Guardian

America's First Choice for Environmental Restoration

A Publication of the Environmental Restoration Program | Travis Air Force Base, California | October 2010

Award-Winning

Inside

Acronyms

AFCEE: *The Air Force Center for Engineering and the Environment provides Air Force leaders with the expertise and professional services needed to protect, preserve, restore, develop and sustain the nation's environmental and installation resources.*

(Photo by Glenn Anderson)

Bioreactor, the Next Generation: A truck pours a mixture of mulch and gravel into an excavation void near the flight line as part of the construction of a second bioreactor on Travis AFB. Microbes in the mixture promote the breakdown of solvent contaminants into harmless compounds.

Bioreactor Version 2.0

New Treatment System Takes on Toughest Solvent Site

By Glenn Anderson
Travis Environmental Project Manager

Of the 23 contaminated groundwater sites on Travis AFB, the largest and most challenging one is known as the Oil Spill Area, or SS016. It is a large solvent plume that originates near a building that was once used for the cleaning of metal parts, and most of it lies beneath a large portion of the aircraft parking ramp.

To clean up contaminated groundwater, it is usually best to start with the source of contamination. At SS016, the source area is in fractured bedrock and tight clay soil, which is why a thermal oxidation unit was initially selected by Travis and environmental regulatory representatives to start the cleanup process. Thermal oxidation (Therm-Ox) burns up contaminated vapor with natural gas, and a Therm-Ox unit uses a vacuum to draw the solvents out of the soil.

Although the SS016 Therm-Ox unit was successful in getting rid of contaminants, it did not seem to achieve any measureable amount of cleanup. Contaminant concentrations in the groundwater were still very high, and the unit was burning up a lot of natural gas and generating a lot

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Visit our Environmental Restoration Program web site at ***http://www.travis.af.mil/enviro***

Guardian
Travis Air Force Base, California

Staff

Chief, Asset Management Flight
Dave Musselwhite
Restoration Program Manager
Mark H. Smith
60th AMW Public Affairs
Merrie Schilter-Lowe

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Merrie Schilter-Lowe
60th AMW Public Affairs
400 Brennan Circle
Travis AFB, CA 94535
(707) 424-2011
merrie.schilterlowe@us.af.mil

Questions and comments about the environmental web site may be sent to:

enviropa@travis.af.mil

Pencil Us In.....

VIEWPOINT

Mark H. Smith
Travis AFB Remedial Program Manager

…for an opportunity to learn about and comment on our groundwater cleanup.

These days, it is so easy to make hotel or airline reservations. It only takes is a credit card to put a seat or room in your name, often up to a year in advance. If you have access to the Internet, this can be done without even talking to a human being.

Of course, if your plans change, it is usually easy to cancel or reschedule reservations at a minimal or no cost to you. In this age of high-speed Internet connectivity and web-based services, we have come to expect this level of convenience.

So, when planning your 2011 event calendar, we have a date for you: the evening of Thursday, 20 October 2011. This is the date for the upcoming Travis AFB Groundwater Proposed Plan public meeting. It is scheduled to take place at the Northern Solano County Association of Realtors office in Fairfield, just off of Highway 80.

Why attend a public meeting on groundwater cleanup plans? There are several reasons, starting with learning about the groundwater cleanup that has challenged Travis for over a decade. Long-time readers of the Guardian know that Travis AFB has been using interim solutions since the late 90's to clean up and stop the spread of contaminated groundwater. The time will soon be here to select the final solutions that will complete the cleanups. Knowledge of the details is the first step toward an evaluation of potential solutions.

Second, you learn about the Air Force's proposed remedies for these environmental challenges. Base officials will explain the rationale behind these preferences and describe other options that were also considered.

Third, and most important, you will have an opportunity to comment on the proposed remedies. The Travis AFB Environmental Restoration Program can only be successful when local communities are behind its efforts, and we need feedback from interested community members like you.

