

**RFI TO CMS:  
AN APPROACH TO REGULATORY  
ACCEPTANCE OF SITE REMEDIATION TECHNOLOGIES**

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Lockheed Martin made a smooth transition from RCRA Facility Investigation (RFI) at the National Aeronautics and Space Administrations' (NASA) Michoud Assembly Facility (MAF) to its Corrective Measures Study (CMS) phase within the RCRA Corrective Action Process. We located trichloroethylene (TCE) contamination that resulted from the manufacture of the Apollo Program Saturn V rocket and the Space Shuttle External Tank, began the cleanup, and identified appropriate technologies for final remedies. This was accomplished by establishing a close working relationship with the state environmental regulatory agency through each step of the process, and resulted in receiving approvals for each of those steps. The agency has designated Lockheed Martin's management of the TCE-contamination at the MAF site as a model for other manufacturing sites in a similar situation.

In February 1984, the Louisiana Department of Environmental Quality (LDEQ) issued a compliance order to begin the clean up of groundwater contaminated with TCE. In April 1984 Lockheed Martin began operating a groundwater recovery well to capture the TCE plume. The well not only removes contaminants, but also sustains an inward groundwater hydraulic gradient so that the potential offsite migration of the TCE plume is greatly diminished. This effort was successful, and for the agency to give orders and for a regulated industry to follow them is standard procedure, but this is a passive approach to solving environmental problems. The goal of the company thereafter was to take a leadership, proactive role and guide the MAF contamination clean up to its best conclusion at minimum time and lowest cost to NASA. To accomplish this goal, we have established a positive working relationship with LDEQ, involving them interactively in the implementation of advanced remedial activities at MAF as outlined in the following paragraphs.

The RFI phase began in 1988, two years after the US EPA and LDEQ performed the RCRA Facility Assessment (RFA), when we performed the preliminary soil and groundwater chemical contamination investigation of the MAF site. In 1993, this investigation progressed with a 20-acre geophysical survey of our construction debris landfill that sought the location and depth of buried waste containers. LDEQ participated in the survey, using it as a training exercise. They learned the procedures, observed the operation of the equipment, and learned how to analyze and interpret the data. This streamlined the investigation report review and approval process because the LDEQ was present, they saw what we did, they understood it, and concerns they might have had were already addressed in the field. That they received training they would not have received otherwise, without expense to the agency, fostered a spirit of cooperation that benefited our working relationship.

This experience caused us to recognize that we had an important role in educating regulatory personnel in subjects that are industry- and/or site-specific. In 1995, we held a

seminar at the MAF site for LDEQ personnel assigned to our site which covered TCE-clean up technologies that had potential application for the contamination at MAF. This interchange helped to build between LDEQ and Lockheed Martin a common understanding of the technical challenges facing the MAF site. It allowed LDEQ an opportunity to share in the process of deciding on appropriate technologies, thereby minimizing adversarial relationships and creating an atmosphere of consensus.

In 1997, the MAF site became the focus of a major US EPA regulatory modification for RCRA hazardous waste units. The MAF site had a chemical waste holding pond that received all waste chemicals generated over thirty-four years, during the Apollo and Space Shuttle programs. These wastes included TCE, chromic acid, and alkaline cleaning solutions. The pond was regulated under RCRA as a permitted-regulatory unit and adjacent below ground pipelines and sumps were regulated under the 1984 Hazardous and Solid Waste Amendments (HSWA) to RCRA. As a RCRA unit, the pond was required to be cleaned up to "pristine" conditions whereas the other HSWA units could be cleaned up to a lower, "risk-based" standard, which allowed higher contaminant levels to be left in the ground. The LDEQ wanted Lockheed Martin to clean up the pond first, but Lockheed Martin had reservations about expending the effort and funds to clean up the pond to a higher standard than the surrounding area, when the contaminants still present could re-contaminate the pond. We therefore proposed to the LDEQ that the standard for the pond should match the standard for the surrounding area. At that time, LDEQ was beginning to formulate regulations regarding this type of situation. They communicated our proposal to US EPA. The US EPA issued regulations, shortly thereafter, allowing the lower standard for the risk-based closure of RCRA units, such as the MAF chemical waste pond. In late 1997, we began the closure of the pond, destroying over 30 tons of TCE-related waste. Lockheed Martin's participation in formulating regulatory policy, relieved industry from meeting arbitrary standards and relieved the LDEQ from having to enforce those arbitrary standards.

