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Cleanup Action Plan Compliance Work Plan

Former Chevron Bulk Terminal No. 100-1327
1602 North Northlake Way
Seattle, Washington

June 19, 2014

DRAFT

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Cleanup Action Plan Compliance Work Plan

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Seattle, Washington

Prepared for:
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Acronyms and Abbreviations

ARCADIS	ARCADIS U.S., Inc.
ASTs	aboveground storage tanks
CAP	Cleanup Action Plan
CD	Consent Decree
Chevron	Chevron Environmental Management Company
COCs	constituents of concern
cPAHs	carcinogenic polyaromatic hydrocarbons
CULs	cleanup levels
DNAPL	dense non-aqueous phase liquid
DPE	dual phase extraction
DRO	diesel range organics
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ft^2	square feet
ft bgs	feet bgs
gpm	gallons per minute
GPR	ground penetrating radar
GRO	gasoline range organics
HASP	health and safety plan
HO	heavy oil range organics
LNAPL	light non-aqueous phase liquid
Metro	King County, Seattle, Washington

MTCA	Model Toxics Control Act
MW	groundwater monitoring well
ORP	oxidation-reduction potential
PID	photo-ionization detector
POC	Point of Compliance
PPCD	Prospective Purchaser Consent Decree
PVC	polyvinyl chloride
ROW	right of way
Site	Former Chevron Bulk Plant No. 100-1327 located at Facilities North / King County (Metro), Seattle, Washington
Touchstone	Touchstone Corporation
USTs	underground storage tanks
VOCs	volatile organic compounds

1. Introduction

On behalf of Chevron Environmental Management Company (Chevron) and King County, ARCADIS U.S., Inc. (ARCADIS) has prepared this Cleanup Action Plan (CAP) Compliance Work Plan to document the final actions to be performed to complete all requirements of the Metro-Chevron-Ecology Consent Decree (CD) #99-2-08651-1SEA and Exhibit A – CAP at former Chevron Bulk Plant No. 100-1327 (the Site) located at Facilities North/King County, Seattle, Washington (Metro). The Site and surrounding area are shown on **Figure 1**.

This work plan outlines the steps and procedures to conduct several 2 to 5 day dual-phase extraction (DPE) events and conduct confirmation soil sampling and documents changes to the groundwater monitoring program. This work plan includes the following activities:

- **Over-Drill MW-9**. MW-9 will be over-drilled and replaced with a larger-diameter well casing/screen (MW-9R) to obtain better hydraulic conductivity and extraction rates during DPE events. The location of MW-9 is shown on **Figure 2**.

- **Install Downgradient Piezometers.** Two downgradient piezometers (PZ-1 and PZ-2) will be installed to monitor measurable light non-aqueous phase liquid (LNAPL) and groundwater compliance cleanup levels for the area around MW-9R during and after DPE events. The proposed piezometer locations are shown on **Figure 2**.

- **Install Soil Borings in Southwestern Property Boundary.** Two investigation soil borings (SB-1 and SB-2) will be installed to further evaluate LNAPL and residual saturation levels in soil between historical borings B-12 and B-23. Soil borings SB-1 and SB-2 will also be used to evaluate the need for remediation in that location of the North Yard. The proposed soil boring locations are shown on **Figure 2**.

- **Install Hand Auger Borings in South Yard.** Two hand auger soil borings will be advanced in the South Yard to confirm concentrations of constituents of concern (COCs) at historical soil boring locations HS4, HB7, and HB8. The proposed hand auger locations are shown on **Figure 2**.

- **Dual-phase Extraction Events.** The mobile DPE system will be operated for a period of 2 to 5 days on several occasions to dewater the smear zone, volatilize dissolved phase hydrocarbons trapped in soil pore space, and remove all measurable LNAPL within the soil and groundwater surrounding monitoring well MW-9R. This work will be done in coordination with North Yard dewatering by Touchstone Corporation

(Touchstone) to provide for greater smear zone exposure in the vicinity of MW-9R, resulting in enhanced LNAPL and volatile dissolved phase hydrocarbon removal.

- **Groundwater Monitoring Program Changes.** The sampling protocol and schedule will be modified as discussed during the May 1, 2014 meeting between ARCADIS, Metro, Chevron, and the Washington State Department of Ecology (Ecology). This work plan will document those changes and provide an official vehicle for Ecology approval.

2. Site Description

The Site is located at 1602 North Northlake Way along the north shore of Lake Union in a mixed-use residential and commercial neighborhood. The property is divided into two operable areas: a North Yard located on the north side of North Northlake Way and a South Yard located adjacent to the north shore of Lake Union and south of North Northlake Way. The site boundary as outlined in the CAP includes a public right of way (ROW) between the North Yard and South Yard. All portions of the site are shown in **Figure 1**.

2.1 North Yard

The portion of the Site that is located between North 34th Street (to the north) and North Northlake Place (to the south), and between Woodlawn Avenue North (to the west) and Densmore Avenue North (to the east) is defined as the North Yard. In 2009, Touchstone purchased the North Yard property and entered into a Prospective Purchase Consent Decree (PPCD) to perform additional cleanup activities.

2.2 South Yard

The South Yard is bounded by Lake Union on the southwest, private property on the northwest, North Northlake Place on the northeast, and a property occupied by the Seattle Harbor Patrol on the southeast.

2.3 Public Right of Way between North and South Yard

The portion of the Site between the North Yard and South Yard at North Northlake Place and North Northlake Way is referred to as the public ROW in this report.

2.4 Offsite Area and Adjacent Sites

Other cleanup sites in the vicinity include but are not limited to Northlake Shipyard, with metals-impacted sediments as the primary medium of concern (Ecology, 1994), and the Gas Works Park site, with coal-tar (i.e., dense non-aqueous phase liquid [DNAPL]) and metals-impacted groundwater, soils, and sediments (Ecology, 2005a). The Gas Works Park site also includes the Seattle Harbor Patrol, which previously had underground storage tanks (USTs) and has been affected by migration of contaminants from Gas Works Park.

3. Historical Site Use

Between 1925 and 1927, Standard Oil of California (later Chevron) developed the North and South Yards as a marine bulk fuel storage and distribution facility. The North Yard included 11 aboveground storage tanks (ASTs), transfer piping, truck loading racks, and various small buildings. The petroleum product stored in the North Yard was linked to the South Yard fuel dock by underground piping. According to the CAP (Foster Wheeler, 1998), the ASTs historically stored gasoline, diesel, fuel oil, refined oil, gasoline distillates, and lubricating oils.

Metro acquired the property in 1982 and used it for diesel fueling operations until April 1992, when all remaining diesel products were removed from the Site. Only three truck deliveries of diesel were received in 1991 and according to Metro staff, no gasoline products were ever received or stored onsite by Metro. Metro decommissioned the fueling equipment in 1992 and used the property as a maintenance operations base until selling the North Yard as described in Section 3.1.

3.1 North Yard

The following summarizes the chronology of the North Yard:

- 1925 – Standard Oil Company of California (later Chevron) developed North Yard and reportedly constructed the ASTs and piping.

- 1927 – Chevron constructed the garage along the northern boundary and the tank-truck loading racks.

- 1950 – Available maps show various small buildings and sheds associated with oil delivery on the southern portion on the North Yard.

- 1982 – Metro purchased the property for diesel fueling operations. Metro also used the North Yard property for parking, private offices, lunch and meeting rooms, restrooms, locker rooms, record storage, and a woodworking and paint shop.
- 1992 – Metro decommissioned fueling equipment and cleaned and capped pipelines leading from North Yard to South Yard.
- 1998 – Chevron, Metro, and Ecology entered into a CD for the Site.
- 2007 – Touchstone and Ecology entered into a PPCD for the North Yard.
- 2009 – Touchstone purchased the North Yard from Metro.

3.2 South Yard

The following summarizes the chronology of the South Yard:

- Prior to 1908 – Puget Sound Sheet Metal Works reportedly occupied the South Yard. A number of wood-frame buildings were reportedly present.
- 1912 – A tannery reportedly occupied the South Yard until the late 1920s.
- 1950 – Chevron used a building in the South Yard as a warehouse.
- 1960 – Chevron and a chemical company (California Spray and Chemical Company) reportedly occupied the South Yard. No information on California Spray and Chemical Company activities is available.
- 1982 – Metro purchased the South Yard property. Metro used the property in connection with its diesel fueling operations at the North Yard. Metro also used the South Yard property for storage of equipment and materials and for parking.
- 1992 – Metro decommissioned fueling equipment and cleaned and capped pipelines leading from North Yard to South Yard.
- 1998 – Chevron, Metro, and Ecology entered into a consent decree (CD) for the Site.

3.3 Public Right of Way between North and South Yard

Two sets of subsurface piping were used to transfer product from the South Yard to the North Yard. In 1992, the subsurface piping was cleaned and capped at the south wall of the AST containment area. In 1998, an inspection of piping pits and pipe connections indicated no surface or shallow (within 0.5 foot) petroleum staining or detection in the eight locations tested. The subsurface piping that was closed in place is located under the former North Yard office area, beneath the South Yard and under the dock.

4. Proposed Over-drilling/Piezometer and Soil Boring Installation

4.1 Access and Permitting

An access agreement between ARCADIS and Touchstone (site owner) is currently in place. ARCADIS will coordinate work with Touchstone, which will be performing construction activities during the DPE events. For piezometer and soil boring installation activities, a traffic control plan will be provided by National Barricade. Non-arterial road street/lane closure permits will be provided by the City of Seattle.

4.2 Utility Clearance and Permitting

A public utility clearance using Washington 811 dig alert will be conducted prior to drilling activities. In addition, a private utility locating company will be contracted to survey the Site for underground utilities using ground penetrating radar (GPR) and magnetic locating equipment. Prior to the arrival of the public and private utility locators, the proposed piezometer and soil boring locations shown on **Figure 2** will be marked. Several utilities, including water and gas lines, are known to exist on the Site in the area of proposed piezometer and soil boring locations. Extra caution will be taken to locate, and avoid these utilities.

4.3 Over-drilling MW-9

Well MW-9 will be over-drilled and reinstalled as a 6-inch-diameter well (MW-9R) to enhance DPE effectiveness. MW-9R will be constructed to maximize the groundwater flow area, minimize the likelihood of well fouling with fine-grained sediment accumulation, and allow the use of a larger-diameter down-hole stinger or pump in the well. The depth and screen interval of MW-9R will mirror that of MW-9, with a total depth of 22.5 feet below ground surface (ft bgs). The well will be constructed of 6-inch diameter schedule 40 polyvinyl chloride (PVC) with 0.02-inch slots from 22.5 to 12.5 ft bgs. The sand pack of

#10/20 silica sand will be placed around the well screen to 1 foot above the top of screen. Bentonite seal will be installed above the sand pack followed by neat cement to completion. A locking, water-tight well plug and flush-mounted, 18-inch–diameter, traffic-rated well box will be installed at ground surface.

To further enhance hydraulic conductivity between the well and surrounding formation, water jetting will be used to develop well MW-9R. Water jetting as a well development tool is conducted by introducing high velocity water into the well screen while simultaneously extracting water from the well. Water jetting is an extremely effective way of ensuring a hydraulic connection between the well and the formation by removing fine-grained sediments and fluids introduced during drilling. The Well Install Staging Area is shown on **Figure 3**.

