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United States Environmental Protection Agency

EPA LINER STUDY

Report to Congress

Section 4113(a) of the Oil Pollution Act of 1990

May 1996

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LIST OF EXHIBITS

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ACRONYMS

API	American Petroleum Institute
AST	Aboveground Storage Tank
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CWA	Clean Water Act
DOT	Department of Transportation
EPA	Environmental Protection Agency
ERNS	Emergency Response Notification System
GCS	Ground Water Characterization Study
HDPE	High Density Polyethylene
HMTA	Hazardous Materials Transportation Act
HWST	Federal Hazardous Waste Storage Tank
MMS	Minerals Management Service
NFPA	National Fire Protection Association's Flammable and Combustible Liquids Code
NRC	National Response Center
ODCP	Oil Discharge Contingency Plan
OPA	Oil Pollution Act
OSC	On-Scene Coordinator
PVC	Polyvinyl chloride
RCRA	Resource Conservation and Recovery Act
SPCC	Spill Prevention, Control, and Countermeasures
SIC	Standard Industrial Classification
UST	Underground Storage Tank
VADEQ	Virginia Department of Environmental Quality

EXECUTIVE SUMMARY

PURPOSE

Section 4113(a) of the Oil Pollution Act of 1990 (OPA) requires that: "The President shall conduct a study to determine whether liners or other secondary means of containment should be used to prevent leaking or to aid in leak detection at onshore facilities used for the bulk storage of oil and located near navigable waters." In Executive Order 12777, the President delegated authority to the U.S. Environmental Protection Agency (EPA) to conduct this study.

EPA investigated the nature and magnitude of leaking oil at onshore facilities with aboveground storage tanks (ASTs) that are used for the bulk storage of oil and that are located near navigable waters. The Agency also assessed the technical feasibility of using liners and related systems to detect leaking oil and to prevent leaking oil from contaminating soil and, by way of ground-water pathways, navigable waters. This report to Congress, which presents the findings and recommendations of EPA's study, fulfills the requirements of Section 4113(a) of the OPA.

SCOPE OF THE STUDY

After the OPA became law, EPA staff from the Offices of Emergency and Remedial Response and Congressional Liaison met with Congressional staff to discuss the scope of the study to be conducted under OPA Section 4113(a). Based on these discussions, the Agency decided that the study would focus on the feasibility of using liners and related systems to address oil leaking from ASTs to secondary containment structures (e.g., berms, dikes) and to soil underneath ASTs. An assessment of the feasibility of using liners to address oil leaking from other parts of AST facilities, such as tank truck transfer racks and underground piping, was not specifically addressed during the study. However, because underground piping was identified as a significant potential source of leaking oil at AST facilities, the Agency's recommendations also address this source of contamination.

For this study, EPA defined a liner as an engineered system that makes secondary containment structures more impervious. EPA assessed the technical feasibility of installing liners made from synthetic materials as well as earthen materials within secondary containment structures and under ASTs (i.e., undertank liners). EPA also assessed the feasibility of installing double bottoms on vertical ASTs as "other secondary means of containment," which could be used in place of undertank liners. The Agency also examined other technologies to aid in leak detection and looked at available data on liner costs.

EPA evaluated the effectiveness of liners and double bottoms in reducing the potential for leaking oil to reach soil and navigable waters (i.e., surface waters) via ground-water pathways. Oil discharges to unlined secondary containment systems, such as episodic spills, and continuous leaks from the bottoms of ASTs may contaminate soil and have the potential to be transported downward to ground water. Because ground water often is hydrologically connected to surface water, a ground-water oil plume has the potential to migrate and contaminate surface water. Furthermore, oil that repeatedly contaminates soil as a result of frequent spills may form oil-saturated soil zones, which have the potential to contaminate surface water when precipitation migrates through soil to surface-water bodies. Based on these considerations, EPA assessed the suitability of using liner systems to protect ground water and, in turn, navigable waters by evaluating the effectiveness of these systems in preventing discharged oil from contaminating soil and ground water.

SUMMARY OF FINDINGS

Universe of Facilities

EPA estimates that 502,000 onshore facilities have ASTs and store significant quantities of oil in bulk. Approximately 435,000 of these facilities are required by EPA's Oil Pollution Prevention regulation (40 CFR Part 112) to develop written plans to prevent and control oil discharges and install secondary containment systems for ASTs.[1] EPA estimates that the number of ASTs located at these 502,000 onshore facilities is about 1.8 million. A separate study conducted for the American Petroleum Institute (API) estimates that about 700,000 ASTs are used at facilities in the production, refining, transportation, and marketing sectors of the petroleum industry.[2]

In general, there are two categories of ASTs: (1) vertical ASTs, which are mounted such that the tank bottom rests on a foundation at ground level; and (2) horizontal ASTs, which are supported in saddles such that the tank is suspended above the ground or floor of a secondary containment structure. The storage capacity of horizontal ASTs typically ranges from a few hundred gallons up to 20,000 gallons, while the storage capacity of vertical ASTs typically ranges from several thousand gallons to

[1] The Oil Pollution Prevention regulation (40 CFR Part 112) was initially promulgated on December 11, 1973. After passage of the OPA, two sets of revisions to the regulation were developed. The first set of revisions was proposed on October 22, 1991 (56 FR 54612) in order to clarify the applicability of the regulation. The second set of revisions was promulgated on July 1, 1994 (59 FR 34070) to establish requirements for the development of facility response plans (FRPs). The requirements to develop SPCC plans and to install secondary containment, as referenced in this document, are included in the original regulation. For information on state regulations for liners, see Chapter 3 and Appendix A of this document.

[2] American Petroleum Institute (API), "Aboveground Storage Tank Survey," prepared by Entropy Limited, April 1989. This study did not include ASTs at end-user facilities.

over 10 million gallons. All ASTs have the potential to leak oil, presenting the threat of environmental contamination.

Evidence of Spills

EPA searched for existing data to estimate the number of leaking ASTs, volume discharged, and resulting environmental damage. The Agency found that comprehensive data do not exist to adequately quantify the extent to which the nation's AST inventory is leaking. Existing Federal regulations require facility owners and operators to report oil discharges only if they trigger the reporting thresholds of Clean Water Act (CWA) regulations. Consequently, some leaking oil that contaminates soil and ground water may not be reported to Federal authorities and, therefore, may not be recorded in national spill data bases, such as EPA's Emergency Response Notification System (ERNS).

Existing sources of information evaluated by EPA, however, do indicate that a significant number of ASTs may be leaking or spilling oil. For example, analysis of ERNS data indicate that about 30 percent of all reported oil discharges from onshore facilities, or approximately 1,700 spills annually, are to secondary containment areas, many of which are believed to be unlined. The results of a recent API survey indicate that 85 percent of refineries, 68 percent of marketing facilities, and 10 percent of transportation facilities have known ground-water contamination near their facilities.[3] Some of these facilities store millions of gallons of oil in ASTs. A preliminary report issued by the Virginia Department of Environmental Quality containing statistics on 88 facilities that have 1 million gallons or more of aboveground storage capacity indicates that 88 percent of these facilities reported ground-water contamination.[4] It is not clear from these data whether this oil contamination is caused by past practices or is continuing to occur at these facilities. For example, the results of the API survey referenced above indicate that changes in operation practices, upgraded standards, and improved equipment have significantly reduced reported petroleum spills and accidental releases from ASTs. Spill data also do not allow EPA to determine the extent of oil contamination caused by different sizes or types of facilities. Furthermore, the data are not sufficiently detailed to determine whether the contamination is caused by oil discharging from ASTs or from other areas of the facility. EPA found during the course of this study that underground piping located at onshore facilities also is a potentially significant source of leaking oil. As one indicator of the number of ASTs that could be leaking oil and the corresponding volume discharged, EPA obtained data on AST age and examined the potential relationship between AST age and corrosion rates to estimate the likelihood that ASTs will develop leaks as a function of tank age.

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[3] American Petroleum Institute (API), "A Survey of API Members' Aboveground Storage Tank Facilities," prepared by API Health and Environmental Affairs Department, July 1994.

[4] Virginia Department of Environmental Quality (VADEQ), "The Virginia DEQ Aboveground Storage Tank Regulations," April 4, 1994.

3.

Technical Feasibility

EPA investigated the technical feasibility of liner systems, including double bottoms, by examining the effectiveness of different liner materials and designs for protecting the environment from oil discharges and evaluating the construction feasibility of liner systems. The technical feasibility and unit-cost analysis are based on alternative liner designs for six "model" facilities used to represent the diverse universe of facilities potentially benefitting from liner system installation. These model facilities ranged from small end-user facilities with one horizontally mounted 2,000-gallon AST to a large petroleum bulk terminal with several vertical ASTs with a combined storage capacity of about 50 million gallons. For these model facilities, the alternative designs considered and evaluations of their effectiveness were based largely on discussions with EPA On-Scene Coordinators and owners and operators of facilities using, handling, and storing oil and petroleum products.

For the model facilities with vertical ASTs, EPA developed several technically feasible approaches for installing liners and double bottoms. These approaches include:

- Retrofitting the bottom of an AST with a second steel plate (i.e., installing a double bottom), an interstitial geosynthetic liner on top of the original bottom, and a leak detection system (e.g., a tell-tale drain);
- Installing a liner within the secondary containment system around the AST;
- Installing a liner within the secondary containment system around the AST and retrofitting the bottom of the AST with a second steel plate, an interstitial geosynthetic liner, and leak detection system; and
- Installing a liner within the secondary containment system and installing an undertank liner with a leak detection system during construction of a new AST.

For horizontally mounted tanks, the only option considered was the installation of a liner throughout the entire secondary containment system. During development of these options, EPA considered a range of AST sizes and secondary containment systems, such as structures with pipe penetrations through side walls and those built to accommodate vehicle access.

EPA evaluated four types of liner materials -- soil (e.g., clay), concrete, geomembranes, and steel -- that could be integrated into secondary containment structures. All four liner materials provide roughly equivalent protection provided that they are properly installed and maintained. The cost of liners for secondary containment areas around ASTs varies significantly by material. Although steel and coated concrete liners were found to provide excellent protection and durability, these systems generally are considerably more expensive than soil or geomembrane liners.

Based on the technical feasibility and unit-cost analysis of different liner designs at model facilities, EPA determined that for large facilities it may be less expensive to install a complete liner system at a new facility than to retrofit an existing facility. Depending on the liner type, the cost to install a complete liner system at a new large bulk terminal can be 30 to 50 percent less than the cost to retrofit liners and double bottoms at an existing facility. For example, at a new large bulk petroleum terminal (with about 50 million gallons of storage capacity), a complete liner system is estimated to cost between $.03 and $.08 per gallon of storage capacity, or roughly between $1.5 million and $4 million.[5] In contrast, the cost to retrofit an existing large bulk terminal with a complete liner system is estimated to cost between $.07 to $.11 per gallon, or approximately $3.5 million to $5.5 million. However, for small end-user facilities, the retrofit costs at existing facilities may not be significantly different from installation costs at new facilities. For example, depending on the liner type, the estimated cost to install a liner system at an existing small end-user facility (with one horizontally mounted 2,000-gallon tank) ranges from $2.00 to $4.50 per gallon of storage capacity, or $4,000 to $9,000 on a facility basis, while the estimated liner costs for a *new* small end-user facility range from $1.50 to $4.00 per gallon of storage capacity, or $3,000 to $8,000.

The approaches presented above for installing liners and double bottoms at AST facilities essentially provide two types of protection in preventing leaking oil from reaching unprotected soil and ground water: protection underneath an AST and protection within the secondary containment area around the AST. For example, installing a liner only within the secondary containment area around the AST will prevent oil discharged from the tank into the secondary containment area (e.g., a leak from the side of the tank) from contaminating soil. However, this system will not detect discharged oil nor prevent oil from leaking through a corroded AST bottom and reaching soil, ground water, or surface water. Alternatively, installing a double bottom or undertank liner with a leak detection system beneath an AST will detect leaking oil and prevent oil from reaching soil, but will not prevent discharged oil that fills up an unlined secondary containment system from contaminating soil and possibly ground water. A key issue related to the effectiveness of liner systems is the extent to which liners are properly maintained. The relationship between liner effectiveness and maintenance, and the costs of that maintenance, can vary greatly depending on the purpose and nature of the liners and the inspection and maintenance requirements. Many AST facility owners and EPA personnel expressed concern that although certain types of liners require periodic maintenance to perform effectively, some facility owners may not currently allocate sufficient resources to liner maintenance activities.

[5] In general, the cost to install liner systems at facilities would be better represented in dollars per gallon of throughput rather than dollars per gallon of storage capacity since throughput is a more accurate measure of the economic value of the AST; however, EPA lacks sufficient data on average throughput to present costs on this basis.

RECOMMENDATIONS

The recommendation of this Report to Congress is based primarily on the results of EPA's study of liners as well as insights the Agency has gained over the past 20 years into the problems posed by onshore AST facilities. As a first step toward addressing the potential risks to public health and the environment as a result of contamination from AST facilities located near navigable waters, the Agency recommends initiating, through a *Federal Register* notice or stakeholder workgroups, a process involving broad public participation to develop a voluntary program. This process would give stakeholders the opportunity to share new or additional data and information to characterize the sources, causes, and extent of soil and ground-water contamination and efforts underway to address contamination at AST facilities nationwide. Such data are critical to determining the most appropriate and effective means to reduce contamination.

As envisioned by EPA, the voluntary program would be designed to encourage facility owners or operators, through incentives such as technical assistance, cost savings, and public recognition, to identify and report contamination, take actions to prevent leaks and spills, and remediate soil and ground-water contamination. This program would complement the Agency's efforts to develop cleaner, cheaper, and smarter approaches to environmental problems through innovative solutions that depart from the traditional regulatory approach. The Agency favors a voluntary, rather than regulatory, approach at this time in order to provide greater flexibility in addressing contamination at the vast range of oil storage facility types, sizes, and locations. A voluntary program could focus more directly on facilities that may pose the greatest hazard to public health and the environment. For example, the program may initially focus on larger, older facilities, and facilities located near waters, sensitive areas, or populations. In addition, a voluntary approach could allow implementation of the most appropriate prevention and cleanup activities for each facility. The program would look for incentives for industry to implement reasonable and cost-effective measures to address existing problems and help prevent future ones.

EPA views such a program as a cooperative effort among EPA, State governments, industry, and environmental groups. Based on this study's findings, EPA believes the program should include commitments from facilities to:

- Address known contamination and to assure that existing contamination will not be allowed to migrate offsite;
- Report to appropriate government agencies the status of facility contamination and actions underway to address any problems;
- Adopt the most protective appropriate prevention standards and upgrade equipment as necessary; and

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- Monitor and/or implement leak detection to ensure that new leaks are addressed.

Provided stakeholders commit to the voluntary approach, a successful program will entail the identification of specific actions for participating facilities to undertake and include means for objectively measuring results.

EPA has evaluated the feasibility of conducting a voluntary program to address the problem of AST releases and concluded that a voluntary program is worth pursuing. Factors that support development of a voluntary program include: (1) the universe of large AST facilities is easily defined and represented by several large trade associations; (2) the voluntary program is consistent with the Agency's goal of developing and promoting innovative approaches to achieve environmental goals; (3) clear, achievable overall goals are apparent (i.e., to clean up contamination and prevent future releases); (4) flexible approaches are available to address the problem, thus allowing participants to implement the program in a tailored manner appropriate to their circumstances; (5) EPA is committed to providing technical assistance as well as other incentives; and (6) there are established industry and state practices and standards that can be used as a basis for constructing a comprehensive program.

In keeping with the Agency's initiatives to develop innovative, common-sense approaches to environmental problems, EPA supports a voluntary prevention and cleanup program as a first step in addressing the environmental problem presented by contamination from AST facilities. Industry representatives have expressed their support for such a program as a more cost-effective, flexible alternative than traditional regulation. EPA fully supports such an attempt, and believes it will be successful, provided that it has the full commitment of those involved. The Agency believes it is essential that stakeholders have the opportunity to participate in the development and execution of this voluntary program and will establish an open process for public input into the program's design and implementation.

1. INTRODUCTION

1.1 PURPOSE

Section 4113(a) of the Oil Pollution Act of 1990 (OPA) requires that: "The President shall conduct a study to determine whether liners or other secondary means of containment should be used to prevent leaking or to aid in leak detection at onshore facilities used for the bulk storage of oil and located near navigable waters." In Executive Order 12777, the President delegated authority to the U.S. Environmental Protection Agency (EPA) to conduct this study.

This report to Congress presents EPA's study to assess the extent to which liner systems should be used with ASTs at onshore facilities to detect leaks and/or prevent leaks from reaching soil, ground water, and surface water.[1] As part of this study, EPA investigated the nature and magnitude of leaking oil at onshore facilities with ASTs that are used for the bulk storage of oil. The Agency also assessed the technical feasibility of using liners and related systems to detect leaking oil, and to prevent leaking oil from contaminating soil and, by way of ground-water pathways, navigable waters. This report to Congress, which provides recommendations based on EPA's findings, fulfills Section 4113(a) of OPA.

1.2 BACKGROUND

Concerns about the environmental hazards posed by onshore oil-storage facilities have grown in recent years as a result of several widely publicized oil discharges from such facilities, including significant discharges from tank farms in Fairfax, Virginia, in 1990, and in Sparks, Nevada, in 1989. Such incidents have the potential to cause widespread damage, including contamination of soil, ground-water and surface-water supplies, loss of property, and risks to human health. Because several hundred thousand onshore facilities with ASTs are located throughout the U.S., many near sensitive environments (including ground water and surface water), discharges from ASTs represent a potentially significant environmental hazard.

Oil discharges may originate from many parts of an onshore AST facility, including tanks, loading/unloading areas where oil transfers are conducted between tank trucks or vessels and ASTs, and when oil is transported in underground and aboveground piping. Although liner systems could be installed at certain types of loading/unloading areas and other locations at a facility, EPA decided to focus on the feasibility of using liners and related systems to address oil leaking from ASTs to secondary containment systems and to soil underneath ASTs. This decision was made after consultations with Congressional

[1] For purposes of this study, "surface water" and "navigable water" are used interchangeably.

staff about the intent of OPA Section 4113(a). Although the problems posed by oil discharges at other parts of the facility (including leaks from underground piping) were not directly investigated during this study, EPA gained valuable insights into the nature of these problems.

For this study, EPA defined a liner as an engineered system that makes secondary containment structures more impervious. EPA assessed the feasibility of installing liners within secondary containment structures and under ASTs (i.e., undertank liners). EPA also assessed the feasibility of installing double bottoms on vertical ASTs as "other secondary means of containment," which could be used in place of undertank liners. Secondary containment liners used in conjunction with double bottoms or undertank liners are capable of addressing oil discharges from ASTs into secondary containment areas and to soil underneath vertical ASTs.

EPA evaluated the effectiveness of liner systems, including double bottoms, in reducing the potential for leaking oil to reach soil and surface waters via ground-water pathways.[2] Oil discharges to unlined secondary containment systems, such as episodic spills, and continuous leaks from the bottom of ASTs may contaminate soil and have the potential to migrate downward to ground water. Because ground water often is hydrologically connected to surface water, a ground-water oil plume has the potential to migrate and contaminate surface water. Furthermore, oil that repeatedly contaminates soil as a result of frequent spills may form subsurface oil plumes, which have the potential to contaminate surface water when precipitation migrates through soil to surface-water bodies. Based on these considerations, EPA assessed the suitability of using liner systems to protect navigable waters by evaluating the effectiveness of these systems in preventing discharged oil from contaminating soil and ground water.

For purposes of evaluating the technical feasibility of liner systems at onshore facilities, EPA included as a basis for this study the approximately 500,000 onshore facilities that meet the oil storage capacity threshold of the Oil Pollution Prevention regulation. These facilities have oil storage capacities ranging between several hundred gallons to several million gallons and are found in the majority of industry sectors. As a result, these facilities constitute a diverse and comprehensive group from which to evaluate the technical feasibility of installing liner systems.

1.3 STUDY APPROACH

EPA conducted two principal tasks in preparing this study:

Task 1: Gathered a range of data and information on leaks and spills from ASTs, types of liner systems, and their costs; and

[2] Throughout this study, "liner system" includes both secondary containment liners, undertank liners, and double bottoms.

Task 2: Conducted a technical feasibility analysis of liner systems for a range of typical onshore facilities with ASTs.

EPA gathered data on the number and type of onshore facilities storing oil in bulk, number and type of ASTs facilities and ASTs, and the number and volume of oil discharges from ASTs. EPA conducted interviews with facility owners and operators, manufacturers of liner systems, and Federal and State government personnel about the characteristics of liners systems, including their cost and effectiveness, as well as operation and maintenance requirements. This information was used to support the technical feasibility analysis.

