U.S. EPA TECHNICAL SUPPORT PROJECT
SEMI-ANNUAL MEETING TECHNICAL SESSION MINUTES

April 25-28, 2000
Washington, DC

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PLENARY SESSIONS

Welcome and Opening Remarks

Curt Black (Region 10), co-chair of the Ground Water Forum, welcomed participants to the semi-annual meeting in Washington, DC. Following a brief overview of the Technical Support Project (TSP) and informal introductions by forum members and other meeting participants, Black introduced Bruce Means, Senior Process Manager for the Office of Emergency and Remedial Response (OERR) and Walt Kovalick, Director of the Technology Innovation Office, who provided the opening remarks and updates on progress in the Superfund Program and remediation in the 21st Century, respectively.

Superfund Program Update, Bruce Means, U.S. EPA/Office of Emergency and Remedial Response

Bruce Means indicated that incredible progress has been made by the Superfund Program since the TSP meeting last fall, due in part to decreased interference from CERCLA issues. OERR has increased the site remediation rate from approximately 65 cleanups per year to an average of 85 per year over the last three years. Over 1,000 National Priority List (NPL) sites have final cleanup plans in place. By the end of FY 2000, approximately 60% of non-federal facilities NPL sites will be construction complete. The Superfund Program is on track to achieve the President's goal of 900 construction completes by FY 2002. Over 6,000 removals have been completed to date, and EPA has removed over 32,000 sites from the Superfund inventory. Managers are very pleased with the work that is being done in the Regions, and, as these statistics clearly indicate, the Superfund Program is continuing its record of success in protecting human health and the environment.

The work that the TSP has done in the past few years has increased the credibility of the Superfund Program and its reuse objectives, and facilitated the resolution of issues across political boundaries. Several reforms have contributed to the development of technical innovations and resulted in cost savings, including the Updating Remedies Report and the National Remedy Review Board.

EPA is faced with an ever increasing body of knowledge on technical and scientific issues that pertain to site remediation, which means that managers, scientists, and policy makers must devote substantial resources to staying abreast of these innovative technologies and techniques. TSP has been a key player in the dissemination of this knowledge. As resources shift from site study and remedy selection activities to remedy implementation and post construction, the Agency faces a number of basic management questions. For example, with ground-water cleanups, it is difficult to determine when the cleanup action is complete.

There is little guidance on how to consider data once it is collected, and how to incorporate this data into future decision-making processes. It is difficult to determine the limits of the technology have been reached as opposed to the limits of the design or remedy. The issue of source control and reduction, including how much money site managers are willing to spend to remove increasingly smaller amounts of contaminants, remains to be addressed. What is EPA's role in overseeing the enforcement of institutional controls? These are a few of the many questions that need to be answered and decisions that must be made before we begin future site cleanups. As they move through site cleanups, site managers must feel confident that they are using the best available technology and should be able to justify their remedy decisions. This TSP meeting is an excellent opportunity to network and achieve progress in resolving the issues that continue to challenge the Agency and its efforts.

Remediation in the 21st Century, Dr. Walter Kovalick Jr., U.S. EPA/Technology Innovation Office

Dr. Walt Kovalick, Director of EPA's Technology Innovation Office (TIO), welcomed participants to Washington and thanked the forums for their continued hard work. His presentation is summarized below, but the full PowerPoint text of this presentation will be available with the meeting minutes posted on the Technical Support Project's website (www.epa.gov/tio/tsp).

When remediating sites in the new millennium, EPA will be increasingly relied upon to link site data and cleanup more closely, technologies for solutions (especially in situ), and disciplines in planning and execution. Four particularly important integrating dimensions and principles for the near future include: 1) taking a measure of the problem; 2) executing projects; 3) using technologies; and 4) developing smart solutions.

Taking a Measure of the Problem

In the past, the Agency often determined the nature and extent of contamination without first gaining an operational understanding of project goals. Site characterization was used primarily to assess risk and determine excavation needs. In the future, EPA will focus project activities on cost-effectively achieving clearly defined goals. Site characterization will be used for design, process control, and determining completion. An integrated triad strategy, focusing on systematic planning, dynamic work plans, and onsite analysis, will move EPA into the new millennium.

The Agency will move from using a prescriptive "one size fits all" approach to one that uses performance-based measurement systems (PBMS) to tailor data to meet individual projects' needs. EPA will move away from completely characterizing the nature and extent of groundwater contamination, instead using periodic sampling to clarify characterization. By using many lower quality data points as opposed to a few higher quality data points, the information value of the data set will be increased, resulting in a defensible site decision that reflects the "true" site condition.

Executing Projects

In the past, one project manager has been responsible for many aspects of the remediation process. In the future, the project manager will work with a team of specialists representing all disciplines relevant to the project's needs. Instead of scaling-up from treatability studies, site managers will scale up from field pilot tests. In the future, site managers will choose options and optimize systems throughout a project's life cycle. More efficient multi-media cleanups will replace single media cleanups, ensuring that the whole site is cleaned up at once. Site specific long-term monitoring programs will replace standard quarterly ground-water monitoring. Some of these tactics are already being employed at the North American Innovative Remediation Technology Demonstration Projects, Sandia National Laboratory, and U.S. Air Force Plant 4 in Fort Worth, Texas.

Using Technologies

In the future, treatment trains will replace single remediation technologies and there will be a greater focus on post-construction 5-year reviews. Pump-and-treat systems will focus on optimization, exit strategies, or contingencies, not just containment. These technologies are currently being tested at Cape Kennedy, Camp LeJeune, and at a dry cleaning site in Florida. In 1994, there were one commercial and two pilot surfactant/co-solvent flushing studies underway. By 1999, those numbers had increased to 17 and 18, respectively.

In the past, EPA has used natural attenuation as a primary remedy. In the future, natural attenuation will be the polishing step in the remediation process. Remediation technology applications will be continuously monitored instead of relying only on post remediation performance testing.

Developing Smart Solutions

Instead of the traditional formal communications between stakeholders, EPA will initiate frequent and open technical discussions with those affected by cleanup sites. EPA will pool in-kind resources and hard money instead of "harvesting" money for development or project demonstrations. In the future, the Agency will make an effort to develop partnerships among public-public and public-private entities. The Federal Remediation Technologies Roundtable is one means for EPA to address the prevalent problem of weak commercialization. By using a tactical and strategic approach that employs the talents of the Remediation Technologies Development Forum, the Roundtable identifies and addresses critical research and links demonstrations and deployments in a purposeful way to accelerate maturation. Engineering, hydrogeology, microbiology, agronomy, and chemistry will be used in conjunction with one another to ensure that site cleanups are efficient, cost effective, and thorough.

TechDirect

TechDirect technology information service periodically highlights events of interest to more than 8,000 site remediation and site assessment professionals. This service describes new products and provides instructions on how to obtain them. Dr. Kovalick encouraged all TSP participants to subscribe to this service, and to spread the word to other professionals.

Phytoremediation Training

Introduction to Phytotechnologies—Growing Solutions to Environmental Challenges

Steve Rock, U.S. National Risk Management Research Laboratory

Steve Rock opened the four-hour phytoremediation training session by welcoming participants. The training session provided a fairly in-depth view of plume control and vegetative cap technologies. In addition, terminology and definitions associated with phytoremediation were explained. Rock suggested that to obtain further information, participants download the report *Introduction to Phytoremediation* (EPA 600-R-99-107) from the CLU-IN website at www.clu-in.org/search/. Rock also noted that the Office of Research and Development plans to offer a two-day Phytoremediation State of the Science Conference in Boston on May 1-2. This conference will discuss a number of technical topics not covered in this session including fundamental processes of plants and soil, innovative solutions for metals removal, and brownfields applications and beneficial use of land.

Phytoremediation is an emerging technology and thus, long-term results of implementation are not widely available. The Remedial Technologies Development Forum (RTDF) Phytoremediation Action Team has assembled a bibliography of 1,446 citations on phytoremediation or closely related subjects (www.rtdf.org/public/phyto/phytodoc.htm). It includes peer-reviewed journal articles, presentations and posters from conferences, book chapters, and articles from newspapers and magazines.

The term "phytotechnologies" refers to more than just phytoremediation, which uses plants to clean soil or groundwater. It also encompasses vegetative landfill cover systems, injured site reclamation, and industrial and municipal wastewater treatment where plants are an essential component of the system. The

potential effectiveness for phytotechnologies is dependent on several site-specific factors such as type of contaminant, media, agronomic conditions, climate, etc.

There are several phyto-mechanisms which plants use to degrade soil or groundwater contaminants. These include enhanced rhizosphere biodegradation, accumulation in roots where the contaminant can be translocated to shoots and leaves, phytodegradation (metabolized within the plant), or transpiration of volatile contaminants to the atmosphere. On the other hand, plants may die from contaminants in the soil or ground water, or they may not uptake the contaminant at all. To implement a phyto-technology, one must consider through which mechanisms a plant will degrade the contaminant and in what quantity. Certain mechanisms, like transpiration to the atmosphere, may be undesirable.

Phytoremediation is a growing industry. Eighty universities in the United States and Canada have phytoremediation projects or programs underway. Patents are increasingly being issued for plants to clean up contaminants. There are several applications of phytoremediation: deep rooted trees for intercepting ground water, wetlands or shallow plantings for enhancing degradation, metals extraction, and prairie or tree-based evapotranspiration covers.

Indian mustard plant is a commonly used plant in phytoremediation. A Superfund Innovative Technology Evaluation (SITE) demonstration project in Trenton, New Jersey, is using Indian mustard plants to remove some of the lead and heavy metals from soil contaminated by a former battery recycler. Lead concentrations as high as 24,000 parts per million (ppm) have been measured at the site. The goal is to lower these levels to less than 400 ppm—the NJDEP residential soil cleanup criteria—through phytoremediation. The Indian mustard plants are accumulating the lead in their plant tissue. The process is still not well understood, however, and even after two years of growth a mass balance has not been achieved. The demonstration will be conducted again more carefully to refine the mass balance.

Roots seek water and will try to reach the water table where downward growth stops. If the water table falls, roots will continue to grow deeper to reach the ground water. Plant roots can interrupt the flow of ground water between a source and receptor. For example, a water balance cover can intercept infiltration preventing contamination of the ground water. Or trees roots can intercept a contaminated ground-water plume before it reaches the receptor. Trees with deep root systems such as hybrid poplars are typically used for these purposes.

The general considerations for implementing a phytoremediation system include:

- the nature of the root systems, especially their depth
- time—including the time needed given the growth rate of plants, length of growing seasons, and when an area is targeted to be clean
- the concentration of contaminants
- food chain exposures

Economic considerations include design, installation, and operating costs. Design costs include work plan and report preparation and a treatability study on a greenhouse or pilot scale. Installation costs include site preparation, soil preparation, planting, construction of a monitoring system, and irrigation of the phytoremediation system. Installation costs of phytoremediation systems are generally 25-50% less than conventional systems, and operating costs can be much less as well. Operating costs for phytoremediation systems include maintenance, monitoring, and replanting. The revenue from the sale of plant products can offset some of the operating costs. Potential sources of downtime for the system include damage caused by beavers, locusts, fire, and wind.

Some disadvantages of phytoremediation are:

- It is most applicable to shallow, low- to moderate-level contamination.
- There is a lack of performance data.
- The treatment duration is long.
- Performance is dependent on the season and climate.
- It is not applicable to all wastes.
- In general, existing structures need to be removed.

The advantages are:

- It is an in situ permanent solution.
- Involves low capital and operating costs.
- Can provide high hydraulic pumping pressures.
- A reduced volume for disposal is attained.
- Can be used to treat a wide variety of contaminants.

There have been more than 30 full-scale installations of phytoremediation systems as covers to date and about 11 constructed for plume control. Phytoremediation systems have been implemented at eight Superfund sites and proposed at two more. These systems are being used primarily to treat TCE in ground water, but other contaminants, soil, and pond water are also being treated.

Questions and Answers

Question: Have phytoremediation systems been attempted in urban areas where there is not a lot of space available for trees?

Answer: There have been plans to implement phytoremediation as a brownfields solution. Use of phytoremediation in urban settings will depend on the contaminant. Tree lines have been installed at gas stations to ensure that plume doesn't travel offsite.

Question: It appears the vertical dimension of the root zone defines the capture or treatment zone. So understanding the species of plant or tree will help understand the size of this zone.

Answer: Correct. The trees are being used as engineering tools, not as habitats or ornamentation. Healthy plants are not necessarily preferred. Stressed plants are preferable so they grow deeper and take up more water.

Question: Do certain portions of the root zone extract water or contaminants at higher levels, e.g., the phreatic zone?

Answer: Yes. This will be discussed in upcoming presentations.

Question: Is the Indian mustard plant treated after use?

Answer: Absolutely. The plant is harvested, treated, and disposed as a waste. In addition, the plants may be mined for metals.

Aberdeen Proving Ground Update—Monitoring, System Design/O&M, and Modeling, Steven Hirsh, U.S. EPA/Region 3, Harry Compton, U.S. EPA/ERTC, Bill Schneider, Roy F. Weston

Steve Hirsh opened the presentation of the phytoremediation case study of organic contaminants in the J-Field area of Aberdeen Proving Ground in Maryland. This project is in the feasibility study stage. The costs of planting and maintaining the trees are understood, but long-term monitoring requirements and costs are still unclear. Thus, how to compare the costs of phytoremediation and pump-and-treat systems is also unclear.

The J-Field was used to dispose and burn warfare and industrial waste chemicals and equipment from the 1940s to the late 1970s. A plume of chlorinated solvents (1,1,1-TCA, TCE, PCE, and *cis*-DCE) with concentrations in the 100's of ppm is migrating slowly through the surficial aquifer toward the nearby Chesapeake Bay. Contaminants have not reached the bay but they are discharging to an adjacent wetland. There any human receptors due to the site's remote location.

The remedial options that have been examined for the site include no action, institution controls, ground-water extraction and treatment, plume containment, in situ treatment, monitored natural attenuation, enhanced natural attenuation, and phytoremediation. A minimally intrusive solution at J-Field is desired.

Harry Compton explained that control of the ground-water plume at the J-Field is desired in order to protect a nearby marsh and because it is required by a state policy that requires containment of a plume, regardless of its end use. The design approach for phytoremediation involved an agronomic assessment in September 1995 to assess the fertility of site soils and to determine if soil nutrients or irrigation were needed. This was followed by a tree remediation design from Fall 1995 to Spring 1996 to determine where to plant the trees. Trees were planted March-April 1996 to intercept ground water migrating toward the marsh. Finally, a surface drainage system was installed in May 1996 to ensure trees depended on ground water as a source of water.

The log of the octanol/water partition coefficient of the contaminant is a critical factor in the effectiveness of uptake of ground water by plants. A log K_{ow} of 1-3.5 (moderately hydrophobic) is optimal, which is different than expected. Uptake of ground water depends on plant uptake efficiency, transpiration rate, and the concentration of the chemical in soil water. The uptake of chemicals into plants through the roots is calculated:

$$U = TSCF * T * C$$

Where,

- U = uptake rate of the constant (mg/day)
- TSCF = transpiration stream concentration factor (no units)
- T = transpiration rate of the vegetation (ℓ/day)
- C = aqueous phase concentration in soil or ground water (mg/ℓ)

$$K = U/M_0$$

Where,

- K = first order rate constant for uptake (per year)
- U = contaminant uptake rate (kg/year) (calculated from above)
- M_0 = initial mass of contaminant (kg)

From this information, an estimated clean-up time to a given action level can be calculated.

$$t = -(\ln M/M_0)/K$$

The cleanup time calculated for the J-Field dissolved phase plume was 30 years, so it will not be a quick cleanup. In retrospect, the plume is not ideal for phytoremediation, but it should work well for the top part of the plume. The plume is in the tight soils (interbedded silty sand and clay) of the surficial aquifer, which is 30-40 feet thick. The hydraulic conductivity of the unit is approximately 1 ft/day. The plume is slow moving which is helpful given the time it takes for the trees to grow. The USGS calculated that containment of the plume is achievable by pumping at around 7 gpm. Wells yielded a much lower volume, however, that's why pumping was not feasible.

Initially, the trees were installed in 8-foot deep hollow stem augered holes and the roots were bound so that they would grow straight down. Because the soils at the site are tight, root growth was limited to within the augered holes. The roots could not grow laterally or deeper than 8 feet, which limited their effectiveness and did not provide an anchor during the strong winds of Hurricane Floyd. Silver maple, hybrid poplar, and tulip poplar trees were subsequently planted using several different planting techniques (e.g. 4-inch diameter holes to 3 feet deep and 12-inch diameter deep holes) to compare results. At this time, it is not clear which technique is working better.

Compton noted some examples of phytoremediation systems implemented at other sites with unique site conditions or circumstances. At the Gaseous Diffusion Plant in Piketon, Ohio, trenches were dug through a hardpan layer and backfilled with sand in order to plant the trees. The site has a shallow ground-water table (3-4 feet deep), and the planting process was successful. At a gasoline spill site with a pump-and-treat system in Naples, Utah, native poplars were planted as a polishing step to reduce the estimated cleanup time. At the Oregon Poplar site, both native and hybrid poplars were planted in a random block design that accommodated its future use as a park. This planting scheme was optimized to avoid a "corn row" effect in the trees.

For further information on phytoremediation, please consult the following references:

1) *Technology Evaluation Report: Phytoremediation* (October 1997), by Jerald Schnoor, University of Iowa, available at www.gwrtac.org/html/topics/phytorem.htm; and

2) *Phytoremediation Decision Tree* (December 1999), by the Interstate Technology and Cooperation Work Group Phytoremediation Work Team, available at www.itrcweb.org. (Click on "Guidance Documents.")

Steve Hirsh indicated that monitoring of the phytoremediation system at the J-Field has included measurement of ground-water levels, analysis of ground-water chemistry, and analysis of exposure pathways. The exposure pathway analysis considered measurements of transpiration gases using OP FTIR and flux chambers. The flux chambers were tedlar bags placed over the branches. The bags were injected with CO_2 at atmospheric levels to keep the leaves from dying. Transpired gases were collected in the bags and measured with a GC/MS. The highest measured concentrations of TCE and 1,1,1-TCA have been 250 ppbv and 2,000 ppbv, respectively. Exposure pathway analyses also included evaluation of the number and variety of nematodes in the soil.

The hydrology of the tree is a concern, not just hydraulic containment of the plume. To calculate the water removal rate of trees, the following parameters are required: weather (temperature, relative humidity, solar radiation, wind speed); leaf and stem area; land area; and sap flow. Values to be calculated include evapotranspiration potential, crop coefficient, and leaf area index. The leaf area index is an important parameter for determining the degree of canopy closure. It is important to obtain canopy

closure so that sunlight hits the leaves, rather than the ground. Complete canopy closure occurs when the leaf area index is about 4.

It is recommended that the calculation of water removal rate be averaged for at least eight trees. Many of the parameters will vary depending on the time of year and the time of day. The water removal rate measured at the J-Field is about 7 gpd per tree, with a maximum rate of about 12 gpd per tree. Since there are about 160 trees planted on a half acre plot, the maximum withdrawal that can be achieved is about 2,000 gpd.

A leaf degradation study, tree tissue analysis, and bee studies were also conducted. Bees were used to monitor the site since they collect chemicals from a large area and bring them back to the hive. The bees act as flying "electrostatic dust mops" that sample air, water, soil, and plants. Bioavailable chemicals accumulate in the water, nectar, pollen, resin, and on body hairs of the bees. Bee monitoring can range from simple to very complex as parameters such as hive air, ambient air, pollen, bees, hive temperature, and the percent return of bees.

Bee monitoring was conducted at J-Field to provide a history of bioavailable chemicals and ecological effects; examine the J-Field and environs before, during, and after pit excavation and covering and biosolids application; determine remaining bioavailability and effects of chemicals, if any; and identify previously unknown chemical sources, if any. The chemical analysis for the J-Field bee study included chlorinated and other halogenated organics, petroleum hydrocarbons, ordnance-related organics, and volatile explosives. The results of the bee study showed that samples collected from the base of phytoremediation trees have historically contained chlorinated organics. The levels rose from early March through April 1999. The hives to the south of the removal pits had higher levels, in general, than the hives to the north of the removal pits. The levels of petroleum fuels in all five hive clusters were fairly consistent suggesting that this is a regional background level.

Bill Schneider summarized the field-scale pilot conducted at the J-Field. He explained that the purpose of the pilot was to collect and analyze data to determine whether phytoremediation is capable of restoring a VOC-contaminated aquifer to regulatory approved action levels.

The redox chemistry (dissolved hydrogen, ferric/ferrous iron, sulfate) of the J-Field was measured in a comprehensive round of sampling. The results indicated that the upland area has ferric conditions, and the marsh has highly enriched methanogenic conditions. This is important because the VOCs at the site are susceptible to both biotic and abiotic degradation. The hydrology of the J-Field is considered favorable due the slow moving, shallow, and localized ground-water flow. In addition, the site is remote and protected, and the ground water is not used as a water supply.

The depth to ground water at the site is about 3 feet and becomes shallower toward the marsh. Uptake by trees has created a cone of depression on the water table, and there is a rapid, lateral drop-off in contaminant concentrations. It is not certain whether this drop-off is also due to uptake by trees or to natural attenuation.

An integrated remedial solution incorporating hydraulic containment and remediation was selected for the pilot. Two ground-water circulation wells were installed as active source control in the hot spot area and run for about 60 days. A more natural method, phytoremediation, was used as a polishing step. One well removed about 23 lbs of VOCs; the other removed only 7 lbs. Removal was hampered by inefficiencies in the well design as well as difficulties establishing circulation due to microscale heterogeneities in the soil.

