OZONE CASE STUDY
Active Truck Stop Spill
Central Point, Oregon
Ex-Situ Pilot

Background

A chemical tanker truck accident on I-5 occurred in 1984, contaminating the site. The spill included 50 gallons acetone, 700 gallons 1,1,1-trichloroethane (TCA) and 1000 gallons ethylene glycol. The contamination seeped into the groundwater and contaminated several residential wells along an adjacent road. Based on a residual saturation level of 5%, the remaining TCA mass in the source area soil was estimated to be in the range of 2,000 pounds. Between 1984 and 1998, remedial activities included soil removal, tree planting, and two separate groundwater pump and treat systems.

The following compounds were also found:1,1 Dichloroethane (1,1-DCE), 1,4 Dioxane, 1,1-Dichloroethane (1,1-DCA), and toluene (TOL).

Previous Remediation Efforts

In December 1984, soil excavation removed approximately 150 cubic yards of contaminated soil. In September 1985, an additional 1000 to 2000 cubic yards contaminated soil was excavated and stockpiled on-site. Storm water run-on or run-off controls were not instituted for the stockpiled soil. In addition, the excavation pit was not backfilled until May 1988, when soil was replaced in the excavation. The soil replaced was compacted and capped with 2 feet of topsoil and re-seeded.

A groundwater pump and treat system operated from April 1990 to October 1991, under a consent order issued by the EPA. Groundwater was extracted from two wells located on the adjacent property at a rate of approximately 25 gpm. The groundwater treatment system was composed of a sand filter and two carbon absorption units. Treated water was discharged to a surface water drainage ditch under a National Pollutant Discharge Elimination System (NPDES) permit issued by Oregon Department of Environmental Quality (DEQ). After expiration of the consent order, the treatment system and well pumps were removed from the site.

In 1994, the DEQ installed activated carbon treatment systems on eight private supply wells and began a quarterly groundwater monitoring program. Four wells had detectable levels of chlorinated hydrocarbons, two wells with levels exceeding the MCL for 1,1-DCE.

A second pump and treat system was installed on site in 1995 by the DEQ. Equipment included an air stripper and granular activated carbon. Between July 1995 through August 1997, over 30 million gallons of groundwater containing over 130 pounds of VOC's have been removed from the shallow aquifer, treated, and discharged to surface waters.

Solution

An ex-situ oxidation pilot study was needed to evaluate different types of oxidation and advanced oxidation methodologies and their effectiveness in reducing groundwater contaminants to below DEQ discharge limits. Piper Environmental Group, Inc. provided expert ozone and advanced oxidation system advice, specialized equipment, field assistance, and interpretation of testing results for an overall successful and cost-effective project.

Pilot Test Protocol

Piper Environmental Group, Inc. provided a flexible ozone and advanced oxidation treatment pilot system. The equipment was configured to inject and recirculate ozone (O_3) treated groundwater in its contact, mix, and degas system, with flexibility to run an ultraviolet (UV) reaction chamber or metered hydrogen peroxide (H_2O_2).

The tests included treating site groundwater samples using ozone only or advanced oxidation technologies (O_3+ H_2O_2, and O_3+ UV). Results were evaluated on effectiveness utilizing different oxidation technologies to reduce site groundwater contaminants.

Ozone applied rate was 60 mg/l. Flow-rates were varied through the tests and H2O2 or UV additions were added as described below.

- OZ-1 = Ozone Alone @ 0.5 GPM
- OZ-2 = Ozone Alone @ 0.75 GPM
- OZ-3 = Ozone Alone @ 1 GPM
- OZ H_2O_2-1 = Ozone and H_2O_2 @ 0.5 GPM
- OZ H_2O_2-2 = Ozone and H_2O_2 @ 0.75 GPM
- OZ H_2O_2-3 = Ozone and H_2O_2 @ 1 GPM
- OZUV-1 = Ozone + UV Light @ 0.5 GPM
- OZUV-2 = Ozone + UV Light @ 0.75 GPM
- OZUV-3 = Ozone + UV Light @ 1 GPM
- MCL = Maximum Concentration Limit
- RW = Raw, untreated groundwater

Equipment

One (1) custom skid recirculating at a rate of 10 gpm and a maximum throughput of 1 gpm on inlet + outlet:

- One (1) PVC contact tank with degas valve
- One (1) Mazzei injector
- One (1) ozone destruct
- One (1) 1/3 hp recirculation pump
- Two (2) flowmeters: Inlet/outlet

One (1) skid mounted ozone system:

- One (1) P2000 ozone generator rated at 14 g/hr
- One (1) AS-12 integral oxygen generator 12 scfh