EPA conducted a technical feasibility analysis of liner systems by examining the effectiveness of different liner materials and designs for protecting the environment from oil discharges and evaluating the construction feasibility of liner systems. The technical feasibility and unit-cost analysis is based on alternative liner designs for six "model" facilities used to represent the diverse universe of facilities that meet the oil storage capacity threshold of the Oil Pollution Prevention regulation. These model facilities ranged from small end-user facilities with one horizontally mounted 2,000-gallon AST to a large petroleum bulk terminal with a mix of horizontal and vertical ASTs with a combined storage capacity of about 50 million gallons. For these model facilities, the alternative designs considered and evaluations of their effectiveness were based largely on discussions with facility owner/operators, liner manufacturers, and government personnel.

Based on the results of these two tasks, EPA developed recommendations for minimizing the potential damage to the environment as a result of oil leaking from the nation's AST inventory.

1.4 ORGANIZATION OF REPORT

The remainder of this report is organized as follows:

- Chapter 2 provides background information on AST facilities nationwide and the general characteristics of ASTs, including oil discharges.

- Chapter 3 reviews Federal and State AST regulations and industry practices and standards, and provides estimates of the number of facilities already using liner systems.

- Chapter 4 describes the technical feasibility analysis of alternative liner system designs, and presents unit costs for facilities to install these liner systems.

- Chapter 5 presents EPA's recommendations.

In addition, appendices are included that provide supporting documentation for the various analyses discussed in the report.

2. BACKGROUND ON ASTs

This chapter provides information on AST facilities and ASTs and describes the potential environmental problems they pose. Specifically, Section 2.1 presents information on the number and type of U.S. facilities with ASTs and the general characteristics of ASTs nationwide. Section 2.2 describes the types of oil discharges from ASTs and the potential impacts on soil, ground water, and surface water. Section 2.3 presents information on the status of the U.S. AST inventory and the extent to which which oil discharges may be occurring at these ASTs.

2.1 PROFILE OF AST FACILITIES AND ASTs

EPA reviewed existing Agency reports, State information, and industry studies to develop a profile of the number and type of onshore facilities storing oil in bulk, and the number and type of ASTs. This information was used to:

- Analyze the types and characteristics of facilities with ASTs; and

- Develop representative facilities, or model facilities, to serve as the basis for developing technically feasible options for using liner systems with ASTs, and determining the corresponding facility costs.

This section provides information on the number and type of AST facilities and the number and general characteristics of ASTs.

2.1.1 Profile of AST Facilities

Section 4113(a) of OPA did not provide EPA with specific direction on the types of "onshore facilities used for the bulk storage of oil" that should be examined or the distance that qualifies a facility as being "located near navigable waters." As a result, EPA adopted a broad interpretation of this statutory language when preparing this report to avoid underestimating the number of ASTs that potentially benefit from using liners systems. Specifically, EPA used the storage capacity thresholds of the Oil Pollution Prevention regulation as the criteria to define the universe of facilities and ASTs that would be analyzed in the study because: (1) this regulation affects a diverse population of facilities from many industry sectors; and (2) the Agency previously conducted a study that provides estimates of the number and type of these facilities. These findings are discussed below.

EPA's "Spill Prevention, Control, and Countermeasures Facilities Study" (hereafter referred to as the *Facilities Study*)[3] provides estimates of the number of facilities that meet the storage capacity threshold of the Oil Pollution Prevention regulation because they have: (1) oil storage capacity greater than 42,000 gallons underground; (2) combined oil storage capacity greater than 1,320 gallons aboveground; or (3) greater than 660 gallons in a single tank aboveground. Exhibit 2-1 presents estimates of these facilities by Standard Industrial Classification (SIC) code category and three storage capacity tiers: 1,320 to 42,000 gallons; 42,001 to 1 million gallons; and greater than 1 million gallons. For purposes of this report, these facility storage capacity categories are referred to as small, medium, and large, respectively. EPA estimates that there are approximately 505,000 facilities that meet the storage capacity threshold of the Oil Pollution Prevention regulation. About 81 percent of these facilities are small, 18 percent are medium, and 1 percent are large.

This 505,000 estimate overstates the number of onshore facilities where AST liners systems could be installed because approximately 3,000 of these facilities are offshore oil production platforms that are currently regulated by the Department of the Interior's Minerals Management Service (MMS). Furthermore, not all of the remaining facilities are necessarily located near navigable waters. Specifically, EPA estimates that 435,000 of the 502,000 facilities (505,000 facilities minus 3,000 offshore production facilities) have the potential to discharge oil in harmful quantities into or upon the navigable waters of the U.S. or adjoining shorelines. Nevertheless, EPA elected to include facilities not located near navigable waters in this study because many of these facilities have the potential to contaminate surface water if they discharge oil to soil and ground water, which could be hydrologically connected to surface water.

As shown in Exhibit 2-1, facilities that meet the storage capacity threshold of the Oil Pollution Prevention regulation span many SIC code categories, and include facilities as diverse as farms, manufacturing facilities, and transportation facilities. Despite this industry diversity, these facilities may be grouped into three broad categories corresponding to how oil is used at these facilities. Specifically, oil is consumed or used as a raw material or end-use product (storage/consumption); marketed, refined, and distributed as a wholesale or retail good (storage/distribution); or pumped from the ground as part of oil exploration or production activities (production). Facilities in these three use categories have different characteristics in terms of basic physical and operating characteristics, such as the number and type of ASTs, throughput, and number and type of transfer points. For example, farms that use oil and diesel to heat buildings and power machinery are likely to have fewer ASTs and ancillary equipment and less product turnover than fuel oil dealers and bulk terminal facilities, which distribute petroleum

[3] U.S. EPA, Emergency Response Division, "Spill Prevention, Control, and Countermeasures Facilities Study," January 1991.

EXHIBIT 2-1

ESTIMATED NUMBER OF FACILITIES MEETING THE SPCC STORAGE CAPACITY THRESHOLDS

Facility Category	SIC (where applicable)	Oil Storage Capacity: 1,321 - 42,000 gallons (above ground only)	Oil Storage Capacity: 42,001 - 1,000,000 gallons	Oil Storage Capacity: >1,000,000 gallons	Total	"Best Estimate"
Farms	01/02	137,100 - 138,400	neg. - 1,300	0	137,100 - 139,700	138,400
Coal Mining/Nonmetallic Minerals Mining	12/14	2,500 - 4,500	500 - 900	neg. - 200	3,000 - 5,600	4,300
Oil Production[a/]	131	118,000 - 233,000	41,000 - 82,000	neg.	159,000 - 315,000	237,000
Contract Construction	15/16/17	2,000 - 3,600	500 - 900	0	2,500 - 4,500	3,500
Manufacturing:						
Food and Kindred Products	20	3,000 - 3,500	600 - 700	100	3,700 - 4,300	4,000
Chemicals and Allied Products	28	3,000 - 5,500	600 - 1,100	neg. - 100	3,600 - 6,700	5,150
Petroleum Refining	29	1,000 - 1,200	800 - 900	300 - 400	2,100 - 2,500	2,300
Stone, Clay, Glass, and Concrete	32	1,000 - 8,500	200 - 1,700	neg. - 100	1,200 - 10,300	5,750
Primary Metal Industries	33	1,000 - 2,000	200 - 400	neg. - 400	1,200 - 2,800	2,000
Other Manufacturing[b/]	20 - 39	4,000 - 8,000	800 - 1,600	100	4,900 - 9,700	7,300
Railroad Fueling	401	0	100 - 600	neg.- 100	100 - 700	400
Bus Transportation	411/413/414/417	1,200 - 1,600	300 - 400	0	1,500 - 2,000	1,750
Trucking and Warehousing/ Water Transportation Services	42/446	3,200 - 3,600	800 - 900	100	4,100 - 4,600	4,350
Air Transportation	458	0	500 - 600	neg.	500 - 600	550
Pipelines	46	0 - 400	neg. - 300	200 - 300	200 - 1,000	600
Electric Utility Plants	491	3,700	600	500	4,800	4,800
Petroleum Bulk Stations and Terminals	5171	1,400	8,800	2,200	12,400	12,400

EXHIBIT 2-1 (continued)

ESTIMATED NUMBER OF FACILITIES MEETING THE SPCC STORAGE CAPACITY THRESHOLDS

Facility Category	SIC (where applicable)	Oil Storage Capacity: 1,321 - 42,000 gallons (above ground only)	Oil Storage Capacity: 42,001 - 1,000,000 gallons	Oil Storage Capacity: >1,000,000 gallons	Total	"Best Estimate"
Gasoline Service Stations	554	0	4,200 - 11,100	neg. - 100	4,200 - 11,200	7,700
Fuel Oil Dealers	5983	2,500 - 5,500	100 - 2,800	neg. - 300	2,600 - 8,600	5,600
Vehicle Rental	751	0	neg. - 300	0	neg. - 300	150
Commercial and Institutional:						
Health Care[c/]	N/A	1,700 - 1,900	300 - 1,400	neg. - 200	2,000 - 3,500	2,750
Education[d/]	N/A	4,900 - 5,000	100 - 800	neg. - 100	5,000 - 5,900	5,450
Military Installations	N/A	100 - 200	300	100 - 200	500 - 700	600
Other Commercial and Institutional	N/A	46,600 - 46,800	1,000 - 1,800	neg. - 200	47,600 - 48,800	48,200
TOTAL		337,900 - 478,300	62,300 - 122,200	3,600 - 5,700	403,800 - 606,200	
"BEST ESTIMATE"		408,100	92,250	4,650		505,000

Note: N/A means not applicable and neg. means negligible (i.e., less than 50). The "best estimate" is the midpoint of the range.

a/ This includes the 3,000 offshore facilities currently regulated by the Department of the Interior's Minerals Management Service (MMS).

b/ Other industrial manufacturing establishments in SICs 20 through 39, except SICs 20, 28, 29, 32, and 33.

c/ For the medium and large capacity tiers, data were available only for hospitals (SIC 806), which are included in the Health Care subcategory.

d/ For the medium and large capacity tiers, data were available only for colleges (SIC 822), which are included in the Education subcategory.

Source: U.S. Environmental Protection Agency, "Spill Prevention, Control, and Countermeasures Facilities Study," January 1991.

products to end-users. This characterization is important for developing model facilities, which provide the basis for developing technically feasible options for installing liners at these facilities.

The typical storage capacity of these facilities varies significantly, from several thousand gallons for farms and small industrial manufacturers to tens-of-millions gallons for petroleum bulk terminals. Similarly, the number of ASTs at these facilities varies considerably from one or two per facility to over 100 per facility. The model facilities discussed in Chapter 4 were developed to represent the range in storage capacity and number of ASTs at these facilities.

2.1.2 Profile of ASTs

In general, there are two categories of ASTs: vertical ASTs and horizontal ASTs. The storage capacity of horizontal ASTs typically ranges from a few hundred gallons up to 20,000 gallons, while the storage capacity of vertical ASTs typically ranges from several thousand gallons to over 10 million gallons. Vertical ASTs are mounted such that the tank bottom rests on a ground-level foundation, such as a concrete pad or ring wall. Small vertical tanks (e.g., less than 42,000 gallons), which are commonly used in the oil production industry, often are installed on a concrete pad, which, in addition to the tank bottom, may serve as a secondary barrier to prevent leaked oil from reaching soil and to aid in leak detection by channeling oil to the side of the tank where it may be visually detected.[4]

As the volume and the tank diameter of vertical ASTs increase, ring-wall foundations become more economical than concrete pads. Ring walls, normally made of reinforced concrete, provide a foundation or footing upon which the AST wall rests. The AST bottom plate typically rests on hard-packed soil, sand, or other fill material. Based on engineering experience, as ASTs reach 40,000 to 50,000 gallons of storage capacity, the combination of size and weight considerations are such that ring-wall foundations become more economical than concrete pads.[5] Unlike vertical tanks with concrete pads, leaks from the bottom side of vertical ASTs with ring walls have the potential to go undetected for extended periods of time before oil seeps to the edge of the AST, is detected during ground-water monitoring operations, or creates a sheen in a nearby stream or river.

Horizontal ASTs typically are supported in saddles that are bolted to secondary containment structures, such that tank is suspended above the ground or floor of a

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[4] Concrete pads used with small ASTs often are manufactured with radial groves that aid in leak detection by channeling discharge oil to the side of the tank.

[5] An analysis of data provided by the *Entropy Study* (see footnote #9) generally confirms this experience. Specifically, for the oil production sector, approximately 88 percent of all ASTs with a storage capacity of less than 42,000 gallons are set on concrete pads.

secondary containment structure. Leaks from horizontal ASTs are generally easy to detect because facility personnel can readily see the underside of the tank.

The overwhelming majority of existing ASTs are fabricated using carbon steel, although stainless steel, reinforced concrete, and fiberglass materials also have been used for certain AST applications. The wall thickness of vertical ASTs may vary significantly, from 0.1875 inches for a 10,000-gallon AST to 1.135 inches for a 10 million-gallon tank. Similarly, the thickness of the annular bottom ring of a vertical AST may vary significantly. The bottom plates of a vertical AST must be constructed with a minimum thickness of 0.25 inches,[6] exclusive of any corrosion allowance specified by the purchaser, while the annular ring supporting the bottom-to-shell weld may be as thick as 0.75 inches for the larger ASTs. The thickness of the bottom is a critical factor in determining the potential for an AST to develop corrosion-related leaks (as discussed in Section 2.3.3). ASTs are either erected at the site (i.e., field erected) or are shop-fabricated by a manufacturer and then transported to the site. Virtually all ASTs with storage capacity greater than 50,000 gallons are field erected because of transportation constraints and construction considerations. Because the vast majority of ASTs are constructed with steel materials and, therefore, are susceptible to corrosion, these ASTs have the potential to leak oil.

EPA estimates that the number of ASTs at the 502,000 onshore facilities that meet the storage capacity threshold of the Oil Pollution Prevention regulation is about 1.8 million.[7,8] Based on the 1989 API "Aboveground Storage Tank Survey"[9] (hereafter referred to as the *Entropy Study*), about 700,000 ASTs are used at facilities in the production, refining, transportation and marketing sectors of the petroleum industry. These two estimates differ because the number of ASTs at all facilities that meet the storage capacity threshold of the Oil Pollution prevention include ASTs outside the petroleum industry, such as ASTs at end-user facilities (e.g., farms).

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[6] When specified by the purchaser, a minimum nominal thickness of 6 millimeters for all bottom plates is acceptable.

[7] U.S. EPA, Emergency Response Division, "Estimate of the Number of Aboveground Storage Tanks at Onshore Facilities," October 1994.

[8] An alternative order-of-magnitude estimate was developed by multiplying the number of small, medium, and large facilities that meet the storage capacity threshold of the Oil Pollution Prevention regulation (presented in Exhibit 2-1) by the number of ASTs typically found at each of these facility size categories: two ASTs, seven ASTs and 17 ASTs for small, medium, and large facility categories, respectively. The estimates of the typical number of tanks was developed based on analysis conducted in support of revisions to the Oil Pollution Prevention regulation. Based on this approach, the number of ASTs are estimated to be about 1.5 million.

[9] American Petroleum Institute, "Aboveground Storage Tank Survey," prepared by Entropy Limited, April 1989 (hereafter referred to as the *Entropy Study*).

Exhibits 2-2 and 2-3 present data on the percentage distribution of ASTs by age and storage capacity, respectively. Exhibit 2-2 presents the distribution of ASTs by age for 700,000 tanks, which was obtained from the *Entropy Study*. About 32 percent of these ASTs are between 0 to 10 years old, while nearly 27 percent of these ASTs are between 11 to 20 years old. AST age may be a critical factor for determining the likelihood that leaks will develop as a result of corrosion (as discussed in Section 2.3.3).

Exhibit 2-3 shows the estimated distribution of ASTs by storage capacity (gallons) based on data provided by New York.[10] As shown in the exhibit, the largest proportion of ASTs have a storage capacity of between 1,000 and 10,000 gallons. This distribution is similar to the distribution of ASTs by storage capacity in the petroleum industry. Specifically, in Exhibit 2-4, AST distribution by storage capacity based on the New York State data is compared to similar data provided by the *Entropy Study*. As shown in the exhibit, both sources of data indicate that most ASTs are less than 21,000 gallons. This comparison suggests that the distribution of ASTs within the petroleum industry by storage capacity is similar to the overall distribution of ASTs by storage capacity – because the New York State data include ASTs from many industry sectors.

2.2 OIL DISCHARGES FROM ASTs

In general, AST oil discharges may be classified into two broad groups/categories: leaks and spills. These categories are useful for understanding how oil discharged from ASTs affects the environment and how different types of liner systems could aid in detecting discharges or preventing oil from contaminating surface water by way of tributary ground water.

Leaks typically originate from the bottom of vertical ASTs as a result of perforations in the bottom plates, which are often caused by corrosion. Leaks also may originate from the sidewalls of vertical ASTs, as well as any point on the surface of a horizontal AST. However, such leaks can be detected visually as part of a periodic tank inspection program and, therefore, may be addressed before significant contamination occurs. Although the amount of oil discharged per hour (or day) from ASTs as a result of leaks can be relatively small compared to spills (e.g., a leak rate of one gallon per hour versus a spill of hundreds or thousands of gallons), substantial volumes of oil may be discharged to soil underneath an AST over time because leaks may continue undetected for years. Leaked oil is commonly carried through the soil layer by precipitation and migrates downward to ground water. In addition, leaked oil may migrate horizontally to the edge of the AST bottom where it can be visually detected.

[10] Under New York State's Environmental Conservation Law, both existing and new facilities with a combined aboveground and underground storage capacity exceeding 1,100 gallons are required to register with the State in order to operate. Facilities are required to provide general facility information and detailed tank-specific information, including the storage capacity of ASTs, to the New York State Department of Environmental Conservation (NYDEC) by filling out an application form. This information is entered into a computer data base, which is maintained by the NYDEC.

