FEBRUARY 27, 2013

GROUNDWATER EXTRACTION AND TREATMENT SYSTEM
PILOT TESTING
CORRECTIVE MEASURES STUDY WORKPLAN
ADDENDUM NO. 6

RAYTHEON COMPANY

(FORMER HUGHES AIRCRAFT COMPANY)

1901 WEST MALVERN AVENUE

FULLERTON, CALIFORNIA

PREPARED FOR:
RAYTHEON COMPANY

HARGIS + ASSOCIATES, INC.
HYDROGEOLOGY • ENGINEERING

HARGIS + ASSOCIATES, INC.
HYDROGEOLOGY • ENGINEERING

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February 27, 2013

VIA FEDERAL EXPRESS – STANDARD

Mr. William F. Jeffers, PE
Hazardous Substances Engineer
CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
DEPARTMENT OF TOXIC SUBSTANCES CONTROL
9211 Oakdale Avenue
Chatsworth, CA 91311-6505

Re: Transmittal of Groundwater Extraction and Treatment System Pilot Testing Corrective Measures Study Work Plan, Addendum No. 6, Raytheon Company, (Former Hughes Aircraft Company), 1901 West Malvern Avenue, Fullerton, California

Dear Mr. Jeffers:

Enclosed is one hard copy with a compact disc that contains a copy of the above-referenced report. If you have any questions or require further information, please contact us at 858-455-6500.

Sincerely,

HARGIS + ASSOCIATES, INC.

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HARGIS + ASSOCIATES, INC.

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RAYTHEON COMPANY
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1901 WEST MALVERN AVENUE
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TABLE OF CONTENTS

Section Page

TABLE OF CONTENTS (continued)

TABLES

Table

FIGURES

TABLE OF CONTENTS (continued)

APPENDICES

Appendix

ACRONYMS AND ABBREVIATIONS

APT	APTwater, Inc.
CACA	Corrective Action Consent Agreement
CMS	Corrective Measures Study
1,1-DCE	1,1-Dichloroethylene
DTSC	California Environmental Protection Agency, Department of Toxic Substances Control
gpm	Gallons per minute
H+A	Hargis + Associates, Inc.
H_2O_2	Hydrogen peroxide
HSPs	Health and Safety Plans
HVOCs	Halogenated volatile organic compounds
lbs	Pounds
LGAC	Liquid phase granular activated carbon
NPDES	National Pollutant Discharge Elimination System
O&M	Operation and maintenance
OCSD	Orange County Sanitation District
RCRA	Resource Conservation and Recovery Act
the Site	1901 West Malvern Avenue, Fullerton, California
Trojan	Trojan UV, Inc.
UV	Ultraviolet
VOCs	Volatile organic compounds
WDRs	Waste Discharge Requirements
Workplan	Addendum 6 to the Corrective Measures Study Workplan: Extraction and Treatment System Pilot Testing Workplan

GROUNDWATER EXTRACTION AND TREATMENT SYSTEM
PILOT TESTING
CORRECTIVE MEASURES STUDY WORKPLAN

ADDENDUM NO. 6

RAYTHEON COMPANY
(FORMER HUGHES AIRCRAFT COMPANY)
1901 WEST MALVERN AVENUE
FULLERTON, CALIFORNIA

1.0 INTRODUCTION

This Workplan Addendum 6 to the Groundwater Extraction and Treatment System Pilot Testing Corrective Measures Study (CMS) Workplan (Hargis + Associates, Inc. [H+A], 2003a) has been prepared by H+A on behalf of Raytheon Company for the former Hughes Aircraft Company Facility site located at 1901 West Malvern Avenue, Fullerton, California (the Site) (Figures 1 and 2). This CMS Workplan Addendum 6 is a Groundwater Extraction and Treatment System Pilot Testing Workplan (Workplan). The Workplan presents details regarding additional actions which are proposed in response to previously completed pilot testing activities detailed in Addendum 5 to the CMS Workplan, and Groundwater Extraction and Treatment System Alternative Technology Bench and Pilot Test Summary Report (H+A, 2011f and 2012b).

The proposed pilot testing program within the CMS will be conducted in association with the general requirements of a Resource Conservation and Recovery Act (RCRA) Corrective Action Consent Agreement (CACA) (California Environmental Protection Agency, Department of Toxic Substances Control [DTSC], 2003). This phase of the program will provide information to support evaluation and selection of the final groundwater clean-up plan as part of the CMS for the Site. This Workplan Addendum proposes replacement of the current on-site APTwater, Inc. (APT) advanced oxidation pilot-test treatment process with a Trojan UV, Inc. (Trojan) advanced oxidation pilot-test treatment process to determine design and operational parameters for a potential future full-scale system utilizing *ex situ* chemical oxidation in combination with liquid phase granular activated carbon (LGAC) for the treatment of dissolved phase contaminant mass while maintaining consistent compliance with applicable treated groundwater discharge requirements. This Workplan also proposes converting an existing monitor well to a pilot test extraction well and constructing the associated conveyance pipeline/controls to connect to the existing pilot test system extraction pipeline, pending accessible routing of potential pipeline to the monitor well. The proposed pilot testing program will be implemented following DTSC review and approval of this Workplan Addendum; obtaining site access; design and procurement of necessary equipment; and revision of the existing Orange County Sanitation District (OCSD) permit to discharge treated groundwater to the sanitary sewer.

1.1 PURPOSE AND SCOPE

The pilot testing activities proposed as part of this Workplan are intended to evaluate system operational parameters in response to extended groundwater extraction, and to evaluate groundwater hydraulic and water quality responses along with continued pilot system operational parameters during operations of the proposed additional pilot extraction well. Specifically, this test is intended to confirm that compliant treatment of groundwater with fluctuating concentrations of certain volatile organic compounds (VOCs) and 1,4-dioxane can be maintained. This test will be conducted concurrent with additional proposed groundwater assessment (H+A, 2013b), ongoing groundwater monitoring and Site activities to facilitate evaluation of groundwater clean-up plans in the CMS Report, and support DTSC's selection of the final groundwater Corrective Measure remedy and preparation of a Statement of Basis for public review and comment prior to final implementation.

1.2 BACKGROUND

A summary of previously completed investigations, site conditions, regulatory background, and pilot testing procedures that are subjects of the CACA were presented in the Additional Groundwater Assessment Work Plans and well installation reports, CMS Pilot Test Work Plans and Pilot Test Summary Reports (H+A, 2003a, 2003b, 2004a, 2004b, 2005a, 2008a, 2008b, 2009c, and 2011f). A description of the geologic and hydrogeologic conditions at and in the vicinity of the Site is provided in Well Construction and Groundwater Monitoring Reports (H+A, 2005b, 2009a, 2009b, 2011a to 2011d, 2012a, and 2013a). A description of additional proposed groundwater assessment tasks is provided in an Additional Groundwater Assessment Work Plan Addendum No. 5 (H+A, 2013b). A summary of the status of pilot testing activities and recently completed groundwater assessment activities conducted at the Site are presented in the following sections.

1.2.1 Pilot Testing

This section summarizes the pilot test operation through the fourth quarter of 2012. The pilot test system consists of three groundwater extraction wells, the treatment system, and the routing of treated groundwater to the sanitary sewer under a permit issued by the OCSD. The initial phase of pilot testing extracted groundwater from two extraction wells (MW-21 and EW-01), and the current phase of pilot testing is operating using one extraction well (EW-02). The current treatment system processes extracted groundwater through an advanced oxidation unit that utilizes ozone and hydrogen peroxide (H_2O_2), followed by a granular activated carbon polish prior to discharge to the sanitary sewer.

Initial startup of the pilot groundwater extraction and treatment system took place on July 8, 2008. From July 2008 through November 2009, the pilot system was operated with extraction wells EW-01 and MW-21 operating at a combined rate of approximately 20 gallons per minute (gpm) on a nearly continuous basis. Pilot system expansion took place between November 2009 and March 2010 in order to incorporate extraction well EW-02 into the extraction well network. During this time, the pilot test treatment equipment was also modified to increase the treatment system capacity from 20 gpm to 50 gpm, which is the maximum allowable flowrate in accordance with the sewer discharge permit. Beginning in March 2010, the pilot test system was operated near the maximum capacity of approximately 50 gpm on a nearly continuous basis entirely from extraction well EW-02. During December 2011, a synthetic media pilot test was started. The purpose of the synthetic media pilot test was to evaluate the efficacy of treating water collected from extraction well MW-21 using a synthetic resin for contaminant removal. In order to conduct the synthetic media pilot test, extraction wells EW-02 and MW-21 were operated at approximately 40 gpm and 10 gpm, respectively. The synthetic media pilot test was completed on March 9, 2012, and operation of the pilot groundwater and extraction treatment system was restored to 50 gpm, entirely from extraction well EW-02. Extraction wells EW-01 and MW-21 are on standby for the current phase of pilot testing, but may be used for future phases of pilot testing or as part of a full-scale, pump-and-treat system.

A graphical representation of the system operational time in relation to water level measurements at the extraction wells has been provided (Figure 4). The influent concentrations of 1,4-dioxane and 1,1-dichloroethylene (1,1-DCE), the principal VOCs in extracted groundwater, have been monitored during the pilot testing (Figure 5). The concentration of both 1,4-dioxane and 1,1-DCE were generally higher during the initial phase of pilot system operations when groundwater was extracted from extraction wells MW-21 and EW-01. Since startup of the pilot system in July 2008, approximately 115 pounds of VOCs and 20 pounds of 1,4-dioxane have been removed from groundwater through November 2012 (Figure 6).

One of the objectives of the pilot testing was to determine if 1,4-dioxane could be treated without formation of bromate, a secondary treatment system byproduct. Bromate is a regulated compound in drinking water, and can be formed from naturally occurring bromide in groundwater when ozonation treatment is used. The effluent of the current advanced oxidation treatment system had frequent detections of 1,4-dioxane and/or bromate above respective treatment goals during the 2008/2009 initial phase of pilot testing operations when groundwater was extracted from extraction wells MW-21 and EW-01 (Figure 7). In March 2010 the second phase of pilot testing was initiated and groundwater was extracted from extraction well EW-02. During this time, 1,4-dioxane and/or bromate were sporadically detected above respective treatment goals in the ozone-peroxide advanced oxidation treatment system effluent, but generally at lower concentrations than during the initial phase (Figure 7). The production of bromate and/or incomplete treatment of 1,4-dioxane limits the feasibility of the current treatment technology at this Site, and therefore, the pilot and bench testing outlined in this Pilot Test Work Plan Addendum will evaluate an alternative advanced oxidation treatment processes that can reduce 1,4-dioxane and VOC concentrations without forming bromate above its target treatment goal.

1.2.2 Groundwater Assessment

Recent groundwater assessment activities have focused on delineation of the distribution of VOCs, principally 1,1-DCE and to a lesser extent trichloroethylene, and 1,4-dioxane in the primary transport zone, which for the purposes of this document will be referred to as the Target Zone (also referred to as Site Conceptual Groundwater Model Hydrostratigraphic Unit B). In accordance with the Additional Groundwater Assessment Work Plan Addendum 4, two monitor wells were recently installed and sampled in 2012 to assess the depth of the Target Zone and distribution of VOCs and 1,4-dioxane in the Target Zone west of the Site (Table 1) (H+A, 2011e and 2013c [in press]). Based on the results of the recent groundwater assessment, three additional groundwater monitor wells are proposed to support evaluation and selection of the final groundwater clean-up plan as part of the CMS for the Site (H+A, 2013b).

2.0 PILOT TEST ADDENDUM OVERVIEW

Additional pilot testing will consist of four activities, the first two of which would be conducted concurrently, as follows: 1) continued operation of the pilot test system with existing treatment equipment; 2) installation of an extraction well vault at monitor well MW-29 and construction of additional associated conveyance pipeline/controls (if accessible); 3) replacement of the existing APT pilot test treatment equipment (ozone-peroxide) with Trojan pilot test treatment equipment (ultraviolet [UV] light-peroxide); and 4) operation of the new pilot extraction well (MW-29) with existing extraction well EW-2, and the treatment system with new Trojan pilot-test treatment equipment.

This Workplan Addendum provides details regarding the conversion of existing monitor well MW-29 to a pilot extraction well, installation of conveyance pipeline, replacement of the existing pilot treatment equipment, and follow-on operation of the new pilot extraction well and pilot treatment system. The objective of these pilot testing activities are:

- To obtain additional hydraulic data to assess the extraction rate required to contain 1,1-DCE and 1,4-dioxane within the Target Zone at the western edge of the Site;
- To assess the reliability and efficiency of the Trojan advanced oxidation system to meet discharge limitations for 1,4-dioxane and chlorinated alkenes in an influent groundwater stream with concentrations that may fluctuate over time;
- To confirm the reliability and efficiency of the Trojan advanced oxidation system to meet discharge limitations for by-products (i.e. bromate) generated as a potential by-products of the oxidation process for groundwater extracted from the Target Zone at the Site;
- To determine the operation and maintenance (O&M) requirements necessary to maintain destruction efficiencies; and
- To obtain data which would provide design criteria for, and long-term costs associated with, operation of a potential future full-scale chemical oxidation treatment system.

2.1 PILOT TEST RATIONALE

In order to fulfill the objectives of this test, conversion of monitor well MW-29 to a pilot extraction well, installation of conveyance pipeline from the new pilot extraction well to the existing extraction pipeline, and replacement of the APT advanced oxidation pilot treatment equipment with Trojan advanced oxidation pilot treatment equipment are proposed. The proposed Trojan pilot treatment system is expected to operate for a period of 24 or more months in duration. The test would involve treatment and subsequent discharge of groundwater extracted from extraction wells EW-02 and MW-29 at flowrates of approximately 40 gpm and 10 gpm, respectively. To accommodate the potential for future up-scaling of the pilot treatment system to a potential future full-scale remedy, certain design considerations will be given to minimize the potential need for future retrofitting. This will include constructing pipeline conveyance to accommodate increased extraction flowrates.

The Trojan advance oxidation pilot treatment system will consist of components similar to those utilized during the current long-term pilot treatment system started on July 8, 2008: extraction pump(s), a filtration system, a chemical oxidation system, a LGAC system, and other ancillary equipment required for operation of the treatment system (Appendices A and B). The proposed equipment layout is provided in Figure 3.

2.2 EXTRACTION PUMP

The groundwater to be treated as part of this pilot test would be extracted from existing monitor well MW-29 and existing extraction well EW-02 (Figure 2). A submersible pump capable of maintaining flow at approximately 10 gpm to 20 gpm will be set in monitor well MW-29 (Figure 2). Extraction well EW-02 already has a pump installed capable of producing 40 gpm. Power to the MW-29 pump will be supplied via a proposed utility connection to an existing transformer in the vicinity of the well. Extraction well EW-02 already has power supplied to the well.

2.3 FILTRATION

The Trojan advanced oxidation pilot system requires relatively sediment free water (particles must be less than 100 microns). Therefore, an existing nominal 25-micron, in-line filter system will be maintained to filter groundwater prior to treatment through the Trojan advanced oxidation system (Figure 3). The in-line filter system consists of two filters operated in parallel to allow filter media change without interruption of system operation. Based on the operation of the APT HiPox™ advanced oxidation pilot test, it is expected that this filter system will provide sufficient filtering capacity. However, modifications may be made if operation indicates additional filtering capacity is required.

2.4 CHEMICAL OXIDATION SYSTEM

The chemical oxidation technologies under consideration at the Site for *ex situ* treatment of 1,4-dioxane and chlorinated alkenes dissolved in groundwater is the Trojan UVPhox™ Model 12AL30 developed by Trojan which uses UV light in combination with H_2O_2. The Trojan advanced oxidation technology was previously bench tested using source water from extraction wells EW-02 and MW-21, and was shown to be an effective method for destroying 1,4-dioxane and chlorinated alkenes dissolved in groundwater (Appendix C). An extended pilot test of the Trojan advanced oxidation process is proposed to ensure that groundwater can be treated to meet applicable discharge limits for either surface stormwater discharges, recycled water uses, or re-injection to groundwater while sustaining the required destruction efficiencies for 1,4-dioxane and chlorinated alkenes without formation of regulated by-products.

2.4.1 Ultraviolet Light / Hydrogen Peroxide System

A UV/peroxide advanced oxidation system will be installed to evaluate its effectiveness and implementability for potential future corrective measures at the Site. The UV/peroxide system utilizes UV light to supply the energy necessary for H_2O_2 to dissociate which produces hydroxyl radicals capable of destroying contaminants in groundwater. This system will be assessed to confirm the reliability and efficiency of the UV/peroxide system to meet discharge limitations of

1,4-dioxane and chlorinated alkenes in an influent groundwater stream with concentrations that fluctuate over time (Figure 5).

When implemented in combination with peroxide, the UV oxidation typically utilizes amalgam low-pressure lamps. Conditions which may limit the effectiveness of the system are:

- Turbidity – high turbidity may limit the transmission of UV light through the groundwater stream, reducing the amount of H_2O_2 that is converted to hydroxyl radicals and thereby reducing the overall destruction efficiency; while this reduces the amount of hydroxyl radicals that are formed, contaminant mass may still be directly oxidized by H_2O_2.
- Fouling – the UV generating lamp is contained within a quartz sleeve; presence of heavy metal ions (greater than 10 milligrams per liter) and insoluble oil or grease may cause fouling of the quartz sleeve.

2.4.2 Hydrogen Peroxide Storage

An existing chemical-resistant, double-contained tank will be utilized for storage and mixing of the H_2O_2 solution. A 35 percent H_2O_2 solution from the tank will be supplied to the Trojan UVPhox™ reactor via a transfer/metering pump. The tank is double-contained to reduce the risk of a release of the H_2O_2 solution.

2.5 LIQUID PHASE GRANULAR ACTIVATED CARBON

LGAC is a developed technology proven to remove halogenated volatile organic compounds (HVOCs) from groundwater, but it is inefficient for removal of 1,4-dioxane in groundwater. HVOCs in the inlet groundwater are adsorbed to the surface of LGAC contained in a pressure vessel. The existing LGAC system will be placed after the Trojan advanced oxidation pilot treatment system to remove residual chlorinated alkanes that were not destroyed in the Trojan reactor (Figure 3). A series of two carbon vessels will be operated in series. Each vessel will contain approximately 1,000 pounds (lbs) of LGAC, for a total capacity of approximately 2,000 lbs. The first unit in series is to be considered the primary treatment unit; the second vessel will provide a safety factor, allowing detection of breakthrough prior to discharge of untreated groundwater.

3.0 PILOT TEST METHODOLOGY

The proposed extended duration pilot test is designed to allow assessment of the effects of fluctuating influent concentrations on system performance and is also expected to provide information related to design and operation of a full-scale system utilizing chemical oxidation and carbon adsorption as primary treatment. The following sections outline pilot test methodologies that will be utilized to fulfill the project objectives including: test duration; system design considerations and operating procedures; and monitoring frequency.

