MEMORANDUM

TO: David Bowers, Montana Department of Environmental Quality (DEQ)
FROM: Tetra Tech, Inc. [EMI Unit]
DATE: May 23, 2018
RE: Montana Pole and Treating Plant (MPTP)
Analysis of Soil Cleanup Level for Pentachlorophenol Protective of Groundwater

Executive Summary

Soil cleanup levels for pentachlorophenol (PCP) at the Montana Pole and Treating Plant (MPTP) site have been established based on risk to human health associated with direct exposure to vadose zone soils. These soil cleanup levels did not consider the impact of leaching PCP from the vadose zone to groundwater outside of the land treatment unit (LTU) offload footprint. This memo presents the background and development of a soil cleanup level for PCP that meets the MPTP Record of Decision (ROD) groundwater cleanup level (1 microgram per liter [ug/L]) (U.S. Environmental Protection Agency [EPA] and Montana Department of Environmental Quality [DEQ] 1993). Five lines of evidence are employed in the assessment of this cleanup level:

1. Empirical Site Evidence – Monitoring Well Data,
2. Empirical Site Evidence – North Side Soil Data,
3. Empirical Site Evidence – Near Creek Recovery Trench (NCRT) Data,
4. Results of Synthetic Precipitation Leaching Procedure (SPLP) Testing, and
5. Results of a Spreadsheet Mixing Model.

These lines of evidence support PCP soil cleanup levels ranging from 0.56 milligrams per kilogram (mg/kg) to 26.9 mg/kg. Accounting for the biases associated with the various lines of evidence a “realistically conservative” value of 2.0 mg/kg is proposed for the site.

1.0 Introduction

The MPTP site is located in Butte, Montana, and operated as a wood treating facility from 1946 to 1984 (EPA and DEQ 1993). A site map is provided as Exhibit 1. During most of this period, a solution of about 5 percent PCP, mixed with petroleum carrier oil similar to diesel, was used to preserve poles, posts, and bridge timbers. The PCP solution was applied to wood products in butt vats and pressure cylinders (retorts). Creosote was used as a wood preservative for a brief period in 1969.

Phase 4 of the remedial action is ongoing and involves continued capture and treatment of contaminated groundwater and biological treatment of contaminated soils. This phase also includes offloading soil in the LTU as lifts of surface soil are remediated to below the cleanup levels set for the site in the MPTP ROD for certain contaminants of concern. The soil currently remaining in the LTU is scheduled to be offloaded in 2018; this will be the final offload.

A data gaps investigation addressing site-wide concentrations of selected contaminants in soil was completed in mid-2017; a final report presenting the results of this investigation was issued in November 2017 (Tetra Tech 2017). The 30 percent design for the LTU offload was submitted to DEQ on January 30, 2018, and the final design will be submitted mid-summer 2018. The design will include offloading all the remaining soil from the LTU with onsite disposal beneath an engineered impermeable cap and cover soil, removing and disposing of the LTU liner and associated materials and equipment, and reclaiming the current LTU and retention pond areas.

The MPTP ROD established a PCP soil cleanup level of 34 (mg/kg) and a PCP groundwater cleanup level of 1.0 (µg/L) (EPA and DEQ 1993). The basis for the ROD PCP soil cleanup level was noted as "risk;" it corresponds to a 1.0×10^{-6} excess cancer risk for recreational use for soil, and a noncancer health hazard quotient less than 1.0. The basis for the ROD PCP groundwater cleanup level was noted as the "maximum contaminant level (MCL)," and a 1.7×10^{-6} excess cancer risk for drinking water. A noncancer health hazard quotient was not noted in the ROD for PCP in groundwater.

The ROD PCP cleanup level for soil (34 mg/kg), did not consider the potential impact that leaching of PCP from treated LTU soils, and other potentially contaminated site soils, might have on the quality of subjacent groundwater. That is, it did not assess whether offloaded treated soil from the MPTP LTU, or other site soils exhibiting concentrations of up to 34 mg/kg could result in a concentration of PCP in groundwater greater than the ROD 1 µg/L groundwater cleanup level.

PCP is logical to target for leaching to groundwater as it is mobile in surface soil, subsurface soil, and groundwater. Unlike PCP, polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (furans), collectively referred to as "dioxins," are not mobile in soil and therefore would not leach from soil to groundwater. However, dioxins can be mobilized if present in a carrier oil. Based on data collected during remedy implementation, the ROD soil cleanup level of 0.20 microgram/kilogram (µg/kg) for dioxin toxicity equivalence quotient (TEQ) in soil has not been achieved with biological treatment at the LTU. The Fourth FYR Report (April 2017) indicated that the average dioxin TEQ concentrations associated with treated soils from the LTU ranged from 0.7 to 2.8 µg/kg, and also stated that:

> "it is also possible that some dioxins are introduced to the trenches in sheens of oils, though in recent years observations of sheens have been limited to just a few instances at the NHRT and are not commonplace."

In 2018 the DEQ recalculated the site-specific cleanup levels (SSCLs) for PCP in soil for the MPTP site using updated exposure parameters and toxicity criteria (DEQ 2018). The recalculated cleanup levels are provided in the table below, along with the preliminary remediation goals (PRGs) provided in the MPTP ROD.

Chemical of Concern	Recreational Use		Industrial Use		Construction Worker	
	PRG	SSCL	PRG	SSCL	PRG	SSCL
PCP	34 mg/kg[1]	36 mg/kg	9 mg/kg	7 mg/kg[2]	Not applicable	77 mg/kg

Notes:
1 ROD recreational use cleanup level
2 Proposed cleanup level for industrial use

The above table indicates the industrial SSCL for PCP (7.0 mg/kg) would be the lowest recalculated cleanup level, but this value is based only on risk to human health, and does not take into account leaching of PCP from surface soil, subsurface soil to a depth of 15 feet outside of the offload footprint. Thus, the effect of leaching PCP from soil outside of the offload footprint (PCP-contaminated soil that will not be protected by an engineered impermeable cap) must be considered. This memorandum addresses this issue.

2.0 Lines of Evidence

This memorandum addresses the issue noted above by developing five lines of evidence that support a PCP soil cleanup level that would be protective of groundwater and thus meet the MPTP ROD groundwater cleanup level for PCP (1.0 µg/L). These lines of evidence include:

1. Empirical Site Evidence – Monitoring Well Data,
2. Empirical Site Evidence – North Side Soil Data,
3. Empirical Site Evidence – Near Creek Recovery Trench (NCRT) Data,
4. Results of Synthetic Precipitation Leaching Procedure (SPLP) Testing, and
5. Results of a Spreadsheet Mixing Model.