There is some early evidence that natural attenuation is occurring. There is a sharp decline in contaminant concentration, there are breakdown products present, and there is favorable redox chemistry. One of the breakdown products is vinyl chloride, however, which must be limited. The high concentrations of VOCs create an unfavorable condition for natural attenuation. DNAPL has not been detected at the site, but a lot more investigation needs to be done. The presence or absence of DNAPL at the J-Field remains one of the greatest uncertainties about the site.

There were several goals of modeling the integrated remedial program for hydraulic containment and remediation of the shallow portion of the plume. These goals included estimating VOC mass removal, determining configurations for hot spots for source control, estimating the VOC mass discharge to the marsh, and possibly estimating the cleanup time. The model incorporates a lot of existing information on the local hydrostratigraphic units. The key is that the initial layering for the fate and transport could be based on a simulation using the EarthVision 3-D visualization tool. The mass of the dissolved contaminant phase could thus be calculated.

The success of phytoremediation as a polishing step was evaluated from field data such as transpiration gas, sap flow, and water level measurements. Analytical modeling methods, which are useful as a screening tool, were used to estimate the capture zone and placement of trees. For fate and transport information, MODFLOW -RT3D was used. The model estimated the VOC mass removal and the most effective placement of ground-water circulation wells.

The design of the remedial solution considered the effect of the ground-water circulation wells, natural attenuation, and phytoremediation on the VOC plume. The 172 hybrid poplar trees were modeled as pumping wells. MODFLOW-RT3D simulated the zone of influence, and the results showed that the zone of influence got smaller with depth as expected. The trees were not effective on the deeper portions of the contaminated aquifer—there was little or no effect on the aquifer below 15 feet. The upwelling toward the marsh is a key advantage to the success of phytoremediation at the site.

In one modeling scenario, the ground-water circulation wells were shown to dominate in terms of mass removal, removing approximately 1,200 lbs of VOCs over the next 40 years. Natural attenuation also is a major contributor to mass removal, although the mechanism is unclear and vinyl chloride is produced. Phytoremediation, in comparison, was shown to contribute only 5-8% of the mass removal, and the fate of the VOCs after uptake was not determined. The estimate of VOC removal is conservative due to rhizoshere fixation. Phytoremediation provides partial hydraulic containment during peak growing seasons.

Questions and Answers

Question: Where are the contaminants going once the trees take them up? Are they going into the leaves and then contributing to surface contamination when the leaves fall?

Answer: There is some degradation of contaminants in the rhizosphere, and we think the TCE is being degraded within the trees, we're just not sure where. The leaves are not releasing volatile organics, so it is not likely that contaminants are in the fallen leaves.

Hydrologic Considerations in Phytoprocesses, Jim Weaver, U.S. EPA, National Exposure Research Laboratory, Ecosystems Research Division

The water balance at a site determines the pattern of flow in the aquifer, the amount of water withdrawn by vegetation, and the first-order effectiveness of phytoremediation. The scientific principle governing ground-water flow is the ground-water flow equation:

$$L\ C\ (KbLh) + q + P + I - Q_s - ET = SMh/Mt$$

Where,

K = hydraulic conductivity
b = aquifer thickness
h = hydraulic head
q = source/sink
P = precipitation
I = irrigation
Q_s = surface runoff
ET = evapotranspiration
S = storage coefficient/specific yield

This equation is solved in ground-water flow models. The majority of ground-water flow modeling is based upon an assumption of steady state:

$$L\ C\ (KbLh) + q + P + I - Q_s - ET = 0$$

Thus in solute transport, it is assumed that contaminant transport is slow compared to ground-water response time, and climate is averaged over time.

Modeling can be used in phytoremediation to predict plume location and the potential for phytoremediation. This requires an estimation of evapotranspiration rates, the local pattern of aquifer recharge, and simulated flow in the aquifer. Evapotranspiration is important because it reduces the average net recharge of the aquifer and can prevent plume diving. In addition, it can create an upward flux of water.

Evapotranspiration can be determined with the Penman-Monteith Equation:

$$E_{rc} = F^1_{rc}\ A + F^2_{rc}\ D$$

Where,

E_{rc} = reference crop evapotranspiration (mm/d)
A = available energy for evapotranspiration (mm/d)
D = average vapor pressure deficit (kPa)
F^1_{rc} , F^2_{rc} = functions of temperature, wind speed, and site elevation

Average evaporation values are also available for across the United States. The highest evaporation levels in the country generally correspond to areas with the lowest precipitation levels such as the desert Southwest. The average precipitation in Central Florida is 140 cm/yr; documented estimates of evapotranspiration range from 50-130 cm/yr. Evapotranspiration rates are very site-specific.

Evapotranspiration affects the pattern of recharge, which, in turn, can affect the plume. Weaver showed an example of a plume of BTEX and MTBE in East Patchogue, New York. A gravel pit directly over the plume receives recharge that is twice the estimated average of Long Island. Measured contaminant concentrations show the plume is driven deeper as a result of the enhanced recharge at the gravel pit.

In another example, a sump at a BRAC site in Orlando, Florida, has contaminated ground water with PCE and TCE . The plume is discharging to Lake Druid. Runoff from a parking lot enhances recharge and

causes the plume to dive over a short distance. The flow path is greatly affected by the varied local land use (buildings, pavement, ditches, grass, and shoreline).

An analytical recharge model was used to determine if the recharge from the ditch is causing the plume diving and the amount of recharge required to produce the depth of displacement observed. The model is a one-dimensional analytical element model that predicts the upper bound of contaminant distribution based on aquifer parameters and the recharge rate and matches the observed plume diving to an input recharge rate. It is valid only for flow in water table aquifers. Results of the model show that 110 inches of recharge per year are required to explain the plume diving.

MODFLOW, a 3-dimensional, steady-state ground water flow model was also used. The model required fine-scale layering to simulate the plume diving and evapotranspiration losses. The model was used to simulate existing conditions (including the enhanced recharge from the ditch), plume diving with re-routing of water from the ditch, and evapotranspiration with trees planted near the source in the parking lot. The last scenario assumed no recharge due to the plantations, but evapotranspiration at rates of 50, 80, and 130 cm/yr. Removing the recharge from the parking lot was expected to reverse the plume diving trend, and the trees would create an upward ground-water flow.

MODFLOW showed an upward gradient to a depth of 23 feet that resulted from an evapotranspiration rate of 80 cm/yr. This upward gradient was further increased to a depth of 30 feet from a rate of 130 cm/yr. The depth of contamination at the site is 34 feet. Thus, MODFLOW indicates a potential to control the plume by diverting runoff from the parking lot. Planting trees at the source potentially affects a maximum of 77-88% of the contaminant depth. An estimate of mass removal is still needed.

In conclusion, vertical characterization is required for delineating plumes, especially those considered for phytoremediation. Localized recharge distribution controls plume diving. Evapotranspiration estimates have uncertainty, but are generally bounded by pan evaporation rates.

Vegetative Cover Systems: Definitions, Examples, Design, Steve Rock, U.S. EPA, National Risk Management Research Laboratory

Steve Rock clarified that vegetative covers refer to plants as landfill covers, not plants on landfill covers. There is no barrier layer beneath them. A vegetative cover system is a long-term, self-sustaining cover of plants growing in or over contaminated materials. It reduces risk to acceptable levels and requires minimal maintenance. Regulators want to ensure that vegetative cover systems prevent physical contact with contaminated materials, ground-water contamination, and the production of harmful gas. They also want to ensure durability of the system and performance equivalent to that of RCRA covers.

Covers in arid and semi-arid climates—those receiving less than 20 inches of precipitation per year—typically use mixed local plants such as prairie grasses. Arid and semi-arid climates have a shallow root zone with 70% of the roots in the upper three feet of soil; there is unconsolidated native soil to the frost line. Cover designs for wet climates use hybrid poplars or willows planted into the soil and waste. The roots of these trees can reach 8-10 feet deep. One thousand of these trees per acre will use 5-25 gallons per tree per day.

Hydrologic components to consider in the design of evapotranspiration covers are precipitation, transpiration, evaporation, surface flow, soil storage or water holding capacity, and recharge and infiltration. These parameters can be monitored with rain gauges, sap flow meters, weirs or tip buckets,

and data from meteorological stations. Vadose zone monitoring stations might consist of a datalogger attached to soil moisture probes, soil temperature sensors, and soil water pressure sensors.

There are two types of vegetative covers: evapotranspiration caps and phytoremediation caps. Evapotranspiration caps, or water-balance covers, are composed of soil and plants to maximize the evapotranspiration process. They provide hydraulic control. Risk reduction relies on leachate control. Phytoremediation caps are designed to minimize water infiltration as well as degrade waste. Degradation occurs through uptake of contaminated water by the tree, root zone microbiology, and plant metabolism.

The function of a cover can evolve from treatment to containment. The plant roots penetrate the edges of the waste and promote microbial degradation of the waste. This decreases toxicity and creates aerobic conditions. As the roots penetrate further, they create a "moving front." Once the roots reach equilibrium, there is no further penetration and a water balance is achieved.

Evapotranspiration caps are appropriate in the following situations:

- where the water balance is protective of ground water
- when gas capture is not an issue
- where conventional covers may not be feasible
- where a conventional cover is a contingency
- all of the above

Due to seasonal fluctuations, a water balance should be performed for evapotranspiration caps to determine when they will be effective. In the water balance, the amount of infiltration each month is compared to the amount of water the plant uses in order to determine the amount of leachate that will be produced. The cap will not work after the leaves have fallen from the trees or if the grasses have gone into remission for the winter, so sites with high winter precipitation may not be suitable for evapotranspiration covers. Depending on the water storage capacity of the soil, however, there may be enough desiccation in the summer to hold the winter precipitation.

Climate is an important consideration when designing an evapotranspiration cap because the precipitation rate and seasonal timing affect soil storage capacity. In addition, humid areas require a thicker layer of soil. Another consideration for the use of evapotranspiration caps is the land use.

There are several models available for designing evapotranspiration caps, including HELP, EPIC, UnSat-H, and Hydrus-2. None of the models are perfect, but Hydrus-2 is probably the best. An Alternative Covers Assessment Project (ACAP) report *Numerical Models for Landfill Design and Monitoring* comparing 13 codes (CREAMS, HSSWDS, HELP, MULTIMED, SOILINER, DRASTIC, HRS, HARM, DPM, RELRISK, NCAPS, RCRASTD, PCLTF) can be downloaded from ftp://dri.edu/acap/files/reports/final.

Monitoring Devices and Systems, Dr. Craig Benson, University of Washington

Due to a flight cancellation, Dr. Benson was not able to make his presentation to the Technical Support Project. His presentation materials can be downloaded, however, from the Internet at ftp.dri.edu/acap/file. The file to download is ACAP_Boston.

Superfund, RCRA, and Equivalence Issues, Andrea McLaughlin and Ken Skahn, U.S. EPA/ Office of Emergency and Remedial Response

Andrea McLaughlin indicated that EPA's liquids management strategy has two goals: to minimize leachate generation by keeping liquids out of the landfill; and to detect, collect, and remove leachate as it is generated.

EPA is currently developing two landfill guidance documents that will address these goals. One, the "Technical Guidance for RCRA/CERCLA Final Covers," is an update to the 1991 RCRA guidance. This update will incorporate alternative design and materials. The other guidance, "Use of Selected Alternative Covers at CERCLA Municipal Landfills" will address Subtitle D closures. Subtitle D closure criteria (40 CFR 258.60) require that the infiltration layer must have a permeability less than or equal to the permeability of the bottom layer, or a permeability no greater than 1×10^{-5} cm/sec, whichever is less. The guidance says that a state may approve the use of alternative cover if it achieves an equivalent reduction in infiltration.

The RCRA program is delegated to the states. Some states have taken the federal requirements and made them more stringent. For instance, the State of Illinois requires that the permeability of the infiltration layer be at least 1×10^{-7} cm/sec. Many states likely will make provisions for alternative covers, but they must require a permeability of at least 1×10^{-5} cm/sec.

In regards to covers on CERCLA landfills, statutory requirements require that all remedies must meet or waive applicable or relevant and appropriate requirements (ARARs), and that response actions must be protective. ARARs are any standard, requirement, criterion, or limitation under any federal environmental law, or any *promulgated* standard, requirement, criterion, or limitation under a state environmental law. Closure requirements are generally identified as ARARs by the state.

An alternative cover may be used if state regulations include an alternative cover provision; otherwise, an ARAR waiver may be necessary. Section 300.430(f) of the National Contingency Plan contains an equivalent standard performance ARAR waiver. This waiver says that "the alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard...through use of another method or approach." In order to obtain an ARAR waiver, the RCRA Subtitle D infiltration rate must be achieved at *all times*; it is not an average infiltration rate. If equivalence is demonstrated, the cover may be compared to other alternatives in the feasibility study using the nine criteria.

To summarize, an alternative cover is possible for CERCLA landfills if the closure is Subtitle D; state regulations include an alternative cover provision or the ARAR is waived; an equivalent infiltration rate is demonstrated; and the nine criteria analysis is favorable.

Ken Skahn indicated that the new guidance will provide details on materials, maintenance, and monitoring of alternative covers like vegetative caps, not just equivalence requirements. Alternative covers act as evapotranspiration barriers and capillary fringe barriers.

A standard landfill cover has a layer of soil covered by a layer of top soil or a surface treatment over the waste. A layer of coarse soil is typically added to an alternative cover that serves as an additional barrier to infiltration as a result of the change in capillary pressure. The steps for designing an alternative cover are as follows:

1) Determine if gas collection is required.
2) Identify critical infiltration events. Keep in mind that covers should last 100s of years.
3) Calculate the minimum storage capacity based on the maximum precipitation events.

4) Characterize soil properties to determine the storage capacity of the soil.
5) Calculate the soil thickness multiplying by a safety factor of 1.5 or using a minimum thickness of 3 feet.
6) Determine the vegetation and the surface treatment.
7) Establish adequacy of design using predictive modeling.

Step 7 is still a weak point because a good model for establishing adequacy of design does not exist. OERR is working with ORD, however, on developing one.

Equivalence of a cover is demonstrated using predictive modeling to show that an alternative cover will perform as well as the Subtitle D cover. This is verified by performance monitoring using an instrumented test pad. The test pad that Skahn provided as an example was 6 by 20 m and equipped with lysimeters. The pad, which drained toward a sump, was constructed under the cover and provided good verification data.

There are several issues that remain to be addressed, however, such as when is a membrane required to control landfill gas, what constitutes failure of the landfill, and are alternate covers appropriate only for arid and semi-arid areas? In addition, an appropriate predictive model is needed.

Questions and Answers

Question: Have there been any failures of alternative covers?

Answer: There have been failures in test conditions, but not where a cover has been fully implemented.

Question: How do alternative covers affect a bioreactor landfill where water is needed to function?

Answer: Alternative covers are not appropriate for bioreactor landfills since a barrier to collect the gases is needed.

Question: Vegetative caps are typically viewed as more cost effective. How is this possible when fill must be purchased for the cap?

Answer: Fill from the site can be used. It does not necessarily have to be purchased.

Use of Native Plants in Federal Landscaping, Scott Fredericks, U.S. EPA/ERTC

The use of native plants in vegetative caps is becoming more important due to a Presidential Executive Order requiring that for federal grounds, federal projects, and federally funded projects, agencies shall, where cost-effective and to the extent practicable, use regionally native plants for landscaping. More than 200 plants have become extinct since the 1800s, and nearly 5,000 native species are at risk. Use of native plants has ecological value in that it is essential for biodiversity and ecosystem integrity. Plants also have economic value in that they are sources of genetic and raw materials that can provide medicines and food, as well as being used in landscaping. Native plants create a self-sustaining ecosystem without the need for fertilizers, pest control, etc.

A second executive order addresses management of invasive species. The United States is losing 6,000 acres per day to invasive species. There are 400 serious invaders. Characteristics of these invaders

include that they love bare soil, they exhibit rapid growth and maturity, they have a prolific seed production and rampant vegetation spread, and they out-compete native species.

For further information, please consult the following websites:
www.nps.gov/plants
www.ert.org
www.barc.usda.gov
www.mobot.org
www.audubonintl.org
www.rce.rutgers.edu/weeds
www.for-wild.org

ERTC has resources including a directory of native plant wholesalers (by state). This soon will be available on the web. ERTC also has a directory of ecosystem restoration experts and has written a white paper on native plants.

Update on St. Joseph Site in Michigan, Mark Henry, Michigan Department of Environmental Quality, Environmental Response Division

Mark Henry, the State of Michigan's RPM for the St. Joseph site, updated the forums on the status of the chlorinated solvent plume at the St. Joseph site. In a study, this site had been cited as a good example of natural attenuation of the ground-water plume. The source area at the site is a mixture of fuels and TCE, which has led to the anaerobic biodegradation of the TCE to vinyl chloride in much of the plume. Modeling predicted that the remnants of the plume would discharge into Lake Michigan 100 yards from the shoreline. The concentrations were not expected to be detectable in the lake at the discharge point.

Henry has developed a sampler for sediment pore water and used it to test the modeling results. The sampler is a thin pipe (**c**-inch diameter) with a cross bar at the top. The pipe has slots at the bottom end to allow water to enter after a plastic plug (to keep sediment from entering the pipe) is dislodged. Water is withdrawn from the target depth with a polyethylene syringe fitted with a tygon tube that attaches to the top of the device. The device can also be used under water. After water has been drawn into the syringe, it is transferred to a VOA vial. The sample locations are marked by GPS. Portable onsite equipment to was used to measure pH, temperature, turbidity, dissolved oxygen, and dissolved iron. The sampler can also be used as a kind of manometer to tell whether a shallow water body is gaining or losing. If the meniscus in the barrel below the surface of the water, it is losing.

To test his hypothesis that the discharge point for the plume was much closer to the shore than the PRP's model predicted, Henry took samples along a transect perpendicular to the plume flow direction. The chemical results of these samples indicated very high levels (6 mg/R) of chlorinated compounds which were not what the model predicted. A second line of sampling was performed perpendicular to the transect to determine how far out into the lake the discharge was occurring. The results of this sampling indicated that concentrations fell rapidly with distance and the plume ended some 75 feet from shore.

Henry was subsequently asked whether the concentrations were as high as they were because the samples were collected and calm days with no wave action to mix the contaminants. This theory was subsequently tested by sampling on a day when there were 5-foot waves; the results were essentially the same.

The site stratigraphy is a sandy water table aquifer overlying a clay. The plume is unusual in that the water overlying it was not contaminated. Henry suspects that the original release came down through the aquifer in a somewhat thin line where it subsequently pooled on the clay. Over time, the NAPL in the sand dissolved and went away while that on the clay continued to serve as a source.

The sampler is also useful in that it is hand pushed; therefore, the operator can feel the material being penetrated and sense what it is. The sampler cannot be pushed through packed fine sands but works well in clays and coarser sands. Henry obtained a shallow vertical profile of the plume by pushing the sampler to refusal, taking a sample, and then withdrawing it at set intervals and sampling again. In doing this he discovered a gravel layer. This gravel layer appears to be an old gravel stream bed that is probably acting as a conduit for the plume which may explain why there does not appear to be much spreading of the plume with distance (has stayed approximately 150-300 feet wide). Since the initial sampling event, the lake level has dropped and revealed a gravel outcrop at the shore line.

Henry also collected water samples about 1-foot off the bottom of the lake in the plume area and detected vinyl chloride. Sampling was done during a calm period and it is not certain whether the same results would be obtained with wave action.

Since the plume is not at a steady state and is migrating faster than expected toward Lake Michigan via the gravel bed, the ROD for natural attenuation will probably have to be revisited. Remediation decisions will be somewhat complicated since the site has been redeveloped into an expensive residential area. Henry suggested that a permeable reactive barrier installed near the shore might be best option to treat the plume.

Questions and Answers

Question: How do you know that the full extent of the plume lies within the transect area?

Answer: I don't, but I extended the shoreline survey a quarter mile in each direction and did not get any significant hits. The PRP did some sampling in deeper water near a line of piers that were constructed in the early 1940s to act as a wave break and are alleged to be keyed into the underlying clay aquitard. They reported some contamination (400 µg/ℓ) in the shallow sediments on the landward side of the pier.

Question: Are you marketing the sample devices?

Answer: Yes. I have a provisional patent on the device and am considering charging about $35 a piece.

Question: Will the ROD need to be revisited?

Answer: The PRP will now be held to the more restrictive ACL in the ROD, and the Michigan ground-water/surface water interface regulations may be an ARAR. The regulations allow ground-water concentrations that are 10 times the action level to discharge into the lake. This results in a regulatory limit of 150 µg/ℓ of vinyl chloride. Currently, concentrations are an order of magnitude higher.

Question: How does this change the natural attenuation study performed at the site?

Answer: It has to be revisited. For example if you compare the concentrations at the point of compliance transect with what is found at the discharge point in the lake, the numbers are the same if not a little bit higher. The plume is attenuating at its edges as you can observe the concentrations falling. However there

seems to be a core that is not attenuating. There is a lot of biological action going on because you can see byproducts but full attenuation is not occurring.

Question: Would localized addition of an oxidant work as a solution?

Answer: Maybe. However, given the depth and location of the plume (near housing) they are thinking that placing a permeable reactive barrier across the discharge area would be best.

Question: Has vinyl chloride been detected in other places in the lake?

Answer: No.

Question: What is the maximum effective depth of the sampler?

