



OZONE CASE STUDY

Mixed Industrial & Dry Cleaners Site Southern California In-Situ Ozone Injection

Background

The site was previously occupied by light industrial facilities including an auto repair shop, laundry cleaning services, restaurant equipment refurbishing and a restaurant. BTEX and TPH were primary Contaminants of Concern (COC).

Seventeen (17) underground storage tanks (USTs) were removed in 2009 during a site remedial investigation. Over the last two years prior to ozone injection, multiple relevant environmental activities took place at the site, including extensive soil excavation that extended to a depth of approximately 45 feet bgs, application of BIOX® at the bottom of excavation, LNAPL recovery effort, and ongoing soil gas and groundwater monitoring programs.

Solution

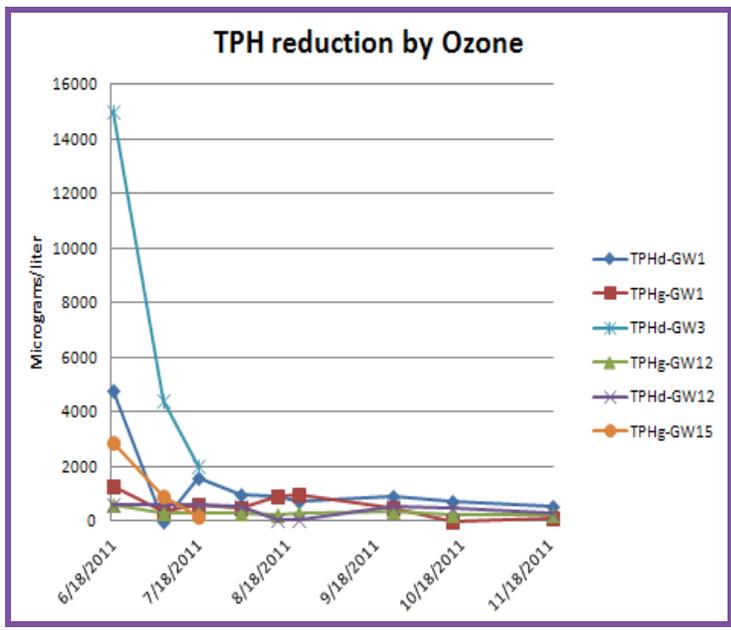
Piper Environmental Group, Inc.'s 28 pound per day (PPD) ozone trailer was chosen for in-situ chemical oxidation (ISCO) based on safety, implementation ease, cost, and most importantly, the absence of negative impact to groundwater quality and site occupants. The remediation goal was to perform a successful pilot test and demonstrate ozone's ability to reduce COC. The ozone sparging system operated for two months, June - August, 2011. Ozone injection was accomplished through a series of five sparge points (screens at 74 feet bgs), with a depth to groundwater at 71 feet bgs. Piper Environmental Group, Inc. provided engineering, design assistance, the ozone trailer system, monitoring and control components and in-situ monitoring devices. During installation and start-up, ran ozone tubing and connected to wellheads, completed Health and Safety Training and system operational training. For a week following start-up, Piper Environmental Group, Inc. assisted in collecting groundwater samples. Total ozone production during project totaled 700 pounds. The final gas stream composition was ~ 2 % ozone.

Results

Overall COC reductions ranged from 80-100% during two month pilot study. Some monitoring wells were 70-75 feet from injection wells and results were unexpectedly positive from 95% of all monitoring points.

Free product, TPHg, and TPHd reduction rates of 28.6% - 100% were seen during study with one well rebounding slightly post injection. It was suspected TPH would overload ozone demand and thus lessen overall effectiveness on other COC. This did not occur. Consistent continued reduction three months post injection for all COC's occurred.

With 70 reference points of wells and COC's, 67 showed significant improvement or were ND at beginning and end of test. Only three showed small increases in COC's.



BTEX concentrations reduced 83.2% PCE reduced 59.4%, and TCE dropped 31% across the site. The results were far better than anticipated, especially combined with the other significant COC reductions.

