Department of Energy

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February 28, 2025

Ms. April Webb
Interim Federal Facility Agreement Manager
Division of Waste Management
Kentucky Department for Environmental Protection
300 Sower Boulevard, 2nd Floor
Frankfort, Kentucky 40601

PPPO-02-10031265-25

Mr. Brian Begley
Federal Facility Agreement Manager
U.S. Environmental Protection Agency, Region 4
61 Forsyth Street
Atlanta, Georgia 30303

Dear Ms. Webb and Mr. Begley:

TRANSMITTAL OF THE COMPILATION OF MEETING SUMMARIES AND WHITE PAPERS (FISCAL YEAR 2024), DOE/LX/07-2516&D1

Please find enclosed the *Compilation of Meeting Summaries and White Papers (Fiscal Year 2024)*, DOE/LX/07-2516&D1, for your reference. This compilation is a product of the Paducah Site's Groundwater Modeling Working Group, which is composed of members from the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency, the Kentucky Division of Waste Management, and the Kentucky Research Consortium for Energy and the Environment.

This document is not defined as a primary or a secondary document by the Federal Facility Agreement. Comments received from the Groundwater Modeling Working Group on the meeting summaries have been incorporated into this compilation.

DOE requests acknowledgement of receipt of the subject document no later than March 21, 2025. If you have any questions or require additional information, please contact me at (270) 217-2029.

Sincerely,

APRIL LADD

Digitally signed by APRIL LADD
Date: 2025.02.28 10:05:10 -06'00'

April Ladd
Federal Facility Agreement Manager
Portsmouth/Paducah Project Office

Enclosure:
Compilation of Meeting Summaries and White Papers (Fiscal Year 2024),
DOE/LX/07-2516&D1

Administrative Record File—General Reference Compendium

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DOE/LX/07-2516&D1
Primary Document

Compilation of Meeting Summaries and White Papers (Fiscal Year 2024)

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

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DOE/LX/07-2516&D1

Compilation of Meeting Summaries and White Papers (Fiscal Year 2024)

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

Date Issued—February 2025

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

FY	fiscal year
KRCEE	Kentucky Research Consortium for Energy and the Environment
KY	Commonwealth of Kentucky
MWG	Modeling Working Group
PGDP	Paducah Gaseous Diffusion Plant
RGA	Regional Gravel Aquifer
TVA	Tennessee Valley Authority
UCRS	Upper Continental Recharge System

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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) that were completed during fiscal year (FY) 2024. Activities for the MWG from September 2017 through July 2022 are documented in prior FY compilations of meeting summaries (DOE/LX/07-2437&D1, DOE/LX/07-2451&D1, DOE/LX/07-2475&D1, DOE/LX/07-2485&D1, and DOE/LX/07-2499&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 2024 meetings. The following meeting summaries are included in the appendices.

- October 4, 2023, Meeting Summary (Appendix A)
    - Attachment 1: Groundwater Strategy Potentiometric Map, May 2023, and Groundwater Elevation Data for Tennessee Valley Authority (TVA) Wells, May 2023
    - Attachment 2: Precipitation and Ohio River Stage Data (January–September 2023)
- January 10, 2024, Meeting Summary (Appendix B)
    - Attachment 1: Groundwater Strategy Potentiometric Map, August 2023, and Groundwater Elevation Data for TVA Wells, August 2023
    - Attachment 2: Metropolis Lake Maps
    - Attachment 3: Surface Water and Sediment Samples from Lower Reach of Little Bayou Creek
    - Attachment 4: Precipitation and Ohio River Stage Data (January–December 2023)
- April 3, 2024, Meeting Summary (Appendix C)
    - Attachment 1: Groundwater Strategy Potentiometric Map, November 2023, and Groundwater Elevation Data for TVA Wells, November 2023
    - Attachment 2: 2023 Sitewide Groundwater Model Update
    - Attachment 3: Precipitation and Ohio River Stage Data (January–March 2024)
- July 17, 2024, Meeting Summary (Appendix D)
    - Attachment 1: Groundwater Strategy Potentiometric Map, February 2024, and Groundwater Elevation Data for TVA Wells, February 2024
    - Attachment 2: Kentucky Research Consortium for Energy and the Environment (KRCEE) Presentation
    - Attachment 3: Precipitation and Ohio River Stage Data (January–June 2024)

Organizations that participate in the MWG are the U.S. Department of Energy, the U.S. Environmental Protection Agency Region 4, the Commonwealth of Kentucky (KY) Energy and Environment Cabinet, the KY Radiation Health Branch, KRCEE, and TVA.

Throughout FY 2024, 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.

- November 2023
- February 2024
- May 2024
- August 2024

During FY 2024, the Paducah Site Groundwater MWG participated in the development of three white papers by reviewing and providing input to those papers. These white papers are pending finalization and are planned to be included in the FY 2025 update to this document:

- *Regional and Localized Groundwater Flow and Trichloroethene Trends, East Side of Downgradient Northeast Plume, Paducah, Kentucky*, FRNP-RPT-0316 (Groundwater Strategy White Paper #2).

- *Regional and Localized Groundwater Flow and Trichloroethene Trends, West Side of the Southwest Plume, Paducah, Kentucky*, FRNP-RPT-0320 (Groundwater Strategy White Paper #1).

- *North Extent of Trichloroethene Plumes (Impact to Ohio River) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, FRNP-RPT-0321 (Groundwater Strategy White Paper #3).

Two additional white papers were in development in FY 2024 and are planned to be reviewed by the Paducah Site Groundwater MWG in FY 2025:

- *Trichloroethene Extent and Trends in West Side of Downgradient Northeast Plume, Paducah, Kentucky*, FRNP-RPT-0354 (Groundwater Strategy White Paper #7).

- *Trichloroethene Extent and Trends in East Side of Downgradient Northwest Plume, Paducah, Kentucky,* FRNP-RPT-0355 (Groundwater Strategy White Paper #8).

APPENDIX A

PADUCAH SITE GROUNDWATER MODELING WORKING GROUP MEETING SUMMARY—OCTOBER 4, 2023

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ACRONYMS[1]

ACO	administrative consent order
AIP	agreement in principle
amsl	above mean sea level
ASER	annual site environmental report
BGOU	burial grounds operable unit
CA	cost analysis
CAS	chemical abstracts service
CB	colloidal borescope
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	contaminant of concern
COPC	chemical or radionuclide of potential concern
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
EE	engineering evaluation
EECA	engineering evaluation/cost analysis
EMP	environmental monitoring plan
EPA	U.S. Environmental Protection Agency
ERH	electrical resistance heating
ESD	explanation of significant differences
EW	extraction well
FRNP	Four Rivers Nuclear Partnership, LLC
FS	feasibility study
FY	fiscal year
GW	groundwater
GWOU	groundwater operable unit
HU	hydrogeological unit
IRA	interim response action
KDEP	Kentucky Department for Environmental Protection
KRCEE	Kentucky Research Consortium for Energy and the Environment
KY	Commonwealth of Kentucky
LASAGNA	Lasagna™ in-situ Remediation Technology
LBCSP	Little Bayou Creek seep
LRGA	lower Regional Gravel Aquifer
MOA	memorandum of agreement
MRGA	middle Regional Gravel Aquifer
MW	monitoring well
MWG	Modeling Working Group
NEPCS	northeast plume containment system
NGVD	National Geodetic Vertical Datum
NWPGS	northwest plume groundwater system
O&M	operations and maintenance
OREIS	Oak Ridge Environmental Information System

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

OU	operable unit
PEGASIS	PPPO Environmental Geographic Analytical Spatial Information System
PEMS	Project Environmental Measurements System
PGDP	Paducah Gaseous Diffusion Plant
PT	pressure transducer
P&T	pump and treat
PTZ	permeable treatment zone
PZ	piezometer
Q	quarter
QAPP	quality assurance project plan
RACR	remedial action completion report
RAO	remedial action objective
RGA	Regional Gravel Aquifer
RI	remedial investigation
ROD	Record of Decision
SOU	soils operable unit
SWMU	solid waste management unit
SWOU	surface water operable unit
TOC	top of casing
TS	treatability study
TVA	Tennessee Valley Authority
UCRS	upper continental recharge system
URGA	Upper Regional Gravel Aquifer
VI	vapor intrusion
VOC	volatile organic compound
WAG	waste area grouping
WDA	waste disposal alternative
WKWMA	West Kentucky Wildlife Management Area

Paducah Site Groundwater Modeling Working Group
Meeting Summary—October 4, 2023

MWG Attendees:

DOE
Rich Bonczek ✓
Brian Looney (SRNL)

ETAS
Martin Clauberg ✓
Bruce Stearns
Tracy Taylor ✓

KRCEE
Steve Hampson ✓
Alan Fryer ✓

TVA
Matthew Alpin
Tabitha Ester ✓
Anna Fisher
Jeffrey Frazier (WSP) ✓
Eric Wallis ✓

EPA and Contractors
Noman Ahsanuzzaman ✓
Ben Bentkowski ✓
Eva Davis ✓
Jonathan Dziekan
Bei Huang ✓
Mac McRae ✓
Victor Weeks ✓

Kentucky
Stephanie Brock
Mary Evans ✓
Nathan Garner
Will Grasch ✓
Brian Lainhart
Todd Mullins ✓
Bart Schaffer ✓
April Webb ✓

FRNP
Evan Clark
Bryan Clayton
Sarah Cronk ✓
Ken Davis ✓
Rob Flynn
Bruce Ford
Stefanie Fountain ✓
Josue Gallegos
LeAnne Garner
Jeffrey King
Bruce Meadows
Todd Powers ✓
Corey Wallace
Dawit Yifru ✓
Emilye Garner ✓

✓ 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. Additions or revisions to the agenda items are noted in [].

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

No comments were received to the 7/19/2023 Meeting Summary (sent to participants on 9/18/2023). This summary will be considered final.

A request to confirm meeting participants was sent on 9/20/2023 and each group has provided an updated listing of attendees for the start of Fiscal Year (FY) 2024.

No comments were received to the July 19, 2023 Meeting Summary. The meeting summary for July 19, 2023 Meeting is now final.

2. FY 2023 Work Plan/Schedule

Activity	Date
~~Provide Draft Agenda Including FY 2023 Work Plan/Schedule (October/FY23Q1) to MWG~~	~~9/28/2022~~
~~Quarterly Meeting (October/FY23Q1)~~	~~10/5/2022~~

Activity	Date
~~Submit Final Lithologic Technical Paper to EPA and KY~~	~~10/7/2022~~
~~Provide Olmsted Dam White Paper to MWG for Review~~	~~10/19/2022~~
~~Submit Draft MWG Compilation (FY 2022) to MWG~~	~~1/5/2023 Actual 12/21/2022~~
~~Submit "Assessment of Northwest Plume Capture at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky" (Capture White Paper) to MWG for Review~~	~~1/10/2023~~
~~Submit Final Lithologic Technical Paper to EPA and KY~~	~~1/13/2023~~
~~Submit Revised FY 2023 Work Plan (included in this summary)~~	~~1/18/2023 Actual 2/13/2023~~
~~Quarterly Meeting (January/FY23Q2)~~	~~1/18/2023~~
~~MWG Provide Comments on Capture White Paper~~	~~1/27/2023 (schedule tied to FYR)~~
~~MWG Provide Comments on Olmsted Dam White Paper~~	~~2/1/2023 Actual 2/2/2023~~
~~MWG Concurs with FY 2023 Work Plan~~	~~2/1/2023~~
~~MWG Provide Comments on Draft MWG Compilation (FY 2022)~~	~~1/27/2023 Actual 2/3/2023~~
~~Submit Draft TCE Degradation Rate White Paper to MWG~~	~~2/16/2023 (Planning Date) Actual 3/1/2023~~
~~Submit Final MWG Compilation (FY 2022)~~	~~3/2/2023 Actual 2/13/2023~~
~~MWG Provide Comments on Draft TCE Degradation Rate White Paper~~	~~4/7/2023 (Previously 3/23/2023)~~
~~Quarterly Meeting (April/FY23Q3)~~	~~4/5/2023~~
~~Quarterly Meeting (July/FY23Q4)~~	~~7/19/2023 (Previously 7/12/2023)~~
~~Provide Draft Agenda Including FY 2024 Work Plan/Schedule (October/FY24Q1) to MWG~~	~~9/27/2023~~

The group did not have questions or comments on the schedule.

3. Draft FY 2024 Work Plan/Schedule

Activity	Date
Quarterly Meeting (October/FY 2024Q1)	10/4/2023
MWG Concurs with FY 2024 Work Plan	11/3/2023
Quarterly Meeting (January/FY 2024Q2)	1/10/2024
Submit Draft MWG Compilation (FY 2023) to MWG	1/12/2024
MWG Provide Comments on Draft MWG Compilation (FY 2023)	2/11/2024
Submit Final MWG Compilation (FY 2023)	3/10/2024
Quarterly Meeting (April/FY 2024Q3)	4/3/2024
Quarterly Meeting (July/FY 2024Q4)	7/17/2024

Note: White Papers will be added to schedule once the FY2024 Groundwater Strategy Project (GWSP) Project Management Plan (PMP) is finalized.

The group did not have questions on the schedule. FRNP requested the MWG concur on this portion of the FY 2024 Work Plan by 11/3/2023. EPA and KY each provided email concurrence of the schedule during the meeting.

4. Draft FY 2024+ Work Plan/Schedule

Activity	Date
Provide Draft Agenda Including FY 2025 Work Plan/Schedule (October/FY 2025Q1) to MWG	10/2/2024
Quarterly Meeting (October/FY 2025Q1)	10/9/2024 (Planning date)

The group did not have questions or comments on the schedule.

5. Update on Water Levels

Synoptic water level events are being collected quarterly. The potentiometric map for the synoptic water level event for May 22-26, 2023 is included in Attachment 1. May 2023 groundwater elevation data for TVA wells collected by KY are also included in Attachment 1. Potentiometric maps will be included in the annual MWG compendia.

V. Weeks (EPA) noted the effectiveness of the pumping systems as a contour north of the site is being pulled to the east.

K. Davis (FRNP) noted a cone of depression on the north end of TVA that may be a result of an issue with the survey reference for D30 in the files used to generate the potentiometric maps. ***T. Ester (TVA) will provide the survey reference information.***

N. Ahsanuzzaman (EPA) asked about the impact of TVA water features on groundwater flow. TVA noted that these water features are lined and do not contribute to groundwater flow. The group discussed the location of Metropolis Lake (north of the Paducah Site and east of TVA) and the modeling assumptions associated with the lake. K. Davis described the lake as a "window" into the RGA. N. Ahsanuzzaman noted that the potentiometric map indicates flow to the lake but not to the Ohio River, which does not match the modeled flow in this area and also noted that the river is a larger sink/recipient of water than the lake. N. Ahsanuzzaman also noted that the potentiometric maps are helpful; R. Bonczek (DOE) reminded the group that the quarterly potentiometric maps are included with the agenda for each meeting and that they are published annually in the MWG compilation document. ***S. Fountain (FRNP) will confirm the modeling assumptions used for Metropolis Lake and will provide the recent potentiometric maps to the MWG.***

The May 2023 potentiometric map included in Attachment 1 has been updated from the version provided with the meeting agenda to reflect the correct monitoring well survey information for the TVA well D30.

6. Update on Paducah Site Groundwater Strategy

The GWSP is a multi-year plan with multiple activities planned. The specific timing and scope of each activity are developed by DOE based on data collected in the prior year(s).

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

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

The FY 2024 GWSP PMP is in development and multiple white papers are planned for FY 2024. Once the GWSP PMP is finalized, a listing of planned white papers will be provided to the MWG. Several of these white papers will support EI discussions related to "Human Exposure Under Control."

The final FY 2024 GWSP PMP is with DOE for approval and is anticipated be available in a few weeks.

EPA is internally coordinating change of the "human exposure under control" performance measure from "insufficient data" to "yes" with consideration of the vapor intrusion studies that have been done at the site. Changing the "groundwater under control" performance measure from "no" to "yes" may be supported by the 2022 plume map update and other supporting analysis recently presented during the Groundwater Modeling Working Group meetings.

FRNP will be providing a revised EI determination following KY format in FY2024. Schedule for this as well as forthcoming GWSP White Papers, will be provided.

Performance Measure	Status at this Superfund Site	What does this mean?
Human Exposure Under Control	Insufficient Data	**Yes** means assessments indicate that across the entire site: 1. There are currently no unacceptable human exposure pathways; and 2. EPA has determined the site is under control for human exposure. **No** means an unsafe level of contamination has been detected at the site and a reasonable expectation exists that people could be exposed. **Insufficient data** means that, due to uncertainty regarding exposures, one cannot draw conclusions as to whether human exposures are controlled, typically because: 1. Response to the contamination has not begun; or 2. The response has begun, but it has not yet generated information sufficiently reliable to evaluate whether there are currently any unacceptable human exposure pathways at the site.
Groundwater Migration Under Control	No	**Yes** means EPA reviewed all information on known and reasonably expected groundwater contamination. EPA concluded the migration of contaminated groundwater is stabilized and there is no unacceptable discharge to surface water. EPA will conduct monitoring to confirm that affected groundwater remains in the original area of contamination. **No** means EPA has reviewed all information on known and reasonably expected groundwater contamination, and the migration of contaminated groundwater is not stabilized. **Insufficient data** means that due to uncertainty regarding contaminated groundwater migration, EPA cannot draw conclusions as to whether the migration of contaminated groundwater is stabilized.

From:
https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.Healthenv&id=0404794#Perform,
accessed 9/20/2023.

EPA believes there will be agreement internally in FY2024 to update the Performance Measure of Human Exposure Under Control as "Insufficient Data" to "Yes."

EPA noted they likely will be able to update the Performance Measure of Groundwater Migration Under Control from "No" to "Yes" for TCE and Tc-99.

EPA noted that emerging contaminants will need to be factored in to the EI determination. DOE requested guidance on their inclusion and noted that a new emerging contaminant had been published earlier in the week.

Water Line Leaks. FRNP and KY continue to develop information related to the leak in the main raw water line from the Ohio River to the site. The location of the water line leak along Water Line Road about a mile from the creek crossing. Repairs to the line and backfilling of the holes are in progress.

FRNP noted the leak has been repaired and backfilling is in progress.

Seeps. There have been no seep results above the maximum concentration limit (MCL) for trichloroethene (TCE) for many years. LBCSP5 routinely has flow and is able to be sampled, whereas many of the other previously identified seeps do not have flow consistently.

A new five-year grant to support the Hydrolithostratigraphic Database Project is pending and KRCEE continues to work on refinements to the database through current grant extensions. The most recent Database, R12 (September 2023), is posted on the KRCEE website for download. R12 rendered surfaces are also posted as .pdf and .jpg files for download or online review at: https://ukrcee.org/projects/geological-science-and-engineering (Note: Page down on link to 'R12 KRCEE PGDP Hydrolithostratigraphic Database' heading. Dbase is download only. Suggest download of .jpg surface files to view in Microsoft Photos which provides easy mouse navigation and zoom capabilities) ***KRCEE requested that the group review the R12 database and rendered surfaces and provide comments***.

The group discussed TCE surface water sampling data from Little Bayou Creek near the seeps or downstream of the seeps. K. Davis noted there is data from downstream and from a sediment location further upstream of LBCSP5. Prior to 2010, surface water was sampled for metals and organics and after 2010, surface water sampling has focused on PCBs and TCE. ***FRNP will provide this information to the group at the next quarterly meeting.***

KRCEE has a task (proposals were submitted in September) 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. KRCEE is reviewing associated equipment capabilities for seeps identification, including hand held meters and fiber optic. Physical access and determining temperature gauging/gradients are also being evaluated. KRCEE had relayed during the previous meeting that there are concerns with flying the drone below the tree canopy and that a test flight was scheduled for September.

S. Hampson (KRCEE) shared that a drone test was conducted in early August but the infrared (IR) did not transmit during air flight. The unit was sent back to the vendor. S. Hampson discussed that KRCEE had performed another proof-of-concept test flight last Tuesday (September 26, 2023) at Hay Spring (an open karst spring) and that IR info will be available from that test run. The next test area (planned to be tested in the next 30 days) is at Terrapin Creek. ***KRCEE will share drone test results with the group and S. Fountain (FRNP) and K. Davis (FRNP) will be added to distribution list.***

"No Go" Areas for Monitoring Well Installations. The topic is retained, but restructured to provide a look-ahead at planned or potential changes rather than a backward look at changes. Several standing questions on this topic will be developed and included in future MWG meeting agendas.

- **Planned site activities with potential to impact Monitoring Well Installations?** None known at this time. Reprioritization of remedial projects is being considered by the FFA parties.
- **Applicable Quarterly Kentucky Department Fish & Wildlife Resources (KDFWR) meeting discussions?**
    - Meeting held 8/2/2023. The next meeting is scheduled for 10/25/2023. Discussion topics included:
        - AOC 112 (a berm/dam for a fish pond in the WKWMA)
        - AOC 113 (the rubble pile near the iron bridge in the WKWMA)
    - KDFWR is aware that the site is repairing the leaks in the raw water line and will backfill the holes created by the leaks.

- **Have any changes to the "No Go" Areas map occurred since the last meeting or map revision?** None known at this time.

The group did not have comments on this topic.

Sitewide Groundwater Model Update. The overarching goal of the model update is to develop a model to support remedial decision making. The update to the Paducah Site groundwater is in progress. DOE Paducah, KRCEE, and DOE Savannah River National Laboratory (SRNL) have reviewed the model and report and have provided their feedback. The DOE Low-Level Waste Disposal Facility Federal Review Group (LFRG) provided an additional external review with comments provided on September 26, 2023. Responses to the comments are planned for October 6, 2023 with a comment resolution meeting with the LFRG on October 11, 2023. A final revised report is planned for submittal to DOE on October 31, 2023.

Review and "approval" or "acknowledgement" of the model will be discussed with the MWG. A meeting to brief the MWG will be scheduled. EPA noted that they plan to acknowledge and accept the model update. EPA has requested that the external reviewer comments be shared as part of the deliverable to EPA and KY.

R. Bonczek (DOE) gave additional overview of the LFRG review of the model and noted their focus is different from the original intent of the model update. Given the change in the planned use of the model, there may be some changes to the model. Currently, resolution on the changes is expected by October 31, 2023 with a final report due to EPA and KY in November or December 2023.

7. Anthropogenic Recharge

This sub-topic will capture discussion on site changes, such as the recent changes to the high pressure fire water system. Development of a timeline to track changes to site operations that could impact the water balance at the site (e.g., removal of the high pressure fire water line from service, removal of the second raw water line from service, etc.) is being maintained. A water balance study is included as an appendix to the 2023 modeling report. Historically, intake water volume was around 4 million gallons per day (mgd) and is now closer to 1 mgd as shown in the water balance study.

The group did not have comments on this topic.

8. Plant-Wide Seismic Update

DOE and FRNP periodically review whether there are any ways to further reduce (temporarily) sources of noise to facilitate new testing without disrupting site activities. Seismic investigation is not currently a project (either DOE or KRCEE).

There was no evidence of faulting encountered during the C-400 remedial investigation. Kentucky Geological Survey (KGS) is working on regional compilation of seismic data focused on extents of the New Madrid centroid and on the northwest leg along the Mississippi River and that KGS plans to generate a report this year to summarize information compiled to date. KRCEE/KGS is updating some testing equipment.

The Waste Disposal Alternatives project is being considered by the FFA parties for early implementation and that the candidate siting may be revisited. Prior discussions on seismic evaluation for siting an on-site waste disposal facility (OSWDF) concluded adequate information existed for a Remedial Investigation/Feasibility Study, but that additional seismic evaluation would be needed for actual siting of an OSWDF.

S. Hampson relayed information from Dr. Woolery on recently upgraded seismic equipment. This equipment can "see" 5 meters below ground surface with the new SH-wave acquisition method from ground surface and discern the top of the RGA.

9. Precipitation and Ohio River Stage

Attachment 2 includes precipitation and Ohio River stage charts through mid-September 2023.

K. Davis noted there was no major flood in 2023 compared to 2022. The only significant rain event for the year occurred in July and the site is 12 inches above normal rainfall for the year. ***The 20-year average precipitation curve will be added to the bottom chart.***

10. Synoptic Water Level Events and Ohio River Levels

The location where the creeks shift from gaining to losing may impact the flow model (although the model is not very sensitive to this parameter) and is an area of interest to the group going forward.

The group did not have comments on this topic.

11. 2022 Plume Map Document Update

The 2022 update to the Plume Map Document was issued on 7/11/2023. KY provided comments to the document on 8/8/2023. An errata to correct Figure 5 was provided to the MWG on 8/29/2023. EPA accepted the document on 8/30/2023 and KY accepted the document on 9/5/2023. This topic is proposed to be removed from the MWG agenda until the next update is initiated.

The group agreed by consensus to remove this topic from the agenda.

12. Projects on the "Watch Topics" List

- **TVA Changes.** TVA has completed construction of a 3,800 ft sheet pile wall in close proximity to Little Bayou Creek and several seeps in December 2021. The wall is intended to stabilize the creek's bank, as opposed to control groundwater. Based on the information available in the TVA drawings, the sheet pile wall extends a significant depth into the RGA. The wall joints are not sealed, and the sheet piles themselves are solid (not perforated).

TVA has compiled and reviewed available data to support their groundwater model update, which is planned to be performed in 2023. TVA has provided to FRNP relevant as-built information and boring logs. The information indicates that the cutoff wall is not as deep as originally thought.

TVA had previously relayed that a replacement well may be installed to replace the wells that were closed due to the construction of the TVA impoundment sheet pile wall.

TVA previously provided drawings and boring logs associated with the sheet pile wall to FRNP. ***FRNP will review and assess whether there is sufficient information in the vicinity of the sheet pile wall to understand groundwater flow in the vicinity of the wall.***

FRNP will provide KRCEE boring data associated with the TVA sheet pile wall.

S. Hampson (KRCEE) will provide the KRCEE lithology database to TVA for review.

- **Emerging Contaminants**
  - PFAS
    - PFAS is discussed as part of the Risk Assessment Working Group and has ties to this working group as well.
    - The Paducah Site continues to participate in the DOE HQ PFAS Working Group Meetings.
    - The preliminary assessment (PA) guidance (Guide for Investigating Historical and Current Uses of Per-and Polyfluoroalkyl Substances at Department of Energy Sites) is final and available at: https://www.energy.gov/sites/default/files/2023-02/Final%20PFAS%20Investigation%20Guide%20Final%20%28002%29_0.pdf
    - PFAS Coordinating Committee put *PFAS Storage and Disposal Guidance for DOE* on-hold pending release of EPA's updated *Interim Guidance on Destroying and Disposing of Certain PFAS and PFAS-Containing Materials*.
    - The DOE Environmental Sampling Guidance is final and available at: PFAS Environmental Sample Guidance 2023 (energy.gov)
    - The DOE LFRG memo on disposal of PFAS is awaiting signature at DOE HQ. This memo gives LFRG approval for disposal of PFAS-containing waste into facilities with Operating Disposal Authorization Statements like the PORTS OSWDF.
    - Paducah has a question into DOE HQ regarding the potential for disposal of PFAS or PFAS-containing materials in a Subtitle D landfill (e.g., the U-Landfill). A formal request to DOE HQ has not been made on this topic.
  - For Paducah, the main PFAS activity for 2023 is the in-progress PFAS screening assessment project.
    - Sampling is completed with a technical report planned to be available to the MWG in the second quarter of FY 2024.
    - Environmental sampling status as of 8/31/2023:

Sample Type and Planned Month	Planned	Sampled	% Complete
MWs (Complete)	191	191*	100%
Potable Water (Complete)	5	5	100%
Surface Water (Complete)	16	16	100%

Treated Wastewater (Complete)	1	1	100%
Leachate (Complete)	3	3	100%
GW and Treated GW (Complete)	6	6	100%
Total	**222**	**222**	**100%**

* MW376, MW377, and MW389 were not able to be sampled due to insufficient water.

- Remaining project activities and schedule:
  - Laboratory analyses – completion end of September 2023
  - Data validation and verification – completion early November 2023
  - Provide initial draft report to DOE for review – early-February 2024
  - Provide finalized report to DOE for review – mid-March 2024
  - Provide report to EPA and KY – late-March 2024

KRCEE asked if there are surface water PFAS samples near the seeps. There currently is no offsite property sampling for PFAS planned. Samples of Ohio River water at the site treatment plant and potable water have been collected and analyzed for PFAS.

PFAS data from the potable water samples will be posted to PEGASIS and results from other samples will be posted after final data validation. The group discussed data qualifiers for the PFAS results and that there will be three sets of qualifiers. There is currently no guidance available for qualifying PFAS data. 100% of the results from the PFAS Screening Assessment will be validated as PFAS is an emerging contaminant.

The group discussed that MW315 at the Fire Training Area may be screened across the water table and that the water interface is an important component of the CSM for PFAS. The group discussed that recently-released DOE PFAS guidance indicates that the vadose zone-water table interface may be high concentration zone of PFAS at release sites, generally speaking (with site-specific circumstances influencing distribution as well).

DOE is developing a website for reporting the status of PFAS information for the DOE sites. Updates will be made in early 2024 and the update will be available in late 2024.

The group discussed that DOE is required to submit notifications to headquarters for disposal of PFAS.

EPA provided a link to PFAS Resources, Data and Tools: https://www.epa.gov/pfas/pfas-resources-data-and-tools

- 1,4-Dioxane
  - 1,4-dioxane was historically used as a stabilizer in 1,1,1-trichloroethane and dichloroethane.
  - The group plans to discuss fate & transport characteristics of 1,4-dioxane (compared to TCE) during a MWG meeting in FY 2024.

The group did not have comments on this topic.

13. FY 2024 Site Management Plan (SMP)

- Proposed overall cleanup strategy
    - C-400: explanation of significant differences (ESD) for Northwest Plume
    - Environmental media Record of Decision (ROD)
    - Decontamination and decommissioning Action Memorandum
    - Waste Disposal Alternatives (WDA) and on-site waste disposal facility (OSWDF) ROD
    - Final Consolidated Site Operable Unit (CSOU) ROD

The FY 2024 SMP is not finalized; discussions on the cleanup strategy are ongoing.

A C-400 D2 RI report is anticipated in December 2023.

14. Meeting Presentations

MWG members should provide any presentation requests to Stefanie. Potential topics for future meetings:

- Environmental Indicator analyses
- 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.)
- Summary of WSP 2023 plume stability analysis
- Groundwater model updates
- Topics from the Site Management Plan

A special meeting for groundwater model updates will be planned.

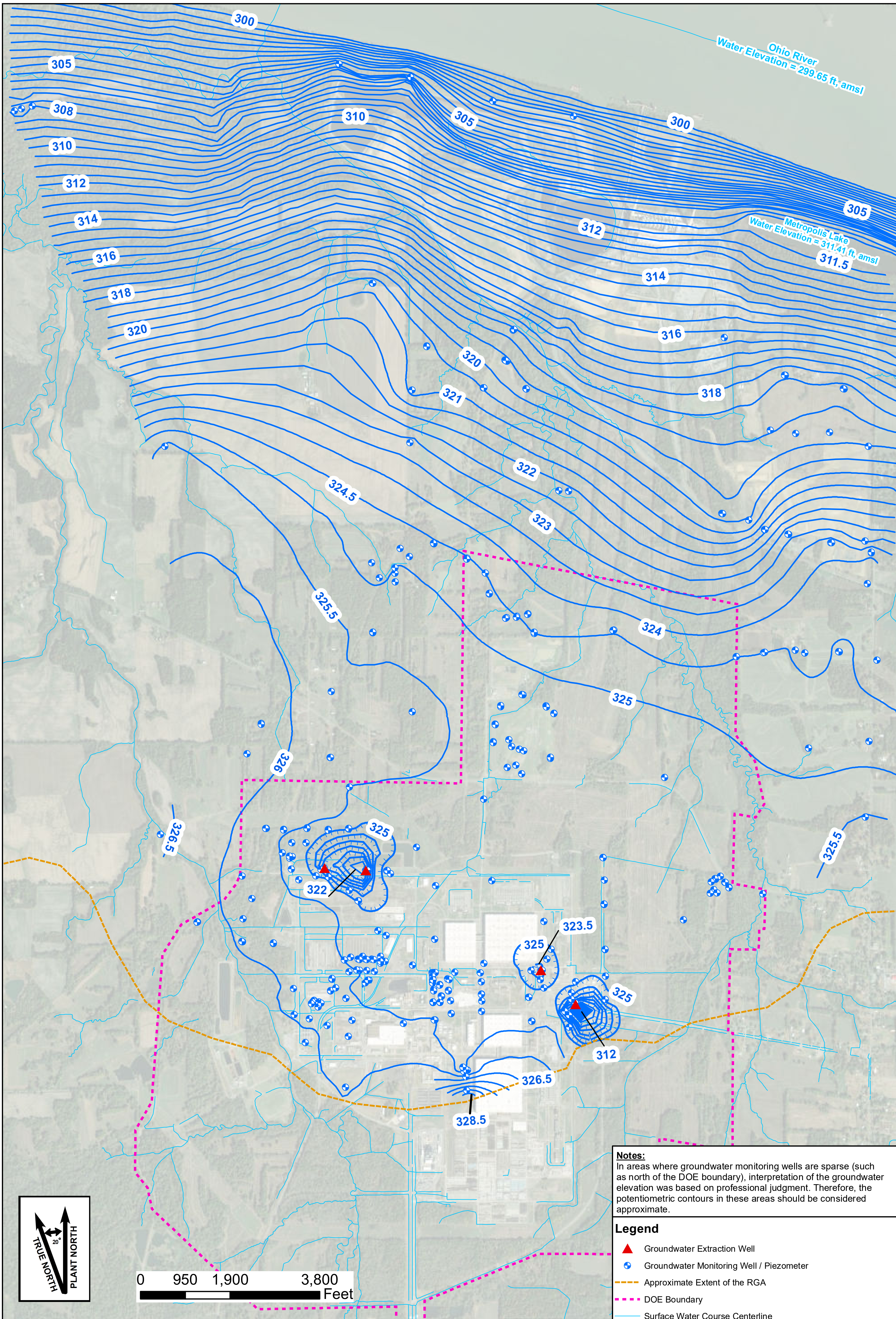
A presentation of the 2023 plume stability will be provided and is planned for January.

15. Poll MWG Members/Open Discussion

Attachment 1

Groundwater Strategy Potentiometric Map
May 2023

Groundwater Elevation Data for TVA Wells
May 2023



MAP SOURCE INFORMATION

Map Generation Date and Location - 10/07/2023 Geosyntec\\fedprojects-01\paducah$\Knoxville\GW Strategy\GIS\MXDs\2022-2023 Potentiometric Surface Maps
Map Layer Location: Geosyntec\\fedprojects-01\paducah$\Knoxville\GW Strategy\GIS\MXDs\2022-2023 Potentiometric Surface Maps\May 2023 Potentiometric Surface Map_10062023.mxd
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 provided by FRNP on 11/8/2022.
DOE Property Boundary provided by FRNP on 2/4/2021.
Northing and easting of wells obtained from Pegasis, downloaded on 6/14/2022.
Groundwater elevation was based on the 5/22/2023 - 5/26/2023 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 5/22/2023 - 5/26/2023.
Groundwater elevation for the TVA wells were provided by the Kentucky Division of Waste Management letter to DOE (#KY8-890-008-982) dated 06/12/2023. Water elevation at Metropolis Lake was provided by FRNP on 5/30/2023.
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. May 2023 RGA Potentiometric Surface Map

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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	372.77	369.38	760787.88	1946731.54	Active	65.2	75.2	307.57	297.57	319.58	53.19	5/25/2023_0957	29.63 in	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	319.25	53.3	5/25/2023_1000	29.63 in	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	319.26	50	5/25/2023_1003	29.63 in	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	319.03	47.87	5/25/2023_1006	29.63 in	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	322.89	49.93	5/25/2023_0955	29.63 in	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	319.98	54.96	5/25/2023_1011	29.63 in	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	302.44	29.72	5/25/2023_0925	29.62 in	TOC
TVA-D30B	SHF-D30B	2" PVC	Upper RGA	324.36	320.6	757594	1955563.41	Active	42.7	52.7	281.66	271.66	297.89	26.47	5/25/2023_0923	29.62 in	TOC
TVA-D17	SHF-D17	2" PVC	Upper RGA	365.43	362.8	758809.17	1950015.71	Active	14	17	351.43	348.43	316.33	49.1	5/25/2023_1022	29.63 in	TOC
TVA-D11B	SHF-D11B	2" PVC	Upper RGA	321.79	319.2	753434.76	1958481.44	Active	32	42	315.75	305.45	305.89	15.9	5/25/2023_0918	29.62 in	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	307.21	16.54	5/25/2023_0827	29.62 in	TOC
SHF-201B	SHF-201B	4" PVC	Upper RGA	323.75	320.2	746641.107	1960082.768	Active	32	37	291.75	286.75	308.3	15.45	5/25/2023_0826	29.62 in	TOC
SHF-201A	SHF-201A	4" PVC	Upper RGA	323.75	320	747030.226	1960036.252	Active	14.5	24.5	309.25	299.25	308.22	15.53	5/25/2023_0825	29.62 in	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	320.88	41.97	5/25/2023_0820	29.62 in	TOC
SHF-101G	SHF-101G	4" PVC	Upper RGA	322.43	318.8	754685.75	1957635.07	Active	32	37.3	290.43	285.13	307.18	15.25	5/25/2023_0911	29.62 in	TOC
Ohio River Elevation						831.9815	14996.63							300.11	5/25/2023_1025	29.63 in	TVA Inlet

LEGEND:

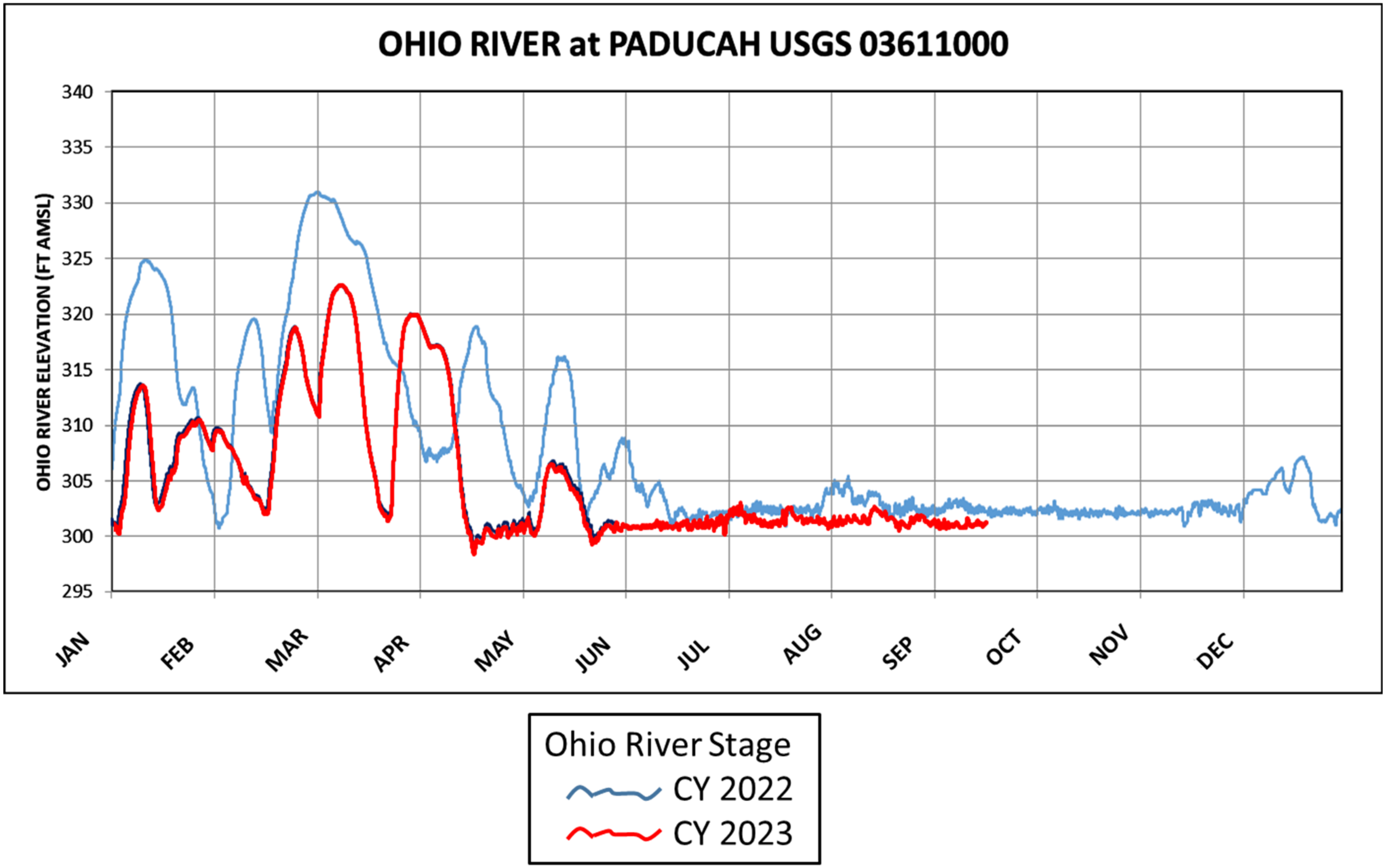
TOC: Top of Casing

DTW: Depth to Water

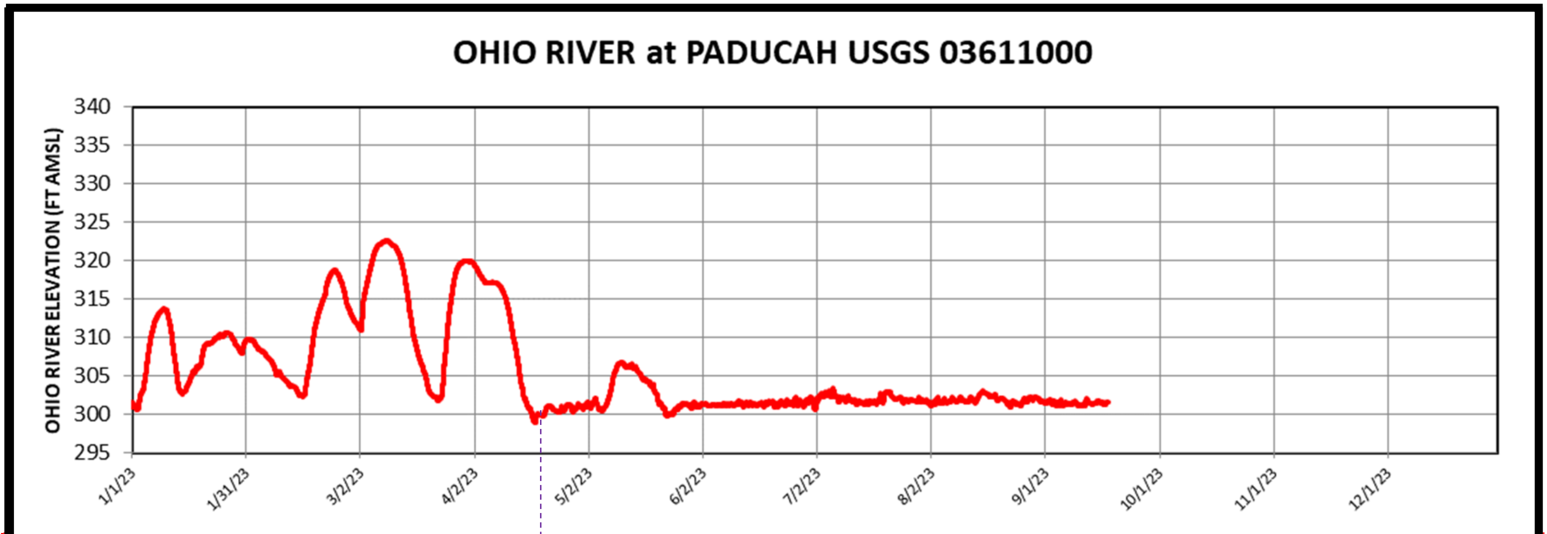
National Geodetic Vertical Datum of 1929 (NGVD 29).

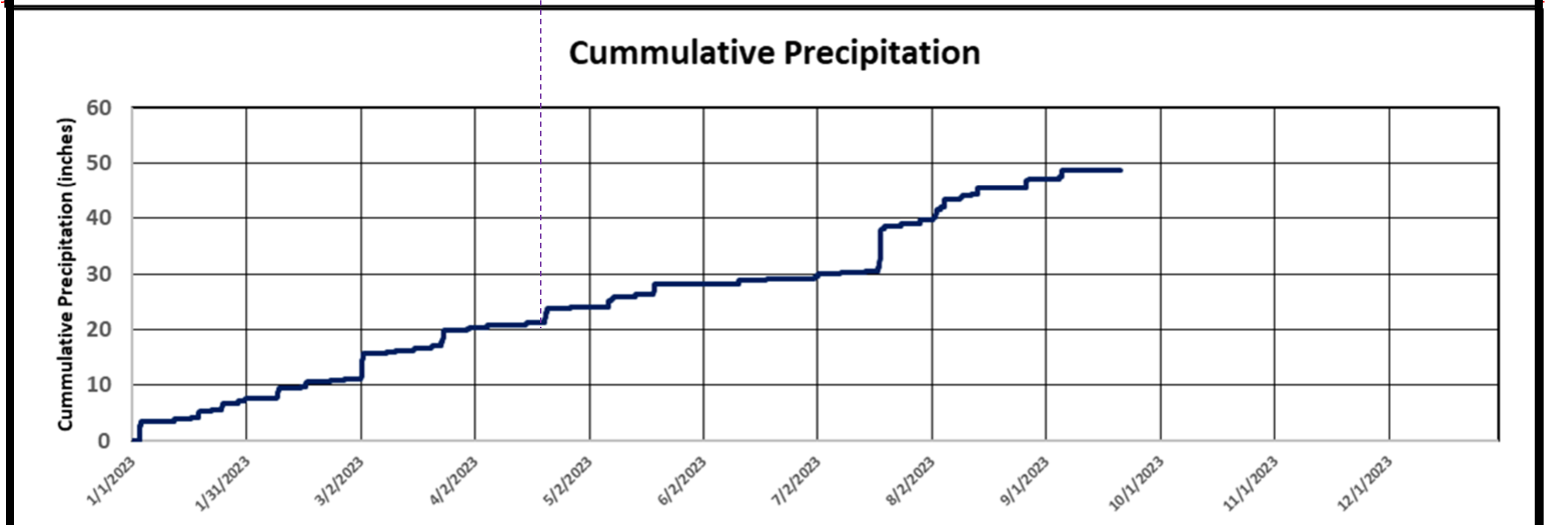
Attachment 2

Precipitation and Ohio River Stage Data



OHIO RIVER at PADUCAH USGS 03611000
OHIO RIVER ELEVATION (FT AMSL)
340
335
330
325
320
315
310
305
300
295
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Ohio River Stage
CY 2022
CY 2023


OHIO RIVER at PADUCAH USGS 03611000
OHIO RIVER ELEVATION (FT AMSL)
340
335
330
325
320
315
310
305
300
295
1/1/23
1/31/23
3/2/23
4/2/23
5/2/23
6/2/23
7/2/23
8/2/23
9/1/23
10/1/23
11/1/23
12/1/23


Cummulative Precipitation
Cummulative Precipitation (inches)
60
50
40
30
20
10
0
1/1/2023
1/31/2023
3/2/2023
4/2/2023
5/2/2023
6/2/2023
7/2/2023
8/2/2023
9/1/2023
10/1/2023
11/1/2023
12/1/2023

APPENDIX B

PADUCAH SITE GROUNDWATER MODELING WORKING GROUP MEETING SUMMARY—JANUARY 10, 2024

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ACRONYMS[1]

AFFF	aqueous-film-forming foam
AIP	agreement in principle
AP	Advanced Placement®
ASAP	as soon as possible
ASER	annual site environmental report
bgs	below ground surface
CAB	Citizens Advisory Board
CAER	Center for Applied Energy Research
CB	colloidal borescope
CBPC	community based participatory communication
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CoD	College of Design
CRS	comment response summary
CSM	conceptual site model
CUSSO	Central United States Seismic Observatory
D&D	decontamination and decommissioning
DOE	U.S. Department of Energy
DQO	data quality objective
DWGIS	data warehouse development/deployment
EAP	enzyme activity probes
ECI	Exhibit Concepts, Inc.
EES	Earth and Environmental Sciences
EM	Environmental Management
EMP	environmental monitoring plan
EPA	U.S. Environmental Protection Agency
ERH	electrical resistance heating
ET-DSP	Electro Thermal Dynamic Stripping Process
F&T	fate and transport
FT	fate and transport
FFA	Federal Facility Agreement
FRNP	Four Rivers Nuclear Partnership, LLC
FS	feasibility study
FY	fiscal year
GW	groundwater
GWSP	Groundwater Strategy Project
GWOU	groundwater operable unit
HS	high school
ID	identify
IGS	Illinois Geological Survey
ITRC	Interstate Technology & Regulatory Council
KGS	Kentucky Geological Survey
KRCEE	Kentucky Research Consortium for Energy and the Environment
KTC	Kentucky Technical College
KWRRI	Kentucky Water Resources Research Institute
KY	Commonwealth of Kentucky
LBC	Little Bayou Creek

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

LRGA	Lower Regional Gravel Aquifer
M	million
MCHS	Marshall County High School
MRGA	Middle Regional Gravel Aquifer
MW	monitoring well
MWG	Modeling Working Group
NMSZ	New Madrid Seismic Zone
NWP	northwest plume?
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
PI	preliminary investigation
PM	project manager
PPE	personal protective equipment
PPPO	Portsmouth/Paducah Project Office
P-QAPP	programmatic quality assurance project plan
PRS	Paducah Remediation Services, LLC
PT	pressure transducer
P&T	pump and treat
PVC	polyvinyl chloride
PWS	public water system
PZ	piezometer
Q	quarter
REDOX	reduction-oxidation
RFP	request for proposal
RGA	Regional Gravel Aquifer
RI	remedial investigation
SADA	spatial analysis decision assistance
SCI	stable carbon isotope
SME	subject matter expert
SRNL	scenarios selection tool
STEM	science, technology, engineering, and mathematics
SW	surface water
SWMU	solid waste management unit
T-RFLP	terminal restriction fragment length polymorphism
TMDL	total maximum daily load
TRS	Thermal Remediation Services
TVA	Tennessee Valley Authority
UCRS	upper continental recharge system
UK	University of Kentucky
UK-CHFS	Kentucky Cabinet for Health and Family Services
ULF	ultra low frequency
UN	United Nations
URGA	Upper Regional Gravel Aquifer
VI	vapor intrusion
VM	virtual museum
VSAP	vertical seismic array Paducah
VSP	visual sample plan
WDA	waste disposal alternative
WKWMA	West Kentucky Wildlife Management Area

Paducah Site Groundwater Modeling Working Group
Meeting Summary—January 10, 2024

MWG Attendees:

DOE
Rich Bonczek ✓
Brian Looney (SRNL)

ETAS
Martin Clauberg ✓
Bruce Stearns ✓
Tracy Wood ✓

KRCEE
Steve Hampson
Alan Fryer ✓

TVA
Matthew Alpin ✓
Tabitha Ester ✓
Anna Fisher
Jeffrey Frazier (WSP)
Eric Wallis

EPA and Contractors
Noman Ahsanuzzaman ✓
Ben Bentkowski
Eva Davis ✓
Jonathan Dziekan
Bei Huang ✓
Mac McRae ✓
Victor Weeks ✓

Kentucky
Stephanie Brock
Mary Evans ✓
Nathan Garner ✓
Will Grasch
Brian Lainhart
Todd Mullins
Bart Schaffer
April Webb ✓

FRNP
Evan Clark ✓
Bryan Clayton
Sarah Cronk ✓
Ken Davis ✓
Rob Flynn ✓
Bruce Ford ✓
Stefanie Fountain ✓
Josue Gallegos ✓
Emilye Garner ✓
LeAnne Garner ✓
Jeffrey King ✓
Bruce Meadows
Todd Powers ✓
Corey Wallace ✓
Dawit Yifru ✓

✓ Indicates the Attendee was present

Also present: Joe Ricker (WSP), Tim Goist (WSP), and David Winchell (WSP)

Original meeting agenda items are provided followed by meeting notes; the meeting notes are provided in italics with action items noted in green. Additions or revisions to the agenda items are noted in [].

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

Comments were received from multiple members to the 10/4/2023 Meeting Summary (sent to participants on 12/5/2023). Items commented on included the discussion of PFAS and the MW315 monitoring well and the KRCEE activities. These items have been revised and the revised meeting summary will be sent out to the MWG with the summary for this meeting.

No additional comments were received to the 10/4/2023 Meeting Summary. The revised meeting summary for the 10/4/2023 Meeting will be sent to the MWG with this meeting's summary.

2. FY 2024 Work Plan/Schedule

Activity	Date
~~Quarterly Meeting (October/FY 2024Q1)~~	~~10/4/2023~~
~~MWG Concurs with FY 2024 Work Plan~~	~~11/3/2023~~

Quarterly Meeting (January/FY 2024Q2)	1/10/2024
Submit Draft MWG Compilation (FY 2023) to MWG	1/12/2024
MWG Provide Comments on Draft MWG Compilation (FY 2023)	2/11/2024
Submit Final MWG Compilation (FY 2023)	3/10/2024
Quarterly Meeting (April/FY 2024Q3)	4/3/2024
Quarterly Meeting (July/FY 2024Q4)	7/17/2024

Note: White Papers will be added to schedule once the FY2024 Groundwater Strategy Project (GWSP) Project Management Plan (PMP) schedule is finalized. See Agenda Item 5 for additional information.

The group did not have questions or comments this agenda item.

3. Draft FY 2024+ Work Plan/Schedule

Activity	Date
Provide Draft Agenda Including FY 2025 Work Plan/Schedule (October/FY 2025Q1) to MWG	10/2/2024
Quarterly Meeting (October/FY 2025Q1)	10/9/2024 (Planning date)

The group did not have questions or comments on this agenda item.

4. Update on Water Levels

Synoptic water level events are being collected quarterly. TVA provided survey reference information for TVA location D30 following the October 2023 meeting. The updated May 2023 potentiometric map was included with the October 2023 meeting summary. The potentiometric map for the synoptic water level event for August 21-24, 2023 and the August 2023 groundwater elevation data for TVA wells collected by KY are included in Attachment 1. Potentiometric maps will be included in the annual MWG compendia.

During the October 2023 meeting, the group discussed the handling of Metropolis Lake in the sitewide groundwater flow model (see Attachment 2 for a figure showing the location of Metropolis Lake). The sitewide groundwater model incorporates Metropolis Lake as follows:

- Metropolis Lake is simulated with a hydraulic conductivity value of 500,000 ft/day assigned to the area corresponding to the lake in model layer 1 (upper portion of the RGA). This was done based on the assumption that the lake is in direct hydraulic connection with the RGA and the lake represents open water.
    - The top elevation of model layer 1 corresponds to the top of the RGA (i.e., the contact of the RGA and the UCRS), as defined using the Lithology Database (Revision 11) surfaces developed by KRCEE, and ranges from 2 ft to 22.69 ft thick.
- Three additional groundwater elevation targets were added in layer 1 to constrain model-calibrated water levels in the Metropolis Lake area (see figure in Attachment 2) using a water level measurement from August 2022. These targets were used based on the assumption that Metropolis Lake surface water is in direct hydraulic connection with the RGA.
    - When possible, water level data measured at Metropolis Lake are incorporated into the potentiometric maps.

A compiled package of recent potentiometric maps was provided to the MWG separately per discussions during the October 2023 meeting.

The group did not have questions or comments on this agenda item.

5. Update on Paducah Site Groundwater Strategy

The GWSP is a multi-year plan with multiple activities planned. The specific timing and scope of each activity are developed by DOE based on data collected in the prior year(s).

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

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

The activities defined in the GWSP PMP include:

Activity No.	Issue of Concern
Human Exposure Under Control	
1	TCE Extent West of PGDP (SW Plume)
2	TCE Extent East of PGDP (Downgradient NE Plume)
3	North Extent of PGDP TCE Plumes (Impact to Ohio River)
4	Nature and Extent of Contaminants Currently Contributed by Little Bayou Creek Seeps
5	Nature and Extent of Dissolved-Phase Contaminants Other than TCE and technetium-99 (Tc-99)
Groundwater Migration Under Control	
6	Capture Efficiency of NW Plume EWs
7	TCE Extent and Trends in East Side of Downgradient NW Plume
8	TCE Extent and Trends in West Side of Downgradient NE Plume
9	RGA Dissolved-Phase and DNAPL Contaminant Impacts to the McNairy Formation
Groundwater MWG Inputs	
10	Characterize Underflow from the Terrace Area
11	Expansion of Groundwater Monitoring Network
12	Water Balance Study
13	Continuous RGA Water Level Monitoring
14	Synoptic Water Level Measurement
15	Water Level Divide Study
16	Hydraulic Conductivity
Additional Activities	
17	MW Survey Study
18	Groundwater Chemical Trend Evaluation
19	TCE Degradation Rates

The final FY 2024 GWSP PMP has been approved by DOE and includes:

- Collection of quarterly synoptic water levels during FY 2024 (Activity 14)
- Water level collection for Activities 6 and 8
- Development of white papers for Activities 1, 2, 3, 7, 8, 9, 11, 13, and 15 (note that Activity 8 white paper has been substituted for Activity 5 white paper planned in the PMP in support of EI documentation)
- Scoping of FY 2025 and beyond tasks for activities 4, 8, and 10

The following three white papers (started as part of the FY 2023 GWSP PMP) have been reviewed by DOE and are in the process of being revised and are discussed as part of

- Activity #1 White Paper: Regional and Localized Groundwater Flow and Trichloroethene Trends, West Side of the Southwest Plume
- Activity #2 White Paper: Regional and Localized Groundwater Flow and Trichloroethene Trends, East Side of Downgradient Northeast Plume
- Activity #3 White Paper: North Extent of Trichloroethene Plumes (Impact to Ohio River) at the Paducah Gaseous Diffusion Plant

These three white papers, combined with the Activity #8 white paper as well as the 2022 plume map update and other supporting analysis recently presented during the Groundwater Modeling Working Group meetings, will be incorporated into the EI documentation determination that will be prepared to support the revision of the "groundwater under control" performance measure from "no" to "yes"

EPA is internally coordinating change of the "human exposure under control" performance measure from "insufficient data" to "yes" with consideration of the vapor intrusion studies that have been done at the site. EPA believes there will be agreement internally in FY2024 to update the Performance Measure of Human Exposure Under Control as "Insufficient Data" to "Yes" and that EPA noted they likely will be able to update the Performance Measure of Groundwater Migration Under Control from "No" to "Yes" for TCE and Tc-99.

During the October 2023 meeting, EPA noted that emerging contaminants will need to be factored in to the EI determination. The group will discuss and consider guidance from EPA on emerging contaminants inclusion.

FRNP will compile a list of white papers completed and status, including where they are located if finalized. This list will be included as an attachment to the next meeting agenda.

Water Line Leaks. FRNP and KY continue to develop information related to the leak in the main raw water line from the Ohio River to the site. The location of the water line leak along Water Line Road about a mile from the creek crossing. Repairs to the line and backfilling of the holes are in progress.

The group did not have questions or comments on this agenda item.

Seeps. There have been no seep results above the maximum concentration limit (MCL) for trichloroethene (TCE) for many years. LBCSP5 routinely has flow and is able to be sampled, whereas many of the other previously identified seeps do not have flow consistently.

During the October 2023 meeting, the group discussed TCE surface water sampling data from Little Bayou Creek near the seeps or downstream of the seeps. Prior to 2010, surface water was sampled for metals and organics and after 2010, surface water sampling has focused on PCBs and TCE.

KRCEE provided the R12 Hydrolithostratigraphic Database in the October 2023 meeting summary and has requested that the group review the R12 database and rendered surfaces and provide comments back to S. Hampson.

KRCEE has a task (proposals were submitted in September) 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. KRCEE is reviewing associated equipment capabilities for seeps identification, including hand held meters and fiber optic. Physical access and determining temperature gauging/gradients are also being evaluated. KRCEE had relayed during the previous meeting that there are concerns with flying the drone below the tree canopy. A test was performed in September and several additional test flights were conducted in October and November. The additional flights included test flights at Hayes Spring (Princeton, KY) utilizing known temperature targets and a test flight comparing FLIR unit results to results from other FLIR units that have been successfully deployed for agricultural purposes in State.

Seeps are a topic of GWSP Activity #4. K. Davis shared a summary of surface water and sediment samples from the lower reach of Little Bayou Creek (Attachment 3).

KRCEE relayed that there are two primary concerns with using a drone for the seep surveys:

- *The tree canopy poses a risk to the drone. Vertical flights at select locations along the creeks with 360 deg. optical scanning are being evaluated.*
- *There are significant insurance requirements for deploying the drone.*

Thermal scanning for seeps is optimal when temperature gradients between the seep water and the surface water is greatest (i.e., in summer or winter); KRCEEs preference for use of FLIR is to deploy in the winter for temperature contrast and when the leaves are off the trees. Deployment of fiber optic cables in creek bed stretches is also under consideration.

"No Go" Areas for Monitoring Well Installations. The topic is retained, but restructured to provide a look-ahead at planned or potential changes rather than a backward look at changes. Several standing questions on this topic will be developed and included in future MWG meeting agendas.

- **Planned site activities with potential to impact Monitoring Well Installations?** Reprioritization of remedial projects is included in the recently approved 2023 Site Management Plan.
- **Applicable Quarterly Kentucky Department Fish & Wildlife Resources (KDFWR) meeting discussions?**
    - Meeting held 10/25/2023. The next meeting is scheduled for 1/17/2024. Discussion topics included:
        - DOE will not be removing any debris from AOC 113 (the rubble pile near the iron bridge in the WKWMA).
        - DOE continues repairing leaks in the raw water line and will backfill the holes created by the leaks.

    - Procurement continues for a subcontractor to remove 83 former electrical transmission lines.
    - Illegal dumping of trash in the WKWMA continues to be a concern, and increased security patrols have been requested.
- **Have any changes to the "No Go" Areas map occurred since the last meeting or map revision?** None known at this time.

The group did not have questions or comments on this agenda item.

Sitewide Groundwater Model Update. The overarching goal of the model update is to develop a model to support remedial decision making. The update to the Paducah Site groundwater model is in progress. DOE Paducah, KRCEE, and DOE Savannah River National Laboratory (SRNL) have reviewed the model and report and have provided their feedback. The DOE Low-Level Waste Disposal Facility Federal Review Group (LFRG) provided an additional external review with comments provided on September 26, 2023. During the October 2023 meeting, R. Bonczek (DOE) gave an additional overview of the LFRG review of the model and noted their focus is different from the original intent of the model update. The DOE PPPO office has also requested that the lead modeler for the on-site waste disposal facility (OSWDF) model at PORTS review the model in preparation for resumption of the Waste Disposal Alternatives (WDA) project at Paducah. Given the change in the planned use of the model, there may be some changes to the model. Currently, resolution on the changes is expected in January or February 2024.

Review and "approval" or "acknowledgement" of the model will be discussed with the MWG. A meeting to brief the MWG will be scheduled. EPA noted that they plan to acknowledge and accept the model update. EPA has requested that the external reviewer comments be shared as part of the deliverable to EPA and KY.

EPA relayed to the group that they plan to "acknowledge" the model and associated report and requested that the 3rd party review comments be provided with the report. DOE will provide a summary of the comments as multiple comments are related to the potential performance assessment for an OSWDF and are not relevant to the Sitewide flow model. DOE gave the example of the LFRG comments on near-field modeling needed for an OSWDF, which the Sitewide flow model is not intended to do. DOE also relayed that KRCEE had several comments on the low concentration model outputs near the Ohio River, which are related in part to the large domain of the model, but which do not prevent the model from providing inputs to decisions on remedial approaches at the site.

6. Anthropogenic Recharge

This sub-topic will capture discussion on site changes, such as the recent changes to the high pressure fire water system. Development of a timeline to track changes to site operations that could impact the water balance at the site (e.g., removal of the high pressure fire water line from service, removal of the second raw water line from service, etc.) is being maintained. A water balance study (part of GWSP Activity #12) is included as an appendix to the 2023 modeling report. Historically, intake water volume was around 4 million gallons per day (mgd) and is now closer to 1 mgd as shown in the water balance study.

The group did not have questions or comments on this agenda item.

7. Plant-Wide Seismic Update

DOE and FRNP periodically review whether there are any ways to further reduce (temporarily) sources of noise to facilitate new testing without disrupting site activities.

There was no evidence of faulting encountered during the C-400 remedial investigation. Kentucky Geological Survey (KGS) is working on regional compilation of seismic data focused on extents of the New Madrid centroid and on the northwest leg along the Mississippi River and that KGS plans to generate a report this year to summarize information compiled to date. KRCEE/KGS is updating some testing equipment.

The WDA project is included in the recently approved FY 2024 Site Management Plan (SMP) and candidate siting will be revisited as part of resuming the project. Prior discussions on seismic evaluation for siting an OSWDF concluded adequate information existed for a Remedial Investigation/Feasibility Study, but that additional seismic evaluation would be needed for actual siting of an OSWDF. S. Hampson relayed during the October 2023 meeting that there is information from Dr. Woolery on recently upgraded seismic equipment. This equipment can "see" 5 meters below ground surface with the new SH-wave acquisition method from ground surface as shallow as approximately 5 meters below ground surface.

For the WDA project, DOE is discussing having UK perform a site-wide seismic investigation under the current KRCEE grant in CY 2024. This project will include several planning meetings, including meetings with EPA, KY, and DOE HQ. The meetings are expected to begin in late January and be completed in February. Subsequent to the meetings, two phases of field investigation are expected, a general site-wide investigation and a more detailed investigation of one or two candidate locations for the Paducah OSWDF. The seismic information collected is critical to development of the 90% design needed for completion of the Paducah OSWDF performance analysis/composite analysis (PA/CA) and Record of Decision (ROD) approval.

DOE and KRCEE are evaluating a sitewide seismic project. The project would have four phases:

1. *Planning phase with development of a statement of work in January. KRCEE or a contractor may perform proof of concept equipment testing during this phase.*
2. *Scoping meetings with FRNP in early February.*
3. *Scoping meetings with EPA/KY and DOE headquarters in late February.*
4. *Field mobilization by April or May with two phases of field work: a low-resolution investigation across site then high-resolution testing of 1-2 sites for OSWDF siting and design, including Holocene fault investigation.*

The goal would be to complete the seismic project in FY 2024 to meet the OSWDF design and PA/CA schedules. Under the Decision 2029 schedule, the PA/CA must start no later than mid-2025.

EPA intends to bring in seismic SMEs to participate in a seismic project.

8. Precipitation and Ohio River Stage

Attachment 4 includes precipitation and Ohio River stage charts through mid-December 2023.

Precipitation in 2023 was above normal average. The river stage has been near constant and fairly low for the last 8 months. The November 2023 potentiometric map should be useful for steady-state interpretation.

9. Synoptic Water Level Events and Ohio River Levels

The location where the creeks shift from gaining to losing may impact the flow model (although the model is not very sensitive to this parameter) and is an area of interest to the group going forward.

Select monitoring wells also continue to be monitored with pressure transducers and more frequent manual water level measurements as part of the GWSP and will be incorporated into selected White Papers.

10. Projects on the "Watch Topics" List

- **TVA Changes.** TVA has completed construction of a 3,800 ft sheet pile wall in close proximity to Little Bayou Creek and several seeps in December 2021. The wall is intended to stabilize the creek's bank, as opposed to control groundwater. Based on the information available in the TVA drawings, the sheet pile wall was thought to extend a significant depth into the RGA. The wall joints are not sealed, and the sheet piles themselves are solid (not perforated).

  TVA has compiled and reviewed available data to support their groundwater model update, which is planned to be performed in 2023. TVA has provided to FRNP relevant as-built information and boring logs. The information indicates that the sheet pile wall is not as deep as originally thought.

  TVA had previously relayed that a replacement well may be installed to replace the wells that were closed due to the construction of the TVA impoundment sheet pile wall.

  FRNP provided KRCEE boring data associated with the TVA sheet pile wall and S. Hampson (KRCEE) provided the KRCEE lithology database to TVA for review following the October 2023 meeting.

  FRNP has an open action to review and assess whether there is sufficient information in the vicinity of the sheet pile wall to understand groundwater flow in the vicinity of the wall.

  The group discussed that as the sheet pile wall does not fully intersect the RGA and as the wall is not sealed, the wall is not anticipated to significantly impact groundwater flow. The KRCEE seep investigation may provide information on whether the wall has an impact on seeps in the area.

- **Emerging Contaminants**
  - PFAS
    - PFAS is discussed as part this working group and has ties to the Risk Assessment Working Group (RAWG) as well.
    - An update to Paducah and PORTS PFAS information in the DOE-wide PFAS Assessment is expected in fall 2024. Paducah participated in the beta test of the

Annual Site PFAS Status Update survey platform; site data is to be submitted through this platform by January 31.

- The Paducah Site continues to participate in the DOE HQ PFAS Working Group Meetings. Rich is a member of the DOE PFAS Coordinating Committee and DOE-EM PFAS Roundtable and plans to coordinate Paducah information and actions with Oak Ridge and Portsmouth.
    - The PFAS Coordinating Committee last met on November 8, 2023. DOE Coordinating Committee guidance documents are complete, but are being held for distribution until EPA completes their guidance.
    - The DOE-EM PFAS Roundtable had its initial meeting on December 6, 2023. This initial meeting focused on the purpose of the group and included some general discussions about consistency across the DOE-EM complex.
    - The DOE HQ PFAS Working Group last met on November 16, 2023.
    - The DOE LFRG Memo on disposal of PFAS-containing waste is ready for signature but is being held until the release of the revised EPA and final DOE disposal guidance that are expected to be available in January 2024. This memo gives LFRG approval for disposal of PFAS-containing waste into facilities with Operating Disposal Authorization Statements, such as the PORTS OSWDF.
    - Paducah has a question into DOE HQ regarding the potential for disposal of PFAS or PFAS-containing materials in a Subtitle D landfill (e.g., the U-Landfill). A formal request to DOE HQ has not been made on this topic.
- For Paducah, the main PFAS activity for FY 2024 is the in-progress PFAS screening assessment project.
    - Sampling is completed and a technical report is planned to be available in the second quarter of FY2024.
    - Environmental sampling status as of 12/14/2023: Data assessment and validation has been completed and data evaluation is in progress. Data validation was performed on 100% of the results.
    - During the September 13, 2023 meeting, the group discussed reporting for the Sitewide PFAS Screening Assessment. The scope of the technical report is expected to include: context, sampling performed, data quality objectives, development of reference/background concentrations, and results. EPA requested scoping of the reporting and a meeting including EPA HQ representatives. A list of times for scoping meeting(s) will be provided once briefings to DOE-PPPO and HQ are complete.

There is a new DOE Region 4 PFAS working group; R. Bonczek is a member.

The Paducah Site response to the DOE-EM annual PFAS survey has been drafted and is in DOE review. The survey is anticipated to be published by DOE in late FY 2024 and will be shared with this group if possible.

Scoping on the Paducah Site PFAS screening assessment project report is planned and the report is now planned to be drafted by mid-March. Potential future PFAS sampling is under consideration. The group discussed that Oak Ridge has completed their historical assessment and that PFAS was discussed in the Oak Ridge ETTP five year review.

- 1,4-Dioxane
  - 1,4-dioxane was historically used as a stabilizer in 1,1,1-trichloroethane and dichloroethane.
  - The group plans to discuss fate & transport characteristics of 1,4-dioxane (compared to TCE) during a MWG meeting in FY 2024.

The group discussed that 1,4-dioxane is included in the analytical suite for projects, as appropriate. A high concentration result was obtained during the C-400 remedial investigation, but confirmation of the result with resampling has not been possible as the well has been dry since that sample was collected.

11. FY 2024 Site Management Plan (SMP)

The FY 2024 SMP was approved in December and includes the reprioritization for site remedial projects, including:

- C-400 area extraction well and Northwest Plume modification in 2025
- Environmental Media Record of Decision (ROD) in 2029
- Decontamination and Decommissioning Action Memorandum in 2029
- Waste Disposal Alternatives (WDA) and on-site waste disposal facility (OSWDF) ROD in 2029
- Final Consolidated Site Operable Unit (CSOU) ROD (date to be determined)

The FY 2024 SMP included a preliminary plan for Decision 2029. The full plan for Decision 2029 is intended to be included in the FY 2026 SMP. DOE relayed to the group that these dates are for the D1 document submittals and that the contractor dates are 6-12 months earlier.

12. Meeting Presentations

A presentation of the WSP 2023 plume stability analysis will be shared during the meeting.

A special meeting for groundwater model updates will be planned following completion of the third-party reviews.

MWG members should provide any presentation requests to Stefanie. Potential topics for future meetings:

- Environmental Indicator analyses
- Lithology
- TCE degradation rates
- Site water balance items (e.g., leaks from piping, above and below ground piping, building foundation gravel layers, etc.)
- Groundwater model updates
- Topics from the Site Management Plan

- 1,4-dioxane fate and transport

WSP presented on the plume stability analysis. The major conclusions of the analysis include that the plume footprints continue to get smaller and that the plume can be accurately represented with fewer monitoring points. While fewer monitoring points would result in a more cost effective and efficient monitoring program, there are other constraints (e.g., permit required sampling) that must be reviewed before wells could be removed (abandoned) from the network. The group discussed that the analysis is a good tool for communicating with managers and the public. ***The presentation will be made available to the group after the meeting*** *and WSP will be available for any questions that may be posed after the meeting.*

The following topics were added to the potential presentation list:

- *Seismic primer*
- *PFAS screening assessment project summary*

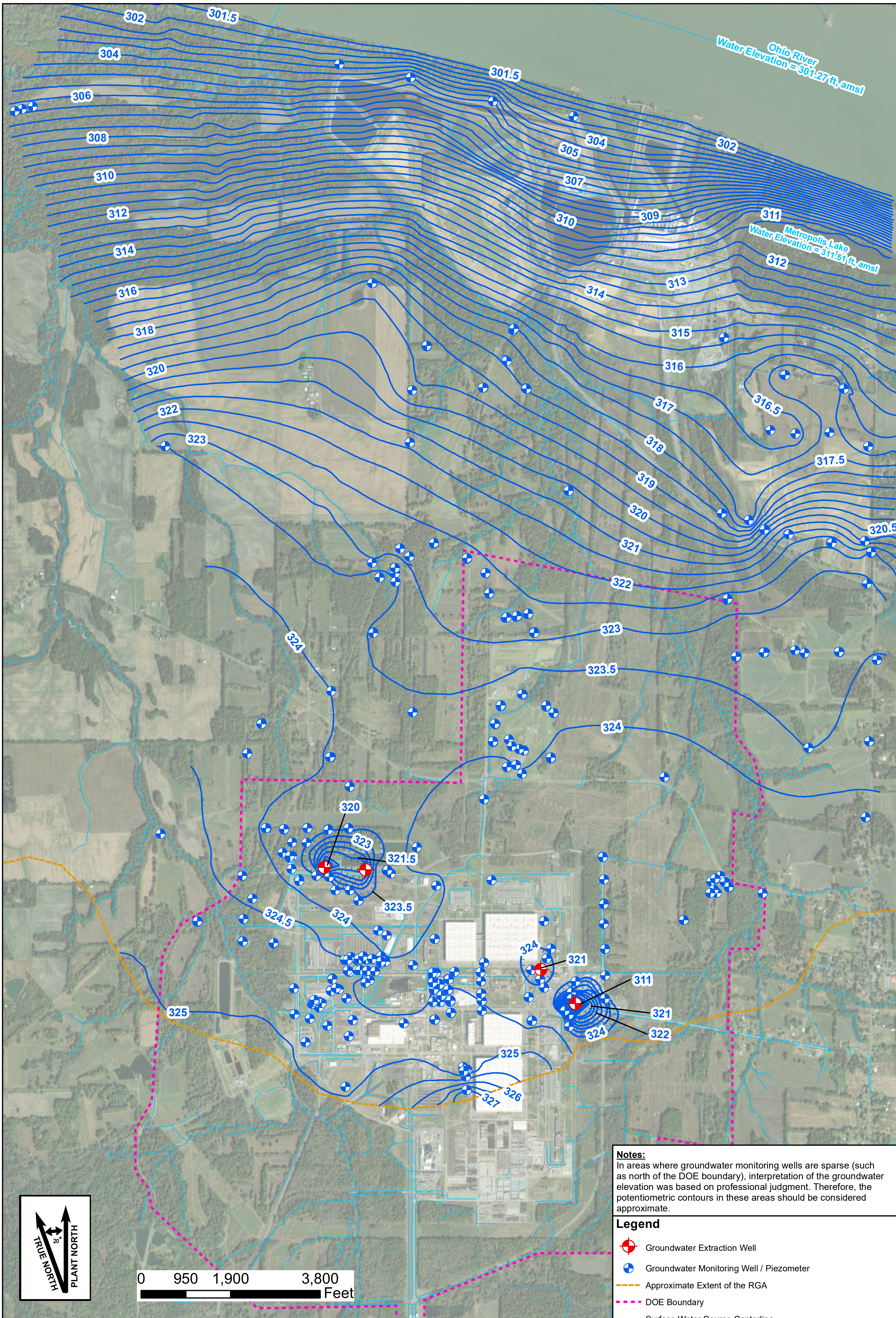
DOE's preferred presentation topics are: 1) seismic primer; 2) PFAS screening assessment project summary; and 3) Groundwater model updates. ***FRNP will provide the presentation topic in advance of the next meeting.***

13. Poll MWG Members/Open Discussion

Attachment 1

Groundwater Strategy Potentiometric Map
August 2023

Groundwater Elevation Data for TVA Wells
August 2023



MAP SOURCE INFORMATION

Map Generation Date and Location - 10/08/2023 Geosyntec\\fedprojects-01\paducah$\Knoxville\GW Strategy\GIS\MXDs\2022-2023 Potentiometric Surface Maps
Map Layer Location: Geosyntec\\fedprojects-01\paducah$\Knoxville\GW Strategy\GIS\MXDs\2022-2023 Potentiometric Surface Maps\August 2023 Potentiometric Surface Map_10082023.mxd
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 provided by FRNP on 11/8/2022.
DOE Property Boundary provided by FRNP on 2/4/2021.
Northing and easting of wells obtained from Pegasis, downloaded on 6/14/2022.
Groundwater elevation was based on the 8/21/2023 - 8/24/2023 measurements. Groundwater elevation of extraction wells was measured on 08/28/2023 and was provided by FRNP on 9/14/2023.
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 5/22/2023 - 5/26/2023.
Groundwater elevation for the TVA wells were provided by the Kentucky Division of Waste Management letter to DOE (#KY8-890-008-982) dated 08/30/2023. Water elevation at Metropolis Lake was provided by FRNP on 8/24/2023.
amsl = above mean sea level

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Figure 1. August 2023 RGA Potentiometric Surface Map

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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	372.77	369.38	760787.88	1946731.54	Active	65.2	75.2	307.57	297.57	316.67	56.1	8/24/2023_1118	29.58	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	317.24	55.31	8/24/2023_1123	29.58	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	316.25	53.01	8/24/2023_1124	29.58	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	316.22	50.68	8/24/2023_1127	29.58	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	320.82	52	8/24/2023_1115	29.58	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	316.84	58.1	8/24/2023_1133	29.58	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	305.35	26.81	8/24/2023_1350	29.55	TOC
TVA-D30B	SHF-D30B	2" PVC	Upper RGA	324.36	320.6	757594	1955563.41	Active	42.7	52.7	281.66	271.66	298.77	25.59	8/24/2023_1356	29.55	TOC
TVA-D17	SHF-D17	2" PVC	Upper RGA	365.43	362.8	758809.17	1950015.71	Active	14	17	351.43	348.43	315.41	50.02	8/24/2023_1342	29.55	TOC
TVA-D11B	SHF-D11B	2" PVC	Upper RGA	321.79	319.2	753434.76	1958481.44	Active	32	42	315.75	305.45	303.34	18.45	8/24/2023_1405	29.55	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	306.4	17.35	8/24/2023_1317	29.56	TOC
SHF-201B	SHF-201B	4" PVC	Upper RGA	323.75	320.2	746641.107	1960082.768	Active	32	37	291.75	286.75	306.44	17.31	8/24/2023_1316	29.56	TOC
SHF-201A	SHF-201A	4" PVC	Upper RGA	323.75	320	747030.226	1960036.252	Active	14.5	24.5	309.25	299.25	306.35	17.4	8/24/2023_1315	29.56	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	319.55	43.3	8/24/2023_1310	29.56	TOC
SHF-101G	SHF-101G	4" PVC	Upper RGA	322.43	318.8	754685.75	1957635.07	Active	32	37.3	290.43	285.13	305.23	17.20	8/24/2023_1402	29.55	TOC
Ohio River Elevation						831.9815	14996.63							301.7	8/24/2023_1130	29.58	TVA Inlet

LEGEND:

TOC: Top of Casing

DTW: Depth to Water

National Geodetic Vertical Datum of 1929 (NGVD 29).

