29. The Discharger and interested agencies and persons were notified of the intent to prescribe waste discharge requirements for this discharge and provided with an opportunity for a public hearing and an opportunity to submit written comments.

30. In a public meeting, all comments pertaining to this Order were heard and considered.

IT IS HEREBY ORDERED that, pursuant to Sections 13263 and 13267 of the California Water Code, Dischargers, in order to meet the provisions contained in Division 7 of the California Water Code, and regulations and guidelines adopted thereunder, shall comply with the following:

A. CONDITIONS OF ELIGIBILITY

1. A discharger may seek coverage under this Order to:

    a. Add specific amendments directly to groundwater or indirectly through the soil column for the purpose of facilitating in situ remediation of waste constituents. The Discharger must demonstrate the effectiveness of the selected amendment(s), and demonstrate control of side reactions and breakdown products under site conditions.

2. To be covered under this Order, a discharger must provide the following:

    a. A Notice of Intent/Report of Waste Discharge (Attachment A) following the instructions included in Attachment B, including additional information as required in Attachment 1 to the Notice of Intent;

    b. A Regional Water Board approved Work Plan, Work Plan Addendums (if applicable), and/or a Remedial Action Plan or Cleanup Plan which includes application of an amendment that qualifies for coverage under this Order (The approval for the Work Plan or Remedial Action Plan needs to be dated within 24 months of the date of the Notice of Intent);

    c. A proposed Monitoring and Reporting Program, based on Attachment C, incorporated herein by reference;

    d. The first annual fee in accordance with the current version of the California Code of Regulation, Title 23, Division 7, Chapter 9, Waste Discharge Report and Requirements Article 1 -- fees for a discharge. The check or money order shall be made payable to the “State Water Resources Control Board”.

    e. A Contingency Plan to be implemented to correct unacceptable water quality effects.

3. This Order covers the following actions:

4. The discharge of amendments to land or groundwater in areas other than that proposed for remediation is prohibited.

5. Discharge of waste classified as 'hazardous' under Section 2521, Chapter 15 of Title 23 or 'designated', as defined in Section 13173 of California Water Code is prohibited.

6. The discharge of amendments to property that is not under the control of the Discharger is prohibited. The “area under the control” of the Discharger is considered to be at the horizontal borders of the application area and owned by the Discharger and/or where the Discharger holds an agreement with the property owner for purposes of investigation and remediation.

7. If background groundwater contains concentrations of a constituent found in the amendment, above its WQO as listed in Finding 18, then the concentration of the consituent in the amendment as added cannot be greater than its WQO.

D. DISCHARGE SPECIFICATIONS

1. The Discharger shall not inject any amendments into the aquifer prior to receiving the Notice of Applicability nor prior to the construction of all necessary monitor wells listed in the Monitoring and Reporting Progam.

2. The groundwater shall not be amended with materials other than those approved in the Notice of Applicability.

3. The Discharger will minimize the amount of amendments injected to the extent practicable.

E. GROUNDWATER DISCHARGE SPECIFICATIONS

1. The discharge from a groundwater treatment plant shall be only to those locations shown on Attachment E as provided with each individual Notice of Applicability.

2. The discharge flow from the groundwater treatment system shall not exceed that specified in the Notice of Applicablility.

3. In the cases where treated or amended groundwater is recirculated back into the contaminant plume as part of in-situ treatment, non-target pollutants in the injectant must meet the limitations in Table 1 below or background concentrations as determined under Monitoring and Reporting Program R5-2015-0012.

4. In the cases where treated groundwater as part of a groundwater extraction and treatment system is discharged, or as part of an in-situ treatment project discharge outside of the plume, then the discharge shall not contain pollutants, for which the

Discharger is responsible for, in excess of the values found in Table 1. For constituents that are not the responsibility of the Discharger, the concentrations shall not exceed background values as established under Monitoriing and Reporting Program R5-2015-0012.

Table 1: Effluent Limits for groundwater discharged to land (above or below ground surface:

Constituent	Effluent Limit
trichloroethene	0.5 µg/L
tetrachlorethene	0.5 µg/L
vinyl chloride	0.5 µg/L
cis 1,2-dichlorethene	0.5 µg/L
1,2-dichlorethene	0.5 µg/L
1,2-dichloroethane	0.4 µg/L
1,1-dichloroethene	0.5 µg/L
1,1-dichloroethane	0.5 µg/L
1,2,3-trichloropropane	0.5µg/L
1,2-dichloropropane	0.5 µg/L
1-chloropropane	0.5 µg/L
propene	28 µg/L
perchlorate	6 ug/L
carbon tetrachloride	0.5 µg/L
cyanide	10 µg/L
dieldrin	0.0022 µg/L

5. In the case of application of extracted groundwater to land as part of a phytoremediation project, then the discharge shall not contain concentrations of pollutants that are not targeted for phytoremediation in excess of those in Table 1. For pollutants not found in Table 1, the concentrations shall not exceed background concentrations as established under Monitoring and Reporting Program R5-2015-0012. In addition, if the phytoremediation project is for the remediation of nitrogen, then the discharge shall not be excess of the value detemined to be needed for plant growth as specified in the Notice of Applicablity.

F. GROUNDWATER LIMITATIONS

1. The discharge shall not cause the pH of the groundwater at the compliance points, downgradient and outside the treatment and transition zones, to shift outside the range of 6.5 to 8.5.

2. The release, injection, discharge, or addition of amendments from a remediation system shall not cause the groundwater at the compliance wells listed in Table 1 of the Monitoring and Reporting Program, which is attached to the Notice of Applicability, and any revisions thereto, to contain concentrations of chemical constituents, including the amendments and by-products of the in-situ treament process, in amounts that exceed the Water Quality Objectives listed in Finding No. 18.

gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted, is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

14. The Discharger shall permit authorized staff of the Regional Water Board:

    a. entry to the project site covered by this Order or in which any required records are kept;

    b. access to copy any records required to be kept under terms and conditions of this Order;

    c. inspection of monitoring equipment or records; and

    d. sampling of groundwater or any discharge .