LDEQ began recognizing our leadership role in addressing site remediation issues. In the fall of 1998, LDEQ invited Lockheed Martin to provide a graphical display at an LDEQ-sponsored seminar concerning our below ground, highly active natural biological TCE degradation process. This was followed by another LDEQ invitation to speak at their spring 1999 annual environmental conference on the three remediation technologies to be pilot tested later that year. In November 2000, LDEQ again participated in an in-house remediation technology seminar at MAF, with invited speakers with extensive experience at contaminated sites such as ours. During this period, LDEQ suffered budget cuts and lost staff. Had we not taken an early, active role in directing our own clean up, the diminished LDEQ might have delayed our program. Also, our initiative allowed the LDEQ to direct its limited resources to sites that needed more guidance.

The CMS phase began in 1998. Three remediation technologies were selected to reduce the risk posed by the underground TCE plume. These technologies were soil hydrofracturing, natural attenuation through bioremediation, and permeable reactive barriers. Pilot tests were conducted from July 1999 through January 2000. The soil hydrofracturing pilot test demonstrated that significant quantities of sand could be injected into low-permeability, clayey and silty soils at a depth of 9 feet to 35 feet, improve the flow of groundwater through those soils, and capture TCE contamination.

The natural attenuation through bioremediation pilot test demonstrated that TCE degradation by indigenous bacteria could be enhanced by providing ethanol as a food source to promote bacterial growth. An additional test demonstrated that in situ chemical oxidation did not adversely affect the anaerobic dechlorinating bacteria or their ability to degrade TCE. The permeable reactive barrier pilot test demonstrated that zero valent iron could significantly reduce concentrations of TCE and its degradation products, and that a permeable barrier around a below-sea level storm drain manhole could lower the water table and limit the infiltration of TCE-contaminated groundwater into the MAF surface water. LDEQ officials visited the site several times to learn about the technologies and observe the test procedures. These site visits helped to sustain the spirit of collaboration, relieved Lockheed Martin of having to explain everything after the fact, and prevented misunderstandings that might have caused delays in program implementation.

The next iteration of pilot tests to be conducted later this year, will involve the advancement of the use of these technologies for full-scale implementation. The soil hydrofracturing test will be performed in areas more representative of where the technique is needed, including beneath manufacturing areas and along underground conduits such as storm drains and abandoned chemical sewers. Field-implementation of the natural attenuation through bioremediation test will involve the sequential oxidation of TCE followed by bacterial enhancement with ethanol. The permeable reactive barrier will be enhanced with the addition of shallow trenches to the same depth as the original barrier, constructed adjacent to but below a storm drain system that receives an ongoing flow of infiltrating TCE-contaminated groundwater. The LDEQ has tentatively approved these plans that were communicated to them through periodic reports, based on discussions with Lockheed Martin.

In summary, Lockheed Martin's transition from RFI to CMS was facilitated by our positive interaction with LDEQ. Based on the experience described above, we offer the following recommendations to accelerate site remediation project schedules and avoid adverse regulatory actions: (1) Have frequent face-to-face discussions with regulatory agencies about your site; (2) involve regulators in all phases of site remediation projects; (3) provide information and training to regulatory staff concerning industry-specific or site-specific conditions that would allow LDEQ to better understand constraints on the development of technology pilot tests and site remediation final remedies; (4) allow regulators to have frequent input into site remediation technical planning; and (5) initiate regulatory policy and changes in policy when appropriate. Lessons from Lockheed Martin's experience benefit both industry and regulators in achieving environmental goals.