Attachment 2

Metropolis Lake Maps

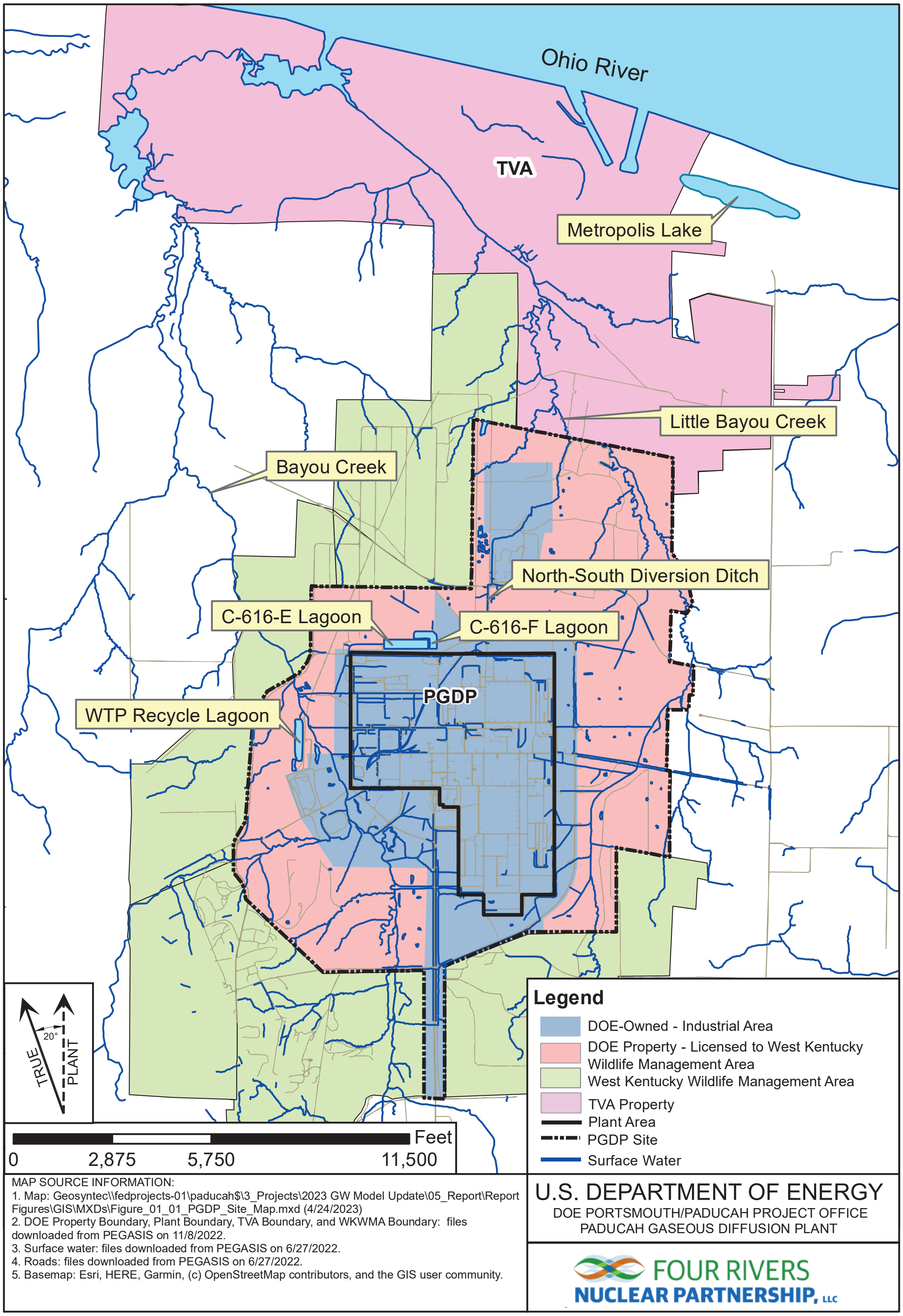

Figure 1.1. PGDP Site Map

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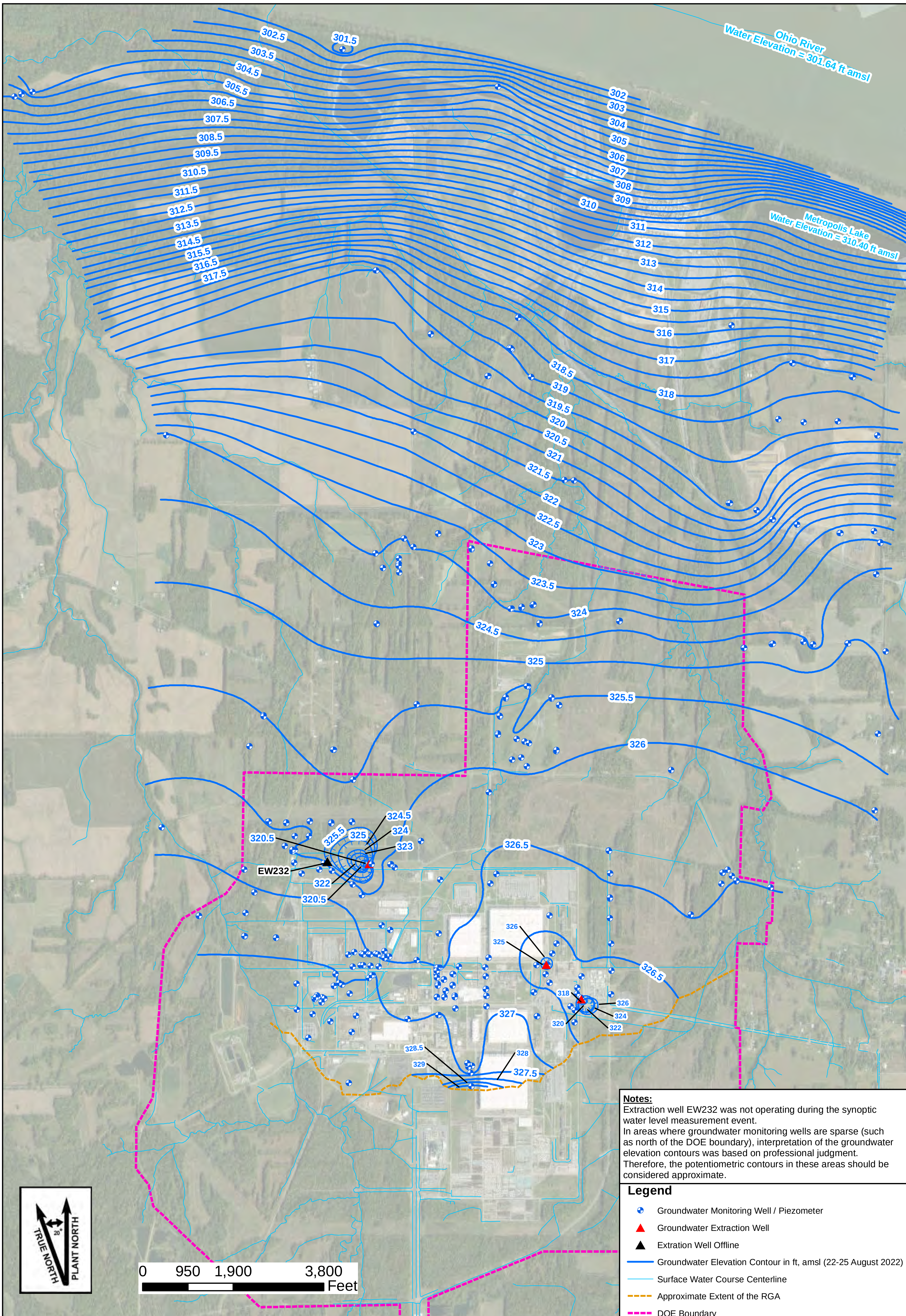

MAP SOURCE INFORMATION

Map Generation Date and Location - 9/22/2022 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\August 2022 Potentiometric Surface Map 9_28_22.mxd
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 3.23. Sitewide Potentiometric Map for August 2022

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Attachment 3

Surface Water and Sediment Samples from Lower Reach of Little Bayou Creek

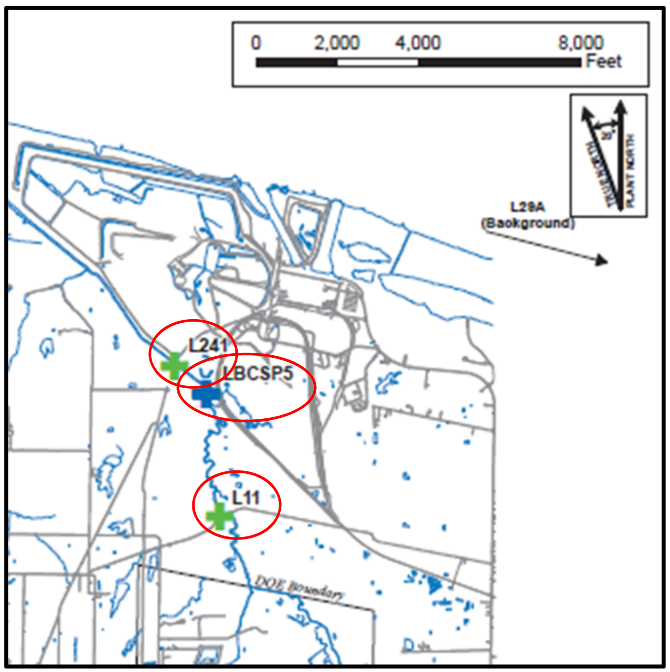
Surface Water and Sediment Samples from Lower Reach of Little Bayou Creek

DOE samples the lower reach of Little Bayou Creek at three locations for surface water and two locations for sediment.

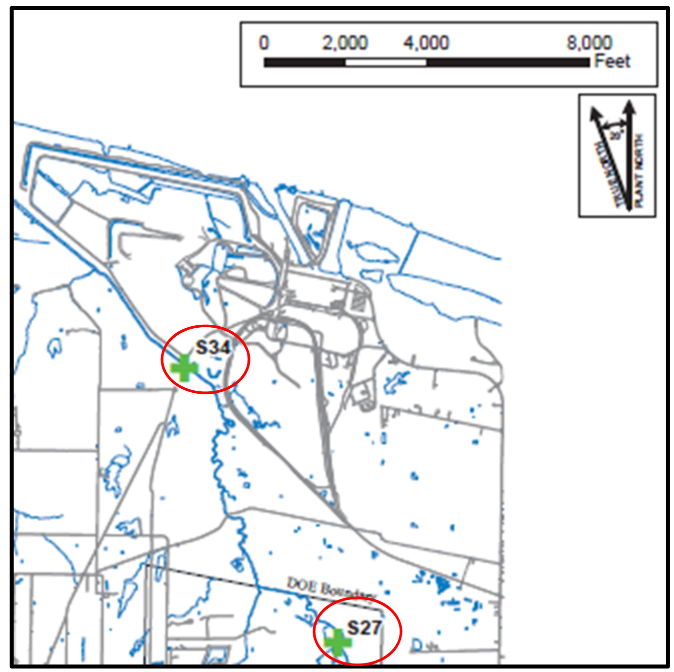
Surface water analyses are available for the period 1991 through 2023 in PEGASIS. Few samples were collected between 1991 and 1996. Beginning in 1997, an average of eleven samples per year combined have been collected from the three surface water sample locations.

Sediment samples are available for the period 1999 through 2022 in PEGASIS. An average of four samples per year combined have been collected from the two sediment sample locations.

Surface Water Samples L11, L241, & LBCSP5



Sediment Samples S27 & S34



Maps excerpted from Figures C.16 and C.17 of *Environmental Monitoring Plan Fiscal Year 2024 Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, November 2023

Lower Reach of Little Bayou Creek: Surface Water Analyses Summary

SCREENING PARAMETERS AND MAJOR ANIONS AND CATIONS		TRACE METALS		ORGANICS		RADIONUCLIDES	
CHEMICAL_NAME	**STD_UNITS**	**CHEMICAL_NAME**	**STD_UNITS**	**CHEMICAL_NAME**	**STD_UNITS**	**CHEMICAL_NAME**	**STD_UNITS**
Alkalinity	ug/L	Aluminum	ug/L	Ammonia	ug/L	Activity of U-235	pCi/L
Conductivity	umho/cm	Antimony	ug/L	PCB-1016	ug/L	Alpha activity	pCi/L
Dissolved Oxygen	ug/L	Arsenic	ug/L	PCB-1221	ug/L	Americium-241	pCi/L
Flow Rate	mgd	Barium	ug/L	PCB-1232	ug/L	Beta activity	pCi/L
Hardness - Total as CaCO3	ug/L	Beryllium	ug/L	PCB-1242	ug/L	Cesium-134	pCi/L
pH	Std Unit	Cadmium	ug/L	PCB-1248	ug/L	Cesium-137	pCi/L
Suspended Solids	ug/L	Chromium	ug/L	PCB-1254	ug/L	Cobalt-60	pCi/L
Temperature	deg F	Cobalt	ug/L	PCB-1260	ug/L	Dissolved Alpha	pCi/L
Turbidity	NTU	Copper	ug/L	PCB-1268	ug/L	Dissolved Beta	pCi/L
Ammonia as Nitrogen	ug/L	Iron	ug/L	Polychlorinated biphenyl	ug/L	Neptunium-237	pCi/L
Calcium	ug/L	Lead	ug/L	Trichloroethene	ug/L	Plutonium-238	pCi/L
Chloride	ug/L	Manganese	ug/L			Plutonium-239/240	pCi/L
Cyanide	ug/L	Nickel	ug/L			Potassium-40	pCi/L
Magnesium	ug/L	Selenium	ug/L			Suspended Alpha	pCi/L
Mercury	ug/L	Silver	ug/L			Suspended Beta	pCi/L
Nitrate/Nitrite as Nitrogen	ug/L	Thallium	ug/L			Technetium-99	pCi/L
Phosphorous	ug/L	Total Uranium	ug/L			Thorium-228	pCi/L
Potassium	ug/L	Uranium	ug/L			Thorium-230	pCi/L
Sodium	ug/L	Vanadium	ug/L			Thorium-232	pCi/L
		Zinc	ug/L			Thorium-234	pCi/L
						Uranium	pCi/L
						Uranium-234	pCi/L
						Uranium-235	pCi/L
						Uranium-238	pCi/L
COUNT OF ADDITIONAL ANALYSES							
L11: 4		L11: 1		L11: 0		L11: 9	
L241: 0		L241: 2		L241: 76		L241: 4	
LBCSP5: 6		LBCSP5: 0		LBCSP5: 102		LBCSP5: 8	

Lower Reach of Little Bayou Creek: Sediment Analyses Summary

SCREENING PARAMETERS AND MAJOR ANIONS AND CATIONS		TRACE METALS		ORGANICS		RADIONUCLIDES	
CHEMICAL_NAME	STD_UNITS	CHEMICAL_NAME	STD_UNITS	CHEMICAL_NAME	STD_UNITS	CHEMICAL_NAME	STD_UNITS
Grain Size Diameter	%	Aluminum	ug/kg	PCB-1016	ug/kg	Activity of U-235	pCi/g
Grain Size Diameter Fines	%	Antimony	ug/kg	PCB-1221	ug/kg	Alpha activity	pCi/g
Moisture	%	Antimony, Dissolved	ug/kg	PCB-1232	ug/kg	Alpha activity	pCi/kg
Moisture	wt %	Arsenic	ug/kg	PCB-1242	ug/kg	Americium-241	pCi/g
Particle Size	%	Arsenic, Dissolved	ug/kg	PCB-1248	ug/kg	Americium-241	pCi/kg
Percent Moisture	%	Barium	ug/kg	PCB-1254	ug/kg	Beta activity	pCi/g
Total Organic Carbon (TOC)	ug/kg	Barium, Dissolved	ug/kg	PCB-1260	ug/kg	Beta activity	pCi/kg
Calcium	ug/kg	Beryllium	ug/kg	PCB-1268	ug/kg	Cesium-137	pCi/g
Magnesium	ug/kg	Cadmium	ug/kg	Polychlorinated biphenyl	ug/kg	Cesium-137	pCi/kg
Mercury	ug/kg	Cadmium, Dissolved	ug/kg			Cobalt-60	pCi/g
Potassium	ug/kg	Chromium	ug/kg	147 Other Organic Parameters	ug/kg	Cobalt-60	pCi/kg
Sodium	ug/kg	Chromium, Dissolved	ug/kg			Neptunium-237	pCi/g
Sodium, Dissolved	ug/kg	Cobalt	ug/kg			Neptunium-237	pCi/kg
		Copper	ug/kg			Plutonium-238	pCi/g
		Copper, Dissolved	ug/kg			Plutonium-239/240	pCi/g
		Iron	ug/kg			Plutonium-239/240	pCi/kg
		Iron, Dissolved	ug/kg			Potassium-40	pCi/g
		Lead	ug/kg			Potassium-40	pCi/kg
		Lead, Dissolved	ug/kg			Technetium-99	pCi/g
		Manganese	ug/kg			Technetium-99	pCi/kg

Lower Reach of Little Bayou Creek: Sediment Analyses Summary (Continued)

SCREENING PARAMETERS AND MAJOR ANIONS AND CATIONS

CHEMICAL_NAME	STD_UNITS

TRACE METALS

CHEMICAL_NAME	STD_UNITS
Nickel	ug/kg
Selenium	ug/kg
Selenium, Dissolved	ug/kg
Silver	ug/kg
Thallium	ug/kg
Thallium, Dissolved	ug/kg
Total Uranium	ug/kg
Uranium	ug/kg
Uranium, Dissolved	ug/kg
Uranium-234	ug/kg
Uranium-235	wt %
Uranium-235	ug/kg
Uranium-238	ug/kg
Vanadium	ug/kg
Vanadium, Dissolved	ug/kg
Zinc	ug/kg
Zinc, Dissolved	ug/kg

ORGANICS

CHEMICAL_NAME	STD_UNITS

2,377 Analyses/13% Detections
87 PCB detections
26 PAH detections
137 SVOA detections
59 VOA detections

RADIONUCLIDES

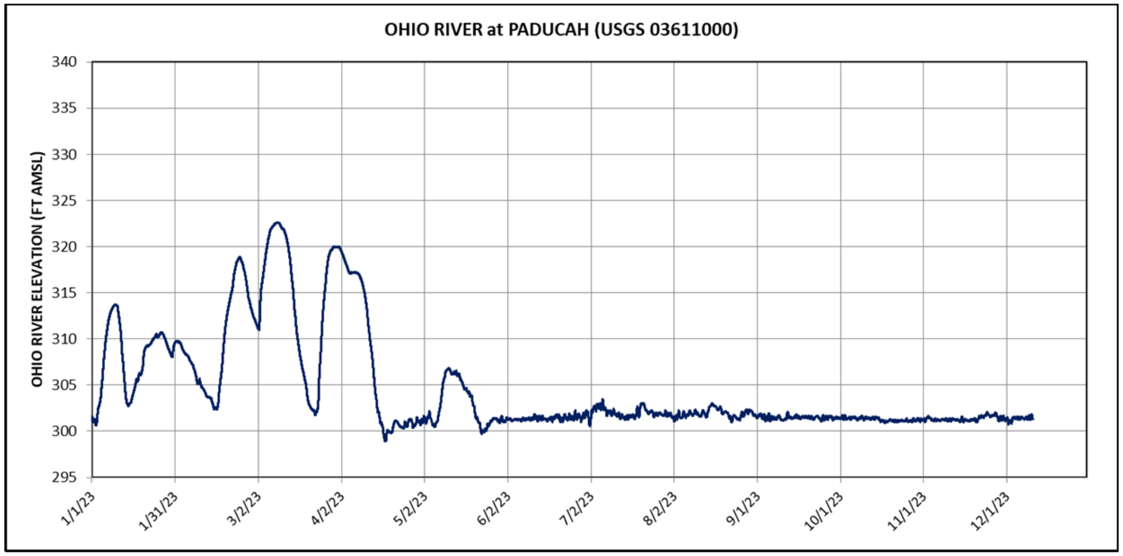
CHEMICAL_NAME	STD_UNITS
Thorium-228	pCi/g
Thorium-230	pCi/g
Thorium-230	pCi/kg
Thorium-232	pCi/g
Thorium-234	pCi/g
Total Uranium	pCi/g
Uranium	pCi/kg
Uranium-234	pCi/g
Uranium-234	pCi/kg
Uranium-235	pCi/g
Uranium-235	pCi/kg
Uranium-238	pCi/g
Uranium-238	pCi/kg

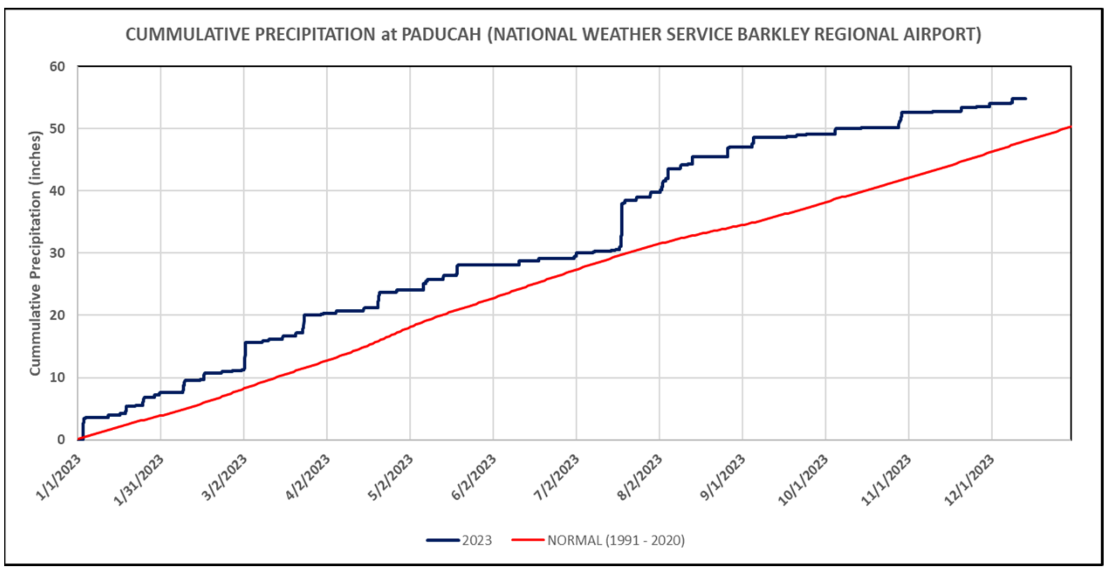
COUNT OF ADDITIONAL ANALYSES

Screening Parameters and Major Anions and Cations	Trace Metals	Organics	Radionuclides
S27: 0	S27: 0	S27: 0	S27: 0
S34: 0	S34: 0	S34: 1	S34: 0

Attachment 4

Precipitation and Ohio River Stage Data


OHIO RIVER at PADUCAH (USGS 03611000)
OHIO RIVER ELEVATION (FT AMSL)
340
335
330
325
320
315
310
305
300
295
1/1/23
1/31/23
3/2/23
4/2/23
5/2/23
6/2/23
7/2/23
8/2/23
9/1/23
10/1/23
11/1/23
12/1/23


CUMMULATIVE PRECIPITATION at PADUCAH (NATIONAL WEATHER SERVICE BARKLEY REGIONAL AIRPORT)
Cummulative Precipitation (inches)
60
50
40
30
20
10
0
1/1/2023
1/31/2023
3/2/2023
4/2/2023
5/2/2023
6/2/2023
7/2/2023
8/2/2023
9/1/2023
10/1/2023
11/1/2023
12/1/2023
2023
NORMAL (1991 - 2020)

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APPENDIX C

PADUCAH SITE GROUNDWATER MODELING WORKING GROUP MEETING SUMMARY—APRIL 3, 2024

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ACRONYMS[1]

AIP	agreement in principle
amsl	above mean sea level
AT123D	analytical transient 1-, 2-, 3-dimensional
CB	colloidal borescope
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CRS	comment response summary
CSM	conceptual site model
DOE	U.S. Department of Energy
DTW	depth to water
EMP	environmental monitoring plan
EPA	U.S. Environmental Protection Agency
ETAS	Enterprise Technical Assistance Services, Inc.
FRNP	Four Rivers Nuclear Partnership, LLC
FS	feasibility study
FY	fiscal year
GW	groundwater
GWSP	groundwater strategy project
KRCEE	Kentucky Research Consortium for Energy and the Environment
KY	Commonwealth of Kentucky
LBCSP	Little Bayou Creek seep
MEPAS	multimedia environmental pollutant assessment system
MNA	monitored natural attenuation
MODFLOW	modeling program
MW	monitoring well
MWG	Modeling Working Group
NWP	Northwest Plume
OREIS	Oak Ridge Environmental Information System
OU	operable unit
PEGASIS	PPPO Environmental Geographic Analytical Spatial Information System
PGDP	Paducah Gaseous Diffusion Plant
P-QAPP	programmatic quality assurance project plan
PT	pressure transducer
PTS	pump and treat system
PZ	piezometer
Q	quarter
RFP	request for proposal
RGA	Regional Gravel Aquifer
RI	remedial investigation
SESOIL	seasonal soil model
SI	site investigation
SWMU	solid waste management unit
SWP	Southwest Plume
TBD	to be determined
TIC	top of inner casing
TVA	Tennessee Valley Authority
UCRS	upper continental recharge system

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

VI	vapor intrusion
WDA	waste disposal alternative

Paducah Site Groundwater Modeling Working Group
Meeting Summary—April 3, 2024

MWG Attendees:

DOE
Tom Reed ✓

ETAS
Martin Clauberg ✓
Bruce Stearns ✓
Tracy Wood

KRCEE
Steve Hampson ✓
Alan Fryar ✓

TVA
Matthew Alpin ✓
Tabitha Ester
Anna Fisher
Jeffrey Frazier (WSP) ✓
Eric Wallis

EPA and Contractors
Noman Ahsanuzzaman
Ben Bentkowski
Eva Davis ✓
Jonathan Dziekan
Bei Huang ✓
Mac McRae ✓
Victor Weeks ✓

Kentucky
Stephanie Brock
Mary Evans
Nathan Garner ✓
Will Grasch ✓
Brian Lainhart
Todd Mullins
Bart Schaffer
Sonja Smiley
April Webb ✓

FRNP
Evan Clark ✓
Bryan Clayton
Sarah Cronk
Ken Davis ✓
Bruce Ford ✓
Stefanie Fountain ✓
Josue Gallegos ✓
Emilye Garner ✓
LeAnne Garner
Jeffrey King
Bruce Meadows
Karen Price ✓
Dawit Yifru ✓

✓ 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. Additions or revisions to the agenda items are noted in [].

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

Tom Reed is the now PPPO contact for the MWG:
Office: 859-219-2838 / Email: Tom.Reed@pppo.gov

No comments were received on the 1/13/2024 Meeting Summary (sent to participants on 2/15/2024). This summary will be considered final.

No additional comments were received to the 1/3/2024 Meeting Summary. The revised meeting summary for the 10/4/2023 Meeting will be sent to the MWG with this meeting's summary.

2. FY 2024 Work Plan/Schedule

Activity	Date
~~Quarterly Meeting (October/FY 2024Q1)~~	~~10/4/2023~~
~~MWG Concurs with FY 2024 Work Plan~~	~~11/3/2023~~
~~Quarterly Meeting (January/FY 2024Q2)~~	~~1/10/2024~~

Activity	Date
~~Submit Draft MWG Compilation (FY 2023) to MWG~~	~~1/12/2024~~
~~MWG Provide Comments on Draft MWG Compilation (FY 2023)~~	~~2/11/2024~~
~~Submit Final MWG Compilation (FY 2023)~~	~~3/10/2024~~
Quarterly Meeting (April/FY 2024Q3)	4/3/2024
Quarterly Meeting (July/FY 2024Q4)	7/17/2024

Note: White Papers will be added to schedule once the FY2024 Groundwater Strategy Project (GWSP) Project Management Plan (PMP) schedule is finalized. See Agenda Item 5 for additional information.

The group did not have questions or comments this agenda item.

3. Draft FY 2024+ Work Plan/Schedule

Activity	Date
Provide Draft Agenda Including FY 2025 Work Plan/Schedule (October/FY 2025Q1) to MWG	10/2/2024
Quarterly Meeting (October/FY 2025Q1)	10/9/2024 (Planning date)

The group did not have questions or comments this agenda item.

4. Update on Water Levels

Synoptic water level events are being collected quarterly. The potentiometric map for the synoptic water level event for 11/13-17/2023 and the November 2023 groundwater elevation data for TVA wells collected by KY are included in Attachment 1. Potentiometric maps will be included in the annual MWG compendia.

M. Alpin (TVA) shared that TVA is planning to install six new monitoring wells (five screened in the RGA and one screened above the RGA). TVA plans to share a map of the new wells as well as the boring logs and well installation logs with K. Davis (FRNP) who will share these with the rest of the group, as appropriate.

5. Update on Paducah Site Groundwater Strategy

The GWSP is a multi-year plan with multiple activities planned. The specific timing and scope of each activity are developed by DOE based on data collected in the prior year(s).

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

- Change status of two Environmental Indicator (EI) Performance Measures to "Yes"
    - Human exposure under control
    - Groundwater migration under control
- Resolution of data needs
- Groundwater Modeling Working Group (MWG) recommended model [uncertainties]

The activities defined in the GWSP PMP include:

Activity No.	Issue of Concern
Human Exposure Under Control	
1	TCE Extent West of PGDP (SW Plume)
2	TCE Extent East of PGDP (Downgradient NE Plume)
3	North Extent of PGDP TCE Plumes (Impact to Ohio River)
4	Nature and Extent of Contaminants Currently Contributed by Little Bayou Creek Seeps
5	Nature and Extent of Dissolved-Phase Contaminants Other than TCE and technetium-99 (Tc-99)
Groundwater Migration Under Control	
6	Capture Efficiency of NW Plume EWs
7	TCE Extent and Trends in East Side of Downgradient NW Plume
8	TCE Extent and Trends in West Side of Downgradient NE Plume
9	RGA Dissolved-Phase and DNAPL Contaminant Impacts to the McNairy Formation
Groundwater MWG Inputs	
10	Characterize Underflow from the Terrace Area
11	Expansion of Groundwater Monitoring Network
12	Water Balance Study
13	Continuous RGA Water Level Monitoring
14	Synoptic Water Level Measurement
15	Water Level Divide Study
16	Hydraulic Conductivity
Additional Activities	
17	MW Survey Study
18	Groundwater Chemical Trend Evaluation
19	TCE Degradation Rates

The final FY 2024 GWSP PMP has been approved by DOE and includes:

- Collection of quarterly synoptic water levels during FY 2024 (Activity 14)
- Water level collection for Activities 6 and 8
- Development of white papers for Activities 1, 2, 3, 7, 8, 9, 11, 13, and 15 (note that Activity 8 white paper has been substituted for Activity 5 white paper planned in the PMP in support of EI documentation)
- Scoping of FY 2025 and beyond tasks for activities 4, 8, and 10

The following three white papers (started as part of the FY 2023 GWSP PMP) have been reviewed by DOE and are in the process of being revised.

- Activity #1 White Paper: Regional and Localized Groundwater Flow and Trichloroethene Trends, West Side of the Southwest Plume
- Activity #2 White Paper: Regional and Localized Groundwater Flow and Trichloroethene Trends, East Side of Downgradient Northeast Plume
- Activity #3 White Paper: North Extent of Trichloroethene Plumes (Impact to Ohio River) at the Paducah Gaseous Diffusion Plant

These three white papers, combined with the Activity #8 white paper as well as the 2022 plume map update and other supporting analysis recently presented during the Groundwater Modeling Working

Group meetings, will be incorporated into the EI documentation determination that will be prepared to support the revision of the "groundwater under control" performance measure from "no" to "yes."

EPA is internally coordinating change of the "human exposure under control" performance measure from "insufficient data" to "yes" with consideration of the vapor intrusion studies that have been done at the site. EPA believes there will be agreement internally in FY2024 to update the Performance Measure of Human Exposure Under Control from "Insufficient Data" to "Yes" and that EPA noted they likely will be able to update the Performance Measure of Groundwater Migration Under Control from "No" to "Yes" for TCE and Tc-99.

During the October 2023 meeting, EPA noted that emerging contaminants will need to be factored into the EI determination. The group will discuss and consider guidance from EPA on emerging contaminants inclusion.

The group did not have questions or comments this agenda item.

Water Line Leaks. FRNP and KY continue to develop information related to the leak in the main raw water line from the Ohio River to the site. The location of the water line leak along Water Line Road is about a mile from the creek crossing. Repairs to the line and backfilling of the holes are in progress.

The group did not have questions or comments this agenda item.

Seeps. KRCEE will provide an update on their task to look at seeps using a drone equipped with FLIR (Forward Looking InfraRed).

S. Hampson and A. Fryar (KRCEE) provided an update on the seeps observations using drone-based thermal camera (DBTC) and noted that the preliminary results were promising. Two passes were performed along the majority of the reaches along Little Bayou Creek from Anderson Road to the confluence of Bayou Creek. Temperature signatures were observed at known seeps. A signature was also observed where Little Bayou Creek incises the RGA and the drone photography was good. Some areas were not able to be accessed with the drone. There was no evidence of beaver dams during the data collection. KRCEE plans to perform another deployment with a smaller drone in July and also plans to deploy fiber optic cable in the creek for distributed temperature sensing. KRCEE plans to provide a presentation to the group at the next meeting.

"No Go" Areas for Monitoring Well Installations. The topic is retained, but restructured to provide a look-ahead at planned or potential changes rather than a backward look at changes. Several standing questions on this topic will be developed and included in future MWG meeting agendas.

- **Planned site activities with potential to impact Monitoring Well Installations?** Reprioritization of remedial projects is included in the approved 2023 Site Management Plan.
- **Applicable Quarterly Kentucky Department Fish & Wildlife Resources (KDFWR) meeting discussions?**
    - Meeting held 1/17/2024. The next meeting is scheduled for 4/3/2024. Discussion topics included:

  - DOE has pushed the electrical transmission line removal project to FY 2025.
  - Swift & Staley, Inc. (SSI) is reviewing the low water crossing.
  - Inspections within the West Kentucky Wildlife Management Area (WKWMA) are not anticipated this quarter, but fences at the iron bridge may be installed next quarter.
  - WKWMA updated everyone on the upcoming hunting seasons and large AKC Master Event in Early October (runs about 12 days).
- **Have any changes to the "No Go" Areas map occurred since the last meeting or map revision?** None known at this time.

The group did not have questions or comments this agenda item.

Sitewide Groundwater Model Update. The overarching goal of the model update is to develop a model to support remedial decision making. The update to the Paducah Site groundwater model is in progress. DOE Paducah, KRCEE, and DOE Savannah River National Laboratory (SRNL) have reviewed the model and report and have provided their feedback. The DOE Low-Level Waste Disposal Facility Federal Review Group (LFRG) provided an additional external review; the LFRG review of the model focus was different from the original intent of the model update. The lead modeler for the on-site waste disposal facility (OSWDF) model at PORTS has reviewed the model in preparation for resumption of the Waste Disposal Alternatives (WDA) project at Paducah. The revised report was submitted to DOE on 3/7/2024.

Review and "approval" or "acknowledgement" of the model will be discussed with the MWG. A meeting to brief the MWG will be scheduled. EPA noted that they plan to acknowledge and accept the model update. EPA has requested that the external reviewer comments be shared as part of the deliverable to EPA and KY. DOE will provide a summary of the comments as multiple comments are related to the potential performance assessment for an OSWDF and are not relevant to the Sitewide flow model.

Attachment 2 includes the presentation on the model for today's meeting.

K. Davis (FRNP) and J. Gallegos (FRNP/Geosyntec) provided a presentation to the group on the 2023 update to the Sitewide groundwater model. EPA discussed that their intent is to accept the model and agree to use the model as a tool in remedial decisions and planning. EPA had several questions on the model and will provide these in writing following the meeting. DOE shared that the path forward on the report is to provide comments to FRNP. The Report is expected to be made available to the group following revision to address the comments.

S. Hampson (KRCEE) discussed their concerns regarding the model over prediction of TCE results in the distal reaches of the plumes and that the modeled results in these distal areas do not reflect analytical TCE results. This over-prediction was discussed during the presentation and additional discussion on this feature of the model output is included in the report. KRCEE noted that they are in concurrence with the other model outputs.

6. Anthropogenic Recharge

This sub-topic will capture discussion on site changes, such as the recent changes to the high pressure fire water system. Development of a timeline to track changes to site operations that could impact the water balance at the site (e.g., removal of the high pressure fire water line from service, removal of the second raw water line from service, etc.) is being maintained. A water balance study (part of GWSP Activity #12) is included as an appendix to the 2023 modeling report. Historically, intake water volume was around 4 million gallons per day (mgd) and is now closer to 1 mgd as shown in the water balance study.

The group agreed by consensus to keep this topic on the agenda for the next meeting.

7. Plant-Wide Seismic Update

There was no evidence of faulting encountered during the C-400 remedial investigation. Kentucky Geological Survey (KGS) is working on regional compilation of seismic data focused on extents of the New Madrid centroid and on the northwest leg along the Mississippi River and that KGS plans to generate a report this year to summarize information compiled to date. KRCEE/KGS is updating some testing equipment.

The WDA project is included in the approved FY 2024 Site Management Plan (SMP) and candidate siting will be revisited as part of resuming the project. Prior discussions on seismic evaluation for siting an OSWDF concluded adequate information existed for a Remedial Investigation/Feasibility Study, but that additional seismic evaluation would be needed for actual siting of an OSWDF.

For the WDA project, DOE is working with UK to develop a site-wide seismic investigation under the current KRCEE grant in CY 2024. This project will include several planning meetings, including meetings with EPA, KY, and DOE HQ. The project would have four phases:

1. Planning phase with development of a statement of work in January. KRCEE or a contractor may perform proof of concept equipment testing during this phase.
2. Scoping meetings with FRNP in early February.
3. Scoping meetings with EPA/KY and DOE headquarters in late March.
4. Field mobilization by April or May with two phases of field work: a low-resolution investigation across site then high-resolution testing of 1-2 sites for OSWDF siting and design, including Holocene fault investigation.

The goal would be to complete the seismic project in FY 2024 to meet the OSWDF design and PA/CA schedules. Under the Decision 2029 schedule, the PA/CA must start no later than mid-2025. Several meetings have been held internally and a meeting with EPA was held 3/27/2024.

The seismic information collected is critical to development of the 90% design needed for completion of the Paducah OSWDF performance analysis/composite analysis (PA/CA) and Record of Decision (ROD) approval.

KRCEE has held several seismic project planning meetings with DOE, FRNP and then with EPA and KY. Data quality objectives (DQOs) were planned to be provided to DOE the week following the meeting. The intent remains to perform field work in the summer of 2024 and complete reporting by

March 2025. KRCEE is working with a subcontractor to develop field investigation methodologies and cost estimates. The scope of the project has been revised to focus on the candidate sites for on on-site waste disposal facility with a Sitewide seismic project to be evaluated later due to schedule and budget constraints. The latter is relevant to redevelopment discussions, including those associated with the Kentucky Nuclear Development Workgroup.

8. Precipitation and Ohio River Stage

Attachment 3 includes precipitation and Ohio River stage charts through mid-March 2024.

K. Davis (FRNP) shared the observation from the charts that the two earlier flood events on the chart are related to local precipitation, but that the third flood event was related to a high Mississippi River stage from precipitation elsewhere. January was a relatively wet month and February through April have been relatively dry.

9. Synoptic Water Level Events and Ohio River Levels

The location where the creeks shift from gaining to losing may impact the flow model (although the model is not very sensitive to this parameter) and is an area of interest to the group going forward. Select monitoring wells also continue to be monitored with pressure transducers and more frequent manual water level measurements as part of the GWSP and will be incorporated into selected White Papers.

See Items 5 and 8 for discussion relevant to this topic. No additional information was brought forward by the group in relation to this item.

10. Projects on the "Watch Topics" List

- **Emerging Contaminants**
  - PFAS
    - PFAS is discussed as part this working group and has ties to the Risk Assessment Working Group (RAWG) as well.
    - The Paducah Site continues to participate in the DOE HQ PFAS Working Group Meetings. Kelly Layne is a member of the DOE PFAS Coordinating Committee and DOE-EM PFAS Roundtable and plans to coordinate Paducah information and actions with Oak Ridge and Portsmouth.
      - The PFAS Coordinating Committee last met on 3/20/2024.
      - The DOE-EM PFAS Roundtable had its initial meeting on 12/6/2023. The second meeting was held 3/6/2024; Paducah presented PFAS investigation results (Fire Training Area and potable water) and the work plan/QAPP for the Site-wide PFAS Project at this meeting.
      - The DOE HQ PFAS Working Group last met on 2/21/2024.
      - The new DOE Region 4 Working Group is expected to meet soon.
      - The Paducah Site response to the DOE-EM annual PFAS survey was sent to DOE HQ at the end of January 2024. The survey is anticipated to be published by DOE in late FY 2024 and will be shared with this group if possible.

        - The DOE LFRG Memo on disposal of PFAS-containing waste is ready for signature but is being held until the release of the revised EPA and final DOE disposal guidance that are expected to be available in January 2024. This memo gives LFRG approval for disposal of PFAS-containing waste into facilities with Operating Disposal Authorization Statements, such as the PORTS OSWDF.
        - The DOE guidance on disposal of PFAS-containing waste is planned to be updated in early 2024. EPA guidance is expected to allow for disposal of PFAS waste in Subtitle D landfills. The use of U landfill for PFAS wastes would require DOE headquarters communication.
        - Paducah has a question into DOE HQ regarding the potential for disposal of PFAS or PFAS-containing materials in a Subtitle D landfill (e.g., the U-Landfill). A formal request to DOE HQ has not been made on this topic.
    - For Paducah, the main PFAS activity for FY 2024 is the in-progress PFAS screening assessment project.
        - Sampling is completed and a technical report is planned to be submitted to DOE by 3/28/2024.
        - The scope of the technical report will include: context, sampling performed, data quality objectives, and results. Scoping, including EPA HQ representatives, on the report outline was completed on February 22, 2024. Additional scoping meeting(s) will occur once briefings to DOE-PPPO and HQ are complete.
        - FY 2025 PFAS-related tasks, if developed, will be discussed with the FFA managers. Planning for the Northwest Plume groundwater treatment system includes the potential to update the system to include liquid phase carbon treatment to treat higher VOC concentrations. If added, the carbon should also address PFAS in extracted water.

The group did not have questions or comments this agenda item.

- 1,4-Dioxane
    - 1,4-dioxane was historically used as a stabilizer in 1,1,1-trichloroethane and dichloroethane.
    - The group plans to discuss fate & transport characteristics of 1,4-dioxane (compared to TCE) during a MWG meeting in FY 2024.
    - 1,4-dioxane is included in the analytical suite for projects, as appropriate.
    - 1,4-dioxane requires different treatment technology from what is currently part of the two site groundwater treatment systems.
    - The recently transmitted 2023 Five-Year Review includes a section summarizing emerging contaminant work at the Paducah Site, including the recent 1,4-dioxane results at C-400.

The group did not have questions or comments this agenda item and agreed by consensus to continue to track this item.

11. FY 2024 Site Management Plan (SMP)

The FY 2024 SMP included a preliminary plan for Decision 2029. The full plan for Decision 2029 is intended to be included in the FY 2026 SMP. The plan includes the reprioritization for site remedial projects, including (dates are for the D1 document submittals):

- C-400 area extraction well and Northwest Plume modification in 2025
- Environmental Media Record of Decision (ROD) in 2029
- Decontamination and Decommissioning Action Memorandum in 2029
- Waste Disposal Alternatives (WDA) and on-site waste disposal facility (OSWDF) ROD in 2029
- Final Consolidated Site Operable Unit (CSOU) ROD (date to be determined)

The group did not have questions or comments this agenda item.

12. Meeting Presentations

A presentation of the 2023 sitewide groundwater model will be shared during this meeting.

MWG members should provide any presentation requests to Stefanie. Potential topics for future meetings:

- Environmental Indicator analyses
- Lithology
- TCE degradation rates
- Site water balance items (e.g., leaks from piping, above and below ground piping, building foundation gravel layers, etc.)
- Topics from the Site Management Plan
- 1,4-dioxane fate and transport
- Seismic primer
- PFAS screening assessment project summary

A summary of the 2023 sitewide groundwater model was shared with the group (see discussion above).

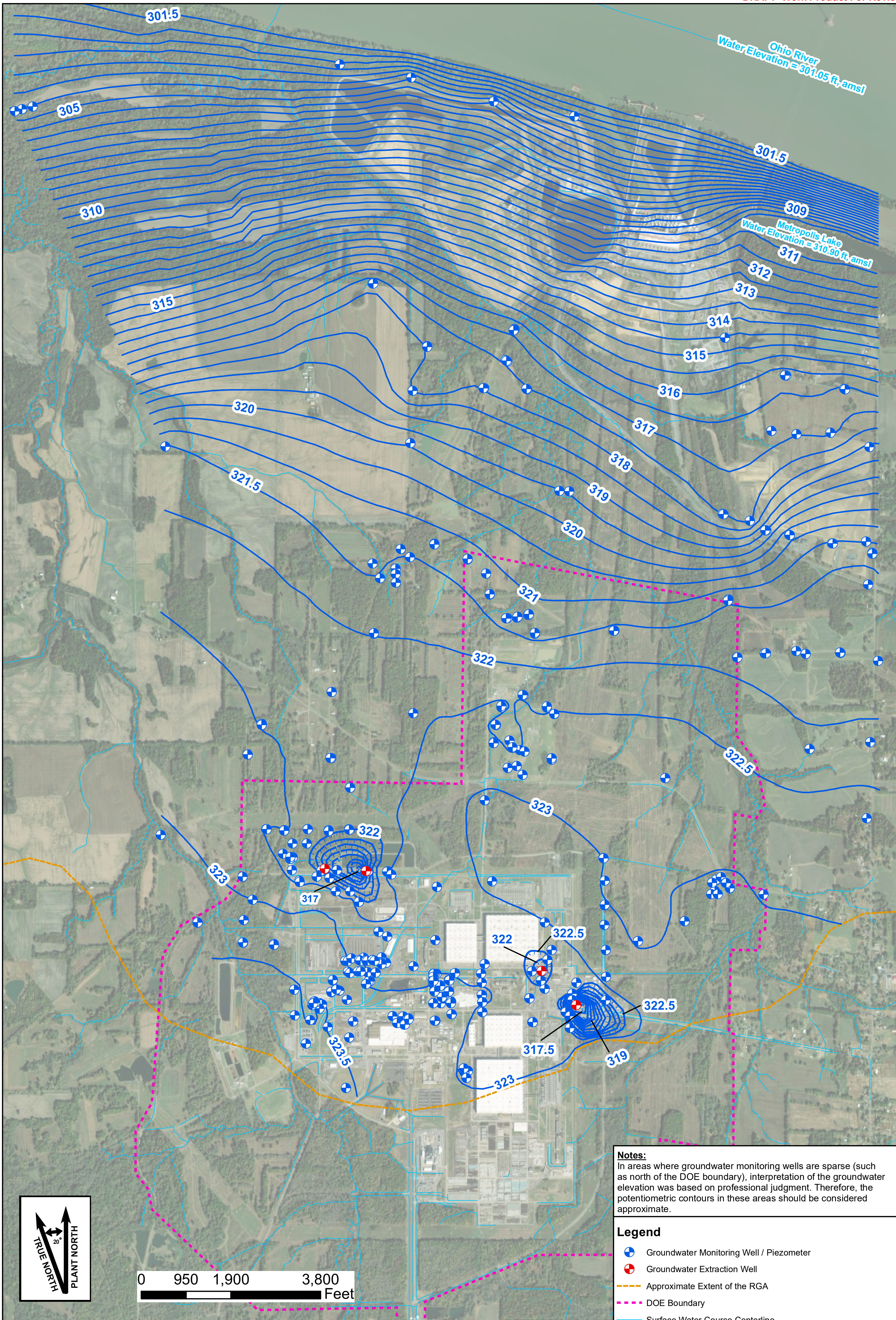
KRCEE plans to present on their work involving DBTC and stream/seeps surveys of Bayou Creek and Little Bayou Creek at the next quarterly meeting.

13. Poll MWG Members/Open Discussion

Attachment 1

Groundwater Strategy Potentiometric Map
November 2023

Groundwater Elevation Data for TVA Wells
November 2023



MAP SOURCE INFORMATION

Map Generation Date and Location - 01/16/2024 Geosyntec\\fedprojects-01\paducah$\Knoxville\GW Strategy\GIS\MXDs\2022-2023 Potentiometric Surface Maps
Map Layer Location: Geosyntec\\fedprojects-01\paducah$\Knoxville\GW Strategy\GIS\MXDs\2022-2023 Potentiometric Surface Maps\November 2023 Potentiometric Surface Map.mxd
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 provided by FRNP on 11/8/2022.
DOE Property Boundary provided by FRNP on 2/4/2021.
Northing and easting of wells obtained from Pegasis, downloaded on 6/14/2022.
Groundwater elevation was based on the 11/13/2023 - 11/17/2023 measurements. Groundwater elevation of extraction wells was measured on 11/13/2023 and was provided by FRNP on 11/29/2023.
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 11/13/2023 - 11/17/2023.
Groundwater elevation for the TVA wells were provided by the Kentucky Division of Waste Management letter to DOE (#KY8-890-008-982) dated 12/04/2023. Water elevation at Metropolis Lake was provided by FRNP on 11/20/2023.
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. November 2023 RGA Potentiometric Surface Map

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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	372.77	369.38	760787.88	1946731.54	Active	65.2	75.2	307.57	297.57	318.18	54.59	11/30/2023_1011	29.60	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	316.85	55.70	11/30/2023_1014	29.60	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	317.02	52.24	11/30/2023_1017	29.60	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	316.79	50.11	11/30/2023_1020	29.60	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	321.02	51.80	11/30/2023_1009	29.60	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	317.37	57.57	11/30/2023_1026	29.60	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	305.01	27.15	11/30/2023_1232	29.57	TOC
TVA-D30B	SHF-D30B	2" PVC	Upper RGA	324.36	320.6	757594	1955563.41	Active	42.7	52.7	281.66	271.66	298.68	25.68	11/30/2023_1236	29.57	TOC
TVA-D17	SHF-D17	2" PVC	Upper RGA	365.43	362.8	758809.17	1950015.71	Active	14	17	351.43	348.43	314.63	50.80	11/30/2023_1222	29.57	TOC
TVA-D11B	SHF-D11B	2" PVC	Upper RGA	321.79	319.2	753434.76	1958481.44	Active	32	42	315.75	305.45	302.69	19.10	11/30/2023_1245	29.57	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	304.49	19.26	11/30/2023_0937	25.59	TOC
SHF-201B	SHF-201B	4" PVC	Upper RGA	323.75	320.2	746641.107	1960082.768	Active	32	37	291.75	286.75	304.71	19.04	11/30/2023_0938	25.59	TOC
SHF-201A	SHF-201A	4" PVC	Upper RGA	323.75	320	747030.226	1960036.252	Active	14.5	24.5	309.25	299.25	304.6	19.15	11/30/2023_0939	25.59	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	318.01	44.84	11/30/2023_0952	29.60	TOC
SHF-101G	SHF-101G	4" PVC	Upper RGA	322.43	318.8	754685.75	1957635.07	Active	32	37.3	290.43	285.13	304.59	17.84	11/30/2023_1242	29.57	TOC
Ohio River Elevation						831.9815	14996.63							300	11/30/2023_1255	29.57	TVA Inlet

LEGEND:

TOC: Top of Casing

DTW: Depth to Water

National Geodetic Vertical Datum of 1929 (NGVD 29).

Attachment 2

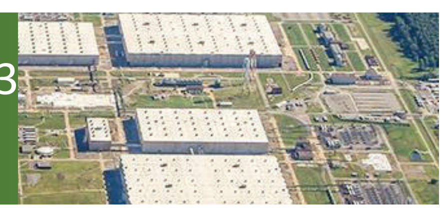
2023 Sitewide Groundwater Model Update

2023 Sitewide Groundwater Flow Model Update
Project Briefing for DOE LFRG

DRAFT Work Product – For Discussion Only

Presentation Outline

- Modeling Team
- Modeling Objective and Scope
- Conceptual Site Model (CSM)
- Groundwater (GW) Flow Model
- Fate & Transport (F&T) Model
- 2016 Model recommendations



2023 Modeling Team

DOE

- Rich Bonczek

FRNP/Geosyntec Consultants

- Stefanie Fountain –Project Manager
- Ken Davis – Lead Geologist
- Denise Tripp* - Lead GW modeler
  * Retired
- Jeffrey King - Lead GW modeler
- Josue Gallegos – Data Visualization* and GW Modeler
  * Using Environmental Visualization System (EVS)
- Corey Wallace – GW Modeler
- Dawit Yifru – Data Management (GW Strategy Program)

Falta Environmental

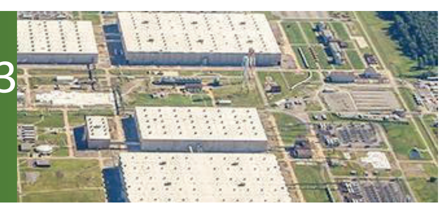
- Ron Falta – Modeling Strategy and Peer Review

DOE/ETAS

- Martin Clauberg
- Tracy Taylor
- Bruce Stearns

SRNL Technical Review

- Brian Looney

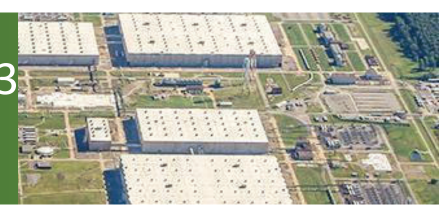


SRNL Role and Project Expectations

Provide an independent, third-party review of the 2016 GW Model Update:

- Review historical modeling documents including 2008, 2012, and 2016 GW model updates and Kentucky Research Consortium for Energy and Environment (KRCEE) fate and transport modeling.
- Attend team meetings as requested with the U.S. Department of Energy (DOE) and FRNP to discuss historical modeling (i.e., kickoff meeting), modeling approach, model calibration, and model sensitivity/uncertainty.
- Attend Quarterly Modeling Working Group (MWG*) Meetings.
- Attend periodic meetings to update the MWG.
- Review and provide input to the 2023 GW Model Update Report.

* MWG includes DOE, ETAS, FRNP, KRCEE, EPA, and KDEP



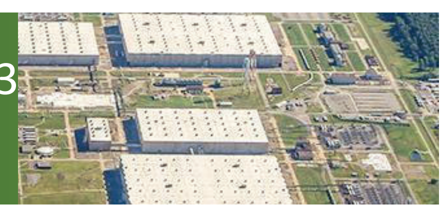
Modeling Objective and Scope

Objective:

- Update the 2016 GW Model to:
  - Address uncertainties
  - Obtain concurrence from the U.S. Environmental Protection Agency (EPA)and Kentucky Department for Environmental Protection (KDEP)
  - Support environmental restoration, demolition, and waste disposal projects
    - Remedial decisions for the dissolved phase plume and source areas
    - Siting, design, and approval for construction and operation of a future CERCLA disposal facility

Scope:

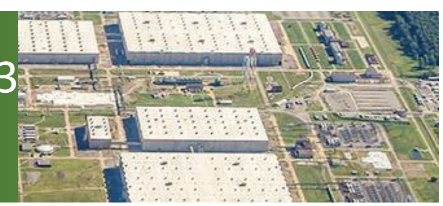
- Evaluate available data to address uncertainties identified for the 2016 GW Model
- Incorporate new available data into the 2016 GW Model to simulate current conditions
- Calibrate the GW flow model to wet (transient) and dry (steady-state) conditions
- Develop a fate and transport (F&T) model
- Iterate: inform flow model with F&T model; inform F&T model with flow model



Model Codes Employed

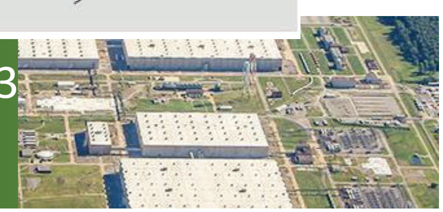
- MODFLOW
- MT3D
- PEST
- REMChlor
- HELP

Conceptual Site Model (CSM)



Paducah & Geologic Provinces of the U.S.

Paducah Site
- Located at north end of Mississippi Embayment
- Nashville Arch was source of Lower Continental Deposits gravel



Surface Hydrology of the PGDP

Yellow highlighting marks the primary stretches of Bayou and Little Bayou Creek.

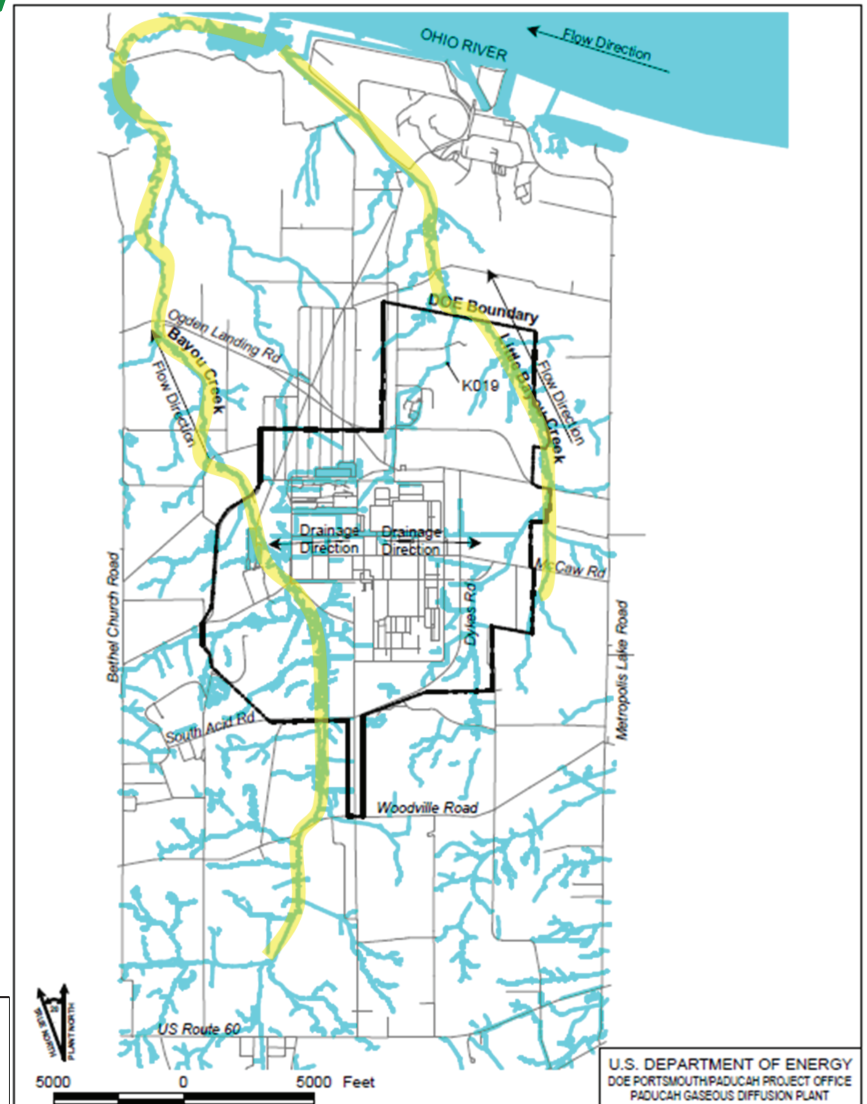
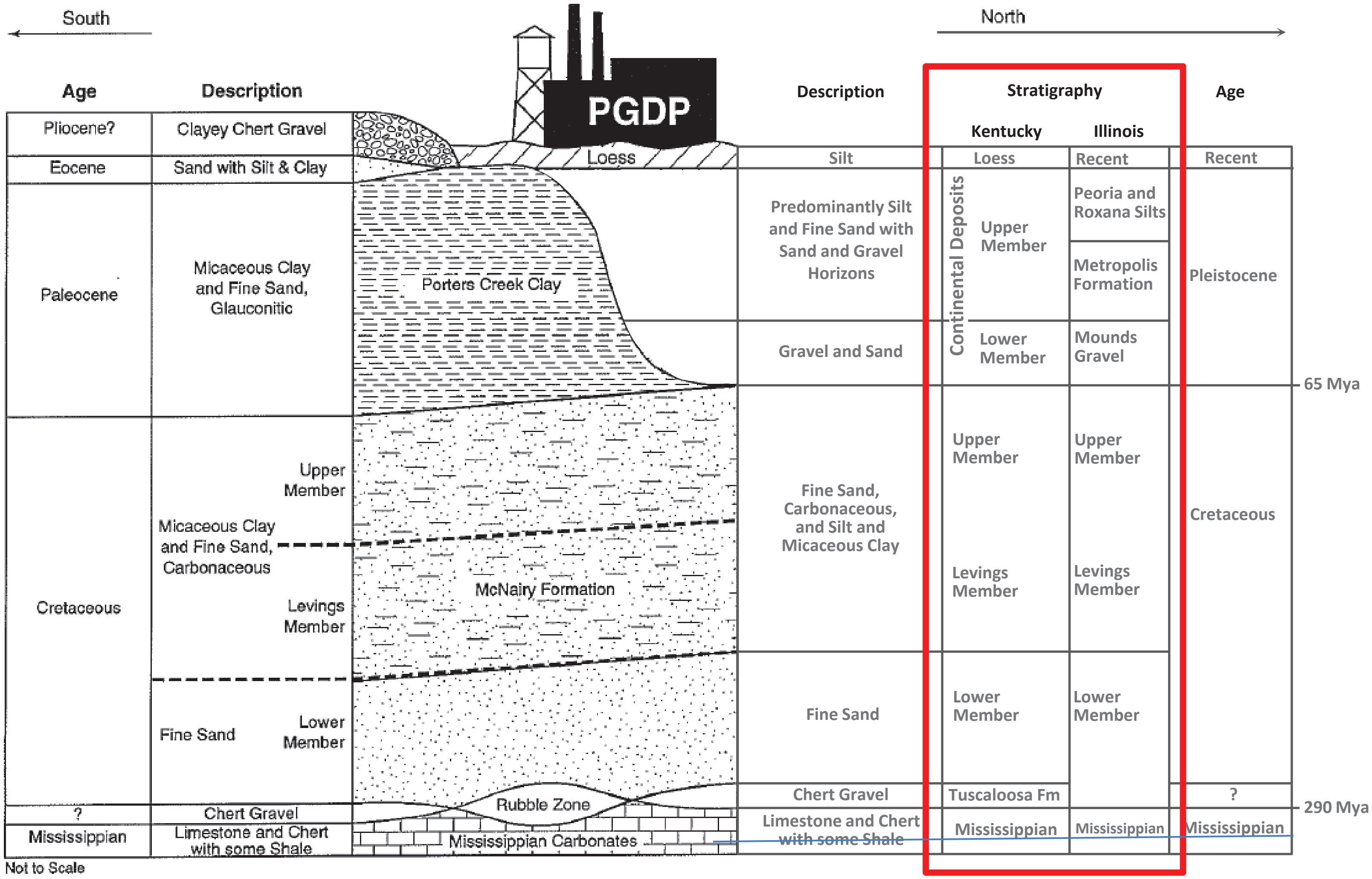


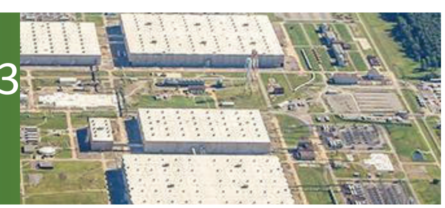
Figure 3.3. Surface Water Features in the Vicinity of the DOE Site

Adapted from *Surface Water Operable Unit (On-Site) Site Investigation and Baseline Risk Assessment Report at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, 2008

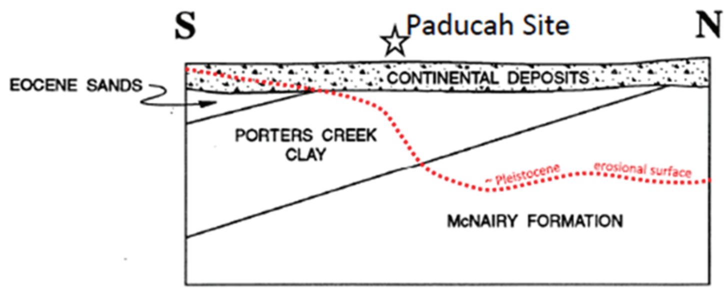
C-28

Kentucky vs Illinois Stratigraphy



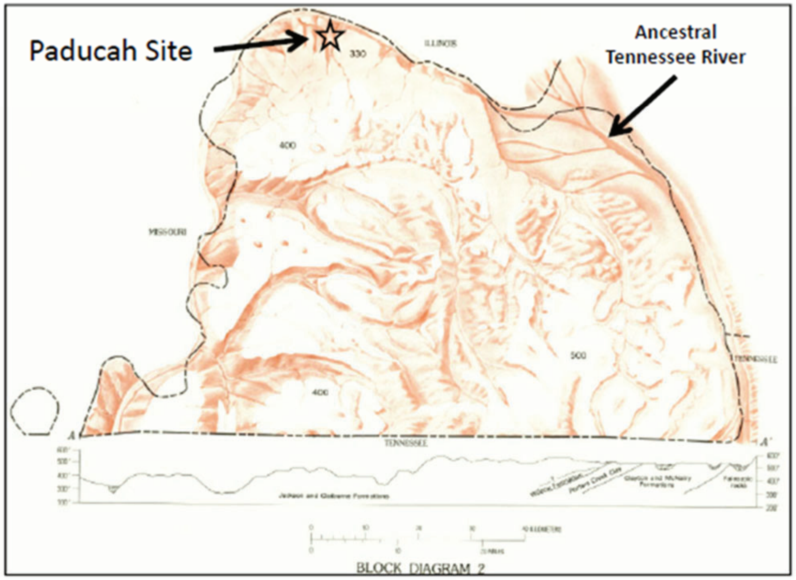


Generalized Depositional Sequence for the Continental Deposits: Miocene(?)-Pliocene



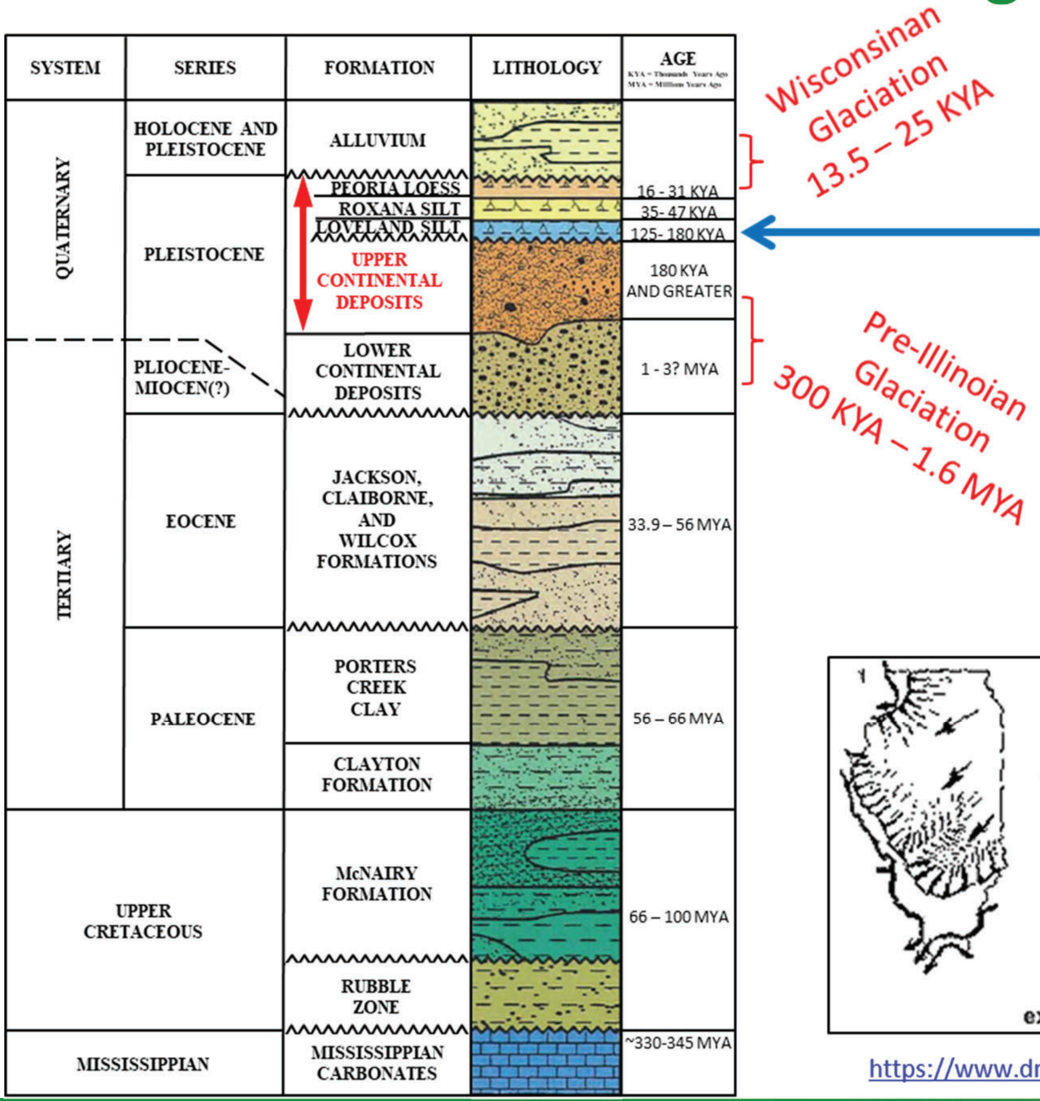
(A)

During the Miocene (?)-Pliocene, alluvial fan deposits blanketed the site.

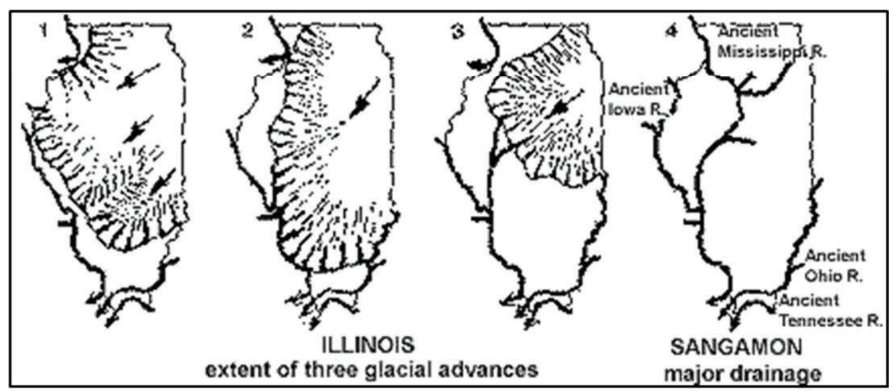


Initial Deposition of Jackson Purchase Alluvial Fan
U.S.G.S. Map I-1217

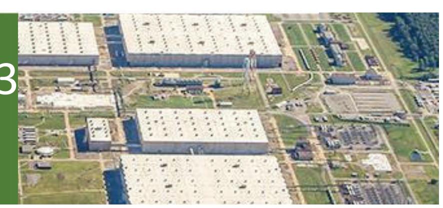
Paducah Site Geologic Column



C-30



https://www.dnr.illinois.gov/education/Pages/SchwegmanGlacier.aspx



PADUCAH GW FLOW SYSTEMS

Jackson Purchase Stratigraphy

Adapted from *Geologic Map of Kentucky*, Kentucky Geological Survey, 2009

MAPPED UNITS OF WEST-CENTRAL KENTUCKY AND JACKSON PURCHASE REGION (WESTERN KENTUCKY) (NOTE: NOT ALL UNITS LABELED)

UCRS

RECENT

af	Artificial fill (compacted rock debris from highway, railroad, and reservoir construction; or mine tailings)

QUATERNARY

Qal	Alluvium
Qe	Eolian sand, dune sand
Qala	Alluvium and lacustrine deposits
Qao	Older alluvium
Qt	Terrace deposits
Qlt	Lacustrine and terrace deposits
Qlf	Lacustrine and fluvial deposits
Qcd	Glacial outwash, Cary substage
Qtd	Glacial outwash, Tazewell substage
Ql	Loess
sd	Sand and silt deposits, sand of alluvium, lacustrine, and fluvial deposits
gr	Gravel of alluvium, lacustrine, and fluvial deposits

RGA

TERTIARY and QUATERNARY

QTc	Continental deposits
QTg	Chert gravel or gravel deposits

TERRACE

TERTIARY

Tj	Jackson Formation
Tc	Claiborne Formation
Tw	Wilcox Formation
Tp	Porters Creek Clay

McN

CRETACEOUS and TERTIARY

TKcm	Clayton and McNairy Formations

CRETACEOUS

Km	McNairy Formation
Kt	Tuscaloosa Formation

BEDROCK

PENNSYLVANIAN

IPmcl	McLeansboro Group
IPm	Mattoon Formation
IPbm	Bond and Mattoon Formations
IPb	Bond Formation
IPp	Patoka Formation
IPsh	Shelburn Formation
IPsc	Shelburn and Carbondale Formations
IPc	Carbondale Formation
IPt	Tradewater Formation
IPtc	Tradewater and Caseyville Formations
IPca	Caseyville Formation

MISSISSIPPIAN

Mcu	Chesterian series (upper part)
Mbw	Buffalo Wallow Formation
Ml	Leitchfield Formation
Mk	Kinkaid Limestone
Mkc	Kinkaid Limestone, Degonia Sandstone, and Clore Limestone
Mkp	Kinkaid Limestone, Degonia Sandstone, Clore Limestone, and Palestine Sandstone
Mdc	Degonia Sandstone and Clore Limestone
Mdm	Degonia Sandstone, Clore Limestone, Palestine Sandstone, and Menard Limestone
Mcp	Clore Limestone and Palestine Sandstone
Mpt	Palestine Sandstone
Mme	Menard Limestone
Mmt	Menard Limestone, Walterburg Sandstone, Vienna Limestone, and Tar Springs Sandstone
Mwv	Waltersburg Sandstone and Vienna Limestone
Mts	Tar Springs Sandstone
Mcm	Chesterian series (middle part)
Mgd	Glen Dean Limestone
Mh	Hardinsburg Sandstone
Mhgc	Hardinsburg Sandstone, Golconda Formation, and Cypress Sandstone
Mgo	Golconda Formation
Mgh	Haney Limestone Member
Mgb	Big Clifty Sandstone Member
Mgbc	Big Clifty Sandstone and Beech Creek Limestone Members
Mgcy	Big Clifty Sandstone Member and Cypress Sandstone
Mcl	Chesterian series (lower part)
Mgc	Beech Creek Limestone Member
Mgcc	Beech Creek Limestone Member and Cypress Sandstone
Mg	Girkin Formation
Me	Elwren Sandstone
Mr	Reelsville Limestone
Mrs	Reelsville Limestone and Sample Sandstone
Msa	Sample Sandstone
Mbp	Beaver Bend Limestone, Mooretown Formation, and Paoli Limestone
Mmoh	Mooretown Formation (shale member)
Mmos	Mooretown Formation (sandstone member)
Mc	Cypress Sandstone
Mcb	Cypress Sandstone, Paint Creek Shale, and Bethel Sandstone
Mpc	Paint Creek Limestone
Mpr	Paint Creek Limestone, Bethel Sandstone, and Renault Limestone
Mbe	Bethel Sandstone
Mre	Renault Limestone
Msg	Ste. Genevieve Limestone
Mssu	Ste. Genevieve Limestone and St. Louis Limestone, upper member
Mss	St. Louis Limestone and Salem Limestone
Msll	St. Louis Limestone, lower member
Ms	Salem Limestone
Msw	Salem and Warsaw Limestones
Mhb	Harrodsburg Limestone
Mw	Warsaw Formation
Mfp	Fort Payne Formation

DEVONIAN and MISSISSIPPIAN

MDc	Chattanooga Shale
Dsj	Sellersburg and Jeffersonville Limestones

SILURIAN

Slwl	Louisville Limestone, Waldron Shale, and Laurel Dolomite

ORDOVICIAN

Oc	Cumberland Formation

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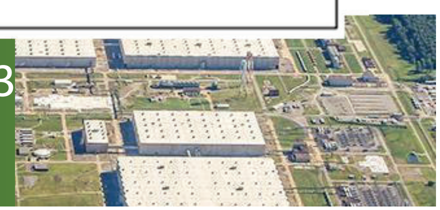
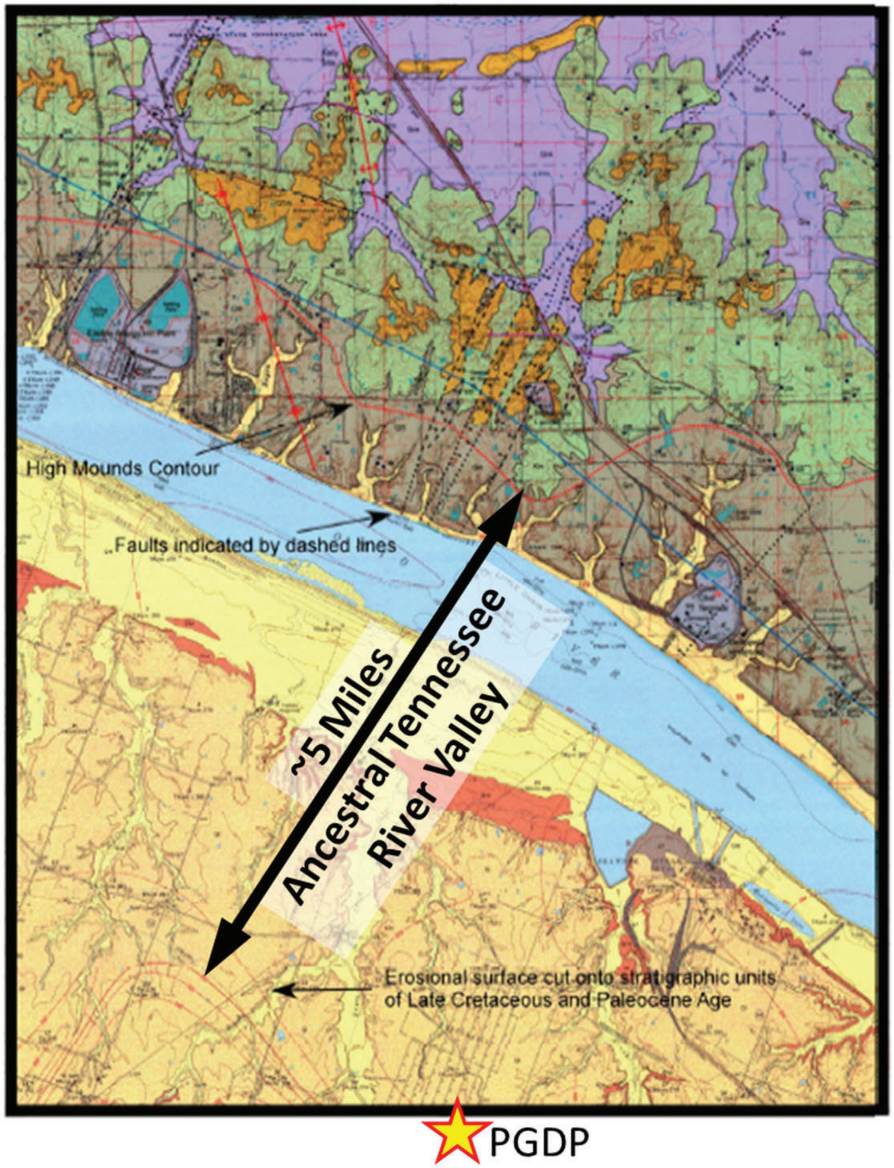
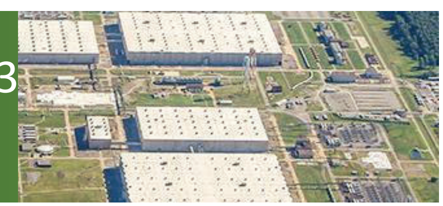


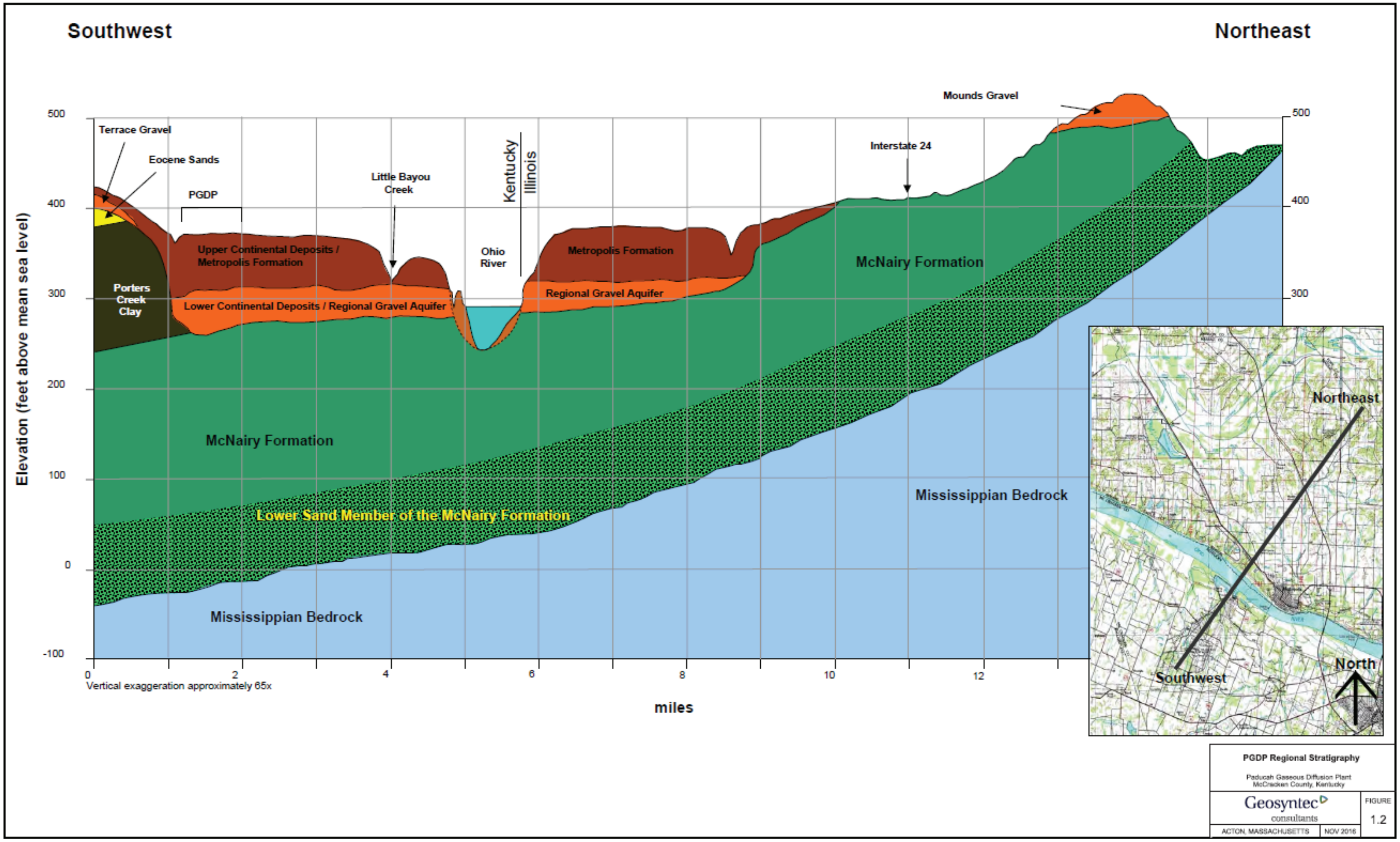
Paducah Site and Illinois Portion of Joppa Quadrangle



Adapted from *Lithologic and Stratigraphic Compilation of Near-Surface Sediments for the Paducah Gaseous Diffusion Plant, McCracken County, KY*, UK MS Thesis by John Sexton, 2006



Depositional/Erosional Structure



Source: Adapted from Paducah Remediation Services, 2009; Figure 1
Note: Regional Gravel Aquifer thickness is variable. See Figure 3.4.

