ECF-HANFORD-20-0078
Revision 0

PREPARATION OF THE HANFORD SITE WATER TABLE MAP FOR JANUARY TO MARCH 2020

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

CH2MHILL
Plateau Remediation Company

P.O. Box 1600
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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APPROVED
By Lynn M. Ayers at 8:52 am, Jan 19, 2021

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ENVIRONMENTAL CALCULATION COVER PAGE (Continued)

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Terms

2D	two-dimensional
3D	three-dimensional
CHPRC	CH2M Hill Plateau Remediation Company
ECF	environmental calculation file
GIS	geographic information system
HEIS	Hanford Environmental Information System
HISI	Hanford Information System Inventory
HSU	Hydrostratigraphic Unit
MODFLOW-USG	unstructured version of modular finite-difference flow model
P&T	pump and treat
PLROC	parameter list processor
SME	subject matter expert
TRIM	Tikhonov Regularized Inverse Method
USGS	United States Geological Survey

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1 Purpose

This environmental calculation file (ECF) describes the methodology and data used to prepare the 2020 Hanford Site water table map. Water table maps are prepared annually for the Hanford Site and are used by researchers, the regulatory agencies, and stakeholders for many purposes, including the following:

- Determining groundwater flow directions and flow rates
- Identifying recharge and discharge areas
- Determining the interaction between groundwater and surface water bodies
- Calibrating groundwater flow models
- Assessing the impact of liquid effluent disposal practices on groundwater flow
- Assessing the impact of groundwater pump-and-treat operations on localized groundwater flow patterns
- Assessing the effect of water-level and flow-direction changes on the suitability of well networks used for groundwater quality sampling

2 Background

SGW-38815, *Water-Level Monitoring Plan for the Hanford Site Soil and Groundwater Remediation Project*, describes the program for collecting manual water-level measurements at the Hanford Site. During March of each year, a comprehensive set of manual water-level measurements is collected from multiple aquifer systems throughout the Hanford Site. These measurements are collected in March because the stage of the Columbia River is typically near its annual average level, and aquifer water levels near the river are believed to be the most representative of annual average flow conditions. Additional measurements are collected at some sites along the river during high- and low-stage conditions as needed, but these measurements are not the subject of this ECF.

In 2020, the annual March campaign was interrupted by a work stoppage related to the coronavirus pandemic. March 2020 measurements were completed in wells along the River Corridor before the stoppage. For the rest of the Hanford Site, measurements were selected between January and February 2020. In a few areas, data were extrapolated based on previous trends. Section 4.2 provides additional detail in input data (water-level measurements and pumping rates).

The water-level measurements are stored in the HydroDat database, and SGW-38815 describes the process of collecting and verifying the data. Water-level measurements in HydroDat are available within the Hanford Environmental Information System (HEIS) database, which can be accessed using the Environmental Dashboard Application (http://environet.hanford.gov/eda/).

3 Methodology

This chapter describes the Tikhonov Regularized Inverse Method (TRIM) that was used to produce continuous gridded depictions of groundwater elevations encompassing the Hanford Site.

3.1 Method Description

TRIM is a formal mathematical technique that is used to trade the complexity of a calculation method or parameterization that is being used to analyze measured data against the “fit” obtained to those data

(Tikhonov and Arsenin, 1977, *Solutions of Ill-Posed Problems*). When the method is used with an underlying deterministic model, Tikhonov regularization is used to constrain the parameters of the model while attempting to attain a satisfactory fit to measured data that also comports with independent or subject matter expert (SME) knowledge and information.

Development of a piecewise, continuous grid of groundwater elevations is accomplished by the following:

- Developing a single-layer (i.e., two-dimensional [2D]) steady-state simulation of dominant groundwater flow characteristics over the entire Hanford Site, and
- Using Tikhonov regularization to constrain parameter complexity to prevent over-fitting to the measured water-level data

The TRIM implements a common application of Tikhonov regularization, by supplementing the measurement dataset (in this case, sitewide water-level measurements in first quarter of 2020) with other information derived from SME knowledge. This knowledge is cast as "prior information" representing an anticipated system condition (e.g., understanding the distribution and variability of hydraulic conductivity). The addition of this information results in a mathematical technique referred to as penalized-least-squares regression, because a penalty is incurred when the parameters deviate too far from the anticipated system condition specified by the SME. The size of the penalty incurred during the regression is controlled using a weight parameter, referred to as the global regularization weight parameter and commonly denoted by μ (Doherty, 2015, *Calibration and Uncertainty Analysis for Complex Environmental Models, PEST: Complete Theory and What it Means for Modelling in the Real World*). The size of this penalty is "traded" against the degree to which the simulation matches the measurement data: to attain a better fit to the measurement data, a larger penalty is usually incurred by deviating farther from the anticipated system condition.

This method of specifying the anticipated system condition is most commonly specified as either (a) a "preferred-value" (it is desired that the best fit to the data be attained while parameter values are close to a specified value) or (b) a "preferred-difference" condition (it is desired that the best fit to the data be obtained while parameter values show minimal difference between each other).

The "preferred-difference" approach, also referred to as "smoothness" regularization, is used in cases where the regression should seek as good a fit as can be obtained while keeping parameters as homogeneous as possible. In the context of the groundwater-level data analysis in this ECF, particularly for sedimentary aquifer materials such as those encountered in the Hanford unconfined aquifer, the system condition is typically presumed to be homogeneous and therefore suitable for the "preferred-difference" approach.

3.2 Limitations

The simplified 2D groundwater flow simulator that underlies TRIM, developed using the MODFLOW-USG code (unstructured version of modular finite-difference flow model; Panday et al., 2013, "MODFLOW-USG Version 1: An Unstructured Grid Version of MODFLOW for Simulating Groundwater Flow and Tightly Coupled Processes Using a Control Volume Finite-Difference Formulation"), was applied to match groundwater-level data and obtain water-table contours based on those data. The groundwater-elevation contours are obtained by trading off the complexity of the parameterization of the groundwater simulator versus the fit to the measured data. The simplified groundwater simulator is used as an alternative to distance-weighted interpolation methods (such as kriging) to interpolate between the measured data because the simulator can incorporate the effects of

large-scale trends in the hydraulic conductivity. Because the resulting piecewise-continuous groundwater elevation grids depict hydraulic gradients that comport with SME knowledge of subsurface conditions, they are suitable for particle-tracking analyses to estimate rates and directions of groundwater flow and potential contaminant migration. However, the simplified 2D groundwater flow simulation that underlies TRIM is not a substitute for existing three-dimensional (3D) groundwater flow and contaminant transport models at the Hanford Site, such as the Plateau to River model (P2R Model). There are many simplifications in the underlying groundwater flow simulator developed for the TRIM analyses in this ECF. These simplifications include use of a single layer representing only water table conditions; the regularization objective sought in TRIM of homogeneity without specific regard for the values or physical meaning of the resulting parameters; and the simplified representation of the lateral boundaries of the area of interest. Because of these and other simplifications and limitations, the TRIM method is intended only support the development of sitewide maps of water levels from the measured water-level data, and the simplified MODFLOW-USG simulation underlying TRIM should not be used as an alternative to the existing 3D groundwater flow and contaminant transport models.

4 Assumptions and Inputs

This chapter discusses assumptions and input data used for the groundwater flow analysis and groundwater elevation mapping.

4.1 Assumptions

Water-level contour maps were constructed using a method that combines the use of a simplified groundwater flow simulator together with Tikhonov regularization implemented in calibration mode. The resulting groundwater elevation contour maps provide plausible interpretations of groundwater levels and hydraulic gradients between measured locations that match measured water levels and monitoring wells to an acceptable degree. There is a reasonable balance between the fit to the data and parameter complexity.

The reliability of the contours is influenced by several factors, including the following:

- The reliability and representativeness of the measured or recorded water levels
- The distribution of monitoring wells
- The relationship between the open interval(s) of the monitoring wells and those of any extraction and injection wells

4.2 Input Data

Appendix A lists the water-level data used as input. Only those wells yielding water-level measurements representative of the water-table elevation were used to generate the water-table map. The criteria for determining if a particular well yields representative water-table elevations are described in SGW-38815. Wells with open intervals extending from the water table to no more than 15 m (50 ft) below the water table are most suitable for water-table mapping. Wells with longer open intervals are used for mapping only where there is no significant vertical gradient or no other nearby more suitable well exists (SGW-38815). This determination is made on a case-by-case basis.

Hanford Site water-table maps are typically based on water-level measurements made during a Sitewide campaign in March of each year (designated "PROJ_MAR_2020" in the database). However, in 2020, the annual March campaign was interrupted by a work stoppage related to the Corona virus pandemic and the data selection criteria needed to be relaxed. The following selection criteria were used:

1. Use "PROJ_MAR_2020" measurements where available – these measurements were available for the entire River Corridor, which is most influenced by seasonal variations (342 records).
2. If no "PROJ_MAR_2020" data, use "PROJ_FEB_2020" where available – The 200 East Area low-gradient network was measured in late February; several other well groups were also measured in February (94 records).
3. If data from items 1 and 2 are not available, select other water-level data from the January through March time period (64 records).
4. If no water-level data are available for the first quarter and there are areas of uncertainty, use control points based on extrapolation of data trends (13 records; Appendix A provides more information).

Of the 513 data points used for mapping, 75% were measured between February 26 and March 17; 22% were measured between January 1 and February 20; and ~2% were extrapolated. Because the majority of the measurements were made in March – including all of those within the River Corridor, the region most influenced by changing river stage – the 2020 map is considered representative of the March water table.

The water table within the 200 East Area is very flat. The hydraulic gradient in this region varies from 10^{-6} to 10^{-5} m/m, and it has been estimated that the water-table elevations vary by no more 0.04 m (0.13 ft) across this region. An important source of error in water-level measurements is deviation of the well bores from vertical. If a well deviates from vertical, the depth-to-water measurement will be greater than the true vertical depth to water. This error causes calculated water-level elevations to be too low. The magnitudes of such errors are generally less than 0.10 m (0.33 ft), but errors greater than 1.0 m (3.3 ft) have been documented. In the 200 East Area, the error caused by the well deviation from vertical can mask the variation in water levels between wells. To correct for deviation error in wells in this area, gyroscope surveys have been performed to map the position of the borehole in 3D space. Once this is done, the difference between the measured depth to water and the true vertical depth to water can be determined. This difference can then be used to correct the water-level measurements. Wells used for the 200 East Area map were predominantly those in which a gyroscope survey has been performed, referred to as the low-gradient network wells.

Pump and treat (P&T) systems operating in the 100 and 200 Areas have a large impact on water-table elevations. Monthly pumping volumes were obtained from the supervisory control and data acquisition database, then used to calculate average pumping rates for the period January through March 2020 (Table A-2). Because the simplified groundwater flow simulator represents flow conditions only in the unconfined aquifer, pumping rates were set to zero for wells that are screened in other aquifers. These included wells located in the 200 West Area that are screened below Ringold lower mud unit and wells located in the 100 Area that are screened in the Ringold upper mud aquifer.

5 Software Applications

Software used to perform the calculations for this ECF was in accordance with CH2M HILL Plateau Remediation Company's (CHPRC's) controlled software management procedure, which implements DOE O 414.1D, *Quality Assurance*.

5.1 Approved Software

The software used for this ECF is approved, managed, and used consistent with CHPRC's controlled software management procedures under the following software lifecycle documentation:

- CHPRC-00257, *MODFLOW and Related Codes Functional Requirements Document*
- CHPRC-00258, *MODFLOW and Related Codes Software Management Plan*
- CHPRC-00259, *MODFLOW and Related Codes Software Test Plan*
- CHPRC-00260, *MODFLOW and Related Codes Requirements Traceability Matrix*
- CHPRC-00261, *MODFLOW and Related Codes Acceptance Test Report*

CHPRC-00258 distinguishes between safety software and support software based on whether the software calculates reportable results or provides run support, visualization, or similar functions. Brief descriptions of the software are provided in Section 5.2.

5.2 Software Description

A controlled calculation software, MODFLOW-USG (Panday et al., 2013), was used for the calculations that support this ECF.

- **Software title**: MODFLOW-USG: An Unstructured Grid Version of MODFLOW for Simulating Groundwater Flow and Tightly Coupled Processes Using a Control Volume Finite-Difference Formulation
- **Software version**: 1.2.00, approved as CHPRC Build 8 compiled to default single precision
- **Executable Name**: mfusg-chprc08spv.exe
- **Hanford Information Systems Inventory (HISI) identification number**: 2517
- **Workstation type and property number (from which software is run)**: S.S. Papadopulos and Assoc., Inc., FE616

5.2.1 Software Installation and Checkout

Safety software installations are checked and tested in accordance with CHPRC-00258 using the installation tests provided in CHPRC-00259. Executables are obtained from the CHPRC software owner (who maintains the configuration-managed copies in MKS Integrity®). Software installation and checkout forms are required and must be approved for installations used to perform model runs. Approved users are registered in the HISI authorized users list for safety software.

5.2.2 Statement of Valid Software Application

The software identified above was used consistent with intended uses, as identified in CHPRC-00257, and is a valid use of this software for this application. The software was used within its limitations, as identified in CHPRC-00257.

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5.3 Support Software

The following software programs are classified as support software by CHPRC-00258.

- **PEST**: Estimates parameter values that minimize the objective function(s) to calibrate models using inverse theory (Doherty, 2015)
- **PLPROC:** Spatially interpolates pilot point parameter values to the model grid (Doherty, 2016, *PLPROC: A Parameter List Processor*)
- **Groundwater Vistas™**: Provided graphical tools used for model quality assurance and model input/output review (Rumbaugh and Rumbaugh, 2017, *Groundwater Vistas Version 7)*
- **AlgoMesh®**: Used to generate model grid (HydroAlgorithmics, 2016, *AlgoMesh User Guide*)
- **Surfer®**: Data interpolation for visualization, water-level contour shapefile generation, and quality assurance

6 Calculation

This section describes the calculations performed to produce the sitewide water table map. The following steps were taken to develop the necessary input files, perform the calculations, and post-process the outputs to produce the results presented in this ECF.

For calculations using MODFLOW USG and PEST, two linked calculation tools are needed to obtain the necessary piecewise grid:

1. A method for calculating groundwater elevations throughout the area; and
2. A method for implementing the Tikhonov regularization technique to evaluate the tradeoff between complexity and data fit

6.1 Groundwater Elevation Calculations

To calculate groundwater elevations for the Hanford Site, a simplified 2D simulation of groundwater flow conditions was constructed. Throughout the Hanford Site the predominant factors that affect groundwater flow patterns are:

- The high-hydraulic conductivity sediments that comprise the Hanford Formation and the Cold Creek gravel unit
- The location of the Ringold unit E and Ringold Lower Mud lower hydraulic conductivity sediments and basalts that are lateral to or subcrop within the high-conductivity sediments
- Operation of P&T systems in 100 and 200 Areas
- Lateral sources of water, particularly along the northwest and southwest extents of the 200 West Area
- Inflows and outflows to and from the Columbia River along the north and east sides, and Yakima River at the south side of the Hanford Site

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® Surfer is a registered trademark of Golden Software, LLC, Golden, Colorado.

For the purposes of this ECF, these predominant factors are represented by developing and parameterizing a simplified single-layer (2D) steady-state simulation of groundwater flow using the unstructured grid release of the MODFLOW program, MODFLOW-USG.

The MODFLOW-USG simulation code is a control-volume finite difference formulation of the widely used finite-difference U.S. Geological Survey (USGS) MODFLOW groundwater flow simulator. An advantage of the unstructured grid formulation implemented in MODFLOW-USG is that it can support irregular, non-rectangular, grids. In particular, MODFLOW-USG can support a Voronoi grid, which is well suited to the purpose of this exercise because a much smaller number of cells is needed to discretize the area encompassing the Hanford Site, and a grid can be refined in areas where finer resolution is necessary such as at the location of pumping and monitoring wells.

The simplified 2D simulation of groundwater flow conditions was constructed as follows:

1. Grid: A single-layer grid was constructed using a Voronoi mesh. The Voronoi mesh was designed using the software program AlgoMesh® (HydroAlgorithmics, 2016) that enables the user to adjust the number of cells, their geometry, aspect ratios, and density in focused areas of the domain. AlgoMesh® writes a file that defines the Voronoi mesh in a format that can be read by the Groundwater Vistas™ program, from which the MODFLOW-USG specific input files are generated and through which initial parameters and boundary conditions are developed. The theoretical top elevation was set using the digital elevation map in meters and the bottom elevation of the unconfined aquifer unit was set as the top of the of the Ringold lower mud (ECF-HANFORD-13-0029, *Development of the Hanford South Geologic Framework Model*) in the 200 and 300 Areas and Ringold upper mud in the 100 Area (ECF-HANFORD-13-0020, *Process for Constructing a Three-dimensional Geological Framework for Hanford Site's 100 Area*). In regions where the Ringold mud is not present, the bottom of the unconfined aquifer unit was set as the top elevation of the basalt.

2. Hydraulic conductivity.

    a) Based on SME knowledge, the hydraulic conductivity of the sediments within which the water table resides was discretized into hydrostratigraphic unit (HSU) zones, representing the Hanford Formation, Cold Creek gravel unit, Ringold Formation unit E, Ringold lower mud and Basalt Formation. Delineation of HSUs at the elevation of the water table was approximated by intersecting the 2018 sitewide water-table grid with 3D geological framework models of the Hanford Site. These geological framework models include ECF-HANFORD-13-0029 for the 200 Area and ECF-Hanford-13-0020 for the 100 Area. Hydrostratigraphic units are shown in Figure 1.

    b) To calibrate the water table within basalt formations in areas where the water table resides below the basalt surface, the model grid was refined with concentric perimeters around basalt outcrops within Gable Mountain and Gable Butte and represented as three separate zones. Small basalt outcrops in the Gable Gap area and basalt formation in area between Trench 94 and Gable Mountain are represented as single zones.

3. Lateral boundary conditions.

    a) Specified-fluxes were used to represent the natural recharge representing mountain-front recharge arising from infiltration of snowmelt, agricultural return-flows from irrigation, and runoff from elevated areas. The major sources of mountain-front recharge to the Hanford Site are the ephemeral Cold Creek, Dry Creek streams and Rattlesnake Springs. To approximate the groundwater flux entering the calculational domain, prescribed flux boundary conditions were defined and scaled in the Tikhonov regularized calibration process.

b) Specified-heads were used to represent the flow to and from the Columbia River on the northern and eastern side and the Yakima River at the southern part of the calculational domain. Hydraulic gradients in the vicinity of the rivers are highly variable because the river stage is affected by dams. To remove the effect of the hourly and daily variability of the river stages and their effect on water levels in the monitoring wells, specified-heads along Columbia and Yakima Rivers are linearly interpolated using average river stage data for the period January through March 2020, which were obtained from Hanford river gage data stored in HEIS database and from two USGS stations: Yakima River (station ID 12510500) and Clover Island (station ID 12514500). In locations where Hanford river gage data were missing, river levels were approximated using measured water levels at nearby monitoring wells.

4. Recharge.

   a) Natural recharge from precipitation at the Hanford Site is typically small, but highly variable spatially and temporally, ranging from near zero to more than 100 mm/yr. Natural recharge for the TRIM model, spatially and temporally varying, is derived from the recharge evolution tool described in ECF-HANFORD-15-0019, *Hanford Site-Wide Natural Recharge Boundary Conditions for Groundwater Models*. Shapefiles produced from the recharge evolution tool containing recharge estimates on an annual basis were used to produce a spatially weighted average recharge value for each model cell in the model domain.

   b) Distribution of anthropogenic recharge related to the historical wastewater discharges associated with Hanford Site activities were tabulated in EMDT-BC-0002, *Vadose Zone Attenuated Recharge, Electronic Modeling Data Transmittal Boundary Condition (Artificial Recharge)-0002*. EMDT-BC-0002 includes the magnitudes and locations of operational discharges for the simulated time periods in the model on a yearly timestep. Locations of discharge include waste sites, ponds, sewer discharge, french drains, and documented unplanned releases for the entire operational period and projections of future discharges.

5. Groundwater extraction and injection. P&T systems in the 100 and 200 Areas have a large impact on water table elevations. Extraction and injection wells were represented using the MODFLOW-USG "WEL" package. Table A-1 in Appendix A lists the well names and average pumping rates assumed for the period January through March 2020. The locations of the pumping wells used in the calculations are shown in Figures 2 to 4.

The boundary conditions and initial parameter values were defined in text files in a format that can be read by the MODFLOW-USG program. The resulting simplified groundwater flow simulator is 2D (i.e., a single layer) and is composed of 56,815 cells with the resolution of the mesh refined in areas of particular interest, such as near groups of pumping and monitoring wells. The resulting grid, boundaries, and initial hydraulic conductivity zones are shown in Figure 1.

