2017 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT TALEN MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION

Per Requirements of 40 CFR §§ 257.90(e)

Prepared for:
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Prepared by:

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January 2018

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ACRONYMS AND ABBREVIATIONS

(Alphabetic order)

1&2 BAP	Colstrip 1&2 Bottom Ash Pond
1&2 B Pond	Colstrip 1&2 B Flyash Pond
3&4 BAP	Colstrip 3&4 Bottom Ash Pond
3&4 EHP	Units 3 & 4 Effluent Holding Pond
Appendix III	Appendix III to 40 CFR Part 257—Constituents for Detection Monitoring
Appendix IV	Appendix IV to 40 CFR Part 257—Constituents for Assessment Monitoring
ANOVA	Analysis of Variance
ARM	Administrative Rules of Montana
ASD	Alternative Source Demonstration
BAP	Bottom Ash Pond
bgs	below ground surface
BWWC	Board of Water Well Contractors
CCR	Coal Combustion Residuals
CCR Rule	2015 EPA Coal Combustion Residuals Rule
CCR units	All active CCR landfills, surface impoundments, and lateral expansions
CFR	Code of Federal Regulations
Colstrip SES	Colstrip Steam Electric Station
cutoff wall	Bentonite-Amended Concrete Cutoff Wall
DNRC	Department of Natural Resources and Conservation
DO	Dissolved Oxygen
DQIs	Data Quality Indicators
GWMP	Coal Combustion Residuals Rule Comprehensive Groundwater Monitoring Plan
MDEQ	Montana Department of Environmental Quality
Non-CCR Rule	Describes facilities not regulated by the CCR Rule
NTUs	Nephelometric Turbidity Units
PARCC	Precision, Accuracy, Representativeness, Completeness and Comparability
QA/QC	Quality Assurance and Quality Control

RCRA	Resource Conservation and Recovery Act
SSI	Statistically Significant Increase
SSL	Statistically Significant Level
STEP	Units 1&2 Stage II Evaporation Pond
STEP E Cell/ Old Clearwell	Colstrip 1&2 STEP E Cell and Colstrip 1&2 STEP Old Clearwell
SWFPR	Site-Wide False Positive Rate
Talen	Talen Montana, LLC
TDS	Total Dissolved Solids
TukeyHSD	Tukey Honest Significant Difference
UPL	Upper Prediction Limit
US EPA	U.S. Environmental Protection Agency

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1.0 INTRODUCTION

1.1 PURPOSE

On April 17, 2015, the United States Environmental Protection Agency (US EPA) published the final rule to regulate the disposal of Coal Combustion Residuals (CCR) as solid waste under subtitle D of the Resource Conservation and Recovery Act (RCRA). The "CCR Rule" sets minimum criteria for existing and new CCR landfills and existing and new CCR surface impoundments. All active CCR landfills, surface impoundments, and lateral expansions (CCR units) are subject to groundwater monitoring and corrective action under Code of Federal Regulations (CFR) Title 40 Parts 257.90 through 257.98. Among the groundwater monitoring and corrective action requirements in the CCR Rule is an annual groundwater monitoring and corrective action report, as prescribed in §257.90 (e).

The purpose of this report is to satisfy the annual groundwater monitoring and corrective action report requirement for CCR units at the Colstrip Steam Electric Station (Colstrip SES) in Colstrip, MT for calendar year 2017 (and 2016). As this is the first annual report for the Colstrip SES, monitoring activities and results discussed herein are congruent with the initial timeframes established in §257.90(b)(1), whereby owners or operators of existing CCR units must be in compliance with the following groundwater monitoring requirements by October 17, 2017:

- Install the groundwater monitoring system as required by 40 CFR §257.91;
- Develop the groundwater sampling and analysis program to include the selection of statistical procedures that will be used for evaluating the groundwater monitoring data as required by 40 CFR §257.93;

- Initiate the detection monitoring program as per 40 CFR 257.94(b) to include obtaining a minimum of eight independent samples for each background and downgradient well; and
- Begin evaluating the groundwater monitoring data for statistically significant increases over background levels for the constituents listed in Appendix III as per 40 CFR §257.94.

Operators of new CCR units must similarly comply with installation of the groundwater monitoring system and development of the sampling and analysis program prior to initial receipt of CCR in the new CCR unit; and the owner must initiate detection monitoring (§257.90(b)(2)). The initial timeframes listed above are specific to groundwater monitoring requirements of the detection monitoring program (§257.94); thus, the groundwater monitoring and corrective action program at the Colstrip SES remained in detection (or background) monitoring status throughout calendar years 2016 and 2017. A general description of the Colstrip SES, CCR units at the Colstrip SES, and the groundwater monitoring systems associated with those CCR units is presented in Section 1.2. Specific annual reporting requirements of the CCR Rule (§257.90 (e)) are outlined in Section 1.3.

1.2 SITE DESCRIPTION

Talen Montana, LLC (Talen) is the operator of the Colstrip SES, located in Colstrip, Montana (Figure 1-1). The Colstrip SES is co-owned by Talen, PacifiCorp, Puget Sound Energy, Inc., Portland General Electric Company, Avista Corporation, and NorthWestern Corporation.

The Colstrip SES consists of four coal-fired generating units. Colstrip Units 1&2 are 333-megawatt coal-fired steam electric generating units and have been in service since 1975 and 1976, respectively. Colstrip Units 3&4 are 805-megawatt generating units adjacent to Units 1&2. Unit 3 came on line in October 1983 and began producing commercial power in 1984. Unit 4 came on line near the end of 1985 and began producing commercial power in April of 1986. Process water and effluent holding ponds serving Units 1&2 were put into service in 1975. The pond system servicing Units 3&4 has been in use since 1983.

There are several surface impoundments, process ponds, and closed landfills at the Colstrip SES that are not regulated by the CCR Rule. These ponds/landfills are designated as "non-CCR Rule" facilities because they have not contained or do not contain CCR and/or because they ceased receiving CCR prior to the effective date of October 19, 2015 [§257.50(d)]. Select non-CCR pond/landfill facilities are identified in Figure 1-1 with a dashed border along their approximate footprint.

The Colstrip SES has 13 CCR units that are regulated by the CCR Rule (Figure 1-1). The CCR units are constructed in one of three areas of the facility: the Plant Site (contains CCR units for all four generating units); the Units 1&2 Stage II Evaporation Pond (STEP); and the Units 3 & 4 Effluent Holding Pond (3&4 EHP). The CCR units are listed according to the area of the facility in which they are constructed, as follows.

- Plant Site CCR Units
  - Colstrip 1&2 B Flyash Pond (1&2 B Pond)
  - Colstrip 1&2 Bottom Ash Pond (1&2 BAP)
  - Colstrip 3&4 Bottom Ash Pond (3&4 BAP)
- Units 1&2 Stage II Evaporation Pond (STEP) CCR Units
  - Colstrip 1&2 STEP D Cell (STEP D Cell)
  - Colstrip 1&2 STEP E Cell (STEP E Cell)
  - Colstrip 1&2 Old Clearwell (STEP Old Clearwell)
- Units 3&4 Effluent Holding Pond (3&4 EHP) CCR Units
  - Colstrip 3&4 EHP A Cell (3&4 EHP A Cell)
  - Colstrip 3&4 EHP B Cell (3&4 EHP B Cell)
  - Colstrip 3&4 EHP C Cell (3&4 EHP C Cell)
  - Colstrip 3&4 EHP D/E Cell (3&4 EHP D/E Cell)
  - Colstrip 3&4 EHP G Cell (3&4 EHP G Cell)
  - Colstrip 3&4 EHP J Cell (3&4 EHP J Cell)
  - Colstrip 3&4 EHP J-1 Cell (3&4 EHP J-1 Cell)

The history of construction for all of the individual CCR units at the Colstrip SES was reviewed in accordance with 40 CFR §257.73(c)(1) (Geosyntec 2016a). Based on liner construction details presented in the history of construction, all existing CCR surface impoundments were determined to be unlined surface impoundments because they do not meet the criteria of 40 CFR § 257.71(a)(1)(i), (ii), or (iii) (Geosyntec 2016b). Colstrip 3&4 EHP J-1 Cell is the exception, as it is newly constructed and includes a liner that meets criteria of 40 CFR § 257.72. Further, 3&4 EHP J-1 Cell will be constructed as an overfill of 3&4 EHP J Cell; whereby, the alternative bottom liner of 3&4 EHP J-1 Cell will also act as the final cover system for 3&4 EHP J Cell. Although the remaining CCR units are considered unlined, the actual liner construction materials vary from low-permeability clay to double geo-synthetic liners with seepage collection systems. A bentonite-amended concrete cutoff wall (cutoff wall) extends around the perimeter of the 3&4 EHP. Construction details specific to each CCR unit are further discussed in the History of Construction Report (Geosyntec 2016a).

Two streams of CCR are produced during operation of the Colstrip SES: 1) scrubber slurry, which includes fly ash and flue gas desulfurization solids from the air pollution control system; and 2) bottom ash, which has a larger particle size than fly ash and is collected at the bottom of the boilers. The scrubber slurry is transferred by pipeline to either the Units 1 & 2 STEP (for CCR generated at Units 1 & 2) or to the Units 3 & 4 EHP (for CCR generated at Units 3 & 4). Scrubber slurry is dewatered at either the Units 1&2 or Units 3&4 Paste Plant and deposited in the corresponding active CCR unit as a paste. Bottom ash is dewatered in designated bottom ash ponds that are found near the generating units on the Plant Site. Most bottom ash is transported via truck to the Units 3&4 EHP for disposal.

1.3 REPORTING REQUIREMENTS

An annual report documenting the CCR Rule monitoring and corrective action activities for the previous calendar year will be completed by January 31 of each year. This initial report for calendar years 2016 and 2017 will be placed in the Colstrip SES operating record by January 31, 2018 [§257.105(h)(1)] and on the public internet site within 30 days of placement in the operating record [§257.107(h)(1)].

Requirements of the annual groundwater monitoring and corrective action report are listed in §257.90 (e), as follows:

- A map showing the location of the CCR unit(s) and associated background and downgradient monitoring wells (40 CFR §257.90 (e)(1));
- Narrative describing work undertaken to install or abandon monitoring wells during the previous year (40 CFR §257.90 (e)(2));
- A summary of monitoring data collected during the previous year under 40 CFR §§ 257.90-257.98, including a breakdown of the number of upgradient and downgradient samples from wells included in the monitoring program for specific CCR units, and whether the sample was for detection and or assessment purposes (40 CFR §257.90 (e)(3));
- The rate and direction of groundwater flow beneath each CCR unit will be evaluated for each sampling event in accordance with §257.93(c);
- A narrative of the statistical evaluation, particularly as it relates to a transition between detection and assessment monitoring (40 CFR §257.90 (e)(4));
- Demonstrations, if applicable, that a source other than a CCR unit caused a statistically significant increase (SSI) over background or that the SSI was a result of error (40 CFR §257.94 (e)(2));
- A projection of key monitoring or corrective action activities planned for the upcoming year; and
- Other pertinent information as described in 40 CFR §§ 257.90-257.98 (40 CFR §257.90 (e)(4)).

Where applicable, each of the reporting requirements is satisfied herein. Note that there was no transition between detection and assessment monitoring in 2017. Further, no alternative source demonstrations (ASD) were conducted or necessary, as groundwater quality data were not evaluated for SSI in 2017.

1.4 ORGANIZATION

Field, laboratory, and data analysis methods used to obtain and evaluate 2016 and 2017 CCR Rule groundwater monitoring data are described in Section 2.0. Fulfillment of each of the annual reporting requirements listed in Section 1.3 is addressed specifically for each CCR unit in individual Sections 3.0 through 8.0 of this report. Assumptions and limitations to groundwater quality data collection and analysis are discussed in Section 9.0. Conclusions based on 2016 and 2017 monitoring results are summarized in Section 10.0; and groundwater monitoring and corrective actions planned for 2018 are outlined in the final section of this report (Section 11.0).

2.0 GROUNDWATER MONITORING DATA COLLECTION AND ANALYSIS

Groundwater monitoring data collected and analyzed in 2016 and 2017 were done so in accordance with requirements of §257.90 through §257.94, as outlined in the Coal Combustion Residuals Rule Comprehensive Groundwater Monitoring Plan Talen Montana, LLC (GWMP [Hydrometrics, Inc. 2017a]). This section describes in general how tasks related to each of the annual reporting requirements were met for 2016 and 2017. A comprehensive description of methodology is included in the GWMP (Hydrometrics, Inc. 2017a). Results for each of the six groundwater monitoring systems in place at 13 CCR units at the Colstrip SES are discussed in Sections 3.0 through 8.0.

2.1 GROUNDWATER MONITORING WELL INSTALLATION

Colstrip SES operators have installed and continue to monitor an extensive network of wells that pre-date and are used for water resources monitoring purposes beyond the scope of the CCR Rule. The regulatory impetus for these wells is discussed in the GWMP (Hydrometrics, Inc. 2017a). Several of these pre-existing wells are in locations that can serve as both water resources monitoring sites and CCR unit monitoring wells; but not all of the existing wells satisfy the specific completion and location requirements of §257.91. As a result, the groundwater monitoring systems at Colstrip SES CCR units utilize a combination of existing and new (completed in 2016 or 2017) monitoring wells.

2.1.1 General Groundwater Monitoring Well/System Installation

All individual monitoring wells are completed in compliance with requirements of §257.91(e)(1) and (2) (Hydrometrics, Inc. 2017a, 2017b). Further, in accordance with the Performance Standard of §257.91(a)(1) and (2), Colstrip SES groundwater monitoring systems consist of a sufficient number of wells, installed at appropriate locations and depths, to yield groundwater samples from the uppermost aquifer that accurately represent the quality of background groundwater that has not been affected by leakage from a CCR unit and that accurately represent the quality of groundwater passing the waste boundary of each CCR unit at the Colstrip SES. Per 40 CFR §257.91(b)(1) and (2), the number, spacing, and

depths of monitoring wells included in the Colstrip SES groundwater monitoring systems were selected based upon thorough evaluation of site-specific technical information and hydrogeologic characterization (Hydrometrics, Inc. 2017a). The number of monitoring wells included in groundwater monitoring systems for all CCR surface impoundments meets or exceeds the minimum requirements of 40 CFR §257.91(c)(1) and (2). In accordance with §257.91(f), the Colstrip SES has obtained a certification from a qualified professional engineer stating that the groundwater monitoring system has been designed and constructed to meet the performance standard of §257.91(a), site-specific technical information of §257.91(b), and minimum number of wells required by §257.91(c) (Hydrometrics, Inc. 2017b). Logs of lithology and well construction for all of the monitoring wells associated with Colstrip SES CCR units are included in Appendix A.

All monitoring wells used in CCR groundwater monitoring systems were surveyed with survey-grade Global Positioning System equipment using a common coordinate system and vertical datum. All wells were surveyed in the US State Plane coordinate system for Montana 2500 (NAD 1983); and the United States Geological Survey Benchmark U217 (NAVD 88) was held for vertical control (Dowl 2017). Coordinates (Easting and Northing) and elevations of ground surface, measuring point and casing heights above ground surface are listed on the well logs in Appendix A.

As allowed by 40 CFR §257.91(a)(1)(i) and (ii), some of the Colstrip SES groundwater monitoring systems rely on background wells that are not hydraulically upgradient of CCR management areas; these wells provide data that are as representative or more representative than data from upgradient wells. Circumstances where background wells other than upgradient wells are used are described in the GWMP (Hydrometrics, Inc. 2017a) and are further discussed where applicable herein.

Per 40 CFR §257.91(d), the owner or operator of multiple CCR units may install multi-unit groundwater monitoring systems instead of separate groundwater monitoring systems at each CCR unit. Multi-unit groundwater monitoring systems are installed under the stipulations that the multi-unit groundwater monitoring system is equally as capable of detecting

monitored constituents at the waste boundary as individual systems [40 CFR §257.91(d)(1)]; and that all unlined surface impoundments included in the multi-unit system must be retrofitted or closed in accordance with 40 CFR §257.101(a) in the event that any of the constituents listed in Appendix IV of the CCR Rule are detected at statistically significant levels (SSL) above groundwater protection standards (established under 40 CFR §257.95(h)) at any time after October 19, 2015 [40 CFR §257.91(d)(2)].

Talen has elected to install and operate two multi-unit groundwater monitoring systems at the Colstrip SES.

1.) A multi-unit system is used to collectively monitor Colstrip 1&2 STEP E Cell and the STEP Old Clearwell; and
2.) All seven of the CCR units at the 3&4 EHP (3&4 EHP A Cell, 3&4 EHP B Cell, 3&4 EHP C Cell, 3&4 EHP D/E Cell, 3&4 EHP G Cell, 3&4 EHP J Cell, and 3&4 EHP J-1 Cell) are monitored via a multi-unit groundwater monitoring system.

Individual groundwater monitoring systems are installed at each of the Plant Site CCR units (1&2 B Pond, 1&2 BAP, and 3&4 BAP) and at STEP D Cell. Thus, a total of six groundwater monitoring systems are used to monitor 13 CCR Units at the Colstrip SES.

2.1.2 Monitoring Wells Installed or Decommissioned in 2016 and 2017 (§257.90(e)(2))

A total of 44 new monitoring wells were installed for the purpose of CCR unit monitoring in 2016 and 2017. New wells were installed at each of the 13 CCR units to supplement the existing monitoring well network. These new wells are identified with "-CCR" following the well number (for example 155M-CCR). All new wells were drilled and completed as detailed in the GWMP (Hydrometrics, Inc. 2017a). Completion methods are in accordance with §257.91(e)(1) and (2) and requirements of the Montana Department of Natural Resources and Conservation (DNRC) Board of Water Well Contractors (BWWC), as found in Administrative Rules of Montana (ARM) 36.21.801 through 809.

Cuttings from new CCR well borings were logged on-site for lithology, including texture, color, relative moisture, and origin (alluvium, colluvium, bedrock, etc.) by a geologist, hydrogeologist, or engineer. A log of borehole lithology and well completion was prepared

for each new CCR well and was submitted to the BWWC via the Montana Bureau of Mines and Geology Groundwater Information Center database.

Well 152SP-CCR, designated as a downgradient well at the Units 3&4 Bottom Ash Pond, was decommissioned in 2017. Details are discussed in Section 5.0.

2.2 GROUNDWATER ELEVATIONS, FLOW RATES, AND DIRECTION §257.93(C)

In accordance with §257.93(c), depth to water measurements made immediately prior to purging and sample collection are subtracted from known measuring point elevations to attain accurate groundwater level elevations. Groundwater elevations in wells of common groundwater monitoring systems were measured within a period of time short enough to avoid temporal variations in groundwater flow that could limit the accuracy of groundwater flow rate and direction calculations.

The groundwater flow rate (velocity) and direction at each CCR unit are evaluated based on the groundwater elevation data and known hydraulic properties of the uppermost hydrostratigraphic unit(s). The predominate groundwater flow direction is evaluated by triangulating the groundwater elevations between a minimum of three monitoring wells positioned around each CCR unit. Average linear groundwater velocity is calculated by dividing the specific discharge or Darcy flux by the effective porosity of the surrounding formation:

$$V=K*i/\eta e \qquad \textbf{[Equation 2-1]}$$

Where: V = linear velocity (ft/day)
K = Hydraulic conductivity (ft/day)
i = hydraulic gradient (ft/ft)
ηe = Effective porosity
(dimensionless).

Hydraulic gradients used in the calculations are interpreted from potentiometric (direction-of-flow) maps for each CCR unit; and hydraulic conductivity values used in the calculations were supplied by results of extensive aquifer testing conducted near each of the CCR units

(Hydrometrics, Inc. 2017a). Groundwater level elevations at all wells in the Colstrip SES groundwater monitoring systems are found in Appendix B. Appendix C includes hydrographs constructed of data collected during CCR Rule groundwater monitoring at each well in 2016 and 2017. Results of groundwater level monitoring and velocity calculations at specific groundwater monitoring systems are further discussed in Sections 3 through 8.

2.3 GROUNDWATER SAMPLE COLLECTION

Groundwater sampling and analysis was conducted at each CCR unit in 2016 and 2017 according to the methods, sample frequencies, preservation and handling techniques, quality assurance quality control protocols, and analytical procedures outlined in the GWMP (Hydrometrics, Inc. 2017a).

In general, groundwater samples were collected using low flow sampling techniques consistent with Montana Department of Environmental Quality (MDEQ) Site Response Section Low-Flow Purging and Sampling Guidelines (MDEQ, 2005). Dedicated positive displacement bladder pumps that allow for adjustable pumping rates consistent with low flow purging and sampling methodology were used. In order to minimize purging time and reduce turbidity, the pump intake was positioned within the well screen at each well at a level exhibiting the greatest laminar flow from the formation, typically near the mid-section of the screen. However, in very low yield wells with limited water columns, the pump intake is positioned near the bottom of the well.

Optimum pumping rates for each well were determined during the initial few sampling events and maintained during subsequent events. Drawdown was generally not allowed to exceed 0.3 feet at the established pumping rate. Where drawdown exceeding 0.3 feet was observed at low yield wells, which are common to the Colstrip Area and CCR monitoring systems, samples were collected after stabilization of field parameters was achieved. Stability criteria consistent with EPA Low Stress Purging and Sampling Procedure for the Collection of Groundwater from Monitoring Wells (US EPA January 2010) were used for all CCR wells, regardless of yield.

Field indicator parameters for stabilization (dissolved oxygen (DO), SC, oxidation-reduction potential (ORP), pH, and temperature) were measured using a flow-through cell to minimize potential effects from atmospheric exposure. Turbidity was measured in the discharge water immediately prior to sample collection. A turbidity value of 10 nephelometric turbidity units (NTUs) was targeted for sample collection; and additional purging was conducted if the measured turbidity was greater than 10 NTUs. Field meters were calibrated daily according to factory instructions, with results recorded on calibration forms.

Groundwater samples were collected in the appropriate sample containers, preserved, and placed in a cooler on ice for delivery to a commercial laboratory for analysis of the parameters listed in Table 2-1. The parameter list includes all of the Constituents for Detection Monitoring as listed in Appendix III to part 257 and all Constituents for Assessment Monitoring as listed in Appendix IV to part 257. All groundwater quality samples were analyzed for total recoverable metals, per §257.93(h)(2)(i). The entire set of data collected at Colstrip-SES CCR groundwater monitoring systems in 2016 and 2017 are included in Appendix D.