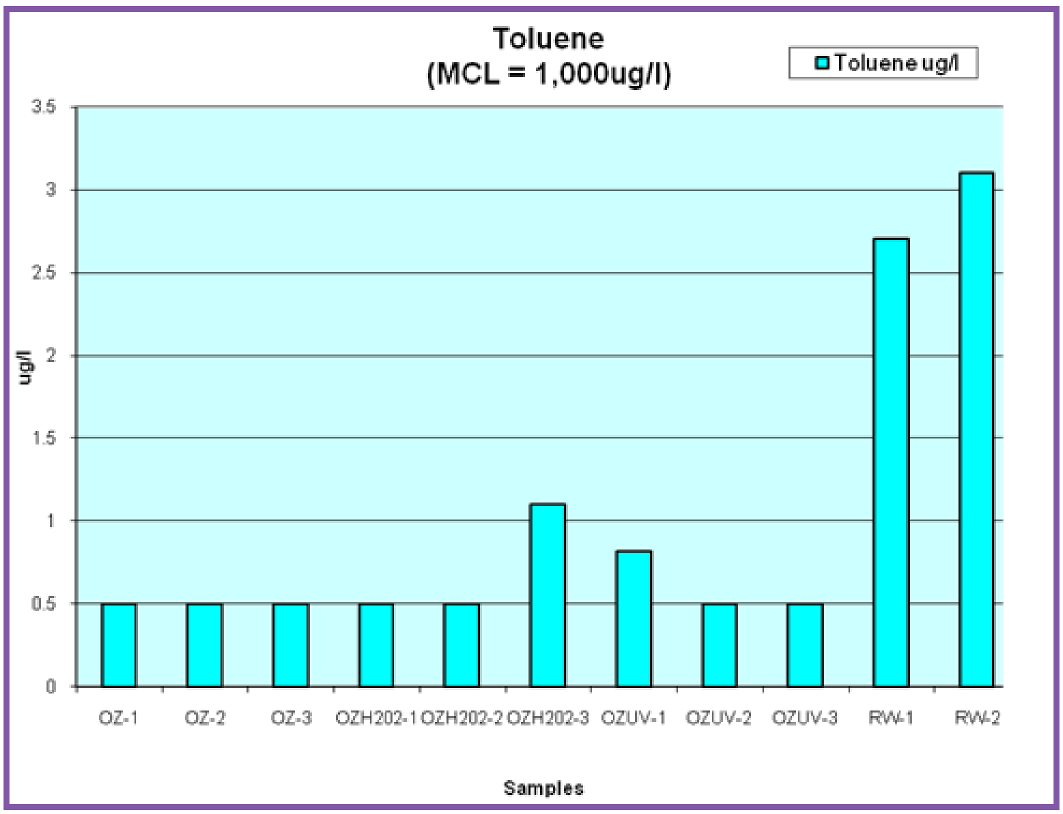
Results

Toluene and BTEX, in general, are easily remediated via ozone alone, whether it is in-situ or ex-situ. Advanced oxidation is not required.

For this study, it is noted that ozone at various doses provided the same excellent reduction. However, there were surprising fluctuations in Toluene levels in advanced oxidation.

Note at lowest dose, O3+ H2O2 was least effective, while O3 + UV at the highest dose was also not as effective as any other dosing.

Toluene Reduction



Results

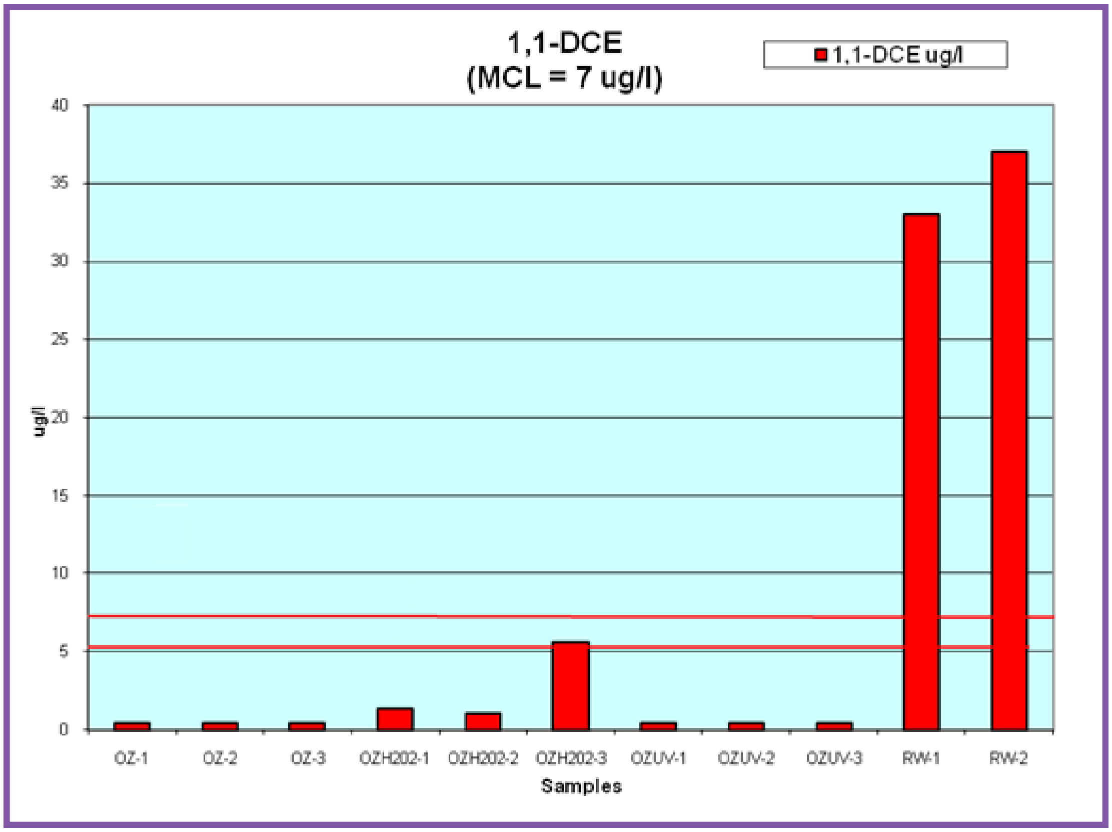
The focus of treatment and analysis was on 1,1 DCE , Toluene, and 1,4 Dioxane.

