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Clayton GROUP SERVICES

APR 08 2002

April 4, 2002

Mr. Barney Chan
Alameda County Health Care Services
1131 Harbor Bay Parkway, Suite 250
Alameda, California 94502-6577

Clayton Project No.: 70-97066.00

Subject: Workplan to Install Two (2) Offsite Groundwater Monitoring Wells and Implement Preliminary Remediation Measures
Former Lemoine Sausage Factory
630 29th Avenue, Oakland, California

Dear Mr. Chan:

Clayton Group Services Inc. (Clayton) has prepared this workplan that outlines the methods to install two new offsite groundwater monitoring wells and implement preliminary remediation measures at 630 29th Avenue in Oakland, California, Figure 1. The workplan is submitted at the request of the Alameda County Health Care Services (ACHCS) letter dated January 28, 2002.

This workplan outlines a scope of work, and work methods for the installation, surveying, development and initial groundwater sampling of two new groundwater monitoring wells. The installation of monitoring wells will be subject to workplan approval by the ACHCS and permit issuance by the Alameda County Public Works Agency (ACPWA).

BACKGROUND

A one 1,000-gallon gasoline UST and associated fueling dispenser and were formerly located east of the facility building. The UST was located beneath the sidewalk adjacent to 7th Street and supplied the dispenser located in a "cubby hole" near the building's roll-up door. The UST and associated piping were removed on November 21, 1996 and confirmation soil samples indicated that petroleum hydrocarbon as gasoline had been historically released from the UST system.

Further site characterization investigations were performed and groundwater was impacted with both petroleum hydrocarbons and chlorinated solvents. The source of chlorinated solvents with the exception of 1,2- Dichloroethane has not been discerned at this time. To date eleven (11) monitoring wells and piezometers have been installed at the site and eight (8) are monitored on a quarterly basis.

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To address ACHCS concerns with the present definition of the hydrocarbon plume, two monitoring wells will be installed west of the subject property. The proposed locations for the new monitoring wells are shown in Figure 1.

SCOPE OF WORK

To further define the extent of the hydrocarbon plume and monitor groundwater conditions at the subject property, two groundwater monitoring wells will be installed and sampled. Clayton will conduct the following specific tasks:

- Prefield Activities
- Install Two New Groundwater Monitoring Wells
- Groundwater Monitoring Well Development
- Monitoring Well Surveying
- Collect Groundwater Samples
- Implement Preliminary Remediation Measures in the Vicinity of Monitoring Wells MW-9
- Laboratory Analysis
- Project Management and Report Preparation

Task 1: Prefield Activities

Clayton will prepare a site specific Health and Safety Plan (HASP) for the work proposed at the site in accordance with the requirements of the State of California General Industry Safety Order (GISO) 5192 and Title 29 of the Code of Federal Regulations, Section 1910.120 (29 CFR 1910.120). A copy of the health and safety plan was kept onsite during field activities. The HASP will detail the work to be performed, safety precautions, emergency response procedures, nearest hospital information, and onsite personnel responsible for managing emergency situations.

Clayton will obtain two monitoring well installation permits from the ACPWA, and schedule a C-57 licensed drilling contractor to install the monitoring wells. Clayton will mark the site's property with white paint and notify Underground Service Alert (USA) with at least 48 hours prior to drilling, as required by law. Clayton will also contract a professional utility locating service to attempt to identify the location of underground utilities in the vicinity of proposed boring locations. Clayton will not advance a boring within three feet from a known underground utility.

In addition, the new monitoring wells will be located on property owned by others and Clayton will need to secure access agreements from all affected parties.

Task 2a: Monitoring Well Installation

A limited access drill rig equipped with eight-inch diameter hollow stem augers will be used to drill boreholes for monitoring well installation. While drilling boreholes, an 18-inch long California modified split spoon sampler lined with three two-inch diameter, six-inch long brass sleeves will be used to collect soil samples from boreholes. One sample drive will be performed every five-foot of borehole penetration. Based on the historical depth to water measurements, Clayton anticipates that groundwater will be encountered at depths of approximately 5 to 10 feet below ground surface.