15. The Regional Water Board may review this Order periodically and may revise requirements when necessary. In addition, the discharger shall file a report of waste discharge with the Executive Officer at least 120 days before making any material change or proposed change in the character, location, or volume of the discharge.

16. This Order is in effect until terminated by the Executive Officer. Project coverage under this Order may be terminated by the Executive Officer at any time upon giving reasonable notice to the discharger.

I, Pamela C. Creedon, Executive Officer, do hereby certify that the foregoing is a full, true, and correct copy of an Order adopted by the California Regional Water Quality Control Board, Central Valley Region, on 6 February 2015.

_Original Signed by:_____
PAMELA C. CREEDON, Executive Officer

9/30/2014: AMM-AST-MLP

ATTACHMENT C

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

MONITORING AND REPORTING PROGRAM NO. R5-2015-0012

FOR
IN-SITU GROUNDWATER REMEDIATION
AND DISCHARGE OF TREATED GROUNDWATER TO LAND

NOTE: THIS MONITORING AND REPORTING PROGRAM SHALL BE CUSTOMIZED TO FIT THE SITE-SPECIFIC NEEDS OF THE PROJECT. CONSTITUENTS TO BE SAMPLED, SAMPLING FREQUENCY AND REPORTING FREQUENCY NEED TO BE SPECIFIED FOR THE PROJECT. THE TABLES PROVIDE TEMPLATES AND LIKELY CONSTITUENT LISTS THAT NEED TO BE MODIFIED TO MEET THE SITE-SPECIFIC NEEDS.

This Monitoring and Reporting Program (MRP) describes requirements for monitoring a groundwater remediation system for NAME OF SITE AND LOCATION. This MRP is issued pursuant to Water Code Section 13267. The Discharger shall not implement any changes to this MRP unless and until a revised MRP is issued by the Executive Officer. As appropriate, California Regional Water Quality Control Board, Central Valley Region (Central Valley Water Board) staff shall approve specific sample station locations prior to implementation of sampling activities.

All samples should be representative of the volume and nature of the discharge or matrix of material sampled. The time, date, and location of each grab sample shall be recorded on the sample chain of custody form.

GROUNDWATER MONITORING

As shown on Figure x, there are xx monitor wells, xx extraction wells, and xx injection wells/trenches associated with this site. The groundwater monitoring program for these wells and any treatment system wells installed subsequent to the issuance of this MRP shall follow the schedule below. Monitor wells with free phase petroleum product or visible sheen shall be monitored, at a minimum, for product thickness and depth to water. The volume of extracted groundwater, if applicable, shall also be provided in quarterly monitoring reports. Sample collection and analysis shall follow standard EPA protocol.

The monitor wells, extraction wells and/or injection wells shall be sampled according to the schedule in Table 1 and the samples analyzed by the methods in Table 2, as follows:

Table 1: Sampling Frequency and Constituent Suite

Well Number[1]	Constituent[2]	Frequency[3]	Monitoring Objective
			Compliance[4]
			Treatment Zone[5]
			Transition Zone[6]
			Background[7]

[1] Well numbers and locations as shown on Figure X.

[2] Constituent analytical methods are listed in Table 2.
[3] i.e., weekly, monthly, quarterly, semi-annually, annually, other. Semi-annual sampling occurs 1st and 3rd quarters, annual sampling occurs in the 1st quarter, biennial sampling occurs every two years in the 1st quarter, with the first sample during year two.
[4] Wells used to determine compliance with water groundwater limitations.
[5] Wells sampled to evaluate in-situ bioremediation progress inside the treatment zone.
[6] Wells sampled to evaluate migration of pollutants within the treatment zone.
[7] Wells used to develop background concentrations.

NOTE: ADD OR DELETE CONSTITUENTS AND METHODS AS NEEDED IN TABLES 2 THROUGH 6. TABLE 2 PROVIDES THE GENERAL LIST OF CONSTITUENTS THAT ARE MOST LIKELY TO BE SAMPLED FOR AT AN INSITU REMEDIATION SITE

Table 2: Analytical Methods

Constituent	Method[1]	Maximum Practical Quantitation Limit (µg/L)[2]
Volatile Organic Compounds	EPA 8020 or 8260B	0.5
Sodium	EPA 200.7	100
Potassium	EPA Method 300	20
Volatile Organic Acids	EPA 6500	1,000
Orthophosphate	Hach Method 8131	30
Ethane	Modified EPA 602	0.1
Ethene	Modified EPA 602	0.1
Methane	Modified EPA 602	0.1
Total Dissolved Solids	EPA 160.1	10,000
Total Organic Carbon	EPA 415	300
Chloride	EPA 6500	300
Nitrate	EPA 6500	300
Sulfate	EPA 6500	200
Sulfide	Hach Method 8131	30
Iron, Total and Dissolved	EPA 200.7	100
Ferrous and Ferric Iron	EPA 200, 6020 or SM3000	100
Hexavalent Chromium	EPA 7199	1
Phosphorous	EPA 200.7, 365	1,000
Metals, Total and Dissolved[3]	EPA 200.7, 200.8	Various
1,2,3-Trichloropropane[4]	EPA 8260B[4]	0.5 µg/L[4]

[1] Or an equivalent EPA Method that achieves the maximum Practical Quantitation Limit.
[2] All concentrations between the Method Detection Limit and the Practical Quantitation Limit shall be reported as an estimated value.
[3] Metals include barium cadmium, calcium, total chromium, copper, lead, magnesium, manganese, mercury, molybdenum, nickel and silica.
[4] If 1,2,3-TCP in a monitor well is expected to exceed 0.5 µg/L, then Method 8260B may be used. If the concentration is expected to exceed 0.02 µg/L, then EPA Method 504.1 is to be used. If 1,2,3-TCP is not detected greater than 0.02 µg/L, then SRL 524M-TCP must be used in the next regularly scheduled sampling event.

FIELD SAMPLING

In addition to the above sampling and laboratory analyses, field sampling and analysis shall be conducted each time a monitor well or extraction well is sampled. The sampling and analysis of field parameters shall be as specified in Table 3.

