting summary (sent to participants on 1/28/2021). No comments were received on the included outline and the outline is considered final.

During the July 14, 2021 MWG meeting the group discussed that during the C-400 Remedial Investigation, no water has been observed in the UCRS in monitoring points installed through the foundation of the C-400 building. It was discussed that the C-400 building observations may not be representative of the buildings of interest in this white paper.

The schedule for the Large Building PZ White Paper will be revised due to several other ongoing activities and will be provided to the MWG when finalized.

Information available on the historical and archived plant drawings show that the process buildings were constructed similar to one another and have a thin (9-inch to 12-inch) compacted gravel layer underlying the concrete floor of the buildings. There are drain lines in the compacted gravel layer, but the limited thickness of the gravel likely would make installation of piezometers in the gravel layer impractical. The lack of water in the piezometers installed in the much thicker gravel layer (5 to 8 ft thick) underlying the concrete at C-400 also indicates that it is unlikely that there is water storage under the process building concrete floors. KY suggested the team assess probing the concrete under the process building floors to confirm the gravel thickness and confirm the gravel is not saturated.

7. CSM for the RGA in SWMU 211-A Remedial Action Work Plan

Section 1.1.2, "Regional Hydrogeology," references an axis in describing thickness trends for gravel deposits forming the RGA. EPA would like to discuss if the use of the term axis has any implied significance to groundwater flow direction(s) (i.e., a north-south lateral groundwater flow divide) or any implication for implied subsurface structural feature(s) forming the RGA (i.e., the existence of an east-west fault-controlled structural low).

The site geologist explained the east-west trend is consistent with ancestral Tennessee River and is believed to be an erosional surface (thalweg is the geomorphology term). EPA suggested that the Paducah Site area may have several generations of seismic activities, overprinting of seismicity could

be happening, and east-west faulting may have occurred. Steve Hampson had a follow-up after discussion with Dr. Woolery and Dr. Zhu.

Steve Hampson reported that an east-west trend is prevalent at PGDP, as evidenced in both regional and local studies. Regional faults commonly trend northeast-southwest but that there could be local structural controls under PGDP that could influence groundwater flow. Seismic studies have not previously been conducted between the east and west fences and from the Porters Creek terrace to north fence because it was not possible to filter out the noise of the operating plant. Most of the plant infrastructure is no longer operating and Steve Hampson discussed that Dr. Woolery has noted there are now seismic reflection techniques that could give a better view of what the structure is beneath the site.

DOE and FRNP are reviewing whether there are any ways to further reduce (temporarily) sources of noise to facilitate new testing without disrupting site activities. Dr. Woolery has offered to support any requests or initiatives that may develop regarding additional seismic surveys at the Paducah Site.

No comments were received on this topic during the meeting.

8. CSM for the McNairy in the C-400 Complex Area

FRNP has set up a website to house a library of McNairy information. Access the website at the following link: https://fourriversnuclearpartnership.com/McNCSM. The site requires a password that has been sent separately. Contact Stefanie if you need the password to the website.

A lithology white paper is being prepared as part of the resolution of dispute on the CERCLA Five Year Review. DOE will issue the technical paper within one month of submittal of the D1 C-400 Complex OU RI/FS Report to support the review and comment of the C-400 specific data interpretation as part of the C-400 Complex OU RI/FS Report review process and the performance of the FY 2023 Five-Year Review revised protectiveness determinations for the Northeast, Northwest, and Water Policy response actions. The regulatory milestone date for the D1 C-400 Complex OU RI/FS Report has been revised to October 7, 2022.

A draft schedule and annotated outline for the paper were discussed during the October 2020 Groundwater MWG meeting. The schedule was revised to reflect the new C-400 Complex OU RI/FS Report date and was discussed during the January 13, 2021 meeting (see below). The plan continues to be that the draft Lithology Paper will be available to the MWG before the D1 C-400 Report is submitted so that substantive comments may be addressed prior to the D1 C-400 Report being issued. The Lithology Paper will then be revised and submitted.

Activity	Target Start	Target Finish	Notes
~~FRNP/DOE Develop Outline for Draft McNairy Lithologic Technical Paper~~	~~7/7/2020~~	~~9/30/2020~~	COMPLETE
~~Provide Draft McNairy Lithologic Technical Paper Outline to MWG~~		~~9/30/2020~~	COMPLETE
~~MWG Review Draft McNairy Lithologic Technical Paper Outline~~	~~9/30/2020~~	~~10/7/2020~~	COMPLETE
~~Quarterly Meeting (October/FY21Q1)~~		~~10/7/2020~~	COMPLETE
~~FRNP/DOE Revise Draft Outline for McNairy Lithologic Technical Paper Based on MWG Discussions~~	~~10/7/2020~~	~~10/22/2020~~	COMPLETE

Activity	Target Start	Target Finish	Notes
~~Provide Final Outline for McNairy Lithologic Technical Paper to MWG~~		~~10/22/2020~~	COMPLETE
~~Quarterly Meeting (January/FY21Q2)~~		~~1/13/2021~~	COMPLETE
~~Quarterly Meeting (April/FY21Q3)~~		~~4/7/2021~~	COMPLETE
~~Quarterly Meeting (July/FY21Q4)~~		~~7/14/2021~~	
Collect C-400 Lithology Data	5/17/2021	3/16/2022	From C-400 Schedule
FRNP/DOE Develop Draft McNairy Lithologic Technical Paper Text	8/4/2021	3/10/2022	
Quarterly Meeting (October/FY21Q3)		10/6/2021	
Finish Collection of C-400 Lithology Data		3/16/2022	From C-400 Schedule
FRNP/DOE Incorporate C-400 Results into Draft McNairy Lithologic Technical Paper	3/16/2022	8/11/2022	
Develop C-400 RI Report	3/17/2022	9/14/2022	From C-400 Schedule
Issue Draft McNairy Lithologic Technical Paper to MWG		8/11/2022	
MWG Review and Provide Comments on Draft McNairy Lithologic Technical Paper	8/11/2022	9/12/2022	
MWG Meeting to Discuss Draft McNairy Lithologic Technical Paper		8/24/2022	Draft FY2021 MWG Work Plan Date
MWG Provide Comments on Draft McNairy Lithologic Technical Paper		9/12/2022	
C-400 RI Report Submitted to EPA and KY		10/7/2022	Current Milestone
FRNP/DOE Revise Draft McNairy Lithologic Technical Paper	9/12/2022	11/7/2022	No formal CRS
Submit Final McNairy Lithologic Technical Paper to EPA and KY		11/7/2022	Tech Paper Due 1 Month After C-400 RI Report (Currently 10/8/2022)

Items shown in strikeout text are completed.

The KRCEE spreadsheet database of soil boring logs (R10 HydroLitho Dbase posted 121620.xlsx) is available at https://fourriversnuclearpartnership.com/McNCSM.

The final annotated outline was included in the October 14, 2020 MWG meeting summary (sent to participants on 11/23/2020 and with agreed-upon revisions discussed during the 1/13/2021 meeting). No comments were received on the outline and the outline was considered final. The MWG plans to discuss the Draft McNairy Lithologic Technical Paper text between the July 2022 and October 2022 MWG meetings.

The group discussed that observations from the C-400 field investigation drilling does not indicate fault interruption in the McNairy. DNAPL has not been observed in the McNairy to date, indicating migration through the RGA is not occurring. It is reasonable to conclude that if this is not occurring at C-400, it is likely not occurring elsewhere at the site.

The group discussed the schedule for the McNairy Lithology Paper and the need for rapid turnaround on any comments. KY is open to meetings on the paper to facilitate the quick review.

9. Resurvey of wells

The field resurveying effort for the monitoring well reference point elevations was completed October 9, 2020 and the data review was completed in November 2020. The data are in the process of being reviewed for upload to OREIS.

A white paper summarizing the approach and scope of the resurvey work was developed and has been appended to the 2021 update to the P-QAPP.

A second white paper on potential impacts of the new survey data and the impact to the groundwater model will be developed. The draft outline for this paper, *Evaluation of the 2016 Groundwater Model with Updated Reference Point Elevation for the Groundwater Monitoring Network at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, was discussed during the July 14, 2021 MWG meeting and was included in the meeting summary (sent to participants on 8/2/2021). No comments were received on the outline and the outline was considered final. This second survey white paper is currently planned to be appended to the 2016 Groundwater Model Report. KY and EPA have agreed on this approach and DOE will confirm the approach with Site management when the paper is developed in draft.

No comments were received on this topic during the meeting.

10. Precipitation and Ohio River Stage

Attachment 4 includes precipitation and Ohio River stage charts through September 15, 2021.

The charts were discussed and show that the Ohio River is currently at base stage following a drought over the summer. Typically, winter rain events result in Ohio River flood stage conditions.

11. Projects on the "Watch Topics" List

- **TVA Changes.** During the October 2020 and January 2021 meeting, the MWG discussed the construction of the new ash ponds and a recent RFP for a 3,800 ft sheet pile wall to be constructed in close proximity to Little Bayou Creek and several seeps. The sheet pile wall may intercept the RGA and influence the creek.

  During the July 14, 2021 meeting, the MWG discussed the sheet pile wall being installed by TVA along Little Bayou Creek and along the southwest portion of the existing coal combustion residuals (CCR) landfill (as shown on the Figure 1). The wall is intended to stabilize the creek's bank, as opposed to control groundwater. KY/TVA provided as-built drawings showing the installation depth of the wall. A cross section of the sheet pile wall, the creek, and the interpolated upper and lower limits of the RGA is shown in Figure 2.

  Based on the information available in the TVA drawings, the sheet pile wall, the wall extends a significant depth into the RGA. The wall joints are not sealed, and TVA will confirm that the sheet piles themselves are solid (not perforated). TVA will confirm whether the notations are design or as-built and relay findings to the group; TVA will also confirm the depths of the sheet pile wall construction. The wall construction is currently estimated at 80-90% complete.

- **Consider stream gauging in relation to the synoptic water levels.** Stream gauging has been discussed as part of out-year activities. See October 2018 Meeting Summary for additional

information. Stream gauging will support new modeling. The figure on the next page depicts the planned alignment of the sheet pile wall.

During FY 2022, quarterly walkdowns of portions of Little Bayou Creek are planned to identify any new seeps as part of the Groundwater Strategy project and to identify locations for potential future stream gauging, as appropriate.

Refer to Summary Item 5, Update on Paducah Site Groundwater Strategy, for more information on the group's discussion regarding stream walkdowns.

Seeps. There have been no seep results above the maximum concentration limit (MCL) for trichloroethene (TCE) for many years. The location of the seeps and TCE data for the seeps are depicted on Figure 3. KY clarified that some of the seeps on the figure are in the creek and some are on the banks of the creek.

The group discussed that LBCSP5 routinely has flow and is able to be sampled, whereas many of the other previously identified seeps do not have flow consistently. KY reported that they have revised their stream walkdowns to go further up and downgradient of LBCSP5. KY also suggested the use of thermal imaging for seep identification in the winter months.

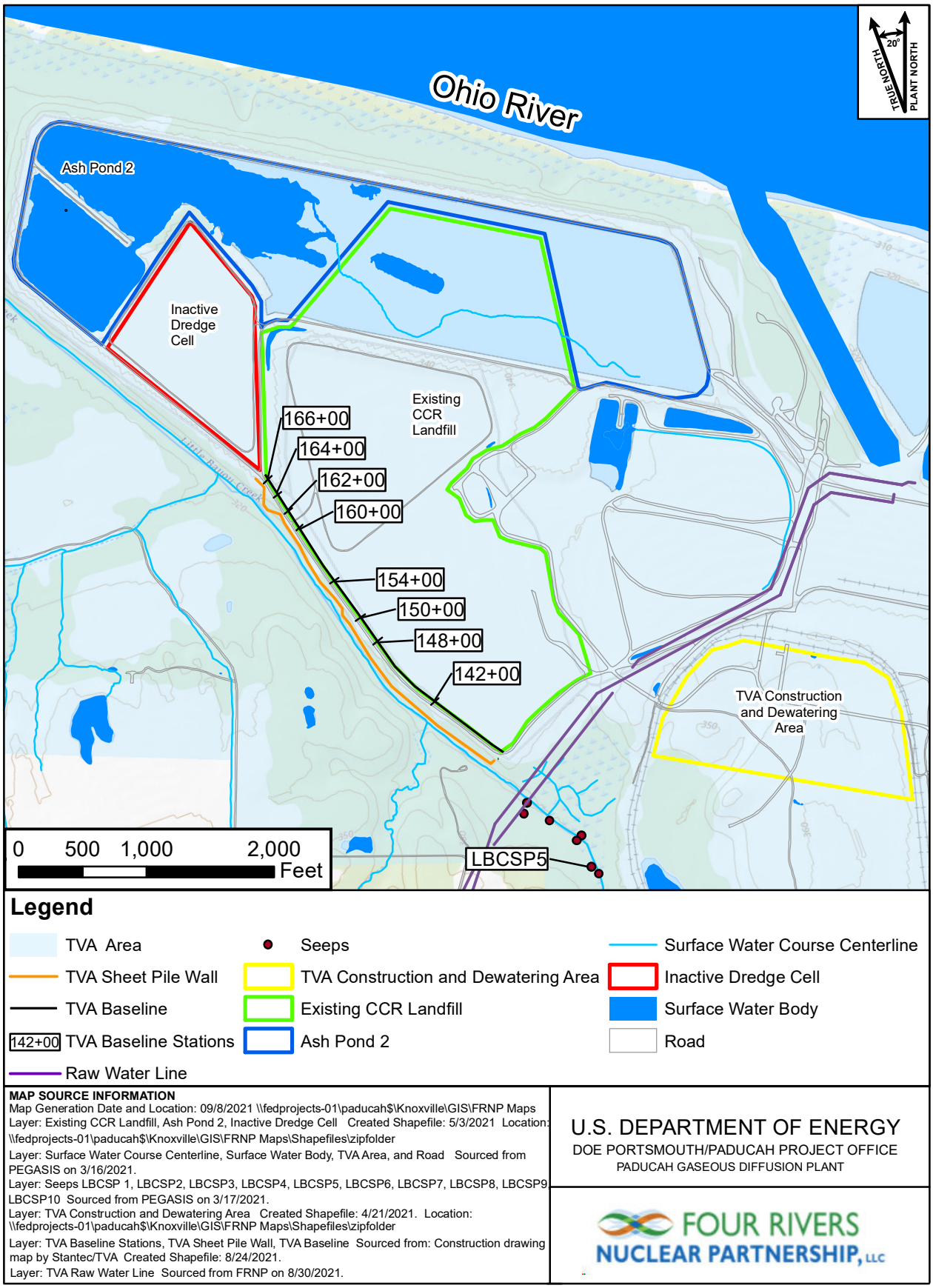
- **"No Go" Areas for Monitoring Well Installations.**
    - Corridors where overhead transmission lines have been removed have been considered for monitoring well placement, especially with respect to the west side of the NE Plume. Previously, overhead transmission lines prevented installation of wells to the west in the northern-most transect of wells. A new substation (C-538) has been constructed east of the C-755 trailer complex. On the west side of the new substation, 161kV overhead lines are being installed along the existing overhead line corridor. On the east side of the new substation, 161kV overhead lines (near the C-755 parking lot and between K010 and K011) are being installed along the 161kV lines. Most of the overhead lines have been taken down from McCaw Road to the plant with only a static line remaining on the towers on the south into the C-331 yard.
        - The 161 KV feeder line from TVA to C-531 Switchyard are in the process of being removed.

- Map of the formerly unavailable utility corridor area(s) is included as Figure 4.

Power line corridor east of the C-764-U Landfill area (looking south). Photo taken September 6, 2021.

The group discussed the current power line configurations and noted that the remaining line on the east work in the photo is not a high power transmission line and is possibly a telecommunication line. The group discussed the area to the west of MW463 and WM464. FRNP will continue to monitor impacted power lines, will confirm the operational status of the new substation, will request any available information on future plans for decommissioning of other power lines, and will update Figure 4 accordingly for the next meeting.

Figure 1


Ohio River
TRUE NORTH
20°
PLANT NORTH
Ash Pond 2
Inactive Dredge Cell
Existing CCR Landfill
166+00
164+00
162+00
160+00
154+00
150+00
148+00
142+00
TVA Construction and Dewatering Area
LBCSP5
0 500 1,000 2,000 Feet
Legend
TVA Area
Seeps
Surface Water Course Centerline
TVA Sheet Pile Wall
TVA Construction and Dewatering Area
Inactive Dredge Cell
TVA Baseline
Existing CCR Landfill
Surface Water Body
142+00 TVA Baseline Stations
Ash Pond 2
Road
Raw Water Line
MAP SOURCE INFORMATION
Map Generation Date and Location: 09/8/2021 \\fedprojects-01\paducah$\Knoxville\GIS\FRNP Maps
Layer: Existing CCR Landfill, Ash Pond 2, Inactive Dredge Cell Created Shapefile: 5/3/2021 Location: \\fedprojects-01\paducah$\Knoxville\GIS\FRNP Maps\Shapefiles\zipfolder
Layer: Surface Water Course Centerline, Surface Water Body, TVA Area, and Road Sourced from PEGASIS on 3/16/2021.
Layer: Seeps LBCSP 1, LBCSP2, LBCSP3, LBCSP4, LBCSP5, LBCSP6, LBCSP7, LBCSP8, LBCSP9 LBCSP10 Sourced from PEGASIS on 3/17/2021.
Layer: TVA Construction and Dewatering Area Created Shapefile: 4/21/2021. Location: \\fedprojects-01\paducah$\Knoxville\GIS\FRNP Maps\Shapefiles\zipfolder
Layer: TVA Baseline Stations, TVA Sheet Pile Wall, TVA Baseline Sourced from: Construction drawing map by Stantec/TVA Created Shapefile: 8/24/2021.
Layer: TVA Raw Water Line Sourced from FRNP on 8/30/2021.
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PADUCAH GASEOUS DIFFUSION PLANT
FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

Figure 2

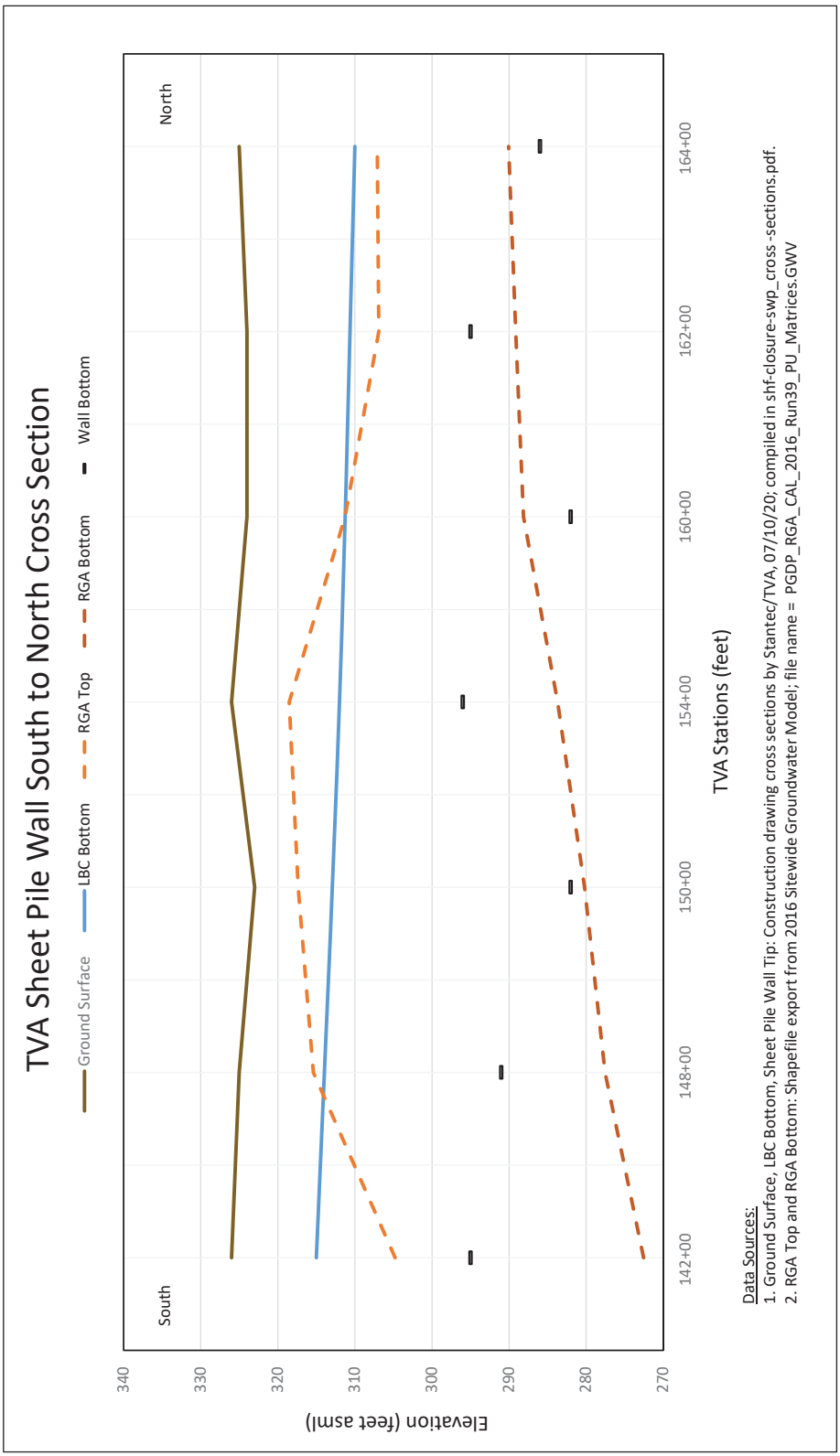
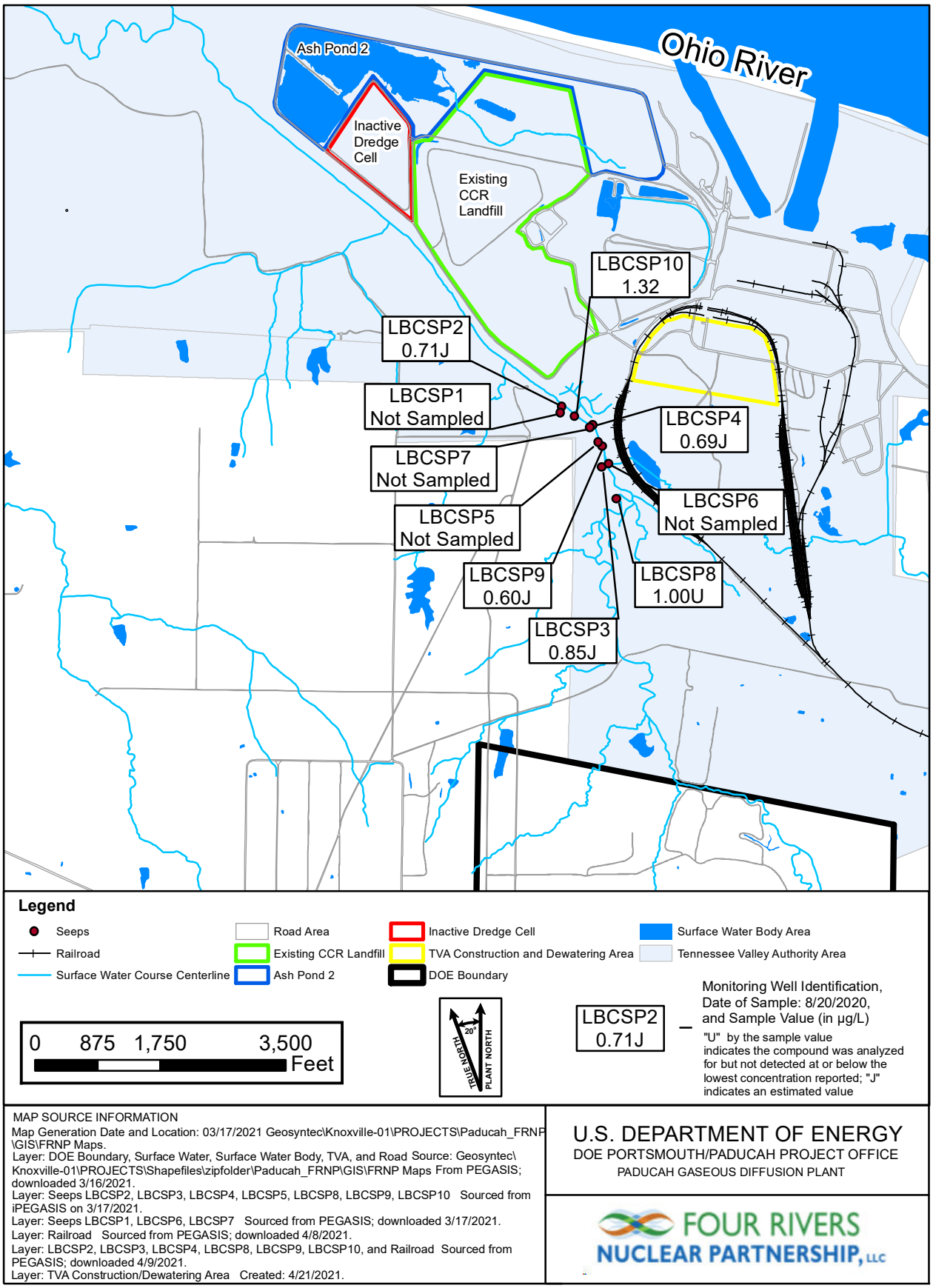

TVA Sheet Pile Wall South to North Cross Section
Ground Surface
LBC Bottom
RGA Top
RGA Bottom
Wall Bottom
South
North
Elevation (feet asml)
340
330
320
310
300
290
280
270
142+00
148+00
150+00
154+00
160+00
162+00
164+00
TVA Stations (feet)
Data Sources:
1. Ground Surface, LBC Bottom, Sheet Pile Wall Tip: Construction drawing cross sections by Stantec/TVA, 07/10/20; compiled in shf-closure-swp_cross -sections.pdf.
2. RGA Top and RGA Bottom: Shapefile export from 2016 Sitewide Groundwater Model; file name = PGDP_RGA_CAL_2016_Run39_PU_Matrices.GWV

Figure 3


Ohio River
Ash Pond 2
Inactive Dredge Cell
Existing CCR Landfill
LBCSP10 1.32
LBCSP2 0.71J
LBCSP1 Not Sampled
LBCSP4 0.69J
LBCSP7 Not Sampled
LBCSP6 Not Sampled
LBCSP5 Not Sampled
LBCSP9 0.60J
LBCSP8 1.00U
LBCSP3 0.85J
Legend
Seeps
Railroad
Surface Water Course Centerline
Road Area
Existing CCR Landfill
Ash Pond 2
Inactive Dredge Cell
TVA Construction and Dewatering Area
DOE Boundary
Surface Water Body Area
Tennessee Valley Authority Area
0 875 1,750 3,500 Feet
TRUE NORTH
20°
PLANT NORTH
LBCSP2 0.71J
Monitoring Well Identification, Date of Sample: 8/20/2020, and Sample Value (in µg/L)
"U" by the sample value indicates the compound was analyzed for but not detected at or below the lowest concentration reported; "J" indicates an estimated value
MAP SOURCE INFORMATION
Map Generation Date and Location: 03/17/2021 Geosyntec\Knoxville-01\PROJECTS\Paducah_FRNP\GIS\FRNP Maps.
Layer: DOE Boundary, Surface Water, Surface Water Body, TVA, and Road Source: Geosyntec\Knoxville-01\PROJECTS\Shapefiles\zipfolder\Paducah_FRNP\GIS\FRNP Maps From PEGASIS; downloaded 3/16/2021.
Layer: Seeps LBCSP2, LBCSP3, LBCSP4, LBCSP5, LBCSP8, LBCSP9, LBCSP10 Sourced from iPEGASIS on 3/17/2021.
Layer: Seeps LBCSP1, LBCSP6, LBCSP7 Sourced from PEGASIS; downloaded 3/17/2021.
Layer: Railroad Sourced from PEGASIS; downloaded 4/8/2021.
Layer: LBCSP2, LBCSP3, LBCSP4, LBCSP8, LBCSP9, LBCSP10, and Railroad Sourced from PEGASIS; downloaded 4/9/2021.
Layer: TVA Construction/Dewatering Area Created: 4/21/2021.
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PADUCAH GASEOUS DIFFUSION PLANT
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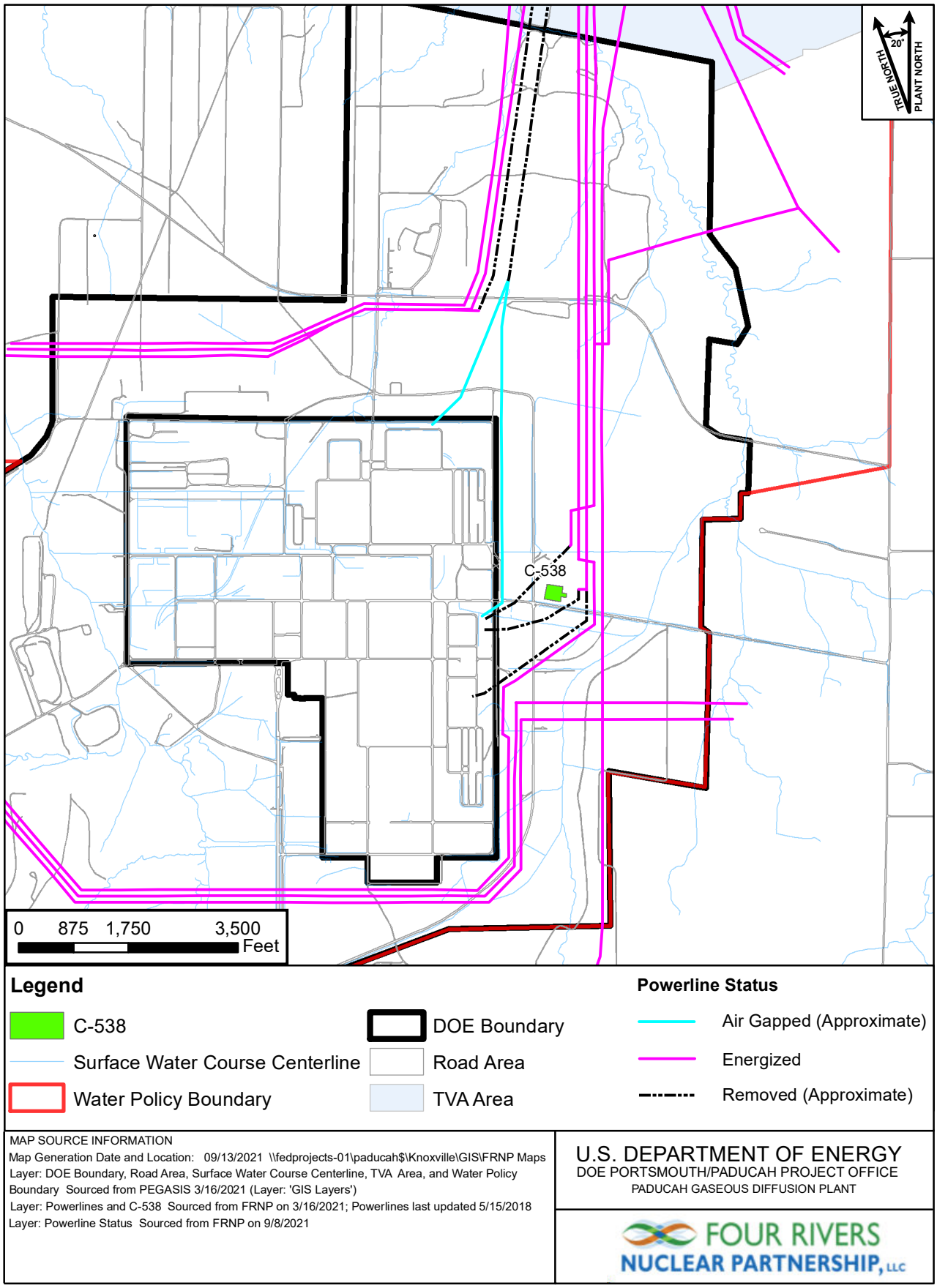
Figure 4


TRUE NORTH
20°
PLANT NORTH
C-538
0 875 1,750 3,500
Feet
Legend
C-538
Surface Water Course Centerline
Water Policy Boundary
DOE Boundary
Road Area
TVA Area
Powerline Status
Air Gapped (Approximate)
Energized
Removed (Approximate)
MAP SOURCE INFORMATION
Map Generation Date and Location: 09/13/2021 \\fedprojects-01\paducah$\Knoxville\GIS\FRNP Maps
Layer: DOE Boundary, Road Area, Surface Water Course Centerline, TVA Area, and Water Policy Boundary Sourced from PEGASIS 3/16/2021 (Layer: 'GIS Layers')
Layer: Powerlines and C-538 Sourced from FRNP on 3/16/2021; Powerlines last updated 5/15/2018
Layer: Powerline Status Sourced from FRNP on 9/8/2021
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- **Wetlands map layer.** The site is working on new wetlands maps.
    - Different projects have used different source data for wetlands and floodplains maps.
    - The map layers previously available in PEGASIS did not include information from the Waste Disposal Alternatives (WDA) project.

  These updates will be uploaded and available through PEGASIS. No field work is being performed as part of the map updates. As part of the ongoing map consistency project, these shapefiles are being reviewed and layers will be made available in PEGASIS.

  No comments were received on this topic during the meeting.

12. FY 2022 Presentations

- October 2021: FRNP to present on the *2016 Update of the Paducah Gaseous Diffusion Plant Sitewide Groundwater Flow Model* (DOE/LX/07-2415&D2).

The EarthCon presentation will be moved back in the schedule as their contract with DOE is pending. MWG members should provide any presentation requests to Stefanie. Potential topics for future meetings:

- C-400 Complex remedial investigation
- Lithology
- TCE degradation rates

Following the presentation, a number of items were discussed by the group:

- *The group asked why only Outfall 001 was specifically included in the modeling: DOE and FRNP will review the project notes to understand if the other outfalls (i.e., 008, 009, or 010) were considered for explicit inclusion in the model.*
- *The group asked whether there are any discrepancies with the new survey data for the monitoring wells: the analysis is ongoing, but the preliminary review shows no large change in levels or residuals that would result in an impact to the model calibration.*
- *EPA noted that there were a number of comments from EPA at the time of the modeling work that were not incorporated into the model.*
- *KY proposed that a dialog be initiated on the current version of the model and whether an update should be performed.*
- *EPA asked how the model would be used to drive remedial decisions and whether there was benefit to update the model for some of the marginal items. DOE explained that the focus of the model was on source areas and that the model downgradient results were a good representation of the plume configuration at the time of the modeling. The group discussed that the utility of the model as a predictive tool would only be appropriate for a certain amount of time due to ongoing changes in the operational stance at the site.*
- *KRCEE performed a review of the 2016 flow model: 2018 KRCEE report,* Review for the 2016 Update of the Paducah Gaseous Diffusion Plant Sitewide Groundwater Flow Model*; and a review of the 2008 TCE transport model: 2020 KRCEE report,* Interim TCE Transport Model for the Paducah Gaseous Diffusion Plant Site.

The group discussed the topic of the January 12, 2022 quarterly meeting should be a follow-up to the presentation provided during this meeting (Summary of the 2016 Groundwater Flow Model Update). The follow-up presentation will focus on the comments from EPA and KY on the 2016 Groundwater Flow Model Update as well as the suggestions included in the 2018 KRCEE report, Review for the 2016 Update of the Paducah Gaseous Diffusion Plant Sitewide Groundwater Flow Model.

13. Poll MWG Members/Open Discussion

The next meeting will be January 12, 2022 and the agenda and presentation slides will be provided by January 5, 2022. The group should send any agenda suggestions directly to Stefanie Fountain.

Attachment 1

Groundwater Elevation Data for TVA Wells Collected by KY on August 25, 2021

OREIS Name	Well	Description	Aquifer	Top of Casing	Top of Ground	xconv Easting (Ft)	yconv Northing (Ft)	Status	Screen Top Depth (Ft)	Screen bot depth (Ft)	tscreenelev (Ft)	bscreenelev (Ft)	GW Elev. (Datum - DTW)	Water Level	Date & Time	Barometric Pressure (inHg)	Measuring Point
TVAGW-6D	TVAGW-6D	4" PVC	Upper RGA	368.8	365.9	760787.8774	1946731.539	active	58.3	68.3	307.6	297.6	316.24	52.56	08/25/2021_0945	29.69	TOC
TVAGW-5D	TVAGW-5D	4" PVC	Upper RGA	368.5	365.7	760131.6259	1947315.953	active	60.1	70.1	305.6	295.6	315.41	53.09	08/25/2021_0948	29.69	TOC
TVAGW-4D	TVAGW-4D	4" PVC	Upper RGA	365.8	363	759456.7195	1947561.73	active	57	67.5	306	295.5	316.31	49.49	08/25/2021_0951	29.69	TOC
TVAGW-3D	TVAGW-3D	4" PVC	Upper RGA	363.8	360.9	758982.49	1947793.858	active	65.3	75.3	295.6	285.6	316.35	47.45	08/25/2021_0953	29.69	TOC
TVAGW-2D	TVAGW-2D	4" PVC	Upper RGA	370	367.1	759966.7809	1944870.473	active	55.6	65.6	311.5	301.5	322.62	47.38	08/25/2021_0940	29.69	TOC
TVAGW-1D	TVAGW-1D	4" PVC	Upper RGA	370.1	367.5	757847.0459	1946203.79	active	56	66	311.5	301.5	315.29	54.81	08/25/2021_1001	29.69	TOC
TVA-D8A	SHF-D8A	4" PVC	Upper RGA	331.82	329	754060.01	1953586.25	active	17.5	27.5	311.5	301.5	330.02	1.8	08/25/2021_1119	29.68	TOC
TVA-D75B	SHF-D75B	2" PVC	Upper RGA	353.08	350	753297.07	1955971.69	active	48	58	302	292	309.26	43.82	08/25/2021_1101	29.68	TOC
TVA-D74B	SHF-D74B	2" PVC	Upper RGA	331.99	329	756125.35	1956489.82	active	39	49	290	280	308.34	23.65	08/25/2021_1027	29.69	TOC
TVA-D30B	SHF-D30B	2" PVC	Upper RGA	324.61	320.9	757594	1955563.41	active	39	49	281.9	271.9	303.3	21.31	08/25/2021_1022	29.69	TOC
TVA-D17	SHF-D17	2" PVC	Upper RGA	365.43	362.8	758809.17	1950015.71	active	14	17	348.8	345.8	316.58	48.85	08/25/2021_1138	29.67	TOC
TVA-D11B	SHF-D11B	2" PVC	Upper RGA	321.79	319.2	753434.76	1958481.44	active	32	42	287.2	277.2	302.61	19.18	08/25/2021_1041	29.68	TOC
TVA-D10	SHF-D10	4" PVC	Upper RGA	351.74	351	752950.26	1956644.9	active	36.5	46.5	31.5	304.5	305.91	45.83	08/25/2021_1058	29.68	TOC
SHF-201C	SHF-201C	4" PVC	Upper RGA	323.75	320	746799.24	1960068.889	active	44.5	54.5	275.5	265.5	305.91	17.84	08/25/2021_1203	29.67	TOC
SHF-201B	SHF-201B	4" PVC	Upper RGA	323.75	320.2	746641.107	1960082.768	active	32	37	288.2	283.2	305.96	17.79	08/25/2021_1204	29.67	TOC
SHF201A	SHF201A	4" PVC	Upper RGA	323.75	320	747030.226	1960036.252	active	14.5	24.5	305.5	295.5	305.88	17.87	08/25/2021_1205	29.67	TOC
SHF-102G	SHF-102G	4" PVC	Upper RGA	362.85	359.1	845764.387	1927473.284	active	47.1	57.4	312	301.7	320.35	42.5	08/25/2021_1153	29.67	TOC
TVA River Elevation														301.18	08/25/2021_1300	29.66	TVA

LEGEND:
TIC: Top of Casing
DTW: Depth to Water
National Geodetic Vertical Datum of 1929 (NGVD 29).

Attachment 2

2020 Plume Map Document Summary

Final 2020 Plume Map Document Summary
September 2, 2021

Objective: Discuss changes to the Plume Map Document for the 2020 Update compared to the 2018 Update

1. 2020 Update: FRNP 2021. *Trichloroethene and Technetium-99 Groundwater Contamination in the Regional Gravel Aquifer for Calendar Year 2020 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, FRNP-RPT-0175, Four Rivers Nuclear Partnership, August.
2. 2018 Update: FRNP 2019. *Trichloroethene and Technetium-99 Groundwater Contamination in the Regional Gravel Aquifer for Calendar Year 2018 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, FRNP-RPT-0074, Four Rivers Nuclear Partnership, June.

General Information

- The document presents the revised groundwater plume maps for both trichloroethene (TCE) and technetium-99 (Tc-99) within the Regional Gravel Aquifer (RGA) at the end of calendar year 2020
- Revised every two years to:
  - provide a basis for timely incorporation of routine groundwater monitoring and characterization data
  - demonstrate the progress of groundwater cleanup to date, and
  - facilitate planning to optimize the site groundwater cleanup.
- An alternate interpretation showing the maximum values observed during 2019 to 2020 is available in Appendix A
- Appendix A contains tables and trend charts of TCE and Tc-99 sampling results collected for the last 10 years and plume maps showing the maximum values observed during 2019 and 2020.
  - Added a trend line to the charts for this update
- Appendix B contains the most recent TCE and Tc-99 values from 2019 and 2020 from PGDP RGA monitoring wells (MWs)

Document Updates from 2018 to 2020:

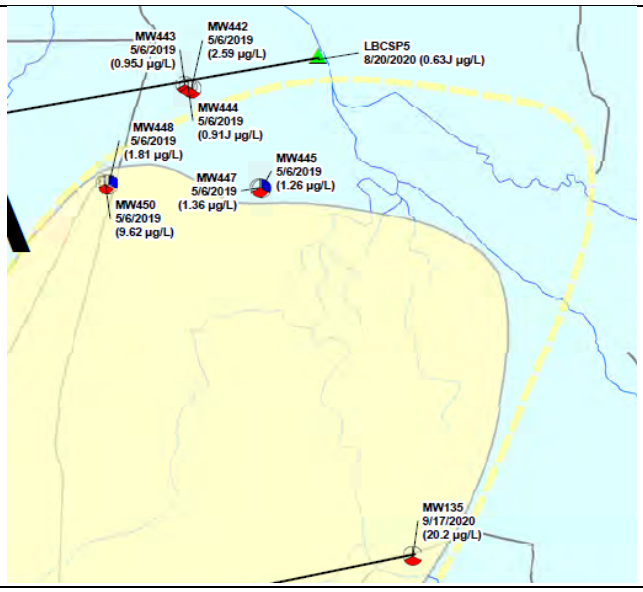
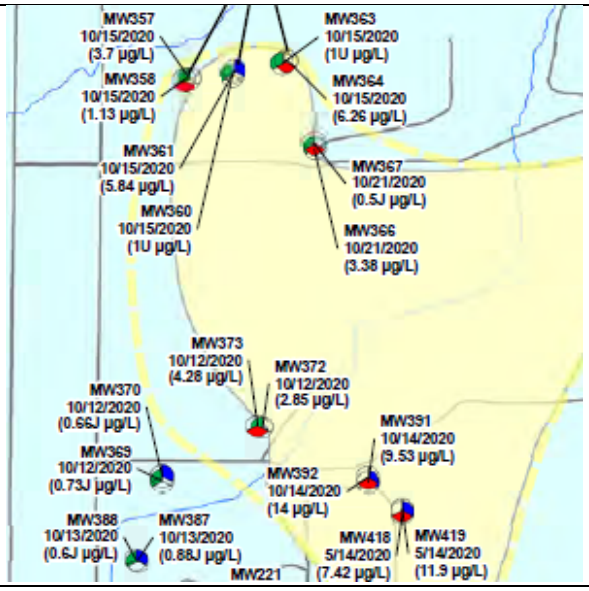
- Regional Gravel Aquifer (RGA) Potentiometric Surface Maps
  - August 24-26, 2020 - 276 data points
  - August 12-15, 2019 - 264 data points
    - EW235 was not operational
- Plume maps
  - No change to TCE plume depiction methodology or contour intervals shown
  - No change to Tc-99 plume depiction methodology; added contour for the derived concentration standard of 1,930 pCi/L (DOE 2020)
  - Summary of included wells

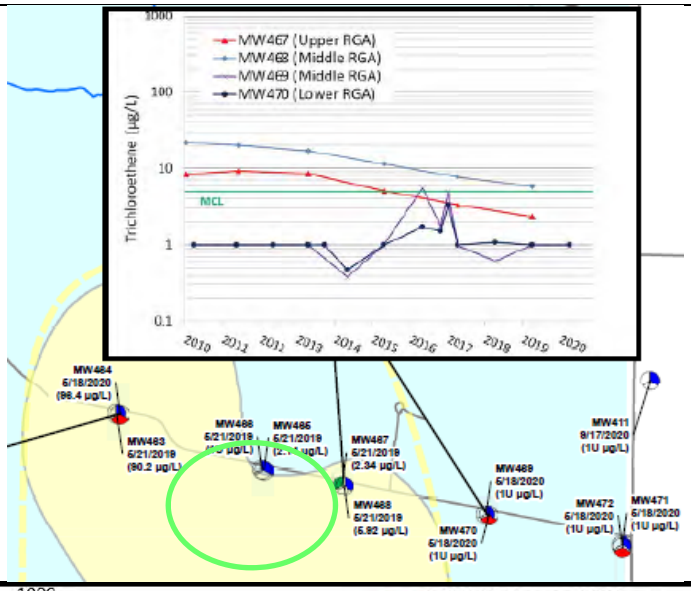
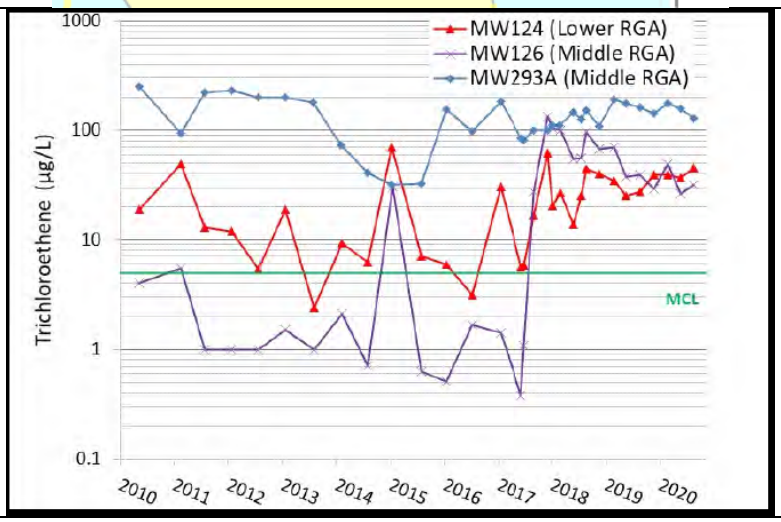
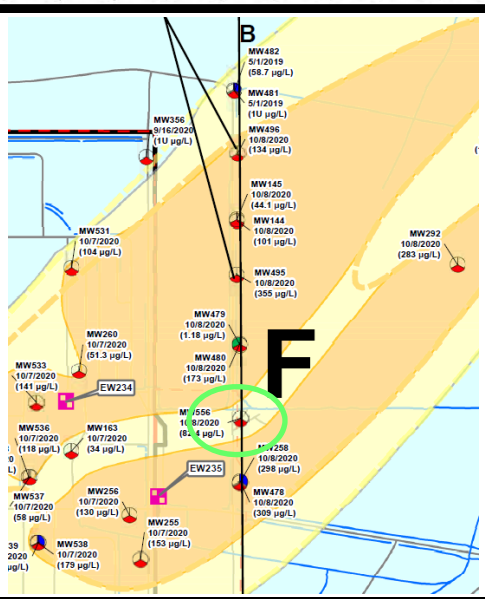
	TCE		Tc-99	
	2018 Update	2020 Update	2018 Update	2020 Update
Monitoring Wells	233	235	224	198
Residential Wells	13	13	13	7

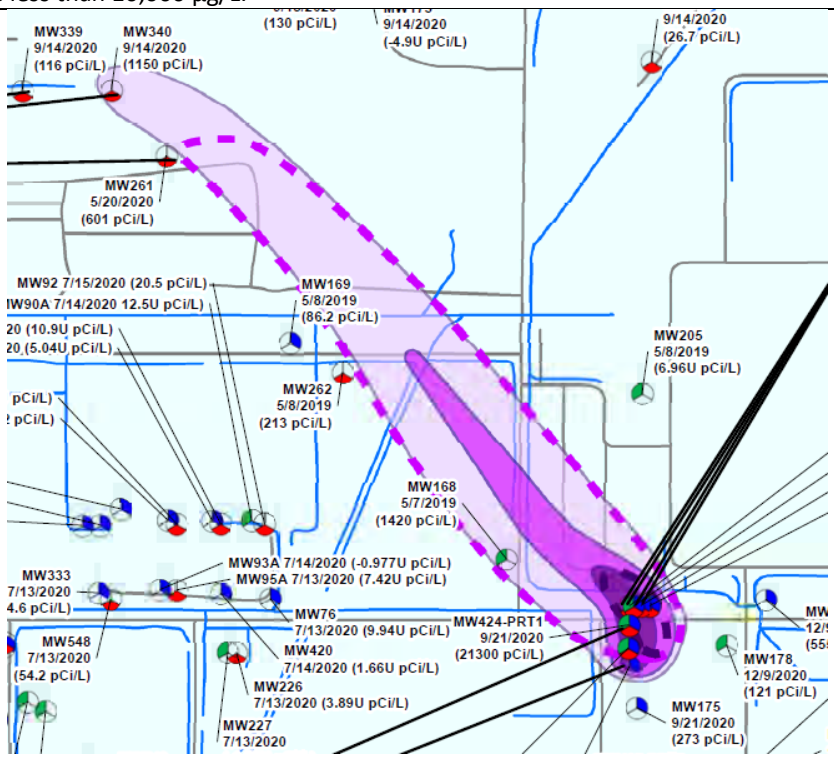
Overall Conclusions:

- A comparison of isoconcentration contours for the 2018 and 2020 plumes indicates that the footprints for each plume are generally similar.
- A dominant control on the hydraulic potential field of the RGA is the stage of the Ohio River, which is the primary discharge zone of the RGA.

- Summary of Changes to the TCE and Tc-99 Plumes

Northwest Plume		
North extent of NW Plume (Figure 3, Area A)	The seep that is sampled in Little Bayou Creek, LBCSP5, has declined from 47.5 µg/L TCE in June 2014 to 0.63J µg/L in its most recent sampling event in August 2020. The declining TCE trend at the seeps supports shrinking the plume length.	
Middle portion of NW Plume (Figure 3, Area B)	Changes in TCE concentrations at some downgradient locations continue to reflect trends associated with changes in pumping stress in the area.	
S/T/U Landfill Area (Figure 3, Area C)	During 2020, TCE concentrations in MW366 and MW357/MW358 dropped below 5 µg/L. Consequently, the 5 µg/L contour delineating the northwest toe of the plume was retracted southward.	

Northeast Plume		
North extent of NE Plume (Figure 5, Area D)	In 2020, TCE concentrations MW465/MW466 dropped below 5 µg/L. Consequently, the contour defining the northern extent of the 5 µg/L TCE isoconcentration contour from 2018 was retracted.	
NE Plume vicinity of EW331 and EW332 (Figure 5, Area E)	TCE concentrations in the east side of the former extraction well field, EW331 and EW332, which had increased significantly in the 2017 to 2018 sampling period, are demonstrating stable or, in the case of MW126, decreasing trends in the 2019 to 2020 sampling period.	
South portion of NE Plume (Figure 5, Area F)	The 100 to 1,000 µg/L boundary in this area is similar to the 2018 interpretation. A zone of 5 to 100 µg/L is depicted around MW556 which decreased from 147 µg/L in October 2018 to 82.4 µg/L in October 2020.	

Central Site Area Including Southwest Plume		
Central Portion of TCE Plume (Figure 7)	The overall footprint in 2020 is similar to previous years. The 10,000 µg/L contour to the south of the C-400 Building source area has been migrated northward. All of the most recent samples from the MW505/MW506/MW507 well nest contained TCE concentrations that were less than 10,000 µg/L.	
Tc-99 Plume (Figure 10)	The area exceeding 900 pCi/L for Tc-99 lies within the 1,000–10,000 µg/L TCE isocontour footprint, with the exception of MW168. From the 2018 interpreted contour, the 900 pCi/L contour was moved northward. The 3,790 pCi/L isoconcentration contour was moved slightly to the west to exclude MW421. The southern extent of the 900 pCi/L and the 3,790 pCi/L contours were moved southward to include MW342.	

Attachment 3

2022 EMP Schedule for Groundwater Strategy Project

Monitoring Wells Planned For Colloidal Borescope and Pressure Transducer Deployment

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW20 (also R4)	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW63		M1			M1			M1			M1	
MW65		M1			M1			M1			M1	
MW66		M1			M1			M1			M1	
MW67		M1			M1			M1			M1	
MW68		M1			M1			M1			M1	
MW71		M1			M1			M1			M1	
MW72		M1			M1			M1			M1	
MW73		M1			M1			M1			M1	
MW76		M1			M1			M1			M1	
MW77 (PZ)		M1			M1			M1			M1	
MW78		M1			M1			M1			M1	
MW79		M1			M1			M1			M1	
MW80		M1			M1			M1			M1	
MW81		M1			M1			M1			M1	
MW84		M1			M1			M1			M1	
MW86		M1			M1			M1			M1	
MW87		M1			M1			M1			M1	
MW89		M1			M1			M1			M1	
MW90A		M1			M1			M1			M1	
MW92		M1			M1			M1			M1	
MW93		M1			M1			M1			M1	
MW95A		M1			M1			M1			M1	
MW98	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW99		M1			M1			M1			M1	
MW100		M1			M1			M1			M1	
MW102		M1			M1			M1			M1	
MW103		M1			M1			M1			M1	
MW106A	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW108		M1			M1			M1			M1	
MW120		M1			M1			M1			M1	
MW121		M1			M1			M1			M1	
MW122		M1			M1			M1			M1	
MW123		M1			M1			M1			M1	
MW124		M1			M1			M1			M1	

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Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW125		M1			M1			M1			M1	
MW126		M1			M1			M1			M1	
MW132		M1			M1			M1			M1	
MW133		M1			M1			M1			M1	
MW134		M1			M1			M1			M1	
MW135	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW137		M1			M1			M1			M1	
MW139		M1			M1			M1			M1	
MW144		M1			M1			M1			M1	
MW145		M1			M1			M1			M1	
MW146		M1			M1			M1			M1	
MW147		M1			M1			M1			M1	
MW148		M1			M1			M1			M1	
MW150		M1			M1			M1			M1	
MW155	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW156	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW161		M1			M1			M1			M1	
MW163		M1			M1			M1			M1	
MW165A		M1			M1			M1			M1	
MW168		M1			M1			M1			M1	
MW169		M1			M1			M1			M1	
MW173		M1			M1			M1			M1	
MW175		M1			M1			M1			M1	
MW178	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW185		M1			M1			M1			M1	
MW188		M1			M1			M1			M1	
MW191		M1			M1			M1			M1	
MW193		M1			M1	M1+CB		M1	M1+CB		M1	
MW194		M1			M1			M1			M1	
MW197		M1			M1			M1			M1	
MW199		M1			M1			M1			M1	
MW200	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW201		M1			M1			M1			M1	
MW202		M1			M1			M1			M1	
MW203		M1			M1			M1			M1	
MW205		M1			M1			M1			M1	
MW220		M1			M1			M1			M1	
MW221		M1			M1			M1			M1	

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Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW222		M1			M1			M1			M1	
MW223		M1			M1			M1			M1	
MW224		M1			M1			M1			M1	
MW225		M1			M1			M1			M1	
MW226		M1			M1			M1			M1	
MW227		M1			M1			M1			M1	
MW233		M1			M1			M1			M1	
MW236		M1			M1			M1			M1	
MW238		M1			M1			M1			M1	
MW239		M1			M1			M1			M1	
MW240		M1			M1			M1			M1	
MW241A		M1			M1			M1			M1	
MW242		M1			M1			M1			M1	
MW243		M1			M1			M1			M1	
MW244		M1			M1			M1			M1	
MW245		M1			M1			M1			M1	
MW247		M1			M1			M1			M1	
MW248		M1			M1			M1			M1	
MW249		M1			M1			M1			M1	
MW250		M1			M1			M1			M1	
MW252		M1			M1			M1			M1	
MW253A		M1			M1			M1			M1	
MW255		M1			M1			M1			M1	
MW256		M1			M1			M1			M1	
MW257		M1			M1			M1			M1	
MW258		M1			M1			M1			M1	
MW260		M1			M1			M1			M1	
MW261		M1			M1			M1			M1	
MW262		M1			M1			M1			M1	
MW283		M1			M1			M1			M1	
MW284		M1			M1			M1			M1	
MW288		M1			M1			M1			M1	
MW291		M1			M1			M1			M1	
MW292		M1			M1			M1			M1	
MW293A		M1			M1			M1			M1	
MW294A		M1			M1			M1			M1	
MW325		M1			M1			M1			M1	
MW326		M1			M1			M1			M1	

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Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW327		M1			M1			M1			M1	
MW328		M1			M1			M1			M1	
MW329		M1			M1			M1			M1	
MW330		M1			M1			M1			M1	
MW333		M1			M1			M1			M1	
MW337		M1			M1			M1			M1	
MW338		M1			M1			M1			M1	
MW339		M1			M1			M1			M1	
MW340		M1			M1			M1			M1	
MW341	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW342		M1			M1			M1			M1	
MW343		M1			M1			M1			M1	
MW345		M1			M1			M1			M1	
MW346		M1			M1			M1			M1	
MW347		M1			M1			M1			M1	
MW353		M1			M1			M1			M1	
MW354	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW355		M1			M1			M1			M1	
MW356		M1			M1			M1			M1	
MW357		M1			M1			M1			M1	
MW358		M1			M1			M1			M1	
MW360		M1			M1			M1			M1	
MW361		M1			M1			M1			M1	
MW363		M1			M1			M1			M1	
MW364		M1			M1			M1			M1	
MW366		M1			M1			M1			M1	
MW367		M1			M1			M1			M1	
MW369		M1			M1			M1			M1	
MW370		M1			M1			M1			M1	
MW372		M1			M1			M1			M1	
MW373		M1			M1			M1			M1	
MW376		M1			M1			M1			M1	
MW380		M1			M1			M1			M1	
MW381		M1			M1			M1			M1	
MW384		M1			M1			M1			M1	
MW385		M1			M1			M1			M1	
MW387		M1			M1			M1			M1	
MW388		M1			M1			M1			M1	

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Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW391		M1			M1			M1			M1	
MW392		M1			M1			M1			M1	
MW394		M1			M1			M1			M1	
MW395		M1			M1			M1			M1	
MW397		M1			M1			M1			M1	
MW409		M1			M1			M1			M1	
MW410		M1			M1			M1			M1	
MW411*		M1			M1			M1			M1	
MW414		M1			M1			M1			M1	
MW415		M1			M1			M1			M1	
MW416		M1			M1			M1			M1	
MW417		M1			M1			M1			M1	
MW418		M1			M1			M1			M1	
MW419		M1			M1			M1			M1	
MW420		M1			M1			M1			M1	
MW421		M1			M1			M1			M1	
MW422		M1			M1			M1			M1	
MW423		M1			M1			M1			M1	
MW424		M1			M1			M1			M1	
MW425		M1			M1			M1			M1	
MW426		M1			M1			M1			M1	
MW427		M1			M1			M1			M1	
MW428		M1			M1			M1			M1	
MW429A		M1			M1			M1			M1	
MW430		M1			M1			M1			M1	
MW431	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW432	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW433		M1			M1			M1			M1	
MW435		M1			M1			M1			M1	
MW439	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT
MW440		M1			M1			M1			M1	
MW441	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT
MW442	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT
MW443		M1			M1			M1			M1	
MW444		M1			M1			M1			M1	
MW445	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW447		M1			M1			M1			M1	
MW448		M1			M1			M1			M1	

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Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW450		M1			M1			M1			M1	
MW451		M1			M1			M1			M1	
MW452		M1			M1			M1			M1	
MW453		M1			M1			M1			M1	
MW454		M1			M1			M1			M1	
MW455		M1			M1			M1			M1	
MW456		M1			M1			M1			M1	
MW457		M1			M1			M1			M1	
MW458		M1			M1			M1			M1	
MW459		M1			M1			M1			M1	
MW460		M1			M1			M1			M1	
MW461		M1			M1			M1			M1	
MW462		M1			M1			M1			M1	
MW463		M1			M1			M1			M1	
MW464		M1			M1			M1			M1	
MW465		M1			M1			M1			M1	
MW466		M1			M1			M1			M1	
MW467		M1			M1			M1			M1	
MW468		M1			M1			M1			M1	
MW469		M1			M1			M1			M1	
MW470		M1			M1			M1			M1	
MW471		M1			M1			M1			M1	
MW472		M1			M1			M1			M1	
MW473		M1			M1			M1			M1	
MW474		M1			M1			M1			M1	
MW475		M1			M1			M1			M1	
MW476		M1			M1			M1			M1	
MW477		M1			M1			M1			M1	
MW478		M1			M1			M1			M1	
MW479		M1			M1			M1			M1	
MW480		M1			M1			M1			M1	
MW481		M1			M1			M1			M1	
MW482		M1			M1			M1			M1	
MW483		M1			M1			M1			M1	
MW484		M1			M1			M1			M1	
MW485		M1			M1			M1			M1	
MW486A		M1			M1			M1			M1	
MW487		M1			M1			M1			M1	

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Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW488		M1			M1			M1			M1	
MW489		M1			M1			M1			M1	
MW490		M1			M1			M1			M1	
MW491		M1			M1			M1			M1	
MW492	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW493		M1			M1			M1			M1	
MW494		M1			M1			M1			M1	
MW495		M1			M1			M1			M1	
MW496		M1			M1			M1			M1	
MW497		M1			M1			M1			M1	
MW498		M1			M1			M1			M1	
MW499		M1			M1			M1			M1	
MW500		M1			M1			M1			M1	
MW501		M1			M1			M1			M1	
MW502		M1			M1			M1			M1	
MW503		M1			M1			M1			M1	
MW504		M1			M1			M1			M1	
MW505		M1			M1			M1			M1	
MW506		M1			M1			M1			M1	
MW507		M1			M1			M1			M1	
MW524		M1			M1			M1			M1	
MW525	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW526	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW527	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW528		M1			M1			M1			M1	
MW529	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW530		M1			M1			M1			M1	
MW531		M1			M1			M1			M1	
MW532 (PZ)		M1			M1			M1			M1	
MW533		M1			M1			M1			M1	
MW534 (PZ)		M1			M1			M1			M1	
MW535 (PZ)		M1			M1			M1			M1	
MW536		M1			M1			M1			M1	
MW537		M1			M1			M1			M1	
MW538		M1			M1			M1			M1	
MW539		M1			M1			M1			M1	

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Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW540 (PZ)		M1			M1			M1			M1	
MW541 (PZ)		M1			M1			M1			M1	
MW542		M1			M1			M1			M1	
MW543		M1			M1			M1			M1	
MW544		M1			M1			M1			M1	
MW545		M1			M1			M1			M1	
MW546		M1			M1			M1			M1	
MW547		M1			M1			M1			M1	
MW548		M1			M1			M1			M1	
MW549		M1			M1			M1			M1	
MW550		M1			M1			M1			M1	
MW551		M1			M1			M1			M1	
MW553 (PZ)		M1			M1			M1			M1	
MW554 (PZ)		M1			M1			M1			M1	
MW555 (PZ)		M1			M1			M1			M1	
MW556		M1			M1			M1			M1	
PZ107		M1			M1			M1			M1	
PZ109		M1			M1			M1			M1	
PZ110		M1			M1			M1			M1	
PZ114		M1			M1			M1			M1	
PZ115		M1			M1			M1			M1	
PZ117		M1			M1			M1			M1	
PZ118		M1			M1			M1			M1	
PZ287		M1			M1			M1			M1	
PZ289		M1			M1			M1			M1	
PZ290		M1			M1			M1			M1	
PZ349		M1			M1			M1			M1	
PZ351		M1			M1			M1			M1	
EW232		M1			M1			M1			M1	
EW233		M1			M1			M1			M1	
EW234		M1			M1			M1			M1	
EW235		M1			M1			M1			M1	
MW557		M1			M1			M1			M1	
MW558		M1			M1			M1			M1	
MW559		M1			M1			M1			M1	

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Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW560		M1			M1			M1			M1	
MW561		M1			M1			M1			M1	
MW562		M1			M1			M1			M1	
MW563		M1			M1			M1			M1	
MW564		M1			M1			M1			M1	
MW565		M1			M1			M1			M1	
MW566		M1			M1			M1			M1	
MW567		M1			M1			M1			M1	
MW568		M1			M1			M1			M1	
MW569		M1			M1			M1			M1	
MW570		M1			M1			M1			M1	
MW571		M1			M1			M1			M1	
MW572		M1			M1			M1			M1	
MW573		M1			M1			M1			M1	
MW574		M1			M1			M1			M1	

CB: colloidal borescope
PT: pressure transducer
M1: Manual water level collected once per month
Color coding is used to show colloidal borescope data collection groups.
*Collect manual water level measurement when accessible.

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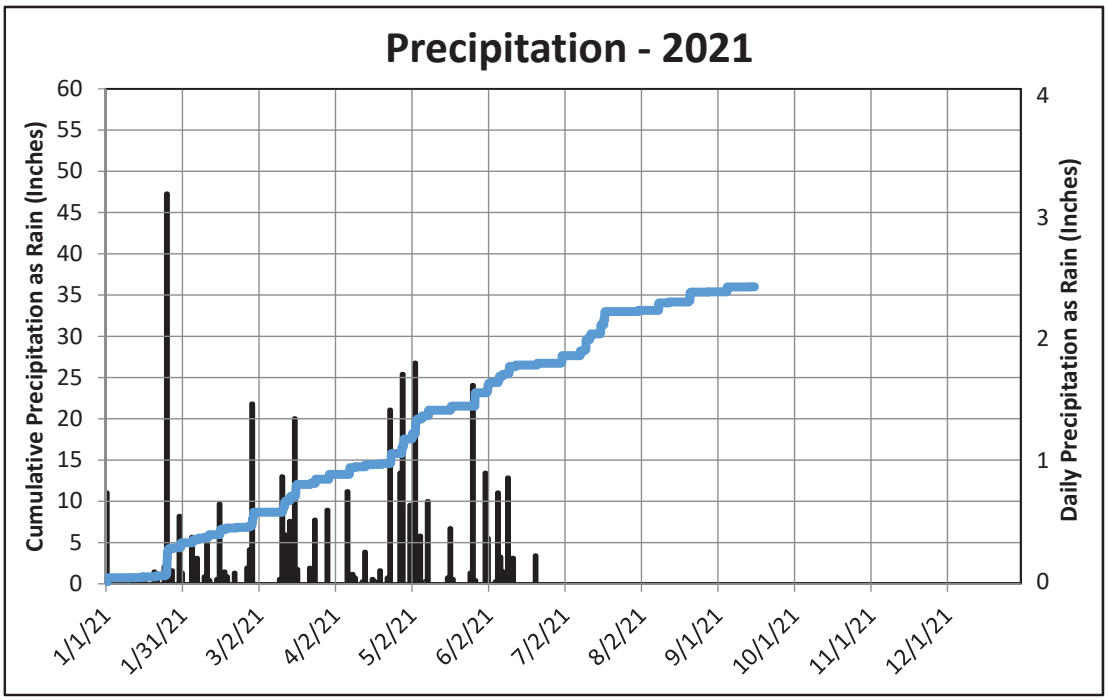
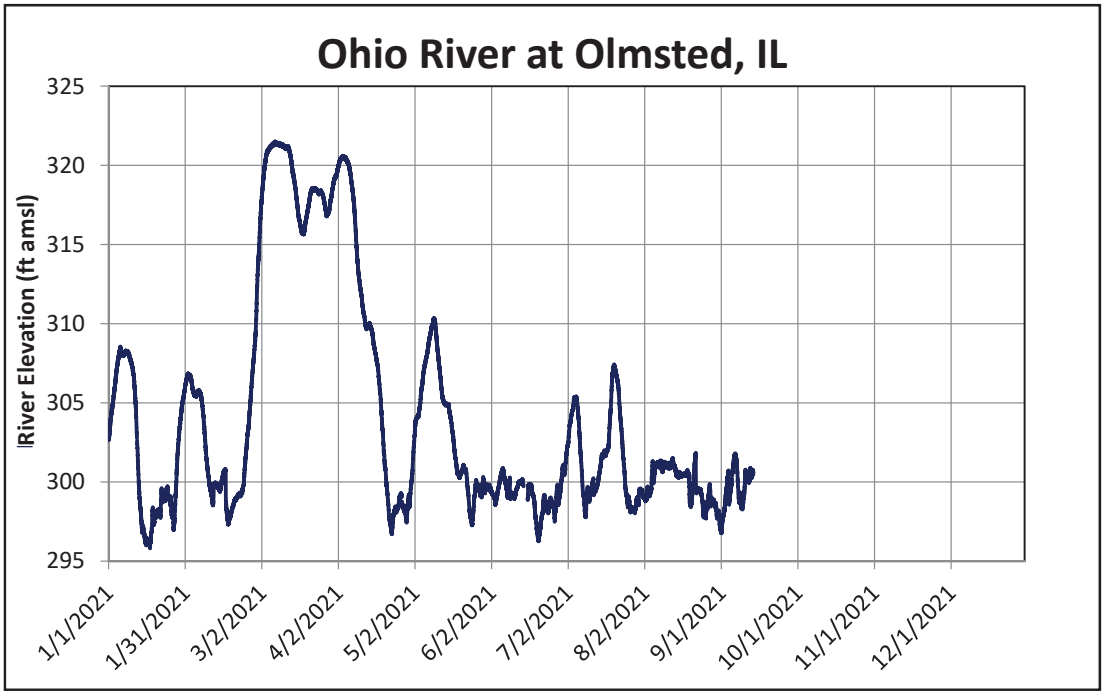
Attachment 4

Precipitation and Ohio River Stage Data


Precipitation - 2021
Cumulative Precipitation as Rain (Inches)
Daily Precipitation as Rain (Inches)
60
55
50
45
40
35
30
25
20
15
10
5
0
4
3
2
1
0
1/1/21
1/31/21
3/2/21
4/2/21
5/2/21
6/2/21
7/2/21
8/2/21
9/1/21
10/1/21
11/1/21
12/1/21


Ohio River at Olmsted, IL
River Elevation (ft amsl)
325
320
315
310
305
300
295
1/1/2021
1/31/2021
3/2/2021
4/2/2021
5/2/2021
6/2/2021
7/2/2021
8/2/2021
9/1/2021
10/1/2021
11/1/2021
12/1/2021

Attachment 5

Presentation: 2016 Sitewide Paducah Groundwater Flow Model

Summary of the 2016 Groundwater Flow Model Update

Presented by Denise Tripp
Groundwater Modeling Working Group
Quarterly Meeting
October 6, 2021

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Presentation Outline

- Modeling Objective
- Modeling history
- Hydrologic Conceptual Site Model (CSM)
- 2016 Groundwater (GW) Model Update
  - Configuration
  - Calibration and Validation
  - Sensitivity Analysis
- Conclusions and Recommendations

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Objective of Sitewide 2016 GW Modeling at PGDP

To develop a tool that can be relied on to assist in:

- Determining additional data needs
- Evaluating potential remedies (e.g., evaluation of extraction well capture zones)
- Developing cleanup criteria in decision documents (e.g., refinement of soil cleanup levels to protect groundwater and setting of monitoring goals)
- Providing inputs needed for remedy design

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History of Sitewide GW Modeling at PGDP

- First GW model developed in 1990, revised through 1997
- Next substantial revision in 2008 excluded UCRS and McNairy from the model domain
- Revised in 2012 to evaluate extraction well performance under variable anthropogenic recharge conditions
- Update in 2016 to include revisions based on review of existing site data and technical discussions by the Modeling Working Group (MWG)

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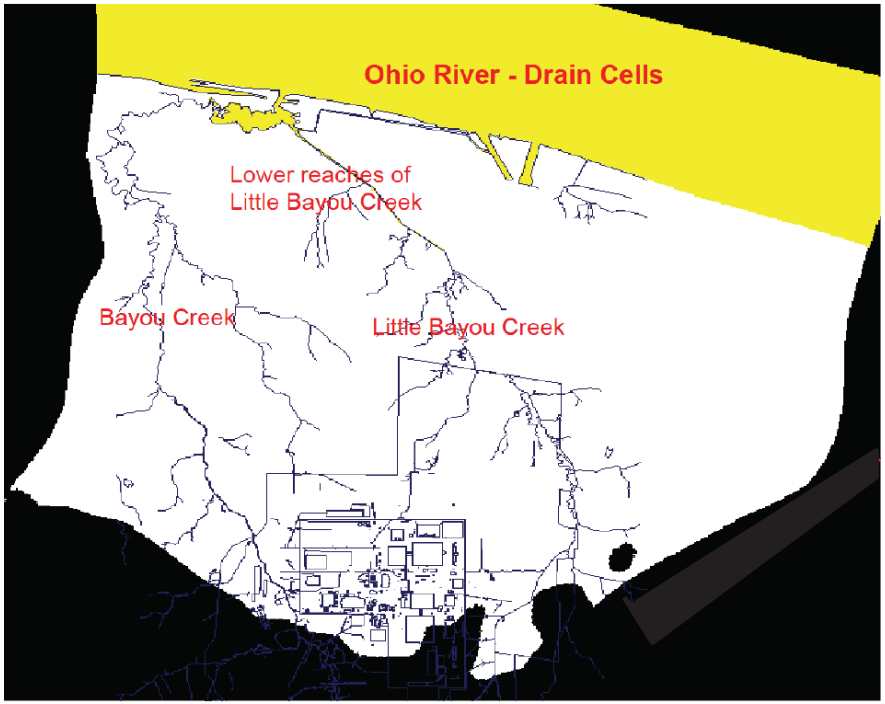
2008 GW model

- UCRS flow is primarily vertical, represented by recharge
- McNairy flow volume is << RGA flow, represented as a no flow boundary
- Ohio River and lower Bayou Creek and Little Bayou Creek are represented as drains
- Single stress period calibration to 1995 pre-pumping water levels

2008 Model Domain



Source: DOE 2017. 2016 Update of the Paducah Gaseous Diffusion Plant Sitewide Groundwater Flow Model, A Product of the Paducah Gaseous Diffusion Plant Site Groundwater Modeling Working Group, July. DOE/LX/07-2415&D2

2012 GW Model

- Based on 2008 model domain
- Revised RGA top and bottom elevations based on existing KRCEE lithologic database
- Calibrated to 7 steady-state stress periods with unique anthropogenic and ambient recharge rates and 1 transient stress period (10-day NW plume extraction test)

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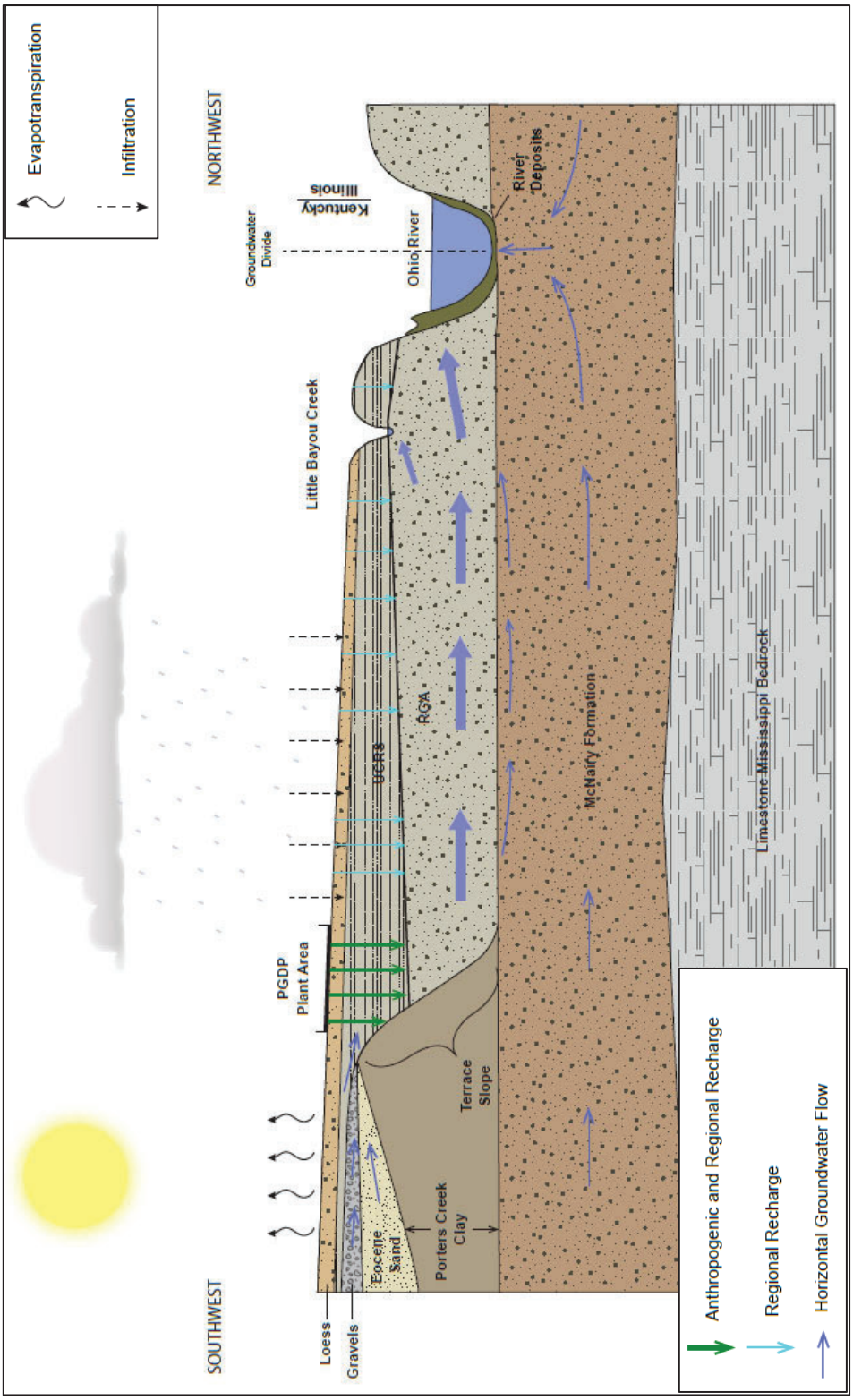
2016 GW Model Update

- **Objective:** Update the 2012 model to include more recent PGDP Site data collected from the period 2012 to 2016
- **Approach:**
  - Incorporated revisions identified by the MWG through review and analysis of available site data
  - Performed using MODFLOW2005
  - Calibrated using PEST (PEST-SVD coupled with pilot points)
  - Included a sensitivity analysis to identify parameters with the greatest influence on simulated plume trajectories
  - Validated using observed water levels from additional synoptic events and pumping test data

PGDP CSM



Source: DOE 2017

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Data Analysis

- RGA top and bottom surface elevations developed by KRCEE using updated Lithologic data base
- Terrace Gravel recharge estimated using hydrograph base flow separation techniques
- Ohio River, Bayou Creek (BC), and Little Bayou Creek (LBC) elevations using stream gage data
- Calibration data sets identified from historical water level synoptic event data
- Plant operations evaluated to estimate potential anthropogenic recharge
- UCRS lithology and clay thickness evaluated to estimate recharge in the plant area

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2016 GW Model Revisions

- Incorporate data from the KRCEE lithologic database
  - Refine the extent of southern RGA boundary
  - Adjust the RGA top and bottom elevations
- Add focused recharge on Terrace boundary cells to represent groundwater flow from East and West Terrace
- Convert drain cells representing the Ohio River and lower reaches of LBC and BC to river cells
- Configure recharge zones to account for anthropogenic sources in the plant area
- Calibrate to 2 stress periods representing unique periods of operation and precipitation

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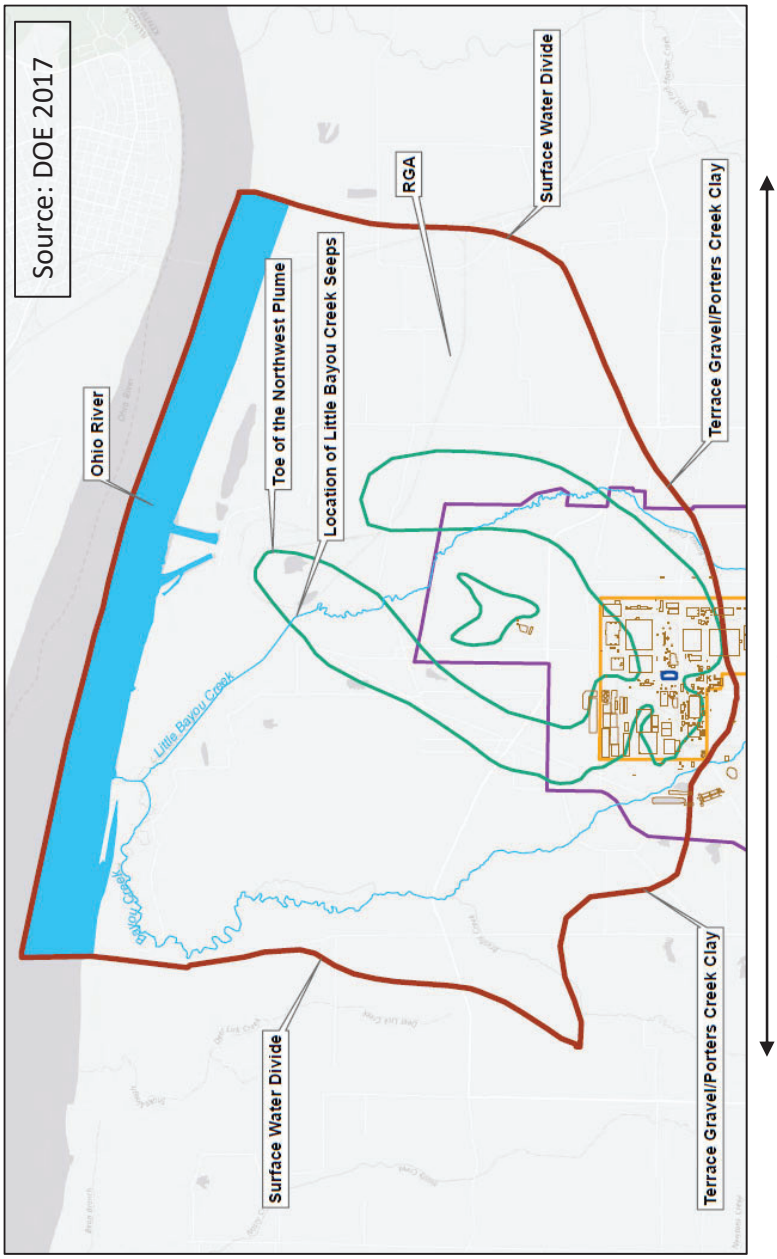
2016 Model Domain



- 3 layers
- 50 feet x 50 feet grid cells

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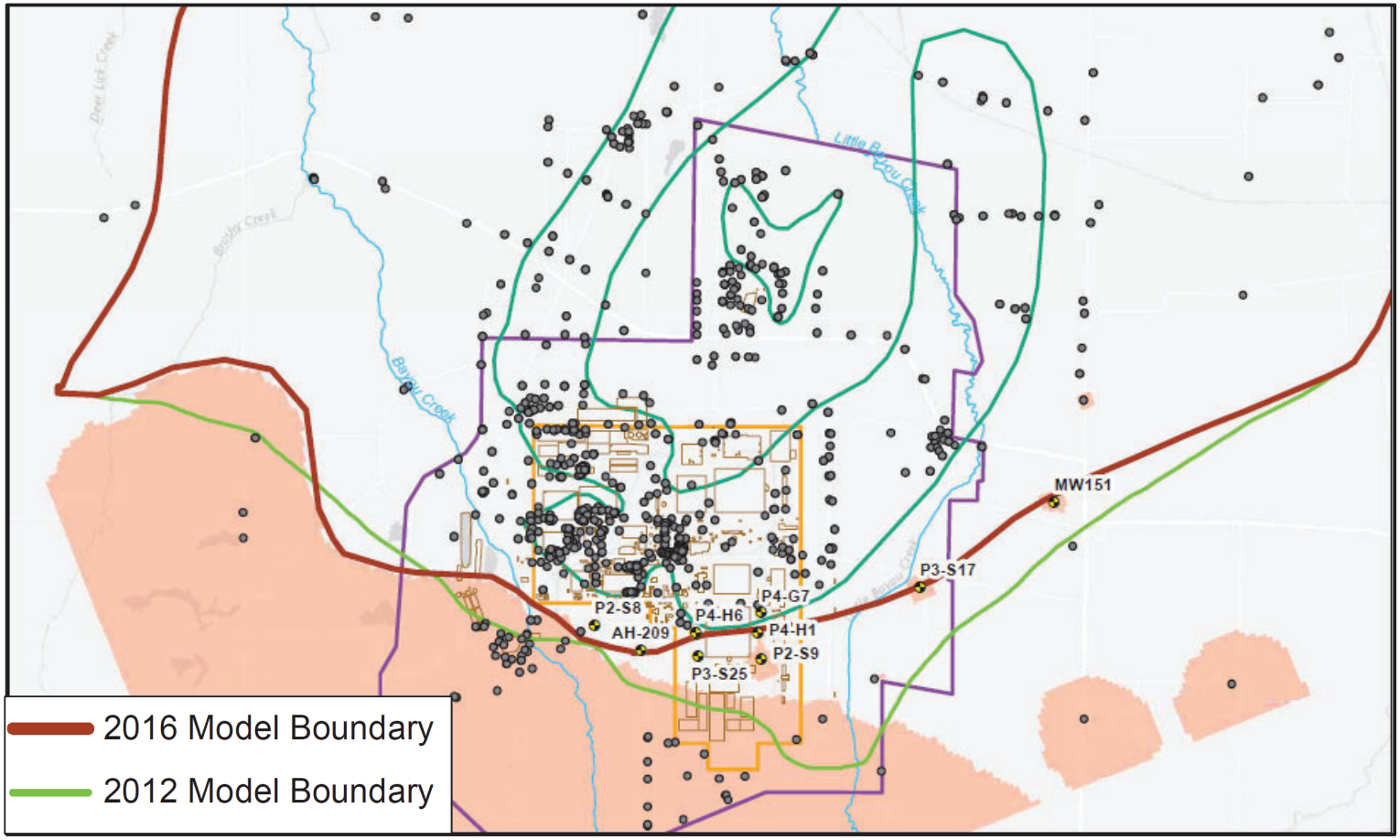
Revision to Southern Extent of Model Domain



Source: DOE 2017

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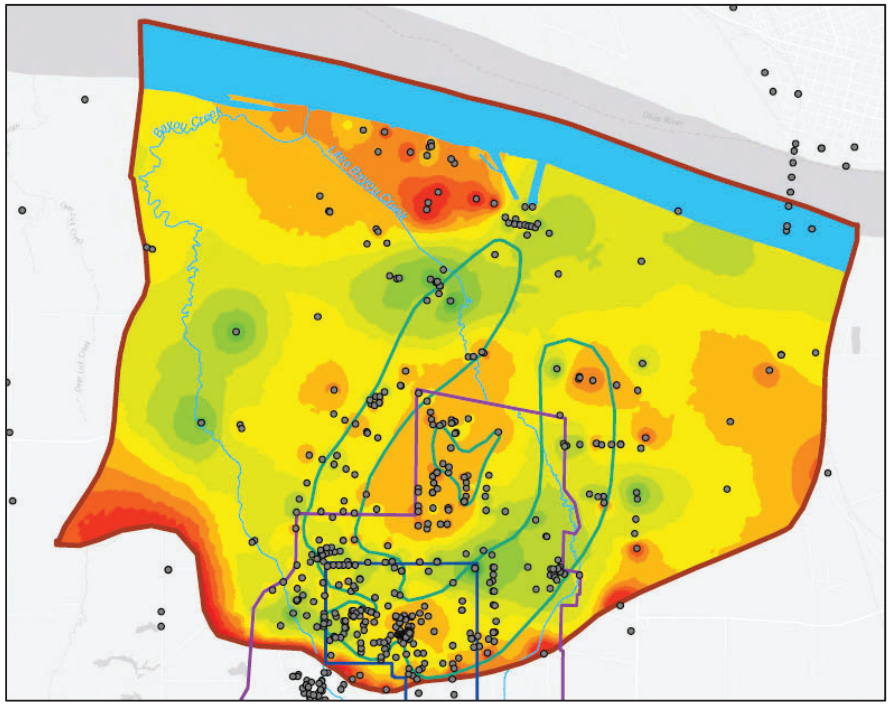
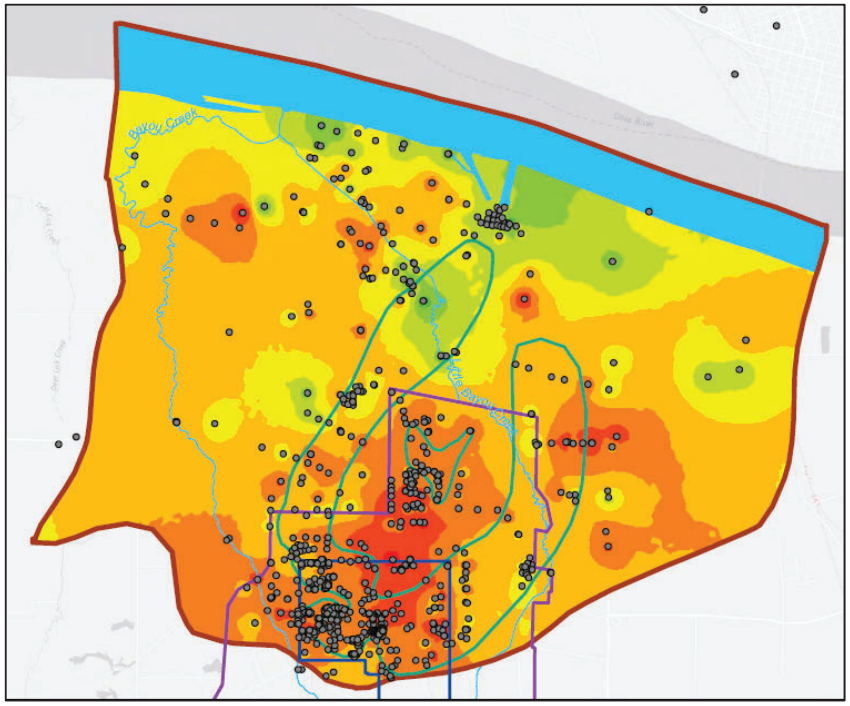
RGA Surface Elevations



Model RGA Bottom Elevation (ft amsl)

- 250 - 255
- 255 - 260
- 260 - 265
- 265 - 270
- 270 - 275
- 275 - 280
- 280 - 285
- 285 - 290
- 290 - 295
- 295 - 300
- 300 - 305
- 305 - 310



Model RGA Top Elevation (ft amsl)

- 285 - 290
- 290 - 295
- 295 - 300
- 300 - 305
- 305 - 310
- 310 - 315
- 315 - 320
- 320 - 325
- 325 - 330

Source: DOE 2017

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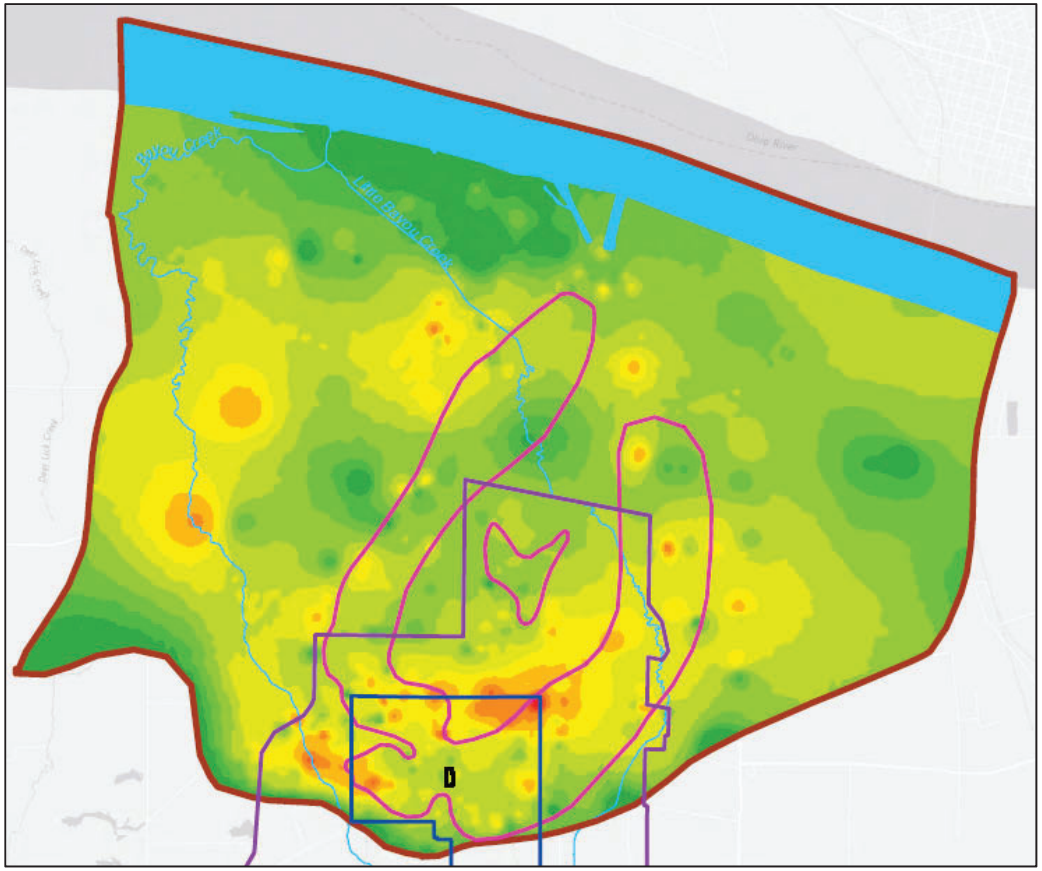
RGA Thickness



Model RGA Thickness (ft)

- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60
- 60 - 65
- 65 - 90

Source: DOE 2017

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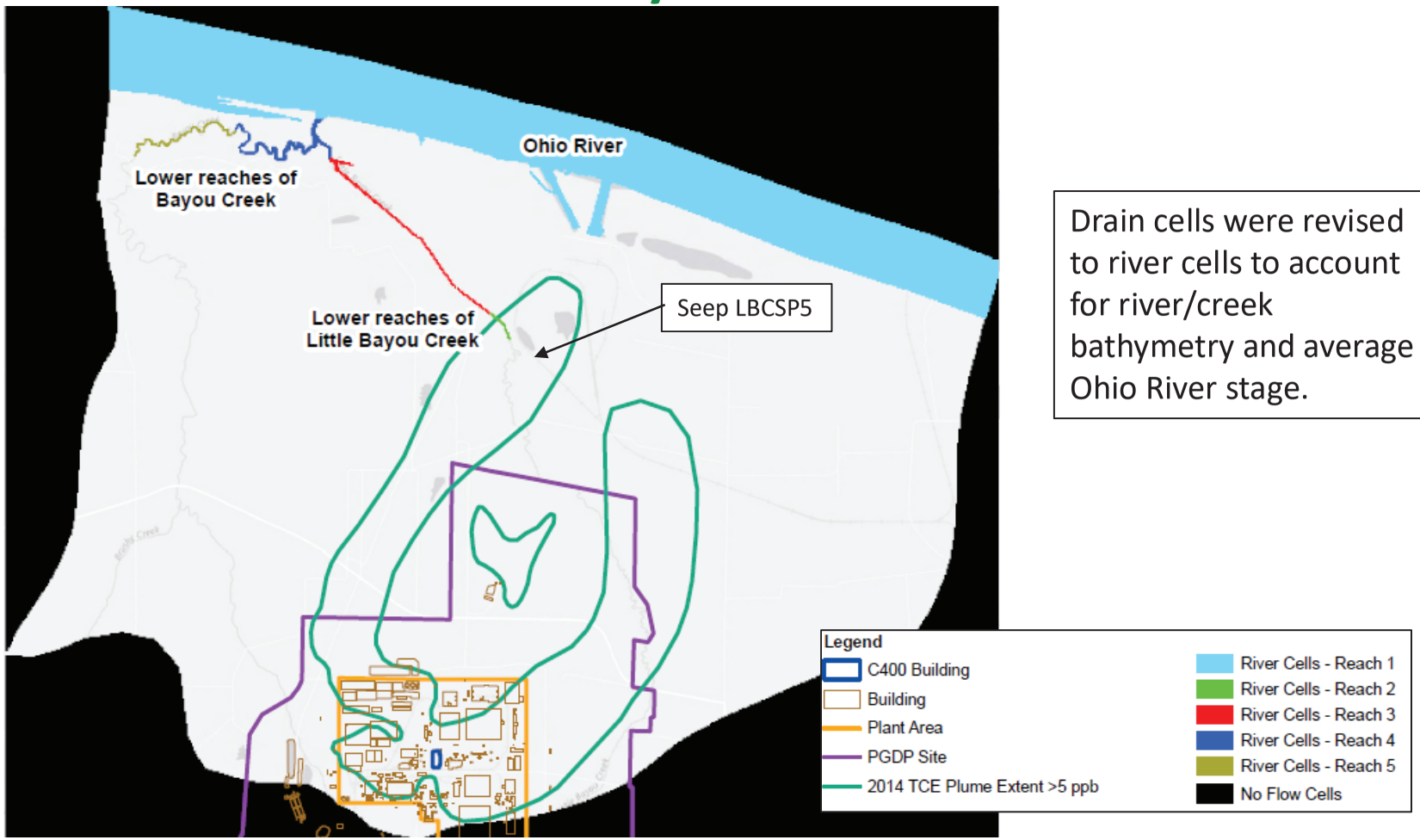
Boundary Conditions



Drain cells were revised to river cells to account for river/creek bathymetry and average Ohio River stage.