Soil cores will be logged for lithological content by the Unified Soil Classification System (USCS), color using a Munsell color chart, relative moisture content, competency, blow counts, and other observable distinguishing characteristics (for example, rootlets or odor). A photo-ionization detector (PID) will be used to field screen soil for the presence of VOCs. Lithological details and other field observations will be entered onto exploratory boring log sheets.

All hollow stem auger drill stems and downhole sampling equipment will be steam cleaned after each use. The soil cuttings and decontamination water will be containerized in separate United States Department of Transport (DOT) approved 55-gallon drums. The drums will be sealed, labeled with content information and generation date, and stored onsite pending future disposal.

Task 2b: Groundwater Monitoring Well Construction

Two groundwater monitoring wells will be constructed within the eight-inch diameter boreholes. The well screen section will be constructed with two-inch diameter schedule 40 poly-vinyl chloride (PVC) casing perforated with 0.010-inch slots and fitted with a PVC end cap. The well screen casing will be flush threaded to the necessary length of two-inch diameter schedule 40 PVC blank pipe to complete the well casing to surface. The monitoring well screen casing will be set from approximately five feet below first encountered water to five feet above first encountered.

The well screen filter pack will be constructed by pouring Lonestar number 2/12 graded sand from the bottom of the borehole annular space to two feet above the top of the well screen casing. A two-foot interval of 3/8-inch bentonite pellets will be placed in the annular space above the top of the sand filter pack. The bentonite will be hydrated and allowed to swell. The remaining annular space to approximately one-foot below ground surface will be filled with a neat cement grout containing approximately five percent bentonite powder. A traffic rated Christy box will be placed around the top of each well casing and secured in place with concrete. A lockable expanding well cap will be used to secure each wellhead. A V-notch will be placed on the top of the north facing rim of each monitoring well casing for use as a surveying and depth to water measurement reference point. Well construction details will be recorded onto well construction field logs.

Task 2c: Groundwater Monitoring Well Development

The annular grout seals will be allowed to set for three days prior to well development. Well development will be performed to remove sediment that has accumulated in the well casing and filter pack sand during well construction, and also to help stabilize the filter pack sand and aquifer material surrounding the well screen intake area.

The depths to groundwater and total length of the monitoring well casing will be measured to determine the quantity of water column within each well casing. A monitoring well development rig equipped with a two-inch surge block will be used to agitate water and well construction materials prior to and during well development. A submersible pump or bailer will be used to purge groundwater and sediment from well casings. Well development will be continued until water quality parameters (pH, temperature, specific conductivity, and turbidity) have stabilized. A minimum of 10 well casing volumes of water will be purged from monitoring wells during development. Purge water will be stored onsite in sealed, labeled, DOT approved 55-gallon drums pending future disposal. Groundwater quality parameters will be recorded onto well development field logs.

Task 2d: Monitoring Well Surveying

A State of California Licensed Land Surveyor will survey the location and elevation of each monitoring well, to comply with State of California Assembly Bill 2886. The survey will include the top of well casing elevation (north face) and top of Christy box rim elevation; the elevation data will be surveyed to 0.01-foot accuracy. The northing and easting co-ordinates will be surveyed to 0.1-foot (that is equivalent to latitude and longitude co-ordinates to seven decimal degree) accuracy and referenced to a recognized survey monument.

Task 3: Groundwater Monitoring Well Sampling

Approximately four well casing volumes of water will be purged from each monitoring well prior to sampling. A submersible pump will be used to purge groundwater from each monitoring well. Water quality parameters (pH, specific conductivity, temperature and visual turbidity) will be recorded onto groundwater sampling field logs. Water quality parameters will be measured at; the initial standing water column in the well casing prior to purging, and following the removal of each subsequent well casing volume of water.

