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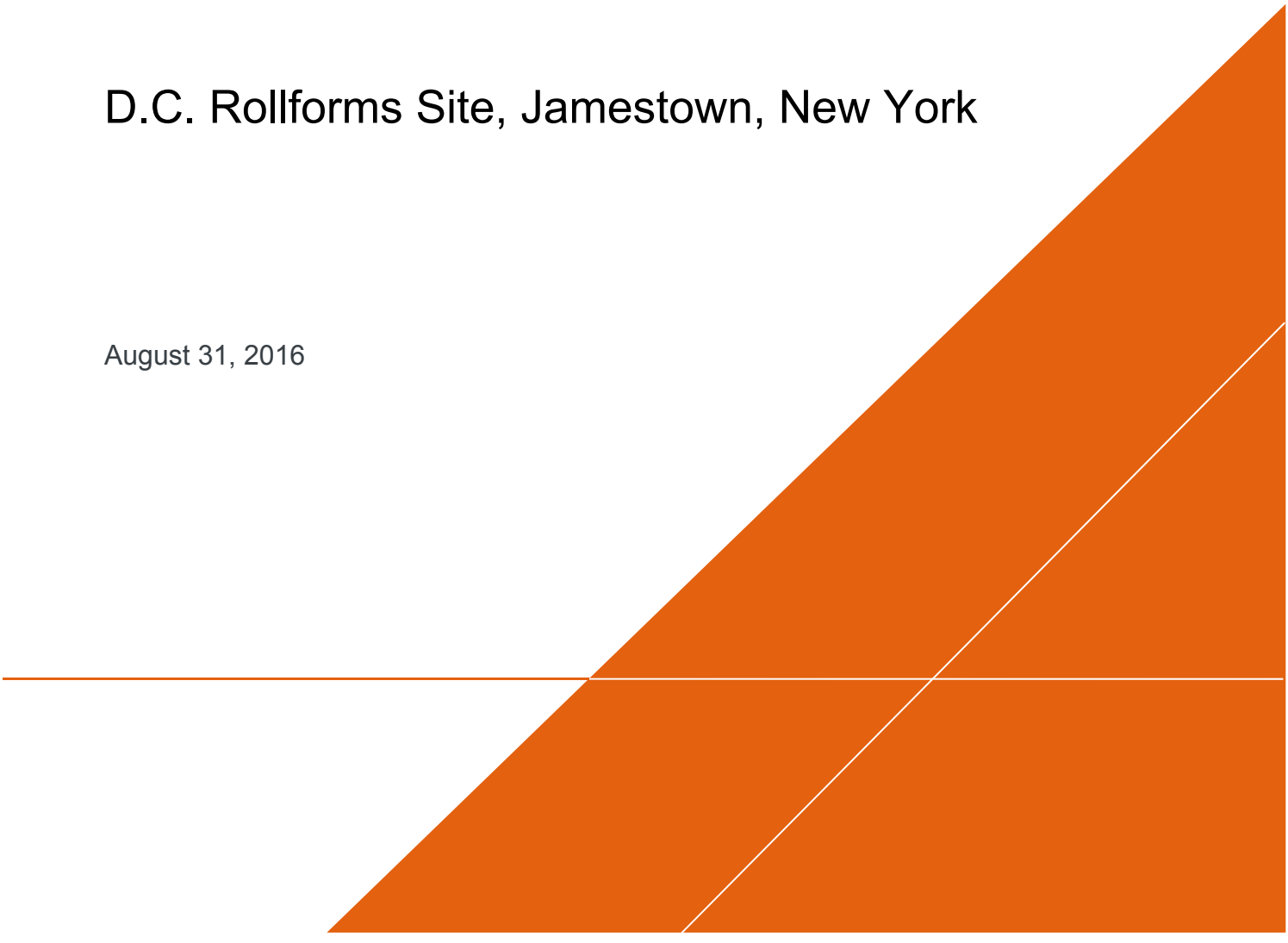
IN-SITU CHEMICAL OXIDATION PILOT TEST WORK PLAN

D.C. Rollforms Site, Jamestown, New York

August 31, 2016



IN-SITU CHEMICAL OXIDATION PILOT TEST WORK PLAN

D.C. Rollforms Site, Jamestown, New York

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ACRONYMS AND ABBREVIATIONS

bgs	Below ground surface
COCs	Chemicals of concern
FS	Feasibility Study
g/L	Grams per liter
HASP	Health and Safety Plan
IRMs	Interim remedial measures
ISCO	In-situ chemical oxidation
NYSDEC	New York State Department of Environmental Conservation
PPE	Personal protective equipment
psi	Pounds per square inch
PVC	Polyvinyl chloride
RI	Remedial Investigation
ROD	Record of Decision
SDS	Safety Data Sheet
TPH	Total petroleum hydrocarbon
VOCs	Volatile organic compounds

1 INTRODUCTION

This In-Situ Chemical Oxidation (ISCO) pilot test work plan (work plan) has been prepared by Arcadis of New York on behalf of Ingersoll Rand Company for the D.C. Rollforms Site (herein referred to as the "site") located in in Jamestown, New York (Figure 1).

In order to enhance remediation of the residual groundwater plume at the site, a pilot-scale ISCO injection approach, utilizing alkaline activated sodium persulfate as the oxidant, will be implemented at the site. Persulfate has been selected as the oxidant, because of its applicability to treat the primary groundwater chemicals of concern (COCs) such as chlorinated volatile organic compounds (VOCs) and total petroleum hydrocarbon (TPH).

This Work Plan presents the methodology, implementation, performance monitoring of the ISCO injection to be conducted at the site and the health and safety requirements related to ISCO injection.

1.1 Project Background

The D.C. Rollforms site is an inactive hazardous waste State Superfund site located in Jamestown, New York. Arcadis has completed the Remedial Investigation (RI) and Feasibility Study (FS) in accordance with the New York State Department of Environmental Conservation (NYSDEC) Consent Order for the RI/FS and has implemented a number of interim remedial measures (IRMs) as part of initiating cleanup of the site. The selected remedy for the site was finalized in the Record of Decision (ROD) during 2003. The ROD finalized the remedy and remedial goals for cleanup of chlorinated VOCs in groundwater, free product recovery, an oil seep along the Chadakoin River and focused removal of sediments. In 2007, Arcadis completed construction of the remedy and is currently operating the groundwater collection and treatment system.

1.2 Project Rationale and Objectives

The ISCO pilot test described in this report will be performed to evaluate a viable remedial alternative to the current pump and treat program to address the source areas onsite, and ultimately reduce the remedial life-cycle costs for the site. ISCO is a proven technology for degrading COCs present at the site. However, the success of the ISCO depends on site specific conditions, such as, natural oxidant demand, subsurface geology, and injectability, etc. Data collected during the pilot test will be utilized for determining whether the technology can be successfully implemented on a full-scale basis. If the results are favorable the pilot test data will be utilized for establishing the design parameters of a full-scale application.

The objective of the ISCO pilot test implementation is to destroy COCs mass in groundwater while gathering information that can be used to improve its effectiveness of a full-scale application if needed. The injection will be conducted utilizing a series of injection wells within the target treatment area (**Figure 2**). The objectives for this pilot-scale ISCO injection are to evaluate:

- injection design parameters such as achievable injection flow rates and safe injection pressures;
- distribution and longevity of the injected persulfate/activator in the targeted injection zones;

- hydraulic properties of the subsurface in the vicinity of the injection area (e.g., migratory porosity, which can be estimated based on the hydraulic responses to injection);
- efficacy of ISCO technology and designed dosing of persulfate/activator on the treatment of groundwater COCs at the site; and,
- recommendations for any contingent actions (e.g., additional injection wells or injection events), additional monitoring, and the potential effect of ISCO activities on ongoing vacuum enhanced pumping system.

The results of the injection and performance monitoring and recommendations for further remedial activities will be documented in a Pilot Test Summary Report following the completion of the performance monitoring period.

1.3 Technology Overview

ISCO is an in-situ remedial technology that can be used to treat soil and groundwater impacted with a wide range of organic constituents. ISCO is achieved by delivering chemical oxidants to contaminated media, such that target constituents are transformed to less toxic compounds and ultimately into carbon dioxide and water, and specifically for oxidation of chlorinated compounds at the site, chloride.

ISCO involves injection of oxidant reagents, such as sodium persulfate (proposed for this pilot test), permanganate, hydrogen peroxide, and ozone, into an aquifer to facilitate treatment. Persulfate is a relatively new (10 years) oxidant to the industry that has considerable longevity in the subsurface, ranging from weeks to months. This stability is due to slower reaction kinetics. When compared to the rapid kinetics of catalyzed hydrogen peroxide and ozone, the use of persulfate allows for a comparatively greater radius of influence when deployed via injections. Persulfate requires activation in order for sulfate and hydroxyl radicals to be produced and improve kinetics. Activators include chelated iron, a base compound, hydrogen peroxide, existing organics and metals at the site (ambient activation) or heat to increase reaction kinetic rates.

The selection of oxidant and activation method and optimal dosing are typically evaluated through a laboratory-based treatability test and verified in the field via pilot-scale injection tests. ISCO injection tests are typically conducted by slightly pressurized injection or by gravity feeding the persulfate solution and activator into the subsurface. Groundwater quality parameters (i.e., specific conductance, pH, and depth to water) and injected oxidant are normally monitored during injection for real-time determination of injection breakthrough in the field. Groundwater COCs and presence of oxidant are also monitored during and after the injection test to evaluate the effectiveness of the ISCO technology and to obtain site-specific design parameters for potential larger scale implementation.

1.4 Implementation Methodology

The ISCO pilot-scale injection will be conducted to enhance remediation of the residual groundwater plume located to the south of the treatment building near monitoring wells MW-8S and MW-14 (Figure 1). Alkaline activated sodium persulfate, as the selected oxidant, will be injected into three injection wells. Based on the results of laboratory treatability, sodium hydroxide and sodium persulfate concentration will be determined. Injection will be conducted simultaneously into multiple injection wells through gravity

feeding, or under slight pressures if practical injection flow rates cannot be achieved through gravity feeding. A pre-injection baseline sampling event and three post injection performance monitoring events will be conducted following the injection to evaluate the efficacy of ISCO approach for addressing residual COCs in groundwater at the site and to obtain the optimized injection parameters, if additional injection activities are warranted.