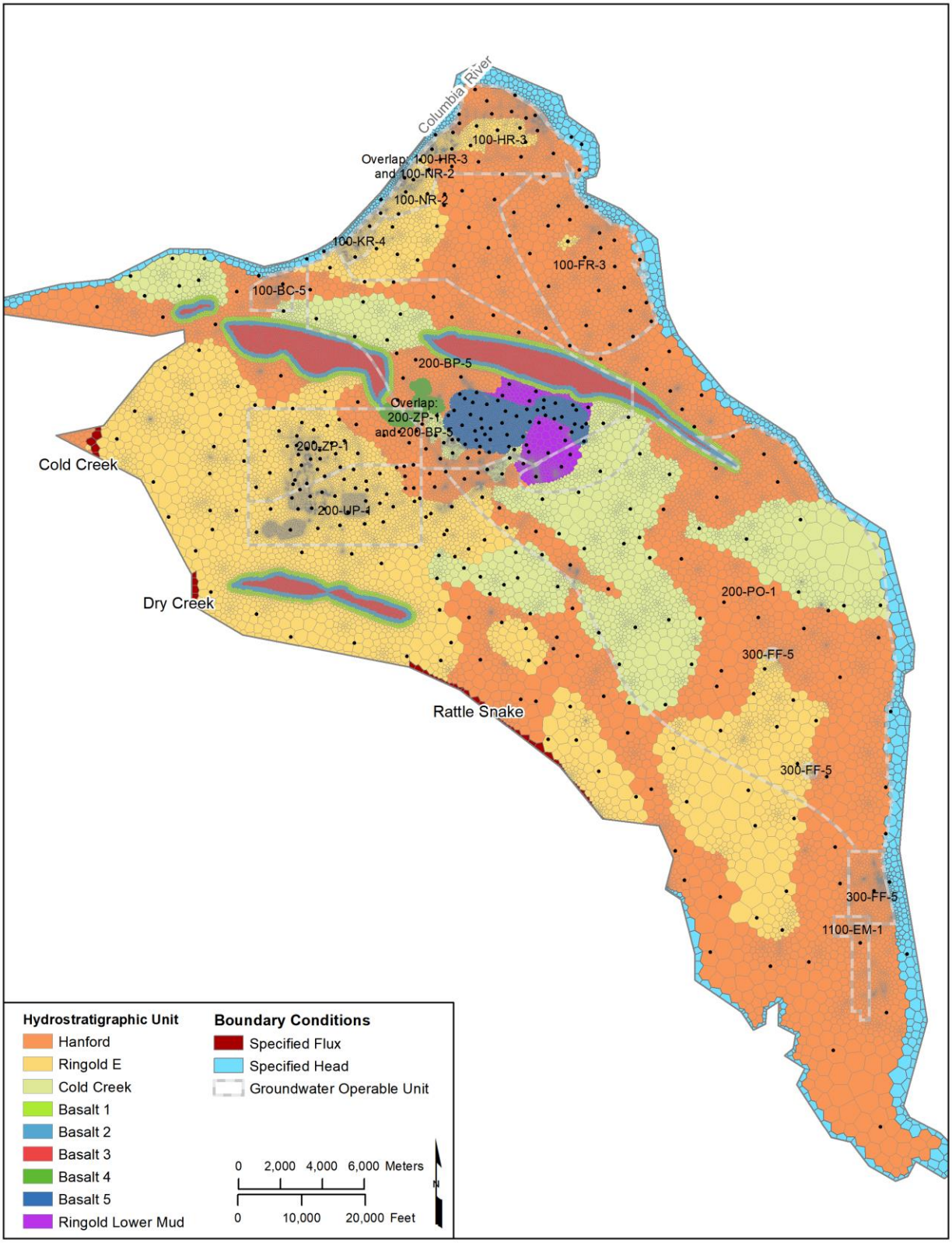

Figure 1. Site-Wide Boundary Conditions, HSU Zones and Location of Pilot Points Used in Calibration

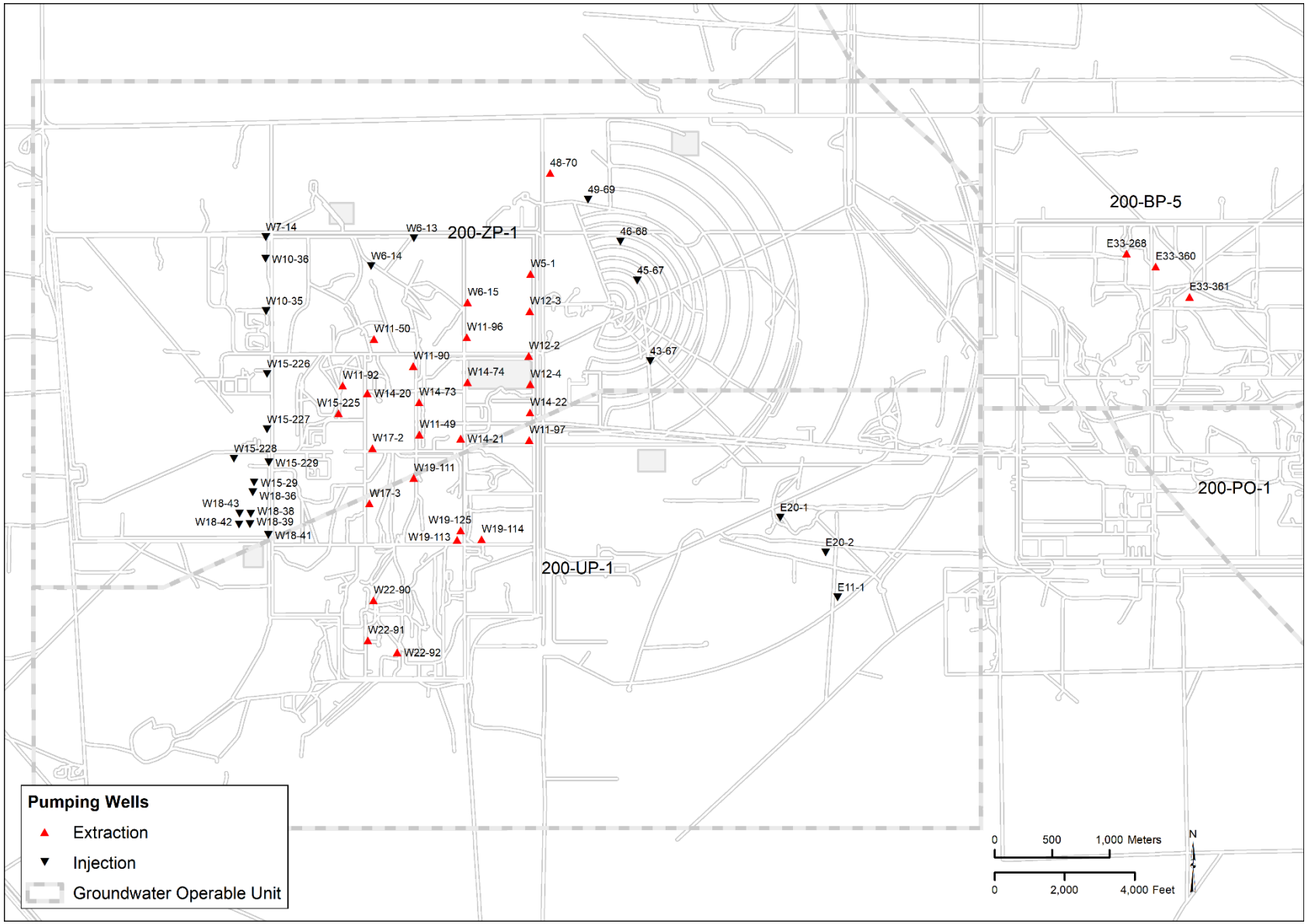

Figure 2. Extraction and Injection Wells Used in TRIM Calculations for the 200 Areas

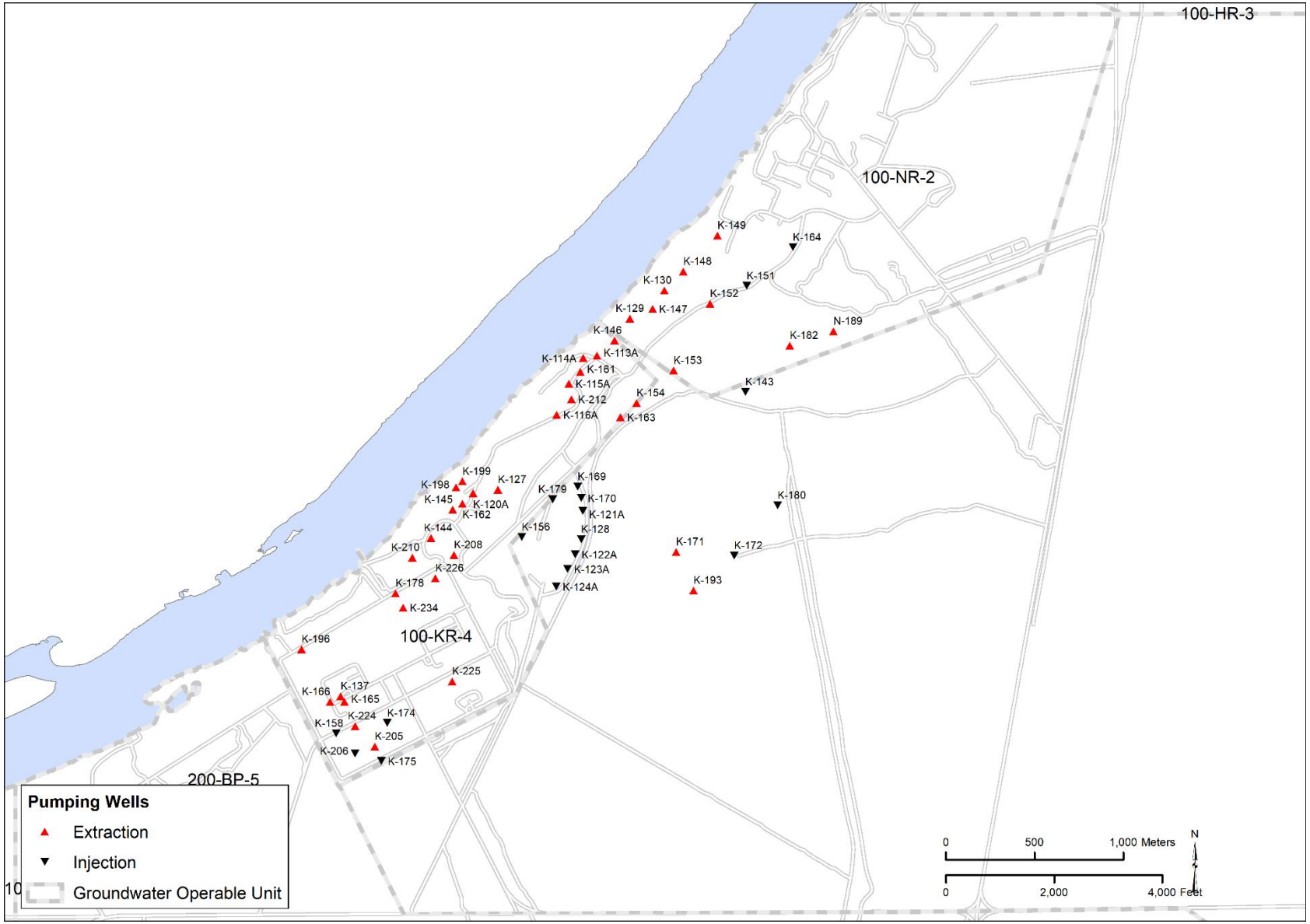

Figure 3. Extraction and Injection Wells Used in TRIM Calculations for the 100-K and 100-N Areas

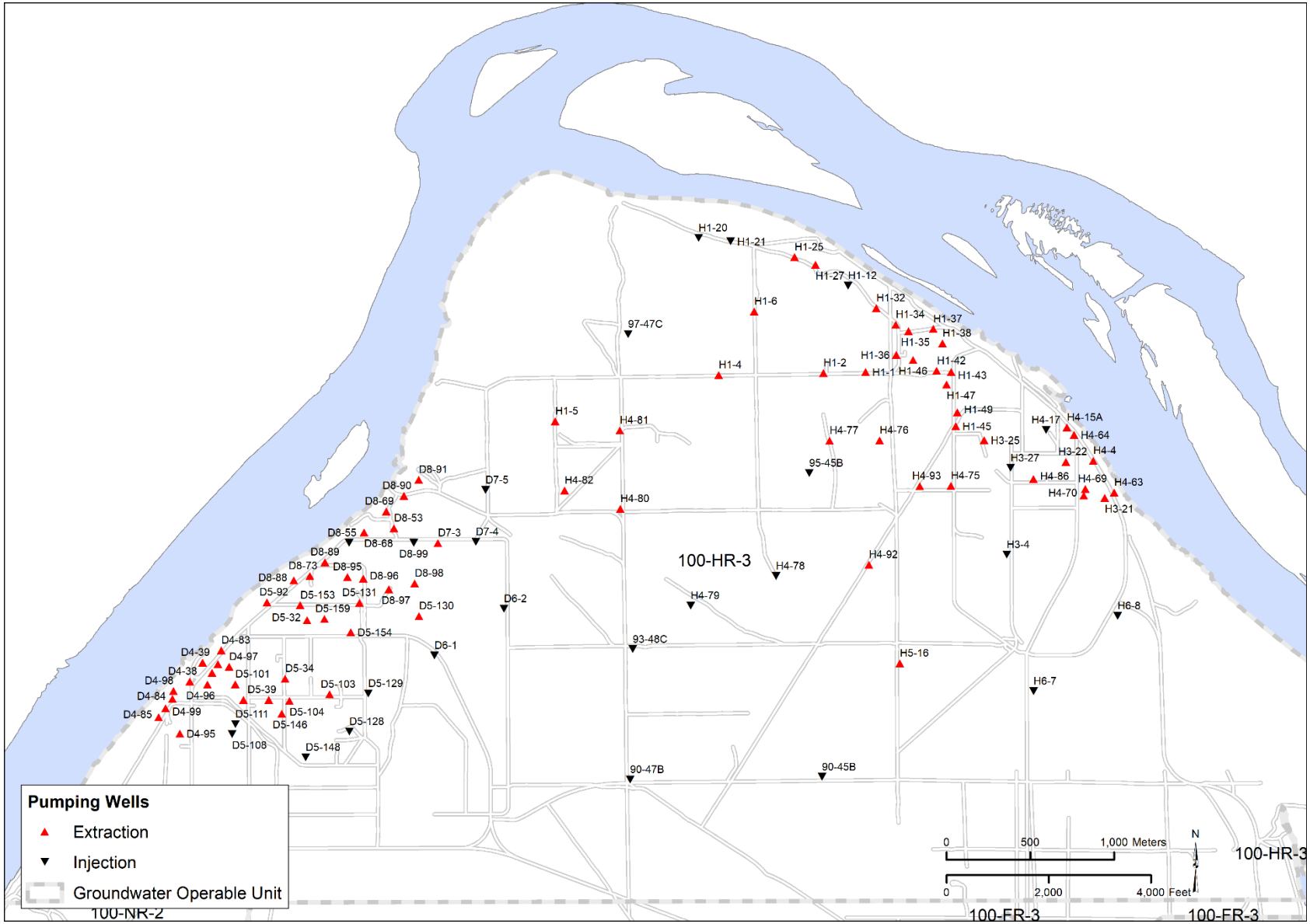

Figure 4. Extraction and Injection Wells Used in TRIM Calculations for the 100-D and 100-H Areas

6.2 Tikhonov Regularization

The method of Tikhonov regularization is implemented in several commonly used software packages and programming environments. One of these is the parameter estimation and uncertainty analysis program PEST (Doherty, 2015), which implements Tikhonov regularization as a constrained parameter estimation and calibration procedure. PEST was selected for this ECF, as it is used widely at the Hanford Site to assist with the calibration of groundwater models and many other models, using a suite of utilities to link it to groundwater models and other programs.

During traditional parameter estimation, PEST seeks to minimize the measurement objective function, which is the sum of squared weighted residuals[1]. When incorporating Tikhonov regularization, the objective function is augmented with a second term that quantifies in a similar manner the degree of deviation from the preferred system condition, by calculating a sum-of-squared-weighted differences between the preferred condition and the actual condition that is represented by the value of the parameters (Tonkin and Doherty, 2005, "A Hybrid Regularized Inversion Methodology for Highly Parameterized Environmental Models"; Doherty, 2015; Doherty, 2018, *PEST Model-Independent Parameter Estimation User Manual Part I: PEST, SENSAN, and Global Optimisers*).

The mode of operation for the PEST software's implementation of the Tikhonov regularization is referred to as regularization mode and incorporates this composite objective function with measurement and differences components. In this mode, the PEST program updates the values of the parameters that provide an improved fit to the measured values and calculates the global regularization weight parameter that enables the measurement component of this composite objective function to meet a target value ascribed by the user as representing an "acceptable" fit (Doherty, 2015).

Because the simulator underlying the TRIM is 2D and steady-state, only the horizontal hydraulic conductivity was calibrated. To account for heterogeneity, a set of pilot points was assigned to each sediment HSU zone (Figure 1) and Basalt formation (Basalt-5) and their initial horizontal hydraulic conductivity was defined as homogeneous. Homogeneity represents the "preferred system condition" at the start of the Tikhonov regularization that followed. A parameter list processor, PLPROC package (Doherty, 2016), was used to interpolate the horizontal conductivity values of the pilot points to the Voronoi calculational grid. Pilot point locations are depicted in Figure 1. Hydraulic conductivity in Basalt zones 1 through 4 were assumed constant and calibrated as constant zones.

Values for the parameters of the simplified 2D groundwater flow simulator were iteratively updated using the Tikhonov regularization method implemented in PEST, by obtaining successive improvements in the fit between the calculated and measured groundwater levels in the calibration data set. This calibration process occurred in two sub-steps.

1. An initial calibration using the PEST estimation process was undertaken to produce a groundwater elevation map that approximated the measured groundwater levels but resulted in minimal deviation from the preferred system condition of homogeneity. This provided initial estimates for (a) the flow rates at each of the specified flux boundaries, and (b) the hydraulic conductivity of the pilot points in each of the five HSU zones.

2. A series of iterations of Tikhonov regularized inversion was executed using PEST in regularization mode. These iterations explored how trading off the variance of the simulator parameters against the fit to the data affected patterns of groundwater flow and hydraulic gradients. For this second step, the values of the hydraulic conductivity for all pilot points were estimated via the regularized inversion

[1] A residual is defined as the difference between an observed and a simulated value.

process. A preferred difference (i.e., smoothness) Tikhonov regularization scheme was defined for each pilot point within the five HSU zones by specifying equations that minimize the (square of the) difference in the value of the prior information (i.e., hydraulic conductivity) between neighboring pilot points within the same HSU zone. These equations were entered into the "Prior Information" section in the PEST control file. During this second step it was observed that a small number of monitoring wells consistently accounted for a significant proportion of the measurement objective function (i.e., the misfit). The measurements associated with these wells were consequently ascribed a low-valued or zero-valued weight in the regression. The full set of calibration targets, measured and estimated water levels, and their associated weights, is listed in Appendix A, Table A-2.

A scatter plot of calibration results of the observed versus the simulated groundwater elevations for nonzero weighted targets is provided in Figure 5. Summary statistics for the calibration residuals are provided on Table 1.

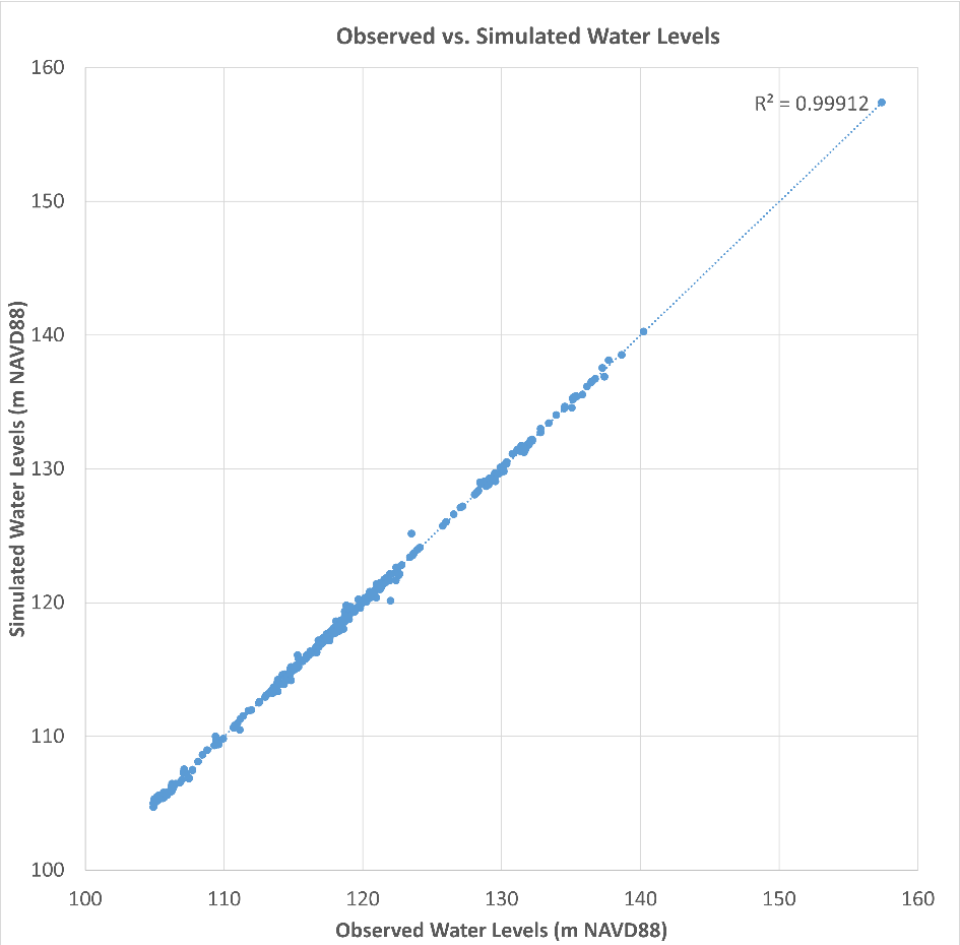

Figure 5. Comparison of Observed Versus Simulated Water Levels

Table 1. Residual Summary Statistics

Correlation	1.000
Average Residual (m)	-0.004
Maximum Residual (m)	1.86
Minimum Residual (m)	-1.64
Sum of Squares for Errors (m^2)	24.88
Mean Square Error (m)	4.85E-02
Root Mean Square Error (m)	0.220
Observation Range (m)	52.48
Root Mean Square Error/Observation Range (m)	0.004
Coefficient of Determination (R^2)	0.9991

The simulated heads were imported into the Groundwater Vistas graphical user interface and then exported as a regular grid using the Surfer (*.grd) raster format. To generate water-level contours, the grid was imported into Surfer and then exported into geographic information system (GIS) shapefiles. After reviewing the water-level contours, contours in some areas adjacent to the no-flow boundaries were noted to exhibit irregular shapes. These irregularities are due to the equation solution method, referred to as the "upstream weighting formulation" (Niswonger et al., 2011, *MODFLOW–NWT, A Newton formulation for MODFLOW–2005*), which was used to simulate the effect of "dry" cells. This upstream weighting formulation promotes numerical continuity and stability of the calculations by preventing cells becoming "dry," but in doing so the value calculated in the cell does not represent a "true" water-table elevation but rather an elevation that is at or below the base of the unconfined aquifer. These areas are outside the area of interest to this ECF; however, to remove the artifacts caused by this method, the contours were imported in ArcMap and the contours in those areas were erased.

Maps of the simulated groundwater-level contours together with the measured water levels are presented in Chapter 7.

7 Results

The main results of this water-level mapping effort are GIS feature classes containing the contours for the Hanford Site water-table map for the first quarter of 2020. As discussed in Section 4.2, the first quarter map is considered representative of the water table in March 2020.These feature classes will be used to support map generation for the annual groundwater monitoring report for 2020. Figures 6 through 13 illustrate the resultant contours.

