



United States Department of Energy

Savannah River Site

**Treatability Study Data Report for Groundwater Injection and Discharge
Canal Neutralization at the D-Area Groundwater Operable Unit (OU) (U)**

2024 Data and Information

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LIST OF ACRONYMS AND ABBREVIATIONS

1Q	first quarter
2Q	second quarter
3Q	third quarter
4Q	fourth quarter
amsl	above mean sea level
bgs	below ground surface
CaCO ₃	calcium carbonate
CPRB	Coal Pile Runoff Basin
D&D	deactivation and decommissioning
DAG	D-Area Groundwater
DCSA	D-Area Coal Storage Area
ft	feet
gpm	gallons per minute
m	meters
OU	operable unit
PFAS	per- and polyfluoroalkyl substances
RSER/EE/CA	Removal Site Evaluation Report/Engineering Evaluation/Cost Analysis
SCDES ¹	South Carolina Department of Environmental Services
SRNS	Savannah River Nuclear Solutions, LLC
SRS	Savannah River Site
USEPA	U.S. Environmental Protection Agency
UTRA	Upper Three Runs aquifer

¹ The South Carolina Department of Environmental Services (SCDES) was previously known as South Carolina Department of Health and Environmental Control prior to July 1, 2024.

1.0 INTRODUCTION

The Savannah River Site (SRS) has continued implementation of a groundwater treatability study in D Area to reduce the acidic conditions in groundwater (Savannah River Nuclear Solutions, LLC [SRNS] 2019a). The acidic conditions were caused by the storage of coal in the former 484-17D D-Area Coal Storage Area (DCSA) and the subsequent runoff into the 489-D Coal Pile Runoff Basin (CPRB). This data report summarizes all actions and data that have been taken during 2024 as presented and required in the *Treatability Study Work Plan for Groundwater Injection and Discharge Canal Treatment at the D-Area Groundwater (DAG) Operable Unit (OU)* (SRNS 2019) and subsequent data reports (2020 DAG OU Data Report [SRNS 2021a]; 2021 DAG OU Data Report [SRNS 2022a]; 2022 DAG OU Data Report [SRNS 2023a]; 2023 DAG OU Data Report [SRNS 2024]).

The coal-fired 484-D Powerhouse was put into operation in 1952 and provided electricity and steam for the D-Area facilities and other areas at SRS. The major ancillary facilities associated with the powerhouse are the former 484-17D DCSA, the 489-D CPRB, and four ash basins (Figure 1). For over 60 years, the 484-17D DCSA was a staging area for coal prior to its use in the powerhouse. Exposure of the coal to rainwater caused the degradation of iron sulfide (pyrite, a mineral commonly found in coal) to sulfuric acid. As a result, the soils underneath the 484-17D DCSA, associated storm water runoff, and groundwater underlying the area have been acidified. Due to acidic conditions, metals were leached from the coal and the natural soil minerals in the underlying vadose zone and aquifer. This has resulted in a metals (e.g., aluminum, beryllium, and cobalt) and sulfate groundwater plume in the Upper Three Runs Aquifer (UTRA) (Figures 2 through 5). Currently, acidic groundwater outcrops into the D-Area Effluent Discharge Canal at pH levels generally below 4.

Although maintenance actions conducted in 2012 and 2013 removed virtually all the coal present at the 484-17D DCSA, the vadose zone soils beneath the 484-17D DCSA remained acidified. To address the vadose zone soils, a Removal Site Evaluation Report/Engineering Evaluation/Cost Analysis (RSER/EE/CA) was submitted in 2019 to describe a non-time critical removal action for

neutralization of the soils to a depth of 1.2 meters (m) (4 feet [ft]) at the 484-17D DCSA (SRNS 2018). This removal action was completed in 2020, including a limestone cobble groundcover to provide for a long-term pH buffering effect that will slowly infiltrate into the vadose zone. Subsequent soil pH sampling was completed in the summer of 2022. A Removal Action Report, summarizing the removal action and pH adjustment of the vadose zone soils, was submitted in December 2022 (SRNS 2022b).

This treatability study is designed to address the continuing acidic conditions in the shallow groundwater beneath the 484-17D DCSA and 489-D CPRB as well as the discharge to surface water in the D-Area Effluent Discharge Canal.

2.0 PROJECT DESCRIPTION

The vadose zone and groundwater within the upper water table aquifer beneath the 484-17D DCSA and the 489-D CPRB are impacted by low pH conditions (< pH of 4) that are expected to last for decades under natural groundwater conditions. The low-pH groundwater is currently outcropping into the D-Area Effluent Discharge Canal, which later converges with Beaver Dam Creek and flows through the Savannah River floodplain to the Savannah River. If the pH of the aquifer can be adjusted to more normal, less acidic conditions, the groundwater and surface water conditions in the D-Area Effluent Discharge Canal would improve.

This study is testing the viability of an approach to remediation that contains two relatively simple elements:

- Add higher pH, potable groundwater sourced from production wells in D Area into the water table aquifer upgradient of the low-pH, metals, and sulfate plumes using injection wells. The injected production well water is naturally buffered, which will aid in the neutralization of acidic conditions currently present in the water table aquifer. The injected production well water will also raise the elevation of the water table that will help displace the low-pH groundwater within the aquifer.
 - Treat the low-pH surface water that outcrops into the D-Area Effluent Discharge Canal by adjusting the pH with calcium carbonate (CaCO_3) reactive structure(s).
-

A general schematic of the DAG OU treatability study is provided in Figure 6.

Injection of Production Well Water

Two potable water production wells (PW 3D and PW 136D) are in D-Area northwest of the 484-D Powerhouse. Both production wells were used for operations and are screened approximately 195 - 229 m (640 - 750 ft) below ground surface (bgs) within the McQueen Branch Aquifer. These production wells produce groundwater with a pH of approximately 6.0 to 6.5 containing low, but measurable, levels of carbonate alkalinity. Injecting this water into the upper water table aquifer upgradient of the low-pH, metals, and sulfate plumes will raise the elevation of the water table and increase groundwater flow velocity horizontally to displace the low-pH groundwater currently present in the aquifer. The alkalinity will buffer the system and partially neutralize acidity in the aquifer. Both production wells are artesian and produce over 200 gallons per minute (gpm) each without the use of pumps. The well head pressure of the wells is approximately 5 to 10 pounds per square inch and supports enough flow and pressure to deliver large volumes of water to the proposed injection field, as shown by artesian well flow testing conducted in 2019 on both production wells (SRNS 2021a) as well as the ongoing performance of the groundwater injections and flow from the production well PW 136D.

The production well water has been piped to the 484-17D DCSA and 489-D CPRB and is being injected into the upper water table aquifer with a series of injection wells (Figure 7). A portion of the injection well field has been installed and is described in Section 5.1. Creating a water mound approximately 1.5 m (5 ft) above current conditions is expected to increase the volume of groundwater outcropping into the D-Area Effluent Discharge Canal. The original estimation expected that the production wells can supply enough water to fill the pore space volume (the space between the sediment grains in the vadose zone) to create the 1.5 m (5 ft) water mound in approximately 100 days. The original pore space volume was calculated by multiplying the surface area of the 484-17D DCSA and the 489-D CPRB by the proposed rise in water elevation (1.5 m [5 ft]) by the porosity (30%) and converting to gallons. A total of approximately 19 million gallons was originally estimated to be needed to raise the water table 1.5 m (5 ft). Based on aqueous chemical equilibrium modeling software, a total of 10 pore space volumes of injected potable groundwater could significantly displace and raise the pH levels in the upper water table within a

three-year study period. The production wells are expected to support the groundwater injection study in addition to future remedial activities if needed (SRNS 2016a).

In 2023 SRS revisited the assumptions in the original estimation and determined that the potential area that would need to have the water table raised 5 ft would need to be expanded to include additional area to the D-Area Effluent Discharge Canal. This would increase the pore volume size from 19 million gallons to 75 million gallons and additionally increase the time needed to inject one pore volume (SRNS 2023a). Again, in early 2024, SRS revisited the assumptions in the previous estimations (Appendix D of the 2024 report [SRNS 2024]). It was determined that the area needed to be expanded again, which increased the pore volume size from 75 million gallons to up to 154.2 million gallons. In addition, the pH of the injected water was determined to be closer to 6.0 rather than 6.5, as used initially. These further assumptions and calculations subsequently increased the number of pore volumes needed and the total time of injection (SRNS 2024). No further changes in the conceptual model or calculations occurred in 2024.

Although the water table is expected to rise approximately 1.5 m (5 ft) into the vadose zone, groundwater injection is not intended to be the only treatment for the vadose zone and is not expected to remove all the acidity from the vadose zone. However, the production well water to be injected within the upper water table aquifer is anticipated to provide an important, but small, buffering interaction to mitigate the low-pH groundwater. The 484-17D DCSA RSER/EE/CA action that added neutralization amendments to the vadose zone soils (SRNS 2018) was intended to reduce acidity in the vadose zone source that has contributed to groundwater contamination. Due to the higher water table condition created by injection, acidity is expected to be gradually released from the now-saturated lower vadose zone soils. However, the lower vadose zone soils that will not become saturated (i.e., remaining above the elevated water table) are not expected to be neutralized or have much change in pH as a result of the groundwater injection treatability study. The lower vadose zone will eventually see the buffering effects of the upper vadose zone amendments through their dissolution and infiltration over time. The combined (or synergistic) effects of the two actions will be apparent from the measurement of the parameters described in the Treatability Study Work Plan and the 484-17D DCSA RSER/EE/CA (SRNS 2018), and the regular DAG OU groundwater and surface water monitoring that occur concurrently.

Reactive Structures in D-Area Effluent Discharge Canal

An increase in the amount of acidic water outcropping into the D-Area Effluent Discharge Canal is expected to occur as groundwater elevations rise and low-pH groundwater is displaced. Titration test results using surface water from the D-Area Effluent Discharge Canal indicate that contact of surface water with a high purity CaCO_3 reactive structure will raise the pH of the surface water to over 6.0 (SRNS 2016b). Figure 8 shows the carbonate consumption rates associated with the neutralization of the sulfuric acid and illustrates a titration curve of the test. Although the installation of one reactive structure should be sufficient to raise the pH of the surface water, two reactive structures were installed to further ensure pH adjustment is sufficient over time. CaCO_3 marble chips, placed within the stream in two sections downgradient of the acidic groundwater discharge point within the D-Area Effluent Discharge Canal, are expected to allow enough contact time with the surface water for pH adjustment to natural conditions (Figures 6, 8, and 9). The use of high purity CaCO_3 (typically greater than 90% CaCO_3) limits the introduction of undesirable materials into the surface water (silt, clay, reactive minerals, etc.). The description of installation, the data collected to date, and maintenance associated with the CaCO_3 reactive structures are summarized in Section 5.2.

3.0 TEST OBJECTIVES

The objective of this treatability study is to determine the effectiveness of injecting higher-pH potable groundwater to:

- Displace the acidic groundwater out of the upper water table aquifer of the UTRA in the vicinity of and downgradient of the 484-17D DCSA and 489-D CPRB to improve the aquifer conditions (increase the pH), which will reduce or eliminate the dissolved metal groundwater plumes.
 - Increase the pH level of the D-Area Effluent Discharge Canal surface water with CaCO_3 reactive structures prior to discharge into Beaver Dam Creek, the Savannah River floodplain, and the Savannah River.
-

The results of the treatability study and the 484-17D DCSA non-time critical removal action will be used to support the development of the DAG OU Corrective Measures Study/Feasibility Study, currently scheduled to be submitted by March 9, 2028.

Monitoring of water table elevations and pH measurements in surrounding monitoring wells and streams, as well as metal analyses of groundwater and surface water, will be used to determine the impact of the production well water injections. Stream flow measurements will document any increases in flow in the D-Area Effluent Discharge Canal from the groundwater injections.

4.0 SAMPLING AND ANALYSIS

Measurements of water table elevations, stream flow, pH and other field parameters, and sample collection for metal and sulfate analyses in surface water and/or groundwater are conducted following the *SRS 3Q1 Manual: Environmental Requirements and Program Documents, Procedure 9015: Sampling Groundwater Monitoring Wells, Tanks/Vessels (Sample Ports or Spigots) and Surface Water* (SRNS 2023b).

Table 1 includes the stations that were monitored in 2024 and identifies the sampling frequency and constituents that were monitored. Figure 10 shows the locations of the monitored stations. A total of 41 wells and 9 surface water stations outside of the injection field are being monitored. Twenty-three monitoring wells and all 9 surface water stations included sampling for metals and sulfate and field measurements for pH and other routine field analyses. Seventeen (17) wells are only visited for water elevations, including 4 that were added to water elevation monitoring starting in first quarter (1Q)2024 (DCB 51D) or second quarter (2Q)2024 (DCB 54, DCB079, and DCB080). Well DCB087C was installed in the former coal storage area on August 8, 2024 with the existing well cluster (DCB087A and DCB087D) and was added to monitoring and sampling in fourth quarter (4Q)2024. Gordon Aquifer well DCB087D was also added to metals and sulfate sampling starting in 1Q2024 for comparison with the other wells in the cluster.

A potentiometric surface map of the UTRA during 2Q2024 is provided in Figure 11, and a pre-injection water elevation map from 2Q2020 is provided for comparison in Figure 12. Water elevations dropped 1-4 feet overall in D-Area from 2Q2020 to 2Q2024 in wells upgradient or side gradient of the injection wells; however, the water elevations in the area around the

484-17D DCSA and 489-D CPRB are slightly elevated. Water elevations were measured monthly for the first eight months after groundwater injections began in March 2022. Monthly water elevation measurements were conducted throughout all of 2023 and half of 2024 (1Q2024 and 2Q2024) (although only required quarterly in 2024), then switched to quarterly in the second half of 2024 (third quarter [3Q]2024 and 4Q2024). A map of the acidic groundwater with the 2Q2024 pH data is provided in Figure 2, and a map of the sulfate plume is provided in Figure 4. Pre-injection plume maps from 2Q2020 are provided in Figures 3 and 5.

Stream flow measurements were collected within the D-Area Effluent Discharge Canal, the tributary to the east, and downgradient in Beaver Dam Creek where it is safely accessible. Flow measurements are made quarterly at DSWM-4, DSWM-4A, DSWM-4B, and DSWM-5 and monthly at DSWM-4C, DSWM-6, DSWM-7 and DSWM-9; however, manual flow measurements will cease in 2025 and be replaced by continuous monitoring via a new stream gauge (DSWM-8B) described in section 5.2. Groundwater and surface water samples are monitored for the metals included in the DAG OU monitoring program (Appendix A, Table A-1). Monitoring also includes field pH measurements and other routine field measurements (i.e., oxidation/reduction potential, dissolved oxygen, specific conductance, total alkalinity [as CaCO₃], turbidity, water temperature, and water elevation [at wells]).

One round of sampling occurred in 2Q2020 for baseline data before production well water injections began. This data was supplied in the 2020 DAG OU Treatability Study Data Report (SRNS 2021a) and are included in Appendix A, Table A-2 of this report for comparison. Groundwater injections began in March 2022 after preliminary testing of the injection wells. Monthly groundwater elevation measurements were conducted until 3Q2024 when quarterly measurements were taken thereon. Hydrographs of the data are provided in Appendix B. Analytical sampling of monitoring wells and surface water stations were conducted quarterly. Monthly pH measurements were conducted at the reactive structures at surface water stations as described in section 5.2. All 2024 analytical and field data are provided in Appendix A, Table A-1 and discussed in Sections 5.1 and 5.2.

Any adjustments needed to the monitoring plan based on field conditions or monitoring results will be discussed with the United States Department of Energy – Savannah River, United States

Environmental Protection Agency (USEPA), and South Carolina Department of Environmental Services (SCDES) for approval prior to implementation. The 2Q and 4Q DAG OU monitoring will not be impacted by the treatability study and will continue as normally scheduled. As field conditions warrant, adjustments such as varying injection flow rates or well re-development could also be employed. Any permanent discontinuation of an injection well will be communicated with USEPA and SCDES.

5.0 TREATABILITY STUDY PROGRESS AND DATA

Due to the discovery of unfavorable injection sediments within the UTRA, potential interferences with deactivation & decommissioning (D&D) activities in D Area, and delays in field personnel availability due to COVID-19 management practices, a stepped approach has been taken with implementation of the DAG OU treatability study. Ten (10) injection wells have been installed; five were installed during 2020 (DGI007, DGI010, DGI014, DGI016, and DGI019), and five were installed during 2021 (DGI011, DGI012, DGI013, DGI015, and DGI017) (Figure 7). An existing groundwater well, DCB 2A, was also used to inject water. A letter with the request to operate as part of the Underground Injection Control Permit, including the well installation reports, was submitted to SCDES and copied to USEPA after installation of the 10 new injection wells (SRNS 2011b). The injection wells were originally planned to be screened within the upper water table aquifer (located in the upper zone of the UTRA in D Area) at approximately 3.7 – 9.8 m (12 – 32 ft) bgs. However, due to the abundance of clays, sandy clays, and silty sands, especially near the 484-17D DCSA, the wells were installed deeper within the mid to lower zone of the UTRA (Table 2). A cross-sectional view of the sediments including all 10 installed injection wells is shown in Figures 13 and 14. Additionally, the two CaCO_3 reactive structures were installed within the D-Area Effluent Discharge Canal in 2020. Ongoing monthly monitoring of pH and metal analyses within the D-Area Effluent Discharge Canal was performed upgradient, between, and downgradient of the CaCO_3 reactive structures to determine the efficacy of both the CaCO_3 material and structure design. Before groundwater injections began, SRS collected per- and polyfluoroalkyl substances (PFAS) samples from both production wells PW 3D and PW 136D on December 17, 2021. Samples were analyzed using method EPA533 for 25 constituents. Results

from both wells were non-detect for all PFAS constituents. The complete sample results were provided in Appendix A, Table A-2 of the January 2023 Data Report (SRNS 2023a).

Details on each portion of the treatability study project are provided below.

5.1 Injection Piping System

Due to COVID-19 related delays and material supply issues, the procurement and installation of the piping system did not start until December 2021. The main piping system consists of 6-inch and 4-inch high-density polyethylene pipes, and the installation was completed on February 24, 2022. Figure 7 shows the general layout of the piping system from PW 136D to the injection wells, Figure 15 displays the installation of the piping system, and Figure 16 displays the typical piping setup at the injection wells. Bi-weekly inspections of the passive piping and injection system are conducted which include taking flow totalizer readings at each of the injection wells. Additional information associated with the preliminary testing of the injection wells with the piping system can be found in the January 2023 DAG Treatability Study Report (SRNS 2023a).

5.1.1 Groundwater Injection Observations

After completion of the initial testing at each of the injection wells, continuous groundwater injection into 11 wells (all 10 new wells and DCB 2A, which was already present) at once was initiated on March 21, 2022. Initially the injection flow rate was targeted at 5 gpm at each well to observe how the wells operated over time. After 3 weeks of injections, with most of the 11 injection wells continuing to operate at 5 gpm, the target injection rate was increased to 10 gpm. In late April 2023, due to continued injection operations being successful, targeted injection rates were increased to 12 gpm. Well DGI014 displayed a decrease in flow when the other wells were increased, likely due to less water pressure to that well. Additionally, there were ongoing issues with water bubbling up to the surface at well DCB 2A, and the decision was made to discontinue injections into DCB 2A. The flow valve was shut off at DCB 2A in April 2023, and no additional issues have been observed.

On October 16, 2024 flow was attempted to target 18 gpm at each injection well, if possible. The main valve at the PW 136D production well was fully opened and the individual injection well

isolation valves were adjusted to try to target approximately 18 gpm. Flow at lower performing injection wells (DGI-011, DGI-012) and at DGI-017 did not increase. Flow at DGI010, DGI013, and DG014 slightly decreased, likely due to changing pressures from adjustments of flow at other injection wells. Injection wells DGI016 and DGI019 showed the most increase in flow. Other wells did see a response, although were not able to achieve a flow rate near 18 gpm.

All injection well isolation valves have been fully opened (except DGI016 at ~80% opened), indicating that the current piping and injection system is nearing its full capacity at the current artesian pressure conditions. SRS is currently evaluating if adding the additional production well, PW 3D, to the current piping system, or other alternatives not yet explored, would be beneficial or if the piping system is limiting the total amount of flow. The initial testing of the production wells could supply up to approximately 300 gpm (under unrestricted flow), however the addition of the ~3,700 ft piping system and injection wells has reduced the max flow to approximately 100 gpm.

Figure 17 shows the flow rates for each of the injection wells (the electronic data set is provided in the Excel table, tab “Injection_Data”). The majority of the wells (7 out of 11) have been able to keep injection rates up, although a slight decrease in time is generally observed. Injections into the ten 6-inch injection wells have been continuous since injections began in March 2022. As previously stated, injections were discontinued into DCB 2A due to water bubbling up to the ground surface. Injection wells DGI011 and DGI012 accept less than 2 gpm and continue to underperform. SRS is currently evaluating the possibility of adding in PW 3D to the piping system and/or if an additional alternative would be more appropriate.

Figure 18 shows the cumulative groundwater injection volume. During 2024, a total of approximately 46.7 million gallons were injected into the UTRA. This makes a total of approximately 124 million gallons injected since March 2022. It can be observed that 80% of the early 2024 refined estimate of one pore volume (approximately 154.2 million gallons) of water, has been injected into the 10 injection wells in about 1,000 days. The 10 active injection wells were allowing a total of 97 gpm of water being injected as of the end of December 2024.

5.1.2 *Water Level Observations*

Appendix B presents the hydrographs at the monitoring wells over the past 12 years. Rainfall during 2024 was above average with 54 inches of rain, but was approximately 9 inches lower than 2023 levels. Water elevations decreased from 2020 to 2022, but then increased in 2023 and 2024 due to above average rainfall in 2023 and 2024 in wells upgradient or side gradient of the injection wells; however, the water elevations in the area around the 484-17D DCSA and 489-D CPRB are slightly more elevated over the injection period (Figures 11 and 12). All monitoring wells display similar water elevations in 2024 as compared to 2023 regardless of whether they are near/downgradient of the injection wells or outside/upgradient of the injection area (Appendix B). The wells near the injection wells have shown a continued increase in water elevation from the continuous groundwater injections (e.g., DCB 5A, DCB 6, DCB 7, DCB 8, DCB 49, DCB087A/D). A majority of downgradient wells have not displayed a significant increase in water elevation; potentially only up to approximately a 1-ft increase. Well DCB 8 shows the highest increase in water elevation (a 5-ft increase); however, this well is located in the area of groundwater injections near injection well DGI016.

It is evident from the hydrographs that the water levels in downgradient wells have not increased significantly over their previous water elevations, but this is as water elevations decreased across D-Area between 2020 to 2024. With the revised higher pore volume calculation of ~154 million gallons and current injection rate of ~100 gpm, groundwater levels may not be able to be raised in a broad scale at 5 ft above normal levels, or at least in a short time period as previously predicted. Further water elevation trending will continue to be conducted for analysis.

5.1.3 *Groundwater pH and Analytical Observations*

The recorded pH levels at the monitoring wells are presented in Appendix C. The pH levels do not show any significant increase after about 1,000 days of groundwater injection, for an overall 124 million gallons injected or approximately 0.8 pore volume of the revised conceptual estimate. At stations directly downgradient from the injection area pH levels remain consistent at wells DCB 4A, DCB 6, DCB 21A/B/C, DCB 34A/C, DCB 37A/C, and DCB087A (Appendix C). Increases in pH are likely to take additional time as overall buildup of water within the aquifer and movement

of the groundwater aquifer is gradual, and residual acidity within the aquifer sediments are likely contributing to ongoing acidity.

Groundwater and surface water metal analyses were conducted quarterly after groundwater injections began. These results, as shown in Table A-1 and in the Appendix C time-series plots for pH, aluminum, beryllium, cobalt, iron, nickel, and sulfate, also do not yet show any overall significant change in concentrations as a result of the groundwater injections, consistent with lack of changes in observed in pH values.

A few decreasing trends are noted in 1 to 5 monitoring wells (i.e., DCB 6, DCB 21A, DCB 35A, DCB 34C, DCB087A) for aluminum, beryllium, cobalt, nickel, and/or sulfate (Appendix B). However, it cannot be determined if these decreases have occurred due to dilution factors from the groundwater injections or from reductions in additional dissolved metals loading from the 484-17D DCSA and 489-D CPRB due to previous removal actions at those units. Results from new well DCB087C do show higher pH levels and lower metal concentrations than other lower UTRA well clusters and results are more similar to the GA well (DCB087D) results.

5.1.4 Overall Observations of Groundwater Injections

Based on the groundwater injection flow rates and totals observed in Figures 17 and 18, and water elevation and contaminant concentration trends presented in Appendices B and C, the following overall observations can be made:

1. Groundwater injections are working as conceptualized in most of the injection wells, though deeper than originally designed based on observed site-specific hydrogeologic properties. The UTRA aquifer formation is accepting groundwater without much reduction in injection rates over time.
 2. The water levels in downgradient wells have not risen as much as anticipated, with only a 1-ft increase in water elevations being observed in general away from the injection line.
 3. Neither pH levels nor metal concentrations are showing significant changes from the background (pre-injection) levels at most monitoring stations.
-

Based on similar observations from the 2022 and 2023 data and the 2024 observations cited above, the conceptual design was revisited in early 2024 (as presented in Appendix D of the June 2024 Data Report [SRNS 2024]). In general, the following observations were noted:

1. The pore volume calculations were likely to have been underestimated. Taking into account the total low-pH plume area (i.e., not just the immediate area at the 484-17D DCSA and 489-D CPRB and area to the D-Area Effluent Discharge Canal), a reanalysis estimates a pore volume of approximately 154.2 million gallons as compared to the original estimate of 19 million gallons, as well as the 2023 estimate of 75 million gallons. At an injection rate of 120 gpm total and a pore volume of approximately 154.2 million gallons, it will take approximately 110 years to achieve a pH increase to 5.5. If the target pH is lowered to 5, then it is estimated to take approximately 24 years of groundwater injection without the addition of pH buffering agents (base).
2. An analysis of groundwater transport modeling indicates that the groundwater injections will reach the extent of the low-pH plume within 3 years.

Based on the results of the groundwater injections over the last nearly three years (34 months), an additional increase in injection flow rate was attempted in October 2024, but total flow was only increased from approximately 84 gpm to 100 gpm. SRS is currently evaluating the possibility of adding in PW 3D to the piping system and/or if an additional alternative would be more appropriate. The current SCDES groundwater withdrawal permit can support additional use of the production well(s).

5.2 CaCO₃ Reactive Structures

Due to the ongoing and further expected acidic conditions within the D-Area Effluent Discharge Canal, two CaCO₃ reactive structures were installed during 2020. To perform initial testing of the design and function of the structures, the structures were installed at separate times. One reactive structure was installed in February 2020, and a surface water pH increase was observed following its installation. The second reactive structure was installed downgradient of the first structure in October 2020 and a further increase in pH was observed.

Since construction of the reactive structures, it has been observed that during periods of prolonged or heavy rains, stream flow increases and surface water tops over the reactive structures. This is part of the design not to restrict the stream during flooding events; however, this consequently also reduces the contact time of the surface water with the reactive structures. Additionally, increased sediment and leaf drop litter over the previous years have been observed to create a layer of detritus that limits stream flow through the CaCO_3 reactive structures. As a result, surface water was overtopping the CaCO_3 reactive structures, even in low rainfall periods. In effect, the efficacy of the reactive structures has declined in the previous years.

To address this, the original reactive structures were intentionally breached on December 11, 2023 to eliminate the damming effects in the D-Area Effluent Discharge Canal. Subsequently in the first half of March 2024, both reactive structures were redesigned, and one was relocated, to improve performance and limit detritus buildup. The new reactive structures were constructed by installing limestone riprap on the upstream side to help break up and block detritus from clogging up the larger marble aggregate. It is expected that use of larger marble aggregate instead of small chips will allow more water flow over time. A small amount of limestone riprap was also added at the downstream side of the reactive structures to help minimize displacement of the aggregate during higher flow events (Figure 9, 2024 Redesign). Limestone riprap was used instead of granitic rock to aid in pH adjustment of the surface water. One reactive structure was constructed at the location of the original first reactive structure in-between surface water stations DSWM-8 and DSWM-8A, and the other reactive structure was constructed downstream of the confluence of the tributary canal with the main canal between surface water stations DSWM-4C and DSWM-7 (Figure 22). Photographs of the new reactive structures are provided in Figure 23. In addition to the redesign, reactive structure maintenance was conducted on December 11, 2024, which included removal of detritus, mixing and adding of marble aggregate, and installation of additional limestone riprap as needed. Additional semi-annual maintenance activities are planned to remove and reduce debris that limits water flow through the structures.

As a result of the rearranged reactive structures, quarterly surface water and monthly pH monitoring locations were adjusted accordingly. Surface water station DSWM-8A, which was located between the original reactive structures, was replaced with DSWM-7 located between the

reworked reactive structures. DSWM-8 was replaced with stations DSWM-4C and DSWM-6 as the upgradient monitoring stations. Station DSWM-9 continues to monitor downgradient of both structures (Figure 10). Figure 21 displays the field pH measurements collected monthly upgradient, between, and downgradient of the two CaCO_3 reactive structures at these locations. Surface water pH increases are occurring as water flows through the reactive structures, with the pH increasing after each structure; however, notice only one of the 12 pH measurement events in 2023 were >5 . After the reactive structures were reworked in March 2024, pH measurements in between the reactive structures increased slightly compared to previous years, and pH measurements taken downgradient were observed to be above 5 except only once in 2024 (April 11, 2024 with a measurement of 4.7).

Due to inconsistencies with collecting stream flow measurements and to reduce potential errors, SRS installed a permanent and continual (every 15 minutes) electronic stream flow data logger (DSMW-8B) downgradient of the downstream reactive structure on September 13, 2024. Calibration of the stream flow gauge was conducted through October 9, 2024, thus readings after this date are considered accurate. This allows constant real-time monitoring of the flow within the D-Area Effluent Discharge Canal and will be more useful in trending measurements and identifying changes that may occur from the groundwater injections or rain events. Note that the first and largest spike in flow was seen around September 26, 2024, when hurricane Helene made landfall.

In 2024, stream flow measurements were manually recorded monthly at DSWM-4C, DSWM-6, DSWM-7, and DSWM-9 and quarterly at all other stations when safe to do so. In the future, flow measurements will only be collected autonomously at electronic stream gauge DSWM-8B. Stream flow measurements taken manually since 2020 are shown in Figure 19, and the measurements taken since September 13, 2024, with the continuous monitoring station DSWM-8B are presented in Figure 20. As expected, stream flow rates fluctuate with site conditions and rain events. The data is inconclusive if stream flows have increased due to the groundwater injections.

Appendix A, Table A-1 contains all the surface water data analytical and field results from the 2024 sampling. Appendix A, Table A-2 includes the 2Q2020 pre-injection analytical and field results for comparison. Some decreases in surface water metal concentrations were observed as a

result of the pH changes in surface water. Figures 24 and 25 display concentrations of pH vs aluminum, beryllium, sulfate, cobalt, and nickel at surface water stations DSWM-4C, DSWM-6, DSWM-7, DSWM-8, DSWM-8A, and DSWM-9 from 2014 through 2024. The increases in pH generally cause decreases in surface water for all metals and sulfate concentrations.

6.0 DATA COLLECTION AND REPORTING

Data (field measurements, sample results, flow rates, etc.) will continue to be collected and presented in a combination of tabular form, graphs, and time-series plots for calendar year 2025. Only small deviations in concentrations have been observed between past sampling events, and it is believed that semi-annual sampling would provide sufficient data to support this treatability study, especially since the estimated time needed to impart large changes in groundwater and surface water are expected to take longer than originally thought. Therefore, SRS proposes conducting semi-annual sampling of monitoring wells and at some surface water stations (DSWM-4, DSMW-4A, DSWM-4B, DSWM-5, and DSWM-10) in future sampling events. Surface water sampling for metals and sulfate directly upgradient, in-between, and downgradient of the reactive structures (DSWM-4C, DSWM-6, DSWM-7, and DSWM-9) will remain quarterly and surface water pH monitoring will remain monthly.