3.1 DURATION

The proposed temporary pilot testing system is expected to operate for a period of 24 months or more in duration.

3.2 DESIGN CONSIDERATIONS

The proposed pilot system will be configured as presented in the conceptual treatment system overview (Figure 3).

The Trojan UVPhox™ reactor will be operated at conditions which will be established by the manufacturer, Trojan. Based on the results of the bench test completed in 2011, Trojan was able to generate a destruction curve which will be used to design a site-specific reactor that will provide efficient contaminant reduction. The basic operation of the Trojan UVPhox™ system involves dosing the extracted groundwater with H_2O_2. The peroxide-groundwater stream is then passed through a reactor which exposes the stream to UV light along the flow path.

The carbon adsorption system will be designed to remove residual VOCs from the Trojan UVPhox™ reactor effluent water stream. Carbon units will be sized assuming there is no reduction of chlorinated alkane concentrations by the Trojan UVPhox™ reactor. Therefore, the units will provide sufficient capacity for reduction of the maximum expected chlorinated alkane concentrations. The currently proposed layout includes a total of two units in series; the first unit would contain 1,000 lbs of carbon and would act as the primary treatment unit. Breakthrough of the primary treatment unit, that is, detection of VOCs in the effluent water of the second unit in series, would prompt a carbon change-out event. A second 1,000-lb unit would be installed in series as a polish unit, allowing detection of VOC breakthrough prior to discharge of groundwater.

An excess of H_2O_2 in the oxidation system effluent water stream may result in the liberation of oxygen gas in the carbon units. Therefore, design considerations will be made for venting of oxygen to prevent accumulation of the gas within the carbon units.

3.3 OPERATING PROCEDURES

The system will be operated on a continuous basis, 24 hours per day, 7 days per week, for the duration of the test with the exception of periodic shutdowns related to scheduled maintenance and system upsets. The pilot test system will be designed for automated, unattended operation. A technician will assess the system operation on a regular basis to confirm all equipment is functioning properly. At a minimum, one Site visit will be conducted daily for the first five days of operation, weekly for the first month of operation and then visits will be completed weekly to monthly thereafter. If significant changes are made to the treatment system layout or operations, daily visits will again be conducted for a minimum of five days after completion of the modification.

During the Site visits, the technician will record operating parameters including: totalizer readings, pressure readings, flowrates, temperatures, and operation of safety devices. Additionally, samples for field or laboratory analysis will be collected as necessary to comply with permit requirements and as needed to confirm proper system operation, as detailed below. Log sheets will be completed with each Site visit.

3.4 MONITORING PROGRAM

The proposed pilot treatment system will be outfitted with sample ports and flow and pressure instruments at selected locations within the treatment system (Figure 3). The pilot study monitoring program includes collection of water quality samples, monitoring of operating parameters, and measurement of water levels in the pumped well and other surrounding wells.

3.4.1 Water Quality

Water quality samples will be collected throughout operation of the pilot test. Sampling locations include: extraction wellhead(s), system influent, filtration system effluent, chemical oxidation system effluent, carbon system breakthrough point, and carbon system effluent. If a single extraction well is in operation, the extraction wellhead sample location and the system influent sample location will represent identical compositions so, only one set of samples will be collected. However, if more than one extraction well is in operation, combined influent samples will be collected in addition to samples from the individual extraction wellheads. Chemical oxidation system effluent samples will be collected periodically to assess destruction efficiencies through the oxidation system. The carbon breakthrough sample will be collected from the effluent of the first carbon unit in series.

The proposed sampling plan includes collection of daily samples of selected compounds for the first five days of operation in order to confirm proper operation of the system (Table 2). Weekly samples will be collected for the first four weeks. After the first month of operation, samples will be collected monthly and/or quarterly and as required for maintaining compliance with permit discharge requirements. If major modifications to the system equipment or operating parameters are made after the first month of operation, daily and weekly sampling will be repeated to ensure that the modifications have not adversely effected system operation and that discharge permit compliance is maintained. Major modifications will include adjustments which are likely to effect system discharge concentrations.

The constituents included for sampling are based on several criteria: compounds/constituents that are typically required as part of National Pollutant Discharge Elimination System (NPDES) or Waste Discharge Requirements (WDR) permits, compounds that are typically regulated by the OCSD that have been detected at the Site, and/or compounds/constituents that affect system efficiency.

The sampling frequency and compounds to be sampled are detailed in Table 2.

The water samples will be collected using sample containers specified in the Standard Operating Procedures presented in the Appendices to the Additional Groundwater Assessment Workplan, where specified (H+A, 2003b). The detection limits, analytical method, and sample containers for constituents/compounds not specified in the previous document are presented in Table 2.

3.4.2 Treatment System Flow and Pressure

Flow totaling meters will be installed to record the total volume of water extracted from the extraction well(s) and an effluent flow meter will be installed on the discharge line to record the total volume of water discharged. These meters will also be utilized to obtain instantaneous flowrate at these points. The flowrate(s) and total volume(s) will be recorded weekly, at a minimum, and more regularly as needed to compliantly operate the system.

Pressures will be monitored at pressure gauges that will be installed in the pipelines as part of the pilot treatment system (Figure 3). These pressures will be monitored to ensure that the various components of the treatment system are not operated above the design capacities. Additionally, pressure readings will be utilized to determine when certain maintenance activities are required, such as filter changes or carbon backwashing.

3.4.3 Water Levels

Water levels will be continuously monitored in the pumped well(s) and surrounding monitor wells using pressure transducers for the duration of the pilot test. In addition, water levels will be measured periodically in the pumped well(s) and surrounding wells using a calibrated water level sounder. In surrounding monitor wells, manual water level measurements will be completed on the day of system startup, prior to and after startup of the system. Manual water level measurements will be completed in the extraction well(s) when the extraction pump(s) is set, then daily for the first five days of operation, and monthly thereafter. Transducer data will be downloaded each quarter coincident with Site-wide manual water level measurements at all monitor wells as part of the quarterly groundwater monitoring program. Monitor wells where transducers may be installed include: MW-08, MW-15, MW-13, MW-16, MW-18, MW-22 through MW-25, MW-26A through MW-26C, and MW-27 through MW-29, MW-30A and MW-30B, and MW-31 (Figure 2).

3.5 WATER QUALITY CONSIDERATIONS

There are at least four potential options for long-term end use of treated groundwater at the Site. The potential end use options include: surface water under an NPDES permit; injection to groundwater under a WDR permit; reclaim water under applicable county and/or WDR permits; or routing treated groundwater to the sewer under an industrial discharge permit. The water quality considerations for surface water, injection and sewer end use options were summarized in the Workplan for the previously completed short-duration pilot test (H+A, 2004a). The water quality for reclaim water end use would depend on specific water use and will be evaluated with the City of Fullerton in the first half of 2013.

Objectives of this test involve confirming the reliability of the proposed system to consistently meet discharge requirement of an NPDES permit or a WDR permit. Therefore, the proposed discharge for the extended duration pilot test is into the sanitary sewer, requiring an industrial discharge permit through the OCSD. Pending approval of this Workplan, a request will be made to the OCSD to modify the existing discharge permit to incorporate the proposed new Trojan treatment equipment. The existing industrial discharge permit allows discharge of the treated groundwater to the sanitary sewer at a rate of up to 50 gpm.

The proposed monitoring plan detailed above would be adjusted as needed to ensure compliance with the discharge requirements of the pertinent discharge permit.

3.6 PILOT TEST PROCEDURES

Additional details regarding O&M procedures related to pilot testing activities will be provided in a subsequent submittal after finalization of the system design and final specification of treatment system components.

4.0 HEALTH AND SAFETY

All field work will be completed in accordance with the Site Health and Safety Plan for Phase 2 RCRA Facility Investigation and the Site Health and Safety Plan for Groundwater Extraction and Treatment Pilot Testing, Corrective Measures Study Workplan Addendum No. 4, Revision 2 (HSPs) (H+A, 1996 and 2011g). The HSP will be modified as necessary to account for activities not previously conducted at the Site.

5.0 PROJECT SCHEDULE AND REPORTING

A detailed project schedule for the proposed pilot testing outlined in this Workplan Addendum will be provided in a separate submittal upon approval of this Workplan.

Descriptions and results of pilot test activities will be provided in quarterly Pilot Test Status Reports. These reports will be submitted to DTSC approximately two months following each quarter of pilot test operation to allow incorporation of applicable laboratory data in the respective reports. These reports will include a summary of the quarter's operational data, such as, total volumes extracted/discharged and system flowrates, copies of all analytical data related to system operation for the quarter, and details related to any major modifications or repairs made to the system. A final report providing an overall discussion of the pilot test results, conclusions, and recommended follow-up work will be submitted within 60 days of receiving final laboratory reports at the completion of pilot testing activities. In addition, compliance reports will be submitted in accordance with discharge permit requirements.

6.0 REFERENCES CITED

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TABLE 1

PREVALENT VOLATILE ORGANIC COMPOUNDS AND 1,4-DIOXANE IN GROUNDWATER
FOURTH QUARTER 2012

			Concentration (micrograms per liter)													
			VOLATILE ORGANIC COMPOUNDS (FEDERAL MCL/CALIFORNIA MCL)													Semi-VOCs
Well Identifier / Sample Identifier	Date Sampled	QA Code	Benzene (5/1)	Carbon Tetrachloride (5/0.5)	Chloroform (80/80)	1,1-DCA (--/5)	1,2-DCA (5/0.5)	1,1-DCE (7/6)	cis-1,2-DCE (70/6)	PCE (5/5)	1,1,1-TCA (200/200)	1,1,2-TCA (5/5)	TCE (5/5)	TCFM (--/150)	Toulene (1,000/150)	1,4-DIOXANE (3*/1**)
Regional Groundwater System Monitor and Extraction Wells																
MW-08	11/7/2012	ORG	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	**22**	**2.6**	< 0.50	< 0.50	< 0.50	**57**	< 0.50	< 0.50	**4.4**
MW-08 Historical Range* **			< 0.50 - 0.95	< 0.50	< 0.50 - 0.86	< 0.50 - 5.1	< 0.50 - 0.99	< 0.50 - 500	< 0.50 - 10	< 0.50 - 1.3	< 0.50 - < 5.0	< 0.50 - < 5.0	< 0.50 - 480	< 0.50 - 1.0	< 0.50	0.38 - 130
MW-21	11/5/2012	ORG	< 5.0	< 5.0	< 5.0	**24**	< 5.0	**2,000**	< 5.0	**6.1**	< 5.0	**6.8**	**16**	< 5.0	< 5.0	**240**
MW-21 Historical Range* **			< 0.50 - < 25	< 0.50 - 1.9	< 0.50 - 4.6	< 0.50 - 71	< 0.50 - 8.9	200 - 4,900	< 0.50 - 2.4	< 0.50 - 12	< 0.50 - 2.0	< 0.50 - 27	< 0.50 - 46	< 0.50 - 0.53	< 0.50 - < 10	11 - 1,100
MW-26C	11/07/12	ORG	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.20
MW-26C Historical Range* **			< 0.50	< 0.50	< 0.50	< 0.50 - 1.7	< 0.50	< 0.50 - 120	< 0.50	< 0.50 - 0.79	< 0.50	< 0.50 - 0.77	< 0.50	< 0.50	< 0.50 - 22	< 0.20 - 55 E
MW-28	11/07/12	ORG	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	**5.2**	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	**2.2**
MW-28 Historical Range* **			< 0.50	< 0.50	< 0.50	< 0.50 - 0.94	< 0.50	0.84 - 76 E	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.20 - 19
MW-29	11/07/12	ORG	< 1.0	< 1.0	< 1.0	**4.6**	**1.2**	**560**	< 1.0	**6.6**	< 1.0	**1.6**	**5**	**1.7**	< 1.0	**250**
Historical High/Low										**HIGH**				**HIGH**		
MW-29 Historical Range* **			< 0.50 - < 1.0	< 0.50 - < 1.0	< 0.50 - 0.80	1 - 9.2	< 0.50 - 1.4	99 - 900 E	< 0.50 - < 1.0	< 0.50 - 1.5	< 0.50 - < 1.0	< 0.50 - 2.3	0.58 - 7.5	< 0.50 - 1.2	< 0.50	29 - 301
MW-30A	11/06/12	ORG	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	**0.84**	< 0.50	< 0.50	< 0.50	< 0.50	**0.98**	< 0.50	< 0.50	< 0.20
MW-30A Historical Range* **			< 0.50	< 0.50	< 0.50	< 0.50 - 3	< 0.50 - 0.67	< 0.50 - 290	< 0.50	< 0.50 - 0.58	< 0.50	< 0.50 - 1.1	< 0.50 - 1.8	< 0.50	< 0.50	< 0.20 - 110
MW-30B	11/06/12	ORG	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	**14**	**3.2**	< 0.50	< 0.50	< 0.50	**68**	< 0.50	**1.6**	< 0.20
MW-30B Historical Range* **			< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50 - 21 E	< 0.50 - 5.6	< 0.50	< 0.50	< 0.50	< 0.50 - 88	< 0.50	< 0.50- 4.5	< 0.20 - 28 E
MW-31	11/06/12	ORG	< 0.50	< 0.50	< 0.50	**0.8**	< 0.50	**170**	< 0.50	< 0.50	< 0.50	< 0.50	**9.2**	< 0.50	< 0.50	**2.3**
MW-31 Historical Range* **			< 0.50	< 0.50	< 0.50	< 0.50 - 3.6	< 0.50	25 - 430	< 0.50 - 1.2	< 0.50	< 0.50	< 0.50	2.2 - 17	< 0.50	< 0.50 - 0.83	0.25 - 7
MW-32B	11/07/12	ORG	< 0.50	< 0.50	< 0.50	**0.92**	< 0.50	**100**	**5.4**	< 0.50	< 0.50	< 0.50	**66**	< 0.50	< 0.50	**3.4**
Historical High/Low						**HIGH**							**HIGH**			**HIGH**
MW-32B Historical Range* **			< 0.50	< 0.50	< 0.50	< 0.50 - 0.76	< 0.50	16 - 120	1.9 - 5.7	< 0.50	< 0.50	< 0.50	24 - 63	< 0.50	< 0.50	0.39 - 3.0
MW-33	11/06/12	ORG	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	**4.6**	< 0.50	< 0.50	< 0.50	< 0.50	**0.79**	< 0.50	< 0.50	< 0.20
MW-33 Historical Range* **			< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	1.7 - 12	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50 - 1.6	< 0.50	< 0.50 - 1.4	< 0.20 - < 2.0
MW-34A	11/06/12	ORG	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.20
MW-34A Historical Range* **			< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50 - 1.6	< 0.50 - 2.8	< 0.20 - < 2.0
MW-34B	11/07/12	ORG	<1.0	<1.0	<1.0	**7.9**	**1.7**	**590 E**	<1.0	<1.0	<1.0	**2.6**	**1.4**	<1.0	<1.0	**260**
MW-34B	11/07/12	SPT	<0.50	<0.50	<1.0	**6.4**	**1.5**	**180 E**	<1.0	<1.0	<1.0	**3.0**	**1.4**	<10	<1.0	**320**
Historical High/Low							**HIGH**									**HIGH**
MW-34B Historical Range* **			< 0.50 - <5.0	< 0.50 - <5.0	< 0.50 - <5.0	< 0.50 - 9.8	< 0.50 - < 1.0	20 - 1,100	< 0.50 - <5.0	< 0.50 - <5.0	< 0.50 - <5.0	< 0.50 - 1.3	< 0.50 - 1.6	< 0.50 - <5.0	< 0.50 - 2.6	4.1 - 250
MW-34C	11/06/12	ORG	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.20
MW-34C Historical Range* **			< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	0.50 - 9.6	< 0.20 - < 2.0

TABLE 1

PREVALENT VOLATILE ORGANIC COMPOUNDS AND 1,4-DIOXANE IN GROUNDWATER
FOURTH QUARTER 2012

Well Identifier / Sample Identifier	Date Sampled	QA Code	Benzene (5/1)	Carbon Tetrachloride (5/0.5)	Chloroform (80/80)	1,1-DCA (--/5)	1,2-DCA (5/0.5)	1,1-DCE (7/6)	cis-1,2-DCE (70/6)	PCE (5/5)	1,1,1-TCA (200/200)	1,1,2-TCA (5/5)	TCE (5/5)	TCFM (--/150)	Toulene (1,000/150)	1,4-DIOXANE (3*/1**)
			……………………Concentration (micrograms per liter)													Semi-VOCs
			VOLATILE ORGANIC COMPOUNDS (FEDERAL MCL/CALIFORNIA MCL)													
Regional Groundwater System Monitor and Extraction Wells (cont'd)																
MW-35A	11/06/12	ORG	< 0.50	< 0.50	**0.72**	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.20
Historical High/Low					**LOW**											
MW-35A Historical Range* **			< 0.50	< 0.50	1.5 - 67	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.20 - < 2.0
MW-35B	11/06/12	ORG	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.20
MW-35B Historical Range* **			< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.20 - < 2.0
MW-35C	11/06/12	ORG	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.20
MW-35C Historical Range* **			< 0.50	< 0.50	< 0.50 - 120	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.20 - < 2.0
MW-36	11/07/12	ORG	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	**27**	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	**0.88**	**1.4**
MW-3600	11/07/12	FD	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	**25**	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	**0.59**	**1.4**
Historical High/Low																
MW-36 Historical Range* **			< 0.50	< 0.50	< 0.50 - 120	< 0.50 - 0.52	< 0.50	2.9 - 45	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	1.1 - 5.9	< 0.20 - 2.8
MW-37	10/26/12	ORG	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	**0.73**	<2.0
MW-3700	10/26/12	FD	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	**1.3**	<2.0
MW-37	10/26/12	SPT	< 0.50	< 0.50	< 1.0	< 1.0	< 0.50	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 10	**1.4**	<1.0
MW-37	11/07/12	ORG	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.20
MW-3700	11/07/12	FD	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.20
MW-37	11/07/12	SPT	< 0.50	< 0.50	< 1.0	< 1.0	< 0.50	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 10	< 1.0	<1.0
MW-37 Historical Range* **			< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	<0.50 - 1.4	<0.20
EW-01	11/05/12	ORG	< 0.50	< 0.50	< 0.50	**1.8**	< 0.50	**190**	< 0.50	< 0.50	< 0.50	**0.75**	< 0.50	< 0.50	< 0.50	**83**
EW-01 Historical Range* **			< 0.50 - 2	< 0.50 - 0.55	< 0.50 - 1.2	< 0.50 - 16	< 0.50 - 4.2	< 0.50 - 1,600 E	< 0.50 - 0.52	< 0.50 - 3.3	< 0.50 - < 2.5	< 0.50 - 10	< 0.50 - 2.8	< 0.50 - < 5.0	< 0.50 - 4.6	5.1 - 710
EW-02	9/6/12	ORG	< 0.50	< 0.50	< 0.50	**0.58**	< 0.50	**62**	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	**11**
EW-02	10/15/12	ORG	< 0.50	< 0.50	< 0.50	**0.74**	< 0.50	**75**	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	**18**
EW-02	11/5/12	ORG	< 0.50	< 0.50	< 0.50	**0.52**	< 0.50	**63**	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	**12**
EW-02 Historical Range* **			< 0.50	< 0.50	< 0.50	< 0.50 - 1.5	< 0.50	37 - 160	< 0.50	< 0.50	< 0.50	< 0.50 - 0.59	< 0.50	< 0.50	< 0.50 - 0.85	6.4 - 48

TABLE 1

PREVALENT VOLATILE ORGANIC COMPOUNDS AND 1,4-DIOXANE IN GROUNDWATER
FOURTH QUARTER 2012

			……Concentration (micrograms per liter)……													
			VOLATILE ORGANIC COMPOUNDS (FEDERAL MCL/CALIFORNIA MCL)													Semi-VOCs
Well Identifier / Sample Identifier	Date Sampled	QA Code	Benzene (5/1)	Carbon Tetrachloride (5/0.5)	Chloroform (80/80)	1,1-DCA (--/5)	1,2-DCA (5/0.5)	1,1-DCE (7/6)	cis-1,2-DCE (70/6)	PCE (5/5)	1,1,1-TCA (200/200)	1,1,2-TCA (5/5)	TCE (5/5)	TCFM (--/150)	Toulene (1,000/150)	1,4-DIOXANE (3*/1**)
QUALITY ASSURANCE/QUALITY CONTROL SAMPLES																
TB-090612	9/6/12	TB	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	NA
TB-101512	10/15/12	TB	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	NA
TB-102612A	10/26/12	TB	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	NA
TB-102612B	10/26/12	TB-SPT	< 0.50	< 0.50	< 1.0	< 1.0	< 0.50	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 10	< 1.0	NA
TB-110512	11/5/12	TB	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	NA
TB-110512	11/5/12	TB	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	NA
TB-110612	11/6/12	TB	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	NA
TB-110712	11/7/2012	TB	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	NA
TB-110712A	11/7/2012	TB-SPT	< 0.50	< 0.50	< 1.0	< 1.0	< 0.50	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 10	< 1.0	NA
RB-11072012	11/07/12	RB	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.20

NOTE: Detections are shown in **BOLD** type.