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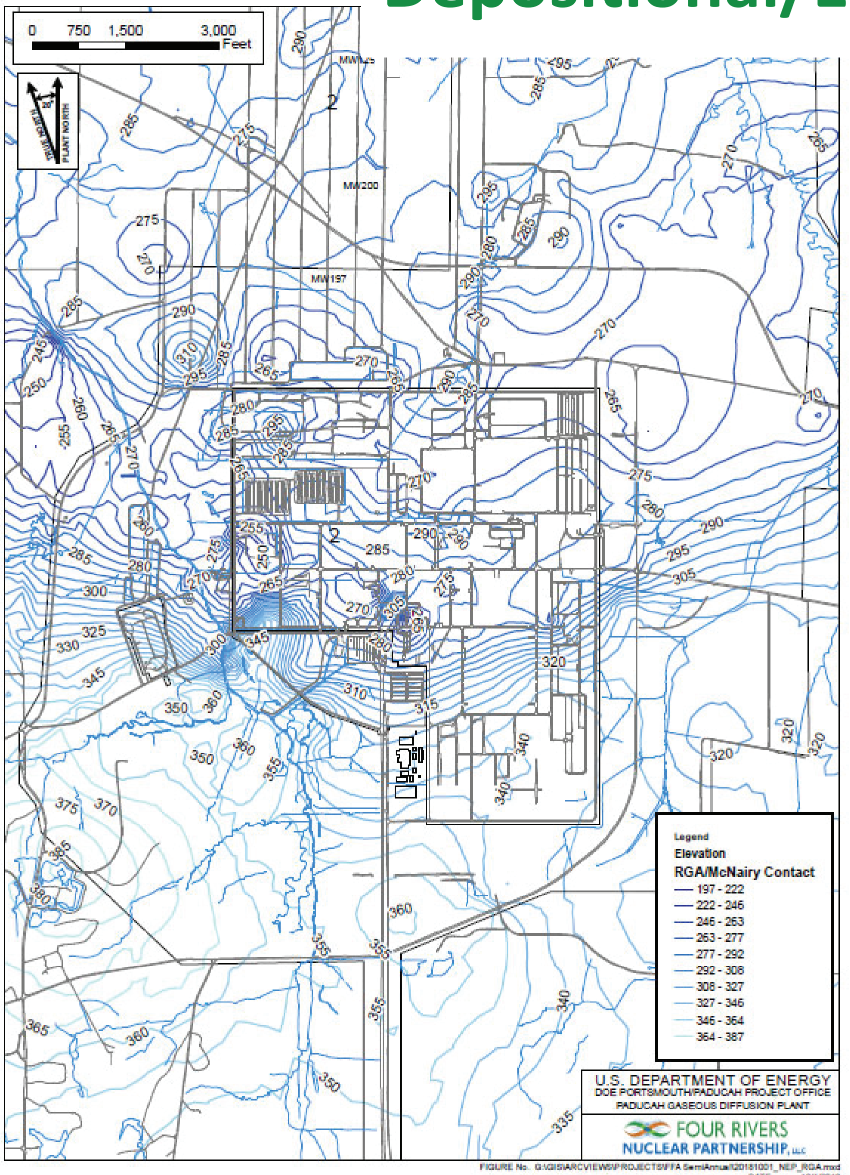
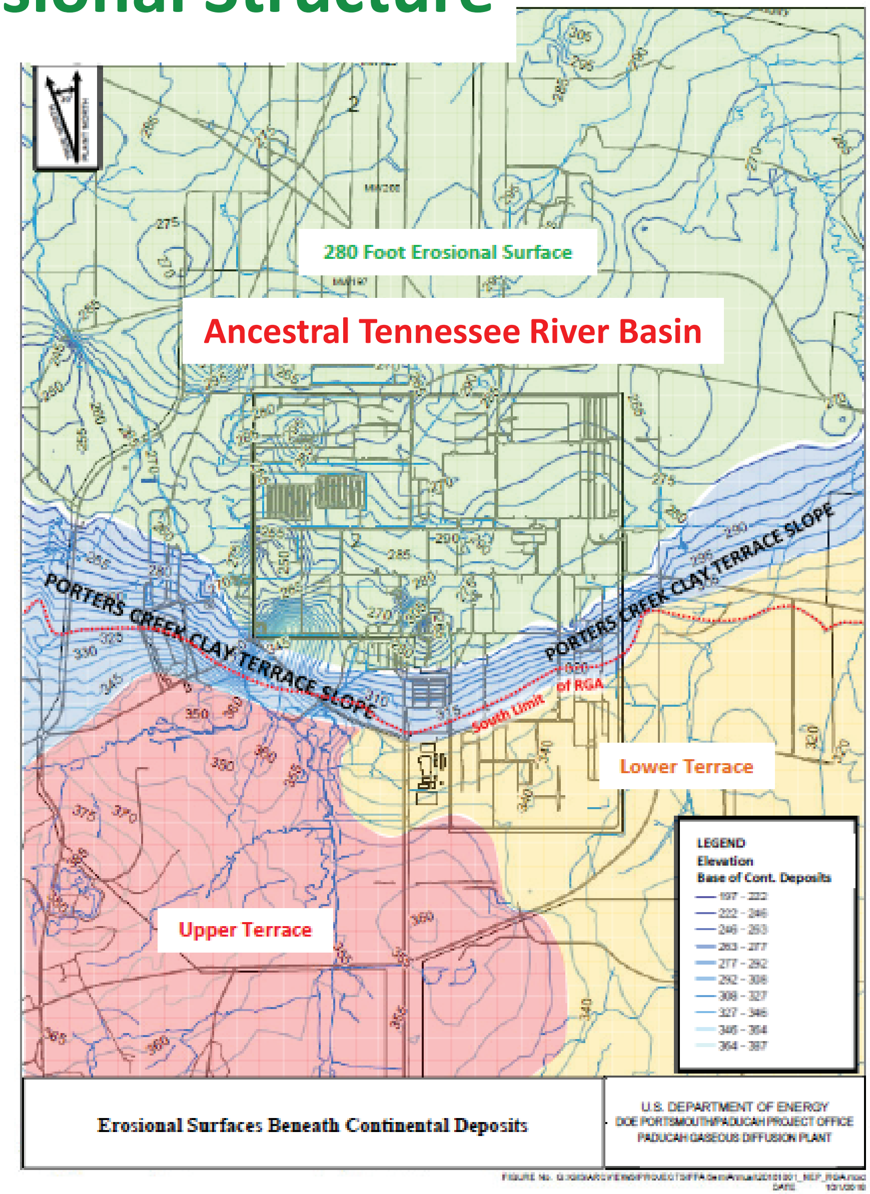
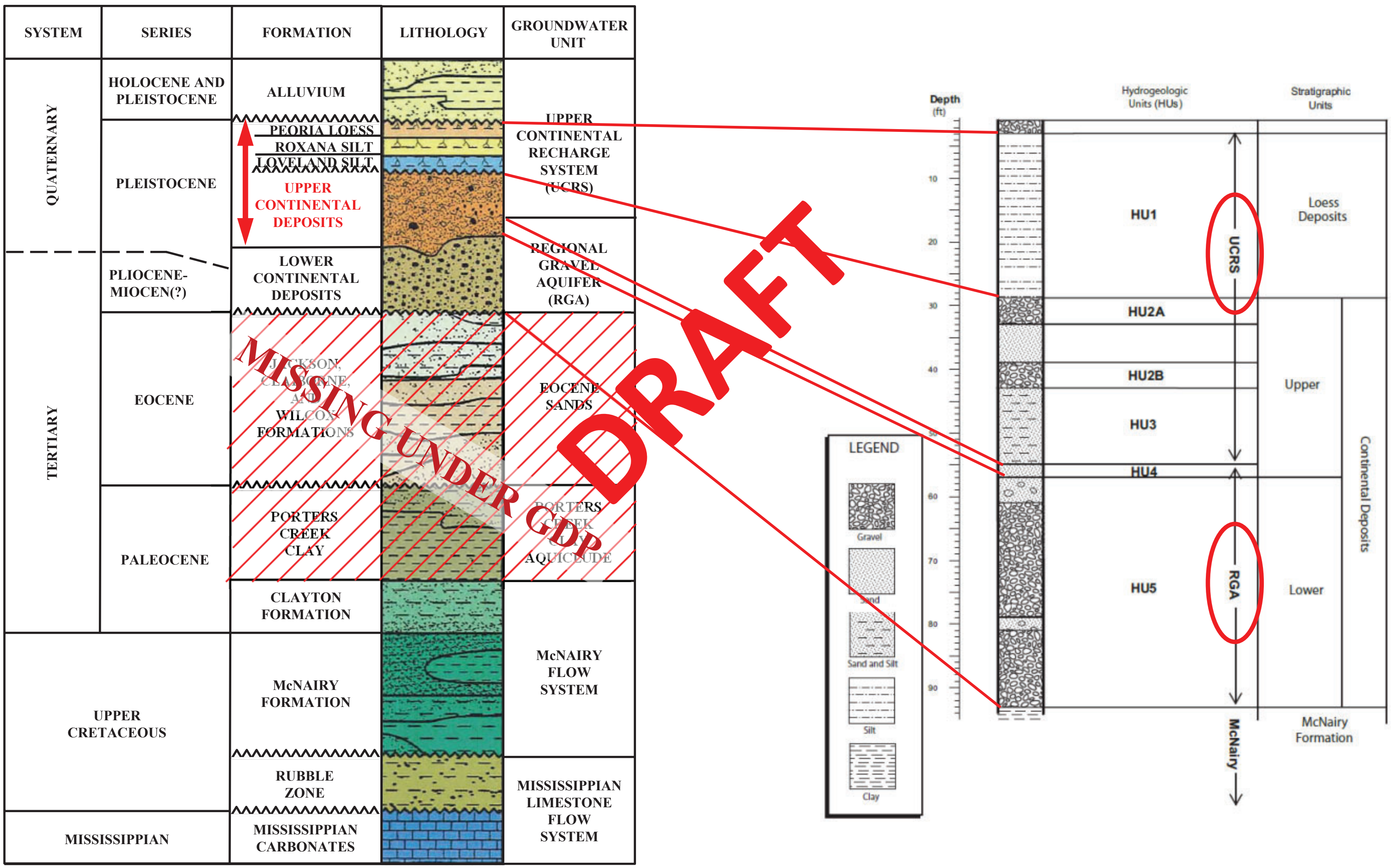
Depositional/Erosional Structure





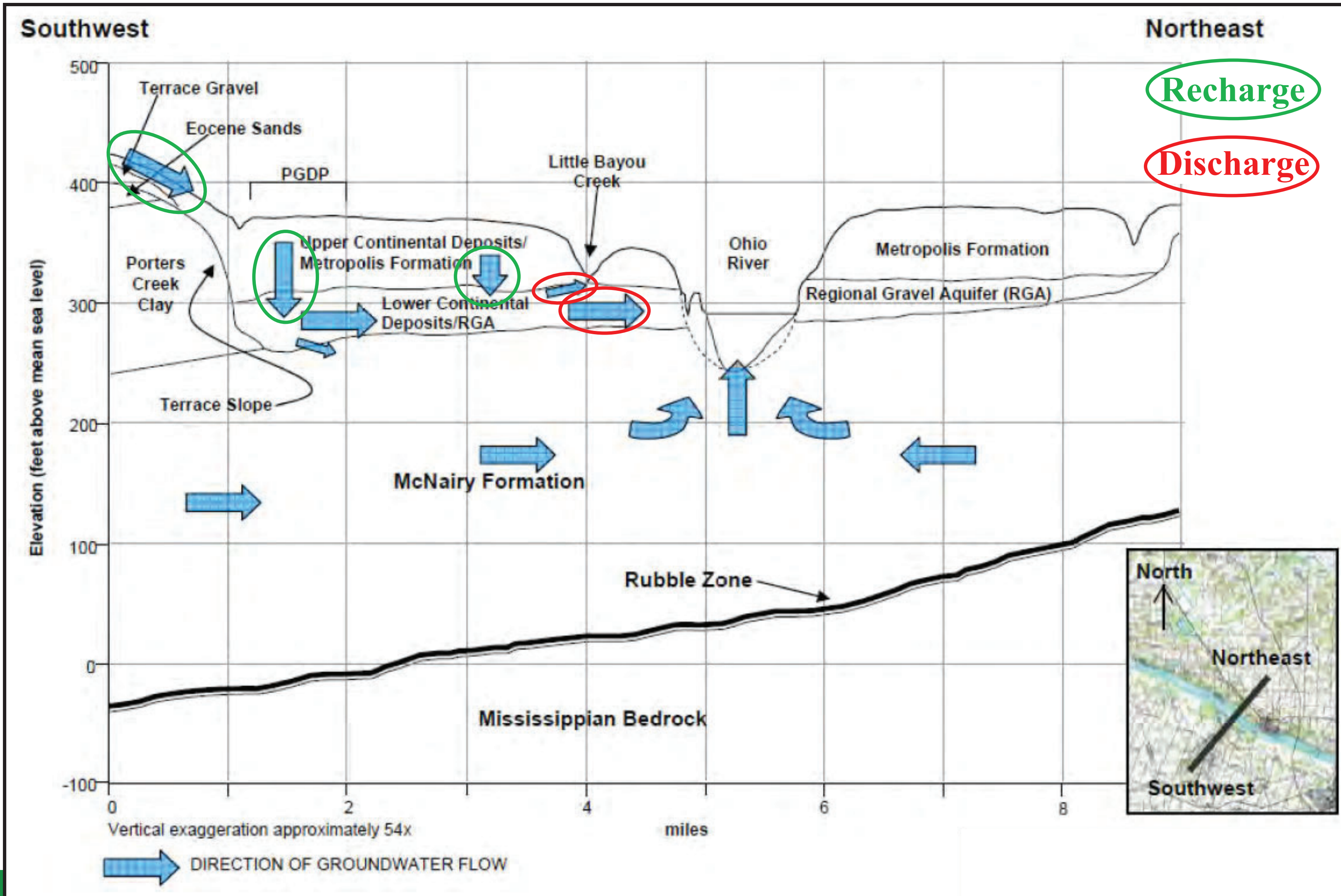
Stratigraphy vs Hydrogeologic Units (HUs)



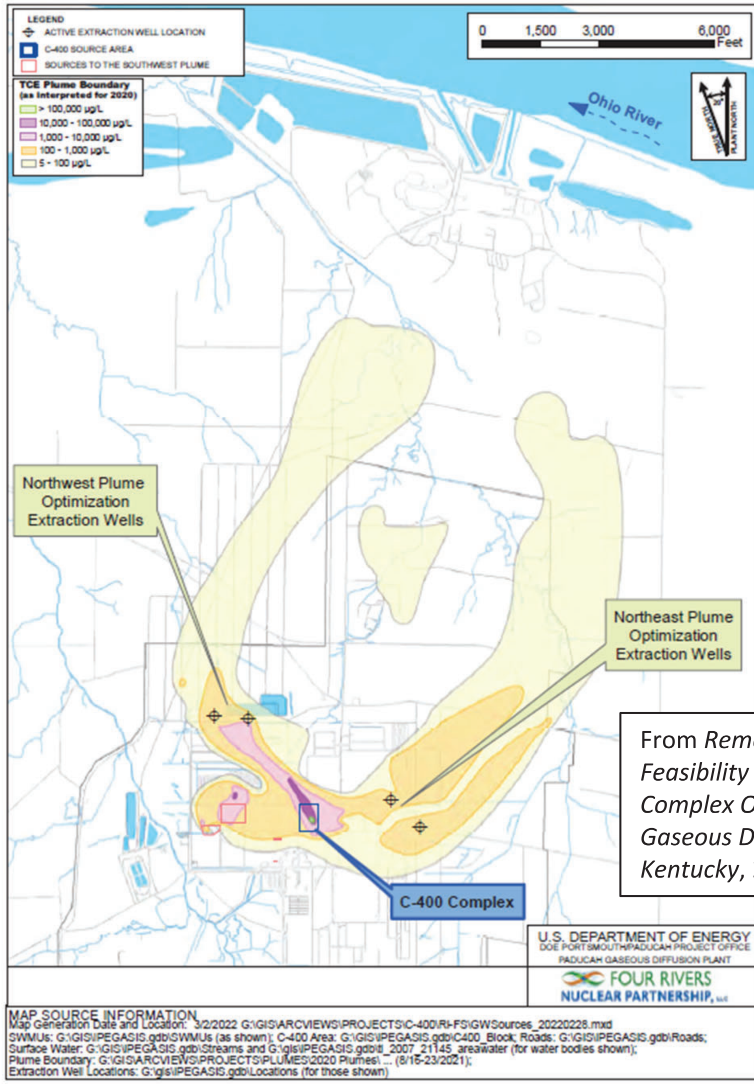
2023 Sitewide Groundwater Model Briefing – September 6, 2023

DRAFT Work Product – For Discussion Only

Groundwater Balance



2022 TCE Plumes of PGDP



From *Remedial Investigation/ Feasibility Study Report for the C-400 Complex Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, 2022

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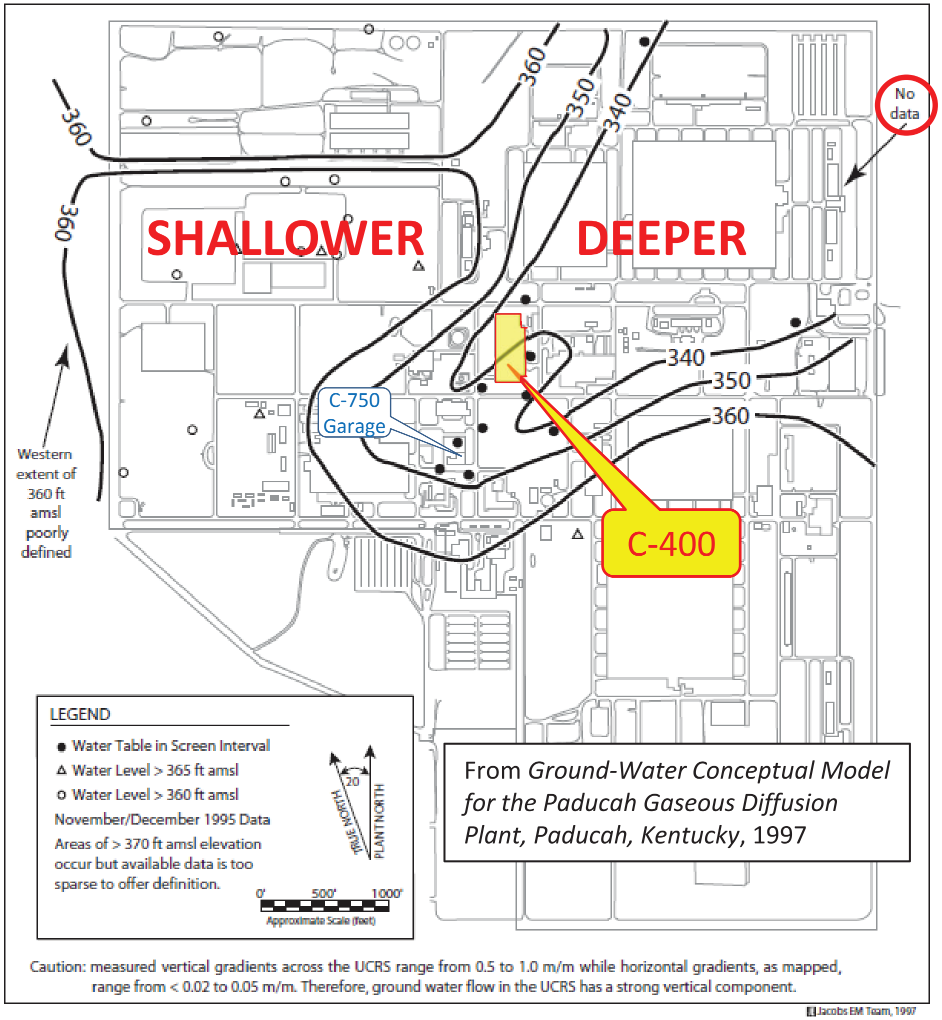
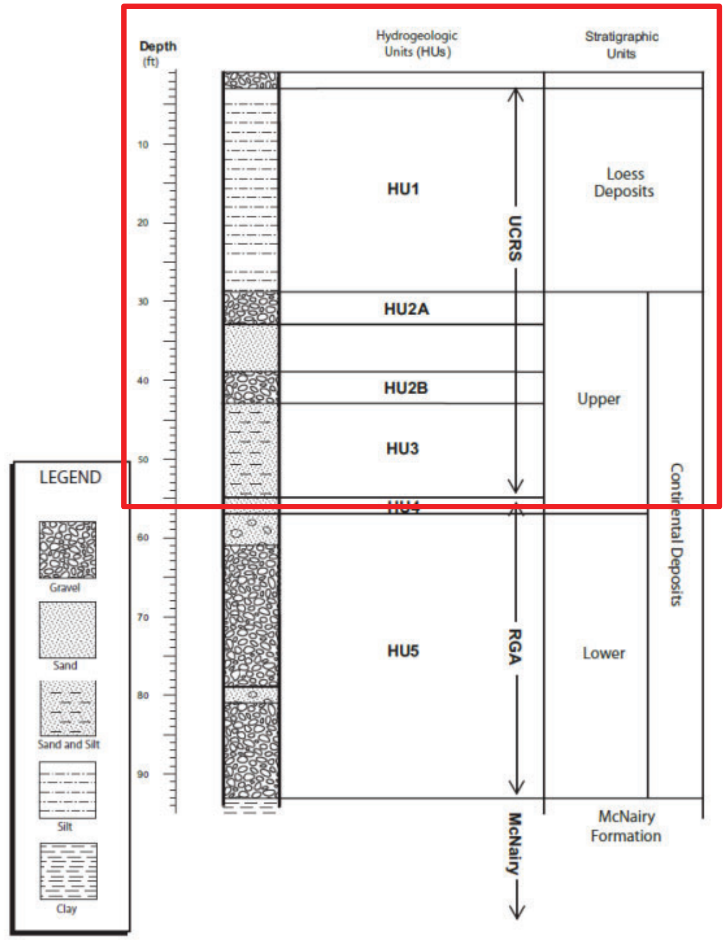
Water Table


360
350
340
No data
SHALLOWER
DEEPER
340
350
360
C-750 Garage
C-400
Western extent of 360 ft amsl poorly defined
LEGEND
Water Table in Screen Interval
Water Level > 365 ft amsl
Water Level > 360 ft amsl
November/December 1995 Data
Areas of > 370 ft amsl elevation occur but available data is too sparse to offer definition.
TRUE NORTH
PLANT NORTH
0' 500' 1000'
Approximate Scale (feet)
From *Ground-Water Conceptual Model for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, 1997
Caution: measured vertical gradients across the UCRS range from 0.5 to 1.0 m/m while horizontal gradients, as mapped, range from < 0.02 to 0.05 m/m. Therefore, ground water flow in the UCRS has a strong vertical component.
Jacobs EM Team, 1997

UCRS: Upper Continental Recharge System
- Paducah-specific: named for Upper Continental Deposits

- Top (0 – 55 ft depth) sequence of frigid lake deposits, overlain by loess, under the gaseous diffusion plant and extending north to the Ohio River
- Consists of (from top to bottom – C-400 area common depths):
  - 0 – 28 ft: **HU1** (loess deposits with upper soil horizon)
  - 28 – 43 ft: **HU2** (horizon of common sand and gravel units interbedded with fine sand)
  - 43 – 55 ft: **HU3** (sequence of interbedded very-fine-to-fine sand, silt, and clay units and upper semi-confining aquitard of RGA)



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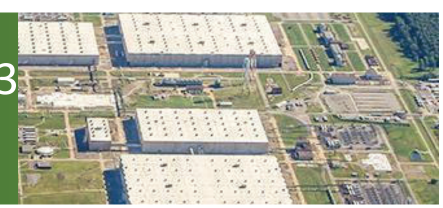
DRAFT Work Product – For Discussion Only



UCRS: Vertical Gradients

Two Populations

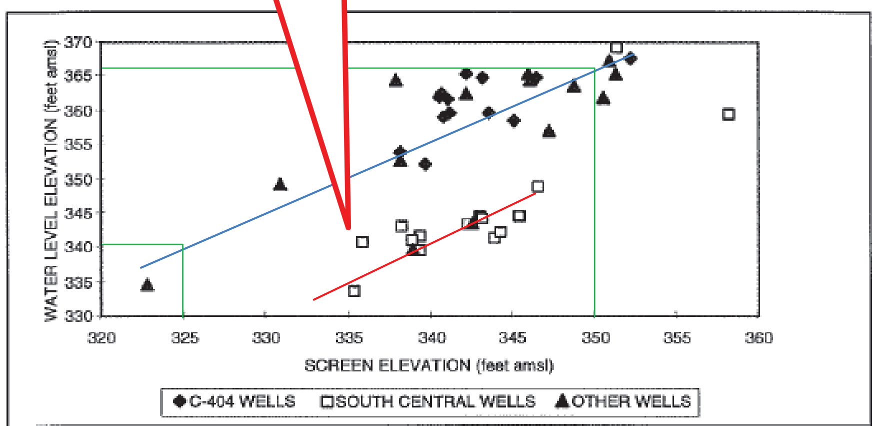
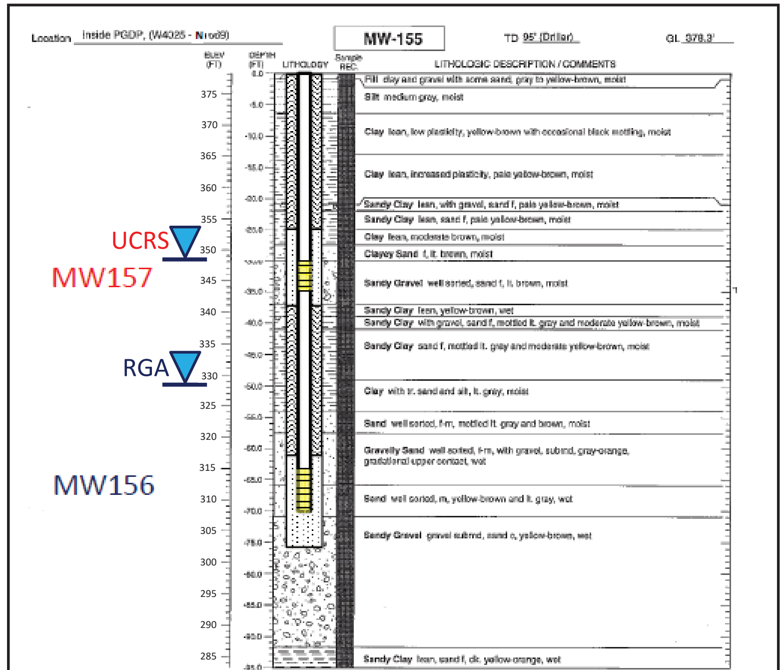
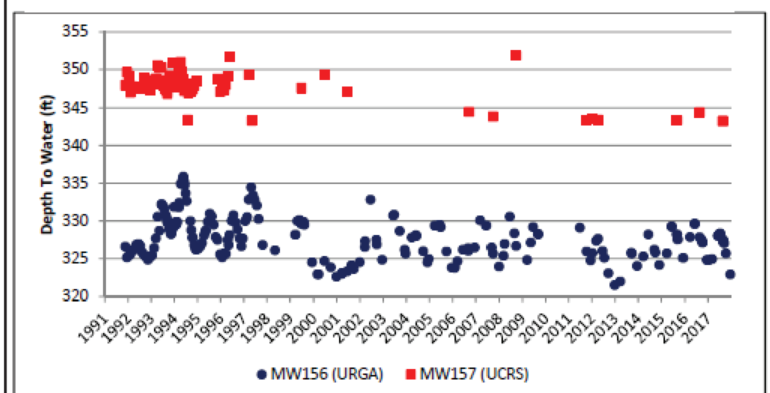


Figure 3-3. Plot of Water Level Versus Well Screen for Upper Continental Recharge System Wells

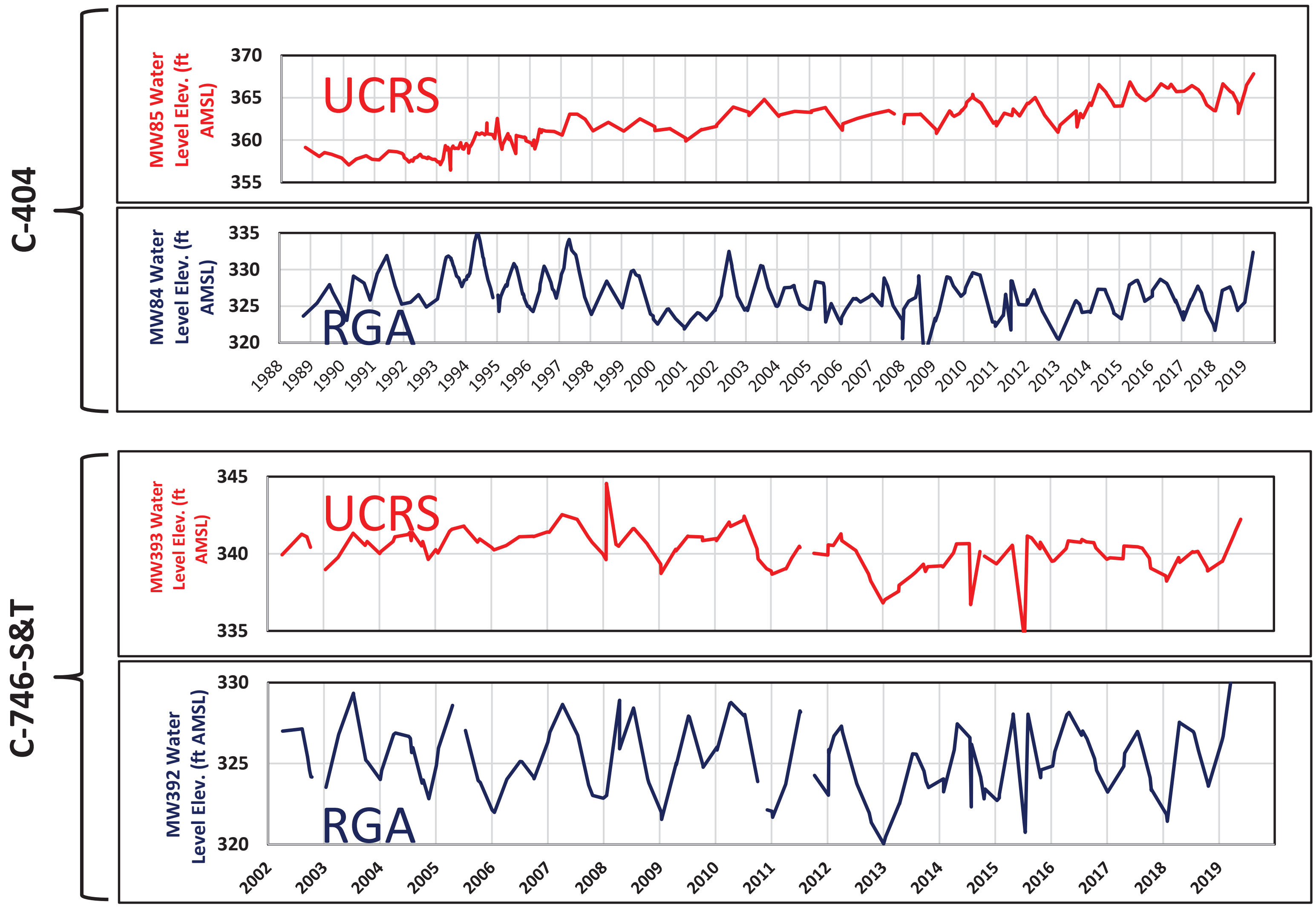
From *Ground-Water Conceptual Model for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, 1997

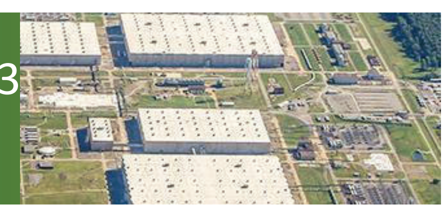




DRAFT Work Product – For Discussion Only

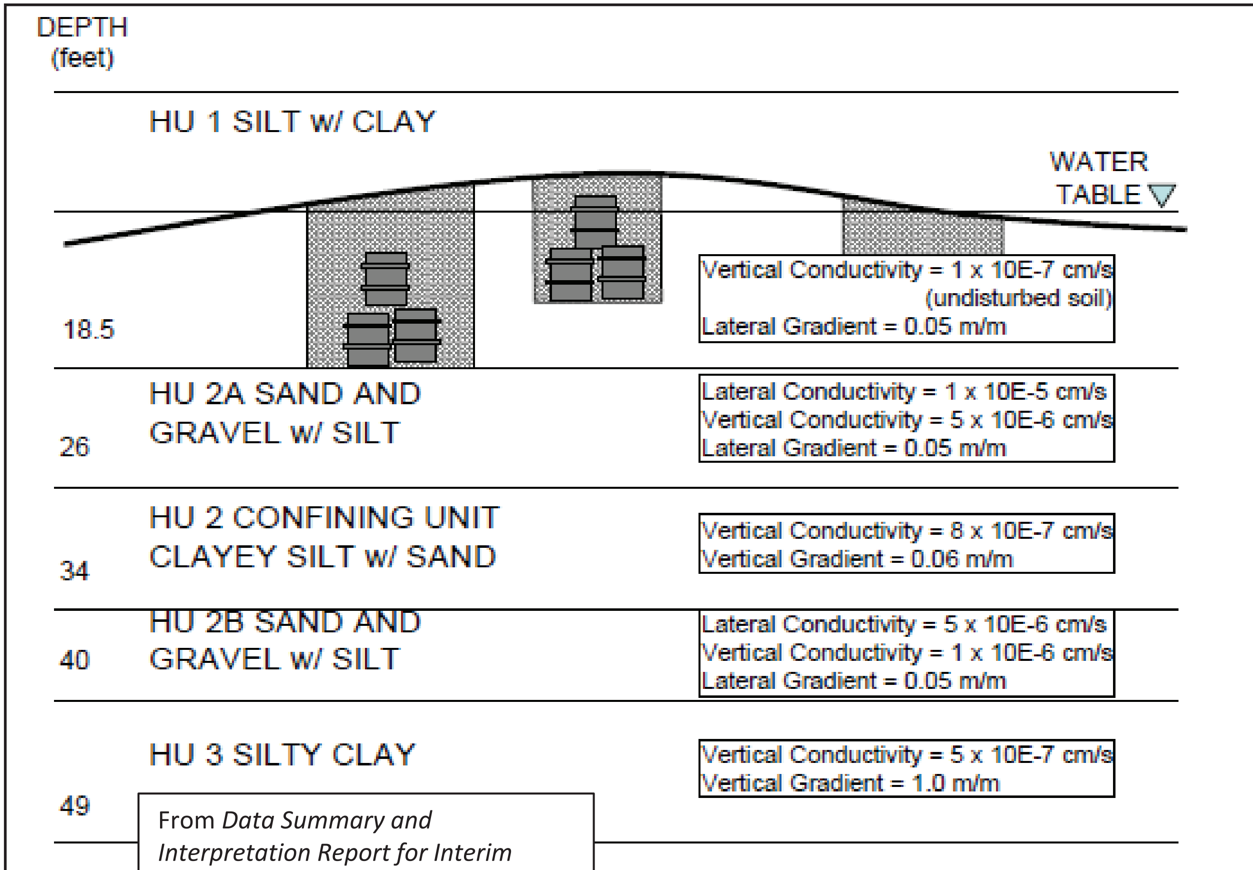
UCRS: Vertical Gradients





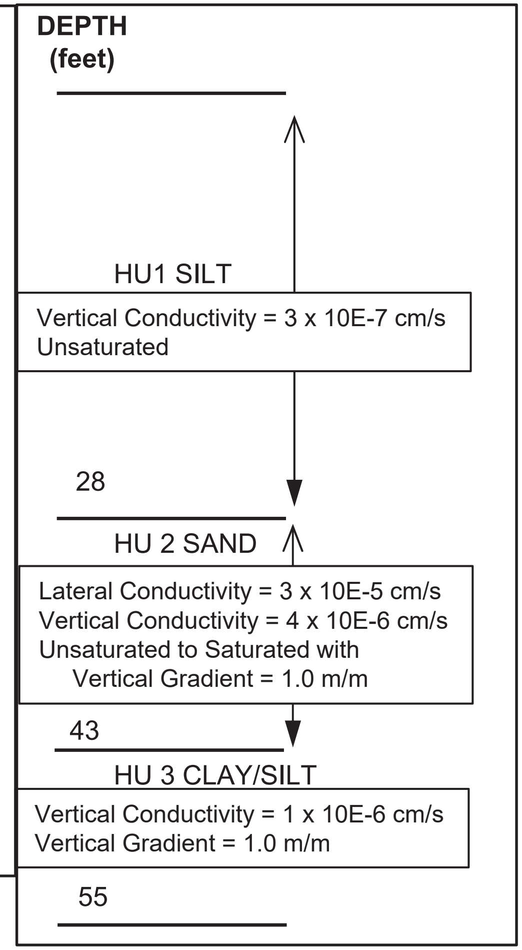
UCRS: Hydraulic Conductivity

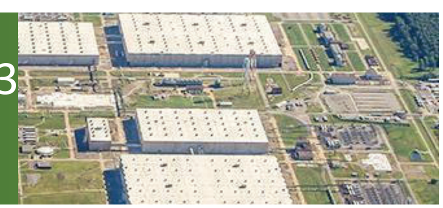
SWMU 2



From *Data Summary and Interpretation Report for Interim Remedial Design at Solid Waste Management Unit 2 of Waste Area Grouping 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, 1997

C-400





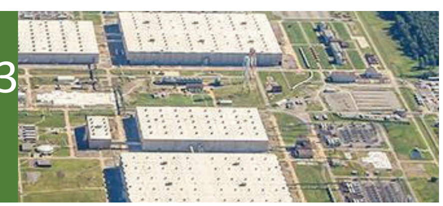
UCRS: Porosity

Adapted from *Remedial Investigation Report for Waste Area Grouping 6 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, 1999

Sample #	Avg Depth	HU	Soil Texture	Porosity (%)	Representative Member
400210SA010	12	1	SILT with little clay	32	
400208SA010	12.25	1	SILT with little clay	33	
026001SA010	10	1	sandy SILT with little clay	35	SILT with ~35% porosity
400038SA010	7.25	1	--	36	
400212SA010	8.25	1	silty CLAY	37	
400036SA010	8.25	1	SILT with some clay	45	
400212SA030	28.25	~~3~~	SILT with some sand and little clay	25	
400038SA045	47.25	2	SAND with some clay and little silt	30	
400207SA045	48	2	SAND with little clay	35	
400036SA030	21	2	GRAVEL with little clay	38	SAND with ~39% porosity
400038SA030	27.25	2	SAND with some silt and little clay	40	
400036SA045	45	2	SAND with some clay and little silt	40	
400208SA045	47	2	SAND with little silt and clay	47	
400210SA045	52	3	sandy SILT with some clay	33	CLAY/SILT with ~36% porosity
026001SA045	44	3	sandy CLAY with some silt	38	

2023 Sitewide Groundwater Model Briefing – September 6, 2023

DRAFT Work Product – For Discussion Only



UCRS: GW Flow Example

Darcy's Law:

$Q = -KiA$

Q = quantity/time (e.g. cm^3/sec)
K = hydraulic conductivity (cm/sec)
i = hydraulic gradient
A = cross-sectional area (cm^3)

$Q/A = -Ki$

Flow rate:

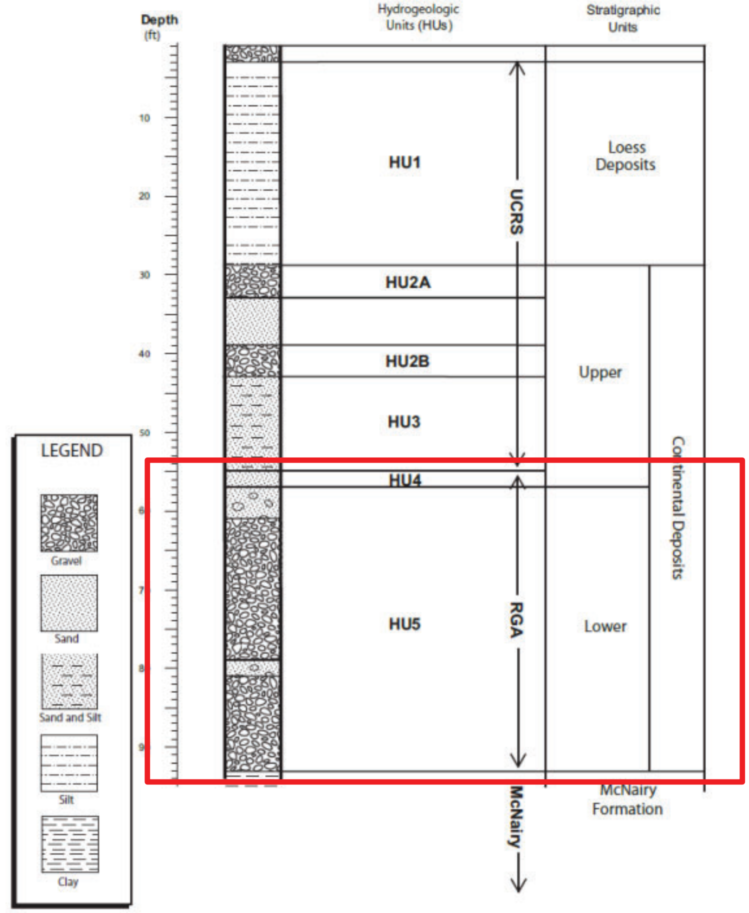
$(Q/A)/n_e$ = flow rate (v)
n_e = effective porosity

Vertical Flow @ C-404							
HU	**K (cm/s)**	**i (m/m)**	**n_e**	**v (cm/s)**	**v (ft/d)**	**thickness (ft)**	**time (yr)**
HU1	1.00E-07	-1	0.25	-4.00E-07	-1.13E-03	13	31.39
HU2A	5.00E-06	-1	0.25	-2.00E-05	-5.67E-02	7.5	0.36
HU2 Confining	8.00E-07	-1	0.25	-3.20E-06	-9.07E-03	8	2.41
HU2B	1.00E-06	-1	0.25	-4.00E-06	-1.13E-02	6	1.45
HU3	5.00E-07	-1	0.25	-2.00E-06	-5.67E-03	9	4.35
					Total:	**43.5**	**39.96**

RGA: Regional Gravel Aquifer
- Paducah-specific: named for local function

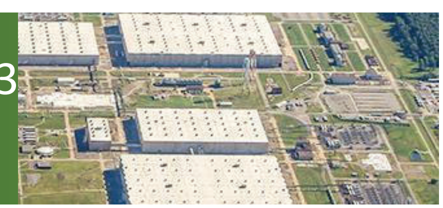
- Bottom (55 – 85 ft depth) thin horizon of lacustrine facies sand overlying braided stream deposits of ancestral Tennessee River, under the gaseous diffusion plant and extending north to the Ohio River

- Consists of (from top to bottom – C-400 area):
  - 55 – 57 ft: **HU4** (laminated to thin-bedded – defined by iron/manganese staining - poorly graded, fine sand horizon, locally present)
  - 57 – 93 ft: **HU5** (weakly bedded deposits of gravelly sand and sandy gravel)

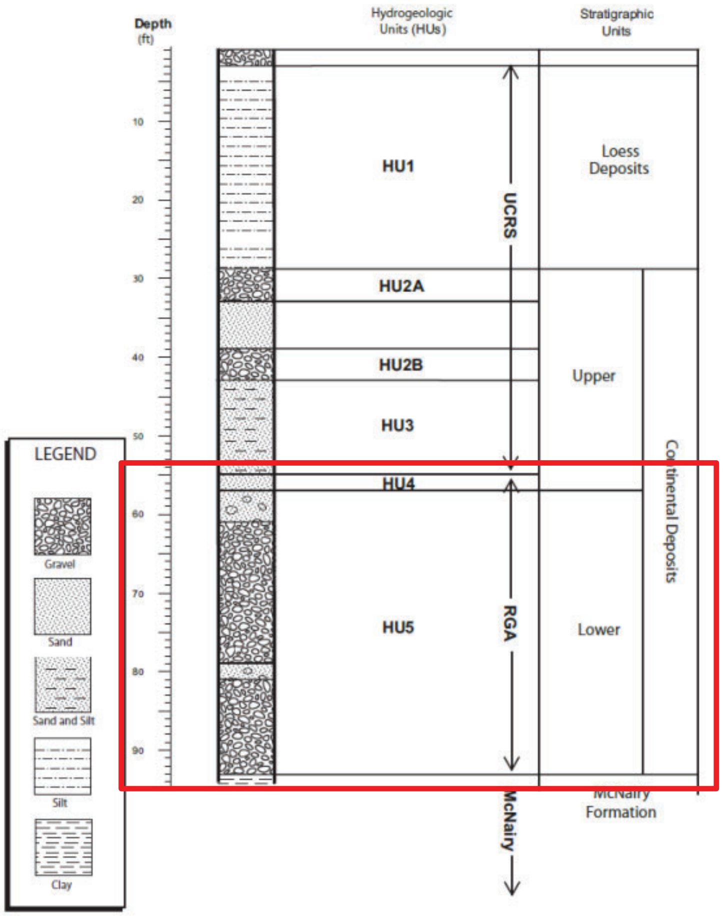


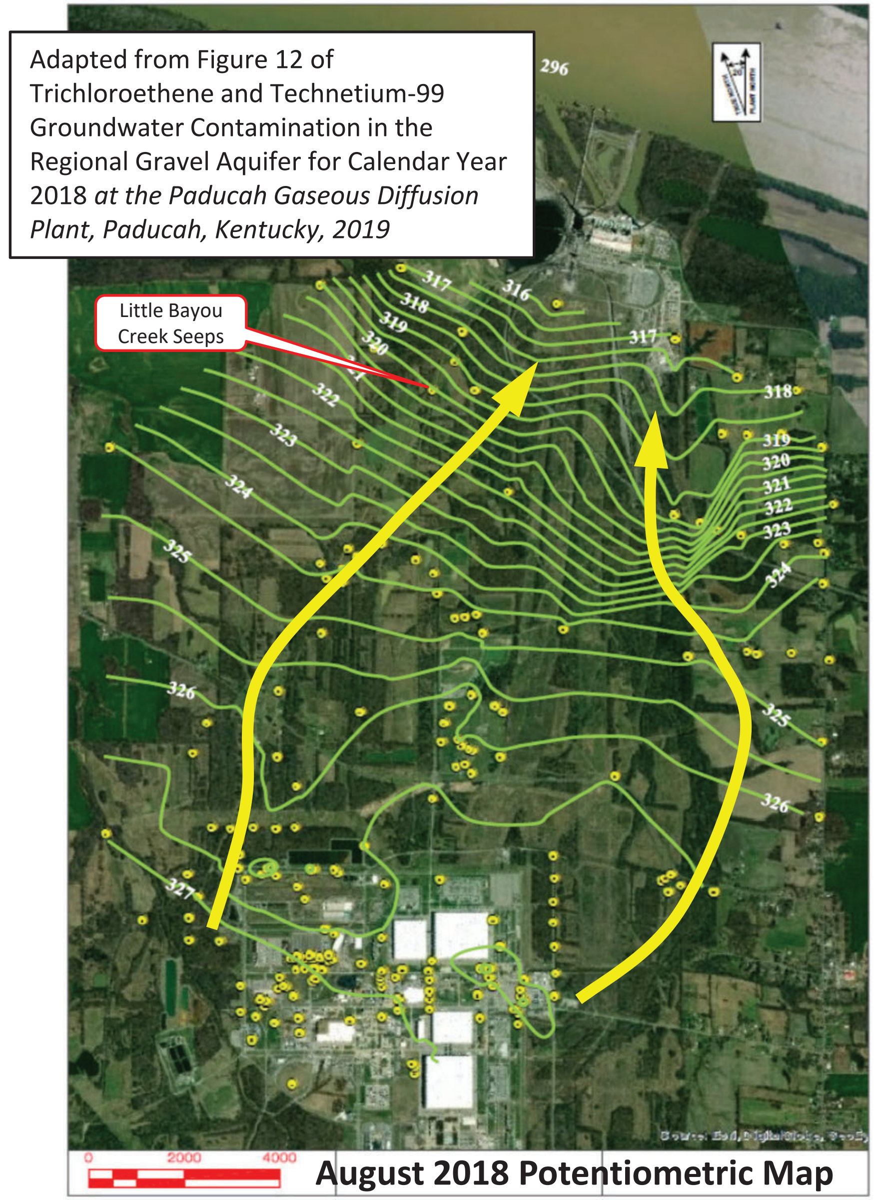
2023 Sitewide Groundwater Model Briefing – September 6, 2023

DRAFT Work Product – For Discussion Only

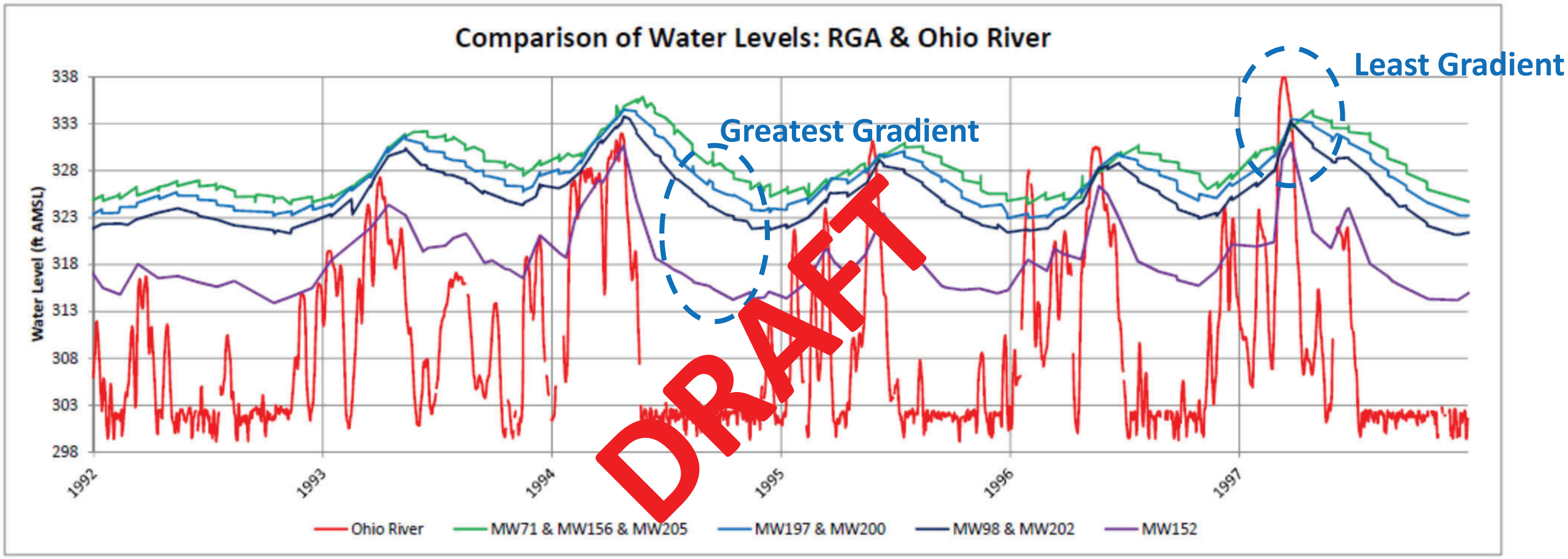


RGA (HU4 & HU5): Potentiometric Surface





RGA: Gradients



- Gradient typically least under industrial facility and greatest near Ohio River
- Varies with season and Ohio River stage
- Common gradient is 10^{-4} ft/ft

RGA: Hydraulic Conductivity

EW229 (NW Plume N Well Field)
Initial–3,580 ft/day
Min–3,500 ft/day
Max–3,600 ft/day

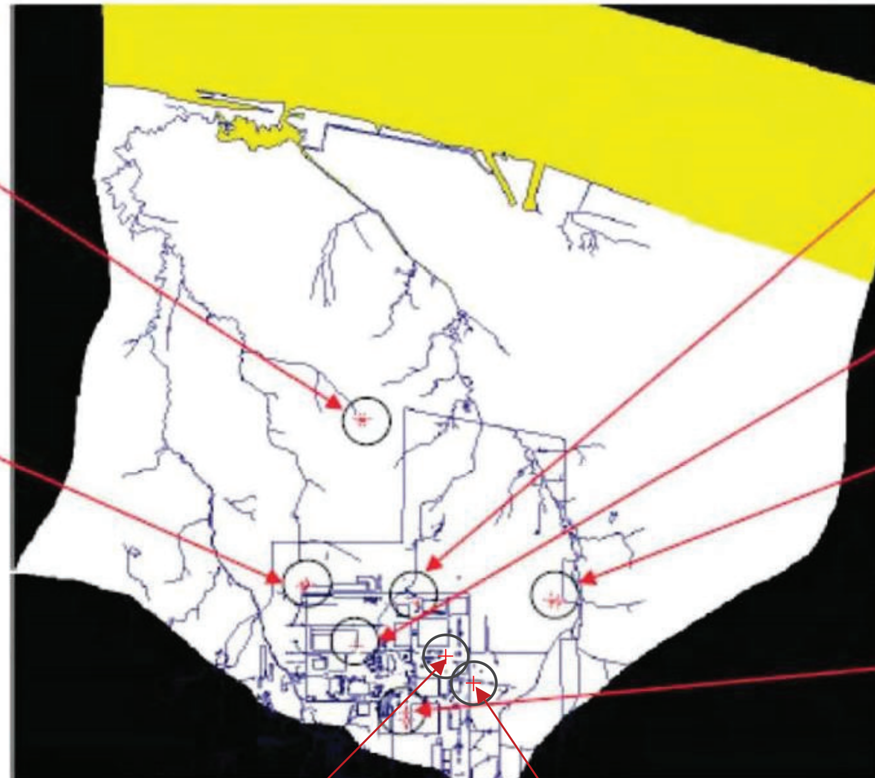
EW231 (NW Plume S Well Field)
Initial–1,175 ft/day
Min–1,000 ft/day
Max–1,350 ft/day

PW1 (Phase II Site Investigation)
Initial–131 ft/day
Min–86 ft/day
Max–175 ft/day

MW79 (C-404)
Initial–107 ft/day
Min–96 ft/day
Max–117 ft/day

EW331 & EW332 (NE Plume Well Field)
Initial–925 ft/day
Min–640 ft/day
Max–1,210 ft/day

W108 (Phase III GW Investigation)
Initial–700 ft/day
Min–570 ft/day
Max–750 ft/day



EW234 (NE Plume Optimization
Initial- 392 ft/day
Min- 350 ft/day
Max- 392 ft/day

EW235 (NE Plume Optimization
Initial- 37 ft/day
Min- 37 ft/day
Max- 37 ft/day

Adapted *from 2016 Update of the Paducah Gaseous Diffusion Plant Sitewide Groundwater Flow Model,* 2017

Extraction Well Locations and Pumping Test Results
Paducah Gaseous Diffusion Plant
McCracken County, Kentucky
Geosyntec consultants
ACTON, MASSACHUSETTS | NOV 2016
FIGURE 5.2

Source: DOE, 2010; Figure 6.1 (the 2008 model domain is shown)

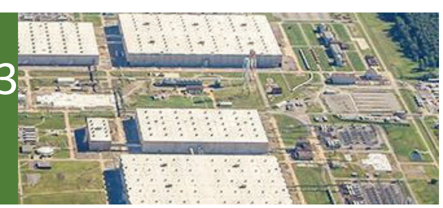
RGA: Porosity

Sample #	Depth (ft)	HU	Soil Texture	Porosity (%)	Representative Member
400208SA060	56 - 58	4	**SAND with little clay**	31	Sand with porosity of ~34%
026001SA056	56*	4	**SAND**	36	
400210SA060	57 - 62	5	**Gravel with little sand and silt**	27	
400036SA080	79*	5	**GRAVEL with some sand and little silt and clay**	32	
400210SA070	62 - 67	5	**Gravel with little sand and silt**	34	
400036SA060	62*	5	**GRAVEL with some silt and little sand**	35	
400210SA090	92 - 92.5*	5	**sandy Gravel with little clay and silt**	36	
400038SA060	61 - 63	5	**GRAVEL with little sand and clay**	37	
400210SA080	79.5 - 80*	5	**Gravel with little sand and silt**	37	
400036SA070	69*	5	**GRAVEL with some sand and silt**	38	
400212SA080	77 - 79	5	**GRAVEL with some sand and little silt**	38	Gravel with some sand and porosity of ~38%
400212SA090	87 - 89	5	**Gravel with some sand and little silt**	38	
400208SA070	66 - 68	5	**GRAVEL with little sand**	39	
400036SA090	91*	5	**SAND**	39	
400212SA070	67 - 69	5	GRAVEL with little sand and silt	40	
026001SA070	67 - 72*	5	GRAVEL with little silt	41	
026001SA080	77 - 82*	5	GRAVEL with little silt	41	
400038SA070	71 - 73	5	**GRAVEL with little sand and silt**	42	
400207SA080	77 - 79	5	**GRAVEL with some sand and little silt**	44	

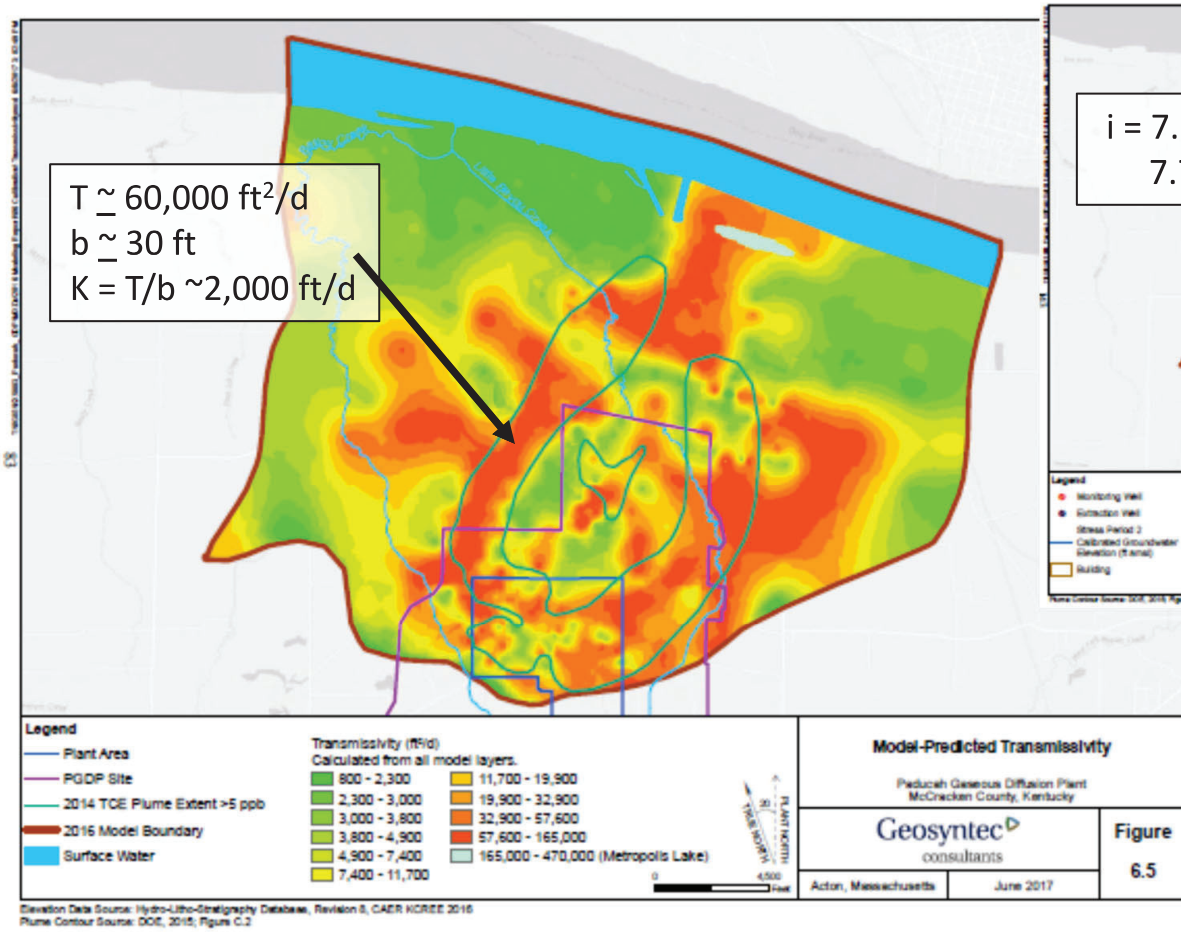
Adapted from *Remedial Investigation Report for Waste Area Grouping 6 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, 1999

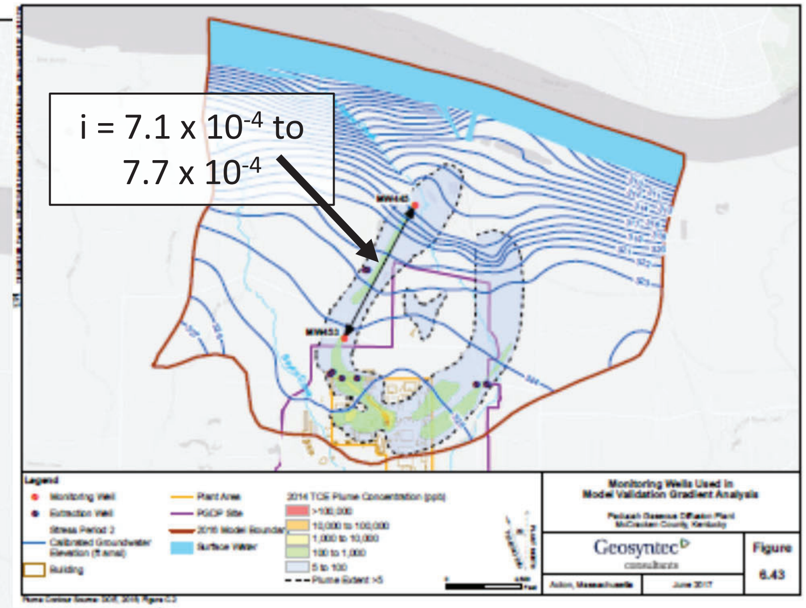
* depth of associated analytical sample

Average HU4: 34
Average HU5: 38
Median HU5: 38



RGA: GW Flow Example





Figures from *2016 Update of the Paducah Gaseous Diffusion Plant Sitewide Groundwater Flow Model*, 2017

$-Ki/n_e$ = flow rate (v)

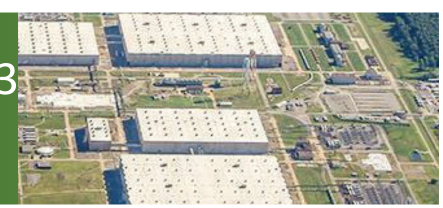
$v = [(2,000 \text{ ft/d}) \times (7.4 \times 10^{-4})]/0.30 =$ 4.9 ft/d

GW flow velocity in the plumes is thought to average 0.5 – 2 ft/d

2016 GW Flow Model

2016 Model Update

- 2015-2017: 27 Meetings with Modeling Working Group Members (DOE, EPA, KY and contractors)
- 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
  - KY: 47 comments
  - EPA: 16 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
- 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

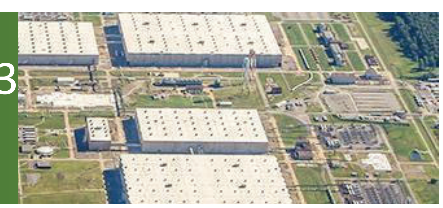


May 5, 2017 KDEP Technical Comments

- 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 in 20220524 DRAFT GW MWG Meeting Summary April 2022.pdf (Attachment 7).

May 12, 2017 EPA Technical Comments

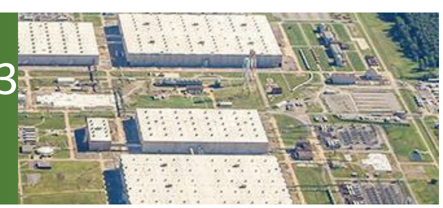
- 16 Comments
  - General response: Future modeling efforts and additional data collection will be discussed with the MWG to address the limitations/uncertainties identified, and any decisions will be dependent upon the risk of not addressing the uncertainty and the availability of funding.
  - Details of each specific recommendation added to the report or applicable to the comment are provided in 20230718 2023 GW Model Update Briefing_FINAL DRAFT. Pdf available on the FTP/project website.



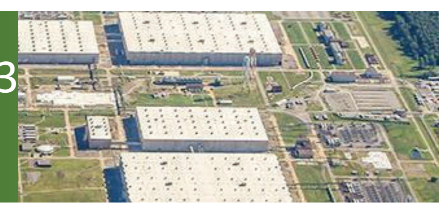
August 9, 2017 EPA Acknowledgement

- 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.