Table 3: Field Sampling Requirements

Parameters	Units	Practical Quantitation Limit	Analytical Method
Groundwater Elevation	Feet, Mean Sea Level	0.01 feet	Measurement
Oxidation-Reduction Potential	Millivolts	10 millivolts	Field Meter
Electrical Conductivity	uhmos/cm	50 µS/cm^2	Field Meter
Dissolved Oxygen	mg/L	0.2 mg/L	Field Meter
pH	pH Units (to 0.1 units)	0.1 units	Field Meter
Temperature	$^oF/^oC$	0.1 $^oF/^oC$	Field Meter

All wells that are purged shall be purged until pH, temperature, conductivity and dissolved oxygen are within 10% of the previous value.

Field test instruments (such as those used to test pH and dissolved oxygen) may be used provided that:

1. The operator is trained in proper use and maintenance of the instruments;
2. The instruments are calibrated prior to each monitoring event;
3. Instruments are serviced and/or calibrated by the manufacturer at the recommended frequency; and
4. Field calibration reports are submitted as described in item (b) of the “Reporting” section of this MRP.

TREATMENT PLANT EFFLUENT MONITORING

NOTE: ADD OR DELETE CONSTITUENTS AND METHODS AS NEEDED IN TABLE 4. TABLE 4 PROVIDES THE GENERAL LIST OF CONSTITUENTS THAT ARE MOST LIKELY TO BE SAMPLED FOR AT AN IN-SITU REMEDIATION SITE

The effluent from the groundwater treatment system shall be sampled on a monthly basis as follows in Table 4: **NOTE: FREQUENCY CAN BE ADJUSTED AS WARRANTED**

Table 4: Treatment Plant Effluent Sampling Requirements

Parameters	Units	Type of Sample
Volatile Organics	µg/L	Grab
Metals	µg/L	Grab
Pesticides	µg/L	Grab
Cyanide	µg/L	Grab
Petroleum Hydrocarbons	µg/L	Grab
Total Dissolved Solids	mg/L	Grab

Parameters	Units	Type of Sample
Electrical Conductivity	µhmos/cm	Grab
Dissolved Oxygen	mg/L	Grab
pH	pH Units (to 0.1 units)	Grab

IN-SITU DISCHARGE MONITORING

The Discharger shall monitor daily the discharge of water and amendments that are injected into the groundwater according to the requirements specified in Table 5. Each amendment addition shall be recorded individually, along with information regarding the time period over which the amendment was injected into the aquifer.

Table 5: Discharge Monitoring Requirements

Parameters	Units	Type of Sample
Injected Volume	gallons per day	Meter
Amendment(s) Added	pounds per day	Measured
Biocide Added	pounds per day	Measured

AMENDMENT ANALYSIS

Prior to use, amendments shall be analyzed for the constituents listed in Table 6. The analysis should be done on a mixture of the amendment and deionized water at the estimated concentration that would be injected during the pilot project.
SOME CONSTITUENTS CAN BE ELIMINATED DEPENDING ON THE AMENDMENT

Table 6: Amendment Analytical Requirements

Constituent	Method[1]	Maximum Practical Quantitation Limit (µg/L)[2]
Volatile Organic Compounds	EPA 8020 or 8260B	0.5
General Minerals[3]		
Metals, Total and Dissolved[4]	EPA 200.7, 200.8	Various
Semi-Volatile Organic Compounds	EPA Method 8270	5.0
Total Dissolved Solids	EPA 160.1	10,000
pH	meter	NA
Electrical Conductivity	meter	NA

[1] Or an equivalent EPA Method that achieves the maximum Practical Quantitation Limit.
[2] All concentrations between the Method Detection Limit and the Practical Quantitation Limit shall be reported as an estimated value.
[3] General Minerals include: alkalinity, bicarbonate, potassium, chloride, sulfate, total hardness, nitrate, nitrite, ammonia.

[4] Metals include arsenic, barium, cadmium, calcium, total chromium, copper, iron, lead, manganese, magnesium, mercury, molybdenum, nickel, selenium and silica.

ESTABLISHMENT OF BACKGROUND CONCENTRATION VALUES

NOTE: SPECIFIC BACKGROUND CONSTITUENTS DEPEND UPON THE NATURE OF THE AMENDMENTS, TREATMENT PROCESSES, AND ANTICIPATED INSITU REACTIONS.

The Discharger shall develop background values for concentrations of constituents such as dissolved iron, dissolved manganese, metal xxx, total dissolved solids and electrical conductivity in groundwater following the procedures found in CCR Section 20415(e)(10). The Discharger shall submit a proposal to develop the background concentrations by **XX XXXXX XXXX**.

REPORTING

NOTE: CUSTOMIZE THE REPORTING FREQUENCY. QUARTERLY REPORTS ARE RECOMMENDED AND THIS SECTION IS DEVELOPED AROUND THAT CONCEPT

When reporting the data, the Discharger shall arrange the information in tabular form so that the date, the constituents, and the concentrations are readily discernible. The data shall be summarized in such a manner as to illustrate clearly the compliance with this Order. In addition, the Discharger shall notify the Central Valley Water Board within 48 hours of any unscheduled shutdown of any soil vapor and/or groundwater extraction system. The results of any monitoring done more frequently than required at the locations specified in the Monitoring and Reporting Program shall also be reported to the Central Valley Water Board.

As required by the California Business and Professions Code Sections 6735, 7835, and 7835.1, all reports shall be prepared by a registered professional Civil Engineer or Geologist or their subordinate and signed by the registered professional.

The Discharger shall submit quarterly electronic data reports, which conform to the requirements of the California Code of Regulations, Title 23, Division 3, Chapter 30. The quarterly reports shall be submitted electronically over the internet to the Geotracker database system by the 1st day of the second month following the end of each calendar quarter by **1 February, 1 May, 1 August, and 1 November** until such time as the Executive Officer determines that the reports are no longer necessary.

