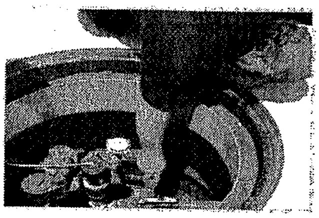
# Underground Storage Tanks

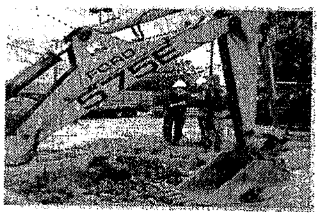




There are approximately 617,000 underground storage tanks (USTs) nationwide that store petroleum or hazardous substances. The greatest potential threat from a leaking UST is contamination of groundwater, the source of drinking water for most Americans. EPA, states, and tribes work together to protect the environment and human health from potential UST releases. You can learn more about USTs on our Basic Information page.



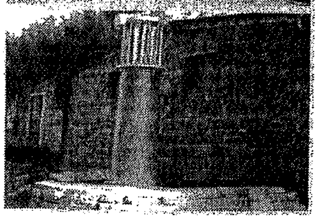
**Preventing UST Releases**
Regulations require that USTs be protected from spills, overfills, and corrosion. This section includes information and resources to help UST owners and operators meet those requirements.



**Cleaning Up UST Releases**
Regulations require that leaking USTs be cleaned up to restore and protect groundwater sources. This section includes information and resources to help UST owners and operators meet those requirements.

**Biofuels**
The biofuels compendium provides information regarding storage of ethanol and biodiesel fuels.

**Petroleum Brownfields**
The redevelopment of petroleum contaminated brownfields has significant positive impacts on local communities.



**USTs In Indian Country**
EPA provides technical and financial support to tribal governments to prevent and clean up releases from USTs in Indian country.

# Modeling Subsurface Petroleum Hydrocarbon Transport

The **OnSite** set of online tools for site assessment contains calculators for

- formulas,
- models,
- unit conversion factors and
- scientific demonstrations

to assess the impacts from ground water contaminants. For a quick overview of the calculators, read the **fact sheet** (PDF, 2 pp , 259 KB, **About PDF**), the extended **report** (PDF, 81 pp., 1.4 MB, **About PDF**), or join the **listserver** to receive updates on **OnSite** and the Internet modeling course.
Calculator **introduction**, **full list of calculators**
Highlights: **chemical properties**, **vertical gradient**, **gradient from 3 or more points**, **effective solubility**, **retardation factor**, **plume diving**
Examples: a company **assessing a site**, a regulator **reviewing a report**, fate & transport **review**

For more ideas and information on subsurface transport modeling, check our course on **Modeling Subsurface Transport of Petroleum Hydrocarbons**.

# The OnSite On-line Calculators For Subsurface Contaminant Transport Site Assessment

Office of Research and Development

National Exposure Research Laboratory

The U.S. Environmental Protection Agency (EPA) has developed a suite of on-line calculators called "OnSite" for assessing transport of environmental contaminants in the subsurface. The calculators are available on the Internet at http://www.epa.gov/athens/onsite and are divided into four categories:

1) Parameter Estimates
   - Hydraulic gradient
   - Moisture content in a sample
   - Retardation factor
   - Henry's constants
   - Estimated longitudinal dispersivity
   - Darcy's Law
   - Seepage Velocity
   - Effective solubility from fuels
   - Multiphase mass distribution
2) Simple Transport Models
   - Plume diving
   - Steady plume length
   - One-dimensional transport from a pulse, continuing, or fuel source
   - "Domenico" models: steady state centerline, unsteady
3) Unit Conversions
   - Flow rates
   - Hydraulic conductivity
   - Half lives/rate constants
   - Henry's Law constants
   - Dates/sequential times
   - Latitude-longitude to distance
4) Scientific Demos
   - Darcy flow in a laboratory column
   - Unsteady mass balance
   - Flow in a one-dimensional aquifer
   - Borehole concentration averaging

Purpose of OnSite: The purpose of these calculators is to provide methods and data for common calculations used in assessing impacts from subsurface contamination. Parameter estimates are included in OnSite for the convenience of experienced personnel, the education of inexperienced personnel, and for the potential to provide consistency among a diverse user community. The simple transport models were developed for two purposes — to demonstrate concepts of ground water flow and contaminant transport and to calculate concentrations given a set of input parameters. Unit conversions were provided for unit sets unique to subsurface transport calculations. These were intended to facilitate the correct application of transport formulas, because some of the units and conversions included are unfamiliar to many people. The scientific demos were outgrowths of modeling courses, where general concepts of transport need to be introduced.

A focus of some of the methods is on simple calculations, such as the retardation factor. Ideally there would be nearly universal ability to perform this calculation, but interaction with various client groups showed this not to be the case. Even for experienced analysts, the availability of a prepackaged calculation is viewed as a convenience. Beyond obvious labor savings, "convenience" facilitates correct application of the principles and ultimately more scientific decision making. Web site usage statistics show that even the

www.epa.gov/nerl/

# The OnSite On-line Calculators

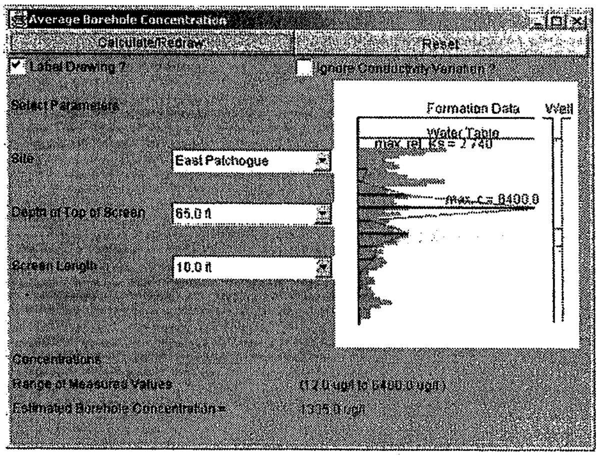
simple calculators are used commonly. A somewhat different class of calculation is represented by the effective solubility calculator. This calculator determines concentrations of chemicals in equilibrium with various fuels. In contrast to the retardation factor, the formula itself is much less well-known, and the required input data are not commonly available. In this case the calculator provides a unique resource to the community as the ability to calculate this quantity is not expected to be widespread.

Unique concepts were introduced through the calculators, primarily to the underground storage tank community. The premier example of this concerns the effect of rainwater infiltration on contaminant plumes. Research conducted at contaminated sites showed that plumes were pushed downward, rather than diluted. Development and testing of assessment methodologies provided software for predicting this behavior. Providing an on-line calculator (plume diving) placed this technology directly into the hands of the Leaking Underground Storage Tank community. The calculators allow estimation of the amount of vertical displacement of the plume (plume diving) and show the effects on measured concentrations of placing well screens in the wrong vertical position (average borehole concentration).

History: Since their inception in 1998 the calculators have been used by several state agencies, EPA Regional Offices and private consulting firms. From the web logs we know that there has been a steady increase in usage of the site and that the most commonly-used calculators are the estimators for effective solubility, the retardation coefficient, plume diving in aquifers, estimation of hydraulic gradients, seepage velocity and moisture contents. In June of 2002, web site usage went above 10,000 per month for the first time.

Computer Details: The calculators are implemented in either JavaScript or Java. JavaScript is well suited for a simple calculation that does not require a graphical output. Java was used to create applets for calculations with complex inputs or the need for graphical output. In either case all calculation is performed on the end-user's computer. No information that is entered into any OnSite calculator is collected by EPA. EPA does, however, accumulate statistics on the number of times pages are accessed, browsers used, user's domain names (.com, .edu, .gov, etc), and similar generalized information (see http://www.epa.gov/epafiles/usenotice.htm for details)

Ideas for new calculators are developed from suggestions from users and in response to requests for information. These have come from State Agencies, EPA Regional and Program Offices and the private sector.




