EPA 510-R-00-002

Risk-Based Decision Making Performance Assessment Study Bulletin #2

Study Results and Recommendations for RBDM Program Performance Monitoring

Practical measures have been developed for evaluating the impact of Risk-Based Decision Making (RBDM) on state underground storage tank corrective action programs. These measures have been used to evaluate the effect of RBDM on the corrective action programs of five pilot states. In a majority of the pilot states, implementation of an RBDM program resulted in an increase in case closures and a decrease or stabilization in case backlog. Additional findings indicate that these RBDM programs successfully targeted low-risk sites for closure while retaining higher-risk sites for further action. Minor modifications to state program databases will allow for a more detailed evaluation of program performance measures.

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Introduction

The Risk-Based Decision Making (RBDM) Performance Assessment Study has been conducted as a research effort designed to assist state and territorial environmental regulatory agencies with the evaluation of their individual RBDM programs for Underground Storage Tanks (USTs). The specific goals of this study were to: i) develop practical, quantitative measures for evaluating the impact of RBDM on achieving state agency management goals, ii) apply these measures to five state RBDM programs to evaluate program performance, and iii) provide general guidelines for other state and territorial environmental agencies interested in tracking the performance of their RBDM programs.

This Bulletin reviews the procedures and results of this RBDM Performance Study and presents guidelines for monitoring and evaluating the effectiveness of RBDM programs. In addition, self-reported evaluations of two other state programs are included. The study was funded by the United States Environmental Protection Agency (USEPA) Office of Underground Storage Tanks (OUST) under Assistance Agreement #X825708-01 to the American Society for Testing and Materials (ASTM). Groundwater Services, Inc. (GSI), of Houston, Texas, has conducted the study. The results have been reviewed by the participating states, USEPA regions, USEPA OUST, and by Partnership in RBCA Implementation (PIRI).

Risk-Based Decision Making

The USEPA Office of Solid Waste and Emergency Response (OSWER) Directive 9610.17 encourages all state UST programs to apply RBDM to the corrective action process at petroleum release sites. RBDM is a flexible decision management framework that is customized to fit the needs of individual agency programs. When applied to the UST corrective action process, RBDM may also be referred to as Risk-Based Corrective Action or "RBCA". The ASTM RBCA Standard E-1739-95 is one example of an RBDM framework that has been used by states to design or

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augment their corrective action programs. An RBDM program typically includes three principal activities:

- *Risk-Based Site Prioritization:* Prioritize sites based on the timing or magnitude of potential impacts to human health and the environment.
- *Site-Specific, Risk-Based Remediation Goals:* Determine risk-based concentration limits for affected environmental media designed to prevent impacts on human health and the environment. Tier 1 remediation goals represent generic concentration limits, based on conservative default assumptions. Tier 2 and Tier 3 provide site-specific media cleanup limits based on additional site data and more sophisticated data analysis.
- *Remedy Selection:* Select remediation alternatives, such as removal or exposure control, to address site-specific risk drivers.

RBDM is a science-based process that offers a clearly defined and consistent basis for site evaluation and remediation. As a result, implementation of RBDM corrective action programs is expected to result in increased program efficiency and improved risk reduction.

RBDM Performance Assessment Study Background

Five state environmental regulatory agencies have participated in this preliminary study to evaluate the effectiveness of their RBDM programs:

- ***Illinois***: Illinois Environmental Protection Agency, Leaking Underground Storage Tank Section
- ***Iowa***: Iowa Department of Natural Resources, Underground Storage Tank Section
- ***North Carolina***: North Carolina Department of Environment and Natural Resources, Groundwater Section
- ***Texas***: Texas Natural Resource Conservation Commission, Remediation Division
- ***Utah***: Utah Department of Environmental Quality, Division of Environmental Response and Remediation

Each of the selected pilot states has implemented a state RBDM program and expressed interest in evaluating their program performance. To provide geographical balance, no more then one state per USEPA Region was selected for this study. In addition to the five pilot states, this bulletin summarizes the program performance of two states, Michigan and Alabama, which have evaluated the impact of their RBDM programs independent of this study.

For this study, the pilot states provided input on their individual program goals, the performance measures currently utilized in their state, and the utility and feasibility of the RBDM performance criteria developed for this study. In addition, each pilot state provided program performance data in the form of program databases, and assisted with internal program evaluations and interpretations of study results.