4.4 Piezometer Installation and Construction

Two piezometers (PZ-1 and PZ-2) will be installed to monitor depth to water, measurable LNAPL, and vacuum radius of influence during the DPE events. PZ-1 will be located approximately 10 to 15 feet southwest and downgradient of extraction well MW-9R and installed to 22.5 ft bgs with a 10-foot-4-inch-diameter casing and a 0.02–inch slotted schedule 40 PVC screen. PZ-2 will be installed approximately 20 feet southeast and downgradient of extraction well MW-9R and advanced to 22.5 ft bgs with a 10-foot-4-inch-diameter casing and 0.02-inch slotted schedule 40 PVC screen. The sand pack of #10/20 silica sand will be placed around the well screen to 1 foot above the top of screen. Bentonite seal will be installed above the sand pack followed by neat cement to completion. A locking, water-tight well plug and flush-mounted, 10-inch–diameter, traffic-rated well box will be installed at ground surface. DPE piezometer locations are identified on **Figure 2**.

The initial 8 feet of the borehole will be cleared using an air-knife and vacuum truck to reduce the potential for damage to underground utilities.

During drilling, soil samples will be collected for lithological description by split spoon at 2.5-foot intervals from 2.5 ft bgs to 22.5 ft bgs at each boring. Soil samples will be screened in the field for volatile organic compounds (VOCs) using a photo-ionization detector (PID). PID readings, soil types, and other pertinent geologic data will be recorded on the boring log. The Well Install Staging Area is shown on **Figure 3**.

4.5 Soil Boring Installation

Two soil borings (SB-1 and SB-2) will be installed in the southern boundary of the North Yard to allow sampling in areas of historical soil exceedances. The borings will be advanced as shown on **Figure 2** between B-12, which contained concentrations of diesel range organics (DRO) in excess of the DRO cleanup level (CUL) at a depth of 12.5 ft bgs, and B-23, which contained concentrations of DRO in excess of the DRO CUL at a depth of 10 ft bgs. Samples will be collected at depths previously reported as containing COCs in excess of site CULs and at other depths if field screening indicates that LNAPL may be present (sheen testing). During drilling, soil samples will be collected for lithological description and chemical analysis at 2.5-foot intervals from 2.5 ft bgs to the bottom of the boring (20 ft bgs). The soil samples will be placed in laboratory-provided containers with appropriate preservatives and stored in an ice-chilled cooler prior to delivery to the analytical laboratory. Soil from each sample interval will be screened in the field for VOCs using a PID. Soil samples will be analyzed for the following:

- Gasoline range organics (GRO) by Northwest Method NWTPH-Gx, and
- DRO and heavy oil range organics (HO) by Northwest Method NWTPH-Dx.

PID readings, soil types, and other pertinent geologic data will be recorded on the boring log.

4.6 Hand Auger Installation

Two hand auger locations (HB-10 and HB-11) will be installed in the center of the South Yard to allow sampling in areas of historical soil exceedances. Soil borings locations are shown on **Figure 2** and samples will be collected at depths previously reported as containing COCs in excess of site CULs. HB-10 will be located in close proximity to historical borings HS4 and HB8. HS4 and HB8 contained concentrations of DRO in excess of the DRO CUL at depths of 0.3 ft bgs and 1 ft bgs, respectively. HB-11 will be placed in close proximity to historical boring HB7. Hand auger boring HB7 contained concentrations of lead in excess of the lead CUL at 4 ft bgs. All samples will be placed in laboratory-provided containers with appropriate preservatives and stored in an ice-chilled cooler prior to delivery to the analytical laboratory. Soil from each sample interval will be screened in the field for VOCs using a PID. Samples will be analyzed for the following:

- GRO by Northwest Method NWTPH-Gx;
- DRO and HO by Northwest Method NWTPH-Dx; and

- Total lead by U.S. Environmental Protection Agency (EPA) Method 6010 (HB-10 only).

PID readings, soil types, and other pertinent geologic data will be recorded on the boring log.

5. Dual Phase Extraction System Events

5.1 Introduction

The source of measurable LNAPL observed in MW-9 is within the North Yard property. Touchstone will be performing remedial excavation that will remove the LNAPL source such that remaining LNAPL will be located within a finite horizontal and vertical area immediately adjacent to MW-9. Following Touchstone's excavation, the remaining area where LNAPL may be present is estimated to be approximately 900 square feet (ft^2), compared to the nearly 40,000 ft^2 where LNAPL is currently distributed throughout the North Yard. To address this small area of remaining LNAPL in the immediate vicinity of MW-9, DPE events will be conducted while Touchstone has the North Yard dewatered for excavation.

DPE has been used to remove LNAPL observed at the Site but efforts were not successful because of the large plume footprint coupled with fine-grained materials, which limited the effectiveness when DPE was applied on select wells. With the proposed dewatering and additional source removal through excavation, DPE will be focused on the very limited area where LNAPL remains around MW-9. During periods of falling water table conditions, like those that will occur when Touchstone dewaters the North Yard during excavation activities, the LNAPL volume trapped in soil under two-phase conditions (water-saturated soil) located below the natural static water table is progressively exposed to three-phase conditions (air-water-LNAPL) as the soil is desaturated. Under three-phase conditions, LNAPL droplets in the soil coalesce, and the LNAPL phase is more mobile for a given saturation than under two-phase conditions. This enhances the mobility of the LNAPL in the desaturated soil interval and causes LNAPL thickness to increase when the water table elevation drops. As the water table falls, LNAPL recovery is much more efficient via gravity drainage (fluid extraction events). In some cases, applied high vacuum in conjunction with fluid extraction (DPE configuration) can further enhance liquid drainage by improving the dewatering cone of depression around the extraction well.

5.2 Dual Phase Extraction System and Equipment

A mobile DPE remediation trailer owned and operated by ARCADIS will be utilized during the DPE events. Enclosed within the mobile trailer is a 15 horsepower rotary claw blower capable of moving air at 320 cubic feet per minute at 22 inches of mercury vacuum. The high vacuum blower extracts both liquid and vapors through a system manifold to a vapor/liquid knockout tank. A pump capable of handling 15 gallons per minute (gpm) of water then transfers liquids into an oil/water separator while vapor is routed through two granular activated carbon vessels prior to discharge to the atmosphere. The oil/water separator removes LNAPL from the liquid stream into a product storage tank while separated groundwater is pumped into a 630-gallon polyethylene tank temporarily stored onsite. The tank will be staged just south of the DPE trailer within secondary containment.

A 2-inch–diameter, reinforced, flexible PVC vacuum hose will be connected to a temporary DPE manifold containing a differential pressure gauge connected to a pitot tube for air flow measurements, a vapor sampling port, a vacuum gauge, and flow control valve. If high levels of moisture are observed in the manifold, PID measurements and flow rates can be collected from the sampling port located after the knockout tank within the system trailer. An aboveground hose will connect the manifold to the extraction wellhead using a jet pump well seal to allow for an airtight seal around the groundwater extraction stinger. The mobile trailer will be placed within a secondary containment berm to ensure that impacted groundwater is not released back to the ground surface in case of a spill. The enclosed trailer houses critical components to ensure that automatic shutdown occurs under an alarm condition and will allow for continuous operation without constant operator oversight. This system will be temporarily staged in an exclusion zone in the southwestern parking strip of Woodlawn Avenue North (in close proximity to MW-9R). A portable tow-behind diesel generator will power the system trailer and be staged in front of the trailer within secondary containment. Scheduled diesel refills will be made prior to start of the event. The potential locations of the DPE work area are shown on **Figure 4**. The location of the DPE trailer will be determined prior to starting work as to establish a work area that will not impact construction activities being conducted in the North Yard.

During DPE operation, system readings, including runtime, flow rates, VOC concentrations, flow totalizer values, and system vacuum, will be measured periodically.

Additional field equipment needed during DPE events include:

- PID
- 5-Gas Air Monitor
- Magnehelic Gauges
- Digital Manometer

- Extraction wellhead adaptors with vacuum gauges, stinger ports, and bleed valves (see **Figure 1**) for 6-inch well
- In-Line Manifold with cam locks and parameter collection ports
- Monitoring wellhead adaptors with vacuum gauges (one 6-inch well Campbell seal)
- Pitot Tube
- Handheld Anemometer
- Fire Extinguisher
- First Aid Kit with emergency eye wash
- Oil/water interface probe
- Lower explosive limit (LEL) meter
- Pressure transducers (2)
- Gast Air sampling pump

5.3 Pre-mob Office Work

Special consideration will be given to ensure that ARCADIS equipment will not interfere with Touchstone's construction activities. ARCADIS field staff will review the field implementation plan and discuss with the project team the site-specific hazards and the sequence of activities that need to be conducted during a kick-off meeting. The site-specific health and safety plan (HASP) addresses the risks and hazards associated with DPE activities. Task-specific job safety analyses (JSAs) have been developed for specific activities. A copy of the HASP will be maintained onsite.

5.4 DPE System Setup Procedures

Twenty-four hours before the start of the field event, ARCADIS will barricade off the parking strip exclusion zone to prevent parked vehicles from blocking the staging area. System setup will include staging and locating the remediation trailer onto secondary containment. Prior to system startup, emergency shutoffs will be reviewed and all emergency equipment (first aid kit, eye wash, fire extinguisher, etc.) will be placed in a marked location. Additionally, depth to water using an oil/water interface probe and monitoring well headspace for VOCs concentrations using a PID will be measured at monitoring well MW-9R and piezometers PZ-1 and PZ-2.

A 2-inch-diameter Schedule 40 PVC or flexible reinforced PVC hose stinger will be placed within the well. The stinger inlet will be set 3 feet below water level or 6 inches above the bottom of the casing if measurable groundwater is not observed. Vacuum will then be applied to MW-9R using the DPE system trailer. The vacuum should be adjusted so that the stinger vacuum and casing vacuum ratio approaches 1:1. Target vacuum should be greater than 8 inches of mercury measured at the wellhead.

To ensure the system is optimized for DPE, the following parameters should be collected every half hour for the first 4 hours of system operation:

- Extraction well casing vacuum
- Stinger vacuum
- Baseline and recharge LNAPL/water levels in MW-9R
- Vacuum, LNAPL, and water levels in PZ-1 and PZ-2
- Vacuum in system blower
- Influent PID/flame ionization detector (FID) reading
- Total volume of extracted groundwater and LNAPL

5.5 Dual Phase Extraction Operation

Based on collected system parameters, the casing bleed valve, applied vacuum rates, and stinger depths will be adjusted to target the casing to a stinger vacuum ratio of 1:1. If casing vacuum is much lower than the applied stinger vacuum, the casing bleed valve should be opened. If casing/stinger vacuum ratios approach 1:1 at an applied vacuum rate on the casing of less than 8 inches of mercury, a downhole pump may be installed within the well to enhance dewatering. Once target operating parameters have been reached, parameters need to be periodically recorded at the following frequency:

Time Elapsed	Frequency
0-4 hours	Every 0.5 hour
4-8 hours	Every 1-4 hours
8-120 hours	Twice per day

Based on the schedule shown above, the following parameters will be recorded in **Table 1**:

- Vacuum and flow at the manifold or post knockout tank
- Casing vacuum
- Vacuum at the well casing
- Total extracted volume of water in oil/water separator and containment tank
- Breathing zone 5 gas readings

After every complete field day, field personnel will call the ARCADIS engineer to discuss the system run status.

5.6 Post-Event Monitoring

Upon completion of the initial DPE event, well MW-9R and piezometers PZ-1 and PZ-2 will be gauged every 10 days. If measurable LNAPL is discovered, as many as two additional DPE events may be performed.

6. Surfactant Injections

6.1 Introduction

As a contingency during subsequent DPE events, surfactant may be used to enhance LNAPL removal. Surfactant injection and subsequent extraction have been successfully used as an alternative soil and groundwater remediation solution at LNAPL-impacted sites.