Answer: It generally will reach refusal before 2 feet.

RCRA Corrective Action Update, Robert W. Hall, Chief, Corrective Action Programs Branch

Robert Hall provided an update on the RCRA Corrective Action Program (CA). He stated that the number of RCRA sites subject to CA is comparable to CERCLA and the actual universe is probably larger. Tim Fields, the Assistant Administrator of OSWER, has implemented RCRA cleanup reforms after noticing there was little movement in the CA program. The program is, by and large, a delegated one with 32 states having primacy and the headquarters corrective action program has only 25 staff. On July 8, 1999 Fields announced the implementation of what is commonly called the RCRA Cleanup Reforms. After examining the program it was decided that they would start operating on results based guidance; promoting existing flexibility in RCRA; involving the public in a more meaningful way; and using enforcement more often.

RCRA in October 1999 issued a Federal Register Notice stating that it does not intend to finalize the Corrective Action Proposal put out in 1990 (Subpart S). The RCRA program was designed to be implemented by the states. Currently there are 32 authorized states with the number expected to eventually reach 40. To move the program forward, Headquarters decided to undertake a campaign of guidance development and outreach.

The Office of Solid Waste is required to create measurable goals and report progress on a yearly basis. There are two goals that have been proposed for all sites (henceforth called environmental indicators). They are 1. Make a finding that human exposures at a site are under control; and 2. Make a finding at a site that ground-water migration of contaminant plumes has been controlled. They did this as triage measure. They needed to prioritize their sites and bring them under some kind of control. If they focus their resources and can get the majority of their high risk sites in a position that they can say exposure is under control and ground-water migration is under control then they can start thinking about bringing the same sites into a more complete cleanup position. There are 1714 high priority sites (with more medium and low priority designations). The goals for these high priority sites are to have human exposures controlled at 95% of the sites and plume containment achieved at 70% by the end of 2005. Regions 1, 3, 4, 5, and 9 have the most sites.

A new *Draft Handbook of Ground Water Policies for RCRA Corrective Actions* will be up on the corrective action web page at http://www.epa.gov/correctiveaction on April 24. It summarizes all ground-

water policies and puts them in one place. The handbook will highlight areas of flexibility. Mr. Hall went on to list the following guidance documents, workshops, and meetings:

1 RCRA/CERCLA Handbook on Ground Water Monitoring and Site Characterization –update on the RCRA 1992 Technical guidance that was never finalized. It will focus on site characterization and innovative site monitoring technologies. It is scheduled to be out in the fall.
2 Unified Guidance for Statistical Guidance at RCRA Facilities. This document updates previous statistical guidance documents and is scheduled to be finalized in the fall.
3 Corrective Action Completion Policy Guidance Document This is to provide owners/operators with guidance on how to show that their corrective action is complete.
4 Results Based Correction Action-- tailoring oversight. Policy that says basically the cooperative the owner operator the less oversight the agency will perform.
5 Future results-based guidance documents on Presumptive Remedies, Performance Standards, Innovative Technologies, Targeted Data Collection, and Owner Operator Initiated Corrective Action.
6 Corrective Action Workshops. These are to be held in Orlando, May 16-18; Kansas City, June 12-16; and Boston, July 11-14. They will be creating online training modules for the entire course with the first covering Remediation Waste Management.
7 RCRA National Meeting will be held in Washington, DC , August 15-18.

The Office of Solid Waste is creating a RCRA Brownfields program. There are four pilots located in Bethlehem Steel in Lackawanna, New York, Blue Valley in Kansas City, Missouri, Peco Energy, Chester, Pennsylvania, and CBS facility in Bridgeport, Connecticut. These sites will be featured at the Brownfields Conference in Atlantic City in October.

In returning to the discussion on Environmental Indicators that are part of OSW's GPRA goals, Mr. Hall stated that they would have to be careful in making these findings and needed to ensure all exposures were considered including ground-water/surface water interfaces and the contaminated ground water to indoor air pathway. The Corrective Action program has issued interim guidance to the Regions on how to judge "containment." This guidance includes the ten times rule of thumb for ground-water/surface water interfaces.

Questions and Answers

Question: The Region does not have the technical resources to meet these goals nor do the states.

Answer: Hall stated he recognizes this and has been lobbying for more resources. He hopes for more resources in the next fiscal year.

Question: Environmental Indicators at Federal Facilities. Some of these sites are huge and exposures are diverse even occupational safety and health type from contamination. How were you going to measure these exposures?

Answer: He stated that because of the size of most of these facilities, and their general isolation they may not be such a difficult problem as they initially appear. They will have to deal with on-site residences but he thinks these may not be that close to operations. On the other hand the determination is site wide and there is a lot of ground to cover.

Question: At many sites the determination of no offsite migration is hard to tell because the characterization that has been done is poor. Will there be a finding of no migration at these types of sites.

Answer: Nobody said the determination would be trivial, if they don't know they don't know. They have to report accurately because of both the potential human health consequences and the political ones if they say no migration and it is subsequently discovered there was.

Question: The RCRA staff will be following a check list type of determination. Will the staff making a no migration determination know anything about ground water?

Answer: The determination has to be made by someone who understands the site characteristics and requires a counter signature by the supervisor.

Question: Five year review guidance states that you should team with technical staff. Maybe RCRA could look at that program.

Answer: Mr. Hall stated they are looking for ideas.

Question: As you stated it is a delegated program. How do you instill a sense of urgency in the states?

Answer: Mr. Fields has stated that this will be one of the hardest things to do. They have some strings in terms of grant money and he does outreach during regional reviews and for example by paying to bring RCRA state staff to National Meeting and workshops He also, during his regional review visits at least one state office and tells them that if this program is seen to be failing by the Hill then there is a good chance that they and EPA will loose control of how it is implemented. This approach does generate some response.

Question: You have cited a lack of progress in corrective action to date. Why has this occurred?

Answer: They found that in trying to emulate the Superfund program they were putting something in place they couldn't implement and there was very little enforcement activity.

Question: You has stated you see a need for greater interactions with the Forum, but there has been a marked decline in RCRA participants. They just don't have the time.

Answer: Heard that at the Ground Water Forum this morning and know it's true. His presence here today is an indication that will change.

Question: What will you do if you don't get technical support?

Answer: It's a problem. You can't force people to say "yes" when it's not.

OSWER Topics Matt Charsky, U.S. EPA/Office of Emergency and Remedial Response, John Kingscott, U.S. EPA/Technology Innovation Office

Matt Charsky provided an overview of activities and related guidance development underway within OERR. Overall, OERR is conducting 15 projects addressing hazardous waste issues:

- *Contaminated Aquatic Sediment Remediation Guidance*: Technical guidance for RPMs in the development and evaluation of remediation alternatives for contaminated sediments in streams, lakes, harbors, wetlands, and ocean margins. Four sub-groups are addressing monitored natural attenuation, capping, dredging, and no-action alternatives

Contact: Ernie Watkins (703-603-9011)
Sherri Clark (703-603-9043)

Target Date: Summer 2000 (regional review)
Fall 2000 (public comment)
October 30, 2000

- *Fact Sheet: Mercury in Soil*: Guidance on sampling techniques for mercury and response strategy, including available treatment technologies

  Contact: Craig Beasley (703-603-9015)

  Target Date: August 31, 2000 (internal draft)
  January 1, 2001

- *Filtration of Ground Water Samples*: EPA policy that clarifies ground water sampling issues while providing flexibility for handling diverse Superfund issues. Policy will be coordinated with the RCRA Handbook

  Contact: Daniel Thornton (703-603-8811)
  Rob Hitzig (703-603-9047)

  Target Date: September 1, 2000

- *Landfill Guidance and Regional Support*: Updated guidance on RCRA/CERCLA final covers for landfills, which will address designs, lessons learned, and long-term maintenance

  Contact: Ken Skahn (703-603-8801)

  Target Date: Summer 2000 (workgroup review)
  December 30, 2001

- *Methods for Assessing Landfill Gas Emissions and Health Risks at Superfund Landfills*: Report that addresses approved sampling methods for constituents typically found in landfill gas, recommendations on characterization techniques, and health risk assessment approaches

  Contact: Andrea Mclaughlin (703-603-8793)

  Target Date: [to be determined; second internal draft underway]

- *Presumptive Remedy Directive Update: VOCs*: Evaluation of whether presumptive remedies for volatile organic compounds (VOCs) in soil require update to reflect performance of new technologies

  Contact: JoAnn Camacho (732-906-6916)

  Target Date: May 1, 2001

- *Presumptive Remedy for Radionuclides*: Development of presumptive remedies for radionuclides, based on similarity to metals in soils

  Contact: Andrea Mclaughlin (703-603-8793)

  Target Date: April 30, 2001

- *Presumptive Remedy Policy Directive: Alternative Landfill Covers*: Directive that identifies criteria for determining whether an alternative cover is a viable remedial option at a CERCLA landfill

  Contact: Andrea Mclaughlin (703-603-8793)

  Target Date: [to be determined; subsequent to completion of updated guidance on RCRA/CERCLA landfill covers]

- *RAGS: Probabilistic Risk Assessment Guidance*: RAGS (Volume 3) guidance and tools for probabilistic analysis in risk assessments; public comment ended April 21, 2000; modeling workshops scheduled at various locations

  Contact: Steve Chang (703-603-9017) Target Date: July 2000 (external peer review); September 30, 2001

- *RAGS: Using Background in Risk Assessment*: Guidance on technical methods for estimating background constituent concentrations at NPL sites and on risk management options; first draft only applicable to soils

  Contact: Sherri Clark (703-603-9043) Target Date: Fall 2000

- *Relation of Groundwater and Land Use for Remedy Decisions*: Policy on the relationship between future ground water use and future land use for remedy decisions; first internal draft available for review

  Contact: Stuart Walker (703-603-8748) Target Date: June 30, 2000

  In response to OERR's request for feedback during the TSP meeting on whether this policy would be useful, comments indicated that such policy would be helpful in addressing inquiries commonly placed to EPA regions. Meeting participants also agreed that a Headquarters memorandum is warranted to provide assistance to the Regions in addressing technical impracticalities, potential drivers for remedy decisions, and the role of drinking water quality in remedy decisions. Headquarters representatives indicated that OERR does not wish to formalize additional technical impracticabilities addressing potential ground water/land use decisions, and recommended that such issues be addressed on a site-specific basis.

- *Woodtreaters Presumptive Remedy: Users' Guide and Potential Update*: Evaluation of the need to update presumptive remedies (excluding ground water contamination) for wood treatment facilities (excluding federal facilities), and development of a users' guide to provide information on dioxin-related issues

  Contact: Frank Avvisato (703-603-8949) Target Date: internal final draft under review; external draft may be issued by June 2000

- *Institutional Controls: An RPM's Guide to Identifying, Evaluating, and Selecting ICs at Superfund and RCRA Corrective Action Cleanups*: Fact sheet providing an overview of ICs commonly used and an outline of factors to be considered when evaluating ICs as part of a remedy; available for review at http://intranet.epa.gov/oerrinet/review/index.htm.

  Contact: Michael Bellot (703-603-8905) Target Date: comments from EPA regions, states, and tribes due May 10, 2000

- *Soil Screening Guidance for Radionuclides: User's Guide and Technical Document*: Guidance for screening site areas, exposure pathways, and radionuclides of concern

Contact: Stuart Walker (703-603-8748) Target Date: April 2000; regional review anticipated in May 2000

- *Long-Term Monitoring of Monitored Natural Attenuation Remedies*:

Contact: Herb Levine (415-744-2312) Target Date: [to be determined; currently under workgroup development

John Kingscott summarized key activities underway within the Technology Innovation Office (TIO):

- *State Dry Cleaning Initiative*: TIO is sponsoring activities of the newly-formed State Coalition for Remediation of Dry Cleaners. The coalition represents an effort to facilitate progress in states that are implementing existing dry cleaner remediation programs (Connecticut, Florida, Illinois, Kansas, Minnesota, North Carolina, Oregon, South Carolina, Tennessee, and Wisconsin) and to assist other states in establishing formal programs. Among its various plans, the Coalition aims to: (1) develop model legislation for the dry cleaning industry; and (2) exchange technical information on cleanup activities taken at dry cleaner sites. Case studies, the results of a state survey, cost data, innovative technology updates, and other related technical information are available on TIO's CLU-IN website at: www.clu-in.org.programs. Rich Steimle (TIO) may be reached at 703-603-7195 or steimle.richard@epa.gov for additional information on this initiative.

- *Manufactured Gas Plant Initiative*: Although few manufactured gas plant (MGP) sites are listed on the NPL, as many as 50,000 are located in the U.S. TIO developed this initiative in an effort to: (1) address hazardous waste constituents and problems common to MGP facilities; (2) take advantage of a potential economy of scale resulting from multiple-facility ownership by certain utility companies; and (3) utilize the extensive expertise available from MGP trade associations. TIO has developed an associated document, *Compendium on Expediting Site Characterization and Remediation at Manufactured Gas Plant Sites*, which soon will be released and available on the CLU-IN Website. This compendium will address related case studies, site characterization, remediation, administrative issues, and specific technologies. Additional information is available from Kingscott at 703-603-7189 or kingscott.john@epa.gov.

- *Optimization of Ground Water Pump-and-Treat*: This initiative focuses on facilitating the optimization of pump-and-treat technology for ground water remediation. Efforts concentrate on four components of the initiative:

  (1) *Hydraulic flow optimization*. This strategy involves the use of new technologies and systems to optimize pumping locations and rates. The results of optimization studies conducted at three diverse sites are available (as two volumes) on the CLU-IN Website.

  (2) *The Environmental Security Program.* Application of pump and treat optimization techniques to remove specific constituents is underway at three DOD sites, with final results expected to be released in 2002.

  (3) *Geostatistical studies.* EPA is examining various monitoring regimes for pump and treat applications in order to identify methods for reducing sampling redundancy. Dion Novak or David Wilson (Region 5) may be contacted at 312-886-4737 or 312-886-1476, respectively, for information specific to this work.

  (4) *U.S. Army Corps of Engineer study*. Site-specific study results, which may be available in September 2000, will be used to help screen fund-lead Superfund sites at which optimization systems may be employed and to identify additional cost savings potentials and optimization technologies.

  Kathy Yager (TIO) serves as the EPA Headquarters contact (732-321-6738 or yager.kathleen@epa.gov) for these and other pump-and-treat optimization developments.

- *National Action Plan for Removal of DNAPLS*: The National Action Plan for Removal of DNAPLS is a new program established by the Federal Remediation Technologies Roundtable. The Roundtable is an inter-agency federal group that meets semi-annually to identify projects that may be implemented jointly to address environmental issues. Examples of past or ongoing Roundtable efforts to address hazardous site issues, which are described on the Internet at www.frtr.gov, include a sampling and analysis matrix, remediation screening matrix, and a compendium of 200 case studies on remediation technology demonstrations. The Roundtable participated in recent success at the Visalia Pole Yard in Visalia, CA, whereby innovative technologies are in use to remove DNAPLs. This work has led to efforts to identify other sites at which innovative technologies such as steam injection, six-phase heating, and co-solvent flushing are employed for DNAPL removal. The Roundtable is establishing an expert panel to provide technical assistance in DNAPL issues and to help address administrative problems at sites with DNAPL contamination. Jim Cummings (TIO) may be reached at 703-603-7197 or cummings.james@epa.gov for additional information.

- *Measurement and Monitoring for the 21st Century (21M²)*: Recognizing the need to identify improved techniques for measurement and monitoring (M^2) at hazardous waste sites, TIO has initiated a program that focuses on field analysis of measurement and monitoring techniques employed in the field. To date, approximately 12 projects have been identified for inclusion in this program, and additional projects are under solicitation by TIO. Examples of M^2 projects include Pneulog™ testing for soil vapor extraction, monitoring of continuous particulate emissions, coordination of sensor technology developers with equipment vendors, and improved use of the Agency's Small Business Innovation Research Program for cleanup technology needs. In order to avoid slowing the development progress of innovative technologies such as these, TIO does not validate technology performance under this initiative, but gathers from involved vendors key information that is made available to technology users. Dan Powell (TIO) may be reached at 703-603-7196 or powell.dan@epa.gov for additional information.

- *DNAPL in Fractured Rock*: EPA has entered into a memorandum of agreement with Canada to share information on cleaning DNAPL in fractured rock. Accordingly, Canada will host an international conference in Toronto during the spring of 2001 to discuss new DNAPL research, models, and verification. EPA will convene a workshop in Connecticut prior to the conference in order to prepare information to be shared at the conference. This initiative includes recent development of a Website that will allow users to enter specific technology information that may be shared easily by others. To date, data on 18 sites has been entered into the information system. Persons wishing to share their technical expertise in this area are invited to contact Rich Steimle (TIO) at 703-603-7195 or steimle.richard@epa.gov.

GROUND WATER FORUM

KABIS Samplers, Tom Kabis, Sibak Industries

The KABIS sampler is a discrete depth stainless steel bailer that introduces VOA vials directly to the screened area. It comes in two sizes: 3-inch wide for 4-inch or wider wells; and 1.75-inch wide for 2-inch wells. The bullet-shaped bailer unscrews into a top and bottom piece. The top piece holds a rack where three (3-inch bailer) or one (1-inch bailer) open VOA vials can be screwed in place where they will fill directly with the overflow going into the bottom of the bailer. The 3-inch bailer can also be fitted with a 1-liter bottle.

The bailer is then screwed together and lowered down a well to the depth at which the sample is to taken. There is no purge, and the sampler relies on a net flow through the well screen. There are two small capillary tubes that have been drilled into the cap. As long as the bailer is moving, Sibak claims that surface tensions at the tubes will keep water from entering the bailer. The bailer needs to be lowered at a constant rate. When the bailer stops moving, the pressures are overcome and the bailer fills through one tube while air exists through the other. It takes 2-3 minutes to fill the smaller bailer and 4-6 minutes to fill the larger one. The bailer is then brought to the surface where it is unscrewed, and the VOA vials are retrieved and capped. If extra water is needed for other sample measurements, the volume below the bottles is available for pouring into sample containers.

Sibak markets a special VOA cap that has an inner liner shaped like a cone. This design pushes the excess water out of the bottle and forms a bubbleless seal. For additional water at the same depth, the sampler can be lowered into the well without the VOA vials to obtain more volume.

To show that water was not entering the bailer as it descended into the well, Sibak attached a video camera just above it. The camera film indicated no escaping bubbles until the sampler was stopped. The KABIS sampler as been used at depths up to 800 feet at Hanford. The sampler is currently going through the Environmental Technologies Verification (ETV) Program, and Sibak expects a positive report.

For more information, consult www.Sibak.com.

Questions and Answers

Question: What happens if the bailer gets hung up in the well while being lowered?

Answer: If the bailer does not descend for more than 5-10 seconds while it is being lowered, then it needs to be brought up and examined.

Question: With this device, it appears you need to know where the highest concentration is in the screened interval before you sample.

Answer: Vertical profiling will be needed to determine if there is a concentration gradient within the interval. If vertical profiling is done, you need to start at the uppermost sampling point and work down because the exhaust bubbles will disturb the water above the sampler.

At the Burke site in PA, vertical profiling was done with the Kabis sampler, and a few days later the EPA purged three volumes and sampled the well with bailers. A comparison of the analytical values showed that the values were comparable.

Question: When more than one atmosphere of pressure is put across both holes, won't this compress the air inside and allow water to enter without showing any bubbles?

Answer: We don't think so.

A New Low-Cost Multi-Level Ground Water Monitoring System, Murray Einearson, Conor Pacific

One of the major problems with placing multi-port samples is in sealing the joints between casing sections so that water at different levels does not mix and potentially contaminate the discrete sample. The continuous modular tubing (CMT) system solves that by custom making the well with a continuously extruded medium density polyethylene (MDPE) casing material. This custom-built tubing used by Conor Pacific has seven chambers: six outer chambers with a single circular one extending down the center. This allows for seven separate depths to be sampled. The maximum depth of the well is dependent upon the maximum length the manufacturer can extrude and ship.

Sampling depths are chosen to sample the most permeable areas. Holes are drilled at the appropriate depths into the tubing, and a screen is attached across them. In Einearson's experience, the screened intervals have ranged from 4 inches to 1 foot. To seal the chamber, another hole is drilled below the screen and a hot melt polyethylene plug is inserted. Conor Pacific was concerned with the integrity of the seal, so tests were performed to determine its ability to withstand various water pressures. To prevent low viscosity air below the seal, another hole can be drilled and the chamber will eventually fill with water.

The CMT well can be installed in two different fashions. The first is to lower the tubing with appropriate centering devices into an open borehole. The well is then completed by tremieing alternate layers of sand and bentonite slurry. The problem with this method is ensuring that the layers are placed at the appropriate depths. The second method, which Einearson prefers, is to complete the well above ground. In this method, polyethylene mesh bags are filled with sand or bentonite chips and attached to the tubing at the appropriate spacings around the screen locations. The tubing is then fed down a cased borehole (preferably sonic or dual-cased reverse air rotary percussion drill rigs). The bentonite plugs are sized to be snug against the casing wall so when it is withdrawn, the bentonite provides a good seal with the formation as it swells.

First Case History: Conor Pacific was retained by several oil companies to address MTBE releases in the Charnock Basin in Santa Monica, California. The releases had caused the City of Santa Monica to shut down its water supply wells. An ongoing investigation had placed a number of conventional monitoring wells in the area. Conor Pacific's investigation assessed the representativeness of the samples from these wells. They installed a 200-foot CMT well that was completed at the surface before being lowered into the casing of a sonic rig. Seven depths were monitored; the screens were placed after evaluating the drilling logs of the previously placed conventional monitoring wells and those of the CMT boring. The cost of installing the CMT well was about a quarter of a conventional well of the same depth ,and this well allowed monitoring of seven discreet levels.