The updated sampling schedule documenting the groundwater and surface water monitoring station sampling changes for 2025 is provided in Table 3. Future data reports will include maps depicting the water table, pH, beryllium, and sulfate to compare to pre-injection levels. SRS will submit the next report by April 30, 2026.

7.0 SUMMARY

Baseline sampling was conducted for the treatability study monitoring network in 2Q2020. Ten of the proposed 20 injection wells have been installed in addition to existing well DCB 2A. Groundwater injections have been continuous since injections began in March 2022, and production well water is currently being injected at approximately a combined 97 gpm. This rate is lower than the 120-gpm total flow rate conceptualized in the original design; however, the majority of the injection wells have been able to accept more water than anticipated, which has compensated for installing half (10 of 20) of the proposed injection wells. A stepped approach has

been taken with the DAG OU treatability study, and another increase in injection flow rates was attempted in October 2024, however, now with the main valve fully opened, it appears the piping/injection system is reaching its maximum flow possible with the current setup. SRS is currently evaluating the possibility of adding in PW 3D to the piping system and/or if an additional alternative would be more appropriate. Installation of additional injection wells are not planned at this time.

Rainfall during 2024 was above average, but less than 2023 levels. However, groundwater elevations in 2024 were similar to levels in 2023 which showed an overall increase in water elevations from 2021 and 2022 when water levels dropped from the 2020 levels. Although, groundwater elevations were still below 2020 levels. Groundwater injection over the initial nearly three years (34 months) shows that 80% of the 2024 revised conceptual estimate of one pore volume of 154.2 million gallons has been injected into the aquifer formation (i.e., actual injection was approximately 124 million gallons). However, the water levels have increased less than expected in downgradient monitoring wells, with an approximately 1 ft increase being achieved in downgradient wells. The conceptual model was revisited to assess the initial assumptions of the effects of groundwater injections. A reanalysis estimates a pore volume of approximately 154.2 million gallons if the total low-pH plume area is considered and not just the immediate area at the 484-17D DCSA and 489-D CPRB. At an injection rate of 120 gpm total, it will take approximately 110 years to accomplish a pH increase to 5.5 over the entire plume. If the target pH is lowered to 5, then it is estimated to take approximately 24 years of groundwater injection without the addition of pH buffering agents (base). Additionally, an analysis of groundwater transport modeling indicates that the groundwater injections will reach the extent of the low-pH plume within 3 years. No major changes in groundwater pH and metals have been observed as a result of the groundwater injections.

Monthly monitoring of surface water pH in the D-Area Effluent Discharge Canal is occurring upgradient, between, and downgradient of the CaCO_3 reactive structures, with quarterly sampling for metals analyses also taking place. The CaCO_3 reactive structures in the D-Area Effluent Discharge Canal are raising the pH of the surface water. However, due to sediment/leaf detritus build up, water flow through the structures had been greatly diminished in 2022 and 2023, and the

pH is was not being raised to above 5. Surface water sampling has indicated with increases in pH some metals concentrations (e.g., aluminum, beryllium, and cobalt) in surface water decrease.

Maintenance and reworking of the reactive structures were conducted in 2023 and 2024 to address the sediment/leaf detritus issue. The original reactive structures were intentionally breached on December 11, 2023 to eliminate the damming effects in the D-Area Effluent Discharge Canal. Subsequently in the first half of March 2024, redesigned reactive structures were constructed with limestone riprap and larger marble aggregate. The subsequent surface water data indicates the efficacy of the structures has been improved and pH adjustment is occurring. Routine semi-annual maintenance of the reactive structures will be implemented to minimize sediment and leaf detritus build-up on the new reactive structures to allow flow through the structures.

Due to the expected longer timeframe to see substantial pH and metal adjustments to the groundwater and surface water as a result of the groundwater injections, groundwater and surface water monitoring will be reduced from quarterly to semiannually as shown in Table 3. Quarterly sampling for metals and sulfate will continue at the surface water stations upstream, between, and downgradient of the current reactive structures (DSWM-4C, DSWM-6, DSWM-7, and DSWM-9). These four surface water stations will continue monthly pH monitoring as well. New surface water stream gauge station DSWM-8B will replace manually collected stream flow measurements.

The anticipated length of the treatability study was originally estimated at a minimum of three years of groundwater injection. However, further reevaluation of the hydrological properties and data collected to date indicates that it's likely to take at least 10 to 110 years of injection to substantially change the aquifer conditions. Analysis of the production well flow rates, injection operation, aquifer acceptance, field data, sample data, and performance of the CaCO_3 reactive structures will determine the optimal length of the treatability study. SRS will continue to operate the DAG OU Treatability Study for at least another year. The next DAG OU Treatability Study report including activities and data collected in 2025 will be submitted by April 30, 2026.

8.0 REFERENCES

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Table 1. D-Area Treatability Study 2024 Monitoring Network and Sampling Schedule

Monitoring Well Information							Sampling Frequency	
Station	Station Type	Ground Elevation (ft amsl)	Total Depth (ft bgs)	Screen Length (ft)	Screened Interval (ft bgs)	Screened Interval (ft amsl)	Monthly	Quarterly
PW 3D	Production Well	128.75	736	10, 50	670 - 680, 690 - 730	-541.25 - -551.25, -651.25 - -601.25		
PW 136D	Production Well	132.5	765	30, 40	640 - 670, 710 - 750	-507.5 - -537.5, -577.5 - -617.5		Pressure Reading
DCB 3A	Monitoring Well	131.2	36.8	30	5 - 35	126.2 - 96.2	WL - 1Q24 & 2Q24	WL
DCB 4A	Monitoring Well	127.5	37	30	5 - 35	122.5 - 92.5	WL - 1Q24 & 2Q24	M
DCB 5A	Monitoring Well	120.9	37	30	5 - 35	115.9 - 85.9	WL - 1Q24 & 2Q24	WL
DCB 6	Monitoring Well	131.5	23.7	20	2 - 22	129.5 - 109.5	WL - 1Q24 & 2Q24	M
DCB 7	Monitoring Well	130.9	23.9	20	2 - 22	128.9 - 108.9	WL - 1Q24 & 2Q24	WL
DCB 8	Monitoring Well	134.8	26.5	20	4.5 - 24.5	130.3 - 110.3	WL - 1Q24 & 2Q24	M
DCB 9	Monitoring Well	120.2	25	20	2.9 - 22.9	117.3 - 97.3	WL - 1Q24 & 2Q24	WL
DCB 10	Monitoring Well	121.8	24.1	20	2 - 22	119.8 - 99.8	WL - 1Q24 & 2Q24	M
DCB 21A	Monitoring Well	126.6	20	10	6.5 - 16.5	120.1 - 110.1	WL - 1Q24 & 2Q24	M
DCB 21B	Monitoring Well	126.7	27	2.5	22 - 24.5	104.7 - 102.2	WL - 1Q24 & 2Q24	M
DCB 21C	Monitoring Well	126.8	44	2.5	36 - 38.5	90.8 - 88.3	WL - 1Q24 & 2Q24	M
DCB 22A	Monitoring Well	125.3	18.5	10	5.5 - 15.5	119.8 - 109.8	WL - 1Q24 & 2Q24	M
DCB 23A	Monitoring Well	119.2	16	10	3.5 - 13.5	115.7 - 105.7	WL - 1Q24 & 2Q24	WL
DCB 23B	Monitoring Well	119.1	27.5	2.5	22.5 - 25	96.6 - 94.1	WL - 1Q24 & 2Q24	M
DCB 23C	Monitoring Well	119.1	35	2.5	30 - 32.5	89.1 - 86.6	WL - 1Q24 & 2Q24	M
DCB 26AR	Monitoring Well	122.7	26	14.3	11 - 25.3	111.7 - 97.4	WL - 1Q24 & 2Q24	WL
DCB 33B	Monitoring Well	140.5	37	10	26.5 - 36.5	114 - 104	WL - 1Q24 & 2Q24	WL
DCB 34A	Monitoring Well	128	26	10	16 - 26	112 - 102	WL - 1Q24 & 2Q24	M
DCB 34C	Monitoring Well	127.6	59.3	10	46.8 - 56.8	80.8 - 70.8	WL - 1Q24 & 2Q24	M
DCB 35A	Monitoring Well	118.2	25	10	14.8 - 24.8	103.4 - 93.4	WL - 1Q24 & 2Q24	M
DCB 35C	Monitoring Well	118	44	10	33.8 - 43.8	84.2 - 74.2	WL - 1Q24 & 2Q24	M
DCB 36A	Monitoring Well	123.9	20	10	9.8 - 19.8	114.1 - 104.1	WL - 1Q24 & 2Q24	M
DCB 36C	Monitoring Well	123.8	37	10	26.5 - 36.5	97.3 - 87.3	WL - 1Q24 & 2Q24	M

M = Metals and field parameters including pH
WL = Water elevation measurement only
amsl = above mean sea level

Table 1. D-Area Treatability Study 2024 Monitoring Network and Sampling Schedule (continued/end)

Monitoring Well Information							Sampling Frequency	
Station	Station Type	Ground Elevation (ft amsl)	Total Depth (ft bgs)	Screen Length (ft)	Screened Interval (ft bgs)	Screened Interval (ft amsl)	Monthly	Quarterly
DCB 37A	Monitoring Well	126.5	25.9	10	15.7 - 25.7	110.8 - 100.8	WL - 1Q24 & 2Q24	M
DCB 41A	Monitoring Well	130.6	33	10	22.3 - 32.32	108.28 - 98.28	WL - 1Q24 & 2Q24	WL
DCB 44A	Monitoring Well	134.6	26.5	15	11.3 - 26.3	123.3 - 108.3	WL - 1Q24 & 2Q24	WL
DCB 45A	Monitoring Well	134.9	25.2	15	9.7 - 24.7	125.2 - 110.2	WL - 1Q24 & 2Q24	WL
DCB 49	Monitoring Well	122	16.5	12.5	3.35 - 15.85	118.65 - 106.15	WL - 1Q24 & 2Q24	WL
DCB 51A	Monitoring Well	157.69	157.69	10	19.37 - 29.37	138.32 - 128.32	WL - 1Q24 & 2Q24	WL
DCB 51D (added 1Q24)	Monitoring Well	157.57	103.65	10.05	93.3 - 103.35	64.27 - 54.22	WL - 1Q24 & 2Q24	WL
DCB 53	Monitoring Well	113.58	41	10.1	26 - 36.1	87.58 - 77.48	WL - 1Q24 & 2Q24	WL
DCB 54 (Added 2Q24)	Monitoring Well	111.13	44.85	10.05	34.5 - 44.55	76.63 - 66.58	WL - 2Q24	WL
DCB 70A	Monitoring Well	116.49	12.5	10	1.8 - 11.8	114.69 - 104.69	WL - 1Q24 & 2Q24	M
DCB077	Monitoring Well	127.7	31.7	20	9.7 - 29.7	118 - 98	WL - 1Q24 & 2Q24	M
DCB078 (Added 2Q24)	Monitoring Well	126.7	41.7	20	19.7 - 39.7	107 - 87	WL - 1Q24 & 2Q24	M
DCB079 (Added 2Q24)	Monitoring Well	127.8	45.7	20	23.7 - 43.7	104.1 - 84.1	WL - 2Q24	WL
DCB080	Monitoring Well	116.1	35.1	20	13.1 - 33.1	103 - 83	WL - 1Q24 & 2Q24	WL
DCB087A	Monitoring Well	131.81	30.4	10	18 - 28	113.81 - 103.81	WL - 1Q24 & 2Q24	M
DCB087C (Added 4Q24)	Monitoring Well	131.24	74.2	10	61.9 - 71.9	69.34 - 59.34		M
DCB087D (Added 1Q24)	Monitoring Well	132	117.3	10	105 - 115	27 - 37	WL - 1Q24 & 2Q24	M
DSWM-4	Surface Water Station	--	--	--	--	--		M
DSWM-4A	Surface Water Station	--	--	--	--	--		M
DSWM-4B	Surface Water Station	--	--	--	--	--		M
DSWM-4C	Surface Water Station	--	--	--	--	--	pH	M
DSWM-5	Surface Water Station	--	--	--	--	--		M
DSWM-6	Surface Water Station	--	--	--	--	--	pH	M
DSWM-7	Surface Water Station	--	--	--	--	--	pH	M
DSWM-9	Surface Water Station	--	--	--	--	--	pH	M
DSWM-10	Surface Water Station	--	--	--	--	--		M

M = Metals and field parameters including pH
WL = Water elevation measurement only
pH = pH reading of surface water only for performance monitoring of the reactive structures
amsl = above mean sea level

Table 2. D-Area Injection Well Screen Zone Depths

Injection Well	Screen Zone (ft bgs)	Screen Zone (ft amsl)	Month/Year Installed
DGI007	21.49 - 42.41	112.91 - 91.99	December/2019
DGI010	30.51 - 51.43	103.22 - 82.3	December/2019
DGI011	24.2 - 45.1	108.67 - 87.77	February/2021
DGI012	26.6 - 47.5	105.57 - 84.64	February/2021
DGI013	34.1 - 55.0	97.42 - 76.52	February/2021
DGI014	34.58 - 55.5	97.73 - 76.81	February/2020
DGI015	35.1 - 56.0	97.47 - 76.57	February/2021
DGI016	34.26 - 55.18	98.24 - 77.32	January/2020
DGI017	34.1 - 55.0	98.35 - 77.45	March/2021
DGI019	23.72 - 44.64	108.25 - 87.33	January/2020
DCB 2A	5.0 – 35.0	127.4 - 97.4	March/1984

Installed during 2020
Installed during 2021
Existing well

amsl- above mean sea level

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Table 3. D-Area Treatability Study Monitoring Network and Sampling Schedule for 2025

Monitoring Well Information							Sampling Frequency		
	Station Type	Ground Elevation (ft amsl)	Total Depth (ft bgs)	Screen Length (ft)	Screened Interval (ft bgs)	Screened Interval (ft amsl)	Monthly	Quarterly	Semi-annually 2Q & 4Q
PW 3D	Production Well	128.75	736	10, 50	670 - 680, 690 - 730	-541.25 - -551.25, -651.25 - -601.25			
PW 136D	Production Well	132.5	765	30, 40	640 - 670, 710 - 750	-507.5 - -537.5, -577.5 - -617.5		Pressure Reading	
DCB 3A	Monitoring Well	131.2	36.8	30	5 - 35	126.2 - 96.2		WL	
DCB 4A	Monitoring Well	127.5	37	30	5 - 35	122.5 - 92.5		WL	M
DCB 5A	Monitoring Well	120.9	37	30	5 - 35	115.9 - 85.9		WL	
DCB 6	Monitoring Well	131.5	23.7	20	2 - 22	129.5 - 109.5		WL	M
DCB 7	Monitoring Well	130.9	23.9	20	2 - 22	128.9 - 108.9		WL	
DCB 8	Monitoring Well	134.8	26.5	20	4.5 - 24.5	130.3 - 110.3		WL	M
DCB 9	Monitoring Well	120.2	25	20	2.9 - 22.9	117.3 - 97.3		WL	
DCB 10	Monitoring Well	121.8	24.1	20	2 - 22	119.8 - 99.8		WL	M
DCB 21A	Monitoring Well	126.6	20	10	6.5 - 16.5	120.1 - 110.1		WL	M
DCB 21B	Monitoring Well	126.7	27	2.5	22 - 24.5	104.7 - 102.2		WL	M
DCB 21C	Monitoring Well	126.8	44	2.5	36 - 38.5	90.8 - 88.3		WL	M
DCB 22A	Monitoring Well	125.3	18.5	10	5.5 - 15.5	119.8 - 109.8		WL	M
DCB 23A	Monitoring Well	119.2	16	10	3.5 - 13.5	115.7 - 105.7		WL	
DCB 23B	Monitoring Well	119.1	27.5	2.5	22.5 - 25	96.6 - 94.1		WL	M
DCB 23C	Monitoring Well	119.1	35	2.5	30 - 32.5	89.1 - 86.6		WL	M
DCB 26AR	Monitoring Well	122.7	26	14.3	11 - 25.3	111.7 - 97.4		WL	
DCB 33B	Monitoring Well	140.5	37	10	26.5 - 36.5	114 - 104		WL	
DCB 34A	Monitoring Well	128	26	10	16 - 26	112 - 102		WL	M
DCB 34C	Monitoring Well	127.6	59.3	10	46.8 - 56.8	80.8 - 70.8		WL	M
DCB 35A	Monitoring Well	118.2	25	10	14.8 - 24.8	103.4 - 93.4		WL	M
DCB 35C	Monitoring Well	118	44	10	33.8 - 43.8	84.2 - 74.2		WL	M
DCB 36A	Monitoring Well	123.9	20	10	9.8 - 19.8	114.1 - 104.1		WL	M
DCB 36C	Monitoring Well	123.8	37	10	26.5 - 36.5	97.3 - 87.3		WL	M

M = Metals and field parameters including pH
WL = Water elevation measurement only
amsl = above mean sea level

Table 3. D-Area Treatability Study Monitoring Network and Sampling Schedule for 2025 (continued/end)

Monitoring Well Information							Sampling Frequency		
	Station Type	Ground Elevation (ft amsl)	Total Depth (ft bgs)	Screen Length (ft)	Screened Interval (ft bgs)	Screened Interval (ft amsl)	Monthly	Quarterly	Semi-annually 2Q & 4Q
DCB 37A	Monitoring Well	126.5	25.9	10	15.7 - 25.7	110.8 - 100.8		WL	M
DCB 41A	Monitoring Well	130.6	33	10	22.3 - 32.32	108.28 - 98.28		WL	
DCB 44A	Monitoring Well	134.6	26.5	15	11.3 - 26.3	123.3 - 108.3		WL	
DCB 45A	Monitoring Well	134.9	25.2	15	9.7 - 24.7	125.2 - 110.2		WL	
DCB 49	Monitoring Well	122	16.5	12.5	3.35 - 15.85	118.65 - 106.15		WL	
DCB 51A	Monitoring Well	157.69	157.69	10	19.37 - 29.37	138.32 - 128.32		WL	
DCB 51D	Monitoring Well	157.57	103.65	10.05	93.3 - 103.35	64.27 - 54.22		WL	
DCB 53	Monitoring Well	113.58	41	10.1	26 - 36.1	87.58 - 77.48		WL	
DCB 54	Monitoring Well	111.13	44.85	10.05	34.5 - 44.55	76.63 - 66.58		WL	
DCB 70A	Monitoring Well	116.49	12.5	10	1.8 - 11.8	114.69 - 104.69		WL	M
DCB077	Monitoring Well	127.7	31.7	20	9.7 - 29.7	118 - 98		WL	M
DCB078	Monitoring Well	126.7	41.7	20	19.7 - 39.7	107 - 87		WL	M
DCB079	Monitoring Well	127.8	45.7	20	23.7 - 43.7	104.1 - 84.1		WL	
DCB080	Monitoring Well	116.1	35.1	20	13.1 - 33.1	103 - 83		WL	
DCB087A	Monitoring Well	131.81	30.4	10	18 - 28	113.81 - 103.81		WL	M
DCB087C	Monitoring Well	131.24	74.2	10	61.9 - 71.9	69.34 - 59.34		WL	M
DCB087D	Monitoring Well	132	117.3	10	105 - 115	27 - 37		WL	M
DSWM-4	Surface Water Station	--	--	--	--	--			M
DSWM-4A	Surface Water Station	--	--	--	--	--			M
DSWM-4B	Surface Water Station	--	--	--	--	--			M
DSWM-4C	Surface Water Station	--	--	--	--	--	pH	M	
DSWM-5	Surface Water Station	--	--	--	--	--			M
DSWM-6	Surface Water Station	--	--	--	--	--	pH	M	
DSWM-7	Surface Water Station	--	--	--	--	--	pH	M	
DSWM-9	Surface Water Station	--	--	--	--	--	pH	M	
DSWM-10	Surface Water Station	--	--	--	--	--			M

M = Metals and field parameters including pH
WL = Water elevation measurement only
pH = pH reading of surface water only for performance monitoring of the reactive structures
amsl = above mean sea level

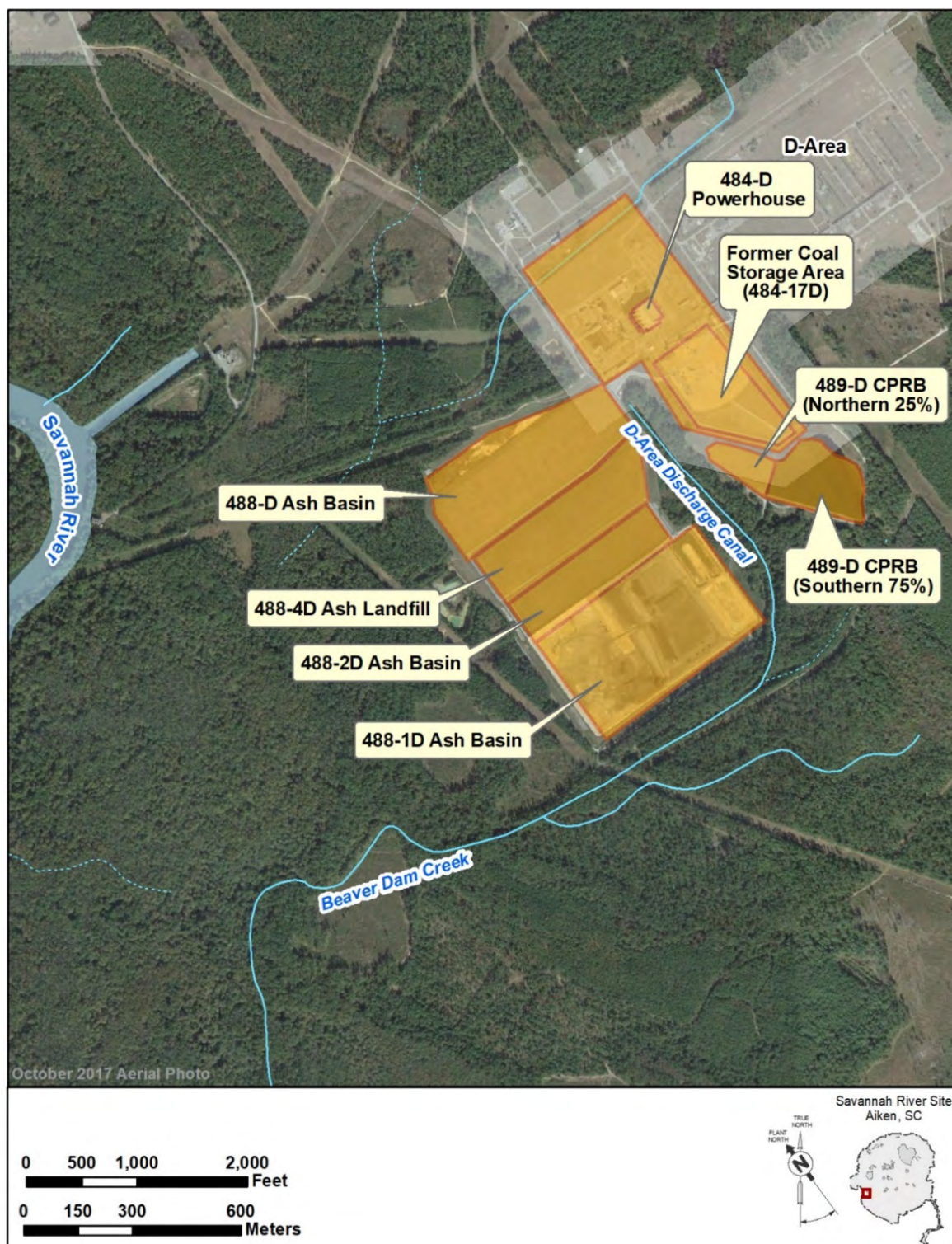


Figure 1. D-Area Powerhouse Associated Facilities

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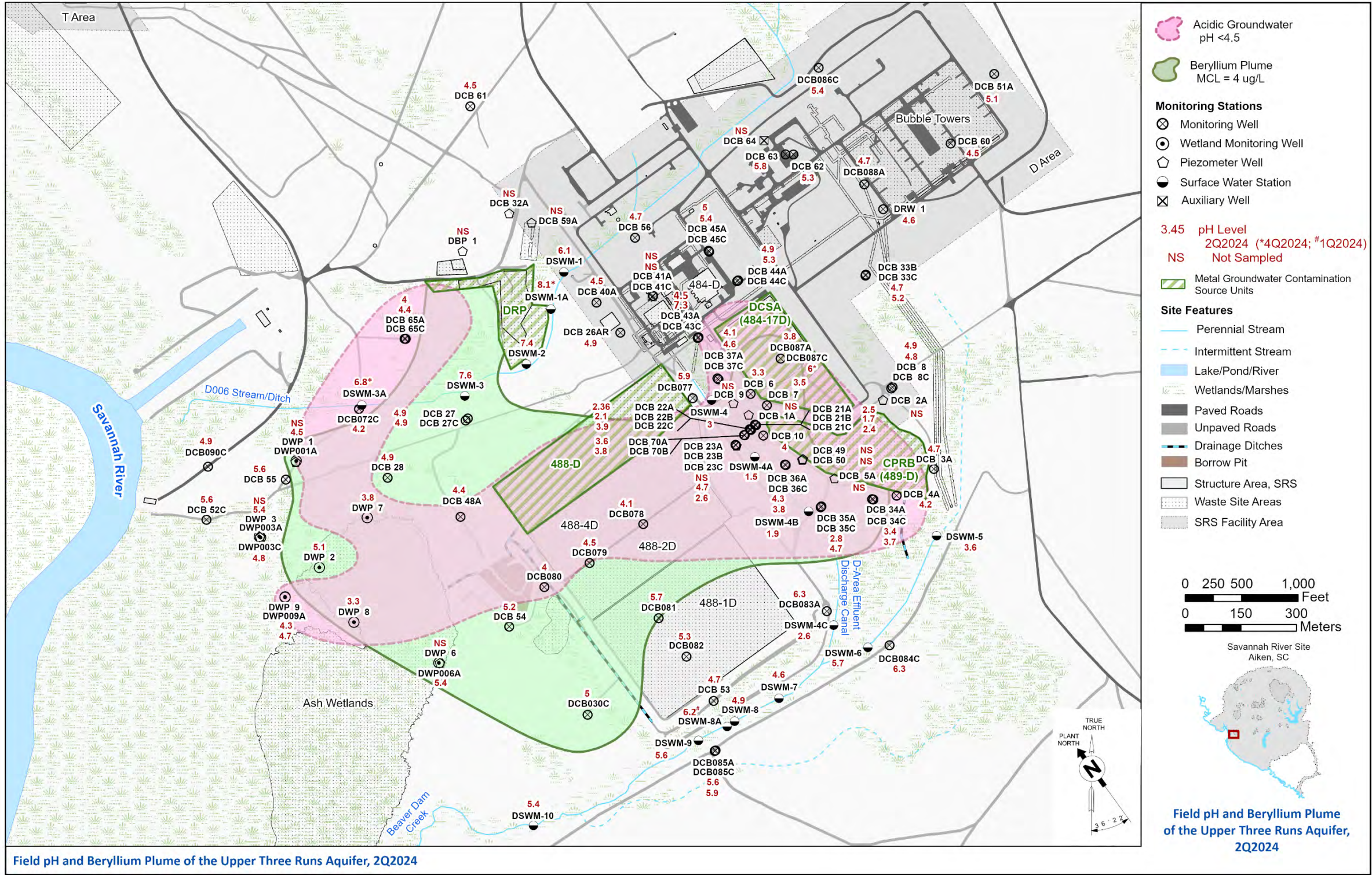


Figure 2. D-Area Groundwater 2Q2024 pH and Beryllium Plume

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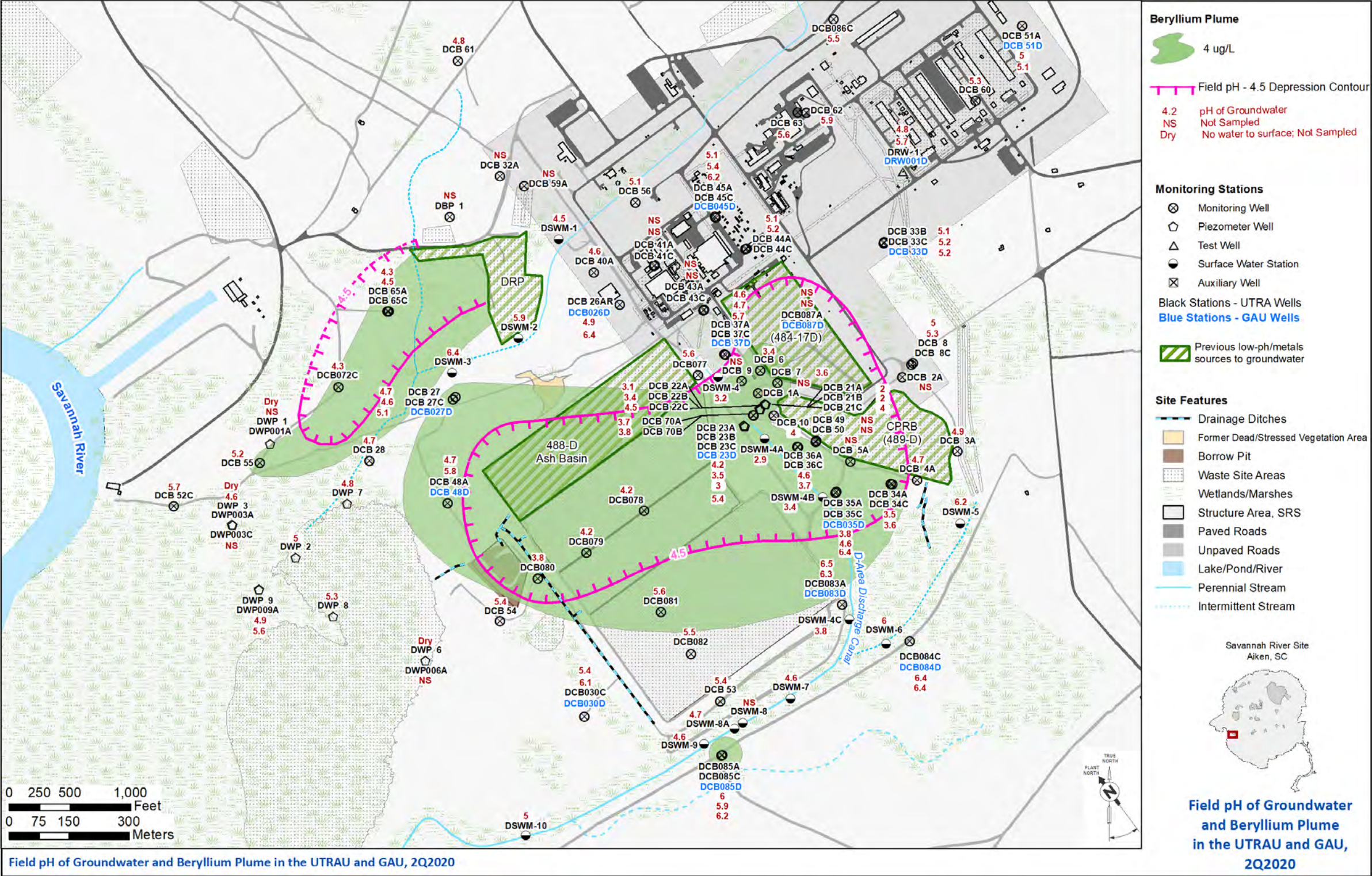