Analysis of both contaminants revealed excellent reduction to below clean up target utilizing ozone alone.

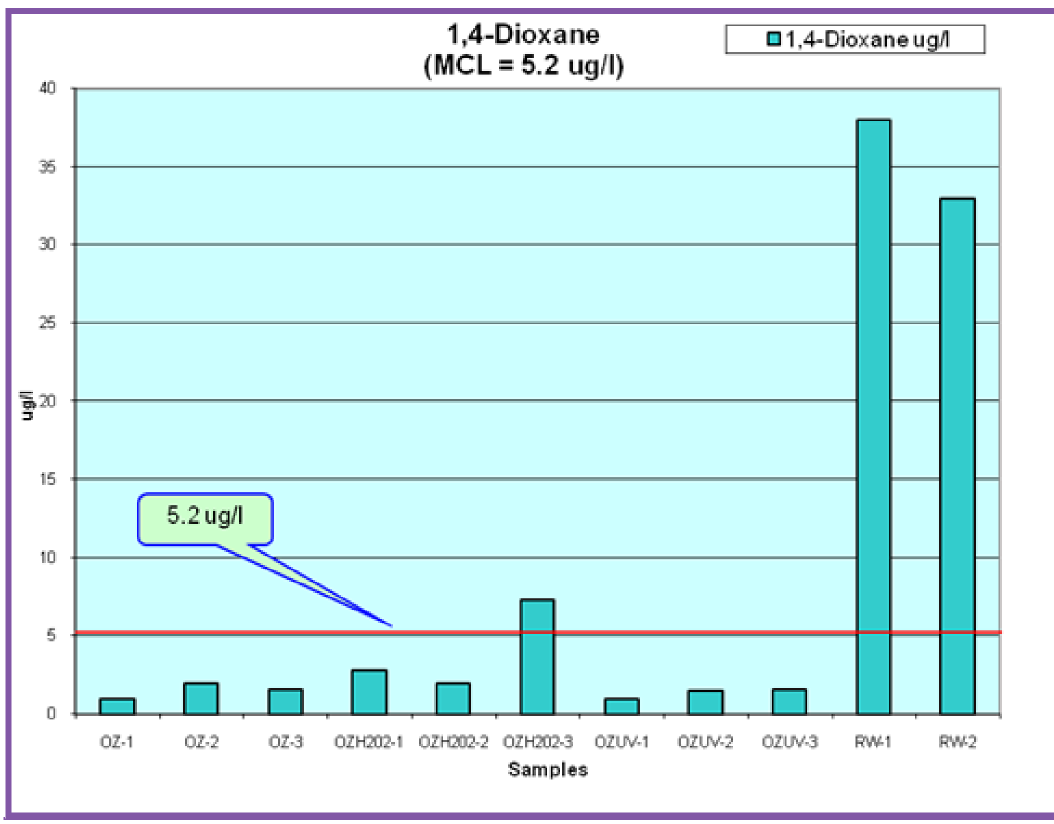
Removal efficiencies were 99% for 1,1 DCE and 97% for 1,4 Dioxane respectively.

The following two charts reflect the effect of all three oxidation technologies.

