



Landfill Number 3 Iron Sequestration System



Site History

Landfill 3 (LF003) encompasses three Department of Defense Installation Restoration Program sites:

- 1) a landfill
- 2) a Fire Protection Training Area (FPTA), and
- 3) a laboratory chemical disposal area.

Figure 1 depicts the general site location of LF003 and the groundwater treatment plant (GWTP) on base.

Historical investigations have indicated the following site contaminant characteristics:

- High concentrations of volatile organic compounds (VOCs) were detected in groundwater
- Free-phase chlorinated solvents (DNAPL) are perched on a confining clay layer beneath the landfill
- VOCs detected in groundwater were also detected in seeps north-northeast of LF003 draining into an unnamed intermittent creek located adjacent to the north boundary of the site.

Current LF003 Remedy

The Corrective Action Plan identified an interim remedial approach that consists of:

- 1) source control via slurry wall containment and operation of the DNAPL recovery system
- 2) operation of extraction wells for hydraulic control within the slurry wall
- 3) operation of extraction wells and an extraction trench north of the containment area for dissolved plume control
- 4) installation of RCRA cap over the landfill
- 5) operation of landfill vapor capture and treatment system
- 6) land use controls.

The leachate collection and groundwater extraction systems transfer groundwater to the Robins Air Force Base GWTP. Figure 2 shows the site plan for LF003, including the remedial system components.

Challenges

Iron Fouling of Wells and Conveyance Lines

- The groundwater in the vicinity of LF003 contains high levels of dissolved iron, which make recovery and conveyance of this water difficult. Contamination changes the water chemistry, making it more acidic and less oxygenated. These changes enable the groundwater to dissolve iron, a natural component of site soil, which would otherwise not be soluble (or "dissolve-able").
- When the groundwater is subsequently drawn to recovery wells the water chemistry changes again, now making the dissolved iron insoluble, causing it to precipitate, or form solids.
- These iron solids clog recovery wells, pumps, pipelines, and treatment systems.

An illustration of the iron deposits is included as Photograph 1. Extracted groundwater from LF003 travels approximately 2 miles to the GWTP through a double-wall high-density polyethylene (HDPE) pipeline as shown on Figure 3.

Hazardous Chemical Storage

- Historically, at this site and many others like it, operators dealt with this fouling by periodically removing it using harsh, hazardous chemical cleaners, such as 50% hydrogen peroxide.
- At LF003, high concentration hydrogen peroxide has been used to clean the pipelines. The hydrogen peroxide is stored at LF003 in a 2,000-gallon tank.
- Storage of hazardous chemicals also represents a health and safety issue for system operators.

Goals For Addressing Iron Fouling:

- 1) increase operational safety
- 2) reduce the use and storage of hazardous materials
- 3) successfully prevent iron fouling in the recovery and conveyance system
- 4) lower operational costs

Potential Solutions:

New, "green" chemistry makes two alternative methods feasible.

- 1) Remove iron from the groundwater as soon as it is recovered as a pre-treatment step.
- 2) Use deposit control chemicals. These chemicals keep the iron dissolved and mobile, preventing it from forming solids in the recovery and treatment system.

Pilot studies were performed for both options. While both methods were determined to be technically feasible at this site, the latter was deemed to be more cost-effective.