2023 GW Flow Model

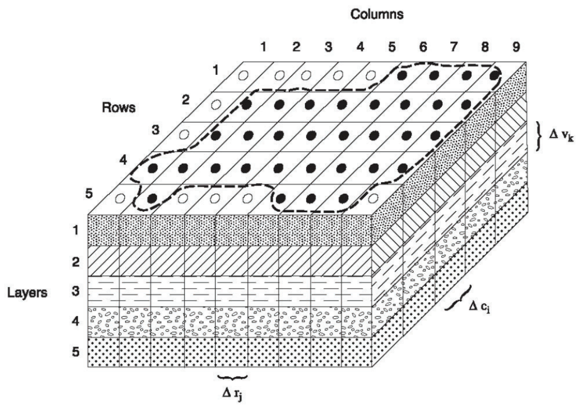


2023 GW Flow Model Discussion: Outline

- Model Code (MODFLOW)
- Discretization (Grid, Layering, & Time)
- Initial Conditions
- Boundary Conditions (MODFLOW Packages)
- Parameters
- Calibration
- Mass Balance
- Sensitivities

Model Code: MODFLOW

- MODFLOW is a modular finite difference groundwater modeling code, developed by the U.S. Geological Survey (USGS)
- MODFLOW 2005 was selected for this model update as it is widely accepted version of MODFLOW and was used in the previous (2016) model.
- Groundwater Vistas was used to build the model, and visualize results

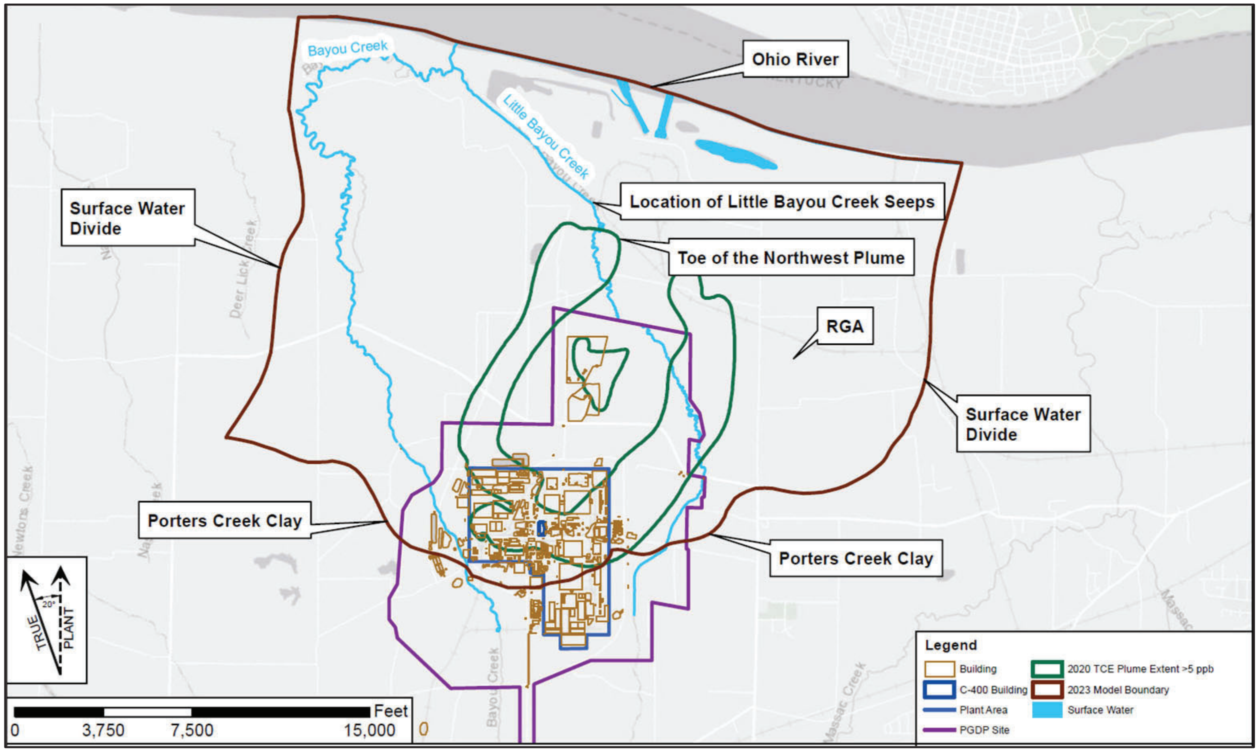


Example MODFLOW model grid
From McDonald and Harbaugh (1988)

C-58

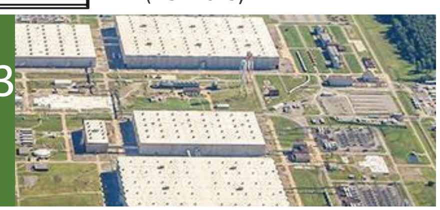
Discretization: Grid

- Model Grid Extent based on the PGDP Hydrologic Basin as defined below
- Uniform model cell size is 50 ft x 50ft
  - consistent with past (2016) model
  - Cell size selected to minimize long run times for flow and transport calibration



From Figure 3.32
D1 2023 GW Model Report
(DOE 2023)

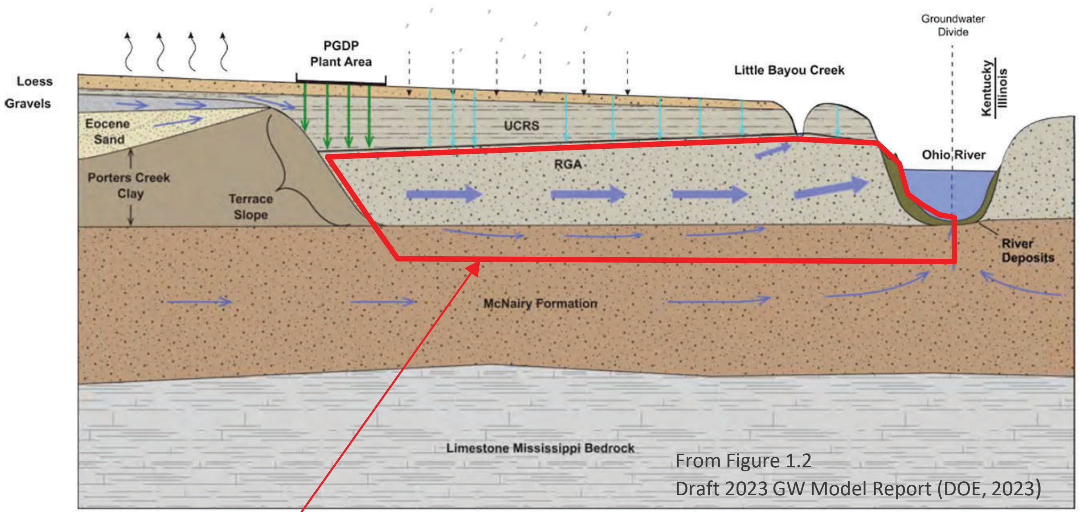
C-59



Discretization: Layering

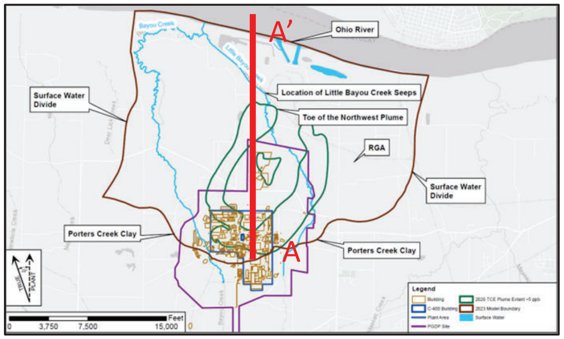
- Model Layering Represents both the RGA and McNairy Formation
  - Layering does not represent the UCRS or ground surface

CSM Cross Section
(not to scale)



Approximate Vertical Extent of Model Domain

Model Cross Section Line
(see next slide)



From
D1 2023 GW Model Report
(DOE 2023)

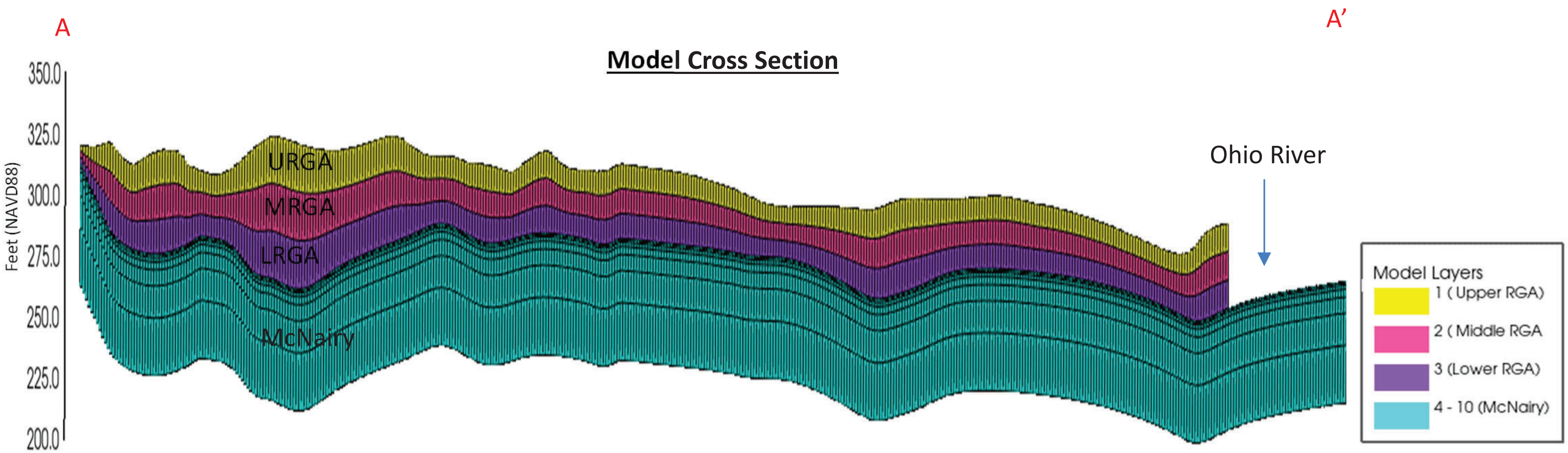
Table 4.1. Model Layers

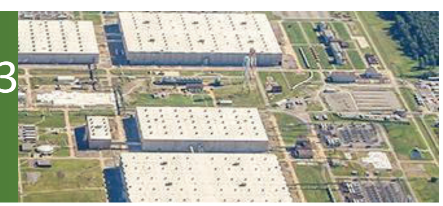
Layer Number	Geologic Unit	Layer Thickness Range (ft)
1	RGA	2 to 22.69
2	RGA	2 to 22.69
3	RGA	2 to 22.69
4	McNairy Upper Member	0.82
5		0.82
6		1.64
7		3.28
8		6.56
9		13.12
10		23.75

Discretization: RGA Layering

- RGA in the model represented by 3 layers
- RGA model elevations were derived from RGA surfaces provided by the Kentucky Research Consortium for Energy and Environment (KRCEE)
  - KRCEE maintains a database of PGDP lithologic data and interpreted geologic contacts
  - Top of RGA (top of layer 1) and bottom of RGA (bottom of layer 3) based on KRCEE Lithology Database (R11) interpolated surfaces, created by KRCEE
  - Surfaces provided by KRCEE were generally reviewed at a high level for appropriateness
- Layer thickness was calculated using simple raster/grid math, with top and bottom of KRCEE RGA surfaces as inputs

C-61

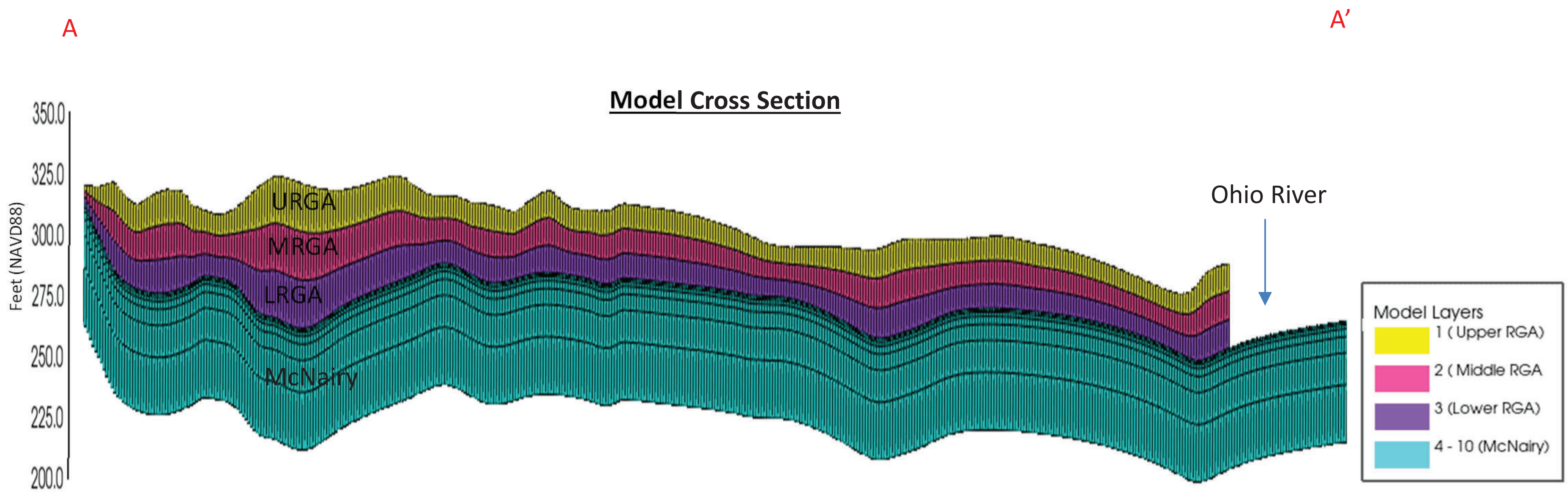




Discretization: McNairy Layering

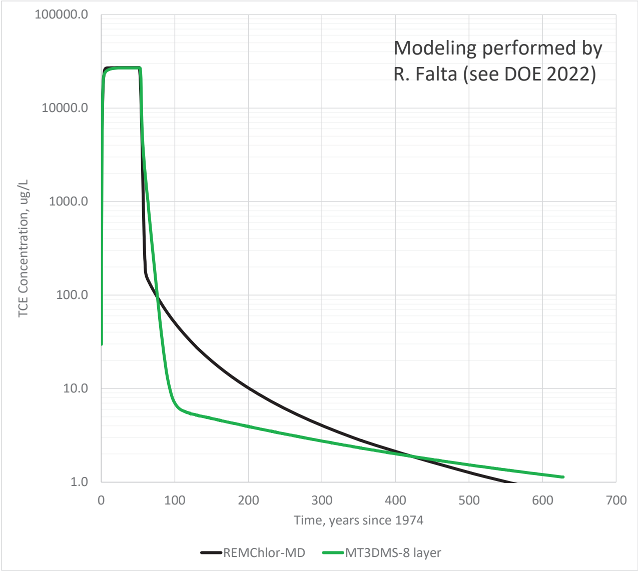
- McNairy Formation has 3 members: upper, middle, and lower
  - Only the upper member of McNairy (i.e., upper 50 ft) was simulated as contamination decreases with depth and is generally not encountered in the deeper members of the McNairy [D1 2023 GW Model Report (2023) and D1 C-400 RI/FS Report (2022)]
- McNairy Formation represented by 7 layers (Layers 4 to 10)
- McNairy layering added to support simulation of matrix diffusion in the transport model

C-62

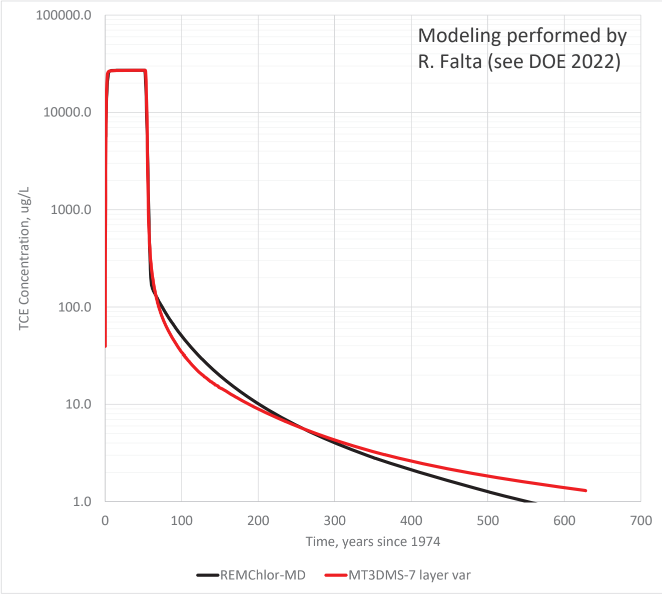


Discretization: McNairy Layering

- Thickness of McNairy layering is variable, to more accurately simulate matrix diffusion in the McNairy using MT3DMS
- Number of layers and layer thickness was determined by simulating TCE concentrations in the C-400 area using various layering schemes, and comparing the results to a pre-existing C-400 REMChlor-MD semi-analytical model (DOE 2022)



Comparison of REMChlor-MD result with MT3DMS using 5 variable thickness layers for the McNairy



Comparison of REMChlor-MD result with MT3DMS using 7 variable thickness layers for the McNairy

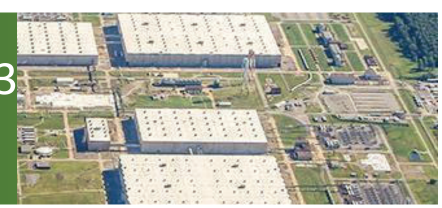
Discretization: Time

- Model was subdivided into 3 stress periods:
  - 2 stress periods (SPs) to simulate transient, seasonally “wet” conditions, when river and groundwater elevations are elevated
  - 1 stress period (SP) to simulate steady state, seasonally dry conditions, when river and groundwater elevations are on average low

Table 4.2. Model Stress Period Setup

Stress Period	Type	Climate Condition	Representative Time Period	Period Length (Days)	Number of Time Steps	Time Step Multiplier
1	Transient	Wet	2/22/21 to 4/5/21	42	6	1
2	Transient	Wet	4/6/21 to 4/26/21	21	3	1
3	Steady-State	Dry	August 2022	1	1	1

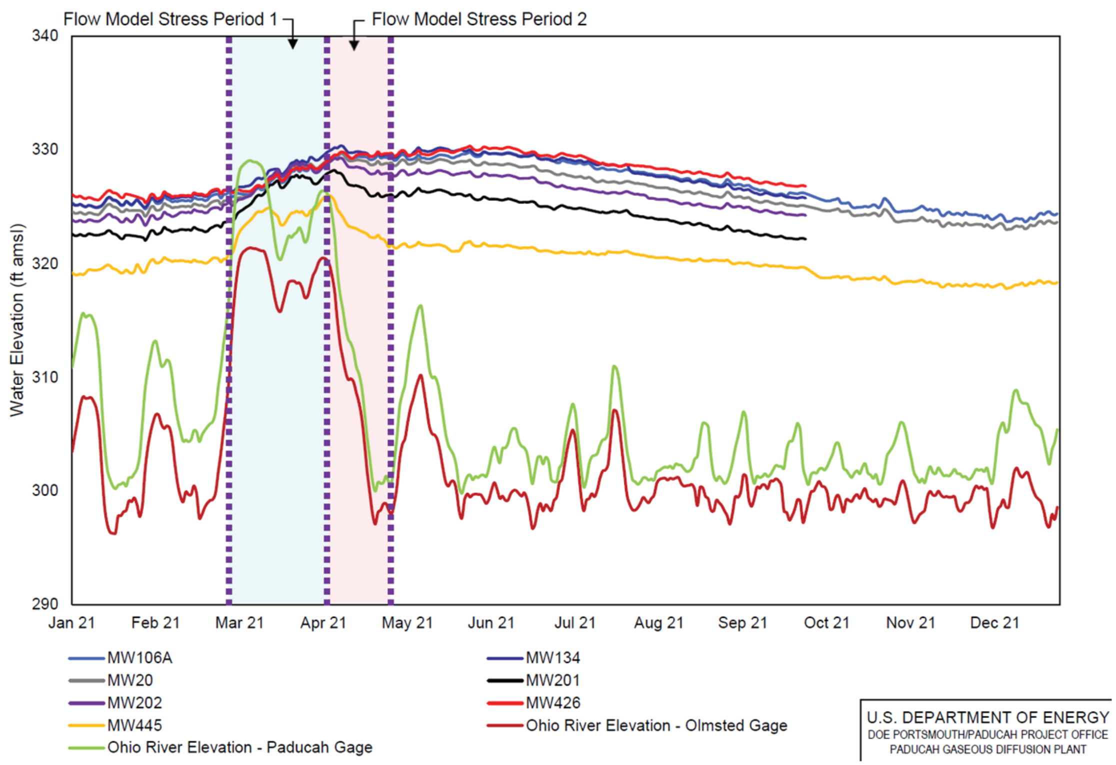
From D1 2023 GW Model Report (DOE 2023)



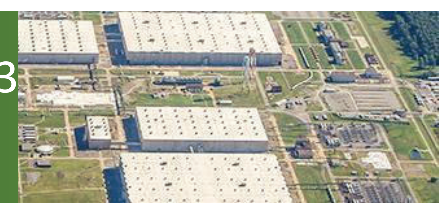
C-65

Discretization: Time

- “Wet” SP1 and SP2 represent February to April 2021
  - SP1 represents river level rise; SP2 represents river level decline
- Date range also selected based on available pressure transducer data
  - For example, 2021 had more sitewide pressure transducer data than 2022

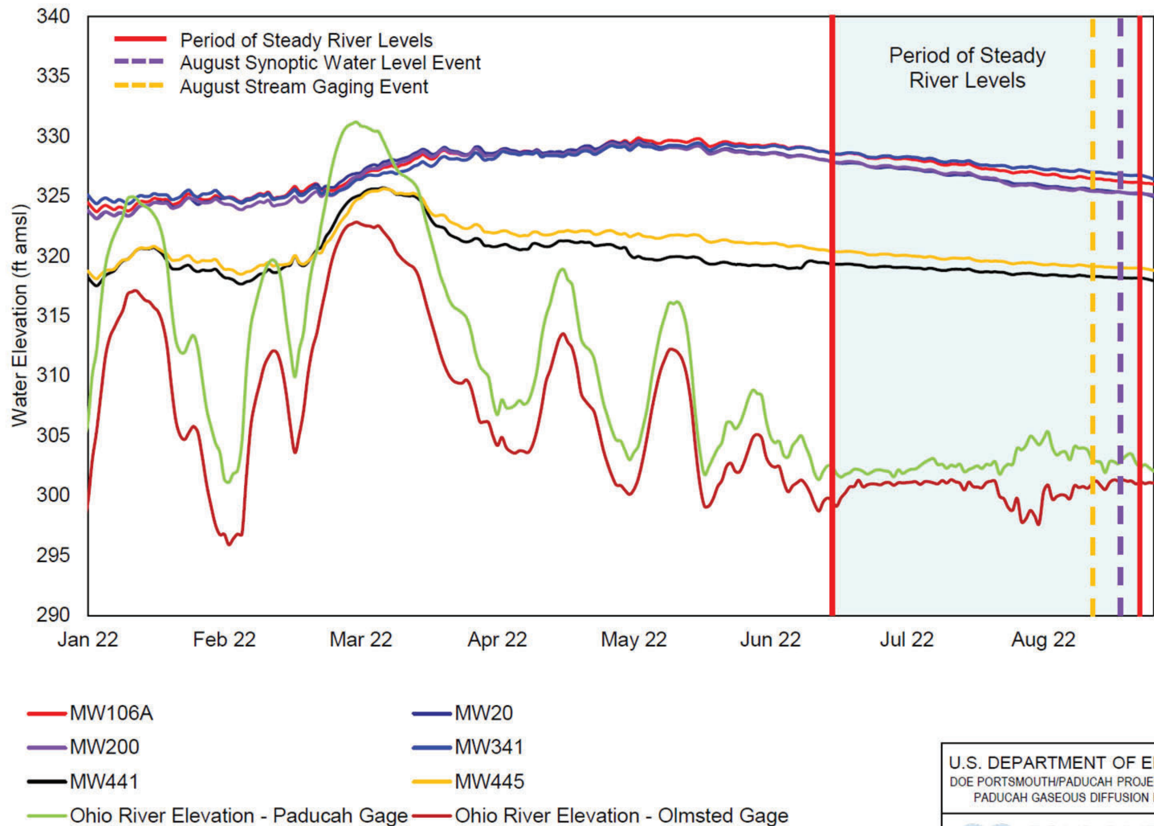


From Figure 4.1
D1 2023 GW Model Report
(DOE 2023)



Discretization: Time

- “Dry” SP3 represents seasonally dry conditions that approach steady state, during months of June to August



From Figure 4.2
D1 2023 GW Model Report
(DOE 2023)

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

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

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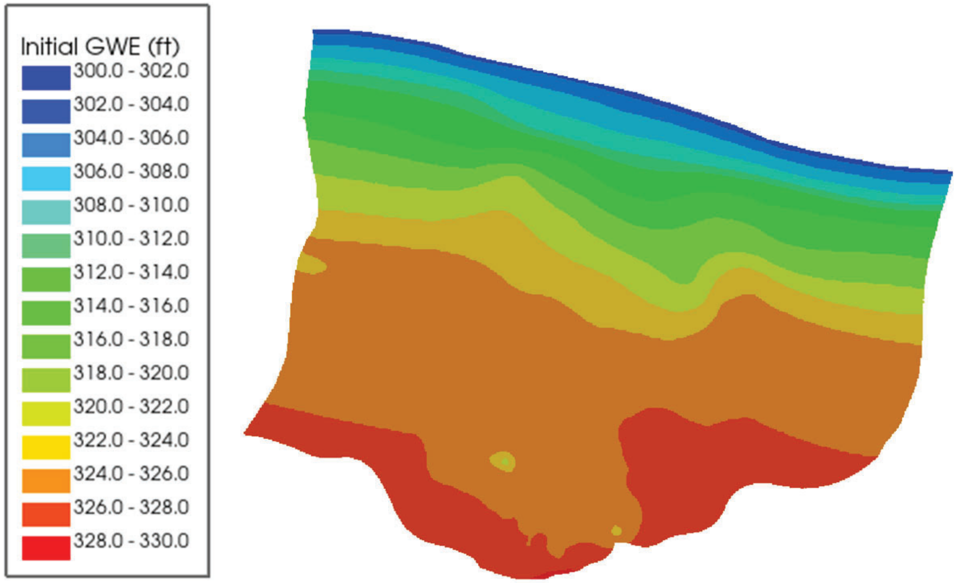
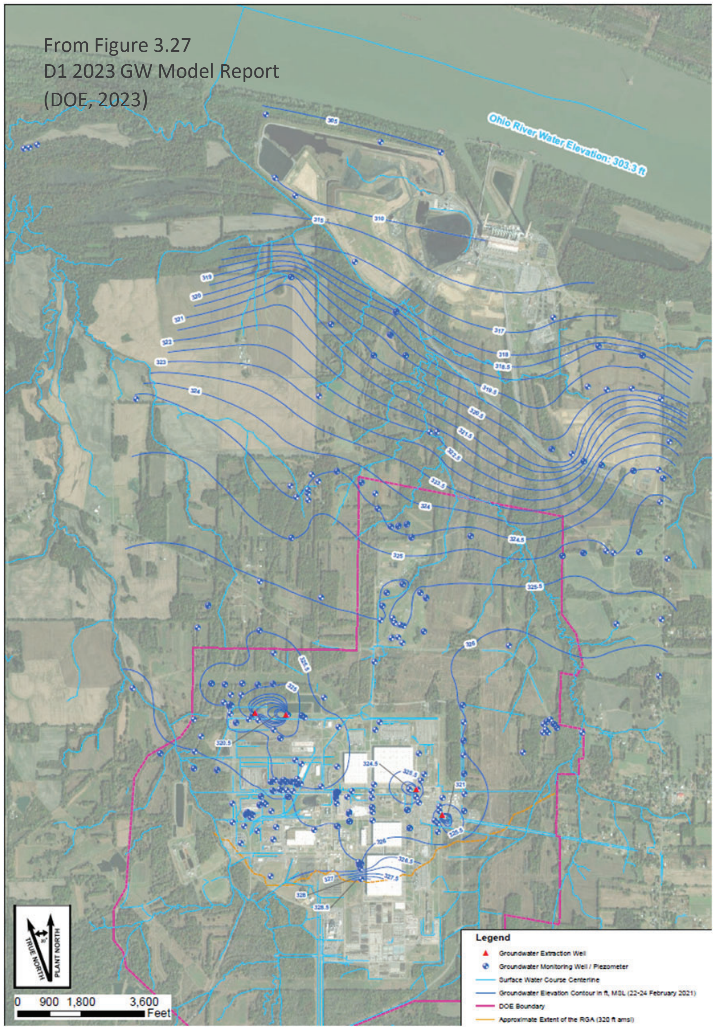
Initial Conditions

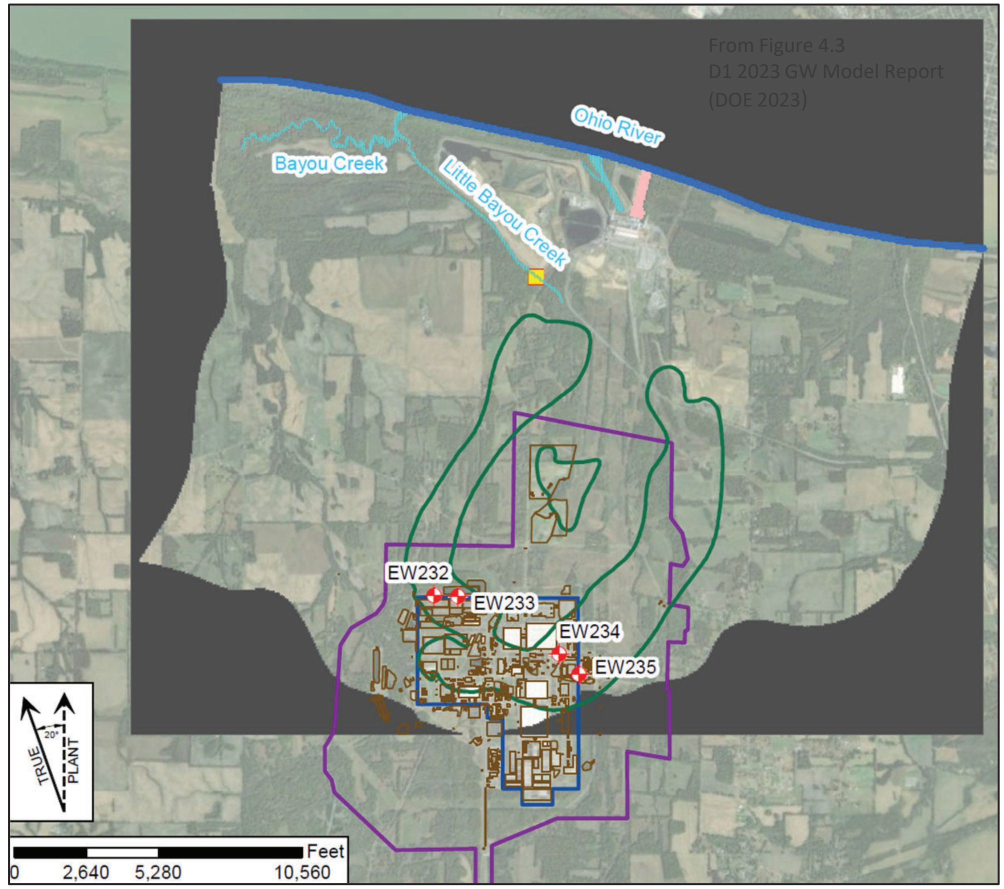
- A Sitewide RGA groundwater elevation surface was used to define initial conditions for SP1
  - Surface was interpolated from February 2021 data
  - Surface was used to define initial conditions in RGA layers and McNairy layers, as water levels in the McNairy are very similar to the RGA

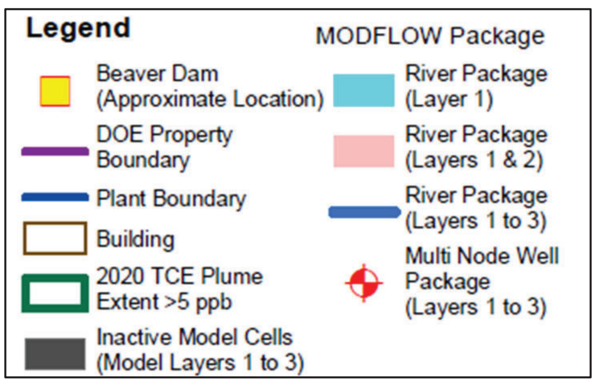




Boundary Conditions: RGA

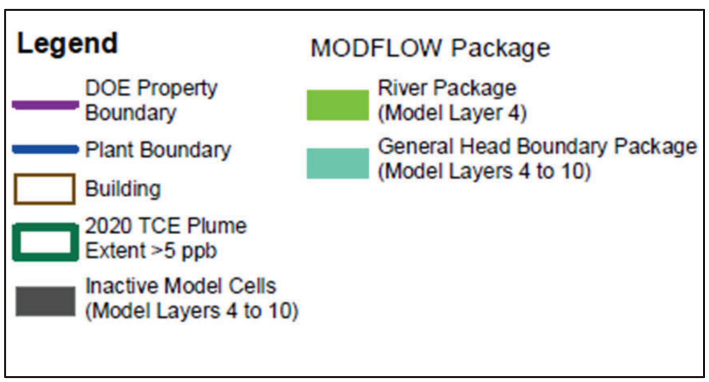
- MODFLOW Packages were used to simulate the following boundary conditions:
  - River Package: Ohio River and Creeks
  - Multi-Node Well Package: Extraction Wells
  - Recharge Package: Aquifer Recharge

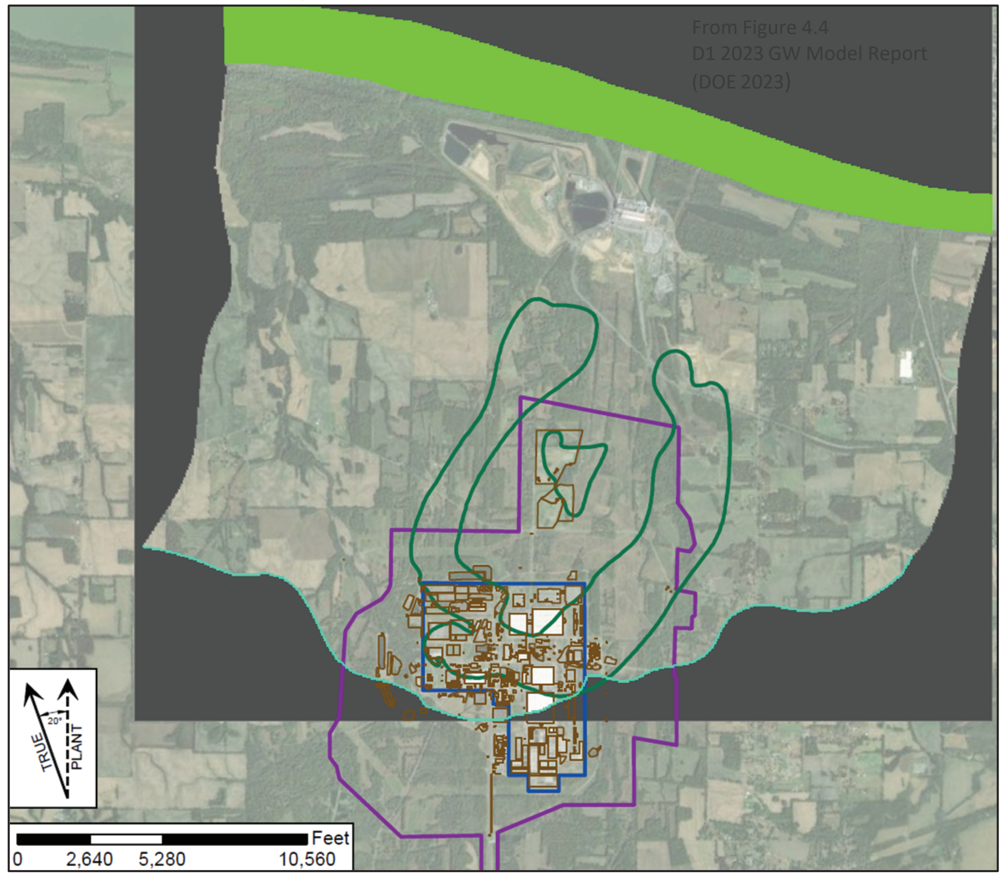


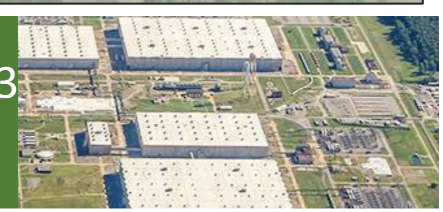


Boundary Conditions: McNairy

- MODFLOW Packages were used to simulate the following boundary conditions:
  - River Package: Ohio River and Creeks
  - General Head Boundary Package: Upgradient Inflow from McNairy Formation







Boundary Condition: Ohio River

- Ohio River Model Configuration is based on CSM that indicates river incises the RGA and in contact with the McNairy
  - River package assigned to side banks of Ohio River, to simulate lateral discharge of groundwater from the RGA through the river side banks
  - River package also assigned to McNairy to simulate upward discharge of groundwater from the McNairy to the base of the river

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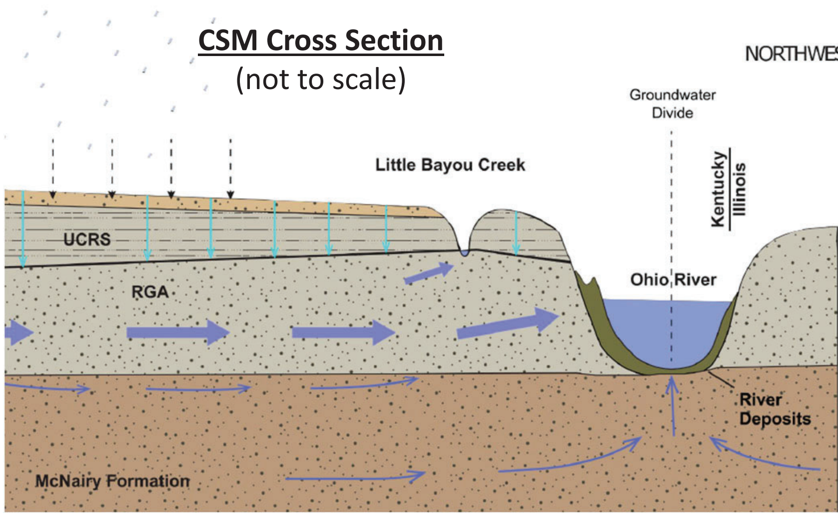
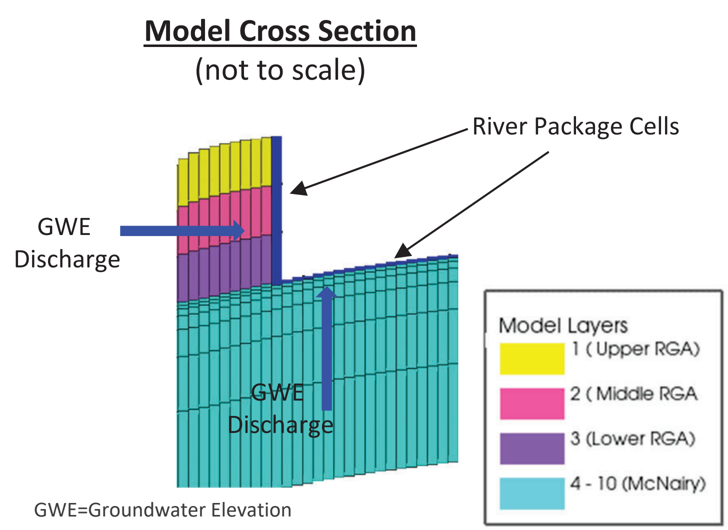


From Figure 1.2
D1 2023 GW Model Report (DOE 2023)



GWE=Groundwater Elevation

Boundary Condition: Ohio River

- Average Ohio River elevations were applied to the model boundary

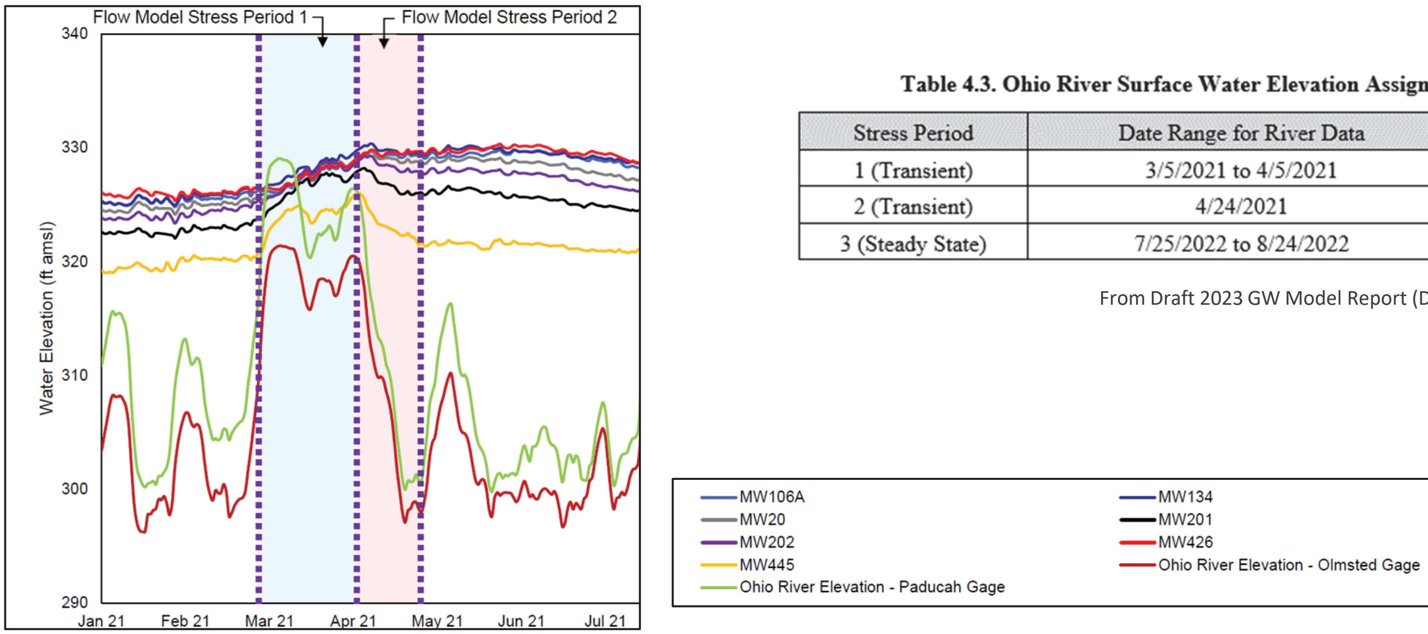


Table 4.3. Ohio River Surface Water Elevation Assigned to Model Stress Periods

Stress Period	Date Range for River Data	Average River Elevation (ft)
1 (Transient)	3/5/2021 to 4/5/2021	322.1
2 (Transient)	4/24/2021	299.1
3 (Steady State)	7/25/2022 to 8/24/2022	301.7

From Draft 2023 GW Model Report (DOE 2023)

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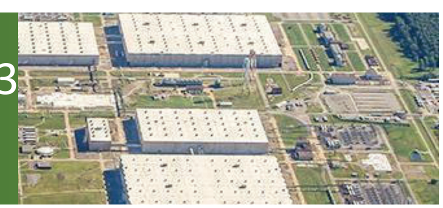
- River bottom elevations used in River Package were defined to be slightly above the bottom of each model layer as bathymetry data is not available

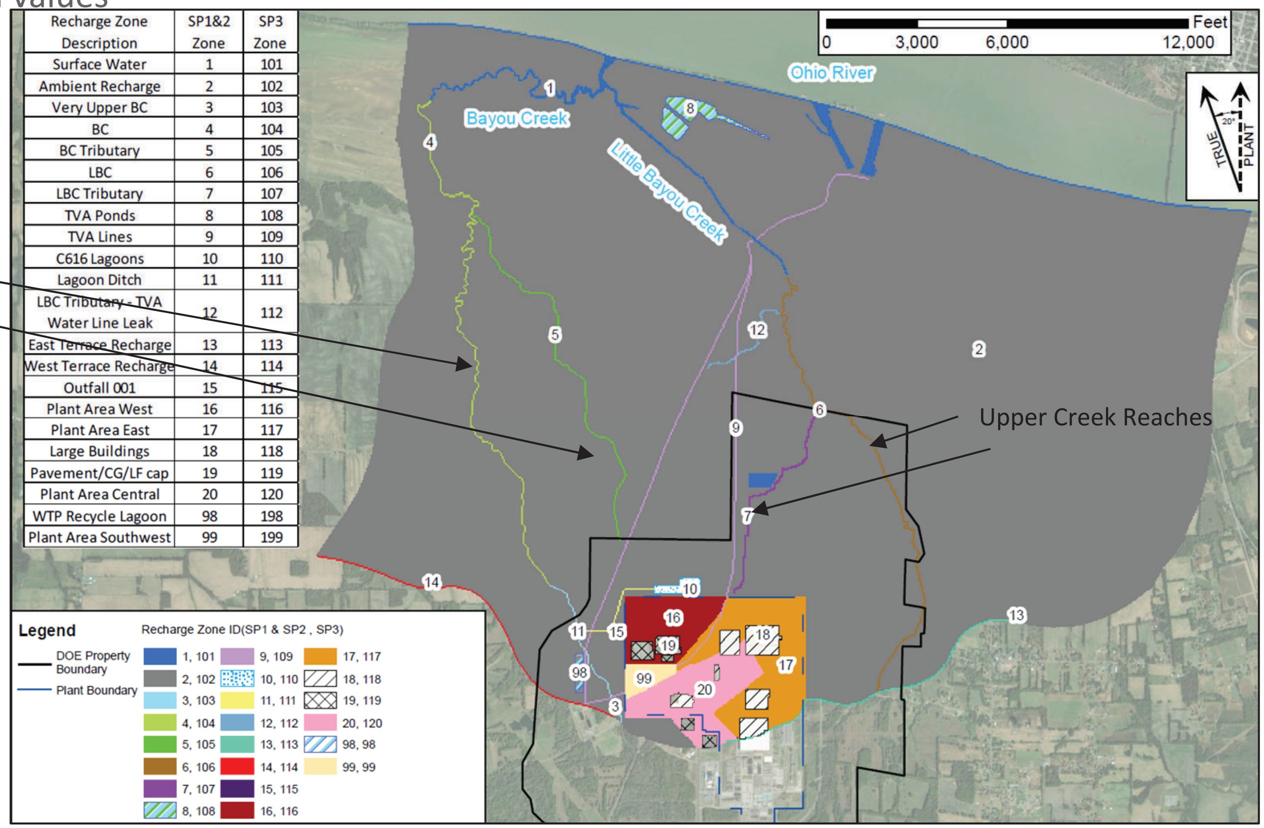
- Conductance was calibrated



Boundary Condition: Upper Creek Reaches

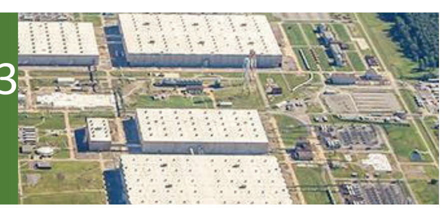
- Upper reaches of Bayou Creek, Little Bayou Creek, and creek tributaries are simulated using MODFLOW Recharge Package, consistent with prior (2016) model
  - Simulated via recharge based on conceptualization that the upper creek reaches incise only into the UCRS
  - Recharge rates are calibrated values

Upper Creek Reaches



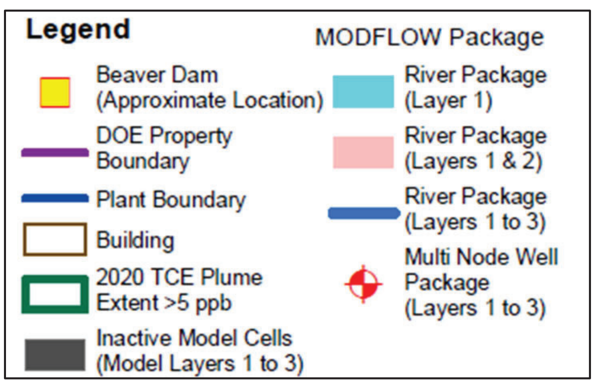
Recharge Zone Description	SP1&2 Zone	SP3 Zone
Surface Water	1	101
Ambient Recharge	2	102
Very Upper BC	3	103
BC	4	104
BC Tributary	5	105
LBC	6	106
LBC Tributary	7	107
TVA Ponds	8	108
TVA Lines	9	109
C616 Lagoons	10	110
Lagoon Ditch	11	111
LBC Tributary - TVA Water Line Leak	12	112
East Terrace Recharge	13	113
West Terrace Recharge	14	114
Outfall 001	15	115
Plant Area West	16	116
Plant Area East	17	117
Large Buildings	18	118
Pavement/CG/LF cap	19	119
Plant Area Central	20	120
WTP Recycle Lagoon	98	198
Plant Area Southwest	99	199

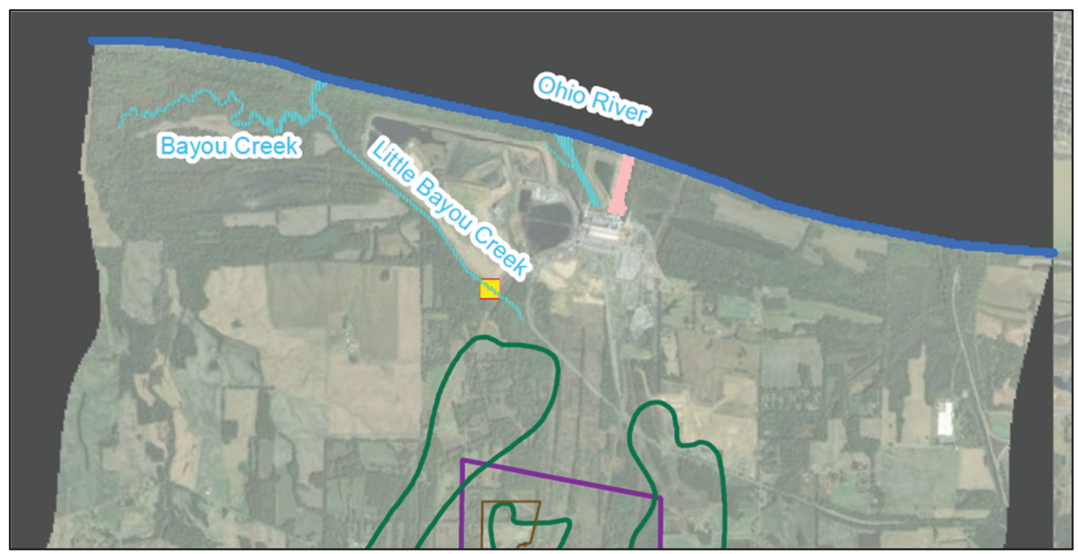
From Figure 4.7, D1 2023 GW Model Report (DOE 2023)



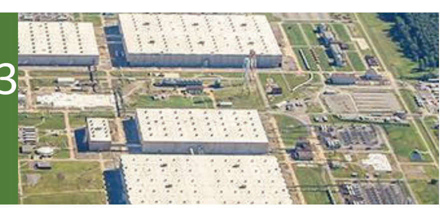
Boundary Condition: Lower Creek Reaches

- Lower reaches of Bayou Creek and Little Bayou Creek are simulated using MODFLOW River Package, consistent with prior (2016) model
  - Simulated with river package as data suggests lower reaches gain groundwater
  - Creek bottom elevations based on 1994 Army Corps of Engineer investigation
  - Creek water elevations based on typical water depths of 1.5ft for Little Bayou Creek and 3 ft for Bayou Creek
  - During times of high river elevations the creek water elevations were overridden by the Ohio River elevation where the derived creek water elevation for a cell was less than the Ohio River stage
  - Conductance values were calibrated





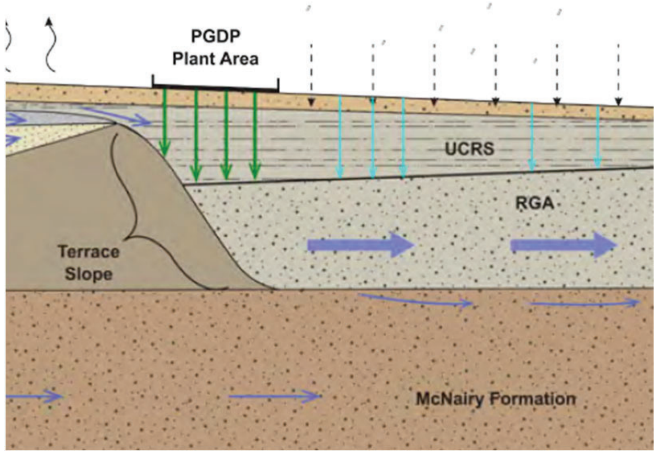
From Figure 4.3, D1 2023 GW Model Report (DOE 2023)



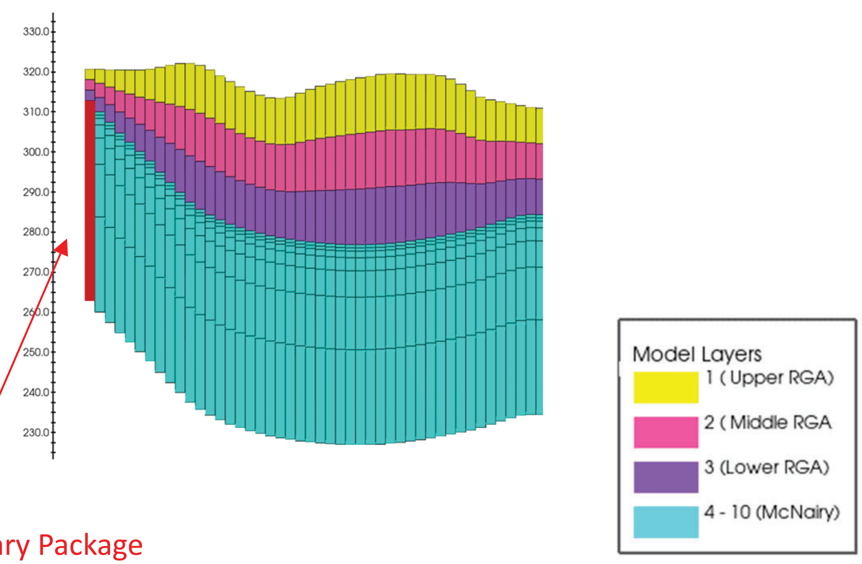
Boundary Condition: McNairy Inflow

- Upgradient Inflow from McNairy simulated using the General Head Package
  - Represents inflow from portion of McNairy that is upgradient of the PGDP hydrologic basin
  - Boundary inserted into layers 4 to 10
  - Inflow rates were estimated during calibration but constrained using ranges of inflows calculated from 2021 and 2022 hydraulic gradients

CSM Cross Section
(not to scale)



Model Cross Section
(not to scale)



From Figure 1.2, D1 2023 GW Model Report (DOE 2023)

General Head Boundary Package

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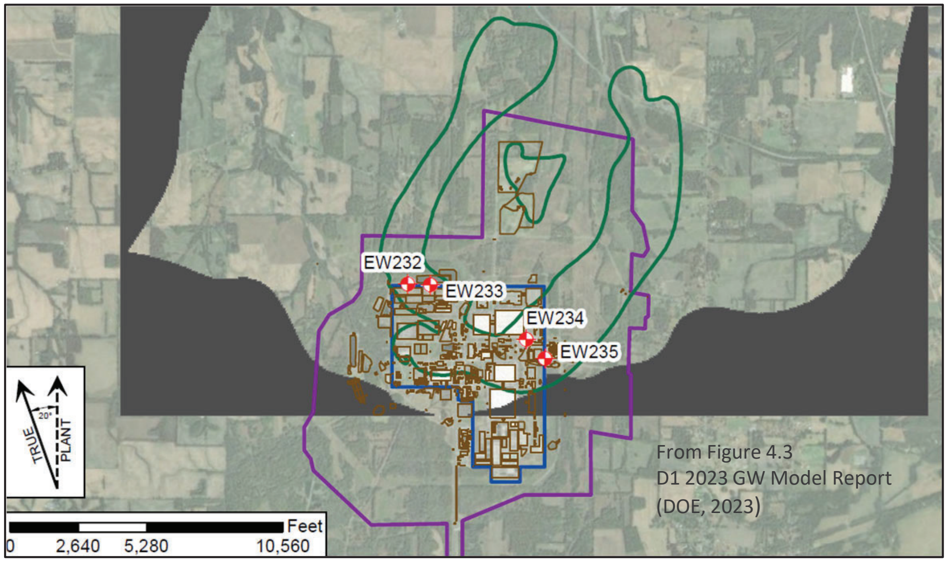
Boundary Condition: Extraction Wells

- Extraction wells were simulated using the MODFLOW Multi Node Package
  - Consistent with prior (2016) model
  - Pumping wells are screened in the RGA
  - Pumping rates are average monthly rates

Table 4.4. Model Pumping Rates (gpm)

Period	Monthly Average Used	EW234	EW235	EW232	EW233
SP1	March 2021	100	75	100	96
SP2	April 2021	100	75	102	98
SP3	August 2022	99	75	0	110

From Draft 2023 GW Model Report (DOE 2023)



From Figure 4.3 D1 2023 GW Model Report (DOE, 2023)

Boundary Condition: Aquifer Recharge

- Aquifer recharge simulated using MODFLOW Recharge Package
- Model simulates 4 sources of recharge:
  - Recharge from infiltration of precipitation
  - Recharge from surface water (i.e., upper reaches of creeks)
  - Recharge from Terrace Gravel inflow
  - Anthropogenic Recharge

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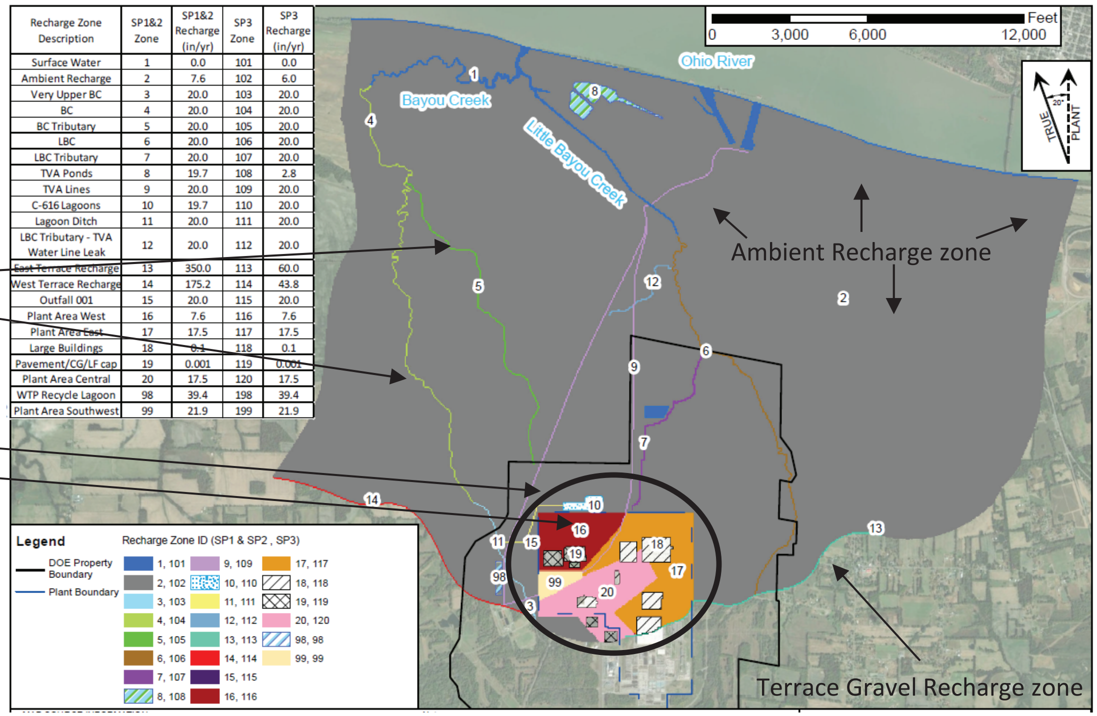
Recharge Zone Description	SP1&2 Zone	SP1&2 Recharge (in/yr)	SP3 Zone	SP3 Recharge (in/yr)
Surface Water	1	0.0	101	0.0
Ambient Recharge	2	7.6	102	6.0
Very Upper BC	3	20.0	103	20.0
BC	4	20.0	104	20.0
BC Tributary	5	20.0	105	20.0
LBC	6	20.0	106	20.0
LBC Tributary	7	20.0	107	20.0
TVA Ponds	8	19.7	108	2.8
TVA Lines	9	20.0	109	20.0
C-616 Lagoons	10	19.7	110	20.0
Lagoon Ditch	11	20.0	111	20.0
LBC Tributary - TVA Water Line Leak	12	20.0	112	20.0
East Terrace Recharge	13	350.0	113	60.0
West Terrace Recharge	14	175.2	114	43.8
Outfall 001	15	20.0	115	20.0
Plant Area West	16	7.6	116	7.6
Plant Area East	17	17.5	117	17.5
Large Buildings	18	0.1	118	0.1
Pavement/CG/LF cap	19	0.001	119	0.001
Plant Area Central	20	17.5	120	17.5
WTP Recycle Lagoon	98	39.4	198	39.4
Plant Area Southwest	99	21.9	199	21.9



From Figure 4.7
D1 2023 GW Model Report
(DOE 2023)

Model Recharge

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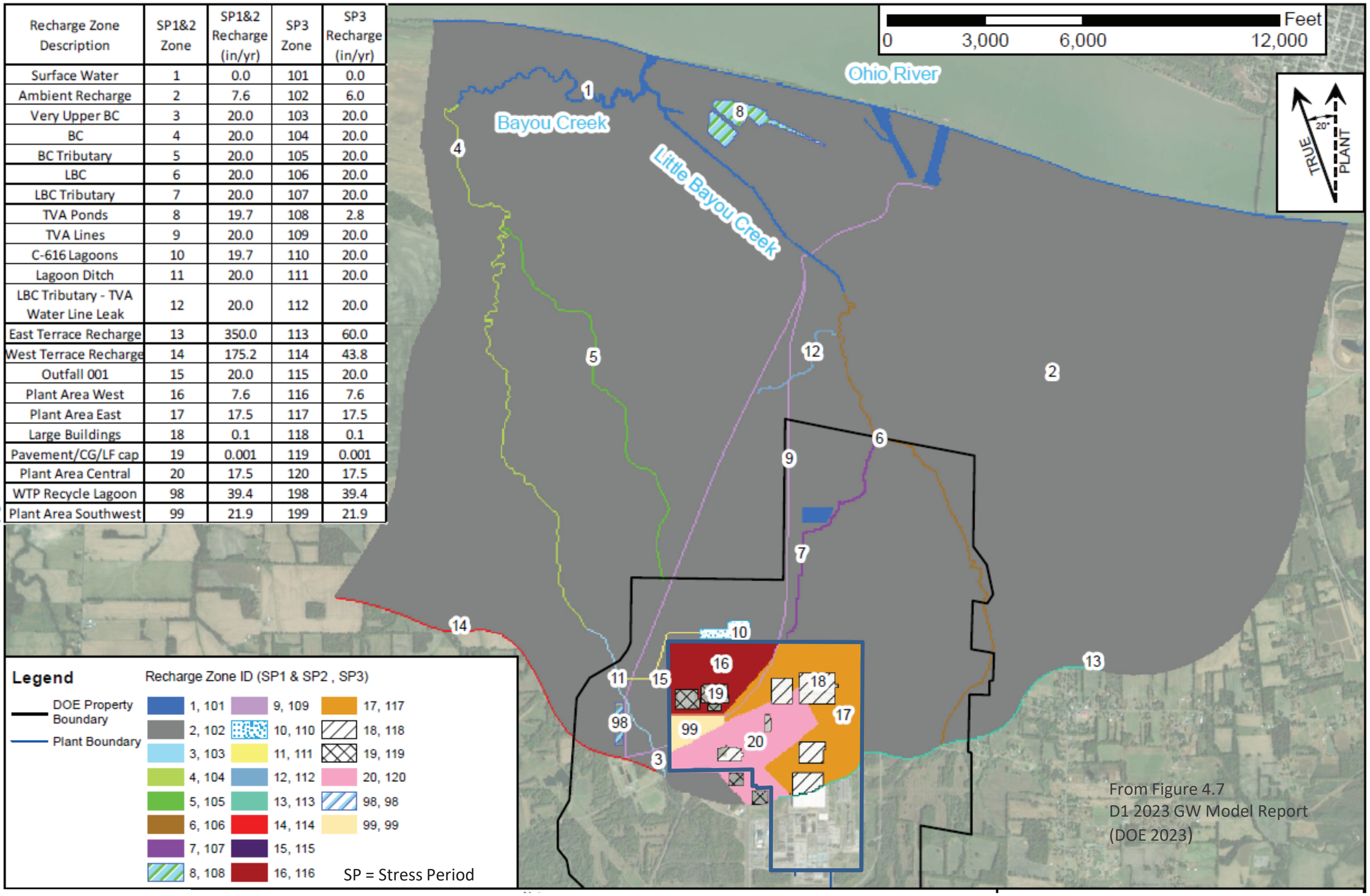
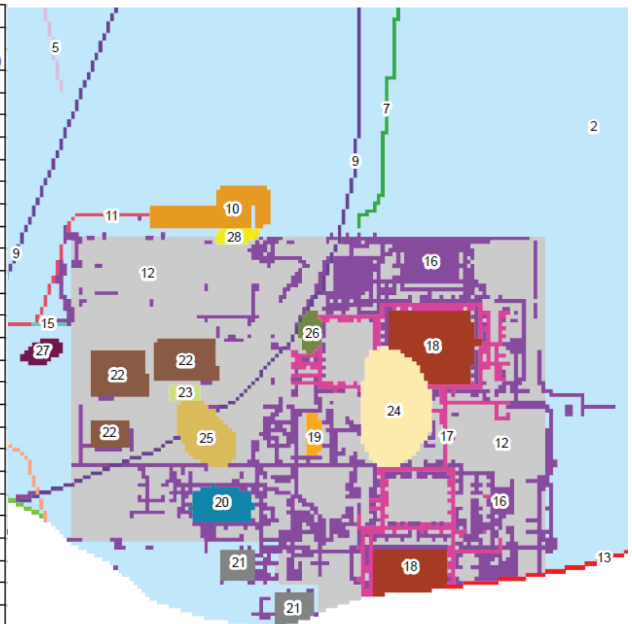


2023 Sitewide Groundwater Model Briefing – September 6, 2023

DRAFT Work Product – For Discussion Only

2016 GW Model vs. 2023 GW Model Recharge

Zone	Calibrated Recharge (inches/year) Stress Period 1 (February 1995)	Stress Period 2 (September 2014)
2	3.6	4.3
3	25.0	25.0
4	20.0	20.0
5	20.0	20.0
6	20.0	17.4
7	20.0	20.0
8	20.0	20.0
9	9.0	9.0
10	12.0	12.0
11	10.0	10.0
12	3.6	4.3
13	70.0	60.0
14	35.9	30.8
15	15.0	15.0
16	14.4	22.0
17	18.8	30.0
18	30.0	30.0
19	10.0	16.0
20	0.001	0.001
21	0.001	0.001
22	0.001	0.001
23	0.001	0.001
24	45.0	45.0
25	14.7	40.0
26	15.0	20.0
27	19.5	40.0
28	28.9	20.4



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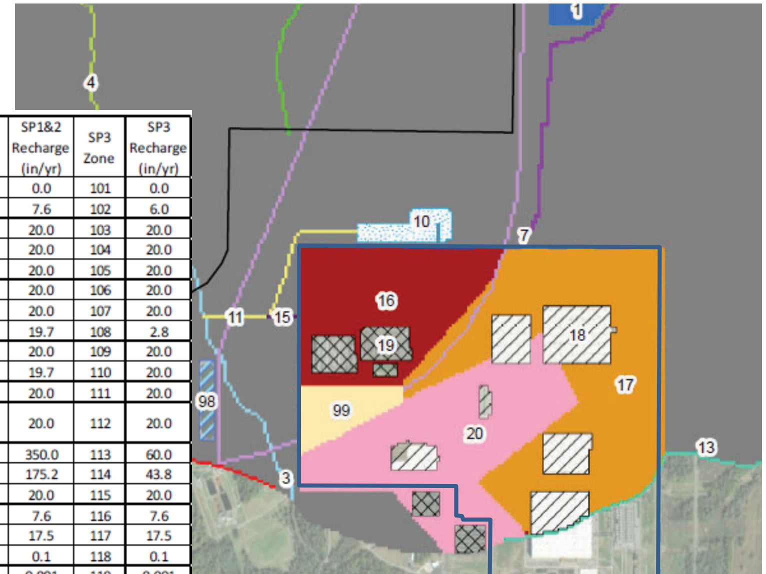
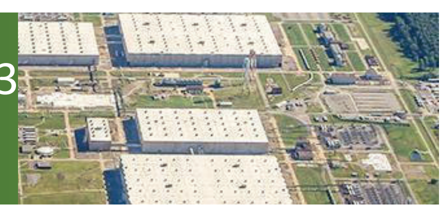


- Subject of regulator comment
- Recharge zonation simplified in the 2023 GW model
- Large process building recharge reduced from 30 inches/year to 0.1 inches/year
- Ambient recharge rates are comparable
- 2023 GW model maximum plant area recharge rate limited to 22 inches/year in response to regulator comment

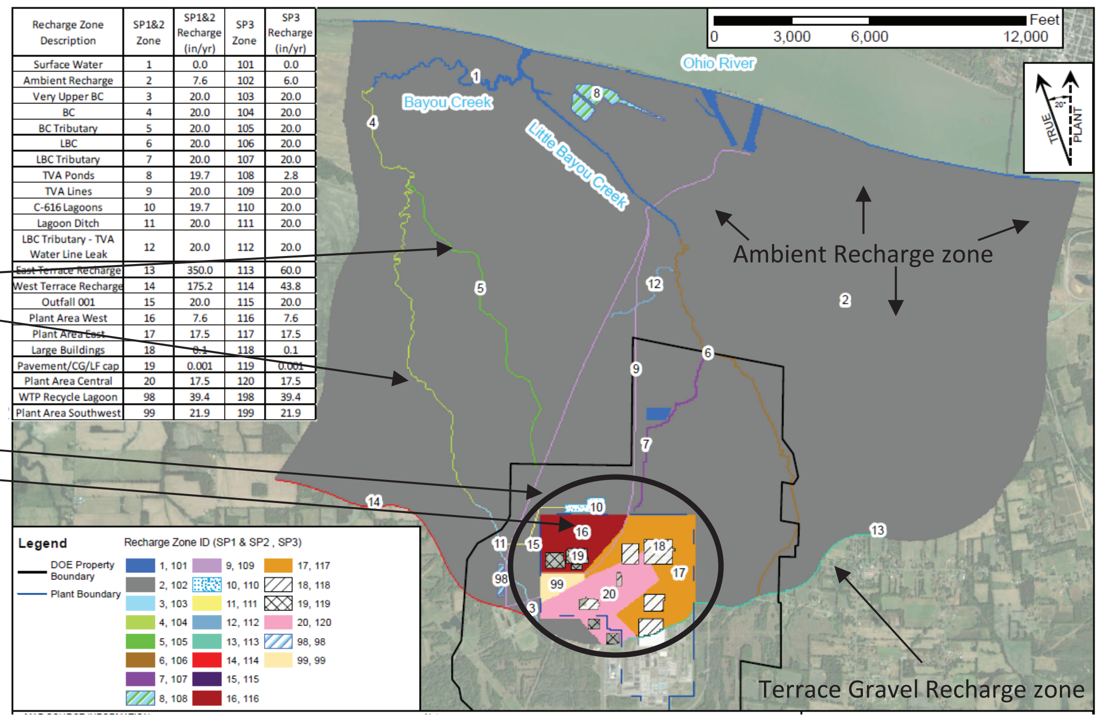


Boundary Condition: Aquifer Recharge

- Ambient Recharge calibrated to be within prior estimated range
  - Ambient ranges between 6.0 to 7.6 in/yr
  - Prior estimated range is 2.64 to 7.64 in/yr (DOE 2010)
- Anthropogenic recharge is consistent with prior models (DOE 2022)
  - Ranges between 7.6 to 22 in/yr

Upper Creek Reaches
(linear zones)

Anthropogenic Recharge Zones
Anthropogenic Recharge Zones



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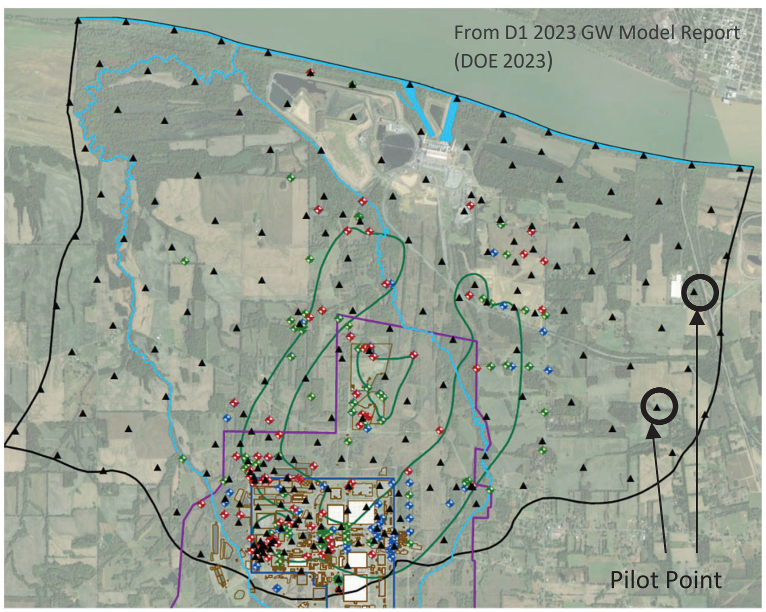
From Figure 4.7
D1 2023 GW Model Report
(DOE 2023)

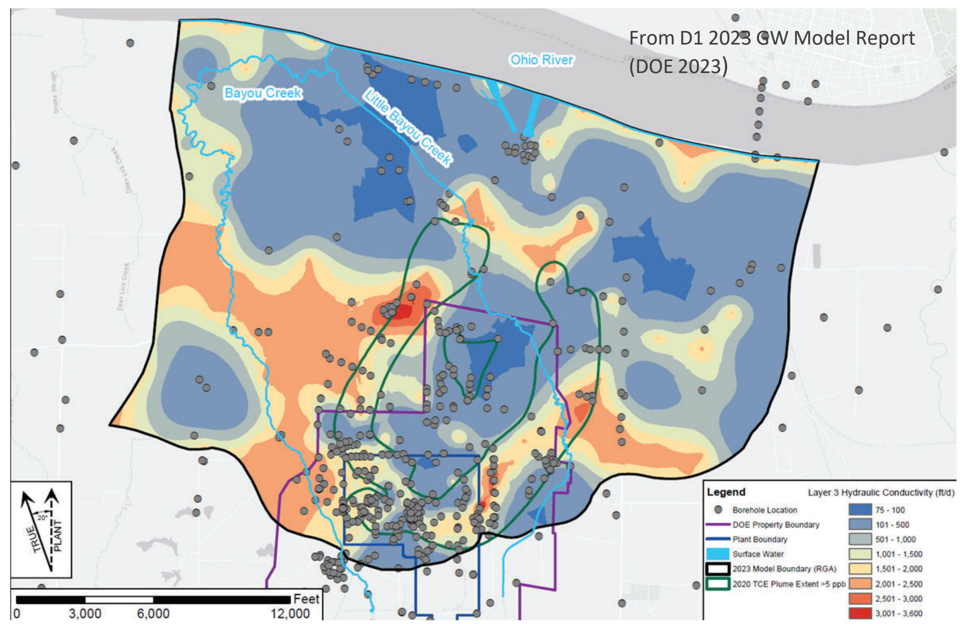
Parameter: Hydraulic Conductivity

- Hydraulic Conductivity was the primary parameter within the model
- Distribution of conductivity in the model was defined using pilot-points
  - Conductivity values were assigned to the pilot points, and constrained based on site specific values (e.g., slug test or pumping test derived conductivity estimates)
  - Kriging was then used to interpolate conductivity values at cells between pilot points
  - Conductivity was adjusted during calibration

Pilot Point Distribution



Example of Calibrated Conductivity field (layer 3)



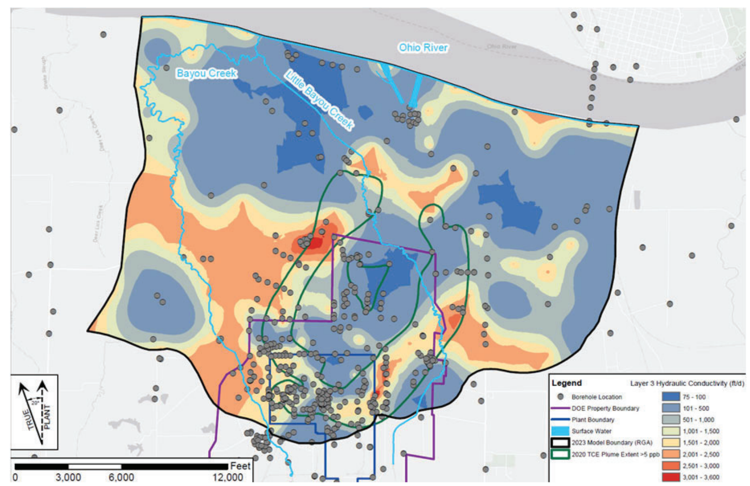
Parameter: Hydraulic Conductivity, Cont.