Your comments and the responses to them will be recorded in a portion of the upcoming Groundwater Record of Decision, known as (what else, but) the Responsiveness Summary. You can find the Responsiveness Summaries from the four previous Travis AFB decision documents in the library section of the Travis AFB Environmental Restoration Program (ERP) web site. We value your comments and will respond to them promptly and professionally.

Finally, you will have the opportunity to meet the members of the Travis Restoration Advisory Board (RAB). RAB members live in your neighborhood, are interested in environmental programs on Travis, and volunteer their time to review ERP progress and offer the community's point of view on restoration issues. Over its 15-year history, the contributions of the RAB have been invaluable to the success of the Travis ERP, and you will get to see the RAB in action. There is still plenty to do and lots of opportunity for public involvement, so if you are interested in becoming a Travis RAB member, this is a great way to see and hear what goes on in a public forum.

We know a lot can happen between now and October 2011, so we will let you know if this public meeting date changes. Also, if your plans change

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Bioreactor

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of greenhouse gases.

"It was like digging an underground swimming pool with a soup spoon," said Mr. Mark Smith, Travis Remedial Program Manager. "The Therm-Ox unit was barely making a dent in the solvent cleanup, and the amount of natural gas that it burned seemed wasteful. To complicate matters, our field team discovered the source of the solvent contamination, just north of the Therm-Ox unit's location. To be successful, we need to clean up the source area first. So, we needed a more effective cleanup strategy."

This is where the Bioreactor enters the picture. The January 2009 edition of the Guardian described the construction of the first Travis bioreactor and the way that it works. In summary, it creates the groundwater conditions that allow microbes to break down solvents into harmless compounds. It looks like an underground percolator with a mulch/gravel mixture instead of coffee grounds. Microbes attach themselves to the gravel particles and live off the carbon in the mulch.

The first Travis bioreactor was tested at the base battery and electric shop (site DP039) where solvents were used to clean electrical parts. After almost two years of technology evaluation, the short-term effectiveness of the bioreactor concept appears promising in dealing with solvent source areas in clay soil. So, although new and unproven as a long-term solution, it seemed ideal for the treatment of the SS016 source area as well.

Lay the Pipe Down: Environmental construction specialists place one of two water distribution manifolds across the top of the bioreactor. Solvent-contaminated groundwater will flow out of the manifolds and into the mulch-gravel mixture. (Photo by Glenn Anderson)

Each Travis bioreactor runs entirely on solar-generated electricity. Solar panels power an extraction pump that recirculates nutrient-rich treated water around the contaminated area. Groundwater recirculation increases the effective range of the treatment zone. Since they are not connected to the base electrical system, they do not create greenhouse gases from either electricity generation or natural gas burning.

Another advantage of the bioreactor is that a lot of solvents are removed from the subsurface during the excavation, speeding up the cleanup process. Although any excavation project can be expensive and generate a lot of waste that must be sent to a landfill for disposal, it is still relatively cheap compared to the long-term cost of running an extraction system for years to remove the same amount of solvents.

Of course, there is always room for improvement, and this next generation of bioreactors is no exception. The SS016 bioreactor uses an improved design and better materials to increase its effective range and solvent cleanup efficiency over the DP039 bioreactor.

First, the excavation depth for the SS016 is 25 feet, compared to 20 feet for the DP039 bioreactor. This means that more solvent contamination that was bound to soil particles could be removed from the excavation. Also, this increased the bioreactor's underground volume where most of the microbial activity takes place. A greater volume increases the bioreactor's efficiency so it can process more contaminated water each day.

Second, to take advantage of its increased size, the SS016 bioreactor has been connected to a nearby 300-foot horizontal well that runs underneath the adjacent aircraft parking ramp. The horizontal well extracts contaminated water from a much larger area, so the recirculation area at SS016 is much larger than that at DP039.

"The horizontal well connection is very important to this cleanup strategy, because we cannot build treatment systems around aircraft parking," remarked Mr. Smith. "We always have to keep the base mission in mind when selecting and carrying out cleanup actions, and this well offers the best way to clean up groundwater that lies under feet of concrete in a high security area."