Figure 3. D-Area Groundwater 2Q2020 pH and Beryllium Plume

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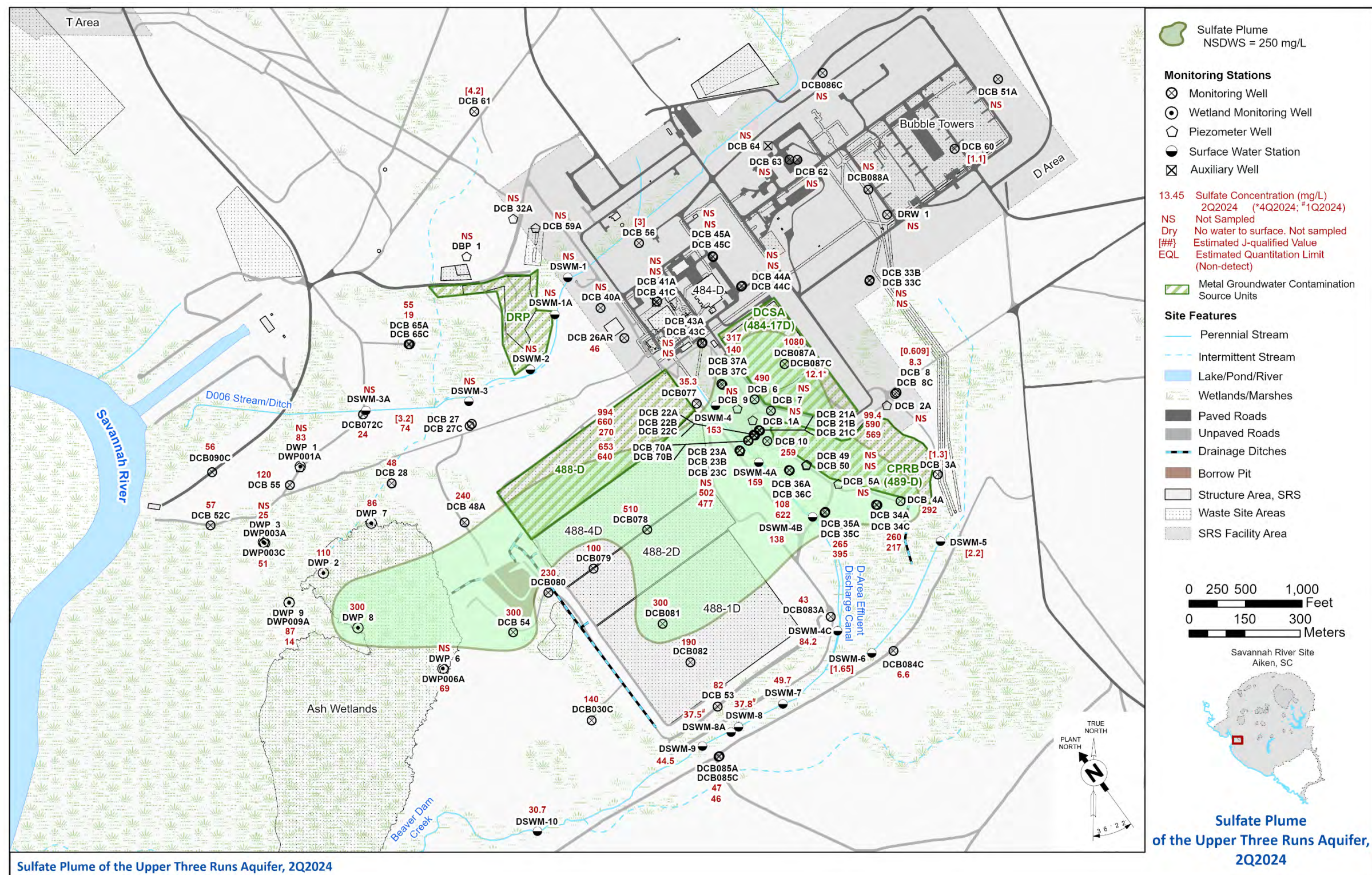
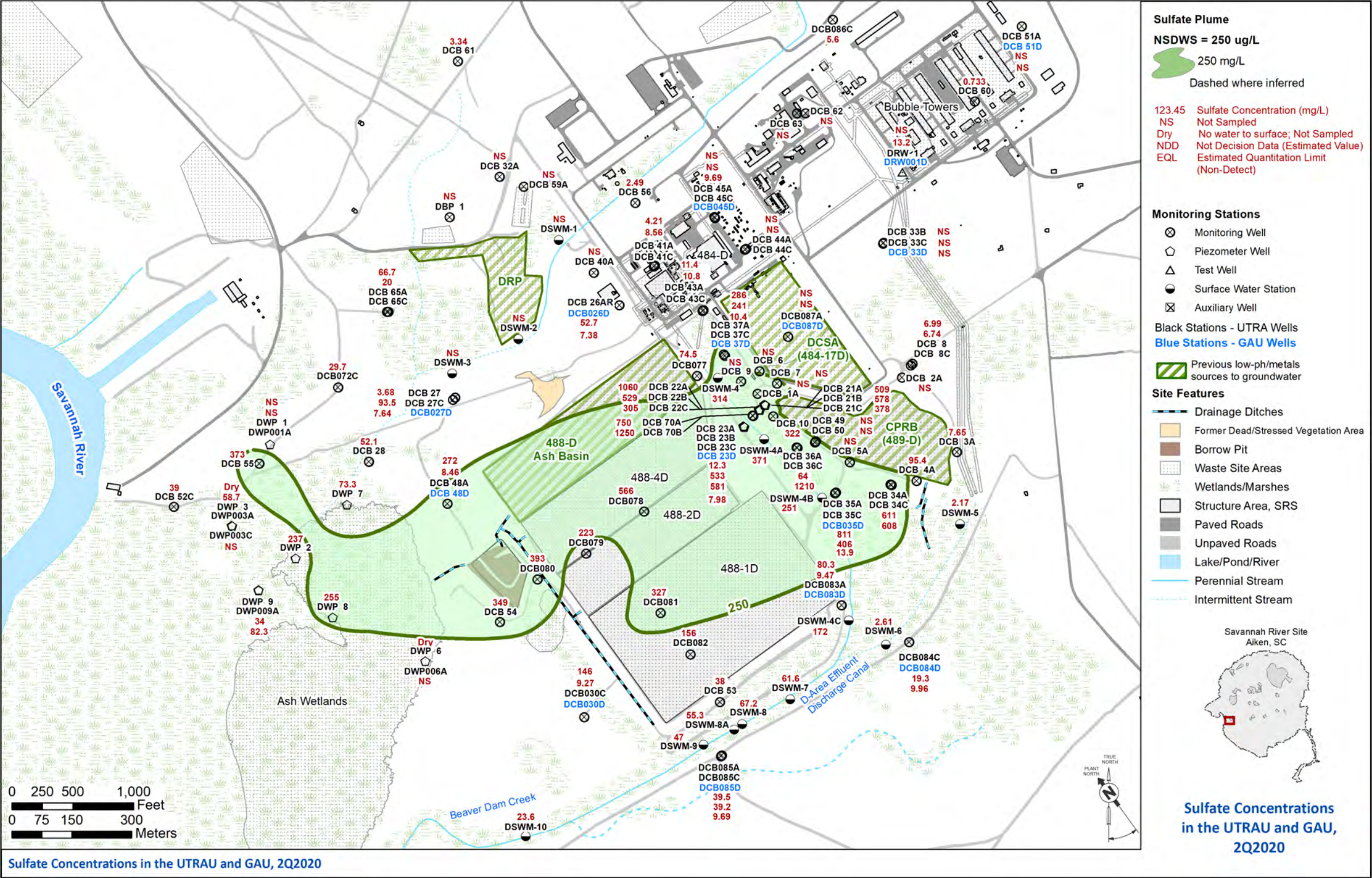


Figure 4. D-Area Groundwater 2Q2024 Sulfate Plume

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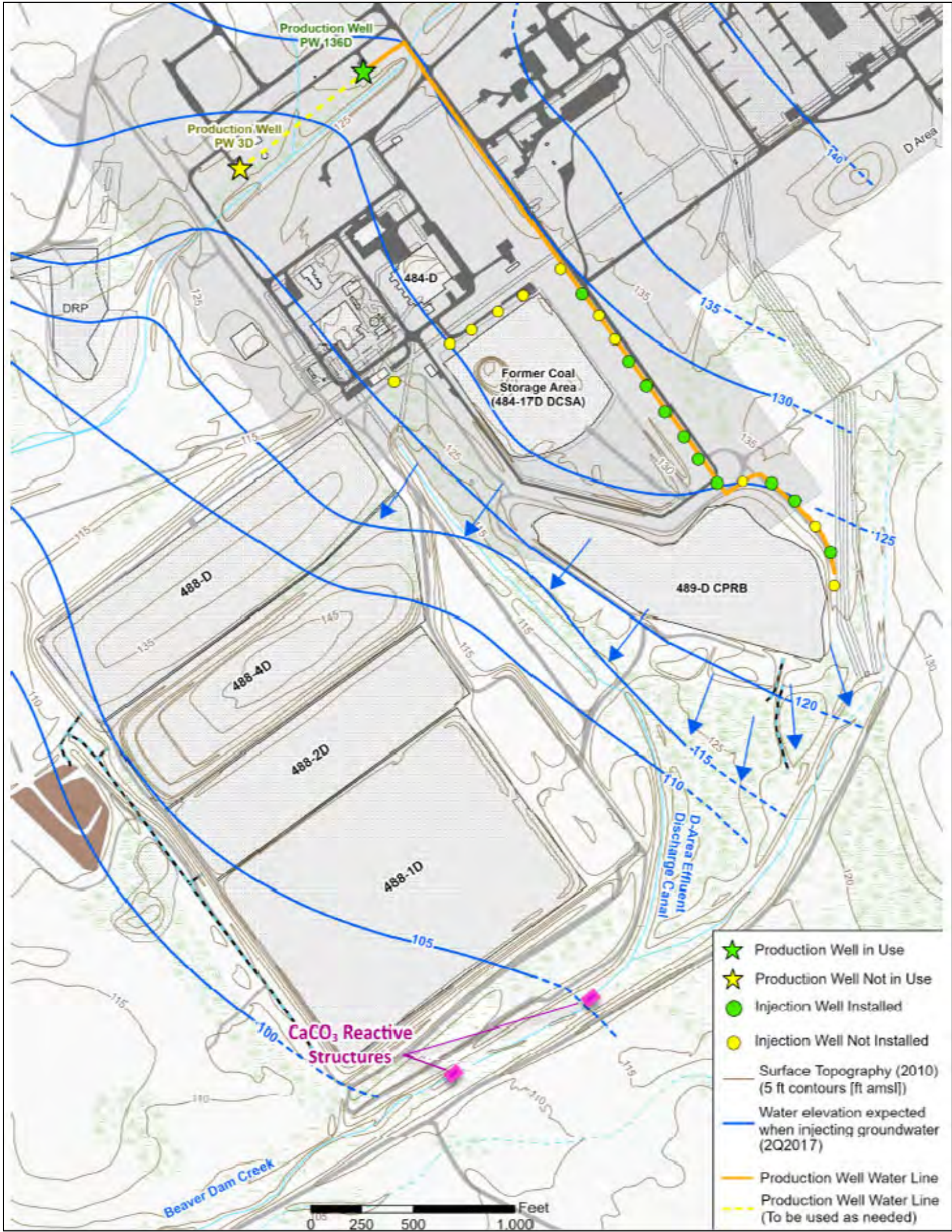


Figure 6. D-Area Treatability Study Injection Wells, Reactive Structure, and Projected Water Table Elevation

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Figure 7. D-Area Injection Wells Installed and Production Well Piping

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Water Volume, ml	CaCO ₃ Mass, g	Initial pH	Final pH	Mass CaCO ₃ per Water Volume, mg/l
Initial		3		0
200	0.018	3.08	3.99	90
200	0.05	3.05	5.75	250
200	0.1	3.02	6.15	500
50	0.1	2.98	6.64	2,000
50	0.25	2.93	6.50	5,000
50	0.5	2.90	6.60	10,000

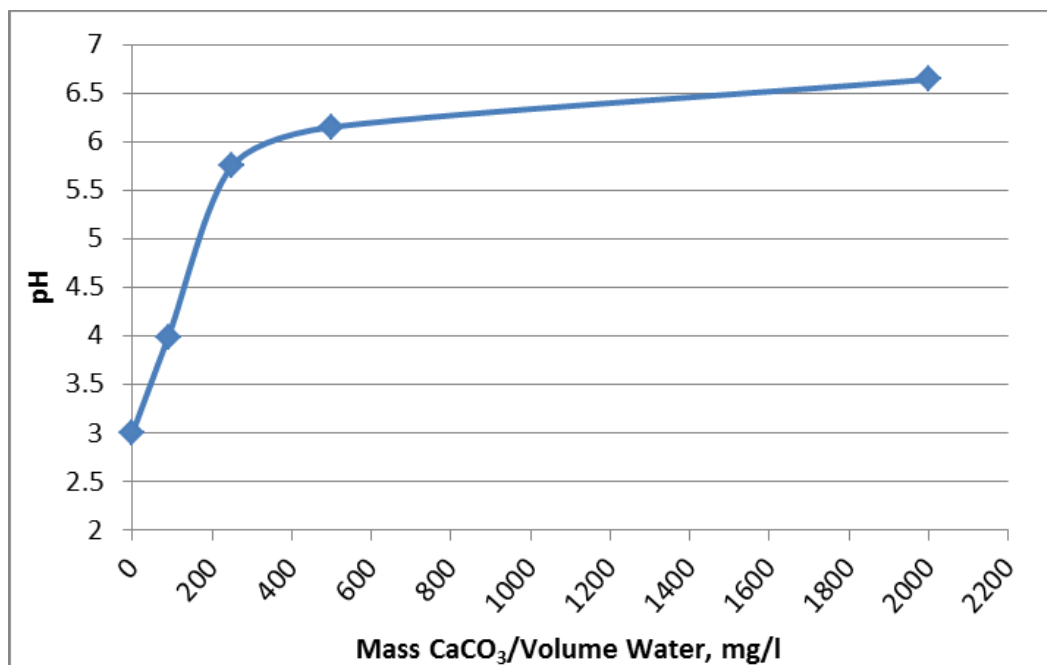


Figure 8. Titration Test Chart and Graph of D-Area Discharge Canal Acidic Surface Water with Calcium Carbonate Additions

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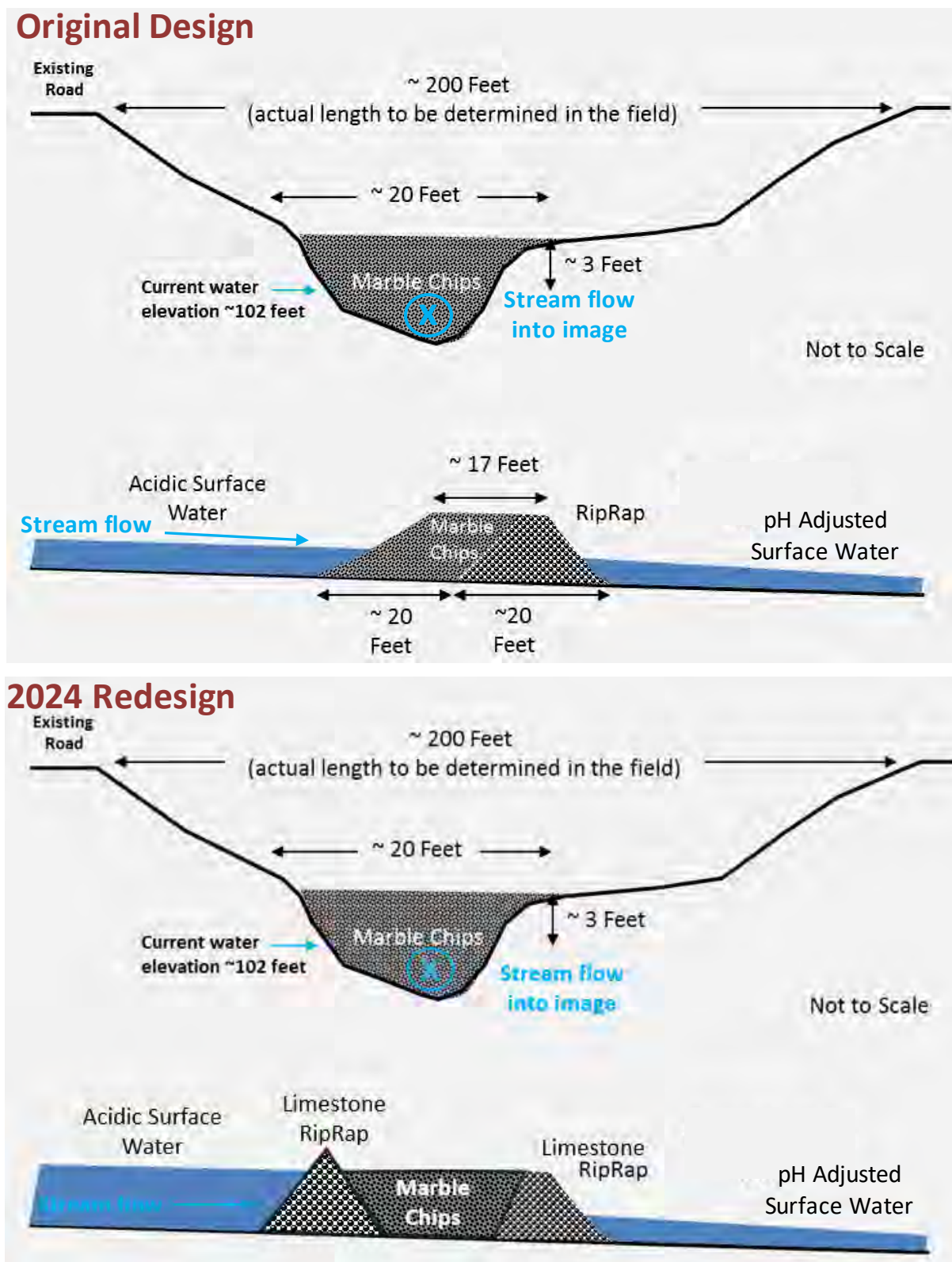


Figure 9. Diagram of CaCO_3 Reactive Structures in the D-Area Discharge Canal

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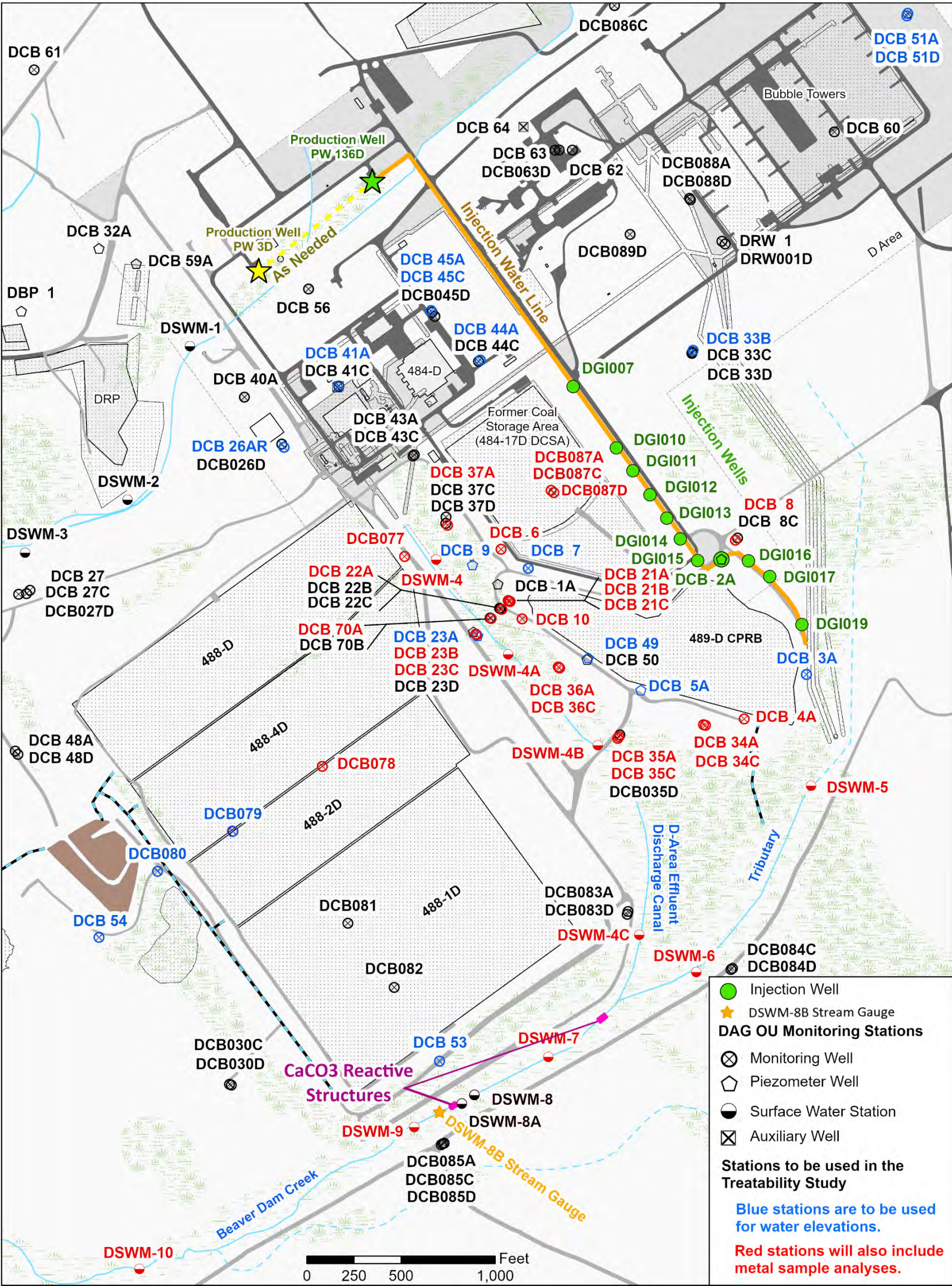


Figure 10. D-Area Treatability Study Monitoring Locations

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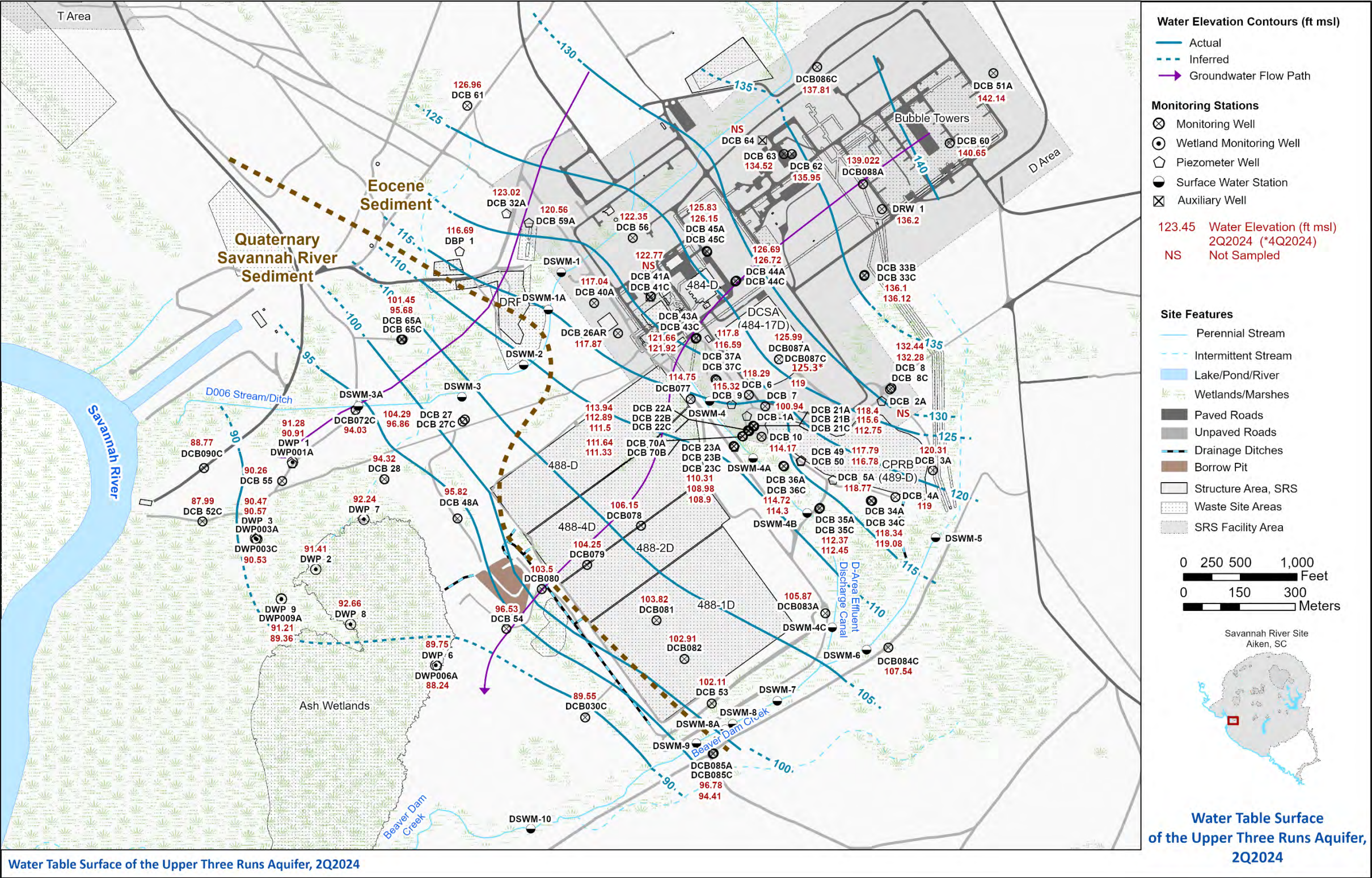


Figure 11. D-Area Groundwater OU UTRA Potentiometric Surface (2Q2024)

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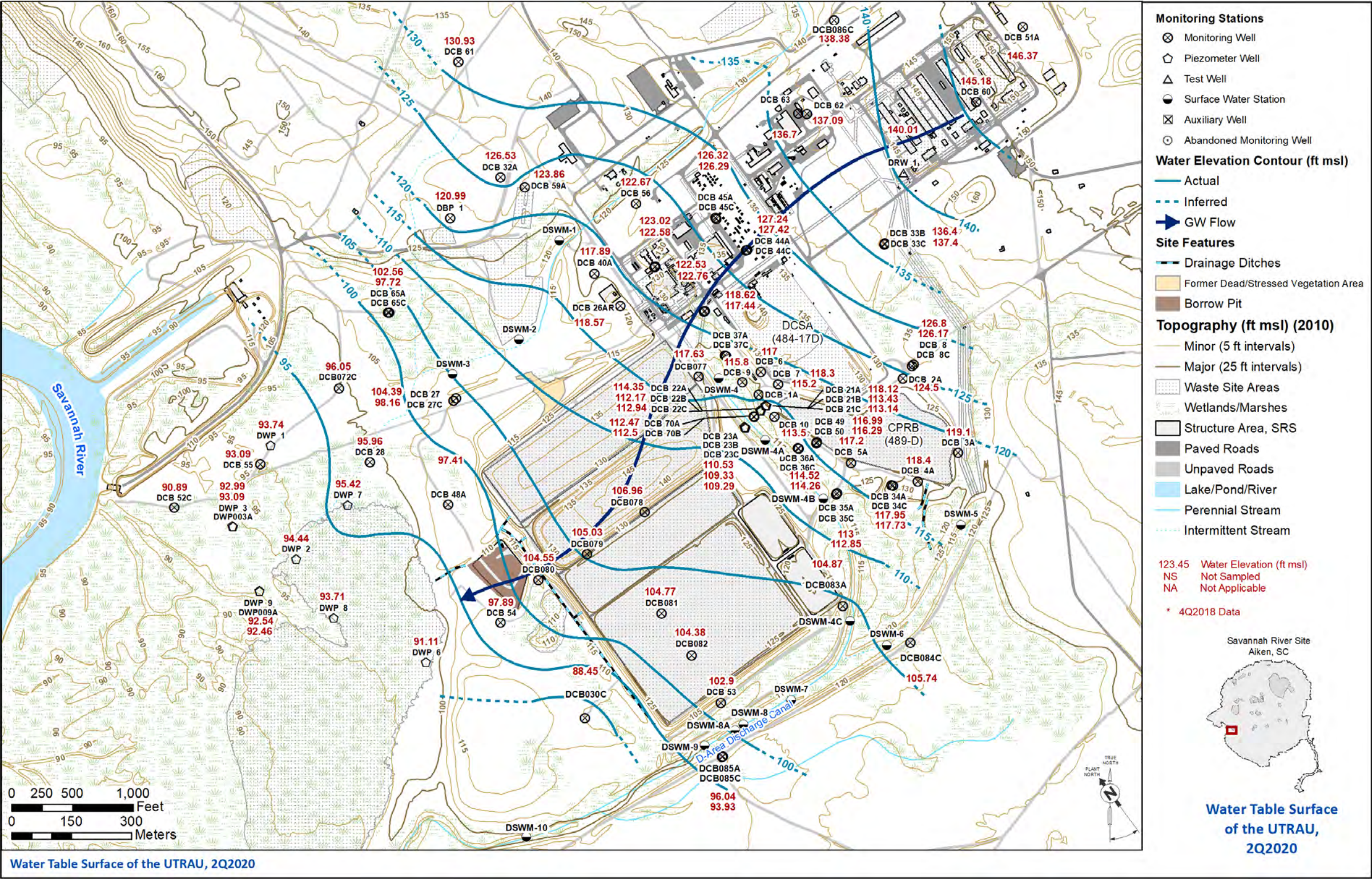


Figure 12. D-Area Groundwater OU UTRA Potentiometric Surface (2Q2020)

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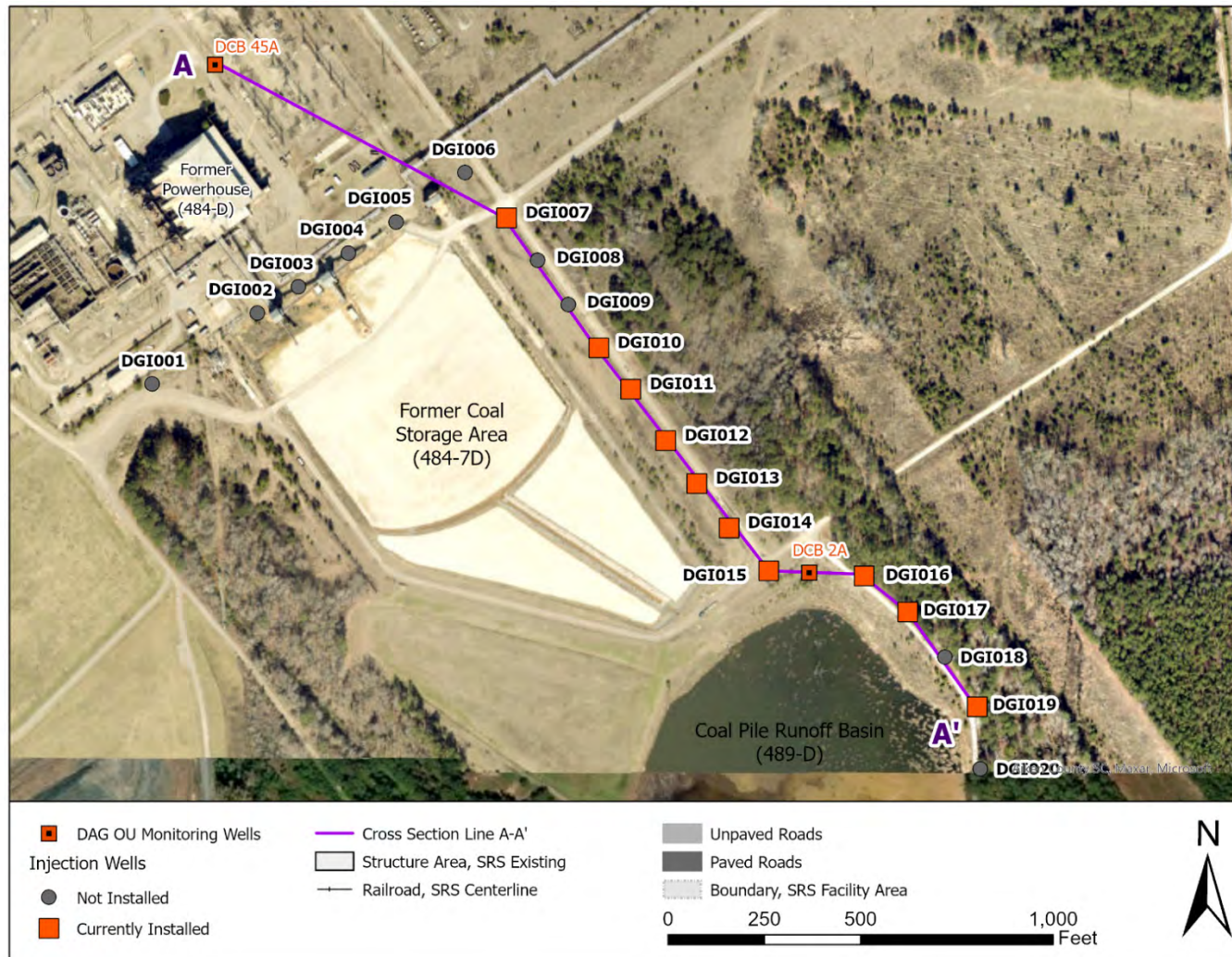