2.4 QUALITY ASSURANCE/QUALITY CONTROL

Quality assurance and quality control (QA/QC) procedures were selected and followed (Hydrometrics, Inc. 2017a) to help identify method and/or data anomalies and help reduce and correct data inconsistencies, if present, in the 2016 and 2017 groundwater monitoring dataset for the Colstrip SES. The QA/QC program incorporates Data Quality Indicators (DQIs) for precision, accuracy, representativeness, completeness and comparability (PARCC) parameters specific to sampling and analytical results. Data validation for CCR monitoring data followed MDEQ's Data Validation Guidelines for Evaluating Analytical Data (MDEQ, 2016) in conjunction with additional criteria (i.e. EPA Functional Guidelines, 2016) and professional judgement for data qualification determination.

2.5 STATISTICAL METHODS

In accordance with § 257.93(d), background groundwater quality must be established in hydraulically upgradient or background wells for each of the constituents required in the

particular groundwater monitoring program that applies to the CCR unit as determined under § 257.94(a) (detection monitoring) or § 257.95(a) (assessment monitoring). Specific statistical methods must be chosen from the list provided in §257.93(f)(1) through (5), which include parametric analysis of variance, analysis of variance based on ranks (non-parametric), a tolerance or prediction interval approach, a control chart approach, or another statistical test that meets the performance standards of §257.93(g).

Statistical methods discussed in this 2017 annual report include those used to establish background groundwater quality for the constituents found in Appendix III to part 257 for detection monitoring (Table 2-1). In compliance with the appropriate performance standards, as listed in §257.93(g)(1) through (6), and specified in Section 5 of the GWMP (Hydrometrics, Inc. 2017) for the Colstrip SES, parametric or non-parametric prediction intervals, as appropriate to either a normal or non-normal data distribution, were calculated on an interwell or intrawell basis at each of the Colstrip SES CCR Units. In accordance with §257.93(f)(6), a certification from a qualified professional engineer was prepared stating that the selected statistical method is appropriate for evaluating the groundwater monitoring data for the CCR management areas (Hydrometrics, Inc. 2017c).

All statistical procedures selected for use in evaluating Colstrip SES CCR groundwater monitoring data were conducted in a manner consistent with Environmental Protection Agency's Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance (US EPA, 2009) and EPRI's Groundwater Monitoring Guidance for the Coal Combustion Residuals Rule (EPRI, 2015). Further, statistical analyses conducted on 2016 and 2017 data conformed to performance standards outlined in §257.93(g)(1 through 6). Statistical methods and results specific to each of the Colstrip SES CCR units are presented in Sections 3.0 through 8.0.

Data collected under the CCR Rule are evaluated on a constituent/well pair basis. As such, chosen statistical methods may vary by well and amongst constituents at a given well at any of the Colstrip SES groundwater monitoring systems based on the characteristics of the specific dataset (i.e. normality, number of non-detect data, shifts or trends, spatial and

temporal variability, etc.). In general, background detection monitoring data from the Colstrip SES was statistically evaluated using the following work flow:

- Summary statistics such as mean and standard deviation were calculated for each well/constituent pair in the potential background dataset for each CCR unit or groundwater monitoring system.
- The data distribution of each well/constituent pair was tested for normality to inform later selection of parametric or non-parametric statistical tests.
- The spatial variability of each constituent at each CCR unit or groundwater monitoring system was evaluated to identify differences in mean or variance across each well network that may limit data pooling or interwell comparison.
- Based on data distribution (normal or non-normal) and evidence of spatial variability, parametric or non-parametric and interwell or intrawell prediction intervals were selected as the final method for establishing background. However, because the CCR units at the Colstrip SES are existing surface impoundments and most are operated nearby other potential sources (CCR-regulated and non-CCR Rule facilities) of process water to groundwater, statistical intervals were calculated largely on an interwell basis. Where significant spatial variability was detected in the distribution of a given constituent at a CCR unit, prediction limits were calculated that would account for the extreme upper values (or extreme upper and lower values for pH) in the background dataset.

Statistical analyses outlined above and described in the sections to follow were evaluated using either the R graphical user interface (R Core Team 2017) or ChemStat (Starpoint Software 2010) statistical software.

2.5.1 Data Distribution (Normality)

If sample data can be shown to be normally distributed, or a transformation can be performed such that the transformed data are normally distributed (e.g. log-normal distribution), assumptions can be made regarding the population mean and variance that allow one to estimate the probability of any value within the population. For example, a parametric test can be conducted on normally distributed data to calculate an Upper Prediction Limit (UPL)

that is greater than the maximum value observed in the sample data set. For data that are non-normal, the population distribution is unknown; and statistical tests are limited to non-parametric tests that are based on ranked sample data (typically the largest or second largest value of a given constituent).

The Shapiro-Wilk test for normality was conducted for each well/constituent pair in the Colstrip SES groundwater monitoring systems. Where possible, parametric tests were used for data that follow the normal distribution. Raw data that are not normally distributed, as evidenced by the Shapiro-Wilk test, were transformed using the natural logarithm and re-tested. Data that are not log-normally distributed were subject to non-parametric tests. To maximize the utility of the tests, the Shapiro-Wilk statistic was compared to critical points for three different α -levels (0.01, 0.05, and 0.1). If the test statistic exceeded the critical point for any of the three α -levels, normality was accepted as a reasonable model for the underlying population.

2.5.2 Stationarity and Spatial Variability

Stationarity, as evaluated on 2016 and 2017 CCR groundwater monitoring data at the Colstrip SES, refers to statistically identifiable differences in mean and/or variance across the well field of a groundwater monitoring system for a given CCR Unit (i.e., spatial non-stationarity). Non-stationarity limits the pooling of data across multiple background wells or the proper upgradient-to downgradient comparison of background wells against distinct compliance wells. Where non-stationarity is identified, the usual approach is to perform intrawell comparisons (US EPA 2009). However, in the case of wells with known impacts to groundwater quality from previous releases, establishing a proper baseline for an intrawell prediction limit or control chart is problematic. Where significant spatial variability was identified at a given CCR unit of the Colstrip SES, data were culled to include only the well or wells that were most representative of the upper bound of groundwater quality at the immediate upgradient waste boundary and/or a non-parametric version of an interwell test was selected. One way parametric analysis of variance (ANOVA), Tukey Honest Significant Difference (TukeyHSD) procedures, non-parametric ANOVA (Kruskal-Wallis test), and/or

side-by-side box plots were used to identify spatial variability of groundwater quality data at background wells for each CCR Unit.

2.5.3 Prediction Limits

Prediction intervals were the primary statistical methodology utilized for the purposes of establishing detection monitoring at CCR Units of the Colstrip SES. Where applicable, parametric prediction limits for future values were calculated using Equation 2-2. The standard deviation (s) and mean ($\bar{X}$) were calculated explicitly from the sample data. The value assigned to the K-multiplier is a function of the number of observations in the background dataset (variable at Colstrip SES but a minimum of 8), the number of compliance wells to be evaluated in the statistical comparison (variable by CCR unit), the number of constituents (seven, per Appendix III to part 257), the sampling frequency (assumed to be semi-annual), the significance level of the test, and the number of re-samples allowed if a retesting strategy is used.

$$PL = \bar{X} \pm Ks \qquad \textbf{[Equation 2-2]}$$

Where: PL = prediction limit

K = multiplier

$\bar{X}$ = sample mean

s = sample standard deviation

To streamline the prediction limit selection process, a 1 of 2 retesting plan was assumed for each parametric or non-parametric prediction limit. This means that if a SSI is detected, as evidenced by a future observation above the prediction limit, a second sample will be collected for verification of the SSI. If the re-sample is less than the calculated prediction limit, then no SSI exists. Parametric prediction limits were calculated consistent with procedures outlined in the Unified Guidance (US EPA 2009).

Non-parametric prediction intervals are computationally much simpler. Non-parametric UPL were assigned as the maximum background value of each constituent or constituent/well pair from the 2016/2017 data set. The non-parametric UPL will be compared directly to future observations using a 1 of 2 retesting plan.

Consistent with Unified Guidance (US EPA 2009) and the GWMP (Hydrometrics, Inc. 2107a), an annual site-wide false positive rate (SWFPR) of 0.1 will be targeted for all CCR Units. Considering the number of future statistical comparisons that will be conducted at each CCR unit, based on number of constituents, downgradient wells, and sample frequency (semi-annual), the per test significance levels (α) needed to attain the targeted SWFPR would range from less than 0.01 to approximately 0.05. Higher confidence levels (lower α) are required at CCR units with fewer wells and lower confidence levels (higher α) are allowed at units with more wells. The minimum targeted confidence level used for parametric prediction limit determination was 95% ($\alpha = 0.05$); however, confidence levels were variable based on data distribution, sample size, etc. Assuming equal values of relevant parameters (sample size, number of constituents, number of wells), confidence levels of non-parametric tests are generally much lower (α are higher) than those of parametric tests. Elevated non-parametric α-levels make it difficult to attain SWFPR targets. Non-parametric confidence levels and significance levels were calculated explicitly and are reported with test results herein. Although a 1 of 2 retesting scheme is allowed for all tests (non-parametric or parametric), the reported non-parametric confidence and α levels only consider a single well-constituent comparison. If the allowed re-tests are conducted during future comparisons, α-levels will be adjusted and reported.

TABLE 2-1. REQUIRED ANALYTICAL PARAMETERS

Appendix III – Detection Monitoring Analytical Parameters		
Analyte	**Method**	**Reporting Limit (mg/L)**
Boron (B)*	E200.7/E 200.8	0.05
Calcium (Ca)*	E200.7/E 200.8	1
Chloride (Cl)	E 300.0/ SM 4500CL-B	1
Fluoride (F)	A4500-F C	0.1
Sulfate (SO_4)	E 300.0	1
Total Dissolved Solids (TDS)	A2540C	10
pH (field/laboratory)	A4500-H B	0.1
Appendix IV – Assessment Monitoring Analytical Parameters		
Antimony (Sb)*	E200.7/E 200.8	0.001
Arsenic (As)*	E200.7/E 200.8	0.001
Barium (Ba)*	E200.7/E 200.8	0.05
Beryllium (Be)*	E200.7/E 200.8	0.001
Cadmium (Cd)*	E200.7/E 200.8	0.001
Chromium (Cr)	E200.7/E 200.8	0.005
Cobalt (Co)*	E200.7/E 200.8	0.005
Lead (Pb)*	E200.7/E 200.8	0.001
Lithium (Li)*	E200.7/E 200.8	0.1
Mercury (Hg)*	EPA 245.1	0.0001
Molybdenum (Mo)*	E200.7/E 200.8	0.001
Selenium (Se)*	E200.7/E 200.8	0.001
Thallium (Tl)*	E200.7/E 200.8	0.0005
Fluoride (F)	A4500-F C	0.1
Radium 226 & 228 combined	E 903.0/RA-05	1 pCi/L

* Metals will be analyzed as total recoverable metals.

Analytical methods from *Standard Methods for the Examination of Water and Wastewater 22nd Edition* (A) (APHA 2012), *Methods for Chemical Analysis of Water and Waste March (E)* (EPA 600/4-79/020) (US EPA March 1983), or *Radiochemistry Procedures Manual* (EPA 520/5-84-006) (RA-05) (US EPA June 1984).

3.0 COLSTRIP 1&2 B FLYASH POND

3.1 LOCATION AND DESCRIPTION

Per §257.90 (e)(1), the Colstrip 1&2 B Flyash Pond (1&2 B Pond) and all upgradient (or background) and downgradient monitoring wells that are part of the 1&2 B Pond groundwater monitoring system are identified in Figure 3-1. Further discussion of the direction of groundwater flow is presented in Section 3.2 to follow. A summary of wells in the 1&2 B Pond groundwater monitoring system is presented in Table 3-1.

The 1&2 B Pond groundwater monitoring system consists of five wells that were in existence prior to publication of the CCR rule (38M, 39M, 72M, AB-25S, and AB-26S). Seven new wells (157S-CCR, 158S-CCR, 159S-CCR, 160M-CCR, 162M-CCR, 163M-CCR, and 164M-CCR) were installed in 2016 expressly for use in the CCR groundwater monitoring program. No wells associated with the 1&2 B Pond were decommissioned in 2016 or 2017. However, well AB-25S was struck by mobile equipment and the above ground portion of the well casing and the protective surface casing were damaged in December 2017. The well casing and protective casing were repaired and the well was returned to service. Well AB-25S will be re-surveyed in 2018 to account for any changes in water level measuring point elevation that may have occurred during the casing repair.

Background wells 38M and 39M are upgradient of 1&2 B Pond and any other CCR or process water facilities at the Colstrip SES. These background wells are completed in the McKay Coal and were chosen as such because the first productive groundwater horizon at the upgradient 1&2 B Pond boundary is also encountered in the McKay Coal. Upgradient wells at the waste boundary (72M, 162M-CCR, 163M-CCR, and 164M-CCR) are referred to as intermediate wells. Separate groupings of background and intermediate wells were assigned to the 1&2 B Pond groundwater monitoring system for two reasons: 1.) because it was unknown until monitoring was conducted if intermediate wells were reliably upgradient of the CCR unit (i.e. outside the influence of potential mounding); and 2.) to provide additional data for potential use in an alternative source demonstration, as allowed by §257.94(e)(2). Based on 2016 and 2017 water level and groundwater quality data,

intermediate wells completed in the McKay coal are upgradient and best represent current groundwater quality that passes the upgradient boundary of the 1&2 B Pond. The intermediate wells represent site specific conditions that include potential prior influences from upgradient facilities that are not regulated by the CCR Rule (see Figure 3-1); but these wells are not impacted by the regulated unit. Direction of groundwater flow is discussed in Section 3.2. Groundwater quality and statistical analysis of water quality at background and intermediate wells are discussed in Section 3.3 and 3.4.

The downgradient wells listed in Table 3-1 were selected to monitor the uppermost hydrostratigraphic unit directly downgradient of 1&2 B Pond. These wells are spaced along the downgradient edge of 1&2 B Pond in order to intersect all pathways of groundwater flowing through the uppermost aquifer from beneath the CCR impoundment. Downgradient monitoring wells are completed in first groundwater encountered in the McKay Coal (160M-CCR), interburden bedrock (159S-CCR), fill (AB-25S, AB-26S), or fill and interburden (157S-CCR and 158S-CCR).

3.2 GROUNDWATER ELEVATIONS, FLOW RATES, AND DIRECTION §257.93(C)

Groundwater elevations calculated from depth to water level measurements made at the 1&2 B Pond groundwater monitoring system in 2016 and 2017 are presented in Appendix B. Water level elevation hydrographs for each well in the 1&2 B Pond groundwater monitoring system are included in Appendix C. Figure 3-2 shows a spring 2016 potentiometric map of groundwater flow through the shallow deposits (e.g. spoil, interburden, alluvium) on the Plant Site, and in particular, at the 1&2 B Pond. Similarly, a spring 2016 potentiometric map of the McKay Coal horizon is shown in Figure 3-3. Groundwater flow through strata in the vicinity of the pond is generally in a west-northwest direction towards East Fork Armells Creek, the prominent local surface water feature. Erosion has occurred west of the 1&2 B Pond along East Fork Armells Creek such that the shallow coal (Rosebud), interburden, McKay Coal and portions of the shallow sub-McKay strata may be absent. Alluvial deposits have replaced these units. Note that as groundwater in the McKay Coal approaches the crop or erosion line west/northwest of 1&2 B Pond, the McKay potentiometric surface becomes very similar to the shallower hydrostratigraphic units (e.g. spoil and alluvium).

Numerous groundwater capture wells are actively pumping between 1&2 B Pond and East Fork Armells Creek. The local influence of the capture wells on groundwater flow direction can be seen in potentiometric maps constructed with 2016 water level elevations (Figures 3-2 and 3-3). While seasonal effects may influence groundwater levels in shallow and McKay intervals near the CCR unit, capture systems - including the 1&2 B Pond under-liner collection system - likely have the greatest influence on water levels and direction of flow. Hydrographs for wells surrounding the 1&2 B Pond (Appendix C) indicate that water levels fluctuated by as much as nearly 12 feet (at AB-26S) during the 2016 and 2017 monitoring period. Figures 3-4 and 3-5 show spring 2017 potentiometric surface maps of the shallow and McKay Coal hydrostratigraphic units, respectively. Temporary downtime at the 1&2 B Pond under-liner collection system in 2017 resulted in higher groundwater elevations, as compared to those observed in spring 2016 (Figures 3-2 and 3-3).

Average linear groundwater velocities at CCR wells along the prominent direction of flow (southeast to northwest) at the 1&2 B Pond were calculated according to Equation 2-1, using representative hydraulic properties previously presented in the GWMP (Hydrometrics, Inc. 2017a). Shallow groundwater (in spoils, interburden, etc.) is not consistently present upgradient of 1&2 B Pond; and the flow rate downgradient of the CCR unit varied in 2016 and 2017 based on operation of the 1& 2 B Pond underdrain. During operation of the underdrain (2016), the hydraulic gradient west of 1&2 B Pond was approximately 0.025 (see Figure 3-2). Water level elevations west of 1&2 B Pond rose and the gradient approximately doubled (0.05) when the underdrain was off in 2017. Based on an average K of 1.6 ft/day, and an η_e of 0.35, the average linear groundwater velocity downgradient of the CCR unit was estimated to be 0.11 ft/day (41 ft/year) while the underdrain was pumping and 0.22 ft/day (82 ft/year) under static conditions in 2016 and 2017. In the McKay coal, the average groundwater velocity in 2016 and 2017 was approximately 0.76 ft/day (277 ft/year) based on K = 5.7 ft/day, i = 0.012 (Figures 3-3 and 3-5), and η_e =0.09.

3.3 SAMPLE COLLECTION SUMMARY (§257.90(e)(3))

A total of 111 groundwater quality samples were collected at the 1&2 B Pond groundwater monitoring system, as listed in Table 3-2. A minimum of eight but up to 10 initial samples

were collected for detection monitoring at each upgradient, intermediate, and downgradient well between April 2016 and August 2017. Compliance samples for SSI determination (detection monitoring) were collected at each 1&2 B Pond downgradient well in August 2017. The compliance samples were collected from each downgradient well to determine whether or not there is a statistically significant increase (SSI) over background values of Appendix III detection monitoring parameters, as required by §257.93(h)(1). Background values for each of the Appendix III constituents at the 1&2 B Pond are established in Section 3.4; however, final SSI determination was not completed in calendar year 2017 and is not included in this annual report. All samples were analyzed for constituents listed in Appendices III and IV to part 257 and results are summarized in Appendix D.

3.4 STATISTICAL DETERMINATION OF BACKGROUND (§257.93(d))

Known process water impacts to groundwater at the 1&2 B Flyash Pond preclude the use of intrawell comparisons. As described above, upgradient groundwater quality for the 1&2 B Flyash Pond was represented using data collected at intermediate wells (72M, 162M-CCR, 163M-CCR and 164M-CCR) that are located directly upgradient of the waste unit boundary and completed in the first reliable groundwater. Because previous groundwater monitoring indicates that some groundwater quality impacts could be expected downgradient of the 1&2 B Pond, future upgradient to downgradient groundwater quality comparisons made directly to intermediate wells will not only provide an adequate SSI determination but it will effectively assess the potential for alternative source demonstration (ASD) in a single step.

Side-by-side box plots constructed of data collected at the 1&2 B Flyash Pond in 2016 and 2017 are presented in Figures 3-6 and 3-7 to illustrate differences in the distribution of detection monitoring constituents, including differences in distributions between background, intermediate, and downgradient wells. There are apparent differences in the distribution and maximum values of Appendix III constituents between downgradient and either set of upgradient wells (intermediate and background) that are not as evident between values of the same constituents at background and intermediate wells. However, distributions of some of the Appendix III constituents have higher maxima in intermediate wells than in the designated background wells. Use of potentially impacted intermediate wells to establish

representative upgradient water quality will result in conservatively higher prediction limits. Where SSI are determined in future comparisons between downgradient and upgradient intermediate wells, no alternative source demonstration is necessary (or appropriate) and Colstrip SES operators may proceed with assessment monitoring per §257.95. If SSI are not determined in future comparisons between downgradient and upgradient intermediate wells, compelling justification for an ASD likely exists. Note that box plots do not constitute the formal statistical evaluation required by §257.93(h)(1) and SSI are not evaluated in this annual report.

Statistical evaluation of spatial variability at the 1&2 B Flyash Pond is discussed further in Section 3.4.2, following tests for normality in Section 3.4.1.

3.4.1 Data Distribution

Tests of normality were conducted using the Shapiro-Wilk procedure for all candidate upgradient well-constituent pairs of the 1&2 B Flyash groundwater monitoring system to establish the appropriateness of normal theory (parametric) or distribution-free (non-parametric) tests for all of the detection monitoring constituents. Results are found in Appendix F.

Normal or log-normal distributions were observed for boron, calcium, chloride, sulfate, and TDS at well 162M-CCR; calcium, sulfate and TDS at well 163M-CCR; boron and chloride at well 164M; and boron, calcium, chloride and TDS at well 72M. Fluoride could not be formally evaluated for wells 162M-CCR, 163M-CCR, and 164M-CCR, as all of the individual observations at those wells in 2016 and 2017 were of a single value (0.2 mg/L). The remaining constituents were neither normally or log-normally distributed at 162M-CCR, 163M-CCR, 164M-CCR and 72M.

3.4.2 Spatial Variability

Side-by-side box plots of Appendix III detection monitoring constituents for the 1&2 B Flyash groundwater monitoring system are shown in Figures 3-6 & 3-7. Examination of the box plots provides an initial indication of the spatial variability of each of the seven detection

monitoring constituents between the upgradient wells. Box plots for the intermediate wells (72M, 162M-CCR, 163M-CCR and 164M-CCR) show that localized calcium concentrations in well 162M-CCR were apparently higher than the rest of the upgradient data set. In addition, box plots for well 164M indicated a high level of variability in the boron, calcium, chloride, sulfate, and TDS results. Increasing trends for these analytes were also identified using Mann-Kendall trend analysis (Section 3.4.3). As such, calcium in well 162M-CCR and boron, calcium, chloride, sulfate, and TDS in well 164M-CCR were statistically excluded from the background dataset for prediction limit purposes.