1.5 Work Plan Organization

The Work Plan is organized in the following sections:

- Section 2 – Health and Safety – The health and safety procedures and personal protection equipment (PPE) requirement related to ISCO injection activities are discussed in this section.

- Section 3 – Well Network – This section describes the different aspects of the injection well installations, waste disposal and well network for injection and performance monitoring.

- Section 4 – ISCO Injection Implementation – This section details ISCO injection activities and injection monitoring.

- Section 5 – Performance Monitoring – This section describes the monitoring program for the evaluation of ISCO performance.

- Section 6 – Reporting – This section presents the report outline and other pertinent information that will be submitted as a deliverable.

- Section 7 – Project Schedule – Project milestones and their respective dates are presented in this section.

2 HEALTH AND SAFETY

The existing site specific Health and Safety Plan (HASP) will be updated to include health and safety requirements related to the ISCO injection activities to be conducted at the site. The Safety Data Sheets (SDS) for sodium persulfate and sodium hydroxide and the ISCO Injection Hazard Analysis Forms for injection of activated sodium persulfate will be added to the HASP. The SDS, and Hazard Analysis Forms have been included in this Work Plan as **Appendices A** and **B,** respectively. The updated HASP will be kept readily available during all on-site activities. During field activities, each day will begin with a health and safety tailgate briefing including all field staff and subcontractors. A summary of ISCO injection specific hazards prevention methods and a list of personal protective equipment (PPE) used for ISCO injection are as follows:

ISCO Hazard Prevention:

- Inhalation: wear full-face respirator while handling sodium persulfate powder during mixing
- Sodium persulfate and sodium hydroxide exposure:
    - wear proper PPE, notably nitrile gloves and a face shield to prevent splashing during mixing and handling

    - assure that all materials/piping/manifolds are chemically compatible with the corrosivity of persulfate (no carbon steel or brass)
- Chemical Test Kit reagent exposure: wear proper PPE
- Excessive heat generated during sodium hydroxide solution mixing: mix solution slowly, add concentrated sodium hydroxide solution into water and avoid adding water into concentrated sodium hydroxide solution
- Spills: utilize secondary containment, absorbent socks, dilution, neutralization
- Leaks: conduct clean (potable) water injection to test piping and connections for leaks prior to ISCO injection
- Fires: store chemicals away from heat, moisture, and combustible materials
- Trip hazards: keep work area clear within tank batch mixing area, near wells/hoses, etc. (watch footing)
- Pinch points and sharp edges: mark pinch points, tape off sharp edges
- Back strain: use proper lifting techniques
- Noise: use ear plugs
- Pressure: use proper tools, fittings, and pressure gauges, wear proper PPE
- Splash: shower/eye wash station for personal decontamination, wear proper PPE

ISCO PPE:

- Tyvek®/Tychem suit with hood
- Goggles and Full Face Shield
- Full face respirator with cartridges for vapor and dust to be changed out every 6 to 8 hours of utilization
- Inner Nitrile gloves and outer cut resistant polyvinyl chloride (PVC)/rubber gloves
- Chemically resistant elbow-length gloves
- Steel-toed boots
- Chemical-resistant overboots slip-ons
- Chemical-resistant apron

3 WELL NETWORK

To target the residual groundwater COCs at the site, an ISCO pilot injection will be performed simultaneously via manifolds at multiple injection wells (Figure 1). Applicable and available injection and monitoring wells construction summary is presented in Table 1. Groundwater monitoring, including baseline sampling, dose-response monitoring and post injection performance monitoring will be conducted in selected monitoring wells (Table 2). The injection and monitoring well network may be revised based on the field observations. The injection and monitoring well network is discussed in detail in this section.

3.1 Injection Well Network

Based on the historic groundwater elevation data, the direction of groundwater flow is in a west-northwesterly direction towards the Chadakoin River. To ensure reagent distribution in the target area, three injection wells (IW-6, IW-7, and IW-8) were installed on June 22, 2016. The wells were screened

above the dense till approximately 5.8 to 14.9 feet below ground surface (bgs) east-southeast (upgradient) of MW-8S, MW-12, MW-13, and MW-14. The spacing between the injection wells is approximately 14 to17 feet. The locations of the injection wells are shown on Figure 1. Three of the inactive injection wells, IW-2 through IW-4, may be utilized for injection if injection rates at the new injection wells are insufficient to injection target volume in a reasonable time.

3.1.1 Utility Clearance

Prior to well installation, Arcadis' Health and Safety protocols require that applicable municipal and private underground utilities will be identified. Existing underground utilities were identified utilizing the following processes:

- Dig Safely New York One-Call was notified
- Reviewed Site record drawings
- Performed visual site inspections
- Hand cleared each boring location to 5 feet vertical depth.

3.1.2 Well Installation

Injection well boreholes were advanced using hollow-stem auger drilling techniques. Each injection well was constructed with 2-inch diameter schedule 40 PVC casing and approximately 6 to 8 feet of 2-inch diameter stainless steel V-wire wrap well screen (0.010-inch slot) set approximately 5.8 to 14.9 feet bgs. The annular space around the well screen was backfilled with #2 filter pack to 1-foot above top of screen, followed by 2-foot of #00N choker sand, and neat Portland cement to the surface. Wells were completed with flush-mount well covers set inside a concrete pad and secured with a cam-lock fitting. Well construction logs are presented as Appendix A.

3.1.3 Well Development and Baseline Sampling

Following installation, the injection wells were developed on June 29, 2016 by surging and pumping to remove the fine sediments entrained during well installation and to consolidate the sand pack around the screened interval. A surge block and submersible pump was utilized to develop each well. During well development, grab groundwater sample(s) were collected and field-screened for total nephelometric turbidity units (NTUs). Well development was conducted for approximately two hours, or until turbidity is reduced to 50 NTUs, or less, as deemed practicable. During well development, sustained extraction rates (maximum extraction rate without drying out the well) were determined and recorded. The sustained extraction rates data will be utilized for estimating likely injection rates.

Following well development and required equilibration period with the surrounding aquifer, the injection wells will be sampled for VOCs, and sodium in accordance with the site specific sampling protocol. During sampling field parameters (pH, specific conductance, dissolved oxygen, oxidation reduction potential, and temperature), depth to water, and background sodium persulfate concentrations (if any) will be recorded. The injection well baseline data may be useful for defining extend of VOCs in the target location. Additionally, monitoring wells MW-8S, MW-12, MW-13, MW-14, ESI-7, OW-5, and OW-6 will be sampled

for baseline sodium data. Baseline field parameters and persulfate data will be collected for monitoring wells ESI-7, OW-5, OW-6, RW-1, RW-2, RW-3, and VEP-1 through VEP-5.

3.1.4 Well Installation Derived Waste Disposal

The soil cuttings from the injection well installation were containerized in labeled 55-gallon steel drums and staged onsite will be characterized for off-site disposal. The development water was placed in labeled 55-gallon steel drums and will be treated onsite with the groundwater collection and treatment system.

3.2 Monitoring Well Network

Within the target treatment area, VOC-impact is persistent primarily near monitoring wells MW-8S, MW-12, MW-13, and MW-14 in the overburden matrix over the dense till. The groundwater gradient is to the west-northwesterly direction. During and following ISCO solution injection monitoring wells MW-8S, MW-12, MW-13, and MW-14 will be monitored to evaluate the performance of the ISCO pilot test. To assess the extent of downgrading migration of ISCO solution monitoring wells ESI-7, OW-5, OW-6, RW-1, RW-2, RW-3, and VEP-1 through VEP-5 will be monitored. The monitoring plan is presented in Table 2.

4 ISCO INJECTION IMPLEMENTATION

The following sections describe the details of the injection program, including components of injection system, injection solution composition and volume, injection procedure, and monitoring during ISCO implementation. During ISCO injection event, applicable duel phase extraction wells (VEP-1, VEP-2, and VEP-3) located near ISCO injection area will be isolated from the existing treatment system to prevent the extraction of ISCO solution. If needed the treatment system operation may be stopped temporarily.

4.1 Injection Setup

An injection system piping and instrumentation diagram (P&ID) is presented on Figure 2 and summarized in this section. The injection system will consist of solution mixing tanks (for sodium persulfate and sodium hydroxide), pumps for solution mixing/injection, and water transferring from the existing underground storage tank (UST) to mixing tanks, manifold for solution distribution, flow totalizer, pressure indicator, flexible hose, and well head fittings. Injection solution will be distributed via aboveground hose to the injection wellheads. The well head fittings will consist of a pressure gauge and a vent port. The parts and components of equipment and supplies that will be in contact with injection solution will be made of materials chemically compatible with sodium persulfate and sodium hydroxide.

Secondary containment will be used to prevent potential minor leaks and spills of the injection solution from the tank and the manifold from getting to the ground surface. The solution mixing tanks, mixing and injection pumps, and solution distribution manifold with flow totalizers and flow control gate valves will be placed inside the secondary containment. The secondary containment will be required to have at least 110% of a volumetric capacity standard set by the USEPA. Unused sodium persulfate and sodium hydroxide will be stored inside a lockable fenced area near the injection system. Injection pumps are compressor driven diaphragm pumps. A portable generator will be utilized to drive the compressor. The

electrical power extension cord (with a ground fault circuit interrupter), compressed air hose, and injection hose will be arranged appropriately to prevent potential tripping and electrical hazards.

4.2 Injection Reagent and Solution

Injection solution will be prepared using groundwater treated by existing onsite treatment system. If the treatment system is not in operation or volume of treated water is not sufficient for injection solution preparation, clean water from a local water vendor may be used. The clean water will be temporarily stored in a storage tank prior to being pumped to the injection solution mixing tanks. The injection solution will be prepared in 250- or 500-gallon tanks placed in the secondary containment.