- Model estimated RGA horizontal conductivities fall within the range of pumping test derived estimates
  - RGA Hydraulic conductivity values estimated from Pumping Test studies range from 37 ft/day to 3,600 ft/day
- Model estimated McNairy horizontal conductivities is 0.38 ft/d
  - Falls within range of slug test derived conductivity values (0.08 ft/d to 0.52 ft/d)
- Vertical anisotropy was not calibrated and assumed to have a value of 10
  - i.e., vertical conductivity is 1/10th of horizontal conductivity

Table 5.2. Pilot Point Hydraulic Conductivity

Statistic	Layers 1 to 3	Layer 1	Layer 2	Layer 3
Hydraulic Conductivity: All Model Cells				
Average	851	770	889	895
Geometric Mean	539	493	586	541
Standard Deviation	723	671	707	780
Minimum	75	79	75	81
Maximum	3,602	3,527	3,602	3,574
Range	3,527	3,448	3,527	3,493
Number of Cells	675,429	224,771	225,329	225,329

From D1 2023 GW Model Report (DOE, 2023)



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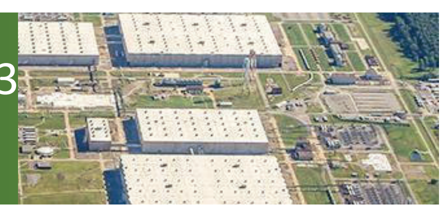
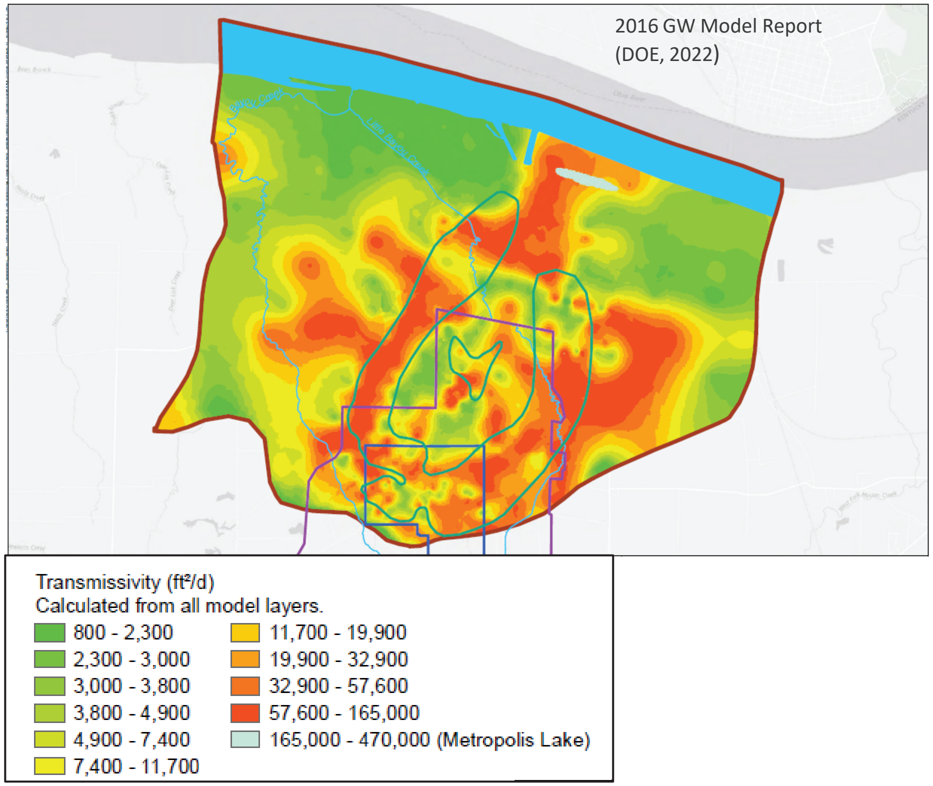
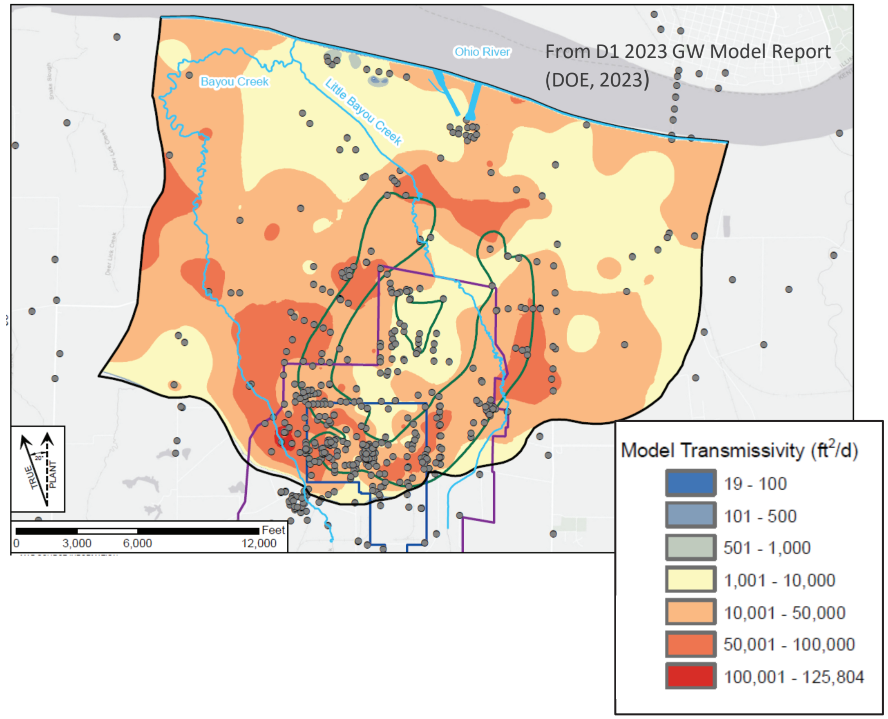


2016 GW Model vs. 2023 GW Model Transmissivity





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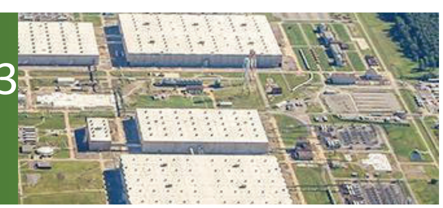
- Subject of regulator comment
- Additional data have led to refinements to configuration
- The refined configuration is consistent with the depositional history of the site and the CSM
- Zones of higher transmissivity coincident with plume trajectories are consistent in both models
- 2023 model maximum transmissivity values are approximately 10% lower than 2016 model

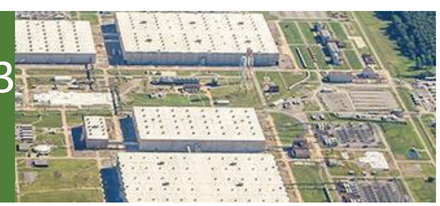
Parameter: Storage

- Storage parameters were input to the transient stress periods
- For simplicity it was assumed storage was homogeneous within each aquifer unit
- Specific Storage and Specific Yield values were assigned to the RGA
  - Specific Yield was assigned as there are some areas in the RGA near the river that are not fully confined
- Specific Storage was assigned to the McNairy
  - McNairy is assumed to be fully saturated based on CSM and groundwater elevations of the RGA and McNairy
- All storage values were based on literature values and varied during calibration



Flow Model Calibration

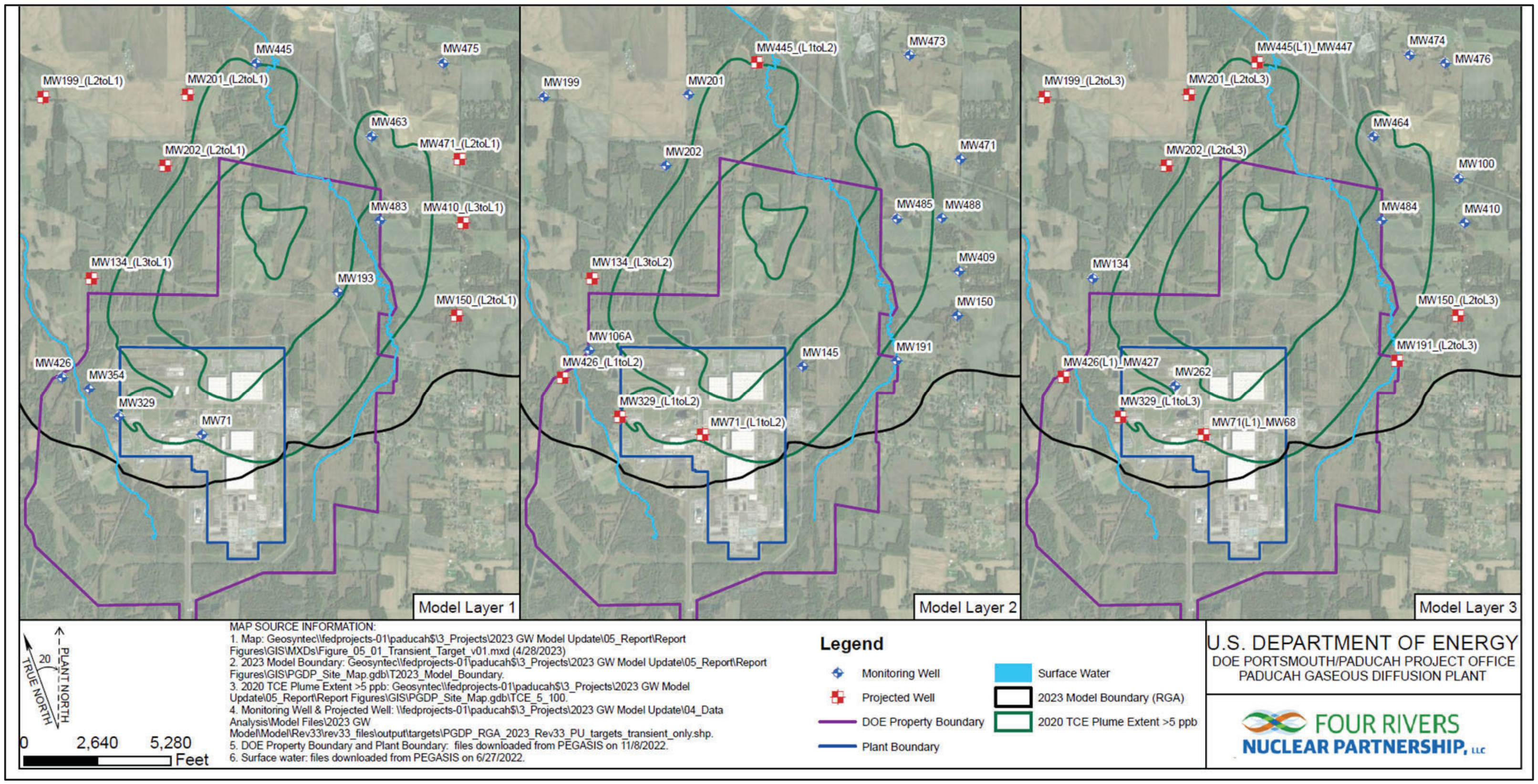
- Model was calibrated to the following data sets/targets
  - Monitoring well water levels
  - Groundwater discharge (flux) – Little Bayou Creek (LBC) measured August 2022
  - Groundwater Flow direction (trajectory) – based on long term, steady state TCE plume flow paths and extents
- Calibrated Boundaries and Parameters include:
  - Recharge
  - River and creek conductance
  - Hydraulic conductivity
  - Storage
- Calibration Methodology:
  - Model was calibrated using PEST
  - PEST (Doherty 2020) is a parameter estimation software that iteratively adjusts parameters to achieve model calibration
  - PEST_HP using PEST-SVD Assist



Calibration: Transient Groundwater Targets

- Daily average pressure transducer data from 29 RGA Monitoring Wells were used as transient calibration targets
  - Data from March 1, 2021 to April 26, 2021 was used to define targets

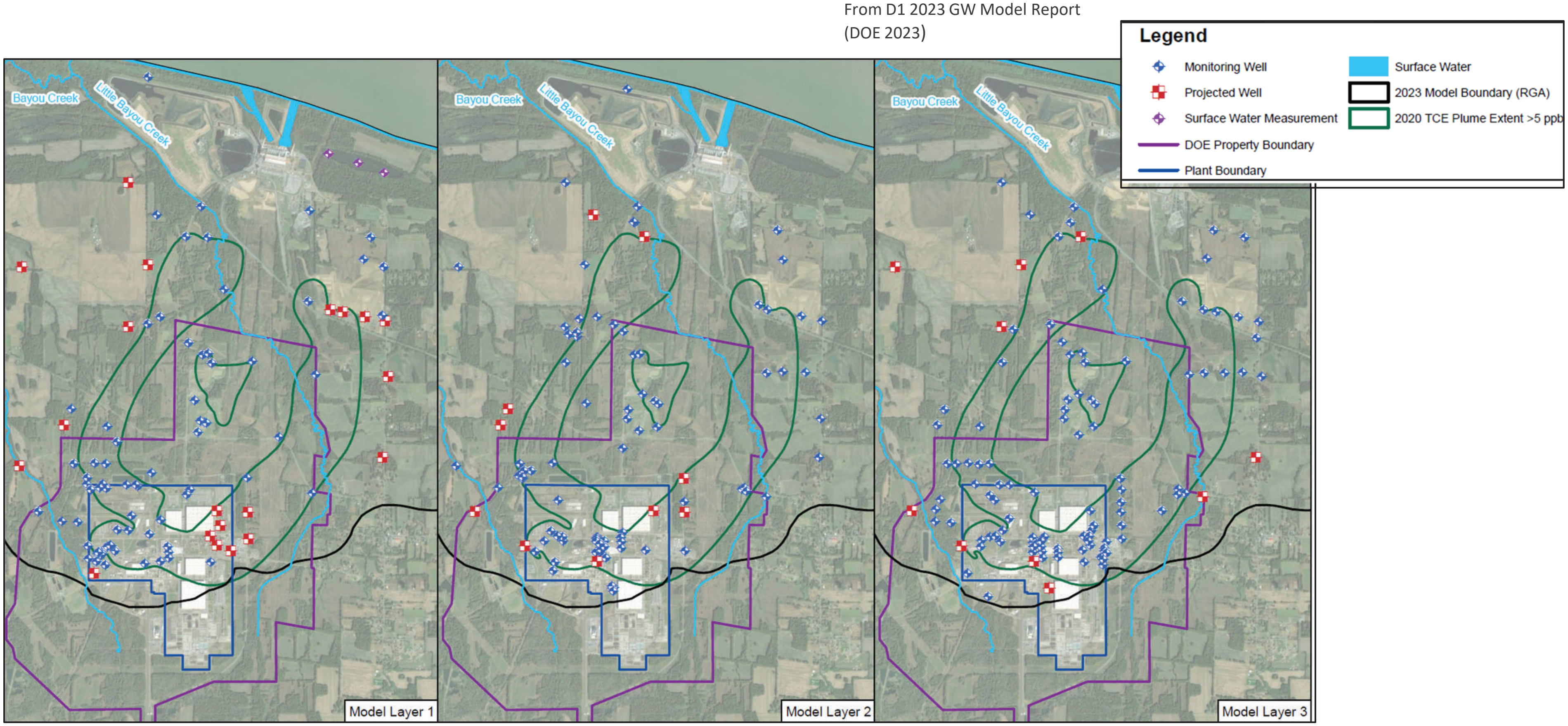
From D1 2023 GW Model Report (DOE 2023)

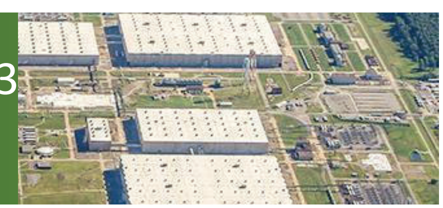


Calibration: Steady State Groundwater Targets (RGA)

- Groundwater elevations manually collected in August 2022 from 266 RGA Monitoring Wells and 8 McNairy Wells were used as steady state calibration targets

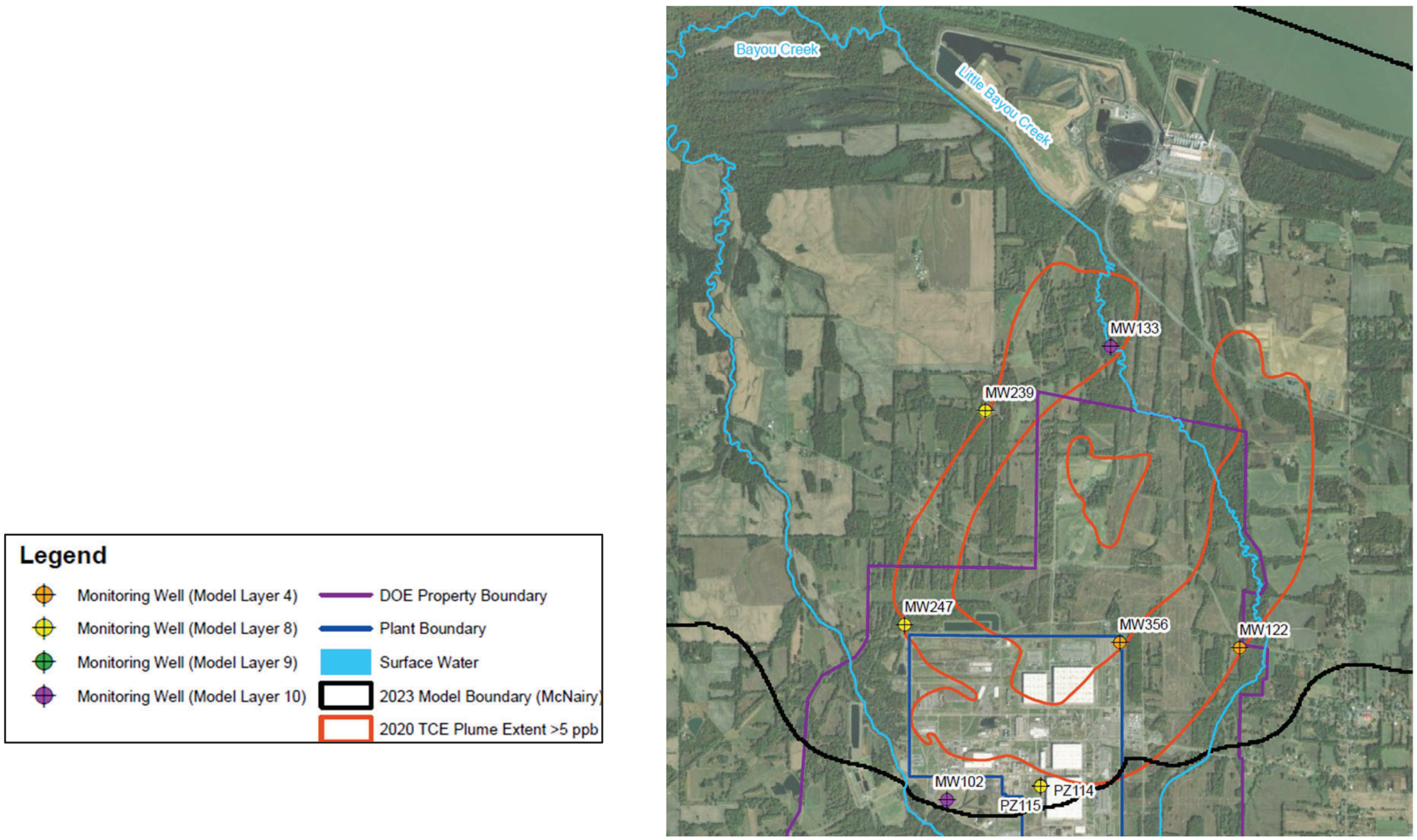
From D1 2023 GW Model Report
(DOE 2023)





Calibration: Steady State Groundwater Targets (McNairy)

- Groundwater elevations manually collected in August 2022 from 266 RGA Monitoring Wells and 8 McNairy Wells were used as steady state calibration targets



From D1 2023 GW Model Report (DOE 2023)

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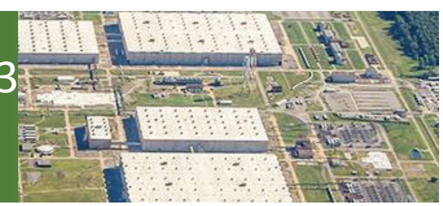
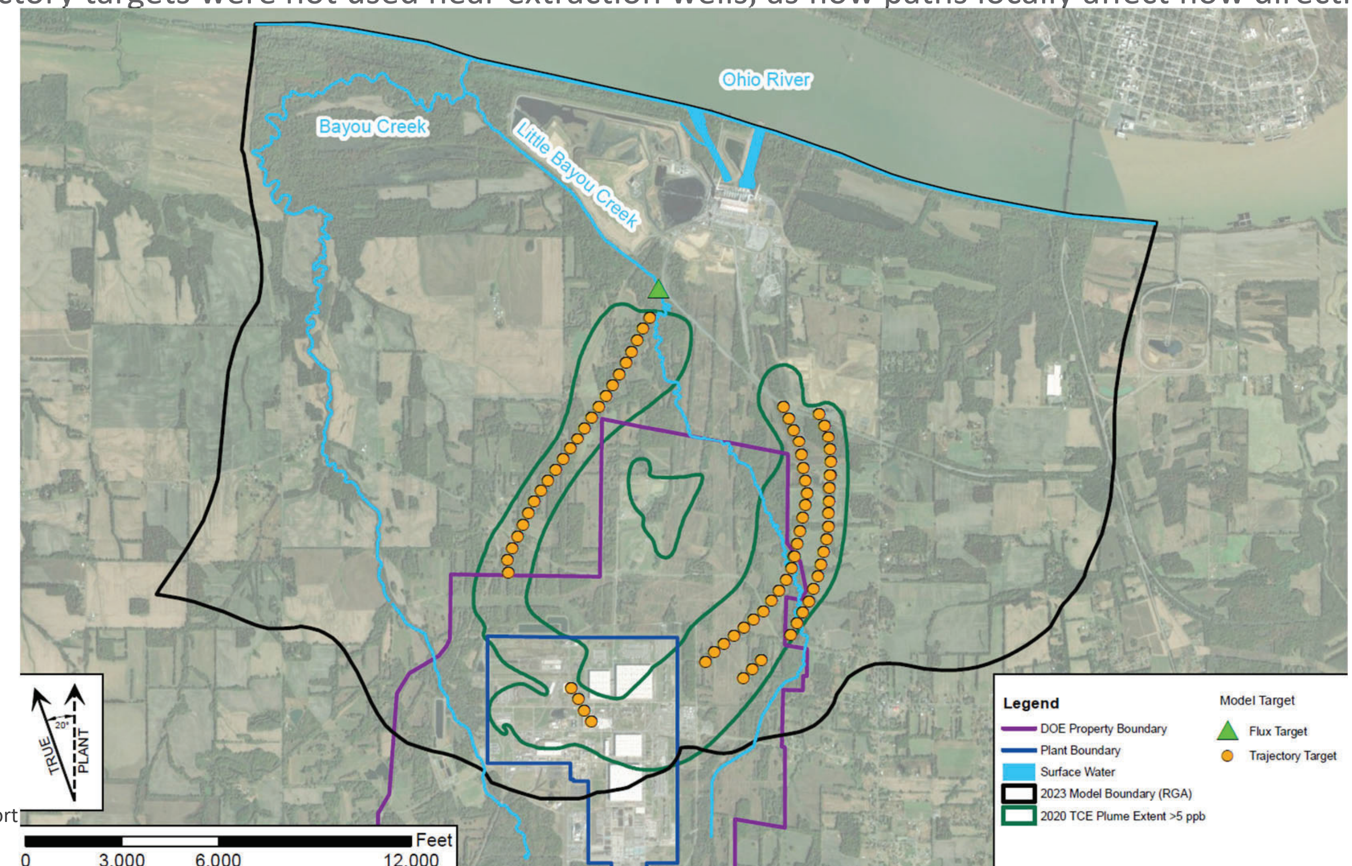


Calibration: Flux and Trajectory Targets

- One Flux target was used based on August 2022 measurements from Little Bayou Creek
- 222 trajectory targets (74 per layer) were used
  - Trajectory targets were not used near extraction wells, as flow paths locally affect flow direction



From D1 2023 GW Model Report (DOE 2023)

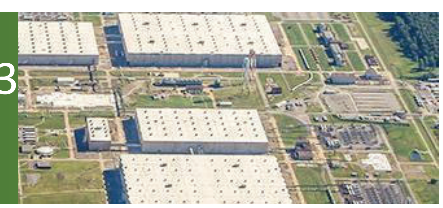
Calibration: Groundwater Statistics

- Calibration statistics of Groundwater Elevation Targets indicate that the model is well calibrated
  - Target residuals for overall model are on average close to zero
    - Exception: Transient targets in the Plant Area
  - Scaled RMS error for SP3 is <5%
    - Goal is <10%

Table 5.7 Groundwater Elevation Calibration Statistics: Entire Model

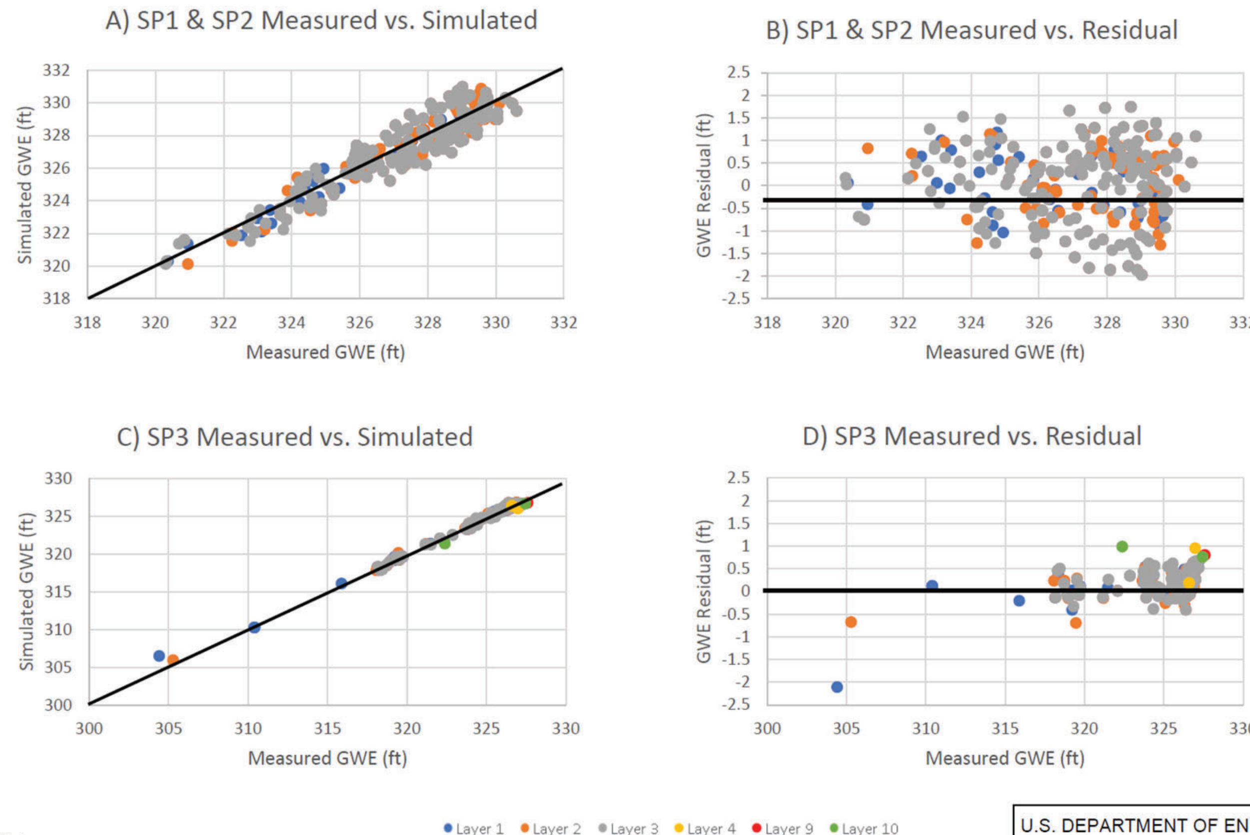
Model Statistics	Stress Period 1 & 2 (Transient)	Stress Period 3 (Steady-State)
Residual Mean (ft)	0.10	0.17
Residual Std Deviation (ft)	0.84	0.29
Absolute Residual Mean (ft)	0.71	0.25
Residual Sum of Squares (ft^2)	319.78	36.09
RMS Error (ft)	0.84	0.34
Min. Residual (ft)	-1.97	-2.11
Max Residual (ft)	1.74	0.99
Range in Observations (ft)	10.31	23.19
Scaled RMS Error	0.082	0.015
Number of Observations	450	317

From D1 2023 GW Model Report
(DOE, 2023)



Calibration: Groundwater Graphs

- Graphs of Simulated GWE and GWE residuals support that model is calibrated
  - Simulated GWEs generally match measured GWEs
- SP1/SP2 shows a larger spread in residuals; this is related to the temporal discretization of the "wet" period
  - Calibration residuals can be improved by adding more stress periods
- In SP3 Layer 1, an outlier residual is seen
  - This is from a TVA well
  - It is speculated that some sort of localized condition is affecting groundwater there, but there is no information to confirm.



Note:
1. SP = Model Stress Period.
2. GWE = Groundwater Elevation.
3. Graphs represent targets for the entire model.

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FOUR RIVERS

From D1 2023 GW Model Report (DOE 2023)

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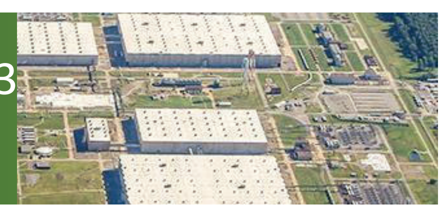

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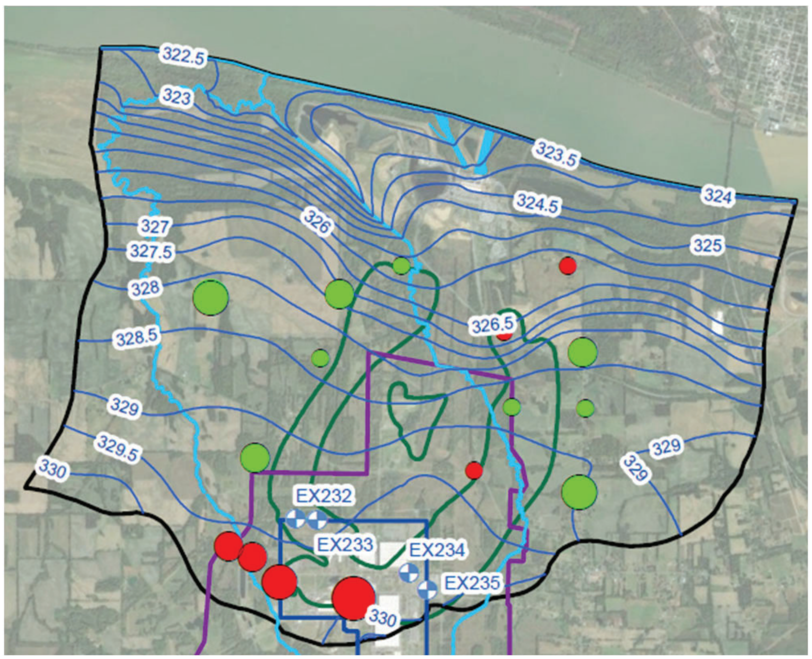
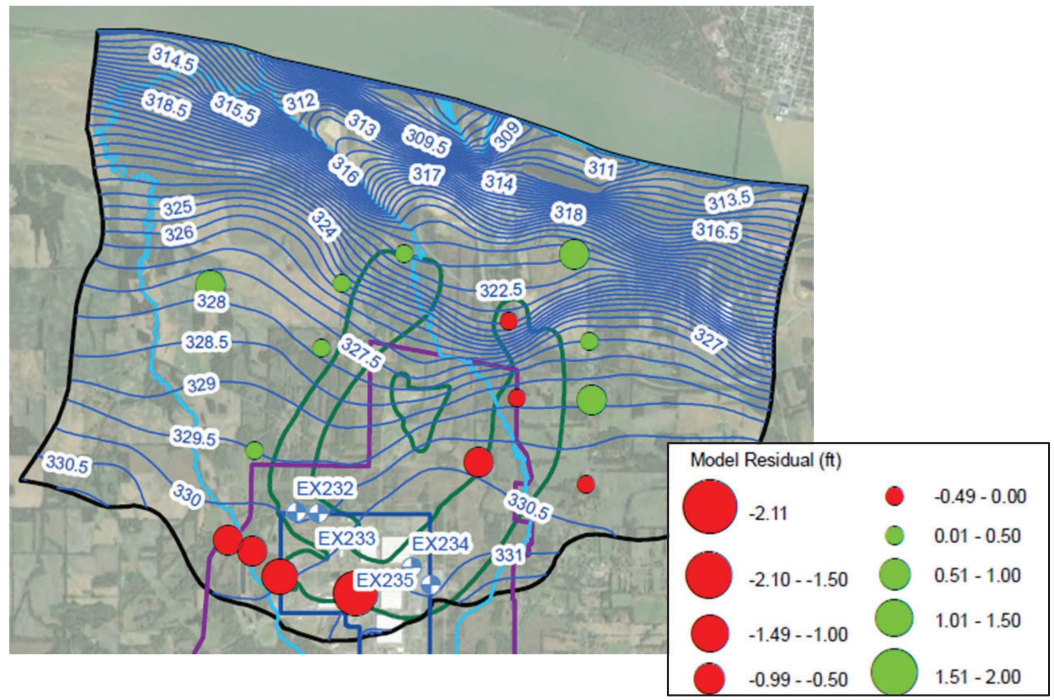
Calibration: Groundwater Transient Residuals

- Spatial bias is seen in groundwater elevation residuals, for Transient Stress Periods 1 & 2
  - Model tends to overestimate groundwater elevations in the Plant area by approximately 0.5 ft to 2 ft
  - Model tends to underestimate groundwater elevations north of the Plant Area by approximately 0.5 ft to 2 ft
  - This is likely due to the time discretization chosen to approximate the groundwater system response to a relatively rapid rise and drop in river water levels. Additional stress periods would allow for higher resolution in boundary conditions representing the river water levels.

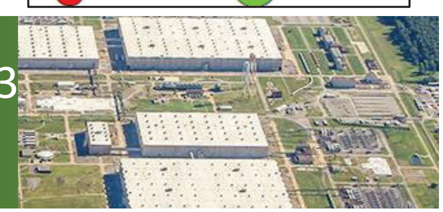
Stress Period 1 Residuals (Layer 1)



Stress Period 2 Residuals (Layer 1)



From D1 2023 GW Model Report (DOE 2023)

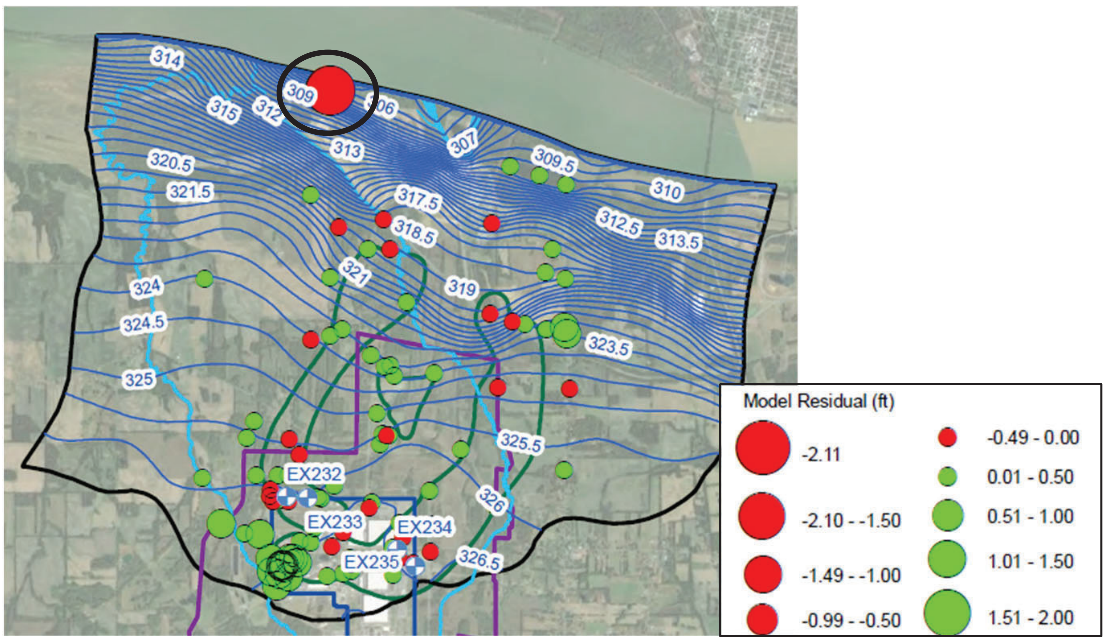


C-92

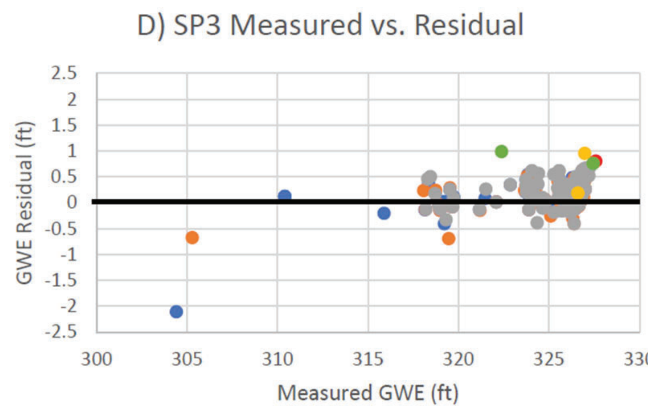
Calibration: Groundwater Steady State Residuals

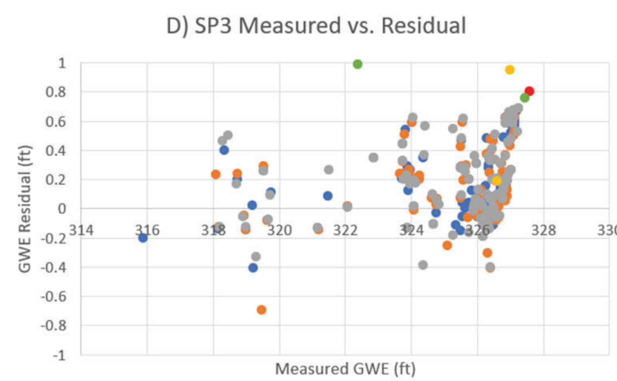
- In steady-state stress period 3, positive and negative residuals are reasonably spread across the model domain, and are on average less than 0.5ft, indicating little spatial bias and a good calibration
  - The exception is the outlier TVA well
  - Not enough information is known to inform model in the TVA CCR ponds area

Stress Period 3 Residuals (Layer 1)



From D1 2023 GW Model Report (DOE 2023)





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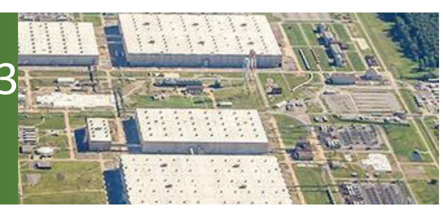
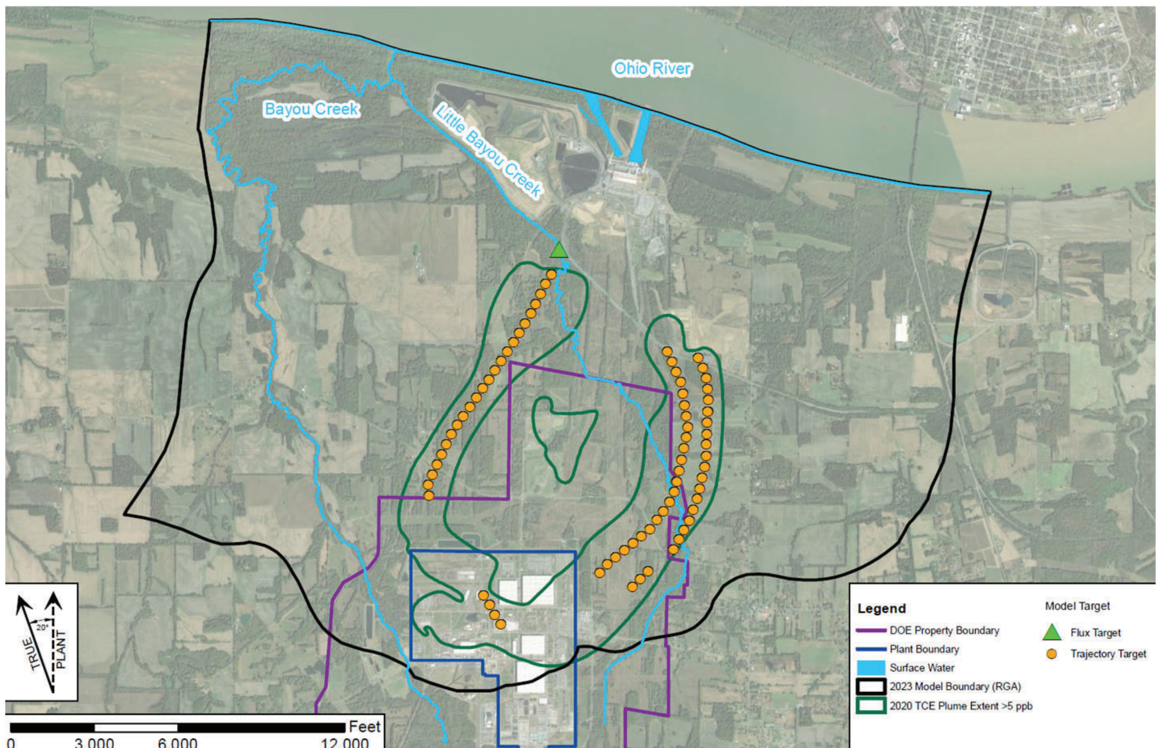


Calibration: Flux Residuals

- Measured discharge at Little Bayou Creek is 134.6 gpm
- Model predicted steady state discharge at Little Bayou Creek is 126.5 gpm
- Model slightly underestimates discharge, but the percent error is 6%, which is reasonable for groundwater discharge predictions.



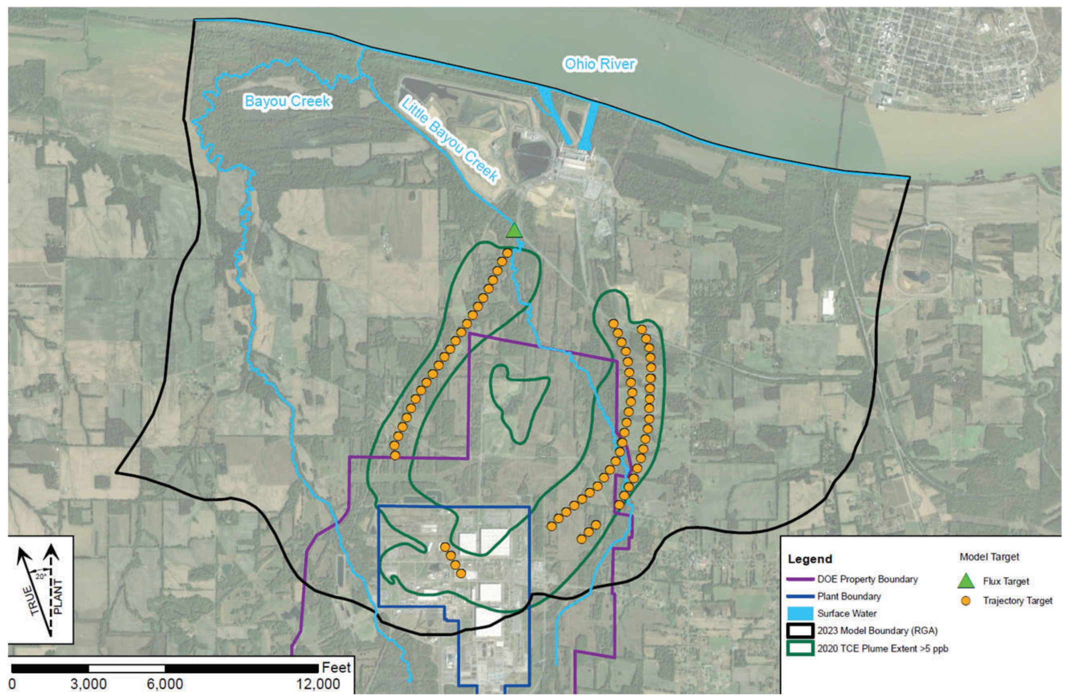
From D1 2023 GW Model Report (DOE 2023)

Calibration: Trajectory Target Residuals

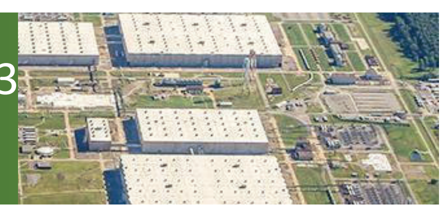
- Steady state residuals show that the model is well calibrated
  - Scaled RMS is 6%
- Transient targets have higher residuals, on average
  - Scaled RMS is 14%
  - This high RMS is due to using targets developed using long term, steady state plume extents
  - Primary purpose of using trajectory targets in the transient stress periods was to constrain PEST

Table 5.9. Flow Direction Calibration Statistics

Statistic	Stress Period 1 & 2	Stress Period 3
	Un-Weighted	Un-Weighted
Residual Mean	-0.51	0.59
Residual Std Deviation	12.1	4.97
Absolute Residual Mean	7.76	3.75
Residual Sum of Squares	2.93E+05	5.57E+03
RMS Error	12.11	5.01
Min. Residual	-104.15	-11.81
Max Residual	34.43	13.74
Range in Observations	84.6	84.6
Scaled RMS Error	0.143	0.059
Number of Observations	1998	222



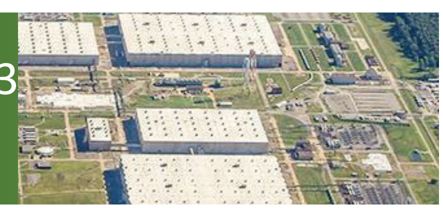
From D1 2023 GW Model Report (DOE 2023)



Mass Balance

- Overall Model mass balance (or flow) error is small:

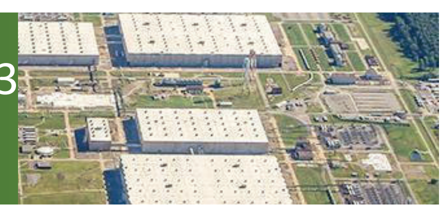
Stress Period	Time (days)	Flow Error (ft^3/d)	% Error
1	7	75.63	0.00
	14	59.75	0.00
	21	523.13	0.05
	28	64.00	0.01
	35	12.50	0.00
	42	-5.50	0.00
2	49	3.13	0.00
	56	0.75	0.00
	63	0.75	0.00
3	64	0.13	0.00



Mass Balance

- Inflows under Steady State conditions
  - 82% of inflow is from Ambient Recharge
  - 10% of inflow is from Anthropogenic recharge (total)
  - 8% of inflow is due to surface water or inflow from terrace gravel
- Outflows under Steady State conditions
  - 79% of model outflow is discharge to the Ohio River
  - 14% of model outflow discharges to Little Bayou Creek
  - 7% of model outflow is to extraction wells

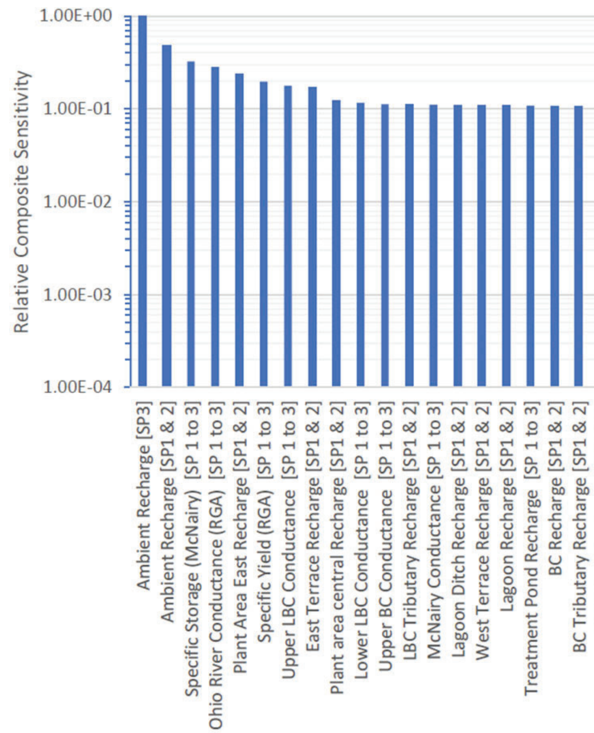
Model Source/Sink Description	MODFLOW Package	Zone/Well/Reach ID	SP3 Flow Rate (gpm)	Percent of Total Flow
Ohio River	Recharge	101	0	0.0
Ambient		102	123,109,025	81.9
Very Upper Bayou Creek		103	224,146	0.1
Bayou Creek		104	898,781	0.6
Bayou Creek Tributary		105	562,562	0.4
Little Bayou Creek		106	744,955	0.5
Little Bayou Creek Tributary		107	397,749	0.3
TVA Ponds		108	193,400	0.1
TVA Lines		109	1,525,070	1.0
C 616E and C-616F Lagoons		110	540,586	0.4
Lagoon Ditch		111	147,233	0.1
LBC Tributary associated TVAWater Line Leak		112	206,566	0.1
East Terrace		113	1,397,603	0.9
West Terrace		114	1,053,938	0.7
Outfall 001		115	21,975	0.0
Plant Area West		116	1,644,605	1.1
Plant Area East		117	6,856,850	4.6
Large Buildings		118	13,481	0.0
Pavement/compacted gravel/LF cap		119	60	0.0
Plant Area Central		120	5,199,425	3.5
WTP Recycle Lagoon		98	563,063	0.4
Plant Area Southwest		99	1,157,406	0.8
Extraction Well 232	Multi-node Well	EW232	0	0.0
Extraction Well 233		EW233	-4,081,000	-2.7
Extraction Well 234		EW234	-3,686,183	-2.5
Extraction Well 235		EW235	-2,776,813	-1.8
Ohio River in RGA	River	1	-116,809,616	-77.7
Ohio River in McNairy		6	-2,055,228	-1.4
Little Bayou Creek		2	-4,690,153	-3.1
Little Bayou Creek		3	-16,150,121	-10.7
Bayou Creek		4	2,018,103	1.3
Bayou Creek		5	1,623,928	1.1
McNairy Inflow	General Head	1	148,630	0.1
		Total In	150,249,137	100.0
		Total Out	-150,249,112	-100.0



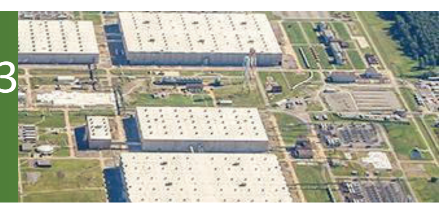
Sensitivity: Model Parameters & Boundaries

- Sensitivity analysis of calibrated parameters and select boundaries was performed using PEST
  - Sensitivities were scaled relative to the most sensitive model parameter
- The most sensitive parameters (in order of descending sensitivity) are:
  1. Ambient Recharge (all SPs)
  2. McNairy specific storage
  3. Ohio River Conductance (RGA)
  4. Plant Area East Recharge (SP1 and SP2)
  5. RGA specific yield
  6. Little Bayou Creek Conductance (upper reach)
  7. East Terrace Recharge

C-97

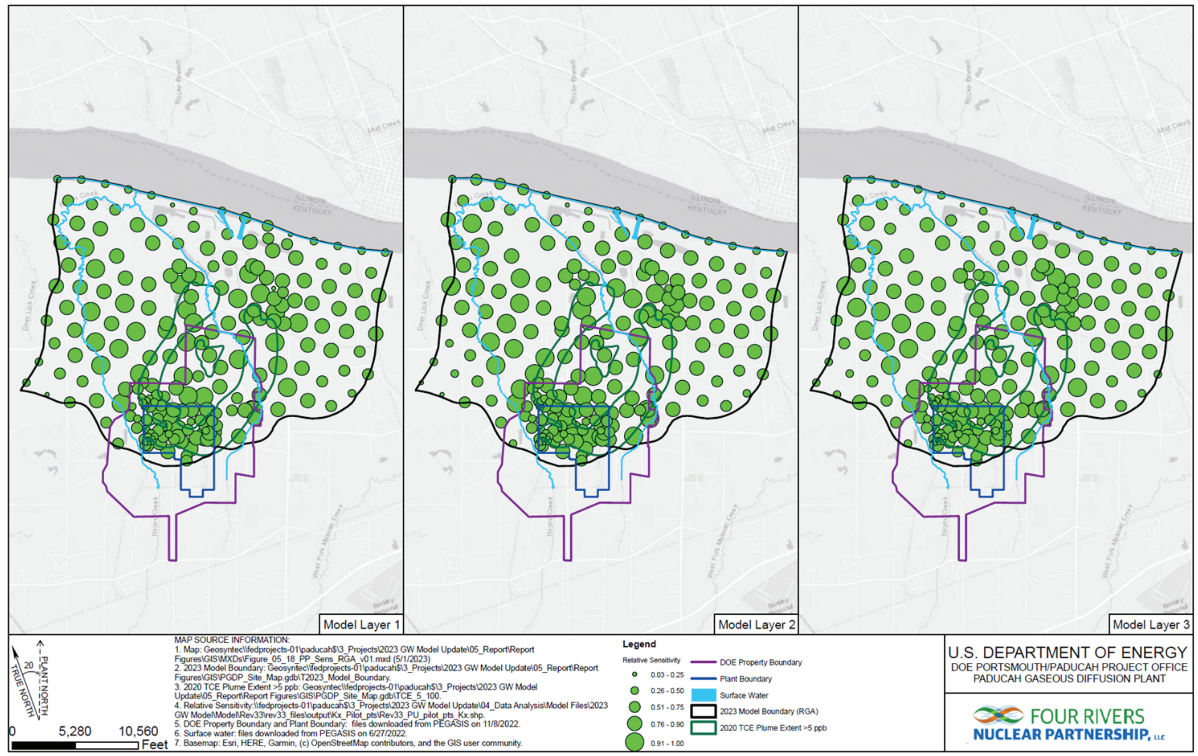


From Figure 5.17 D1 2023 GW Model Report (DOE 2023)



Sensitivity: Hydraulic Conductivity

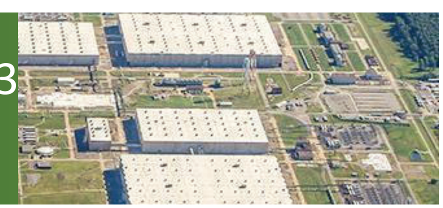
- PEST was also used to calculate sensitivity of pilot points
  - Sensitivities were scaled relative to the most sensitive model parameter
- All pilot point sensitivities are within two orders of magnitude of the most sensitive pilot point, indicating that unique hydraulic conductivities can be estimated for all pilot points in the model



From Figure 5.18 D1 2023 GW Model Report (DOE 2023)

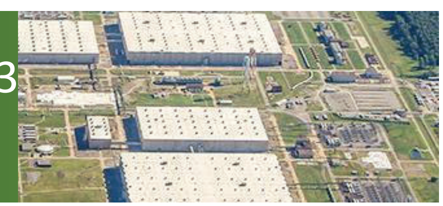
Calibrated Flow Model Evaluation

- The flow model represents the updated CSM and more accurately represents the geology and groundwater flow beneath PDGP by including the Upper McNairy
- Model estimated hydraulic conductivities fall within the range of site-specific values
- Recharge values are consistent with past evaluations and modeling efforts
- Groundwater, flux, and trajectory targets closely approximate observed values, indicating that the model is reasonably calibrated



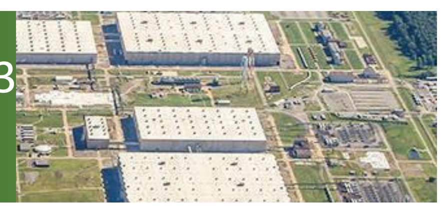
Calibrated Flow Model Limitations

- The model does not explicitly simulate flow in the UCRS
- The calibrated anthropogenic recharge is supported by multiple lines of evidence; a lithology-based evaluation (DOE 2022), a site water balance study, and HELP modeling. As with most groundwater models, the model configuration and calibrated input parameters are not a unique solution and it is recognized that alternative model-predicted anthropogenic recharge rates potentially would have resulted if the model had used other reasonable values of lower hydraulic conductivity.
- Characterization of the contact area between the Terrace Gravel and the UCRS defining the southern model boundary is based on a limited number of monitoring wells.
- Limited data are available to quantify the volumetric flow rates in Bayou Creek and Little Bayou Creek to determine where and in what quantities water enters and exits the creeks and characterize seasonal variability.



Calibrated Flow Model Limitations, Cont.

- Groundwater flow from the Terrace Gravel is an estimate from an evaluation of baseflow in upper Bayou Creek.
- The model does not simulate flow in the middle and lower members for the McNairy.



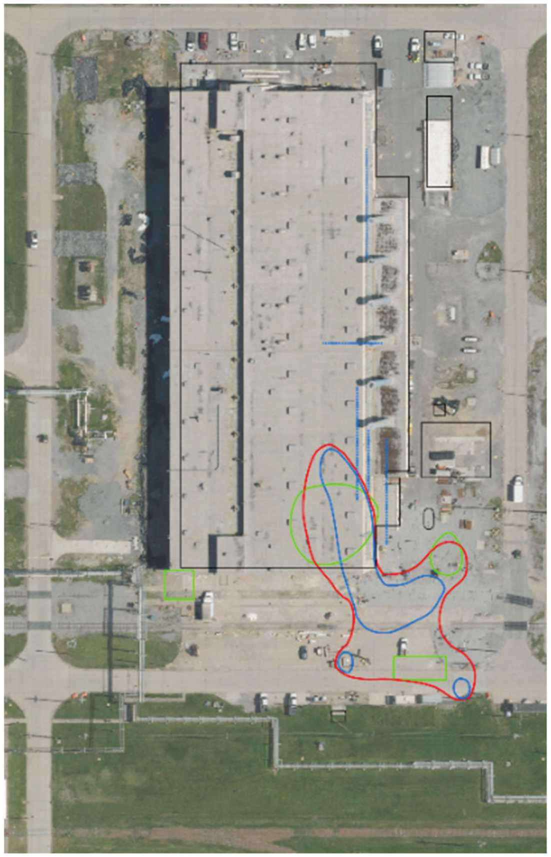
F&T Model

C-102

Transport Model Data Analysis

- Plume Configuration
  - Changes in extent and concentration through time
- Mass Trends
- Source Areas
- TCE Degradation

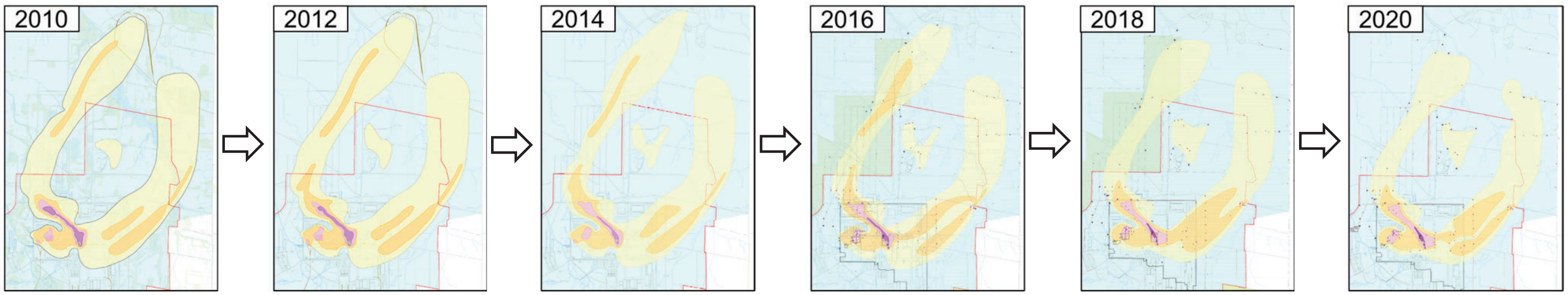
C-103



C-400 Confirmed/Probable DNAPL Source Zones
From Figure 7.4
Draft 2023 GW Model Report (DOE 2023)

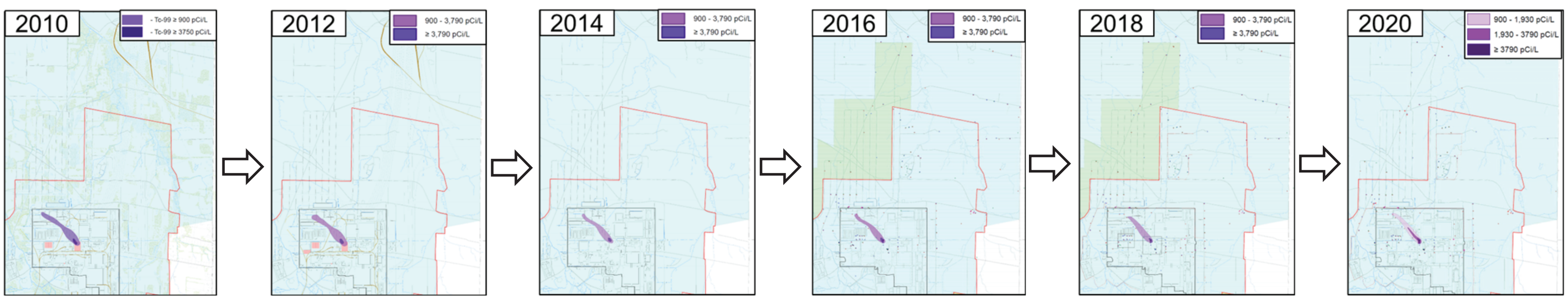
Plume Configuration

- Provide information about changes in extent and concentration through time



TCE

Source: Biennial Plume Map Documents

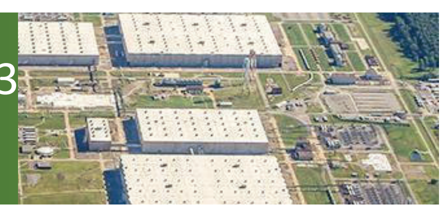


Tc-99

Source: Biennial Plume Map Documents

2023 Sitewide Groundwater Model Briefing – September 6, 2023

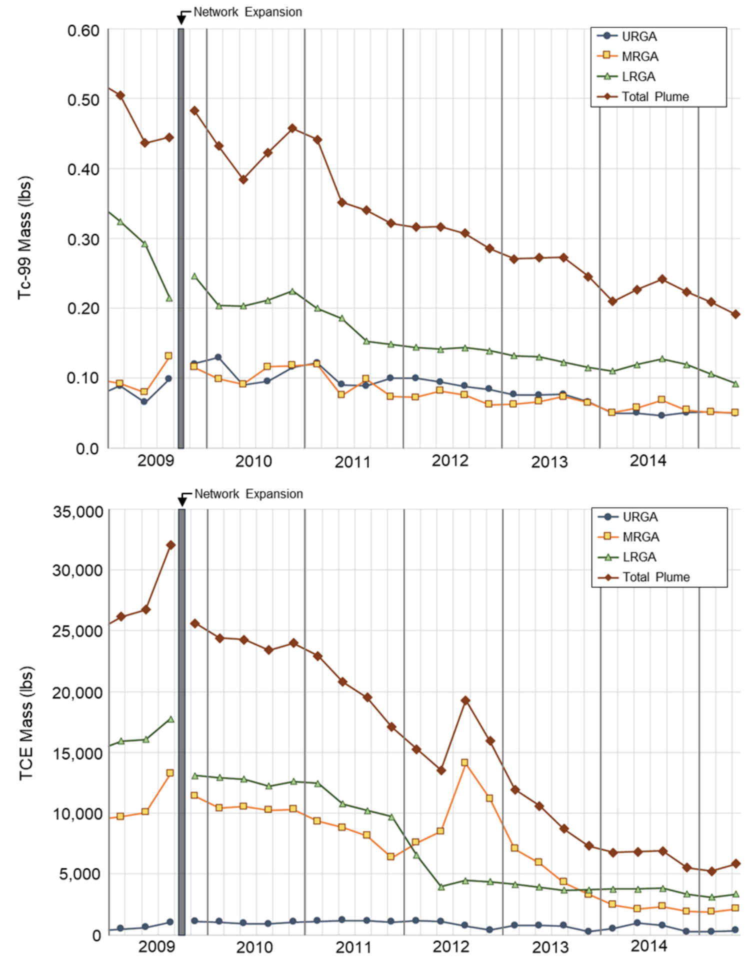
DRAFT Work Product – For Discussion Only



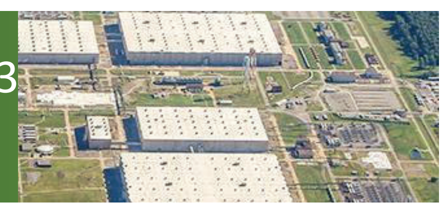
Mass Trends

- Estimated mass of TCE and Tc-99 in the RGA is dependent upon the number of wells in the monitoring well network both on-site and off-site
  - Analysis indicated a sufficient number of monitoring wells after 2009
- Between 2009 and 2015, both the TCE and Tc-99 plumes were observed to be decreasing in the upper, middle, and lower RGA
- The majority of the estimated TCE mass was reported for the middle and lower RGA, with significantly less mass reported for the upper RGA
- The majority of Tc-99 mass was reported to be in the lower RGA
  - The upper and middle RGA have similar mass, both lower than the lower RGA

C-105

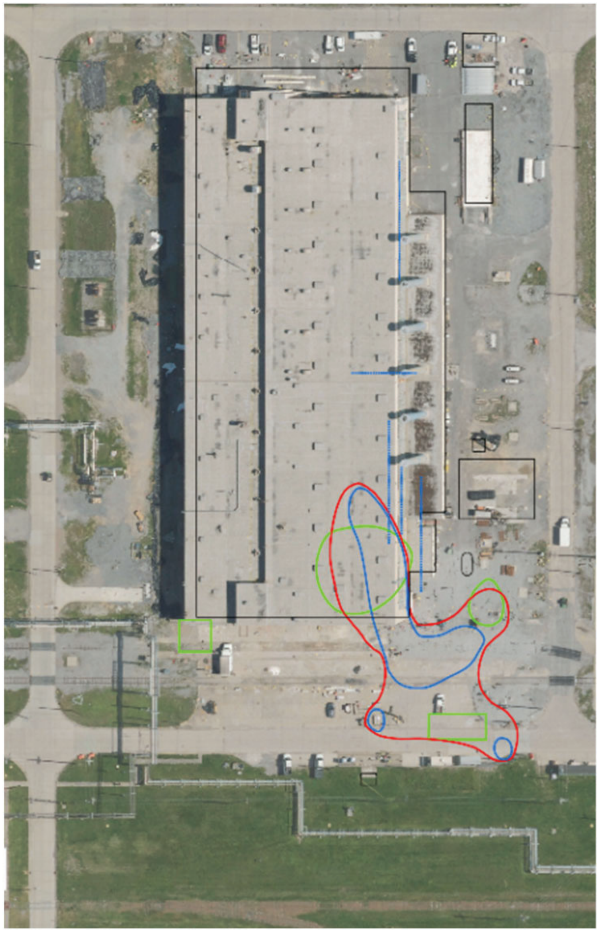


TCE and Tc-99 Mass Trends
From Figure 7.3
Draft 2023 GW Model Report (DOE 2023)



Source Areas: TCE

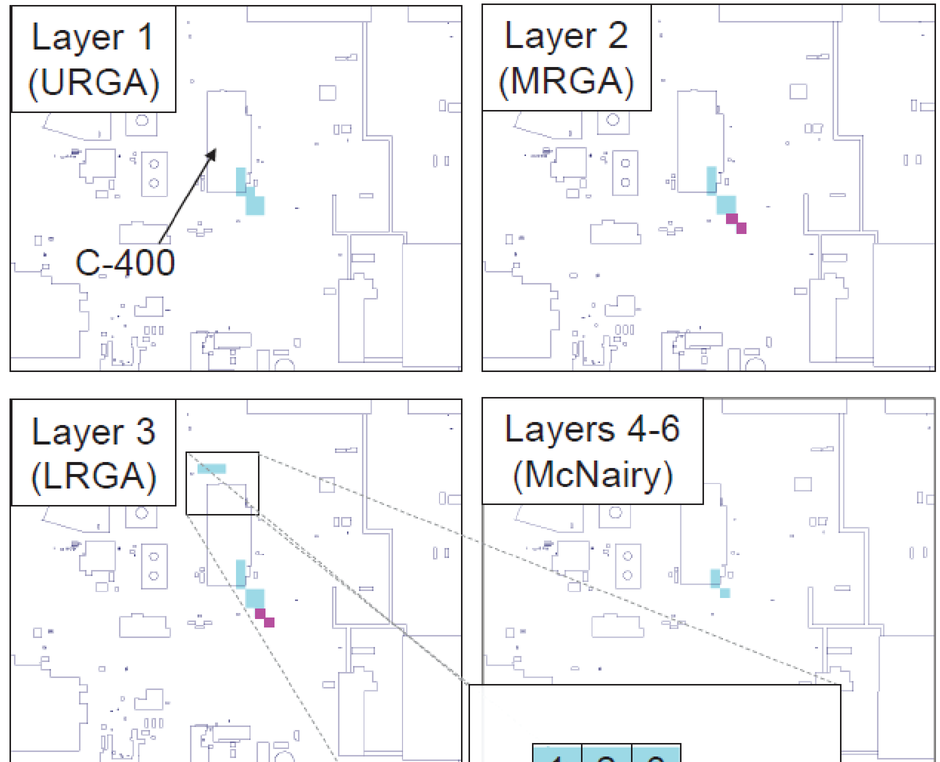
- Primary source zone in SE corner of C-400 Complex
- Second source zone associated with North-South Diversion Ditch located NW of C-400
- TCE enters flow system through DNAPL dissolution
- The majority (~57%) of the TCE plume mass exists in the lower RGA, and decreases in the middle RGA (~37%) and upper RGA (~6%)
- Plume stability analysis indicates dissolved mass of TCE decreased from 30,000 lb in 2009 to ~6,000 lb by 2015

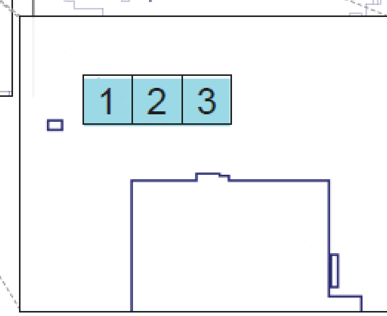


C-400 Confirmed/Probable DNAPL Source Zones
From Figure 7.4
Draft 2023 GW Model Report (DOE 2023)

C-106

Source Areas: TCE

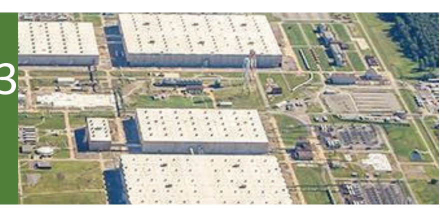




Legend

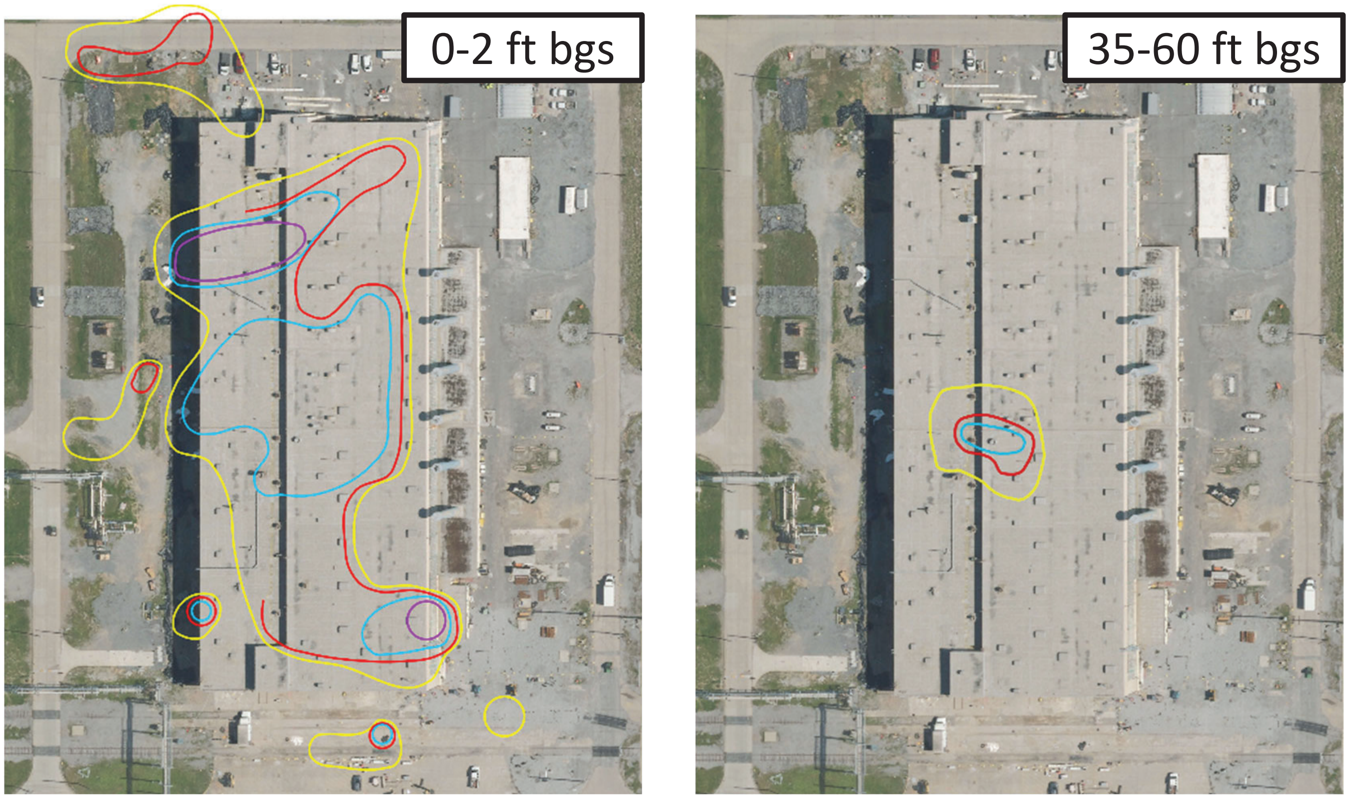
- Constant Concentration Model Cell
- Displacement after Steam Treatability Study
- Facilities

TCE Source Zones
From Figure 8.3
Draft 2023 GW Model Report (DOE 2023)



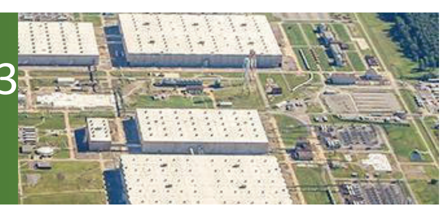
Source Areas: Tc-99

- The primary source of Tc-99 is within UCRS soils overlying the RGA at the C-400 Complex
- Tc-99 widely distributed in shallow soils, but concentrations decrease with depth
- Tc-99 enters RGA flow system through recharge from the UCRS



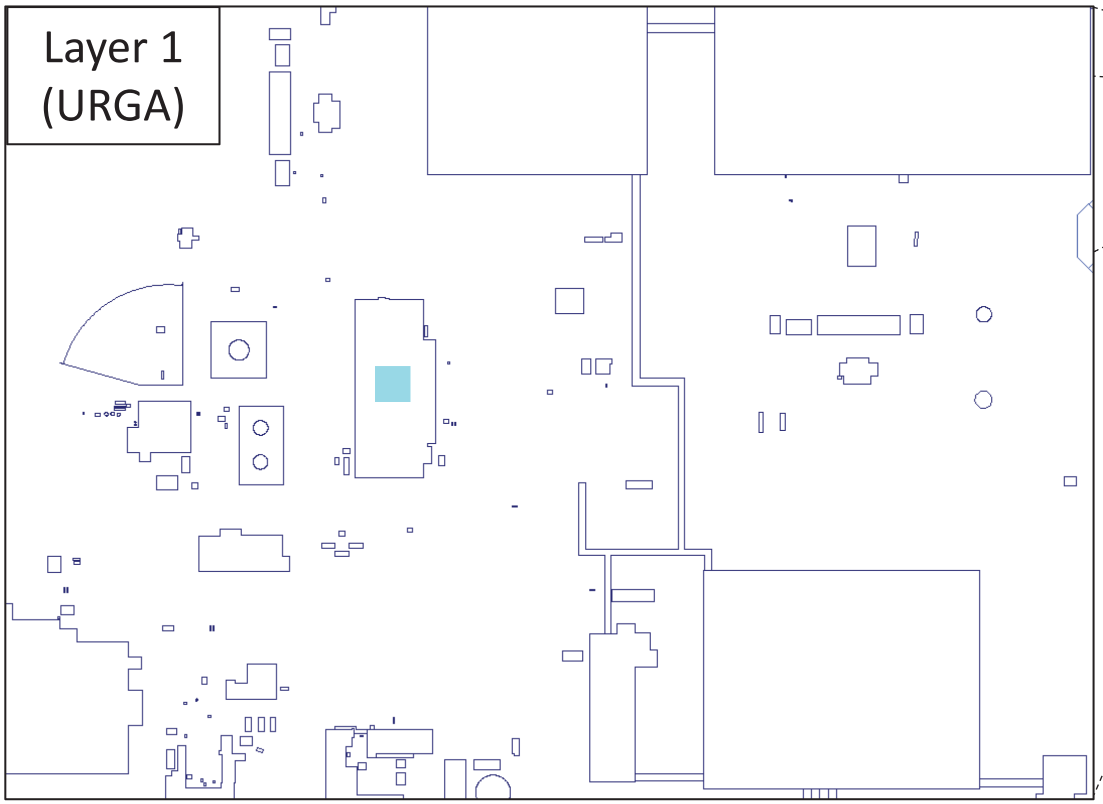
Technetium-99 Isopleths
- 35.7 pCi/g
- 100 pCi/g
- 200 pCi/g
- 500 pCi/g

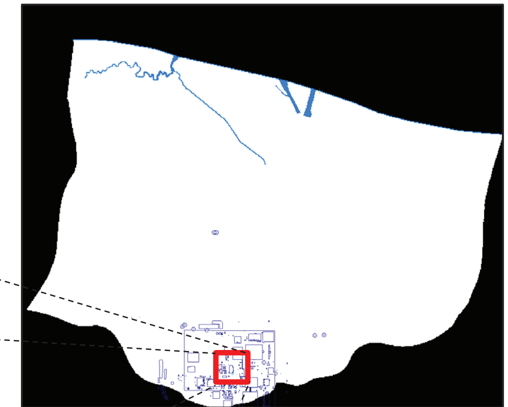
Maximum UCRS Soil Tc-99 Concentrations in Shallow and Deep Soil
From Figure 7.5
Draft 2023 GW Model Report (DOE 2023)



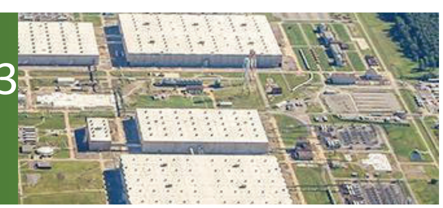
Source Areas: Tc-99

C-109



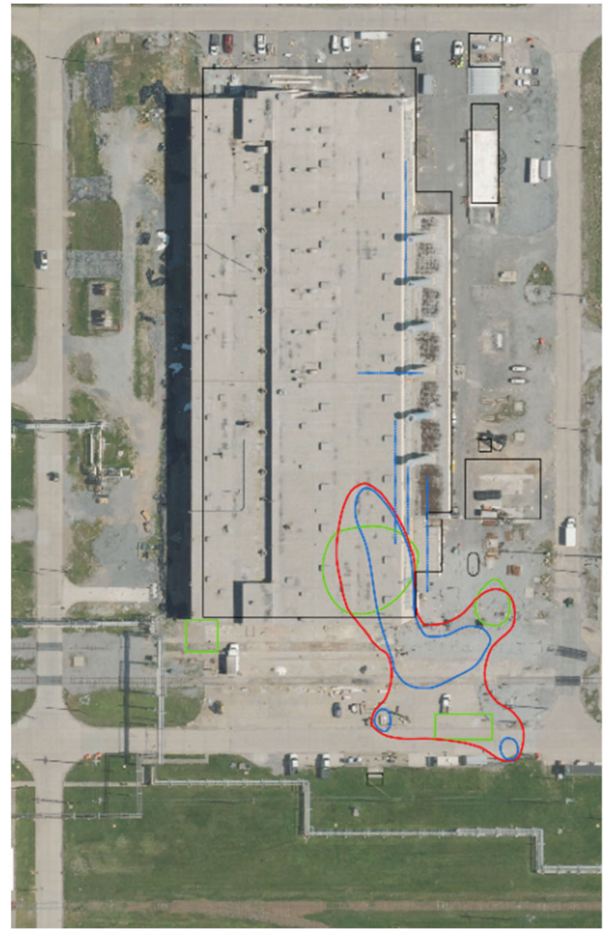


Tc-99 Source Zones
From Figure 8.5
Draft 2023 GW Model Report (DOE, 2023)

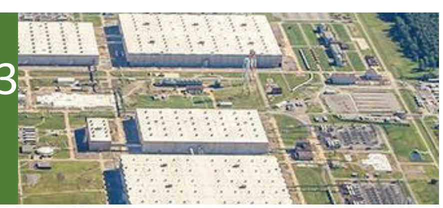


Degradation: TCE

- RGA demonstrates favorable conditions for biotic (aerobic) and abiotic degradation
- Available data regarding TCE degradation is summarized in a 2023 white paper, *Degradation of Trichloroethene at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (FRNP 2023)
- Degradation rates were estimated, in part, from a comparison between dissolved TCE concentrations in the plume to Tc-99 concentrations at the same locations.
- Rates estimated consistent with literature values for aerobic TCE degradation
  - 9 – 25 years

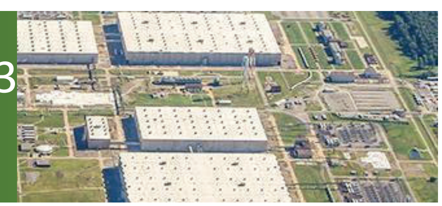


C-400 Confirmed/Probable DNAPL Source Zones
From Figure 7.4
Draft 2023 GW Model Report (DOE 2023)



Degradation: TCE

- 1997 Natural Attenuation Evaluation (Clausen et al. 1997)
  - Degradation was occurring and that it was consistent with—though relatively slow in comparison to—literature values for reductive dechlorination.
- 2007 NW Plume Evaluation (DOE 2008, KRCEE 2008)
  - Lines of evidence:
    - Microbial degradation was occurring in PGDP's aerobic groundwater environment
    - TCE is preferentially degraded along NW Plume flowpaths relative to the tracer chloride
    - Appropriate genetic material is present in the RGA and enzymes are present and actively being produced in the RGA
    - Based on evaluations of the stable carbon isotopes data, aerobic degradation of TCE is occurring
    - geochemical evaluations indicated that dissolved oxygen, pH, and oxidation-reduction potential (ORP) sources are sufficient to support populations of aerobic bacteria capable of TCE biodegradation
  - Estimated degradation rates for PGDP of 9.4 to 26.7 years
- Estimated TCE degradation rates for PGDP, based on comparison of plume scale TCE transport to a tracer (Tc-99), are consistent with the published literature for aerobic cometabolism in large aerobic plumes and are on the order of 9 to 25 years half-life.



Transport Model Configuration

- Stress Periods
  - Simulation timeframe
  - Timeline
- Extraction Wells
- Boundary Conditions
- Source Areas – TCE and Tc-99
  - Initial groundwater concentrations
  - Source zone configuration
- Transport Parameters

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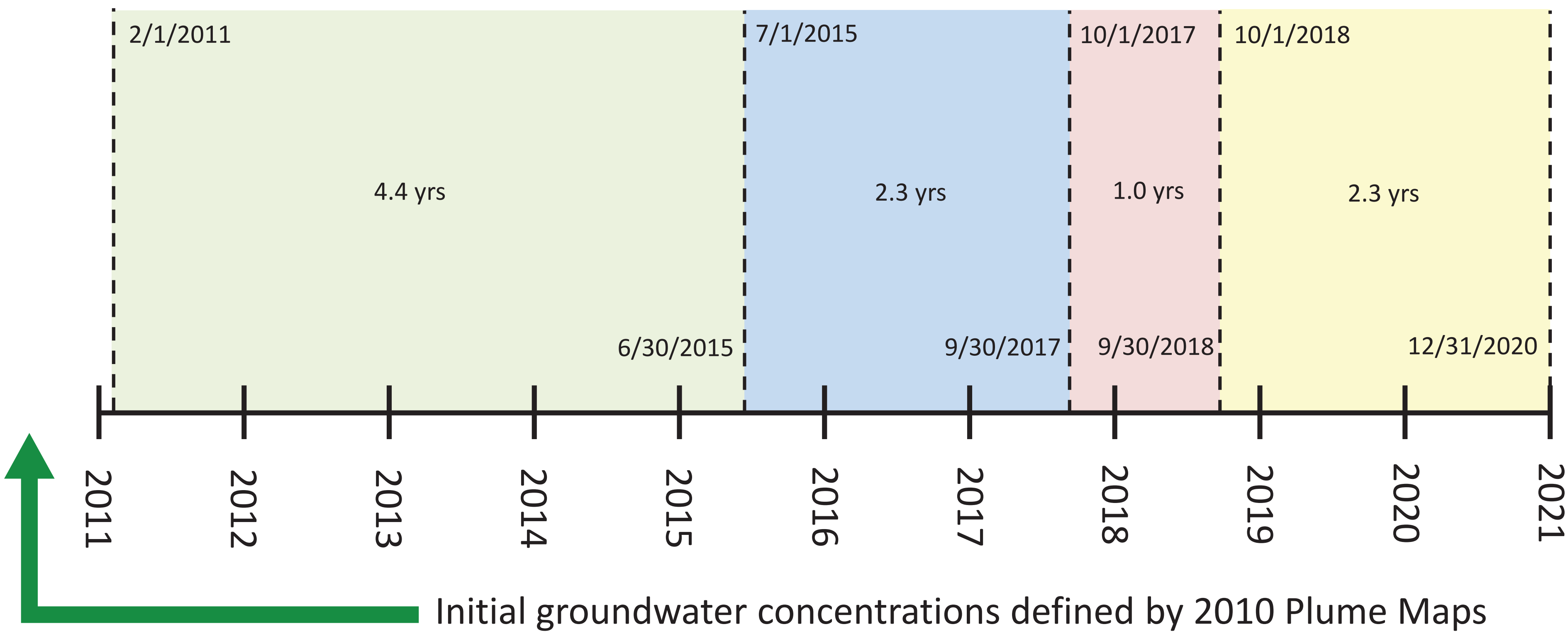
Stress Periods

Stress Period	Basis of Time Period	Hydraulic Stresses
1	Start - Start of NW Plume EW231/232 pumping End - Completion of PhaseIIb Steam Treatability Study	NW Plume EWs 232/233 NE Plume EWs 331/332
2	End- Start of new NE Plume EWs	No Change
3	End - Completion of Olmsted Dam in Oct 2018	NE Plume EWs replaced with EWs 234/235
4	Assumes 2020 Plume Map defines conditions through end of 2020	NW Plume EWs optimized; Ohio River average stage increased.



2023 Sitewide Groundwater Model Briefing – September 6, 2023

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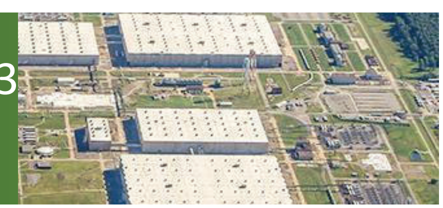
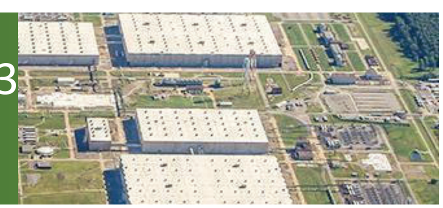


Extraction Wells

- Extraction data for wells in the NE Plume (NEP) and NW Plume (NWP) were provided as volumes extracted each day
- Daily values were averaged into monthly values for all months on record
  - For data where extraction volumes were provided for each individual NEP or NWP well, the average proportion of volume pumped was calculated
- Average extraction rates were calculated for each stress period based on the associated dates.