FOOTNOTES

1,1-DCA = 1,1-Dichloroethane
1,2-DCA = 1,2-Dichloroethane
1,1-DCE = 1,1-Dichloroethene
cis-1,2-DCE = cis-1,2-Dichloroethene
PCE = Tetrachloroethene
1,1,1-TCA = 1,1,1-Trichloroethane
1,1,2-TCA = 1,1,2-Trichloroethane

TCE = Trichloroethene
TCFM = Trichlorofluoromethane
(<) = Less than; the value is the Limit of Detection for that compound
* = 1,4-Dioxane Action Level of 3 ug/L
** = California Notification Level for 1,4-Dioxane of 1 ug/L
*** = Historical Range determined using original samples exclusively
Semi-VOCs = Semivolatile organic compounds

NA = Not analyzed for constituent
FD = Field duplicate sample
ORG = Original sample
E = Data qualified as Estimated in accordance with quality control criteria.
SPT = Split sample
RB = Rinsate blank sample
TB = Trip blank sample

ug/l = Micrograms per liter
MCL = Maximum Contaminant Level
QA = Quality Assurance

HARGIS + ASSOCIATES, INC.

TABLE 2

PILOT TREATMENT TEST PROPOSED SAMPLING SCHEDULE

				SAMPLE FREQUENCY AND LOCATION																		
				Daily Samples[1]: Days 1-5				Weekly Samples[1]: Weeks 1-4					Monthly Samples: Week 5+						Quarterly Samples: Week 1+			
COMPOUND(S) / CONSITITUENT	ANALYTICAL METHOD	SAMPLE CONTAINER	REPORTING DETECTION LIMITS (milligrams per liter)	Influent (**INF**)	Post-Oxidation (**POX**)	Carbon Breakthrough (**CBT**)[3]	Post-Carbon (**CEFF**)	Influent (**INF**)	Post-Filter (**PF**)	Post-Oxidation (**POX**)	Carbon Breakthrough (**CBT**)[3]	Post-Carbon (**CEFF**)	Extraction Wells (**Well ID**)[2]	Influent (**INF**)	Post-Filter (**PF**)	Post-Oxidation (**POX**)	Carbon Breakthrough (**CBT**)[3]	Post-Carbon (**CEFF**)	Extraction Wells (**Well ID**)[2]	Influent (**INF**)	Post-Oxidation (**POX**)	Post-Carbon (**CEFF**)
COMPOUNDS/CONSTITUENTS NORMALLY REQUIRED AS PART OF NPDES OR WDR PERMITS, PURSUANT TO CRWQCB REGION 8 ORDER NO. R8-2003-0085																						
Volatile Organic Compounds	8260B	3 - 40 mL VOA, HCl	QAPP[4]	X	X	X	X	X		X	X	X	X	X		X	X	X				
1,4-Dioxane	8270 Modified	1 L Amber	0.002	X				X					X	X								
1,4-Dioxane	8270 SIM	1L Amber	0.0002		X					X						X						
Total Suspended Solids	SM2540D	250 mL poly	10												X							
Total Dissolved Solids	SM2540C	250 mL poly	10																X	X	X	X
SELECTED METALS																						
Dissolved Metals (Iron, Manganese, Calcium, Sodium, Magnesium)	6010B	500 mL poly	QAPP[4]	(a)															X	X		
Selenium	6010B	500 mL poly, HNO_3	QAPP[4]																X	X		
SELECTED INORGANIC CONSTITUENTS																						
Hydroxide Alkalinity	SM2320B	250 mL poly	2.0	(a)															X	X		
Bicarbonate Alkalinity	SM2320B	250 mL poly	2.0	(a)															X	X		
Carbonate Alkalinity	SM2320B	250 mL poly	2.0	(a)															X	X		
Total Alkalinity	SM2320B	250 mL poly	2.0	(a)															X	X		
BROMATE EVALUATION																						
Bromate	317.0	125 mL poly	0.0005		X					X						X						
Bromide	300.0	125 mL poly	0.05	(a)				(a)					X	X								
OTHER CONSTITUENTS/COMPOUNDS																						
Total Organic Carbon	SM5310B	3 - 40 mL VOA, HCl	3.0	(a)															X	X	X	
Anions (Chloride, Sulfate, Nitrate, Nitrite, and Phosphate)	300.0	500 mL poly	Varies	(a)															X	X	X	
Chemical Oxygen Demand	410.4	125 mL poly, H_2SO_4	5.0	(a)															X	X	X	
Field Parameters																						
Dissolve Oxygen (DO)	N/A	N/A	N/A	X	X		X	X		X		X	X	X		X	X	X				
Electrical Conductance (EC)	N/A	N/A	N/A	X	X		X	X		X		X	X	X		X	X	X				
Redox Potential	N/A	N/A	N/A	X	X		X	X		X		X	X	X		X	X	X				
Temperature	N/A	N/A	N/A	X	X	X	X	X		X	X	X	X	X		X	X	X				
pH	N/A	N/A	N/A	X	X		X	X		X		X	X	X		X	X	X				
Turbidity	N/A	N/A	N/A	X				X	X				X	X	X							
Flow-Meter	N/A	N/A	N/A	X			X	X				X	X	X				X				
Residual Hydrogen Peroxide	N/A	N/A	N/A		(a)	(a)	(a)			X	X	X				X	X	X				

TABLE 2

PILOT TREATMENT TEST PROPOSED SAMPLING SCHEDULE

FOOTNOTES

(a) Only one sample to be collected during sampling period.

1 Daily and weekly samples collected during the first month of operation will be repeated after major modifications to system equipment or operating parameters, as detailed in the Workplan.

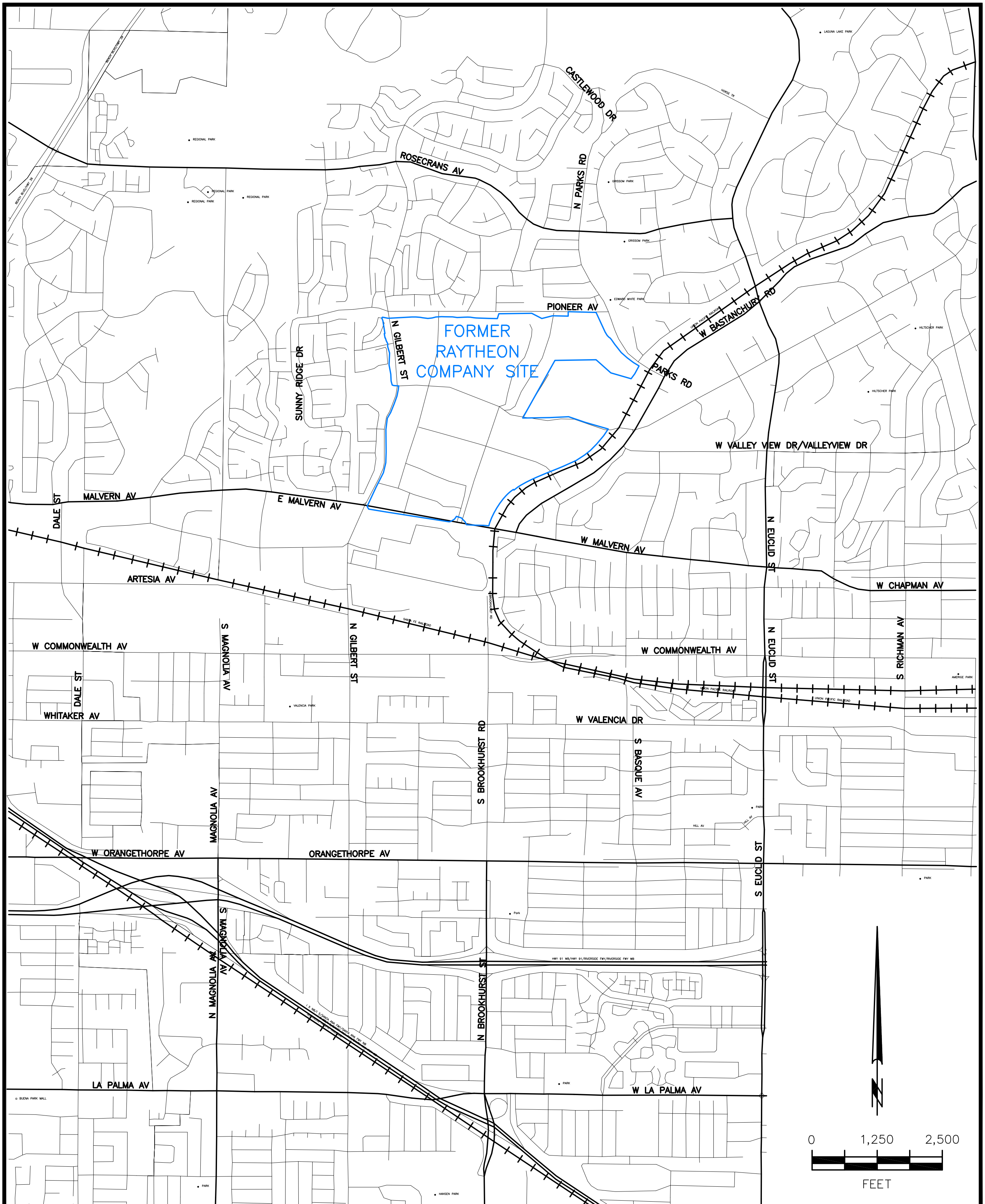
2 Extraction well samples will be collected at individual well-heads. The combined extraction well streams will be sampled at the treatment system Influent sample port.

3 Carbon breakthrough will be collected from the effluent of the first carbon unit in series; when breakthrough of the first unit is detected, the breakthrough sample will be collected from the effluent of the second carbon unit in series.

4 QAPP, Quality Assurance Project Plan, Appendix B of Additional Groundwater Assessment Workplan, Hargis + Associates, Inc., April 25, 2003.

CRWQCB = California Regional Water Quality Control Board, Santa Ana Region 8
NPDES = National Pollutant Discharge Elimination System
WDR = Waste Discharge Requirement
N/A = Not applicable
mL = Milliliter
VOA = Volatile organic analysis
HCl = Hydrochloric acid
HNO_3 = Nitric acid
H_2SO_4 = Sulfuric acid

EPA = U.S. Environmental Protection Agency
SM = Standard Method
L = Liter
poly = High density polyethylene bottle



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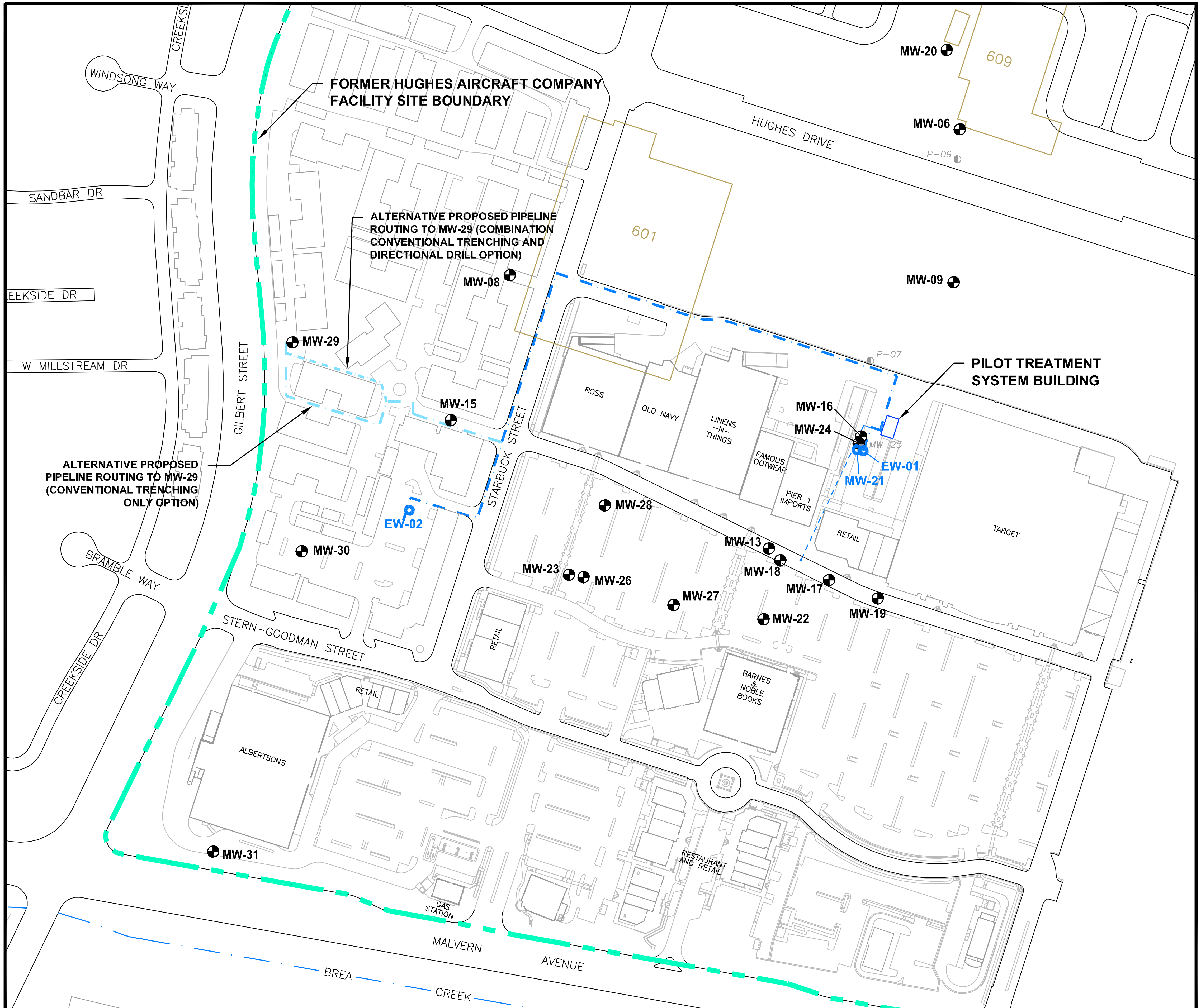
HARGIS + ASSOCIATES, INC.
Hydrogeology/Engineering

FIGURE 1. SITE LOCATION



EXPLANATION

EW-01	EXISTING PILOT TEST EXTRACTION WELL
MW-16	GROUNDWATER MONITOR WELL
P-09	PERCHED ZONE PIEZOMETER
MW-25	GROUNDWATER PIEZOMETER
	EXISTING CONVEYANCE PIPELINE
	PROPOSED CONVEYANCE PIPELINE
	EXISTING EFFLUENT DISPOSAL PIPELINE TO SEWER CONNECTION
609	FORMER RAYTHEON BUILDING, DEMOLISHED MID-2000
RETAIL	RETAIL AND COMMERCIAL BUILDINGS OF AMERIGE HEIGHTS DEVELOPMENT
	DRIVEWAYS, PARKING LOTS AND OTHER HARDSCAPE OF SITE RE-DEVELOPMENT