Figure 13. Installed Injection Wells and Cross Section Line A-A'

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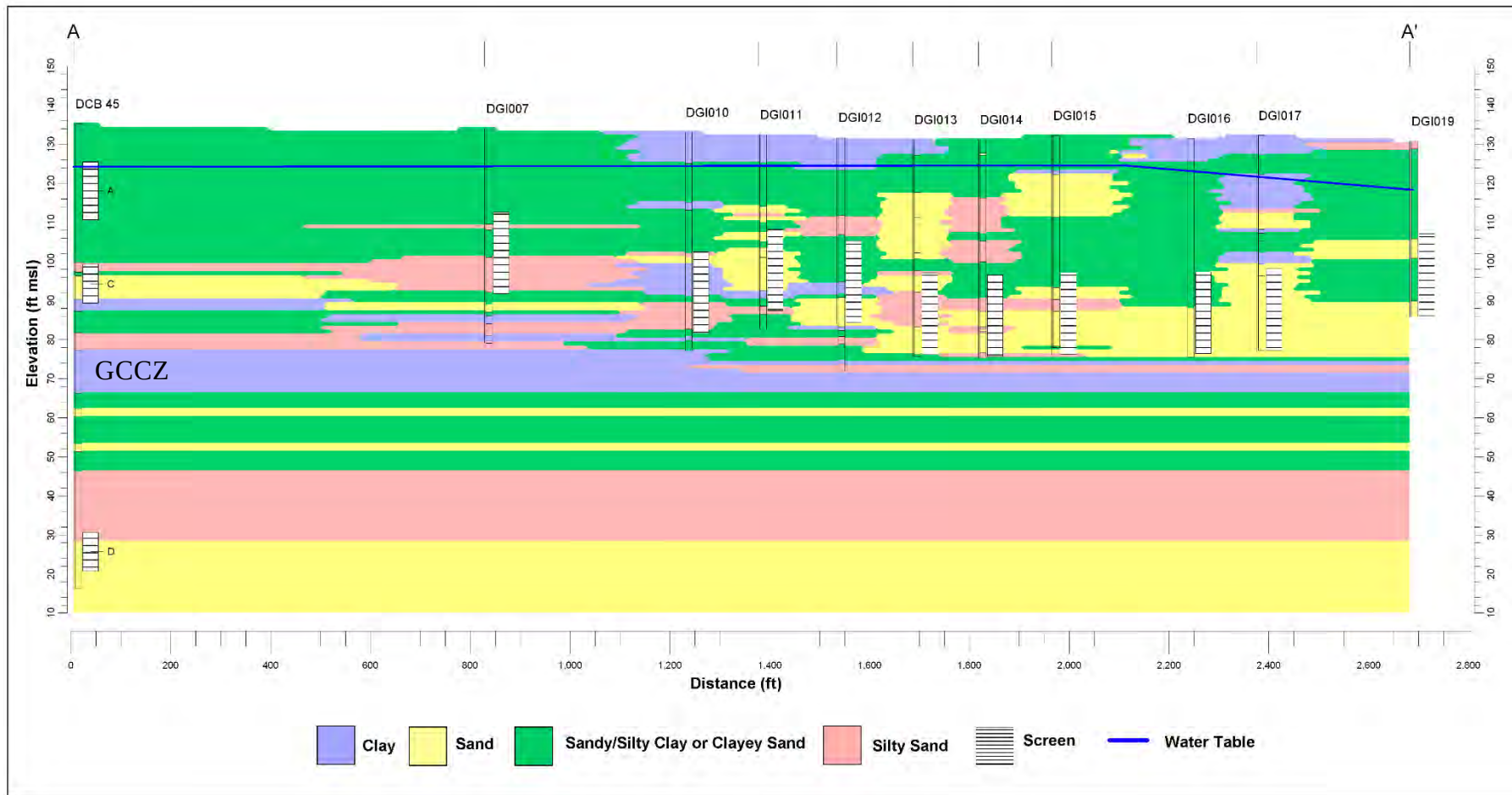


Figure 14. D-Area Injection Well Lithological Cross-Section A-A'

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Figure 15. D-Area Treatability Study Pipeline Installation

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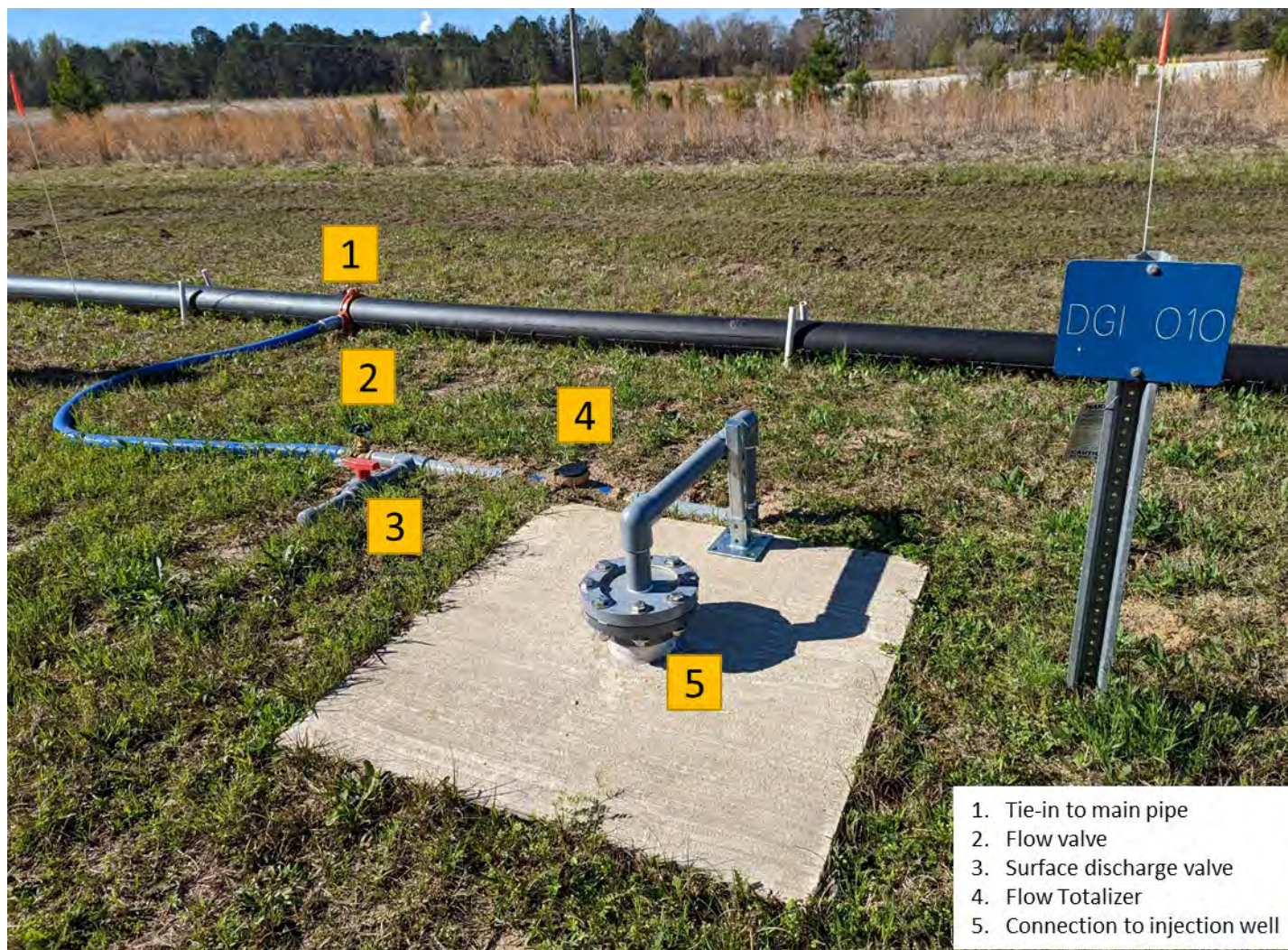
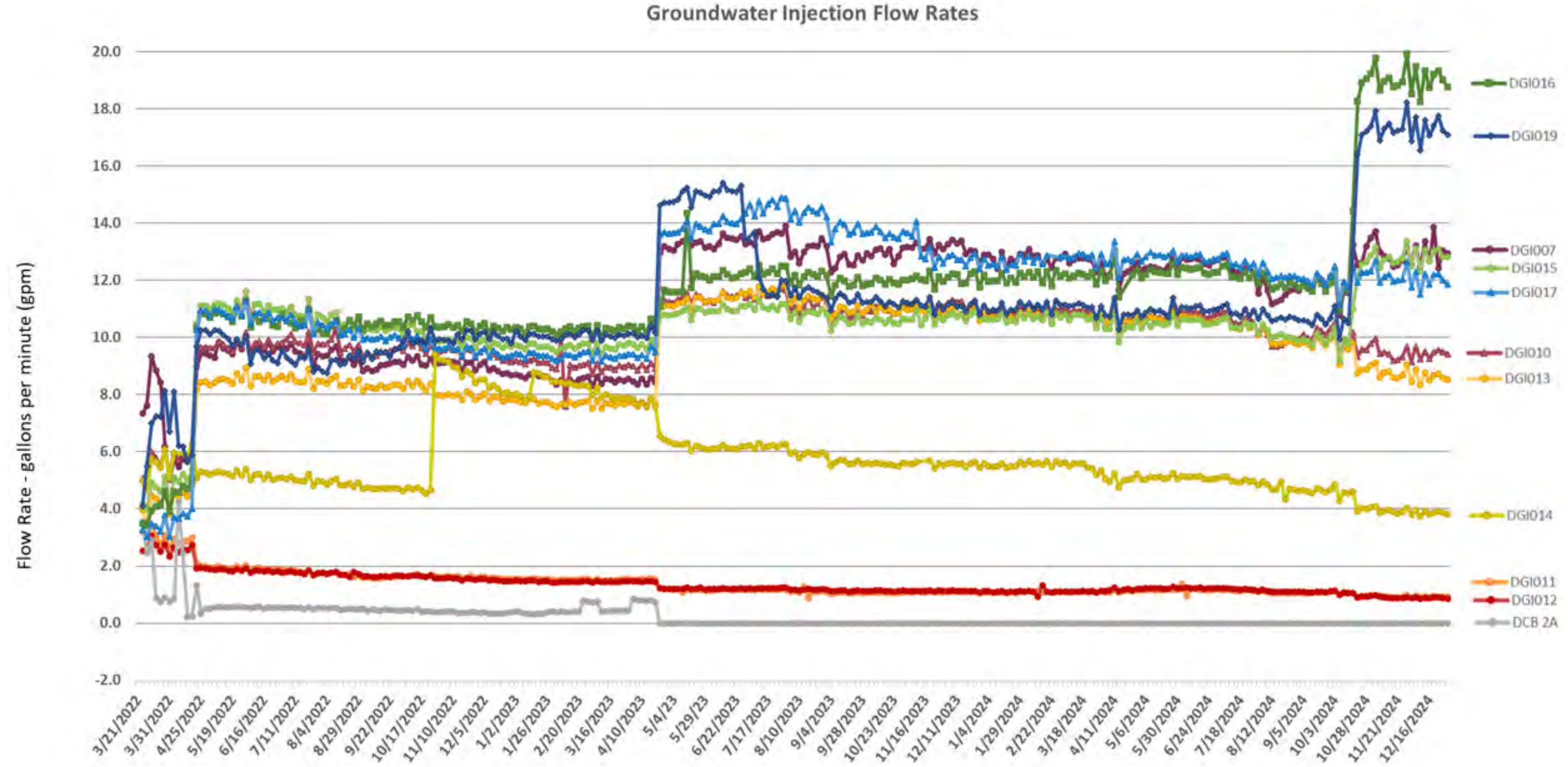


Figure 16. Injection Well Connection to Pipeline (DGI010)

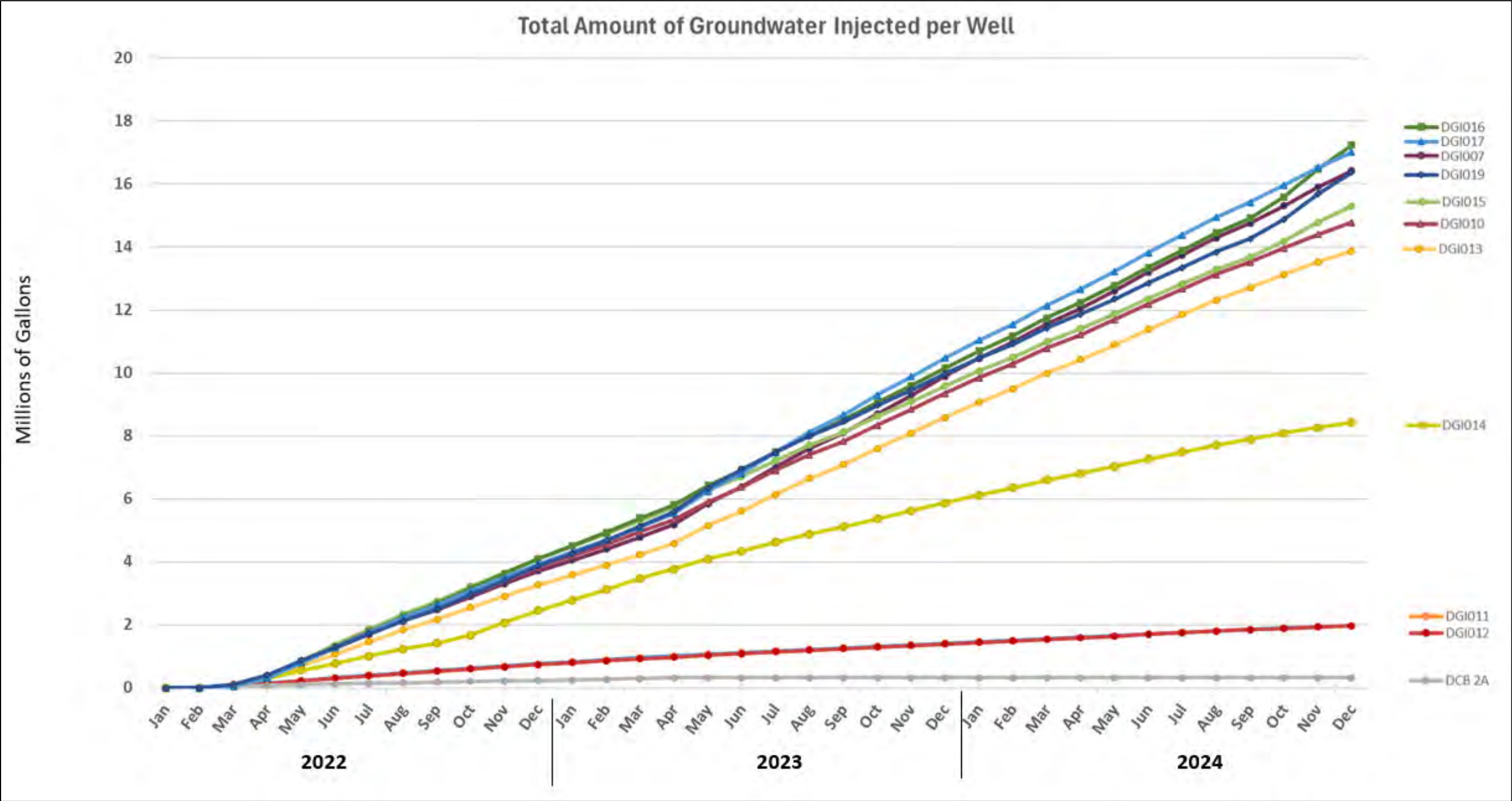
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(the electronic data set is provided in the Excel table, tab "Injection_Data")

Figure 17. Graph of Injection Well Flow Rates for 2022 through 2024

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(the electronic data set is in the Excel table, tab “Injection_Data”)

Figure 18. Cumulative Groundwater Injection Volumes Per Well (in millions of gallons)

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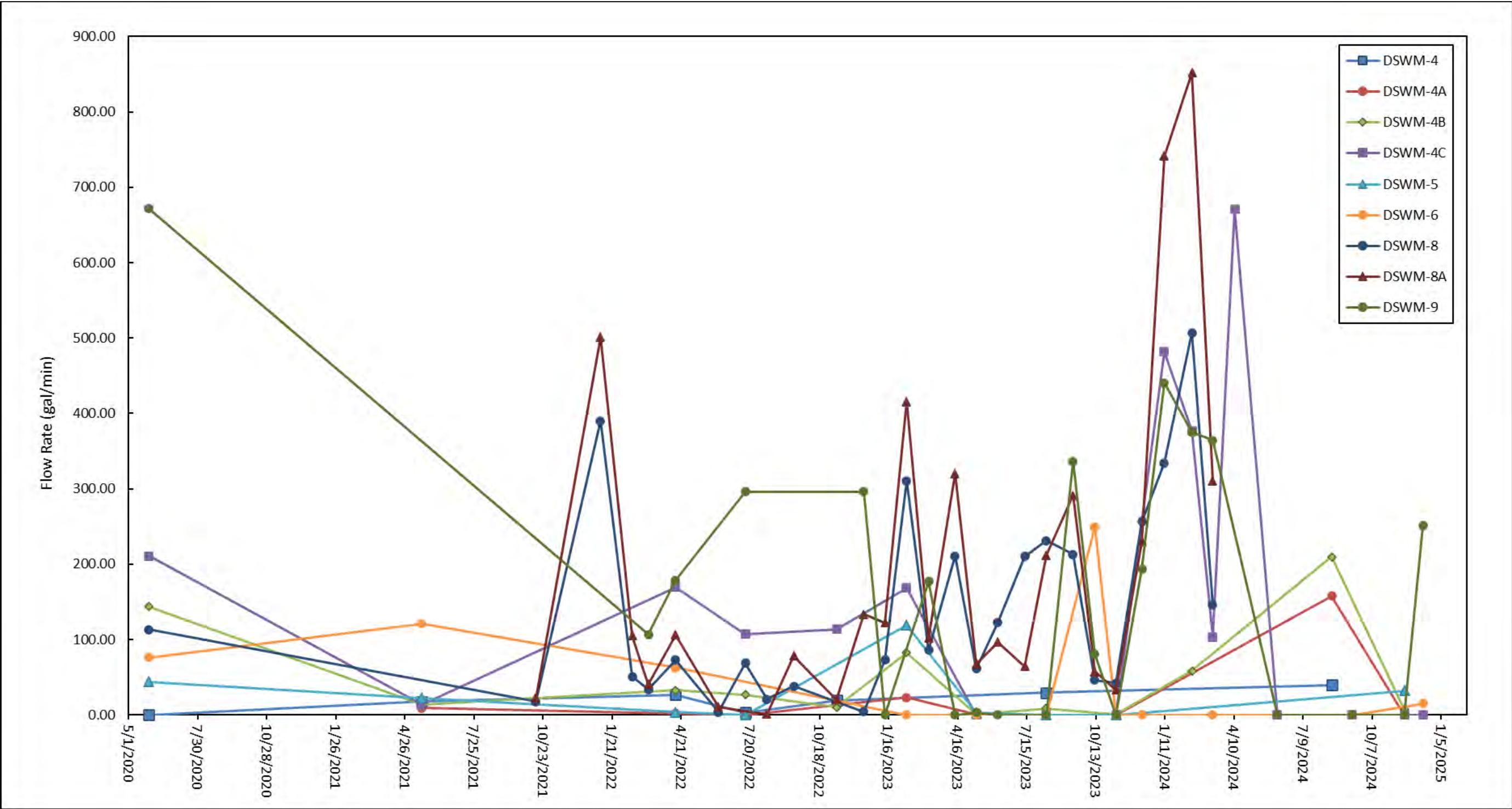


Figure 19. D-Area Effluent Discharge Canal Stream Flow Measurements

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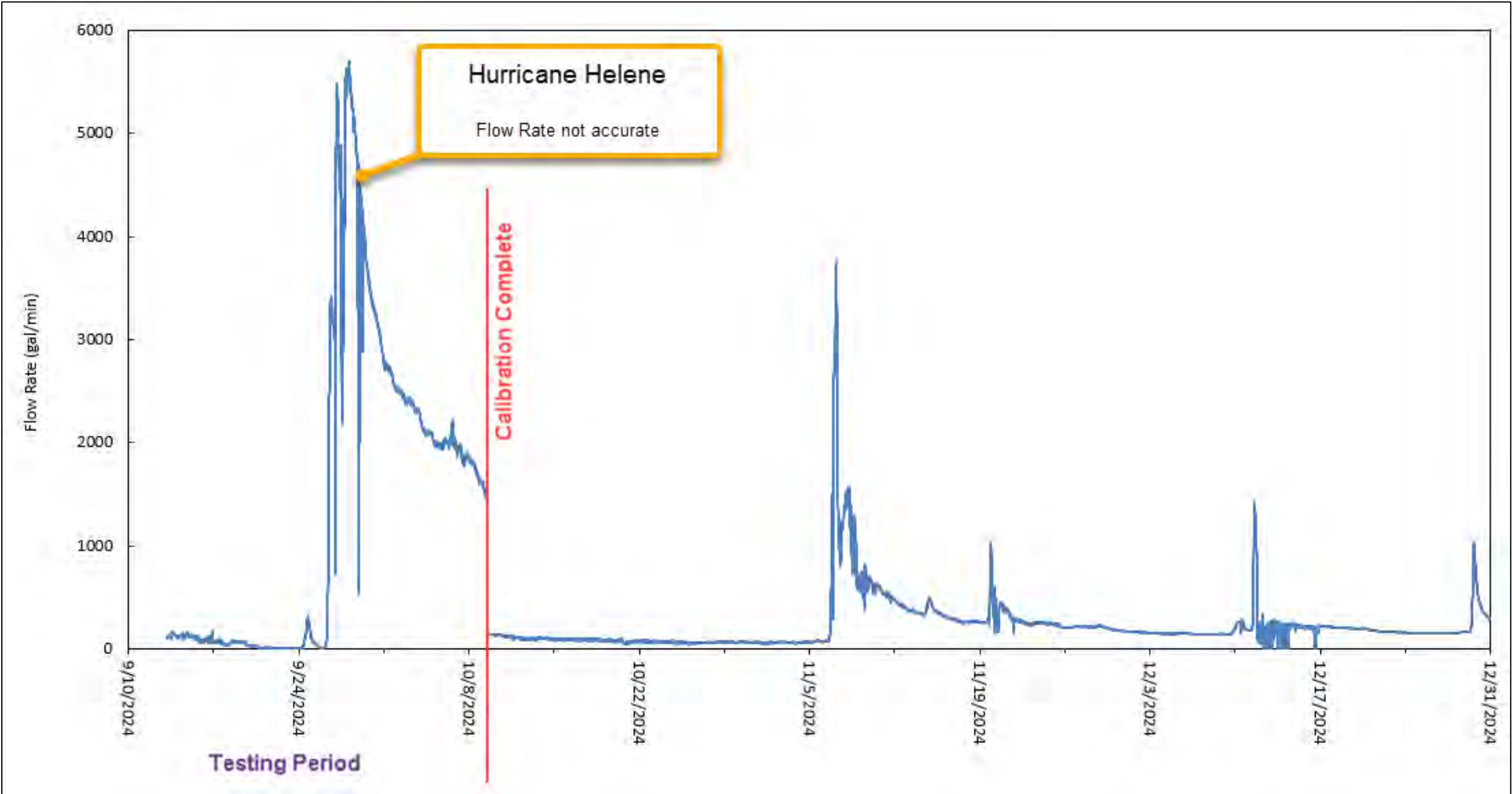


Figure 20. D-Area Effluent Discharge Canal Stream Continuous Flow Measurements

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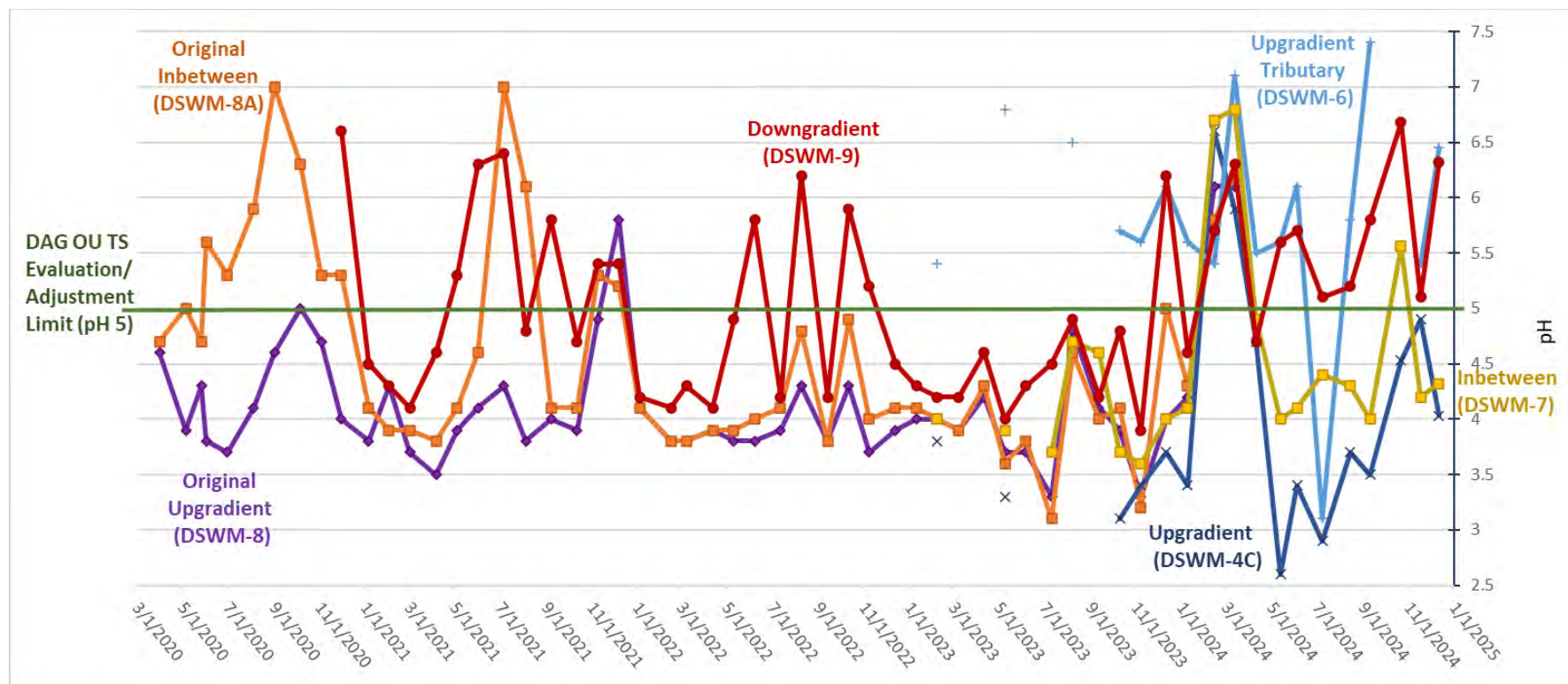


Figure 21. CaCO_3 Reactive Structure Surface Water pH Results

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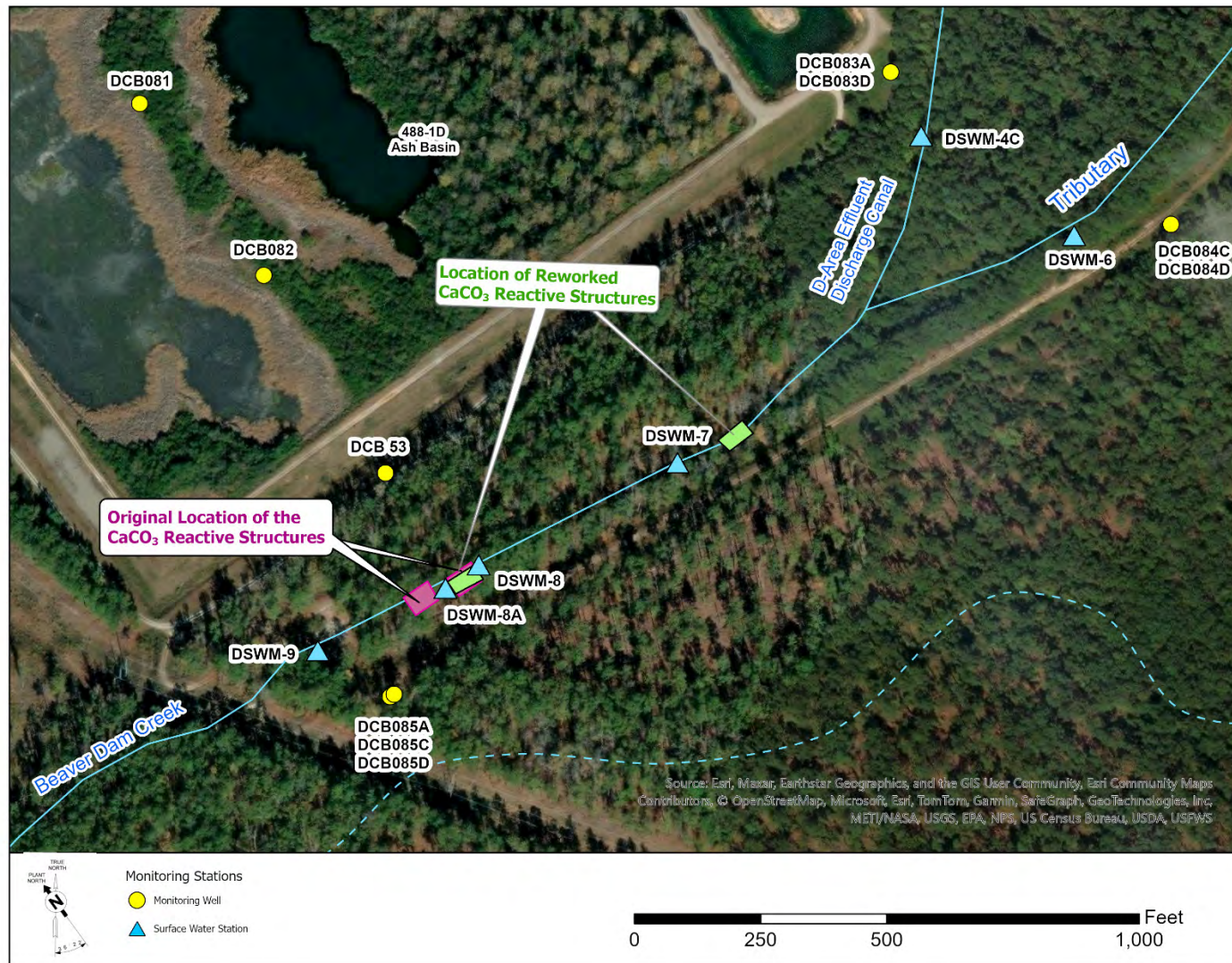