Source: DOE 2017

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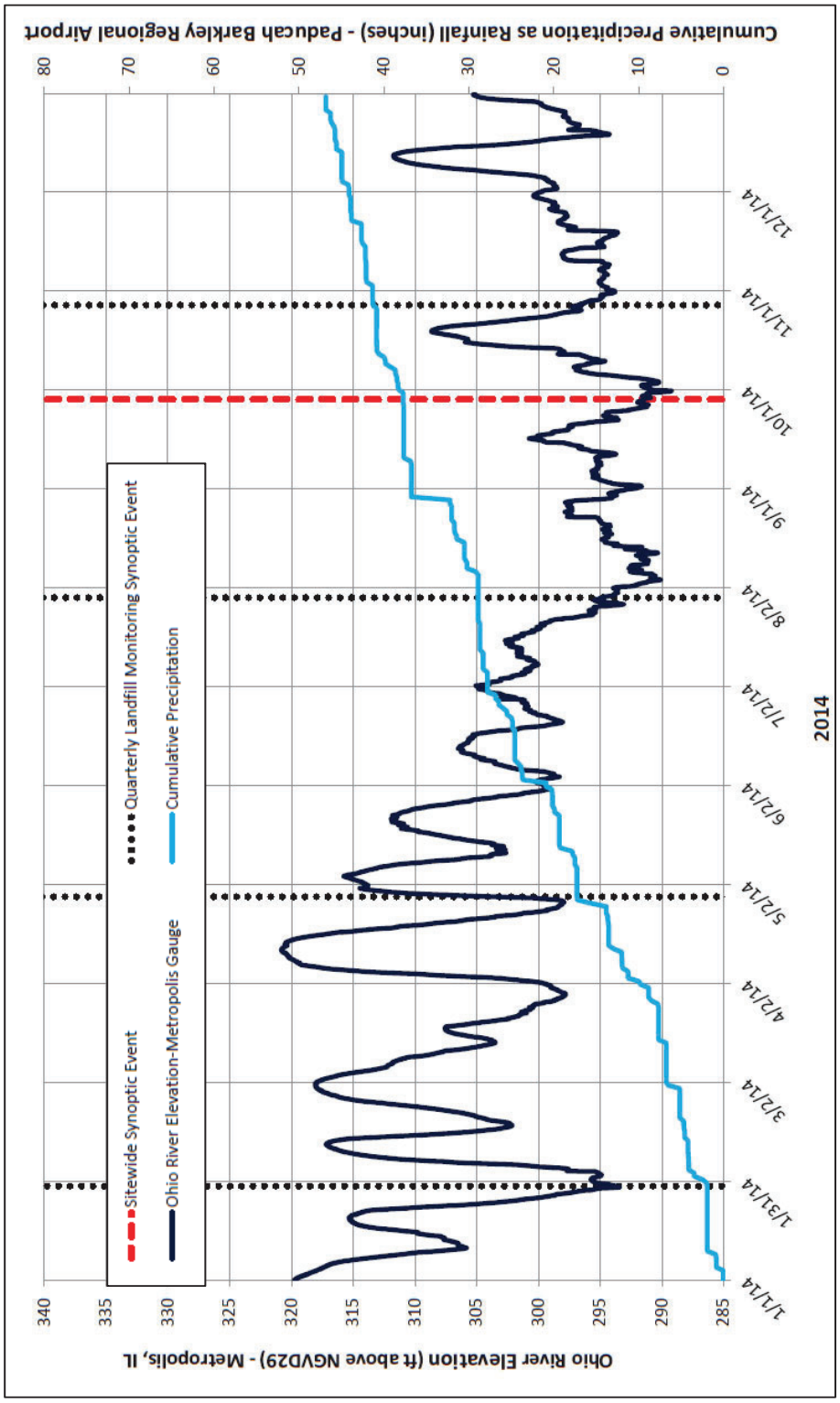
Ohio River Elevations



Source: DOE 2017

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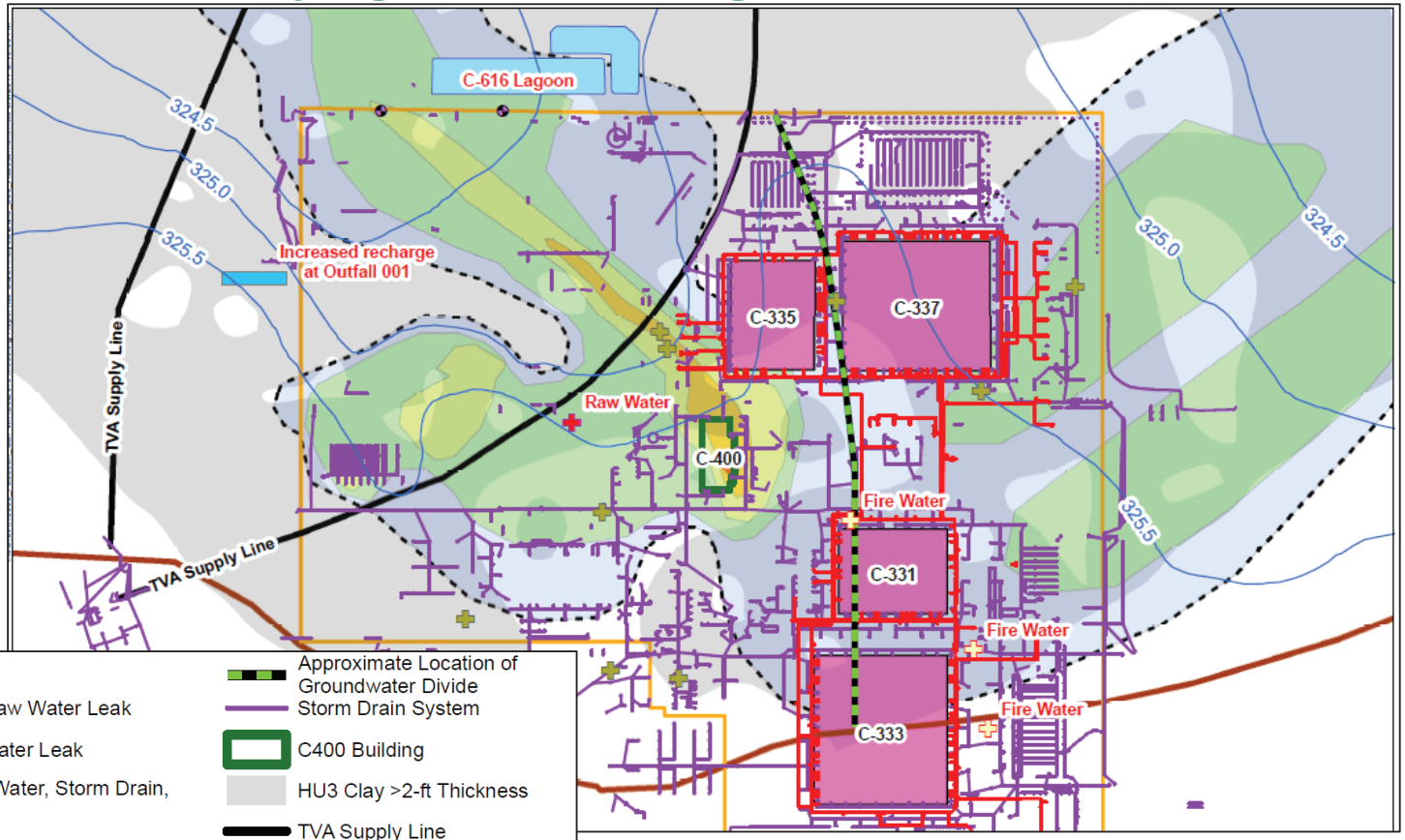
Anthropogenic Recharge Evaluation



Source: DOE 2017

Legend

- Known 2016 TVA Raw Water Leak
- Known 2016 Fire Water Leak
- Known 2016 Plant Water, Storm Drain, or RCW Leak
- Extraction Well
- September 2014 RGA Water Level Contour (ft amsl)
- High Pressure Fire Water Line (40 gpm leak, unknown location)
- Approximate Location of Groundwater Divide
- Storm Drain System
- C400 Building
- HU3 Clay >2-ft Thickness
- TVA Supply Line
- Plant Area
- 2016 Model Boundary
- Roof Drain to Gravel Sublayer

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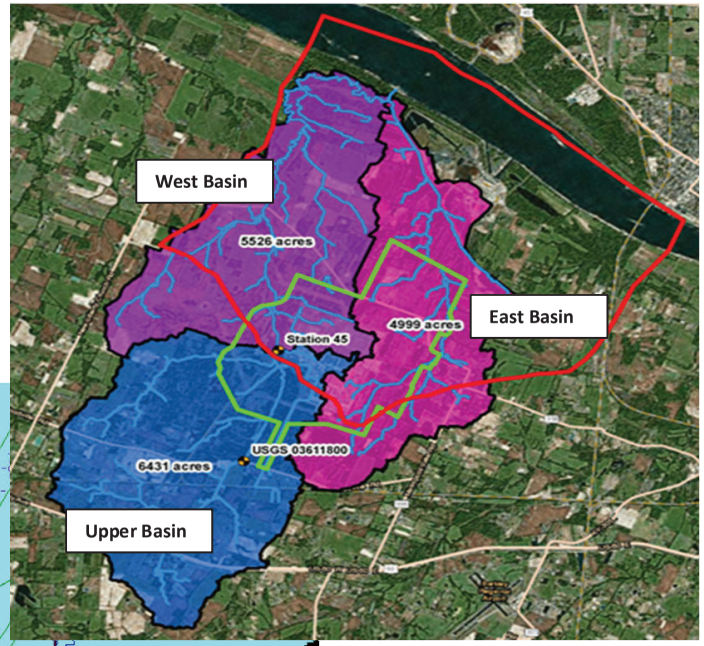
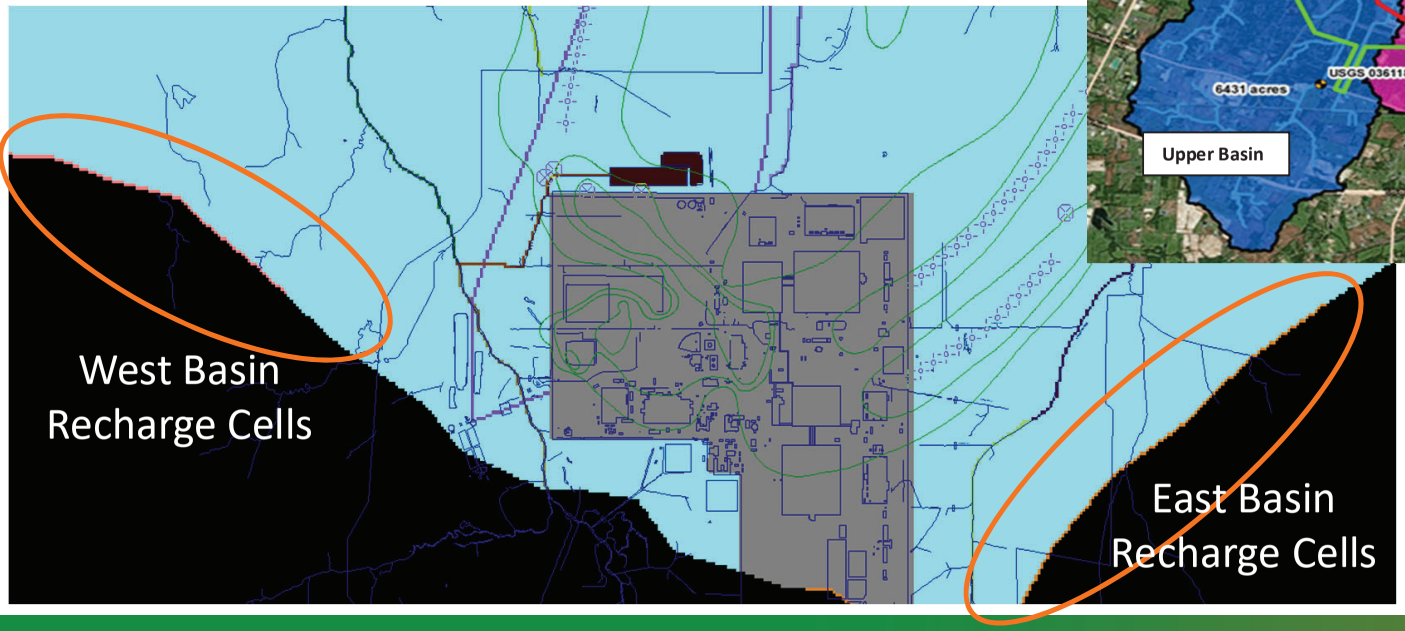
Recharge from Terrace Gravel

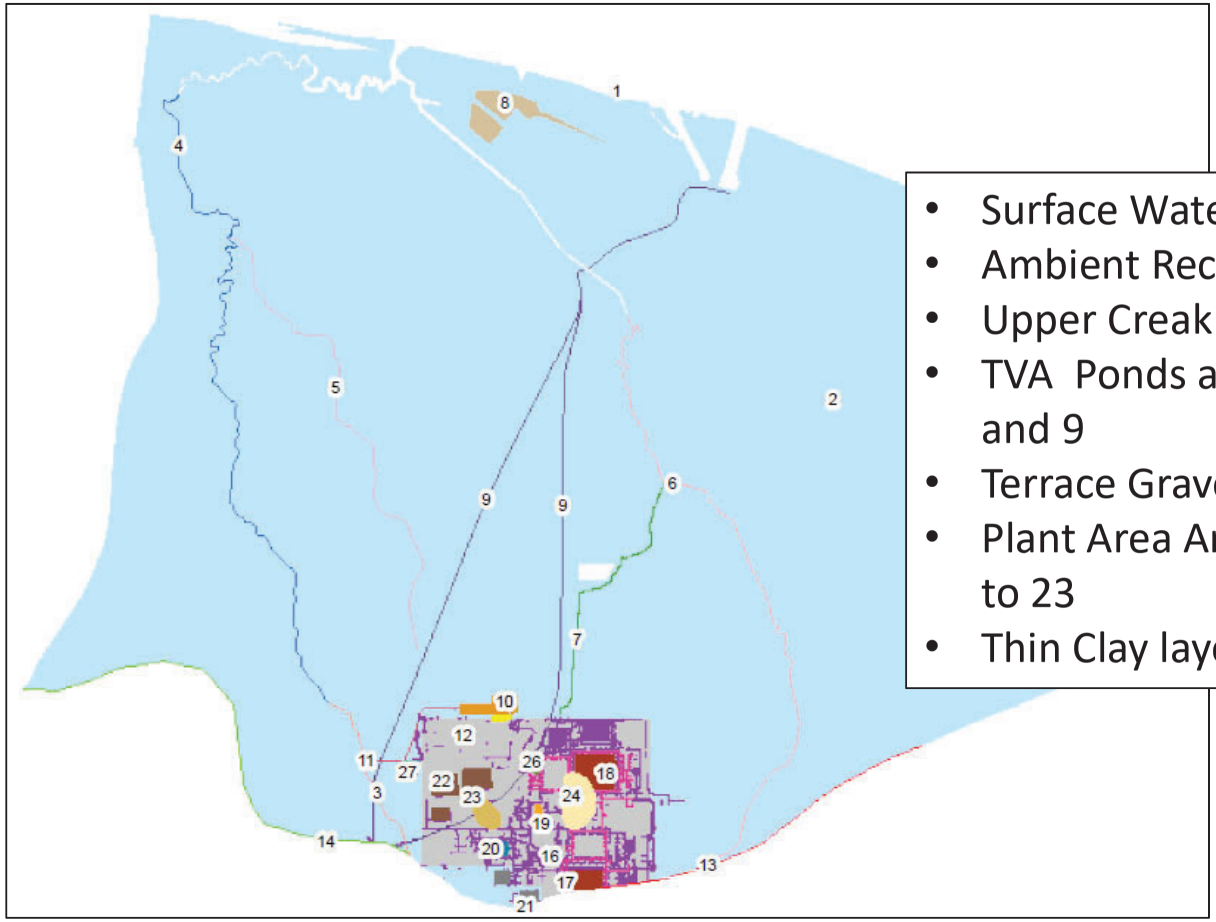
- Two lines of recharge cells added along the model boundary at the intersection of the Terrace with the UCRS within the East and West Basins
- Top elevation of Porters Creek Clay prevents recharge in the intermediate area.





Source: DOE 2017

Model Recharge Zones



- Surface Water (no recharge) – Zone 1
- Ambient Recharge – Zone 2
- Upper Creak Reaches – Zones 3 to 7
- TVA Ponds and Water Lines – Zones 8 and 9
- Terrace Gravel – Zones 13 and 14
- Plant Area Anthropogenic – Zones 10, 15 to 23
- Thin Clay layer – Zones 24 to 28

Source: DOE 2017

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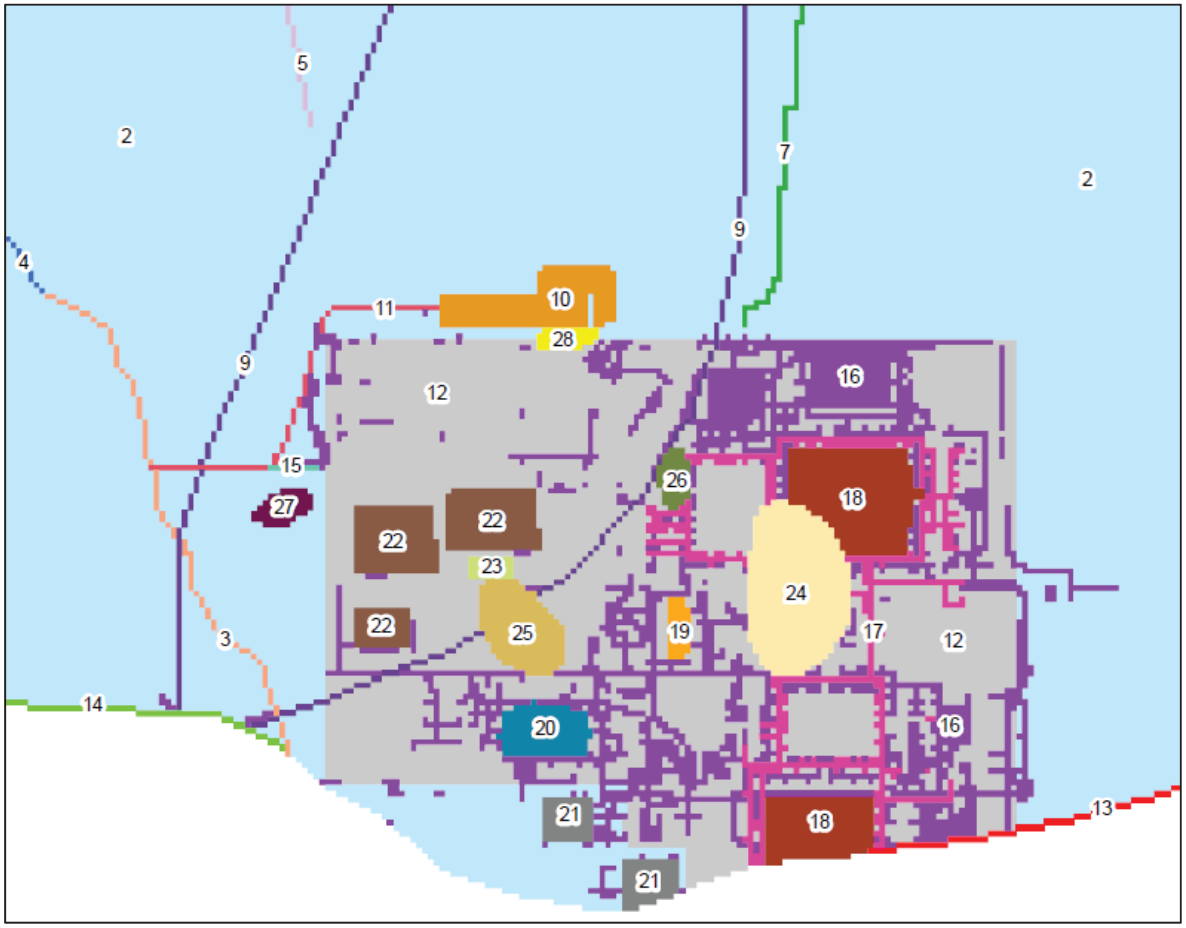
Plant Area Recharge Zones



- 2 Ambient
- 3 Very Upper Bayou Creek
- 4 Bayou Creek
- 5 Bayou Creek Tributary
- 6 Little Bayou Creek
- 7 Little Bayou Creek Tributary
- 9 TVA Lines
- 10 Lagoon
- 11 Lagoon Ditch
- 12 Plant Area
- 13 East Terrace Recharge
- 14 West Terrace Recharge
- 15 Outfall 001
- 16 Storm Drains
- 17 High Pressure Fire Water Lines
- 18 Compromised Roof Drains - Process Buildings
- 19 Compromised Roof Drain - C400
- 20 Competent Roof Drain - C720
- 21 Paved Areas
- 22 Compacted Gravel
- 23 Capped Landfill
- 24 Thin Clay Recharge Area 1
- 25 Thin Clay Recharge Area 2
- 26 Thin Clay Recharge Area 3
- 27 Thin Clay Recharge Area 4
- 28 Thin Clay Recharge Area 5

Source: DOE 2017

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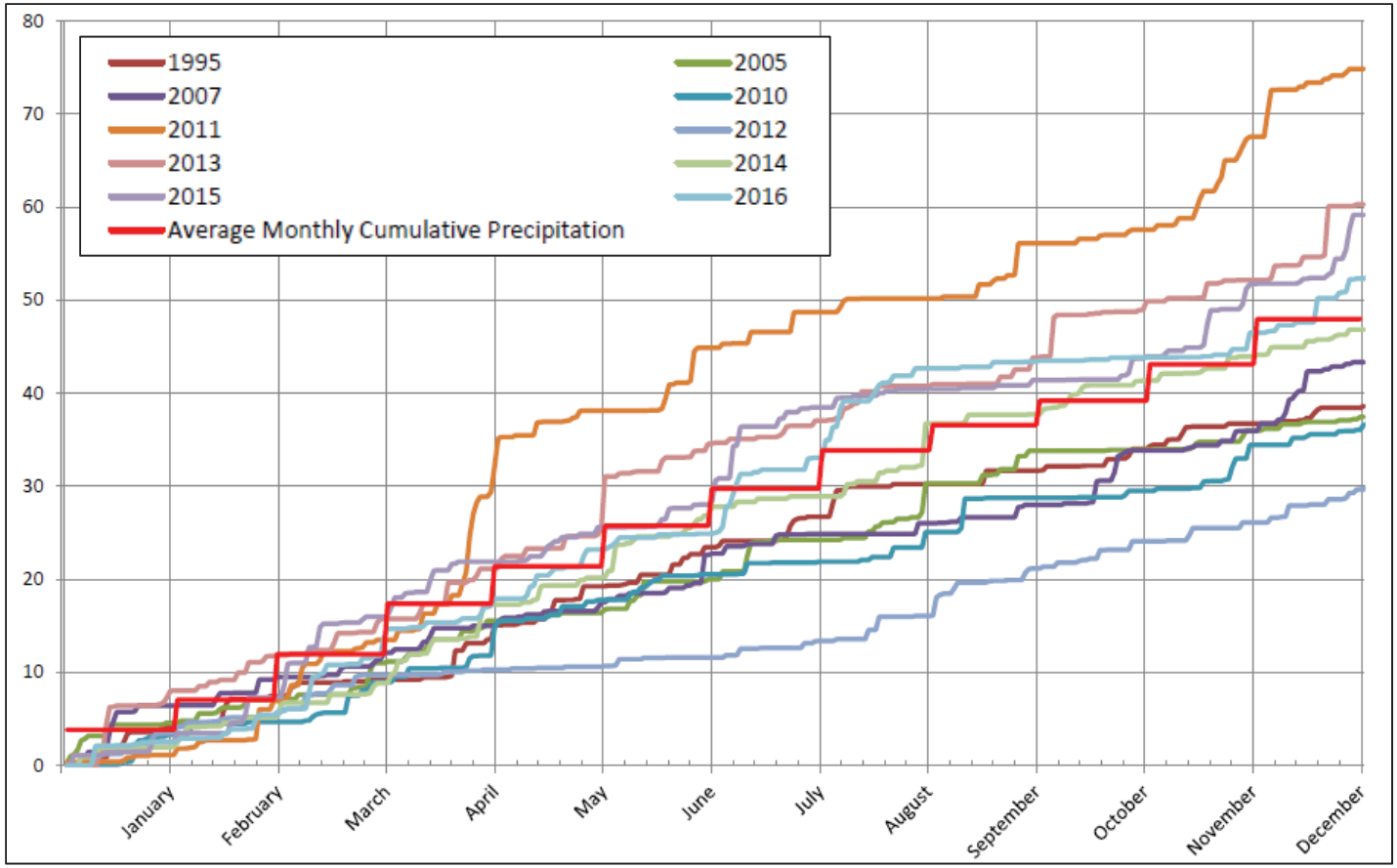
Historical Annual Cumulative Precipitation (inches)
Barkley Regional Airport



Source: DOE 2017

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Calibration

- Calibrated to two stress periods:
  - February 1995 (non-pumping conditions)
  - September 2014 (steady state conditions with extraction system)
- Calibration Targets
  - Monitoring well groundwater elevation targets
  - Flux targets from seepage measurements in LBC
  - Hydraulic conductivity derived from pumping tests
  - Flow direction or trajectory targets from plume flow paths
- Manual and automated (PEST) parameter adjustments
  - Hydraulic conductivity
  - Recharge
  - Conductance (hydraulic conductivity) in River, BC, and LBC sediments
- RGA Hydraulic conductivity estimated using pilot points

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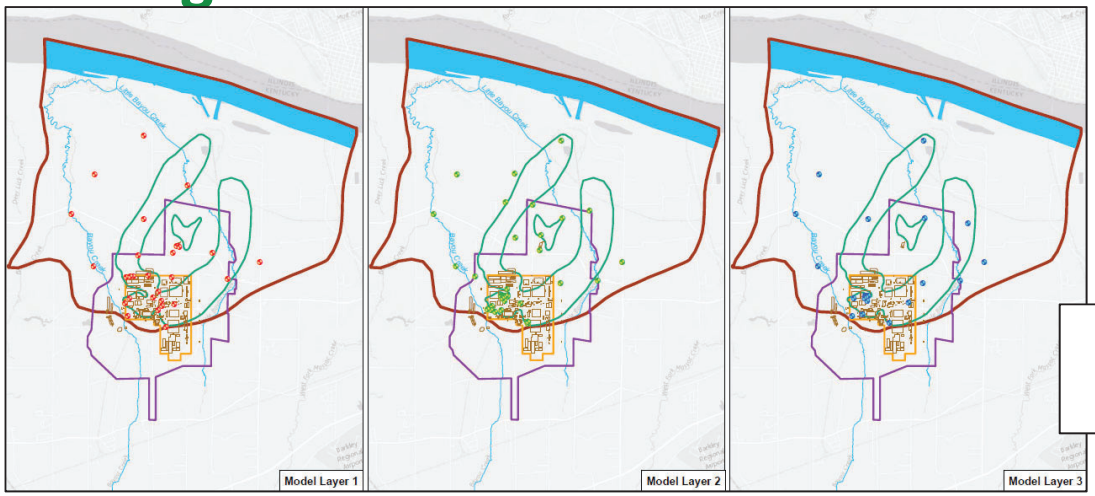
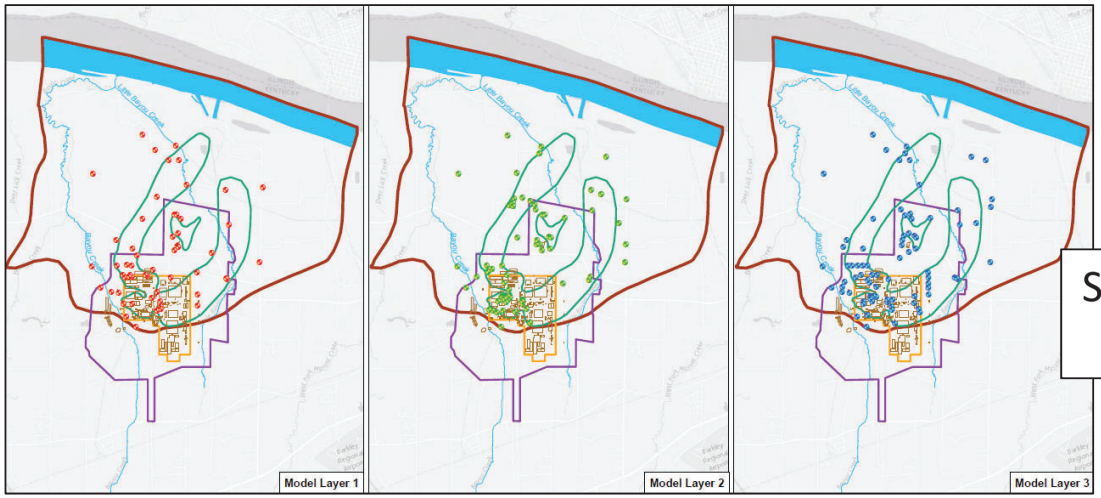
Monitoring Well Groundwater Elevation Targets



February 1995
84 targets



September 2014
220 Targets

Source: DOE 2017

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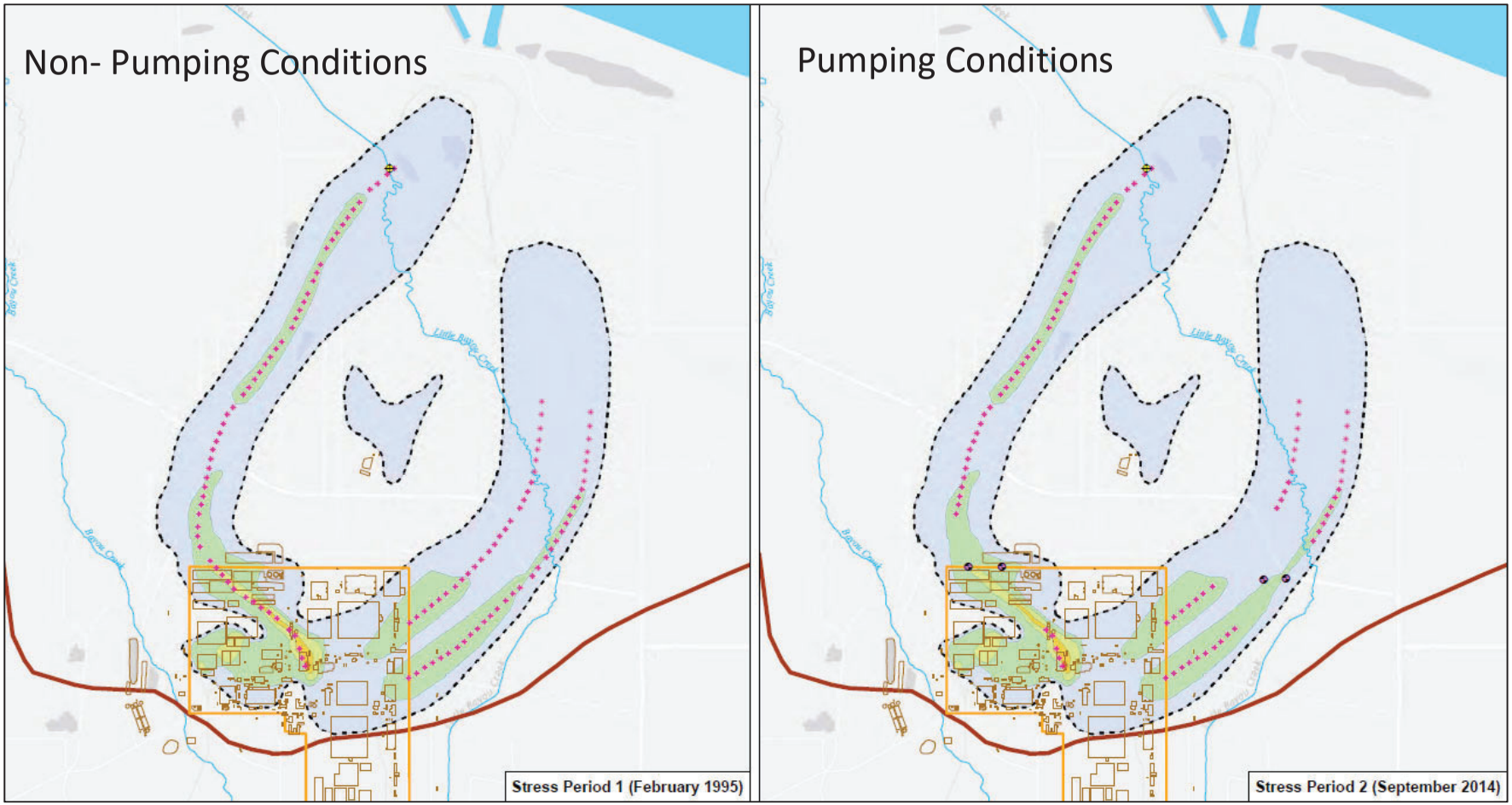
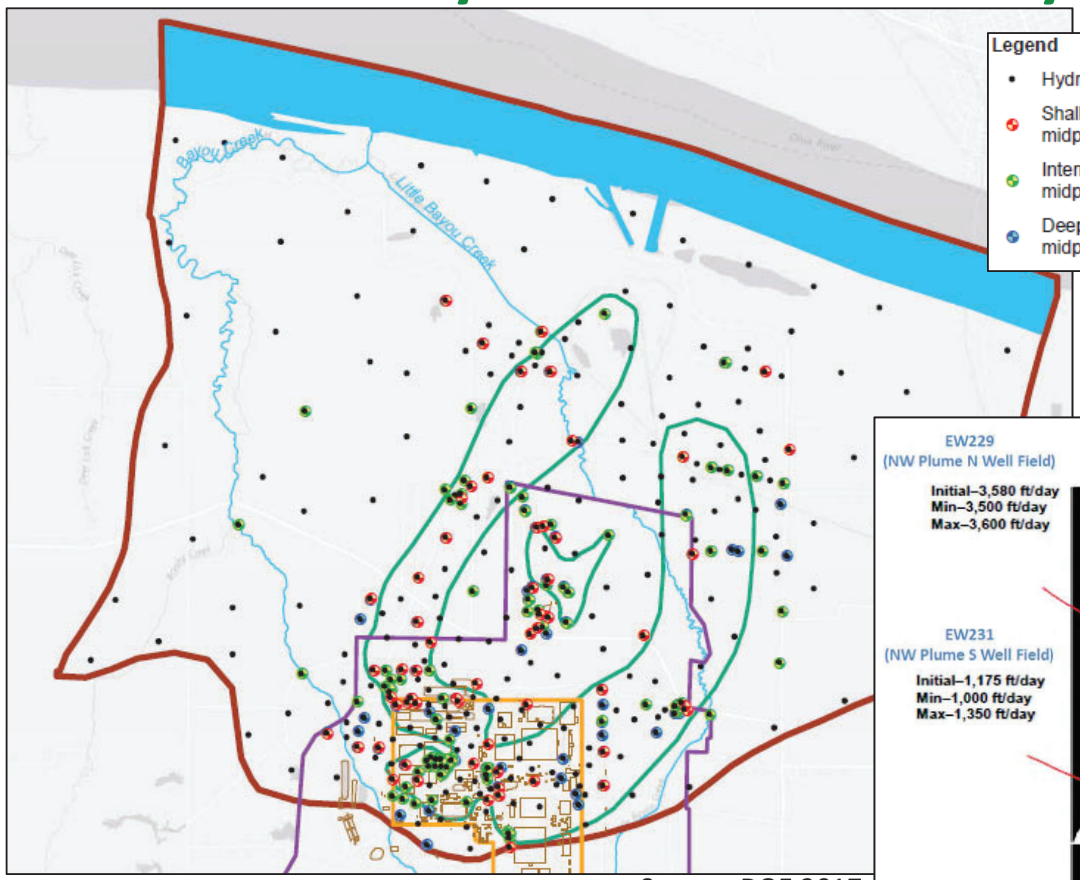
Flow Direction and Flux Targets

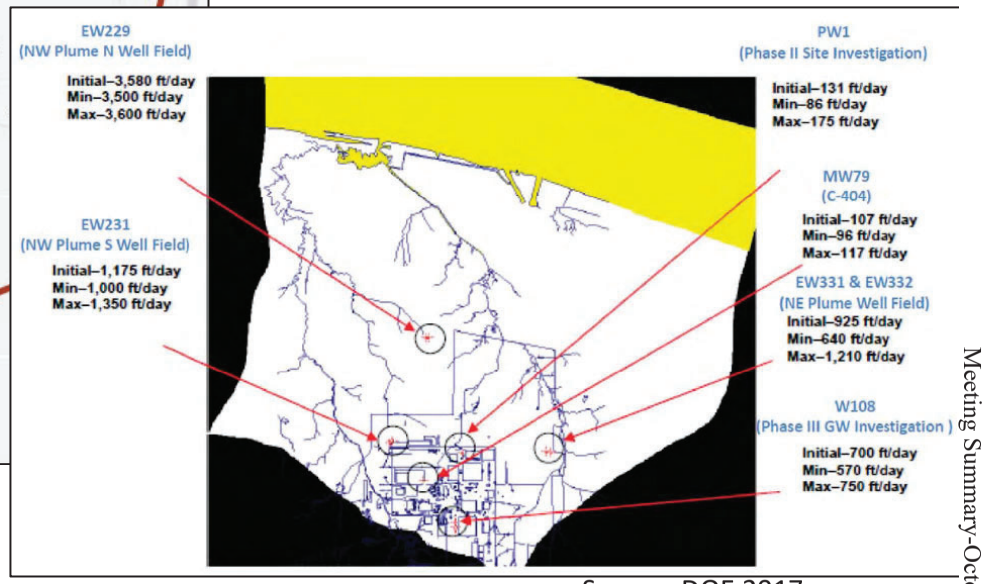


Source: DOE 2017

Hydraulic Conductivity Pilot Points



Source: DOE 2017



Source: DOE 2017

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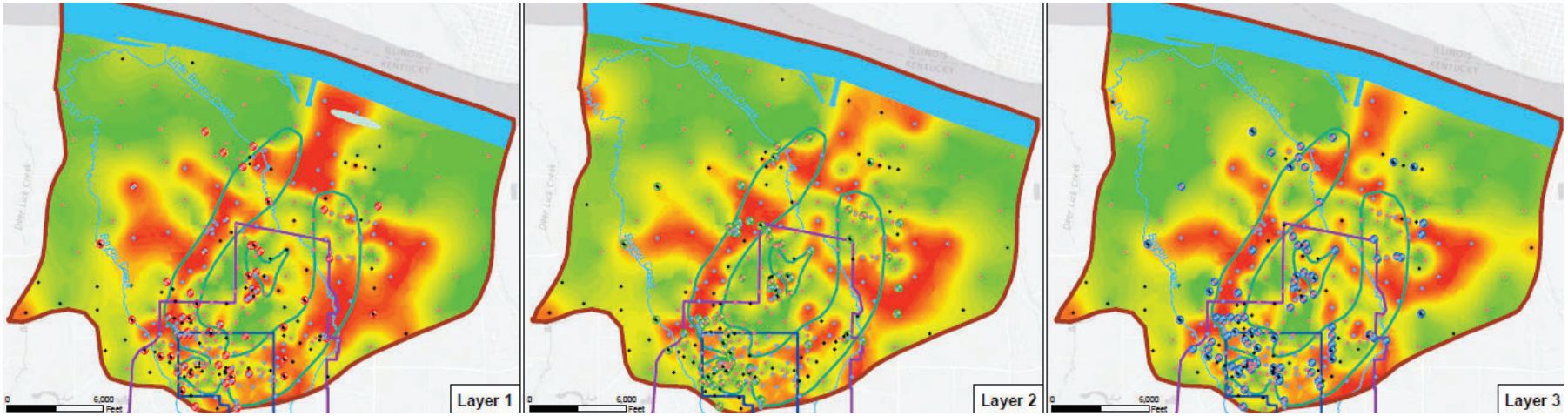
Model Predicted Hydraulic Conductivity



- Kx Pilot Point
- Kx Pilot Point at Maximum Constraint
- Kx Pilot Point at Minimum Constraint
- Water Level Target - Layer 1
- Water Level Target - Layer 2
- Water Level Target - Layer 3

Hydraulic Conductivity (ft/d)

86 - 97	132 - 156	466 - 679	1,503 - 1,856
97 - 100	156 - 190	679 - 827	1,856 - 2,392
100 - 104	190 - 251	827 - 1,009	2,392 - 3,119
104 - 116	251 - 335	1,009 - 1,237	3,119 - 3,600
116 - 132	335 - 466	1,237 - 1,503	50,000 (Metropolis Lake)

Source: DOE 2017

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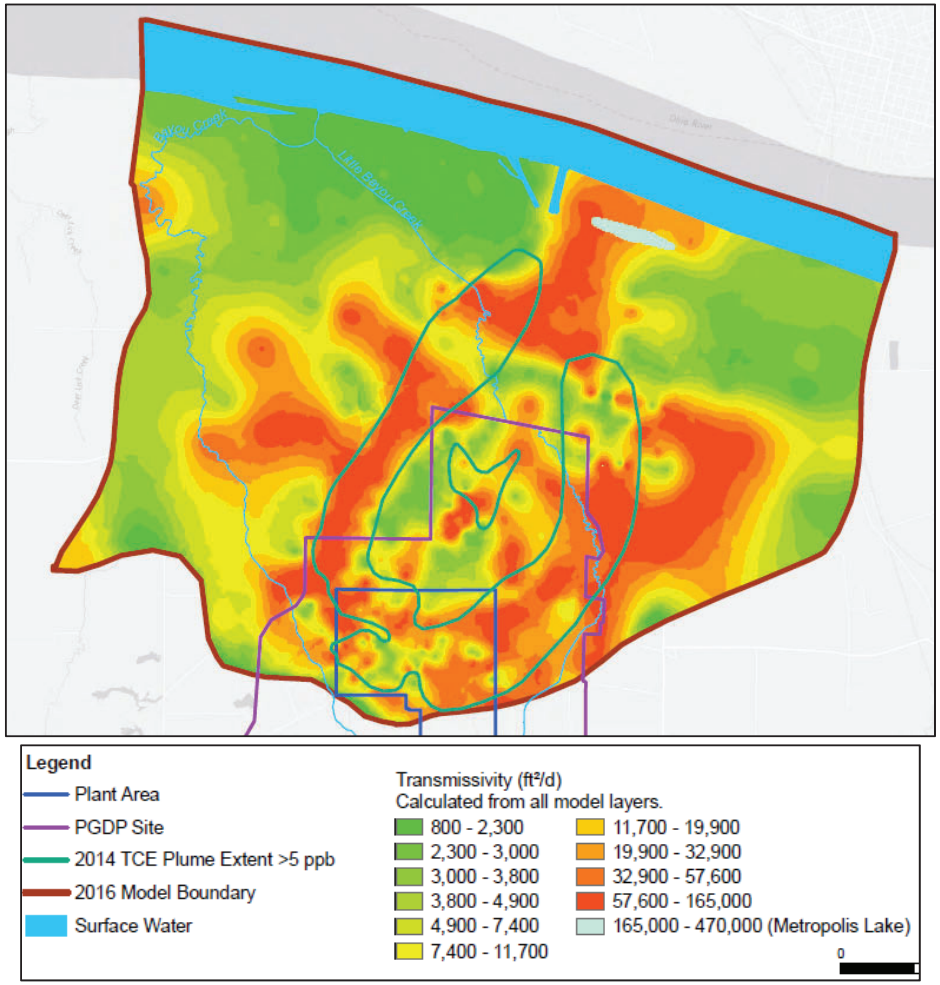
Model Predicted Transmissivity



$$T = K * b$$

T= Transmissivity
K = Hydraulic Conductivity
b = thickness

Source: DOE 2017

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Water Level Target Residual Statistics

- Residual = Observed - Calculated
- Minimize residual statistics
- Scaled Root Mean Square Error (RMSE) < 10 %
- Minimize spatial bias

Statistic	Stress Period 1 (February 1995)	Stress Period 2 (September 2014)
Residual Mean	0.02	0.03
Absolute Residual Mean	0.35	0.24
Residual Std. Deviation	0.49	0.31
Sum of Squares	20.12	21.46
RMS Error	0.49	0.31
Min. Residual	-1.37	-0.67
Max. Residual	2.20	1.08
Number of Observations	84	220
Range in Observations	11.54	9.53
Scaled Residual Std. Deviation	0.04	0.03
Scaled Absolute Residual Mean	0.03	0.02
Scaled RMS Error	0.04	0.03
Scaled Residual Mean	0.002	0.003

Notes:

1. Units are in ft.
2. Negative residuals denote overestimates and positive residuals denote underestimates.

Source: DOE 2017

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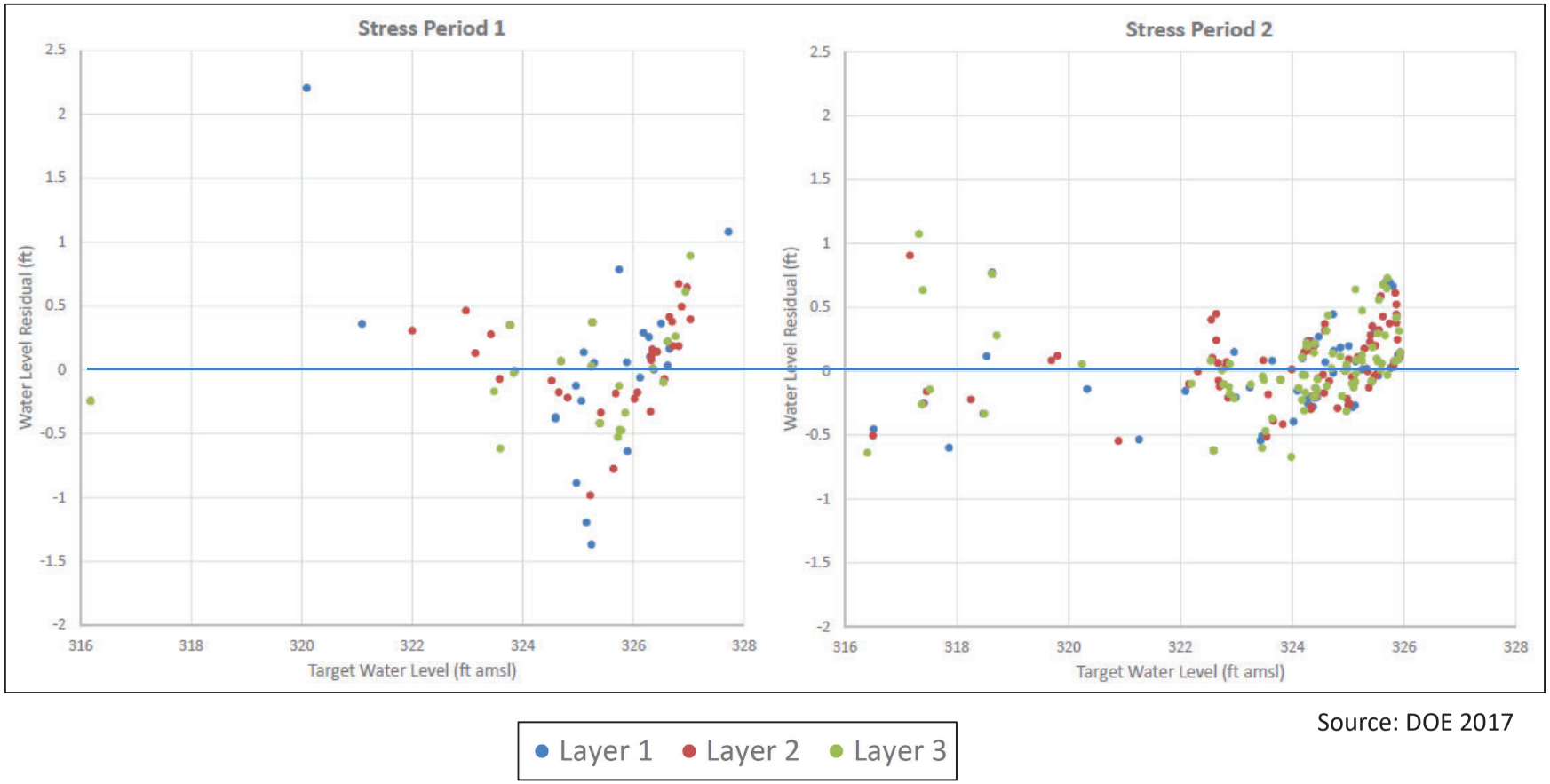
Water Level Target Residual Vs Target Water Level



Source: DOE 2017

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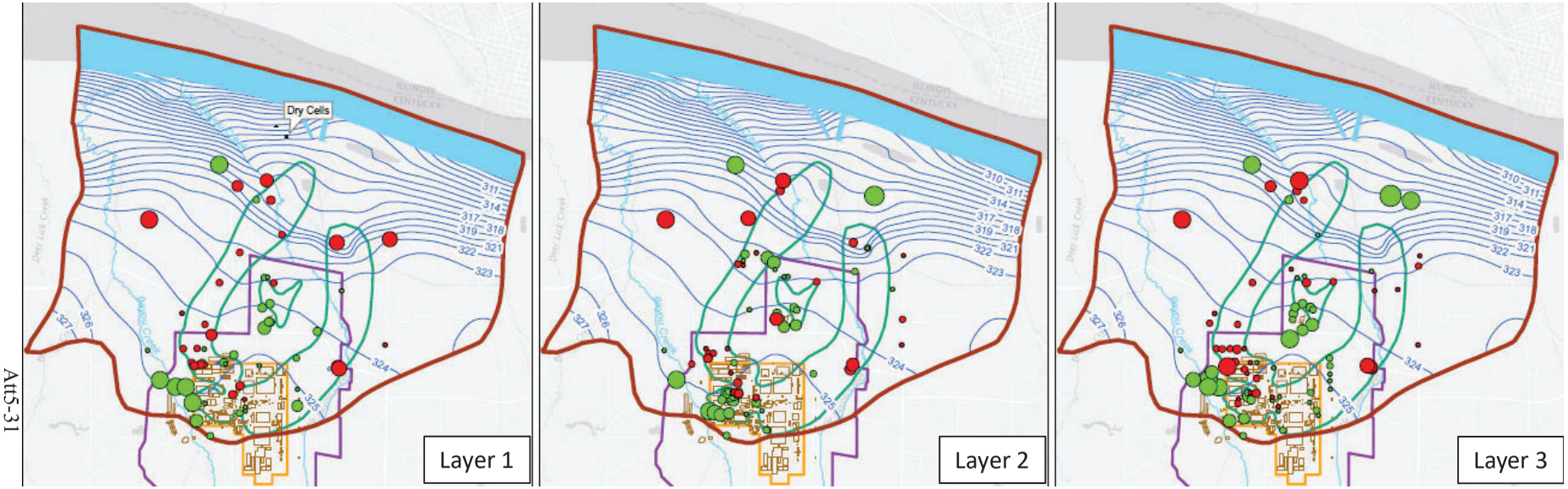
Water Level Target Residual Spatial Distribution



Source: DOE 2017

Stress Period 2 - September 2014

Water Level Residual (ft)
Negative residuals denote overestimates and postive residuals denote underestimates.

-1.4 to -1.2	-0.6 to -0.5	-0.2 to -0.1	0.2 to 0.3	0.6 to 0.8
-1.2 to -1.0	-0.5 to -0.4	-0.1 to 0.0	0.3 to 0.4	0.8 to 1.0
-1.0 to -0.8	-0.4 to -0.3	0.0 to 0.1	0.4 to 0.5	1.0 to 1.2
-0.8 to -0.6	-0.3 to -0.2	0.1 to 0.2	0.5 to 0.6	1.2 to 2.2

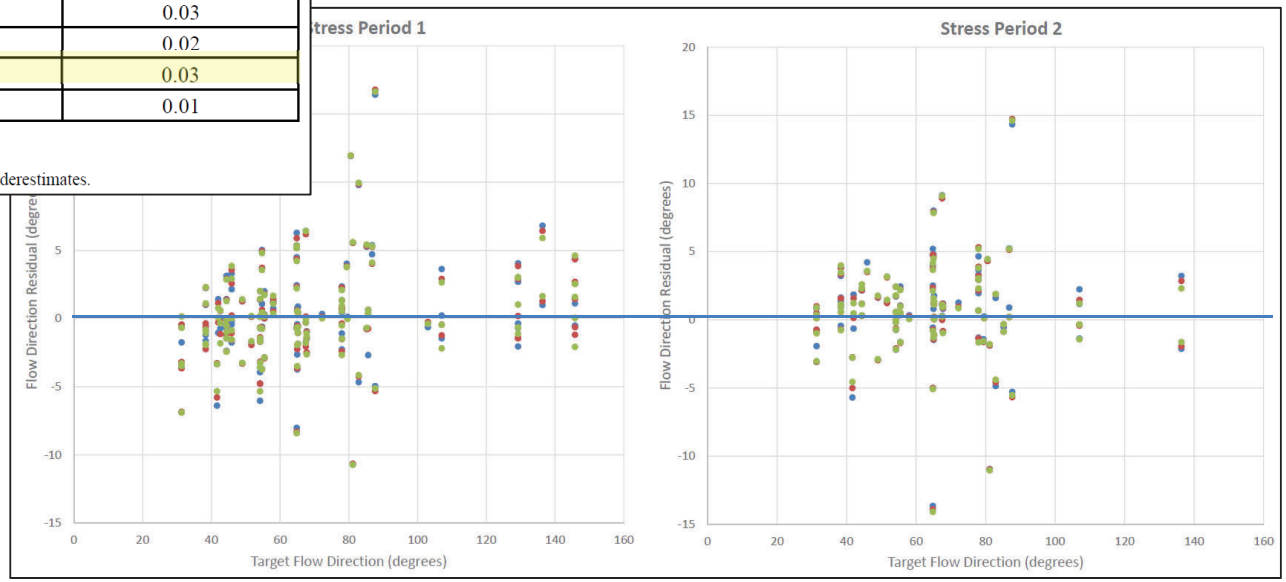
DRAFT Work Product – For Discussion Only

Flow Direction Target Residual Statistics

Statistic	Stress Period 1 (February 1995)	Stress Period 2 (September 2014)
Residual Mean	0.21	0.64
Absolute Residual Mean	2.41	2.36
Residual Std. Deviation	3.55	3.53
Sum of Squares	4,505.01	3,354.10
RMS Error	3.55	3.58
Min. Residual	-10.74	-14.09
Max. Residual	16.79	14.73
Number of Observations	357	261
Range in Observations	114.46	105.00
Scaled Residual Std. Deviation	0.03	0.03
Scaled Absolute Residual Mean	0.02	0.02
Scaled RMS Error	0.03	0.03
Scaled Residual Mean	0.00	0.01

Notes:
1. Units are in degrees.
2. Negative residuals denote overestimates and positive residuals denote underestimates.

Source: DOE 2017



Source: DOE 2017

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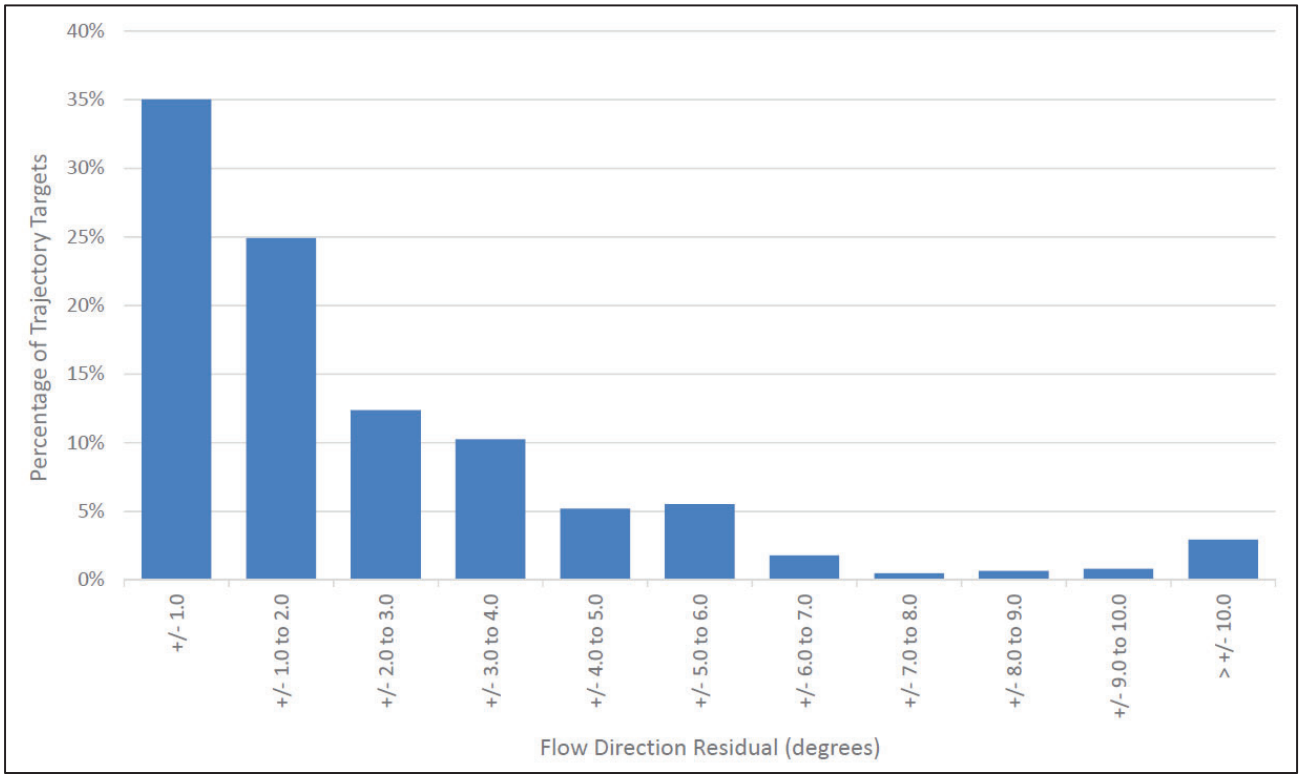
Flow Direction Target Residuals



Source: DOE 2017

- 60% targets within +/- 2 degrees
- 90% targets within +/- 5 degrees

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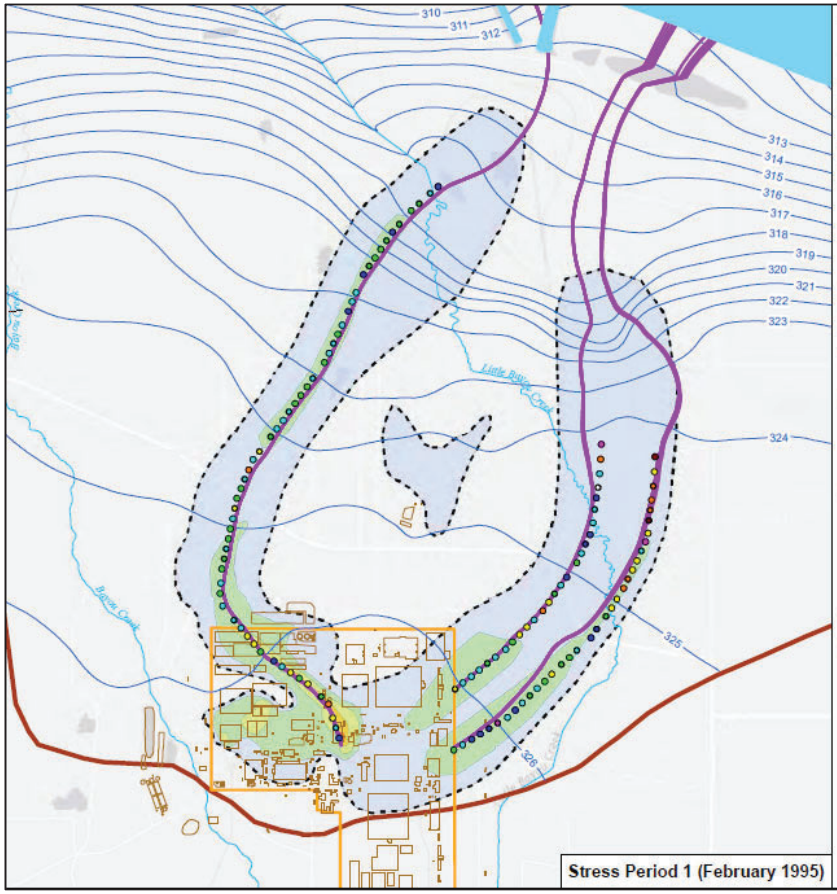
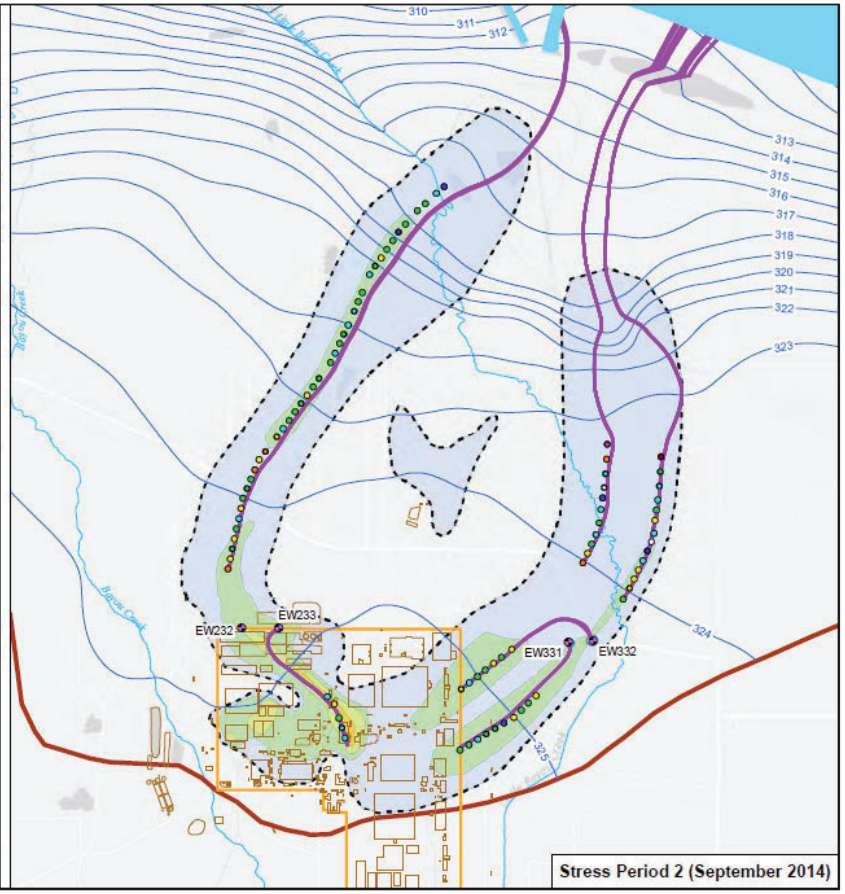
Model Predicted Flow Paths





Source: DOE 2017

Forward Particle tracking

DRAFT Work Product – For Discussion Only

Mass Balance

Recharge

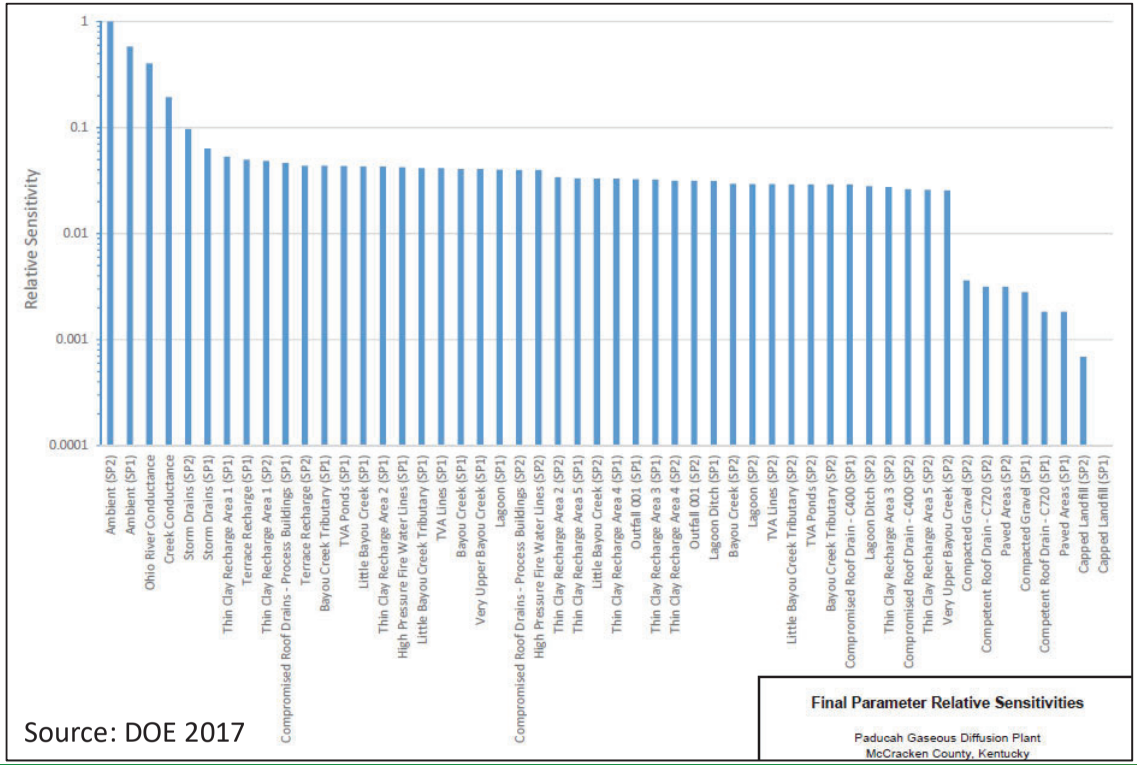
- Precipitation: 81%,
- Plant Operations (anthropogenic): 13 to 14%
- Upper Reaches of BC and LBC: 3%
- Terrace Gravel: 2%

Discharge

- Ohio River: 66%
- Discharge to lower reaches BC and LBC: 20%
- Groundwater Extraction: 14%

Model Sensitivity

- For the most sensitive parameters, the effect on plume trajectory with a 25% reduction/increase in parameter value was evaluated
- Pathlines aligned well with plume directories with two exceptions (decrease in Ohio River Conductance and Increase in Ohio River stage (320 ft amsl)



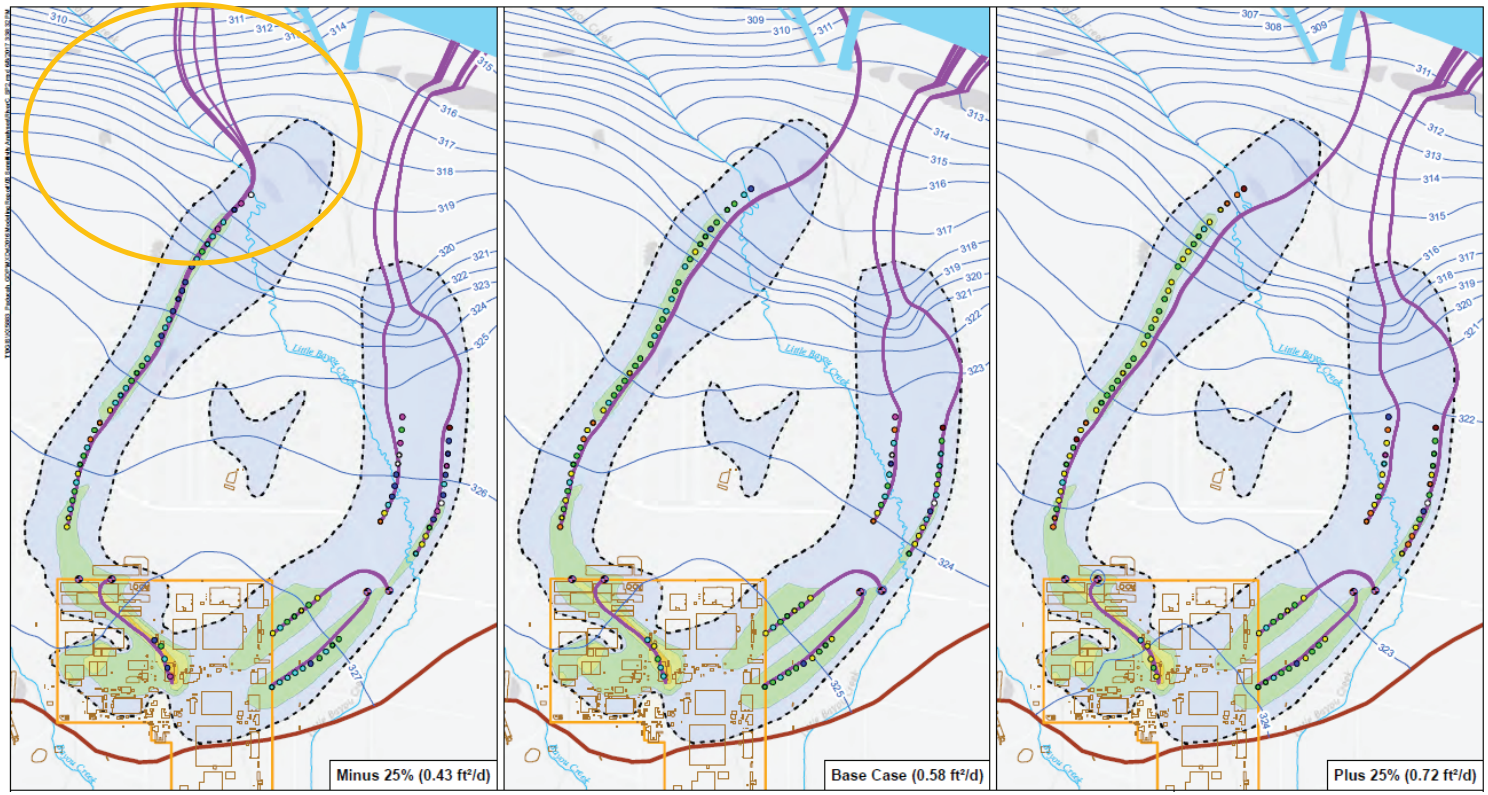
Source: DOE 2017

Most Sensitive Parameters

- Ambient Recharge
- Ohio River Conductance
- BC and LBC Conductance
- Storm Drain Recharge Area
- Thin Clay Recharge Area
- Compromised Roof Drain Recharge Area
- High Pressure Fire Water Recharge Area
- Terrace Recharge
- Ohio River Elevation

DRAFT Work Product – For Discussion Only

Model Sensitivity – Ohio River Conductance



Source: DOE 2017

Westward shift in the NW plume trajectory with 25% decrease in the hydraulic conductivity of the river sediments

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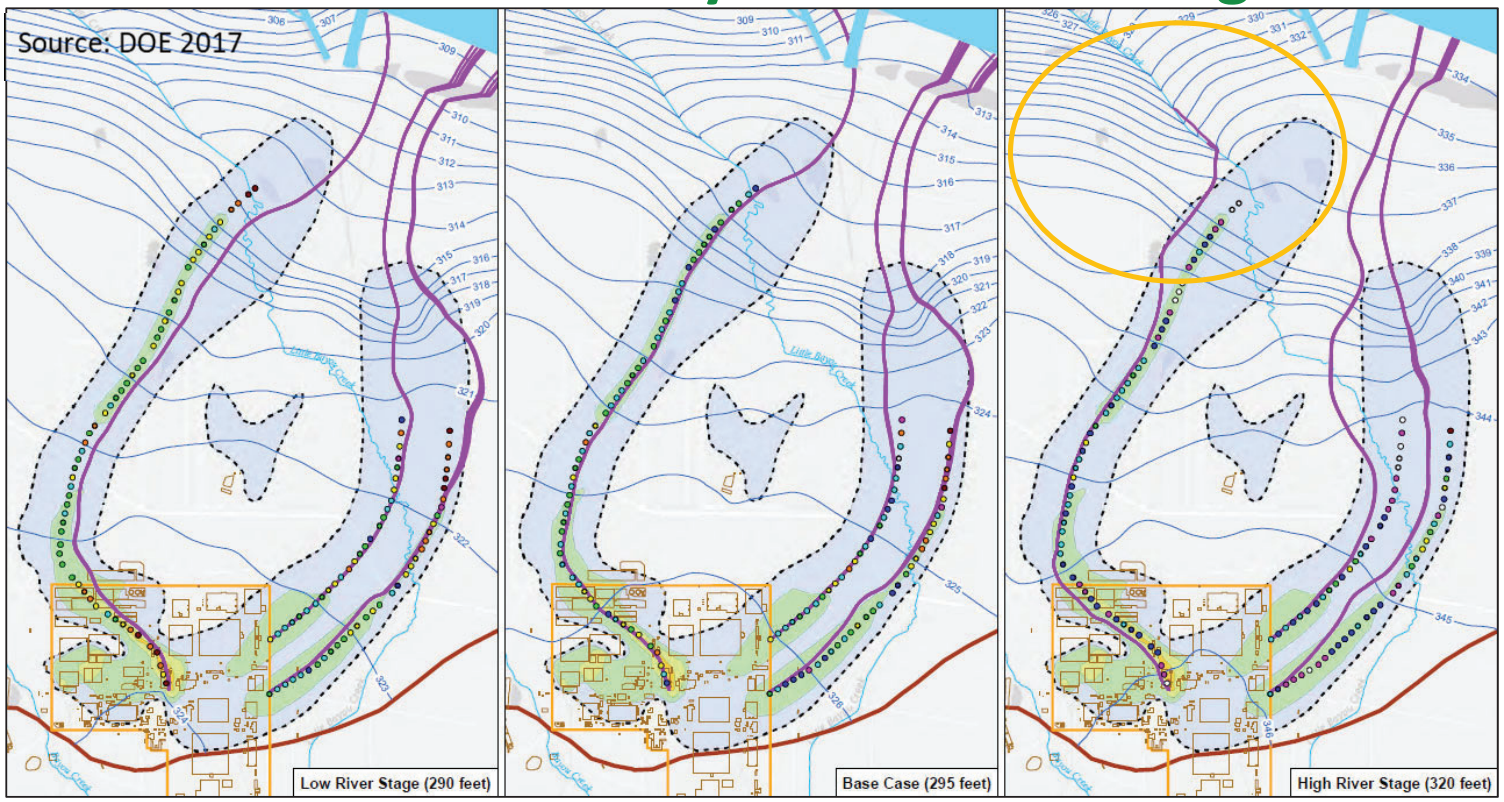
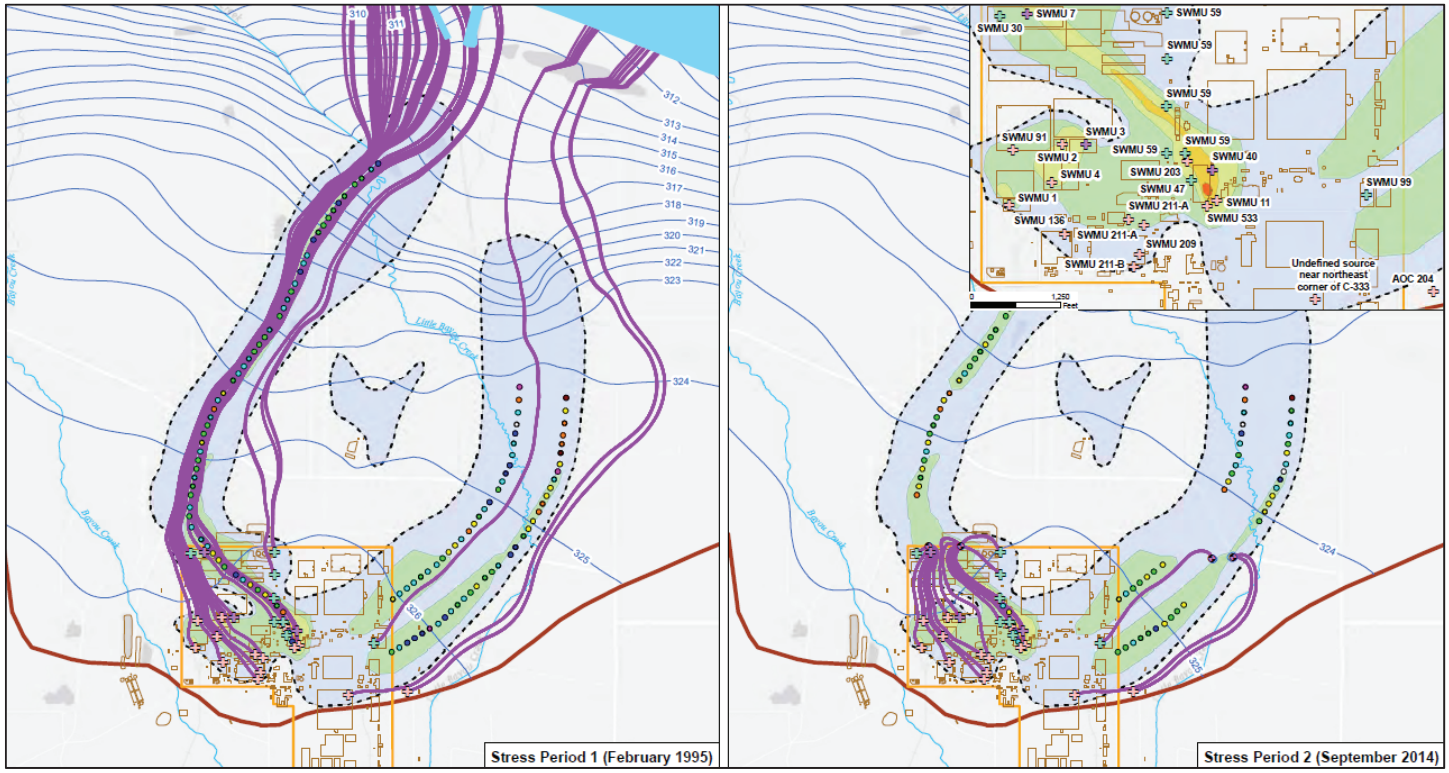
Model Sensitivity – Ohio River Stage



- Low and High river stages correspond to the lowest observed (290 ft) and the 90th percentile (320 ft)
- High river stage results in minimal shift of the NE Plume pathlines and a more pronounced shift on the NW Plume pathlines with discharge to LBC under steady state conditions

Source Area Flow Path Analysis



Source: DOE 2017

- Evaluate near field flow paths in the plant area
- UCRS source areas are approximate - RGA entry points are not known
- Pathlines general align well with the 2014 Plume delineation

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Validation – Alternative Synoptic Events

- Seven synoptic events representing steady state flow
  - Drought conditions: July 2012
  - Flooding conditions: April 2011
- Ohio River stage adjusted to match observed elevation for each synoptic event date
- Evaluated
  - Plume Trajectory
  - Gradient between the plant and Ohio River

Monitoring Period	Number of Water Level Targets	Ohio River Stage[1] (feet amsl)	Monitoring Event Type	Annual Precipitation (in/yr)
3rd Quarter 2005	110	300.0[2]	Sitewide Synoptic	37.5
April 12, 2011	212	327.2	Sitewide Synoptic	74.9
October 10, 2011	202	295.5	Sitewide Synoptic	74.9
July 17, 2012	184	290.0	Sitewide Synoptic	30.1
September 24, 2013	203	292.5	Sitewide Synoptic	60.3
September 1, 2015	205	296.7	Sitewide Synoptic	59.2
August 23, 2016	216	298.0[2]	Sitewide Synoptic	52.5

Source: DOE 2017

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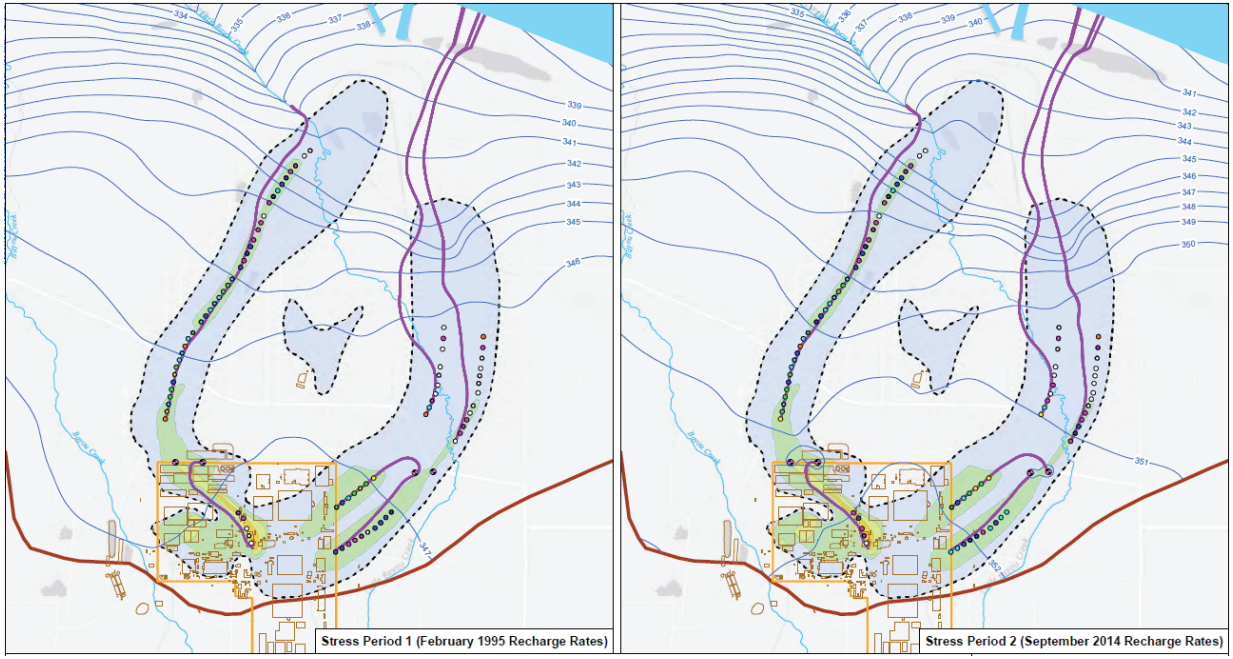
Validation – Plume Trajectory

April 2011 flooding scenario – Ohio River = 327.2 ft amsl



Source: DOE 2017

- Pathlines generally align with plume trajectories for river stage <300 ft amsl
- Under flooding conditions pathlines show more westerly flow direction with discharge to LBC near the NW plume

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Validation – Gradient Analysis

	Calibration		Validation						
Statistic	SP1 Feb 1995	SP2 Sept 2014	SP2 Q3 2005	SP2 Apr 2011	SP2 Oct 2011	SP2 July 2012	SP2 Sept 2013	SP2 Sept 2015	SP2 Aug 2016
River Stage Elevation[1]	295.2	295.2	300.0	327.2	295.5	290.0	292.5	296.7	298.0
Model Calculated Gradient[2]	0.00082	0.00074	0.00075	0.00071	0.00074	0.00077	0.00075	0.00074	0.00073
Observed Gradient[2]	NA[5]	0.00075	NA[5]	0.00032	0.00068	0.00067	0.00069	0.00088	0.00083
Percent Difference[3,4]	NA[5]	1.5%	NA[5]	-120.0%	-9.4%	-13.4%	-9.0%	16.4%	11.5%

[1] River stage elevation is in feet amsl.

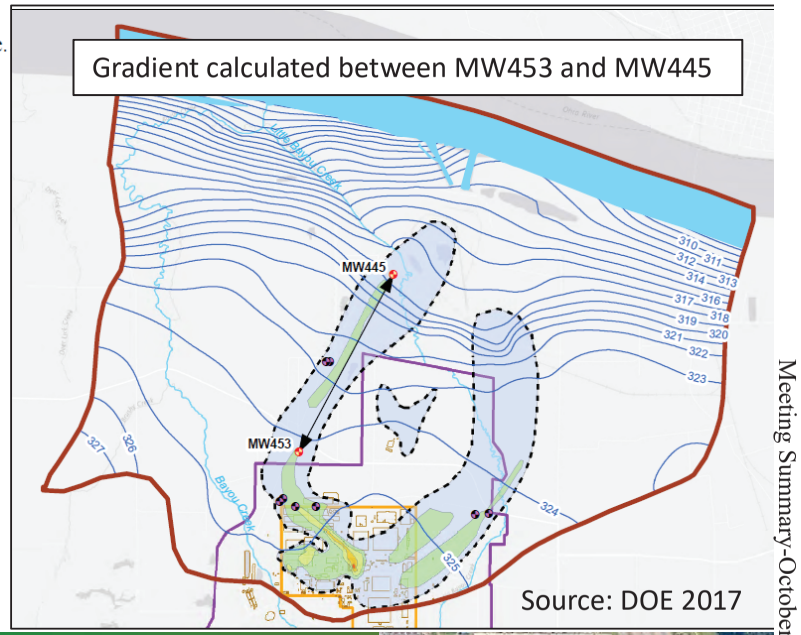
[2] Gradient is calculated by dividing the distance between monitoring wells MW453 and MW445 into the calculated or observed head difference.

[3] Percent Difference = ((Observed gradient-calculated gradient)/observed gradient)*100.

[4] A negative percent difference denotes an overestimate and a positive percent difference denotes an underestimate.

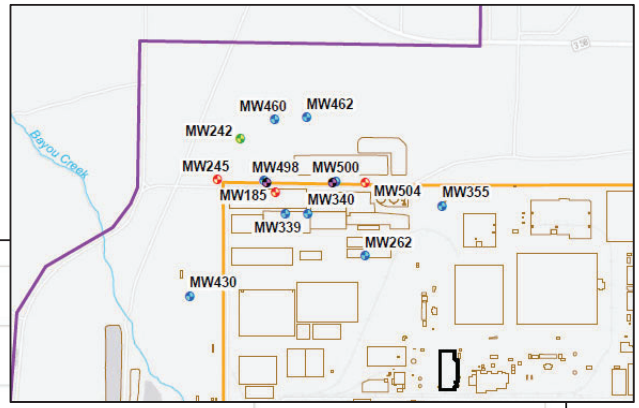
[5] No observation data available for MW453 and MW445 on this date.

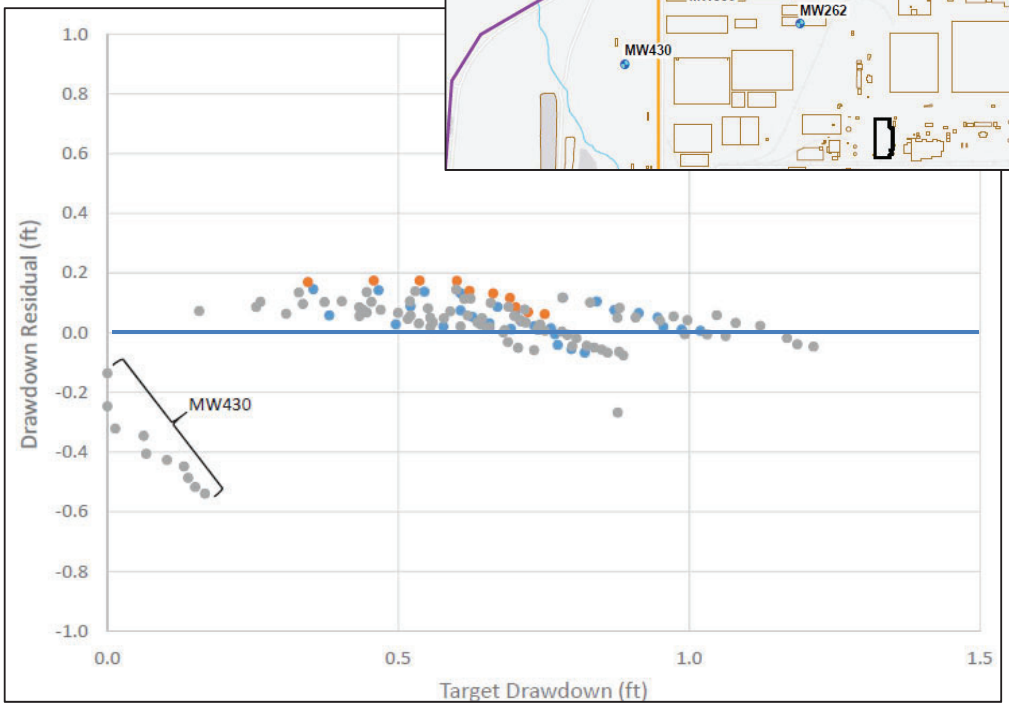
- Calculated gradient range (0.00071 to 0.00077) compares well to the calibrated model (0.00074).
- With constant recharge and K, simulated heads adjust to the river stage such that the gradient across the site remains constant to balance model discharge with model recharge
- Comparison of the model calculated gradient ranges from -9.0% to 16.4%, excluding April 2011 flooding



Validation – EW232 and EW233 Pumping Test

- 10-day pumping test in October 2010
- Simulated using an initial SS stress period followed by ten 1-day transient stress periods
- Calibrated storativity was consistent with EW231 pumping test data analysis (approx. 740 feet west)
- Reasonable match to drawdown at target wells
- Lesser match at MW430 which showed inconsistent response during the pumping test





Source: DOE 2017

DRAFT Work Product – For Discussion Only

Conclusions

The 2016 Sitewide Groundwater flow model:

- Honors the conceptual model with respect to recharge and discharge rates, relative recharge and discharge volumes, and the predicted range of RGA hydraulic conductivities.
- Reasonably matches target water level elevations in the plant area and across the model domain.
- Reasonably reproduces the Northeast and Northwest Plumes flow paths under steady state conditions and Ohio river levels at approximately 297 ft amsl.
- Predicts flow at the toe of the Northwest Plume migrates westward with increased discharge to LBC, rather than northward to the Ohio River For Ohio River stages above 297 ft amsl.
- Reasonably represents the hydraulic gradient from the plant area to the furthest extent of the Northwest Plume, except in the case of extreme flooding conditions.

Model assumptions and limitations:

- The model is formulated and calibrated as a steady-state model, on a regional scale, and its domain limit does not include portions of the PGDP Site south of the RGA.
- Use of the groundwater model for specific project needs, limits on the application of the model for site or project-specific requirements and determinations of the appropriate use of the model should be made by appropriate project personnel on a case-by-case basis.

Recommendations:

- Potential data collection needs were identified by the MWG for consideration in future model updates.
- These should be reviewed in the context of data obtained since 2017 through projects such as the Groundwater Strategy Project and C-400 Remedial Investigation.

References

DOE 2017. 2016 Update of the Paducah Gaseous Diffusion Plant Sitewide Groundwater Flow Model, A Product of the Paducah Gaseous Diffusion Plant Site Groundwater Modeling Working Group, July. DOE/LX/07-2415&D2

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APPENDIX B

GROUNDWATER MODELING WORKING GROUP MEETING SUMMARY—JANUARY 12, 2022

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ACRONYMS[1]

AIP	agreement in principle
amsl	above mean sea level
BBC	Big Bayou Creek
BC	Bayou Creek
CB	colloidal borescope
CCR	coal combustion residual
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CRS	comment response summary
CSM	conceptual site model
CY	calendar year
DNAPL	dense nonaqueous phase liquid
DOE	U.S. Department of Energy
DQO	data quality objective
DTW	depth to water
EMP	environmental monitoring plan
EPA	U.S. Environmental Protection Agency
ETAS	Enterprise Technical Assistance Services, Inc
EW	extraction well
FFA	Federal Facility Agreement
FRNP	Four Rivers Nuclear Partnership, LLC
FS	feasibility study
FY	fiscal year
GIS	geographic information system
gpm	gal per minute
GUI	graphical user interface
GW	groundwater
GWSP	Groundwater Strategy Project
HQ	headquarters
KDEP	Kentucky Department of Environmental Protection
KGS	Kentucky Geological Survey
KRCEE	Kentucky Research Consortium for Energy and the Environment
KWRRI	Kentucky Water Resources Research Institute
KY	Commonwealth of Kentucky
LBC	Little Bayou Creek
LBCSP	Little Bayou Creek seep
LRGA	Lower Regional Gravel Aquifer
MCL	maximum concentration limit
McN	McNairy
MOA	memorandum of agreement
MRGA	Middle Regional Gravel Aquifer
MSL	mean sea level
MW	monitoring well
MWG	Modeling Working Group
NEP	northeast plume
NEPCS	northeast plume containment system
NGVD	National Geodetic Vertical Datum
OREIS	Oak Ridge Environmental Information System

[1] Acronym list was not part of the original meeting summaries.

OU	operable unit
PCC	Porters Creek Clay
PEGASIS	PPPO Environmental Geographic Analytical Spatial Information System
PEST	parameter estimation
PFAS	per- and polyfluoroalkyl substances
PGDP	Paducah Gaseous Diffusion Plant
PI	preliminary investigation
PPPO	Portsmouth/Paducah Project Office
P-QAPP	programmatic quality assurance project plan
PT	pressure transducer
PVC	polyvinyl chloride
PZ	piezometer
Q	quarter
RFP	request for proposal
RGA	Regional Gravel Aquifer
RI	remedial investigation
RMS	root mean squared
SVD	singular value decomposition
SW	surface water[2]
SWMU	solid waste management unit
TBD	to be determined
TIC	top of inner casing
TVA	Tennessee Valley Authority
UCRS	upper continental recharge system
UK	University of Kentucky
UKCE	University of Kentucky Department of Civil Engineering
UKEES	University of Kentucky Earth and Environmental Sciences
URGA	Upper Regional Gravel Aquifer
VI	vapor intrusion
WDA	waste disposal alternative
WLE	water level elevation

[2] This definition for SW only applies to page B-95; all other instances of SW in this appendix are the acronym for southwest.

Paducah Site Groundwater Modeling Working Group
Proposed Meeting Summary—January 12, 2022

MWG Attendees:

DOE
Rich Bonczek ✓
Dave Dollins ✓

ETAS
Martin Clauberg ✓
Bruce Stearns ✓
Tracy Taylor ✓

KRCEE
Steve Hampson ✓

TVA
Tabitha Ester✓
Anna Fisher
Dominic Norman

EPA and Contractors
Noman Ahsanuzzaman
Ben Bentkowski ✓
Eva Davis ✓
Mac McRae ✓
Victor Weeks ✓

Kentucky
Brian Begley ✓
Stephanie Brock
Nathan Garner ✓
Brian Lainhart
Bart Schaffer
Chris Travis ✓

FRNP
Austin Buckhalter
Evan Clark ✓
Bryan Clayton
Lisa Crabtree
Sarah Cronk ✓
Ken Davis ✓
Rob Flynn
Bruce Ford
Stefanie Fountain ✓
LeAnne Garner
Ansel McClelland ✓
Bruce Meadows ✓
Jason Orr ✓
Todd Powers ✓
Joe Tarantino ✓
Denise Tripp ✓
Dawit Yifru ✓

Original meeting agenda items are provided followed by meeting notes; the meeting notes are provided in italics with action items noted in green.