Removal of LNAPL from the soil matrix is difficult due to adsorption to the soil matrix and the high interfacial tension between LNAPL and groundwater (Flaming et al., 2003). The addition of surfactants into the subsurface affects LNAPL recoverability and aids in its removal through several mechanisms (Bai, 1997) such as:

- changes in the interfacial tension between LNAPL and groundwater
- decreases in the viscosity of LNAPL
- desorbtion of residual LNAPL entrained in the soil matrix

- formation of micelles that micro-emulsify the organic components of LNAPL, making the petroleum more readily available for subsequent biodegradation in the aqueous phase (Tworkowski and Baer, undated)

Other advantages of surfactant injection include increased biodegradation following LNAPL removal. Several studies indicate a temporary increase in the solubility of LNAPL and an increased dissolution of molecules in the aqueous phase, which increases the bioavailability to microorganisms (Paria, 2007). Also, the surfactant injection/extraction work can serve as a diagnostic tool. If the surfactant injection/extraction effectively removes LNAPL from around a monitoring well and the well does not recharge, then the LNAPL is truly residual and immobile, not drainable, and thus not capable of flowing from zones outside of the surfactant treatment influence into the monitoring well.

6.2 Surfactant Application

Prior to surfactant injection, well MW-9R and piezometers PZ-1 and PZ-2 will be registered with the Underground Injection Control (UIC) Program with Ecology. Permitting with the UIC Program will be initiated upon approval of this work plan in the event that surfactant injection is required

Before the first injection event, well MW-9R and piezometers PZ-1 and PZ-2 will be gauged with an oil/water interface probe to verify the presence of LNAPL in the wells. Baseline oxidation-reduction potential (ORP) and conductivity measurements will be collected using a YSI-556 meter or equivalent in monitoring well MW-9R and will be compared to historical groundwater monitoring data. Also, surfactant will be measured in extracted groundwater samples to assess the extent of residual surfactant concentration in the well during extraction. During the pilot test, only monitoring well MW-9R will be used for injection so that the groundwater in piezometers PZ-1 and PZ-2 can be evaluated to verify that the surfactant does not travel beyond the vicinity of the injected borehole.

A 4 percent solution of the biosurfactant “Release,” manufactured by Environmental Chemical Solutions and sold under the Gold Crew label, (or similar product) will be gravity fed into monitoring well MW-9R at a controlled flow rate. Release was chosen due to its ability to lower surface tension and to promote biodegradation of residual hydrocarbon impacts. The biosurfactant is nontoxic, food grade, non-ionic, and biodegradable. Results of testing using the California Department of Health Services 96-hour Acute Aquatic Toxicity Screening Test of a similar Gold Crew product, Gold Crew – 150, in a mixture with diesel fuel show the mixture is non-hazardous. The Release information, material safety data sheet, and toxicity information are included in **Appendix C**.

A mixing tank will be used to mix a 4 percent solution of surfactant and water obtained from the municipal water supply. A flow totalizer will be used to apply the surfactant by gravity feed into the well. The surfactant will not be injected under pressure to minimize the potential outward displacement of LNAPL. This will allow the surfactant to soak the near-borehole soil and create the groundwater-surfactant-LNAPL emulsion for subsequent extraction.

ORP and conductivity readings from piezometers PZ-1 and PZ-2 will be logged from periodically collecting parameters immediately before surfactant application and during injection. Readings will be confirmed by obtaining one groundwater sample with a disposable bailer prior to surfactant injection and following every 25 gallons of surfactant solution injected. Groundwater will be placed in a clear, unused glass jar, shaken vigorously, and examined for bubbles. An increase in conductivity confirmed with the presence of soap bubbles in the jar will indicate downgradient migration of surfactant and injection will cease. Results will be monitored to identify when cessation of surfactant application is required.

Upon completing the injection, conductivity and ORP in piezometers PZ-1 and PZ-2 will be monitored for an additional 60 minutes to determine if surfactant migrated. Prior to extraction on the following day, conductivity and ORP measurements will be taken from well MW-9R and piezometers PZ-1 and PZ-2.

6.3 Surfactant Extraction

The surfactant will be allowed to remain in the subsurface overnight before extraction is conducted on the treatment well (MW-9R). The mobile DPE system will be connected to the surfactant application well via a wellhead adaptor and a PVC “stinger” for extraction operations. The PVC “stinger” will be set at approximately 3 feet below the groundwater level to improve recovery.

Previous pilot tests for surfactant treatment of soils indicate that sufficient surfactant removal occurs after extracting three times the volume of applied surfactant. Extraction will be paused three times to allow periodic monitoring of the extracted groundwater in the vacuum truck tank to evaluate the presence of surfactant and LNAPL and collect groundwater samples from the well for visual inspection. These pauses will also allow groundwater to recharge in the monitoring well, potentially improving recovery. Additional groundwater will be extracted if deemed necessary by the field staff.

Visual inspections of the extracted water should indicate a Winsor Type III reaction showing three distinct phases of petroleum hydrocarbon impacts (see photograph on Release informational sheet in **Appendix C**). Observations should indicate a dissolved phase, a micro-emulsion phase, and an LNAPL phase in the sample. Mobile DPE will continue until the Windsor Type III characteristics or bubbles are no longer observed and visual characterization indicates that a sufficient volume of the groundwater-surfactant-LNAPL emulsion has been recovered.

A spike above background conductivity or a decrease in ORP may also indicate the presence of surfactant. If the surfactant is suspected to be left in the well or has migrated to PZ-1 or PZ-2, extraction may be continued for a longer period of time. Adjustments to the injection/extraction schedule will be made in the field to verify that the surfactant is recovered. Extraction events will continue after no evidence of surfactant is found in MW-9R, PZ-1, or PZ-2. The event will continue under normal DPE procedures.

6.4 Contingency Plan

In the unlikely event that measureable LNAPL is still present in MW-9R or PZ-1 and/or PZ-2 after the third DPE event, then other source removal actions will be evaluated. If this occurs, Chevron, and Metro will schedule a meeting with Ecology to discuss remedial alternatives to address remaining source materials.

7. Groundwater Monitoring Program Changes

7.1 Groundwater Monitoring Event Schedule

Baseline compliance groundwater monitoring will be conducted prior to cleanup actions in the North Yard. It is anticipated that the baseline compliance monitoring event will be conducted in June 2014 and consist of sampling the following points of compliance (POCs), as per the approved CAP:

- North Yard: monitoring wells MW-19, MW-20, and MW-21
- South Yard: monitoring wells MW-4, MW-7, MW-8A, MW-25, MW-26, AGI-2, and MLU-1 through MLU-3
- All other wells will be gauged for the presence of LNAPL. In particular, monitoring wells MW-3, MW-9, MW-10, MW-27, SMPN-1, SMPN-2, and SMPN-3.

Once cleanup actions are complete in the North Yard, compliance groundwater monitoring events will be conducted. In a meeting with Chevron, Metro, and Ecology on May 1, 2014, Ecology agreed to change the groundwater monitoring frequency to semi-annually. It is anticipated that the first compliance groundwater monitoring event will be conducted in November 2014, or within one month of North Yard excavation completion. North and South Yard compliance wells are noted above. Gauging of all other monitoring wells will continue on a semi-annual basis with the exception of monitoring wells MW-3, MW-10, MW-27, and SMPN-1 through SMPN-3 because these wells will be removed during North Yard cleanup actions. Groundwater compliance will be achieved upon five consecutive semi-annual groundwater monitoring events with analytical results less than the groundwater CULs. If the first event is conducted in November 2014, the proposed compliance groundwater monitoring schedule will be as follows:

Proposed Compliance Groundwater Monitoring Schedule

November 2014	May 2015	November 2015
March 2016	September 2016	

The semi-annual schedule is proposed to shift to the first and third quarters of the year to compensate for seasonal variability. The proposed schedule may change based on the actual construction schedule for the North Yard.

7.2 Filtered Samples for cPAHs

During each sampling event since 2012, one unfiltered and one field filtered sample (i.e., two separate samples) have been collected for carcinogenic polyaromatic hydrocarbons (cPAHs) to determine whether cPAHs detected in excess of CULs are dissolved or sorbed to fine-grained sediments. Results from the filtered samples were considered only when concentrations of cPAHs are detected in the unfiltered samples. Chevron and Metro have requested that filtered samples for cPAHs be considered as viable confirmation samples. During the May 1, 2014 meeting between Chevron, Metro, and Ecology, Ecology approved the use of filtered samples for cPAHs as compliance samples effective in May 2014. Beginning with the June 2014 baseline groundwater monitoring event, and each subsequent event, only filtered cPAH samples will be submitted for analysis.

8. Summary Report Preparation

DPE events will be summarized in a report following the completion of the final event. Groundwater sampling and gauging results will be presented in a Baseline Groundwater Monitoring Report to be submitted by the end of August 2014.

9. References

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Figures

Appendix A

Standard Operating Procedures – Well Installation

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Appendix B

Standard Operating Procedures – Well Development

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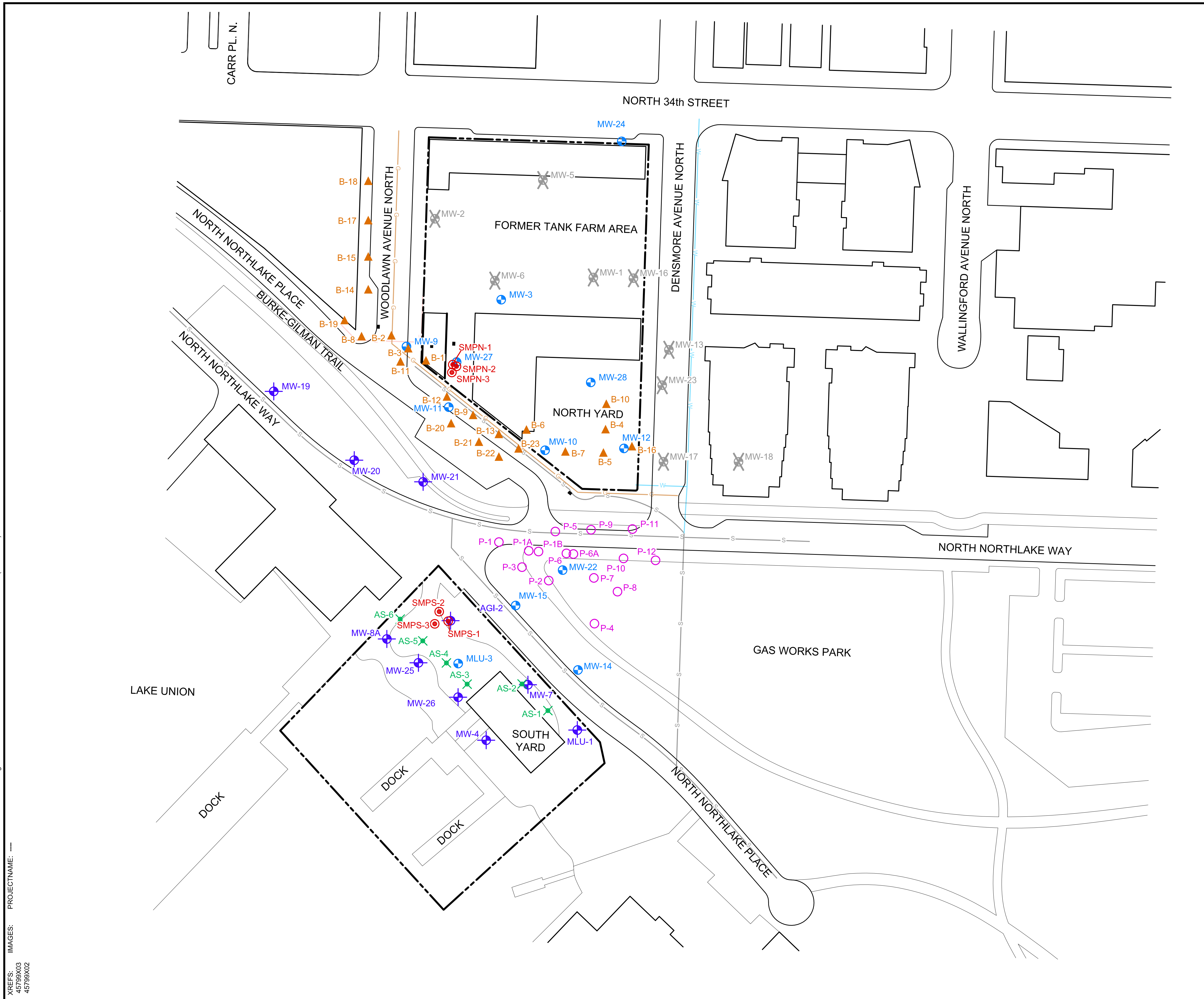
Appendix C

Surfactant Material Safety Data Sheet



LEGEND:

- 2007 BORING LOCATIONS
- GROUNDWATER MONITORING WELL
- ABANDONED MONITORING WELL
- BIOSPARGE INJECTION WELL
- COMPLIANCE MONITORING WELL
- SEPARATE–PHASE MONITORING POINT LOCATION
- CATCH BASIN
- SOIL BORING LOCATION
- NATURAL GAS LINE (APPROX.)
- UNDERGROUND ELECTRIC LINE (APPROX.)
- WATER LINE (APPROX.)
- SEWER LINE (APPROX.)