For the pilot test, sodium persulfate will be used as the ISCO oxidant. Sodium persulfate concentration and the type and concentration of activator will be determined through the bench test. However, for this Work Plan, it is assumed that 40 grams per liter (g/L) of persulfate activated with 3 to 1 molar ratio of sodium hydroxide to sodium persulfate will be used for preparing the injection solution. The injection solution will be prepared in small batches by mixing sodium persulfate and sodium hydroxide with water. The solution will be prepared in batches on an as-needed basis to eliminate or reduce potential leftover solution at the end of each injection day. To achieve a radius of influence (ROI) of 10 feet, approximately 1,200 gallons of injection solution is estimated to be required per injection well. This estimated volume is based on the assumed 5% mobile porosity of the overburden matrix. Based on the total injection volume of 3,600 gallons and 40 g/L of sodium persulfate activated with 3 to 1 molar ratio of sodium hydroxide to sodium persulfate in the injection solution, an approximate 1,200 pounds of sodium persulfate and approximately 600 pounds of sodium hydroxide (dry basis) will be needed. The actual injection volume required to achieve adequate distribution of reagents is contingent upon field observations.

4.3 Field Implementation

Prior to the injection of mixed solution, a clean (potable) water injection will be conducted to test the injection system for any potential leaks in the piping configuration. In the case of leaking occurs, the leaks will be fixed prior to the start of reagent injection.

Injection solutions of sodium persulfate and sodium hydroxide will be either gravity fed or pumped at low pressure (<1 pounds per square inch [psi]) into the injection wells. A recirculation line may be setup to direct solution back to the mixing tank to reduce the pressure applied to well heads. Upon alkaline activation, the mixture of concentrated sodium hydroxide and sodium persulfate may generate heat and/or gas. Though it anticipated that mixed reagent will not be detrimental for injection process, Arcadis field crew will be vigilant about the injection process conditions (injection flow rate, injection pressure, and cumulative volume injected). The alkaline activated persulfate solution will be distributed to the injection wellhead of each injection well via aboveground manifold and hoses. Each injection leg of the manifold will be equipped with a flow totalizer to record volume injected at each injection well and a flow control valve to control the flow rate and to achieve an even distribution of the injection solution in each of the injection locations. A hazard analysis from for ISCO injection of alkaline activated sodium persulfate is included in Appendix B, which describes work steps, potential hazards, and critical actions for hazard prevention associated with each steps.

Based on Arcadis' experience with injection into similar formations, an injection flow rate of approximately 1 gallon per minute (gpm) is anticipated. If the actual injection rate is significantly less than 1 gpm, unmanned overnight injection may be performed under gravity flow to complete the injection event within the anticipated one week timeframe. Once the injection is completed approximately 5 to 10 gallons of water will be injection into each wells to rinse the injection components and then the injection system will be depressurized by opening the vent valves. The well head assembly will be disconnected from the well and placed over a 5-gallon bucket. The shut-off valve on the assembly will then be opened to drain the hose into the bucket. While one field staff is holding and securing the bucket, the other will walk slowly from the manifold toward the well head and lift the section of hoses while walking to move/push the residual solution in the hose into the bucket. The drained solution will be poured slowly into the injection wells.

5 PERFORMANCE MONITORING

This section describes the monitoring to be performed during injection activities (process monitoring), including monitoring of injection field parameters, dose response and hydraulic response, and post injection monitoring, including monitoring of field parameters, and sampling for VOCs, sodium, and persulfate from selected wells. The details of the injection monitoring program are provided in Table 2.

5.1 Process Monitoring During Injection

The injection solution flow rates, cumulative injected volumes, and wellhead pressures will be monitored and recorded in an injection log. When injection is conducted under pumping, wellhead pressures will be monitored closely and adjusted as necessary during injection. Injection flow rates and cumulative injected volumes at each individual wells will be monitored with designated flow totalizers, and overall injection flow rates and total injected volume will be recorded and calculated based on the changes of volumes in solution tanks. In addition, mixed reagent quantities, pH, and specific conductance of sodium persulfate and sodium hydroxide solutions will be recorded for every batch. Persulfate concentration of the alkaline activated persulfate solution will be analyzed in selected batches using a field test kit. Solution pH, temperature and conductance will be monitored using an YSI600 or similar portable device.

5.2 Dose-Response Monitoring

Dose-response monitoring will be performed at up to four (4) monitoring wells (MW-8S, MW-12, MW-13, and MW-14) during injection by monitoring of real-time field parameters, specifically specific conductance, pH, temperature, redox potential, and persulfate (using field test kit) at least twice per day. Field parameters and persulfate data will be collected from RW-1, RW-2, RW-3, VEP-1, and VEP-2 once per day, and from ESI-7, OW-5, OW-6, VEP-3, VEP-4, and VEP-5 once the injection is completed.

Sodium persulfate and sodium hydroxide contain inorganic ions that are in correlation to solution salinity and conductance. The higher the concentrations of sodium persulfate and sodium hydroxide, the higher the corresponding conductance. These real-time data will be utilized to evaluate the arrival of injection solution at selected monitoring wells. Breakthrough at a specific well location will be determined when a sample exhibits an increase in persulfate concentration, and/or an increase in pH and specific conductance. The field parameters will be measured using hand held instruments every four hours or at a

frequency sufficient to capture arrival of injection solution. Additionally, hydraulic response will be monitoring by manual gauging of water level at the dose-response monitoring wells.

5.3 Post-Injection Performance Monitoring

Post-injection groundwater monitoring will be performed at monitoring wells surrounding the injection wells to observe the timing and concentration of injected solution arrival and disappearance at each location. Monitoring will include three round of post-injection monitoring events. Monitoring will be performed using a combination of down-hole monitoring and grab sampling. Based on field observations, groundwater samples will be collected for the laboratory analyses of VOCs, and sodium on month-1, month-3 and month-6 following the injection event. Post injection monitoring data will be collected from injection wells IW-6 through IW-8, and monitoring wells ESI-7, OW-5, OW-6, MW-8S, MW-12, MW-13, MW-14, VEP-1, VEP-2, VEP-3, VEP-4, and VEP-5. The details of the post-injection monitoring plan is presented in Table 2.

While the exact timing of the sampling events will be adjusted based on the field screening results, at the selected monitoring wells three rounds of sampling of groundwater will occur for laboratory analysis of VOCs and sodium. It should be noted that the sampling events will be supplemented with the ongoing monitoring program wherever appropriate. A detailed monitoring plan is presented in Table 2.

6 REPORTING

Data collected during the pilot test will be evaluated against the performance objectives and the results will be summarized in an ISCO Pilot Test Summary Report. The report will assess the effectiveness of ISCO, determine basis-of-design parameters for full-scale ISCO implementation, and the potential effect of ISCO activities on ongoing vacuum enhanced pumping system.

7 SCHEDULE

Arcadis anticipates the bench test results will be available in early September 2016 and pilot test will be implemented in October 2016 and conducted over a six month period. Within 60 days of the availability of the post-injection performance monitoring data the ISCO Pilot Test Summary Report will be submitted to the Department for their review.

TABLES

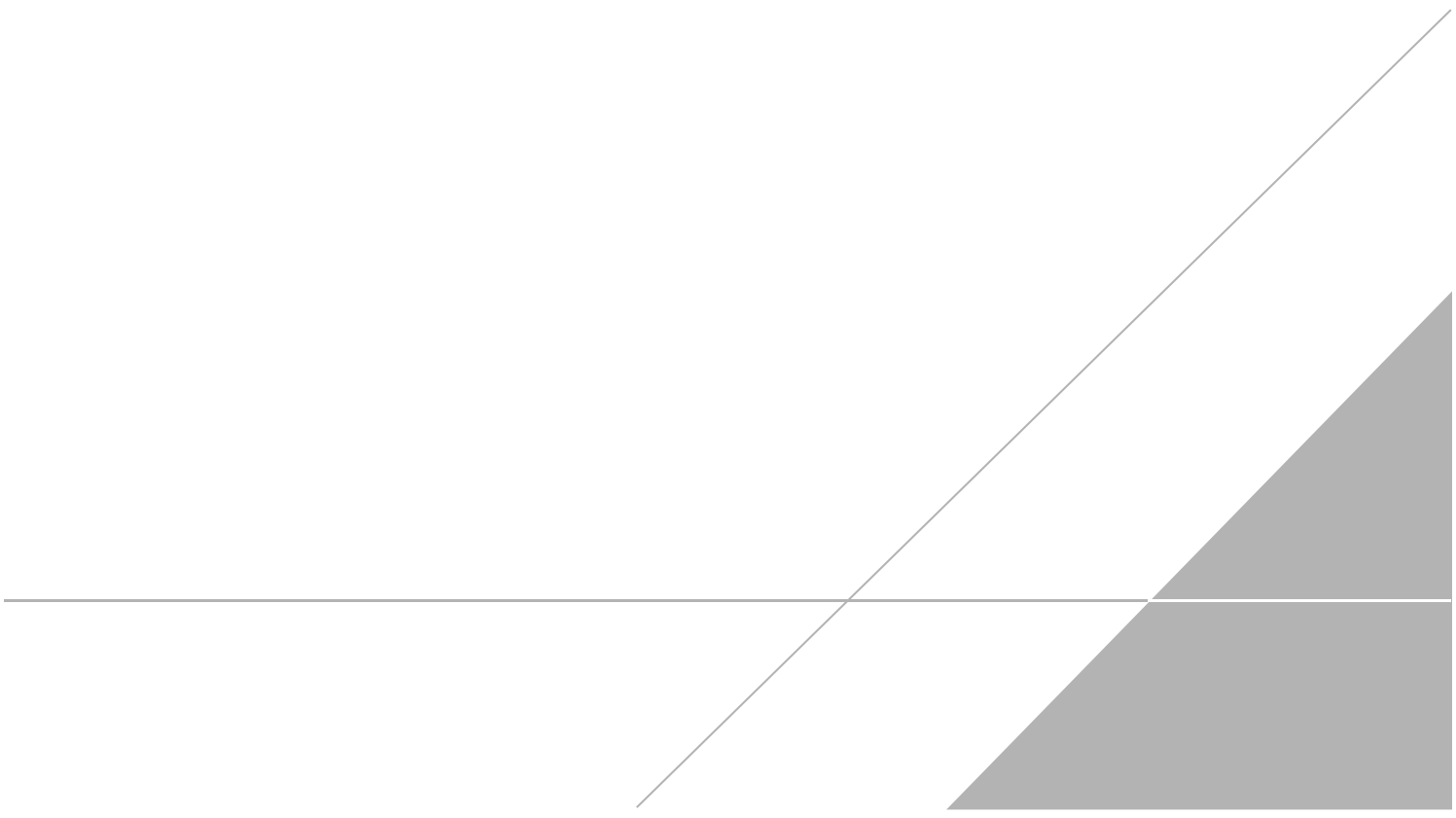

Table 1. Well Construction Details
D.C. Rollforms, Ingersoll Rand, Jamestown, New York.