Finally, the mulch used in the SS016 bioreactor is more mature and of much greater quality than that in the DP039 bioreactor. Mature mulch can create

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a lot more dissolved organic carbon, which provides the building blocks for microbial growth.

Similar to the DP039 bioreactor, the bottom of the SS016 bioreactor is lined with a layer of iron pyrite, which promotes the chemical treatment of solvents and their intermediate breakdown products. This ensures a complete conversion of solvents into harmless compounds. Also, an emulsified type of vegetable oil was sprayed into the mulch during the SS016 bioreactor construction to kick-start the biological activity.

Microbes that live off of solvents perform well in an oxygen-poor environment, and a layer of clay soil on top of the mulch prevents air from leaking into the bioreactor's treatment zone. An asphalt cap covers the bioreactor, and removable posts prevent vehicles from driving over and damaging it.

If the SS016 bioreactor proves to be as successful as its DP039 precursor, it has the potential to cut decades off of the site's original estimated cleanup time, and save a lot of energy in the process. "Most base personnel will not be aware what the bioreactor is doing or what is quietly happening beneath their feet," stated Mr. Smith.

Viewpoint

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and you cannot attend the meeting, there are other ways to submit comments on these proposals, which will be described in the Proposed Plan available on the Travis ERP web site a year from now.

We know you have a lot to do, so we want to make the process for commenting on the Travis cleanup program to be as easy and painless as making a hotel reservation. So, please, pencil us in.

The Anatomy of a Bioreactor

In the January 2009 edition of the Guardian, we described how a bioreactor works. But as you will see, the construction details of this groundwater cleanup technology make the difference between a successful cleanup and failure.

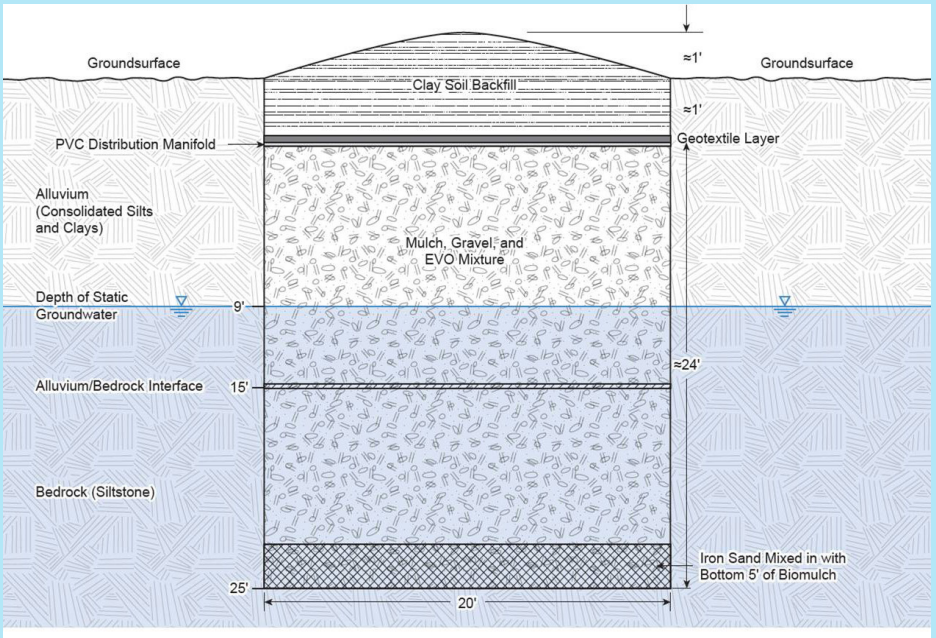
As stated before, most of the bioreactor consists of mulch, gravel and emulsified vegetable oil (EVO). These are the materials that create an oxygen-poor environment and allow a population of microbes to develop and thrive by removing chlorine ions from solvent molecules. The EVO is an easily-digested carbon source that gets the biological processes started, and the mulch provides a long-term source of carbon to keep the processes going. Both organic materials provide the building blocks for microbe reproduction.

