APPENDIX B - Interim Compliance Monitoring Plan

US Magnesium
Groundwater Discharge Permit Application
Interim Compliance Monitoring Plan

June 6, 2018

Prepared for:

US Magnesium LLC

Prepared by:

Stantec Consulting Services, Inc.

Sign-off Sheet

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1.0 INTRODUCTION AND PURPOSE

The US Magnesium facility (Facility) processing plant produces a low-pH wastewater stream that is currently conveyed to unlined evaporation ponds, the Current Waste Pond (CWP) receives approximately 1100 gallons per minute (gpm) of process plant wastewater which overflows eastward into the Old Waste Pond (OWP) (refer to site map shown in **Figure 1**). An expanded and retrofitted wastewater evaporation pond (Retrofitted Waste Pond [RWP]) utilizing vertical hydraulic barrier wall technology is proposed for the Facility to meet requirements outlined in Utah Administrative Code R317-6.

This document has been created in response to comments and discussions with the Utah Department of Environmental Quality (UDEQ) Division of Water Quality (DWQ), United States Environmental Protection Agency (USEPA), and US Magnesium on the Groundwater Discharge Permit (GWDP) application submitted to DWQ on December 15, 2017. The purpose of this document is to present an interim groundwater monitoring program for the Facility to be implemented prior to RWP construction.

2.0 FACILITY WASTEWATER TRACERS

Selection of appropriate parameters that will reliably indicate potential migration of Facility wastewater into groundwater surrounding the future hydraulic barrier wall is key to the compliance monitoring program. Considering the unique wastewater and groundwater (high total dissolved solids [TDS]) at the US Magnesium site, the most effective Facility wastewater tracers for groundwater and surface water should meet the following criteria:

- Exhibit distinctive signatures between Facility wastewater and native groundwater
- Be chemically conservative while being transported in groundwater (i.e. amount of measured tracer is not lost or added to groundwater via interaction with aquifer matrix)
- Have no other sources in the system, other than plant wastewater and native groundwater
- Can be detected analytically at low concentrations in a high total dissolved solids TDS matrix.

In addition to utilization of paired piezometers to monitor hydraulic effectiveness of the proposed groundwater hydraulic barrier wall, the December 13, 2017 groundwater discharge permit application (GWDP) proposed use of chemical tracers to indicate migration of Facility wastewater beyond the proposed barrier wall. Major ions (chloride, sulfate, calcium, sodium, potassium, and bicarbonate) were not considered during this initial phase due to their high natural concentrations in native groundwater adjacent to Great Salt Lake. However, seven metals were proposed as groundwater compliance analytes because they have been found at elevated concentrations in the Facility wastewater stream compared to downgradient groundwater at locations where, based on available information, groundwater has not been impacted by Facility wastewater (i.e., at piezometer PZ-6, and surface water sampling location HBD shown on **Figure 2**). Following discussions with UDEQ DWQ, and further evaluation by US Magnesium and Stantec, the unique characteristics of the site groundwater indicate these proposed analytes (i.e., seven metals) would not be effective Facility wastewater tracers.

Groundwater at the US Magnesium site is classified as Class IV groundwater according to UDEQ standards, with total dissolved solids (TDS) concentrations ranging from 29,000 mg/L on the west side to 300,000 mg/L at the eastern edge of the Old Waste Pond (OWP) adjacent to Great Salt Lake. The neutral to basic pH of native groundwater at the site makes use of the proposed metals problematic as they are not chemically conservative in the subsurface. During subsurface migration from the plant to downgradient locations, the metals derived from the wastewater are likely to undergo sorption, desorption, and ion exchange reactions along the migration path,

potentially altering their chemical mass during transport. In addition, mineral dissolution and precipitation may also change the chemical mass in the groundwater during transport.