These five lines of evidence are discussed individually in the following sections.

Line of Evidence #1 - Empirical Site Evidence – Monitoring Well Data

Another supporting line of evidence related to the potential for leaching of PCP in soils is the relatively low concentration of PCP in groundwater observed in samples at three monitoring wells on the south side of the MPTP site (wells MW-A-95, MW-09, and GW-09). These wells are located downgradient of previous LTU offloads and are not believed to be substantially influenced by other potential continuing sources of PCP (see Exhibit 2).

Monitoring well MW-A-95 is located immediately downgradient of soil offloaded from the LTU in 2007, but in a location not expected to be affected by any other continuing sources of PCP (Exhibit 2). Surficial soil samples collected in 2017 from the 2007 offload area near well MW-A-95 and analyzed for PCP exhibited concentrations between 25 mg/kg and 32 mg/kg. However, since 2007, the concentration of PCP in groundwater at well MW-A-95 has generally been below 1 µg/L, with a few values between 1 µg/L and 5 µg/L (Exhibit 2).

Monitoring well MW-09 is located immediately downgradient of soil offloaded from the LTU in 2005, but in a location not expected to be affected by any other continuing sources of PCP (Exhibit 2). A surficial soil sample collected in 2017 from the 2005 offload area near well MW-09 exhibited a PCP concentration of 38 mg/kg. However, since 2005 the concentration of PCP in groundwater at well MW-09 has always been well below 1 µg/L (Exhibit 2).

Monitoring well GW-09 is located immediately downgradient of soil offloaded from the LTU in 2005 and 2007, but in a location not expected to be affected by any other continuing sources of PCP (Exhibit 2). A soil sample from the most western offload area upgradient of well GW-09 was not collected during the Data Gap Investigation (Tetra Tech 2017). However, the concentration of PCP in soil samples collected directly from the LTU soil in 2003 was 26.9 mg/kg, and in 2006 was 13.6 mg/kg (average value equal to 20.25 mg/kg) (Tetra Tech 2015). As noted in the Data Gap Investigation (Tetra Tech 2017), the concentration of PCP in soils from the 2005 and 2007 offloads ranged from 25 mg/kg to 38 mg/kg (average value equal to 31.5 mg/kg) (Exhibit 2). Therefore, this line of evidence assumes that soil in the most western offload area upgradient of well GW-09 likely ranges between about 20 mg/kg and 38 mg/kg (average value equal to about 26 mg/kg).

However, since 2005 the concentration of PCP in groundwater at well GW-09 has generally been well below 1 µg/L, except for a few likely anomalous higher values (Exhibit 2). The site conceptual model suggests that occasionally higher concentrations of PCP in groundwater may be the result of groundwater that has come in contact with residual oil in the “smear zone” as discussed in the Annual Sampling and Monitoring Report (Tetra Tech 2018).

It is also important to note that, with very few exceptions over the 2005 to 2018 period of record, the PCP plume footprint based on the 1 µg/L contour interval has not extended west of the location of monitoring well MW-A-95. This observation suggests that PCP-contaminated soil (as high as 38 mg/kg) associated with the 2005 and 2007 LTU offloads has not resulted in an increase in the concentration of PCP in groundwater immediately downgradient of the offload areas.

<u>Summary</u>: With few exceptions, groundwater collected from wells downgradient of the 2005 and 2007 offloads consistently exhibited PCP concentrations below the ROD groundwater standard (1 µg/L), even

though they were located immediately downgradient of locations where surficial soil has exhibited PCP concentrations that range between 25 mg/kg and 38 mg/kg. These observations support development of a PCP soil cleanup level as high as 38 mg/kg.

Line of Evidence #2 - Empirical Site Evidence – North Side Soil Data

Surface and subsurface soil data were collected during the 2017 Final Soil and Surface Water Data Gap Investigation (Tetra Tech 2017). The highest concentrations of PCP in soil were found in grids N-G and N-H at the 5 to 10 foot depth interval (Exhibit 3). The highest soil PCP concentrations in grid N-G was 2,500 µg/kg (equal to 2.5 mg/kg); the highest PCP concentrations in soil in grid N-H was 2,400 µg/kg (equal to 2.4 mg/kg) (Exhibit 3). However, a groundwater solute plume of PCP, as defined by the 1 µg/L isoconcentration line is not present downgradient of these sample locations, and the concentration of PCP in five downgradient wells has consistently been less than 1µg/L (Exhibit 3) suggesting concentrations of up to 2.5 mg/kg in soil do not affect the concentration of PCP in groundwater.

<u>Summary</u>:

PCP-contaminated soil on the north side of the MPTP site exhibiting concentrations of up to 2.5 mg/kg is not associated with PCP in groundwater at concentrations equal to or greater than 1 µg/L. This line of evidence supports a PCP soil cleanup level as low as 2.5 mg/kg that would be protective of groundwater.

Line of Evidence #3 – Empirical Site Evidence – NCRT Data

The MPTP site provides empirical data to assess potential PCP impacts to groundwater from remaining PCP impacts in surface soils, as described below.

LTU soils were offloaded on the northern part of the Site in 1999, covering most of the area between the near highway recovery trench (NHRT) and the NCRT as shown on Exhibit 4. Leaching of PCP from that offloaded soil would presumably affect most of the water discharging to the NCRT (in addition to any other continuing sources of PCP that would impact water collected at the NCRT, such as unexcavated soil east of the MPTP water treatment plant building upgradient of the NCRT).

The average concentration of PCP in soil offloaded from the LTU in 1999 was approximately 14 mg/kg, based on sampling performed at that time (Exhibit 4).

The concentration of PCP in water extracted at the NCRT declined in the years that immediately followed the offload (as a result of previous excavation at the site), and stabilized soon thereafter (by late 2002) at concentrations generally between 4 µg/L and 10 µg/L.

Scaling the offloaded soil concentration of 14 mg/kg by a factor of 10, and similarly scaling the observed concentrations at the NCRT, suggests PCP concentrations of 1.4 mg/kg in soil would likely alter PCP concentrations in groundwater no more than approximately 0.4 µg/L to 1.0 µg/L (at or below the groundwater cleanup level of 1 µg/L).