To keep the gravel/mulch mixture in continuous contact with contaminated groundwater, a solar-powered pump brings the water into the bioreactor through two PVC distribution manifolds. Small holes in the manifolds ensure an even distribution of water under low pressure. A geotextile layer covers the manifolds to keep the holes from getting plugged up.

At the top of the bioreactor, a layer of clay soil covers the geotextile material and keeps oxygen-rich air from entering the reactive material. This also keeps the population of "solvent-eating" microbes active. The clay is shaped so that rain water drains away from the bioreactor, and only contaminated groundwater enters the mulch.

At the bottom of the bioreactor, a layer of an iron sand and mulch mixture creates a small chemical treatment zone that can break down any residual solvents or byproducts of the biological process. This allows solvent-free water that contains a small amount of dissolved organic carbon (DOC) to flow out of the bioreactor and into the local soil. The DOC promotes solvent breakdown outside of the bioreactor.

Not shown in the diagram is a ring of nine removable aluminum bollards that protect the bioreactor from vehicle traffic. Also, an astroturf-like cover over the clay backfill prevents erosion from wind and rain. It also presents a clean and organized appearance that is suitable for an active airfield.



Oil That's Good for the Environment

By Glenn Anderson
Travis Environmental Project Manager

Just about everyone who reads a newspaper or watches television is at least familiar with the drama that took place in the Gulf of Mexico this year. A ruptured well from a drilling rig explosion released an unknown (but undoubtedly huge) volume of crude oil into the waters of the Gulf, adversely impacting both the habitat of a large number of plant and animal species and the regional economy.

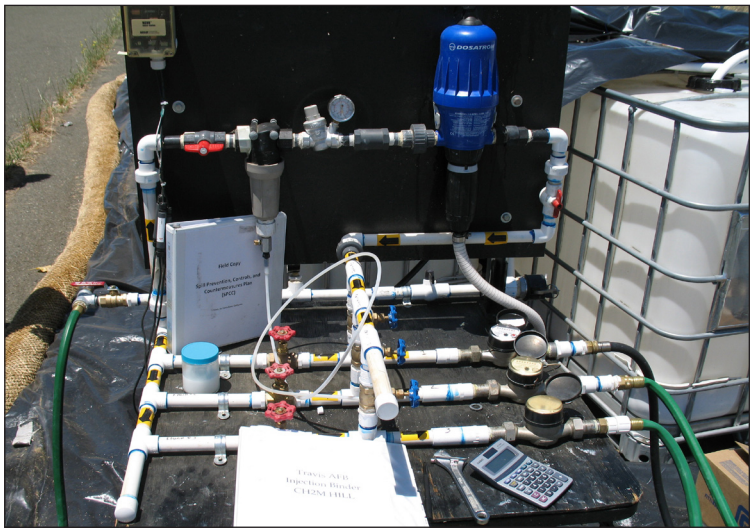
With images of gushing oil and thoughts of environmental disaster in mind, it is hard to imagine that anyone would actually choose to inject oil INTO the environment. However, that is exactly what is being tested at several solvent-contaminated groundwater sites on Travis AFB. And the early results look promising.

Of course, the oil that is used in these cleanup tests is not the thick, black, heavy crude that is processed and ends up in our gas tanks. Rather, it is similar to the light vegetable oil that ends up on our salads.

So, how does this oil injection strategy work? It starts with an understanding of the molecular chemistry of contamination. A typical solvent is a chlorinated hydrocarbon, which means that chlorine ions are attached to strings of carbon atoms. To 'decontaminate' the solvent, the chlorine ions have to be stripped one at a time from the carbon molecule. The scientific term for this process is reductive dechlorination. Fortunately, there are naturally-occurring microscopic organisms in the soil that obtain energy (and thus survive) by removing these chlorine ions. Once all of the chlorine ions have been removed and replaced with hydrogen ions, the remaining carbon molecule is harmless.