*The Average Borehole Concentration calculator that is illustrating the concentration that would be seen in a well with a 10 foot long screen located 65 feet below the ground surface. The maximum peak concentration nearby this well was 6400 ug/l, but the effect of borehole averaging was to reduce the observed concentration to 1335 ug/l.*

For More Information, Contact:


Jim Weaver, weaver.jim@epa.gov
U.S. Environmental Protection Agency
Athens, GA 30605-2700
706-355-8329


http://www.epa.gov/athens/onsite

# Ground Water and Ecosystems Restoration Research





## Center for Subsurface Modeling Support (CSMoS)

Center for Subsurface Modeling Support • U.S. EPA NRMRL/GWERD Ada, OK •

**Important Information**

**Discussion of Domenico Approximation used in BIOCHLOR, BIOSCREEN, FOOTPRINT, and REMChlor Models**

### CSMoS

The Center for Subsurface Modeling Support (CSMoS) provides public domain ground-water and vadose zone modeling software and services to public agencies and private companies throughout the nation. CSMoS is located in Ada, Oklahoma at the National Risk Management Research Laboratory (NRMRL), the U.S. EPA's Center for Ground-Water Research. The primary aims of CSMoS are to provide direct technical support to EPA and State decision makers in subsurface model applications and to manage and support the ground-water models and databases resulting from the research at NRMRL. This research encompasses the transport and fate of contaminants in the subsurface, the development of methodologies for protection and restoration of ground-water quality, and the evaluation of subsurface remedial technologies. As a result, a major focus of CSMoS entails coordinating the use of models for risk assessment, site characterization, remedial activities, wellhead protection, and Geographic Information Systems (GIS) application. In these ways, CSMoS performs an active role in protecting, restoring, and preserving our nation's ground-water resources.

http://www.epa.gov/ada/csmos/models.html
Last updated on Friday, December 4th, 2009.

# Ground Water and Ecosystems Restoration Research





## CSMoS Ground-Water Modeling Software

Center for Subsurface Modeling Support • U.S.EPA NRMRL/GWERD Ada, OK •

**Free Public Domain Ground-Water and Vadose Zone Models**

CSMoS distributes various public domain ground-water and vadose zone models. Click here to view a short description of all models. Models and manuals are available through various different options. You can:

- Click the links in the table below to view installation instructions, system requirements, model descriptions and files available for download.
- Send blank CDs, ZIP disks, or 3.5" floppy diskettes to CSMoS. CSMoS will copy the requested models or manuals to disks and return the disks to you.
- Contact Mark Stacy (stacy.mark@epa.gov) (580) 436-8724 for other arrangements.

CSMoS provides free technical support for many of the models listed in the table below.

Join the CSMoS e-mail list to receive news about new releases of public domain ground-water models, version updates, bugs, fixes, and other important items.

Want more? CSMoS also maintains an on-line database of commercially available ground-water modeling software.

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Click here for Important Disclaimers

| Model | Version | Release Date | Platform |
|---|---|---|---|
| | | | |
| BIOCHLOR2.2 | 2.2 | June 2002 | Windows 95/98/NT, Excel |
| BIOPLUME II | 1.1 | October 1989 | DOS |
| BIOPLUME III | 1.0 | September 1997 | Windows 95/98 |
| BIOSCREEN | 1.4 | July 1997 | Windows 95/98/NT, Excel |
| CHEMFLO | 1.30 | August 1990 | DOS |
| CHEMFLO-2000 | 2003 | April 2003 | Windows 95/98/NT/2000/XP, Linux, Solaris, Mac OS X |
| CZAEM | 1.1 | August 1996 | DOS |
| 2DFATMIC | 1.0 | August 1997 | DOS |
| 3DFATMIC | 1.0 | August 1997 | DOS |
| FOOTPRINT | 1.0 | June 2008 | Windows 98 or higher, MS .NET Framework, Excel |
| GEOEAS | 1.2.1 | April 1991 | DOS, UNIX |
| GEOPACK | 1.0.e | January 1990 | DOS |
| HSSM-DOS | 1.0 | April 1994 | DOS |
| HSSM-Windows | 1.20.e | September 1997 | Windows 95/98 |
| HSSM en Español | 1.20.e | September 1997 | Windows 95/98 |
| Infiltration Models | | | Mathcad |
| MODFLOW Manual | | February 1993 | DOS |
| MOFAT | 2.0.a | May 1991 | DOS |
| MT3D EXIT Disclaimer | 5.2 | October 2006 | DOS |
| NAPL Simulator | 1.0 | October 1997 | DOS, UNIX |
| OWL | 1.2 | March 2004 | Windows 95/98/NT/2000/XP |
| PESTAN | 4.0 | May 2007 | Windows 98 or higher |
| REMChlor | 1.0 | December 2007 | Windows 98 or higher |
| RETC | 1.1 | November 1994 | DOS |
| RITZ | 2.12 | January 1988 | DOS |
| STF | 2.0 | June 1991 | DOS |
| UTCHEM | 6.1 | February 1999 | Windows/UNIX |
| Virulo | 1.0 | August 2002 | Windows/UNIX/Mac |
| VLEACH | 2.2.a | May 2007 | Windows 98 or higher |
| WhAEM 2000 | 3.2.1 | September 2007 | Windows 98/NT/2000/XP |
| WHPA | 2.2 | September 1993 | DOS |

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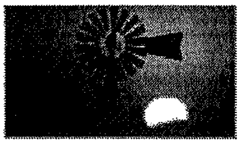
# Groundwater



Groundwater is the water found in underground aquifers. A significant portion of the drinking water supply for the United States comes from underground sources. The oil and natural gas industry is keenly aware of the vulnerability of this resource, and works to ensure that it is not endangered.

API supports industry's pollution prevention efforts by conducting research on the behavior and fate of petroleum in soil and groundwater, and the best ways to clean up underground petroleum releases. Much of API's research effort focuses on the breakdown of petroleum by naturally-occurring microscopic organisms and other processes, and ways to enhance these processes.

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Updated: January 5, 2009

# Managing Soil Contamination in the United States: Policy and Practice

Matthew C. Small, Ph.D., P.G.
U.S. Environmental Protection Agency
Region 9 Underground Storage Tanks Program Office
75 Hawthorne Street, WST-8, San Francisco, CA 94105
Phone: 415-972-3366 email: small.matthew@epa.gov

### Abstract

Soil contamination in the United States is managed using a risk-based decision making process. In other words, we don't ask, "how much soil contamination can be cleaned up?" Instead we ask, "how much contamination can be safely left in place?" The determination of "safe" levels of contamination is based upon the potential for exposure and the toxicity of the contaminants of concern in soil. Potential for exposure is determined by evaluating potential exposure pathways from source to receptor given current or reasonably anticipated land use. Soil cleanup goals are then calculated for any complete exposure pathways based upon toxicity and the route of exposure. In some cases, institutional or engineering controls are also used to limit the potential for exposure. In order to prevent a continuous degradation of environmental quality, risk-based cleanup approaches must be combined with strong contamination prevention programs. In addition, alternative risk management approaches should be incorporated into an overall risk reduction strategy.

### Introduction

Soil contamination in the United States is managed using a risk-based decision making (RBDM) approach. There is not enough money or resources available to clean up all soil contamination in the United States to uncontaminated conditions. Basing cleanup decisions on risk reduction allows resources that are inevitably finite, to be allocated across sites for maximum risk reduction benefit. However, this change in emphasis from engineered on-site mass (or concentration) reduction to risk-reduction at the point of exposure may also result in greater quantities of residual soil contamination being left in place at some sites upon cleanup completion. Though this may be a more economically efficient approach to cleanup, it knowingly accepts some finite cost of the remaining contamination or the associated environmental resource degradation, and in at least some cases the cost may be higher than we realize.