1,1-DCE Reduction



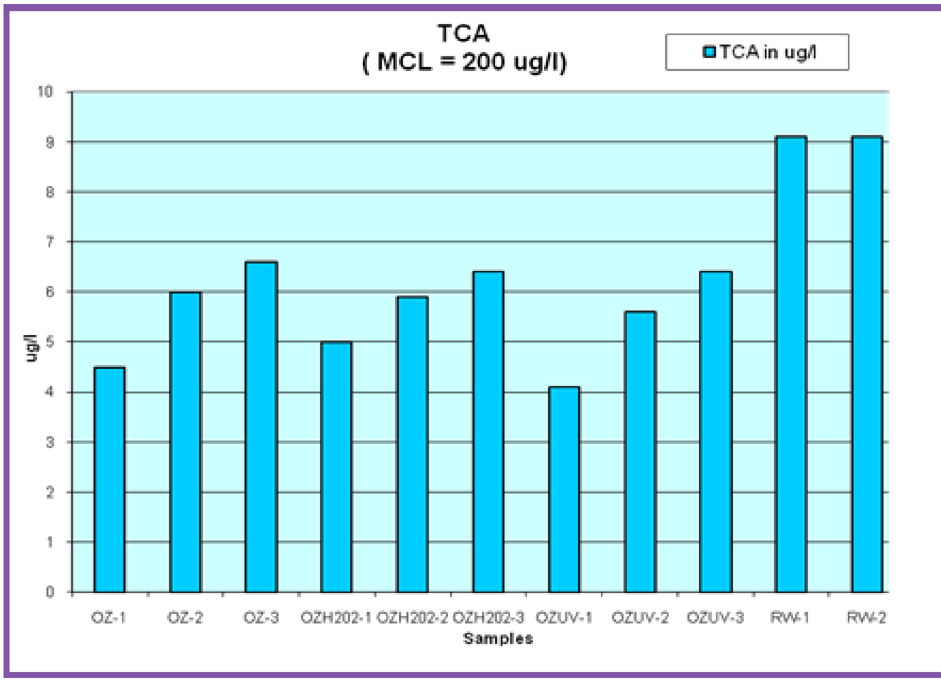
1,4-Dioxane Reduction



Results

Laboratory analyses of treated water samples revealed site groundwater contaminants were easily reduced to below the Oregon DEQ discharge limits using ozone alone. Treatment using ozone was effective for all groundwater contaminants and exhibited removal efficiencies as high as 99%.

The other advance oxidation technologies (O_3+ H_2O_2 and O_3+UV) performed equally well in treating the contaminants. It was determined ozone alone was sufficient for the full-scale treatment system and would result in significant cost-savings vs. more complex advanced oxidation systems.



The graph to the left summarizes the concentrations of TCA in groundwater with various oxidation methods.

Ozone combined with UV was slightly more effective than ozone alone for TCA reduction during the pilot study. It was expected that ozone + H_2O_2 would be drastically superior to ozone alone or ozone + UV.

Higher concentration ozone gas and better contacting and mixing is believed to provide better results for ozone alone.

Chlorinated Solvents Information

Chlorinated solvents have properties that make them useful for degreasing fats, oils, waxes, and resins. They are used widely and have been manufactured in large quantities. Some chlorinated solvents are dichloromethane, tetrachloroethene, trichloroethane, and tricholoroethene. The U.S. production of these compounds in 1980 were 255,000, 347,000, 314,000, and 121,000 metric tons, respectively.

Chlorinated solvents in general are harmful to human and ecological health. They can cause or are suspected of causing cancer, and are toxic or harmful to aquatic organisms.

Spills and leaks of chlorinated solvents have caused widespread subsurface contamination in the environment. Commonly these contaminants are present in the subsurface in the form of non-aqueous phase liquids (NAPL, the bulk chemical product), as dissolved contaminants in ground water, associated with aquifer sediments, and as vapors in the unsaturated zone. Because the density of these NAPL's is greater than water, they tend to sink in ground water systems. which results in a complex dispersal and plume patterns, long-term sources in the subsurface, and difficult clean-up.

Conclusion

Piper Environmental Group, Inc. recommended a full-scale water treatment system design based on an ozone-only approach, which would operate reliably and comply with Oregon DEQ discharge limits.

The pilot study demonstrated the effectiveness of using ozone in reducing all site groundwater contaminants to below Oregon DEQ requirements.

In addition, the pilot study showed specifically that ozone alone was effective in treating target compounds 1,1-DCE, 1,4-dioxane, and toluene. Advanced oxidation methods such as ozone + H_2O_2 and ozone + UV were not required.

Additional products and services for in-situ and ex-situ applications are here: http://www.peg-inc.com

Company Profile

Piper Environmental Group, Inc. offers ozone technology, equipment, and services for a wide-range of environmental applications. The company designs, manufactures, and integrates ozone systems and related equipment for short and long-term projects, offering equipment for rent or purchase. Services include project design assistance, oxidation pilot studies, contract service, equipment repair, con-

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