Well	Well Diameter	Slot Size	Material Type	Screen Depth Interval *	Geologic Unit
*IW-6	2"	0.010"	PVC casing; SS screen	5-15	Fill/Till
*IW-7	2"	0.010"	PVC casing; SS screen	5-15	Fill/Till
*IW-8	2"	0.010"	PVC casing; SS screen	5-15	Fill/Till
ESI-7	2"	0.020"	PVC	5-15	Fill/Till
MW-8S	4"	0.010"	PVC	4-9	Fill
MW-12	4"	0.010"	PVC	5-10	Fill
MW-13	2"	0.010"	PVC	5-10	Fill
MW-14	2"	0.010"	PVC	5-10	Fill
OW-5	2"	0.010"	PVC	3.5-10	Fill
OW-6	2"	0.010"	PVC	3.5-10	Fill
VEP-1	6"	0.020"	PVC	5.5-10.5	Fill
VEP-2	6"	0.020"	PVC	5.5-10.5	Fill
VEP-3	6"	0.020"	PVC	5.5-10.5	Fill
VEP-4	6"	0.020"	PVC	5.5-10.5	Fill
VEP-5	6"	0.020"	PVC	5.5-10.5	Fill

Notes:
* proposed construction details of new injection wells

Table 2. Proposed Monitoring Program[1]
D.C. Rollforms, Ingersoll Rand, Jamestown, New York.

<table>
<tr><th rowspan="2">Well ID</th><th colspan="4">Baseline Monitoring</th><th colspan="3">Injection Performance Monitoring</th><th colspan="4">Post-Injection Performance Monitoring[8]</th></tr>
<tr><th>VOCs[2]</th><th>Metals[3]</th><th>Persulfate[4]</th><th>Field Parameters[5] and DTW[6]</th><th>Persulfate[4]</th><th>Field Parameters[5] and DTW[6]</th><th>Injection Parameters[7]</th><th>VOCs[2]</th><th>Metals[3]</th><th>Persulfate[4]</th><th>Field Parameters[5] and DTW[6]</th></tr>
<tr><td>Injection Solution</td><td>--</td><td>--</td><td>--</td><td>--</td><td>Once per day</td><td>pH and conductivity only for every batch</td><td>--</td><td>--</td><td>--</td><td>--</td><td>--</td></tr>
<tr><td>IW-6</td><td>X</td><td>X</td><td>X</td><td>X</td><td>--</td><td>--</td><td>Every two hours during injction</td><td colspan="2" rowspan="3">Months 3, and 6 following completion of injection</td><td colspan="2" rowspan="3">Months 1, 3, and 6 following completion of injection</td></tr>
<tr><td>IW-7</td><td>X</td><td>X</td><td>X</td><td>X</td><td>--</td><td>--</td><td>Every two hours during injction</td></tr>
<tr><td>IW-8</td><td>X</td><td>X</td><td>X</td><td>X</td><td>--</td><td>--</td><td>Every two hours during injction</td></tr>
<tr><td>MW-8S</td><td>--</td><td>X</td><td>X</td><td>X</td><td colspan="2" rowspan="4">At least twice per day</td><td>--</td><td colspan="4" rowspan="4">Months 1, 3, and 6 following completion of injection</td></tr>
<tr><td>MW-12</td><td>--</td><td>X</td><td>X</td><td>X</td><td>--</td></tr>
<tr><td>MW-13</td><td>--</td><td>X</td><td>X</td><td>X</td><td>--</td></tr>
<tr><td>MW-14</td><td>--</td><td>X</td><td>X</td><td>X</td><td>--</td></tr>
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<tr><td>OW-5</td><td>--</td><td>X</td><td>X</td><td>X</td><td>--</td><td>--</td></tr>
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<tr><td>RW-1</td><td>--</td><td>--</td><td>X</td><td>X</td><td colspan="2" rowspan="5">Once per day</td><td>--</td><td>--</td><td>--</td></tr>
<tr><td>RW-2</td><td>--</td><td>--</td><td>X</td><td>X</td><td>--</td><td>--</td><td>--</td></tr>
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<tr><td>VEP-1</td><td>--</td><td>--</td><td>X</td><td>X</td><td>--</td><td>--</td><td>--</td></tr>
<tr><td>VEP-2</td><td>--</td><td>--</td><td>X</td><td>X</td><td>--</td><td>--</td><td>--</td></tr>
<tr><td>VEP-3</td><td>--</td><td>--</td><td>X</td><td>X</td><td colspan="2" rowspan="3">At the end of Injection</td><td>--</td><td>--</td><td>--</td></tr>
<tr><td>VEP-4</td><td>--</td><td>--</td><td>X</td><td>X</td><td>--</td><td>--</td><td>--</td></tr>
<tr><td>VEP-5</td><td>--</td><td>--</td><td>X</td><td>X</td><td>--</td><td>--</td><td>--</td></tr>
</table>

Notes:
1. Sampling and monitoring locations, parameters and schedule may be adjusted by the leading engineer in the field based on field observation
2. Site specific VOCs
3. Metals analysis will include total sodium analysis
4. Persulfate to be analyzed by commercially available field test kits.
5. Field Parameters include pH, specific conductivity, oxidation reduction potential(ORP), dissolved oxygen, and temperature
6. DTW - depth-to-water, manually gauged with water level meters
7. Injection Parameters include injection flowrate, cumulative injection volume, injection well head pressure
8. Sampling events will be supplemented with the ongoing monitoring program wherever appropriate
-- not applicable

FIGURES

LEGEND

- Monitoring Well
- Recovery Well (passive)
- Injection Well (inactive)
- Observation Well
- Vacuum Enhanced Pumping Well
- VEP Valve Box
- Proposed Injection Well
- Property Line
- Interlocking Sheet Pile/Hydraulic Barrier Wall
- High Water Mark
- Bundled Process Line
- Discharge Line
- Recovery Well Piping
- Vacuum Line
- Overhead Electrical/Telecom Line
- Sanitary Sewer Line
- Bollard Pipe
- Effluent Pipe Clean Out
- Fire Hydrant
- Sewer Manhole
- Utility Pole

NOTE: All locations are approximate.

0 40 80

SCALE IN FEET

PROJECTION: NAD 1983 StatePlane New York West FIPS 3103 Feet

AERIAL SOURCE: ESRI Online Imagery (June 2013).

INGERSOLL RAND - DC ROLLFORMS SITE
NYSDEC SITE NO. 907019, JAMESTOWN, NEW YORK
ISCO PILOT TEST WORK PLAN

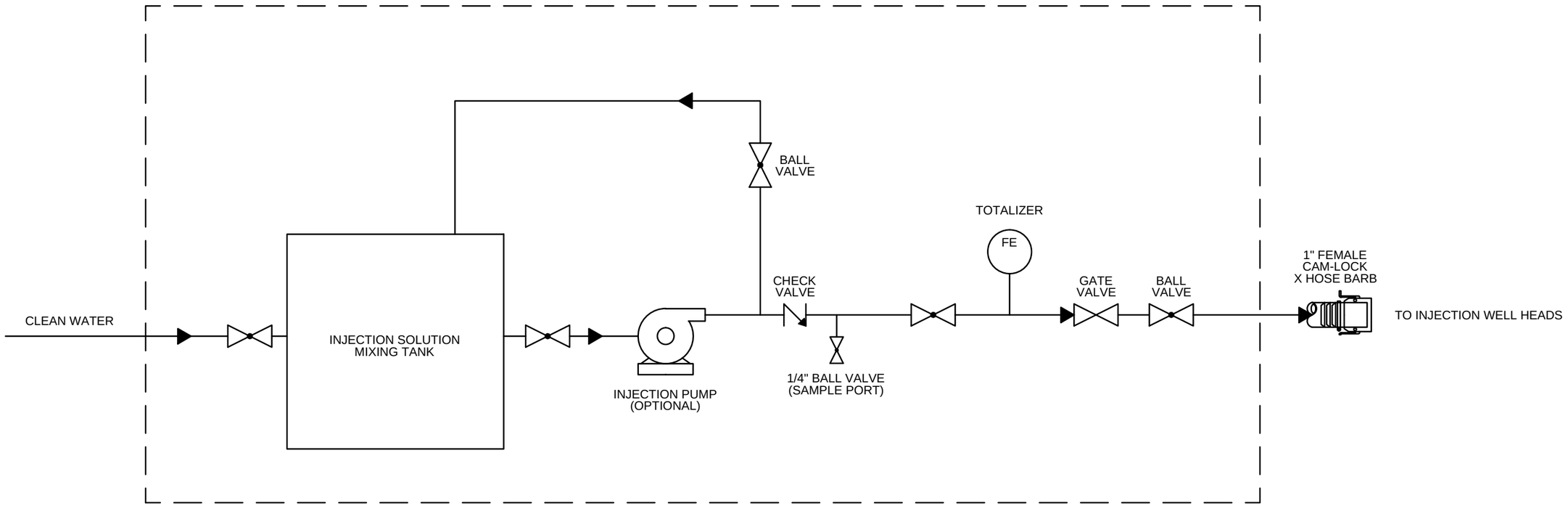
Injection Well Layout

ARCADIS Design & Consultancy for natural and built assets

FIGURE 1

CITY: (KNOXVILLE) DIV/GROUP:(ENV/GIS) PIC:() PM:(M.SANFORD/M.WACKSMAN) TM:(M.AHMAD/T.CARIGNAN) BY: BALTOM
PROJECT: AY000219.0020 PATH: G:\GIS\DC ROLLFORMS\MAPDOCS\2016\ISCO COST ESTIF1 DCR_ISCO CE SITE PLAN.MXD SAVED: 2/7/2016