Another site-specific challenge is the analytical uncertainty which results from the high TDS nature of the site waters. High dilution required to successfully analyze samples increases uncertainty in analytical results of major ions and metals, resulting in greater uncertainty when comparing samples through time and thus the ability to identify potential migration of wastewater to subsurface locations. In response to these factors, US Magnesium proposes using a set of organic constituents as interim compliance parameters, while simultaneously carrying out a proof-of-concept/feasibility study of the practicability of using stable isotopes as compliance parameters as outlined in the *Isotope Study Work Plan* (Stantec, 2018)

3.0 INTERIM GROUNDWATER COMPLIANCE MONITORING NETWORK

The US Magnesium site has an extensive network of monitoring wells and piezometers that, along with surface water monitoring locations, offer suitable coverage to detect current impacts and migration of Facility wastewater in groundwater prior to and during construction of the proposed barrier wall. A successful monitoring program will identify wastewater impacted groundwater that has migrated laterally beyond the CWP/OWP embankments, or vertically across the deeper silty clay unit to the underlying lower aquifer zone.

For the interim period between initial permit issuance and hydraulic barrier wall construction, US Magnesium proposes the use of six (6) shallow compliance wells, located downgradient of the proposed barrier wall, and 3 deep compliance wells located along the CWP/OWP divide and at downgradient locations (See **Table 3-1** and **Figure 2**). In order to document the signature of the wastewater, which may change due to changes in US Magnesium process and mingling with previously infiltrated wastewater, US Magnesium proposes collection of six surface water samples, one collected at the outlet of the main wastewater discharge ditch and three collected from the ponds (**Figure 2**). US Magnesium also proposes collection of surface water samples from the hydraulic barrier ditch (HBD) on the north side of the OWP embankment and the section of the Skull Valley Diversion Ditch (SVDD) on the east side of the OWP embankment (**Figure 2**).

Table 3-1: Proposed Locations for Routine Compliance Sampling

Locations	Number of Samples
Surface Water Locations	
Main Wastewater Discharge Ditch	1
Waste pond samples (two in CWP one in OWP)	3
Surface water locations downgradient of OWP (HBD & SVDD)	2
Groundwater Locations	
Shallow Compliance Wells (above Silty Clay Unit): PZ-5, PZ-6, PZ-7, MW-11	4
Deep Compliance Wells (below Silty Clay Unit): MW-21, MW-22B, MW-23, MW-9, MW-10	5
Total Number of Samples	**15**

4.0 INTERIM COMPLIANCE MONITORING OF ORGANIC WASTEWATER TRACERS

The following baseline compliance monitoring plan has been designed to meet requirements outlined in Utah Administrative Code R317-6. Baseline and ongoing monitoring of organic wastewater tracers is proposed.

4.1 ORGANIC WASTEWATER TRACERS

Given the characteristics presented in Section 2.0 for effective groundwater tracers at the site, US Magnesium has identified five organic constituents as Facility wastewater tracers (**Table 4-1).**

Table 4-1: Proposed Organic Wastewater Tracers

Constituent	Molar Mass[(a)] (grams/mol)	Solubility at 25°C (mg/L)[(a)]	log K_{ow}[(a)]
Trichloroacetic Acid	163.38	54,000	1.33
Bromoform	252.73	3,100	2.40
Chloroform	119.4	7,950	1.97
Dibromochloromethane	208.3	2,700	2.16
Bromodichloromethane	163.8	3,968[(b)]	2.00

(a)- Properties from pubchem.ncbi.nlm.nih.gov

(b) At 30 degrees Celsius

°C – degrees Celsius

Kow – octanol/water partition coefficient

mg/L – milligrams per liter

Surface and groundwater samples across the CWP/OWP area were collected and analyzed for these organic constituents in February 2014, as shown on **Figure 3**. These organic wastewater tracers are well suited as wastewater tracers due to:

- Their high solubility in water (>1,000 mg/L) and relatively low octanol/water partition coefficients (K_{ow}) (<4) values indicate they are likely to stay in solution and not sorb to the aquifer matrix during subsurface migration (See **Table 4-1**).
- Distinct concentrations in wastewater versus unimpacted groundwater, as shown in **Figure 3.** These organic parameters have not been detected in downgradient surface water and groundwater locations (PRI-7-001, MW-10, PZ-6), and they have not been detected in wells completed below the deeper silty clay unit (MW-21, MW-22B, MW-23, MW-9, and MW-10); however, they have been detected in evaporation pond waters and some shallow groundwater monitoring wells (i.e., PRI7-007, PRI5-002, PZ-8, PZ-12).
- Analyses for the proposed organic wastewater tracers are not affected by site water matrix (high TDS, low pH). (Analyses of major ions and metals analyses are affected by high TDS and low pH).

However, a future change in wastewater chemistry is expected after a planned wastewater treatment plant is installed. A large reduction in halogenated organic compounds in the Facility wastewater will result, which will make organic compound tracers less useful and more difficult to interpret over time. Stable isotopes may eventually be used as compliance monitoring parameters. To evaluate the potential usefulness of monitoring stable isotopes to detect wastewater-impacted waters, an initial isotope study is proposed in the *Isotope Study Plan* (Stantec, 2018).

4.2 GROUNDWATER SAMPLING PLAN

The initial compliance sampling round will include analyses for a full suite of organic and inorganic constituents for sample locations not previously analyzed for the full suite of analytes, and will include those analytes required for the US Magnesium's Remedial Investigation (RI) *OWP/CWP Area Hydrologic Conceptual Site Model* sampling event conducted in February 2014 (ERM, 2016). After one set of full-suite analytes is obtained for the sample locations not previously analyzed for the full suite, groundwater samples will be collected and analyzed for the five organic tracers listed in **Table 4-1** at proposed sampling locations shown in **Figure 2**. Once a total of eight (8) sampling rounds have been completed at each compliance groundwater location, statistical methods may be used to establish baseline conditions and groundwater protection levels for each compliance well will be proposed.

4.2.1 Groundwater Sampling Locations

US Magnesium proposes sampling at nine (9) groundwater monitoring wells, four (4) wells screened in the upper aquifer zone (above the Deeper Silty Clay Unit) and five (5) wells screened below the Deeper Silty Clay Unit (**Table 4-2** and **Figure 2**). These monitoring points are located horizontally downgradient of the proposed RWP boundary or beneath the Deeper Silty Clay Unit within the footprint of the RWP (i.e., MW-21, MW-22, and MW-23) , wherein the barrier wall acts as a lateral boundary and the Deeper Silty Clay Unit acts as a vertical boundary.

Table 4-2: Proposed Interim Compliance Groundwater Sampling Locations

Well ID	Ground Surface (feet amsl)	Top of Casing (feet bgs)	Easting (feet)	Northing (feet)	Screen Interval (feet bgs)	Number of Prior Samples Collected	Number of Samples Remaining to Establish Baseline Conditions
PZ-5	4211.00	4214.46	1303806.869	7512000.959	3.5 – 13.5	0	8
PZ-6	4210.54	4214.22	1307692.164	7512137.538	3.5 – 13.5	1	7
PZ-7	4205.36	4212.33	1307696.183	7508202.891	3.5 – 13.5	0	8
MW-9	4211.29	4213.87	1303819.642	7512001.016	59 – 69	1	7
MW-10	4210.61	4213.20	1307700.25	7512136.867	68 – 78	1	7
MW-11	4204.02	4206.75	1308131.727	7512468.79	3.0– 13	0	8
MW-21	4215.50	4218.18	1302061.29	7508971.65	50 – 60	1	7
MW-22B	4215.68	4218.15	1303132.68	7507914.81	54 – 64	1	7
MW-23	4216.98	4219.58	1305159.33	7506505.51	56.1 – 66.1	1	7

amsl – above mean sea level
bgs – below ground surface

4.2.2 Groundwater Sampling Methods

4.2.2.1. Methods. Groundwater samples will be collected utilizing low-flow techniques as described in Standard Operating Procedure (SOP) 7 (Stantec, 2018). (Referenced SOPs are the same as those previously approved by USEPA in May 2017 for the *Field Data Collection Work Plan* [Stantec, 2017]). Groundwater levels will be recorded prior to the start of sampling as described in SOP-7.