By applying a RBDM approach to soil contamination cleanup, we have gone from asking, "how much contamination can we clean up?" to asking, "how much contamination can we safely leave in place?" This subtle but important shift in perspective has potentially far-reaching implications for the way we manage soil contamination. Because of the difficulties associated with removing contamination from the subsurface the answer to the first question of how much can we clean up has often been "not much, at least in the short run." Therefore, we have already been leaving some contamination in place by default or as a result of our inability to remove it with the resources that have been allocated.

**Risk-Based Decision Making (RBDM), Deciding What is Safe**

Addressing the question of how much contamination we can safely leave in place becomes a risk management decision. Risk management at contaminated soil sites usually takes the form of preventing harmful impacts to receptors as expressed through cleanup concentration goals. On a regional scale this means determining which contamination, or contaminated sites will do the least resource damage if left in place.

*Concentration-Based Cleanup Goals*
State and Federal regulations require that the lateral and vertical extent of soil contamination be defined through environmental sampling and investigation. Based on data gathered during the site assessment process sources of contamination, potential migration pathways, and human and ecological receptors are defined. Exposure Assessment is used to evaluate the potential for contaminants to migrate from soil through water or air and impact a receptor (Figure 1).

When a complete exposure pathway is found between the source of contamination and a receptor, risk assessment is used to evaluate the impacts to the receptor. Chemical dose response data from laboratory studies with animals is extrapolated to estimate health impacts in humans. These estimates are generally based on either toxic effects of a compound expressed as reference dose or carcinogenic effects expressed as a slope factor. Reference doses and slope factors are combined with standard exposure factors to determine concentrations that will not exceed acceptable risk levels. Acceptable risk levels are usually set at a non-carcinogenic hazard Quotient of less than 1 and an incremental cancer risk between one in ten thousand ($1 \times 10^{-4}$) and one in a million ($1 \times 10^{-6}$). Standard risk calculations can then be used to determine concentrations that will not exceed acceptable risk levels, as shown in the example equations for combined exposures to carcinogenic and non-carcinogenic contaminants in residential soil respectively (EPA, 2002a).

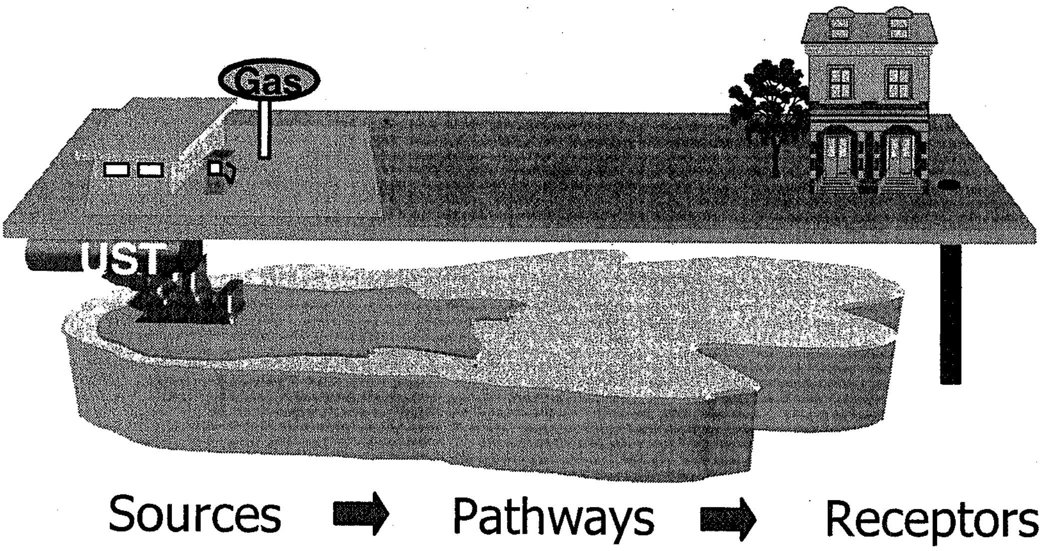


**Figure 1. Exposure assessment is used to evaluate the potential for contaminants to migrate from soil through pathways such as aquifers to receptors.**

$$C(mg/kg) = \frac{TR \; x \; AT_c}{EF_r \; [(\frac{IFS_{adj} \; x \; CSF_o}{10^6 mg/kg}) + (\frac{SFS_{adj} \; x \; ABS \; x \; CSF_o}{10^6 mg/kg}) + (\frac{InhF_{adj} \; x \; CSF_i}{VF_w^a})]}$$

$$C(mg/kg) = \frac{THQ \; x \; BW_c \; x \; AT_n}{EF_r \; x \; ED_c \; [(\frac{1}{RfD_o} \; x \; \frac{IRS_c}{10^6 mg/kg}) + (\frac{1}{RfD_o} \; x \; \frac{SA_c \; x \; AF \; x \; ABS}{10^6 mg/kg}) + (\frac{1}{RfD_i} \; x \; \frac{IRA_c}{VF_s^a})]}$$

Where:

C = "safe" concentration in soil (mg/kg)
CSFo = Cancer slope factor oral (mg/kg-d)
CSFi = Cancer slope factor inhaled (mg/kg-d)
RfDo = Reference dose oral (mg/kg-d)
RfDi = Reference dose inhaled (mg/kg-d)
TR = Target cancer risk $10^{-6}$
THQ = Target hazard quotient 1
BWa = Body weight, adult (kg) 70
BWc = Body weight, child (kg) 15
ATc = Averaging time - carcinogens (days) 25550
ATn = Averaging time - noncarcinogens (days) ED*365
SAa = Exposed surface area for soil/dust (cm2/day) adult resident 5700, worker 3300
SAc = Exposed surface area, child in soil (cm2/day) 2800

AFa = Adherence factor, soils (mg/cm2) adult resident 0.07, adult worker 0.2
AFc = Adherence factor, child (mg/cm2) 0.2
ABS = Skin absorption defaults (unitless)
IRAa = Inhalation rate - adult (m3/day) 20
IRAc = Inhalation rate - child (m3/day) 10
IRWa = Drinking water ingestion - adult (L/day) 2
IRWc = Drinking water ingestion - child (L/day) 1
IRSa = Soil ingestion - adult (mg/day) 100
IRSc = Soil ingestion - child (mg/day), 200
IRSo = Soil ingestion - occupational (mg/day) 100
EFr = Exposure frequency - residential (d/y) 350
EFo = Exposure frequency - occupational (d/y) 250
EDr = Exposure duration - residential (years) 30
EDc = Exposure duration - child (years) 6
EDo = Exposure duration - occupational (years) 25
Age-adjusted factors for carcinogens:
IFSadj = Ingestion factor, soils ([mg-yr]/[kg-d]) 114
SFSadj = Dermal factor, soils ([mg-yr]/[kg-d]) 361
InhFadj = Inhalation factor, air ([m3-yr]/[kg-d]) 11
IFWadj = Ingestion factor, water ([L-yr]/[kg-d]) 1.1
VFw = Volatilization factor for water (L/m3) 0.5
PEF = Particulate emission factor (m3/kg)
VFs = Volatilization factor for soil (m3/kg)

Using this approach, risk-based "safe" concentrations can be established for a variety of exposure pathways including soil ingestion, ingestion or contact with water that has been in contact with contaminated soil, dermal contact with contaminated soil, and inhalation of vapors volatilizing from contaminated soil. Generic, conservative parameters are used to develop screening levels that can be used rapid preliminary risk evaluation (EPA, 2002b). Site-specific parameters along, contaminant fate and transport modeling, and alternative points of compliance can then be used to calculated site-specific "safe" concentrations.