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



NOT TO SCALE

INGERSOLL RAND - DC ROLLFORMS SITE
NYSDEC SITE NO. 907019
JAMESTOWN, NEW YORK
ISCO PILOT TEST WORK PLAN

PROPOSED INJECTION PIPING AND INSTRUMENTATION DIAGRAM

ARCADIS Design & Consultancy for natural and built assets

FIGURE
2

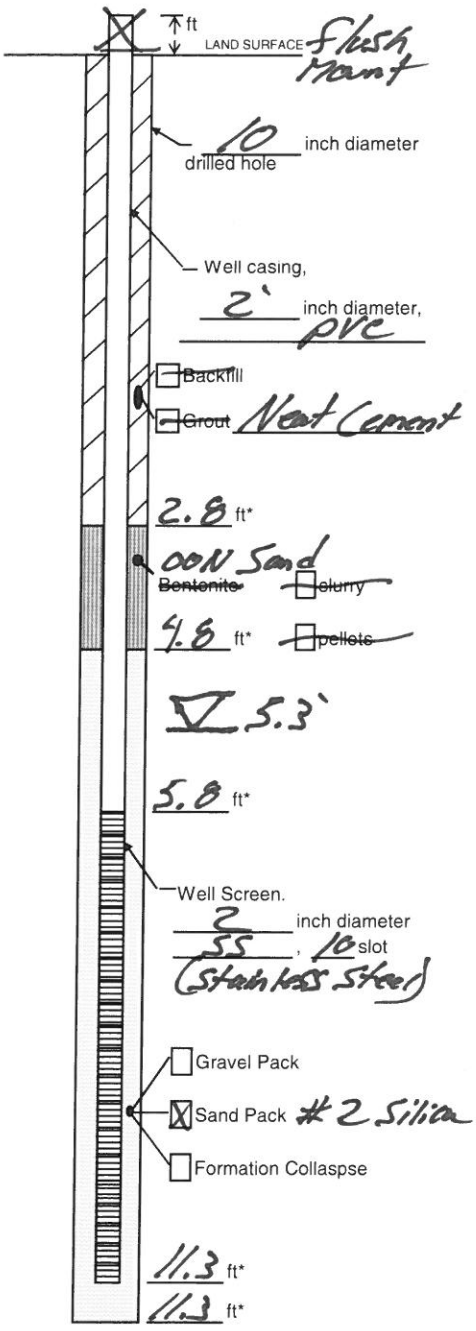
APPENDIX A

Well Construction Logs

ARCADIS

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project DL Roll forms Well IW-6

Town/City Jamestown

County Chautauqua State NY

Permit No. N/A

Land-Surface Elevation and Datum:

_____ feet ☐ Surveyed ☐ Estimated

Installation Date(s) 06/22/16

Drilling Method 6 3/4 Hollow Stem Auger (HSA)

Drilling Contractor Nothnagle Drilling

Drilling Fluid None

Development Technique(s) and Date(s)

6 1/4 HSA

Fluid Loss During Drilling N/A gallons

Water Removed During Development _____ gallons

Static Depth to Water 5.23 feet below M.P. (Surface)

Pumping Depth to Water _____ feet below M.P.

Pumping Duration _____ hours

Yield _____ gpm Date _____

Specific Capacity _____ gpm/ft

Well Purpose Injection well

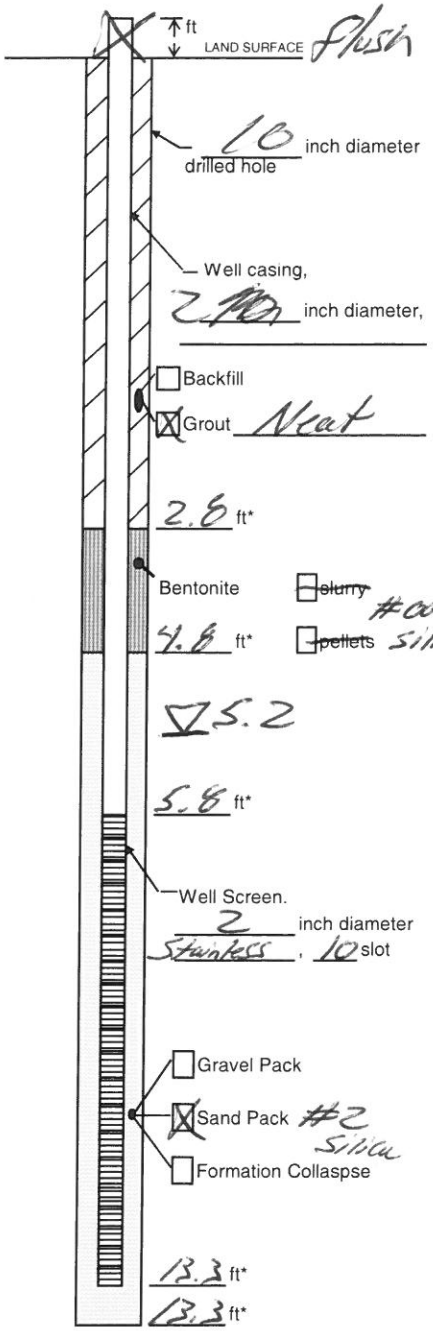
Remarks 55 screen cut (Custom) in field to just below water table 5.5' 55 screen. 5.8' PVC Riser - Cam Lock fitting on top

Prepared by J. Baxter

ARCADIS

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project DC Rollforms Well TW-7

Town/City Jamestown

County Chautauqua State NY

Permit No. N/A

Land-Surface Elevation and Datum:

_____ feet ☐ Surveyed ☐ Estimated

Installation Date(s) 06/23/16

Drilling Method 6 1/4 10"

Drilling Contractor Nothnagle Drilling

Drilling Fluid None

Development Technique(s) and Date(s)

6 1/4 HSA

Fluid Loss During Drilling N/A gallons

Water Removed During Development _____ gallons

Static Depth to Water 5.25 feet below M.P.

Pumping Depth to Water _____ feet below M.P.

Pumping Duration _____ hours

Yield _____ gpm Date _____

Specific Capacity _____ gpm/ft

Well Purpose Injection Well

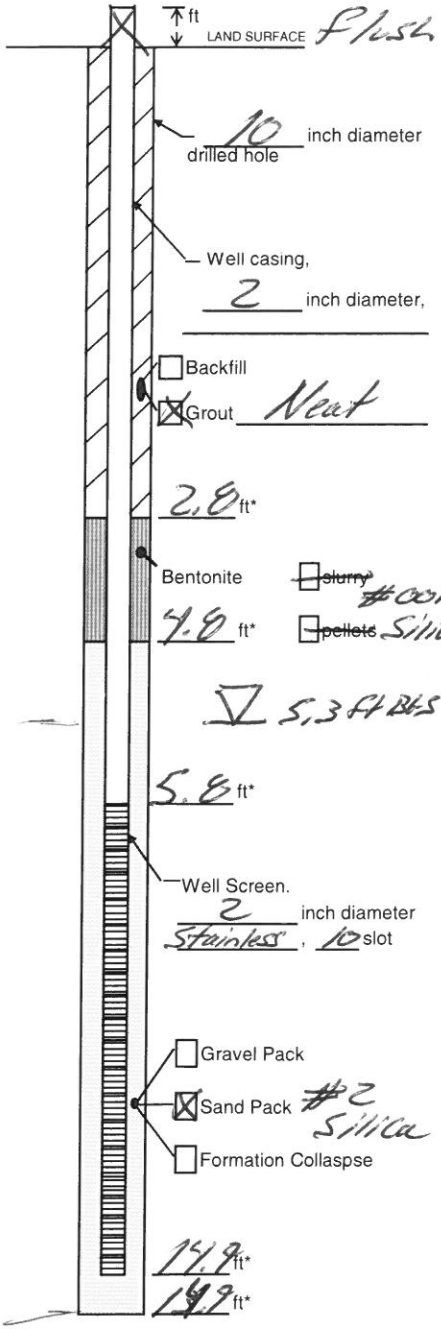
Remarks 5S Screen Custom Cut to length 0.5' below water table 7.5' Screen 5.8' PVC Riser CamLock fitting at Surface

Prepared by J. Baxter

ARCADIS

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project DC Roll Forms Well IW-8

Town/City Jamestown

County Chautauqua State NY

Permit No. N/A

Land-Surface Elevation and Datum:

_____ feet ☐ Surveyed ☐ Estimated

Installation Date(s) 6/23/16

Drilling Method 6 1/4 10"

Drilling Contractor Nothnagle Drilling

Drilling Fluid None

Development Technique(s) and Date(s)

6/24 USA

Fluid Loss During Drilling N/A gallons

Water Removed During Development _____ gallons

Static Depth to Water 5.3 feet below M.P.

Pumping Depth to Water _____ feet below M.P.

Pumping Duration _____ hours

Yield _____ gpm Date _____

Specific Capacity _____ gpm/ft

Well Purpose Injection well

~~SS Screen Custom Cut~~

~~40~~

Remarks SS Screen Custom Cut to length

0.3' of Screen is Threads. This was taken into account in Setting 9.1' of Screen

Prepared by J. Baxter

APPENDIX B

Safety Data Sheets

MATERIAL SAFETY DATA SHEET

Klozur®

MSDS Ref. No.: 7775-27-1-12
Date Approved: 05/13/2009
Revision No.: 5

This document has been prepared to meet the requirements of the U.S. OSHA Hazard Communication Standard, 29 CFR 1910.1200 and Canada's Workplace Hazardous Materials Information System (WHMIS) requirements.

1. PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME:	Klozur®
SYNONYMS:	Sodium Persulfate, Sodium Peroxydisulfate; Disodium Peroxydisulfate
GENERAL USE:	In situ and ex situ chemical oxidation of contaminants and compounds of concern for environmental remediation applications.

MANUFACTURER

FMC CORPORATION
FMC Peroxygens
1735 Market Street
Philadelphia, PA 19103
(215) 299-6000 (General Information)
msdsinfo@fmc.com (Email - General Information)

EMERGENCY TELEPHONE NUMBERS

(303) 595-9048 (Medical - U.S. - Call Collect)

For leak, fire, spill, or accident emergencies, call:
(800) 424-9300 (CHEMTREC - U.S.A. & Canada)

2. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW:

- White, odorless, crystals
- Oxidizer.
- Decomposes in storage under conditions of moisture (water/water vapor) and/or excessive heat causing release of oxides of sulfur and oxygen that supports combustion. Decomposition could form a high temperature melt. See Section 10 ("Stability and Reactivity").