Given that there are known continuing sources of PCP to groundwater collected at the NCRT other than leaching from offloaded soil, such as unexcavated soil near the water treatment plant building (upgradient of the NCRT), the calculations above are conservative and the impacts to groundwater caused by leaching from surficial soil would be expected to be less than the range of values presented above.

Summary: PCP concentrations of 1.4 mg/kg in soil would likely affect PCP concentrations in groundwater no more than approximately 0.4 µg/L to 1.0 µg/L (at or below the groundwater cleanup level of 1 µg/L). As described in the preceding paragraph, this range of values is conservative and the impacts to groundwater resulting from leaching from surficial soil are likely biased high (in other words, actual impacts are expected to be less than the calculated values).

Line of Evidence #4 – SPLP Results

The guidance document for the New Jersey Department of Environmental Protection (NJDEP) SPLP V3.1 spreadsheet model (NJDEP 2013) states:

> "T*he SPLP is an EPA SW-846 test method that can be used with soil samples from a contaminated site to estimate the site-specific adsorption-desorption potential of a contaminant that may affect ground water. The SPLP procedure (SW-846 Method 1312) consists of a batch equilibrium experiment in which a contaminant is partitioned between soil solids and an extracting solution, using a 20:1 ratio of solution to solid. The resulting solution is known as the leachate. Method 1312 directs the user to compare contaminant concentrations in the SPLP leachate with "appropriate criteria" to determine whether the contaminated soil represents an unacceptable leaching threat.*"

The NJDEP SPLP V3.1 spreadsheet model (NJDEP 2013) was used to estimate a soil cleanup level for the MPTP site that may be protective of groundwater in hydrologic and hydrogeologic conditions similar to those found in New Jersey (Exhibit 5). Application of, and results from, the NJDEP SPLP spreadsheet model at the MPTP site are considered conservative from the perspective of protecting human health and the environment, because the NJDEP SPLP methodology was developed for an area that receives 46 inches of precipitation per year compared with about 12.75 inches of precipitation per year at the MPTP site. A higher degree of leaching would occur in a wetter environment (New Jersey) compared with a drier environment (Butte, Montana). However, the NJDEP SPLP spreadsheet model was applied in this line of evidence because it is readily available, in the public domain, easy to apply, provides consistent and reproducible (albeit conservative) results, and because a comparable model does not currently exist for the State of Montana.

Before the NJDEP SPLP spreadsheet model was run, a total of 17 soil samples from the north and south areas of the MPTP site were collected on a random basis and then analyzed for PCP in soil and the required SPLP parameters. The lithology of the soil samples was characteristically silty sand, clayey sand, and gravelly sand. Complete results from these analyses are provided in the Final Soil and Surface Water Data Gap Investigation Report (Tetra Tech 2017).

The NJDEP SPLP spreadsheet model was then applied using a calculated dilution-attenuation factor (DAF) (equal to 20) and default NJDEP chemical-specific values for PCP, including the NJDEP spreadsheet default values for water solubility (1.95E+03 milligrams per liter [mg/L]) and Henry's Law constant (1.00E-06 [dimensionless]). The health-based groundwater quality criterion (GWQC) for the SPLP spreadsheet model was set to the MPTP ROD groundwater cleanup level (1.0 µg/L). The NJDEP spreadsheet model yields a conservative "SPLP soil remediation standard" of 0.56 mg/kg (Exhibit 5) using MPTP site data. However, Tetra Tech (2017) established that a more reasonable value might be closer to 2.2 mg/kg considering the MPTP site-specific DAF is closer to 79, about 4 times greater than the default model DAF of 20 (Tetra Tech 2017).

Summary: The NJDEP SPLP spreadsheet model calculated a conservative soil cleanup level (0.56 mg/kg) that would be protective of groundwater; however, a reasonable range could be 0.56 mg/kg to 2.2 mg/kg taking into account a site-specific DAF (79), the low rate of infiltration, and the large volume of dilution available in the aquifer.

Line of Evidence #5 – Mixing Model

A mixing model written in Excel 2016 was used to calculate the minimum, median, and maximum incremental impacts to groundwater caused by leaching from offloaded treated soils in the Final Soil and Surface Water Data Gap Investigation Report (Exhibit 6) (see Tetra Tech 2017 for details). Estimates were based on measured concentrations of PCP in unfiltered leachate from the outlet of the LTU, the amount of precipitation expected to infiltrate through the soil horizons (including the offloaded soils), the physical properties of the vadose zone and aquifer, and the estimated groundwater flux associated with the offload area south of Interstate 15/90.

Concentrations of PCP in LTU leachate are based on unfiltered samples collected from the LTU discharge before it enters the LTU pond for the 2011 to 2017 period of record. PCP concentrations in the undiluted, unfiltered leachate from the outlet of the LTU range from approximately 20 µg/L to 4,350 µg/L (Exhibit 6). The concentration of PCP in LTU soils ranged from 14 to 34 mg/kg during this same time period (Tetra Tech 2015). The higher value is associated with a very large storm event (similar to a 100-year event) that likely flushed contaminated material out of the LTU discharge system and into the leachate which was sampled. Data collected during the large storm event in 2011 are clearly biased-high, but were nonetheless included for completeness. Details related to all calculations and assumptions are provided in the final data gap report (Tetra Tech 2017) and are also summarized in Exhibit 3. Key findings are summarized below:

Estimated Range of Impacts - Leaching of PCP in Offloaded Soil to Groundwater

Incremental Impact to Groundwater	**Concentration (μg/L)**
Minimum	0.25
Median	25
Maximum	55*

Note:
* Value is biased high due to datum associated with large flood event in 2011.

Summary: The estimated incremental impact of mixing LTU leachate with subjacent groundwater ranges between 0.25 μg/L and 55 μg/L; however, the maximum value is likely biased high because the sample was collected during a large storm event.