EXHIBIT 2-2

DISTRIBUTION OF ASTS BY AGE CATEGORY

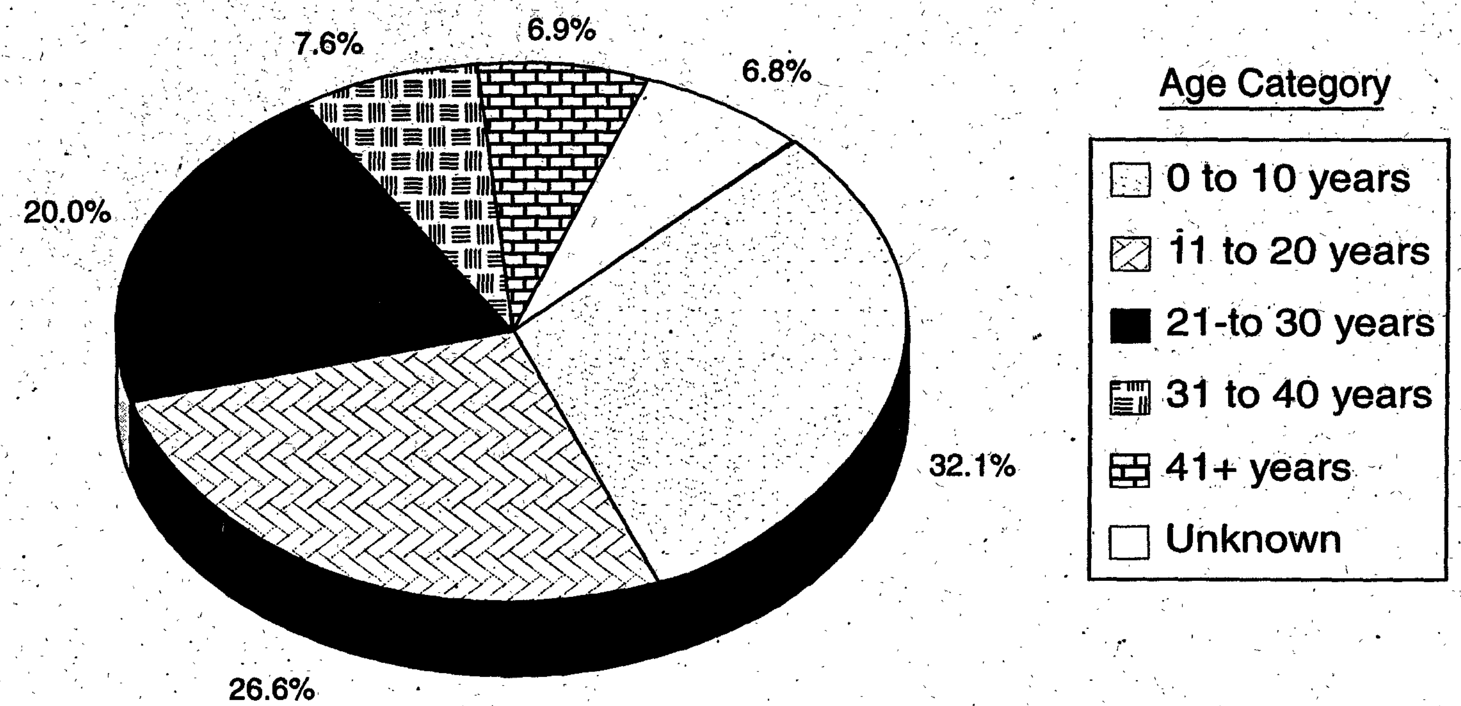


EXHIBIT 2-3

DISTRIBUTION OF ASTs BY STORAGE CAPACITY TIER

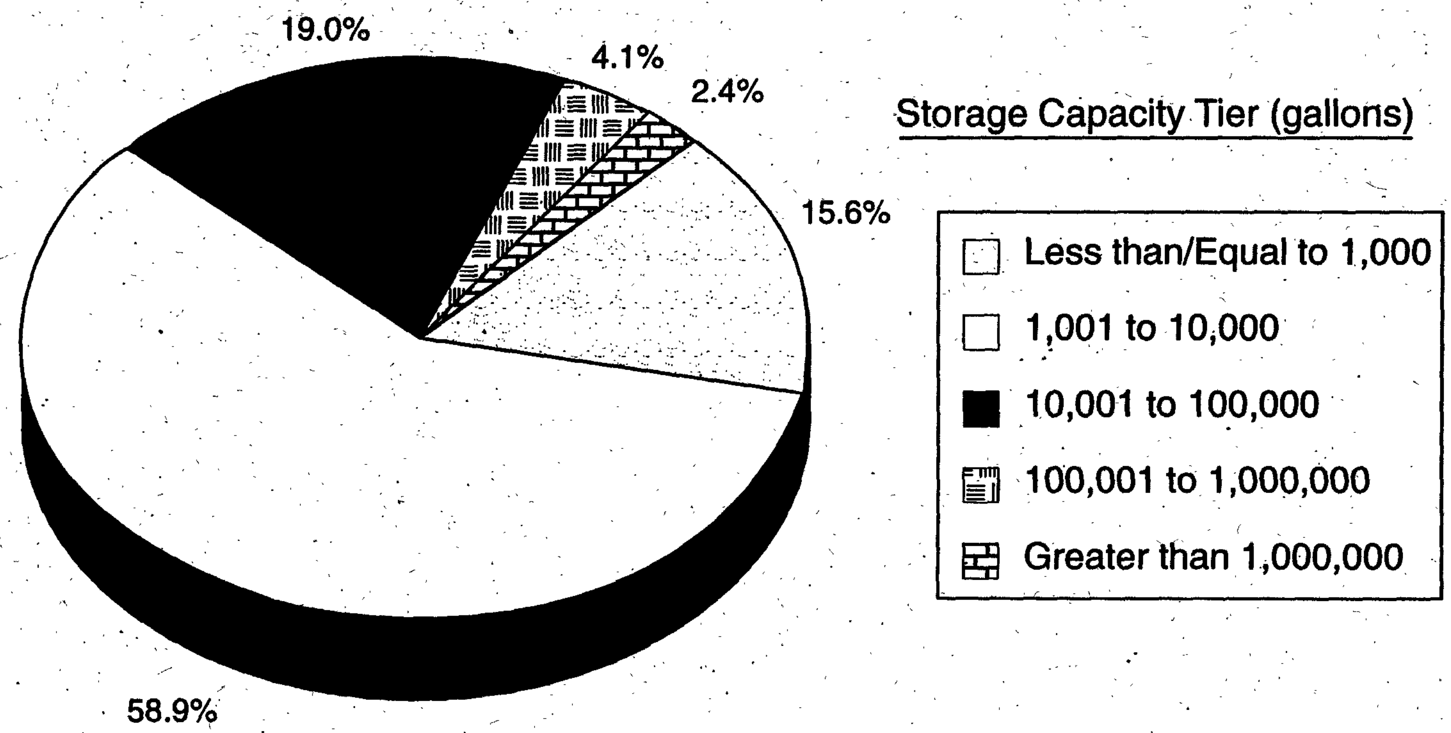


EXHIBIT 2-4

DISTRIBUTION OF ASTs BY STORAGE CAPACITY BY DATA SOURCE

SOURCE OF DATA	AST STORAGE CAPACITY TIER (Gallons)				
	less than or equal to 21,000	21,001 to 42,000	42,001 to 420,000	420,001 to 4,200,000	greater than 4,200,000
New York State	90.7%	2.1%	3.1%	3.6%	0.5%
API/Entropy Study	82.8%	6.4%	6.0%	4.2%	0.6%

Spills are episodic events, whereby potentially significant quantities of oil may be discharged rapidly into secondary containment areas and beyond. Spills from ASTs may occur as a result of operator error, for example, during loading operations (e.g., vessel or tank truck - AST transfer operation), or as a result of structural failure (e.g., brittle fracture) because of inadequate maintenance of the AST. Oil discharged from spills may fill up secondary containment structures (e.g., diked areas) that surround ASTs and, if the secondary containment system is unlined, migrate through soil and ground water to surface water. A range of secondary containment liner systems to address the potential problems posed by oil spilled into secondary containment areas is discussed in Chapter 4.

Oil discharged from ASTs as a result of either spills or leaks has the potential to contaminate the environment. Oil spills from ASTs may adversely affect soil, ground water, surface water, ecosystems, and organisms. Spilled oil can move over the ground or through the soil and can be carried along by precipitation. Precipitation that falls on the land surface enters into a number of different pathways of the hydrologic cycle. Some of the water will drain across the land directly into a stream channel, while some will seep through the soil and become ground water. Ground water flows through the rock and soil layers of the earth until it too discharges as a spring or as a seepage into a stream, lake, or ocean. Soil contamination (e.g., oil spilled onto the ground from an AST) may therefore be carried down into the ground water by precipitation, and this contamination may then be discharged into surface water. Such a scenario is specifically contemplated in EPA's underground storage tank (UST) technical requirements at 40 CFR part 280. Under the UST regulation, a suspected tank leak must be reported if released petroleum is discovered at the site or in the surrounding area (such as the presence of free product or vapors in soils, basements, sewer and utility piping, and nearby surface water).

A great deal of research has already been conducted on the effects of oil on the environment. Spilled and leaked oil can damage farmland and adversely affect water supplies by polluting wells or water intakes on surface streams. Soil contamination also may threaten aquatic or terrestrial wildlife and may contribute to pollution in lakes, rivers, freshwater wetlands, estuaries, beaches, and ocean waters (where runoff is a major source of oil pollution). Oil in sewers, pipeline trenches, or foundation fills can increase the risk of fire and explosion. In addition, lethal effects of oil on organisms may include bird mortality caused by oiled feathers, fish mortality, and egg or larval stage losses. Sublethal effects of AST oil spills on aquatic organisms could include stress-related disease and disruption in behavior patterns or reproduction.

Various technologies are available to remediate oil-contaminated soil, although use of these technologies can present site-specific difficulties. For example, incineration has been demonstrated to achieve remediation cleanup goals, but is relatively costly and may not be acceptable to the public. Surface-enhanced bioremediation, on the other hand, is not feasible at all sites; the hydrogeology of the site must not allow for rapid transport of the contaminants to the ground water, and the soil must be compatible with the introduction of nutrients.

Similarly, there are various remediation options to handle oil-contaminated ground water. Most of these options are either containment technologies (e.g., slurry walls) or some variation of the traditional "pump-and-treat" approach. Ground-water pump-and-treat systems can be very costly, and treatment goals may take 30 years or longer to achieve. It should also be noted that for certain stratigraphies (e.g., fractured bedrock or karst topographies), restoration of contaminated aquifers may not be achievable or feasible with existing technologies.

Exhibit 2-5 highlights three case studies illustrating the problems posed by AST facilities and concerns regarding the potential for oil to contaminate soil, ground water, and surface water.

2.3 STATUS OF ASTs NATIONWIDE

EPA conducted an extensive data collection effort to estimate the number of leaking ASTs. Specifically, the Agency investigated Federal government data bases, such as the Emergency Response Notification System (ERNS), and contacted several States about data on AST leaks. The Agency found that comprehensive data do not exist to quantify adequately the extent to which the nation's AST inventory is leaking. Existing Federal regulations require facility owners and operators to report oil discharges that reach navigable waters and thereby trigger the reporting thresholds of Clean Water Act (CWA) regulations. Consequently, AST oil discharges that affect only soil and ground water and that do not initially reach surface water are generally not reported. Despite these limitations, existing data sources evaluated by EPA suggest that a significant number of ASTs may be leaking or spilling oil.

Section 2.3.1 discusses EPA's review of Federal reporting requirements related to oil discharges. Section 2.3.2 describes the available information on the extent to which ASTs are leaking oil. Section 2.3.3 provides an age profile of the AST universe and examines the potential relationship between leak probability and tank age.

EXHIBIT 2-5

CASE STUDIES

Case Study #1:
COLDBROOK ENERGY FACILITY

On April 17, 1993, about 35,000 gallons of gasoline spilled from a 6-inch crack in an AST at the Coldbrook Energy Facility in Hampden, Maine. The tank was surrounded by an unlined containment dike that contained the spilled material. Remediation measures employed at the site included recovery wells and trenches dug into the contaminated soil. Response crews also deployed sorbent boom along the banks of the nearby Penobscot River as a precautionary measure. Fortunately, only small amounts leached into the river during periods of low tide, producing a light sheen ("World Spill Briefs," *Golub's Oil Pollution Bulletin*, Vol. 5 No. 12, May 1993, p. 7).

Case Study #2:
STAR TANK FARM

At the Star Enterprise Inc. tank farm in Fairfax, Virginia, more than 150,000 gallons of oil is sitting on ground water beneath the Star site and a neighboring community. The site was first investigated in September 1990, after migration of the underground plume produced a light sheen on a nearby creek. Officials at Star Enterprise acknowledge that a missing overflow container at the loading area of the tank farm could have allowed thousands of gallons of oil to seep into the soil and ground water undetected; it is not clear whether this is the only source of petroleum discharges at the site, and investigations are continuing.

Case Study #3:
SPARKS BULK FUEL TANK FARM

An example of a larger petroleum spill to land affecting soil and, subsequently, ground water occurred at a bulk fuel tank farm in Sparks, Nevada. In 1989, a 3- to 5-million-gallon petroleum plume was discovered extending a mile east of the facility into a gravel pit. The oil from the plume appeared to be seeping through the gravel pit walls and collecting into a water pool in the bottom of the pit. The gravel company that owned the gravel pit pumped the solution out of the pit and into containment ponds for treatment. The pumping action drew the area ground water down to the pit bottom, diverting it from its natural flow south into the Truckee River. Regulators said that if the pumping were to stop, the contaminated ground water would continue downstream and end up in the river.

2.3.1 Federal Reporting Requirements

The Hazardous Materials Transportation Act (HMTA), as amended, the CWA, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the Resource Conservation and Recovery Act (RCRA) all contain requirements for reporting releases of hazardous materials to the environment under certain conditions. For oil discharges, however, these reporting requirements are not inclusive because releases from ASTs to land that do not directly affect surface water or that are not related to transportation are generally not covered.

The U.S. Department of Transportation (DOT) maintains several systems for reporting transportation-related hazardous material. Under the HMTA, as amended, DOT collects information on releases of hazardous materials, including oil products, during transport by highway, rail, pipeline, water, or air. In some circumstances, information regarding spills from ASTs may be included in DOT's systems (e.g., an oil release from a tank connected to a pipeline). Many AST discharges, however, are not transportation-related.

The oil discharge regulations promulgated at 40 CFR part 110 and 33 CFR part 153 under the CWA require that an oil discharge to U.S. waters or adjoining shorelines, or in ocean waters out to approximately 200 miles from the shore, must be reported immediately to the National Response Center (NRC) if it meets one of the following three conditions:

- Causes a sheen to appear on the surface of the water;
- Violates applicable water quality standards; or
- Causes a sludge or emulsion to be deposited beneath the surface of the water or upon the adjoining shorelines.

Traditionally, the CWA reporting requirements have not been interpreted to encompass oil discharges to soil that reach ground water, but do not migrate to surface water.

In contrast, CERCLA does require that releases of hazardous substances to land and ground water be reported to the NRC. However, CERCLA's list of regulated substances excludes petroleum products unless they are specifically listed. In general, crude oil and refined petroleum products are not listed under CERCLA. Both CWA discharges and CERCLA releases reported to the NRC or EPA are contained in ERNS.

Finally, the RCRA Subtitle I requirements cover petroleum releases to land, but only if they originate from an UST system. The Federal UST regulations (at 40 CFR part 280) implement Subtitle I. Such underground storage systems are broadly defined to include tanks (together with underground piping) that have a volume that is 10 percent or more beneath the ground surface. UST owners and operators must report suspected releases of any volume of petroleum to the environment, as well as spills or overfills that exceed 25 gallons (or other amount specified by the implementing agency). ASTs would be covered only if they fit within the UST definition, and release reports would be maintained by the implementing agency (usually a State agency).

Based on these considerations, EPA believes that shortcomings exist with regard to requirements for the reporting of discharges of oil from ASTs that initially only affect soil and ground water, and that further action may be warranted to address this issue.

2.3.2 Discharges from ASTs

EPA analyzed ERNS data to estimate the number of reported oil discharges that occur from ASTs annually. The ERNS data base is the Federal government's central source of data on reported discharges of oil and hazardous substances. The oil spill data contained in ERNS include information collected primarily from initial release notifications received by the NRC, U.S. Coast Guard, and EPA. ERNS data indicate that roughly 30 percent of reported oil discharges from facilities are to secondary containment areas. This discharged oil could be addressed by liner systems installed within secondary containment systems.

Of the States that EPA contacted, only Virginia provided detailed information on oil discharges from AST facilities. The Virginia Department of Environmental Quality (VADEQ) recently implemented a regulatory program that requires certain AST facilities to: (1) register all applicable ASTs with VADEQ; (2) satisfy financial responsibility requirements; (3) submit an Oil Discharge Contingency Plan (ODCP); and (4) participate in the AST pollution prevention program. In particular, under the ODCP requirements, facilities with an aggregate oil storage capacity of greater than 1 million gallons must submit a Ground Water Characterization Study (GCS).[11] This study requires facilities to monitor ground water for signs of oil contamination. Based on GCSs submitted by 88 facilities to VADEQ as of April 4, 1994, about 88 percent of facilities (77 facilities) reported ground-water contamination. The data were not sufficient to determine whether this contamination is the result of past practices or is continuing to occur at these facilities.

API conducted a survey in 1994 to determine the extent to which member facilities in the refining, marketing, and transportation sectors of the petroleum industry have ground-water contamination.[12] About 300 facilities, or 85 percent, of 350 API member facilities completed the survey. The results of the survey indicate that 85

[11] Virginia Regulation 680-14-12: Facility and AST Registration Requirements, effective September 22, 1993.

[12] American Petroleum Institute, "A Survey of API Members' Aboveground Storage Tank Facilities," prepared by API Health and Environmental Affairs Department, July 1994.

percent of refineries, 68 percent of marketing facilities, and 10 percent of transportation facilities have known ground-water contamination near their facilities. Furthermore, the majority of these facilities are remediating the contaminated ground water. According to API, the results of this survey may be extrapolated to all API member facilities. Again, it is not clear from these data whether this contamination is continuing to occur at these facilities. However, API reports that improved equipment and operating practices over the last 5 years have reduced reported petroleum spills and accidental releases. These improvements include:

- In 1991, API published standard 653 as guidance for establishing inspection intervals for AST bottoms. This standard also "incorporates an AST inspector certification program that establishes minimum education and experience qualifications and provides for the testing of candidates."

- Guidance on the development of an overfill prevention program is provided in API Recommended Practice 2350.

- Systems and operating procedures to remove, recover, or properly handle tank water-bottoms have been or are being implemented at storage facilities.

- Survey results indicate the use of cathodic protection for buried AST-associated piping has increased.

2.3.3 Age Profile of ASTs

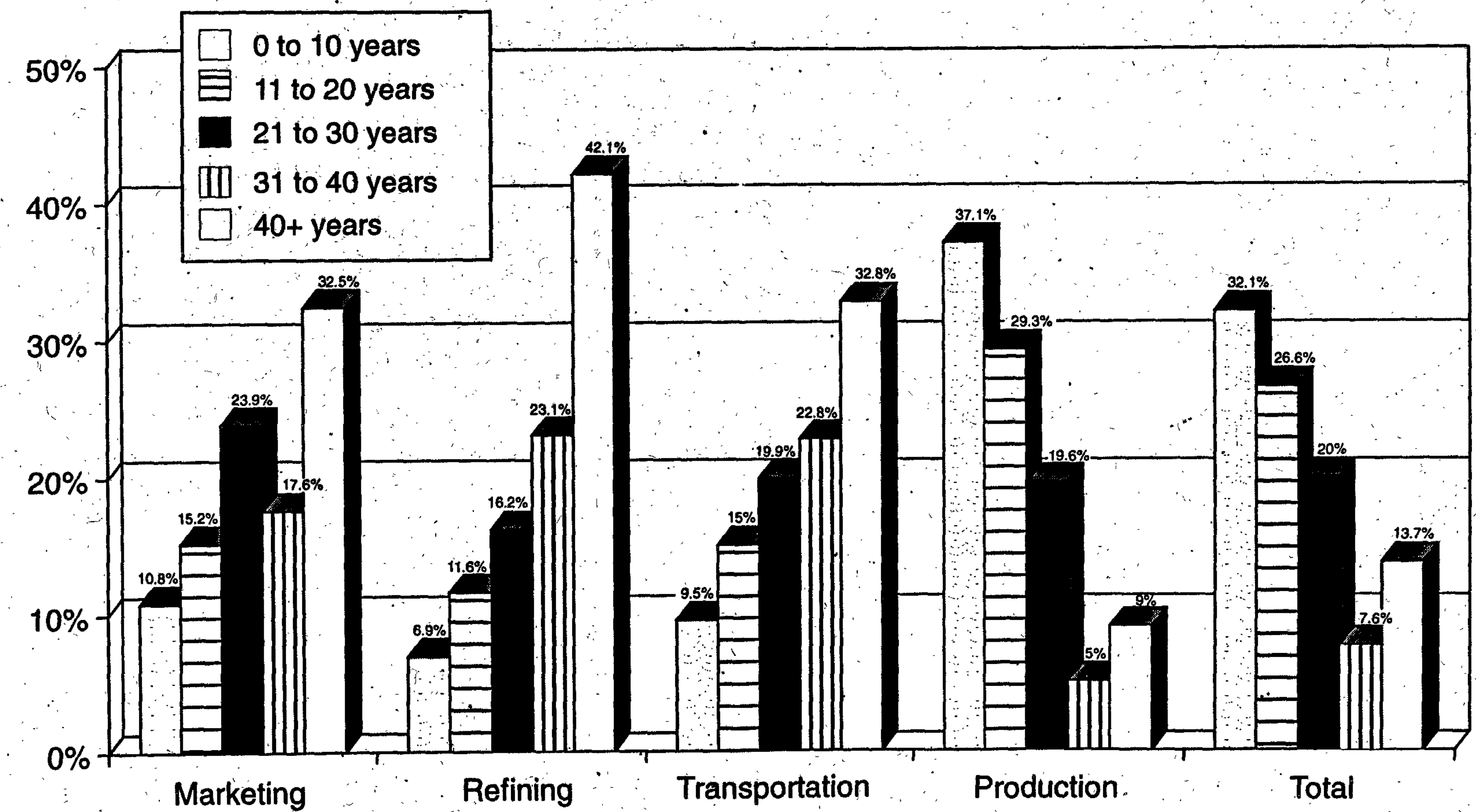
EPA obtained data on AST age and examined the potential relationship between AST age and corrosion rates to estimate the likelihood that ASTs will develop leaks as a function of tank age.