POTENTIAL HEALTH EFFECTS: Airborne persulfate dust may be irritating to eyes, nose, lungs, throat and skin upon contact. Exposure to high levels of persulfate dust may cause difficulty in breathing in sensitive persons.

3. COMPOSITION / INFORMATION ON INGREDIENTS

Chemical Name	CAS#	Wt.%	EC No.	EC Class
Sodium Persulfate	7775-27-1	>99	231-892-1	Xn-O; R8-R22-R36/37/38-R42/43

4. FIRST AID MEASURES

EYES: Flush with plenty of water. Get medical attention if irritation occurs and persists.

SKIN: Wash with plenty of soap and water. Get medical attention if irritation occurs and persists.

INGESTION: Rinse mouth with water. Dilute by giving 1 or 2 glasses of water. Do not induce vomiting. Never give anything by mouth to an unconscious person. See a medical doctor immediately.

INHALATION: Remove to fresh air. If breathing difficulty or discomfort occurs and persists, contact a medical doctor.

NOTES TO MEDICAL DOCTOR: This product has low oral toxicity and is not irritating to the eyes and skin. Flooding of exposed areas with water is suggested. For gastric lavage or emesis induction, consider the possible aggravation of esophageal injury, and the expected absence of system effects. Treatment is controlled removal of exposure followed by symptomatic and supportive care.

5. FIRE FIGHTING MEASURES

EXTINGUISHING MEDIA: Deluge with water.

FIRE / EXPLOSION HAZARDS: Product is non-combustible. On decomposition releases oxygen which may intensify fire. Presence of water accelerates decomposition.

FIRE FIGHTING PROCEDURES: Do not use carbon dioxide or other gas filled fire extinguishers; they will have no effect on decomposing persulfates. Wear full protective clothing and self-contained breathing apparatus.

FLAMMABLE LIMITS: Non-combustible

SENSITIVITY TO IMPACT: No data available

SENSITIVITY TO STATIC DISCHARGE: Not available

6. ACCIDENTAL RELEASE MEASURES

RELEASE NOTES: Spilled material should be collected and put in approved DOT container and isolated for disposal. Isolated material should be monitored for signs of decomposition (fuming/smoking). If spilled material is wet, dissolve with large quantity of water and dispose as a hazardous waste. All disposals should be carried out according to regulatory agencies procedures.

7. HANDLING AND STORAGE

HANDLING: Use adequate ventilation when transferring product from bags or drums. Wear respiratory protection if ventilation is inadequate or not available. Use eye and skin protection. Use clean plastic or stainless steel scoops only.

STORAGE: Store (unopened) in a cool, clean, dry place away from point sources of heat, e.g. radiant heaters or steam pipes. Use first in, first out storage system. Avoid contamination of opened product. In case of fire or decomposition (fuming/smoking) deluge with plenty of water to control decomposition. For storage, refer to NFPA Bulletin 430 on storage of liquid and solid oxidizing materials.

COMMENTS: VENTILATION: Provide mechanical general and/or local exhaust ventilation to prevent release of dust into work environment. Spills should be collected into suitable containers to prevent dispersion into the air.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

EXPOSURE LIMITS

Chemical Name	ACGIH	OSHA	Supplier
Sodium Persulfate	0.1 mg/m^3 (TWA)		

ENGINEERING CONTROLS: Provide mechanical local general room ventilation to prevent release of dust into the work environment. Remove contaminated clothing immediately and wash before reuse.

PERSONAL PROTECTIVE EQUIPMENT

EYES AND FACE: Use cup type chemical goggles. Full face shield may be used.

RESPIRATORY: Use approved dust respirator when airborne dust is expected.

PROTECTIVE CLOTHING: Normal work clothes. Rubber or neoprene footwear.

GLOVES: Rubber or neoprene gloves. Thoroughly wash the outside of gloves with soap and water prior to removal. Inspect regularly for leaks.

9. PHYSICAL AND CHEMICAL PROPERTIES

ODOR:	None
APPEARANCE:	White crystals
AUTOIGNITION TEMPERATURE:	Not applicable. No evidence of combustion up to 800°C. Decomposition will occur upon heating.
BOILING POINT:	Not applicable
COEFFICIENT OF OIL / WATER:	Not applicable
DENSITY / WEIGHT PER VOLUME:	Not available
EVAPORATION RATE:	Not applicable (Butyl Acetate = 1)
FLASH POINT:	Non-combustible
MELTING POINT:	Decomposes
ODOR THRESHOLD:	Not applicable
OXIDIZING PROPERTIES:	Oxidizer
PERCENT VOLATILE:	Not applicable
pH:	typically 5.0 - 7.0 @ 25 °C (1% solution)
SOLUBILITY IN WATER:	73 % @ 25 °C (by wt.)
SPECIFIC GRAVITY:	2.6 (H_2O=1)
VAPOR DENSITY:	Not applicable (Air = 1)
VAPOR PRESSURE:	Not applicable

10. STABILITY AND REACTIVITY

CONDITIONS TO AVOID:	Heat, moisture and contamination.
STABILITY:	Stable (becomes unstable in presence of heat, moisture and/or contamination).
POLYMERIZATION:	Will not occur
INCOMPATIBLE MATERIALS:	Acids, alkalis, halides (fluorides, chlorides, bromides and iodides), combustible materials, most metals and heavy metals, oxidizable materials, other oxidizers, reducing agents, cleaners, and organic or carbon containing compounds. Contact

with incompatible materials can result in a material decomposition or other uncontrolled reactions.

HAZARDOUS DECOMPOSITION PRODUCTS: Oxygen that supports combustion and oxides of sulfur.

COMMENTS: PRECAUTIONARY STATEMENT: Pumping and transport of Klozur persulfate requires appropriate precautions and design considerations for pressure and thermal relief.

Decomposing persulfates will evolve large volumes of gas and/or vapor, can accelerate exponentially with heat generation, and create significant and hazardous pressures if contained and not properly controlled or mitigated.

Use with alcohols in the presence of water has been demonstrated to generate conditions that require rigorous adherence to process safety methods and standards to prevent escalation to an uncontrolled reaction.

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11. TOXICOLOGICAL INFORMATION

EYE EFFECTS: Non-irritating (rabbit) [FMC Ref. ICG/T-79.029]

SKIN EFFECTS: Non-irritating (rabbit) [FMC Ref. ICG/T-79.029]

DERMAL LD_{50}: > 10 g/kg [FMC Ref. ICG/T-79.029]

ORAL LD_{50}: 895 mg/kg (rat) [FMC Ref. ICG/T-79.029]

INHALATION LC_{50}: 5.1 mg/l (rat) [FMC Ref. I95-2017]

SENSITIZATION: May be sensitizing to allergic persons. [FMC Ref. ICG/T-79.029]

TARGET ORGANS: Eyes, skin, respiratory passages

ACUTE EFFECTS FROM OVEREXPOSURE: Dust may be harmful and irritating. May be harmful if swallowed.

CHRONIC EFFECTS FROM OVEREXPOSURE: Sensitive persons may develop dermatitis and asthma [Respiration 38:144, 1979]. Groups of male and female rats were fed 0, 300 or 3000 ppm sodium persulfate in the diet for 13 weeks, followed by 5000 ppm for 5 weeks. Microscopic examination of tissues revealed some injury to the gastrointestinal tract at the high dose (3000 ppm) only. This effect is not unexpected for an oxidizer at high concentrations. [Ref. FMC I90-1151, Toxicologist 1:149, 1981].

CARCINOGENICITY:

NTP:	Not listed
IARC:	Not listed
OSHA:	Not listed
OTHER:	ACGIH: Not listed

---

12. ECOLOGICAL INFORMATION

ECOTOXICOLOGICAL INFORMATION:

Bluegill sunfish, 96-hour LC_{50} = 771 mg/L [FMC Study I92-1250]
Rainbow trout, 96-hour LC_{50} = 163 mg/L [FMC Study I92-1251]
Daphnia, 48-hour LC_{50} = 133 mg/L [FMC Study I92-1252]
Grass shrimp, 96-hour LC_{50} = 519 mg/L [FMC Study I92-1253]

CHEMICAL FATE INFORMATION: Biodegradability does not apply to inorganic substances.

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13. DISPOSAL CONSIDERATIONS

DISPOSAL METHOD: Dispose as a hazardous waste in accordance with local, state and federal regulatory agencies.

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14. TRANSPORT INFORMATION

U.S. DEPARTMENT OF TRANSPORTATION (DOT)

PROPER SHIPPING NAME:	Sodium Persulfate
PRIMARY HAZARD CLASS / DIVISION:	5.1 (Oxidizer)
UN/NA NUMBER:	UN 1505
PACKING GROUP:	III
LABEL(S):	5.1 (Oxidizer)
PLACARD(S):	5.1 (Oxidizer)
MARKING(S):	Sodium Persulfate, UN 1505
ADDITIONAL INFORMATION:	Hazardous Substance/RQ: Not applicable

49 STCC Number: 4918733

This material is shipped in 225 lb. fiber drums, 55 lb. poly bags and 1000 - 2200 lb. IBC's (supersacks).

INTERNATIONAL MARITIME DANGEROUS GOODS (IMDG)

PROPER SHIPPING NAME: Sodium Persulfate

INTERNATIONAL CIVIL AVIATION ORGANIZATION (ICAO) / INTERNATIONAL AIR TRANSPORT ASSOCIATION (IATA)

PROPER SHIPPING NAME: Sodium Persulfate

OTHER INFORMATION:

Protect from physical damage. Do not store near acids, moisture or heat.

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15. REGULATORY INFORMATION

UNITED STATES

SARA TITLE III (SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT)

SECTION 302 EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355, APPENDIX A):
Not applicable

SECTION 311 HAZARD CATEGORIES (40 CFR 370):
Fire Hazard, Immediate (Acute) Health Hazard

SECTION 312 THRESHOLD PLANNING QUANTITY (40 CFR 370):
The Threshold Planning Quantity (TPQ) for this product, if treated as a mixture, is 10,000 lbs; however, this product contains the following ingredients with a TPQ of less than 10,000 lbs.: None

SECTION 313 REPORTABLE INGREDIENTS (40 CFR 372):
There are no ingredients in this product, which are subject to Section 313 reporting requirements.