Unfortunately, these soil microbes are anaerobic and are not active when there is a lot of oxygen in the groundwater. To create an oxygen-poor environment for them, vegetable oil is injected into the soil beneath the water table. A second group of aerobic microbes use the oil as a food source; similar to humans, they also need oxygen to 'digest' the oil. When most of the oxygen is used up, the aerobic microbes become inactive and the anaerobic microbes can begin to work on the solvents.

One challenge with this strategy is the achievement of an even distribution of oil throughout the solvent-contaminated area. If the oil fills up the spaces between soil particles, it can block the movement of additional oil through the soil. So, the vegetable oil is first emulsified before it is injected. An emulsion is a suspension of one liquid (such as oil) in a second liquid (such as water) with which the first one will not mix. The emulsified vegetable oil (EVO) flows around the soil particles and spreads evenly around the injection point.



Control of the flow of the EVO - water mixture into the subsurface is critical to the success of this type of groundwater remediation, and this valve station is able to monitor and control the injection process in multiple wells. (Photo by Glenn Anderson)

A series of injection wells were installed in a field as part of a biobarrier demonstration project. The project consisted of the injection of about 25,000 pounds of EVO across a solvent plume at Site DP039. The EVO formed a reactive zone that treats dissolved solvents. (Photo by Lonnie Duke)

Travis AFB is testing two versions of the EVO injection strategy. In one version, the oil is injected into an area with the highest solvent concentrations. The idea is to knock out the high concentrations and make it easier to clean up the remaining solvents. This approach works well at sites where a lot of groundwater cleanup has already taken place by more conventional means, such as groundwater extraction and treatment. Three test sites (SS015, SD036, and SD037) have been selected to evaluate this version.

Site SS015 is known as the Solvent Spill Area which covers about 1.4 acres near the aircraft parking ramp.

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Former facilities in this area were used for stripping paint from aircraft parts. Site SD036 consists of Buildings 872, 873, and 876 as well as several paved areas in an active industrial portion of the base. Site SD037 encompasses a number of industrial buildings in the western part of the base as well as an aircraft parking ramp. The buildings contain an oil/water separator, sumps, wash-racks, and a jet fuel hydrant system.

The SD037 test took place over a period of three weeks in August with the injection of about 37,000 pounds of EVO into a cluster of wells. To ensure an even distribution of EVO throughout the subsurface, several thousand gallons of clean water were pumped into the injection wells after the EVO injection was finished.

Another oil injection strategy involves the construction of a line of injection wells across a solvent plume, creating an underground groundwater treatment zone, known as a biobarrier. Dissolved solvents that enter the zone through natural groundwater flow are consumed by anaerobic microbes that live in the zone. Clean water exits the treatment zone. The biobarrier approach is being tested with the solvent plume at Site DP039, where 25,000 pounds of vegetable oil was injected last August.

One significant advantage of oil injection over traditional groundwater cleanup methods is that the treatment takes place in the subsurface (in place) wherever the contaminants are located, so heavily-engineered piping and above-ground treatment systems are not needed. This saves on operation and maintenance as well as energy costs.

Another advantage is that it is a lot easier to inject oil into tight clay soil compared to the extraction of contaminants from that soil. Therefore, oil injection can treat contaminants in most soil types, compared to groundwater extraction systems that are most effective in soil through which groundwater can easily flow, such as sand and gravel.

A final advantage is that groundwater treatment through oil injection can take place in high traffic or security areas where a lot of piping and treatment equipment would not be welcome, such as aircraft runways or parking ramps. As a result, groundwater treatment does not interfere with base operations.

However, once the oil injection is complete, this strategy requires a robust monitoring program. "One concern with this type of groundwater treatment is that it can stall if the microbes use up all of the oil," said Mr. Mark Smith, Travis Remedial Program Manager. "If that happens, we end up with a lot of chlorinated breakdown chemicals that can be worse healthwise than the original solvents. To keep this from happening, we simply add more oil."