Upon purging sufficient water from the monitoring wells, groundwater for laboratory analysis will be retrieved using a disposable bailer and transferred into laboratory supplied sample containers. The sample container size and sample preservative will correspond to requested analytical method. Sample containers will be sealed, labeled with identifying information, logged onto the chain-of-custody, and temporarily stored in a chilled ice-chest while awaiting transportation to the laboratory. Groundwater purged from monitoring wells for sampling purposes will be stored onsite in sealed, labeled, DOT approved 55-gallon drums pending future disposal.

Task 4: Laboratory Analysis

Groundwater samples will be submitted for one or more of the following analytical methods:

- USEPA Method 8015M for total petroleum hydrocarbons as gasoline (TPHG)
- USEPA Method 8020 for aromatic hydrocarbons; benzene, toluene, ethylbenzene and total xylenes (BTEX).
- USEPA Method 8010 for halogenated organic compounds
- Fuel oxygenates by USEPA Method 8260

Samples will be submitted to a State of California certified laboratory for analysis on standard ten day turn-round time basis.

Task 5: Implement Preliminary Remedial Measures in the Vicinity of Monitoring Well MW-9

The initial TPHG and BTEX sampling results from monitoring well MW-9 indicated that benzene concentration in groundwater exceeded the City of Oakland Tier 1 risk based corrective action level. As such, the ACHCS requested in letter dated January 28, 2002, that preliminary remedial measures be implemented in the vicinity of monitoring well MW-9. Clayton proposes to implement remedial activities by performing a bioremediation pilot study.

Clayton prepared and presented a *Risk Assessment and Feasibility Study* (RI/FS) for the site, dated February 16, 2001. From site characterization testing performed during the RI/FS, heterotrophic bacteria that are capable of degrading petroleum hydrocarbons were identified from within the plume area. However, site characterization also indicated that oxygen and macronutrients (primarily nitrogen and orthophosphate compounds) are depleted would be required to be added to promote optimum bacterial activity.

[redacted] collectively termed treatment wells. Readily available liquid macronutrients will be injected through the treatment wells. Approximately 1-gallon of commercial fertilizer

(Miracle Gro™ or similar product) will be injected into each well. To ensure that macronutrients have the opportunity to disperse through the subsurface prior to oxygenation, the macronutrients will be injected approximately one-week prior to peroxide injection.

In the RI/FS, Clayton recommended the use of oxygen release compounds (ORCs) in the form of a slurry, however, as the treatment wells have a pre-packed filter that will most likely clog if injected with a slurry, Clayton is recommending the use of liquid hydrogen peroxide as a substitute oxygen source.

Hydrogen peroxide readily decomposes to liberate oxygen by the following reaction:

Hydrogen peroxide → water + oxygen

$$H_2O_2 \rightarrow H_2O + \frac{1}{2} O_2 + \text{heat}$$

Chemical information data sheets are presented in Appendix A. For the first application, approximately 30 gallons of 5-wt% peroxide will be injected into each treatment well.

The remedial effectiveness of the bioremediation pilot study will be evaluated based on petroleum hydrocarbon analytical results for groundwater samples collected from monitoring wells MW-9 and MW-2 in future (second and third quarter, 2002) groundwater monitoring events.

Task 5a: Repair Sidewalk and Excavate Former Tank Pit to Place Oxygen Release Compounds

The concrete sidewalk located above the former UST excavation has sagged and in need of repair. Clayton proposes raise the existing (sagged) sidewalk and excavate to approximately 2-feet below the water levels (historically measured at 4 to 6 feet below street grade). Oxygen release compounds (ORC) will be placed in the excavation pit and act as a source of oxygen to groundwater. Clayton proposes to place approximately 180 pounds of ORC slurry in the excavation.

The saturated portion of the excavation will be backfill with crushed rock and cover with geotextile fabric. The remaining portion of the excavation will be backfilled with soil removed from the excavation and compacted to 90% relative density. The replacement sidewalk will be constructed to match existing.