RBDM Program Goal and Performance Measures

The overall goal of state UST programs is to protect human health and the environment from releases associated with leaking underground storage tank (LUST) sites. In order to achieve this goal,

the RBDM programs implemented by the pilot states addressed in this study shared the following objectives:

- *Risk Reduction:* Reduce the human health and ecological risks associated with LUST sites.
- *Expedited Site Evaluation, Remediation, and Closure*: Streamline the site assessment process to close sites which do not pose an unacceptable risk to human health or the environment and expedite the remediation of sites with unacceptable risks.
- *Cost Control/Resource Allocation*: Reduce the cost of site remediation and closure without compromising protection of human-health and the environment. Focus available resources on high-risk sites. Reduce the administrative cost of program management.

TABLE 1: LIST OF SUGGESTED PERFORMANCE MEASURES FOR EVALUATION OF LUST RBDM PROGRAMS

PROGRAM GOAL	PERFORMANCE MEASURE	TRACKING DESCRIPTION	SITE DATA REQUIRED
Risk Reduction	Composite Site Classification Profile (see Figure 3)	Distribution of risk-based site classification ratings or sum of site classification scores through time	Initial site classification, Current site classification, Site score (i.e., high score for high risk)
	Composite Constituent Reduction Factor (CRF) Profile	Distribution or sum of individual site CRFs (CRF is max site concentration / site cleanup goal)	Initial and current site constituent concentrations, Applicable site-specific clean-up standard
	Cleanup Completed	Number of corrective actions resulting in case closure	Closure date
Expedited Evaluation, Remediation, Closure	Case Backlog	Number of sites currently managed by the state program	Incident reporting date, Closure date
	No Action Sites	Percentage and overall number of sites not requiring corrective action following risk-based site evaluation	Closure date, Basis for closure
	Action Plans Not Requiring Agency Approval	Percentage and overall number of new sites not requiring agency approval of action plan (e.g., RAP or CAP)	Date of self-implementation notice, Action Plan approval date
	Time to Action Plan Approval	Time from incident reporting to state approval of a corrective action plan	Incident reporting date, Action Plan approval date
	Time to Closure	Time from incident reporting to site closure	Incident reporting date, Closure date
Cost Control / Resource Allocation	Administrative Oversight	Resource allocation for program management per case closure, per active site, and for overall program	Program labor costs, Program head count, Case backlog, Total site closures per year
	Remediation Cost	Total expense from incident reporting to case closure for the responsible party or for the state reimbursement fund	Site remediation cost (including assessment and closure costs), Remediation cost reimbursed by state fund

To assist states in evaluating the benefits of their RBDM programs, this study has identified quantitative performance measures that correspond to each of the three common RBDM program goals (see Table 1). By tracking these parameters over time for their LUST site population, states can measure progress with regard to risk reduction, expedited site evaluation, remediation, closure, and cost control.

The suggested performance measures should be viewed as a menu of options, from which each regulatory authority can select the most appropriate measures for their specific program. These performance measures are described in more detail in the prior Performance Assessment Study Bulletin #1 issued in March 1999 (ASTM, 1999). To determine the impact of RBDM implementation on program performance, these measures have been used to evaluate program performance based on data available from each of the pilot states.

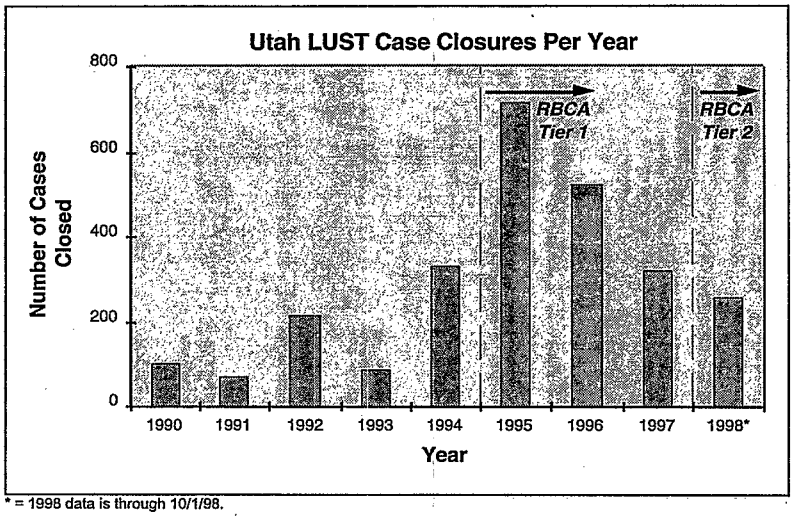
Evaluation of Pilot State Programs: Findings and Implications