1. Call for Issues from Groundwater Modeling Working Group (MWG) Members

No comments were received to the October 6, 2021, Meeting Summary (sent to participants on 10/26/2021). This summary will be considered final.

No comments were received to the October 6, 2021 Meeting Summary. The meeting summary is now final.

2. FY 2022 Work Plan/Schedule

The dates for several activities were revised following the October 6, 2021 meeting. The revised schedule is shown below.

Activity	Date
~~Quarterly Meeting (October/FY22Q1)~~	~~10/6/2021~~
~~MWG Concurs with FY 2022 Work Plan/Schedule~~	~~11/12/2021~~
~~Submit Draft Meeting Summaries and White Papers Compilation (FY21)~~	~~11/15/2021~~
~~MWG Provide Comments on Draft Compilation of Meeting Summaries and White Papers (FY21)~~	~~11/30/2021~~
~~Submit Final Meeting Summaries and White Papers Compilation (FY21)~~	~~12/21/2021 Planned~~ ~~12/13/2021 Actual~~
Quarterly Meeting (January/FY22Q2)	1/12/2022
Submit Draft Large Building PZ White Paper to MWG	2/17/2022

Activity	Date
Submit Draft Survey White Paper 2 to MWG	3/18/2022
MWG Review Draft Large Building PZ White Paper	3/25/2022
Quarterly Meeting (April/FY22Q3)	4/6/2022
Submit Final Large Building PZ White Paper to EPA and KY	5/19/2022
Quarterly Meeting (July/FY22Q4)	7/13/2022
Submit Draft McNairy Lithologic Technical Paper to MWG	8/11/2022
MWG Meeting to Discuss Draft McNairy Lithologic Technical Paper	8/24/2022
MWG Provide Comments on Draft McNairy Lithologic Technical Paper	9/12/2022

Color code for schedules:

Due date	Quarterly meeting
Submittal date	Concurrence/acknowledgement date

b. FY 2023 Activities

Activity	Date
Quarterly Meeting (October/FY23Q1)	10/5/2022
Submit Final McNairy Lithologic Technical Paper to EPA and KY	11/7/2022

No comments were received on the working group schedule or planning dates.

3. Update on Water Levels

Synoptic water level events are being collected quarterly, and since the last meeting (October 6, 2021) a synoptic event occurred on November 15-18, 2021. Potentiometric maps for the synoptic water level events in November 2020, February 2021, May 2021, and August 2021, as well as select pressure transducer data plots are included in Attachment 1.

Groundwater elevation data for TVA wells collected by KY occurred on November 16, 2021 and is included as Attachment 2.

The group discussed that the 2021 potentiometric maps are generally consistent with prior potentiometric maps.

The group appreciates the access to monitoring wells and information on monitoring well status that TVA is providing. TVA plans to abandon several monitoring wells along Little Bayou Creek (e.g., AR76, AR75B, and B10). Tabitha Ester (TVA) continues to coordinate with Brian Lainhart (KY) on collection of water level measurements and monitoring well abandonment plans.

4. Update on Paducah Site Groundwater Strategy

The overall objectives for the GWSP is to develop a groundwater strategy that closes out various issues for the site:

- Change status of two Environmental Indicator Performance Measures to “Yes”
  - Human exposure under control
  - Groundwater migration under control
- Resolution of data needs
- Groundwater Modeling Working Group (MWG) recommended maintenance and updates

The project objectives and draft schedule were originally discussed during the April 10, 2019 MWG meeting and included in the Compilation of Meeting Summaries and White Papers (2019–July 2020) (DOE/LX/07-2451&D1). The GWSP is a multi-year plan with near-term (0-3 years) activities and longer-term (beyond 3 years) activities planned. The specific timing and scope of each activity are developed by DOE based on data collected in the prior year(s). The GWSP and the C-400 OU Remedial Investigation projects are separate, but where activities overlap they are coordinated and the relevant information obtained from the remedial investigation will be incorporated into the GWSP.

The Groundwater Strategy Project (GWSP) field data collection schedule for FY 2022 is included as Attachment 3.

The FY 2022 plan includes quarterly walkdowns of a portion of Little Bayou Creek. During the October 6, 2021 meeting the group discussed that seeps may not be able to be observed during quarterly walkdowns, specifically during periods where the Ohio River is elevated above normal pool and where the seeps are not accessible or visible due to the Ohio River backing up into the creek. KY recommended instead coordinating the walkdowns with precipitation and river stage forecasts. Stream gauging is not planned for FY 2022 due to the ongoing construction of the TVA sheet pile wall and the intent to observe the system for any changes resulting from the presence of the wall.

A creek bank walkdown of Little Bayou Creek in the vicinity of the new TVA sheet pile wall was performed December 2, 2021.

FRNP continues to coordinate with KY on the AIP monitoring wells sampling schedule.

The group discussed the challenges of performing Little Bayou Creek (e.g., deep water at times and deeply incised banks) walkdowns and the potential for using drone-mounted infrared cameras to detect temperature gradients for seep identification. KRCEE has previously attempted use of drones with thermal cameras for seep detection with limited success; EPA relayed a recent successful seep identification project where drones with high-resolution thermal cameras were used. EPA will provide details on the technology employed to the group.

5. Discussion on Installation of Piezometers …Associated with Several of the Large Process Buildings

Preliminary information to be collected for the "Installation of piezometers …associated with several of the large process buildings…." white paper will benefit from the information learned during the vapor intrusion (VI) project. The D1 VI Work Plan was finalized in December 2020 and field sample collection occurred February 22, 2021 through March 9, 2021. The D1 VI Report was submitted to EPA and KY in September 2021 and comments on the report were received December 28, 2021. The D2 VI Report is in preparation.

The schedule for this white paper has been revised as shown below to allow for integration of VI Report information into the white paper, as appropriate.

Activity	Target Start	Target Finish
~~Quarterly Meeting (October/FY21Q1)~~		~~10/7/2020~~
~~Develop Outline for Large Building PZ White Paper~~	~~10/14/2020~~	~~12/11/2020~~

Activity	Target Start	Target Finish
~~Provide Large Building PZ White Paper Outline to MWG~~		~~12/11/2020~~
~~MWG Review Large Building PZ White Paper Outline~~	~~12/11/2020~~	~~1/13/2021~~
~~Quarterly Meeting (January/FY21Q2)~~		~~1/13/2021~~
~~Revise Outline for Large Building PZ White Paper Based on MWG Discussions~~	~~1/13/2021~~	~~1/28/2021~~
~~VI Field Sampling / Laboratory Analysis / Validation~~	~~Feb 21~~	~~Apr 21~~
~~Quarterly Meeting (April/FY21Q3)~~		~~4/7/2021~~
~~Quarterly Meeting (July/FY21Q4)~~		~~7/14/2021~~
Develop Draft Large Building PZ White Paper	9/1/2021	1/12/2022
Quarterly Meeting (October/FY22Q1)		10/6/2021
Submit Draft Large Building PZ White Paper to MWG		2/17/2021
Quarterly Meeting (January/FY22Q2)		1/12/2022
MWG Review and Provide Comments on Draft Large Building PZ White Paper	1/23/2022	3/25/2022
MWG Meeting to Discuss Draft Large Building PZ White Paper		TBD
Revise Draft Large Building PZ White Paper	2/17/2022	4/15/2022
Submit Final Large Building PZ White Paper to EPA and KY		5/19/2022

Items shown in strikeout text are completed.

The draft annotated outline was included in the January 13, 2021 MWG meeting summary (sent to participants on 1/28/2021). No comments were received on the included outline and the outline is considered final.

During the July 14, 2021 MWG meeting the group discussed that during the C-400 Remedial Investigation, no water has been observed in the UCRS in monitoring points installed through the foundation of the C-400 building. It was discussed that the C-400 building observations may not be representative of the buildings of interest in this white paper.

The schedule for this paper was revised following the October 6, 2021 meeting. The revised schedule is shown above.

During the October 6, 2021 meeting the group discussed that information available on the historical and archived plant drawings show that the process buildings were constructed similar to one another and have a thin (9 to 12 inches thick) compacted gravel layer underlying the concrete floor of the buildings. There are drain lines in the compacted gravel layer, but the limited thickness of the gravel likely would make installation of traditional piezometers in the gravel layer impractical. The lack of water in the piezometers installed in the much thicker gravel layer (5 to 8 ft thick) underlying the concrete at C-400 also indicates that it is unlikely that there is water storage under the process building concrete floors. KY suggested the team assess probing the concrete under the process building floors to confirm the gravel thickness and confirm the gravel is not saturated.

Based on the above and several discussion had on the VI project, a revision of the paper title to reflect the more comprehensive nature of the paper (i.e., a recognition of other sources of anthropogenic recharge), is proposed: “Evaluation of Anthropogenic Recharge Associated with the Process Buildings in Support of the Sitewide Groundwater Model, Paducah Gaseous Diffusion Plant, Paducah, Kentucky.”

As of this meeting, the draft white paper is in DOE review.

Ken Davis (FRNP) provided a summary of the roof replacement history at the site and the findings of the construction drawings review:

- *The C-331 and C-335 roofs were replaced in 1981.*
- *Roof repairs were implemented at C-333 and C-337 in 2016-2017.*
- *There were reports of floor intrusion of water from below the foundations going back to 2002.*
- *The process buildings were constructed with a thin gravel layer under the concrete foundation (unlike at C-400 which has a 5 to 8 ft thick gravel layer underlying the concrete foundation).*
- *There is no gravel associated with the control rooms/basements in the process buildings, but there is gravel associated with the building footers.*
- *The paper includes a graded approach to understanding water presence under the process buildings and, as part of the graded approach, a modified piezometer design is included in the paper.*

The paper has been retitled from the outline included in the January 13, 2021 MWG meeting summary (sent to participants on 1/28/2021), but the contents of the paper generally reflect that outline. The draft paper is in internal review and is planned to be provided to the MWG on 2/17/2022.

6. CSM for the RGA in SWMU 211-A Remedial Action Work Plan

Section 1.1.2, "Regional Hydrogeology," references an axis in describing thickness trends for gravel deposits forming the RGA. EPA would like to discuss if the use of the term axis has any implied significance to groundwater flow direction(s) (i.e., a north-south lateral groundwater flow divide) or any implication for implied subsurface structural feature(s) forming the RGA (i.e., the existence of an east-west fault-controlled structural low).

The site geologist explained the east-west trend is consistent with ancestral Tennessee River and is believed to be an erosional surface (thalweg is the geomorphology term). EPA suggested that the Paducah Site area may have several generations of seismic activities, overprinting of seismicity could be happening, and east-west faulting may have occurred. Steve Hampson had a follow-up after discussion with Dr. Woolery and Dr. Zhu.

Steve Hampson reported that an east-west trend is prevalent at PGDP, as evidenced in both regional and local studies. Regional faults commonly trend northeast-southwest but that there could be local structural controls under PGDP that could influence groundwater flow. Seismic studies have not previously been conducted between the east and west fences and from the Porters Creek terrace to north fence because it was not possible to filter out the noise of the operating plant. Most of the plant infrastructure is no longer operating and Steve Hampson discussed that Dr. Woolery has noted there are now seismic reflection techniques that could give a better view of what the structure is beneath the site.

DOE and FRNP are reviewing whether there are any ways to further reduce (temporarily) sources of noise to facilitate new testing without disrupting site activities. Dr. Woolery has offered to support any requests or initiatives that may develop regarding additional seismic surveys at the Paducah Site.

There was no new information on this topic available during the meeting, similar to several recent meetings. The group agreed to keep this topic on the next meeting agenda, but to retitle the discussion, "Plant-Wide Seismic Update."

7. CSM for the McNairy in the C-400 Complex Area

FRNP has set up a website to house a library of McNairy information. Access the website at the following link: https://fourriversnuclearpartnership.com/McNCSM. The site requires a password that has been sent separately. Contact Stefanie if you need the password to the website.

A lithology white paper is being prepared as part of the resolution of dispute on the CERCLA Five Year Review. DOE will issue the technical paper within one month of submittal of the D1 C-400 Complex OU RI/FS Report to support the review and comment of the C-400 specific data interpretation as part of the C-400 Complex OU RI/FS Report review process and the performance of the FY 2023 Five-Year Review revised protectiveness determinations for the Northeast, Northwest, and Water Policy response actions. The regulatory milestone date for the D1 C-400 Complex OU RI/FS Report has been revised to October 7, 2022.

A draft schedule and annotated outline for the paper were discussed during the October 2020 Groundwater MWG meeting. The schedule was revised to reflect the new C-400 Complex OU RI/FS Report date and was discussed during the January 13, 2021 meeting (see below). The plan continues to be that the draft Lithology Paper will be available to the MWG before the D1 C-400 Report is submitted so that substantive comments may be addressed prior to the D1 C-400 Report being issued. The Lithology Paper will then be revised and submitted.

Activity	Target Start	Target Finish	Notes
~~FRNP/DOE Develop Outline for Draft McNairy Lithologic Technical Paper~~	~~7/7/2020~~	~~9/30/2020~~	COMPLETE
~~Provide Draft McNairy Lithologic Technical Paper Outline to MWG~~		~~9/30/2020~~	COMPLETE
~~MWG Review Draft McNairy Lithologic Technical Paper Outline~~	~~9/30/2020~~	~~10/7/2020~~	COMPLETE
~~Quarterly Meeting (October/FY21Q1)~~		~~10/7/2020~~	COMPLETE
~~FRNP/DOE Revise Draft Outline for McNairy Lithologic Technical Paper Based on MWG Discussions~~	~~10/7/2020~~	~~10/22/2020~~	COMPLETE
~~Provide Final Outline for McNairy Lithologic Technical Paper to MWG~~		~~10/22/2020~~	COMPLETE
~~Quarterly Meeting (January/FY21Q2)~~		~~1/13/2021~~	COMPLETE
~~Quarterly Meeting (April/FY21Q3)~~		~~4/7/2021~~	COMPLETE
~~Quarterly Meeting (July/FY21Q4)~~		~~7/14/2021~~	COMPLETE
~~Quarterly Meeting (October/FY21Q3)~~		~~10/6/2021~~	COMPLETE
Quarterly Meeting (January/FY22Q2)		1/12/2022	
FRNP/DOE Develop Draft McNairy Lithologic Technical Paper Text	8/4/2021	3/10/2022	
Finish Collection of C-400 Lithology Data		3/16/2022	From C-400 Schedule Drilling completed 12/2/2021
FRNP/DOE Incorporate C-400 Results into Draft McNairy Lithologic Technical Paper	3/16/2022	8/11/2022	

Activity	Target Start	Target Finish	Notes
Quarterly Meeting (April/FY22Q3)		4/6/2022	
Develop C-400 RI Report		9/14/2022	From C-400 Schedule
Quarterly Meeting (July/FY22Q4)		7/13/2022	
Issue Draft McNairy Lithologic Technical Paper to MWG		8/11/2022	
MWG Review and Provide Comments on Draft McNairy Lithologic Technical Paper	8/11/2022	9/12/2022	
MWG Meeting to Discuss Draft McNairy Lithologic Technical Paper		8/24/2022	Draft FY2021 MWG Work Plan Date
MWG Provide Comments on Draft McNairy Lithologic Technical Paper		9/12/2022	
Quarterly Meeting (October/FY23Q1)		10/5/2022	Planning date
C-400 RI Report Submitted to EPA and KY		10/7/2022	Current Milestone
FRNP/DOE Revise Draft McNairy Lithologic Technical Paper	9/12/2022	11/7/2022	No formal CRS
Submit Final McNairy Lithologic Technical Paper to EPA and KY		11/7/2022	Tech Paper Due 1 Month After C-400 RI Report (Currently 10/7/2022)

Items shown in strikeout text are completed.

The KRCEE spreadsheet database of soil boring logs (R10 HydroLitho Dbase posted 121620.xlsx) is available at https://fourriversnuclearpartnership.com/McNCSM.

The final annotated outline was included in the October 14, 2020 MWG meeting summary (sent to participants on 11/23/2020 and with agreed-upon revisions discussed during the 1/13/2021 meeting). No comments were received on the outline and the outline was considered final. The MWG plans to discuss the Draft McNairy Lithologic Technical Paper text between the July 2022 and October 2022 MWG meetings.

During the October 6, 2021 meeting, the group discussed that observations from the C-400 field investigation drilling does not indicate fault interruption in the McNairy. DNAPL has not been observed in McNairy soils to date, indicating DNAPL migration through the RGA into the McNairy is not occurring. It is reasonable to conclude that if this is not occurring at C-400, it is likely not occurring elsewhere at the site. The group also discussed the need for rapid turnaround on any comments and KY indicated their willingness to have a meeting on the paper to facilitate the quick review.

The group discussed the findings of the C-400 remedial investigation did not indicate any deep sources of DNAPL that would penetrate the basements or the McNairy formation and that concentrations generally decreased with depth.

The group discussed the scope of the Lithologic Technical Paper. The group agreed to include the final annotated outline with this summary (see Attachment 7; attachment added to the end of the summary to preserve attachment designations from the meeting agenda) and the April 6, 2022 meeting agenda.

8. Resurvey of wells

The field resurveying effort for the monitoring well reference point elevations was completed October 9, 2020 and the data review was completed in November 2020. The data are in the process of being reviewed for upload to OREIS.

A white paper summarizing the approach and scope of the resurvey work was developed and has been appended to the 2021 update to the P-QAPP.

A second white paper on potential impacts of the new survey data and the impact to the groundwater model will be developed. The draft outline for this paper, *Evaluation of the 2016 Groundwater Model with Updated Reference Point Elevation for the Groundwater Monitoring Network at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, was discussed during the July 14, 2021 MWG meeting and was included in the meeting summary (sent to participants on 8/2/2021). No comments were received on the outline and the outline was considered final. This second survey white paper is currently planned to be appended to the 2016 Groundwater Model Report. DOE, KY and EPA have agreed on this approach.

The group discussed the status of this paper (in preparation) with planned provision to the MWG by 3/18/2022. The paper focuses on the adequacy of the model in light of new monitoring well survey data; no modeling has been performed as part of the paper development. The paper includes an evaluation on the residuals from the 2016 modeling calibration and any impact the new survey data have on that calibration.

9. Precipitation and Ohio River Stage

Attachment 4 includes precipitation and Ohio River stage charts through December 31, 2021.

The group discussed that the site experienced consistent precipitation throughout 2021, with 8 inches less total precipitation than in 2020. The Ohio River has been at base levels for the past several months. The group also discussed that the August 2021 and November 2021 potentiometric maps may be good for evaluating steady-state groundwater conditions across the site.

10. Projects on the "Watch Topics" List

- **TVA Changes.** During the October 2020 and January 2021 meeting, the MWG discussed the construction of the new ash ponds and a recent RFP for a 3,800 ft sheet pile wall to be constructed in close proximity to Little Bayou Creek and several seeps. The sheet pile wall may intercept the RGA and influence the creek.

  During the July 14, 2021 meeting, the MWG discussed the sheet pile wall being installed by TVA along Little Bayou Creek and along the southwest portion of the existing coal combustion residuals (CCR) landfill (as shown on the Figure 1). The wall is intended to stabilize the creek's bank, as opposed to control groundwater. KY/TVA provided as-built drawings showing the installation depth of the wall. A cross section of the sheet pile wall, the creek, and the interpolated upper and lower limits of the RGA is shown in Figure 2.

  Based on the information available in the TVA drawings, the sheet pile wall, the wall extends a significant depth into the RGA. The group discussed during the October meeting that the wall joints are not sealed, and TVA will confirm that the sheet piles themselves are solid (not perforated). TVA will confirm whether the notations are design or as-built and relay findings to the group; TVA

will also confirm the depths of the sheet pile wall construction. The wall construction was estimated at 80-90% complete during the October meeting.

The construction on the TVA sheet pile wall was completed in December 2021. Tabitha Ester (TVA) will follow-up on the sheet pile as-built elevation information and whether the sheet pile is porous or if just the joints are porous.

This topic will be retained on the next meeting agenda.

- **Consider stream gauging in relation to the synoptic water levels.** Stream gauging has been discussed as part of out-year activities. See October 2018 Meeting Summary for additional information. Stream gauging will support new modeling. The figure on the next page depicts the planned alignment of the sheet pile wall.

  During FY 2022, quarterly walkdowns of portions of Little Bayou Creek are planned to identify any new seeps as part of the Groundwater Strategy project and to identify locations for potential future stream gauging, as appropriate.

  KY requests the group consider if water level events can be performed in response to changes in Ohio River stages. FRNP/DOE will review the historical documentation for a prior paper on groundwater level responses to Ohio River stage elevations (e.g., Clausen paper?). This Watch Topic will become a new agenda topic titled, "Synoptic Water Level Events and Ohio River Levels," in the next meeting agenda.

  Seeps. There have been no seep results above the maximum concentration limit (MCL) for trichloroethene (TCE) for many years. The location of the seeps and TCE data for the seeps are depicted on Figure 3. KY clarified that some of the seeps on the figure are in the creek and some are on the banks of the creek.

  During the October 6, 2021 meeting, the group discussed that LBCSP5 routinely has flow and is able to be sampled, whereas many of the other previously identified seeps do not have flow consistently. KY reported that they have revised their stream walkdowns to go further up and downgradient of LBCSP5. KY also suggested the use of thermal imaging for seep identification in the winter months.

  See also Agenda Item 4, Update on Paducah Site Groundwater Strategy.

  See the discussion on seeps included with Topic 4, Update on Paducah Site Groundwater Strategy. This Watch Topic will be combined with "Groundwater Strategy" in the next meeting agenda.

- **"No Go" Areas for Monitoring Well Installations.**
  - Corridors where overhead transmission lines have been removed have been considered for monitoring well placement, especially with respect to the west side of the NE Plume. Previously, overhead transmission lines prevented installation of wells to the west in the northern-most transect of wells. A new substation (C-538) has been constructed east of the C-755 trailer complex. On the west side of the new substation, 161kV overhead have been installed along the existing overhead line corridor. On the east side of the new substation, 161kV overhead lines (near the C-755 parking lot and between K010 and K011) were installed along the 161kV lines. Most of the overhead lines have removed from McCaw Road to the plant with only a static line remaining on the towers on the south into the C-331 yard.

- The 161 KV feeder line from TVA to C-531 Switchyard has been removed.
- Map of the formerly unavailable utility corridor area(s) is included as Figure 4.

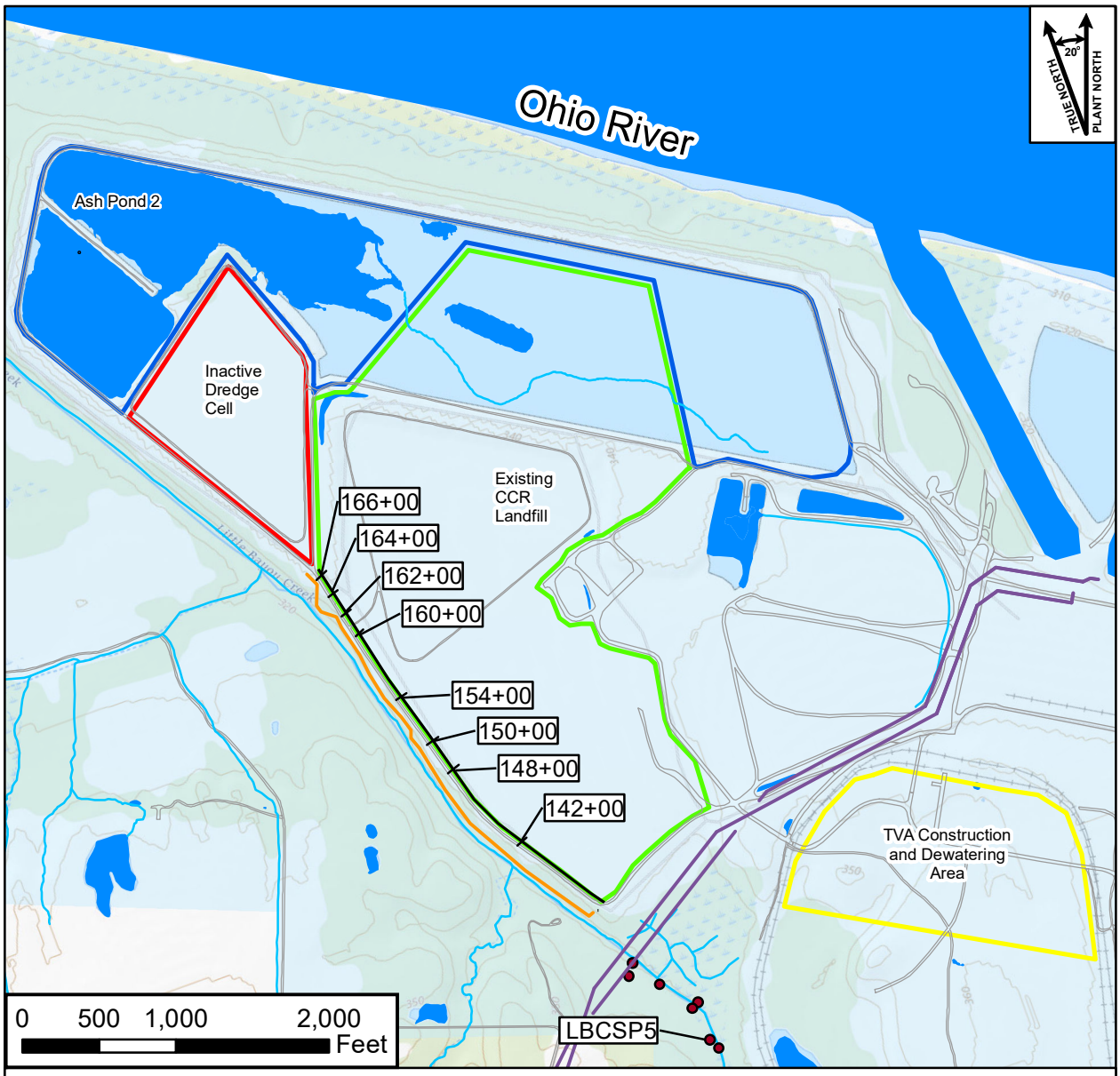
Power line corridor east of the C-764-U Landfill area (looking south). Photo taken September 6, 2021.

During the October 6, 2021 meeting the group discussed the current power line configurations and noted that the remaining most easterly line in the photo is not a high power transmission line and is possibly a telecommunication line.

The new switchyard (C-538) is now operational. No additional changes to the power lines depicted on Figure 4 are anticipated. Other medium and low voltage lines around the plant would need to be accounted for in any project, including monitoring well installation. Generally these lines would have 50 ft buffer.

The group noted no additional changes to the power line configurations are planned and that this topic will be moved to "Groundwater Strategy" in the next meeting agenda, as that project includes activities for the evaluation of the need for new monitoring well locations.

Figure 1



Legend

TVA Area	Seeps	Surface Water Course Centerline
TVA Sheet Pile Wall	TVA Construction and Dewatering Area	Inactive Dredge Cell
TVA Baseline	Existing CCR Landfill	Surface Water Body
142+00 TVA Baseline Stations	Ash Pond 2	Road
Raw Water Line		

MAP SOURCE INFORMATION
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Layer: Surface Water Course Centerline, Surface Water Body, TVA Area, and Road Sourced from PEGASIS on 3/16/2021.
Layer: Seeps LBCSP 1, LBCSP2, LBCSP3, LBCSP4, LBCSP5, LBCSP6, LBCSP7, LBCSP8, LBCSP9, LBCSP10 Sourced from PEGASIS on 3/17/2021.
Layer: TVA Construction and Dewatering Area Created Shapefile: 4/21/2021. Location: \\fedprojects-01\paducah$\Knoxville\GIS\FRNP Maps\Shapefiles\zipfolder
Layer: TVA Baseline Stations, TVA Sheet Pile Wall, TVA Baseline Sourced from: Construction drawing map by Stantec/TVA Created Shapefile: 8/24/2021.
Layer: TVA Raw Water Line Sourced from FRNP on 8/30/2021.

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Figure 2

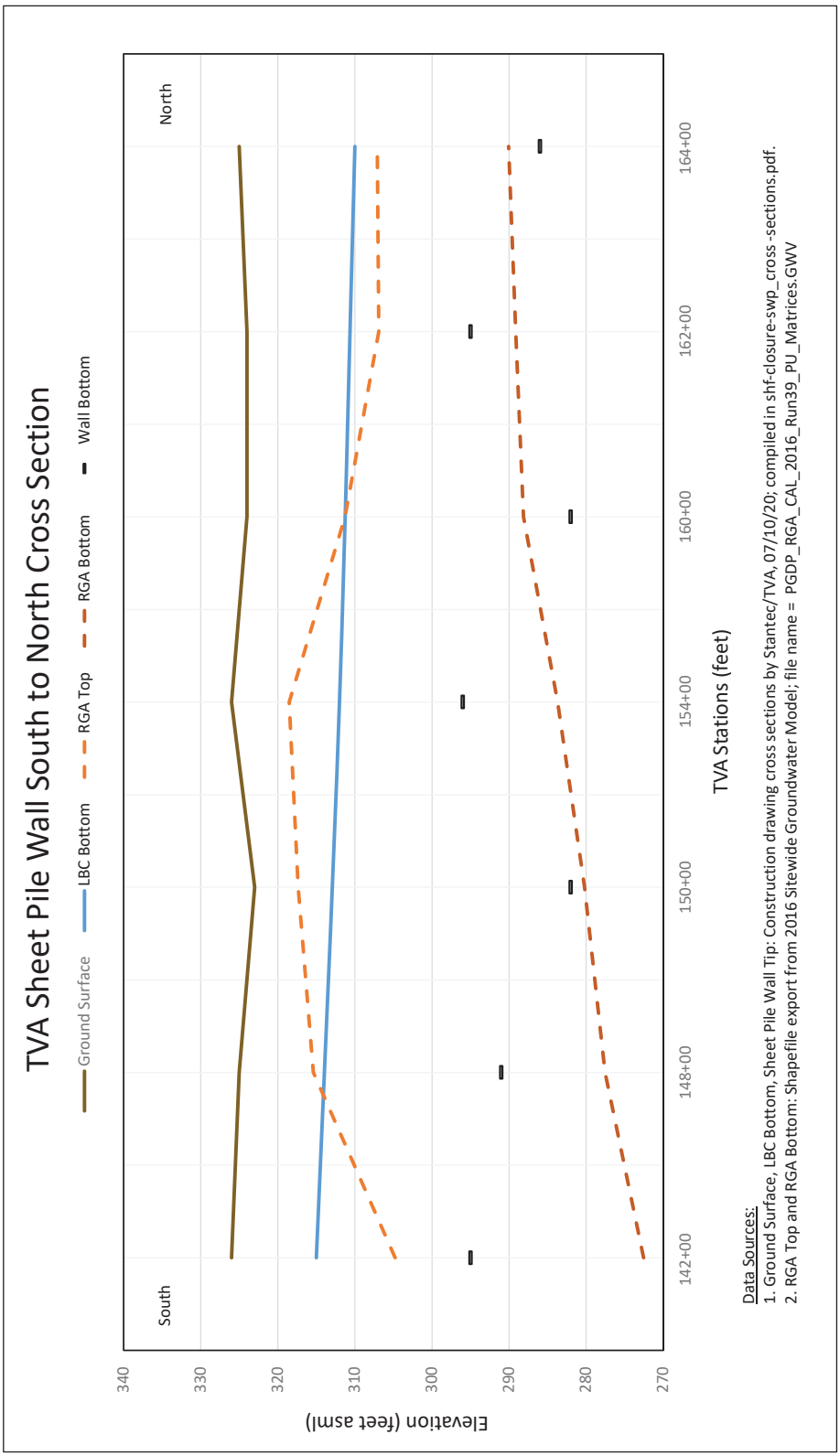
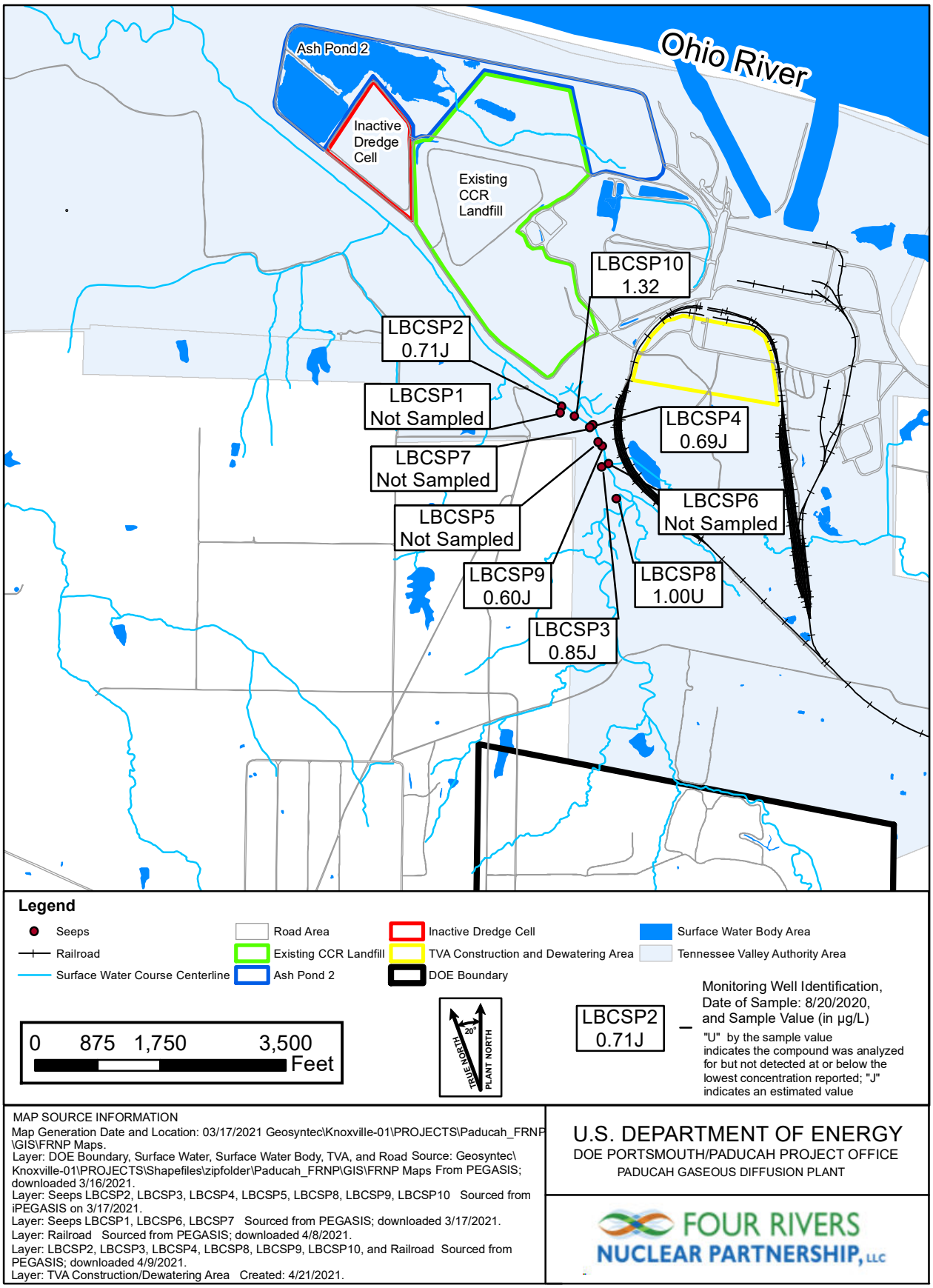

TVA Sheet Pile Wall South to North Cross Section
Ground Surface
LBC Bottom
RGA Top
RGA Bottom
Wall Bottom
South
North
Elevation (feet asml)
340
330
320
310
300
290
280
270
142+00
148+00
150+00
154+00
160+00
162+00
164+00
TVA Stations (feet)
Data Sources:
1. Ground Surface, LBC Bottom, Sheet Pile Wall Tip: Construction drawing cross sections by Stantec/TVA, 07/10/20; compiled in shf-closure-swp_cross -sections.pdf.
2. RGA Top and RGA Bottom: Shapefile export from 2016 Sitewide Groundwater Model; file name = PGDP_RGA_CAL_2016_Run39_PU_Matrices.GWV

Figure 3


Ohio River
Ash Pond 2
Inactive Dredge Cell
Existing CCR Landfill
LBCSP10 1.32
LBCSP2 0.71J
LBCSP1 Not Sampled
LBCSP4 0.69J
LBCSP7 Not Sampled
LBCSP6 Not Sampled
LBCSP5 Not Sampled
LBCSP9 0.60J
LBCSP8 1.00U
LBCSP3 0.85J
Legend
Seeps
Railroad
Surface Water Course Centerline
Road Area
Existing CCR Landfill
Ash Pond 2
Inactive Dredge Cell
TVA Construction and Dewatering Area
DOE Boundary
Surface Water Body Area
Tennessee Valley Authority Area
0 875 1,750 3,500 Feet
TRUE NORTH
20°
PLANT NORTH
LBCSP2 0.71J
Monitoring Well Identification, Date of Sample: 8/20/2020, and Sample Value (in µg/L)
"U" by the sample value indicates the compound was analyzed for but not detected at or below the lowest concentration reported; "J" indicates an estimated value
MAP SOURCE INFORMATION
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Layer: DOE Boundary, Surface Water, Surface Water Body, TVA, and Road Source: Geosyntec\Knoxville-01\PROJECTS\Shapefiles\zipfolder\Paducah_FRNP\GIS\FRNP Maps From PEGASIS; downloaded 3/16/2021.
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Layer: Seeps LBCSP1, LBCSP6, LBCSP7 Sourced from PEGASIS; downloaded 3/17/2021.
Layer: Railroad Sourced from PEGASIS; downloaded 4/8/2021.
Layer: LBCSP2, LBCSP3, LBCSP4, LBCSP8, LBCSP9, LBCSP10, and Railroad Sourced from PEGASIS; downloaded 4/9/2021.
Layer: TVA Construction/Dewatering Area Created: 4/21/2021.
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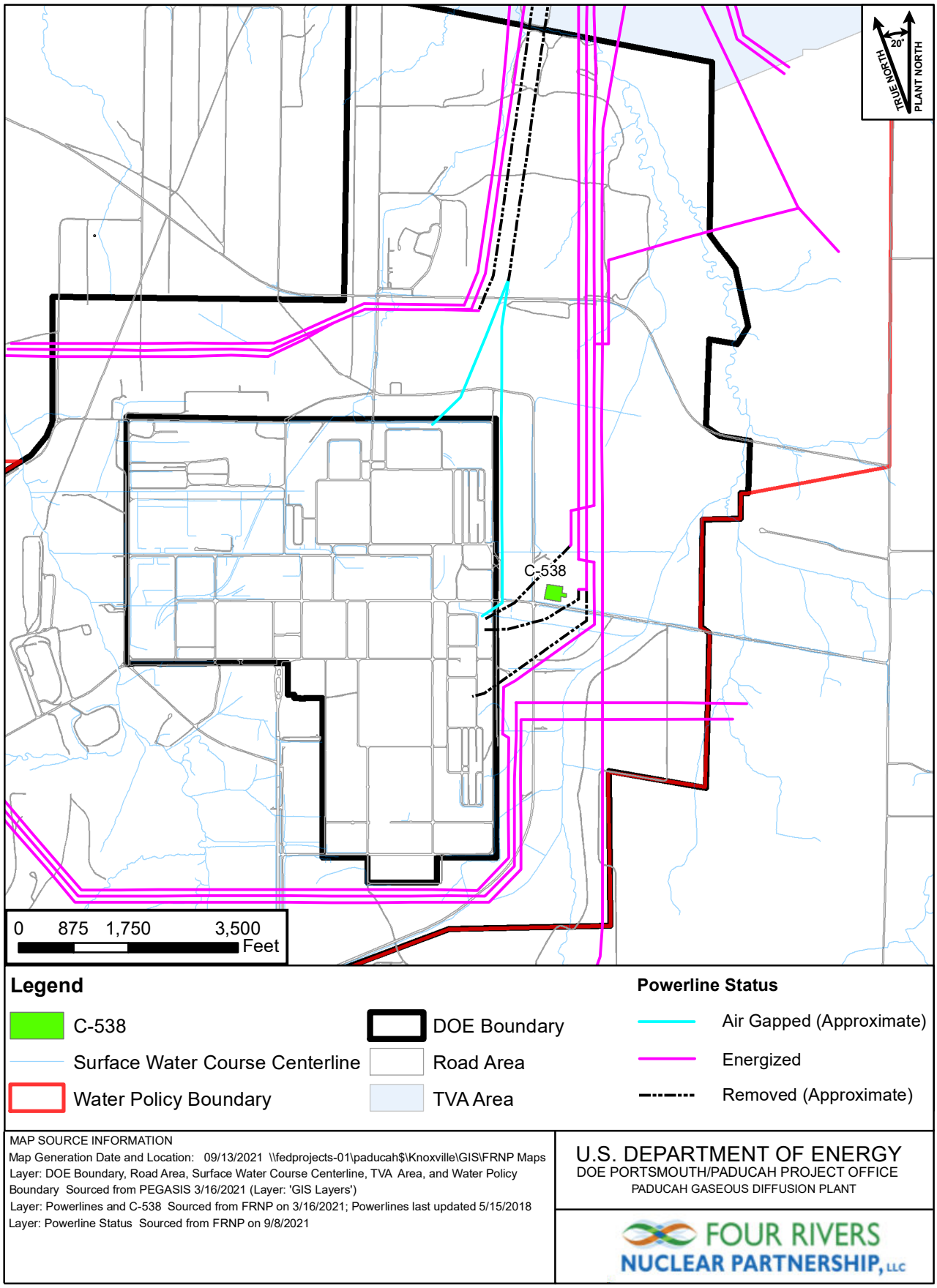
Figure 4


TRUE NORTH
20°
PLANT NORTH
C-538
0 875 1,750 3,500
Feet
Legend
C-538
Surface Water Course Centerline
Water Policy Boundary
DOE Boundary
Road Area
TVA Area
Powerline Status
Air Gapped (Approximate)
Energized
Removed (Approximate)
MAP SOURCE INFORMATION
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Layer: DOE Boundary, Road Area, Surface Water Course Centerline, TVA Area, and Water Policy Boundary Sourced from PEGASIS 3/16/2021 (Layer: 'GIS Layers')
Layer: Powerlines and C-538 Sourced from FRNP on 3/16/2021; Powerlines last updated 5/15/2018
Layer: Powerline Status Sourced from FRNP on 9/8/2021
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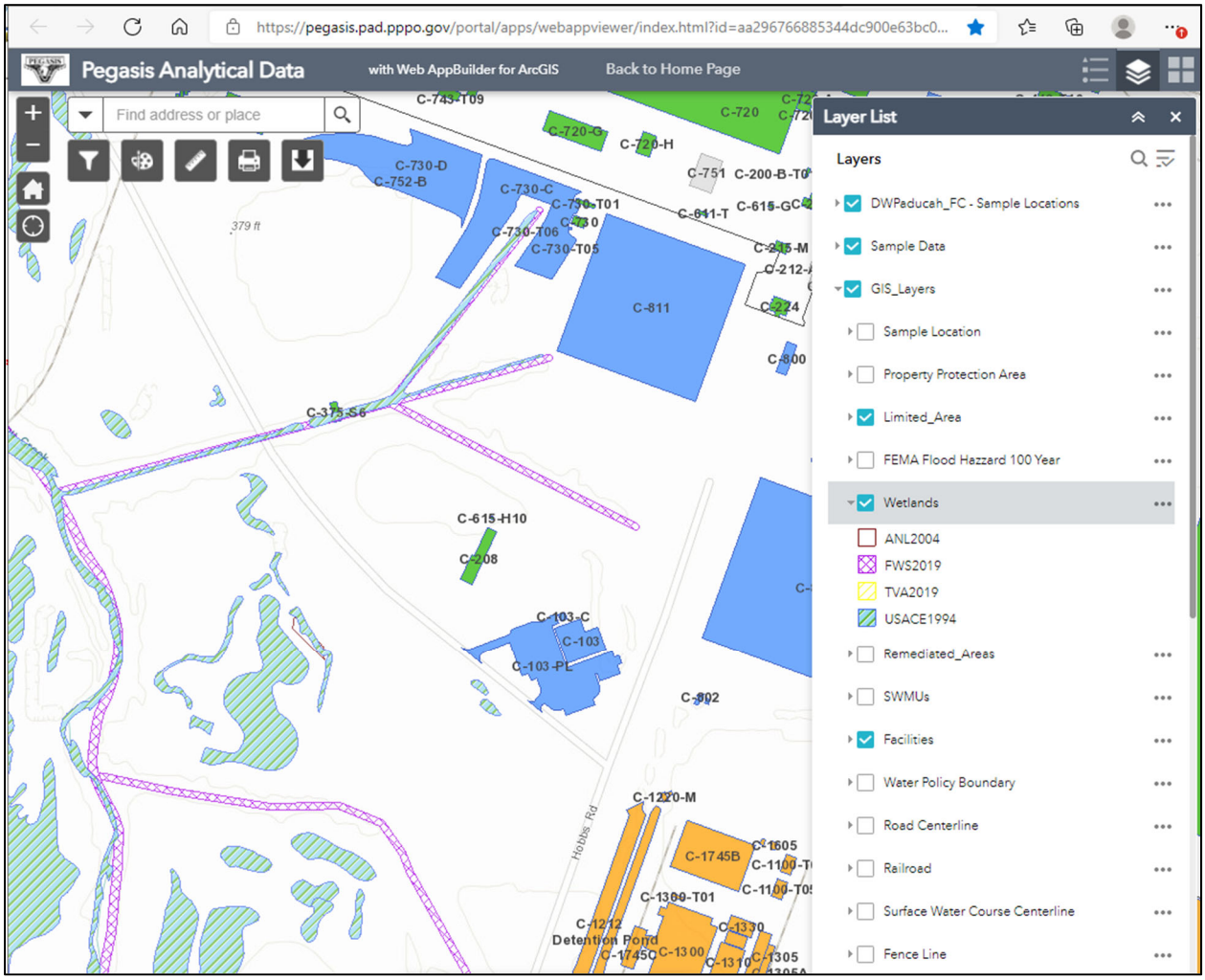
- **Wetlands map layer.** The site completed the review of wetlands maps in October 2021.
    - Different projects have used different source data for wetlands and floodplains maps.
    - The map layers previously available in PEGASIS did not include information from the Waste Disposal Alternatives (WDA) project.

  These updates are available through PEGASIS. No field work was performed as part of the map updates.

  The group discussed that this effort unified the wetlands information available in PEGASIS. The information may only display at certain scales. A screenshot of the layer is provided:



- ***New Watch Topic: PFAS.*** *PFAS is discussed as part of the Risk Assessment Working Group and has ties to this working group as well. DOE and FRNP are proceeding with data quality objectives (DQOs) and sampling plan development for a PFAS groundwater sampling project. The current plan for the project is to complete the DQOs and sampling plan in FY 2022 with sampling to be performed in FY 2023. Updates on this project will be provided to the group as they become available.*

  Rich Bonczek (DOE) is a member of the DOE PFAS Coordinating Committee. The next DOE HQ PFAS Working Group meeting is 1/20/2022.

EPA will provide recent documents supplied to EPA RPMs to DOE.

11. FY 2022 Presentations

The EarthCon presentation will be moved back in the schedule as their contract with DOE is pending. MWG members should provide any presentation requests to Stefanie. Potential topics for future meetings:

- C-400 Complex remedial investigation
- Lithology
- TCE degradation rates
- Site water balance items (e.g., leaks from piping, above and below ground piping, building foundation gravel layers, etc.)

The April 6, 2022 presentation will be Attachment 5, Presentation: Summary of EPA and KY Comments to the 2016 Sitewide Paducah Groundwater Flow Model as there was not time to present this during the January 12, 2022 meeting. DOE inquired whether one of the EPA principal reviewers would be present for the presentation so the EPA perspective could be represented.

- October 2021: FRNP presented on the *2016 Update of the Paducah Gaseous Diffusion Plant Sitewide Groundwater Flow Model* (DOE/LX/07-2415&D2).

  Following the presentation, a number of items were discussed by the group:

  - The group asked why only Outfall 001 was specifically included in the modeling: DOE and FRNP reviewed the project notes to understand if the other outfalls (i.e., 008, 009, or 010) were considered for explicit inclusion in the model. From the Modeling Working Group Meeting Minutes—June 24, 2016 (2016 Groundwater Flow Model Report, Appendix A, page A-30):

    > Brian asked Denise if she found anything else of interest during her site visit. Denise noted that it had rained heavily for about an hour when she arrived at the site. Brian mentioned adding recharge points at outfall points but added that flow amounts are uncertain. Denise responded that she did not identify any areas other than outfall 001 that appeared to be areas of increased recharge.

    The group discussed the following technical basis for inclusion of Outfall 001 in the 2016 sitewide model:

    - *During model calibration, water levels in this area were undercalculated and the calibration residuals were inconsistent with physical observational data*
    - *Water was observed in this outfall during the 2016 sitewide model update site walk*
    - *C-612 discharges to Outfall 001 and this is the only site outfall with consistently larger flows*
    - *The outfall was added to the associated model zone, improving the calibration*
    - *This same process of calibration improvement was employed in the pre-2016 models*
    - *Other outfalls were incorporated into surface water features represented in the model*
    - *The UCRS is not included in the 2016 sitewide groundwater model*

- The group asked whether there are any discrepancies with the new survey data for the monitoring wells: the analysis is ongoing, but the preliminary review shows no large change in levels or residuals that would result in an impact to the model calibration.
- EPA noted that there were a number of comments from EPA at the time of the modeling work that were not incorporated into the model.
- KY proposed that a dialog be initiated on the current version of the model and whether an update should be performed.
- EPA asked how the model would be used to drive remedial decisions and whether there was benefit to update the model for some of the marginal items. DOE explained that the focus of the model was on source areas and that the model downgradient results were a good representation of the plume configuration at the time of the modeling. The group discussed that the utility of the model as a predictive tool would only be appropriate for a certain amount of time due to ongoing changes in the operational stance at the site.
- KRCEE performed a review of the 2016 flow model: 2018 KRCEE report, *Review for the 2016 Update of the Paducah Gaseous Diffusion Plant Sitewide Groundwater Flow Model*; and a review of the 2008 TCE transport model: 2020 KRCEE report, *Interim TCE Transport Model for the Paducah Gaseous Diffusion Plant Site*.

Following the April 6, 2022, meeting presentation, the group will discuss whether groundwater modeling should be added as a Watch Topic.

The January 12, 2022 quarterly meeting presentations are follow-ups to the October 6, 2021 presentation, *Summary of the 2016 Groundwater Flow Model Update.*

The Attachment 6, Presentation: KRCEE Independent Review of the 2016 Sitewide Paducah Groundwater Flow Model was provided to the group by Steve Hampson (KRCEE). Following the presentation, the group discussed:

- *Steve Hampson (KRCEE) will provide the KRCEE documents associated with the presentation.*
- *Review of the model results indicates the plume reacts differently on each side of the groundwater divide (i.e., northeast and northwest). This is a function of the source terms input into the model and there is acknowledged uncertainty on the northeast side. The 2016 model efforts were valuable but underscore the challenges and uncertainties on the northeast side of the groundwater divide. The 2008 groundwater model overpredicts the plume footprint, whereas the 2016 model underpredicts the plume footprint. If the project were to err on the side of protectiveness, the 2008 model would be more appropriate.*
- *DOE notes that the development of the 2016 sitewide groundwater model approach likely incorporated too many constraints on inputs and may have been more representative if the constraints had been applied later in the model development.*

The group discussed the site project priorities have shifted from the Dissolved Phase OU, at the time of the 2016 sitewide groundwater modeling effort, to the current source actions in progress or planned for the near future.

DOE/FRNP will compile a list of recommendations from the KRCEE presentation/model reviews and the comments to the 2016 sitewide groundwater model; this list will be added to future agendas for this group.

12. Poll MWG Members/Open Discussion

No items were brought forward by the members.

Attachment 1

Groundwater Strategy Potentiometric Maps and Pressure Transducer Data

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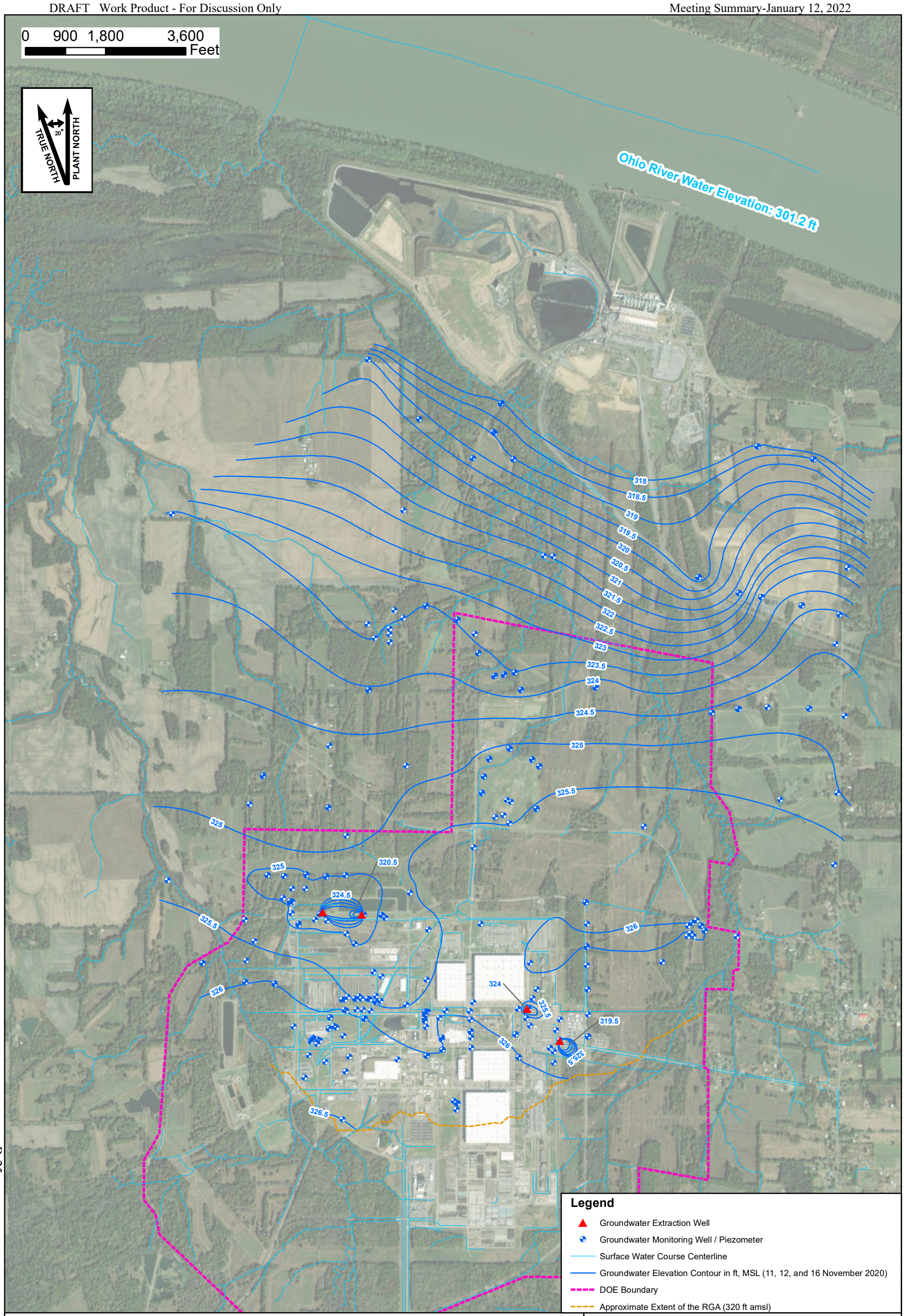

MAP SOURCE INFORMATION

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Image Source: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Shapefile for Surface Water Course Centerline was obtained from Pegasis (https://pegasis.pad.pppo.gov/), downloaded on 12/1/2021.
DOE Property Boundary provided by FRNP 2/4/2021.
Northing and easting of wells obtained from Pegasis, downloaded on 10/5/2021.
Groundwater elevation was based on the August 12-15, 2019 measurements. Ohio River elevation was estimated as the average
of elevations measured by the USGS at Paducah Station USGS 0361100 and Olmsted, IL Station (USGS 03612600) between November 11-24, 2020.

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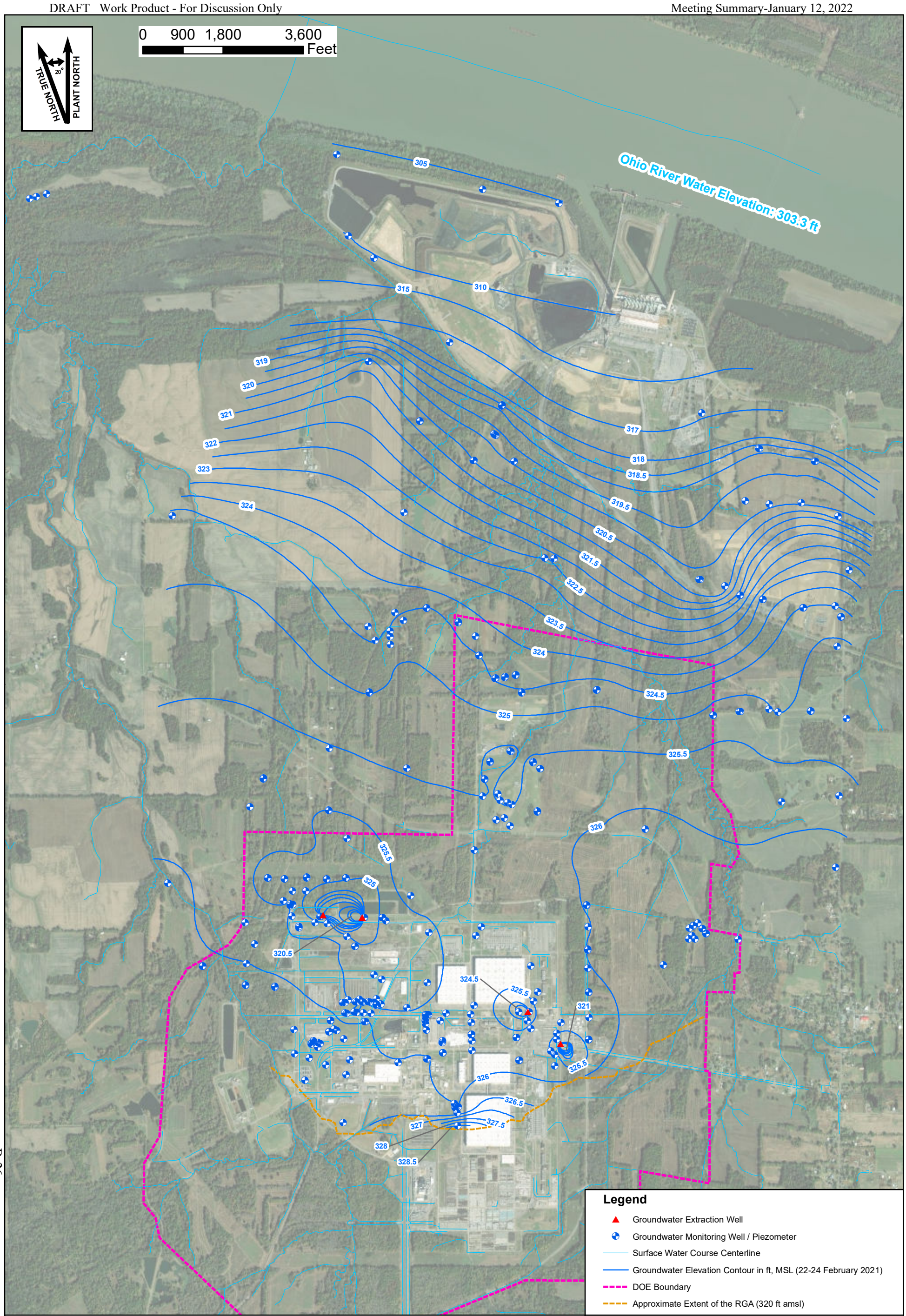
Figure 1. November 2020 RGA Potentiometric Surface Map



MAP SOURCE INFORMATION

Map Generation Date and Location - 12/1/2021 Geosyntec\\fedprojects-01\paducah$\Knoxville\GW Strategy\GIS\MXDs\2020-2021 Potentiometric Surface Maps
Map Layer Location: Geosyntec\\fedprojects-01\paducah$\Knoxville\GW Strategy\GIS\MXDs\2020-2021 Potentiometric Surface Maps\February 2021 Potentiometric Surface Map.mxd
Image Source: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Shapefile for Surface Water Course Centerline was obtained from Pegasis (https://pegasis.pad.pppo.gov/), Downloaded on 12/1/2021.
DOE Property Boundary provided by FRNP 2/4/2021.
Northing and easting of wells obtained from Pegasis, downloaded on 10/5/2021. Northing and easting of SHF and TVAGW series wells obtained from OREIS on 10/15/2021.
Groundwater elevation was based on the February 22-24, 2021 measurements. Ohio River elevation was estimated as the average of elevations measured by the USGS at Paducah Station USGS 0361100 and Olmsted, IL Station (USGS 03612600) between February 22-24, 2021.

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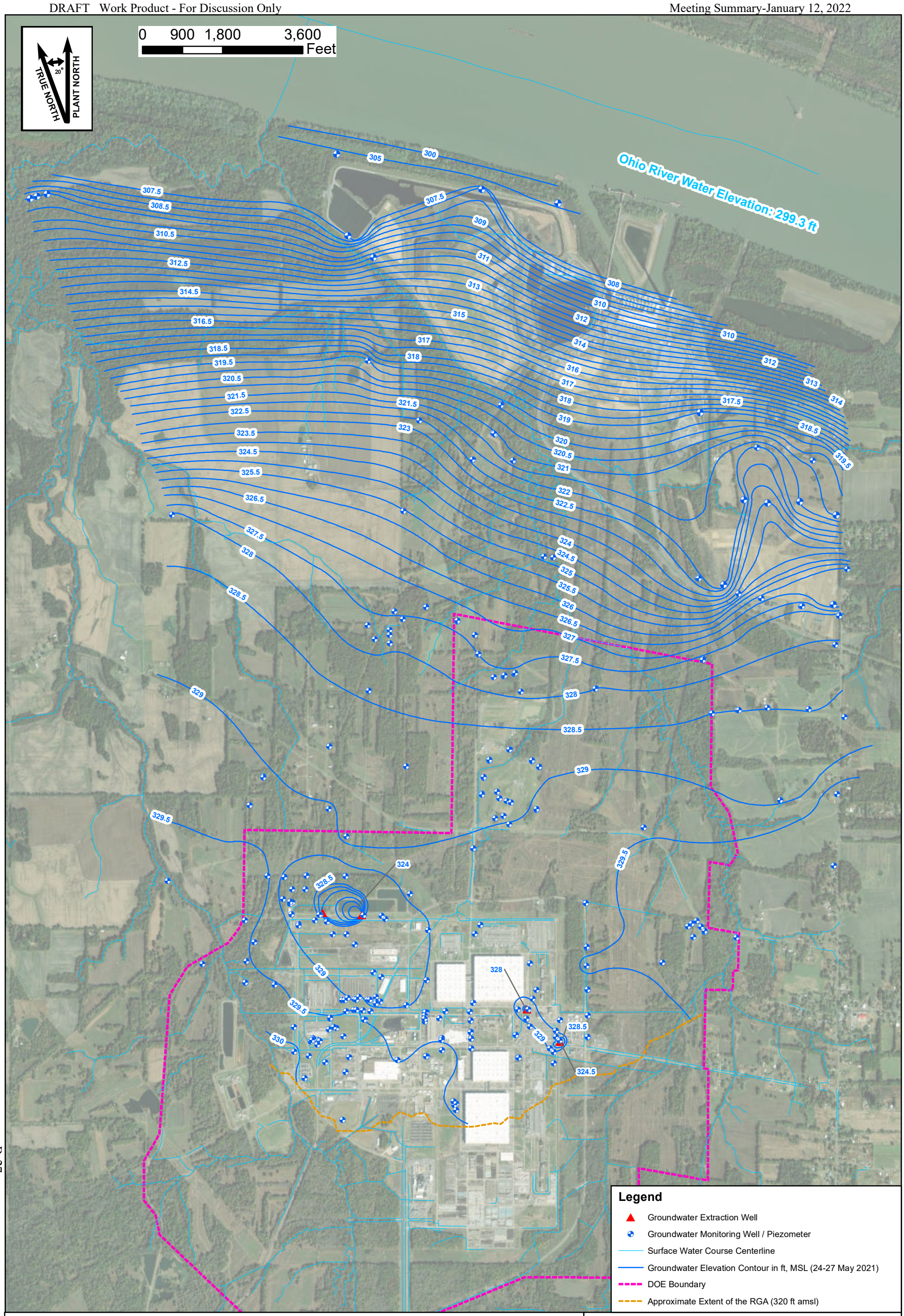
Figure 2. February 2021 RGA Potentiometric Surface Map



MAP SOURCE INFORMATION

Map Generation Date and Location - 12/1/2021 Geosyntec\\fedprojects-01\paducah$\Knoxville\GW Strategy\GIS\MXDs\2020-2021 Potentiometric Surface Maps
Map Layer Location: Geosyntec\\fedprojects-01\paducah$\Knoxville\GW Strategy\GIS\MXDs\2020-2021 Potentiometric Surface Maps\May 2021 Potentiometric Surface Map.mxd
Image Source: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Shapefile for Surface Water Course Centerline was obtained from Pegasis (https://pegasis.pad.pppo.gov/), Downloaded on 12/1/2021.
DOE Property Boundary provided by FRNP 2/4/2021.
Northing and easting of wells obtained from Pegasis, downloaded on 10/5/2021. Northing and easting of SHF and TVAGW series wells obtained from OREIS on 10/15/2021.
Groundwater elevation was based on the May 24-27, 2021 measurements. Ohio River elevation was estimated as the average of elevations measured by the USGS at Paducah Station USGS 0361100 and Olmsted, IL Station (USGS 03612600) between May 24-27, 2021.

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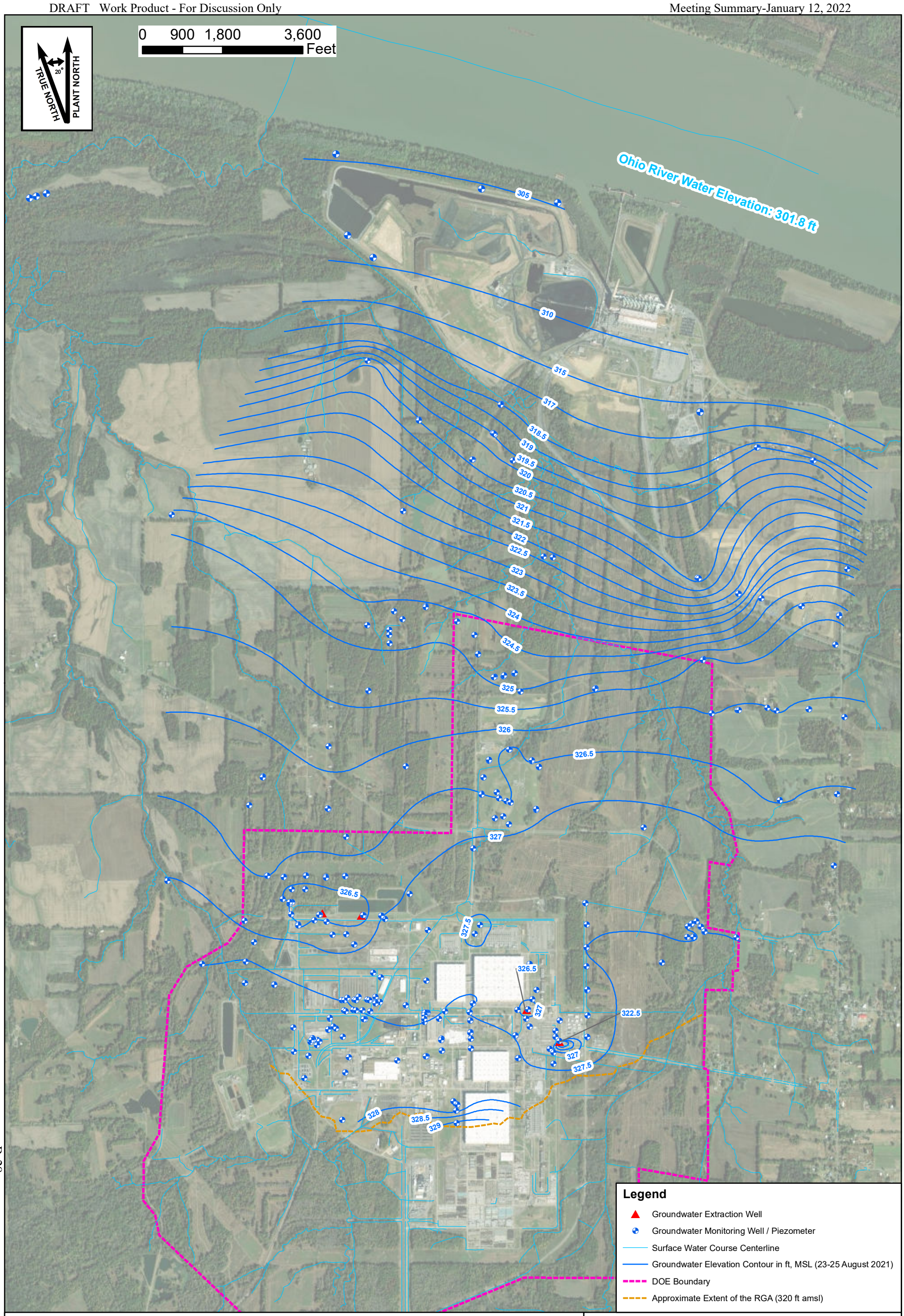
Figure 3. May 2021 RGA Potentiometric Surface Map



MAP SOURCE INFORMATION

Map Generation Date and Location - 12/1/2021 Geosyntec\\fedprojects-01\paducah$\Knoxville\GW Strategy\GIS\MXDs\2020-2021 Potentiometric Surface Maps
Map Layer Location: Geosyntec\\fedprojects-01\paducah$\Knoxville\GW Strategy\GIS\MXDs\2020-2021 Potentiometric Surface Maps\August 2021 Potentiometric Surface Map.mxd
Image Source: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Shapefile for Surface Water Course Centerline was obtained from Pegasis (https://pegasis.pad.pppo.gov/), downloaded on 12/1/2021.
DOE Property Boundary provided by FRNP 2/4/2021.
Northing and easting of wells obtained from Pegasis, downloaded on 10/5/2021. Northing and easting of SHF and TVAGW series wells obtained from OREIS on 10/15/2021.
Ohio River elevation was estimated as the average of elevations measured by the USGS at Paducah Station USGS 0361100 and Olmsted, IL Station (USGS 03612600) between August 23-25, 2021.

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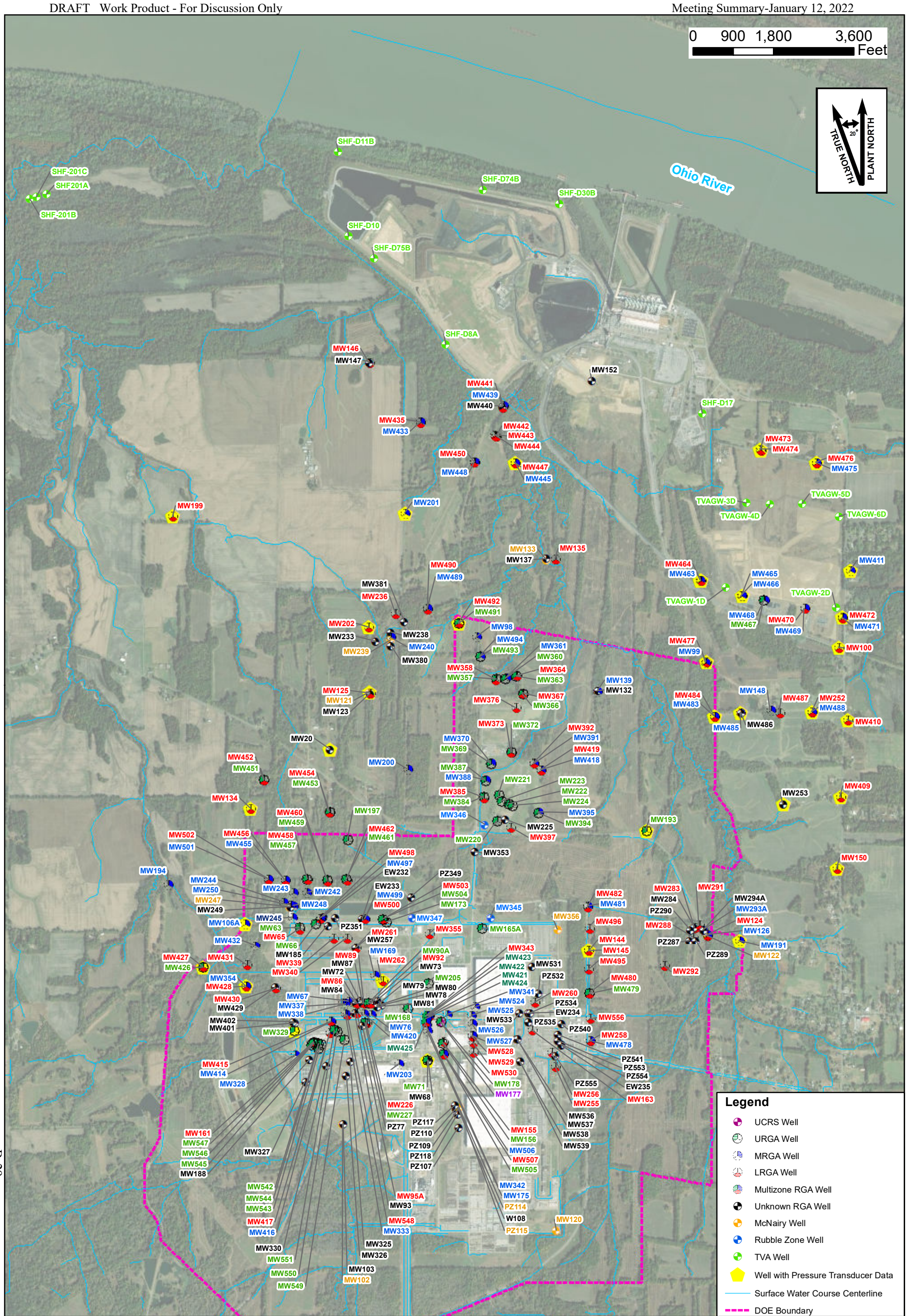
Figure 4. August 2021 RGA Potentiometric Surface Map



MAP SOURCE INFORMATION

Map Generation Date and Location - 11/18/2021 Geosyntec\\fedprojects-01\paducah$\Knoxville\GW Strategy\GIS\MXDs\2020-2021 Potentiometric Surface Maps
Map Layer Location: Geosyntec\\fedprojects-01\paducah$\Knoxville\GW Strategy\GIS\MXDs\2020-2021 Potentiometric Surface Maps\Figure 5 Synoptic Water Level Measurement Wells DY.mxd
Image Source: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Shapefiles for DOE Boundary and Surface Water Course Centerline were obtained from Pegasis (https://pegasis.pad.pppo.gov/), downloaded on 3/16/2021.
Northing and easting of wells obtained from Pegasis, downloaded on 10/5/2021.

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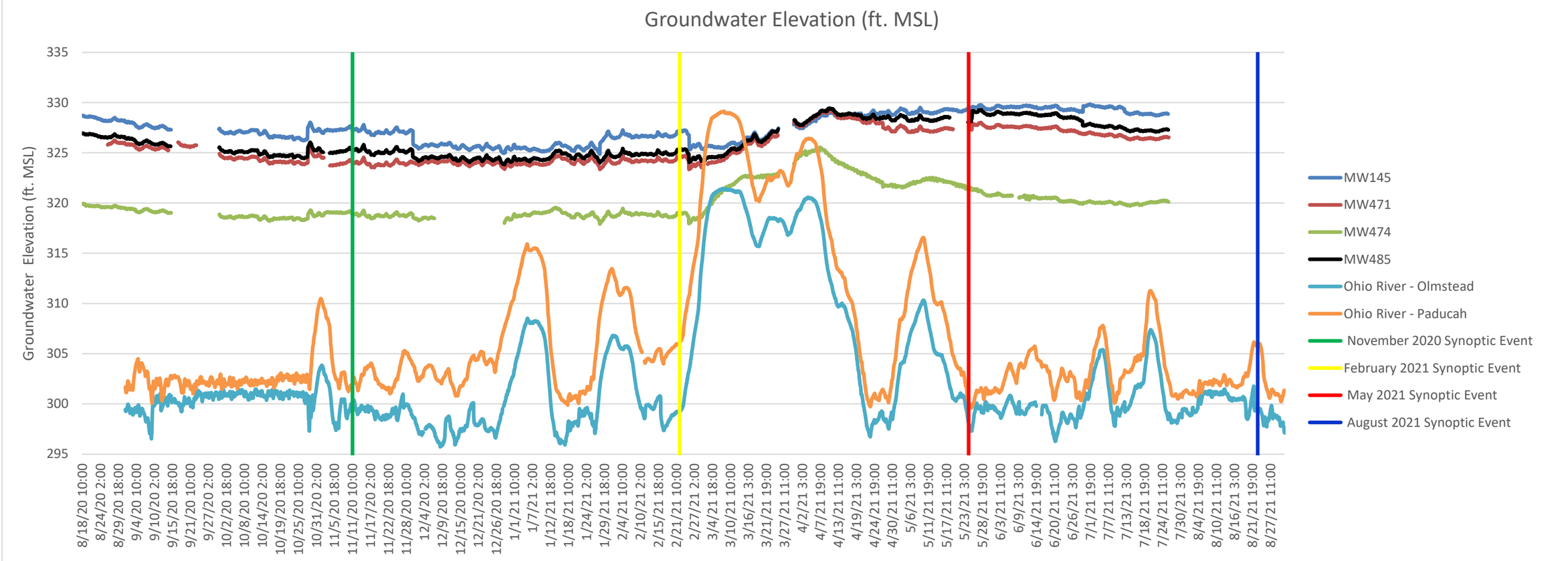
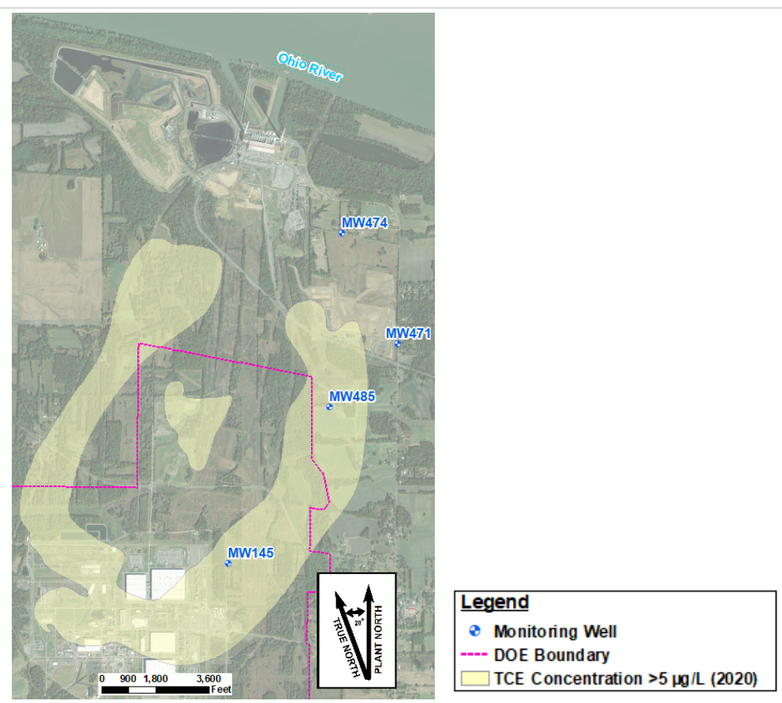
Figure 5. Synoptic Water Level and Pressure Transducer Measurement Wells

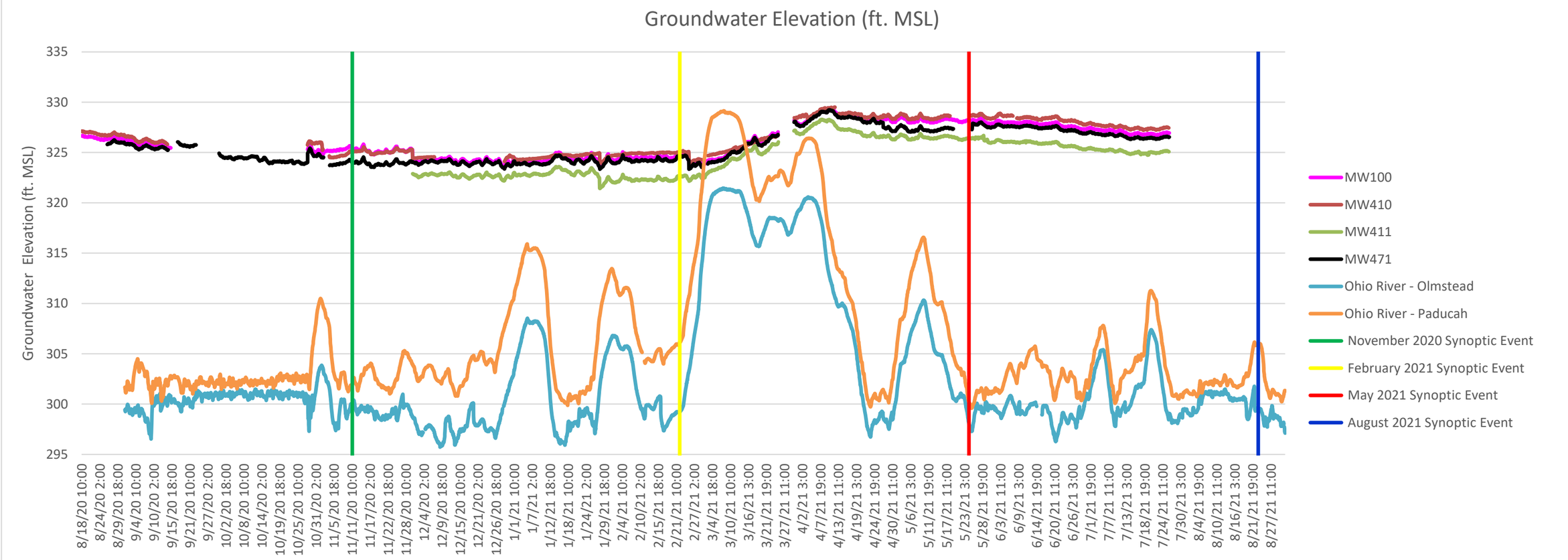
Pressure Transducer Data Along NE Plume

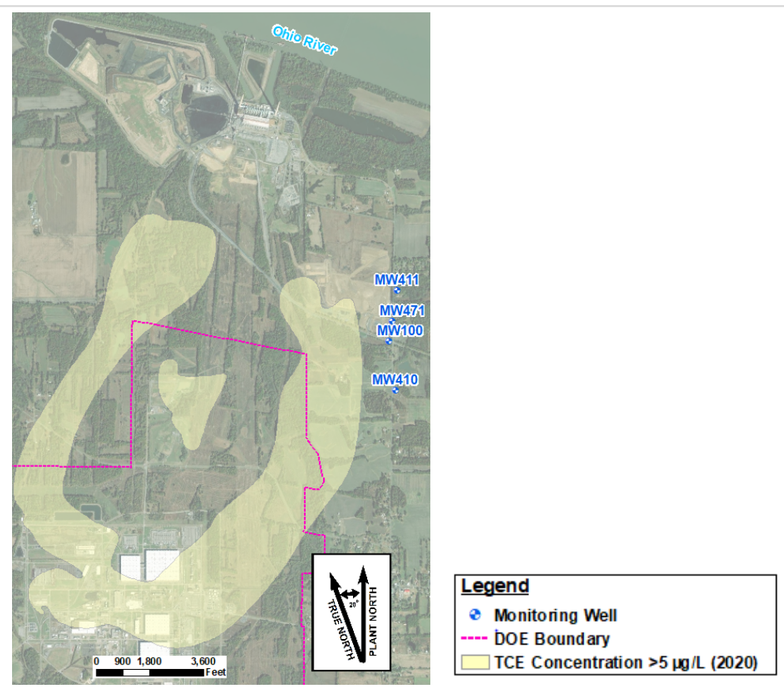




Key Map

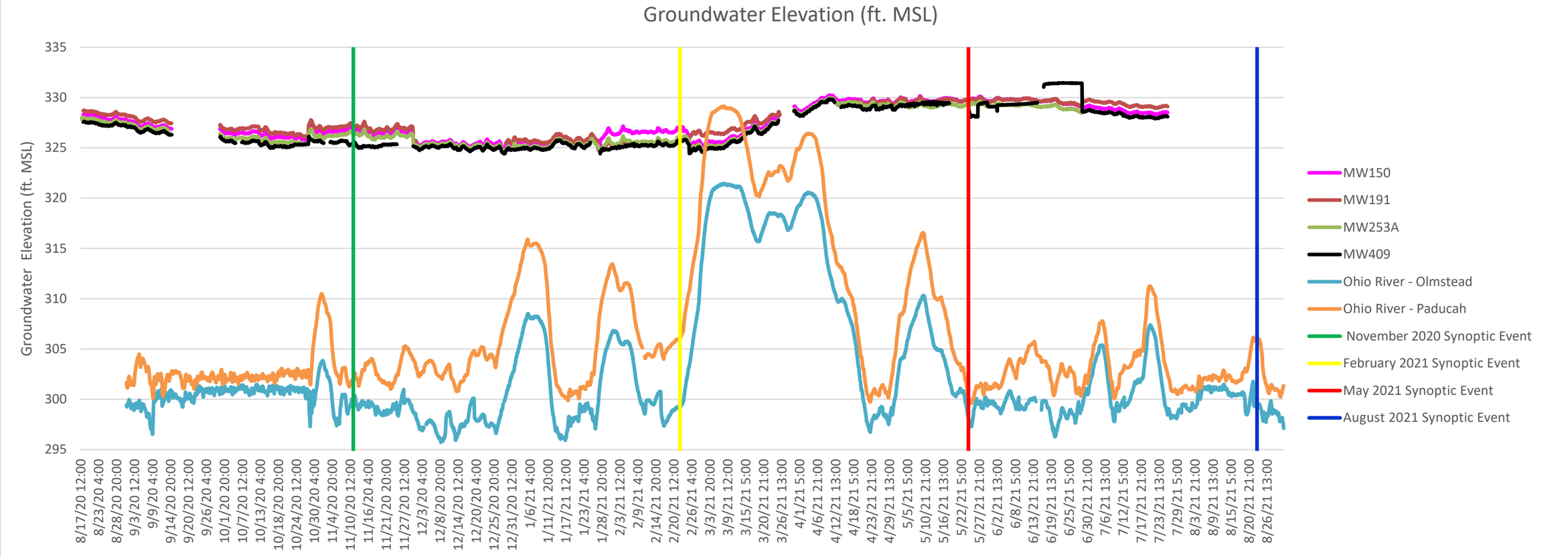
Pressure Transducer Data NE Plume - North

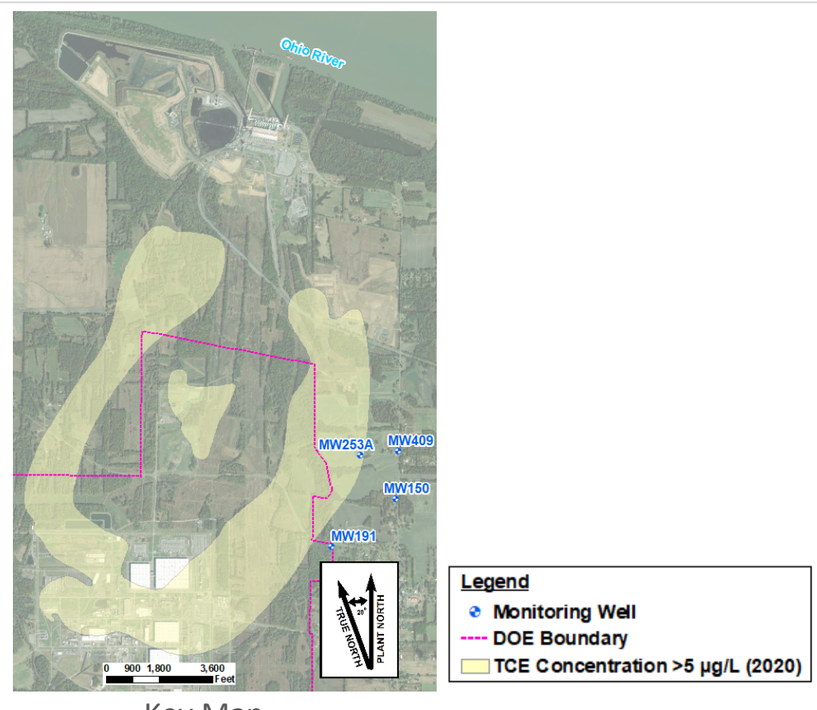




Key Map

Pressure Transducer Data NE Plume - South

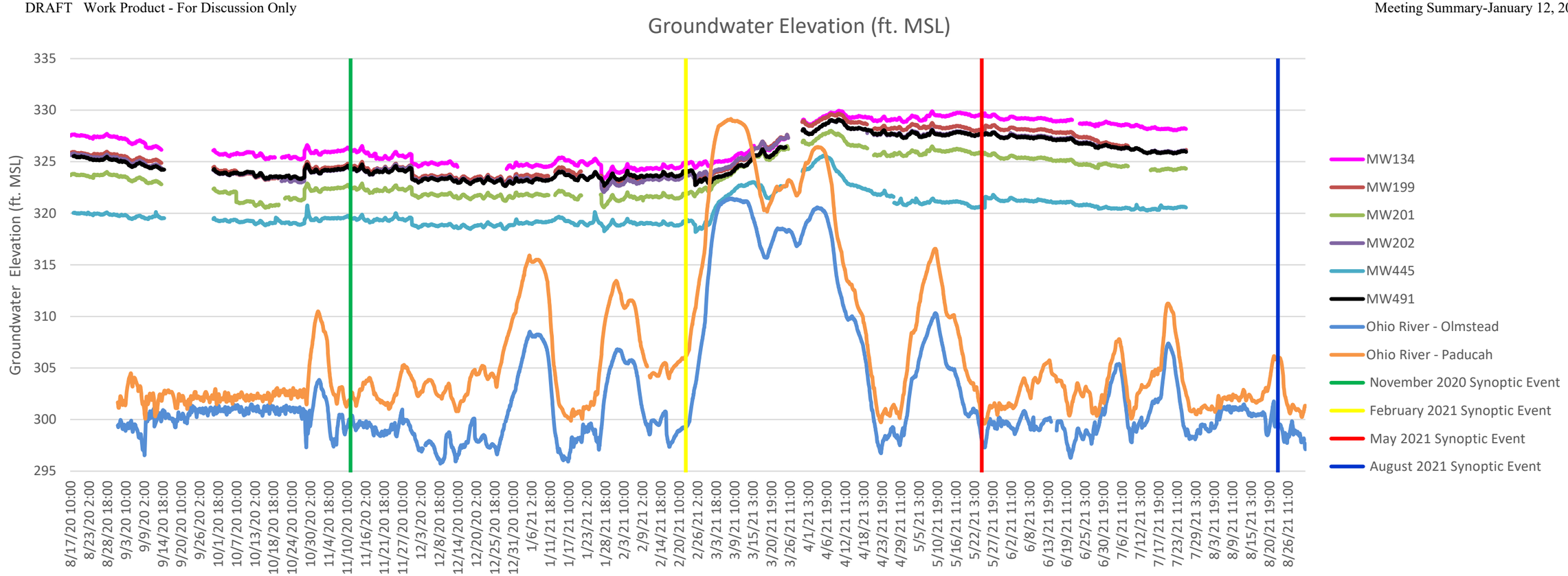


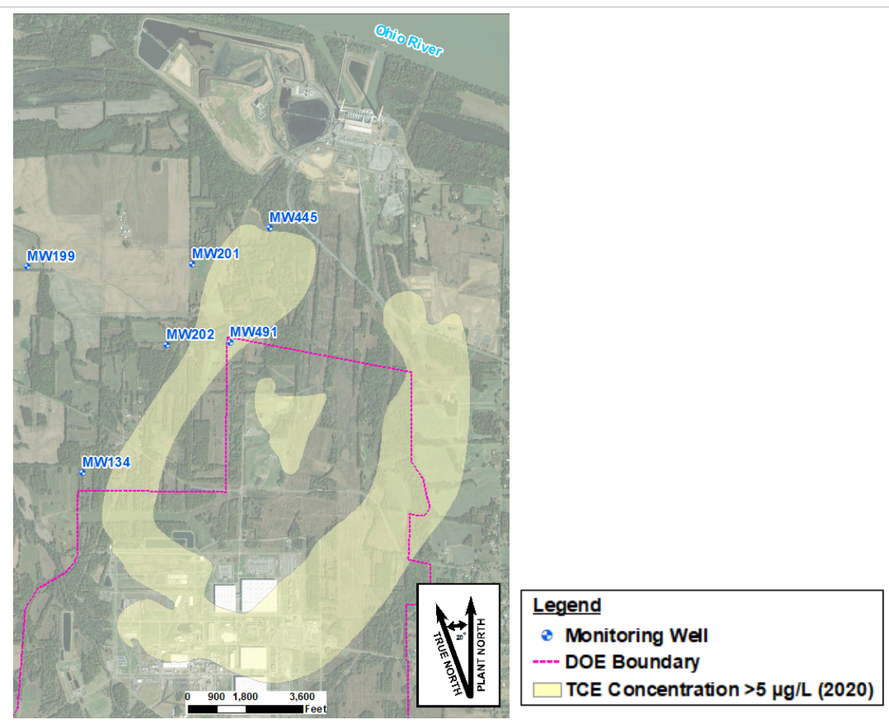


Key Map

DRAFT Work Product - For Discussion Only

Pressure Transducer Data NW Plume - North

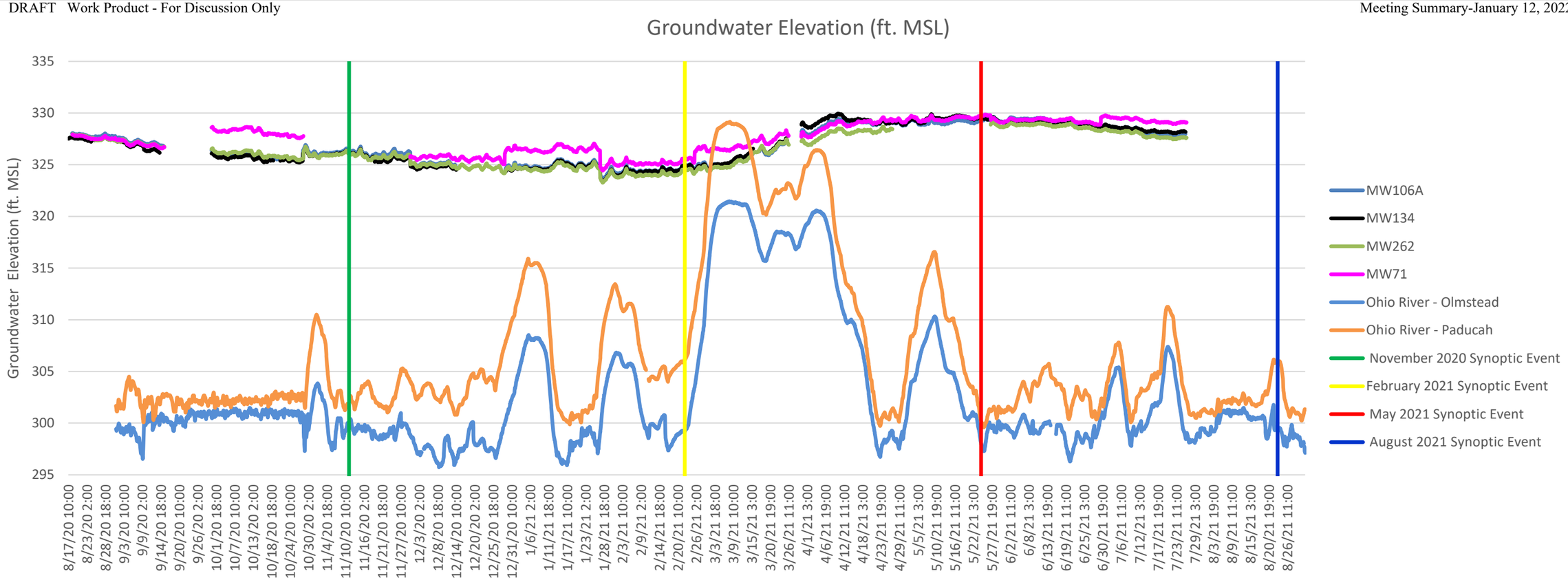


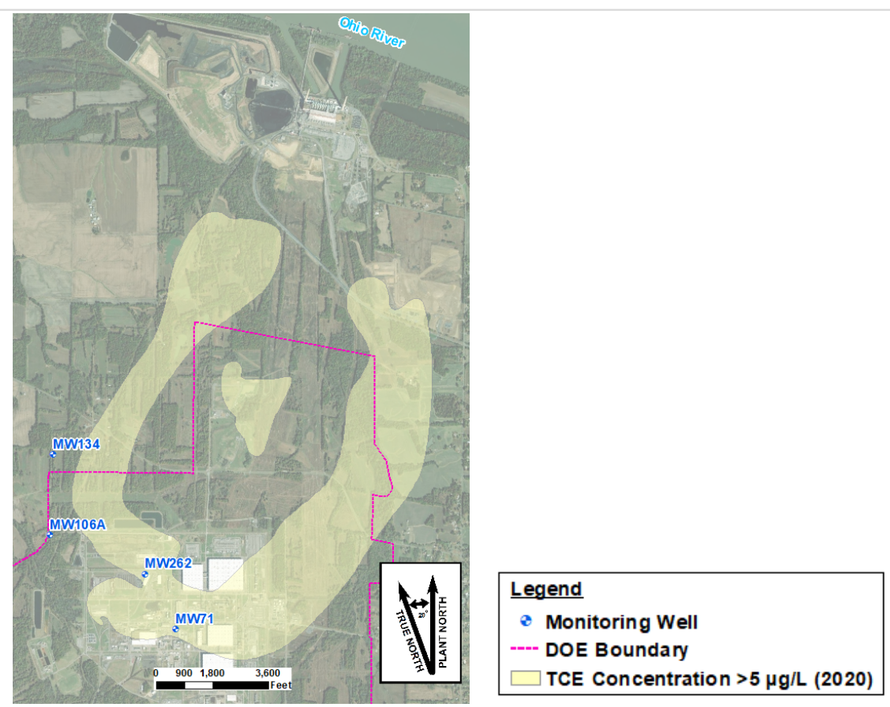


Key Map

DRAFT Work Product - For Discussion Only

Pressure Transducer Data NW Plume - South

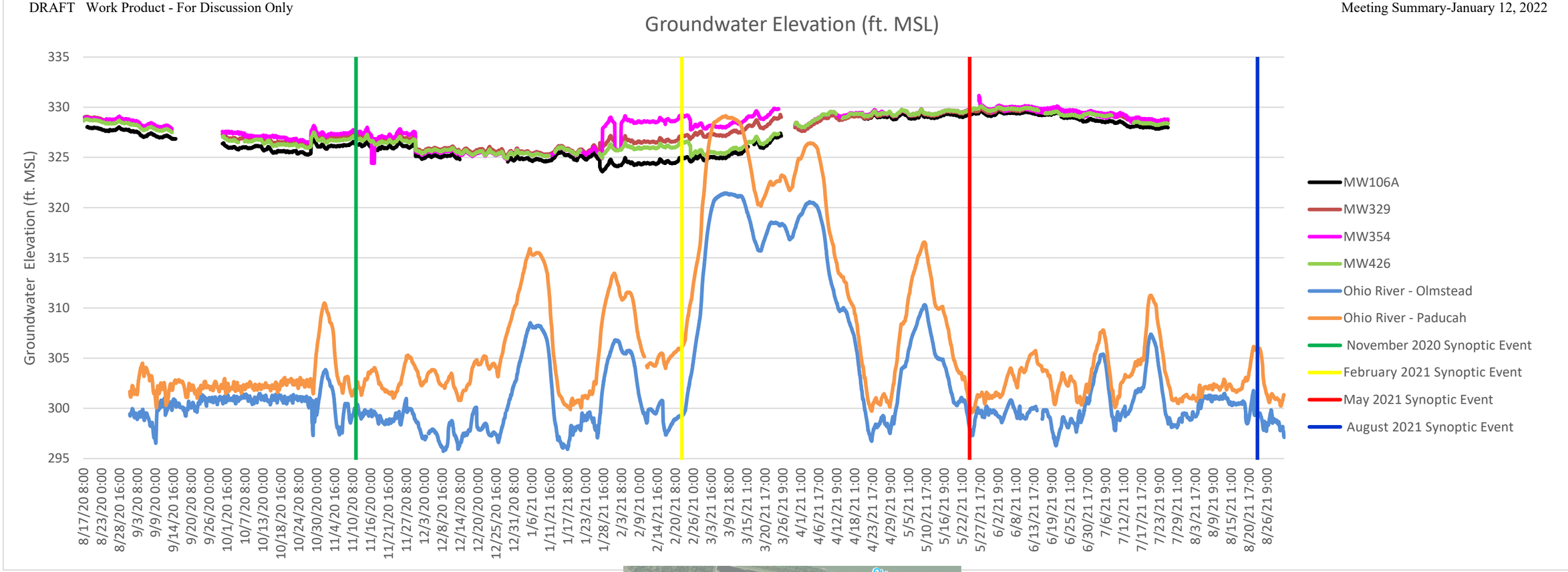


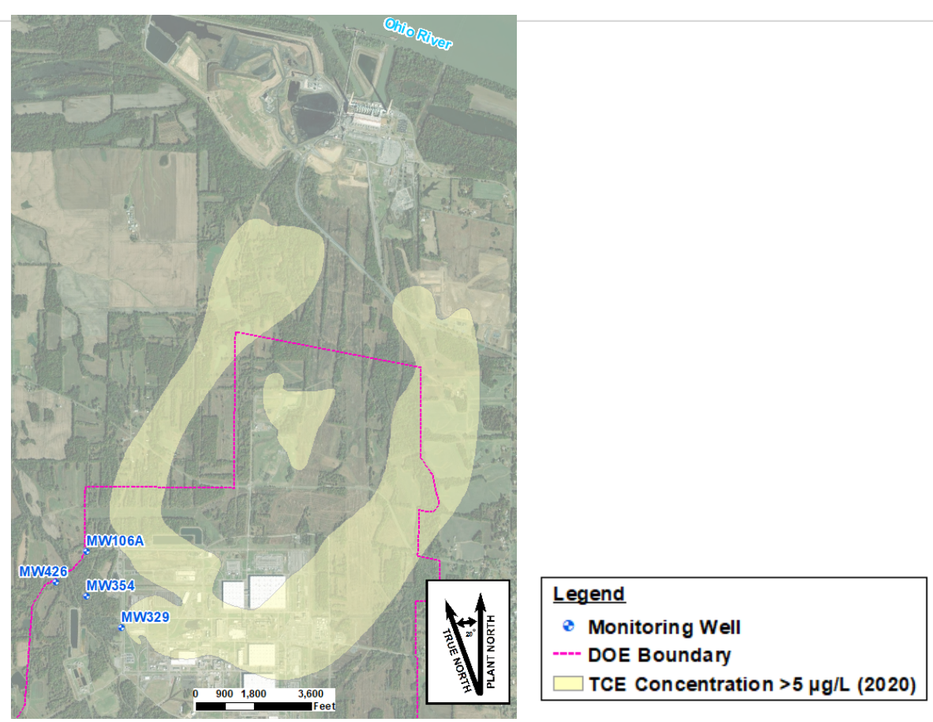


Key Map

Pressure Transducer Data SW Plume Area

DRAFT Work Product - For Discussion Only





Key Map

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Attachment 2

Groundwater Elevation Data for TVA Wells Collected by KY on November 16, 2021

OREISName	Well	Description	Aquifer	Top of Casing	Top of Ground	xconv Easting (Ft)	yconv Northing (Ft)	Status	Screen Top Depth (Ft)	Screen bot depth (Ft)	tscreenelev (Ft)	bscreenelev (Ft)	GW Elev. (Datum - DTW)	Water Level	Date & Time	Barometric Pressure (inHg)	Measuring Point
TVAGW-6D	TVAGW-6D	4" PVC	Upper RGA	368.8	365.9	760787.8774	1946731.539	active	58.3	68.3	307.6	297.6	314.46	54.34	11/16/2021_1007	29.61	TOC
TVAGW-5D	TVAGW-5D	4" PVC	Upper RGA	368.5	365.7	760131.6259	1947315.953	active	60.1	70.1	305.6	295.6	314.22	54.28	11/16/2021_1010	29.61	TOC
TVAGW-4D	TVAGW-4D	4" PVC	Upper RGA	365.8	363	759456.7195	1947561.73	active	57	67.5	306	295.5	314.7	51.1	11/16/2021_1012	29.61	TOC
TVAGW-3D	TVAGW-3D	4" PVC	Upper RGA	363.8	360.9	758982.49	1947793.858	active	65.3	75.3	295.6	285.6	315.08	48.72	11/16/2021_1014	29.61	TOC
TVAGW-2D	TVAGW-2D	4" PVC	Upper RGA	370	367.1	759966.7809	1944870.473	active	55.6	65.6	311.5	301.5	320.3	49.7	11/16/2021_1002	29.61	TOC
TVAGW-1D	TVAGW-1D	4" PVC	Upper RGA	370.1	367.5	757847.0459	1946203.79	active	56	66	311.5	301.5	313.95	56.15	11/16/2021_1020	29.61	TOC
TVA-D75B	SHF-D75B	2" PVC	Upper RGA	353.08	350	753297.07	1955971.69	active	48	58	302	292	308.64	44.44	11/16/2021_1449	29.51	TOC
TVA-D74B	SHF-D74B	2" PVC	Upper RGA	331.99	329	756125.35	1956489.82	active	39	49	290	280	307.59	24.4	11/16/2021_1441	29.51	TOC
TVA-D30B	SHF-D30B	2" PVC	Upper RGA	324.61	320.9	757594	1955563.41	active	39	49	281.9	271.9	302.62	21.99	11/16/2021_1424	29.52	TOC
TVA-D17	SHF-D17	2" PVC	Upper RGA	365.43	362.8	758809.17	1950015.71	active	14	17	348.8	345.8	315.67	49.76	11/16/2021_1405	29.52	TOC
TVA-D11B	SHF-D11B	2" PVC	Upper RGA	321.79	319.2	753434.76	1958481.44	active	32	42	287.2	277.2	302.29	19.5	11/16/2021_1431	29.52	TOC
TVA-D10	SHF-D10	4" PVC	Upper RGA	351.74	351	752950.26	1956644.9	active	36.5	46.5	31.5	304.5	304.86	46.88	11/16/2021_1446	29.51	TOC
SHF-201C	SHF-201C	4" PVC	Upper RGA	323.75	320	746799.24	1960068.889	active	44.5	54.5	275.5	265.5	304.77	18.98	11/16/2021_1345	29.53	TOC
SHF-201B	SHF-201B	4" PVC	Upper RGA	323.75	320.2	746641.107	1960082.768	active	32	37	288.2	283.2	305	18.75	11/16/2021_1343	29.53	TOC
SHF201A	SHF201A	4" PVC	Upper RGA	323.75	320	747030.226	1960036.252	active	14.5	24.5	305.5	295.5	304.86	18.89	11/16/2021_1342	29.53	TOC
SHF-102G	SHF-102G	4" PVC	Upper RGA	362.85	359.1	845764.387	1927473.284	active	47.1	57.4	312	301.7	319.34	43.51	11/16/2021_1330	29.53	TOC
TVA River Elevation														300.4	11/16/2021_1502	29.51	TVA

LEGEND:
TIC: Top of Casing
DTW: Depth to Water
National Geodetic Vertical Datum of 1929 (NGVD 29).