4.2.2.2. Field Parameters. Water quality parameters will be measured in the field and recorded prior to collection of groundwater samples as described in SOP-7 (Stantec, 2018a). These field-measured parameters will include:

- Temperature
- pH

- Specific conductivity
- Dissolved oxygen
- Oxygen reduction potential (ORP)
- Turbidity
- Field chlorine.

ORP data will be used to calculate eH values utilizing the electrode solution based conversion per USEPA procedures (USEPA, 2017).

4.2.2.3. Laboratory Analytes. Groundwater samples collected from locations that have not previously been sampled and analyzed for the full suite of analytes (see **Table 4-2**) will be analyzed for the same full suite of analytes as analyzed for the February 2014 sampling event (ERM, 2016). These analytes are listed below in **Table 4-3**. Once all wells have had one sample analyzed for a full suite of analytes, groundwater samples will be analyzed for the five organic compliance parameters listed in **Table 4-4**, as well as field parameters listed above.

Table 4-3: Full Suite Analytes and Analytical Methods

Analyte	Method
Alkalinity, Total as $CaCO_3$	EPA 310.1/SM2320B
Total & Dissolved Metals (Ca, Mg, K, Na, Al, Sb, As, Ba, Be, Cd, Cr, Co, Cu, Fe, Pb, Mn, Mo, Ni, Se, Ag, Tl, V, Zn)	EPA 6010 ICP
Total & Dissolved Mercury	7470 CVAA
Anions (Br, Cl, F, Nitrate as N, Nitrite as N, Phosphate as P, Sulfate)	EPA 300.0
Hexavalent Chromium	EPA 218.6 LL
Perchlorate	EPA 6850
Total Dissolved Solids	EPA 160/SM2540C
Total Cyanide	SW9012B
Volatile Organic Compounds (VOCs)	EPA 8260
Semi-Volatile Organic Compounds (SVOCs)	EPA 8260
Benzo(k)fluoranthene	EPA SW8270C SIM
Total Organic Solids	EPA SW9060
Oil & Grease	EPA E1664
Benzaldehyde	EPA 8315
Specific Gravity	SM 2710
Haloacetic Acids	EPA 552.3
Dioxins/Furans Conogers	EPA Method 1613B/E1668/8290
Biphenyls	EPA Method 1668A

Table 4-4: Interim Compliance Analytes and Analytical Methods

Analyte	Method
Trichloroacetic Acid	EPA 552.3
Bromoform	EPA 8260
Chloroform	EPA 8260
Dibromochloromethane	EPA 8260
Bromodichloromethane	EPA 8260

4.2.3 Groundwater Sampling Frequency

Groundwater samples will be collected three times a year (spring, summer, and fall) at locations described in **Section 4.2.1** until a total of eight (8) rounds of laboratory and field parameter measurements are collected for each location. US Magnesium plans to begin sampling in fall 2018, and expects to complete all baseline groundwater quality sampling in summer of 2021. Following completion of baseline sampling, groundwater compliance limits will be determined through discussions between US Magnesium and the DWQ.

4.3 SURFACE WATER SAMPLING PLAN

Surface water samples will be collected coincident with groundwater sampling events at the locations identified at proposed sampling locations until a total of eight (8) samples have been acquired at each groundwater monitoring location.

4.3.1 Surface Water Sampling Locations

US Magnesium will collect surface water samples from six locations as indicated in **Figure 2** and **Table 4-5**. Surface water sampling includes collection of 4 samples of wastewater and surface water from two surface compliance locations (HBD and SVDD). The purpose of the surface water sampling is to document potential changes in wastewater composition due to changes in US Magnesium processes, and to ensure wastewater is not migrating to the adjacent HBD/SVDD.