This approach incorporates risk reduction as the driving force for cleanup decisions. Cleanup goals are based on reducing concentrations at the site to levels that will not exceed a predetermined risk at the point of exposure. The estimate of risk reduction is typically contingent on site conditions and land use remaining relatively static into the future.

*Engineering and Institutional Controls*
With increased attention and funding being focused on redevelopment of contaminated properties, or Brownfields, there is often pressure to employ a combination of concentration reduction and exposure pathway elimination through the use of engineering and institutional controls. Engineering controls are usually barriers such as slurry walls, asphalt caps, or vapor barriers under foundations that prevent migration of contaminants from soil to receptors. Institutional controls typically take the form of regulating and

permitting activities that create the potential for exposure such as soil excavation and water well drilling. The key challenge for institutional and engineering controls is ensuring the longevity of these controls by providing for appropriate monitoring and enforcement.

**Alternative Risk Management Approaches**

There are a number of limitations associated with the current risk-based approach employed in the United States. In general, synergistic effects are not accounted for. In fact, some chemicals may interact to increase or decrease overall toxicity. Pre-remediation exposures are often neglected. Elevated background risks for heavily impacted communities may also be neglected. The following alternative risk assessment and risk management paradigms hold some promise for addressing these issues if they can be integrated into with the current risk-based decision making approach.

- *Anti-degradation Policies* - Policies and regulations requiring environmental restoration to pre-release conditions. Typically applied to water resources. Often economically and technically difficult to achieve.

- *Pollution Prevention* - accomplished through best management practices for chemical storage, transportation, and handling, land use planning, waste minimization, and programs that provide incentives for protecting resources.

- *Precautionary Principle* - "When an activity raises environmental threats, precautionary measures should be taken even if some cause-and-effect relations are not fully established scientifically. The proponent of an activity should bear the burden of proof" Replace the Environmental Protection Agency approach where chemicals are ok to use until proven hazardous with the Food and Drug Administration approach where drugs are dangerous until proven safe.

- *Use of Biodegradable Industrial Chemicals* - Recalcitrant compounds such as halogenated organics and ethers are some of the most widespread, problematic, and toxic compounds in the environment. Biodegradable substitutes exist for many of these compounds in most applications (Thornton, 2001).

- *Life Cycle Analysis* - Evaluate the entire production, use, disposal, and waste management cycle for chemicals. Particularly recalcitrant chemicals in widespread use. Process inventory, impact assessment, time and location independent effects may ignore local impacts and thresholds. Often expressed as negative effect on number of years that can be lived in good health.

- *Environmental Justice* - Environmental protection is a right, not a privilege. Environmental protection is not equal across class and racial lines. For example, preferential siting of hazardous waste facilities. High correlations have been found between minority populations and levels of toxic pollutants. Accusations of less aggressive cleanups in minority communities.

- *Long-term Management of Residual Contamination* - Institutional controls, permitting restrictions (wells and excavations), well-head protection and vulnerability analysis, land-use restrictions based on aquifer vulnerability and basin management, long-term plume and site tracking using geographic information systems (GIS), multi-agency data sharing and access

**Incentives and Disincentives for Contaminating Soil (Accountability)**

Historically soil contamination has been treated as an accident, with no moral retribution or punishment for owners and operators who showed a good faith effort to clean up. As polluters were still liable for the damage, a strong disincentive to releasing petroleum remained, namely, the staggering cost of cleaning up. However, RBDM may only require polluters to clean up when there is a risk. This removes much of the financial disincentive for contaminating, particularly in "lower risk" areas. In light of this we may need to re-examine disincentives for contaminating soils. Given all of the programs and priorities competing for resources we don't want to pour money into the ground unless it will be well used. However, there is some cost associated with resource damage and loss of beneficial uses of soils.

The costs of resource damage and loss of beneficial uses can be difficult to quantify, but it may be worthwhile to explore ways to hold polluters more financially accountable for current and future worth of damaged environmental resources. Possible approaches include requiring contribution to a trust fund, paying for source water protection programs in the impacted watershed, or undertaking supplemental environmental projects to compensate for the value of the resources which have been damaged. For example, let us consider a hypothetical case where contaminated ground water under a site is worth $100 and it costs $50 to remove half of the contamination, but $150 to remove the remaining contamination. In other words the cost of the resource damage may be less than the cost of the cleanup, but it is not zero. Perhaps it would be appropriate to remove the first $50 of contamination, and charge the responsible party $50 more for the damages associated with leaving the remaining contamination in the ground.

**Conclusions**

Preventing soil contamination in the first place is the best way to protect soil resources. This can be accomplished through best management practices, land use planning, waste minimization, and programs that provide incentives for protecting resources. We must also be more proactive in managing the potential for soil contamination. We can use land-use planning and basin management plans to reduce the potential for resource damage from contaminant releases in the future. Communities can choose to site potentially contaminating activities in areas where the potential to impact soil and water resources is lower.

When soil does become contaminated, we must continue to hold responsible parties accountable. We must use all of the risk management approaches at our disposal for resource restoration, public health protection, and cleanup. Managing short-term exposure risks through source control, engineered and monitored remediation, engineering controls to prevent exposure, monitored natural attenuation (when appropriate), and engineered containment (when appropriate). Managing long-term exposure risks through institutional controls, permitting restrictions (wells and excavations), land-use restrictions, and multi-agency data sharing and access.

**Acknowledgments**
Hun Seak Park, of the Washington State Department of Ecology along with Jim Weaver, Patrick Wilson, and Stan Smucker of U.S. EPA have contributed invaluable discussions and clarifications. The Authors would also like to thank Korea Environment Institute and Dr. Yong Ha Park for the kind invitation to submit this manuscript.

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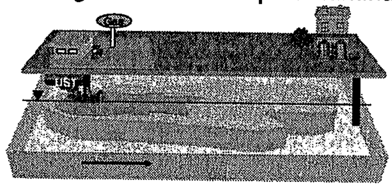
# Managing the Risks of Petroleum Product Contamination in the U.S.

Matthew Small, Ph.D., P.G.
U.S. Environmental Protection Agency
Region 9, San Francisco, CA
415-972-3366 small.matthew@epa.gov

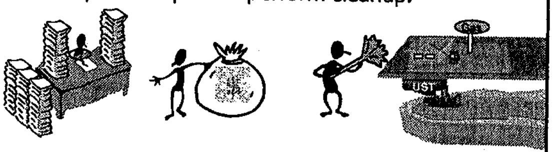
## Cleaning up Petroleum Releases in the United States

- Petroleum releases are considered accidents.
- Responsible parties are required to investigate and clean up contamination.




## Petroleum Cleanup Process in the United States

- State Regulators set cleanup goals and monitor progress.
- State Funds pay for cleanup.
- Responsible parties perform cleanup.




## How Clean is Clean?

- How much cleanup is required?
- What are the cleanup goals?
- Can we restore the site to uncontaminated conditions?

## Reality of Cleanup

- We don't have enough money or resources to clean up all petroleum release sites to uncontaminated conditions.
  - State funds have been going bankrupt.
  - Gas stations have gone out of business.
- Economic surrender, we can't do it all.

## Cleanup Goals for Petroleum Contamination Have Changed!

- We used to ask,

  "how much contamination can we clean up?"

- **Now** we ask,

  "how much contamination can we **safely** leave in place?"

## Deciding What is Safe

- Exposure assessment:
  - Extent of contamination and chemicals of concern.