Task 6: Project Management and Report Preparation

Upon completion of the laboratory analysis, Clayton will prepare a report documenting groundwater monitoring well installation, development, and sampling field methods. The report will include a description of the site, geological and well construction logs, copies of well development and sampling field logs, laboratory analytical data sheets, a tabulation of laboratory analytical results and depth to water measurements, figures delineating monitoring well locations and groundwater flow direction, and conclusions and recommendations.

SCHEDULE

Clayton will begin to initiate the tasks outlined in this workplan upon receiving ACHCS authorization to proceed. Field activities will be scheduled based on subcontractor availability and the ability to obtain all necessary permits and access agreements. Clayton anticipates that field activities will take approximately 3 days (1-days for monitoring well installation, 1-day for monitoring well development, and 1-day for groundwater sampling) to complete. Regulatory specifications require that for newly constructed monitoring wells the annular seal be allowed 72-hours (3-days) to cure before well development may take place. A further 24-hour (1-day) stabilization period is required following well development prior to groundwater sampling. Groundwater samples will be submitted on a standard ten-day turnaround time. The total time to complete field activities, submit samples and receive laboratory analytical results is estimated at three weeks.

The bioremediation pilot study will be initiated following receipt by Clayton of the first quarter 2002 groundwater analytical results (expected by mid April, 2002). Overall, project completion will be dependent on response time provided by the ACHCS and the ability to obtain permits and access agreements.

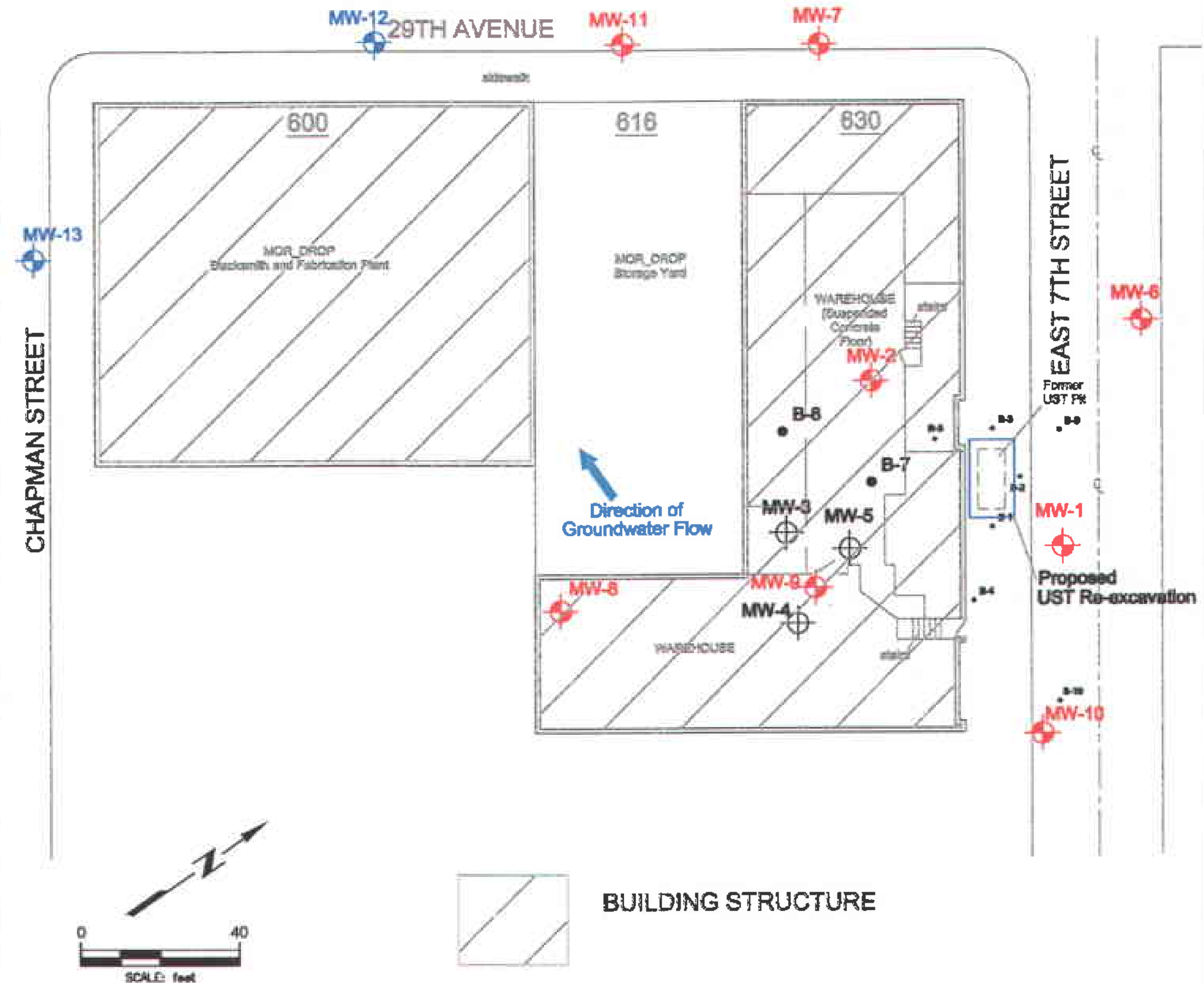
Please contact the undersigned at (925) 426-2600 if you have questions or require additional information.