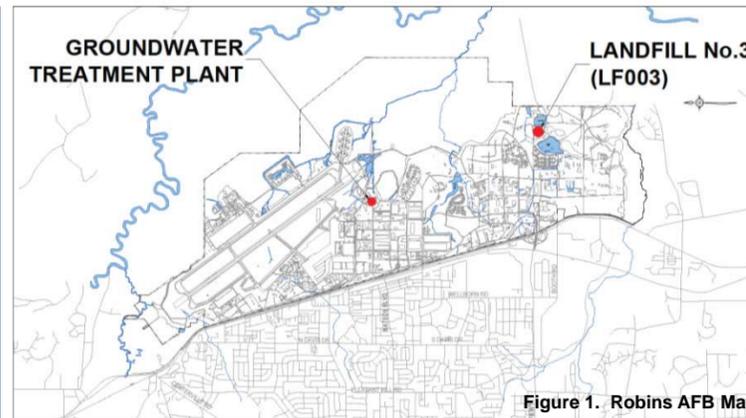


Figure 1. Robins AFB Map

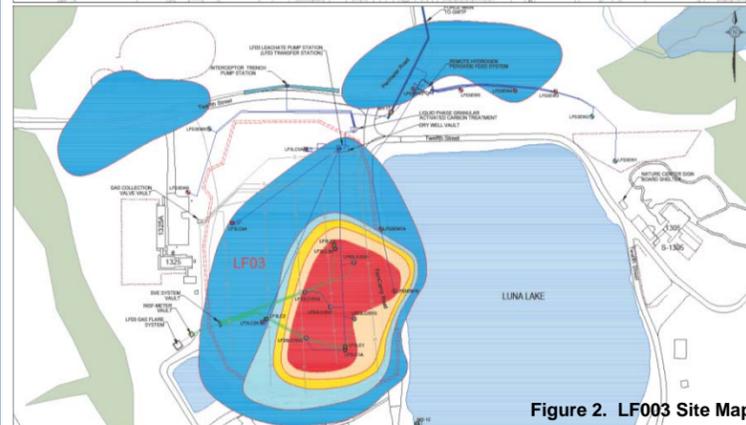


Figure 2. LF003 Site Map

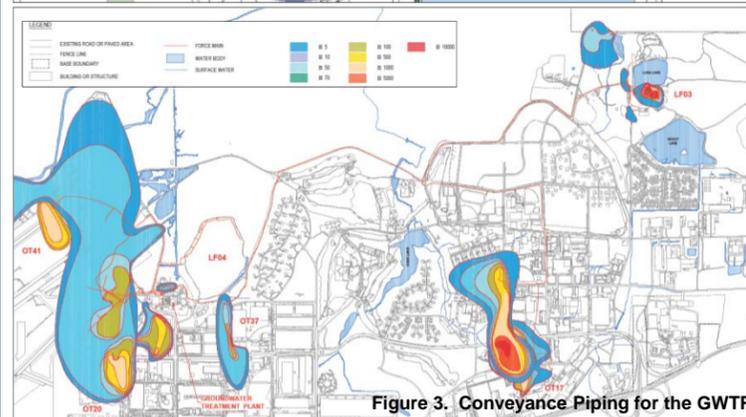


Figure 3. Conveyance Piping for the GWTP



Photograph 1. Iron Deposits on Extraction Well Caps



Photograph 2. Before and During Pilot Test at Extraction Well 3

Deposit Control Chemicals: How Do They Work?

These products are mixtures of various non-toxic chemicals that keep iron from forming solids, or keep any solids that do form from growing ("agglomerating") or settling in the treatment system. They are water-based liquids, chemically similar to detergents, which are added to the recovered groundwater at part-per-million levels.

Deposit control chemicals contain:

- Sequesterants: "spider-like" molecules that react with iron keeping it dissolved
- Reducing agents: chemicals that keep iron in its more soluble ferrous form
- Dispersants: polymers with excess electronic charges, which are transferred to suspended solids, making them repel each other and thus stay suspended
- Crystal modifiers: chemicals that interrupt the geometry of crystal growth and keep solids small and suspended

Description of System Components

At LF003, a unique system to add deposit control chemicals directly to the recovery wells is being installed. The system involves:

- Retrofitting of the recovery wellheads, which allows some of the recovered water to be dosed with deposit control chemical and returned to the well itself, keeping the well, recovery pumps, and pipelines free of iron solids.
- The required equipment includes a chemical storage tank and precision chemical feed pumps.
- This configuration feeds deposit control chemicals to each wellhead via polyethylene tubing, from a central location near the chemical storage tank.

Why Was This Technology Selected?