Each quarterly report shall include the following minimum information:

(a) a description and discussion of the groundwater sampling event and results, including trends in the concentrations of pollutants and groundwater elevations in the wells, how and when samples were collected, and whether the pollutant plume(s) is delineated;

(b) field logs that contain, at a minimum, water quality parameters measured before, during, and after purging, method of purging, depth of water, volume of water purged, etc.;

(c) groundwater contour maps for all groundwater zones, if applicable;

(f) an identification of any data gaps and potential deficiencies/redundancies in the monitoring system or reporting program; and

(g) if desired, a proposal and rationale for any revisions to the groundwater sampling plan frequency and/or list of analytes.

A letter transmitting the monitoring reports shall accompany each report. Such a letter shall include a discussion of requirement violations found during the reporting period, and actions taken or planned for correcting noted violations, such as operation or facility modifications. If the Discharger has previously submitted a report describing corrective actions and/or a time schedule for implementing the corrective actions, reference to the previous correspondence will be satisfactory. The transmittal letter shall contain the penalty of perjury statement by the Discharger, or the Discharger's authorized agent, as described in the Standard Provisions General Reporting Requirements Section B.3.

The Discharger shall implement the above monitoring program on the first day of the month following adoption of this Order.

Ordered by: Original signed by

PAMELA C. CREEDON Executive Officer

6 February 2015
(Date)

09/22/14:AMM,AST,MLP

Volatile organic compounds (VOCs), petroleum hydrocarbons, perchlorate and fumigants have impacted groundwater at numerous sites within the Central Valley Region and cause or threaten adverse impacts to existing and potential beneficial uses of groundwater resources. Those sites are being required to clean up the pollution and restore the beneficial uses of the groundwater. This cleanup can take many forms. The two most common methods of cleanup of groundwater pollution are pump and treat, and in-situ remediation. The operation and discharge of a pump and treat system is generally regulated under site-specific or general waste discharge requirements. Prior to this General Order, General Order No. R5-2008-0149 was adopted in December 2008 and this Order updates that Order. Before Order No. R5-2008-0149, in-situ groundwater remediation projects have had site-specific waste discharge requirements issued. The process to develop and adopt site-specific waste discharge requirements can be lengthy. Many in-situ treatment processes have common components and issues that can be regulated under general waste discharge requirements.

In-situ remediation of groundwater pollution at most sites includes the use and application of biological, chemical, and/or physical treatment processes. These processes include addition of oxygen, chemical oxidation/reduction, and the addition of nutrients, carbon and/or bacteria to enhance biodegradation. The method of delivery can be via injection to soil or groundwater in-situ, or via groundwater recirculation (extraction and treatment with return of treated groundwater to the impacted aquifer zone). In most instances the in-situ remediation processes will cause reducing or oxidizing conditions within the aquifer in order to either reduce or oxidize the target pollutant. The remediation processes can result in exceedances of water quality objectives that are generally limited in duration and/or in a relatively small portion of the aquifer. These waste discharge requirements allow exceedances of water quality objectives to occur while oxidation/reduction processes are taking place, but only within the treatment zone.

Oxidation/reduction reactions take place when an electron is transferred from one compound to another. The electron donor becomes oxidized, and the electron receptor becomes reduced. These are always coupled reactions. If a compound is reduced, another must necessarily be oxidized to provide the electron. Reducing environments are typified by the absence of oxygen and are can also be referred to as anaerobic environments. Oxidative environments contain oxygen and are also referred to as aerobic environments.

Reducing Environment Processes

The primary reduction processes that are effective on perchlorate, nitrate, sulfate and VOCs are anaerobic in nature as aerobic processes are generally not effective on most highly chlorinated VOCs. Aerobic dechlorination or aerobic cometabolism of perchloroethylene (PCE) and trichloroethylene (TCE) has not

been successful at most sites. Therefore, reductive dechlorination of VOCs requires development of anaerobic conditions within the groundwater contaminant plume. PCE can be sequentially reduced to TCE, thence to cis1,2-dichloroethylene, vinyl chloride and finally to ethane. Along the way the rate of reduction, consortium of bacteria involved in the process, and groundwater conditions may change. Reduction of VOCs may even stall at a stage if the correct conditions and bacteria are not present. Perchlorate reduction appears to occur more readily than VOCs and stalling at a particular stage in the dechlorination process does not occur.

In order to develop a reducing environment to achieve reduction of chlorinated hydrocarbons and perchlorate, concentrations of oxygen and nitrate need to be significantly depleted. Oxygen and nitrate are more easily reduced than the chlorinated compounds and will utilize the electrons preferentially over the chlorinated compounds. Elevated concentrations of dissolved iron and manganese may also inhibit reduction of the chlorinated hydrocarbons by being electron acceptors.

There are three types of anaerobic reduction that may be occurring:

> **Direct Anaerobic Reductive Dechlorination** is a biological reaction in which bacteria gain energy and grow as one or more chlorine atoms on the chlorinated hydrocarbon molecule are replaced with hydrogen. In this reaction, the chlorinated compound serves as the electron acceptor, and the hydrogen serves directly as the electron donor (USEPA, 2000a).
>
> **Cometabolic Anaerobic Reductive Dechlorination** is a reaction in which a chlorinated compound is reduced by a non-specific enzyme or co-factor produced during microbial metabolism of another compound (i.e., the primary substrate) in an anaerobic environment. For the cometabolic process to be sustained, sufficient primary substrate is required to support growth of the transforming microorganisms.
>
> **Abiotic Reductive Dechlorination** is a chemical degradation reaction, not associated with biological activity in which a chlorinated hydrocarbon is reduced by a reactive compound. Addition of an organic substrate and creation of an anaerobic environment may create reactive compounds, such as metal sulfides, that can degrade chlorinated aromatic hydrocarbons (ITRC, 2007).

Of those three, direct anaerobic reductive dechlorination is the primary process for biological reduction of VOCs. In order to accomplish the complete reduction to ethane, the appropriate species of bacteria must be present. Lacking the complete consortium of bacteria could cause the process to stall at cis-1,2-DCE and vinyl chloride. If this condition occurs, adding bacteria that are known to

effectively reduce cis-1,2-DCE and vinyl chloride is an option to correct the problem.