The most comprehensive data currently available on the age of ASTs are provided by the *Entropy Study*. This study provides estimates of the number of ASTs by several age categories for each industry sector. These data are shown in Exhibit 2-6. As shown in the exhibit, the distribution of ASTs by age category is roughly similar for the marketing, refining, and transportation sectors, in that the majority of ASTs within each of these sectors are over 40 years old. However, in the oil production sector, most ASTs are less than or equal to 10 years of age. Because the number of ASTs in the production sector is significantly greater than the number of ASTs in the other sectors, the overall age distribution for ASTs in the petroleum industry is similar to the age distribution for ASTs in the production sector.[13]

[13] Specifically, the number of tanks in the production, marketing, refining, transportation, sectors is estimated by the *Entropy Study* to be 572,620, 88,529, 29,727, and 9,197, respectively, for a total of 700,073. About 82 percent of all ASTs are in the production sector.

EXHIBIT 2-6

PERCENTAGE OF ASTS BY AGE CATEGORY



Source: *Entropy Study*

EPA investigated the potential relationship between the age of ASTs and failure rates based on data provided in a study conducted by the Suffolk County Department of Health Services in 1988 entitled, "Final Report, Tank Corrosion Study" (hereafter referred to as the *Suffolk County Study*). During the 1980s, Suffolk County, New York, enacted legislation that required all unprotected bare steel USTs to be replaced with protected storage tanks by 1990 -- whether or not there was evidence that the USTs were leaking oil. As a result, this program provided a valuable sample of data to estimate leak probabilities as a function of age because leaking USTs were included in the sample along with perfectly functional USTs.

Hundreds of USTs were inspected as part of this program to determine the extent to which corrosion caused leaks. A relationship between UST tank age and the probability that USTs will develop a leak caused by corrosion was identified.[14] Specifically, the original design wall thickness appears to be a key factor influencing the amount of time a bare steel tank will remain free of perforations. USTs with thicker walls normally will take longer to develop a perforation due to corrosion than USTs with thinner walls, all other factors being equal (e.g., the acidity of the soil). Because the rate at which tank walls fail due to corrosion is related to tank age, the age of the tank may be used as an indicator to predict the likelihood that tank walls will develop perforations. Exhibit 2-7 presents the percentage of USTs that would fail due to corrosion by age category, based on estimates from the results of the *Suffolk County Study*.

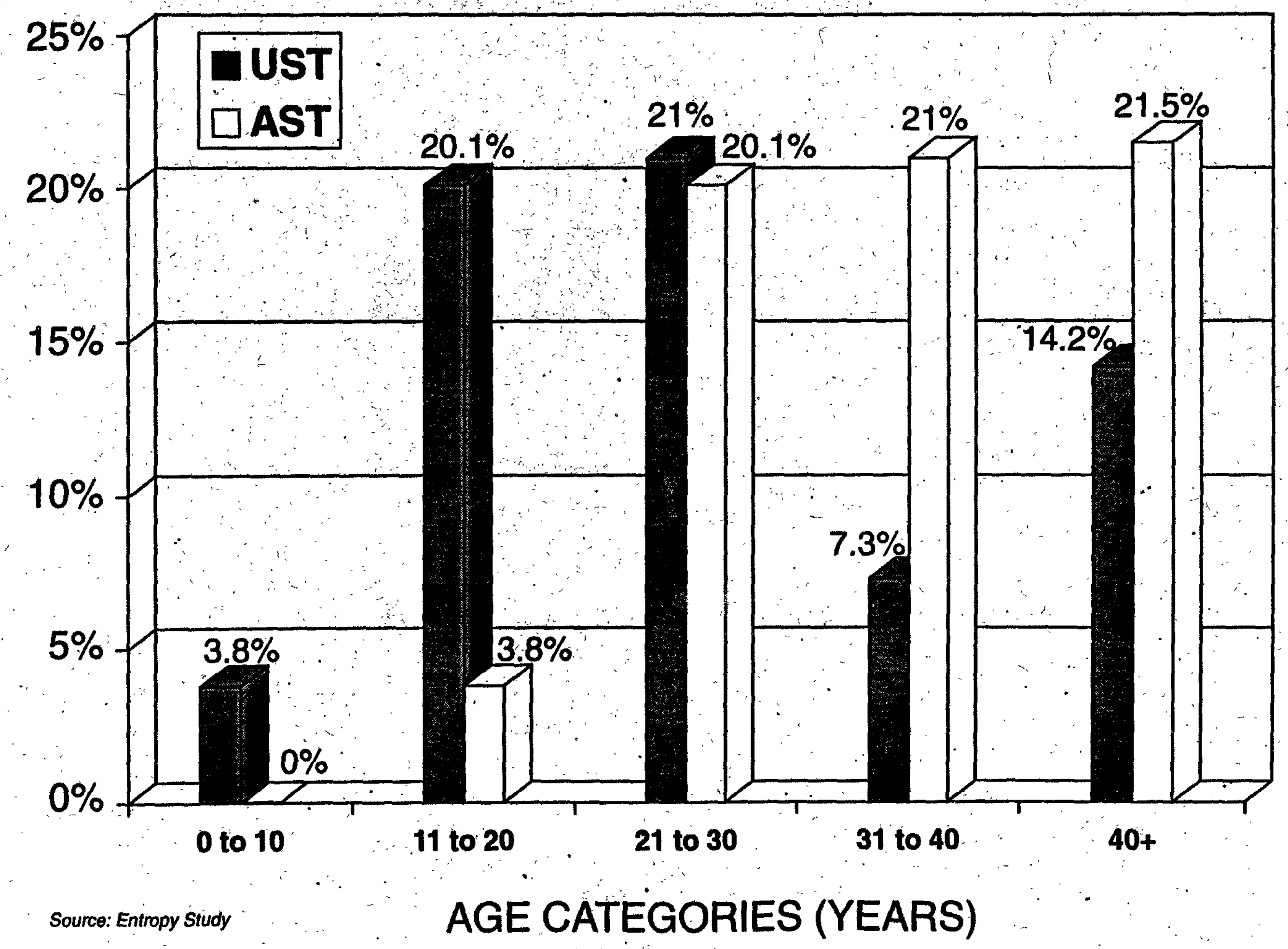
In extrapolating the results of the *Suffolk County Study* to ASTs, EPA modified some of the assumptions regarding the relationship between the tank age and the probability of leaks because of the differences between the nominal wall thickness of USTs and the nominal thickness of AST bottoms. Specifically, ASTs are generally constructed using thicker bottoms than are USTs walls as a result of structural considerations and industry standards. Based on these considerations, EPA assumed that, on average, ASTs fail as a result of corrosion 10 years later than USTs. This 10-year estimate was based on the added nominal bottom thickness for ASTs as specified in current industry standards. Exhibit 2-7 presents EPA's estimates of the percentage of ASTs that fail due to corrosion by age category.

As shown in the exhibit, ASTs less than 10 years old are assumed not to fail as a result of corrosion. AST failure due to bottom corrosion is generally greatest for tanks older than 40 years. Specifically, the likelihood of a corrosion-related failure of the tank bottom for ASTs in this age category is estimated to be about 22 percent.

[14] Other factors that may affect the likelihood of corrosion-related tank failure include: (1) acidity of the soils; (2) height of the water table; and (3) the presence of tank design features such as baffles or deflection plates.

EXHIBIT 2-7

PERCENT CORROSION FAILURE IN EACH AGE GROUP



Source: Entropy Study

The probability rates for corrosion-related failure of ASTs estimated here do not consider the effects of using cathodic protection systems to retard corrosion of the bottom plate of vertical ASTs. Specifically, cathodic protection systems have the potential to reduce the rate at which the bottoms of ASTs corrode if these systems are properly maintained. EPA did not adjust the probability estimates as a result of cathodic protection because data on the use of cathodic protection systems with ASTs are incomplete and cathodic protection is effective only if it is properly maintained.

3. EXISTING REGULATIONS AND INDUSTRY PRACTICES FOR LINER SYSTEMS

EPA reviewed Federal and State regulations and industry practices to gather information on the specifications of liner systems and to estimate the number of AST facilities currently required to use liners. Section 3.1 discusses the results of EPA's review of Federal and State AST regulations. Section 3.2 summarizes recommended industry practices related to AST liners and double bottoms. Section 3.3 presents EPA's estimate of the number and type of facilities required to use liner systems as a result of State regulations.

3.1 REVIEW OF FEDERAL AND STATE AST REGULATIONS

3.1.1 Federal Regulations

In general, existing Federal regulations affecting AST facilities do not explicitly require the use of liners or double bottoms with ASTs. However, section 112.7(c) of the Oil Pollution Prevention regulation, which is the primary Federal regulation addressing oil discharge control and response equipment and procedures for AST facilities, requires that "appropriate containment and/or diversionary structures or equipment to prevent discharged oil from reaching a navigable water course should be provided" and that such containment be "...sufficiently impervious to contain spilled oil." This regulatory requirement could be met by constructing a secondary containment system, such as a dike, with materials that have a low permeability (i.e., resist the penetration of oil through the material) or by adding a liner to the secondary containment system to provide this protection. However, this requirement does not specify a permeability standard, such as how far oil may move through the material per unit time (e.g., 1 millionth of a centimeter per second). Although EPA does not have comprehensive data on the quality of secondary containment structures at AST facilities nationwide, information provided by EPA field personnel indicates that the quality of secondary containment systems (e.g., the permeability of the materials) varies considerably.

The Federal UST regulation under RCRA Subtitle I (at 40 CFR part 280) and the Federal Hazardous Waste Storage Tank (HWST) regulation under RCRA Subtitle C (at 40 CFR part 264) require that facility owners and operators consider the installation of liners as a protective option for USTs and HWSTs. Although the Federal UST and HWST regulations do not specify liner materials or designs, these regulations establish performance criteria for containment materials and structures. For example, the UST regulation mandates a permeability for liners of 1×10^{-6} centimeters per second (cm/sec). The HWST regulation requires that external liner systems be capable of preventing lateral and vertical migration of the waste if a release from the tank(s) should occur.

Leak detection practices or devices are required by the UST and HWST regulations. The UST regulation specifies that leak detection equipment must be able to detect a 0.2 gallon-per-hour leak and that tanks must be inspected monthly. The HWST regulation requires that leak detection systems be in continuous operation and be capable of detecting a release within 24 hours or at the earliest practicable time.

In general, ASTs (and associated piping) that have less than 10 percent of their volume below the ground surface are not subject to the Federal UST regulations. The HWST regulations affect only ASTs that contain hazardous wastes. Thus, Federal regulations do not require facilities with ASTs containing oil to have liner systems within secondary containment systems.

3.1.2 State Regulations

EPA conducted a review of current and proposed AST regulations for the 50 States to gather information on liner requirements and specifications and to determine quantitatively the extent to which States require facilities to have liner systems. The results of this review of regulations for each State is briefly summarized in Appendix A.

EPA identified nine States that have promulgated or have proposed regulations that specify the use of "impermeable" secondary containment systems, liners, or other diversionary structures and systems to prevent discharges of oil from reaching soil, ground water, or surface water: Alaska, Connecticut, Florida, Maryland, New Jersey, New York, Rhode Island, South Dakota, and Wisconsin.[13] For each of these States, the following information is provided below and summarized in Exhibit 3-1:

- The applicability of the requirements to different sizes and/or types of facilities; and

- Specifications that address secondary containment (including liner specifications) and leak detection procedures and/or equipment.

Alaska (18 ACC 75): Alaska requires that all new and existing crude oil storage facilities with a total storage capacity of more than 5,000 barrels (and non-crude facilities with a storage capacity of more than 10,000 barrels) locate their tanks within a "sufficiently impermeable" secondary containment area. Secondary containment *under* tanks at new installations must include "impermeable" liners or double bottoms. Liner and permeability specifications apply to new facilities and new secondary containment areas only:

[13] Connecticut's regulations were proposed at the time of this review.

EXHIBIT 3-1

SUMMARY OF STATE REGULATORY REVIEW FOR THE NINE STATES

REGULATION	SECONDARY CONTAINMENT LINERS	UNDERTANK LINERS	LINER MATERIALS	PERMEABILITY RATE (CM/SEC)	LEAK DETECTION WITH LINERS[a/]
Alaska	✓	✓	✓[b]	1×10^{-7} [b/]	✓
Connecticut (proposed)	✓	N/A	N/A	1×10^{-5}	✓
Florida	✓	✓	✓	1×10^{-7}	–
Maryland	✓	N/A	N/A	1×10^{-4}	–
New Jersey	✓	✓	✓	1×10^{-7}	–
New York	✓	✓	✓	1×10^{-6}	✓
Rhode Island	✓	✓	✓	1×10^{-6}	–
South Dakota	✓	✓	✓	1×10^{-6}	✓
Wisconsin	✓	✓	✓	N/A	N/A

Notes:

✓ Regulations require these specific provisions

N/A Not applicable; these provisions are not part of the regulation

a/ States indicated by a "–" require visual detection. States indicated by ✓ also require additional measures such as inventory control or automatic leak detection equipment.

b/ New facilities are required to have a liner that has a permeability of 1×10^{-7} cm/sec (layer of manufactured material in the area under the tank) or 1×10^{-6} cm/sec (layer of natural or manufactured material) for new secondary containment structures, excluding undertank applications

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- "Sufficiently impermeable" for new installations consists of a "layer of natural or manufactured material of sufficient thickness, density, and composition to produce a maximum permeability for the substance being contained of 1×10^{-6} cm/sec."

- "Impermeable" liners for new installations consist of a "layer of manufactured material of sufficient thickness, density, and composition to produce a maximum permeability for the substance being contained of 1×10^{-7} cm/sec."

Alaska requires that each tank at new and existing installations must be equipped with a leak detection system that can be used externally to "detect leaks in the bottom of the tank, such as secondary catchment under the tank bottom with a leak detection sump, a sensitive gauging system, or another leak detection system approved by the department." The owner or operator must check for the presence of leaks or spills daily at a staffed facility and at least once a month at an unstaffed facility.

Connecticut (RSCA proposed 22a 449): The proposed regulations would require facilities with aggregate storage of more than 1,320 gallons, or that have a single tank of more than 660 gallons, to have secondary containment in the form of "impermeable... dikes" around all tanks. These volume specifications are consistent with the Federal Oil Pollution Prevention regulation. These regulations would apply equally to both new and existing facilities.

- Dike permeability must be less than 1×10^{-5} cm/sec. The dikes may be either above or below grade, but the depth of a dike may not exceed 10 feet below the outside finished grade. The diked area must contain at least 100 percent of the volume of the largest enclosed tank.

Proposed leak detection specifications, like those for most of the eight other States, will require regular visual inspections around tanks and transfer piping. Connecticut also proposes to mandate weekly inventory measurement/record reconciliation procedures to detect slow leaks that have the potential to escape visual checks.

Florida (FAC 17-762): Florida law specifies "impervious secondary containment" systems. The regulations apply to all new facilities with a storage capacity of greater than 550 gallons. All existing facilities with a storage capacity of greater than 550 gallons must comply with the regulations by the year 2000, except for certain shop-fabricated tank systems.[14]

- The liner systems may be synthetic, concrete, or clay-based, and they must be capable of containing 110 percent of the largest tank enclosed by the secondary containment area, unless that tank is itself enclosed in a concrete vault, or is double walled.

- The definition of "impervious" varies depending on the liner material used. For synthetic systems, it is 1×10^{-7} cm/sec. Concrete liners must only be "product tight." Clay-based liner systems must be individually approved by the Florida Department of Environmental Protection.

[14] Vehicular fuel-storing shop-fabricated systems that store or use 1,000 gallons or less per month or 10,000 gallons or less per year also must comply with these regulations by the year 2000. Other aboveground shop-fabricated tanks may be retrofitted with double bottoms rather than an undertank impermeable liner. All alterations must be installed to regulatory specifications by the year 2000.

Specified leak detection measures consist of visual inspections or other appropriate measures. Inspections should be conducted around "tanks and integral piping," and must be conducted at least once per month.

Maryland (CMR 26:12): Maryland law specifies that secondary containment must be "capable of effectively holding the total volume of the largest storage container located within the area enclosed by the dike or wall." The regulations apply to new and existing facilities with a total storage capacity of greater than or equal to 10,000 gallons. Facilities with a storage capacity of less than 10,000 gallons, if judged to be a reasonable threat to State waters, also are subject to the regulations. The regulations prohibit the construction of tanks, dikes, or walls in wetlands or 100-year floodplains, unless a permit is obtained.

- Liner materials are not specified, nor are any designs except that the system must consist of continuous dikes or walls.
- The permeability of the system must be 1×10^{-4} cm/sec or less, for an unspecified liquid. Provisions for storm water collection/release are not specified.

Maryland requires visual inspections for leak detection. Areas to be included in each inspection are "seams, rivets, nozzle connections, valves, pumps, and pipelines directly connected to aboveground storage tanks." Inspections must be conducted at least once per month.

New Jersey (NJAC 7 1E-2): New Jersey requires that "any leak must be prevented from becoming a discharge." The regulations apply to new and existing "major facilities" – facilities with a storage capacity of greater than or equal to 200,000 gallons. However, existing facilities are exempt from the secondary containment liner requirement if the following conditions are met: (1) the containment system (with a containment volume at least as large as the largest tank) can protect ground water for the period of time needed to clean up and repair or stop the leak; (2) the containment system allows visual inspection for leaks; and (3) the containment system is inspected daily.

- All secondary containment systems must have a permeability of 1×10^{-7} cm/sec or less.
- Dikes, berms, walls, curbing, gutters, ponds, lagoons, and basins are all listed as acceptable secondary containment designs. The system must be capable of containing 100 percent of the volume of the largest enclosed tank, plus have a means for accommodating 6 inches of rainwater.

Leak detection is required in the form of visual inspections. Areas that must be protected include the secondary containment areas and systems, storage tanks, aboveground pipes, and valves. Secondary containment/storage tank areas must be inspected at least once per week; secondary containment systems that are not impermeable (at existing facilities only) must be inspected daily.

New York (6NYCRR612-614): New York requires a "secondary containment system" around all ASTs with a storage capacity of greater than or equal to 10,000 gallons, or any tank that could reasonably be expected to discharge oil to the waters of the State. The regulations for new facilities are more stringent than the regulations for existing facilities. For example, owners of new facilities with new stationary tanks must: (1) install double bottoms on tanks; or (2) install an "impervious barrier" underneath the tanks.

- The secondary containment system may consist of a "combination of dikes, liners, pads, ponds, impoundments, curbs, ditches, sumps, receiving tanks, and other equipment capable of containing the product stored."

- The system must perform such that "spills of petroleum and chemical components of petroleum will not permeate, drain, infiltrate, or otherwise escape to the ground waters or surface waters of the State."[15] If the secondary containment system is constructed of earthen material, a release may only result in a "minimal amount of soil contamination." For diked systems, the regulation specifies the use of the performance design standards in Section 2-2.3.3 of the National Fire Protection Association's Flammable and Combustible Liquids Code (NFPA 30).

- Although the volume of the diked area need only be 100 percent of the largest tank volume (i.e., no precipitation allowance is stipulated), storm water collection must be controlled with either a manually operated sump or siphon, or a storm drain with manually controlled valves.

- For new facilities, the imperviousness of the double bottom or undertank barrier must be 1×10^{-6} cm/sec or better.

Visual inspection and inventory records reconciliation are required. The visual inspections must concentrate on the exterior surfaces (e.g., valves, pipes, etc.) and leak detection instruments (e.g., gauges or alarms). Visual inspections must be conducted monthly, and reconciliation of daily inventory records "must be kept current."

Rhode Island (OPCR 10-11): Rhode Island requires that a secondary containment system be in place around all oil-storing facilities that have a total storage capacity of greater than 500 gallons. New (or substantially modified) facilities are

[15] New York State provides a guidance document for inspectors and facility owners to aid in understanding the regulations. This document lists some permeability criteria for certain substances, even though no permeability rates are specified in the regulation.

regulated more stringently in that their secondary containment systems must consist of an "impermeable barrier" underneath all aboveground tanks. Rhode Island's regulations are similar to New York State's regulations; in many cases, the language is identical.

- Secondary containment may consist of a combination of dikes, liners, pads, impoundments, curbs, ditches, sumps, receiving tanks, or other equipment.

- The secondary containment system must be constructed so that petroleum spills "will not permeate, drain, infiltrate, or otherwise escape to the ground water or surface water before clean up can occur." Also, if earthen materials are used for the secondary containment structure, a spill should only be able to cause "a minimum amount of soil contamination."

- Dike construction must be in accordance with the standards are specified by Section 2-2.3.3 of NFPA 30, except that the capacity of the secondary containment area must be 110 percent of the largest tank volume.