Figure 22. Location of the Reworked CaCO₃ Reactive Structures

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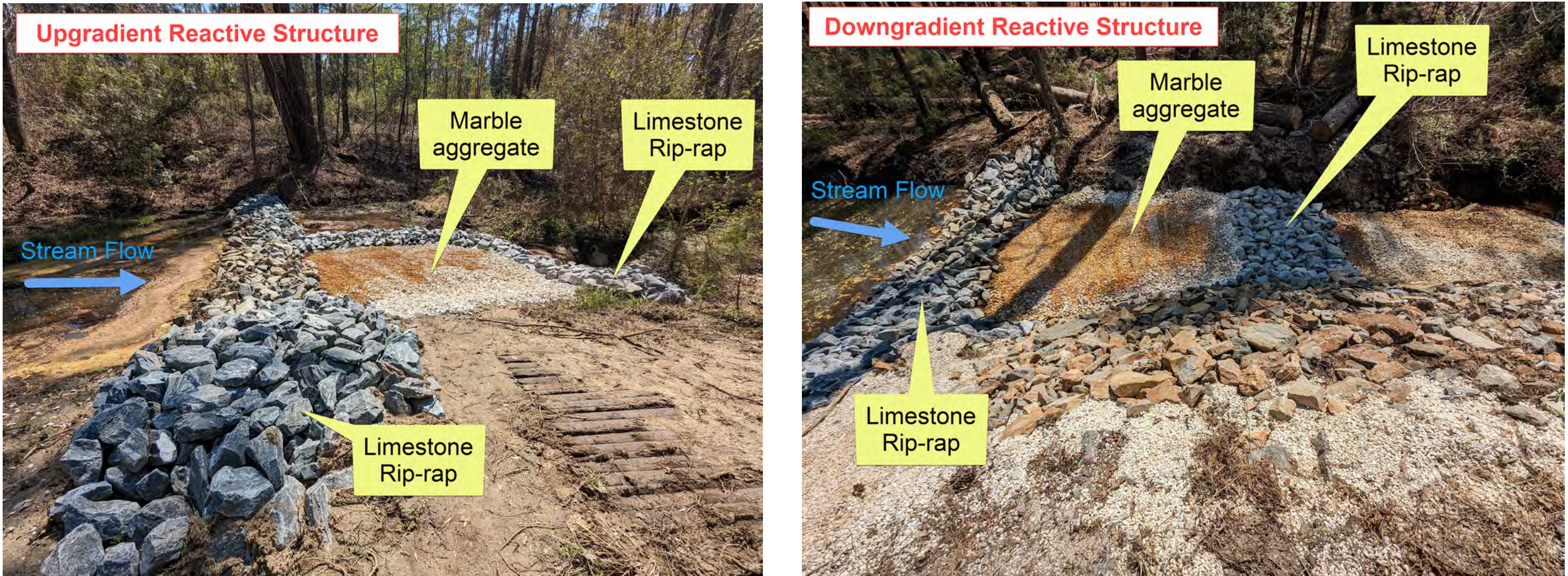


Figure 23. D-Area Effluent Discharge Canal Reactive Structures (March 2024)

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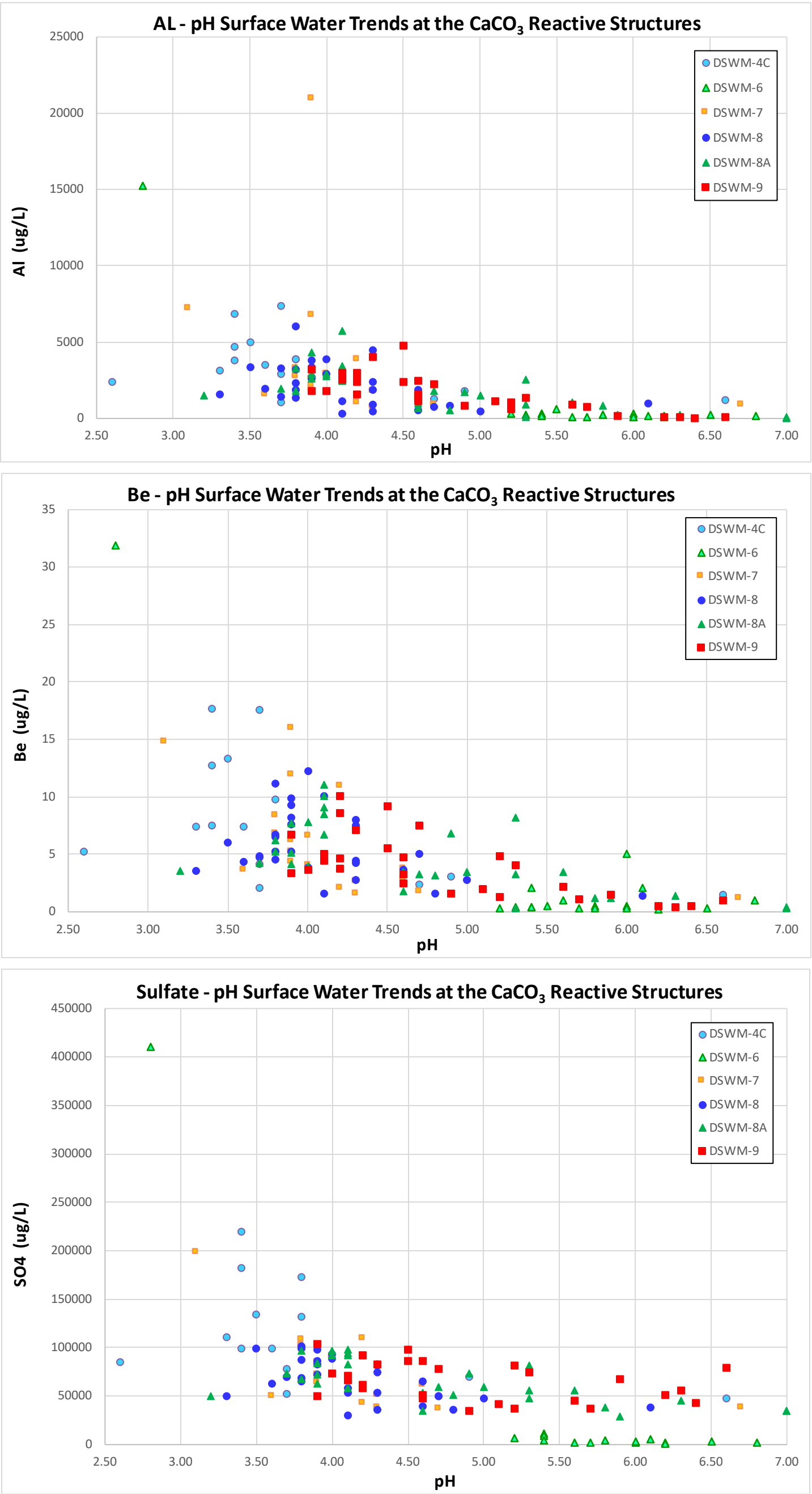


Figure 24. Surface Water Concentrations of pH vs. Beryllium, Aluminum, and Sulfate at Multiple Surface Locations in the D-Area Effluent Discharge Canal

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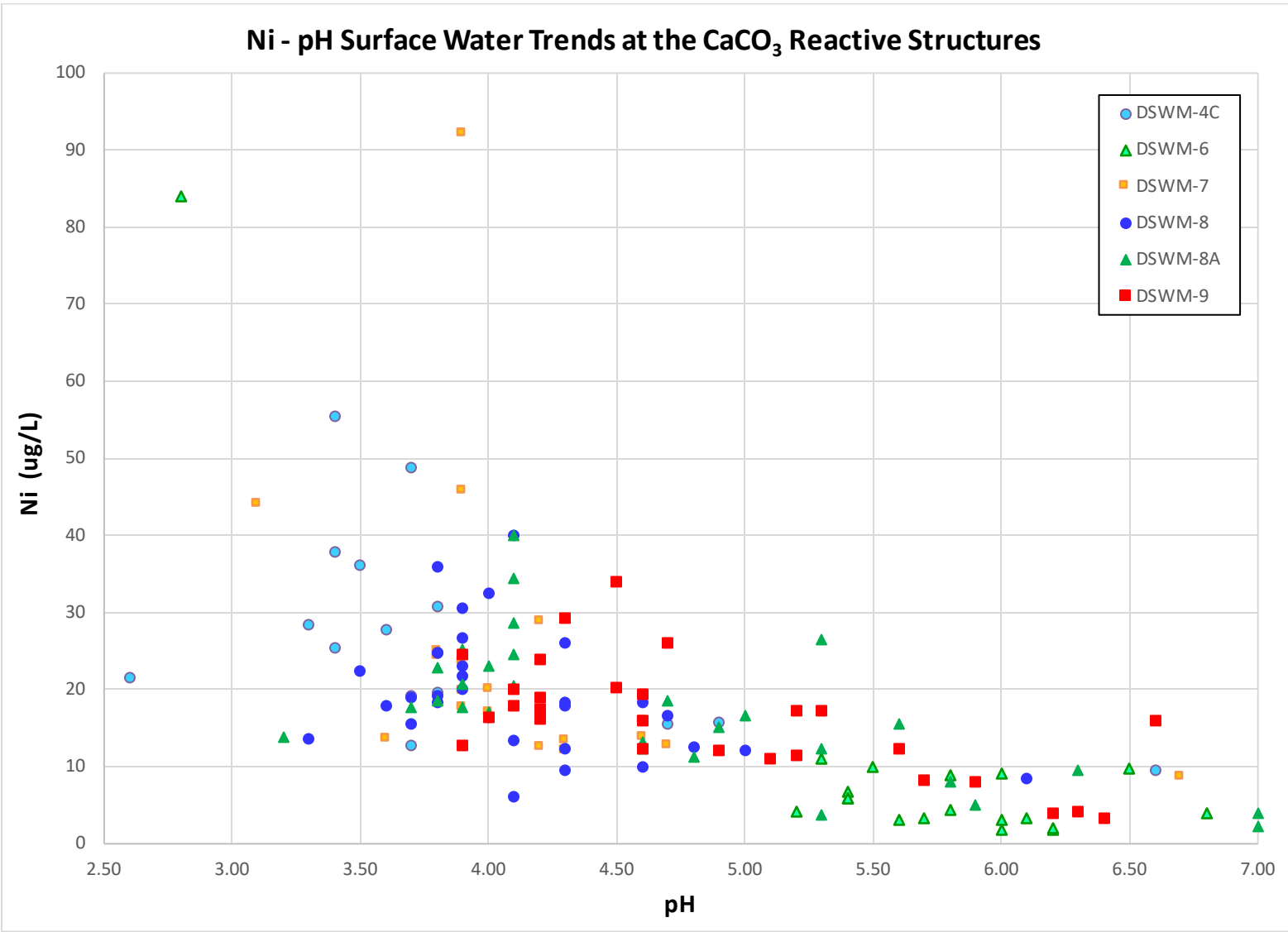
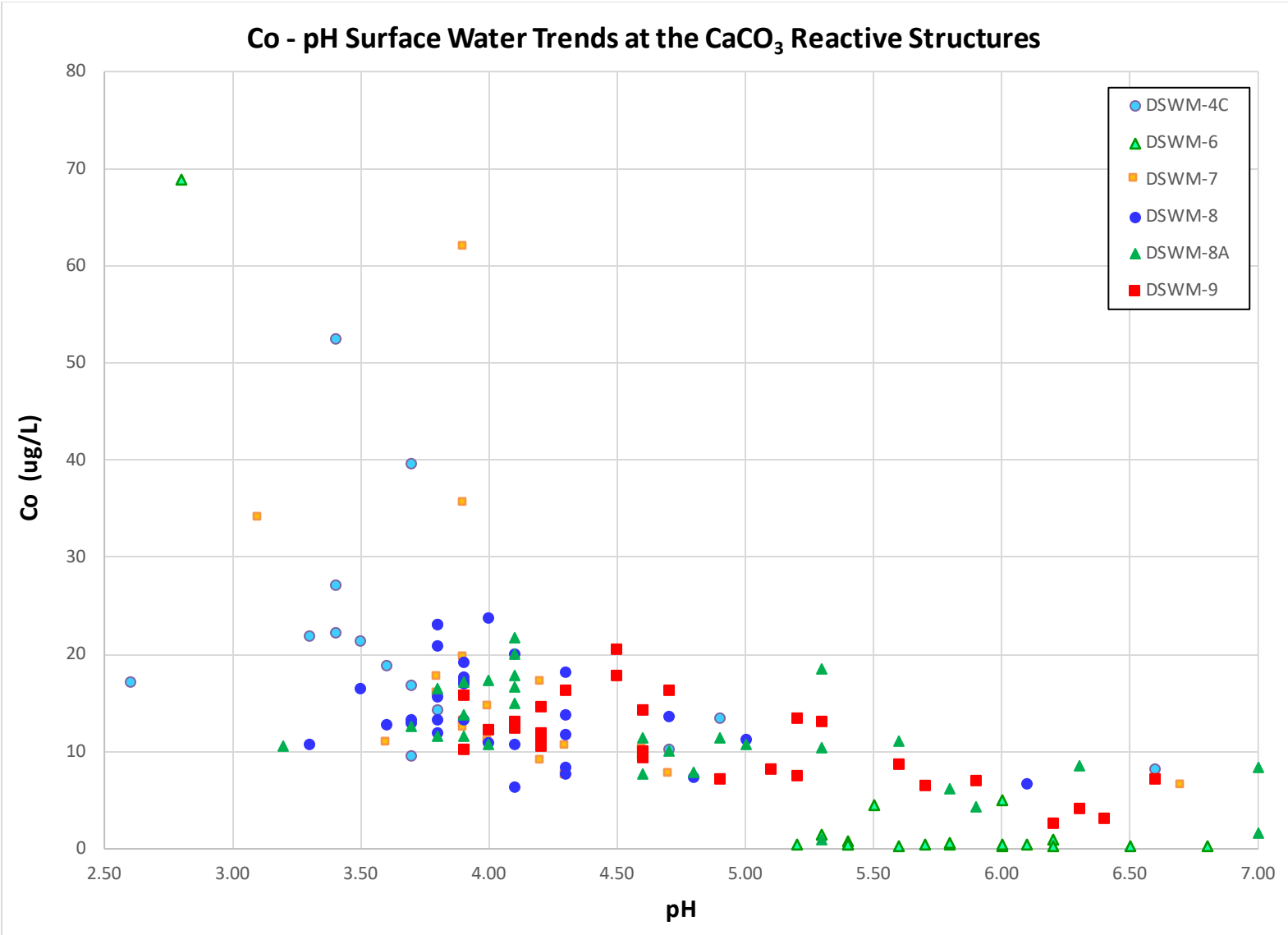


Figure 25. Surface Water Concentrations of pH vs Cobalt and Nickel at at Multiple Surface Locations in the D-Area Effluent Discharge Canal

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APPENDIX A

D-Area Groundwater Treatability Study Data Tables

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Table A-1.
D-Area Groundwater Treatability
Study Data Table (2024)

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Table A-1. D-Area Groundwater Treatability Study Data Table (2024)

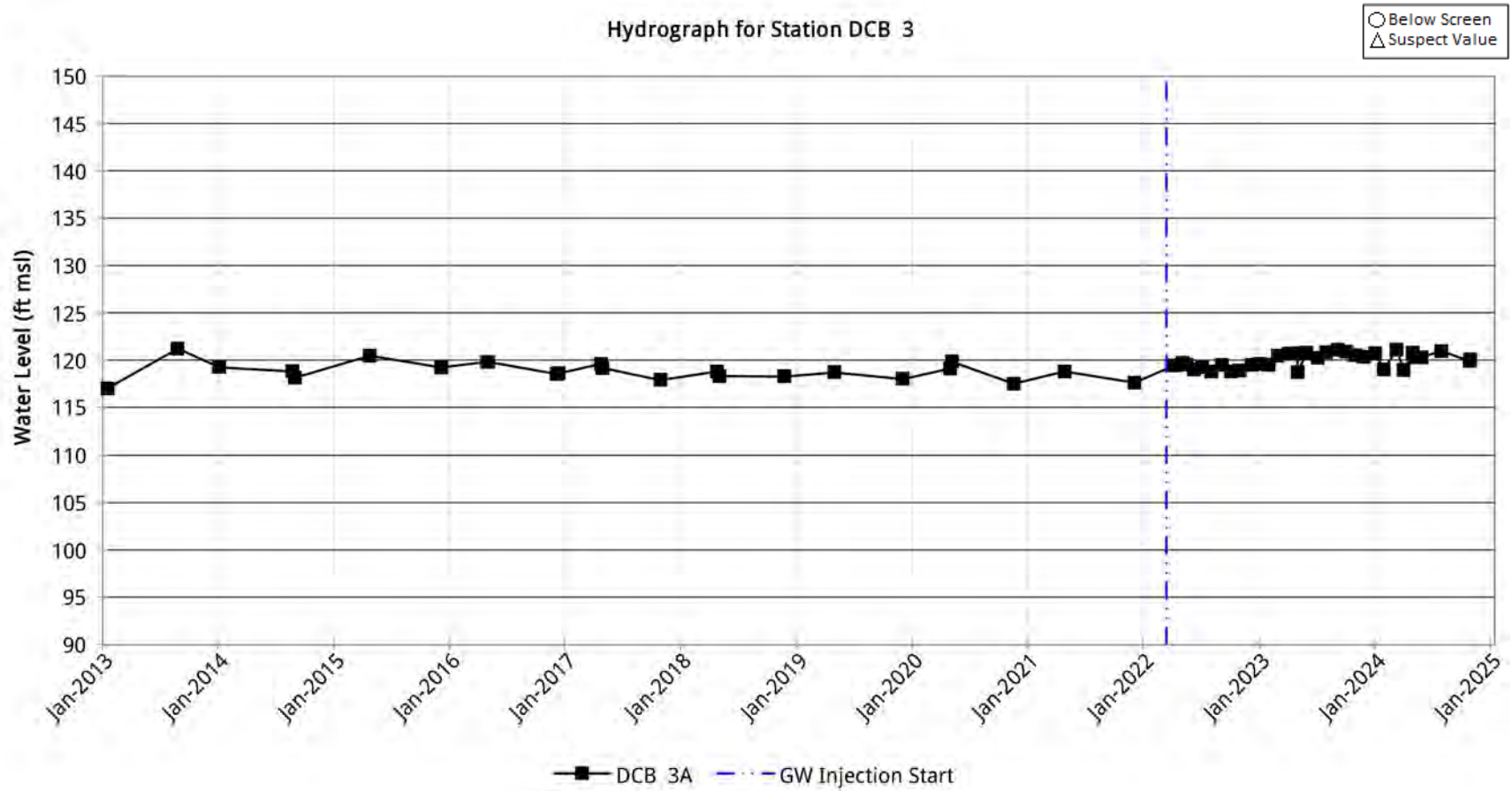
Table A-1. D-Area Groundwater Treatability Study Data Table (2024)										D Area Analyte Suite									
Field Data										Inorganics									
day-month-year SAMPLE COLLECTION DATE																			
ft																			
ft																			
day-month-year SYNCHRONOUS MEASUREMENT DATA																			
ft																			
TURBIDITY																			
pH																			
WATER TEMPERATURE																			
SPECFIC CONDUCTANCE																			
TOTAL ALKALINITY (AS CaCO3)																			
OXIDATION/REDUCTION POTENTIAL																			
OXYGEN																			
Constituent																			
FIELD CONDITIONS																			

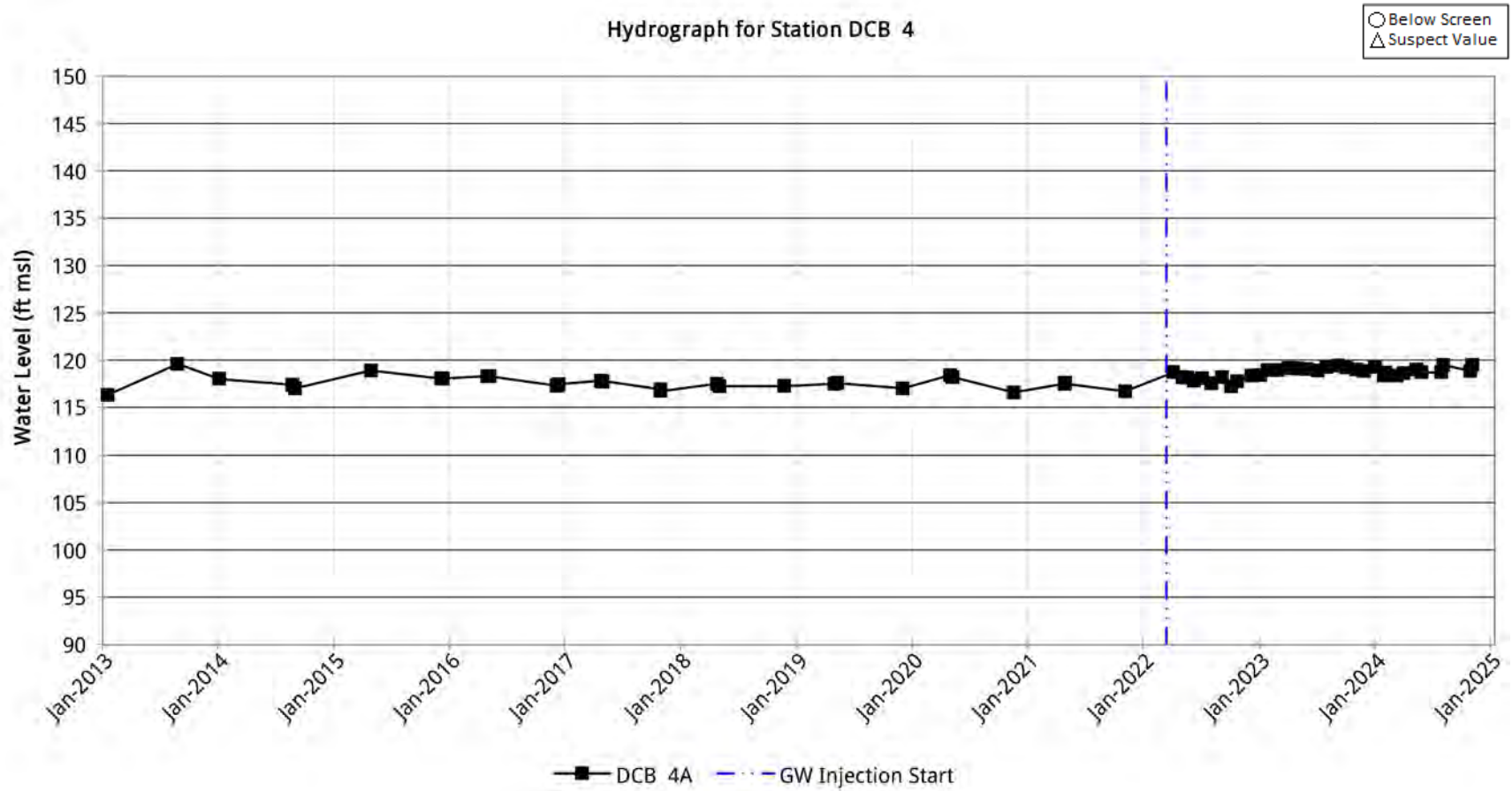
Table A-2. D-Area Groundwater Treatability Study Data Table (2020)			Field Data																							D Area Analyte Suite																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
			SAMPLE COLLECTION DATE	SYNCHRONOUS MEASUREMENT DATE	SYNCHRONOUS WATER ELEVATION	SAMPLING EVENT DEPTH TO WATER	SAMPLING EVENT WATER ELEVATION	VOLUME PURGED	TURBIDITY	PH	WATER TEMPERATURE	SPECIFIC CONDUCTANCE	TOTAL ALKALINITY (AS CaCO3)	OXIDATION/REDUCTION POTENTIAL	OXYGEN	Constituent	FIELD CONDITIONS	Inorganics																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
																		ALUMINUM	ANTIMONY	ARSENIC	BARIUM	BERYLLIUM	CADMIUM	CALCIUM	CHROMIUM	COBALT	COPPER	IRON	LEAD	MAGNESIUM	MANGANESE	MERCURY	NICKEL	POTASSIUM	SELENIUM	SILVER	SODIUM	SULFATE	THALLIUM	URANIUM	VANADIUM	ZINC																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
Station	Well Use	Aquifer Zone	day-month-year	day-month-year	ft	ft	ft	gal	NTU	pH	degC	uS/cm	mg/L	mV	mg/L	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS	NPDS	Unit	PRG	NSDWS

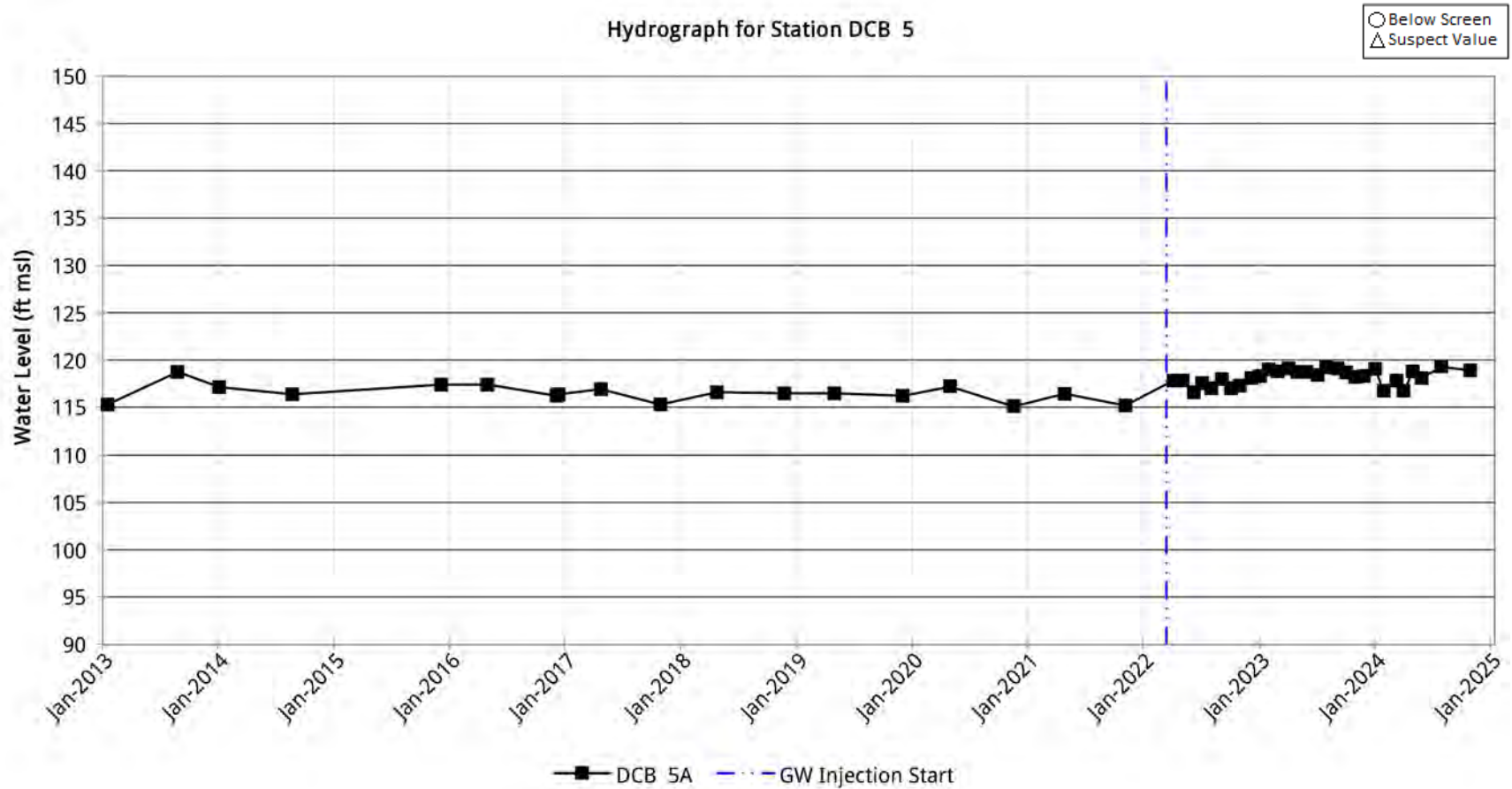
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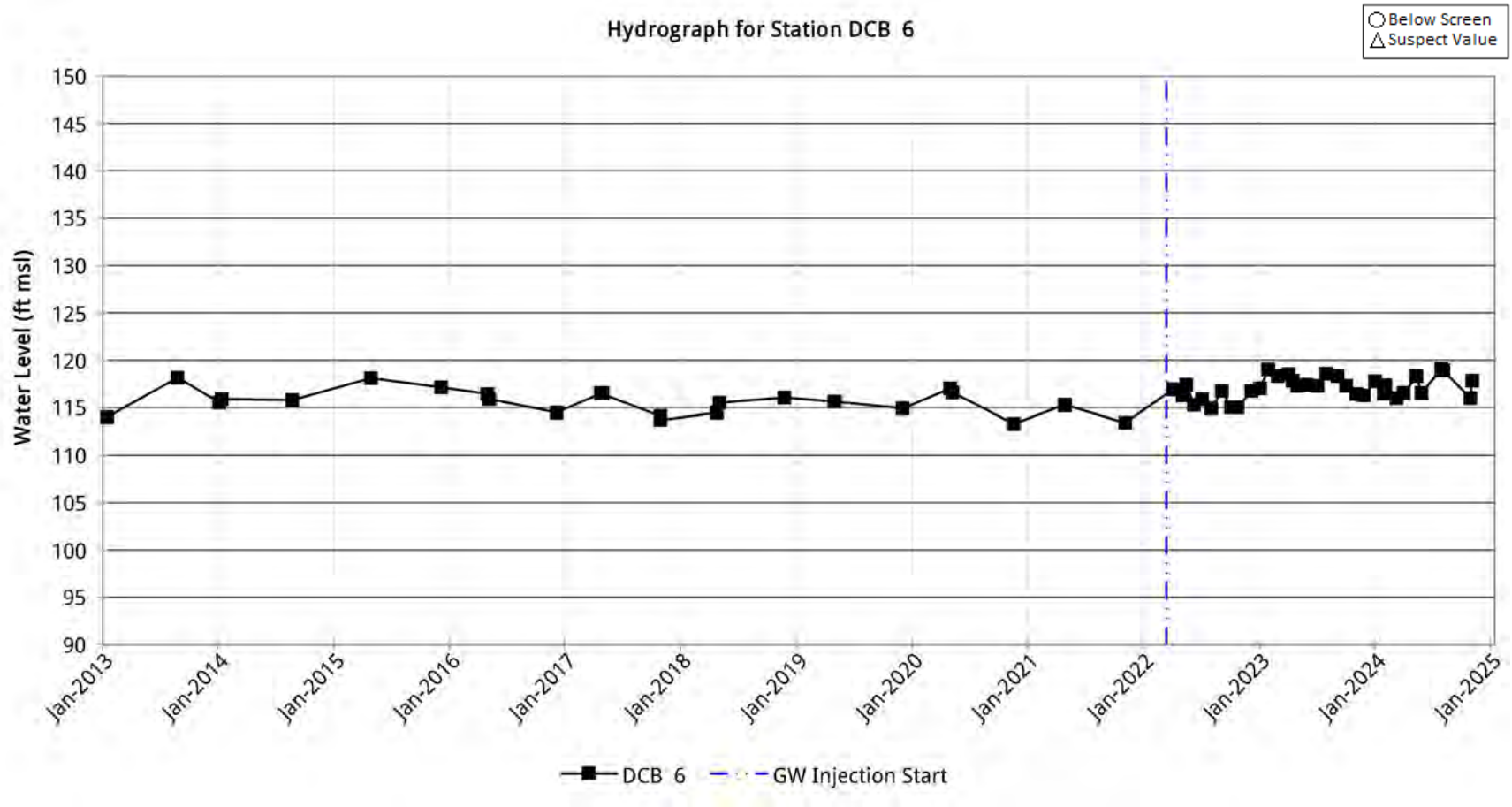
Water Level Hydrographs