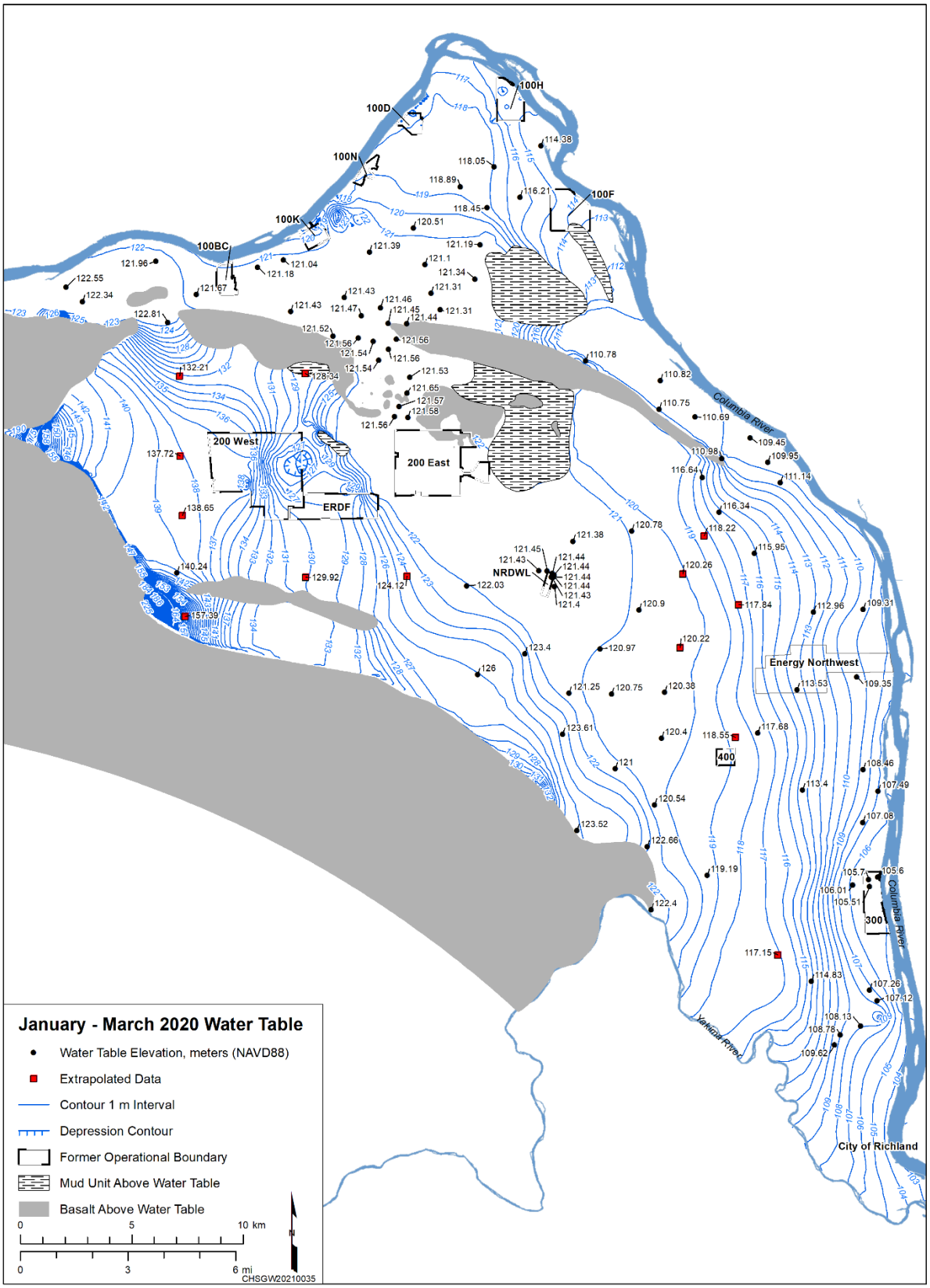

Figure 6. Hanford Site Water Table, March 2020

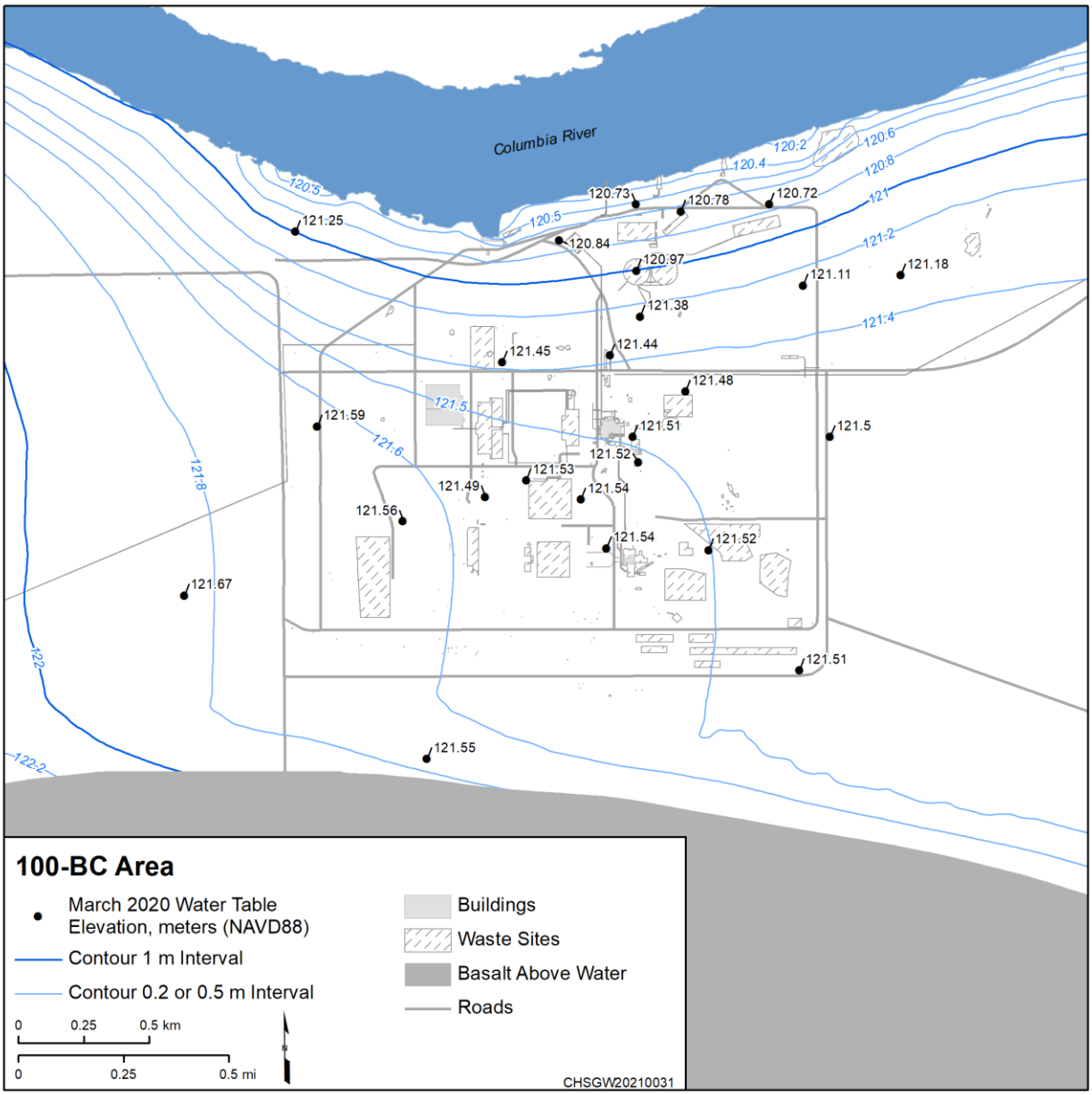

Figure 7. 100-BC Area Water Table, March 2020

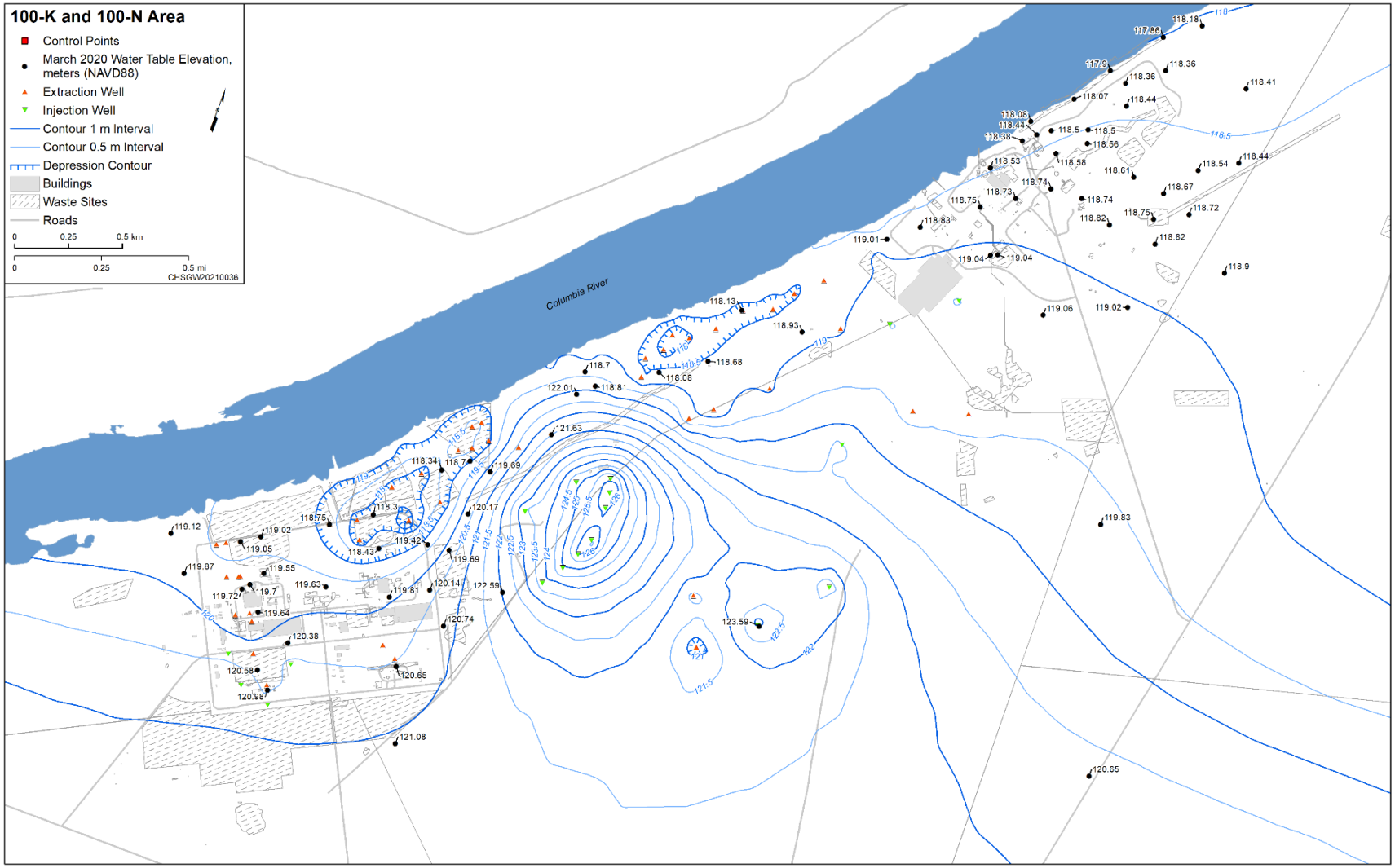

Figure 8. 100-K and 100-N Area Water Table, March 2020

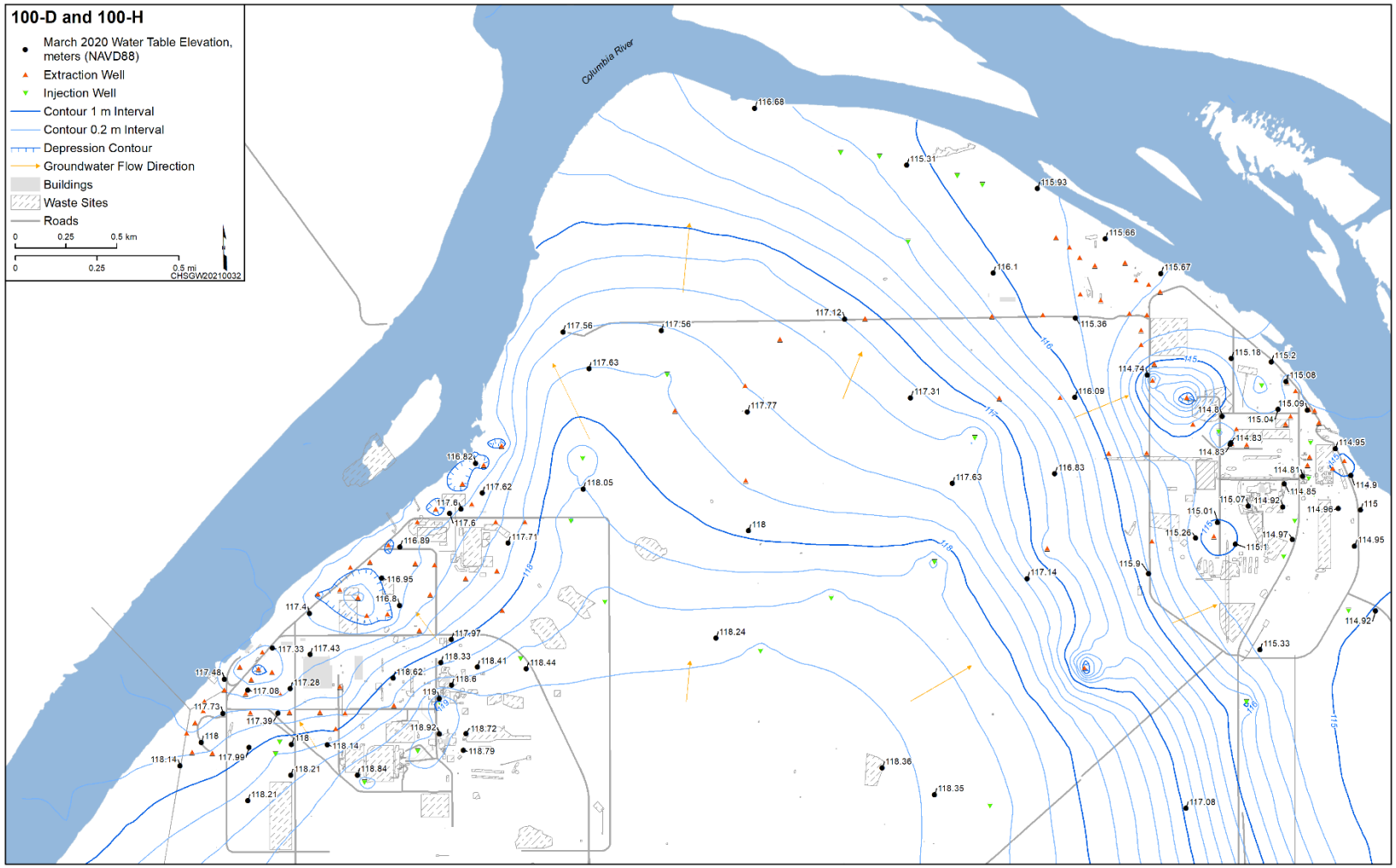

Figure 9. 100-D and 100-H Area Water Table, March 2020

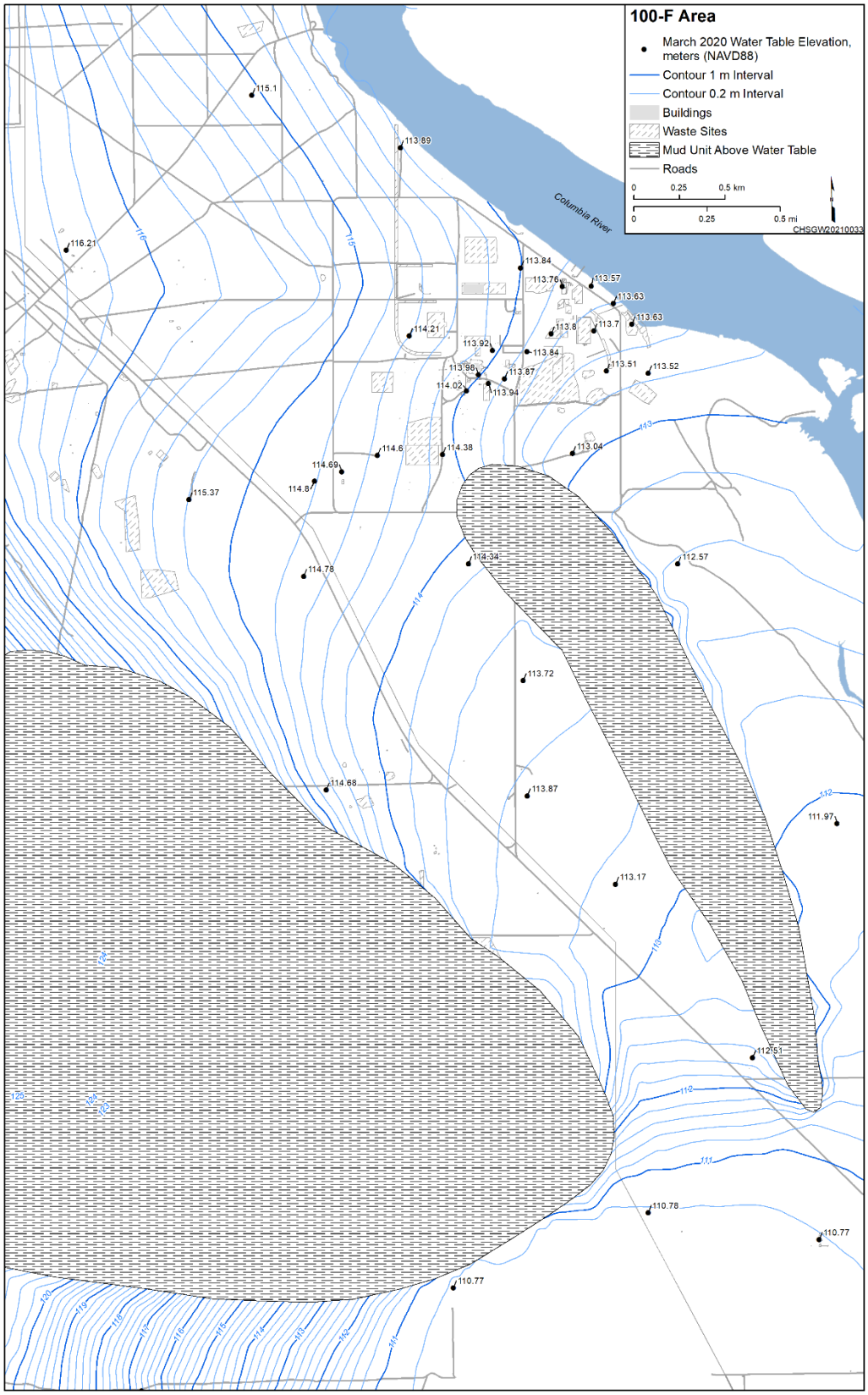

Figure 10. 100-F Area Water Table, March 2020

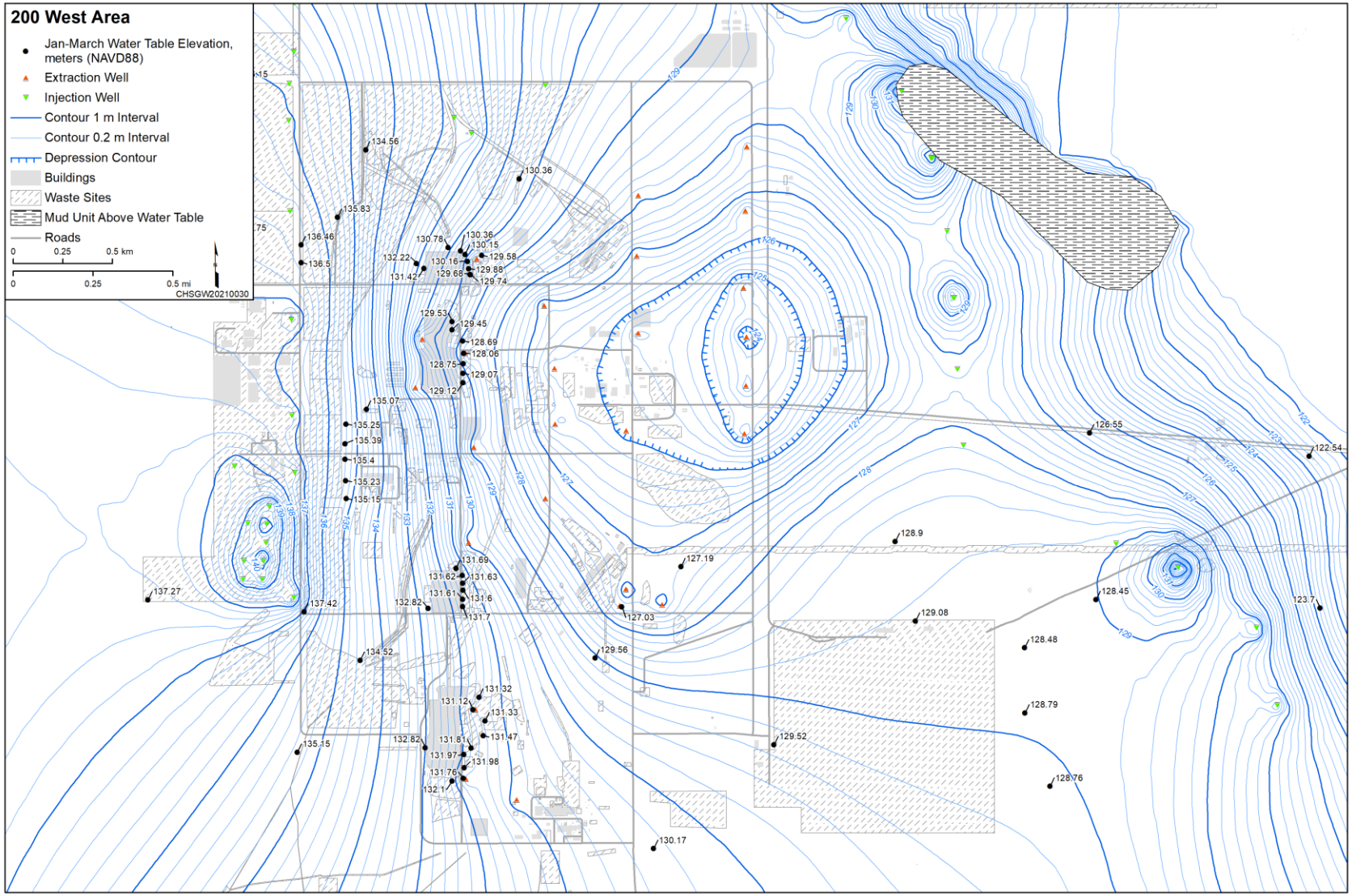

Figure 11. 200 West Area Water Table, January-March 2020

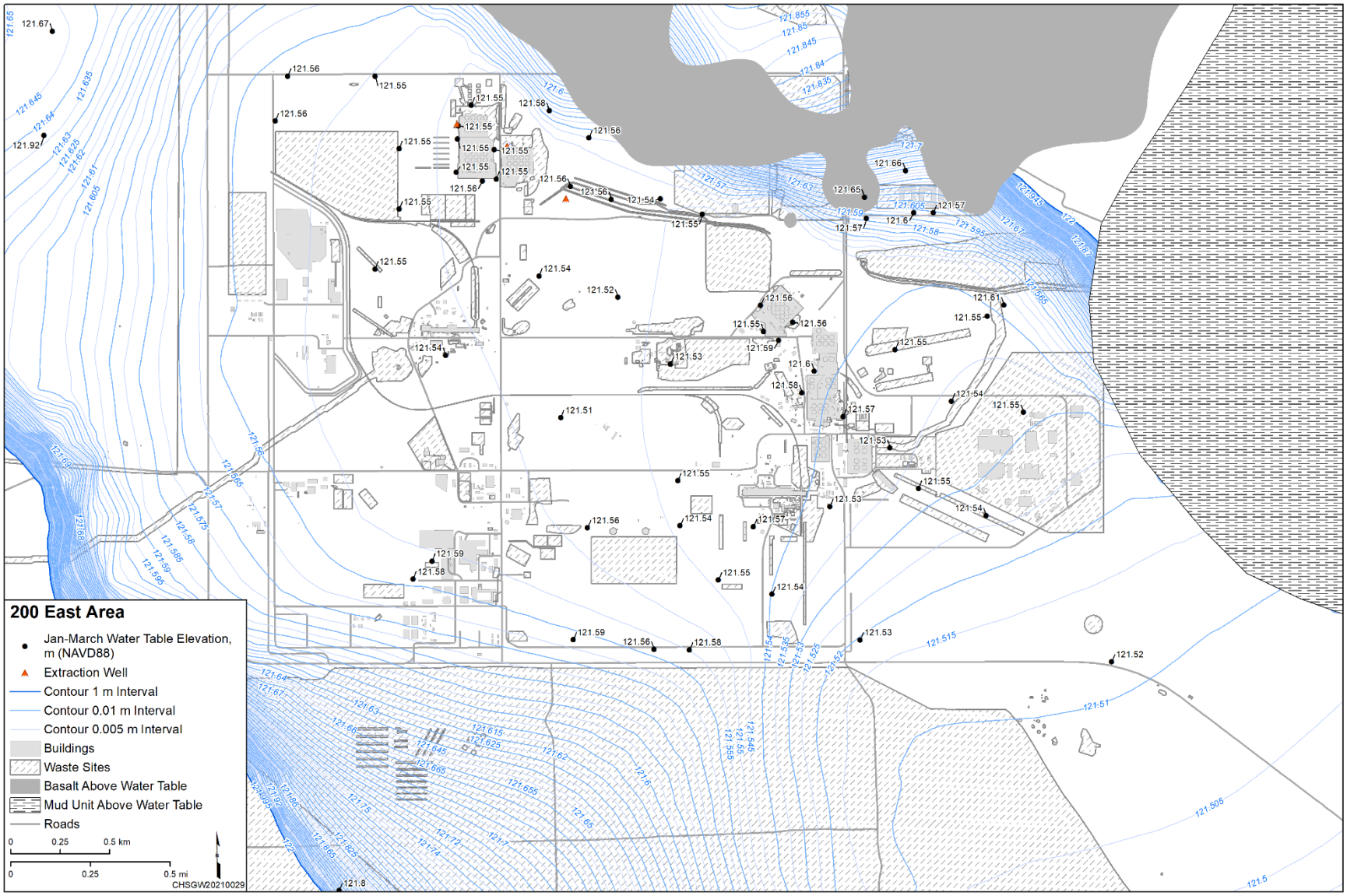

Figure 12. 200 East Area Water Table, January-March 2020

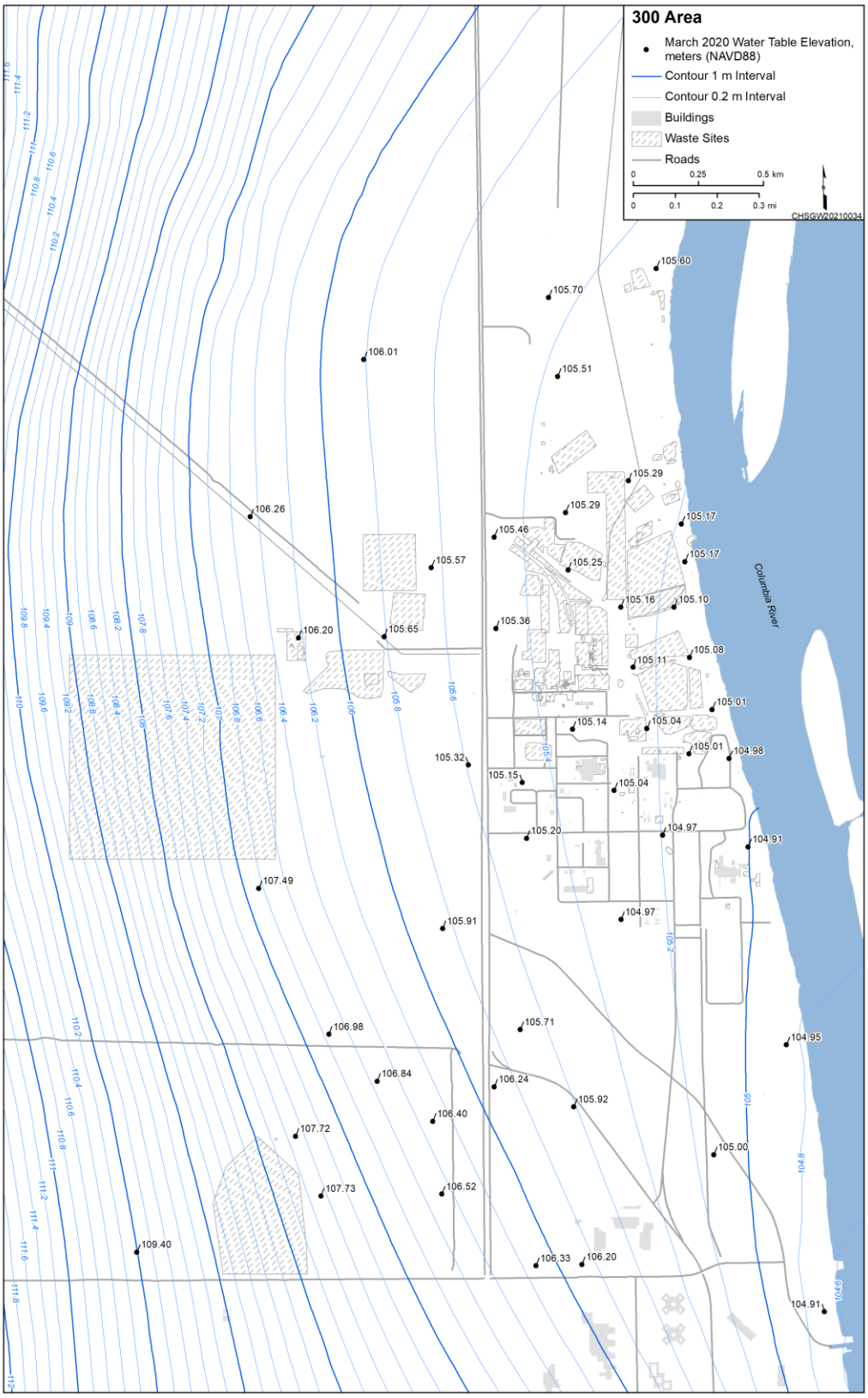

Figure 13. 300 Area Water Table, March 2020

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Appendix A

Water-Level Measurements

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A1 Input Data

Table A-1 lists average flow rates for extraction and injection wells used in the water-table simulations. Flow rates of zero indicate that either the well was not in use or is not screened in the unconfined aquifer.

Table A-2 lists measured water levels, modeled water level, and the difference between the two (residuals). See Section 6.2 of the main text for an explanation of weights.

Table A-3 summarizes the data used for extrapolating water levels to fill data gaps in locations where no 2020 measurement was available. Figures A-1 through A-13 show the extrapolated trends.

Table A-1. Extraction and Injection Well Flow Rates

Well Name	System	Flow Rate (gal/min)*	Well Name	System	Flow Rate (gal/min)*
200 Areas					
299-E11-1	200W	69.91	299-W18-44	200W	0.00
299-E20-1	200W	85.87	299-W19-111	200W	-27.54
299-E20-2	200W	59.02	299-W19-113	200W	-43.40
299-W10-35	200W	98.89	299-W19-114	200W	-76.14
299-W10-36	200W	63.39	299-W19-125	200W	-49.99
299-W11-49	200W	-107.73	299-W22-90	200W	-24.91
299-W11-50	200W	-77.93	299-W22-91	200W	-29.92
299-W11-90	200W	-82.32	299-W22-92	200W	-25.04
299-W11-92	200W	-91.51	299-W5-1	200W	-99.42
299-W11-96	200W	-96.52	299-W6-13	200W	71.15
299-W11-97	200W	-128.82	299-W6-14	200W	145.55
299-W12-2	200W	-109.70	299-W6-15	200W	-88.22
299-W12-3	200W	-108.78	299-W6-16	200W	0.00
299-W12-4	200W	-133.70	299-W7-14	200W	109.99
299-W14-20	200W	-71.23	699-38-64	200W	0.00
299-W14-21	200W	-98.13	699-40-67	200W	0.00
299-W14-22	200W	-114.26	699-42-67	200W	0.00
299-W14-73	200W	-86.44	699-43-67	200W	31.20
299-W14-74	200W	-107.81	699-43-67B	200W	0.00
299-W15-225	200W	-90.90	699-44-67	200W	0.00
299-W15-226	200W	158.46	699-45-67	200W	36.26
299-W15-227	200W	154.56	699-45-67B	200W	0.00

Table A-1. Extraction and Injection Well Flow Rates

Well Name	System	Flow Rate (gal/min)*	Well Name	System	Flow Rate (gal/min)*
299-W15-228	200W	131.52	699-46-68	200W	54.90
299-W15-229	200W	108.12	699-47-78	200W	0.00
299-W15-29	200W	103.37	699-47-78C	200W	0.00
299-W17-2	200W	-93.51	699-48-70	200W	-74.41
299-W17-3	200W	-107.52	699-49-69	200W	39.98
299-W18-36	200W	89.38	299-E33-268	BP5	-15.94
299-W18-37	200W	0.00	299-E33-344	BP5	0
299-W18-38	200W	80.43	299-E33-350	BP5	0
299-W18-39	200W	45.82	299-E33-351	BP5	0
299-W18-41	200W	145.55	299-E33-360	BP5	-85.32
299-W18-42	200W	29.99	299-E33-361	BP5	-47.61
299-W18-43	200W	29.97			
100-HR-3 Operable Unit					
199-D5-104	DR5	-25.05	199-H4-18	HR3	0.00
199-D5-20	DR5	0.00	199-H4-4	HR3	-2.09
199-D5-32	DR5	-18.71	199-H4-63	HR3	-26.42
199-D5-39	DR5	-4.87	199-H4-64	HR3	-2.79
199-D5-92	DR5	-5.01	199-H1-1	HX	-38.75
199-D4-101	DX	0.00	199-H1-12	HX	26.46
199-D4-14	DX	-14.02	199-H1-2	HX	-2.27
199-D4-34	DX	-4.42	199-H1-20	HX	21.03
199-D4-38	DX	-5.16	199-H1-21	HX	13.80
199-D4-39	DX	-10.48	199-H1-25	HX	21.00
199-D4-83	DX	-4.95	199-H1-27	HX	34.20
199-D4-84	DX	-5.26	199-H1-3	HX	0.00
199-D4-85	DX	-20.67	199-H1-32	HX	-2.09
199-D4-95	DX	-19.52	199-H1-33	HX	0.00
199-D4-96	DX	-9.99	199-H1-34	HX	-11.16
199-D4-97	DX	-13.23	199-H1-35	HX	-12.74

Table A-1. Extraction and Injection Well Flow Rates

Well Name	System	Flow Rate (gal/min)*	Well Name	System	Flow Rate (gal/min)*
199-D4-98	DX	-13.67	199-H1-36	HX	-0.95
199-D4-99	DX	-19.77	199-H1-37	HX	-5.45
199-D5-101	DX	-12.21	199-H1-38	HX	-0.80
199-D5-103	DX	-29.10	199-H1-39	HX	0.00
199-D5-108	DX	19.12	199-H1-4	HX	-0.52
199-D5-111	DX	8.41	199-H1-40	HX	0.00
199-D5-127	DX	-18.38	199-H1-42	HX	-0.67
199-D5-128	DX	65.00	199-H1-43	HX	-7.78
199-D5-129	DX	118.54	199-H1-45	HX	-48.45
199-D5-130	DX	-1.73	199-H1-46	HX	-3.33
199-D5-131	DX	-20.39	199-H1-47	HX	-0.60
199-D5-146	DX	-29.41	199-H1-48	HX	0.00
199-D5-148	DX	91.77	199-H1-49	HX	-5.37