Hydrogen has a lead role as a direct electron donor in the anaerobic dechlorination of chlorinated aromatic hydrocarbons. Hydrogen is generated by fermentation of non-chlorinated organic substrates, including naturally occurring organic carbon, accidental releases of anthropogenic carbon (fuel), or introduced substrates such as carbohydrates (sugars), alcohols, and low-molecular-weight fatty acids (lactates, acetates, etc.). As hydrogen is produced by fermentative organisms, it is rapidly consumed by other bacteria, including denitrifiers, iron-reducers, sulfate-reducers, methanogens, and dechlorinating microorganisms. For anaerobic reductive dechlorination to occur, dechlorinators must successfully compete against other microorganisms that also utilize hydrogen (ITRC, 2007).

Generally, there are not sufficient numbers of bacteria naturally present to conduct an effective anaerobic dehalogenation process. To increase the concentration of bacteria biostimulation is implemented by injecting a carbon source or substate into the groundwater. For the degradation of chlorinated ethenes, the injected carbon source provides for cell growth and ferments to produce products like hydrogen, providing an electron donor for the reductive dechlorination process. By adding electron donors, methanogenic and/or sulfate-reducing conditions can be achieved at a site, which can be used to dechlorinate cis-1,2-DCE and vinyl chloride. Complete reductive dechlorination to ethene without the accumulation of cis-1,2-DCE and vinyl chloride is most likely to occur under these strongly-reducing conditions (ITRC, 2007).

Biostimulation also may include injecting limiting nutrients, such as phosphorus or nitrogen. The advantage of biostimulation is that native populations present in the subsurface are already acclimated to the site, so enhancements such as the addition of nutrients will increase their biodegradation capacity. The disadvantage is that subsurface geology of a site may interfere with the introduction of nutrients, including the formation of preferential flow patterns due to fractures and impermeable lithology affecting the distribution of additives. Important subsurface characteristics to consider for biostimulation include velocity of the groundwater, and hydraulic conductivity of the soil. Pilot studies are usually conducted to provide additional site-specific information before full-scale implementation (ITRC, 2007).

Substrates added to promote reductive dechlorination come in many forms and may be soluble, low viscosity, high viscosity or solid. Soluble substrates, such as sugars, citric acid and lactic acid, may be applied in an aqueous phase offering uniform distribution throughout the aquifer. These dissolved substrates travel with advective groundwater flow and are typically applied continuously or periodically. The soluble substrates are consumed rather quickly and must be frequently replenished.

Substrates that are viscous are less mobile than soluble substrates, but they tend to last longer in the subsurface. Slow release materials such as vegetable oil or HRC^{TM}, which are intended to be long lasting, may require a single or limited number of injections. The low mobility of viscous substrates may lead to non-uniform distribution and require different application mechanisms to achieve the desired distributions. These substrates are relatively immobile and rely on advective and dispersive qualities of soluble compounds (lactic acid for the HRC and metabolic acids for the oil) to deliver them throughout the subsurface (ITRC, 2007).

Moderate viscosity fluids such as emulsions of vegetable oil have a relatively high mobility as compared to solid or highly viscous materials that allows more uniform distribution within the aquifer. Emulsified oils slowly release hydrogen through fermentation of fatty acids. Other moderate viscosity substrates that could be used include, chitin, whey and oleate.

Oxidative Environment Processes

As with reductive processes, oxidation processes can be either chemically or biologically induced. A chemical oxidant removes electrons from constituents in the vicinity of the oxidant and the oxidant becomes reduced. In a biological oxidation process, one compound is the electron donor and another compound is the electron acceptor. An example of biological oxidation happens with fuel contaminants in groundwater. In an aerobic environment, fuel can provide the carbon and the electrons for microbial metabolism, and the oxidizing agent is oxygen, which is the electron acceptor. In the absence of oxygen, nitrate also serves as an electron acceptor. The fuel becomes degraded as it is oxidized.

Remediation of groundwater pollution, including VOCs, benzene, toluene, ethylbenzene, xylenes, organic pesticides, munitions (i.e., HMX, RDX), petroleum hydrocarbons or MTBE can potentially be achieved using chemical or biological oxidation processes. This involves injecting oxidants directly into the source and the downgradient plume, or delivering oxidants by means of a groundwater recirculation system. The oxidant reacts with the pollutants, producing innocuous substances such as carbon dioxide, water, and chloride. The four main chemical oxidants used are permanganate, peroxide, persulfate and ozone.

The ability of the oxidant to react with a certain contaminant in the field depends on kinetics, stoichiometry, thermodynamics and delivery of the oxidant. On a microscale, kinetics or reaction rates are the most important. The rates of oxidation reactions are dependent on many variables, such as, pH, temperature, concentration of the reactants, catalysts, reaction by-products, and impurities

(oxidant scavengers, organic matter, etc.) that all must be taken into consideration.

The oxidant needs to be delivered in such a manner that the oxidant comes into the contact with the pollutant to be oxidized. The delivery goal is to ensure that the oxidant is dispersed evenly throughout the groundwater needing to be remediated. The solubility and rate of reaction of the oxidant need to be considered when developing the method of delivery of the oxidant.

Treatment Zone

The treatment zone is the area where the oxidation/reduction processes take place. During oxidation, several changes in water quality parameters can occur. The oxidation process can cause trivalent chromium present in formation materials and dissolved in the aquifer to be converted to hexavalent chromium, a much more toxic form of chromium. In addition, chlorides will be liberated if the pollutants being oxidized are chlorinated compounds. Increases in salts can occur if the oxidant being used has a salt component such as sodium or potassium.