CERCLA (COMPREHENSIVE ENVIRONMENTAL RESPONSE COMPENSATION AND LIABILITY ACT)

CERCLA DESIGNATION & REPORTABLE QUANTITIES (RQ) (40 CFR 302.4):
Unlisted, RQ = 100 lbs., Ignitability

TSCA (TOXIC SUBSTANCE CONTROL ACT)

TSCA INVENTORY STATUS (40 CFR 710):
All components are listed or exempt.

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)
RCRA IDENTIFICATION OF HAZARDOUS WASTE (40 CFR 261):
Waste Number: D001

CANADA

WHMIS (WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM):

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all the information required by the Controlled Products Regulations.

Hazard Classification / Division: C
D2A
D2B

Domestic Substance List: All components are listed or exempt.

INTERNATIONAL LISTINGS

Australia (AICS): Listed
China: Listed
Japan (ENCS): (1)-1131
Korea: KE-12369
Philippines (PICCS): Listed

HAZARD AND RISK PHRASE DESCRIPTIONS:

EC Symbols:	Xn	(Harmful)
	O	(Oxidizer)
EC Risk Phrases:	R8	(Contact with combustible material may cause fire)
	R22	(Harmful if swallowed.)
	R36/37/38	(Irritating to eyes, respiratory system and skin.)
	R42/43	(May cause sensitization by inhalation or by skin contact.)

16. OTHER INFORMATION

HMIS

Health	1
Flammability	0
Physical Hazard	1
Personal Protection (PPE)	J

Protection = J (Safety goggles, gloves, apron & combination dust & vapor respirator)

HMIS = Hazardous Materials Identification System

Degree of Hazard Code:
4 = Severe
3 = Serious
2 = Moderate
1 = Slight
0 = Minimal

NFPA

Health	1
Flammability	0
Reactivity	1
Special	OX

SPECIAL = OX (Oxidizer)

NFPA (National Fire Protection Association)

Degree of Hazard Code:
4 = Extreme
3 = High
2 = Moderate
1 = Slight
0 = Insignificant

REVISION SUMMARY:
This MSDS replaces Revision #4, dated September 18, 2006.
Changes in information are as follows:
Section 1 (Product and Company Identification)
Section 3 (Composition / Information on Ingredients)
Section 15 (Regulatory Information)
Section 16 (Other Information)

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Safety Data Sheet

1. IDENTIFICATION OF THE MATERIAL AND SUPPLIER

Product Name: **PEARL CAUSTIC SODA**

Other name(s): Sodium hydroxide; Soda lye; Sodium hydrate; White caustic; Caustic soda solid; Caustic soda pearl; Solid caustic soda.

Recommended Use: General chemical.

Supplier: Orica Australia Pty Ltd
ABN: 99 004 117 828
Street Address: 1 Nicholson Street,
Melbourne 3000
Australia
Telephone Number: +61 3 9665 7111
Facsimile: +61 3 9665 7937
Emergency Telephone: **1 800 033 111 (ALL HOURS)**

2. HAZARDS IDENTIFICATION

This material is hazardous according to criteria of Safe Work Australia; HAZARDOUS SUBSTANCE.

Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for Transport by Road and Rail; DANGEROUS GOODS.

Risk Phrases: Causes severe burns. Risk of serious damage to eyes.

Safety Phrases: Do not breathe dust. Avoid contact with skin and eyes. In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. Wear suitable protective clothing, gloves and eye/face protection. In case of accident or if you feel unwell, seek medical advice immediately (show the label whenever possible).

Poisons Schedule: S6 Poison.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Components	CAS Number	Proportion	Risk Phrases
Sodium hydroxide	1310-73-2	100%	R35, R41

4. FIRST AID MEASURES

For advice, contact a Poisons Information Centre (e.g. phone Australia 131 126; New Zealand 0800 764 766) or a doctor.

Inhalation:
Remove victim from area of exposure - avoid becoming a casualty. Remove contaminated clothing and loosen remaining clothing. Allow patient to assume most comfortable position and keep warm. Keep at rest until fully recovered. If patient finds breathing difficult and develops a bluish discolouration of the skin (which suggests a lack of oxygen in the blood - cyanosis), ensure airways are clear of any obstruction and have a qualified person give oxygen through a face mask. Apply artificial respiration if patient is not breathing. Seek immediate medical advice.

Skin Contact:
If spilt on large areas of skin or hair, immediately drench with running water and remove clothing. Continue to wash skin and hair with plenty of water (and soap if material is insoluble) until advised to stop by the Poisons Information Centre or a doctor. For skin burns, cover with a clean, dry dressing until medical help is available.

Eye Contact:
If in eyes, hold eyelids apart and flush the eye continuously with running water. Continue flushing until advised to stop by a Poisons Information Centre or a doctor, or for at least 15 minutes.

Ingestion:
Immediately rinse mouth with water. If swallowed, do NOT induce vomiting. Give a glass of water. Seek immediate medical assistance.

Medical attention and special treatment:
Treat symptomatically. Can cause corneal burns.

5. FIRE FIGHTING MEASURES

Hazards from combustion products:
Non-combustible material.

Precautions for fire fighters and special protective equipment:
Fire fighters to wear self-contained breathing apparatus and suitable protective clothing if risk of exposure to products of decomposition.

Suitable Extinguishing Media:
Not combustible, however, if material is involved in a fire use: Fine water spray, normal foam, dry agent (carbon dioxide, dry chemical powder).

Hazchem Code: 2W

6. ACCIDENTAL RELEASE MEASURES

Emergency procedures:
Clear area of all unprotected personnel. If contamination of sewers or waterways has occurred advise local emergency services.

Methods and materials for containment and clean up:
Wear protective equipment to prevent skin and eye contact and breathing in dust. Work up wind or increase ventilation. Cover with damp absorbent (inert material, sand or soil). Sweep or vacuum up, but avoid generating dust. Collect and seal in properly labelled containers or drums for disposal. Caution - heat may be evolved on contact with water.

7. HANDLING AND STORAGE

This material is a Scheduled Poison S6 and must be stored, maintained and used in accordance with the relevant regulations.

Conditions for safe storage:
Store in a cool, dry, well ventilated place and out of direct sunlight. Store away from foodstuffs. Store away from incompatible materials described in Section 10. Keep containers closed when not in use - check regularly for spills.

Precautions for safe handling:
Avoid skin and eye contact and breathing in dust. Keep out of reach of children. There is a risk of splash-back causing injury if Pearl Caustic Soda is added to HOT water.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Sodium hydroxide: Peak Limitation = 2 mg/m3

As published by the National Occupational Health and Safety Commission.

Peak Limitation - a ceiling concentration which should not be exceeded over a measurement period which should be as short as possible but not exceeding 15 minutes.

These Exposure Standards are guides to be used in the control of occupational health hazards. All atmospheric contamination should be kept to as low a level as is workable. These exposure standards should not be used as fine dividing lines between safe and dangerous concentrations of chemicals. They are not a measure of relative toxicity.

Engineering controls:
Ensure ventilation is adequate to maintain air concentrations below Exposure Standards. Avoid generating and breathing in dusts. Use with local exhaust ventilation or while wearing dust mask. Keep containers closed when not in use.

Personal Protective Equipment:
The selection of PPE is dependant on a detailed risk assessment. The risk assessment should consider the work situation, the physical form of the chemical, the handling methods, and environmental factors.

Orica Personal Protection Guide No. 1, 1998: F - OVERALLS, SAFETY SHOES, CHEMICAL GOGGLES, GLOVES, DUST MASK.

Wear overalls, chemical goggles and impervious gloves. Avoid generating and inhaling dusts. If dust exists, wear dust mask/respirator meeting the requirements of AS/NZS 1715 and AS/NZS 1716. Always wash hands before smoking, eating, drinking or using the toilet. Wash contaminated clothing and other protective equipment before storage or re-use.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical state:	Solid
Colour:	White
Molecular Formula:	NaOH
Solubility:	Soluble in water.
Specific Gravity:	2.13 @20°C
Relative Vapour Density (air=1):	Not available
Vapour Pressure (20 °C):	Not available
Flash Point (°C):	Not applicable
Flammability Limits (%):	Not available
Autoignition Temperature (°C):	Not available
Melting Point/Range (°C):	318
Boiling Point/Range (°C):	1390
pH:	12.7 (1% aqueous solution)

10. STABILITY AND REACTIVITY

10. STABILITY AND REACTIVITY

Chemical stability: Stable. Hygroscopic: absorbs moisture or water from surrounding air.

Conditions to avoid: Avoid dust generation. Avoid exposure to moisture. Avoid contact with foodstuffs.

Incompatible materials: Incompatible with ammonium salts , acids , chlorinated hydrocarbons , aluminium , zinc , lead , tin , and their alloys .

Hazardous decomposition products: None known.

Hazardous reactions: Reacts with ammonium salts, evolving ammonia gas. In the presence of moisture, the material is corrosive to aluminium, zinc and tin producing highly flammable hydrogen gas. May react violently with acids and chlorinated hydrocarbons . Can react vigorously with water .

11. TOXICOLOGICAL INFORMATION

No adverse health effects expected if the product is handled in accordance with this Safety Data Sheet and the product label. Symptoms or effects that may arise if the product is mishandled and overexposure occurs are:

Ingestion: Swallowing can result in nausea, vomiting, diarrhoea, abdominal pain and chemical burns to the gastrointestinal tract.

Eye contact: A severe eye irritant. Corrosive to eyes; contact can cause corneal burns. Contamination of eyes can result in permanent injury.

Skin contact: Contact with skin will result in severe irritation. Corrosive to skin - may cause skin burns.

Inhalation: Breathing in dust may result in respiratory irritation.

Long Term Effects:
No information available for the product.

Toxicological Data: No LD50 data available for the product.

12. ECOLOGICAL INFORMATION

Ecotoxicity Avoid contaminating waterways.