Attachment 3

2022 Groundwater Strategy Project Planning Dates and EMP Schedule

Groundwater Strategy Project Planning Dates

Activity	Planning Date
FY 2022 Groundwater Strategy Project Management Plan	Dec-2021
FY 2022 Q1 Potentiometric Map	4/6/2022
Quarterly Meeting (April/FY22Q3)	4/6/2022
Activity #4 White Paper: Comparison of Regional Groundwater Flow Pre- and Post-Construction and Operation of Olmsted Dam	4/8/2022
FY 2022 Q2 Potentiometric Map	7/13/2022
Quarterly Meeting (July/FY22Q4)	7/13/2022
Activity #2 White Paper: Regional and Localized Groundwater Flow and TCE Trends, East Side of Downgradient Northeast Plume	8/18/2022
Activity #8 White Paper: Regional and Localized Groundwater Flow and TCE Trends, West Side of Downgradient Northeast Plume	Oct-2022
FY 2022 Q3 Potentiometric Map	Oct-2022
Quarterly Meeting (October/FY23 Q1)	Oct-2022
FY 2022 Groundwater Strategy Project Management Plan	Nov-2022
FY 2022 Q4 Potentiometric Map	Jan-2023
Quarterly Meeting (October/FY23 Q1)	Jan-2023

Monitoring Wells Planned For Colloidal Borescope and Pressure Transducer Deployment

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW20 (also R4)	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW63		M1			M1			M1			M1	
MW65		M1			M1			M1			M1	
MW66		M1			M1			M1			M1	
MW67		M1			M1			M1			M1	
MW68		M1			M1			M1			M1	
MW71		M1			M1			M1			M1	
MW72		M1			M1			M1			M1	
MW73		M1			M1			M1			M1	
MW76		M1			M1			M1			M1	
MW77 (PZ)		M1			M1			M1			M1	
MW78		M1			M1			M1			M1	
MW79		M1			M1			M1			M1	
MW80		M1			M1			M1			M1	
MW81		M1			M1			M1			M1	
MW84		M1			M1			M1			M1	
MW86		M1			M1			M1			M1	
MW87		M1			M1			M1			M1	
MW89		M1			M1			M1			M1	
MW90A		M1			M1			M1			M1	
MW92		M1			M1			M1			M1	
MW93		M1			M1			M1			M1	
MW95A		M1			M1			M1			M1	
MW98	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW99		M1			M1			M1			M1	
MW100		M1			M1			M1			M1	
MW102		M1			M1			M1			M1	
MW103		M1			M1			M1			M1	
MW106A	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW108		M1			M1			M1			M1	
MW120		M1			M1			M1			M1	
MW121		M1			M1			M1			M1	
MW122		M1			M1			M1			M1	
MW123		M1			M1			M1			M1	
MW124		M1			M1			M1			M1	

Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW125		M1			M1			M1			M1	
MW126		M1			M1			M1			M1	
MW132		M1			M1			M1			M1	
MW133		M1			M1			M1			M1	
MW134		M1			M1			M1			M1	
MW135	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW137		M1			M1			M1			M1	
MW139		M1			M1			M1			M1	
MW144		M1			M1			M1			M1	
MW145		M1			M1			M1			M1	
MW146		M1			M1			M1			M1	
MW147		M1			M1			M1			M1	
MW148		M1			M1			M1			M1	
MW150		M1			M1			M1			M1	
MW155	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW156	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW161		M1			M1			M1			M1	
MW163		M1			M1			M1			M1	
MW165A		M1			M1			M1			M1	
MW168		M1			M1			M1			M1	
MW169		M1			M1			M1			M1	
MW173		M1			M1			M1			M1	
MW175		M1			M1			M1			M1	
MW178	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW185		M1			M1			M1			M1	
MW188		M1			M1			M1			M1	
MW191		M1			M1			M1			M1	
MW193		M1			M1	M1+CB		M1	M1+CB		M1	
MW194		M1			M1			M1			M1	
MW197		M1			M1			M1			M1	
MW199		M1			M1			M1			M1	
MW200	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW201		M1			M1			M1			M1	
MW202		M1			M1			M1			M1	
MW203		M1			M1			M1			M1	
MW205		M1			M1			M1			M1	
MW220		M1			M1			M1			M1	
MW221		M1			M1			M1			M1	

Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW222		M1			M1			M1			M1	
MW223		M1			M1			M1			M1	
MW224		M1			M1			M1			M1	
MW225		M1			M1			M1			M1	
MW226		M1			M1			M1			M1	
MW227		M1			M1			M1			M1	
MW233		M1			M1			M1			M1	
MW236		M1			M1			M1			M1	
MW238		M1			M1			M1			M1	
MW239		M1			M1			M1			M1	
MW240		M1			M1			M1			M1	
MW241A		M1			M1			M1			M1	
MW242		M1			M1			M1			M1	
MW243		M1			M1			M1			M1	
MW244		M1			M1			M1			M1	
MW245		M1			M1			M1			M1	
MW247		M1			M1			M1			M1	
MW248		M1			M1			M1			M1	
MW249		M1			M1			M1			M1	
MW250		M1			M1			M1			M1	
MW252		M1			M1			M1			M1	
MW253A		M1			M1			M1			M1	
MW255		M1			M1			M1			M1	
MW256		M1			M1			M1			M1	
MW257		M1			M1			M1			M1	
MW258		M1			M1			M1			M1	
MW260		M1			M1			M1			M1	
MW261		M1			M1			M1			M1	
MW262		M1			M1			M1			M1	
MW283		M1			M1			M1			M1	
MW284		M1			M1			M1			M1	
MW288		M1			M1			M1			M1	
MW291		M1			M1			M1			M1	
MW292		M1			M1			M1			M1	
MW293A		M1			M1			M1			M1	
MW294A		M1			M1			M1			M1	
MW325		M1			M1			M1			M1	
MW326		M1			M1			M1			M1	

Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW327		M1			M1			M1			M1	
MW328		M1			M1			M1			M1	
MW329		M1			M1			M1			M1	
MW330		M1			M1			M1			M1	
MW333		M1			M1			M1			M1	
MW337		M1			M1			M1			M1	
MW338		M1			M1			M1			M1	
MW339		M1			M1			M1			M1	
MW340		M1			M1			M1			M1	
MW341	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW342		M1			M1			M1			M1	
MW343		M1			M1			M1			M1	
MW345		M1			M1			M1			M1	
MW346		M1			M1			M1			M1	
MW347		M1			M1			M1			M1	
MW353		M1			M1			M1			M1	
MW354	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW355		M1			M1			M1			M1	
MW356		M1			M1			M1			M1	
MW357		M1			M1			M1			M1	
MW358		M1			M1			M1			M1	
MW360		M1			M1			M1			M1	
MW361		M1			M1			M1			M1	
MW363		M1			M1			M1			M1	
MW364		M1			M1			M1			M1	
MW366		M1			M1			M1			M1	
MW367		M1			M1			M1			M1	
MW369		M1			M1			M1			M1	
MW370		M1			M1			M1			M1	
MW372		M1			M1			M1			M1	
MW373		M1			M1			M1			M1	
MW376		M1			M1			M1			M1	
MW380		M1			M1			M1			M1	
MW381		M1			M1			M1			M1	
MW384		M1			M1			M1			M1	
MW385		M1			M1			M1			M1	
MW387		M1			M1			M1			M1	
MW388		M1			M1			M1			M1	

Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW391		M1			M1			M1			M1	
MW392		M1			M1			M1			M1	
MW394		M1			M1			M1			M1	
MW395		M1			M1			M1			M1	
MW397		M1			M1			M1			M1	
MW409		M1			M1			M1			M1	
MW410		M1			M1			M1			M1	
MW411*		M1			M1			M1			M1	
MW414		M1			M1			M1			M1	
MW415		M1			M1			M1			M1	
MW416		M1			M1			M1			M1	
MW417		M1			M1			M1			M1	
MW418		M1			M1			M1			M1	
MW419		M1			M1			M1			M1	
MW420		M1			M1			M1			M1	
MW421		M1			M1			M1			M1	
MW422		M1			M1			M1			M1	
MW423		M1			M1			M1			M1	
MW424		M1			M1			M1			M1	
MW425		M1			M1			M1			M1	
MW426		M1			M1			M1			M1	
MW427		M1			M1			M1			M1	
MW428		M1			M1			M1			M1	
MW429A		M1			M1			M1			M1	
MW430		M1			M1			M1			M1	
MW431	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW432	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW433		M1			M1			M1			M1	
MW435		M1			M1			M1			M1	
MW439	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT
MW440		M1			M1			M1			M1	
MW441	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT
MW442	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT
MW443		M1			M1			M1			M1	
MW444		M1			M1			M1			M1	
MW445	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW447		M1			M1			M1			M1	
MW448		M1			M1			M1			M1	

Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW450		M1			M1			M1			M1	
MW451		M1			M1			M1			M1	
MW452		M1			M1			M1			M1	
MW453		M1			M1			M1			M1	
MW454		M1			M1			M1			M1	
MW455		M1			M1			M1			M1	
MW456		M1			M1			M1			M1	
MW457		M1			M1			M1			M1	
MW458		M1			M1			M1			M1	
MW459		M1			M1			M1			M1	
MW460		M1			M1			M1			M1	
MW461		M1			M1			M1			M1	
MW462		M1			M1			M1			M1	
MW463		M1			M1			M1			M1	
MW464		M1			M1			M1			M1	
MW465		M1			M1			M1			M1	
MW466		M1			M1			M1			M1	
MW467		M1			M1			M1			M1	
MW468		M1			M1			M1			M1	
MW469		M1			M1			M1			M1	
MW470		M1			M1			M1			M1	
MW471		M1			M1			M1			M1	
MW472		M1			M1			M1			M1	
MW473		M1			M1			M1			M1	
MW474		M1			M1			M1			M1	
MW475		M1			M1			M1			M1	
MW476		M1			M1			M1			M1	
MW477		M1			M1			M1			M1	
MW478		M1			M1			M1			M1	
MW479		M1			M1			M1			M1	
MW480		M1			M1			M1			M1	
MW481		M1			M1			M1			M1	
MW482		M1			M1			M1			M1	
MW483		M1			M1			M1			M1	
MW484		M1			M1			M1			M1	
MW485		M1			M1			M1			M1	
MW486A		M1			M1			M1			M1	
MW487		M1			M1			M1			M1	

Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW488		M1			M1			M1			M1	
MW489		M1			M1			M1			M1	
MW490		M1			M1			M1			M1	
MW491		M1			M1			M1			M1	
MW492	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW493		M1			M1			M1			M1	
MW494		M1			M1			M1			M1	
MW495		M1			M1			M1			M1	
MW496		M1			M1			M1			M1	
MW497		M1			M1			M1			M1	
MW498		M1			M1			M1			M1	
MW499		M1			M1			M1			M1	
MW500		M1			M1			M1			M1	
MW501		M1			M1			M1			M1	
MW502		M1			M1			M1			M1	
MW503		M1			M1			M1			M1	
MW504		M1			M1			M1			M1	
MW505		M1			M1			M1			M1	
MW506		M1			M1			M1			M1	
MW507		M1			M1			M1			M1	
MW524		M1			M1			M1			M1	
MW525	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW526	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW527	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW528		M1			M1			M1			M1	
MW529	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW530		M1			M1			M1			M1	
MW531		M1			M1			M1			M1	
MW532 (PZ)		M1			M1			M1			M1	
MW533		M1			M1			M1			M1	
MW534 (PZ)		M1			M1			M1			M1	
MW535 (PZ)		M1			M1			M1			M1	
MW536		M1			M1			M1			M1	
MW537		M1			M1			M1			M1	
MW538		M1			M1			M1			M1	
MW539		M1			M1			M1			M1	

Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW540 (PZ)		M1			M1			M1			M1	
MW541 (PZ)		M1			M1			M1			M1	
MW542		M1			M1			M1			M1	
MW543		M1			M1			M1			M1	
MW544		M1			M1			M1			M1	
MW545		M1			M1			M1			M1	
MW546		M1			M1			M1			M1	
MW547		M1			M1			M1			M1	
MW548		M1			M1			M1			M1	
MW549		M1			M1			M1			M1	
MW550		M1			M1			M1			M1	
MW551		M1			M1			M1			M1	
MW553 (PZ)		M1			M1			M1			M1	
MW554 (PZ)		M1			M1			M1			M1	
MW555 (PZ)		M1			M1			M1			M1	
MW556		M1			M1			M1			M1	
PZ107		M1			M1			M1			M1	
PZ109		M1			M1			M1			M1	
PZ110		M1			M1			M1			M1	
PZ114		M1			M1			M1			M1	
PZ115		M1			M1			M1			M1	
PZ117		M1			M1			M1			M1	
PZ118		M1			M1			M1			M1	
PZ287		M1			M1			M1			M1	
PZ289		M1			M1			M1			M1	
PZ290		M1			M1			M1			M1	
PZ349		M1			M1			M1			M1	
PZ351		M1			M1			M1			M1	
EW232		M1			M1			M1			M1	
EW233		M1			M1			M1			M1	
EW234		M1			M1			M1			M1	
EW235		M1			M1			M1			M1	
MW557		M1			M1			M1			M1	
MW558		M1			M1			M1			M1	
MW559		M1			M1			M1			M1	

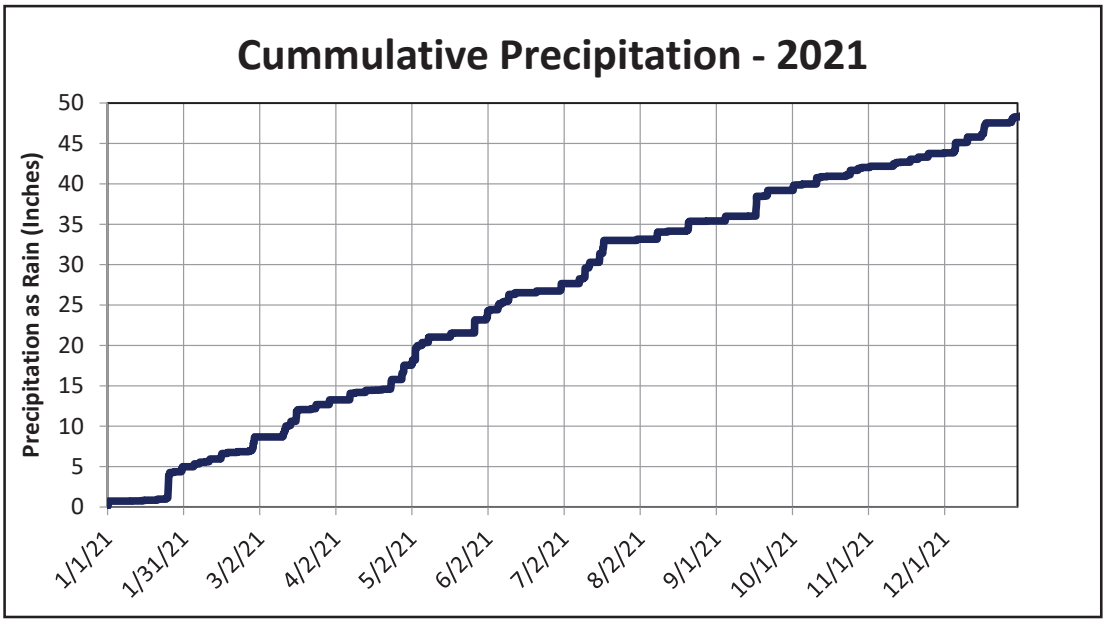
Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

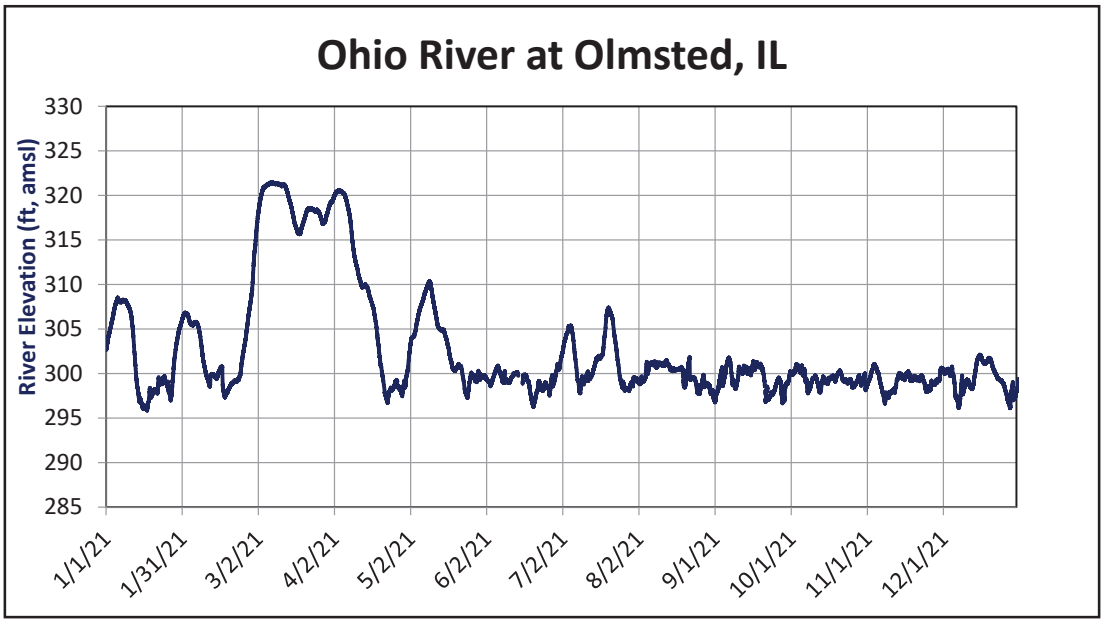
Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW560		M1			M1			M1			M1	
MW561		M1			M1			M1			M1	
MW562		M1			M1			M1			M1	
MW563		M1			M1			M1			M1	
MW564		M1			M1			M1			M1	
MW565		M1			M1			M1			M1	
MW566		M1			M1			M1			M1	
MW567		M1			M1			M1			M1	
MW568		M1			M1			M1			M1	
MW569		M1			M1			M1			M1	
MW570		M1			M1			M1			M1	
MW571		M1			M1			M1			M1	
MW572		M1			M1			M1			M1	
MW573		M1			M1			M1			M1	
MW574		M1			M1			M1			M1	

CB: colloidal borescope
PT: pressure transducer
M1: Manual water level collected once per month
Color coding is used to show colloidal borescope data collection groups, where each color designates a different group of locations that are planned to be collected together.
*Collect manual water level measurement when accessible.

Attachment 4

Precipitation and Ohio River Stage Data


Cummulative Precipitation - 2021
Precipitation as Rain (Inches)
50
45
40
35
30
25
20
15
10
5
0
1/1/21
1/31/21
3/2/21
4/2/21
5/2/21
6/2/21
7/2/21
8/2/21
9/1/21
10/1/21
11/1/21
12/1/21


Ohio River at Olmsted, IL
River Elevation (ft, amsl)
330
325
320
315
310
305
300
295
290
285
1/1/21
1/31/21
3/2/21
4/2/21
5/2/21
6/2/21
7/2/21
8/2/21
9/1/21
10/1/21
11/1/21
12/1/21

Attachment 5

Presentation: Summary of EPA and KY Comments to the 2016 Sitewide Paducah Groundwater Flow Model

Summary of the 2016 Groundwater Flow Model Update Summary of Comments

Groundwater Modeling Working Group
Quarterly Meeting
January 12, 2022

DRAFT Work Product – For Discussion Only

Presentation Outline

- MWG meetings and report timeline
- KDEP Comments
- EPA Comments
- Recommendations and Data needs
- KRCEE Independent Review (separate presentation)
  - February 2018: Review for the 2016 Update of the Paducah Gaseous Diffusion Plant Sitewide Groundwater Flow Model

MWG Meetings and Report Timeline

- 2015-2017: 27 Meetings

2/10/2015	7/8/2016	1/6/2017
2/18/2015	8/5/2016	1/20/2017
11/12/2015	8/16/2016	3/3/2017
3/29/2016	8/24/2016	3/23/2017
4/29/2016	8/31/2016	5/31/2017
5/13/2016	9/16/2016	7/19/2017
6/3/2016	9/30/2016	9/19/2017
6/10/2016	10/14/2016	
6/14/2016	10/25/2016	
6/24/2016	12/13/2016	

- April 3, 2017: Draft update submitted (DOE/LX/07-2415&D1)
  - https://eic.pad.pppo.gov/Search.aspx?accession=ENV 1.J.1-01128
- May 5 and 12, 2017: KDEP and EPA provide comments
- July 17, 2017: Final update submitted (DOE/LX/07-2415&D2)
  - https://eic.pad.pppo.gov/Search.aspx?accession=ENV 1.J.1-01133
- August 9, 2017: EPA acknowledgement

May 5, 2017 KDEP Technical Comments

- 47 Comments
  - Comments 1-13, 15-16, 18-24, 26-40 Editorial
  - Comment 17 rescinded during discussions
  - Comment 46 was addressed in the D1
  - Comments 14, 25, 41, 42, 43, 44, 45, and 47 resulted in additions to Section 8.2, Recommendations
    - General response: "An additional bullet is added to the list of recommendations in Section 8.2 Recommendations, page 157. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/ uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding."
    - Details of each specific recommendation added to the report or applicable to the comment are provided on the following slides.
    - A status update (as of this presentation) is provided for each item, as appropriate.

Summary - May 5, 2017 KDEP Technical Comments

Comment	Topic	Associated Recommendation(s) in the Report	2021 Status
14	Streamflow data	In D1: "To quantify the volumetric rates at which water enters and exits streams, efforts may be made to gage flows in various portions of BC and LBC to determine where and in what quantities water enters and exits the creeks and to coordinate the stream gauging event with a sitewide water level synoptic measurement event."	Streamflow data from Little Bayou Creek and Bayou Creek are planned to be collected as part of the Groundwater Strategy Project (GWSP) Activity #4 (Nature and Extent of Dissolved-Phase Contaminants Currently Contributed by Little Bayou Creek Seeps) and Activity #12 (Water Balance Study).
25	Roof drains	In D1: "To evaluate changes in post closure site operation that may affect anthropogenic recharge in the plant area, monitoring and documentation (including dates) of the enacted utility optimization program (performed by others) are recommended." Added to D2: "Recharge related to the process building roof drains is poorly understood. Future model efforts should compile available information regarding the chronology of roof drain repair to understand temporal variability better and reduce uncertainty in recharge estimates."	Roof drain repairs were made in 2016 and 2017 at C-333 and C-337. A white paper, *Characterization of Roof Drain Leaks to Gravel Subbase of Paducah Site Process Buildings*, is being developed through MWG. This item is also included in the GWSP Activity #12 (Water Balance Study).
41	Hydraulic conductivity (K)	Added to D2: "Additional slug test performed on a selection of appropriate monitoring wells will define hydraulic conductivity better across the model domain. Future discussions should include selecting an appropriate slug test method and criteria for selecting test wells."	Additional K data and lithology data are being collected as part of the C-400 RI. A white paper, *Measurement of Hydraulic Conductivity in the Regional Gravel Aquifer Using Monitoring Wells at the Paducah Site*, was prepared as part of GWSP Activity #16 (Hydraulic Conductivity).

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Summary - May 5, 2017 KDEP Technical Comments, Continued

Comment	Topic	Associated Recommendation(s) in the Report	2021 Status
42	TVA data/ groundwater flow north of the site	Added to D2: "To understand the groundwater flow north of the site better, the TVA monitoring system data should be compiled and verified (especially datums) for use in future models."	KY has been documenting the current TVA monitoring wells and obtains quarterly depth to water level measurements from TVA monitoring wells coordinated with the site synoptic water level measurement events. GWSP Activity #11 (Expansion of GW Monitoring Network) includes compilation and verification (especially datums) of the TVA monitoring system data.
43	Large building gravel thickness	Added to D2: "Installation of piezometers equipped with continuous water level monitors beneath several of the large buildings would define the thickness of the sub-slab gravel base and the temporal water level fluctuations beneath several of the large buildings better."	Roof drain repairs were made in 2016 and 2017 at C-333 and C-337. A white paper, *Characterization of Roof Drain Leaks to Gravel Subbase of Paducah Site Process Buildings*, is being developed through MWG.
44	Water balance	Added to D2: "A Water Balance Study to identify significant sources of anthropogenic recharge in the model domain may provide a better understanding of key components of anthropogenic recharge and reduce uncertainty in recharge estimates for future model updates."	A water balance study is planned to be performed as part of GWSP Activity #12 (Water Balance Study).

Summary - May 5, 2017 KDEP Technical Comments, Continued

Comment	Topic	Associated Recommendation(s) in the Report	2021 Status
45	Additional MWs to address general uncertainties	Added to D2: "Installation of additional monitoring wells, located inside and outside of the plants industrial area would reduce uncertainty regarding groundwater flow direction, contaminant distribution, and potential source areas for future model updates."	Multiple activities under the GWSP are intended to collected data to better understand where additional monitoring wells may be needed.
47	Groundwater divide	Added to D2: "Conducting tracer tests in the vicinity of the apparent groundwater divide located east of the C-400 Building to refine understanding of groundwater flow in this area should be considered for future model update efforts."	Tracer tests will be considered as part of GWSP Activity #15 (Water Level Divide Study). Contaminant analyses and groundwater level measurements for the Northeast Plume Containment System (NEPCS) Optimization Project and the C-400 RI may provide an adequate understanding of groundwater flow in the area of the apparent groundwater divide.

May 12, 2017 EPA Technical Comments

- 16 Comments
  - Noman Ahsanuzzaman (NA): 14 comments and Eva Davis (ED): 2 comments
    - Comment NA 1 details two major concerns that were addressed through responses to other comments
  - General response: Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.
  - Details of each specific recommendation added to the report or applicable to the comment are provided on the following slides.
  - Discussion specific to the comments is provided on the following slides.
  - A status update (as of this presentation) is provided for each item, as appropriate.

May 12, 2017 EPA Technical Comments, Continued

- Topics of technical disagreement
  - Hydraulic conductivity (K) values
  - Anthropogenic recharge rates
  - Trajectory targets and flow paths
  - Transient river stage
  - Number of stress periods
  - Metropolis Lake
  - Calibration statistics

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Summary - May 12, 2017 EPA Technical Comments

Comment	Topic	Associated Recommendation(s) in the Report	Discussion and 2021 Status
NA 2	Calibration: use of excessively high recharge rates and K values	Five of the 20 recommendations included in the report are intended to address uncertainties and data needs specifically related to recharge. Added to the D2: "Additional slug test performed on a selection of appropriate monitoring wells will define hydraulic conductivity better across the model domain. Future discussions should include selecting an appropriate slug test method and criteria for selecting test wells."	A white paper, *Measurement of Hydraulic Conductivity in the Regional Gravel Aquifer Using Monitoring Wells at the Paducah Site*, was prepared as part of GWSP Activity #16 (Hydraulic Conductivity).
NA 3	Calibration: excessive use of trajectory targets	Not directly addressed by recommendations in the report. Each of the 20 recommendations included in the report are intended to address uncertainties and data needs related to the model.	From Responses to Comments (RTC): "The use of trajectory targets, in addition to flux and head targets, was demonstrated to be an essential element in the calibration process (i.e., the plume trajectories could not be simulated accurately without the use of trajectory targets)."

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Summary - May 12, 2017 EPA Technical Comments, Continued

Comment	Topic	Associated Recommendation(s) in the Report	Discussion and 2021 Status
NA 4	Extraction well capture and higher transmissivity channels along flow paths is not validated	Not directly addressed by recommendations in the report. Each of the 20 recommendations included in the report are intended to address uncertainties and data needs related to the model.	From RTC: "The size of the capture zone indicated by particle flow paths is a function of transmissivity and recharge specified across the plant area and may indicate that the constraint limitations applied to the PEST calibration are not representative of site conditions (i.e., higher hydraulic conductivity and recharge may be more representative of site conditions)."

Summary - May 12, 2017 EPA Technical Comments, Continued

Comment	Topic	Associated Recommendation(s) in the Report	Discussion and 2021 Status
NA 5	Transient river stages are not accounted for; inclusion of only 2 stress periods vs 5	In D1: "The hydraulic connection of the RGA to the Ohio River and the nature of river bank storage remain important aquifer parameters potentially justifying further study to support the model and to assess the impact of transient conditions. Continuous RGA water level records are recommended over a period of a year in the vicinity of the Ohio River and along a transect of wells extending back to the PGDP industrial area." In D1: "The groundwater system in the PGDP Hydrologic Basin is in a transient state for much of the year, except in dry periods typically experienced in the fall. The model simulates steady state conditions and is calibrated to periods with relatively low river stage. Validation simulations indicate that during higher Ohio River stages the Northwest Plume discharges to LBC and flows west parallel to the creek. This is consistent with early plume depictions, based on water quality data, showing the plume paralleling LBC (Figure 4.5 of DOE 2010). Consideration of transient seasonal conditions at high Ohio River stages should be considered in the use of the model for evaluating remedial strategies."	From RTC: "Water level response to rising and falling river stages is a transient process, such that synoptic water level data collected during periods of variable river stage would not represent the groundwater system during steady state conditions. Use of these transient water levels as calibration targets in a steady state model is not appropriate. Additional continuous water level data collection and sitewide synoptic water level gauging events during different seasons will provide useful information for further evaluation of transient site conditions. As discussed in MWG meetings, the use of two stress periods rather than the five that were identified as suitable for calibration was due to time constraints in the modeling schedule." Synoptic water level measurements are being collected quarterly and continuous water level measurements using pressure transducers are being collected in select wells as part of multiple GWSP activities.

Summary - May 12, 2017 EPA Technical Comments, Continued

Comment	Topic	Associated Recommendation(s) in the Report	Discussion and 2021 Status
NA 6	An extraordinarily high K value for Metropolis Lake instead of a head boundary condition, driving groundwater in the direction of the lake	In D1: "If possible, measurement of the water level elevation at Metropolis Lake should be included in the sitewide water level synoptic event. Consideration also should be given to characterizing the thickness and hydraulic conductivity of the lake bottom sediments if the lake is to be simulated using river boundary condition in future modeling efforts."	From RTC: "As initially stated in the 2008 modeling report, the lake is conceptualized as a "window into the RGA" that does not act as a net source or sink of groundwater. Using a high K value allows the lake to be represented in this way, while still accounting for the fact that it is a surface water body with flat water levels at the lake surface. This method of simulating a lake using a high contrast hydraulic conductivity zone is a common approach and is well documented in technical literature (e.g., Using High Hydraulic Conductivity Nodes to Simulate Seepage Lakes by Mary P. Anderson, Randall J. Hunt, James T. Krohelski, and Kuopo Chung; Vol. 40, No. 2-GROUND WATER-March-April 2002, pages 117-122). Using constant head boundaries may lead to a net loss or gain of water at Metropolis Lake and would require additional data collection for model input. " Water levels for Metropolis Lake are taken quarterly as part of GWSP Activity #14 (Synoptic Water Level Events).

Summary - May 12, 2017 EPA Technical Comments, Continued

Comment	Topic	Associated Recommendation(s) in the Report	Discussion and 2021 Status
NA 7 NA 11	Recharge rate of 22 in/yr should be used as agreed upon by the MWG	In D1: "Anthropogenic recharge rates are estimated over a wide range of values (Section 3.3). As with most groundwater models, the model configuration and calibrated input parameters are not a unique solution. It is recommended that continuous water level recorders be deployed in select monitoring wells/piezometers within the plant area to assess recharge better and its impact on nearby water levels."	From RTC: "The values in Table 3.5 were provided as a basis for estimating the range of maximum recharge based on lithologic descriptions. The appropriate statistic for estimating recharge in the plant area has been discussed, but no agreement by the MWG was made regarding a final value." Initial recharge estimates were overly constrained by the use of the geometric mean: subsequently, the median value was used to not overly constrain the process. A white paper, *Characterization of Roof Drain Leaks to Gravel Subbase of Paducah Site Process Buildings*, is being developed through MWG.

Summary - May 12, 2017 EPA Technical Comments, Continued

Comment	Topic	Associated Recommendation(s) in the Report	Discussion and 2021 Status
NA 8	Recharge rates: Storm drain footprint should not extend beyond the HU3 footprint	In D1: "Two of the main water supply systems and the storm water and HPFW piping were included in the model as discreet recharge zones based on site information (see Section 3.3.2). Assessment of the remaining water supply systems in the plant area, which include the recirculating cooling water and waste heat system, the sanitary water system, and the plant (nonsanitary) water system, is recommended to evaluate potential for contribution to anthropogenic recharge." Added to the D2: "A Water Balance Study to identify significant sources of anthropogenic recharge in the model domain may provide a better understanding of key components of anthropogenic recharge and reduce uncertainty in recharge estimates for future model updates."	From RTC: "The recharge zone for the storm drains (Zone 16) follows the footprint of the storm drain piping and is independent of the HU3 clay unit characterization. The calibrated recharge rate is expected to be on the higher end of the range of values calibrated for anthropogenic recharge because of documented leaks and leakage typical to aging storm water systems. The higher contribution to mass flux is based partially on the relatively large footprint of the recharge zone due to the extensive network across the plant area (see Figures 3.11 and 5.5)." A water balance study is planned to be performed as part of GWSP Activity #12 (Water Balance Study).

May 12, 2017 EPA Technical Comments, Continued

Comment	Topic	Associated Recommendation(s) in the Report	Discussion and 2021 Status
NA 9	The McNairy formation could be a significant formation for DNAPL source accumulation and plume migration and exclusion of the McNairy formation is a major limitation for solute transport modeling	In D1: "Flow rate in the McNairy Formation is negligible compared to the RGA because the hydraulic conductivity is 2 to 3 orders of magnitude lower than in the RGA; however, the McNairy Formation may be significant for DNAPL source accumulation and contaminant transport. Future transport models based on the 2016 flow model will need to consider potential mass flux from the McNairy to the RGA resulting from back diffusion."	From RTC: "With respect to groundwater flow, the CSM recognizes limited flow in the McNairy; however, the RGA is the primary conveyor of groundwater from PGDP to the Ohio River. If the model is used to simulate solute transport in the future, then the best method to model back-diffusion from the McNairy formation will be discussed with the MWG." Associated geotechnical measurements for the McNairy formation are being collected as part of the C-400 RI.

Summary - May 12, 2017 EPA Technical Comments, Continued

Comment	Topic	Associated Recommendation(s) in the Report	Discussion and 2021 Status
NA 10	Recharge rates: excessively high recharge rates for the roof drains	See NA 7	Roof drain repairs were made in 2016 and 2017 at C-333 and C-337. A white paper, *Characterization of Roof Drain Leaks to Gravel Subbase of Paducah Site Process Buildings*, is being developed through MWG.
NA 11	K values: Update the model calibration with a higher ratio of horizontal to vertical hydraulic conductivity	Not directly addressed by recommendations in the report. Each of the 20 recommendations included in the report are intended to address uncertainties and data needs related to the model.	From RTC: "The 10:1 anisotropy ratio referred to in Section 3.3.1 is related to the value reported for the UCRS (see Figure 13 from the Treatability Study Report, DOE/LX/07-2202&D1, December 2015). The 10:1 ratio used as a basis for estimated maximum recharge based on lithology is an appropriate order of magnitude assumption considering the precision of data relied on to conduct the analysis (e.g., variability of lithologic descriptions from boring logs for multiple purposes by multiple inspectors). The anisotropy ratios reported in the treatability study as high as 30:1 are referring to the RGA."

Summary - May 12, 2017 EPA Technical Comments, Continued

Comment	Topic	Associated Recommendation(s) in the Report	Discussion and 2021 Status
NA 12	Calibration statistics: the Scaled RMS Error of greater than 10% would indicate that the calibration of the flow model is not acceptable according to the industry standard	Not directly addressed by recommendations in the report. Each of the 20 recommendations included in the report are intended to address uncertainties and data needs related to the model.	From RTC: "Evaluation of the scaled RMS within the plant area and the applicability of model-wide guidelines in future modeling efforts will be discussed with the MWG…"
NA 13	Calibration statistics: Residual values are high inside the plant area and west of C-400	In D1: "To reduce uncertainty at the contact area between the Terrace Gravel and the UCRS in the vicinity of the southern model boundary, additional monitoring well installation may be considered to collect water level and soil boring information." In D1: "Evaluation of a more accurate method to quantify Terrace underflow to the RGA is recommended."	From RTC: "The high residual values and the low residual values are distributed across the stress periods and layers."

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Summary - May 12, 2017 EPA Technical Comments, Continued

Comment	Topic	Associated Recommendation(s) in the Report	Discussion and 2021 Status
NA 14	The new transect wells should be included in future model calibrations	In D1: "Assessing water level and water quality data collected from the newly installed transect of monitoring wells located east of C-400 Building is recommended. This assessment will facilitate better understanding of the groundwater elevation contours and flow directions that indicate an apparent groundwater divide near the new transect monitoring wells. This apparent groundwater divide is a key feature of the current model calibration."	Data from the transect monitoring wells and other area monitoring wells are collected quarterly as part of the NEPCS project.

Summary - May 12, 2017 EPA Technical Comments, Continued

Comment	Topic	Associated Recommendation(s) in the Report	Discussion and 2021 Status
ED 1	Inadequate information to determine appropriate use of the model	Each of the 20 recommendations included in the report are intended to address uncertainties and data needs.	From RTC: "The report provides details of data analysis, model construction and calibration, assumptions and limitations, and additional data needs as a basis for others outside of the MWG to make their own determination of the appropriateness of the model in the context of a specific application. " Groundwater data are routinely collected as part of several site projects, including the GWSP.

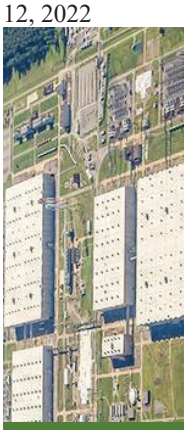
Summary - May 12, 2017 EPA KDEP Technical Comments, Continued

Comment	Topic	Associated Recommendation in the Report	Discussion and 2021 Status
ED 2	Recharge rates, particle trajectories, and highly complex flow patterns compared to sensitivity analysis results	Each of the 20 recommendations included in the report are intended to address uncertainties and data needs related to the complex flow patterns at the site. Five of the recommendations included in the report are intended to address uncertainties and data needs specifically related to recharge. For example, added to the D2: “Installation of additional monitoring wells, located inside and outside of the plants industrial area would reduce uncertainty regarding groundwater flow direction, contaminant distribution, and potential source areas for future model updates.”	Synoptic water level measurements are being collected quarterly and continuous water level measurements using pressure transducers are being collected in select wells as part of the GWSP.

August 9, 2017 EPA Acknowledgement

- EPA acknowledged receipt of the D2 report and responses to EPA and KDEP comments

Based on our review of the draft report (April 2017), the EPA was not able to concur on use of the 2016 Groundwater Flow Model Update to support project-specific environmental cleanup activities under the PGDP Federal Facility Agreement (FFA). No edits were made by DOE in the *Final Groundwater Flow Model* report in response to EPA comments on the draft; however, a copy of EPA's comments, and DOE's responses, are included in Appendix D of the final report, consistent with tri-party discussions. Moving forward, the EPA anticipates that the work group will discuss and resolve EPA's comments on the current version of the model in support of additional data collection and follow-on modeling efforts to ensure that the model supports future environmental media cleanup work under the tri-party PGDP Federal Facility Agreement.



Backup

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May 5, 2017 KDEP Technical Comments

14. Need additional data points from Station 45.

    Response 14: Clarification of this comment was provided by Chris Jung in the May 31, 2017, MWG meeting. The reviewer intended to request that collection of additional streamflow data be considered in future modeling efforts. Consideration for these data is included as a recommendation in Section 8.2.

25. Have the roof drain systems been repaired? Please add text to indicate repair dates.

    Response 25: Information regarding roof drain repair has not been compiled. A bullet to include collection of these data has been added to Section 8.2, “Recommendations.” Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

May 5, 2017 KDEP Technical Comments, Continued

41. Additional slug test performed on a selection of appropriate monitoring wells will better define hydraulic conductivity across the model domain. Future discussions should include selecting an appropriate slug test method and criteria for selecting test wells.

    Response 41: An additional bullet has been added to the list of recommendations in Section 8.2, Recommendations, page 156. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

42. To better understand the groundwater flow north of the site the TVA monitoring system data should be verified (especially datums) and used in future models.

    Response 42: An additional bullet is added to the list of recommendations in Section 8.2 Recommendations, page 157. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

May 5, 2017 KDEP Technical Comments, Continued

43. Perhaps the installation of piezometers beneath several of the large buildings to determine thickness of gravel and if water fluctuates over time.

    Response 43: An additional bullet is added to the list of recommendations in Section 8.2 Recommendations, page 157. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

44. Various components of a Water Balance Study can reduce uncertainty in regards to better understanding anthropogenic recharge.

    Response 44: An additional bullet is added to the list of recommendations in Section 8.2 Recommendations, page 157. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

May 5, 2017 KDEP Technical Comments, Continued

45. Additional MWs can be installed inside and outside of the plants industrial area to reduce uncertainty in regards to groundwater flow direction and chemical concentrations. The data can also be used to help in identifying additional contaminant sources (especially associated with the NE Plume) which the current model suggests.

    Response 45: An additional bullet is added to the list of recommendations in Section 8.2 Recommendations, page 157. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

46. Additional Soil Borings and/or MWs can be installed to further refine the model boundary.

    Response 46: This recommendation already is included in the report in the first bullet of Section 8.2: "To reduce uncertainty at the contact area between the Terrace Gravel and the UCRS in the vicinity of the southern model boundary, additional monitoring well installation may be considered to collect water level and soil boring information."

47. Conduct tracer tests to further define groundwater divide.

    Response 47: An additional bullet is added to the list of recommendations in Section 8.2 Recommendations, page 157. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

May 12, 2017 EPA Technical Comments

Noman Ahsanuzzaman – 14 comments

1. The major concerns of the model are (i) extremely high hydraulic conductivity values in the plant area along with (ii) the extensive use of the trajectory targets during the model calibration. As a result, results in the model calibrated excessively high transmissivity zones along the path of the plumes, essentially creating conduits along those directions. Because of these excessively high transmissivity zones, the extraction wells are capturing not only the particles from the C-400 Building but also the particles from all the source locations within the plant area. In reality, this is extremely unlikely, especially when it is known that drawdowns at the extraction wells are minimal even at high pumping rate. A third major concern is that the model calibration only used two (2) stress periods, even though the MWG agreed to use at least five (5) stress periods representing both high and low river stages. EPA has emphasized these concerns in previous comments on earlier drafts of the report and in multiple modeling work group meetings (see Attachments 1 and 2 to this Enclosure). These concerns are detailed in the comments below.

   Response 1: Comments and concerns are noted. Please see specific responses below.

May 12, 2017 EPA Technical Comments, Continued

2. A major limitation of this model is that the calibration result showed excessively high value of hydraulic conductivity (K) and recharge rate (RR)…EPA asserts that the automated model calibration tool (i.e., PEST) favored higher K value to accommodate higher recharge rate…During the initial MWG meetings, it was agreed that a calibration for low infiltration rate would also be conducted following the calibration for agreed on RR value of 22 in/yr. It is disappointing that the final modeling process only covered the higher end of the expected range for K and even exceeded the range for approved maximum recharge rate.

   2017 Response 2: DOE disagrees with EPA's characterization of the PEST calibration and believes that the presented data supports the accuracy of the calibration. Future efforts to evaluate model calibration should be discussed further with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

3. A major limitation of the model is the excessive use of the trajectory targets during model calibration. These targets were used to drive the groundwater flow from the C-400 Building by forcefully changing the direction of flow towards the direction of the plumes. This approach is no different than the 2008 model where a flow conduit was setup along the same path of these trajectory targets by assigning higher hydraulic conductivity values along that path…Since there are no data available to validate this extremely high contrast in transmissivity values (as shown in Figure 6.5), it is recommended that DOE address this data gap by conducting aquifer pumping tests along the path of the plumes. Also, model output for flux through cross-sections across the two plumes at the plant boundary could be verified against the measured flux from the NW and NE plume extraction wells.

   Response 3: The use of trajectory targets, in addition to flux and head targets, was demonstrated to be an essential element in the calibration process (i.e., the plume trajectories could not be simulated accurately without the use of trajectory targets). Future efforts to collect additional K data in the plant area and evaluate modeled and measured flux will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

May 12, 2017 EPA Technical Comments, Continued

4. The implications of Comments 2 and 3 are evident from Figure 6.35 (attached), where it shows that the extraction wells are capturing particles from all the source locations within the plant area. Since the higher transmissivity channels have been created along the flow path towards the extraction wells, all the particles are ending up in the extraction wells. If this has been true, any release of contaminants anywhere within the plant boundary would most likely be captured by these extraction wells. EPA is not aware of any validation data available to support this modeling result. This is a significant line of evidence for why it is not reasonable to accept the results from the current version of the model for use in CERCLA cleanup activities under the PGDP FFA.

   Response 4: The size of the capture zone indicated by particle flow paths is a function of transmissivity and recharge specified across the plant area and may indicate that the constraint limitations applied to the PEST calibration are not representative of site conditions (i.e., higher hydraulic conductivity and recharge may be more representative of site conditions). Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

May 12, 2017 EPA Technical Comments, Continued

5. Calibration with stress periods at high river stage are necessary for model robustness. The river stage stays at higher elevations about half of the year. Therefore, it is necessary to calibrate the model for the high river stage as well (i.e., the wet season). Transient river stage does not necessarily mean that groundwater is not at steady-state. As stated in the report, transient river condition might Influent the groundwater near the river. Since one of the objectives of the model is to estimate the capture zones around the extraction well networks (see Section 1.1 on page 1), sudden variability of the river stage should not significantly influence groundwater near the extraction wells. The model calibration only used two (2) stress periods, even though the MWG agreed to use at least five (5) stress periods representing both high and low river stages.

   Response 5: Water level response to rising and falling river stages is a transient process, such that synoptic water level data collected during periods of variable river stage would not represent the groundwater system during steady state conditions. Use of these transient water levels as calibration targets in a steady state model is not appropriate. Additional continuous water level data collection and sitewide synoptic water level gauging events during different seasons will provide useful information for further evaluation of transient site conditions. As discussed in MWG meetings, the use of two stress periods rather than the five that were identified as suitable for calibration was due to time constraints in the modeling schedule. For the next model update, inclusion of additional stress periods and collection of additional data will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

May 12, 2017 EPA Technical Comments, Continued

6. Constant or general head boundary condition should be used for the Metropolis Lake instead of assigning an extraordinarily high K value (50,000 ft/d) for the model cells. Such a high K value is driving the groundwater in the direction of the lake, as it is observed in the particle tracking results. Using a head boundary would have much less influence on groundwater moving in the direction of the lake.

   Response 6: As initially stated in the 2008 modeling report, the lake is conceptualized as a "window into the RGA" that does not act as a net source or sink of groundwater. Using a high K value allows the lake to be represented in this way, while still accounting for the fact that it is a surface water body with flat water levels at the lake surface. This method of simulating a lake using a high contrast hydraulic conductivity zone is a common approach and is well documented in technical literature (e.g., *Using High Hydraulic Conductivity Nodes to Simulate Seepage Lakes* by Mary P. Anderson, Randall J. Hunt, James T. Krohelski, and Kuopo Chung; Vol. 40, No. 2-GROUND WATER-March-April 2002, pages 117-122). Using constant head boundaries may lead to a net loss or gain of water at Metropolis Lake and would require additional data collection for model input. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

May 12, 2017 EPA Technical Comments, Continued

7. Based on the minimum clay/silt of 30-35% in the entire model domain, it was assumed in the model that the maximum recharge within the site is 29 in/yr. However, the Modeling Work Group (MWG) agreed to allow a maximum of 22 in/yr recharge based on 40% clay/silt and 60% sand/gravel. It is evident from Figure 3.8 that only a small fraction of the plant area is below the 40% clay/sit threshold. The vast majority of the plant area has clay/silt at 50% or greater. That means based on the harmonic mean, a maximum recharge rate of 18 in/yr would be allowable. The MWG never agreed to use the median hydraulic conductivity in addition to the harmonic mean value for recharge estimation. Therefore, EPA recommends that model calibration should limit the recharge rated to a maximum of 22 in/yr.

   Response 7: It is assumed that the reviewer intended geometric mean when stating harmonic mean. The values in Table 3.5 were provided as a basis for estimating the range of maximum recharge based on lithologic descriptions. The appropriate statistic for estimating recharge in the plant area has been discussed, but no agreement by the MWG was made regarding a final value. During the model calibration process, the maximum constraints based on the geometric mean were realized, and subsequent simulations used the median values to allow the calibration to find values that were not constraint limited. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/ uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

8. It does not appear that the recharge zone for the storm drains (Zone 16) followed the footprint of the HU3 clay unit (see Figures 3.11 and 5.5). In fact, the storm drains are the highest contributor to mass flux of all the anthropogenic recharge boundaries (see Table 6.3). The area covered by these drains should not extend beyond the footprint of the HU3 unit.

   Response 8: The recharge zone for the storm drains (Zone 16) follows the footprint of the storm drain piping and is independent of the HU3 clay unit characterization. The calibrated recharge rate is expected to be on the higher end of the range of values calibrated for anthropogenic recharge because of documented leaks and leakage typical to aging storm water systems. The higher contribution to mass flux is based partially on the relatively large footprint of the recharge zone due to the extensive network across the plant area (see Figures 3.11 and 5.5). Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

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May 12, 2017 EPA Technical Comments, Continued

9. Although the McNairy formation has 2 to 3 orders of lower hydraulic conductivity, it would still be a significant formation for DNAPL source accumulation and plume migration within the McNairy formation. Back diffusion of solvents from the McNairy formation to the Regional Gravel Aquifer (RGA) could be significant as well. Therefore, the exclusion of this potential secondary source zone would be a major limitation if the current version of the groundwater flow model is used simulation is used for solute transport modeling.

   Response 9: With respect to groundwater flow, the CSM recognizes limited flow in the McNairy; however, the RGA is the primary conveyor of groundwater from PGDP to the Ohio River. If the model is used to simulate solute transport in the future, then the best method to model back-diffusion from the McNairy formation will be discussed with the MWG. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

10. The model allowed excessively high recharge rate for the roof drains (e.g., 30 in/yr). To assume this high recharge into groundwater underneath the large buildings is unrealistic. There should be at least some loss from runoff. EPA understands that these buildings have a thick (ca. 10 ft) gravel underneath the foundation and were flooded occasionally in the past. But just because these buildings have standing water, it does not mean that the recharge rate would be higher than the maximum allowable rate limited by the underlying formation. The soil underneath the gravel would limit the recharge, unless the gravel layer cuts into the RGA. Therefore, lithologic limits (which is ≤ 22 in/yr) should apply to these buildings as well.

    Response 10: See Response 7. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

May 12, 2017 EPA Technical Comments, Continued

11. The ratio of the horizontal to vertical hydraulic conductivity does not show a value of 10, as explained in the text. Closer comparison of the data presented in the report shows that the ratio to be between 14 and 20, when the arithmetic and geometric means are compared, respectively. In addition, the model for the C-400 treatability study for steam injection also calibrated the ratio to be in the range of 20 to 30. A higher ratio of the horizontal to vertical hydraulic conductivity would lower the maximum recharge rate allowed in the model as well. Therefore, EPA recommends that DOE update the model calibration with a higher ratio of horizontal to vertical hydraulic conductivity.

    Response 11: It is assumed the text referred to is in Section 3.3.1. The 10:1 anisotropy ratio referred to in Section 3.3.1 is related to the value reported for the UCRS (see Figure 13 from the Treatability Study Report, DOE/LX/07-2202&D1, December 2015). The 10:1 ratio used as a basis for estimated maximum recharge based on lithology is an appropriate order of magnitude assumption considering the precision of data relied on to conduct the analysis (e.g., variability of lithologic descriptions from boring logs for multiple purposes by multiple inspectors). The anisotropy ratios reported in the treatability study as high as 30:1 are referring to the RGA. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

12. Calibration statistics presented in Table 3.6 should also show the Scaled Root Mean Squared (RMS) Error inside the plant boundary, since this is the most important area of interest for model calibration. The observed head range inside the plant area would be much smaller than that shown in the table; hence, the Scaled RMS Error could rise. Note that the Scaled RMS Error of greater than 10% would indicate that the calibration of the flow model is not acceptable according to the industry standard.

    Response 12: Evaluation of the scaled RMS within the plant area and the applicability of model-wide guidelines in future modeling efforts will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

May 12, 2017 EPA Technical Comments, Continued

13. The residual values in Figures 6.9 and 6.10 show a number of calibration targets with high residual values inside the plant area. Some of the targets with higher residual errors are located near the southern boundary. Also, west of the C-400 building shows higher residual errors in all three layers. Changing the boundary values and/or types might help improve the calibration near the southern boundary.

    Response 13: The high residual values and the low residual values are distributed across the stress periods and layers. There does not appear to be any obvious bias that could be addressed by "Changing the boundary values and/or types." Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/ uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

14. Since the new transect wells are located within the high recharge zone (Zone 24) inside the plant area, it is critical to include the water elevation data from these transect wells in future model calibrations. These transect wells could be used to validate the high recharge rates in Zone 24.

    Response 14: Incorporation of these data into the next model evaluation is recommended (Section 8.2, Recommendations). Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

May 12, 2017 EPA Technical Comments, continued

Eva Davis – 2 comments

1. There does not appear to be adequate information in the report to allow others outside of the MWG to make a determination of the appropriateness of the model for a given proposed use.

   Response 1: The report provides details of data analysis, model construction and calibration, assumptions and limitations, and additional data needs as a basis for others outside of the MWG to make their own determination of the appropriateness of the model in the context of a specific application. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

2. [I]t is not clear how 'robust' the model is with respect to the conditions of most of the years and the text in Section 7.2 and 8.2 does not appear to be supported. The fact that large changes in recharge in the plant area (Figures 6.22 to 6.29) do not appear to affect the trajectory of particles in the source area is troubling...Slides 29 to 47 of the February 10 & 11, 2015 work group meeting show a highly complex flow pattern in the ROA in the plant – this is not surprising, due to the anthropogenic recharge in the plant area…Yet the sensitivity analysis for the current model shows that differences in recharge rates don't have an effect on particle trajectory in the plant area. The MWG should consider whether this is a case of particles not being released in in the right place to show the variation in flow directions.

   Response 2: Additional continuous water level data collection is recommended to evaluate transient response to river stage. Collection of synoptic water levels during different times of the year and assessment of 2016 transect data are recommended to improve understanding of sitewide seasonal flow conditions as well as the location of the apparent divide near the new monitoring well transect. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

Attachment 6

Presentation: KRCEE Independent Review of the 2016 Sitewide Paducah Groundwater Flow Model

KRCEE PGDP GW Model Activities

Independent Reviews, Applications & Recommendations

University of Kentucky

Kentucky Research Consortium for Energy and Environment (KRCEE)

Kentucky Water Resources Research Institute (KWRRI)

Kentucky Geological Survey (KGS)

Department of Civil Engineering (UKCE)

Department of Earth and Environmental Sciences (UKEES)

see blue.

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UK - KRCEE Historical Groundwater Model Activities

1. **Mid – Late 1990's** – KYRHB (KY Radiation Health Branch) + KYRHB-AIP, UKCE
   - Reviews and runs of PGDP 1994 GW Flow & Transport Models
2. **Late 1990's to early 2000's** – UKCE + KYRHB + KYRHB-AIP + KRCEE
   - Preliminary reviews and runs of PGDP 1998 GW Flow & Transport Models
3. **2003 to 2007** – KRCEE + KWRRI + UKCE + KGS + SAIC
   - Formal Review & Evaluation of PGDP 1998 GW Flow & Transport Models
   - Application of 1998 GW Flow & Transport Models for *Property Acquisition Study (KRCEE, 2007)* Congressional Report
4. **2006 to 2010** – KRCEE
   - Participation in PGDP 2008 GW Flow & Transport Model Update Development Team
5. **2010 to 2011** – KWRRI + KGS + UKCE + UKEES (note: no 'KRCEE')
   - Independent review of the 2008 PGDP GW Flow & Transport Models*

*Underlined Topics Covered in this Presentation

see blue.
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UK - KRCEE Historical Groundwater Model Activities (cont'd)

6. **2011** – KRCEE + KGS + UKCE + UKEES
   - Property Acquisition Study GW Modeling Update
   - Updated Study outcomes utilizing PGDP 2008 GW Flow & Transport Models
7. **2012 to 2016** - KRCEE
   - Participation in PGDP 2016 GW Flow & Transport Model Update Development Team
8. **2016 to 2017** - KWRRI + KGS + UKCE + UKEES (note: no "KRCEE")
   - Independent review of the 2016 PGDP GW Flow Model
9. **2018 to 2020** – KGS
   - Development of 'Interim Transport Model' utilizing 2016 PGDP GW Flow Model
10. **2016 to Present** - KRCEE
    - Participation in PGDP GW Modeling Project Team activities

*Underlined Topics Covered in this Presentation

see blue.
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KRCEE Independent Groundwater Model Reviews:

Independent PGDP GW Flow Model Reviews

Method - Same for 2008 Flow & Transport & 2016 Flow Models

1. Obtain Model Documents
2. Obtain Model Inputs
3. Review Model Documents
   - Model Objectives
   - Modeling Software (Core Flow Model +/- Modules + Transport Model + GUI)
   - Configuration (Flow System Discretization, Domain, Boundaries/Boundary Types)
   - Calibration (Target Data & Residuals)
   - Verification/Validation (Outcomes)
4. Meet and Discuss Observations
5. Run Model(s)
   - Verify Outputs
6. Meet and Discuss Observations
   - Discuss Recommendations
7. Write Summary, Recommendations & Submit to PPPO

see blue.

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KRCEE Independent Groundwater Model Reviews:

2008 GW Flow Model Review

Software - MODFLOW 2000 , PEST, GW Vistas

Steady State Model

Configuration

1. Domain – Ohio River north, PCC Terrace 315' amsl south, east & west SW divides
   a. RGA only - Exclude UCRS & McNairy[1]
   b. 3 equal layers based on local thickness
      i. Top Layer 1 = Bottom UCRS = Recharge Boundary
      ii. Bottom Layer 3 = Bottom RGA/Top McN Flow System = No Flow Boundary
2. Grid – 50' minimum telescopic mesh to 425'
3. Boundaries
   a. Ohio River - Drain Cells – all 3 layers - Stage 297 feet
4. PCC & east/west surface water divides – No Flow Boundary
5. LBC/BBC – Recharge Cells by reach
6. Metropolis Lake – 'pass through' – Layer 1 (K=50,000 ft/day)
7. Site industrial area relatively simple area recharge zonation – single zone offsite

KRCEE Independent Groundwater Model Reviews:

2008 GW Flow Model Review

Calibration

1. 1 Stress Period
2. Targets - 3 data types used
   a. Water Level Targets - 76 - all February 1995 (Layer 1 = 44; Layer 2 = 20; Layer 3 = 12)
   b. Flux Targets – Ohio River – 4837 gpm
   c. Angle Targets – 1704
      - Based on plume trajectories
3. Parameter estimation (K, Recharge & Flux)
   a. K estimated with PEST using specified pilot points
   b. Recharge – zoned on site/1 zone off site based on precipitation recharge

Results

1. Produced reasonable matches to WLE & potentiometric surfaces
2. Produced reasonable matches to targets (Flux & Angle)

KRCEE Independent Groundwater Model Reviews:

2008 GW Transport Model (MT3D)

Configuration

1. Utilized flow field/fluxes from 2008 MODFLOW Model
2. Transport parameters homogeneous (porosity, bulk density, K_d, half-life, dispersivities)
3. Utilized Finite Difference solution scheme
4. Simulated release/migration history
5. Handled 99Tc and TCE as separate model runs

Calibration

1. First step was estimation of TCE half-life
   a. 10-year half-life estimation based on trial runs of 6, 10 and 16 years
2. Followed by calibration & integration of individual NE, SW, NW Plume runs
   a. Varied spatial and temporal source loads
   b. Targets for NW and SW Plumes were monitored geometries
   c. Targets for NEP were concentration data from a few monitoring wells

KRCEE Independent Groundwater Model Reviews:

2008 GW Flow & Transport Models Review

Review Summary

1. Handling of boundary features based on relative aquifer functions reasonable
2. Auto calibration utilizing PEST achieved reasonable matches to targets
3. Manual adjustment of source and temporal loads achieved reasonable matches to plume geometries (Transport Model)

Review Recommendations

1. Incorporate stratigraphy materials properties to constrain flow model calibration
2. Incorporate site leakage to constrain anthropogenic recharge using upper and lower bounds
3. Calculate flow model w/o SVD to improve spatial distribution of K
4. Add pilot points to future plume flow paths to improve K estimation
5. Re-calibrate the NE TCE plume. Use strategy applied to NW and SW plumes
6. Investigate mass migration into McN by adding a layer beneath RGA Layer 3
7. Consider independent evaluation of UCRS and Terrace Gravels as sources of UCRS recharge

KRCEE Independent Groundwater Model Reviews:

2016 GW Flow & Transport Models Review

Software - MODFLOW 2005 , PEST, PEST-SVD, GW Vistas

Configuration (changes from 2008 Flow Model)

1. Domain – Southern model boundary revised to reflect areal changes to aquifer
2. Grid – remained 50'
3. Boundaries
   a. Ohio River – changed to River Cell Boundary
   b. East/west surface water divides – remained No Flow Boundaries
   c. LBC/BBC – Lower reaches of each changed to River Cell Boundary
4. SP2 included two pump and treat sites (combined 411 gpm)
5. Metropolis Lake remained 'pass through' – Layer 1 (K=50,000 ft/day)

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KRCEE Independent Groundwater Model Reviews:

2016 GW Flow & Transport Models Review

Calibration (same method as 2008 flow model)

1. Stress periods calibrated independently
   a. SP1 'Plant Operating w/o Pump & Treat' calibrated to February 1995
   b. SP2 'Plant Shutdown with Pump & Treat' calibrated to September 2014 Targets
   c. 3 data types used both stress periods
      1. Water Level Targets = 76 (February 1995) & SP2 = 76 (September 2014)
      2. Flux Targets – Changed
         i. Targeted seepage measurements from LBC lower reaches
         ii. Ohio River Flux handled as minimal influence target in SP2
      3. Angle Targets – utilized in both SP1 and SP2
2. Parameter estimation (K, Recharge & Flux)
   a. K estimated with PEST using specified pilot points for each stress period
   b. SP2 Recharge – zoned on site relative to updated data analysis ~ 1 zone off site

Results - SP1 and SP2 calibration runs produced reasonable matches to SP1 & SP2 water level targets

KRCEE Independent Groundwater Model Reviews:

2016 GW Flow Model Review

Summary

1. Recent site data added and recalibrated to two stress periods however there is inconsistency in model calibration & verification
2. SP1 (February 1995) conceptualized at higher water level than SP2 (September 2014)
   a. SP2 total inflow 18% > SP1 total inflow.
   b. Not consistent with Site Conceptual Model as SP2 should have lower total flow
3. 2016 SP1 calibrated to same targets as 2008 flow model but with different total flows
   a. 2008 total inflow 5384 gpm versus 2480 gpm in 2016 SP1
   b. Predicts much slower gw flow in 2016 model than 2008 model which will be a transport problem (see ITM slide 2008)
   c. Suggest better understanding of groundwater basin water budget is needed
4. 2016 model update evaluated by running model with varying Ohio River stages.
   a. Hydraulic gradients did not capture responses to stage variation
   b. Suggest ambient and anthropogenic recharge also impacting gradients
5. Supplemental transient calibration for pump test showed systematic bias.

KRCEE Independent Groundwater Model Reviews:

2016 GW Flow Model Review

Suggestions

1. Revisit calibration of 2016 Flow Model
2. Focus future efforts on transient models utilizing initial conditions from updated flow model

Prologue:

THE FOLLOWING SLIDES for Interim Model

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KRCEE Independent Groundwater Model Reviews:

Interim Transport Model Evaluation

Background

The 2016 model produced a groundwater flow field with a smaller total discharge than the 2008 flow model produced. The goal of this modeling activity is to evaluate impacts of changes in the flow field on simulating TCE plume migration history.

Objectives

1. Incorporate the 2008 transport model parameters into the 2016 flow model.
2. Simulate TCE plume migration for the period of 1966-2008.
3. Compare simulated TCE plume migration with results from the 2008 transport model (and with published/distributed site interpretations of plume concentration extents).*

Interim Model Configuration

- Expand stress periods to cover a period from 1966 to 2008;
- Incorporate 2008 TCE transport model parameters, including density, porosity, TCE distribution coefficient, TCE biodegradation parameter, and dispersivity values
- Incorporate 2008 TCE transport model TCE source terms, including first type TCE boundary for RGA, and secondary type TCE boundary for UCRS;

- -

- Further extend the interim model simulation period to 2018, so that the model result can be compared with latest field data.
- Extend the 2008 model simulation period to 2018 for comparison

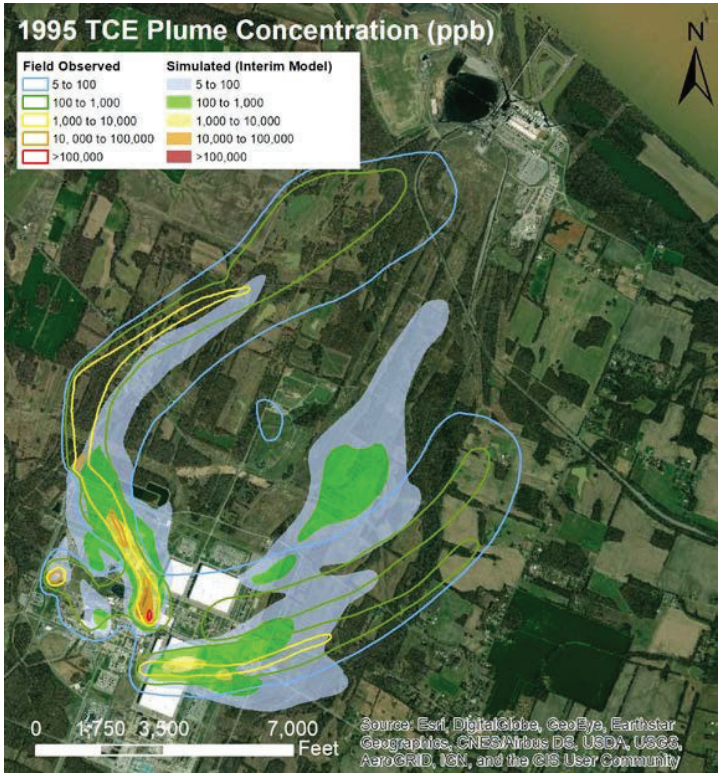
Preliminary Model Result Comparison

*Simulated results from this activity are illustrated in the following slides as 'Interim Model'.
*Each 'Interim Model' result is illustrated adjacent to it's corresponding 2008 (Transport) Model result.
*Published/distributed site plume interpretations based upon field monitoring are identified as 'Field Observed' on the following Interim Model and 2008 Model figures.

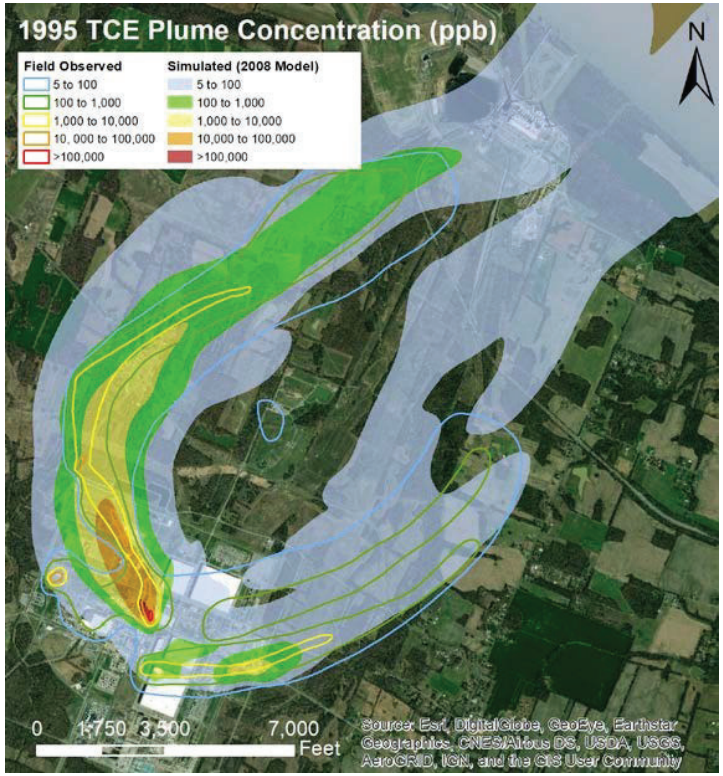
see blue.
Kentucky Geological Survey

Compare Model Results:1995

Interim Model

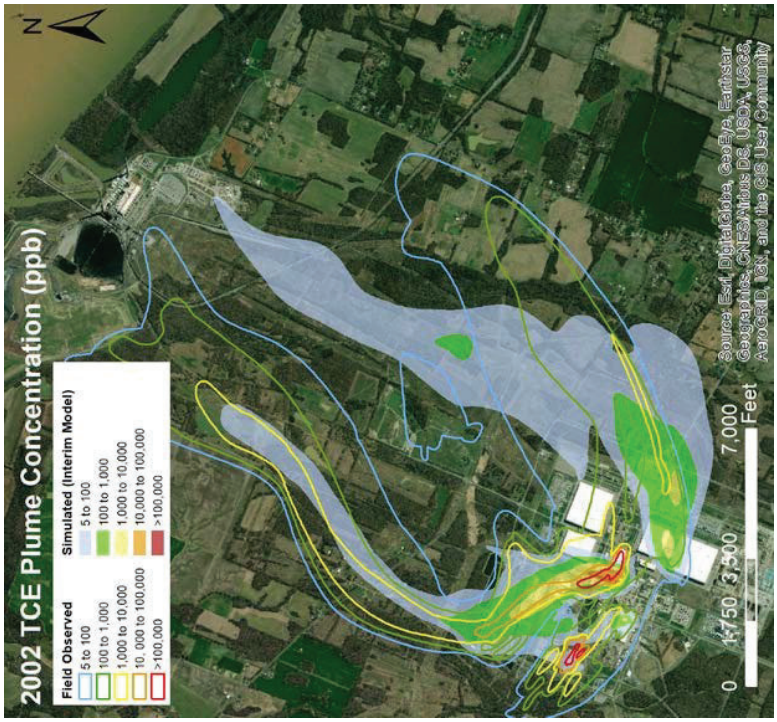


2008 Model

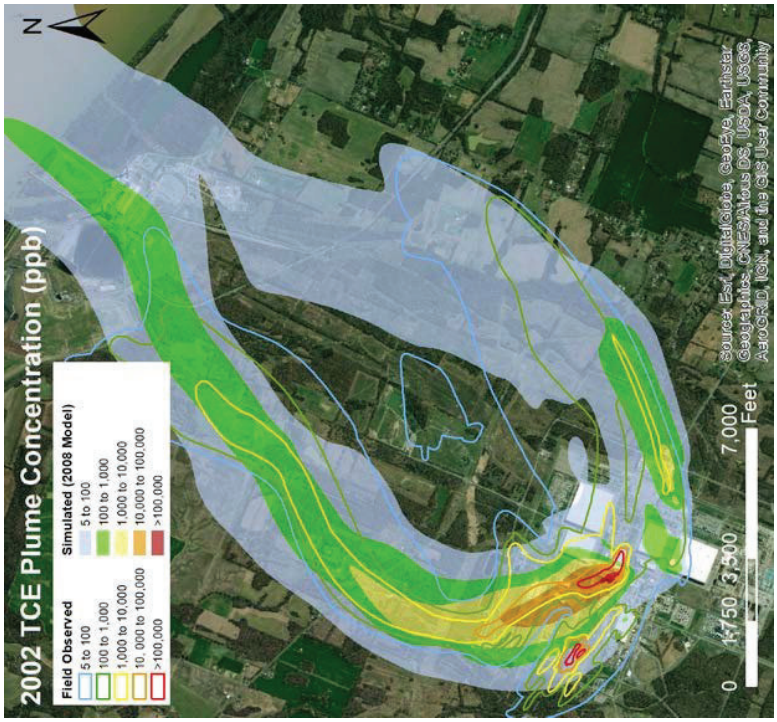


Compare Model Results:2002

Interim Model



2008 Model

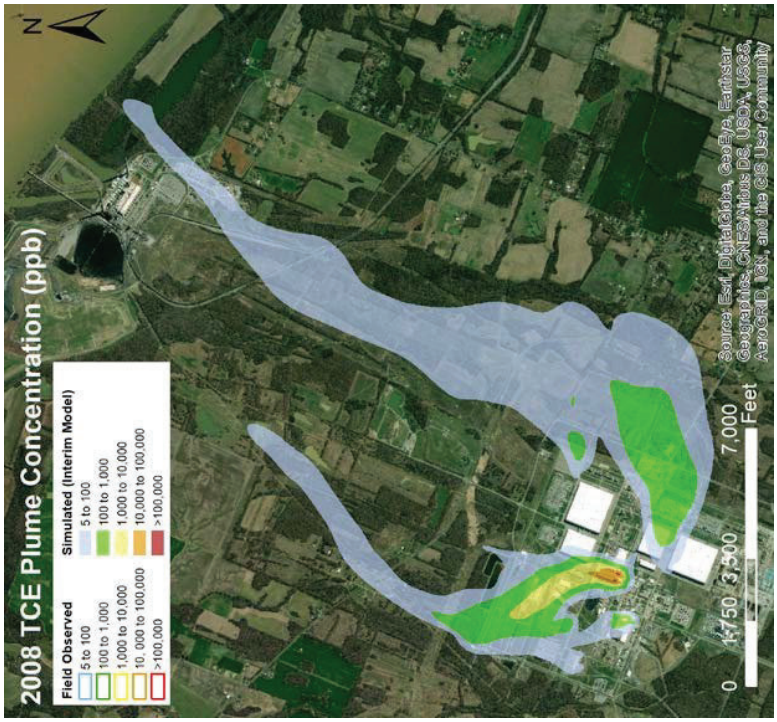


see blue.

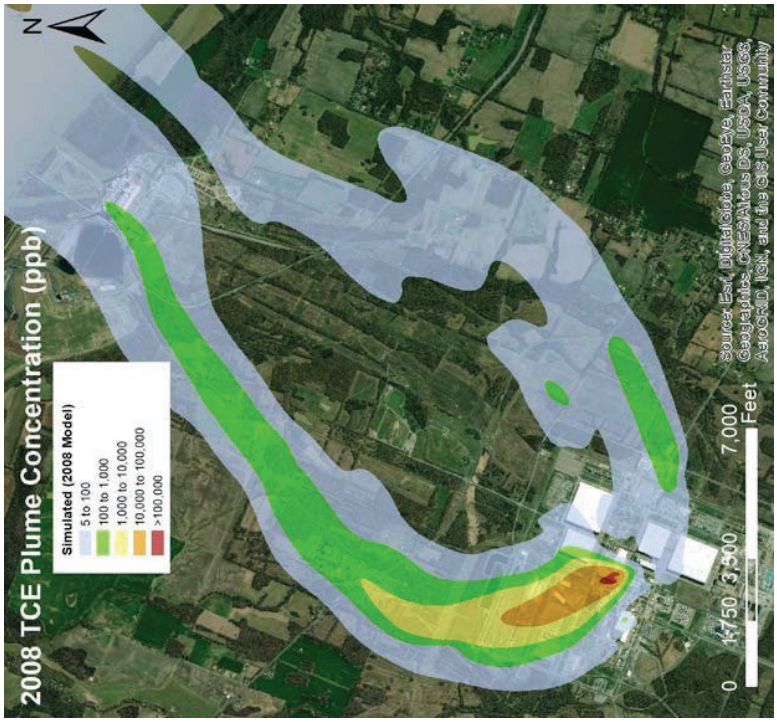
Kentucky Geological Survey

Compare Model Results:2008

Interim Model



2008 Model



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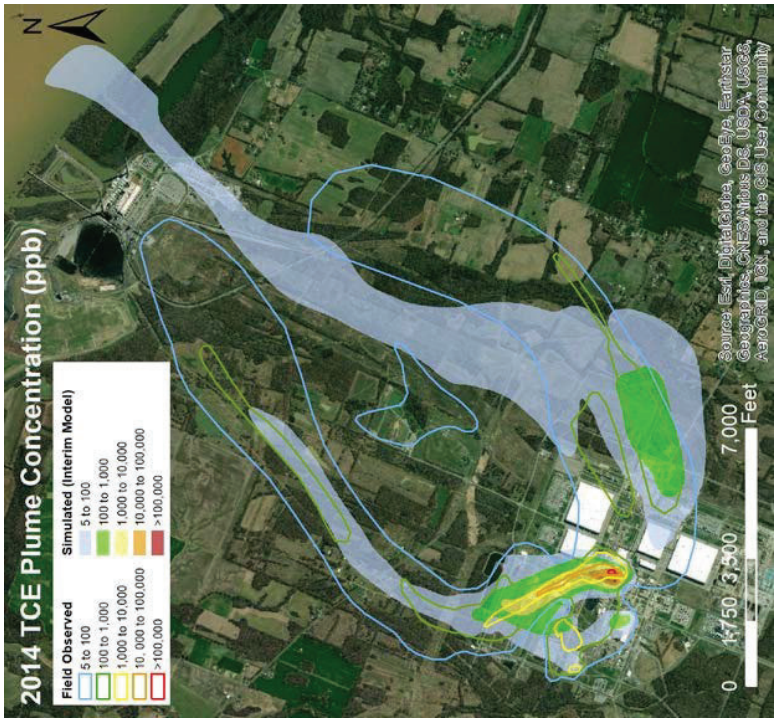
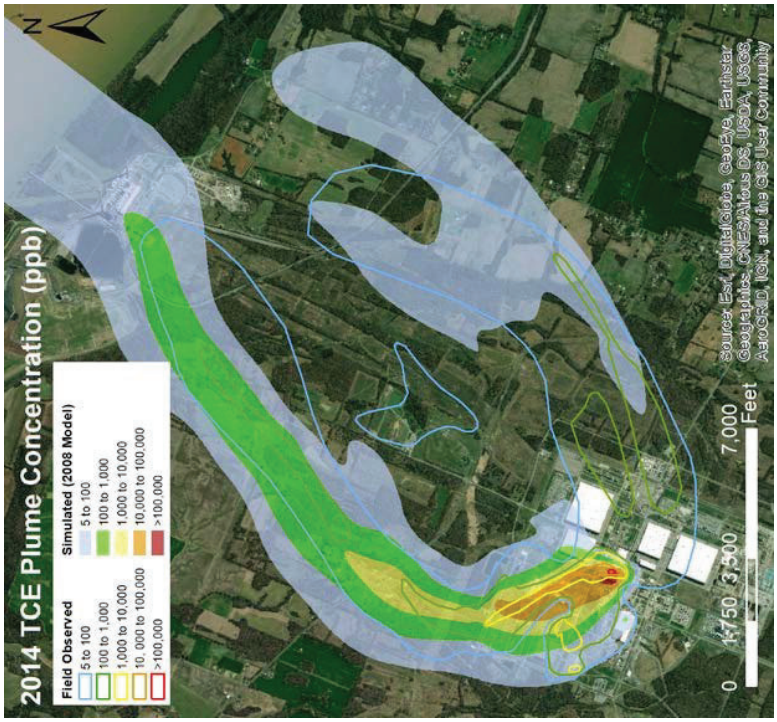
Kentucky Geological Survey

Compare Model Results:2014

Interim Model



2008 Model



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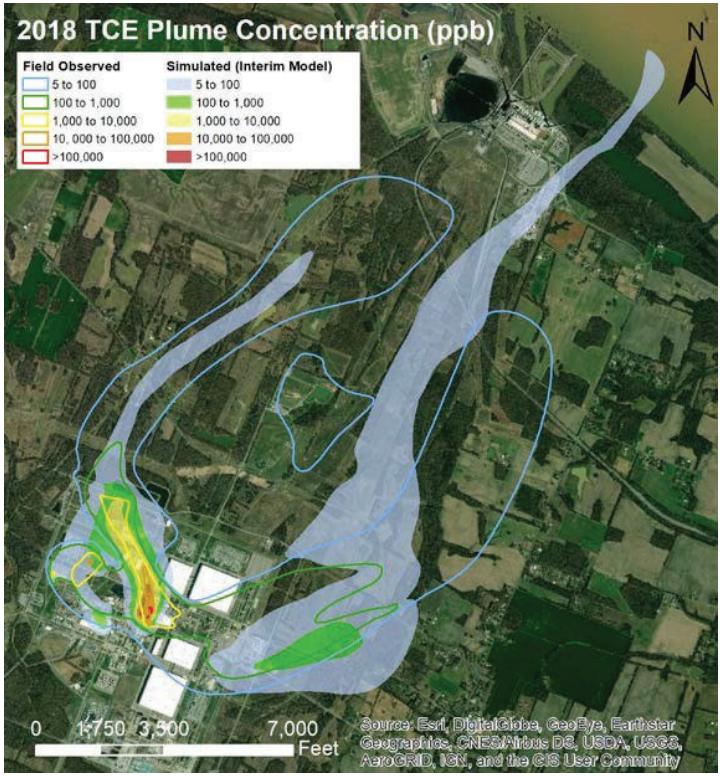
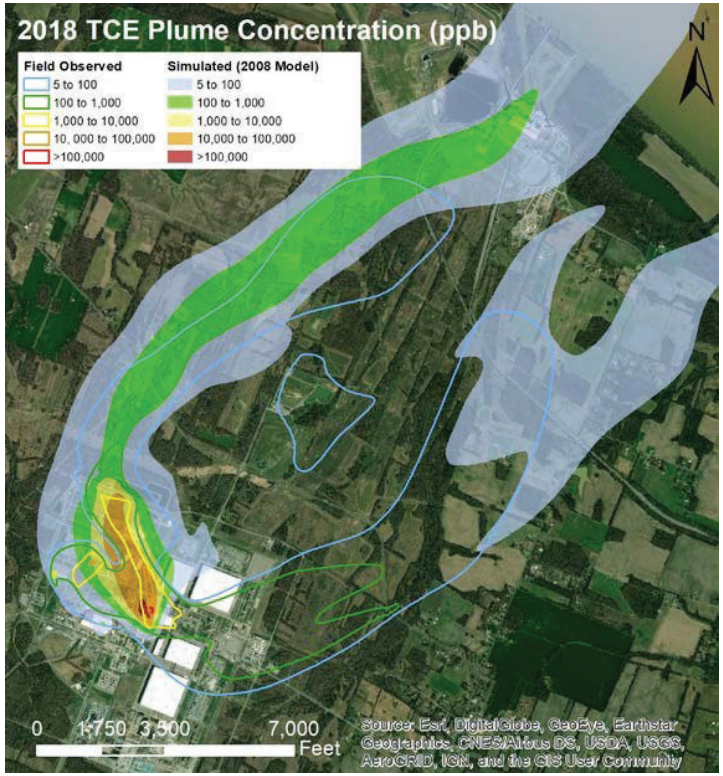
Kentucky Geological Survey

Compare Model Results:2018

Interim Model



2008 Model



Attachment 7

McNairy Lithologic Technical Paper Annotated Outline

DETAILED CORRELATIONS BETWEEN LITHOLOGIC UNITS IN THE McNAIRY FORMATION ACROSS THE PADUCAH SITE

FINAL ANNOTATED OUTLINE

EXECUTIVE SUMMARY

TABLE OF CONTENTS

FIGURES

TABLES

ACRONYMS

ATTACHMENTS

1 INTRODUCTION

1.1 PURPOSE

From the Memorandum of Agreement for Resolution of Informal Dispute Concerning U.S. Environmental Protection Agency and Kentucky Department for Environmental Protection Requirements for Additional Actions or Modifications Regarding the CY 2018 Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/LX/07-2426&D2 (MOA; DOE 2020):

> "As part of the U.S. Environmental Protection Agency's (EPA's) independent assessment of the FY 2018 Five-Year Review, EPA made a protectiveness deferred determination for the Northeast Plume, the Northwest Plume, and Water Policy response actions, until additional data are collected to verify that human exposures are not occurring. EPA determined additional actions are needed, specifically the collection of additional geological data at the C-400 Complex OU and the development of detailed correlations between lithologic units in the McNairy Formation across the entire Paducah Site, to support an accurate characterization of site faulting and the potential for fault-controlled plume migration across the Plant and beyond the Plant boundaries (including the Water Policy Affected Area). EPA requested that the detailed correlations of the McNairy Formation be reported not later than the C-400 Complex OU D1 Remedial Investigation/Feasibility Study (RI/FS) Report.
>
> The following uncertainties were identified regarding protectiveness for the Northwest Plume, Northeast Plume, and Water Policy response actions:
>
> — The presence of unknown contamination in off-site areas.
> — The presence of unknown migration of contamination due to pathways not understood.