Pilot studies were completed to test effectiveness and projected costs of iron removal versus deposit control chemical addition. Photograph 2 depicts the in well pilot study system installed at Extraction Well 3.

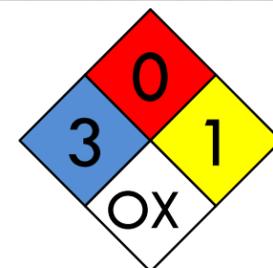
- Iron removal has the advantage of foolproof prevention of deposition in downstream components, but cannot be used to protect recovery wells, pumps and upstream pipelines, and creates solids which require disposal, usually as hazardous waste.
- Deposit control chemicals require less capital investment and O&M effort, but are not always 100% effective at controlling deposits, so periodic cleanings may still be required.
- Use of deposit control chemicals was determined to be the preferred option because it will minimize storage and use of hazardous chemicals, it will not generate hazardous waste, it will keep iron deposits controlled, and will lower operating costs.
- As part of the deposit control, two chemicals, Redux 300 and Redux 340, will need to be stored on site. The NFPA rating system and labels for hydrogen peroxide (currently stored on site), Redux 300, and Redux 340 are shown below. A comparison of the labels indicates that the deposit control chemicals are significantly less hazardous than the 50% hydrogen peroxide.

How Do We Know the System Is Working?

Ongoing monitoring of the rate of iron deposition will indicate how well deposit control chemicals are working. Deposition can be monitored by:

- Observing any loss of recovery well and recovery pump capacities
- Increases in pressure drop of pipelines
- Visual inspections of system components
- Measurements of iron levels throughout the system

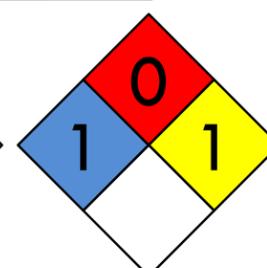
Based upon these observations, chemical dosing can be increased or decreased to adjust effectiveness as needed.



NFPA Label for 50% Hydrogen Peroxide



NFPA Label for Redux 340



NFPA Label for Redux 300

NFPA Rating Explanation Guide					
RATING NUMBER	HEALTH HAZARD	FLAMMABILITY HAZARD	INSTABILITY HAZARD	RATING SYMBOL	SPECIAL HAZARD
4	Can be lethal	Will vaporize and readily burn at normal temperatures	May explode at normal temperatures and pressures	ALK	Alkaline
3	Can cause serious or permanent injury	Can be ignited under almost all ambient temperatures	May explode at high temperature or shock	ACID	Acidic
2	Can cause temporary incapacitation or residual injury	Must be heated or high temperature to burn	Violent chemical change at high temperatures or pressures	COR	Corrosive
1	Can cause significant irritation	Must be preheated before ignition can occur	Normally stable, but high temperatures make unstable	OX	Oxidizing
0	No hazard	Will not burn	Stable	RA	Radioactive
				W	Reacts violently or explosively with water
				W OX	Reacts violently or explosively with water and oxidizing



Current Configuration

Leachate recovered by the leachate recovery wells at Landfill 3 (LF003) is a mixture of non-aqueous phase liquid (NAPL) and groundwater. This mixture is initially separated in a wet well before the groundwater is decanted and conveyed through a liquid-phase granular activated carbon (LGAC) unit for initial volatile organic compound (VOC) capture. From the LGAC unit, the decanted groundwater is pumped to the extracted groundwater force main that conveys all of the extracted groundwater from the LF003 site to the Robins AFB Groundwater Treatment Plant (GWTP).

Challenge

These separate-phase contaminants can create many operating problems in pipelines and treatment system components downstream, and are thus best removed as far upstream as possible. Separation of LNAPL and DNAPL can be complicated by the presence of emulsions, which are temporarily or permanently stable mixtures of fine “bubbles” of these free-phase contaminants in water.