3.0 Summary of Lines of Evidence

The five lines of evidence detailed above are summarized in the table below:

Line of Evidence Number	**Type of Analysis**	**Range of PCP in Soil (mg/kg)**	**Range of PCP in Leachate (μg/L)**	**Range of PCP in Groundwater (μg/L)**	**Range of Possible Soil Cleanup Levels Protective of Groundwater Based on this Line of Evidence (mg/kg)**
#1	Empirical – site monitoring Well Data	20.0 to 38.0	NA	Generally less than 1.0	Less than 20.0
#2	Empirical – north side soil data	2.4 to 2.5	NA	Generally less than 1.0	Less than 2.5
#3	Empirical – NCRT data	14.0	NA	4.0 to 10 $^{\Phi}$	1.4$^{\Phi}$
#4	SPLP results	0.054 to 38.0	0.24 to 2,800	NA	0.56 to 2.2
#5	Mixing model – site data	14.0 to 26.9	20 to 4,350*	0.25 to 55*	14.0 to 26.9

Notes:
NA Not applicable

Notes: (Continued)

* Value is biased high due to datum associated with large flood event in 2011

Φ Value is biased low due to impacts to NCRT from known continuing sources near the water treatment plant.

4.0 Recommendation

Based on the presented lines of evidence, data provided in the summary table above, and best professional judgement, a PCP soil cleanup level equal to 2.0 mg/kg is recommended for PCP-contaminated soil outside of the LTU offload footprint. The weight of existing lines of evidence suggest that leaching of soil exhibiting concentrations of PCP equal to or less than 2.0 mg/kg would not result in subjacent groundwater exceeding the ROD 1 µg/L groundwater cleanup level. The foundation for this recommendation is built on these observations:

- Monitoring wells located immediately downgradient of the 2005 and 2007 offloads have generally exhibited concentrations of PCP in groundwater less than 1 µg/L, even though the concentrations of PCP in offloaded soil are generally greater than 20 mg/kg.
- An area of north-side soils exhibiting up to 2.5 mg/kg does not impact the concentration of PCP in groundwater above the 1 µg/L ROD groundwater cleanup level; a plume of PCP greater than 1 µg/L is not present downgradient of this area.
- The average concentration of PCP in soil offloaded from the LTU in 1999 and placed upgradient of the NCRT was approximately 14 mg/kg. However, concentrations in groundwater collected at the NCRT suggest PCP concentrations of 1.4 mg/kg in soil would likely alter PCP concentrations in groundwater no more than approximately 0.4 µg/L to 1.0 µg/L. These values are conservative given there is unexcavated PCP-contaminated soil near the water treatment plant building (upgradient of the NCRT).
- NJDEP DEP SPLP results (DAF equal to 20) provide a conservatively low soil cleanup level (0.56 mg/kg), but local factors at this site in Montana (such as much lower annual precipitation and recharge, relatively high groundwater flux, and a DAF equal to 79) would suggest that a soil cleanup value closer to 2.2 mg/kg might be appropriate.

5.0 References

Montana Department of Environmental Quality (DEQ). 2018. Memorandum from Aimee Reynolds to David Bowers. Montana Pole Direct Contact Cleanup Level 5-Year Review. April 25.

New Jersey Department of Environmental Protection (NJDEP). 2013. Guidance Document — Development of Site-Specific Impact to Ground Water Soil Remediation Standards Using the Synthetic Precipitation Leaching Procedure, Version 3.0, November.

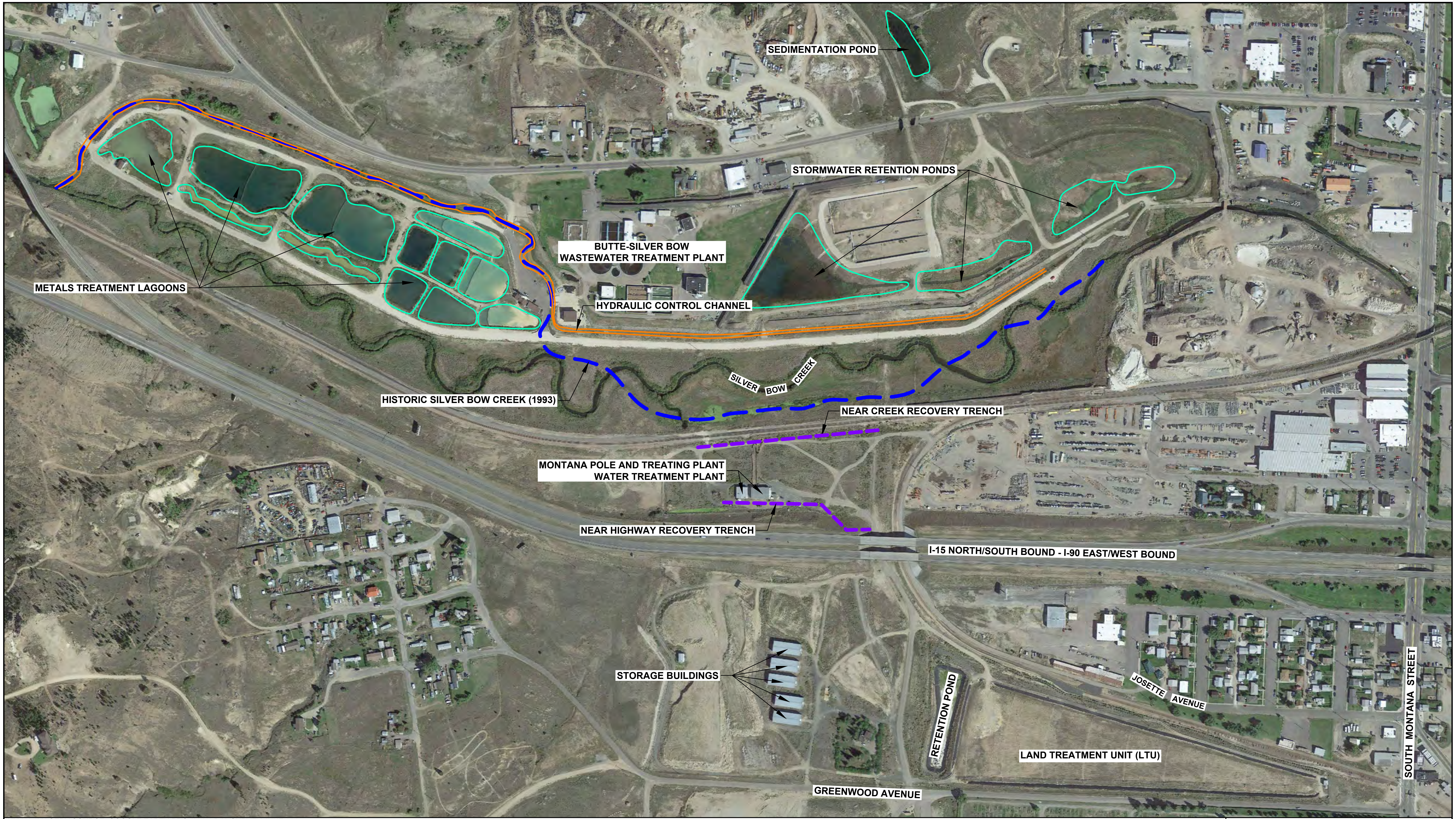
Tetra Tech, Inc. [EMI Unit] (Tetra Tech). 2015. Draft Memorandum, Montana Pole and Treating Plant (MPTP) Land Treatment Unit (LTU) Offload Summary. April 16.

