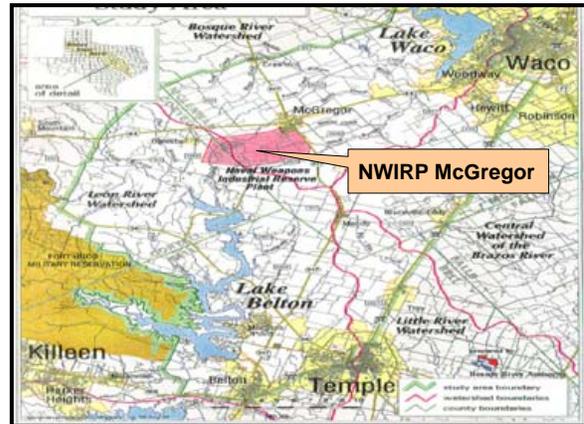


**FY 2006 Secretary of Defense Environmental Award**  
**Category: Environmental Restoration, Installation**  
**Fast-Track Investigation, Restoration, and Redevelopment at**  
**Naval Weapons Industrial Reserve Plant McGregor, Texas**  
Department of the Navy, NAVFAC Southeast



## Introduction

Naval Weapons Industrial Reserve Plant (NWIRP) McGregor was a 9,700-acre government-owned, contractor-operated facility in McGregor, Texas approximately 20 miles southwest of Waco (Figure 1). The U.S. Army Ordnance Corps originally established it in 1942 as the Bluebonnet Ordnance Plant. Over the facility's 50-year history, owners included the U.S. Army, U.S. Air Force, and the U.S. Navy's Naval Air Systems Command (NAVAIR). The NWIRP McGregor mission focused on the research, testing, and manufacturing of solid propellant rocket motors used in missiles such as the Shrike, Sparrow, Phoenix and Sidewinder.



**Figure 1 Facility Location**

At its operation peak, the facility employed nearly 1,400 people, making it the largest employer in the area. Revenues from the facility supported the economies of many local communities including McGregor, Gatesville, Oglesby, and Valley Mills. However, the facility closure adversely impacted the local economy. Congress enacted special legislation that would help turn the property over to the city of McGregor for economic redevelopment.

### Ammonium Perchlorate (AP)

AP is an oxidizing agent that is used in solid-rocket propellant. Because AP is a salt, it dissolves rapidly in water, becomes mobile in groundwater, and persists for many decades under typical ground and surface water conditions. Perchlorate, which disassociates from AP in water, affects the thyroid hormone function by competitively inhibiting iodide anion uptake reducing thyroid hormone production. There is no federal drinking water standard for perchlorate; however, based on a National Academy of Science's review of the toxicological data, a reference dose standard of 0.0007 milligrams per kilogram-body weight of water per day for human consumption was recommended. As a result, the US EPA issued an unenforceable drinking water quality level of 0.024 milligrams per liter (mg/L) as a guidance reference. TCEQ issued a residential groundwater standard of 0.017 mg/L, based on slightly different calculations; however, from 2001 to 2005 the Navy worked with the initial TCEQ groundwater ingestion protection concentration limit (PCL) of 0.004 mg/L.

Prior to the facility closure, a multi-phased Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) was initiated in 1992. The RFI responded to environmental issues raised in the RCRA Facility Assessment completed by the Texas Commission on Environmental Quality (TCEQ). However, a potential setback for economic redevelopment occurred in March 1998 when perchlorate was identified as a contaminant of concern in both soil and groundwater at concentrations up to 91 mg/L. The TCEQ notified the Navy that the US EPA had provided documentation stating that NWIRP McGregor used, stored, and disposed of ammonium perchlorate (AP), which had become an environmental issue throughout the United States. This revelation had the potential of slowing down the goals of cleaning up the site and transferring the property.

Perchlorate had migrated onto offsite properties, potentially impacting the drinking water of over 500,000 citizens of central Texas. The subsequent perchlorate-

focused environmental investigation and remediation was effectively expedited as a result of the cooperation between the Navy, the TCEQ, and US EPA. With effective remedies in place, all 9,700 acres of the facility have been transferred to the City of McGregor for redevelopment. The new tenants, including Dell Computer Corporation, Ferguson Plumbing Company, General Micrographics, In Situ Forms, SpaceX, and McLennan County Electrical Cooperative, have helped to generate 1,000 new jobs for the City of nearly 6,000 residents.