The analysis of the boring logs indicated that the screens of the conventional wells (10 and 15 feet long) were bridging several permeable zones, and their results were likely to reflect a composite sample. Water

samples from the various CMT well intervals were collected with a WaTerra check valve pump and analyzed. The results of the analyses showed that there were permeable areas that had much greater concentrations of MTBE than were being reported in the conventional wells. The conventional well samples were giving an almost exact mathematical composited average. Furthermore, each of the seven sampling ports of the CMT well appeared to be supplying accurate head data.

Questions and Answers

Question: What was the sampling method used in the traditional wells?

Answer: A Grundfos downhole pump was used to purge the wells, and a bailer was used to sample them.

Question: Are there any affects of having the sampling port open in only one direction with respect to ground-water flow?

Answer: I don't think so. The purpose of the sampling is to obtain a sample at the opening, not sample over a large area. However, since there is only one opening, there isn't any flow through and the well does have to be purged.

Question: Were there any problems when pulling the casing, such as having the well come up with it?

Answer: Not to date, but we are aware of the potential problem and are very careful during the withdrawal process.

Question: Any there head differences between the CMT wells and the traditional ones?

Answer: No. The Charnock Basin is essentially a big bowl that is filling up. There is virtually no vertical gradient and very little horizontal gradient.

Question: Do you develop your wells?

Answer: Yes, using nitrogen lift with vacuum extraction. This system achieved a rate of over 1.2 gpm.

Question: What type of tubing is used for the pumps?

Answer: Dedicated Teflon™.

Second Case History: Release of fuel at a service station caused a the shut down of a nearby water bottling company. This release required a quick response. The investigation plan was to place a transect of wells on 25- to 30-foot centers across the path of the suspected plume. The driller was requested to furnish sufficient casing that it could be left in the ground while he went on to drill other borings. This way, the CMT wells could be built on the surface and placed while other borings were being drilled. They were able to install14 wells in 4 days for under $40,000. The average depth of these wells was 60 feet, with the deepest being 120 feet.

This type of deployment allowed for the calculation of the flux of the contaminants. A definition of the flow system (large number of discrete head measures with depth) was obtained, and the MTBE/BTEX plume was defined in three dimensions. The closely spaced monitoring points reduced uncertainty.

Continuous Modular Tubing (CMT) Wells, Jim Pianosi, Solinst Canada Ltd.

Jim Pianosi indicated that there is a new 2**d**-inch outer diameter CMT designed to have the space cut up into ¾-inch interior quarters for sampling four zones. The purpose of this design is to allow for a larger selection of off-the-shelf sampling equipment to be used. Solinst considered trying to make it larger, but 2**d** inches is about as large as the CMT can be made and still coil. The larger size has not been fully deployed, and Solinst is currently working on the design. Since it does not have the multiple walls that the 7-port well has, Solinst wants to ensure that the 90-degree walls are sufficiently strong to prevent any caving from packer or bentonite pressures.

For those who want to save time during the CMT well construction process, Solinst distributes pre-packed screens and bentonite seals. The screen unit comes with an inner screen to fit against the wall of the CMT with a sand pack around it, and an outer screen to allow water to pass through. The unit is slipped over the tubing down to the area where the port has been drilled and fastened. The bentonite seals are also designed to slip over the tubing where they are placed below and above the screen.

If the well designer prefers, Solinst also has developed double-acting packers that can be installed above and below each port. They are connected along the string by tubing and can be inflated using water or air. The packers are about 1-foot long. Longer packers were tested but were too difficult to move along the tubing. Packers can also be used to set off areas in the unsaturated zone if desired. The double-acting part of the packer was needed because the packers had to slide over potentially large lengths of CMT. Hence, an inner bladder that fits against the tubing can be sufficiently evacuated so that it will pull away from the wall and allow for easy sliding. When the packer reaches the appropriate location, the vacuum is released and the inner bladder again rests against the tubing.

The other multi-port sampling system that Solinst carries is the Waterloo system. Its disadvantage to the CMT is that it has many joints. These joints are slip fitted rather than threaded and have been tested to 250 psi. Pumps and pressure transducers can be dedicated at each port. The Waterloo system can be used with both permanent and removable packers. The removable packers are carbon-reinforced gum and filled with either water or air.

Questions and Answers

Question: How many ports can be put in the Waterloo system?

Answer: The maximum number of ports with a pressure transducer and pump is seven. The maximum with only a pump is 12, and the maximum with only a transducer is 24.

Question: Have there been tests on the flexible tubing materials for compatibility with the chemicals in water and their ability to diffuse and move in the materials?

Answer: Solinst has not done any testing.

Question: Regardless of the length the manufacturer can extrude, what do you think is the maximum depth of the CMT?

Answer: 500-600 feet.

Question: Are there an buoyancy problems if there is a large unsaturated zone?

Answer: We haven't encountered any.

Conclusions of the New National Research Council Report on Natural Attenuation, Jackie MacDonald, RAND Corporation

Jackie MacDonald presented the conclusions of the new National Research Council report entitled *Natural Attenuation for Groundwater Remediation* on behalf of the NRC. She noted that Perry McCarty at Stanford University requested the review because he believes that the concept of natural attenuation was being taken too far.

There is an increasing number of sites that are relying on natural attenuation alone for cleanup of both fuel-related releases (over 15,000) and chlorinated organic compounds. The NRC's report (available at www.nap.edu) was based on a review of the technical literature (as of 1998), four public meetings with testimony from various stakeholder groups, and a review of most existing (14) written natural attenuation protocols and policies. The latter were written by a variety of organizations including federal and state agencies, private companies, industry.

The report looked at four major areas of concern:

- Community concerns about natural attenuation
- Scientific basis for natural attenuation
- Approaches for evaluating natural attenuation
- Protocols for documenting natural attenuation

Community Concerns about Natural Attenuation

At sites where communities are aware of ground-water contamination, community representatives often express significant reservations about using natural attenuation as a remedy. Community leaders interviewed as part of the study expressed special concern that natural attenuation allows responsible parties to save on cleanup costs while exposing the community to undue risks. The report made the following recommendations:

- At sites where natural attenuation is proposed as a formal remedy for ground water contamination and where the contamination affects a community, environmental agencies and responsible parties should provide the community with clear evidence indicating which natural attenuation processes are responsible for the loss of contaminants.
- Federal and state environmental regulations and guidelines for cleaning up contaminated sites affecting communities should be changed to allow community involvement as soon as the presence of contamination is confirmed.
- Environmental regulatory agencies and site owners should encourage affected community members to become involved as advisers in decision making and oversight at contaminated sites with the potential to affect the community.
- The EPA, state environmental agencies, and responsible parties should ensure that interested community groups can obtain independent technical advice about natural attenuation and other potential remedies.
- Environmental regulatory agencies and responsible parties should ensure that interested community members can obtain all data concerning the contamination and potential remedies at sites where communities are affected by ground-water contamination.

Scientific Basis for Natural Attenuation

The report examined natural attenuation of all compounds, not just fuels. It states that an increasing number of proposals to use natural attenuation in place of or in conjunction with engineered systems for

cleanup are being received by regulators for a wide variety of contaminants including chlorinated organic chemicals, explosives, metals, and radionuclides. It concludes that although natural attenuation has been well-documented as a method for treating the fuel components benzene, toluene, ethylbenzene, and xylenes (BTEX), it is not well established as a treatment for most other common classes of ground-water contaminants. There is a table associated with the report entitled "Likelihood of Success of Natural Attenuation." It lists chemical classes, the dominant attenuation processes, the current level of understanding (high—good scientific and field data; moderate—confirmed field studies but the mechanism of action poorly understood, and low—no proof), and the likelihood of success given the current level of understanding (high—expected to be effective at 75% of sites it is tried at; moderate— effective at 50% of sites; and low—effective at 25% of sites). After evaluating the literature, the NRC report makes the following major conclusions:

- Natural attenuation is established as a remediation approach for only a few types of contaminants, primarily BTEX.
- Natural attenuation should never be considered a default or presumptive remedy.
- To achieve remediation objectives, natural attenuation may have to continue for many years or decades.
- Natural attenuation of some compounds can form hazardous by-products that in some cases can persist in the environment.
- The presence of contaminant mixtures can enhance or inhibit natural attenuation of any one component of the mixture.

Approaches for Evaluating Natural Attenuation

The NRC report concluded that documenting a decrease in contaminant concentrations is never sufficient to claim natural attenuation is occurring. If the claim that natural attenuation is occurring is to be credible, geochemical and degradation footprints need to be documented, and the site should have a conceptual model showing good understanding. The following recommendations were made:

- At every site where natural attenuation is being considered as a formal remedy for ground water contamination, responsible parties should use footprints of natural attenuation processes to document which mechanisms are responsible for observed decreases in contaminant concentration.
- Responsible parties should prepare a conceptual model of sites being considered for natural attenuation to show where the ground water and contamination are moving.
- Responsible parties should analyze field data on natural attenuation at a level commensurate with the complexity of the site and contaminant type.
- A long-term monitoring plan should be specified for every site at which natural attenuation is approved as a formal remedy for contamination.

Protocols for Natural Attenuation

The NRC report found the protocols uneven and inconsistent. A table that provides an evaluation of each protocol against 14 criteria. The following recommendations were made for improving the protocols:

- The EPA should lead an effort to develop national consensus guidelines for protocols on natural attenuation.
- The national consensus guidelines and all future natural attenuation protocols should be peer reviewed by independent experts who are not affiliated with the authoring organization.
- The national consensus guidelines and future protocols should eliminate the use of "scoring systems" for making decisions on natural attenuation.
- Developers of natural attenuation protocols should write easy-to-understand documents to explain the protocol to nontechnical audiences.

- The EPA, other federal and state agencies, and organizations responsible for contaminated sites should provide additional training on natural attenuation concepts for interested regulators, site owners, remediation consultants, and community and environmental groups.

Questions and Answers

Question: Is the level of understanding for a site is understood not just to be chemical or what happens in a laboratory setting but the processes occurring at an individual site?

Answer: Yes it includes full understanding of the site characterization. At the meeting attended by state regulatory personnel, a number of them indicated that they could tell whether or not natural attenuation was occurring by looking at concentration data over a couple of years. This was disturbing to the committee (even industry members) and they wanted to make it very clear in this report that concentrations alone cannot be used to tell if natural attenuation is occurring.

Question: Does the report distinguish between chemical and physical attenuation?

Answer: Yes, both were considered.

Question: Does the report address hydrogeological settings in terms of high, medium, and low success?

Answer: No. This would have required a large table. However, the report does point out that some will work in most situations and some won't.

Question: Does the report include any work on natural attenuation in fractured rock?

Answer: No.

Question: What is the committee's view on EPA's role in this effort?

Answer: EPA needs to provide guidance on what to look for. They did not recommend that EPA develop protocols.

Question: Did the various protocols get evaluated to determine if they would arrive at the same endpoint?

Answer: No.

Question: Does the report have dissident (i.e., activists') opinions?

Answer: No, but it was written in a fashion to explain things in terms lay people could understand.

Comment: The report is very conservative in that it states the only scientific evidence to support natural attenuation is with BTEX and some chlorinated solvents. It also recommends that multiple lines of evidence be used for all sites. This raises the bar since EPA protocol does allow only historical data to be used.

Comment: The protocol needs to address steps that are generally done well versus steps that are not generally done well (e.g., community involvement, source characterization, and source control). There is a need also to find better ways to monitor sites given that source control and characterization aren't likely to

improve dramatically. There needs to be a contingency plan in place if the natural attenuation appears to be failing.

Use of Geophysical Methods in Contaminated Fractured Rock—Tool Box Approach, Pete Haeni, U.S. Geological Survey

Pete Haeni noted that geophysics is a small part of the fractured rock investigation "pie." It is important to use multiple approaches and integrate the findings when trying to determine ground-water flow in fractured rock. Without the integration, incorrect conclusions most certainly will be drawn.

Haeni advocates the tool box approach—using multiple methods to reduce uncertainty. The data can then be used to improve the conceptual model and to choose where to place sampling and test locations. Benefits of the tool box approach are improved site characterization, much better sampling locations, efficient remediation and monitoring design, and determination of feasibility for remediation. There is no "silver bullet" in geophysics; an investigation must utilize different tools and one should not believe anyone who says one method will tell all.

Haeni's approach to a contaminant problem in fractured rock includes the following elements:

- Review any available historical data
- Look at regional geology
- Perform surface geophysics
- Conduct drilling and utilize fracture cross contamination mitigation measures
- Perform borehole geophysics
- Perform hydrologic testing and tomography
- Perform discrete interval sampling
- Perform chemical sampling

Surface geophysics is a very good tool at sites where not much information is known. It will give good areal information and help optimize boring locations. Methods of surface geophysics include:

Seismic reflection: Seismic reflection is a good tool for locating containers. However, it won't indicate where low-level contaminants are.

Direct current resistivity: Two-dimensional resistivity is a new tool that has only been around for a couple of years. It is a good electrical method for imaging electrical conductance to identify clays, certain rocks, and certain contaminants and for detecting, mapping, and monitoring conductive fluids. Automated data has improved the accuracy of this method.

Azimuthal resistivity: Azimuthal resistivity is a surface technology with directional capabilities (i.e., it gives different readings along a fracture than across it.) The data can be used to plot fracture depth and direction to come up with a gross idea of anisotropy. It takes about one day to complete one circle. This tool is used early on in an investigation.

Electromagnetics: EM-34 is very good for fractured rock. It can detect conductance abnormalities due to contaminant plumes, or in the case of crystalline rock, due to water-bearing fractures. Stated he would worry if he saw on his site a contractor using an EM-34 with the same sized coils as this is probably an old piece of equipment with less resolution. The modern equipment has a large and a small coil. By crossing a site with the coils parallel to the ground as opposed to perpendicular a vertical dipole is created that a measurement of vertical conductivity.

Borehole geophysics also is an excellent tool for fractured bedrock investigations. Conventional logging, such as gamma, resistivity, caliper, temperature logs, should always be done. Radar methods allow one to look beyond the borehole wall. This technique can measure 20-40 meters into crystalline rock to obtain strike and dip data of fractures. Radar does not perform well, however, in conductive fluids or materials such as shales and red rock.

Acoustic televiewer: An acoustic televiewer uses sound in water to provide images of the wall, not fractures.

Optical televiewer: An optical televiewer gives fracture and structural orientations and can be used to orient cores. It should always be used in tandem with an acoustic televiewer; that is, a feature should appear in both images to be considered. Software that accompanies the televiewer forms a virtual borehole image that can be rotated and viewed from any angle. New software called Wellhead allows both core images to be put up on a screen at the same time to be compared.

Flow meters: Flow meters detect ground-water flow through a borehole. It is recommended that they be used under both static and pumping conditions because they can miss fracture zones if only used under static conditions. Flow meters can generally detect transmissive zones and determine relative vertical hydraulic gradients.

Heat-pulse flow meter: goes beneath a fracture that you have identified under pumping conditions and measure flow then go above and continue this up borehole. The pumping gives a constant vertical flow and the flow meter is used to see if any horizontal flow is entering the system and where.

In interpreting borehole data, it is important to be aware of any borehole deviation from vertical. The borehole should be checked to see how far off center it is. Haeni noted an example of a borehole drilled in New York that was 800 feet deep and 200 feet off center.

Cross contamination of different fracture zones must be prevented during borehole geophysics and sampling activities. When sampling open boreholes, it is important to aim for discrete interval samples. Most fracture systems have some element of vertical flow, and the amount of vertical flow is related to different heads in each fracture system. Integrated heads are dominated by the most transmissive zones. When the borehole is open, the fractures are capable of cross contaminating each other, and once this happens samples becomes composites of several different zones. This can lead to misleading results.

Once a fracture become contaminated it is difficult to clean it up due to matrix diffusion. Cross contamination of fractures was found to have occurred at a boring in sedimentary rock that was kept open for about 3 or 4 days. The well subsequently was pumped for over a year, and contaminant concentrations never returned to background. There are a couple of ways to try to prevent cross contamination in an open borehole. The FLuTE system is a flexible, invertible, plastic liner that is placed in the hole immediately after drilling to prevent ambient flow and stop cross connections. The plastic tubing is lowered into the well as it is being filled with water. The water presses the plastic against the borehole sides and stops ambient flow.

The advantages of these liners are that they stop cross contamination and improve fracture sampling. The disadvantages are that a lot of water is pumped in and out, and one can’t be certain that truly ambient water is being sampled. A clear liner that can be used in conjunction with an optical televiewer is currently being tested to locate fracture zones and other features that will allow for a quicker installation of a fully functional continuous modular tubing (CMT).

A new approach being tested is to use the CMT with inflatable packers. As soon as a boring is completed, caliper and temperature logs are run to get a rough estimate of the locations of flowing fractures. Then a blank CMT is run with packers set according to where these producing fractures are. The downhole geophysical equipment is prepared and the CMT is pulled. The next step is to run the measurements and then replace the CMT and re-inflate the packers. The data are examined and the permanent CMT design established. Finally the CMT is pulled again, screens and packers positioned as determined earlier, and the CMT well is now reinserted.

Radar tomography can be used to locate fractures that don't intercept the borehole, and software can provide the strike and dip of these fractures. Radar tomography identifies low-velocity zones indicative of water. Time-lapse tomography can be used to identify connecting fractures between boreholes. In an example of the use of time-lapse tomography, a 20-liter slug of a 5% NaCl solution was injected into an upgradient borehole while a down gradient one was steadily pumped. Tomography was performed between two boreholes lying on a line perpendicular to the theoretical flow path. The tomography image indicated that the salt solution followed a long arcing pathway before getting to the pumping well.

For more information on geophysical applications, consult www.usgs.gov/ogw/bgas.

Questions and Answers

Question: Suppose you have optimized well configurations for a pump-and-treat system, can you use this system to determine if you have achieved containment?

Answer: You might be able to do a salt tracer test, and it would tell you where the plume was flowing and if it was going beyond your capture zone.

Question: Crystalline rock you said you weren't able to correlate transmissive fractures with any sort of fracture mechanic type fracture sets.

Answer: Yes. They have also done outcrop analysis and gone back into the rock with poor results.

Question: Monitoring Natural Attenuation?

Answer: Can't really extrapolate from one place to another. For example if you locate a contaminated area and you think it is flowing in a given direction you might be able to figure out where to place a down gradient well to intercept part of that plume. But with MNA you will need to know what is happening between those two points and that is a very different problem. If you want to place a transect across the flow direction with the intention of understanding the rate of MNA he doesn't believe you can do it with any confidence. Their test site wells are 10 meters apart and it is very difficult to draw fractures from one well to the next.

Someone mentioned that the answer to MNA may be to do the transect and average the data to see where it is going rather than look at individual points.

Question: You mentioned you can get false positive with the acoustic televiewer?

Answer: Yes an example he has seen is in a limestone where a calcite filled fracture looked exactly like an open fracture. So you need the Optical televiewer to confirm. You can get a feature that is not a fracture.

Characterizing Advection and Diffusion in Fractured Rock, Allen Shapiro, U.S. Geological Survey

Allen Shapiro began by comparing unconsolidated and fractured rock permeability differences within a given unit due to channeling. For example in an unconsolidated sand and gravel, an order of magnitude of difference might be expected (10^{-4} to 10^{-5}) while in fractured rock like a granite or schist differences of six orders of magnitude (10^{-4} to 10^{-10}) are typical with no normal distribution.

Spatial persistence is another difference between rock and unconsolidated media. In an unconsolidated sand and gravel aquifer one can ask what is the probability that a point twenty feet from a point with hydraulic conductivity data will have a similar hydraulic conductivity. Hydraulic conductivity can be measured at a few points and a covariance developed to predict the uncertainties with some accuracy. With fractured rock this concept does not exist; covariance comes out as noise. Data cannot be predicted with any certainty unless it's within a well-oriented fracture.

There has been a lot of work to investigate and predict dispersion in unconsolidated material and with some success; however, this work does not apply in fractured rock. To determine flow direction in unconsolidated materials, a hydraulic plane can be drawn between head measurements taken at three points and the direction calculated. The vertical component of flow can be determined with wells set at different depths. In fractured rock, head measurements are generally meaningless because it can never be certain that the measurement points are connected. Shapiro gave an example of a well with three fracture zones producing water. Each zone was packed off and had a stand pipe set in each. The head of each zone decreased with depth. However, this did not necessarily mean that there was a downward gradient in the system because the fracture zones may have not been connected. If the zones were connected, then there would be a downward gradient.

Shapiro has developed a modular system to measure hydraulic head, collect water for chemical sampling, estimate hydraulic properties using three types of methods, and perform single well tracer tests. The system can be shipped to various sites and set up easily. If the Ground Water Forum members have sites they would like to use this equipment, Shapiro would like to discuss the possibility.

In showing slides of granites and schists in Mirror Lake, New Hampshire, Shapiro pointed out that the granites have more fracturing. However, this did not necessarily mean that they have more flow; the schists were just as likely to be as permeable. He tested boreholes with a heat pulse flow meter which he estimates will pick out the top 1 to 1½ order of magnitude of hydraulic conductivity over the length of the well; the meter will miss the lesser producing fractures. This may be sufficient for the projects needs, but in some cases it may be valuable to evaluate all the producing fractures and compare their variability. This is especially true in contaminated situations where the remedy may be flushing the high flow zones but not the lower permeability ones. He restated the fact that fracture density does not necessarily translate into high permeability.