Tetra Tech. 2017. Final Soil and Surface Water Data Gap Investigation Report. November.

Tetra Tech. 2018. Draft 2017 Annual Sampling and Monitoring Report for the Montana Pole and Treating Plant Butte-Silver Bow, Montana. Revision 0.

EXHIBITS

EXHIBIT 1



AERIAL IMAGERY SOURCE: GOOGLE EARTH PRO (2013) DJA SURVEY JUNE 2015

N

200 0 200 400
SCALE IN FEET

Montana Pole and Treating Plant
Butte-Silver Bow Montana

EXHIBIT 1
SITE MAP

TETRA TECH

Exhibit 1_Site Map.dwg - DWH - 04/24/2018

EXHIBIT 2

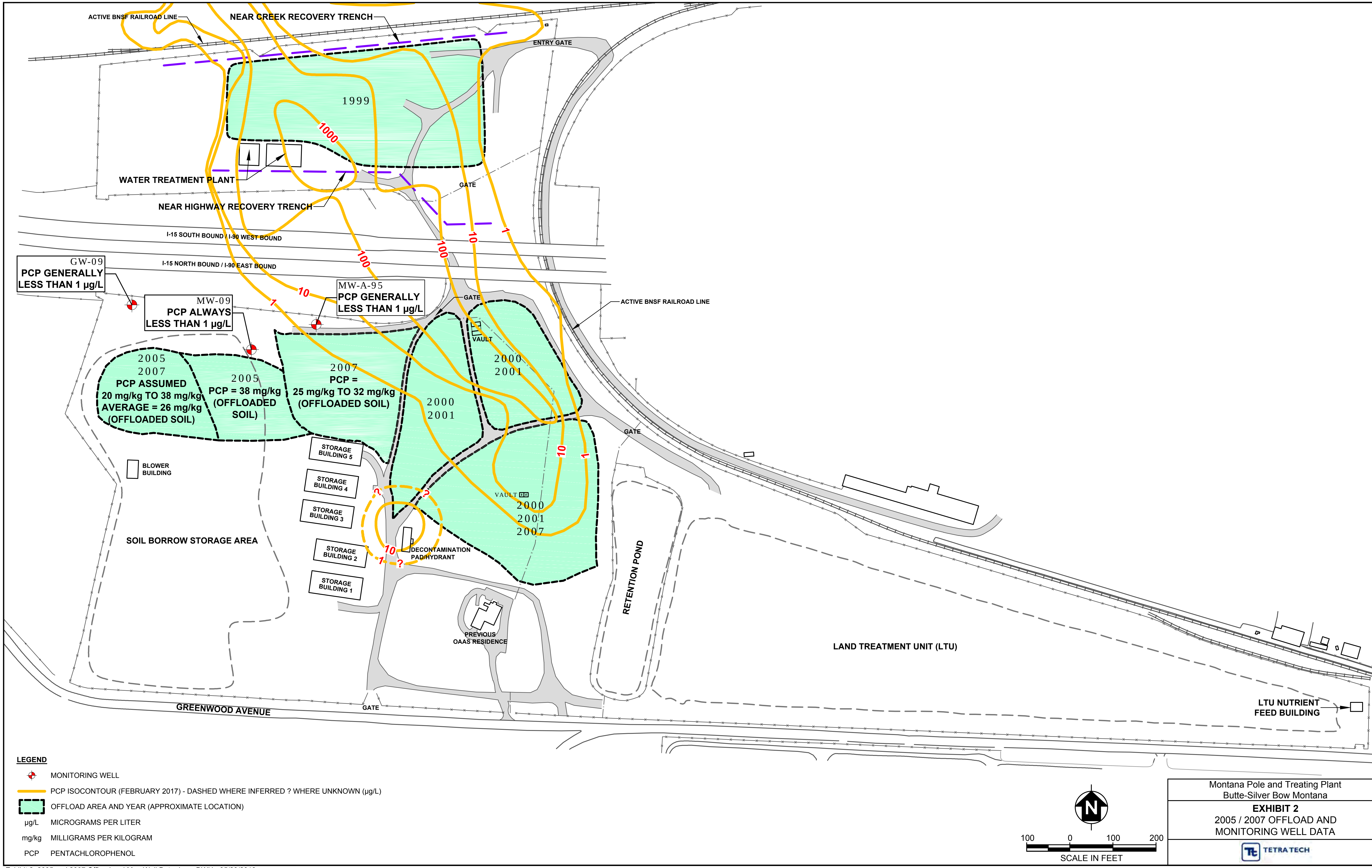
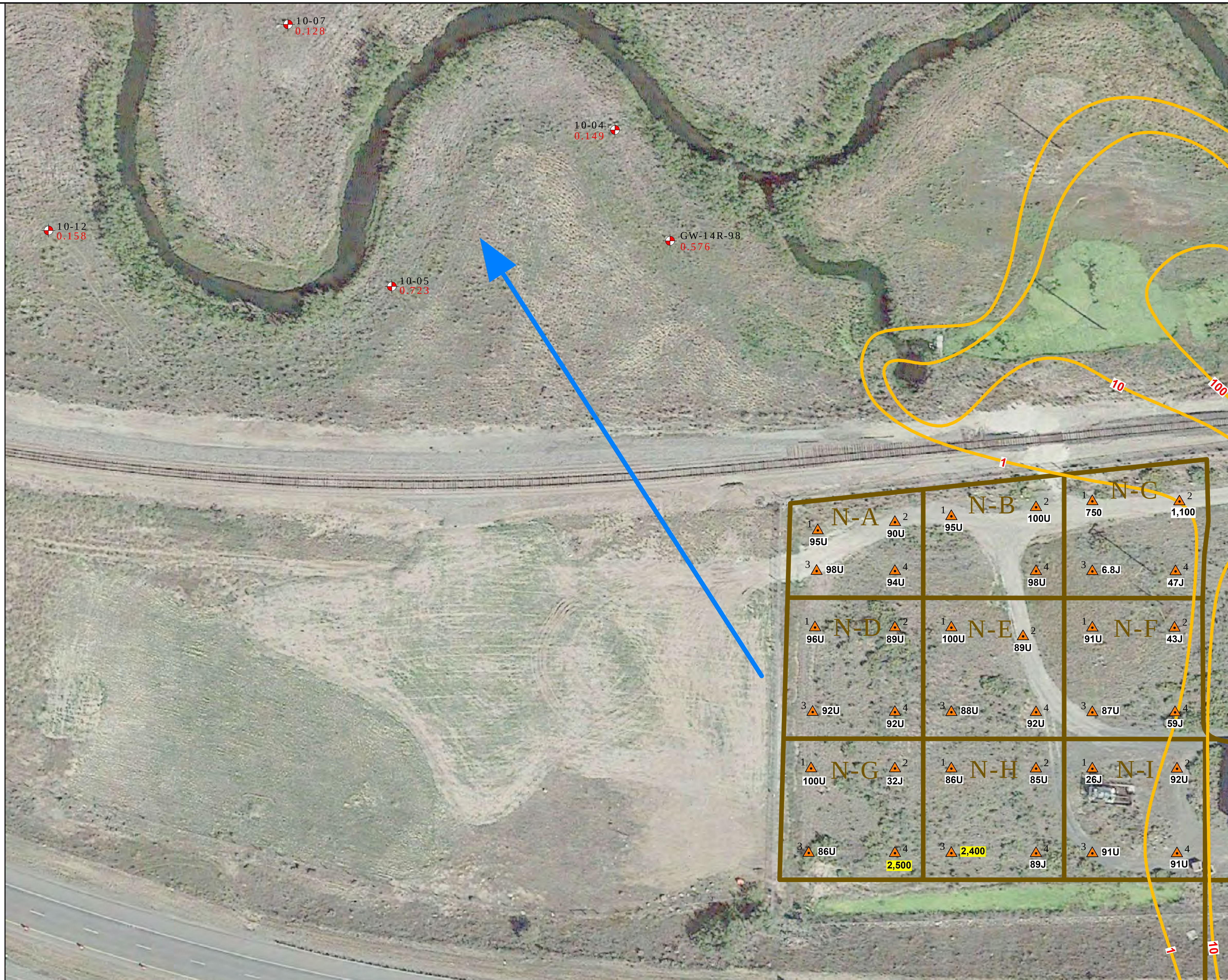