Sincerely,

Warren B. Chamberlain, R.G., C.HG., P.E.
Project Manager
Environmental Services

Jon A. Rosso, P.E.
Director
Environmental Services

WBC/wbc
Attachments
cc: Rita Repko Clayton



Treatment Wells

B-7 ● Proposed Soil Boring Injection Point

MW-3 ⌖ Proposed Injection Wells

LEGEND	SITE PLAN SHOWING PROPOSED MONITORING WELL AND TREATMENT WELL LOCATIONS	Figure	
MW-1 ⌖ Existing Monitoring Well Location MW-12 ⌖ Proposed Location for New Monitoring Wells	FORMER LEMOINE SAUSAGE FACTORY 630 29TH AVENUE OAKLAND, CALIFORNIA Clayton Project No. 70-97066.00	1 2/5/02 sitemap.dwg	Clayton GROUP SERVICES

ATTACHMENT A

HYDROGEN PEROXIDE PRODUCT SPECIFICATIONS

mole fraction

$$50\% \, H_2O_2 = \frac{50g}{50g \, H_2O} = \frac{50/34}{50/34 + 50/18} = \frac{1.47}{1.47 + 2.8} = .344$$

2.8

INTRODUCTION TO HYDROGEN PEROXIDE

physical and chemical properties - summary

$\frac{16}{34} = .47$

34g 16
$H_2O_2 \rightarrow H_2O + \frac{1}{2}O_2$

Hydrogen Peroxide (H_2O_2) solutions are clear, colorless, water-like in appearance, and can be mixed with water in any proportion. At high concentrations, it has a slightly pungent or acidic odor.

H_2O_2 has a molecular weight of 34.02 and **is nonflammable at any concentration**. Its Chemical Abstracts Service Registry Number is 7722-84-1. Other physical and chemical properties of the two standard industrial strengths follow.

$.5 \times .47 = .235$

H_2O_2 Concentration	35%	50%
Active oxygen content, wt.%	16.5	23.5
Density @ 68°:		
Specific gravity	1.132	1.196
lbs per gallon	9.45	9.98
gms-100% per mL	0.397	0.598
Apparent pH	2-3	1-2
Acidity, mg/L (as H_2SO_4)	< 50	< 50
Total heavy metals, mg/L	< 1	< 1
Freezing point, °	-27	-62
Boiling point, °	226	237
Vapor pressure @ 86°, mm Hg	23	18
Viscosity:		
@ 32°, cp	1.81	1.87
@ 68°, cp	1.11	1.17
Heat of decomposition, cal/gm	233	335
Mole fraction	0.22	0.346