Having tested all the fractures in the boreholes for hydraulic conductivity, the results yielded points in space that could not be assumed to be connected; the points were linked using seismic tomography to image the fractures between the boreholes. Seismic tomography interprets the speed of a wave through the rock to a number of receivers located in the other boreholes. Faster arrivals would indicate more intact rock, the slowest, the least intact, with some anisotropy effects. The correlation between the seismic speeds and hydraulic conductivity is not exact, but does give the investigator a place to start in building a conceptual model.

The next step was to pack off the fracture zones and conduct a pumping test. Observations during a pumping test in fractured rock are not what is typically seen in tests in unconsolidated material where smaller drawdowns are observed with increasing distance from the pumping well. With this test, various wells and fracture zones had identical drawdowns regardless of distance from the pumping well. With this information a conceptual model was created. The pumping test data revealed that there are zones of high hydraulic conductivity in the rock, but they are connected by zones of much lower conductivity. There is not one main fracture but many sub-horizontal fractures. They are connected by other systems of less fractured zones with no direct pathway.

The finite difference model MODFLOW was used to model the site. Other models are available, and the most appropriate will depend on site-specific needs.

Chemical transport in fractured rock occurs through advection along fractures, diffusion into the rock matrix itself, and diffusion into lower permeability fractures associated with the high permeability ones, with some of them not being continuous. The porosity of the granite at Mirror Lake is surprisingly high—on the order of 1-2%. A check of the literature confirms these numbers for granites and schists. This has a big impact on remediation since cleanup times may end up being driven by diffusion rates.

Can one use estimates of matrix diffusion obtained in laboratory core samples to estimate field conditions? Investigators conducted tests with different tracers with different diffusion coefficients. It was expected that distinct recovery rates would result, but they didn't. If the results were truly diffusion driven, then the rates in the field would have been 2-3 orders of magnitude greater than those in the laboratory. However, investigators had not accounted for the low permeability fractures associated with the high permeability zones. While materials that entered these fractures would emerge much more quickly than those that diffused into the matrix, it would not be a fast process. In addition, diffusion into the rock matrix would also occur in these lower permeability zones, and diffusion out would be slower than in the high hydraulic conductivity zones.

In summary:

- In characterizing fractured rock, one cannot rely on one technique to do it.
- Spatial heterogeneity is much different than for unconsolidated aquifers.
- Advection and direction cannot be calculated with hydraulic heads.
- Dispersion approaches used in unconsolidated materials do not work in fractured rock.
- Diffusion into lower permeability zones occurs and can be likened to that in clays.
- Characterization is about getting to a conceptual model that works.
- Single hole methods are not sufficient for characterization.
- Cross hole methods are necessary to get spatial connections.
- Effective matrix diffusion from laboratory cores are only a first estimate and may not relate to systems with advection into low permeability fracture zones.
- It does not take much in fractured rock investigations to cross contaminant the system and make it difficult to figure out what is actually happening.

Questions and Answers

Question: Can the dispersion coefficient be estimated?

Answer: A dispersion coefficient was estimated from the tracer tests, at least for the highly permeable zone.

Question: How does one establish true flow directions?

Answer: It's a problem with no simple answer. Hydraulic head is measured with a device with an accuracy to 0.01 feet. In the site example, the gradients in the high permeability zones were on the same order so very difficult to sort out measurement error versus true direction. Regional data can be used to get a better idea of overall flow direction.

Question: You looked at steady state conditions with head differences. What about transient conditions?

Answer: With regards to those occurring during the pumping test, yes, but seasonal static fluctuations of head do not necessarily tell you much.

Question: You have emphasized regional scale but what is the regional context with Mirror Lake? Are the joints extensive?

Answer: In this area two or three regional joints have been mapped. Topography is higher to the west, and the sinks are streams and the lake. There are measurements of rock heads and overburden heads, but there is not evidence of regional faulting that is affecting ground water flow.

Question: Do you plan to develop guidance on establishing a flow field in rock?

Answer: I am a proponent of not only measuring water levels in the bedrock but any other system connected to the rock. Look at how the site fits into the regional context.

Question: You stated that concentrations drop as the material enters fractures. That's not what is commonly thought of as happening.

Answer: As the water enters a fracture, there is absorption and diffusion so the concentration will drop off. However, the diffusion in rock is tied to both porosity and advection. The lower the advection rate, the higher the diffusion.

Hydrogen Release Compound/Oxygen Release Compound, Dr. Stephen Koenigsberg, Regenesis

Stephen Koenigsberg described two products developed at and introduced to the market by Regenesis to aid in the bioremediation of contaminated ground water: hydrogen release compound (HRC™) and oxygen release compound (ORC®).

ORC is a formulation of magnesium peroxide that slowly releases oxygen when hydrated:

$MgO_2 + H_2O$ Y ½$O_2$8+ $Mg(OH)_2$

This reaction provides oxygen to enhance the aerobic biodegradation of compounds such as BTEX, MTBE, and vinyl chloride. The ORC powder is mixed with water and can be injected into the dissolved phase plume using a Geoprobe rig or other direct push techniques. It can also be inserted into monitoring wells in pre-packaged, exchangeable "filter socks." The ORC will stop releasing O_2 when it is dry (<3% moisture). The injection process is relatively inexpensive, although construction of barrier walls containing ORC is more expensive.

ORC has been used at over 5,000 sites. Koenigsberg cited several case studies showing ORC's success in enhancing bioremediation including a BTEX plume in New Mexico where two ORC barriers were constructed to intercept the plume: one 16-well barrier and one 4–well barrier. The results showed a 78% decrease in the total BTEX mass in the vicinity and a 58% decrease in the broader study area. The smaller barrier was found to be more effective due to the lower BTEX concentrations in its vicinity.

MTBE has been found to degrade in the presence of ORC as a result of enhanced biodegradation, not chemical oxidation. However, there is evidence that degradation of MTBE is suppressed in the presence of xylenes and benzene.

HRC is a polylactate ester used to remediate anaerobically degradable chlorinated aliphatic hydrocarbons such as PCE and TCE. HRC is available in two forms: a semi-solid material for borehole implantation to the saturated zone, and a moderately flowable and injectable material. On contact with water, HRC releases lactic acid, which is metabolized by microbes that release hydrogen for anaerobic bioremediation.

Koenigsberg summarized several case studies applying HRC to manage plumes. Concentrations of TCE at a site in New York were as high 26,000 ppb. Approximately 500 pounds of HRC were injected into the clay aquifer in an a 560 sq ft area. The total TCE mass was reduced by 66% after 166 days. Degradation products of TCE were formed and degraded indicating that anaerobic biodegradation was occurring. Ethene was also detected indicating some complete mineralization of the TCE.

HRC wells are relatively inexpensive. One HRC well can be installed at a cost of $1,500-2,000 to treat and area of 500-1,000 square feet for years. There are no design costs associated with the process as you can download the design from www.regenesis.com.

Ground-Water Contamination to Indoor Air, Helen Dawson, U.S. EPA/Region 8

Helen Dawson presented a draft outline that she prepared for a possible Ground Water Forum issue paper on vapor transport of VOCs from ground water and soil to indoor air spaces. The objectives of this paper would be to describe the current thinking on this transport method, identify issues and concerns, and develop a flow diagram to aid in determining when to consider the ground water/soil to indoor air pathway. Dawson has received feedback from Colorado State University, EPA Headquarters, and others on the outline. The outline includes a discussion of the conceptual model, sampling and analytical methods, simulation models, case studies, and a decision tree.

The way the models are now written they depend on the thickness of the capillary zone. There is some discussion as to whether the thickness should be considered or if the diffusion only occurs at the top of the zone. Helen thinks it would be a service to the regulatory community if the Ground Water Forum critiqued the different screening level and numerical models that are available. It would be helpful to explain discrepancies among models, pitfalls and sensitivities of the models, and how best to get a conservative result.

There will be a workshop on the topic of vapor transport to indoor air at the National RCRA Program Meeting in to be held in Washington, DC, in August, and they have invited Johnson and Ettinger—developers of the EPA screening model—as speakers.

Luanne Vanderpool suggested that two issue papers be written: one that addresses the conceptual model and sampling and analysis issues, and one that addresses modeling. Dawson volunteered to write the modeling part of the issue paper, but requested help with writing the sections on the conceptual model and

sampling and analysis issues. Edgar Ethington (Colorado DPHE), Ruth Izraeli (Region 2), and Randy Breeden (Region 8) volunteered to be part of a workgroup to help develop the issue paper(s). It was suggested that National Air and Radiation Environmental Laboratory, NERL-RTP, and NRMRL-RTP be consulted for help with the issue paper. An update on the status of this project will be a subject of the Forum's July conference call.

Workshop on Monitoring the Oxidation Reduction Process During Ground-Water Restoration, Dick Willey, U.S. EPA/Region 1

Dick Willey reported on a workshop he attended this week entitled "Monitoring Redox Processes During Ground Water Restoration." The workshop was concerned with setting data use objectives, data quality, and sampling techniques. Willey noted that Mike Barcelona (University of Michigan) is critical of current sampling practices and how the data are being used. There was the question of how do you measure success—what chemicals should be measured other than the contaminants of concern? The workshop was divided into six sessions:

- Redox processes in petroleum hydrocarbons
- Redox processes in chlorinated chemicals
- Redox processes in inorganic remediation
- Measurement issues with geochemical parameters
- Measurement issues with dissolved gases
- Measurement issues with solid phase.

They hope to have a report out on the workshop by the fourth quarter of this year. The report will be peer reviewed and published by the Office of Research and Development. Willey added that he thinks the topic of oxygen reduction processes (ORP) is complex and worthy of an issue paper.

Question: Did the workshop consider solid phase?

Answer: The consensus of the group was the solid phase was not being addressed.

Passive Bag Diffusion Samplers, Vince Malott, U.S. EPA/Region 6

Vince Malott indicated that passive bag diffusion samplers are now commercially available. These samplers consist of a polyethylene bag within a polyethylene net for protection. The bags cost $16 each and the weight to sink them costs $20. The sampler is suspended in the well for a couple of days. When collecting the sample, the end of the sampler is cut off to fill the sample bottle.

Malott has been using the samplers at a site in the Texas Panhandle in wells screened in the Ogallalah Aquifer. The water table is at 250 feet below ground surface; the wells are 350-380 feet deep and are contaminated with carbon tetrachloride and chloroform. Concentrations of tetrachloride range from 10-56 Fg/R. There is some concern that reuse of the bags over time might put a microbial skin on them that would affect sample quality. However, Malott has had no problems in reusing them.

Malott compared the results of the passive bag diffusion samplers with those collected with double valve pumps and found the results to be within a few ppb of each other. He tried leaving the bag in the well for 48 hours but found he got better results with 72 hours. Another round of sampling will be conducted at the end of May, and the results will be available in June.

The USGS has just finished a comparison of diffusion sampling at Hanscom AFB. A data report will be available soon, with an interpretation report to follow.

Malott noted that some states object to the use of the samplers. Greg Lyssy (Region 6) pointed out that Dames & Moore performed a study that showed the bags had higher concentrations of contaminants then conventional sampling techniques. They think it might be caused by diffusion into the bag with less diffusion out causing contaminants to accumulate.

Dick Willey (Region 1) also pointed to a study by General Electric that revealed microbial action was forming skins on the samplers. As a result, there were more breakdown products in the diffuse sampler than in regular well sample.

Malott also showed another sampling device called a “hydrosleeve,” which has a check valve similar to a bailer. It is designed to sample for inorganic contaminants at a target interval. The sampler must be withdrawn about six times to fill a sample bottle. The method does not require purging, so there is some question regarding the representativeness of metals concentrations.

FEDERAL FACILITIES FORUM

Lead-Based Paint Update, Monica McEaddy, U.S. EPA/Federal Facilities Restoration and Reuse Office

Monica McEaddy briefed the Forum on the results of negotiations between EPA and DOD on the problem of lead contamination in soil and dust due to lead-based paint (LBP) at DOD facilities. EPA and DOD have agreed to base associated guidance on requirements stipulated in U.S. Housing and Urban Development (HUD) Title X, the Residential Lead-Based Paint Hazard Reduction Act of 1992. Accordingly, the two agencies will issue a joint LBP field guide to assist federal personnel in complying with pertinent regulations issued by HUD, EPA, and the Occupational Safety and Health Administration.

The field guide will apply to target housing that will be demolished and redeveloped as real residential property, as well as properties used for existing and anticipated housing. A particular concern to EPA has been the definition of "residential" properties. In accordance with Title X, residential properties defined in the field guide include properties used by children under the age of six, such as nursery schools, day care centers, and designated playgrounds. Specific procedures and standards addressing lead contamination are based on the final HUD 1012/1013 rule and the proposed 403 rule under the Toxic Substances and Control Act (TSCA).

The field guide clarifies that DOD is responsible for conducting an inspection and risk assessment for all target housing in accordance with Title X requirements (which are less detailed than CERCLA requirements), providing related information to the property transferee, and ensuring that the transferee completes abatement. Lead hazards must be abated at pre-1960 housing, and the federal government must evaluate property for LBP hazards at housing built between 1960-1978. The clean-up level for lead in bare soils, which is based on current TSCA regulations, stands at 2,000 parts per million (ppm). For bare soils in children's play areas, however, the CERCLA clean-up level of 400 ppm is applicable. CERCLA regulations will apply at LBP facilities only if a site is included in or overlapping a target housing area that is already addressed under CERCLA or RCRA as part of the Defense Environmental Restoration Program.

Following promulgation of EPA's final TSCA 403 rule, standards outlined in the rule will be formally incorporated into the field guide. EPA and DOD expect to issue the final LBP guidance this summer, at which time it will be posted on EPA's website. In addition, EPA plans to distribute model language for use in Agency comments on findings of suitability for transfer (FOSTs) involving residential properties covered in the field guide, and to issue a related policy memorandum in June, 2000. EPA and DOD also plan to develop FOST language for residential properties not covered in the field guide (such as barracks, commissaries, recreation facilities, and bachelor officer quarters) and for non-residential properties. McEaddy may be contacted at 202-260-2035 or mceaddy.monica@epa.gov for more information.

5-year Review Guidance, Carol Bass, U.S. EPA/Office of Emergency and Remedial Response

Carol Bass, who serves as the EPA Headquarters coordinator for 5-year reviews, provided an overview of the Agency's 5-year review process and an update on development of a 5-year guidance document. As required under CERCLA 121© as amended by SARA and the NCP Part 300.430(f)(f)(ii), statutory 5-year reviews are required every five years after the initiation of remedial action to ensure that human health and the environment are being protected and to evaluate implementation and performance of the

cleanup remedy selected. In addition to statutory reviews, EPA conducts policy reviews at post-SARA sites where the implemented remedy will achieve unlimited use and unrestricted exposure but requires more than five years to complete. Policy reviews also are conducted at pre-SARA sites where completion of remedial action leaves wastes onsite, NPL removal-only sites where wastes are left on site (a total of 15 sites to date), and state or tribal NPL sites where waste is left onsite.

Both statutory and policy 5-year review requirements apply to NPL and non-NPL sites remediated under CERCLA. Federal and state authorities serving as lead cleanup agencies are responsible for conducting these reviews, with EPA concurrence. To clarify responsibilities and facilitate planning for the 5-year review process, EPA regions have begun to incorporate relevant language in FFAs.

While PRPs may conduct studies or investigations supporting 5-year reviews, and are required to provide relevant operations and maintenance data, lead agencies must perform the needed site inspections and conduct the overall 5-year review. Lead agencies may recover costs at PRP-lead sites in accordance with each site's settlement agreement. It is important to note that deletion of a site from the NPL is not contingent upon a 5-year review.

In September 1999, EPA's Office of Inspector General issued a final report recommending that the Agency: eliminate the backlog of overdue 5-year review reports by the end of FY02, improve protectiveness statements, improve follow-up on recommendations, improve the timeliness of and information in annual reports to Congress, and ensure communities are informed of 5-year reviews. Through fiscal year (FY) 1999, a total of 41 5-year reviews were conducted at federal facilities (32 statutory and 9 policy reviews) and 439 were conducted at private sites. During FY00 and FY01, 20 and 18 reviews, respectively, are planned for federal facility sites.

The 5-year review process begins by establishing a review team and review schedule. The lead agency then notifies the site's local community of the pending review and conducts a document review and interviews. A site inspection is conducted to identify any deficiencies, and followed by development of recommendations, required actions, and a protectiveness statement. The process culminates with the preparation of a 5-year report. Typically, the report includes sections covering: an introduction, site chronology, background, remedial actions, the 5-year review process, the 5-year review findings, assessment, deficiencies, recommendations and required actions, protectiveness statement(s), the next review, and other comments. General questions to be answered during the 5-year review include:

- Is the remedy functioning as intended by the decision documents?
- Are the assumptions used at the time of remedy selection still valid?
- Has any other information come to light that could question the protectiveness of the remedy?

OERR is developing guidance to assist lead agencies, the regions, and other involved parties in completing 5-year reviews. The draft guidance was distributed in November 1999 to the states, tribes, federal facilities, trustees, regions, the U.S. Department of Justice, and the Agency for Toxic Substances and Disease Registry. OERR currently is addressing comments on the draft, and plans to issue the final guidance by September 2000. Questions on the 5-year review process or pending guidance may be directed to Bass at 703-924-0681 or bass.carol@epa.gov.

Federal Facility Enforcement Office Update, Craig Hooks, U.S. EPA/Federal Facility Enforcement Office

Craig Hooks provided an overview of FFEO's mission and enforcement progress. FFEO strives to: provide deterrents to environmental pollution, promote greater compliance by the federal sector, and

promote voluntary compliance through incentives and assistance programs. As a newer office within the Agency, FFEO efforts are evolving as environmental regulations and litigation continue to develop. The office is broadening its activities beyond primarily DOE and DOD actions, and beyond primarily Superfund and RCRA enforcement. In FY98, EPA initiated its first federal facility enforcement actions regarding lead-based paint notification provisions, thus establishing that federal authorities are liable for noncompliance to the same extent as private parties.

Hooks highlighted several recent enforcement activities and accomplishments :

- On March 17, 2000, the EPA Environmental Appeals Board ruled against EPA in the Agency's appeal concerning the U.S. Navy's failure to comply with the TSCA Section 1018 Real Estate Notification and Disclosure Rule.

- While EPA has issued field citations and assessed small penalties for UST violations over the past two years, the requirements for UST upgrades have been formally challenged by DOD.

- As a result of new and clarified enforcement authorities, the Agency pursued a higher number of enforcement actions (approximately 50) and assessed or proposed a higher amount in penalties (total of $3.8 million) at federal facilities last year.

- Through the Federal Facilities Multi-Media Enforcement/Compliance Program initiated by FFEO in FY93, 27 multi-media inspections were performed at federal facilities during FY99. These inspections targeted 21 DOD facilities, 2 DOE facilities, and civilian federal agency facilities operated by the U.S. Department of Veterans Affairs, the U.S. Coast Guard, and the U.S. Geological Survey. FFEO is prepared to work with EPA regions in encouraging federal facilities to take advantage of the Agency's self-disclosure policy, which mitigates or eliminates penalties on companies or facilities that voluntarily disclose and correct violations. In accordance with recent FFEO/regional MOAs, each region is required to conduct a minimum of two multi-media inspections at federal facilities each year.

- Through a rider contained in the FY00 Defense Appropriations bill (H.R. 2561, Section 8149), Congress exempted DOD from obligation to pay a penalty or perform a supplemental environmental project (SEP) under any environmental statute unless the payment of the fine or performance of the SEP has been authorized specifically by law. Although EPA does not agree with this position, it will continue to pursue strong enforcement activities at DOD facilities.

- Following 18 months of dispute, the State of Washington Department of Ecology determined that DOE failure to meet milestones for tank waste cleanup at DOE's Hanford facility is subject to enforcement action. The Department of Ecology also determined recently that DOE must comply with RCRA land disposal restriction requirements. Both determinations may be appealed by DOE.

- A new executive order, Greening the Government Through Leadership in Environmental Management, seeks to build on the successes of past environmental executive orders. The order outlines goals and objectives related to environmental management, environmental compliance, right-to-know and pollution prevention, toxic chemical release reduction, toxic chemical and hazardous substance use reduction, and environmentally and economically beneficial landscaping.

- FFEO issued a final environmental management review (EMR) report for federal facilities in November 1999. The report is based on the results and lessons learned from 25 EMRs conducted as pilots in eight EPA regions.
- To address the increased compliance problems identified at U.S. Department of Interior (DOI) facilities, including the Bureau of Indian Affairs, the National Park Service, and the Bureau of Reclamation, the EPA/DOI Compliance Assistance Initiative was begun in 1999. This large-scale, FFEO initiative intends to facilitate environmental compliance and performance at approximately 1,000 DOI facilities.

- The Federal Facilities Compliance Assistance Center, which is available at www.epa.gov/oeca/fedfac/cfa, provides a reference tool for environmental compliance information, links to other environmental offices of government home pages, and other resources for environmental compliance.

Hooks stressed that EPA regions are encouraged to use enforcement authorities other than the U.S. Department of Justice to expedite compliance at federal facilities. FFEO recognizes that it's role in providing assistance to the regions has expanded beyond that involving the development of interagency agreements (IAGs), and now includes IAG implementation and dispute resolution. It was noted that enforcement issues to be clarified in the future include: (1) the need for IAGs at FUDS; and (2) the definition of UXO as a CERCLA hazardous waste.