Reduction processes have similar concerns with chlorides and salts. Reducing conditions will remove dissolved oxygen from the water, and can liberate excess concentrations of dissolved iron and manganese from formation materials, and generate methane, causing secondary water quality problems. These waste discharge requirements recognize that water quality objectives for some parameters may be exceeded within the treatment zone. However, water quality objectives are not allowed to be exceeded outside of the treatment zone. Monitor wells are established downgradient of the treatment zone for use as compliance wells. The monitor wells are used to measure compliance with water quality objectives and groundwater limitations.

The size of the treatment zone should be made as small as feasible, but in most cases will be driven by the plume configuration and design of the treatment system. The treatment zone could include a transition zone where ambient groundwater mixes with the treatment zone, reestablishing ambient oxidative conditions. In contact with the oxygen of ambient groundwater, the elevated concentrations of ferrous iron and dissolved manganese are oxidized, removing them from solution. Methane concentrations return to ambient concentrations much more slowly, and travel further than other reduced species. Therefore, the formation of methane should be avoided to the extent practicable by minimizing the degree of reducing conditions generated by the project. It is not appropriate to significantly increase the size of the treatment zone to simply allow for methane concentrations to reduce back to ambient levels.

Amendment Delivery

The in-situ treatment system is usually one of three types. One type utilizes a groundwater recirculation consisting of extraction and injection wells and provides control of the injectants and treatment zone. The extracted groundwater is amended aboveground and the amended water recharged upgradient of the extraction well. The second type injects the amendments into the groundwater and allows the groundwater to flow though the treatment zone. The third type uses extraction and injection wells to create a barrier with the treatment zone being established within and downgradient of the capture zone of the injection well(s). In this type of system the injection tends to occur downgradient of the extraction wells. The use of extraction and recharge systems is preferred as it provides greater flexibility and control of the treatment zone, and can be operated to help restore the treatment zone to pre-project conditions after remediation of the initial pollution has been completed.

Amendments

These waste discharge requirements require that the injectant materials be analyzed to determine the suitability of the materials to be used for in-situ remediation. Past analyses of various amendments, including corn syrup, molasses, HRC^{TM} and edible oils have shown elevated concentrations of sodium and other salts, and trace metals in some of them. As the groundwater in the Central Valley is in many places adversely impacted by salts, the use of salt-containing amendments is discouraged. A project that proposes using a salt-containing amendment is required to demonstrate that there is no cost-effective, salt-free amendment that can be utilized to achieve adequate remediation of the pollution before allowing the salt-containing amendment to be used. In addition, amendments containing other pollutants such as metals could contribute to exceedances of water quality objectives and/or degradation of the groundwater.

Basin Plan, Beneficial Uses, Background Groundwater Quality and Water Quality Objectives

The *Water Quality Control Plan for the California Regional Water Quality Control Board Central Valley Region, Fourth Edition* (Basin Plan), designates beneficial uses, establishes water quality objectives, and contains implementation plans and policies for all waters of the Basin. Beneficial uses often determine the water quality objectives that apply to a water body. For example, waters designated as municipal and domestic supply must meet the maximum contaminant levels (MCLs) for drinking waters. The Basin Plan sets forth the applicable beneficial uses (industrial, agricultural, and domestic supply in this instance) of groundwater, procedure for application of water quality objectives, and the process for and factors to consider in allocating waste assimilation capacity.

The antidegradation directives of Section 13000 of the California Water Code require that waters of the State that are better in quality than established water quality objectives be maintained "consistent with the maximum benefit to the people of the State." Waters can be of high quality for some constituents or beneficial uses and not others. Policies and procedures for complying with this directive are set forth in the Basin Plan (including by reference State Water Board Resolution No. 68-16, "Statement of Policy With Respect to Maintaining High Quality Waters in California," or "Antidegradation" Policy).

Resolution 68-16 is applied on a case-by-case, constituent-by-constituent basis in determining whether a certain degree of degradation can be justified. It is incumbent upon the Discharger to provide technical information for the Board to evaluate that fully characterizes:

All waste constituents to be discharged;

The background quality of the uppermost layer of the uppermost aquifer;

The background quality of other waters that may be affected;

The underlying hydrogeologic conditions;

Waste treatment and control measures;

How treatment and control measures are justified as best practicable treatment and control;

The extent the discharge will impact the quality of each aquifer; and

The expected degradation to water quality objectives.

In allowing a discharge, the Board must comply with CWC section 13263 in setting appropriate conditions. The Board is required, relative to the groundwater that may be affected by the discharge, to implement the Basin Plan and consider the beneficial uses to be protected along with the water quality objectives essential for that purpose. The Board need not authorize the full utilization of the waste assimilation capacity of the groundwater (CWC 13263(b)) and must consider other waste discharges and factors that affect that capacity.

The project proponent is required to determine background groundwater quality. The background data is used to determine compliance with water quality limitations at the points of compliance downgradient from the treatment zone. As stated above, salts can increase due to the dehalogenation of volatile organics or other pollutants or from salts present in amendments. Metals can be solubilized from aquifer materials by the reduction process, be released from amendments during reactions, or change to more toxic states during the oxidation process. These waste discharge requirements allow a slight increase (20% over background) in metals and salts, as long as water quality objectives are met. A value of less than 20% would be within the error of duplicate analysis

comparability criteria and an exceedance not always verifiable. Water quality objectives for the anticipated pollutants that are found at these remediation projects are established in the Findings. The water quality objectives are established based on the numerical and narrative standards found in the Basin Plan.

Coverage Under the Order

To obtain coverage under the order, the project proponent must submit a Notice of Intent (NOI) and supplemental information listed in Attachment A. The information requirements are significant as these projects are complex and require a great deal of knowledge about the project site and remediation processes. Though the requirement for submittal of information is substantial, it should be information that has already been developed by the project in order to justify the remediation project to the appropriate regulatory agency.

In order for coverage to occur, the project proponent needs to demonstrate through laboratory-scale tests that the proposed project will adequately promote remediation of the pollution. The laboratory-scale tests will also be used to identify potential adverse water quality impacts with the project and help establish monitoring parameters. If there are data from projects sufficiently similar to the proposed project, the proponent can use that information in lieu performing the laboratory-scale testing, as appropriate. Once the project is completed, the project proponent will file for termination of coverage under the general order.