NOTE: NAD83 DATUM

RAYTHEON COMPANY
FULLERTON, CALIFORNIA

GROUNDWATER EXTRACTION AND TREATMENT PILOT TEST SYSTEM

HARGIS + ASSOCIATES, INC.
Hydrogeology/Engineering

02/13

FIGURE 2

PREP BY MER REV BY SPN RPT NO. 532.15 | 410-8888 | A

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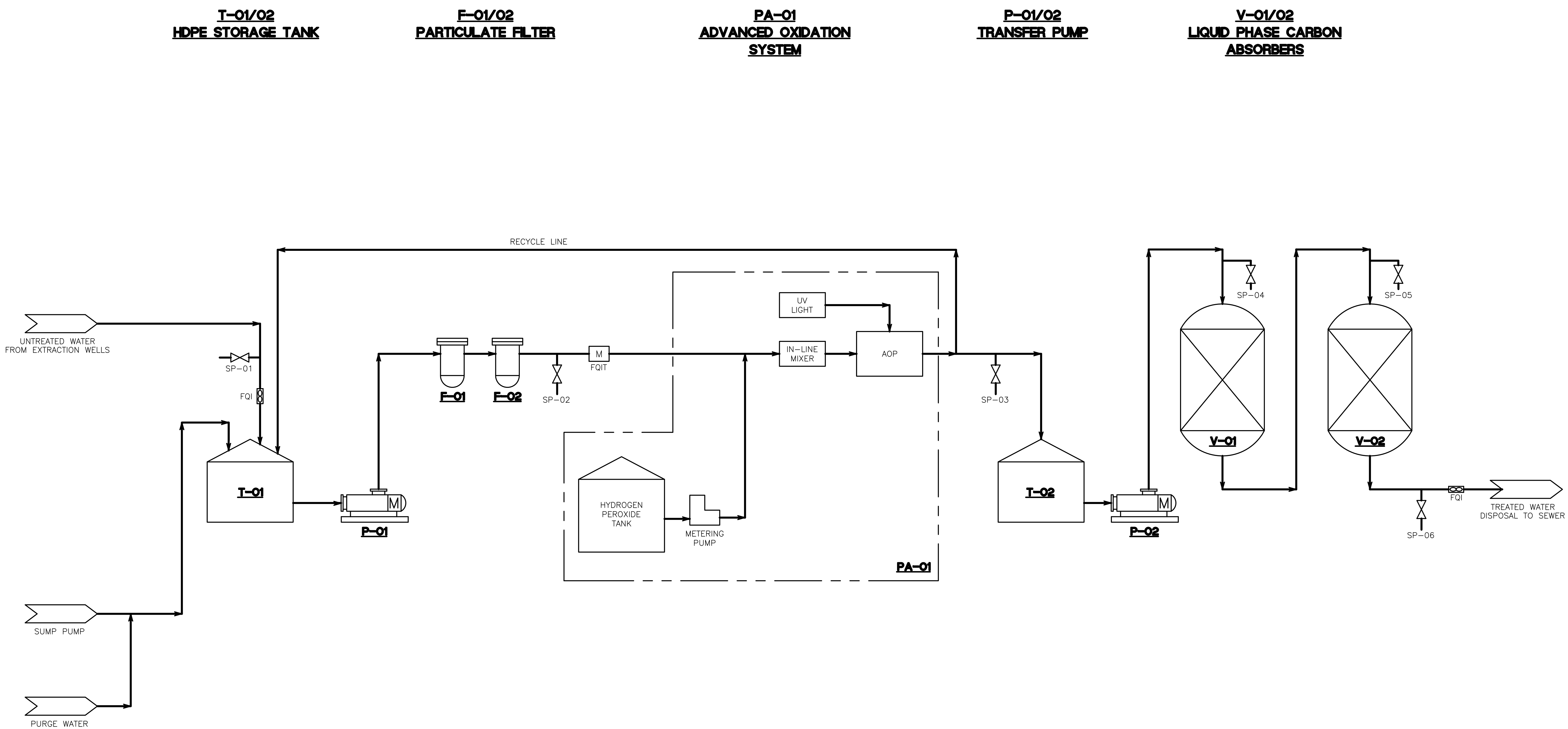

EXPLANATION

AOP	ADVANCED OXIDATION PROCESS
FQI	FLOW QUANTITY INDICATOR
FQIT	FLOW QUANTITY INDICATOR TRANSMITTER
SP	SAMPLE PORT
UV	ULTRA VIOLET

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02/13	RPT NO. 532.15	560-0324	A

HARGIS + ASSOCIATES, INC
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FIGURE 3.
CONCEPTUAL CONFIGURATION OF THE PILOT TEST GROUNDWATER TREATMENT SYSTEM

HARGIS + ASSOCIATES, INC.

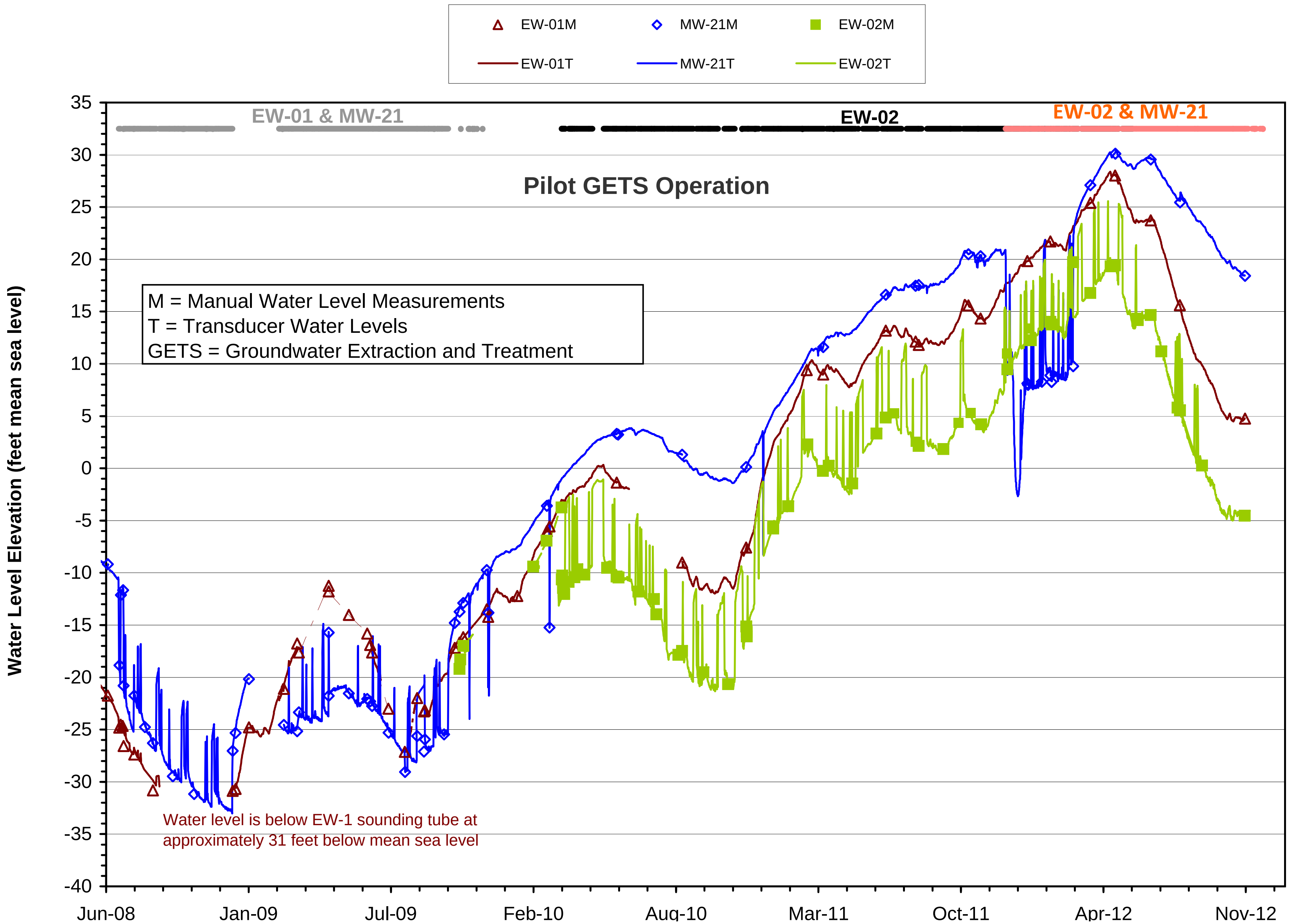

FIGURE 4.
PILOT GROUNDWATER EXTRACTION AND TREATMENT SYSTEM OPERATION AND EXTRACTION WELL WATER LEVELS

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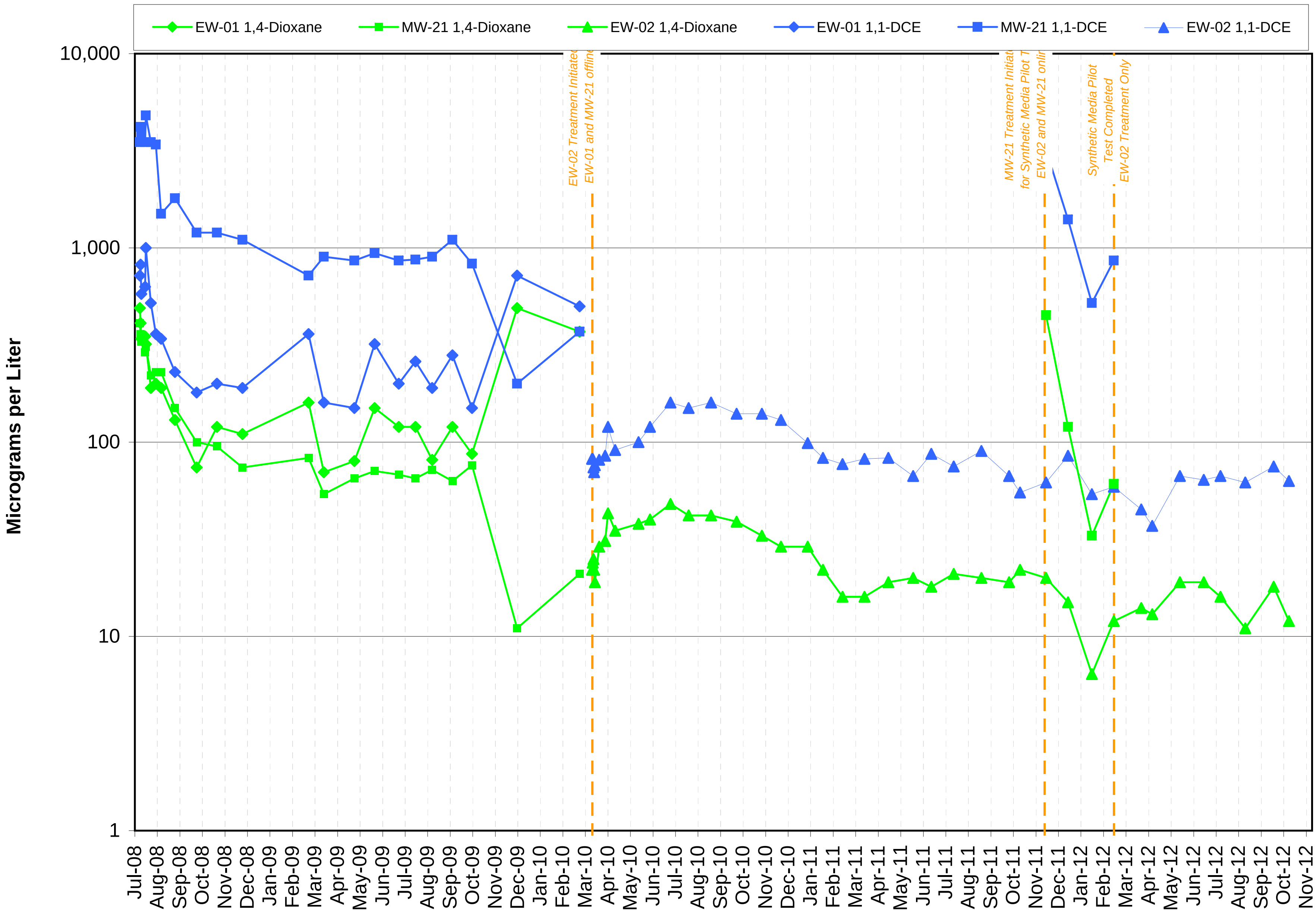

FIGURE 5.
1,1-DICHLOROETHYLENE AND 1,4-DIOXANE IN
EXTRACTION WELLS EW-01, MW-21, AND EW-02

HARGIS + ASSOCIATES, INC.

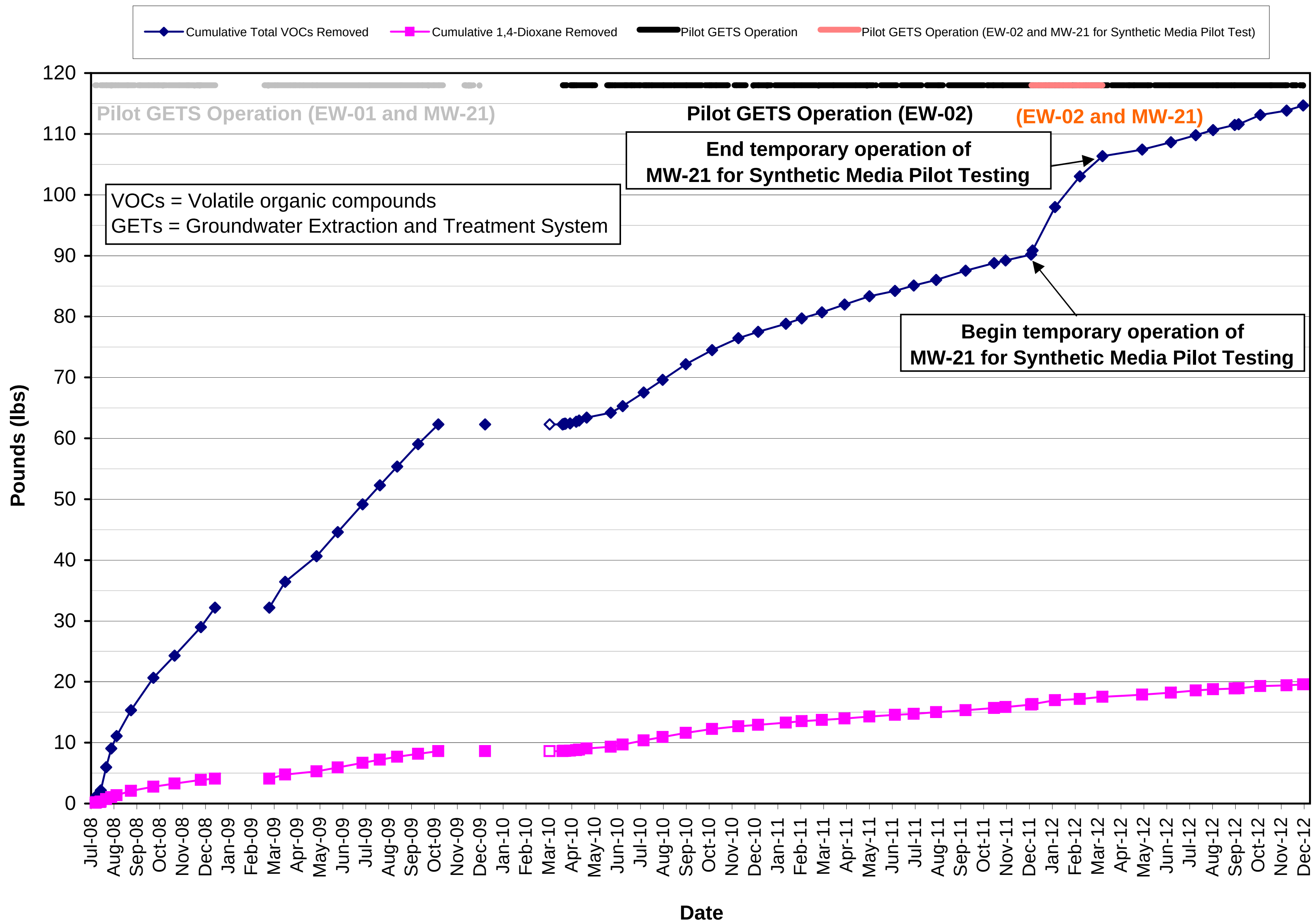

FIGURE 6.

PILOT GROUNDWATER EXTRACTION AND TREATMENT SYSTEM MASS REMOVAL

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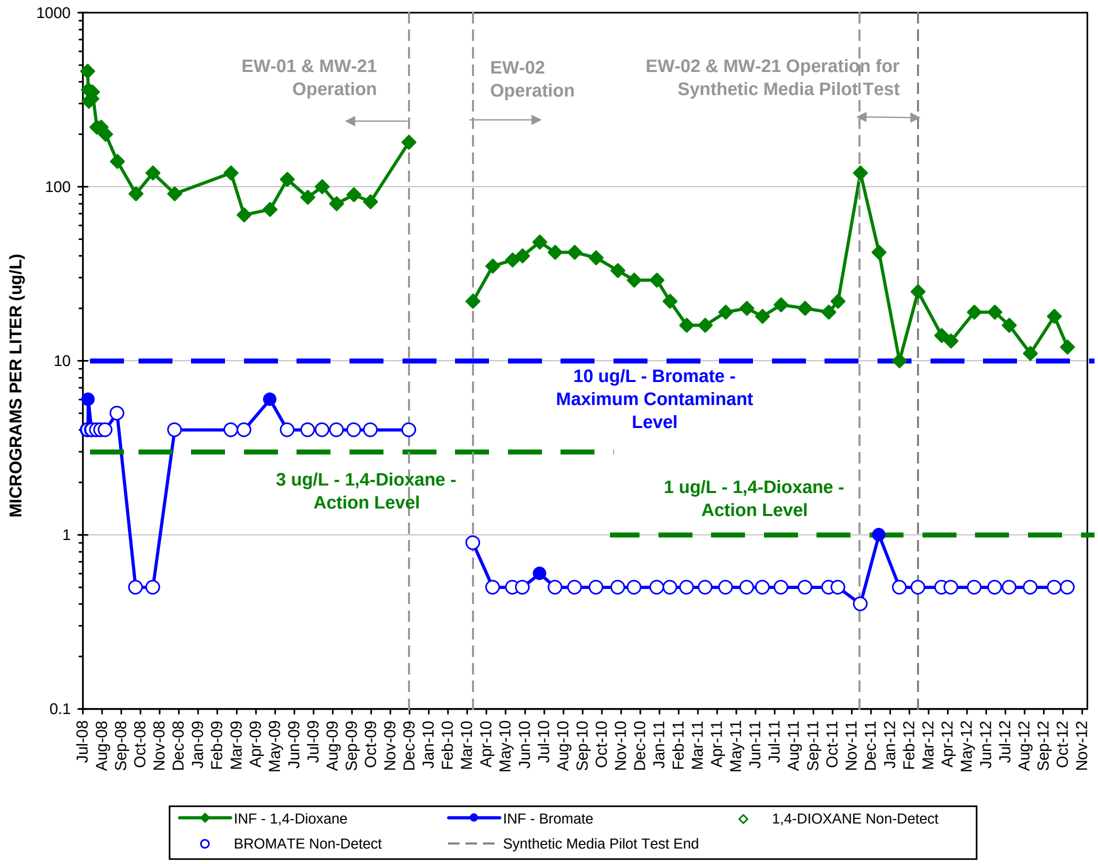
Influent (INF) Concentrations