NOTES:

1. BASE MAP FROM A DRAWING BY SAIC TITLED "SITE MAP", DATED 09–14–07, @ A SCALE OF 1" = 60'. REVISED IN ACCORDANCE WITH A SURVEY DRAWING BY OTAK CONDUCTED IN APRIL & MAY, 2011.
2. ALL LOCATIONS OTHER THAN MONITORING WELLS ARE APPROXIMATE.

0 100' 200'

GRAPHIC SCALE

FORMER CHEVRON BULK PLANT No. 100-1327
FACILITIES NORTH / KING COUNTY (METRO)
SEATTLE, WASHINGTON

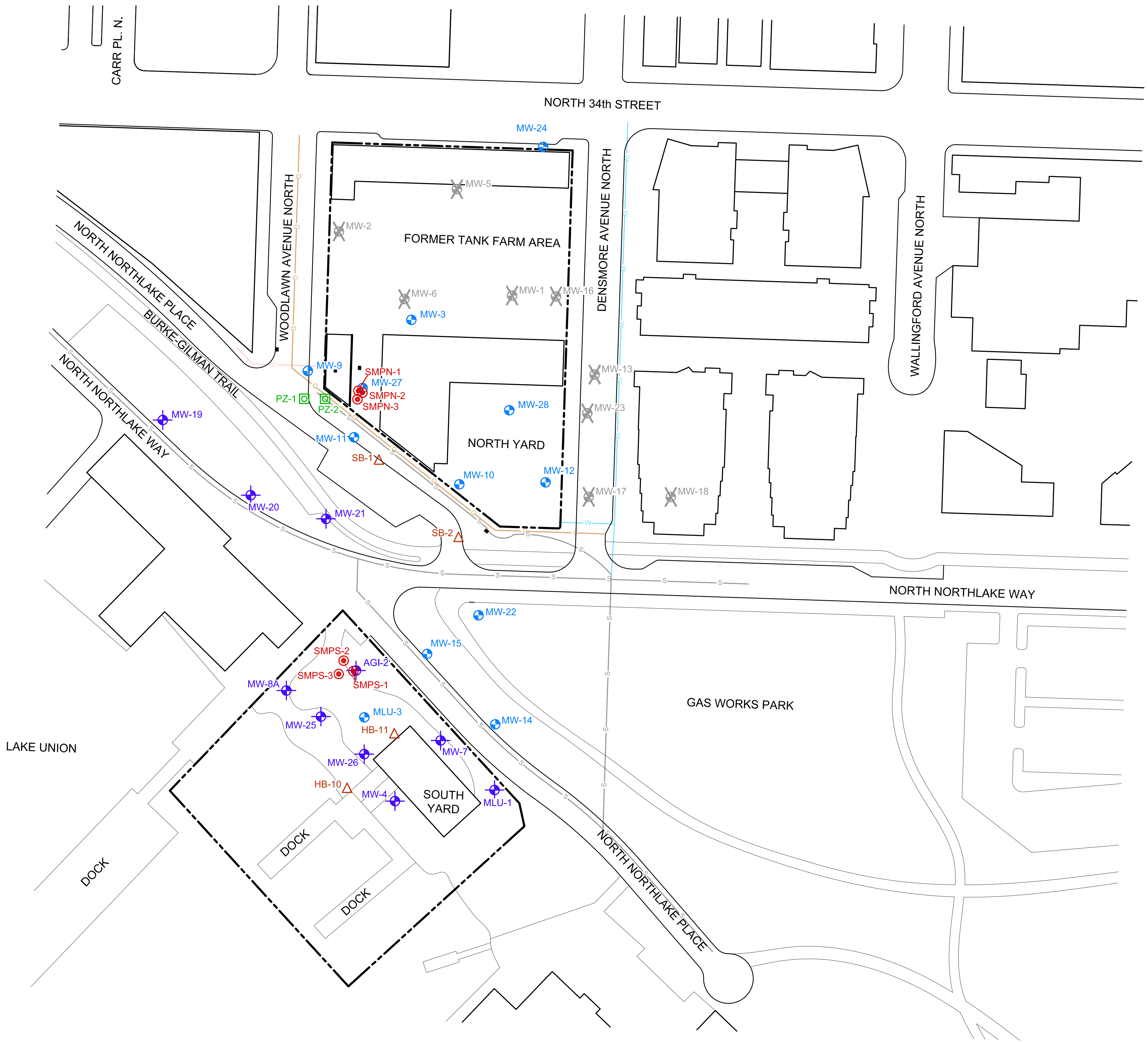
CLEANUP ACTION PLAN COMPLIANCE WORK PLAN

SITE PLAN

ARCADIS

FIGURE

1



LEGEND:

- PROPOSED SOIL BORING LOCATION
- PROPOSED PIEZOMETER LOCATION
- GROUNDWATER MONITORING WELL
- ABANDONED MONITORING WELL
- COMPLIANCE MONITORING WELL
- SEPARATE–PHASE MONITORING POINT LOCATION
- CATCH BASIN
- NATURAL GAS LINE (APPROX.)
- UNDERGROUND ELECTRIC LINE (APPROX.)
- WATER LINE (APPROX.)
- SEWER LINE (APPROX.)

NOTES:

1. BASE MAP FROM A DRAWING BY SAIC TITLED "SITE MAP", DATED 09–14–07, @ A SCALE OF 1" = 60'. REVISED IN ACCORDANCE WITH A SURVEY DRAWING BY OTAK CONDUCTED IN APRIL & MAY, 2011.
2. ALL LOCATIONS OTHER THAN MONITORING WELLS ARE APPROXIMATE.

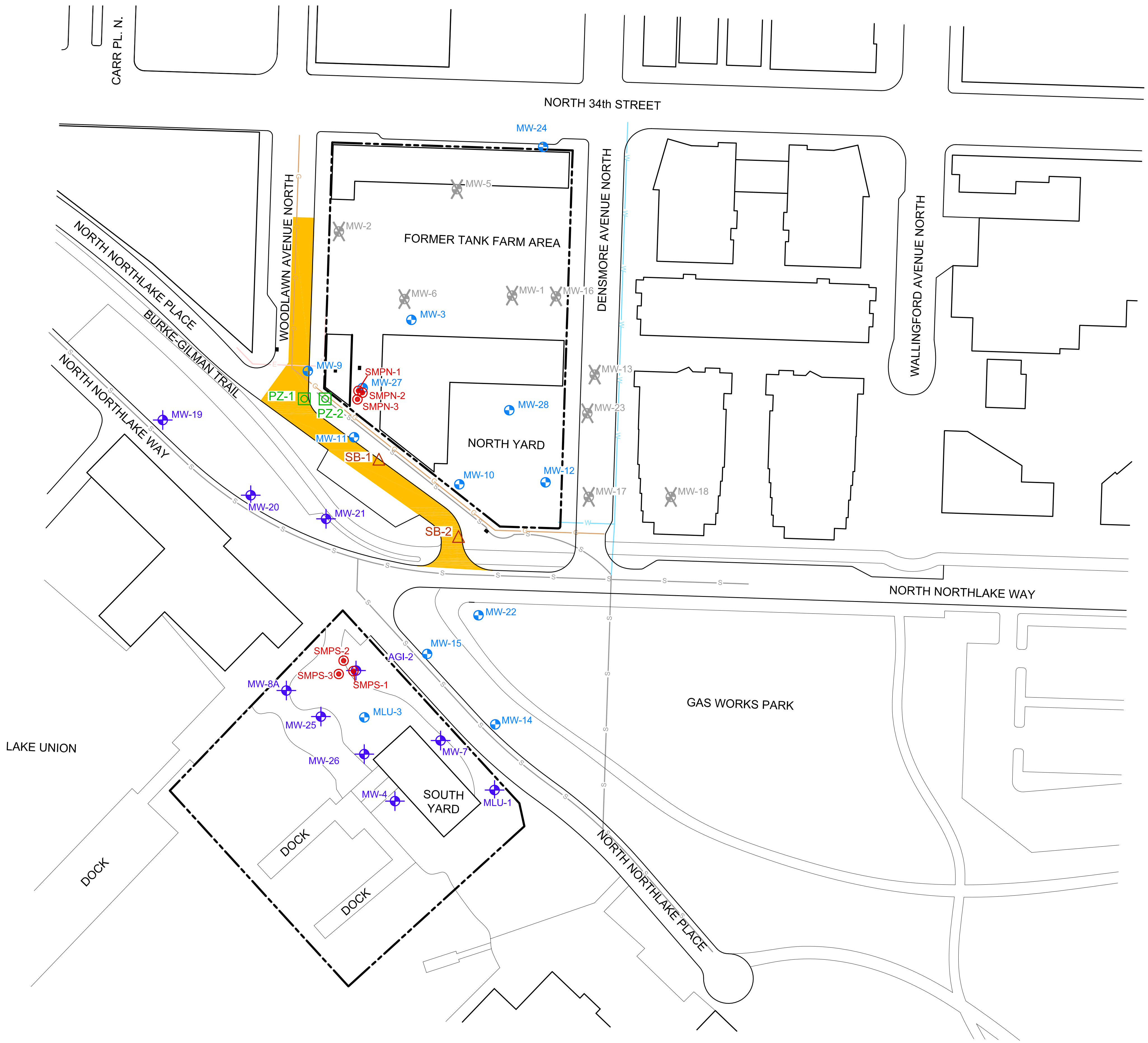
0 100' 200'
GRAPHIC SCALE

FORMER CHEVRON BULK PLANT No. 100-1327
FACILITIES NORTH / KING COUNTY (METRO)
SEATTLE, WASHINGTON
CLEANUP ACTION PLAN COMPLIANCE WORK PLAN

PROPOSED PIEZOMETER / SOIL BORING LOCATIONS

ARCADIS

FIGURE
2



LEGEND:

- WELL INSTALL STAGING AREA
- PROPOSED SOIL BORING LOCATION
- PROPOSED PIEZOMETER LOCATION
- GROUNDWATER MONITORING WELL
- ABANDONED MONITORING WELL
- COMPLIANCE MONITORING WELL
- SEPARATE-PHASE MONITORING POINT LOCATION
- CATCH BASIN
- NATURAL GAS LINE (APPROX.)
- UNDERGROUND ELECTRIC LINE (APPROX.)
- WATER LINE (APPROX.)
- SEWER LINE (APPROX.)

NOTES:

1. BASE MAP FROM A DRAWING BY SAIC TITLED "SITE MAP", DATED 09-14-07, @ A SCALE OF 1" = 60'. REVISED IN ACCORDANCE WITH A SURVEY DRAWING BY OTAK CONDUCTED IN APRIL & MAY, 2011.
2. ALL LOCATIONS OTHER THAN MONITORING WELLS ARE APPROXIMATE.