An assumption of normality was made for each parameter for which normally distributed parameters were observed in all or some of the upgradient wells (boron, calcium, chloride, sulfate, and TDS) and parametric ANOVA (Appendix F) tests were conducted between wells. The non-parametric Kruskal-Wallis test was applied to fluoride and pH to verify the statistical significance of the apparent variability (Appendix F). All tests indicated variable means and/or data distributions with a high degree of statistical certainty between the four upgradient wells. Summary statistics and box plots indicate that water quality in wells 163M-CCR and 72M were similar for most Appendix III constituents.

3.4.3 Trend Analysis

Mann-Kendall trend tests were conducted for each upgradient well-constituent pair as a final check of the applicability of the dataset to represent groundwater quality conditions at the CCR unit boundary. Results are found in Appendix F. Mann-Kendall tests indicated increasing trends for boron, calcium, chloride, and TDS at well 164M-CCR. A trend for sulfate wasn't indicated, but the time-series graph (Appendix E) shows a shift in concentrations. All water quality trends at well 164M-CCR are the result of a similar shift that occurred in late 2016 and early 2017 (Appendix E). Concentrations of boron and chloride in well 164M-CCR increased to levels significantly above the other background wells. This shift is likely not related to impacts from 1&2 B Pond as other wells did not exhibit the same shift. Therefore, prediction limit tests were conducted on the intermediate data set excluding boron, calcium, chloride, sulfate, and TDS in well 164M-CCR. Although statistically significant decreasing trends were identified for several constituents in wells

162M-CCR and 163M-CCR, none of these trends were of the same magnitude as the trends seen in 164M-CCR or of practical significance in determining the final calculation of representative upgradient groundwater quality by interwell prediction limits. Trends will continue to be evaluated in following future sampling events and groundwater quality updates.

3.4.4 Interwell Prediction Limits

Because inconsistent distribution, spatial non-stationarity and/or significant water quality trends were exhibited in the data set, a combination of non-parametric or parametric prediction limits based on data combinations of individual wells were evaluated. A summary of prediction limits is presented in Table 3-3. Methodology used to determine the prediction limits for the 1&2 B Flyash Pond are as follows.

- Boron - Due to a significant increasing trend and maximum boron concentrations in well 164M-CCR, this well was excluded for prediction limit purposes due to spatial variability. Concentrations from a pooled data set from 72M, 162M-CCR and 163M were normally distributed and considered representative of the upgradient water quality for boron. A parametric upper prediction was therefore calculated as 1.6 mg/L based on K-multiplier appropriate for seven constituents, six compliance wells (Table 3-1), and 37 groundwater quality observations.
- Calcium concentrations in well 162M-CCR were determined not to be representative of the background data, as this well exhibits locally higher concentrations, and concentrations in well 164M-CCR showed an upward trend. As such, calcium results in wells 162M-CCR and 164M-CCR were statistically excluded from prediction limit calculations. The upper prediction limit was determined non-parametrically based on the maximum calcium value of 271 mg/L at 72M.
- Well 164M was excluded from prediction limit determination due to significant increasing trends and non-stationary distribution of chloride, sulfate, and TDS concentrations. Upper non-parametric prediction limits were determined based on the maximum values of chloride (112 mg/L), sulfate (3830 mg/L), and TDS (6190 mg/L) at well 162M-CCR.

- All four upgradient intermediate wells were considered for fluoride and pH. These constituents were not normally distributed. The non-parametric prediction limit for fluoride was determined based on the maximum reported value of 0.3 mg/L (72M). Similarly, the reported range in the upgradient dataset for pH was 6.6 (162M-CCR) to 7.3 (163M-CCR and 164M-CCR).

TABLE 3-1. COLSTRIP 1&2 B FLYASH POND MONITORING WELLS

Well Type/ID	Date of Completion	Total Depth (feet bgs)	Perforated Interval (feet bgs)	Hydrostratigraphic Unit
Background Wells				
38M	8/7/1993	113	98-113	McKay Coal
39M	8/8/1993	93.5	84-93.5	McKay Coal
Intermediate Wells – Directly Upgradient of CCR Unit				
72M	11/21/2005	75	64-71	McKay Coal
162M-CCR	4/13/2016	72	67-72	McKay Coal
163M-CCR	4/13/2016	72	67-72	McKay Coal
164M-CCR	4/14/2016	70	65-70	McKay Coal
Downgradient Wells				
AB-25S	8/20/1996	42.5	37.5-42.5	Fill
AB-26S	8/21/1996	37.5	32-37.5	Fill
160M-CCR	4/12/2016	57	52-57	McKay Coal
157S-CCR	4/12/2016	34	29-34	Spoil/Interburden
158S-CCR	4/12/2016	35	30-35	Spoil/Interburden
159S-CCR	4/12/2016	49.5	39.5-49.5	Interburden

Table 3-2. 1&2 B Flyash Pond Sample Collection Summary

Well Type/ID	Total Number of Samples Collected	Number of Initial Samples Detection Monitoring §257.93(d), §257.94(b)	Number of Samples for SSI Determination Detection Monitoring §257.93(h)(1)	Initial Sample [§257.93(d), §257.94(b)] Collection Dates										Detection Monitoring Sample §257.93(h)(1) Collection Dates
Background Wells														
38M	9	9	NA	4/1/16	6/22/16	8/8/16	9/6/16	11/29/16	1/31/17	3/2/17	4/25/17	8/9/17		--
39M	9	9	NA	4/4/16	6/21/16	8/11/16	9/8/16	11/30/16	1/30/17	3/7/17	4/26/17	8/8/17		--
Intermediate Wells														
72M	10	10	NA	2/18/16	4/21/16	6/23/16	8/8/16	9/13/16	12/6/16	1/31/17	3/6/17	5/1/17	8/9/17	--
164M-CCR	9	9	NA	4/27/16	6/23/16	8/8/16	9/13/16	12/7/16	1/31/17	3/6/17	5/2/17	8/9/17		--
163M-CCR	9	9	NA	4/28/16	6/23/16	8/9/16	9/13/16	12/6/16	1/31/17	3/6/17	5/2/17	8/10/17		--
162M-CCR	9	9	NA	4/28/16	6/21/16	8/9/16	9/14/16	12/6/16	1/31/17	3/6/17	4/26/17	8/10/17		--
Downgradient Wells														
AB-25S	10	9	1	2/23/16	4/27/16	6/23/16	8/10/16	9/15/16	12/5/16	2/1/17	3/8/17	4/28/17		8/8/17
AB-26S	10	9	1	2/22/16	4/27/16	6/23/16	8/10/16	9/15/16	12/7/16	2/1/17	3/8/17	4/28/17		8/10/17
157S-CCR	9	8	1	4/27/16	6/21/16	8/9/16	9/14/16	12/7/16	2/2/17	3/7/17	5/1/17			8/8/17
158S-CCR	9	8	1	4/27/16	6/22/16	8/9/16	9/14/16	12/7/16	2/2/17	3/7/17	4/27/17			8/16/17
159S-CCR	9	8	1	4/27/16	6/22/16	8/10/16	9/14/16	12/7/16	2/1/17	3/8/17	4/27/17			8/16/17
160M-CCR	9	8	1	4/28/16	6/23/16	8/10/16	9/15/16	12/7/16	2/1/17	3/9/17	4/27/17			8/16/17

TABLE 3-3. COLSTRIP 1&2 B FLYASH POND PREDICTION LIMITS

Appendix III Parameter	McKay Prediction Limit (mg/L)	Statistical Method
Boron	1.6	Parametric Upper Prediction Limit (except 164M-CCR)(1)
Calcium	271	Non-parametric maximum background (except 162M-CCR & 164M-CCR)(1) & (2)
Chloride	112	Non-parametric maximum background (except 164M-CCR)(1)
Fluoride	0.3	Non-parametric maximum background
pH	6.6 - 7.3	Non-parametric (background range)
Sulfate	3830	Non-parametric maximum background (except 164M-CCR)(1)
TDS	6190	Non-parametric maximum background (except 164M-CCR)(1)

(1) 164M excluded due to increasing trend

(2) 162M excluded, as local calcium concentrations are higher than other unit wells and therefore not representative.

4.0 COLSTRIP 1&2 BOTTOM ASH POND

4.1 LOCATION AND DESCRIPTION

In accordance with §257.90 (e)(1), a map with aerial background imagery for the Colstrip 1&2 Bottom Ash Pond (1&2 BAP); and all upgradient (or background) and downgradient monitoring wells associated with this CCR unit is presented in Figure 4-1. Wells that make up the groundwater monitoring system for the 1&2 BAP are listed in Table 4-1. First groundwater at the 1&2 BAP may be encountered in alluvium, spoils or other shallow unconsolidated sediments, or the McKay Coal. Groundwater flow pathways in all of these units are represented in the 1&2 BAP groundwater monitoring system, as the system includes wells completed in each. Wells with an "A" suffix are completed in alluvium, wells designated with an "S" suffix are completed in shallow sediments, and wells with an "M" suffix are completed in McKay Coal.

The 1&2 BAP groundwater monitoring system consists of eight wells that were in existence prior to publication of the CCR rule. The 1&2 BAP groundwater monitoring system was augmented with six new wells (148A-CCR, 149M-CCR, 150M-CCR, 151M-CCR, 154A-CCR, and 155A-CCR) in 2016. The six new wells were installed as compliance wells at the downgradient edge of the waste boundary. No wells associated with the 1&2 BAP were decommissioned in 2016 or 2017.

Consistent with the setting of 1&2 B Pond, there are a number of process water facilities that are not regulated by the CCR Rule that are located east/southeast of the 1&2 BAP that may have been or are currently upgradient of the regulated unit. Wells 38M and 39M were assigned as background wells that are far outside the influence of any current or former process pond. Existing intermediate upgradient well 13M is nearer to the upgradient boundary and more accurately represents current upgradient groundwater quality conditions in the McKay Coal at the 1&2 BAP. Similarly, well 13S is positioned closer to the CCR unit and is most representative of current groundwater quality conditions in the shallow hydrostratigraphic interval at the upgradient waste boundary. Unlike conditions encountered in the McKay hydrostratigraphic unit, East Fork Armells Creek Alluvium is only present at

the downgradient boundary of the 1&2 BAP. Background alluvial groundwater conditions are represented in the 1&2 BAP groundwater monitoring system at wells 63S and 104A. These wells are located upgradient of 1&2 BAP and any other flow pathways that would be expected from a CCR unit.

Downgradient wells included in the 1&2 BAP groundwater monitoring system are completed as near as possible to the waste boundary in the first water-bearing unit. The downgradient wells are located along the western boundary of the 1&2 BAP from well AB-20S in the southwest to well 154A-CCR in the northwest. While AB-20S was listed in the GWMP (Hydrometrics 2017a) as a downgradient well, based on groundwater flow paths, it is evident that AB-20S is not downgradient of the 1&2 BAP and is more appropriately categorized as an intermediate well (see Table 4-1). As such AB-20S was not included as a background or compliance well; but it may be used as an intermediate well to support ASD in 2018, if necessary. Because the downgradient waste boundary of the 1&2 BAP is coincident with the margin of the ancestral stream bed that eroded the McKay Coal, downgradient wells are completed in alluvium (48S, 148A-CCR, and 155A-CCR), the McKay Coal (150M-CCR and 151M-CCR), or alluvium in direct contact with the McKay Coal (149M-CCR and 154A-CCR).

4.2 GROUNDWATER ELEVATIONS, FLOW RATES, AND DIRECTION §257.93(C)

Figures 4-2 and 4-3 are potentiometric maps of the shallow (interburden, spoils and/or alluvium) and McKay coal hydrostratigraphic intervals, respectively. All static groundwater levels and elevations recorded at the 1&2 BAP groundwater monitoring system prior to sample collection in 2016 and 2017 and a hydrograph for each well are presented in Appendix C.

The direction of flow in both the uppermost hydrostratigraphic unit and the McKay coal is generally from southeast to northwest; but local inflection exists near pumping wells (Figures 4-2 and 4-3). Aside from capture wells, there is not enough seasonal or other natural variability to significantly alter the gradient or direction of flow. The average linear groundwater velocity in the shallow hydrostratigraphic unit (unconsolidated) in 2016 and

2017 is estimated based on equation 2-1 to be 0.42 ft/day (154 ft/year); where the hydraulic gradient (i) = 0.015, hydraulic conductivity (K) = 7 ft/day, and effective porosity (n_e) = 0.25. The average horizontal hydraulic gradient in the McKay coal, based on well 13M which is directly upgradient of the 1&2 BAP and McKay wells downgradient of the 1&2 BAP (e.g. 149M-CCR and 150M-CCR) is approximately 0.03. Assuming an effective porosity of 0.09 for coal and an average hydraulic conductivity of 6.3 ft/day, the rate (seepage velocity) of groundwater flow in the McKay Coal at the 1&2 BAP is 2.1 ft/day (766.5 ft/yr). Steeper gradients at capture wells result in increased flow rates, locally, in both the shallow and McKay coal hydrostratigraphic units.

4.3 SAMPLE COLLECTION SUMMARY (§257.90(e)(3))

A summary of groundwater quality samples collected at the 1&2 BAP groundwater monitoring system in 2016 and 2017 is presented in Table 4-2. A total of 130 samples were collected at this groundwater monitoring system in 2016/2017. A minimum of eight but up to 10 initial samples were collected for detection monitoring at each upgradient, intermediate, and downgradient well between April 2016 and August 2017. Compliance samples for SSI determination (detection monitoring) were collected at each 1&2 B Pond downgradient well in August 2017. The compliance samples were collected from each downgradient well to determine whether or not there is a statistically significant increase (SSI) over background values of Appendix III detection monitoring parameters, as required by §257.93(h)(1). Background values for each of the Appendix III constituents at the 1&2 BAP are established in Section 4.4; however, final SSI determination was not completed in calendar year 2017 and is not included in this annual report. Laboratory analytical results for all samples listed in Table 4-2 are provided in Appendix D.

4.4 STATISTICAL DETERMINATION OF BACKGROUND AT 1&2 BAP

Known process water impacts to groundwater at the 1&2 BAP preclude the use of intrawell comparisons. The 1&2 BAP unit consists of shallow (spoils and/or alluvium) and McKay Coal hydrostratigraphic intervals and both intervals were evaluated separately. As described above, upgradient wells for the shallow hydrostratigraphic interval included wells 13S (directly upgradient of the waste boundary), 63S, and 104A as they collectively represent

shallow groundwater quality upgradient of the 1&2 BAP waste boundary that flows through interburden from the east and alluvium from the south. Wells 104A and 63S are most representative of East Fork Armells Creek gravel water quality and well 13S is most representative of interburden groundwater upgradient of the CCR unit.

Representative upgradient groundwater quality for the McKay strata was represented by data from well 13M. Well 13M is potentially downgradient of CCR facilities that are not regulated by the CCR Rule; however, long-term monitoring at the well indicates that it is not impacted by CCR process water. Side-by-side box plots constructed of data collected at the 1&2 BAP in 2016 and 2017 are presented in Figures 4-4 and 4-5 to illustrate differences in the distribution of detection monitoring constituents, including differences in distributions between upgradient and downgradient wells. Box plots of McKay coal groundwater quality data collected in 2016 and 2017 suggest spatial variability between upgradient intermediate well 13M and both the background (38M and 39M) and downgradient (149M-CCR, 150M-CCR,) well groupings. Discernible differences in the distribution of detection monitoring constituents between 13M and downgradient wells suggests that McKay well 13M provides sufficient data for future upgradient to downgradient groundwater quality comparison for SSI determination.

Formal statistical evaluation of spatial variability at the 1&2 BAP is discussed in Section 4.4.2 following tests for normality in Section 4.4.1. Final prediction limits are discussed in Section 4.4.3.

4.4.1 Data Distribution

Tests of normality were conducted using the Shapiro-Wilk procedure for all background well-constituent pairs of the 1&2 BAP groundwater monitoring system to establish the appropriateness of normal theory (parametric) or distribution-free (non-parametric) tests for all of the detection monitoring constituents. Results are found in Appendix F.

Boron, calcium, chloride, sulfate, and TDS were all found to be normally distributed at all wells in the shallow unit (interburden or alluvium) except for chloride at well 63S and boron

at well 13S. Constituent concentrations at well 13M were normally distributed for boron, calcium, chloride, pH, sulfate and TDS. Fluoride could not be formally evaluated for wells 104A, 63S and 13M, as all of the individual observations at those wells in 2016 and 2017 were of a single value (0.2 mg/L). The remaining constituents were neither normally nor log-normally distributed.

4.4.2 Spatial Variability

Side-by-side box plots of Appendix III detection monitoring constituents for the 1&2 BAP groundwater monitoring system are shown in Figures 4-4 & 4-5. Examination of the box plots provides an initial indication of the spatial variability of each of the seven detection monitoring constituents between wells for both the McKay and alluvial hydrostratigraphic intervals. Box plots show that despite being potentially downgradient of CCR units that are not regulated by the CCR Rule, shallow well 13S does not universally exhibit higher concentrations of Appendix III analytes than background wells 104A and 63S. Some variability is apparent in the distribution of constituents at wells 104A, 63S, and 13S but this variability should necessarily be represented in the determination of upgradient groundwater quality because the shallow hydrostratigraphic unit at the downgradient boundary of 1&2 BAP is sourced from both (alluvium and interburden) flow paths. As discussed in Section 4.4.3, pooled data that included well 13S were used for one Appendix III detection monitoring constituent (chloride) but the remaining six prediction limits were derived from non-parametric data from wells 63S and 104A. Also, as can be seen in Figure 4-4, the boxplots for calcium in McKay well 13M indicate an extreme outlier; therefore, this data point (565 mg/L) was not used in determining the prediction limit for this stratum.

An assumption of normality was made for each parameter for which normally distributed parameters were observed in all or some of the alluvial background wells (boron, calcium, chloride, sulfate, and TDS) and parametric ANOVA (Appendix F) tests were conducted between wells. The non-parametric Kruskal-Wallis test was applied to fluoride and pH to verify the statistical significance of the apparent variability (Appendix F). All tests indicated variable means and/or data distributions with a high degree of statistical certainty between

the three shallow background wells. Summary statistics and box plots, however, indicate that water quality in wells 104A and 63S were similar for most Appendix III constituents.

4.4.3 Interwell Prediction Limits

Because inconsistent distribution and spatial non-stationarity were exhibited in the background data set, combinations of non-parametric or parametric prediction limits were evaluated. A summary of prediction limits is presented in Table 4-3 and Table 4-4. Methodology used to determine the prediction limits for the 1&2 BAP follows.

Shallow

- Chloride - Concentrations from a pooled data set from 104A, 63S, and 13S were normally distributed for chloride. A parametric upper prediction limit was therefore calculated as 218 mg/L based on a K-multiplier appropriate for seven constituents, three compliance wells (Table 4-1), and 29 background observations from the three background wells.
- Prediction limits were determined non-parametrically based on maximum background values from 63S for boron (4.5 mg/L), calcium (499 mg/L), fluoride (0.3 mg/L), sulfate (3320 mg/L), and TDS (5190 mg/L). Similarly, the background range for pH was 7.0 (13S) to 7.4 (104A).

McKay

- Boron, chloride, sulfate, pH, and TDS were all normally distributed in upgradient well 13M. Parametric upper prediction limits were therefore calculated as 0.77 mg/L, 65 mg/L, 2967 mg/L, and 4709 mg/L, respectively based on a K-multiplier appropriate for seven constituents, four compliance wells (Table 4-1), and 10 background observations. The prediction limit range for pH was 7.0 to 7.4.

- Calcium was not normally distributed in well 13M; however, when excluding the outlier of 565 mg/l (see Section 4.4.2), the distribution becomes normal. Therefore, a parametric prediction limit of 502 mg/l was calculated for calcium excluding this outlier with a K-multiplier appropriate for seven constituents, four compliance wells and 9 background observations.
- Fluoride was not normally distributed in well 13M and therefore a non-parametric prediction limit was determined based on the maximum background value for fluoride (0.2 mg/L).