### **Program Summary**

The following major tasks have been completed at NWIRP McGregor:

- The TCEQ and US EPA have approved all environmental investigations, which targeted 15 testing, manufacturing, storage, and disposal Areas throughout the 9,700-acre facility, over 12,000 acres offsite and two major lakes (Belton and Waco), and human health and detailed ecological risk assessments.
- All soil and groundwater remediation systems have been constructed and are operating as designed. Operating Properly and Successfully (OPS) determination was granted by the US EPA in 2006.
- The TCEQ approved the Post Closure Order (PCO).
- The US EPA issued a “Ready for Reuse” determination for the facility in 2006 (Figure 2).
- All 9,700 acres have been transferred to the City of McGregor for economic redevelopment.



*Figure 2 Ready for Reuse Ceremony*

### **Major Accomplishments**

- First Navy and State of Texas PCO; the progressive regulatory strategy resulted in a PCO that replaced the site-wide Groundwater Compliance Plan, scaled the 9,700-acre RCRA permit down to 16.4 acres, and significantly accelerated the City of McGregor’s ability to redevelop and revitalize the facility.
- First Navy non-Base Realignment and Closure (BRAC) OPS determination by the US EPA.
- First Navy facility to receive an US EPA “Ready for Reuse” determination, which acknowledges that environmental conditions at the property are protective of human health and the environment, based on its current and anticipated use for commercial, industrial, and agricultural purposes.
- First full-scale permeable reactive barrier (PRB) (also called biowall) for groundwater remediation of perchlorate and volatile organic compounds (VOCs).
- World’s longest biowall application (nearly three miles).
- Savings of more than \$20 million in remedial construction costs (see Table 1) and expected savings of more than \$1 million annually as a result of the innovative remediation approach, as well as the progressive operation and maintenance (O&M) and project management strategy.
- More than 1,000,000 construction man-hours with no reportable health and safety incidents.
- There were no regulatory violations during the environmental restoration of the facility.
- Reduction in clean-up times by 10 years or more due to the innovative and aggressive remedial approach, which is readily transferable to other Department of Defense (DoD) sites.
- Successful implementation for all accomplishments could only have been achieved through a truly collaborative effort by all stakeholders. Proactive environmental stewardship at the facility, as well as the focus on high-quality economic redevelopment, allowed the Navy to cultivate an unprecedented, trusting and cooperative relationship between the public, regulators and the Navy.

## Fast Track Cleanup and Innovative Technology Implementation

Three technologies have been used to remediate groundwater at NWIRP McGregor: ex situ treatment using a biological fluidized-bed reactor (FBR), in situ treatment using biowalls and bioborings, and natural attenuation. These technologies are described below.

### Ex Situ Groundwater Treatment

As part of interim and full-scale remediation measures in Area M, the Navy constructed more than 5,000 feet of cutoff trenches and surface water holding ponds along the facility's southwest boundary to intercept perchlorate-contaminated groundwater and surface water before it migrated offsite. Subsequently, three 1,000,000 gallon soil cells and one 10,000,000 gallon pond were constructed in the same area to enhance storage capacity, promote groundwater cleanup, and provide a mixing basin to polish treated water as needed (see below). The intercepted groundwater is pumped through a biological FBR that degrades perchlorate to concentrations below laboratory detection limits (<0.00043 mg/L) (Figure 3). Since January 2002, more than 4,500 pounds of perchlorate have been removed from more than 400,000,000 gallons of recovered groundwater. Because of the groundwater collection and treatment system, the plume in Area M has significantly retracted from Lake Belton, which is major drinking water resource for central Texas (Figure 4).



**Figure 3** Area M Biological FBR

**Table 1** NWIRP McGregor Cost-Savings Summary

Implemented Approach	Conventional Alternative	Cost Savings
Negotiated the risk to humans from fish ingestion with state regulators to eliminate the need for remedies along local streams.	Construct an additional 4,000 feet of biowalls along potentially impacted streams.	\$10 million
Implemented innovative in situ technologies to remediate perchlorate.	Use groundwater recovery and ex situ treatment for all impacted Areas.	\$6 million \$1 million (annually)
Installed an automated operating system for the Area M ex situ groundwater treatment system.	Operate manually.	\$200,000 (annually)
Used onsite treatment and existing landfills (prior to capping) to minimize offsite soil disposal.	Transport and remove excavated soil for offsite disposal.	\$1 million
Negotiated with state regulators to avoid the removal of SVOC-impacted soil that was associated with common road paving.	Transport and remove excavated soil for offsite disposal.	\$1 million
Used innovative water management during construction.	Construct onsite water storage basins.	\$1 million
Developed an aggressive and multi-Area construction schedule eliminated multiple subcontractor mobilizations.	Sequential/linear approach with unique subcontractor mobilizations for each remedial action.	\$500,000
Streamlined report and submittal formats.	Multiple review cycles.	\$100,000
<b>Total Cost Savings</b>		<b>&gt;\$20 million</b> <b>\$1.2 million (annually)</b>