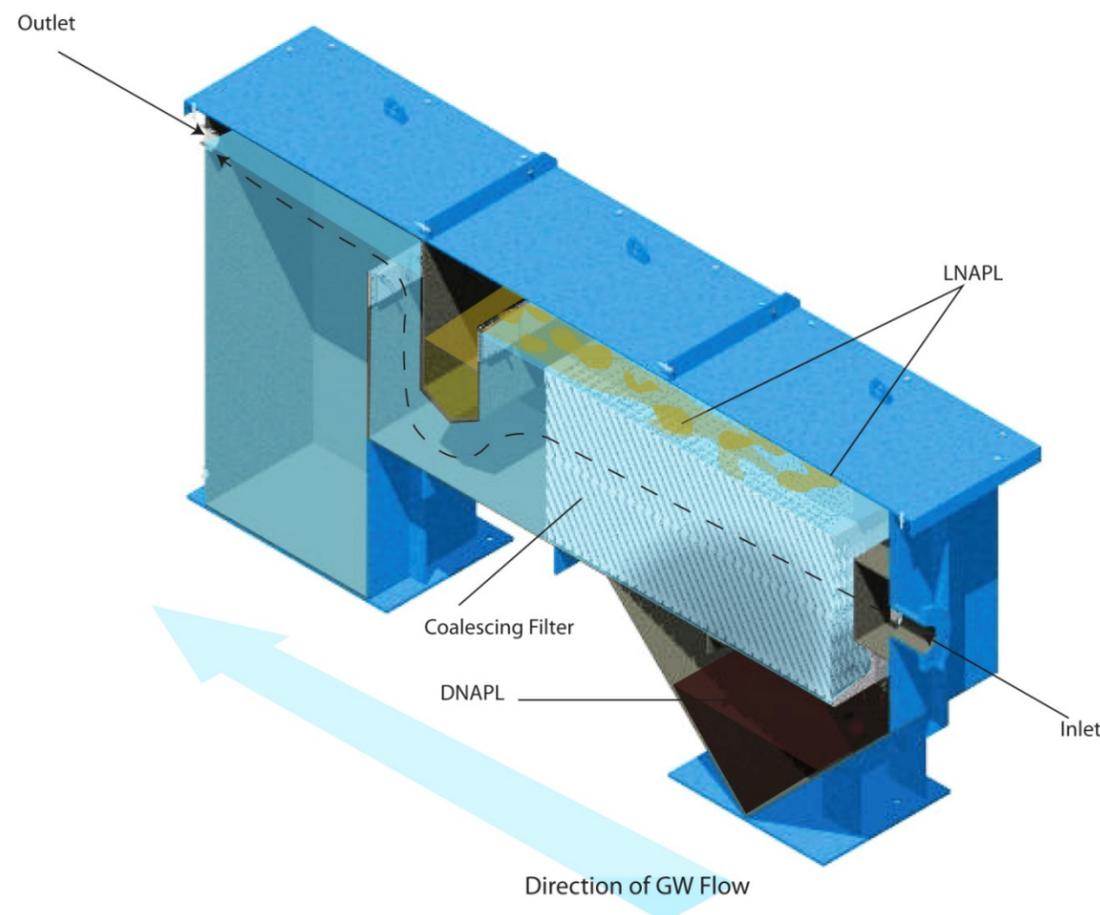


Figure 1. Contaminated Groundwater Flow through an Oil-water Separator



Photograph 1. Contaminated Groundwater Emulsion Before and After Treatment with De-emulsifier

New Configuration

As part of the treatment system upgrade, the existing liquid-phase GAC system used for pre-treatment will be replaced with an oil-water separator system augmented with an emulsion-breaking additive to enhance its effectiveness. LNAPL and DNAPL are periodically removed from the oil-water separator as they accumulate. **Photograph 1** shows before and after treatment using the de-emulsifier. **Figure 1** depicts the groundwater flow through the oil water separator.