199-D5-153	DX	-27.90	199-H1-6	HX	44.71
199-D5-154	DX	-30.78	199-H3-21	HX	-0.09
199-D5-159	DX	-31.88	199-H3-22	HX	0.00
199-D5-34	DX	-39.31	199-H3-25	HX	-57.52
199-D6-1	DX	21.76	199-H3-26	HX	0.00
199-D6-2	DX	74.08	199-H3-27	HX	28.90
199-D7-3	DX	-21.88	199-H3-28	HX	0.00
199-D7-4	DX	117.38	199-H3-29	HX	0.00
199-D7-5	DX	54.30	199-H3-2C	HX	0.00
199-D8-53	DX	-7.37	199-H3-4	HX	-28.44
199-D8-55	DX	-0.04	199-H3-9	HX	0.00
199-D8-68	DX	-31.42	199-H4-12C	HX	0.00
199-D8-69	DX	-22.09	199-H4-69	HX	-7.79
199-D8-73	DX	-0.02	199-H4-70	HX	-4.07
199-D8-88	DX	-1.82	199-H4-71	HX	0.00
199-D8-89	DX	-16.11	199-H4-72	HX	0.00

Table A-1. Extraction and Injection Well Flow Rates

Well Name	System	Flow Rate (gal/min)*	Well Name	System	Flow Rate (gal/min)*
199-D8-90	DX	-21.33	199-H4-73	HX	0.00
199-D8-91	DX	-23.08	199-H4-74	HX	0.00
199-D8-95	DX	-7.19	199-H4-75	HX	-5.06
199-D8-96	DX	-17.18	199-H4-76	HX	0.00
199-D8-97	DX	-12.46	199-H4-77	HX	-3.70
199-D8-98	DX	-22.12	199-H4-78	HX	44.84
199-D8-99	DX	-22.92	199-H4-79	HX	31.53
199-H1-5	DX	26.14	199-H4-86	HX	-4.24
199-H4-80	DX	-18.65	199-H4-92	HX	-20.21
199-H4-81	DX	-17.52	199-H4-93	HX	-0.49
199-H4-82	DX	17.40	199-H5-16	HX	-47.66
699-90-47B	DX	52.65	199-H6-7	HX	34.59
699-93-48C	DX	53.11	199-H6-8	HX	8.88
699-97-61	DX	0.00	699-90-45B	HX	63.18
199-H4-15A	HR3	-17.12	699-95-45B	HX	69.82
199-H4-17	HR3	15.68	699-97-47C	HX	26.50
100-KR-4 Operable Unit					
199-K-113A	KR4	-9.96	199-K-143	KX	70.84
199-K-114A	KR4	-34.26	199-K-146	KX	-7.97
199-K-115A	KR4	-18.51	199-K-147	KX	-18.00
199-K-116A	KR4	-24.64	199-K-148	KX	-14.43
199-K-120A	KR4	-34.16	199-K-149	KX	61.55
199-K-121A	KR4	42.97	199-K-151	KX	61.49
199-K-122A	KR4	73.14	199-K-152	KX	-26.42
199-K-123A	KR4	47.50	199-K-153	KX	-20.13
199-K-124A	KR4	39.20	199-K-154	KX	-49.85
199-K-127	KR4	-15.32	199-K-156	KX	94.81
199-K-128	KR4	91.98	199-K-161	KX	-21.90
199-K-129	KR4	-16.74	199-K-163	KX	-43.67

Table A-1. Extraction and Injection Well Flow Rates

Well Name	System	Flow Rate (gal/min)*	Well Name	System	Flow Rate (gal/min)*
199-K-144	KR4	-54.03	199-K-164	KX	61.85
199-K-145	KR4	-43.93	199-K-169	KX	141.49
199-K-162	KR4	-45.62	199-K-170	KX	134.20
199-K-179	KR4	87.01	199-K-171	KX	-43.66
199-K-198	KR4	-33.96	199-K-172	KX	67.27
199-K-199	KR4	-25.45	199-K-178	KX	-24.91
199-K-137	KW	-14.99	199-K-180	KX	61.22
199-K-158	KW	22.77	199-K-182	KX	-49.02
199-K-165	KW	-39.67	199-K-193	KX	-74.52
199-K-166	KW	-48.93	199-K-208	KX	-34.43
199-K-174	KW	50.40	199-K-210	KX	-40.65
199-K-175	KW	21.48	199-K-212	KX	-43.58
199-K-196	KW	-30.74	199-K-220	KX	0.00
199-K-205	KW	-119.11	199-K-225	KX	-65.06
199-K-206	KW	81.76	199-K-226	KX	-109.63
199-K-224	KW	-39.64	199-K-234	KX	-58.35
199-K-130	KX	-21.16	199-N-189	KX	-26.05

*Positive for injection wells; negative for extraction wells. Average flow rates January 1 - March 31, 2020.

Table A-2. Measurements for 2020 Water Table Map

Well Name	Date	Data Group	Measured Water Level (m) NAVD88	Modeled Water Level (m) NAVD88	Residual (m)	Weight
199-B2-13	3/2/2020	PROJ_MAR_2020	121.249	120.995	0.254	1
199-B2-14	3/2/2020	PROJ_MAR_2020	120.844	120.702	0.142	1
199-B3-1	3/2/2020	PROJ_MAR_2020	120.776	120.641	0.135	1
199-B3-46	3/2/2020	PROJ_MAR_2020	120.721	120.749	-0.028	1
199-B3-47	3/2/2020	PROJ_MAR_2020	120.732	120.519	0.213	1
199-B3-50	3/2/2020	PROJ_MAR_2020	121.105	121.278	-0.173	1
199-B3-52	3/2/2020	PROJ_MAR_2020	120.970	121.007	-0.037	1
199-B4-1	3/2/2020	PROJ_MAR_2020	121.444	121.381	0.063	1
199-B4-14	3/2/2020	PROJ_MAR_2020	121.529	121.542	-0.013	1
199-B4-16	3/2/2020	PROJ_MAR_2020	121.495	121.474	0.021	1
199-B4-4	3/2/2020	PROJ_MAR_2020	121.514	121.496	0.018	1
199-B4-7	3/2/2020	PROJ_MAR_2020	121.520	121.505	0.015	1
199-B4-8	3/2/2020	PROJ_MAR_2020	121.478	121.463	0.015	1
199-B5-1	3/2/2020	PROJ_MAR_2020	121.447	121.382	0.065	1
199-B5-10	3/2/2020	PROJ_MAR_2020	121.491	121.569	-0.078	1
199-B5-12	3/2/2020	PROJ_MAR_2020	121.538	121.527	0.011	1
199-B5-14	3/2/2020	PROJ_MAR_2020	121.586	121.642	-0.056	1
199-B5-2	3/2/2020	PROJ_MAR_2020	121.375	121.263	0.113	1
199-B5-8	3/2/2020	PROJ_MAR_2020	121.508	121.490	0.018	1
199-B8-6	3/2/2020	PROJ_MAR_2020	121.561	121.632	-0.071	1
199-B8-9	3/2/2020	PROJ_MAR_2020	121.535	121.522	0.014	1
199-B9-3	3/2/2020	PROJ_MAR_2020	121.516	121.500	0.016	1
199-D2-11	3/4/2020	PROJ_MAR_2020	118.844	118.733	0.111	1
199-D2-6	3/4/2020	PROJ_MAR_2020	118.213	118.350	-0.137	1
199-D3-2	3/4/2020	PROJ_MAR_2020	118.135	117.863	0.272	1
199-D3-5	3/4/2020	PROJ_MAR_2020	118.210	118.278	-0.068	1
199-D4-13	3/4/2020	PROJ_MAR_2020	117.730	117.597	0.133	1
199-D4-15	3/4/2020	PROJ_MAR_2020	117.394	117.646	-0.252	1