Post-Hipox (POX) Concentrations

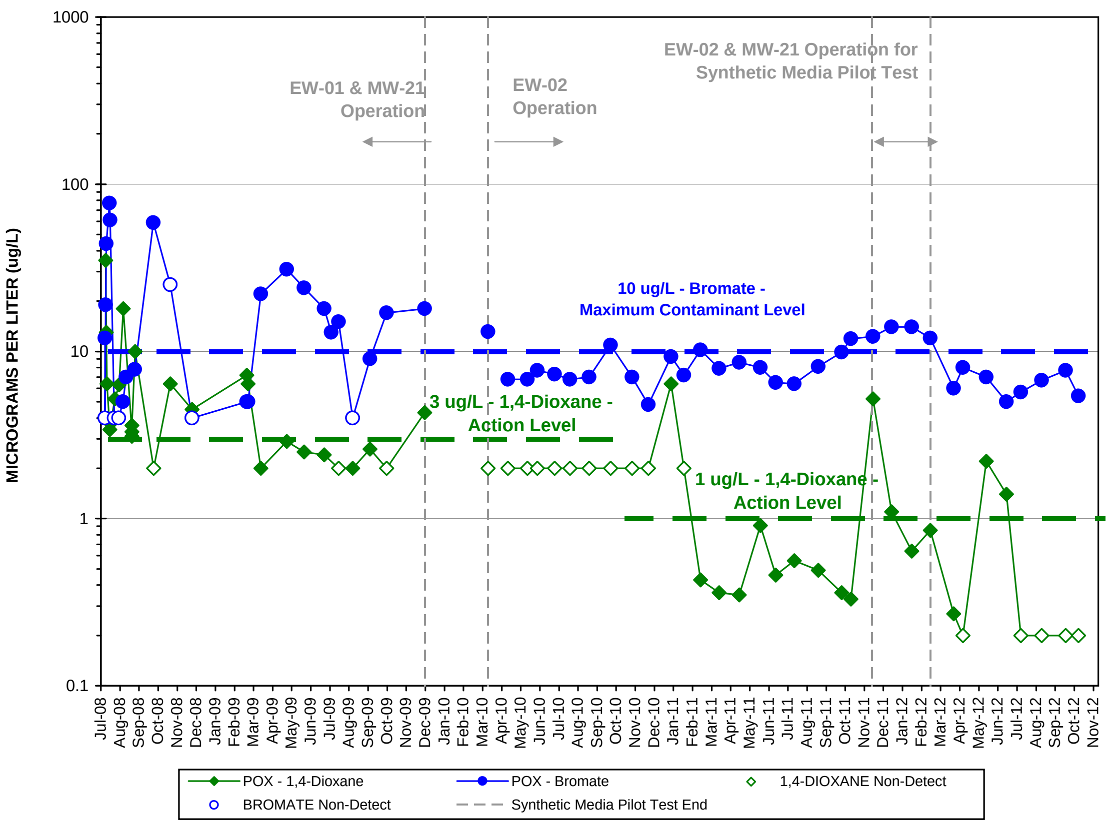


FIGURE 7.
1,4-DIOXANE AND BROMATE IN INFLUENT AND POST-OX. SAMPLES

532 2013-3_cmswp_adndm6_Fig7.xls

ug/L = Micrograms per liter

APPENDIX A

GENERAL SPECIFICATIONS FOR SELECT TREATMENT SYSTEM COMPONENTS

CENTAUR® HSL

Granular Activated Carbon

Description

CENTAUR® HSL is a liquid phase virgin activated carbon that has been manufactured to enhance catalytic functionality. The product is unique in that it concentrates reactants via adsorption and then promotes their reaction on the surface of the carbon pores. CENTAUR® HSL is produced from bituminous coal using a patented process. Although it is not impregnated with transition metals or alkali, CENTAUR® HSL displays the catalytic function of impregnated materials but does not present a disposal problem. CENTAUR® HSL provides a combination of low pressure drop, moderate kinetics, and good resistance to attrition. Thermal reactivation is an option for recycling and reuse of this product. This minimizes operating costs and eliminates disposal concerns.

For VOC & Taste and Odor Removal

CENTAUR® HSL can be used in either groundwater or surface water treatment applications to remove organic compounds. The recommended contact time is 8-15 minutes. Consult a Calgon Carbon Corporation Technical Sales Representative for advice about the proper contact time for your application.

Design Considerations

*For H_2S Removal**

CENTAUR® HSL is intended primarily for use in liquid phase systems to promote catalytic reactions. With oxidation reactions like H_2S to sulfate, the carbon can be utilized in a number of configurations with required contact times of 3 minutes or less. The reaction rate is application specific and has a direct bearing on the Empty Bed Contact Time required. The backwashed and drained density of the product is typically 30 lb./ft³. CENTAUR® HSL requires a minimum dissolved oxygen concentration of a two-to-one ratio with the H_2S concentration.

* Purchase of this product from Calgon Carbon Corporation includes a license under the following U.S. Patents: Numbers 5356849 and 5494869.

Applications

CENTAUR® HSL can be used in liquid phase applications for the promotion of oxidation, reduction, decomposition, and substitution reactions. Common applications are H_2S oxidation to sulfate and taste and odor removal in groundwater and surface water. It can also be used to prevent H_2S corrosion in pipes and pumps.

Features	Benefits
• Catalytic Activity	• Smaller system size due to faster reaction kinetics • Lower capital equipment requirements
• Thermal Reactivation Option	• Eliminates disposal concerns
• Improved Trace Organic Capacity	• More capacity per unit volume which translates to lower carbon use rates resulting in reduced system operating costs
• High Hardness	• Reduced fines from attrition over operational life of carbon which equates to reduced power consumption
• Works at Low Oxidant Levels	• Wide applicability which eliminates the need for chemical addition
• Simple Equipment Design	• Reliable CENTAUR® HSL handles spikes in concentration, without chemical additions
• Enhanced Performance	• Achieves greater degree of contaminant (VOCs & odor compounds) removal at reduced costs

CENTAUR® HSL

Granular Activated Carbon

Specifications	CENTAUR® HSL 8x20	CENTAUR® HSL 8x30
Iodine No., mg/g (min)	825	825
Ash, wt% (max)	7	7
Moisture, wt %, as packed (max)	4	4
Abrasion No. (min)	75	
Apparent Density, g/cc	0.56 min	.550 max
Peroxide Number (max)	14	19
Uniformity Coefficient (max)	2.1	
Effective Size, mm	1.0 - 1.2	
Screen Size, US Sieve Series (max)		
Larger than no. 8	15	15
Smaller than no. 20	4.0	
Smaller than no. 30		4.0

Packaging

200 lb. fiber drum

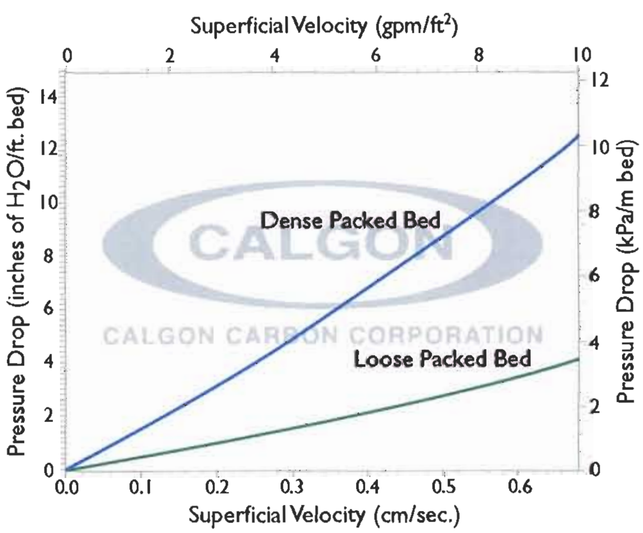
1,000 lb. super sack

33 lb. bag

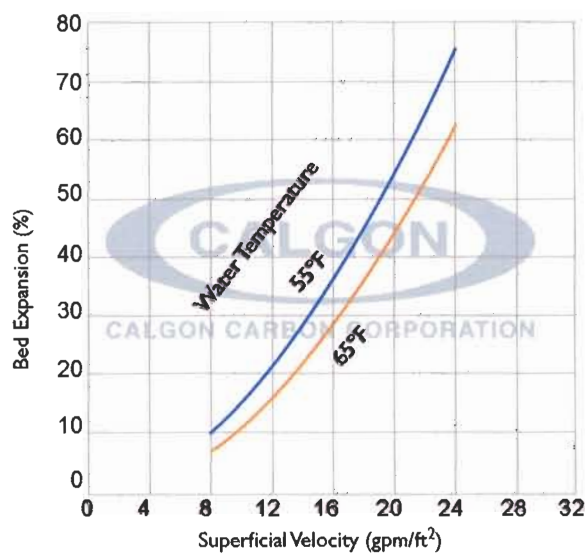
Safety Message

Wet activated carbon preferentially removes oxygen from air. In closed or partially closed containers and vessels, oxygen depletion may reach hazardous levels. If workers are to enter a vessel containing carbon, appropriate sampling and work procedures for potentially low oxygen spaces should be followed, including all applicable Federal and State requirements.

Pressure Drop Curve



Backwash Curve



Visit our website at **www.calgoncarbon.com**

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Your local office

CPM-PB1074-0304

CALGON
CALGON CARBON CORPORATION

Making Water and Air Safer and Cleaner

PROTECT™ TW SERIES

Description

The Protect™ TW series vessels are economical, moderate pressure vessels capable of operating at pressures as high as 75 psi and temperatures up to 140°F. The TW vessels contain from 500 to 2,000 pounds of activated carbon or 18 to 72 ft³ of other granulated media.

Important Features

- Durable carbon steel construction
- Hydrotested to greater than maximum operating pressure
- Chemical resistant internal lining and rust-inhibitive epoxy/urethane exterior finish
- 12″ x 16″ elliptical manway
- Lower PVC laterals positioned for maximum carbon utilization eliminates the need for a media support bed
- Upper PVC distribution laterals allow for backwashing or upflow operation
- Low profile design
- Lifting lugs and forklift guides for portability

Pressure Drop Curve

Estimated pressure drop based on 8x30 mesh carbon.

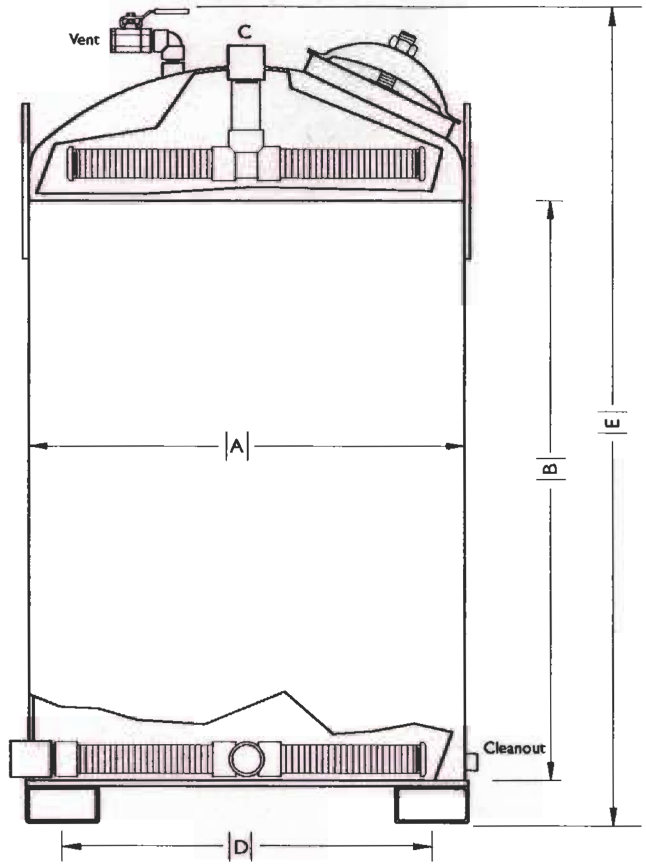
Model Number	TW-18	TW-27	TW-36	TW-54	TW-72
Carbon, lbs.*	500	750	1,000	1,500	2,000
Carbon, ft³	18	27	36	54	72
Recomended Flow Rate, gpm (max)	35	70	70	90	90
Weight, lbs.					
Empty	50	760	760	1,060	1,060
Operating	1,000	1,510	1,760	2,560	3,060

*Estimated weight based on vessel volume.

PROTECT™ TW SERIES

Available Options

- FDA & NSF approved linings
- Custom linings
- Screened drain assembly
- Higher operating temperatures
- Flanged inlet and outlets
- Stainless steel construction
- Stainless steel internals
- Side manway
- Pressure relief/air release valve
- Pre-piped dual systems
- Skid-mounted multi-vessel systems



Safety Message

Wet activated carbon preferentially removes oxygen from air. In closed or partially closed containers and vessels, oxygen depletion may reach hazardous levels. If workers are to enter a vessel containing carbon, appropriate sampling and work procedures for potentially low oxygen spaces should be followed, including all applicable Federal and State requirements.

Model Number	TW-18	TW-27	TW-36	TW-54	TW-72
Diameter (A), in.	30	42	42	48	48
Can Length (B), in.	48	48	48	72	72
Inlet/Outlet (C), fpt	2	2	2	2	2
Forklift Guides (D), in.	25	37	37	43	43
Overall Height (E), in. (approx.)	60	67	67	91	91
Overall Width, in. (approx.)	32	44	44	50	50

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ES-0017-0704

UV/Peroxide

Calgon Carbon
Advanced Oxidation Technologies

Advanced Oxidation for Water Treatment

PROCESS PROFILE

The perox-pure™ and Rayox® processes supplied by Calgon Carbon Oxidation Technologies (CCOT) destroy dissolved organic contaminants in contaminated water. In these processes, a proprietary high-powered, medium pressure lamp emits high energy UV radiation through a quartz sleeve into the contaminated water. An oxidizing agent, hydrogen peroxide, is added to the contaminated water and is activated by the UV light to form oxidizing species called hydroxyl radicals, via:

$$H_2O_2 + UV \longrightarrow 2(\bullet OH)$$

The hydroxyl radical then reacts with the dissolved contaminants, initiating a rapid cascade of oxidation reactions that ultimately fully oxidizes (mineralizes) the contaminants. The success of the systems is based on the fact that the rate constants for the reaction of •OH radicals with most organic pollutants are very high. The hydroxyl radical typically reacts a million to a billion times faster than chemical oxidants such as ozone and hydrogen peroxide. In addition, many organic contaminants undergo a change in their chemical structure by the direct absorption of UV light in the UV-C spectral range emitted by proprietary medium pressure UV lamps.

In the past decade, CCOT has supplied more than 200 full-scale perox-pure™ and Rayox® systems worldwide for the remediation of contaminated groundwater, industrial wastewater, process and drinking water.

The most important process variables affecting the efficiency of UV/H_2O_2 processes are:

- The type and concentration of target organic contaminants
- The type and concentration of the background organic matrix (e.g. COD, DOC, TOC)
- The light transmittance of the water, decreased by color and turbidity
- The concentration of dissolved species such as bicarbonate, nitrate, iron, chloride and pH

If necessary, the UV/H_2O_2 process can be optimized via pre-treatment (e.g. filtration), pH adjustment, and the addition of photocatalysts.

KEY ADVANTAGES

Key advantages of UV/H_2O_2 processes over conventional technologies include:

- On-site destruction treatment technology
- No phase transfer required, thereby eliminating secondary handling
- Can be carried out at ambient temperature and pressure
- Efficient for a wide range of contaminant types and concentrations, including chlorinated alkenes, aromatics, phenols, PAHs, PCBs, alcohols, and ethers
- Quiet and unobtrusive equipment
- Low maintenance and operating requirements, due in large part to the use of a proven patented quartz sleeve cleaner
- Typical oxidation by-products, such as low molecular weight carboxylic acids, are biodegradable, non-toxic, and unregulated for surface discharge. In addition, complete mineralization of organics to carbon dioxide and water can be achieved if desired

APPENDIX B

TROJAN UVPHOX PRODUCT BROCHURE

UV-OXIDATION SOLUTIONS
FOR ENVIRONMENTAL CONTAMINANT TREATMENT

TROJAN UV
WATER CONFIDENCE™

Turn-key UV-oxidation water treatment

State-of-the-art solutions. One trusted source.

Our water resources are under stress due to increasing population, changing rainfall patterns, widespread pollution, and a variety of other factors. For this reason, water providers must strive to make the most of every available water source, even those that have been impacted by contamination. Trojan's Environmental Contaminant Treatment solutions continue our 30-year tradition of providing water confidence with proven UV technology and innovative solutions that help restore and preserve precious water supplies.

Trojan's turn-key UV-oxidation solutions are enabling water suppliers to cost-effectively treat chemical and microbial contaminants that affect the purity of water in drinking water, wastewater reuse and groundwater remediation applications. The revolutionary TrojanUVPhox™ and TrojanUVSwift™ECT provide reliable delivery of UV energy to safeguard water against microorganisms and oxidize environmental contaminants. These robust systems work in tandem with Trojan's sophisticated hydrogen peroxide (H_2O_2) delivery and storage equipment.

Service is an integral part of Trojan's UV-oxidation solutions. For example, our ChemWatch™ technology remotely monitors hydrogen peroxide use, enabling us to automatically schedule hydrogen peroxide deliveries or notify you of unexpected changes in usage. Trojan also oversees replenishment of hydrogen peroxide on an as-needed basis. From our Performance Guarantee of system sizing – to our maintenance, spare parts and lamps – Trojan delivers a level of confidence that can only come from one source.

Cover photo: *Trojan is involved in a number of significant water reuse projects in Southern California that are using highly treated wastewater to prevent seawater from intruding into drinking water aquifers. These water reuse projects are helping to preserve and enhance drinking water supplies used by millions of people.*

What are Environmental Contaminants?

A hidden danger exists in our water supplies

Environmental contaminants are:

- Harmful chemicals that have been detected in streams, lakes, rivers, and groundwater throughout the world
- The result of human activities, such as industrial manufacturing, agriculture, and wastewater discharge
- Also derived from natural sources, such as the taste and odor-causing chemicals generated by algae blooms in lakes and rivers
- Often not sufficiently treated by conventional water treatment facilities

UV-Oxidation Applications

Indirect Potable Water Reuse

Part of the "gold standard" treatment train to purify wastewater to beyond drinking water standards

UV treats recalcitrant organic contaminants such as *N*-nitrosodimethylamine (NDMA) while simultaneously disinfecting the water

UV-oxidation acts as a barrier to:

- Nitrosamines (e.g. NDMA)
- 1,4-Dioxane
- Various pharmaceuticals and personal care products (PPCPs)
- Potential endocrine-disruptor chemicals (EDCs)
- Other unmonitored, unregulated organic contaminants.

Municipal Drinking Water

UV disinfection capability satisfies USEPA LT2 disinfection criteria

UV-oxidation is a barrier to wastewater-derived environmental contaminants introduced upstream of the drinking water facility

UV-oxidation treats:

- Seasonal contaminants such as taste and odor-causing chemicals resulting from algae blooms
- Volatile organic compounds (VOCs)
- Nitrosamines (e.g. NDMA)
- 1,4-Dioxane
- Pesticides
- Other unmonitored and unregulated contaminants derived from upstream wastewater or other sources.