[Forward to Physical Properties]

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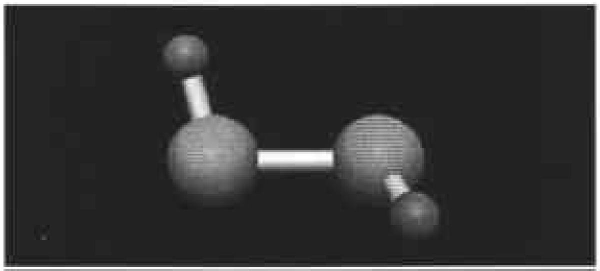
INTRODUCTION TO HYDROGEN PEROXIDE

environmental application overview



$2\,H_2O_2 \longrightarrow 2\,H_2O + O_2$

(hydrogen peroxide ----> water + oxygen)

Introduction

As simple as it may seem, the treatment of contaminated waters is as diverse and complicated as the operations from which it comes. In today's environment, where merely transferring contaminants from one medium to another is no longer acceptable, it is no surprise that a powerful oxidizer that looks like water -- in its appearance, chemical formula and reaction products -- should be so widely used. This is hydrogen peroxide (H2O2) -- a powerful yet versatile oxidant that is both safe and effective.

H_2O_2 Advantages

Powerful - H2O2 is one of the most powerful oxidizers known -- stronger than chlorine, chlorine dioxide, and potassium permanganate. And through catalysis, H2O2 can be converted into hydroxyl radicals (· OH) with reactivity second only to fluorine.

Oxidant	Oxidation Potential, V
Fluorine	3.0
Hydroxyl radical	2.8 ← Fenton's Reagent
Ozone	2.1
Hydrogen peroxide	1.8
Potassium permanganate	1.7
Chlorine dioxide	1.5
Chlorine	1.4

Safe - Despite its power, H2O2 is a natural metabolite of many organisms, which decompose the H2O2 they produce into oxygen and water. H2O2 is also formed by the action of sunlight on water -- a natural purification system for our environment. Consequently, H2O2 has none of the problems of gaseous release or chemical residues that are associated with other chemical oxidants. And since H2O2 is totally miscible with water, the issue of safety is one of concentration. Industrial strength H2O2 is a strong oxidizer and as such requires special handling precautions.

Versatile - The fact that H2O2 is used for seemingly converse applications proves its versatility. For example, it can inhibit microbial growth (as in the biofouling of water circuits) and encourage microbial growth (as in the bioremediation of contaminated groundwaters and soils). Similarly, it can treat both easy-to-oxidize pollutants (iron and sulfides) and difficult to oxidize pollutants (solvents, gasolines and pesticides).

Selective - The reason why H2O2 can be used for such diverse applications is the different ways in which its power can be directed -- termed selectivity. By simply adjusting the conditions of the reaction (e.g., pH, temperature, dose, reaction time, and/or catalyst addition), H2O2 can often be made to oxidize one pollutant over another, or even to favor different oxidation products from the same pollutant.

Widely Used - Since it was first commercialized in the 1800's, H2O2 production has now grown to over a billion pounds per year (as 100%). In addition to pollution control, H2O2 is used to bleach textiles and paper products, and to manufacture or process foods, minerals, petrochemicals, and consumer products (detergents). Its use for pollution control parallels those of the movement itself -- municipal wastewater applications in the 1970's; industrial waste/wastewater applications in the 1980's; and more recently, air applications in the 1990's. Today, H2O2 is readily available throughout the U.S. in drum, tote, mini-bulk, and bulk quantities in concentrations of 35% or 50% by weight.

End Use Industries

- Landfills
- Oil refining
- Mining / metallurgy
- Machining
- Textiles
- Power production
- Composting
- Potable water
- Chemicals and resins
- Food processing
- Electronics
- Pulp and paper
- Timber products
- Hazardous wastes
- Site remediation
- Municipal wastewater

Environmental Applications of H_2O_2

H2O2 applications span the range of possible media: air, water, wastewater, soils and sludges. Depending on the objective, H2O2 may be used either alone or in combination with other processes to enhance their performance.