TABLE 4-1. COLSTRIP 1&2 BOTTOM ASH POND MONITORING WELLS

Well Type/ID	Date of Completion	Total Depth (feet bgs)	Perforated Interval (feet bgs)	Hydrostratigraphic Unit
Background Wells				
104A	5/5/2009	36	16-36	Alluvium
63S	12/15/2003	31.5	15.5-31.5	Alluvium
38M	8/7/1993	113	98-113	McKay Coal
39M	8/8/1993	93.5	84-93.5	McKay Coal
Intermediate Wells – Directly Upgradient of CCR Unit				
13S	5/10/1976	22.5	17-22.5	Interburden
13M	5/10/1976	37.5	25-35	McKay Coal
AB-20S	8/25/1996	47.5	35-47.5	Alluvium
Downgradient Wells				
48S	9/26/1995	34	17-34	Alluvium
148A-CCR	3/31/2016	31	26-31	Alluvium
155A-CCR	4/11/2016	35	25-35	Alluvium
149M-CCR	3/31/2016	25	20-25	Alluvium/McKay Coal
154A-CCR	4/11/2016	25	20-25	Alluvium/McKay Coal
150M-CCR	3/31/2016	25	20-25	McKay Coal
151M-CCR	3/31/2016	26	21-26	McKay Coal

Table 4-2. 1&2 Bottom Ash Pond Groundwater Sample Collection Summary

Well Type/ID	Total Number of Samples Collected	Number of Initial Samples Detection Monitoring §257.93(d), §257.94(b)	Number of Samples for SSI Determination Detection Monitoring §257.93(h)(1)	Initial Sample [§257.93(d), §257.94(b)] Collection Dates										Detection Monitoring Sample §257.93(h)(1) Collection Dates
Background Wells														
104A	10	10	NA	2/24/16	4/26/16	6/28/16	8/3/16	9/6/16	11/30/16	2/13/17	3/7/17	5/1/17	8/21/17	--
63S	9	9	NA	3/31/16	6/27/16	8/3/16	8/29/16	11/28/16	2/15/17	3/14/17	5/2/17	8/21/17		--
38M	9	9	NA	4/1/16	6/22/16	8/8/16	9/6/16	11/29/16	1/31/17	3/2/17	4/25/17	8/9/17		--
39M	9	9	NA	4/4/16	6/21/16	8/11/16	9/8/16	11/30/16	1/30/17	3/7/17	4/26/17	8/8/17		--
Intermediate Wells														
13S	10	10	NA	2/19/16	4/22/16	6/28/16	8/2/16	9/8/16	11/30/16	2/6/17	3/2/17	5/2/17	8/14/17	--
13M	10	10	NA	2/19/16	4/26/16	6/28/16	8/3/16	9/8/16	11/30/16	2/6/17	3/2/17	5/1/17	8/16/17	--
AB-20S	9	9	NA	4/7/16	6/24/16	8/3/16	9/6/16	12/5/16	2/2/17	3/8/17	4/24/17	8/15/2017		--
Downgradient Wells														
48S	10	9	1	2/22/16	4/26/16	6/15/16	7/14/16	9/7/16	12/7/16	2/13/17	3/13/17	4/24/17		8/10/17
148A-CCR	9	8	1	4/12/16	6/15/16	7/14/16	9/7/16	11/29/16	2/13/17	3/13/17	4/24/17			8/21/17
155A-CCR	9	8	1	5/4/16	6/15/16	7/14/16	9/7/16	12/7/16	2/13/17	3/13/17	4/24/17			8/15/17
154A-CCR	9	8	1	5/4/16	6/15/16	7/14/16	9/7/16	12/7/16	2/6/17	3/9/17	4/25/17			8/21/17
149M-CCR	9	8	1	4/11/16	6/15/16	7/14/16	9/7/16	12/7/16	2/7/17	3/13/17	4/25/17			8/14/17
150M-CCR	9	8	1	4/12/16	6/15/16	7/15/16	9/7/16	12/6/16	2/7/17	3/13/17	4/26/17			8/14/17
151M-CCR	9	8	1	4/12/16	6/15/16	7/14/16	9/7/16	12/6/16	2/7/17	3/13/17	5/1/17			8/14/17

TABLE 4-3. COLSTRIP 1&2 BOTTOM ASH POND ALLUVIUM PREDICTION LIMITS

Appendix III Parameter	Alluvial Prediction Limit (mg/L)	Statistical Method
Boron	**4.5**	Non-parametric maximum background
Calcium	**499**	Non-parametric maximum background
Chloride	**218**	Parametric Upper Prediction Limit
Fluoride	**0.3**	Non-parametric maximum background
pH	**7.0 - 7.4**	Non-parametric (background range)
Sulfate	**3320**	Non-parametric maximum background
TDS	**5190**	Non-parametric maximum background

TABLE 4-4. COLSTRIP 1&2 BOTTOM ASH POND MCKAY PREDICTION LIMITS

Appendix III Parameter	McKay Prediction Limit (mg/L)	Statistical Method
Boron	**0.77**	Parametric Upper Prediction Limit
Calcium	**502**	Parametric Upper Prediction Limit
Chloride	**65**	Parametric Upper Prediction Limit
Fluoride	**0.2**	Non-parametric maximum background
pH	**7.0 - 7.4**	Parametric Prediction Limit Range
Sulfate	**2967**	Parametric Upper Prediction Limit
TDS	**4709**	Parametric Upper Prediction Limit

5.0 COLSTRIP 3&4 BOTTOM ASH POND

5.1 LOCATION AND DESCRIPTION

A map with aerial background imagery is shown for the Colstrip 3&4 Bottom Ash Pond (3&4 BAP); and all upgradient (or background) and downgradient monitoring wells that are part of its groundwater monitoring system are identified in Figure 5-1 in accordance with §257.90 (e)(1). A summary of wells in the 3&4 BAP groundwater monitoring system is presented in Table 5-1. All of the wells in the 3&4 BAP groundwater monitoring system are completed in mine spoils.

The 3&4 BAP groundwater monitoring system consists of two background wells (20SP and 21SP-2) and four downgradient wells (22SP, 84SP, 85SP, and 89SP) that were in existence prior to publication of the CCR rule. A single new background well (161SP-CCR) and three new downgradient wells (152SP-CCR, 152SP-2-CCR, and 153SP-CCR) were installed in 2016 and/or 2017 expressly for use in the CCR groundwater monitoring program. Well 152SP-CCR was decommissioned in 2017 after it was struck by a piece of mobile construction equipment and was damaged beyond repair. Well 152SP-CCR was replaced with 152SP-2-CCR. The well casing and steel surface casing at well 20SP were extended in 2017 to match the ground surface elevation which was elevated by approximately nine feet during ongoing construction in the 3&4 BAP area. The measuring point elevation of the well was raised from 3298.77 feet to 3307.58 feet (Dowl 2017). Groundwater quality at the well was not affected by the extension.

As noted, monitoring well 21SP-2 was identified in the GWMP (Hydrometrics, Inc. 2017a) as a background well (Table 5-1). Further review of hydrogeologic data collected in 2016/2017 and groundwater quality data from the period of record (1993 to present) indicate that this well is both downgradient of the 3&4 BAP and has apparent increasing trends of key detection monitoring constituents (e.g. boron). Well 21SP-2 is not used to establish background groundwater quality at the 3&4 BAP.

5.2 GROUNDWATER ELEVATIONS, FLOW RATES, AND DIRECTION §257.93(C)

A potentiometric map of the uppermost hydrostratigraphic interval (spoils) at the 3&4 BAP is presented in Figure 5-2. All static groundwater levels and elevations recorded at the 3&4 BAP groundwater monitoring system prior to sample collection in 2016 and 2017 and a hydrograph for each well constructed using those water level elevations are presented in Appendix C.

As noted in the GWMP (Hydrometrics, Inc. 2017a) and illustrated in Figure 5-2, a hydrologic divide is present south and east of the Colstrip SES plant that separates groundwater flow between the East Fork Armells Creek drainage and the South Fork Cow Creek drainage. The divide occurs naturally but is accentuated locally by mounding from the 3&4 BAP. Pumping at capture wells that are operating on the south and northeast side of the pond and by a dewatering well operated by the neighboring Western Energy Company to the north, known as the WECO well, lowers the water table and causes local influences on the direction of groundwater flow.

Several pumping tests have been conducted on spoil wells around the 3&4 BAP. Hydraulic conductivity estimates from wells that are included in the CCR monitoring program ranged from 5.3ft/day at well 153SP-CCR to 622 ft/day at well 89SP (Hydrometrics, Inc. 2017a) with a median value of about 49 ft/day. These values are relatively high compared to undisturbed bedrock strata which typically range from less than one to a few feet per day. Excluding potentiometric depressions caused by pumping wells, the hydraulic gradient is relatively constant (~0.025) in all directions of flow downgradient of the 3&4 BAP. Assuming an effective porosity of 0.25 for spoils, the average linear groundwater velocity at the 3&4 BAP in 2016/2017 was 4.9 ft/day (1789 ft/year).

5.3 SAMPLE COLLECTION SUMMARY (§257.90(e)(3))

A summary of groundwater quality samples collected at the 3&4 BAP groundwater monitoring system is presented in Table 5-2. A total of 106 samples (excluding abandoned well 152SP-CCR) have been collected at this groundwater monitoring system. A minimum

of eight but up to 13 initial samples were collected for detection monitoring at each upgradient, intermediate, and downgradient well between April 2016 and November 2017. Most compliance samples for SSI determination (detection monitoring) were collected at each 3&4 BAP downgradient well in August through September 2017 sampling events. However, because well 152SP2-CCR was completed as a replacement well approximately one year after the rest of the 3&4 BAP monitoring well network, the compliance sample was not collected there until November. The final sample from each downgradient well was collected to determine whether or not there is a statistically significant increase (SSI) over background values of Appendix III detection monitoring parameters, as required by §257.93(h)(1). Background values for each of the Appendix III constituents at the 3&4 BAP are established in Section 5.4; however, final SSI determination was not completed in calendar year 2017 and is not included in this annual report. Laboratory analytical results for all samples listed in Table 5-1 are provided in Appendix D. Time series plots of detection monitoring constituents are found in Appendix E.

5.4 STATISTICAL DETERMINATION OF BACKGROUND AT 3&4 BAP

Wells 20SP, 21SP-2, and 161SP-CCR were originally included as background wells in the 3&4 BAP groundwater monitoring system (Hydrometrics 2017a). As discussed above, well 21SP-2 was downgradient of the CCR unit in 2016 and 2017; therefore, it was not included as a background well. Well 20SP is near the 3&4 BAP waste boundary and appears to be situated near the hydraulic divide. As such, further examination was conducted using summary statistics and trend tests to establish the relevance of using 20SP as a background well. Water quality trends at 20SP are stable (see Section 5.4.3) and not indicative of process water influences. In addition, summary statistics show that water quality from 20SP is generally similar to 161SP-CCR for most analytes; therefore, samples collected at wells 20SP and 161SP-CCR comprise the background groundwater quality dataset for the 3&4 BAP. Prediction intervals were developed based on this dataset for future interwell comparison methods.

5.4.1 Data Distribution

Tests of normality were conducted using the Shapiro-Wilk procedure for all background well-constituent pairs of the 3&4 BAP groundwater monitoring system to establish the appropriateness of normal theory (parametric) or distribution-free (non-parametric) tests for all of the detection monitoring constituents. Results are found in Appendix F.

Boron, calcium, chloride, sulfate, and TDS were all found to be normally distributed at wells 161SP-CCR and 20SP. Fluoride could not be formally evaluated for well 20SP, as all of the individual observations at those wells in 2016 and 2017 were of a single value (0.2 mg/L). The remaining constituents were neither normally nor log-normally distributed.

5.4.2 Spatial Variability

Side-by-side box plots of Appendix III detection monitoring constituents for the 3&4 BAP groundwater monitoring system are shown in Figures 5-3 and 5-4. Examination of the box plots provides an initial indication of the spatial variability of each of the seven detection monitoring constituents. Box plots show that well 161SP-CCR generally exhibited a broader distribution and/or higher concentrations of Appendix III analytes than 20SP, with the exception of boron and TDS.

An assumption of normality was made for each parameter for which normally distributed parameters were observed in one or both background wells (boron, calcium, chloride, sulfate, and TDS) and parametric ANOVA (Appendix F) tests were conducted between wells. The non-parametric Kruskal-Wallis test was applied to fluoride and pH to verify the statistical significance of the apparent variability (Appendix F). All tests indicated variable means and/or data distributions with a high degree of statistical certainty between the two background wells with the exception of TDS and pH, indicating that the data for these to analytes are likely from the same population.

5.4.3 Trend Analysis

Mann-Kendall trend tests were conducted for each background well-constituent pair as a final check of the applicability of the dataset to represent background groundwater quality

conditions at the CCR unit boundary. Results are found in Appendix F. Mann-Kendall tests indicated increasing trends for chloride at well 161SP-CCR and sulfate at wells 20SP and 161SP-CCR. Mann-Kendall tests indicated decreasing trends for boron and calcium at 161SP-CCR. Time-series graphs confirmed that a slight trend shift occurred in late 2016 and early 2017 (Appendix E) for sulfate at well 20SP, but overall sulfate concentrations were lower than those in 161SP-CCR. The remaining trends identified by the Mann-Kendall tests were of limited practical significance when considering the range of observations; for example, there was a difference of 8 mg/L between the maximum and minimum for chloride at 161SP-CCR. Trends will continue to be evaluated in following future sampling events and background groundwater quality updates.

5.4.4 Interwell Prediction Limits

Because inconsistent distribution and spatial non-stationarity were exhibited in the background data set, both non-parametric and parametric prediction limits were evaluated, as applicable. A summary of prediction limits is presented in Table 5-3. Methodology to determine the prediction limits for the 3&4 BAP follows.

- Calcium - Normality tests indicated that only calcium data in the pooled background data set (161SP-CCR and 20SP) was normally distributed. A parametric upper prediction limit was therefore calculated as 345 mg/L based on K-multiplier appropriate for seven constituents, six compliance wells (Table 5-1), and 21 background observations from the two background wells.
- Due to spatial variability, prediction limits for boron, chloride, pH, fluoride, sulfate, and TDS were determined non-parametrically based on maximum background values from 20SP for boron (0.29 mg/L) and TDS (3730 mg/L). Non-parametric prediction limits for chloride (52 mg/L), fluoride (0.2 mg/L), sulfate (2320 mg/L), and TDS (3730 mg/L) are represented by the highest ranked values in the 161SP-CCR dataset. Similarly, the background range for pH was 7.0 (161SP-CCR) to 7.3 (20SP).

TABLE 5-1. COLSTRIP 3&4 BOTTOM ASH POND MONITORING WELLS

Well Type/ID	Date of Completion	Total Depth (feet bgs)	Perforated Interval (feet bgs)	Hydrostratigraphic Unit
Background Wells				
20SP	7/11/1983	35	25-35	Spoil
21SP-2[†]	8/8/1993	87	47-87	Spoil
161SP-CCR	4/14/2016	70	63 - 73	Spoil
Downgradient Wells				
22SP	7/11/1983	51	31-51	Spoil
84SP	6/17/2008	60	45-60	Spoil
85SP	6/17/2008	63	43-63	Spoil
89SP	6/19/2008	69	49-69	Spoil
152SP-CCR*	4/1/2016	65	55 - 65	Spoil
152SP-2-CCR**	1/19/2017	60	50 – 60	Spoil
153SP-CCR	4/1/2016	90	48 - 58	Spoil

[†]well not used to determine background groundwater quality

*well was abandoned.

**well installed as a replacement for 152SP-CCR.

Table 5-2. 3&4 Bottom Ash Pond Groundwater Sample Collection Summary

Well Type/ID	Total Number of Samples Collected	Number of Initial Samples Detection Monitoring §257.93(d), §257.94(b)	Number of Samples for SSI Determination Detection Monitoring §257.93(h)(1)	Initial Sample [§257.93(d), §257.94(b)] Collection Dates													Detection Monitoring Sample §257.93(h)(1) Collection Dates
Background Wells																	
20SP	10	10	NA	2/18/16	4/29/16	6/20/16	7/28/16	9/26/16	12/1/16	1/27/17	3/9/17	4/25/17	9/8/17				--
21SP-2	12	12	NA	3/31/16	6/20/16	7/28/16	9/27/16	12/6/16	1/27/17	3/9/17	4/25/17	5/31/17	6/28/17	7/31/17	8/31/17		--
161SP-CCR	11	11	NA	4/19/16	6/20/16	8/18/16	9/27/16	12/5/16	2/1/17	5/1/17	5/31/17	6/28/17	8/1/17	9/7/17			--
Downgradient Wells																	
22SP	14	13	1	2/23/16	5/11/16	6/21/16	8/12/16	9/27/16	12/5/16	1/30/17	3/9/2017	3/14/17	5/2/17	5/31/17	6/28/17	8/1/17	9/7/17
84SP	13	12	1	2/23/16	5/11/16	6/21/16	8/12/16	9/26/16	12/5/16	1/31/17	3/14/17	4/14/17	5/31/17	6/27/17	8/1/17		9/8/17
85SP	12	11	1	3/31/16	6/21/16	8/11/16	9/26/16	12/6/16	1/30/17	3/14/17	5/2/17	5/31/17	6/27/17	8/1/17			9/7/17
89SP	13	12	1	2/23/16	5/11/16	6/20/16	8/11/16	9/27/16	12/5/16	1/30/17	3/9/17	5/2/17	5/31/17	6/21/17	8/1/17		8/31/17
152SP-CCR	4	4	NA	4/11/16	6/17/16	8/18/16	9/27/16	Well Damaged* (replaced with 152-SP2)									
152SP2-CCR	9	8	1	2/6/17	3/9/17	4/14/17	5/2/17	5/31/17	6/27/17	8/1/17	9/7/2017						11/30/17
153SP-CCR	12	11	1	4/11/16	6/20/16	8/18/16	9/27/16	12/6/16	1/30/17	3/14/17	4/27/17	5/31/17	6/28/17	8/1/17			9/8/17

TABLE 5-3. COLSTRIP 3&4 BOTTOM ASH POND PREDICTION LIMITS

Appendix III Parameter	Spoil Prediction Limit (mg/L)	Statistical Method
Boron	**0.29**	Non-parametric maximum background
Calcium	**345**	Parametric Upper Prediction Limit
Chloride	**52**	Non-parametric maximum background
Fluoride	**0.2**	Non-parametric maximum background
pH	**7.0 - 7.3**	Non-parametric (background range)
Sulfate	**2320**	Non-parametric maximum background
TDS	**3730**	Non-parametric maximum background

6.0 COLSTRIP 1&2 STEP D CELL

6.1 LOCATION AND DESCRIPTION

A location map of the Colstrip 1&2 STEP D Cell (STEP D Cell) and associated groundwater monitoring wells is shown in Figure 6-1. First groundwater is encountered in sub-McKay bedrock beneath STEP D Cell; and the direction of groundwater flow (discussed in Section 6.2) is generally from southwest to northeast.

Per the GWMP (Hydrometrics, Inc. 2017a), existing wells 371D, 373D, and 388D were assigned as background wells to the STEP D Cell groundwater monitoring system. These wells were presumed to be upgradient of all other sources of facility process water. Background wells 371D, 373D, and 388D are shared by the Colstrip 1&2 STEP E Cell and Old Clearwell multi-unit groundwater monitoring system (Section 7.0). Well 388D is upgradient of STEP D Cell and data collected at this well may be useful to establishing groundwater quality at the upgradient boundary of the CCR unit. However, wells 371D and 373D are not upgradient of STEP D Cell; and other wells in the groundwater monitoring system provide data that are more representative of groundwater quality at the upgradient unit boundary. All wells included in the STEP D Cell groundwater monitoring system are shown in Table 6-1.

Intermediate wells 2018D, 2045D-CCR, and 2046D-CCR are installed at upgradient locations that are closer to the waste boundary and may be most representative of current background groundwater quality conditions at the STEP D Cell. The STEP D Cell groundwater monitoring system contains four downgradient wells (392D, 952D, 953D, and 2055D-CCR). Three new wells (intermediate wells 2045D-CCR and 2046D-CCR and downgradient well 2055D-CCR) were installed in 2016 expressly for use in the CCR groundwater monitoring program. No wells associated with the STEP D Cell were decommissioned in 2016 or 2017.

Process water impacts attributed to seepage or releases from impoundments prior to publication of the CCR Rule were observed in groundwater directly beneath and within the boundaries of the current STEP D Cell before it (D Cell) was constructed in 2011. Capture wells were in place downgradient and within the footprint of STEP D Cell to mitigate these impacts. Notably, capture well 955D was present in the footprint of the pond. Prior to constructing STEP D Cell, 955D was plugged and abandoned. Capture well 955D was replaced with capture well 2019D after STEP D Cell was completed; thus, capture well 2019D is in place to capture and monitor groundwater that was impacted by process water from sources that pre-date STEP D Cell. Data collected at intermediate well 2019D is used to quantify prior impacts and reduce the potential of falsely attributing statistically significant increases of constituents in groundwater to STEP D Cell.

Downgradient monitoring wells 392D, 952D, and 953D were completed before construction of STEP D Cell. Data collected at these downgradient wells prior to publication of the CCR Rule are not used to establish background groundwater quality or determine SSI; however, the data are evaluated to identify water quality trends that may be attributable to STEP D Cell and to aid in selection of an appropriate statistical test method. Although background wells are assigned to the STEP D Cell monitoring system for use with interwell statistics, it is equally likely given the history of groundwater impacts that are unrelated to the regulated unit that intrawell comparisons will be used. Statistical methods used to determine background groundwater quality at STEP D Cell are discussed in Section 6.4. STEP D Cell is designated as a CCR unit because it is expected to start receiving CCR as early as 2018; however, it has not received any CCR to date. All groundwater quality samples collected at the STEP D Cell groundwater monitoring system will be considered background until operators begin placing CCR in the unit.

6.2 GROUNDWATER ELEVATIONS, FLOW RATES, AND DIRECTION §257.93(C)

A potentiometric surface map constructed of groundwater level elevations directly upgradient and downgradient of the STEP D Cell is included as Figure 6-2. First groundwater is encountered in sub-McKay bedrock beneath STEP D Cell; and the general direction of flow

in the uppermost hydrostratigraphic interval is from southwest to northeast. Capture wells in operation east of STEP D Cell create local groundwater depressions.

Water levels recorded prior to sampling during 2016 and 2017 groundwater monitoring activities and groundwater level elevations calculated from observed water levels are provided in Appendix B. Groundwater level elevation hydrographs for STEP D Cell are provided in Appendix C.

Based on aquifer hydraulic properties of bedrock in the STEP D Cell area (Hydrometrics, Inc. 2017a), the average linear groundwater velocity upgradient and beneath the CCR unit along the predominate flow path was approximately 0.09 ft/day (32 ft/year) in 2016/2017. This estimate was made by Equation 2-1: assuming average η_e = 0.19; average K = 1.7 ft/day; and average i = 0.01. However, the gradient northeast of the CCR unit was steeper and velocity was greater by more than an order of magnitude due to the presence of pumping capture wells. Assuming a gradient of 0.19 and constant K and η_e values, the estimated average linear velocity in the downgradient flow path toward capture wells was 1.7 ft/day (621 ft/year) in 2016/2017. The downgradient velocity will vary based on actual pumping water levels; but the direction of groundwater flow is consistent at STEP D Cell as evidenced by data collected in 2016 and 2017.

6.3 SAMPLE COLLECTION SUMMARY (§257.93(e)(3))

A summary of groundwater quality samples collected at the STEP D Cell groundwater monitoring system is presented in Table 6-2. A total of 102 samples were collected at STEP D Cell in 2016 and 2017; all of which were collected as background samples for detection monitoring but were analyzed for Appendix III and IV constituents. As previously noted, all groundwater quality samples collected at the STEP D Cell groundwater monitoring system will be considered background until operators begin placing CCR in the unit.

Groundwater quality results for STEP D Cell are presented in Appendix C. Further discussion of Appendix IV parameters is reserved for the Assessment monitoring phase of the Colstrip-SES CCR groundwater monitoring program. A summary of Appendix III

groundwater quality results at STEP D Cell, including calculation of prediction limits for future comparisons is presented in Section 6.4.

6.4 STATISTICAL DETERMINATION OF BACKGROUND (§257.93(d))

Because Colstrip SES operators have not placed CCR in STEP D Cell, all wells in the groundwater monitoring network (upgradient and downgradient of the CCR unit) were evaluated for efficacy in establishing background groundwater quality. Time series plots for detection monitoring parameters constructed with results of samples collected in 2016 and 2017 are presented in Appendix E. Summary statistics (e.g. minimum, maximum, mean, and standard deviation) for each detection monitoring parameter at each of the STEP D Wells are included in Appendix F.