Federal Facility Restoration and Reuse Office Update, Renee Wynn, Federal Facility Restoration and Reuse Office

Renee Wynn provided an update on FFRRO activities addressing contamination at federal facilities. FFRRO currently maintains 17 staff positions at Headquarters; of these, 10 support Superfund activities and 7 support BRAC activities. Several staff members currently are on Agency detail, and FFRRO is in the process of hiring additional staff to handle the existing and anticipated workloads. Developments have taken place in several ongoing issues faced at federal facilities: the range rule, UXO Management Plan, UXO Handbook, training, and institutional controls.

Range Rule

Tim Fields (Assistant Administrator of the Office of Solid Waste and Emergency Response) and Sherry Goodman (DOD) held a teleconference on April 27, 2000, to determine whether, and if so, how, to proceed in negotiations concerning DOD's proposed range rule. Although intended to provide standards for military range cleanup, the proposed rule describes generalized processes for cleanup. EPA does not agree with this approach and is working through the U.S. Department of Justice to ensure that EPA comment is incorporated in the rule. Promulgation of the rule is expected to occur on August 7, 2000. Jeff Stinson, who is on detail from the U.S. Air Force, serves as the FFRRO point of contact (202-260-6676) for the range rule.

UXO Management Plan

On March 7, 2000, EPA issued an interim document regarding the management of miliary ranges that are transferred for reuse. This document, which encourages adherence to DDSB standards, is intended to provide assistance in lieu of the range rule. These principles of UXO management, however, do not clarify requirements for site characterization, which is a point of disagreement within DOD as well as between DOD and EPA. Regions are encouraged to continue pursuing dispute resolution mechanisms to address inadequate site characterization by DOD. It was noted that, in contrast to past experiences, DOD is adhering increasingly to employment of the CERCLA cleanup process at UXO sites.

UXO Handbook
A draft version of the UXO Handbook has been distributed for internal EPA review. FFRRO recognizes the need for significant revision to the document, however, and requests that comments be held until distribution of the revised version.

Training
FFRRO plans to sponsor training on site characterization and remediation issues faced at federal facilities.

Institutional Controls
In February 2000, EPA issued an IC interim policy, *Institutional Controls and Transfer of Real Property Under CERCLA Section 120(h)(3)(A), (B), or (C)*, which is available on the web at www.epa.gov/swerffrr/whatsnew.htm. FFRRO expect the final policy to be issued in early 2001, following a one-year period of time for implementation of the interim policy. The policy has been met with agreement from DOE but disagreement from DOD.

Past Forum Concerns
Wynn reiterated that FFRRO continues attempts to address concerns expressed by regional and state Forum members in the past, which have focused on reduced BRAC resources, FUDS, remedial construction completions, and UXO.

- *BRAC Resources*: FFRRO currently is preparing budget forecasts for FY01-FY05, including plans to allocate Superfund funding to selected BRAC activities. As occurred this year, significant reductions in Superfund Program funding are expected next year. Based on input from EPA regions, FFRRO is attempting to clarify the actual workload for Superfund projects, excluding the BRAC Program. Headquarters recognizes that the Federal Facilities Program continues to grow, despite popular opinion that the program is downsizing. As a result of reduced EPA funding for BRAC projects, the Agency expects to eliminate certain services to the BRAC Program. This anticipated reduction in federal oversight at BRAC facilities, however, likely will add increased responsibilities to state authorities.

- *FUDS*: EPA is drafting a policy to clarify EPA operations at the approximately 9,000 FUDS identified to date. The policy does not prescribe methods to be used by states, tribes, or other federal agencies, but focuses on the need for governments to cooperate more effectively. FFRRO anticipates that the policy will describe EPA's role as a hybrid between the role taken at federal facilities and that taken at privately-owned sites. Headquarters plans to distribute the draft policy to regions during the waste division directors' meeting in July 2000, followed by distribution to the states and tribes, and lastly to DOD and the public.

The FFRRO update concluded with reiteration of specific and general areas of concern in each region, as expressed in the Forum's "regional roundup." For additional information on FFRRO activities, Wynn may be reached at 202-260-8366 or wynn.renee@epa.gov.

UXO Technology: A Status Report Dr. Jeffrey Marqusee, Strategic Environmental Research and Development Program and Dr. Jim McDonald, Naval Research Laboratory

Dr. Jeffrey Marqusee, who serves as Director of the Environmental Security Technology Certification Program and Technical Director for the inter-agency Strategic Environmental Research and Development Program, presented an overview of UXO management principles employed by DOD, deployable technologies currently in place for UXO detection, and research and development conducted

on UXO technologies. DOD's management principles involve the performance of adequate site characterization and the reflection that advances in technology can provide significant improvements. Adequate site characterization requires the inclusion of a permanent record including sensor data that is digitally recorded and geo-referenced.

UXO site remediation conducted by DOD requires the following steps: an historical/archival records search, planning and coordination, surface clearance/preparation, subsurface investigation, UXO removal/destruction, quality assurance/quality control, and periodic site review. Dr. Marqusee's presentation focused on the state of technology for subsurface investigations, including the historical use of "mag and flag" techniques, the new generation of digital geophysics, advantages of digital geophysical techniques, and emerging processing and sensing technologies. "Mag and flag" involves the detection of UXO based on a real-time analogue signal generated from a magnetometer [mag] or electromagnetic induction [EMI] sensor, and followed by placement of a flag near the detected anomaly.

Jim McDonald presented the results of comparative studies conducted by DOD on sensor cost and performance at an artificial test site with known ordnance (29 Palms) and at two live sites (Laguna Pueblo and the Badlands Bombing Range). Study results indicate that digital geophysics techniques produce a higher probability of detection and lower false alarm rate, and require lower costs to implement. Digital geophysics also offer the additional advantages of providing permanent archived results, performance independent of individual equipment operators, improved performance as a project progresses, and improved quality assurance/quality controls. Overall, DOD has found that digital geophysics offers the potential for more systematic risk management.

DOD typically allocates $8-9 million in funding for research and development (R&D) supporting UXO cleanup. Near-term DOD plans for UXO R&D focus on exploiting new EMI sensors; conducting wide-area surveys for flat, open terrain; further developing statistical sampling approaches; and developing all-terrain geo-location techniques. Over the long-term, DOD plans to address optimum UXO discrimination by mag/EMI technologies, all-terrain airborne capabilities, hand-held filler identification, and alternate technologies such as seismic and chemical methods.

Persons interested in becoming involved with UXO detection issues are invited to participate in activities of the UXO Forum (which is meeting in Anaheim, CA, in May 2000) or to join the three-day UXO workshop to be held in Washington, DC, in the fall of 2000. Dr. Marqusee may be contacted at 703-696-2120 or marqusj@acq.osd.mil for more information.

Cooperative Risk Management, Robert Wilcox, U.S. Army Corps of Engineers, Ordnance and Explosives (OE) Center of Expertise

Robert Wilcox, who serves as Program Manager for the U.S. Army Corps of Engineers' Ordnance and Explosives (OE) Center of Expertise, presented an overview of the cooperative risk management approach used by the USACE at UXO sites. DOD risk management addresses the basic requirements of understanding an operation, minimizing a problem, managing the residual problem, and monitoring the situation. In addition, land use control plans and recurring reviews are critical components of DOD's strategy for ordnance actions.

Ordnance risk management involves the determination of which decisions to be made, the identification of necessary data, the identification of stakeholders, clarification of data and commitments needed to satisfy stakeholders, and methods for ensuring the integrity of communication and data quality. Factors to be considered in ordnance risk management include individual behavior, institutional behavior, and

commitment to protectiveness. Lastly, ordnance risk management provides a plan that maximizes protectiveness, fosters understanding, stimulates participation, builds trust, creates cooperation, and supports commitment.

DOD's cooperative risk management approach is not intended as a trade-off between removals and institutional controls. It was noted that land use controls may be used to restrict behavior associated with UXO at BRAC sites, but cannot be used at FUDS. It also was recognized that DOD's risk management program is relatively new, and that DOD services still operate relatively independently in risk management activities. Wilcox may be reached at 256-895-1508 or Robert.G.Wilcox@hnd01.usace.army.mil for additional information.

Contained Detonation Chamber Technology for the Destruction of UXO, John Donovan, DeMil International, Inc.

John Donovan (DeMil International, Inc.) presented information on a new technology that offers a safe, reliable, economical, and environmentally-friendly alternative to traditional methods of disposal/destruction of UXO. This technology, known as the Donovan Blast Chamber, is a vented, self-contained structure capable of repeated detonations of a suite of energetic materials that traditionally are demilitarized by open burn/open detonation. The Blast Chamber is designed to minimize and/or eliminate the primary three hazards associated with conventional explosive events: overpressure, excessive heat, and fragment distribution. DeMil International, Inc., which developed the Blast Chamber, also offers operating documentation and training materials for facility personnel to use in setting up and operating the detonation systems.

The prototype Blast Chamber, which currently is used for commercial application in Danvers, IL, has withstood over 600,000 detonations over the past 10 years without failure. Based on this success, portable structures have been developed and successfully employed in various commercial, conventional ordnance demilitarization, unexploded ordnance, and counter-terrorism applications. In the near future, portable Blast Chambers will be used for ordnance destruction at the Massachusetts Military Reservation, and in chemical/biological equipment testing for the USACE in cooperation with the Southwest Research Institute. More information on this technology is available from Donovan at 256-536-6885.

Contaminated Sediments Update, Gary Schafer, U.S. EPA/Region 5

Gary Schafer (Region 5), who serves as a Forum liaison between the Contaminated Aquatic Sediment Workgroup and FFRRO, provided an update on sediments-related issues. Although FFRRO has expressed concern that sediment contamination at federal facilities may present unique problems, recent surveys indicate that sediment issues at federal facilities are similar to those faced at private sites. Laura Stankosky (Region 6) mentioned that OERR plans to issue in June 2000 the draft *Contaminated Aquatic Sediment Remediation Guidance*, which will address sediment contamination as a multi-media issue. Regional Forum members are asked to request remedial project managers with contaminated sediment sites to review and comment on the document.

Perchlorate Update, Chris Villarreal, U.S. EPA/Region 6

Chris Villarreal (Region 6) reported that the Interagency Perchlorate Steering Committee is addressing various aspects of the problems posed by perchlorate contamination. The Committee is soliciting regional representatives to provide information on sites with perchlorate contamination; persons interested in providing information may contact Kevin Mayer (Region 9) at 415-744-2248. As part of this information-

gathering effort, members of the Committee currently are visiting selected sites with perchlorate contamination. In particular, bioaccumulation factors for perchlorate are under assessment. The Committee plans to issue its findings later this fall.

Recent Congressional establishment of the San Gabriel Basin Water Quality Initiative provides for San Gabriel Basin water quality projects to be administered by the U.S. Army. The potential impacts of this initiative, the amount of funding available for each project, and the recipients of project funds remain unclear.

Texas Tech has been conducting research on perchlorate data obtained from the Longhorn Army Ammunition Plant in Texas. A one-day field trip this summer to Texas Tech is planned in order to discuss the research findings. Persons interested in participating in the field trip may contact Villarreal at 214-665-6758. Other recent perchlorate developments include: (1) DOD designation of the Air Force as the lead service for managing perchlorate issues at DOD facilities; and (2) pending publication of EPA's Method 314, "Determination of Perchlorate in Drinking Water Using Ion Chromatography."

MTBE Update, Judith McCulley, U.S. EPA/Region 8

Judith McCulley provided an update on recent EPA activities dealing with contamination from methyl tertiary butyl ether (MTBE). In response to recent public media reports, EPA's Office of Research and Development has formed a workgroup to help the Agency address MTBE issues. On June 20-21, 2000, members of the MTBE Workgroup and other invited participants will assemble at a scientist-to-scientist meeting in Chicago to discuss MTBE-related policy, site characterization techniques, modeling, and health effects, as well as other problematic contaminants. Offsite people also will be able to participate in the meeting online through the use of PlaceWare software. McCulley, who is representing the Forum on the MTBE Workgroup, may be contacted at 303-312-6667 for additional information.

Contaminated Sediments Activities, Judith McCulley, U.S. EPA/Region 8

As the Forum's representative on the Agency's Contaminated Aquatic Sediments Workgroup, McCulley reported that the group has held several meetings to address aquatic sediments contamination. The Workgroup has drafted an associated remediation guidance, which will be distributed to EPA regions during this summer. An additional sediments workgroup headed by Rich Norris (OERR) (703-603-9053) is developing a national sediment action plan. Laura Stankosky (Region 6) requested that Forum members provide her with the names of sites at which the use of MNA is under consideration to remediate contaminated sediments, along with the name of each site's manager.

Federal Facility Remediation Seminar, John Quander, U.S. EPA/Technology Innovation Office

John Quander announced that TIO will sponsor the *Federal Facility Remediation Seminar* at two locations this year: (1) in Region 1 on July 11-13 at Hanscom AFB, MA; and (2) in Region 5 on August 22-24 at a location yet to be determined. This advanced-level seminar, for which two pilots were held last year, is intended to provide an opportunity to discuss the issues faced in remediating contaminated federal facilities. TIO actively is seeking participation in the upcoming seminars from EPA regions, other federal agencies, and the states. Quander may be reached at 703-603-7198 or quander.john@epa.gov for additional information.

ENGINEERING FORUM

Landfill Closure Guidance, Ken Skahn, U.S. EPA/Office of Emergency and Remedial Response

Ken Skahn indicated that EPA is revising the current landfill closure guidance because new issues and technologies have emerged since the guidance was last revised in 1991. One major innovation has been the emergence of new, cost effective materials, such as geocomposite clay liners (GCLs), which swell to 20 times their original size when wet. Paper mill sludge may also be used for landfill covers. The capture and treatment of landfill gas will be addressed in the new guidance, as will performance monitoring, which is of particular interest at sites lacking a bottom liner. The issue of long-term maintenance has not been addressed by EPA and will be discussed in the new guidance. Finally, the new guidance will consider alternative designs for landfill covers

The first chapter will address regulatory requirements, including the strategies that can be used to keep liquids out of landfills. The second chapter discusses design considerations and parameters, as well as vegetative covers. The third chapter will examine alternative designs. The fourth chapter considers the use of water balance models, such as the HELP model, while the fifth chapter deals with geotechnical analysis and design, including slope stability and seismic deformations. The final two chapters address lessons learned and long-term maintenance of landfills, including a section on financial planning and 5-year reviews.

Headquarters is about one month away from finishing the second draft of the guidance, which will then be sent to the Regions for review. Following that draft, it will be peer reviewed by states, consultants, and academics, after which it will be issued as final. The final guidance will hopefully be issued by December 2001.

Questions and Answers

Question: In the chapter on lessons learned, will you address cap longevity?

Answer: In the introductory chapter, we will discuss how caps must be designed to minimize maintenance.

Question: Will you discuss past performance information (e.g., how long caps have lasted)?

Answer: This is a crucial component of the landfill design and will be covered throughout the guidance.

Question: Will you include information on institutional controls?

Answer: This will be touched upon in the maintenance section, as we want to promote long-term use.

Question: Have there been studies documenting how materials degrade over time?

Answer: Yes, there have been extensive studies on this topic. Dr. David Daniels, head of civil engineering at University of Illinois, Dr. Rudy Bonaparte, head of Geosyntec, and Steve Dwyer at Sandia National Laboratory have all been examining the degradation of materials over time.

Question: Guidance should discuss dredged materials as filler and the transportation of these materials.

Answer: EPA is working with the U.S. Army Corps of Engineers on the topic of sediment dredging. We will try to address this topic in the guidance.

Question: Does the guidance include 5-year review checklists?

Answer: Yes, we are trying to include the checklists in the guidance.

Landfill Gas Emissions Guidance: Update and Discussion, Andrea McLaughlin, U.S. EPA/Office of Emergency and Remedial Response

Andrea McLaughlin indicated that OERR and the Office of Research and Development (ORD) is developing new guidance for evaluating landfill gas emissions at Superfund sites. The guidance is designed to help managers determine on a site-specific basis whether landfill gas presents risks, and examine methods for collection and control. OERR and ORD welcome input from forum members. The guidance is still in the early stages of development, with the first draft expected in fall 2000. The guidance will then undergo internal review by OERR, followed by Regional and peer reviews. The primary topics to be covered in the guidance include:

- Characterizing landfill gas:
  - –Methane and volatile organic compounds;
- Estimating risk—determining exposure point concentrations:
  - –Ambient air (outdoor inhalation);
  - –Subsurface intrusion into adjacent buildings;
  - –Fires and explosion hazards; and
- Landfill gas control methods.

Among the issues that will be addressed in the guidance are risk characterization, the development of a screening tool, and estimation of subsurface migration.

Risk Characterization

Risk characterization represents a change in EPA's approach for dealing with landfill gas. The Agency will move toward the incorporation of risk analysis for landfill gas contaminants into remedial investigations and feasibility studies (RI/FS). The current approach focuses on methane, including the threats of explosion and damage to caps. The new guidance will recognize that volatile organic compounds (VOCs), such as vinyl chloride, may also be a concern.

Current presumptive remedies assume that addressing landfill gas under RCRA also addresses risk pathways. The new guidance will explain that passive venting may occur (presenting a risk to nearby residents), and that this venting may be an exposure pathway for VOCs.

Development of a Screening Tool

The new guidance introduces a screening tool, which is dependent on modeling, that will help determine which sites may present the greatest risk. This screening tool will identify sites that include landfill gas as a significant risk concern and eliminate those sites that do not pose a risk. The goal is to develop a cost effective tool that will discriminate (not include every site). The guidance also recommends appropriate sampling procedures, using the Landgem model to estimate emission rates of methane and contaminants of concern, and using the Screen3 dispersion model to estimate offsite or onsite exposure point air concentrations. The exposure point concentrations are to be used to evaluate risk and compliance with ARARs. If the model fails, the guidance will recommend collection and control, as further characterization is too costly. One question that remains to be answered is whether

or not the screening tool acts as a reasonable compromise between cost restraints and statistically adequate representation of concentrations of chemicals of concern.

Estimating Subsurface Migration
The new guidance will address exposure pathways as they relate to subsurface migration. The impacts of methane-driven landfill gas on indoor air (based on pressure-driven vapor intrusion models) will also be discussed in the document. The guidance will examine the use of a separate modeling tool (which is available on the Superfund risk assessment home page) that can be used to track the migration of contaminated ground water.

Questions and Answers

Question: Will the new guidance discuss how to characterize gases?

Answer: Yes, that is one of the topics we would like to include in the guidance.

Question: There is a landfill in the Boston area that has a tall chimney in the middle of it; will the new guidance include minimum and maximum dimensions for the height and diameter of the vents?

Answer: Those types of issues should be addressed in the document.

Question: Will the guidance suggest site specific information instead of simply relying on model information?

Answer: We are trying to collect site specific information to include in the data that will be fed into the model databases.

Question: Do the models use site-specific meteorological data?

Answer: Screen3 does not use site-specific meteorological information. The model is fairly conservative.

Landfill Reuse Guidance Documents: Update, Richard Taylor, U.S. EPA/Office of Emergency and Remedial Response

Richard Taylor updated the forum on the landfill reuse guidance being developed by OERR. The new guidance will move away from simply discussing design and will focus more on planning. The target audience for the new guidance will be local communities, developers, and other non-technical individuals and groups. The guidance will address the redevelopment of remediated Superfund waste containment areas for recreational (trails, athletic fields), commercial/light industrial (small office buildings, strip malls), and ecological (wildlife habitat) uses as well as golf courses.

The guidance will include examples of successful reuse case studies in order to make it easier to understand and follow. The first draft of the recreational, commercial/light industrial, and ecological guides are currently being revised and reviewed and will be sent out for wider review shortly. The USACE and CRM are currently working on the golf course guide. Another guide that was intended to address the conversion of landfills into parking lots and paved surfaces has been incorporated into the other guidance documents. Any forum members that are interested in reviewing the guides should contact Andrea McLaughlin at 703-603-8973 or mclaughlin.andrea@epa.gov.

Question: Will the commercial/light industrial guidance discuss what you *cannot* construct on a landfill site?

Answer: The guidance contains no "cans" or "can nots." It is primarily a planning tool.

Question: Does the guidance address retrofitting?

Answer: Yes.

Brave New World of Post-Construction in Superfund, Tracy Hopkins, U.S. EPA/Office of Emergency and Remedial Response

Tracy Hopkins noted that the Superfund pipeline is maturing, and there now are more sites with construction complete (nearly 700) than construction underway. The gap between construction completed sites and deleted sites is increasing, with approximately 85 construction completes per year and 20-25 deletions per year. The Future of Superfund Work Group, which is composed of division directors, has identified the need to focus on post-construction. Hopkins is the Headquarters point of contact for post-construction, and can be reached at (703)603-8788.

Hopkins described recent clarifications to the Superfund Program Implementation Manual (SPIM) definitions, especially for ground water. Hopkins also sought to describe the post-construction pipeline and initiatives, including construction completions, 5-year reviews, operation and maintenance, and partial and full deletions.

Remedial Action Completion for an operable unit is achieved when the designated Regional official (Branch Chief or above, as determined by the EPA Region) approves in writing the interim or final remedial action (RA) report. An interim RA report is used only for ground-water or surface water restoration, when the remedy is operational and functional. A final RA report is used for all other remedies or to amend an interim RA report once cleanup goals have been achieved.

