



**United States Department of Energy**

**Savannah River Site**

**Effectiveness Monitoring Report for the  
Monitored Natural Attenuation (MNA) at  
the Chemicals, Metals, and Pesticides (CMP) Pits  
Operable Unit (OU) (U)**

**March 2017 through March 2018**

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## LIST OF ACRONYMS AND ABBREVIATIONS

1,1,2-TCA	1,1,2-trichloroethane
1,1-DCE	1,1-dichloroethylene
bgs	below ground surface
c-1,2-DCE	cis-1,2-dichloroethylene
CCl <sub>4</sub>	carbon tetrachloride
CMCOC	contaminant migration constituent of concern
CMP	chemicals, metals, and pesticides
COC	constituent of concern
CY	calendar year
DCM	dichloromethane (methylene chloride)
DEHP	bis-(2-ethylhexyl) phthalate
DNAPL	dense non-aqueous phase liquid
EMP	Effectiveness Monitoring Plan
EMR	Effectiveness Monitoring Report
ERH	electrical resistance heating
ft	feet
GA	Gordon aquifer
GCCZ	Green Clay Confining Zone
GWPS	groundwater protection standard
LAZ	lower aquifer zone
m	meters
µg/L	microgram per liter
MAZ	middle aquifer zone
MCL	maximum contaminant level
mg/kg	milligram per kilogram
MNA	monitored natural attenuation
OU	operable unit
PCE	tetrachloroethylene
PDB	passive diffusion bag
RA	remedial action
RCRA	Resource Conservation and Recovery Act
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RG	remedial goal
ROD	Record of Decision
RSL	Regional Screening Level
SCDHEC	South Carolina Department of Health and Environmental Control
SCSU	South Carolina State University
SRNS	Savannah River Nuclear Solutions LLC
SRS	Savannah River Site
SVE	soil vapor extraction
TCCZ	Tan Clay Confining Zone
TCLC	Tan Clay Lower Clay
TCE	trichloroethylene

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**LIST OF ACRONYMS AND ABBREVIATIONS** (*continued, end*)

t-1,2-DCE	trans-1,2-dichloroethylene
TZ	transmissive zone
USEPA	U.S. Environmental Protection Agency
UTRA	Upper Three Runs aquifer
VC	vinyl chloride
VOC	volatile organic compound
WSRC	Westinghouse Savannah River Company LLC (before October 2005)
WSRC	Washington Savannah River Company LLC (October 2005- July 2008)

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## 1.0 INTRODUCTION

This Effectiveness Monitoring Report (EMR) addresses the effectiveness of the Monitored Natural Attenuation (MNA) groundwater remedy at the Chemicals, Metals, and Pesticides (CMP) Pits Operable Unit (OU) for the period from March 2017 to March 2018. The monitoring requirements for the CMP Pits OU are identified in the Effectiveness Monitoring Plan (EMP) (WSRC 2006b).

### 1.1 Operable Unit Background

The CMP Pits OU is located in the central portion of the Savannah River Site (SRS) approximately one mile north of L Area (Figure 1). The subunits of the CMP Pits OU were evaluated in the *RCRA Facility Investigation/Remedial Investigation Addendum with Baseline Risk Assessment for the CMP Pits (U)* (WSRC 2003). The CMP Pits OU is comprised of the following subunits: Ballast Area soils; CMP Pits and associated vadose zone (Field A); vadose zone (Field B); groundwater; and surface water and sediment (Figure 2).

The actual CMP Pits consist of seven former, unlined pits placed in two rows that were designed to receive non-radioactive wastes (chemicals, metals, and pesticides) and operated from August 1971 until February 1979. Once the pits stopped receiving waste, all the open pits were covered with clay and graded. Contaminated soil and debris at the CMP Pits posed a contaminant migration and human health risk and were partially excavated in 1984. A second phase of excavation was performed at Pit 080-183G to remove a portion of significantly contaminated soil and was followed by backfilling of the pit area with clean soil and then capped. However, some contaminated soils were left in place. The previous waste in the pits and associated contaminated soils located in the CMP Pits vadose zone (Field A) were determined to be the source of groundwater contamination.

Electrical Resistance Heating (ERH) with Soil Vapor Extraction (SVE) was selected as the remedial action (RA) for the CMP Pits vadose zone in and around Field A. This remedy targeted the contaminated soil at Pit 080-183G that was left in place after the previous soil excavations which included dense non-aqueous phase liquid (DNAPL) that was present in the clay horizons beneath the pits (Figure 2). The contaminant migration constituents of concern (CMCOCs) that were identified in the Resource Conservation Recovery Act (RCRA) Facility

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Investigation/Remedial Investigation (RFI/RI) Addendum (WSRC 2003) are tetrachloroethylene (PCE) and dichloromethane (DCM).

Groundwater contamination has occurred as a result of contaminants leaching from the source area soils. Following remediation of the CMP Pits vadose zone (Field A) source area, MNA was selected as the RA for the contaminated groundwater.

Surface soil contamination in the Ballast Area and vadose zone contamination in Field B have been successfully remediated via interim RAs. There is no problem warranting action for the surface water and sediment; however, surface water sampling is included as part of the MNA sampling.

## **1.2 Nature and Extent of Contamination**

PCE and DCM (or methylene chloride) were identified as CMCOCs and as principal threat source material for mobility (i.e., transport from the source zone to the aquifer in less than 10 years) in the vadose zone beneath the CMP Pits. The volatile organic compound (VOC) contamination was highest in the northwest pit (Pit 080-183G) at depths between 20 and 60 feet (ft) (6.10 and 18.29 meters [m]) below ground surface (bgs). PCE was the most abundant contaminant at CMP Pits. No constituents of concern (COCs) were identified in the surface soils in the CMP Pits subunit.

In accordance with the Record of Decision (ROD) (WSRC 2004), an ERH/SVE remedy was selected to remove the DNAPL from the vadose zone. Based on the limited lateral and vertical extent of PCE contamination and the intent of the selected remedy defined in the ROD, the ERH treatment area included the extent of PCE contamination above the DNAPL threshold concentrations and comprised an area of approximately 0.05 acres (0.02 hectares) in Field A (Figure 2). Further details of the DNAPL remediation are available in the 2009 EMR (SRNS 2009).

The following VOCs and pesticides were identified as human health COCs in the groundwater for the future industrial worker and/or resident: alpha-benzene hexachloride, beta-benzene hexachloride, delta-benzene hexachloride, dieldrin, lindane, bis-(2-ethylhexyl) phthalate (DEHP), bromodichloromethane, carbon tetrachloride, chloroform, DCM, PCE, and trichloroethylene

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(TCE). Following the EMP for the CMP Pits, both groundwater and surface water are sampled and analyzed for Target Compound List VOCs and/or lindane (WSRC 2006b). DEHP is a common laboratory artifact and is not believed to be present in the groundwater subunit. As of 2010, the constituent DEHP is no longer required to be sampled and/or reported. In 2013, 1,4-dioxane was added to the list of monitored constituents on an annual sampling basis.

Two VOC groundwater plumes exist at the CMP Pits, designated as the main plume and the northeast distal plume. These plumes are moving northward toward Pen Branch. Groundwater modeling indicated that the CMP Pits were the source for the main plume. Particle tracking toward and from the northeast plume suggested that its source was different from that of the main plume (WSRC 2002). A drainage ditch located approximately 361 ft (110 m) north of CMP Pits is a possible source area (Figure 2). It is possible that this ditch was used as a dumping location prior to the use of the actual CMP Pits. Additional characterization for the source of the distal plume using soil gas surveys was presented in the RFI/RI Addendum (WSRC 2003). Results indicated that if a source was previously present in the vadose zone, it has been depleted. It is also plausible, due to the dry zone areas within the transmissive zone (TZ) and to some degree the middle aquifer zone (MAZ), that one plume separated into two distinct plumes over time. Additionally, upwelling of the MAZ as it discharges to the stream most likely brings some contamination up into the TZ. A combination of the three explanations is probable.

As discussed below, the vertical extent of the VOC plume is within the Upper Three Runs aquifer (UTRA) and includes three distinct horizons: the TZ, the MAZ, and the lower aquifer zone (LAZ). The lateral extent of the initial VOC plume was estimated at 46 acres (18.6 hectares), extending from the pit area to Pen Branch.

### **1.3 Observed Hydrostratigraphy at the CMP Pits OU**

In the vicinity of the CMP Pits OU, the aquifers of interest include the UTRA and the underlying Gordon aquifer (GA). Horizontal flow within the UTRA is divided into three discrete horizons that are separated by two semi-continuous confining zones which can be comprised of sandy clays in areas and therefore can be leaky. As noted above, the horizons are: 1) the TZ – a thin aquifer feature that lies above the top portion of the tan clay, the tan clay confining zone (TCCZ), 2) the

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MAZ – a thin aquifer horizon between the TCCZ and the lower portion of the tan clay, the tan clay lower clay (TCLC), and 3) the LAZ - the most substantial portion of the UTRA in the area, which extends to the green clay confining zone (GCCZ) with a thickness up to 100 ft (30.48 m). The GCCZ separates the UTRA from the GA. The confining zones, the TCCZ and TCLC, are hummocky, vary in thickness, and can be almost non-existent or leaky in areas. In general, the TCCZ is thinner than the TCLC.

Using the data collected from lithology pushes done for the 2002 modeling effort and from well installation records, the confining unit surfaces of the TCCZ and TCLC were spatially mapped (Figure 3) and compared to the most current fourth quarter 2017 (4Q2017) water elevation surfaces. Areas where the TZ and MAZ are suspected to be dry were delineated and are shown on Figure 3, as well as on all TZ and MAZ figures, and can be seen in the cross sections (See Section 2.2.2). The top of the TCCZ forms a semi-circular ridge at and north of the CMP Pits (shown as white and light pink shaded elevations in Figure 3), which causes much of the TZ to be dry. This shape is mimicked in the top of the TCLC, but the subsequent dry zone is not as extensive. The dry zones at CMP Pits are not a recent occurrence. Review of water elevation data from the 1980's and 1990's from abandoned wells suggests similar dry zones have existed for decades.

Figure 4 shows the locations of the 72 monitoring wells and seven surface water stations associated with the CMP Pits OU. The map also shows corresponding cross-section lines which depict the local hydrostratigraphic lithology and major contaminant plumes at the CMP Pits OU. The stratigraphy, aquifers and plumes are all, in general, gently sloping towards Pen Branch. However, the confining units appear to slope towards the south in some areas at the main CMP Pits area (Figure 3 and cross-section B-B' [See Section 2.2.2]). Although the TCCZ and the TCLC are depicted as continuous units in the cross-sections, the aquifer behavior in this area shows various elevation heads and contaminant pathways that indicate the confining horizons are discontinuous and/or intermixed with sandy clays in areas. The TZ, TCCZ, MAZ, TCLC, and LAZ units are eventually incised by Pen Branch itself or the local topography. In the CMP Pits OU area of interest (extent of the maps), the TZ is incised by Pen Branch on the east side of the stream reach, the MAZ is incised in the central portion of the stream reach, and the LAZ is incised by Pen Branch

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at the western portion of the stream. The horizontal extent of the TZ and MAZ are depicted on all TZ and MAZ maps.

#### 1.4 Observed Hydrology at the CMP Pits OU

Regional groundwater flow for the UTRA, as depicted in Figure 5, is to the northwest towards Pen Branch from CMP Pits. The last observed potentiometric surfaces from the calendar year (CY) 4Q2017 are displayed for each of the aquifer zones in Figure 6 and Figure 7. These potentiometric surfaces do not show any unusual pattern of flow from previous measurements. Figure 8 depicts the monthly rainfall levels in nearby L Area for 2017, 2016, 2015, 2014, and the 20-year average. Rainfall during 2017 (total of 46.78 inches) measured less than the 2016 measurements, and represents the fifth year in a row above the 20-year average (46.35 inches). The months of January and April were especially wet months. February, March, October, and November were extremely dry months. All wells showed either an increase in water elevation or approximately remained at 2016 measurements. Hydrographs of each well are presented in Appendix A.

A small region of radial flow appears to be superimposed upon the northwestward flow beneath the hill on which the CMP Pits are located and is depicted by the groundwater flow direction arrows in Figure 6. This pattern is due to the locally high topography at CMP Pits (Figure 2) as well as the bowl-like structure of the Tan Clay, especially in the upper TCCZ (Figure 3). Based on water elevations in the MAZ not being fully saturated, it appears the TZ may consist of perched water tables in many locations. The bowl-like structure of the tan clay as depicted in Figure 3 further supports this conclusion as the lower elevation of the TCCZ in the eastern portion of the CMP Pits may locally funnel groundwater to the south and southeast following the slope of the TCCZ before eventually flowing to the north and northwest. Water may mound up in the bowl-like structure as water is pushed towards the northwest from the overall regional groundwater flow and as water flows downslope into the bowl-like structure. As shown in Figure 6 in the TZ, the wells located directly around CMP Pits (CMP 34D, CMP 13D, CMP 35D, CMP 10D, and CMP 11D) display a relatively flat water elevation as all values are within half a foot of each other, but also suggest a south or southwest water elevation gradient. Some years display a more pronounced southerly flow gradient than others. Additionally, the dry zones may be slightly redirecting groundwater flow around the dry areas slightly to the east.

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The flow pattern in the MAZ resembles that of the TZ. Flow directions in the LAZ and GA are less defined, as the horizontal gradients are less across the area, as discussed below. In the area around the CMP Pits and towards the west and north, the water elevations in the LAZ are generally very similar and vary by up to 2 feet (Figure 7). Measurements show that groundwater in the vicinity of Pen Branch flows toward Pen Branch on both the southern and northern side of the stream, further supporting that contaminants originating south of Pen Branch from CMP Pits are not flowing underneath Pen Branch towards the north. Water elevations in the LAZ on the north side of Pen Branch are higher than elevations on the south side of Pen Branch.

Estimated horizontal groundwater linear velocities have been calculated from the groundwater flow paths drawn on Figures 6 and 7 for the TZ, MAZ, and LAZ aquifers using the following equation:

$$\text{Linear Velocity} \left( \frac{\text{ft}}{\text{day}} \right) = \frac{\text{Hydraulic Conductivity} \left( \frac{\text{ft}}{\text{day}} \right)}{\text{Porosity (unitless)}} \times \frac{dh \text{ (ft)}}{dl \text{ (ft)}}$$

The hydraulic conductivity constants (60, 50, and 20 ft/day for the TZ, MAZ, and LAZ, respectively) and porosity values (all 30%) used in the calculations are taken from the modeling efforts (WSRC 2002, SRNS 2017). The value  $dh$  is the difference in head;  $dl$  is the length of the groundwater flow paths shown on Figures 6 and 7. The ratio  $dh/dl$  is the horizontal gradient. The gradient, linear velocity per day and average linear velocity per year were each determined and are provided in Table 2 and described below.

Estimated velocities vary widely within the TZ between 0.91 ft/day on the western side of the CMP Pits and 2.9 ft/day on the eastern side. This variation could be caused by a combination of factors including the large dry zone area and the radial groundwater flow paths at the CMP Pits knoll, as discussed above. The average for the TZ is 2.16 ft/day, or 788.36 ft/year. The MAZ is more uniform in its rates and averages 1.72 ft/day, or 627.97 ft/year. The LAZ's rate is much less than the TZ and MAZ near CMP Pits (approximately 6.9 - 8.7% of the TZ and MAZ rates, respectively) with a rate of 0.50 ft/day, or 183.49 ft/year. Flow is greater near Pen Branch, especially on the north side of Pen Branch, however, flow rates still are less than half that of the TZ and MAZ.

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There is a significant downward component to groundwater flow throughout the UTRA. Water level measurements collected from well clusters during 2017 show an average head drop of 10.8 ft (3.3 m) across the TCCZ and an average of 13.5 ft (4.1 m) across the TCLC. There is an average of a 15.3 ft (4.7 m) drop in head across the Green Clay from the LAZ to the GA. As groundwater approaches Pen Branch, the downward gradient may decrease or even flow upward near and underneath Pen Branch as water discharges into Pen Branch. New monitoring well cluster CMP064BU and CMP064B (both screened in the LAZ) shows a higher water elevation in the lower B screen than the upper BU screen (Figure 7). Other wells, CMP 8 and CMP 8B, located upgradient of the wetland area display a much lower than average downward gradient of approximately 4.2 ft (1.3 m) across the TCLC. The TCCZ and TCLC are not considered thick competent confining clays, but rather are hummocky, vary in thickness, and can be almost non-existent or leaky in areas allowing some degree of flow between aquifers. The steep topography south of Pen Branch incises the TCCZ and TCLC, the sediment around the stream has been reworked over time as the stream meanders, and trees and roots have penetrated the clay layers allowing more interchange between aquifers. Additionally, wells in the wetland area near Pen Branch display water table elevations approximately 1 – 3 ft (0.3 – 0.9 m) above the stream bottom, indicating that Pen Branch is a gaining stream.

## **2.0 REMEDIAL ACTIONS**

This EMR documents the performance of the MNA remedy for the groundwater. Remedial activities for the vadose zone and Ballast Area Soils subunits were performed under an interim RA in 2001 and 2005, respectively (WSRC 1999 and WSRC 2006a). ERH combined with SVE was implemented from 2007 through 2009 to remove DNAPL from the vadose zone (Figure 2). This vadose zone RA mitigated the source term for the groundwater subunit which allows the MNA remedy.

### **2.1 CMP Pits Vadose Zone Remedial Action**

The ERH/SVE RA performed for the CMP Pits vadose zone was implemented to mitigate the CMCOCs PCE and DCM. Details of system construction are provided in the Post-Construction Report (SRNS 2008). ERH/SVE operation began on March 17, 2008. Heating via ERH continued until November 2008. Two SVE systems provided the VOC removal at the CMP Pits well field.

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SVE well effluent vapor concentrations and soil temperature data were analyzed to determine when the source term/DNAPL had been depleted. Operating data from the ERH system was provided in the EMR submitted in June 2009 (SRNS 2009).

In accordance with the EMP, confirmation samples were collected from three core locations. All sample results were below the remedial goal (RG) for PCE (36 mg/kg) and DCM (0.2 mg/kg) (SRNS 2010) meeting the intent of the RA. All remedial equipment and SVE units have been removed and abandoned. Even though the RA was successful and confirmation samples were below RGs, there is a possibility that residual contamination trapped within clay horizons and/or pore space in the vadose zone, in or out of the ERH/SVE zone, could act as a secondary source for groundwater contamination.

## **2.2 Groundwater Monitored Natural Attenuation Remedy**

### **2.2.1 Groundwater Aquifers**

As described above, groundwater analysis has been performed around the CMP Pits in four distinct aquifer zones of the UTRA and the GA. These zones in descending order are 1) the TZ of the UTRA, 2) the MAZ of the UTRA, 3) the LAZ of the UTRA, and 4) the GA.

Groundwater within these aquifers is currently monitored by the 72 wells which have been sampled on a semi-annual or annual basis (Table 1, Figure 4). The TZ includes 13 monitoring wells, the MAZ includes 26 monitoring wells, the LAZ includes 29 monitoring wells (including one extra well, CMP 32B), and the GA includes four monitoring wells. Each of these wells are used for water level measurements and the majority of the wells are sampled for VOCs and/or lindane. Five surface water stations north of CMP Pits located in the Pen Branch stream are used to monitor any discharge of VOCs to the stream. Two additional surface water stations (CMP-SW-20 and CMP-SW-21) were added in 2017 within the tributary to Pen Branch (Figure 4). Table 1 indicates the monitoring network required sampling frequency and the constituents that are monitored.

Based on the evaluation of monitoring data, advection and dispersion are the main MNA processes occurring at CMP Pits. Based on sampling analysis, some degree of biodegradation is occurring

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in the wetland area near Pen Branch, although it is not seen upgradient in the CMP Pits area outside the immediate stream area. The original 2002 groundwater model only accounted for advection and dispersion and estimated the plumes would remain above maximum concentration limits (MCLs) for 50 years (~2050) even if the vadose zone source was completely remediated (WSRC 2002). The updated model conducted in 2017 (See Section 3.0) added sorption and continuing VOC sources in clays and estimated the plumes would remain above MCLs for approximately 100 years (~2117). The increase in time is mostly attributed to sorption.

### **2.2.2 Groundwater Sampling Results**

Groundwater samples were collected from 67 monitoring wells at CMP Pits during the CY17 2Q and 4Q. This includes additional samples collected from some wells that are only used for water level measurements (CMP 56B, CMP 56D, CMP 57B, and CMP 57D) and a well that is not currently part of the monitoring network (CMP 32B). All groundwater results from 2017 are provided in Table 3. Plumes were drawn based on the maximum concentration from the 2017 results. Details on specific contaminants are described in the following subsections. Additional data results gathered from an independent source are discussed in Section 2.2.4.

#### **2.2.2.1 PCE and TCE**

PCE and TCE contamination has been identified in the TZ, MAZ, and LAZ above MCLs. The PCE plumes comprise approximately 46 acres (18.6 hectares) (Figures 9 and 10), and the TCE plumes comprise approximately 45 acres (18.2 hectares) (Figures 16 and 17). The majority of the horizontal plume movement occurs in the MAZ, which is consistent with modeling estimates. Vertical movement of the plumes are occurring as shown by an overall trend of decreasing concentrations in the MAZ, and an increasing trend in portions of the LAZ (Appendix B and Figures 14, 15, and 31). This is also consistent with modeling, as concentrations in the LAZ are predicted to increase over time. Of the 65 monitoring wells sampled in 2017 for VOCs, 31 wells had PCE concentrations above the MCL of 5.0 µg/L and 28 wells had TCE concentrations above the MCL of 5.0 µg/L. Most of the monitoring wells (83%) show a declining or steady (including consistent non-detects) trend in PCE and TCE over the past eight years as shown in the time-series plots for all the wells in Appendix B, Figure 31, and summarized below.

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The following is a summary of the PCE and TCE contaminant trends by aquifer:

**Transmissive Zone:**

The maximum concentrations of PCE and TCE found in the TZ were 795 µg/L for PCE (Figure 9) and 495 µg/L for TCE (Figure 16), both in monitoring well CMP 35D. There were six monitoring wells (out of nine sampled) screened in the TZ that had PCE and/or TCE concentrations above the MCL in 2017. Upgradient wells CMP062D and CMP063D are non-detect for both PCE and TCE.

Wells CMP 10D and CMP 11D have shown consistently high PCE and TCE values; however as shown in Appendix B, the trends for these wells over the past eight years have generally declined. Concentrations in well CMP 10D during 2017 were similar to concentrations during 2016. Concentrations in well CMP 11D during 2017 slightly increased from 2016 concentrations. Contamination in these two wells is a result of contaminants being transported by localized radial groundwater flow at the CMP Pits knoll, as described in Section 1.4 and shown in Figure 6, or by contaminants following the slopes of the confining units. Due to the shape of the TCCZ surface and the subsequent dry area that is created in the TZ, contamination may have been funneled towards the south and southeast towards CMP 10D and CMP 11D. Well clusters CMP062 and CMP063 remain below MCLs showing that contamination has not spread to the south/southeast.

Well CMP 35D has displayed increased concentrations over the last eight years; however, this is as wells CMP 10D and CMP 11D have shown decreases in their concentrations. The inversely related trends in wells CMP 10D and CMP 35D (Figure 30), for both VOCs and lindane, suggest it could be tied to hydrogeologic processes associated with the complex radial groundwater flow patterns due to the surface shape of the TCCZ and resulting dry zones in the TZ. The above average rainfall over the last few years has increased the water table elevations and possibly provided a mechanism for flow towards the northwest in the CMP 10D and CMP 35D area. Above average rainfall may also provide more opportunity for dispersion and diffusion from CMP 10D as there is more water volume available in the TZ. Additionally, the increased water elevations may allow release of trapped secondary sourced contamination in clay horizons or pore space into the groundwater since well CMP 35D is located downgradient of the CMP Pits. Since CMP 35D

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is located directly outside of the capped area, the low permeability cap at CMP Pits may retard infiltration and the effect of water elevation increases may be more pronounced. Figure 30 indicates a possible correlation between water elevation and contaminant levels of PCE at CMP 35D.

The TZ plume geometry is shown in Figure 9 for PCE and in Figure 16 for TCE. The main plume at and around the CMP Pits has remained roughly the same in size with concentrations near the actual pits area continuing to decrease at well CMP 10D but increased at well CMP 35D as previously discussed. The high concentrations have remained relatively confined near well CMP 35D which may indicate that the mass of contaminants has mostly been remediated. PCE and TCE concentrations at well CMP 11D slightly increased. Concentrations at CMP 13D slightly exceeded the PCE MCL but remains below the TCE MCL. Concentrations at well CMP 30D were non-detect for PCE, but TCE was detected below the MCL. Concentrations at CMP 36D continue to be below the MCL for both PCE and TCE. CMP 37D remained at similar concentrations to 2016 values, and concentrations at CMP 38D, slightly increased. The distal plume initially was thought to originate from an alternative source from the CMP Pits, as particle track modeling indicates it could be from a potential previously contaminated drainage ditch north of the CMP Pits (WSRC 2002) (located on all planar figures). As previously mentioned, characterization results of this area indicated that if a source was previously present in the vadose zone, it has been depleted (WSRC 2003). Due to the dry zone areas within the TZ, it is plausible that bifurcation of the plume into two separate plumes occurred over time, or that some contaminant flow went around the dry zone to the east. Discharging of the MAZ and LAZ into the Pen Branch stream likely brings some contamination up into the TZ as the water discharges into Pen Branch. The clay horizons between the aquifers can be thin and/or leaky and the TCCZ and TCLC are at or near ground surface at the location of the distal plume. The steep topography south of Pen Branch incises the TCCZ and other clay layers, the sediment around the stream has been reworked over time as the stream meanders, and trees and roots have penetrated the clay layers allowing more interchange between aquifers. All of these factors are probable explanations for the distal plume.

The distal plume has decreased in both size and core concentrations, with the area in and south of the actual pits area showing the largest reduction in concentrations. A comparison of changes in

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PCE plume concentrations over the last nine years (2017 values compared to 2008 values [Pre ERH/SVE]) can be seen in Figure 14 and Table 4. In the TZ, most plume concentrations have decreased. CMP 35D located directly north of CMP Pits has been increasing in PCE concentrations over the past five years, but remains below historical high levels. Concentrations at wells CMP 10D and CMP 11D have both decreased by approximately 90% and show a large reduction in total mass for the TZ, indicating the source remediation was successful. Concentrations at CMP 35D will continue to be monitored. TCE trends are similar to PCE and are therefore not mapped.

### **Middle Aquifer Zone:**

The maximum concentrations found in the MAZ in 2017 were 314 µg/L for PCE at well CMP 45D (Figure 9) and 154 µg/L for TCE at well CMP 52C (Figure 16). These maximum values are very similar to 2016 concentrations. There are 15 monitoring wells (out of 24 sampled) screened in the MAZ that had PCE concentrations above the MCL in 2017, and 14 monitoring wells had TCE exceedances above the MCL. The majority of the MAZ wells display a steady or decreasing trend in concentrations (Figure 31). One well (CMB 24I) showed an increase in PCE, however, results are far below historical maximum values. Well CMP059C displays a slight increasing trend as this well is near other wells with similar or higher concentrations and is mostly likely due to plume spreading or concentrations from the TZ. CMP 41D displays recent MCL exceedances. This well is located near Pen Branch on the western edge of the PCE and TCE plume. TCE shows a more increasing trend at CMP 41D which is most likely due to VOC degradation occurring in the wetland area. The remaining MAZ wells show decreasing or no significant change in PCE concentrations. Similar trends were observed for TCE in these wells.

PCE and TCE concentrations rapidly decrease once the plume reaches the wetland area near Pen Branch where VOC degradation is occurring.

A comparison of changes in PCE plume concentrations over the last nine years (2017 values compared to 2008 values [Pre ERH/SVE]) can be seen in Figure 14 and Table 4. In the MAZ, core plume concentrations have decreased dramatically by approximately 80%. The plume footprint expanded horizontally with new data points collected in 2016. Concentrations near Pen

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Branch in the wetland area at wells CMP 40D and CMP 39D have decreased, indicating that the main source zone has been sufficiently remediated and VOC degradation is attenuating the plume. TCE trends are similar to PCE and are therefore not mapped.

#### **Lower Aquifer Zone:**

There are 10 monitoring wells (out of 28 sampled) screened in the LAZ that had PCE concentrations above the MCL in 2017, while nine had TCE concentrations above the MCL. The maximum concentrations of PCE and TCE found in the LAZ in 2017 were 448 µg/L for PCE at monitoring well CMP064BU and 205 µg/L for TCE at monitoring well CMP 10C. These maximum concentrations are less than was seen in 2016. CMP064BU is located to the east of well CMP 8B and may indicate a preferential flow path for groundwater or contaminants due to the relatively high concentrations of VOCs (Figure 10). Concentrations at CMP064BU and CMP065B decreased from 2016 levels. PCE and TCE both increased at well CMP 32C; however, concentrations in other nearby and downgradient wells remained similar to last year's values or decreased. Concentrations of both PCE and TCE at CMP 10C are declining. Concentrations at seven wells (CMP 8B, CMP 10B, CMP 13B, CMP 32C, CMP 52BU, CMP 54C, and CMP058B) display increasing trends over the last nine years (Appendix B and Figure 28). The majority of these wells are located in the upper portion of the LAZ. Contamination in the LAZ is limited to the upper half portion of the aquifer as seen in the three cross sections, A – A', B – B', and C-C' (Figures 11, 12, and 13). PCE and TCE concentrations in mid-LAZ plume wells CMP 10B and CMP 13B are slightly increasing; however, CMP 10B has remained at consistent levels just above the MCL for the past three years. Other wells vertically located mid-plume and deeper remain steady, below MCLs, or non-detect, including additional well CMP 32B (Figure 12).

Upgradient wells CMP062B and CMP063B were non-detect for PCE and TCE during 2017. Downgradient wells CMP060B and CMP061B remains non-detect, and well CMP 8B and remain below MCLs. For the past six years, CMP 8B has had low detections of PCE at concentrations in 2017 having a maximum of 2.48 µg/L. VOC results at wells CMP066B and CMP067B, located north of Pen Branch and vertically located mid-LAZ plume (Figure 10), were non-detect indicating that contaminants have not migrated underneath Pen Branch to the northwest (also see discussion in Section 1.4, *Observed Hydrology at the CMP Pits OU*).

Similar to the location of the northeast distal plume in the TZ and MAZ aquifers, VOC contaminants are present in the LAZ. Some upward vertical water elevation heads are present in the LAZ closer to Pen Branch (i.e., CMP064BU and CMP064B) which supports that the LAZ is discharging into Pen Branch (Figure 7). Contaminants are from upgradient clay layers and aquifers.

A comparison of changes in PCE plume concentrations over the last nine years (2017 values compared to 2008 values [Pre ERH/SVE]) can be seen in Figure 15 and Table 4. LAZ plume concentrations have generally increased in the upper half of the aquifer. Increases in the LAZ are expected, as both the previous modeling effort and recent model update also predicted increases in the LAZ over time. The area southeast of CMP 10C is currently on a decreasing trend over the previous seven years, suggesting the majority of source contaminants have been remediated. Concentrations on the western edge of the plume (well CMP 33D) has also decreased. The LAZ plume is likely discharging to Pen Branch as surface water station CMP-SW-08 has had detections of PCE and TCE during 4Q2015 and new monitoring well data to the northeast has shown high concentrations of VOCs. The downgradient wells (CMP060B, CMP061B, and CMP 8B) remain below MCLs. The majority of the plume is most likely reaching Pen Branch and the wetland area east and downgradient of CMP 8B, which also correlates to the TZ and MAZ contaminants near Pen Branch. This is also supported by the additional data presented in Section 2.2.4. TCE trends are similar to PCE and are therefore not mapped.

#### **Gordon Aquifer:**

There are four monitoring wells screened within the GA and all were sampled once during 2017. All results were below MCLs or non-detect for both PCE and TCE. Well CMP 12A detected PCE at a low estimated value of 0.49 µg/L, which is within historical levels, as concentrations fluctuate between non-detect and values significantly less than MCLs. As stated above, the contamination remains in the UTRA and extends down to the upper portion of the LAZ. The GA screened wells are in place to confirm contamination has not migrated farther downward than expected as described in the EMP (WSRC 2006b). Modeling does not predict contamination to reach the GA at levels above MCLs (WSRC 2002, SRNS 2017).

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#### 2.2.2.2 Cis-1,2-Dichloroethylene (c-1,2-DCE)

c-1,2-DCE was detected in six wells in 2017. Concentrations were all low values, with a maximum of 5.77 µg/L at well CMP 40D, well below the 70 µg/L MCL. Wells (CMP 37D, CMP 39D, and CMP 40D) which are located near Pen Branch continue to show the highest concentrations of c-1,2-DCE, suggesting degradation of PCE and TCE is occurring in the Pen Branch wetlands. This is supported by results collected from an independent study, as discussed in Section 2.2.4. c-1,2-DCE is the preferential degradation pathway for TCE as trans-1,2-dichloroethylene (t-1,2-DCE) and 1,1-DCE are non-detect or minimally detected as discussed below.

The lack of high detectable results in other monitoring wells confirms that VOC degradation is not widely occurring and advection and dispersion are the main MNA processes occurring.

#### 2.2.2.3 Trans-1,2-Dichloroethylene (t-1,2-DCE)

In 2017, all t-1,2-DCE results were non-detect.

#### 2.2.2.4 1,1-Dichloroethylene (1,1-DCE)

In 2017, all 1,1-DCE results were non-detect.

#### 2.2.2.5 Vinyl Chloride (VC)

In 2017, VC was detected (1.37 µg/L) in one well, CMP 13B, , less than the MCL of 2 µg/L, during both 2Q2017 and 4Q2017. All other 2017 CMP monitoring results were non-detect for VC.

#### 2.2.2.6 1,4-Dioxane

1,4-Dioxane is analyzed annually at CMP Pits. There is currently no MCL for 1,4-dioxane, but the current United States Environmental Protection Agency (USEPA) tapwater regional screening level (RSL) is 0.46 µg/L. The current lab detection limit of 1 µg/L does not meet the RSL value, while the sample quantitation limit was 3 µg/L. There is no SC certified lab that has detection limits for 1,4-dioxane that can meet the current USEPA RSL. SRS will continue to look for and work with the labs to try to achieve the lowest possible detection limits. The RSL is used as the groundwater protection standard (GWPS) for contouring plume maps (Figures 18 and 19) and cross-sections (Figures 20, 21, and 22).

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Detections occurred in 12 of the 60 wells sampled (20%) at locations within the PCE/TCE plume hotspots. The maximum concentration was 99 µg/L at well CMP 11D. Detects were in the TZ, MAZ (Figure 18) and LAZ (Figure 19). It was not detected in wells north of Pen Branch. In general, 1,4-dioxane is detected around the CMP Pits source area and in the wetland area wells near Pen Branch, but is minimally detected at intermediate wells. As seen in Appendix B, concentrations increased in some wells since 2016, and decreased in others with no significant variations. The distribution of 1,4-dioxane detected in the TZ, MAZ, and LAZ during 2017 is similar to the 2016 findings.

#### 2.2.2.7 Carbon Tetrachloride (CCl<sub>4</sub>)

CCl<sub>4</sub> was detected in 18 wells during 2017, but only exceeded the MCL of 5.0 µg/L in five wells: CMP 8, CMP 10D, CMP 10C, CMP 35D, and CMP064BU, with a maximum concentration of 21.3 µg/L at well CMP064BU. Plume maps were not created due to the limited number of exceedances. All well concentrations are below their historical maximums.

#### 2.2.2.8 Chloroform

Chloroform was detected in 24 wells during 2017. None of the results exceeded the MCL of 80 µg/L. The maximum result was at well CMP 35D with a value of 20.2 µg/L. The highest concentrations coincide with wells that have CCl<sub>4</sub> contamination as chloroform is a degradation product of CCl<sub>4</sub>.

#### 2.2.2.9 Dichloromethane (DCM)

Only one monitoring well, CMP064BU, had DCM detections; concentrations were well below the MCL of 5 µg/L, with a maximum 2017 concentration of an estimated 1.76 µg/L.

#### 2.2.2.10 Bromodichloromethane

In 2017, bromodichloromethane was detected at low concentrations in seven wells. The maximum result was found at CMP 35D at 6.36 µg/L, well below the MCL of 80 µg/L.

#### 2.2.2.11 1,1,2-Trichloroethane (1,1,2-TCA)

In 2017, 1,1,2-TCA was not detected at any of the CMP wells.

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#### 2.2.2.12 Lindane

Twenty wells were analyzed for lindane in 2017. The MCL for lindane is 0.2 µg/L and only three wells (CMP 10D, CMP 10C, and CMP 35D) had lindane concentrations that exceeded this level. (See Figures 23 and 24). CMP 10D values were estimated. Cross-sections with lindane plumes and concentrations are provided in Figures 25 through 27. Most of the 20 wells monitored for lindane in 2017 show slightly decreasing or steady trends in concentrations as shown in Appendix B and Figures 28, 29 and 31.

The highest lindane concentration for 2017 was 5.78 µg/L found in CMP 35D during 2Q2017, concentrations decreased to 4.44 µg/L in 4Q2017. This well has shown fluctuations in concentrations over the years (Appendix B, page B-55). Factors contributing to this include the complex hydrogeology of groundwater flow paths, surface shape of the TCCZ (Section 1.3 and Figure 3), perched water table conditions, and above average rainfall during the last four years (Section 1.4, Figure 6, and Figure 8). Increases at CMP 35D have occurred as concentrations at well CMP 10D have decreased. The inversely related trends in wells CMP 10D and CMP 35D (Figure 30), for both lindane and VOCs, suggest the increases could be tied to hydrogeologic processes associated with the radial groundwater flow patterns due to surface shape of the TCCZ and dry zones in the TZ. Higher water table elevations have possibly provided a mechanism to release contamination trapped in the vadose zone pore space or capillary fringe, as well as for groundwater to flow towards the northwest providing more opportunity for dispersion and diffusion from CMP 10D and CMP Pits. The low permeability cap retards infiltration so the effect of water table elevation increases may be more pronounced since CMP 35D is located directly outside the cap area. Figure 30 indicates a possible correlation between water elevation and contaminant levels of lindane at CMP 35D.

CMP 10C, in the Upper LAZ, shows concentrations generally decreasing the past four years. Well CMP 10B, which is screened at the bottom of the LAZ (Figure 25), remains non-detect. Due to the shape of the TCCZ surface and the subsequent dry area that is created in the TZ (Figure 3), contamination may have been funneled towards the south and southeast towards CMP 10D from the high concentration area around CMP 35D and the CMP Pits. Fluctuating water elevations

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could move groundwater back and forth between CMP 10D and CMP 35D or potentially release contaminants into the water table that were trapped in pore space or clay zones.

Lindane was detected at well CMP064BU (Upper LAZ) at a concentration of 0.195 µg/L during 2Q2017 and dropped to 0.176 in 4Q2017. Well CMP065BU (MAZ) detected lindane at a maximum concentration of 0.0123

The lindane plume is estimated at approximately 2.9 acres (1.2 hectares) in the UTRA (Figures 23 and 24). The majority of the plume (including the highest concentrations) resides in the TZ. The MAZ concentrations slightly decreased in 2017 and all wells were at or below the MCL. The plume is more diffused and spread out within the MAZ (Figure 21) and overall concentrations appear to be decreasing. Within the past five years lindane has been detected above MCLs in only one well, CMP 10C (Figure 24).

A comparison of lindane plume concentrations over the last nine years (2017 values compared to 2008 values) can be seen in Figures 28 and 29 and Table 5. In the TZ, plume concentrations have increased at wells CMP 10D and CMP 35D as discussed above, but contamination is limited to only those two wells. In the MAZ, the area to the north and northwest of the pits has decreased in concentration with no wells exceeding MCLs in 2017. The LAZ has seen increases in concentrations southeast of the pits at well CMP 10C. The increase is believed to be due to the shape of the surface of the Tan Clay, localized radial groundwater flow around the CMP Pits knoll and leaky conditions within the TCCZ and TCLC. Contamination does not extend deeper than the upper portion of LAZ (Figure 25). The lindane plumes have minimally increased in extent in the TZ and LAZ, which is believed to be caused by contamination trapped in the vadose zone pore space or capillary fringe, the stratigraphy of the Tan Clay, subsequent dry areas in the TZ and MAZ, and radial groundwater flow. Although lindane does not diffuse in aquifers as quickly as VOCs, the factors mentioned above may be further hindering contaminant advection and dispersion.

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### 2.2.3 *Surface Water Sampling Results*

Surface water in Pen Branch is sampled semi-annually at seven locations along the groundwater discharge boundary (Figure 4). Two additional locations were added in 2017 in a tributary leading to Pen Branch (CMP-SW-20 and CMP-SW-21).

Surface water samples are analyzed for VOCs. Table 3 and Figures 9, 10, 16, and 17 show the PCE/TCE results at each station. Modeling results show an expected VOC discharge to Pen Branch above MCLs. In 2017, there were no detections of VOCs in surface water. Only once in 4Q2015, PCE was detected above the MCL at 8.49  $\mu\text{g/L}$  at station CMP-SW-08. 1,4-Dioxane was analyzed at all five required surface water stations (CMP-SW-06 through CMP-SW-10) during 4Q2017 and all results were non-detect.

These results agree with the independent data as described in Section 2.2.4 as no surface water samples had detections of VOCs. The surface water stations were all non-detect for 2017. CMP Pits VOC groundwater plume effects on Pen Branch are negligible as VOCs have not been detected in surface water since 4Q2015.

During 4Q2017, all seven surface water samples were analyzed for lindane. Lindane was not detected in any of the surface water samples.

Stream flow measurements were collected in 4Q2017 at six of the seven surface water stations. Stream conditions at CMP-SW-10 are too spread out over the wetlands to measure flow. Measurements are provided in the Field Measurements section of Table 3. Measurements ranged from 0.85 cubic feet per second ( $\text{ft}^3/\text{s}$ ) on the eastern side of Pen Branch and dropped down to 0.502  $\text{ft}^3/\text{s}$  downstream to the west. Measurements taken in the tributary to Pen Branch were 0.383  $\text{ft}^3/\text{s}$  and 0.353  $\text{ft}^3/\text{s}$  at surface water stations CMP-SW-20 and CMP-SW-21, respectively. The tributary is approximately 40 to 45% of the flow after the confluence with Pen Branch. The tributary originates northeast of Road C.

Pen Branch is a gaining stream. The slightly decreasing flow rates downstream are explained by the stream channel widening as it flows west. In the CMP Pit Pen Branch area, the eastern side of Pen Branch is confined to a discrete channel. Downstream, starting west of the CMP-SW-07

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station, the surface topography starts to flatten and causes the stream to become wider and travel less through a single open channel and flows under and around trees, roots, and wetland vegetation. Once at the CMP-SW-10 location, the stream is braided through a wide wetland area that is greater than 200 ft across. A marsh/swamp vegetation coverage has been added to the planar maps.

#### ***2.2.4 Additional Data from Independent Analysis***

Sampling for VOCs was conducted in and around Pen Branch by a South Carolina State University (SCSU) group during 3Q2017 under a grant provided by the United States Department of Energy (USDOE). The focus of the study is the MNA processes occurring in the stream and wetlands around Pen Branch as the VOC plume moves towards and discharges into Pen Branch. Many of the SCSU samples are collected from the groundwater immediately before discharge into Pen Branch. During 3Q2017, SCSU collected 19 groundwater and 9 surface water samples at locations depicted on Figures 32 and 33. A summary of the 2017 results is provided in Table 6. A complete listing of results is provided in Table 7.

The groundwater samples collected were a combination of samples taken from beneath the Pen Branch stream bed and locations immediately adjacent to the stream bed. Groundwater samples were collected using a peristaltic pump or passive diffusion bags (PDBs). Surface water was collected by a bailing-grab method. All samples were analyzed for PCE, TCE, and associated degradation products using a screening level data validation process.

SCSU reported that PCE and TCE were detected in groundwater samples at a maximum concentration of 91 µg/L and 55 µg/L, respectively. These results are similar with the SRS distal plume wells concentrations in the TZ and MAZ. Additionally, the data results confirm that VOC degradation is occurring near the stream and within the plume. The contaminant discharges are thin or discrete which quickly mix with clean surface water, as surface water is not contaminated with PCE or TCE above MCLs. Detections sporadically downgradient indicate there are small discrete preferential pathways where contamination is migrating to Pen Branch in the MAZ and LAZ.

VOC degradation is occurring almost exclusively through the c-1,2-DCE pathway, as results for 1,1-DCE and t-1,2-DCE were all non-detect. Cis-1,2-DCE was detected in 57% of the samples

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with a maximum concentration of 130 µg/L, although most samples were far below the MCL of 70 µg/L. Two groundwater stations (5D1B located on the south bank and 5DB which is collected below the streambed before discharge into Pen Branch) exceeded the c-1,2-DCE MCL. However, the collocated surface water sample and surface water downstream from those stations were non-detect indicating that contaminant discharge is very discrete, not widespread, and that concentrations are quickly reduced once they enter the surface water (Figure 32).

SCSU found VC detections in 39% of the samples concentrated in the area downgradient of well CMP 40D (Figure 33). Eleven samples had detections of VC with the maximum concentration of 92 µg/L, although most of the detections were below 20 µg/L. Ten of the groundwater sampled exceeded the VC MCL of 2 µg/L. All groundwater and surface water results downstream of CMP-SW-07 were non-detect for VC indicating that the main area of VOC degradation is occurring in the wetland area between surface water station CMP-SW-06 and CMP-SW-07. This is the area where VOCs are expected to mainly be discharging to Pen Branch as stations CMP 8 and CMP064BU show relatively high PCE and TCE contamination levels.

Overall, the VOC detections in 2017 were similar to previous years, but with higher counts of degradation product occurrences. The results from the SCSU sampling show discrete areas of preferred groundwater contaminant transport, but also demonstrate that the overall impact to Pen Branch surface water is negligible. Degradation of VOCs in the wetlands through vegetative processes is currently being studied by SCSU. Results and findings will be provided in the next CMP Pits EMR.

### **3.0 2017 UPDATED GROUNDWATER MODEL**

The CMP Pits groundwater model was updated during CY 2017 to revise cleanup timeframes based on contamination trends to date (SRNS 2017). The data collected from all monitoring wells since the last modeling effort in 2002 were incorporated into the modeling parameters. Lithology was updated with the new stratigraphic elevations provided by the new monitoring well locations. The updated model included the addition of sorption/desorption of contaminants and secondary VOC sources in clay layers into the projections for contaminant trends.