0 100' 200'

GRAPHIC SCALE

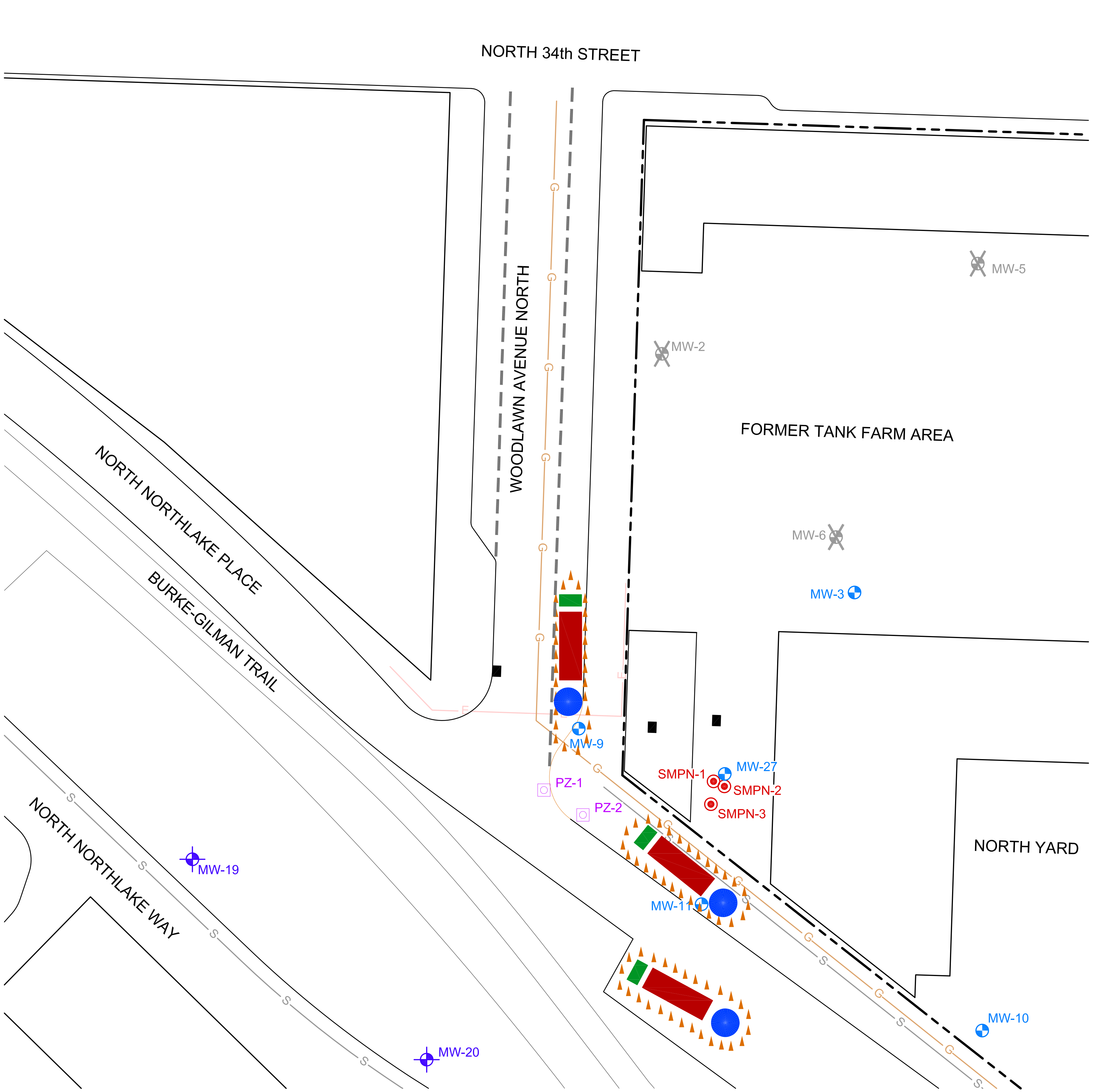
FORMER CHEVRON BULK PLANT No. 100-1327
FACILITIES NORTH / KING COUNTY (METRO)
SEATTLE, WASHINGTON

CLEANUP ACTION PLAN COMPLIANCE WORK PLAN

WELL INSTALL STAGING AREA

ARCADIS

FIGURE 3



LEGEND:

- GROUNDWATER MONITORING WELL
- ABANDONED MONITORING WELL
- COMPLIANCE MONITORING WELL
- SEPARATE–PHASE MONITORING POINT LOCATION
- PROPOSED PIEZOMETER LOCATION
- CATCH BASIN
- PARKING LANE

PROPOSED SETUP LOCATIONS:

- TRAFFIC BARRICADES/CAUTION TAPE
- DPE SYSTEM TRAILER (8'x24')
- SYSTEM GENERATOR
- 6,500 GALLON TANK (10' DIAMETER)

NOTE:

1. BASE MAP FROM A DRAWING BY SAIC TITLED "SITE MAP", DATED 09–14–07, @ A SCALE OF 1"=60'. REVISED IN ACCORDANCE WITH A SURVEY DRAWING BY OTAK CONDUCTED IN APRIL & MAY, 2011.
2. ALL LOCATIONS OTHER THAN MONITORING WELLS ARE APPROXIMATE.

0 40' 80'
GRAPHIC SCALE

FORMER CHEVRON BULK PLANT No. 100-1327
FACILITIES NORTH / KING COUNTY (METRO)
SEATTLE, WASHINGTON
CLEANUP ACTION PLAN COMPLIANCE WORK PLAN

DUAL PHASE EXTRACTION SETUP/ TRAILER SITE PLAN

ARCADIS

FIGURE 4

CITY: SYRACUSE NY DIV/GROUP: ENVCAD DB: E. KRAHMER LD:(Opt) PIC: M. FLEISCHNER PM/TM: S. ZORN TR: S. McGUIRE LYR:(Opt)ON=*;OFF=*REF*
G:\ENVCAD\SYRACUSE\ACT\B0045799\0009\00100\DWG\45799G03.dwg LAYOUT: 4 SAVED: 6/13/2014 1:23 PM ACADVER: 18.1S (LMS TECH) PAGESETUP: --- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 6/13/2014 1:24 PM BY: KRAHMER, ERIC
XREFS: 45799X02 IMAGES: PROJECTNAME: ---

ARCADIS

Appendix A

Standard Operating Procedures –
Well Install

Infrastructure, environment, facilities

Imagine the result

Monitoring Well Installation

Rev. #: 3

Rev Date: February 2, 2011

Approval Signatures

Prepared by: ______________________ Date: 2/2/2011

Reviewed by: ______________________ Date: 2/2/2011
(Technical Expert)

I. Scope and Application

The procedures set out herein are designed to produce standard groundwater monitoring wells suitable for: (1) groundwater sampling, (2) water level measurement, (3) bulk hydraulic conductivity testing of formations adjacent to the open interval of the well.

Monitoring well boreholes in unconsolidated (overburden) materials are typically drilled using the hollow-stem auger drilling method. Other drilling methods that are also suitable for installing overburden monitoring wells, and are sometimes necessary due to site-specific geologic conditions, include: drive-and-wash, spun casing, Rotasonic, dual-rotary (Barber Rig), and fluid/mud rotary with core barrel or roller bit. Direct-push techniques (e.g., Geoprobe or cone penetrometer) and driven well points may also be used in some cases within the overburden. Monitoring wells within consolidated materials such as bedrock are commonly drilled using water-rotary (coring or tri-cone roller bit), air rotary or Rotasonic methods. The drilling method to be used at a given site will be selected based on site-specific consideration of anticipated drilling/well depths, site or regional geologic knowledge, type of monitoring to be conducted using the installed well, and cost.

No oils or grease will be used on equipment introduced into the boring (e.g., drill rod, casing, or sampling tools). No polyvinyl chloride (PVC) glue/cement will be used in constructing or retrofitting monitoring wells that will be used for water-quality monitoring. No coated bentonite pellets will be used in the well drilling or construction process. Specifications of materials to be installed in the well will be obtained prior to mobilizing onsite, including:

- well casing;
- bentonite;
- sand; and
- grout.

Well materials will be inspected and, if needed, cleaned prior to installation.

II. Personnel Qualifications

Monitoring well installation activities will be performed by persons who have been trained in proper well installation procedures under the guidance of an experienced field geologist, engineer, or technician. Where field sampling is performed for soil or bedrock characterization, field personnel will have undergone in-field training in soil or bedrock description methods, as described in the appropriate SOP(s) for those activities.

III. Equipment List

The following materials will be available during soil boring and monitoring well installation activities, as required:

- Site Plan with proposed soil boring/well locations;
- Work Plan or Field Sampling Plan (FSP), and site Health and Safety Plan (HASP);
- personal protective equipment (PPE), as required by the HASP;
- traffic cones, delineators, caution tape, and/or fencing as appropriate for securing the work area, if such are not provided by drillers;
- appropriate soil sampling equipment (e.g., stainless steel spatulas, knife);
- soil and/or bedrock logging equipment as specified in the appropriate SOPs;
- appropriate sample containers and labels;
- drum labels as required for investigation derived waste handling;
- chain-of-custody forms;
- insulated coolers with ice, when collecting samples requiring preservation by chilling;
- photoionization detector (PID) or flame ionization detector (FID);
- ziplock style bags;
- water level or oil/water interface meter;
- locks and keys for securing the well after installation;
- decontamination equipment (bucket, distilled or deionized water, cleansers appropriate for removing expected chemicals of concern, paper towels);

- field notebook.

Prior to mobilizing to the site, ARCADIS personnel will contact the drilling subcontractor or in-house driller (as appropriate) to confirm that appropriate sampling and well installation equipment will be provided. Specifications of the sampling and well installation equipment are expected to vary by project, and so communication with the driller will be necessary to ensure that the materials provided will meet the project objectives. Equipment typically provided by the driller could include:

- drilling equipment required by the American Society of Testing and Materials (ASTM) D 1586, when performing split-spoon sampling;
- disposable plastic liners, when drilling with direct-push equipment;
- drums for investigation derived waste;
- drilling and sampling equipment decontamination materials;
- decontamination pad materials, if required; and
- well construction materials.

IV. Cautions

Prior to beginning field work, underground utilities in the vicinity of the drilling areas will be delineated by the drilling contractor or an independent underground utility locator service. See separate SOP for utility clearance.

Some regulatory agencies require a minimum annular space between the well or permanent casing and the borehole wall. When specified, the minimum clearance is typically 2 inches on all sides (e.g., a 2-inch diameter well requires a 6-inch diameter borehole). In addition, some regulatory agencies have specific requirements regarding grout mixtures. Determine whether the oversight agency has any such requirements prior to finalizing the drilling and well installation plan.

If dense non-aqueous phase liquids (DNAPL) are known or expected to exist at the site, refer to the DNAPL Contingency Plan SOP for additional details regarding drilling and well installation to reduce the potential for inadvertent DNAPL remobilization.

Similarly, if light non-aqueous phase liquids (LNAPLs) are known or expected to be present as “perched” layers above the water table, refer to the DNAPL Contingency

Plan. Follow the general provisions and concepts in the DNAPL contingency plan during drilling above the water table at known or expected LNAPL sites.

Avoid using drilling fluids or materials that could impact groundwater or soil quality, or could be incompatible with the subsurface conditions.

Similarly, consider the material compatibility between the well materials and the surrounding environment. For example, PVC well materials are not preferred when DNAPL is present. In addition, some groundwater conditions leach metals from stainless steel.

Water used for drilling and sampling of soil or bedrock, decontamination of drilling/sampling equipment, or grouting boreholes upon completion will be of a quality acceptable for project objectives. Testing of water supply should be considered.