Sources ➡ Pathways ➡ Receptors

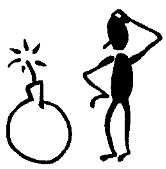
## Deciding What is Safe

- Risk assessment:
  - Chemical dose response data from laboratory studies with animals.
  - Laboratory data extrapolated to humans.
  - Conservative or site-specific exposure data used to calculate cleanup goals based on risk.

$$Risk_c = \frac{C(\mu g/l) \times EF_r \times [(IFW_{adj} \times CSF_o) + (VF_w \times InhF_{adj} \times CSF_i)]}{AT_c \times 1000 \mu g/mg}$$

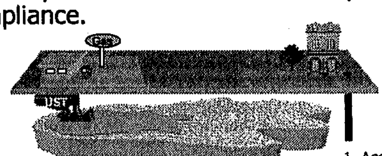
## Cleanup Goals, What is Safe:

- Risk Management.
  - Concentration-based goals:
    - Conservative/generic risk-based goals.
    - Site specific, risk-based goals.
  - Performance-based goals:
    - Containment.
    - Migration control.
  - No action.



## Setting Cleanup Goals, RBCA

- Risk-Based Corrective Action (RBCA) uses models to back-calculate cleanup goals based upon allowable risk at a the point of compliance.




3. Cleanup Goals:
benzene < 50 mg/kg in soil
Benzene < 5 ug/l in water

← 2. Back Calculation (Inverse Modeling)

1. Acceptable risk at point of compliance: $Risk_c < 10^{-6}$

## Setting Cleanup Goals, RBCA

- Tiered approach
  - Tier 1: Generic/Conservative parameters and assumptions.
  - Tier 2: Site specific parameters, conservative assumptions.
  - Tier 3: Site specific parameters and assumptions.
- Alternate points of compliance
  - Property boundary
  - Resource protection point

## Chemicals of Concern at U.S. Petroleum Sites

- Volatiles (gasoline):
  - Benzene, toluene, ethylbenzene, xylene (BTEX).
  - Easy to clean up, easily biodegraded.
- PAH's (diesel):
  - Benzo(a)pyrene, naphthalene, anthracene, chrysene.
  - Relatively easy to clean up, easily biodegraded.
- Oxygenates (gasoline):
  - Methyl tert butyl ether (MTBE), tert-butyl alcohol.
  - Harder to clean up, recalcitrant.
- Everything else (gasoline and diesel):
  - Total petroleum hydrocarbons (TPH).
  - Often ignored and left in place.

## Risk Management

- Risk assessment "how risky is it?"
  - Likelihood of harm to humans and/or the environment.
- Risk management "what shall we do about the risk?"
  - Evaluating regulatory options.
  - Evaluating economic, social, and political consequences of regulatory options.
  - Regulatory decisions and actions.

## Risk Management Decisions

Expressed as Cleanup Goals/Emissions Limits

- Concentration-based goals:
  - Background or non-detect.
  - Generic level, conservative or political.
  - Site specific, risk-based level.
- Performance-based goals:
  - Containment.
  - Migration control.
- No action.

## Risk Management Through Remediation

- Extraction, excavation, and injection.
- Remediation for petroleum contamination has been marginally effective in many cases as demonstrated by MTBE
- For some sites MNA may work as quickly as more active remedial approaches.

## Reality of Cleanup

- Chemicals products don't come out of the ground as fast as they go in.
- No amount of regulatory requirements can speed up the physical laws of nature that determine remediation rates and effectiveness (Walt McNab).
- **We need to work within nature's physical laws to solve contamination problems.**

## What Can We "Safely" Leave in Place?

- What are we leaving in place?
- What is the risk of exposure?
- How can we manage short and long-term risks?

## Updated Regulatory Strategies for Risk Management

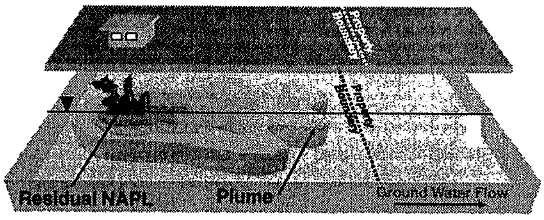
- Continue to hold responsible parties accountable:
  - prevention, prevention, prevention
  - best management practices
  - waste minimization
  - public health protection
  - cleanup
  - resource restoration

## Updated Regulatory Strategies for Risk Management

- Manage short-term exposure risks:
  - source control
  - engineered and monitored remediation
  - engineering controls to prevent exposure
  - Monitored natural attenuation (when appropriate)
  - engineered containment (when appropriate)

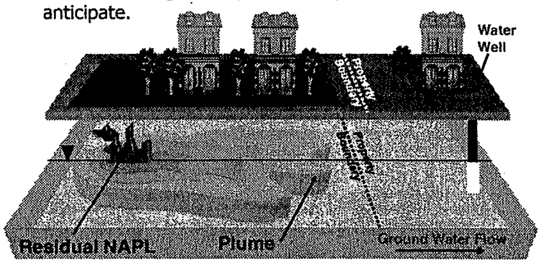
## Long Term Exposure Management: Your Site Today

- Cleaned up to risk-based levels for BTEX and MTBE TPH left in place, based on current land use.
- Property boundary is point of compliance.




## Long Term ExposureManagement: Your Site in 5 Years!

- Land use changes and potential exposures are hard to anticipate.




## Tools for Long-Term Exposure Management

- Engineering controls
  - Migration control.
  - Containment zones.
- Institutional controls
  - Notice to title.
  - Permitting restrictions (wells and excavations).
  - Well-head protection and vulnerability analysis.
  - Land-use restrictions based on aquifer vulnerability and basin management.
  - Long-term plume and site tracking using GIS.
  - Multi-agency data sharing and access.

## Alternative Risk Assessment and Management Paradigms

- Pollution prevention and leak prevention.
- Water quality anti-degradation policies.
- Precautionary principle.
- Use of Biodegradable Industrial Chemicals.
- Life cycle analysis.
- Environmental Justice.
- Long-term exposure management.

## Further Reading

- Risk Guidance
  http://www.epa.gov/nceawww1/metho.htm
- Exposure Factors Handbook
- Guidelines for Exposure Asessment
  http://www.epa.gov/nceawww1/pdfs/guidline.pdf
- Pandora's Poison, Joe Thornton.

U.S. Environmental Protection Agency

Office of Underground Storage Tanks www.epa.gov/oust

# FY 2008 Annual Report On The Underground Storage Tank Program

For nearly a quarter of a century, EPA, states, tribes, and other partners have made significant progress in preventing, detecting, and cleaning up leaks from underground storage tanks (USTs). In Fiscal Year (FY) 2008, EPA's UST program continued these efforts by increasing prevention activities, reducing the number of new releases, and furthering the cleanup of existing releases. The program made good progress toward meeting its established goals for the fiscal year and began to review existing tank regulations, with a goal of updating them to ensure Energy Policy Act requirements apply to all tanks. EPA also developed new Web resources, such as our state fuel delivery prohibition site and a biofuels compendium to provide assistance to states, tribes, and other tank stakeholders.

This report provides a snapshot of program activities conducted in FY 2008 (October 1, 2007 - September 30, 2008) and the advances made in preventing releases, conducting cleanups, and enhancing communication and information sharing efforts. The success and progress of the program during the past year are due to the support and dedication of EPA's partners to prevent groundwater contamination and further protect human health and the environment from UST releases.

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## FY 2008 UST Program Highlights

At the end of FY 2008, there were approximately 623,000 federally-regulated, active USTs at approximately 235,000 sites across the country. Collectively, the UST program has accomplished a great deal.

**Prevention**

√ Two-thirds of active USTs are fully complying with requirements to prevent and detect leaks.

√ UST partners have increased inspection efforts in order to meet the first three-year inspection mandate by 2010, which is mandated in the Energy Policy Act.