Table A-2. Measurements for 2020 Water Table Map

Well Name	Date	Data Group	Measured Water Level (m) NAVD88	Modeled Water Level (m) NAVD88	Residual (m)	Weight
199-D4-19	3/4/2020	PROJ_MAR_2020	118.001	117.726	0.275	1
199-D4-20	3/4/2020	PROJ_MAR_2020	117.989	117.960	0.029	1
199-D4-22	3/4/2020	PROJ_MAR_2020	117.080	117.277	-0.197	1
199-D4-23	3/4/2020	PROJ_MAR_2020	117.483	117.344	0.139	1
199-D5-106	3/5/2020	PROJ_MAR_2020	118.615	118.035	0.580	1
199-D5-13	3/5/2020	PROJ_MAR_2020	116.800	117.172	-0.372	1
199-D5-133	3/5/2020	PROJ_MAR_2020	119.000	118.895	0.105	1
199-D5-14	3/5/2020	PROJ_MAR_2020	117.970	117.954	0.016	1
199-D5-142	3/5/2020	PROJ_MAR_2020	118.604	118.530	0.074	1
199-D5-15	3/5/2020	PROJ_MAR_2020	118.333	118.172	0.161	1
199-D5-16	3/5/2020	PROJ_MAR_2020	118.407	118.330	0.077	1
199-D5-17	3/5/2020	PROJ_MAR_2020	118.921	118.813	0.108	1
199-D5-18	3/5/2020	PROJ_MAR_2020	118.720	118.775	-0.055	1
199-D5-19	3/5/2020	PROJ_MAR_2020	118.786	118.780	0.006	1
199-D5-33	3/5/2020	PROJ_MAR_2020	117.433	117.349	0.084	1
199-D5-36	3/4/2020	PROJ_MAR_2020	117.331	117.198	0.133	1
199-D5-37	3/5/2020	PROJ_MAR_2020	117.401	117.179	0.222	1
199-D5-38	3/4/2020	PROJ_MAR_2020	117.284	117.408	-0.124	1
199-D5-40	3/4/2020	PROJ_MAR_2020	118.003	118.120	-0.117	1
199-D5-43	3/5/2020	PROJ_MAR_2020	118.143	118.231	-0.088	1
199-D6-3	3/5/2020	PROJ_MAR_2020	118.442	118.534	-0.092	1
199-D8-101	3/5/2020	PROJ_MAR_2020	117.709	117.755	-0.046	1
199-D8-4	3/5/2020	PROJ_MAR_2020	116.947	117.022	-0.075	1
199-D8-5	3/5/2020	PROJ_MAR_2020	116.892	117.087	-0.195	1
199-D8-54A	3/5/2020	PROJ_MAR_2020	117.597	117.153	0.444	1
199-D8-70	3/5/2020	PROJ_MAR_2020	117.615	117.309	0.306	1
199-D8-71	3/5/2020	PROJ_MAR_2020	117.600	117.216	0.384	1
199-F1-2	3/9/2020	PROJ_MAR_2020	113.885	114.228	-0.343	1

Table A-2. Measurements for 2020 Water Table Map

Well Name	Date	Data Group	Measured Water Level (m) NAVD88	Modeled Water Level (m) NAVD88	Residual (m)	Weight
199-F5-4	3/9/2020	PROJ_MAR_2020	113.874	113.790	0.084	1
199-F5-42	3/9/2020	PROJ_MAR_2020	113.632	113.521	0.111	1
199-F5-43A	3/9/2020	PROJ_MAR_2020	113.627	113.599	0.028	1
199-F5-44	3/9/2020	PROJ_MAR_2020	113.572	113.667	-0.095	1
199-F5-45	3/9/2020	PROJ_MAR_2020	113.842	113.757	0.085	1
199-F5-46	3/10/2020	PROJ_MAR_2020	113.800	113.668	0.132	1
199-F5-47	3/9/2020	PROJ_MAR_2020	113.935	113.886	0.049	1
199-F5-48	3/9/2020	PROJ_MAR_2020	113.915	114.066	-0.151	1
199-F5-52	3/9/2020	PROJ_MAR_2020	113.840	114.000	-0.160	1
199-F5-54	3/9/2020	PROJ_MAR_2020	113.510	113.327	0.183	1
199-F5-55	3/9/2020	PROJ_MAR_2020	113.698	113.520	0.178	1
199-F5-56	3/9/2020	PROJ_MAR_2020	113.976	114.021	-0.044	1
199-F5-6	3/9/2020	PROJ_MAR_2020	113.762	113.762	0.000	1
199-F6-1	3/9/2020	PROJ_MAR_2020	113.520	113.240	0.280	1
199-F7-1	3/9/2020	PROJ_MAR_2020	114.686	114.713	-0.027	1
199-F7-2	3/9/2020	PROJ_MAR_2020	114.205	114.603	-0.397	1
199-F7-3	3/9/2020	PROJ_MAR_2020	114.598	114.557	0.041	1
199-F8-2	3/9/2020	PROJ_MAR_2020	114.022	113.997	0.025	1
199-F8-4	3/9/2020	PROJ_MAR_2020	113.040	113.068	-0.028	5
199-F8-7	3/9/2020	PROJ_MAR_2020	114.384	114.090	0.294	1
199-H1-7	3/6/2020	PROJ_MAR_2020	115.184	115.270	-0.086	1
199-H3-2A	3/6/2020	PROJ_MAR_2020	114.833	115.184	-0.351	1
199-H3-2B	3/6/2020	PROJ_MAR_2020	114.831	115.186	-0.355	1
199-H3-3	3/6/2020	PROJ_MAR_2020	115.014	114.975	0.039	1
199-H3-5	3/6/2020	PROJ_MAR_2020	115.255	115.078	0.177	1
199-H3-6	3/6/2020	PROJ_MAR_2020	114.997	115.039	-0.042	1
199-H3-7	3/6/2020	PROJ_MAR_2020	114.968	115.045	-0.077	1
199-H4-10	3/6/2020	PROJ_MAR_2020	115.195	115.320	-0.125	1

Table A-2. Measurements for 2020 Water Table Map

Well Name	Date	Data Group	Measured Water Level (m) NAVD88	Modeled Water Level (m) NAVD88	Residual (m)	Weight
199-H4-11	3/6/2020	PROJ_MAR_2020	114.948	115.044	-0.096	1
199-H4-12B	3/6/2020	PROJ_MAR_2020	115.085	115.189	-0.104	1
199-H4-13	3/6/2020	PROJ_MAR_2020	114.897	115.004	-0.107	1
199-H4-15B	3/6/2020	PROJ_MAR_2020	115.075	115.105	-0.030	1
199-H4-16	3/6/2020	PROJ_MAR_2020	114.806	115.031	-0.225	1
199-H4-45	3/6/2020	PROJ_MAR_2020	114.962	115.035	-0.073	1
199-H4-46	3/6/2020	PROJ_MAR_2020	114.921	115.049	-0.128	1
199-H4-47	3/6/2020	PROJ_MAR_2020	114.849	115.053	-0.204	1
199-H4-49	3/6/2020	PROJ_MAR_2020	115.074	115.057	0.017	1
199-H4-6	3/6/2020	PROJ_MAR_2020	114.795	115.107	-0.312	1
199-H4-8	3/6/2020	PROJ_MAR_2020	115.036	115.199	-0.163	1
199-H5-1A	3/6/2020	PROJ_MAR_2020	115.100	114.997	0.103	1
199-H6-1	3/6/2020	PROJ_MAR_2020	114.954	115.037	-0.083	1
199-H6-3	3/6/2020	PROJ_MAR_2020	114.915	114.996	-0.081	1
199-H6-4	3/6/2020	PROJ_MAR_2020	115.326	115.169	0.157	1
199-K-107A	3/3/2020	PROJ_MAR_2020	119.721	119.625	0.096	1
199-K-108A	3/3/2020	PROJ_MAR_2020	119.635	119.645	-0.010	1
199-K-11	3/3/2020	PROJ_MAR_2020	119.632	119.677	-0.045	1
199-K-110A	3/3/2020	PROJ_MAR_2020	119.809	119.918	-0.109	1
199-K-111A	3/3/2020	PROJ_MAR_2020	119.423	119.322	0.101	1
199-K-112A	3/3/2020	PROJ_MAR_2020	118.130	118.258	-0.128	1
199-K-117A	3/3/2020	PROJ_MAR_2020	118.701	119.346	-0.645	1
199-K-118A	3/3/2020	PROJ_MAR_2020	122.006	120.143	1.863	0
199-K-119A	3/3/2020	PROJ_MAR_2020	121.630	121.500	0.130	1
199-K-126	3/3/2020	PROJ_MAR_2020	118.933	118.844	0.089	1
199-K-132	3/3/2020	PROJ_MAR_2020	119.049	119.381	-0.332	1
199-K-142	3/3/2020	PROJ_MAR_2020	118.425	118.544	-0.119	1
199-K-150	3/3/2020	PROJ_MAR_2020	119.008	118.742	0.266	1

Table A-2. Measurements for 2020 Water Table Map

Well Name	Date	Data Group	Measured Water Level (m) NAVD88	Modeled Water Level (m) NAVD88	Residual (m)	Weight
199-K-157	3/3/2020	PROJ_MAR_2020	120.168	120.316	-0.148	1
199-K-159	3/3/2020	PROJ_MAR_2020	118.825	118.705	0.120	1
199-K-18	3/3/2020	PROJ_MAR_2020	118.696	118.960	-0.264	1
199-K-181	3/3/2020	PROJ_MAR_2020	118.745	118.702	0.044	1
199-K-183	3/3/2020	PROJ_MAR_2020	119.872	119.862	0.010	1
199-K-185	3/3/2020	PROJ_MAR_2020	119.023	119.425	-0.402	1
199-K-187	3/3/2020	PROJ_MAR_2020	121.077	121.052	0.025	1
199-K-19	3/3/2020	PROJ_MAR_2020	119.690	120.237	-0.547	1
199-K-191	3/3/2020	PROJ_MAR_2020	122.594	122.044	0.551	1
199-K-204	3/3/2020	PROJ_MAR_2020	119.553	119.592	-0.039	1
199-K-207	3/3/2020	PROJ_MAR_2020	119.686	120.204	-0.517	1
199-K-209	3/3/2020	PROJ_MAR_2020	120.652	120.650	0.002	5
199-K-21	3/3/2020	PROJ_MAR_2020	118.811	119.800	-0.989	1
199-K-22	3/3/2020	PROJ_MAR_2020	118.077	118.615	-0.538	1
199-K-223	3/3/2020	PROJ_MAR_2020	120.584	120.378	0.206	1
199-K-228	3/3/2020	PROJ_MAR_2020	120.143	120.357	-0.214	1
199-K-229	3/3/2020	PROJ_MAR_2020	120.376	120.264	0.112	1
199-K-231	3/3/2020	PROJ_MAR_2020	120.739	120.830	-0.091	1
199-K-232	3/3/2020	PROJ_MAR_2020	118.336	118.530	-0.194	1
199-K-236	3/3/2020	PROJ_MAR_2020	120.976	120.372	0.604	1
199-K-31	3/3/2020	PROJ_MAR_2020	119.117	119.689	-0.572	1
199-K-32A	3/3/2020	PROJ_MAR_2020	118.295	117.871	0.424	1
199-K-34	3/3/2020	PROJ_MAR_2020	119.698	119.617	0.081	1
199-K-36	3/3/2020	PROJ_MAR_2020	120.653	120.567	0.087	1
199-K-37	3/3/2020	PROJ_MAR_2020	118.678	118.547	0.131	1
199-N-105A	3/4/2020	PROJ_MAR_2020	118.443	118.430	0.013	1
199-N-119	3/4/2020	PROJ_MAR_2020	118.072	118.170	-0.098	1
199-N-14	3/4/2020	PROJ_MAR_2020	118.356	118.267	0.089	1

Table A-2. Measurements for 2020 Water Table Map

Well Name	Date	Data Group	Measured Water Level (m) NAVD88	Modeled Water Level (m) NAVD88	Residual (m)	Weight
199-N-165	3/4/2020	PROJ_MAR_2020	119.038	119.071	-0.033	1
199-N-18	3/4/2020	PROJ_MAR_2020	118.442	118.362	0.080	1
199-N-188	3/4/2020	PROJ_MAR_2020	118.750	118.755	-0.005	1
199-N-19	3/4/2020	PROJ_MAR_2020	118.379	118.337	0.042	1
199-N-2	3/4/2020	PROJ_MAR_2020	118.504	118.509	-0.005	1
199-N-27	3/4/2020	PROJ_MAR_2020	118.719	118.686	0.033	1
199-N-28	3/4/2020	PROJ_MAR_2020	118.822	118.815	0.007	1
199-N-3	3/4/2020	PROJ_MAR_2020	118.502	118.392	0.110	1
199-N-32	3/4/2020	PROJ_MAR_2020	118.669	118.673	-0.004	1
199-N-33	3/4/2020	PROJ_MAR_2020	118.608	118.677	-0.069	1
199-N-373	3/4/2020	PROJ_MAR_2020	118.727	118.767	-0.040	1
199-N-374	3/4/2020	PROJ_MAR_2020	118.530	118.462	0.068	1
199-N-376	3/4/2020	PROJ_MAR_2020	118.749	118.752	-0.003	1
199-N-41	3/4/2020	PROJ_MAR_2020	118.438	118.551	-0.113	1
199-N-50	3/4/2020	PROJ_MAR_2020	118.405	118.391	0.014	1
199-N-51	3/4/2020	PROJ_MAR_2020	118.176	118.037	0.139	1
199-N-52	3/4/2020	PROJ_MAR_2020	118.898	118.773	0.125	1
199-N-56	3/4/2020	PROJ_MAR_2020	118.584	118.580	0.004	1
199-N-57	3/4/2020	PROJ_MAR_2020	118.737	118.754	-0.017	1
199-N-62	3/4/2020	PROJ_MAR_2020	118.815	118.842	-0.027	1
199-N-64	3/4/2020	PROJ_MAR_2020	118.743	118.795	-0.052	1
199-N-67	3/4/2020	PROJ_MAR_2020	118.556	118.583	-0.027	1
199-N-71	3/4/2020	PROJ_MAR_2020	119.055	119.180	-0.125	1
199-N-73	3/4/2020	PROJ_MAR_2020	119.038	119.063	-0.025	1
199-N-74	3/4/2020	PROJ_MAR_2020	119.022	119.031	-0.009	1
199-N-76	3/4/2020	PROJ_MAR_2020	118.361	118.270	0.091	1
199-N-81	3/4/2020	PROJ_MAR_2020	118.536	118.581	-0.045	1
199-N-92A	3/4/2020	PROJ_MAR_2020	117.860	118.016	-0.155	1

Table A-2. Measurements for 2020 Water Table Map

Well Name	Date	Data Group	Measured Water Level (m) NAVD88	Modeled Water Level (m) NAVD88	Residual (m)	Weight
199-N-96A	3/4/2020	PROJ_MAR_2020	118.081	118.191	-0.110	1
199-N-99A	3/4/2020	PROJ_MAR_2020	117.901	118.099	-0.198	1
299-E17-18	2/20/2020	PROJ_FEB_2020	121.540	121.540	0.000	10
299-E17-21	2/28/2020	PROJ_FEB_2020	121.590	121.562	0.028	20
299-E17-22	2/20/2020	PROJ_FEB_2020	121.550	121.544	0.006	10
299-E17-23	2/28/2020	PROJ_FEB_2020	121.575	121.555	0.020	10
299-E17-25	2/28/2020	PROJ_FEB_2020	121.560	121.558	0.002	10
299-E18-1	1/27/2020	SAMP_JAN_2020	121.578	121.559	0.019	10
299-E18-2	2/19/2020	PROJ_FEB_2020	121.589	121.556	0.033	10
299-E23-1	2/19/2020	PROJ_FEB_2020	121.512	121.548	-0.036	1
299-E24-16	2/20/2020	PROJ_FEB_2020	121.568	121.542	0.026	10
299-E24-18	2/28/2020	PROJ_FEB_2020	121.538	121.545	-0.006	10
299-E24-21	2/28/2020	PROJ_FEB_2020	121.553	121.544	0.009	10
299-E24-22	1/29/2020	PROJ_JAN_2020	121.576	121.541	0.035	10
299-E24-24	2/28/2020	PROJ_FEB_2020	121.564	121.549	0.015	10
299-E24-25	2/20/2020	PROJ_FEB_2020	121.533	121.544	-0.011	10
299-E24-33	2/28/2020	PROJ_FEB_2020	121.604	121.541	0.063	1
299-E25-19	2/19/2020	PROJ_FEB_2020	121.545	121.534	0.011	20
299-E25-24	2/19/2020	PROJ_FEB_2020	121.539	121.526	0.013	10
299-E25-32P	2/4/2020	SAMP_FEB_2020	121.546	121.531	0.015	10
299-E25-34	2/19/2020	PROJ_FEB_2020	121.542	121.534	0.008	10
299-E25-35	2/19/2020	PROJ_FEB_2020	121.530	121.536	-0.006	10
299-E25-36	2/19/2020	PROJ_FEB_2020	121.533	121.539	-0.006	10
299-E25-93	2/28/2020	PROJ_FEB_2020	121.573	121.539	0.034	10
299-E26-10	2/19/2020	PROJ_FEB_2020	121.571	121.583	-0.012	10
299-E26-13	2/19/2020	PROJ_FEB_2020	121.549	121.539	0.010	10
299-E26-14	2/19/2020	PROJ_FEB_2020	121.662	121.657	0.005	10
299-E26-15	2/26/2020	PROJ_FEB_2020	121.571	121.599	-0.028	10

Table A-2. Measurements for 2020 Water Table Map

Well Name	Date	Data Group	Measured Water Level (m) NAVD88	Modeled Water Level (m) NAVD88	Residual (m)	Weight
299-E26-4	2/19/2020	PROJ_FEB_2020	121.546	121.538	0.008	10
299-E26-77	2/19/2020	PROJ_FEB_2020	121.651	121.618	0.033	10
299-E26-79	2/19/2020	PROJ_FEB_2020	121.597	121.596	0.001	10
299-E27-12	2/20/2020	PROJ_FEB_2020	121.557	121.543	0.014	10
299-E27-137B	2/19/2020	PROJ_FEB_2020	121.523	121.546	-0.023	20
299-E27-14	2/20/2020	PROJ_FEB_2020	121.559	121.542	0.017	20
299-E27-17	2/19/2020	PROJ_FEB_2020	121.539	121.546	-0.007	10
299-E27-18	2/19/2020	PROJ_FEB_2020	121.556	121.546	0.010	10
299-E27-21	2/28/2020	PROJ_FEB_2020	121.586	121.542	0.044	10
299-E27-23	2/20/2020	PROJ_FEB_2020	121.554	121.542	0.012	10
299-E27-8	2/19/2020	PROJ_FEB_2020	121.553	121.544	0.009	10
299-E28-1	2/19/2020	PROJ_FEB_2020	121.543	121.548	-0.005	60
299-E28-17	2/19/2020	PROJ_FEB_2020	121.542	121.551	-0.009	60
299-E28-18	2/19/2020	PROJ_FEB_2020	121.554	121.553	0.002	10
299-E28-27	2/19/2020	PROJ_FEB_2020	121.551	121.551	0.000	10
299-E32-6	2/20/2020	PROJ_FEB_2020	121.557	121.557	0.000	10
299-E32-8	2/20/2020	PROJ_FEB_2020	121.559	121.558	0.001	10
299-E33-14	2/28/2020	PROJ_FEB_2020	121.582	121.569	0.014	10
299-E33-28	2/20/2020	PROJ_FEB_2020	121.548	121.552	-0.004	10
299-E33-31	2/20/2020	PROJ_FEB_2020	121.550	121.548	0.002	10
299-E33-334	2/20/2020	PROJ_FEB_2020	121.553	121.549	0.004	10
299-E33-339	2/20/2020	PROJ_FEB_2020	121.551	121.548	0.003	10
299-E33-34	2/20/2020	PROJ_FEB_2020	121.554	121.555	-0.001	10
299-E33-37	2/20/2020	PROJ_FEB_2020	121.559	121.546	0.013	1
299-E33-38	2/20/2020	PROJ_FEB_2020	121.552	121.549	0.003	10
299-E33-41	2/20/2020	PROJ_FEB_2020	121.550	121.547	0.003	10
299-E33-42	2/20/2020	PROJ_FEB_2020	121.551	121.549	0.002	10
299-E33-49	2/20/2020	PROJ_FEB_2020	121.558	121.548	0.010	10

Table A-2. Measurements for 2020 Water Table Map

Well Name	Date	Data Group	Measured Water Level (m) NAVD88	Modeled Water Level (m) NAVD88	Residual (m)	Weight
299-E34-9	2/20/2020	PROJ_FEB_2020	121.560	121.555	0.005	10
299-W10-1	3/16/2020	PROJ_MAR_2020	132.219	132.093	0.126	1
299-W10-23	3/16/2020	PROJ_MAR_2020	130.777	131.117	-0.340	1
299-W10-24	3/16/2020	PROJ_MAR_2020	130.362	130.514	-0.152	1
299-W10-26	2/19/2020	SAMP_FEB_2020	129.451	129.540	-0.089	1
299-W10-27	2/18/2020	SAMP_FEB_2020	129.528	129.690	-0.162	1
299-W10-28	3/16/2020	PROJ_MAR_2020	131.422	131.722	-0.300	1
299-W10-29	3/16/2020	PROJ_MAR_2020	136.463	136.472	-0.009	2
299-W10-30	3/16/2020	PROJ_MAR_2020	136.499	136.543	-0.043	2
299-W10-31	3/16/2020	PROJ_MAR_2020	135.827	135.552	0.275	2
299-W11-18	3/16/2020	PROJ_MAR_2020	130.359	130.371	-0.012	1
299-W11-39	3/16/2020	PROJ_MAR_2020	130.147	130.154	-0.007	1
299-W11-40	3/16/2020	PROJ_MAR_2020	129.882	129.691	0.191	1
299-W11-41	3/16/2020	PROJ_MAR_2020	129.744	129.610	0.134	1
299-W11-42	3/16/2020	PROJ_MAR_2020	130.163	129.814	0.349	1
299-W11-45	3/16/2020	PROJ_MAR_2020	129.581	129.456	0.125	1
299-W11-47	3/16/2020	PROJ_MAR_2020	129.684	129.626	0.058	1
299-W14-13	2/20/2020	SAMP_FEB_2020	128.057	128.074	-0.017	3
299-W14-14	2/20/2020	SAMP_FEB_2020	129.073	129.123	-0.050	1
299-W14-15	2/20/2020	SAMP_FEB_2020	128.749	128.846	-0.097	1
299-W14-18	2/19/2020	SAMP_FEB_2020	128.686	128.847	-0.161	1
299-W14-19	2/20/2020	SAMP_FEB_2020	129.117	129.283	-0.166	1
299-W15-11	2/26/2020	SAMP_FEB_2020	135.066	134.570	0.496	1
299-W15-152	1/26/2020	SAMP_JAN_2020	135.153	135.204	-0.051	1
299-W15-224	1/26/2020	SAMP_JAN_2020	135.246	135.412	-0.166	1
299-W15-30	1/26/2020	SAMP_JAN_2020	135.402	135.409	-0.006	1
299-W15-83	1/26/2020	SAMP_JAN_2020	135.387	135.434	-0.047	1
299-W15-94	1/26/2020	SAMP_JAN_2020	135.225	135.331	-0.106	1