The five pilot states each maintain a database of all active and closed LUST sites which have been entered into the regulatory process for site remediation. GSI reviewed each database to identify parameters which could be used to evaluate progress toward RBDM program goals. The pilot states implemented RBDM for their corrective action programs between 1994 and 1998 (see Table 2). In order to compare program performance before and after RBDM implementation, performance has been evaluated for the period of 1990 to 1999.

The results of this study support the following general findings with regard to the common program management goals:

- ***Expedited Site Evaluation, Remediation, and Closure***: Immediately following implementation of their RBDM program, 4 of the 5 pilot states observed a dramatic spike in case closures per year and a stabilization or decrease in case backlog. In general, the average case age at time of closure increased following RBDM implementation. Combined with the increase in case closures, this finding indicates that many older cases which have been in the regulatory process for many years are now being addressed. The observed reduction in case backlog is likely to reduce the administrative burden for the regulatory agency, allowing a more efficient allocation of available resources.

  In the first year of the Utah RBCA Tier 1 program (1995), the number of case closures increased by 120%, indicating that a Tier 1 process of generic screening criteria can significantly impact program performance (see Figure 1). Following implementation of a RBDM-based corrective action program in Iowa, 77% of RBCA Tier 1 site assessment reports approved by the DNR resulted in case closure and 28% of Tier 2 site assessments resulted in case closure, indicating that the RBDM process has been effective at identifying sites for closure or remediation. Key results for individual pilot states are summarized in Table 2.
- ***Risk Reduction:*** Available information regarding risk-based site classification (Texas and North Carolina) indicates that most of the LUST site cases



* = 1998 data is through 10/1/98.