Table 4-5: Proposed Surface Water Locations for Interim Compliance Sampling

Surface Water Locations	Surface Water ID	Number of Samples
Main Wastewater Discharge Ditch	Main Ditch	1
Three waste pond samples (two in CWP one in OWP)	NWCWP, SWCWP, OWP	3
Two surface water locations downgradient of OWP	HBD, SVDD	2

4.3.2 Surface Water Sampling Methods

Grab samples of the plant effluent water, wastewater pond water and adjacent ditches will be collected to characterize the wastewater and to monitor for the presence of wastewater in the adjacent HBD and SVDD. Surface water sampling will be performed in accordance with SOP-8, which has previously been approved by the USEPA for US Magnesium RI work (Stantec, 2018a). Field parameters will be recorded prior to collection of surface water samples as described in SOP-8 and will include temperature, pH, specific conductivity, dissolved oxygen, oxygen reduction potential (ORP) and turbidity. ORP will be converted to eH utilizing the electrode solution based conversion per USEPA procedures (USEPA, 2017). Surface water samples collected from locations that have not previously been sampled (SVDD and HBD) will be analyzed for the same full suite of analytes as performed for the RI hydrologic conceptual site model (ERM, 2016). These analytes are listed in **Table 4-3**. Once all surface water locations have been analyzed for one full suite of analytes, surface water samples will be analyzed for the five organic compliance parameters listed in **Table 4-4**, as well as field parameters listed above.

4.3.3 Surface Water Sampling Frequency

Surface water samples will be collected semiannually (during fall and spring) at locations described in **Section 4.3.1** until all locations have a total of eight (8) rounds of laboratory and field parameter measurements. US Magnesium plans to begin sampling in fall 2018, and plans to complete all baseline surface water quality sampling by fall 2022.

Following completion of baseline sampling, groundwater compliance limits will be determined through discussions between US Magnesium and the DWQ.

5.0 PHASED ISOTOPE STUDY

Concurrent to the baseline sampling for organic constituents, US Magnesium will perform a study to determine whether stable isotopes of hydrogen and oxygen of the water molecule may be utilized as compliance parameters. Details of the phased isotope study are presented in the *Isotope Study Plan* (Stantec, 2018). The *Isotope Study Plan* describes utilization of stable isotopes as groundwater tracers, expected isotopic fractionation processes at the US Magnesium site and describes a phased study to determine whether stable isotopes are a viable groundwater tracer at the US Magnesium site.