Table A-2. Measurements for 2020 Water Table Map

Well Name	Date	Data Group	Measured Water Level (m) NAVD88	Modeled Water Level (m) NAVD88	Residual (m)	Weight
299-W17-1	1/22/2020	SAMP_JAN_2020	137.269	137.539	-0.270	1
299-W18-15	3/17/2020	SAMP_MAR_2020	134.520	134.516	0.004	1
299-W18-21	3/5/2020	SAMP_MAR_2020	137.415	136.881	0.534	1
299-W18-260	1/23/2020	SAMP_JAN_2020	131.690	131.372	0.319	0
299-W18-40	1/22/2020	SAMP_JAN_2020	132.819	132.716	0.103	1
299-W19-105	2/11/2020	SAMP_FEB_2020	129.560	129.055	0.505	1
299-W19-107	2/28/2020	SAMP_FEB_2020	127.190	127.194	-0.004	1
299-W19-41	1/22/2020	SAMP_JAN_2020	131.703	131.637	0.066	1
299-W19-42	1/22/2020	SAMP_JAN_2020	131.633	131.361	0.272	1
299-W19-43	2/28/2020	SAMP_FEB_2020	127.032	127.116	-0.084	5
299-W19-44	1/22/2020	SAMP_JAN_2020	131.605	131.562	0.043	1
299-W19-45	1/22/2020	SAMP_JAN_2020	131.595	131.452	0.143	1
299-W19-47	1/22/2020	SAMP_JAN_2020	131.623	131.248	0.375	1
299-W22-113	3/9/2020	SAMP_MAR_2020	131.975	131.800	0.176	1
299-W22-115	3/6/2020	SAMP_MAR_2020	131.809	131.781	0.028	1
299-W22-116	3/9/2020	SAMP_MAR_2020	131.755	131.517	0.238	1
299-W22-80	3/6/2020	SAMP_MAR_2020	132.098	132.144	-0.046	1
299-W22-81	3/5/2020	SAMP_MAR_2020	131.466	131.463	0.003	1
299-W22-84	3/9/2020	SAMP_MAR_2020	131.319	131.451	-0.132	1
299-W22-85	3/6/2020	SAMP_MAR_2020	131.971	131.944	0.027	1
299-W22-93	3/9/2020	SAMP_MAR_2020	131.117	131.376	-0.259	1
299-W22-94	3/6/2020	SAMP_MAR_2020	131.332	131.324	0.008	1
299-W23-21	3/6/2020	SAMP_MAR_2020	132.819	133.002	-0.183	1
299-W26-13	2/28/2020	SAMP_FEB_2020	133.396	133.410	-0.014	1
299-W7-4	3/16/2020	PROJ_MAR_2020	134.561	134.647	-0.086	1
299-W8-1	3/16/2020	PROJ_MAR_2020	136.150	136.150	0.000	1
299-W9-2	3/16/2020	PROJ_MAR_2020	136.752	136.737	0.015	1
3099-47-18B	3/13/2020	PROJ_MAR_2020	104.910	104.695	0.215	1

Table A-2. Measurements for 2020 Water Table Map

Well Name	Date	Data Group	Measured Water Level (m) NAVD88	Modeled Water Level (m) NAVD88	Residual (m)	Weight
399-1-1	3/12/2020	PROJ_MAR_2020	105.173	105.175	-0.002	1
399-1-10A	3/12/2020	PROJ_MAR_2020	105.168	105.195	-0.027	1
399-1-13A	3/12/2020	PROJ_MAR_2020	105.252	105.328	-0.076	1
399-1-14A	3/12/2020	PROJ_MAR_2020	105.286	105.333	-0.047	1
399-1-16A	3/12/2020	PROJ_MAR_2020	105.100	105.175	-0.075	1
399-1-17A	3/12/2020	PROJ_MAR_2020	105.159	105.255	-0.096	1
399-1-18A	3/12/2020	PROJ_MAR_2020	105.512	105.382	0.130	1
399-1-21A	3/12/2020	PROJ_MAR_2020	105.113	105.236	-0.123	1
399-1-6	3/12/2020	PROJ_MAR_2020	105.291	105.267	0.024	1
399-2-3	3/12/2020	PROJ_MAR_2020	105.081	105.141	-0.059	1
399-3-10	3/13/2020	PROJ_MAR_2020	104.978	105.065	-0.087	1
399-3-12	3/13/2020	PROJ_MAR_2020	105.037	105.217	-0.180	1
399-3-18	3/13/2020	PROJ_MAR_2020	105.013	105.099	-0.086	1
399-3-20	3/13/2020	PROJ_MAR_2020	105.010	105.145	-0.134	1
399-3-6	3/13/2020	PROJ_MAR_2020	105.135	105.344	-0.209	1
399-4-1	3/13/2020	PROJ_MAR_2020	104.969	105.197	-0.228	1
399-4-11	3/13/2020	PROJ_MAR_2020	105.038	105.279	-0.241	1
399-4-7	3/13/2020	PROJ_MAR_2020	104.908	105.002	-0.094	1
399-5-1	3/13/2020	PROJ_MAR_2020	105.204	105.487	-0.283	1
399-5-4B	3/13/2020	PROJ_MAR_2020	105.150	105.465	-0.315	1
399-6-1	3/13/2020	PROJ_MAR_2020	105.317	105.592	-0.275	1
399-8-1	3/10/2020	PROJ_MAR_2020	105.363	105.467	-0.104	1
399-8-2	3/10/2020	PROJ_MAR_2020	105.650	105.807	-0.157	1
399-8-3	3/10/2020	PROJ_MAR_2020	105.455	105.461	-0.006	1
399-8-4	3/10/2020	PROJ_MAR_2020	106.198	106.222	-0.024	1
399-8-5A	3/10/2020	PROJ_MAR_2020	105.569	105.631	-0.062	1
699-100-43B	3/5/2020	PROJ_MAR_2020	115.934	115.847	0.087	1
699-101-45	3/5/2020	PROJ_MAR_2020	115.310	116.081	-0.771	0

Table A-2. Measurements for 2020 Water Table Map

Well Name	Date	Data Group	Measured Water Level (m) NAVD88	Modeled Water Level (m) NAVD88	Residual (m)	Weight
699-101-48B	3/5/2020	PROJ_MAR_2020	116.679	116.270	0.409	2
699-10-E12Q	2/26/2020	PROJ_FEB_2020	109.354	109.338	0.016	1
699-11-45A	3/17/2020	PROJ_MAR_2020	125.998	126.027	-0.029	1
699-1-18	3/13/2020	PROJ_MAR_2020	120.399	120.464	-0.065	1
699-14-38	3/13/2020	PROJ_MAR_2020	123.403	123.406	-0.003	3
699-15-26	3/17/2020	PROJ_MAR_2020	120.970	120.993	-0.023	3
699-20-20	3/13/2020	PROJ_MAR_2020	120.895	120.869	0.026	3
699-20-E12	2/28/2020	PROJ_FEB_2020	109.308	109.321	-0.013	1
699-20-E5A	2/28/2020	PROJ_FEB_2020	112.964	112.940	0.024	1
699-2-3	1/7/2020	SAMP_JAN_2020	117.680	117.635	0.045	2
699-2-33A	3/17/2020	PROJ_MAR_2020	123.605	123.566	0.039	1
699-24-33	2/13/2020	PROJ_FEB_2020	121.401	121.432	-0.031	1
699-24-46	2/28/2020	SAMP_FEB_2020	122.026	122.115	-0.089	1
699-25-34B	1/13/2020	SAMP_JAN_2020	121.437	121.437	0.000	1
699-25-34D	1/14/2020	SAMP_JAN_2020	121.433	121.437	-0.004	10
699-25-34F	1/14/2020	SAMP_JAN_2020	121.444	121.437	0.007	10
699-26-33A	1/13/2020	SAMP_JAN_2020	121.439	121.437	0.002	10
699-26-34A	1/14/2020	SAMP_JAN_2020	121.447	121.438	0.009	1
699-26-34B	1/13/2020	SAMP_JAN_2020	121.441	121.437	0.004	10
699-26-38	1/14/2020	SAMP_JAN_2020	121.434	121.441	-0.007	20
699-26-89	2/28/2020	SAMP_FEB_2020	140.241	140.267	-0.026	1
699-29-4	2/28/2020	PROJ_FEB_2020	115.954	116.061	-0.107	1
699-31-31	2/28/2020	PROJ_FEB_2020	121.383	121.434	-0.051	1
699-32-22A	1/20/2020	SAMP_JAN_2020	120.784	120.788	-0.004	6
699-32-43	1/20/2020	SAMP_JAN_2020	121.526	121.497	0.029	1
699-33-56	1/16/2020	SAMP_JAN_2020	121.804	121.926	-0.122	1
699-34-39A	2/13/2020	PROJ_FEB_2020	121.503	121.499	0.004	1
699-34-61	2/18/2020	PROJ_FEB_2020	125.768	125.731	0.037	1

Table A-2. Measurements for 2020 Water Table Map

Well Name	Date	Data Group	Measured Water Level (m) NAVD88	Modeled Water Level (m) NAVD88	Residual (m)	Weight
699-34-72	2/3/2020	SAMP_FEB_2020	130.170	130.260	-0.090	3
699-35-66A	2/18/2020	PROJ_FEB_2020	128.760	129.055	-0.295	3
699-35-78A	2/28/2020	SAMP_FEB_2020	135.147	135.321	-0.174	1
699-35-9	2/28/2020	PROJ_FEB_2020	116.336	116.216	0.120	1
699-36-61A	2/18/2020	PROJ_FEB_2020	123.926	123.957	-0.031	1
699-36-66B	2/18/2020	PROJ_FEB_2020	128.789	128.968	-0.179	5
699-36-70A	3/5/2020	SAMP_MAR_2020	129.516	129.319	0.197	1
699-37-43	2/20/2020	PROJ_FEB_2020	121.522	121.511	0.011	1
699-37-47A	2/20/2020	PROJ_FEB_2020	121.530	121.519	0.011	1
699-37-66	2/18/2020	PROJ_FEB_2020	128.480	128.913	-0.433	1
699-38-61	2/18/2020	PROJ_FEB_2020	123.704	123.718	-0.014	1
699-38-65	2/18/2020	PROJ_FEB_2020	128.449	128.984	-0.535	1
699-38-68A	2/5/2020	SAMP_FEB_2020	129.079	128.824	0.255	5
699-39-0	3/10/2020	PROJ_MAR_2020	111.139	110.492	0.647	0
699-39-68	3/6/2020	SAMP_MAR_2020	128.899	128.704	0.195	5
699-40-12C	3/10/2020	PROJ_MAR_2020	116.638	116.667	-0.029	1
699-40-62	2/18/2020	PROJ_FEB_2020	122.544	122.630	-0.086	1
699-40-65	2/18/2020	PROJ_FEB_2020	126.551	126.610	-0.059	1
699-42-2	3/10/2020	PROJ_MAR_2020	109.952	109.821	0.131	5
699-43-45	1/8/2020	SAMP_JAN_2020	121.609	121.542	0.067	1
699-43-9	3/10/2020	PROJ_MAR_2020	110.979	110.975	0.004	1
699-46-4	3/10/2020	PROJ_MAR_2020	109.451	109.696	-0.245	5
699-46-61	2/20/2020	PROJ_FEB_2020	121.918	121.637	0.281	0
699-47-60	2/20/2020	PROJ_FEB_2020	121.668	121.646	0.022	5
699-48-18	3/10/2020	PROJ_MAR_2020	110.754	110.705	0.049	1
699-48-71	1/14/2020	SAMP_JAN_2020	128.223	128.228	-0.005	5
699-48-77D	2/18/2020	PROJ_FEB_2020	133.934	134.021	-0.087	1
699-49-13E	3/10/2020	PROJ_MAR_2020	110.694	110.636	0.058	4

Table A-2. Measurements for 2020 Water Table Map

Well Name	Date	Data Group	Measured Water Level (m) NAVD88	Modeled Water Level (m) NAVD88	Residual (m)	Weight
699-49-55A	2/20/2020	PROJ_FEB_2020	121.580	121.577	0.003	10
699-49-57A	2/20/2020	PROJ_FEB_2020	121.558	121.585	-0.027	1
699-50-56	2/20/2020	PROJ_FEB_2020	121.573	121.608	-0.035	10
699-51-63	2/13/2020	PROJ_FEB_2020	122.396	121.659	0.737	1
699-51-75	1/23/2020	SAMP_JAN_2020	131.604	131.436	0.168	1
699-52-55	2/13/2020	PROJ_FEB_2020	121.653	121.607	0.046	10
699-54-18B	3/10/2020	PROJ_MAR_2020	110.817	110.706	0.111	1
699-55-55	2/13/2020	PROJ_FEB_2020	121.526	121.605	-0.078	5
699-55-60A	2/13/2020	PROJ_FEB_2020	121.563	121.577	-0.014	1
699-55-76	1/23/2020	SAMP_JAN_2020	131.129	131.452	-0.323	1
699-57-29A	3/6/2020	PROJ_MAR_2020	110.784	110.816	-0.032	5
699-57-59	2/13/2020	PROJ_FEB_2020	121.541	121.568	-0.027	1
699-58-24	3/6/2020	PROJ_MAR_2020	110.766	110.723	0.043	1
699-59-58	2/13/2020	PROJ_FEB_2020	121.562	121.559	0.003	1
699-60-27	3/6/2020	PROJ_MAR_2020	110.779	110.735	0.044	1
699-60-32	3/6/2020	PROJ_MAR_2020	110.801	110.785	0.016	5
699-60-57	2/13/2020	PROJ_FEB_2020	121.558	121.553	0.005	1
699-60-60	2/13/2020	PROJ_FEB_2020	121.538	121.519	0.019	1
699-61-37	3/6/2020	PROJ_MAR_2020	116.649	116.641	0.008	1
699-61-62	2/13/2020	PROJ_FEB_2020	121.557	121.514	0.043	1
699-61-66	2/13/2020	PROJ_FEB_2020	121.523	121.489	0.034	1
699-62-31	3/6/2020	PROJ_MAR_2020	110.771	110.790	-0.019	1
699-63-25A	3/6/2020	PROJ_MAR_2020	110.767	110.793	-0.026	2
699-63-55	3/9/2020	PROJ_MAR_2020	121.438	121.504	-0.066	1
699-63-58	3/9/2020	PROJ_MAR_2020	121.454	121.446	0.009	1
699-63-90	3/3/2020	PROJ_MAR_2020	122.813	122.812	0.001	5
699-64-27	3/6/2020	PROJ_MAR_2020	110.777	110.788	-0.011	1
699-64-62	2/13/2020	PROJ_FEB_2020	121.465	121.434	0.031	1

Table A-2. Measurements for 2020 Water Table Map

Well Name	Date	Data Group	Measured Water Level (m) NAVD88	Modeled Water Level (m) NAVD88	Residual (m)	Weight
699-65-22	3/6/2020	PROJ_MAR_2020	111.185	111.303	-0.118	1
699-65-50	3/9/2020	PROJ_MAR_2020	121.306	121.234	0.072	1
699-65-59A	3/9/2020	PROJ_MAR_2020	121.460	121.409	0.051	1
699-65-72	2/13/2020	PROJ_FEB_2020	121.429	121.468	-0.039	1
699-65-83	3/3/2020	PROJ_MAR_2020	121.548	121.751	-0.203	1
699-66-103	3/3/2020	PROJ_MAR_2020	122.338	122.230	0.108	1
699-66-23	3/6/2020	PROJ_MAR_2020	111.371	111.517	-0.146	1
699-66-64	2/13/2020	PROJ_FEB_2020	121.429	121.448	-0.019	1
699-67-26	3/6/2020	PROJ_MAR_2020	112.513	112.511	0.002	5
699-67-51	3/9/2020	PROJ_MAR_2020	121.309	121.228	0.081	1
699-67-86	3/3/2020	PROJ_MAR_2020	121.667	121.830	-0.163	1
699-68-105	3/3/2020	PROJ_MAR_2020	122.546	122.258	0.289	1
699-69-45O	3/9/2020	PROJ_MAR_2020	121.339	121.132	0.207	1
699-70-23	3/6/2020	PROJ_MAR_2020	111.769	111.911	-0.142	5
699-70-29	3/6/2020	PROJ_MAR_2020	113.168	113.175	-0.007	5
699-71-24	3/6/2020	PROJ_MAR_2020	111.972	111.964	0.008	5
699-71-30C	3/6/2020	PROJ_MAR_2020	113.873	113.361	0.512	1
699-71-34	3/6/2020	PROJ_MAR_2020	114.675	114.686	-0.011	5
699-71-52	3/9/2020	PROJ_MAR_2020	121.096	121.167	-0.071	1
699-71-77	3/3/2020	PROJ_MAR_2020	121.183	121.341	-0.158	1
699-72-73	3/3/2020	PROJ_MAR_2020	121.043	121.261	-0.218	1
699-72-92	3/3/2020	PROJ_MAR_2020	121.960	122.140	-0.180	1
699-73-30	3/6/2020	PROJ_MAR_2020	113.721	113.531	0.190	1
699-73-61	3/9/2020	PROJ_MAR_2020	121.391	121.363	0.028	1
699-74-44	3/9/2020	PROJ_MAR_2020	121.188	121.103	0.085	1
699-75-28	3/6/2020	PROJ_MAR_2020	112.572	112.588	-0.016	5
699-75-31	3/6/2020	PROJ_MAR_2020	114.336	113.880	0.456	1
699-75-34B	3/6/2020	PROJ_MAR_2020	114.776	114.715	0.061	1

Table A-2. Measurements for 2020 Water Table Map

Well Name	Date	Data Group	Measured Water Level (m) NAVD88	Modeled Water Level (m) NAVD88	Residual (m)	Weight
699-77-34B	3/6/2020	PROJ_MAR_2020	114.799	114.808	-0.009	1
699-77-36	3/6/2020	PROJ_MAR_2020	115.370	115.193	0.177	1
699-77-54	3/9/2020	PROJ_MAR_2020	120.510	120.828	-0.318	1
699-78-62	3/3/2020	PROJ_MAR_2020	123.594	123.530	0.064	1
699-80-43S	3/9/2020	PROJ_MAR_2020	118.448	118.268	0.180	1
699-81-38	3/9/2020	PROJ_MAR_2020	116.211	116.363	-0.152	1
699-81-58	3/9/2020	PROJ_MAR_2020	119.828	119.600	0.228	1
699-8-17	3/13/2020	PROJ_MAR_2020	120.383	120.510	-0.127	1
699-8-25	3/17/2020	PROJ_MAR_2020	120.746	120.657	0.089	3
699-8-32	3/17/2020	PROJ_MAR_2020	121.253	121.486	-0.233	1
699-83-47	3/9/2020	PROJ_MAR_2020	118.888	118.827	0.061	1
699-84-35AO	3/6/2020	PROJ_MAR_2020	115.103	115.057	0.046	3
699-86-42	3/9/2020	PROJ_MAR_2020	118.046	117.936	0.110	1
699-87-55	3/4/2020	PROJ_MAR_2020	118.641	118.770	-0.129	1
699-88-41	3/5/2020	PROJ_MAR_2020	117.488	117.662	-0.174	1
699-88-41A	3/5/2020	PROJ_MAR_2020	117.076	116.945	0.131	1
699-89-35	3/5/2020	PROJ_MAR_2020	114.383	114.651	-0.268	1
699-90-37B	3/5/2020	PROJ_MAR_2020	114.913	114.888	0.025	1
699-90-45	3/9/2020	PROJ_MAR_2020	118.345	118.580	-0.235	1
699-91-46A	3/9/2020	PROJ_MAR_2020	118.357	118.635	-0.278	1
699-93-37A	3/5/2020	PROJ_MAR_2020	114.766	114.904	-0.138	1
699-93-48A	3/5/2020	PROJ_MAR_2020	118.237	118.522	-0.285	1
699-94-41	3/5/2020	PROJ_MAR_2020	115.897	115.809	0.088	1
699-94-43	3/5/2020	PROJ_MAR_2020	117.137	117.360	-0.222	1
699-95-45	3/5/2020	PROJ_MAR_2020	117.633	117.527	0.106	1
699-95-48	3/5/2020	PROJ_MAR_2020	117.995	117.960	0.035	1
699-95-51	3/5/2020	PROJ_MAR_2020	118.051	118.201	-0.150	1
699-96-43	3/5/2020	PROJ_MAR_2020	116.825	116.665	0.160	1

Table A-2. Measurements for 2020 Water Table Map

Well Name	Date	Data Group	Measured Water Level (m) NAVD88	Modeled Water Level (m) NAVD88	Residual (m)	Weight
699-96-52B	3/5/2020	PROJ_MAR_2020	116.822	116.968	-0.146	2
699-97-41	3/5/2020	PROJ_MAR_2020	114.739	114.601	0.138	1
699-97-43B	3/5/2020	PROJ_MAR_2020	116.090	116.062	0.028	1
699-97-45	3/5/2020	PROJ_MAR_2020	117.310	117.277	0.033	1
699-97-48B	3/5/2020	PROJ_MAR_2020	117.772	117.652	0.121	1
699-97-51A	3/5/2020	PROJ_MAR_2020	117.630	117.804	-0.174	1
699-98-43	3/5/2020	PROJ_MAR_2020	115.364	115.812	-0.448	1
699-98-46	3/5/2020	PROJ_MAR_2020	117.118	117.189	-0.071	2
699-98-49A	3/5/2020	PROJ_MAR_2020	117.561	117.620	-0.059	1
699-98-51	3/5/2020	PROJ_MAR_2020	117.558	117.560	-0.002	1
699-99-41	3/5/2020	PROJ_MAR_2020	115.667	115.606	0.061	1
699-99-42B	3/5/2020	PROJ_MAR_2020	115.656	115.718	-0.062	1
699-99-44	3/5/2020	PROJ_MAR_2020	116.099	116.038	0.061	1
699-9-E2	3/2/2020	SAMP_MAR_2020	113.525	113.534	-0.009	1
699-S11-E12A	2/26/2020	PROJ_FEB_2020	107.075	107.274	-0.199	1
699-S12-29	3/13/2020	PROJ_MAR_2020	123.520	125.158	-1.638	1
699-S14-20A	3/13/2020	PROJ_MAR_2020	122.658	122.142	0.516	3
699-S19-11	2/26/2020	PROJ_FEB_2020	119.192	119.448	-0.256	2
699-S19-E13	3/10/2020	PROJ_MAR_2020	105.698	105.430	0.268	1
699-S19-E14	3/10/2020	PROJ_MAR_2020	105.601	105.358	0.243	1
699-S20-E10	3/10/2020	PROJ_MAR_2020	106.009	105.807	0.202	1
699-S22-E9A	3/10/2020	PROJ_MAR_2020	106.258	106.454	-0.196	1
699-S24-19Q	3/13/2020	PROJ_MAR_2020	122.403	122.632	-0.229	1
699-S27-E12A	3/13/2020	PROJ_MAR_2020	105.912	105.841	0.071	1
699-S27-E14	3/13/2020	PROJ_MAR_2020	104.971	105.305	-0.334	1
699-S27-E9A	3/13/2020	PROJ_MAR_2020	107.486	106.841	0.645	1
699-S28-E13A	3/13/2020	PROJ_MAR_2020	105.708	105.691	0.017	1
699-S29-E10A	3/13/2020	PROJ_MAR_2020	106.980	106.752	0.228	1