6.4.1 Data Distribution

The Shapiro-Wilk test for normality was conducted on each well/constituent pair for all background, downgradient, and intermediate wells at the STEP D Cell. Results of Shapiro-Wilk tests, at significance levels (α) of 0.1, 0.05, and 0.01 are presented in Appendix F. Based on the results, boron and calcium are normally distributed in all wells of the STEP D Cell groundwater monitoring system. Sulfate is normally distributed in all upgradient and intermediate wells but is non-normal in downgradient well 392D. TDS is not normally distributed in downgradient well 953D but is normal in all other wells. Normality is less common among the sample distributions of chloride, fluoride, and pH. Only wells 392D and 2055D-CCR have background pH data that are normally distributed. Chloride is only normally distributed in three of nine wells and fluoride is only normally distributed in four of nine wells of the STEP D Cell groundwater monitoring system.

The natural logarithm was calculated for all well/constituent pairs that are not normally distributed; and Shapiro-Wilk tests were conducted on the log-transformed data. Results of Shapiro-Wilk tests for log-transformed data (Appendix F) indicate that most of the data that are not normally distributed are also not log-normally distributed. Significant evidence of a log-normal distribution at the lowest critical point ($\alpha = 0.01$) for chloride at wells 392D and 388D were the exceptions. No further data transformations were conducted.

Results of testing for normality indicate that parametric and non-parametric statistical tests are required for background groundwater quality data at the STEP D Cell groundwater monitoring system.

6.4.2 Spatial Variability

Side-by-side box plots were created for each of the wells in the STEP D Cell groundwater monitoring system to further examine the data distribution for each well/constituent pair and to preliminarily evaluate spatial variability of Appendix III detection monitoring constituents. Box plots are presented in Figures 6-3 and 6-4.

In general, the box plots indicate that Appendix III detection monitoring constituents at well 2019D have a higher median value and an overall sample distribution that consists of greater values than other wells in the groundwater monitoring system. As discussed, variable groundwater quality at well 2019D is attributable to its completion at a location with previously known process water impacts from a source other than STEP D Cell. Although less obvious than the differences between 2019D and the rest of the well network, variability between central values (median) and the distribution of detection monitoring constituents at the remaining wells is also apparent in the box plots. The source of this variability may be from a lesser degree of prior process water impacts or it may occur naturally. Spatial variability in the STEP D Cell well network was formally examined via ANOVA tests for constituents that are predominately normally distributed (boron, calcium, sulfate, and TDS) and the Kruskal-Wallis test for constituents that are predominately not normally distributed (chloride, fluoride, pH).

Parametric one-way ANOVA tests were conducted for boron, calcium, sulfate, and TDS between wells within the entire STEP D Cell groundwater monitoring system. Results of the ANOVA tests revealed differences in mean values of all parametric constituents at a significance level (α) of 0.05. Based on obvious differences apparent in side-by-side box plots, the overall differences in means are less important than those exhibited between upgradient and downgradient wells and/or between individual wells with the same upgradient

or downgradient designation. The post hoc Tukey honest significant difference (Tukey HSD) test was evaluated to identify differences in means of parametric constituents between all well pairs. Results of ANOVA and Tukey HSD tests for STEP D Cell are found in Appendix F.

In summary, mean values of boron, calcium, TDS, and sulfate at well 2019D are significantly different ($\alpha = 0.05$) than all other wells in the STEP D Cell groundwater monitoring system. Further, significant spatial variability exists in at least some comparisons between pairs of background wells. For example, sulfate is significantly variable between all pairs of background wells except for 2018D and 2045D-CCR. Boron exhibits less variability in background wells; but mean boron concentrations at 2045D-CCR and 2046D-CCR are both significantly different than that at 388D. Tukey HSD comparisons of mean calcium values at downgradient well pairs are all significantly different ($\alpha = 0.05$) except for between 952D and 392D. Boron, TDS, and sulfate values were significantly different in at least half of all downgradient well pairs. As seen in Appendix F, significant differences were also reported for comparisons made between wells designated as background and downgradient in the STEP D Cell monitoring network.

Results of Kruskal-Wallis tests for STEP D Cell are found in Appendix F. Similar to the parametric tests, the non-parametric evaluation of pH, chloride, and fluoride resulted in significant spatial variability. Individual comparisons were not made for each pair of wells in the STEP D Cell groundwater monitoring system; but significant spatial variability exists within each of the downgradient and upgradient groupings and the groundwater monitoring system as a whole.

6.4.3 Evaluation of Process Water Impacts at Existing Wells

Spatial variability such as that observed in background groundwater quality data in the STEP D Cell groundwater monitoring system often precludes the use of interwell statistical methods and limits comparison of compliance data to an intrawell basis; however, Unified Guidance recommends the use of intrawell testing only when it is clear that spatial variability is not the result of recent releases attributable to the regulated unit (US EPA 2009). Trend

analyses were conducted on available data for Appendix III detection monitoring constituents for the period immediately following construction of STEP D Cell. The analyses were completed using the "emon" package for environmental monitoring in R (Barry and Maxwell 2017). Specifically, Mann Kendall trend tests were evaluated for boron, calcium, chloride, pH, sulfate, and TDS at intermediate capture well 2019D for the period from 2012 to 2016. Similarly, the Mann Kendall test was evaluated for annual observations of each of the same constituents made at existing downgradient wells 392D, 952D, and 953D. The purpose of these tests is to provide statistical evidence that, despite spatial variability between upgradient and downgradient wells, increasing trends in values of Appendix III detection monitoring constituents are not present at downgradient wells following construction of STEP D Cell. Trend plots of boron, calcium, chloride, pH, sulfate, and TDS analytical data for the period from 2012 to 2016 at well 2019D are found in Figure 6-5. Plots of the same parameters during the period from 2011 to 2016 at wells 392D, 952D, and 953D are included in Figures 6-6 through 6-8.

Results of trend analyses indicate significant ($\alpha = 0.05$) decreasing trends at well 2019D for boron, sulfate, and TDS at capture well 2019D during the period from 2012 to 2016. These trends do not include data collected under the current GWMP in compliance with CCR regulation; but the results provide indirect evidence that STEP D Cell has not compounded groundwater quality impacts and that capture well 2019D has operated effectively independent of but concurrently with the CCR unit. No significant trends (decreasing or increasing) were found for calcium, chloride, or pH at well 2019D. Fluoride data are not available at well 2019D for the subject time period; however, fluoride is included in the parameter list for all wells in the CCR GWMP.

Mann-Kendall test results at wells 392D, 952D, and 953D indicated that no increasing or decreasing trends in boron, calcium, pH, sulfate, or TDS are present downgradient of STEP D Cell for the period from 2011 to 2016 (Appendix F). Given the spatial variability in Appendix III detection monitoring constituents and absence of any significant trends caused by the STEP D Cell regulated unit, intrawell prediction limits can be appropriately applied to establish background groundwater quality and in future evaluations of SSI.

6.4.4 Trend Tests

Additional trend analyses were conducted using the Mann-Kendall test for well constituent pairs and groundwater quality data collected during 2016 and 2017. The only statistically significant trend at any of the existing downgradient wells was pH (increasing) at well 392D. However, the practical significance of the trend is null, as the range of pH observed at the well was 7.1 to 7.3 during 2016 and 2017.

Conversely, statistically significant decreasing trends were detected for all constituents at new well 2055D-CCR during 2016 and 2017. A review of water quality trend plots (Appendix E) indicates that values of all detection monitoring parameters have in fact declined since the well was completed. Further trend analysis will be conducted at well 2055D-CCR; and if the trends persist, they will be accounted for before any formal intrawell comparisons are made for determining SSI at STEP D Cell.

6.4.5 Intrawell Prediction Limits

Background groundwater quality was established via intrawell prediction limits for downgradient wells 392D, 952D, 953D, and 2055D-CCR, as shown in Table 6-3.

Where applicable, parametric prediction limits were calculated according to Equation 2-2. Mean values and standard deviations used in the calculations for each well-constituent pair are found in Appendix F (Statistical Analysis). The *K*-multiplier was calculated using the R (R Core Team 2017) script provided in Unified Guidance (US EPA 2009). User specified inputs included: two (2) yearly observations (ne), consistent with a semi-annual sampling program; four (4) compliance wells (w); seven (7) constituents, consistent with the Appendix III list; a one of two (2) re-testing strategy; and background sample sizes (n) consistent with the number of background samples collected at each well (n=10 at 392D and 952D, n=9 at 953D and 2055D-CCR). K-multiplier values output from the R-script were 2.04 and 2.0 for n=9 and n=10 background samples, respectively.

Non-parametric prediction limits were evaluated by selecting the maximum value from each set of well/constituent data that are not normally distributed. Maximum values are found in summary statistics of Appendix F and are listed in Table 6-3. All of the prediction limits will be updated prior to making final SSI determination of detection monitoring parameters.

TABLE 6-1. COLSTRIP 1&2 STEP D CELL MONITORING WELLS

Well Type/ID	Date of Completion	Total Depth (feet bgs)	Perforated Interval (feet bgs)	Hydrostratigraphic Unit
Background Wells				
371D*	8/15/1994	58.5	38.5-58.5	Sub McKay
373D*	8/16/1994	105	75-105	Sub McKay
388D*	11/17/1998	85	85-105	Sub McKay
Intermediate Wells – Directly Upgradient of CCR Unit				
2018D	7/21/2011	100	90-100	Sub McKay
2045D-CCR	4/15/2016	166	151-166	Sub McKay
2046D-CCR	4/15/2016	164	154-164	Sub McKay
2019D**	11/10/2011	71	61-71	Sub McKay
Downgradient Wells				
392D	2/9/1999	88	58-88	Sub McKay
952D	8/12/2004	100	90-100	Sub McKay
953D	8/12/2004	140	130-140	Sub McKay
2055D-CCR	5/4/2016	171	161-171	Sub McKay

*Assigned to STEP D Cell groundwater monitoring system per GWMP (Hydrometrics, Inc. 2017a) but not used in formal statistical evaluation of background groundwater quality per §257.93(d).

**Not used in formal statistical evaluation of background groundwater quality per §257.93(d). Well is used to track prior releases of process water to groundwater that are not associated with the STEP D Cell CCR unit.

Table 6-2. STEP D Cell Groundwater Quality Sample Summary

Well Type/ID	Total Number of Samples Collected	Number of Initial Samples Detection Monitoring §257.93(d), §257.94(b)	Number of Samples for SSI Determination Detection Monitoring §257.93(h)(1)	Initial Sample [§257.93(d), §257.94(b)] Collection Dates										Detection Monitoring Sample §257.93(h)(1) Collection Dates
Background Wells														
371D	9	9	NA	4/6/16	5/25/16	7/11/16	8/22/16	11/10/16	1/11/17	2/16/17	4/10/17	8/1/17		--
373D	9	9	NA	4/6/16	5/25/16	7/11/16	8/22/16	11/10/16	1/30/17	2/16/17	4/10/17	8/1/17		--
388D	9	9	NA	4/6/16	5/25/16	7/11/16	8/22/16	11/9/16	1/11/17	2/15/17	4/11/17	8/8/17		--
Intermediate Wells														
2018D	10	10	NA	2/3/16	4/21/16	6/23/16	7/27/16	8/29/16	11/14/16	1/9/17	2/21/17	4/13/17	8/3/17	--
2045D-CCR	9	9	NA	4/28/16	6/13/16	7/13/16	8/24/16	11/10/16	1/10/17	2/21/17	4/17/17	8/2/17		--
2046D-CCR	9	9	NA	5/2/16	6/13/16	7/13/16	8/24/16	11/10/16	1/10/17	2/15/17	4/11/17	8/2/17		--
2019D (capture)	9	9	NA	4/7/16	5/24/16	7/13/16	9/1/16	11/14/16	1/11/17	2/16/17	4/19/17	8/16/17		--
Downgradient Wells														
392D	10	9	1	2/4/16	4/20/16	6/23/16	8/1/16	8/30/16	11/16/16	2/2/17	2/23/17	4/11/17		8/8/17
952D	10	9	1	2/4/16	4/21/16	6/27/16	8/2/16	9/1/16	11/28/16	2/14/17	3/1/17	4/19/17		8/7/17
953D	9	8	1	4/7/16	6/21/16	8/1/16	9/1/16	11/28/16	2/14/17	3/2/17	4/20/17			8/10/17
2055D-CCR	9	8	1	5/24/16	6/27/16	8/2/16	9/1/16	11/29/16	2/14/17	3/1/17	4/19/17			8/7/17

TABLE 6-3. STEP D CELL INTRAWELL PREDICTION LIMITS

Appendix III Parameter	Intrawell Prediction Limits							
	392D		952D		953D		2055D-CCR	
Boron	**1.0**	NP-PL	**1.27**	P-PL	**0.34**	P-PL	**1.44**	P-PL
Calcium	**204**	P-PL	**218.6**	P-PL	**34**	P-PL	**188**	P-PL
Chloride	**12**	NP-PL	**14**	NP-PL	**14**	P-PL	**18**	P-PL
Fluoride	**0.5**	NP-PL	**0.5**	NP-PL	**2.7**	P-PL	**1.3**	P-PL
pH -Lower	**7.1**	NP-PL	**7.1**	NP-PL	**8.1**	NA	**7.51**	P-PL
pH - Upper	**7.3**	NP-PL	**7.3**	NP-PL	**8.1**	NA	**7.98**	P-PL
Sulfate	**1790**	NP-PL	**1810**	P-PL	**2084**	P-PL	**2502**	NP-PL
TDS	**2780**	NP-PL	**3008**	P-PL	**2950**	NP-PL	**3677**	P-PL

P-PL = parametric prediction limit
NP-PL = non-parametric prediction limit; ordered statistic based on maximum (or minimum) value.
NA = all background values are equal; not a valid parameter for comparison.

7.0 COLSTRIP 1&2 STEP E CELL AND OLD CLEARWELL

A multi-unit groundwater monitoring system is in place to monitor the Colstrip 1&2 STEP E Cell (STEP E Cell) and Colstrip 1&2 Old Clearwell (STEP Old Clearwell). These units are referred to collectively as STEP E Cell and Old Clearwell or STEP E Cell/Old Clearwell in this and subsequent sections of this report. Groundwater monitoring data and analysis presented in this section apply to both CCR units.

7.1 LOCATION AND DESCRIPTION

In accordance with §257.90 (e)(1), a map with aerial background imagery for the STEP E Cell and Old Clearwell and all upgradient (or background) and downgradient monitoring wells included in the multi-unit groundwater monitoring system is presented in Figure 7-1. Wells of the STEP E Cell/Old Clearwell multi-unit groundwater monitoring system are listed in Table 7-1.

The STEP E Cell/Old Clearwell groundwater monitoring system consists of eight wells that were in existence prior to publication of the CCR rule and nine new wells. The existing wells include four background wells (357A, 371D, 373D, and 388D), two intermediate wells (958D and 921A), and two downgradient wells (964D and 974D). New wells drilled expressly for use in the STEP E Cell/Old Clearwell groundwater monitoring system include three intermediate wells (2043D-CCR, 2044D-CCR, and 2047D-CCR) and six downgradient wells (2048D-CCR, 2050D-CCR, 2051D-CCR, 2053D-CCR, 2054D-CCR, and 2056A-CCR). Each of the new wells were drilled in 2016. No wells associated with the STEP E Cell/Old Clearwell groundwater monitoring system were decommissioned in 2016 or 2017.

Similar to STEP D Cell, wells 371D, 373D, and 388D were included in the groundwater monitoring system to evaluate groundwater quality at locations that are upgradient and thereby not influenced by the STEP E Cell and Old Clearwell CCR units. However, data from wells 371D and 373D collected during long-term monitoring that predates the CCR Rule suggest that groundwater quality at these background wells may be impacted by the

SOEP. Groundwater quality at well 388D has been fairly stable; but this well was completed during operation of the SOEP. As such, it is not known if groundwater quality at well 388D is representative of background conditions. Further, well 388D is not explicitly upgradient of STEP E Cell/Old Clearwell; so data from this well would only be used to establish background groundwater quality if wells completed at the western boundary (i.e. intermediate wells) are found to be downgradient or are apparently impacted by the CCR units. Groundwater flow direction at STEP E Cell/Old Clearwell is discussed in Section 7.2. Statistical analysis is discussed in Section 7.4.

Based on the direction of groundwater flow (Section 7.2), intermediate wells 2043D-CCR, 2044D-CCR, and 2047D-CCR are located upgradient of the CCR Units; thus, they are positioned to accurately represent the current quality of upgradient groundwater at STEP E Cell/Old Clearwell. Data from upgradient intermediate wells 2043D-CCR, 2044D-CCR, and 2047D-CCR are compared to data from the designated background wells 371D, 373D, and 388D in preliminary analysis of groundwater quality (i.e. spatial variability) at STEP E Cell and Old Clearwell. (See results in Section 7.4). Some variability is present in the distribution of each of the Appendix III detection monitoring constituents but the original background wells (371D, 373D, and 388D) do not have noticeably lower levels of Appendix III detection monitoring constituents than the intermediate wells. For example, boron concentrations in the upgradient intermediate wells range from 0.2 mg/L to 1.43 mg/L; while boron concentrations in the designated background wells range from 0.72 to 3.26 mg/L. Ultimately, data from the designated background wells were not included in final evaluation of prediction limits to establish upgradient groundwater quality or detect SSI. Wells 371D, 373D, and 388D are to be excluded from the STEP E Cell/Old Clearwell CCR groundwater monitoring system in 2018.

Well 958D was originally included in the groundwater monitoring system as an intermediate well that may produce data representative of groundwater conditions at the immediate upgradient boundary of the CCR units. Well 958D is operated as a pumping capture well; as such, the induced gradient at the well commonly alters the local direction of flow. In the presence of seepage from STEP E Cell, the altered flow direction could result in a flow path

of process water to 958D. Intermediate wells 2043D-CCR, 2044D-CCR, and 2047D-CCR are located upgradient of the CCR Units and are positioned to more accurately represent the quality of background groundwater. Data collected at well 958D is not included in subsequent evaluation of upgradient groundwater quality (Section 7.4).

Alluvium of a narrow tributary drainage to East Fork Armells Creek is found directly beneath portions of STEP E Cell and the Old Clearwell. Seepage to alluvium from the CCR units, if present, would represent a potential flow pathway that would require monitoring under 257.91(a)(2). An additional existing background well (357A) is included to establish background groundwater quality in alluvium. Well 357A is located in the Stocker Creek drainage north of but parallel to the drainage in which the CCR units are constructed; therefore, groundwater quality at well 357A is representative of un-impacted alluvial groundwater consistent with that which would occur naturally in the STEP E Cell/Old Clearwell drainage. Currently, no un-impacted alluvial groundwater exists at the unit boundary of STEP E Cell and the Old Clearwell. Well 921A is included in the groundwater monitoring system at what would be the upgradient boundary of the STEP E Cell/Old Clearwell; however, ongoing groundwater capture (pumping) at the well induces flow from the direction of the CCR units. Groundwater flow direction is discussed further in Section 7.2. Based on the direction of groundwater flow and the potential for process water impacts to groundwater from STEP E Cell at well 921A, this well was not used to establish upgradient groundwater quality.

7.2 GROUNDWATER ELEVATIONS, FLOW RATES, AND DIRECTION §257.93(C)

Groundwater elevations calculated at the STEP E Cell and Old Clearwell multi-unit groundwater monitoring system in 2016 and 2017 are included in Appendix B. Groundwater level hydrographs are found in Appendix C.

7.2.1 Alluvium

A potentiometric map of the alluvial groundwater flow system, constructed of water levels recorded in 2017 is presented in Figure 7-2. Capture at well 921A creates a local depression that induces flow from the direction of the regulated STEP E Cell CCR unit; but as seen in

the alluvial potentiometric map, the direction of flow downgradient of the STEP E Cell and the STEP Old Clearwell is predominately from west to east. The core trench in the STEP Main Dam is constructed across and cuts off the direct conduit for flow through the alluvium. However, a pathway still remains for potential process water impacts to reach alluvium east of the Main Dam, as groundwater migrates vertically downward into bedrock on the inboard side of the dam and then vertically upward outboard of the dam.

From Figure 7-2, the apparent horizontal hydraulic gradient (i) in alluvium east of the STEP E Cell and Old Clearwell is 0.011. Assuming K = 39 ft/day and η_e = 0.16 (Hydrometrics, Inc. 2017a), the average linear velocity of groundwater in alluvium downgradient of the CCR units is approximately 2.68 ft/day (979ft/year).

7.2.2 Sub-McKay Bedrock

A potentiometric surface map of the uppermost bedrock groundwater horizon developed using water level elevations recorded in spring 2016 is shown in Figure 7-3. The general direction of groundwater flow at the STEP E Cell and Old Clearwell CCR units is from southwest to northeast; but a major depression in the potentiometric surface is created at the western boundary of STEP E Cell by pumping capture well 958D. Well 958D was not operated continuously during 2016 and 2017; and a potentiometric surface map constructed with spring 2017 water levels (Figure 7-4) illustrates the distinct changes in groundwater flow patterns that occur while 958D is not pumping. Regardless of whether well 958D is operating or not, intermediate wells 2043D-CCR, 2044D-CCR, and 2047D-CCR are upgradient of the STEP E Cell and Old Clearwell CCR units.

Assuming static conditions at well 958D (Figure 7-4), the apparent hydraulic gradient in bedrock groundwater beneath STEP E Cell and the Old Clearwell is approximately 0.007. The gradient increases by more than three times (~ 0.024) as flow approaches pumping capture wells outboard of the STEP Main Dam. Assuming constant K (1.96ft/day) and η_e (0.165) values (Hydrometrics, Inc. 2017a), the linear velocity of groundwater at STEP E Cell and the Old Clearwell in 2016 and 2017 was about 0.083 ft/day (30.3 ft/year) on the inboard side of the dam and approximately 0.285 ft/day (104 ft/year) downgradient of the CCR units.

7.3 SAMPLE COLLECTION SUMMARY (§257.93(e)(3))

A summary of groundwater quality samples collected at each of the upgradient and downgradient wells in the STEP E Cell and Old Clearwell multi-unit groundwater monitoring system, including sample collection dates, is presented in Table 7-2. A total of 156 samples were collected at this groundwater monitoring system in 2016 and 2017, all of which were required by the detection monitoring program of §257.94. Included in the total is a resample of well 2053D-CCR collected in November 2017. The final sample from each downgradient well was collected to determine whether or not there is a statistically significant increase (SSI) over background values of Appendix III detection monitoring parameters, as required by §257.93(h)(1). Background values for each of the Appendix III constituents at the STEP E Cell and Old Clearwell are established in Section 7.4; however, final SSI determination was not completed in calendar year 2017 and is not included in this annual report. Analytical results of all of the samples discussed above are included in Appendix D.