Groundwater Remediation and Industrial Wastewater

Applicable at Superfund sites, wellhead treatment systems, and in industrial wastewater discharge applications

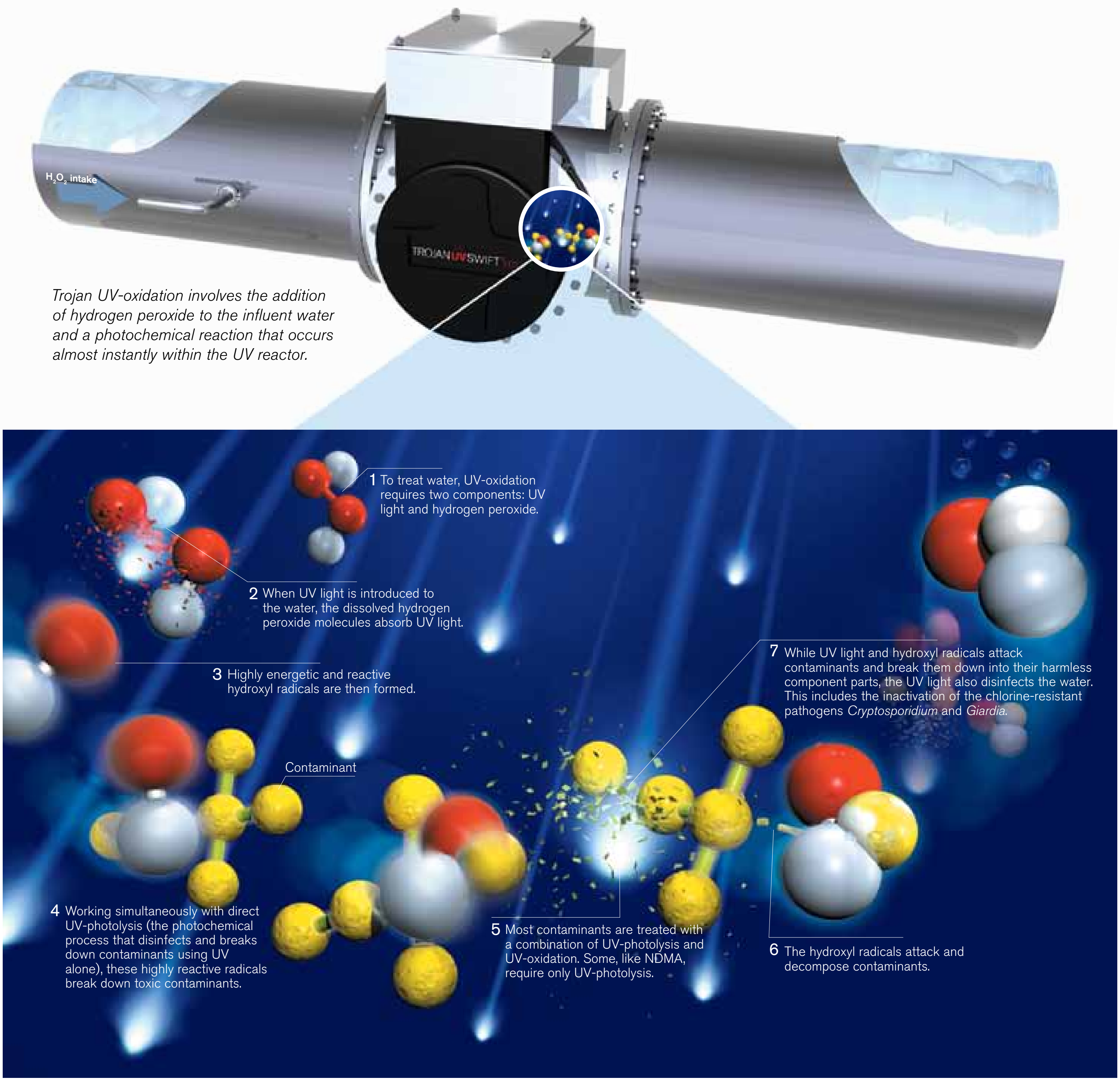
UV-oxidation effectively treats:

- Nitrosamines (e.g. NDMA)
- Hydrazine
- 1,4-Dioxane
- MTBE
- Various compounds that create toxicity
- Other environmental contaminants.

Trojan UV-Oxidation

An invaluable water treatment approach

UV-oxidation is a photochemical process that breaks down chemical contaminants into their harmless or non-odorous component parts almost instantly within the UV reactor. Trojan has revolutionized UV-oxidation, making it an efficient and cost-effective approach to treating many contaminants.



Trojan UV-oxidation involves the addition of hydrogen peroxide to the influent water and a photochemical reaction that occurs almost instantly within the UV reactor.

How UV-Oxidation is quantified: *The amount of energy required to reduce the concentration of a contaminant by 1 log (e.g. 10 ppb to 1 ppb) in 1,000 gallons of water is referred to as the* ***electrical energy per order*** *or* ***EE/O****. It is a measure of a reactor's hydraulic, optical and electrical efficiency. From a capital and O&M cost perspective, a lower EE/O is better.*

Key Benefits

Trojan UV-Oxidation

Dual treatment action provides UV disinfection and contaminant destruction:
Innovative process delivers simultaneous microbial disinfection and elimination of chemical and environmental contaminants

Additional barrier of protection against contaminants in drinking water:
Safeguards against a wide variety of harmful contaminants, including industrial solvents, pesticides, pharmaceuticals, personal care products and other wastewater-derived contaminants

Concurrent disinfection meets EPA guidelines:
Provides simultaneous disinfection in accordance with the upcoming Long-term 2 Enhanced Surface Water Treatment Rule or LT2ESWTR (i.e. >2-log *Cryptosporidium* and *Giardia* credit)

Cost-effective:
Trojan's optimized reactor technology makes UV-oxidation cost-effective for a wide range of applications

Compact design reduces capital costs:
Small footprint relative to ozone and other technologies simplifies installation and significantly reduces building capital costs

Well suited to seasonal treatment:
Effectively treats taste and odor problems related to recurring algae blooms and pesticide contamination due to agricultural runoff

Eliminates difficult to treat contaminants:
Ideal for treatment of NDMA, 1,4-dioxane, and other currently unmonitored and unregulated contaminants in water reuse and groundwater remediation applications

Rapid, by-product-free treatment:
Single unit process treats water almost instantly, without forming bromate, other DBPs, or hazardous gases

Two UV solutions for application flexibility:
UV options include the medium-pressure lamp-based TrojanUVSwift™ECT and the low-pressure, amalgam lamp-based TrojanUVPhox™ – allowing Trojan the flexibility to propose the most economical option for each unique water treatment situation

Easy and safe to operate:
Designed for minimal operator involvement and maximum safety

TrojanUVSwift™ECT

Compact, medium-pressure design for high-volume performance with validated disinfection

Key Benefits:

- High intensity, medium-pressure lamps deliver significant levels of UV energy for microbial disinfection and UV-oxidation of contaminants
- Need for fewer lamps allows a smaller, space-efficient footprint that offers simplified integration into existing piping galleries
- Polychromatic light spectrum is more suitable for certain contaminants
- Useful when large amounts of UV light are required for treatment in a particular contamination situation
- Extensively validated disinfection performance under a wide range of flow rates and water parameters

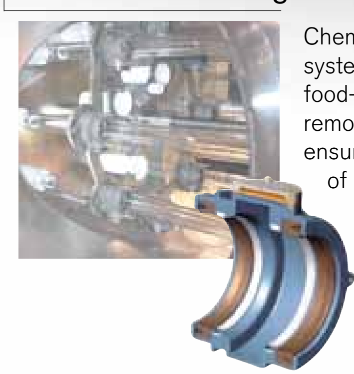
Best Suited for:

- Applications in which contaminant treatment is intermittent (e.g. seasonal taste and odor treatment)
- Elimination of those contaminants that are more efficiently treated with a polychromatic light spectrum (e.g. some pesticides)
- Locations in which electrical power is relatively inexpensive
- Use in treatment plants where space is at a premium
- Treatment of large flow rates

Control Power Panel

Distributes power to the UV lamps, UV sensor(s) and optional ActiClean™ cleaning system. Incorporates a programmable logic controller with input/output connection points and communication hardware.

Dual Action Automatic Cleaning



Chemical and mechanical cleaning system uses Trojan's patented, food-grade ActiClean™ gel to remove fouling and residue, ensuring the maximum amount of UV energy is available for UV-oxidation and disinfection.

Hydrogen Peroxide Storage Tank

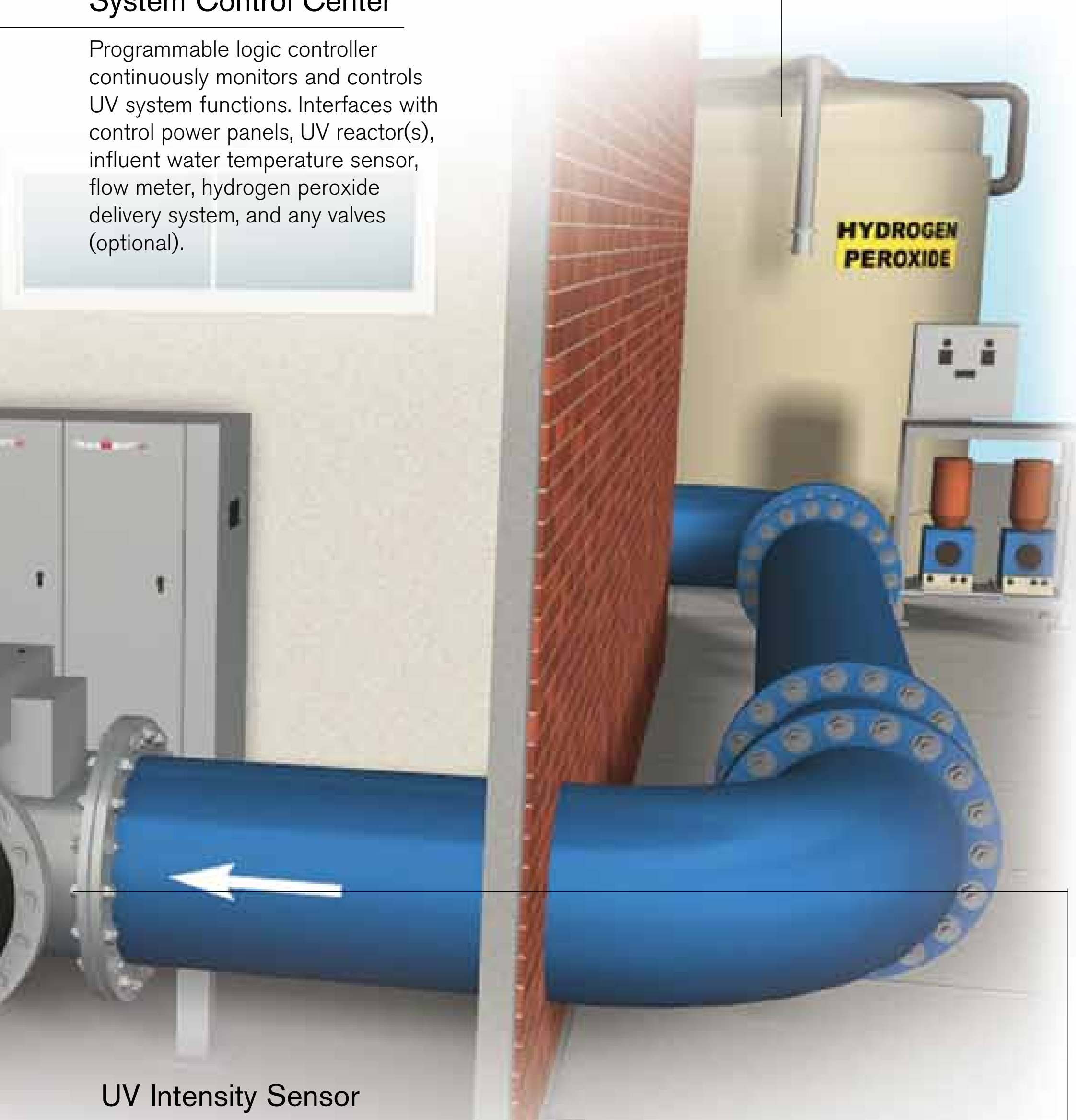
Durable, double-contained, high-density polyethylene resists sun damage. Standard secondary containment provides 110 percent capacity of primary tank.

Hydrogen Peroxide Dosing System

Ensures consistent dosing. Fully maintained by Trojan. ChemWatch™ inventory management system provides usage monitoring, product delivery scheduling, and invoice tracking.

System Control Center

Programmable logic controller continuously monitors and controls UV system functions. Interfaces with control power panels, UV reactor(s), influent water temperature sensor, flow meter, hydrogen peroxide delivery system, and any valves (optional).



Hydrogen Peroxide Dosing Control System (Patent-Pending)

Optimizes hydrogen peroxide delivery in real time. During contamination events (e.g. a taste and odor event), UV reactor interfaces with the hydrogen peroxide dosing system, collecting flow rate, hydrogen peroxide concentration, UV transmittance (using Trojan's Optiview™ system), relative contaminant concentration, and other data. Delivers optimum hydrogen peroxide concentration and UV reactor energy distribution to minimize operational costs.

UV Intensity Sensor

Measures UV intensity within the reactor. Automated cleaning system prevents fouling of the photodiode sensor's quartz sleeve.

UV Reactor

Compact, flow-through design with lamps mounted horizontally and perpendicular to the flow. 316L stainless steel construction.

Compact, Hydraulically-Efficient Reactor

Innovative design substantially reduces footprint and headloss

The TrojanUVSwift™ECT was developed using advanced Computational Fluid Dynamics modeling, resulting in a compact, highly efficient system that minimizes space requirements and installation costs.

Benefits:

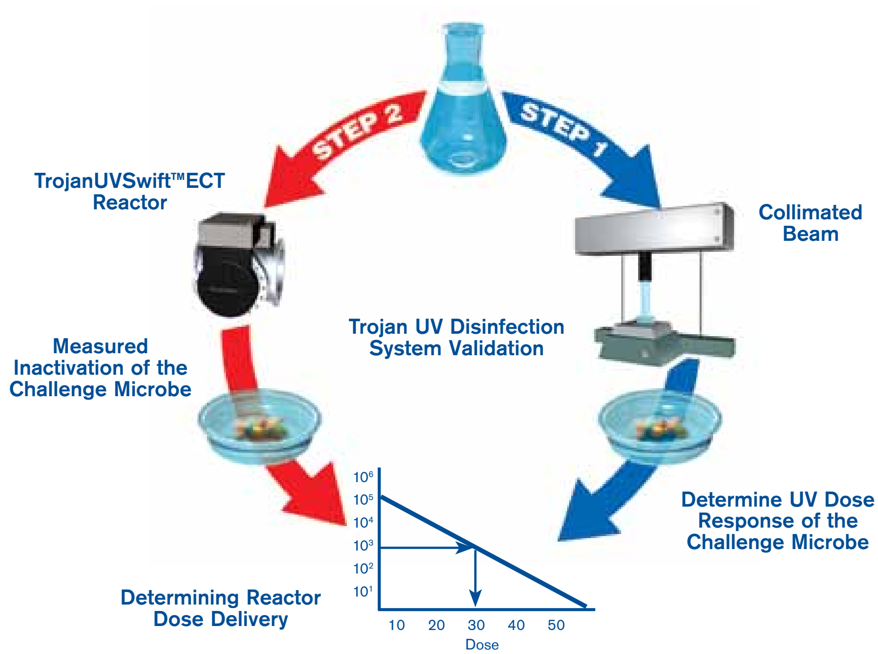
- Compact, in-line design minimizes reactor footprint
- Space requirements for taste and odor treatment are significantly less than ozone equipment/contact tanks – leading to significantly reduced installed capital costs
- Full serviceability from one side of the reactor allows installation in restrictive pipe galleries and against walls for maximum flexibility
- Hydraulically efficient, flow-through design developed through extensive computer analysis to minimize headloss and pumping requirements

Comprehensive Disinfection Validation

Exhaustive third-party testing

Benefits:

- The TrojanUVSwift™ECT shares a platform with the widely successful TrojanUVSwift™ – a system with a significant installed-base for disinfection-only drinking water applications
- Disinfection performance of the TrojanUVSwift™ECT has been accurately documented through rigorous third-party validation
- The specific disinfection dose delivery of the system was determined in the field (bioassay) over a wide range of flow rates and UV transmittance values
- Disinfection performance is validated based on actual kill rate of microorganisms that flow through the reactor in a real world setting
- In the Trojan UV-oxidation process, disinfection occurs simultaneously with the treatment of contaminants



Simultaneous microbial disinfection is a key advantage of Trojan's UV-oxidation process. The disinfection performance of the TrojanUVSwift™ECT in disinfection-only mode has been accurately documented through rigorous, third-party validation.

TROJANUVSWIFT™ECT

Sophisticated Hydrogen Peroxide Dosing Control System

Optimized dose delivery and cost-efficiency

Benefits:

- Sophisticated, patent-pending control system optimizes the UV-oxidation process
- Controls the dosing of hydrogen peroxide, lamp power and on/off status in real time
- Collects and analyzes information on flow rate, hydrogen peroxide concentration, UV transmittance, relative contamination event strength and other data
- Minimizes ongoing operational costs while maintaining optimized UV energy distribution and hydrogen peroxide dosing

Inputs

- Flow rate
- UV transmittance
- H_2O_2 concentration
- Relative strength of the contamination event

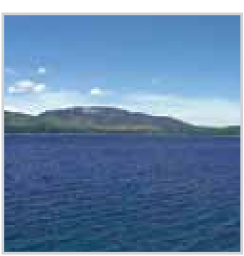
Outputs

- Optimum H_2O_2 concentration
- Optimum lamp power
- Optimum number of lamps in operation
- UV energy output to minimize operation and maintenance (O&M) costs

Ideal for Seasonal Contaminants in Drinking Water

Addresses both disinfection and seasonal contamination

Recurring seasonal contamination events compromise drinking water supplies in many areas. Taste and odor events as a result of 2-methylisoborneol (MIB) or geosmin present in water, for example, can impact the aesthetic quality of drinking water. The TrojanUVSwift™ECT is ideally suited to this challenge, operating in two modes to address the dual needs of communities with seasonal issues:



Disinfection-Only Mode: *Normal operating mode for year-round drinking water treatment. Runs at lower energy levels sufficient for elimination of any microorganisms. Reduces O&M costs for more efficient operation.*

Disinfection + Contaminant Control Mode: *Activated only during taste and odor/pesticide contamination events. Additional UV lamps/reactors are energized and hydrogen peroxide is dosed into the water upstream of the UV system. Initiates a powerful oxidation reaction that destroys contaminants and increases the level of disinfection.*

Benefits:

- Year-round disinfection and simultaneous elimination of seasonal contaminants
- Validated disinfection in accordance with the LT2ESWTR (i.e. >2-log *Cryptosporidium* and *Giardia* credit)
- Provides disinfection barrier where activated carbon (powdered or granular) does not
- Produces no disinfection by-products (DBPs) such as bromate
- Lower capital and O&M costs relative to ozone
- Small footprint simplifies installation and significantly reduces building capital costs relative to ozone and other technologies
- Easily retrofitted into existing plants
- Safer than ozone systems
- Effectively eliminates high concentrations of T&O causing compounds almost instantly inside the UV system
- Flexible — active T&O treatment only when needed (verses GAC which is always "on" and continuously being depleted)

TrojanUVPhox™

Low-pressure, amalgam UV lamps maximize electrical efficiency for year-round treatment

Key Benefits:

- Highest electrical efficiency solution
- Capable of treating large flow rates
- Low-pressure, high-output amalgam lamps deliver lowest electrical energy per order (EE/O) and O&M costs
- Monochromatic light spectrum is more suitable for certain contaminants
- Provides simultaneous microbial disinfection
- Small footprint – vertically stackable, modular design allows for expansion without increasing footprint
- Available in multiple configurations with various numbers of lamps

Best Suited for:

- Water reuse, drinking water, and groundwater remediation requiring treatment of chemical contaminants and disinfection
- Areas where electrical costs are relatively high
- Elimination of NDMA or other contaminants that are more readily treatable with monochromatic lamps
- Year-round treatment applications

Hydrogen Peroxide Storage Tank

Durable, double-contained, high-density polyethylene tank is resistant to sun damage. Standard secondary containment provides 110 percent capacity of primary tank.