6.0 REFERENCES

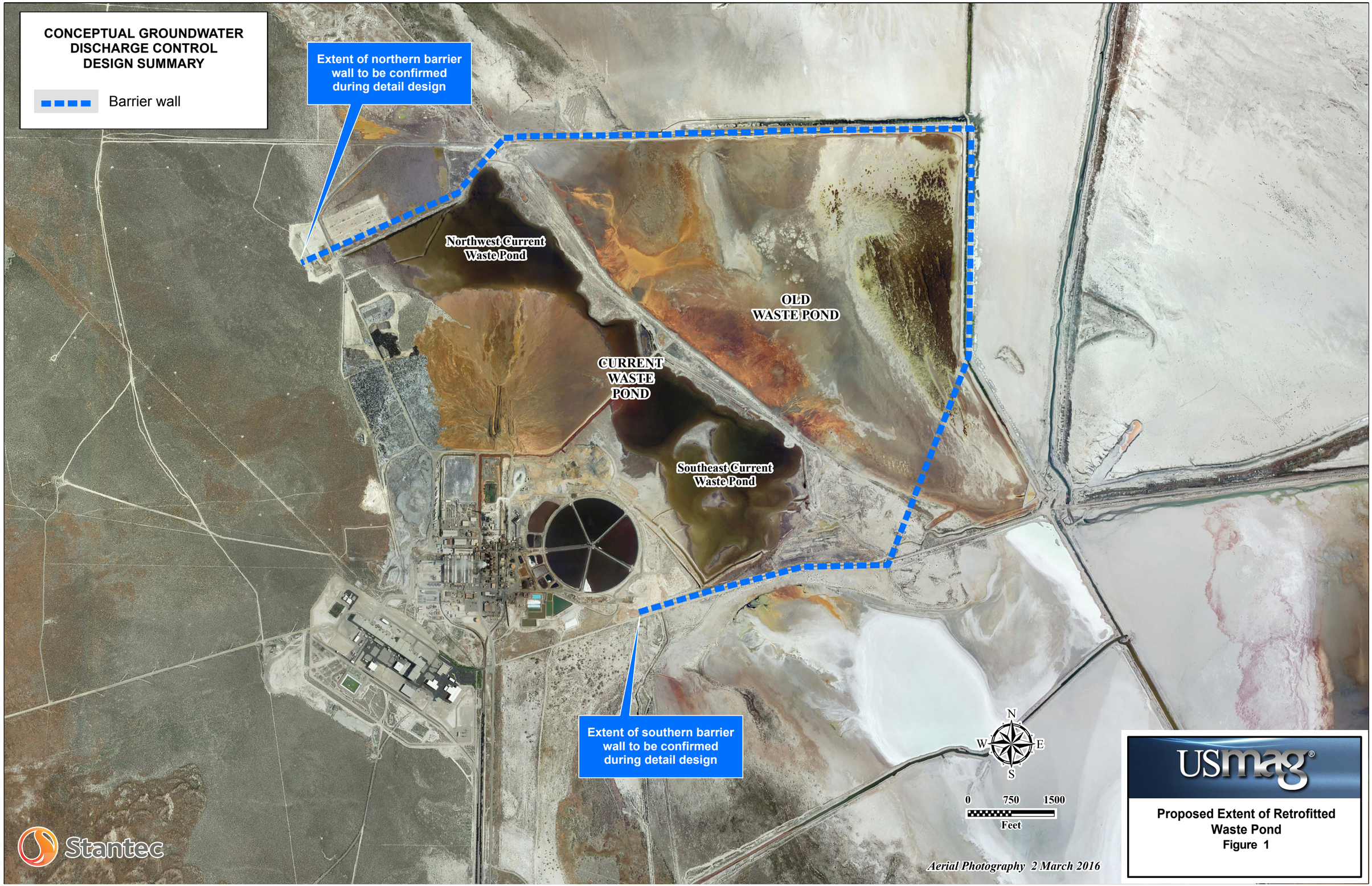
ERM, 2016. *Draft Old Waste Pond/Current Waste Pond Area Hydrologic Conceptual Site Model*, US Magnesium NPL Site, June 2016.

Stantec, 2017. *US Magnesium Groundwater Discharge Permit Application Preparation Field Data Collection Work Plan*. May 2017.

Stantec, 2018. *US Magnesium Groundwater Discharge Permit Isotope Study Plan*. June 2018.

Stantec, 2018a. Groundwater Discharge Permit Application *Standard Operating Procedures for Compliance Monitoring*. June 2018.

USEPA, 2017. *Field Measurement of Oxidation-Reduction Potential* (ORP). U.S. Environmental Protection Agency Region 4, Science and Ecosystem Support Division, April 2017.