To help manage these uncertainties regarding protectiveness, EPA proposed additional characterization of site faulting and the potential for fault-controlled plume migration across the Paducah Site (including the Water Policy Affected Area) as part of the 2023 Five-Year Review.

DOE will develop a technical paper discussing two lithological correlations of the McNairy Formation: one along a north-south transect and the other along an east-west transect (see Figure 1 [of MOA]). The transects will be developed using the existing data from previously drilled 8 deeper soil borings and from 6 discrete locations, that extend near/through the base of the McNairy Formation (which occurs at elevations of -2 to 66 ft amsl beneath the Paducah Site).

— A north-south transect (relative to the Plant coordinate system) of 5 previously drilled soil borings/4 locations over ~ 19,200 ft (~ 3.6 miles), extending from immediately south of the Paducah Site industrial complex to near TVA's Shawnee Steam Plant.

— An east-west transect (relative to the Plant coordinate system) of 4 previously drilled soil borings/3 locations over ~ 5,500 ft (~ 1.0 miles) across the north side of the Plant.

Inputs into the lithological correlations will include a combination of the historical soil boring logs from both the deeper and shallower McNairy Formation within the Paducah Site and the adjacent TVA Shawnee Steam Plant and soil boring logs of the McNairy Formation from the C-400 Complex OU RI/FS (currently underway) that fall along the north-south and east-west transects."

1.2 OBJECTIVES

Characterization of site faulting and the potential for fault-controlled plume migration across the Paducah Site (including the Water Policy Affected Area) are needed to better understand

- the presence of unknown contamination in off-site areas and
- the presence of unknown migration of contamination due to pathways[1] not understood.

DOE will develop a technical paper discussing two lithological correlations of the McNairy Formation: one along a north-south transect and the other along an east-west transect (see Figure 1 [of MOA]) within the Paducah Site and Water Policy Affected Area to assess the presence of fault displacement and, if present, the magnitude of fault displacement.

Inputs into the lithological correlations will include a combination of the historical soil boring logs from both the deeper and shallower McNairy Formation within the Paducah Site and the adjacent TVA Shawnee Steam Plant and soil boring logs of the McNairy Formation from the C-400 Complex OU RI/FS (currently underway) that fall along the north-south and east-west transects.

[1] The term "pathways" is used synonymously with "preferential pathways for contaminant migration."

1.2.1 MEMORANDUM OF AGREEMENT OF INFORMAL DISPUTE
1.2.2 COLLABORATION OF GROUNDWATER MODEL WORKING GROUP

2 BACKGROUND
2.1 McNAIRY GEOLOGIC SETTING
2.1.1 SUMMARY OF HISTORICAL PADUCAH SITE INFORMATION AND STUDIES
2.1.2 CONCERNS
2.1.2.1 Faulting
2.1.2.2 Potential for fault-controlled plume migration

3 HYDROGEOLOGY OF McNAIRY
3.1 DEPOSITIONAL HISTORY
3.2 LITHOLOGIC MEMBERS
3.3 POST-DEPOSITION EROSIONAL/STRUCTURAL SETTING
3.4 McNAIRY GROUNDWATER FLOW SYSTEM

4 RELEVANT FAULT STUDIES
4.1 REGIONAL
4.2 LOCAL
4.3 PADUCAH SITE

5 APPROACH
5.1 DQOs
5.1.1 State the Problem

Characterization of site faulting and the potential for fault-controlled plume migration across the Paducah Site (including the Water Policy Affected Area) are needed to better understand

- the presence of unknown contamination in off-site areas and
- the presence of unknown migration of contamination due to pathways not understood.

This white paper will address characterization of site faulting.

5.1.2 Identify the Decision

The correlation of lithologic units in the McNairy Formation is intended to assess whether there is significant faulting beneath the Paducah Site that could be a contaminant migration pathway.

5.1.3 Identify Inputs to the Decision

Inputs to this characterization will be based on historical soil boring logs of the McNairy Formation at the Paducah Site and the adjacent TVA Shawnee Steam Plant as well as soil boring logs of the McNairy Formation from the C-400 Complex OU RI.

5.1.4 Define the Study Boundaries

1. McNairy Formation
2. Existing soil boring logs of the Paducah Site and adjacent TVA Shawnee Steam Plant
3. Soil boring logs that will be completed for the C-400 Complex Remedial Investigation

5.1.5 Develop a Decision Rule

This correlation will utilize the following decision rules:

1. If a lithologic contact disruption is identified, assess if the discontinuity is fault-related.
   a. The McNairy Formation consists of lagoonal-to-shallow marine deposits with frequent depositional discontinuities.
   b. The McNairy Formation consisted of "soft" sediment deposition that may have resulted in diagenetic-related discontinuities (unrelated to faulting).
   c. Large bioturbation features are abundant.
2. If faulting is identified, assess the orientation and continuity of the structure(s).
   d. The expected trend, consistent with the Fluorspar Area Complex of southern Illinois, is NE-SW.

5.1.6 Specify Limits on Decision Errors

Decision errors will be determined primarily by the frequency of sample collection and impacted by the quality of the data.

5.1.7 Optimize the Design for Obtaining Data

Where marker horizons can be identified, adjacent continuous geologic and geophysical logs may be able to identify small-scale discontinuities (on the order of 5 ft) with reasonable confidence. The resolution of faulting using logs based on grab samples at regular intervals will be governed by the sampling frequency (depth-wise). Initially scrutinizing the available logs to identify candidate marker horizons will increase the effectiveness of the lateral comparison of the logs.

6 DATA SETS

6.1 EXISTING DATA

6.1.1 Lithologic Logs

Soil boring logs are available from reports from individual projects (hardcopy) and in a spreadsheet database prepared by the Kentucky Research Consortium for Energy and Environment (KRCEE) (R9_MSTR_Hydrolithostrat_Dbase_Upload_110419.xlsx).

Historical soil boring logs consist of the following:

— Eight soil borings in six discrete locations that extend to/through the base of the McNairy Formation.

— Approximately 159 soil borings that extend downward to an elevation of 240 ft amsl or deeper (providing characterization of $\geq$40 ft of the upper McNairy/Clayton Formation). Soil boring depths range from 91 to 359 ft.

– A cluster of shallower soil borings are within and near the industrial complex. This includes most of the air-rotary soil borings with grab sample logs and continuous core logs.

— Additional soil borings at the Shawnee Steam Plant extend downward to an elevation of 240 ft amsl or deeper.

Several types of logs are available for the Paducah Site soil borings. A few of the soil borings have geologists' descriptions of continuous core. Several of the soil borings have geologists' descriptions of grab samples collected at regular, frequent intervals. Many of the soil borings have geologists' descriptions of cuttings collected from the cyclone discharge of an air rotary rig. These samples are of limited use for detailed lithologic characterization. However, most of these soil borings also have paper strip logs of natural gamma activity and neutron porosity that may be used to interpret and correlate geology. Three of the deep soil borings have logs of shear wave velocities.

With few exceptions (notably soil boring DB01/DB02), the geologic descriptions are captured in the database of Paducah lithologic logs (R9_MSTR_Hydrolithostrat_Dbase_Upload_110419.xlsx) prepared by KRCEE. Hard copies of the geologic logs are available for all of the soil borings in various project reports.

6.1.2 Geophysical logs

Geophysical logs extending into the McNairy Formation are available for 97 soil borings of the Paducah Site. The majority of these soil borings were drilled by the remedial investigations of Waste Area Groupings 3, 6, and 27; the Data Gaps Investigation associated with the remedial investigation of Waste Area Groupings 8 and 28; and the Phase IV Groundwater Investigation. Most soil boring records include downhole logs for both gamma ray and neutron porosity.

6.2 C-400 Complex RI

The C-400 Complex Remedial Investigation will complete a minimum of 17 soil borings to depths of at least 50 ft within the McNairy Formation. Lithologic logs will be developed for each of the soil borings.

7 DATA ADEQUACY

7.1 DEPTH OF DATA/THICKNESS OF MCNAIRY INVESTIGATED

7.2 SPACING OF SAMPLE LOCATIONS

7.3 QUALITY OF DATA

7.3.1 Sampling method

7.3.2 Vertical frequency

8 ASSESSMENT METHODS

8.1 CROSS SECTIONS

The Paducah Site McNairy soil boring logs can be generalized as two primary populations as discussed below.

- A north-south transect (relative to the plant coordinate system) of ~19,200 ft (approximately 3.6 miles), extending from immediately south of the plant industrial complex to near TVA's Shawnee Steam Plant.
- An east-west transect (relative to the plant coordinate system) of ~ 5,500 ft across the north side of the industrial complex.

For detailed McNairy correlations, the following geologic information should be noted.

- North of the buried Porters Creek Clay Terrace Slope, the top of the McNairy/Clayton Formation is truncated by an erosional unconformity marking the bottom of the channel of the ancestral Tennessee River Valley, commonly occurring at an elevation of approximately 280 ft amsl.
- South of the buried Porters Creek Clay Terrace Slope, the top of the McNairy/Clayton Formation slopes to the south with a shallow dip (<10°) beneath the Porters Creek Clay.

8.2 STRUCTURE CONTOUR MAPS

9 UNCERTAINTIES

9.1 DEPOSITIONAL HETEROGENEITY

9.2 RESOLUTION OF FAULT OFFSET

10 CONCLUSIONS AND RECOMMENDATIONS

11 REFERENCES

ATTACHMENT 1. LITHOLOGIC LOGS

ATTACHMENT 2: GEOPHYSICAL LOGS

ATTACHMENT 3: GEOLOGIC CROSS SECTIONS

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APPENDIX C

GROUNDWATER MODELING WORKING GROUP MEETING SUMMARY—APRIL 6, 2022

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ACRONYMS[1]

AIP	agreement in principle
amsl	above mean sea level
BC	Bayou Creek
CB	colloidal borescope
CCR	coal combustion residual
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CRS	comment response summary
CSM	conceptual site model
CY	calendar year
DNAPL	dense nonaqueous phase liquid
DOE	U.S. Department of Energy
DQO	data quality objective
DTW	depth to water
EMP	environmental monitoring plan
EPA	U.S. Environmental Protection Agency
ETAS	Enterprise Technical Assistance Services, Inc.
EW	extraction well
FFA	Federal Facility Agreement
FLIR	forward looking infrared
FRNP	Four Rivers Nuclear Partnership, LLC
FS	feasibility study
FY	fiscal year
GIS	geographic information system
gpm	gal per minute
GPS	global positioning system
GW	groundwater
GWSP	groundwater strategy project
KDEP	Kentucky Department of Environmental Protection
KRCEE	Kentucky Research Consortium for Energy and the Environment
KY	Commonwealth of Kentucky
LBC	Little Bayou Creek
LBCSP	Little Bayou Creek seep
LiDAR	light detection and ranging
MCL	maximum concentration limit
MOA	memorandum of agreement
MW	monitoring well
MWG	Modeling Working Group
NEPCS	Northeast Plume Containment System
NGVD	National Geodetic Vertical Datum
OREIS	Oak Ridge Environmental Information System
OU	operable unit
PEGASIS	PPPO Environmental Geographic Analytical Spatial Information System
PEST	parameter estimation
PFAS	per-and polyfluoroalkyl substances
PGDP	Paducah Gaseous Diffusion Plant
PPPO	Portsmouth/Paducah Project Office

[1] Acronym list was not part of the original meeting summaries.

P-QAPP	programmatic quality assurance project plan
PT	pressure transducer
PVC	polyvinyl chloride
PZ	piezometer
Q	quarter
RFP	request for proposal
RGA	Regional Gravel Aquifer
RI	remedial investigation
RMS	root mean squared
TBD	to be determined
TIC	top of inner casing
TOC	top of casing
TVA	Tennessee Valley Authority
UCRS	upper continental recharge system
VI	vapor intrusion
WDA	waste disposal alternative

Paducah Site Groundwater Modeling Working Group
Meeting Summary—April 6, 2022

MWG Attendees:

DOE
Rich Bonczek ✓
Dave Dollins ✓

ETAS
Martin Clauberg ✓
Bruce Stearns ✓
Tracy Taylor ✓

KRCEE
Steve Hampson ✓

TVA
Tabitha Ester ✓
Anna Fisher
Dominic Norman

EPA and Contractors
Noman Ahsanuzzaman ✓
Ben Bentkowski ✓
Eva Davis ✓
Mac McRae ✓
Victor Weeks ✓

Kentucky
Brian Begley ✓
Stephanie Brock
Nathan Garner ✓
Brian Lainhart ✓
Bart Schaffer
Chris Travis ✓

FRNP
Austin Buckhalter
Bryan Clayton
Lisa Crabtree ✓
Ken Davis ✓
Rob Flynn
Bruce Ford ✓
Stefanie Fountain ✓
LeAnne Garner
Todd Powers ✓
Joe Tarantino ✓
Denise Tripp ✓
Dawit Yifru ✓
Bruce Meadows ✓
Evan Clark ✓
Jason Orr ✓

Original meeting agenda items are provided followed by meeting notes; the meeting notes are provided in italics with action items noted in green.

The order of the agenda was revised by consensus during the meeting to first address Item 12, Attachment 7-3, the EPA comments on the 2016 site-wide groundwater model.

1. Call for Issues from Groundwater Modeling Working Group (MWG) Members

No comments were received to the January 12, 2022 Meeting Summary (sent to participants on 2/8/2022). This summary will be considered final.

No comments were received to the January 12, 2022 Meeting Summary. The meeting summary is now final.

The group agreed by consensus that Teams will be used for future meetings

2. FY 2022 Work Plan/Schedule

Activity	Date
~~Quarterly Meeting (October/FY22Q1)~~	~~10/6/2021~~
~~MWG Concurs with FY 2022 Work Plan/Schedule~~	~~11/12/2021~~
~~Submit Draft Meeting Summaries and White Papers Compilation (FY21)~~	~~11/15/2021~~
~~MWG Provide Comments on Draft Compilation of Meeting Summaries and White Papers (FY21)~~	~~11/30/2021~~
~~Submit Final Meeting Summaries and White Papers Compilation (FY21)~~	~~12/21/2021 Planned~~ ~~12/13/2021 Actual~~
~~Quarterly Meeting (January/FY22Q2)~~	~~1/12/2022~~
~~Submit Draft Large Building PZ White Paper to MWG~~	~~2/17/2022~~

Activity	Date
~~Submit Draft Survey White Paper 2 to MWG~~	~~3/18/2022~~ ~~Actual: 2/28/2022~~
~~MWG Review Draft Large Building PZ White Paper~~	~~3/25/2022~~
Quarterly Meeting (April/FY22Q3)	4/6/2022
Submit Final Large Building PZ White Paper to EPA and KY	5/19/2022
Submit Draft McNairy Lithologic Technical Paper to MWG	7/1/2022 (was 8/11/2022)
Quarterly Meeting (July/FY22Q4)	7/13/2022
MWG Meeting to Discuss Draft McNairy Lithologic Technical Paper	7/20/2022 (was 8/24/2022)
MWG Provide Comments on Draft McNairy Lithologic Technical Paper	8/1/2022 (was 9/12/2022)

Color code for schedules:

Due date	Quarterly meeting
Submittal date	Concurrence/acknowledgement date

b. FY 2023 Activities

Activity	Date
Quarterly Meeting (October/FY23Q1)	10/5/2022
Submit Final McNairy Lithologic Technical Paper to EPA and KY	11/7/2022

The group discussed that the McNairy Lithologic Technical Paper schedule has been accelerated by approximately 6 weeks. No other comments were received on the working group schedule or planning dates.

3. Update on Water Levels

Synoptic water level events are being collected quarterly. The potentiometric map for the synoptic water level event in November 2021 is included in Attachment 1. A synoptic water level event was performed February 21-23, 2022 and will be included in the next meeting agenda.

Groundwater elevation data for TVA wells collected by KY occurred on February 23, 2022 and is included as Attachment 2. During the January 12, 2022 meeting, the group discussed that TVA plans to abandon several monitoring wells along Little Bayou Creek (e.g., AR76, AR75B, and B10). Tabitha Ester (TVA) continues to coordinate with Brian Lainhart (KY) on collection of water level measurements and monitoring well abandonment plans. Possible localized impacts on water levels due to the TVA sheet pile wall installation are an ongoing topic of discussion (see Agenda Item 11, Projects on the "Watch Topics" List, TVA Changes).

The group discussed that the TVA well water levels will be reviewed for inclusion on future potentiometric maps. FRNP will provide feedback to the group on when the TVA data are needed for review for inclusion. The group discussed that the February potentiometric map that will be included in the next meeting agenda (FY22Q4/July 13, 2022) and represents conditions where the Ohio River elevation is high and where only one of the four extraction wells was operational.

4. Update on Paducah Site Groundwater Strategy

The overall objectives for the GWSP is to develop a groundwater strategy that closes out various issues for the site:

- Change status of two Environmental Indicator Performance Measures to "Yes"

  - Human exposure under control
  - Groundwater migration under control
- Resolution of data needs
- Groundwater Modeling Working Group (MWG) recommended maintenance and updates

The project objectives and draft schedule were originally discussed during the April 10, 2019 MWG meeting and included in the Compilation of Meeting Summaries and White Papers (2019–July 2020) (DOE/LX/07-2451&D1). The GWSP is a multi-year plan with near-term (0-3 years) activities and longer-term (beyond 3 years) activities planned. The specific timing and scope of each activity are developed by DOE based on data collected in the prior year(s). The GWSP and the C-400 OU Remedial Investigation projects are separate, but where activities overlap they are coordinated and the relevant information obtained from the remedial investigation will be incorporated into the GWSP.

The Groundwater Strategy Project (GWSP) field data collection schedule for FY 2022 is included in Attachment 3.

The FY 2022 plan includes quarterly walkdowns of a portion of Little Bayou Creek. During the October 6, 2021 meeting the group discussed that seeps may not be able to be observed during quarterly walkdowns, specifically during periods where the Ohio River is elevated above normal pool and where the seeps are not accessible or visible due to the Ohio River backing up into the creek. KY recommended instead coordinating the walkdowns with precipitation and river stage forecasts. Stream gauging is not planned for FY 2022 due to the ongoing construction of the TVA sheet pile wall and the intent to observe the system for any changes resulting from the presence of the wall.

Seeps. There have been no seep results above the maximum concentration limit (MCL) for trichloroethene (TCE) for many years. The location of the seeps and TCE data for the seeps are depicted on the figure included in Attachment 3. KY clarified that some of the seeps on the figure are in the creek and some are on the banks of the creek.

During the October 6, 2021 meeting, the group discussed that LBCSP5 routinely has flow and is able to be sampled, whereas many of the other previously identified seeps do not have flow consistently. KY reported that they have revised their stream walkdowns to go further up and downgradient of LBCSP5. KY also suggested the use of thermal imaging for seep identification in the winter months.

A creek bank walkdown of Little Bayou Creek in the vicinity of the new TVA sheet pile wall was performed December 2, 2021. The field crew identified the locations of Seeps 1-7 and 9 and noted three other seep areas in the vicinity of Seep 6. Seeps 8 and 10 were not evident. Only three locations had discharge of >0.1 gpm: Seep 4 (< 1 gpm flow), Seep 6 (several gpm flow), and a new seep on the west side of the creek across from Seep 6 (~0.3 gpm). Several of the seeps had no discernable flow and none of the newly observed seeps had flow sufficient to support sampling. No seeps were identified beyond the stretch of Little Bayou Creek where seeps had been identified previously.

The second walkdown attempt was made on March 13, 2022. Little Bayou Creek at the PGDP supply pipe line crossing of the creek (the north end of the "seeps area") was observed to be inundated in response to the current flood on the Ohio River. The water level was ~2 ft below the top of the creek bank at the pipeline crossing, which equates to 6 to 8 ft of water in Little Bayou Creek. It is not currently possible to walk down Little Bayou

Creek to assess the seeps. This finding is consistent with observations that Brian had shared with the MWG from prior year walkdowns performed by KDEP.

Use of drone and camera technology for the seeps observations is in review by FRNP. EPA provided additional information on successful use of drones for this application at a site in Navassa, North Carolina (Attachment 4).

KRCEE relayed that they have a task to look at seeps using a drone equipped with FLIR. The project will look at other project sites then apply what is learned to the Paducah site. The project intends to provide a proof-of-concept and an understanding of whether the seeps have or have not shifted. The drones will be tied to GPS, potentially also with LiDAR.

"No Go" Areas for Monitoring Well Installations. Corridors where overhead transmission lines have been removed have been considered for monitoring well placement, especially with respect to the west side of the NE Plume. A new substation (C-538) has been constructed east of the C-755 trailer complex. On the west side of the new substation, 161kV overhead have been installed along the existing overhead line corridor. On the east side of the new substation, 161kV overhead lines (near the C-755 parking lot and between K010 and K011) were installed along the 161kV lines. Most of the overhead lines have removed from McCaw Road to the plant with only a static line remaining on the towers on the south into the C-331 yard.

The group discussed during the January 12, 2022 meeting that no additional changes to the power line configurations are planned. Other medium and low voltage lines around the plant would need to be accounted for in any project, including monitoring well installation. Generally these lines would have 50 ft buffer. A figure of the current high-voltage overhead power lines is included in Attachment 3.

KY requested that any changes to facility overhead lines be shared with the MWG.

FRNP continues to coordinate with KY on the AIP monitoring wells sampling schedule.

The group agreed by consensus to add a new sub-topic to this agenda item for Anthropogenic Recharge. This sub-topic would capture discussion on site changes such as the recent changes to the high pressure fire water system.

5. Discussion on White Paper: *Evaluation of Anthropogenic Recharge Associated with the Process Buildings in Support of the Sitewide Groundwater Model (Large Building PZ White Paper)*

During the July 14, 2021 MWG meeting the group discussed that during the C-400 Remedial Investigation, no water has been observed in the UCRS in monitoring points installed through the foundation of the C-400 building. It was discussed that the C-400 building observations may not be representative of the buildings of interest in this white paper.

During the October 6, 2021 meeting the group discussed that information available on the historical and archived plant drawings show that the process buildings were constructed similar to one another and have a thin (9 to 12 inches thick) compacted gravel layer underlying the concrete floor of the buildings. There are drain lines in the compacted gravel layer, but the limited thickness of the gravel likely would make installation of traditional piezometers in the gravel layer impractical. The lack of water in the piezometers installed in the much thicker gravel layer (5 to 8 ft thick) underlying the concrete at C-400 also indicates that it is unlikely that there is water storage under the process building

concrete floors. KY suggested the team assess probing the concrete under the process building floors to confirm the gravel thickness and confirm the gravel is not saturated.

During the January 12, 2022 meeting, Ken Davis (FRNP) provided a summary of the roof replacement history at the site and the findings of the construction drawings review:

- The C-331 and C-335 roofs were replaced in 1981.
- Roof [drain] repairs were implemented at C-333 and C-337 in 2016-2017.
- There were reports of floor intrusion of water from below the foundations going back to 2002.
- The process buildings were constructed with a thin gravel layer under the concrete foundation (unlike at C-400 which has a 5 to 8 ft thick gravel layer underlying the concrete foundation).
- There is no gravel associated with the control rooms/basements in the process buildings, but there is gravel associated with the building footers.
- The paper includes a graded approach to understanding water presence under the process buildings and, as part of the graded approach, a modified piezometer design is included in the paper.

The draft paper was provided to the MWG for review on 2/15/2022 with comments requested back by 2/25/2022. Comments were provided by EPA and KY on 3/22/2022 and 3/23/2022, respectively.

KY summarized their comments from the 3/23/2022 email: more evidence is needed to fully characterize the extent and connectivity of gravel subbase (e.g., design vs as-built) and it is unclear how the options presented in the paper will be implemented and address uncertainty. The group discussed whether including other sources (e.g., pipe corridors and tunnels) would have a significant impact on the modeling. FRNP described the challenges of working in the process buildings and that likely only C-337 would be available for the study. Additionally, there are no electric conduits under the buildings, and no gravel backfills behind the walls.

EPA summarized their comments from the 3/22/2022 email: uncertainty regarding the three options proposed The group discussed that the site is not in a position to develop a work plan and agreed that many of the comments to date could be addressed in the DQOs. The group agreed by consensus to move this topic to a new topic in the next MWG meeting agenda.

The group discussed and agreed by consensus to revise the schedule for the Large Building PZ White Paper; revised dates will be provided to the MWG separately. Additionally, the agenda for the July meeting will include a discussion on whether the approaches included in the paper are needed for near-term projects and if the field implementation should be pursued.

Activity	Target Start	Target Finish
~~Quarterly Meeting (October/FY21Q1)~~		~~10/7/2020~~
~~Develop Outline for Large Building PZ White Paper~~	~~10/14/2020~~	~~12/11/2020~~
~~Provide Large Building PZ White Paper Outline to MWG~~		~~12/11/2020~~
~~MWG Review Large Building PZ White Paper Outline~~	~~12/11/2020~~	~~1/13/2021~~
~~Quarterly Meeting (January/FY21Q2)~~		~~1/13/2021~~
~~Revise Outline for Large Building PZ White Paper Based on MWG Discussions~~	~~1/13/2021~~	~~1/28/2021~~

Activity	Target Start	Target Finish
~~VI Field Sampling / Laboratory Analysis / Validation~~	~~Feb 21~~	~~Apr 21~~
~~Quarterly Meeting (April/FY21Q3)~~		~~4/7/2021~~
~~Quarterly Meeting (July/FY21Q4)~~		~~7/14/2021~~
~~Develop Draft Large Building PZ White Paper~~	~~9/1/2021~~	~~1/12/2022~~
~~Quarterly Meeting (October/FY22Q1)~~		~~10/6/2021~~
~~Submit Draft Large Building PZ White Paper to MWG~~		~~2/17/2021~~ ~~Actual: 2/15/2022~~
~~Quarterly Meeting (January/FY22Q2)~~		~~1/12/2022~~
~~MWG Review and Provide Comments on Draft Large Building PZ White Paper~~	~~1/23/2022~~	~~3/25/2022~~
MWG Meeting to Discuss Draft Large Building PZ White Paper		4/6/2022 (was TBD)
Revise Draft Large Building PZ White Paper	2/17/2022*	4/15/2022*
Submit Final Large Building PZ White Paper to EPA and KY		5/19/2022*

Items shown in strikeout text are completed.
* Dates likely to be revised based on meeting discussion presented above.

6. Plant-Wide Seismic Update

Section 1.1.2, "Regional Hydrogeology," references an axis in describing thickness trends for gravel deposits forming the RGA. EPA would like to discuss if the use of the term axis has any implied significance to groundwater flow direction(s) (i.e., a north-south lateral groundwater flow divide) or any implication for implied subsurface structural feature(s) forming the RGA (i.e., the existence of an east-west fault-controlled structural low).

The site geologist explained the east-west trend is consistent with ancestral Tennessee River and is believed to be an erosional surface (thalweg is the geomorphology term). EPA suggested that the Paducah Site area may have several generations of seismic activities, overprinting of seismicity could be happening, and east-west faulting may have occurred. Steve Hampson had a follow-up after discussion with Dr. Woolery and Dr. Zhu.

Steve Hampson reported that an east-west trend is prevalent at PGDP, as evidenced in both regional and local studies. Regional faults commonly trend northeast-southwest but that there could be local structural controls under PGDP that could influence groundwater flow. Seismic studies have not previously been conducted between the east and west fences and from the Porters Creek terrace to north fence because it was not possible to filter out the noise of the operating plant. Most of the plant infrastructure is no longer operating and Steve Hampson discussed that Dr. Woolery has noted there are now seismic reflection techniques that could give a better view of what the structure is beneath the site.

DOE and FRNP are reviewing whether there are any ways to further reduce (temporarily) sources of noise to facilitate new testing without disrupting site activities. Dr. Woolery has offered to support any requests or initiatives that may develop regarding additional seismic surveys at the Paducah Site.

The group discussed that there was no evidence of faulting encountered during the C-400 remedial investigation. The group also discussed whether this topic should follow the lithology paper discussions or if this topic could be advanced independently. KY's understanding is that the current level of plant operations with updated technology may provide a possibility for seismic studies in the plant area.

S. Hampson (KRCEE) is willing to discuss with Dr. Woolery if that is the appropriate next step. There is no funding currently for this type of work, but could be discussed for FY 2023.

7. CSM for the McNairy in the C-400 Complex Area

FRNP has set up a website to house a library of McNairy information. Access the website at the following link: https://fourriversnuclearpartnership.com/McNCSM. The site requires a password that has been sent separately. Contact Stefanie if you need the password to the website.

A lithology white paper is being prepared as part of the resolution of dispute on the CERCLA Five Year Review. DOE will issue the technical paper within one month of submittal of the D1 C-400 Complex OU RI/FS Report to support the review and comment of the C-400 specific data interpretation as part of the C-400 Complex OU RI/FS Report review process and the performance of the FY 2023 Five-Year Review revised protectiveness determinations for the Northeast, Northwest, and Water Policy response actions. The regulatory milestone date for the D1 C-400 Complex OU RI/FS Report has been revised to October 7, 2022.

A draft schedule and annotated outline for the paper were discussed during the October 2020 Groundwater MWG meeting. The schedule was revised to reflect the new C-400 Complex OU RI/FS Report date and was discussed during the January 13, 2021 meeting (see below). The plan continues to be that the draft Lithology Paper will be available to the MWG before the D1 C-400 Report is submitted so that substantive comments may be addressed prior to the D1 C-400 Report being issued. The Lithology Paper will then be revised and submitted.

Activity	Target Start	Target Finish	Notes
~~FRNP/DOE Develop Outline for Draft McNairy Lithologic Technical Paper~~	~~7/7/2020~~	~~9/30/2020~~	COMPLETE
~~Provide Draft McNairy Lithologic Technical Paper Outline to MWG~~		~~9/30/2020~~	COMPLETE
~~MWG Review Draft McNairy Lithologic Technical Paper Outline~~	~~9/30/2020~~	~~10/7/2020~~	COMPLETE
~~Quarterly Meeting (October/FY21Q1)~~		~~10/7/2020~~	COMPLETE
~~FRNP/DOE Revise Draft Outline for McNairy Lithologic Technical Paper Based on MWG Discussions~~	~~10/7/2020~~	~~10/22/2020~~	COMPLETE
~~Provide Final Outline for McNairy Lithologic Technical Paper to MWG~~		~~10/22/2020~~	COMPLETE
~~Quarterly Meeting (January/FY21Q2)~~		~~1/13/2021~~	COMPLETE
~~Quarterly Meeting (April/FY21Q3)~~		~~4/7/2021~~	COMPLETE
~~Quarterly Meeting (July/FY21Q4)~~		~~7/14/2021~~	COMPLETE
~~Quarterly Meeting (October/FY21Q3)~~		~~10/6/2021~~	COMPLETE
~~Quarterly Meeting (January/FY22Q2)~~		~~1/12/2022~~	~~COMPLETE~~
FRNP/DOE Develop Draft McNairy Lithologic Technical Paper Text	8/4/2021	3/10/2022	In progress
Finish Collection of C-400 Lithology Data		3/16/2022	From C-400 Schedule Drilling completed 12/2/2021
FRNP/DOE Incorporate C-400 Results into Draft McNairy Lithologic Technical Paper	3/16/2022	8/11/2022	
Quarterly Meeting (April/FY22Q3)		4/6/2022	

Activity	Target Start	Target Finish	Notes
Issue Draft McNairy Lithologic Technical Paper to MWG		7/1/2022 (was 8/11/2022)	
Quarterly Meeting (July/FY22Q4)		7/13/2022	
MWG Meeting to Discuss Draft McNairy Lithologic Technical Paper		7/20/2022 (was 8/24/2022)	
MWG Review and Provide Comments on Draft McNairy Lithologic Technical Paper	7/1/2022 (was 8/11/2022)	8/1/2022 (was 9/12/2022)	
MWG Provide Comments on Draft McNairy Lithologic Technical Paper		8/1/2022 (was 9/12/2022)	
Develop C-400 RI/FS Report		9/14/2022	From C-400 Schedule
Quarterly Meeting (October/FY23Q1)		10/5/2022	Planning date
C-400 RI Report Submitted to EPA and KY		10/7/2022	Current Milestone
FRNP/DOE Revise Draft McNairy Lithologic Technical Paper	8/1/2022 (was 9/12/2022)	10/7/2022 (was 11/7/2022)	No formal CRS
Submit Final McNairy Lithologic Technical Paper to EPA and KY		11/7/2022	Tech Paper Due 1 Month After C-400 RI Report (Currently 10/7/2022)

Items shown in strikeout text are completed.

The KRCEE spreadsheet database of soil boring logs (R10 HydroLitho Dbase posted 121620.xlsx) is available at https://fourriversnuclearpartnership.com/McNCSM.

The final annotated outline was included in the October 14, 2020 MWG meeting summary (sent to participants on 11/23/2020 and with agreed-upon revisions discussed during the 1/13/2021 meeting). No comments were received on the outline and the outline was considered final. The MWG plans to discuss the Draft McNairy Lithologic Technical Paper text between the July 2022 and October 2022 MWG meetings.

During the October 6, 2021 meeting, the group discussed that observations from the C-400 field investigation drilling does not indicate fault interruption in the McNairy. DNAPL has not been observed in McNairy soils to date, indicating DNAPL migration through the RGA into the McNairy is not occurring. It is reasonable to conclude that if this is not occurring at C-400, it is likely not occurring elsewhere at the site. The group also discussed the need for rapid turnaround on any comments and KY indicated their willingness to have a meeting on the paper to facilitate the quick review.

During the January 12, 2022 meeting, the group discussed the findings of the C-400 remedial investigation did not indicate any deep sources of DNAPL that would penetrate the basements or the McNairy formation and that concentrations generally decreased with depth.

The final annotated outline for this paper was included in the meeting summary for the 1/13/2022 meeting and is included with this agenda as Attachment 5.

The group discussed earlier in the meeting under Agenda Item 2, FY 2022 Work Plan/Schedule, that the McNairy Lithologic Technical Paper schedule has been accelerated by approximately 6 weeks. Due to time limit constraints, the group did not discuss this topic in detail.

8. Resurvey of wells

The field resurveying effort for the monitoring well reference point elevations was completed October 9, 2020 and the data review was completed in November 2020. The data are in the process of being reviewed for upload to OREIS. A white paper summarizing the approach and scope of the resurvey work was developed and has been appended to the 2021 update to the P-QAPP.

A second white paper on potential impacts of the new survey data and the impact to the groundwater model has been developed and is in review with the MWG (draft provided to the group on 2/28/2022). The paper focuses on the adequacy of the model in light of new monitoring well survey data; no modeling has been performed as part of the paper development. The paper includes an evaluation on the residuals from the 2016 modeling calibration and any impact the new survey data have on that calibration. Once finalized, this second survey white paper is currently planned to be appended to the 2016 Groundwater Model Report. DOE, KY and EPA have agreed on this approach.

Any comments to date on the 2/28/2022 document provided to the group will be discussed during this meeting.

Due to time limit constraints, the group did not discuss this topic during the meeting.

9. Precipitation and Ohio River Stage

Attachment 6 includes precipitation and Ohio River stage charts through March 28, 2022.

Due to time limit constraints, the group did not discuss this topic during the meeting.

10. Synoptic Water Level Events and Ohio River Levels

Stream gauging has been discussed as part of out-year activities. See October 2018 Meeting Summary for additional information. Stream gauging will support new modeling.

During FY 2022, quarterly walkdowns of portions of Little Bayou Creek are planned to identify any new seeps as part of the Groundwater Strategy project and to identify locations for potential future stream gauging, as appropriate.

During the January 12, 2022 meeting, KY requested the group consider if water level events can be performed in response to changes in Ohio River stages. FRNP/DOE is reviewing the historical documentation for a prior paper on groundwater level responses to Ohio River stage elevations (e.g., Clausen paper?).

Due to time limit constraints, the group did not discuss this topic during the meeting.

11. Projects on the "Watch Topics" List

- **TVA Changes.** During the October 2020 and January 2021 meeting, the MWG discussed the construction of the new ash ponds and a recent RFP for a 3,800 ft sheet pile wall constructed in close proximity to Little Bayou Creek and several seeps. The sheet pile wall may intercept the RGA and influence the creek.

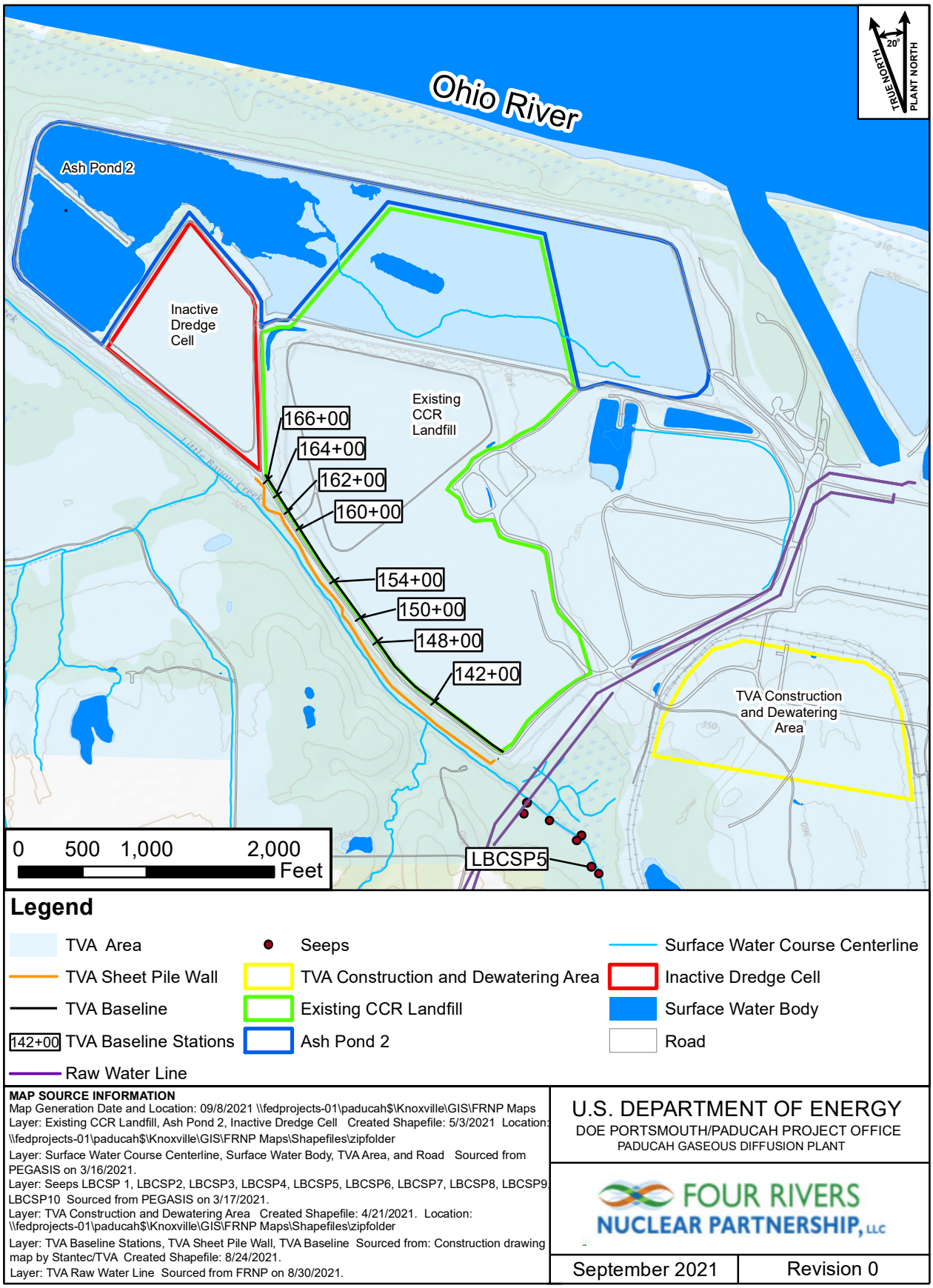
  During the July 14, 2021 meeting, the MWG discussed the sheet pile wall being installed by TVA along Little Bayou Creek and along the southwest portion of the existing coal combustion residuals

(CCR) landfill (as shown on the Figure 1). The wall is intended to stabilize the creek's bank, as opposed to control groundwater. KY/TVA provided as-built drawings showing the installation depth of the wall. A cross section of the sheet pile wall, the creek, and the interpolated upper and lower limits of the RGA is shown in Figure 2.

Based on the information available in the TVA drawings, the sheet pile wall, the wall extends a significant depth into the RGA. The group discussed during the October meeting that the wall joints are not sealed, and TVA will confirm that the sheet piles themselves are solid (not perforated). TVA will confirm whether the notations are design or as-built and relay findings to the group; TVA will also confirm the depths of the sheet pile wall construction. Construction of the TVA sheet pile wall was completed in December 2021. Tabitha Ester (TVA) provided follow-up information on the sheet pile as-built elevations; this information was forwarded to the group on 3/25/2022.

Due to time limit constraints, the group did not discuss this topic during the meeting.

Figure 1


Ohio River
TRUE NORTH
20°
PLANT NORTH
Ash Pond 2
Inactive Dredge Cell
Existing CCR Landfill
166+00
164+00
162+00
160+00
154+00
150+00
148+00
142+00
TVA Construction and Dewatering Area
LBCSP5
0 500 1,000 2,000 Feet
Legend
TVA Area
Seeps
Surface Water Course Centerline
TVA Sheet Pile Wall
TVA Construction and Dewatering Area
Inactive Dredge Cell
TVA Baseline
Existing CCR Landfill
Surface Water Body
142+00 TVA Baseline Stations
Ash Pond 2
Road
Raw Water Line
MAP SOURCE INFORMATION
Map Generation Date and Location: 09/8/2021 \\fedprojects-01\paducah$\Knoxville\GIS\FRNP Maps
Layer: Existing CCR Landfill, Ash Pond 2, Inactive Dredge Cell Created Shapefile: 5/3/2021 Location: \\fedprojects-01\paducah$\Knoxville\GIS\FRNP Maps\Shapefiles\zipfolder
Layer: Surface Water Course Centerline, Surface Water Body, TVA Area, and Road Sourced from PEGASIS on 3/16/2021.
Layer: Seeps LBCSP 1, LBCSP2, LBCSP3, LBCSP4, LBCSP5, LBCSP6, LBCSP7, LBCSP8, LBCSP9, LBCSP10 Sourced from PEGASIS on 3/17/2021.
Layer: TVA Construction and Dewatering Area Created Shapefile: 4/21/2021. Location: \\fedprojects-01\paducah$\Knoxville\GIS\FRNP Maps\Shapefiles\zipfolder
Layer: TVA Baseline Stations, TVA Sheet Pile Wall, TVA Baseline Sourced from: Construction drawing map by Stantec/TVA Created Shapefile: 8/24/2021.
Layer: TVA Raw Water Line Sourced from FRNP on 8/30/2021.
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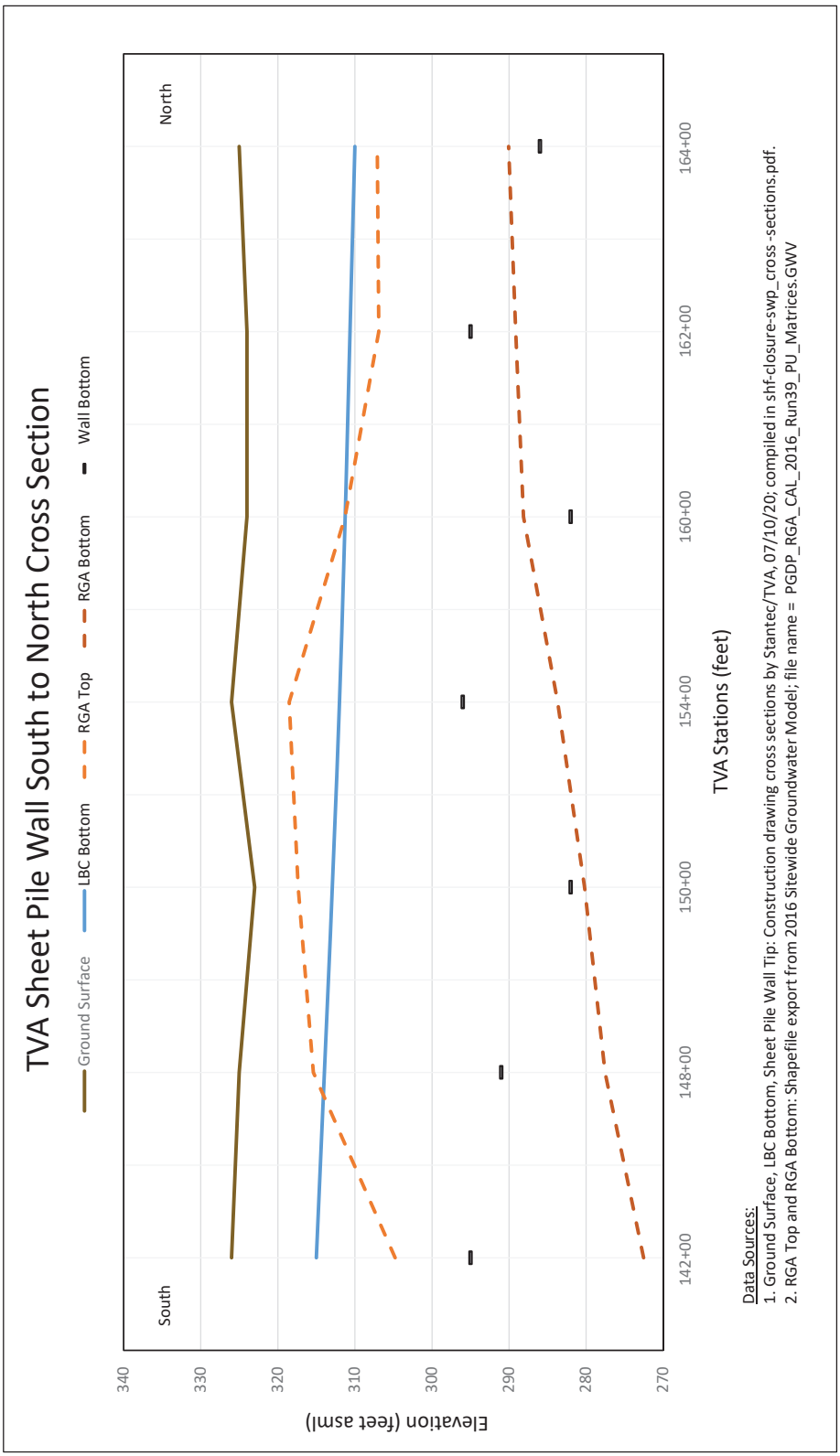
September 2021
Revision 0

Figure 2


TVA Sheet Pile Wall South to North Cross Section
Ground Surface
LBC Bottom
RGA Top
RGA Bottom
Wall Bottom
South
North
Elevation (feet asml)
340
330
320
310
300
290
280
270
142+00
148+00
150+00
154+00
160+00
162+00
164+00
TVA Stations (feet)
Data Sources:
1. Ground Surface, LBC Bottom, Sheet Pile Wall Tip: Construction drawing cross sections by Stantec/TVA, 07/10/20; compiled in shf-closure-swp_cross -sections.pdf.
2. RGA Top and RGA Bottom: Shapefile export from 2016 Sitewide Groundwater Model; file name = PGDP_RGA_CAL_2016_Run39_PU_Matrices.GWV

- **Wetlands map layer.** The site completed the review of wetlands maps in October 2021.
  - Different projects have used different source data for wetlands and floodplains maps.
  - The map layers previously available in PEGASIS did not include information from the Waste Disposal Alternatives (WDA) project.

  This update is complete and available in PEGASIS and a screenshot of the new layer was provided in the January 12, 2022 meeting summary. Propose to remove this watch topic from future meetings.

  The group agreed by consensus to remove this topic from future meetings.

- **PFAS.** PFAS is discussed as part of the Risk Assessment Working Group and has ties to this working group as well. DOE and FRNP are proceeding with data quality objectives (DQOs) and sampling plan development for a PFAS groundwater sampling project. The current plan for the project is to complete the DQOs and sampling plan in FY 2022 with sampling to be performed in FY 2023. Updates on this project will be provided to the group as they become available.

  - Rich Bonczek (DOE) is a member of the DOE PFAS Coordinating Committee.

  - DOE HQ PFAS Working Group meetings were held 1/20/2022 and 3/24/2022.

  Due to time limit constraints, the group did not discuss this topic during the meeting.

12. FY 2022 Presentations

The EarthCon presentation will be moved back in the schedule as their contract with DOE is pending. MWG members should provide any presentation requests to Stefanie. Potential topics for future meetings:

- C-400 Complex remedial investigation
- Lithology
- TCE degradation rates
- Site water balance items (e.g., leaks from piping, above and below ground piping, building foundation gravel layers, etc.)

- October 2021: FRNP presented on the *2016 Update of the Paducah Gaseous Diffusion Plant Sitewide Groundwater Flow Model* (DOE/LX/07-2415&D2).

  Following the presentation, a number of items were discussed by the group:
  - The group asked why only Outfall 001 was specifically included in the modeling: DOE and FRNP reviewed the project notes to understand if the other outfalls (i.e., 008, 009, or 010) were considered for explicit inclusion in the model. From the Modeling Working Group Meeting Minutes—June 24, 2016 (2016 Groundwater Flow Model Report, Appendix A, page A-30):

    > Brian asked Denise if she found anything else of interest during her site visit. Denise noted that it had rained heavily for about an hour when she arrived at the site. Brian mentioned adding recharge points at outfall points but added that flow amounts are uncertain. Denise responded that she did not identify any areas other than outfall 001 that appeared to be areas of increased recharge.

- The group asked whether there are any discrepancies with the new survey data for the monitoring wells: the analysis is ongoing, but the preliminary review shows no large change in levels or residuals that would result in an impact to the model calibration.
- EPA noted that there were a number of comments from EPA at the time of the modeling work that were not incorporated into the model.
- KY proposed that a dialog be initiated on the current version of the model and whether an update should be performed.
- EPA asked how the model would be used to drive remedial decisions and whether there was benefit to update the model for some of the marginal items. DOE explained that the focus of the model was on source areas and that the model downgradient results were a good representation of the plume configuration at the time of the modeling. The group discussed that the utility of the model as a predictive tool would only be appropriate for a certain amount of time due to ongoing changes in the operational stance at the site.
- KRCEE performed a review of the 2016 flow model: 2018 KRCEE report, *Review for the 2016 Update of the Paducah Gaseous Diffusion Plant Sitewide Groundwater Flow Model*; and a review of the 2008 TCE transport model: 2020 KRCEE report, *Interim TCE Transport Model for the Paducah Gaseous Diffusion Plant Site*.

- January 12, 2022: KRCEE presented on their reviews of the Paducah site groundwater models.

- April 6, 2022: FRNP will present as summary of the EPA and KY comments to the *Summary of the 2016 Groundwater Flow Model Update.*

The presentation, Summary of the 2016 Groundwater Flow Model Update*, was made to the group (Attachment 7).*

- *Slide 2: KY clarified for the group that they acknowledged receipt of the final report (dated July 26, 2017).*
- *Slide 8: EPA requested information on whether there is funding to update the model or address topics of technical disagreement. The group discussed that several topics are incorporated into the Groundwater Strategy project. The group also discussed the recommendations from the white paper* Measurement of Hydraulic Conductivity in the Regional Gravel Aquifer Using Monitoring Wells at the Paducah Site *(FRNP-RPT-0010). This white paper is included in the* Compilation of Meeting Summaries and White Papers (2017-2018)*, DOE/LX/07-2437&D1 (DOE 2019).*
- *Slide 9: DOE discussed that there are too many model constraints (e.g., hydraulic conductivity limits) and that there is not enough water in the model (e.g., that the recharge is underestimated) for the KRCEE fate and transport model to replicate the plumes. EPA (N. Ahsanuzzaman) agreed that the correct approach would have been to develop the flow model followed by development of a transport model, as was done for the 2008 model, and that the results of the transport model would inform the flow model, and vice versa, iteratively. The group discussed that slug testing has been evaluated as potentially being able to resolve some uncertainties in the hydraulic conductivity, but that this type of testing is problematic due to the high hydraulic conductivity and is often prohibitively expensive at this site. Long-term pressure transducer data being collected on a North-South transect as part of the Groundwater Strategy project may help inform the model. EPA relayed an ongoing concern that the boundary conditions and recharge are tied to hydraulic conductivity.*
- *Slide 10: The group discussed that there are things happening in the RGA in the region of the NEPCS transect wells that are not well understood and that it appears that there are high conductivity flow paths in this area that cannot be predicted. This was initially evidenced when*

there was unanticipated TCE mass mobilization when the new NEPCS extraction wells were started; the extraction rates for these wells were throttled back due to the larger than anticipated influence of pumping. The group will consider if a white paper on this topic is something the group would like to take on. EPA recommended that their groundwater modeler review the KRCEE papers.

- *Slide 15: FRNP provided a summary of findings relevant to the McNairy Formation from the C-400 remedial investigation. Generally, TCE concentrations decrease with depth into the formation although there is an area in the vicinity of the degreaser tanks that is still under evaluation. DyeLIF testing results indicate there is potentially residual DNAPL a couple feet into the formation. DOE commented that source material in the formation that would require treatment.*
- *Slide 16: EPA discussed the work that Dr. Ron Falta (Clemson University) performed for the steam treatability project at C-400 (interim remedy) and suggested that anisotropy sensitivity analyses incorporate that work's findings. FRNP relayed that the steam treatability employed an anisotropy between 20:1 and 30:1.*
- *General Discussion:*
    - *EPA remarked that they are open to continuing to develop the model within cost and schedule constraints and asked if DOE planned to rely on the model for C-400 given the EPA position that the model cannot be used for remedy selection. DOE replied that management of uncertainties would be key to any future model development and that the team did not intend to rely on the model for remedy selection; the remedy (e.g., hydraulic capture or containment, etc.) is expected to have a larger impact on the model than the model on the remedy evaluation for C-400. The model already shows that remediation is needed at C-400, but there is not much impact on alternatives: the model can be used to inform pumping rates for pump and treat remedial components and a barrier wall would impact the flow field.*
    - *DOE discussed that the next project that would need the model to make a remedial decision would be the Waste Disposal Alternatives project scheduled to resume in 2028-2029 and that the DOE PPPO Manager has requested an approved model be available for that project.*
    - *KY requested additional information on the timing of the Groundwater Strategy activities as they relate to model updates and whether any activities could be accelerated to support a model update.*
    - *EPA acknowledged that there are a lot of technical details to work through and asked that a clear model goal be defined if the meetings on the model resume. KY recommended that a comprehensive list of reasons for the model update be documented. DOE and FRNP are to meet prior to the next MWG meeting to discuss a potential update to the model.*

13. Poll MWG Members/Open Discussion

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Attachment 1

Groundwater Strategy Potentiometric Map
November 2021

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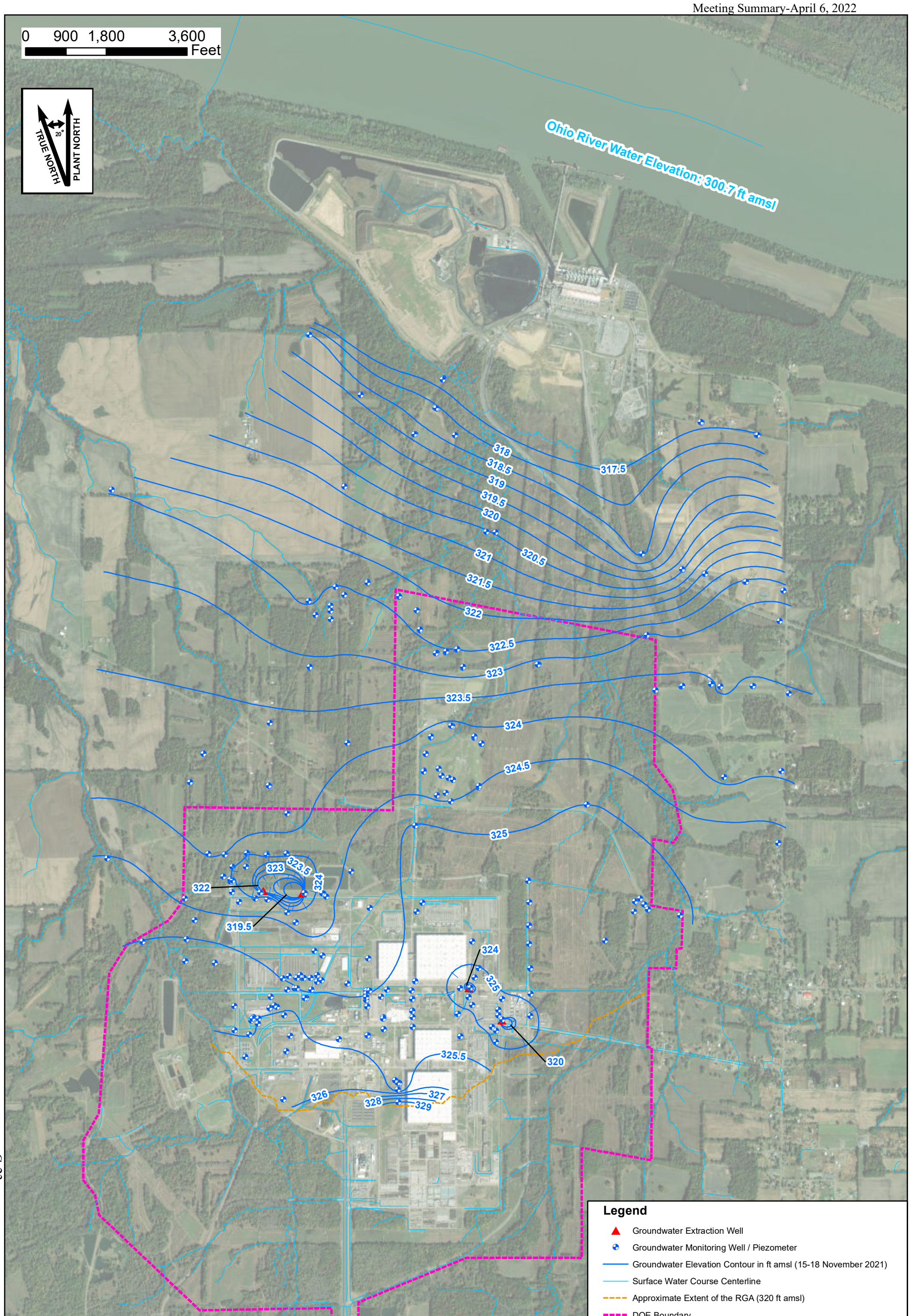

MAP SOURCE INFORMATION

Map Generation Date and Location - 1/31/2022 Geosyntec\\fedprojects-01\paducah$\Knoxville\GW Strategy\GIS\MXDs\2020-2021 Potentiometric Surface Maps
Map Layer Location: Geosyntec\\fedprojects-01\paducah$\Knoxville\GW Strategy\GIS\MXDs\2020-2021 Potentiometric Surface Maps\November 2021 Potentiometric Surface Map.mxd
Image Source: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Shapefile for Surface Water Course Centerline was obtained from Pegasis (https://pegasis.pad.pppo.gov/), downloaded on 12/1/2021.
DOE Property Boundary provided by FRNP 2/4/2021.
Northing and easting of wells obtained from Pegasis, downloaded on 12/7/2021.
Groundwater elevation was based on the November 15-18, 2021 measurements. Ohio River elevation was estimated as the average of elevations measured by the USGS at Paducah Station USGS 0361100 and Olmsted, IL Station (USGS 03612600) between November 15-18, 2021.
amsl = above mean sea level

Note:
In areas where groundwater monitoring wells are sparse (such as north of the DOE boundary), interpretation of the groundwater elevation contours was based on professional judgment. Therefore, the potentiometric contours in these areas should be considered approximate.

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Figure 1. November 2021 RGA Potentiometric Surface Map

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Attachment 2

Groundwater Elevation Data for TVA Wells Collected by KY on February 23, 2022

OREIS NAME	Well	Description	Aquifer	Top of Casing	Top of Ground	xconv Easting (Ft)	yconv Northing (Ft)	Status	Screen Top Depth (Ft)	Screen bot depth (Ft)	tscreenelev (Ft)	bscreenelev (Ft)	GW Elev. (Datum - DTW)	Water Level	Date & Time	Barometric Pressure (inHg)	Measuring Point
TVAGW-6D	TVAGW-6D	4" PVC	Upper RGA	368.8	365.9	760787.8774	1946731.539	active	58.3	68.3	307.6	297.6	317.15	51.65	02/23/2022_1031	30.43	TOC
TVAGW-5D	TVAGW-5D	4" PVC	Upper RGA	368.5	365.7	760131.6259	1947315.953	active	60.1	70.1	305.6	295.6	316.8	51.7	02/23/2022_1034	30.43	TOC
TVAGW-4D	TVAGW-4D	4" PVC	Upper RGA	365.8	363	759456.7195	1947561.73	active	57	67.5	306	295.5	317.32	48.48	02/23/2022_1037	30.43	TOC
TVAGW-3D	TVAGW-3D	4" PVC	Upper RGA	363.8	360.9	758982.49	1947793.858	active	65.3	75.3	295.6	285.6	317.58	46.22	02/23/2022_1041	30.43	TOC
TVAGW-2D	TVAGW-2D	4" PVC	Upper RGA	370	367.1	759966.7809	1944870.473	active	55.6	65.6	311.5	301.5	321.49	48.51	02/23/2022_1028	30.43	TOC
TVAGW-1D	TVAGW-1D	4" PVC	Upper RGA	370.1	367.5	757847.0459	1946203.79	active	56	66	311.5	301.5	316.28	53.82	02/23/2022_1044	30.44	TOC
TVA-D74B	SHF-D74B	2" PVC	Upper RGA	331.99	329	756125.35	1956489.82	active	39	49	290	280	319.41	12.58	02/23/2022_0950	30.42	TOC
TVA-D30B	SHF-D30B	2" PVC	Upper RGA	324.61	320.9	757594	1955563.41	active	39	49	281.9	271.9	319.76	4.85	02/23/2022_1012	30.42	TOC
TVA-D17	SHF-D17	2" PVC	Upper RGA	365.43	362.8	758809.17	1950015.71	active	14	17	348.8	345.8	318.02	47.41	02/23/2022_1019	30.42	TOC
SHF-102G	SHF-102G	4" PVC	Upper RGA	362.85	359.1	845764.387	1927473.284	active	47.1	57.4	312	301.7	321.85	41	02/23/2022_1057	30.40	TOC
TVA River Elevation														320.21	02/23/2022_1020	30.42	TVA

LEGEND:

TIC: Top of Casing

DTW: Depth to Water

National Geodetic Vertical Datum of 1929 (NGVD 29).

Attachment 3

2022 Groundwater Strategy Project Planning Dates and EMP Schedule

Groundwater Strategy Project Planning Dates

Activity	Planning Date
~~FY 2022 Groundwater Strategy Project Management Plan~~	~~Dec-2021~~
~~FY 2022 Q1 Potentiometric Map~~	~~4/6/2022~~
~~Quarterly Meeting (April/FY22Q3)~~	~~4/6/2022~~
FY 2022 Q2 Potentiometric Map	7/13/2022
Quarterly Meeting (July/FY22Q4)	7/13/2022
Activity #4 White Paper: Comparison of Regional Groundwater Flow Pre- and Post-Construction and Operation of Olmsted Dam	7/28/2022 (was 4/8/2022)
Activity #2 White Paper: Regional and Localized Groundwater Flow and TCE Trends, East Side of Downgradient Northeast Plume	8/18/2022
Activity #8 White Paper: Regional and Localized Groundwater Flow and TCE Trends, West Side of Downgradient Northeast Plume	Oct-2022
FY 2022 Q3 Potentiometric Map	Oct-2022
Quarterly Meeting (October/FY23 Q1)	Oct-2022
FY 2022 Groundwater Strategy Project Management Plan	Nov-2022
FY 2022 Q4 Potentiometric Map	Jan-2023
Quarterly Meeting (October/FY23 Q1)	Jan-2023

Monitoring Wells Planned For Colloidal Borescope and Pressure Transducer Deployment

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW20 (also R4)	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW63		M1			M1			M1			M1	
MW65		M1			M1			M1			M1	
MW66		M1			M1			M1			M1	
MW67		M1			M1			M1			M1	
MW68		M1			M1			M1			M1	
MW71		M1			M1			M1			M1	
MW72		M1			M1			M1			M1	
MW73		M1			M1			M1			M1	
MW76		M1			M1			M1			M1	
MW77 (PZ)		M1			M1			M1			M1	
MW78		M1			M1			M1			M1	
MW79		M1			M1			M1			M1	
MW80		M1			M1			M1			M1	
MW81		M1			M1			M1			M1	
MW84		M1			M1			M1			M1	
MW86		M1			M1			M1			M1	
MW87		M1			M1			M1			M1	
MW89		M1			M1			M1			M1	
MW90A		M1			M1			M1			M1	
MW92		M1			M1			M1			M1	
MW93		M1			M1			M1			M1	
MW95A		M1			M1			M1			M1	
MW98	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW99		M1			M1			M1			M1	
MW100		M1			M1			M1			M1	
MW102		M1			M1			M1			M1	
MW103		M1			M1			M1			M1	
MW106A	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW108		M1			M1			M1			M1	
MW120		M1			M1			M1			M1	
MW121		M1			M1			M1			M1	
MW122		M1			M1			M1			M1	
MW123		M1			M1			M1			M1	
MW124		M1			M1			M1			M1	

Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW125		M1			M1			M1			M1	
MW126		M1			M1			M1			M1	
MW132		M1			M1			M1			M1	
MW133		M1			M1			M1			M1	
MW134		M1			M1			M1			M1	
MW135	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW137		M1			M1			M1			M1	
MW139		M1			M1			M1			M1	
MW144		M1			M1			M1			M1	
MW145		M1			M1			M1			M1	
MW146		M1			M1			M1			M1	
MW147		M1			M1			M1			M1	
MW148		M1			M1			M1			M1	
MW150		M1			M1			M1			M1	
MW155	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW156	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW161		M1			M1			M1			M1	
MW163		M1			M1			M1			M1	
MW165A		M1			M1			M1			M1	
MW168		M1			M1			M1			M1	
MW169		M1			M1			M1			M1	
MW173		M1			M1			M1			M1	
MW175		M1			M1			M1			M1	
MW178	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW185		M1			M1			M1			M1	
MW188		M1			M1			M1			M1	
MW191		M1			M1			M1			M1	
MW193		M1			M1	M1+CB		M1	M1+CB		M1	
MW194		M1			M1			M1			M1	
MW197		M1			M1			M1			M1	
MW199		M1			M1			M1			M1	
MW200	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW201		M1			M1			M1			M1	
MW202		M1			M1			M1			M1	
MW203		M1			M1			M1			M1	
MW205		M1			M1			M1			M1	
MW220		M1			M1			M1			M1	
MW221		M1			M1			M1			M1	

Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW222		M1			M1			M1			M1	
MW223		M1			M1			M1			M1	
MW224		M1			M1			M1			M1	
MW225		M1			M1			M1			M1	
MW226		M1			M1			M1			M1	
MW227		M1			M1			M1			M1	
MW233		M1			M1			M1			M1	
MW236		M1			M1			M1			M1	
MW238		M1			M1			M1			M1	
MW239		M1			M1			M1			M1	
MW240		M1			M1			M1			M1	
MW241A		M1			M1			M1			M1	
MW242		M1			M1			M1			M1	
MW243		M1			M1			M1			M1	
MW244		M1			M1			M1			M1	
MW245		M1			M1			M1			M1	
MW247		M1			M1			M1			M1	
MW248		M1			M1			M1			M1	
MW249		M1			M1			M1			M1	
MW250		M1			M1			M1			M1	
MW252		M1			M1			M1			M1	
MW253A		M1			M1			M1			M1	
MW255		M1			M1			M1			M1	
MW256		M1			M1			M1			M1	
MW257		M1			M1			M1			M1	
MW258		M1			M1			M1			M1	
MW260		M1			M1			M1			M1	
MW261		M1			M1			M1			M1	
MW262		M1			M1			M1			M1	
MW283		M1			M1			M1			M1	
MW284		M1			M1			M1			M1	
MW288		M1			M1			M1			M1	
MW291		M1			M1			M1			M1	
MW292		M1			M1			M1			M1	
MW293A		M1			M1			M1			M1	
MW294A		M1			M1			M1			M1	
MW325		M1			M1			M1			M1	
MW326		M1			M1			M1			M1	

Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW327		M1			M1			M1			M1	
MW328		M1			M1			M1			M1	
MW329		M1			M1			M1			M1	
MW330		M1			M1			M1			M1	
MW333		M1			M1			M1			M1	
MW337		M1			M1			M1			M1	
MW338		M1			M1			M1			M1	
MW339		M1			M1			M1			M1	
MW340		M1			M1			M1			M1	
MW341	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW342		M1			M1			M1			M1	
MW343		M1			M1			M1			M1	
MW345		M1			M1			M1			M1	
MW346		M1			M1			M1			M1	
MW347		M1			M1			M1			M1	
MW353		M1			M1			M1			M1	
MW354	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW355		M1			M1			M1			M1	
MW356		M1			M1			M1			M1	
MW357		M1			M1			M1			M1	
MW358		M1			M1			M1			M1	
MW360		M1			M1			M1			M1	
MW361		M1			M1			M1			M1	
MW363		M1			M1			M1			M1	
MW364		M1			M1			M1			M1	
MW366		M1			M1			M1			M1	
MW367		M1			M1			M1			M1	
MW369		M1			M1			M1			M1	
MW370		M1			M1			M1			M1	
MW372		M1			M1			M1			M1	
MW373		M1			M1			M1			M1	
MW376		M1			M1			M1			M1	
MW380		M1			M1			M1			M1	
MW381		M1			M1			M1			M1	
MW384		M1			M1			M1			M1	
MW385		M1			M1			M1			M1	
MW387		M1			M1			M1			M1	
MW388		M1			M1			M1			M1	

Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW391		M1			M1			M1			M1	
MW392		M1			M1			M1			M1	
MW394		M1			M1			M1			M1	
MW395		M1			M1			M1			M1	
MW397		M1			M1			M1			M1	
MW409		M1			M1			M1			M1	
MW410		M1			M1			M1			M1	
MW411*		M1			M1			M1			M1	
MW414		M1			M1			M1			M1	
MW415		M1			M1			M1			M1	
MW416		M1			M1			M1			M1	
MW417		M1			M1			M1			M1	
MW418		M1			M1			M1			M1	
MW419		M1			M1			M1			M1	
MW420		M1			M1			M1			M1	
MW421		M1			M1			M1			M1	
MW422		M1			M1			M1			M1	
MW423		M1			M1			M1			M1	
MW424		M1			M1			M1			M1	
MW425		M1			M1			M1			M1	
MW426		M1			M1			M1			M1	
MW427		M1			M1			M1			M1	
MW428		M1			M1			M1			M1	
MW429A		M1			M1			M1			M1	
MW430		M1			M1			M1			M1	
MW431	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW432	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW433		M1			M1			M1			M1	
MW435		M1			M1			M1			M1	
MW439	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT
MW440		M1			M1			M1			M1	
MW441	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT
MW442	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT
MW443		M1			M1			M1			M1	
MW444		M1			M1			M1			M1	
MW445	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW447		M1			M1			M1			M1	
MW448		M1			M1			M1			M1	

Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW450		M1			M1			M1			M1	
MW451		M1			M1			M1			M1	
MW452		M1			M1			M1			M1	
MW453		M1			M1			M1			M1	
MW454		M1			M1			M1			M1	
MW455		M1			M1			M1			M1	
MW456		M1			M1			M1			M1	
MW457		M1			M1			M1			M1	
MW458		M1			M1			M1			M1	
MW459		M1			M1			M1			M1	
MW460		M1			M1			M1			M1	
MW461		M1			M1			M1			M1	
MW462		M1			M1			M1			M1	
MW463		M1			M1			M1			M1	
MW464		M1			M1			M1			M1	
MW465		M1			M1			M1			M1	
MW466		M1			M1			M1			M1	
MW467		M1			M1			M1			M1	
MW468		M1			M1			M1			M1	
MW469		M1			M1			M1			M1	
MW470		M1			M1			M1			M1	
MW471		M1			M1			M1			M1	
MW472		M1			M1			M1			M1	
MW473		M1			M1			M1			M1	
MW474		M1			M1			M1			M1	
MW475		M1			M1			M1			M1	
MW476		M1			M1			M1			M1	
MW477		M1			M1			M1			M1	
MW478		M1			M1			M1			M1	
MW479		M1			M1			M1			M1	
MW480		M1			M1			M1			M1	
MW481		M1			M1			M1			M1	
MW482		M1			M1			M1			M1	
MW483		M1			M1			M1			M1	
MW484		M1			M1			M1			M1	
MW485		M1			M1			M1			M1	
MW486A		M1			M1			M1			M1	
MW487		M1			M1			M1			M1	

Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW488		M1			M1			M1			M1	
MW489		M1			M1			M1			M1	
MW490		M1			M1			M1			M1	
MW491		M1			M1			M1			M1	
MW492	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW493		M1			M1			M1			M1	
MW494		M1			M1			M1			M1	
MW495		M1			M1			M1			M1	
MW496		M1			M1			M1			M1	
MW497		M1			M1			M1			M1	
MW498		M1			M1			M1			M1	
MW499		M1			M1			M1			M1	
MW500		M1			M1			M1			M1	
MW501		M1			M1			M1			M1	
MW502		M1			M1			M1			M1	
MW503		M1			M1			M1			M1	
MW504		M1			M1			M1			M1	
MW505		M1			M1			M1			M1	
MW506		M1			M1			M1			M1	
MW507		M1			M1			M1			M1	
MW524		M1			M1			M1			M1	
MW525	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW526	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW527	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW528		M1			M1			M1			M1	
MW529	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW530		M1			M1			M1			M1	
MW531		M1			M1			M1			M1	
MW532 (PZ)		M1			M1			M1			M1	
MW533		M1			M1			M1			M1	
MW534 (PZ)		M1			M1			M1			M1	
MW535 (PZ)		M1			M1			M1			M1	
MW536		M1			M1			M1			M1	
MW537		M1			M1			M1			M1	
MW538		M1			M1			M1			M1	
MW539		M1			M1			M1			M1	

Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

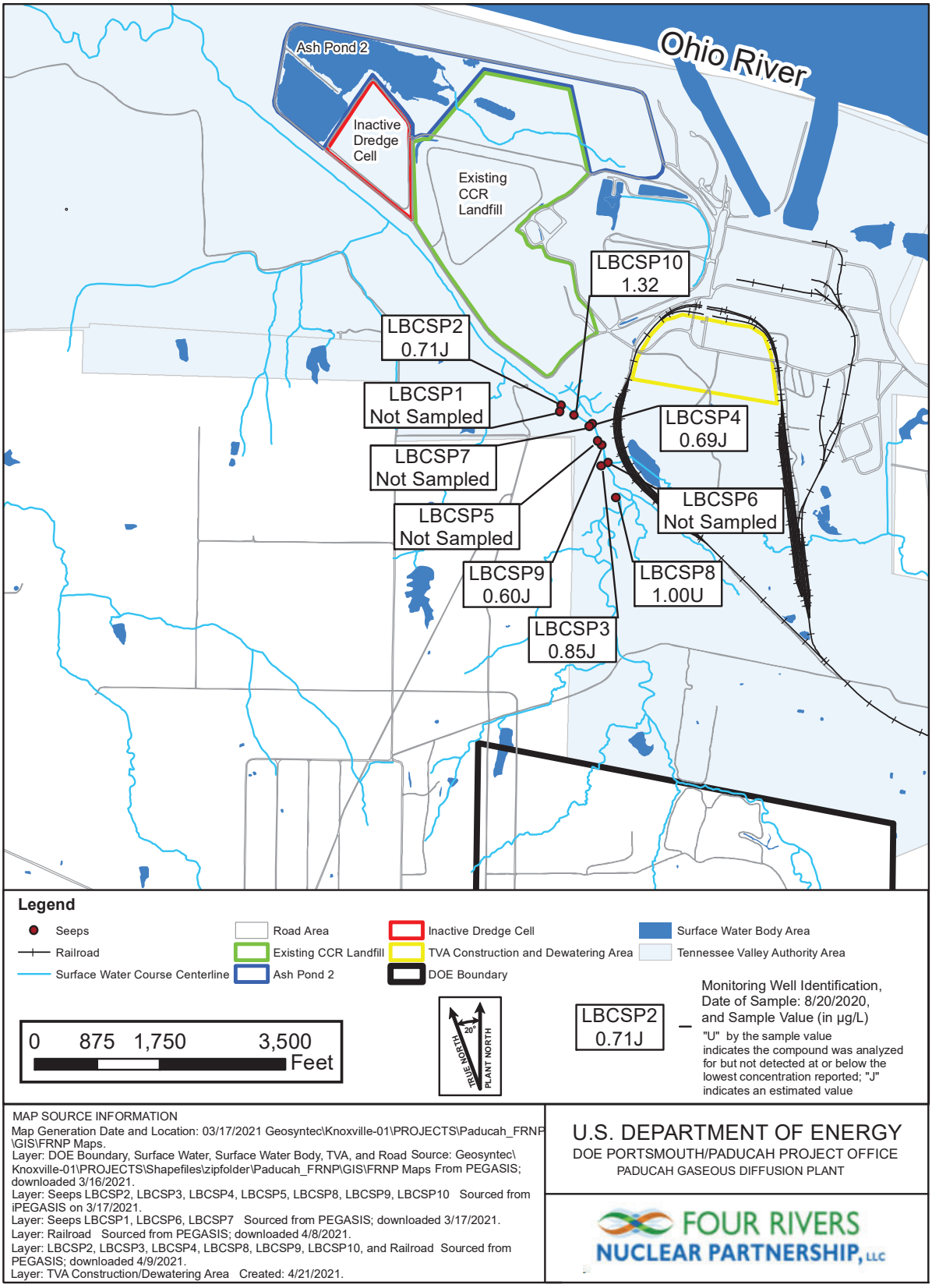
Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW540 (PZ)		M1			M1			M1			M1	
MW541 (PZ)		M1			M1			M1			M1	
MW542		M1			M1			M1			M1	
MW543		M1			M1			M1			M1	
MW544		M1			M1			M1			M1	
MW545		M1			M1			M1			M1	
MW546		M1			M1			M1			M1	
MW547		M1			M1			M1			M1	
MW548		M1			M1			M1			M1	
MW549		M1			M1			M1			M1	
MW550		M1			M1			M1			M1	
MW551		M1			M1			M1			M1	
MW553 (PZ)		M1			M1			M1			M1	
MW554 (PZ)		M1			M1			M1			M1	
MW555 (PZ)		M1			M1			M1			M1	
MW556		M1			M1			M1			M1	
PZ107		M1			M1			M1			M1	
PZ109		M1			M1			M1			M1	
PZ110		M1			M1			M1			M1	
PZ114		M1			M1			M1			M1	
PZ115		M1			M1			M1			M1	
PZ117		M1			M1			M1			M1	
PZ118		M1			M1			M1			M1	
PZ287		M1			M1			M1			M1	
PZ289		M1			M1			M1			M1	
PZ290		M1			M1			M1			M1	
PZ349		M1			M1			M1			M1	
PZ351		M1			M1			M1			M1	
EW232		M1			M1			M1			M1	
EW233		M1			M1			M1			M1	
EW234		M1			M1			M1			M1	
EW235		M1			M1			M1			M1	
MW557		M1			M1			M1			M1	
MW558		M1			M1			M1			M1	
MW559		M1			M1			M1			M1	

Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

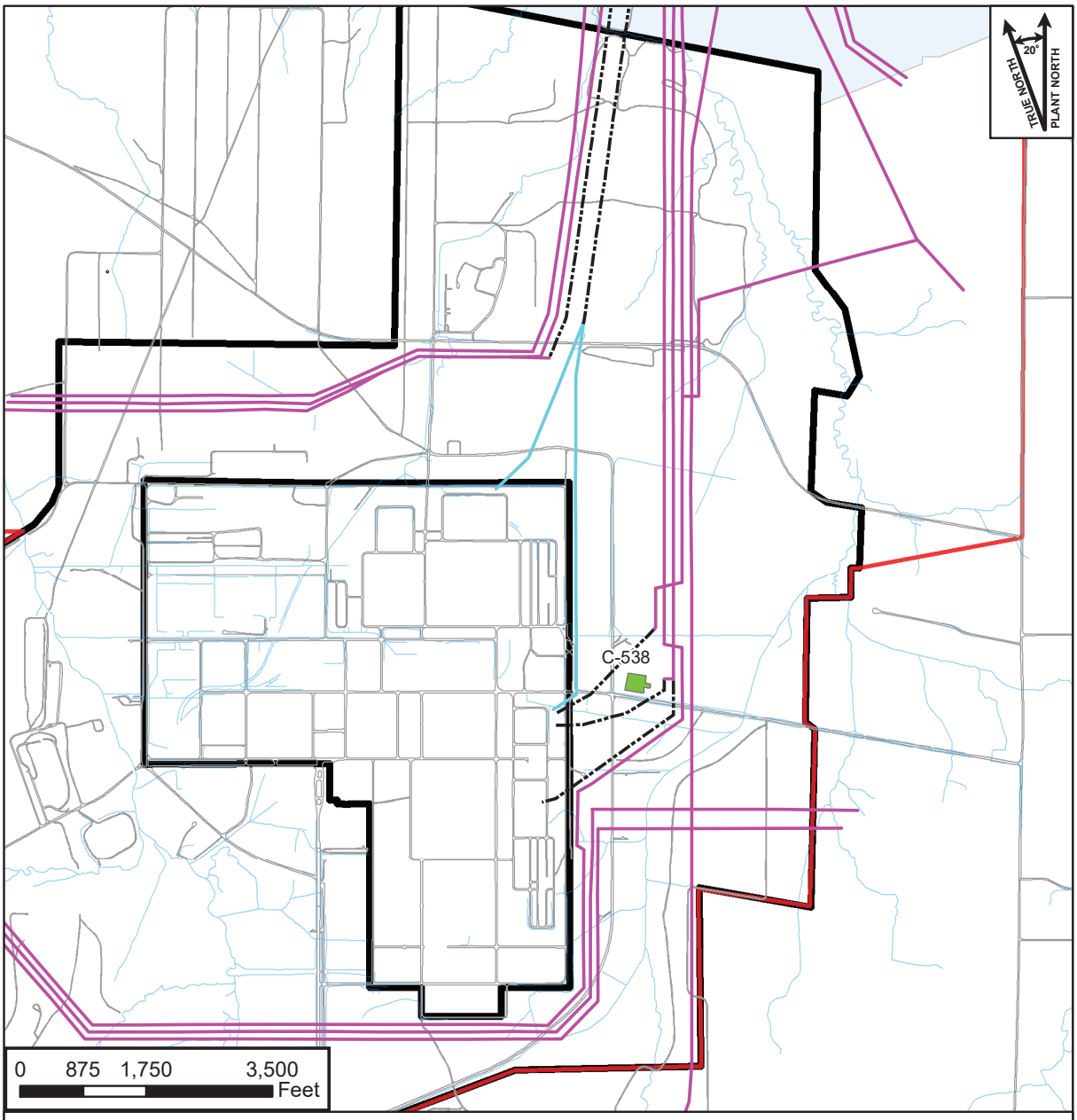
Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW560		M1			M1			M1			M1	
MW561		M1			M1			M1			M1	
MW562		M1			M1			M1			M1	
MW563		M1			M1			M1			M1	
MW564		M1			M1			M1			M1	
MW565		M1			M1			M1			M1	
MW566		M1			M1			M1			M1	
MW567		M1			M1			M1			M1	
MW568		M1			M1			M1			M1	
MW569		M1			M1			M1			M1	
MW570		M1			M1			M1			M1	
MW571		M1			M1			M1			M1	
MW572		M1			M1			M1			M1	
MW573		M1			M1			M1			M1	
MW574		M1			M1			M1			M1	

CB: colloidal borescope
PT: pressure transducer
M1: Manual water level collected once per month
Color coding is used to show colloidal borescope data collection groups, where each color designates a different group of locations that are planned to be collected together.
*Collect manual water level measurement when accessible.

Attachment 3 - Little Bayou Creek Seeps



Attachment 3 - Power Lines Figure



Legend

- C-538
- Surface Water Course Centerline
- Water Policy Boundary
- DOE Boundary
- Road Area
- TVA Area

Powerline Status

- Air Gapped (Approximate)
- Energized
- Removed (Approximate)

MAP SOURCE INFORMATION
Map Generation Date and Location: 09/13/2021 \\fedprojects-01\paducah$\Knoxville\GIS\FRNP Maps
Layer: DOE Boundary, Road Area, Surface Water Course Centerline, TVA Area, and Water Policy Boundary Sourced from PEGASIS 3/16/2021 (Layer: 'GIS Layers')
Layer: Powerlines and C-538 Sourced from FRNP on 3/16/2021; Powerlines last updated 5/15/2018
Layer: Powerline Status Sourced from FRNP on 9/8/2021

U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

Attachment 4

Drone Information Provided by EPA
Navassa, North Carolina Project

Is it Surface Water or is it Groundwater?

The Risk Assessors will want to Know

Ben Bentkowski
Scientific Support Section
R4 Superfund and Emergency Management Division
October 21, 2020

Kerr McGee Chem Corp Site
Navassa, North Carolina

HIGH TIDE FILLS THE MARSH

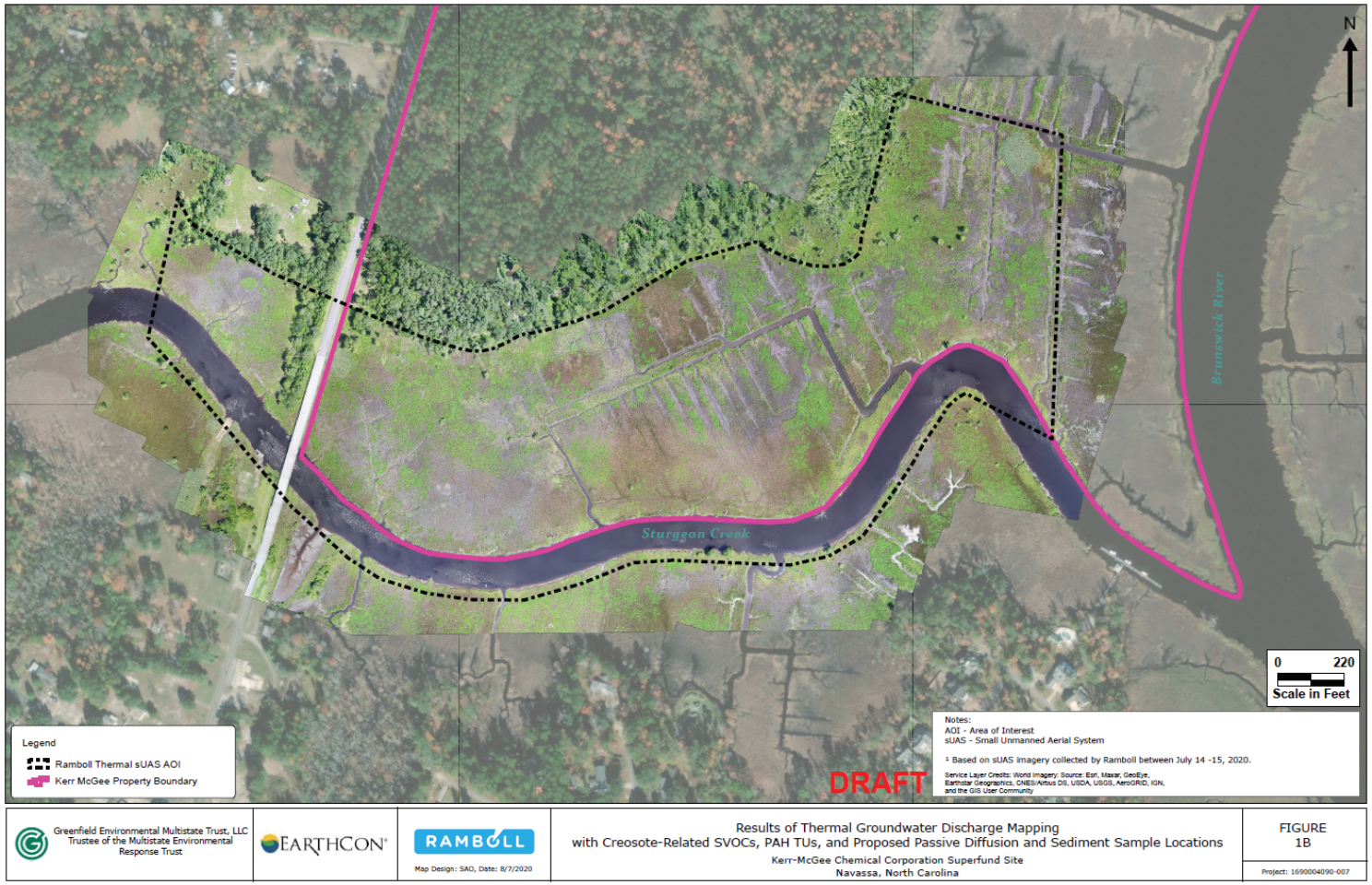
Kerr McGee Chem Corp Site
Navassa, North Carolina

Creosote Wood Treater

Low Coastal Plain

Atlantic Tidal Effects

The purpose is to identify the specific locations of groundwater discharge to see what the maximum concentrations might be affecting the ecological receptors.



Greenfield Environmental Multistate Trust, LLC
Trustee of the Multistate Environmental Response Trust

EARTHCON

RAMBOLL
Map Design: SAO, Date: 8/7/2020

Results of Thermal Groundwater Discharge Mapping
with Creosote-Related SVOCs, PAH TUs, and Proposed Passive Diffusion and Sediment Sample Locations
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

FIGURE
1B
Project: 1690004090-007

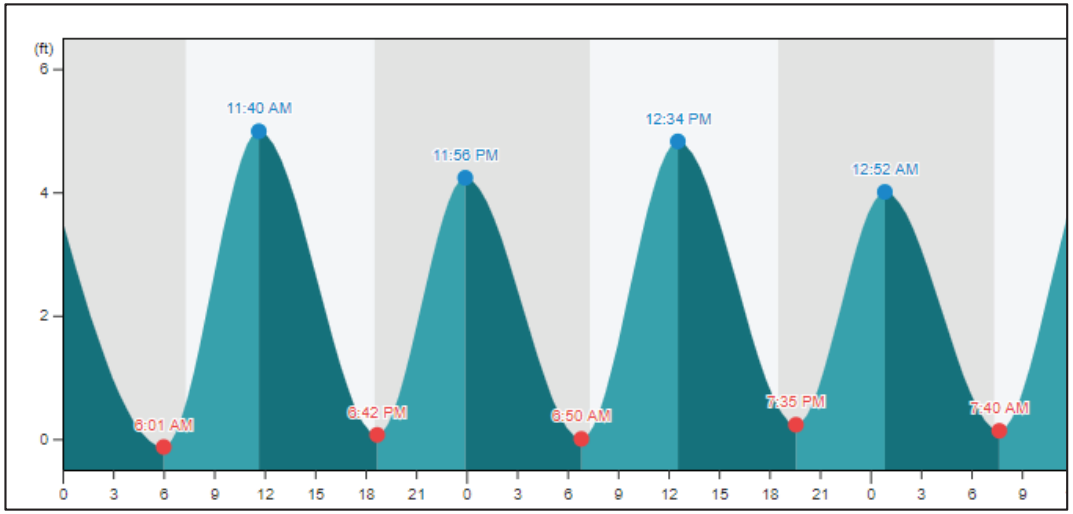
Thanks to the Greenfield Environmental Multistate Trust for the use of these images.

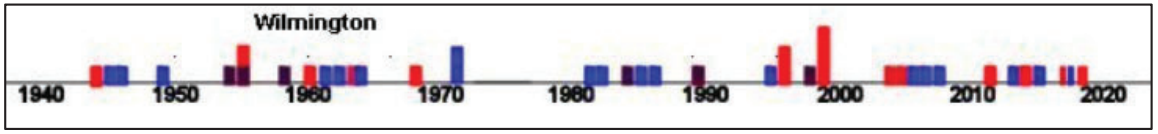
Kerr McGee Chem Corp Site
Navassa, North Carolina

Creosote Wood Treater

Low Coastal Plain

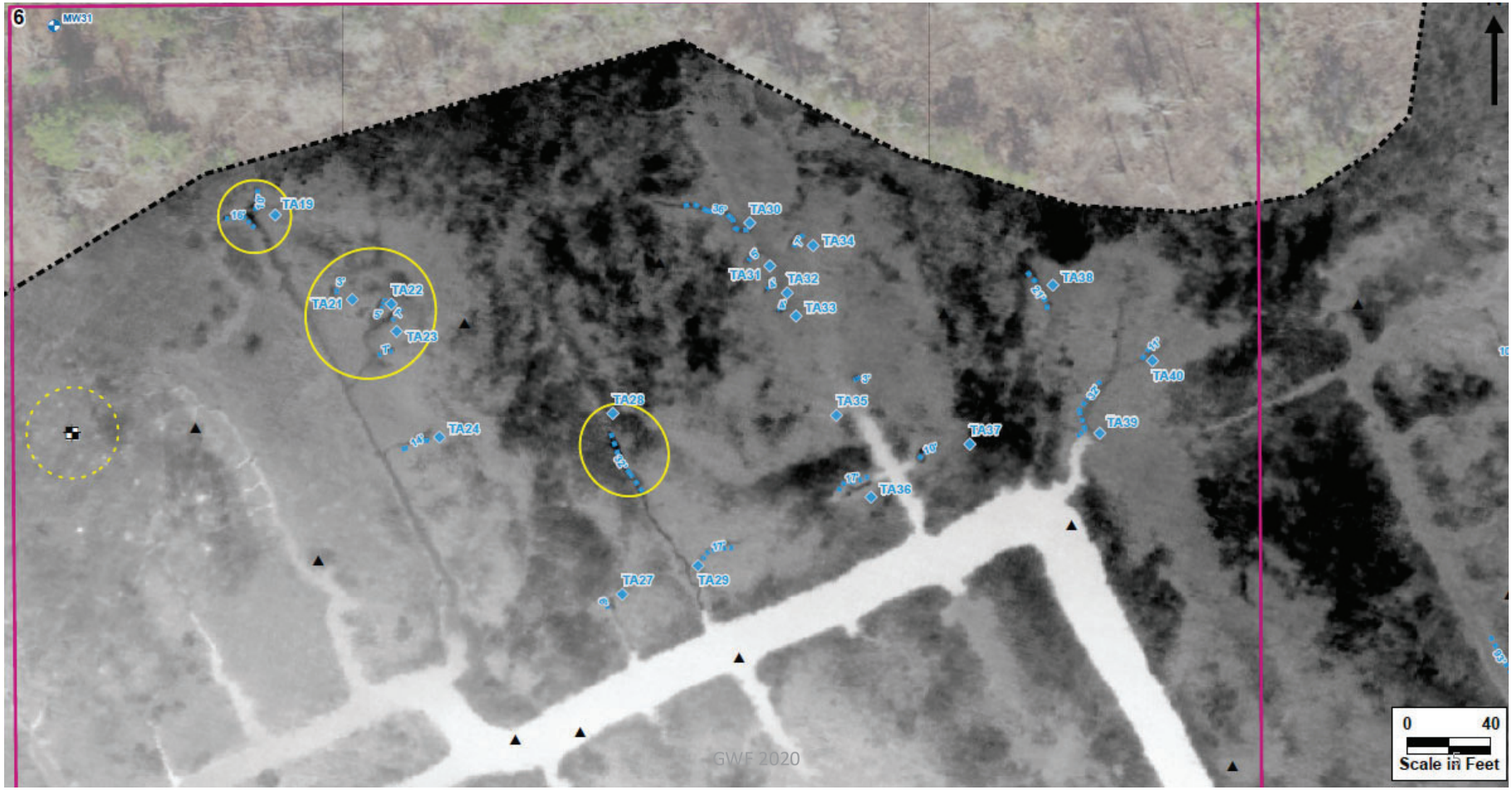
Atlantic Tidal Effects ~5’





Let’s not forget 5’ to 10’ storm surges from hurricanes
Wilmington, NC
#4 in the nation !!