Exhibit 2_2005 and 2007 Offload and Mon Well Data.dwg - DWH - 05/23/2018

EXHIBIT 3



LEGEND

- SAMPLING GRID
- PCP ISOCONTOUR (µg/L - FEBRUARY 2017)
- MONITORING WELL (DATA FROM FEBRUARY 2017) (RESULTS IN MICROGRAMS PER LITER (µg/L))
- INTERPRETED DIRECTION OF GROUNDWATER FLOW; OTHER INTERPRETATIONS ARE POSSIBLE
- SOIL BORING SAMPLE LOCATION - DEPTH = 5-10' (RESULTS IN MICROGRAMS PER KILOGRAM (µg/kg))
- J ESTIMATED VALUE
- U ANALYZED FOR BUT NOT DETECTED ABOVE THE METHOD DETECTION LIMIT
- 2,400 SOIL SAMPLES GREATER THAN 2,000 µg/kg (2 mg/kg)

AERIAL IMAGERY SOURCE:
GOOGLE EARTH PRO (2013) DJA SURVEY JUNE 2015

N

35 0 35 70
SCALE IN FEET

Montana Pole and Treating Plant
Butte-Silver Bow Montana

EXHIBIT 3
NORTH-SIDE SUBSURFACE SOIL (5-10 FEET)
AND MONITORING WELL DATA

TETRA TECH

Exhibit 3_North Subsurface and Mon Well Data.dwg - DWH - 05/23/2018

EXHIBIT 4

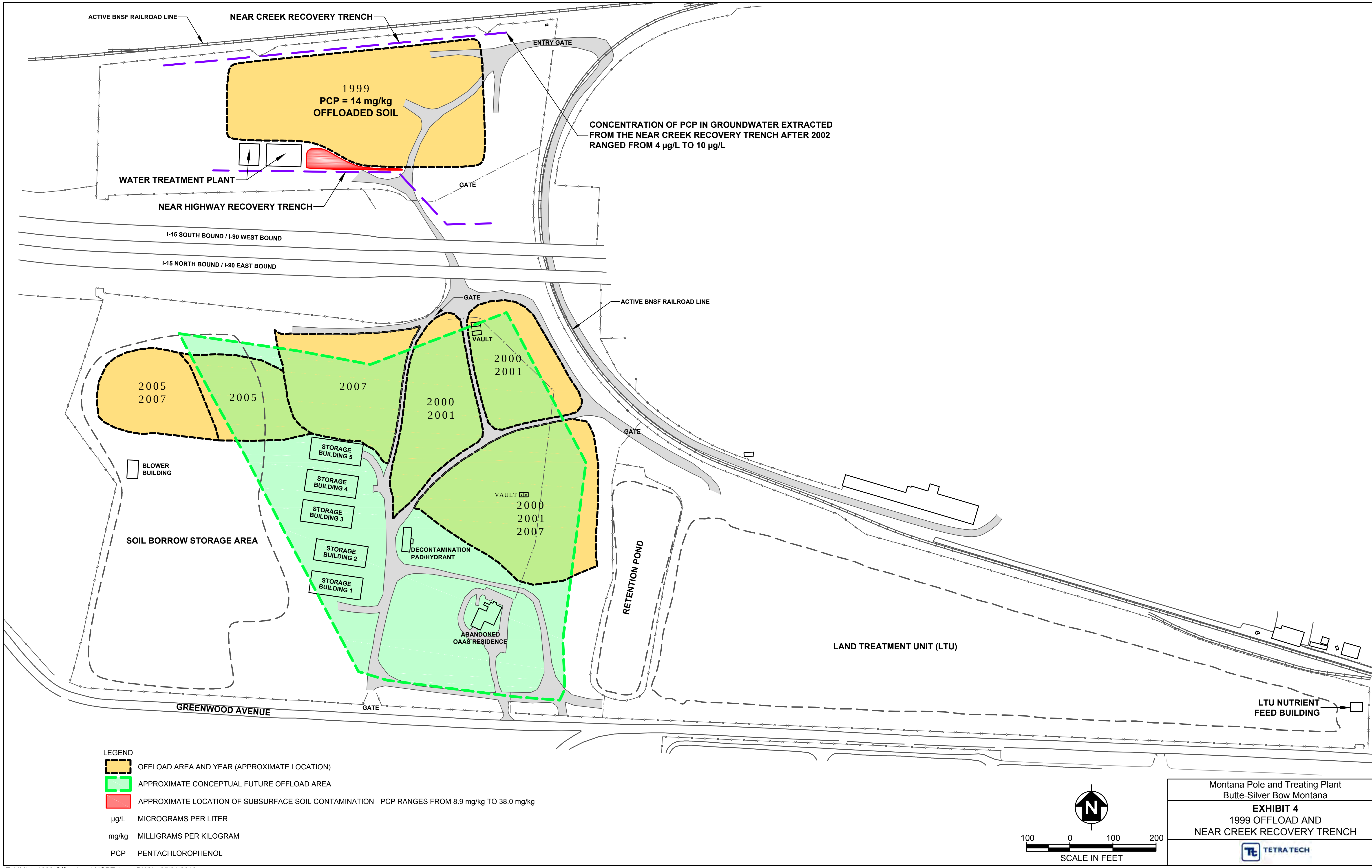


Exhibit 4_1999 Offload and NCRT.dwg - DWH - 05/01/2018

EXHIBIT 5

NJDEP SPLP Spreadsheet, V3.1, November 2013

CALCULATE SITE SPECIFIC IGW STANDARD | Reset Spreadsheet | Print Results | Instructions | Print to file | Exit

Case name/area of concern:	PCP Soil Remediation Level Protective of Groundwater
Case number:	
Sampling date:	5/31/2017
Contaminant:	Pentachlorophenol
CAS No:	87-86-5
Water solubility (mg/L)	1.95E+03 ← enter NA if inorganic
Aqueous reporting limit (µg/L):	7.70E+00 ← if unavailable, enter a value below lowest concentration measured
Soil reporting limit (mg/kg):	8.00E-02 ←
Health-based GWQC (µg/L)	1.00E+00
DAF (20, or site-specific if approved):	20
Leachate Criterion (µg/L):	2.00E+01
Henry's law constant (dimensionless):	1.00E-06 ← enter 0 if inorganic

NOTE:

USE ONE PAGE PER CONTAMINANT, do not leave empty rows between samples

Do not enter samples with soil concentrations at or below the reporting limit.

When leachate concentration is non-detect, enter the aqueous reporting limit

Enter site-specific dilution-attenuation factor (DAF) if desired

Data entry cells (do not skip rows)

Optional data entry

Calculated or locked cells

Indicates that Alternative Remediation Standard needs to be recalculated