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The flow model sufficiently calibrated to head measurements in monitoring wells and displayed similar dry zones within the TZ and MAZ as has been depicted in the CMP Pits EMRs. The model was calibrated to plume behavior over the 2002-2016 period. A continuous vadose zone source and no source was modeled. The difference between the future plume behavior between the two sources modeled was minimal, suggesting that the magnitude and extent of contamination is likely due to the pre-remediation source. Accurate quantification of the source for predicting future plume behavior is not necessary. The PCE flux to drains was calculated to be approximately 1 kg/yr and drops down to 0.2 kg/yr by 2097 (Figure 34). With a continuing source and sorption added to the model, PCE is expected to be above MCLs for approximately 91 years (~2107). As a comparison, the original 2002 model predicted the PCE plume to be above MCLs for 50 years (~2050) if all the vadose zone source was removed and 130 years (~2130) if 85% of the source was removed. The updated model expects TCE to discharge above MCLs for 48 years (~2065). The addition of continuing sources and sorption have not greatly changed the predictions for the CMP Pits VOC plumes as the anticipated time to reach MCLs is within the estimated ranges in the original 2002 model. The updated model predicted that VOCs should be discharging to Pen Branch above MCLs for many decades, however degradation in the wetlands is likely reducing these concentrations and likely reducing the flux of PCE entering Pen Branch.

Lindane and 1,4-dioxane were modeled and are not expected to exceed MCLs or RSLs at discharge locations.

Additional detailed information on the updated model can be found in the modeling report (SRNS 2017).

#### **4.0 SUMMARY**

Surface maps of the Tan Clay (both the TCCZ and the TCLC) have been presented to aid in the understanding of radial groundwater flow at CMP Pits and probable contaminant transport mechanisms. Another year of above average rainfall during 2017 has slightly raised the water table, and the areas estimated to be dry in the TZ and MAZ have marginally decreased in size from last year. Perched water tables most likely exist in parts of the TZ and MAZ. The shape of the tan clay layer and the level of the water table restrict groundwater flow movement in the TZ and

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MAZ and cause complex radial groundwater flow paths. This would explain some increasing contaminant trends, as contaminants may have become re-suspended but limited in lateral movement.

Advection and dispersion are the main MNA processes occurring at CMP Pits. Effectiveness monitoring data collected through 2017 indicates that the MNA remedy is working as predicted. Groundwater and surface water results are consistent with modeling predictions (WSRC 2002, SRNS 2017). Maximum core concentrations are decreasing. Implementation of the ERH/SVE RA has depleted the VOC source term in the vadose zone at the CMP Pits and created conditions which have allowed the MNA remedy for groundwater to work as predicted. Overall, the majority of VOC concentrations are decreasing or steady in the TZ and MAZ. Some increases in the LAZ are most likely due to plume migration vertically from the MAZ to the LAZ consistent with modeling expectations (WSRC 2002, SRNS 2017). Contamination remains in the uppermost portion of the LAZ while many concentrations near the actual CMP Pits are decreasing.

The increase in VOCs and lindane at well CMP 35D appears to be related to water elevation rise releasing contamination trapped in the vadose zone. All lindane concentrations in the MAZ wells have decreased. Lindane has been decreasing in the LAZ at well CMP 10C over the last four years with contamination limited to the upper portions of the LAZ. Only three wells exceed MCLs in 2017. Surface water samples were analyzed for lindane in 4Q2017 and all results were non-detect.

Wells located north of Pen Branch confirm that contamination is not flowing underneath Pen Branch to the northwest and that groundwater on both the north and south sides of Pen Branch discharge into the stream. Wells located in the distal plume area towards the northeast show a possible preferential pathway for groundwater as relatively high levels of VOC contaminants and low concentrations of lindane exist in this area. Dry zones may be slightly redirecting groundwater flow which may explain elevated concentrations to the northeast.

With the elimination of the source term, short term increases are not unusual, as the stratigraphy within the CMP Pits area is highly variable and heterogeneous and high clay content can retard groundwater flow or cause preferential pathways. Additionally, modeling has predicted that contamination will remain above MCLs for many decades. The most important indicator that the

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MNA remedy is performing as predicted is an evaluation of the long-term concentration trends of many monitoring wells and an interpolation of the data showing decrease in plume size over time. Although the overall plume size has minimally changed since the completion of the source term RA seven years ago, core concentrations continue to decline and surface water is minimally impacted as concentrations are generally non-detect. VOC degradation in the wetlands around Pen Branch are likely reducing the flux of VOCs into Pen Branch.

1,4-Dioxane was analyzed at a majority of the CMP Pits wells and at surface water stations in 2017. Detections were found in 20% of the wells with a maximum concentration of 99 µg/L. The plume coincides with the locations of the PCE and TCE plumes, but is only a third of the area. All surface water station samples were non-detect for 1,4-dioxane. Due to its presence in groundwater, 1,4-dioxane is monitored annually.

Screening level data presented within this report from SCSU has shown excellent agreement between the SRS monitoring well and surface water near the Pen Branch stream sampling performed last year. The MNA breakdown products are prevalent in the shallow groundwater around the stream but are non-detect within Pen Branch surface water. Results also suggest that c-1,2-DCE is the main degradation pathway for PCE and TCE which occurs in the area around Pen Branch in the northeast around wells CMP 39D and CMP 40D. SCSU's results indicated VC is present at levels above MCLs in the groundwater downgradient from well CMP 40D, but concentrations quickly drop to non-detect in surface water and downstream indicating no buildup of contaminants.

An updated groundwater model has been developed and was submitted in December 2017 (SRNS 2017). The updated model included updated monitoring data, new monitoring well information, sorption/desorption criteria, continuing sources in clay horizons, and was calibrated to plume behavior over the 2002-2016 period. The results of the model indicated that PCE would exceed MCLs in groundwater for approximately 91 years (~2107). This is within the range estimated in the original 2002 model. Lindane and 1,4-dioxane are not expected to discharge to Pen Branch above MCLs or RSLs.

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## 5.0 REFERENCES

SRNS, 2008. *Post-Construction Report (PCR) for the Chemicals, Metals, and Pesticides Pits Operable Unit (080-170G, 080-171G, 080-180G, 080-181G, 080-182G, 080-183G and 080-190G) (U)*, WSRC-RP-2007-4070, Rev. 1.1, April, Savannah River Nuclear Solutions LLC, Savannah River Site, Aiken, SC

SRNS, 2009. *Effectiveness Monitoring Report for the Electrical Resistance Heating (ERH)/Soil Vapor Extraction (SVE) System and Monitored Natural Attenuation (MNA) at the Chemicals, Metals, and Pesticides (CMP) Pits Operable Unit (OU) (U) March 2008 through March 2009*, SRNS-RP-2009-00573, Rev. 0, June, Savannah River Nuclear Solutions LLC, Aiken, SC

SRNS, 2010. *Effectiveness Monitoring Report for the Electrical Resistance Heating (ERH)/Soil Vapor Extraction (SVE) and Monitored Natural Attenuation (MNA) at the Chemicals, Metals, and Pesticides (CMP) Pits Operable Unit (OU) (U) March 2009 through March 2010*, SRNS-RP-2010-00896, Savannah River Site, Rev. 0, June, Savannah River Nuclear Solutions LLC, Aiken, SC

SRNS, 2017. *Groundwater Flow and Solute Transport Model of the CMP Pits OU (U)*, SRNS-TR-2017-00312, Savannah River Site, Rev. 0, December, Savannah River Nuclear Solutions LLC, Aiken, SC

WSRC, 1999. *Interim Record of Decision Remedial Alternative Selection for the Chemicals, Metals, and Pesticides Pits (U)*. WSRC-RP-98-4192, Rev. 1, August, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC

WSRC, 2002. *Groundwater Modeling for the Chemicals, Metals, and Pesticides (CMP) Pits (U)*. WSRC-RP-2002-4195, October, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC

WSRC, 2003. *RCRA Facility Investigation/Remedial Investigation Addendum with Baseline Risk Assessment for the CMP Pits (U)*, WSRC-RP-2002-4049, Rev. 1.1, August, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC

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WSRC, 2004. *Record of Decision/Remedial Alternative Selection for the Chemicals, Metals, and Pesticides Pits Operable Unit (080-170G, 080-171G, 080-180G, 080-181G, 080-182G, 080-183G and 080-190G) (U)*, WSRC-RP-2004-4090, Rev. 1, December, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC

WSRC, 2006a. *Interim Post-Construction Report (IPCR) for the Chemicals, Metals, and Pesticides (CMP) Pits Operable Unit – Ballast Area (080-170G, 080-171G, 080-180G, 080-181G, 080-182G, 080-183G and 080-190G) (U)*, WSRC-RP-2005-4065, Rev. 1, January, Washington Savannah River Company, Savannah River Site, Aiken, SC

WSRC, 2006b. *Effectiveness Monitoring Plan for the Electrical Resistance Heating (ERH)/Soil Vapor Extraction (SVE) System and Monitored Natural Attenuation at the Chemicals, Metals, and Pesticides Pits Operable Unit (U)*, WSRC-RP-2005-4077, Rev. 1, February, Washington Savannah River Company, Savannah River Site, Aiken, SC

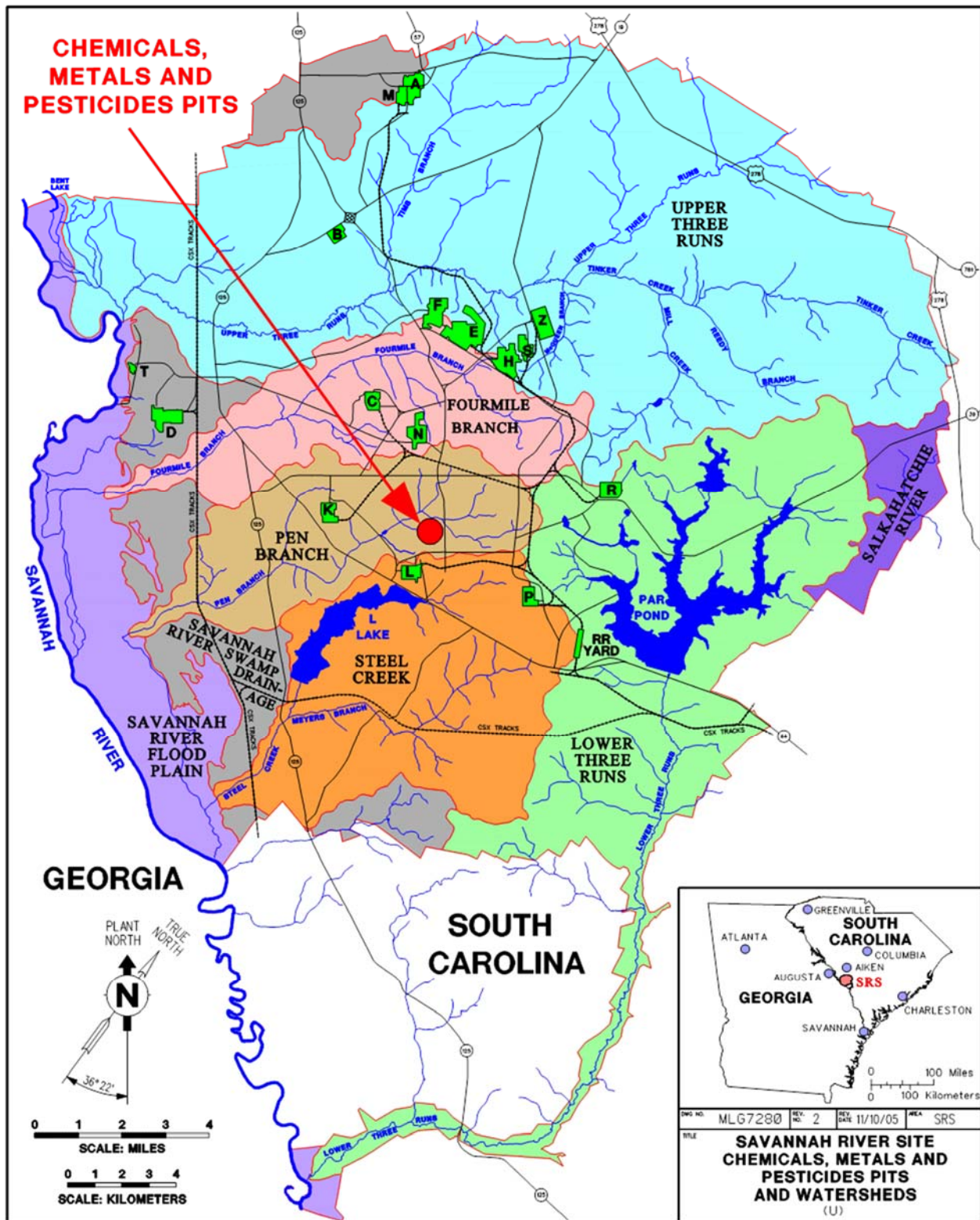


Figure 1. Location of the CMP Pits OU within the Savannah River Site

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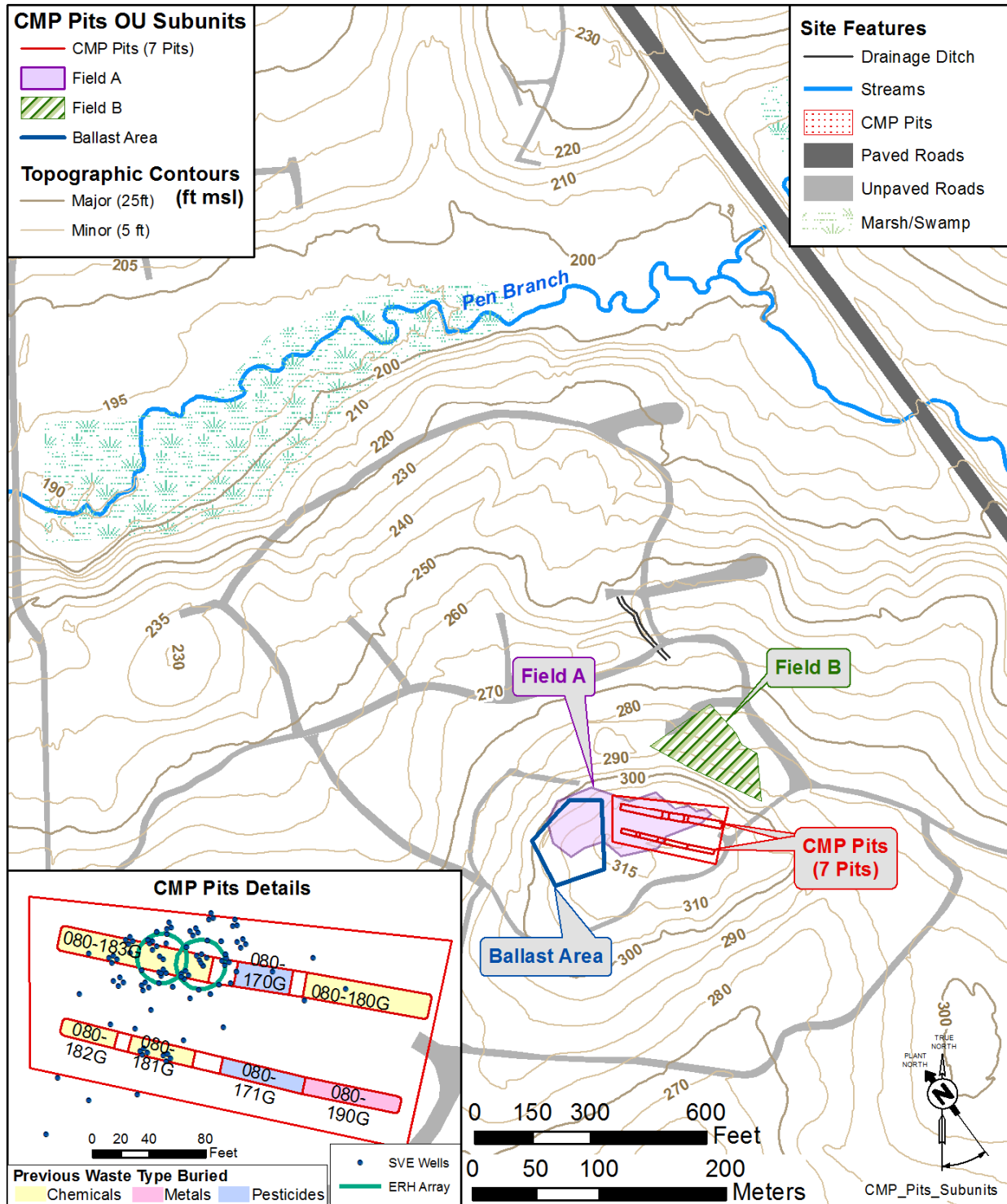


Figure 2. CMP Pits OU Subunits

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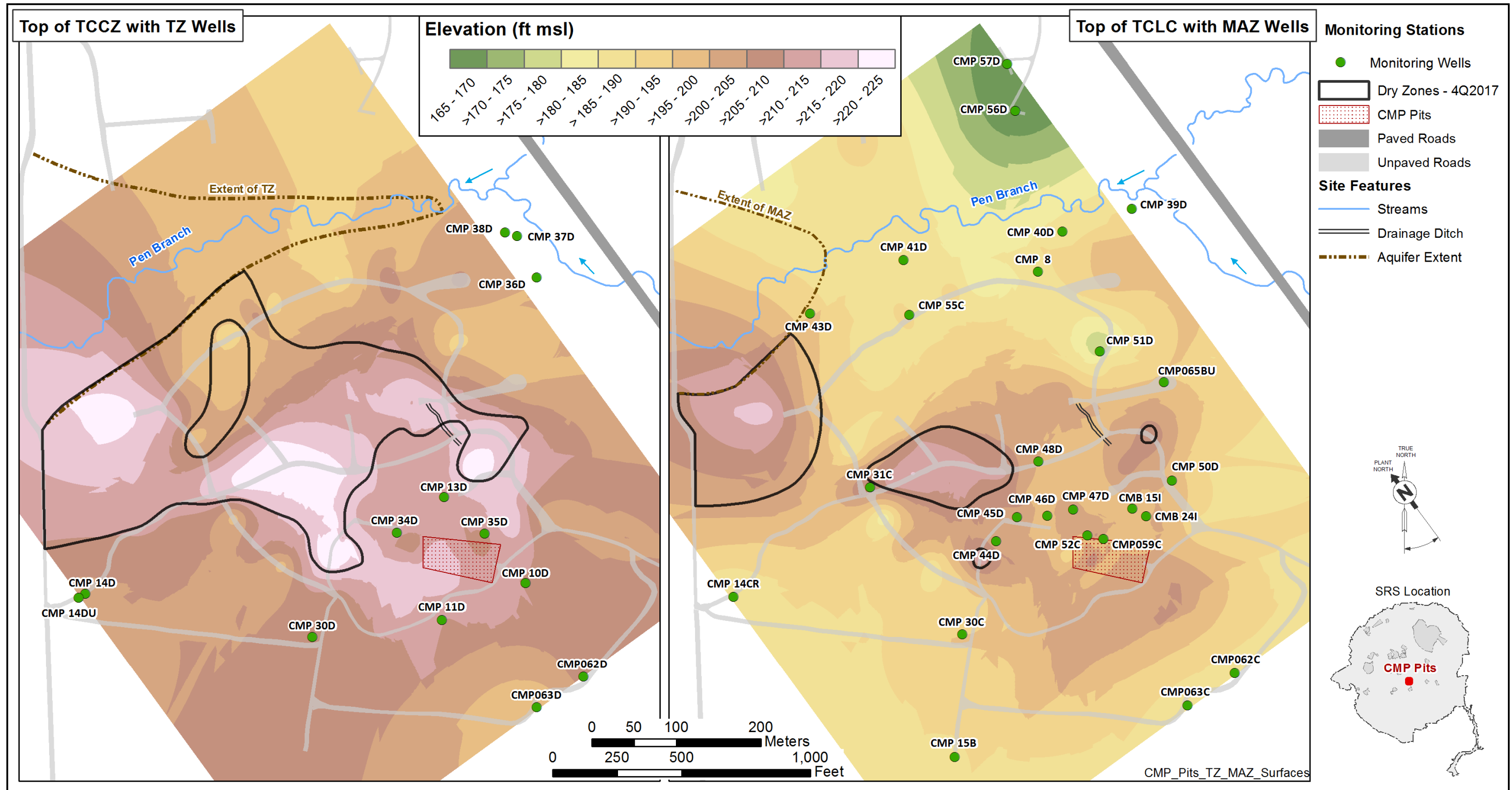


Figure 3. Stratigraphic Surfaces of the TCCZ and TCLC

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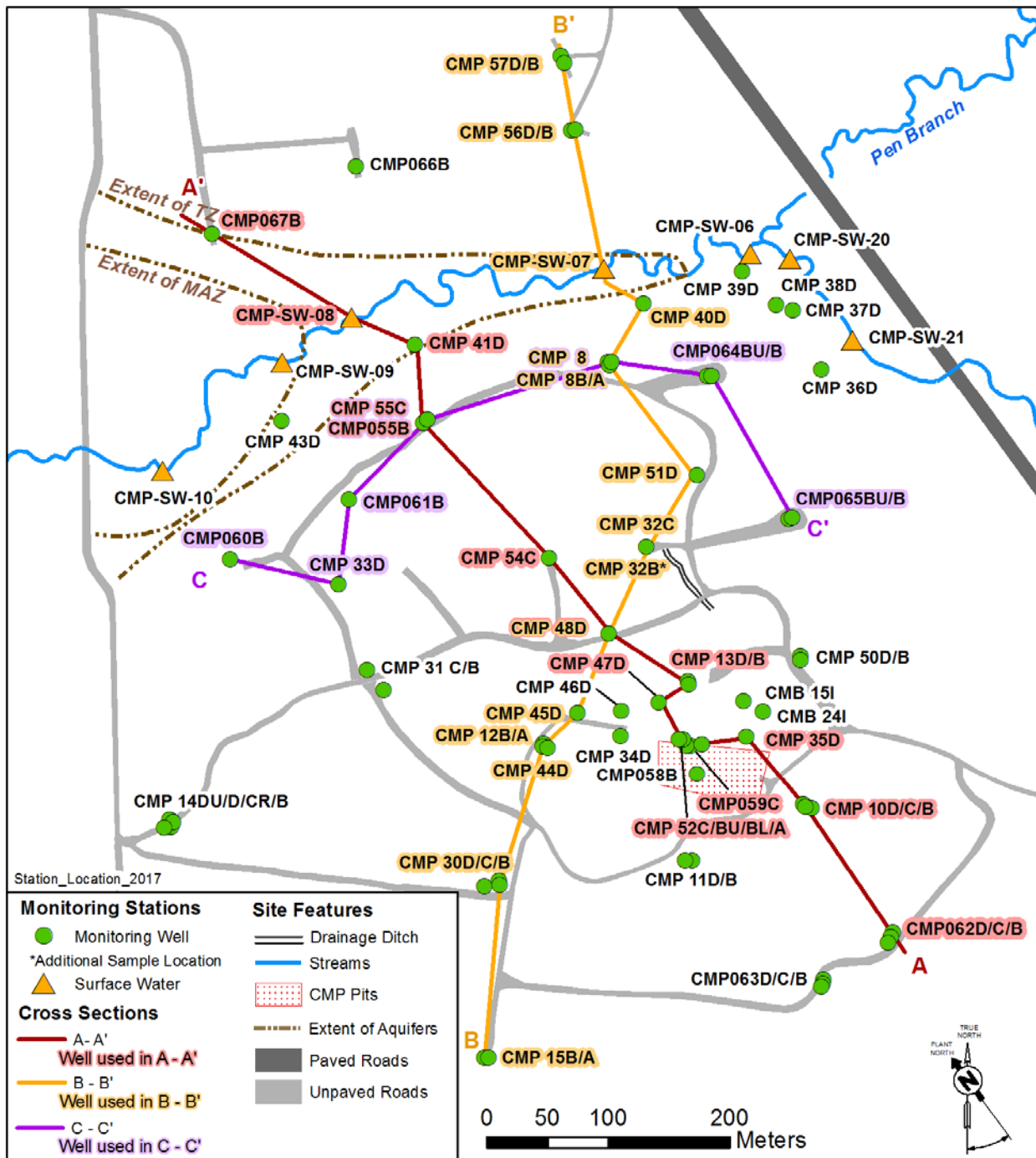


Figure 4. CMP Pits OU Monitoring Network, and Cross Section Lines

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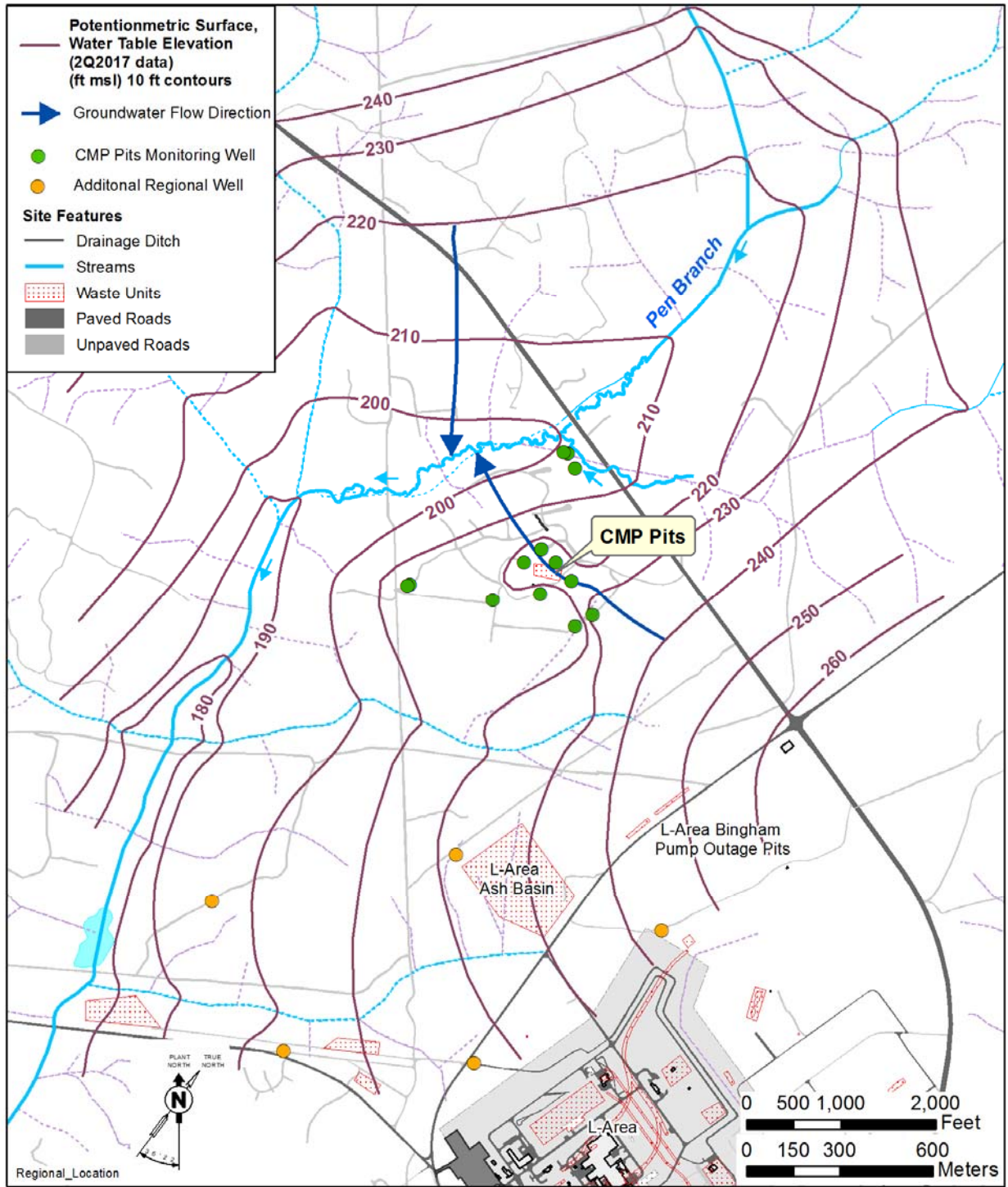


Figure 5. Regional Water Table Potentiometric Surface

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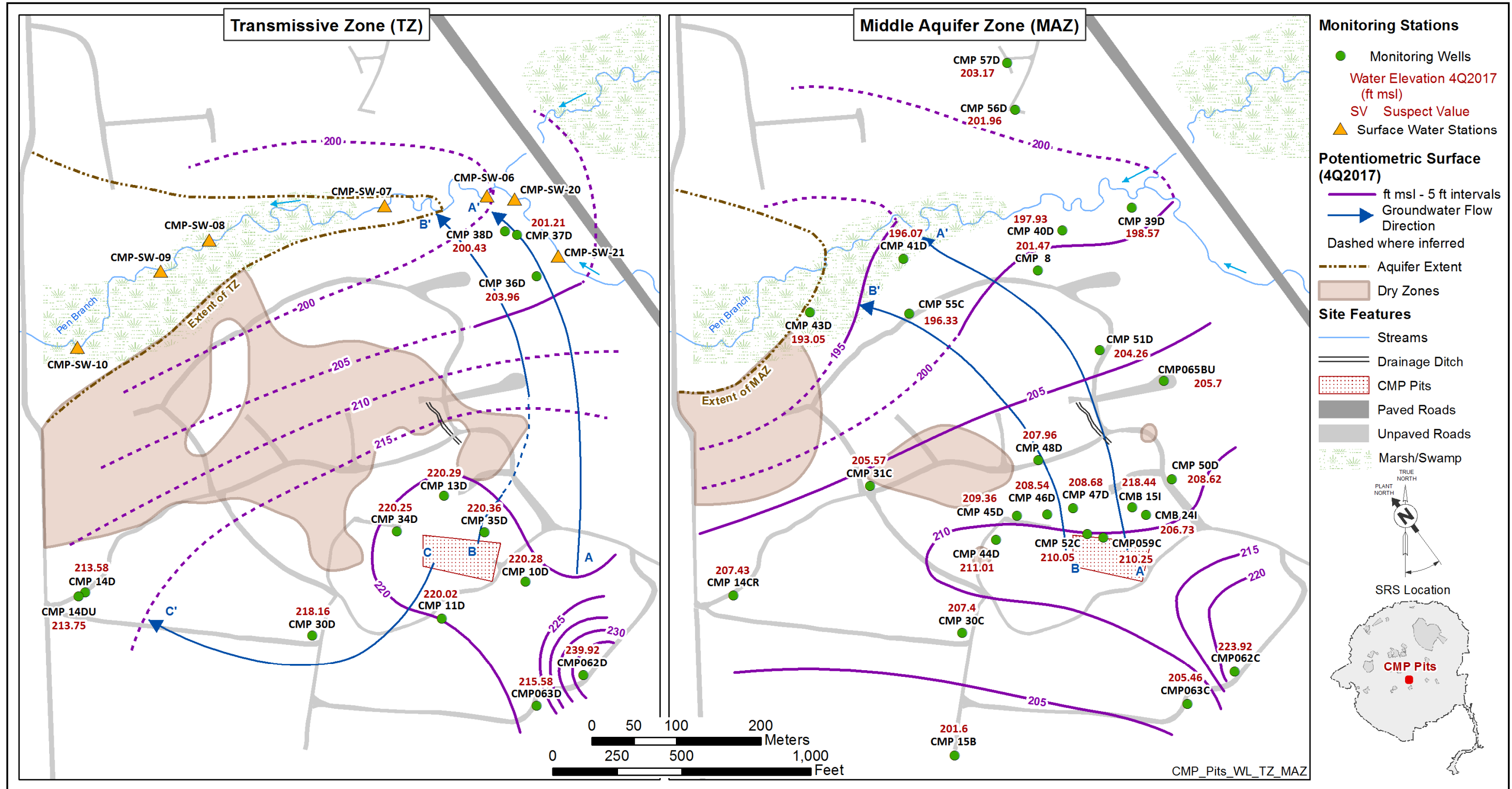


Figure 6. 2017 Potentiometric Surface for the TZ and MAZ

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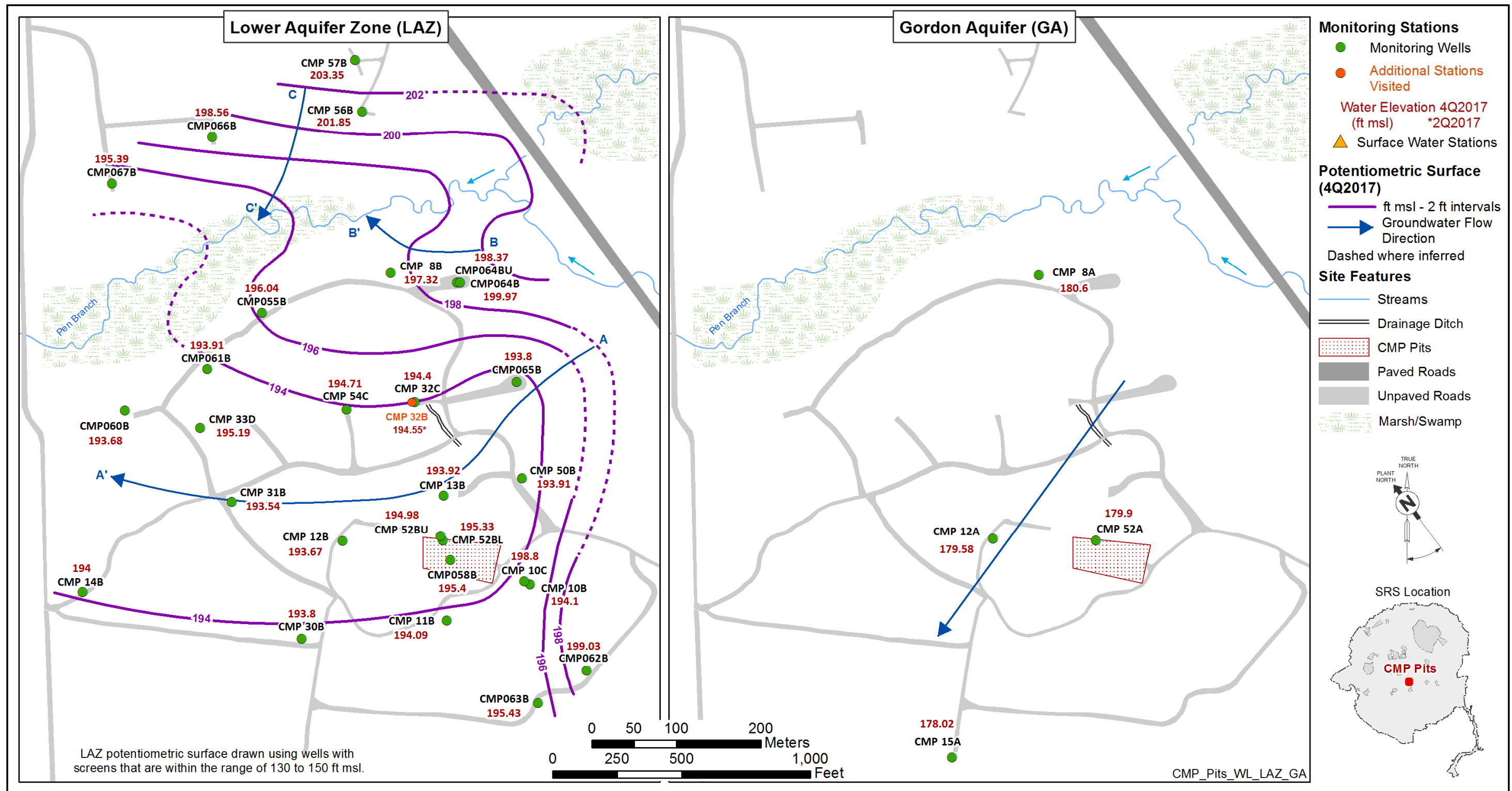


Figure 7. 2017 Potentiometric Surface for the LAZ and GA

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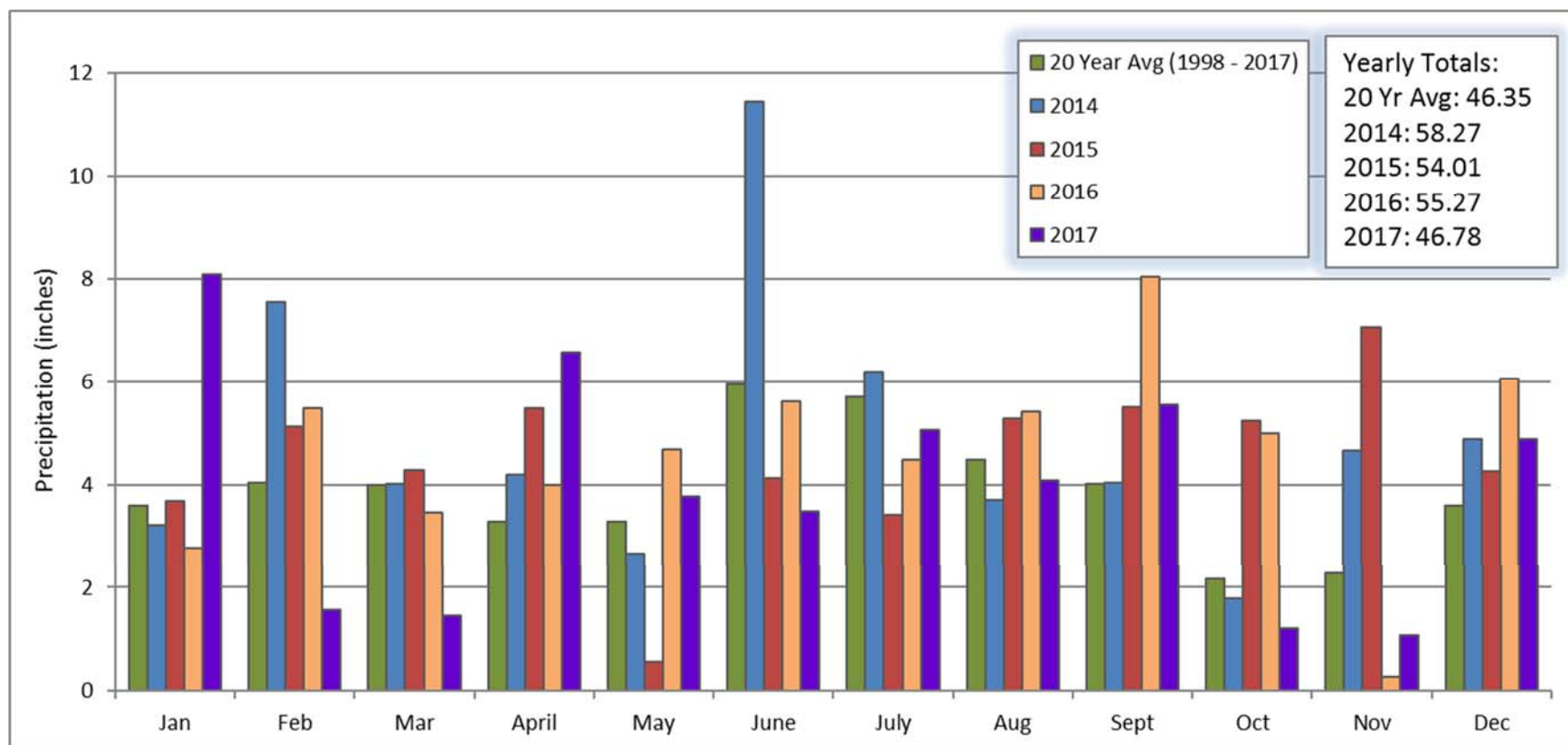


Figure 8. Monthly Rainfall Measurements in L-Area for 2017, 2016, 2015, 2014, and the 20-Year Average

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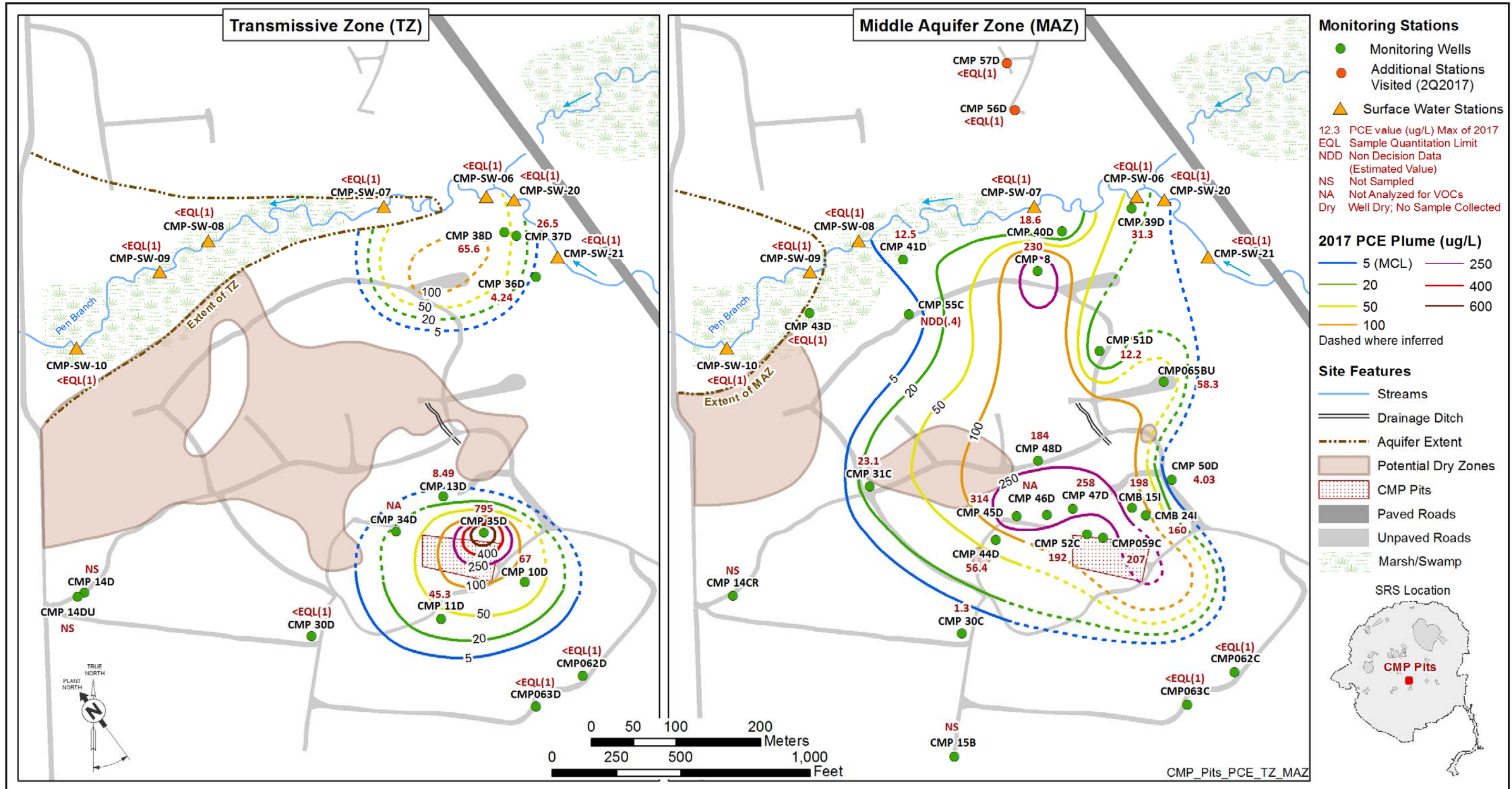


Figure 9. 2017 PCE Plume and Groundwater and Surface Water Results for the TZ and MAZ

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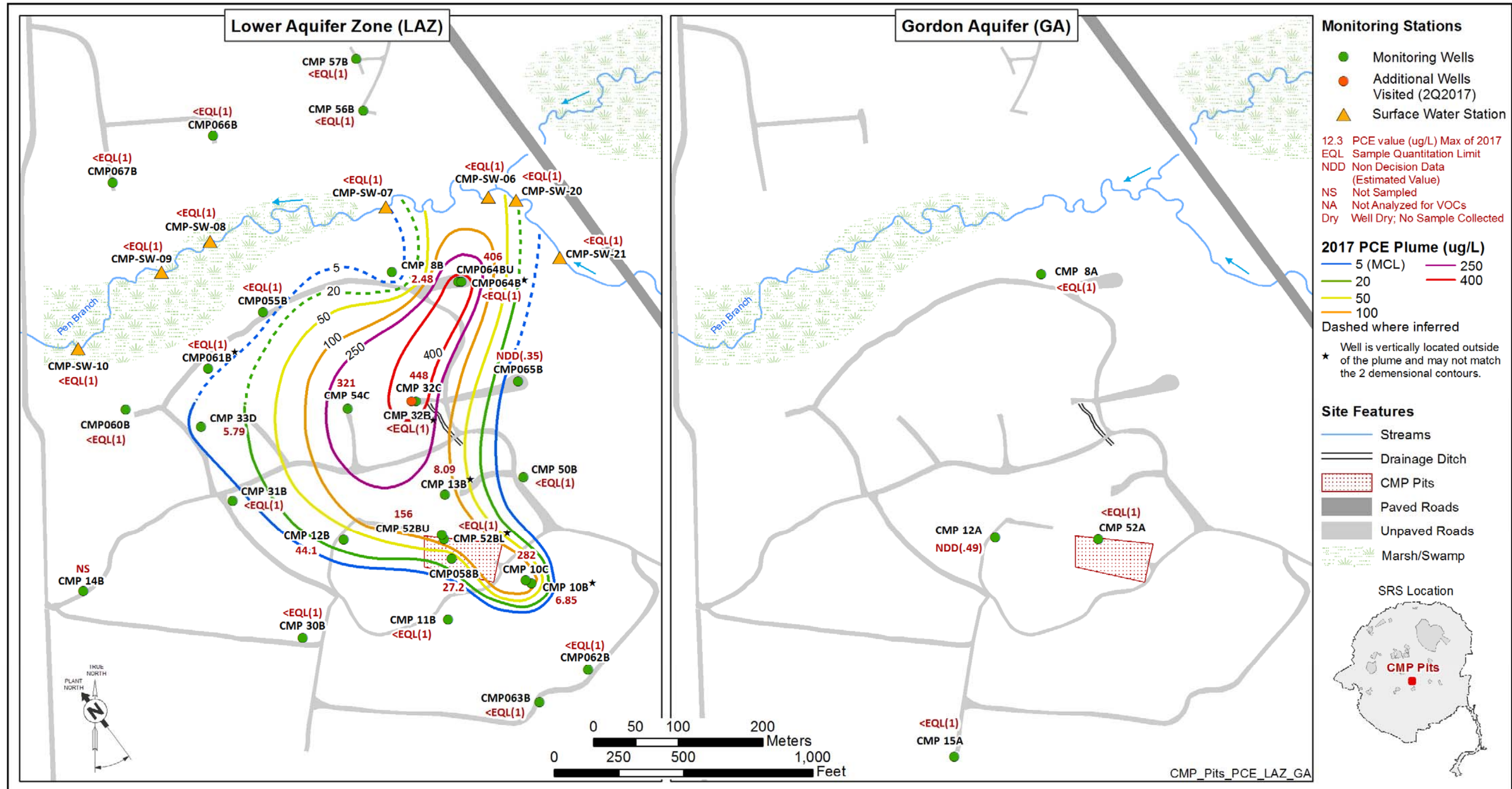