Specifications of materials used for backfilling bore hole will be obtained, reviewed and approved to meet project quality objectives. Bentonite is not recommended where DNAPLs are likely to be present. In these situations, neat cement grout is preferred.

No coated bentonite pellets will be used in monitoring well construction, as the coating could impact the water quality in the completed well.

Monitoring wells may be installed with Schedule 40 polyvinyl chloride (PVC) to a maximum depth of 200 feet below ground surface (bgs). PVC monitoring wells between 200 and 400 feet total depth will be constructed using Schedule 80 PVC. Monitoring wells deeper than 400 feet will be constructed using steel.

V. Health and Safety Considerations

Field activities associated with monitoring well installation will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities.

VI. Procedures

The procedures for installing groundwater monitoring wells are presented below:

Hollow-Stem Auger, Drive-and-Wash, Spun Casing, Fluid/Mud Rotary, Rotasonic, and Dual-Rotary Drilling Methods

1. Locate boring/well location, establish work zone, and set up sampling equipment decontamination area.

2. Advance boring to desired depth. Collect soil and/or bedrock samples at appropriate interval as specified in the Work Plan and/or FSP. Collect, document, and store samples for laboratory analysis as specified in the Work Plan and/or FSP. Decontaminate equipment between samples in accordance with the Work Plan and/or FSP. A common sampling method that produces high-quality soil samples with relatively little soil disturbance is the ASTM D 1586 - Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils. Split-spoon samples are obtained during drilling using hollow-stem auger, drive-and-wash, spun casing, and fluid/mud rotary. Rotasonic drilling produces large-diameter soil cores that tend to be more disturbed than split-spoon samples due to the vibratory action of the drill casing. Dual-rotary removes cuttings by compressed air and allows only a general assessment of geology. High-quality bedrock samples can be obtained by coring.

3. Describe each soil or bedrock sample as outlined in the appropriate SOP. Record descriptions in the field notebook and/or personal digital assistant (PDA). It should be noted that PDA logs must be electronically backed up and transferred to a location accessible to other project team members as soon as feasible to retain and protect the field data. During soil boring advancement, document all drilling events in field notebook, including blow counts (number of blows required to advance split-spoon sampler in 6-inch increments) and work stoppages. Blow counts will not be available if Rotasonic, dual-rotary, or direct-push methods are used. When drilling in bedrock, the rate of penetration (minutes per foot) is recorded.

4. If it is necessary to install a monitor well into a permeable zone below a confining layer, particularly if the deeper zone is believed to have water quality that differs significantly from the zone above the confining layer, then a telescopic well construction should be considered. In this case, the borehole is advanced approximately 3 to 5 feet into the top of the confining layer, and a permanent casing (typically PVC, black steel or stainless steel) is installed into the socket drilled into the top of the confining layer. The casing is then grouted in place. The preferred methods of grouting telescoping casings include: pressure-injection grouting using an inflatable packer installed temporarily into the base of the casing, such that grout is injected out the bottom of the casing until it is observed at ground surface outside the casing; displacement-method grouting (also known as the Halliburton method), which entails filling the casing with grout and displacing the grout out the bottom of the casing by pushing a drillable plug, typically made of wood to the bottom of the casing, following by tremie grouting the remainder of the annulus outside the casing; or tremie grouting the annulus surrounding the casing using a tremie pipe installed to the base of the borehole. In all three cases, the casing is grouted to the ground

surface, and the grout is allowed to set prior to drilling deeper through the casing. Site-specific criteria and work plans should be created for the completion of non-standard monitoring wells, including telescopic wells.

5. In consolidated formations such as competent bedrock, a monitoring well may be completed with an open borehole interval without a screen and sandpack. In these cases, the borehole is advanced to the targeted depth of the top of the open interval. A permanent casing is then grouted in place following the procedures described in Step 4 above. After the grout sets, the borehole is advanced by drilling through the permanent casing to the targeted bottom depth of the open interval, which then serves as the monitoring interval for the well. If open-borehole interval stability is found to be questionable or if a specific depth interval is later selected for monitoring, a screened monitoring well may later be installed within the open-borehole interval, depending on the annular space and well diameter requirements.

6. Before installing a screened well – or after drilling an open-bedrock well –, it is important to confirm that the borehole has been advanced into the saturated zone. This is particularly important for wells installed to monitor the water table and/or the shallow saturated zone, as the capillary fringe may cause soils above the water table to appear saturated. If one or more previously installed monitoring wells exist nearby, use the depth to water at such well(s) to estimate the water-table depth at the new borehole location.

   To verify that the borehole has been advanced into the saturated zone, it is necessary to measure the water level in the borehole. For boreholes drilled without using water (e.g., hollow-stem auger, cable-tool, air rotary, air hammer), verify the presence of groundwater (and /or LNAPL, if applicable) in the borehole using an electronic water level probe, oil-water interface probe, or a new or decontaminated bailer. For boreholes drilled using water (e.g., drive and wash, spun-casing with roller-bit wash, rotasonic, or water rotary with core or roller bit), monitor the water level in the borehole as it re-equilibrates to the static level. In low-permeability units like clay, fine-grained glacial tills, shale and other bedrock formations, it may be necessary to wait overnight to allow the water level to equilibrate. To the extent practicable, ensure that the depth of the well below the apparent water table is deep enough so that the installed well can monitor groundwater year-round, accounting for seasonal water-table fluctuations. In most cases, the well should be installed at least five feet below the water-table depth, determined as described above. When in doubt, err on the side of slightly deeper well installation.

If necessary, the borehole should be drilled deeper to ensure that the well may intersects the water table or a permeable water-bearing zone.

7. Upon completing the borehole to the desired depth, if a screened well construction is desired, install the monitoring well by lowering the screen and casing assembly with sump through the augers or casing. Monitoring wells typically will be constructed of 2-inch-diameter, flush-threaded PVC or stainless steel slotted well screen and blank riser casing. Smaller diameters may be used if wells are installed using direct-push methodology or if multiple wells are to be installed in a single borehole. The screen length will be specified in the Work Plan or FSP based on regulatory requirements and specific monitoring objectives. Monitoring well screens are usually 5 to 10 feet long, but may be up to 25 feet long in very low permeability, thick geologic formations. The screen length will depend on the purpose for the well and the objectives of the groundwater investigation. Typically, the slot size will be 0.010 inch and the sand pack will be 20-40, Morie No. 0, or equivalent. In very fine-grained formations where sample turbidity needs to be minimized, it may be preferred to use a 0.006-inch slot size and 30-65, Morie No. 00, or equivalent sand pack. Alternatively, where monitoring wells are installed in coarse-grained deposits and higher well yield is required, a 0.020-inch slot size and 10-20, Morie No. 1, or equivalent sand pack may be preferred. To the extent practicable, the slot size and sand pack gradation may be predetermined in the Work Plan or FSP based on site-specific grain-size analysis or other geologic considerations or monitoring objectives. A blank sump may be attached below the well screen if the well is being installed for DNAPL recovery/monitoring purposes. If so, the annular space around the sump will be backfilled with neat cement grout to the bottom of the well screen prior to placing the sand pack around the screen. A blank riser will extend from the top of the screen to approximately 2.5 feet above grade or, if necessary, just below grade where conditions warrant a flush-mounted monitoring well. For wells greater than 50 feet deep, centralizers may be desired to assist in centralizing the monitoring well in the borehole during construction.

8. When the monitoring well assembly has been set in place and the grout has been placed around the sump (if any), place a washed silica sand pack in the annular space from the bottom of the boring to a height of 1 to 2 feet above the top of the well screen. The sand pack is placed and drilling equipment extracted in increments until the top of the sand pack is at the appropriate depth. The sand pack will be consistent with the screen slot size and the soil particle size in the screened interval, as specified in the Work Plan or FSP. A hydrated bentonite seal (a minimum of 2 feet thick) will then be placed in the annular space above the sand pack. If non-hydrated bentonite is used, the bentonite

should be permitted to hydrate in place for a minimum of 30 minutes before proceeding. No coated bentonite pellets will be used in monitoring well drilling or construction. Potable water may be added to hydrate the bentonite if the seal is above the water table. Monitor the placement of the sand pack and bentonite with a weighted tape measure. During the extraction of the augers or casing, a cement/bentonite or neat cement grout will be placed in the annular space from the bentonite seal to a depth approximately 2 feet bgs.

9. Place a locking, steel protective casing (extended at least 1.5 feet below grade and 2 feet above grade) over the riser casing and secure with a neat cement seal. Alternatively, for flush-mount completions, place a steel curb box with a bolt-down lid over the riser casing and secure with a neat cement seal. In either case, the cement seal will extend approximately 1.5 to 2.0 feet below grade and laterally at least 1 foot in all directions from the protective casing, and should slope gently away to promote drainage away from the well. Monitoring wells will be labeled with the appropriate designation on both the inner and outer well casings or inside of the curb box lid.

   When an above-grade completion is used, the PVC riser will be sealed using an expandable locking plug and the top of the well will be vented by drilling a small-diameter (1/8 inch) hole near the top of the well casing or through the locking plug, or by cutting a vertical slot in the top of the well casing. When a flush-mount installation is used, the PVC riser will be sealed using an unvented, expandable locking plug.

10. During well installation, record construction details and actual measurements relayed by the drilling contractor and tabulate materials used (e.g., screen and riser footages; bags of bentonite, cement, and sand) in the field notebook.

11. After completing the well installation, lock the well, clean the area, and dispose of materials in accordance with the procedures outlined in Section VII below.

Direct-Push Method

The direct-push drilling method may also be used to complete soil borings and install monitoring wells. Examples of this technique include the Diedrich ESP vibratory probe system, GeoProbe®, or AMS Power Probe® dual-tube system. Environmental probe systems typically use a hydraulically operated percussion hammer. Depending on the equipment used, the hammer delivers 140- to 350-foot pounds of energy with each blow. The hammer provides the force needed to penetrate very stiff/medium dense soil formations. The hammer simultaneously advances an outer steel casing that contains a dual-tube liner for sampling soil. The outside diameter (OD) of the outer casing ranges from 1.75 to 2.4 inches and the OD of the inner sampling tube ranges from 1.1 to 1.8 inches. The outer casing isolates shallow layers and permits the unit to continue to probe at depth. The double-rod system provides a borehole that may be tremie-grouted from the bottom up. Alternatively, the inside diameter (ID) of the steel casing provides clearance for the installation of small-diameter (e.g., 0.75- to 1-inch ID) micro-wells. The procedures for installing monitoring wells in soil using the direct-push method are described below.

1. Locate boring/well location, establish work zone, and set up sample equipment decontamination area.

2. Advance soil boring to designated depth, collecting samples at intervals specified in the Work Plan. Samples will be collected using dedicated, disposable, plastic liners. Describe samples in accordance with the procedures outlined in Step 3 above. Collect samples for laboratory analysis as specified in the Work Plan and/or FSP.

3. Upon advancing the borehole to the desired depth, install the micro-well through the inner drill casing. The micro-well will consist of approximately 1-inch ID PVC or stainless steel slotted screen and blank riser. The sand pack, bentonite seal, and cement/bentonite grout will be installed as described, where applicable, in Step 7 and 8 above.

4. Install protective steel casing or flush-mount, as appropriate, as described in Step 9 above. During well installation, record construction details and tabulate materials used.

5. After completing the well installation, lock the well, clean the area, and dispose of materials in accordance with the procedures outlined in Section VII below.

Driven Well Point Installation

Well points will be installed by pushing or driving using a drilling rig or direct-push rig, or hand-driven where possible. The well point construction materials will consist of a 1- to 2-inch-diameter threaded steel casing with either 0.010- or 0.020-inch slotted stainless steel screen. The screen length will vary depending on the hydrogeologic conditions of the site. The casings will be joined together with threaded couplings and the terminal end will consist of a steel well point. Because they are driven or pushed to the desired depth, well points do not have annular backfill materials such as sand pack or grout.