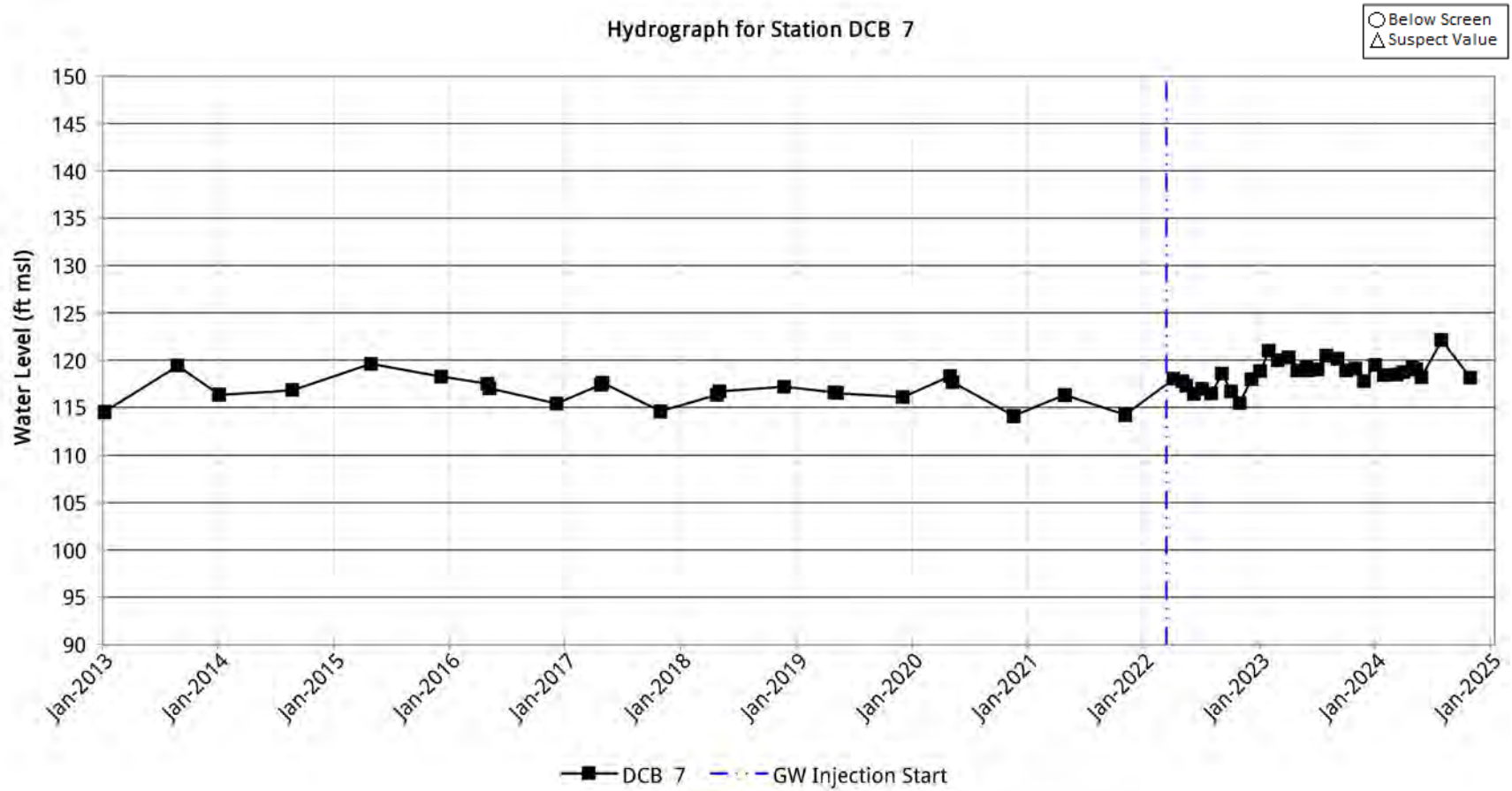
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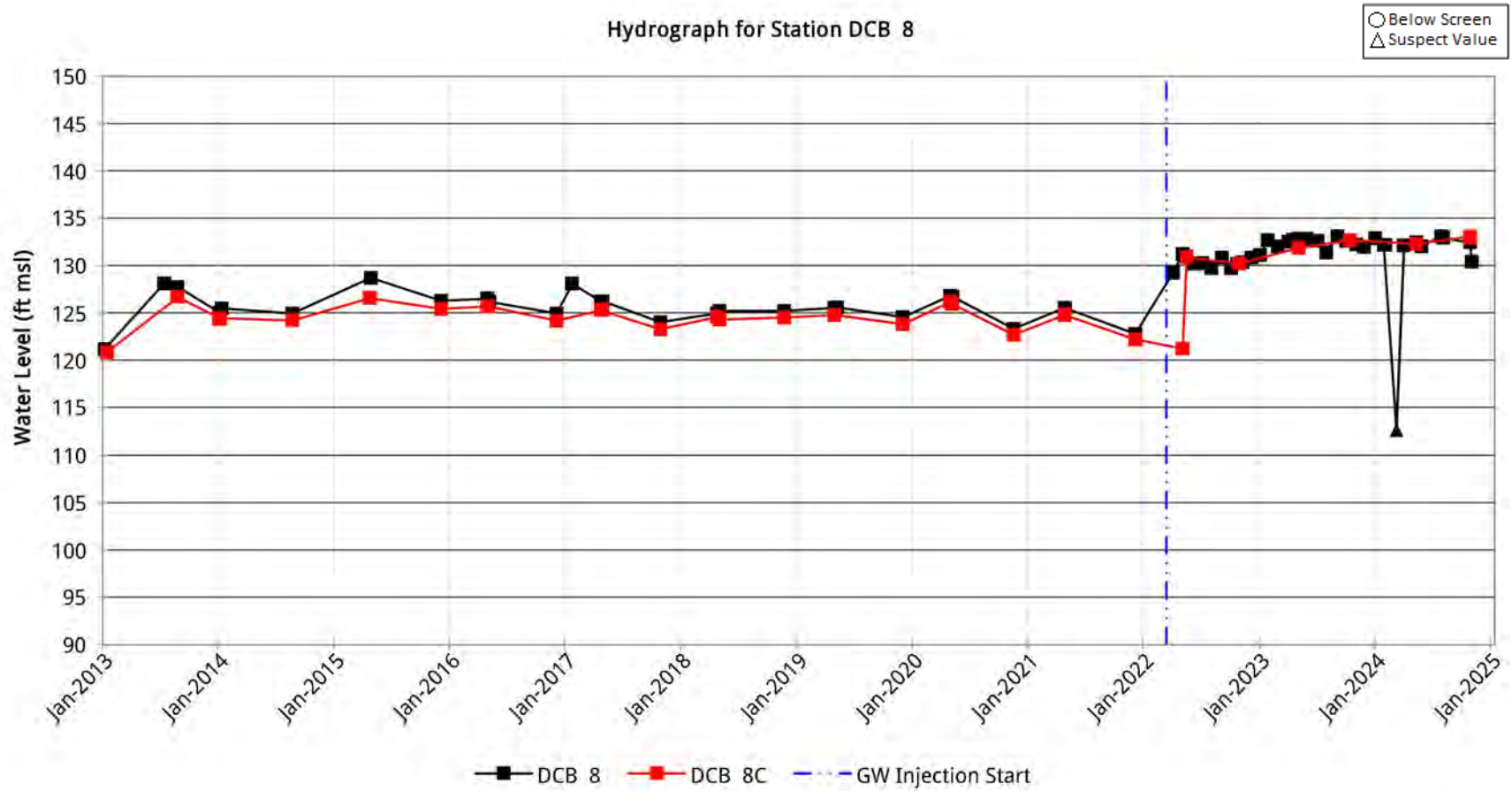