Thermal Anomalies Identified - Low Tide, At Night



Thermal Anomalies on Visible Spectrum Photo - Low Tide

GENERAL DISCHARGE AND SEPARATE DISCHARGE POINTS GATHERING TO A TRICKLE

GWF 2020 7

TRICKLE JOINING A STREAM

Attachment 5

McNairy Lithologic Technical Paper Outline

DETAILED CORRELATIONS BETWEEN LITHOLOGIC UNITS IN THE McNAIRY FORMATION ACROSS THE PADUCAH SITE

FINAL ANNOTATED OUTLINE

EXECUTIVE SUMMARY

TABLE OF CONTENTS

FIGURES

TABLES

ACRONYMS

ATTACHMENTS

1 INTRODUCTION

1.1 PURPOSE

From the Memorandum of Agreement for Resolution of Informal Dispute Concerning U.S. Environmental Protection Agency and Kentucky Department for Environmental Protection Requirements for Additional Actions or Modifications Regarding the CY 2018 Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/LX/07-2426&D2 (MOA; DOE 2020):

> "As part of the U.S. Environmental Protection Agency's (EPA's) independent assessment of the FY 2018 Five-Year Review, EPA made a protectiveness deferred determination for the Northeast Plume, the Northwest Plume, and Water Policy response actions, until additional data are collected to verify that human exposures are not occurring. EPA determined additional actions are needed, specifically the collection of additional geological data at the C-400 Complex OU and the development of detailed correlations between lithologic units in the McNairy Formation across the entire Paducah Site, to support an accurate characterization of site faulting and the potential for fault-controlled plume migration across the Plant and beyond the Plant boundaries (including the Water Policy Affected Area). EPA requested that the detailed correlations of the McNairy Formation be reported not later than the C-400 Complex OU D1 Remedial Investigation/Feasibility Study (RI/FS) Report.
>
> The following uncertainties were identified regarding protectiveness for the Northwest Plume, Northeast Plume, and Water Policy response actions:
>
> — The presence of unknown contamination in off-site areas.
> — The presence of unknown migration of contamination due to pathways not understood.

To help manage these uncertainties regarding protectiveness, EPA proposed additional characterization of site faulting and the potential for fault-controlled plume migration across the Paducah Site (including the Water Policy Affected Area) as part of the 2023 Five-Year Review.

DOE will develop a technical paper discussing two lithological correlations of the McNairy Formation: one along a north-south transect and the other along an east-west transect (see Figure 1 [of MOA]). The transects will be developed using the existing data from previously drilled 8 deeper soil borings and from 6 discrete locations, that extend near/through the base of the McNairy Formation (which occurs at elevations of -2 to 66 ft amsl beneath the Paducah Site).

— A north-south transect (relative to the Plant coordinate system) of 5 previously drilled soil borings/4 locations over ~ 19,200 ft (~ 3.6 miles), extending from immediately south of the Paducah Site industrial complex to near TVA's Shawnee Steam Plant.

— An east-west transect (relative to the Plant coordinate system) of 4 previously drilled soil borings/3 locations over ~ 5,500 ft (~ 1.0 miles) across the north side of the Plant.

Inputs into the lithological correlations will include a combination of the historical soil boring logs from both the deeper and shallower McNairy Formation within the Paducah Site and the adjacent TVA Shawnee Steam Plant and soil boring logs of the McNairy Formation from the C-400 Complex OU RI/FS (currently underway) that fall along the north-south and east-west transects."

1.2 OBJECTIVES

Characterization of site faulting and the potential for fault-controlled plume migration across the Paducah Site (including the Water Policy Affected Area) are needed to better understand

- the presence of unknown contamination in off-site areas and
- the presence of unknown migration of contamination due to pathways[1] not understood.

DOE will develop a technical paper discussing two lithological correlations of the McNairy Formation: one along a north-south transect and the other along an east-west transect (see Figure 1 [of MOA]) within the Paducah Site and Water Policy Affected Area to assess the presence of fault displacement and, if present, the magnitude of fault displacement.

Inputs into the lithological correlations will include a combination of the historical soil boring logs from both the deeper and shallower McNairy Formation within the Paducah Site and the adjacent TVA Shawnee Steam Plant and soil boring logs of the McNairy Formation from the C-400 Complex OU RI/FS (currently underway) that fall along the north-south and east-west transects.

[1] The term "pathways" is used synonymously with "preferential pathways for contaminant migration."

1.2.1 MEMORANDUM OF AGREEMENT OF INFORMAL DISPUTE
1.2.2 COLLABORATION OF GROUNDWATER MODEL WORKING GROUP

2 BACKGROUND
2.1 McNAIRY GEOLOGIC SETTING
2.1.1 SUMMARY OF HISTORICAL PADUCAH SITE INFORMATION AND STUDIES
2.1.2 CONCERNS
2.1.2.1 Faulting
2.1.2.2 Potential for fault-controlled plume migration

3 HYDROGEOLOGY OF McNAIRY
3.1 DEPOSITIONAL HISTORY
3.2 LITHOLOGIC MEMBERS
3.3 POST-DEPOSITION EROSIONAL/STRUCTURAL SETTING
3.4 McNAIRY GROUNDWATER FLOW SYSTEM

4 RELEVANT FAULT STUDIES
4.1 REGIONAL
4.2 LOCAL
4.3 PADUCAH SITE

5 APPROACH
5.1 DQOs
5.1.1 State the Problem

Characterization of site faulting and the potential for fault-controlled plume migration across the Paducah Site (including the Water Policy Affected Area) are needed to better understand

- the presence of unknown contamination in off-site areas and
- the presence of unknown migration of contamination due to pathways not understood.

This white paper will address characterization of site faulting.

5.1.2 Identify the Decision

The correlation of lithologic units in the McNairy Formation is intended to assess whether there is significant faulting beneath the Paducah Site that could be a contaminant migration pathway.

5.1.3 Identify Inputs to the Decision

Inputs to this characterization will be based on historical soil boring logs of the McNairy Formation at the Paducah Site and the adjacent TVA Shawnee Steam Plant as well as soil boring logs of the McNairy Formation from the C-400 Complex OU RI.

5.1.4 Define the Study Boundaries

1. McNairy Formation
2. Existing soil boring logs of the Paducah Site and adjacent TVA Shawnee Steam Plant
3. Soil boring logs that will be completed for the C-400 Complex Remedial Investigation

5.1.5 Develop a Decision Rule

This correlation will utilize the following decision rules:

1. If a lithologic contact disruption is identified, assess if the discontinuity is fault-related.
   a. The McNairy Formation consists of lagoonal-to-shallow marine deposits with frequent depositional discontinuities.
   b. The McNairy Formation consisted of "soft" sediment deposition that may have resulted in diagenetic-related discontinuities (unrelated to faulting).
   c. Large bioturbation features are abundant.
2. If faulting is identified, assess the orientation and continuity of the structure(s).
   d. The expected trend, consistent with the Fluorspar Area Complex of southern Illinois, is NE-SW.

5.1.6 Specify Limits on Decision Errors

Decision errors will be determined primarily by the frequency of sample collection and impacted by the quality of the data.

5.1.7 Optimize the Design for Obtaining Data

Where marker horizons can be identified, adjacent continuous geologic and geophysical logs may be able to identify small-scale discontinuities (on the order of 5 ft) with reasonable confidence. The resolution of faulting using logs based on grab samples at regular intervals will be governed by the sampling frequency (depth-wise). Initially scrutinizing the available logs to identify candidate marker horizons will increase the effectiveness of the lateral comparison of the logs.

6 DATA SETS

6.1 EXISTING DATA

6.1.1 Lithologic Logs

Soil boring logs are available from reports from individual projects (hardcopy) and in a spreadsheet database prepared by the Kentucky Research Consortium for Energy and Environment (KRCEE) (R9_MSTR_Hydrolithostrat_Dbase_Upload_110419.xlsx).

Historical soil boring logs consist of the following:

— Eight soil borings in six discrete locations that extend to/through the base of the McNairy Formation.

— Approximately 159 soil borings that extend downward to an elevation of 240 ft amsl or deeper (providing characterization of $\geq$40 ft of the upper McNairy/Clayton Formation). Soil boring depths range from 91 to 359 ft.

– A cluster of shallower soil borings are within and near the industrial complex. This includes most of the air-rotary soil borings with grab sample logs and continuous core logs.

— Additional soil borings at the Shawnee Steam Plant extend downward to an elevation of 240 ft amsl or deeper.

Several types of logs are available for the Paducah Site soil borings. A few of the soil borings have geologists' descriptions of continuous core. Several of the soil borings have geologists' descriptions of grab samples collected at regular, frequent intervals. Many of the soil borings have geologists' descriptions of cuttings collected from the cyclone discharge of an air rotary rig. These samples are of limited use for detailed lithologic characterization. However, most of these soil borings also have paper strip logs of natural gamma activity and neutron porosity that may be used to interpret and correlate geology. Three of the deep soil borings have logs of shear wave velocities.

With few exceptions (notably soil boring DB01/DB02), the geologic descriptions are captured in the database of Paducah lithologic logs (R9_MSTR_Hydrolithostrat_Dbase_Upload_110419.xlsx) prepared by KRCEE. Hard copies of the geologic logs are available for all of the soil borings in various project reports.

6.1.2 Geophysical logs

Geophysical logs extending into the McNairy Formation are available for 97 soil borings of the Paducah Site. The majority of these soil borings were drilled by the remedial investigations of Waste Area Groupings 3, 6, and 27; the Data Gaps Investigation associated with the remedial investigation of Waste Area Groupings 8 and 28; and the Phase IV Groundwater Investigation. Most soil boring records include downhole logs for both gamma ray and neutron porosity.

6.2 C-400 Complex RI

The C-400 Complex Remedial Investigation will complete a minimum of 17 soil borings to depths of at least 50 ft within the McNairy Formation. Lithologic logs will be developed for each of the soil borings.

7 DATA ADEQUACY

7.1 DEPTH OF DATA/THICKNESS OF MCNAIRY INVESTIGATED

7.2 SPACING OF SAMPLE LOCATIONS

7.3 QUALITY OF DATA

7.3.1 Sampling method

7.3.2 Vertical frequency

8 ASSESSMENT METHODS

8.1 CROSS SECTIONS

The Paducah Site McNairy soil boring logs can be generalized as two primary populations as discussed below.

- A north-south transect (relative to the plant coordinate system) of ~19,200 ft (approximately 3.6 miles), extending from immediately south of the plant industrial complex to near TVA's Shawnee Steam Plant.
- An east-west transect (relative to the plant coordinate system) of ~ 5,500 ft across the north side of the industrial complex.

For detailed McNairy correlations, the following geologic information should be noted.

- North of the buried Porters Creek Clay Terrace Slope, the top of the McNairy/Clayton Formation is truncated by an erosional unconformity marking the bottom of the channel of the ancestral Tennessee River Valley, commonly occurring at an elevation of approximately 280 ft amsl.
- South of the buried Porters Creek Clay Terrace Slope, the top of the McNairy/Clayton Formation slopes to the south with a shallow dip (<10°) beneath the Porters Creek Clay.

8.2 STRUCTURE CONTOUR MAPS

9 UNCERTAINTIES

9.1 DEPOSITIONAL HETEROGENEITY

9.2 RESOLUTION OF FAULT OFFSET

10 CONCLUSIONS AND RECOMMENDATIONS

11 REFERENCES

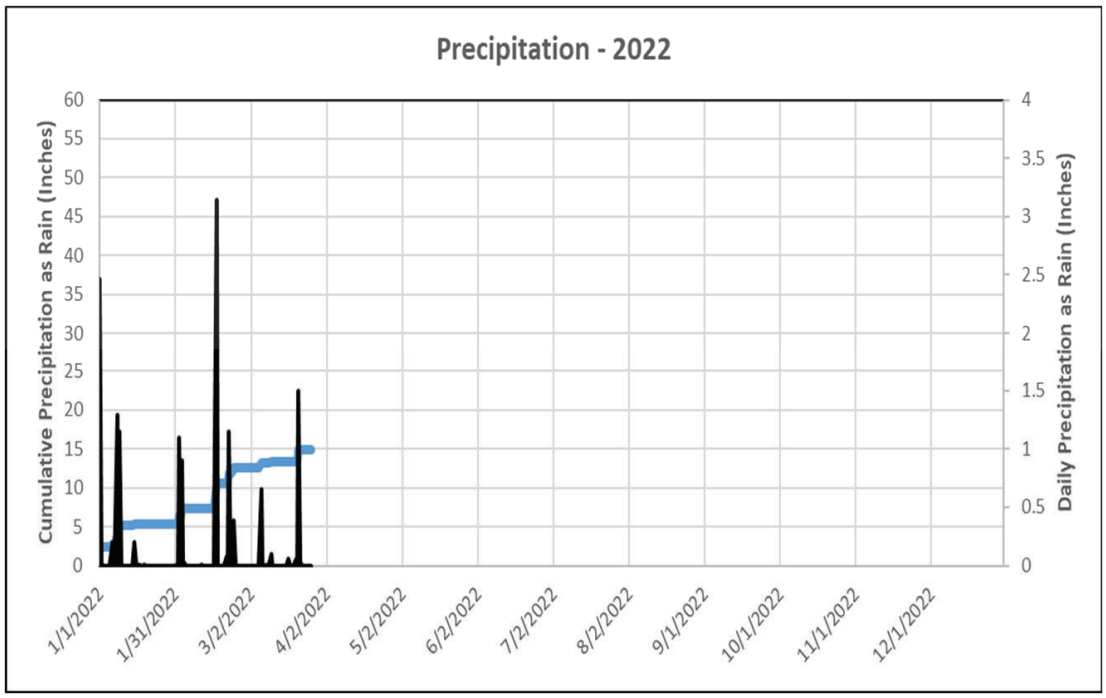
ATTACHMENT 1. LITHOLOGIC LOGS

ATTACHMENT 2: GEOPHYSICAL LOGS

ATTACHMENT 3: GEOLOGIC CROSS SECTIONS

Attachment 6

Precipitation and Ohio River Stage Data


Precipitation - 2022
Cumulative Precipitation as Rain (Inches)
Daily Precipitation as Rain (Inches)
60
55
50
45
40
35
30
25
20
15
10
5
0
4
3.5
3
2.5
2
1.5
1
0.5
0
1/1/2022
1/31/2022
3/2/2022
4/2/2022
5/2/2022
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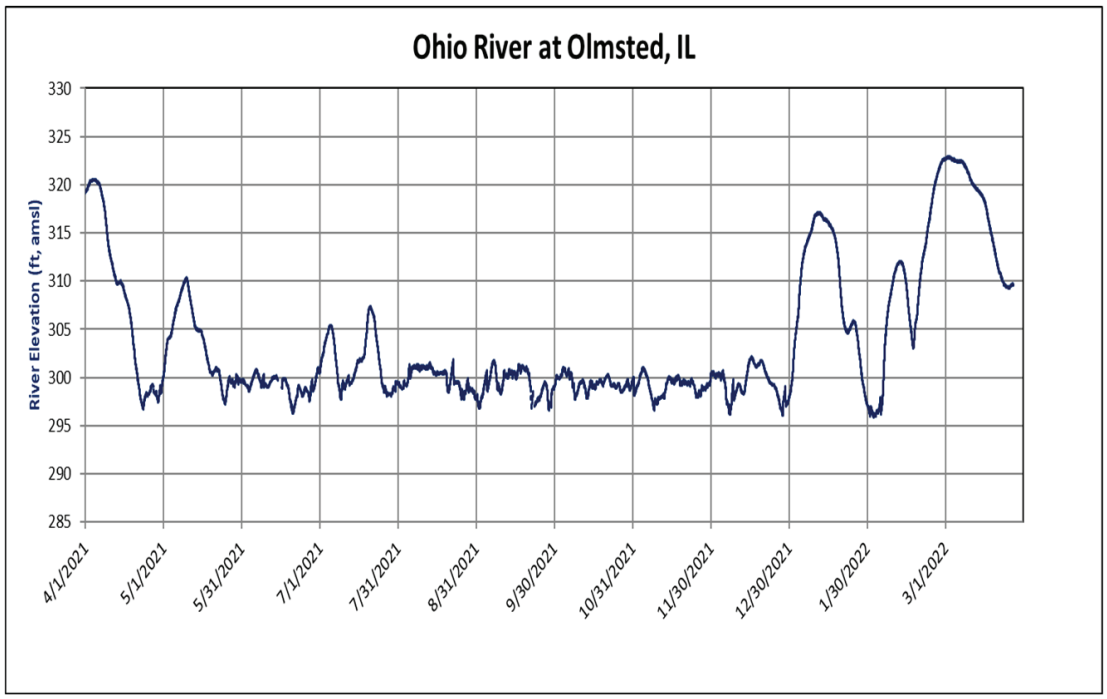
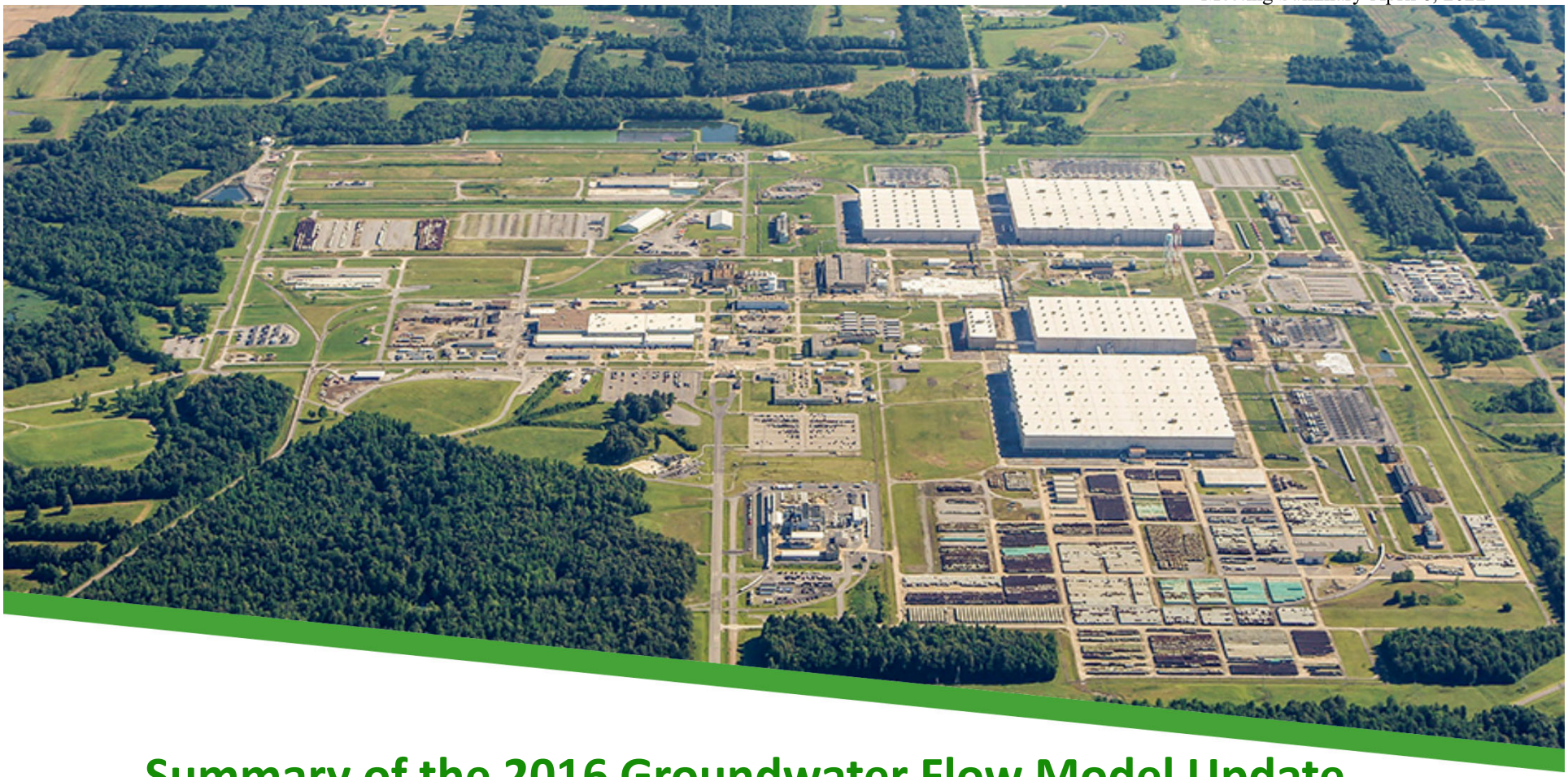
9/1/2022
10/1/2022
11/1/2022
12/1/2022


Ohio River at Olmsted, IL
River Elevation (ft, amsl)
330
325
320
315
310
305
300
295
290
285
4/1/2021
5/1/2021
5/31/2021
7/1/2021
7/31/2021
8/31/2021
9/30/2021
10/31/2021
11/30/2021
12/30/2021
1/30/2022
3/1/2022

Attachment 7

Presentation: Summary of EPA and KY Comments to the 2016 Sitewide Paducah Groundwater Flow Model



Summary of the 2016 Groundwater Flow Model Update Summary of Comments

Groundwater Modeling Working Group
Quarterly Meeting
April 6, 2022

DRAFT Work Product – For Discussion Only

Presentation Outline

- MWG meetings and report timeline
- KDEP Comments
- EPA Comments

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MWG Meetings and Report Timeline

- 2015-2017: 27 Meetings

2/10/2015	7/8/2016	1/6/2017
2/18/2015	8/5/2016	1/20/2017
11/12/2015	8/16/2016	3/3/2017
3/29/2016	8/24/2016	3/23/2017
4/29/2016	8/31/2016	5/31/2017
5/13/2016	9/16/2016	7/19/2017
6/3/2016	9/30/2016	9/19/2017
6/10/2016	10/14/2016	
6/14/2016	10/25/2016	
6/24/2016	12/13/2016	

- April 3, 2017: Draft update submitted (DOE/LX/07-2415&D1)
  - https://eic.pad.pppo.gov/Search.aspx?accession=ENV 1.J.1-01128
- May 5 and 12, 2017: KDEP and EPA provide comments
- July 17, 2017: Final update submitted (DOE/LX/07-2415&D2)
  - https://eic.pad.pppo.gov/Search.aspx?accession=ENV 1.J.1-01133
- August 9, 2017: EPA acknowledgement

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May 5, 2017 KDEP Technical Comments

- 47 Comments
  - Comments 1-13, 15-16, 18-24, 26-40 Editorial
  - Comment 17 rescinded during discussions
  - Comment 46 was addressed in the D1
  - Comments 14, 25, 41, 42, 43, 44, 45, and 47 resulted in additions to Section 8.2, Recommendations
    - General response: "An additional bullet is added to the list of recommendations in Section 8.2 Recommendations, page 157. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/ uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding."
    - Details of each specific recommendation added to the report or applicable to the comment are provided on the following slides.
    - A status update (as of this presentation) is provided for each item, as appropriate.

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Summary - May 5, 2017 KDEP Technical Comments

Comment	Topic	Associated Recommendation(s) in the Report	2021 Status
14	Streamflow data	In D1: "To quantify the volumetric rates at which water enters and exits streams, efforts may be made to gage flows in various portions of BC and LBC to determine where and in what quantities water enters and exits the creeks and to coordinate the stream gauging event with a sitewide water level synoptic measurement event."	Streamflow data from Little Bayou Creek and Bayou Creek are planned to be collected as part of the Groundwater Strategy Project (GWSP) Activity #4 (Nature and Extent of Dissolved-Phase Contaminants Currently Contributed by Little Bayou Creek Seeps) and Activity #12 (Water Balance Study).
25	Roof drains	In D1: "To evaluate changes in post closure site operation that may affect anthropogenic recharge in the plant area, monitoring and documentation (including dates) of the enacted utility optimization program (performed by others) are recommended." Added to D2: "Recharge related to the process building roof drains is poorly understood. Future model efforts should compile available information regarding the chronology of roof drain repair to understand temporal variability better and reduce uncertainty in recharge estimates."	Roof drain repairs were made in 2016 and 2017 at C-333 and C-337. A white paper, *Characterization of Roof Drain Leaks to Gravel Subbase of Paducah Site Process Buildings*, is being developed through MWG. This item is also included in the GWSP Activity #12 (Water Balance Study).
41	Hydraulic conductivity (K)	Added to D2: "Additional slug test performed on a selection of appropriate monitoring wells will define hydraulic conductivity better across the model domain. Future discussions should include selecting an appropriate slug test method and criteria for selecting test wells."	Additional K data and lithology data are being collected as part of the C-400 RI. A white paper, *Measurement of Hydraulic Conductivity in the Regional Gravel Aquifer Using Monitoring Wells at the Paducah Site*, was prepared as part of GWSP Activity #16 (Hydraulic Conductivity).

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Summary - May 5, 2017 KDEP Technical Comments, Continued

Comment	Topic	Associated Recommendation(s) in the Report	2021 Status
42	TVA data/ groundwater flow north of the site	Added to D2: "To understand the groundwater flow north of the site better, the TVA monitoring system data should be compiled and verified (especially datums) for use in future models."	KY has been documenting the current TVA monitoring wells and obtains quarterly depth to water level measurements from TVA monitoring wells coordinated with the site synoptic water level measurement events. GWSP Activity #11 (Expansion of GW Monitoring Network) includes compilation and verification (especially datums) of the TVA monitoring system data.
43	Large building gravel thickness	Added to D2: "Installation of piezometers equipped with continuous water level monitors beneath several of the large buildings would define the thickness of the sub-slab gravel base and the temporal water level fluctuations beneath several of the large buildings better."	Roof drain repairs were made in 2016 and 2017 at C-333 and C-337. A white paper, *Characterization of Roof Drain Leaks to Gravel Subbase of Paducah Site Process Buildings*, is being developed through MWG.
44	Water balance	Added to D2: "A Water Balance Study to identify significant sources of anthropogenic recharge in the model domain may provide a better understanding of key components of anthropogenic recharge and reduce uncertainty in recharge estimates for future model updates."	A water balance study is planned to be performed as part of GWSP Activity #12 (Water Balance Study).

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Summary - May 5, 2017 KDEP Technical Comments, Continued

Comment	Topic	Associated Recommendation(s) in the Report	2021 Status
45	Additional MWs to address general uncertainties	Added to D2: "Installation of additional monitoring wells, located inside and outside of the plants industrial area would reduce uncertainty regarding groundwater flow direction, contaminant distribution, and potential source areas for future model updates."	Multiple activities under the GWSP are intended to collected data to better understand where additional monitoring wells may be needed.
47	Groundwater divide	Added to D2: "Conducting tracer tests in the vicinity of the apparent groundwater divide located east of the C-400 Building to refine understanding of groundwater flow in this area should be considered for future model update efforts."	Tracer tests will be considered as part of GWSP Activity #15 (Water Level Divide Study). Contaminant analyses and groundwater level measurements for the Northeast Plume Containment System (NEPCS) Optimization Project and the C-400 RI may provide an adequate understanding of groundwater flow in the area of the apparent groundwater divide.

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May 12, 2017 EPA Technical Comments

- 16 Comments
  - Noman Ahsanuzzaman (NA): 14 comments and Eva Davis (ED): 2 comments
    - Comment NA 1 details two major concerns that were addressed through responses to other comments
  - General response: Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.
  - Details of each specific recommendation added to the report or applicable to the comment are provided on the following slides.
  - Discussion specific to the comments is provided on the following slides.
  - A status update (as of this presentation) is provided for each item, as appropriate.

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May 12, 2017 EPA Technical Comments, Continued

- Topics of technical disagreement
  - Hydraulic conductivity (K) values
  - Anthropogenic recharge rates
  - Trajectory targets and flow paths
  - Transient river stage
  - Number of stress periods
  - Metropolis Lake
  - Calibration statistics

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Summary - May 12, 2017 EPA Technical Comments

Comment	Topic	Associated Recommendation(s) in the Report	Discussion and 2021 Status
NA 2	Calibration: use of excessively high recharge rates and K values	Five of the 20 recommendations included in the report are intended to address uncertainties and data needs specifically related to recharge. Added to the D2: "Additional slug test performed on a selection of appropriate monitoring wells will define hydraulic conductivity better across the model domain. Future discussions should include selecting an appropriate slug test method and criteria for selecting test wells."	A white paper, *Measurement of Hydraulic Conductivity in the Regional Gravel Aquifer Using Monitoring Wells at the Paducah Site*, was prepared as part of GWSP Activity #16 (Hydraulic Conductivity).
NA 3	Calibration: excessive use of trajectory targets	Not directly addressed by recommendations in the report. Each of the 20 recommendations included in the report are intended to address uncertainties and data needs related to the model.	From Responses to Comments (RTC): "The use of trajectory targets, in addition to flux and head targets, was demonstrated to be an essential element in the calibration process (i.e., the plume trajectories could not be simulated accurately without the use of trajectory targets)."

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Summary - May 12, 2017 EPA Technical Comments, Continued

Comment	Topic	Associated Recommendation(s) in the Report	Discussion and 2021 Status
NA 4	Extraction well capture and higher transmissivity channels along flow paths is not validated	Not directly addressed by recommendations in the report. Each of the 20 recommendations included in the report are intended to address uncertainties and data needs related to the model.	From RTC: "The size of the capture zone indicated by particle flow paths is a function of transmissivity and recharge specified across the plant area and may indicate that the constraint limitations applied to the PEST calibration are not representative of site conditions (i.e., higher hydraulic conductivity and recharge may be more representative of site conditions)."

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Summary - May 12, 2017 EPA Technical Comments, Continued

Comment	Topic	Associated Recommendation(s) in the Report	Discussion and 2021 Status
NA 5	Transient river stages are not accounted for; inclusion of only 2 stress periods vs 5	In D1: "The hydraulic connection of the RGA to the Ohio River and the nature of river bank storage remain important aquifer parameters potentially justifying further study to support the model and to assess the impact of transient conditions. Continuous RGA water level records are recommended over a period of a year in the vicinity of the Ohio River and along a transect of wells extending back to the PGDP industrial area." In D1: "The groundwater system in the PGDP Hydrologic Basin is in a transient state for much of the year, except in dry periods typically experienced in the fall. The model simulates steady state conditions and is calibrated to periods with relatively low river stage. Validation simulations indicate that during higher Ohio River stages the Northwest Plume discharges to LBC and flows west parallel to the creek. This is consistent with early plume depictions, based on water quality data, showing the plume paralleling LBC (Figure 4.5 of DOE 2010). Consideration of transient seasonal conditions at high Ohio River stages should be considered in the use of the model for evaluating remedial strategies."	From RTC: "Water level response to rising and falling river stages is a transient process, such that synoptic water level data collected during periods of variable river stage would not represent the groundwater system during steady state conditions. Use of these transient water levels as calibration targets in a steady state model is not appropriate. Additional continuous water level data collection and sitewide synoptic water level gauging events during different seasons will provide useful information for further evaluation of transient site conditions. As discussed in MWG meetings, the use of two stress periods rather than the five that were identified as suitable for calibration was due to time constraints in the modeling schedule." Synoptic water level measurements are being collected quarterly and continuous water level measurements using pressure transducers are being collected in select wells as part of multiple GWSP activities.

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Summary - May 12, 2017 EPA Technical Comments, Continued

Comment	Topic	Associated Recommendation(s) in the Report	Discussion and 2021 Status
NA 6	An extraordinarily high K value for Metropolis Lake instead of a head boundary condition, driving groundwater in the direction of the lake	In D1: "If possible, measurement of the water level elevation at Metropolis Lake should be included in the sitewide water level synoptic event. Consideration also should be given to characterizing the thickness and hydraulic conductivity of the lake bottom sediments if the lake is to be simulated using river boundary condition in future modeling efforts."	From RTC: "As initially stated in the 2008 modeling report, the lake is conceptualized as a "window into the RGA" that does not act as a net source or sink of groundwater. Using a high K value allows the lake to be represented in this way, while still accounting for the fact that it is a surface water body with flat water levels at the lake surface. This method of simulating a lake using a high contrast hydraulic conductivity zone is a common approach and is well documented in technical literature (e.g., Using High Hydraulic Conductivity Nodes to Simulate Seepage Lakes by Mary P. Anderson, Randall J. Hunt, James T. Krohelski, and Kuopo Chung; Vol. 40, No. 2-GROUND WATER-March-April 2002, pages 117-122). Using constant head boundaries may lead to a net loss or gain of water at Metropolis Lake and would require additional data collection for model input. " Water levels for Metropolis Lake are taken quarterly as part of GWSP Activity #14 (Synoptic Water Level Events).

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Summary - May 12, 2017 EPA Technical Comments, Continued

Comment	Topic	Associated Recommendation(s) in the Report	Discussion and 2021 Status
NA 7 NA 11	Recharge rate of 22 in/yr should be used as agreed upon by the MWG	In D1: "Anthropogenic recharge rates are estimated over a wide range of values (Section 3.3). As with most groundwater models, the model configuration and calibrated input parameters are not a unique solution. It is recommended that continuous water level recorders be deployed in select monitoring wells/piezometers within the plant area to assess recharge better and its impact on nearby water levels."	From RTC: "The values in Table 3.5 were provided as a basis for estimating the range of maximum recharge based on lithologic descriptions. The appropriate statistic for estimating recharge in the plant area has been discussed, but no agreement by the MWG was made regarding a final value." Initial recharge estimates were overly constrained by the use of the geometric mean: subsequently, the median value was used to not overly constrain the process. A white paper, *Characterization of Roof Drain Leaks to Gravel Subbase of Paducah Site Process Buildings*, is being developed through MWG.

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Summary - May 12, 2017 EPA Technical Comments, Continued

Comment	Topic	Associated Recommendation(s) in the Report	Discussion and 2021 Status
NA 8	Recharge rates: Storm drain footprint should not extend beyond the HU3 footprint	In D1: "Two of the main water supply systems and the storm water and HPFW piping were included in the model as discreet recharge zones based on site information (see Section 3.3.2). Assessment of the remaining water supply systems in the plant area, which include the recirculating cooling water and waste heat system, the sanitary water system, and the plant (nonsanitary) water system, is recommended to evaluate potential for contribution to anthropogenic recharge." Added to the D2: "A Water Balance Study to identify significant sources of anthropogenic recharge in the model domain may provide a better understanding of key components of anthropogenic recharge and reduce uncertainty in recharge estimates for future model updates."	From RTC: "The recharge zone for the storm drains (Zone 16) follows the footprint of the storm drain piping and is independent of the HU3 clay unit characterization. The calibrated recharge rate is expected to be on the higher end of the range of values calibrated for anthropogenic recharge because of documented leaks and leakage typical to aging storm water systems. The higher contribution to mass flux is based partially on the relatively large footprint of the recharge zone due to the extensive network across the plant area (see Figures 3.11 and 5.5)." A water balance study is planned to be performed as part of GWSP Activity #12 (Water Balance Study).

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Summary - May 12, 2017 EPA Technical Comments, Continued

Comment	Topic	Associated Recommendation(s) in the Report	Discussion and 2021 Status
NA 9	The McNairy formation could be a significant formation for DNAPL source accumulation and plume migration and exclusion of the McNairy formation is a major limitation for solute transport modeling	In D1: "Flow rate in the McNairy Formation is negligible compared to the RGA because the hydraulic conductivity is 2 to 3 orders of magnitude lower than in the RGA; however, the McNairy Formation may be significant for DNAPL source accumulation and contaminant transport. Future transport models based on the 2016 flow model will need to consider potential mass flux from the McNairy to the RGA resulting from back diffusion."	From RTC: "With respect to groundwater flow, the CSM recognizes limited flow in the McNairy; however, the RGA is the primary conveyor of groundwater from PGDP to the Ohio River. If the model is used to simulate solute transport in the future, then the best method to model back-diffusion from the McNairy formation will be discussed with the MWG." Associated geotechnical measurements for the McNairy formation are being collected as part of the C-400 RI.

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Summary - May 12, 2017 EPA Technical Comments, Continued

Comment	Topic	Associated Recommendation(s) in the Report	Discussion and 2021 Status
NA 10	Recharge rates: excessively high recharge rates for the roof drains	See NA 7	Roof drain repairs were made in 2016 and 2017 at C-333 and C-337. A white paper, *Characterization of Roof Drain Leaks to Gravel Subbase of Paducah Site Process Buildings*, is being developed through MWG.
NA 11	K values: Update the model calibration with a higher ratio of horizontal to vertical hydraulic conductivity	Not directly addressed by recommendations in the report. Each of the 20 recommendations included in the report are intended to address uncertainties and data needs related to the model.	From RTC: "The 10:1 anisotropy ratio referred to in Section 3.3.1 is related to the value reported for the UCRS (see Figure 13 from the Treatability Study Report, DOE/LX/07-2202&D1, December 2015). The 10:1 ratio used as a basis for estimated maximum recharge based on lithology is an appropriate order of magnitude assumption considering the precision of data relied on to conduct the analysis (e.g., variability of lithologic descriptions from boring logs for multiple purposes by multiple inspectors). The anisotropy ratios reported in the treatability study as high as 30:1 are referring to the RGA."

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Summary - May 12, 2017 EPA Technical Comments, Continued

Comment	Topic	Associated Recommendation(s) in the Report	Discussion and 2021 Status
NA 12	Calibration statistics: the Scaled RMS Error of greater than 10% would indicate that the calibration of the flow model is not acceptable according to the industry standard	Not directly addressed by recommendations in the report. Each of the 20 recommendations included in the report are intended to address uncertainties and data needs related to the model.	From RTC: "Evaluation of the scaled RMS within the plant area and the applicability of model-wide guidelines in future modeling efforts will be discussed with the MWG…"
NA 13	Calibration statistics: Residual values are high inside the plant area and west of C-400	In D1: "To reduce uncertainty at the contact area between the Terrace Gravel and the UCRS in the vicinity of the southern model boundary, additional monitoring well installation may be considered to collect water level and soil boring information." In D1: "Evaluation of a more accurate method to quantify Terrace underflow to the RGA is recommended."	From RTC: "The high residual values and the low residual values are distributed across the stress periods and layers."

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Summary - May 12, 2017 EPA Technical Comments, Continued

Comment	Topic	Associated Recommendation(s) in the Report	Discussion and 2021 Status
NA 14	The new transect wells should be included in future model calibrations	In D1: "Assessing water level and water quality data collected from the newly installed transect of monitoring wells located east of C-400 Building is recommended. This assessment will facilitate better understanding of the groundwater elevation contours and flow directions that indicate an apparent groundwater divide near the new transect monitoring wells. This apparent groundwater divide is a key feature of the current model calibration."	Data from the transect monitoring wells and other area monitoring wells are collected quarterly as part of the NEPCS project.

DRAFT Work Product – For Discussion Only

Summary - May 12, 2017 EPA Technical Comments, Continued

Comment	Topic	Associated Recommendation(s) in the Report	Discussion and 2021 Status
ED 1	Inadequate information to determine appropriate use of the model	Each of the 20 recommendations included in the report are intended to address uncertainties and data needs.	From RTC: "The report provides details of data analysis, model construction and calibration, assumptions and limitations, and additional data needs as a basis for others outside of the MWG to make their own determination of the appropriateness of the model in the context of a specific application. " Groundwater data are routinely collected as part of several site projects, including the GWSP.

DRAFT Work Product – For Discussion Only

Summary - May 12, 2017 EPA KDEP Technical Comments, Continued

Comment	Topic	Associated Recommendation in the Report	Discussion and 2021 Status
ED 2	Recharge rates, particle trajectories, and highly complex flow patterns compared to sensitivity analysis results	Each of the 20 recommendations included in the report are intended to address uncertainties and data needs related to the complex flow patterns at the site. Five of the recommendations included in the report are intended to address uncertainties and data needs specifically related to recharge. For example, added to the D2: "Installation of additional monitoring wells, located inside and outside of the plants industrial area would reduce uncertainty regarding groundwater flow direction, contaminant distribution, and potential source areas for future model updates."	Synoptic water level measurements are being collected quarterly and continuous water level measurements using pressure transducers are being collected in select wells as part of the GWSP.

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August 9, 2017 EPA Acknowledgement

- EPA acknowledged receipt of the D2 report and responses to EPA and KDEP comments

Based on our review of the draft report (April 2017), the EPA was not able to concur on use of the 2016 Groundwater Flow Model Update to support project-specific environmental cleanup activities under the PGDP Federal Facility Agreement (FFA). No edits were made by DOE in the *Final Groundwater Flow Model* report in response to EPA comments on the draft; however, a copy of EPA's comments, and DOE's responses, are included in Appendix D of the final report, consistent with tri-party discussions. Moving forward, the EPA anticipates that the work group will discuss and resolve EPA's comments on the current version of the model in support of additional data collection and follow-on modeling efforts to ensure that the model supports future environmental media cleanup work under the tri-party PGDP Federal Facility Agreement.

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Backup

- KDEP Comments and Responses
- EPA Comments and Responses

DRAFT Work Product – For Discussion Only

May 5, 2017 KDEP Technical Comments

14. Need additional data points from Station 45.

    Response 14: Clarification of this comment was provided by Chris Jung in the May 31, 2017, MWG meeting. The reviewer intended to request that collection of additional streamflow data be considered in future modeling efforts. Consideration for these data is included as a recommendation in Section 8.2.

25. Have the roof drain systems been repaired? Please add text to indicate repair dates.

    Response 25: Information regarding roof drain repair has not been compiled. A bullet to include collection of these data has been added to Section 8.2, "Recommendations." Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

DRAFT Work Product – For Discussion Only

May 5, 2017 KDEP Technical Comments, Continued

41. Additional slug test performed on a selection of appropriate monitoring wells will better define hydraulic conductivity across the model domain. Future discussions should include selecting an appropriate slug test method and criteria for selecting test wells.

    Response 41: An additional bullet has been added to the list of recommendations in Section 8.2, Recommendations, page 156. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

42. To better understand the groundwater flow north of the site the TVA monitoring system data should be verified (especially datums) and used in future models.

    Response 42: An additional bullet is added to the list of recommendations in Section 8.2 Recommendations, page 157. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

DRAFT Work Product – For Discussion Only

May 5, 2017 KDEP Technical Comments, Continued

43. Perhaps the installation of piezometers beneath several of the large buildings to determine thickness of gravel and if water fluctuates over time.

    Response 43: An additional bullet is added to the list of recommendations in Section 8.2 Recommendations, page 157. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

44. Various components of a Water Balance Study can reduce uncertainty in regards to better understanding anthropogenic recharge.

    Response 44: An additional bullet is added to the list of recommendations in Section 8.2 Recommendations, page 157. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

DRAFT Work Product – For Discussion Only

May 5, 2017 KDEP Technical Comments, Continued

45. Additional MWs can be installed inside and outside of the plants industrial area to reduce uncertainty in regards to groundwater flow direction and chemical concentrations. The data can also be used to help in identifying additional contaminant sources (especially associated with the NE Plume) which the current model suggests.

    Response 45: An additional bullet is added to the list of recommendations in Section 8.2 Recommendations, page 157. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

46. Additional Soil Borings and/or MWs can be installed to further refine the model boundary.

    Response 46: This recommendation already is included in the report in the first bullet of Section 8.2: "To reduce uncertainty at the contact area between the Terrace Gravel and the UCRS in the vicinity of the southern model boundary, additional monitoring well installation may be considered to collect water level and soil boring information."

47. Conduct tracer tests to further define groundwater divide.

    Response 47: An additional bullet is added to the list of recommendations in Section 8.2 Recommendations, page 157. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

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May 12, 2017 EPA Technical Comments

Noman Ahsanuzzaman – 14 comments

1. The major concerns of the model are (i) extremely high hydraulic conductivity values in the plant area along with (ii) the extensive use of the trajectory targets during the model calibration. As a result, results in the model calibrated excessively high transmissivity zones along the path of the plumes, essentially creating conduits along those directions. Because of these excessively high transmissivity zones, the extraction wells are capturing not only the particles from the C-400 Building but also the particles from all the source locations within the plant area. In reality, this is extremely unlikely, especially when it is known that drawdowns at the extraction wells are minimal even at high pumping rate. A third major concern is that the model calibration only used two (2) stress periods, even though the MWG agreed to use at least five (5) stress periods representing both high and low river stages. EPA has emphasized these concerns in previous comments on earlier drafts of the report and in multiple modeling work group meetings (see Attachments 1 and 2 to this Enclosure). These concerns are detailed in the comments below.

   Response 1: Comments and concerns are noted. Please see specific responses below.

DRAFT Work Product – For Discussion Only

May 12, 2017 EPA Technical Comments, Continued

2. A major limitation of this model is that the calibration result showed excessively high value of hydraulic conductivity (K) and recharge rate (RR)…EPA asserts that the automated model calibration tool (i.e., PEST) favored higher K value to accommodate higher recharge rate…During the initial MWG meetings, it was agreed that a calibration for low infiltration rate would also be conducted following the calibration for agreed on RR value of 22 in/yr. It is disappointing that the final modeling process only covered the higher end of the expected range for K and even exceeded the range for approved maximum recharge rate.

   2017 Response 2: DOE disagrees with EPA's characterization of the PEST calibration and believes that the presented data supports the accuracy of the calibration. Future efforts to evaluate model calibration should be discussed further with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

3. A major limitation of the model is the excessive use of the trajectory targets during model calibration. These targets were used to drive the groundwater flow from the C-400 Building by forcefully changing the direction of flow towards the direction of the plumes. This approach is no different than the 2008 model where a flow conduit was setup along the same path of these trajectory targets by assigning higher hydraulic conductivity values along that path…Since there are no data available to validate this extremely high contrast in transmissivity values (as shown in Figure 6.5), it is recommended that DOE address this data gap by conducting aquifer pumping tests along the path of the plumes. Also, model output for flux through cross-sections across the two plumes at the plant boundary could be verified against the measured flux from the NW and NE plume extraction wells.

   Response 3: The use of trajectory targets, in addition to flux and head targets, was demonstrated to be an essential element in the calibration process (i.e., the plume trajectories could not be simulated accurately without the use of trajectory targets). Future efforts to collect additional K data in the plant area and evaluate modeled and measured flux will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

DRAFT Work Product – For Discussion Only

May 12, 2017 EPA Technical Comments, Continued

4. The implications of Comments 2 and 3 are evident from Figure 6.35 (attached), where it shows that the extraction wells are capturing particles from all the source locations within the plant area. Since the higher transmissivity channels have been created along the flow path towards the extraction wells, all the particles are ending up in the extraction wells. If this has been true, any release of contaminants anywhere within the plant boundary would most likely be captured by these extraction wells. EPA is not aware of any validation data available to support this modeling result. This is a significant line of evidence for why it is not reasonable to accept the results from the current version of the model for use in CERCLA cleanup activities under the PGDP FFA.

   Response 4: The size of the capture zone indicated by particle flow paths is a function of transmissivity and recharge specified across the plant area and may indicate that the constraint limitations applied to the PEST calibration are not representative of site conditions (i.e., higher hydraulic conductivity and recharge may be more representative of site conditions). Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

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May 12, 2017 EPA Technical Comments, Continued

5. Calibration with stress periods at high river stage are necessary for model robustness. The river stage stays at higher elevations about half of the year. Therefore, it is necessary to calibrate the model for the high river stage as well (i.e., the wet season). Transient river stage does not necessarily mean that groundwater is not at steady-state. As stated in the report, transient river condition might Influent the groundwater near the river. Since one of the objectives of the model is to estimate the capture zones around the extraction well networks (see Section 1.1 on page 1), sudden variability of the river stage should not significantly influence groundwater near the extraction wells. The model calibration only used two (2) stress periods, even though the MWG agreed to use at least five (5) stress periods representing both high and low river stages.

   Response 5: Water level response to rising and falling river stages is a transient process, such that synoptic water level data collected during periods of variable river stage would not represent the groundwater system during steady state conditions. Use of these transient water levels as calibration targets in a steady state model is not appropriate. Additional continuous water level data collection and sitewide synoptic water level gauging events during different seasons will provide useful information for further evaluation of transient site conditions. As discussed in MWG meetings, the use of two stress periods rather than the five that were identified as suitable for calibration was due to time constraints in the modeling schedule. For the next model update, inclusion of additional stress periods and collection of additional data will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

DRAFT Work Product – For Discussion Only

May 12, 2017 EPA Technical Comments, Continued

6. Constant or general head boundary condition should be used for the Metropolis Lake instead of assigning an extraordinarily high K value (50,000 ft/d) for the model cells. Such a high K value is driving the groundwater in the direction of the lake, as it is observed in the particle tracking results. Using a head boundary would have much less influence on groundwater moving in the direction of the lake.

   Response 6: As initially stated in the 2008 modeling report, the lake is conceptualized as a "window into the RGA" that does not act as a net source or sink of groundwater. Using a high K value allows the lake to be represented in this way, while still accounting for the fact that it is a surface water body with flat water levels at the lake surface. This method of simulating a lake using a high contrast hydraulic conductivity zone is a common approach and is well documented in technical literature (e.g., *Using High Hydraulic Conductivity Nodes to Simulate Seepage Lakes* by Mary P. Anderson, Randall J. Hunt, James T. Krohelski, and Kuopo Chung; Vol. 40, No. 2-GROUND WATER-March-April 2002, pages 117-122). Using constant head boundaries may lead to a net loss or gain of water at Metropolis Lake and would require additional data collection for model input. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

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May 12, 2017 EPA Technical Comments, Continued

7. Based on the minimum clay/silt of 30-35% in the entire model domain, it was assumed in the model that the maximum recharge within the site is 29 in/yr. However, the Modeling Work Group (MWG) agreed to allow a maximum of 22 in/yr recharge based on 40% clay/silt and 60% sand/gravel. It is evident from Figure 3.8 that only a small fraction of the plant area is below the 40% clay/sit threshold. The vast majority of the plant area has clay/silt at 50% or greater. That means based on the harmonic mean, a maximum recharge rate of 18 in/yr would be allowable. The MWG never agreed to use the median hydraulic conductivity in addition to the harmonic mean value for recharge estimation. Therefore, EPA recommends that model calibration should limit the recharge rated to a maximum of 22 in/yr.

   Response 7: It is assumed that the reviewer intended geometric mean when stating harmonic mean. The values in Table 3.5 were provided as a basis for estimating the range of maximum recharge based on lithologic descriptions. The appropriate statistic for estimating recharge in the plant area has been discussed, but no agreement by the MWG was made regarding a final value. During the model calibration process, the maximum constraints based on the geometric mean were realized, and subsequent simulations used the median values to allow the calibration to find values that were not constraint limited. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/ uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

8. It does not appear that the recharge zone for the storm drains (Zone 16) followed the footprint of the HU3 clay unit (see Figures 3.11 and 5.5). In fact, the storm drains are the highest contributor to mass flux of all the anthropogenic recharge boundaries (see Table 6.3). The area covered by these drains should not extend beyond the footprint of the HU3 unit.

   Response 8: The recharge zone for the storm drains (Zone 16) follows the footprint of the storm drain piping and is independent of the HU3 clay unit characterization. The calibrated recharge rate is expected to be on the higher end of the range of values calibrated for anthropogenic recharge because of documented leaks and leakage typical to aging storm water systems. The higher contribution to mass flux is based partially on the relatively large footprint of the recharge zone due to the extensive network across the plant area (see Figures 3.11 and 5.5). Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

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May 12, 2017 EPA Technical Comments, Continued

9. Although the McNairy formation has 2 to 3 orders of lower hydraulic conductivity, it would still be a significant formation for DNAPL source accumulation and plume migration within the McNairy formation. Back diffusion of solvents from the McNairy formation to the Regional Gravel Aquifer (RGA) could be significant as well. Therefore, the exclusion of this potential secondary source zone would be a major limitation if the current version of the groundwater flow model is used simulation is used for solute transport modeling.

   Response 9: With respect to groundwater flow, the CSM recognizes limited flow in the McNairy; however, the RGA is the primary conveyor of groundwater from PGDP to the Ohio River. If the model is used to simulate solute transport in the future, then the best method to model back-diffusion from the McNairy formation will be discussed with the MWG. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

10. The model allowed excessively high recharge rate for the roof drains (e.g., 30 in/yr). To assume this high recharge into groundwater underneath the large buildings is unrealistic. There should be at least some loss from runoff. EPA understands that these buildings have a thick (ca. 10 ft) gravel underneath the foundation and were flooded occasionally in the past. But just because these buildings have standing water, it does not mean that the recharge rate would be higher than the maximum allowable rate limited by the underlying formation. The soil underneath the gravel would limit the recharge, unless the gravel layer cuts into the RGA. Therefore, lithologic limits (which is ≤ 22 in/yr) should apply to these buildings as well.

    Response 10: See Response 7. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

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May 12, 2017 EPA Technical Comments, Continued

11. The ratio of the horizontal to vertical hydraulic conductivity does not show a value of 10, as explained in the text. Closer comparison of the data presented in the report shows that the ratio to be between 14 and 20, when the arithmetic and geometric means are compared, respectively. In addition, the model for the C-400 treatability study for steam injection also calibrated the ratio to be in the range of 20 to 30. A higher ratio of the horizontal to vertical hydraulic conductivity would lower the maximum recharge rate allowed in the model as well. Therefore, EPA recommends that DOE update the model calibration with a higher ratio of horizontal to vertical hydraulic conductivity.

    Response 11: It is assumed the text referred to is in Section 3.3.1. The 10:1 anisotropy ratio referred to in Section 3.3.1 is related to the value reported for the UCRS (see Figure 13 from the Treatability Study Report, DOE/LX/07-2202&D1, December 2015). The 10:1 ratio used as a basis for estimated maximum recharge based on lithology is an appropriate order of magnitude assumption considering the precision of data relied on to conduct the analysis (e.g., variability of lithologic descriptions from boring logs for multiple purposes by multiple inspectors). The anisotropy ratios reported in the treatability study as high as 30:1 are referring to the RGA. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

12. Calibration statistics presented in Table 3.6 should also show the Scaled Root Mean Squared (RMS) Error inside the plant boundary, since this is the most important area of interest for model calibration. The observed head range inside the plant area would be much smaller than that shown in the table; hence, the Scaled RMS Error could rise. Note that the Scaled RMS Error of greater than 10% would indicate that the calibration of the flow model is not acceptable according to the industry standard.

    Response 12: Evaluation of the scaled RMS within the plant area and the applicability of model-wide guidelines in future modeling efforts will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

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May 12, 2017 EPA Technical Comments, Continued

13. The residual values in Figures 6.9 and 6.10 show a number of calibration targets with high residual values inside the plant area. Some of the targets with higher residual errors are located near the southern boundary. Also, west of the C-400 building shows higher residual errors in all three layers. Changing the boundary values and/or types might help improve the calibration near the southern boundary.

    Response 13: The high residual values and the low residual values are distributed across the stress periods and layers. There does not appear to be any obvious bias that could be addressed by "Changing the boundary values and/or types." Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/ uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

14. Since the new transect wells are located within the high recharge zone (Zone 24) inside the plant area, it is critical to include the water elevation data from these transect wells in future model calibrations. These transect wells could be used to validate the high recharge rates in Zone 24.

    Response 14: Incorporation of these data into the next model evaluation is recommended (Section 8.2, Recommendations). Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

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May 12, 2017 EPA Technical Comments, continued

Eva Davis – 2 comments

1. There does not appear to be adequate information in the report to allow others outside of the MWG to make a determination of the appropriateness of the model for a given proposed use.

   Response 1: The report provides details of data analysis, model construction and calibration, assumptions and limitations, and additional data needs as a basis for others outside of the MWG to make their own determination of the appropriateness of the model in the context of a specific application. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

2. [I]t is not clear how 'robust' the model is with respect to the conditions of most of the years and the text in Section 7.2 and 8.2 does not appear to be supported. The fact that large changes in recharge in the plant area (Figures 6.22 to 6.29) do not appear to affect the trajectory of particles in the source area is troubling...Slides 29 to 47 of the February 10 & 11, 2015 work group meeting show a highly complex flow pattern in the ROA in the plant – this is not surprising, due to the anthropogenic recharge in the plant area…Yet the sensitivity analysis for the current model shows that differences in recharge rates don't have an effect on particle trajectory in the plant area. The MWG should consider whether this is a case of particles not being released in in the right place to show the variation in flow directions.

   Response 2: Additional continuous water level data collection is recommended to evaluate transient response to river stage. Collection of synoptic water levels during different times of the year and assessment of 2016 transect data are recommended to improve understanding of sitewide seasonal flow conditions as well as the location of the apparent divide near the new monitoring well transect. Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.

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APPENDIX D

GROUNDWATER MODELING WORKING GROUP MEETING SUMMARY—JULY 13, 2022

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ACRONYMS[1]

AIP	agreement in principle
amsl	above mean sea level
CAB	citizens advisory board
CB	colloidal borescope
CCR	coal combustion residual
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CHFS	Cabinet of Health and Family Services
CRS	comment response summary
CSM	conceptual site model
DNAPL	dense nonaqueous phase liquid
DOE	U.S. Department of Energy
DQO	data quality objective
DTW	depth to water
EMP	environmental monitoring plan
EPA	U.S. Environmental Protection Agency
ETAS	Enterprise Technical Assistance Services, Inc.
FLIR	forward looking infrared
FRNP	Four Rivers Nuclear Partnership, LLC
FS	feasibility study
FY	fiscal year
FYR	five year review
GIS	geographic information system
gpm	gal per minute
GPS	global positioning system
GW	groundwater
GWSP	Groundwater Strategy Project
HQ	headquarters
KDEP	Kentucky Department for Environmental Protection
KDWM	Kentucky Division of Waste Management
KGS	Kentucky Geological Survey
KRCEE	Kentucky Research Consortium for Energy and the Environment
KY	Commonwealth of Kentucky
LBC	Little Bayou Creek
LBCSP	Little Bayou Creek seep
LiDAR	light detection and ranging
MCL	maximum concentration limit
MMES	Martin Marietta Energy Systems, Inc.
MSL	mean sea level
MW	monitoring well
MWG	Modeling Working Group
NGVD	National Geodetic Vertical Datum
OREIS	Oak Ridge Environmental Information System
OU	operable unit
PEGASIS	PPPO Environmental Geographic Analytical Spatial Information System
PFAS	per- and polyfluoroalkyl substances
PGDP	Paducah Gaseous Diffusion Plant

[1] Acronym list was not part of the original meeting summaries.

PPPO	Portsmouth/Paducah Project Office
P-QAPP	programmatic quality assurance project plan
PT	pressure transducer
PVC	polyvinyl chloride
PZ	piezometer
Q	quarter
RFP	request for proposal
RGA	Regional Gravel Aquifer
RI	remedial investigation
SI	site investigation
SMP	site management plan
SRNL	Savannah River National Laboratory
SSI	Swift & Staley Inc.
TBD	to be determined
TOC	top of casing
TVA	Tennessee Valley Authority
UCRS	Upper Continental Recharge System
UK	University of Kentucky
VI	vapor intrusion

Paducah Site Groundwater Modeling Working Group
Meeting Summary—July 13, 2022

MWG Attendees:

DOE
Rich Bonczek ✓
Dave Dollins ✓

ETAS
Martin Clauberg ✓
Bruce Stearns ✓
Tracy Taylor ✓

KRCEE
Steve Hampson ✓

TVA
Tabitha Ester ✓
Anna Fisher
Dominic Norman

EPA and Contractors
Noman Ahsanuzzaman ✓
Ben Bentkowski
Eva Davis
Mac McRae ✓
Victor Weeks ✓

Kentucky
Brian Begley ✓
Stephanie Brock
Nathan Garner ✓
Brian Lainhart
Bart Schaffer ✓
Chris Travis ✓

FRNP
Austin Buckhalter
Bryan Clayton
Lisa Crabtree ✓
Ken Davis
Rob Flynn
Bruce Ford ✓
Stefanie Fountain ✓
LeAnne Garner
Todd Powers ✓
Joe Tarantino ✓
Denise Tripp ✓
Dawit Yifru
Bruce Meadows
Evan Clark
Jason Orr ✓

✓ Indicates the Attendee was present

Original meeting agenda items are provided followed by meeting notes; the meeting notes are provided in italics with action items noted in green.

1. Call for Issues from Groundwater Modeling Working Group (MWG) Members

No comments were received to the April 6, 2022 Meeting Summary (sent to participants on 5/24/2022). This summary will be considered final.

No comments were received to the April 6, 2022 Meeting Summary. The meeting summary is now final.

2. FY 2022 Work Plan/Schedule

Activity	Date
~~Quarterly Meeting (October/FY22Q1)~~	~~10/6/2021~~
~~MWG Concurs with FY 2022 Work Plan/Schedule~~	~~11/12/2021~~
~~Submit Draft Meeting Summaries and White Papers Compilation (FY21)~~	~~11/15/2021~~
~~MWG Provide Comments on Draft Compilation of Meeting Summaries and White Papers (FY21)~~	~~11/30/2021~~
~~Submit Final Meeting Summaries and White Papers Compilation (FY21)~~	~~12/21/2021 Planned~~ ~~12/13/2021 Actual~~
~~Quarterly Meeting (January/FY22Q2)~~	~~1/12/2022~~
~~Submit Draft Large Building PZ White Paper to MWG~~	~~2/17/2022~~
~~Submit Draft Survey White Paper 2 to MWG~~	~~3/18/2022~~ ~~Actual: 2/28/2022~~
~~MWG Review Draft Large Building PZ White Paper~~	~~3/25/2022~~
~~Quarterly Meeting (April/FY22Q3)~~	~~4/6/2022~~

Activity	Date
~~Submit Draft McNairy Lithologic Technical Paper to MWG~~	~~7/1/2022 (was 8/11/2022)~~
Quarterly Meeting (July/FY22Q4)	7/13/2022
MWG Meeting to Discuss Draft McNairy Lithologic Technical Paper	7/13/2022 (was 7/20/2022)
Submit Final Large Building PZ White Paper to EPA and KY	7/28/2022 (was 5/19/2022)
MWG Provide Comments on Draft McNairy Lithologic Technical Paper	8/1/2022 (was 9/12/2022)

Color code for schedules:

Due date	Quarterly meeting
Submittal date	Concurrence/acknowledgement date

b. FY 2023 Activities

Activity	Date
Quarterly Meeting (October/FY23Q1)	10/5/2022
Submit Final McNairy Lithologic Technical Paper to EPA and KY	11/7/2022

As discussed during the last meeting, the schedule for the Large Building PZ White Paper has been revised; the new date for submittal of the final paper is included above.

The group discussed the plan to hold a meeting to discuss the Draft McNairy Lithologic Technical Paper. EPA did not feel a meeting was needed prior to the comment date and suggested a meeting be considered one week after the comment date. EPA requested an email reminder that comments on the paper are requested by August 1, 2022 be sent to the group (email was sent following the meeting).

3. Update on Water Levels

Synoptic water level events are being collected quarterly. The potentiometric map for the synoptic water level event in February 2022 is included in Attachment 1. The February potentiometric map represents conditions where the Ohio River elevation was high and where only one of the four extraction wells was operational.

A synoptic water level event was performed May 23-24, 2022 and will be included in the next meeting agenda.

Updated groundwater elevation data for TVA wells collected by KY for August 2021, November 2021, and February 2022 is included as Attachment 2. During the January 12, 2022 and April 6, 2022 meetings, the group discussed that TVA plans to abandon several monitoring wells along Little Bayou Creek (e.g., AR76, AR75B, and B10). Tabitha Ester (TVA) continues to coordinate with Brian Lainhart (KY) on collection of water level measurements and monitoring well abandonment plans. Possible localized impacts on water levels due to the TVA sheet pile wall installation are an ongoing topic of discussion (see Agenda Item 11, Projects on the "Watch Topics" List, TVA Changes).

During the last meeting, the group discussed that the TVA well water levels will be reviewed for inclusion on future potentiometric maps. FRNP generally needs water level datasets one month prior to the quarterly meeting for the preceding quarterly measurement event.

B. Begley (KDEP) will check on the TVA well data for the May 2022 water level measurement event (data was provided on July 15, 2022).

TVA wells AR76, AR75B, and B10 have been abandoned and that one new well screened in the RGA has been installed by TVA.

The group agreed by consensus to include the potentiometric maps from 2022 in a separate section of the next MWG compendium document.

The Survey White Paper 2 has been added to the 2017 report on the 2016 Sitewide Groundwater Model Update. No changes have been made to the report or the White Paper. The report is expected to be reissued in the next several weeks.

4. Update on Paducah Site Groundwater Strategy

The overall objectives for the GWSP is to develop a groundwater strategy that closes out various issues for the site:

- Change status of two Environmental Indicator Performance Measures to "Yes"
  - Human exposure under control
  - Groundwater migration under control
- Resolution of data needs
- Groundwater Modeling Working Group (MWG) recommended maintenance and updates

The project objectives and draft schedule were originally discussed during the April 10, 2019 MWG meeting and included in the Compilation of Meeting Summaries and White Papers (2019–July 2020) (DOE/LX/07-2451&D1). The GWSP is a multi-year plan with near-term (0-3 years) activities and longer-term (beyond 3 years) activities planned. The specific timing and scope of each activity are developed by DOE based on data collected in the prior year(s). The GWSP and the C-400 OU Remedial Investigation projects are separate, but where activities overlap they are coordinated and the relevant information obtained from the remedial investigation will be incorporated into the GWSP.

The Groundwater Strategy Project (GWSP) field data collection schedule for FY 2022 is included in Attachment 3.

The FY 2022 plan includes quarterly walkdowns of a portion of Little Bayou Creek. During the October 6, 2021 meeting the group discussed that seeps may not be able to be observed during quarterly walkdowns, specifically during periods where the Ohio River is elevated above normal pool and where the seeps are not accessible or visible due to the Ohio River backing up into the creek. KY recommended instead coordinating the walkdowns with precipitation and river stage forecasts. Stream gauging is not planned for FY 2022 due to the ongoing construction of the TVA sheet pile wall and the intent to observe the system for any changes resulting from the presence of the wall.

Seeps. There have been no seep results above the maximum concentration limit (MCL) for trichloroethene (TCE) for many years. The location of the seeps and TCE data for the seeps are depicted on the figure included in Attachment 3. KY clarified that some of the seeps on the figure are in the creek and some are on the banks of the creek.

During the October 6, 2021 meeting, the group discussed that LBCSP5 routinely has flow and is able to be sampled, whereas many of the other previously identified seeps do not have flow consistently. KY reported that they have revised their stream walkdowns to go further up and downgradient of LBCSP5. KY also suggested the use of thermal imaging for seep identification in the winter months.

A creek bank walkdown of Little Bayou Creek in the vicinity of the new TVA sheet pile wall was performed December 2, 2021. The field crew identified the locations of Seeps 1-7 and 9 and noted three other seep areas in the vicinity of Seep 6. Seeps 8 and 10 were not evident. Only three locations had discharge of >0.1 gpm: Seep 4 (< 1 gpm flow), Seep 6 (several gpm flow), and a new seep on the west side of the creek across from Seep 6 (~0.3 gpm). Several of the seeps had no discernable flow and none of the newly observed seeps had flow sufficient to support sampling. No seeps were identified beyond the stretch of Little Bayou Creek where seeps had been identified previously.

The second walkdown attempt was made on March 13, 2022. Little Bayou Creek at the PGDP supply pipe line crossing of the creek (the north end of the "seeps area") was observed to be inundated in response to the current flood on the Ohio River. The water level was ~2 ft below the top of the creek bank at the pipeline crossing, which equates to 6 to 8 ft of water in Little Bayou Creek. It is not currently possible to walk down Little Bayou Creek to assess the seeps. This finding is consistent with observations that Brian Begley had shared with the MWG from prior year walkdowns performed by KDEP.

Use of drone and camera technology for the seeps observations is in review by FRNP. EPA provided additional information on successful use of drones for this application at a site in Navassa, North Carolina (see April 6, 2022 meeting summary).

KRCEE has a task to look at seeps using a drone equipped with FLIR (Forward Looking InfraRed). The project will look at other project sites then apply what is learned to the Paducah site. The project intends to provide a proof-of-concept and an understanding of whether the seeps have or have not shifted. The drones will be tied to GPS, potentially also with LiDAR. In coordination with the KRCEE project, FRNP/DOE provided KRCEE with a map with potential stream gauge locations and times for data collection for coordination of this effort in support of the Groundwater Strategy Project on June 27, 2022.

"No Go" Areas for Monitoring Well Installations. Corridors where overhead transmission lines have been removed have been considered for monitoring well placement, especially with respect to the west side of the NE Plume. A new substation (C-538) has been constructed east of the C-755 trailer complex. On the west side of the new substation, 161kV overhead have been installed along the existing overhead line corridor. On the east side of the new substation, 161kV overhead lines (near the C-755 parking lot and between K010 and K011) were installed along the 161kV lines. Most of the overhead lines have removed from McCaw Road to the plant with only a static line remaining on the towers on the south into the C-331 yard.

The group discussed during the January 12, 2022 meeting that no additional changes to the power line configurations are planned. Other medium and low voltage lines around the plant would need to be accounted for in any project, including monitoring well installation. Generally these lines would have 50 ft buffer. A figure of the current high-voltage overhead power lines is included in Attachment 3. Any future changes to facility overhead lines that may impact environmental scopes or data collection will be shared with the MWG.

FRNP continues to coordinate with KY on the AIP monitoring wells sampling schedule.

The draft Olmsted Dam White Paper is planned to be submitted to DOE in July. TVA asked if they will be able to see the paper; DOE noted that drafts of non-FFA documents that are reviewed and released to the public can be made available to TVA.

5. Anthropogenic Recharge

The group agreed by consensus to add this sub-topic to the agenda. This sub-topic will capture discussion on site changes such as the recent changes to the high pressure fire water system.

During the prior meeting, the group agreed to discuss whether the approaches included in the paper are needed for near-term projects and if field implementation should be pursued.

a. Discussion on White Paper: *Evaluation of Anthropogenic Recharge Associated with the Process Buildings in Support of the Sitewide Groundwater Model (Large Building PZ White Paper)*

During the July 14, 2021 MWG meeting the group discussed that during the C-400 Remedial Investigation, no water has been observed in the UCRS in monitoring points installed through the foundation of the C-400 building. It was discussed that the C-400 building observations may not be representative of the buildings of interest in this white paper.

During the October 6, 2021 meeting the group discussed that information available on the historical and archived plant drawings show that the process buildings were constructed similar to one another and have a thin (9 to 12 inches thick) compacted gravel layer underlying the concrete floor of the buildings. There are drain lines in the compacted gravel layer, but the limited thickness of the gravel likely would make installation of traditional piezometers in the gravel layer impractical. The lack of water in the piezometers installed in the much thicker gravel layer (5 to 8 ft thick) underlying the concrete at C-400 also indicates that it is unlikely that there is water storage under the process building concrete floors. KY suggested the team assess probing the concrete under the process building floors to confirm the gravel thickness and confirm the gravel is not saturated.

During the January 12, 2022 meeting, Ken Davis (FRNP) provided a summary of the roof replacement history at the site and the findings of the construction drawings review:

- The C-331 and C-335 roofs were replaced in 1981.
- Roof [drain] repairs were implemented at C-333 and C-337 in 2016-2017.
- There were reports of floor intrusion of water from below the foundations going back to 2002.
- The process buildings were constructed with a thin gravel layer under the concrete foundation (unlike at C-400 which has a 5 to 8 ft thick gravel layer underlying the concrete foundation).
- There is no gravel associated with the control rooms/basements in the process buildings, but there is gravel associated with the building footers.
- The paper includes a graded approach to understanding water presence under the process buildings and, as part of the graded approach, a modified piezometer design is included in the paper.

The draft paper was provided to the MWG for review on 2/15/2022. Comments were provided by EPA and KY on 3/22/2022 and 3/23/2022, respectively.

KY summarized their comments from the 3/23/2022 email: more evidence is needed to fully characterize the extent and connectivity of gravel subbase (e.g., design vs as-built) and it is

unclear how the options presented in the paper will be implemented and address uncertainty. The group discussed whether including other sources (e.g., pipe corridors and tunnels) would have a significant impact on the modeling. FRNP described the challenges of working in the process buildings and that likely only C-337 would be available for the study. Additionally, there are no electric conduits under the buildings, and no gravel backfills behind the walls.

EPA summarized their comments from the 3/22/2022 email: uncertainty regarding the three options proposed. The group discussed that the site is not in a position to develop a work plan and agreed that many of the comments to date could be addressed in the DQOs.

Activity	Target Start	Target Finish
~~Quarterly Meeting (October/FY21Q1)~~		~~10/7/2020~~
~~Develop Outline for Large Building PZ White Paper~~	~~10/14/2020~~	~~12/11/2020~~
~~Provide Large Building PZ White Paper Outline to MWG~~		~~12/11/2020~~
~~MWG Review Large Building PZ White Paper Outline~~	~~12/11/2020~~	~~1/13/2021~~
~~Quarterly Meeting (January/FY21Q2)~~		~~1/13/2021~~
~~Revise Outline for Large Building PZ White Paper Based on MWG Discussions~~	~~1/13/2021~~	~~1/28/2021~~
~~VI Field Sampling / Laboratory Analysis / Validation~~	~~Feb 21~~	~~Apr 21~~
~~Quarterly Meeting (April/FY21Q3)~~		~~4/7/2021~~
~~Quarterly Meeting (July/FY21Q4)~~		~~7/14/2021~~
~~Develop Draft Large Building PZ White Paper~~	~~9/1/2021~~	~~1/12/2022~~
~~Quarterly Meeting (October/FY22Q1)~~		~~10/6/2021~~
~~Submit Draft Large Building PZ White Paper to MWG~~		~~2/17/2021~~ ~~Actual: 2/15/2022~~
~~Quarterly Meeting (January/FY22Q2)~~		~~1/12/2022~~
~~MWG Review and Provide Comments on Draft Large Building PZ White Paper~~	~~1/23/2022~~	~~3/25/2022~~
~~MWG Meeting to Discuss Draft Large Building PZ White Paper~~		~~4/6/2022~~ ~~(was TBD)~~
Revise Draft Large Building PZ White Paper	2/17/2022*	7/27/2022*
Submit Final Large Building PZ White Paper to EPA and KY		7/28/2022* (was 5/19/2022)

Items shown in strikeout text are completed.
* Dates revised based on prior meeting discussion.

The white paper is in review with DOE at the time of the meeting. The group did not have any other comments on this agenda topic.

6. Plant-Wide Seismic Update

Section 1.1.2, "Regional Hydrogeology," references an axis in describing thickness trends for gravel deposits forming the RGA. EPA would like to discuss if the use of the term axis has any implied significance to groundwater flow direction(s) (i.e., a north-south lateral groundwater flow divide) or any implication for implied subsurface structural feature(s) forming the RGA (i.e., the existence of an east-west fault-controlled structural low).

The site geologist explained the east-west trend is consistent with ancestral Tennessee River and is believed to be an erosional surface (thalweg is the geomorphology term). EPA suggested that the Paducah Site area may have several generations of seismic activities, overprinting of seismicity could be happening, and east-west faulting may have occurred. Steve Hampson had a follow-up after discussion with Dr. Woolery and Dr. Zhu.

Steve Hampson reported that an east-west trend is prevalent at PGDP, as evidenced in both regional and local studies. Regional faults commonly trend northeast-southwest but that there could be local structural controls under PGDP that could influence groundwater flow. Seismic studies have not previously been conducted between the east and west fences and from the Porters Creek terrace to north fence because it was not possible to filter out the noise of the operating plant. Most of the plant infrastructure is no longer operating and Steve Hampson discussed that Dr. Woolery has noted there are now seismic reflection techniques that could give a better view of what the structure is beneath the site.

DOE and FRNP are reviewing whether there are any ways to further reduce (temporarily) sources of noise to facilitate new testing without disrupting site activities. Dr. Woolery has offered to support any requests or initiatives that may develop regarding additional seismic surveys at the Paducah Site.

During the April 6, 2022 meeting, the group discussed that there was no evidence of faulting encountered during the C-400 remedial investigation. The group also discussed whether this topic should follow the lithology paper discussions or if this topic could be advanced independently. KY's understanding is that the current level of plant operations with updated technology may provide a possibility for seismic studies in the plant area. S. Hampson (KRCEE) is willing to discuss with Dr. Woolery if that is the appropriate next step. There is no funding currently for this type of work, but could be discussed for FY 2023.

Seismic investigation is not currently a project (either DOE or KRCEE). The group discussed that this topic may be informed by the McNairy Lithologic Technical Paper and that seismic information will be needed for the selection of the on-site waste disposal facility and potentially for the Groundwater Operable Unit Dissolved Phase Plume project.

The group agreed by consensus to shorten the text associated with this topic in the next agenda.

The group also discussed the potential for KRCEE/UK Kentucky Geologic Survey (UK-KGS) to perform thermal imaging of seeps.

7. CSM for the McNairy in the C-400 Complex Area

FRNP has set up a website to house a library of McNairy information. Access the website at the following link: https://fourriversnuclearpartnership.com/McNCSM. The site requires a password that has been sent separately. Contact Stefanie if you need the password to the website.

The KRCEE spreadsheet database of soil boring logs (R10 HydroLitho Dbase posted 121620.xlsx) is available at https://fourriversnuclearpartnership.com/McNCSM.

A lithology white paper has been prepared as part of the resolution of dispute on the CERCLA Five Year Review. DOE will issue the final technical paper within one month of submittal of the D1 C-400 Complex OU RI/FS Report to support the review and comment of the C-400 specific data interpretation as part of the C-400 Complex OU RI/FS Report review process and the performance of the FY 2023 Five-Year Review revised protectiveness determinations for the Northeast, Northwest, and Water

Policy response actions. The regulatory milestone date for the D1 C-400 Complex OU RI/FS Report has been revised to October 7, 2022.

A draft schedule and annotated outline for the paper were discussed during the October 2020 Groundwater MWG meeting. The schedule was revised to reflect the new C-400 Complex OU RI/FS Report date and was discussed during the January 13, 2021 and April 6, 2022 meetings (see below).

Activity	Target Start	Target Finish	Notes
~~FRNP/DOE Develop Outline for Draft McNairy Lithologic Technical Paper~~	~~7/7/2020~~	~~9/30/2020~~	COMPLETE
~~Provide Draft McNairy Lithologic Technical Paper Outline to MWG~~		~~9/30/2020~~	COMPLETE
~~MWG Review Draft McNairy Lithologic Technical Paper Outline~~	~~9/30/2020~~	~~10/7/2020~~	COMPLETE
~~Quarterly Meeting (October/FY21Q1)~~		~~10/7/2020~~	COMPLETE
~~FRNP/DOE Revise Draft Outline for McNairy Lithologic Technical Paper Based on MWG Discussions~~	~~10/7/2020~~	~~10/22/2020~~	COMPLETE
~~Provide Final Outline for McNairy Lithologic Technical Paper to MWG~~		~~10/22/2020~~	COMPLETE
~~Quarterly Meeting (January/FY21Q2)~~		~~1/13/2021~~	COMPLETE
~~Quarterly Meeting (April/FY21Q3)~~		~~4/7/2021~~	COMPLETE
~~Quarterly Meeting (July/FY21Q4)~~		~~7/14/2021~~	COMPLETE
~~Quarterly Meeting (October/FY21Q3)~~		~~10/6/2021~~	COMPLETE
~~Quarterly Meeting (January/FY22Q2)~~		~~1/12/2022~~	~~COMPLETE~~
~~FRNP/DOE Develop Draft McNairy Lithologic Technical Paper Text~~	~~8/4/2021~~	~~3/10/2022~~	~~COMPLETE~~
~~Finish Collection of C-400 Lithology Data~~		~~3/16/2022~~	~~COMPLETE~~
FRNP/DOE Incorporate C-400 Results into Draft McNairy Lithologic Technical Paper	3/16/2022	8/11/2022	In progress
~~Quarterly Meeting (April/FY22Q3)~~		~~4/6/2022~~	
~~Issue Draft McNairy Lithologic Technical Paper to MWG~~		~~7/1/2022 (was 8/11/2022)~~	
Quarterly Meeting (July/FY22Q4)		7/13/2022	
MWG Meeting to Discuss Draft McNairy Lithologic Technical Paper		7/20/2022 (was 8/24/2022)	
MWG Review and Provide Comments on Draft McNairy Lithologic Technical Paper	7/1/2022 (was 8/11/2022)	8/1/2022 (was 9/12/2022)	
MWG Provide Comments on Draft McNairy Lithologic Technical Paper		8/1/2022 (was 9/12/2022)	
Develop C-400 RI/FS Report		9/14/2022	From C-400 Schedule
Quarterly Meeting (October/FY23Q1)		10/5/2022	Planning date
C-400 RI Report Submitted to EPA and KY		10/7/2022	Current Milestone
FRNP/DOE Revise Draft McNairy Lithologic Technical Paper	8/1/2022 (was 9/12/2022)	10/7/2022 (was 11/7/2022)	No formal CRS

Activity	Target Start	Target Finish	Notes
Submit Final McNairy Lithologic Technical Paper to EPA and KY		11/7/2022	Tech Paper Due 1 Month After C-400 RI Report (Currently 10/7/2022)

Items shown in strikeout text are completed.

The final annotated outline was included in the October 14, 2020 MWG meeting summary (sent to participants on 11/23/2020 and with agreed-upon revisions discussed during the 1/13/2021 meeting). No comments were received on the outline and the outline was considered final. The final annotated outline for this paper was included in the meeting summary for the 1/13/2022 meeting and was included with the April 6, 2022 agenda and summary.

During the October 6, 2021 meeting, the group discussed that observations from the C-400 field investigation drilling does not indicate fault interruption in the McNairy. DNAPL has not been observed in McNairy soils to date, indicating DNAPL migration through the RGA into the McNairy is not occurring. It is reasonable to conclude that if this is not occurring at C-400, it is likely not occurring elsewhere at the site. The group also discussed the need for rapid turnaround on any comments and KY indicated their willingness to have a meeting on the paper to facilitate the quick review. During the January 12, 2022 meeting, the group discussed the findings of the C-400 remedial investigation did not indicate any deep sources of DNAPL that would penetrate the basements or the McNairy formation and that concentrations generally decreased with depth.

The draft paper was issued to the MWG for review on [June 30], 2022.

EPA discussed that for C-400, they believe the paper has enough data and agreed that faulting was not observed and although other parts of the site do not have as high a resolution of data as the C-400 area, that the risk of faulting is low. They acknowledge that some projects may use the McNairy Formation as a vertical boundary. This paper should be factored into the CERCLA Five Year Review (FYR) with a strong conclusion that faulting was not observed in the primary area of concern at the site and that this issue from the 2018 FYR should be closed out. EPA discussed use of a FYR addenda to the 2023 FYR for this process and noted that there is good risk control due to good evidence of no faulting at C-400. KDEP recommended that the FYR addenda not go beyond the conclusions presented in the paper. DOE noted that a FYR kickoff call is planned for the fall for scoping and that the open issues from the 2018 FYR should be on that meeting agenda.

8. Resurvey of wells

The field resurveying effort for the monitoring well reference point elevations was completed October 9, 2020 and the data review was completed in November 2020. The data are in the process of being reviewed for upload to OREIS. A white paper summarizing the approach and scope of the resurvey work was developed and has been appended to the 2021 update to the P-QAPP.

A second white paper on potential impacts of the new survey data and the impact to the groundwater model was reviewed by the MWG (draft provided to the group on 2/28/2022). The paper focuses on the adequacy of the model in light of new monitoring well survey data; no modeling has been performed as part of the paper development. The paper includes an evaluation on the residuals from the 2016 modeling calibration and any impact the new survey data have on that calibration. No comments were received on the white paper. As agreed to during the last meeting, this white paper has been appended to the 2016 Groundwater Model Report.

Propose to remove this topic from future MWG meeting agendas.

This scope is complete; the group agreed by consensus to remove this topic from the next meeting agenda. Future discussions on monitoring well survey control will be included with the Update on Paducah Site Groundwater Strategy.

9. Precipitation and Ohio River Stage

Attachment 4 includes precipitation and Ohio River stage charts through June 27, 2022.

The group did not have any comments on this agenda topic.

10. Synoptic Water Level Events and Ohio River Levels

Stream gauging has been discussed as part of out-year activities. See October 2018 Meeting Summary for additional information. Stream gauging will support new modeling.

During FY 2022, quarterly walkdowns of portions of Little Bayou Creek are planned to identify any new seeps as part of the Groundwater Strategy project and to identify locations for potential future stream gauging, as appropriate.

During the January 12, 2022 meeting, KY requested the group consider if water level events can be performed in response to changes in Ohio River stages. FRNP/DOE has reviewed the historical documentation for a prior paper on groundwater level responses to Ohio River stage elevations:

MMES 1995. *Final Report on Drive-Point Profiling of the Northwest Plume and Analysis of Related Data*, KY/ER-66R, April. https://eic.pad.pppo.gov/Search.aspx?accession=I-04613-0032

- Pages 28 (PDF page 41) through 39 (PDF page 53) are included as Attachment 5.

The group did not have any comments on this agenda topic.

11. Projects on the "Watch Topics" List

- **TVA Changes.** During the October 2020 and January 2021 meeting, the MWG discussed the construction of the new ash ponds and a recent RFP for a 3,800 ft sheet pile wall constructed in close proximity to Little Bayou Creek and several seeps. The sheet pile wall may intercept the RGA and influence the creek.

  During the July 14, 2021 meeting, the MWG discussed the sheet pile wall being installed by TVA along Little Bayou Creek and along the southwest portion of the existing coal combustion residuals (CCR) landfill (as shown on the Figure 1). The wall is intended to stabilize the creek's bank, as opposed to control groundwater. KY/TVA provided as-built drawings showing the installation depth of the wall.

  Based on the information available in the TVA drawings, the sheet pile wall, the wall extends a significant depth into the RGA. The group discussed during the October meeting that the wall joints are not sealed, and TVA will confirm that the sheet piles themselves are solid (not perforated). TVA will confirm whether the notations are design or as-built and relay findings to the group; TVA will also confirm the depths of the sheet pile wall construction. Construction of the TVA sheet pile wall was completed in December 2021. Tabitha Ester (TVA) provided follow-up information on the sheet pile as-built elevations; this information was forwarded to the group on 3/25/2022.

A cross section of the sheet pile wall, the creek, and the interpolated upper and lower limits of the RGA is shown in Figure 2. The figures were compared to the final as-build drawings. Figure 1 has been updated; Figure 2 as presented at the last meeting and included again here matched the final as-built drawings.

The group discussed that some portions of the sheet pile wall extend into the McNairy Formation and that restriction of flow in the RGA may result in new seeps in Little Bayou Creek (LBC). The group also discussed that the sheet pile wall is constructed of solid panels with joints that are not sealed. T. Ester (TVA) will confirm this with her team. KDEP noted that there have been decreases in TCE concentrations in the LBC seeps over time, and that they are interested in understanding the impacts of the wall on groundwater flow and whether the wall will result in a shift in the plume(s). The group noted that there is not pressure data on both sides if the wall and the impact of the wall on the groundwater flow model is not currently known.

KDEP continues to do creek walkdowns to look for seeps. The most recent KDEP walkdown was in late 2021 and they plan to do again in August. KDEP will coordinate the next walkdown with KRCEE/UK-KGS and FRNP requested that KDEP.

Figure 1

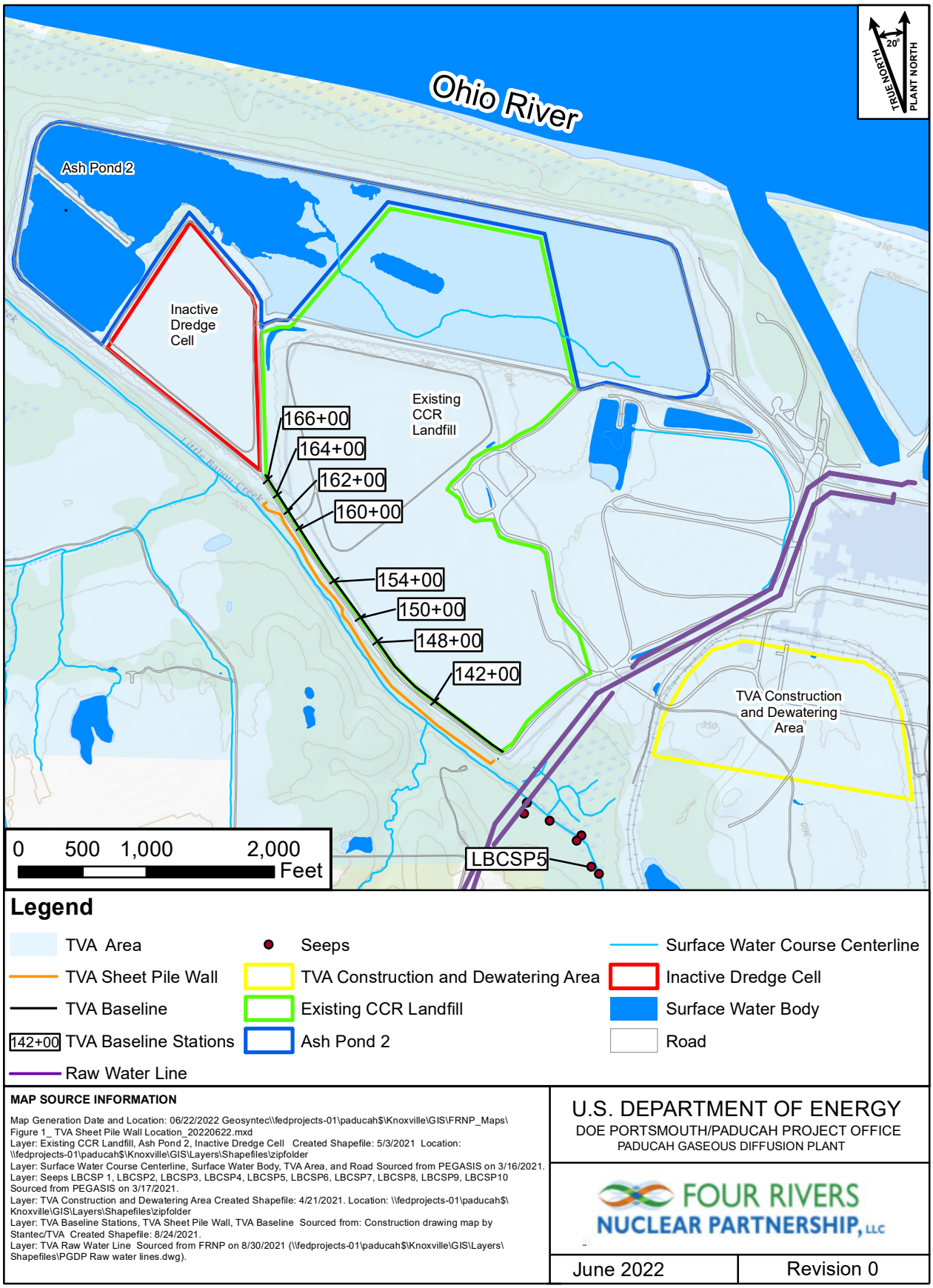
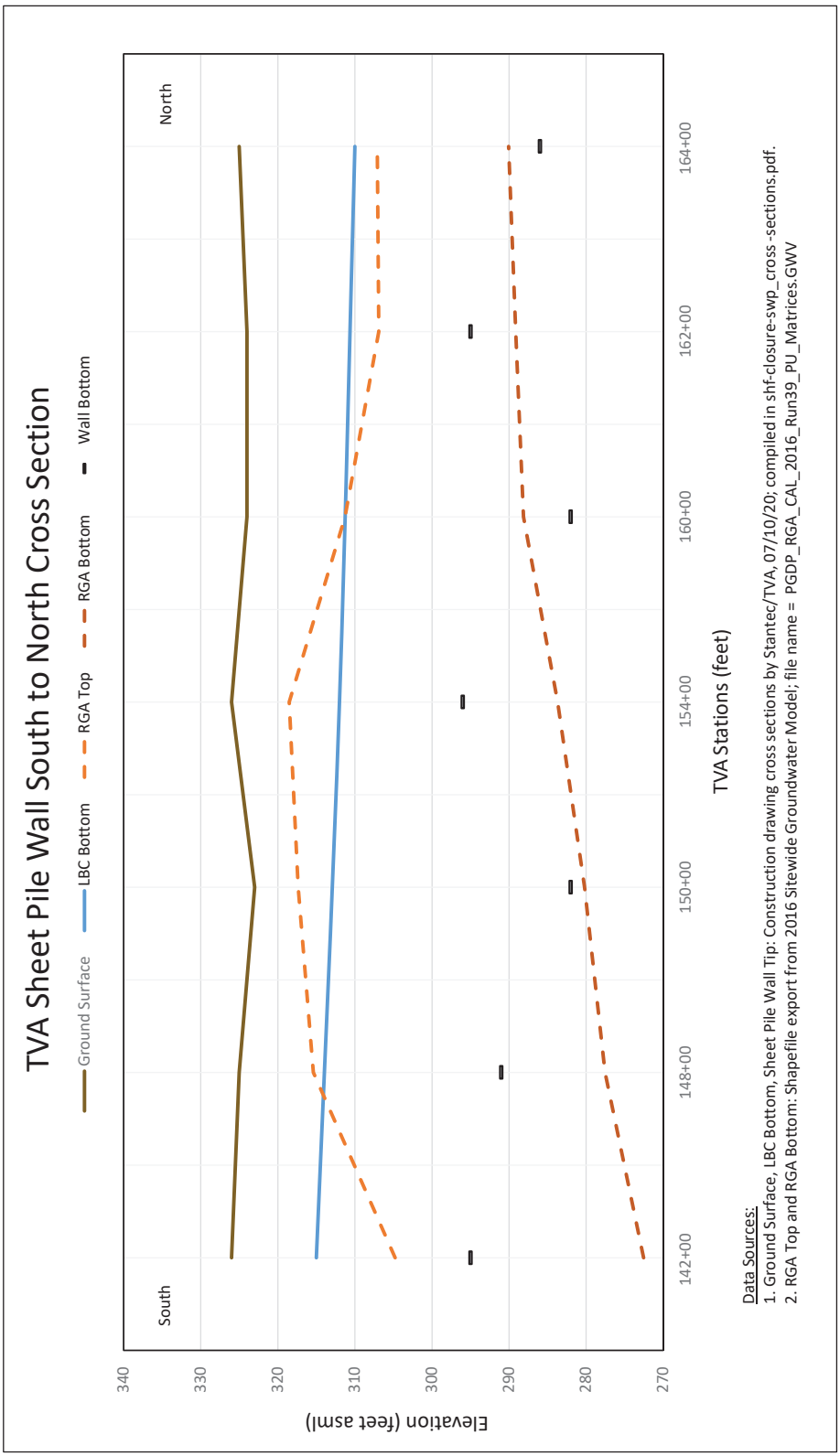

Ohio River
TRUE NORTH
20°
PLANT NORTH
Ash Pond 2
Inactive Dredge Cell
Existing CCR Landfill
166+00
164+00
162+00
160+00
154+00
150+00
148+00
142+00
TVA Construction and Dewatering Area
LBCSP5
0 500 1,000 2,000 Feet
Legend
TVA Area
TVA Sheet Pile Wall
TVA Baseline
142+00 TVA Baseline Stations
Raw Water Line
Seeps
TVA Construction and Dewatering Area
Existing CCR Landfill
Ash Pond 2
Surface Water Course Centerline
Inactive Dredge Cell
Surface Water Body
Road
MAP SOURCE INFORMATION
Map Generation Date and Location: 06/22/2022 Geosyntec\\fedprojects-01\paducah$\Knoxville\GIS\FRNP_Maps\
Figure 1_ TVA Sheet Pile Wall Location_20220622.mxd
Layer: Existing CCR Landfill, Ash Pond 2, Inactive Dredge Cell Created Shapefile: 5/3/2021 Location:
\\fedprojects-01\paducah$\Knoxville\GIS\Layers\Shapefiles\zipfolder
Layer: Surface Water Course Centerline, Surface Water Body, TVA Area, and Road Sourced from PEGASIS on 3/16/2021.
Layer: Seeps LBCSP 1, LBCSP2, LBCSP3, LBCSP4, LBCSP5, LBCSP6, LBCSP7, LBCSP8, LBCSP9, LBCSP10
Sourced from PEGASIS on 3/17/2021.
Layer: TVA Construction and Dewatering Area Created Shapefile: 4/21/2021. Location: \\fedprojects-01\paducah$\
Knoxville\GIS\Layers\Shapefiles\zipfolder
Layer: TVA Baseline Stations, TVA Sheet Pile Wall, TVA Baseline Sourced from: Construction drawing map by
Stantec/TVA Created Shapefile: 8/24/2021.
Layer: TVA Raw Water Line Sourced from FRNP on 8/30/2021 (\\fedprojects-01\paducah$\Knoxville\GIS\Layers\
Shapefiles\PGDP Raw water lines.dwg).
U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT
FOUR RIVERS
NUCLEAR PARTNERSHIP, LLC
June 2022
Revision 0

Figure 2


TVA Sheet Pile Wall South to North Cross Section
Ground Surface
LBC Bottom
RGA Top
RGA Bottom
Wall Bottom
South
North
Elevation (feet asml)
340
330
320
310
300
290
280
270
142+00
148+00
150+00
154+00
160+00
162+00
164+00
TVA Stations (feet)
Data Sources:
1. Ground Surface, LBC Bottom, Sheet Pile Wall Tip: Construction drawing cross sections by Stantec/TVA, 07/10/20; compiled in shf-closure-swp_cross -sections.pdf.
2. RGA Top and RGA Bottom: Shapefile export from 2016 Sitewide Groundwater Model; file name = PGDP_RGA_CAL_2016_Run39_PU_Matrices.GWV

- **PFAS.** PFAS is discussed as part of the Risk Assessment Working Group and has ties to this working group as well. DOE and FRNP are proceeding with data quality objectives (DQOs) and sampling plan development for a PFAS groundwater sampling project. The current plan for the project is to complete the DQOs and sampling plan in FY 2022 with sampling to be performed in FY 2023. Updates on this project will be provided to the group as they become available.