VII. Waste Management

Investigation-derived wastes (IDW), including soil cuttings and excess drilling fluids (if used), decontamination liquids, and disposable materials (well material packages, PPE, etc.), will be placed in clearly labeled, appropriate containers, or managed as otherwise specified in the Work Plan, FSP, and/or IDW management SOP.

VIII. Data Recording and Management

Drilling activities will be documented in a field notebook. Pertinent information will include personnel present on site, times of arrival and departure, significant weather conditions, timing of well installation activities, soil descriptions, well construction specifications (screen and riser material and diameter, sump length, screen length and slot size, riser length, sand pack type), and quantities of materials used. In addition, the locations of newly-installed wells will be documented photographically or in a site sketch. If appropriate, a measuring wheel or engineer's tape will be used to determine approximate distances between important site features.

The well or piezometer location, ground surface elevation, and inner and outer casing elevations will be surveyed using the method specified in the site Work Plan. Generally, a local baseline control will be set up. This local baseline control can then be tied into the appropriate vertical and horizontal datum, such as the National Geodetic Vertical Datum of 1929 or 1988 and the State Plane Coordinate System. At a minimum, the elevation of the top of the inner casing used for water-level measurements should be measured to the nearest 0.01 foot. Elevations will be established in relation to the National Geodetic Vertical Datum of 1929. A permanent mark will be placed on top of the inner casing to mark the point for water-level measurements.

IX. Quality Assurance

All drilling equipment and associated tools (including augers, drill rods, sampling equipment, wrenches, and any other equipment or tools) that may have come in contact with soil will be cleaned in accordance with the procedures outlined in the appropriate SOP. Well materials will also be cleaned prior to well installation.

X. References

American Society of Testing and Materials (ASTM) D 1586 - *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils*.

Appendix B

Standard Operating Procedure –
Well Development

ARCADIS
Infrastructure, environment, facilities

Imagine the result

Well Development – Water Jetting

Standard Operating Procedure

Rev. #: 1

Rev Date: July 2, 2010

Approval Signatures

Prepared by: Erin Hauber (signature) Date: 7/6/10

Erin Hauber

Reviewed by: (signature) Date: 7/6/10

Royce Face, PE. PG

Reviewed by: (signature) Date: July 2, 2010

Kevin Wilson, PG

1. Scope and Application

This standard operating procedure (SOP) provides an overview of jetting with water as a method of well development. While the goal of groundwater sampling is to obtain water samples that are representative of natural, undisturbed hydrogeologic conditions, all drilling methods disturb geologic materials around the well bore to some extent. Development of remediation wells (monitoring wells, piezometers, injection wells, extraction wells) is needed to repair (to the extent practicable) damage to the formation caused by drilling, and to remove fine-grained sediments and drilling fluids introduced during the drilling process. Well development enhances the hydraulic connection between the well and the surrounding formation, ensuring that the screen transmits groundwater that is representative of the surrounding formation. Periodic redevelopment may also be necessary to improve the operation of extraction or injection wells.

The ultimate goal of any development technique is to create a filter pack that is coarsest near the well screen and becomes progressively finer until it blends with the native formation. The ideal development would merge the filter pack seamlessly into the formation, without a noticeable change in grain size.

Development through jetting introduces high velocity water into the well screen while simultaneously evacuating water from the well (ideally maintaining an in-well water level that is equal to or below the static water level, but always less than 20 percent of the available head space in the well). Prior to and/or following jetting, the screened interval can be gently surged using a surge block, bailer, or inertia pump with optional surge block fitting to remove fines freed from filter pack during the jetting process.

Design and selection of the appropriate jetting equipment and delivery pressure will be based on site-specific parameters (well construction details), tubing, and pump specifications. The disposal of investigation derived waste (IDW) generated during the jetting process must also be taken into consideration.

In general, jetting involves lowering either single or multiple small diameter pipe(s) or tube(s) equipped with nozzles into the well screen and injecting a high velocity horizontal stream of water through the pipe(s) into the screen openings. The jets are moved vertically along the screened interval and rotated, if needed, to effectively address the entire screen surface area. Typical jetting assemblies include a submersible pump to extract the injected water and maintain the static water level, but alternate removal methods (air lifting, centrifugal pump) are acceptable.

Jetting tools usually have two to four nozzles; however, site conditions and well diameter will ultimately dictate the number of nozzles used at a specific well. Nozzle orifice sizes are selected to produce velocities between approximately 100 and 300 feet per sec (ft/sec). The injected (and extracted) flow into the well and the approximate pressure delivered by the jetting pump to achieve the target jetting velocities can be determined by considering the following:

- screen material and opening configuration
- nozzle specifications
- pressure losses from pump manifold to nozzles
- pump and tubing pressure limitations
- screen exit velocity
- IDW generation and/or recirculation options.

The attached jetting design tool (see Section X. References) can be used to estimate the target manifold pressure and injection/extraction flow rate for a specific remediation well.

II. Personnel Qualifications

Well development activities will be performed by persons who have been trained in proper field procedures. Well development activities will be performed under the guidance of an experienced field geologist, engineer, or technician.

III. Equipment List

General materials for well development include:

- personal protective equipment (PPE) and any other safety equipment required by the site-specific Health and Safety Plan (HASP)
- cleaning equipment
- water level meter and/or oil/water interface probe
- water quality meter that is capable of recording pH, temperature, conductivity, and turbidity (optional)

- photoionization detector (PID) to measure headspace vapors (recommended; may be required by the site-specific HASP)
- plastic sheeting
- graduated pails
- drum(s) or tank(s) to contain purge water, and equipment to move the container(s)
- field notebook
- well construction logs (or summary table) indicating completed well depths and screened intervals
- monitoring well keys.

Materials needed specifically for development by jetting include:

- Down-hole jetting assembly consisting of:
  - Two or three jetting nozzles pointed outward in the horizontal plane.
    - Select jet nozzles rated for velocities between 150 and 300 ft/sec. Higher velocities may damage the well, whereas lower velocities will be less effective at penetrating the filter pack.
    - Nozzles should spray in a wide angle horizontal fan (e.g., 145°). An array of three nozzles with overlapping fans is preferred. If the combined spray arc is not a full 360°, the assembly will need to be rotated throughout the well development process.
    - The nozzles must be equally spaced to hydraulically balance the jetting tool.
    - Since a larger orifice will require a higher injection rate to achieve the same velocity, small-orifice jets (approximately 0.016 inch to 0.065 inch in diameter) are preferred.
  - A rate-controllable submersible pump (or alternate pumping device) attached below the jetting nozzles (or above the jetting nozzles, if jetting at the very bottom of the screen is required).
    - The pump capacity should be greater than the anticipated jetting flow required to jet at the target velocity (for the full array of jets).
  - A flexible rubber flange (or collar) attached between the jetting nozzles and the submersible pump.
    - The flange prevents flow from the jet to the pump from occurring within the well casing, thereby forcing the flow through the screen and filter pack.
    - Flanges should be constructed of flexible rubber and sized appropriately to slide freely up and down inside the well casing, yet provide a partial seal against vertical flow.

  - Associated tubing and control wire bundled together (e.g., with zip ties or heat shrink plastic wrapping). The jetting assembly must be sufficiently rigid and bundled to minimize friction between the well casing and the jetting tool and allow vertical movement and rotation (if necessary). Ease of jetting tool movement within the well can become a concern in small (i.e., 2-inch) diameter wells if the jetting tool is not properly designed.

- Above-grade jetting assembly consisting of:
  - potable water supply (e.g., 250-gallon water tote)
  - above-grade water pump (e.g., booster pump) and recirculation or pressure relief line into supply water tank, if needed
  - injection manifold consisting of the following:
    - poly vinyl chloride (PVC) or steel pipe, with an input connection from the water pump and branches to each jetting line (all piping and tubing must be pressure rated to withstand jetting pressures)
    - pressure gage
    - gate valves on each output line
  - Storage tank for extracted water
  - Filter unit (if recirculation is used)
    - If recirculation is being used, sediment must be removed prior to re-injection.
    - Sediment may erode nozzle orifices (thereby reducing delivered pressure), harm the jetting pump, and abrade screen material,

- Power supplies for jetting pump and submersible pump.

IV. Cautions

- Delivery pressures greater than 150 pounds per square inch (psi) are often required to achieve effective jetting velocities. All tubing/piping, connections, and pumps should be rated for the anticipated delivery pressures, and should be inspected for damage prior to and periodically during use.

- Care should be taken when testing the jetting tool above ground. Similar to a pressure washer, high pressure water exiting the jets may pose a risk if it comes into direct contact with skin.

- The type of screen opening greatly affects what percentage of the jetted water reaches the formation surrounding the filter pack (i.e., v-shaped continuous slot screens transfer the high velocity stream more effectively than louvered screens).

- Water exiting the jetting tool should not exceed the recommended screen exit velocity of 0.05 ft/sec to prevent possible damage to the well screen.

- Continuous movement of the jetting tool is recommended to minimize formation of cavities within the filter pack and to protect the screen.
- Water pressure should not exceed 100 psi when jetting PVC screens.
- Only use sediment-free water with the jetting tool to minimize damage to the well screen from abrasive particles, avoid erosion of the nozzle orifice (which could cause a reduction in nozzle velocity), and protect the jetting pump.
- Avoid using development fluids or materials that could impact groundwater or soil quality, or could be incompatible with the subsurface conditions.

V. Health and Safety Considerations

Field activities associated with well development by jetting will be performed in accordance with the site-specific HASP, a copy of which will be present onsite during such activities. Note that additional precautions may be required to account for the use of pressurized equipment or handling large storage vessels.

VI. Procedure

The procedures for developing a well using the jetting method are outlined below. These procedures are applicable to wells that are screened primarily in clay and silt formations.

1. Don appropriate PPE (as required by the HASP).
2. Using a non-phosphate cleaner (e.g., Alconox) and potable water, clean and double rinse all non-dedicated equipment that will enter the well (refer to separate equipment cleaning procedures where applicable).
3. Breathing zone testing is recommended (to be determined by the project team). If required:
   a. Open the well cover while standing upwind of the well; remove the well cap. Insert the PID probe approximately 4 to 6 inches into the casing or the well headspace; cover with gloved hand.
   b. Record the PID reading in the field notebook.
   c. If the well headspace reading is less than 5 PID units, proceed; if the headspace reading is greater than 5 PID units, screen the air within the breathing zone. If the PID reading in the breathing zone is below 5 PID

units, proceed. If the PID reading is above 5 PID units, move upwind from the well for 5 minutes to allow the volatiles to dissipate, then repeat the breathing zone test. If the reading is still above 5 PID units, don the appropriate respiratory protection in accordance with the requirements of the HASP. Record all PID readings.

4. Measure the depth to water and total well depth. Check for the presence of non-aqueous phase liquid (NAPL). *If NAPL is present do not continue development until consulting with the task manager (or TKI specialist).* Compare the well depth to the as-built construction details. Calculate the volume of water in the well casing.

5. Hydraulic testing is recommended to evaluate the effectiveness of the jetting process (implementation will be determined by the project team). If hydraulic testing is to be performed, the following process can be used:

    a. Lower a pump into the well and begin pumping while monitoring the water level in the well.
    b. Adjust the pumping rate to achieve steady flow from the well, with drawdown in the well at 20 to 30 percent of the original water column.
    c. Record this flow rate and drawdown and calculate the initial specific capacity: $\mathrm{SC} = \frac{\mathrm{Flow\ (Q)}}{\mathrm{drawdown\ (\Delta h)}}$

6. Determine final jetting/purging parameters and set-up:

    a. Calculate the operational jetting pressure (manifold gage reading) to achieve the target jet velocity (i.e., 150 to 300 ft/sec) based on the jet nozzle manufacturer's specifications (e.g., 200 psi at 0.5 gallons per minute [gpm]), tubing losses, and equipment pressure rating. See attached calculation worksheet.
    b. Water recirculation should not be completed unless approved by the project manager. Recirculation of sediment-laden water may damage the well screen or jetting pump.
    c. Lower the jetting tool into the well. Check that the swabbing flange is loose enough to permit the tool to move up and down inside the well casing without significant effort.
    d. Place a water level meter into the well to monitor the water level during development.