Updates to Previous General Order R5-2008-0149

This General Order updates Order R5-2008-0149 in several ways. First, it establishes effluent limitations for discharges from groundwater treatment systems to ground. There are times when in-situ remediation systems extract groundwater, amend it and inject or infiltrate the amended water back into the groundwater. There can be some pollutants that that are not targeted by the in-situ remediation system and those pollutants may be required to be removed prior to discharge. The effluent limits are set at best available technology for removal of VOCs (effluent limit is 0.5 µg/L), at water quality objectives or background, whichever is greater, for pollutants such as perchlorate, chloride, TDS and other non-volatiles. This Order adds sulfate specifically to the list of pollutants that are covered and affirms that other pollutants can be considered once sufficient information has been supplied that verifies the efficacy of the proposed treatment method on the pollutant in the groundwater. Other changes were made to the monitoring program to improve its functionality and coverage of potential monitoring options.

There have been over 50 projects utilizing Order No. R5-2008-0149. All the projects operating under that Order will remain under the Order. Subsequent applicants will be issued coverage under this Order. Order No. R5-2008-0149 will be rescinded once all Notices of Applicability are terminated upon the completion of their specific projects.

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ATTACHMENT B

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

INSTRUCTIONS

FOR COMPLETING THE **NOTICE OF INTENT** TO COMPLY WITH THE TERMS OF GENERAL WASTE DISCHARGE REQUIREMENTS ORDER NO. R5-2015-0012 FOR IN-SITU GROUNDWATER REMEDIATION AND DISCHARGE OF TREATED GROUNDTWATER TO LAND

The Notice of Intent is to be submitted by responsible parties that elect to obtain coverage under the above General Order. If you have any questions regarding the completion of any part of the following form, please contact your Regional Board representative, as described on page 3. Much of the information needed to complete this form may be available from County Use Permit engineering reports or county records. Any additional information supplied, as detailed in Attachment 1, should be included on attached sheets and list all attachments with the titles and dates in the spaces provided.

1. RESPONSBILE PARTY INFORMATION

You must provide the information listed below for ALL persons or entities that hold legal interests associated with the facility or real property on which it is located. These may include, but are not limited to, owners, leaseholders, lessees, and operators.

Under *Owner Name/Address*, include the legal name of the business entities and/or persons who own the facility undergoing remedial activities, the owner's mailing address, and phone number.

Under *Operator Name*, include the name of the business entities or persons who actually operate the facility only if different than the owner.

Under *Mailing Address*, include the mailing address where legal notices may be received by the operator if it is different form the physical facility address. You may specify another contact person at the mailing address if desired.

Check the appropriate Owner type. Both the Owner and the Operator will be named in the Notice of Applicability and will receive legal notices and invoices at these addresses.

2. TREATMENT SITE INFORMATION:

Provide the Facility name, the physical address of the treatment location, the facility contact person (preferably a responsible employee with offices at the facility), and phone number at the facility. Do not use a P.O. Box number in this section. If there is no street address, use closest street and nearest cross street.

3. LOCATION OF FACILITY

Enter the Assessor's Parcel Number(s) (APN). This number is located on the property tax bill and can also be obtained from the County Assessor's Office. Indicate the APN for both the facility and any land discharge areas owned by the Discharger. Specify the closest surface water body in the vicinity of the facility, such as a creek, canal, or river.

Submit the complete NOI, supplemental information, and the first annual fee in the form a check payable to *State Water Resources Control Board* to the appropriate Regional Board office. The fee shall be that required by the current version of the California Code of Regulation, Title 23, Division 7, Chapter 9, Waste Discharge Report and Requirements, Article 1**, fees for discharge for a Threat to Water Quality and Complexity ranking of 3B.**

For projects within Alameda, Alpine, Amador, Calaveras, Colusa, Contra Costa, El Dorado, Glenn Lake, Napa, Nevada, Placer, Sacramento, San Joaquin, Sierra, Solano, Stanislaus, Sutter, Yolo, and Yuba Counties, submit the NOI and filing fee to:

Regional Water Quality Control Board, Central Valley Region
11020 Sun Center Drive, Suite 200
Rancho Cordova, CA 95670-6114
(916) 464-4625

For projects within Fresno, Kern, Kings, Madera, Mariposa, Merced, Tulare and Tuolumne Counties, submit the NOI and filing fee to:

Regional Water Quality Control Board, Central Valley Region
1685 "E" Street
Fresno, CA 93706
(559) 445-5116

For projects within Butte, Lassen, Modoc, Plumas, Shasta, and Tehama Counties, submit the NOI and filing fee to:

Regional Water Quality Control Board, Central Valley Region
415 Knollcrest Drive, Suite 100
Redding, CA 96002
(530) 224-4845

Attachment 1 to NOI
Notice of Intent Additional Information Requirements

A Final Approved Work Plan and CEQA document for the project. Any of the information required below that is contained in the work plan need not be reproduced separately from the work plan.

B Final Approved Remedial Action Plan or Cleanup Plan. If a Remedial Action Plan has been approved, a copy of the Remedial Action Plan should also be provided.

C Location:

i) USGS Quad Sheet delineating location.
ii) Another figure showing a closer view of the site.
iii) A description of the remediation area and area surrounding the remediation area.

D Bench Scale/Pilot Scale Testing:

i) Results from bench scale or pilot-scale testing that demonstrates that the proposed project is likely to be successful at the site. If the data provided is from a different project location, the provided information needs to support that the tested site is substantially similar to the proposed project site in regards to soil properties and makeup.

E Geology/Hydrogeology:

i) A description of the geology/hydrogeology of the site and surrounding area within ¼ mile of the site.
ii) Geologic cross-sections through the site, both perpendicular and parallel to the groundwater flow direction.
iii) Table of monitor wells in the vicinity including as-built information.