Well 2053D-CCR was re-sampled in November 2017 after initial data review of the August 2017 sample noted a high turbidity value and a subsequent anomalous data result for radium 226 + 228. The increase in turbidity was likely caused by iron-related bacteria. It is also likely that the increase in radium 226 + 228 was related to conditions favorable to the presence and growth of the bacteria. As such, the August 2017 sample is not considered representative for turbidity and radium 226 + 228. Results for the November 2017 sample were within concentration ranges seen prior to August 2017 (see Appendix D). Ongoing groundwater quality samples will be collected using low-flow methods as specified in Section 2.3 of this report and the GWMP (Hydrometrics 2017a); but a high volume purge will be conducted on this well one day prior to each sampling event to remove suspended sediment and reduce turbidity. If variable and un-representative radium 226 + 228 results persist, more aggressive well treatment or replacement options may be evaluated.

7.4 STATISTICAL DETERMINATION OF BACKGROUND (§257.93(d))

Background groundwater quality for the alluvium and bedrock hydrostratigraphic intervals is established in this section. Alluvial background groundwater quality is based solely on samples collected well 357A because alluvial wells at the waste boundary of STEP E Cell (e.g. 921A) cannot reasonably be assumed to be un-impacted by process water from a CCR unit. While not a formal statistical test, a comparison of summary statistics presented in Appendix F for wells 357A and 921A provide preliminary justification for that assumption.

Per the GWMP (Hydrometrics, Inc. 2017a), sub-McKay background groundwater quality is to be determined using data that are most representative of conditions at the upgradient CCR unit boundary. Depending on groundwater flow patterns these data could originate from wells labeled as either 'background' or 'intermediate' in Table 7-1. As previously discussed, the designated background and intermediate wells are potentially impacted by process water sources that are not regulated by the CCR Rule. However, the intermediate wells are more appropriately positioned at the immediate boundary of STEP E Cell. Because the groundwater flow direction mapped in 2016 and 2017 indicated that wells 2043D-CCR, 2044D-CCR, and 2047D-CCR were consistently upgradient of the CCR unit, they are the likely choice for bedrock upgradient groundwater quality determination. Detection monitoring groundwater quality results are statistically evaluated herein to select the final representative well locations and determine representative upgradient groundwater quality.

7.4.1 Data Distribution

Tests of normality were conducted using the Shapiro-Wilk procedure for all candidate background well-constituent pairs of the STEP E Cell/Old Clearwell groundwater monitoring system to establish the appropriateness of normal theory (parametric) or distribution-free (non-parametric) tests for all of the detection monitoring constituents. Results are found in Appendix F.

Boron, chloride, pH, sulfate, and TDS were all found to be normally distributed at alluvial well 357A; thus, parametric methods are appropriate for establishing background

groundwater quality prediction limits for those constituents in alluvium. Conversely, calcium and fluoride were neither normally nor log-normally distributed, limiting statistical evaluation of those parameters in alluvium to non-parametric methods.

In general, boron, calcium, sulfate, and TDS were normally distributed in the candidate upgradient bedrock wells. Calcium at well 371D was the only distribution-free exception. Chloride was found to be normally distributed in three of six candidate wells and was log-normally distributed in a fourth (388D). Fluoride was only normally distributed at well 2047D-CCR. Neither of wells 371D or 2044D-CCR could be formally evaluated, as all of the individual observations at those wells in 2016 and 2017 were of a single value (non-detectable < 0.1 mg/L at 371D; and 0.2mg/L at 2044D-CCR). The normal distributional model was found to fit pH at wells 371D and 2044D-CCR but none of the other wells.

7.4.2 Spatial Variability

Side-by-side box plots of Appendix III detection monitoring constituents in alluvial groundwater monitoring wells of the STEP E Cell/Old Clearwell groundwater monitoring system are presented in Figure 7-5. Note the obvious apparent differences in the distribution of most parameters between background well 357A, intermediate well 921A, and downgradient well 2056A-CCR.

Box plots for detection monitoring constituents in bedrock monitoring wells are shown in Figures 7-6 and 7-7. Examination of the boxplots provides an initial indication of the spatial variability of each of the seven detection monitoring constituents; but formal statistical evaluation in the form of one-way parametric ANOVA tests (Appendix F) better quantify the variability in the mean and distribution of these well-constituent pairs. ANOVA tests indicate that overall the means of boron, calcium, sulfate, and TDS are highly significantly variable between wells. Further, Tukey HSD test results indicate that very few well pairs have statistically similar means (Appendix F). Wells 371D and 373D have statistically similar means for boron. Wells 2043D-CCR and 2044D-CCR have statistically similar means for sulfate, calcium, and TDS. Wells 388D and 2047D-CCR have similar means for

sulfate and TDS. All other well pair comparisons for detection monitoring parameters have statistically different distributions.

Results of ANOVA eliminate background wells 371D, 373D, and 388D for two reasons: 1.) the variability precludes pooling these data with data from other wells that would result in meaningful enhancements of statistical power or reduction in error; and 2.) the variability suggests that these wells have groundwater quality that is different from and therefore less representative than those at the CCR unit boundary (i.e. 'intermediate' wells 2043D-CCR, 2044D-CCR, and 2047D-CCR).

7.4.3 Trend Analysis

Groundwater quality trends at representative background wells 357A, 2043D-CCR, 2044D-CCR, and 2047D-CCR were evaluated using the Mann-Kendall trend test in the 'emon' package for R (Barry and Maxwell 2017) as shown in Appendix F. Although statistically significant trends were identified for boron (decreasing) and pH (increasing) at well 2047D-CCR and for chloride and sulfate (increasing) at well 357A, none of these were of practical significance and all were ignored in final calculation of background groundwater quality by interwell prediction limits. Specifically, the range of boron concentrations at well 2047D-CCR was 0.2 to 0.28 mg/L and the range of pH at the same well was 8.1 to 8.2. Any trends within those ranges are negligible in background groundwater quality determination. Trend plots for each of the STEP E Cell/Old Clearwell upgradient wells can be found in Appendix E.

Well 357A has been monitored for groundwater quality since 1984. Sulfate and chloride concentrations are variable at the well, presumably due to its completion in shallow alluvium, but no obvious temporal (even seasonal) trends are present in the long-term data. Chloride and sulfate data collected at 357A as required in §257.93(d) and §257.94(b) during 2016 and 2017 are consistent with the long-term ranges observed at the well. These data are used without accounting for trend to establish background alluvial groundwater quality for the STEP E Cell and Old Clearwell CCR units.

7.4.4 Interwell Prediction Limits

In conformance with the preliminary statistical evaluation presented above, prediction limits of bedrock background groundwater quality at STEP E Cell and Old Clearwell were calculated based on data collected at wells 2043D-CCR, 2044D-CCR, and 2047D-CCR. Because inconsistent distribution and spatial non-stationarity were exhibited in the background data set for bedrock groundwater, a combination of non-parametric and parametric prediction limits were evaluated. A summary of the bedrock prediction limits is presented in Table 7-3. Prediction limits of alluvial groundwater quality were calculated using data from well 357A, which also required a combination of parametric and non-parametric tests. A summary of prediction limits for alluvial background groundwater quality is found in Table 7-4. A narrative of the final determination the prediction limits is as follows.

<u>Bedrock</u>

- Boron, calcium, pH, sulfate, and TDS –Parametric prediction limits were calculated for each of these parameters on the assumption of normality for at least one representative background well at the STEP E Cell/Old Clearwell. Significant differences in the mean and noticeably lower values of boron, calcium, sulfate, and TDS at well 2047D-CCR excluded it from consideration in the upper prediction limit calculation. Well 2047D-CCR data were similarly excluded from pH prediction limit, as pH at this well exhibits locally high values that are not representative of the greater bedrock groundwater flow system at STEP E Cell/Old Clearwell (Figure 7-7). Calcium, sulfate, and TDS data were pooled between wells 2043D-CCR and 2044D-CCR. Boron data from well 2043D-CCR and pH data from well 2044D-CCR were used in the prediction limit calculations. A K-multiplier appropriate for seven constituents, 8 compliance bedrock wells (Table 7-1), and 9 background observations (Table 7-2) was interpolated bi-linearly from Table 19-1 of the Unified Guidance (US EPA 2009). The final K-multiplier for each of the parametric constituents was 2.62.

Equation 2-2 was evaluated for boron, calcium, pH, sulfate, and TDS as follows:

Constituent	Mean	Standard deviation	Calculation $PL = \bar{X} \pm Ks$	Prediction Limit*
Boron	1.38	0.063	1.38 + 2.62*0.063	1.55
Calcium	314	9.7	314 + 2.62*9.7	339
pH	6.99	0.06	6.99 ± 2.62*0.06	6.8 – 7.15
Sulfate	2039	91.4	2039 + 2.62*91.4	2279
TDS	3332.2	113.6	3332.2 + 2.62*113.6	3630

*Confidence level = 96.7%; α = 0.033.

- Chloride – The upper prediction limit for chloride in sub-McKay bedrock was set at the maximum value of 16 mg/L observed at well 2044D-CCR in 2016/2017, excluding a detected outlier (35 mg/L, see Figure 7-6). Assuming a semi-annual sampling interval and n = 9 background observations at well 2044D-CCR, a confidence level of 81.8% (α = 0.18) per well/constituent test applies to this prediction limit.
- Fluoride – The upper prediction limit for fluoride in bedrock groundwater at the STEP E Cell/Old Clearwell groundwater monitoring system was set at the maximum value of 0.3 mg/L, as observed at well 2043D-CCR in 2016/2017. This prediction limit excludes fluoride data at well 2047D-CCR that are on the order of 10 times greater than any of the other background wells and four to 10 times greater than any of the downgradient wells. A box plot illustrating the outlying distribution of fluoride at well 2047D-CCR as compared to the rest of the STEP E Cell/Old Clearwell monitoring wells is shown in Figure 7-6. The estimated confidence level of semi-annual future comparisons to this non-parametric prediction limit is 81.8% (α = 0.18).

Alluvium

- Boron, chloride, pH, sulfate, and TDS – Each of these parameters was normally distributed at well 357A so parametric prediction limits were used to establish background levels. A K-multiplier appropriate for seven constituents, one compliance alluvial well (2056A-CCR), and 9 background observations (Table 7-2) was

interpolated bi-linearly from Table 19-1 of the Unified Guidance (US EPA 2009) to be 1.88. Equation 2-2 was evaluated using values of mean and standard deviation (Appendix F) for each of these constituents at well 357A, as follows:

Constituent	Mean	Standard deviation	Calculation $PL = \bar{X} \pm Ks$	Prediction Limit*
Boron	0.4256	0.0433	0.4256 + 1.88*0.0433	0.5
Chloride	14.56	1.51	14.56 + 1.88*1.51	17.4
pH	7.389	0.06	7.389 ± 1.88*0.06	7.28 – 7.5
Sulfate	1282	115.19	1282 + 1.88*115.19	1499
TDS	2169	94.4	2169 + 1.88*94.4	2346

*Confidence level = 91.3%; $\alpha = 0.087$.

- Calcium and fluoride – The upper prediction limits for calcium and fluoride in alluvial groundwater at the STEP E Cell/Old Clearwell groundwater monitoring system were set at the maximum values observed at well 357A in 20016/2017. From Appendix F, the prediction limits are 201 mg/L and 0.3 mg/L for calcium and fluoride, respectively. The estimated confidence level of semi-annual future comparisons to these non-parametric prediction limits is 81.8% ($\alpha = 0.18$).

TABLE 7-1. COLSTRIP 1&2 STEP E CELL AND OLD CLEARWELL MONITORING WELLS

Well Type/ID	Date of Completion	Total Depth (feet bgs)	Perforated Interval (feet bgs)	Hydrostratigraphic Unit
Background Wells				
357A	11/15/1984	18	8 – 18	Alluvium
371D*	8/15/1994	58.5	38.5-58.5	Sub McKay
373D*	8/16/1994	105	75-105	Sub McKay
388D*	11/17/1998	85	85-105	Sub McKay
Intermediate Wells – Directly Upgradient of CCR Unit				
921A*	8/17/2000	76	56-76	Alluvium
958D*	8/16/2004	160	140-160	Sub McKay
2043D-CCR	4/14/2016	121	111 - 121	Sub McKay
2044D-CCR	4/14/2016	140	130 - 140	Sub McKay
2047D-CCR	5/2/2016	140	125-140	Sub McKay
Downgradient Wells				
2056A-CCR	6/16/2016	36	31-36	Alluvium
964D	5/3/2005	107	27-107	Sub McKay
974D	5/1/2006	40	35-40	Sub McKay
2051D-CCR	5/3/2016	50	40-50	Sub McKay
2053D-CCR	5/4/2016	73	58-73	Sub McKay
2054D-CCR	5/4/2016	120	105-120	Sub McKay
2048D-CCR	5/2/2016	160	145-160	Sub McKay
2050D-CCR	5/3/2016	63	48-63	Sub McKay

*Assigned to STEP E Cell/Old Clearwell groundwater monitoring system per GWMP (Hydrometrics, Inc. 2017a) but not used in formal statistical evaluation of background groundwater quality per §257.93(d).

Table 7-2. Colstrip 1&2 STEP E Cell/Colstrip 1&2 STEP Old Clearwell

Well Type/ID	Total Number of Samples Collected	Number of Initial Samples Detection Monitoring §257.93(d), §257.94(b)	Number of Samples for SSI Determination Detection Monitoring §257.93(h)(1)	Initial Sample [§257.93(d), §257.94(b)] Collection Dates										Detection Monitoring Sample §257.93(h)(1) Collection Dates
Background Wells														
357A	9	9	NA	4/7/16	6/20/16	7/26/16	8/25/16	11/22/16	2/2/17	2/28/17	4/17/17	8/8/17		--
371D	9	9	NA	4/6/16	5/25/16	7/11/16	8/22/16	11/10/16	1/11/17	2/16/17	4/10/17	8/1/17		--
373D	9	9	NA	4/6/16	5/25/16	7/11/16	8/22/16	11/10/16	1/30/17	2/16/17	4/10/17	8/1/17		--
388D	9	9	NA	4/6/16	5/25/16	7/11/16	8/22/16	11/9/16	1/11/17	2/15/17	4/11/17	8/8/17		--
Intermediate Wells														
921A	9	9	NA	4/6/16	6/21/16	7/26/16	8/30/16	11/17/16	1/30/17	2/23/17	4/18/17	8/2/17		--
958D (capture)	10	10	NA	2/24/16	4/21/16	5/26/16	7/13/16	8/30/16	11/17/16	1/30/17	2/23/17	4/18/17	8/2/17	--
2047D-CCR	9	9	NA	5/24/16	6/23/16	7/27/16	8/29/16	11/17/16	1/10/17	2/21/17	4/13/17	8/2/17		--
2044D-CCR	9	9	NA	4/28/16	6/20/16	7/26/16	8/30/16	11/17/16	1/12/17	2/23/17	4/18/17	8/7/17		--
2043D-CCR	9	9	NA	4/28/16	7/12/16	8/11/16	8/30/16	11/17/16	1/11/17	2/16/17	4/18/17	8/7/17		--
Downgradient Wells														
2056A-CCR	9	8	1	6/28/16	7/28/16	8/25/16	10/13/16	11/28/16	2/1/17	2/28/17	4/20/17			8/9/17
964D	10	9	1	2/2/16	4/20/16	5/27/16	7/13/16	8/25/16	11/16/16	2/2/17	2/22/17	4/10/17		8/8/17
974D	9	8	1	4/5/16	5/25/16	7/12/16	8/24/16	11/16/16	1/30/17	2/27/17	4/11/17			8/2/17
2053D-CCR	10	9	1	5/20/16	6/22/16	7/28/16	8/31/16	11/22/16	2/15/17	3/1/17	4/18/17	8/9/2017		11/16/17
2054D-CCR	9	8	1	5/19/16	6/22/16	7/28/16	8/31/16	11/22/16	2/1/17	2/28/17	4/20/17			8/9/17
2048D-CCR	9	8	1	5/19/16	6/22/16	7/28/16	8/31/16	11/22/16	2/1/17	2/27/17	4/12/17			8/9/17
2050D-CCR	9	8	1	5/19/16	6/22/16	7/28/16	8/31/16	11/22/16	2/1/17	2/28/17	4/20/17			8/9/17
2051D-CCR	9	8	1	5/20/16	6/22/16	7/29/16	8/31/16	11/21/16	2/1/17	3/1/17	4/19/17			8/8/17

TABLE 7-3. STEP E CELL AND OLD CLEARWELL BEDROCK PREDICTION LIMITS

Appendix III Parameter	Sub-McKay Prediction Limit (mg/L)	Statistical Method
Boron	**1.55**	Parametric Prediction Limit (2043D-CCR)
Calcium	**339**	Parametric Prediction Limit (2043D-CCR and 2044D-CCR)
Chloride	**16**	Non-parametric ordered statistic (max background Cl)
Fluoride	**0.3**	Non-parametric ordered statistic (excludes 2047D-CCR)
pH	**Lower – 6.8** **Upper – 7.15**	Parametric Prediction Limit (2044D-CCR))
Sulfate	**2279**	Parametric Prediction Limit (2043D-CCR and 2044D-CCR)
TDS	**3630**	Parametric Prediction Limit (2043D-CCR and 2044D-CCR)

TABLE 7-4. STEP E CELL AND OLD CLEARWELL ALLUVIUM PREDICTION LIMITS

Appendix III Parameter	Sub-McKay Prediction Limit (mg/L)	Statistical Method
Boron	**0.5**	Parametric Prediction Limit (357A)
Calcium	**201**	Non-Parametric Prediction Limit (357A)
Chloride	**17.4**	Parametric Prediction Limit (357A)
Fluoride	**0.3**	Non-Parametric Prediction Limit (357A)
pH	**Lower – 7.28** **Upper – 7.5**	Upper and Lower Parametric Prediction Limits (357A)
Sulfate	**1499**	Parametric Prediction Limit (357A)
TDS	**2346**	Parametric Prediction Limit (357A)

8.0 COLSTRIP UNITS 3&4 EFFLUENT HOLDING POND CCR UNITS

A single multi-unit groundwater monitoring system is in place to monitor seven CCR Units at the Units 3&4 Effluent Holding Pond (3&4 EHP). As such, data and analysis presented in this section apply to the following:

- Colstrip 3&4 EHP A Cell (3&4 EHP A Cell);
- Colstrip 3&4 EHP B Cell (3&4 EHP B Cell);
- Colstrip 3&4 EHP C Cell (3&4 EHP C Cell);
- Colstrip 3&4 EHP D/E Cell (3&4 EHP D/E Cell);
- Colstrip 3&4 EHP G Cell (3&4 EHP G Cell);
- Colstrip 3&4 EHP J Cell (3&4 EHP J Cell); and
- Colstrip 3&4 EHP J-1 Cell (3&4 EHP J-1 Cell).

8.1 LOCATION AND DESCRIPTION

A location map of the 3&4 EHP CCR Units and associated groundwater monitoring wells is shown in Figure 8-1. Use of a single multi-unit groundwater monitoring system was chosen at the 3&4 EHP due to the condensed arrangement of CCR units and common waste boundary created by a bentonite-amended concrete cutoff wall (cutoff wall) around the impoundments. Individual CCR units, non-CCR Rule impoundments, and the cutoff wall are shown in Figure 8-1.

Hydrogeologic conditions in the 3&4 EHP area are discussed in the GWMP (Hydrometrics, Inc. 2017a). The direction of groundwater flow at the 3&4 EHP is discussed in Section 8.2 to follow. Based on prevailing hydrogeology and pond construction details, the uppermost hydrostratigraphic units that may be influenced by CCR are the Rosebud Coal interval, alluvium, McKay Coal, and/or sub-McKay bedrock. Through a monitoring program that pre-dates CCR regulation, Colstrip SES operators have identified process water impacts downgradient of the 3&4 EHP in each of the uppermost units; and a network of capture wells are in place around the 3&4 EHP to recover impacted groundwater. However, for the purposes of CCR monitoring, the Rosebud Coal and/or clinker (thermally altered bedrock that is left in place after in-situ Rosebud coal fires) is not considered to be an aquifer because

it does not contain usable quantities of natural groundwater. Notably too, there is no alluvium directly abutted to the 3&4 EHP boundary. Flow to the alluvium from the 3&4 EHP has to either go through fill that extends from the toe of the dam to the 3&4 EHP Main Dam Sump, or through McKay Coal or sub-McKay bedrock. The McKay Coal or sub-McKay bedrock is the first hydrostratigraphic interval present at the base of the cutoff wall that extends around the perimeter of the 3&4 EHP. For this reason, the McKay Coal and sub-McKay bedrock are the primary units included in the 3&4 EHP CCR groundwater monitoring program.

The groundwater monitoring system at the 3&4 EHP includes seven background wells and 32 downgradient monitoring wells. Wells included in the 3&4 EHP CCR unit monitoring system are listed in Table 8-1. The 3&4 EHP groundwater monitoring system consists of 24 wells that were in existence prior to publication of the CCR rule. Fifteen new wells were installed in 2016 expressly for use in the CCR groundwater monitoring program; they are identified in Table 8-1 with the –CCR suffix. No wells associated with the 3&4 EHP were decommissioned in 2016 or 2017.

Three background wells and 11 downgradient monitoring wells comprise the McKay Coal monitoring network. Two of the background wells (601M and 1182M-CCR) are located southeast of the 3&4 EHP. The third McKay background well (WM-127) is located southwest of the 3&4 EHP and was completed prior to construction of the facility. The eleven downgradient McKay wells are nearly evenly spaced around the perimeter of the 3&4 EHP. No McKay Coal wells are present north of the 3&4 EHP because the McKay Coal is burned or cropped out and eroded in that area.

Wells 1020D and 1138D were selected as the background wells for the sub-McKay component of the groundwater monitoring system. Based on previous long-term groundwater quality observations and the current direction of groundwater flow, these wells are outside of potential influences from the 3&4 EHP. However, because the 3&4 EHP CCR units are positioned over top of a groundwater divide at a local recharge point, there are no true upgradient wells available to the 3&4 EHP groundwater monitoring system in any of the

uppermost hydrostratigraphic units. Per §257.91(a)(1)(i) and (ii), use of background wells that are not hydraulically upgradient of CCR units are allowed as long as the wells provide data that are as representative or more representative than data from upgradient wells. Wells 1020D and 1138D satisfy this requirement. A combination of 20 new and existing wells (Table 8-1) are located around the perimeter of the 3&4 EHP to serve as downgradient sub-McKay monitoring wells.