- For new or substantially modified facilities, "impermeable" is defined as a permeability rate for water of 1×10^{-6} cm/sec or less. The barrier must not degrade in an underground environment or in the presence of oil. In addition, the entire secondary containment area (not just the undertank area) for new facilities must be constructed with a permeability rate for water of 1×10^{-6} cm/sec or less.

Regular facility inspections are required to detect potential leaks. The inspections must focus on all exterior surfaces of tanks, pipes, valves, and other equipment such as gauges, cathodic protection monitoring equipment, or other warning systems. The inspections must be conducted so that any potentially severe structural imperfections are identified, such as cracks, excessive settlement, or corrosion. These inspections must be performed at least monthly.

South Dakota (SCAC 74:03:30): The regulations are applied differently to new and existing facilities and to different sized facilities – new, large facilities are regulated the most stringently. "Small" facilities are those that have a total storage capacity of less than or equal to 250,000 gallons, and "large" facilities are those that have a total storage capacity of greater than 250,000 gallons.

- The containment system for new, "large" facilities may consist of double-walled and/or double-bottomed tanks, dikes, liners, pads, impoundments, curbs, ditches, sumps, receiving tanks, or other equipment capable of holding the material stored. For all containment designs except double-walled tanks, the containment volume must be 110 percent of the largest single enclosed tank. For "new" facilities, the containment structures may be built with native soils, clays, bentonite, or synthetic materials; however, the permeability of liquid through the finished floors and walls of the containment structure must be 1 x 10^{-6} cm/sec or less.

- "Small" new and existing facilities must comply with either: (1) the secondary containment requirements, as described in the bullet above; (2) the release detection requirements, as described below; or (3) certain tank performance standards, as outlined in the regulation.

- "Large" existing facilities must build a containment structure around all tanks that is capable of storing 110 percent of the volume of the largest tank. No permeability standard is provided. "Impermeable" barriers (defined as a permeability of 1 x 10^{-6} cm/sec or less for an unspecified liquid) must be built underneath all aboveground piping, and all piping must be cathodically protected.

"Large" (new and existing) facilities must perform specified leak detection measures; "small" (new and existing) facilities are provided with options for implementing leak detection standards, as described above. Facilities are required to use automatic leak detection equipment, and workers at the facilities also must conduct regular facility inspections. Monthly reconciliations of inventory records shall be made with daily measurements of product storage. Inspections of exterior surfaces of tanks, overfill devices, release detection devices, valves, gauges, and cathodic protection equipment must be conducted. Automatic detection systems shall be continuously engaged. Inspections of equipment must be conducted at least twice per calendar year, not to exceed 15 months between inspections in consecutive years.

Wisconsin (ILHR AR 10): Wisconsin requires lined secondary containment systems, which must perform as "impervious barriers" to the product stored for all aboveground, oil-storing tanks with a storage capacity greater than or equal to 110 gallons at new facilities.[16] Existing facilities are given a choice among various secondary containment options; in addition, existing facilities with a combined storage capacity of less than or equal to 5,000 gallons are completely exempt.

- The term "impervious" is not defined in the regulations, and permeabilities for the floors and walls of the secondary containment area are not specified.

- For new facilities, construction guidelines for dikes are specific: "Dike walls or floors made of earthen or other permeable materials shall be lined with asphalt, concrete, a synthetic or manufactured liner, or prefabricated basin." Dike design must be in accordance with Section 2-2.3.3 of NFPA 30, with the following additions: (1) the volume of the contained area must be 125

[16] For farms, this minimum storage tank capacity is increased to 1,100 gallons.

percent of the largest single tank volume, as opposed to 100 percent as specified by NFPA 30; (2) the walls *and* floors of the contained area must be impervious to the material stored; and (3) provisions must be made for the removal of collected rainwater.

- Existing facilities must comply with one or more of the following by May 1, 2001: (1) all of the secondary containment rules as described above, except that the containment volume may be *either* (a) 125 percent of the largest single enclosed tank volume, or (b) 100 percent of the largest single enclosed tank volume, with provisions for removal of rainwater (with valves or a sump); (2) leak detection, in the form of inventory control/reconciliation, tank gauging, tightness testing, vapor monitoring, or some other approved method; (3) installation of a double bottom on tanks; or (4) lining of the tank interior with a suitable product (the lining must cover the tank's bottom and extend a minimum of two feet up from the exterior grade, along the inside of the tank and the lining must then pass a series of inspections).

Leak detection is not a requirement for new facilities and is contained in the State regulations only as an option for compliance for existing AST systems.

3.2 INDUSTRY PRACTICES AND STANDARDS

EPA conducted a review of industry practices and standards related to liner systems to gather additional information on the technical aspects of these systems and when these systems are recommended. EPA found that although many industry associations have developed detailed standards related to the construction and operation of ASTs, few industry standards or practices explicitly recommend the use of secondary containment liners and/or double bottoms. However, at the time this review was being conducted, several industry associations, including Underwriters Laboratory and the International Fire Code Institute, were revising their recommended practices related to ASTs. API and NFPA recently completed their revisions, and the standards relating to liner systems are briefly summarized below.

In the July 1993 version of the API's Standard 650, "Welded Steel Tanks for Oil Storage," API adopted a policy recommending the use of release prevention barriers in new AST construction. API encourages owners or operators planning to construct new ASTs to consult this document. Double bottoms and undertank liners are both discussed as possible release prevention options. In addition, API states that if the tank owner decides the undertank area is to be constructed for leak detection, then the permeability of the leak detection barrier shall not exceed 1×10^{-7} cm/sec.

NFPA 30, "Flammable and Combustible Liquids Code" (1993 edition) states that "Facilities shall be provided so that any accidental discharge...will be prevented from endangering important facilities, or reaching waterways." Specifically, NFPA requires that discharge prevention measures be used with aboveground secondary containment-type tanks if they meet any of the following criteria: (1) tank capacity is greater than or equal to 12,000 gallons; (2) piping connections to the tank are below the normal maximum liquid level; (3) prevention systems for liquid released from the tank by siphon flow are not provided; (4) means are not provided for determining the level of liquid in the tank; (5) an alarm (triggered when the liquid in the tank reaches 90 percent of capacity) is not provided; (6) a system which automatically shuts off delivery when the liquid level reaches 95 percent of capacity is not provided; (7) spacing between adjacent tanks is less than 3 feet; (8) the tank is not capable of resisting damage form the impact of a motor vehicle, or does not have suitable collision barriers in place; or (9) emergency venting is not provided between any enclosed interstitial space.

EPA's review of industry standards regarding liner systems indicated that these standards primarily consist of recommended/suggested practices, and not requirements. EPA does not have information on the number of facilities that have installed liner systems due to voluntary compliance with these industry standards.

3.3 ESTIMATE OF THE NUMBER OF FACILITIES ALREADY USING LINERS OR RELATED SYSTEMS

The total number of facilities that could benefit from using liners, presented in Chapter 2, was adjusted to account for facilities located in States that already require liner systems. Specifically, facilities in six States currently must use liner systems that are comparable to liner systems considered in Chapter 4.[17] EPA estimated the number of facilities in these six States that meet the storage capacity threshold of the Oil Pollution Prevention regulation and that are required to comply with State liner requirements. This estimate was developed for each storage capacity tier and by SIC code, and was subtracted from the total number of facilities that meet the storage capacity threshold of the Oil Pollution Prevention regulation to estimate the number of facilities that currently do not to use liner systems. The results of this analysis are presented in Exhibit 3-2. The total number of facilities subject to the six States' liner requirements is estimated to be 83,723. This estimate includes approximately 66,000 "small" facilities, 17,000 "medium" facilities, and 723 "large" facilities. Therefore, the estimated number of facilities not using liner systems currently is about 421,000.

[17] These six states are: Alaska, Florida, New Jersey, New York, Rhode Island, and South Dakota.

EXHIBIT 3-2

ESTIMATED NUMBER OF FACILITIES NOT CURRENTLY REQUIRED TO INSTALL LINERS

Facility Type	SIC Code	Estimated Number Facilities in each of Three Storage Capacity Tiers			
		1,321-42,000 gallons	42,001-1 mill. gallons	> 1 million gallons	Totals
Farms	01/02	121,261	572	0	121,833
Coal Mining/Nonmetal Minerals	12/14	3,084	616	87	3,787
Oil Production	131	138,950	49,743	0	188,693
Contract Construction	15/16/17	2,670	668	0	3,338
Manufacturing:					
Food and Kindred Products	20	2,682	537	82	3,301
Chemicals and Allied Products	28	3,526	668	38	4,232
Petroleum Refining	29	893	690	273	1,856
Stone, Clay, Glass, Concrete	32	3,932	785	40	4,757
Primary Metal Industries	33	1,215	244	155	1,614
Other Manufacturing	20-39	4,795	959	76	5,830
Railroad Fueling	401	0	350	50	400
Bus Transportation	411/413/414/417	1,079	269	0	1,348
Trucking/Warehousing/Water Transportation Services	42/446	2,870	717	82	3,669
Air Transportation	458	0	458	0	458
Pipelines	46	183	136	227	546
Electric Utility Plants	491	3,339	542	441	4,322
Petroleum Bulk Stations and Terminals	5171	1,217	7,547	1,887	10,651
Gasoline Service Stations	554	0	5,967	39	6,006
Fuel Oil Dealers	5983	3,154	1,031	107	4,292
Vehicle Rental	751	0	119	0	119
Commercial and Institutional[a]	N/A	47,183	2,635	343	50,161
TOTAL		342,033	75,253	3,927	421,213

[a] Includes military installations, health care, education, and other commercial and institutional facilities.

4. TECHNICAL FEASIBILITY AND UNIT COST OF LINERS AND RELATED SYSTEMS

4.1 OVERVIEW

This chapter presents EPA's evaluation of the technical feasibility of alternative liner systems and estimates of the unit costs to install secondary containment liners and tank double bottoms. EPA investigated the technical feasibility of liner systems by examining the effectiveness of different liner materials and designs for protecting the environment from oil discharges and evaluating the construction feasibility of liner systems. The technical feasibility and unit-cost analysis is based on alternative liner designs for six "model" facilities used to represent the diverse universe of facilities potentially benefitting from the installation of secondary containment liners and double bottoms. The alternative designs examined in this analysis and evaluations of their effectiveness were based largely on discussions with EPA On-Scene Coordinators (OSCs) and owners and operators of facilities using, handling, and storing oil and petroleum products.

The characteristics of the model facilities also were used to develop unit-cost estimates. The estimated costs of installing liners at new facilities and retrofitting liner systems to existing facilities were based on material, installation, and engineering cost information provided by liner manufacturers and installers, and are presented in this chapter in terms of dollars-per-gallon of storage capacity.

The remainder of this chapter is organized as follows. Section 4.2 discusses the six model facilities used to represent AST facilities that currently do not use liners. Section 4.3 presents an overview of liner materials, costs, and effectiveness; current liner practices; and the conceptual designs for the liner systems analyzed in this study. Evaluation of these designs is presented in Section 4.4. Section 4.5 addresses the use of leak detection methods at ASTs.

4.2 DESCRIPTION OF MODEL FACILITIES

The technical feasibility and estimated cost of liner systems were based on the characteristics of six "model" facilities intended to represent the universe of facilities potentially benefiting from the use of liners.[18] The "model facility" approach was selected because the technical feasibility and cost to install and maintain liner systems varies significantly depending on the specific characteristics of a facility (e.g., the number,

[18] The estimated number of facilities not currently using liner systems is presented in Chapter 3.

size, type, and arrangement of tanks). The model facility approach also is necessary because the diverse nature of facilities potentially benefitting from liners precludes developing facility characteristics for each of the 16 industrial categories of facilities with ASTs. Development of the six model facilities, shown in Exhibits 4-1 through 4-6, reflects information previously collected about facilities storing, handling, and using oil.

The six model facilities and their principal characteristics that affect liner installation costs are described below. All of the model facilities are assumed to have secondary containment dikes around their tanks although other forms of secondary containment, such as directed drainage to collection ponds or sumps, also are possible.

Model Facility 1: Small End User - Heating Oil Supply (Exhibit 4-1) consists of a one horizontal 2,000-gallon heating oil tank used to supply fuel to a boiler or furnace for industrial or commercial purposes (e.g., school, hospital, or small manufacturer).[19] The tanks are filled by fuel delivery trucks, and the oil is used on site.

Model Facility 2: Small End User - Motor Fuel Storage (Exhibit 4-2) is a motor fueling operation with a total storage capacity of 24,000 gallons (in three 8,000-gallon horizontal tanks). The tanks are filled by fuel delivery trucks and unloaded to motor vehicles.

Model Facility 3: Type 1 Bulk Storage - Distribution (Exhibit 4-3) is a small bulk plant with a combined storage capacity of 45,000 gallons in three 15,000-gallon shop-fabricated, vertical tanks storing motor fuel and possibly heating oil.[20] Fuel delivery trucks are loaded and unloaded from a loading rack at the facility.

Model Facility 4: Type 2 Bulk Storage - Distribution (Exhibit 4-4) has a combined storage capacity of 104,000 gallons in six horizontal tanks (three of 10,000-gallon capacity and three of 8,000-gallon capacity) and two shop-fabricated, vertical tanks (each of 25,000-gallon capacity). It also has a loading rack area.

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[19] Horizontal tanks are cylindrically shaped tanks positioned so that the long axis of the tank is parallel to the ground. Because of this orientation, horizontal tanks are usually supported off the ground by concrete or metal "saddles" conformed to the rounded tank bottom. Horizontal tanks are typically less than 42,000 gallons and are shop-fabricated (i.e., assembled entirely at the place of manufacture).

[20] Vertical tanks are cylindrically shaped tanks whose main axis is perpendicular to the ground. Vertical tanks typically range in size from less than several hundred gallons to over 1 million gallons. Vertical tanks may be shop-fabricated if small, or field-erected (i.e., assembled on-site).