Long-Term Response Actions (LTRA) pertain to Fund-financed operation of ground-water and surface water restoration remedies for the first 10 years. (Bioremediation and soil vapor extraction (SVE) are not considered LTRAs.) Federal facility actions go directly into O&M; LTRA (Fund lead) or PRP lead actions begin on the date that the Interim RA Report is signed.

Operation and Maintenance (O&M) are the activities required to maintain the effectiveness and integrity of the remedy once RA is complete. In the case of LTRA, O&M encompasses the continuous operation of restoration measures beyond the 10 years specified in the National Contingency Plan. For containment remedies, O&M begins when the Final RA is signed.

Cleanup goals for ground-water and surface water restoration are achieved when the designated Regional official approves in writing the Final Remediation Action Report. CERCLIS does not currently support this sub-action of O&M.

Construction Completions

Richard Jeng (703-603-8749) is the OERR point of contact for construction completions. The OSWER Directive 9320.2-09A-P, "Close Out Procedures for National Priorities List Sites" (January 2000), can be found at: http://www.epa.gov/superfund/resources/closeout/index.htm. The Directive describes the process for accomplishing remedial action completion, construction completions, and site deletion for final

National Priorities List sites; combines several fact sheets, memoranda, and the Close Out Procedures for NPL sites of August 1995 into comprehensive guidance; addresses the process for partial deletion of sites; and provides recommended format and content for close out documents.

Through FY99, there have been a total of 670 construction completions (CCs). There were 85 CCs in FY99, 87 in FY98, and 88 in FY97. The goal for the year FY00 is 85 CCs, which would bring the cumulative total to approximately 755 CCs. As of April 10, 2000, there have been 13 CCs in FY00, and 31 candidates in CERCLIS3. The 700th site celebration is approaching. The goal for FY01 (subject to appropriation) is 75 CCs.

Five-Year Reviews

Carol Bass (703-924-0681) is the OERR point of contact for 5-year reviews. There have been 478 5-year reviews completed through FY99, with 136 reviews overdue. EPA has made a commitment to eliminate the backlog by the end of FY02. The Agency has set aside $2.6 million (from Remedial Action Advice of Allowance) in FY00 to conduct five-year reviews.

The Office of the Inspector General completed an audit of the 5-year review process, and a final report was issued on September 30, 1999. OERR is following up on the recommendations, which include:

- Eliminating the backlog of overdue reports by the end of FY02 (SCAP targets or GPRA measures);
- Establishing this backlog as FMFIA Agency-level weakness;
- Improving protectiveness statements;
- Improving follow-ups on recommendations;
- Improving timeliness of and information contained in annual reports to Congress;
- Ensuring communities are informed of 5-year reviews.

The draft "Comprehensive Five-Year Review Guidance" (October 1999) is available online at: http://intranet.epa.gov/oerrinet/review/index.htm (internal EPA only), or at http://www.afbca.hq.af.mil/closeout/. The purpose of this draft guidance is to establish procedures for conducting 5-year reviews, facilitate consistency of 5-year reviews across the 10 EPA Regions, clarify current policy, and delineate roles and responsibilities of various entities in conducting or supporting 5-year reviews. The comment period has closed, and EPA is incorporating comments The final guidance is anticipated in September 2000. EPA and other lead agencies are encouraged to use the draft guidance, in the meantime, to conduct 5-year reviews.

Operation and Maintenance

Hopkins mentioned that there is quite a bit of confusion over O&M because the real world uses O&M differently than EPA. O&M is not a response action and can continue after site deletion. States, PRPs, and federal facilities must pay for O&M. CERCLIS and Information Management Systems (IFMS) show some Fund-lead O&M events, which should not exist. This indicates that there has been some miscoding in the past, and help is needed to remedy these mistakes. RFF is investigating O&M expenditures, and many questions have arisen, including:

- What if the PRP fails to preform O&M or goes bankrupt?
- What if capital expenditures are needed during O&M?
- What if states will not assume groundwater restoration after 10 years?

These questions remain to be answered. RFF may conduct of survey of Regions and states to get input into these topics.

Optimizing Pump and Treat

EPA recognizes that there are many facets to optimization, and the Technology Innovation Office has been examining hydraulic optimization techniques. USACE has developed Remedial Systems Evaluation tools to address optimization. The optimization of pump and treat systems requires an initial investment in order to determine possible savings. This may become an EPA initiative.

Deletions and Partial Deletions

The OERR point of contact for partial deletions is Silvina Fonseca (703-603-8799), and the OERR deletions point of contact is Karen Tomimatsu (703-603-8738). Region 5 leads the pack with number of deletions completed (48) as of April 13, 2000. Region 10 has deleted the highest percentage of NPL sites (22.5%) as of the end of FY99. In FY00, Regions 3 and 6 plan to have the most number of deletions (9 each), while in FY01, Region 5 anticipates 24 deletions.

Questions and Answers

Question: When will states be able to stop funding O&M?

Answer: The states, PRPs, and federal facilities are responsible for funding O&M and 5-year reviews. Reuse of sites may relieve the states of this burden.

Question: What happens on privately-owned fund lead sites with ICs? Do we need to continue to do 5-year reviews?

Answer: ICs mean that some waste was left onsite, so we need to continue to do 5-year reviews. Once a site has been deleted, it can be placed back on the NPL administratively, but the Agency would like to avoid doing this too often.

Design/Construct Contracts Work Group: Progress Briefing, Tracy Hopkins, U.S. EPA/ Office of Emergency and Remedial Response

The Contracts 2000 Strategy, which was released in 1998, deviated from the long-term contractor strategy, particularly in the area of RACs contracts. The goals of Contacts 2000 are to balance national consistency with Regional flexibility, increase competition, increase socio-economic participation, and adopt new contracting methods and vehicles. The Contracts 2000 subgroup recommended splitting out the construction portion of the contract, an idea that the head of contracts and OSWER signed off on. Hopkins was asked to co-chair a work group that examined implementation strategies. Project officers, contracting officers, and RPMs are represented in the work group.

At the initial work group meeting, Steve Luftig, Director of Emergency and Remedial Response, voiced his concern about having RPMs manage construction contracts. Many work group members echoed his concern and expressed this to management, who in turn asked them to present management with several options for consideration. At the meeting in Atlanta, the work group invited several small contracting firms, who told the participants that the new strategy of dividing design and construction would not necessarily benefit them directly, in partial violation of the Contracts 2000 principles. The work group decided that how contracts are sized will have the greatest affect on small business advantages. Management further informed the work group that no additional full-time employees or resources would be made available for the new strategy.

Fran Costanzi (Region 8) arranged for the Engineering Forum to become involved in a survey of RPMs. The results of the survey are still being tabulated, but some preliminary statistics are available, including:

- 56% of RPMs responded to the survey.
- 45% said they would be willing to take on added responsibilities.
- 30% had managed a construction contract in the past.
- 23% thought they had the expertise needed to manage a construction contract.
- 11% thought their Region had appropriate resources to accomplish the goals of the new strategy.
- 25% were willing to relocate.

The results indicate that there are issues of liability (personal and Agency-wide) that must be addressed for this strategy to move forward. There appears to be pockets of expertise in different Regions, but not all Regions have the resources or expertise to move forward with this strategy at the moment.

In May, the work group will present four options to management, including:

- menu option–Regions have the flexibility to pick contracts based on expertise;
- RD contracts and separate RA contracts;
- Small RACs contracts–structured in size and duration to attract small businesses; and
- All construction goes to USACE.

The menu option is preferred.

Scoping Session on Joint Projects Between U.S. EPA/Office of Research and Development and the USACE Center of Expertise

Forum members noted the need for guidance for collecting geotechnical process parameters and general water quality parameters for feasibility study selection of remedial systems. It would be useful to know which information to collect up front during site characterization activities. JoAnn Camacho noted that there is an existing screening matrix that has recently been updated and is available on CD ROM. It was decided that a work group should be established to look into this matter. Work group members include: Richard Ho (Region 2), Ed Mead (USACE), Camille Hueni (Region 6), JoAnn Camacho (ERT/Edison), Jo Ann Cola (Region 9), and Juan Parra (FFRRO).

The second item discussed was the use of USACE's Remediation System Evaluation (RSE) checklists for completing 5-year reviews. USACE HTRW Center of Expertise developed 22 checklists to review remediation systems. The objective of these checklists is to increase the effectiveness of existing long-term remediation systems. USACE terminology for these checklists is The following checklists are available (accurate as of April, 2000):

- Above-Ground Treatment Systems Performance Checklist;
- Advanced Oxidation Technologies Checklist;
- In-situ Air Sparging Surface Performance Checklist;
- Air Stripping Performance Checklist;
- Bioventing Subsurface Performance Checklist;
- Vapor/Off-Gas Blower and Piping Systems Checklist;
- Landfill Off-Gas Treatment, Thermal Oxidation Checklist;
- Process Instrumentation and Control Checklist;
- Environmental Monitoring Checklist;
- Treatment Water Disposal Checklist;
- Ground Water Extraction Systems Subsurface Performance Checklist;

- Chemical feed and Storage Performance Checklist;
- Filtration System Performance Checklist;
- Remediation Systems Evaluation Checklist;
- Liquid Piping and Pumping Systems Checklist;
- Liquid Phase Carbon Adsorption Checklist;
- Metals Precipitation Performance Checklist;
- Oil-Water Separation Performance Checklist;
- Solids Handling Checklist;
- Soil Vapor Extraction Subsurface Performance Checklist;
- Vapor Phase Carbon Absorption Checklist; and
- Extraction, Injection and Monitoring Wells Performance Checklist.

The checklists are available at:
http://www.environmental.usace.army.mil/library/guide/rsechk/rsechk.html. Forum members suggested providing a clear link to these checklists through EPA's website.

USACE technical assistance or support for completing 5-year reviews is available through the existing generic Interagency Agreement. Funding is available for this support. The benefits of using these checklists needs to be more clearly defined; (i.e.,do they save time or money?). EPA RPMs need to be reminded that the checklists are available and can be a useful tool in conducting reviews. A work group was established to define the uses of RSEs and develop a strategy for increasing their use. The member of the work group include Steve Kinser (Region 7), Jo Ann Cola (Region 9), Richard Ho (Region 2), Tony Holoska (Region 5), and Gregg Mellema (USACE).

Superfund Redevelopment Initiative: Policy Discussion and Pilot Studies, Melissa Friedland, U.S. EPA/Office of Emergency and Remedial Response

Melissa Friedland spoke to the forum about the Superfund Redevelopment Initiative (SRI), which represents a new way of looking at Superfund sites. The SRI is a nationally coordinated effort to facilitate the return of Superfund sites to productive use by selecting response actions consistent with the anticipated use. The SRI has four main elements: pilots, policy refinements, partnerships, and promotion. "Paradigm" could be considered a fifth element, as the SRI forces people to think beyond the cleanup and to write a new story. The SRI is in the process of reviewing pilot applications. They will also be giving money to states and local governments to make Superfund cleanup decisions consistent with reuse, and reviewing policy documents to further the goals of the initiative. SRI is also attempting to form partnerships with organizations such as the United States Soccer Foundation.

SRI has basic operating principles, the most important of which is the protection of human health and the environment. Proper enforcement is a primary goal of the SRI; they do not encourage less protective remedies or reopening RODS. There are many selected benefits for reuse. The 170 NPL sites now in productive reuse have created 11,000 permanent jobs, generating $250 million in annual income and $10 million in state taxes. Approximately 13,000 acres are currently being reused for ecological or recreational purposes.

Lessons Learned from Past Successes

In order to integrate reuse into the cleanup process, EPA must:

- Consider reuse early in the cleanup process.
- Enhance local government participation.

- Encourage the use of Prospective Purchaser Agreements (in conjunction with the Department of Justice).

To improve stakeholder interaction, EPA should:

- Document and communicate successes.
- Share experiences across sites.
- Educate site managers.

Pilot Program

EPA placed a notice in the Federal Register announcing that 50 sites would be chosen for a pilot program. Each pilot could receive up to $100,000 in financial assistance or services from allowable activities to help political subdivisions, federally recognized Indian tribes, and states be more fully involved in predicting future land uses. To date, 56 applications have been received from 26 states.

The states and USACE have been involved in reviewing applications. Ten pilots have been awarded as of April 2000, and the remainder will be announced at a meeting in Washington in June 2000. The three categories of assistance are: 1) cooperative agreements; 2) facilitation services; and 3) personnel under the IPA Act. The first round of pilots was not competitive, but the second round is. A notice published in the Federal Register in December 1999 detailed the eligibility criteria, evaluation factors, and types of assistance for Round 2. $5.3 million has been requested by applicants.

The Proposal Evaluation Panel will meet in Washington in May to evaluate the remaining applications. Tim Fields, Assistant Administrator, Solid Waste and Emergency Response, will make the final selections. There has been a lot of focus on sites that have the potential to become financially lucrative. Many sites that are located in remote regions have a tremendous potential for ecological reuse, which can lead to other, more tangible benefits to nearby communities.

The SRI website can be found at http://www.epa.gov/superfund/programs/recycle/index.htm.

Questions and Answers

Question: How do you redevelop a site without reopening RODs or consent decrees?

Answer: We are working on that. In the past, we have used the benefits of a “pilot” to get around many of the restrictions.

Question: Do the agreements contain a covenant not to sue?

Answer: Yes. We must work with the Department of Justice, which can be a slow and tedious process. We are trying to get people to think about redevelopment prior to the ROD.

Question: Do all properties have to be economically beneficial?

Answer: Those with the potential for financial gain (e.g., commercial/light industrial sites) are more popular, but many sites in remote areas can be redeveloped for recreational or ecological use, which has a good public relations value.

Question: How is the public involved in this process?

Answer: There is a public notice and comment period for each site. We have a section that deals with community involvement in the application, and we follow up with telephone calls to ensure that the community is behind the redevelopment.

Question: Can pilot grants be used for remediation?

Answer: No, they can only be used for redevelopment.
Question: Can the SRI be incorporated in the regulations instead of just being an initiative?

Answer: This has been discussed, but so far no bills have been introduced.

Question: Who drives the process?

Answer: This varies. It can be the developer, the community, states, PRPs, and even RPMs.

Question: Have developers helped undertake the remedy?

Answer: Yes.

Can we restore the American Landscape to Remediated Sites? Dr. Steven Handel, Rutgers University

Dr. Handel is a restoration ecologist who lives and works in the New York metropolitan area. He uses native plant species to help restore anthropogenically disturbed areas, such as landfills and construction sites. Agencies such as EPA can spend millions of dollars redeveloping a formerly contaminated or unusable site for productive use, but the public still may not perceive the site as being completely safe. Ecological restoration is as much a productive end use as commercial or industrial redevelopment and can be used to complement EPA's mission to protect human health and the environment. As metropolitan areas begin to melt together, as is particularly evident in the Northeastern United States, green spaces become more rare and, hence, more valuable. By restoring native ecosystems, developers can raise surrounding property values while at the same time contributing to biodiversity and other measures of ecological stability. Most native ecosystems have been extensively studied, and botanists, biologists, and ecologists are familiar with the different plant and animal species that are native to particular habitats.

Many people do not understand the difference between restoration ecology and landscape architecture. Landscape architects are charged with creating plant communities using commercial species that require constant attention. Landscape architects are primarily interested in creating aesthetically pleasing arrangements in areas such as public parks or private gardens. These high maintenance plant communities do not function or reproduce in the same ways that native ecosystems do. Restoration ecologists focus on wildlife value and ecological function. They use a natural mix of native plants and herbs to recreate a landscape that closely mimics the environment that existed before the area was disturbed by humans. The goal of restoration ecologists is to restore and maximize function in native plant communities. Restored ecosystems do not require long-term maintenance and are characterized by a natural succession of species. Success is achieved when natural processes are occurring in a functioning ecosystem. The U.S. government has increased efforts, particularly in the past few decades, to maximize natural habitat, increase biodiversity, and limit the spread of invasive species. Restoration ecologists can assist with these beneficial activities.

Some naturally occurring ecosystems, such as the prairie community, require disturbance to function naturally. Disturbance by humans can be part of the natural process for some plant communities. Wildfires and animal grazing used to go unchecked in the Plains states, providing natural disturbance that allowed the prairie plant communities to flourish. Today, humans must set controlled fires or bulldoze vast tracts of land to achieve the natural prairie ecosystem.

Dr. Handel discussed his restoration efforts at a former construction site adjacent to the World's Fairgrounds in Flushing Meadows, New York. The City of New York needed to install a sewage pipe through a wetland, but the New York State Department of Environmental Conservation (NYSDEC) would not issue the permit until the City agreed to mitigate the disturbed wetland. The City agreed and called in Dr. Handel to recreate a natural wetland using native plant species. The City eventually spent $200,000 on the restoration.

After the new pipe was laid, the land was regraded using soil naturally found in the area. The most important concept in the restoration of wetlands in to get the hydrology correct. Dr. Handel selected 20 species of natural herbs and plants, which were haphazardly planted in the allotted area by contractors. The contractors did not consult an ecologist regarding placement of the plants, so Dr. Handel and his team reconfigured the placement of the plants after the contractors left. The site did very well, and a full herb community flourished. Some species fared better than others, as was expected. Eventually purple loosestrife, an invasive weed, began to take over the area. Beetles were used as a biological control to curb the spread of this non-native species. In addition, Dr. Handel created a turtle nesting area onsite using sandy soil and special vegetation.

Mircosite differences, such as these, are needed to help create the mosaic that is the American landscape. In many instances, we can only achieve a caricature of the natural landscape. There are too many buildings, people, and invasive species to restore the landscape to its original state. A pragmatic approach is essential for this type of endeavor. Ecologists must consider a number of environmental factors when beginning a restoration event, including climate, topography, soils, hydrology, and biology. A team of professionals must carefully evaluate prescriptions and choose species based on current knowledge. When preparing a site for restoration, ecologists must consider offsite issues such as soil amendment, seed and planting stock, and procurement, as well as onsite issues, such as landform drainage, fencing, cleanup, cultivation, and weed and invasive species control. Other important considerations include timing, fertilization, mulching, watering, predator control, and monitoring. There may be a need for secondary restoration after sites have been modified or redisturbed.

Dr. Handel then discussed a site in West Virginia where mountain top removal to reach a coal seam had filled stream valleys with rubble. Residents and local government filed a lawsuit against the mining company, and a local district court ruled the company in violation of the Clean Water Act.
Federal law requires that, following strip mining, the site must be returned to the same or better condition. The Southern Appalachians exhibit some of the most diverse forests in North America. At these mining sites, however, native plants rarely return to the disturbed area, and the site is often overrun by invasive species and weeds. After time, a stagnant monoculture of weeds or nonindigenous plants results. This type of landscape is now illegal in West Virginia, thanks in part to lawsuits filed against the Federal Government by non-profit environmental groups. One of the most critical mechanisms for getting native plants to take root in strip mined areas is to import productive soil to the area. Seed dispersion, seed viability, and seed predators all have an affect on the failure or success of native plant species in these areas. The creation of vegetative islands in close proximity to forest remnants is an excellent way to begin the restoration process. In the end, the more degraded the landscape, the less hope exists for returning the area to its former state.

Dr. Handel also discussed the restoration of a 25-acre landfill near the Meadowlands in New Jersey. The site was surrounded by freeways, empty fields, and other landfills. He planted 9,000 seeds from native shrubs on the landfill, some of which took root and flourished. Of the original 9,000 seeds he planted, approximately 130 seedlings survived after 4 years, representing seven species of plants. Recruitment in the area was poor and the soil was not very fertile. The overburden soil was chosen by engineers to protect the landfill cap, not to grow plants. The engineers did not consider ecological value in their remedy.

Restoration specifications must consider the function of various plants. To get native plants to return, more than just seeds are needed. Many shrubs and plants require shade to grow and seed dispersal mechanisms to reproduce. Bees, birds, and ants are common vehicles for the dispersion of seeds and pollen.

When evaluating what species of native plant should be used for restoration at particular sites, ecologists must take into consideration what species of herbivores are common to the area. Short-term fencing may be needed to protect the plants from herbivores. Ecologists and site managers should also make sure that the genotypes for the restored species can survive under the site-specific conditions (e.g., climate, soil type). Often times contractors search for the cheapest bargains and do not consider that alien genotypes may not fare well in a particular area. Restoration serves as both an ecological opportunity and as a means of conservation. Ecological restoration sustains ecosystem processes, contributes to habitat links, and teaches us about reproductive ecology and community dynamics.

Questions and Answers

Question: Earlier we heard that money drives many redevelopments. How can you justify ecological restoration to a community that is interested in financial benefits?

Answer: Ecological restoration is the only option for reuse at some sites where communities don't have the infrastructure to sustain commercial or industrial uses. In some instances, restoring an area can increase property values. The public relations benefit is perhaps the most important justification. In regards to restored sites, people consider native woodlands safer than recreational uses such as soccer fields.

Question: Do you need to continually check up on a site after it is restored?

Answer: Not always. One of the benefits of ecological restoration as opposed to landscape architecture is that restored ecosystems can be left alone with minimal maintenance costs. You do need to occasionally check for the spread of invasive species.

Question: What would you recommend this type of restoration for sites that are naturally semi-barren such as in Wyoming?

Answer: The first step would be to contact a local ecologist for suggestions on native species that would do well in a particular environment. The soil should be engineered to permit invasion of native shrubs rather than revegetating the entire site.

Question: Are there any cost savings that can be realized from ecological restoration?

Answer: Yes. The materials needed for ecological restoration (soil, seeds) is very cheap. If a site looks good, it will have a positive affect on local land value and will result in better community relations. A non-profit group, such as the Nature Conservancy, may be interested in assuming the management of the site.