Table A-2. Measurements for 2020 Water Table Map

Well Name	Date	Data Group	Measured Water Level (m) NAVD88	Modeled Water Level (m) NAVD88	Residual (m)	Weight
699-S29-E11	3/13/2020	PROJ_MAR_2020	106.837	106.546	0.291	1
699-S29-E12	3/13/2020	PROJ_MAR_2020	106.243	105.899	0.344	1
699-S29-E13A	3/12/2020	PROJ_MAR_2020	105.915	105.607	0.308	1
699-S29-E16A	3/12/2020	PROJ_MAR_2020	104.953	104.857	0.096	1
699-S30-E10A	3/13/2020	PROJ_MAR_2020	107.724	107.496	0.229	1
699-S30-E11A	3/13/2020	PROJ_MAR_2020	106.397	106.306	0.091	1
699-S30-E15A	3/12/2020	PROJ_MAR_2020	105.000	105.131	-0.131	1
699-S31-E10B	3/13/2020	PROJ_MAR_2020	107.731	107.462	0.269	1
699-S31-E11	3/13/2020	PROJ_MAR_2020	106.522	106.467	0.055	1
699-S31-E8A	3/13/2020	PROJ_MAR_2020	109.400	110.002	-0.602	2
699-S3-25	3/13/2020	PROJ_MAR_2020	120.998	121.402	-0.404	2
699-S32-E13A	3/13/2020	PROJ_MAR_2020	106.199	105.870	0.329	1
699-S32-E13B	3/13/2020	PROJ_MAR_2020	106.327	106.117	0.210	1
699-S34-E15	3/13/2020	PROJ_MAR_2020	105.758	105.625	0.133	1
699-S36-E13A	3/13/2020	PROJ_MAR_2020	107.257	107.271	-0.014	1
699-S37-E14	3/13/2020	PROJ_MAR_2020	107.120	107.539	-0.419	1
699-S3-E12	2/26/2020	PROJ_FEB_2020	108.456	108.621	-0.165	1
699-S41-E12	3/13/2020	PROJ_MAR_2020	108.129	108.109	0.020	1
699-S42-E8A	3/13/2020	PROJ_MAR_2020	108.782	108.972	-0.190	1
699-S43-E7A	3/13/2020	PROJ_MAR_2020	109.615	109.397	0.218	1
699-S6-E14A	2/26/2020	PROJ_FEB_2020	107.485	106.904	0.581	1
699-S6-E4K	2/13/2020	SAMP_FEB_2020	113.400	113.417	-0.017	1
699-S8-19	3/13/2020	PROJ_MAR_2020	120.535	120.552	-0.017	3
SPC-P-1	3/17/2020	PROJ_MAR_2020	114.829	114.175	0.654	2
699-2-7	N/A	N/A	118.547 *	118.713	-0.166	2
699-26-15A	N/A	N/A	120.257 *	120.059	0.201	1
699-31-11	N/A	N/A	118.216 *	118.329	-0.113	1
699-19-88	N/A	N/A	157.390 *	157.392	-0.002	1

Table A-2. Measurements for 2020 Water Table Map

Well Name	Date	Data Group	Measured Water Level (m) NAVD88	Modeled Water Level (m) NAVD88	Residual (m)	Weight
699-25-70	N/A	N/A	129.919 *	130.111	-0.192	1
699-25-55	N/A	N/A	124.120 *	124.108	0.012	1
699-34-88	N/A	N/A	138.635 *	138.531	0.104	1
699-43-89	N/A	N/A	137.723 *	138.121	-0.398	1
699-55-89	N/A	N/A	132.212 *	132.200	0.013	1
699-55-70	N/A	N/A	128.336 *	128.366	-0.030	1
699-S31-1	N/A	N/A	117.143 *	117.064	0.079	2
699-21-6	N/A	N/A	117.841 *	117.775	0.066	1
699-15-15A	N/A	N/A	120.223 *	120.234	-0.011	2

Reference: NAVD88, N*orth American Vertical Datum of 1988*.
*Extrapolated; see Table A-3

PROJ_FEB_2020, PROJ_JAN_2020, and PROJ_MAR_2020 = project measurements scheduled for February, January, and March 2020, respectively

SAMP_FEB_2020, SAMP_JAN_2020, and SAMP_MAR_2020 = measurements prior to sampling in February, January, and March 2020, respectively

N/A = not applicable (no measurements made in first quarter of 2020)

Table A-3. Summary of Data Used for Extrapolating Control Points

Well	Data Period	Number of Data Points	2020 Estimated Water Level (m NAVD88)	Trend Line
699-15-15A	2015-2019	5	120.22	Linear
699-19-88	2016-2019	15	157.39	Linear
699-21-6	2017-2019	4	117.84	Linear
699-25-55	2017-2019	5	124.12	Linear
699-25-70	2013-2019	12	129.92	Linear
699-26-15A	2013-2019	9	120.26	Linear
699-2-7	2018-2019	4	118.55	Linear
699-31-11	2001-2019	9	118.22	Polynomial
699-34-88	2017-2019	4	138.635	Linear
699-43-89	2018-2019	3	137.72	Linear
699-55-70	2014-2019	6	128.34	Linear
699-55-89	2013-2019	8	132.21	Linear
699-S31-1	2015-2019	5	117.143	Linear

Reference: NAVD88, *North American Vertical Datum of 1988*.