Figure 10. 2017 PCE Plume and Groundwater Results for the LAZ and GA

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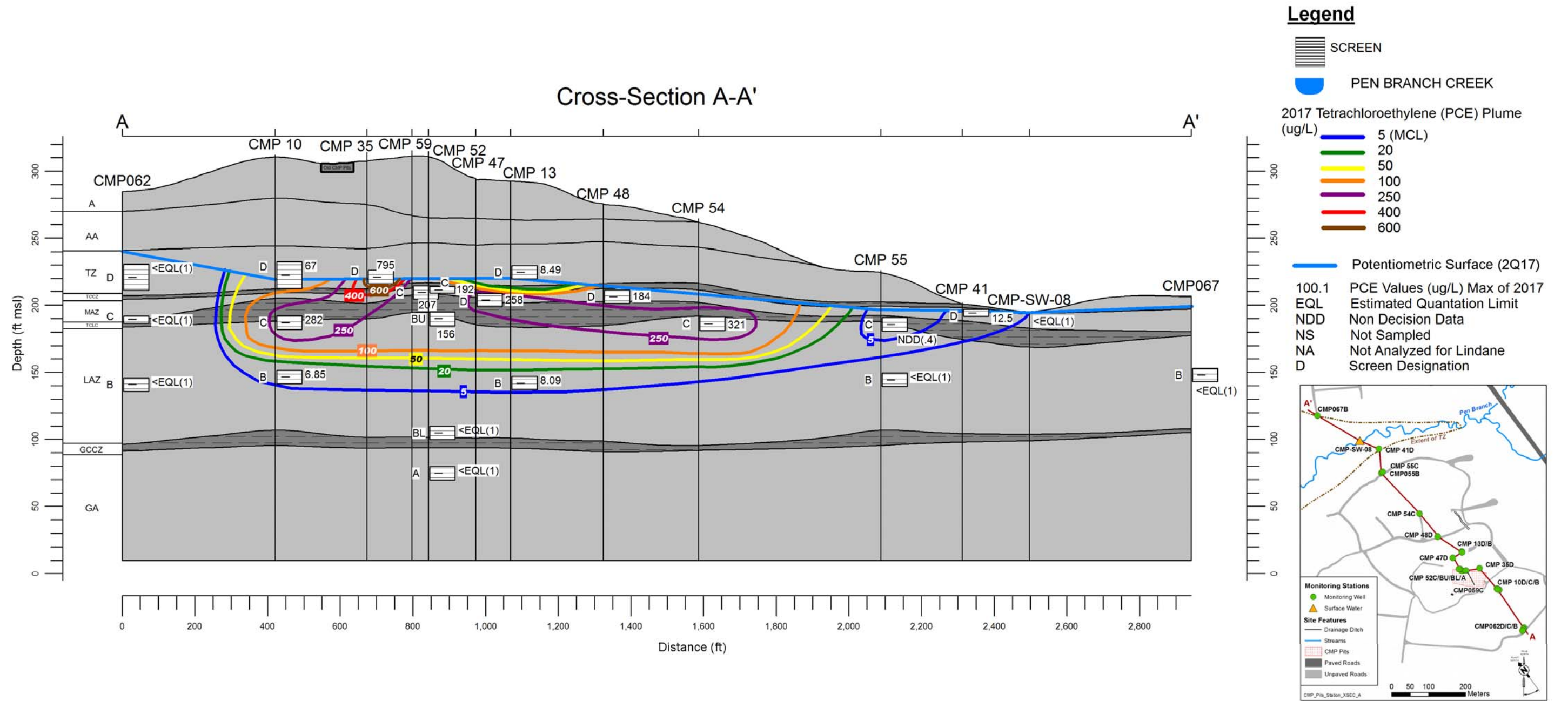


Figure 11. Cross Section A - A' at the CMP Pits OU Area with 2017 PCE Plume and Results

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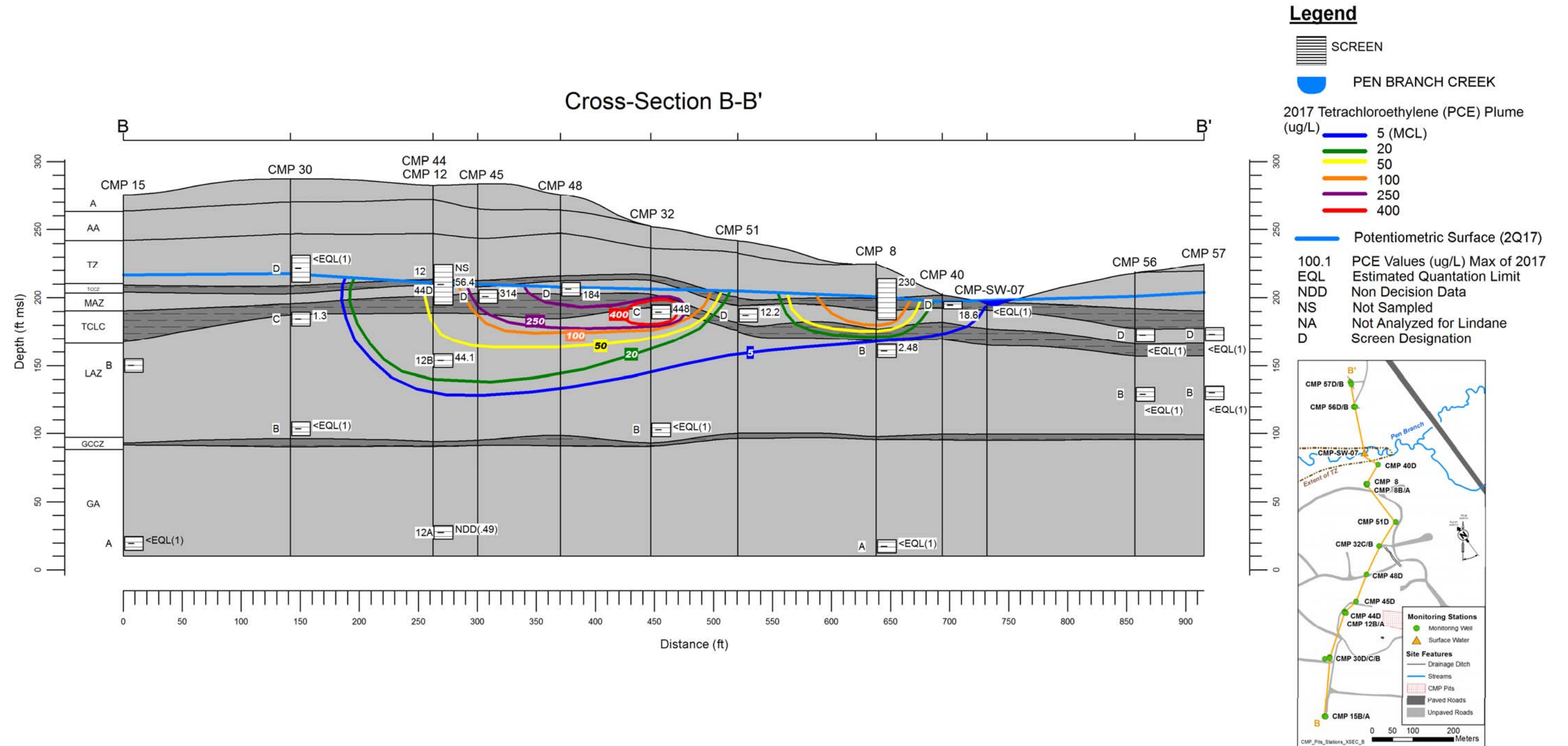


Figure 12. Cross Section B - B' at the CMP Pits OU Area with 2017 PCE Plume and Results

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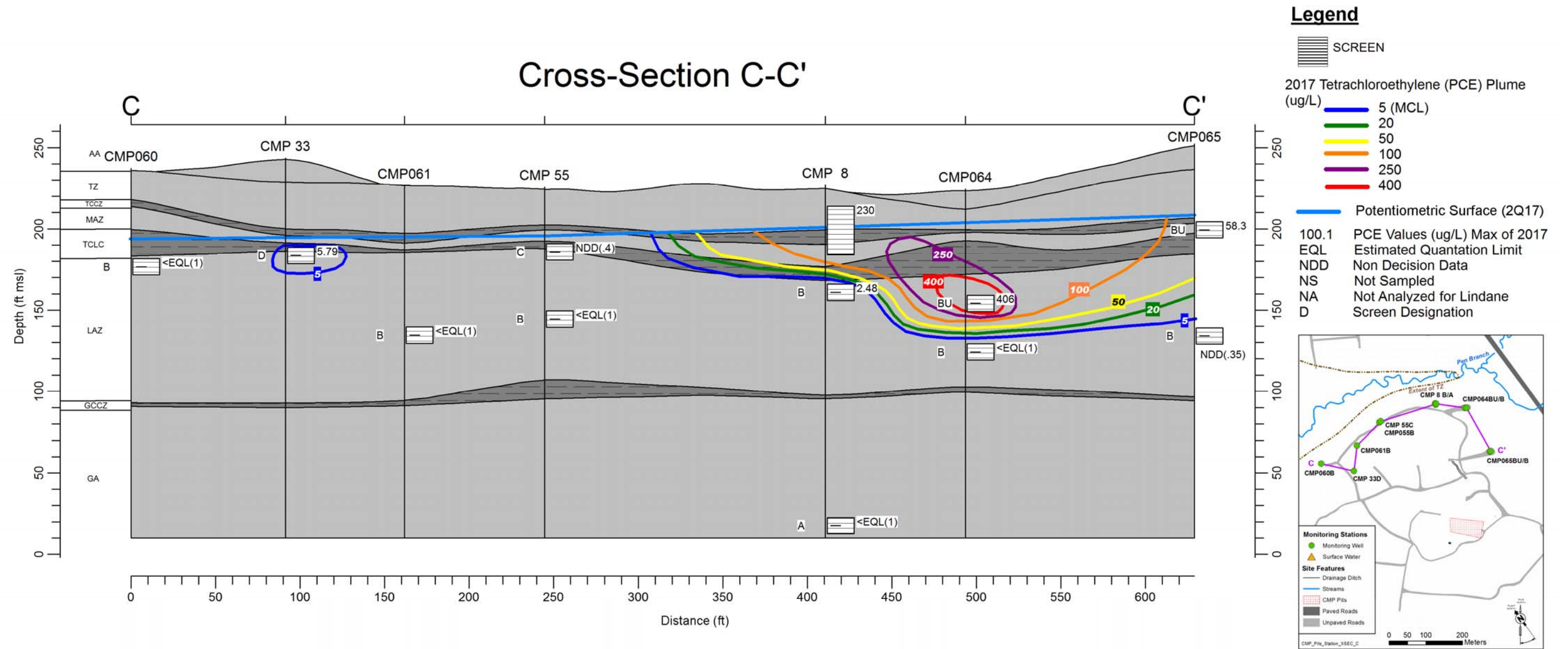


Figure 13. Cross Section C - C' at the CMP Pits OU Area with 2017 PCE Plume and Results

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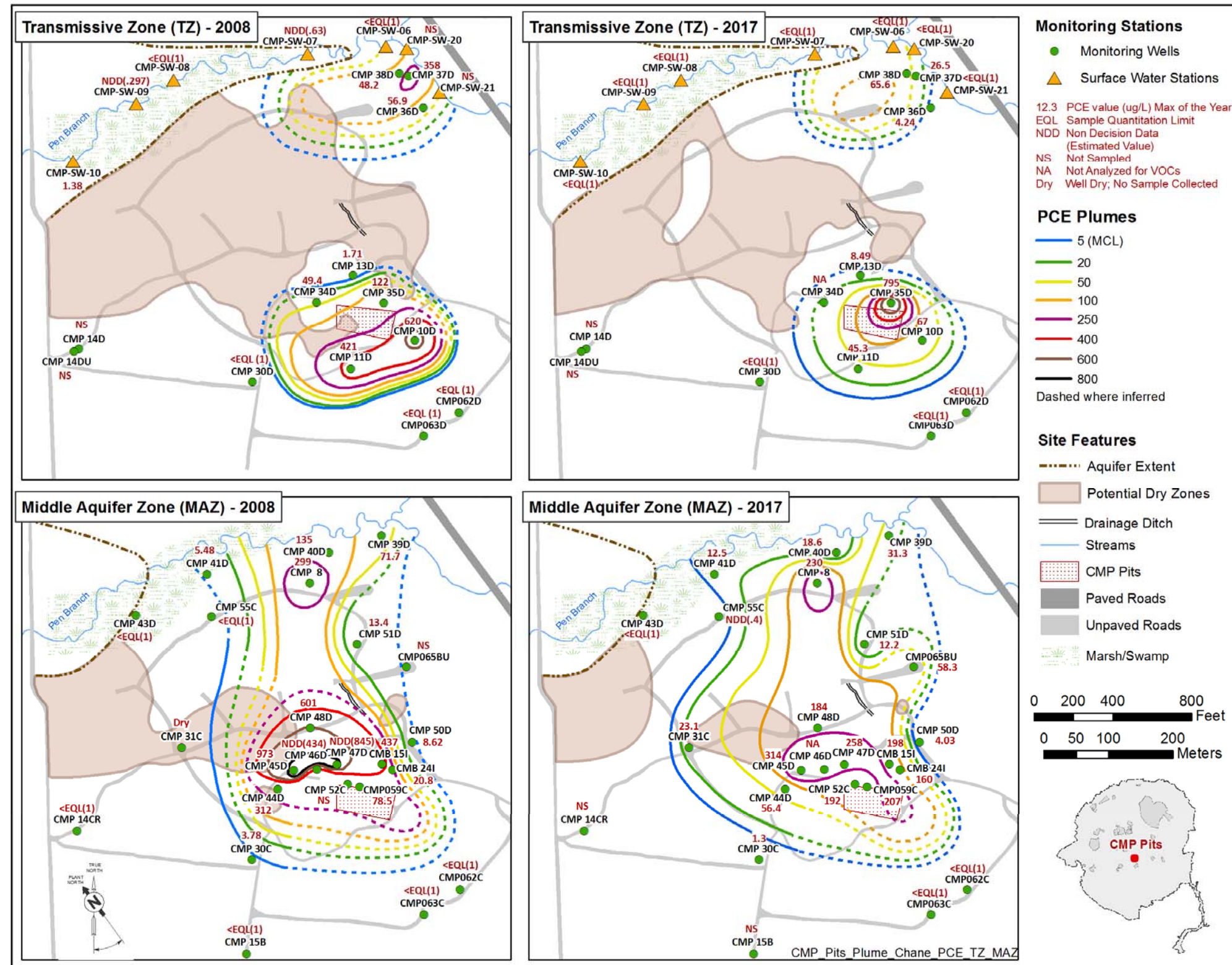


Figure 14. PCE Plume Comparison from 2008 and 2017 in the TZ and MAZ

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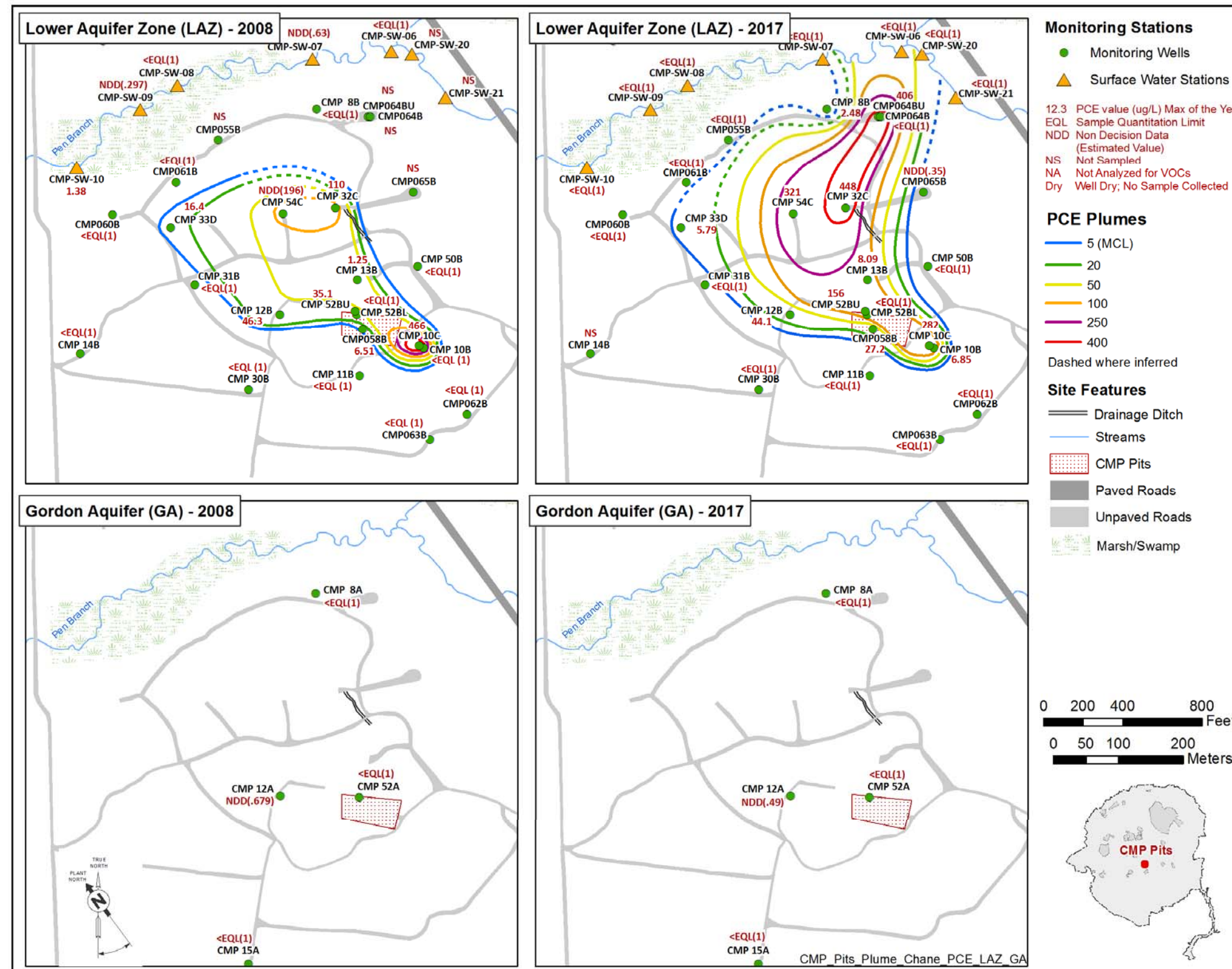


Figure 15. PCE Plume Comparison from 2008 and 2017 in the LAZ and GA

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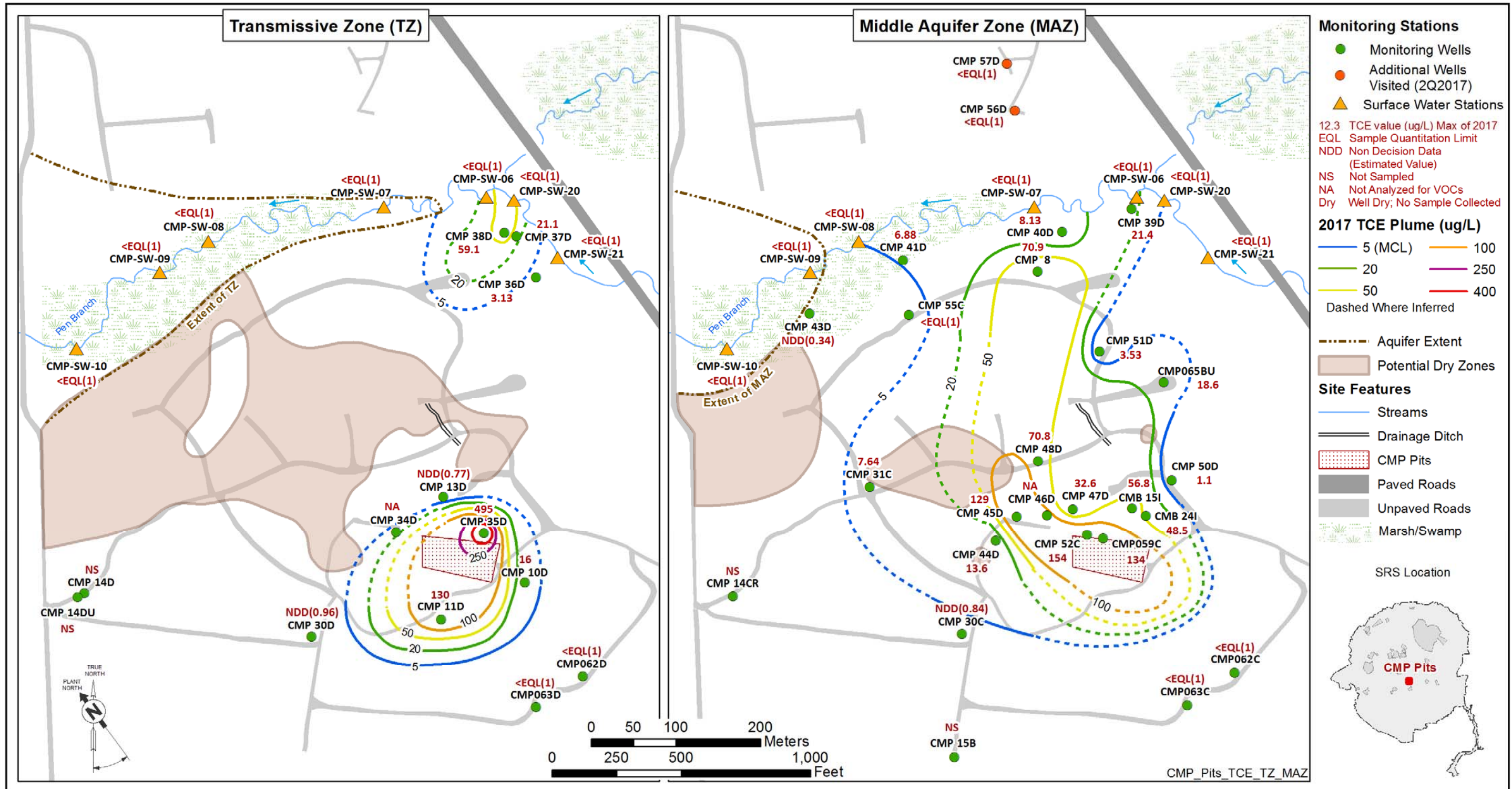


Figure 16. 2017 TCE Plume and Groundwater and Surface Water Results in the TZ and MAZ

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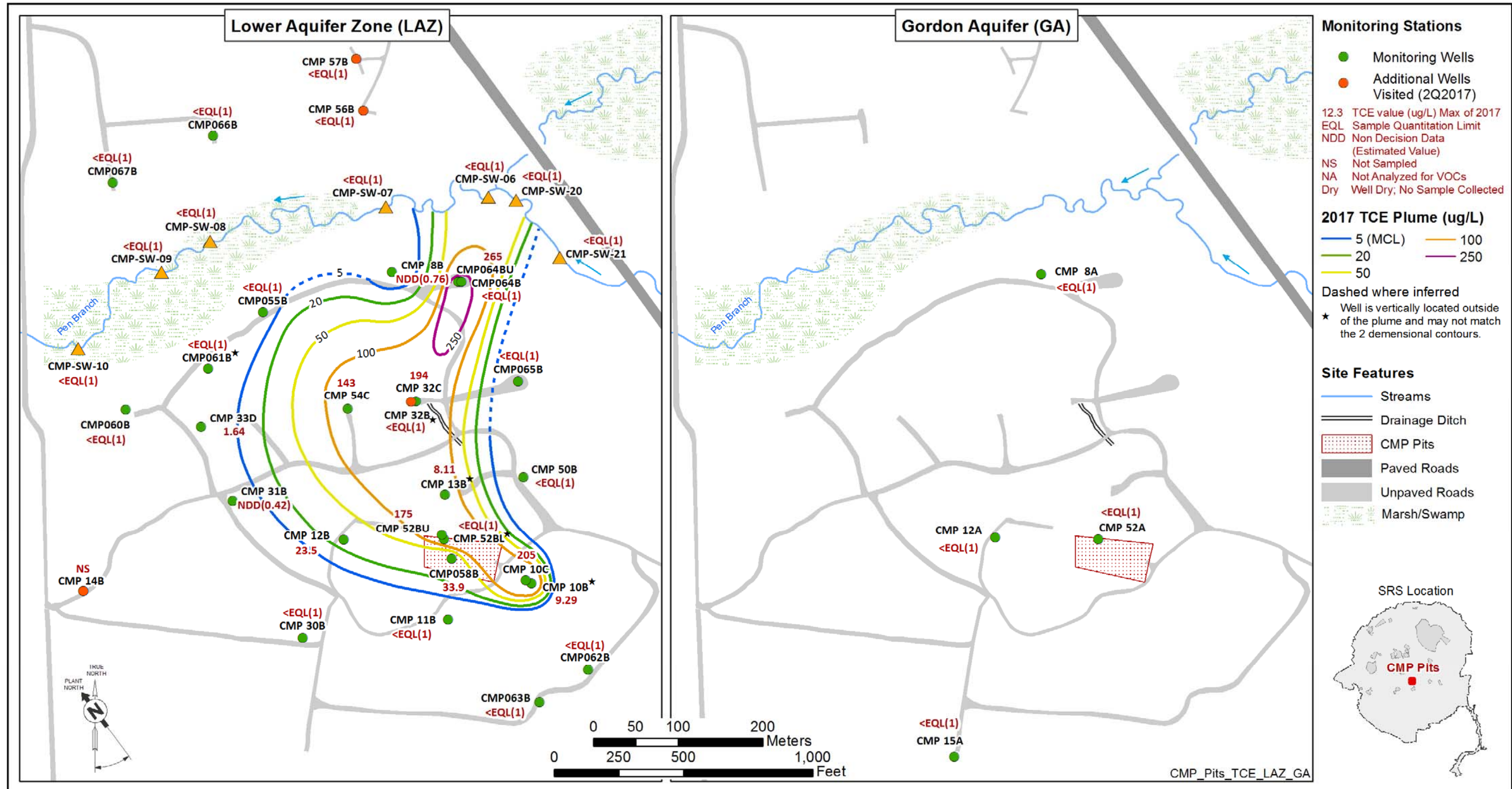


Figure 17. 2017 TCE Plume and Groundwater Results for the LAZ and GA

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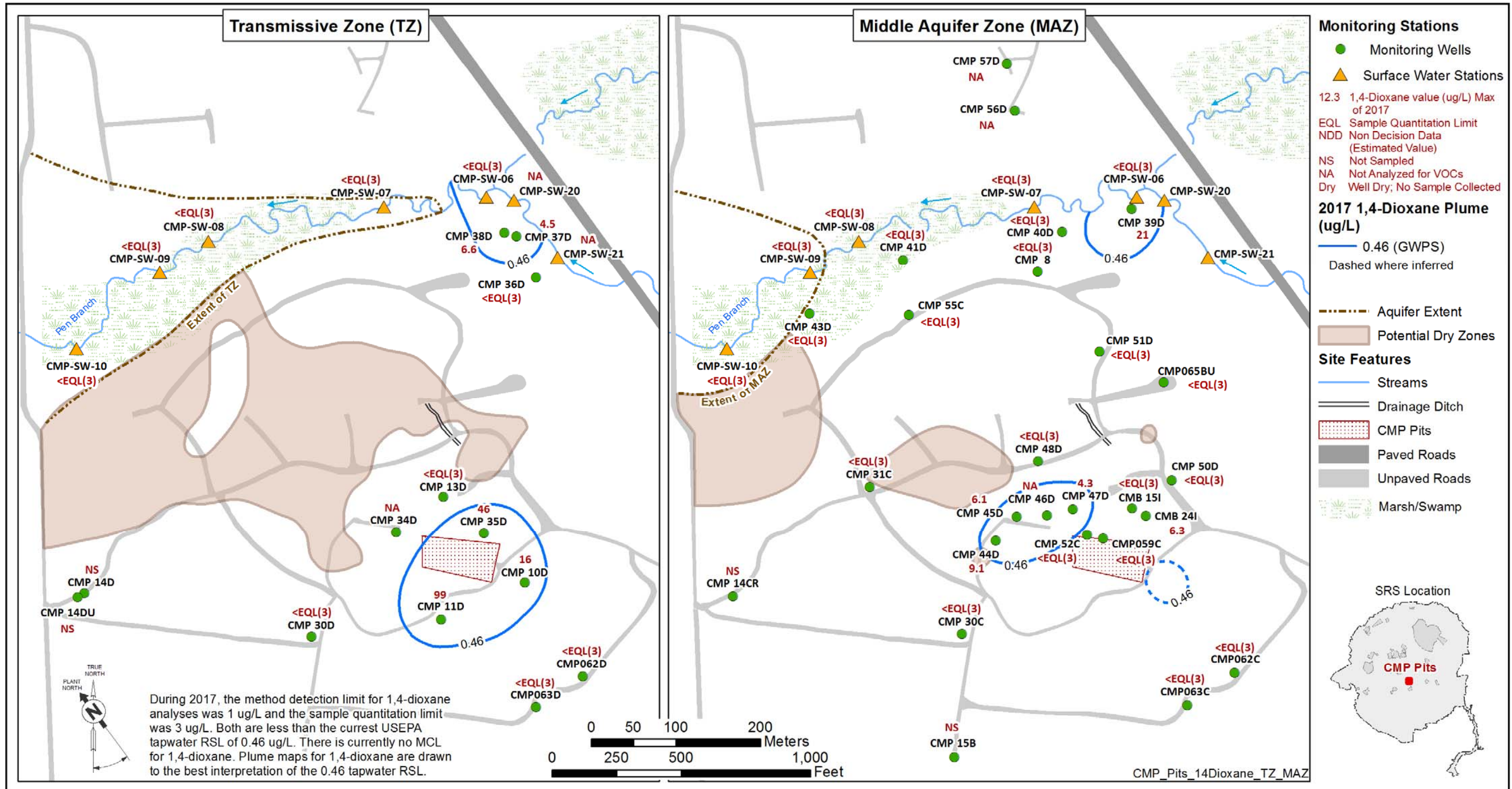


Figure 18. 2017 1,4-Dioxane Plume and Groundwater Results for the TZ and MAZ

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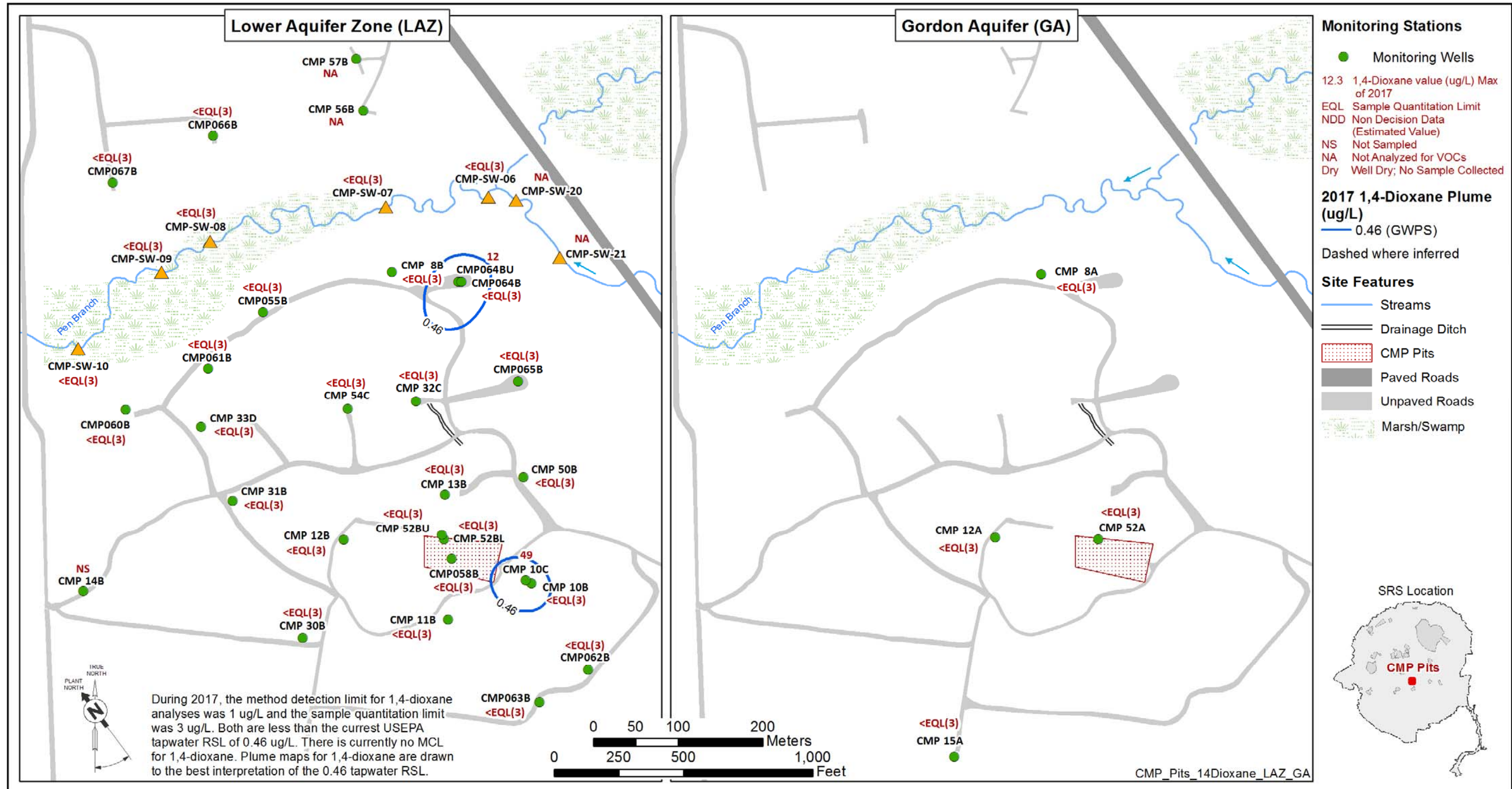


Figure 19. 2017 1,4-Dioxane Plume and Groundwater Results for the LAZ and GA

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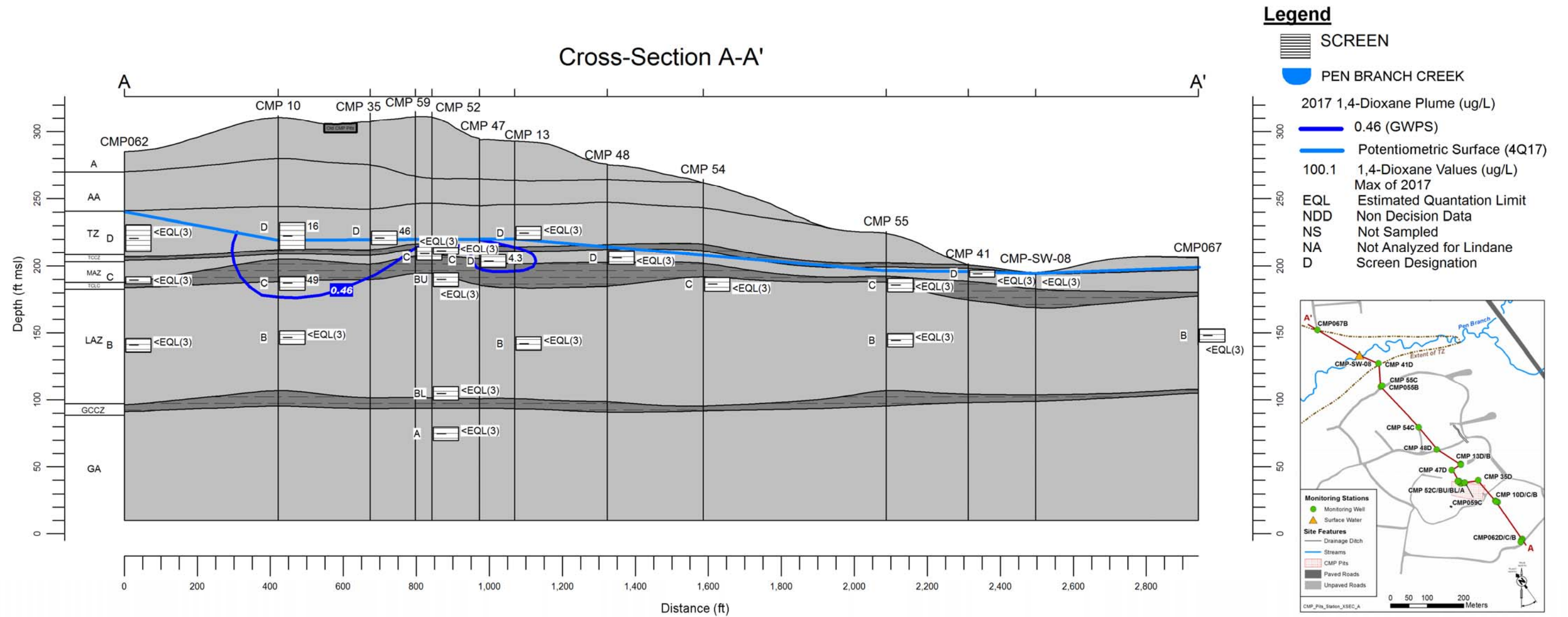


Figure 20. Cross Section A - A' at the CMP Pits OU Area with 2017 1,4-Dioxane Plume and Results

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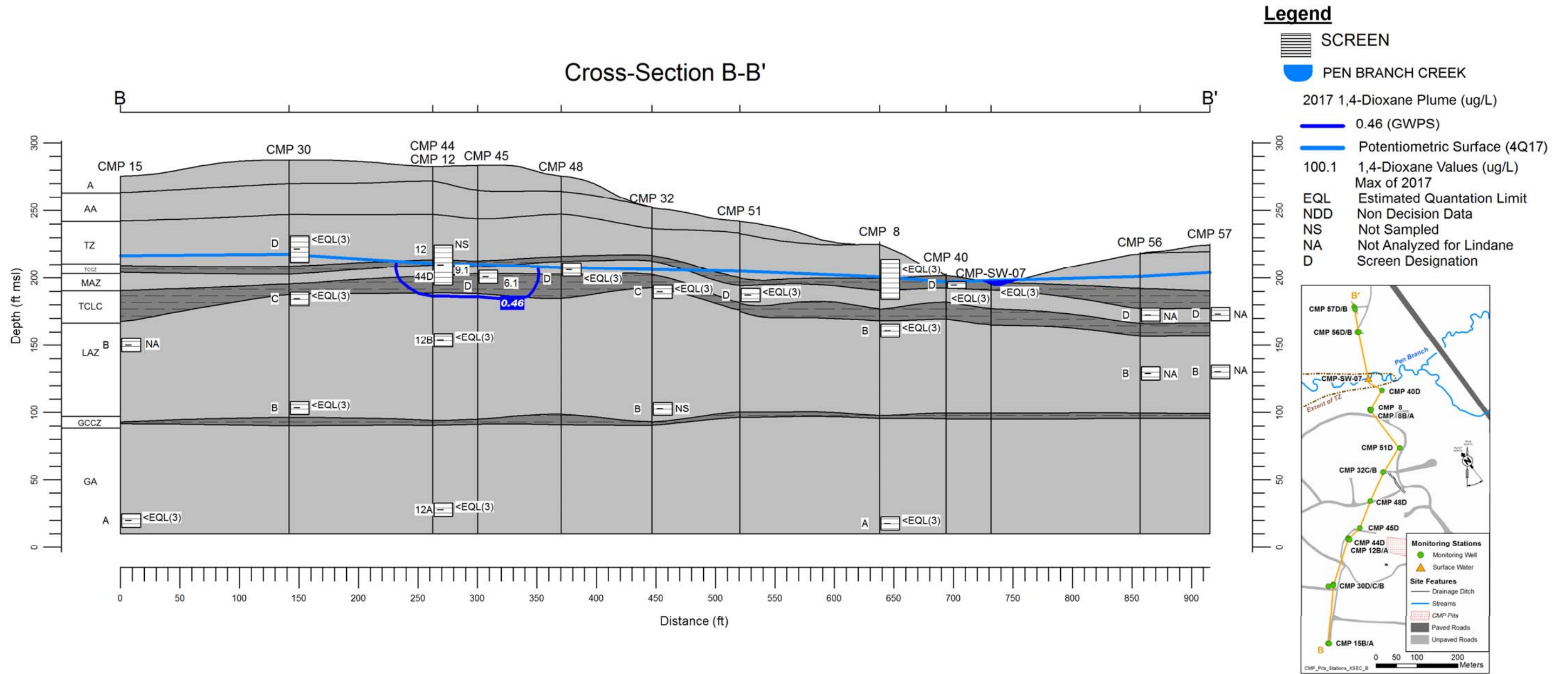


Figure 21. Cross Section B - B' at the CMP Pits OU Area with 2017 1,4-Dioxane Plume and Results

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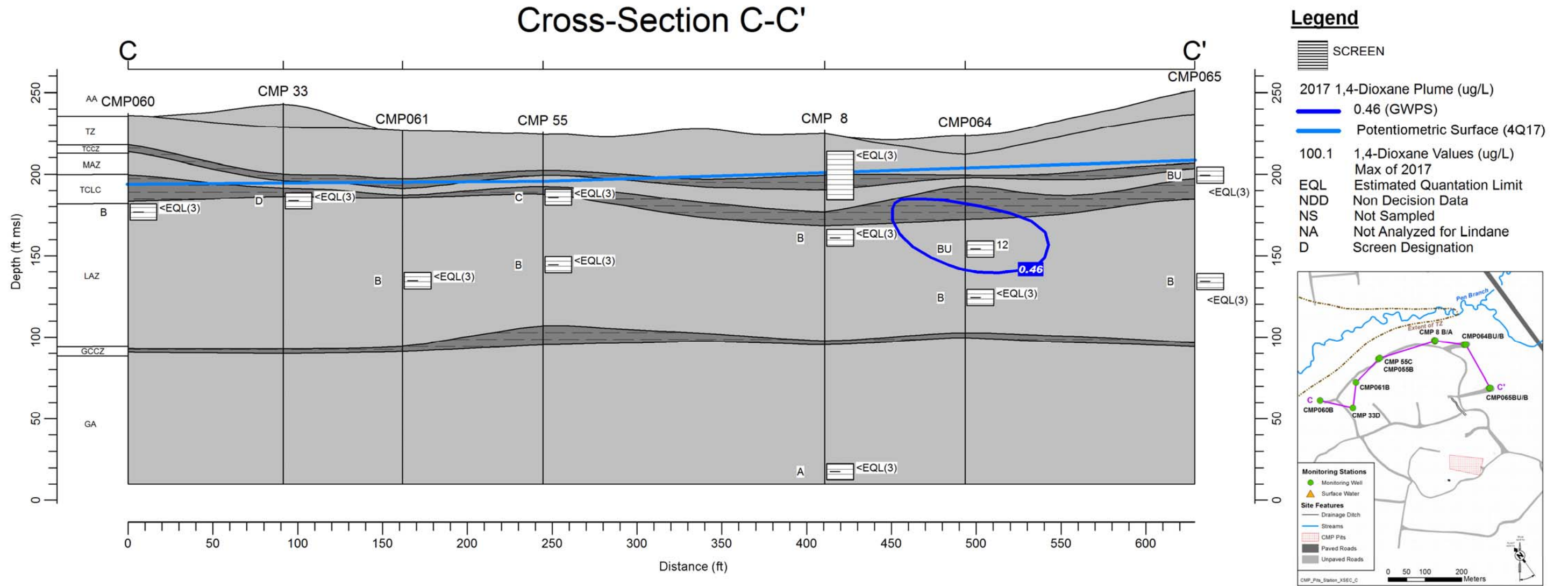


Figure 22. Cross Section C - C' at the CMP Pits OU Area with 2017 1,4-Dioxane Plume and Results