As mentioned previously, the alluvium is not directly abutted to the 3&4 EHP boundary. Flow to the alluvium from the 3&4 EHP has to go through sub-McKay bedrock. The 3&4 EHP was designed and constructed to include containment measures to collect seepage that would otherwise reach alluvium downgradient of the 3&4 EHP Main Dam. Well 1188S-CCR is completed in shallow unconsolidated sediments (fill) that are part of an engineered drainage feature (toe drain). Because water that is present at well 1188S-CCR will inherently be captured by the toe drain and no true alluvial groundwater is present as the uppermost aquifer beneath the 3&4 EHP, no formal statistical analysis will be made of alluvial wells in the 3&4 EHP groundwater monitoring system during the detection monitoring phase. Well 1188S-CCR is included in the 3&4 EHP monitoring system to confirm that alluvium is not present at the 3&4 EHP waste boundary. Since water at 1188S-CCR issues from sub-McKay bedrock, the practical statistical comparison is to background groundwater quality in bedrock; however, this is a redundant comparison since well 1187D-CCR was completed in bedrock and paired location with 1188S-CCR.

Two background alluvial wells (1022A and 1186A-CCR) are included in the 3&4 EHP groundwater monitoring system. Because there is no alluvium upgradient of the 3&4 EHP, the background wells are completed in the Cow Creek (1186A-CCR) and upper South Fork Cow Creek (1022A) drainages (Figure 8-1). If necessary, background groundwater quality collected at wells 1022A and 1186A-CCR may be determined and used for potential comparison to future corrective action compliance wells in alluvium farther downgradient of the 3&4 EHP Main Dam. However, those analyses are not included in this report.

8.2 GROUNDWATER ELEVATIONS, FLOW RATES, AND DIRECTION §257.93(C)

Groundwater elevations recorded at monitoring wells in the 3&4 EHP groundwater monitoring system through 2017 are found in Appendix B and hydrographs are provided in Appendix C.

8.2.1 McKay Coal

A McKay Coal potentiometric map of the 3&4 EHP Area from spring 2016 is shown in Figure 8-2. Where the McKay Coal hydrostratigraphic interval is present at the 3&4 EHP boundary (i.e. cutoff wall), the direction of groundwater flow is typically perpendicular to the pond boundary. Groundwater in the McKay Coal flows radially away from the southwest corner of the 3&4 EHP and to the south on the south side of the 3&4 EHP. At the northwest corner of the 3&4 EHP, groundwater in the McKay Coal flows in a north/northwesterly direction. Potentiometric contours are absent north of the 3&4 EHP where the McKay Coal is burned and/or removed by erosion. Except for limited local influence around capture well 657M, groundwater capture in the McKay Coal interval outside the 3&4 EHP does not affect the direction of flow.

Converging groundwater flow appears to be occurring in coal in the area between wells 600M and 601M, southeast of the 3&4 EHP. The base of the McKay is higher at 601M than at 600M. The higher water levels in this area may be a function of the higher base of the coal. While wells 601M and 1182M-CCR are not upgradient of the 3&4 EHP, they are opposite of the groundwater divide and provide groundwater quality data that is representative of un-impacted background conditions. Although the current potentiometric map suggests flow from the 3&4 EHP in the direction of background well WM-127, no changes in groundwater quality are apparent throughout the period of record (which pre-dates the 3&4 EHP) at the background well (Hydrometrics, Inc. 2017a).

The rate of groundwater flow in the McKay coal at the 3&4 EHP is variable based on flow direction. Flow to the west/southwest has a low hydraulic gradient (i ~0.007) compared to flow in either the southerly (i ~ 0.03) or easterly (i ~ 0.015) directions. Average K values of

2.3 ft/day, 7 ft/day, and 1.1 ft/day are assumed for the McKay coal west, south, and east of the 3&4 EHP, respectively (Hydrometrics, Inc. 2017a). Assuming a constant η_e of 0.09 for coal, the resultant average linear groundwater velocities in 2017 were approximately 0.18 ft/day (66 ft/year) to the west, 2.3 ft/day (852 ft/year) to the south, and 0.18 ft/day (66 ft/year) to the east. Although flow rates to the east and west are similar in magnitude, flow in the west is controlled by the low gradient and flow in the east is controlled by the low K.

8.2.2 Sub-McKay Bedrock

A representative potentiometric surface map for sub-McKay groundwater, constructed using water level elevations recorded from the 3&4 EHP groundwater monitoring system in 2017, is presented in Figure 8-3. A groundwater divide appears to be present in the sub-McKay at the southwest corner of the 3&4 EHP. In this area, groundwater generally flows to the east-southeast or to the north.

Groundwater in the sub-McKay is generally flowing northward on the north side of the 3&4 EHP. Groundwater flow is affected locally by capture wells installed on the east and west abutments of the 3&4 EHP Main Dam. The potentiometric surface in the bottom of the 3&4 EHP Main Dam drainage is lower than that on the abutment, indicating that groundwater may be flowing from the bedrock into fill near the toe of the dam and/or alluvium farther downgradient. Horizontal hydraulic gradients of the northerly flow component are steep (up to 0.2 but more typically ~ 0.09). Assuming an average K of 2 ft/day and η_e of 0.21, the estimated linear groundwater flow velocity in this area was 0.85 ft/day (312 ft/year).

At the northeast corner of the 3&4 EHP, the orientation of the potentiometric lines changes indicating a change in groundwater flow directions from the north to the east. On the east side and southeast corner of the 3&4 EHP, groundwater is flowing east-southeast. The hydraulic gradient is about 0.05 at the southeast corner of the 3&4 EHP. Groundwater flow velocities were calculated between 0.07 to 0.34 ft/day (26 to 124 ft/year). Contours (and flow direction) are affected locally by groundwater capture wells such as 565D.

8.3 SAMPLE COLLECTION SUMMARY (§257.93(e)(3))

A summary of groundwater quality samples collected at each of the background and downgradient wells in the 3&4 EHP groundwater monitoring system, including the dates the samples were collected, is presented in Table 8-2. A total of 489 samples were collected in 2016/2017; 402 of which were collected at downgradient wells and 87 of which were collected to establish background groundwater quality. All of the samples collected in 2016 and 2017 were required by the detection monitoring program of §257.94; and all but the final sample collected at each of the downgradient wells was collected to establish background groundwater quality in accordance with §257.94(b). The final sample from each downgradient well was collected to determine whether or not there is a statistically significant increase (SSI) over background values of Appendix III detection monitoring parameters, as required by §257.93(h)(1). Background groundwater quality for each of the Appendix III constituents is established in Section 8.4; however, final SSI determination was not completed in calendar year 2017 and is not included in this annual report.

Laboratory analytical results for all samples listed in Table 8-2 are provided in Appendix D. Time series plots for Appendix III detection monitoring parameters at background wells are found in Appendix E.

8.4 STATISTICAL DETERMINATION OF BACKGROUND (§257.93(d))

Known process water impacts to groundwater from the CCR units at the 3&4 EHP preclude the use of intrawell comparisons; however, spatial variability in means between wells in both the sub-McKay bedrock and McKay coal intervals largely excludes pooling data for interwell statistical analysis. Side-by-side box plots constructed of data collected at the 3&4 EHP in 2016 and 2017 are presented in Figures 8-4 through 8-12 to illustrate differences in the distribution of detection monitoring constituents, including differences in distributions between background and downgradient wells. Formal statistical evaluation of spatial variability at the 3&4 EHP is discussed in Section 8.4.2 following tests for normality in Section 8.4.1.

8.4.1 Data Distribution

Results of Shapiro-Wilk tests (Appendix F) for well constituent pairs at the 3&4 EHP were consistent with previous groundwater monitoring systems in that boron, calcium, sulfate, and TDS were generally found to be normally distributed; but chloride, fluoride, and pH were less likely to follow the normal distributional model. This was the case at both bedrock background wells (1020D and 1138D) as boron, calcium, sulfate, and TDS were normally distributed; but none of chloride, fluoride, or pH were normally (or log-normally) distributed.

The distributional model of detection monitoring constituents in McKay Coal background wells was less consistent. Only calcium and chloride were normally distributed at well 1182M-CCR; but boron and sulfate were log-normally distributed at the same well. Boron, pH, sulfate, and TDS were normally distributed at 601M. None of the non-normal constituents (calcium, chloride, pH) at 601M were found to be log-normally distributed. All of the constituents at well WM-127 were normally distributed except for fluoride and pH. All of the fluoride observations at well WM-127 in 2016 and 2017 were identical (0.2 mg/L), which precluded evaluation by the Shapiro-Wilk test. Neither the raw or log transformed pH observations were normally distributed.

8.4.2 Spatial Variability

Examination of side-by-side box plots for sub-McKay wells 1020D and 1138D (Figures 8-4 through 8-10) and/or review of summary statistics at these wells (Appendix F) provides an initial indication that there are likely differences in the mean and variance between most all of the detection monitoring constituents in the background dataset. Formal one-way parametric ANOVA were evaluated for each of the four normally distributed parameters (boron, calcium, sulfate, and TDS) and the non-parametric Kruskal-Wallis test was applied to chloride, fluoride, and pH to verify the statistical significance of the apparent variability (Appendix F). All tests indicated variable means and/or data distributions with a high degree of statistical certainty ($p < \alpha = 0.05$).

Similar variability was suspected in McKay coal background wells. An assumption of normality was made for boron, calcium, chloride, sulfate, and TDS in the McKay wells and

parametric ANOVA (Appendix F) were conducted on a between wells basis. Each of the ANOVA tests indicated variable means and/or data distributions with a high degree of statistical certainty ($p < \alpha = 0.05$). Further evaluation of well pairings was conducted using the TukeyHSD; whereby the means of all well pairs were found to be statistically different at $p < 0.05$. The remaining constituents (pH and Fluoride) were subject to a by-well comparison via the non-parametric Kruskal-Wallis test. These data were also found to vary significantly by well ($p < \alpha = 0.05$, Appendix F).

8.4.3 Trend Analysis

Mann-Kendall trend tests (Barry and Maxwell 2017) were conducted for each background well-constituent pair as a final check of the applicability of the dataset to represent background groundwater quality conditions at the CCR unit boundary. Results are found in Appendix F. While some of the test results indicated statistically significant trends (increasing or decreasing), a review of the time series plots (Appendix E) and summary statistics revealed that the trends had no practical significance on the outcome of background groundwater quality projections. For example, statistically significant ($p < \alpha = 0.05$) decreasing trends were detected for TDS at both of the sub-McKay background wells 1020D and 1138D. On a y-axis scaled appropriately for these analyses, slope of the TDS trend line is nearly imperceptible for either well (Appendix E). Further, the range of observations (maximum – minimum) is approximately 200 mg/L, or about 10% of the observed values. Trends will continue to be evaluated in following future sampling events and background groundwater quality updates. However, at present, none of the identified trends at 3&4 EHP background wells have any bearing on the determination of background groundwater quality.

8.4.4 Interwell Prediction Limits

Because inconsistent distribution and spatial non-stationarity were exhibited in the background data sets for both the sub-McKay and McKay Coal groundwater flow pathways, a combination of non-parametric or parametric prediction limits based on data from individual (non-pooled) wells were calculated. A summary of sub-McKay prediction limits is presented in Table 8-3. McKay Coal prediction limits are found in Table 8-4. A narrative of the final determination the prediction limits is as follows.

Sub-McKay

- Boron, calcium, sulfate, and TDS – Each of these constituents was normally distributed but had significantly different means in background wells 1020D and 1138D. The distribution of boron, calcium, sulfate, and TDS at well 1138D had generally higher individual values, sample mean, and maximum than well 1020D; thus, upper parametric prediction intervals were calculated for each of these constituents using only data from well 1138D. A K-multiplier appropriate for seven constituents, 20 compliance bedrock wells (Table 8-1), and 13 background observations (Table 8-2) was interpolated bi-linearly from Table 19-1 of the Unified Guidance (US EPA 2009). The final K-multiplier for each of the parametric constituents was 2.74. Equation 2-2 was evaluated for boron, calcium, sulfate, and TDS using values of mean and standard deviation (Appendix F) for each parameter at well 1138D as follows:

Constituent	Mean	Standard deviation	Calculation $PL = \bar{X} \pm Ks$	Prediction Limit*
Boron	1.162	0.067	1.162 + 2.74*0.067	1.35
Calcium	284	16.847	284 + 2.74*16.847	330
Sulfate	1652	94.265	1652 + 2.74*94.265	1912
TDS	2611	53.613	2611 + 2.74*53.613	2759

*Confidence level = 98.1%; α = 0.019.

- Chloride – The upper prediction limit for chloride in sub-McKay bedrock for 3&4 EHP CCR units was set at the maximum value of 10 mg/L, observed at well 1138D in 2016/2017. Assuming a semi-annual sampling interval and n = 13 background observations at well 1138D, a confidence level of 86.6% (α = 0.134) per well/constituent test applies to this prediction limit.
- Fluoride – The upper prediction limit for fluoride in sub-McKay bedrock for 3&4 EHP CCR units was set at the maximum value of 0.5 mg/L, observed at well 1138D in 2016/2017. The fluoride upper prediction limit excludes an extreme outlier (0.9 mg/L) that was observed at well 1020D (see box plot, Figure 8-7). Assuming a semi-

annual sampling interval and n = 13 background observations at well 1138D, a confidence level of 86.6% (α = 0.134) per well/constituent test applies to this prediction limit.

- pH – Non-parametric upper and lower prediction limits for pH were assigned based on maximum (7.6) and minimum (7.1) values observed in 2016 and 2017 at either of background wells 1020D or 1138D. Accounting for background samples collected from both wells, and assuming a semi-annual sampling requirement, a confidence level of 92.9% (α = 0.072) was estimated for this prediction limit.

McKay

- Boron, calcium, and chloride – The distribution of boron, calcium, and chloride at well WM-127 had generally higher individual values, sample mean, and maximum than the other two background McKay wells (601M and 1182M-CCR). Each of these three constituents was normally distributed at well WM-127; and upper parametric prediction intervals were calculated from the 2016/2017 data. A K-multiplier appropriate for seven constituents, 11 compliance bedrock wells (Table 8-1), and 13 background observations (Table 8-2) was interpolated bi-linearly from Table 19-1 of the Unified Guidance (US EPA 2009). The final K-multiplier for each of the parametric constituents was 2.463. Equation 2-2 was evaluated for boron, calcium, and chloride using values of mean and standard deviation (Appendix F) for each parameter at well WM-127, as follows:

Constituent	Mean	Standard deviation	Calculation $PL = \bar{X} \pm Ks$	Prediction Limit*
Boron	1.79	0.094	1.79 + 2.463*0.094	2.02
Calcium	475.9	21.975	475.9 + 2.463*21.975	530
Chloride	18.92	1.605	18.92 + 2.463*1.605	23

*Confidence level = 97.4%; α = 0.026.

- Fluoride – The upper prediction limit for fluoride in McKay coal groundwater at the 3&4 EHP CCR units was set at the maximum value of 0.5 mg/L, as observed at well 601M in 2016/2017. (Confidence level = 86.6%; $\alpha = 0.134$).
- pH – Non-parametric upper and lower prediction limits for pH were assigned based on maximum (7.4) and minimum (6.8) values observed in 2016 and 2017 at any of the McKay background wells (Confidence level = 86.6%; $\alpha = 0.134$).
- Sulfate – Well WM-127 had the highest values of sulfate in background groundwater of the McKay coal at the 3&4 EHP; however, the distribution of sulfate at this well appears to be locally isolated and is not representative of background sulfate conditions at the 3&4 EHP boundary. From the sulfate boxplots (Figure 8-12), it is seen that even the lowest sulfate value in the distribution at well WM-127 is greater than the highest value at any of the other background or downgradient wells. As such, the upper prediction limit for sulfate in McKay coal groundwater at the 3&4 EHP was evaluated using the log-normally distributed data at well 1182M-CCR. Calculation of the sulfate prediction limit is as follows.

Constituent	Mean	Standard deviation	Calculation $PL = \bar{X} \pm Ks$	Prediction Limit*
Raw sulfate	1407	233.99	--	--
ln-sulfate	7.238	0.14778	$e^{(7.23 + 2.46*0.148)}$	2002

*Confidence level = 97.4%; $\alpha = 0.026$.

- TDS – Similar to high sulfate values observed at WM-127, a locally elevated distribution of TDS was also observed at this well in 2016 and 2017. A comparison of TDS at WM-127 relative to other background and downgradient wells at the 3&4 EHP is provided in the boxplot of Figure 8-12. The elevated TDS are not attributable to the CCR units but neither are they representative of background groundwater quality at the unit boundary. The maximum TDS concentrations observed at well 1182M-CCR (3230 mg/L) was assigned as the non-parametric upper prediction limit (Confidence level = 86.6%; $\alpha = 0.134$).

Table 8-1. 3&4 EHP MONITORING WELLS

Well Type/ID	Date of Completion	Total Depth (feet bgs)	Perforated Interval (feet bgs)	Hydrostratigraphic Unit
Background Wells				
1186A-CCR*	4/8/2016	17	12-17	Alluvium
WM-127	4/19/1981	96	85-94	McKay Coal
601M	10/23/1987	84	74-84	McKay Coal
1182M-CCR	4/6/2016	92	87-92	McKay Coal
1020D	10/13/2005	70	55-70	Sub McKay
1138D	11/9/2011	75	65-75	Sub McKay
1022A*	7/26/2005	17	7-17	Alluvium
Downgradient Wells				
1188S-CCR**	4/11/2016	19	14-19	Unconsolidated Fill
WM-126	4/16/1981	77.5	68-77.5	McKay Coal
555M	6/26/1982	76	66-76	McKay Coal
590M	10/17/1985	33	25-33	McKay Coal
1000M	1/11/2005	92	82-92	McKay Coal
1004M	1/18/2005	104	94-104	McKay Coal
1006M	1/19/2005	96	86-96	McKay Coal
1176M-CCR	3/24/2016	30	20-30	McKay Coal
1178M-CCR	3/28/2016	106	96-106	McKay Coal
1181M-CCR	4/4/2016	74	69-74	McKay Coal
1183M-CCR	4/6/2016	60	55-60	McKay Coal
1185M-CCR	4/8/2016	85	80-85	McKay Coal
EAP-527	12/2/1981	199	189-194	Sub McKay
588D	10/16/1985	160	120-160	Sub McKay
602S	8/9/1993	65	45-65	Sub McKay
614D	11/5/1998	120	80-120	Sub McKay
615D	11/15/1998	125	85-125	Sub McKay
622D-P	2/17/1999	75	45-75	Sub McKay
659D	8/23/2004	138	98-138	Sub McKay
664D	8/25/2004	130	90-130	Sub McKay
1008D	1/20/2005	160	140-160	Sub McKay
1009D	1/21/2005	204	184-204	Sub McKay
1082D	4/23/2009	124	94-124	Sub McKay
1116D	8/4/2010	143	104-143	Sub McKay
1119D	8/6/2010	186	174-186	Sub McKay
1174D-CCR	3/23/2016	260	250-260	Sub McKay
1175D-CCR	3/24/2016	75	65-75	Sub McKay
1177D-CCR	3/24/2016	155	145-155	Sub McKay
1179D-CCR	3/28/2016	169	159-169	Sub McKay
1180D-CCR	4/4/2016	140	130-140	Sub McKay
1184D-CCR	4/8/2016	137	127-137	Sub McKay
1187D-CCR	4/11/2016	51	41-51	Sub McKay

*Alluvial wells not used in statistical analysis.