F Groundwater Information:

i) Narrative description of the occurrence and quality of groundwater at the site, including upgradient and downgradient conditions
ii) A figure depicting groundwater monitor wells/piezometers and water supply wells
iii) Figures showing groundwater potentiometric surface maps for each layer of interest.
iv) Figure showing water supply wells within 1-mile of the project location, along with any available information regarding construction, use and pumping rates.

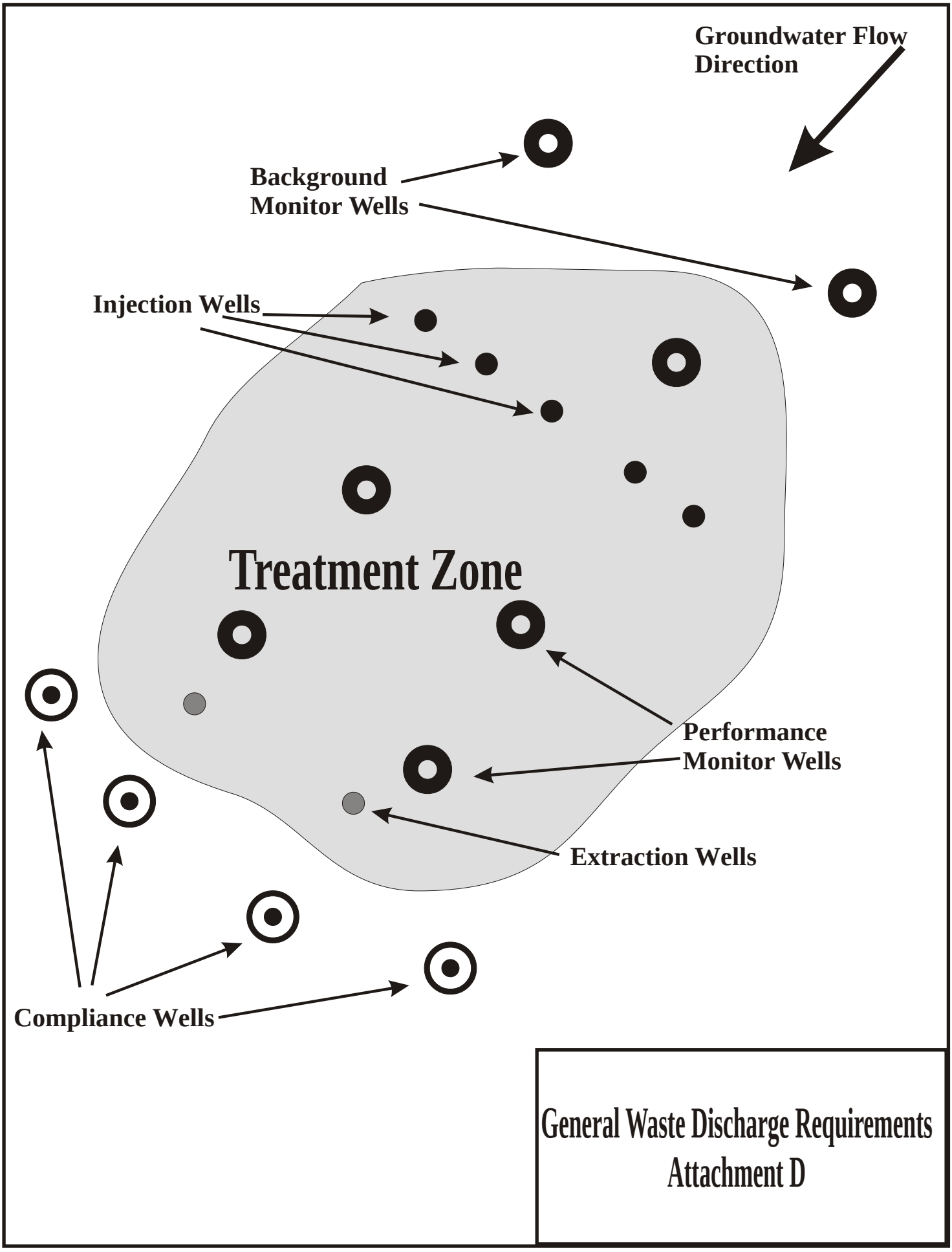
G Water Quality Information:

i) Tables of water quality data for each monitor well within the area of the testing. Wells segregated into monitor zones, and upgradient, downgradient and within the plume wells. The data should include detection and reporting levels for the analyses listed.
ii) Water quality data should include VOCs, general minerals, metals (need to include iron, manganese, total chromium, hexavalent chromium, . . .), sulfate, nitrate, ammonia, dissolved oxygen, oxidation/reduction potential, chemical oxygen demand, total dissolved solids, electrical conductivity, temperature
iii) Figures depicting the groundwater contaminant plume configurations for each of the monitor zones.
iv) Tables presenting background concentrations of COCs, injectant components and potential breakdown products.

H Project Proposal:

i) Proposed injection points
ii) Injectant(s) to be used for remediation and for biofouling control
iii) Analysis of the injectants – VOCs, semi-VOCs, metals, general minerals, pH, TDS. . .
iv) Potential breakdown products of COCs and injectants. Estimated concentrations of the injectants and breakdown products remaining at the conclusion of the project. The estimated concentrations need to be compared to background concentrations of the pollutants.
v) Proposed injectant rates and concentrations.
vi) Proposed tracer compounds, application concentration rates, and concentrations of tracer within treatment zone for conducting tracer tests
vii) Delineation of treatment zone – including figure
viii) Delineation of transition zone – including figure
ix) Proposed monitoring program – frequency, methods, quantitation and detection limits – use Attachment C as template.
x) Treatment system, if any, description and proposed operation
xi) List of proposed wells, and figure delineating the locations of the wells, for monitoring upgradient and downgradient groundwater quality and groundwater elevations. Wells should be designated for the treatment zone, transition area within treatment zone and compliance wells at the treatment zone downgradient boundary.
xii) Contingency Plan – Plan for corrective actions if violations are found at the points of compliance.

I List of Interested Parties
J Draft Fact Sheet



General Waste Discharge Requirements
Attachment D

General Waste Discharge Requirements
Attachment E
Treated Water Discharge Locations