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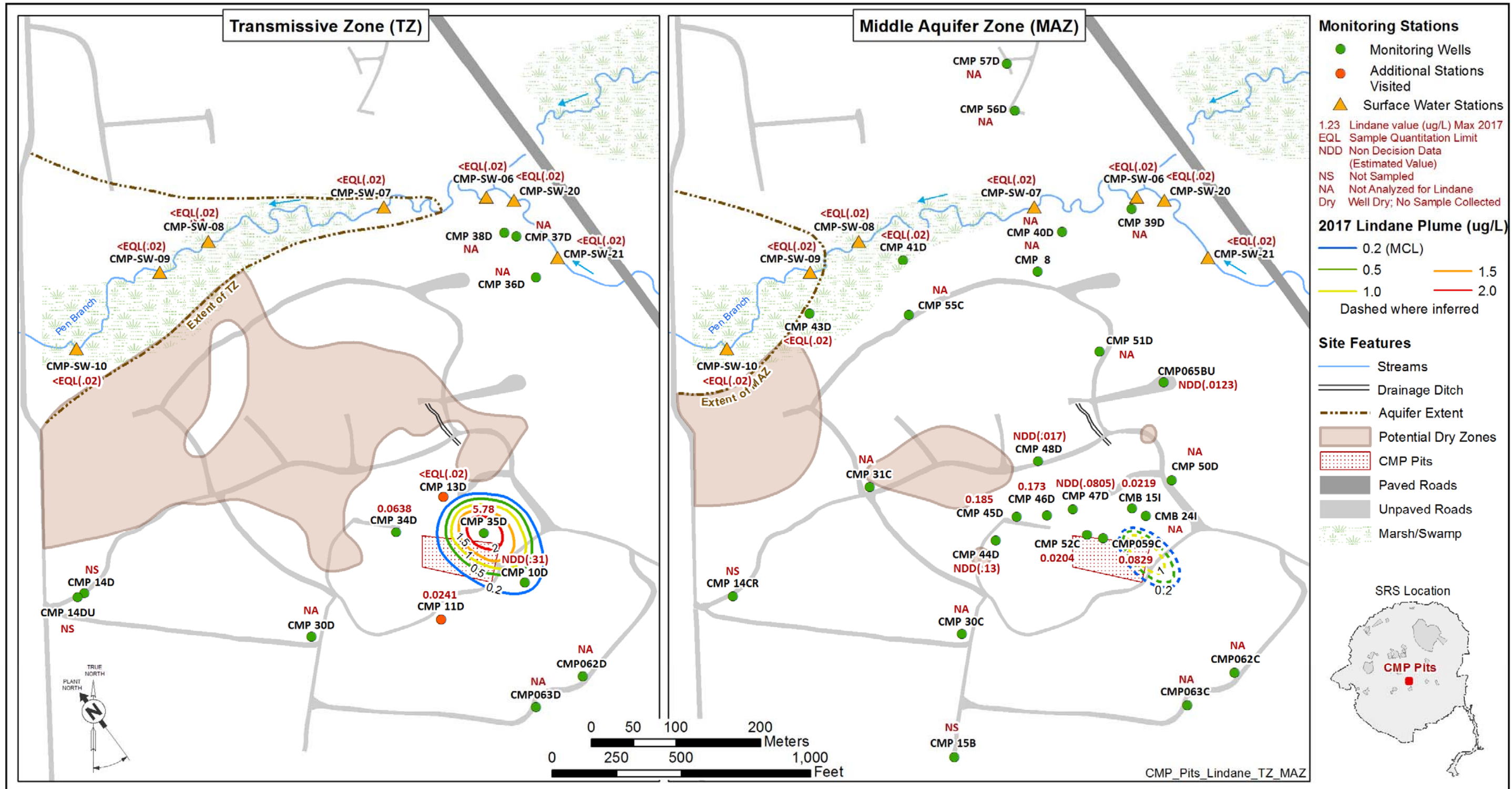


Figure 23. 2017 Lindane Plume and Groundwater Results for the TZ and MAZ

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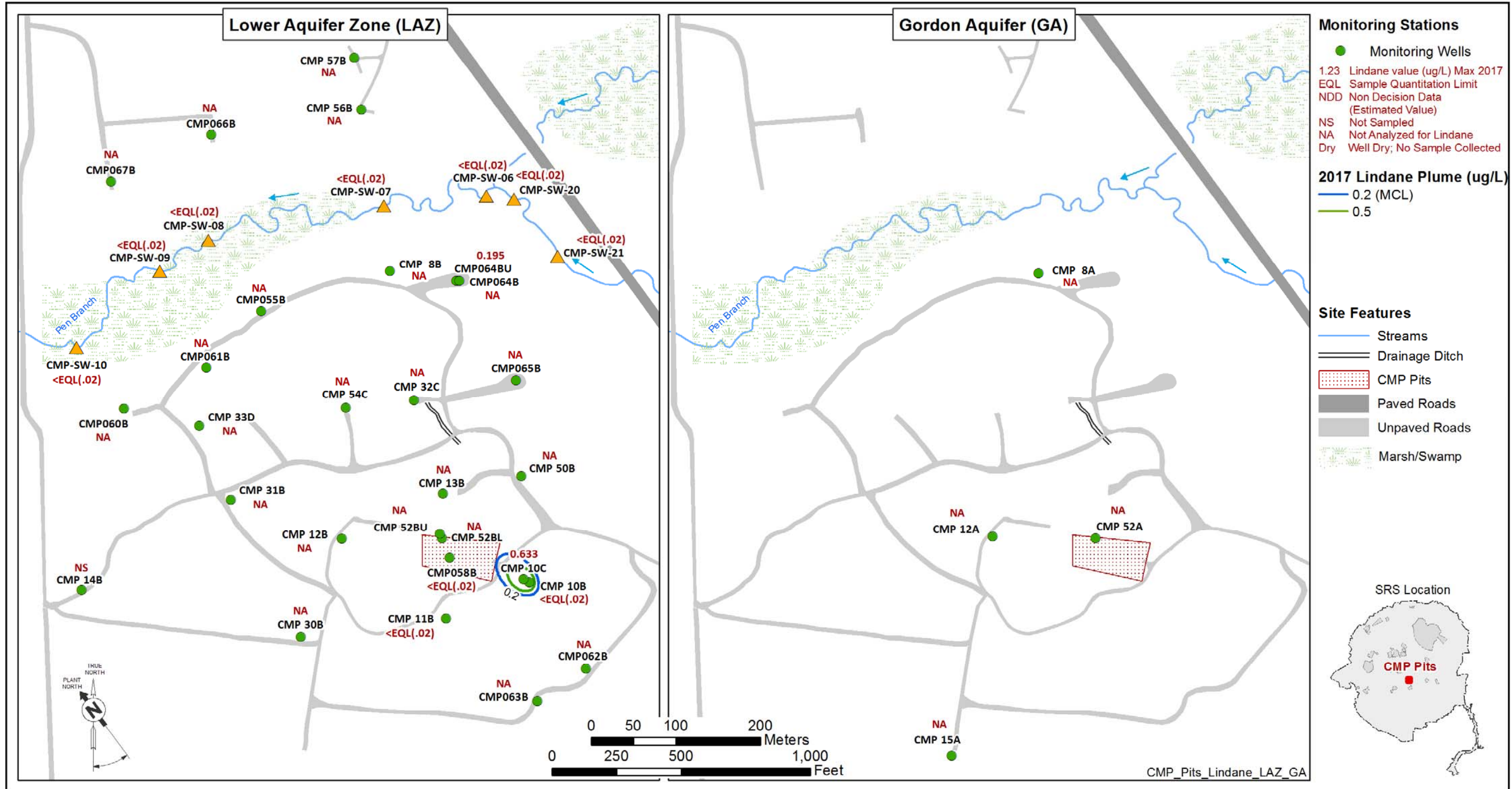


Figure 24. 2017 Lindane Plume and Groundwater Results for the LAZ and GA

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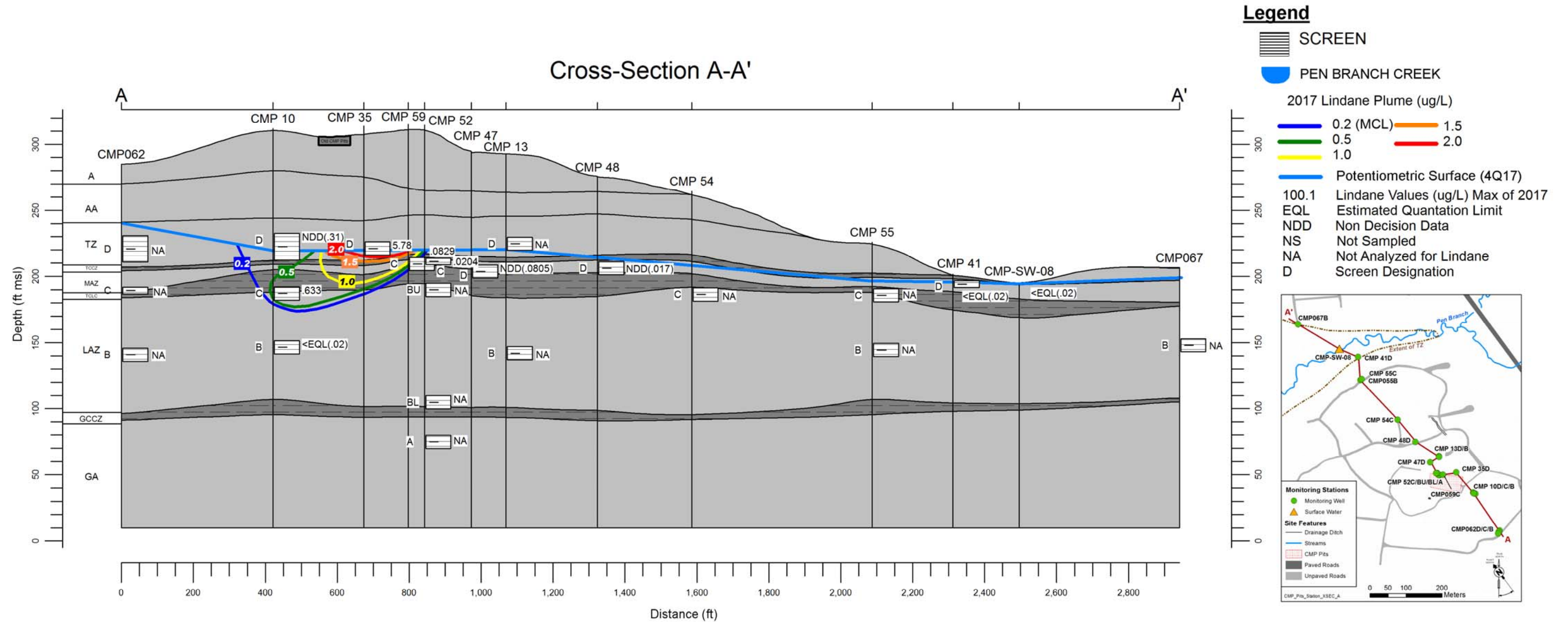


Figure 25. Cross Section A - A' at the CMP Pits OU Area with 2017 Lindane Plume and Results

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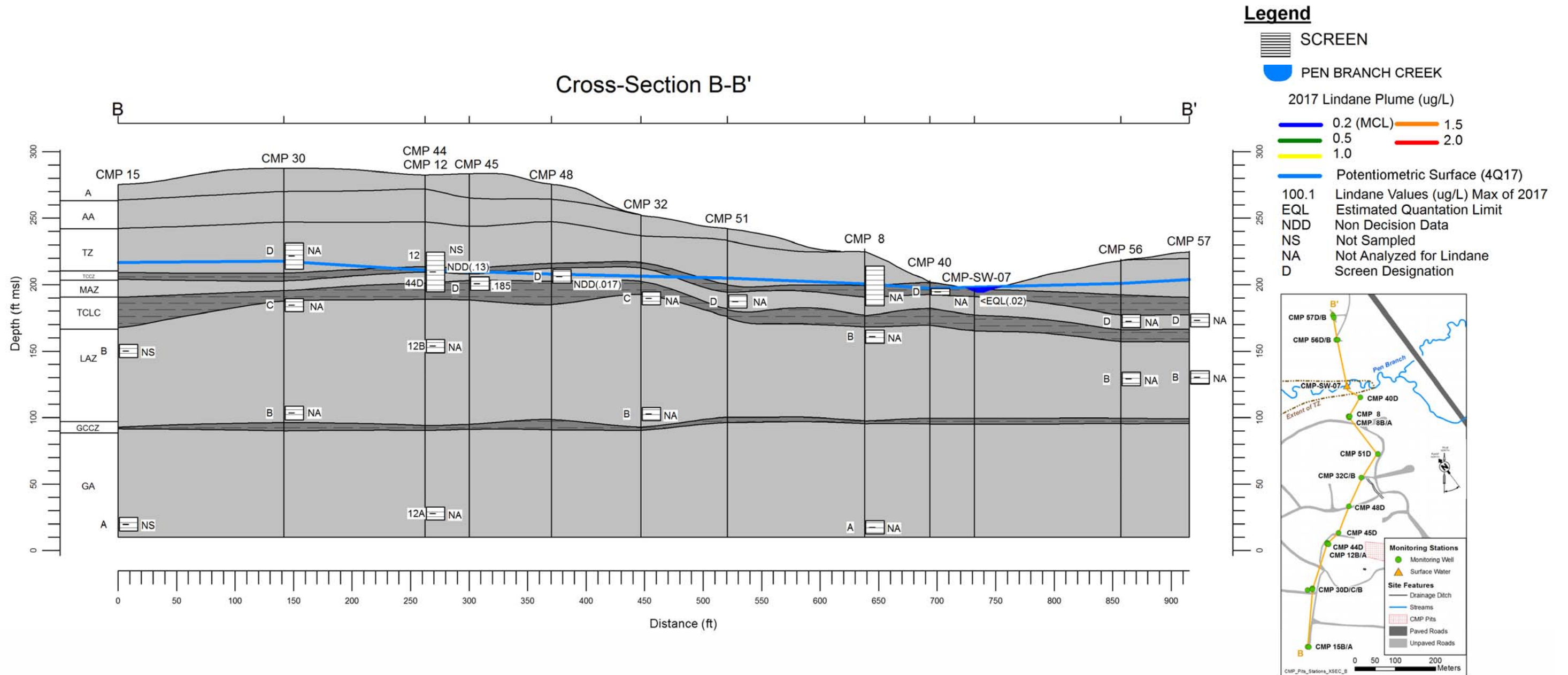


Figure 26. Cross Section B - B' at the CMP Pits OU Area with 2017 Lindane Plume and Results

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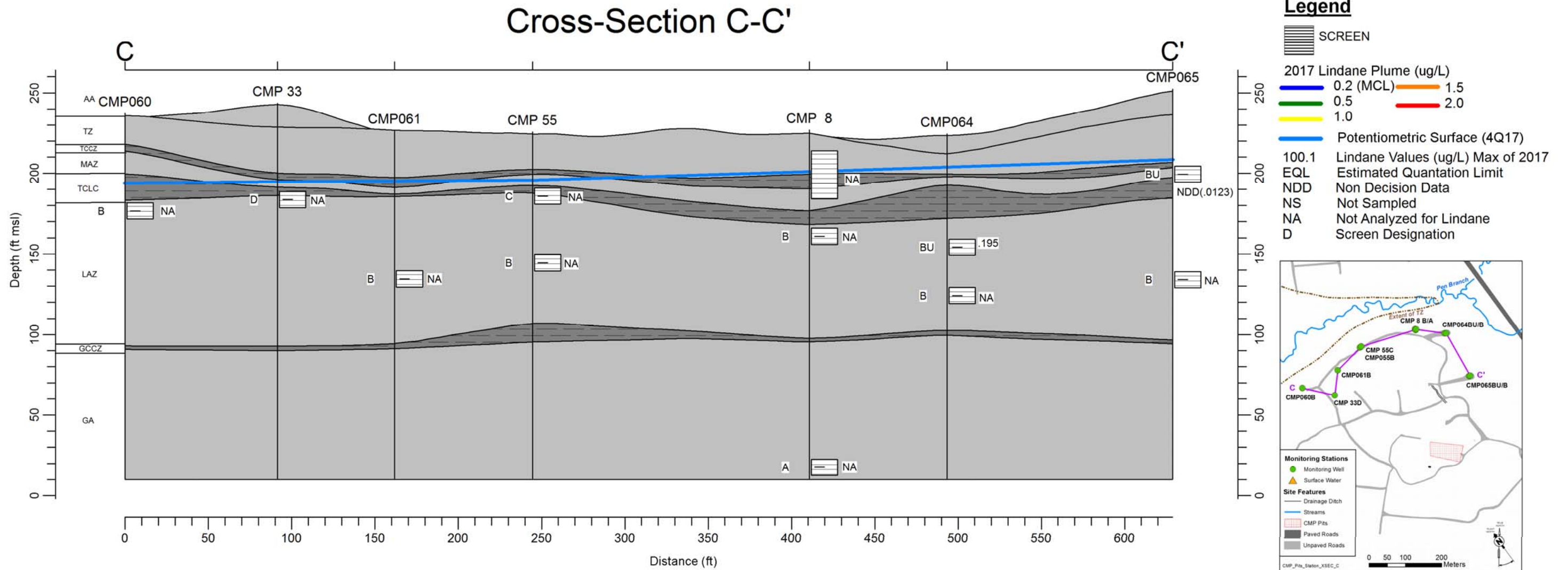


Figure 27. Cross Section C - C' at the CMP Pits OU Area with 2017 Lindane Plume and Results

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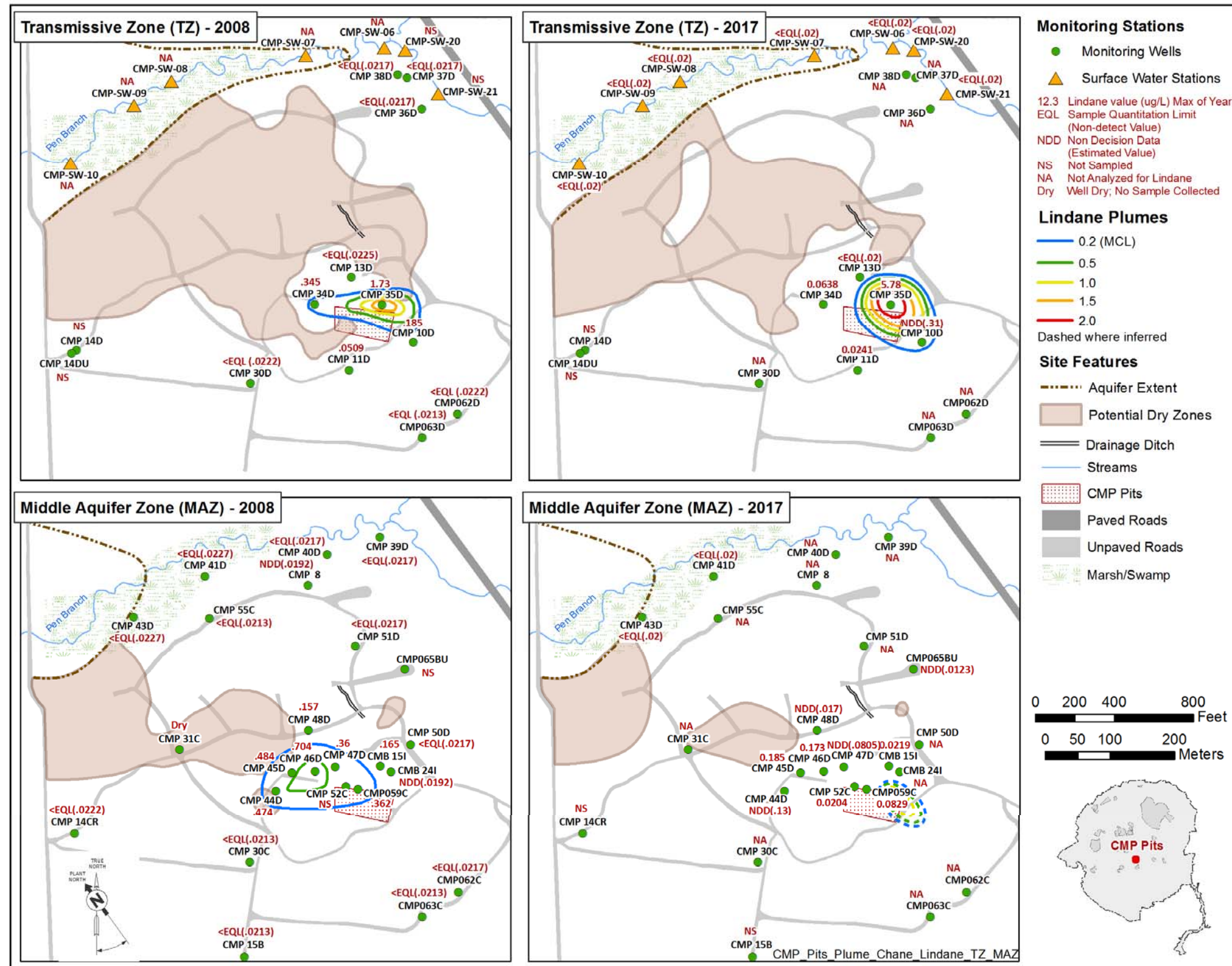


Figure 28. Lindane Plume Comparison from 2008 and 2017 in the TZ and MAZ

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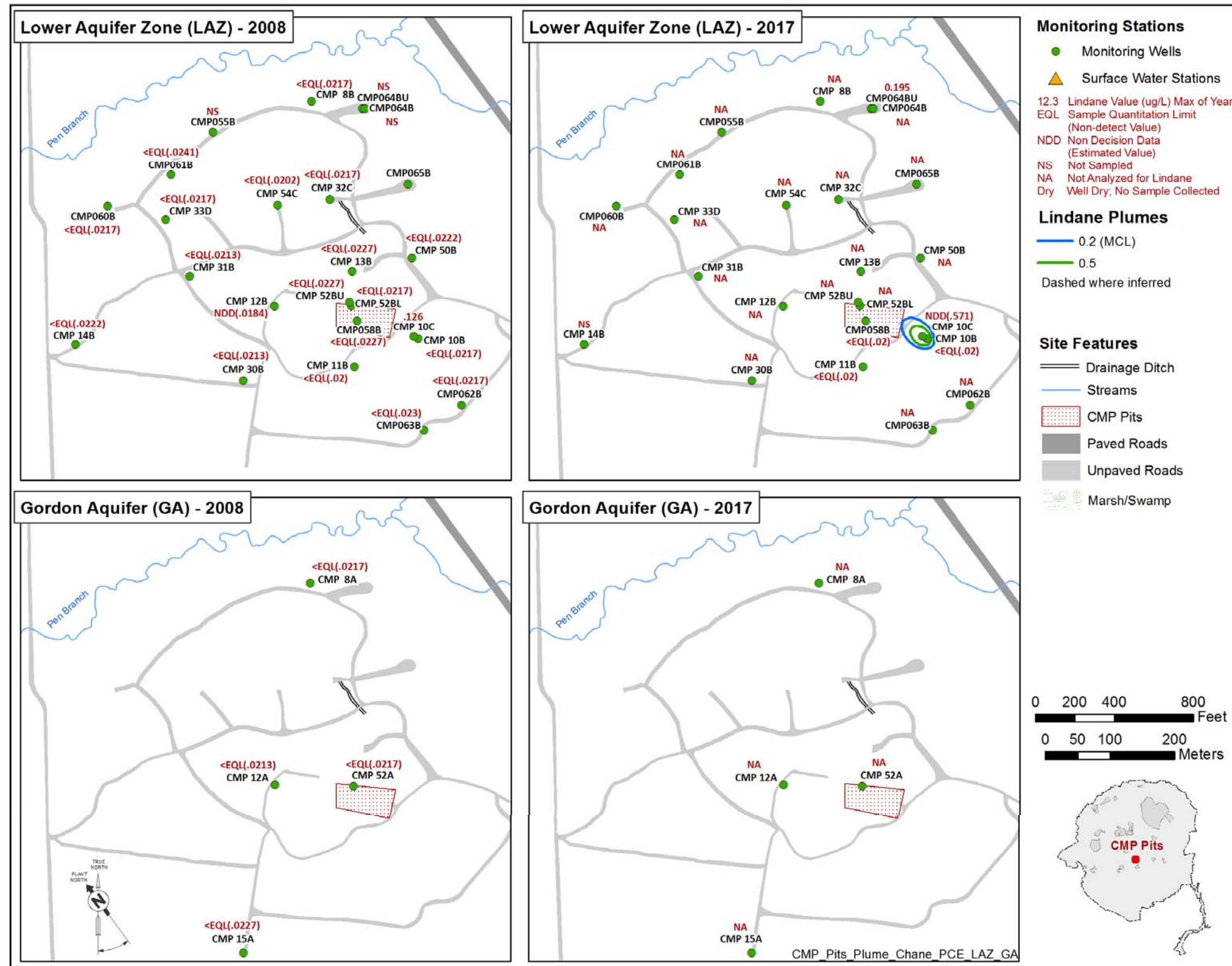


Figure 29. Lindane Plume Comparison from 2008 and 2017 in the LAZ and GA

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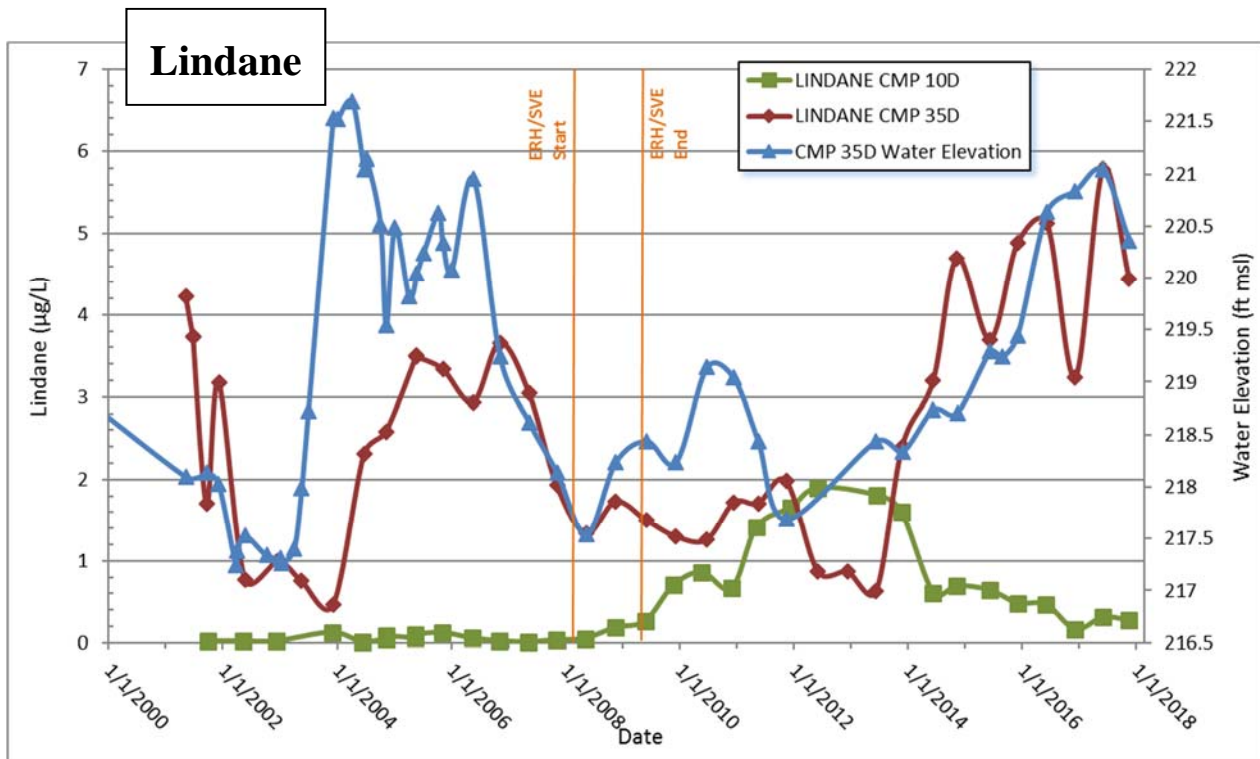
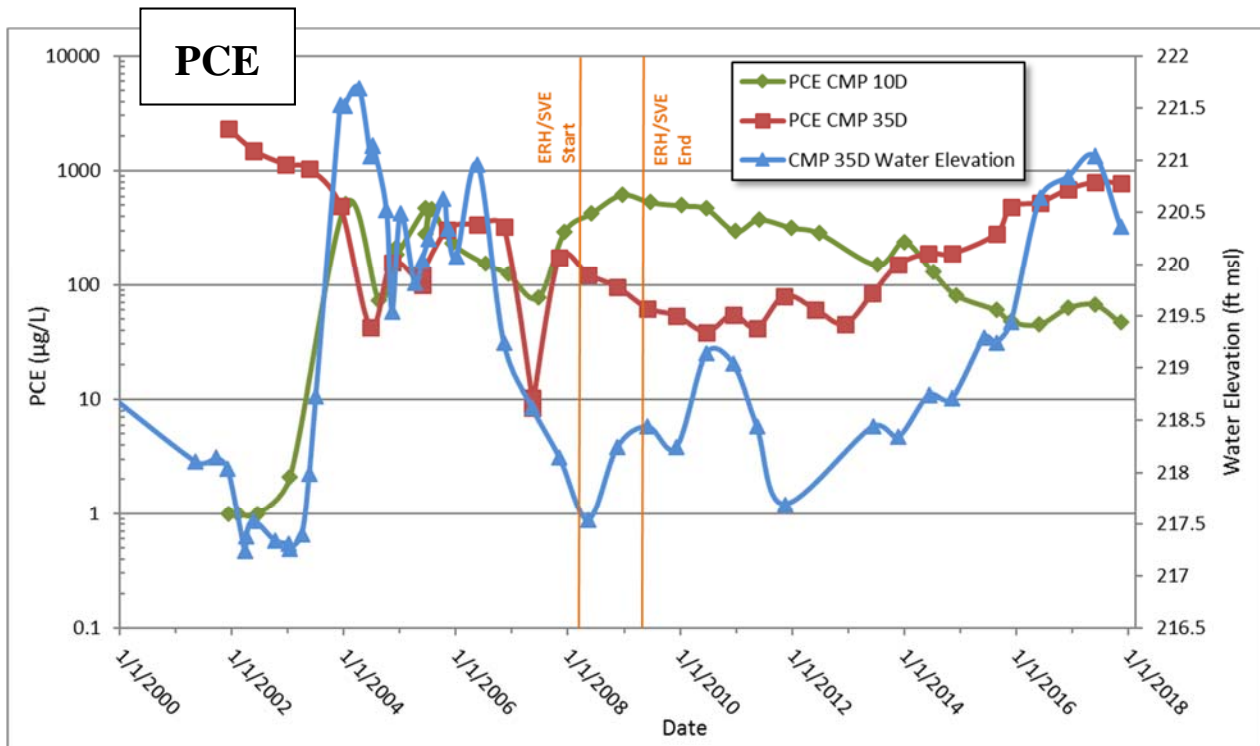
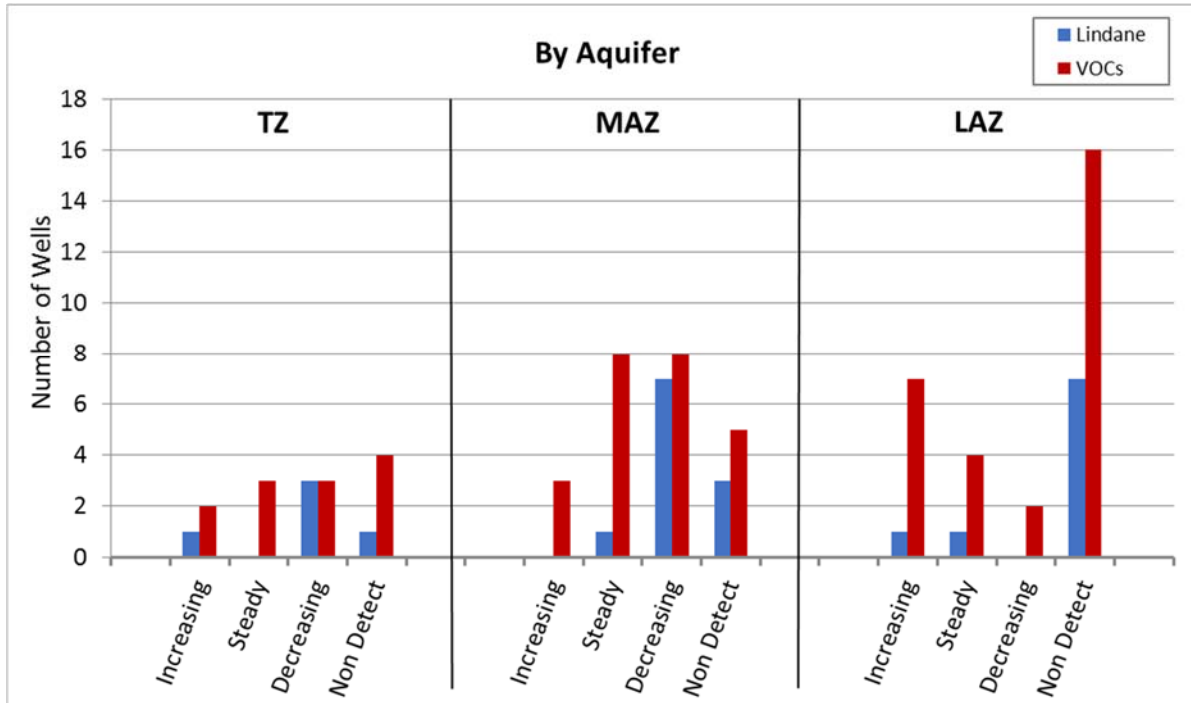
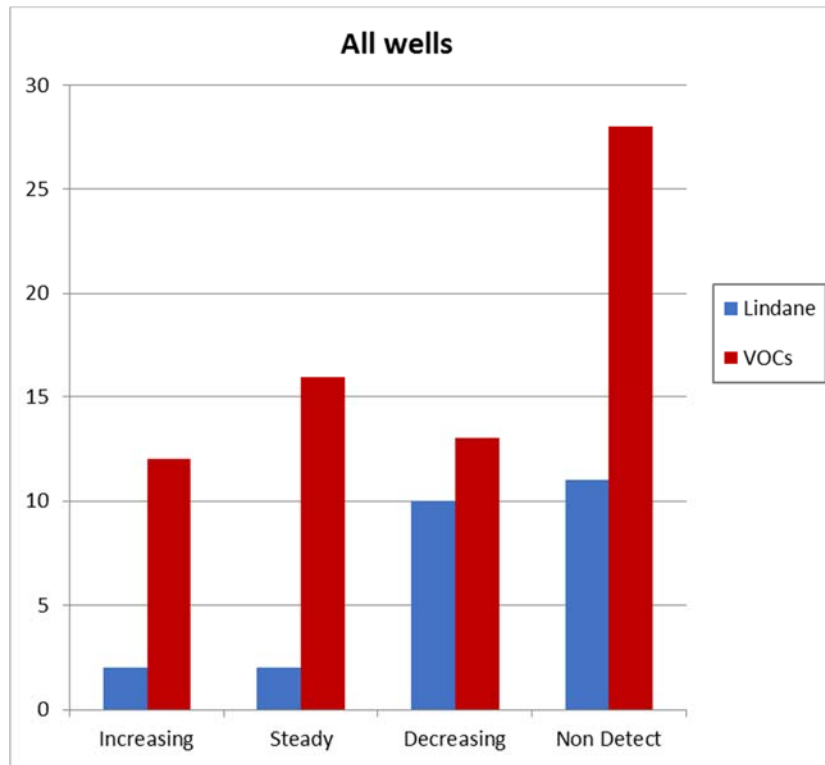


Figure 30. Comparison of PCE and Lindane Trends in CMP 10D and CMP 35D

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Identification of the wells trend type can be found on the “Trends” tab in the Excel file (CMP\_EMR\_2018) located on the CD supplied with this report.

**Figure 31. Contaminant Concentration Well Trends and Well Trends by Aquifer**

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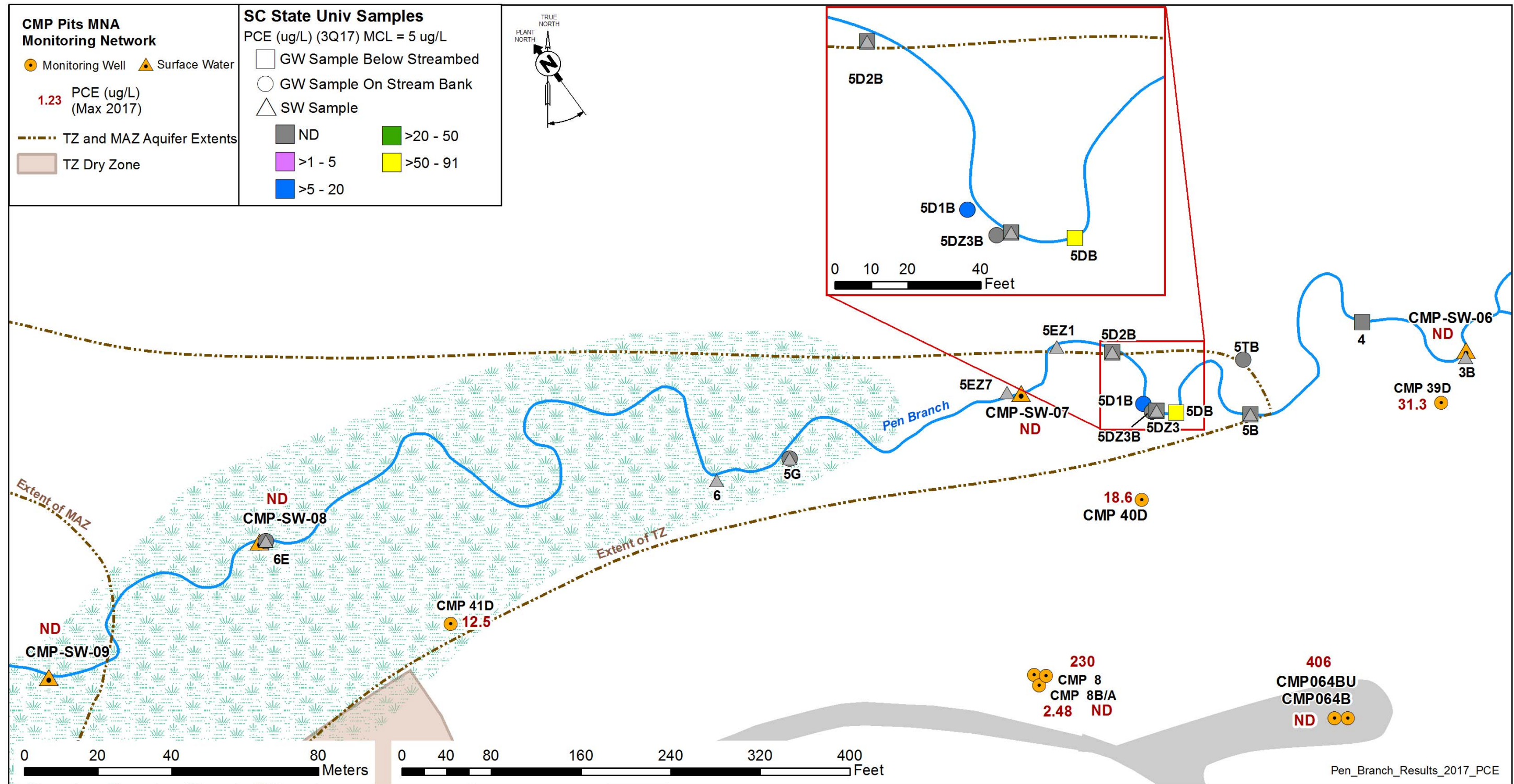


Figure 32. Independent Pen Branch Sampling Area and Summary of 2017 Results for PCE

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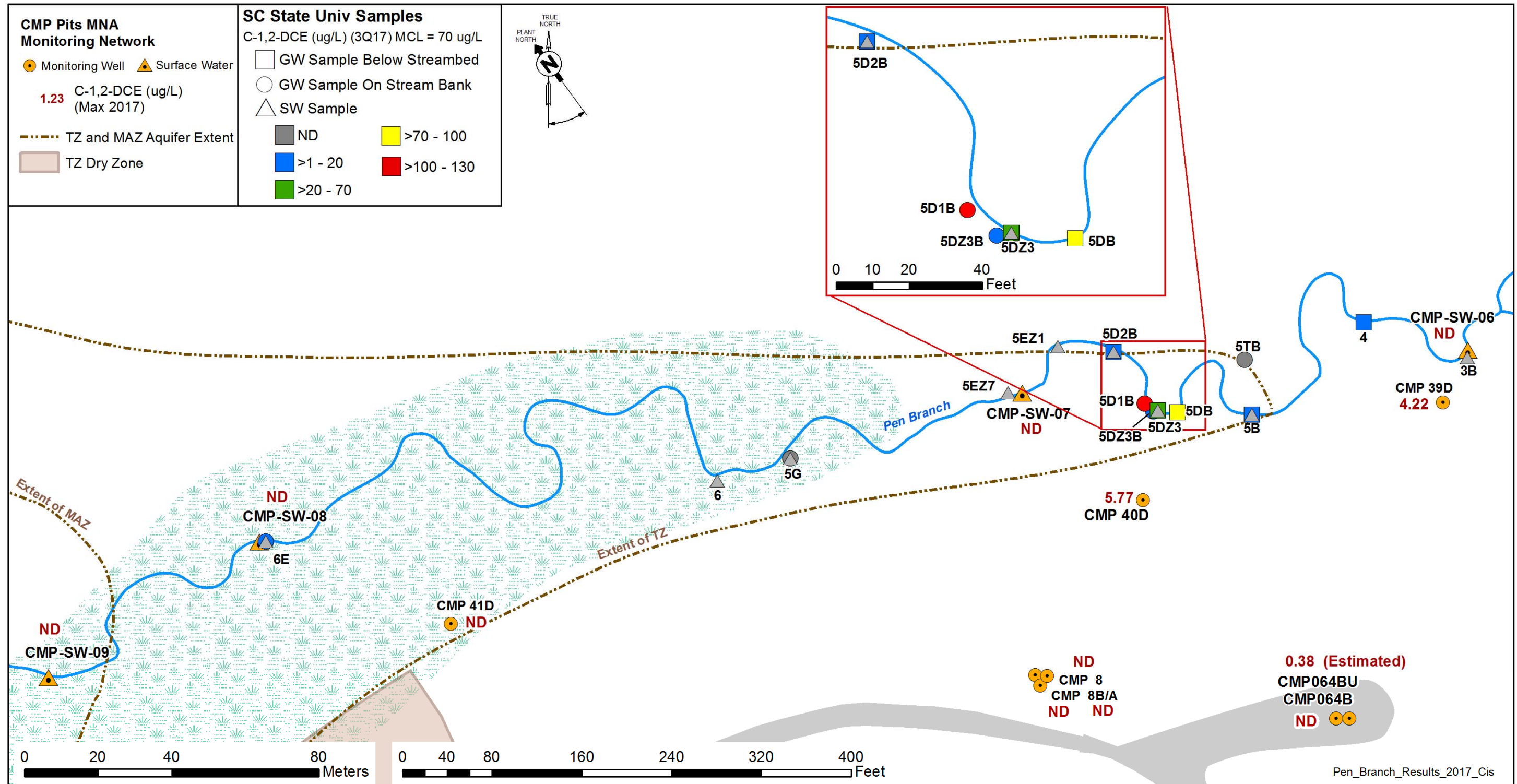


Figure 33. Independent Pen Branch Sampling Area and Summary of 2017 Results for C-1,2-DCE

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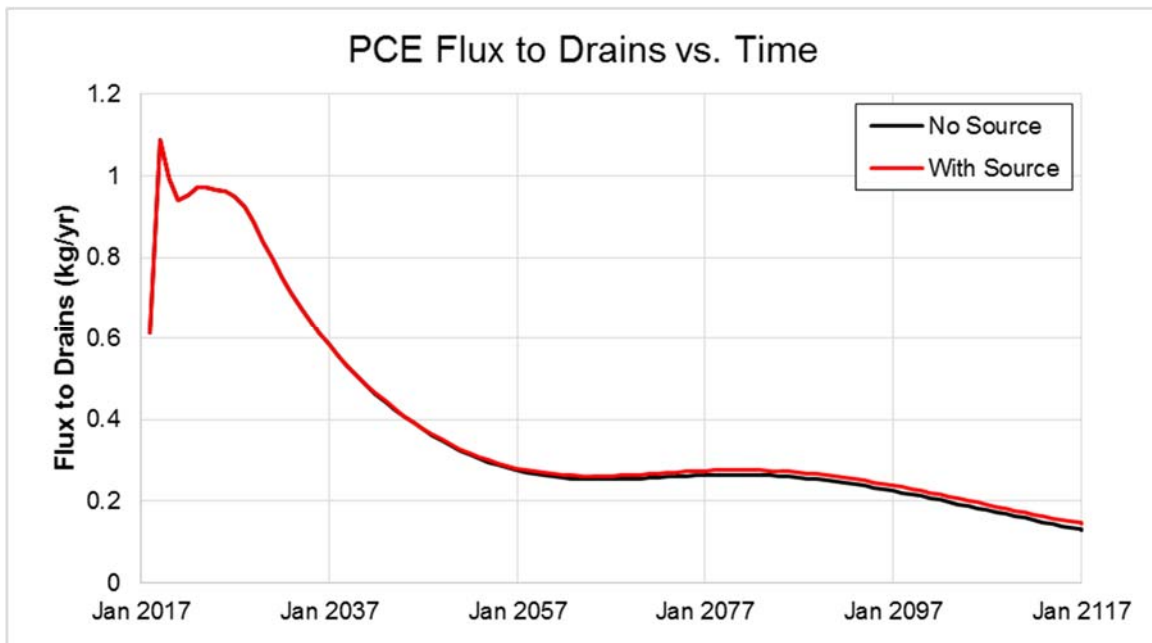


Figure 34. Modeled PCE Flux vs Time to Pen Branch

**Table 1. CMP Pits OU MNA Monitoring Network**

Station	Aquifer Unit	Lab Analyses			Screen Zone (ft msl)		screen length (ft)
		VOCs	1,4-Dioxane	Lindane	Bottom	Top	
CMB 15I	MAZ	2Q, 4Q	4Q	2Q, 4Q	210.7	212.4	1.7
CMB 24I	MAZ	2Q, 4Q	4Q		201	203	2
CMP 8	MAZ	2Q, 4Q	4Q		184	214	30
CMP 8A	GA	2Q	2Q		13.7	23.5	9.8
CMP 8B	LAZ (Upper)	2Q, 4Q	4Q		156.6	166.6	10
CMP 10B	LAZ (Mid)	2Q, 4Q	4Q	2Q, 4Q	137.4	147.4	10
CMP 10C	LAZ (Upper)	2Q, 4Q	4Q	2Q, 4Q	179.6	189.6	10
CMP 10D	TZ	2Q, 4Q	4Q	2Q, 4Q	209.6	229.6	20
CMP 11B	LAZ (Mid)	2Q, 4Q	4Q	2Q, 4Q	139.7	149.7	10
CMP 11D	TZ	2Q, 4Q	4Q		209.47	229.87	20.4
CMP 12A	GA	2Q	2Q		22.1	32.1	10
CMP 12B	LAZ (Mid)	2Q, 4Q	4Q		148	158	10
CMP 13B	LAZ (Mid)	2Q, 4Q	4Q		134.2	144.2	10
CMP 13D	TZ	2Q, 4Q	4Q		217.5	227.5	10
CMP 14B	LAZ (Mid)				130	140	10
CMP 14CR	MAZ				186.49	196.49	10
CMP 14D	TZ				204.1	224.5	20.4
CMP 14DU	TZ				202.57	212.57	10
CMP 15A	GA	2Q	2Q		14.2	24.2	10
CMP 15B	MAZ				145.1	155.1	10
CMP 30B	LAZ (Lower)	2Q, 4Q	4Q		97.4	107.5	10.1
CMP 30C	MAZ	2Q, 4Q	4Q		179.5	189.5	10
CMP 30D	TZ	2Q, 4Q	4Q		211.6	231.6	20
CMP 31B	LAZ (Lower)	2Q, 4Q	4Q		110.03	120.03	10
CMP 31C	MAZ	2Q, 4Q	4Q		197.9	207.9	10
CMP 32C	LAZ (Upper)	2Q, 4Q	4Q		185.2	195.2	10
CMP 32B <sup>1</sup>	LAZ (Lower)				97.7	107.7	10
CMP 33D	LAZ (Upper)	2Q, 4Q	4Q		178.6	188.6	10
CMP 34D	TZ			2Q, 4Q	215.6	225.6	10
CMP 35D	TZ	2Q, 4Q	4Q	2Q, 4Q	213.8	223.8	10
CMP 36D	TZ	2Q, 4Q	4Q		199.2	204.2	5
CMP 37D	TZ	2Q, 4Q	4Q		193.3	198.3	5
CMP 38D	TZ	2Q, 4Q	4Q		196.7	201.7	5
CMP 39D	MAZ	2Q, 4Q	4Q		190.9	195.9	5
CMP 40D	MAZ	2Q, 4Q	4Q		192.13	197.13	5
CMP 41D	MAZ	2Q, 4Q	4Q	2Q	191.7	196.7	5
CMP 43D	MAZ	2Q, 4Q	4Q	2Q	187.8	192.8	5
CMP 44D	MAZ	2Q, 4Q	4Q	2Q, 4Q	204.06	214.06	10
CMP 45D	MAZ	2Q, 4Q	4Q	2Q, 4Q	195.84	205.84	10
CMP 46D	MAZ			2Q, 4Q	198.44	208.44	10
CMP 47D	MAZ	2Q, 4Q	4Q	2Q, 4Q	196.37	206.37	10

<sup>1</sup> Well or surface water station is not part of the official monitoring network.