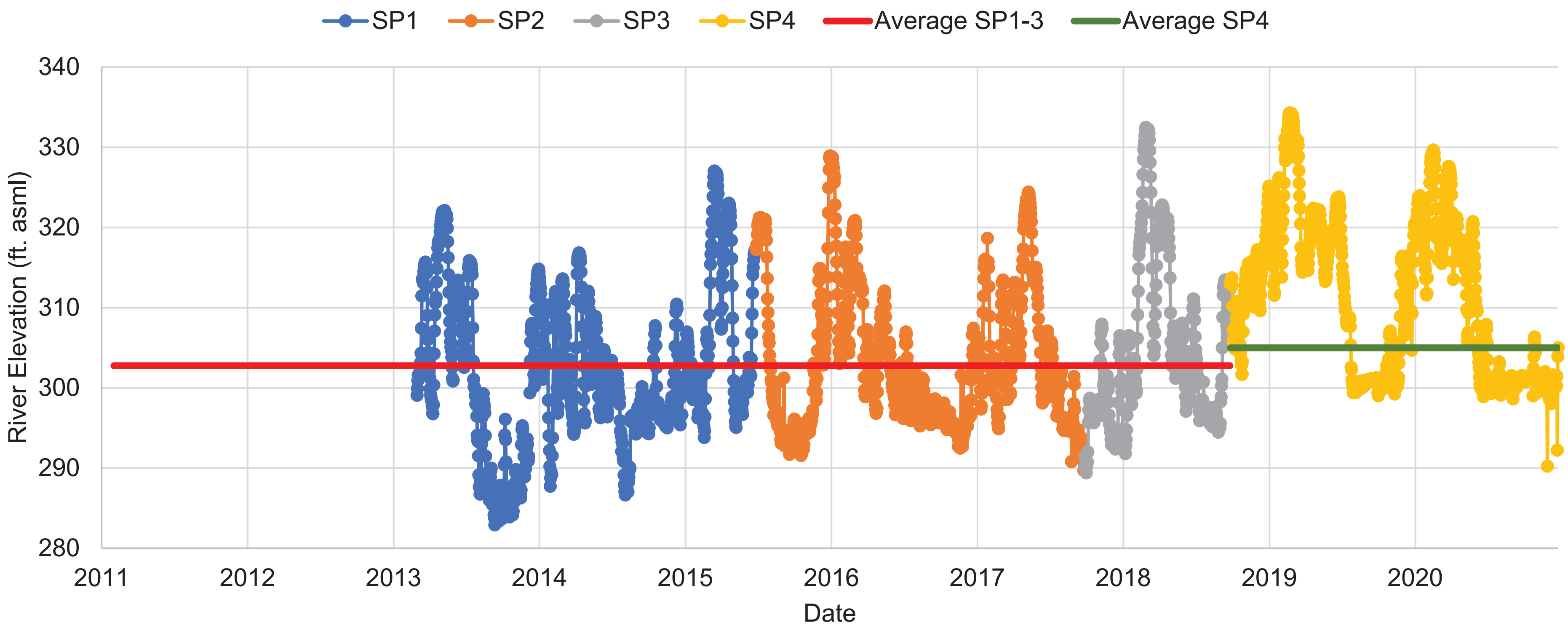
Period	Dates	Average Pumping Rate (gpm)					
		EW331	EW332	EW234	EW235	EW232	EW233
SP1	Feb. 2011 - Jun. 2015	91	65	--	--	97	100
SP2	Jul. 2015 - Sept. 2017	99	86	--	--	88	88
SP3	Oct. 2017 - Sept. 2018	--	--	117	90	97	95
SP4	Oct. 2018 - Dec. 2020	--	--	92	70	100	98

From Attachment 1
2023 Groundwater Model Update Input Parameters
Calculation Package DAC-ENV-FA5950-0044

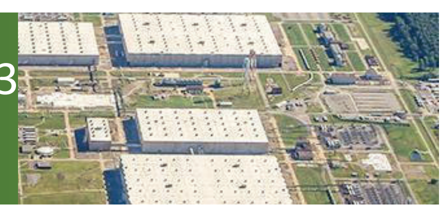


Boundary Conditions: Ohio River Stage

- Ohio River stage calculated based on observed river stage data obtained from the USGS
  - Data were downloaded for the USGS gauges at Paducah, KY and Olmsted, IL
- River stage assigned to the northern boundary of the model domain was the average of stage values at the two locations

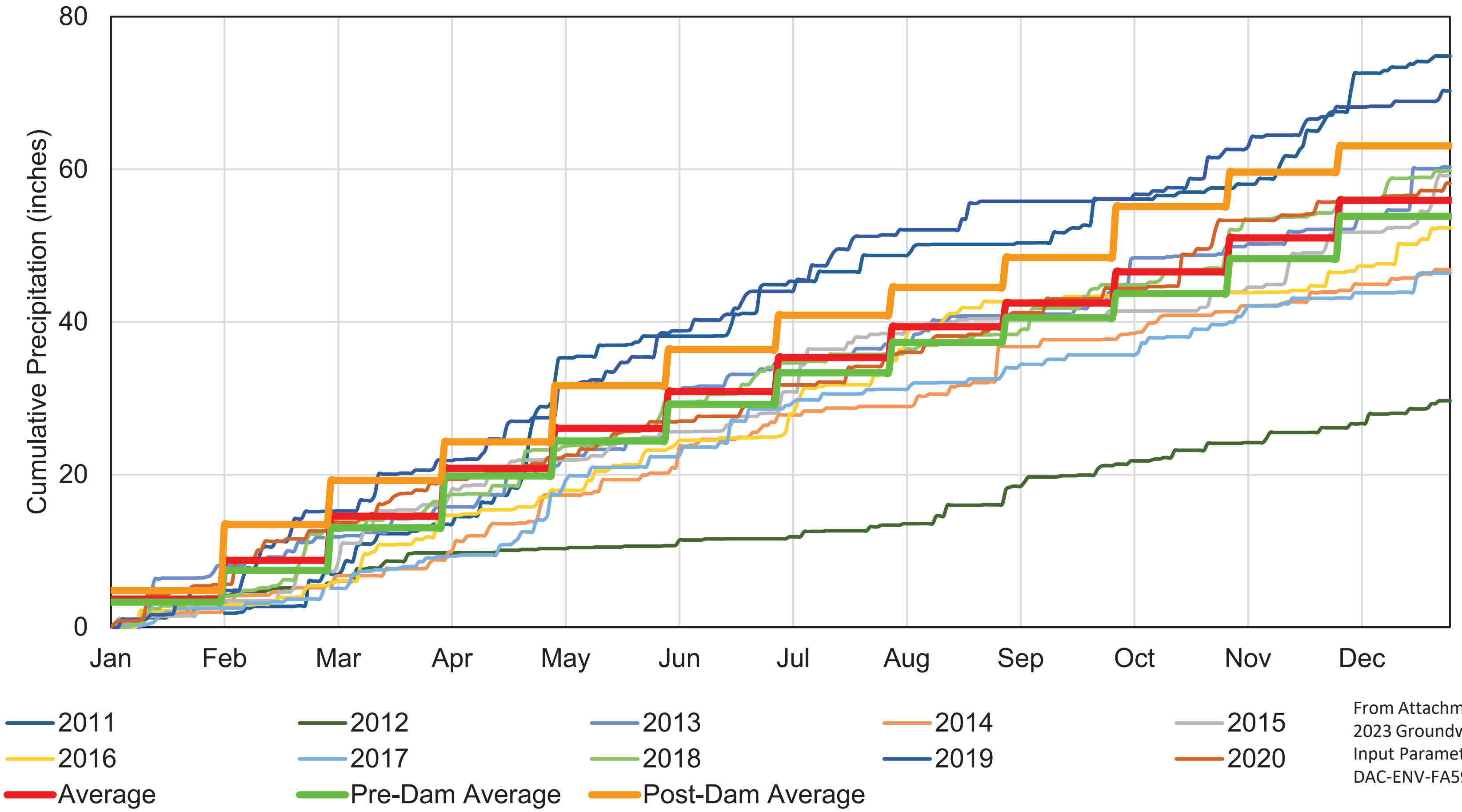


From Attachment 5
2023 Groundwater Model Update Input Parameters
Calculation Package DAC-ENV-FA5950-0044



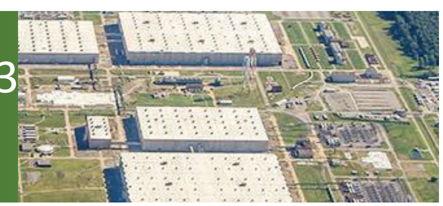
Boundary Conditions: Precipitation

- Daily precipitation values were obtained from NOAA for the Paducah Barkley Regional Airport precipitation gauge
- Daily values were used to calculate average monthly precipitation



From Attachment 7
2023 Groundwater Model Update
Input Parameters Calculation Package
DAC-ENV-FA5950-0044

C-116

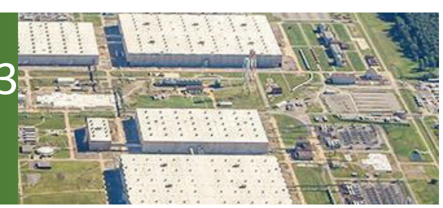


Boundary Conditions: Calibration

- Recharge and river stage boundary conditions were adjusted until Plant Area modeled groundwater elevations roughly matched observed values before and after installation of the Olmsted Dam
- Observed pre- and post-Olmsted Dam groundwater elevations were calculated for each month during the 2011 – 2020 period

Date	Pre-Dam GW Elevations (ft amsl)			Post-Dam GW Elevations (ft amsl)			Difference (ft)		
	Plant Area Average	On-Site Average	Off-Site Average	Plant Area Average	On-Site Average	Off-Site Average	Plant Area Average	On-Site Average	Off-Site Average
January	324.7	324.4	324.3	326.3	326.6	325.9	1.6	2.2	1.7
February	324.0	325.1	322.3	328.2	328.6	328.0	4.1	3.6	5.7
March	324.4	324.2	322.3	330.6	331.3	330.6	6.2	7.1	8.3
April	326.2	325.9	324.6	332.4	332.4	330.6	6.2	6.5	6.1
May	326.6	327.4	326.2	332.7	332.4	329.9	6.0	5.0	3.7
June	328.3	327.7	326.0	332.7	332.2	329.0	4.4	4.6	2.9
July	327.1	326.3	323.5	331.8	331.1	330.4	4.7	4.8	7.0
August	327.1	326.4	323.6	329.7	329.0	325.3	2.7	2.6	1.7
September	326.7	325.2	322.9	327.8	327.5	324.2	1.2	2.3	1.3
October	325.4	324.0	321.5	325.7	325.3	323.1	0.3	1.2	1.6
November	324.6	322.7	319.5	325.8	325.0	322.1	1.2	2.2	2.6
December	323.6	323.2	319.9	325.6	324.9	322.4	2.0	1.7	2.5
Average	325.7	325.2	323.0	329.1	328.9	326.8			

From Attachment 11
2023 Groundwater Model Update Input Parameters Calculation
Package DAC-ENV-FA5950-0044



Boundary Conditions: Calibration, Cont.

- Recharge rates related to creeks and anthropogenic recharge do not vary much between wet and dry conditions in the calibrated flow model, so only ambient recharge and terrace recharge zones were adjusted for this calibration
- Ambient and terrace recharge rates are lower in the pre-dam period than the post-dam period based on observed differences in the precipitation data for the two periods

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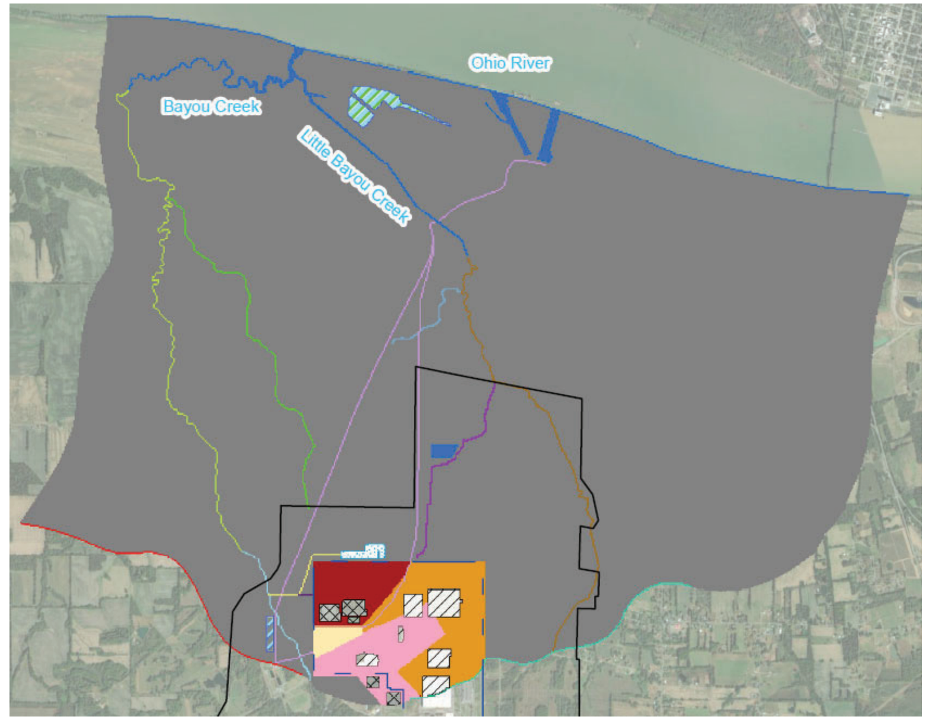
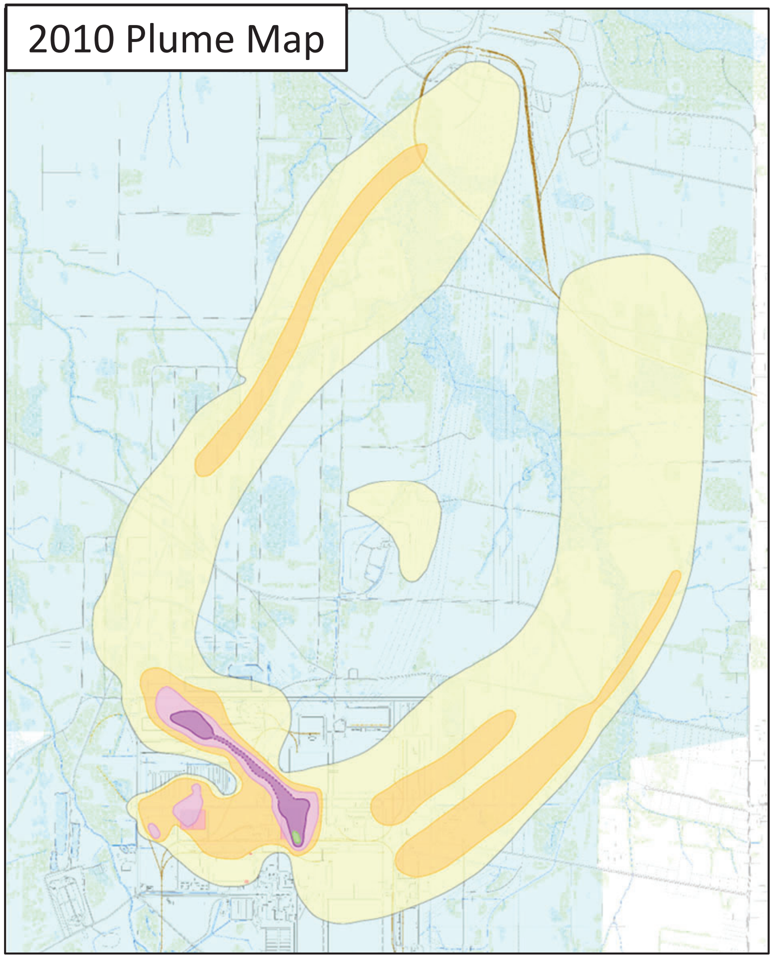


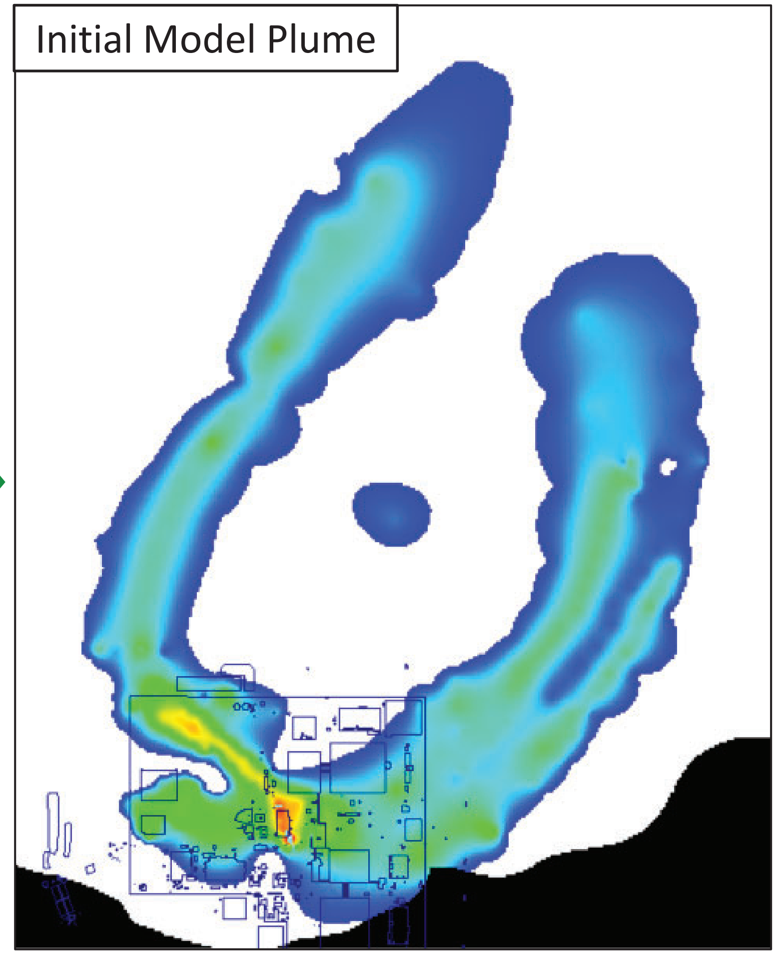
From Figure 4.7
Draft 2023 GW Model Report
(DOE 2023)

- The pre-dam period is from 2011 through the installation of the Olmsted Dam in late 2018. The post-dam period is from the installation of the Olmsted Dam in late 2018 through 2020.

Initial Concentrations: TCE

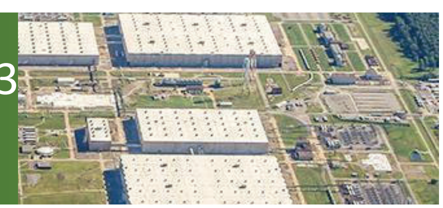


Source: 2012 Biennial Plume Map



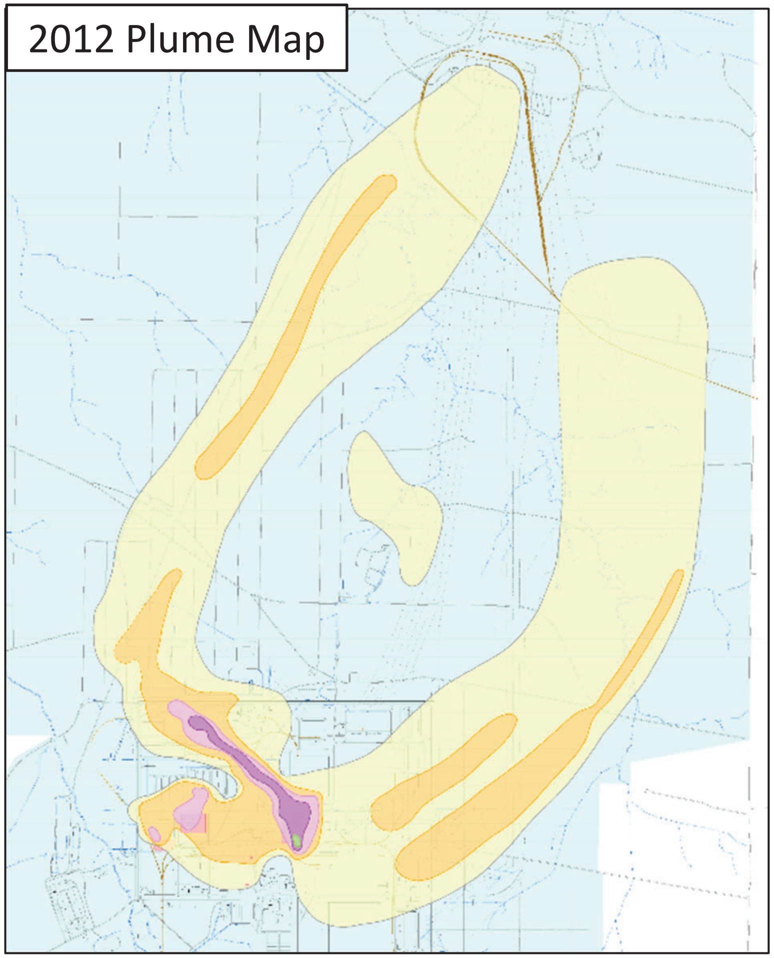
From Figure 8.1, Draft 2023 GW Model Report (DOE 2023)

DRAFT Work Product – For Discussion Only



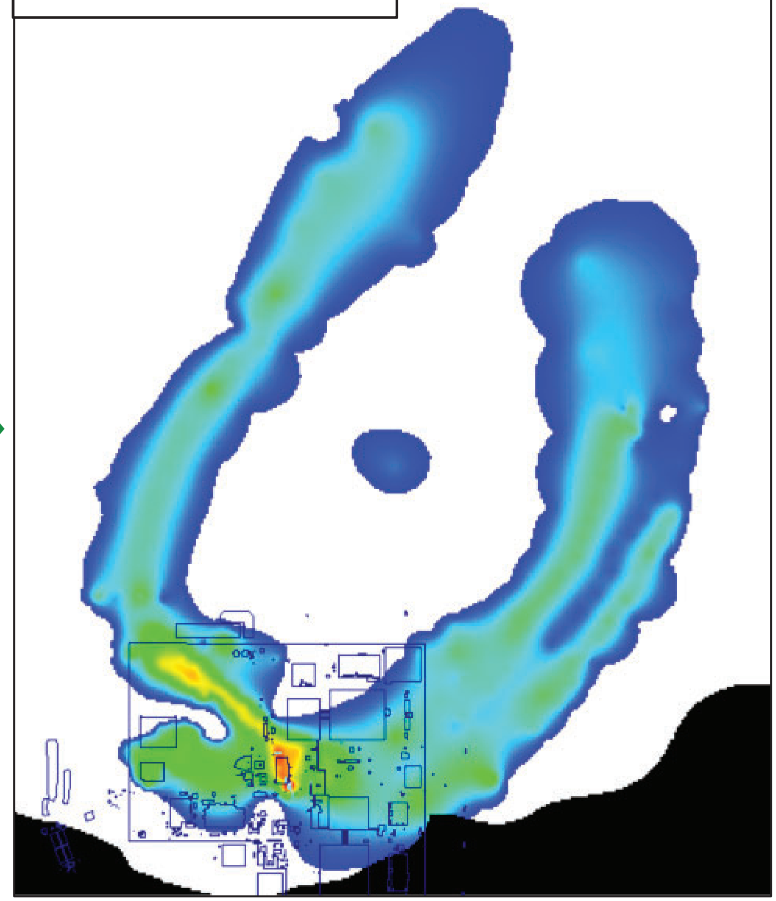
Initial Concentrations: TCE

2012 Plume Map



Source: 2012 Biennial Plume Map

Initial Model Plume



From Figure 8.1, Draft 2023 GW Model Report (DOE 2023)

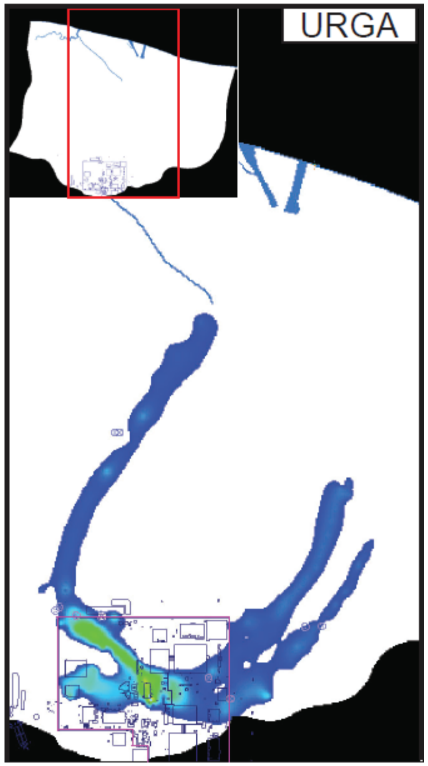
Additional interpretation using data collected in subsequently installed MWs to refine concentrations during calibration

Initial Concentrations: TCE

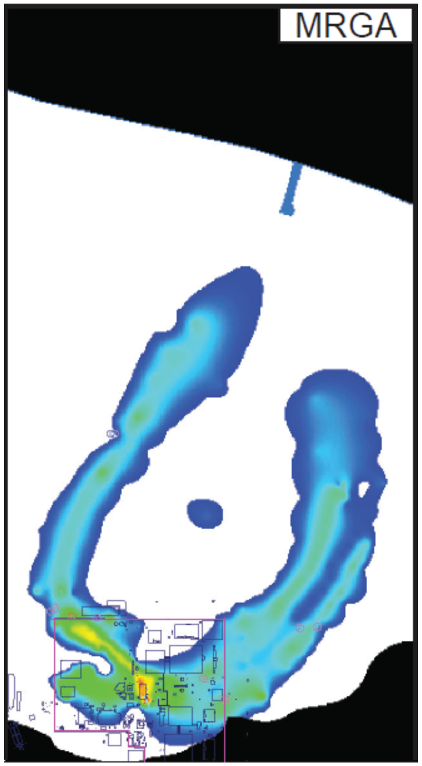
Concentrations adjusted for each layer based on relative mass reported in upper, middle, and lower RGA during Plume Stability Analysis (EarthCon, 2017)

- Highest initial TCE concentrations in Layer 3 coincide with 2010 Plume Map
- Layer 1 is 8.5% of layer 3; layer 2 is 81.9% of layer 3

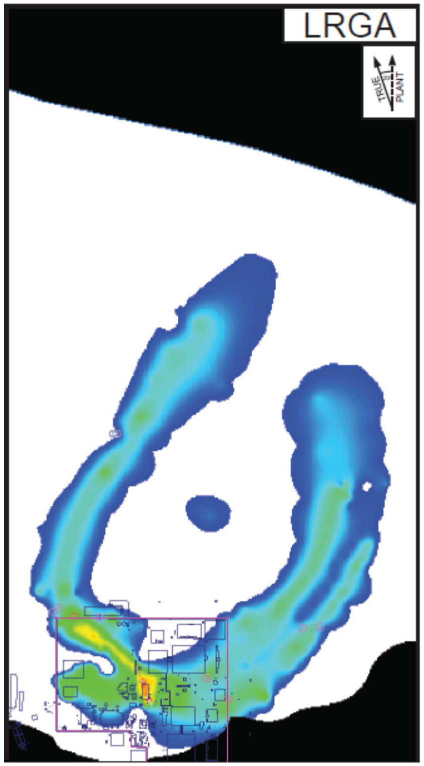
Layer 1



Layer 2



Layer 3

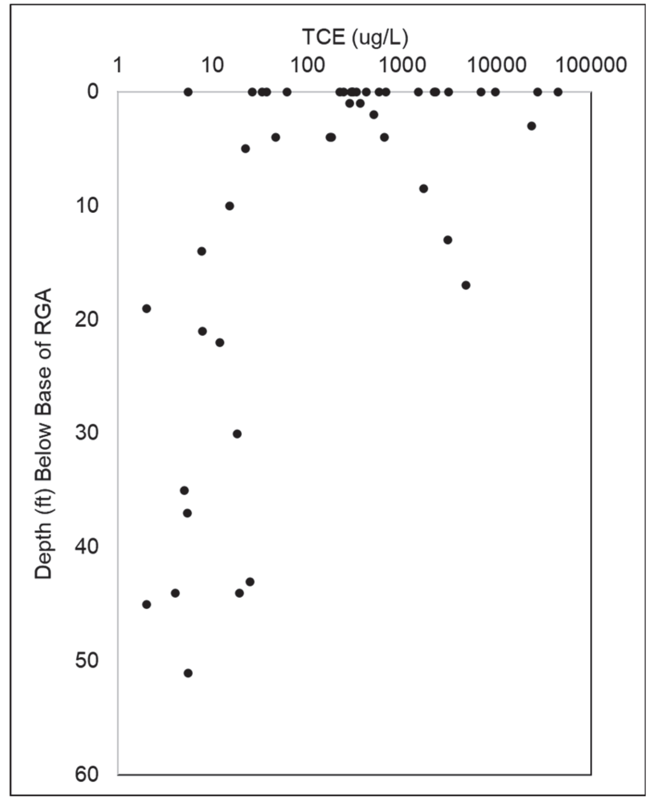


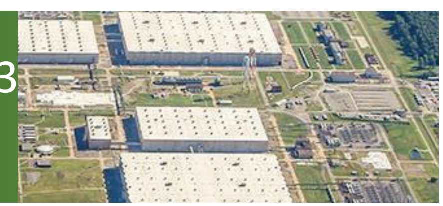
From Figure 8.1, Draft 2023 GW Model Report (DOE 2023)

Initial Concentrations: TCE

Initial TCE concentrations in McNairy Formation

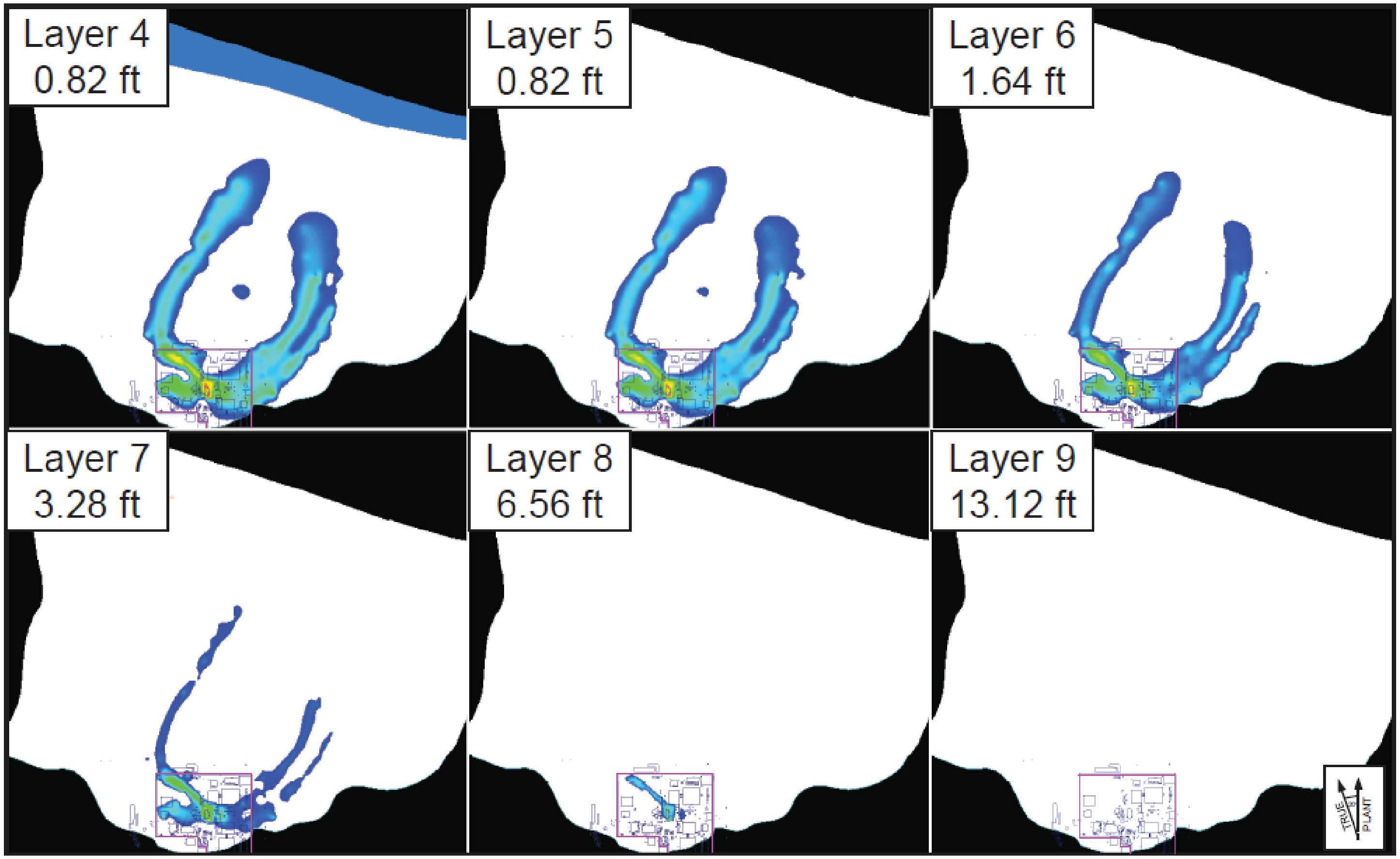
- Specified in upper McNairy layers (Layers 4 – 8) to represent mass derived through matrix diffusion
- Estimated from initial concentrations in the lower RGA (Layer 3) based on observations at C-400 Complex
- Logarithmic relationship observed between depth and TCE concentration
- Assumed TCE concentrations diminish to non-detect roughly 20 feet below base of RGA
- Relationship between TCE concentrations in lower RGA and McNairy developed to calculate initial concentrations across entire model domain





Initial Concentrations: TCE

Initial TCE concentrations in McNairy Formation



Layer	Depth (ft)
3	0.00
4	0.82
5	1.64
6	3.28
7	6.56
8	13.12
9	26.25

From Figure 8.2
Draft 2023 GW Model Report
(DOE 2023)

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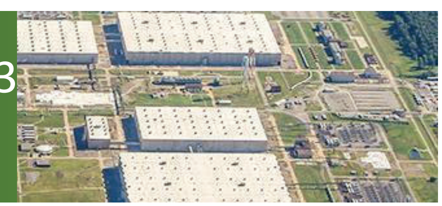
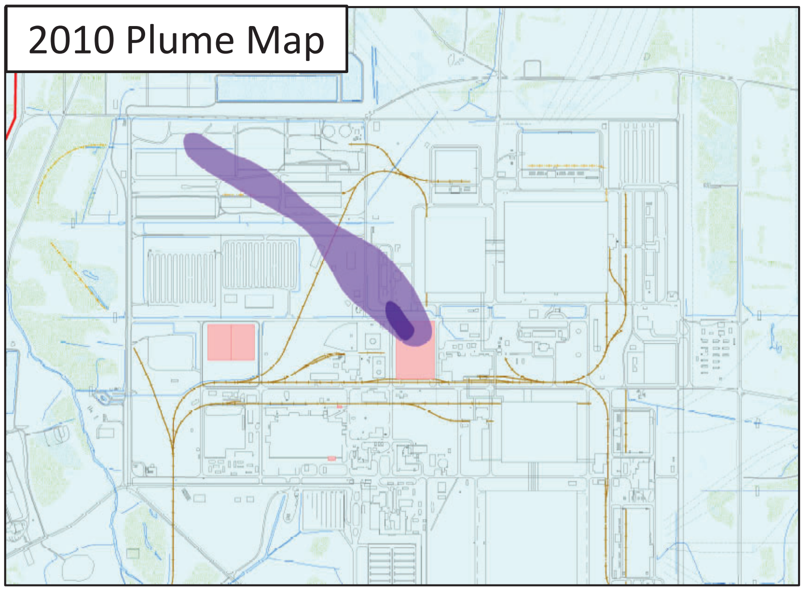


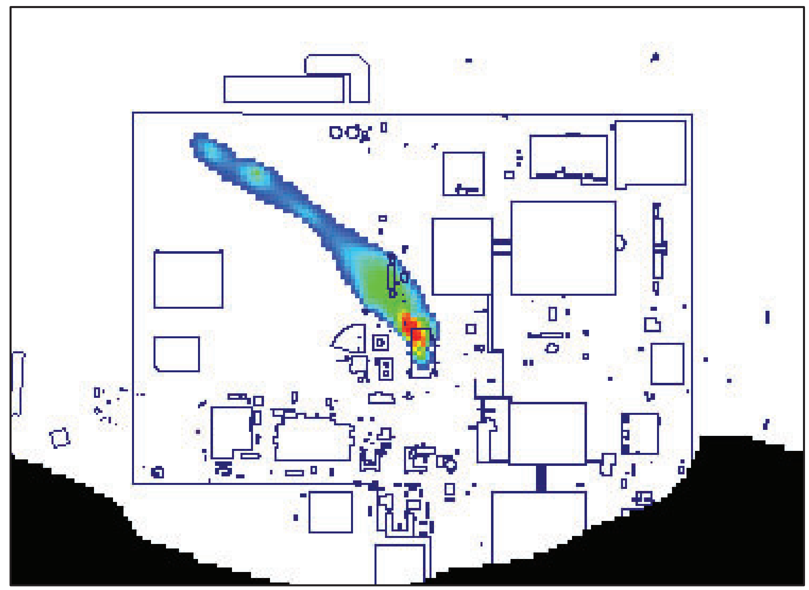
C-124

Initial Concentrations: Tc-99

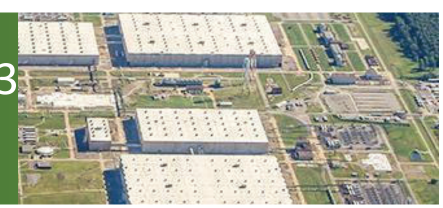
- Initial Tc-99 concentrations in RGA based on 2010 Plume Map
- All three layers coincide with 2010 plume map contours



Source: 2010 Biennial Plume Map

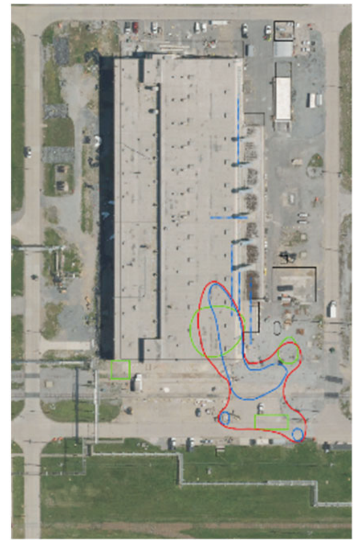


From Figure 8.4
Draft 2023 GW Model Report
(DOE 2023)



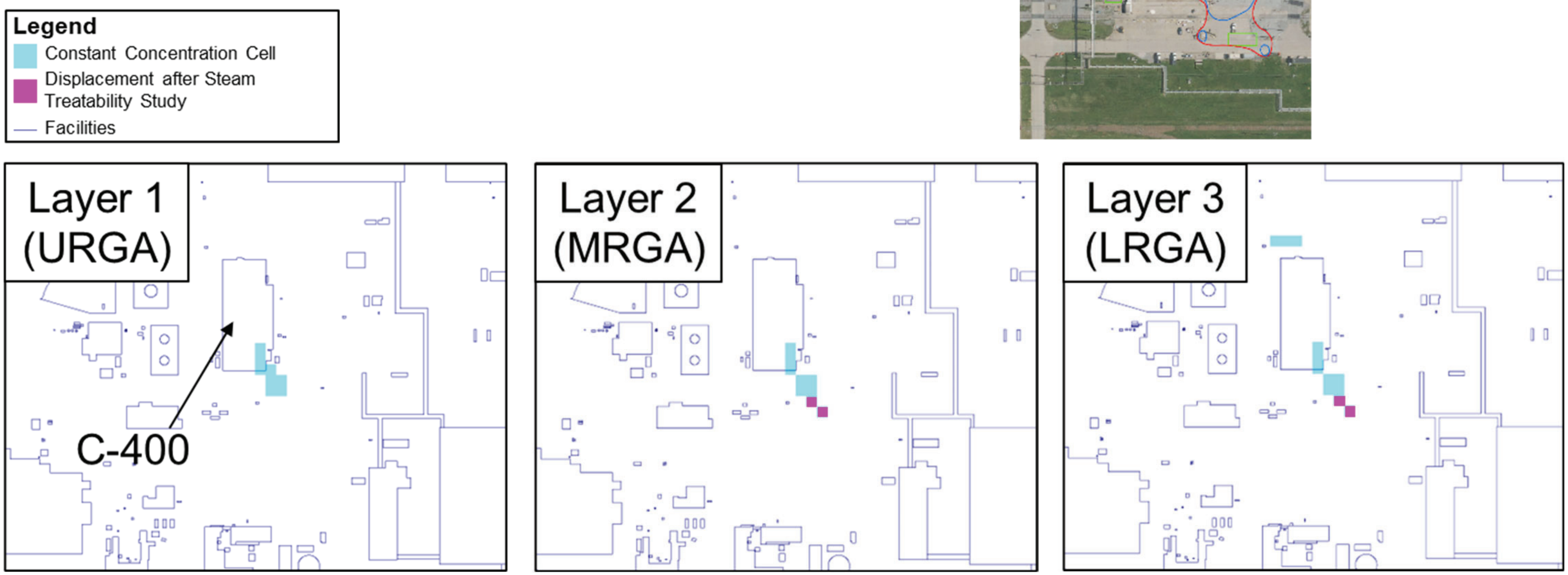
Source Zones: TCE

- Configured as constant concentration cells to represent DNAPL
- Primary source located near SE corner of C-400
- Short-term impacts from 2015 steam treatability study represented in Layers 2 and 3 in SP3 only



C-400 Confirmed/Probable DNAPL Source Zones
From Figure 7.4
Draft 2023 GW Model Report (DOE 2023)

C-125



From Figure 8.3, Draft 2023 GW Model Report (DOE 2023)

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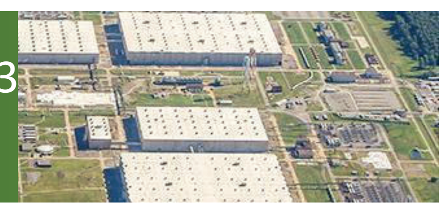
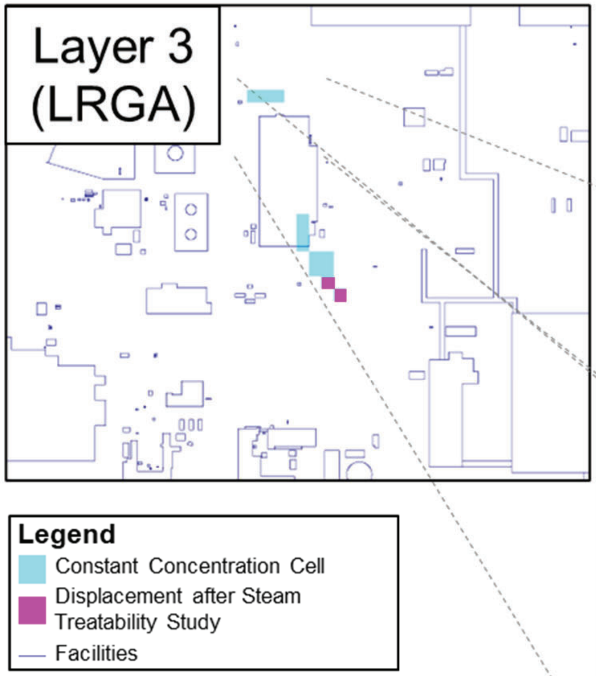


Source Zones: TCE

- Secondary source of TCE associated with the NSDD, which receives runoff from the north side of the C-400 Cleaning Building that is then pumped to the C-616 lagoon and released through Outfall 001 to Bayou Creek

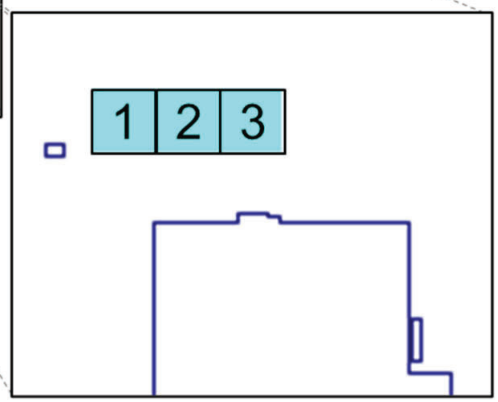


From Figure 8.3, Draft 2023 GW Model Report (DOE 2023)

	NW Cell 1	NW Cell 2	NW Cell 3	SE Source				Steam Treatability	
	Layer 3			Layer 1	Layer 2	Layer 3	Layers 4-6	Layer 2	Layer 3
FTSP1	30,000	70,000	150,000	10,000	10,000	25,000	10,000	--	--
FTSP2	25,000	65,000	75,000	1,0000	10,000	20,000	10,000	22,000	10,000
FTSP3	10,000	50,000	60,000	10,000	10,000	15,000	10,000	--	--
FTSP4	15,000	50,000	60,000	10,000	10,000	10,000	10,000	--	--

Note: All concentrations are in micrograms per liter (µg/L).

From Table 8.2, Draft 2023 GW Model Report (DOE 2023)



Concentrations in NSDD source zone decrease through time

C-126

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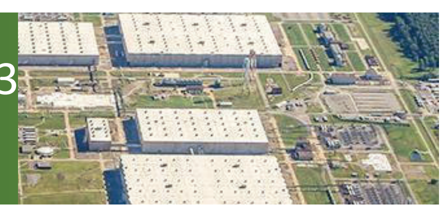
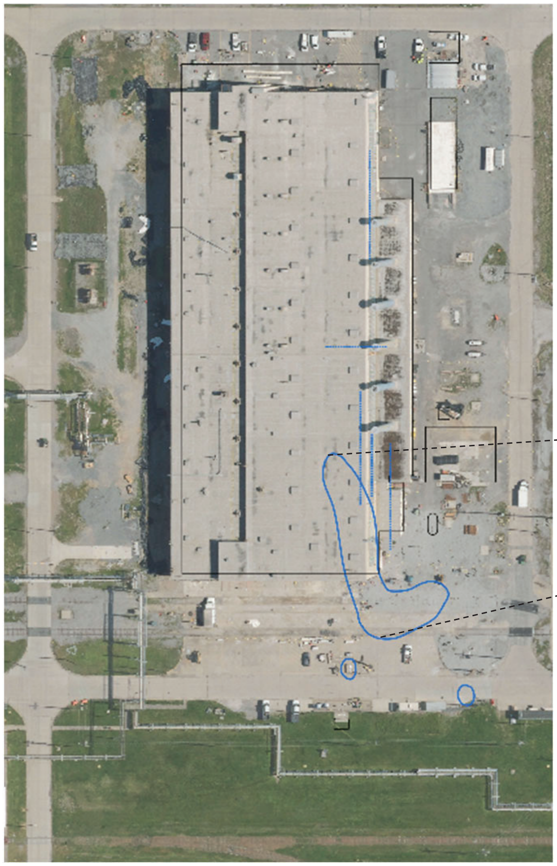
DRAFT Work Product – For Discussion Only

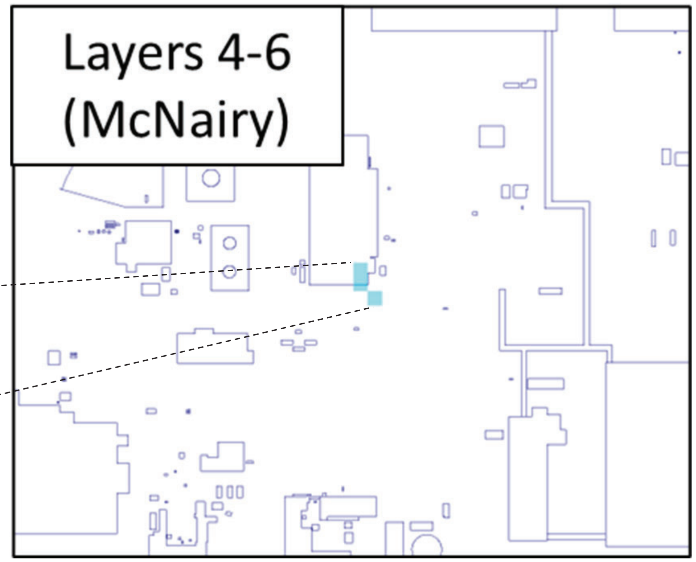


Source Zones: TCE

- Source zone also included in the upper 3 feet of the McNairy (Layers 4-6) to represent DNAPL which has migrated below the base of the RGA



C-400 Confirmed/Probable DNAPL Source Zones
From Figure 7.4
Draft 2023 GW Model Report (DOE 2023)



From Figure 8.3, Draft 2023 GW Model Report (DOE 2023)

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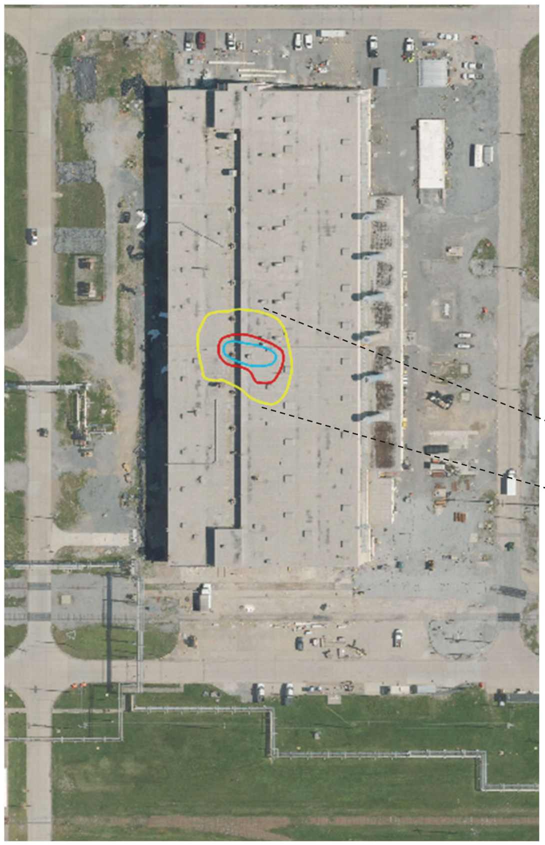
Source Zones: Tc-99

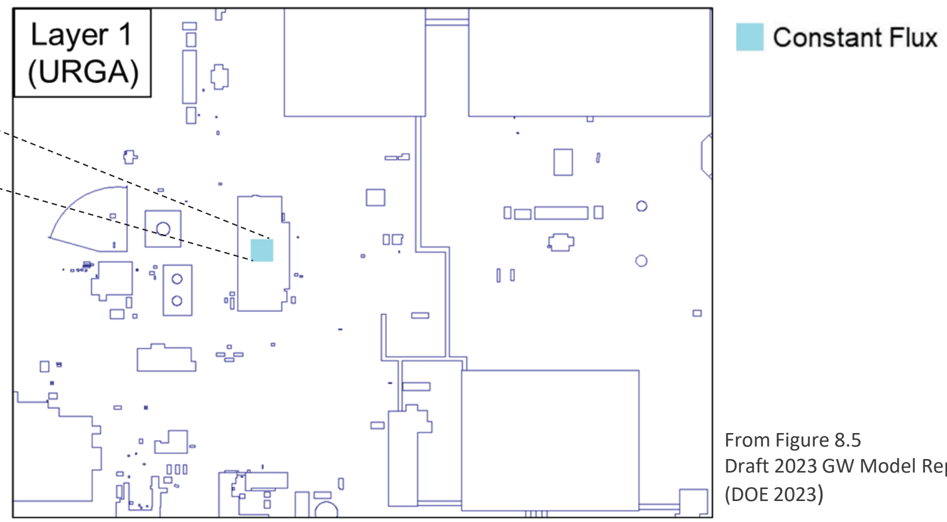
- Tc-99 source to the model is through recharge from the UCRS beneath C-400
- Recharge concentrations were specified by stress period to correspond with the increase in Tc-99 concentrations at downgradient monitoring wells



From Figure 7.5, Draft 2023 GW Model Report (DOE 2023)

From Table 8.3
Draft 2023 GW Model Report
(DOE, 2023)

	Recharge Rate (inches/year)	Recharge Concentration (pCi/L)
FTSP1	1.0	1,000,000
FTSP2	1.0	75,000,000
FTSP3	1.0	75,000,000
FTSP4	1.0	75,000,000



From Figure 8.5
Draft 2023 GW Model Report
(DOE 2023)

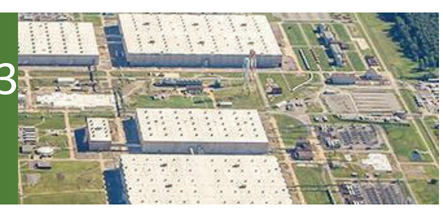
Transport Model Parameters

- All remained fixed during transport simulations
- All properties assigned uniformly across model domain and in all layers
- Values of porosity, K_d, and bulk density derived from C-400 RI/FS

Parameter	Value	Unit	Data Source
Molecular Diffusion Coefficient	9.1×10^{-6}	cm^2/s	Pankow and Cherry, 1996
RGA Porosity	0.283	--	DOE 2022b
McNairy Porosity	0.472	--	DOE 2022b
Dispersion—Longitudinal	50	ft	Length of 1 model cell
Dispersion—Transverse	5	ft	Calculated
Dispersion—Vertical	0.5	ft	Calculated
TCE K_d RGA	0.04	L/kg	DOE 2022b
TCE K_d McNairy	0.077	L/kg	DOE 2022b
Tc-99 K_d RGA	0.945	L/kg	Calibrated
Tc-99 K_d McNairy	1.215	L/kg	DOE 2022b
Bulk Density RGA	1,888	kg/m^3	DOE 2022b
Bulk Density McNairy	1,419	kg/m^3	DOE 2022b
TCE Half Life TCE—RGA	15	years	2007 Northwest Plume Evaluation
TCE Half Life TCE—McNairy	15	years	Same as RGA estimate*

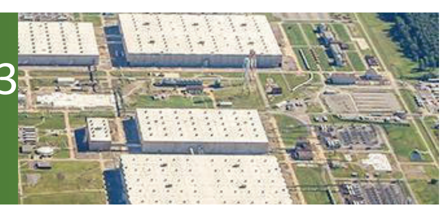
*Degradation rates may be higher due to higher fraction of organic carbon content.
Notes:
K_d: distribution coefficient
S: second

From Table 8.4
Draft 2023 GW Model Report
(DOE 2023)



Transport Model Calibration

- Calibration Methodology
  - TCE
  - Tc-99
- Evaluation of Numerical Solution Schemes
- Mass Balance
- Sensitivity and Correlation Analyses
  - Initial groundwater concentrations
  - Source zone configuration
- Biological Half-Life Evaluation



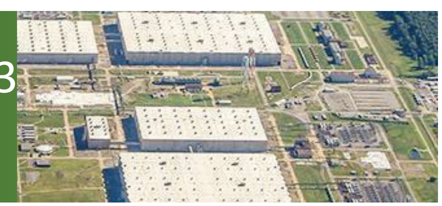
Calibration Methodology

TCE

- TCE transport was calibrated using multiple target types
  - Monitoring well concentration data reported in biannual plume maps reports from 2010 to 2020
  - Visual comparison of simulated and published plume maps
  - Extraction well mass removal rates
- Calibrated by manually adjusting source zone locations and concentrations
- Model inputs iteratively adjusted until modeled TCE concentrations and plume distributions best matched observed data

Tc-99

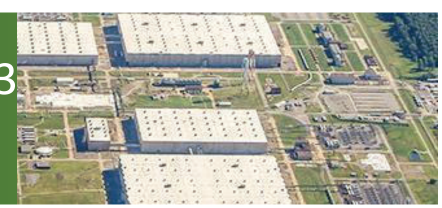
- Tc-99 transport was calibrated using multiple target types
  - Monitoring well concentration data reported in biannual plume maps reports from 2010 to 2020
  - Visual comparison of simulated and published plume maps
- Calibrated by manually adjusting source zone recharge rate and influent concentrations beneath C-400
- Influent concentrations adjusted by stress period to match concentration trends
- Model inputs iteratively adjusted until modeled Tc-99 concentrations and plume distributions best matched observed data



Calibration Methodology

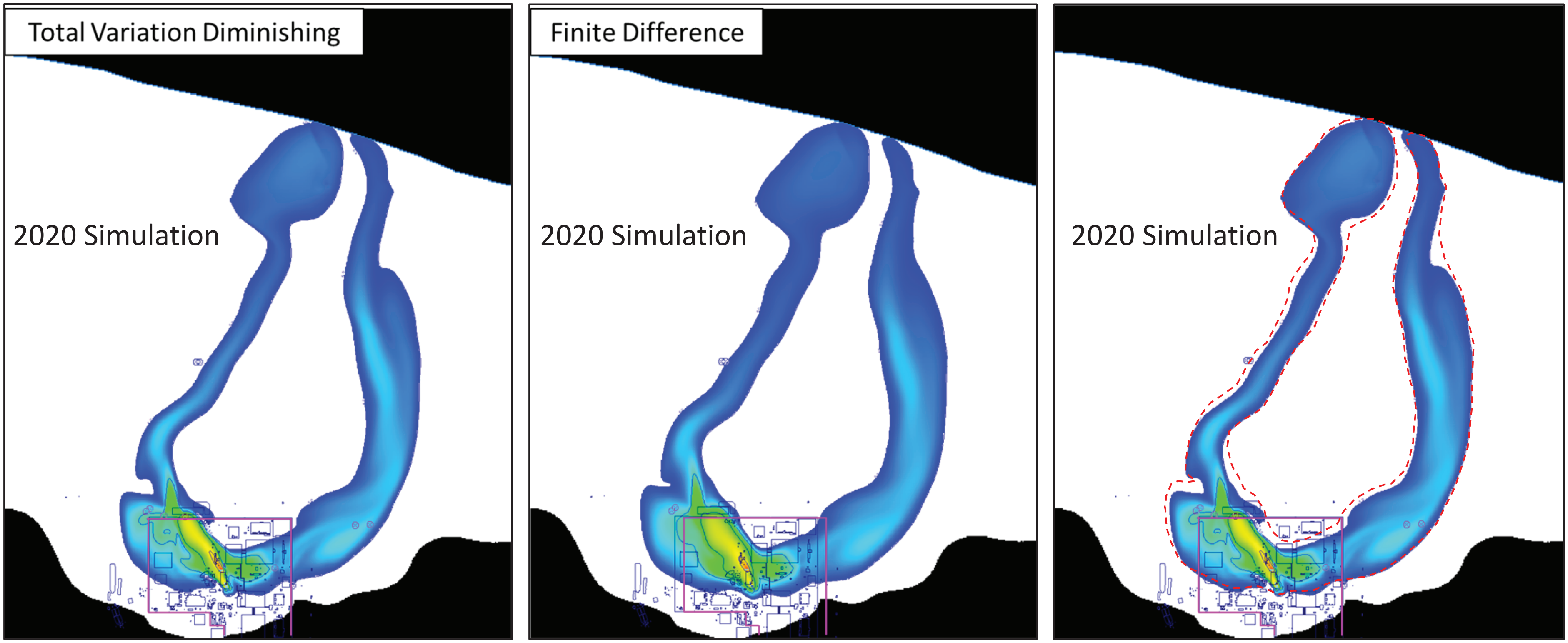
- Monitoring well concentration data were used to evaluate concentration trends and summary residual statistics
- 230 TCE concentration targets and 224 Tc-99 concentration targets were specified, each with between 1 and 5 data points
- Monitoring wells were distributed based on reported screen elevations

DRAFT Work Product – For Discussion Only



Evaluation of Numerical Schemes

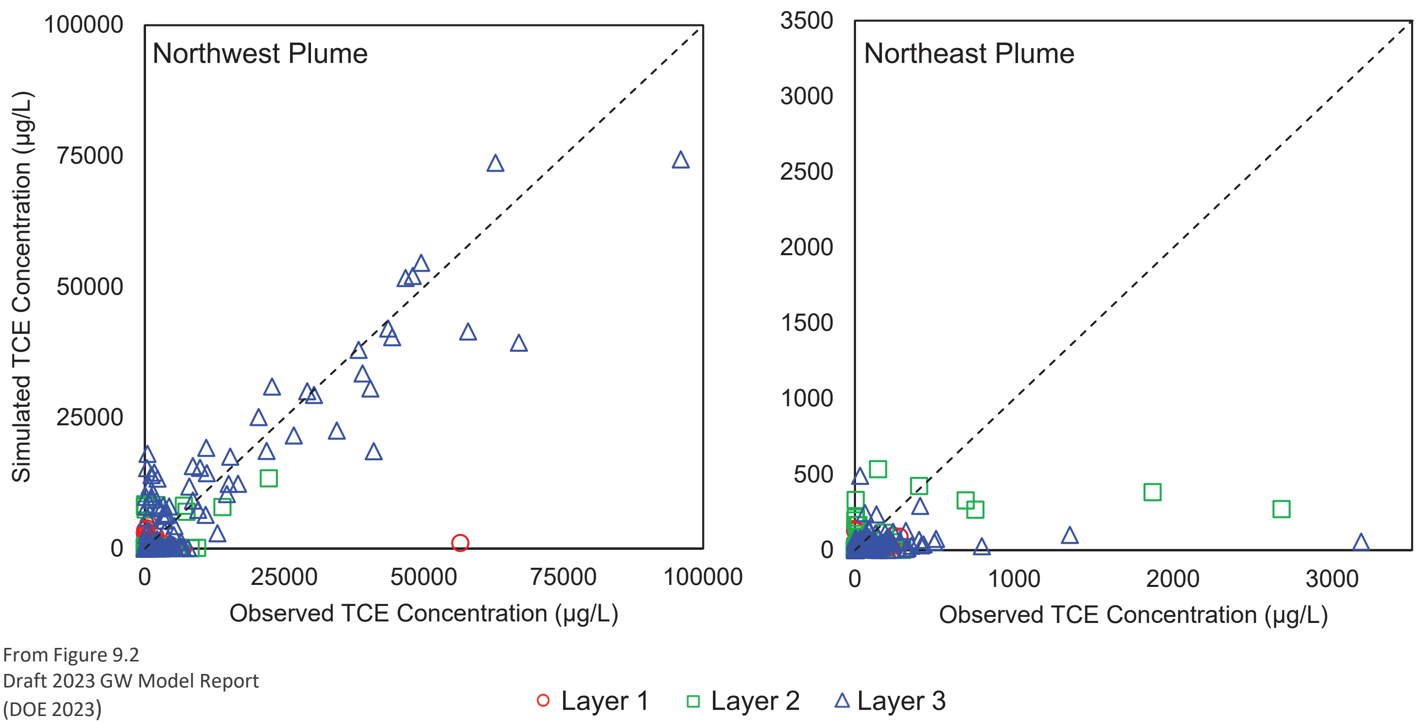
- Simulations were run using both finite difference (FD) and total variation diminishing (TVD) schemes
- FD resulted in more dispersion transverse to primary flow direction (towards Ohio River)
  - FD runs more efficiently (>1 hr) but TVD more accurate



From Figure 9.1
Draft 2023 GW Model Report
(DOE 2023)

Calibration Results: TCE

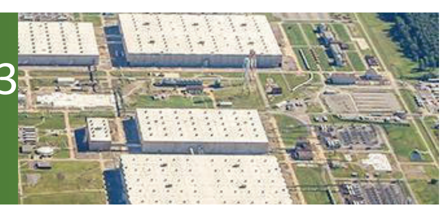
- Model performance evaluated through analysis of TCE residuals, calculated as observed minus simulated concentrations
- Residuals along one-to-one line indicate a good match between observed and simulated



From Figure 9.2
Draft 2023 GW Model Report
(DOE 2023)

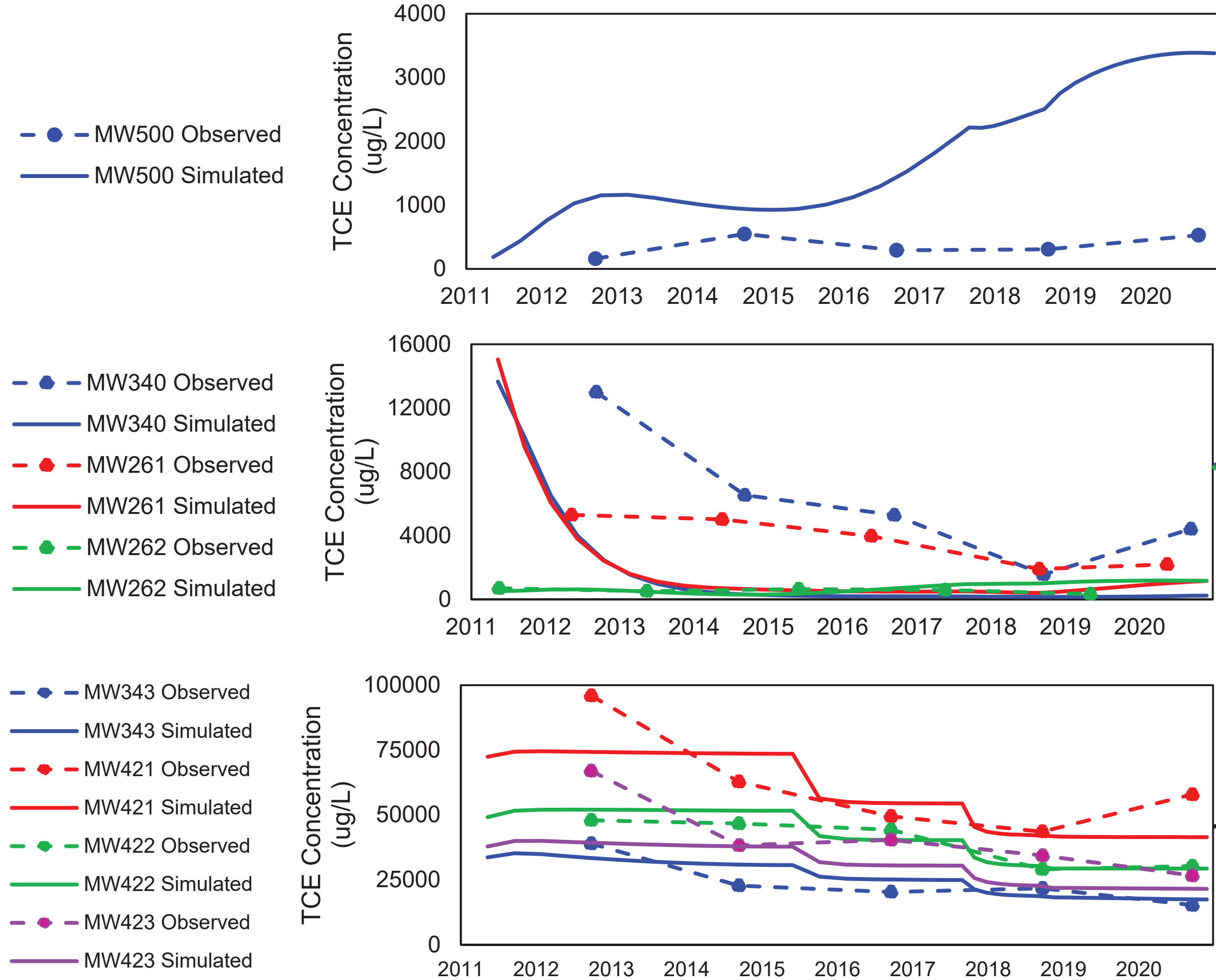
2023 Sitewide Groundwater Model Briefing – September 6, 2023

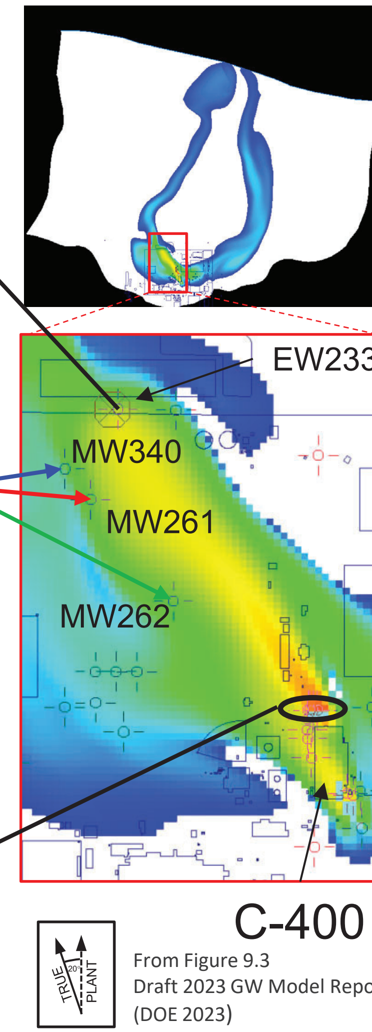
DRAFT Work Product – For Discussion Only



Calibration Results: TCE

- Modeled TCE concentrations at key monitoring wells analyzed against observed trends



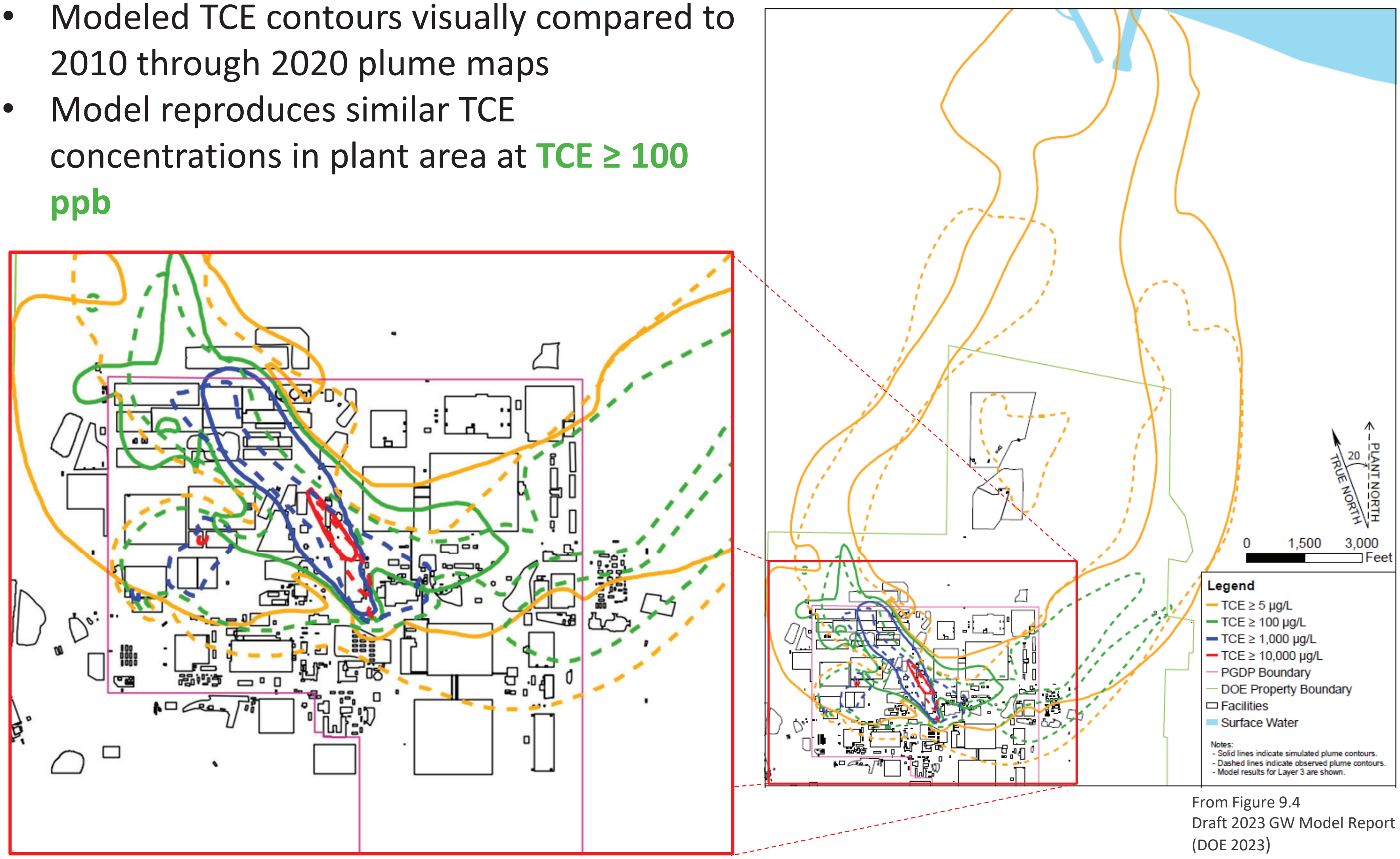


From Figure 9.3
Draft 2023 GW Model Report
(DOE 2023)

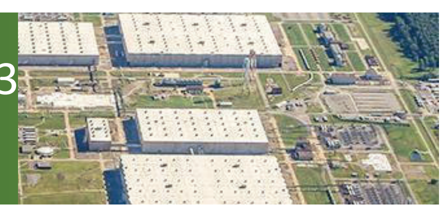
C-135

Calibration Results:TCE

- Modeled TCE contours visually compared to 2010 through 2020 plume maps
- Model reproduces similar TCE concentrations in plant area at **TCE ≥ 100 ppb**



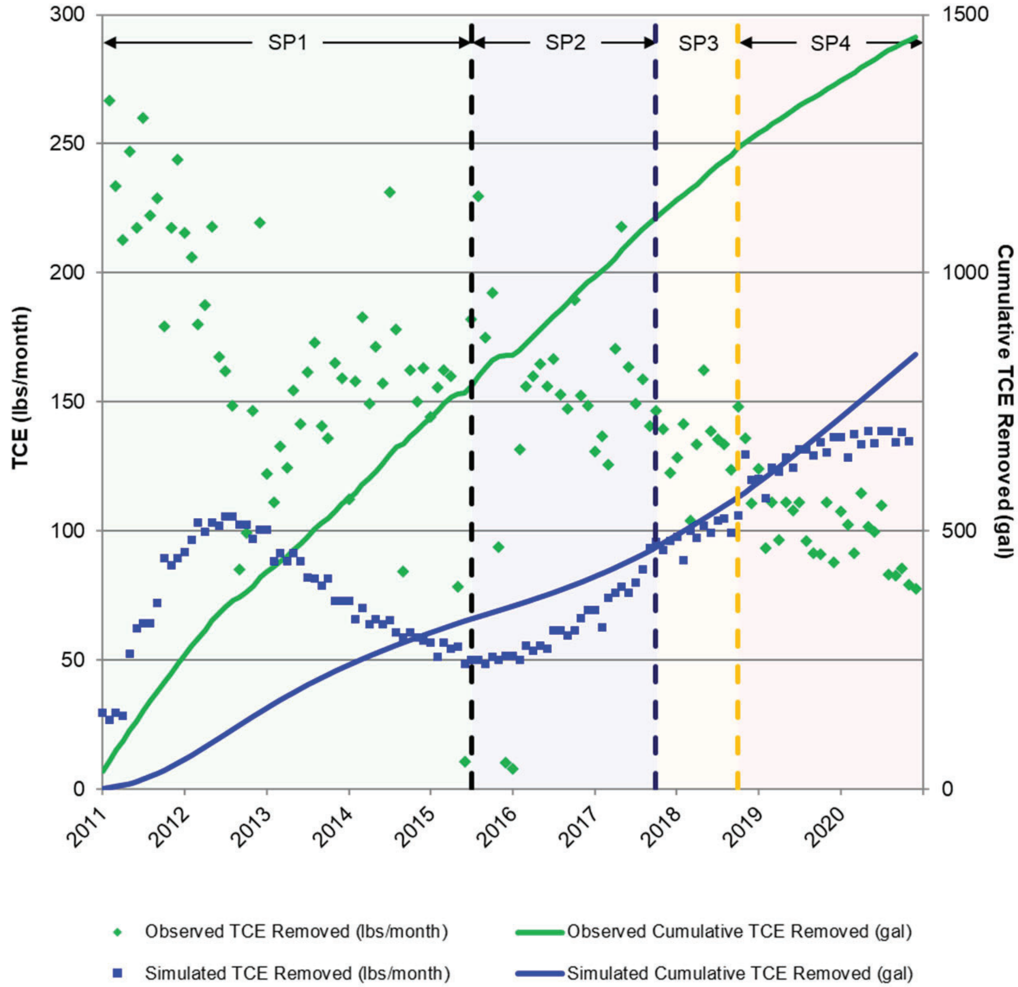
From Figure 9.4
Draft 2023 GW Model Report
(DOE 2023)



Mass Balance: TCE

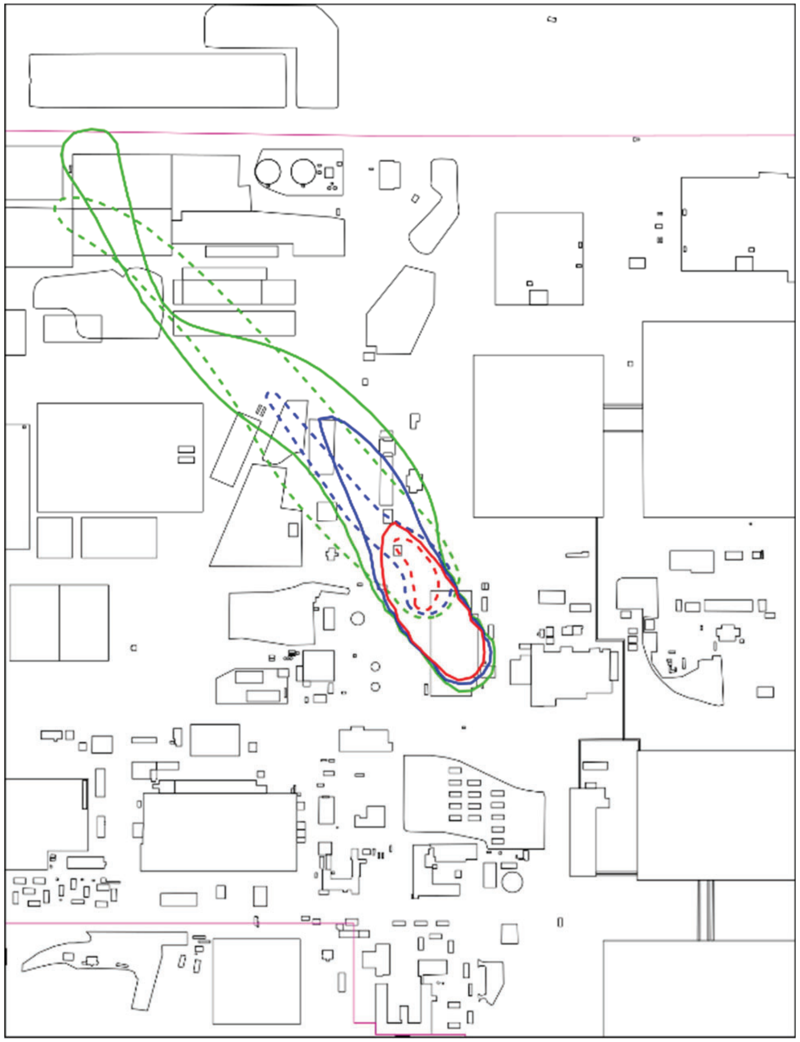
- Monthly rate and cumulative volume of TCE removed compared to observed data
- During transport stress period 1, simulated TCE removal rate and cumulative volume lower than observed
- Majority of early mass is from mass represented by initial concentration field
  - Travel time of 8 – 10 years to reach NWP EWs
- Reasonable match to observed concentrations by SP4

C-137

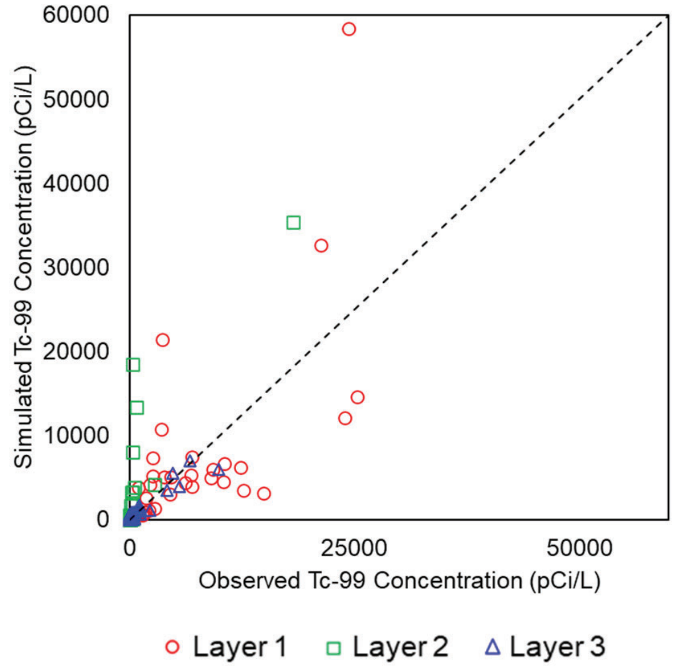


From Figure 9.8
Draft 2023 GW Model Report
(DOE 2023)

Calibration Results: Tc-99



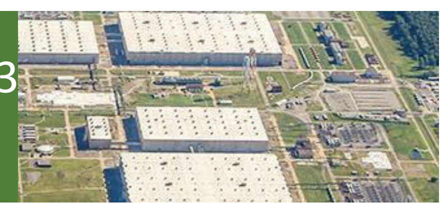
From Figure 9.7
Draft 2023 GW Model Report (DOE 2023)