EXHIBIT 4-1

MODEL FACILITY 1: SMALL END USER - SUPPLY

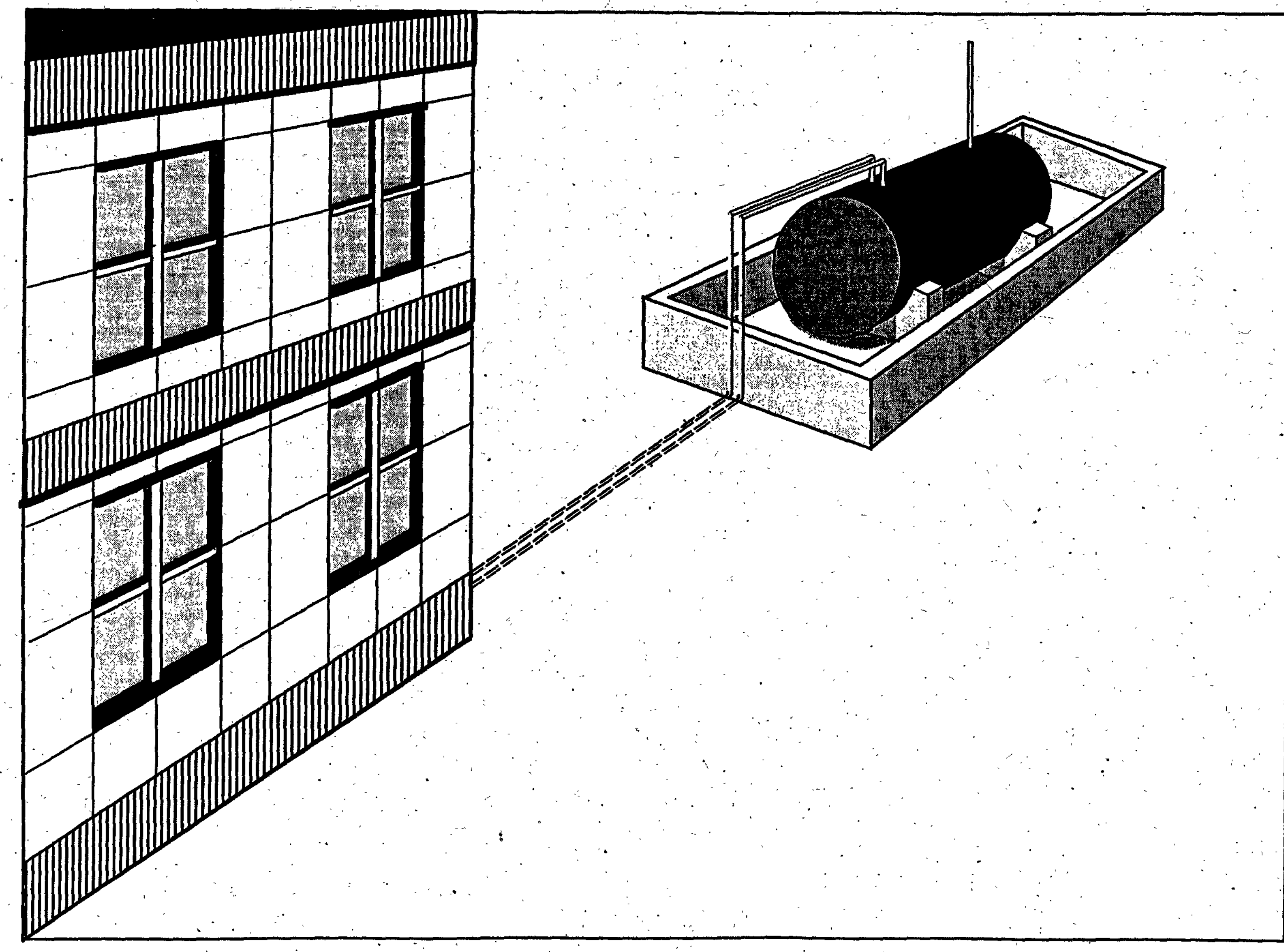


EXHIBIT 4-2

MODEL FACILITY 2: SMALL END USER - STORAGE/MOTOR FUEL

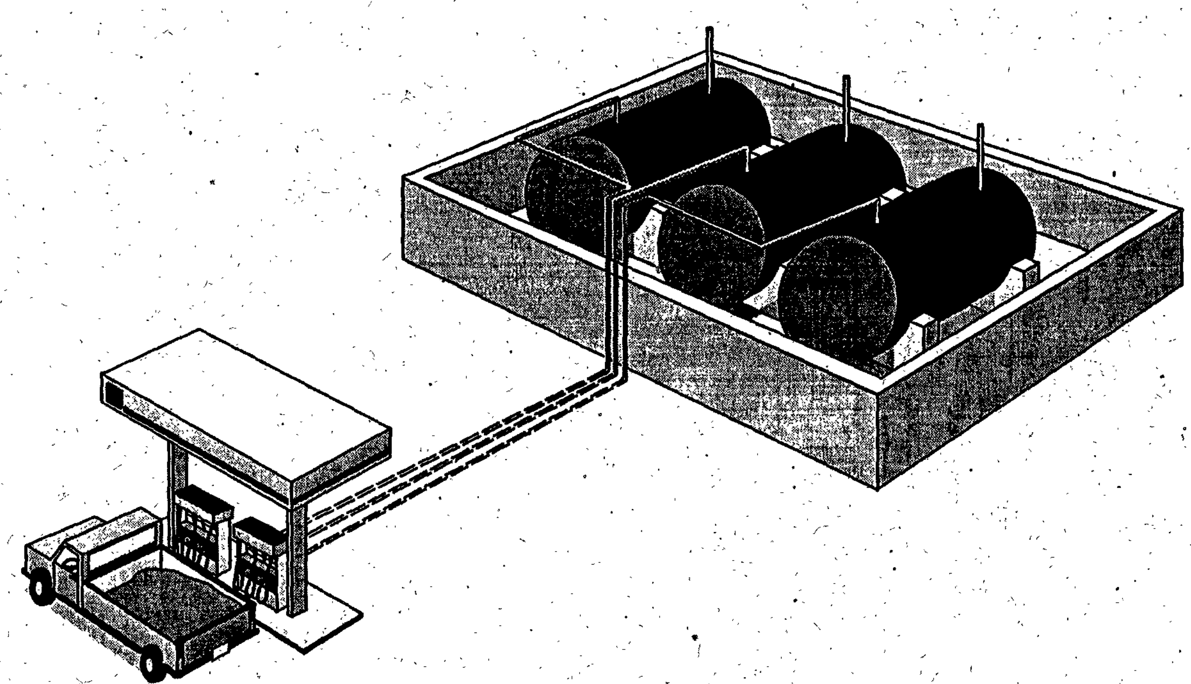


EXHIBIT 4-3

MODEL FACILITY 3: SMALL BULK STORAGE - DISTRIBUTION

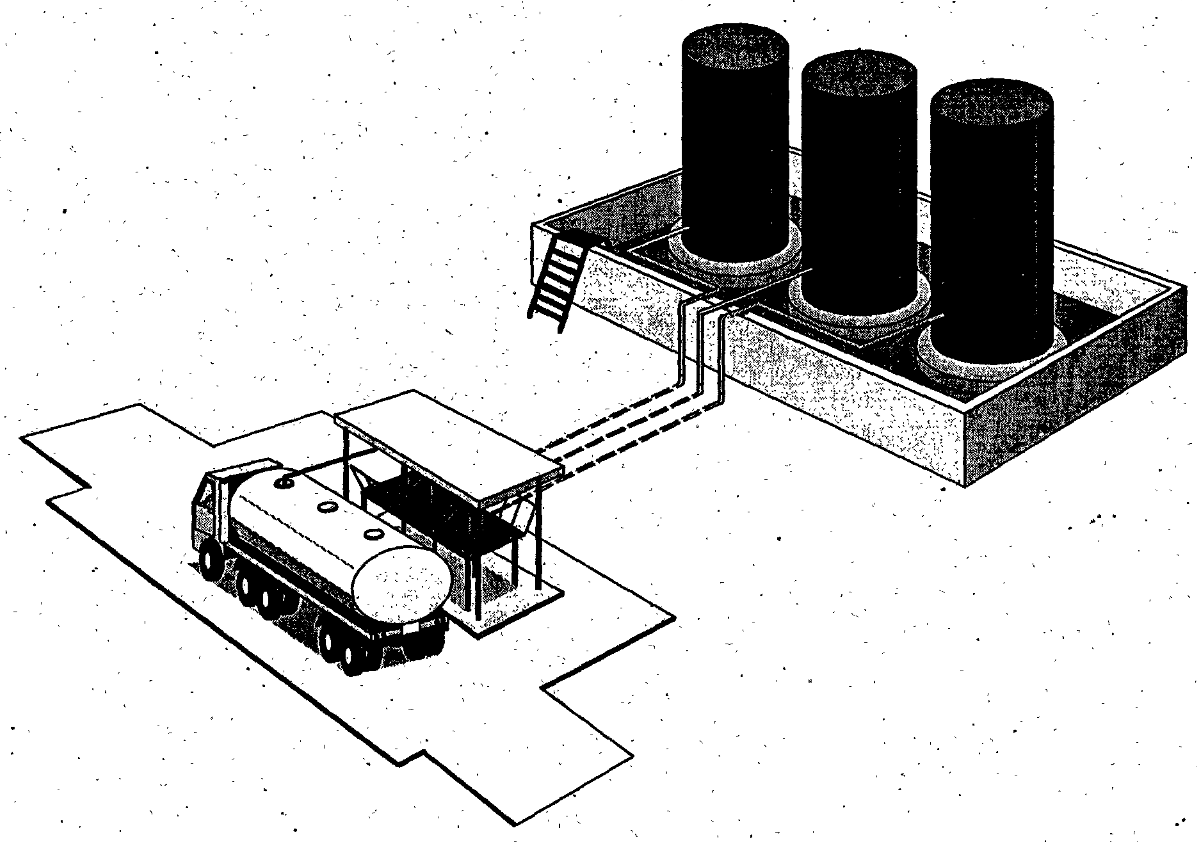


EXHIBIT 4-4

MODEL FACILITY 4: MEDIUM BULK STORAGE - DISTRIBUTION

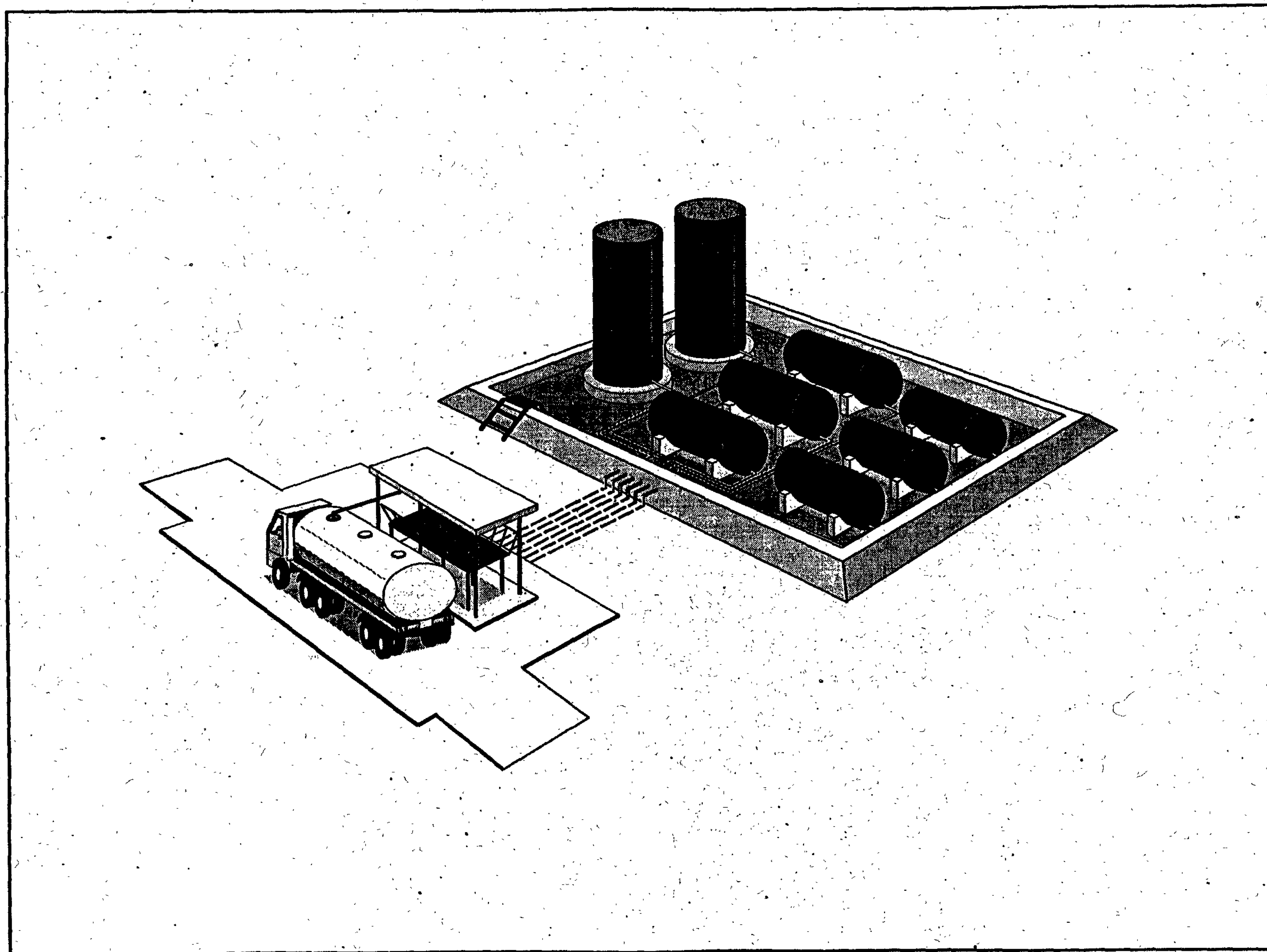


EXHIBIT 4-5

MODEL FACILITY 5: LARGE BULK STORAGE - DISTRIBUTION

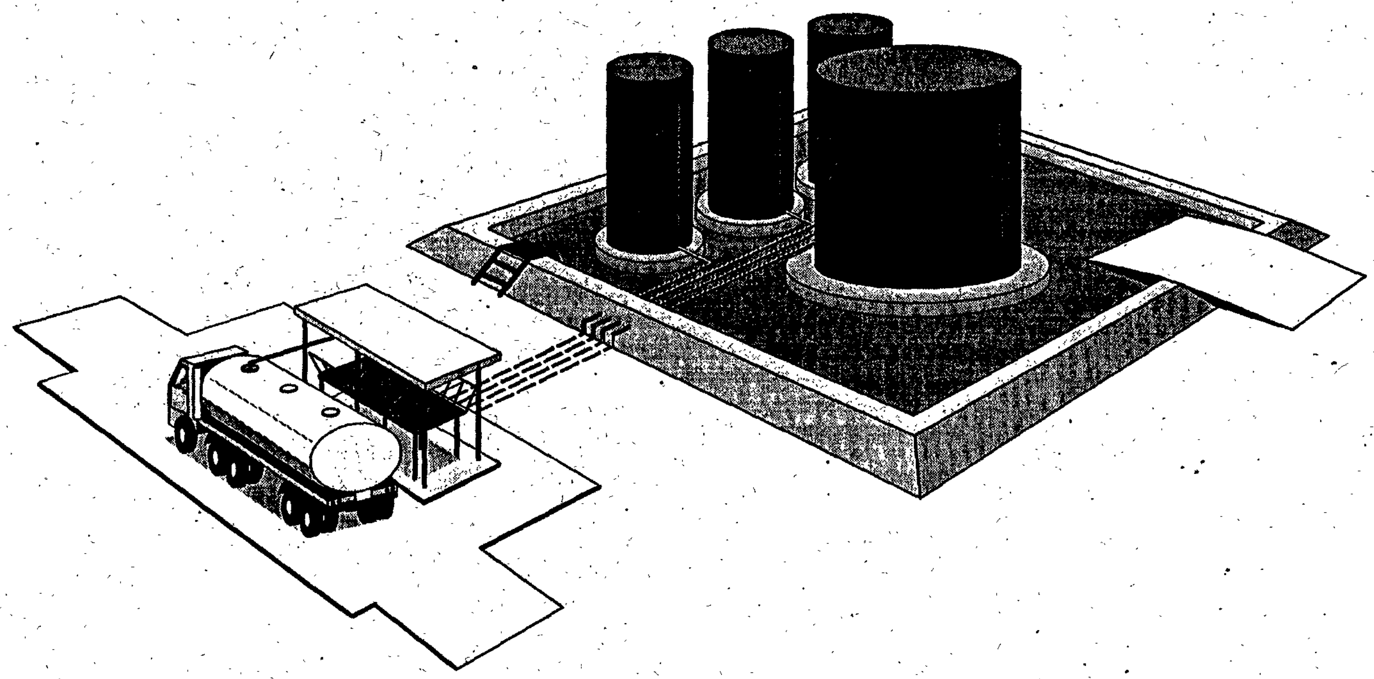
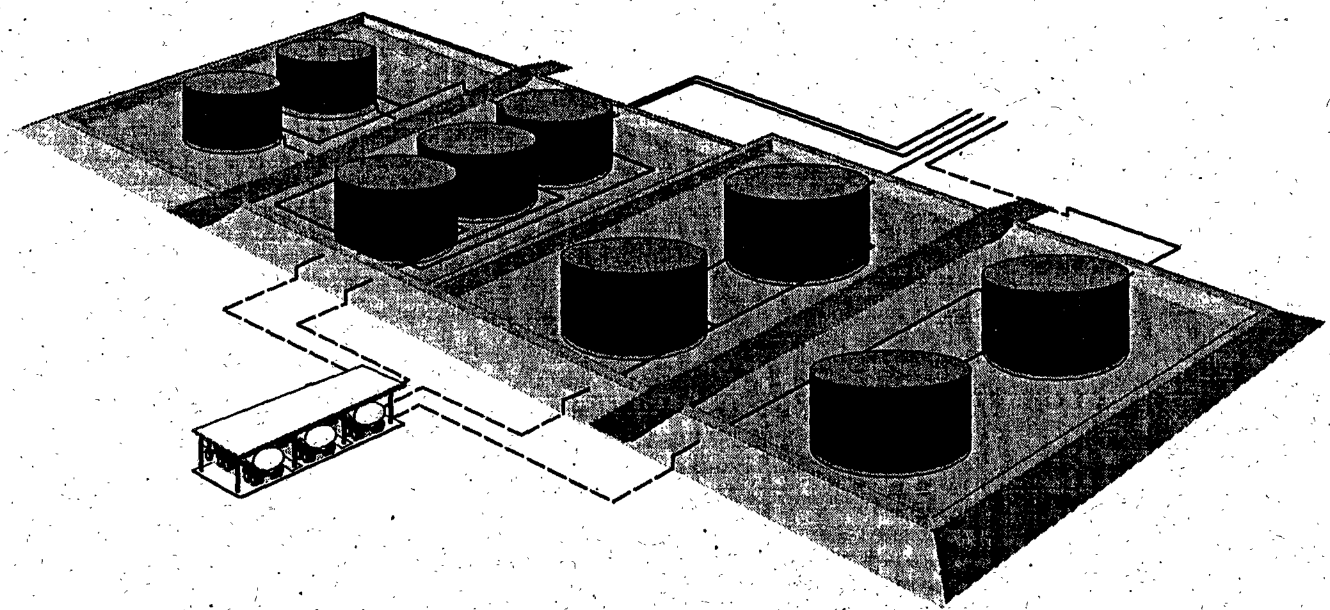


EXHIBIT 4-6

MODEL FACILITY 6: LARGE OIL TERMINAL - DISTRIBUTION



Model Facility 5: Type 3 Bulk Storage - Distribution (Exhibit 4-5) has a total storage capacity of 325,000 gallons, including three 25,000-gallon shop-fabricated, vertical tanks and a 250,000-gallon field-erected vertical tank located on a ring-wall foundation. Loading rack areas for loading and unloading are also present at this type of facility.

Model Facility 6: Large Oil Terminal - Distribution (Exhibit 4-6) has a mixture of nine large-diameter, field-erected, vertical tanks with a combined storage capacity of 50.5 million gallons. The tanks consist of: four 10-million-gallon tanks (200-foot diameter); three 3-million-gallon tanks (120-foot diameter); and two 750,000-gallon tanks (80-foot diameter). Product is transferred to the tanks from barges and/or tankers at off-loading piers and loaded into distribution trucks at loading racks.

The characteristics of the six model facilities are summarized in Exhibit 4-7.

EXHIBIT 4-7

SUMMARY OF CHARACTERISTICS OF MODEL FACILITIES

	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	MODEL 6
Total Capacity (gallons)	2,000	24,000	45,000	104,000	325,000	50,500,000
No. of Tanks	1	3	3	8	4	9
Facility Type	End user	End user	Distribution	Distribution	Distribution	Distribution
Size	Small	Small	Medium	Medium	Medium	Large

Note: Facility size categories are defined as small being 1,321 to 42,000 gallons; medium being 42,001 to 1 million gallons; and large being greater than 1 million gallons.

EPA then estimated the number of AST facilities represented by each model facility. For this report, EPA categorized by "size" and "use" the types of facilities in the 16 industrial sectors identified in Chapter 3 as not currently required to install liners (presented in Exhibit 3-2). The "size" categories are small, medium, or large, and the "use" categories (based on how the oil or petroleum products are used at facilities in that industrial sector) are:

- **Production**, which includes all facilities in SIC code 131 (Oil Production);

- **Storage/Distribution**, which includes all facilities in SIC code 46 (Pipelines), SIC code 5171 (Petroleum Bulk Stations/ Terminals), SIC code 554 (Gasoline Service Stations), and SIC code 5983 (Fuel Oil Dealers); and

- **Storage/Consumption**, which includes facilities in all other industrial sectors.[21]

Exhibit 4-8 shows the results of this categorization by size and use; for example, 138,950 AST facilities are small production facilities (i.e., have a total storage capacity of between 1,320 and 42,000 gallons).

Next, one or more of the model facilities developed for this report was assigned to represent all facilities in each size and use category (e.g., small storage/distribution facilities). This assignment was based on previous analyses conducted by EPA (described in Appendix B) which developed typical storage capacities for facilities in each size and use category. For example, a typical small storage/consumption facility is estimated to have a storage capacity of approximately 2,000 gallons, which is the same as the assumed storage capacity of Model Facility 1. Consequently, all 198,529 small storage/consumption facilities that currently are not required to have liners are represented by Model Facility 1. The results of assigning facilities to the model facilities developed for this report also are presented in Exhibit 4-8.

Several of this report's model facilities represent facilities from more than one size and use category. In addition, because the size categories are broad, certain size and use categories are best represented by more than one model facility. In these cases, the difference between the typical storage capacity of the facilities in that size and use category and the storage capacity of the model facilities in this analysis provided the basis for allocating among two model facilities.[22] For example, small storage/distribution facilities are estimated to typically have a total storage capacity of approximately 10,000 gallons (see Appendix B for a detailed description), for which no single model facility in this report corresponds closely. Therefore, small storage/distribution facilities are best represented by a mix of Model Facilities 1 and 2, which are assumed to have 2,000 and 24,000 gallons of storage capacity, respectively. As the "typical" small storage/distribution facility (10,000 gallons) is closer in storage capacity to that of Model Facility 1 (2,000 gallons) than Model Facility 2 (24,000 gallons), a larger percentage of facilities were allocated to Model Facility 1. Of the estimated 4,554 small storage/distribution facilities, 2,898 facilities are estimated to be best represented by Model Facility 1, and the remaining 1,656 facilities are estimated to be best represented by Model Facility 2.

[21] These size and use categories were originally developed by EPA for use in estimating the costs of implementing the requirements of the Oil Pollution Act of 1990 (U.S. EPA, Emergency Response Division, "Regulatory Impact Analysis of Revisions to the Oil Pollution Prevention Regulation (40 CFR 112) to Implement the Facility Response Planning Requirements of the Oil Pollution Act of 1990", June 1994). See Appendix B of this report for additional information comparing that analysis to the estimates presented here.

[22] An alternative allocation formula was used for medium storage/distribution facilities, as described in Appendix B.

EXHIBIT 4-8

CATEGORIZATION OF FACILITIES NOT CURRENTLY REQUIRED TO INSTALL LINERS

FACILITY SIZE AND USE CATEGORY	PRODUCTION	STORAGE/ DISTRIBUTION	STORAGE/ CONSUMPTION	TOTAL
Small	138,950 facilities Model Facilities 2 and 3	4,554 facilities Model Facilities 1 and 2	198,529 facilities Model Facility 1	342,033
Medium	49,743 facilities Model Facility 4	14,681 facilities Model Facilities 3 and 5	10,829 facilities Model Facilities 4 and 5	75,253
Large	Negligible Not Applicable	2,221 facilities Model Facility 6	1,706 facilities Model Facility 6	3,927
Total	188,693	21,456	211,064	421,213

Note: Size categories are defined as small being 1,321 to 42,000 gallons; medium being 42,001 to 1 million gallons; and large being greater than 1 million gallons.

The estimated total number of facilities represented by each model facility is as follows:

• Model Facility 1:	201,427
• Model Facility 2:	49,296
• Model Facility 3:	97,277
• Model Facility 4:	55,623
• Model Facility 5:	13,663
• Model Facility 6:	3,927
Total # Facilities	421,213

4.3 LINER SYSTEM DESIGNS AND PRACTICES

Liners are engineered systems that enhance the imperviousness of secondary containment structures that surround ASTs.[23] Secondary containment structures vary greatly depending on the size of the tanks and the physical characteristics of the facility and may be constructed of compacted native soil (e.g., clay), concrete, or other synthetic material.[24] Secondary containment structures are typically designed to hold the entire contents of the tank or tank battery within the structure and serve to contain any spilled oil or product in the event of a leak or sudden discharge. Liners may be installed within secondary containment structures in several ways. Liners may be placed to cover the entire interior area of a secondary containment system, including the area beneath any tanks (i.e., undertank liners). Alternatively, especially for facilities with existing vertical tanks in direct contact with the ground, liners may be installed throughout the interior area of the secondary containment except underneath existing vertical tanks. Although it is technically feasible to move an existing AST temporarily in order to install an undertank liner beneath its normal resting area, it is usually considerably more expensive than installing a double bottom, which serves the same purpose of protecting against leaks from failing tank bottoms.

Double bottoms protect against leaking or failing tank bottoms in vertical tanks. When in direct contact with the ground, the tank bottom is susceptible to corrosion (rusting of the metal), which eventually reduces the thickness of the tank bottom, resulting in the development of perforations (e.g., pinpoint holes) and, if left unrepaired, rips and tears. In contrast, horizontally mounted tanks are smaller and are much less susceptible to corrosion because they are typically supported off the ground by concrete or metal saddles or other platforms. Double-bottom tanks have a second steel surface above the outer tank bottom or tank foundation to provide additional protection against

[23] Secondary containment is a general term that includes all structures designed to channel and contain a spill or leak from an AST or storage facility. Secondary containment structures may include graded surfaces leading to a collections pond, diked or bermed areas around tanks, or sumps.