Table 1. CMP Pits OU MNA Monitoring Network (continued)

Station	Aquifer Unit	Lab Analyses			Screen Zone (ft msl)		Screen Length (ft)
		VOCs	1,4-Dioxane	Lindane	Bottom	Top	
CMP 48D	MAZ	2Q, 4Q	4Q	4Q – 3 <sup>rd</sup> year*	198.83	208.83	10
CMP 50B	LAZ (Upper)	2Q, 4Q	4Q		167.33	172.33	5
CMP 50D	MAZ	2Q, 4Q	4Q		202.99	212.99	10
CMP 51D	MAZ	2Q, 4Q	4Q		182.27	192.27	10
CMP 52A	GA	2Q	2Q		66.65	76.65	10
CMP 52BL	LAZ (Lower)	2Q, 4Q	4Q		96.59	106.59	10
CMP 52BU	LAZ (Upper)	2Q, 4Q	4Q		180.91	190.91	10
CMP 52C	MAZ	2Q, 4Q	4Q		204.69	209.69	5
CMP 54C	LAZ (Upper)	2Q, 4Q	4Q		178.34	188.34	10
CMP055B	LAZ(Upper)	2Q, 4Q	4Q		136.4	146.4	10
CMP 55C	MAZ	2Q, 4Q	4Q		177.62	187.62	10
CMP 56B	LAZ (Mid)				124.6	134.6	10
CMP 56D	MAZ				167.55	177.55	10
CMP 57B	LAZ (Mid)				125.25	135.25	10
CMP 57D	MAZ				168.21	178.21	10
CMP058B	LAZ (Upper)	2Q, 4Q	4Q	2Q, 4Q	182.7	192.6	9.9
CMP059C	MAZ	2Q, 4Q	4Q	2Q, 4Q	200.8	210.7	9.9
CMP060B	LAZ (Upper)	2Q, 4Q	4Q		171.6	181.6	10
CMP061B	LAZ (Mid)	2Q, 4Q	4Q		129.5	139.5	10
CMP062B	LAZ (Mid)	2Q	2Q		136	146	10
CMP062C	MAZ	2Q	2Q		186.8	191.8	5
CMP062D	TZ	2Q	2Q		210.6	230.6	20
CMP063B	LAZ (Mid)	4Q	2Q		126.1	136.1	10
CMP063C	MAZ	4Q	2Q		184.4	189.4	5
CMP063D	TZ	4Q	2Q		195.7	215.7	20
CMP064BU	LAZ (Upper)	2Q, 4Q	4Q	2Q, 4Q	149.2	159.2	10
CMP064B	LAZ (Lower)	2Q, 4Q	4Q		118.8	128.8	10
CMP065BU	MAZ	2Q, 4Q	4Q	2Q, 4Q	194.37	204.37	10
CMP065B	LAZ (Mid)	2Q, 4Q	4Q		128.94	138.94	10
CMP066B	LAZ (Mid)	4Q	4Q		138.7	148.7	10
CMP067B	LAZ (Mid)	4Q	4Q		143.1	153.1	10
CMPSW-06	SW	2Q, 4Q	4Q				
CMPSW-07	SW	2Q, 4Q	4Q				
CMPSW-08	SW	2Q, 4Q	4Q				
CMPSW-09	SW	2Q, 4Q	4Q				
CMPSW-10	SW	2Q, 4Q	4Q				
CMP-SW-21 <sup>2</sup>	SW	2Q, 4Q	4Q				
CMP-SW-22 <sup>2</sup>	SW	2Q, 4Q	4Q				

\*Lindane is analyzed every third year (i.e., 2017, 2020, 2023 etc)

<sup>1</sup> Well or surface water station is not part of the official monitoring network.

<sup>2</sup> New well or surface water station sampled in 2017. Proposed sampling is included in Lab Analysis columns.

**Table 2. CMP Pits OU Horizontal Groundwater Flow Velocities (4Q17)**

GW Flow Line	Gradient (dh/dl)	Velocity (ft/day)	Velocity (ft/year)
<b>TZ</b>			
A - A'	0.01332	2.66	972.70
B - B'	0.01452	2.90	1060.57
C - C'	0.00454	0.91	331.79
<b>TZ Avg.</b>		<b>2.16</b>	<b>788.36</b>
<b>MAZ</b>			
A - A'	0.00924	1.54	562.71
B - B'	0.01139	1.90	693.22
<b>MAZ Avg.</b>		<b>1.72</b>	<b>627.97</b>
<b>LAZ</b>			
A - A'	0.00219	0.15	53.24
B - B'	0.00717	0.48	174.64
C - C'	0.01325	0.88	322.60
<b>LAZ Avg.</b>		<b>0.50</b>	<b>183.49</b>

dh= difference in head; dl= difference in length

**Table 3. CMP Pits OU Annual MNA Results, 2017**

*See insert on the next page*

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Table 4. CMP Pits OU PCE Max Results from 2008 and 2017 (µg/L)

Station	Aquifer	2008 Max (Pre ERH/SVE)	2017 Max
CMP 10D	TZ	620	67
CMP 11D	TZ	421	45.3
CMP 13D	TZ	1.71	8.49
CMP 14D	TZ	NS	NA
CMP 14DU	TZ	NS	NA
CMP 30D	TZ	<EQL(1)	<EQL(1)
CMP 34D	TZ	49.4	NA
CMP 35D	TZ	122	795
CMP 36D	TZ	56.9	4.24
CMP 37D	TZ	358	26.5
CMP 38D	TZ	48.2	65.6
CMP062D	TZ	<EQL(1)	<EQL(1)
CMP063D	TZ	<EQL(1)	<EQL(1)
CMB 15I	MAZ	437	198
CMB 24I	MAZ	20.8	160
CMP 8	MAZ	299	230
CMP 14CR	MAZ	<EQL(1)	NS
CMP 15B	MAZ	<EQL(1)	NS
CMP 30C	MAZ	3.78	1.3
CMP 31C	MAZ	NS - Dry	23.1
CMP 39D	MAZ	71.7	31.3
CMP 40D	MAZ	135	18.6
CMP 41D	MAZ	5.48	12.5
CMP 43D	MAZ	<EQL(1)	<EQL(1)
CMP 44D	MAZ	312	56.4
CMP 45D	MAZ	973	314
CMP 46D	MAZ	NDD(434)	NA
CMP 47D	MAZ	NDD(845)	258
CMP 48D	MAZ	601	184
CMP 50D	MAZ	8.62	4.03
CMP 51D	MAZ	13.4	12.2
CMP 52C	MAZ	NS	192
CMP 55C	MAZ	<EQL(1)	NDD(.4)
CMP 56D	MAZ	NS	<EQL(1)
CMP 57D	MAZ	NS	<EQL(1)
CMP059C	MAZ	78.5	207
CMP062C	MAZ	<EQL(1)	<EQL(1)
CMP063C	MAZ	<EQL(1)	<EQL(1)
CMP065BU	MAZ	NS	58.3

Station	Aquifer	2008 Max (Pre ERH/SVE)	2017 Max
CMP 8B	LAZ	<EQL(1)	2.48
CMP 10B	LAZ	<EQL(1)	6.85
CMP 10C	LAZ	466	282
CMP 11B	LAZ	<EQL(1)	<EQL(1)
CMP 12B	LAZ	46.3	44.1
CMP 13B	LAZ	1.25	8.09
CMP 14B	LAZ	<EQL(1)	NS
CMP 30B	LAZ	<EQL(1)	<EQL(1)
CMP 31B	LAZ	<EQL(1)	<EQL(1)
CMP 32C	LAZ	110	448
CMP 33D	LAZ	16.4	5.79
CMP 50B	LAZ	<EQL(1)	<EQL(1)
CMP 52BL	LAZ	<EQL(1)	<EQL(1)
CMP 52BU	LAZ	35.1	156
CMP 54C	LAZ	NDD(196)	321
CMP055B	LAZ	NS	<EQL(1)
CMP 56B	LAZ	NS	<EQL(1)
CMP 57B	LAZ	NS	<EQL(1)
CMP058B	LAZ	6.51	27.2
CMP060B	LAZ	<EQL(1)	<EQL(1)
CMP061B	LAZ	<EQL(1)	<EQL(1)
CMP062B	LAZ	<EQL(1)	<EQL(1)
CMP063B	LAZ	<EQL(1)	<EQL(1)
CMP064BU	LAZ	NS	406
CMP064B	LAZ	NS	<EQL(1)
CMP065B	LAZ	NS	NDD(.35)
CMP066B	LAZ	NS	<EQL(1)
CMP067B	LAZ	NS	<EQL(1)
CMP 8A	GA	<EQL(1)	<EQL(1)
CMP 12A	GA	NDD(0.679)	NDD(.49)
CMP 15A	GA	<EQL(1)	<EQL(1)
CMP 52A	GA	<EQL(1)	<EQL(1)
CMP-SW-06	SW	<EQL(1)	<EQL(1)
CMP-SW-07	SW	NDD(0.63)	<EQL(1)
CMP-SW-08	SW	<EQL(1)	<EQL(1)
CMP-SW-09	SW	<EQL(1)	<EQL(1)
CMP-SW-10	SW	1.38	<EQL(1)
CMP-SW-20	SW	NS	<EQL(1)
CMP-SW-21	SW	NS	<EQL(1)

EQL=Sample Quantitation Limit (non-detect result); NDD=Not Decision Data (estimated result); NS = Not sampled; NA= Not analyzed for VOCs

Table 5. CMP Pits OU Lindane Max Results from 2008 and 2017 (µg/L)

Station	Aquifer	2008 Max (Pre ERH/SVE)	2017 Max
CMP 10D	TZ	0.185	NDD(.31)
CMP 11D	TZ	0.0509	0.0241
CMP 13D	TZ	<EQL(0.0225)	<EQL(.02)
CMP 14D	TZ	NS	NS
CMP 14DU	TZ	NS	NS
CMP 30D	TZ	<EQL(0.0222)	NA
CMP 34D	TZ	0.345	0.0638
CMP 35D	TZ	1.73	5.78
CMP 36D	TZ	<EQL(0.0217)	NA
CMP 37D	TZ	<EQL(0.0217)	NA
CMP 38D	TZ	<EQL(0.0217)	NA
CMP062D	TZ	<EQL(1)	NA
CMP063D	TZ	<EQL(1)	NA
CMB 15I	MAZ	0.165	0.0219
CMB 24I	MAZ	NDD(0.0192)	NA
CMP 8	MAZ	NDD(0.0192)	NA
CMP 14CR	MAZ	<EQL(0.0222)	NS
CMP 15B	MAZ	<EQL(0.0213)	NS
CMP 30C	MAZ	<EQL(0.0213)	NA
CMP 31C	MAZ	NS - Dry	NA
CMP 39D	MAZ	<EQL(0.0217)	NA
CMP 40D	MAZ	<EQL(0.0217)	NA
CMP 41D	MAZ	<EQL(0.0227)	<EQL(.02)
CMP 43D	MAZ	<EQL(1)	<EQL(.02)
CMP 44D	MAZ	0.474	NDD(0.13)
CMP 45D	MAZ	0.484	0.185
CMP 46D	MAZ	0.704	0.173
CMP 47D	MAZ	0.36	NDD(.0805)
CMP 48D	MAZ	0.157	NDD(.017)
CMP 50D	MAZ	<EQL(0.0217)	NA
CMP 51D	MAZ	<EQL(0.0217)	NA
CMP 52C	MAZ	NS	0.0204
CMP 55C	MAZ	<EQL(0.0213)	NA
CMP 56D	MAZ	NS	NA
CMP 57D	MAZ	NS	NA
CMP059C	MAZ	0.362	0.0829
CMP062C	MAZ	<EQL(0.0213)	NA
CMP063C	MAZ	<EQL(0.0217)	NA
CMP065BU	MAZ	NS	NDD(.0123)

Station	Aquifer	2008 Max (Pre ERH/SVE)	2017 Max
CMP 8B	LAZ	<EQL(0.0217)	NA
CMP 10B	LAZ	<EQL(0.0217)	<EQL(.02)
CMP 10C	LAZ	0.126	0.633
CMP 11B	LAZ	<EQL(0.02)	NDD(.02)
CMP 12B	LAZ	NDD(0.0184)	NA
CMP 13B	LAZ	<EQL(0.0227)	NA
CMP 14B	LAZ	<EQL(0.0222)	NS
CMP 30B	LAZ	<EQL(0.0213)	NA
CMP 31B	LAZ	<EQL(0.0213)	NA
CMP 32C	LAZ	<EQL(0.0217)	NA
CMP 33D	LAZ	<EQL(0.0217)	NA
CMP 50B	LAZ	<EQL(0.0222)	NA
CMP 52BL	LAZ	<EQL(0.0217)	NA
CMP 52BU	LAZ	<EQL(0.0227)	NA
CMP 54C	LAZ	<EQL(0.0202)	NA
CMP 56B	LAZ	NS	NA
CMP 57B	LAZ	NS	NA
CMP055B	LAZ	NS	NA
CMP058B	LAZ	<EQL(0.0227)	<EQL(.02)
CMP060B	LAZ	<EQL(0.0217)	NA
CMP061B	LAZ	<EQL(0.0241)	NA
CMP062B	LAZ	<EQL(0.023)	NA
CMP063B	LAZ	<EQL(0.0217)	NA
CMP064B	LAZ	NS	NA
CMP064BU	LAZ	NS	0.195
CMP065B	LAZ	NS	NA
CMP066B	LAZ	NS	NA
CMP067B	LAZ	NS	NA
CMP 8A	GA	<EQL(0.0217)	NA
CMP 12A	GA	<EQL(0.0213)	NA
CMP 15A	GA	<EQL(0.0227)	NA
CMP 52A	GA	<EQL(0.0217)	NA
CMP-SW-06	SW	NA	<EQL(.02)
CMP-SW-07	SW	NA	<EQL(.02)
CMP-SW-08	SW	NA	<EQL(.02)
CMP-SW-09	SW	NA	<EQL(.02)
CMP-SW-10	SW	NA	<EQL(.02)
CMP-SW-20	SW	NS	<EQL(.02)
CMP-SW-21	SW	NS	<EQL(.02)

EQL=Sample Quantitation Limit (non-detect result); NDD=Not Decision Data (estimated result); NS = Not sampled;  
NA= Not analyzed for lindane

Table 6. SCSU Pen Branch Area 2017 Sample Results Summary

Analyte	Number of detects	Minimum Detected Result (µg/L)	Maximum Result (µg/L)
<b>Groundwater (19 samples)</b>			
PCE	3	5.2	91
TCE	2	5.3	55
1,1-DCE	ND	ND	ND
cis-1,2-DCE	16	1.4	130
trans-1,2-DCE	ND	ND	ND
VC	11	1.4	92
<b>Surface Water (9 samples)</b>			
PCE	ND	ND	ND
TCE	ND	ND	ND
1,1-DCE	ND	ND	ND
cis-1,2-DCE	ND	ND	ND
trans-1,2-DCE	ND	ND	ND
VC	ND	ND	ND

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Table 7. SCSU Complete Pen Branch Area 2017 Sample Results

STATION ID	COLLECTION DATE	Sample Type	Sample Location	PCE	TCE	1,1-DCE	CIS-1,2-DCE	T-1,2-DCE	VC
SCSU-CMP-3B	7/19/2017	SW - Grab	Within Stream	ND	ND	ND	ND	ND	ND
SCSU-CMP-4	7/31/2017	GW - Pump	Below Stream Bottom	ND	ND	ND	1.4	ND	9.8
SCSU-CMP-4	7/12/2017	GW - PDB	Below Stream Bottom	ND	ND	ND	2.8	ND	17
SCSU-CMP-5B	7/19/2017	SW - Grab	Within Stream	ND	ND	ND	ND	ND	ND
SCSU-CMP-5B	7/31/2017	GW - Pump	Below Stream Bottom	ND	ND	ND	9.5	ND	5.3
SCSU-CMP-5B	7/12/2017	GW - PDB	Below Stream Bottom	ND	ND	ND	19	ND	14
SCSU-CMP-5D1B	7/31/2017	GW - Pump	South Bank	ND	ND	ND	30	ND	15
SCSU-CMP-5D1B	7/12/2017	GW - PDB	South Bank	5.2	5.3	ND	130	ND	31
SCSU-CMP-5D2B	7/19/2017	SW - Grab	Within Stream	ND	ND	ND	ND	ND	ND
SCSU-CMP-5D2B	7/31/2017	GW - Pump	Below Stream Bottom	ND	ND	ND	2.9	ND	ND
SCSU-CMP-5D2B	7/12/2017	GW - PDB	Below Stream Bottom	ND	ND	ND	3.5	ND	1.4
SCSU-CMP-5DB	7/31/2017	GW - Pump	Below Stream Bottom	2.5	ND	ND	92	ND	ND
SCSU-CMP-5DB	7/12/2017	GW - PDB	Below Stream Bottom	91	55	ND	20	ND	ND
SCSU-CMP-5DZ3	7/19/2017	SW - Grab	Within Stream	ND	ND	ND	ND	ND	ND
SCSU-CMP-5DZ3	7/31/2017	GW - Pump	Below Stream Bottom	ND	ND	ND	21	ND	15
SCSU-CMP-5DZ3	7/12/2017	GW - PDB	Below Stream Bottom	ND	ND	ND	39	ND	92
SCSU-CMP-5DZ3B	7/31/2017	GW - Pump	South Bank	ND	ND	ND	5.4	ND	12
SCSU-CMP-5DZ3B	7/12/2017	GW - PDB	South Bank	ND	ND	ND	9.2	ND	36
SCSU-CMP-5EZ1	7/19/2017	SW - Grab	Within Stream	ND	ND	ND	ND	ND	ND
SCSU-CMP-5EZ7	7/19/2017	SW - Grab	Within Stream	ND	ND	ND	ND	ND	ND
SCSU-CMP-5G	7/19/2017	SW - Grab	Within Stream	ND	ND	ND	ND	ND	ND
SCSU-CMP-5G	7/31/2017	GW - Pump	South Bank	ND	ND	ND	ND	ND	ND
SCSU-CMP-5G	7/12/2017	GW - PDB	South Bank	ND	ND	ND	ND	ND	ND
SCSU-CMP-5TB	7/31/2017	GW - Pump	North Bank	Dry	Dry	Dry	Dry	Dry	Dry
SCSU-CMP-5TB	7/12/2017	GW - PDB	North Bank	ND	ND	ND	ND	ND	ND
SCSU-CMP-6	7/19/2017	SW - Grab	Within Stream	ND	ND	ND	ND	ND	ND
SCSU-CMP-6E	7/19/2017	SW - Grab	Within Stream	ND	ND	ND	ND	ND	ND
SCSU-CMP-6E	7/31/2017	GW - Pump	South Bank	ND	ND	ND	2	ND	ND
SCSU-CMP-6E	7/12/2017	GW - PDB	South Bank	ND	ND	ND	2.2	ND	ND

All result unit in µg/L; ND= Non-detect; <MCL >MCL

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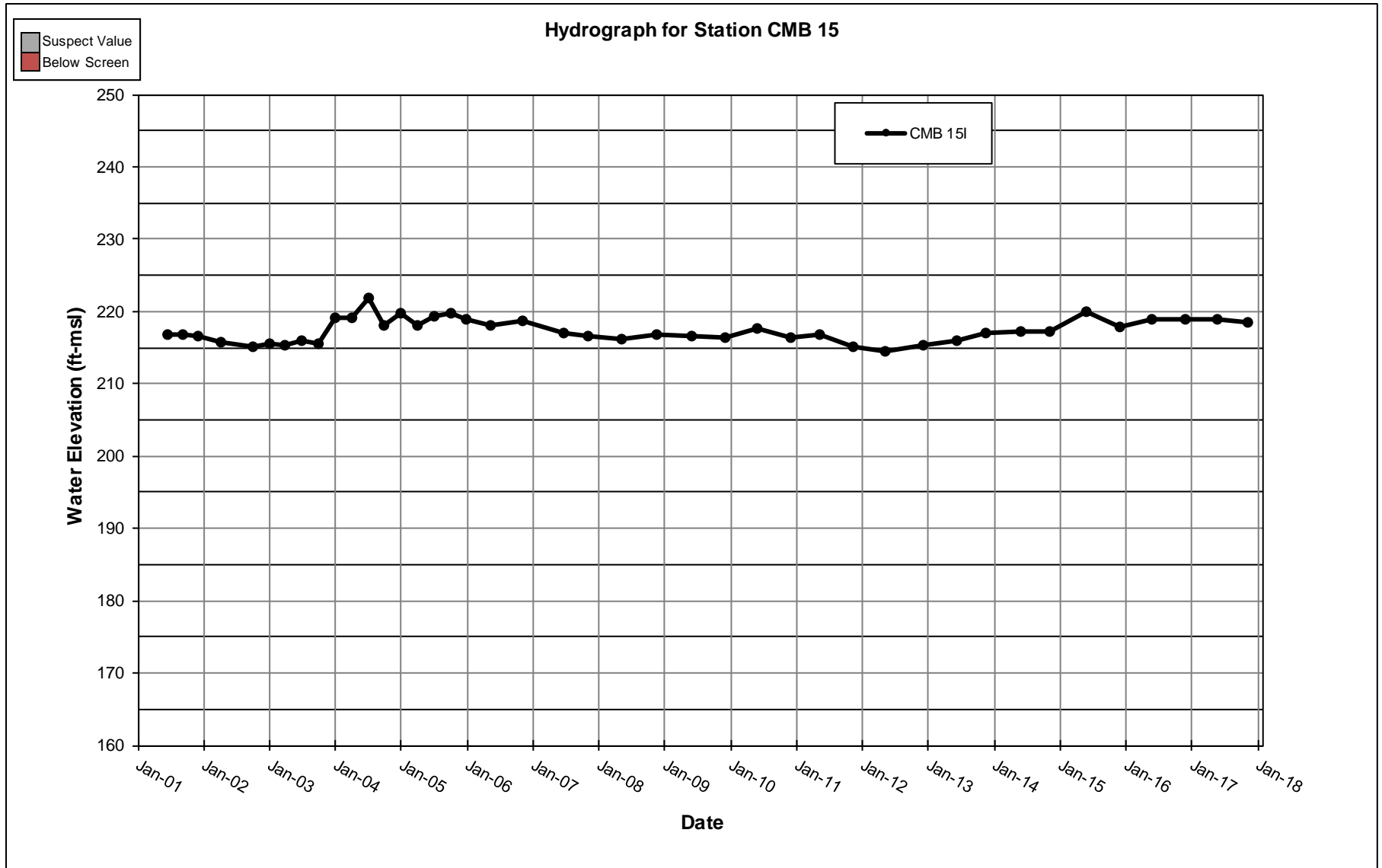
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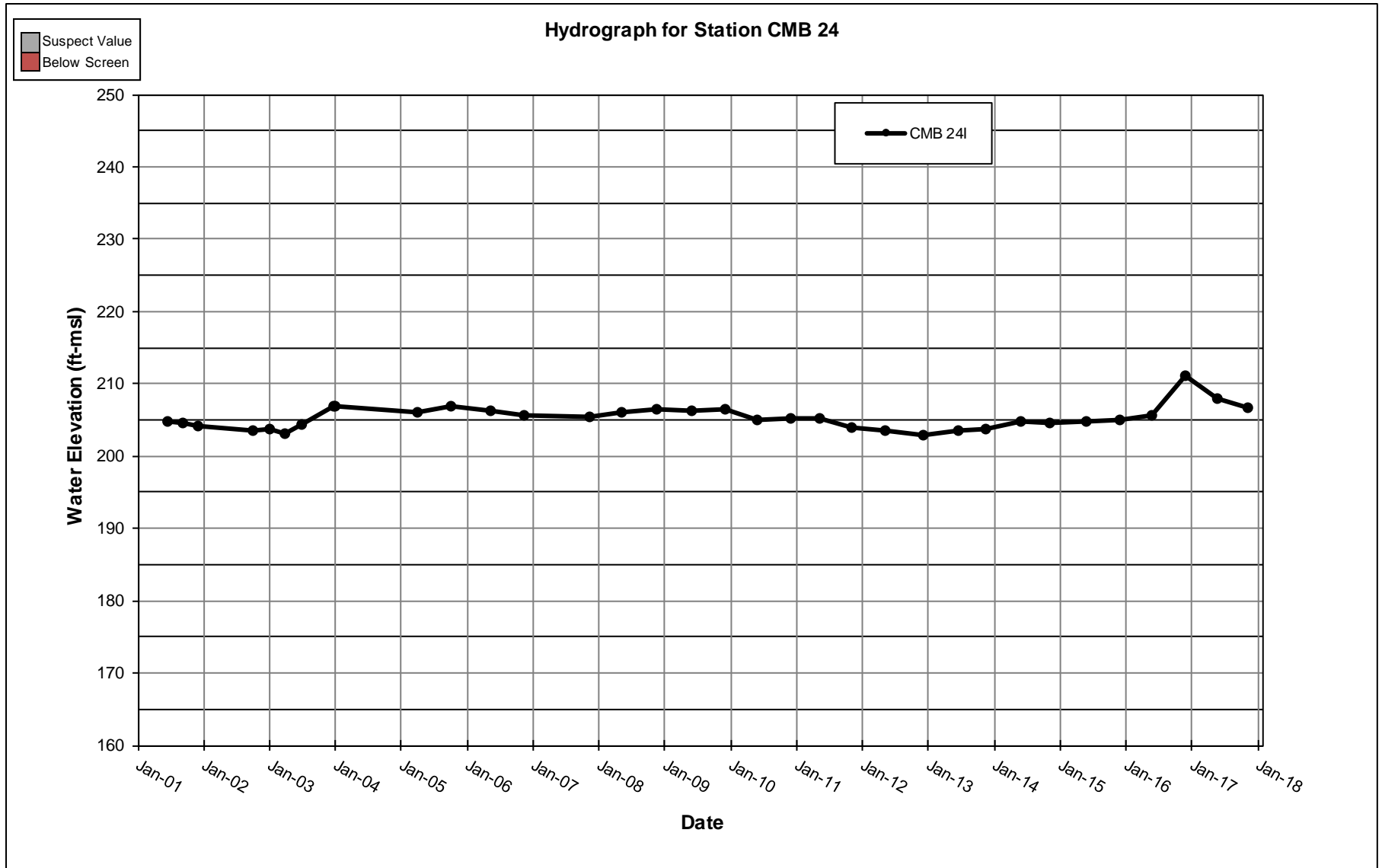
## Appendix A

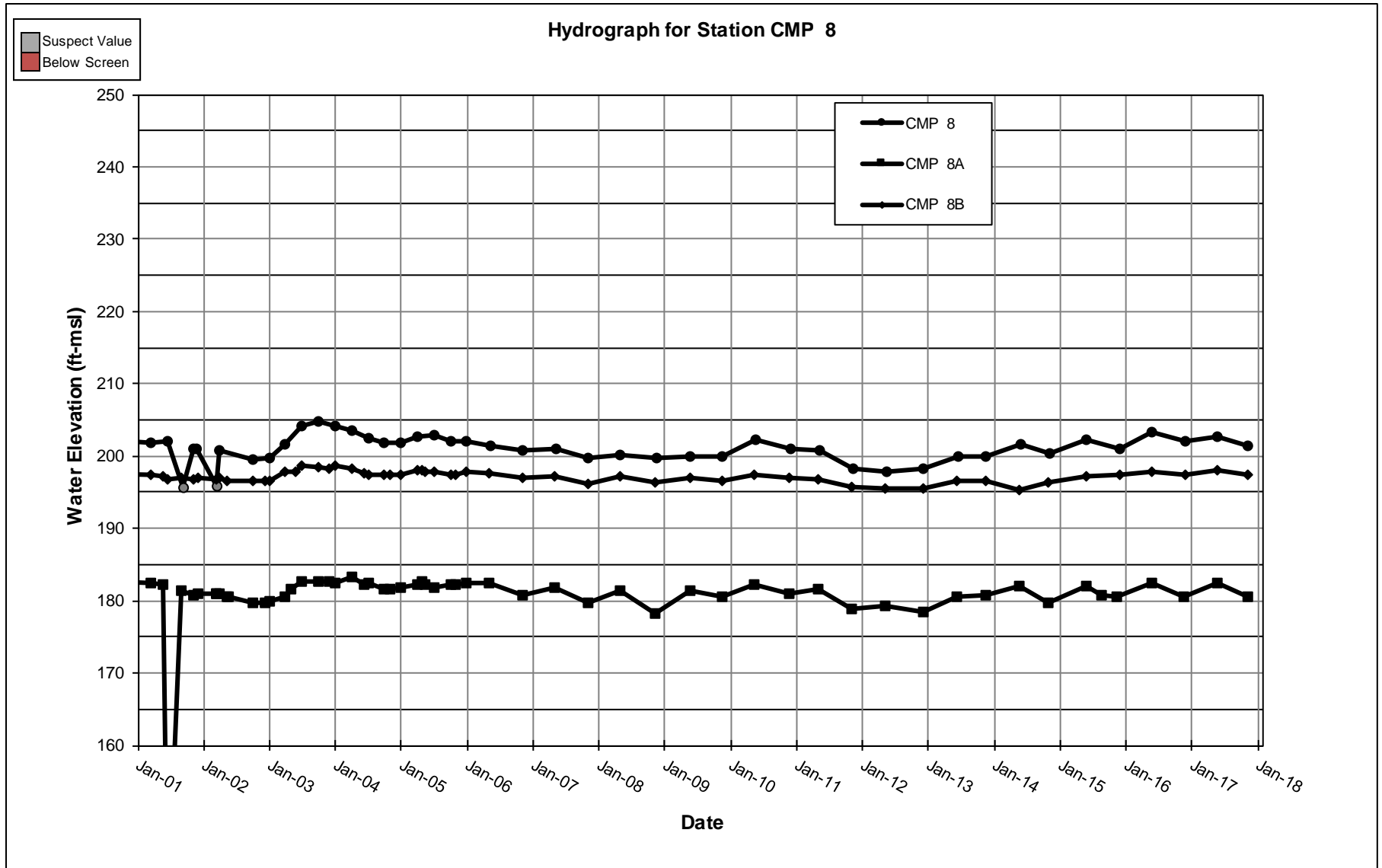
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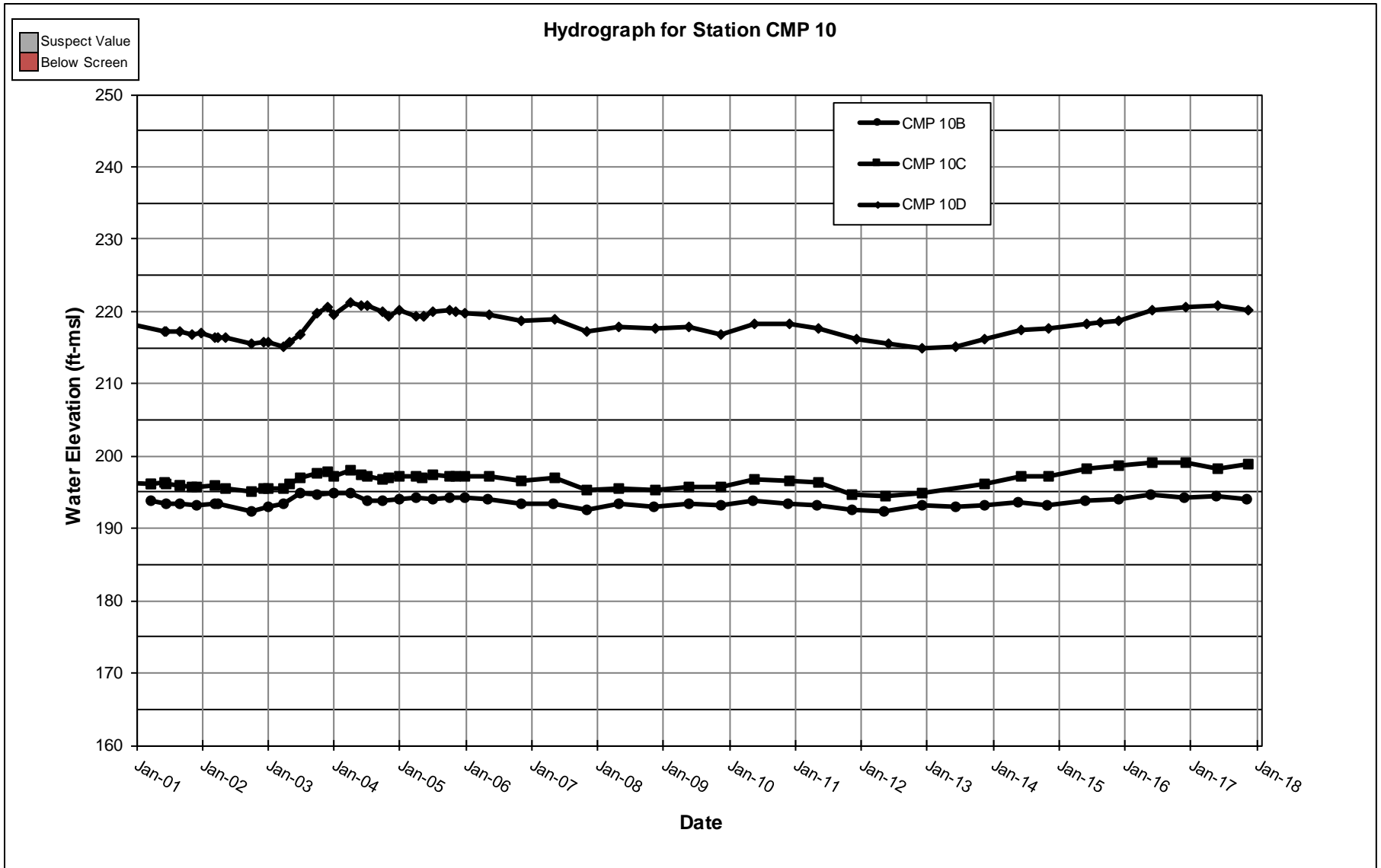
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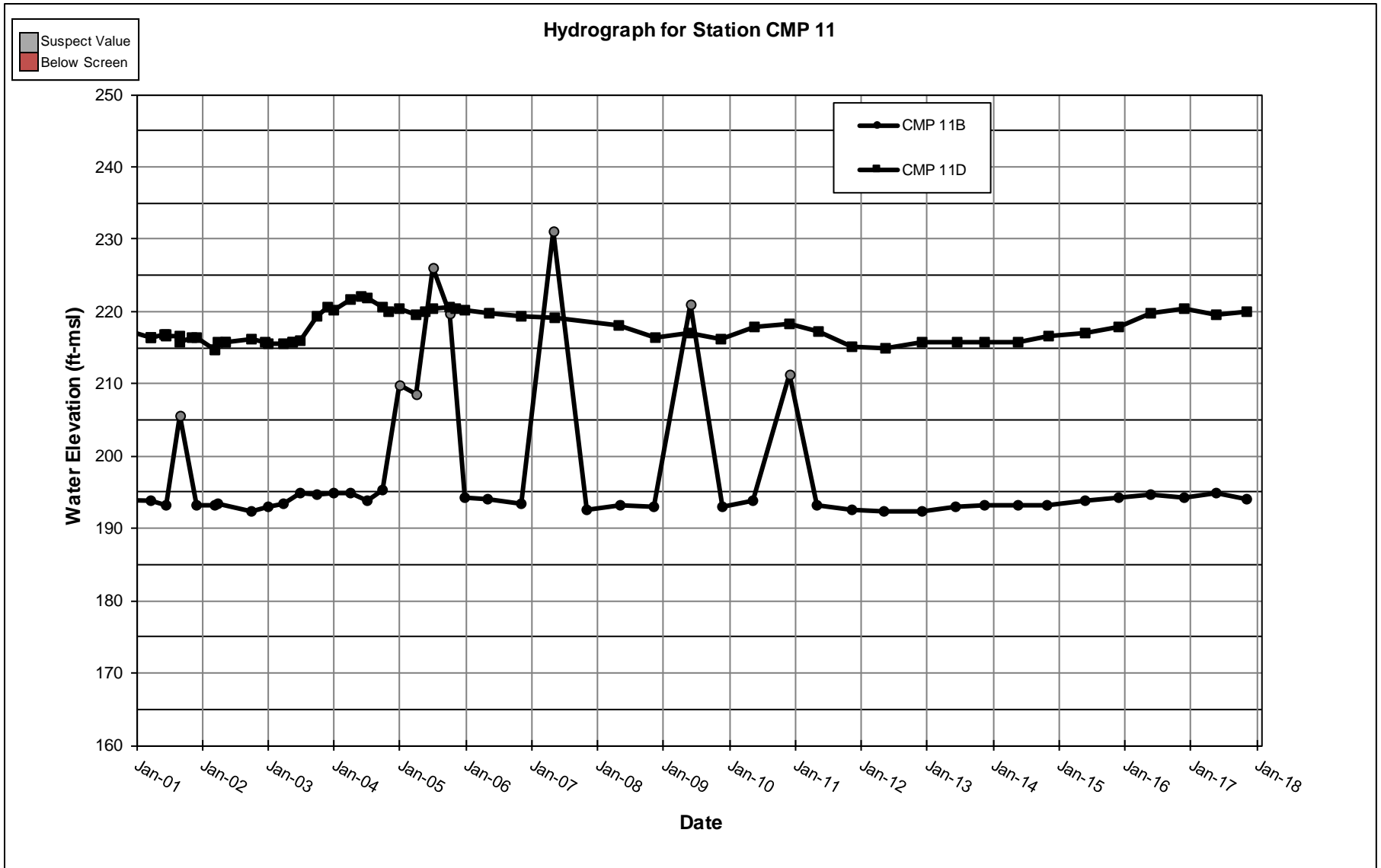
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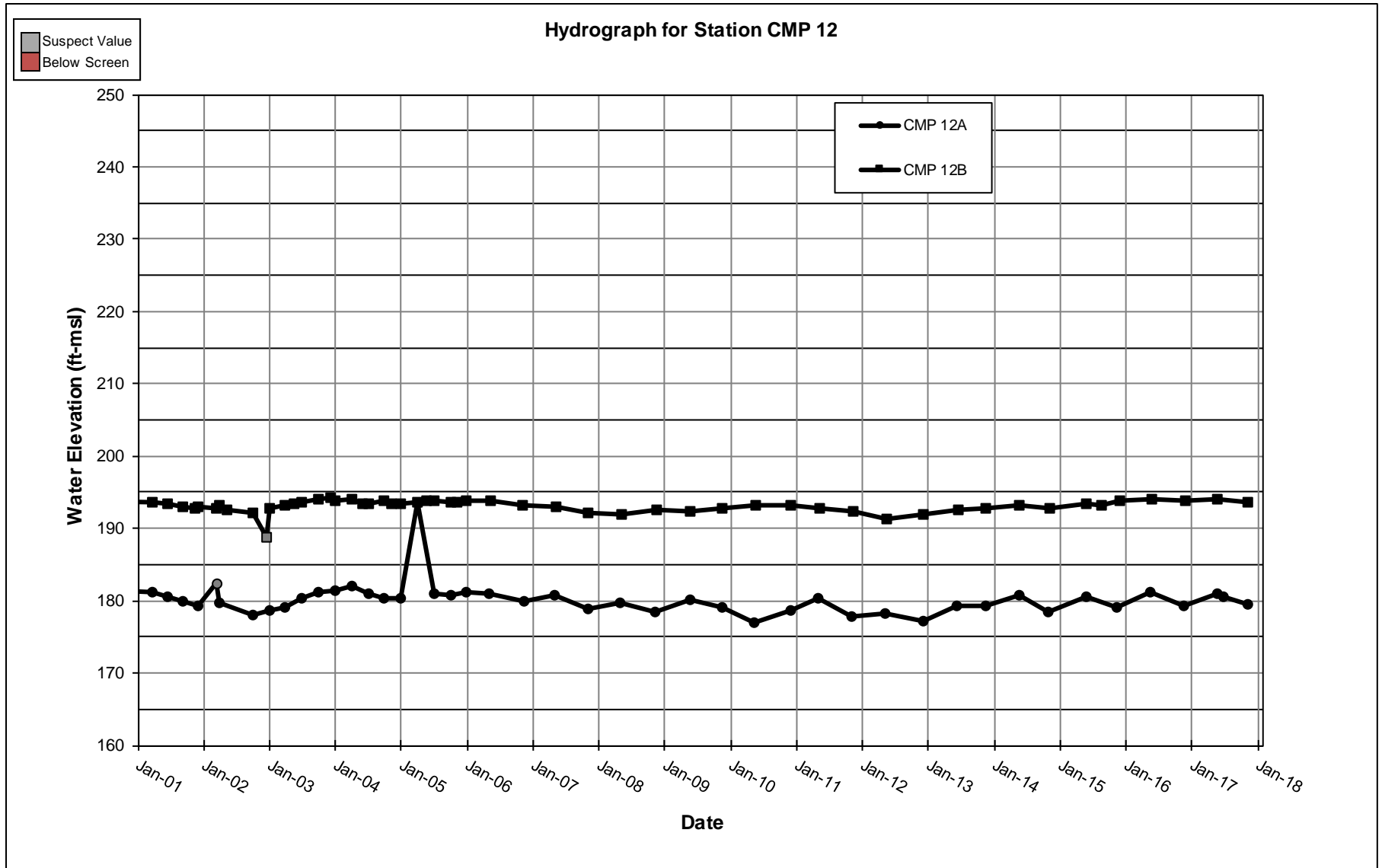