Basewide Groundwater Treatment Plant



Site History

During the mid-1990s, the multi-site (basewide) pump and treat (P&T) system was installed as a primary remediation strategy for several restoration sites. The Groundwater Treatment Plant (GWTP) you see here is centrally located east of the Greater Base Industrial Area (GBIA) to support the P&T system by treating the groundwater prior to discharge to the Ocmulgee River.

The GWTP operates under National Pollutant Discharge Elimination System (NPDES) permit number GA0002852. The GWTP is primarily designed to reduce trichloroethene (TCE) concentrations from a maximum of approximately 3,000–4,000 micrograms per liter (µg/L) to below the permit limit of 80.7 µg/L, but operations are also able to remove other volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and inorganic constituents. The location of the GWTP on Base is depicted in Figure 1.

Current GWTP Configuration

Figure 2 shows the current configuration of the Basewide P&T systems. At the GWTP, the groundwater is treated using the process shown on Figure 3. The GWTP has a design capacity of up to 1,200 gallons per minute (gpm). With all of the P&T systems online, the GWTP was treating between 600–800 gpm. Currently, it is treating approximately 300 gpm, which eventually will decrease to approximately 45 gpm as remediation strategies at the contributing restoration sites change.

Challenges

Reduced Flow and Higher Concentrations:

- Under the latest remediation strategy for the Base, all of the P&T remedies, except Landfill Number 3 (LF003), will be replaced by more aggressive treatment technologies.
- LF003 must maintain its leachate collection and groundwater extraction systems for hydraulic control of the source area located within the landfill slurry wall and for hydraulic control of the dissolved plume located outside of the landfill.
- Contaminated groundwater flow into the GWTP will decrease from approximately 600 gpm to approximately 45 gpm.
- Contaminant concentrations from LF003, as compared to other restoration sites, are higher in magnitude. Because only LF003 groundwater will be treated at the GWTP, groundwater from the other restoration sites with lower contaminant concentrations will not dilute higher contaminant concentrations in the LF003 groundwater.

Hazardous Waste Generation:

- The current GWTP configuration includes granular activated carbon (GAC) units, which remove residual hydrogen peroxide and organics after UV-Ox treatment. GAC must be replaced between 1 and 2 times per year. The resulting waste from spent carbon can be characteristically hazardous, which incurs increased handling, transporting, and disposal costs.
- High concentration hydrogen peroxide is also part of the current treatment process.
- Additional safety procedures must be followed by the operations and maintenance personnel for hydrogen peroxide use and GAC replacement.

Goals for the New Treatment System

- Increase operational efficiency
- Increase operational safety

Achieved by:

- Installing a system that closely fits the design criteria
- Installing a system with lower maintenance costs
- Reducing the use of hazardous materials
- Reducing generation of hazardous waste

Ozone Treatment of Groundwater

1. What is Ozone?

Ozone is a gas made up of three oxygen atoms and is identified as O₃. It will be produced on site (no storage or handling) from air and electricity. It is very noticeable by its sweet, pungent odor. Most people are familiar with the scent, as it is the scent noticed in instances such as a lightning strike, walking by a welder, or even turning on a copying machine.

2. How is Ozone Made?

Ozone is made from oxygen (O₂) when charged with a high voltage electrical source. The chemical reaction that occurs to create ozone is shown on Figure 6.

3. How Does Ozone Work?

During the time the gas is in the O₃ state, it is the second most powerful oxidant and the strongest single oxidant available to oxidize contaminants of concern at Robins AFB. The contaminants break down to carbon dioxide (CO₂), water (H₂O), chloride (Cl₂), and less persistent & toxic molecules.