Groundwater concentrations continued to decrease during the post-remedial monitoring events, indicating source area was effectively remediated and we expect minimal rebounding. To determine this, baseline soil and groundwater sampling was conducted on June 18, 2011. Post-remediation soil and groundwater sampling continued August - December, 2011 to demonstrate treatment effectiveness.

Ozone System Description

- ◆ 5 ozone sparge wells
- ◆ 10 monitoring wells
- ◆ 4 multi-depth vapor extraction wells
- ◆ 500 lineal feet of 1/2-inch Teflon tubing
- ◆ All piping and tubing located in PVC conduits
- ◆ Ozone wells were modified monitoring wells to be deconstructed and used as such post-study
- ◆ Packers used as a means to modify the monitoring wells to allow for ozone sparging
- ◆ Depths of sparge points varied from 71 to 74 feet below ground surface

Ozone Generation Trailer

- ◆ Ozone generator produces 28 PPD
- ◆ Final gas stream composition: ~2% ozone
- ◆ Generator operated at 15 psig at 8 SCFM

Ozone Monitoring System

- ◆ High Concentration and Ambient Ozone monitors contained in ozone trailer

Treatment Zone Summary

- ◆ 16,600 cubic yards of soil treated
- ◆ Treatment area 22,500 square feet
- ◆ Depth to groundwater 71 feet
- ◆ Groundwater depth 2-4 feet
- ◆ Thickness of treatment zone 20-30 feet

Timeline

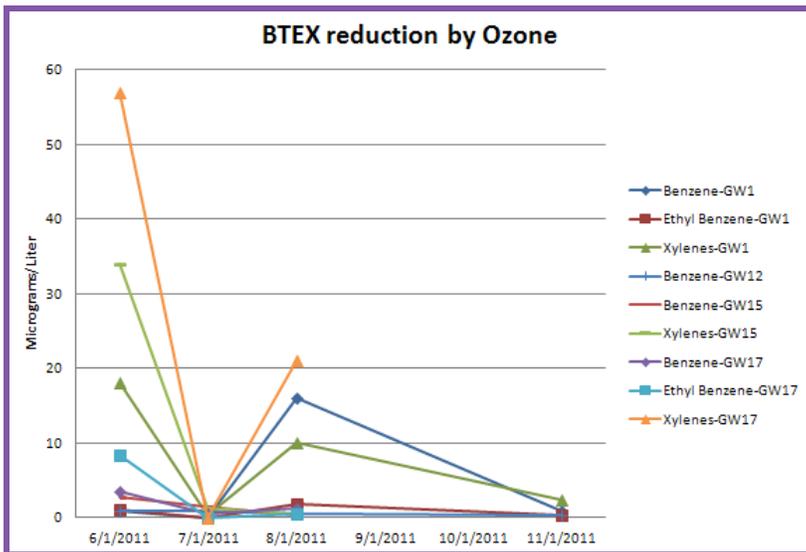
- ◆ Ozone sparge started June 27, 2011
- ◆ Treatment concluded August 22, 2011

With special consideration and appreciation to our project partners:

**Mr. Mehdi Bettahar, Mr. Jim Leu, and
Mr. Ryan Dominguez of Parsons
(see www.parsons.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, consulting. Our area of expertise is large remediation projects.



Groundwater Treatment Summary

The project was successful and paved the way for future high-output ozone systems for remediation.

- ◆ Pilot ozone system operational for 2 months.
- ◆ Approximately 700 pounds of ozone were generated and injected into subsurface treatment zone.
- ◆ Ambient ozone gas monitoring strategy and PLC operational safeguards were effective.
- ◆ Significant, permanent reduction in dissolved VOC and TPH concentrations observed in groundwater monitoring wells.
- ◆ Most COC levels continued falling post study.
- ◆ Minimal rebound in dissolved concentrations of VOCs and TPH observed during the last three months post-treatment.
- ◆ Equipment performed safely, effectively, reliably, produced desired results, saving time and money.