FIGURE 1: EFFECT OF RBDM ON LUST CASE CLOSURES IN UTAH

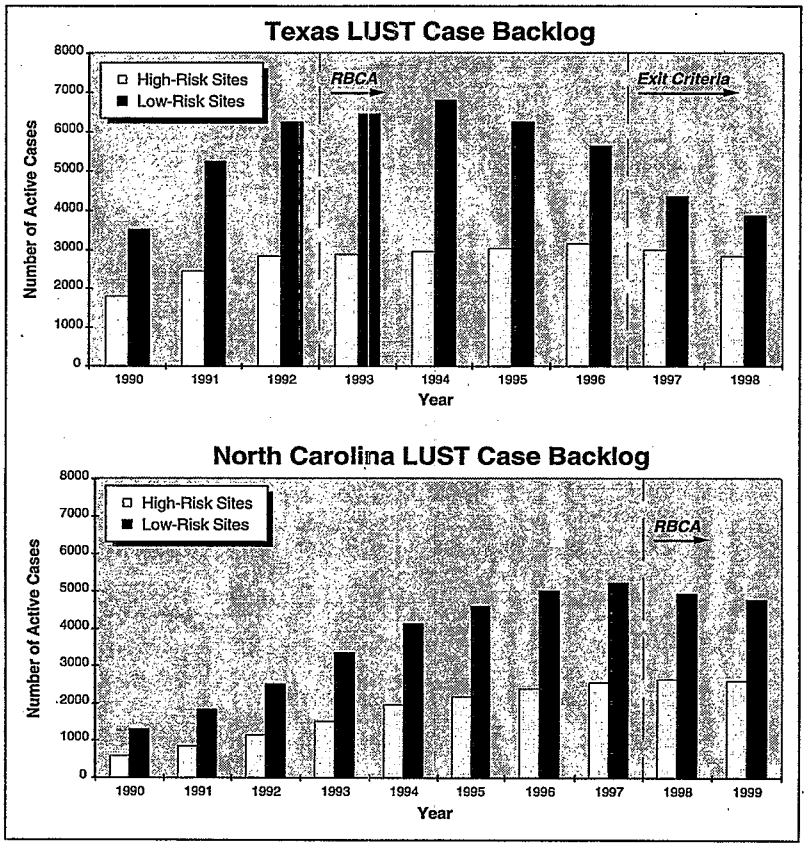


FIGURE 2: EFFECT OF RBDM ON LUST CASE BACKLOG IN TEXAS AND NORTH CAROLINA

closed by these state RBDM programs are low-risk sites (see Figure 2). These examples demonstrate that RBDM programs are effectively meeting the state program objective of closing low-risk cases while retaining higher-risk cases in the regulatory process for further evaluation or remediation. The reduced backlog of low-risk sites should allow available resources to be more effectively targeted to the higher-risk sites.

- *Cost Control/Resource Allocation*: Cost data in the LUST site databases provided by the pilot states were not sufficient to measure the cost impacts of RBDM at this time. However, the significant reductions in case backlog reported by some states clearly corresponds to reduced program costs.

  An internal cost survey was conducted by the Texas Natural Resource Conservation Commission to determine the impact of RBCA implementation on the cost of site remediation. Between 1994 and 1998, remediation/closure costs were reduced by 70% for soil-only sites (median cost reduced to $24,000/site from $80,000/site), and by 58% for low-risk groundwater impact sites (median cost reduced to $107,000 from $250,000/site).

Potential Confounding Factors

Interpretation of the impact of RBDM on program performance may be complicated by confounding factors such as the 1998 upgrade deadline, changes in staffing at state regulatory agencies, or changes in state funding of site remediation. These factors can also impact the program measures designed to measure the effectiveness of RBDM. To control for these confounding factors, the impact of the RBDM on program performance independent of confounding factors is best understood through the evaluation of multiple performance measures which cover all of the RBDM program objectives.

Results from Other States

In addition to the five states evaluated for this study, Michigan and Alabama have independently evaluated the performance of their LUST management programs following the implementation of RBDM. Alabama Department of Environmental Management (DEM), UST Corrective Action Unit implemented an RBDM program in April 1998 and is currently tracking performance. In the first year of the program, Alabama DEM saw a reduction of 106 active cases classified as low-risk sites and a corresponding increase of 115 closed cases (4% of the active case population). Although recently implemented, the Alabama RBDM program appears to be successful in closing low-risk sites (Malaier, 2000).

Michigan Department of Environmental Quality (DEQ), Storage Tank Division implemented an RBDM program in April 1995. In 1996, Michigan DEQ reported a 61% increase in LUST case closures compared to the average case closure rate for 1990 to 1995. In addition, Michigan DEQ achieved a 30% decrease in case backlog from 1995 to 1998. Implementation of the RBDM program resulted in a 24% average reduction in remediation/closure costs for UST sites, representing a $39,000 cost savings per site (Michigan DEQ, 1996).

TABLE 2. RESULTS FOR PILOT STATE RBDM PROGRAM PERFORMANCE EVALUATION

STATE / AGENCY	RBDM PROGRAM IMPLEMENTATION	DATABASE	PERFORMANCE MEASURES		
			LUST SITE REMEDIATION/ CLOSURE	RISK REDUCTION	COST CONTROL
Texas Texas Natural Resource Conservation Commission, Remediation Division	Risk-Based Corrective Action for Leaking Storage Tank Sites, January 1994. Exit Criteria, September 1997.	Responsible Party Remediation Database	• 46% increase in case closures 1996 to 1997. • 31% decrease in case backlog 1994 to 1998.	Preferential closure of low-risk cases, remediation of higher-risk cases.	58 to 70% decrease in remediation cost for low-risk soil or groundwater sites.
Utah Department of Environmental Quality, Division of Environmental Response and Remediation	Risk-Based Corrective Action Tier 1, September 1995. Risk-Based Corrective Action Tier 2, June 1998.	Leaking Underground Storage Tank Database	• 120% increase in case closures 1994 to 1995. • 53% decrease in case backlog 1994 to 1998.	ID	ID
North Carolina Department of Environment and Natural Resources, Groundwater Section	Risk-Based Corrective Action for UST sites, January 1998.	Incident Management Database	• 46% increase in case closures 1997 to 1998. • 1% decrease in case backlog 1997 to 1999.	Preferential closure of low-risk cases, remediation of higher-risk cases.	ID
Iowa Department of Natural Resources, Underground Storage Tank Section	Risk-Based Corrective Action, January 1997.	UST/LUST Database	• 134% increase in case closures '94-'96 to '97-'99. • 14% decrease in case backlog 1996 to 1999.	ID	ID
Illinois Illinois Environmental Protection Agency, Leaking Underground Storage Tank Section	Tiered Approach to Corrective Action Objectives, January 1997.	Leaking Underground Storage Tank Database	• 8% decrease in case closures 1996 to 1997. • 8% increase in case backlog 1996 to 1998.	ID	ID