[24] Some of these materials also may be used as liners to secondary containment structures made of more permeable materials.

leaks in the event of corrosion-induced failure of the bottom surface. Generally, the interstitial space between the two steel bottoms of the tank includes a geosynthetic liner and a leak detection system. Although the choice of a second steel bottom may provide additional opportunity for corrosion, the interstitial leak detection system would alert the facility operator to any failure of the system, and the geosynthetic liner would prevent oil from discharging to the environment until repairs could be made. The space around the interstitial liner and leak detection system also is filled with concrete or sand to provide additional structural support to the inner tank bottom. For purposes of this report, EPA analyzed double bottoms as "other means of secondary containment," which could be used in place of undertank liners.

EPA analyzed other alternatives to double bottoms, but did not find these options to be as usable as double bottoms. For example, one of the options considered was the use of electronic fluid flow indicators in horizontal wells placed beneath ASTs to detect leaking petroleum products. Although this technology is relatively inexpensive, it detects a leak only after oil has contaminated the underlying soil. For purposes of this study, double bottoms are preferred over this option because double bottoms would aid in detecting a leak before soil contamination could occur.

Another option considered was the installation of a geomembrane liner along the inside walls and bottom of an AST. Although this option is not a form of leak detection, it is a viable method for preventing oil from leaking into the underlying soil provided that the product stored in the AST is compatible with the liner material. If it is not, degradation of the liner could occur. The use of double bottoms, however, would provide greater flexibility in the type of product that could be stored in the AST.

To gather information on current industry practice relating to liners, EPA surveyed OSCs (EPA technical staff directly implementing the current SPCC Program), facility owners and operators, liner manufacturers and installers, and State officials responsible for AST regulatory programs.[25] These interviews were meant to provide a general assessment of the advantages and disadvantages of various liner designs and materials from a broad representation of knowledgeable sources. The interviews were intended to gather background information rather than be a rigorous, scientifically valid survey. The following section summarizes the information obtained from the interviews on five topics: the types of liner materials in use, the costs of using liners, liner use practices, opinions on liner effectiveness, and leak detection practices.

[25] OSCs from each of the 10 EPA Regions, 13 facility owners/operators in 10 States, 15 liner manufacturers, 7 installers, 2 manufacturers of spray-on coatings, and State environmental agency staff in all 50 States were contacted. Three representatives of the insurance industry were also contacted regarding the availability of data on the probabilities and sizes of discharges from ASTs. However, these insurance industry contacts were not able to provide any new information beyond that already identified from other sources.

4.3.1 Liner Materials Currently in Use

Impervious soils[26] (clay, soil-bentonite mixtures), concrete, bituminous concrete, geomembranes (polymeric sheets and bentonite mats), and steel liner systems are all used by industry. Spray-on liner systems also are available and tend to be used in conjunction with concrete secondary containment structures, although some manufacturers have developed spray-on systems that work with earthen berms (the material adheres to and seals the surface of the dike wall or berm, preventing product from permeating through cracks or other imperfections).

Facility owners and operators reported that most secondary containment structures are made from earthen materials. Five out of 13 facility owners/operator respondents further indicated that impervious soil was the preferred liner material. In contrast, manufacturers and installers reported that synthetics were the most common materials used for secondary containment liners. The synthetic materials most often cited by the manufacturer and installer respondents were high density polyethylene (HDPE), polyvinyl chloride (PVC), XR-5®, Hypalon®, and Hytrel®.

4.3.2 Cost of Liners

Opinions varied on the cost to install, operate, and maintain liner systems. Several owners and operators mentioned that, in their experience, maintaining geomembrane systems is expensive. However, several liner manufacturers asserted that geomembrane liner systems have low operation and maintenance (O&M) costs following the initial installation; most of the liner manufacturers and installers interviewed suggested that the only routine maintenance necessary is a periodic inspection, and repair if damage is found.

Installed liner cost quotes from different companies varied significantly, even for identical liner materials. In addition, recommended liner thicknesses also varied significantly for identical liner materials and applications.

4.3.3 Liner Use Practices

In general, liners are not consistently used throughout the industry. Five of the 13 owners/operators who were contacted said that liners were not used at their facilities. Four facilities had incorporated liners into new designs and on some retrofitted tanks and secondary containment structures. OSCs and owners/operators agreed that liner systems are used primarily at large facilities (i.e., with total storage capacity greater than 1 million gallons) and that small facilities (i.e., less than 42,000 gallons) usually use liners only when mandated by State regulations.

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[26] For purposes of this report, the term "impervious soil" means a naturally occurring or adapted soil that has a hydraulic conductivity of 1×10^{-6} cm/s or less.

The liner manufacturer and installer respondents stated that, while some existing facilities are being retrofitted with new tank bottoms (double bottoms) and liners in secondary containment areas, it is mostly *new* facilities that are protected with these systems. Most respondents agreed that, in general, few existing facilities appear to be retrofitted with liner systems, except in the States that mandate liners.

State regulation of ASTs, including the required use of liners, varies. Twenty-seven States have adopted, in varying degrees, the National Fire Protection Association (NFPA) standards or other fire codes related to ASTs. Fifteen States have specific AST requirements in their regulations; seven States require liners at AST facilities.[27] Of the seven States that require liners, six specify maximum permeability liners. Two additional States are proposing liner regulations with specific permeability requirements. Four States specify that AST facilities must adhere to the Oil Pollution Prevention regulation, while another four States delegate the regulation of ASTs to local agencies. Four States that currently do not regulate ASTs have proposed or will be proposing AST regulations.

4.3.4 Liner Effectiveness

Liner manufacturers and installers report that the *design* life of a liner is between 15 and 30 years, except for spray-on liners whose design life is between 8 and 15 years. These numbers are conservative estimates of the life span of a liner based on the manufacturer's warranty, which is derived from accelerated tests performed to evaluate liner effectiveness and longevity.

Although OSCs have limited experience with liners, those interviewed agree that with proper installation and maintenance, liners are effective in preventing ground-water contamination and in detecting leaks from AST bottoms.[28] However, facility owner/operator respondents stated that liner maintenance is not always a high priority, and poor maintenance can significantly reduce the effectiveness of certain types of liners.

Each type of liner has different requirements with regard to proper maintenance and repairs, as briefly described below.

- **Impervious Soil.** Some silty clay liners require constant or periodic hydration using a sprinkler or irrigation system. Facilities also sometimes apply controls to prevent liner penetration from animal activity or undesirable vegetation, and regularly inspect the liner for damage from heavy precipitation, erosion, and settling. If the original soil liner is damaged, it may need to be completely replaced.

[27] See Chapter 3 for a discussion of State regulations and industry practices related to liner systems.

[28] OSCs also noted that most spills occur outside of the tank secondary containment areas, such as at loading racks during product transfer operations. Such spills would not be addressed by liners in tank secondary containment areas.

- **Coated or Uncoated Concrete.** Some concrete liners may require evaluation of the expansion/contraction joints. Such an evaluation could include periodically confirming wall-to-floor integrity, and checking for cracking. Facilities also typically evaluate the integrity of concrete coatings.

- **Geomembranes.** Routine maintenance of geomembrane liners typically includes visual inspection of liner integrity and, in some cases, testing of the seams. Facilities may also use controls to prevent liner penetration from animals or vegetation.

4.3.5 Liner Designs Used in this Study

For this study, EPA developed representative liner system designs that could be used at the six model facilities as a basis to evaluate liner system technical feasibility and installation costs. To provide a visual description of how different types of liner system designs can be applied at a facility, Exhibit 4-9 shows a general schematic of a *generic* AST facility, consisting of a single, large, vertically-mounted AST; a smaller, horizontally mounted AST; an aboveground piping system; and a lined, diked containment area with an access road within it.

Exhibit 4-9 also indicates the areas of the generic facility that are presented in detail in Exhibits 4-10 through 4-14, as described below. Some designs may be more suitable than others for various liner applications.

- **Exhibit 4-10** presents cross-section details of liner installations in a containment area using four alternative types of liner materials: an impervious soil liner, a concrete liner, a geomembrane liner, and a bentonite mat liner. Although the designs depicted are typical examples, various designs and installation methods exist for these liner materials.

- **Exhibit 4-11** shows details of the liner system at the interface of the vertical tank (i.e., where the tank base meets the liner material) for the same four liner materials as shown in Exhibit 4-10. These drawings show that liner systems do not protect against discharges from tank bottoms.

- **Exhibit 4-12** details methods for securing liners to tank foundations and foundations for above-ground piping supports that penetrate the floor of the secondary containment area.

- **Exhibit 4-13** presents designs for installing liners where access roads are entirely within the secondary containment area.