UV Reactor Chamber

Welded, electropolished 316L stainless steel. Contains one or two UV reactors – arrays of lamps operated together.

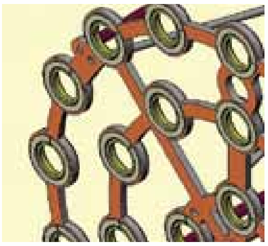
Hydrogen Peroxide Dosing System

Ensures consistent dosing. Fully maintained by Trojan. ChemWatch™ inventory management system provides usage monitoring, product delivery scheduling, and invoice tracking.

Flanges

Available sizes range from 4 to 20 inches.

Optional Wiping System



Food-grade rubber wipers ensure maximum treatment efficiency by maintaining optimal transmittance of quartz sleeves.

Power Distribution Center

Houses the electronic ballasts and control board with local display. Each power distribution center provides power distribution for one UV reactor.

Control Board

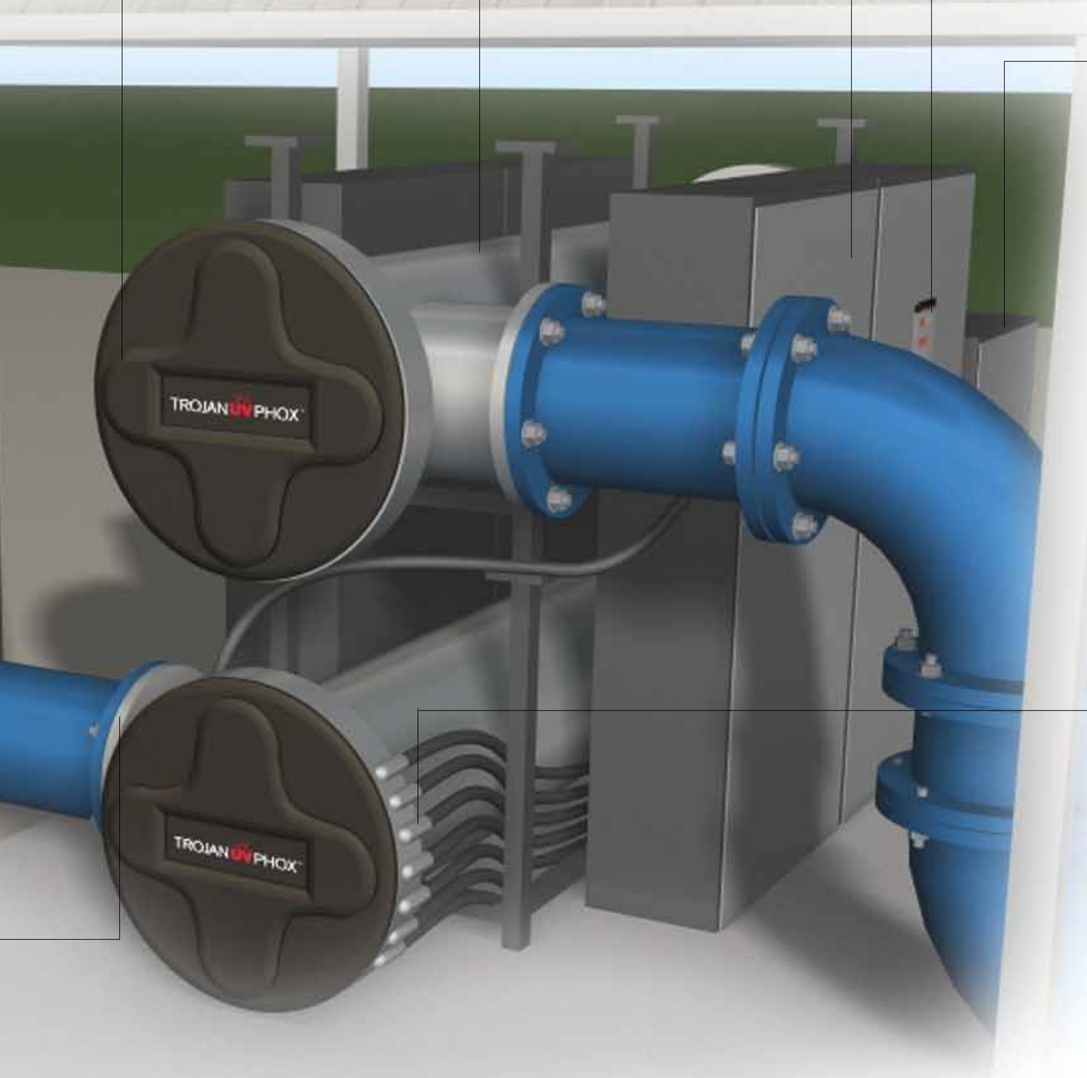
Door-mounted interface displays the UV Intensity (mW/cm^2), Elapsed Time (hours), Lamp Status/Ballast Status and Alarm Conditions.

Optional System Control Center

Optional programmable logic controller continuously monitors and controls UV system functions. Interfaces with power distribution center(s), UV reactor(s), influent water temperature sensor, flow meter, hydrogen peroxide delivery system, and any valves (optional).

UV Intensity Sensor

Highly accurate photodiode sensor monitors UV output within the reactor. Mounted in the sensor port on the side wall of the reactor for easy access.



Modular Compact Reactor

Innovative design maximizes efficiency and minimizes footprint

The modular design of the TrojanUVPhox™ allows space efficient configurations capable of treating large flow rates.

Benefits:

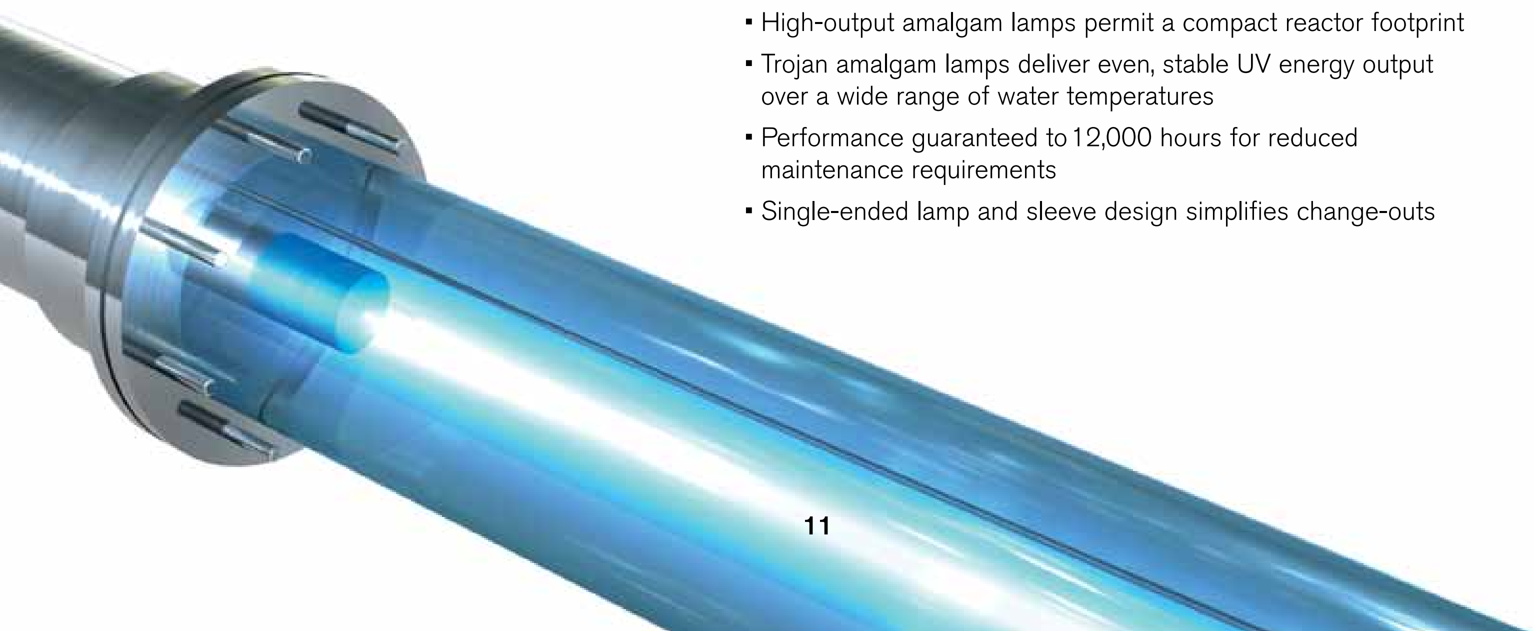
- More contaminant treatment per input power than competing contaminant treatment systems
- Vertically stackable, modular design allows for system expansion without increasing footprint
- Proven reactor design – reactor configuration and components have demonstrated superior performance in thousands of installations
- Scalable system is available in multiple configurations and various lamps per reactor to handle virtually any flow rate
- Reactor designed using computational fluid dynamics modeling and other advanced computer simulation tools to ensure optimum lamp spacing, uniform flow field, and significant efficiency advantages
- Chambers constructed of electropolished 316L stainless steel for a smooth interior and exterior finish, long life, and durability

High-Output Amalgam Lamps

Advanced, energy-efficient lamps reduce electrical costs

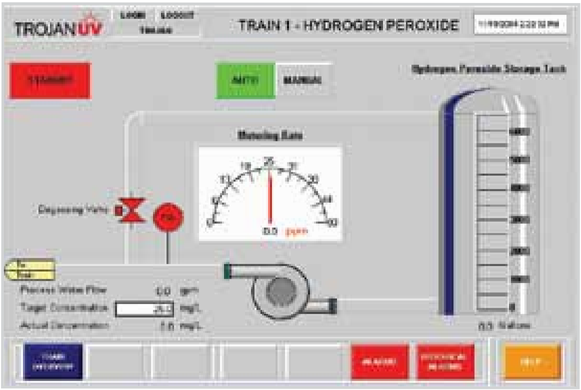
Benefits:

- Energy efficient lamps with high UVC-range UV light output
- High-output amalgam lamps permit a compact reactor footprint
- Trojan amalgam lamps deliver even, stable UV energy output over a wide range of water temperatures
- Performance guaranteed to 12,000 hours for reduced maintenance requirements
- Single-ended lamp and sleeve design simplifies change-outs



Sophisticated Controls

Integrated, user-friendly systems ensure optimized operation



User-friendly, integrated control systems automate delivery of UV energy and hydrogen peroxide for efficient contaminant treatment and microbial disinfection with minimal requirements of operators.

Benefits:

- UV controls are integrated with hydrogen peroxide system to ensure smooth operation with minimal operator involvement
- Easy-to-use, digital interfaces are menu-driven for simple operation and comprehensive display of system status
- Optional control algorithm minimizes electrical consumption by dimming lamps automatically while maintaining performance
- Another optional control algorithm matches UV energy output to flow rate – a process called "flow pacing" – to minimize O&M costs
- Controls interface seamlessly with plant SCADA for full integration of facility operation and alarm systems

Operator-Friendly System with Optional Sleeve Wiping

Designed for maximum UV energy delivery and minimum maintenance

Benefits:

- Optional sleeve wiping system ensures lamps deliver maximum UV energy for disinfection and UV-oxidation of contaminants
- Sleeve wiping improves efficiency and minimizes operational EE/O values
- Automated wiping at preset intervals provides ongoing prevention of sleeve fouling
- Sleeve wiping takes place while the system is online and operating – so there is no need to shut down or bypass the reactor
- Single-ended lamp and sleeve design simplifies lamp change-outs and reduces maintenance time and expense
- Lamp change-outs can be completed without depressurizing or draining the reactor – the procedure takes only minutes per lamp, and does not require tools
- UV sensor is mounted on the outside of the reactor for easy access

Single-ended lamps and the optional sleeve wiping system of the TrojanUVPhox™ simplify and reduce maintenance requirements and their associated costs.

Hydrogen Peroxide (H_2O_2)

Safe, effective, and fully managed for worry-free water treatment

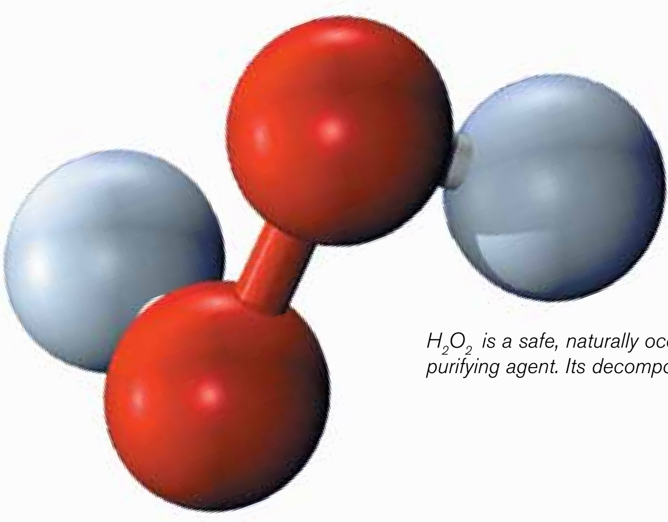
- Hydrogen peroxide (H_2O_2) is the oxidant used in UV-oxidation
- Trojan's integrated UV-oxidation offerings include full service and management of this consumable component and its related equipment
- H_2O_2 monitoring, replenishment, and equipment maintenance are done for you
- Installation and all maintenance is performed by experienced, highly trained professionals
- H_2O_2 is a liquid, so there is no potential for gaseous leaks that can endanger surrounding communities
- No requirement for hazard permit or evacuation plan
- No special handling or safety equipment required
- Any spills are localized and are cleaned up with water (decomposition by-products are water and oxygen)

Automated H_2O_2 Supply and Delivery

NSF-grade Hydrogen Peroxide plus the benefits of complete support and logistics

- Reliable supply of technical grade or high-purity NSF-approved drinking water grade H_2O_2
- Remotely monitored H_2O_2 inventory and management
- All handling of H_2O_2 is done by Trojan – your plant operators never have direct contact with peroxide
- Automatically scheduled deliveries and customized usage reports
- Trojan UV-oxidation packages include a specified period of H_2O_2 supply, delivery, and proper maintenance and servicing of storage and dosing equipment
- Continuation of the H_2O_2 service package is available simply by continuing to purchase H_2O_2 from Trojan

Trojan's turn-key programs eliminate additional demands on plant staff. Our full service offering includes remote monitoring of H_2O_2 levels, automated delivery scheduling, and all peroxide handling and equipment maintenance.



H_2O_2 is a safe, naturally occurring compound and a very effective purifying agent. Its decomposition by-products are water and oxygen.

Comprehensive H_2O_2 Equipment & Services

Turn-key program eliminates training and handling requirements

Trojan UV-oxidation systems are fully integrated packages that include the UV equipment and control systems, as well as everything required to dose the water stream with H_2O_2 including:

Trojan UV-oxidation solutions include complete H_2O_2 storage, delivery and monitoring systems that meet the most stringent safety standards.