### In Situ Groundwater Treatment

Biowalls and bioborings were used as the primary groundwater remediation technology at the site except for Area M, where the ex situ treatment system was installed. These innovative and cost-effective biological PRBs quickly evolved from rudimentary bench-scale studies conducted in 1999 to full-scale status, such that nearly

three miles of biowalls were installed from 2002 to 2005 to remediate onsite and offsite groundwater. During the initial bench scale studies, the Navy determined that:

- Site groundwater contained indigenous bacteria that could degrade perchlorate and VOCs under amended geochemical conditions.
- PRBs could be installed in the shallow contaminated aquifer at a fraction of the cost of a conventional pump and treat system.
- No discharge permits had to be obtained as long as remediation occurred in the ground.
- The PRBs would not impact site operations (i.e., farming and cattle grazing).

As a result, the Navy developed an aggressive PRB remediation construction schedule based on the following key factors and priorities:

- Intercept the groundwater-to-surface water pathway.
- Prevent further groundwater migration to offsite property.
- Remediate offsite contamination on a timetable that would eliminate the need to place institutional controls (deed restrictions) on offsite property owners' groundwater.

More than 13,000 feet of PRBs and 1,300 bioborings were installed by the summer of 2005, creating the world's longest PRB application. As shown in the adjacent photographs, the PRBs were excavated with a hydraulic excavator (shallow trenches) or rock-trencher (deep trenches) and backfilled with a mixture of mushroom compost, pine wood chips, soybean oil, and limestone aggregate. Diffuser pipes were installed on the bottom of each trench to allow for future injections of soybean oil or other carbon substrates as needed. Rows of bioborings, which comprise multiple, closely-spaced 12-inch diameter soil borings backfilled with the PRB media, were installed where PRB construction was difficult.

The trenches were capped with a compacted clay layer to limit seeps and surface infiltration. Reducing conditions were quickly established within the biowalls, leading to perchlorate removal. Monitoring results indicated that the PRBs had reduced perchlorate concentrations from 1 mg/L to below the laboratory detection limit. Figure 4 illustrates the impact that the biowalls have had on the perchlorate plume at Area S.

In August 2006, after four years of passive operation, nearly 22,000 pounds of emulsified edible oil substrate (EOS®) and dilution water were readily injected into 15 onsite and offsite biowall segments in Area S, where the initial full-scale system was installed in 2002. The impact of the supplemental substrate injection on long-term biowall effectiveness will continue to be evaluated with ongoing long-term groundwater monitoring at the site.



**Photo 1** Biowall site preparation



**Photo 2** Biowall trenching



**Photo 3** Biowall media before placement



**Photo 4** Media backfilling

## Natural Attenuation in Groundwater

Perchlorate concentrations throughout the groundwater plumes at NWIRP McGregor continue to decrease via natural attenuation (dilution) at a rate of 5 percent to 7 percent every year, which complements engineered perchlorate remediation. This natural decrease can be attributed to these factors:

- The facility is closed; no additional AP has been delivered to the site since 1998.
- All significant soil sources have been identified and removed.
- Perchlorate is highly mobile and moves with groundwater.
- Due to site geology and hydrogeology, rain easily infiltrates into the shallow aquifer further diluting the perchlorate plumes.

Strategically placed PRBs and natural attenuation proves to be a highly cost-effective approach, saving the Navy millions of dollars while achieving the offsite cleanup goals.

## Ex Situ Soil Treatment

Three multipurpose soil cells were constructed in 2001 to address perchlorate-contaminated soil and source area groundwater in Area M (Figure 5). These soil cells were designed to provide the following functions:

- Soil treatment units using anaerobic landfarming.
- Amendment infiltration basins for source area groundwater treatment.
- Groundwater treatment lagoons for ex situ treatment system polishing.
- Supplemental water storage units during the wet season.

The soil cells enabled anaerobic soil treatment while allowing carbon- and nutrient-rich water to infiltrate into the perchlorate-contaminated aquifer. Subsequent water, soil, and sediment analyses indicate that the soil cells have successfully reduced perchlorate concentrations below laboratory detection limits.