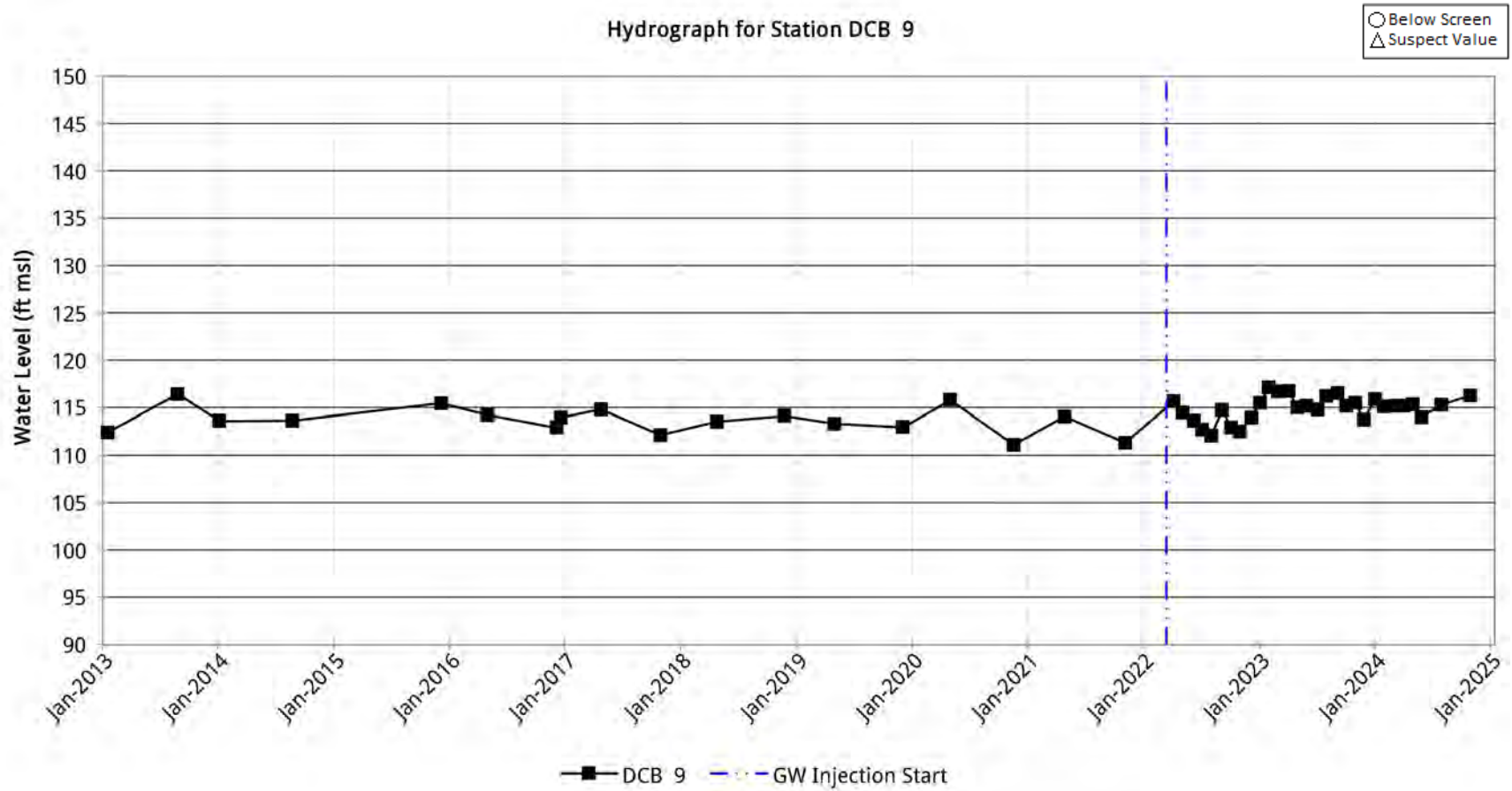


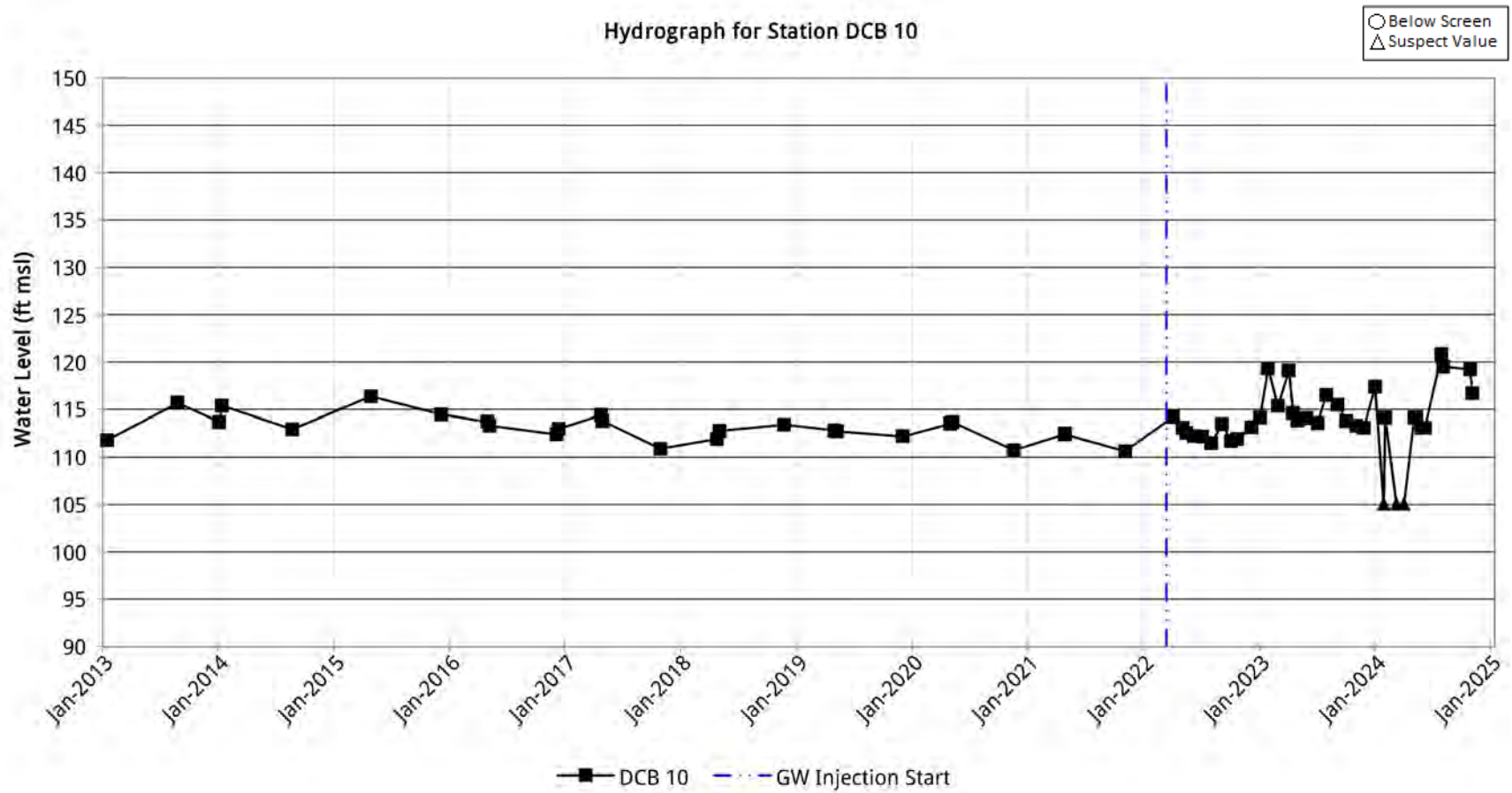


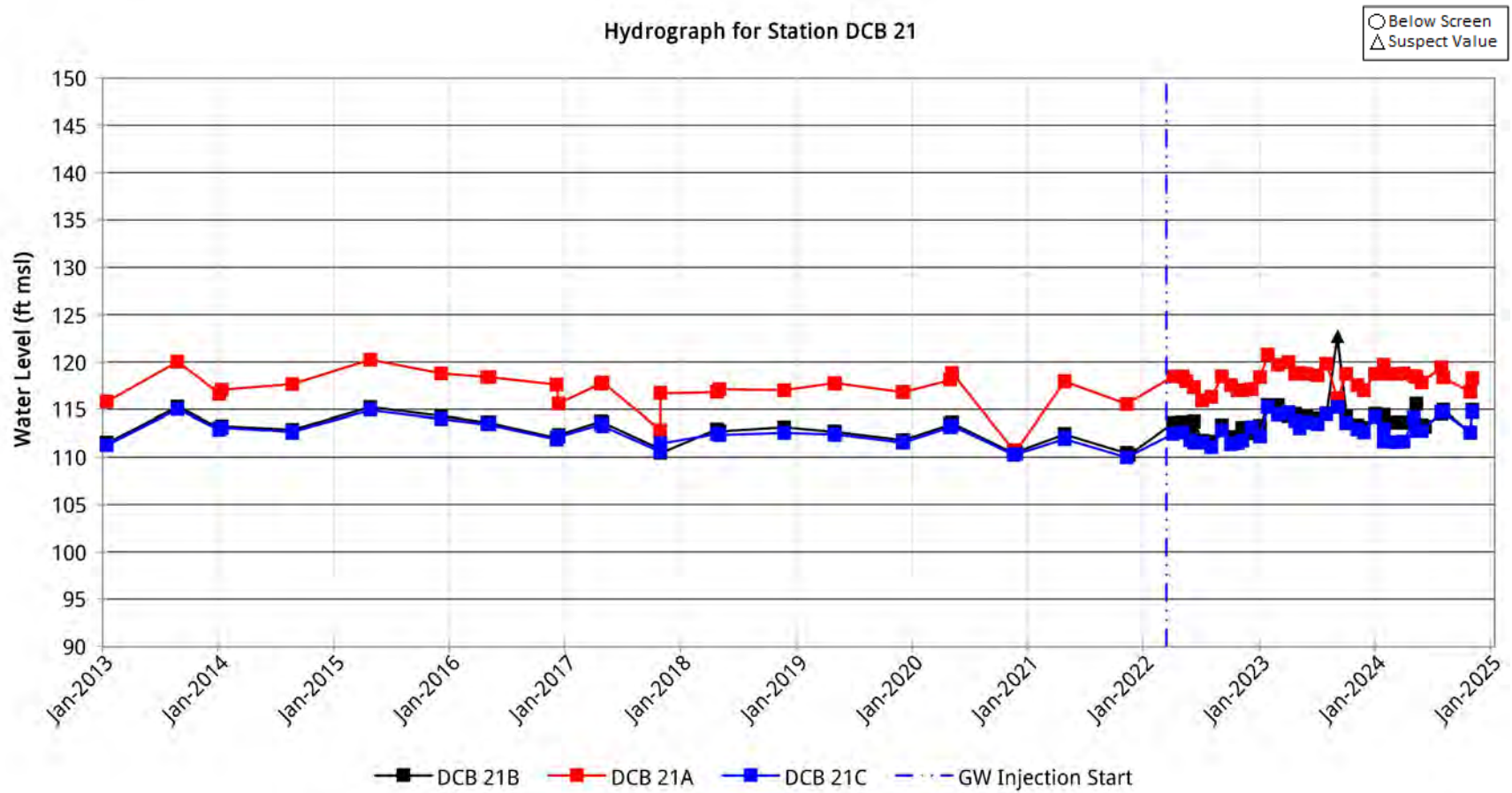


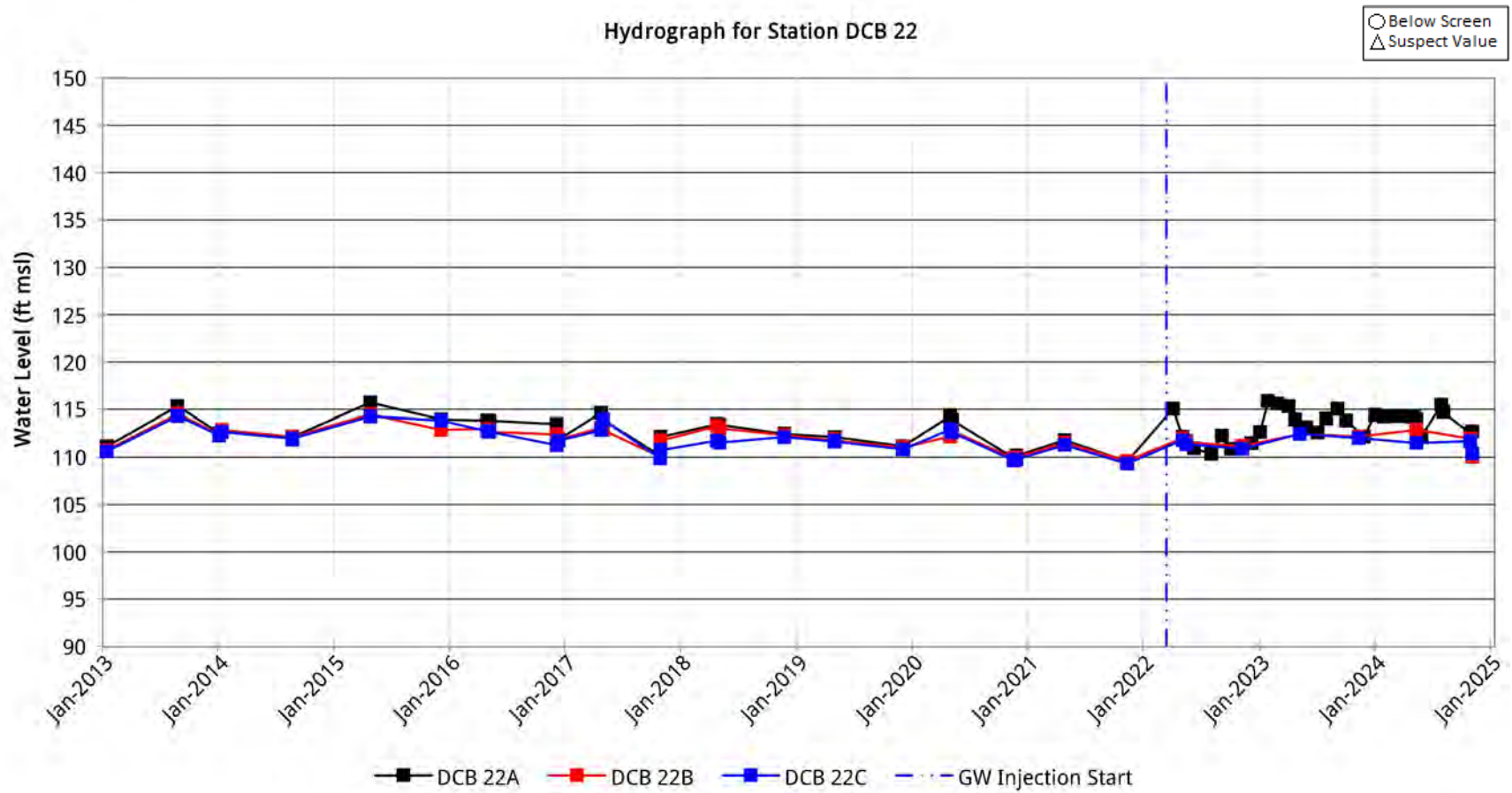


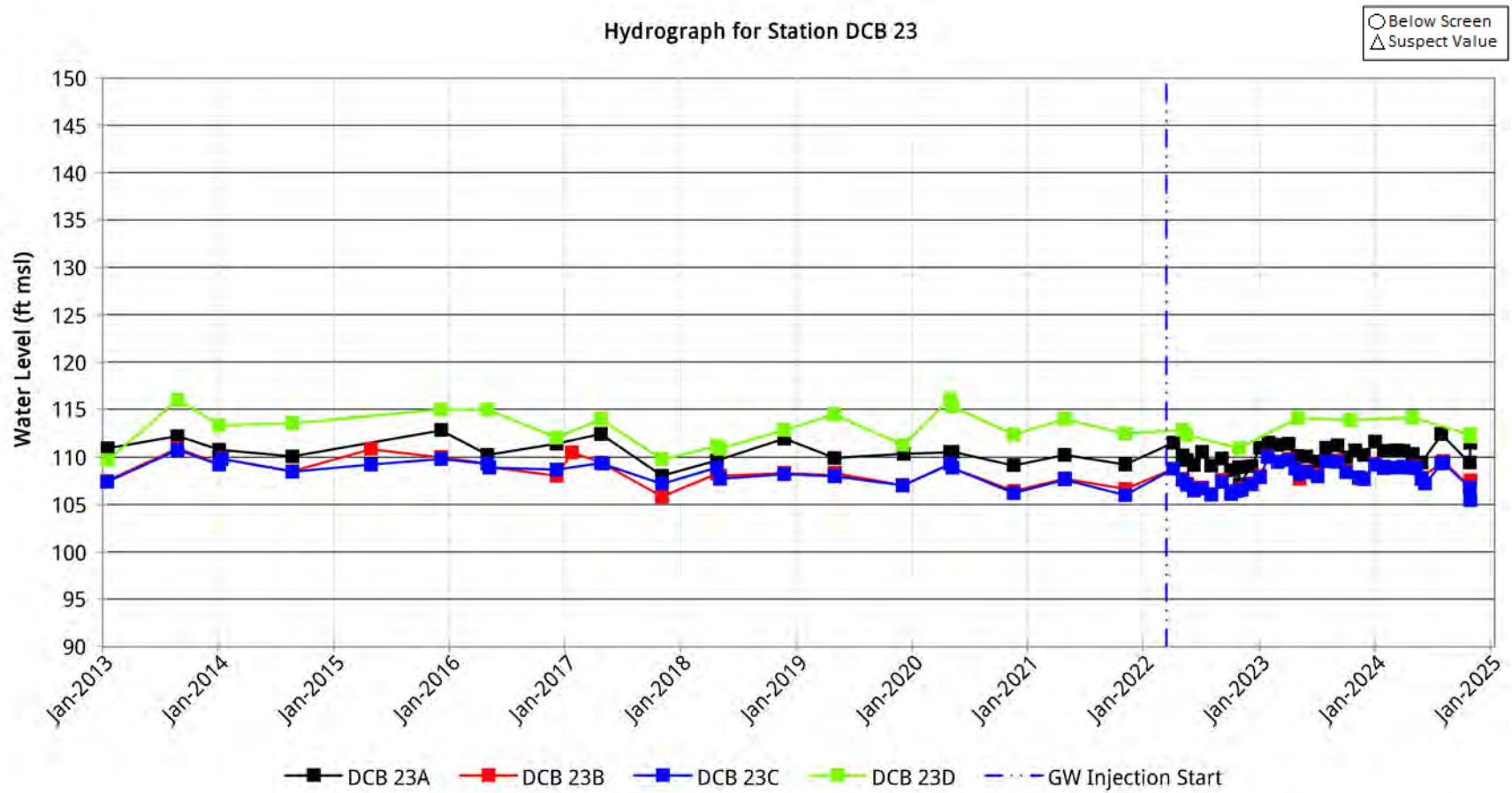


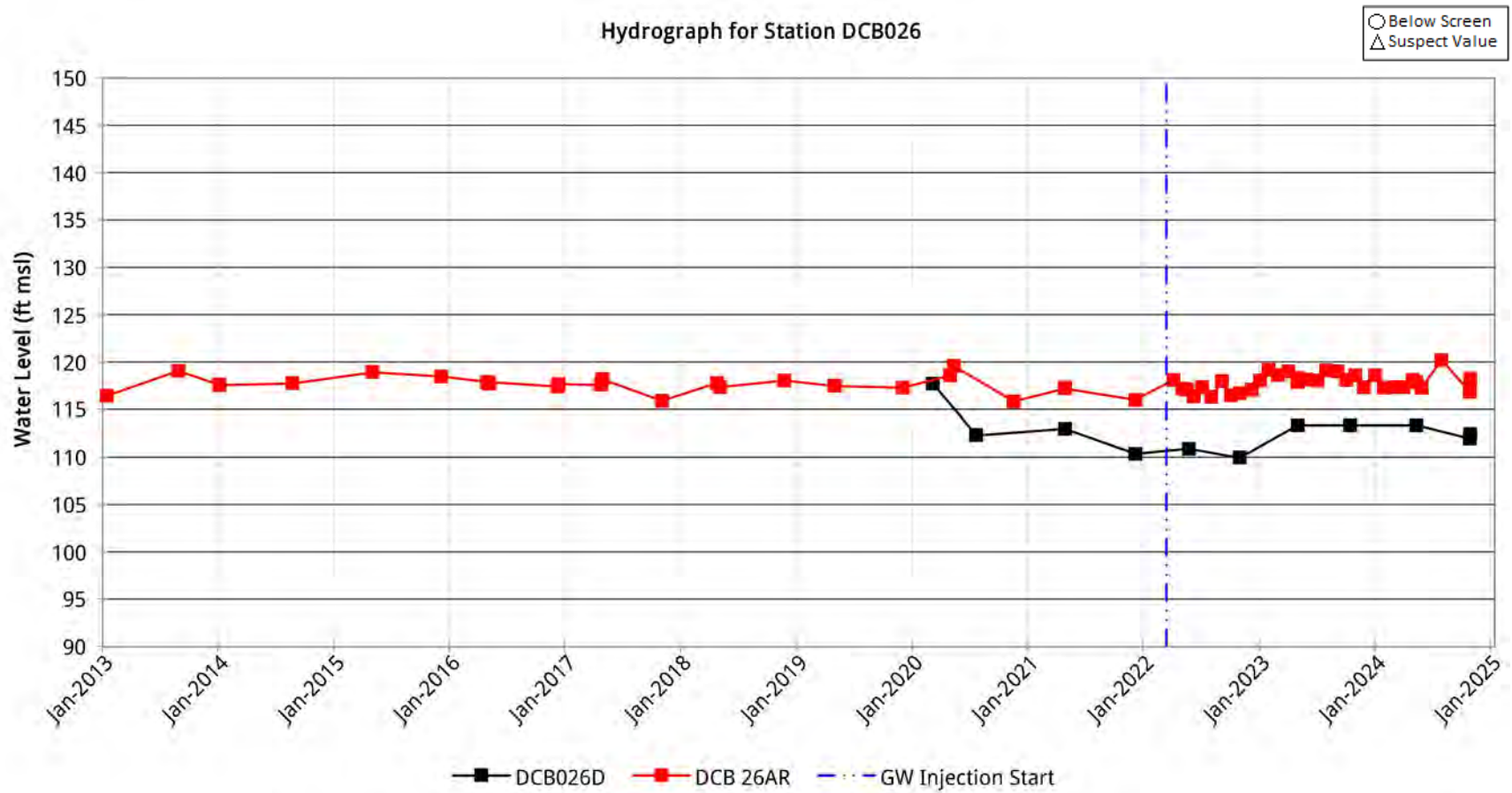


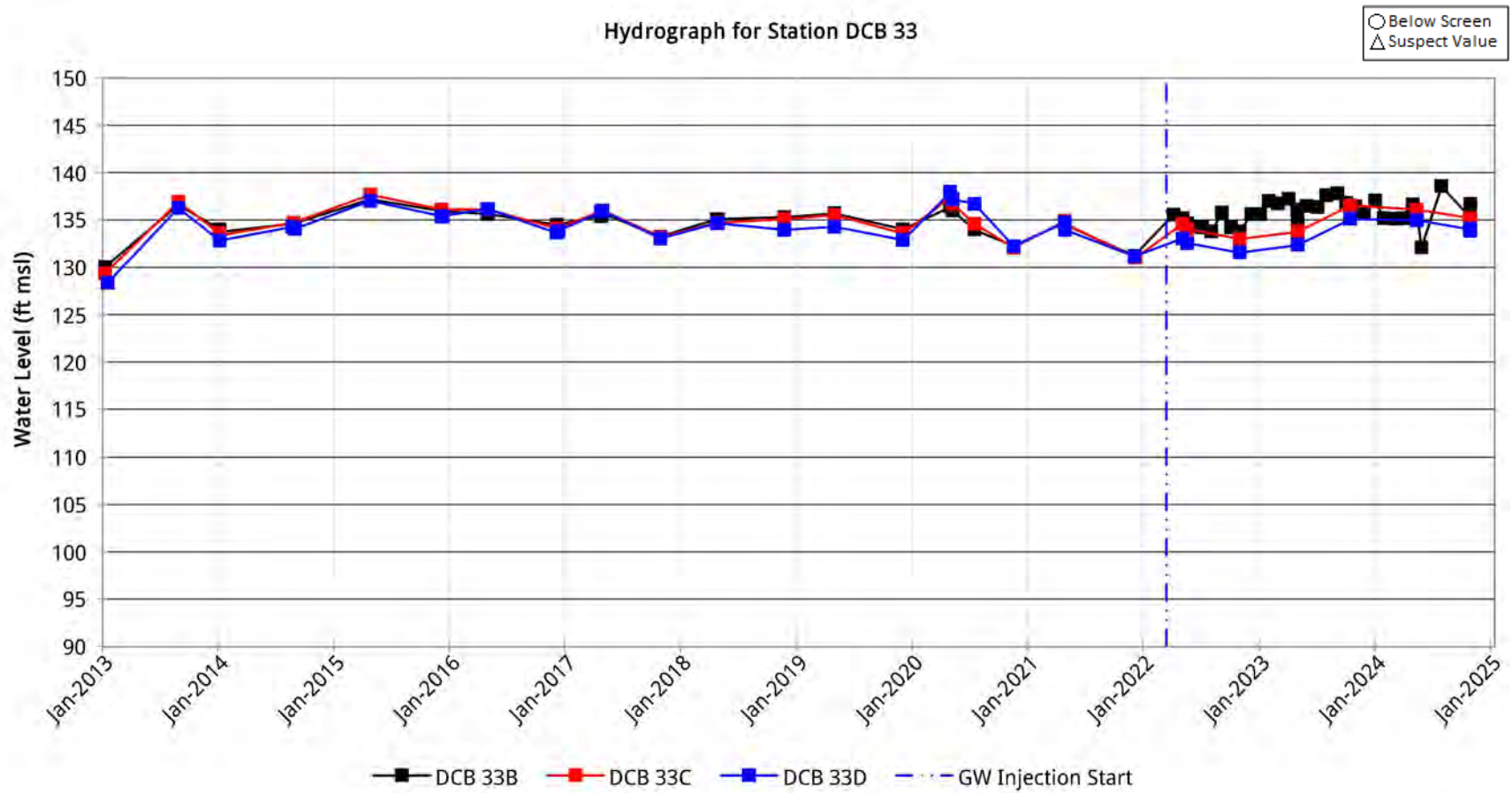


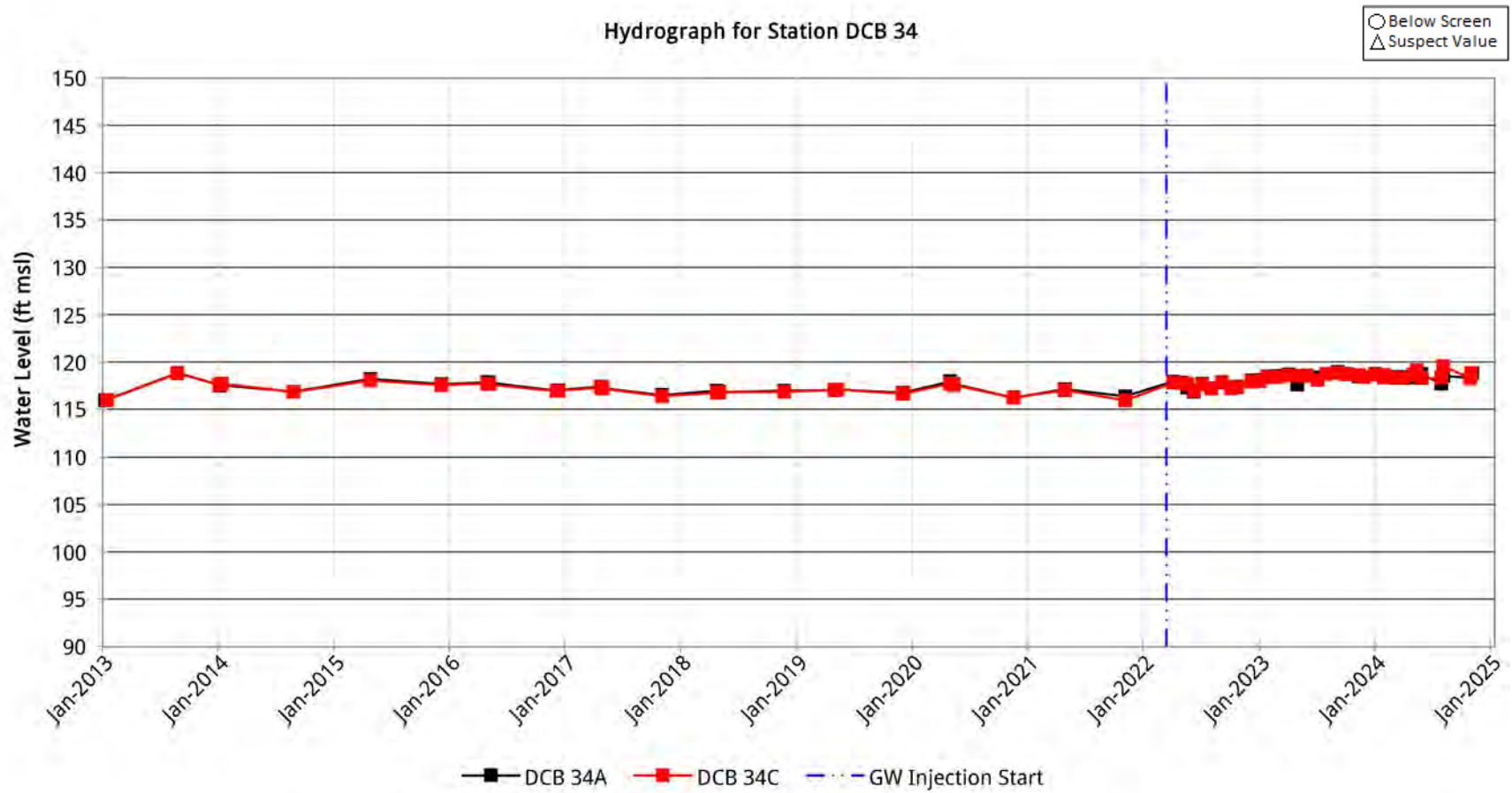


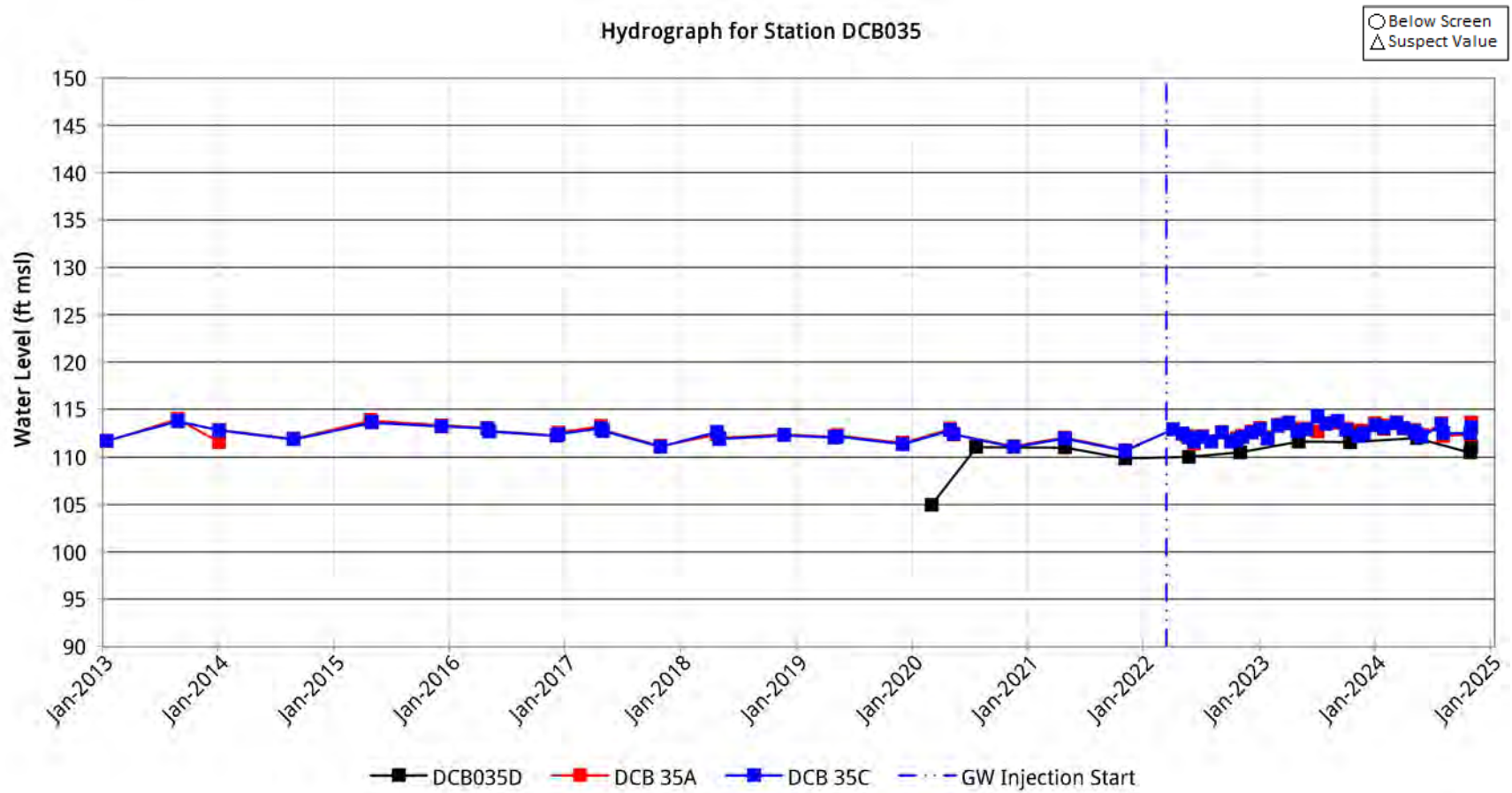


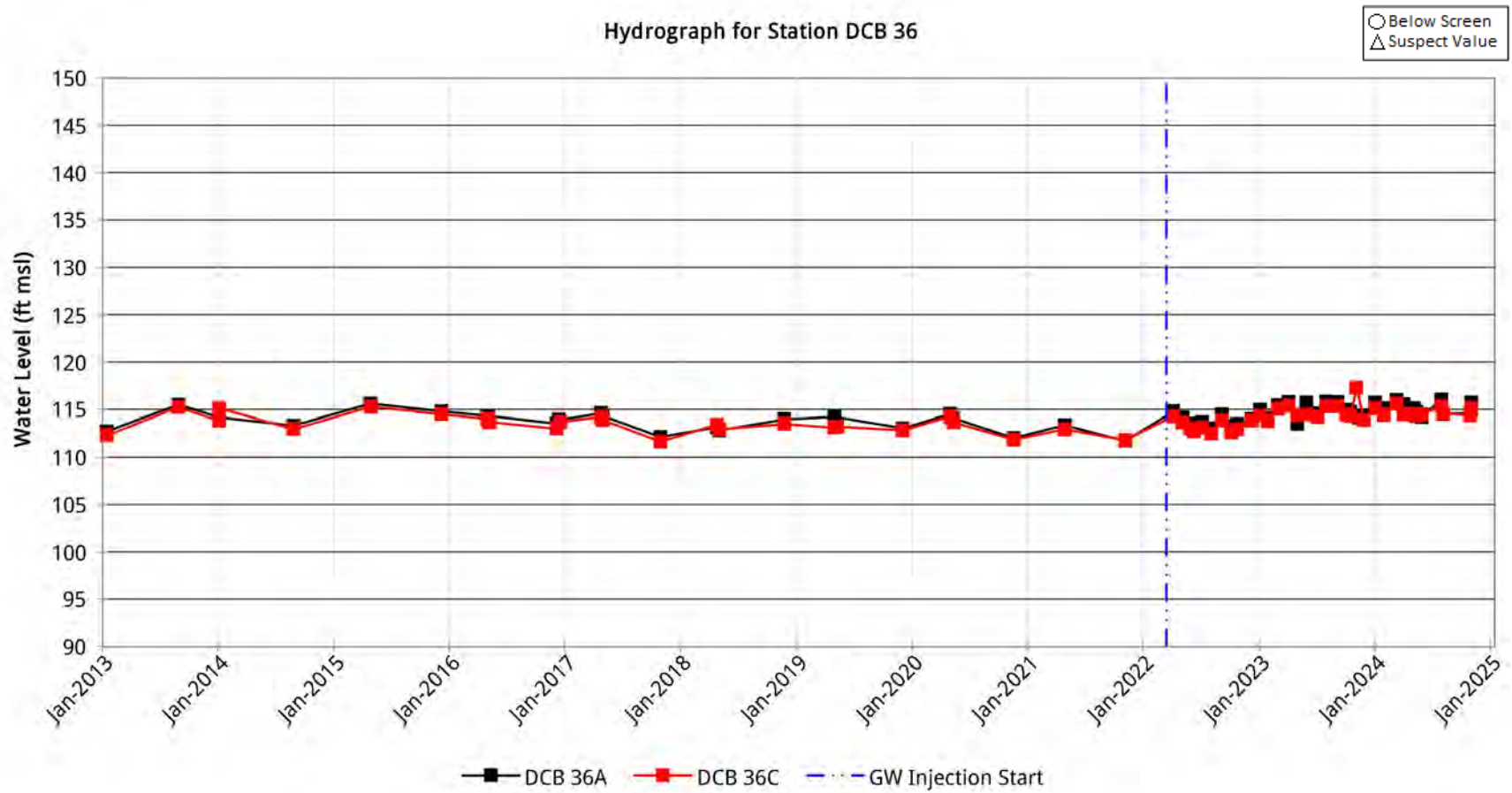


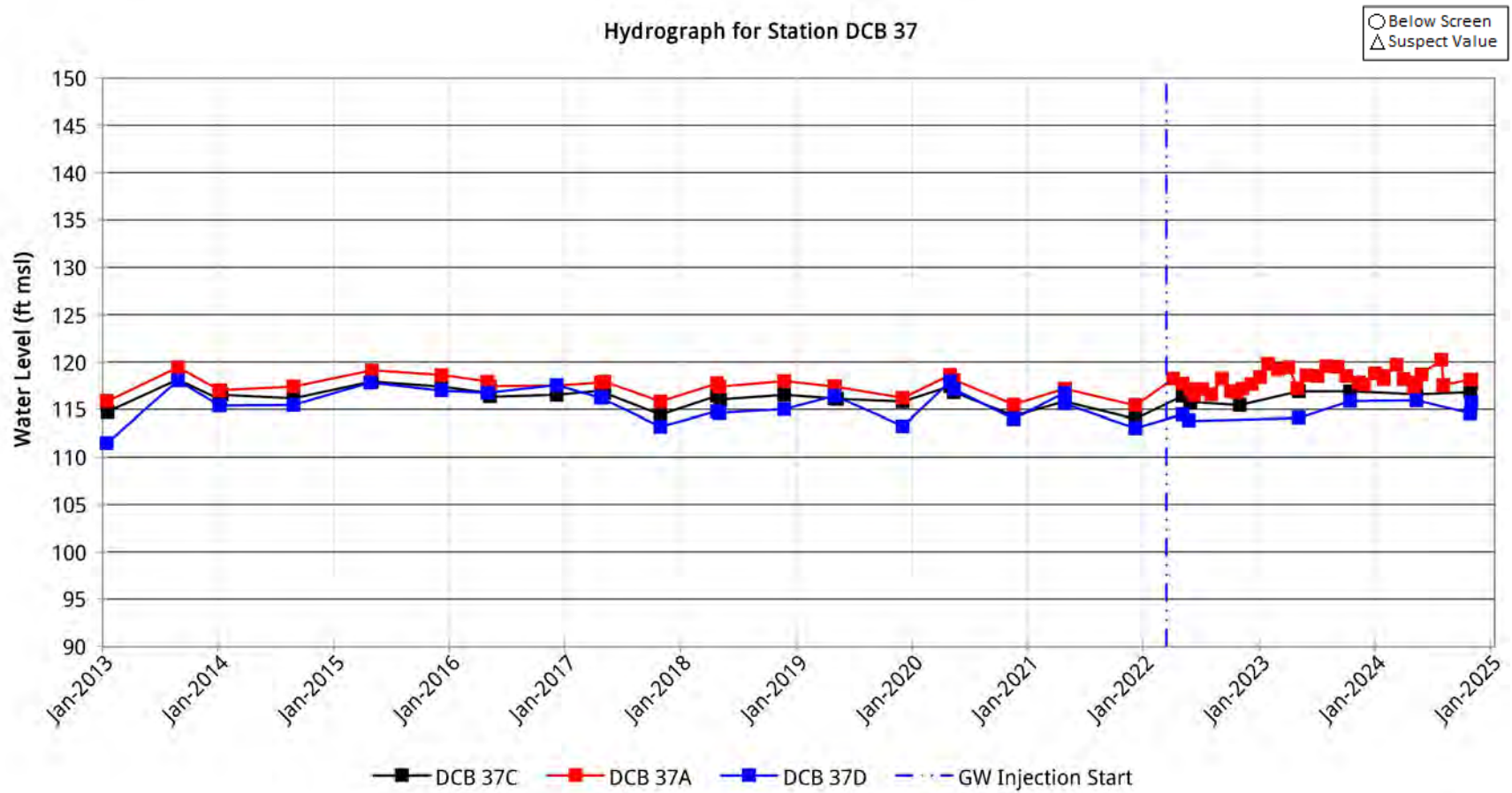


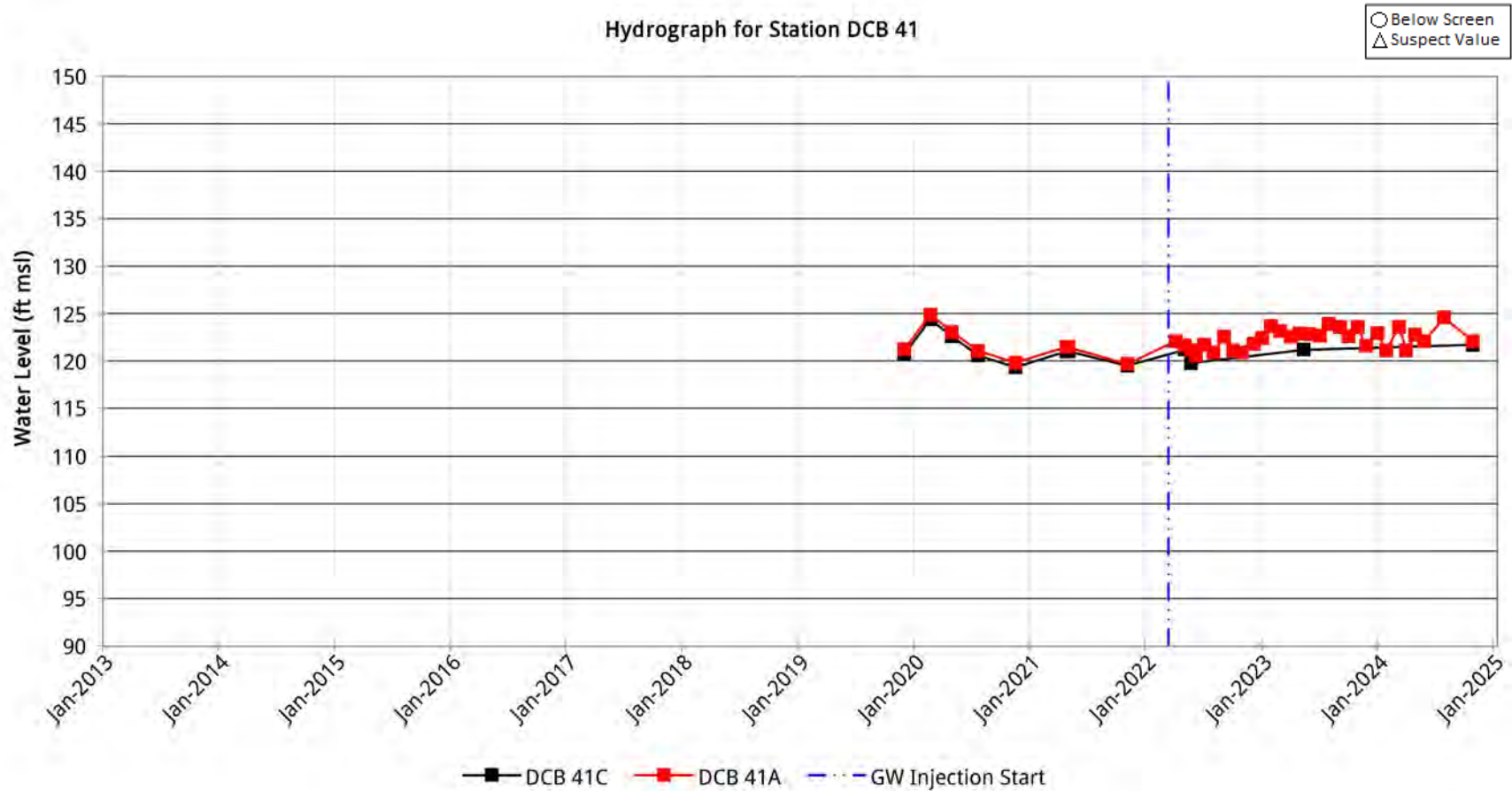


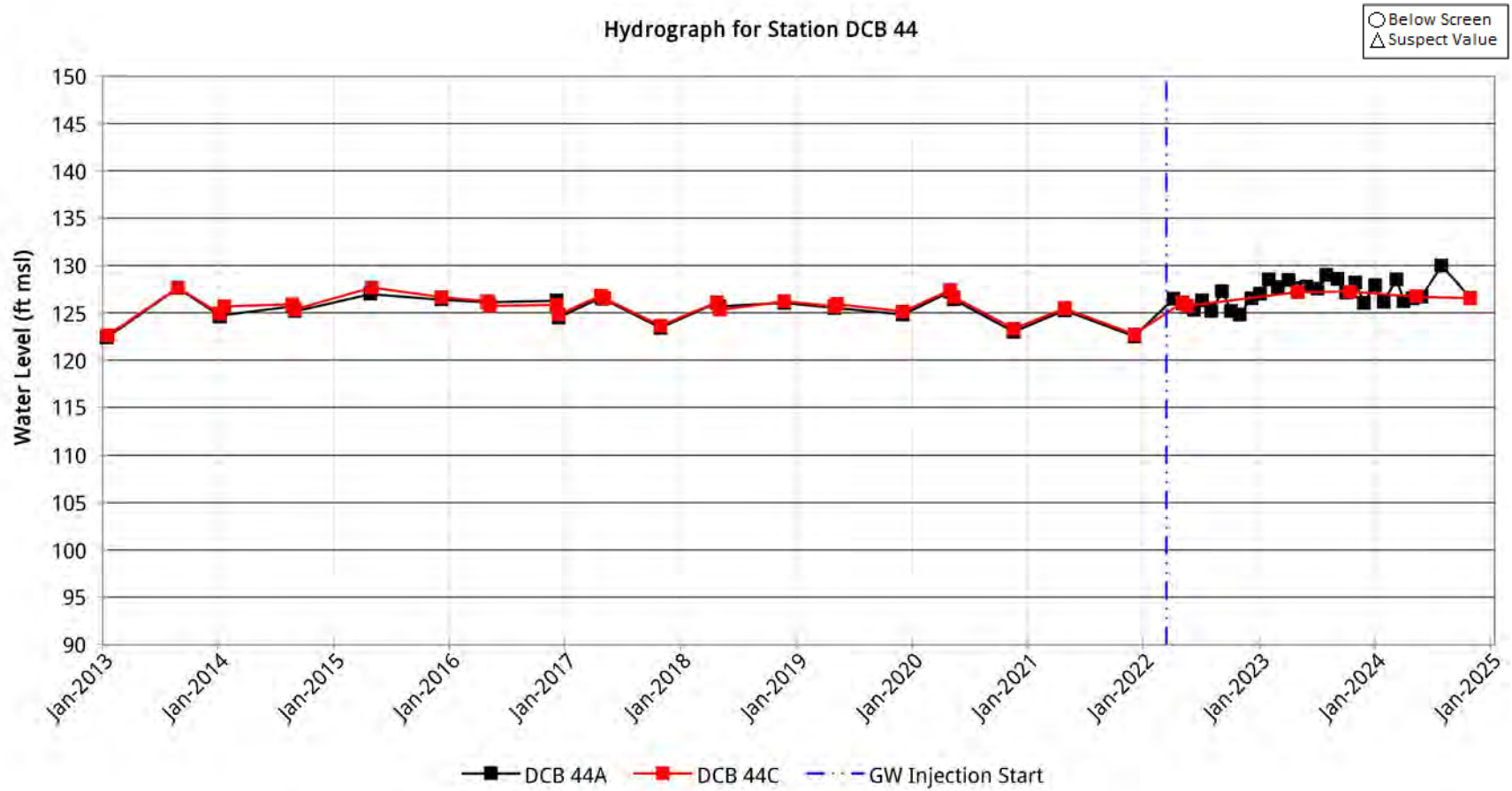


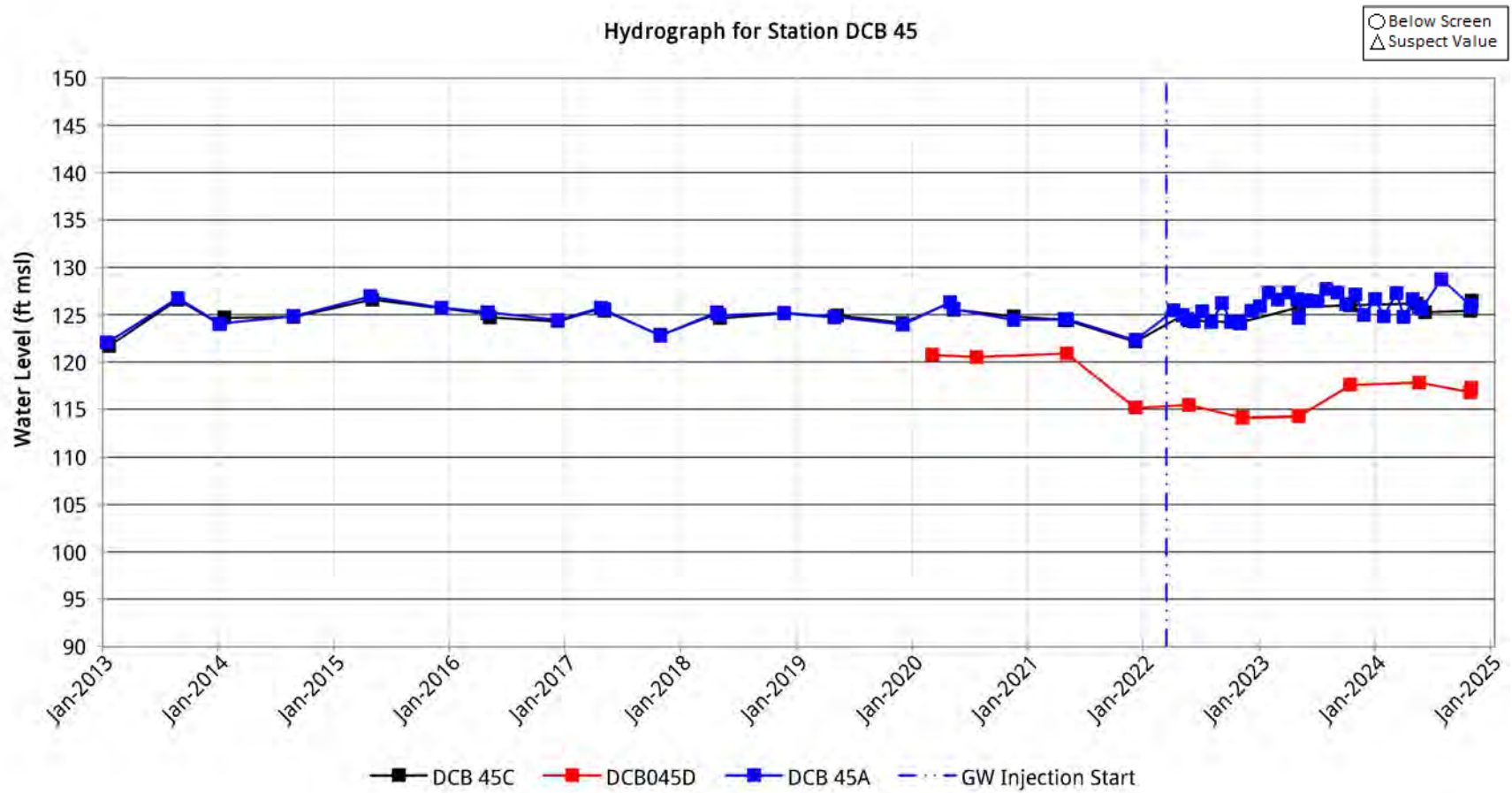