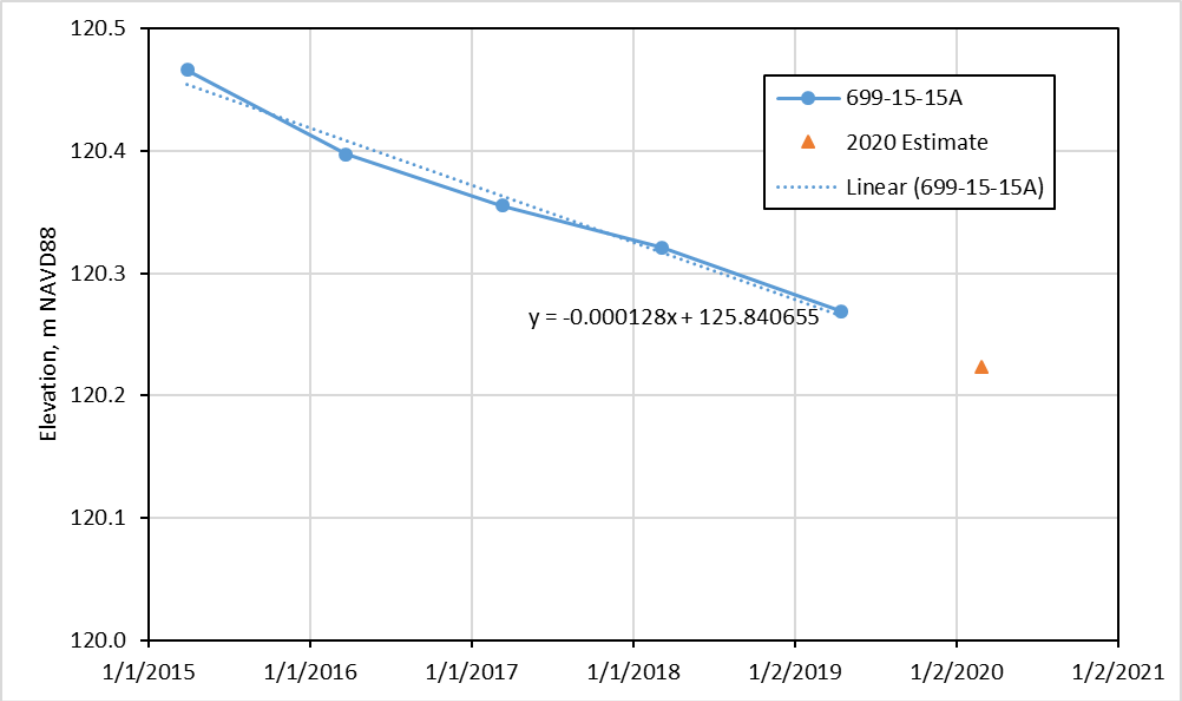

Figure A-1. Extrapolated Water Level Trend for Well 699-15-15A

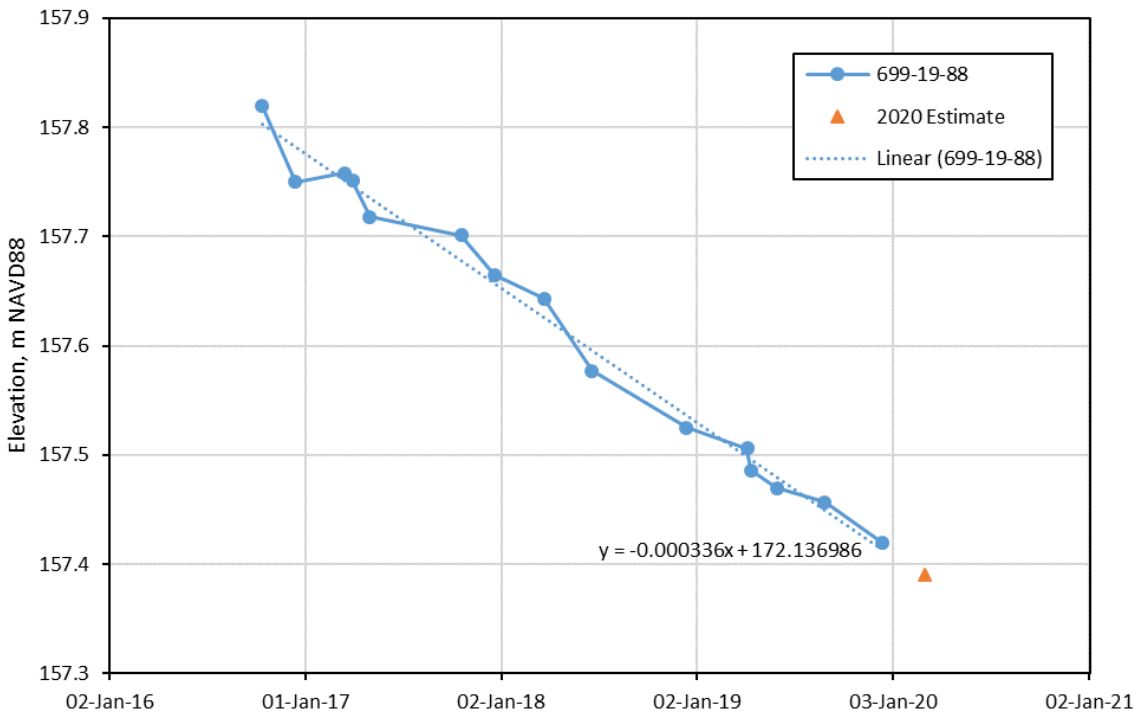

Figure A-2. Extrapolated Water Level Trend for Well 699-19-88

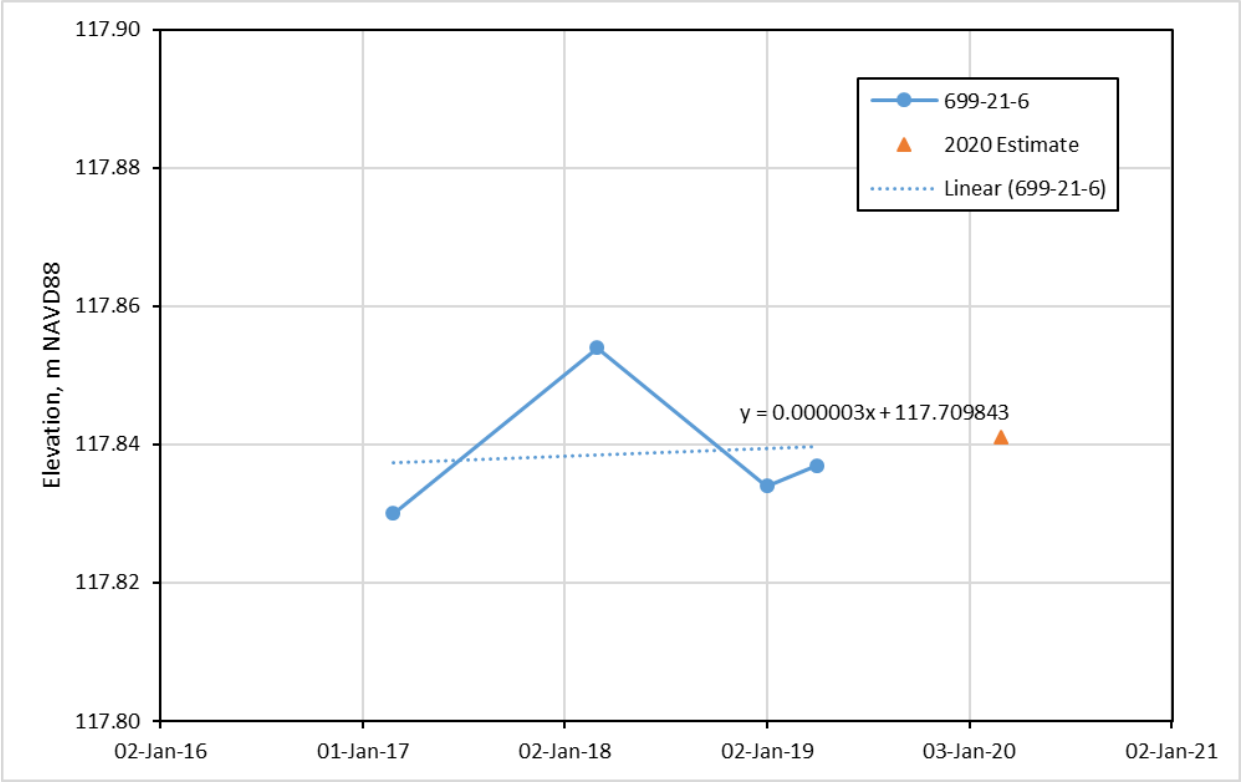

Figure A-3. Extrapolated Water Level Trend for Well 699-21-6

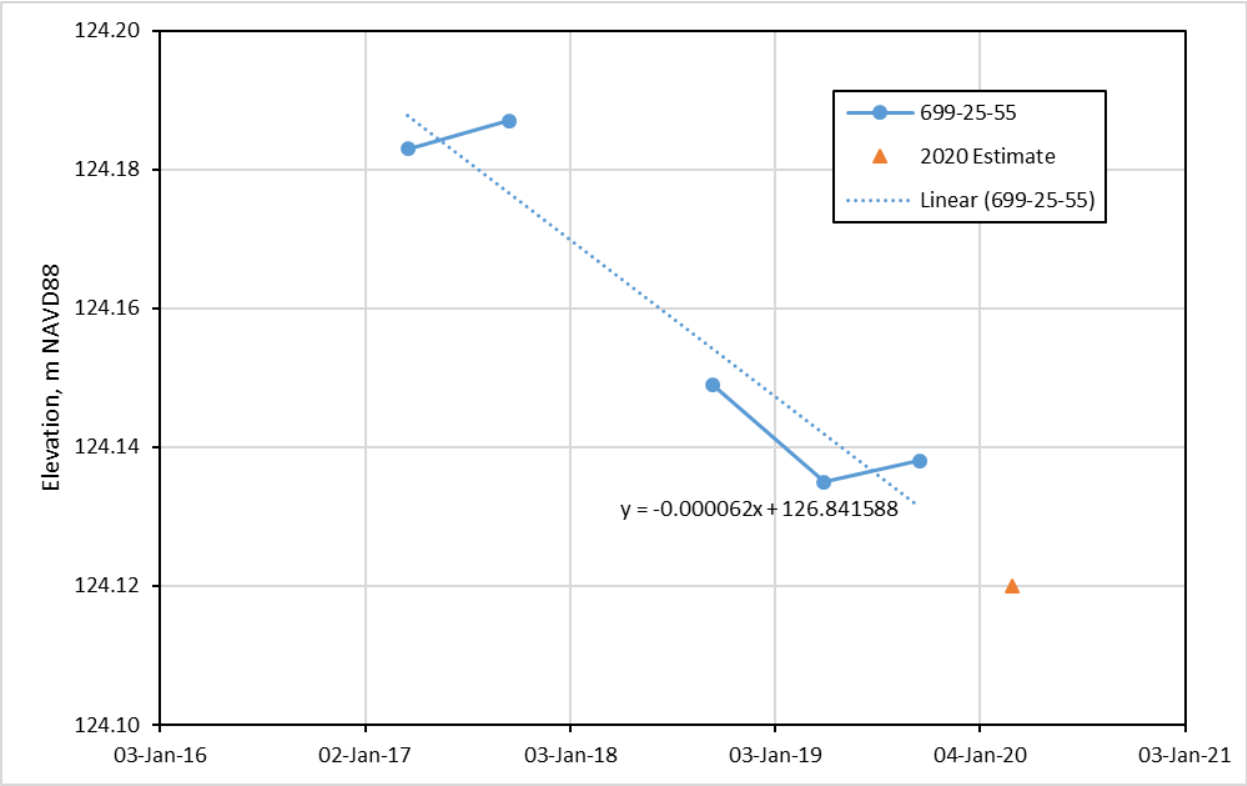

Figure A-4. Extrapolated Water Level Trend for Well 699-25-55

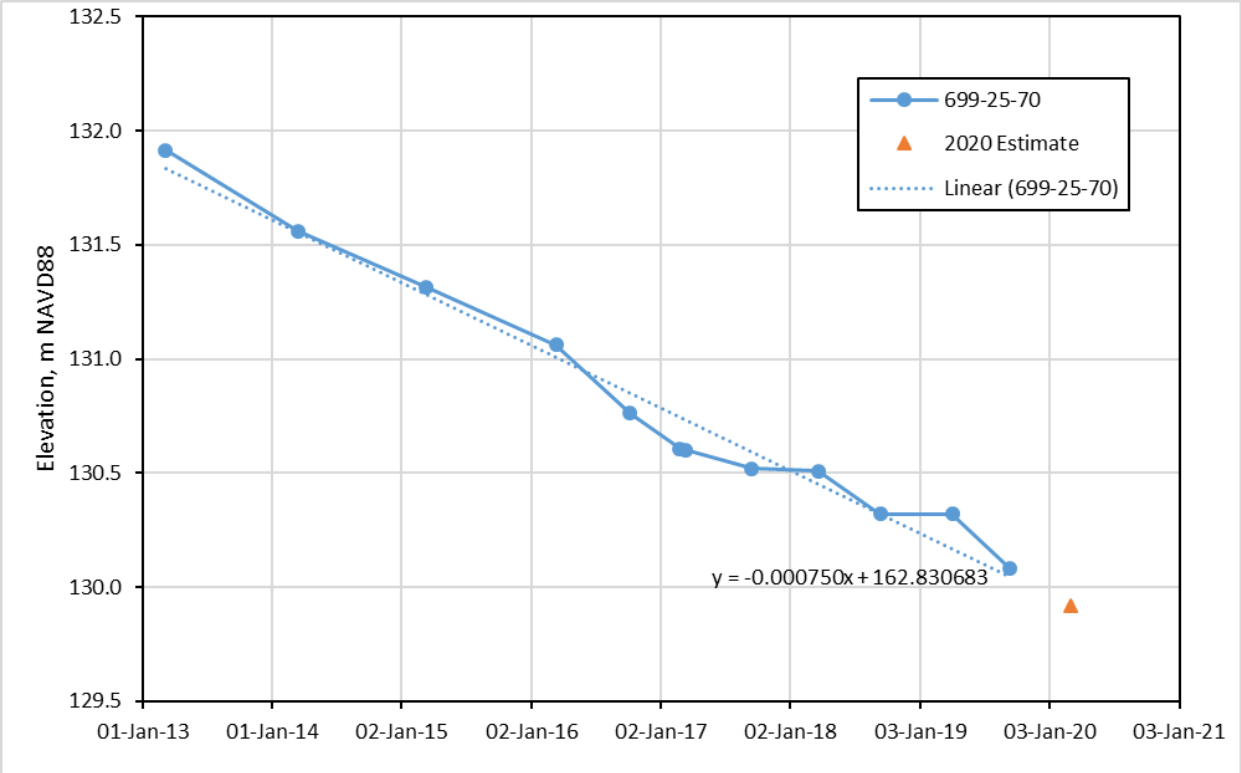

Figure A-5. Extrapolated Water Level Trend for Well 699-25-70

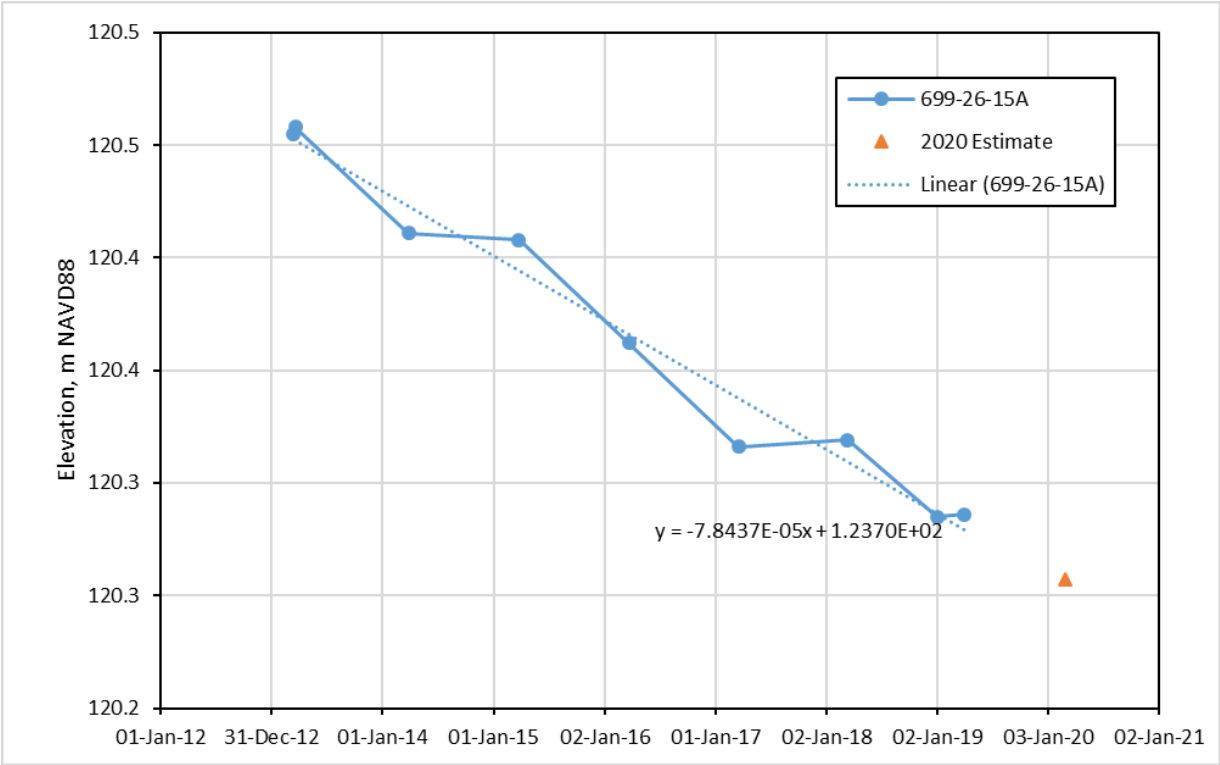

Figure A-6. Extrapolated Water Level Trend for Well 699-26-15A

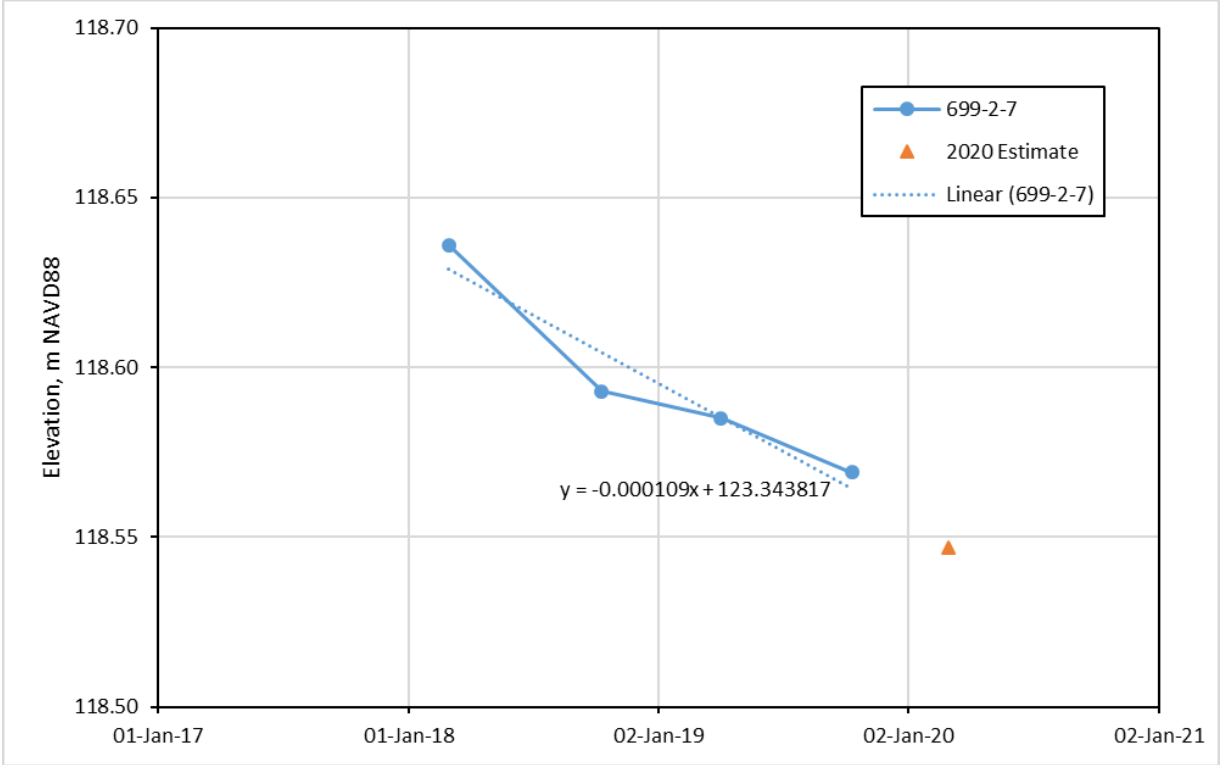

Figure A-7. Extrapolated Water Level Trend for Well 699-2-7

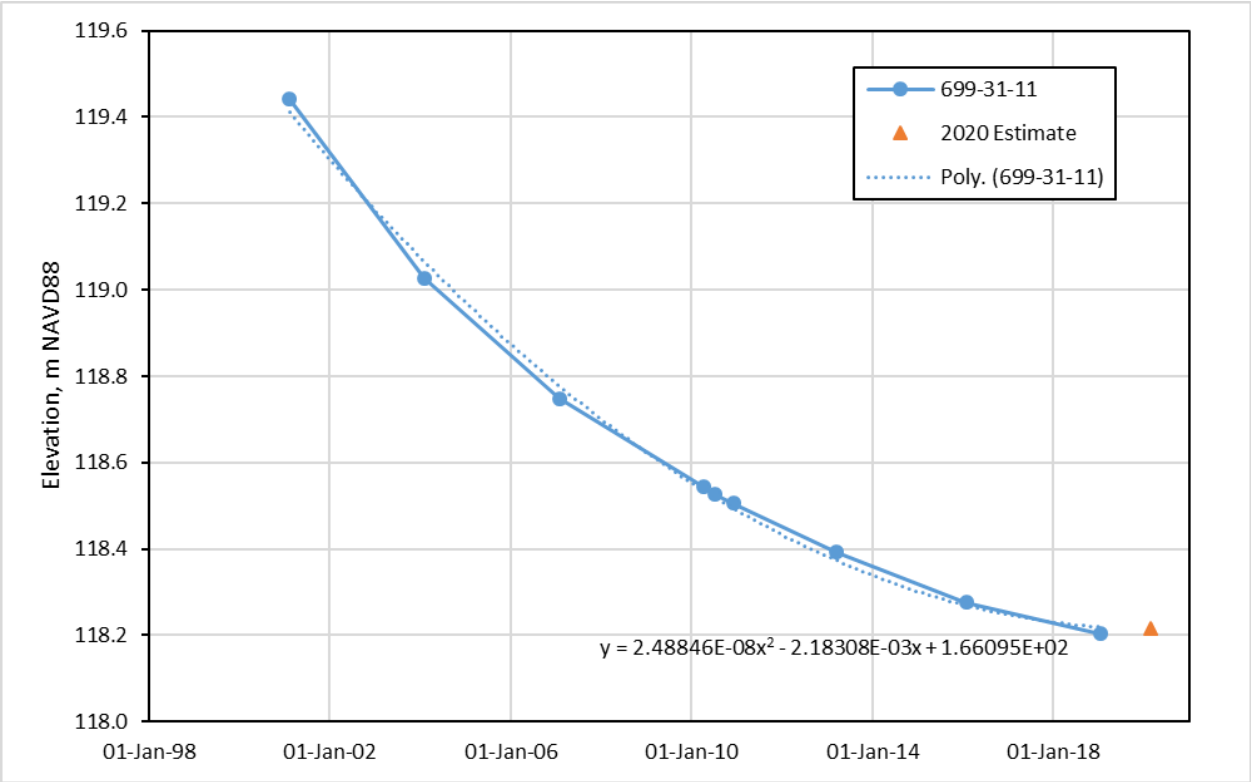

Figure A-8. Extrapolated Water Level Trend for Well 699-31-11

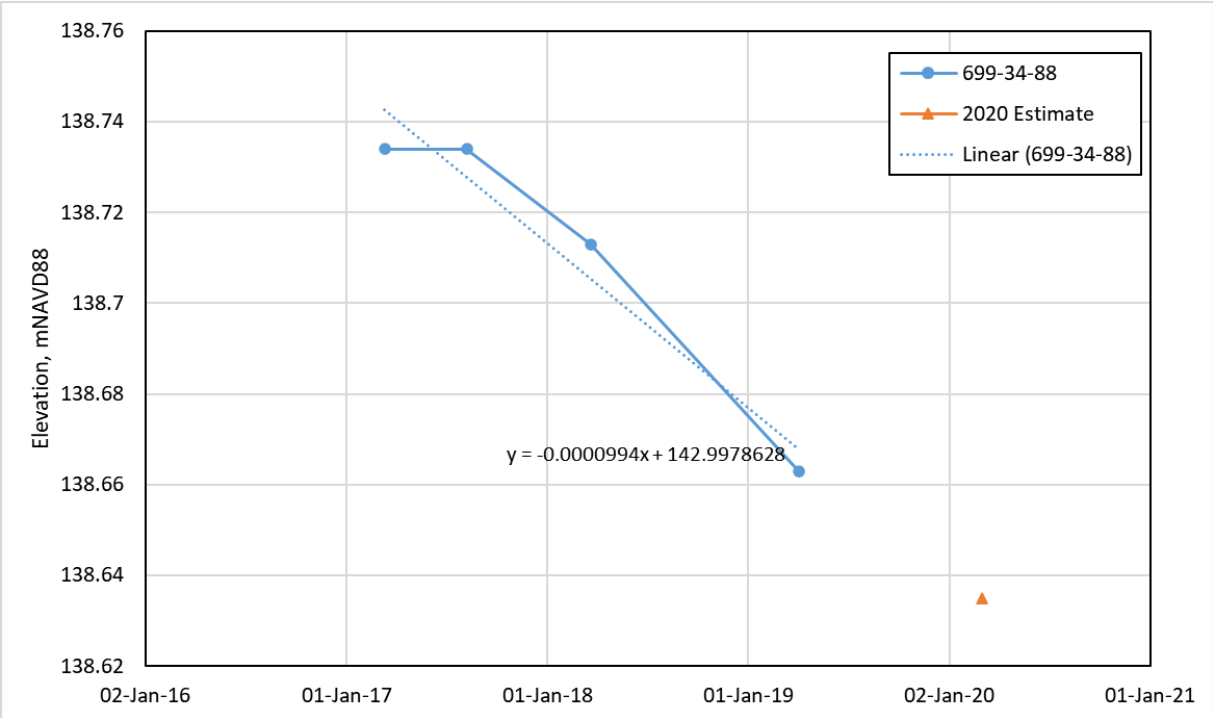

Figure A-9. Extrapolated Water Level Trend for Well 699-34-88

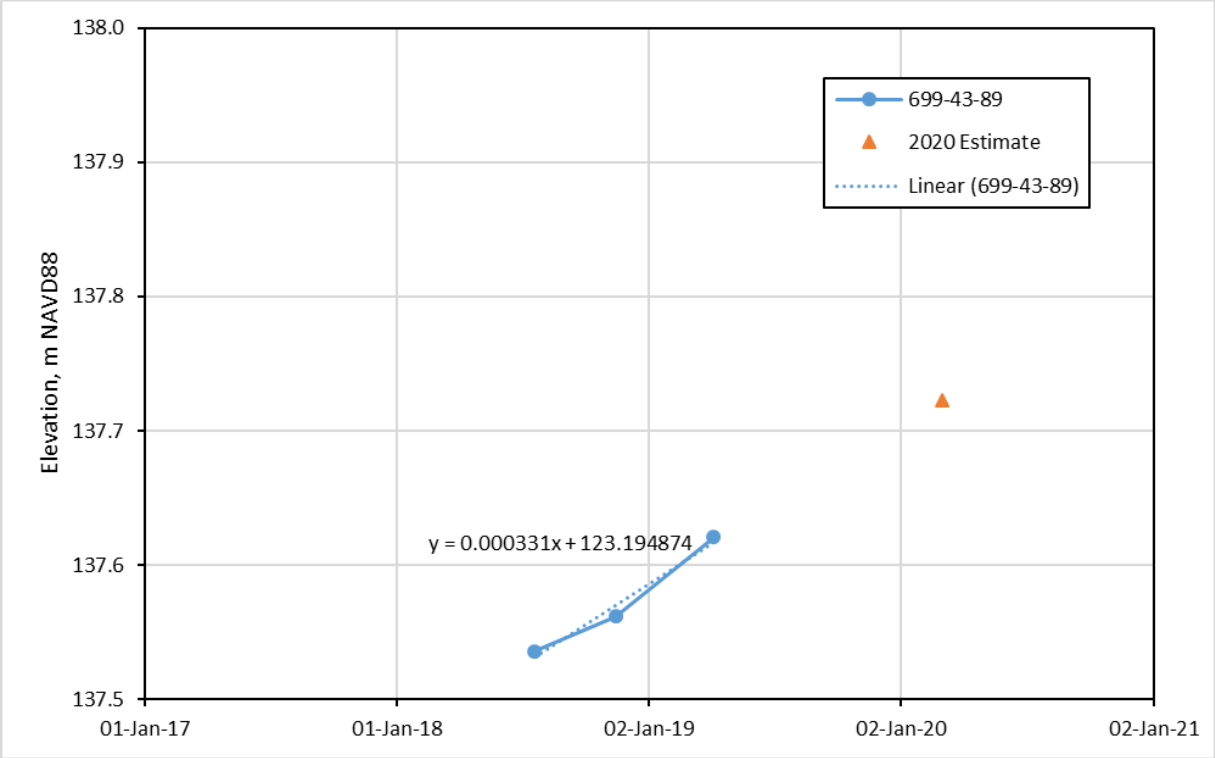

Figure A-10. Extrapolated Water Level Trend for Well 699-43-89

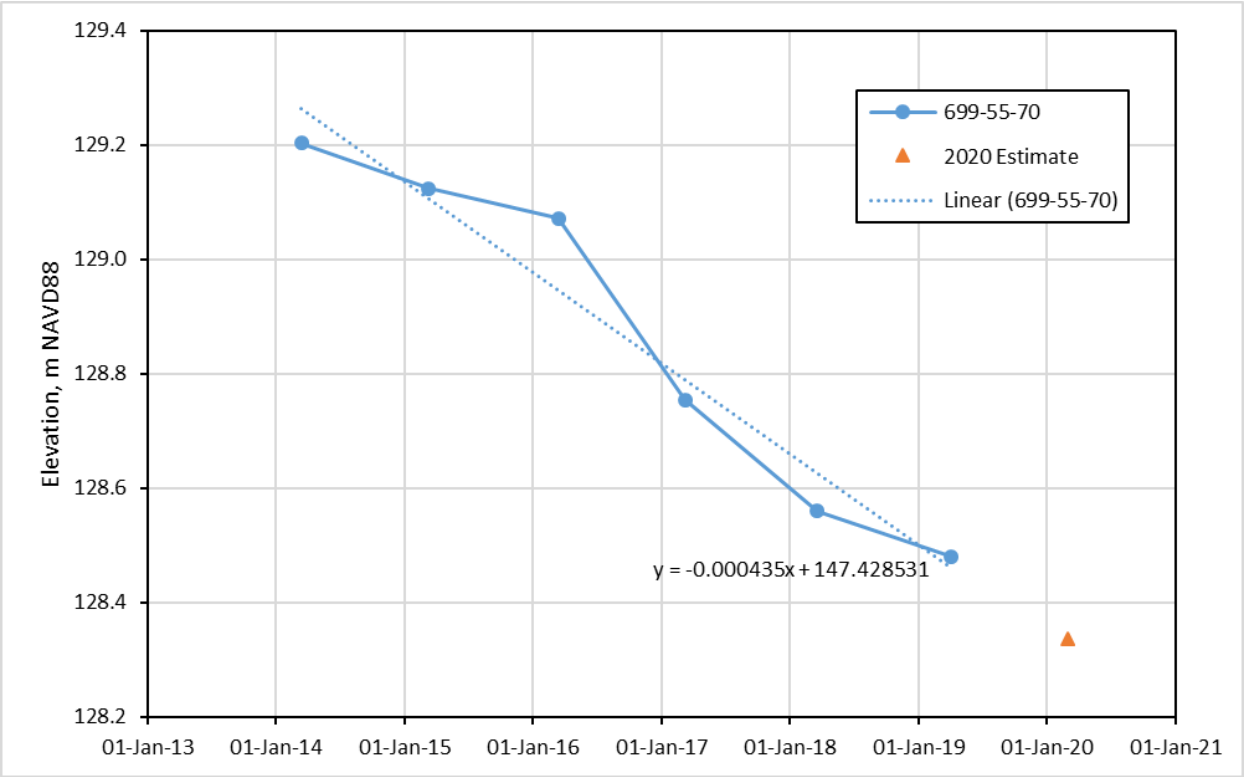

Figure A-11. Extrapolated Water Level Trend for Well 699-55-70A

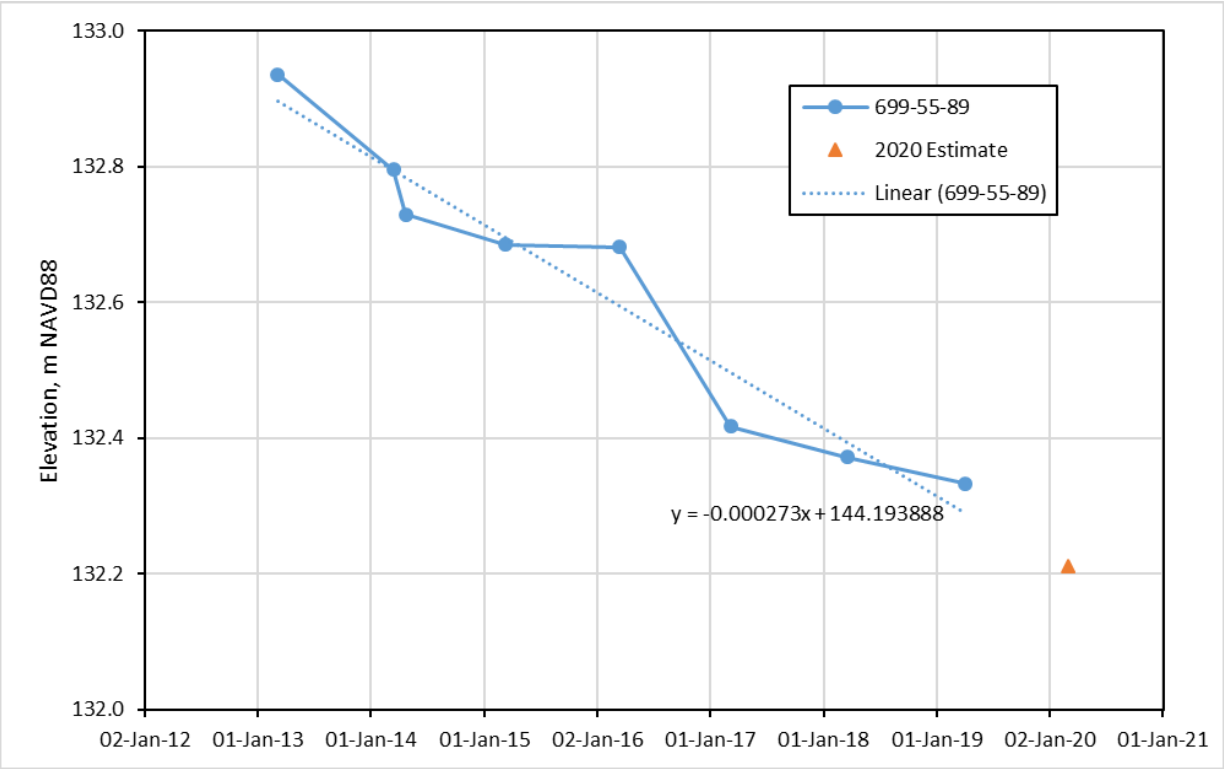

Figure A-12 Extrapolated Water Level Trend for Well 699-55-89

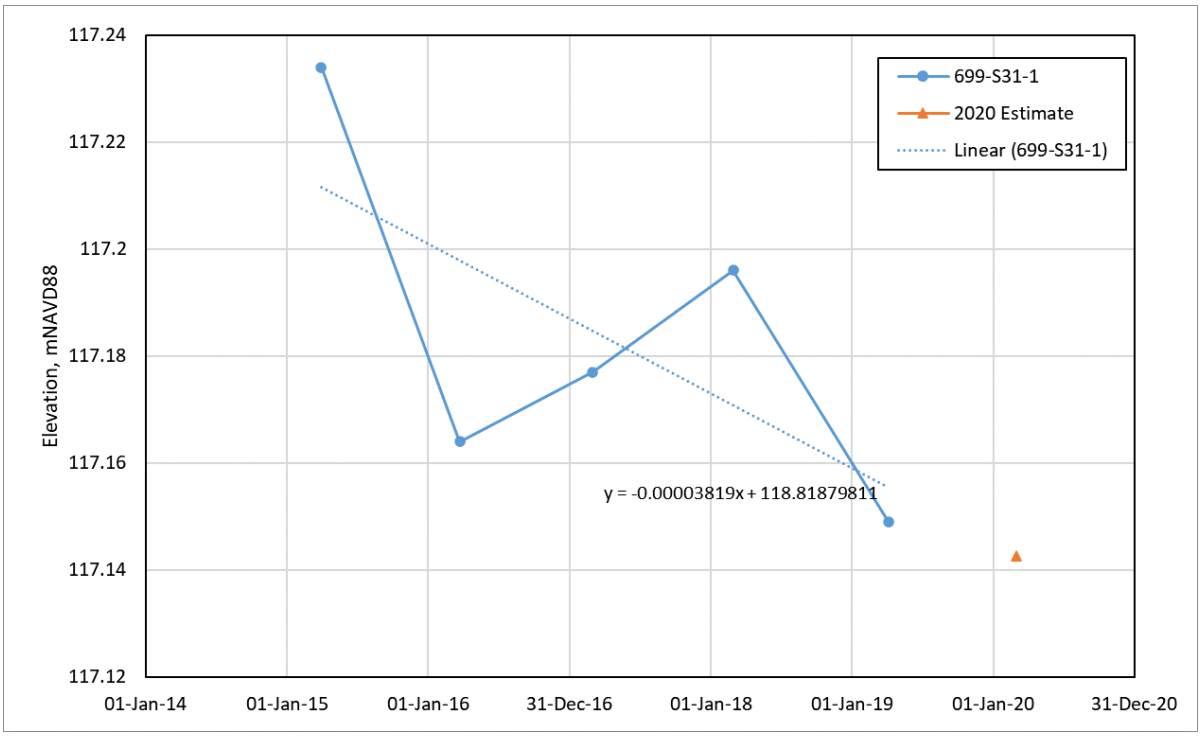

Figure A-13. Extrapolated Water Level Trend for Well 699-S31-1

A2 Reference

NAVD88, 1988, *North American Vertical Datum of 1988*, as revised, National Geodetic Survey, Federal Geodetic Control Committee, Silver Spring, Maryland. Available at: https://www.ngs.noaa.gov/datums/vertical/.