√ The number of new UST releases identified each year continues to decline, with just over 7,300 new leaks found in FY 2008 (meeting EPA's goal to reduce releases to fewer than 10,000).

√ EPA began regulation development to incorporate Energy Policy Act requirements and review existing regulations.

**Cleanup**

√ Since the inception of the program, UST partners have completed more than 377,000 cleanups.

√ Of the 479,000 leaks reported since the beginning of the program, about 80 percent have been addressed, leaving a backlog of almost 103,000 old leaks remaining to be cleaned up.

√ In FY 2008, UST partners cleaned up 12,768 sites, meeting 98 percent of EPA's annual goal to clean up 13,000 leaking UST (LUST) sites.

√ EPA developed a new plan of action to promote cleaning up and reusing petroleum brownfields, of which there are approximately 200,000.

√ EPA continued our study to characterize the LUST cleanup backlog and improve the pace of cleanups.

*Underground storage tanks are located at gas stations and other non-retail locations*

**FY 2008 GPRA***
**National UST Program**
**Goals And Accomplishments**

| | Goal | Actual |
|---|---|---|
| Cleanups — Total | 13,000 | 12,768 |
| Cleanups — Indian Country | 30 | 40 |
| Significant Operational Compliance Rate | 68% | 66% |
| New Reported Releases | <10,000 | 7,364 |

**Government Performance Results Act of 1993*

Annually, the UST prevention and cleanup programs receive about $100 million to prevent, detect, and clean up leaks from federally-regulated USTs. The vast majority of that funding is provided directly to states and tribes to implement their prevention and cleanup programs.

# Advances In Preventing Releases

Since the beginning of the UST program, preventing petroleum releases into the environment has been one of the primary goals of the program. EPA and our partners have made major progress in reducing the number of new releases, but thousands of new leaks are still discovered each year. The lack of proper operation and maintenance of UST systems is a main cause of these new releases. EPA is working with states, tribes, and other partners to advance prevention efforts and quickly detect releases when they occur.

In recent years, these efforts have been enhanced by the release prevention requirements mandated in the Energy Policy Act of 2005. To address these mandates, EPA produced several grant guidelines to help states carry out the requirements. Some of the states already have requirements in place that meet the requirements, and other states are working to implement the provisions in the upcoming years. EPA continues to work with states and tribes to prevent UST releases and meet the mandates initiated with the Energy Policy Act.

## UST Universe End Of FY 2008

| | | |
|---|---|---|
| **States** | Active Tanks: | 620,663 |
| | Closed Tanks: | 1,689,935 |
| **Indian Country** | Active Tanks: | 2,656 |
| | Closed Tanks: | 5,623 |

## Reducing Confirmed Releases

In FY 2008, EPA, states, and tribes focused on bringing UST systems into compliance and keeping them in compliance with release detection and prevention requirements. One way the program assesses the relative success of these prevention efforts is to measure the number of confirmed releases each year. EPA's goal for FY 2008 was to reduce confirmed tank releases to fewer than 10,000.

There's been a steady reduction in underground storage tank confirmed releases, from almost 67,000 in FY 1990 to 7,364 in FY 2008.

*Inspecting under the dispenser*

## Working To Increase UST Facility Compliance

One of the key elements in preventing releases is to increase a facility's operational compliance with UST regulations. Significant operational compliance (SOC) means that a facility has the necessary equipment required by current UST regulations to prevent and detect releases and performs the necessary UST system operation and maintenance. In FY 2008:

√ The **national SOC rate** was **66 percent**; although below our target, it is a three percent increase over last year's rate.

√ The **SOC rate in Indian country** was **57 percent**, an 11 percent increase over last year's rate.

**In FY 2008, EPA provided $1.5 million for the UST prevention program in Indian country; EPA also provided $29 million to states for UST prevention activities.**

## Preventing Releases In Indian Country

Tribes and EPA worked to improve UST compliance in Indian country in FY 2008 by enhancing inspection efforts, developing additional compliance-focused assistance agreements with tribes, and providing training to tribal environmental professionals and facility owners and operators.

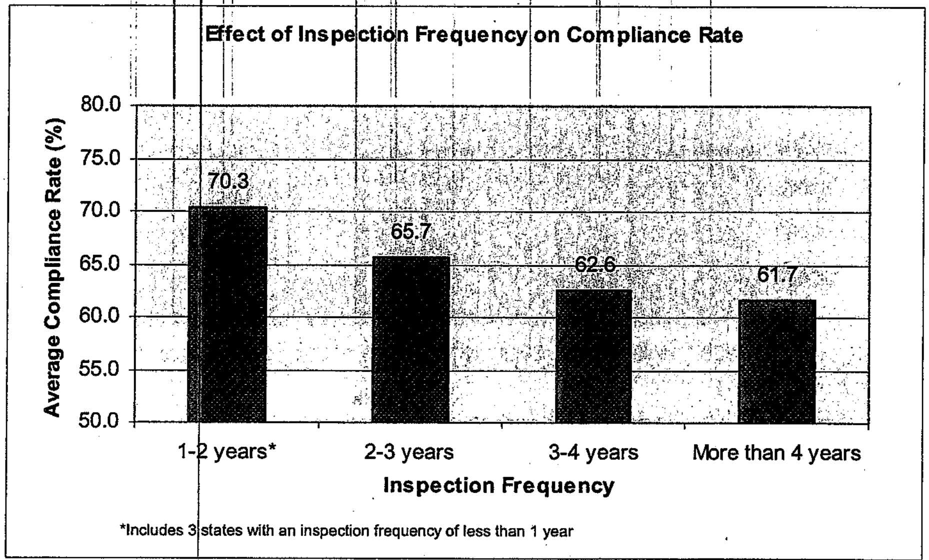
In addition, the second annual national Tribal/EPA meeting, held in October 2008, helped identify tribal issues, build collaboration, and work toward continued partnerships and improvements in the UST program in Indian country.

## Steady Progress Implementing Energy Policy Act Provisions

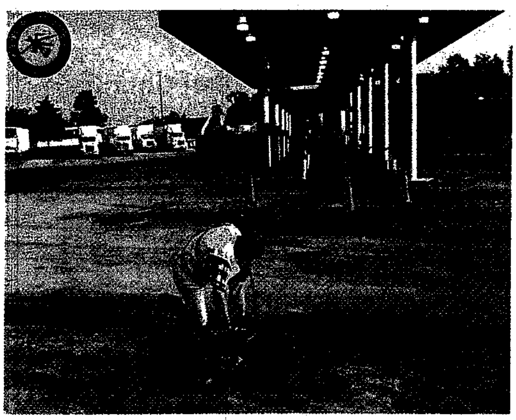
The Energy Policy Act of 2005 mandated numerous changes that focus on reducing underground storage tank releases and significantly affect federal and state underground storage tank programs. Over the past few years, EPA and states have made significant progress toward meeting the Act's requirements. For example, all states except one have grant agreements in place to implement Energy Policy Act provisions. More than 30 states have delivery prohibition and secondary containment programs up and running, with the remaining states finalizing regulations to implement these requirements.

The Energy Policy Act also included on-site inspection requirements. EPA and states have long recognized the importance of inspections in preventing releases, and inspecting USTs has always been a priority in the tanks program. But the inspection requirements of the Energy Policy Act brought greater program oversight to this effort by mandating that all USTs not inspected since 1998 be inspected by August 8, 2007. EPA and all states successfully completed this requirement.

Additionally, the Energy Policy Act requires that tanks are to be inspected every three years after the initial requirement — and EPA, states, and tribes are now working to meet the next inspection requirement. There are about 235,000 active facilities that need to be inspected for this three-year cycle, and in FY 2008 approximately 100,000 facilities were inspected. With the first three-year cycle ending in August 2010, the majority of states are on track to meet this requirement, and EPA is working with remaining states to identify collaborative ways to meet the deadline.