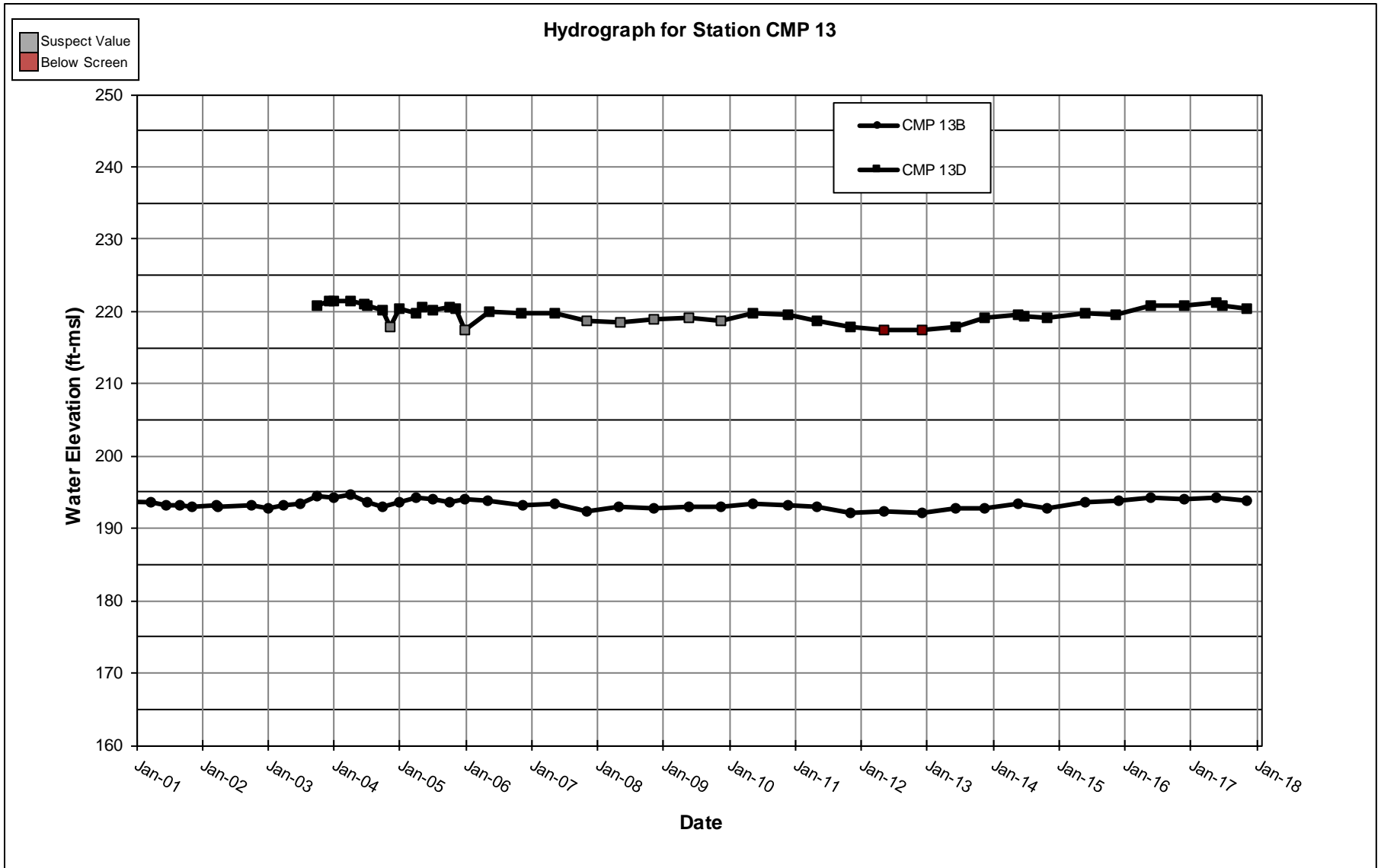


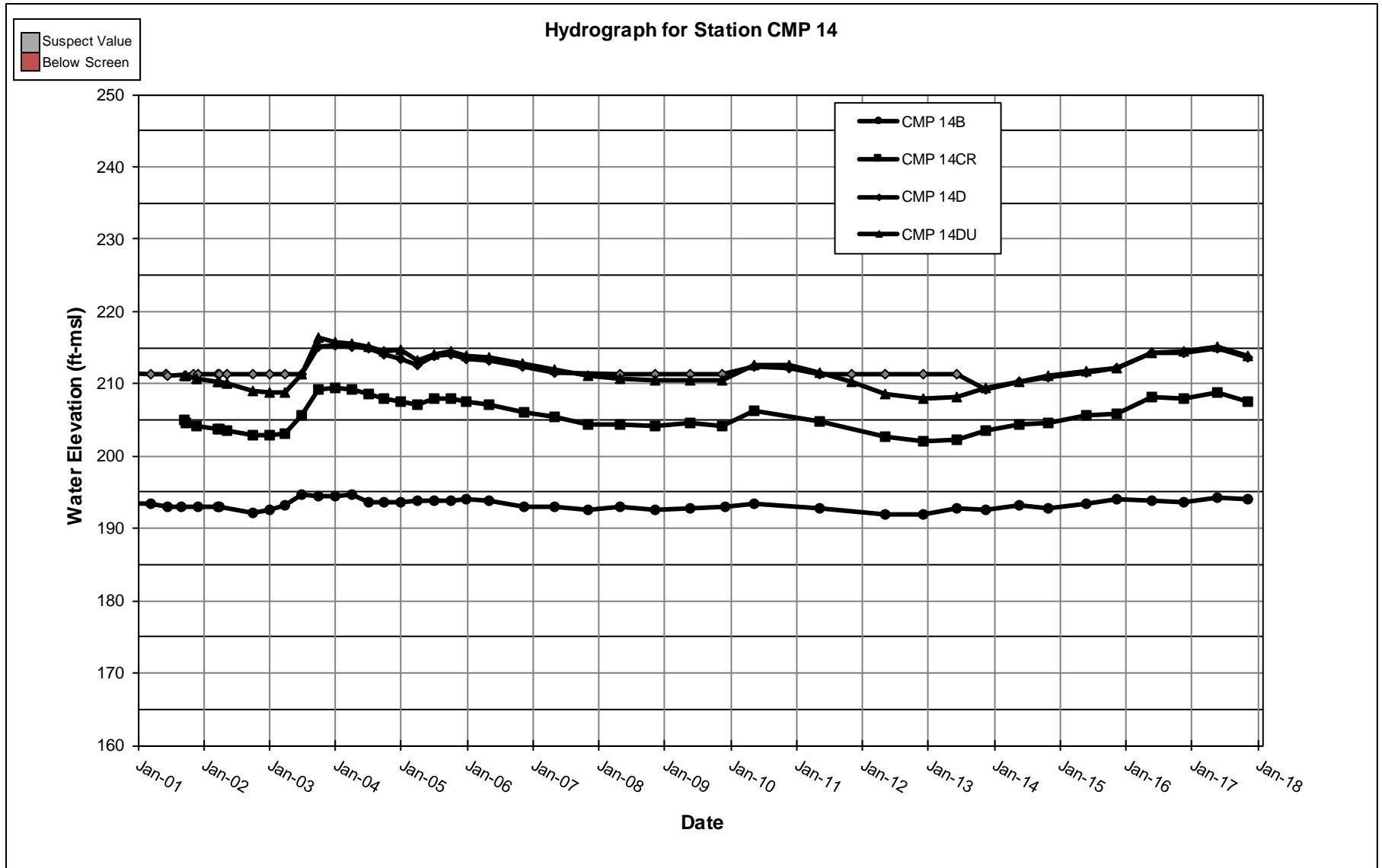


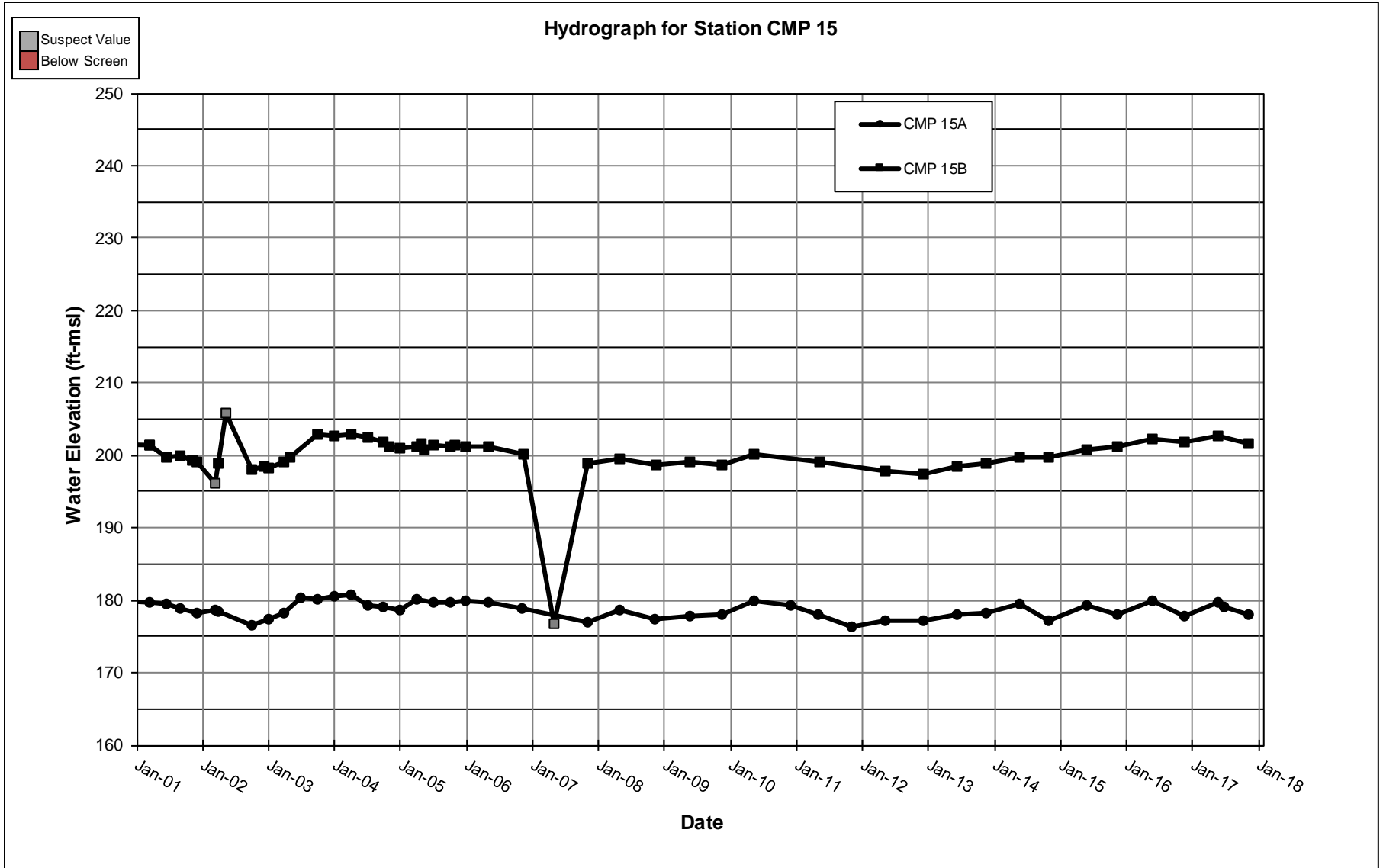


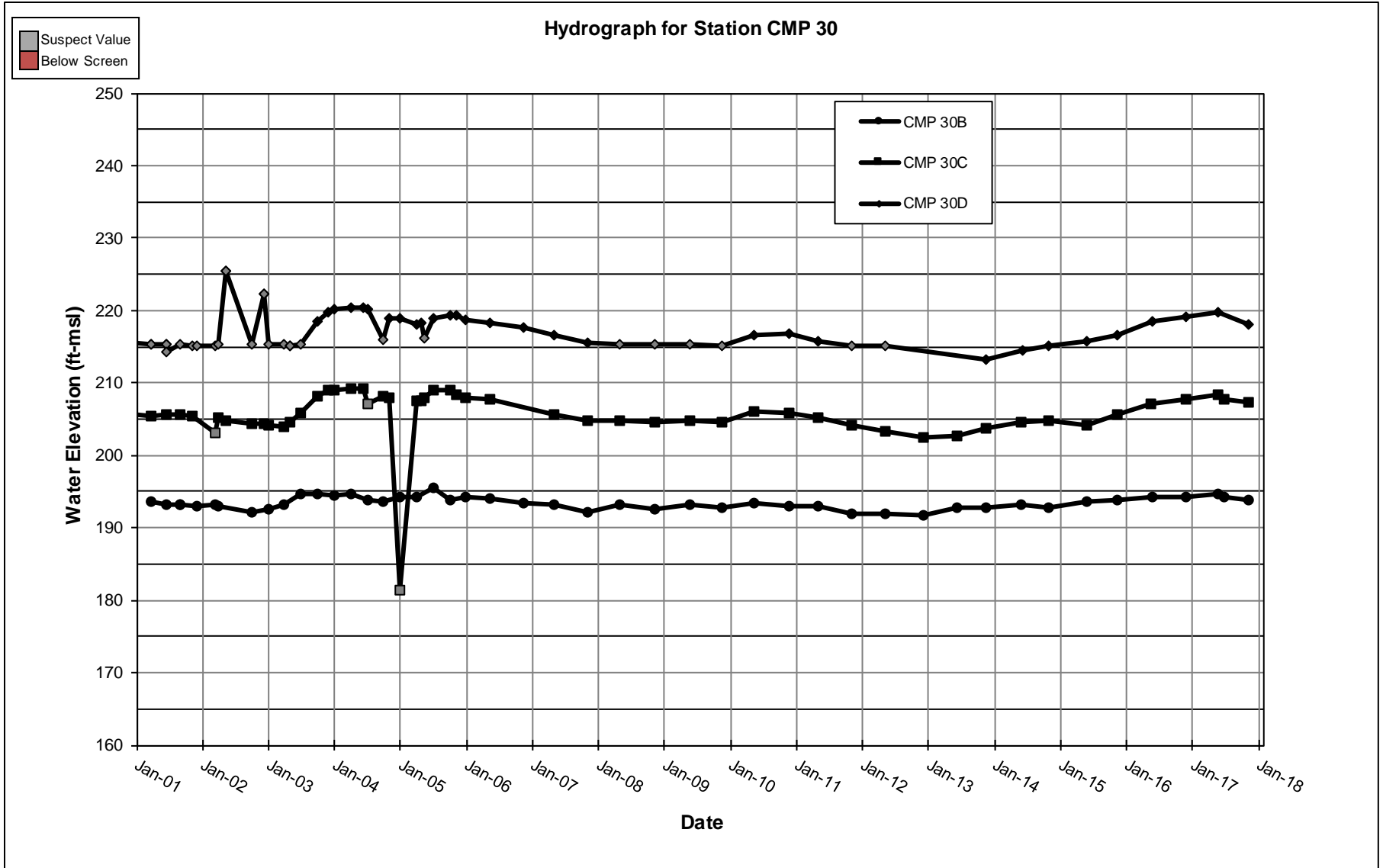


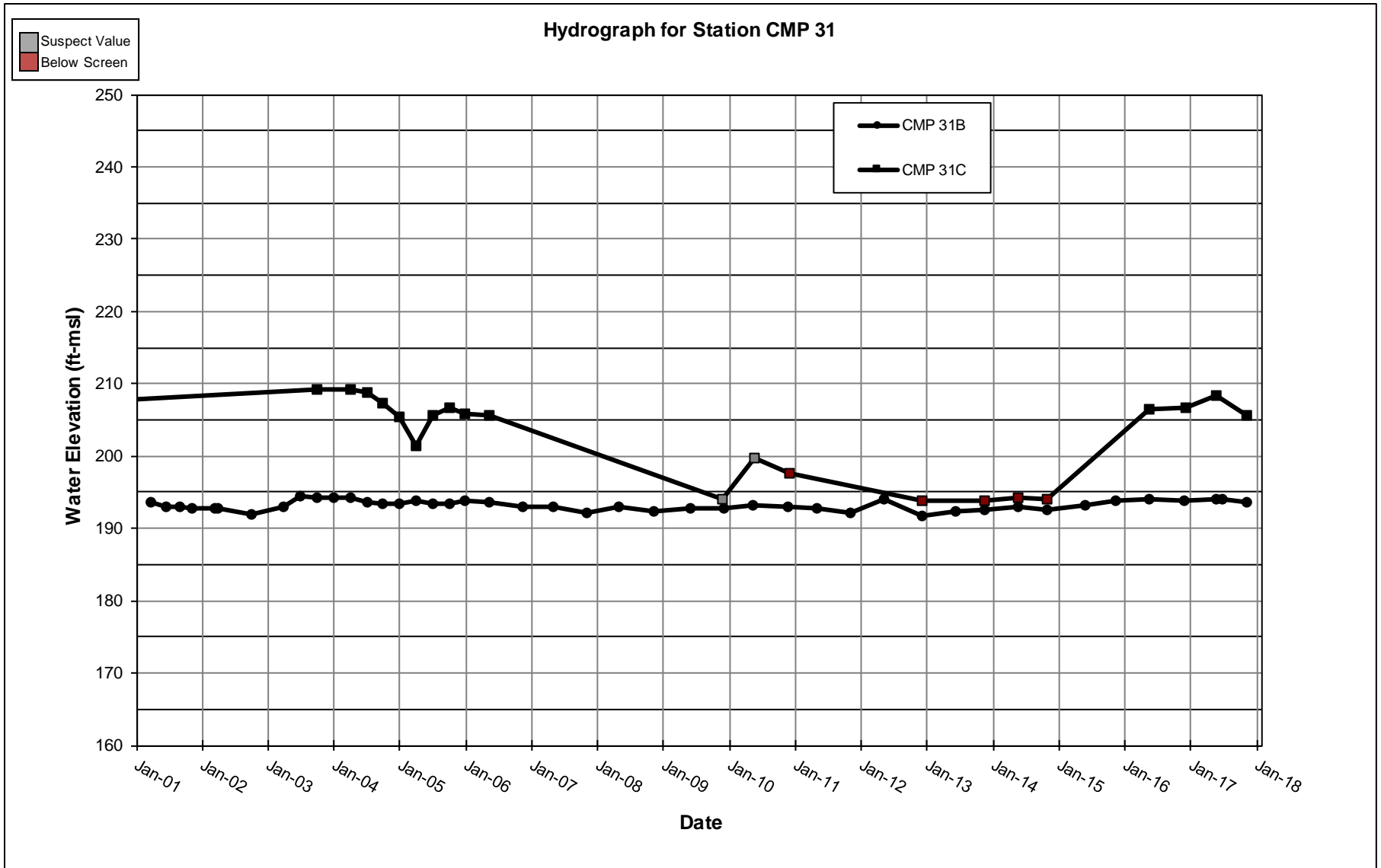


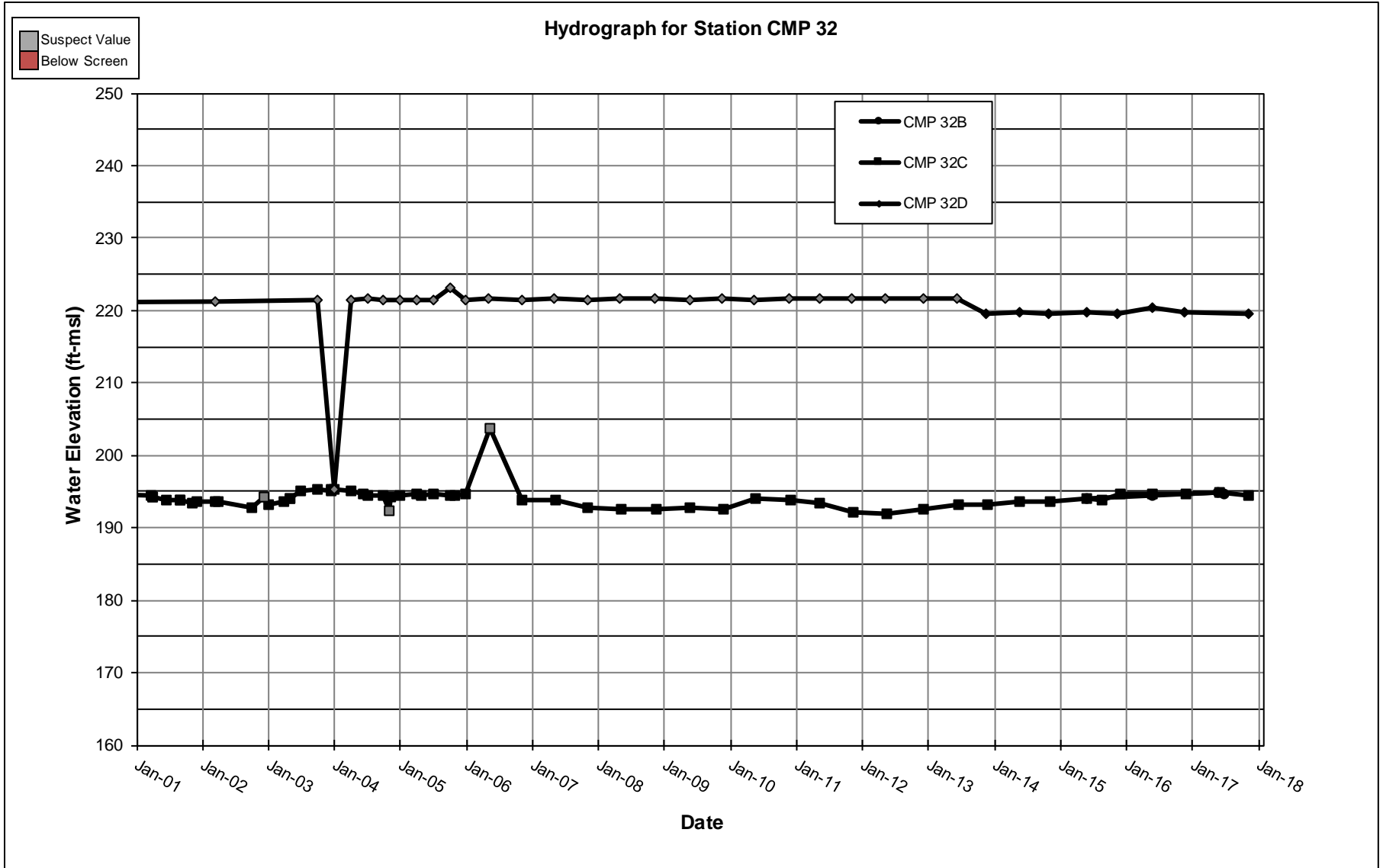


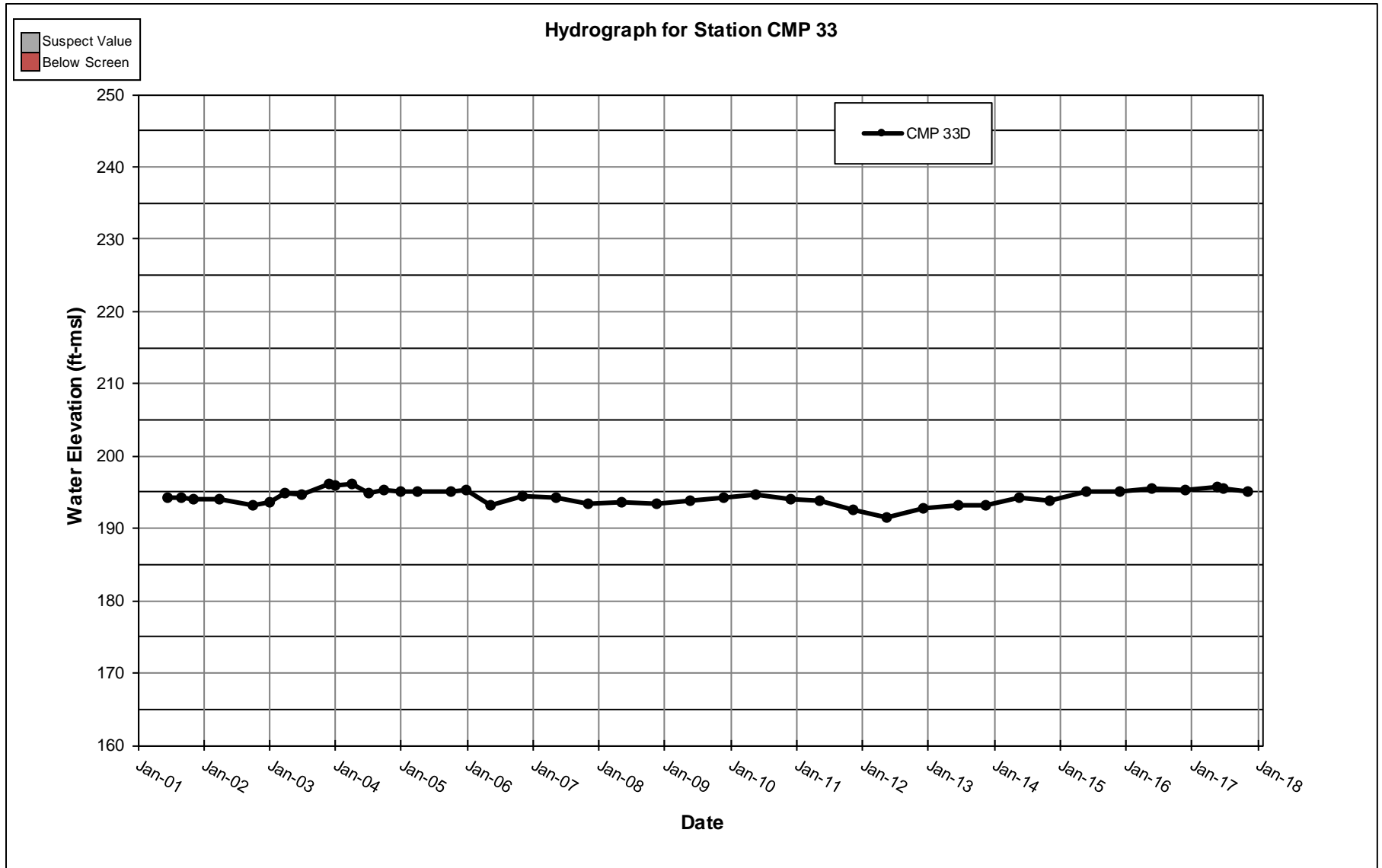


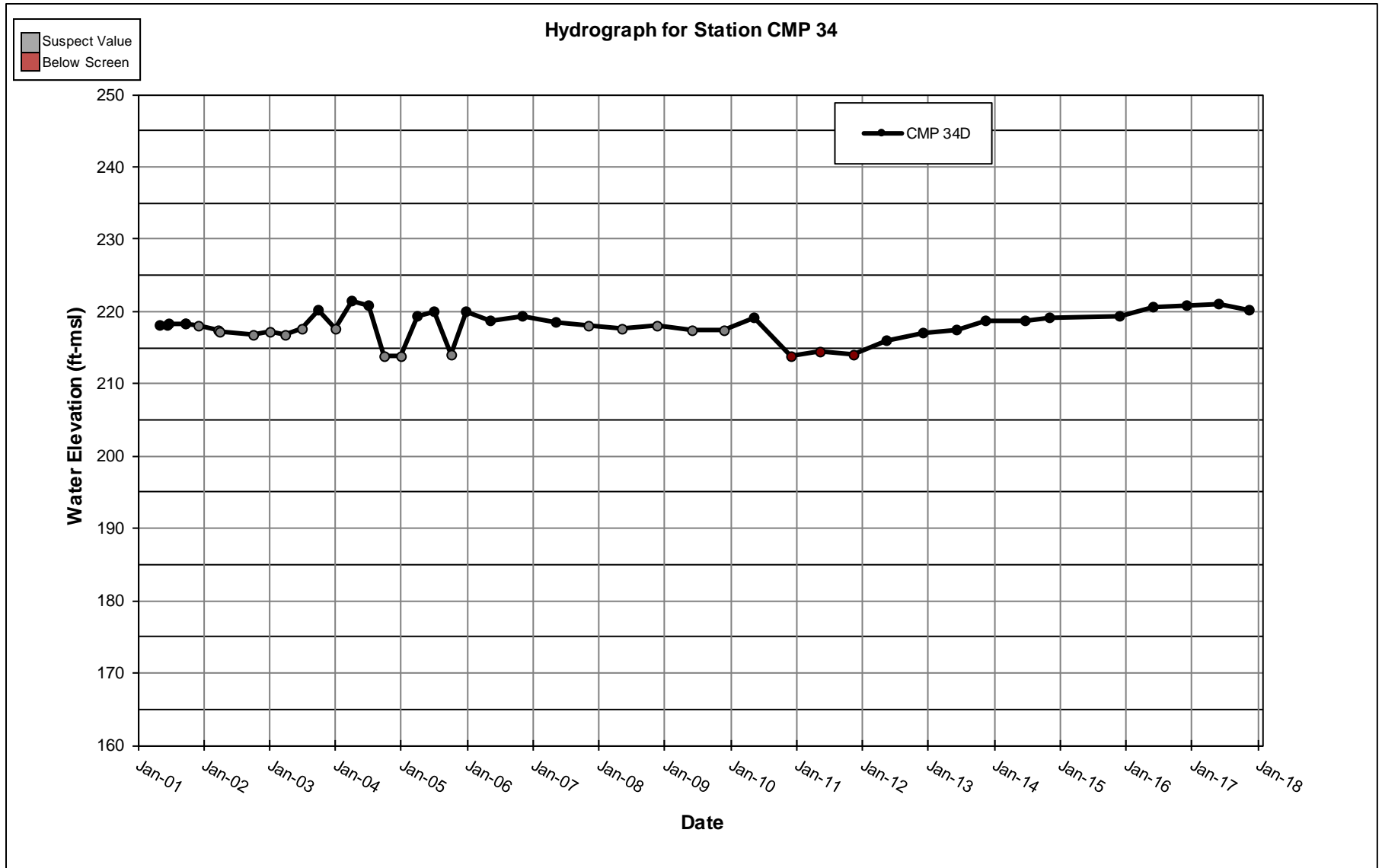


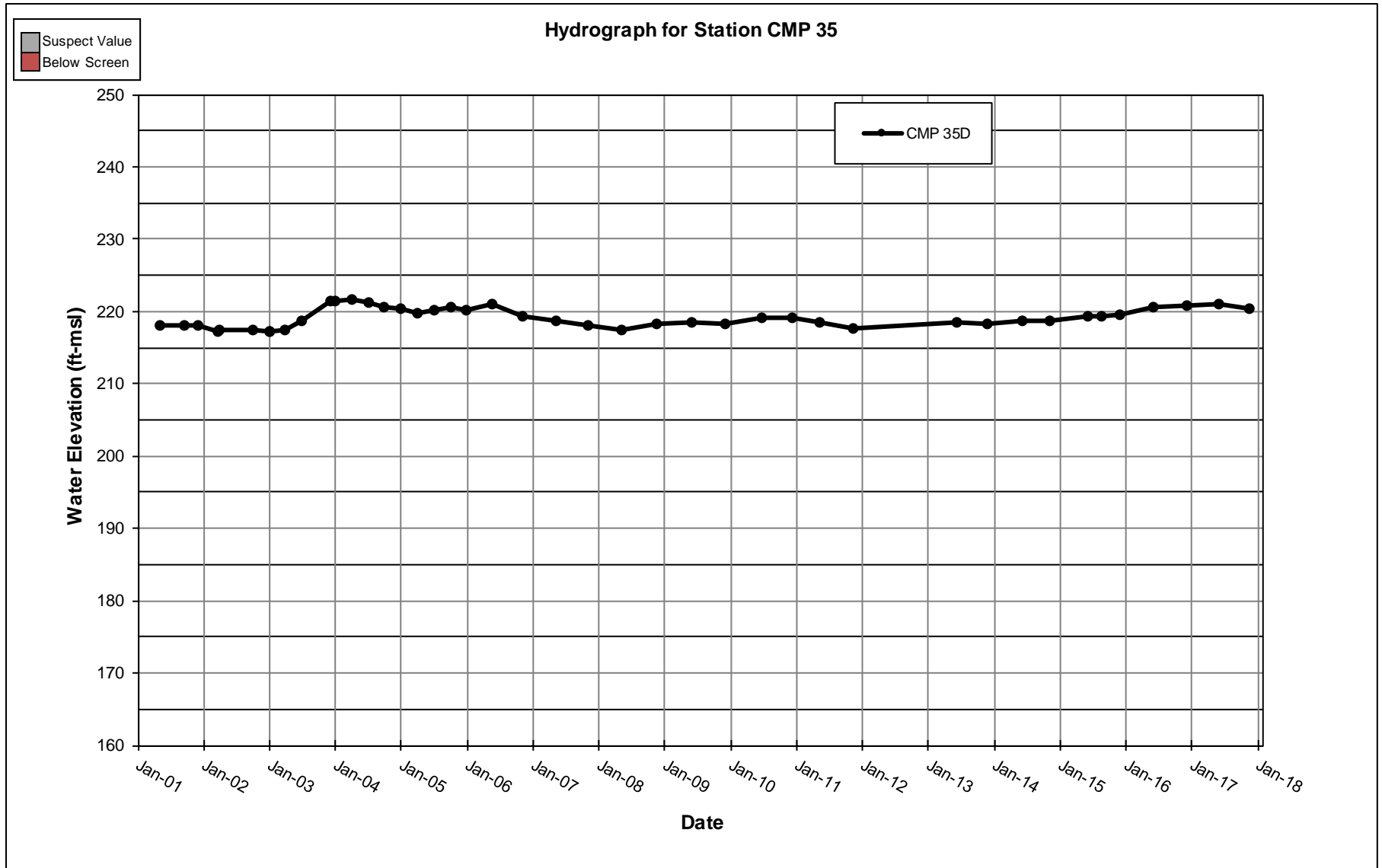


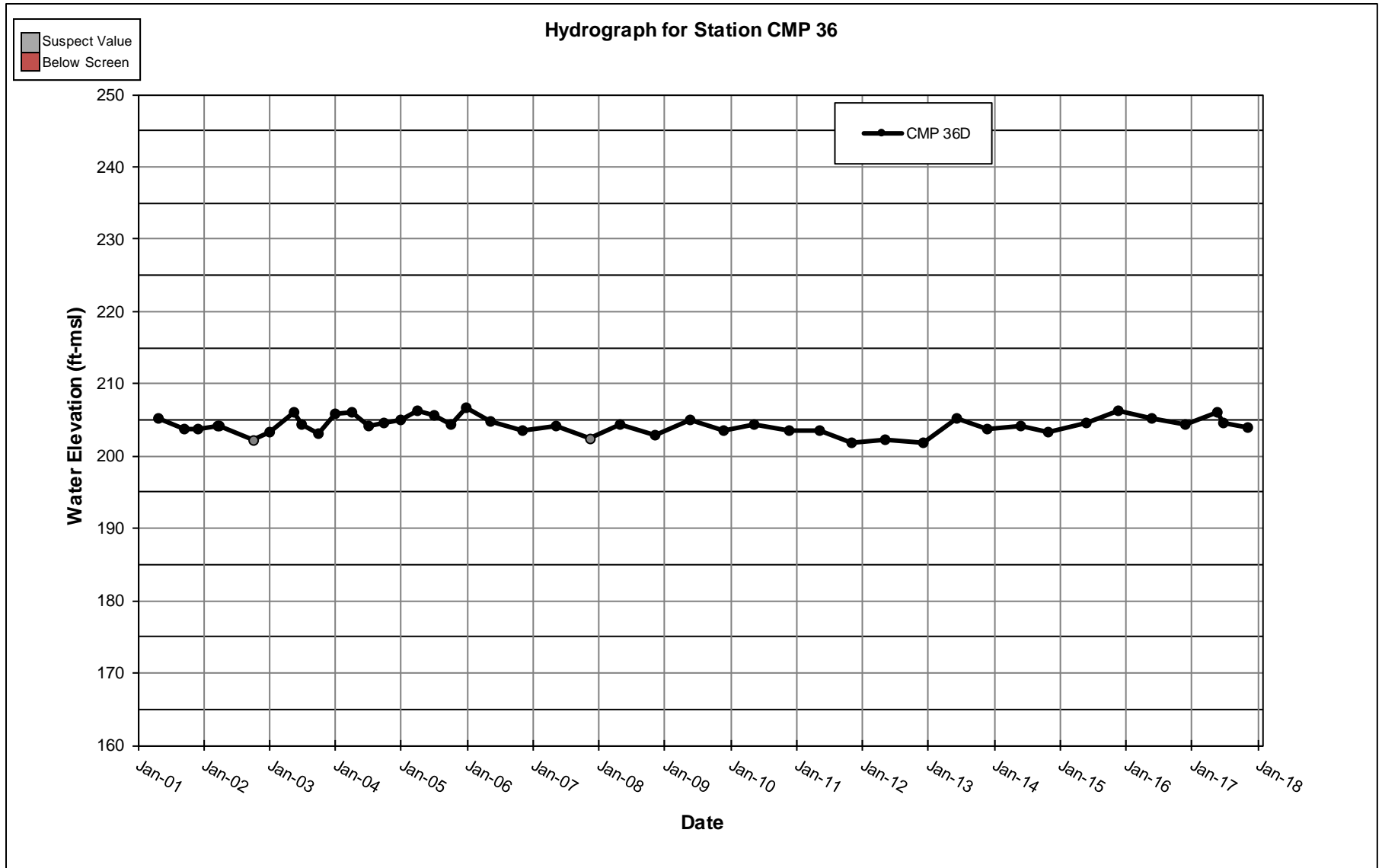


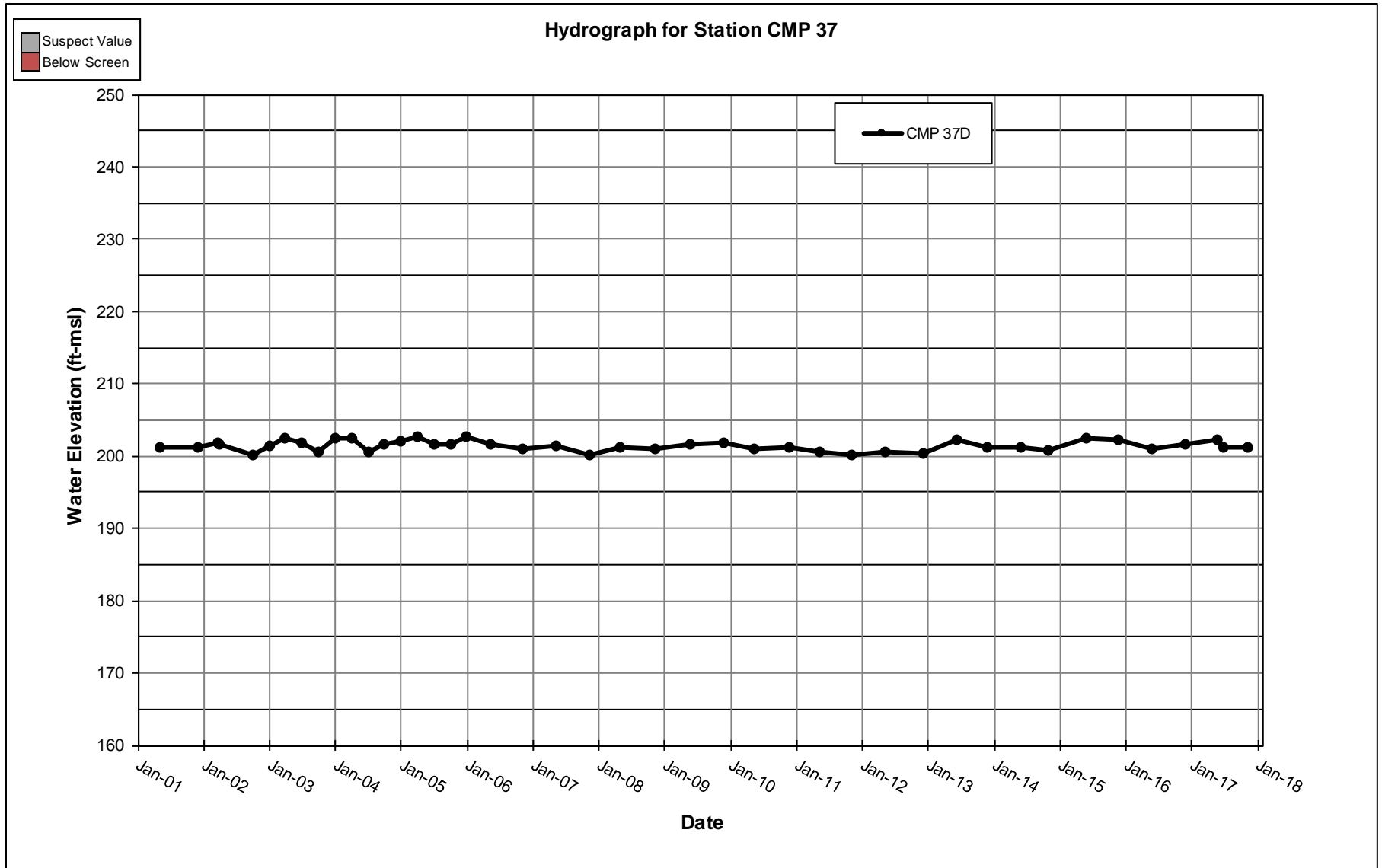


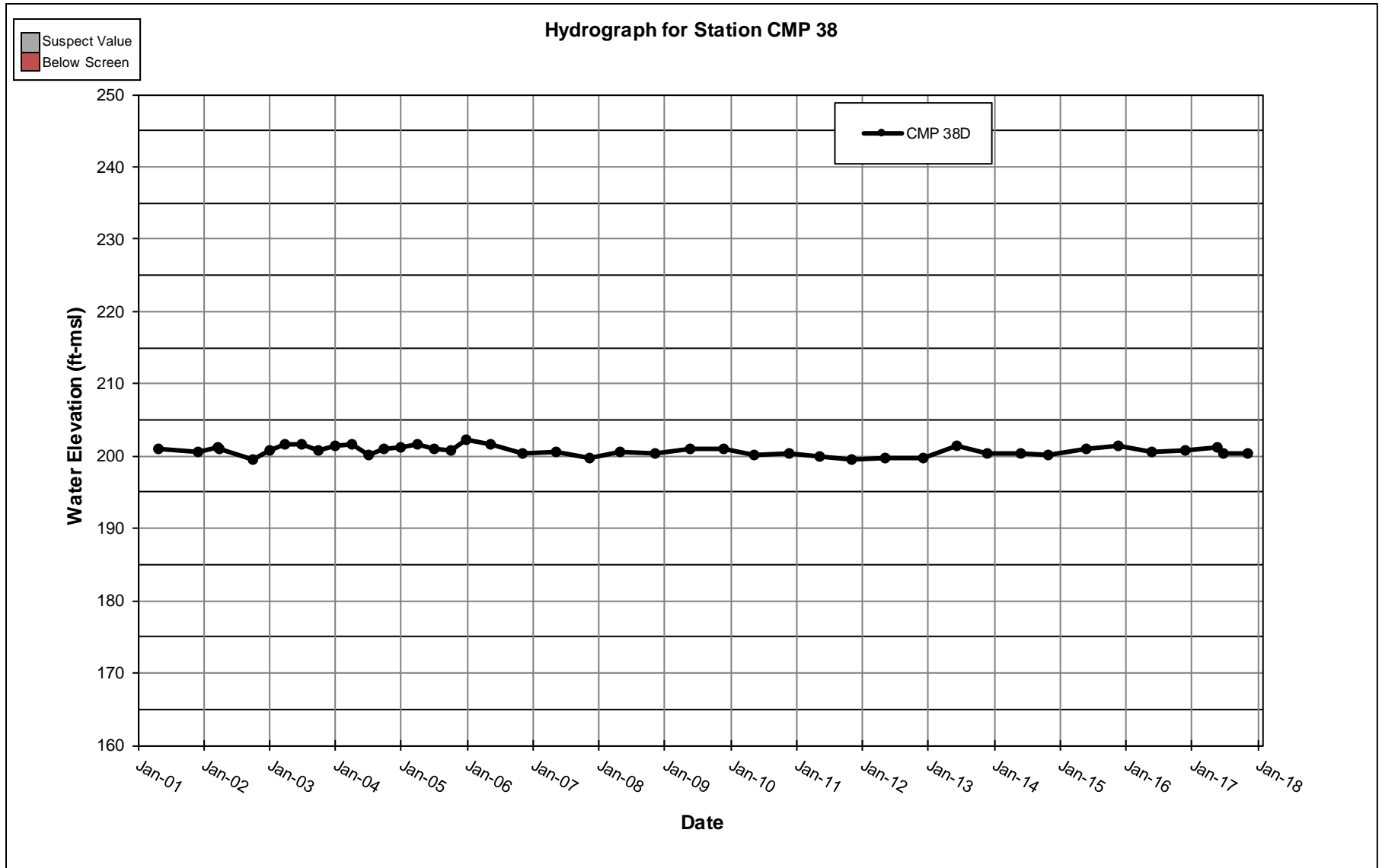


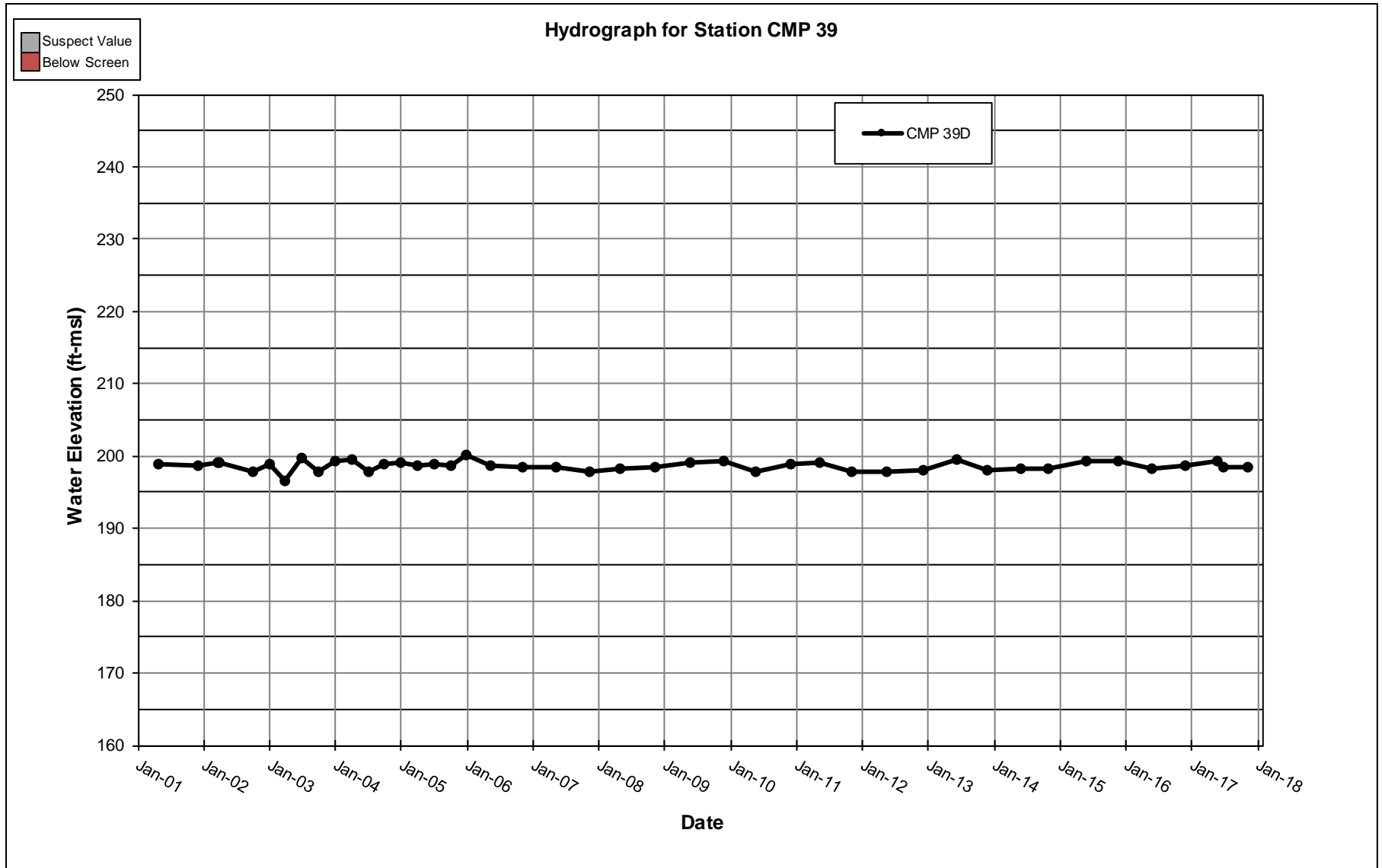