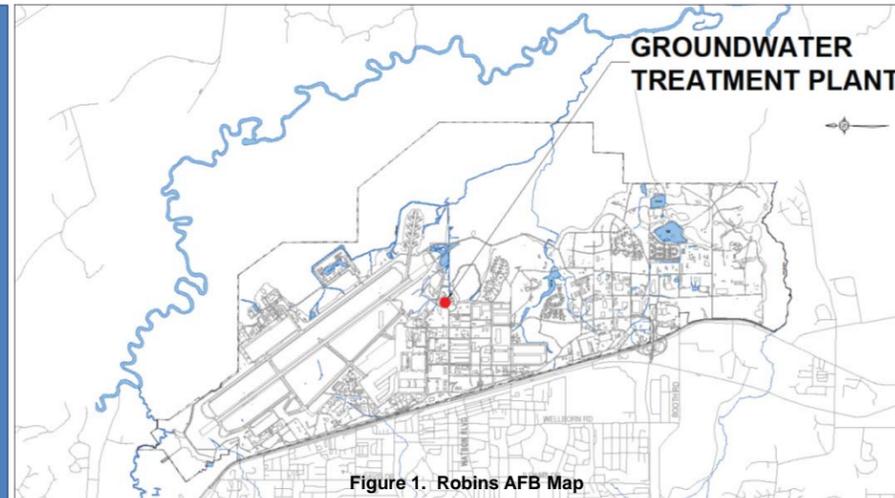


Figure 1. Robins AFB Map

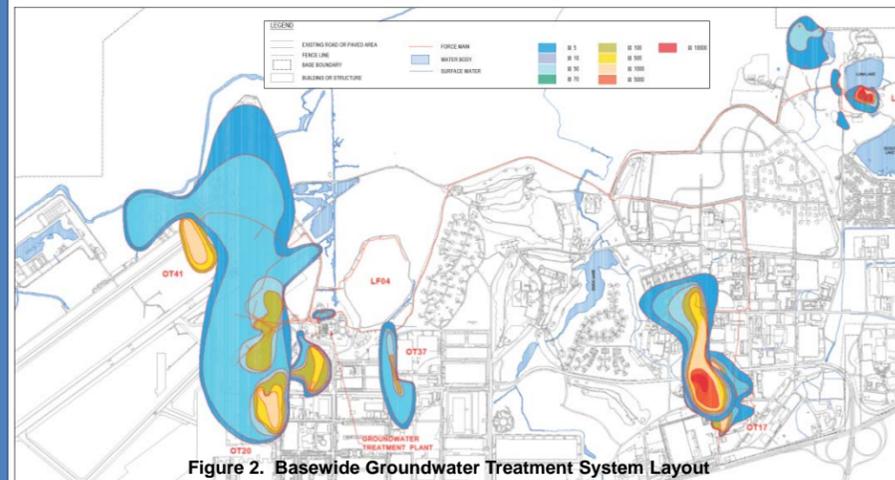


Figure 2. Basewide Groundwater Treatment System Layout

OZONE DEMAND CALCULATIONS					
Contaminant	Molecular Weight	Molar Concentration for Total Flow	Moles Ozone/ Moles Contaminant	Molar Ozone Demand	Ozone Demand (g/L)
Chlorobenzene	112.56	2.66E-05	12.0	3.19E-04	4.73E-02
1,2-DCB	147.01	1.59E-05	13.0	2.06E-04	
1,3-DCB	147.01	1.09E-06	13.0	1.41E-05	
1,4-DCB	147.01	3.90E-06	13.0	5.07E-05	
Trichloroethene	131.39	4.03E-05	6.0	2.42E-04	
cis-1,2-DCE	165.83	5.80E-06	5.0	2.90E-05	
Toluene	92.14	2.98E-06	12.0	3.57E-05	
MEK	72.11	5.16E-06	13.0	6.70E-05	
Xylenes	106.16	1.72E-06	13.0	2.23E-05	
Ozone	48.00			9.86E-04	

Minimum Requirements per Day		
Ozone	25.60	lb/day @ 45 gal/min
Total VOCs	7.11	lb/day @ 45 gal/min
Supply	100	lb/day

Notes:
 lb/day - pounds per day
 gal/min - gallons per minute
 g/L - grams per liter
 VOCs - volatile organic compounds
 DCB - dichlorobenzene
 DCE - dichloroethene
 MEK - methyl ethyl ketone