NOTE: ID = Insufficient Data

General Recommendations for RBDM Performance Monitoring

Evaluation of the pilot state databases shows that most states track data to provide important information on the performance of their regulatory program with regard to key management objectives. However, additional data that would allow for a more complete assessment of program performance was often available in individual site reports but was not recorded electronically. In many cases, minor modifications of database parameters may be required to incorporate the quantitative performance measures identified in this study (see Table 1). Customizing a state program for the purpose of an RBDM

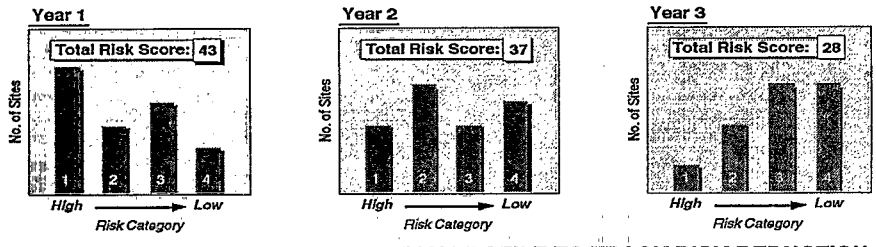


FIGURE 3: USE OF SITE CLASSIFICATION PROFILE TO TRACK RISK REDUCTION

performance assessment involves the following steps: i) using the list provided in Table 1 as a guide, select or create relevant performance measures that address key program objectives; ii) review the current state database to determine whether required data is currently recorded; and iii) modify the current state database to include the missing data fields. The LUST module of "UST Access," a database system developed by the USEPA Office of Underground Storage Tanks (OUST), is an example of a database that contains many of the required data fields and can also be readily modified or queried for evaluation purposes. For more information on UST Access, contact USEPA OUST at the web address provided at the end of this bulletin.

In addition to these general guidelines, results of this pilot study show that the following database parameters can significantly impact the ability to track program performance:

1) Basis for Closure: As a supplement to the time to closure measure, a "Basis for Closure" field can be used to record the reason that the case qualified for closure. Tracking the reason for case closure would assist in identifying the types of sites being managed efficiently under RBDM, as well as those for which achieving closure is still difficult. In addition, this field will allow a more complete interpertation of the "time to closure" measure.

To assist in analysis of this performance data, the reason for closure should be based on defined categories, such as those listed on Table 3.

2) Risk Reduction: Surveying the risk-based site classification of the LUST site population over time (as shown on Figure 3) can serve as a convenient measure of risk-reduction. If the RBDM program is effectively reducing risk, the site classification profile should reflect a general shift toward low-risk categories from year to year. However, to measure risk reduction, the site classification system must be based on the magnitude and immediacy of potential impacts on site receptors, using criteria similar to those employed in the ASTM RBCA site classification system (ASTM, 1995). Classification systems based on physical site characteristics (e.g., soil type, groundwater velocity, chemical contaminants) do not reflect the change in risk conditions as remediation progresses and risks are mitigated. Furthermore, to quantify risk reduction, both the initial and the current risk classification must be recorded for each site. The initial risk classification remains fixed; however, the current risk classification can change as site remediation progresses.

TABLE 3. POTENTIAL LUST CASE CLOSURE CATEGORIES

CLOSURE CATEGORY	DESCRIPTION
No Action	Soil and groundwater constituent concentrations are less than generic screening levels; no remedy or monitoring required.
Risk Assessment	Soil and groundwater constituent concentrations are less than site-specific risk-based standards; no remedy or monitoring required.
Soil Excavation	Site qualified for closure following excavation of affected site soils.
Monitored Natural Attenuation	Site qualified for closure following monitored natural attenuation of affected groundwater.
Active Soil Remedy	Site qualified for closure following on-site treatment of soils.
Active Groundwater Remedy	Site qualified for closure following active groundwater remediation.