EPA will continue to work with states to ensure continued progress implementing all Energy Policy Act requirements. Additionally, because more frequent inspections result in increased compliance rates, we will continue to focus on enhancing UST inspection efforts.



*Inspecting a spill bucket*

## Developing Federal Credentials For Tribal Inspectors

Designating tribal inspectors as authorized representatives of EPA to inspect USTs can help increase the geographic coverage and frequency of inspections in Indian country. It also helps enhance relationships and increase the capabilities of tribal inspectors. There are currently four tribes which have federally-credentialed inspectors who can conduct federal UST inspections at their tribal facilities and potentially other facilities. The tribes are:

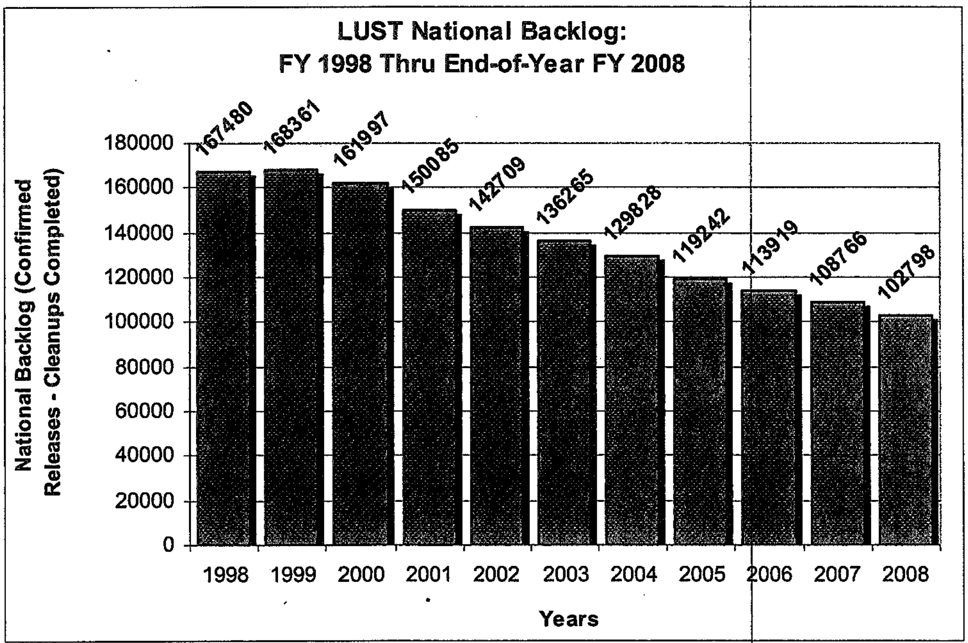
- √ Eastern Band of the Cherokee Indians
- √ Navajo Nation
- √ Nez Perce Tribe
- √ Shoshone-Bannock Tribes

EPA will continue to work with tribes to train other tribal inspectors and issue additional credentials.

# Advances In Cleaning Up Releases

Over the past quarter century, the UST program has made great progress in cleaning up leaking underground storage tanks. EPA works with states and tribes to clean up LUST sites, promote innovative approaches to streamline the remediation process, and address the hurdles in reducing the backlog of cleanups.

In FY 2008, EPA and its state and tribal partners continued to make progress in cleaning up petroleum leaks by initiating 8,156 cleanups and completing 12,768 cleanups, of which 40 cleanups were completed in Indian country. The cleanup backlog, which is the difference between the cumulative number of confirmed releases and cleanups completed, also continued to decline from 167,480 sites a decade ago to 102,798 sites as reported at the end of FY 2008.




*Cleaning up a release at an underground storage tank site*

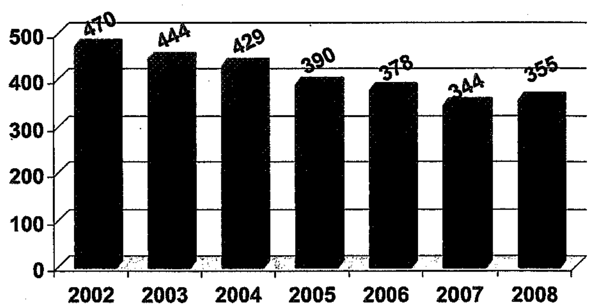
## Continuing Cleanup Progress In Indian Country

EPA has primary responsibility for implementing the LUST program in Indian country and actively works with tribes to identify, assess, and clean up UST releases. In FY 2008, EPA exceeded its annual goal by completing 40 cleanups in Indian country. Over the past seven years, the LUST cleanup backlog in Indian country has declined by 25 percent. This success is due partly to focused efforts by EPA and tribes to complete the remaining cleanups necessary at older sites and to the increased use of the Indian country cleanup contracts. For nearly a decade, these contracts have been supported by the LUST Trust Fund and maintained by EPA for cleanup activities in Indian country.

Additionally, in FY 2008 EPA provided LUST funds directly to the Navajo Nation and the Nez Perce Tribe to conduct cleanups. This direct funding furthered their capability to develop and manage their cleanup programs and reduce the number of remaining cleanups in Indian country.

**In FY 2008, EPA provided $2.6 million for LUST cleanups in Indian country; EPA also provided $61.2 million to states for LUST cleanups.**

**LUST Cleanup Backlog in Indian Country**



## Backlog Study Update

Historically, we've made great progress in cleaning up LUST sites. But the rate of progress has slowed and the number of cleanups completed each year has declined — from a high of 20,834 in FY 2000 to 12,768 in FY 2008. To learn more about this, EPA in 2006 began collecting and analyzing data associated with the cleanup backlog to more accurately characterize the cleanup backlog; help us better understand the reasons for the decline; and develop strategies for slowing, if not reversing, the trend.

In phase 1 of the backlog study, EPA discovered that two-thirds of the national cleanup backlog is located in ten states. In 2008, EPA began phase 2 of the study, working with those ten states plus four additional states to ensure representation from each EPA region.

EPA has worked closely with the 14 participant states, gained better understandings of how each individual program functions, and identified available state data. Participating states have provided a great deal of support and information. EPA is organizing the data to analyze both state cleanup program attributes and site attributes. EPA plans to use the phase 2 results to better understand challenges to the cleanup program nationally, focus future efforts, and identify national and state-specific strategies for completing cleanups.

**States Participating In The Backlog Study**

**California**
**Florida**
**Illinois**
**Michigan**
**Montana**
**Nebraska**
**New Hampshire**
**New Jersey**
**New York**
**North Carolina**
**Pennsylvania**
**South Carolina**
**Texas**
**Washington**

## Update On Hurricane Funding To Impacted States

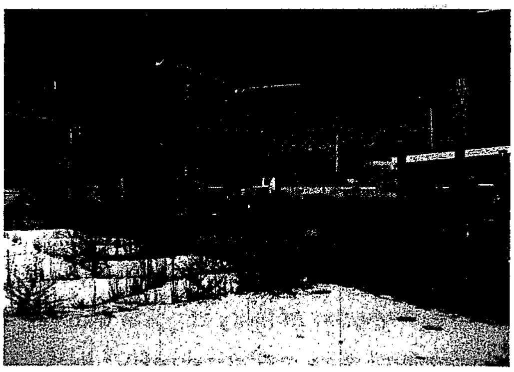
In 2006, Congress appropriated approximately $15 million for hurricane-related leaking UST expenses in states impacted by hurricanes Katrina and Rita. EPA provided grant funds to Alabama, Louisiana, and Mississippi to assess and remediate petroleum releases from hurricane-impacted UST facilities. So far, these three states have done a great deal to address issues resulting from the hurricanes.