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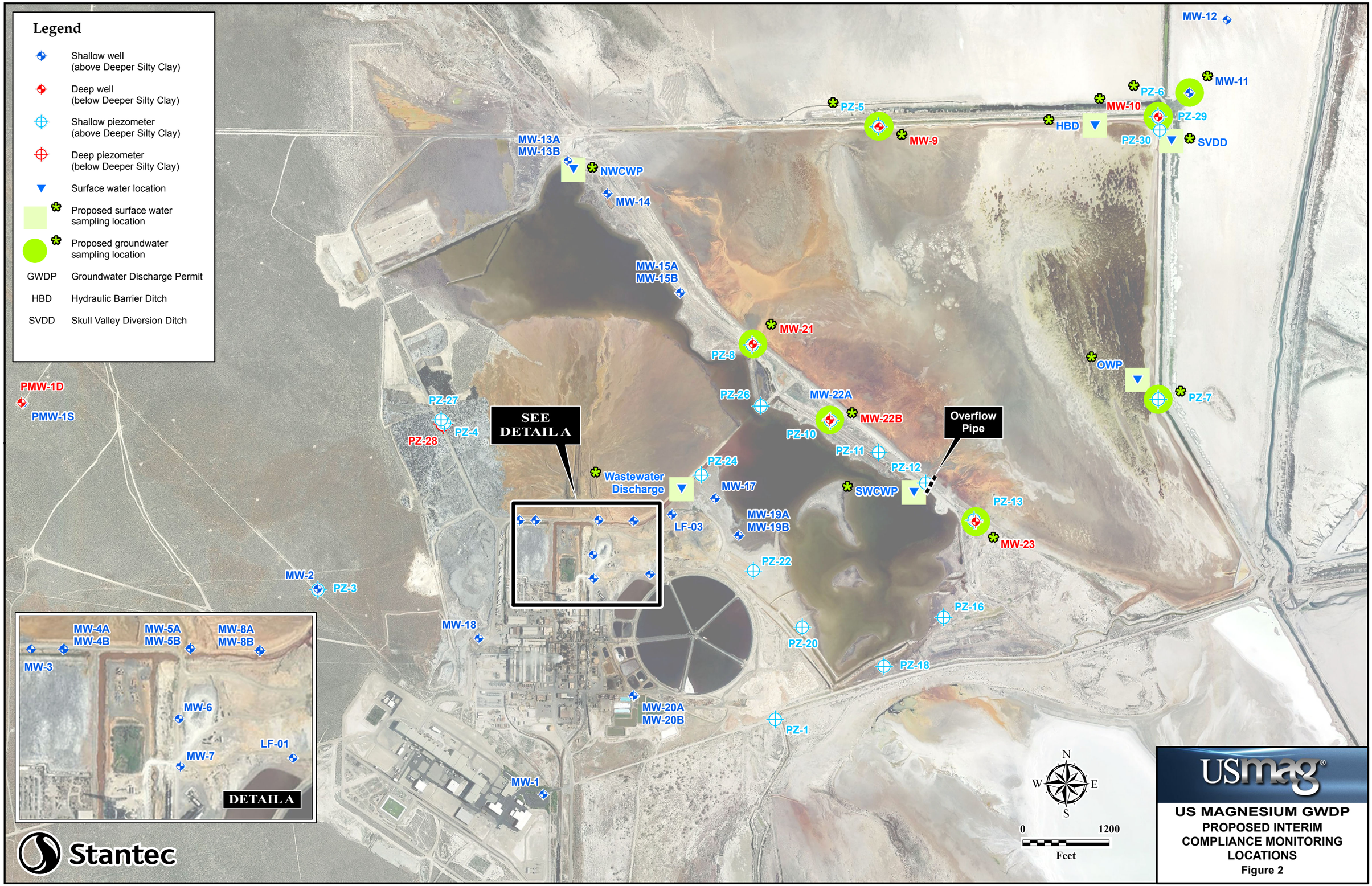
Legend
Shallow well (above Deeper Silty Clay)
Deep well (below Deeper Silty Clay)
Shallow piezometer (above Deeper Silty Clay)
Deep piezometer (below Deeper Silty Clay)
Surface water location
Proposed surface water sampling location
Proposed groundwater sampling location
GWDP Groundwater Discharge Permit