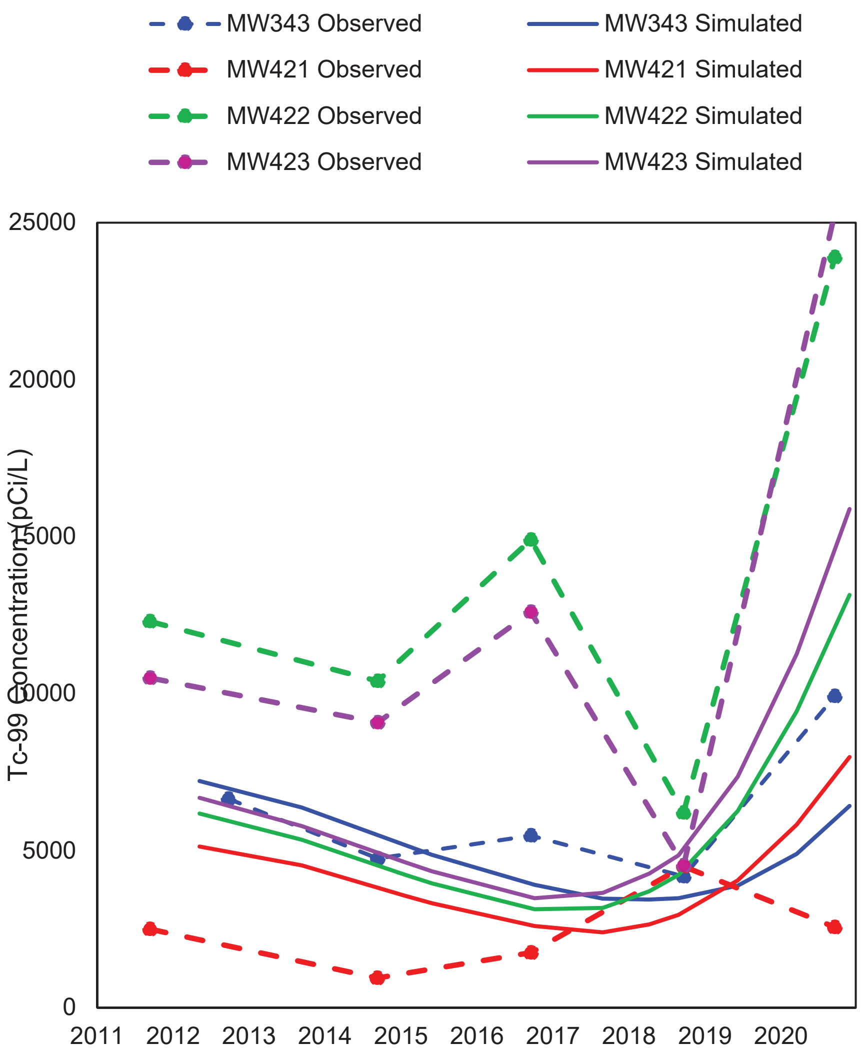
From Figure 9.5
Draft 2023 GW Model Report (DOE 2023)

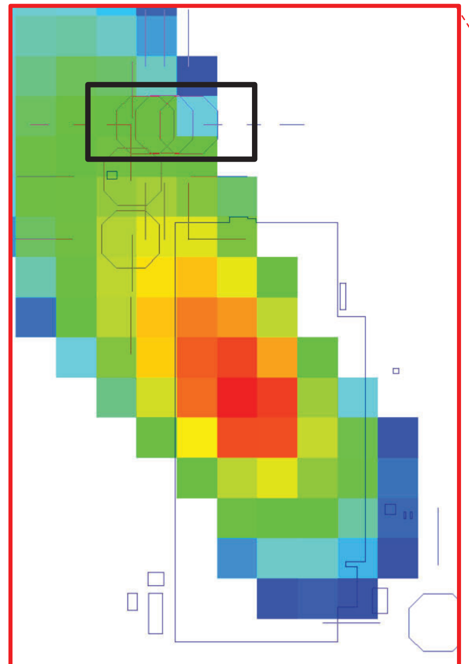
- Residuals well-distributed along one-to-one line, indicating good match
- Plume contours provide a reasonable match to 2020 delineation

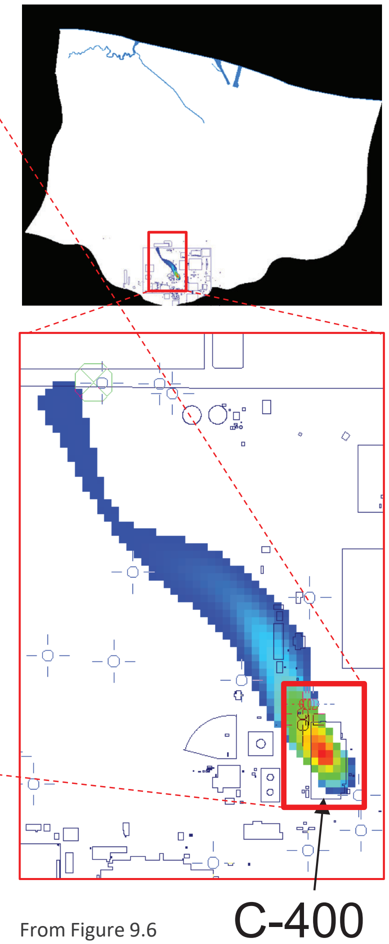
C-138



Calibration Results: Tc-99

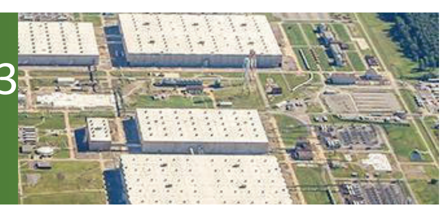




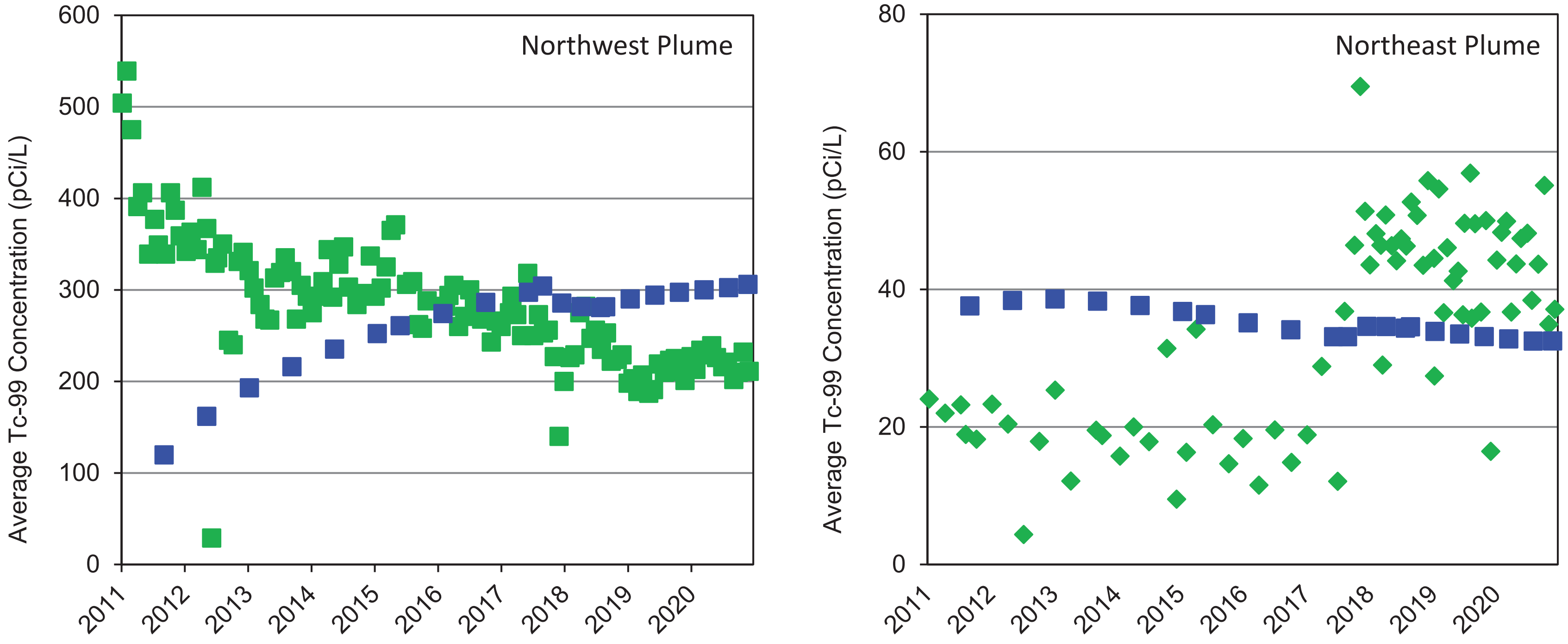


	Recharge Rate (inches/year)	Recharge Concentration (pCi/L)
FTSP1	1.0	1,000,000
FTSP2	1.0	75,000,000
FTSP3	1.0	75,000,000
FTSP4	1.0	75,000,000

From Figure 9.6
Draft 2023 GW Model
Report (DOE 2023)



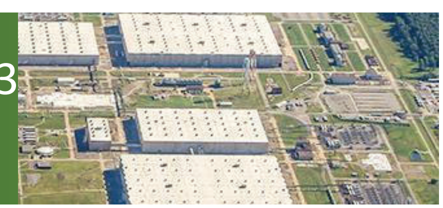
Mass Balance: Tc-99



From Figure 9.9
Draft 2023 GW Model
Report (DOE 2023)

- Simulated average concentration at NEP and NWP EWs compared to observed influent concentrations
- Plots suggest initial Tc-99 mass in RGA may be underestimated

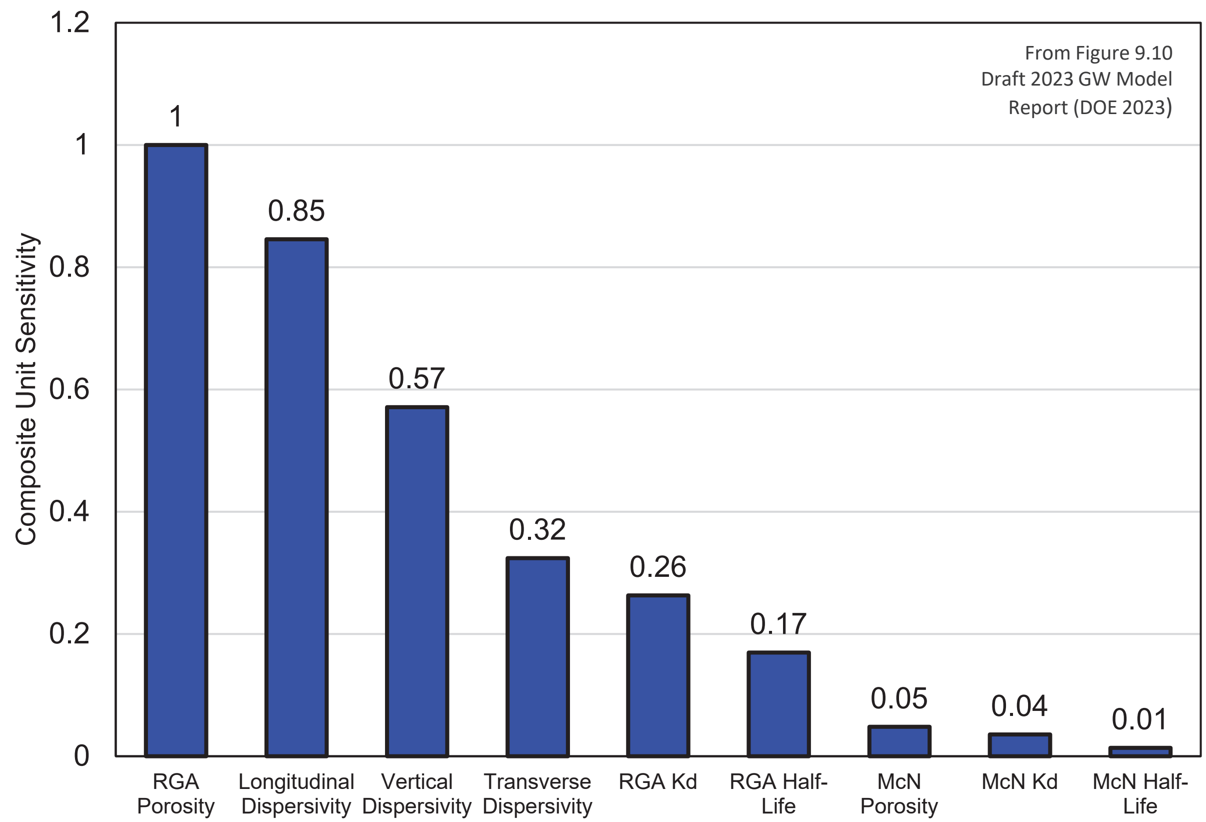
C-140

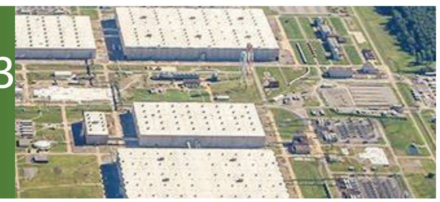


Sensitivity Analysis

- Single PEST iteration performed on calibrated TCE model using TVD solution scheme
- Calculate scaled composite sensitivities using temporal TCE MW concentrations as calibration targets
- Model predictions most sensitive to RGA porosity
- Dispersivity values were next most sensitive
- Transport characteristics of McNairy have small influence on plume dynamics

C-141





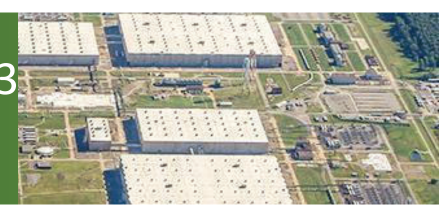
Correlation Analysis

- Many transport model input parameters are highly correlated
- Porosity is inversely correlated to K_d and biological half-life

From Table 9.1
Draft 2023 GW Model
Report (DOE 2023)

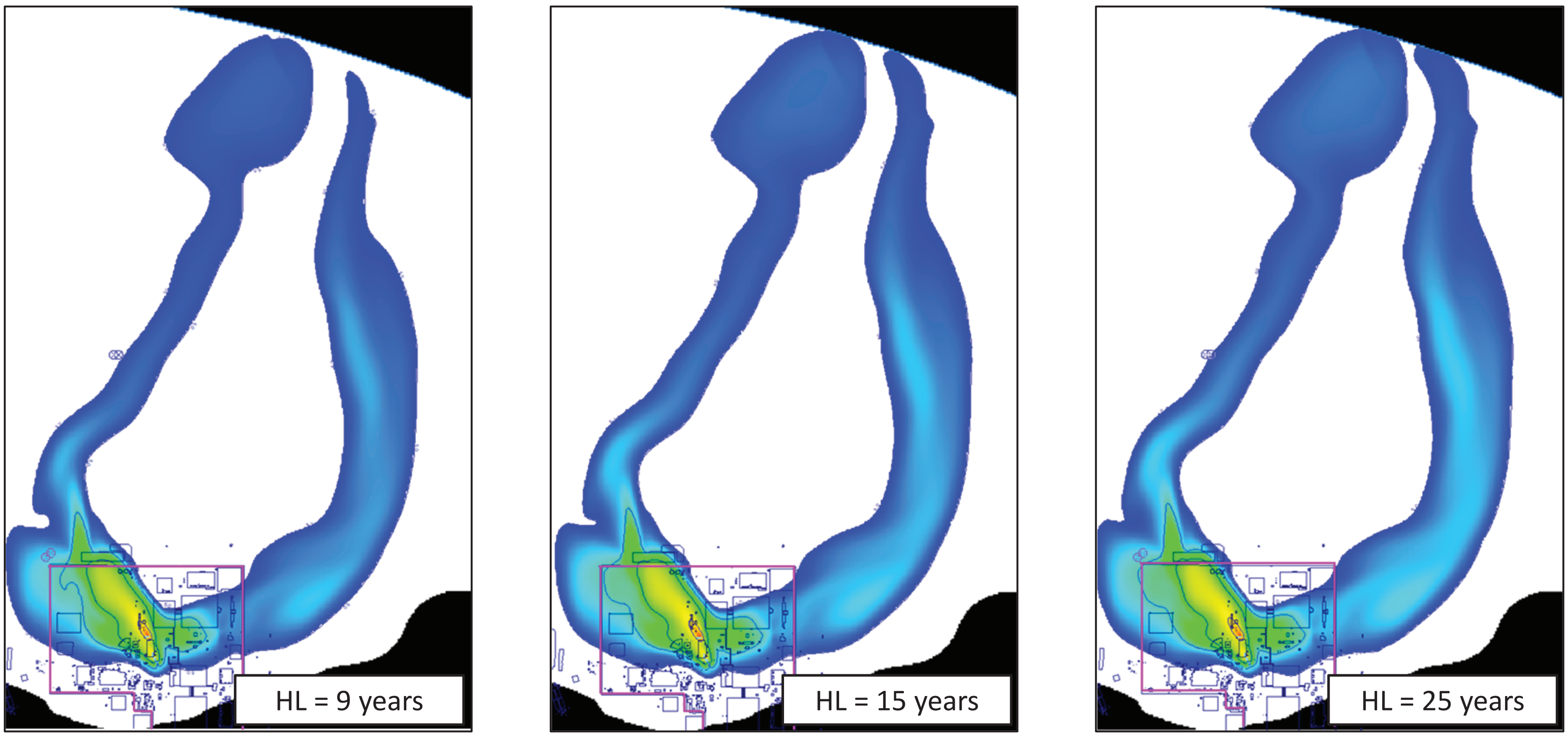
- K_d is positively correlated with biological half-life
- Both K_d and porosity are highly sensitive, and were fixed to site measured data
- Biological half-life is also sensitive, but estimates from site-studies provide a range of values

	RGA Porosity	McN Porosity	RGA Kd	McN Kd	RGA Half-Life	McN Half-Life	Longitudinal Dispersivity	Transverse Dispersivity	Vertical Dispersivity
RGA Porosity	1	0.55	-1.00	-0.67	-0.81	0.04	-0.13	0.07	-0.14
McN Porosity	0.55	1	-0.55	-0.17	-0.83	0.67	-0.13	-0.06	-0.27
RGA Kd	-1.00	-0.55	1	0.63	0.80	-0.03	0.17	-0.10	0.13
McN Kd	-0.67	-0.17	0.63	1	0.51	0.21	-0.13	0.07	0.13
RGA Half-Life	-0.81	-0.83	0.80	0.51	1	-0.53	0.08	0.01	0.26
McN Half-Life	0.04	0.67	-0.03	0.21	-0.53	1	0.05	-0.04	-0.49
Longitudinal Dispersivity	-0.13	-0.13	0.17	-0.13	0.08	0.05	1	-0.79	-0.43
Transverse Dispersivity	0.07	-0.06	-0.10	0.07	0.01	-0.04	-0.79	1	0.09
Vertical Dispersivity	-0.14	-0.27	0.13	0.13	0.26	-0.49	-0.43	0.09	1

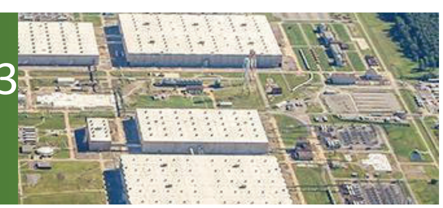


Biological Half-Life Evaluation

- Simulations performed for TCE biodegradation half-lives of 9, 15, 25 years
- Lower half-life results in a narrower plume with relatively limited extent
  - TCE contamination does not reach Ohio River for 9-year half-life
- The 25-year half-life is somewhat wider with higher TCE concentrations

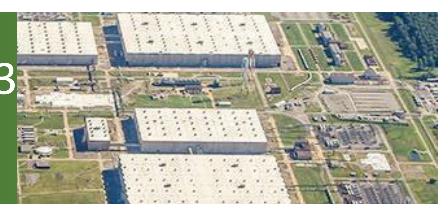


From Figure 9.11, Draft 2023 GW Model Report (DOE 2023)



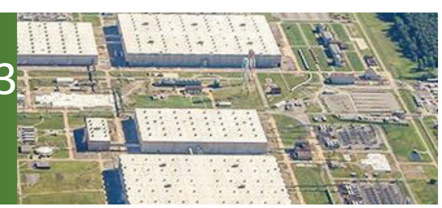
Calibrated Transport Model Evaluation

- The transport model reasonably matches the NW TCE Plume geometries and concentration distributions
- The model-predicted NE TCE Plume underestimates concentrations and plume extents, indicating potential upgradient source areas that have yet to be fully characterized
- The downgradient boundaries of the simulated TCE plumes extend beyond the boundaries of the observed plumes
  - Concentrations are less than 20 µg/L and within the range of uncertainty contributed by several factors including numerical dispersion, grid geometry, and initial concentrations
- The calibrated Tc-99 model reasonably matches known plume geometries depicted by the 900 pCi/L contour line and monitoring well concentrations



Calibrated Transport Model Limitations

- TCE sources represent the primary sources of TCE, and do not account for lesser sources or yet to be characterized sources
- Sensitive parameters (e.g., porosity, K_d) were simulated using bulk values that do not account for spatial variability
- Calibrated half-life is a sitewide estimate with inherent uncertainty
  - May be managed via sensitivity analysis where remedial designs are evaluated at the calibrated value and at values that represent expected bounds
- Although within the range of uncertainty for predictive fate and transport modeling, the model over-predicts lower range concentrations at more distal locations from the plume sources compared to concentrations observed in monitoring wells in this area

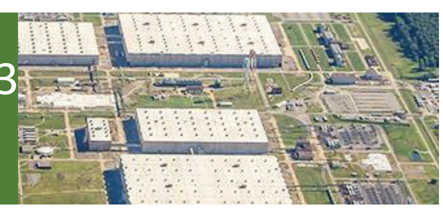


Calibrated Transport Model Limitations

- Near the Ohio River, the downgradient boundary of the simulated NE and NW TCE plumes extend beyond the boundary of the observed plumes
- Simulated concentrations in this area are less than 20 µg/L and within the range of uncertainty contributed by a number of factors including numerical dispersion grid geometry (e.g., 50 × 50 ft cells) and initial concentrations
- The transport model simulates annual average groundwater conditions and does not account for the effects due to flooding conditions during periods of high river stages that would periodically impede or reverse groundwater flow in the vicinity of Little Bayou Creek and the river

Model Conclusions

- The calibrated flow model provides a representation of the groundwater flow system within the PGDP Hydrologic Basin for transient conditions that typically occur during the wetter months of the year and steady-state conditions, which typically occur during the drier months.
- The transport model produces similar TCE and Tc-99 NW Plume geometries primarily sourced from releases at the C-400 Complex.
- The downgradient boundary of the simulated NE and NW TCE plumes extend beyond the boundary of the observed plumes.
- The transport model underestimates concentrations in the NE Plume indicating potential upgradient sources (e.g., in the vicinity of C-333) yet to be characterized.
- Application of the model for site or project-specific requirements and determinations of the appropriate use of the model should be made on a case-by-case basis.



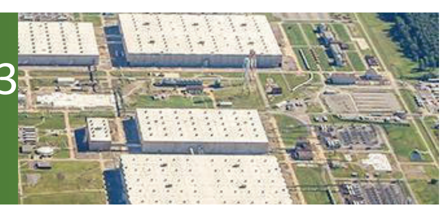
Backup Slides

DRAFT Work Product – For Discussion Only

McNairy TCE

- Using the calculated TCE concentrations at the bottom of each McNairy model layer as a baseline, the values in each layer were scaled upwards in quintuplicate by a constant factor.
- This upward scaling sequentially increased the calculated TCE concentration in the RGA to a high value near the maximum observed in the 2010 Plume Map Update.
- The baseline values were also scaled downwards in quintuplicate by a constant factor to sequentially decrease the calculated TCE concentration in the RGA to a low value near the minimum observed in the 2010 Plume Map Update.

Layer[1]	Depth[2] (ft)	Each column here is the column to the right multiplied by 2.					TCE (ug/L)[3]	Each column here is the column to the left divided by 2.						Linear Relationship[4]
		2×→	2×→	2×→	2×→	2×→		←×1/2	←×1/2	←×1/2	←×1/2	←×1/2	←×1/2	
3	0.00	51432.5	25716.3	12858.1	6429.1	3214.5	1607.3	803.6	401.8	200.9	100.5	50.2	25.1	--
4	0.82	36273.8	18136.9	9068.5	4534.2	2267.1	1133.6	566.8	283.4	141.7	70.8	35.4	17.7	y = 0.7053x
5	1.64	25582.9	12791.4	6395.7	3197.9	1598.9	799.5	399.7	199.9	99.9	50.0	25.0	12.5	y = 0.4974x
6	3.28	12725.1	6362.5	3181.3	1590.6	795.3	397.7	198.8	99.4	49.7	24.9	12.4	6.2	y = 0.2474x
7	6.56	3148.3	1574.2	787.1	393.5	196.8	98.4	49.2	24.6	12.3	6.1	3.1	1.5	y = 0.0612x
8	13.12	192.7	96.4	48.2	24.1	12.0	6.0	3.0	1.5	0.8	0.4	0.2	0.1	y = 0.0037x
9	26.25	0.7	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--



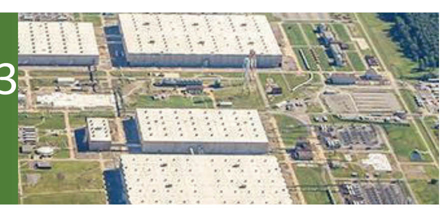
Boundary Conditions: Calibration

Target On-Site WLs	
Pre-Dam	325.7
Post-Dam	329.1

Data Range (based on Rev26 recharge values)					
Zone	Location	Min	Max	Initial (in/yr)	Initial (ft/d)
13	East Terrace Recharge	60.00	350.00	205.00	0.0468037
14	West Terrace Recharge	43.80	175.20	109.50	0.0250000
2	Ambient Outside Plant Area	6.00	7.62	6.81	0.0015549

Ambient Recharge	0.00129	5.65	325.5	Pre-Dam	Ambient and terrace recharge in the pre-dam period were decreased relative to the post-dam period based on trends observed on the Precipitation tab.
East Terrace	0.0388	169.95			
West Terrace	0.0207	90.78			
Ohio River Stage (ft)	301.4	301.40			
Ambient Recharge	0.00155	6.81	329.1	Post-Dam	Decreased river stage for all SPs by changing "spring/winter" period to Nov-Jul.
East Terrace	0.0468	205.00			
West Terrace	0.0250	109.50			
Ohio River Stage (ft)	304.4	304.40			

C-150



Tortuosity in the RGA & McNairy

- Tortuosity was used to estimate the effective molecular diffusion
  - For unconsolidated sediments, estimates of tortuosity can be obtained based on the hydraulic conductivity of the medium

$$\tau = 0.77K^{0.040}$$

(where K is in m/s)

$$D_e = \tau \times D$$

(where D is in ft²/d)

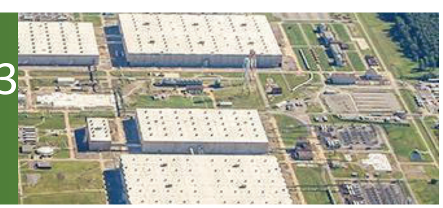
RGA		
Parameter	**Value**	**Unit**
K	1500	ft/day
K	5.29E-03	m/s
D	9.10E-06	cm^2/sec
D	0.00085	ft^2/day
Tortuosity	0.62	--
D_e	5.28E-04	ft^2/day

McNairy		
Parameter	**Value**	**Unit**
K	0.1	ft/day
K	3.53E-07	m/s
D	9.10E-06	cm^2/sec
D	0.00085	ft^2/day
Tortuosity	0.43	--
D_e	3.60E-04	ft^2/day

RGA		
Parameter	**Value**	**Unit**
K	1500	ft/day
K	5.29E-03	m/s
D	1.00E-09	cm^2/sec
D	9.30E-08	ft^2/day
Tortuosity	0.62	--
D_e	5.80E-08	ft^2/day

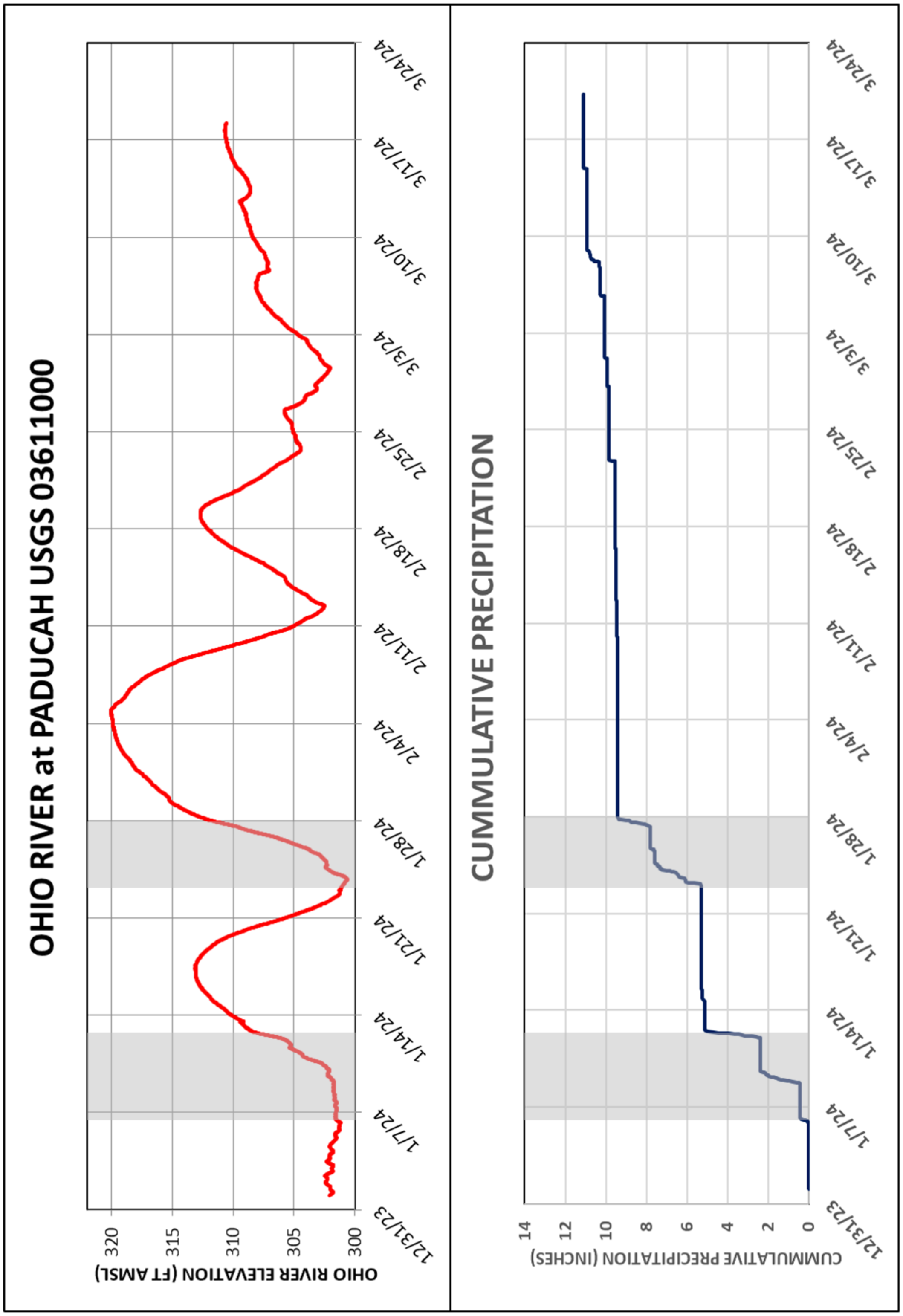
McNairy		
Parameter	**Value**	**Unit**
K	0.1	ft/day
K	3.53E-07	m/s
D	1.00E-09	cm^2/sec
D	9.30E-08	ft^2/day
Tortuosity	0.43	--
D_e	3.95E-08	ft^2/day

- D = free water molecular diffusion coefficient
- D_e = effective molecular diffusion coefficient
- K values used in calculations are assumed spatial average values from the groundwater flow model



Attachment 3

Precipitation and Ohio River Stage Data



OHIO RIVER at PADUCAH USGS 03611000
OHIO RIVER ELEVATION (FT AMSL)
300
305
310
315
320
12/31/23
1/7/24
1/14/24
1/21/24
1/28/24
2/4/24
2/11/24
2/18/24
2/25/24
3/3/24
3/10/24
3/17/24
3/24/24
CUMMULATIVE PRECIPITATION
CUMMULATIVE PRECIPITATION (INCHES)
0
2
4
6
8
10
12
14

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APPENDIX D

PADUCAH SITE GROUNDWATER MODELING WORKING GROUP MEETING SUMMARY—JULY 17, 2024

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ACRONYMS[1]

AIP	agreement in principle
amsl	above mean sea level
CB	colloidal borescope
CCR	coal combustion residuals
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CRS	comment response summary
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.
FRNP	Four Rivers Nuclear Partnership, LLC
FS	feasibility study
FY	fiscal year
GW	groundwater
GIS	geographic information system
GWSP	Groundwater Strategy Project
KDEP	Kentucky Department for Environmental Protection
KRCEE	Kentucky Research Consortium for Energy and the Environment
KY	Commonwealth of Kentucky
KYRHB	Kentucky Radiation Health Branch
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
PGDP	Paducah Gaseous Diffusion Plant
PT	pressure transducer
P-QAPP	programmatic quality assurance project plan
PZ	piezometer
Q	quarter
RGA	Regional Gravel Aquifer
RI	remedial investigation
SVOC	semi volatile organic compound
TBD	to be determined
TOC	top of casing
TVA	Tennessee Valley Authority
UCRS	Upper Continental Recharge System
VI	vapor intrusion
VOC	volatile organic compound
WDA	waste disposal alternative

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

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Paducah Site Groundwater Modeling Working Group
Meeting Summary—July 17, 2024

MWG Attendees:

DOE
Tom Reed ✓

ETAS
Martin Clauberg ✓
Bruce Stearns ✓
Tracy Wood

KRCEE
Steve Hampson ✓
Alan Fryar ✓

TVA
Matthew Alpin
Tabitha Ester ✓
Anna Fisher
Jeffrey Frazier (WSP) ✓
Eric Wallis

EPA and Contractors
Noman Ahsanuzzaman
Ben Bentkowski
Eva Davis ✓
Jonathan Dziekan
Bei Huang ✓
Mac McRae ✓
Victor Weeks ✓

Kentucky
Stephanie Brock
Mary Evans ✓
Nathan Garner ✓
Will Grasch ✓
Brian Lainhart
Todd Mullins
Bart Schaffer ✓
Sonja Smiley ✓
April Webb ✓
Baili Galliher ✓

FRNP
Evan Clark
Bryan Clayton ✓
Sarah Cronk
Ken Davis ✓
Bruce Ford ✓
Stefanie Fountain ✓
Josue Gallegos ✓
Emilye Garner ✓
Steve Kenworthy ✓
Jeffrey King ✓
Bruce Meadows
Megan Mulry ✓
Karen Price ✓
Dawit Yifru ✓

✓ 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. Additions or revisions to the agenda items are noted in [].

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

The 4/3/2024 meeting summary was transmitted to the MWG on 4/26/2024.

No additional comments were received to the 4/3/2024 Meeting Summary. EPA indicated they did not have any comments; KY stated they would review the summary and provide comments.

2. FY 2024 Work Plan/Schedule

Activity	Date
~~Quarterly Meeting (October/FY 2024Q1)~~	~~10/4/2023~~
~~MWG Concurs with FY 2024 Work Plan~~	~~11/3/2023~~
~~Quarterly Meeting (January/FY 2024Q2)~~	~~1/10/2024~~
~~Submit Draft MWG Compilation (FY 2023) to MWG~~	~~1/12/2024~~
~~MWG Provide Comments on Draft MWG Compilation (FY 2023)~~	~~2/11/2024~~
~~Submit Final MWG Compilation (FY 2023)~~	~~3/10/2024~~

Activity	Date
~~Quarterly Meeting (April/FY 2024Q3)~~	~~4/3/2024~~
~~Provide White Papers 1-2-3 to MWG~~	~~5/30/2024~~
~~MWG Provide Comments on White papers 1-2-3~~	~~6/27/2024~~
Quarterly Meeting (July/FY 2024Q4)	7/17/2024

The group did not have questions or comments on this agenda item.

3. Draft FY 2024+ Work Plan/Schedule

Activity	Date
Provide Draft Agenda Including FY 2025 Work Plan/Schedule (October/FY 2025Q1) to MWG	10/2/2024
Quarterly Meeting (October/FY 2025Q1)	10/9/2024 (Planning date)

The group did not have questions or comments on this agenda item.

4. Update on Water Levels

Synoptic water level events are being collected quarterly. The potentiometric map for the synoptic water level event for 2/21-23/2024 and the February 2024 groundwater elevation data for TVA wells collected by KY are included in Attachment 1. Potentiometric maps will be included in the annual MWG compendia.

Ken Davis (FRNP) pointed out the cones of depression for this quarter's potentiometric maps stretch across the whole Paducah Site, implying higher capture efficiency of migrating contaminants. Steve Hampson (KRCEE) agreed that the maps now better reflect all the efforts that have been made to assess and analyze groundwater at the site.

TVA is planning to install six new monitoring wells (five screened in the RGA and one screened above the RGA). TVA plans to share a map of the new wells as well as the boring logs and well installation logs with K. Davis (FRNP) who will share these with the rest of the group, as appropriate.

TVA is planning on installation of new monitoring wells this year (not yet started). Dawit Yifru (FRNP/Geosyntec) pointed out that the top of casing elevation for the TVA wells in the Attachment 1 Table need to be corrected these were corrected on the potentiometric map. Ken and Dawit will work with TVA to identify the needed correction(s).

5. Update on Paducah Site Groundwater Strategy

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

- Change status of two Environmental Indicator (EI) Performance Measures to "Yes"
    - Human exposure under control
    - Groundwater migration under control
- Resolution of data needs

- Groundwater Modeling Working Group (MWG) recommended model [uncertainties]

The activities defined in the GWSP PMP include:

Activity No.	Issue of Concern
	Human Exposure Under Control
1	TCE Extent West of PGDP (SW Plume)
2	TCE Extent East of PGDP (Downgradient NE Plume)
3	North Extent of PGDP TCE Plumes (Impact to Ohio River)
4	Nature and Extent of Contaminants Currently Contributed by Little Bayou Creek Seeps
5	Nature and Extent of Dissolved-Phase Contaminants Other than TCE and technetium-99 (Tc-99)
	Groundwater Migration Under Control
6	Capture Efficiency of NW Plume EWs
7	TCE Extent and Trends in East Side of Downgradient NW Plume
8	TCE Extent and Trends in West Side of Downgradient NE Plume
9	RGA Dissolved-Phase and DNAPL Contaminant Impacts to the McNairy Formation
	Groundwater MWG Inputs
10	Characterize Underflow from the Terrace Area
11	Expansion of Groundwater Monitoring Network
12	Water Balance Study
13	Continuous RGA Water Level Monitoring
14	Synoptic Water Level Measurement
15	Water Level Divide Study
16	Hydraulic Conductivity
	Additional Activities
17	MW Survey Study
18	Groundwater Chemical Trend Evaluation
19	TCE Degradation Rates

The following three white papers (started as part of the FY 2023 GWSP PMP) have been provided to the MWG for review.

- Activity #1 White Paper: Regional and Localized Groundwater Flow and Trichloroethene Trends, West Side of the Southwest Plume
- Activity #2 White Paper: Regional and Localized Groundwater Flow and Trichloroethene Trends, East Side of Downgradient Northeast Plume
- Activity #3 White Paper: North Extent of Trichloroethene Plumes (Impact to Ohio River) at the Paducah Gaseous Diffusion Plant

The following two white papers have been provided to DOE for review.

- Activity #7 White Paper: Trichloroethene Extent and Trends in East Side of Downgradient Northwest Plume, Paducah, Kentucky
- Activity #8 White Paper: Trichloroethene Extent and Trends in West Side of Downgradient Northeast Plume, Paducah, Kentucky

White Papers for Activities #1, #2, #3, and #8 white paper, as well as the 2022 plume map update and other supporting analysis recently presented during the Groundwater Modeling Working Group meetings, will be incorporated into the EI documentation determination that will be prepared to support the revision of the "groundwater under control" performance measure from "no" to "yes."

EPA has changed the "human exposure under control" performance measure from "insufficient data" to "yes" with consideration of the vapor intrusion studies that have been done at the site.

DOE and FRNP are discussing potential FY 2025 groundwater strategy scope(s).

Victor Weeks discussed the elements needed to revise the "groundwater under control" EI from "no" to "yes" and that the White Papers 5 and 9 may be higher priority than other remaining activities. Victor's expectation is that it will take EPA quite a bit of time to properly address all the steps of the Superfund enterprise Management System (SEMS) questions.

The Activity 15 paper was discussed with the conclusion that the groundwater divide is generally at the C-400 Building. The divide may shift somewhat based on season or activities at the site, but historically returns to the same area at the C-400 Building. Because of these and other considerations, the Activity 15 paper has been recommended to be put on hold.

FRNP discussed that the Groundwater Strategy will be reevaluated in the context of the ongoing discussions on reprioritization of the remedial strategy at the site (referred to as Decision 2029).

Water Line Leaks. FRNP and KY continue to develop information related to the leak in the main raw water line from the Ohio River to the site. The location of the water line leak along Water Line Road is about a mile from the creek crossing. Repairs to the line and backfilling of the holes are in progress.

The group did not have questions or comments on this agenda item.

Seeps. KRCEE will provide an update on their task related to seeps observations using drone-based thermal camera (DBTC). The KRCEE presentation is included as Attachment 2.

KRCEE presented on Continued Drone-Based Thermal Camera Proof-of-Concept for Little Bayou Creek Seeps *(Attachment 2). Additional drone survey is planned for August 2024 and KRCEE plans to mark seeps in the field for survey. The group discussed that there are not currently plans to sample seeps.*

EPA noted a potential issue with the seep locations in PEGASIS versus the KRCEE maps showing the centerline of Little Bayou Creek.

"No Go" Areas for Monitoring Well Installations. The topic is retained, but restructured to provide a look-ahead at planned or potential changes rather than a backward look at changes. Several standing questions on this topic will be developed and included in future MWG meeting agendas.

- **Planned site activities with potential to impact Monitoring Well Installations?** Reprioritization of remedial projects is included in the approved 2023 Site Management Plan.
- **Applicable Quarterly Kentucky Department Fish & Wildlife Resources (KDFWR) meeting discussions?**

- Meeting held [7/10/2024]. The next meeting is scheduled for [8/28/2024]. Discussion topics included:
  - DOE has pushed the electrical transmission line removal project to FY 2025.
  - Swift & Staley, Inc. (SSI) is reviewing the low water crossing.
  - Inspections within the West Kentucky Wildlife Management Area (WKWMA) are not anticipated this quarter, but fences at the iron bridge may be installed next quarter.
  - WKWMA updated everyone on the upcoming hunting seasons and large AKC Master Event in Early October (runs about 12 days).
- **Have any changes to the "No Go" Areas map occurred since the last meeting or map revision?** None known at this time.

The group did not have questions or comments on this agenda item.

Sitewide Groundwater Model Update. The overarching goal of the model update is to develop a model to support remedial decision making. The update to the Paducah Site groundwater model is in progress. DOE Paducah, KRCEE, and DOE Savannah River National Laboratory (SRNL) have reviewed the model and report and have provided their feedback. The DOE Low-Level Waste Disposal Facility Federal Review Group (LFRG) provided an additional external review; the LFRG review of the model focus was different from the original intent of the model update. The lead modeler for the on-site waste disposal facility (OSWDF) model at PORTS has reviewed the model in preparation for resumption of the Waste Disposal Alternatives (WDA) project at Paducah. The revised report was provided to EPA and KY on 5/21/2024 with acknowledgement requested by 7/14/2024.

EPA has requested that the external reviewer comments be shared as part of the deliverable to EPA and KY. DOE will provide a summary of the comments as multiple comments are related to the potential performance assessment for an OSWDF and are not relevant to the Sitewide flow model.

The group did not have questions or comments on this agenda item. Since the meeting, both EPA and KY have acknowledged the model report and EPA provided comments for consideration during the next model update.

6. Anthropogenic Recharge

This sub-topic will capture discussion on site changes, such as the recent changes to the high pressure fire water system. Development of a timeline to track changes to site operations that could impact the water balance at the site (e.g., removal of the high pressure fire water line from service, removal of the second raw water line from service, etc.) is being maintained. A water balance study (part of GWSP Activity #12) is included as an appendix to the 2023 modeling report. Historically, intake water volume was around 4 million gallons per day (mgd) and is now closer to 1 mgd as shown in the water balance study.

The group did not have questions or comments on this agenda item.

7. Plant-Wide Seismic Update

The WDA project is included in the approved FY 2024 Site Management Plan (SMP) and candidate siting will be revisited as part of resuming the project. For the WDA project, DOE is working with UK to develop a site-wide seismic investigation under the current KRCEE grant in CY 2024. Field mobilization is planned for 2024 for high-resolution testing of 1-2 sites for OSWDF siting and design, including Holocene fault investigation. The goal would be to complete the seismic project in FY 2024 to meet the OSWDF design and PA/CA schedules. Under the Decision 2029 schedule, the PA/CA must start no later than mid-2025. Several meetings have been held internally and a meeting with EPA was held 3/27/2024.

KRCEE is working with a subcontractor to develop field investigation methodologies and cost estimates. A Sitewide seismic project will be evaluated later due to schedule and budget constraints. The Sitewide seismic project is relevant to redevelopment discussions, including those associated with the Kentucky Nuclear Development Workgroup.

The KRCEE proposal has been received by DOE and the scope and schedule are close to being finalized. EPA requested regular updates.

8. Precipitation and Ohio River Stage

Attachment 3 includes precipitation and Ohio River stage charts through mid-June 2024.

Ken Davis (FRNP) provided a summary of the charts. The group did not have any additional questions or comments on this agenda item.

9. Synoptic Water Level Events and Ohio River Levels

The location where the creeks shift from gaining to losing may impact the flow model (although the model is not very sensitive to this parameter) and is an area of interest to the group going forward.

The group did not have questions or comments on this agenda item.

10. Projects on the "Watch Topics" List

- **Emerging Contaminants**
  - PFAS
    - The Paducah Site continues to participate in the DOE HQ PFAS Working Group Meetings. Kelly Layne is a member of the DOE PFAS Coordinating Committee and DOE-EM PFAS.
      - There is a new DOE Region 4 Working Group.
      - The Paducah Site response to the DOE-EM annual PFAS survey was sent to DOE HQ at the end of January 2024. The survey is anticipated to be published by DOE in late FY 2024 and will be shared with this group if possible.
      - The DOE LFRG Memo on disposal of PFAS-containing waste is ready for signature but is being held until the release of the revised EPA and final

DOE disposal guidance. This memo gives LFRG approval for disposal of PFAS-containing waste into facilities with Operating Disposal Authorization Statements, such as the PORTS OSWDF.

- The DOE guidance on disposal of PFAS-containing waste is planned to be updated in 2024. EPA guidance is expected to allow for disposal of PFAS waste in Subtitle D landfills.
- Paducah has a question into DOE HQ regarding the potential for disposal of PFAS or PFAS-containing materials in a Subtitle D landfill (e.g., the U-Landfill). A formal request to DOE HQ has not been made on this topic.

▪ For Paducah, the main PFAS activity for FY 2024 is the in-progress PFAS screening assessment project.
  - Sampling is completed and a technical report is in DOE review.

▪ FY 2025 PFAS-related tasks, if developed, will be discussed with the FFA managers. Planning for the Northwest Plume groundwater treatment system includes the potential to update the system to include liquid phase carbon treatment to treat higher VOC concentrations. If added, the carbon should also address PFAS in extracted water.

EPA discussed that PFAS should be considered as part of Groundwater Strategy and in the fiscal year 2025 update to the Environmental Monitoring Plan.

DOE plans to schedule a meeting with EPA and KY when the PFAS screening assessment project report is finalized. This may be added to a future Routine Paducah Groundwater Update meeting (next meeting scheduled for 8/1/1024).

o 1,4-Dioxane

▪ The group plans to discuss fate & transport characteristics of 1,4-dioxane (compared to TCE) during a MWG meeting in FY 2024.

▪ 1,4-dioxane requires different treatment technology from what is currently part of the two site groundwater treatment systems.

▪ The 1,4-dioxane result from MW407 Port 1 was re-assessed by the laboratory at FRNP's request
  - The analysis for 1,4-Dioxane as a VOC was nondetect
  - The analysis for 1,4-Dioxane as a SVOC in the same sample was 2.33E+06 ppb
  - From the laboratory:
    - o 1,4-Dioxane does not purge well from water, nor does it extract very well using method 3510.
    - o Due to this, methods 522 or 8270E SIM are probably the best choices for analyses.
  - ~~In looking at the data for sample 543602001 (MW407P1400RI1-21R), it appears that a very large, saturated peak is present at the retention time for 1,4-Dioxane. The data was restored and processed, and the large peak is not 1,4-Dioxane. It is TCE. The result is being revised in OREIS/PEGASIS to be rejected by laboratory review.~~

- ~~1,4-Dioxane analyses yielded infrequent detections in soil and groundwater.~~
- ~~SW-8270 SIM has been added to the P-QAPP for 1,4-dioxane analysis.~~

EPA discussed that 1,4-dioxane analyses should be added to C-612 effluent. EPA also suggested that the influent and effluent from the groundwater treatment systems should be analyzed for 1,4-dioxane. DOE stated that this single hit from this single location during the C-400 Remedial Investigation needed to be verified before additional investigation.

Following the meeting, the information related to sample 543602001 continues to undergo additional review.

11. FY 2024 Site Management Plan (SMP)

The FY 2024 SMP included a preliminary plan for Decision 2029. The full plan for Decision 2029 is intended to be included in the FY 2026 SMP. The plan includes the reprioritization for site remedial projects, including (dates are for the D1 document submittals):

- C-400 area extraction well and Northwest Plume modification in 2025
- Environmental Media Record of Decision (ROD) in 2029
- Decontamination and Decommissioning Action Memorandum in 2029
- Waste Disposal Alternatives (WDA) and on-site waste disposal facility (OSWDF) ROD in 2029
- Final Consolidated Site Operable Unit (CSOU) ROD (date to be determined)

The group did not have questions or comments on this agenda item.

12. Meeting Presentations

KRCEE will provide a on their work involving Drone-Based Thermal Camera (DBTC) and stream/seeps surveys of Bayou Creek and Little Bayou Creek (Attachment 2).

MWG members should provide any presentation requests to Stefanie. Potential topics for future meetings:

- Environmental Indicator analyses
- Lithology
- TCE degradation rates
- Site water balance items (e.g., leaks from piping, above and below ground piping, building foundation gravel layers, etc.)
- Topics from the Site Management Plan
- 1,4-dioxane fate and transport
- Seismic primer
- PFAS screening assessment project summary

EPA discussed that PFAS is an area of interest for a future presentation.

13. Poll MWG Members/Open Discussion

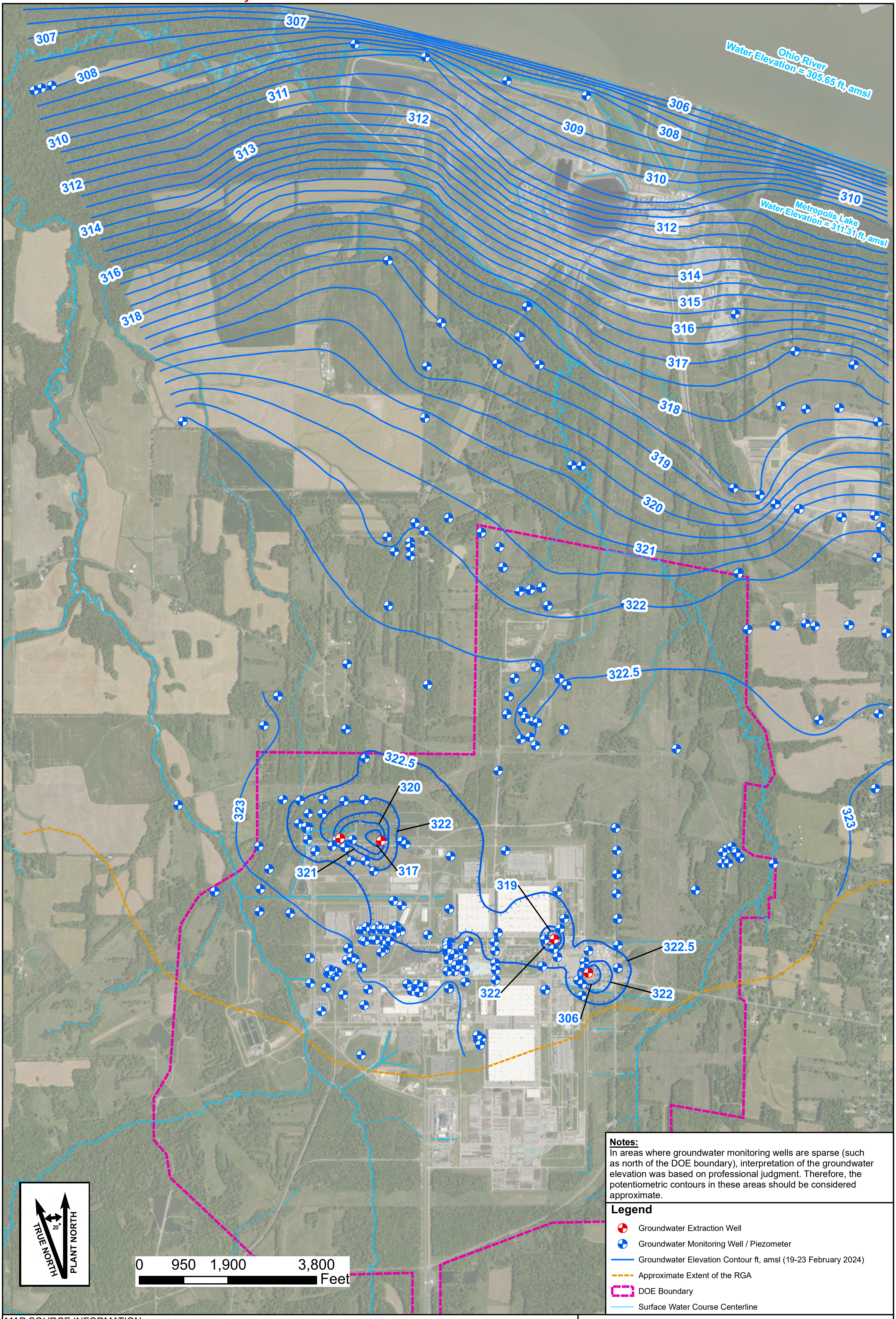
The group did not have additional questions or comments for the group.

Attachment 1

Groundwater Strategy Potentiometric Map
February 2024

Groundwater Elevation Data for TVA Wells
February 2024

DRAFT Work Product For Discussion Only



MAP SOURCE INFORMATION

Map Generation Date and Location - 4/24/2024 9:02 AM Geosyntec\\fedprojects-01\paducah$\Knoxville\GW Strategy\Monthly Groundwater Data Analysis\31 February 2024\Calculation Package
Map Layer Location: Geosyntec\\fedprojects-01\paducah$\2_GIS\APRX\Quarterly Synoptic Potentiometric Map\February 2024 Pot Map
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 and DOE boundary obtained from https://pegasis.pad.pppo.gov/, downloaded on 1/15/2024.
Northing and easting of wells obtained from Pegasis, downloaded on 6/14/2022.
Groundwater elevation was based on the 2/19/2024 - 2/24/2024 measurements obtained from FRNP on 3/12/2024. Depth to groundwater in extraction wells was measured on 2/19/2024 and was provided by FRNP on 3/13/2024.
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 2/19/2024 - 2/24/2024.
Groundwater elevation for the TVA wells were provided by the Kentucky Division of Waste Management letter to DOE (#KY8-890-008-982) dated 4/02/2024.
Water elevation at Metropolis Lake was provided by FRNP on 3/12/2024.
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 2024 RGA Potentiometric Surface Map

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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	372.77	369.38	760787.88	1946731.54	Active	65.2	75.2	307.57	297.57	318.42	54.35	2/21/2024_1043	29.66	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	318.22	54.33	2/21/2024_1045	29.66	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	318.25	51.01	2/21/2024_1047	29.66	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	318.17	48.73	2/21/2024_1049	29.66	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	321.64	51.18	2/21/2024_1040	29.66	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	318.43	56.51	2/21/2024_1053	29.66	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	308.26	23.90	2/21/2024_1116	29.65	TOC
TVA-D30B	SHF-D30B	2" PVC	Upper RGA	324.36	320.6	757594	1955563.41	Active	42.7	52.7	281.66	271.66	303.78	20.58	2/21/2024_1137	29.64	TOC
TVA-D17	SHF-D17	2" PVC	Upper RGA	365.43	362.8	758809.17	1950015.71	Active	14	17	351.43	348.43	315.64	49.79	2/21/2024_1107	29.65	TOC
TVA-D11B	SHF-D11B	2" PVC	Upper RGA	321.79	319.2	753434.76	1958481.44	Active	32	42	315.75	305.45	312.6	9.19	2/21/2024_1129	29.64	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	308.04	15.71	2/21/2024_0928	29.68	TOC
SHF-201B	SHF-201B	4" PVC	Upper RGA	323.75	320.2	746641.107	1960082.768	Active	32	37	291.75	286.75	307.82	15.93	2/21/2024_0927	29.68	TOC
SHF-201A	SHF-201A	4" PVC	Upper RGA	323.75	320	747030.226	1960036.252	Active	14.5	24.5	309.25	299.25	307.75	16	2/21/2024_0926	29.68	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	319.16	43.69	2/21/2024_0938	29.68	TOC
SHF-101G	SHF-101G	4" PVC	Upper RGA	322.43	318.8	754685.75	1957635.07	Active	32	37.3	290.43	285.13	310.53	11.9	2/21/2024_1125	29.64	TOC
Ohio River Elevation						831.9815	14996.63	Active						305.4	2/21/2024_1152	29.63	TVA Inlet

LEGEND:

TOC: Top of Casing

DTW: Depth to Water

National Geodetic Vertical Datum of 1929 (NGVD 29).

Note: The Top of Casing reference elevations shown herein will require correction.

Attachment 2

KRCEE Presentation

Continued Drone-Based Thermal Camera Proof-of-Concept for Little Bayou Creek Seeps

E. Glynn Beck
Kentucky Geological Survey
University of Kentucky

Flights conducted on
February 29 – March 1, 2024, and
March 6 – 7, 2024

DJI Matrice 300

DJI Zenmuse H20T

LBC Thermal Flights Summary

Flown on Feb. 29 and Mar. 1
15 flights

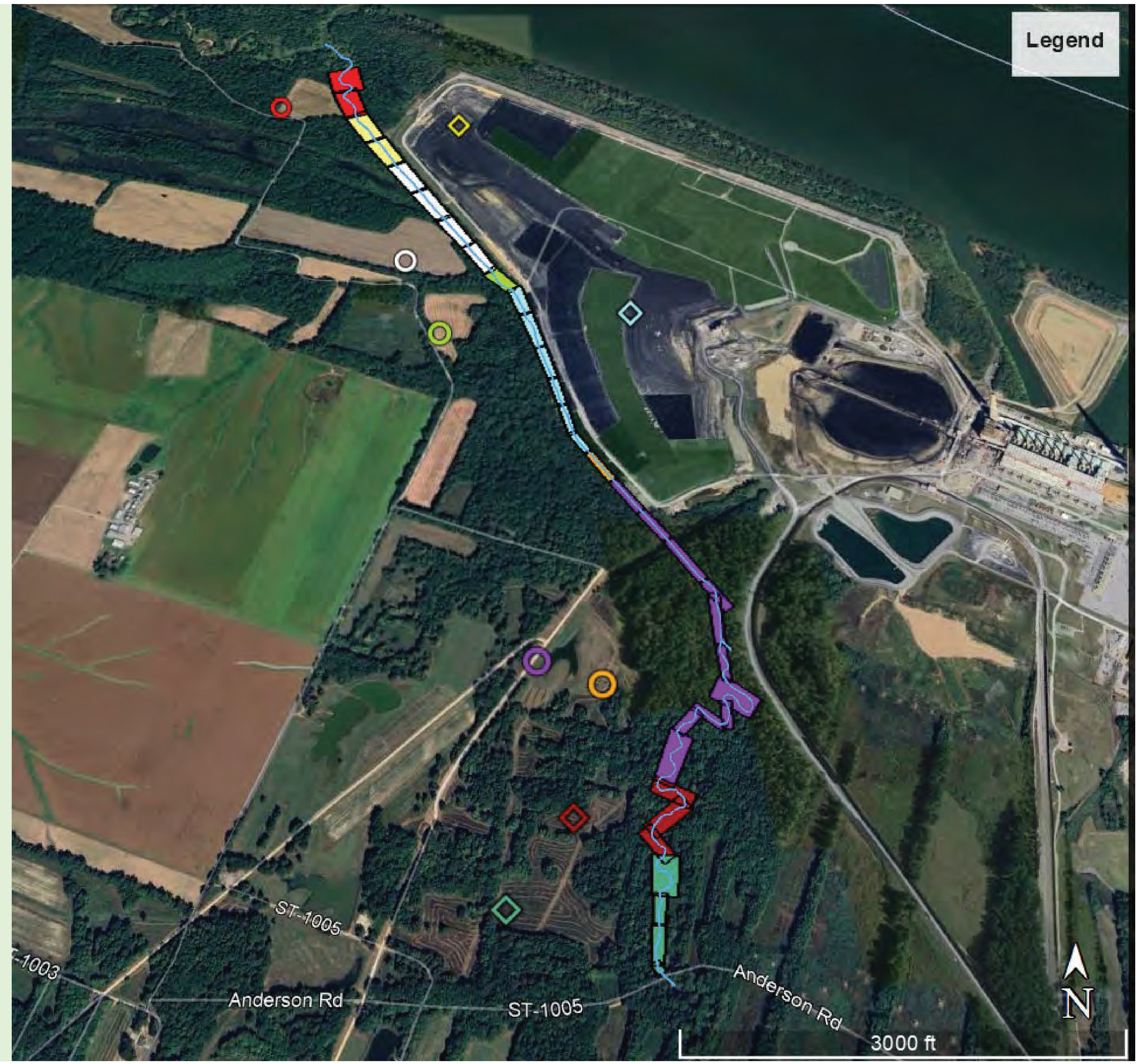
Air temperatures (F)
2/28: 74 – 29 (@ midnight)
2/29: 48 – 24
3/1: 45 – 37

LBC water temp (F)
2/28: 55.5
2/29-3/1: I forgot my thermometer

Flown on Mar. 6 and Mar. 7
19 flights

Air temperatures (F)
3/5: 75 – 58
3/6: 62 – 51
3/7: 60 – 49

LBC water temp (F)
3/6 and 3/7: 58.6 and 58



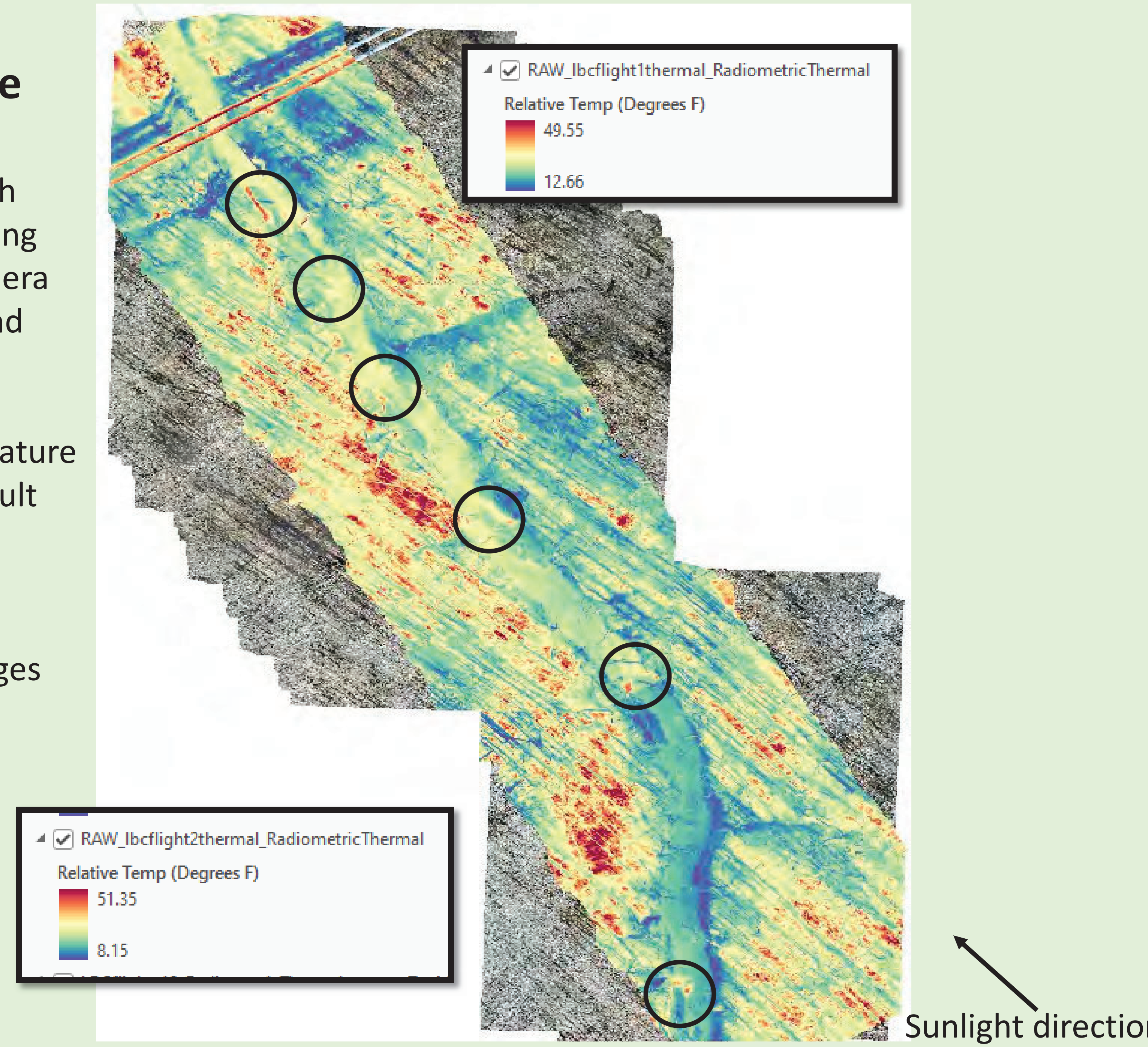
Relative vs absolute temperature

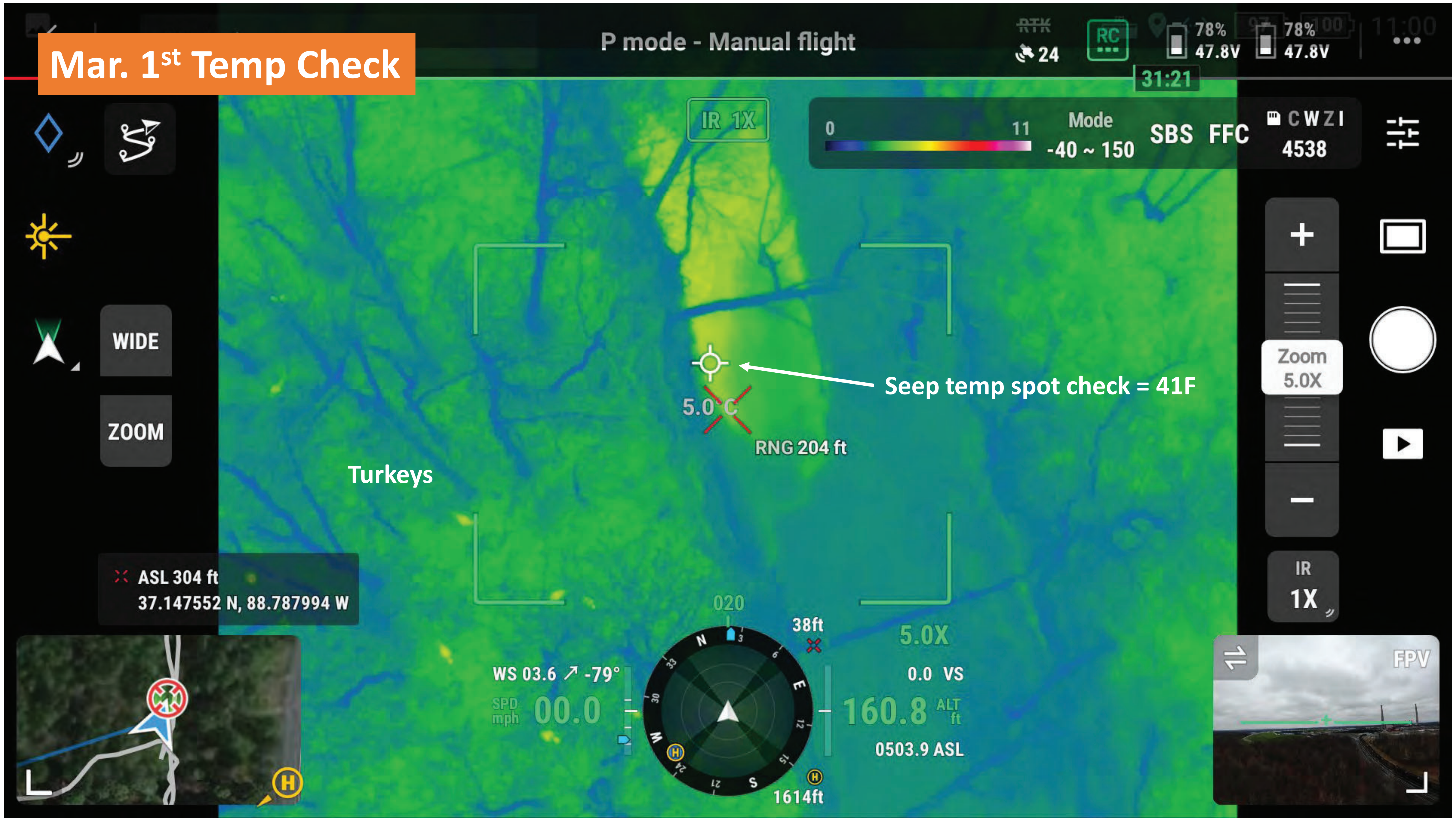
A drone-based thermal camera senses how much heat radiates from an object and from surrounding objects. The largest input for a drone-based camera can be the background radiation from the sky and ambient air temperature.

These "outside" influences can skew the temperature measured by the thermal camera, which can result in a "relative temperature" range and not an absolute temperature range.

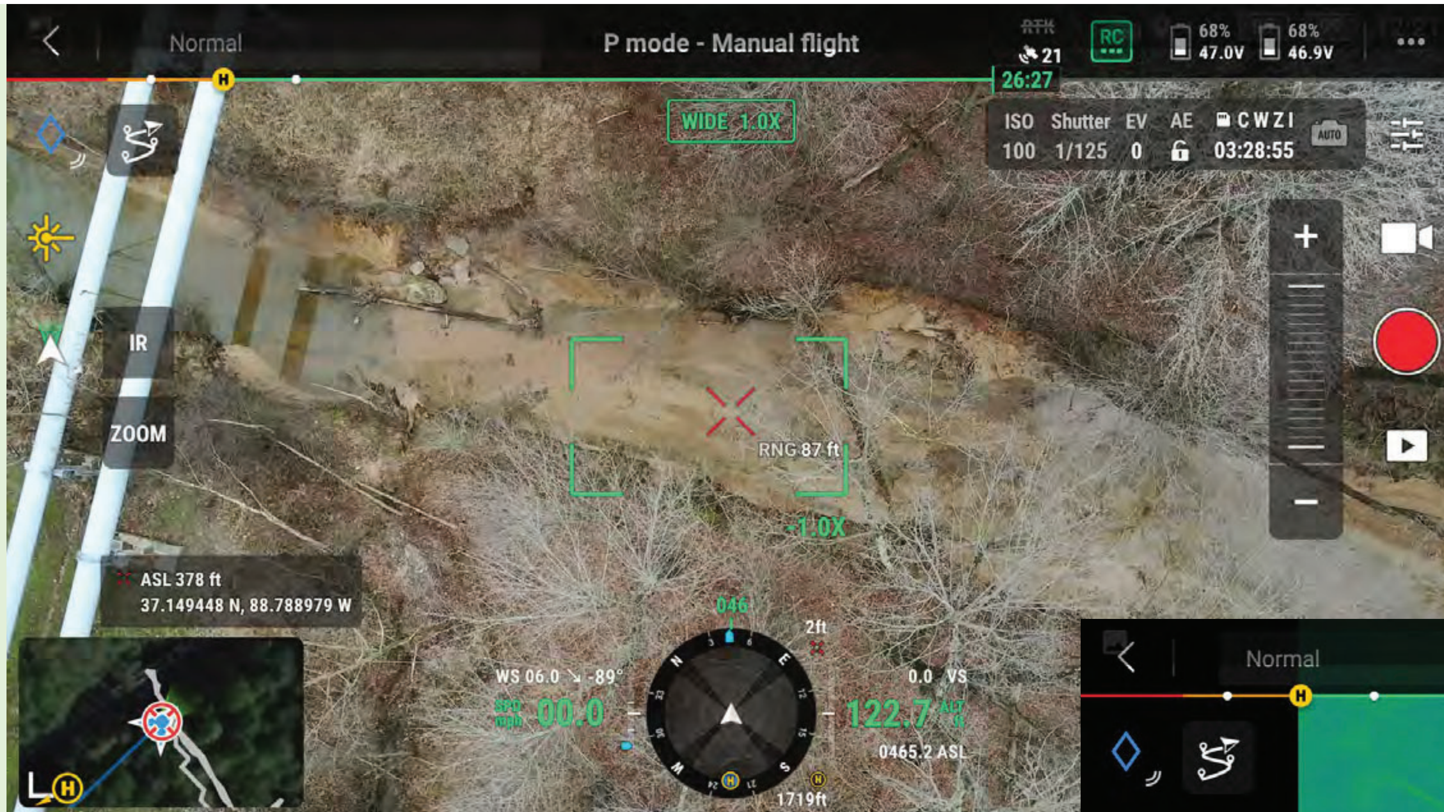
Relative temp scales to the right show temp ranges below freezing, which are not equivalent to absolute temps.