    - Rich Bonczek (DOE) is a member of the DOE PFAS Coordinating Committee.

    - DOE HQ PFAS Working Group meeting was held 5/26/2022.

    - DOE, EPA, and KY met on June 23, 2022 to discuss the draft Quality Assurance Project Plan Worksheets for the planned PFAS screening investigation.

  As part of the DOE PFAS Coordinating Committee, R. Bonczek is part of a group that is developing sampling approaches.

  The revised QAPP worksheets are planned to be discussed during the Routine Paducah Groundwater Update meeting on July 21, 2022. DOE/FRNP plan to send the revised worksheets to EPA and KDEP by July 18, 2022. The project plan is to finalize the worksheets by July 27, 2022 and once DOE approves the worksheets, they will be incorporated into the FY 2023 Environmental Monitoring Plan (EMP). One more meeting on the worksheets with EPA and KDEP is planned for September. The sampling is planned to be implemented in FY 2023. The group discussed data quality for the sampling and DOE noted that the intent would be to complete a Site Investigation (SI) with the data and that the analytical methods will have detection limits as low as technically possible and still be affordable.

12. FY 2022 Presentations

The EarthCon presentation will be moved back in the schedule as their contract with DOE is pending. MWG members should provide any presentation requests to Stefanie. Potential topics for future meetings:

- C-400 Complex remedial investigation
- Lithology
- TCE degradation rates
- Site water balance items (e.g., leaks from piping, above and below ground piping, building foundation gravel layers, etc.)

- October 2021: FRNP presented on the *2016 Update of the Paducah Gaseous Diffusion Plant Sitewide Groundwater Flow Model* (DOE/LX/07-2415&D2).

- January 12, 2022: KRCEE presented on their reviews of the Paducah site groundwater models.

- April 6, 2022: FRNP presented a summary of the EPA and KY comments to the *Summary of the 2016 Groundwater Flow Model Update.*

No presentation is planned to be provided during the July 13, 2022 meeting to allow the group to discuss the draft Lithology Paper.

The EarthCon contract has not yet been executed, but may be in time for EarthCon to provide a review of the previous work performed and potentially have an update completed by July 2023. Other

presentation topics could include the groundwater model update, or topics from the Site Management Plan (SMP). Topics should be forwarded to S. Fountain (FRNP).

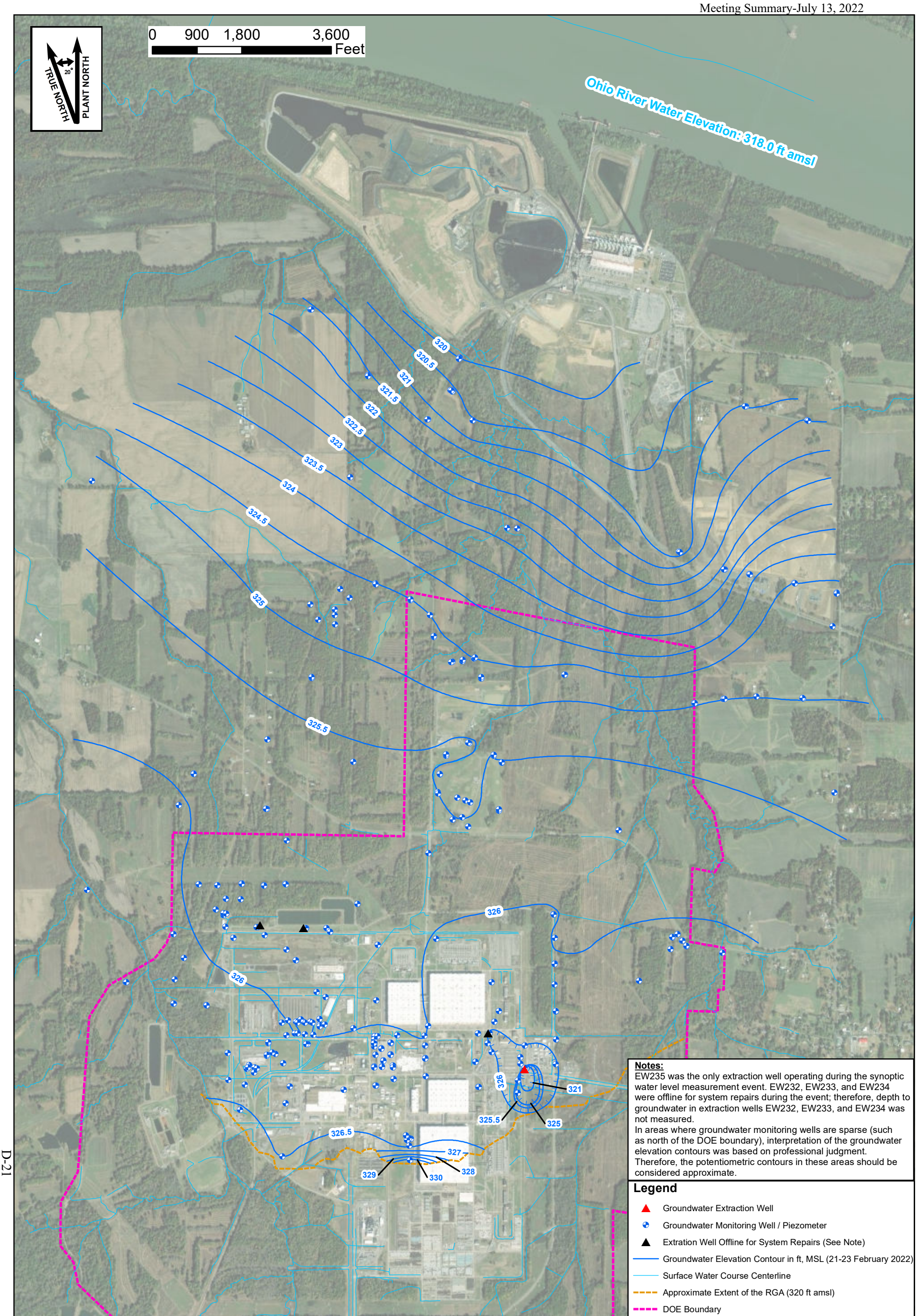
13. Poll MWG Members/Open Discussion

The group agreed by consensus to add Sitewide Groundwater Model Update as a topic under Update on Paducah Site Groundwater Strategy for the next meeting agenda.

The update to the model is being accelerated at DOE PPPO manager direction and should be under contract in August. Savannah River National Laboratory (SRNL) will participate in the update and will review the 2008 and 2016 model updates and provide input to the 2023 update. DOE noted that the prior collaborative approach was not successful, so for this update, the modelling will be performed and discussions will be held following submittal of the draft model report. DOE plans to discuss data needs and recommendations from the 2016 model update during the October 2022 MWG meeting. The overarching goal of the model update is to obtain EPA and KDEP approval to use the model to support remedial decision making. EPA suggested that DOE not seek approval on the model and that use of the model be decided on a project-specific basis.

Attachment 1

Groundwater Strategy Potentiometric Map
February 2022



MAP SOURCE INFORMATION

Map Generation Date and Location - 3/18/2022 Geosyntec\\fedprojects-01\paducah$\Knoxville\GW Strategy\GIS\MXDs\2021-2022 Potentiometric Surface Maps
Map Layer Location: Geosyntec\\fedprojects-01\paducah$\Knoxville\GW Strategy\GIS\MXDs\2021-2022 Potentiometric Surface Maps\February 2022 Potentiometric Surface Map.mxd
Image Source: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Shapefile for Surface Water Course Centerline was obtained from Pegasis (https://pegasis.pad.pppo.gov/), downloaded on 12/1/2021.
DOE Property Boundary provided by FRNP 2/4/2021.
Northing and easting of wells obtained from Pegasis, downloaded on 12/7/2021.
Groundwater elevation was based on the February 21-23, 2022 measurements. Ohio River elevation was estimated as the average of elevations measured by the USGS at Paducah Station USGS 0361100 and Olmsted, IL Station (USGS 03612600) between February 21-23, 2022.
amsl = above mean sea level

U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

Figure 1. February 2022 RGA Potentiometric Surface Map

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Attachment 2

Groundwater Elevation Data for TVA Wells
Updated Datasets: August 2021, November 2021, and February 2022

ANDY BESHEAR
GOVERNOR

REBECCA W. GOODMAN
SECRETARY

TONY HATTON
COMMISSIONER

ENERGY AND ENVIRONMENT CABINET
DEPARTMENT FOR ENVIRONMENTAL PROTECTION

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June 27, 2022

Ms. Tracey Duncan
U.S. Department of Energy
Portsmouth/Paducah Project Office
5501 Hobbs Road
Kevil, KY 42053

RE: Revised Groundwater Elevation Data for TVA Wells Collected on August 25, 2021, November 16, 2021, and February 25, 2022

Ms. Duncan:

On April 19, 2022, TVA management notified KDWM that monitoring well casings had been extended several feet on a few wells associated with their new landfill. TVA also stated that these modifications occurred sometime in July or August of 2021. These changes likely impacted the groundwater elevation measurements KDWM AIP collected during August 2021 and did impact the measurements collected in November 2021 and February 2022. To rectify the measurements previously submitted, KDWM is resubmitting elevations for all water levels collected. This includes new datums and corrected monitoring well elevations for: TVAGW-1D, TVAGW-2D, TVAGW-3D, TVAGW-4D, TVAGW-5D and TVAGW-6D. TVA well surveys use the National Geodetic Vertical Datum of 1929 (NGVD 29). Please find the attached supporting documentation for water elevations associated with these three synoptic water level events. KDWM will also transmit an electronic version of these tables for inclusion into PEGASIS.

If you have any questions or require additional information, please contact Brian Begley at (502) 782-6317 or Brian.Begley@ky.gov

Sincerely,

Brian D. Begley, P.G., Supervisor
Paducah Site Section
Hazardous Waste Branch – Paducah Site Section

An Equal Opportunity Employer M/F/D

Ms. Tracey Duncan
Page 2 of 5
June 27, 2022

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DWM File: #970-A; Graybar: ARM20210004 (2021 AIP Sample Results)

OREIS Name	Well	Description	Aquifer	Top of Casing	Top of Ground	X-conv Easting (Ft)	Y-conv Northing (Ft)	Status	Screen Top Depth (Ft)	Screen bot Depth (Ft)	tscreenelev (Ft)	bscreenelev (Ft)	GW Elev. (Datum - DTW)	Water Level	Date & Time	Barometric Pressure (inHg)	Measuring Point
TVAGW-6D	TVAGW-6D	4" PVC	Upper RGA	372.77	369.38	760787.88	1946731.54	active	65.2	75.2	307.57	297.57	320.21	52.56	08/25/2021_0945	29.69	TOC
TVAGW-5D	TVAGW-5D	4" PVC	Upper RGA	372.55	369.14	760131.63	1947315.95	active	66.9	76.9	305.65	295.65	319.46	53.09	08/25/2021_0948	29.69	TOC
TVAGW-4D	TVAGW-4D	4" PVC	Upper RGA	369.26	365.84	759456.72	1947561.73	active	63.3	73.3	305.96	295.96	319.77	49.49	08/25/2021_0951	29.69	TOC
TVAGW-3D	TVAGW-3D	4" PVC	Upper RGA	366.9	363.42	758982.49	1947793.86	active	71.3	81.3	295.6	285.6	319.45	47.45	08/25/2021_0953	29.69	TOC
TVAGW-2D	TVAGW-2D	4" PVC	Upper RGA	372.82	369.24	759966.78	1944870.47	active	61.2	71.2	311.62	301.62	325.44	47.38	08/25/2021_0940	29.69	TOC
TVAGW-1D	TVAGW-1D	4" PVC	Upper RGA	374.94	371.56	757847.05	1946203.79	active	63.4	73.4	311.54	301.54	320.13	54.81	08/25/2021_1001	29.69	TOC
TVA-D8A	SHF-D8A	4" PVC	Upper RGA	331.82	329	754060.01	1953586.25	active	17.5	27.5	314.32	304.32	330.02	1.8	08/25/2021_1119	29.68	TOC
TVA-D75B	SHF-D75B	2" PVC	Upper RGA	353.08	350	753297.07	1955971.69	active	48	58	305.08	295.08	309.26	43.82	08/25/2021_1101	29.68	TOC
TVA-D74B	SHF-D74B	2" PVC	Upper RGA	331.99	329	756125.35	1956489.82	active	39	49	292.99	282.99	308.34	23.65	08/25/2021_1027	29.69	TOC
TVA-D30B	SHF-D30B	2" PVC	Upper RGA	324.61	320.9	757594	1955563.41	active	39	49	285.61	275.61	303.3	21.31	08/25/2021_1022	29.69	TOC
TVA-D17	SHF-D17	2" PVC	Upper RGA	365.43	362.8	758809.17	1950015.71	active	14	17	351.43	348.43	316.58	48.85	08/25/2021_1138	29.67	TOC
TVA-D11B	SHF-D11B	2" PVC	Upper RGA	321.79	319.2	753434.76	1958481.44	active	32	42	289.79	279.79	302.61	19.18	08/25/2021_1041	29.68	TOC
TVA-D10	SHF-D10	4" PVC	Upper RGA	351.74	351	752950.26	1956644.9	active	36.5	46.5	315.24	305.24	305.91	45.83	08/25/2021_1058	29.68	TOC
SHF-201C	SHF-201C	4" PVC	Upper RGA	323.75	320	746799.24	1960068.889	active	44.5	54.5	279.25	269.25	305.91	17.84	08/25/2021_1203	29.67	TOC
SHF-201B	SHF-201B	4" PVC	Upper RGA	323.75	320.2	746641.107	1960082.768	active	32	37	291.75	286.75	305.96	17.79	08/25/2021_1204	29.67	TOC
SHF201A	SHF201A	4" PVC	Upper RGA	323.75	320	747030.226	1960036.252	active	14.5	24.5	309.25	299.25	305.88	17.87	08/25/2021_1205	29.67	TOC
SHF-102G	SHF-102G	4" PVC	Upper RGA	362.85	359.1	845764.387	1927473.284	active	47.1	57.4	315.75	305.45	320.35	42.5	08/25/2021_1153	29.67	TOC
Ohio River Elevation														301.18	08/25/2021_1300	29.66	TVA

LEGEND:

TOC: Top of Casing

DTW: Depth to Water

National Geodetic Vertical Datum of 1929 (NGVD 29).

OREIS Name	Well	Description	Aquifer	Top of Casing	Top of Ground	X-conv Easting (Ft)	Y-conv Northing (Ft)	Status	Screen Top Depth (Ft)	Screen bot Depth (Ft)	tscreenelev (Ft)	bscreenelev (Ft)	GW Elev. (Datum - DTW)	Water Level	Date & Time	Barometric Pressure (inHg)	Measuring Point
TVAGW-6D	TVAGW-6D	4" PVC	Upper RGA	372.77	369.38	760787.88	1946731.54	active	65.2	75.2	307.57	297.57	318.43	54.34	11/16/2021_1007	29.61	TOC
TVAGW-5D	TVAGW-5D	4" PVC	Upper RGA	372.55	369.14	760131.63	1947315.95	active	66.9	76.9	305.65	295.65	318.27	54.28	11/16/2021_1010	29.61	TOC
TVAGW-4D	TVAGW-4D	4" PVC	Upper RGA	369.26	365.84	759456.72	1947561.73	active	63.3	73.3	305.96	295.96	318.16	51.1	11/16/2021_1012	29.61	TOC
TVAGW-3D	TVAGW-3D	4" PVC	Upper RGA	366.9	363.42	758982.49	1947793.86	active	71.3	81.3	295.6	285.6	318.18	48.72	11/16/2021_1014	29.61	TOC
TVAGW-2D	TVAGW-2D	4" PVC	Upper RGA	372.82	369.24	759966.78	1944870.47	active	61.2	71.2	311.62	301.62	323.12	49.7	11/16/2021_1002	29.61	TOC
TVAGW-1D	TVAGW-1D	4" PVC	Upper RGA	374.94	371.56	757847.05	1946203.79	active	63.4	73.4	311.54	301.54	318.79	56.15	11/16/2021_1020	29.61	TOC
TVA-D75B	SHF-D75B	2" PVC	Upper RGA	353.08	350	753297.07	1955971.69	active	48	58	305.08	295.08	308.64	44.44	11/16/2021_1449	29.51	TOC
TVA-D74B	SHF-D74B	2" PVC	Upper RGA	332.16	329	756125.35	1956489.82	active	42.3	52.3	289.86	279.86	307.76	24.4	11/16/2021_1441	29.51	TOC
TVA-D30B	SHF-D30B	2" PVC	Upper RGA	324.36	320.9	757594	1955563.41	active	42.7	52.7	281.66	271.66	302.37	21.99	11/16/2021_1424	29.52	TOC
TVA-D17	SHF-D17	2" PVC	Upper RGA	365.43	362.8	758809.17	1950015.71	active	14	17	351.43	348.43	315.67	49.76	11/16/2021_1405	29.52	TOC
TVA-D11B	SHF-D11B	2" PVC	Upper RGA	321.79	319.2	753434.76	1958481.44	active	32	42	289.79	279.79	302.29	19.5	11/16/2021_1431	29.52	TOC
TVA-D10	SHF-D10	4" PVC	Upper RGA	351.74	351	752950.26	1956644.9	active	36.5	46.5	315.24	305.24	304.86	46.88	11/16/2021_1446	29.51	TOC
SHF-201C	SHF-201C	4" PVC	Upper RGA	323.75	320	746799.24	1960068.889	active	44.5	54.5	279.25	269.25	304.77	18.98	11/16/2021_1345	29.53	TOC
SHF-201B	SHF-201B	4" PVC	Upper RGA	323.75	320.2	746641.107	1960082.768	active	32	37	291.75	286.75	305	18.75	11/16/2021_1343	29.53	TOC
SHF201A	SHF201A	4" PVC	Upper RGA	323.75	320	747030.226	1960036.252	active	14.5	24.5	309.25	299.25	304.86	18.89	11/16/2021_1342	29.53	TOC
SHF-102G	SHF-102G	4" PVC	Upper RGA	362.85	359.1	845764.387	1927473.284	active	47.1	57.4	315.75	305.45	319.34	43.51	11/16/2021_1330	29.53	TOC
Ohio River Elevation														300.4	11/16/2021_1502	29.51	TVA

LEGEND:

TOC: Top of Casing

DTW: Depth to Water

National Geodetic Vertical Datum of 1929 (NGVD 29).

OREIS Name	Well	Description	Aquifer	Top of Casing	Top of Ground	xcoordy Easting (Ft)	ycoordy Northing (Ft)	Status	Screen Top Depth (Ft)	Screen bot depth (Ft)	tscreenelev (Ft)	bscreenelev (Ft)	GW Elev. (Datum - DTW)	Water Level	Date & Time	Barometric Pressure (inHg)	Measuring Point
TVAGW-6D	TVAGW-6D	4" PVC	Upper RGA	372.77	369.38	760787.88	1946731.54	active	65.2	75.2	307.57	297.57	321.12	51.65	02/23/2022 1031	30.43	TOC
TVAGW-5D	TVAGW-5D	4" PVC	Upper RGA	372.55	369.14	760131.63	1947315.95	active	66.9	76.9	305.65	295.65	320.85	51.7	02/23/2022 1034	30.43	TOC
TVAGW-4D	TVAGW-4D	4" PVC	Upper RGA	369.26	365.84	759436.72	1947561.73	active	63.3	73.3	305.96	295.96	320.78	48.48	02/23/2022 1037	30.43	TOC
TVAGW-3D	TVAGW-3D	4" PVC	Upper RGA	366.9	363.42	758982.49	1947795.86	active	71.3	81.3	295.6	285.6	320.68	46.22	02/23/2022 1041	30.43	TOC
TVAGW-2D	TVAGW-2D	4" PVC	Upper RGA	372.82	369.24	759966.78	1944870.47	active	61.2	71.2	311.62	301.62	324.31	48.51	02/23/2022 1028	30.43	TOC
TVAGW-1D	TVAGW-1D	4" PVC	Upper RGA	374.94	371.56	757847.05	1946208.79	active	63.4	73.4	311.54	301.54	321.12	53.82	02/23/2022 1044	30.44	TOC
TVA-D74B	SHF-D74B	2" PVC	Upper RGA	332.16	329	756125.35	1956489.82	active	42.3	52.3	289.86	279.86	319.58	12.58	02/23/2022 0950	30.42	TOC
TVA-D30B	SHF-D30B	2" PVC	Upper RGA	324.36	320.9	757594	1955562.41	active	42.7	52.7	281.66	271.66	319.51	4.85	02/23/2022 1012	30.42	TOC
TVA-D17	SHF-D17	2" PVC	Upper RGA	365.43	362.8	758809.17	1950015.71	active	14	17	351.43	348.43	318.02	47.41	02/23/2022 1019	30.42	TOC
SHF-102G	SHF-102G	4" PVC	Upper RGA	362.85	359.1	845764.387	1927473.284	active	47.1	57.4	315.75	305.45	321.85	41	02/23/2022 1057	30.40	TOC
Ohio River Elevation														320.21	02/23/2022 1020	30.42	TVA

LEGEND:

TOC: Top of Casing

DTW: Depth to Water

National Geodetic Vertical Datum of 1929 (NGVD 29).

Attachment 3

2022 Groundwater Strategy Project Planning Dates and EMP Schedule

Groundwater Strategy Project Planning Dates

Activity	Planning Date
~~FY 2022 Groundwater Strategy Project Management Plan~~	~~Dec 2021~~
~~FY 2022 Q1 Potentiometric Map~~	~~4/6/2022~~
~~Quarterly Meeting (April/FY22Q3)~~	~~4/6/2022~~
FY 2022 Q2 Potentiometric Map	7/13/2022
Quarterly Meeting (July/FY22Q4)	7/13/2022
Activity #4 White Paper: Comparison of Regional Groundwater Flow Pre- and Post-Construction and Operation of Olmsted Dam	7/28/2022 (was 4/8/2022)
Activity #2 White Paper: Regional and Localized Groundwater Flow and TCE Trends, East Side of Downgradient Northeast Plume	8/18/2022
Activity #8 White Paper: Regional and Localized Groundwater Flow and TCE Trends, West Side of Downgradient Northeast Plume	Oct-2022
FY 2022 Q3 Potentiometric Map	Oct-2022
Quarterly Meeting (October/FY23 Q1)	Oct-2022
FY 2022 Groundwater Strategy Project Management Plan	Nov-2022
FY 2022 Q4 Potentiometric Map	Jan-2023
Quarterly Meeting (October/FY23 Q1)	Jan-2023

Monitoring Wells Planned For Colloidal Borescope and Pressure Transducer Deployment

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW20 (also R4)	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW63		M1			M1			M1			M1	
MW65		M1			M1			M1			M1	
MW66		M1			M1			M1			M1	
MW67		M1			M1			M1			M1	
MW68		M1			M1			M1			M1	
MW71		M1			M1			M1			M1	
MW72		M1			M1			M1			M1	
MW73		M1			M1			M1			M1	
MW76		M1			M1			M1			M1	
MW77 (PZ)		M1			M1			M1			M1	
MW78		M1			M1			M1			M1	
MW79		M1			M1			M1			M1	
MW80		M1			M1			M1			M1	
MW81		M1			M1			M1			M1	
MW84		M1			M1			M1			M1	
MW86		M1			M1			M1			M1	
MW87		M1			M1			M1			M1	
MW89		M1			M1			M1			M1	
MW90A		M1			M1			M1			M1	
MW92		M1			M1			M1			M1	
MW93		M1			M1			M1			M1	
MW95A		M1			M1			M1			M1	
MW98	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW99		M1			M1			M1			M1	
MW100		M1			M1			M1			M1	
MW102		M1			M1			M1			M1	
MW103		M1			M1			M1			M1	
MW106A	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW108		M1			M1			M1			M1	
MW120		M1			M1			M1			M1	
MW121		M1			M1			M1			M1	
MW122		M1			M1			M1			M1	
MW123		M1			M1			M1			M1	
MW124		M1			M1			M1			M1	

Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW125		M1			M1			M1			M1	
MW126		M1			M1			M1			M1	
MW132		M1			M1			M1			M1	
MW133		M1			M1			M1			M1	
MW134		M1			M1			M1			M1	
MW135	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW137		M1			M1			M1			M1	
MW139		M1			M1			M1			M1	
MW144		M1			M1			M1			M1	
MW145		M1			M1			M1			M1	
MW146		M1			M1			M1			M1	
MW147		M1			M1			M1			M1	
MW148		M1			M1			M1			M1	
MW150		M1			M1			M1			M1	
MW155	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW156	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW161		M1			M1			M1			M1	
MW163		M1			M1			M1			M1	
MW165A		M1			M1			M1			M1	
MW168		M1			M1			M1			M1	
MW169		M1			M1			M1			M1	
MW173		M1			M1			M1			M1	
MW175		M1			M1			M1			M1	
MW178	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW185		M1			M1			M1			M1	
MW188		M1			M1			M1			M1	
MW191		M1			M1			M1			M1	
MW193		M1			M1	M1+CB		M1	M1+CB		M1	
MW194		M1			M1			M1			M1	
MW197		M1			M1			M1			M1	
MW199		M1			M1			M1			M1	
MW200	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW201		M1			M1			M1			M1	
MW202		M1			M1			M1			M1	
MW203		M1			M1			M1			M1	
MW205		M1			M1			M1			M1	
MW220		M1			M1			M1			M1	
MW221		M1			M1			M1			M1	

Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW222		M1			M1			M1			M1	
MW223		M1			M1			M1			M1	
MW224		M1			M1			M1			M1	
MW225		M1			M1			M1			M1	
MW226		M1			M1			M1			M1	
MW227		M1			M1			M1			M1	
MW233		M1			M1			M1			M1	
MW236		M1			M1			M1			M1	
MW238		M1			M1			M1			M1	
MW239		M1			M1			M1			M1	
MW240		M1			M1			M1			M1	
MW241A		M1			M1			M1			M1	
MW242		M1			M1			M1			M1	
MW243		M1			M1			M1			M1	
MW244		M1			M1			M1			M1	
MW245		M1			M1			M1			M1	
MW247		M1			M1			M1			M1	
MW248		M1			M1			M1			M1	
MW249		M1			M1			M1			M1	
MW250		M1			M1			M1			M1	
MW252		M1			M1			M1			M1	
MW253A		M1			M1			M1			M1	
MW255		M1			M1			M1			M1	
MW256		M1			M1			M1			M1	
MW257		M1			M1			M1			M1	
MW258		M1			M1			M1			M1	
MW260		M1			M1			M1			M1	
MW261		M1			M1			M1			M1	
MW262		M1			M1			M1			M1	
MW283		M1			M1			M1			M1	
MW284		M1			M1			M1			M1	
MW288		M1			M1			M1			M1	
MW291		M1			M1			M1			M1	
MW292		M1			M1			M1			M1	
MW293A		M1			M1			M1			M1	
MW294A		M1			M1			M1			M1	
MW325		M1			M1			M1			M1	
MW326		M1			M1			M1			M1	

Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW327		M1			M1			M1			M1	
MW328		M1			M1			M1			M1	
MW329		M1			M1			M1			M1	
MW330		M1			M1			M1			M1	
MW333		M1			M1			M1			M1	
MW337		M1			M1			M1			M1	
MW338		M1			M1			M1			M1	
MW339		M1			M1			M1			M1	
MW340		M1			M1			M1			M1	
MW341	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW342		M1			M1			M1			M1	
MW343		M1			M1			M1			M1	
MW345		M1			M1			M1			M1	
MW346		M1			M1			M1			M1	
MW347		M1			M1			M1			M1	
MW353		M1			M1			M1			M1	
MW354	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW355		M1			M1			M1			M1	
MW356		M1			M1			M1			M1	
MW357		M1			M1			M1			M1	
MW358		M1			M1			M1			M1	
MW360		M1			M1			M1			M1	
MW361		M1			M1			M1			M1	
MW363		M1			M1			M1			M1	
MW364		M1			M1			M1			M1	
MW366		M1			M1			M1			M1	
MW367		M1			M1			M1			M1	
MW369		M1			M1			M1			M1	
MW370		M1			M1			M1			M1	
MW372		M1			M1			M1			M1	
MW373		M1			M1			M1			M1	
MW376		M1			M1			M1			M1	
MW380		M1			M1			M1			M1	
MW381		M1			M1			M1			M1	
MW384		M1			M1			M1			M1	
MW385		M1			M1			M1			M1	
MW387		M1			M1			M1			M1	
MW388		M1			M1			M1			M1	

Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW391		M1			M1			M1			M1	
MW392		M1			M1			M1			M1	
MW394		M1			M1			M1			M1	
MW395		M1			M1			M1			M1	
MW397		M1			M1			M1			M1	
MW409		M1			M1			M1			M1	
MW410		M1			M1			M1			M1	
MW411*		M1			M1			M1			M1	
MW414		M1			M1			M1			M1	
MW415		M1			M1			M1			M1	
MW416		M1			M1			M1			M1	
MW417		M1			M1			M1			M1	
MW418		M1			M1			M1			M1	
MW419		M1			M1			M1			M1	
MW420		M1			M1			M1			M1	
MW421		M1			M1			M1			M1	
MW422		M1			M1			M1			M1	
MW423		M1			M1			M1			M1	
MW424		M1			M1			M1			M1	
MW425		M1			M1			M1			M1	
MW426		M1			M1			M1			M1	
MW427		M1			M1			M1			M1	
MW428		M1			M1			M1			M1	
MW429A		M1			M1			M1			M1	
MW430		M1			M1			M1			M1	
MW431	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW432	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW433		M1			M1			M1			M1	
MW435		M1			M1			M1			M1	
MW439	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT
MW440		M1			M1			M1			M1	
MW441	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT
MW442	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT
MW443		M1			M1			M1			M1	
MW444		M1			M1			M1			M1	
MW445	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW447		M1			M1			M1			M1	
MW448		M1			M1			M1			M1	

Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW450		M1			M1			M1			M1	
MW451		M1			M1			M1			M1	
MW452		M1			M1			M1			M1	
MW453		M1			M1			M1			M1	
MW454		M1			M1			M1			M1	
MW455		M1			M1			M1			M1	
MW456		M1			M1			M1			M1	
MW457		M1			M1			M1			M1	
MW458		M1			M1			M1			M1	
MW459		M1			M1			M1			M1	
MW460		M1			M1			M1			M1	
MW461		M1			M1			M1			M1	
MW462		M1			M1			M1			M1	
MW463		M1			M1			M1			M1	
MW464		M1			M1			M1			M1	
MW465		M1			M1			M1			M1	
MW466		M1			M1			M1			M1	
MW467		M1			M1			M1			M1	
MW468		M1			M1			M1			M1	
MW469		M1			M1			M1			M1	
MW470		M1			M1			M1			M1	
MW471		M1			M1			M1			M1	
MW472		M1			M1			M1			M1	
MW473		M1			M1			M1			M1	
MW474		M1			M1			M1			M1	
MW475		M1			M1			M1			M1	
MW476		M1			M1			M1			M1	
MW477		M1			M1			M1			M1	
MW478		M1			M1			M1			M1	
MW479		M1			M1			M1			M1	
MW480		M1			M1			M1			M1	
MW481		M1			M1			M1			M1	
MW482		M1			M1			M1			M1	
MW483		M1			M1			M1			M1	
MW484		M1			M1			M1			M1	
MW485		M1			M1			M1			M1	
MW486A		M1			M1			M1			M1	
MW487		M1			M1			M1			M1	

Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW488		M1			M1			M1			M1	
MW489		M1			M1			M1			M1	
MW490		M1			M1			M1			M1	
MW491		M1			M1			M1			M1	
MW492	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT
MW493		M1			M1			M1			M1	
MW494		M1			M1			M1			M1	
MW495		M1			M1			M1			M1	
MW496		M1			M1			M1			M1	
MW497		M1			M1			M1			M1	
MW498		M1			M1			M1			M1	
MW499		M1			M1			M1			M1	
MW500		M1			M1			M1			M1	
MW501		M1			M1			M1			M1	
MW502		M1			M1			M1			M1	
MW503		M1			M1			M1			M1	
MW504		M1			M1			M1			M1	
MW505		M1			M1			M1			M1	
MW506		M1			M1			M1			M1	
MW507		M1			M1			M1			M1	
MW524		M1			M1			M1			M1	
MW525	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW526	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW527	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW528		M1			M1			M1			M1	
MW529	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT	M1+PT+CB	M1+PT
MW530		M1			M1			M1			M1	
MW531		M1			M1			M1			M1	
MW532 (PZ)		M1			M1			M1			M1	
MW533		M1			M1			M1			M1	
MW534 (PZ)		M1			M1			M1			M1	
MW535 (PZ)		M1			M1			M1			M1	
MW536		M1			M1			M1			M1	
MW537		M1			M1			M1			M1	
MW538		M1			M1			M1			M1	
MW539		M1			M1			M1			M1	

Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

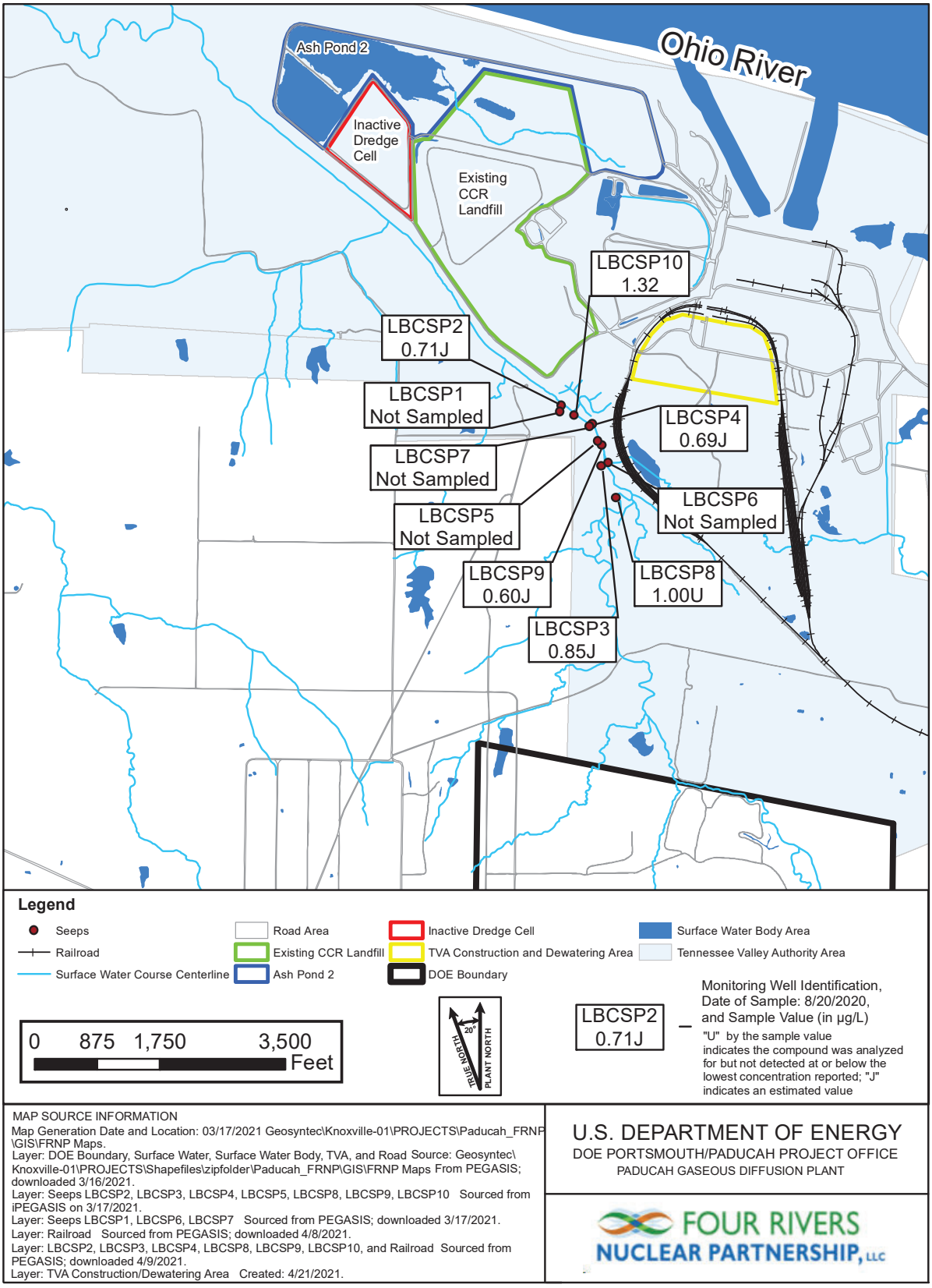
Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW540 (PZ)		M1			M1			M1			M1	
MW541 (PZ)		M1			M1			M1			M1	
MW542		M1			M1			M1			M1	
MW543		M1			M1			M1			M1	
MW544		M1			M1			M1			M1	
MW545		M1			M1			M1			M1	
MW546		M1			M1			M1			M1	
MW547		M1			M1			M1			M1	
MW548		M1			M1			M1			M1	
MW549		M1			M1			M1			M1	
MW550		M1			M1			M1			M1	
MW551		M1			M1			M1			M1	
MW553 (PZ)		M1			M1			M1			M1	
MW554 (PZ)		M1			M1			M1			M1	
MW555 (PZ)		M1			M1			M1			M1	
MW556		M1			M1			M1			M1	
PZ107		M1			M1			M1			M1	
PZ109		M1			M1			M1			M1	
PZ110		M1			M1			M1			M1	
PZ114		M1			M1			M1			M1	
PZ115		M1			M1			M1			M1	
PZ117		M1			M1			M1			M1	
PZ118		M1			M1			M1			M1	
PZ287		M1			M1			M1			M1	
PZ289		M1			M1			M1			M1	
PZ290		M1			M1			M1			M1	
PZ349		M1			M1			M1			M1	
PZ351		M1			M1			M1			M1	
EW232		M1			M1			M1			M1	
EW233		M1			M1			M1			M1	
EW234		M1			M1			M1			M1	
EW235		M1			M1			M1			M1	
MW557		M1			M1			M1			M1	
MW558		M1			M1			M1			M1	
MW559		M1			M1			M1			M1	

Monitoring Wells Planned for Colloidal Borescope and Pressure Transducer Deployment (Continued)

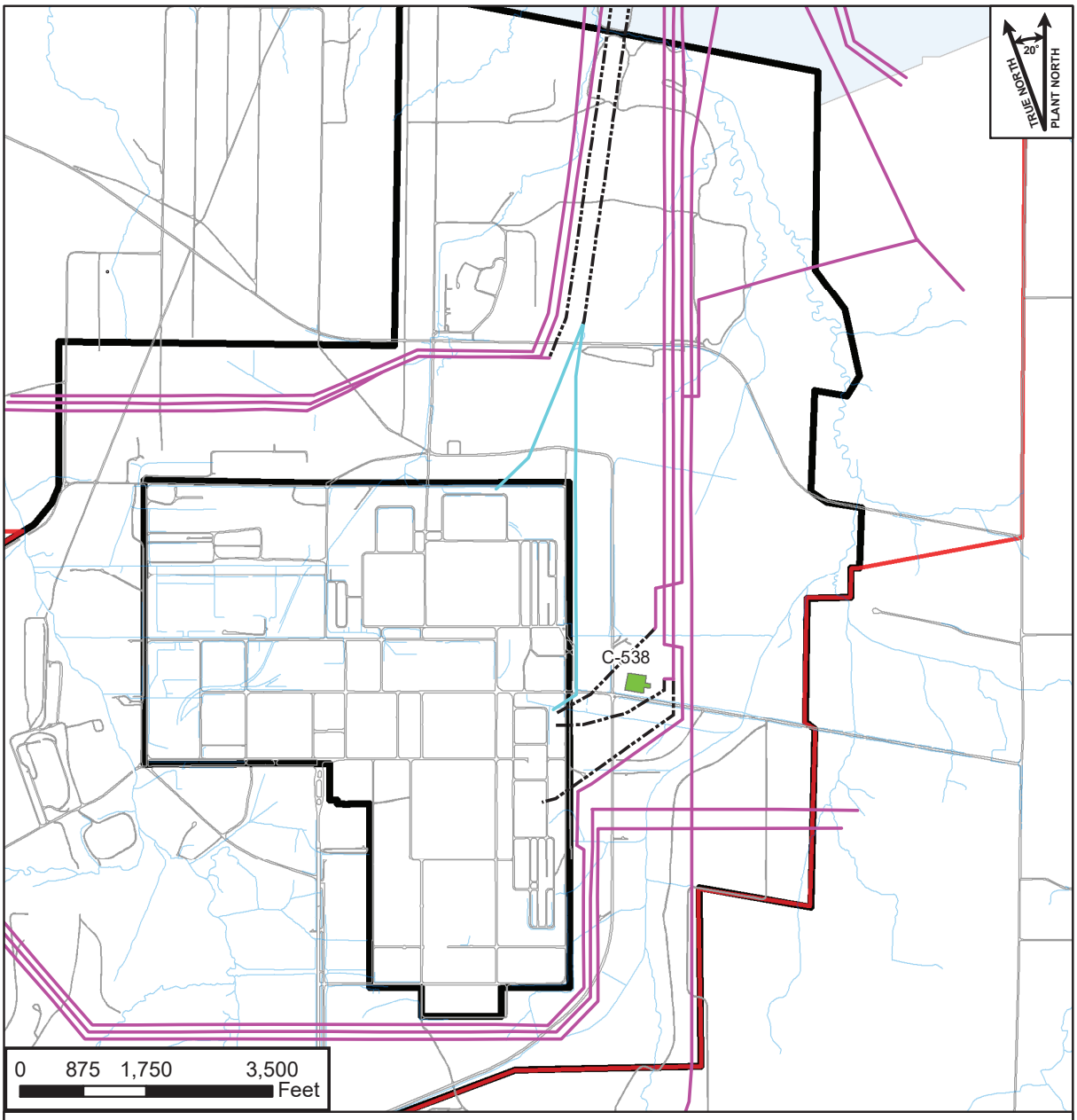
Well Number	MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10	MONTH 11	MONTH 12
MW560		M1			M1			M1			M1	
MW561		M1			M1			M1			M1	
MW562		M1			M1			M1			M1	
MW563		M1			M1			M1			M1	
MW564		M1			M1			M1			M1	
MW565		M1			M1			M1			M1	
MW566		M1			M1			M1			M1	
MW567		M1			M1			M1			M1	
MW568		M1			M1			M1			M1	
MW569		M1			M1			M1			M1	
MW570		M1			M1			M1			M1	
MW571		M1			M1			M1			M1	
MW572		M1			M1			M1			M1	
MW573		M1			M1			M1			M1	
MW574		M1			M1			M1			M1	

CB: colloidal borescope
PT: pressure transducer
M1: Manual water level collected once per month
Color coding is used to show colloidal borescope data collection groups, where each color designates a different group of locations that are planned to be collected together.
*Collect manual water level measurement when accessible.

Attachment 3 - Little Bayou Creek Seeps



Attachment 3 - Power Lines Figure



Legend

- C-538
- Surface Water Course Centerline
- Water Policy Boundary
- DOE Boundary
- Road Area
- TVA Area

Powerline Status

- Air Gapped (Approximate)
- Energized
- Removed (Approximate)

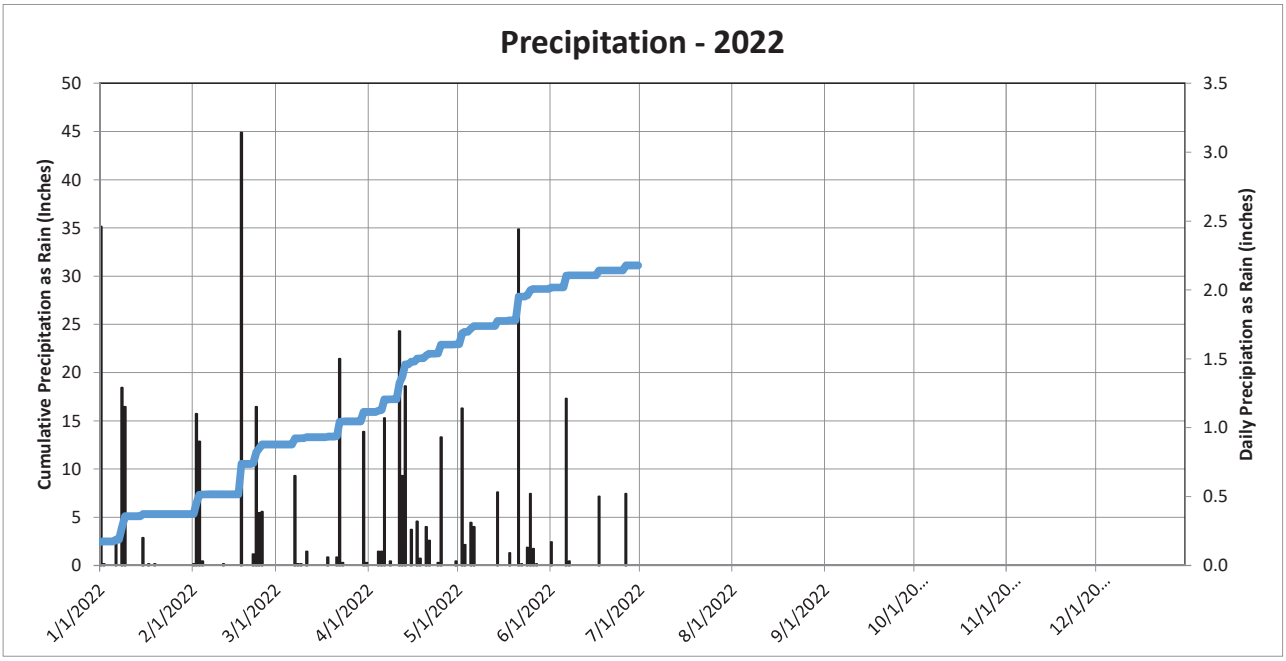
MAP SOURCE INFORMATION
Map Generation Date and Location: 09/13/2021 \\fedprojects-01\paducah$\Knoxville\GIS\FRNP Maps
Layer: DOE Boundary, Road Area, Surface Water Course Centerline, TVA Area, and Water Policy Boundary Sourced from PEGASIS 3/16/2021 (Layer: 'GIS Layers')
Layer: Powerlines and C-538 Sourced from FRNP on 3/16/2021; Powerlines last updated 5/15/2018
Layer: Powerline Status Sourced from FRNP on 9/8/2021

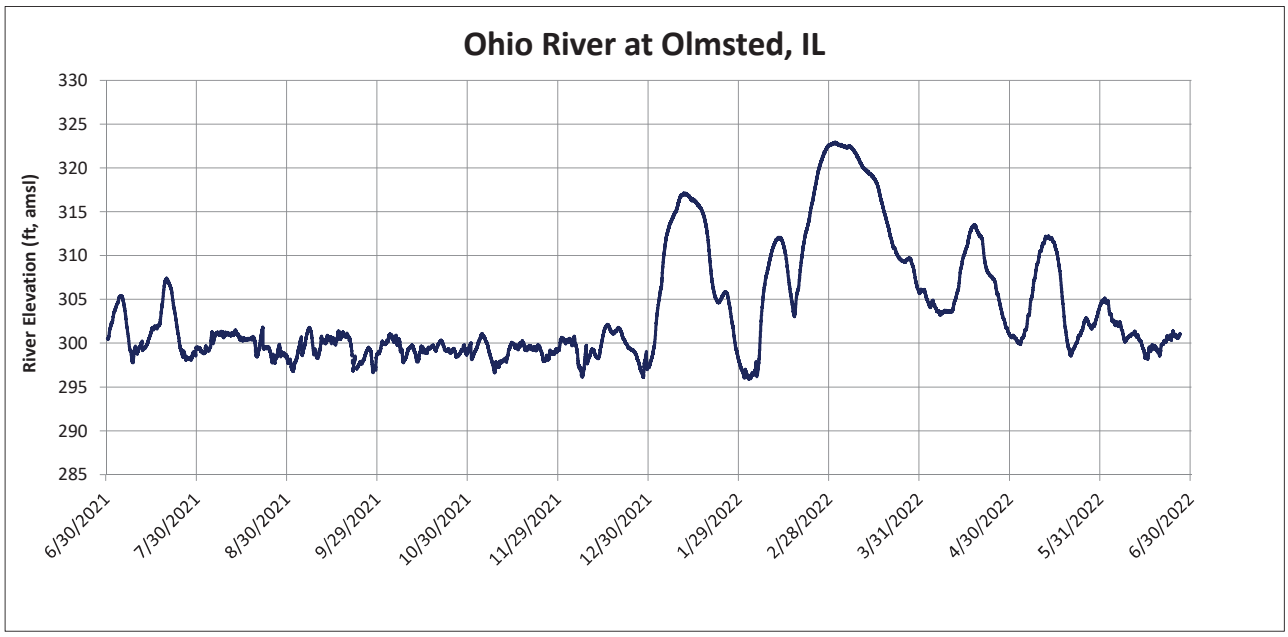
U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

Attachment 4

Precipitation and Ohio River Stage Data


Precipitation - 2022
Cumulative Precipitation as Rain (Inches)
Daily Precipitation as Rain (inches)
50
45
40
35
30
25
20
15
10
5
0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1/1/2022
2/1/2022
3/1/2022
4/1/2022
5/1/2022
6/1/2022
7/1/2022
8/1/2022
9/1/2022
10/1/20...
11/1/20...
12/1/20...


Ohio River at Olmsted, IL
River Elevation (ft, amsl)
330
325
320
315
310
305
300
295
290
285
6/30/2021
7/30/2021
8/30/2021
9/29/2021
10/30/2021
11/29/2021
12/30/2021
1/29/2022
2/28/2022
3/31/2022
4/30/2022
5/31/2022
6/30/2022

Attachment 5

Pages from: MMES 1995. *Final Report on Drive-Point Profiling of the Northwest Plume and Analysis of Related Data*, KY/ER-66R, April.

both TCE and ^{99}Tc analyses. A continuous supply of water throughout the year originates from the C-616 lagoon and drains into a ditch located north of SWMUs 7 and 30 and outside the plant perimeter fence. Another ditch adjacent and north of the SWMUs receives surface water runoff during periods of precipitation and backflow from the C-616 lagoon drainage ditch. Comparison of water levels in the ditch with monitoring wells in the UCRS indicate comparable levels throughout the year suggesting the ditch is a recharge source to the UCRS.

Based on observations from numerous well clusters, groundwater moves vertically from the UCRS to the RGA (Clausen et al., 1992b). The vertical flow component predominates over the horizontal flow component. Figures 3.6 and 3.7 are hydrographs of well clusters located in the Northwest Plume area with one well completed in the UCRS top and bottom of the RGA and McNairy Formation. The differences in head indicate flow from the UCRS to the RGA. A detailed analytical analysis was performed using well data at C-404 to determine the resultant groundwater vectors (Clausen et al., 1992b). The current conceptual model is during periods of recharge (ie. winter months) the sand lenses within the UCRS fill with water and are analogous to small-scale perched water bearing zones. The depth of the perched water zone is dependent upon the presence and depth of the sand lenses. For example, a monitoring well completed at locations A and D (Figure 3.8) would exhibit similar water levels. However, monitoring wells completed at locations B and C would exhibit different water levels. It is for this reason that potentiometric maps of the UCRS are inappropriate since the depth to water is dependent upon the depth of the sand lenses. In the absence of a sand lens, no shallow water table exists; although wetting fronts from recharge events are likely present.

Once filled, the sand lenses drain throughout the summer months (i.e., low recharge high evapotranspiration [Figure 3.8]). In some cases, the sand lenses are small and leaky enough that water completely drains out before recharge begins again. This pattern of events has been observed in several UCRS wells at the site which become seasonally dry. The results of this investigation substantiate the conceptual model of shallow flow within the UCRS presented in Clausen et al., 1992b. Therefore, the water present in the UCRS is not representative of a laterally extensive unconfined aquifer or water table aquifer.

3.2.2 Regional Gravel Aquifer

Potentiometric maps for the RGA are included in Appendix E. Several observations are apparent from studying the maps:

1) Flow direction within the RGA is seasonally dependent and tied to changes in the Ohio River stage with flow toward the Ohio River.

2) Groundwater flow directions on-site appear more erratic near the southern terrace.

3) Groundwater mounding is evident near the PGDP C-616 surface water lagoon and the TVA ash pile.

4) Contour complexity is also a function of data density corresponding with more wells located on-site and increased convolution of constant head lines.

5) Low hydraulic gradients exist on-site, suggesting a highly transmissive aquifer.

6) Horizontal gradients increase north of the PGDP plant site with the highest gradients adjacent to the Ohio River.

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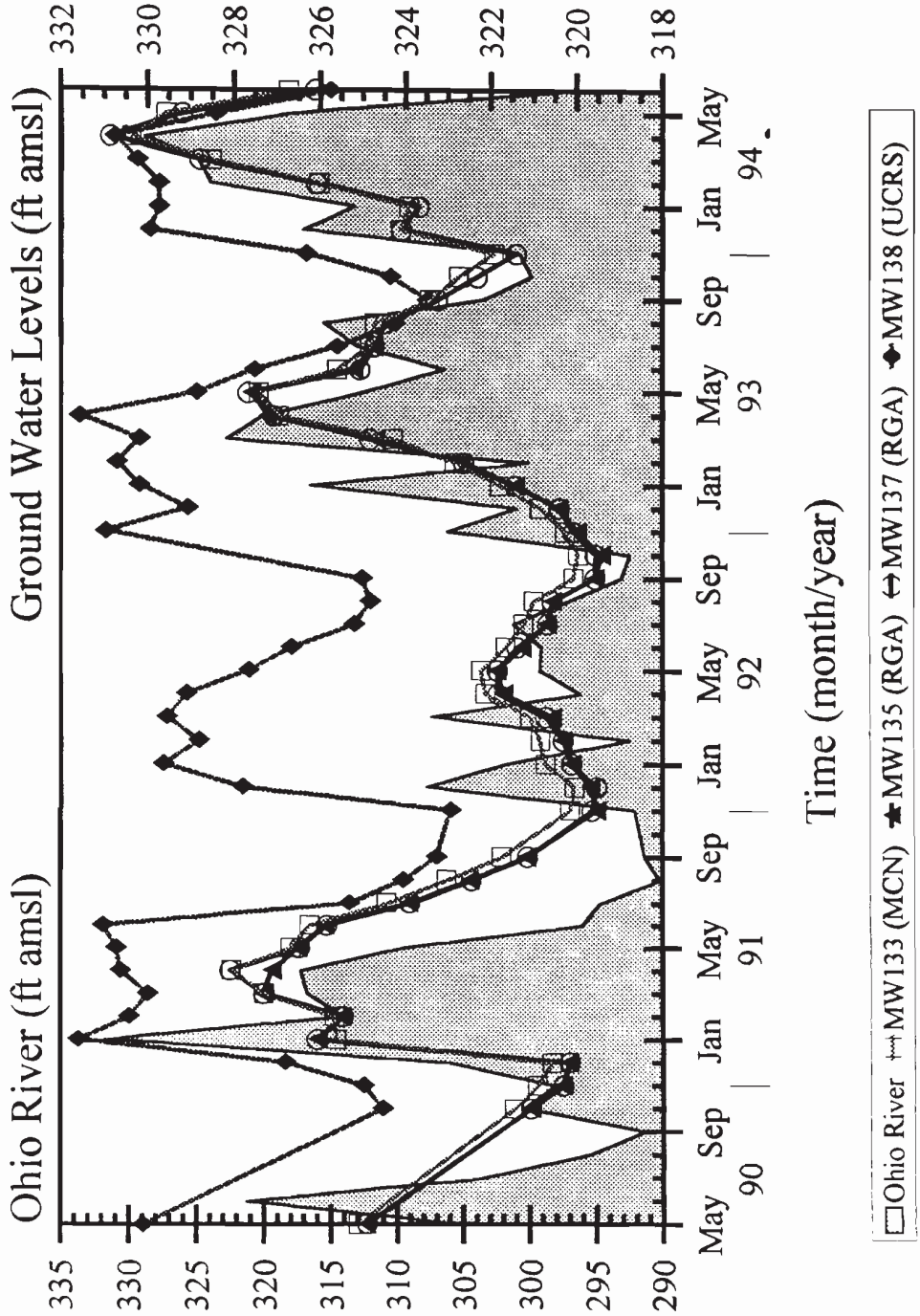


Figure 3.6. Hydrographs of monitoring wells MW133, MW135, MW137, and MW138.

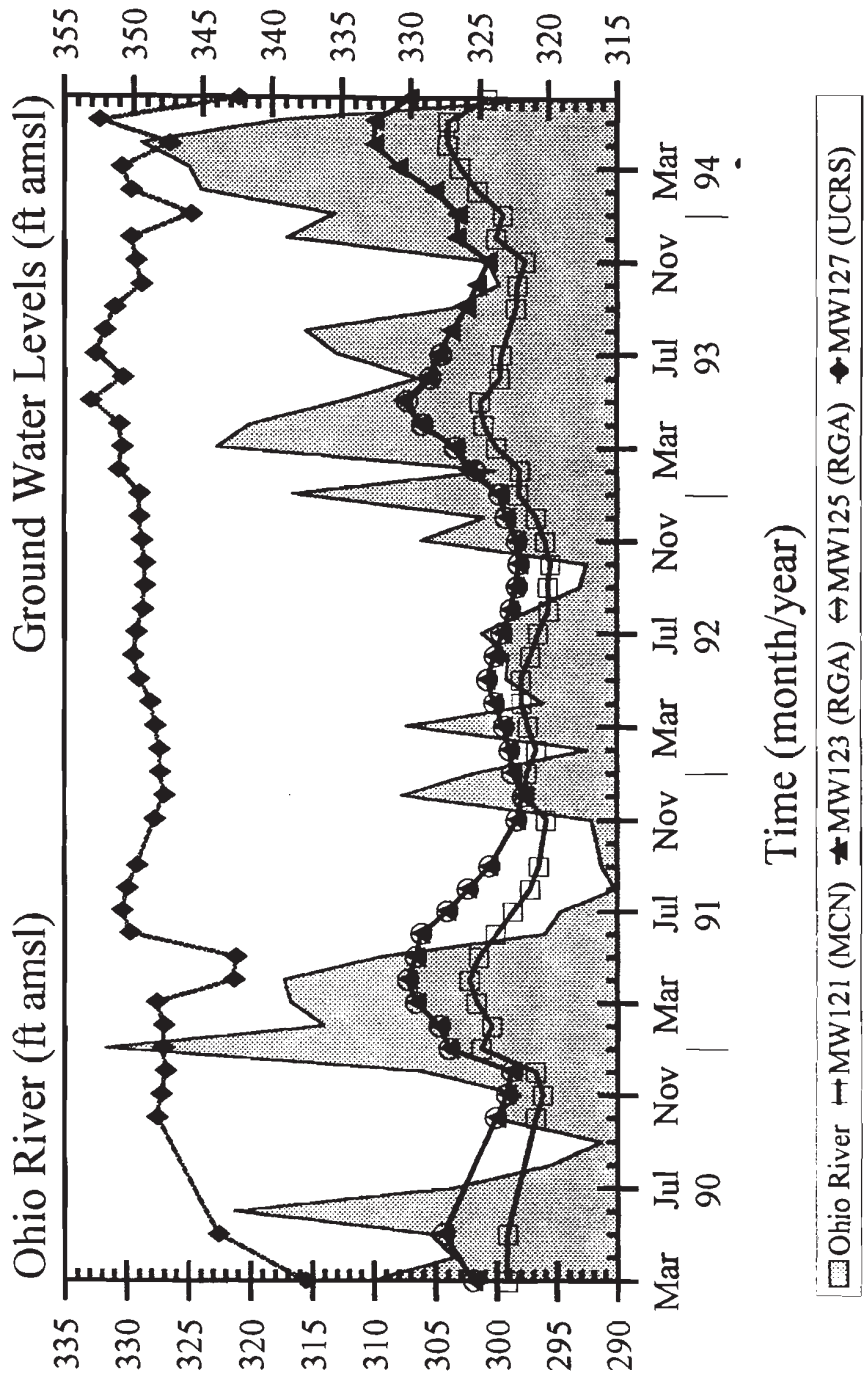


Figure 3.7. Hydrographs of monitoring wells MW121, MW123, MW125, and MW127.

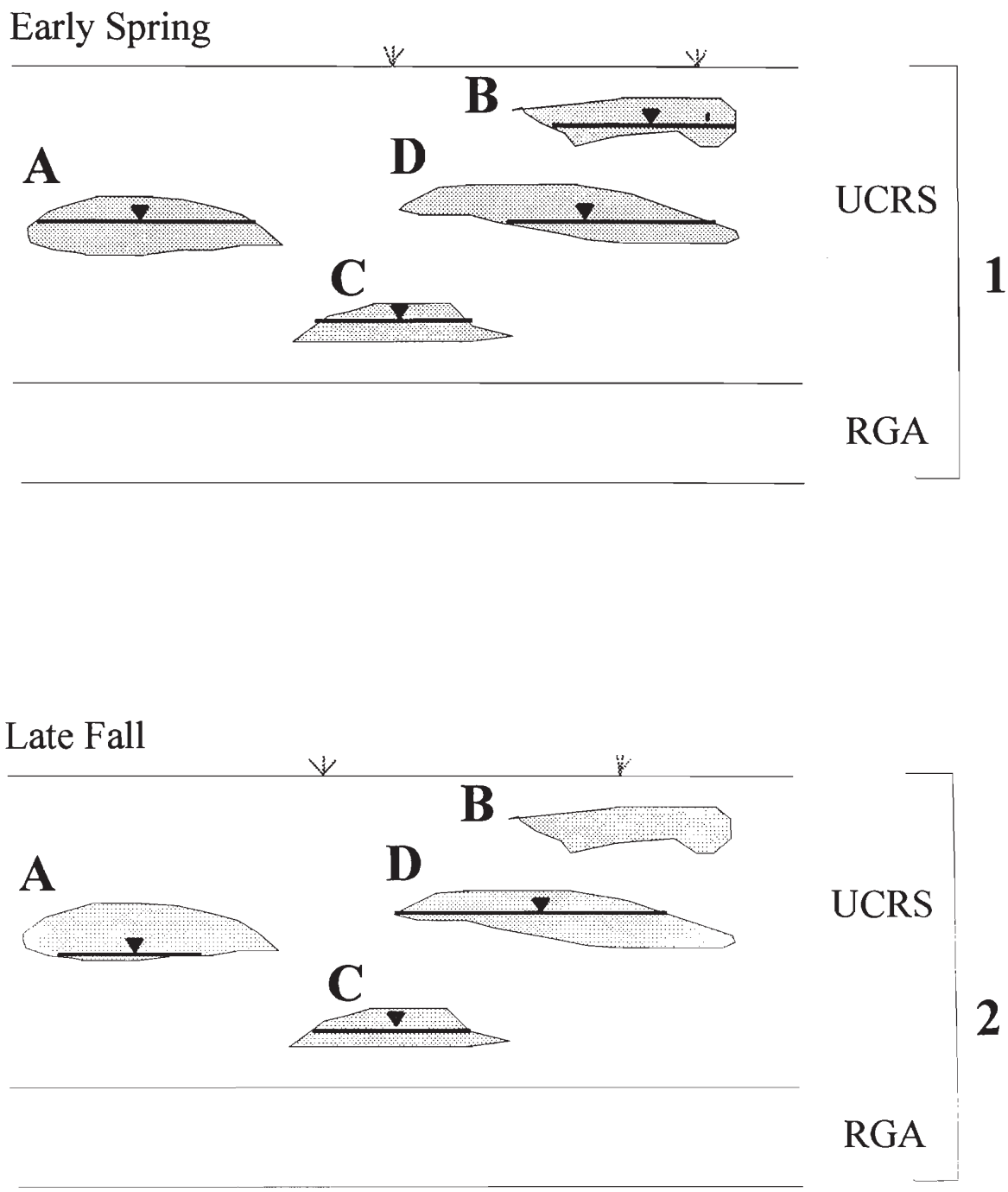


Figure 3.8. Conceptual model of UCRS hydraulic behavior.

7) Flow off the terrace to the RGA is restricted to an area located near the center of the southern plant boundary. The terrace appears to be a no-flow boundary east and west of this location.

3.2.2.1 Horizontal Flow Gradients

Within the RGA the lateral flow gradient is very low, on average 0.0006. However, the flow gradient is not constant across the area of study with three distinct flow regions evident (on-site, mid-zone, and near-river). The on-site region is characterized by nearly flat gradients, except immediately adjacent the terrace south of the plant site. Differences in gradient can be attributed to the transmissivity and the thickness of the RGA.

Adjacent to the Ohio River the gradient increases. The change in gradient near the river suggests a change in material from aquifer gravel to silt laden river gravel. During periods of high Ohio River stage levels, the river acts as a no-flow boundary to the RGA flow system. As a consequence, groundwater is deflected downstream to the river. Rapid stage increases in the Ohio River can also result in flow from the Ohio River to the RGA as bank storage. Flow reversals are evident for the monitoring well cluster MW152 and MW153 (Figure 3.9). When the Ohio River level drops, water moves back from the aquifer into the river. Flow at MW152 and MW153 is primarily upwards from the RGA to UCRS.

3.2.2.2 Aquifer and Ohio River Interaction

Larson and Clark (1992) classified alluvial aquifers based on two Darcy flux components, referred to as baseflow and underflow. Generally, groundwater flow is assumed to be perpendicular toward rivers (baseflow) which fully penetrate alluvial aquifers (Larson and Clark, 1992). Under this scenario, groundwater flow can be reversed (i.e., bank storage) during periods of high river stage. The magnitude and duration of water level change produced in the aquifer is a function of the hydraulic properties of the aquifer and the duration of the river fluctuation. Underflow is the component of groundwater flow parallel to the river and in the same direction of stream flow. The major conclusion from the study of 24 alluvial systems is that the regional groundwater flow component can be inferred from geomorphologic data (Larson and Clark, 1992). Underflow conditions predominate when:

1) Channel gradient exceeds 0.008.
2) Sinuosity is less than 1.3.
3) River penetration is less than 20 percent.
4) Width-to-depth ratio is greater than 60.
5) Fluvial valley depositional system is the result of valley fill or mixed load to bedload.

A cursuary, qualitative analyses of the Ohio River near the PGDP site indicate conditions 1, 2, 4, and 5 exist based on USGS data. The degree of river penetration into the aquifer is unknown. Figure 3.10 is a presentation of RGA hydrographs for monitoring wells located at the northwest corner of the PGDP site. For the most part, the seven monitoring wells exhibit similar seasonal fluctuations in water levels. Several data points appear anomalous and likely represent errors in measurement or transcription of data. Figure 3.11 is a synthetic hydrograph developed by averaging the water levels for each time period. The consolidation of data allows for comparisons between the response of wells completed in the RGA and the Ohio River. It is evident from Figure 3.11 that changes in the Ohio River stage elicit a response in the RGA. Figure 3.12 presents hydrographs of monitoring wells which lie in a line perpendicular with the Ohio River and extending to the PGDP site. The magnitude in response is greatest for these wells closest to the river and decreases with increasing distance (Figure 3.12). The average depth of the Ohio River is 21 ft with the width varying from 2800 to 4800 ft (Mays, 1994). The

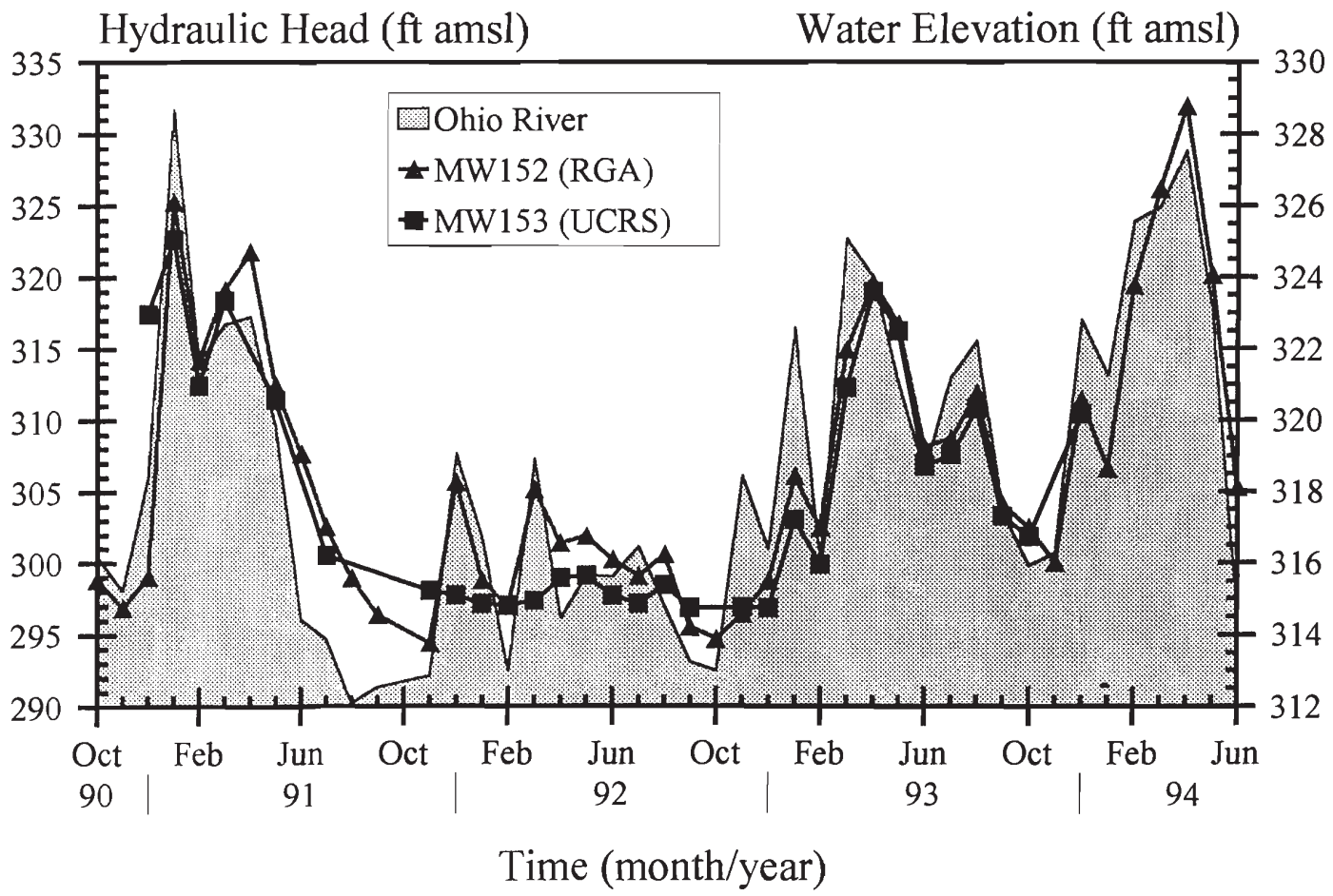


Figure 3.9. Hydrographs of monitoring wells near the Ohio River.

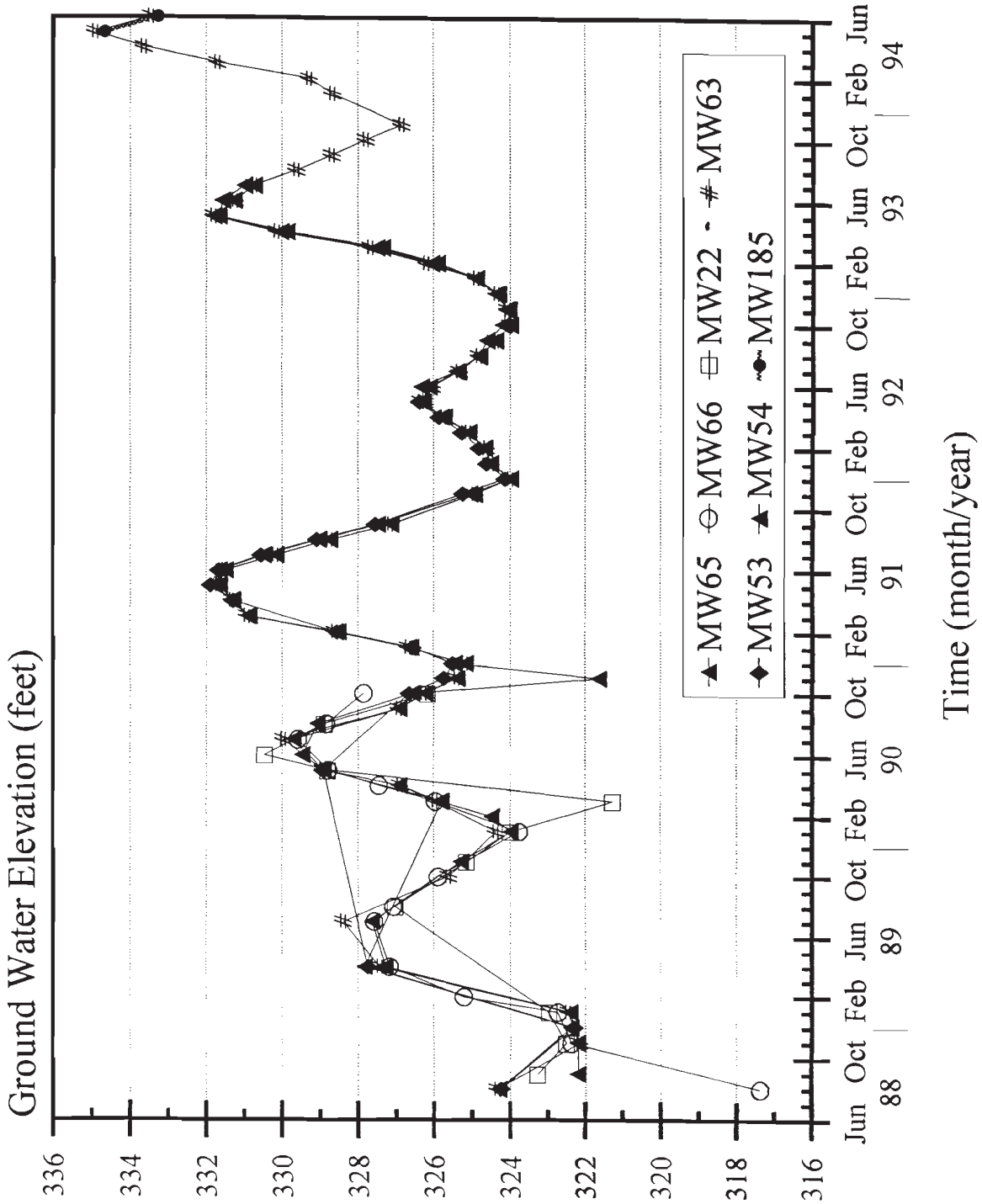


Figure 3.10. Hydrographs of monitoring wells located at the northwest corner of the plant site.

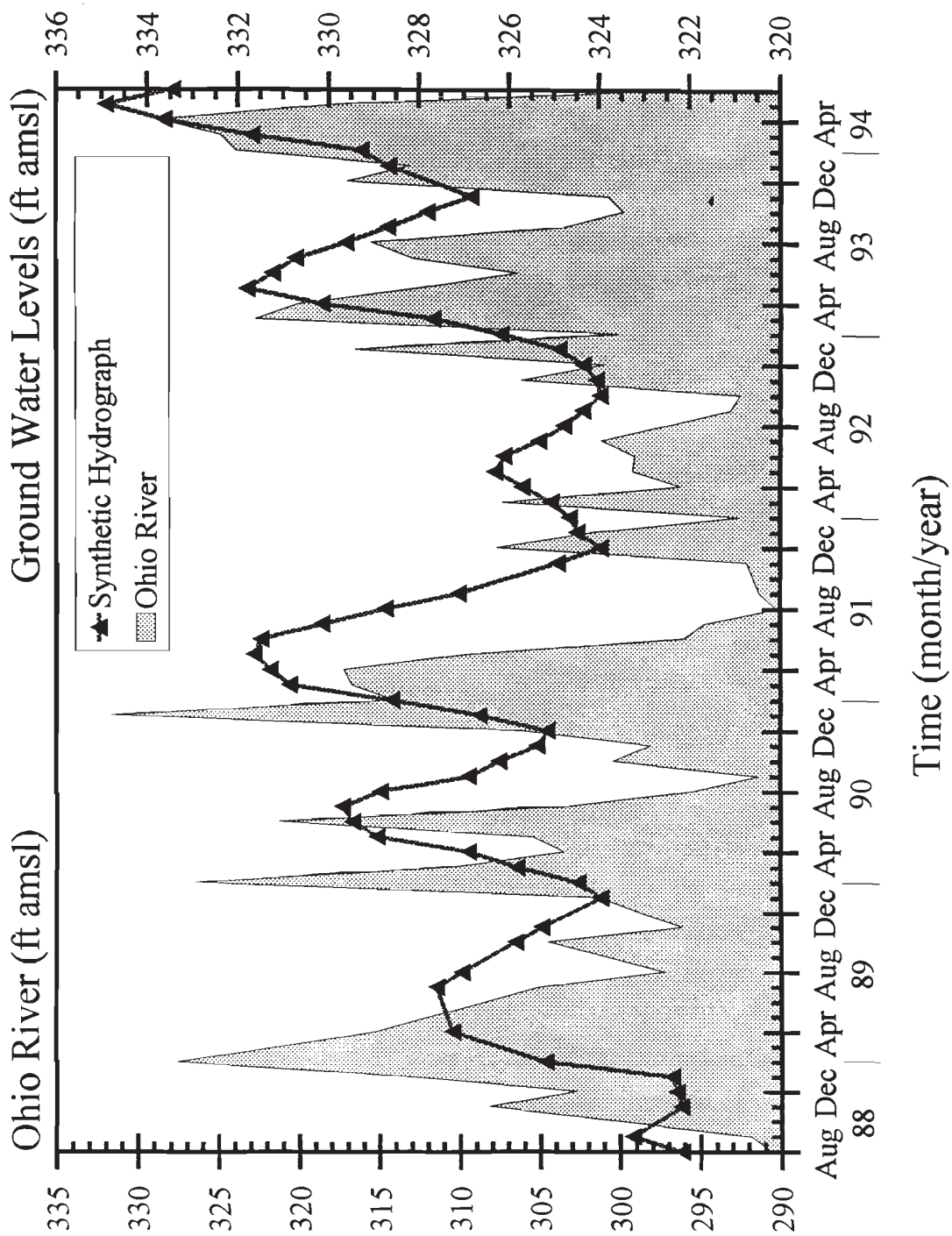


Figure 3.11. Comparison of Ohio River stage and synthetic hydrograph developed from monitoring wells located at the northwest corner of the PGDP site.

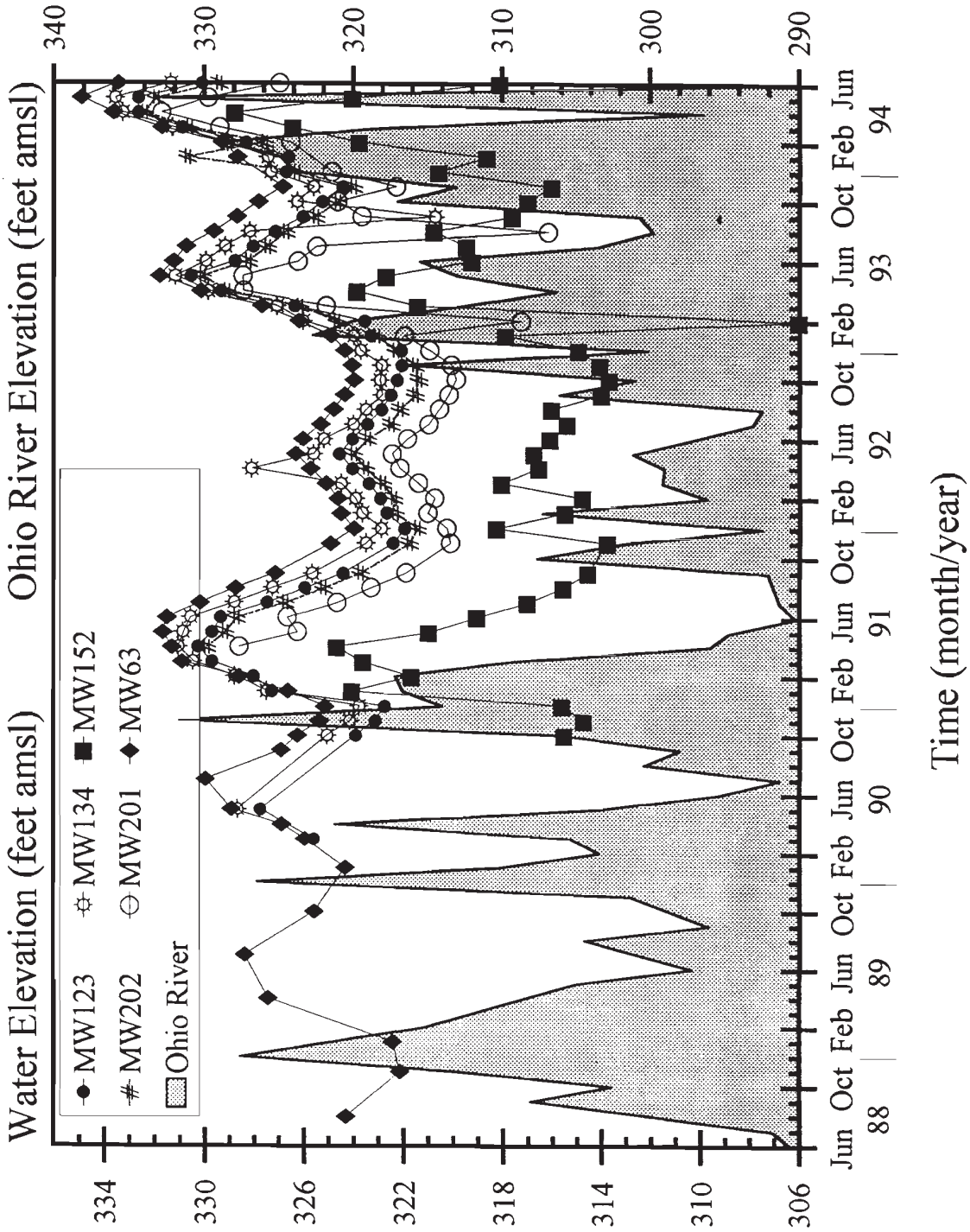


Figure 3.12. Comparison of Ohio River stage and water levels for monitoring wells in a line perpendicular to the Ohio River. Wells located furthest from the river are present at the top of the figure.

sinuosity of the Ohio River is low and suspended-load material is predominant. Based on this analysis, the RGA and Ohio River interact as underflow system although a mixed system is possible. Additional analyses is needed for differentiation. It is possible both conditions exist with flow seasonally dependent. Thus, the previous assumption of baseflow (Clausen et al., 1992b) from the aquifer to the Ohio River appears not to apply. One consequence of this change in interpretation is the Northwest Plume will not reach the Ohio River immediately downgradient of the plant site (near TVA property). Near the river, the plume will change direction and flow parallel to the river and be dispersed downgradient (i.e., to the west). Contaminant levels will be reduced from those calculated in Appendix E because of increased dispersion, dilution, and increased surface water interaction.

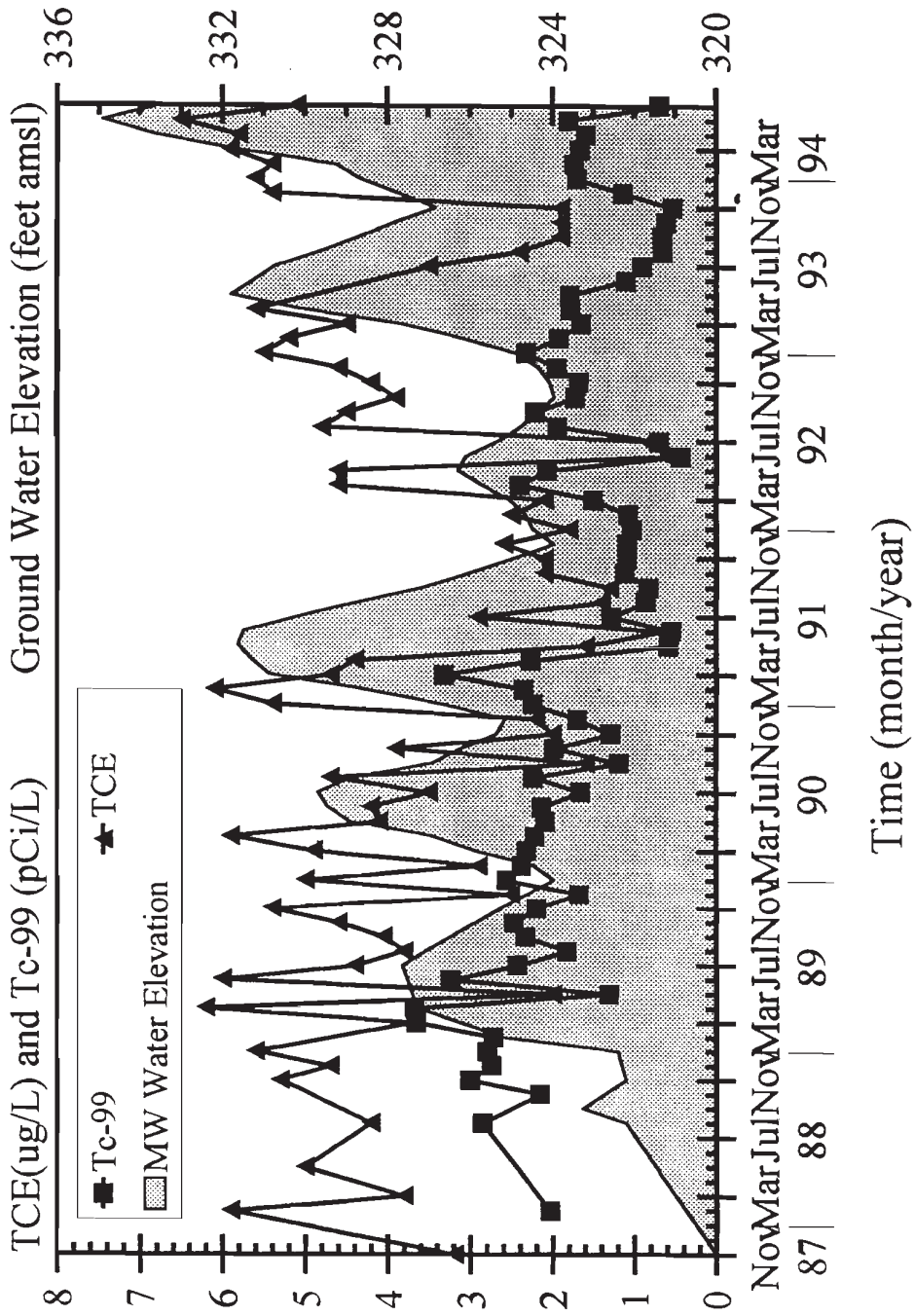
The lag response of hydraulic head in the aquifer to changes in Ohio River stage suggest minimal penetration of the RGA by the Ohio River (Figure 3.12). However, the degree of river penetration is highly variable. However, the delay evident in Figure 3.12 could be attributed to the deposition of fine-grained material at the base of the river, reducing the hydraulic connection. Decreased hydraulic conductivity at the river could have an affect of delaying the response at the monitoring wells since the energy wave is retarded through the fine-grained material. A decrease in hydraulic conductivity due to deposition of fine-grained material is suggested by the increased hydraulic gradient (Appendix E). Figure 3.12 indicates an increase in river stage results in an increase in hydraulic head for monitoring wells in the RGA. This suggests an energy wave that propagates through the aquifer as a result of increased river stage. The wells in Figure 3.12 are in a perpendicular line from the river to the plant site. All of the wells are sampled on the 13th to 15th of the month. The monthly data is insufficient to determine the lag time between wells to calculate the transmissivity of the fine-grained sediment.

Data loggers have been placed on a number of monitoring wells to gather data necessary for this evaluation. These results will be reported in a later study. It is clear a lag response is evident for the aquifer wells (Figure 3.12). Monitoring wells closest to the Ohio River respond first and progressively later with increasing distances. The lag and magnitude of response in the monitoring wells suggest a rise in the RGA water levels occurs in response to a rise in the Ohio River stage, which represents bank storage of water.

As discussed in Section 1.4, Clausen et al., 1992b, postulated the RGA behaves as a semi-confined aquifer system as exemplified by Freeze and Witherspoon (1967). Under this scenario, the effect of an energy wave through the aquifer would be an increase in hydraulic pressure. Rising water levels are evidence for the increase in aquifer pressure. Infiltration is controlled by the transmissivity of the formation and the water pressure of the aquifer. During periods of high river stage, a buildup in aquifer pressure occurs with a concomitant decrease in infiltration through the overlying aquitard. Ultimately, this leads to a decrease in groundwater recharge and an increase in surface water runoff. The implication of this scenario during high river stage is there will be a decrease in infiltration through the waste unit which is fully saturated. Therefore, there will be a decrease in contaminant concentration from water leaving the source area. Figure 3.13 suggests that increased hydraulic pressure corresponds to an decrease in contaminant concentration for a well immediately downgradient of SWMUs 7 and 30.

3.2.2.3 Flow Direction

As stated in Section 3.2.2, the general flow within the RGA is northeast with flow direction dependent upon the time of year. Figure 3.12 compares Ohio River stage and hydraulic head in monitoring wells located in a line perpendicular to the river and within the Northwest Plume. It is evident periods of high water levels occur in late winter and correspond to high Ohio River stage. In turn, periods of high river stage result in a more northeasterly flow of groundwater, except immediately adjacent to the river (Appendix E). During low river stage, flow is approximately due north. These



Att5-13

Figure 3.13. Comparison of RGA water level fluctuations with TCE and ^{99}Tc levels at MW66.

transient flow conditions can also cause the contaminant plume to move back and forth seasonally. The degree of wobble cannot be determined with the spacing of the current monitoring network. However, it cannot be more than several hundred feet based on the distances separating current monitoring wells. Data from R17, located 2376 m (7600 ft) downgradient from the plant site, indicates seasonal fluctuations in contaminant concentrations (Figure 3.14). The TCE and ^{99}Tc fluctuations correspond to increases and decreases in the hydraulic head and the river stage. This smearing of the plume has the affect of increasing the volume of contaminated water which results in a decrease in concentration levels due to dispersion. When the high concentration zone passes through the monitoring, well contaminant levels increase. Smearing of the plume also has implications for hydraulic containment.

In the area of SWMUs 7 and 30, groundwater mounding is evident in the vicinity of the C-616 lagoon (Appendix E). However, the mound is only evident during periods when the Ohio River elevation is low, usually in early spring. This finding is consistent with modeling conducted by GeoTrans (1990). A sensitivity analysis comparing the actual head values versus the computed head values resulted in a cluster of high residual numbers in the C-616 lagoon vicinity. The computer results suggest groundwater recharge from the C-616 was not accounted for in the model.

3.2.2.4 Flow Velocity

Important aquifer parameters can be derived by using the present extent of the Northwest Plume. Retardation of TCE is assumed negligible in the velocity calculations. This appears to be a reasonable assumption since the ratio of TCE/^{99}Tc does not change throughout the plume. A decrease in TCE/^{99}Tc downgradient from the source unit would be evidence for retardation of TCE. See Section 3.3.2 for additional discussion of TCE/^{99}Tc ratios. Retardation calculations are based on measurements of the fraction of organic carbon (f_{oc}) in the RGA. Analysis of samples yielded a range of f_{oc} from 0.001 to 0.0002 with a mean of 0.0005 (CH2M Hill, 1992). Using an apparent sorption coefficient (k_{oc}) for TCE of 2.54 (CH2M Hill, 1992) and the equation:

$$\{3\} \quad K_d = K_{oc} * f_{oc}$$

where K_d = distribution coefficient a value of 0.127 g/cm^3 was determined (CH2M Hill, 1991). Using the K_d value, a retardation factor of TCE can be calculated using the following equation:

$$\{4\} \quad R_{TCE} = 1 + (\sigma * K_d) / n$$

where σ = relative bulk density of the RGA, and n = porosity.

The bulk density of the RGA was assumed to be 2.12 g/cm^3 (CH2M Hill, 1992). McConnell (1992) estimated an R_{TCE} for the RGA of 1.6 ml/g based on computer modeling. An R equal to one implies minimal to no retardation. Therefore, sorption is insignificant for the Northwest Plume. A summary of all hydraulic property data for the RGA is presented in Clausen et al., 1992b.

The distance from MW185 to the leading edge of the plume (MW152), along the centerline of the plume, is approximately 4876 m (16,000 ft). Assuming an instantaneous release from the burial ground occurred in 1958, the date of earliest known use of the Contaminated Burial Ground B yields 36 years of contaminant migration. Based on the extent of contamination, a maximum flow velocity of 0.37 m/day (1.3 ft/day) is derived for the RGA (Table 3.0).