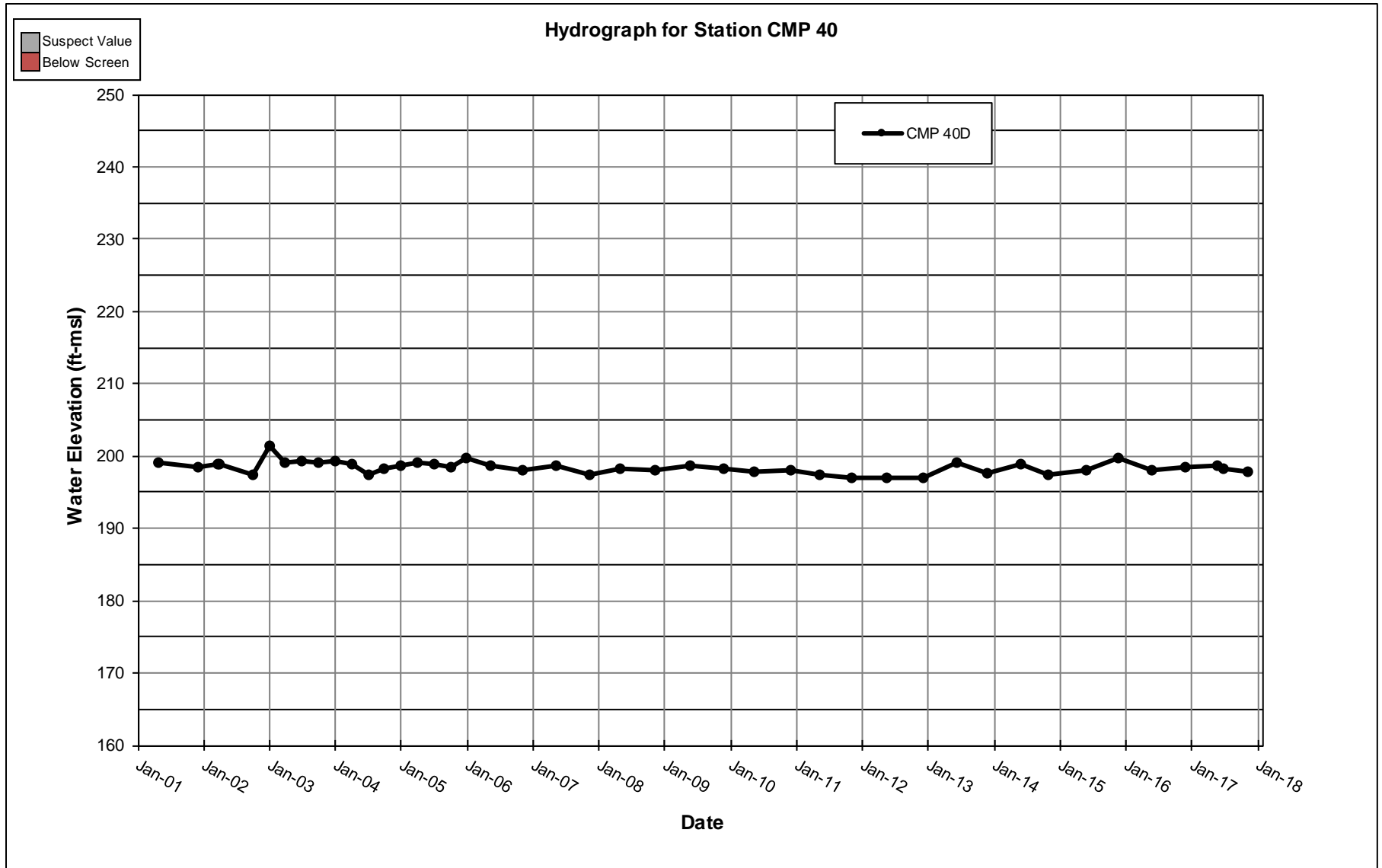


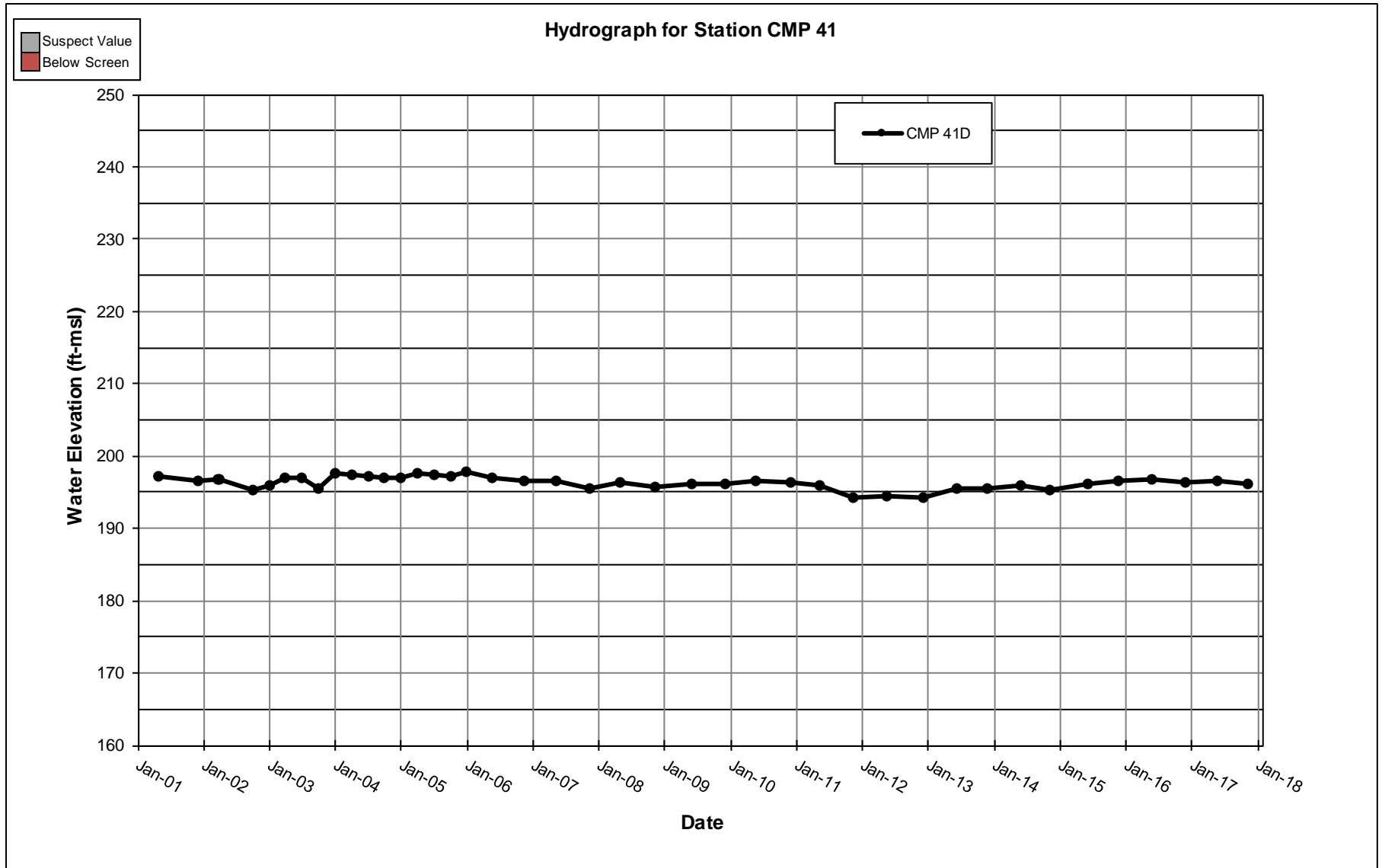


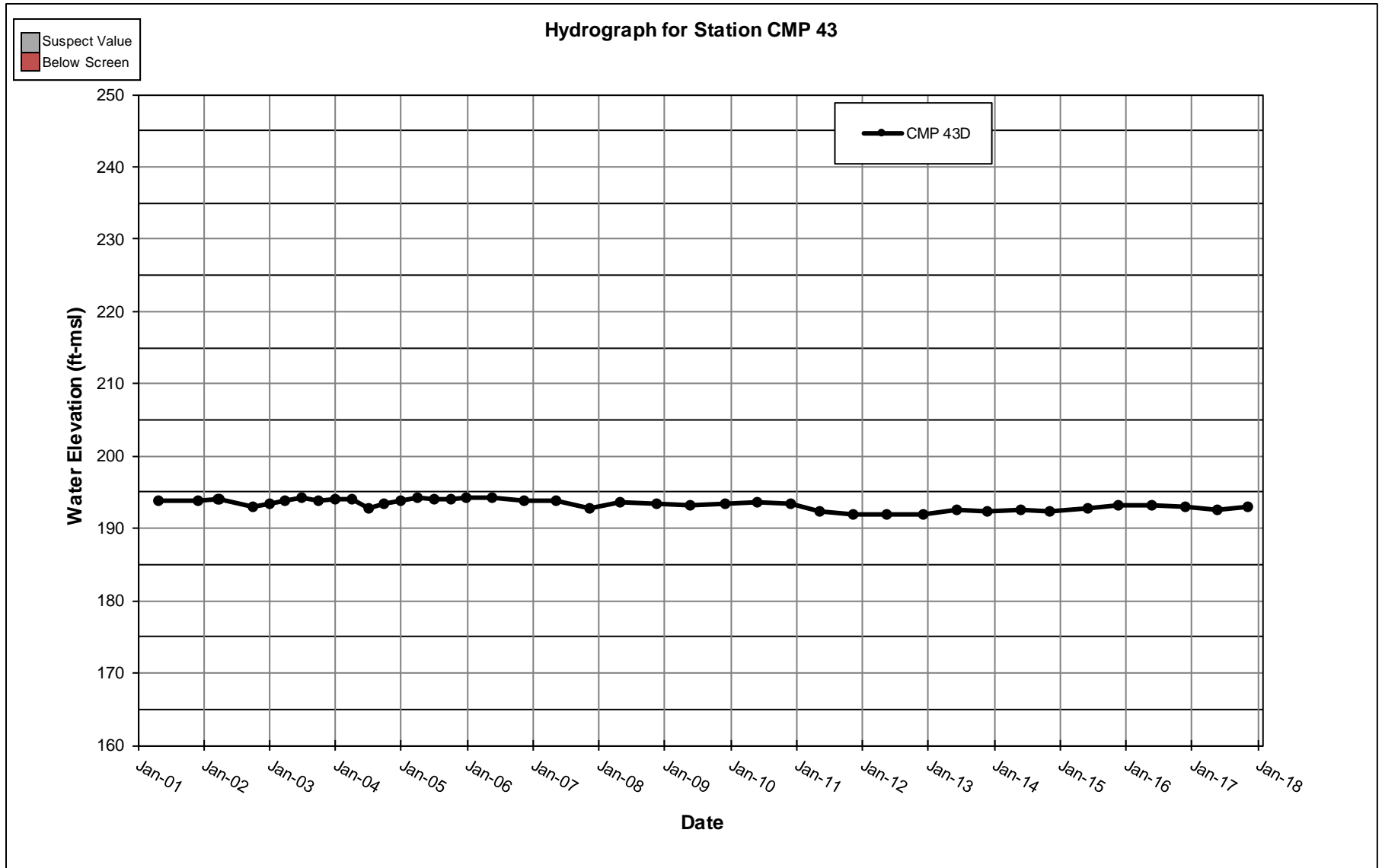


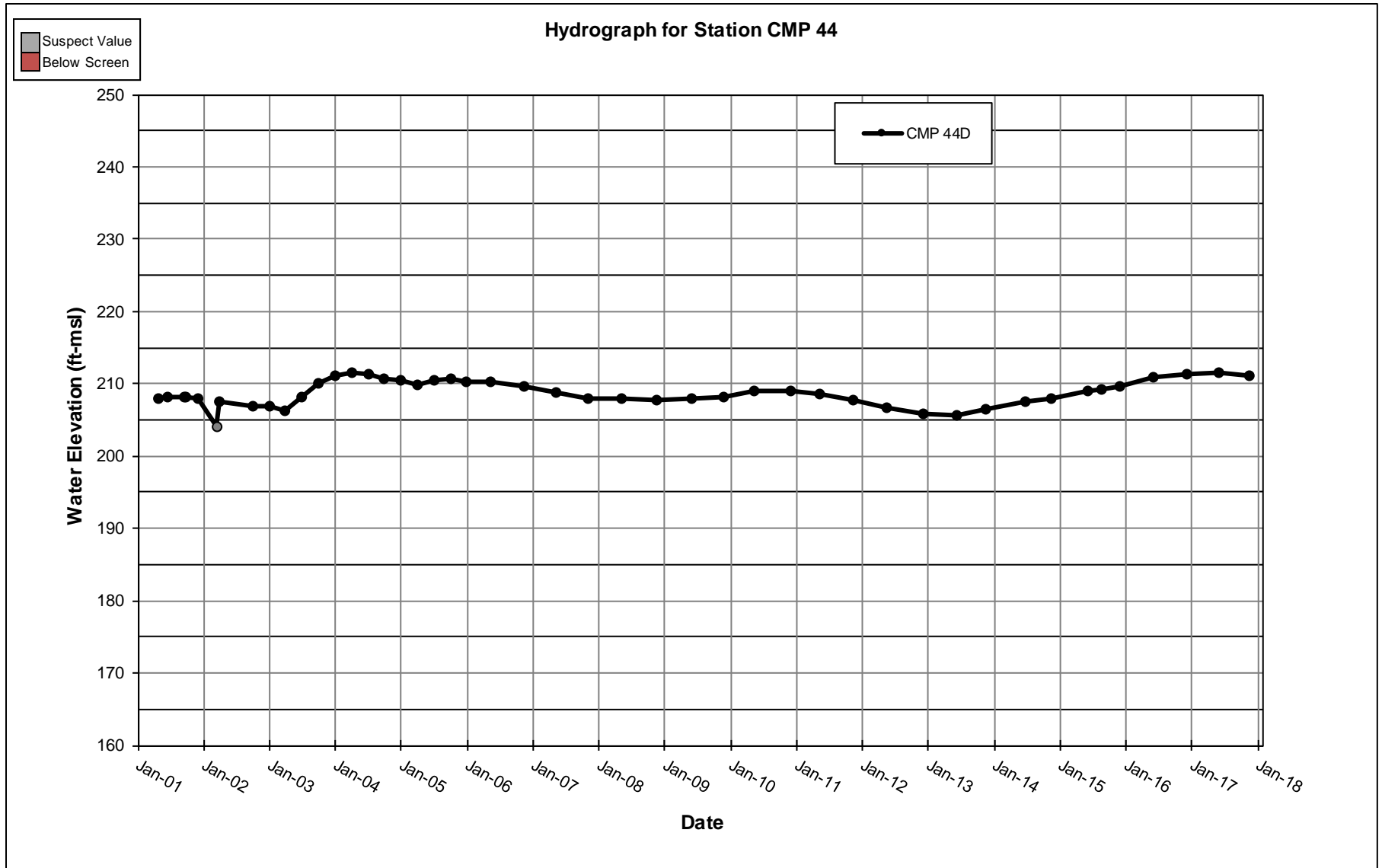


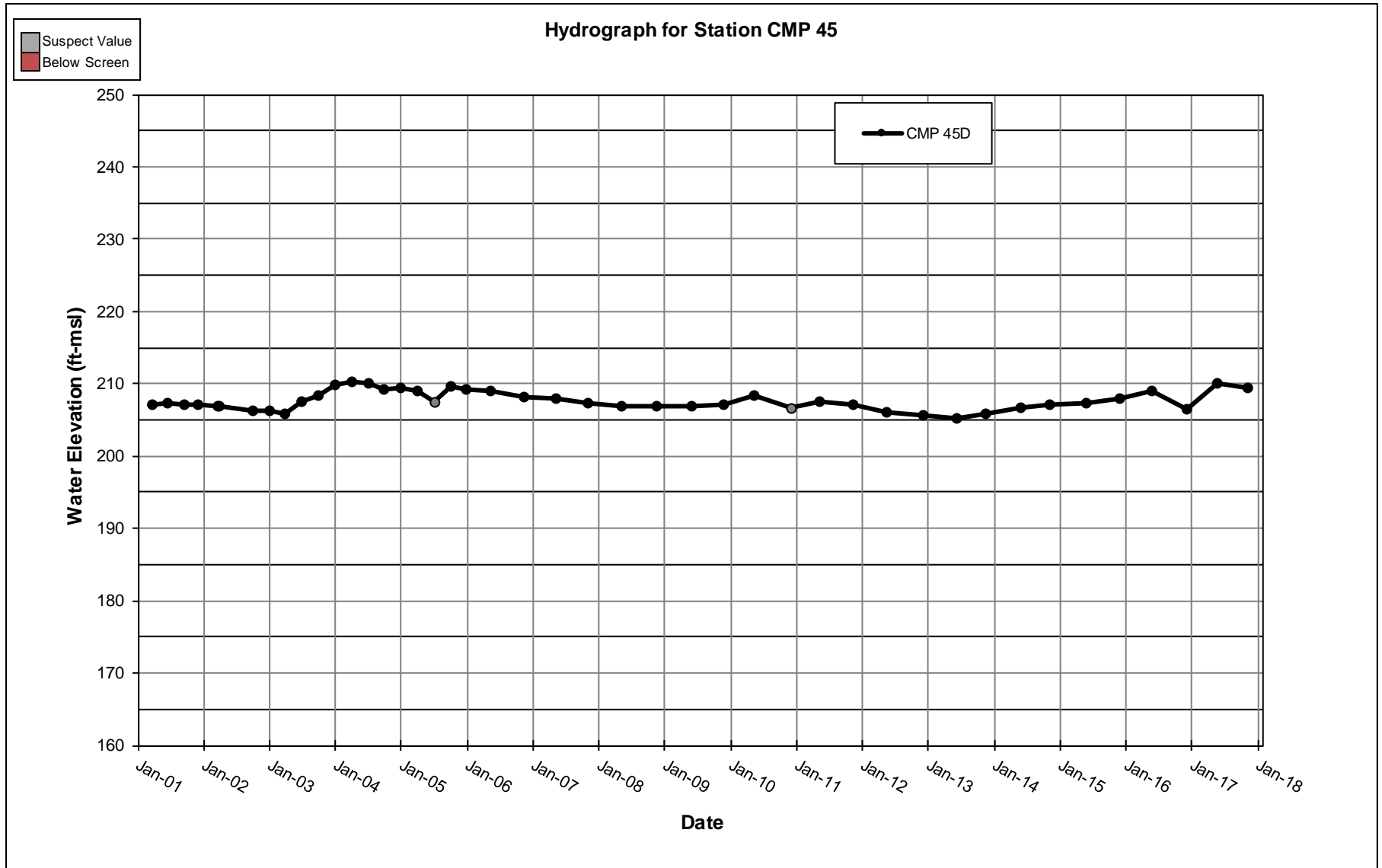


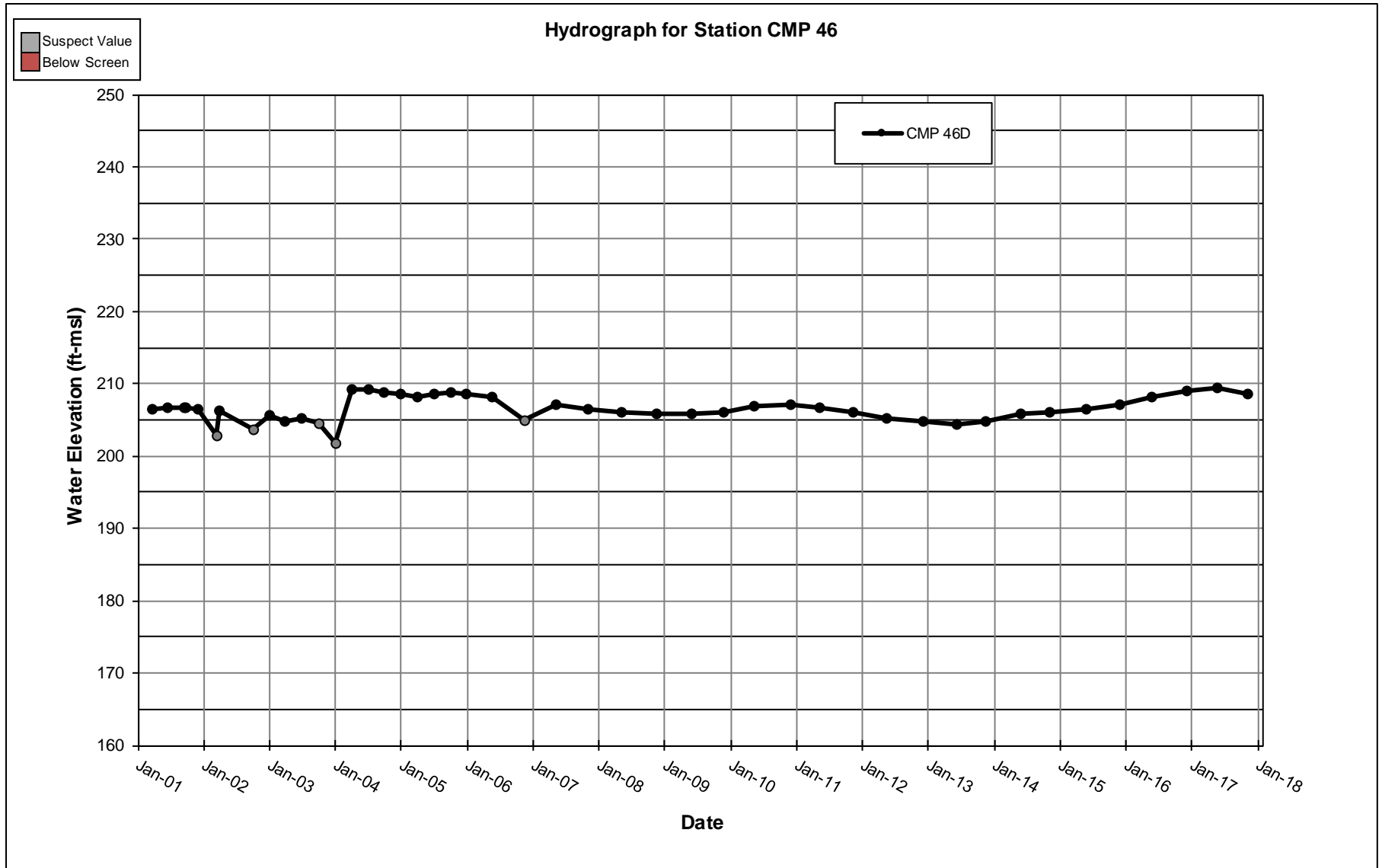


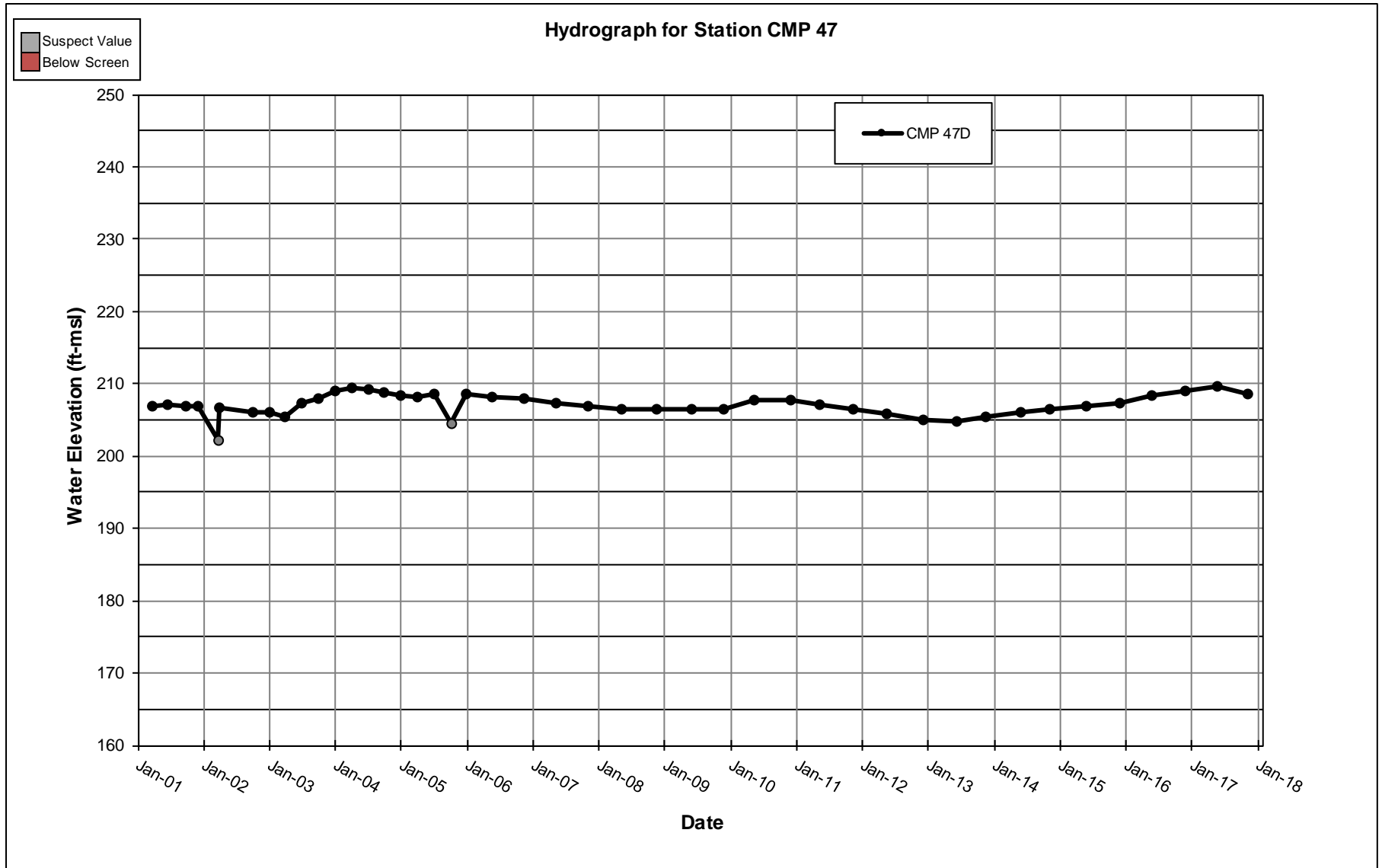


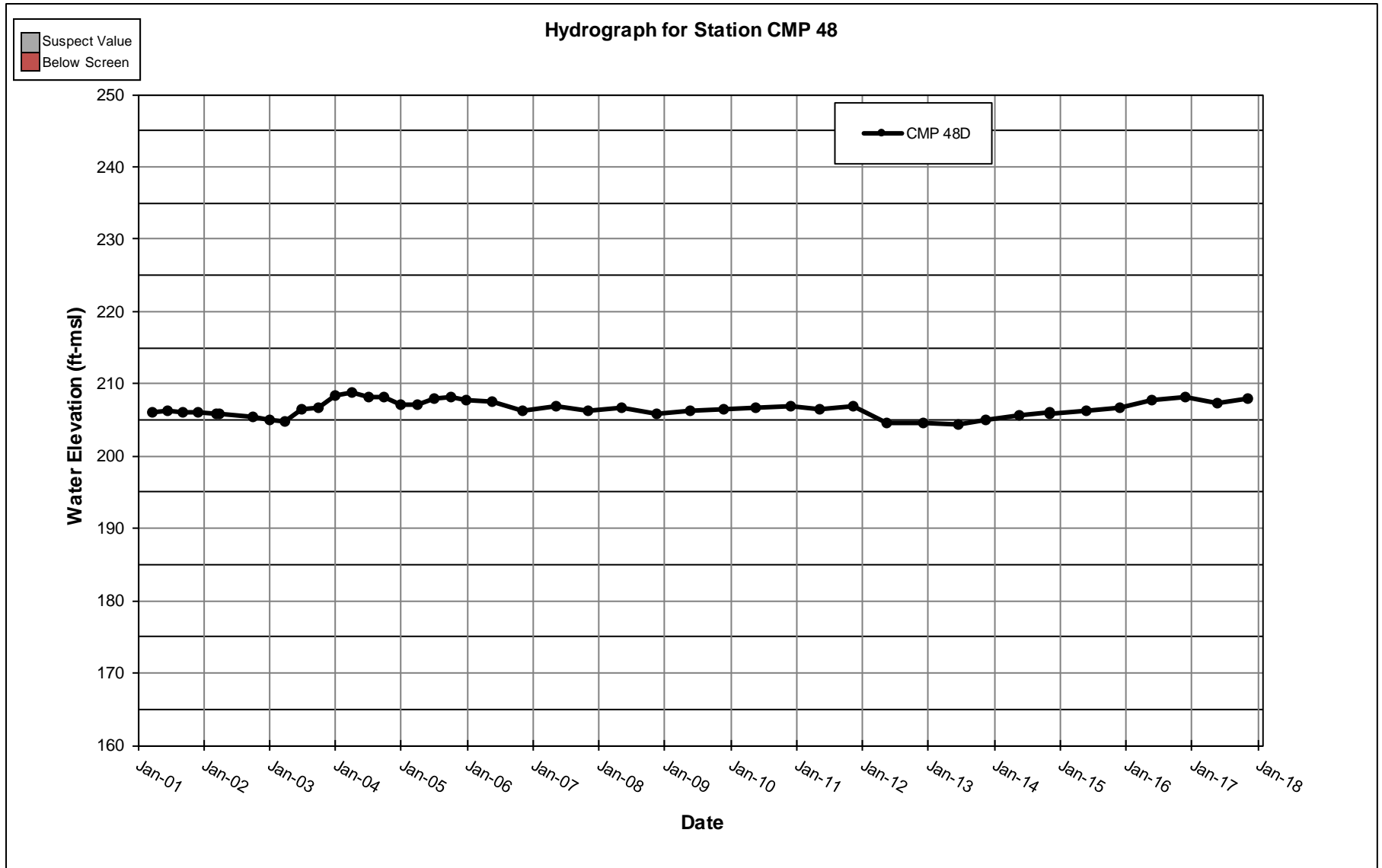


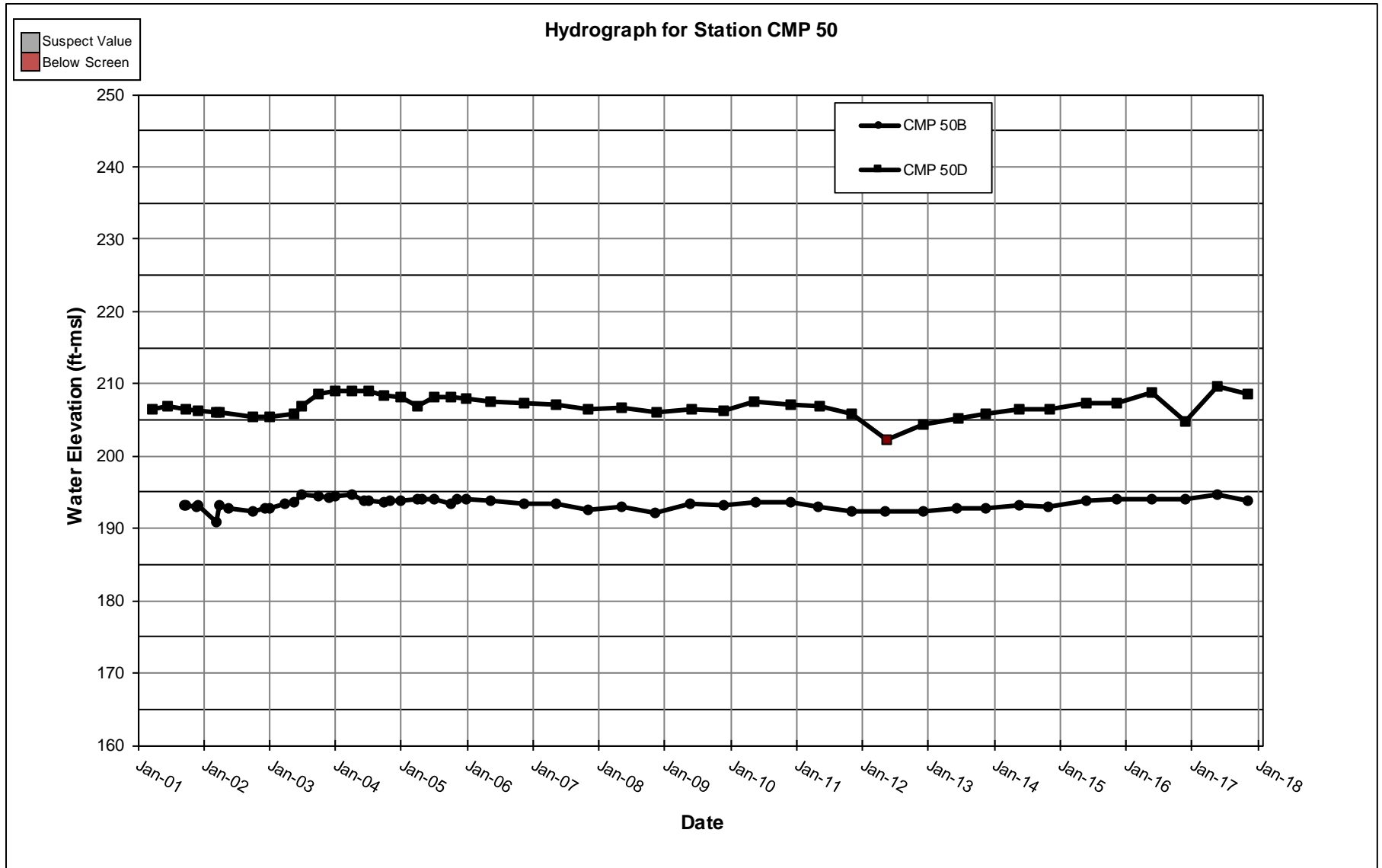


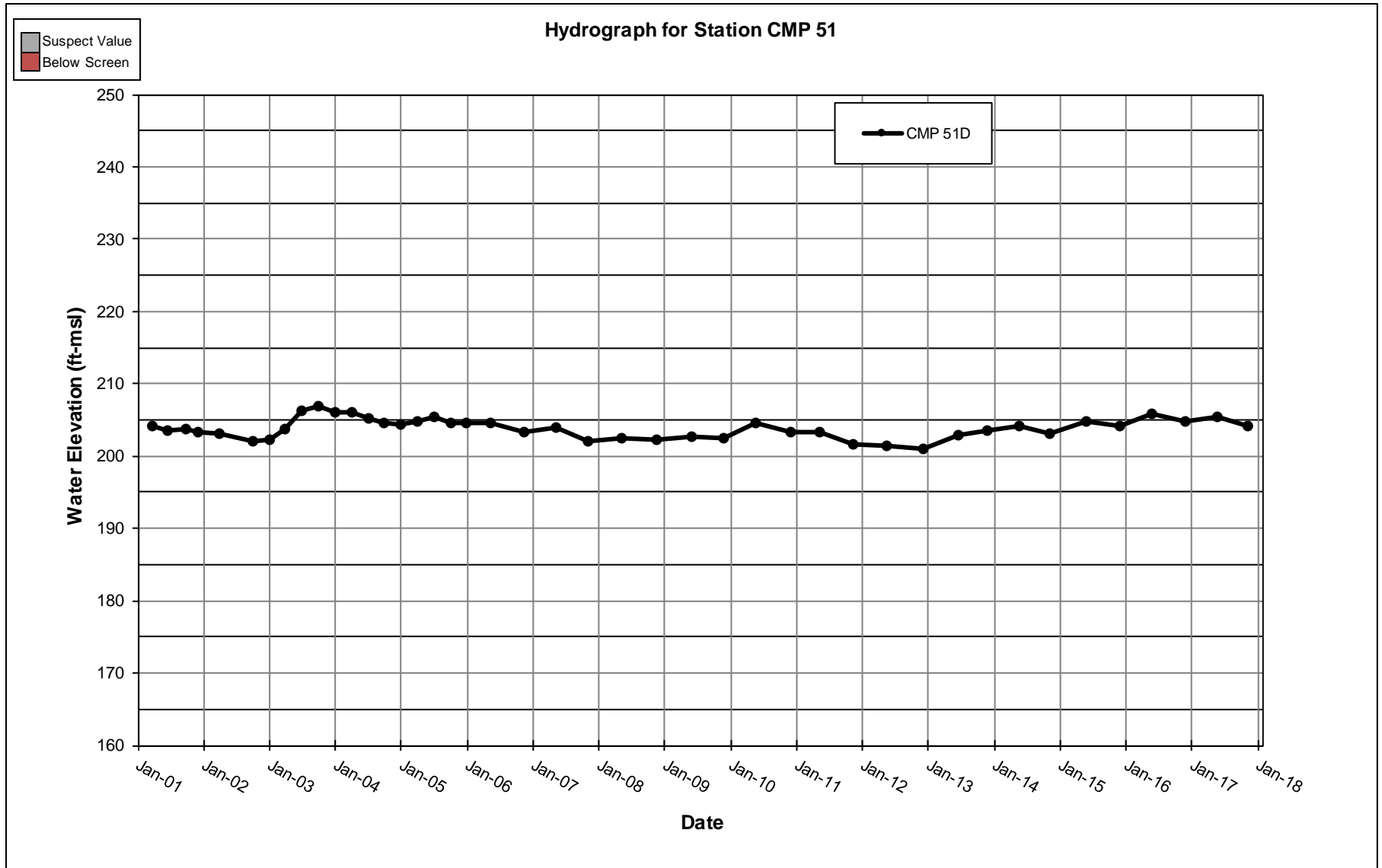


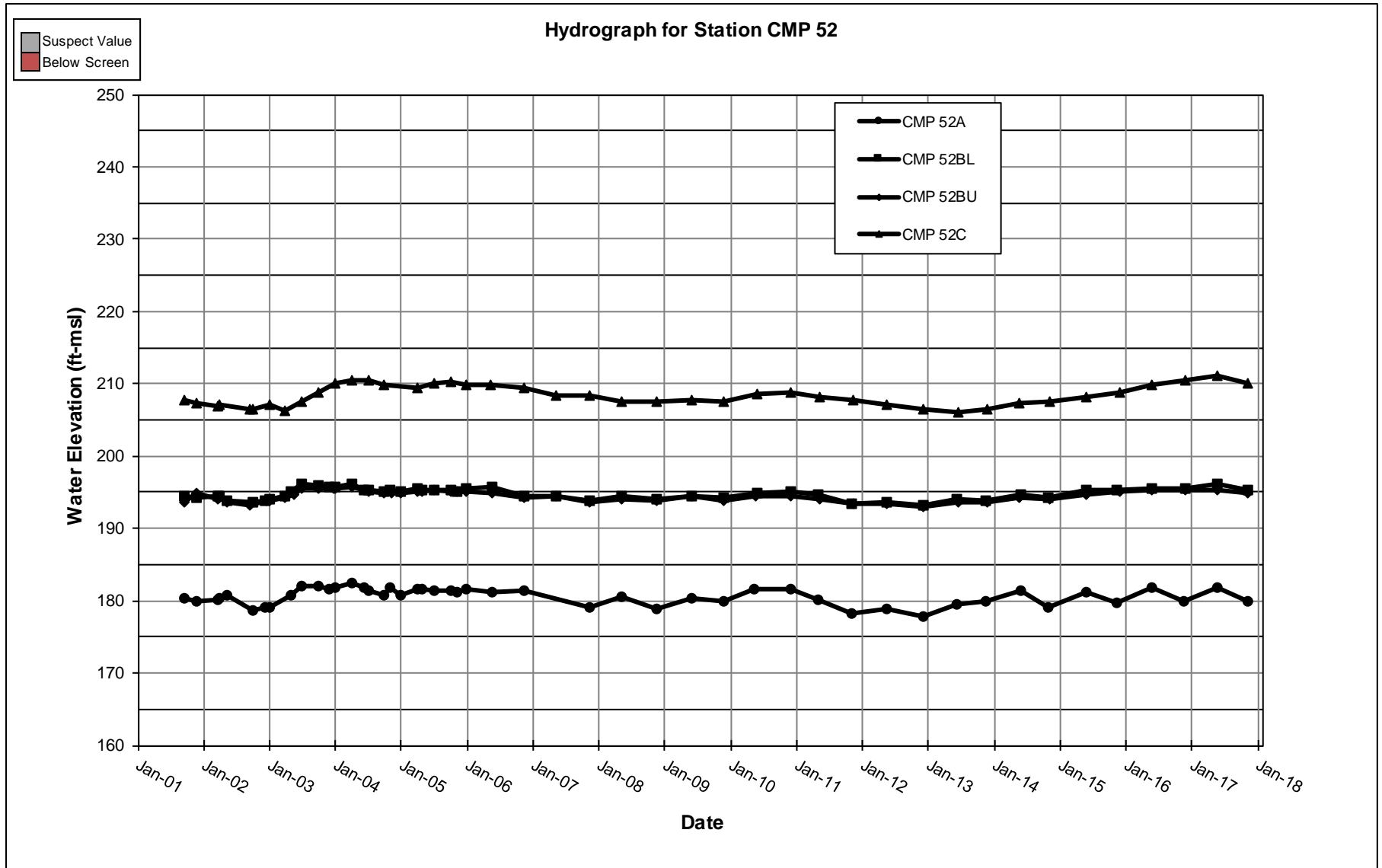


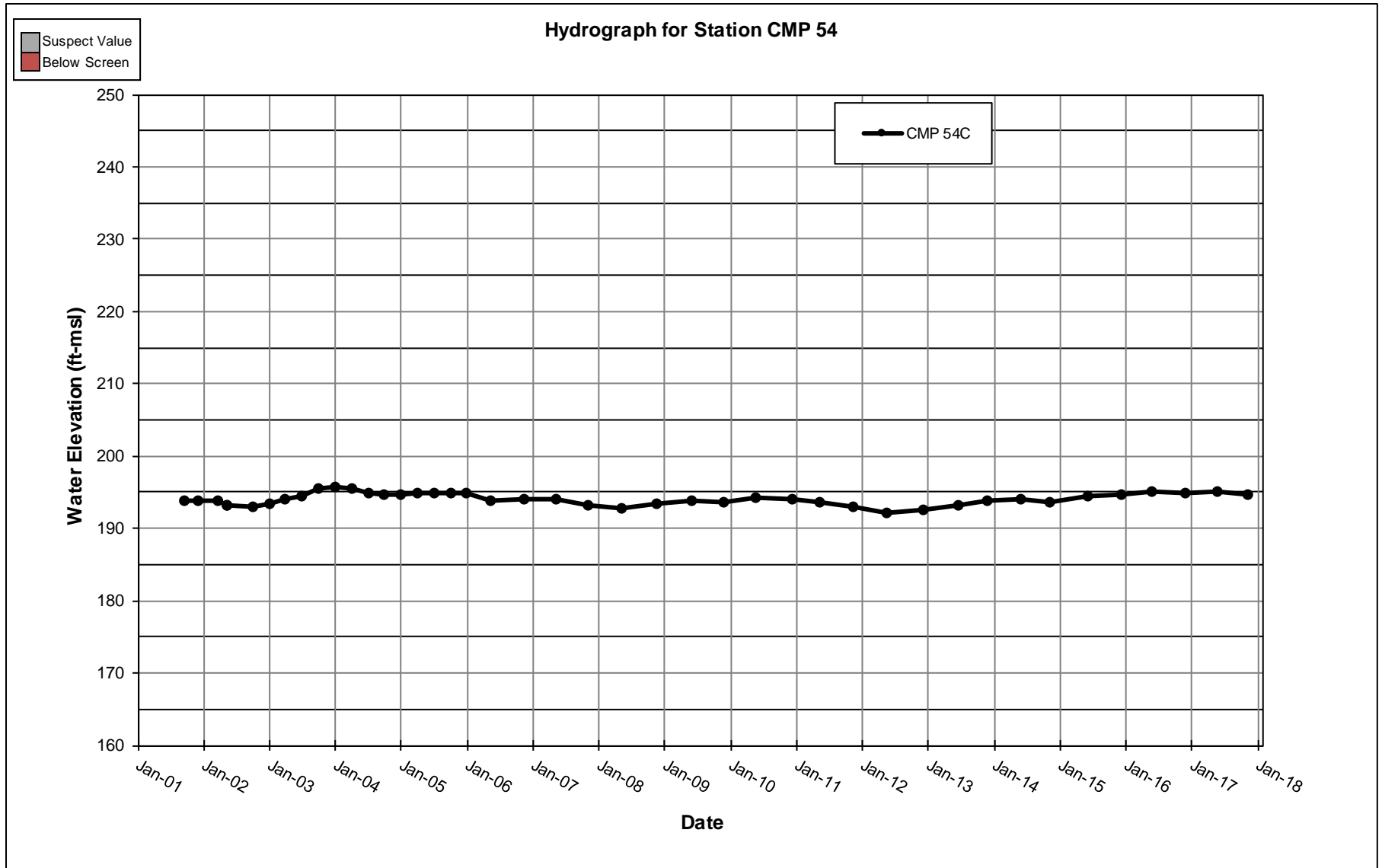


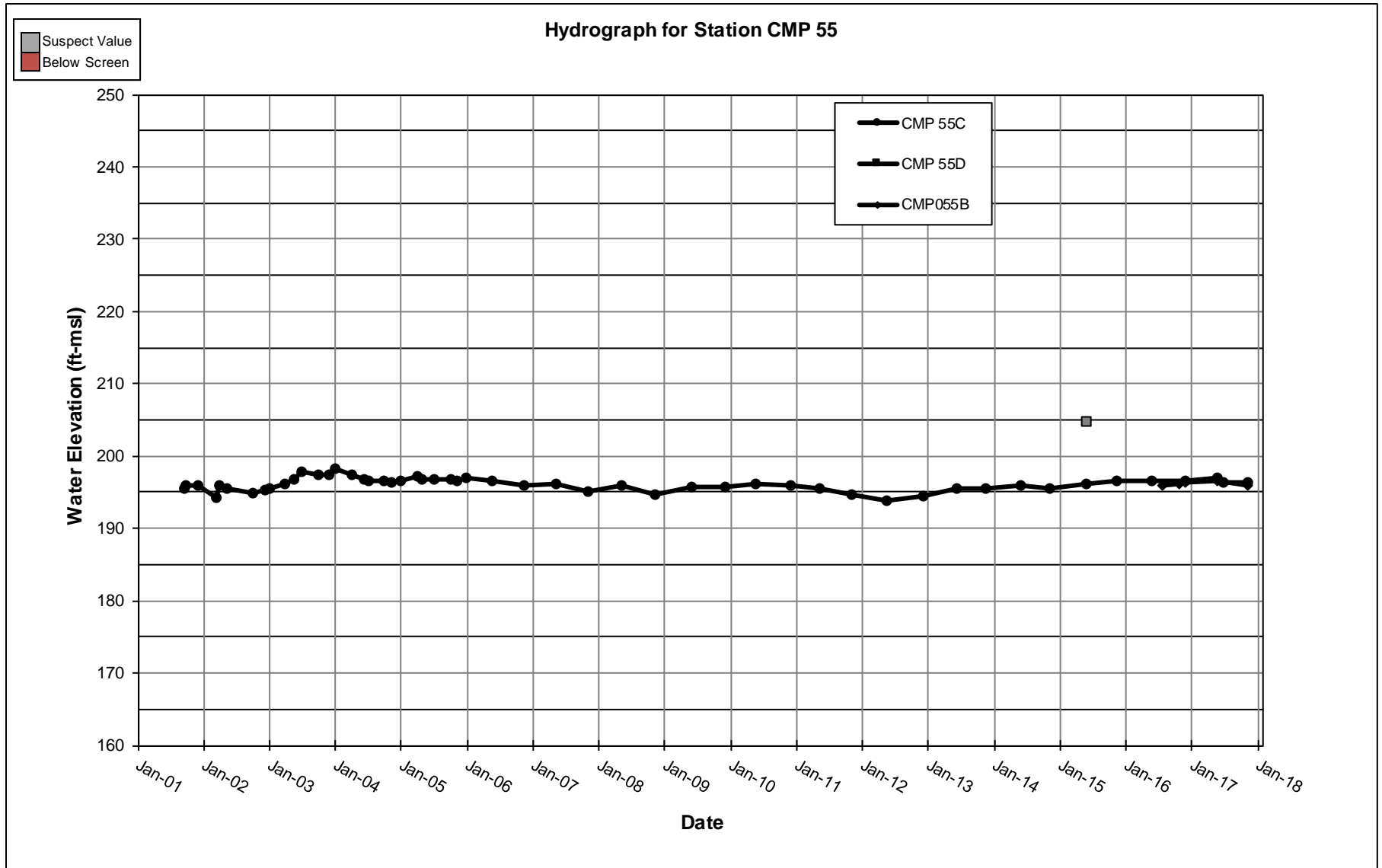


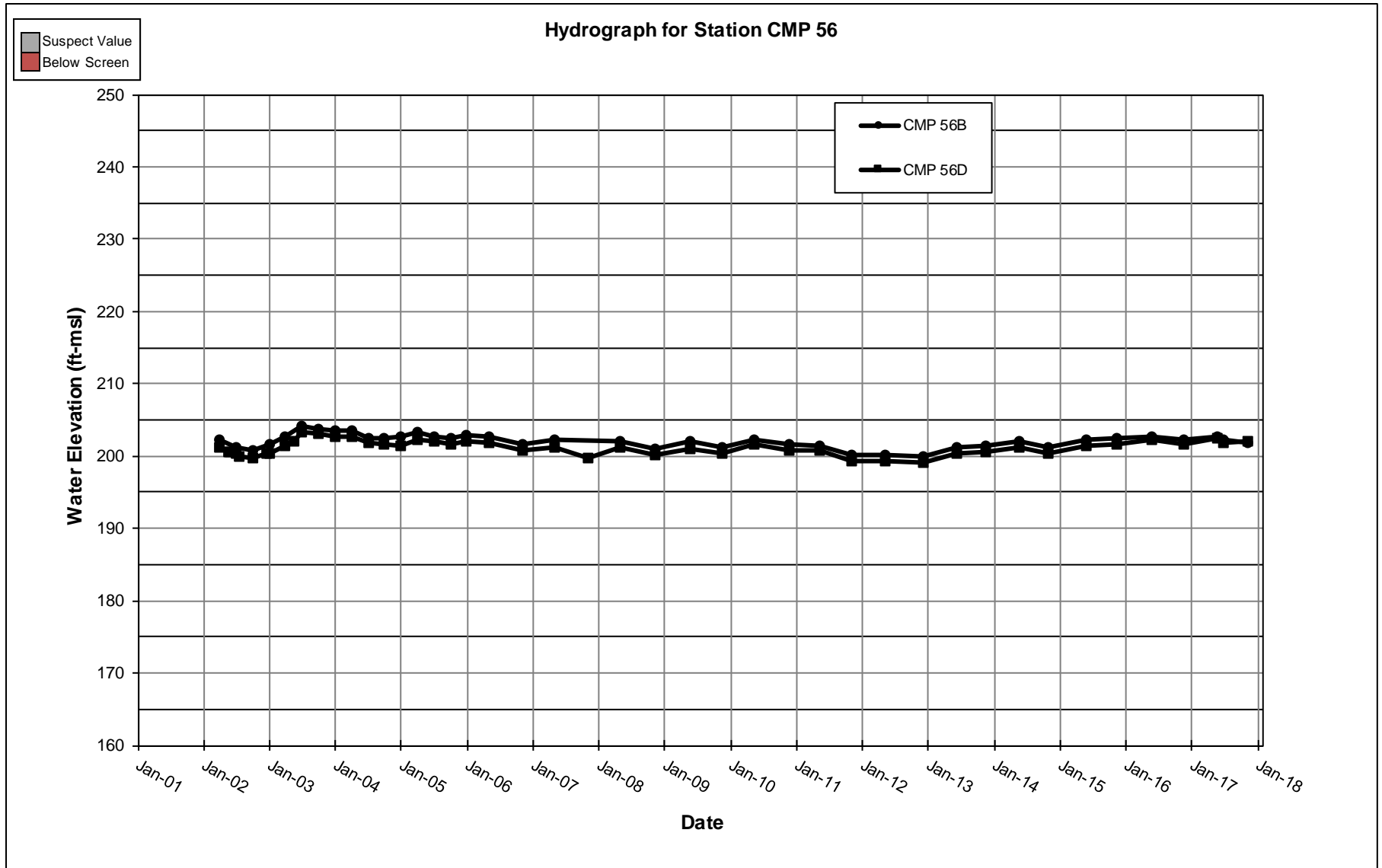