Sample ID	Soil sample weight (kg)	Leachate Volume (L)	Total Soil Concentration (mg/kg)	SPLP Leachate Concentration (µg/L)	Final pH of Leachate (except VOCs)	Optional data				Kd (L/kg)	% Contaminant in Leachate	Field leachate concentration (µg/L)	Pass or fail?
						Sampling Depth (ft)	Soil Type	Organic Carbon (mg/kg)	Organic Carbon (%)				
A-3-10	0.1	2	0.083	0.24	9.5	10		300	30	325.8	5.78	0.24	PASS
A-1-10	0.1	2	0.086	0.24	9.4	10		1230	123	338.3	5.58	0.24	PASS
J-1-10	0.1	2	0.054	0.27	9.12	10		6310	631	180.0	10.00	0.27	PASS
N-Y-1-10	0.1	2	0.56	3.1	8.79	10		28800	2880	160.6	11.07	3.10	PASS
N-X-1-10	0.1	2	0.23	5.7	9.35	10		1370	137	20.4	49.57	5.70	PASS
F-1-10	0.1	2	0.33	5.8	9.39	10		2240	224	36.9	35.15	5.80	PASS
N-U-1-10	0.1	2	0.48	6	9.41	10		1170	117	60.0	25.00	6.00	PASS
N-O-1-10	0.1	2	0.36	9.4	9.32	10		2850	285	18.3	52.22	19.51	PASS
N-C-2-10	0.1	2	1.1	37	8.6	10		14000	1400	9.7	67.27	111.30	FAIL
N-G-4-10	0.1	2	2.5	73	8.58	10		4650	465	14.2	58.40	173.61	FAIL
N-H-3-10	0.1	2	2.4	88	9.18	10		3070	307	7.3	73.33	323.19	FAIL
N-R-1-12	0.1	2	7.5	300	9.15	11.5		3010	301	5.0	80.00	1455.37	FAIL
N-S-1-12	0.1	2	2.5	260	9.25	11.5		3700	370	0.0	208.00	16293.71	FAIL
N-N-2-12	0.1	2	10	930	9.83	11.5		926	92.6	0.0	186.00	65174.83	FAIL
N-Q-2-12	0.1	2	29	2400	9.37	11.5		5430	543	0.0	165.52	189007.02	FAIL
N-P-1-10	0.1	2	34	3000	9.59	10		3030	303	0.0	176.47	221594.44	FAIL
N-T-1-10	0.1	2	38	2800	9.51	10		955	95.5	0.0	147.37	247664.37	FAIL

SPLP RESULTS for

OPTION 1a: All adjusted leachate concentrations are below the leachate criterion

OPTION 1a NOT VALID

OPTION 1b: Simple inspection of tabulated results to find highest acceptable standard

REMEDIATION STANDARD = 0.56 mg/kg

OPTION 2: Remediation standard using site-specific Kd value

Kd ratio = 3383333.33, USE MINIMUM Kd

Kd USED FOR CALCULATING STANDARD = . L/kg

result before rounding = 0.0031 mg/kg

REMEDIATION STANDARD = 0.08 mg/kg (controlled by soil PQL)

OPTION 3: Remediation standard using linear regression

Number of points = 10

(points were eliminated because leachate concentrations were not above the aqueous reporting limit)