13. DISPOSAL CONSIDERATIONS

Disposal methods:
Refer to local government authority for disposal recommendations. Dispose of material through a licensed waste contractor. Decontamination and destruction of containers should be considered.

14. TRANSPORT INFORMATION

Road and Rail Transport
Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for Transport by Road and Rail; DANGEROUS GOODS.

UN No: 1823
Class-primary 8 Corrosive
Packing Group: II
Proper Shipping Name: SODIUM HYDROXIDE, SOLID
Hazchem Code: 2W

Marine Transport
Classified as Dangerous Goods by the criteria of the International Maritime Dangerous Goods Code (IMDG Code) for transport by sea; DANGEROUS GOODS.

UN No: 1823
Class-primary: 8 Corrosive
Packing Group: II
Proper Shipping Name: SODIUM HYDROXIDE, SOLID

IMDG EMS Fire: F-A
IMDG EMS Spill: S-B

Air Transport
Classified as Dangerous Goods by the criteria of the International Air Transport Association (IATA) Dangerous Goods Regulations for transport by air; DANGEROUS GOODS.

UN No: 1823
Class-primary: 8 Corrosive
Packing Group: II
Proper Shipping Name: SODIUM HYDROXIDE, SOLID

15. REGULATORY INFORMATION

Classification: This material is hazardous according to criteria of Safe Work Australia; HAZARDOUS SUBSTANCE.

Hazard Category: C: Corrosive

Risk Phrase(s):
R35: Causes severe burns.
R41: Risk of serious damage to eyes.

Safety Phrase(s):
S22: Do not breathe dust.
S24/25: Avoid contact with skin and eyes.
S26: In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
S36/37/39: Wear suitable protective clothing, gloves and eye/face protection.
S45: In case of accident or if you feel unwell, seek medical advice immediately (show the label whenever possible).

Poisons Schedule: S6 Poison.

This material is listed on the Australian Inventory of Chemical Substances (AICS).

16. OTHER INFORMATION

This safety data sheet has been prepared by Orica SDS Services.

Reason(s) for Issue:
5 Yearly Revised Primary SDS

This SDS summarises to our best knowledge at the date of issue, the chemical health and safety hazards of the material and general guidance on how to safely handle the material in the workplace. Since Orica Limited cannot anticipate or control the conditions under which the product may be used, each user must, prior to usage, assess and control the risks arising from its use of the material.

If clarification or further information is needed, the user should contact their Orica representative or Orica Limited at the contact details on page 1.

Orica Limited's responsibility for the material as sold is subject to the terms and conditions of sale, a copy of which is available upon request.

APPENDIX C

Hazard Analysis Form

ACTIVITY HAZARDS ANALYSIS

Overall Risk Assessment Code (RAC) (Use highest code): L

Date: 06/01/16 Project: D.C. Rollforms Site

Activity: Sodium Persulfate and Sodium Hydroxide Injection, Handling, and Treatment

Activity Location: Jamestown, NY

Prepared By: Mushtaque Ahmad

Risk Assessment Code Matrix

E = Extremely High Risk
H = High Risk
M = Moderate Risk
L = Low Risk

Severity	Probability				
	Frequent	Likely	Occasional	Seldom	Unlikely
Catastrophic	E	E	H	H	M
Critical	E	H	H	M	L
Marginal	H	M	M	L	L
Negligible	M	L	L	L	L

Add Identified Hazards

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS	RAC
X	Site reconnaissance and walk-around	Slips/trips/falls can occur from uneven ground surface, slippery walkways or from tripping over equipment	Survey the site upon arrival. Note any site conditions that may pose a potential hazard, and make note of any changes since the last injection event.	L
X		Personnel could be struck by vehicle	• Secure work area with cones. • Position vehicle to serve as a barrier between personnel and site traffic. • Unload equipment as close to the work area as possible. • Plan the location where the trailer carrying injection equipment will be set up making sure to not block any ingress/egress to the site.	L
X	Setting up of injection equipment	Pinch points can cause hand injury- • Pinch points and sharp edges/burrs can be present on the metal clamps, cam-lock, and other injection equipment.	• Wear work leather gloves.	L
X		Heavy equipment can fall and strike personnel	• Make sure that the wheels of the vehicles have been chocked prior to operation and unloading. • Use proper lifting technique	L
X		Truck and/or trailer becomes stuck on soft or uneven ground causing potential property damage and impact injury to workers during extraction	Plan setup and factor weight of full tanks when accessing and egressing from injection areas, ensure adequate hose lengths are available to pump solutions to wells in soft ground areas from stable road surface other firm surface.	L
X	Load, unload and set up of required PPE, equipment including waterline hoses, injection hoses, flow meters and supplies in/out of vehicle or storage area	Ergonomic strain from improper lifting techniques or awkward body positions/twisting	• Follow proper lifting technique, bending with the knees and not with the back. Avoid twisting at the waist when lifting. • Ask a buddy for help when lifting objects weighing over 55 lbs. (as a general guide; may vary on specific circumstances)	L
X		Slips/trips/falls can occur from walking over dragging and unsecured hoses	• Keep coiled hoses ends secured to coil when loading and unloading, stop and pick up dangling hoses that could be a trip hazard when carrying.	L

ACTIVITY HAZARDS ANALYSIS

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS	RAC
X	Connecting the water supply to the injection trailer	Lifting hoses resulting in a back injury	• Do not lift more than your personal limits. • Use a second person if needed or when lifting hoses >55 lbs. • Lift with your knees and not your back.	L
X		Possible pressure build up can result in equipment failure or flying objects that can cause personal injury	• Check equipment and valves before making connections. • Check the water valves are in the off position. • Make the hose connections and secure the cam locks with counter pins. • Open supply valves slowly to avoid damage to hoses or personnel. • Check supply lines and valves for leaking after water/sodium persulfate and sodium hydroxide supply is on. • Tether hose connections if securing devices are not present. . Depressurize before disconnecting any system component.	L
X	Connect the injection trailer to a power supply	Electrocution or power surge resulting in equipment damage, injury or loss of life	• Inspect power cords for evidence of damage to the wire or connector. If damage is present, do not use power cord. • Inspect connection of power supply for evidence of damage. Use GFCI 'pigtail'.	L
X		Misuse of generator can cause electrocution, fire or equipment failure	• If using generator on injection trailer inspect components for damage. • Check oil/fuel levels and fill if necessary. • Inspect injection trailer control panel for evidence of damage to switches, circuits or breakers before connecting power. • Connect power cord then power supply. Watch for wet or other conductive surfaces.	L
X	Connecting the injection well head to the injection wells	Pressure build up in wells can cause well caps to fly off causing head or bodily injury	• When opening injection wells, be sure your body is not over the well when opening. • Be sure that safety glasses are worn and your head is facing away from the well when opening.	L
X	Mixing of sodium persulfate and water	Breathing or contact with sodium persulfate can irritate nose, throat and lungs causing coughing, wheezing and/or shortness or breath. Contact may cause skin allergy resulting in itching and skin rash	• Use full-face respirator with P100 cartridges as needed. • Wear chemical protective clothing; splash shield (as needed) and gloves to minimize contact with skin/eyes/face when handling solid or solution.	L
X		Lifting/handling bags of sodium persulfate can result in muscle strain	• Do not lift more than your personal limits. • Use a second person if needed or when lifting >55 lbs. • Lift with your knees and not your back.	M
X	Mixing of sodium hydroxide and water	Breathing or contact with sodium persulfate can irritate nose, throat and lungs causing coughing, wheezing and/or shortness or breath. Contact may cause skin allergy resulting in itching and skin rash	• Use full-face respirator with P100 cartridges as needed. • Wear chemical protective clothing; splash shield (as needed) and gloves to minimize contact with skin/eyes/face when handling solid or solution.	M
X		Lifting/handling of bags of solids can result in muscle strain	• Do not lift more than your personal limits. • Use a second person if needed or when lifting >55 lbs. • Lift with your knees and not your back.	L

ACTIVITY HAZARDS ANALYSIS

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS	RAC
X	Pump solution into wells and read pressure and flow gauges	Pressure can build up resulting in hose or flow meter failure leading to possible injury	• Start injections at low flow rate and adjust as needed. Secure cam locks to hoses or flow meters with counter pins/locking device/zipties. • Never place any body part directly over well head. • Monitor pressures and stress points of the system during injection (connections, valves, threaded fitting, etc.) • When injection is complete, ensure there is no pressure prior to disassembly. • Shut down injection and let formation de-pressurize itself before disconnection hoses.	L
X		Cold/wet conditions can cause improper well-head adapted connections, i.e. PVC glue/ cement may not cure properly	• Connect during a warmer day and for a cold weather injection event do any PVC glue related work a few days ahead of the injection event.	L
X		Slips/trips/falls can occur due to hoses laying on the ground resulting in injury	• Practice good housekeeping techniques. • For hoses used during introductions, avoid walking over hoses as much as practicable. • Use high visibility marking and warning devices and secure hose if traveling across a designated facility walking area.	L
X	Clean Equipment	Slips/trips/falls can occur from water and soap causing slippery surfaces. Tripping can occur from equipment being laid out for cleaning	• Be aware of surroundings when cleaning equipment. • Maintain good footing and walk slowly on wet/slippery surfaces.	L
X		Heavy lifting of equipment can cause muscle strain	• Use proper lifting techniques. Request assistance when lifting heavy equipment.	L
X	Site restoration/loading of equipment	Tripping on equipment laying on the ground	• Secure all equipment after use. • Leave the site clean and free from any trash or debris. • Secure all wells, gates and entrances to the site.	L
X		Heavy lifting can cause muscle strain	• Use proper lifting techniques when loading equipment.	L
X	Inspect injection trailer and demobilize from site	Improperly loading the trailer can cause flying debris on the roadway. Improper trailer connections can cause the trailer to detach during demobilization.	• Be sure all line items on the check list are satisfactory before departing from the site.	L

Add Items

	EQUIPMENT	TRAINING	INSPECTION
X	Vehicles/Trailer	40 hr. Hazwoper	Perform inspection of vehicle at the start and end of each day and prior to each use.
X	PPE		Before each use.
X			

ACTIVITY HAZARDS ANALYSIS

Involved Personnel:

Acceptance Authority (digital signature): _____

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