Travis AFB first tested the injection of pure vegetable oil that was not emulsified in 2000 at Site SS015, and it resulted in the destruction of a fair amount of solvents. Unfortunately, a military construction project forced the test to conclude early. Also, injection methods were not as advanced as they are today, so not a lot of oil was pumped into the contaminated groundwater. When the injected oil was used up, the process stalled and breakdown chemicals remained in the groundwater. A new injection plan is currently being developed that will demonstrate that a follow-on application of emulsified vegetable oil can restart a stalled groundwater cleanup remedy.

A team of environmental contractors track the injection of EVO into several wells, creating a biobarrier. The EVO is delivered to a site in 270-gallon totes. The upgradient phytostabilization study area can be seen in the background. (Photo by Lonnie Duke)

This strategy also requires a lot of time. It takes a while to establish the environmental conditions that promote the biological cleanup of solvents and even longer to reach established cleanup goals. However, because the oil can reach contaminants in tight clay layers more effectively than most groundwater extraction methods, it may actually speed up the long-term cleanup of the more challenging solvent sites.

"Probably the best reason to test the vegetable oil strategy at multiple sites is that it fits well with our overall Green and Sustainable Remediation approach to cleanup," remarked Mr. Smith. "Highly engineered groundwater processing systems may look impressive and work well at the start of a site cleanup, but Mother Nature offers clean and quiet solutions that can help us to achieve cleanup levels and close sites."

Field Notes from Summer 2010

By Lonnie Duke
Travis Environmental Project Manager

Traditionally, the annual construction season begins in the spring as soon as the soil dries out from the winter rains, continues through the heat of the summer, and ends in a fever pitch as everyone tries to complete their projects before the start of the next wet season.

It has been another very busy construction season for the Travis AFB Restoration program, and we're not finished yet! The following bullets summarize the restoration field events that took place this year.

- Injected 25,000 lbs of emulsified vegetable oil (EVO) to form a bio-barrier at site DP039 (see page 5)
- Injected 37,000 lbs of EVO to treat a high contaminant concentration area at site SD037 (see page 5)
- Completed additional site characterization in preparation for EVO injections at site SD036 and SS015 (see page 5)
- Completed further site characterization, installed monitoring wells and constructed our second solar powered bio-reactor at site SS016 (see page 1)
- Collected sufficient data to support a soil cleanup action at site FT005
- Restarted the North Groundwater Treatment Plant using activated carbon vessels for treatment. Solar panels provide a sufficient amount of electricity to extract the groundwater and push the water through the carbon for treatment.
- Converted the South Base Boundary Groundwater treatment plant to carbon-only treatment which allowed us to turn off the energy intensive air stripper treatment system. Contamination concentrations have dropped to the point where the air stripper is no longer necessary.
- Installed a sturdy barb-wire chain link fence around the entire Corrective Action Management Unit (CAMU) at LF007. Posted signs to ensure that visitors are aware of the CAMU's function and land use restrictions.
- And, landscaped the phytostabilization area at site DP039 to protect the eucalyptus trees from potential fire damage. The July 2009 Guardian describes in detail the potential use of trees to clean up solvent-contaminated groundwater.

As I mentioned, there is still a lot to do before the ground gets too wet to carry out field work. We will soon inject EVO at site SD036 and SS015, as described on page 5. We have another large groundwater sampling event coming up, as part of our Groundwater Sampling and Analysis Program. This involves nearly two months of taking water level measurements and analyzing groundwater samples to demonstrate how our cleanup efforts are progressing. And finally, we are scheduled to start next month the construction of a small groundwater treatment system to remove a plume of Methyl Tertiary Butyl Ether (MTBE) that is migrating to the south of the gas stations on Travis Avenue. I hope to describe this project in the January 2011 newsletter.

Like I said, it's been another busy construction season.