7. To maintain the static water level in the well, the rate of water extraction must equal or exceed the rate of injection. A water level above baseline will drive fines suspended in the water column into the formation and therefore decrease the effectiveness of development. Carefully monitor the water level

to insure that it does not exceed 20 percent of the available head space in the well.

8. Jet and purge the saturated portion of the well screen in 2-foot increments, as follows:

    a. Start jetting in the bottom 2-foot interval of the well screen (or as close to the bottom of the screen as practical, based on the jetting assembly). While jetting:

        i. Pump from beneath (or above) the jetting tool at a rate sufficient to maintain the water-level in the well at or below the static water level.

        ii. Gently swab the well while pumping by slowly moving the jetting tool up and down the well screen at no greater than 0.5 ft/sec. Vigorous surging is not appropriate. Do not reverse the up/down stroke suddenly.

        iii. Hold the jetting tool loosely and away from the body. If jetting/surging rates are imbalanced or a filter pack blockage prevents flow, the tool may push upward or downward. Do not force the tool to remain stationary; adjust jetting/surging rates as needed.

        iv. Do not let the tool remain in one position for longer than a few seconds.

    b. Continue jetting in the 2-foot interval for 10 minutes, rotating the tool (if necessary) and covering the well screen interval multiple times.

    c. Repeat steps 8a through 8b in the next 2-foot interval of screen until the entire length of the saturated screen interval has been developed.

    d. Sediment loading and turbidity of the extracted water should improve throughout the jetting process. Visual observations of the sediment and turbidity should be recorded in the field notes or the well development form (see Section X, References). The project team may opt to record water quality parameters (temperature, conductivity, pH, turbidity) during development.

9. Monitor and record water use (i.e., volume of potable water injected and volume of water purged by pumping) throughout the development process. Increasing the extraction rate or decreasing the injection rate may be necessary to prevent the water level in the well from rising above static conditions or to prevent the well from going dry.

10. After development, measure the depth to water and the total well depth, and check for the presence of non-aqueous phase liquid (NAPL). Confirm that the total depth of the well matches the as-built well depth within a reasonable tolerance. If a discrepancy exists, note it, and evaluate it to the degree feasible. Continue development if necessary.

11. If hydraulic testing was completed prior to development, a test should be completed at the end of development activities to ascertain the level of improvement (see Step 5). Additional development may be needed if the well does not meet design criteria.

12. When complete, re-secure the well cover.

13. Using a non-phosphate cleaner (e.g., Alconox) and potable water, clean and double rinse all non-dedicated equipment that entered the well (refer to separate equipment cleaning procedures where applicable). Place disposable materials in plastic bags for appropriate disposal, and decontaminate reusable, downhole pump components and/or bailer.

VII. Waste Management

IDW generated during well development may include disposable equipment and PPE, purged groundwater, and water associated with equipment cleaning. All disposable and liquid waste should be handled and disposed in accordance with project plans and applicable regulations.

VIII. Data Recording and Management

Well development activities will be documented in a proper field notebook and/or Personal Digital Assistant (PDA). Pertinent information will include:

- General Field Notes:
  - personnel present onsite
  - times of arrival and departure
  - significant weather conditions
  - timing of well development activities
- Jetting Field Notes:
  - observations of NAPL
  - manifold pressure
  - water levels before and during testing
  - observations of purge water color, turbidity, odor, and sheen over time
  - purge rate
  - initial and final total depth of well
  - hydraulic testing parameters (if specified by project technical lead)

IX. References

Jetting Design Tool

Well Development Form

ARCADIS

Appendix C

Surfactant Material Safety Data Sheet

Gold Crew Release

Always use Gold Crew in compliance with all federal, state and local rules with regulations

Environmental Chemical Solutions (ECS) / Gold Crew Products division manufactures products for in-situ and ex-situ bioremediation projects and has the ability to desorb and solubilize the hydrocarbon in the substrate. When applied through injection wells, Gold Crew desorbs the contaminant by stripping the hydrocarbon off the soil particles and mobilizing it to the pore space creating a large interfacial surface area. This action allows a mass removal through a High Vacuum Extraction (HVE) system.

Gold Crew does not cause or catalyze specific chemical reactions, nor does it contain any bacteria cultures. The basic principle is to solubilize the hydrocarbon into small-encapsulated particles in a water/oxygen bearing solution. This process desorbs the hydrocarbon molecules from the soil particles for extraction and promotes the natural attenuation process.

Flash Point	Non Flash		
Pour Point	22F	ASTM	D 97-66
Viscosity at 100F	126FUS	ASTM	D-445-74
Viscosity at 32F	35cSt		
Specific Gravity at 60F	1.0382	ASTM	D-1298-67
pH	9.8	ASTM	D-1293-65
Ionic Activity	nonionic	Weatherburn Test – Federal Register Vol. 40, No. 28; 2003.3-4.14	
Cloud Point	-2C		
Surface Tension @ 0.03%	28.2 dynes	ASTM	D1331
@ 0.06%	27.8 dynes		
@ 6.0%	27.7 dynes		

International Chemical Systems, Inc.

ENVIRONMENTAL CHEMICAL SOLUTIONS

"Delivering Solutions to the Customer"

MATERIAL SAFETY DATA SHEET
HYDROCARBON DESORPTION AGENT

RELEASE

GOLD CREW HDA-E081

Emergency: 1-877-253-2665

SECTION I - GENERAL INFORMATION

Name:	Release, Gold Crew HDA-E081, Hydrocarbon Desorption Agent
Manufacturer	Environmental Chemical Solutions P.O. Box 2029 Gig Harbor, WA 98335 Tel: (877) 253-2665 Fax: (253) 853-1340 www.ecschem.com
Generic Description	Water Based, Biodegradable, Wetting Agents & Surfactants
HMIS Code	Health 0, Fire 0, Reactivity 0
HMIS Key	4 = Extreme, 3 = High, 2 = Moderate, 1 = Slight, 0 = Insignificant
D.O.T. Class	Not regulated: not hazardous
Formula:	Proprietary

SECTION II - HAZARDOUS INGREDIENTS

This product does not contain any hazardous ingredients as defined by CERCLA and California's Prop. 65

SECTION III - PHYSICAL & CHEMICAL CHARACTERISTICS

Flash Point:	None	Melting Point:	32F
Specific Gravity:	1.0315 ±.01	Vapor Pressure mm/Hg:	NA
Pounds Per Gallon	8.6	Vapor Density Air 1:	NA
Solubility in Water	Complete	Reactivity with Water:	No
Viscosity	15 Centipoise	Surface Tension @ 5%:	27.7 Dyne/cm at 25°C
Evaporation Rate:	>1 as compared to Water	pH:	10.0 ±.5
Appearance:	Clear Liquid Unless Dyed	Fire Extinguisher Media:	NA
Odor:	Light Fragrance	Fire Fighting Procedures:	NA

SECTION IV - Fire and Explosion Data

Special Fire Fighting Procedures	NA	Percent Volatile by Volume	NA
Unusual Fire and Explosion Hazards	None	Flammable Limit	NA
Solvent for Clean-Up	Water	Auto Ignite Temperature	NA
Flash Point	NA	Fire Extinguisher Media	NA

SECTION V - SPECIAL PRECAUTIONS AND SPILL/LEAK PROCEDURES

Precautions to be taken in Handling and Storage: Use good normal hygiene.
Precautions to be taken in case of Spill or Leak -
Small spills. Soak up with absorbent materials.
Large spills: dike and contain. Remove with vacuum truck or pump to storage/salvage vessel. Soak up residue with absorbent materials.

Waste Disposal Procedures: Dispose in an approved disposal area or in a manner that complies with all local, state, and federal regulations.

SECTION VI - HEALTH HAZARDS

Threshold Limit Values: NA

Signs and Symptoms of Over Exposure-

Acute: Moderate eye irritation. Skin: Causes redness, edema, drying of skin.
Chronic: Pre-existing skin and eye disorders may be aggravated by contact with this product.

Medical Conditions Generally Aggravated by Exposure: Unknown

Carcinogen: No

Emergency First Aid Procedures -

Eyes: Flush thoroughly with water for 15 minutes. Get medical attention.
Skin: Remove contaminated clothing. Wash exposed areas with soap and water. Wash clothing before reuse. Get attention if irritation develops.
Ingestion: Get medical attention.
Inhalation: None considered necessary.

SECTION VII - SPECIAL PROTECTION INFORMATION

Respiratory Protection:	Not necessary	Ventilation Required:	Normal
Local Exhaust Required:	No	Protective Clothing:	Gloves, safety glasses, wash clothing before reuse.

SECTION VIII - PHYSICAL HAZARDS

Stability:	Stable	Incompatible Substances:	None known
Polymerization:	No	Hazardous Decomposition Products:	NA

SECTION IX - TRANSPORT & STORAGE

DOT Class	: Not Regulated/Non Hazardous	Freeze Temperature	: 28°F
Storage	: 35°F-120°F	Freeze Harm	: None
Shelf Life	: Approximately one year unopened		

SECTION X - REGULATORY INFORMATION

The Information on this Material Safety Data Sheet reflects the latest information and data that we have on hazards, properties, and handling of this product under the recommended conditions of use. Any use of this product or method of application, which is not described on the Product label or in this Material Safety Data Sheet is the sole responsibility of the user. This Material Safety Data Sheet was prepared to comply with the OSHA Hazardous Communication Regulation.

All information appearing herein is based upon data obtained by the manufacturer and technical sources. Judgments as to the suitability of information herein for the purchaser's purposes are necessarily purchaser's responsibility. Therefore, although reasonable care has been taken in the preparation of this information, ICS, ECS or Gold Crew, or its distributors extends no warrantees, makes no representations and assumes no responsibility as to the suitability of such information for application to purchasers intended purposes or for consequences of its use.

13 March 2001

Gold Crew
17151 Newhope Street, Suite 201
Fountain Valley, California 92708

Attention: Mr. Jim Figueira

Dear Mr. Figueira:

The following are the results of the California Department of Health Services (DOHS) 96-hour Acute Aquatic Toxicity Screening Test performed on the Gold Crew -150 sample prepared as per your specifications on 28 February 2001. MBC utilized the latest California Department of Health Services procedures (Polisini 1988) for testing the sample.

Currently, Title 22, Section 66261.24, Article 6 of the California Code of Regulations requires wastes to pass the 96-hour Aquatic Toxicity testing with greater than 50% survival at the 500 mg/l (ppm) concentration and 60% survival at the 750 mg/l (ppm) concentration for compliance using the data from the screen testing. The Department of Health Services will use this data to consider the mixture for designation as a non-hazardous material.

MBC Sample Number 01-185 - Client Identification: 2.5% Gold Crew - 150 / Diesel Fuel

PERCENT SURVIVAL

250 ppm	100%
500 ppm	100%
750 ppm	100%

LC_{50} > 750 ppm of Gold Crew - 150 / #2 Diesel Fuel

Application rate: 1 part 2.5% Gold Crew - 150 to 6 parts #2 Diesel Fuel

If you have any questions or require further information, please contact me at your convenience.

Cordially,

MBC *Applied Environmental Sciences*

Michael J. Mancuso

Michael J. Mancuso
Vice President Operations