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APPENDIX E

POTENTIOMETRIC MAPS

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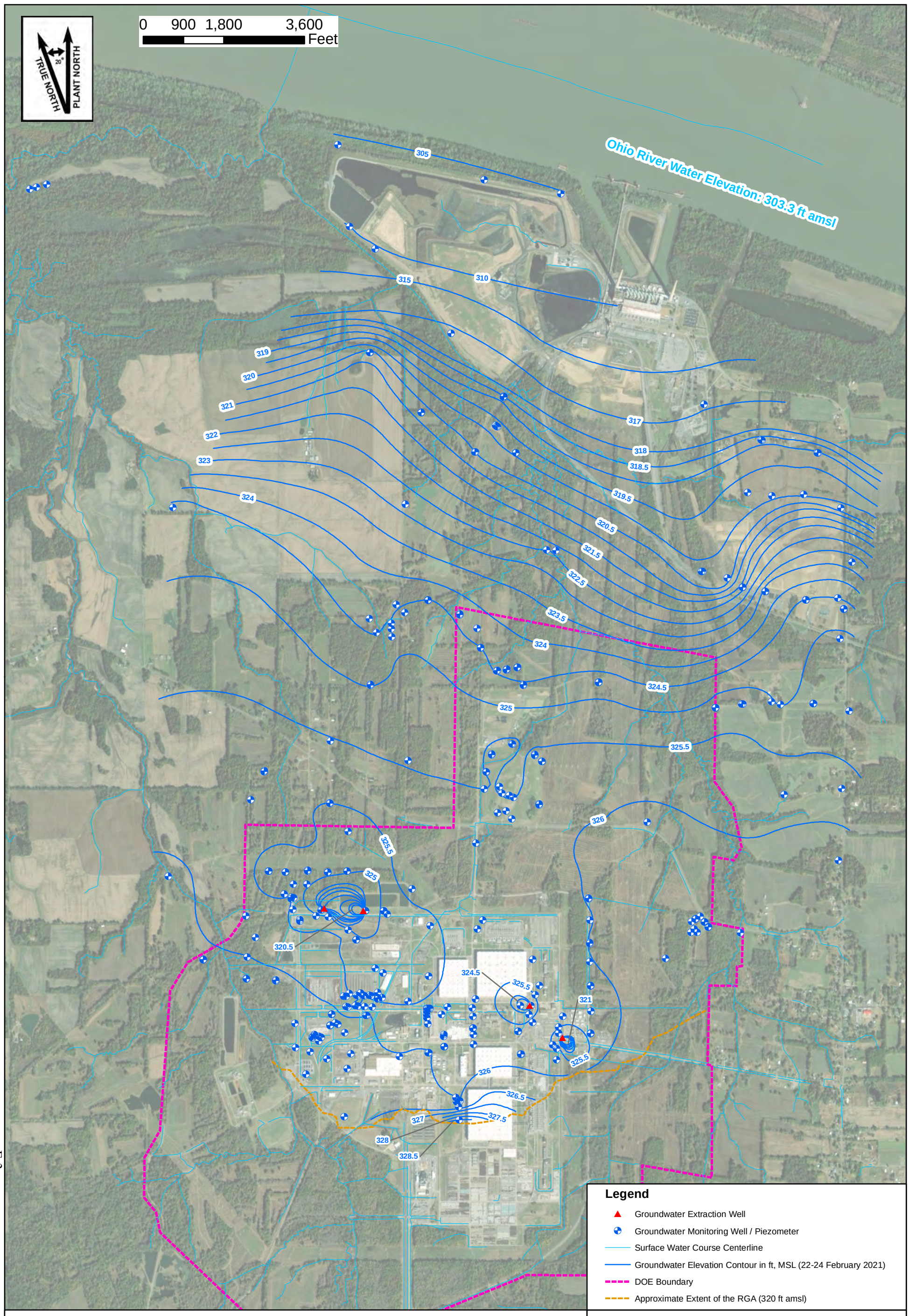

MAP SOURCE INFORMATION

Map Generation Date and Location - 8/8/2022 Geosyntec\\fedprojects-01\paducah$\Knoxville\GW Strategy\GIS\MXDs\2020-2021 Potentiometric Surface Maps
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Image Source: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Shapefile for Surface Water Course Centerline was obtained from Pegasis (https://pegasis.pad.pppo.gov/), Downloaded on 12/1/2021.
DOE Property Boundary provided by FRNP 2/4/2021.
Northing and easting of wells obtained from Pegasis, downloaded on 10/5/2021. Northing and easting of SHF and TVAGW series wells obtained from OREIS on 10/15/2021.
Groundwater elevation was based on the February 22-24, 2021 measurements. Ohio River elevation was estimated as the average of elevations measured by the USGS at Paducah Station USGS 0361100 and Olmsted, IL Station (USGS 03612600) between February 22-24, 2021.

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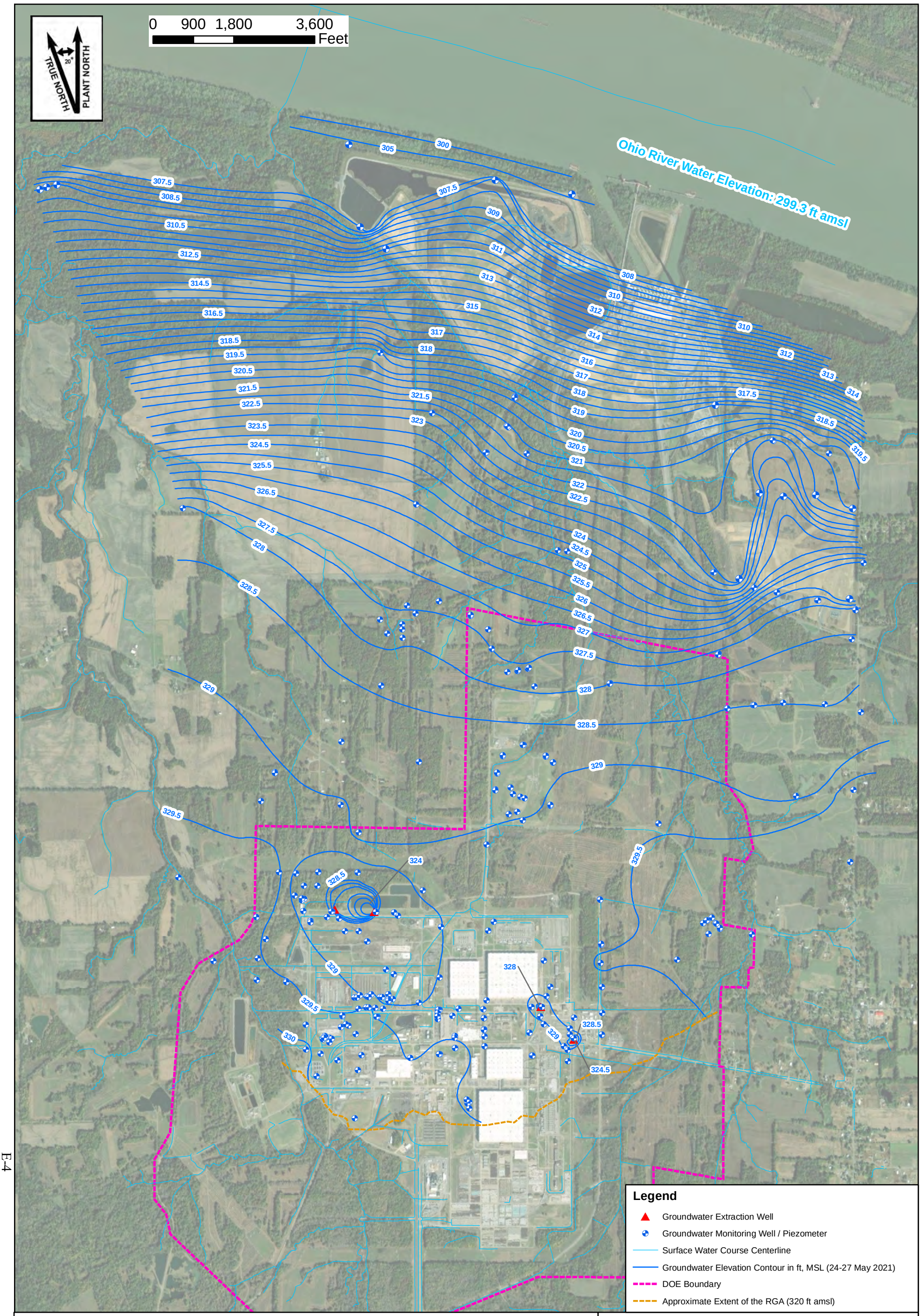
Figure E.1. Regional Gravel Aquifer Potentiometric Surface Map (February 2021)



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DOE Property Boundary provided by FRNP 2/4/2021.
Northing and easting of wells obtained from Pegasis, downloaded on 10/5/2021. Northing and easting of SHF and TVAGW series wells obtained from OREIS on 10/15/2021.
Groundwater elevation was based on the May 24-27, 2021 measurements. Ohio River elevation was estimated as the average
of elevations measured by the USGS at Paducah Station USGS 0361100 and Olmsted, IL Station (USGS 03612600) between May 24-27, 2021.

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Figure E.2. Regional Gravel Aquifer Potentiometric Surface Map (May 2021)

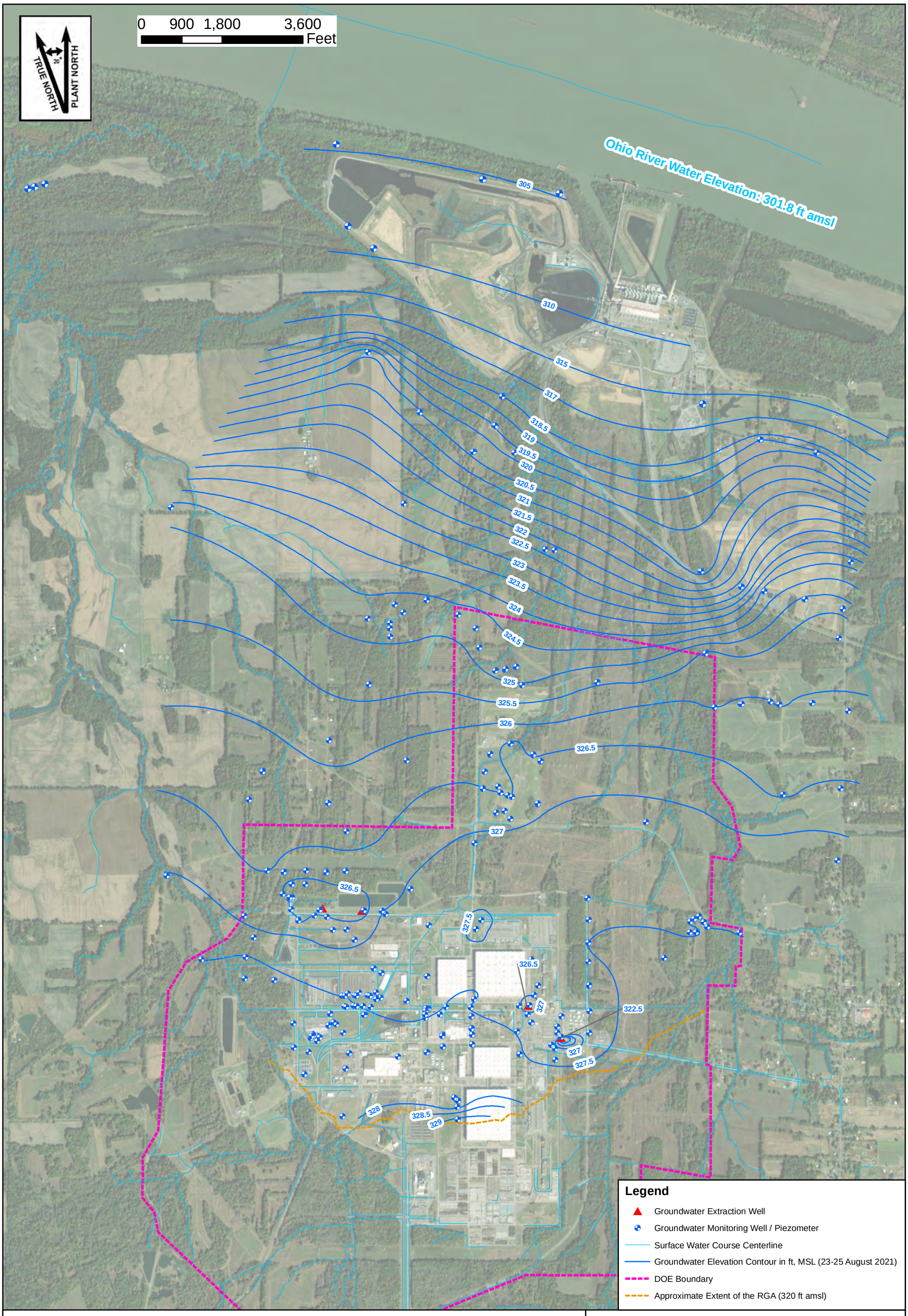

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Image Source: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Shapefile for Surface Water Course Centerline was obtained from Pegasis (https://pegasis.pad.pppo.gov/), downloaded on 12/1/2021.
DOE Property Boundary provided by FRNP 2/4/2021.
Northing and easting of wells obtained from Pegasis, downloaded on 10/5/2021. Northing and easting of SHF and TVAGW series wells obtained from OREIS on 10/15/2021.
Ohio River elevation was estimated as the average of elevations measured by the USGS at Paducah Station USGS 0361100 and Olmsted, IL Station (USGS 03612600) between August 23-25, 2021.

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Figure E.3. Regional Gravel Aquifer Potentiometric Surface Map (August 2021)

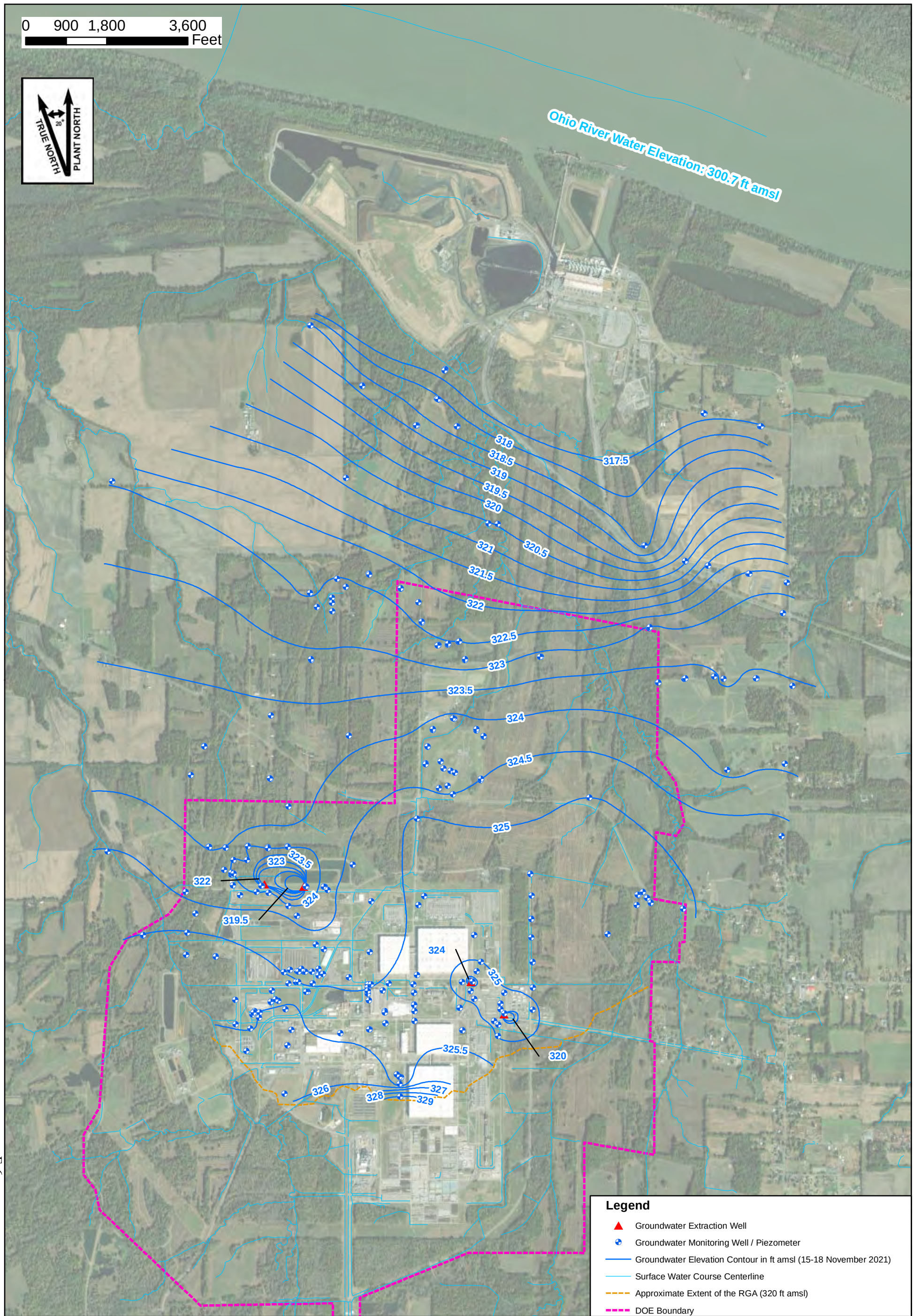

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Image Source: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Shapefile for Surface Water Course Centerline was obtained from Pegasis (https://pegasis.pad.pppo.gov/), downloaded on 12/1/2021.
DOE Property Boundary provided by FRNP 2/4/2021.
Northing and easting of wells obtained from Pegasis, downloaded on 12/7/2021.
Groundwater elevation was based on the November 15-18, 2021 measurements. Ohio River elevation was estimated as the average of elevations measured by the USGS at Paducah Station USGS 0361100 and Olmsted, IL Station (USGS 03612600) between November 15-18, 2021.
amsl = above mean sea level

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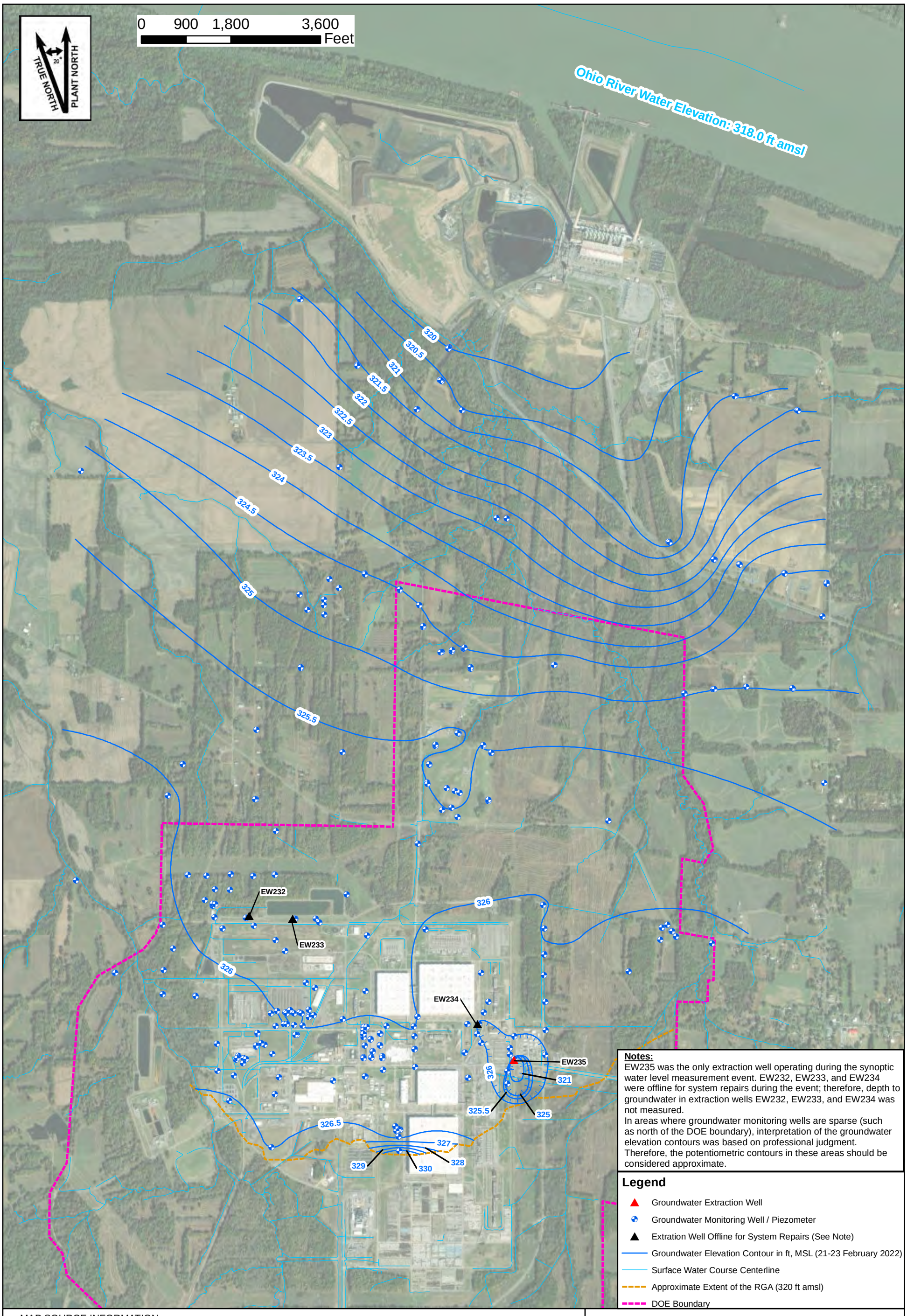
Figure E.4. Regional Gravel Aquifer Potentiometric Surface Map (November 2021)



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Shapefile for Surface Water Course Centerline was obtained from Pegasis (https://pegasis.pad.pppo.gov/), downloaded on 12/1/2021.
DOE Property Boundary provided by FRNP 2/4/2021.
Northing and easting of wells obtained from Pegasis, downloaded on 12/7/2021.
Groundwater elevation was based on the February 21-23, 2022 measurements. Ohio River elevation was estimated as the average of elevations measured by the USGS at Paducah Station USGS 0361100 and Olmsted, IL Station (USGS 03612600) between February 21-23, 2022.
amsl = above mean sea level

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Figure E.5. Regional Gravel Aquifer Potentiometric Surface Map (February 2022)

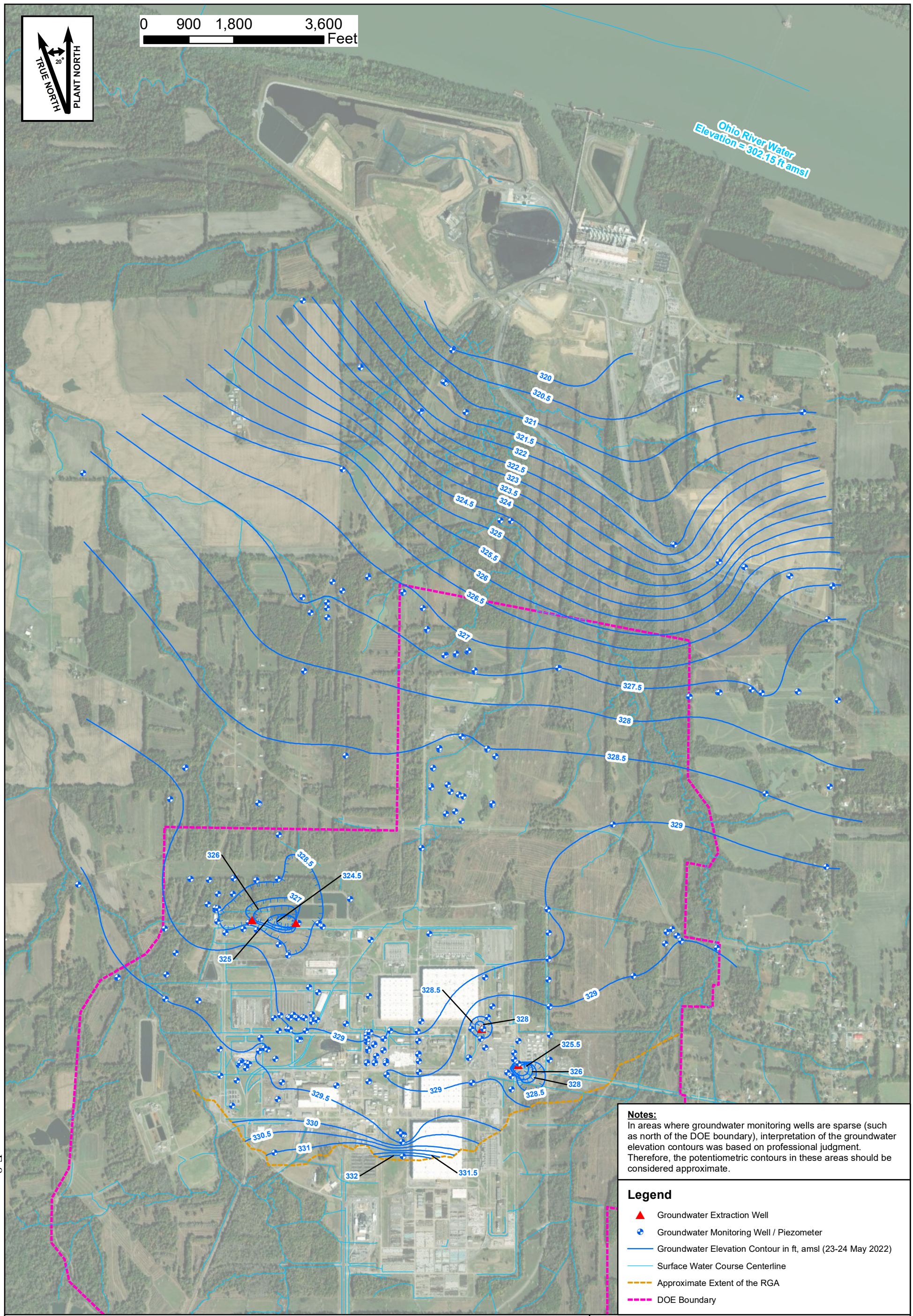

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Image Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Shapefile for Surface Water Course Centerline was obtained from Pegasis (https://pegasis.pad.pppo.gov/), downloaded on 6/27/2022.
DOE Property Boundary provided by FRNP 2/4/2021.
Northing and easting of wells obtained from Pegasis, downloaded on 6/14/2022.
Groundwater elevation was based on the May 23-24, 2022 measurements. Ohio River elevation was estimated as the average of elevations measured by the USGS at Paducah Station USGS 0361100 and Olmsted, IL Station (USGS 03612600) between May 23-24, 2022.
amsl = above mean sea level

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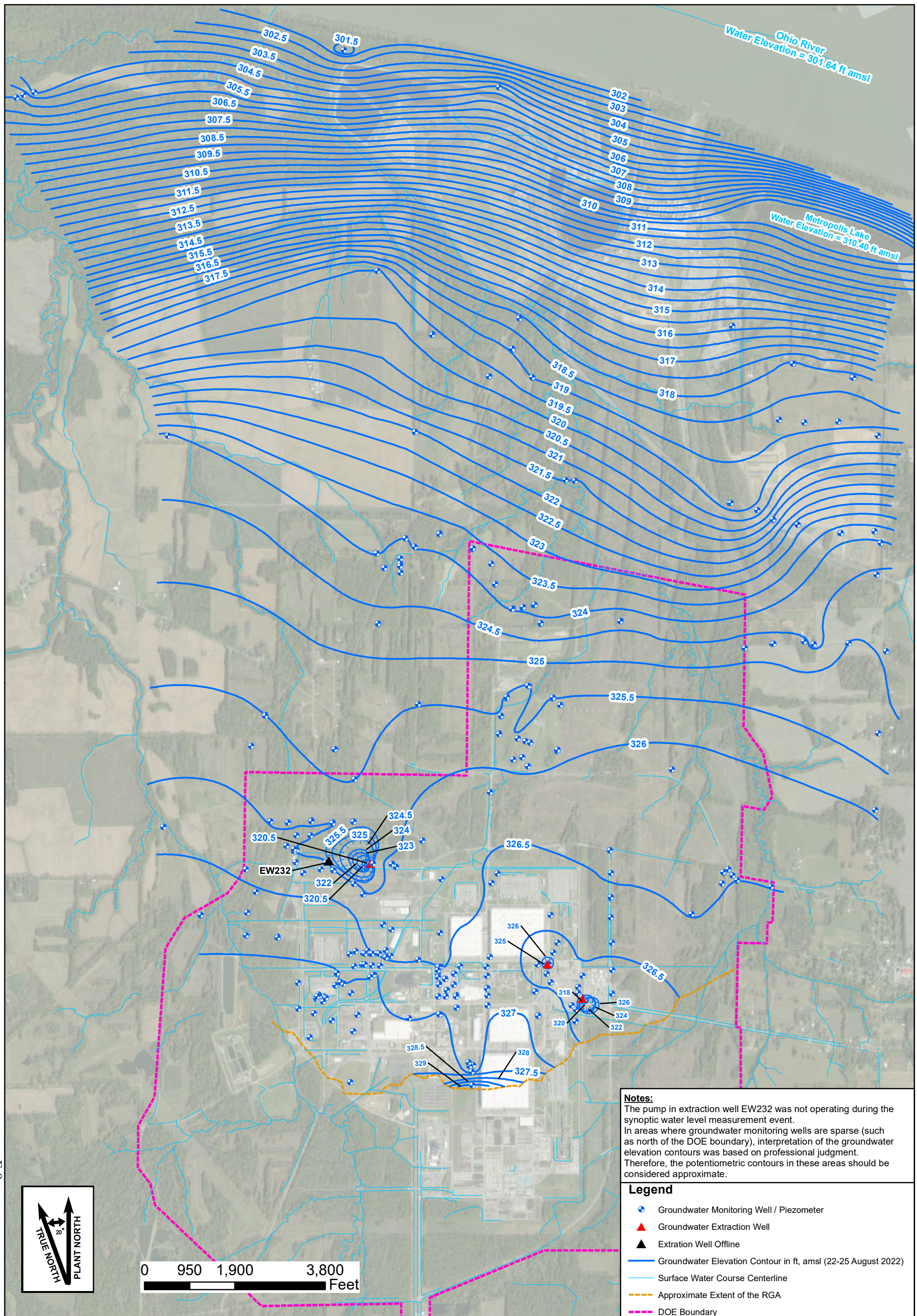
Figure E.6. Regional Gravel Aquifer Potentiometric Surface Map (May 2022)



Notes:
The pump in extraction well EW232 was not operating during the synoptic water level measurement event.
In areas where groundwater monitoring wells are sparse (such as north of the DOE boundary), interpretation of the groundwater elevation contours was based on professional judgment. Therefore, the potentiometric contours in these areas should be considered approximate.

Legend

- Groundwater Monitoring Well / Piezometer
- Groundwater Extraction Well
- Extration Well Offline
- Groundwater Elevation Contour in ft, amsl (22-25 August 2022)
- Surface Water Course Centerline
- Approximate Extent of the RGA
- DOE Boundary

MAP SOURCE INFORMATION

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Image Source: Aerial 2021: http://pegasis.pad.pppo.gov:6080/arcgis/services; and
Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.
Shapefile for Surface Water Course Centerline was obtained from Pegasis (https://pegasis.pad.pppo.gov/), downloaded on 6/27/2022.
DOE Property Boundary provided by FRNP 2/4/2021.
Northing and easting of wells obtained from Pegasis, downloaded on 6/14/2022.
Groundwater elevation was based on the 8/22/2022 - 8/25/2022 measurements. Ohio River elevation was estimated as the average of elevations measured by the USGS at Paducah Station USGS 0361100 and Olmsted, IL Station (USGS 03612600) between 8/22/2022 - 8/25/2022.
Groundwater elevation for the TVA wells were provided by the Kentucky Division of Waste Management on 9/1/2022. Water elevation at Metropolis Lake was provided by FRNP on 8/30/2022.
amsl = above mean sea level

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Figure E.7. Regional Gravel Aquifer Potentiometric Surface Map (August 2022)

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APPENDIX F

EVALUATION OF ANTHROPOGENIC RECHARGE ASSOCIATED WITH THE PROCESS BUILDINGS IN SUPPORT OF THE SITEWIDE GROUNDWATER FLOW MODEL, PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY

FRNP-RPT-0224

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FRNP-RPT-0224

Evaluation of Anthropogenic Recharge Associated with the Process Buildings in Support of the Sitewide Groundwater Flow Model, Paducah Gaseous Diffusion Plant, Paducah, Kentucky

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

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Evaluation of Anthropogenic Recharge Associated with the Process Buildings in Support of the Sitewide Groundwater Flow Model, Paducah Gaseous Diffusion Plant, Paducah, Kentucky

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Prepared by
FOUR RIVERS NUCLEAR PARTNERSHIP, LLC,
managing the
Deactivation and Remediation Project at the
Paducah Gaseous Diffusion Plant
under Contract DE-EM0004895

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ACRONYMS

CSM	conceptual site model
D&D	decontamination and decommissioning
D&R	deactivation and remediation
DOE	U.S. Department of Energy
DQO	data quality objective
EI	environmental indicator
EPA	U.S. Environmental Protection Agency
KDEP	Kentucky Department for Environmental Protection
MWG	modeling working group
OU	operable unit
PGDP	Paducah Gaseous Diffusion Plant
PPE	personal protective equipment
RGA	Regional Gravel Aquifer
UCRS	Upper Continental Recharge System
USEC	United States Enrichment Corporation

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EXECUTIVE SUMMARY

An uncertainty identified in the *2016 Update of the Paducah Gaseous Diffusion Plant Sitewide Groundwater Flow Model*, DOE/LX/07-2415&D2, was the quantity of induced groundwater infiltration derived from leaks of the roof drain systems of the large process buildings at the U.S. Department of Energy (DOE) Paducah Gaseous Diffusion Plant (PGDP). Assuming the process buildings were constructed on a thick gravel sub-slab layer (i.e., similar to the construction of the C-400 Cleaning Building), then the gravel may have formed a seasonal reservoir which leaked into the groundwater system.

Historical anecdotal evidence of water leaks in the floor slab of these buildings during large rain events suggests that water had been leaking from the sub-slab roof drain system piping. DOE funded repair and replacement of problem roof drain system components in the C-333 Process Building and C-337 Process Building (the two largest process buildings), during 2016 and 2017.[1] Construction drawings for the large process buildings reveal that the gravel sub-slab layer is only 9 to 12 inches thick.

This white paper presents process building construction information and an investigational approach to assess the current formation of a seasonal reservoir in the gravel sub-slab layer of the process buildings. If the field investigation included in this approach is carried forward, the investigation would include the following:

- Additional field reconnaissance and coordination with the facility owner(s) to identify three locations in process buildings C-335 and C-337 for the installation of vibrating wire piezometer/data logger systems;
- A short-duration construction task to install the vibrating wire piezometer/data logger systems;
- A one-year period of automated monitoring by the vibrating wire piezometer/data logger systems to assess water level trends in the gravel sub-slab layer of the process buildings; and
- A summary data report with an assessment of the volume of area-wide groundwater recharge for the one-year period of monitoring.

The thin, compacted nature of the subgrade gravel layer beneath the floor slab of all four of the process buildings limits the significance of variable saturation in the gravel layer; however, the gravel fill around the foundation footers of each of the buildings remains a potential reservoir for rain event recharge. Should a field study proceed to assess infiltration beneath the process buildings, the project data will provide input to the next update of the site groundwater flow model and future groundwater actions at PGDP.

The 2016 update of the sitewide groundwater flow model included 21 recommendations to address uncertainties in future model revisions (DOE 2017). Among the recommendations was the following:

> Recharge related to the process building roof drains is poorly understood. Future model efforts should compile available information regarding the chronology of roof drain repair to better understand temporal variability and to reduce uncertainty in model recharge estimates.

[1] No sub-slab drain lines were repaired or replaced during the 2016–2017 roof drain project. Aboveground piping was added to bypass the sub-slab drain lines where the sub-slab drain lines were suspected to be compromised.

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1. INTRODUCTION

The Paducah Gaseous Diffusion Plant (PGDP) Modeling Working Group (MWG), which included representatives from the U.S. Environmental Protection Agency (EPA), the Kentucky Department for Environmental Protection (KDEP), Kentucky Research Consortium for Energy and Environment, and the U.S. Department of Energy (DOE) and their technical consultants, identified a need for an investigation to characterize roof drain leaks to the gravel sub-slab layer of the large process buildings at the PGDP, and to assess the significance of the roof drain leak-induced recharge to the groundwater flow system.[2] A white paper outline was used to summarize an investigation plan; this plan was presented at the January 13, 2021, MWG meeting and approved as part of that meeting's summary.

1.1 PADUCAH GASEOUS DIFFUSION PLANT OVERVIEW

PGDP is an inactive gaseous diffusion plant located in western Kentucky that was used to produce enriched uranium beginning in 1952. DOE managed PGDP until 1993 when the United States Enrichment Corporation (USEC) assumed management and operation of PGDP under a lease agreement with DOE on July 1, 1993. Uranium enrichment ceased in May 2013 and USEC returned management of PGDP to DOE in October 2014.

The uranium enrichment process facility consisted of diffusion cascades and extensive support facilities. The cascades were housed in four large process buildings. Process buildings C-331 and C-333 are located on the south side of PGDP. Process buildings C-335 and C-337 are located on the north side of PGDP (Figure 1).

1.2 ENVIRONMENTAL REMEDIATION PROGRAM OVERVIEW

Site cleanup activities are divided into 11 operable units (OUs) (DOE 2020).

- C-400 Complex OU
- Groundwater OU
- Surface Water OU
- Lagoons OU
- Burial Grounds OU
- Soils OU
- Soils and Slabs OU
- Facility Decontamination and Decommissioning (D&D) OU
- Depleted Uranium Hexafluoride (DUF_6) Footprint Underlying Soils OU
- Comprehensive Site OU
- CERCLA Waste Disposal Alternatives OU

Completion of these OUs is required to achieve delisting of the site from the National Priorities List. This white paper and any subsequent investigation have bearing on the Groundwater OU, Soils and Slabs OU, and Facility D&D OU.

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[2] No other underground water systems, other than a few sanitary water and sewer lines, are located under the process buildings (see appendix for archive plant drawings). Other water services, including the fire suppression system, transition from below ground to above ground at the process buildings.

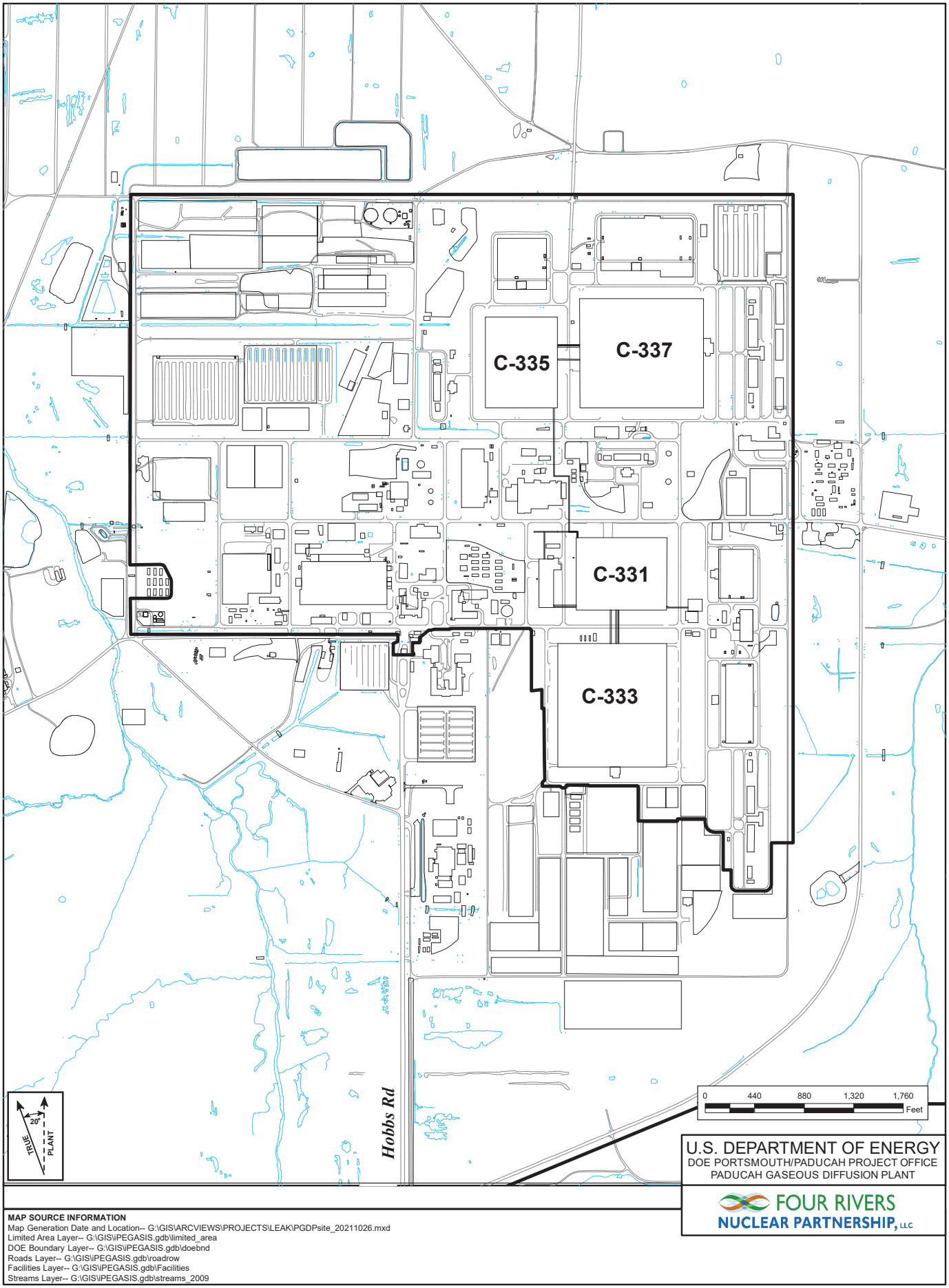

Figure 1. Location of PGDP Large Process Buildings

1.3 2016 UPDATE OF THE SITEWIDE GROUNDWATER FLOW MODEL

The 2016 PGDP sitewide groundwater model simulates groundwater flow within the Regional Gravel Aquifer (RGA). The following are the primary revisions to the 2012 groundwater model that were implemented:

- Optimizing calibration periods, building on calibrations performed prior to 2016;
- Converting the lower reaches of Bayou Creek, Little Bayou Creek, and the Ohio River from drain to river boundary conditions;
- Including groundwater flow originating upgradient of the model from the Terrace Gravel;
- Revising the southern model boundary at the limit of the RGA; and
- Updating anthropogenic recharge zonation in the plant area.

Various sources of anthropogenic recharge (i.e., recharge that is caused or produced by human activity) were recognized as being present in the plant area (e.g., leaking water lines, infiltration from drainage ditches, leakage from lagoons, compromised roof drain leaks). The 2016 update of the groundwater flow model attributed the second highest recharge zonation to the C-333 and C-337 process buildings (i.e., 30 inches of recharge per year) due, in part, to roof drain leakage.

1.4 INTERACTION WITH OTHER PROJECTS

This assessment of the process buildings for roof drain leaks is supplemental to the following two projects in the PGDP Environmental Restoration Program:

- Groundwater Strategy; and
- Future update of the Sitewide Groundwater Flow Model.

Ongoing projects that provide context and information to this assessment include the following:

- C-400 Complex Remedial Investigation; and
- Plant Industrial Area Vapor Intrusion Study.

1.4.1 Groundwater Strategy Project

PGDP is implementing a groundwater strategy project (FRNP 2020) to provide information to refine the conceptual site model (CSM) for groundwater in preparation for the final remedy for the Groundwater OU dissolved-phase plumes actions, to provide additional data regarding the status of PGDP environmental indicators (EIs), and to address recommended maintenance and updates to the groundwater CSM from the groundwater MWG meetings.

EPA and KDEP EIs are used to measure performance and to communicate progress made in protecting human health and the environment, and sites are designated in each of these areas as “Insufficient Data,” “Under Control,” or “Not Under Control.” A fundamental goal of the Groundwater Strategy Project is to determine what information is needed or what additional information is to be collected to change the status of the EIs for “Human Exposure Under Control” and “Groundwater Migration Under Control” at the Paducah Site to a “yes.”

The Groundwater Strategy Project consists of a number of activities, including a water balance study. The results of this study of roof drain recharge will have direct bearing on the site's water balance study.

1.4.2 Future Update of the Sitewide Groundwater Flow Model

The 2016 update of the sitewide groundwater flow model included 21 recommendations to address uncertainties in future model revisions (DOE 2017). Among the recommendations was the following:

"Recharge related to the process building roof drains is poorly understood. Future model efforts should compile available information regarding the chronology of roof drain repair to understand temporal variability better and reduce uncertainty in recharge estimates."

In addition to documenting roof drain repairs, this white paper and the approach for subsequent investigation, if executed, would support a qualitative assessment of roof drain recharge to the PGDP groundwater system.

1.4.3 C-400 Complex Remedial Investigation

Fieldwork for the C-400 Complex Remedial Investigation began in 2019 and concluded in 2021. Part of that investigation included the installation of two piezometers inside the C-400 Cleaning Building, in the 5- to 8-ft thick gravel foundation base underlying the C-400 floor slab, to assess the significance of roof drain leakage. Continuous water level monitoring in the piezometers from May 27, 2021, to March 1, 2022, using pressure transducer/data logger assemblies, did not detect the presence of water. Moreover, soil borings through the C-400 floor slab revealed the soils immediately underlying the gravel base were often desiccated.

1.4.4 Plant Industrial Area Vapor Intrusion Study

Plant Industrial Area Vapor Intrusion Preliminary Risk Assessment Report, Paducah Gaseous Diffusion Plant, Paducah Kentucky, DOE/LX/07-2471&D1, documents a plant-wide assessment of vapor intrusion risk (DOE 2021). Fieldwork for the project was conducted in February 2021 and March 2021. Sub-slab vapor sampling for the project did not detect the presence of water in any of the three samples taken below C-337, the one process building sampled.[3]

2. PROCESS BUILDINGS

The PGDP diffusion cascade included two enrichment systems. Each system contained two large process buildings and an accompanying purge and product building. The southern PGDP cascade consisted of process buildings C-331 and C-333; the northern PGDP cascade, process buildings C-335 and C-337. Table 1 lists the process buildings, area covered by a roof, and representative runoff amounts.

[3] The vapor intrusion study fieldwork was performed in February 2021–March 2021 and the observations of the absence of water may not be reflective of seasonal variations.

Table 1. Roof Areas and Representative Runoff Amounts

Process Building	Covered Area (acres)	Runoff from 1-inch Rain (gal)[a,b,c]
C-331	11.87	322,000
C-333	24.54	666,000
C-335	11.88	322,000
C-337	24.54	666,000

[a] Approximate. Building covered area provided by Portsmouth/Paducah Project Office Environmental Geographic Analytical Spatial Information System (PEGASIS) on October 8, 2021.
[b] The 2016 roof drain repair design 100-year, 1-hour rainfall for Paducah, Kentucky, was 3.25 to 3.5 inches/hour (ICC 2014, Figure 1106.1).
[c] Method of calculation: https://www.usgs.gov/special-topics/water-science-school/science/rain-and-precipitation?qt-science_center_objects=0#qt-science_center_objects

The process buildings were constructed with roof drain systems consisting of vertical conductor pipes joined to lateral sub-slab storm drain pipes. Drain lines for the C-331 and C-335 process buildings were primarily 4-inch diameter, cast iron pipes in four storm drain corridors underlying each building (archive drawings F1-1-M and J1-1-M; see Appendix).[4] Drain lines for C-333 and C-337 included 6-, 8-, and 12-inch diameter, drainage and storm sewer pipes (presumably concrete), along 11 storm drain corridors underlying each building (archive drawings G1-1-M and L1-1-M; see Appendix).[5] Short tributary drain lines were plumbed to each storm drain corridor. The drain lines were sloped to flow to underground storm drain systems outside of the process buildings. For each of the process buildings, the deep ends of the drain lines, at the building walls, were several feet (i.e., 3.4 to 7.0 ft) below the base of the floor slab.

The roof drain systems in process buildings C-333 and C-337 developed unacceptable rain water intrusion (e.g., upwards leakage) through the floor slabs during large rain events, reported as early as 2002 (Figures 2 and 3). Two main areas of concern were identified in C-337. C-333 had one primary area of concern. It was assumed that one section of the subfloor drain line in C-333 was no longer functional and possibly collapsed.

In response to these findings, DOE repaired and replaced drain lines in both buildings in 2016 and 2017,[6] bypassing flow to the storm drain system in the areas of unacceptable rain water intrusion. The new roof drain piping discharges through near-ceiling-level drain laterals, to above-grade piping, then to storm drains located outside the process buildings.

Essentially no other underground water systems, other than a few sanitary water and sewer lines, are under the process buildings. During rain events, the roof drain system has the largest flow of the underground water systems. Other water services, including the fire suppression system, transition from below ground to above ground at the process buildings. The construction of the process buildings did not include foundation water drainage systems (i.e., French drains).

[4] A major roof replacement project for C-331 and C-335 was completed in 1981. The project sloped the roofs with drainage to the north and south outside walls of C-331 and to the east and west outside walls of C-335, eliminating flow to the interior roof drain systems.
[5] The 4-inch cast iron pipes were designed to not leak. Some leakage can be expected from the 6- to-12-inch diameter drainage and storm sewer pipes.
[6] No sub-slab drain lines were repaired or replaced during the 2016–2017 roof drain project. Aboveground piping was added to bypass the sub-slab drain lines where the sub-slab drain lines were suspected to be compromised.

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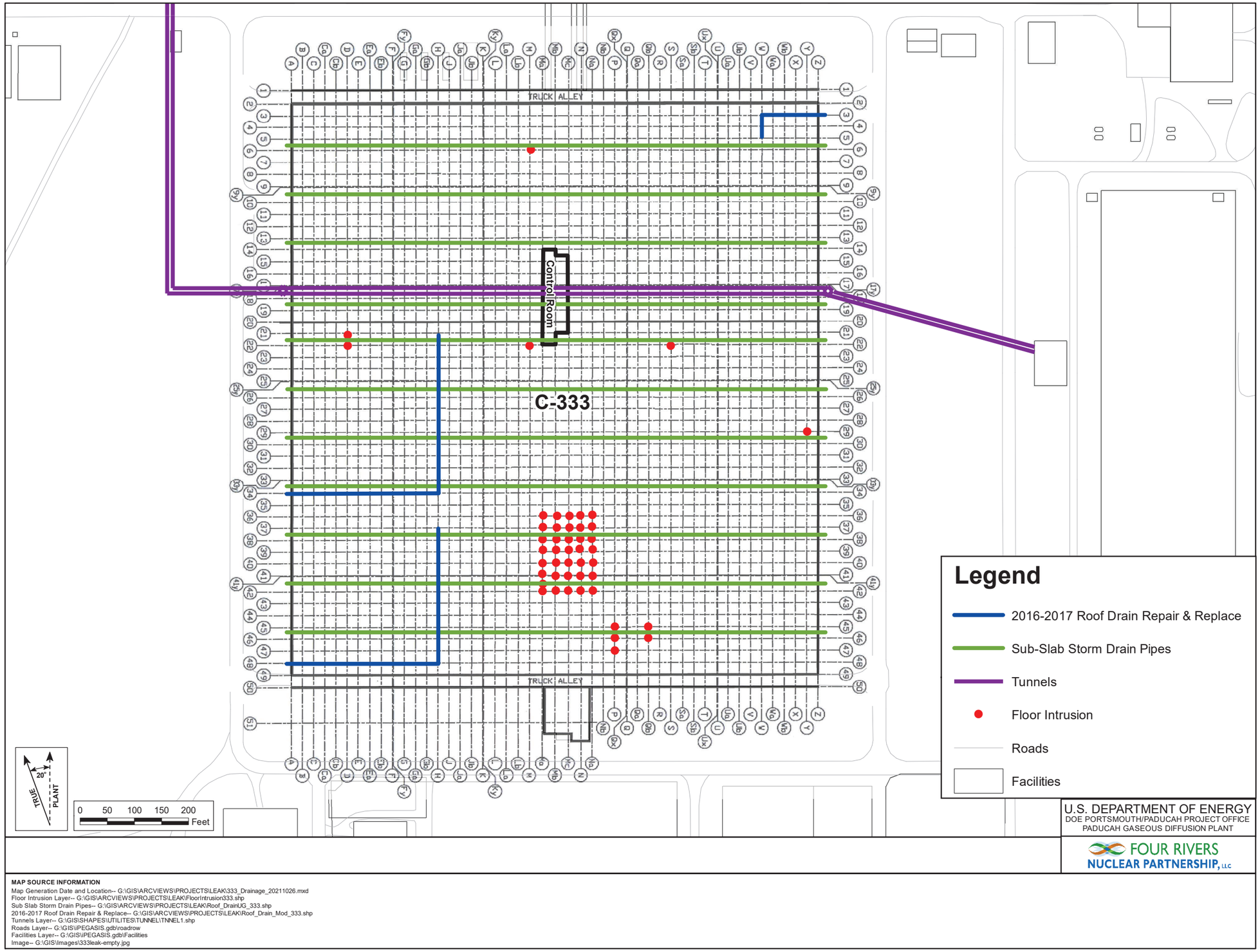


Figure 2. C-333 Process Building Water Intrusion

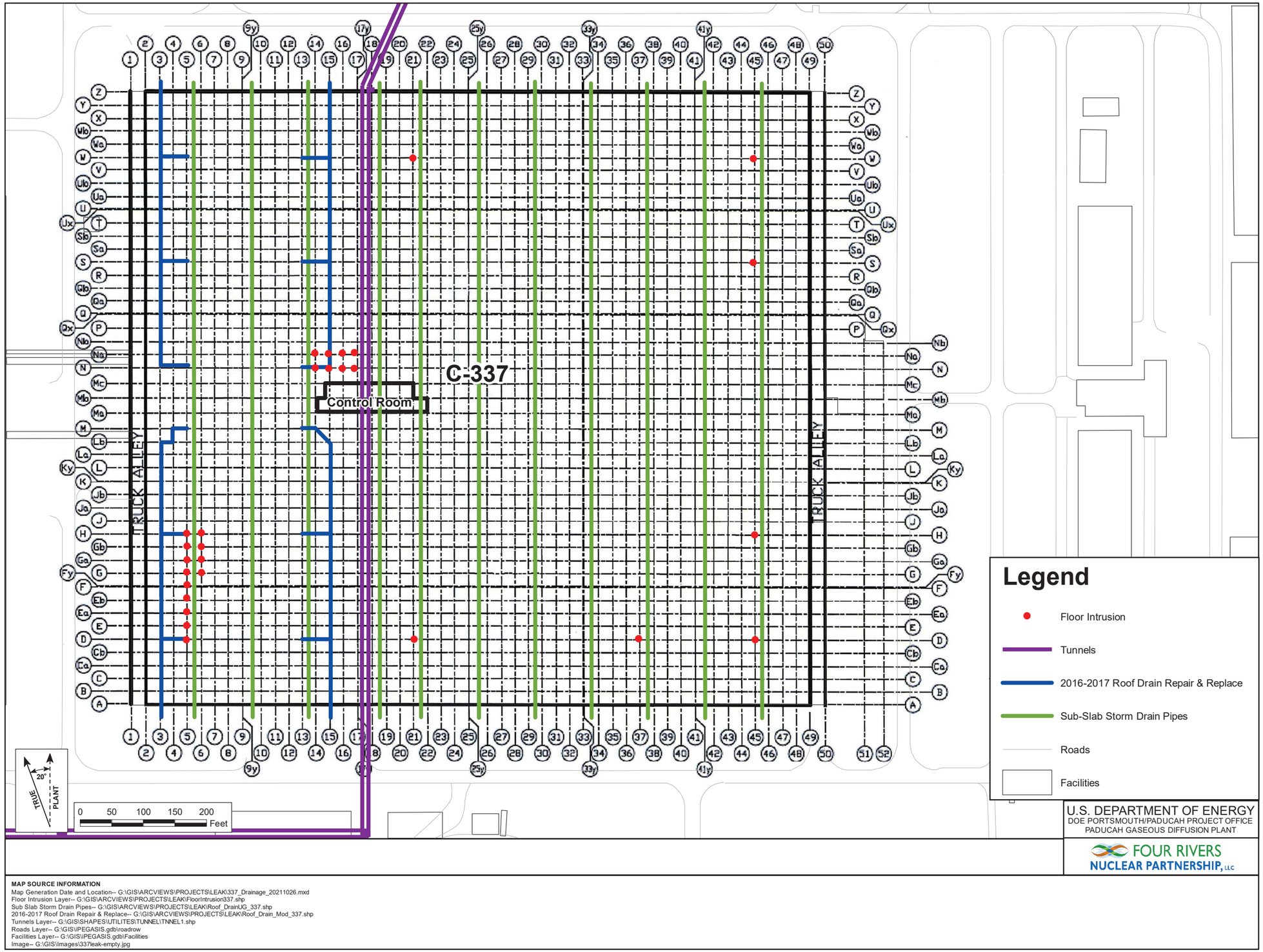


Figure 3. C-337 Process Building Water Intrusion

2.1 SUB-SLAB CONSTRUCTION

Construction drawings of PGDP provided precise measurements for sub-slab construction of the process buildings. All four foundations of the process buildings were similar; all were constructed on concrete footers (archive drawings F1-1-S, G1-1-S/G1-2-S, J1-1-S, and L1-1-S/L1-2-S; see Appendix). The footers extended a minimum of 4 ft below the floor slab (sometimes deeper), to meet bearing design criteria.

Excluding the exterior walls and truck alley, C-331 and C-335 each had approximately 900 underlying footers and C-333 and C-337 each had 2,100 underlying footers. The foundation designs typically required one foot of gravel fill around each of the footers, which increased the volume of the gravel sub-slab layer for each of the process buildings. Figure 4 provides a longitudinal section of C-333 as an example which illustrates the placement of the process building footers.

The foundation plans for each of the process buildings included notes on the design construction.[7] For C-331, the note read:

> A 12" compacted working surface consisting of a natural mixture of gravel, sand, & binder such as the Lafayette stratum existing on or near the site shall be provided under all slabs on ground....Backfill over footings to be approved fill material consisting of suitable material obtained during excavation or new material such as the Lafayette deposit. Compaction to be 95% of Proctor density.

The plans for C-333, C-335, and C-337 were similar to the C-331 plans, with the exception of requiring only a 9-inch thick compacted working surface.

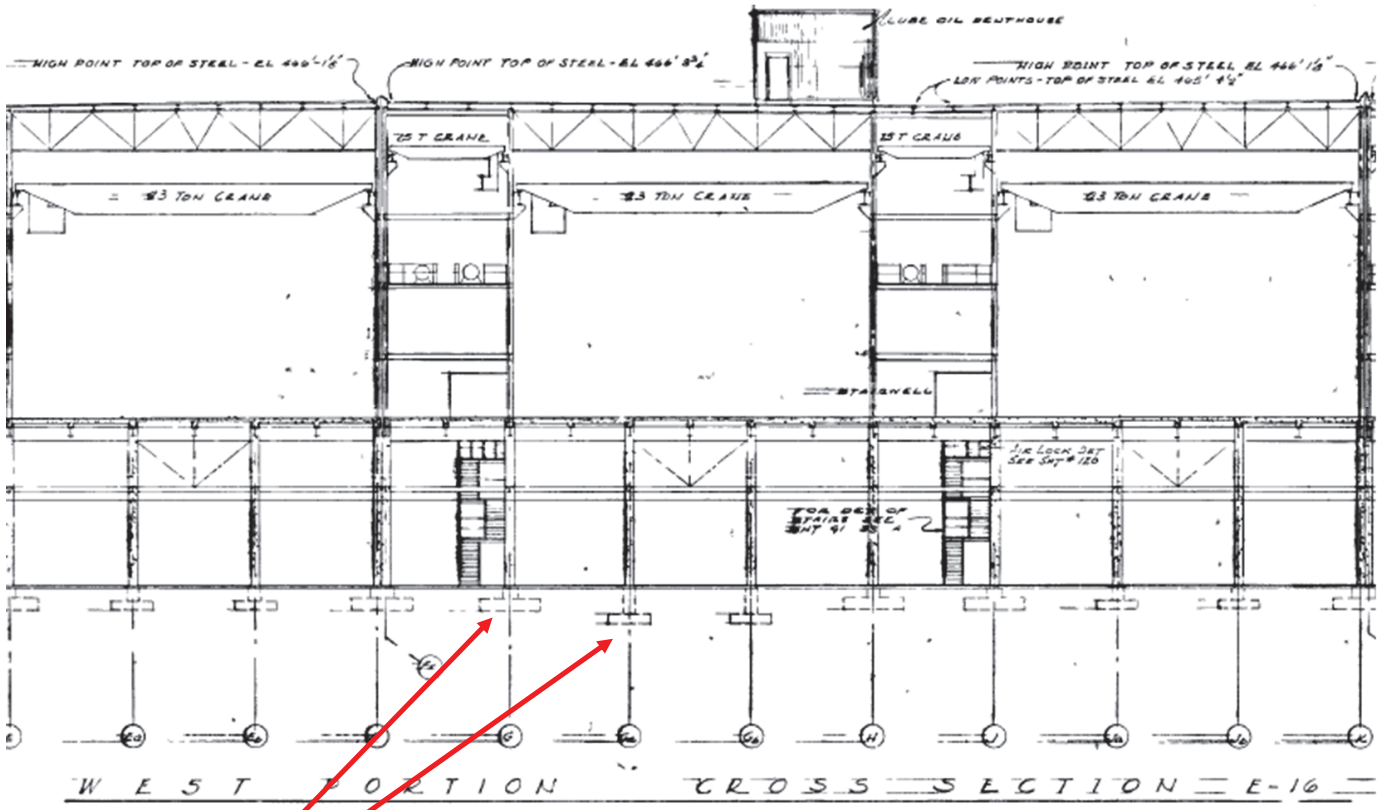
The ground floors for all four buildings were specified to be 6 inches thick. For C-335, the foundation plan required the area be graded and compacted to an elevation of 379.5 ft before any footing was constructed with the design ground floor elevation being 380.0 ft. For C-337, the "graded and compacted" elevation was 380.5 ft with the design ground floor elevation being 381.0 ft. The ground floors for C-331 and C-333 were similarly constructed with design ground floor elevations of 383.0 ft for C-331 and 384.0 ft for C-333.

Each of the process buildings had small control room basements (measuring approximately 110 ft by 50 ft). The basement floor was commonly 5- to 5¾-inches thick, and 10 ft 10 inches below the floor slab with no gravel sub-slab layer. The basements in C-331 and C-335 had 2-ft deep sumps encased in 6-inch thick concrete. The basements in C-333 and C-337 had 5-ft deep sumps encased in 10-inch thick concrete. These sumps were not attached to sub-slab drainage lines but were used as catch areas for water that accumulated in the basements.

2.2 HYDROGEOLOGY

As determined by numerous geologic investigations at the PGDP and summarized in the 2016 groundwater flow model revision (DOE 2017), the PGDP process buildings are underlain by upper continental deposits, which include, in order from top to bottom, the Peoria Loess, Roxana Silt, Loveland Silt, and the Metropolis Formation (KRCEE 2006). The north half of the C-333 Process Building and all of the C-331, C-335, and C-337 process buildings are underlain at depth by a sand and gravel unit of the lower continental deposits that is approximately 30-ft thick. Under the south half of C-333, the upper continental deposits overlie at

[7] In the drawing notes, "the Lafayette stratum" and "Lafayette deposit" are references to the geologic unit presently referred to as the Terrace Gravel.



Excerpt of 1/15/1952 Version of Drawing G1-16-A

Footers

See Appendix for complete Drawing G1-16-A

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Figure 4. Example Longitudinal Section through C-333 Process Building

depth Porters Creek Clay. Ultimately, groundwater flow is downward through the upper continental deposits to recharge the shallow aquifer system developed in the lower continental deposits, the RGA. The vertically downward groundwater flow system is known as the Upper Continental Recharge System (UCRS). Some lateral flow can occur locally in the UCRS where infrastructures, such as water and drain lines, are present.

As summarized in Figure 3.8 of the 2016 model revision, clay and silt are the dominant soil textures in the upper continental deposits (DOE 2017). Permeameter tests of clay units of the upper continental deposits have measured a vertical hydraulic conductivity range of 2.83×10^{-5} ft per day to 5.87×10^{-2} ft per day, with a geometric mean of 1.11×10^{-3} ft per day. The model-estimated ambient recharge rate for precipitation ranges from 3.63 inches per year to 4.29 inches per year. Where leaking water utilities overlie a thin clay zone in the UCRS, the model predicted up to 45 inches per year of recharge through the UCRS. Based on the thick gravel sub-slab layer of C-400,[8] the model assumed a similar gravel sub-slab layer for the process buildings. The model predicts 30 inches per year recharge may be realized under C-333 and C-337, which were known to have compromised roof drains.

3. APPROACH FOR SUBSEQUENT INVESTIGATION

The presence of a thin gravel sub-slab layer, instead of a thick gravel sub-slab layer beneath each of the process buildings is the basis for a significant revision to the CSM, with respect to anthropogenic recharge at PGDP. The gravel fill around the foundation footers of each of the buildings may be a potential reservoir for storage of leaks from the roof drain system and recharge to the groundwater system. A period of monitoring the trends of water saturation in the gravel fill around the footers to assess the annual rate of groundwater recharge beneath the process buildings would address this uncertainty. The proposed method to place vibrating wire piezometers equipped with data logger systems at the bottom of the gravel fill around building footers would acquire a near-continuous, automated record of the height of the water column around the building footers.

A piezometer investigation would require a small drill rig to install the vibrating wire piezometers (at locations that would be determined during building walkdowns) and further would require equipping each vibrating wire piezometer with a data logger assembly to provide near-continuous measuring of water levels. A field crew would make quarterly visits to inspect, maintain, and download the data loggers. A small drill rig would be required initially to install the vibrating wire piezometers and then to abandon the piezometers at the end of the investigation.

Factors that influence the selection of investigation locations include the following:

- Facility physical characteristics;
- Schedule of deactivation and remediation (D&R) activities; and
- Building walkdowns.

The process equipment, building columns, and metal building bracings constrain access to much of the building floors. Contamination by radioactivity and polychlorinated biphenyl (PCBs) limit accessible areas.

[8] PGDP's C-400 Cleaning Building was assumed to be constructed over a 5- to 8-ft thick gravel foundation based on observations during previous investigations at C-400.

Moreover, continuing building operations restrict potential areas for on-site investigation. The final locations for investigation activities will require the approval of the facility manager.

3.1 FACILITY PHYSICAL CHARACTERISTICS

The process building foundation features are key factors in the selection of on-site investigation locations. All of the process buildings are of similar construction with 6-inch thick concrete floor slabs overlying 9 to 12 inches of compacted gravel. The building columns that support the roof rest upon concrete footers that were designed to be a minimum of 4 ft deep. The gravel backfill around each column footer is a localized occurrence of increased gravel thickness. In general, the investigation would target the gravel fill around the building footers in the vicinity of the storm drain piping.

In addition to the location of the sub-slab storm drain piping, the locations of basements and other foundation penetrations are potential considerations for on-site investigation. No storm drain piping is present under the process building basements. Tunnel locations under the floor slabs are areas where no gravel sub-slab layer is present and are not suitable for investigation locations.

3.2 DEACTIVATION AND REMEDIATION

Key D&R projects for the process buildings include cascade system interior deposits removal and deactivation of the fire suppression systems. Table 2 provides the scheduled milestone dates for these activities (SST 2021). C-333 will be the first of the process buildings to have completed D&R. Open system work on the process gas equipment is currently underway; therefore, C-333 is not a candidate for investigation. The earliest activities in the other process buildings are sufficiently distal to not impact a near-term investigation.

Table 2. Process Buildings D&R Schedule

Process Building	Deposit Removal Completion and Fire System Deactivation
C-331	FY 2047
C-333	FY 2027
C-335	FY 2043
C-337	FY 2041

3.3 BUILDING WALKDOWNS

The C-335[9] and C-337 process buildings were selected to represent the smaller and larger process buildings for subsequent study because the buildings were adjacent, which will facilitate future field efforts and the buildings currently are not subject to D&R activities. Building walkdowns were performed on October 14, 2021, in both C-335 and C-337 to identify potential locations for the on-site investigation. The primary criteria for the investigation locations were as follows:

[9] A major roof replacement project for C-335 was completed in 1981. The project sloped the roof with drainage to the east and west outside walls, eliminating runoff flow to the interior roof drain system.

- The investigation areas should be located within the building aisle that overlies the sub-slab storm drain or in an adjacent aisle, with the vibrating wire piezometers located within a distance of 20 ft from the storm drain line;

- The investigation locations should not interfere with access to process equipment, utilities, or storage areas or rooms within the process buildings; and

- The investigation locations should not interfere with foot or vehicular traffic within the buildings.

Overhead electrical lines are common in the ground floors of the process buildings, presenting a potential contact hazard to tall equipment. The suitability of many of the identified potential investigation locations for vibrating wire piezometer construction (e.g., with a drill rig) is contingent upon the ability of plant utilities to isolate electricity to the overhead lines or to adequately insulate the lines.

The ground floors of both C-335 and C-337 are radioactive materials areas which require radiological worker training (or escort by a radiation-trained worker) and basic personal protective equipment (PPE), communications, and backup lighting for entry. Additional radiological zones, primarily radiological buffer areas and nuclear criticality areas, require further training and PPE for entry. Areas marked as radiological buffer areas and nuclear criticality areas were not considered for investigation locations.

Some floor areas have coatings to isolate PCB contamination resulting from previous leaks and spills. Drilling in these areas would contaminate the drilling equipment and the drilling crew and mobilize the contamination within the buildings. These areas were not considered for investigation locations.

The process buildings include some recessed floor areas for equipment and tanks. Indications of recent water accumulation were not evident in the recessed floor areas during the building walkdowns.

The walkdowns identified 16 potential investigation locations within C-335 and 63 potential investigation locations within C-337. The locations were adequately distributed to allow selection of representative sites for drilling through the floor and subsequent data collection. Three preliminary locations for the vibrating wire piezometers were identified in each of the two process buildings (See Figures 5, 6, 7, and 8). One of the selected locations in C-337 is a known site of leakage of the sub-slab storm drain lines and is marked by a sign that reads, “No vehicular traffic heavier than a golf cart/gator allowed in this area.” No other areas marked with similar signs were present. Each of the preliminary locations were reviewed and approved by a process building facility manager.

4. PIEZOMETER INVESTIGATION

This section presents the approach for the vibrating wire piezometer investigation, should it be implemented.

The diameter of commonly available vibrating wire piezometers (i.e., 0.5 to 1.4 inches) is a primary consideration in the method of construction. A minimum 2- to 3-inch diameter borehole will be required to install the vibrating wire piezometer.

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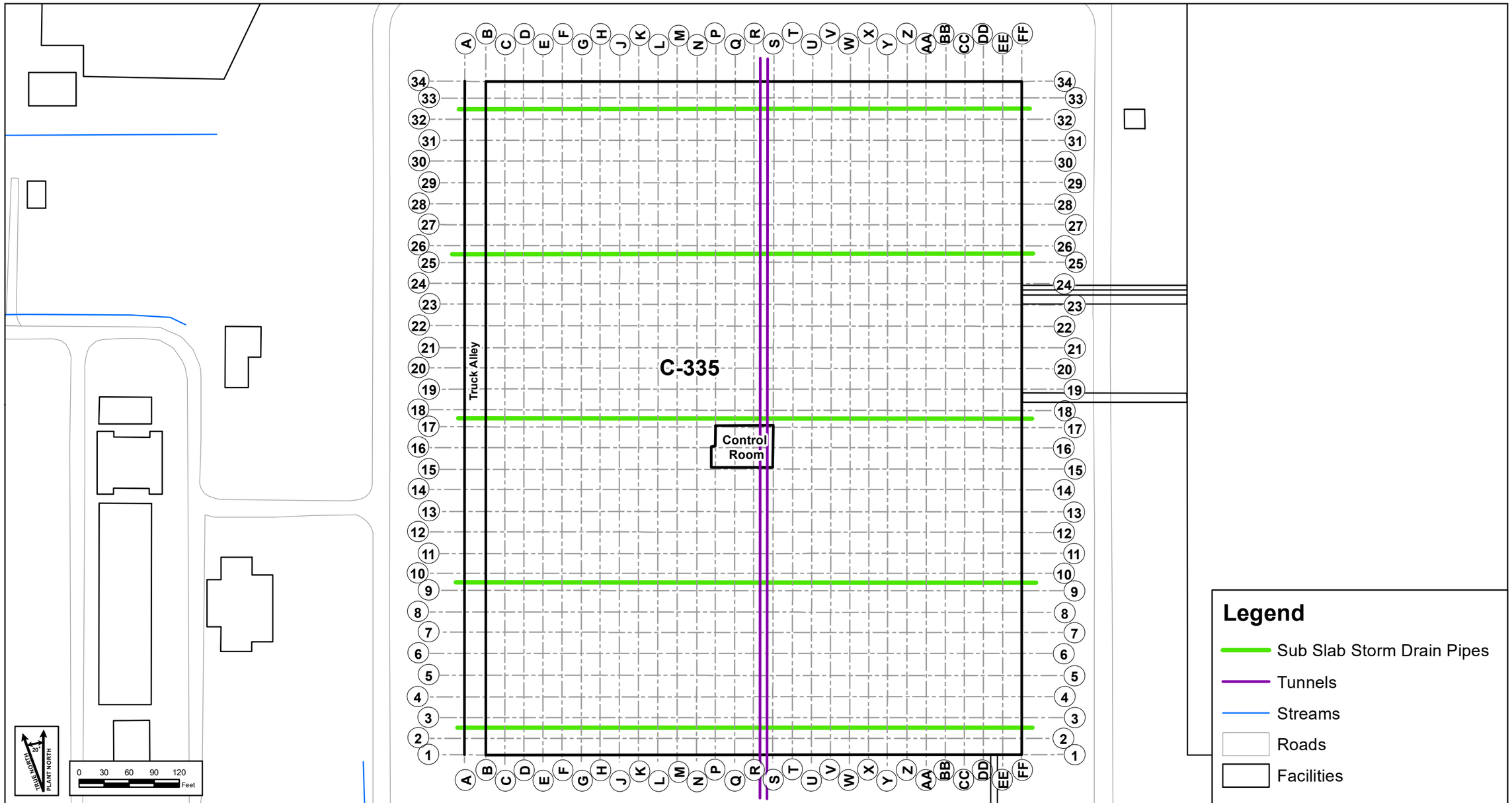

MAP SOURCE INFORMATION

Map Generation Date and Location: \\fedprojects-01\paducah$\Knoxville\GIS\mxd\335_Drainage_20211117.mxd
C-335 Grid: \\fedprojects-01\paducah$\Knoxville\GIS\shapefiles\C-335\C-335_Grid.shp (FRNP Location - G:\GIS\Raster\C-335_Grid.shp)
Sub Slab Storm Drain Pipes: \\fedprojects-01\paducah$\Knoxville\GIS\shapefiles\C-335\Sub_Slab_Storm_Drain_Pipes.shp (FRNP Location - G:\GIS\ARCVIEWS\PROJECTS\LEAK\Sub_Slab_Storm_Drain_Pipes.shp)
Tunnels: \\fedprojects-01\paducah$\Knoxville\GIS\shapefiles\C-335\C-335_Tunnels.shp (FRNP Location - G:\GIS\SHAPES\UTILITES\TUNNEL\TNNEL1.shp)
Streams, Roads, and Facilities from PEGASIS; downloaded 11/17/2021

Note: Map generated on behalf of FRNP by Geosyntec.

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Figure 5. Storm Drains Beneath C-335 Process Building

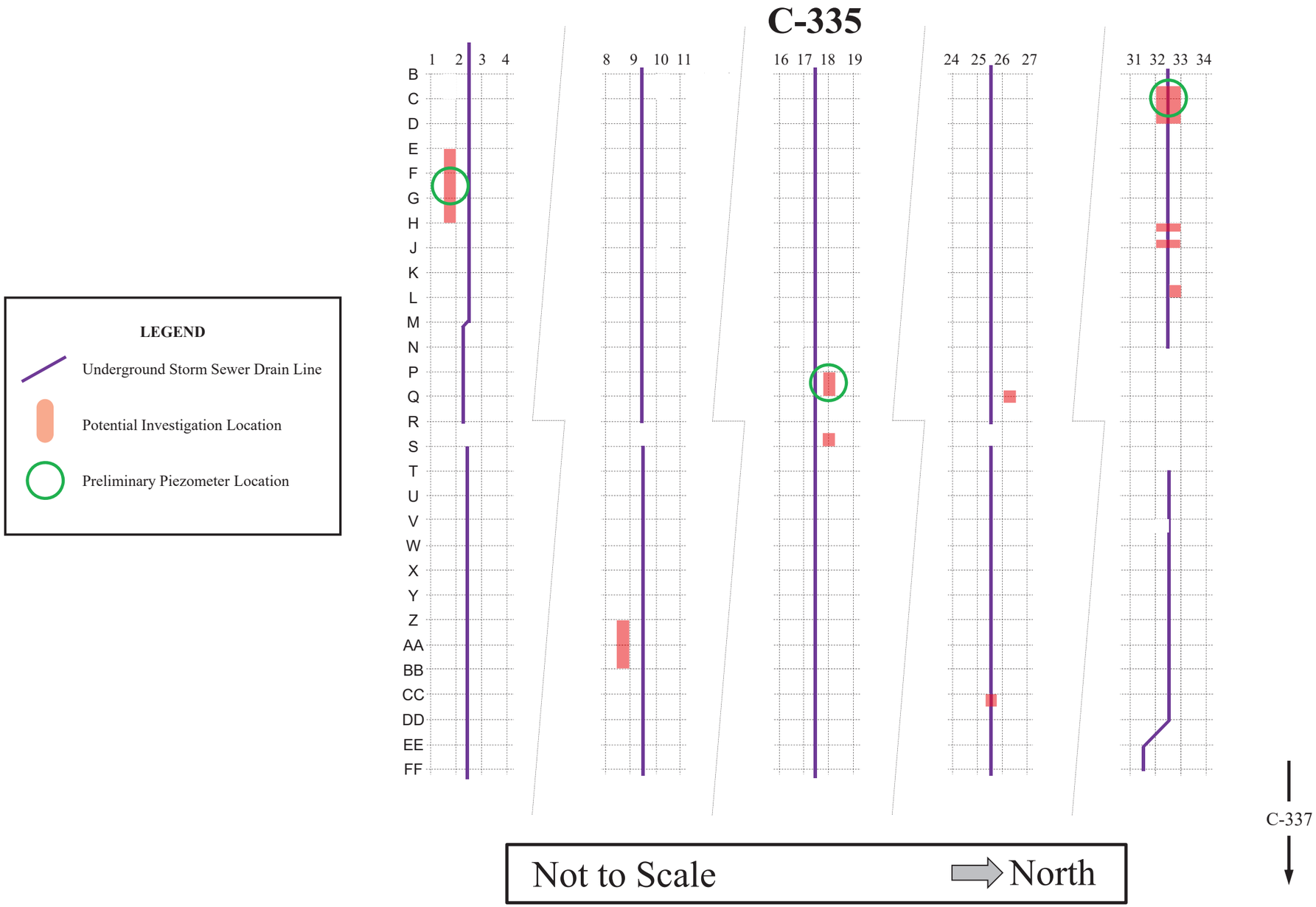

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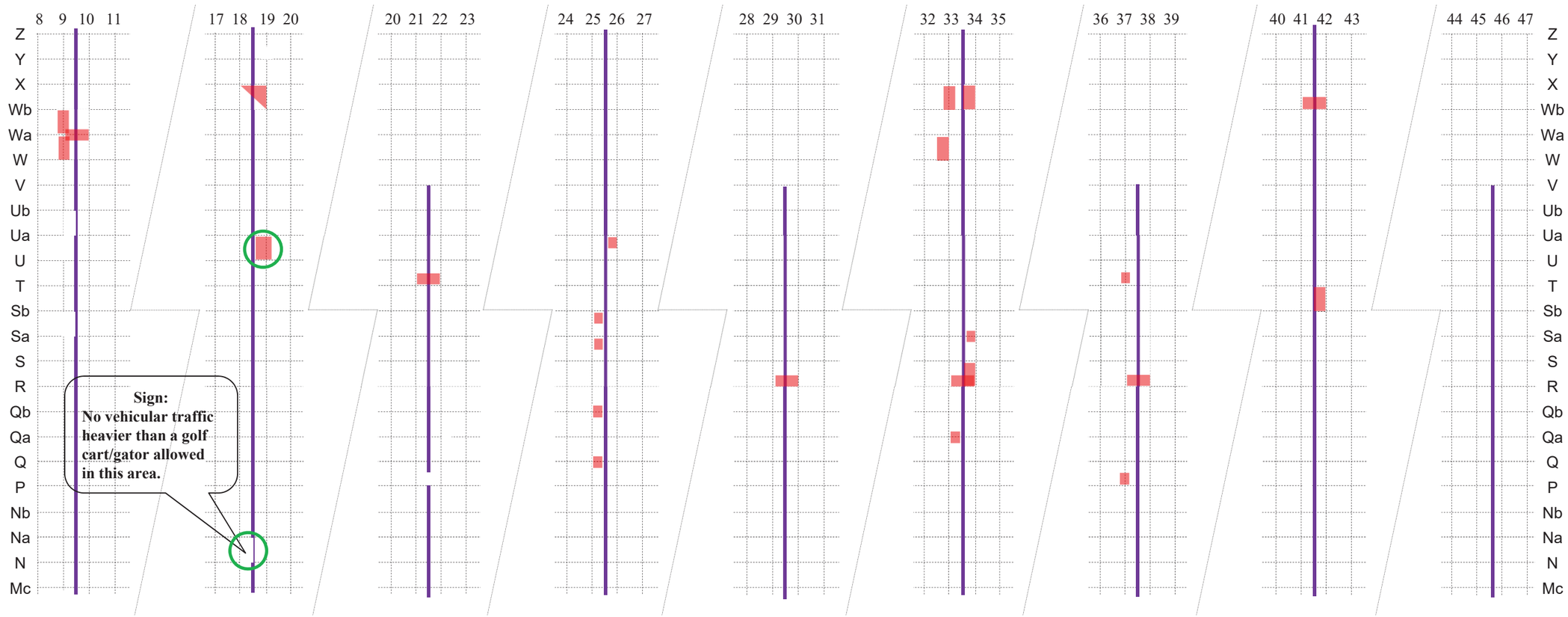
Figure 6. Location of Potential Investigation Areas inside C-335 Process Building

C-337 NORTH

Note: storm drain lines in aisles 5/6 and 13/14 were not part of walk down because previous roof drain repairs bypassed these storm drains.



← C-335 —

LEGEND

Underground Storm Sewer Drain Line

Potential Investigation Location

Preliminary Piezometer Location

Not to Scale

North

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Figure 7. Location of Potential Investigation Areas inside C-337 Process Building (North)

C-337 SOUTH

Note: storm drain lines in aisles 5/6 and 13/14 were not part of walk down because previous roof drain repairs bypassed these storm drains.

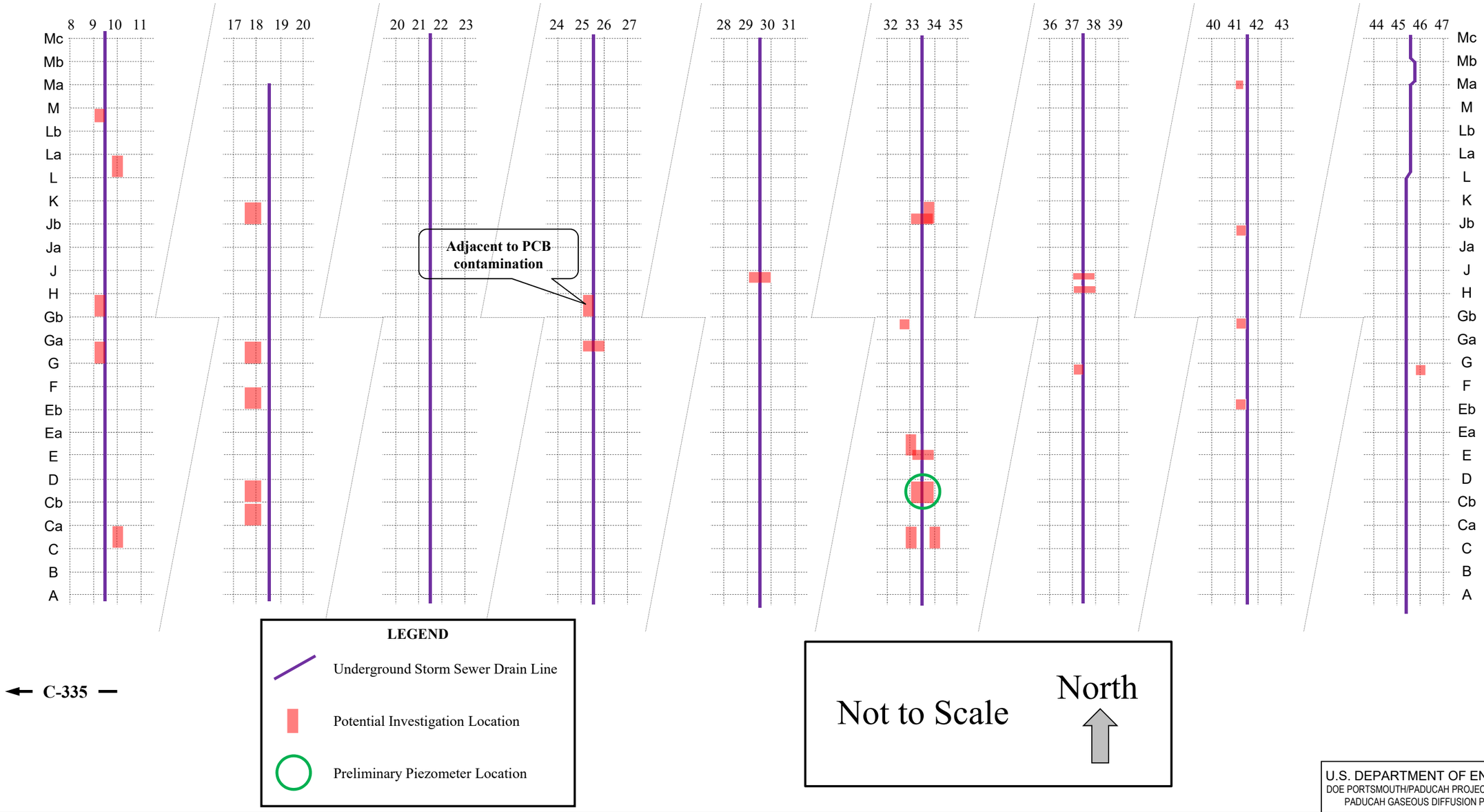

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Figure 8. Location of Potential Investigation Areas inside C-337 Process Building (South)

Other vibrating wire piezometer construction considerations include the following:

- Surface completion (i.e., floor cord protector for vibrating wire piezometer cable and protective housing for data logger—to be mounted to building column or structural element);
- Vibrating wire piezometer depth;
- Sand pack (sand gradation and height) around the vibrating wire piezometer; and
- Floor seal (to eliminate the possibility of infiltration of water from the floor into the sand pack).

4.1 PIEZOMETER CONSTRUCTION AND OPERATION

The vibrating wire piezometers require special design to meet the unique project requirements (i.e., near-continuous monitoring of an absent or thin water column) (see Figure 9) and to facilitate abandonment of the vibrating wire piezometers at the conclusion of the project period. The bottom of each of the vibrating wire piezometers will be set in a constructed, sand-filled pocket to protect the piezometer and provide hydraulic connection with the gravel fill. The following considerations and criteria apply.

- Vault surface completions offer advantages for traffic areas but are difficult to access and maintain where pressure transducers are deployed; therefore, the vibrating wire piezometers will be constructed with cable extending across the floor to the adjacent building column (or other structural element) where the data logger will be mounted in waterproof housing. A floor cord protector will be required to protect the vibrating wire piezometer cable from foot and vehicular traffic.
- The vibrating wire piezometers will be set in 2- to 3-inch diameter boreholes and drilled to the base of the gravel fill (a minimum depth of 4 ft below the floor slab). If the base of the gravel fill is not water saturated at the time of drilling, the borehole will be extended 0.5 ft below the base of the gravel to allow emplacement of the vibrating wire piezometer with the filter tip pointing upwards.
- If the base of the gravel fill is not water-saturated at the time of construction, the vibrating wire piezometer will be emplaced in a small, sand-filled canvas bag with its filter tip pointing upwards (to allow easy re-entry of water should the gravel saturate at a later time).
- Coarse to very coarse filter pack sand (e.g., 5-16 or 4-10 sieve size) will be placed around each of the vibrating wire piezometer sand bags (and buried cables) to facilitate hydraulic connection of the vibrating wire piezometer to the gravel fill while preventing collapse of the gravel fill into the piezometer borehole.

Each vibrating wire piezometer will be equipped with a data logger to document water level measurements on an hourly basis. Measurements will be made each hour to correspond with barometric pressure measurements taken by the National Weather Service at the Barkley Regional Airport, Paducah, Kentucky. Manual water level measurements will be documented at both set up and recovery of the vibrating wire piezometers.

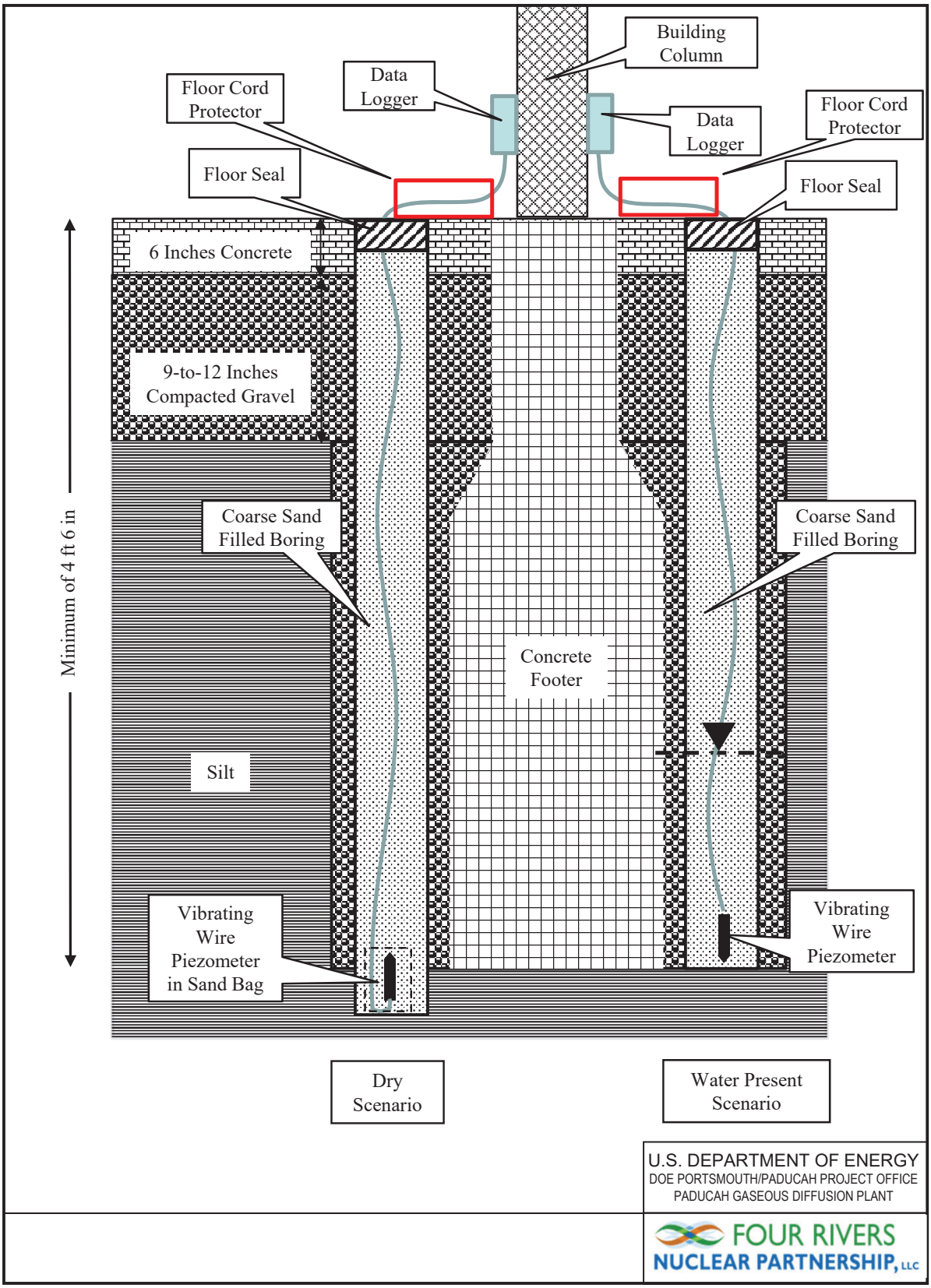

Figure 9. Vibrating Wire Piezometer Designs

4.2 DRILLING METHOD

Aisle widths and height clearances within the process buildings significantly limit the size of a drill rig that can be used for this project. Moreover, overhead electrical wiring restricts the working height of the drill rig mast. Direct push technology (e.g., Geoprobe Systems®) offers the unique advantage of accessibility in this application. The direct push method is able to use a small, tracked drill rig. If the 2- to 3-inch diameter borehole precludes the application of direct push technology to create the borehole, many of the same rigs are capable of operating small-diameter augers suitable for drilling the boreholes.

The primary activities associated with drilling for this project are drilling through the concrete floor slab, sub-slab gravel layer, and approximately 4 to 6 ft of underlying gravel; and drilling to install the vibrating wire piezometers. These activities would result in the generation of a limited amount of investigation-derived waste that must be managed for final disposition. The primary waste categories associated with the simple assessments of the presence of water would be concrete floor and borehole drill cuttings and used PPE. In addition, the eventual abandonment of the vibrating wire piezometers will generate some waste construction material (sand).

The primary concerns associated with these wastes would be radioactive contamination (i.e., low-level radioactive wastes) and PCBs [Toxic Substances Control Act waste, as amended (PCB bulk-product waste and/or PCB remediation waste)]. All waste generated would be managed according to CP2-WM-0001, *Four Rivers Nuclear Partnership, LLC, Paducah Deactivation and Remediation Project Waste Management Plan*.

5. PRELIMINARY DATA QUALITY OBJECTIVES

The vibrating wire piezometer investigation requires quality measurements of rainfall amounts, depth to water, and barometric pressure that can be optimized with data quality objectives (DQOs).

The DQO process is a planning tool, based on the scientific method, that identifies an environmental problem and defines the data collection process needed to support decisions regarding that problem [EPA QA/G-4, *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA 2006)]. The steps outlined in the DQO process have been used to develop the scope of the process buildings vibrating wire piezometer study. These steps formulate a set of criteria that will achieve the desired control of uncertainty, which will allow conclusions to be made with acceptable confidence.

The first step in the DQO process is to identify the problem to be resolved. The following is the overall problem statement developed for this study.

> Roof drain systems of some of the Paducah Site process buildings are known to have leaked, and may continue to leak, into the gravel sub-slab layer and may be acting as points of infiltration where foundation drainage systems are not present, not functioning as designed, or do not have sufficient capacity for drainage.

The following summarizes the application of the ensuing six steps of the DQO process in bullet format.

- IDENTIFY THE DECISION: Characterize the long-term variation of saturation within the gravel fill beneath the floors of the process buildings relative to precipitation events and the rate of infiltration if water-filled porosity is present.

- IDENTIFY THE INPUTS:

  — Precipitation and barometric measurements for the area of PGDP.
  — Vibrating wire piezometers with continuous water level record.
  — Manual set-up and abandonment water level measurements.

- DEFINE THE BOUNDARIES:

  — Process buildings C-331, C-333, C-335, and C-337.
  — Duration of measurements: one year.

- DEVELOP A DECISION RULE: **IF** water level measurements demonstrate temporally variable saturation of the sub-slab gravel fill of the process buildings, **THEN** determine how saturation variation relates to precipitation events.

- SPECIFY TOLERABLE LIMITS ON DECISION ERRORS:

  — ±0.05 inches (0.004 ft) precipitation (i.e., extrapolation of 0.01 inch accuracy at measurement point, Barkley Regional Airport to PGDP);

  — ±0.01 inches (i.e., mercury) barometric pressure (measurement at Barkley Regional Airport);

  — ±0.03 ft manual water level measurement (i.e., combination of accuracy of instrument and precision of measurement); and

  — ±0.07 inches (0.006 ft) water level measurement from vibrating wire piezometer (resolution of low-pressure vibrating wire piezometer).

- OPTIMIZE THE DESIGN: Locate the vibrating wire piezometers next to building foundation footers in proximity to roof drain piping systems. Place the vibrating wire piezometers at the base of the gravel fill. Abandon the vibrating wire piezometers after the completion of measurements. The results from this investigation will be considered representative of conditions under the four large process buildings.

6. CONCLUSIONS AND RECOMMENDATIONS

This white paper outlines an investigation approach to address uncertainty in the amount of groundwater infiltration related to leaks of the process building roof drain systems. Data assessment and reporting will be constrained primarily by the number of investigation locations within the process buildings and the occurrence of water in the gravel layer. Should a field study proceed to assess infiltration beneath the process buildings, the project data will provide input to the next update of the site groundwater flow model and to future groundwater actions at PGDP.

7. REFERENCES

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APPENDIX

ARCHIVE PLANT DRAWINGS (CD)

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APPENDIX

ARCHIVE PLANT DRAWINGS (CD)

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