Soil concentration midrange = 19.18

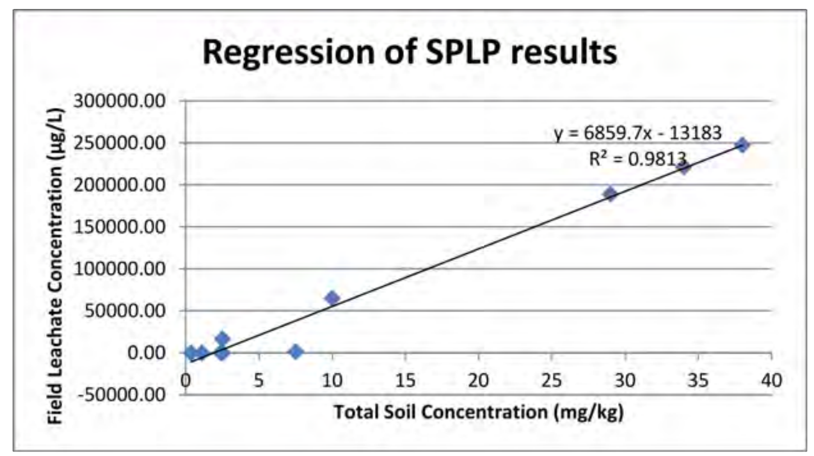
Number of points above midrange = 3

Enough points above midrange? NO

R-Square high enough? YES

Leachate criterion within range of leachate concentrations? YES

OPTION 3 NOT VALID



Montana Pole and Treating Plant
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EXHIBIT 5
SPLP RESULTS

TETRA TECH

EXHIBIT 6

CALCULATIONS

Conversions		
Convert micrograms to pounds	2.2046E-09	
convert cubic feet to liters	28.316	
Recharge Calculation		
Recharge = Area *Groundwater Recharge Rate		
	30,959	cubic feet per year
	876,635	Liters per year
Mass of PCP Leached Calculation		
Mass of PCP leached per year from south offloaded soil = leachate concentration * volume of recharge		
Minimum mass of PCP leached per year		
	17,532,701	micrograms per year
	0.04	pounds per year
Median mass of PCP leached per year		
	1,753,270,088	micrograms per year
	3.87	pounds per year
Maximum mass of PCP leached per year		
	3,813,362,441	micrograms per year
	8.41	pounds per year
Groundwater Flux per Year Calculation		
Flux = hydraulic conductivity * gradient * area perpendicular to groundwater flow		
	6,718	cubic feet per day
	2,452,110	cubic feet per year
	69,433,949	liters per year
Dilution Attenuation Factor Calculation		
Volume of clean groundwater divided by volume of contaminated groundwater from recharge		
	79	unit less
Groundwater Impact from Leachate Calculation		
Concentration of PCP in leachate divided by the dilution attenuation factor		
minimum impact	0.25	micrograms per liter
median impact	25.3	micrograms per liter
maximum impact	54.9	micrograms per liter

CONCENTRATIONS OF PCP IN LTU LEACHATE - 2011 TO 2017

Station ID	Sample ID	Sample Date	Chemical	Concentration	Units
LTUDIS	LTUDIS050211	5/2/2011	PENTACHLOROPHENOL	4,350	UG/L
LTUDIS	LTUDIS061311	6/13/2011	PENTACHLOROPHENOL	3,261	UG/L
LTUDIS	LTUDIS081312	8/13/2012	PENTACHLOROPHENOL	25.6	UG/L
LTUDIS	LTUDIS081213	8/12/2013	PENTACHLOROPHENOL	679	UG/L
LTUDIS	LTUDIS081114	8/11/2014	PENTACHLOROPHENOL	149	UG/L
LTUDIS	LTUDIS081015	8/10/2015	PENTACHLOROPHENOL	61.4	UG/L
LTUDIS	LTUDIS050216	5/2/2016	PENTACHLOROPHENOL	975	UG/L
LTUDIS	LTUDIS080816	8/8/2016	PENTACHLOROPHENOL	16.7	UG/L
LTUDIS	LTUDIS080816	8/8/2016	PENTACHLOROPHENOL	17.4	UG/L
LTUDIS	LTUDIS080317	8/3/2017	PENTACHLOROPHENOL	21.6	UG/L

ASSUMPTIONS

Input	Value	Unit	Source
Precipitation	12	inches per year	This value is based on the 30-year period of record from 1981 to 2010 (www.usclimatedata.com).
Precipitation	1	foot per year	
Area of previously offloaded soil south of Interstate 15/90	`	square feet	Calculated from offloaded areas shown in Figure 1B. Assume an approximately square shape for calculating the area perpendicular to groundwater flow. This shape yields a conservative estimate of the clean groundwater flowing into the south area.
Aquifer thickness	22	feet	Average site value based on remedial investigation report (Atalantic Richfield Company [ARCO] 1993; page 1-23).
Groundwater Recharge (assume 10 percent)	1	inch per year	Assumed value based upon professional judgement and physical properties of site.
Groundwater Recharge (assume 10 percent)	0.083	foot per year	
Hydraulic conductivity	100	feet per day	Value based upon various sources and the remedial investigation (ARCO 1993), see attachment 2 in Tetra Tech 2016a for a full discussion on the rationale.
Hydraulic gradient	0.005	unit less	Value based upon remedial investigation (ARCO 1993; pages 3-12) and annual monitoring (Tetra Tech 2016b).
Leachate concentration (minimum)	20	micrograms per liter	Approximate minimum concentration of PCP measured in retention pond discharge. Concentration on 8/3/2017 was 21.6 micrograms per liter.
Leachate concentration (median)	2,000	micrograms per liter	Approximate median concentration of PCP measured in retention pond discharge. Calculated as the median from the minimum and maximum concentrations.
Leachate concentration (maximum)	4,350	micrograms per liter	Approximate maximum concentration of PCP measured in retention pond discharge. Concentration on 5/2/2011 was 4,350 micrograms per liter.
Minimum Mass of PCP under Interstate 15/90	6,700	pounds	Tetra Tech 2013. Feasibility Level Analysis for In Situ Treatment Beneath Interstate 15/90. Page 4.
Median Mass of PCP under Interstate 15/90	10,000	pounds	Tetra Tech 2013. Feasibility Level Analysis for In Situ Treatment Beneath Interstate 15/90. Page 4.
Maximum Mass of PCP under Interstate 15/90	13,400	pounds	Tetra Tech 2013. Feasibility Level Analysis for In Situ Treatment Beneath Interstate 15/90. Page 4.

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EXHIBIT 6
MIXING MODEL

TETRA TECH