√ Of the 280 sites impacted, assessments have been performed at about 98 percent — or 274 — of the sites
√ 236 releases were confirmed
√ 142 cleanups have been completed

In 2009, states will continue to monitor and assess sites, develop corrective action plans, and continue cleaning up the remaining release sites.

## Revitalizing Abandoned Gas Stations

There are more than 450,000 brownfields across the U.S., of which about 200,000 are estimated to be impacted by petroleum. Many of these sites are old abandoned gas stations that blight the environmental and economic health of surrounding neighborhoods. EPA awards grants to local areas, states, tribes, and organizations to assess and clean up these petroleum brownfields.



*Abandoned gas stations are scattered along highways and in neighborhoods*

In FY 2008, EPA issued a new Petroleum Brownfields Action Plan, available at **www.epa.gov/oust/rags/petrobfactionplan.pdf**, which promotes cleaning up and reusing petroleum brownfields. In the plan, EPA identifies four strategic initiatives, with specific actions and activities to achieve the Agency's goal. The plan demonstrates EPA's commitment to cleaning up petroleum-contaminated brownfields sites and fostering their reuse.

Also in 2008, EPA through its Brownfields grant program continued to support petroleum brownfields efforts by providing approximately $22.2 million in grants to 99 local communities to clean up and assess petroleum brownfields sites. Part of those grant dollars were revolving loans to enable states, local communities, and tribes to make low interest payments to carry out cleanup activities at brownfields properties. The list of the communities receiving these grants is grouped by EPA Region and is available at **www.epa.gov/oust/rags/pbgrants.htm**.

# Enhancing Communication And Information Sharing

Through communication and information sharing, EPA and its partners have made great improvements in the UST program. To enhance these collaborative efforts, EPA actively reviews and revises UST program communication methods to ensure the Agency is effectively sharing vital program information.

In FY 2008, EPA's UST program expanded its current Web areas to include new information and an up-to-date UST Indian country program directory. In addition, EPA and its partners held the 20th National Tanks Conference in Atlanta, GA in March 2008. The conference provided the UST community a wealth of learning and networking opportunities that will help us better work together to protect human health and the environment from UST releases.

## New Resources On OUST's Web Site

**State Delivery Prohibition Web Area**
**www.epa.gov/oust/dp/index.htm**

This Web area helps petroleum and hazardous substance delivery companies determine the applicable requirements in each state and territory. The area provides links to applicable state and territory laws, regulations, and policies related to delivery prohibition.

**Biofuels Compendium Web Area**
**www.epa.gov/oust/altfuels/bfcompend.htm**

This Web-based compendium provides UST stakeholders with information regarding storing ethanol and biodiesel fuels. Because of the increased production and use of biofuels, UST stakeholders need to be aware of the technical and policy issues related to storing alternative fuels.

**UST Indian Country Program Directory**
**www.epa.gov/oust/pubs/usinctrdir.htm**

This directory, available on EPA's Web site, provides at-a-glance contact information for tribal and EPA UST program contacts and is a helpful tool to improve communication and information sharing between tribes and EPA on UST issues.

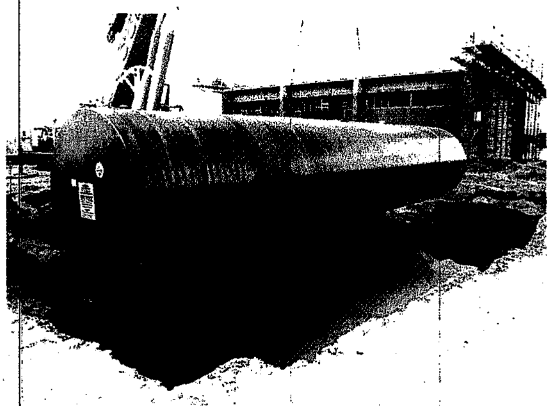
**To keep the public informed, EPA posts mid- and end-of-year activity reports that provide information on compliance, releases, and cleanups across the country. The FY 2008 end-of-year activity report is available at: www.epa.gov/oust/cat/camarchv.htm .**

## Developing A National Tribal Grant

In FY 2008, EPA began developing a new national assistance agreement that will provide tribal governments and UST facilities in Indian country with compliance assistance, training, and collaborative opportunities to support UST release prevention. This new five-year agreement, which will be awarded in 2009, will support efforts to improve UST facility compliance throughout Indian country.

### Celebrating 25 Years Of Tank Progress

November 2009 marks 25 years since the underground storage tank program was established. EPA is commemorating this milestone by issuing a 25th anniversary booklet, which is available on EPA's Web site at **www.epa.gov/oust/pubs/25annrpt.htm** .



*Installing a new underground storage tank at a facility*

# Looking Ahead

FY 2008 was a year of advancement and achievement. UST partners made good progress toward meeting our goals and made significant progress in advancing prevention and cleanup efforts, while also expanding communication and information sharing.

Challenges remain, though, as there is still much work to be done to prevent releases and to clean up contaminated sites. In 2009 and upcoming years, EPA will focus on the traditional goals of the program — preventing and cleaning up releases — and will also:

- √ Continue to work with states to meet the mandates and deadlines of the Energy Policy Act of 2005;
- √ Work with tribes to continue implementing the tribal strategy;
- √ Ensure that each UST facility in the country is inspected once every three years;
- √ Explore better ways to identify compliance and cleanup challenges and to pinpoint solutions;
- √ Develop strategies to help revitalize communities and clean up abandoned gas station sites;
- √ Ensure adequate funding is available for cleanups;
- √ Address technical and regulatory issues involved with alternative fuels; and
- √ Continue the process to update our regulations.

EPA looks forward to increasing collaboration and working with state, tribal, and other UST partners to achieve further progress in the tanks program in order to better protect human health and the environment from petroleum releases.

## Developing Regulations

EPA is revising the 1988 federal underground storage tank regulations to require that the 2005 Energy Policy Act provisions apply to USTs in Indian country and in states that do not have state program approval. The Agency is also considering revisions to the existing requirements, as appropriate.

EPA is working closely with states, tribes, industry, and other stakeholders regarding our rulemaking plans and efforts. We plan to issue a proposed rule in spring 2010, followed by a final regulation that will carry the underground tank program into the future.


*Most of the fuel supply in the U.S. contains ethanol*

**$200 Million Recovery Act Money For Cleaning Up Tank Leaks**

**See www.epa.gov/oust/eparecovery for information about the LUST funds appropriated in the American Reinvestment and Recovery Act of 2009**

**www.recovery.gov**

## Addressing Alternative Fuels

Alternative fuels continue to pervade the nation's fuel supply. As more distributors blend biofuels into their product to meet state and national mandates, many USTs throughout the country currently store some level of ethanol or biodiesel. While tank equipment manufacturers strongly recommend specific equipment for the use of high-level blends of biofuels (such as E-85), less is documented about the integrity and compatibility of older systems with mid- or high-level biofuel blends.

To address this data gap, EPA's tank program is working with the Agency's Office of Research and Development (ORD) to identify unknowns and develop a plan for laboratory and field testing of UST components. This testing will assess the compatibility of older UST system components with a range of biofuel blends, as well as the functionality of various leak detection systems to be used with these fuels.

Additionally, ORD is continuing its work to evaluate the transport and degradation of biofuels in the subsurface and the investigation of tools, models, and technologies used in remediation.

**EPA-510-R-09-001, March 2009**
**U.S. Environmental Protection Agency**
**Office of Solid Waste and Emergency Response**
**Office of Underground Storage Tanks**

***For further information please contact:***

**U.S. EPA/OUST**
**1200 Pennsylvania Avenue, N.W.**
**Mail Code: 5401P**
**Washington, DC 20460**
**Phone: 703-603-9900**
**Fax: 703-603-0175**
**www.epa.gov/oust**