<u>Stand-Alone Applications</u>

Odor control - Oxidizes hydrogen sulfide, mercaptans, amines and aldehydes. H2O2 may be applied directly to aqueous wastes containing these odorants, or to wet scrubbers used to remove them from airstreams. If the odors are the result of biological activity, H2O2 may instead be added as a preventative to eliminate the anoxic conditions which favor the generation of odors.

Corrosion control - destroys residual chlorine and reduced sulfur compounds thiosulfates, sulfites, and sulfides) which form corrosive acids when condensed onto processing equipment and oxidized by air.

BOD/COD removal - Oxidizes both organic and inorganic pollutants which contribute to BOD and COD -- catalytic, H2O2 may be needed to oxidize the more resistant substances. H2O2 may also affect BOD/COD removal by enhancing the performance of other processes (see below).

Inorganic oxidation - Oxidizes cyanides, NOx/SOx, nitrites, hydrazine, carbonyl sulfide, and other reduced sulfur compounds mentioned above (odor/corrosion control).

Organic oxidation - Hydrolyzes formaldehyde, carbon disulfide, carbohydrates, organophosphorus and nitrogen compounds, and various water-soluble polymers; and (with catalysis) destroys phenols, BTEX pesticides, solvents, plasticizers, chelants, and virtually any other organic requiring treatment.

Metals oxidation - Oxidizes ferrous iron, manganese, arsenic, and selenium to improve their adsorption, filtration, or precipitation from process waters and wastewaters.

Toxicity reduction/Biodegradability improvement - With catalysis, chemically digests complex organics into smaller, less toxic and more biodegradable fragments.

Disinfection/Bio-control - Checks excess biogrowth in water supplies and cooling circuits, and (with catalysis) disinfects process waters and biological effluents.

Enhancement (Combination) Applications

Flocculationlprecipitation - Oxidizes metal complexes and improves the performance of inorganic flocculants.

Air Flotation - Releases evenly dispersed microbubbles which entrain emulsified fats, oils and greases to enhance their removal in air flotation units and grease traps.

Biotreatnent - As a pretreatment - degrades toxic, refractory or bio-inhibitory organics, rendering them more amenable to biodegradation. In con junction with - provides a supplemental source of dissolved oxygen *in-situ* (penetrating both soil columns and bioflocs, eliminating the sludge bulking phenomenon). As a polishing step - destroys trace levels of organics that pass through biotreatment, providing the ancillary benefit of disinfection.

Filtration - Controls biofouling of UF and RO membranes while eliminating foul odors from media filters.

Carbon adsorption - Enhances the adsorption of many pollutants while providing dissolved oxygen to support biologically-active carbon beds (improving removal efficiencies still further).

Air scrubbers - Replaces chlorine for deodorizing offgases and controlling VOC's. Depending on the target pollutant(s), catalytic or Advanced Oxidation Processes may be required.

Incineration - Provides supplemental oxygen to improve combustion efficiencies and lower operating temperatures.

H2O2 Processes

Simple H2O2 - Most H2O2 applications involve its simple injection into the water stream with no requirement for additional chemicals or equipment. These include the control of biogrowth (slime), the supply of supplemental oxygen, the removal of FOG and chlorine residuals, and the oxidation of sulfides/sulfites, metals, and other easy-to-oxidize components of BOD/COD. Activation of H2O2 in these applications may be affected by the adjustment/control of pH, temperature, and/or reaction time.

Catalytic H2O2 - The more difficult-to-oxidize pollutants may require the H2O2 to be activated with catalysts such as iron, copper, manganese, or other transition metal compounds. These catalysts may also be used to speed up H2O2 reactions that may otherwise take hours or days to complete. H2O2 catalysis may occur either in solution (using soluble catalysts) or in packed columns (using solid catalysts).