Using this approach, total risk reduction over time for the full LUST case population can be quantified as illustrated in Figure 3.

The site constituent reduction factor (CRF, the ratio of site concentration to site-specific clean-up standard for specific constituents) can be used as an additional measure of site risk reduction over time. This performance measure requires that both the initial and current site concentrations and the applicable site-specific clean-up standards be recorded for key constituents. However, the CRF may be difficult to interpret at sites where exposure control remedies are selected.

3) Remediation Cost: Information on the cost of site remediation is typically recorded in a database separate from the other program performance data. In addition, cost data is often limited to reimbursed costs for sites eligible for state funded remediation.

The addition of a "Total Remediation Cost" field to the primary state database would allow an analysis of remediation costs for all sites regulated under the state corrective action program. This cost data can be collected by requesting an estimated total remediation cost, inclusive of site assessment and response action costs, as part of the final request for case closure.

4) Specific Constituents: As demonstrated by the recent focus on MTBE at LUST sites, the presence of fuel oxygenates in groundwater may have a significant impact on regulatory program performance of RBDM. Recording the specific constituents which exceed remediation goals at each site could serve to illustrate the effect of individual constituents on case closure, remediation cost, or other performance measures.

For some states, recording additional program performance data in an electronic database may represent a significant burden in terms of cost and manpower required to obtain, validate, and input the data. Clear and simple guidelines for submittal of required site reports can serve to reduce the burden of recording

program performance data. For example, standardized reports or summary forms can provide key performance data in standardized locations, facilitating the transfer of this data to the state database. Alternatively, states can request submittal of an electronic data summary which contains key performance data formatted for direct transfer to the state database.

Conclusions

In the majority of pilot states, implementation of an RBDM program resulted in an immediate increase in site closures and a stabilization or decrease in case backlog. The reduction in case-backlog represents a decreased administrative burden for the corrective action program. Average age at closure generally increased which, combined with the increase in case closures, indicates that many older sites are being closed using RBDM. Evaluation of site risk classifications in the backlog population indicates that the RBDM programs are effectively targeting low-risk sites for closure while retaining higher-risk for further action. Additional study is needed to determine the impact of RBDM on the remediation and closure of these higher-risk sites.

Next Steps

As demand for government accountability increases, more states will need to utilize performance measures to document program performance and identify opportunities for increased efficiency. In addition, as a result of the Government Performance and Results Act of 1993, which requires formal cost/benefit evaluations of many federal government programs, agencies are under increasing pressure to effectively track program performance. Many state programs are facing similar pressures due to state legislative mandates. As state RBDM programs mature and additional performance data are collected, future bulletins may be issued to track performance assessment efforts and address specific issues that may arise. Future bulletins will be available at: www.epa.gov/OUST/rbdm

Additional Information

For more information on RBDM programs and their implementation, see the following sources:

Websites

OUST Risk-Based Decision-Making: **www.epa.gov/OUST/rbdm**

ASTM Standards: **www.astm.org**

RBCA State Policy Issues Database: **www.gsi-net.com/RBCAPOL**

Publications

1. American Society for Testing and Materials, 1995, "Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites," ASTM E-1739-95, Philadelphia, PA.
2. American Society for Testing and Materials, 1998, "Standard Provisional Guide for Risk-Based Corrective Action," ASTM PS 104-98, Philadelphia, PA.
3. American Society for Testing and Materials, 1999, "Risk-Based Decision-Making Performance Assessment Study Bulletin #1: Study Background, Potential Performance Measures, and Preliminary Findings," Philadelphia, PA. http://www.epa.gov/swerust1/rbdm/techimpl.htm
4. Groundwater Services, Inc., 1995, "Tier 2 RBCA Guidance Manual," Houston, Texas, 713/522-6300.
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6. Michigan DEQ, 1996, "Impact of 1995 and 1996 Amendments to Part 213, Leaking Underground Storage Tanks, 1994 PA 451, As Amended," State of Michigan Department of Environmental Quality.

7. USEPA Office of Solid Waste and Emergency Response (OSWER), 1996, "Use of Risk-Based Decision-Making in UST Corrective Action Programs," OSWER Directive 9610.17.