A fencing contractor uses a Bobcat augur tool to drill a series of post holes around the Travis AFB CAMU. Fence posts were placed loosely in the holes and were later encased in concrete. (Photo by Lonnie Duke)

Two custom-built gates are installed at both ends of the Travis AFB CAMU, and the top of the fence is lined with three-strand barbed wire. This allows authorized personnel to enter the CAMU but restricts access to others. (Photo by Lonnie Duke)

Meeting Agenda

6:30 - 7:00 p.m. Open Forum:

The open forum allows RAB and community members to discuss ongoing Travis AFB restoration program activities with the Travis AFB environmental staff on a one-to-one basis.

7:00 - 9:00 p.m. RAB General Meeting

I. **Welcome and Introductions**

II. **Approval of Minutes**

III. **Additional Agenda Items and Questions**

IV. **Discussion Topics**
- Bioreactor 2.0
- Vegetable Oil Projects
- 2010 Field Activities

Break

V. **Cleanup Program Status**
- Energy Reduction in Cleanup

VI. **Regulatory Agency Reports**

VII. **Focus Group Reports**

VIII. **RAB/Public Questions**

IX. **Set Time and Place for Next RAB Meeting**

X. **Set Focus Group Meeting Times**

Adjourn

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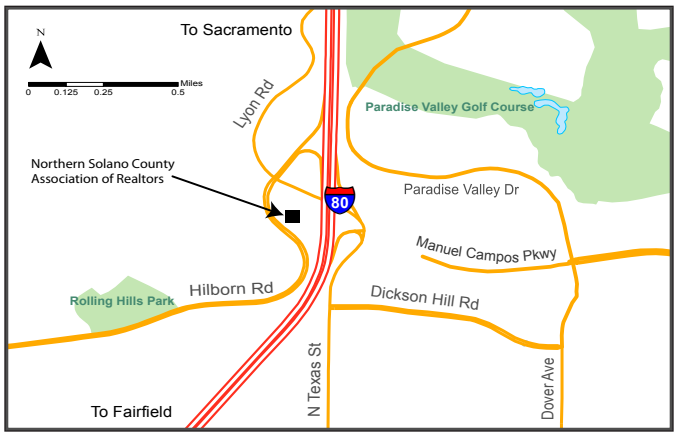
Travis AFB Restoration Advisory Board Meeting

October 21, 2010
7 p.m.

Northern Solano County Association of Realtors
3690 Hilborn Road
Fairfield, CA



Location of Information Repositories

Vacaville Public Library
1020 Ulatis Drive
Vacaville, CA 95688

(707) 449-6290

Monday-Thursday: 10 a.m. - 9 p.m.
Friday-Saturday: 10 a.m. - 5 p.m.
Sunday: 1 p.m. - 5 p.m.

Fairfield-Suisun Com. Library
1150 Kentucky Street
Fairfield, CA 94533

(707) 421-6500

Monday-Thursday: 10 a.m. - 9 p.m.
Friday-Saturday: 10 a.m. - 5 p.m.
Sunday: 1 p.m. - 5 p.m.

Mitchell Memorial Library
510 Travis Boulevard
Travis AFB, CA 94535

(707) 424-3279

Monday-Thursday: 10 a.m. - 9 p.m.
Friday: Closed
Saturday: 12 p.m. - 6 p.m.
Sunday: 12 p.m. - 6 p.m.

If you would like more information or need special accommodations for the RAB meeting, please contact Mark Smith, (707) 424-3062. You can also view our web site at http://www.travis.af.mil/environ

For more information about Travis AFB's restoration program, please contact:

Mark Smith
Restoration Program Manager
Travis AFB
(707) 424-3062
mark.smith.6@us.af.mil

Marcus Simpson
Public Participation Specialist
Cal EPA/DTSC
(916) 255-6683
(866) 495-5651
msimpson@dtsc.ca.gov

David Cooper
Community Involvement
Coordinator, U.S. EPA
(415) 972-3245
(800) 231-3075
cooper.david@epa.gov

Community Relations
60 CES/CEANR (Environmental Restoration)
411 Airmen Drive, Building 570
Travis AFB, CA 94535-2001
(707) 424-4359