> *Solution catalysis* - The most commonly used solution catalyst is iron, which when used with H2O2 is referred to as Fenton's Reagent. The reaction requires a slightly acidic pH and results in the formation of highly reactive hydroxyl radicals (. OH) which are capable of degrading most organic pollutants. Another solution catalyst is copper, which is often used to destroy cyanides. Other metals also show catalytic activity wth,202and may be used to selectively destroy specific pollutants.
>
> *Packed column catalysis* - Solid catalysts eliminate the need to add soluble metals to the wastestream, and may offer greater flexibility in terms of reaction rates, selectivity, and the need for pH adjustment. This is an active area of research and many new developments are underway for a variety of applications.

Advanced Oxidation Processes (AOP's) - AOP's represent the newest development in H2O2 technology, and are loosely defined as processes that generate highly reactive oxygen radicals without the addition of metal catalysts. Typically, this means combining H2O2 with ozone or ultraviolet light. The result is the on-site total destruction of even refractory organics without the generation of sludges or residues. This technology is being widely applied to treat contaminated groundwaters, to purify and disinfect drinking waters and process waters, and to destroy trace organics in industrial effluents.

[To Physical and Chemical Properties]

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Former Lemoine Sausage Factory
ORC Application Calculation

TANK EXCAVATION - GROUNDWATER TREATMENT

Excavation Length (ft)	15
Excavation Width (ft)	6
Thickness of Saturated Treatment Zone (ft)	2
Porosity	0.35
(sand = 0.3, silt = 0.35, clay = 0.4)	
Pore Volume (gallons)	471

Dissolved Phase Hydrocarbon Level (ppm)	50
(For gasoline sites use BTEX measurements)	
Dissolved Phase HC Mass (lbs)	0.2
Additional Demand Factor	8
(REGENESIS recommends a factor of about 8)	
Loaded HC Mass (lbs)	1.6
Oxygen Required (lbs)	4.8
ORC Required (lbs)	48
ORC Unit Cost	$ 10.00
Total Cost of ORC	$ 480

FOR SOLUTE TRANSPORT MODEL ENTER VALUES BELOW

GW Velocity (ft / day)	0.3
Compliance Pt. (ft)	100
Ratio of O2 provided : O2 required (percent)	100%
HC Level at compliance point after selected ratio of O2 in ppm	0.00

APPENDIX H

ESTIMATE OF INORGANIC NUTRIENTS AND TREATMENT AREA
Former Lemoine Sausage Factory
630 29th Avenue
Oakland, California

TYPICAL RATIO FOR SOIL AMENDMENTS 100 : 10 : 1

NUTRIENT REQUIREMENT CALCULATIONS

	C	N	P
Mass ratio required	1	0.17	0.024 ← ok
Carbon mass available (mg/L)	41		
Required nutrients (mg/L)		(41×.17) 6.97	0.984

Average Site Concentrations in groundwater Within treatment zone		7.00	0.38

Nitrogen Compounds not required (but recommended due to sporadic distribution of N in groundwater)
OrthoPhosphate required

Estimated Volume of Groundwater within Treatment Area

(50' x 50' x 10') plume core	40,000	ft^3
soil porosity (n=0.33)	13,200	ft^3
	370,260	**Liters**
Nitrogen required	2,580,712	mg
	2.58	**kg**
OrthoPhosphate required	364,336	mg
	0.36	**kg**

RADIUS OF INFLUENCE PER INJECTION POINT

Groundwater seepage velocity (v = Ki/n)	**0.2240**	**ft/day**
K = 2.8 ft/day for silty sand (from Freeze & Cherry) conductivity		
i = 0.02 ft/ft gradient		
n = 0.25 effective porosity (med gravel)		
Distance travelled in 270 days	**60.48**	**ft**
Assume 3-ft diameter ORC pancake	**3**	**ft**
Radius of Influence of Injection Points	**63.48**	**ft**