Table 1. Ozone Demand Calculations

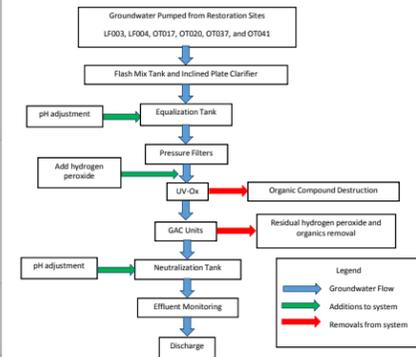


Figure 3. Current GWTP Treatment Process

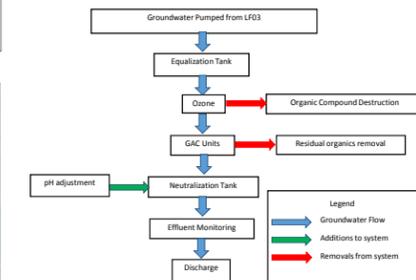


Figure 4. New GWTP Treatment Process

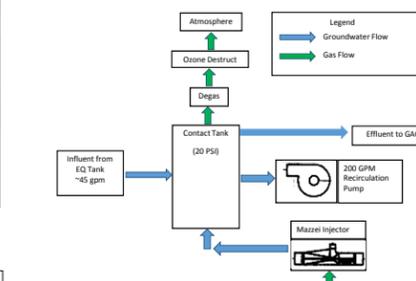


Figure 5. Ozone Process

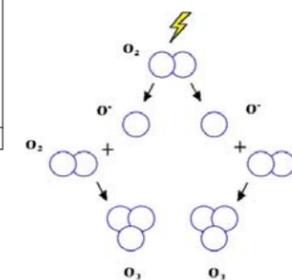


Figure 6. Ozone Formation Chemical Reaction

Description of Ozone System Components

All large wastewater ozone systems have similar major components:

- An air compressor
- An oxygen concentrator
- An ozone generator

Another critical component is the ozone injection methodology. At the GWTP, this will consist of:

- A high pressure recirculation pump
- An eductor to pull the ozone into the side stream recirculation system
- Flash reactors
- Mixing nozzles
- A 316L stainless steel contacting, mixing, and degassing tank

Critical to ensuring success is to provide consistent ozone gas flow, steady pressure in the recirculation system, and set water flow through the system. Due to potentially variable flows at the GWTP, the design includes fluctuating the effluent flow to match the influent flow. This ensures that the side stream injection system will continue to operate exactly as intended.

Figure 4 illustrates the new GWTP treatment process with ozone instead of UV-Ox, and Figure 5 is a brief detail of the ozone treatment process. Calculations to determine the ozone needed for the system are shown in Table 1. Photograph 2 depicts the ozone system.

Why was this Technology Selected?

A pilot study was conducted on site with a 1 gpm flowrate and utilized the worst-case contaminated leachate. An average 67% reduction on contaminants of concern was observed. The pilot study provided enough documentation to utilize statistical analysis to determine potential success. Additionally, the ozone concentration was increased for full scale to 10% concentration by weight, to ensure the most effective destruction of contaminants. Photograph 1 shows the pilot test equipment used.

Ozone was the selected technology because it will minimize storage and use of hazardous chemicals, it will not generate hazardous waste, it effectively reduces contaminant concentrations, and will lower operating costs.

How Do We Know the System is Working?

Effectiveness of ozone technology will be determined by analyzing the effluent to observe the destruction of the contaminants of concern and their daughter products.

For control of the ozone concentrations, an Oxidation Reduction Potential (ORP) dual channel monitor will be added to the system controls to indicate the ORP of the influent (pre-ozone) and effluent (post-ozone). This will serve two purposes:

- To ensure an increase of ozone levels through the treatment system, indicating appropriate injection and solubility of the ozone for contacting contaminants.
- To prevent the ozone concentrations from being too high (most likely due to low contaminant load), the ozone generator will reduce output accordingly.



Photograph 1. Pilot Test Setup



Photograph 2. Ozone System