Double Containment Tank Systems

- High density polyethylene construction with integral secondary containment
- Fully conform to the most stringent safety standards
- Includes fill line, inspection ports, overflow pipe, vent, and ultrasonic level sensor
- Available in a range of sizes

Metering Pump Assembly Skids

- Standard equipment includes ProMinent™ pumps for precise H_2O_2 metering
- Passivated 316L stainless steel suction and discharge piping ensures product quality
- Includes backpressure regulator, pressure relief valves, and calibration assembly for maximum safety
- Electrical control panel provides manual or automatic ON/OFF operation of either pump

Full Equipment Maintenance and Ongoing Service

- Comprehensive maintenance program and support
- Includes preventative maintenance, remote diagnostics, and process optimization support as treatment conditions change

Trojan's Turn-Key UV-Oxidation Solutions

Trojan is your single-source solution for UV-oxidation systems. We provide everything needed to perform UV-oxidation, including our many years of technical experience in treating chemical contaminants and engineering expertise to handle the most technically challenging projects. Packages include:

- UV equipment:
  - TrojanUVSwift™ECT or
  - TrojanUVPhox™
- Storage tanks engineered specifically for hydrogen peroxide and with secondary containment standard
- Electronically controlled hydrogen peroxide metering pumps
- Performance Guarantee – Trojan guarantees sizing when a representative water sample is provided
- Ongoing supply and as-needed delivery of NSF- or technical-grade H_2O_2
- Remote monitoring, control, and inventory management of H_2O_2 using the ChemWatch™ system
- UV lamp supply and replacement

TROJAN UV SWIFT™ ECT

TrojanUVSwift™ECT Product Specifications		
Reactor Model	**L24**	**L30**
Number of Lamps	8	8,16
Dimensions/Miscellaneous		
Approximate Dimensions		
Width (in/m)	54/1.4	62/1.6
Length (Flange to Flange) (in/m)	35/0.9	53/1.35
Overall Height (in/m)	38/1.0	49/1.25
Required for Service beyond End Cap (in/m)	24/ 0.6	48/1.2
Vertical Distance Required for Service (in/m)	88/2.2	88/2.2
Maximum Operating Pressure (psi /kPa)	150 / 1034	75 / 517 or 150 / 1034
Dry Reactor | Wet Reactor Weight	1500 lbs/680 kg | 2240 lbs/1016 kg	2178 lbs/990 kg | 4050 lbs/1837 kg (75 psi model)
Electrical/Control Power Panel		
Electrical Supply	480, 575 or 600 V, 3 wire + ground, 60 Hz (575 and 600 V requires step-down transformer)	
Maximum Power Supply Range	8 lamp - 83 kVA unbalanced	8 lamp - 103 kVA unbalanced 16 lamp - 202 kVA unbalanced
Nominal kW Input per Lamp	9.6	12.3
Panel Rating	Type 12 Indoor	
Enclosure Dimensions (HxWxD)	86.75" x 94" x 23.5" | 2.2 m x 2.4 m x 0.6 m (4 cabnets per reactor [16L30])	

TROJAN UV PHOX™

TrojanUVPhox™ Product Specifications				
Single Reactor Model	**12AL30**	**18AL50**	**30AL50**	**72AL75**
Dual Reactor Model	**NA**		**D30AL50**	**D72AL75**
Number of Lamps (single reactor)	12	18	30	72
Number of Lamps (dual reactor)	NA		60	144
Dimensions/Miscellaneous				
Overall Length (in/m)	76/1.9	82.25/2.1	Single 82.25/2.2 | Dual 147.25/3.8	Single 86.5/2.2 | Dual 147.75/3.8
End Cap Diameter (in/m)	20.5/0.5	29.25/0.7	29.25/0.7	41.25/1.0
Required for Service Beyond End Cap (in/m)	66/1.7			
Flange Size Options (in)	8, 4		12, 8, 4	20, 16, 12, 8
Maximum Operating Pressure (psi/kPa)	100/690			65/450
Dry Reactor | Wet Reactor Weight (lb/kg)	300/136 | 600/272	1400/635 | 2100/952	Single: 1600/726 | 2100/998 Dual: 3000/1360 | 4300/1950	Single: 2100/952 | 3700/1680 Dual: 3700/1680 | 7200/3270
Electrical/Power Distribution Center				
Electrical Supply	480V, 3 phase, 4 wire + ground, with 120VAC, single phase, 2 wire + ground for environmental			
Approximate Panel Power Draw (kW, Single Reactor)	3	4.6	7.8	18.5
Panel Rating	Type 12 Indoor, Type 4X Indoor, Type 4X outdoor (sun sheltered)			
Enclosure Dimensions (HxWxD)	48" x 40" x 12" | 1.2 m x 1.0 m x 0.3 m		Single: 80.25" x 47.25" x 23.75" ; Dual: 80.25" x 96" x 23.75"	

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Hach/Trojan Technologies (China): 86-10-65150290

Products in this brochure may be covered by one or more of the following patents:
CA 2,239,925; CA 2,477,030; CA 2,422,045; CA 2,381,307; US 7,077,965; US 7,018,544; US 7,102,140; US 7,282,720; US 7,368,725; US 7,531,095; US 7,390,225; US 6,659,431; US 5,418,370; US 6,635,613; US 7,018,975; US RE36,896; AU 2,381,307; AU 782018; CN 00811520.6; CN 1289648C; CN 94191814.9; EP 1094035; EP 1,210,296; MX 223502.
Other patents pending.

OA-E-M&S-5.2-D-CA0001-0510

TROJAN UV
WATER CONFIDENCE™

APPENDIX C

TROJAN UV
BENCH-SCALE UV/H2O2 TREATMENT OF MW-21 (AND EW-02) GROUNDWATER SAMPLE FROM FULLERTON, CALIFORNIA PRELIMINARY TEST RESULT

Prepared by Trojan Technologies, Inc.
February 8, 2012
Updated July 9, 2012

Bench-Scale UV/H2O2 Treatment of MW-21 Groundwater Sample from Fullerton, California

Preliminary Test Result

Trojan Technologies
February 8, 2012
Updated July 9, 2012

1. INTRODUCTION

Trojan Technologies has performed bench-scale treatability tests to evaluate the application of the UV/H_2O_2 advanced oxidation process (AOP) to treat the contaminated groundwater samples EW-02 and MW-21 from Fullerton, California. This work was performed at the request of Hargis + Associates, Inc. The groundwater is contaminated by 1,4-dioxane as well as several volatile organic compounds (VOCs). Well MW-21 represents the water with the highest contamination levels whereas well EW-02 represents the water with the lowest contamination level. Trojan will rely on the results of these bench-scale tests together with a proprietary model of the UV systems and the UV/hydrogen peroxide (H_2O_2) AOP to recommend a full-scale UV system together with a hydrogen peroxide injection skid. This AOP system will treat 1,4-dioxane to below 0.2 µg/L and most VOCs to below 0.5 µg/L from 150 gpm of either EW-02 or MW-21 groundwater.

2. OBJECTIVES

The objective of this study is to evaluate the water quality of wells EW-02 and MW-21 and recommend a full-scale UV/H_2O_2 system capable of reducing 1,4-dioxane and VOCs from 150 gpm of either well to their respective target concentrations.

3. PROCEDURES

Phase I: Background Water Quality Evaluation

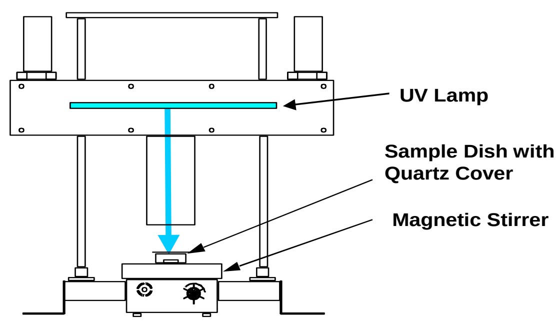
Trojan's routine background water quality testing comprised the following steps:

1. Perform routine water quality measurements including pH, alkalinity, dissolved organic carbon (DOC), nitrate (NO_3^-) and Cl_2 (free & total)).
2. UV transmittance (UVT) analysis over the wavelength range from 200 to 400 nanometers. A Cary 100 Spectrophotometer using quartz cuvettes of various pathlengths will be used to measure the absorbance of the water. Absorbance (A) will be measured between 200 and 400 nm. Calibration of the instrument prior to each run will be performed using Milli-Q water in the same cuvettes.
3. Determination of background hydroxyl radical scavenging demand. To determine background hydroxyl scavenging demand, water samples will be spiked with hydrogen peroxide (H_2O_2) and a photochemical reagent and exposed to a known amount of UV light (intensity and exposure time). Then concentrations of the spiked reagent will be measured before and after irradiation. The resulting dose response of the reagent is used to determine the capacity of other constituents present in the water to scavenge hydroxyl radicals, thereby diverting oxidative action from the target contaminants.

Phase II: Bench-Scale UV/H_2O_2 Treatment

The bench-scale work involves the use of a low-pressure collimated beam (LPCB) apparatus depicted in Figure 1. This apparatus consists of an enclosure housing a low-pressure UV lamp similar to that of the proposed full-scale UV system. Extending from the bottom of this enclosure is a collimating tube which results in essentially collimated UV radiation reaching a petri dish containing 55 ml of the water sample. The UV irradiance reaching the water sample is accurately measured using an International Light model IL1700 radiometer system. Prior to UV exposure the sample may be spiked with hydrogen peroxide and para-chlorobenzoic acid (pCBA). The dish is covered with a flat quartz filter disc to minimize contaminant losses due to volatilization. At time zero the spiked sample is exposed to the UV and the degradation rate of the contaminants is determined by measuring their concentration after various exposure times.

FIGURE 1
Collimated Beam Apparatus



Trojan Technologies Inc.

Figure 1: UV/H2O2 Bench-Scale Apparatus

4. TEST RESULT

The results of the phase I water quality evaluation are summarized in Table 1 and Figure 2. Although the organic contaminant analyses for these two samples are quite different, the parameters reported in Table 1 do not indicate significant differences. MW-21 does have approximately twice the DOC level as EW-02 but the level is still quite low. The pH and alkalinity values are typical for a groundwater. Nitrate levels are quite high at 26 and 33.7 ppm respectively for EW-02 and MW-21. The UV transmittance values at the 254 nm wavelength that is emitted by the low-pressure lamp are quite high for both samples.

Table 1: Phase I Water Quality Evaluation

Water Sample	DOC	Alkalinity	pH	Nitrate	UVT at 254 nm
	ppm	ppm as $CaCO_3$		ppm as NO_3^-	%
EW-02	0.53	213	7.63	26.4	98.9
MW-21	1.03	239	7.33	33.7	97.7

The hydroxyl radical scavenging test is designed to allow the calculation of the demand for hydroxyl radicals associated with the water matrix (e.g., organic contaminants, inorganic contaminants, NOM, etc.). As described, this is performed by monitoring the degradation of the probe compound pCBA at a specific H_2O_2 dose with the low pressure collimated beam. Figure 2 presents the empirical results of this test for both EW-02 and MW-21. It is difficult to directly compare the results presented because different H_2O_2 doses were used for each sample. It is expected that the hydroxyl radical demand for MW-21 would be much higher than that for EW-02 due to the higher VOC contamination levels. Therefore, to ensure measurable reductions of the probe compound for MW-21 a higher hydrogen peroxide concentration was used for that sample.

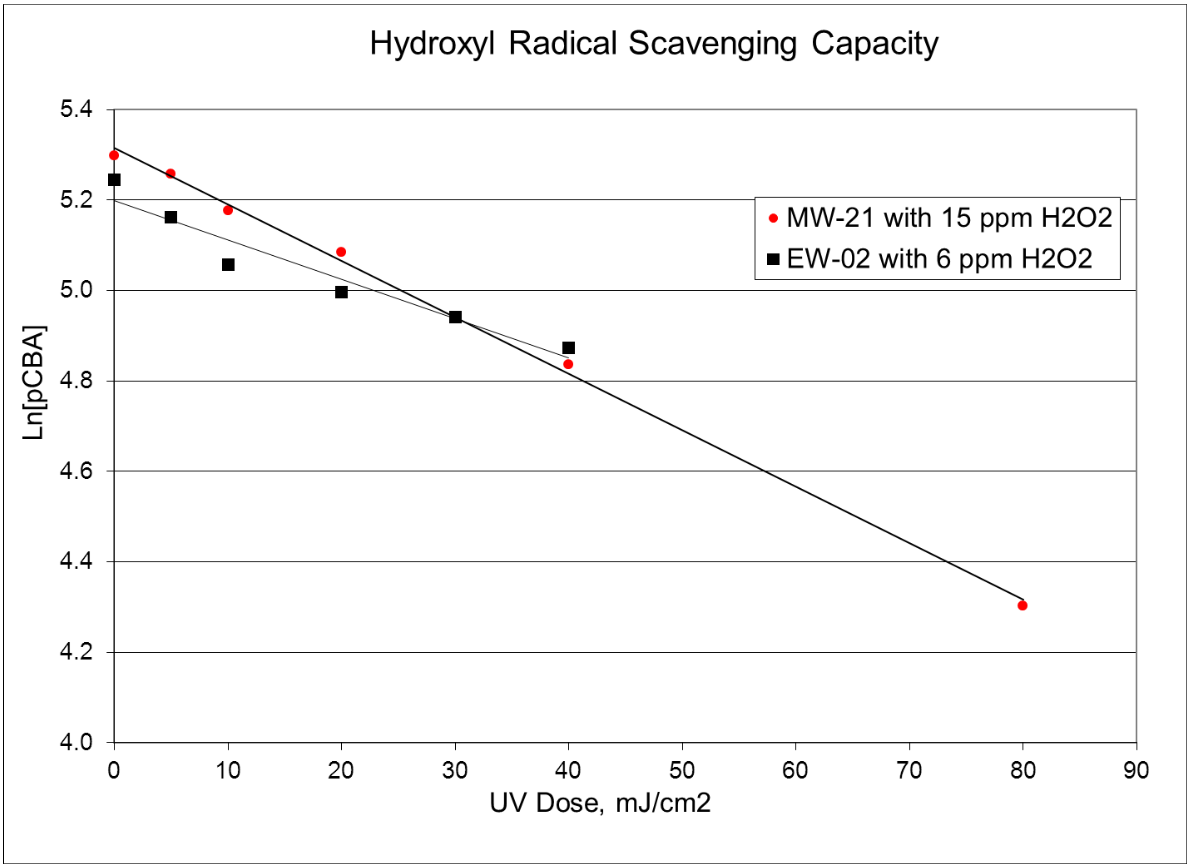


Figure 2: Hydroxyl Radical Scavenging Test Result

In addition to these phase I results, Trojan sent aliquots of each of the EW-02 and MW-21 water samples to Weck Laboratories in Industry California to perform 1,4-dioxane and VOC analyses of the water to be tested by Trojan. The significant results for MW-21 are 1,1-DCE levels of 3,300 µg/L (ppb) and 1,4-dioxane levels of 770 µg/L (ppb). Treatment targets for 1,4-dioxane and 1,1-DCE were identified as 0.2 µg/L and 0.5 µg/L respectively. Therefore, 1,1-DCE must be treated by 3.8-log (i.e., Log(3300/0.5)) and 1,4-dioxane must be treated by 3.6-log (i.e., Log(770/0.2)). Similarly, the analytical results for EW-02 were 18 ppb of 1,4-dioxane and 45 ppb of 1,1-DCE. The associated treatment requirements for EW-02 were based on analytical results from December 2011 which indicated that 2.04-log reduction of each contaminant was required.

The results from the phase II tests are summarized in Figure 3 below. It is confirmed by these results that neither pCBA nor 1,4-dioxane degrade by direct UV photolysis and 1,1-DCE only degrades very slowly. Nevertheless, the same UV exposure with 15 ppm H_2O_2 results in significantly increased destruction rates. The rates of destruction for these UV/H_2O_2 tests are in the order 1,4-dioxane < pCBA < 1,1-DCE. This is the expected result based on the hydroxyl radical rate constants for these compounds reported in the literature and used by Trojan's proprietary sizing model. As such the UV equipment sizing recommendation is based on the required treatment of 1,4-dioxane. If the 1,4-dioxane treatment target is met then the 1,1-DCE target will be exceeded.

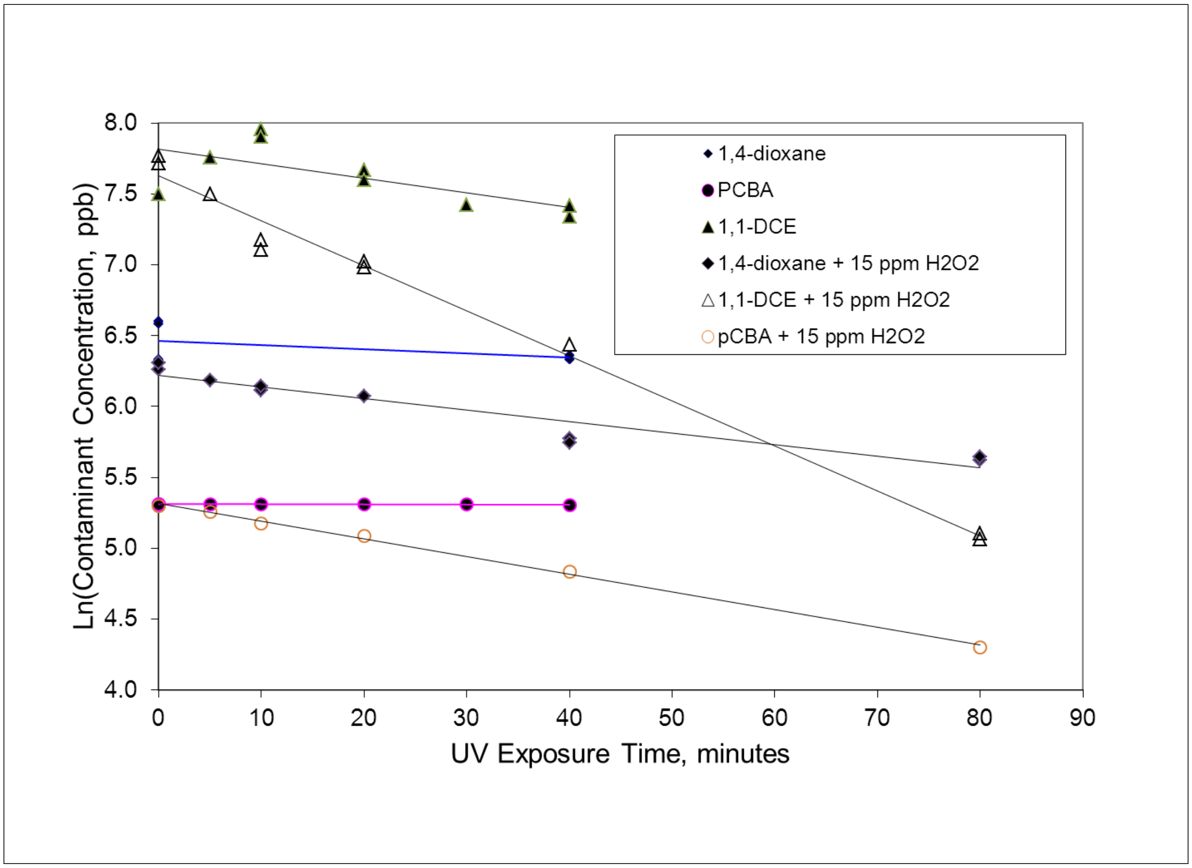


Figure 3: Phase II – LPCB UV/H_2O_2 Treatment Kinetics

Furthermore, Trojan's model together with the kinetic parameters (i.e., quantum yields & hydroxyl radical rate constants) for the other VOC compounds present in the groundwater can be used to predict their treatment also. Table 2 presents the expected treatment of the VOCs identified in the MW-21 and EW-02 water samples.

Table 2: Expected Treatment Levels of All Detected VOCs

	MW-21			EW-02		
	[Inf], µg/L	[Eff], µg/L	Log Reduction	[Inf], µg/L	[Eff], µg/L	Log Reduction
1,4-Dioxane	770	0.20	3.6	22	0.20	2.04
1,1-DCE	3300	0.00	8.74	55	0.00	4.95
TCE	22	0.00	3.84	ND		2.26
PCE	8.9	0.00	4.18	ND		3.73
1,1,2-TCA	20	14.5	0.14	ND		0.08
1,1-DCA	51	34.5	0.17	0.69	0.56	0.09
1,2-DCA	7	3.9	0.26	ND		0.15

ND – Non-detect

5. CONCLUSION

From the test result, it can be demonstrated that the UV/H_2O_2 technology can remove the 1,4-dioxane and 1,1-DCE required for this groundwater. Trojan has utilized these results for both the water quality evaluation and the contaminant treatment kinetics together with its proprietary mechanistic model of the UV/H_2O_2 process to recommend a UV system size for the full-scale treatment of both MW-21 and EW-02 groundwaters.