## Partnerships Addressing Regulatory and Environmental Issues

NWIRP McGregor success is directly attributed to the teaming arrangement that developed early in the perchlorate investigation phase. Teaming partners included the Navy, TCEQ, US EPA, and the Navy's subcontractors. With the team united and focused on restoration, property transfer and economic redevelopment, major process roadblocks were either avoided altogether or smoothly managed. The RCRA permit management is an excellent example of the team's cooperation. To completely transfer the remaining 3,700 acres to the City, two critical issues had to be addressed by the teaming partners:

- *How would the remaining noncontiguous land parcels be handled as part of a RCRA permit?*
- *Whose names would be on the permit(s) after the parcels are transferred to the City of McGregor?*

These questions could have been major hurdles for economic redevelopment of the site. However, the Navy and the TCEQ developed an innovative regulatory solution: instead of perpetuating NWIRP McGregor's RCRA permit,

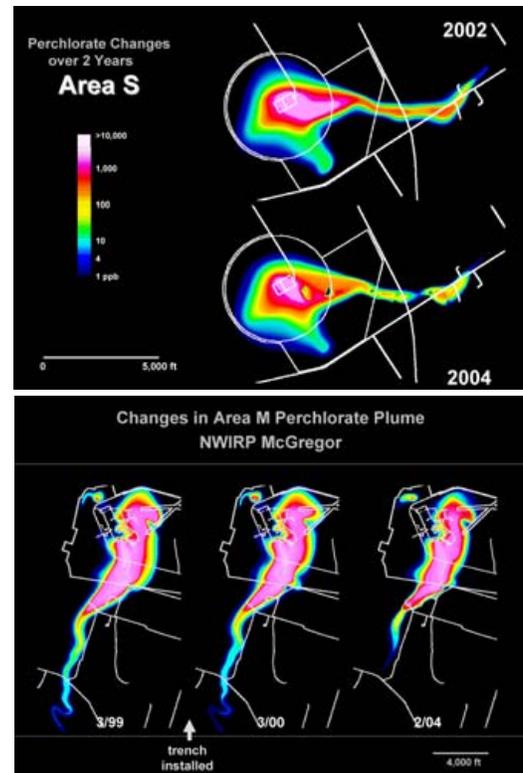


Figure 4 Plume Reduction at Areas M and S



Figure 5 Area M Treatment System

environmental liability and actions would be incorporated into a PCO document that the Navy would maintain. This progressive decision eliminated the need for a facility-wide RCRA permit and the associated regulatory burdens that likely would have hindered business development efforts. The PCO was signed and approved by TCEQ in September 2006. Although this PCO was the fourth presented to the TCEQ, it was the first to be approved.

Besides this partnering relationship, community leaders and local, state, and federal officials have been updated on the project through quarterly restoration advisory board (RAB) meetings. The community actively participated and utilized the RAB meetings to access the Navy and regulatory agencies to ask questions and voice their concerns. Throughout the project, the team responded to community concerns through regular public meetings to present the steps being taken to address both onsite and offsite contaminant migration.

### **Reducing Risk to Human Health and the Environment**

In addition to mitigating risks to human health and the environment from perchlorate in surface soil, surface water, and groundwater by implementing remedial actions or through negotiations with the regulators, several other contaminants of concern were addressed as part of the NWIRP McGregor Restoration Program:

- Areas D, F, and M chlorinated VOC-impacted soil was excavated and removed for offsite disposal.
- Areas F, M, and S surface soil with metals concentrations above ecological risk criteria was excavated and consolidated under the Area M landfill cap.
- Area S surface soil with metals, VOC, and energetics concentrations above ecological risk criteria was excavated and consolidated under the Area S landfill cap.

### **Opportunities for Small and Disadvantaged Businesses**

As summarized below, over \$20 million in contracts were issued to specialized Small and Disadvantaged Businesses:

- All of the biowalls were constructed by Small Disadvantaged Native American Owned firms.
- The Navy's progressive Environmental Multiple Award Contract (EMAC) program was used to access small disadvantaged businesses for the design and construction of the 22-acre Area D and the 12-acre Area M caps.
- The Area E 8-acre landfill cap was constructed by a Service Disabled Veteran Owned firm.
- Area S RCRA 11-acre landfill cap was constructed by a Small Disadvantaged Native American Owned firm.
- Over \$1 million in contracts were issued to local craft and local service firms.

### **Key Community-Related Achievements**

Due to the uniqueness of the project, the team (especially the Navy) had to have flexible and adaptable remediation design and implementation plans. As part of this effort, the Navy met with local landowners whose properties were impacted by contaminated groundwater to discuss the type, design, and locations of remedial systems that would be installed on their properties. The Navy made every effort to consider and address offsite property owner concerns. This fostered a trusting relationship between the Navy and the local stakeholders. Furthermore, through team's partnering efforts with the City of McGregor, the team was able to respond quickly to the city's property requests to allow property to be transferred in anticipation of new tenants.

The team also created an avenue for educating and disseminating perchlorate information to the community and stakeholders on both the local and national levels. Congressional and senatorial staffers were routinely updated on NWIRP McGregor's progress in Washington, D.C. and McGregor, Texas.

Finally, the Navy worked closely with the Army Corps of Engineers (ACOE) in their two-year environmental study which focused on the water quality of the Brazos and Leon river basins - and the ACOE study results supported the Navy's findings that the people were indeed safe from perchlorate contamination.