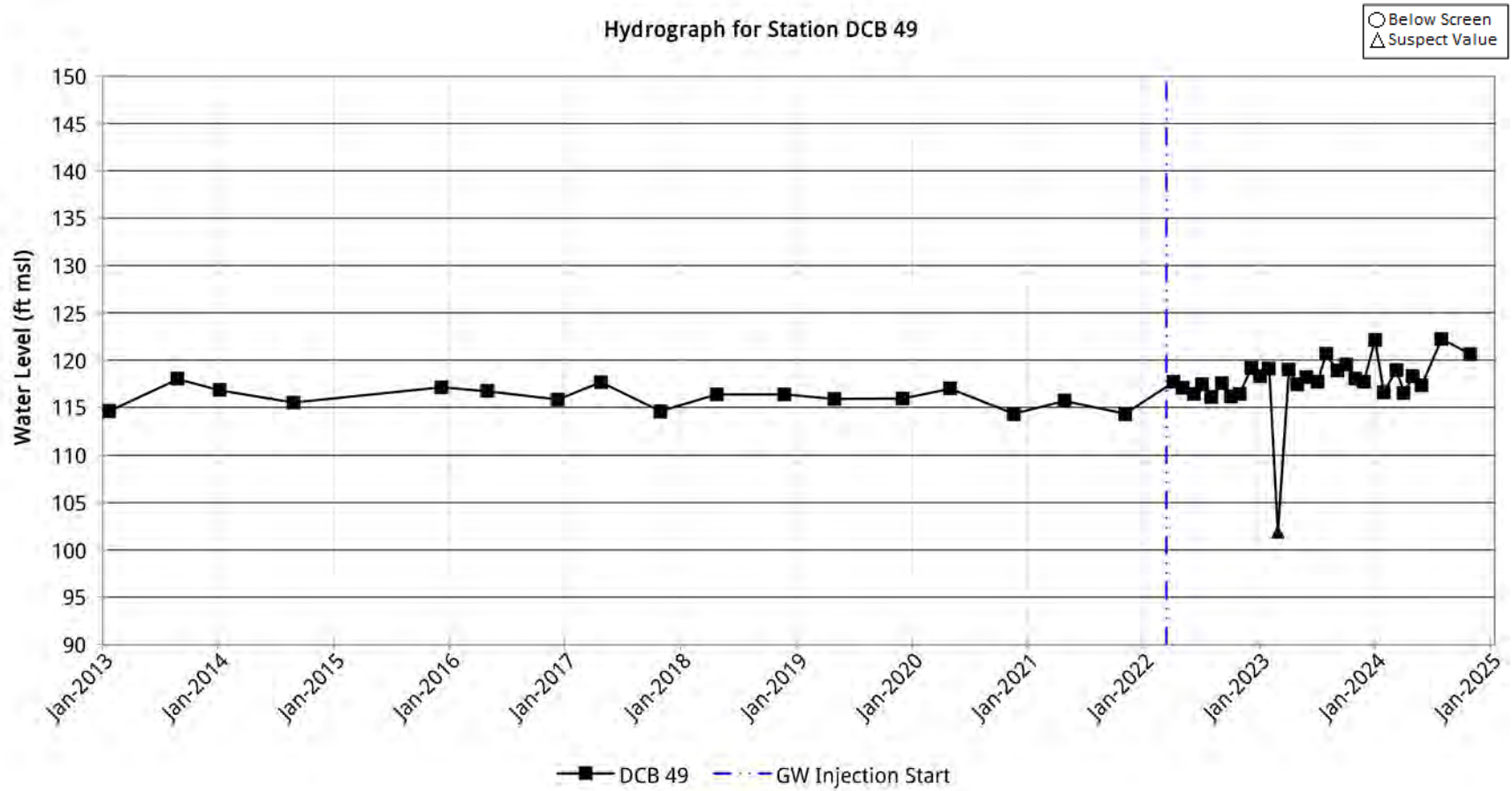


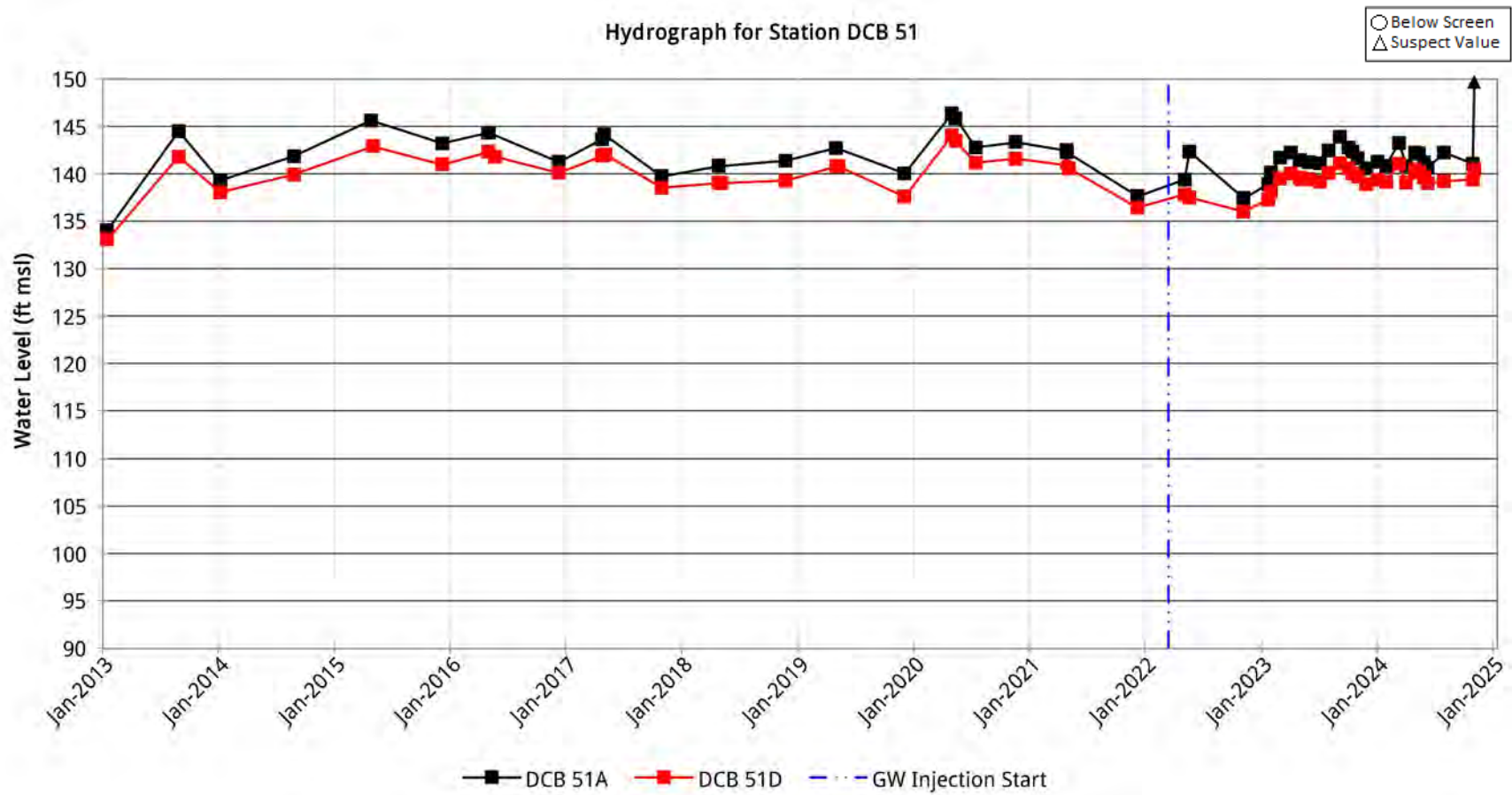


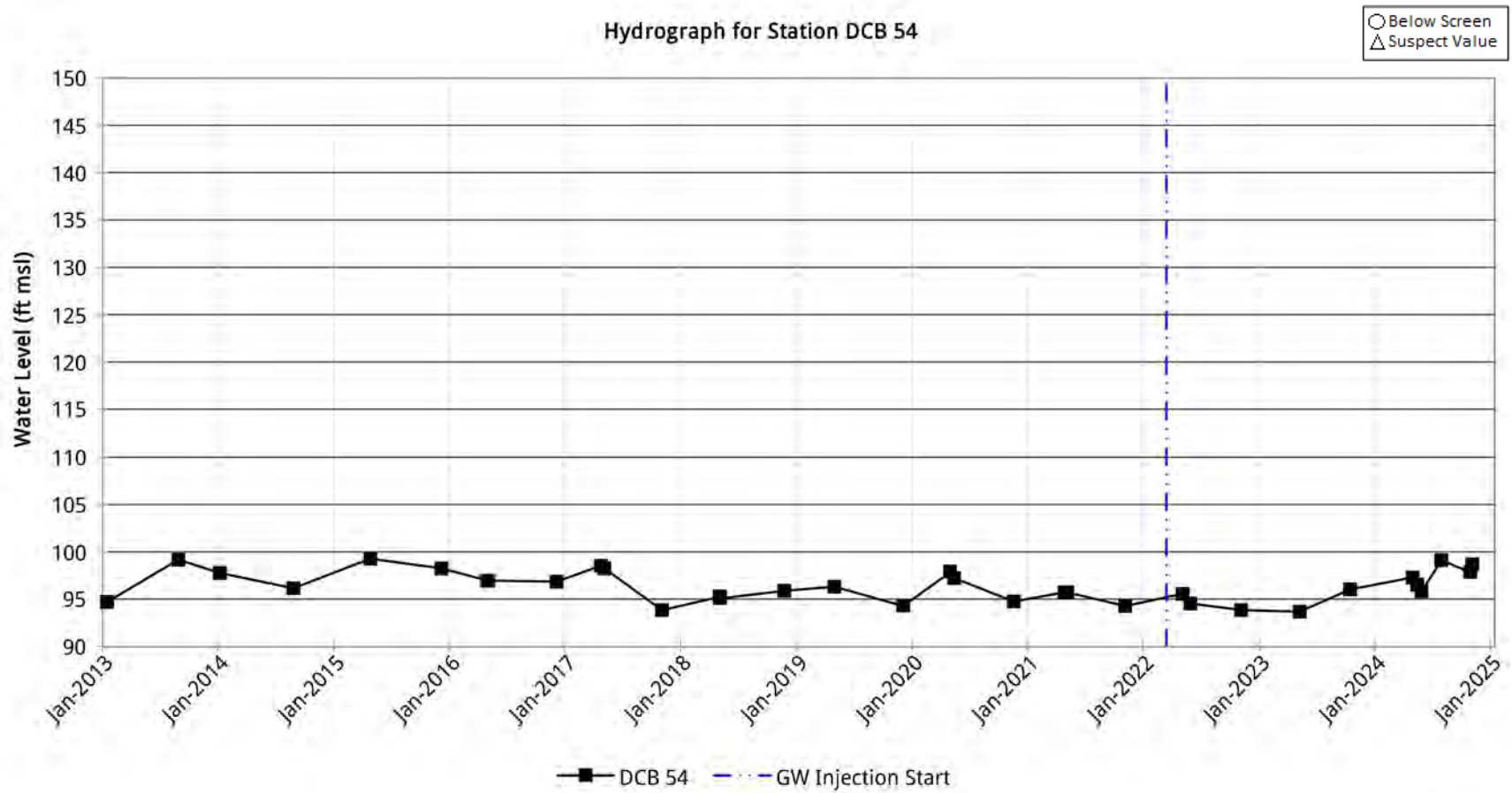


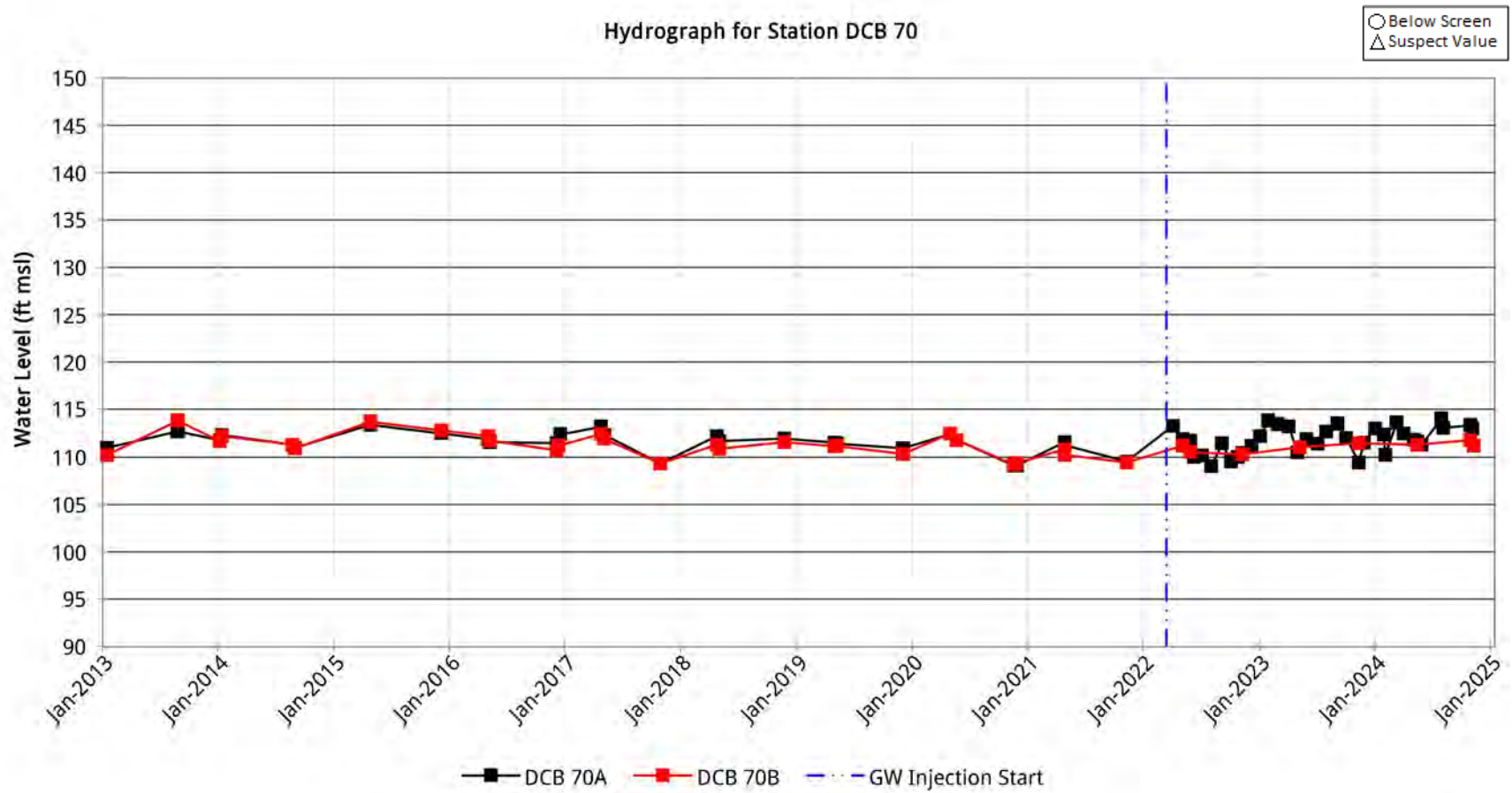


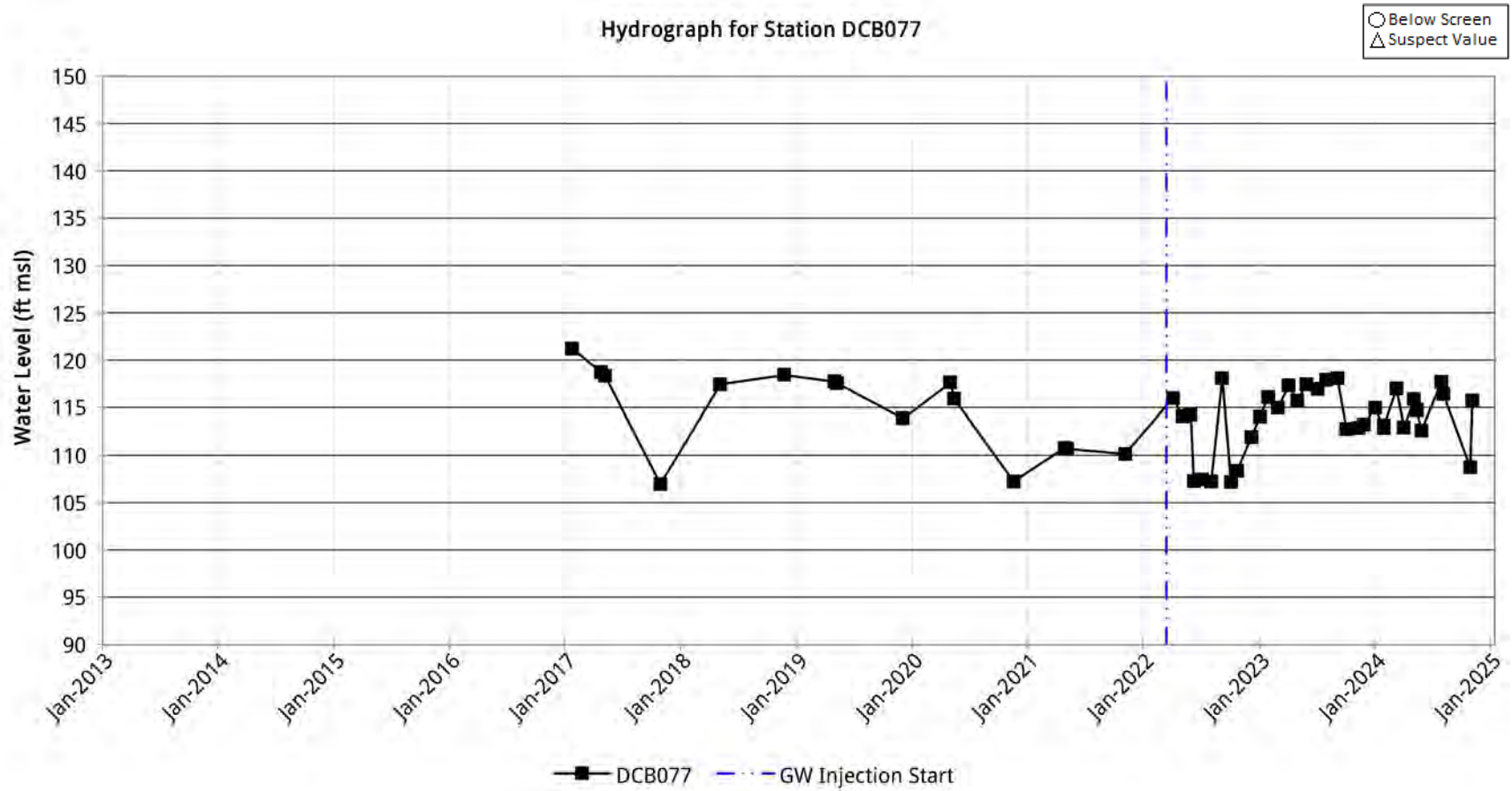


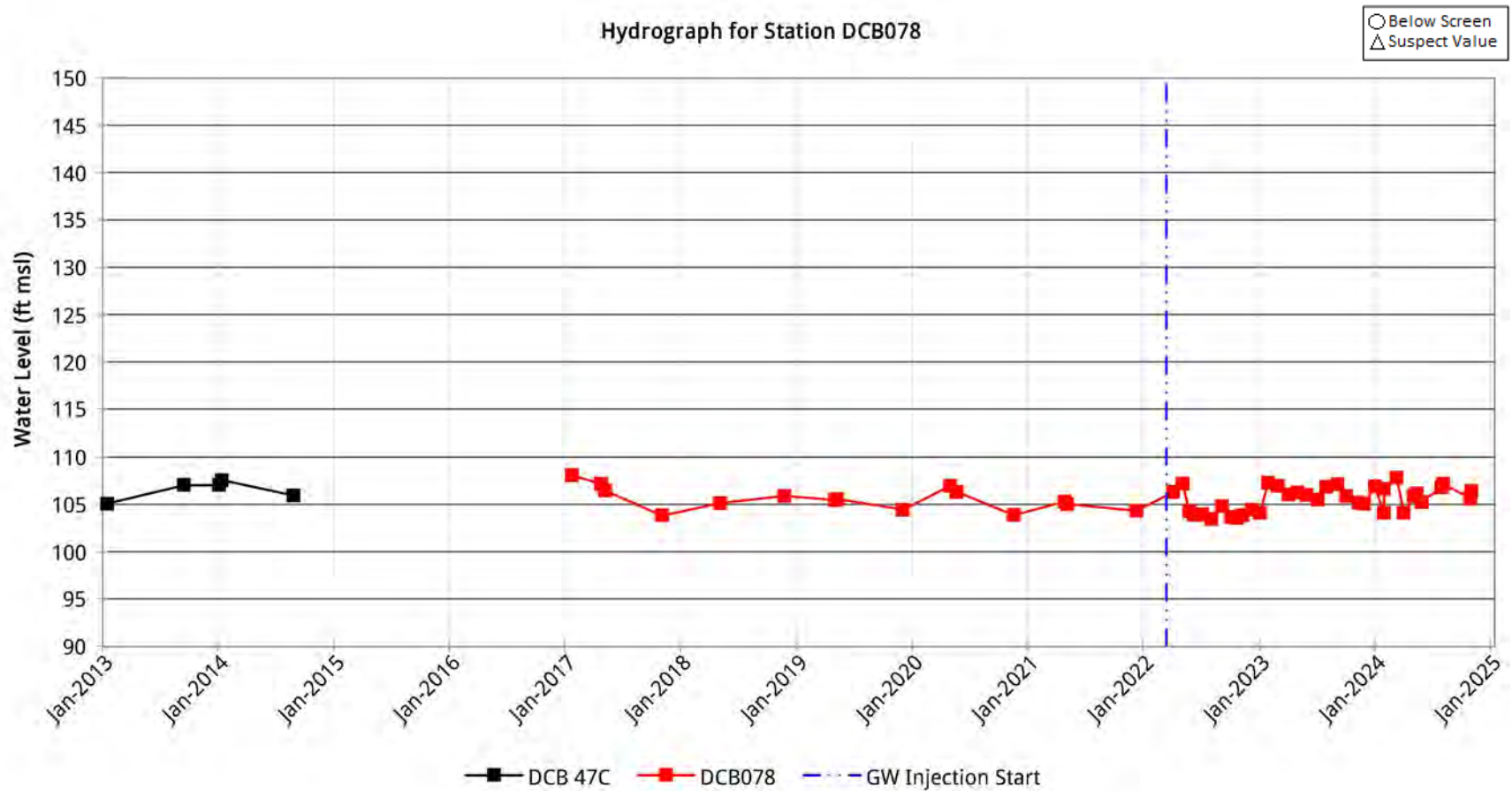


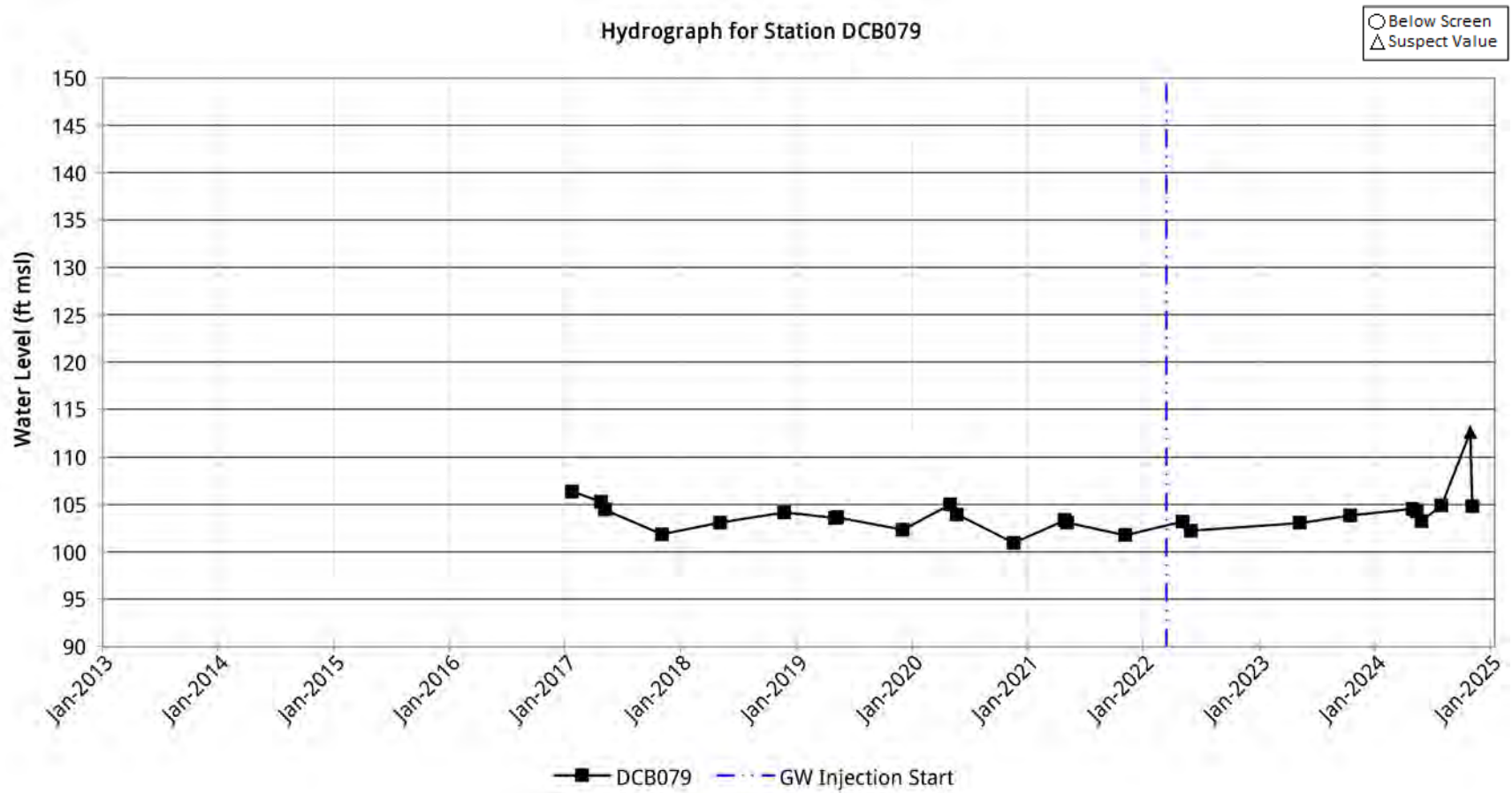


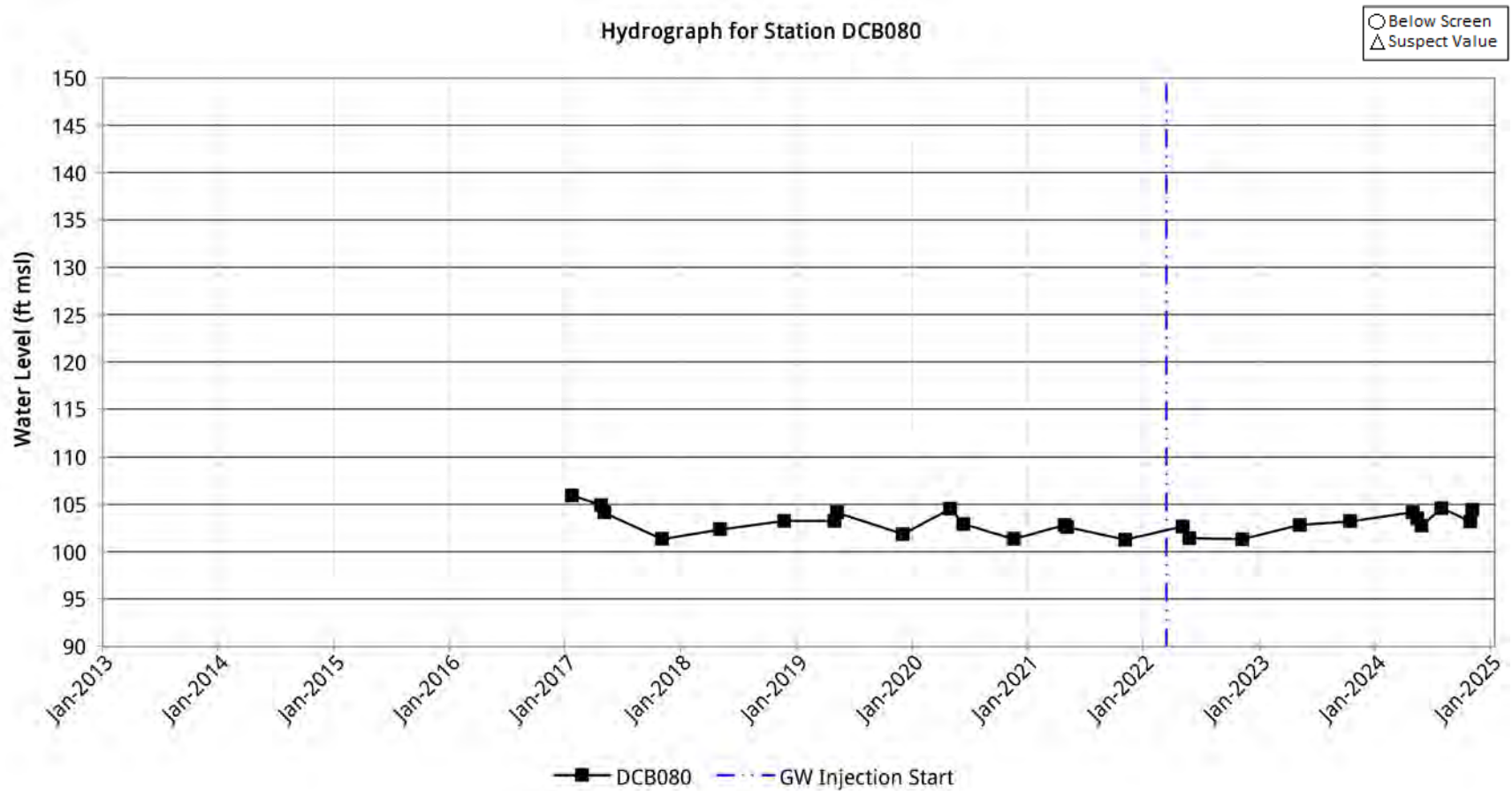


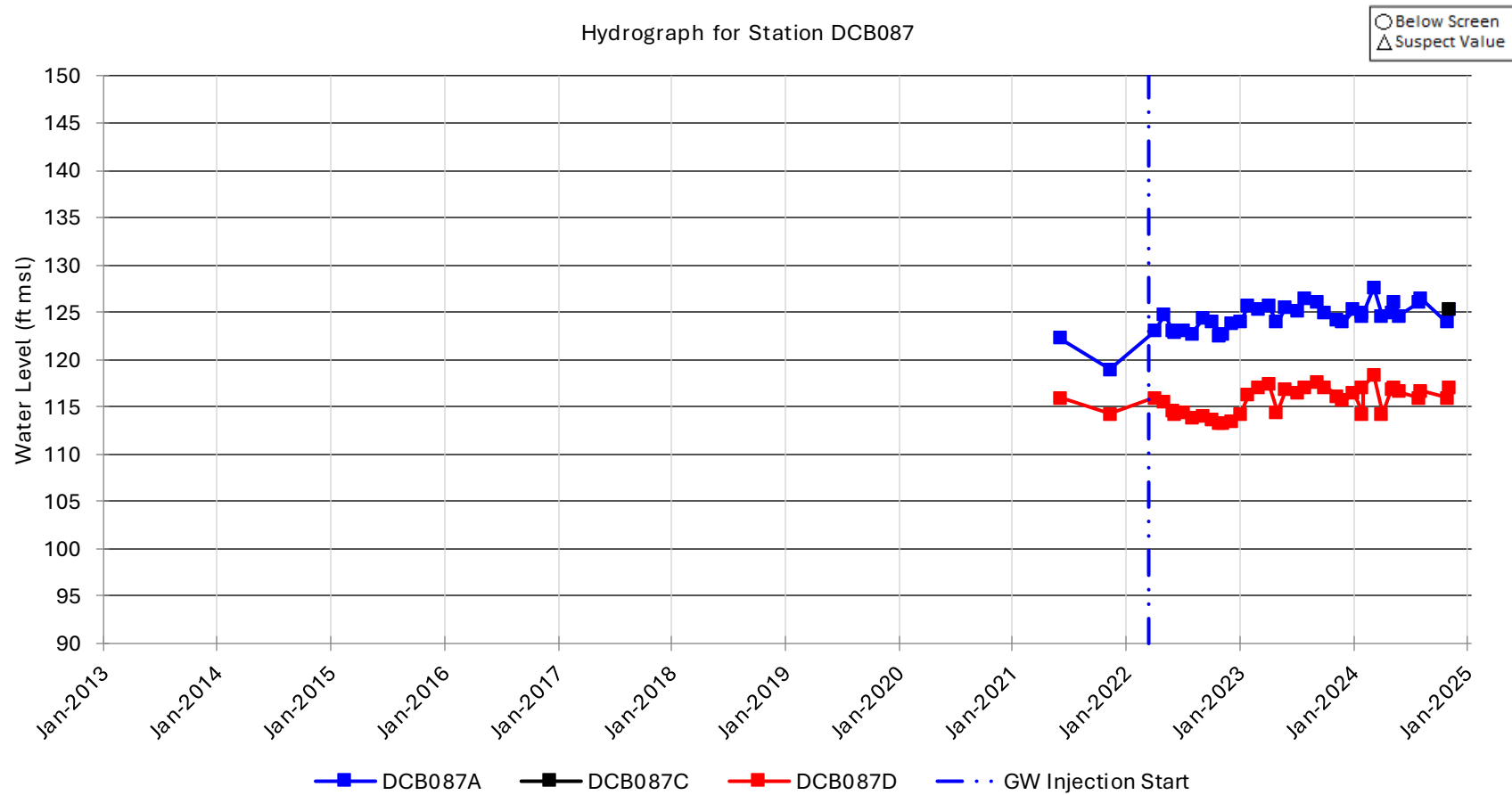












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Appendix C

Times-Series Plots

of pH, Aluminum, Beryllium, Cobalt, Iron, Nickel, and Sulfate

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