The Role of Soil in Restoration, Dr. Sally Brown, University of Washington

Soil scientists view soil as an endlessly fascinating living entity that is necessary for plant life. For many environmental scientists, however, soil is mainly recognized as a repository for contaminants, such as metals and toxic organic compounds. Contaminants can be isolated or removed from the media by washing the soil, covering the site with a protective barrier, or paving over the area. Ecosystem restoration is becoming an increasingly attractive option for remediating or reusing contaminated waste sites.

An ecosystem is composed of plants, animals, and the structures and media that support these organisms. Soil is an essential medium for plant growth. The relative success of some cleanup remedies, such as phytoremediation, relies heavily on the composition and health of the soil. Plants need physical support, air, water, and nutrients to grow. Soil provides physical support for plants, anchoring them to the ground. Soil should be thick enough to stabilize plants in windy conditions, but friable enough to allow root penetration. Plants are aerobic and need air to survive, which is commonly absorbed through the roots. Excess water in the soil or poor diffusion rates prevent the adsorption of air by the roots and can lead to suffocation. Plants have a constant demand for water, so soils must be able to store sufficient amounts for plant use during periods when rain is not plentiful. Finally, plants need nutrients to survive. Soil is the main source for the 18 or so nutrients that are essential to plant growth. Different amounts of macro and micro nutrients are needed for plant growth; in general, the following amounts of different elements are needed:

Macro Nutrients (mg/kg or ppm)		**Micro Nutrients (mg/kg or ppm)**
N	25,000 - 40,000	Zn > 20
K	20,000	Mn > 20
Ca	5,000	Cu > 5
S	1,500 - 4,500	Fe >50
Mg	3,000	B 60
P	2,000 - 4,000	Mo, Co, Ni < 3

We can understand how soil is able to provide all of these nutrients by examining it from a pedological perspective. The naturally occurring transformation of rock to soil may take hundreds of thousands of years. During this process, different soil profiles and horizons are created. There are five factors that are important for soil formation: parent material, topography, climate, time, and biota. During this process, organic matter is broken down into clays, which then become soils. There are 12 general classifications of soil, the most fertile of which is mollisol, which is commonly found under grasslands. Mollisol takes approximately 10,000 years to form and consists of a thick layer of topsoil and three distinct horizons of similar thickness. Alfisol is commonly found in Maryland and Virginia and develops under wet conditions over the course of 100,000 years. Environmental scientists usually have two to three years to create good soil conditions for plant growth at waste sites.

When restoring a plant community, a restoration ecologist or project manager can either use clean soil from onsite, or import soil from another location. The filler soil must be able to supply the plants with nutrients, air, water, and physical support. To build an ecosystem, a soil scientist needs to build or "renovate" the soil. The topsoil and 'A' horizon are the most important components of the renovated soil. The A horizon consists of differing proportions of organic matter, air, water, and minerals. Inorganic

mineral components, such as sand (0.02-2mm), silt (0.002-0.02mm), and clay (<0.002mm), need to be present in the appropriate proportions and be aggregated to permit root penetration and water and air movement.

Water found in soil contains a solution of nutrients, organics, and organisms. Soil needs to have sufficient water-holding capacity to retain water after rainfall. Different soil types have different abilities to store water that is available to plants. Clays can hold the greatest amount of water, while sands have the lowest field capacity for water retention. The water quality must be good in order for plants to survive. If the water that penetrates the soil is too salty, the plants will be unable to utilize the water.

The percentage of organic matter in soils is small, but of vital importance. This organic fraction includes plant roots and exudates, and the creatures that feed off of them. Some second level consumers commonly found in soil include mites, slugs, worms, beetles, and protozoa. Soil organisms are ubiquitous and are found in the air, on shoes, in animal droppings. When restoring an ecosystem, there is no need to inject these organisms, as they will arrive on their own. The health of these organisms is vital for the sustainability of the ecosystem and its functions. They eat plants and other organic matter and, in doing so, release nutrients into the soil. Through the recycling of nutrients you have sustainability. The National Soil Survey Center of the USDA's National Resource Conservation Service is an excellent resource for soil information. Their website is http://www.statlab.iastate.edu:80/soils/nssc/.

Bulk density is an appropriate variable to test for when restoring a site or preparing an area for phytoremediation. Bulk density is a measure of how much dry soil weighs per unit volume, and is largely a function of soil structure, with optimum values ranging from 1.0 to 1.6 g/cm^3. High bulk density can reduce root growth due to slow air and water movement and gas build up. It is difficult for roots to push through dense soil. Reducing bulk density increases the available water to plants, water infiltration, air exchange, and root penetrability, which in turn increases nutrient availability and physical support. Air and water comprise a very small fraction of the weight of dry soil. The majority of the weight comes from the inorganic fraction (generally 2.6-2.75 Mg/m^3, or 2,200 pounds). The organic fraction also contributes to the soil weight (generally 0.2 Mg/m^3, or 200 pounds). Bulk density can be decreased by adding a greater amount of organic matter (0.2 Mg/ha vs. 2.65 Mg/ha). This will help promote soil aggregation, which in turn will create more pore space and reduce bulk density.

Soil pH is another important variable. When investigating a site, one should always test the pH of surrounding uncontaminated soil. The target pH for healthy soil is generally between 5.5 and 7. A pH of less than 5.5 or greater than 7.5 can be detrimental to certain plants and soil organisms. A pH of less than 5.5 is acidic and can have a harmful affect on plants and other organisms because of the increased solubility of aluminum and magnesium. At a low pH, these metals, which are common in most soils, can be phytotoxic. If a site is contaminated with metals, keeping the pH high will reduce availability. Some plants need a higher pH, such as clovers and legumes. Adding lime to the soil will reduce the acidity level of the soil. The amount of lime required will depend on the soil type and texture and the target pH. The state agricultural extension can be consulted to determine the amount of lime needed.

Soil salinity is another important variable, especially in arid environments. Soils in arid environments tend to have a pH greater than 7 and accumulate calcium, magnesium, sodium, and potassium. Of these, sodium can pose the biggest problem. Soils with excess salt cannot be phytoremediated if the electrical conductivity (EC) is too high for plants to grow. Salt affected soils can be classified as normal (EC < 4/ESP < 15), saline, sodic, and saline-sodic. EC and sodium limit a plants' access to water and destroy the soil structure. In addition, sodium can cause the disruption of soil aggregates. Excess sodium can be

removed from soils by adding calcium, clean water, and organic matter. Proper management is essential to maintaining productivity.

Organic matter is the key to soil health and productivity. It improves aggregation, water infiltration, water-holding capacity, nutrient availability, and nutrient retention. Approximately 5% of the soil should consist of organic matter. Among the sources of organic matter are manures (animal and biosolids), yard waste, compost, and pulp and paper sludges. It is important for organic matter to have the appropriate carbon:nitrogen ratio. Plants and microbes can use nitrogen from organic matter, but if the ratio is too high, the nitrogen will become immobilized or unavailable. If the ratio of carbon to nitrogen is less than 24:1, you will have excess nitrogen which will be available for plant growth, resulting in a healthy and large population of microorganisms. If the ratio of carbon to nitrogen is greater than 24:1, you will have a deficient amount of nitrogen, making nitrogen unavailable for plant growth. Plants may be stunted and chlorotic due to the deficiency, and there will be a reduced population of microorganisms. Some common carbon:nitrogen ratios for types of organic matter are: sawdust (600:1), alfalfa hay (13:1), corn stover (61:1), wheat straw (80:1), manure (20:1), and biosolids (7:1). All municipalities make biosolids and generate yard waste, which is often made available at little or no cost. Local industries may also have organic residuals that must dispose of.

Finally, the availability of nutrients is essential for healthy soil. If soil from a waste site potentially contains toxins, the soil test laboratory should be made aware of this. Disturbed materials often have micro nutrient deficiencies or toxicities; you may need a very mild extractant like water rather than DTPA (diethylenetrizmine pentaacetic acid). Some common sources for nutrients include commercial fertilizers and organic matter.

Natural Habitat Restoration on Landfills, Dr. Steven Handel, Rutgers University

As a restoration ecologist, Dr. Handel is interested in creating plant systems that can function without constant human attention. After many years of studying landfills, he discovered that they do not develop in the same way that other disturbed areas do. Dr. Handel presented a series of case studies to illustrate this phenomenon.

The Freshkills landfill on Staten Island is the largest sanitary landfill in North America. Most large landfills are located close to urban centers and are viewed as eyesores by those who live and work nearby. Landfills typically remain active for several years, then are closed, capped, and monitored by local governments for a period of 30 years. Traditional landfills are covered with a clay or geomembrane cap and two feet of soil. Simple vegetation may be added to prevent soil erosion. Although most engineers and site managers settle for this basic remedy, soil scientists and restoration ecologists have the knowledge and expertise to restore native plant species to the remediated area while maintaining the integrity of the cap. One of the main functions of the cap is to prevent rainwater from percolating through the waste, thereby contaminating ground water. The addition of native plant species to the top of a landfill not only prevents soil from eroding, but also intercepts a portion of the rainwater that would otherwise seep into the soil. In a wooded area, 20% of the rainwater never reaches the ground. An additional 10% is absorbed by the plants' roots before reaching the cap. Since many landfills are located near cities, ecological restoration presents an excellent opportunity to contribute to the enhancement of biodiversity while providing green space for a large number of people.

As part of an experiment, some of Dr. Handel's colleagues planted a selection of 19 commercially available tree and shrub species (including bayberries, red maples, and pin oaks) on top of a landfill 15 years ago. Few species remain today, due in part to the poor soil quality atop the protective cap. After 15

years, 164 woody stems, most of which were bayberries, were present in and around the original patch of seedlings. Nearly 3,500 other woody stems were growing on the site, however, representing 12 species of trees and shrubs (of which ten were native to North America) and six species of vines. Eighty-two percent of the tree recruits and 79% of the shrub recruits were native to North America. Sixteen of the eighteen invading species were dispersed on the site by birds.

Dr. Handel next discussed a landfill that he restored near the town of Carney in northern New Jersey. The landfill, which had not been disturbed for 25 years, is located in the Meadowlands and is surrounded by freeways and other landfills. The site was an "orphaned" landfill, which means that there is no money available to restore the site. The first step to restoring the site was to find a good soil source. Dr. Handel found a large amount of healthy soil, composed mainly of glacial till, at a construction site in Manhattan. The trucking companies were happy to transport the soil to the Meadowlands for free to avoid a tipping fee. The soil covered 20 acres to a depth of 2 feet, and had good texture and bulk density, but few microorganisms. The till was supplemented with 25,000 cubic yards of well-rotted, composted yard waste from Teaneck, New Jersey. Building the soil took more than 1½ years.

Dr. Handel then applied for $2,000 worth of permits (for disturbing a landfill), which were granted. Annual grasses were used as a temporary erosion control measure for the first season. Then, using a grant from a local non-profit organization, Dr. Handel planted eight species of fast growing, fast reproducing plants and shrubs. Species with fruit that contains many seeds were chosen so that birds could disperse the seeds more rapidly and effectively. Studies have shown that most seeds are dropped by birds within 15 meters of the parent tree. Small clusters of trees and shrubs spaced apart act like islands, attracting migrating birds. In this instance, most of the bird-dispersed seeds ended up within 10 meters of the planted clusters. Three test plots, consisting of wildflowers, were planted on the site to see how quickly they spread; in general, the wildflowers spread rapidly.

Dr. Handel was asked to help restore a portion of the Freshkills landfill on Staten Island. The 3,000-acre site holds all of the waste that has been generated by New York City since World War II. The lower level of the cap is composed of clay, topped with a geomembrane and two feet of grass-covered soil. Under current regulations, the City must mow the grass on top of the landfill twice a year. There are no woody plants on top of the landfill because many people fear that the roots will penetrate the cap. As part of an experiment, Dr. Handel planted 17 species of native trees, plants, and shrubs in a small section of the landfill. In all, 2,924 individuals were planted; within 1 year, approximately 20% of the seedlings were themselves producing seeds and growing roots. Five new seedlings from the original species were found at the site one year later. Over 1,000 other woody seedlings were growing onsite, representing 23 species of plants that are native to North America; six non-native species were also found on the site. Seventy-one percent of the plants were bird dispersed. Because there is often not enough money to plant seedlings throughout an entire site, managers and ecologists should plant clusters of trees and shrubs. Birds and other animals will often disperse the seeds, eventually conjoining the clusters together. What is not clear is whether to plant many small clusters or a few large clusters.

Dr. Handel conducted another study using clusters of 7, 21, 42, and 70 seedlings. All of the species used were fast growing, fast reproducing, and had seeds that could be easily dispersed by birds. Using 1-meter by 1-meter seed traps, Dr. Handel counted the number of seeds that were dispersed at various distances from the parent clusters. He found that the few larger patch sizes (those with 70 seedlings) fared better than the many smaller clusters (those with 7 seedlings). More seeds are found close to forest remnants than further away, demonstrating the importance of small patches of mature plants and trees. High numbers of seedlings were also found near erosion gullies. The abundance of different species of bees mimicked that of seeds; more bees were found near the edge of the forest remnant and in erosion gullies.

A major obstacle to ecological restoration of landfills is the misguided belief that woody plant roots will penetrate the cap. In fact, the roots of most woody plant species remain in the upper horizons of soil where air and water are prevalent. In areas with landfill caps, tree roots tend to "pancake" outward instead of penetrating the cap. Upon examining root systems on trees that were dug up from atop a landfill cap, researches have found that roots rarely extend more than 25 centimeters below the surface. An acidic clay cap is a bad place for tree roots, and they will choose the path of least resistence when seeking water and nutrients. Today's geomembranes are stronger than the maximum pushing power of roots.

Ecological restoration using native plant and tree species is an excellent option for landfill sites. Managers do not have to worry about issues such as settlement, and the public perception of the site will be greatly enhanced. Ecologically restored landfills require minimal maintenance and can end up saving money in the long run.

Questions and Answers

Question: Did you use control groups in the experiment with trees roots and caps?

Answer: Yes, and the roots of the control group also stayed in the top horizon of soil, although they did penetrate a little deeper.

Question: Are roots a greater concern in arid environments?

Answer: Tap roots exhibit a high degree of plasticity and will turn when they reach a cap or inhospitable soil. The penetration of rainwater into the landfill is not as great a concern in areas with little rain.

Question: How does the "pancaking" of roots affect the stability of the trees in wind?

Answer: Roots that spread out are as almost as effective as deep roots in providing the needed physical support for a tree. Some wind throw is to be expected at any site, and this disruption provides an excellent opportunity for other, more adaptive species to take root.

North Parcel Redevelopment Initiative, Operating Industries, Inc., Monterey Park, California, Russell Mechem, U.S. EPA/Region 9

The Operating Industries, Inc. (OII) Superfund site is located approximately 10 miles southeast of downtown Los Angeles, California. The 190-acre landfill, which is divided into two parcels, contains 38 million cubic yards of waste and 330 million gallons of liquid industrial waste. The North Parcel covers 45 acres and poses limited risks, while the South Parcel covers 145 acres and poses a higher risk. The South Parcel is over 275 feet high with a slope of 38 degrees.

Over 2,500 houses are located within 1 mile of the site, which straddles the border between the towns of Monterey Park and Montebello. The multi-jurisdictional governance adds to the complexity of the site, as does the fact that the site borders two U.S. Congressional districts. Although both towns are concerned with health issues, the town of Monterey Park is also interested in site redevelopment. The competing interests and perspectives have led to some complex community dialogue and debate, which presents a serious challenge to attaining a win/win solution.

The OII site is classified as a "megasite" in terms of size, complexity, and cost. The technical, legal, and institutional issues, combined with multiple contamination sources and pathways, multiple operable units, multiple enforcement actions, and a large number (~4,000) of potentially responsible parties (PRPs) make the OII site one of the most complex Superfund sites in U.S. history.

OII was used as a public landfill from 1948 to 1984. EPA listed the site on the National Priorities List (NPL) in 1986. Approximately 5,400 cubic feet of landfill gas is being collected from the landfill every minute, mostly on the South Parcel. Vinyl chloride and methane have been detected in surrounding homes, and leachate has been observed oozing into residents' yards. The ground water is contaminated with organic and inorganic substances. As part of the implementation strategy, EPA is using risk-based operable units and phased enforcement actions (including consent decrees and unilateral administrative orders).

There have been many tangible successes at the site, including the implementation of Superfund reforms (e.g., reduced oversight for cooperative and competent PRPs and expedited design-build construction) and the use of state-of-the-art technology (e.g., evapotranspiration monocover, award-winning leachate treatment plant, landfill gas treatment system). To date, the site has been stabilized, the leachate seepage has been stopped, and the landfill gas is being collected and managed. In addition, there have been multiple successfully negotiated enforcement actions, which have reinforced collaborative and credible working relationships among stakeholders. The community has been extensively involved in the project and has supported the efforts of state and federal officials. But significant work remains to be done prior to construction complete, including North Parcel remediation and redevelopment, final remedy negotiations, and implementation of the final remedy.

EPA is adopting a Brownfields-type strategy for the North Parcel, which is well-suited for redevelopment. The North Parcel is level, has an adequate areal extent, is stable with no significant subsidence, and is zoned for commercial redevelopment. The plans for the site include a retail and entertainment center. If redeveloped, the site would require long-term operation and maintenance, a stormwater management system, security and monitoring systems, and, most importantly, a gas management system (including a gas collection system, RCRA Subtitle C cap, and a landfill gas treatment system). The ground water remedy calls for perimeter liquids control, natural attenuation, long-term monitoring, and focused active pumping as a contingency action. The redevelopment of the OII Superfund site would be beneficial to all involved parties, including EPA, the PRPs, the towns of Monterey Park and Montebello, and the developers.

The deal is still being negotiated, but some key settlement components include consent decrees and property option and transfer agreements. The deal also calls for the establishment of at least on trust, and includes provisions for covenants-not-to-sue. Some critical success factors include open and timely communication among all parties, adoption of a collaborative approach combined with strategic partnering, a strong project sponsor, sensitivity to stakeholder cultures and processes, interest-based multilateral negotiations, strong project management and scheduling, and a focus on project marketability and market-driven processes.

Question: Were there regularly scheduled public meetings?

Answer: Yes, there were public meetings scheduled at least every six months in the initial planning phase; they have been less frequent as the project has entered the later stages.

Question: Did the community members provide input when planning for the redevelopment of the North Parcel?

Answer: Yes, they did. The residents of the City of Montebello were a bit more leery of redeveloping the site, but they eventually agreed to the concept.

SVE Optimization Initiative, Off-Gas Treatment Technologies, and Thermal Approaches for DNAPL Remediation, Jim Cummings, TIO

Jim Cummings provided forum members with a summary of the Soil Vapor Extraction (SVE) Optimization Initiative. Cummings noted that current SVE systems lower concentrations of contaminants to a point where concentration levels become asymptotic with cleanup goals. There are several problems with current methods of SVE that must be addressed by EPA. The asymptotic myth is too simplistic a mechanism for making remedial action determinations. Air streams from clean zones often dilute the streams from contaminated zones, a problem that is especially common when contaminants are extracted and monitored using a common manifold. In addition, overly optimistic estimates of effective air flow result in a lack of contact with source zones. More precise and comprehensive methods of site characterization must be developed to increase the optimization of SVE systems. The development of innovative system designs and monitoring methods will also increase the proficiency of SVE systems. Mid-course correction should become more common as improvements are made to characterization and monitoring techniques.

Cummings then discussed a new procedure developed by PRAXIS to optimize SVE systems that uses pneumatic well logging, known as PneuLog™. This profiling involves using a probe to take continuous air samples and measure the air velocity at all levels throughout the length of the well. The results are expected to provide a better picture of where the contamination is and where the airflow is greatest, better defining the lithology. The information can be used to model possible impacts of remaining contamination on ground water and to optimize the SVE system by only drawing from those portions of the well where the contamination exists. Data from a representative number of wells coupled with the historical concentration profile, flow data, and additional information from new wells, allow an optimized system to be designed. Optimization includes increasing or decreasing flow from wells, shutdown of some extraction wells, and/or installation of new extraction wells. The primary goals for optimization are to reduce long-term operational costs and accelerate cleanup. A secondary goal is to more accurately forecast the operation time for a system to achieve its cleanup criteria. PneuLog™ offers the potential to better delineate the variable permeability in heterogeneous subsurface conditions and to determine the areas of most significant contaminant concentration.

Cummings spoke about the remediation of DNAPLs, noting that through FY97, 89% of ground-water remedies were pump-and-treat only, 6% were pump-and-treat combined with an in situ remedy, and 5% used an in situ remedy only. He noted that there is an internal policy tension between remedies that simply contain the contaminants and those that actively remediate source areas. Cummings elaborated on some of the language that was contained in the ROD for the Del Amo Superfund site near Los Angeles, California.

Cummings detailed the use of stream-enhanced in situ thermal remediation at the 2-acre Southern California Edison Co. (Visalia) Superfund site in California. The removal mechanisms at the Visalia site include viscosity reduction, solubility increase, vaporization/steam distillation, and in situ oxidation. Approximately 865,000 pounds of creosote have been removed from the site. In the absence of extensive venture capital to augment cleanup funds, natural attention may be the most cost effective measure.

Cummings solicited forum members for information on a potential site that has source term removal and requires plume monitoring; if anyone has any suggestions, please contact Jim at 703-6037197 or cummings.james@epa.gov.

Cummings concluded with a discussion of a new six-phase heating device that has six active electrodes, complete with a seventh neutral electrode in the center that serves as a vent.

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