**1188S-CCR used to verify absence or presence of alluvium. Not used in statistical evaluation.

Table 8-2. 3&4 EHP Multi-unit Groundwater Monitoring System Sample Collection Summary

Well Type/ID	Total Number of Samples Collected	Number of Initial Samples Detection Monitoring §257.93(d), §257.94(b)	Number of Samples for SSI Determination Detection Monitoring §257.93(h)(1)	Initial Sample [§257.93(d), §257.94(b)] Collection Dates													Detection Monitoring Sample §257.93(h)(1) Collection Dates
Background Wells																	
1186A-CCR	12	12	NA	4/12/16	5/25/16	7/6/16	9/28/16	12/1/16	1/10/17	2/22/17	4/21/17	5/30/17	6/27/17	7/19/17	8/21/17		--
1022A	12	12	NA	4/5/16	6/15/16	7/27/16	9/28/16	11/22/16	1/23/17	3/8/17	4/19/17	5/30/17	6/14/17	7/26/17	8/29/17		--
WM-127	13	13	NA	2/10/16	4/26/16	6/1/16	7/11/16	10/13/16	11/28/16	1/10/17	2/22/17	4/11/17	5/30/17	6/13/17	7/24/17	8/25/17	--
601M	12	12	NA	4/4/16	6/14/16	7/12/16	8/30/16	11/21/16	1/10/17	2/14/17	4/19/17	5/17/17	6/22/17	7/18/17	8/23/17		--
1182M-CCR	12	12	NA	5/3/16	6/15/16	7/26/16	8/30/16	11/22/16	1/10/17	2/15/17	4/19/17	5/17/17	6/22/17	7/25/17	8/24/17		--
1020D	13	13	NA	2/24/16	4/25/16	5/27/16	7/6/16	8/24/16	11/22/16	1/11/17	2/23/17	4/19/17	5/30/17	6/14/17	7/24/17	8/28/17	--
1138D	13	13	NA	2/24/16	4/28/16	6/15/16	7/27/16	9/28/16	11/22/16	1/11/17	2/22/17	4/19/17	5/30/17	6/26/17	7/26/17	8/29/17	--
Downgradient Wells																	
1188S-CCR	13	12	1	4/20/16	6/16/16	7/27/16	10/11/16	11/16/16	11/29/16	1/23/17	3/8/17	4/24/17	5/15/17	6/13/17	7/17/17		8/22/17
WM-126	13	12	1	2/10/16	4/25/16	6/16/16	7/26/16	8/25/16	11/17/16	12/29/16	2/16/17	4/11/17	5/17/17	6/27/17	7/24/17		8/30/17
555M	13	12	1	2/16/16	4/21/16	5/26/16	7/5/16	8/23/16	11/15/16	12/27/16	3/7/17	4/13/17	5/17/17	6/15/17	7/19/17		8/28/17
590M	13	12	1	2/11/16	5/4/16	6/13/16	7/12/16	8/23/16	11/14/16	12/29/16	2/23/17	4/20/17	5/18/17	6/22/17	7/18/17		8/23/17
1000M	13	12	1	2/12/16	5/11/16	6/14/16	8/17/16	10/12/16	11/29/16	1/25/17	2/27/17	4/10/17	5/18/17	6/15/17	7/26/17		8/29/17
1004M	13	12	1	2/11/16	4/27/16	6/1/16	7/11/16	8/24/16	11/30/16	1/23/17	2/27/17	4/12/17	5/18/17	6/23/17	7/25/17		8/31/17
1006M	13	12	1	2/18/16	4/27/16	5/30/16	7/6/16	8/25/16	11/30/16	1/24/17	2/27/17	4/18/17	5/16/17	6/26/17	7/25/17		8/30/17
1176M-CCR	12	11	1	4/19/16	5/31/16	7/8/16	8/23/16	11/15/16	1/24/17	2/23/17	4/13/17	5/30/17	6/27/17	7/31/17			8/29/17
1178M-CCR	12	11	1	5/3/16	6/15/16	7/26/16	8/29/16	11/21/16	1/11/17	2/15/17	4/21/17	5/16/17	6/22/17	7/26/17			8/22/17
1181M-CCR	12	11	1	4/12/16	6/22/16	7/27/16	10/17/16	11/29/16	1/12/17	2/22/17	4/10/17	5/31/17	6/26/17	7/31/17			8/30/17
1183M-CCR	12	11	1	5/2/16	6/15/16	8/12/16	10/17/16	11/30/16	1/25/17	2/27/17	4/18/17	5/31/17	6/28/17	8/1/17			8/31/17
1185M-CCR	12	11	1	5/3/16	6/1/16	7/11/16	8/24/16	11/17/16	1/25/17	3/8/17	4/12/17	5/31/17	6/28/17	7/27/17			8/29/17
EAP-527	12	11	1	4/22/16	5/30/16	7/7/16	10/12/16	11/28/16	1/9/17	2/15/17	4/20/17	5/17/17	6/21/17	7/20/17			8/22/17
588D	13	12	1	2/9/16	5/3/16	6/14/16	7/12/16	10/13/16	12/1/16	1/24/17	2/21/17	4/18/17	5/30/17	6/28/17	8/1/17		8/30/17
602S	13	12	1	2/4/16	5/10/16	6/16/16	7/28/16	10/13/16	11/15/16	1/26/17	2/22/17	4/25/17	5/16/17	6/14/17	7/13/17		8/24/17
614D	13	12	1	2/17/16	4/26/16	5/31/16	7/7/16	10/11/16	11/17/16	1/26/17	3/6/17	4/10/17	5/15/17	6/14/17	7/24/17		8/25/17
615D	13	12	1	2/5/16	4/26/16	5/27/16	7/8/16	8/29/16	11/17/16	1/26/17	3/6/17	4/24/17	5/18/17	6/15/17	7/25/17		8/24/17
622D-P	12	11	1	4/4/16	6/16/16	7/28/16	10/11/16	11/17/16	1/26/17	3/7/17	4/24/17	5/15/17	6/13/17	7/19/17			8/22/17
659D	13	12	1	2/10/16	4/27/16	6/15/16	7/26/16	8/25/16	11/17/16	12/29/16	3/6/17	4/10/17	5/17/17	6/27/17	7/24/17		8/30/17
664D	13	12	1	2/16/16	4/21/16	5/26/16	7/5/16	8/23/16	11/15/16	1/25/17	3/7/17	4/13/17	5/17/17	6/15/17	7/19/17		8/29/17
1008D	13	12	1	2/11/16	4/27/16	5/31/16	7/7/16	8/24/16	11/30/16	1/12/17	2/15/17	4/12/17	5/18/17	6/23/17	7/25/17		8/30/17
1009D	13	12	1	2/17/16	5/10/16	6/14/16	8/17/16	10/12/16	12/1/16	1/11/17	2/28/17	4/11/17	5/17/17	6/15/17	7/25/17		8/28/17
1082D	13	12	1	2/17/16	4/20/16	5/25/16	7/5/16	8/22/16	11/16/16	12/28/16	2/28/17	4/10/17	5/16/17	6/14/17	7/26/17		8/28/17
1116D	13	12	1	2/4/16	4/20/16	5/25/16	7/5/16	8/22/16	11/16/16	12/28/16	2/16/17	4/12/17	5/16/17	6/14/17	7/25/17		8/23/17
1119D	13	12	1	2/17/16	4/21/16	6/13/16	7/12/16	8/22/16	11/29/16	1/9/17	2/21/17	4/12/17	5/16/17	6/14/17	7/26/17		8/29/17
1174D-CCR	12	11	1	4/29/16	6/14/16	8/12/16	10/17/16	11/30/16	1/24/17	2/28/17	4/20/17	5/18/17	6/27/17	8/2/17			8/31/17
1175D-CCR	12	11	1	4/19/16	5/26/16	7/6/16	8/25/16	11/15/16	1/24/17	2/23/17	4/13/17	5/30/17	6/27/17	7/31/17			8/30/17
1177D-CCR	12	11	1	4/19/16	5/31/16	7/7/16	8/23/16	11/21/16	2/21/17	3/27/17	4/20/17	5/16/17	6/21/17	7/18/17			8/22/17
1179D-CCR	12	11	1	5/2/16	5/30/16	7/7/16	10/12/16	11/28/16	1/9/17	2/14/17	4/20/17	5/18/17	6/14/17	7/20/17			8/24/17
1180D-CCR	12	11	1	4/13/16	5/26/16	7/6/16	8/24/16	11/28/16	1/12/17	2/21/17	4/10/17	5/31/17	6/15/17	7/24/17			8/24/17
1184D-CCR	12	11	1	4/13/16	6/1/16	7/11/16	8/24/16	12/1/16	1/25/17	3/8/17	4/12/17	5/31/17	6/28/17	7/27/17			8/30/17
1187D-CCR	12	11	1	5/3/16	6/16/16	7/27/16	8/29/16	11/16/16	1/23/17	3/8/17	4/24/17	5/15/17	6/13/17	7/17/17			8/22/17

TABLE 8-3. 3&4 EHP SUB-MCKAY PREDICTION LIMITS

Appendix III Parameter	Sub-McKay Prediction Limit (mg/L)	Statistical Method
Boron	**1.35**	Parametric Prediction Limit (1138D)
Calcium	**330**	Parametric Prediction Limit (1138D)
Chloride	**10**	Non-parametric ordered statistic (max background Cl)
Fluoride	**0.5**	Non-parametric ordered statistic (max background F)
pH	**Lower – 7.1** **Upper – 7.6**	Non-parametric ordered statistic (minimum and maximum background)
Sulfate	**1912**	Parametric Prediction Limit (1138D)
TDS	**2759**	Parametric Prediction Limit (1138D)

TABLE 8-4. 3&4 EHP MCKAY COAL BACKGROUND GROUNDWATER QUALITY SUMMARY

Appendix III Parameter	McKay Prediction Limit (mg/L)	Statistical Method
Boron	**2.02**	Parametric Upper Prediction Limit (WM-127)
Calcium	**530**	Parametric Upper Prediction Limit (WM-127)
Chloride	**23**	Parametric Upper Prediction Limit (WM-127)
Fluoride	**0.5**	Non-parametric ordered statistic (max background F)
pH	**Lower – 6.8** **Upper – 7.4**	Non-parametric ordered statistic (minimum and maximum background)
Sulfate	**2002**	Parametric Upper Prediction Limit (ln transformation 1182M-CCR)
TDS	**3230**	Non-parametric ordered statistic (max background TDS, excludes WM-127)

9.0 ASSUMPTIONS AND LIMITATIONS

Pursuant to the performance standard of §257.91(a)(1) and (2), owners or operators of a CCR unit must install a groundwater monitoring system that accurately represents the quality of background groundwater that has not been affected by leakage from a CCR Unit and that accurately represents the quality of groundwater passing the waste boundary of the CCR Unit. Based on review of site-specific hydrogeologic information (Hydrometrics, Inc. 2017a), reliance on the Colstrip SES groundwater monitoring system certification per §257.91(f) (Hydrometrics, Inc. 2017b), and in consideration of any explicit qualifiers listed previously within this report, it is assumed that groundwater quality data collected at the Colstrip SES and presented and analyzed in this report are representative of conditions at the upgradient and downgradient CCR unit boundaries. However**,** results of assessments made based on hydrogeological and hydrogeochemical conditions consistent with those of the complex depositional environment and suite of inorganic constituents found at the Colstrip SES are subject to and limited by a high degree of natural variability. Known variability is accounted for in the evaluation presented in this report; but if conditions are encountered through subsequent groundwater monitoring or site evaluation that would defy the assumption of representativeness of the data, background groundwater quality should be re-evaluated.

Wells of the CCR groundwater monitoring systems are a subset of a larger groundwater monitoring network that was installed to monitor and mitigate known process water impacts to groundwater from certain CCR surface impoundments and non-CCR Rule facilities. When coupled with naturally heterogeneous groundwater quality, groundwater quality variability that is potentially caused by process water further complicates the statistical determination of background groundwater quality at CCR units. Where previous influences from non-CCR Rule facilities are thought to exist, those non-CCR Rule influences are represented in the background groundwater quality in as much as they could be separated from impacts caused by CCR units. It is assumed, based on conditions described herein, that previous process water influences are not over-represented in background groundwater quality determination such that they would lead to undue false negative results in future

comparisons (i.e. failing to predict SSI where one is present); and that they are not under-represented such that they would produce false positive results (i.e. predicting an SSI where none is present).

The list of statistical methods in §257.93(f)(1) through (5) explicitly includes four options (parametric analysis of variance, analysis of variance based on ranks (non-parametric), a tolerance or prediction interval approach, or a control chart approach) but also allows for another statistical test that meets the performance standards of §257.93(g). The prediction limit approach is highly flexible and can accommodate a wide variety of groundwater monitoring networks (US EPA 2009); and it is assumed that this approach is applicable to site specific conditions at the Colstrip SES. However, the prediction limit approach taken in this analysis and results of that approach are one of many possible outcomes that could result from evaluation of data at the Colstrip SES.

Selection of a method other than the prediction limit approach would have categorical differences in execution and potential differences in results of individual well-constituent comparisons to downgradient water quality observations. Further, selection of an alternate retesting strategy and/or comparisons to future means or medians (as opposed to comparisons to future observations) during development of the prediction limit strategy could affect the outcome of specific limits in the background groundwater quality determination. If retesting were excluded from prediction limit development, higher upper prediction limits would result. However, if a more robust retesting strategy was applied (e.g. 1 of 3) lower prediction limits but more opportunity for re-sampling would prevail. Prediction limit tests on individual future values and a 1 of 2 sample retesting strategy is included in the development of prediction limits for the Colstrip SES as a pragmatic approach that results in a relatively high upper limit, provides sufficient statistical power, and adequately controls the theoretical per-test false positive rate (α) when applied in accordance with Unified Guidance (US EPA 2009). Further, the 1 of 2 strategy allows for re-testing, if necessary, but is not as costly or time consuming at a site where process water impacts to groundwater are likely and regulatory compliance deadlines and hydrogeologic conditions may not allow for excessive resampling.

There are currently 64 downgradient compliance wells in the six Colstrip SES groundwater monitoring systems combined. There are seven constituents required for background detection monitoring; and each well-constituent pair must be evaluated for SSI on a semiannual basis throughout the detection monitoring program. This equates to 896 statistical comparisons annually or 448 comparisons per detection monitoring event. Unified Guidance (US EPA 2009) recommends and most of the pertinent statistical analyses included herein were conducted under a targeted SWFPR of 0.1. At this rate, nearly 90 false positives could result from statistical comparisons to prediction limits per year. Because the number of detection monitoring constituents is fixed at seven, and the groundwater monitoring network must have a sufficient number of wells for adequate characterization, there is little that can be done to reduce the number of required comparisons. This is referred to as the 'multiple comparisons problem' and it is discussed at length in the Unified Guidance (US EPA 2009). Reductions in the probability of false positive error will likely only decrease as a function of increasing the background sample size. Specifically for non-parametric tests within the range of background sample sizes (n = 9 to 13) at the Colstrip SES, the per-constituent significance level (α) cannot be limited to an acceptable false positive rate without considering a very robust retesting scheme. Regardless of the theoretical reduction in α, the non-parametric statistical test is applied in the exact same manner, by comparing the highest ranked (largest) observed value in the background data set to a future observation.

Finally, background groundwater quality is established by the prediction limit approach for each of the seven Appendix III constituents (boron, calcium, chloride, fluoride, pH, sulfate, and TDS). The prediction limits presented in Sections 3 through 8 will be used to evaluate SSI in future comparisons to downgradient groundwater quality; thus it is assumed that each of these constituents is a valid indicator of process water impacts from the Colstrip SES CCR units. This is a valid assumption for most of the constituents (boron, calcium, chloride, sulfate, and TDS), as they have long been used in some capacity to evaluate process water impacts to groundwater at the Colstrip SES. However, based on a review of Colstrip SES groundwater quality data, fluoride and pH are questionable indicators of process water impacts. Statistical comparison of parameters that are not typical indicators of process water impacts limits the meaningfulness of the tests.

10.0 CONCLUSIONS

In compliance with the initial timeframes established in §257.90(b)(1), the following groundwater monitoring requirements were completed at the Colstrip SES by October 17, 2017:

- Installation of the groundwater monitoring system as required by 40 CFR §257.91;
- Development of the groundwater sampling and analysis program to include the selection of statistical procedures that will be used for evaluating the groundwater monitoring data as required by 40 CFR §257.93 (Hydrometrics, Inc. 2017a);
- Detection monitoring, as per 40 CFR 257.94(b), to include obtaining a minimum of eight independent samples for each background and downgradient well; and
- Initial evaluation of groundwater monitoring data for statistically significant increases over background levels for the constituents listed in Appendix III as per 40 CFR §257.94. Upper limits of background groundwater quality were estimated using prediction intervals; but final SSI determination was not completed by the end of 2017.

Each of the requirements of §257.90(e) were addressed in this 2017 annual groundwater monitoring and corrective action report.

- Maps showing the location of each CCR unit and associated background and downgradient monitoring wells (40 CFR §257.90 (e)(1)) were prepared and provided in Sections 3.0 through 8.0.
- A narrative of work undertaken to install or abandon monitoring wells during the previous calendar year (2016 and 2017) (40 CFR §257.90 (e)(2)) was included in Section 2.0 and/or Sections 3.0 through 8.0 of this report. Well logs for all of the CCR unit groundwater monitoring systems are in Appendix A.
- Per 40 CFR §257.90 (e)(3), all monitoring data collected during 2016/2017 under 40 CFR §§ 257.90-257.98 are presented in Appendix D. As noted, each background or upgradient well associated with a CCR unit was sampled at least 8 but as many as 13 times for detection monitoring purposes.

- The rate and direction of groundwater flow beneath each CCR unit was evaluated for each sampling event in accordance with §257.93(c). At most of the CCR units and/or groundwater monitoring systems, the rate and direction of flow were consistent throughout the 2016/2017 groundwater monitoring period. Noted exceptions to this occurred at the 1&2 B Pond and STEP E Cell/Old Clearwell, where intermittent operation of groundwater capture systems altered the direction and/or rate of flow.
- A narrative of the statistical evaluation, as required by 40 CFR §257.90 (e)(4) was provided in this report. Specifically, parametric or non-parametric prediction limits, appropriate to the distributional model of each constituent in the background dataset, were calculated for all potential groundwater flow pathways at each CCR unit. Intrawell prediction limits were determined to be most appropriate at STEP D Cell; and interwell prediction limits were determined at all other CCR units or groundwater monitoring systems at the Colstrip SES.
- No transition between detection and assessment monitoring occurred or was documented in 2017.
- SSI were not evaluated during 2017; thus no alternative source demonstrations (40 CFR §257.94 (e)(2)) were conducted.

A projection of key monitoring or corrective action activities planned for the upcoming year is provided in Section 11.

11.0 PROJECTION OF KEY GROUNDWATER MONITORING ACTIVITIES FOR UPCOMING YEAR 2018

A projection of key monitoring or corrective action activities planned for the Colstrip SES in the upcoming year (2018) is as follows.

For all CCR groundwater monitoring systems at the Colstrip SES, analytical results for the Appendix III constituents will be evaluated for SSIs in accordance with 40 CFR 257.93(f) through (h) by January 15, 2018. If a SSI is identified for one or more of the Appendix III constituents during detection monitoring at any compliance well, an investigation into the cause of the SSI may commence as deemed appropriate. If necessary, the affected downgradient well(s) will be resampled and analyzed for the constituent(s) with SSI as soon as possible after SSI determination. Analytical results from resampling will be evaluated according to the approved detection monitoring statistical analysis methods. If the resample results are not statistically higher than background, then no SSI exists and detection monitoring will continue in 2018. If the resample results are statistically higher than background, then an SSI is indicated, and further evaluation will be conducted. If evidence is found that the SSI resulted from a source other than the CCR unit, or resulted from error, then a written demonstration that the SSI did not result from the CCR unit will be prepared and submitted within 90 days of detecting the SSI. The written demonstration will be certified by a qualified professional engineer and included in the operating record and 2018 annual report.

Per §257.94(e)(1), an assessment monitoring program will be established for each CCR unit with an SSI; and in accordance with §257.95(b), each well will be sampled and analyzed for Appendix IV assessment monitoring parameters within 90 days of the determination of the SSI (by April 15, 2018). A notice will be submitted in the Colstrip SES operating record stating that an assessment monitoring program has been established for each affected CCR unit within 30 days of establishing the program (by May 15, 2018). Within 90 days (by July 14, 2018) of obtaining the results of the initial assessment monitoring sample, all applicable

wells will be resampled for Appendix III and IV parameters and results will be recorded in the facility operating record [§257.95(d)(1)]. As required by §257.95(d)(2), groundwater protection standards will be established for all assessment monitoring constituents detected in either the §257.95(b) (April 15, 2018) or §257.95(d)(1) (July 14, 2018) sampling event. Complete statistical evaluation to determine if there is an exceedance of groundwater protection standards for Appendix IV assessment monitoring constituents at a statistically significant level (SSL) will be completed by October 12, 2018. Finally, as required by §257.95(d)(3), results of assessment monitoring sampling, background concentrations of assessment monitoring parameters, and groundwater protection standards will be included in the 2018 annual groundwater monitoring and corrective action report. The progression of activities listed above is based on a best working understanding of the CCR Rule compliance timeline and may be subject to change as interpretation of the CCR Rule evolves.

In addition to those activities described above, key monitoring activities or changes to groundwater monitoring systems identified previously in this report for specific CCR units at the Colstrip SES are summarized as follows. The Colstrip SES CCR GWMP (Hydrometrics 2017a) will be updated in 2018 to include these changes.

<u>1&2 B Pond</u>

- Downgradient compliance well AB-25S will be re-surveyed using a horizontal and vertical datum that is consistent with the rest of the monitoring well network (Dowl 2017) to accommodate accurate water level elevation measurements in 2018.

<u>1&2 Bottom Ash Pond</u>

- Well AB-20S was originally assigned to the downgradient monitoring well network at 1&2 BAP; but groundwater flow conditions indicate that AB-20S was upgradient of the CCR unit throughout 2016 and 2017. Well AB-20S is downgradient of 1&2 B Pond; but was not used as a compliance well for that CCR unit as it is redundant to the existing 1&2 B Pond downgradient network. Well AB-20S will be re-assigned as an intermediate well and potentially used in support of ASD in 2018.

3&4 Bottom Ash Pond

- Well 21SP-2 was originally assigned to the background monitoring well network at 3&4 BAP; but groundwater flow conditions indicate that 21SP-2 was downgradient of the CCR unit throughout 2016 and 2017. Well 21SP-2 was not used to establish background groundwater quality prediction intervals; and alternately, it will be used as a compliance well to monitor the eastern flow component downgradient of 3&4 BAP in 2018.

STEP D Cell

- Background groundwater quality sample collection will continue for Appendix III and IV detection and assessment monitoring constituents at downgradient compliance wells 392D, 952D, 953D, and 2055D-CCR. Updates to intrawell background groundwater quality prediction limits will be made, as appropriate, until CCR are placed in STEP D Cell.
- Despite the use of intrawell statistics at STEP D Cell, ongoing monitoring at upgradient or intermediate wells 388D, 2018D, 2019D, 2045D-CCR, and 2046D-CCR will continue in 2018. Groundwater quality results at the retained upgradient wells will be used to evaluate potential site-wide groundwater quality changes that could affect future intrawell groundwater quality comparisons at downgradient wells 392D, 952D, 953D, and 2055D-CCR (i.e. if a universal trend in groundwater quality changes occurs in the area of STEP D Cell, it will be advantageous to have data collected upgradient of the CCR unit to separate potential process water influences from an alternate source of the trend).

STEP E Cell and Old Clearwell

- Upgradient background wells 2043D-CCR, 2044D-CCR, and 2047D-CCR were used to establish background groundwater quality at STEP E Cell/Old Clearwell in accordance with §257.93(d) and will continue to be monitored for that purpose in conjunction with the applicable detection monitoring or assessment monitoring program in 2018. Although the intermediate wells were used to establish representative upgradient groundwater quality, monitoring for the purposes of the

CCR Rule will continue at background wells 371D, 373D, and 388D. Data from these wells will be used to evaluate potential site-wide groundwater quality changes. These wells are impacted by process water from Non-CCR Rule facilities and/or are not representative of conditions at the immediate upgradient waste boundary of either STEP E Cell or STEP Old Clearwell.

- High volume purging will be conducted at well 2053D-CCR prior to low flow sampling to address turbidity issues that could lead to unrepresentative groundwater quality data. As addressed in Section 7.3, more aggressive well treatment or replacement options may be evaluated if variable groundwater quality results persist at 2053D-CCR in 2018.

Units 3&4 EHP Multi-Unit Groundwater Monitoring System

- Groundwater monitoring for the applicable detection monitoring or assessment monitoring program will continue in 2018 without changes to the purpose, number, or location of wells identified in the 3&4 EHP groundwater monitoring system (Table 8-1), unless changes are necessary based on future groundwater quality results.

12.0 REFERENCES

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FIGURES FOR THE
2017 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT, COLSTRIP STEAM ELECTRIC STATION
TALEN MONTANA, LLC

Report figures are included as ATTACHMENTS to this electronic file

PDF files are created by Section (i.e. SECTION 3 Figures_CCR Annual GWM Report.pdf)

APPENDICES A through F

(Appendices A through F are included as ATTACHMENTS to this report)