HBD Hydraulic Barrier Ditch
SVDD Skull Valley Diversion Ditch
MW-12
MW-11
PZ-6
MW-10
PZ-29
PZ-5
HBD
MW-9
PZ-30
SVDD
MW-13A
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PROPOSED INTERIM COMPLIANCE MONITORING LOCATIONS
Figure 2
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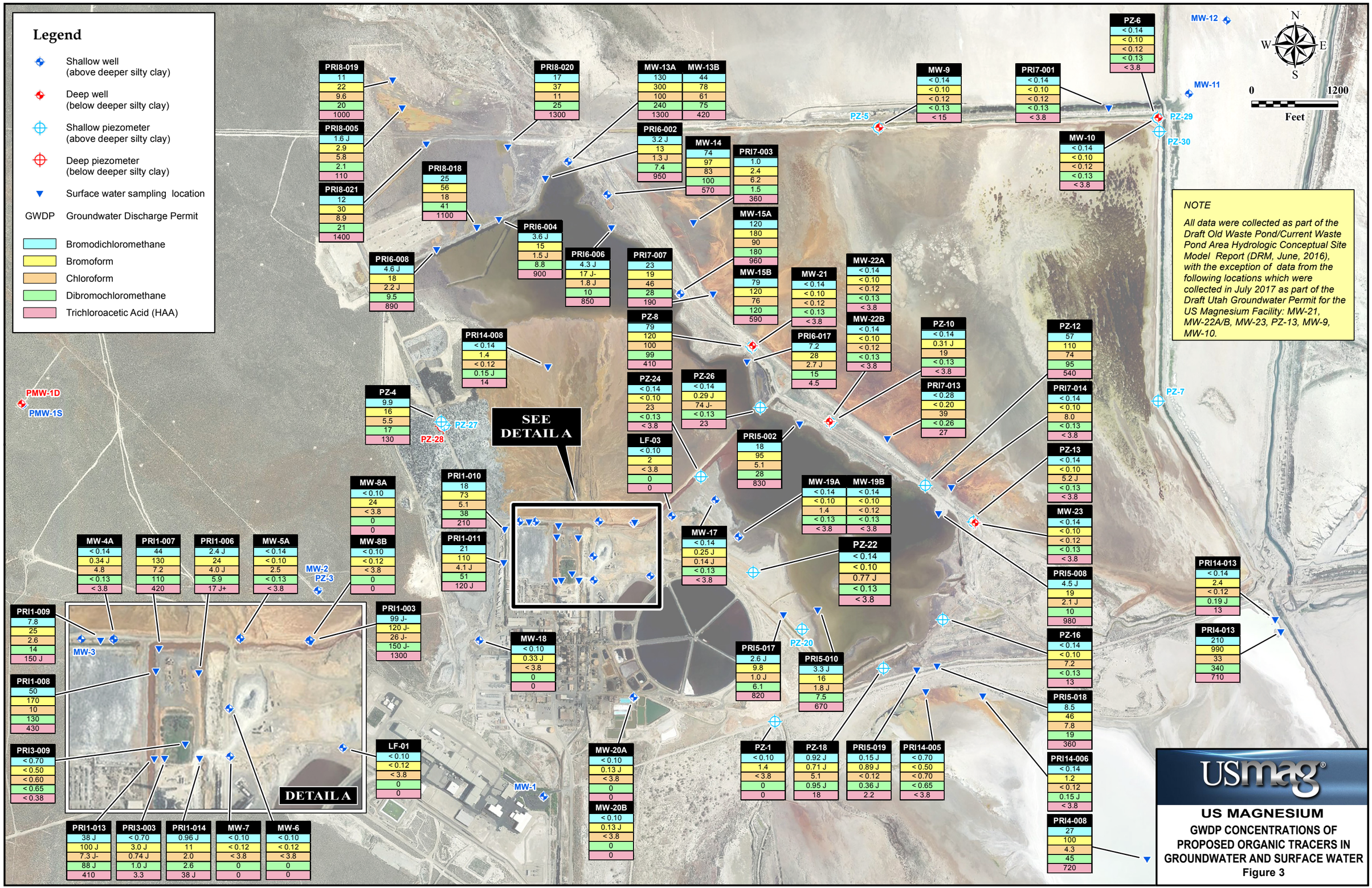

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