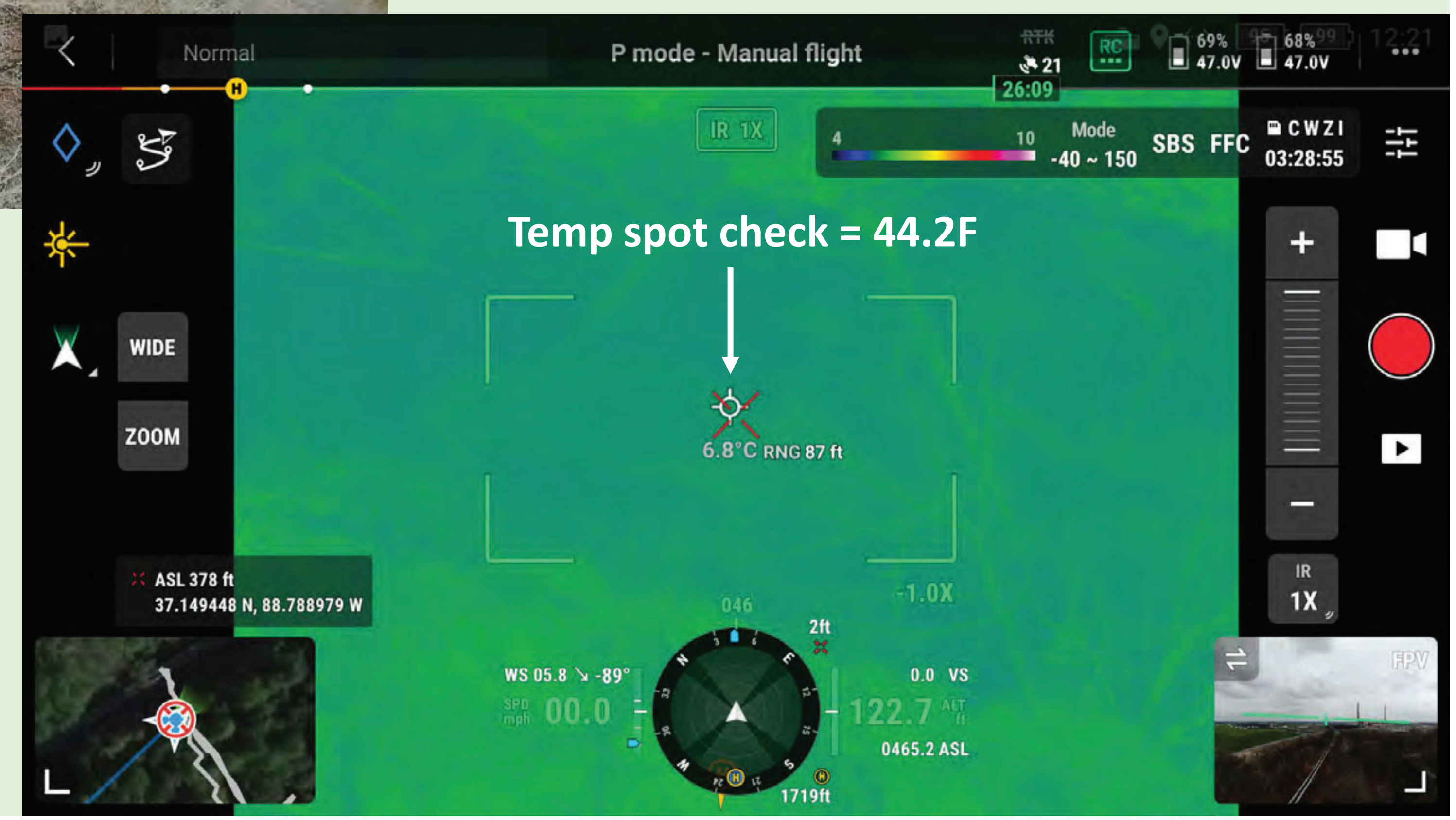
Hot spots along Little Bayou Creek were seen.
Winter = hot/warm spots
Summer = cold/cool spots




Mar. 1st Temp Check
P mode - Manual flight
RTK
24
RC
78%
47.8V
78%
47.8V
31:21
IR 1X
0
11
Mode
-40 ~ 150
SBS
FFC
C W Z I
4538
WIDE
ZOOM
Zoom
5.0X
5.0°C
RNG 204 ft
Seep temp spot check = 41F
Turkeys
ASL 304 ft
37.147552 N, 88.787994 W
IR
1X
020
38ft
5.0X
WS 03.6 ↗ -79°
SPD mph
00.0
0.0 VS
160.8 ALT ft
0503.9 ASL
1614ft
FPV

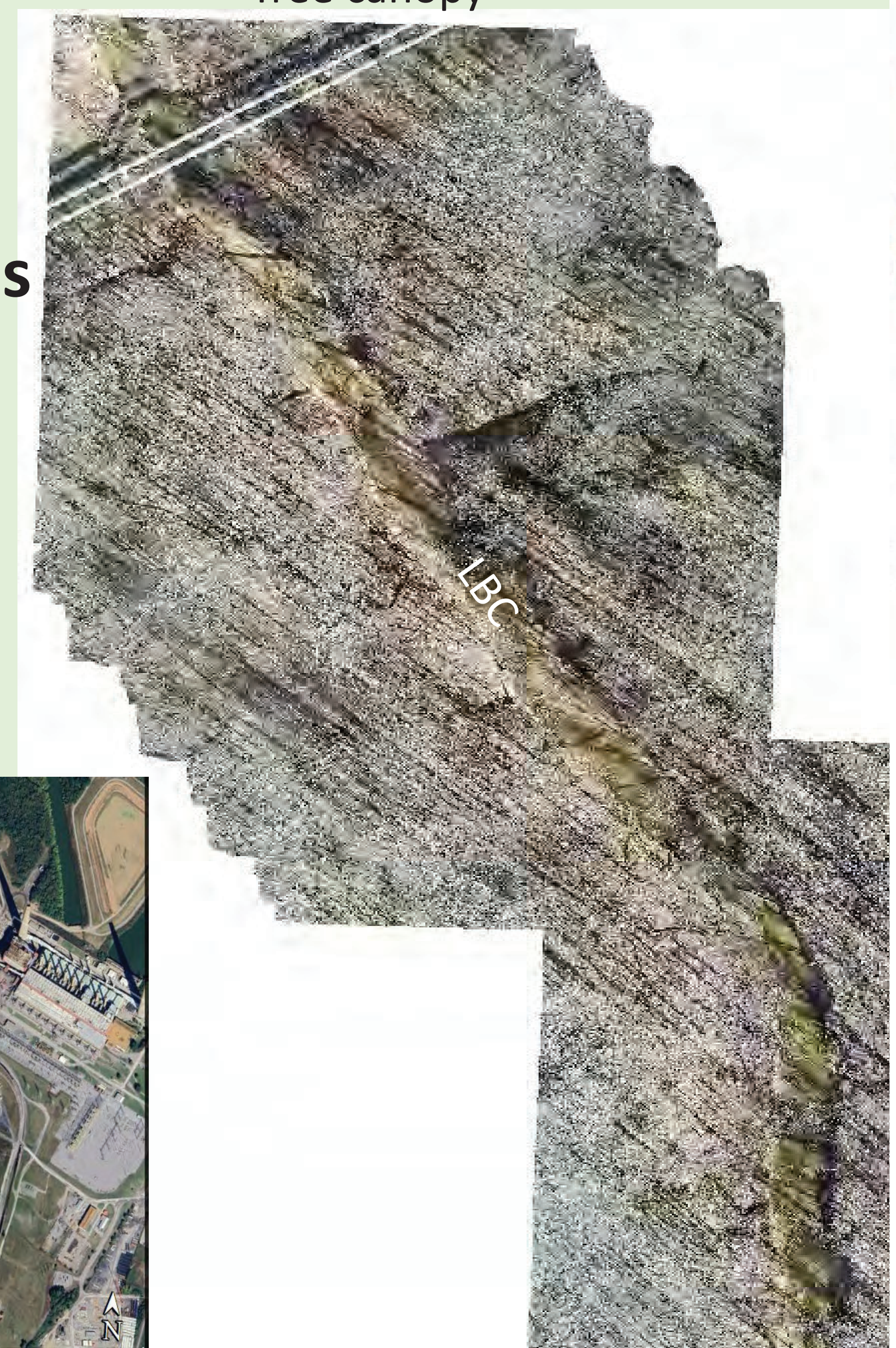
Mar. 7th Temp Check

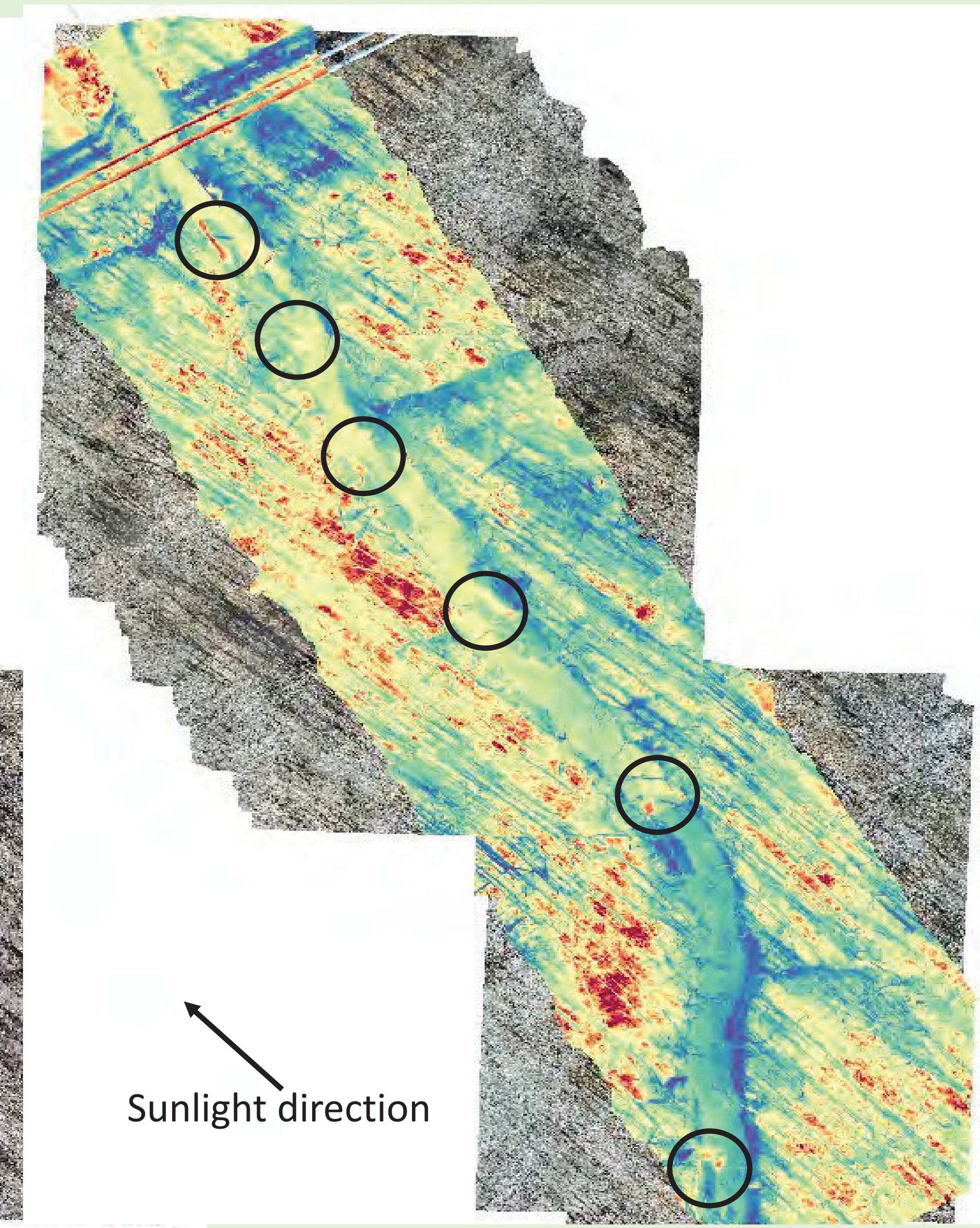


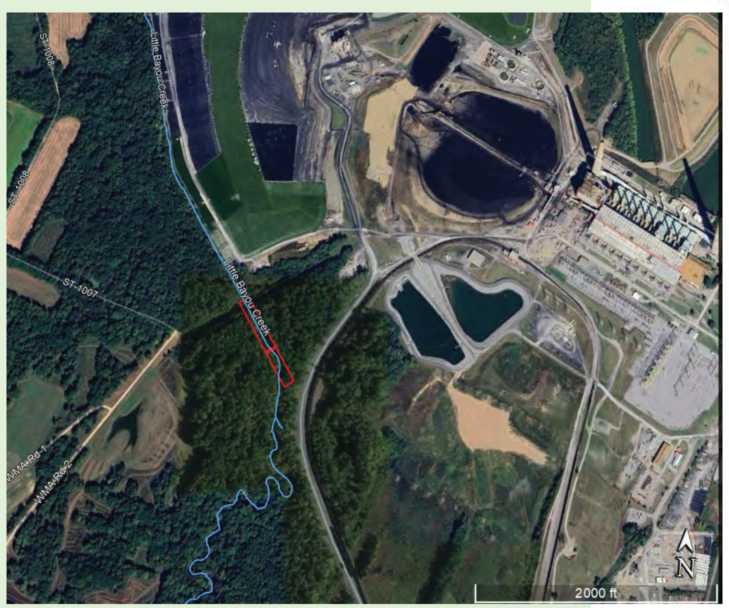


Examples of Results from the Feb. 29th Flights

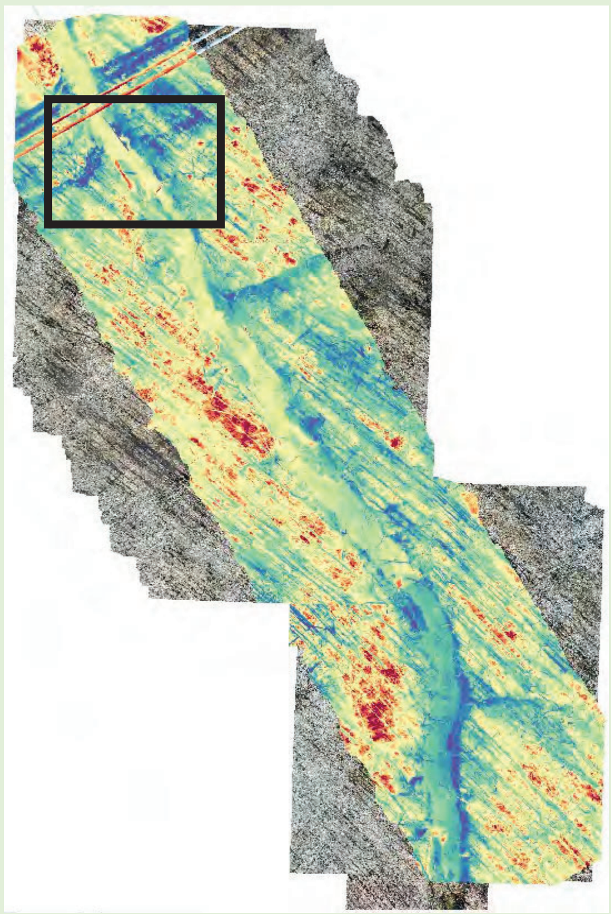
Examples of Results from the Feb. 29th Flights



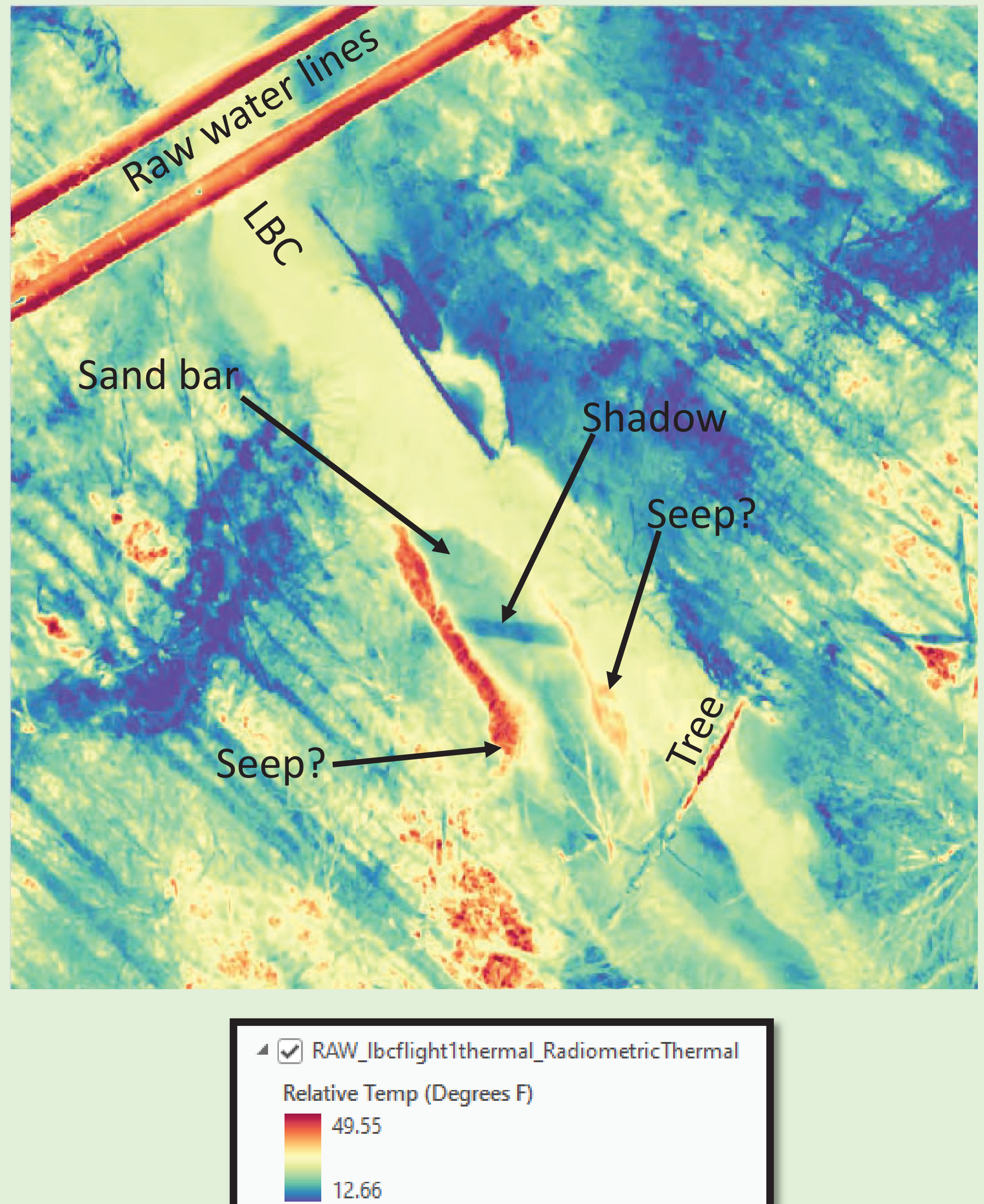


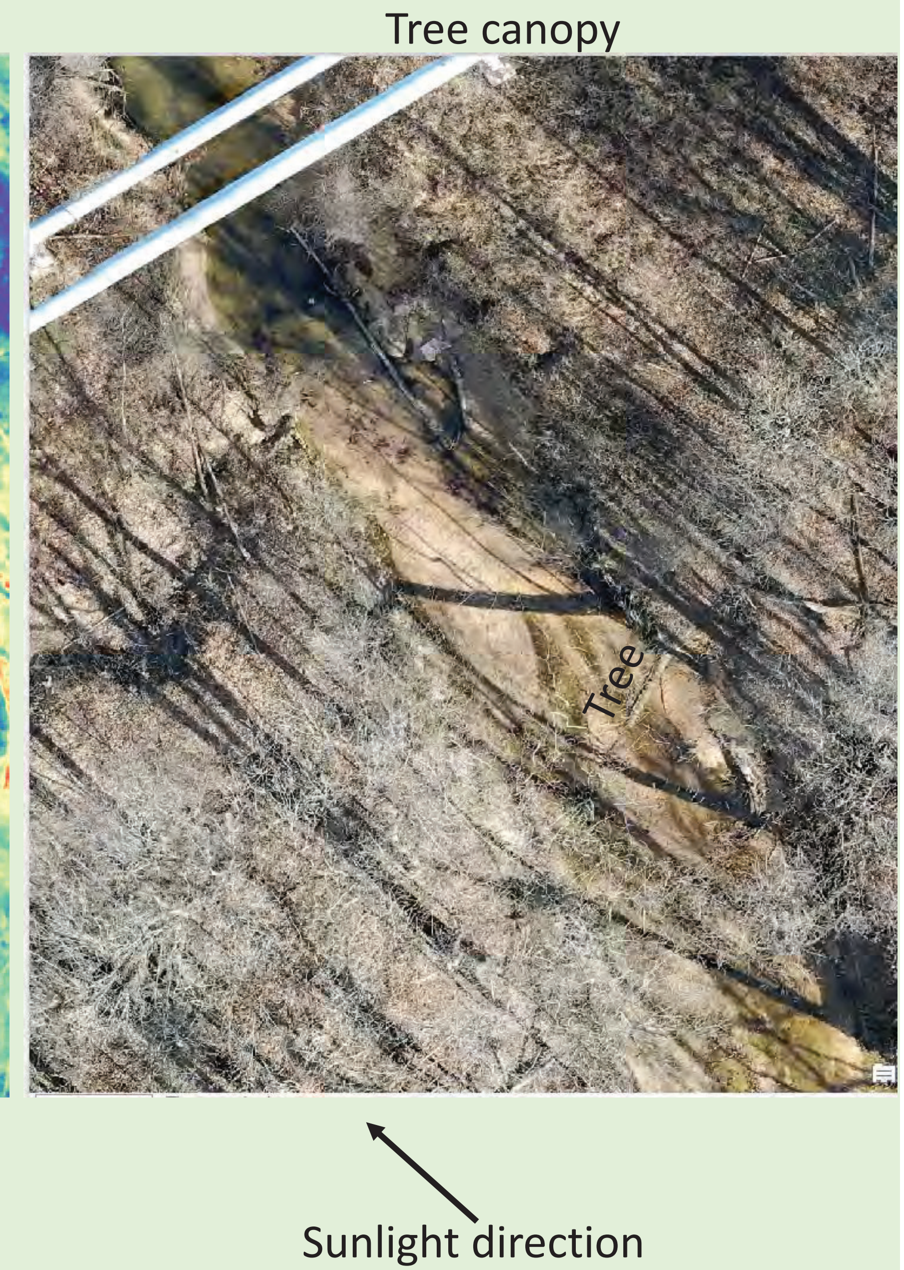


Feb. 29th Example 1

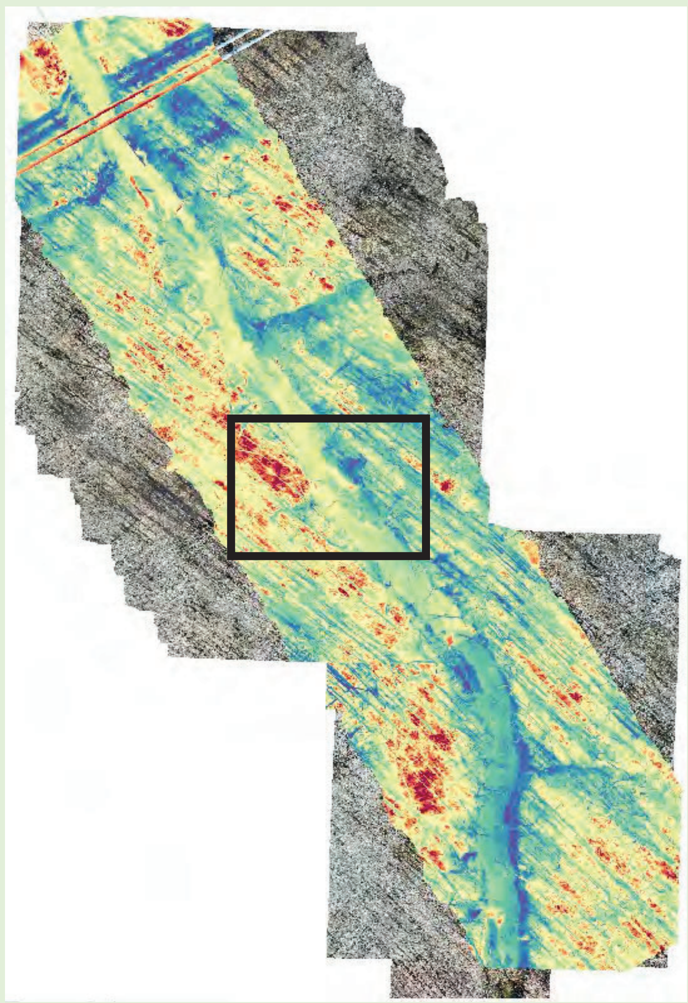


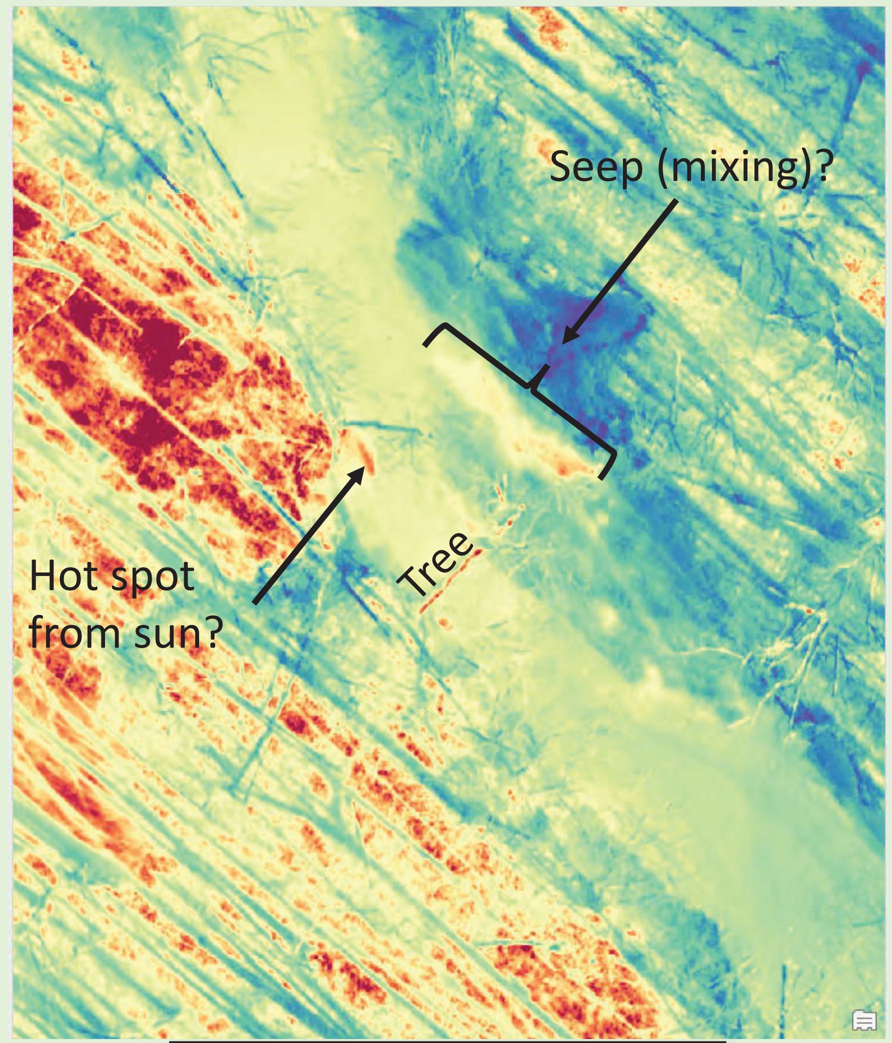
Time of flight: 9:09am
Air temp: 34F
Altitude: 60m





Feb. 29th Example 2





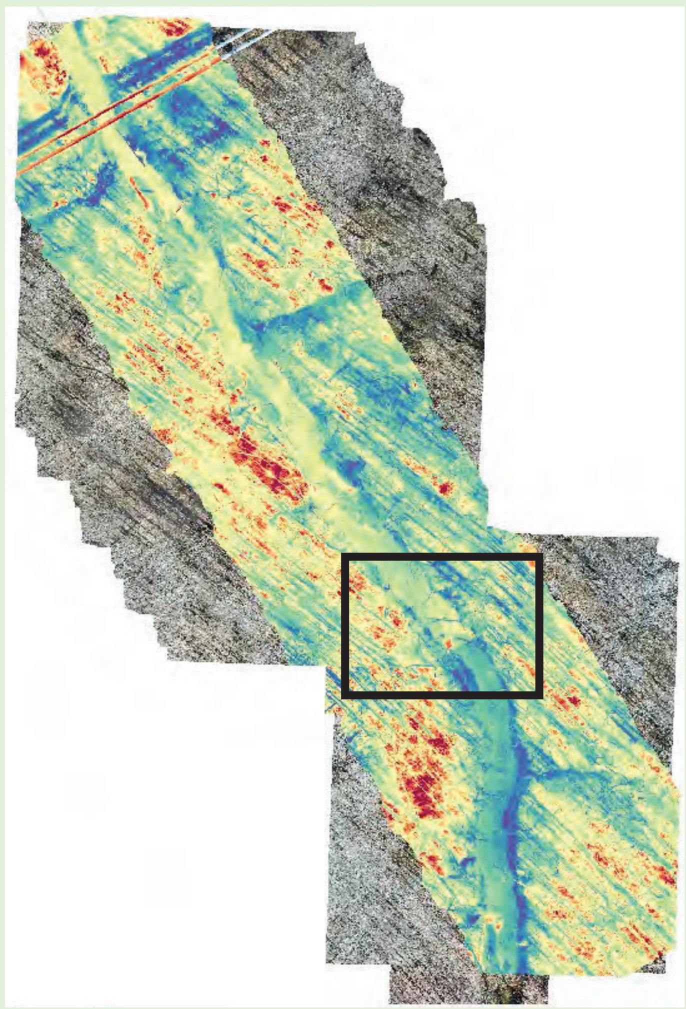
RAW_lbcflight2thermal_RadiometricThermal
Relative Temp (Degrees F)
51.35
8.15

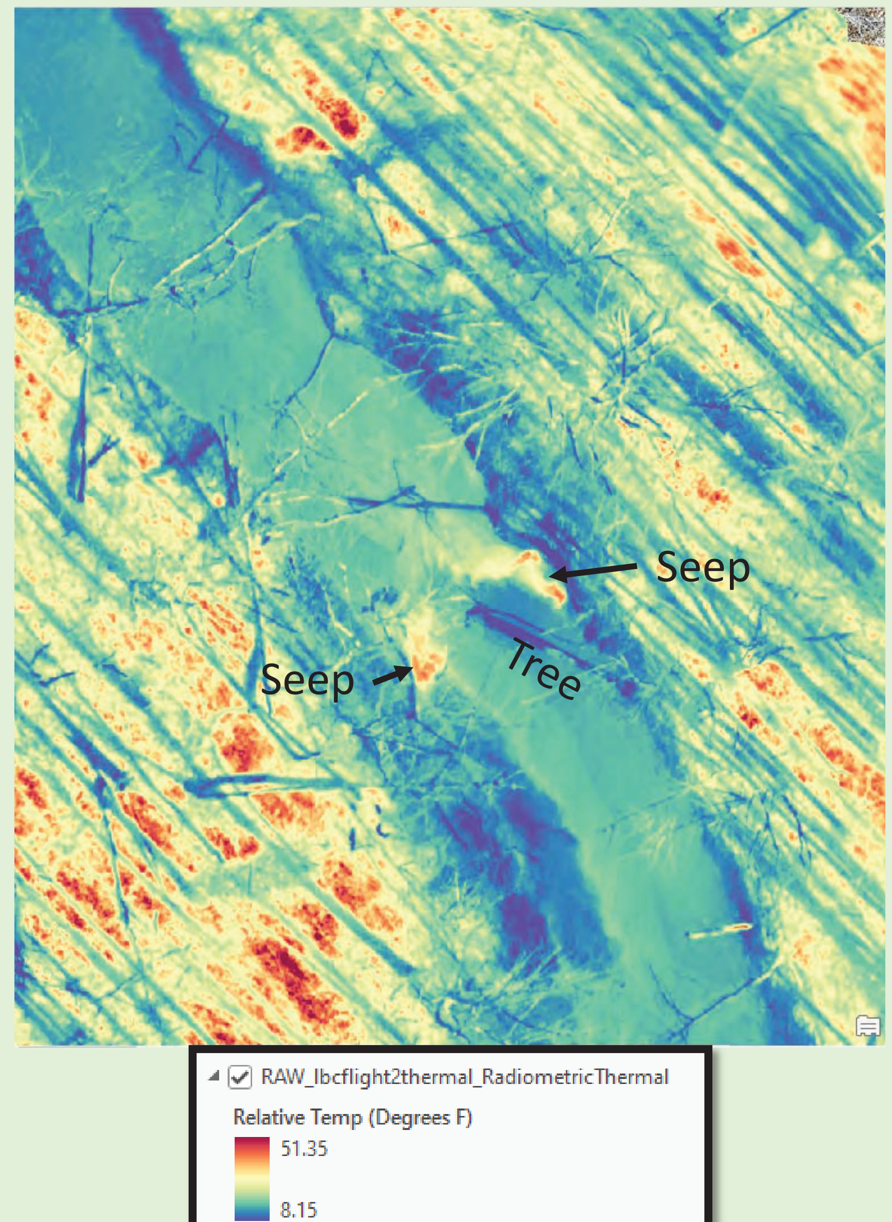
Tree canopy

Sunlight direction

Time of flight: 9:09am
Air temp: 34F
Altitude: 60m

Feb. 29th Example 3



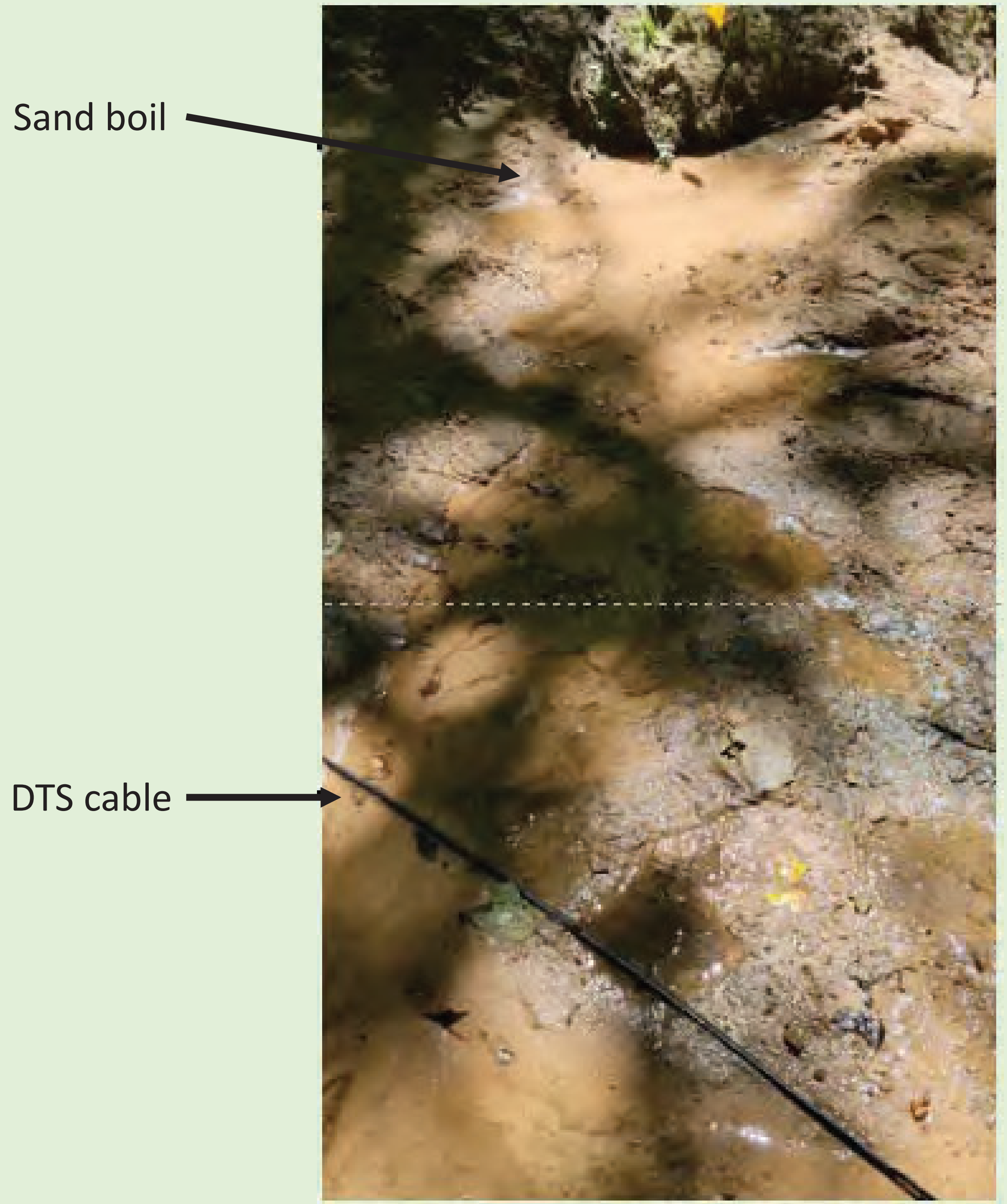


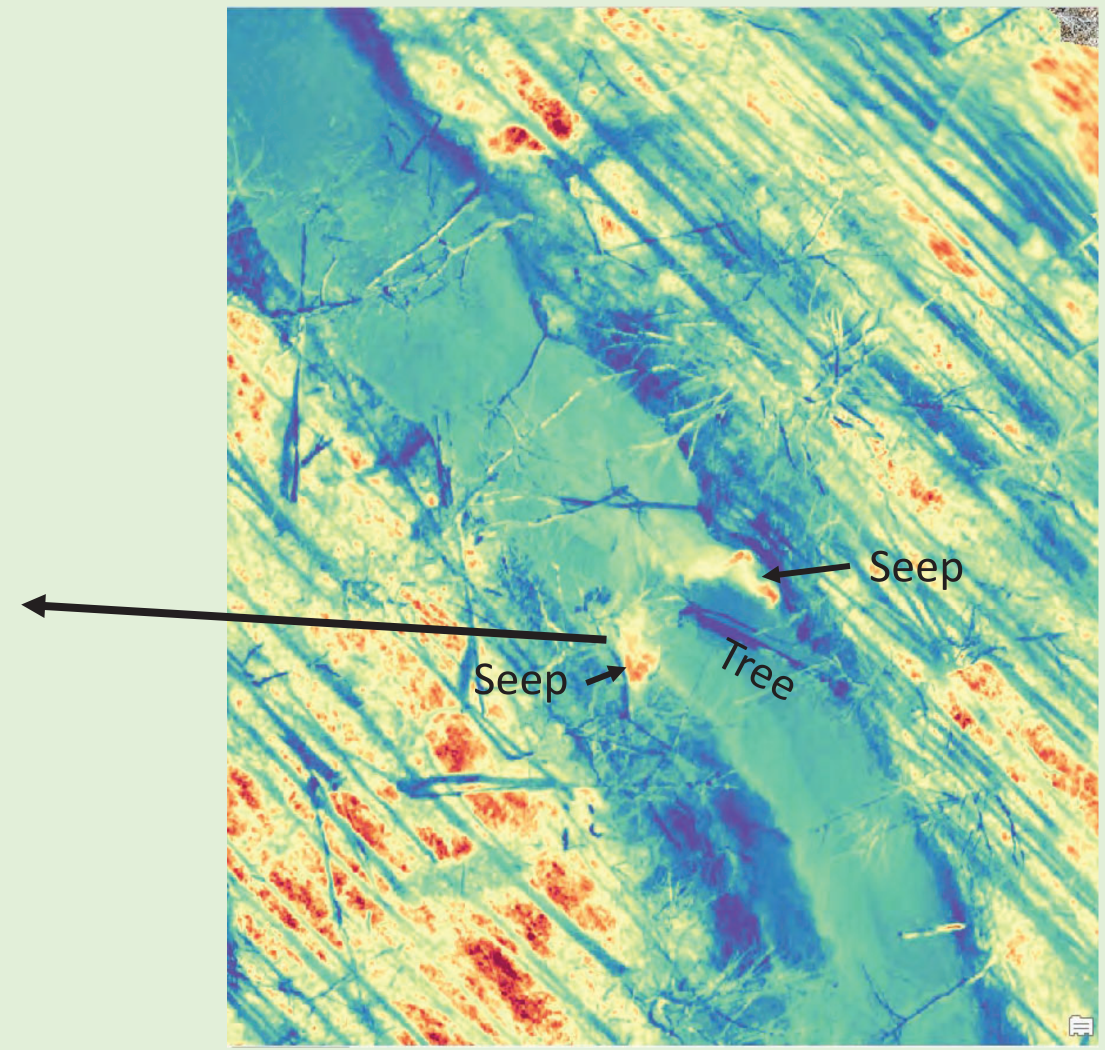
Tree canopy

Sunlight direction

Time of flight: 9:33am
Air temp: 35F
Altitude: 60m

Seep 5

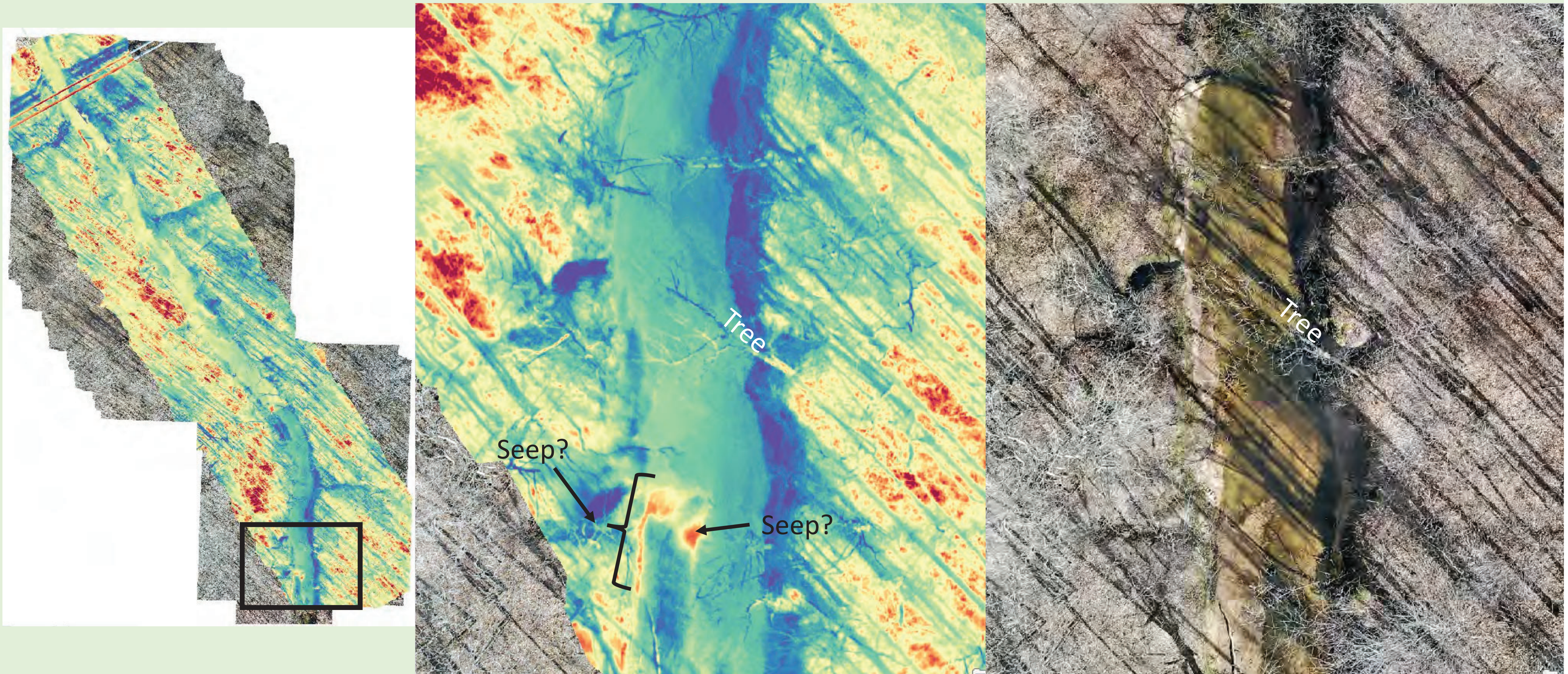


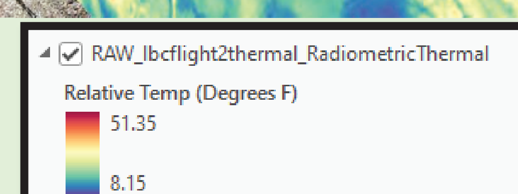


See Video Clip

Feb. 29th Example 4

Tree canopy





Sunlight direction

Time of flight: 9:33am
Air temp: 35F
Altitude: 60m

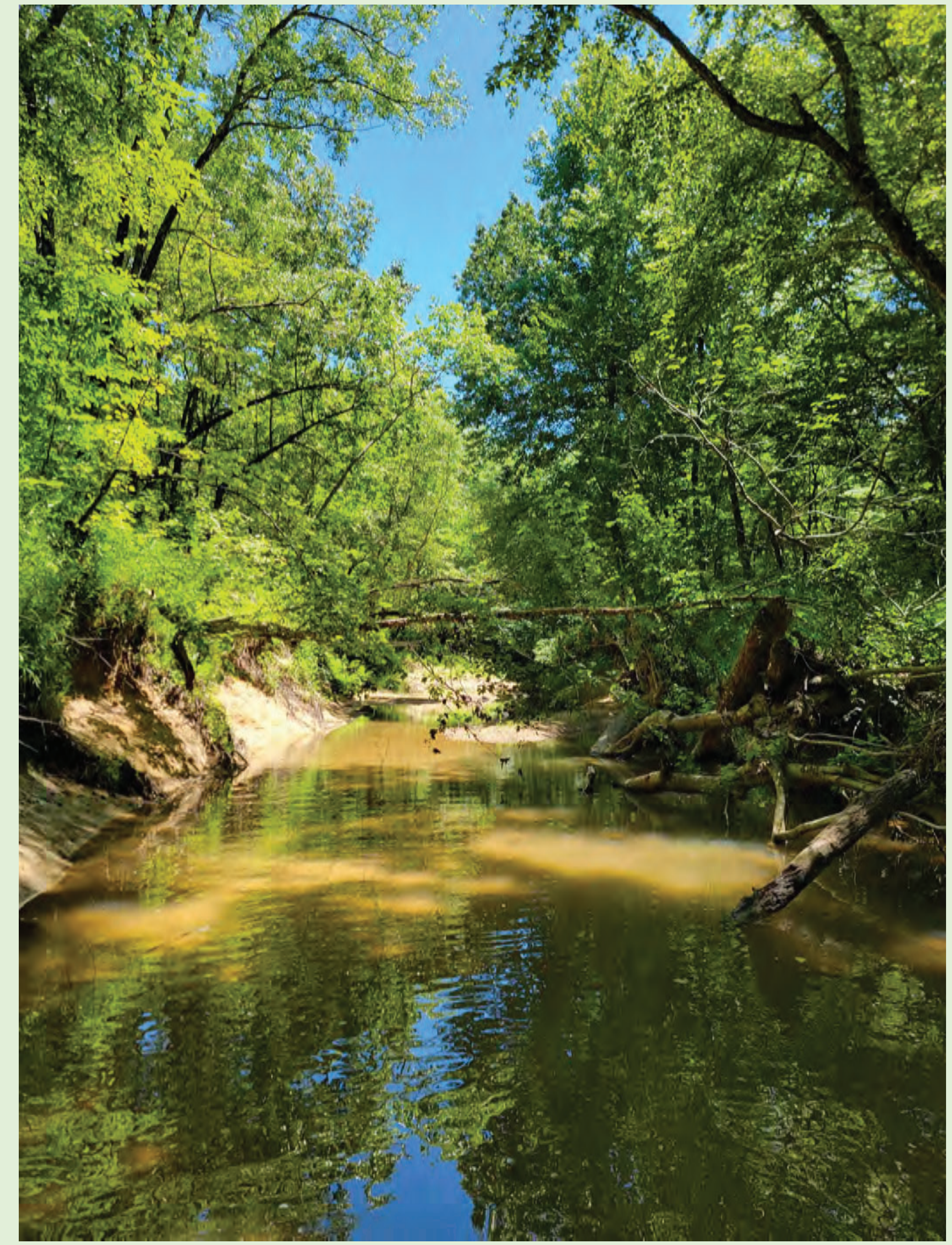
Planned August Flights

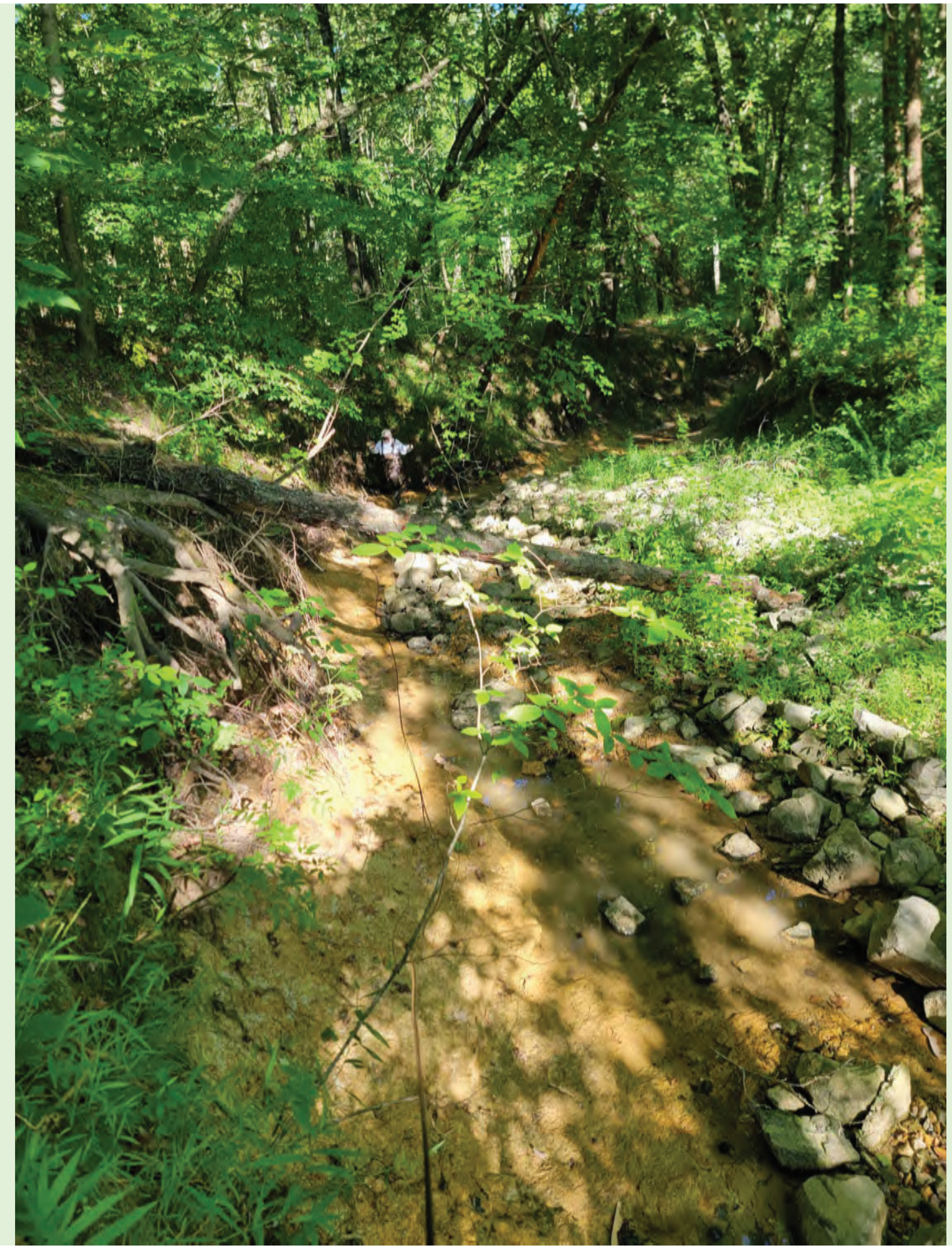
- Fly Little Bayou Creek above the canopy with full leaf on (Anderson Road to near the confluence of Bayou Creek). Equipment will include the Matrice 300 drone and the H20T camera.

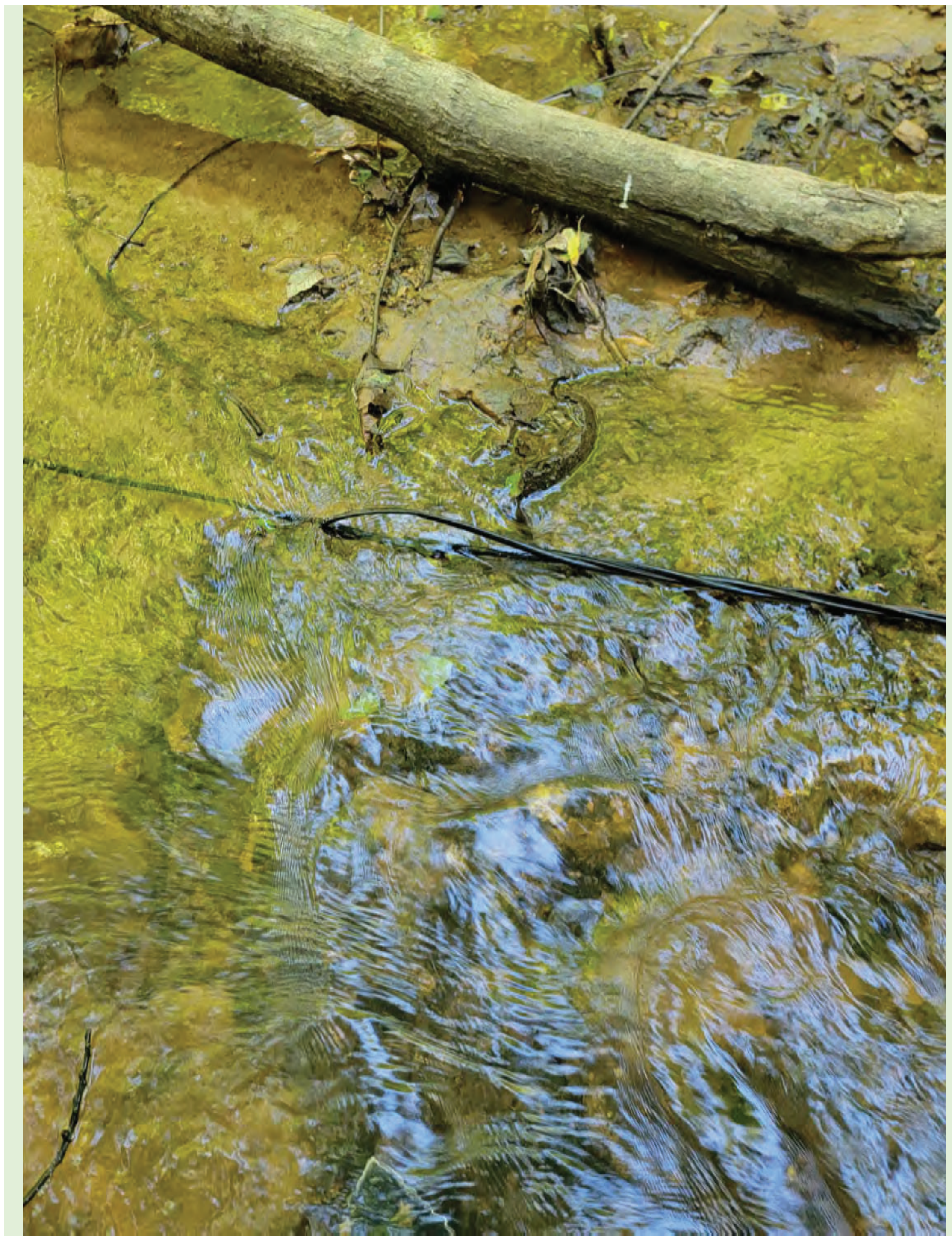
- Fly Little Bayou Creek below the canopy (as much as possible from Anderson Road to near the confluence of Bayou Creek). Equipment will include the DJI M3T drone and thermal camera.

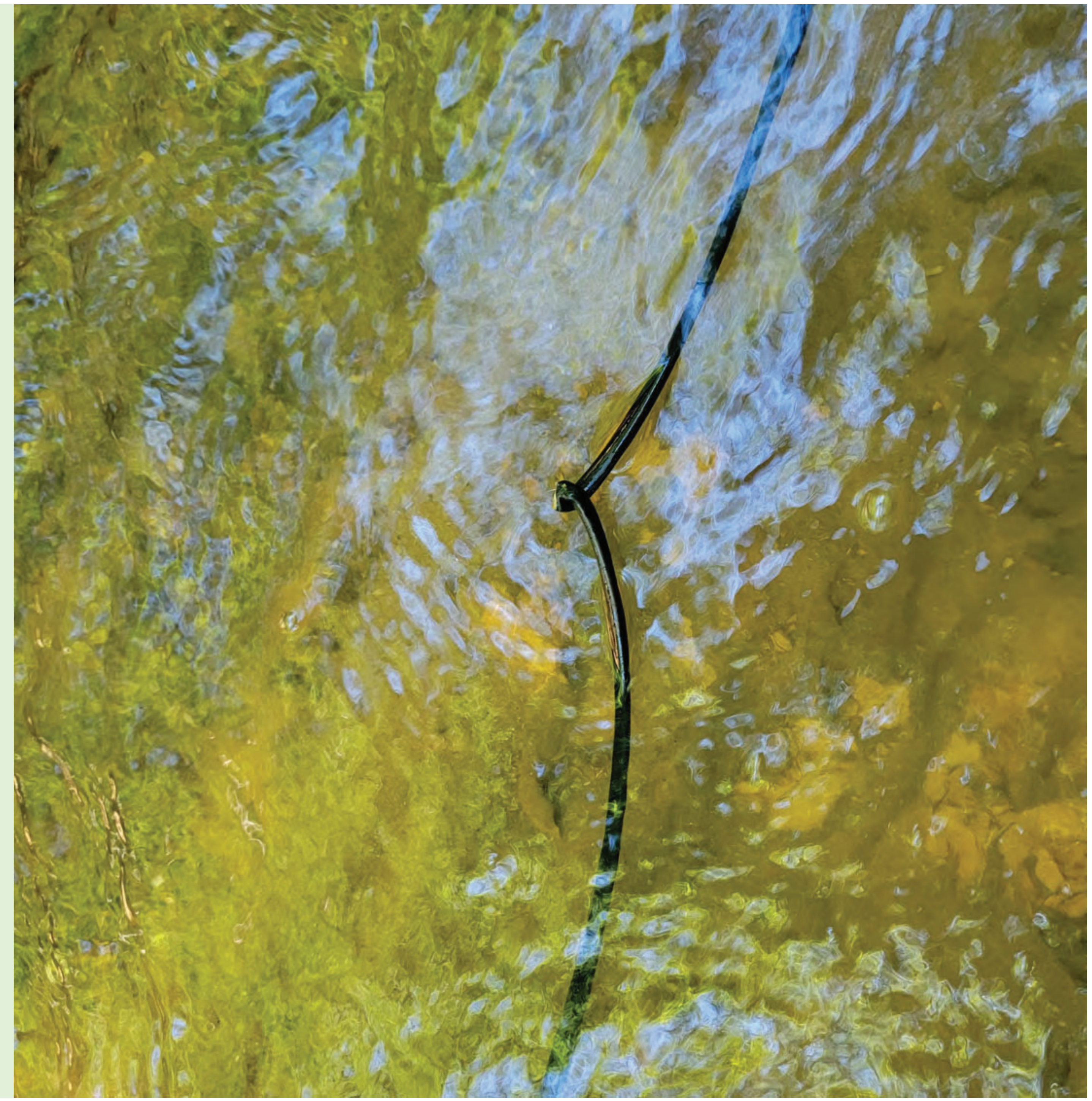
<u>Challenges to flying below the canopy</u>

Steep/vertical and tall (> 6ft) banks
Leaning and fallen trees
Hanging limbs/vines
Deep water (> 3ft)
Fairly narrow channel (< 30ft)
Drone launch and land locations in channel









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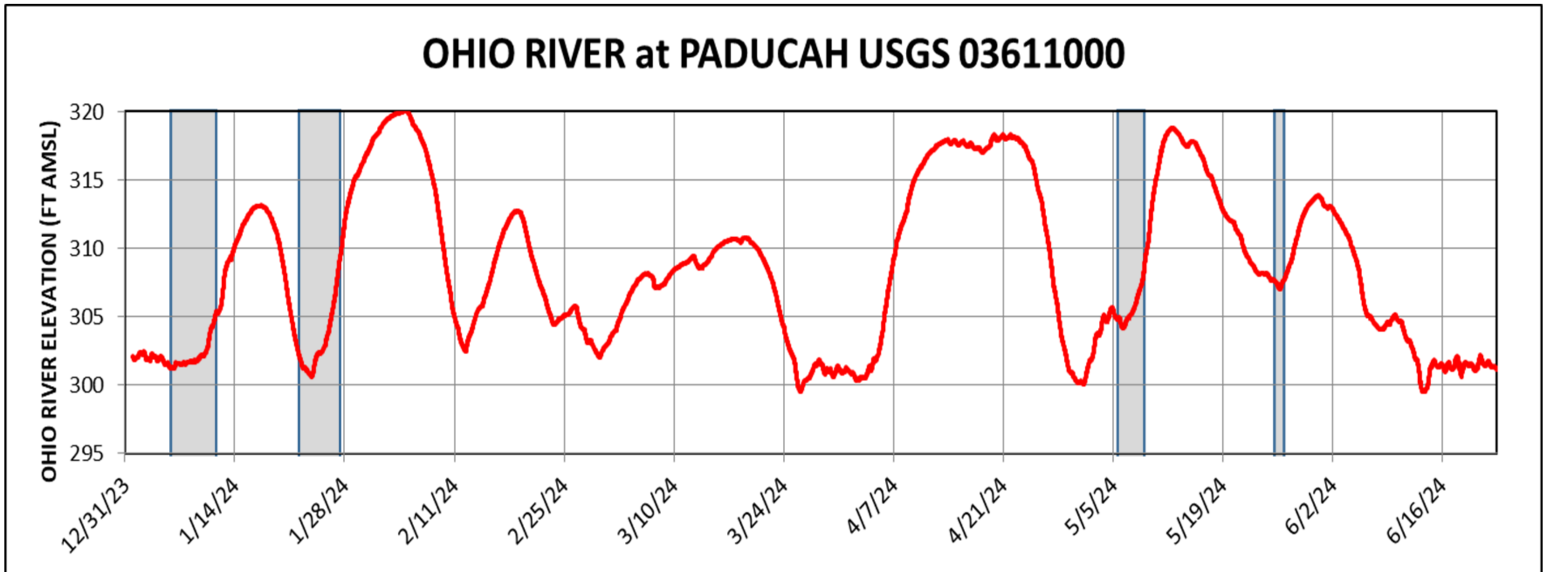
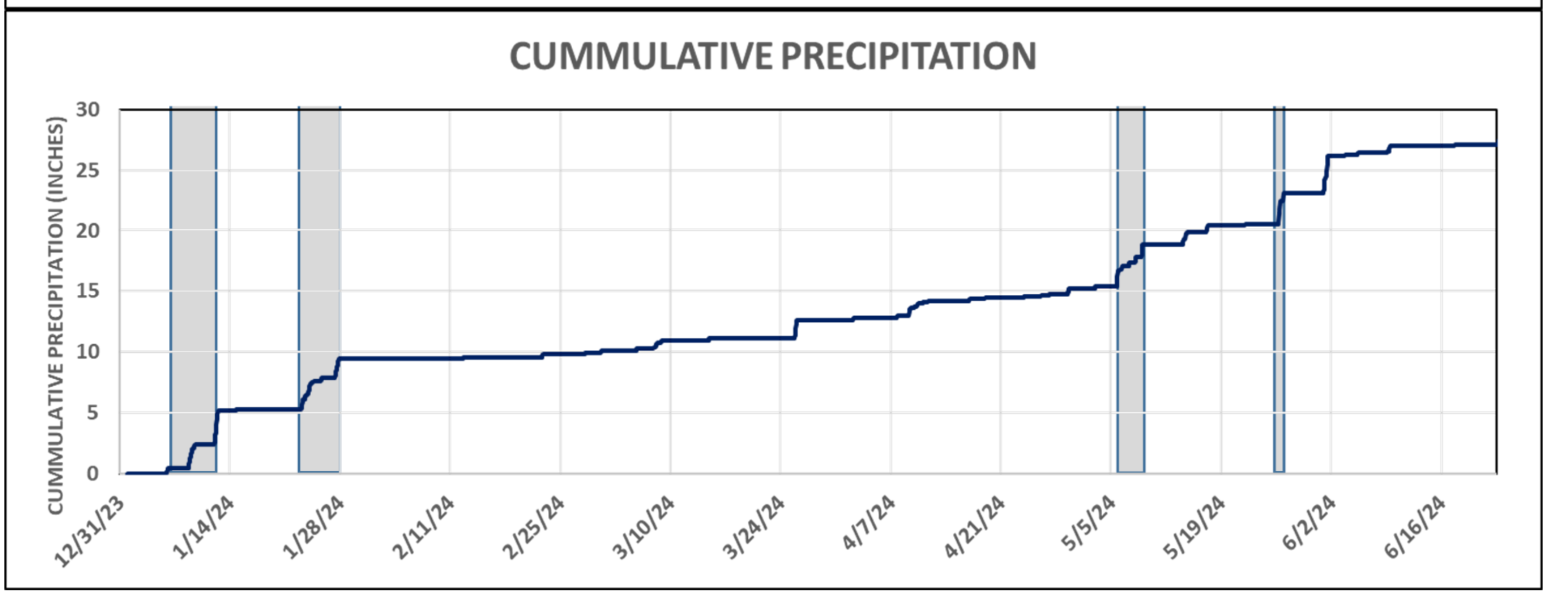
Attachment 3

Precipitation and Ohio River Stage Data


OHIO RIVER at PADUCAH USGS 03611000
OHIO RIVER ELEVATION (FT AMSL)
320
315
310
305
300
295
12/31/23
1/14/24
1/28/24
2/11/24
2/25/24
3/10/24
3/24/24
4/7/24
4/21/24
5/5/24
5/19/24
6/2/24
6/16/24


CUMMULATIVE PRECIPITATION
CUMMULATIVE PRECIPITATION (INCHES)
30
25
20
15
10
5
0
12/31/23
1/14/24
1/28/24
2/11/24
2/25/24
3/10/24
3/24/24
4/7/24
4/21/24
5/5/24
5/19/24
6/2/24
6/16/24

APPENDIX E

POTENTIOMETRIC MAPS

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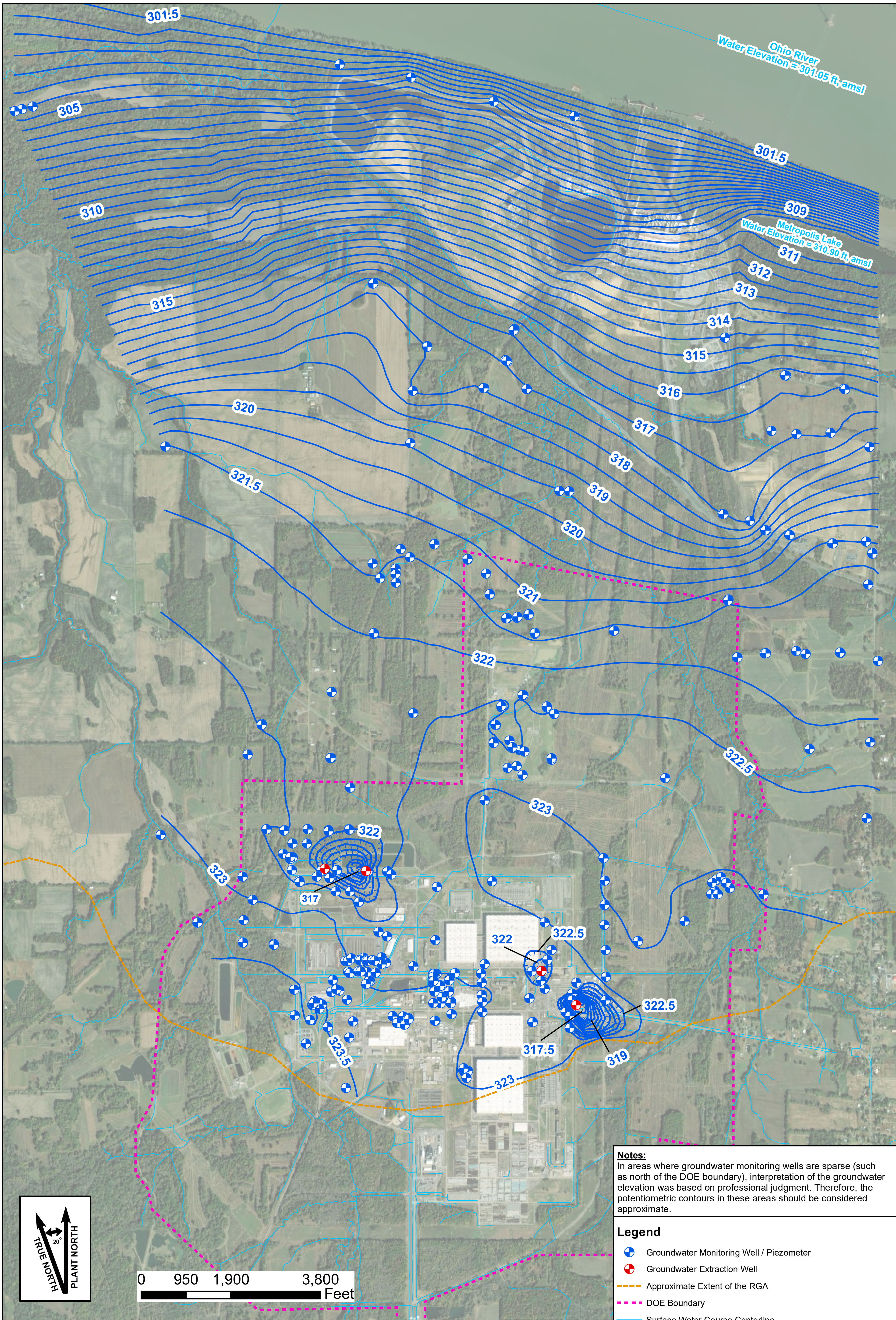

MAP SOURCE INFORMATION

Map Generation Date and Location - 01/16/2024 Geosyntec\\fedprojects-01\paducah$\Knoxville\GW Strategy\GIS\MXDs\2022-2023 Potentiometric Surface Maps
Map Layer Location: Geosyntec\\fedprojects-01\paducah$\Knoxville\GW Strategy\GIS\MXDs\2022-2023 Potentiometric Surface Maps\November 2023 Potentiometric Surface Map.mxd
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 provided by FRNP on 11/8/2022.
DOE Property Boundary provided by FRNP on 2/4/2021.
Northing and easting of wells obtained from Pegasis, downloaded on 6/14/2022.
Groundwater elevation was based on the 11/13/2023 - 11/17/2023 measurements. Groundwater elevation of extraction wells was measured on 11/13/2023 and was provided by FRNP on 11/29/2023.
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 11/13/2023 - 11/17/2023.
Groundwater elevation for the TVA wells were provided by the Kentucky Division of Waste Management letter to DOE (#KY8-890-008-982) dated 12/04/2023. Water elevation at Metropolis Lake was provided by FRNP on 11/20/2023.
amsl = above mean sea level

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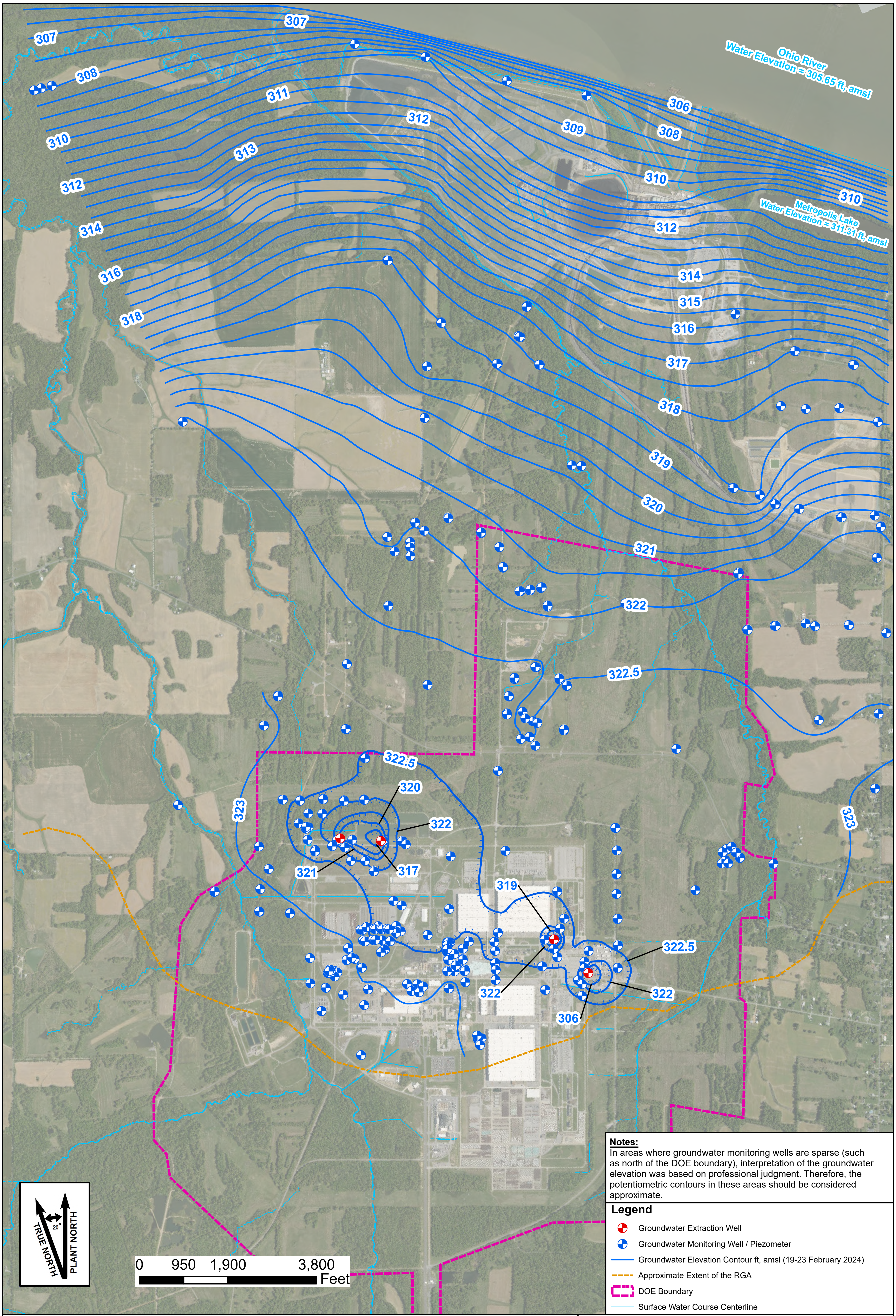
PADUCAH GASEOUS DIFFUSION PLANT

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

Figure E.1. November 2023 RGA Potentiometric Surface Map



MAP SOURCE INFORMATION

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Map Layer Location: Geosyntec\\fedprojects-01\paducah$\2_GIS\APRX\Quarterly Synoptic Potentiometric Map\February 2024 Pot Map
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 and DOE boundary obtained from https://pegasis.pad.pppo.gov/, downloaded on 1/15/2024.
Northing and easting of wells obtained from Pegasis, downloaded on 6/14/2022.
Groundwater elevation was based on the 2/19/2024 - 2/24/2024 measurements obtained from FRNP on 3/12/2024. Depth to groundwater in extraction wells was measured on 2/19/2024 and was provided by FRNP on 3/13/2024.
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 2/19/2024 - 2/24/2024.
Groundwater elevation for the TVA wells were provided by the Kentucky Division of Waste Management letter to DOE (#KY8-890-008-982) dated 4/02/2024.
Water elevation at Metropolis Lake was provided by FRNP on 3/12/2024.
amsl = above mean sea level

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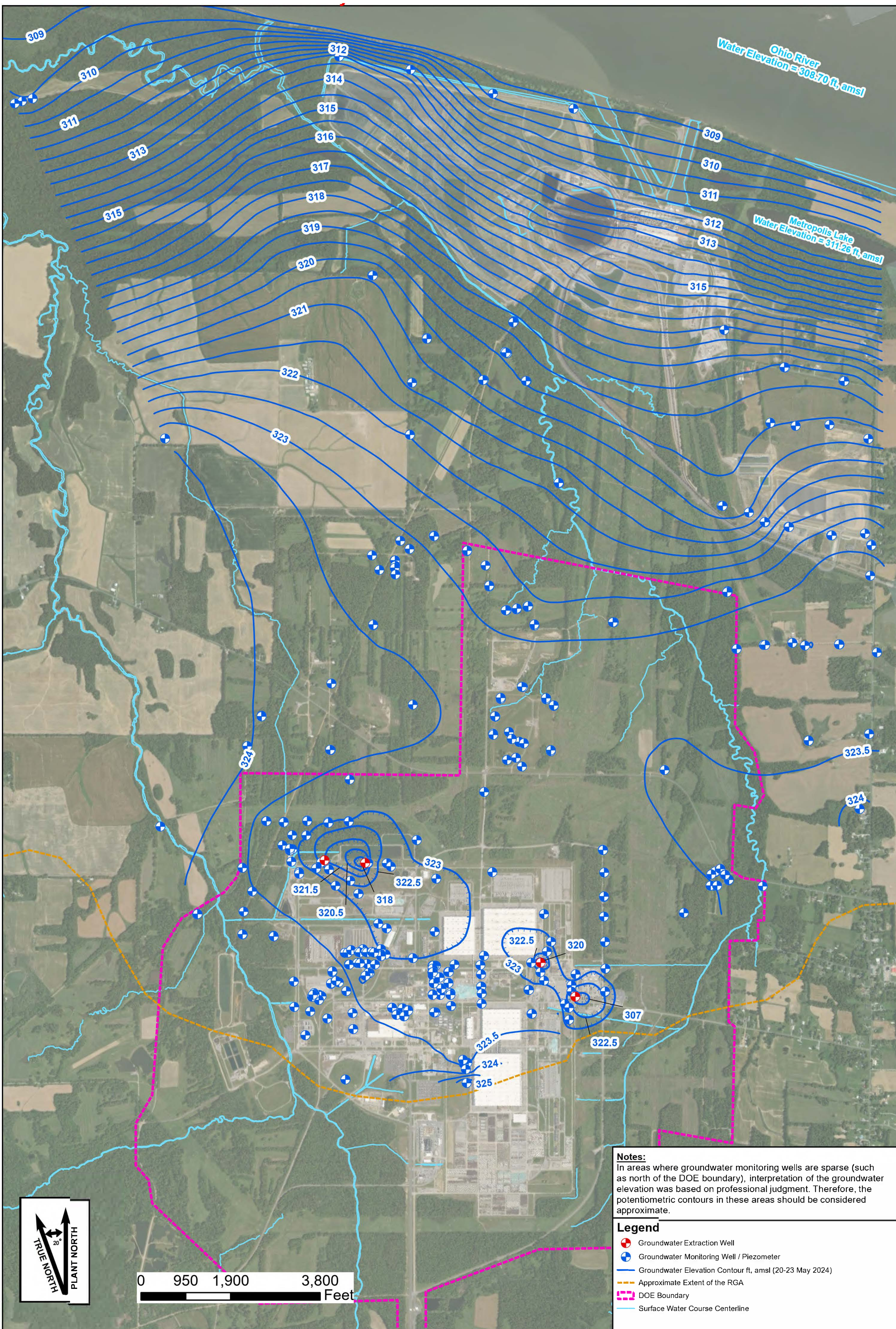
Figure E.2. February 2024 RGA Potentiometric Surface Map



Map Source Information
Map Generation Date and Location - 07/10/2024 Geosyntec\\fedprojects-01\paducah$\2_GIS\APRX\Quarterly Synoptic Potentiometric Map\May2024_PotentiometricMap
Map Layer Location: Geosyntec\\fedprojects-01\paducah$\2_GIS\APRX\Quarterly Potentiometric Map\May2024_PotentiometricMap\May2024_PotentiometricMap.aprx
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 and DOE Property Boundary were obtained from Pegasis (https://pegasis.pad.pppo.gov/), verified 06/27/2024
Northing and easting of wells obtained from FRNP on 04/25/2024, verified 06/27/24
Groundwater elevation was based on the 05/20/2024 - 05/23/2024 measurements obtained from FRNP on 06/24/2024. Depth to groundwater in extraction wells was measured on 05/20/2024 and was provided by FRNP on 06/24/2024.
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 05/20/2024 - 05/23/2024.
Groundwater elevation for the TVA wells were provided by the Kentucky Division of Waste Management letter to DOE (#KY8-890-008-982) dated 06/07/2024.
Water elevation at Metropolis Lake was provided by FRNP on 06/24/2024.
amsl = above mean sea level

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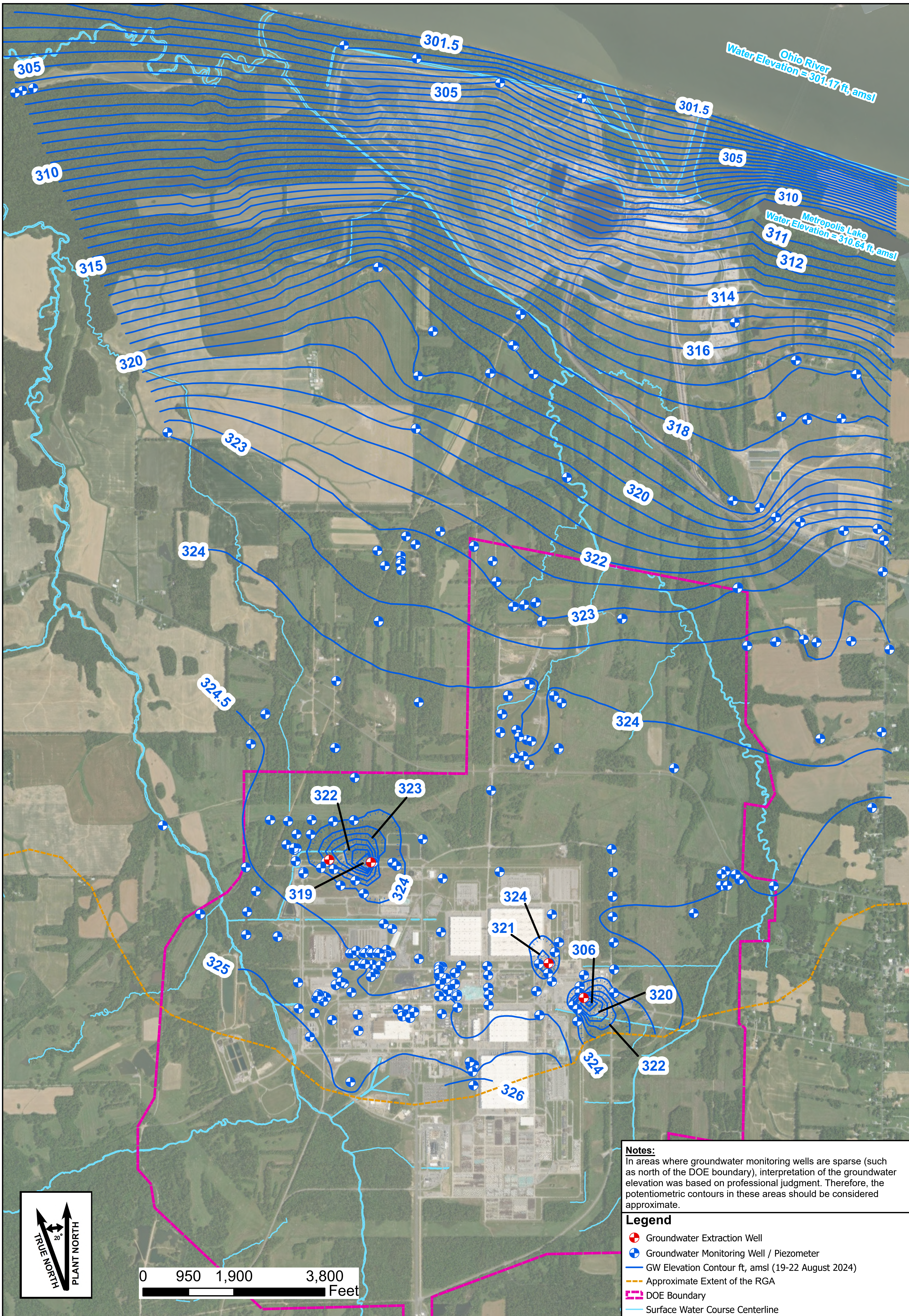
Figure E.3. May 2024 RGA Potentiometric Surface Map



Map Source Information
Map Generation Date and Location - 9/24/2024 \\fedprojects-01\paducah$\2_GIS\APRX\Quarterly Synoptic Potentiometric Map\August 2024\
Map Layer Location: Geosyntec\\fedprojects-01\paducah$\2_GIS\APRX\Quarterly Synoptic Potentiometric Map\August 2024\August 2024 Potentiometric Map_v2.aprx 9/24/2024
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 and DOE boundary obtained from https://pegasis.pad.pppo.gov/, downloaded on 1/15/2024.
Northing and easting of the monitoring wells, piezometers, and extraction wells were obtained from Pegasis on 4/25/2024.
Groundwater elevation was based on the 8/19/2024 - 8/22/2024 measurements obtained from FRNP on 9/11/2024. Depth to groundwater in extraction wells was measured on 8/19/2024 and was provided by FRNP on 9/12/2024.
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 8/19/2024 - 8/22/2024.
Groundwater elevation for the TVA wells were provided by the Kentucky Division of Waste Management letter to DOE (#KY8-890-008-982) dated 9/12/2024.
Water elevation at Metropolis Lake was provided by FRNP on 9/03/2024.
amsl = above mean sea level

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Figure E.4. August 2024 RGA Potentiometric Surface Map