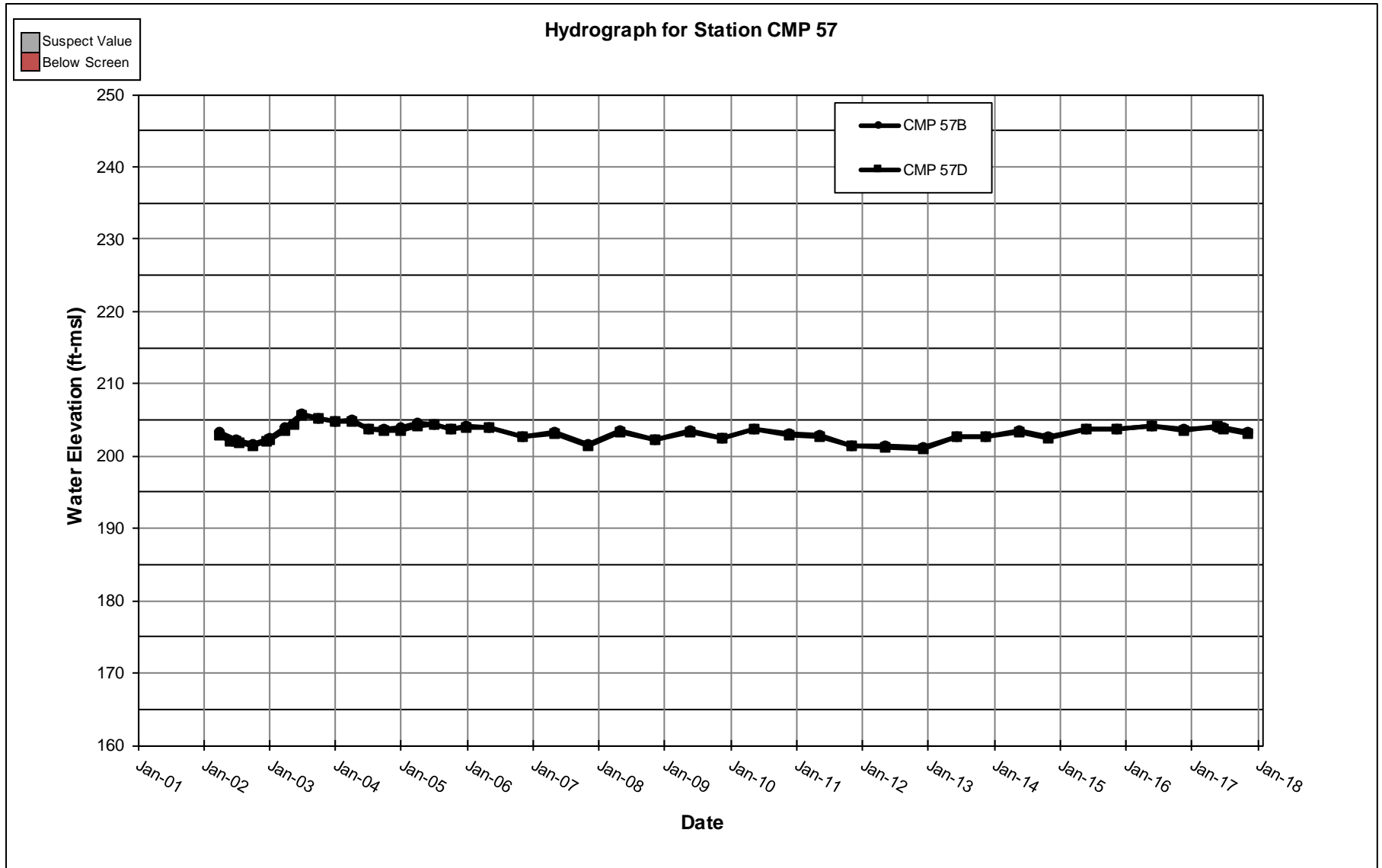


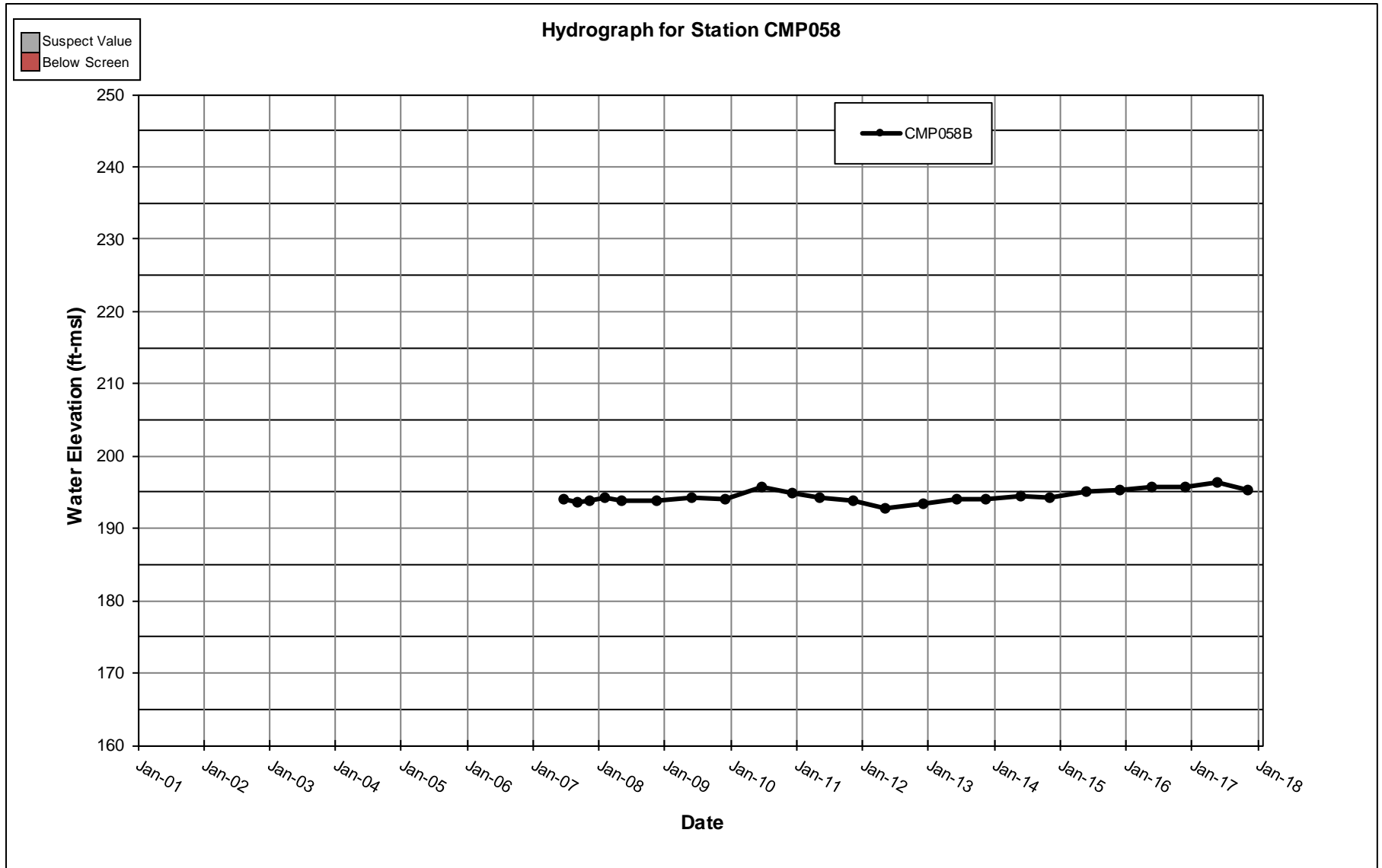


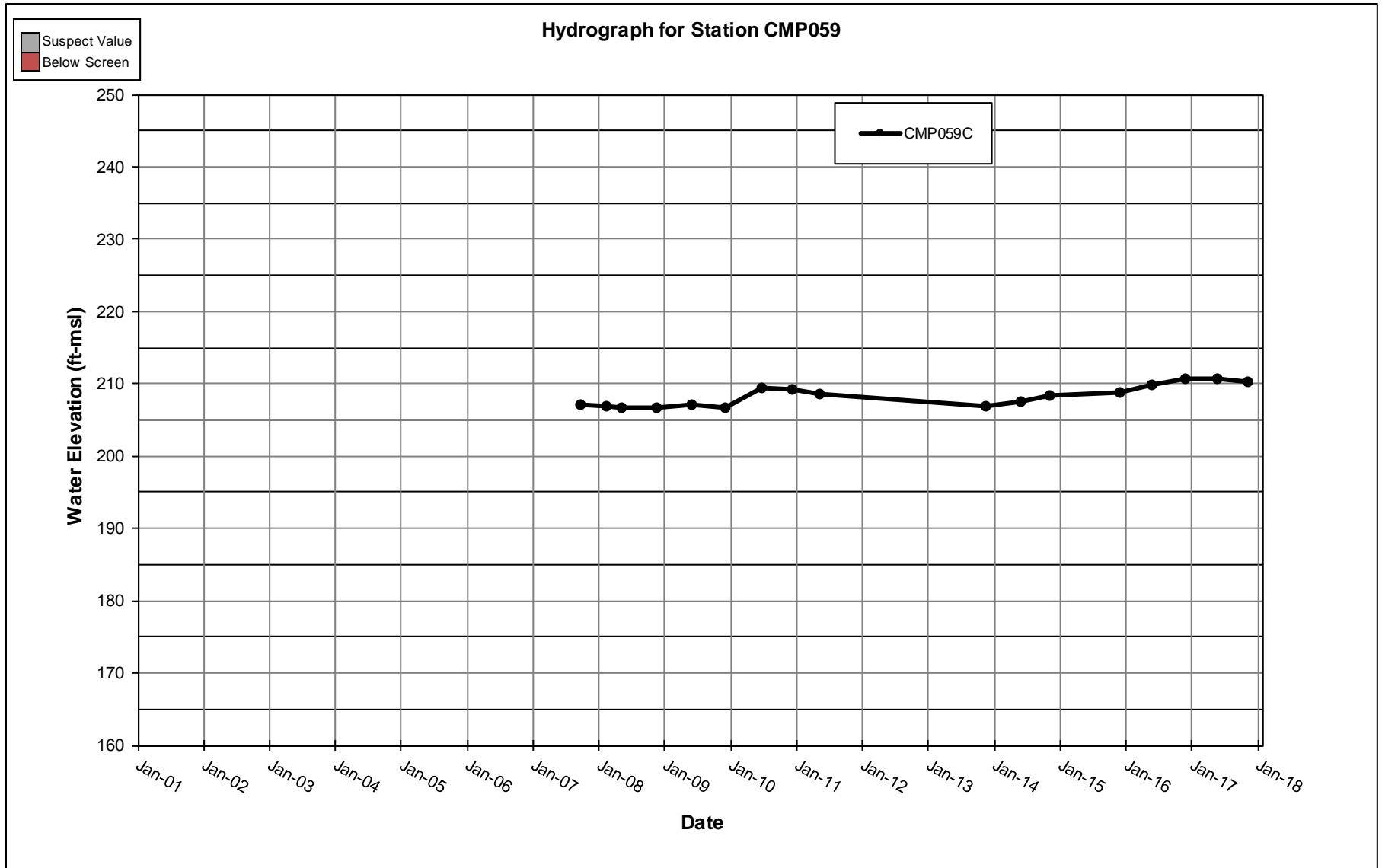


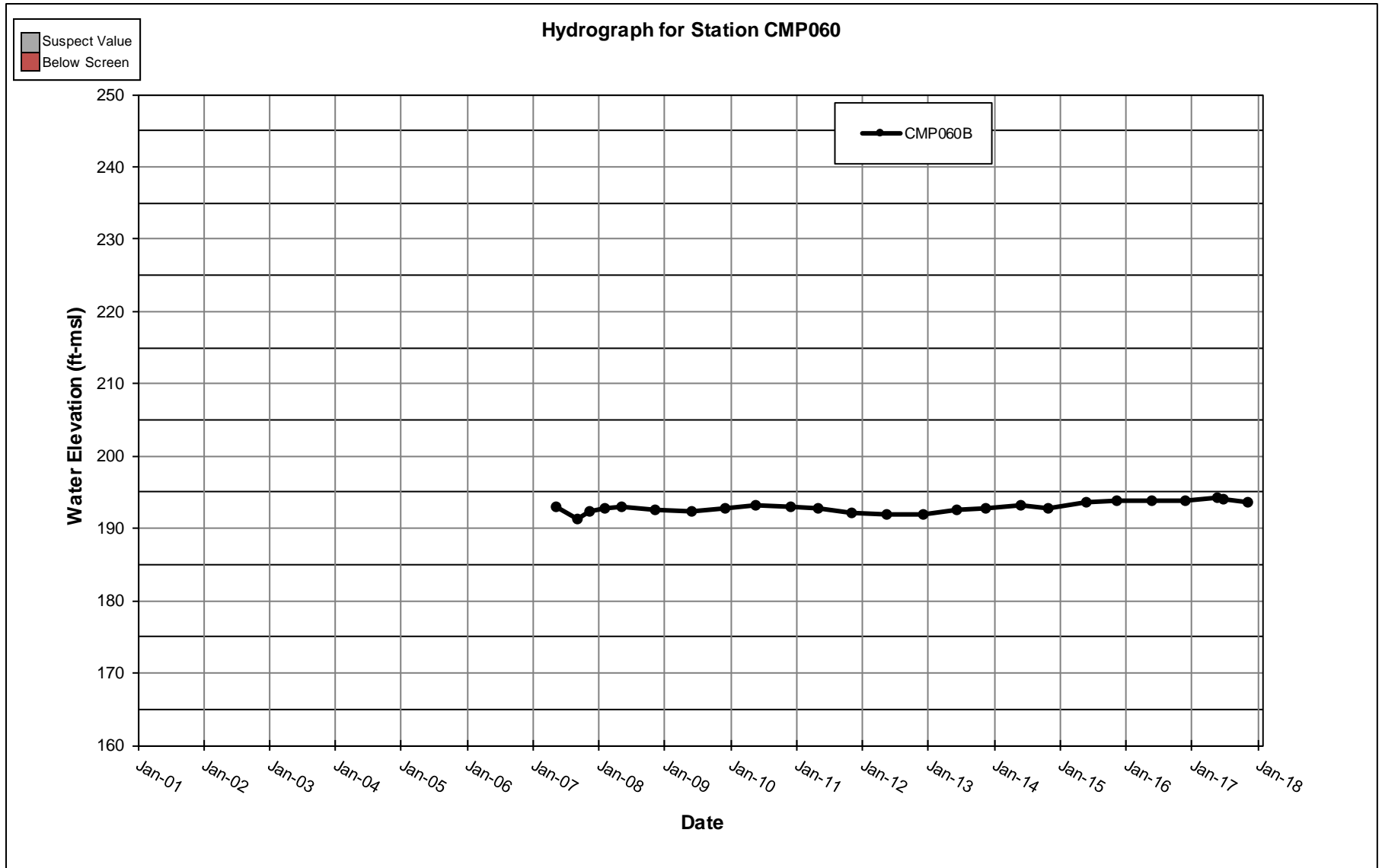


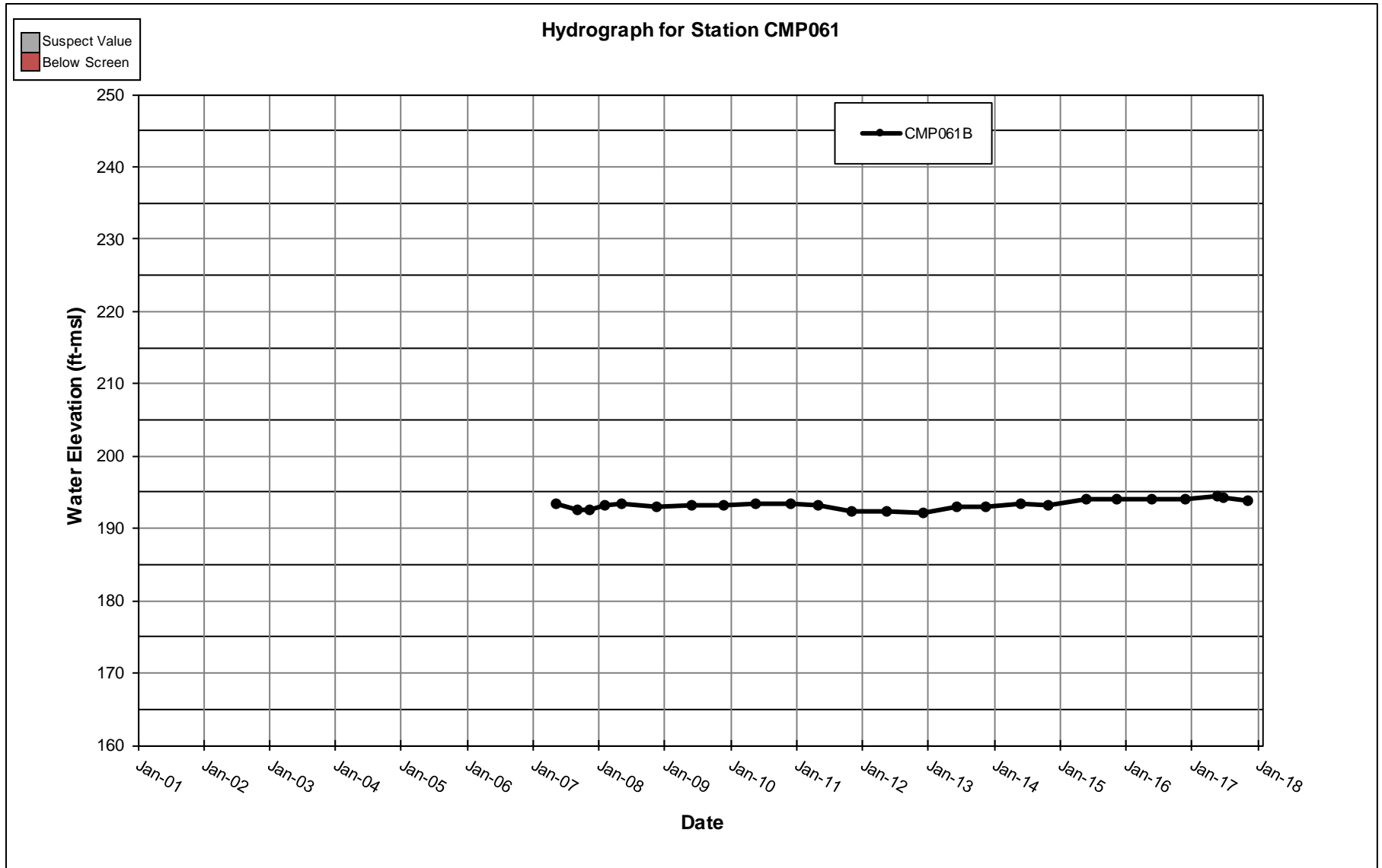


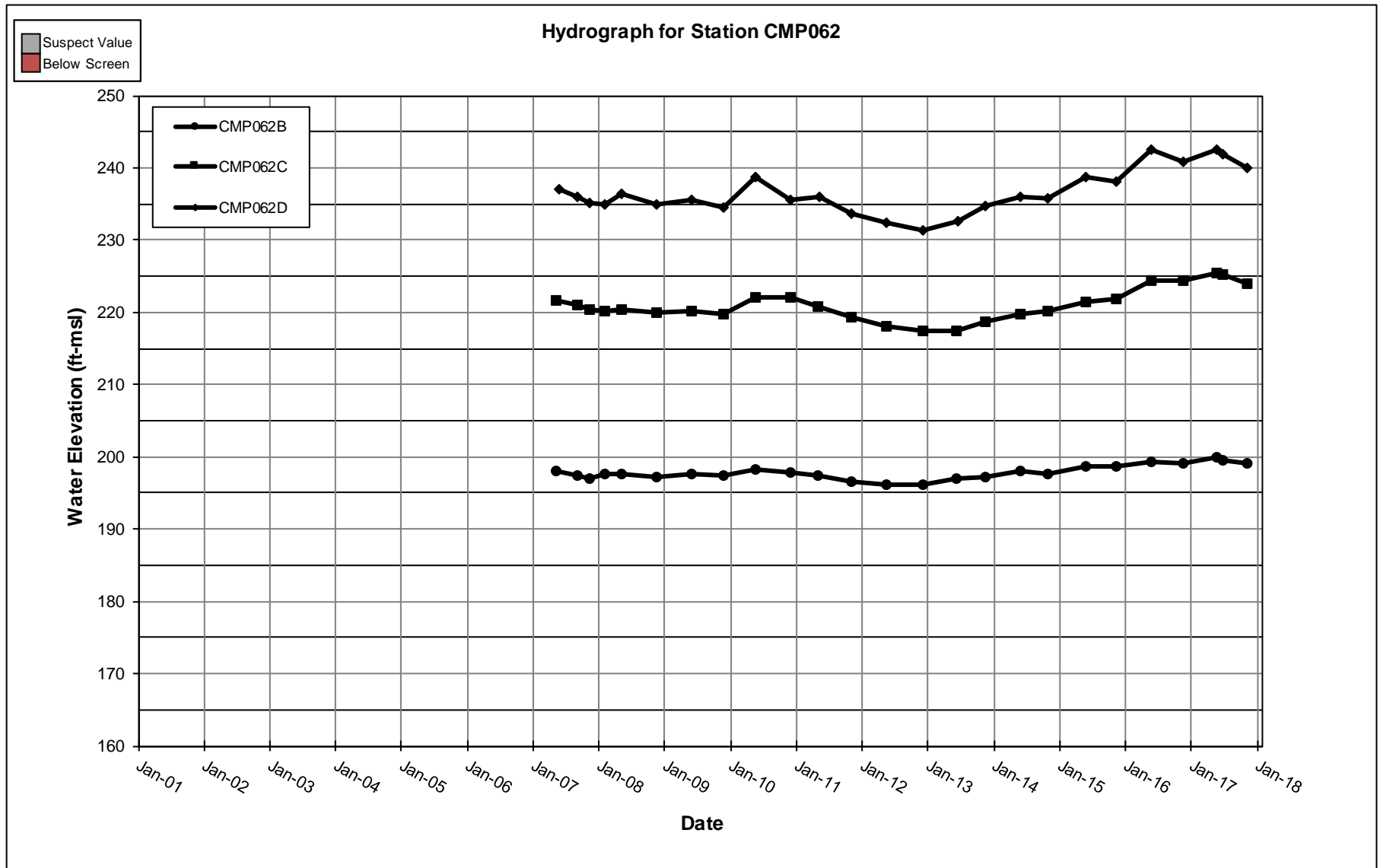


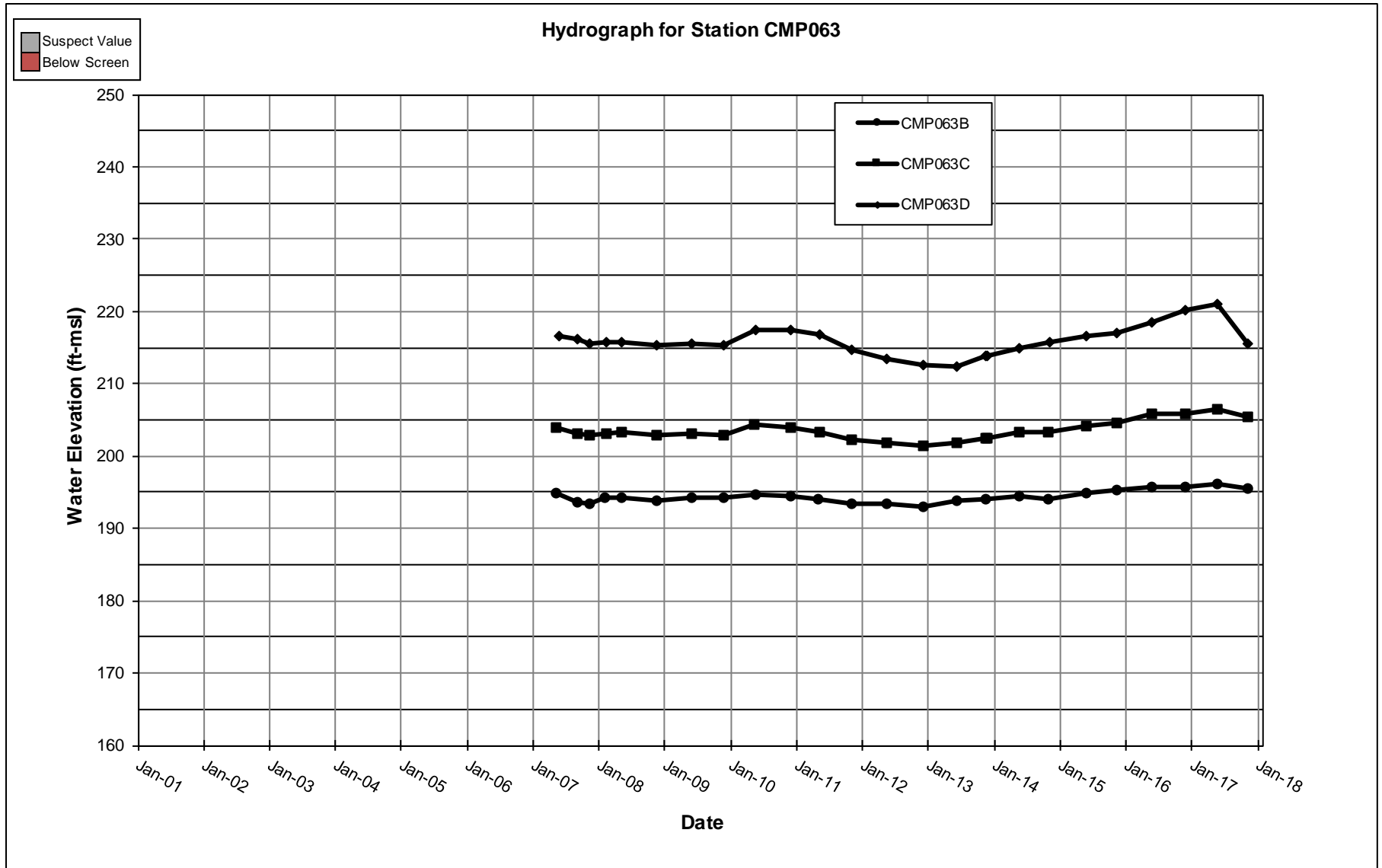


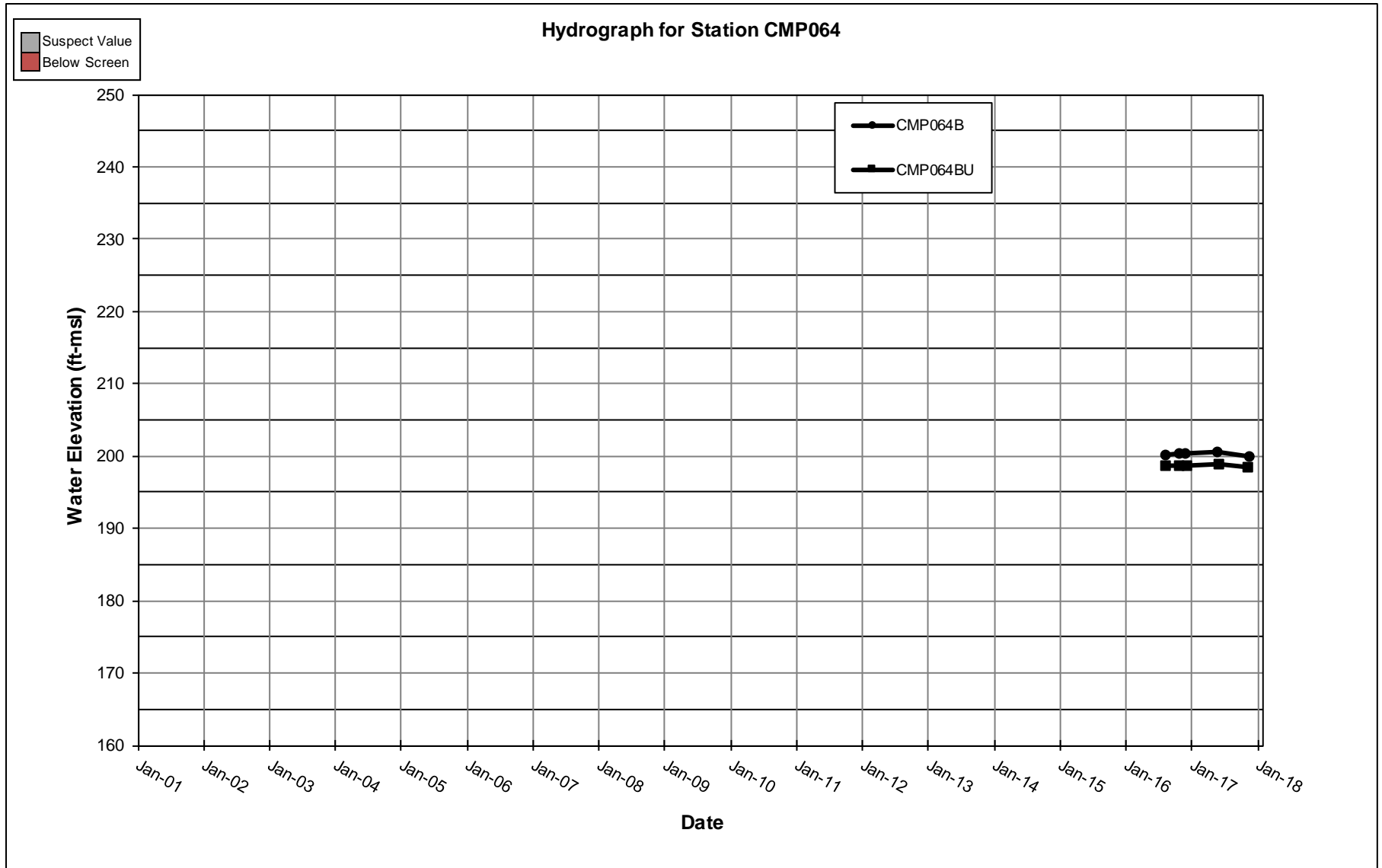


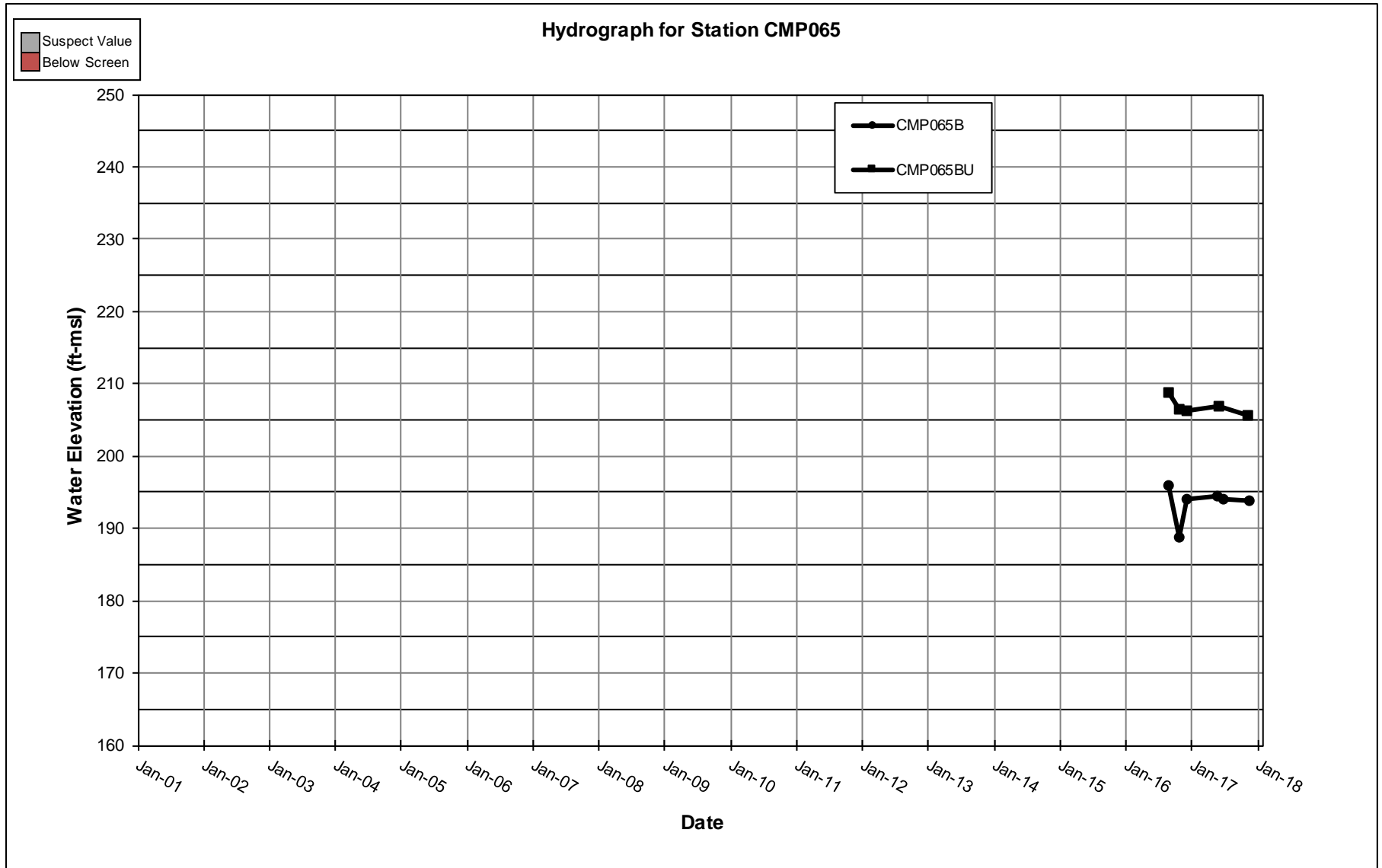


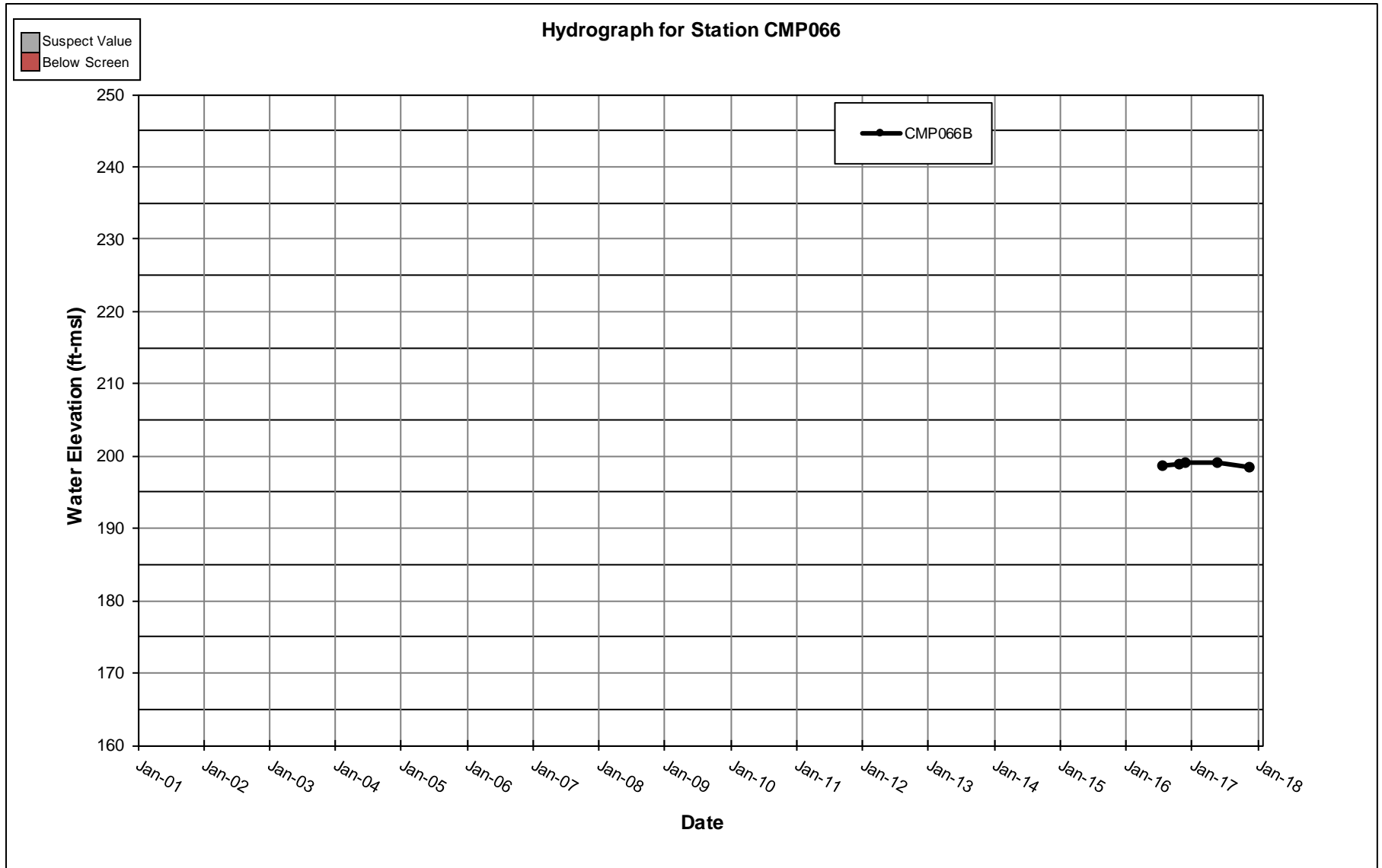


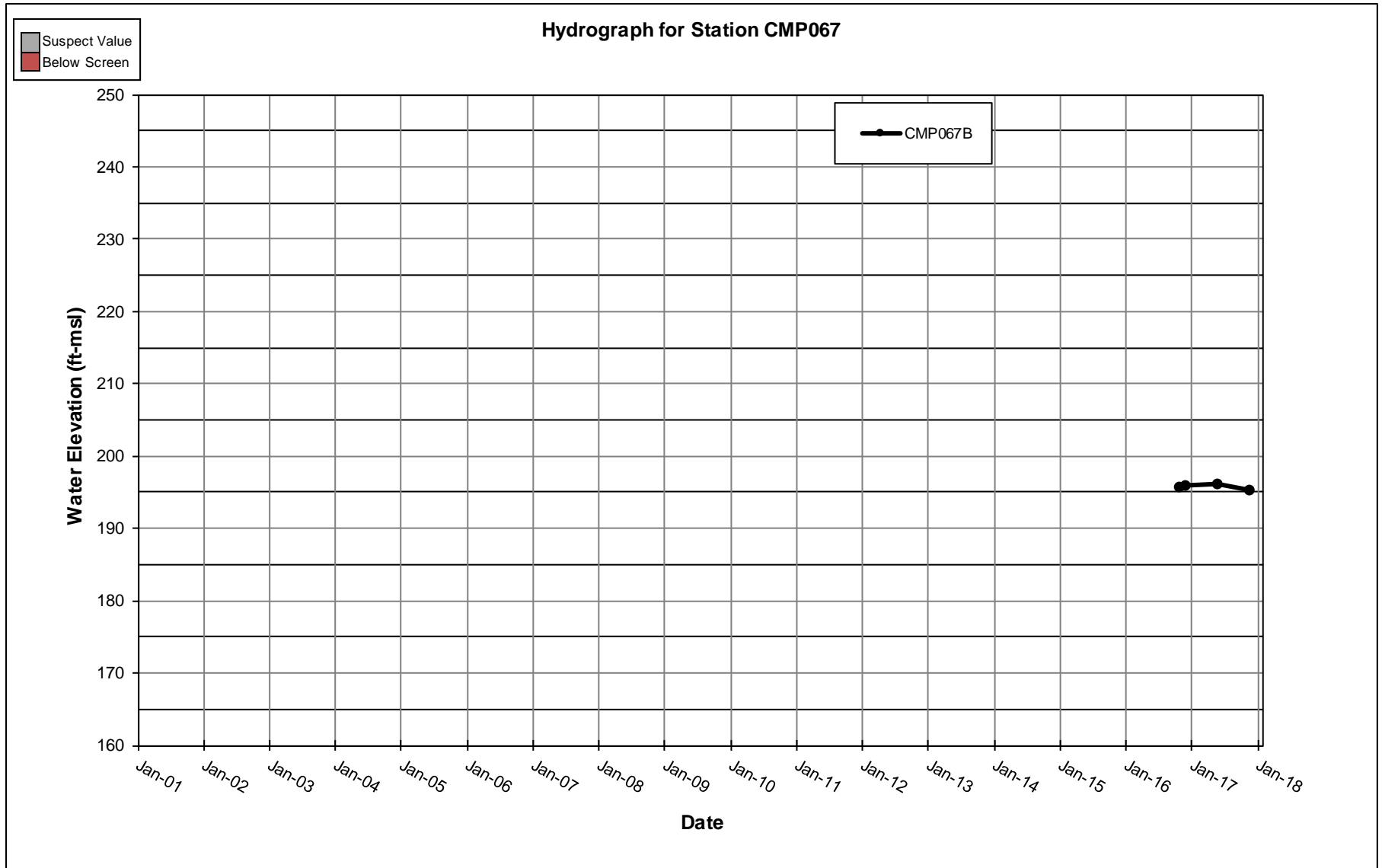












## Appendix B

### Time-Series Plots

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