EXHIBIT 4-9

GENERAL SCHEMATIC: ABOVEGROUND STORAGE FACILITY

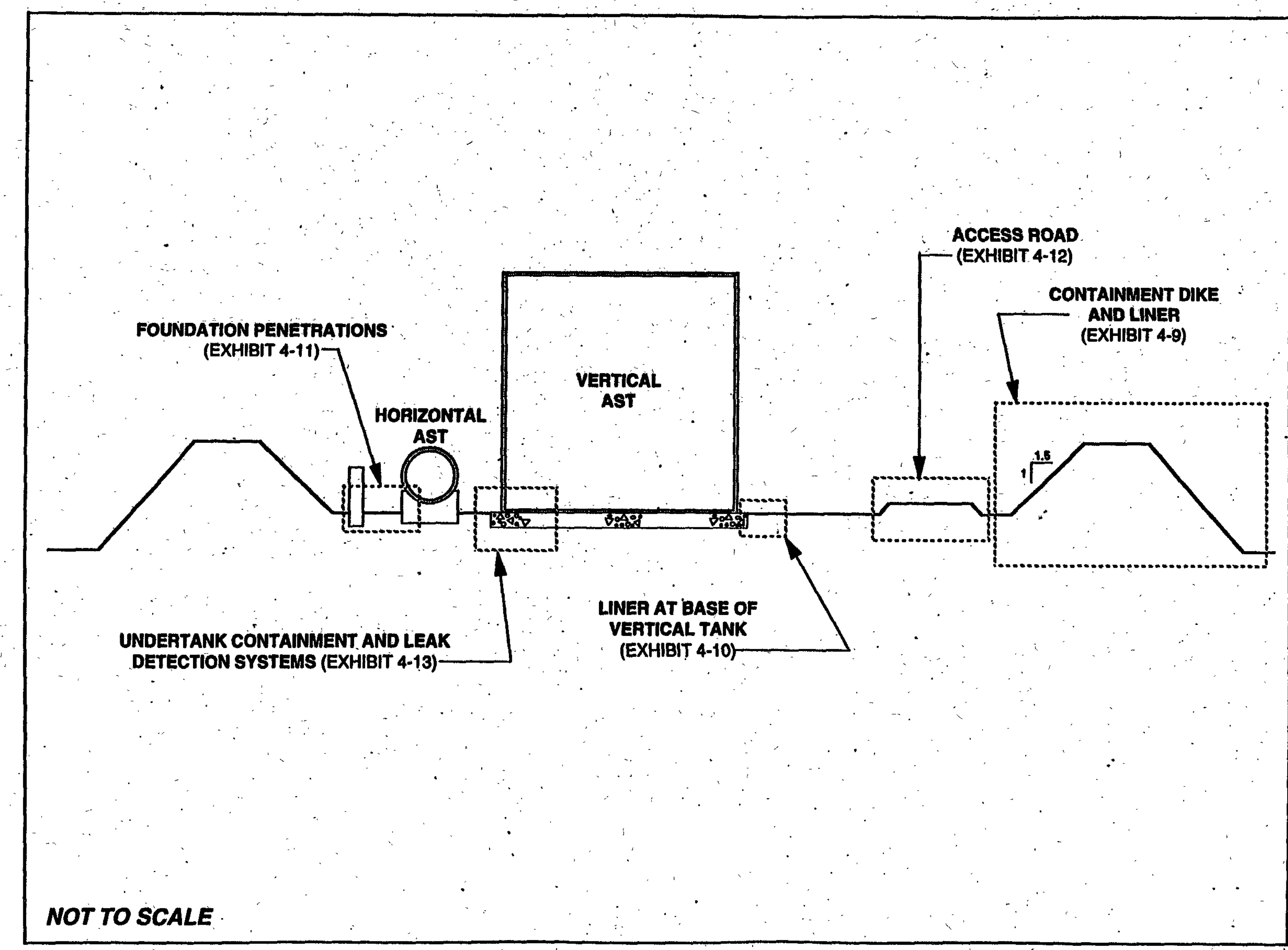


EXHIBIT 4-10

DETAILS: CONTAINMENT DIKE AND LINER

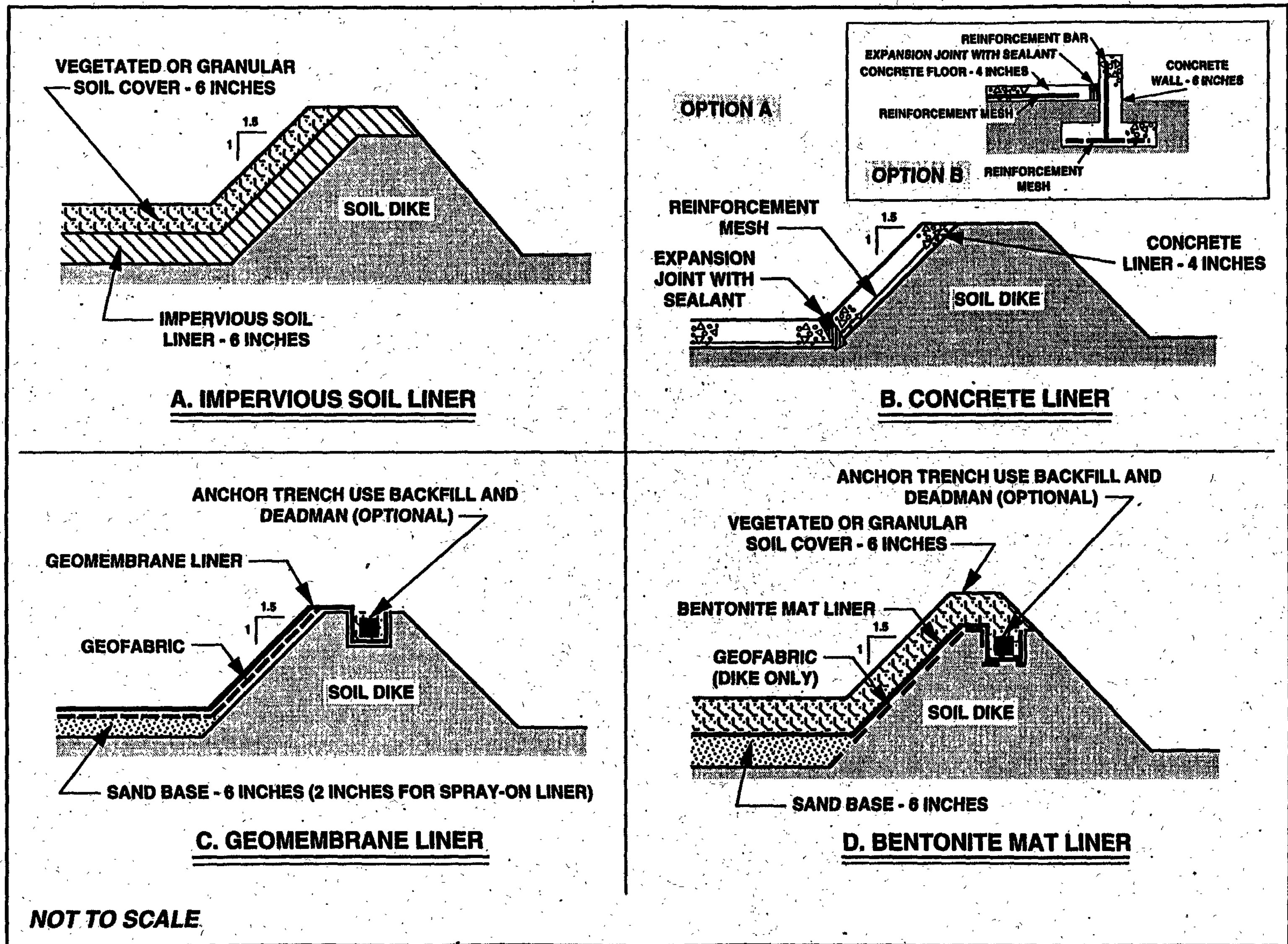


EXHIBIT 4-11

DETAILS: LINER AT BASE OF VERTICAL TANK

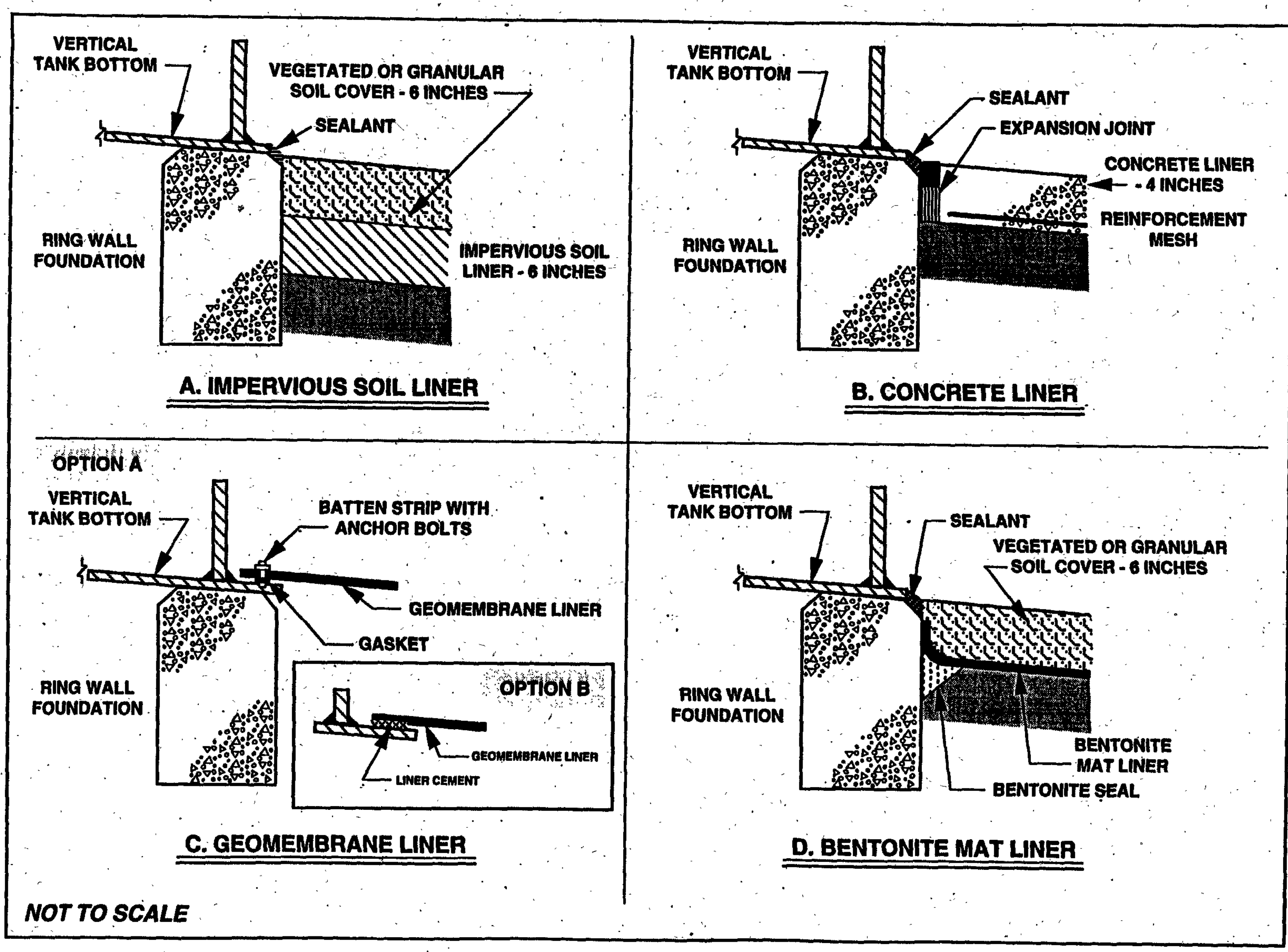


EXHIBIT 4-12

DETAILS: FOUNDATION PENETRATION

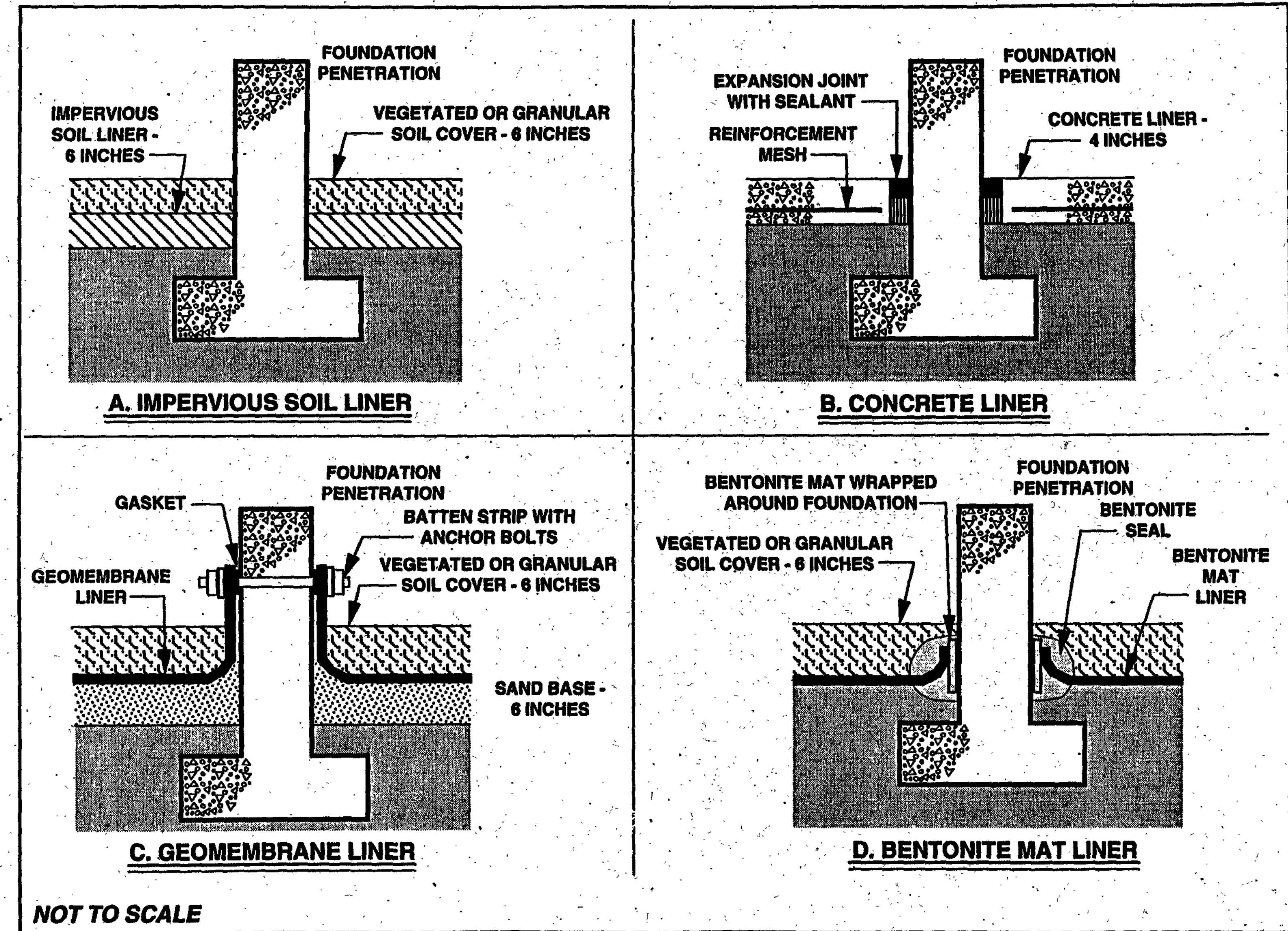


EXHIBIT 4-13

DETAILS: ACCESS ROAD

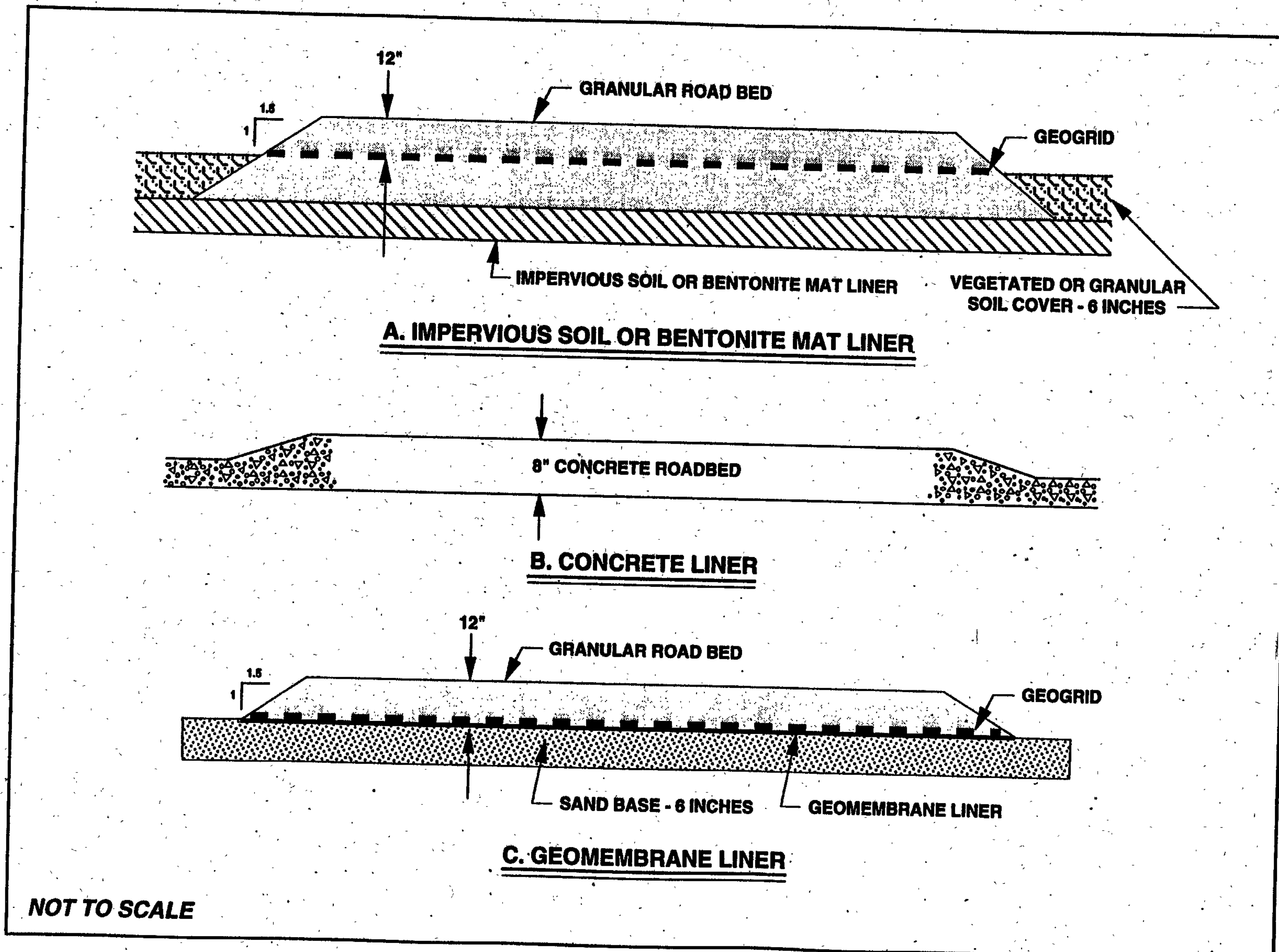
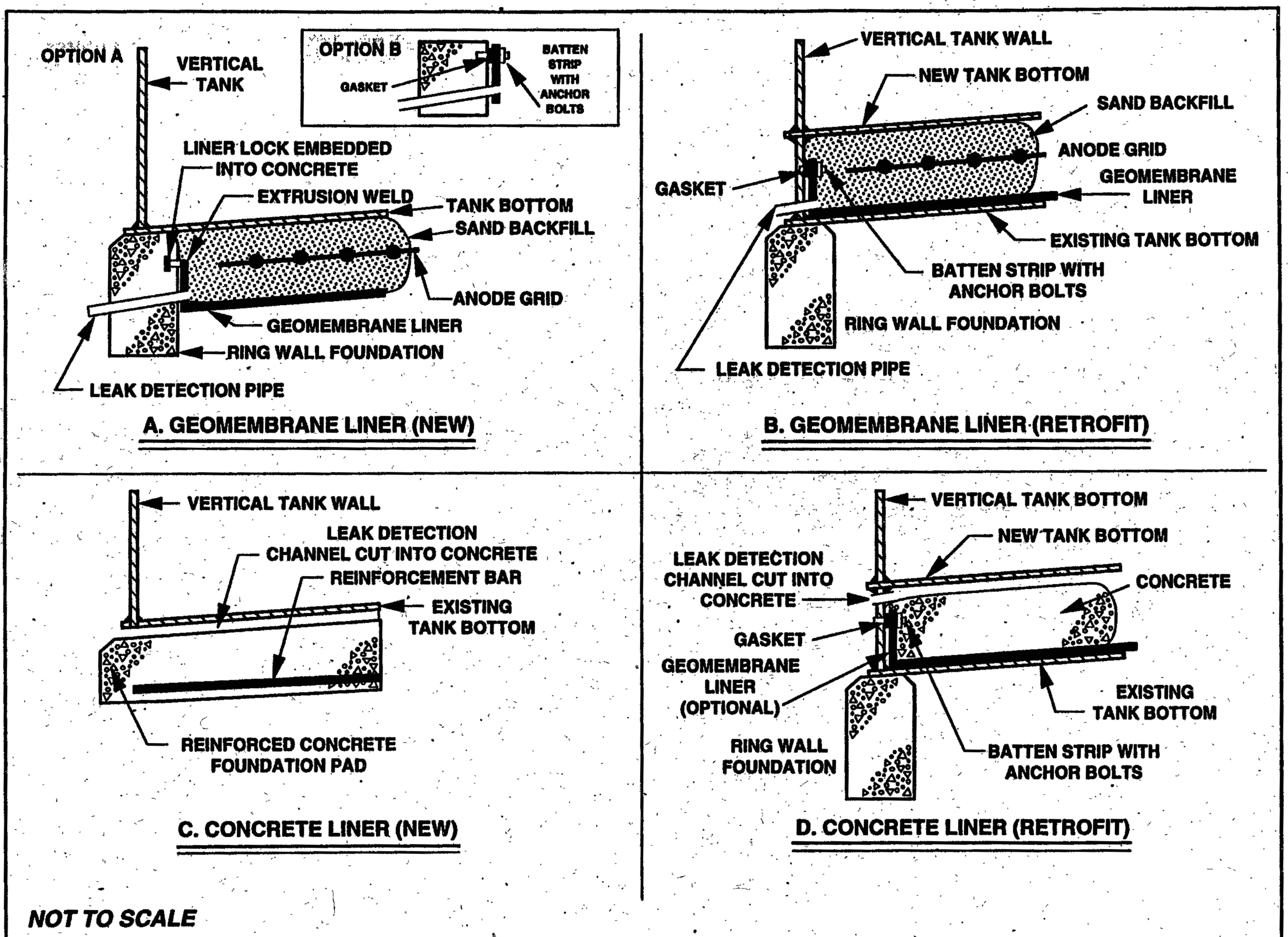


EXHIBIT 4-14

DETAILS: UNDERTANK CONTAINMENT SYSTEM



- **Exhibit 4-14** presents four possible designs for addressing leaks from tank bottoms of vertical ASTs, which may not be controlled by a secondary containment liner system.[29] Two designs are for undertank liner systems installed with new tanks, while the other two are for retrofitting existing tanks with double bottoms and leak detection systems.

4.4 LINER FEASIBILITY EVALUATION

EPA assessed the technical feasibility of liner systems based on the degree of environmental protection afforded, ease of construction, and cost, as described below.[30]

- **Environmental Protection.** Environmental protection constitutes protecting ground water, aiding in leak detection, and preventing oil spills from reaching surface waters. The degree of environmental protection provided by a liner system depends on its permeability, which is influenced by among other factors: workmanship in installation; quality and regularity of upkeep; chemical resistivity; resistance to weathering caused by ultraviolet exposure, freeze/thaw cycles, erosion, and wet/dry cycles; and resistance to other damage caused by vandalism, animal activity, and undesirable vegetation.

- **Ease of Construction.** Factors that complicate construction include constrained site conditions, adverse climatic conditions, material availability, and the skill of the installers.

- **Cost.** Cost includes capital costs for materials and installation, annual operating costs (e.g., animal and vegetation control, security, and hydration of clay-based material) and maintenance costs, such as liner system repairs.

Exhibit 4-15 summarizes the feasibility of using liners at oil-storing AST facilities for environmental protection and shows the constructibility of liner systems. Liner systems are rated relative to each other on a scale from 1 to 5, where 1 is distinctively inferior to other ratings and 5 is distinctively superior.

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[29] Undertank leaks are often very difficult to detect. The potential damage to the environment from an undertank leak is decreased greatly when an undertank liner is in place. EPA found that a number of potential designs are available for undertank containment and leak detection and evaluated two commonly used designs shown in Exhibit 4-14. Both designs include leak detection, which should be an integral part of every undertank containment design.

[30] Information in this section is intended to provide a general comparison of liner materials and their relative advantages and disadvantages. This information should not be construed as constituting governmental approval of any specific design or product; EPA does not endorse or recommend specific liner products or materials.

EXHIBIT 4-15

COMPARATIVE ANALYSIS OF LINERS FOR ENVIRONMENTAL PROTECTION AND CONSTRUCTION EASE

FEASIBILITY CRITERIA	ALTERNATIVE SYSTEMS							
	IMPERVIOUS SOIL		CONCRETE		GEOMEMBRANES			STEEL
	NATIVE SILTY CLAY	MODIFIED SOIL	UNCOATED	COATED	POLYMERIC SHEETS	BENTONITE MAT	POLYSULFIDE SPRAY-ON	
ENVIRONMENTAL PROTECTION								
1. Inherent Permeability	3	3	2	4	4	4	5	5
2. Workmanship Requirements	High	High	Moderate	Moderate	Moderate	Low	Moderate	Moderate
3. Chemical Resistivity	5	5	5	4	2 to 4	5	4	5
4. Resistance to Weathering Caused by:								
• ultraviolet exposure	NA	NA	4	3	3	NA	3	5
• freeze/thaw action	2	2	2	3	5	3	5	5
• erosion	2	2	4	4	5	3	5	5
• wet/dry cycles	2	1	4	4	5	1	5	5
5. Resistance to Other Damage Caused by:								
• vandalism	5	5	5	3	2	5	3	4
• animal activity	2	2	5	4	3	2	3	5
• undesirable vegetation	2	2	3	5	5	2	5	5
CONSTRUCTION EASE								
1. Adverse Site Conditions[a]	High	Low	High	High	Low	Moderate	Moderate	Moderate
2. Adverse Climatic Conditions[a]	High	Moderate	Moderate	Low	High	High	Low	Moderate
3. Material Availability	2	3	3	3	5	5	5	4
4. Availability of Skilled Labor	2	5	4	3	3 to 4	4	3	2

NOTES: [a] "High" indicates that construction of the liner would be difficult under the conditions listed under the Feasibility Criteria, "Moderate" indicates that construction of the liner would be moderately difficult, and "Low" indicates that construction of the liner would be relatively easy under the conditions listed under the Feasibility Criteria.

NA = Not Applicable

Alternatives are rated relative to each other on a scale from 1 to 5 (inferior to superior).

4.4.1 Protection of the Environment and Construction Ease

Impervious soil. Impervious soils (see footnote #26) include native silty clay and soils mixed with bentonite. The inherent permeability of these soils is rated in the mid-range among the liner materials that were evaluated; however, oil resistivity is high. Impervious soil liners are susceptible to degradation from weathering, animal activity, and vegetation. Construction of liners from impervious soils is relatively simple at new facilities, but generally more difficult at existing facilities.

Concrete. Concrete is widely used for secondary containment, especially at smaller facilities. The ability of concrete containment structures to protect the environment varies depending on the condition of the concrete surface, particularly its degree of cracking. Uncoated concrete is more permeable than coated concrete, whose permeability is similar to that of geomembranes, and both coated and uncoated concrete are highly resistant to oil. Both coated and uncoated concrete are relatively resistant to weathering except that uncoated concrete is susceptible to damage from freezing and thawing especially if the concrete is cracked. Concrete systems are generally easy to construct in new applications and more difficult for retrofit applications of existing obstructions such as pumps and pipes.

Geomembranes. A wide range of geomembrane liner materials are available, including polymeric sheets, bentonite mats, and spray-on coatings compounded with polysulfide. The inherent impermeability of liners made from these materials is high, and oil resistivity is generally good. These protective qualities can be degraded by weathering caused by exposure to the sun and, in the case of bentonite mats, cracking caused by wet/dry cycles. Exposed geomembranes and polysulfide coatings may be susceptible to damage from vandalism or animal activity. Animal activity and undesirable vegetation are also of concern with bentonite mats. Repairs to geomembrane liners may be costly and must be made promptly upon discovery. The ease of installing geomembrane liners varies depending largely on the stiffness of the material. Geomembrane liner systems can be installed in either new or existing facilities.

Steel. Steel liner systems are not widely used, although they are well suited for small horizontal tanks (up to approximately 20,000-gallon capacity) and when space limitations require erection of a high vertical wall. Because steel resists all oil products and is essentially impermeable, it is highly protective of the environment. Compared to other liner systems, steel liner systems offer the greatest resistance to weathering and other damage. Construction of steel liners requires extensive design and planning prior to installation, and steel liner systems are generally more difficult to install in existing facilities than in new facilities because of existing obstructions such as pipes and pumps. Retrofitting existing containment areas may pose safety problems because welding may be required close to flammable products; as a result, tank contents may have to be removed and the tank cleaned before the installation can begin. Compared to other liner systems, steel is not economical for most facilities.

4.4.2 Estimated Facility Costs

The estimated capital unit costs for both retrofitting existing facilities and for installing liner systems at new facilities are shown in Exhibit 4-16. O&M costs are addressed qualitatively in Exhibit 4-17. The cost estimates presented in the exhibits are meant to be representative estimates based on the characteristics of the model facilities rather than definitive estimates applicable to a specific type of facility. Capital costs for existing facilities are based on installing a secondary containment liner system (except underneath tanks) and installing double bottoms on all vertical ASTs.[31] For new facilities, costs are estimated assuming that undertank liners would be installed along with the secondary containment liner.

The exhibits do not include steel liners because their cost is prohibitive except in special circumstances. Costs are presented in 1991 dollars, corresponding to when most of the information on installation and O&M costs was collected. The cost estimates presented in the exhibits were developed based on information in the 1991 Means construction cost data estimating guide, which presents average costs for 30 major cities.[32] In addition, the cost estimates reflect the following assumptions:

- Grubbing, soil excavation, and grading costs are not included in the cost estimates for new facilities, but are included in the estimates for installation at existing facilities.
- Concrete liners are 4 inches thick.
- Liners comprising polymeric sheets are placed on top of a layer of sand 6 inches deep.
- Liners comprising bentonite mats are covered with 6 inches of soil that is seeded with grass, fertilized, and mulched.
- The cost of installing an impervious soil liner involves the material price, loading, hauling 5 miles one way, dumping, spreading, and compacting.
- The liner is assumed to be covered with 6 inches of soil that is seeded with grass, fertilized, and mulched.

[31] Vertical ASTs are assumed to rest on concrete pads that provide protection comparable to a double bottom. Horizontally mounted tanks are assumed to be supported off the ground by saddles, which allows installation of the secondary containment liner beneath them.

[32] *Means Site Work and Landscape Cost Data*, 11th Edition, R.S. Means Co..

EXHIBIT 4-16

COMPARATIVE COST ANALYSIS OF LINER MATERIALS BY MODEL FACILITY[a]

MODEL FACILITY[b]	ESTIMATED LINER CAPITAL COSTS PER MODEL FACILITY[c]						
	IMPERVIOUS SOIL		CONCRETE		GEOMEMBRANES		
	Native Silty Clay	Modified Soil	Uncoated	Coated	Polymeric Sheets	Bentonite Mat	Polysulfide Spray On
#1 New Facility	$5,000	$5,000	$3,000	$8,000	$4,000	$4,000	$5,000
Existing Facility	$6,000	$5,000	$4,000	$9,000	$7,000	$4,000	$5,000
#2 New Facility	$11,000	$9,000	$9,000	$22,000	$13,000	$9,000	$12,000
Existing Facility	$15,000	$11,000	$11,000	$24,000	$18,000	$12,000	$14,000
#3 New Facility	$18,000	$16,000	$17,000	$28,000	$20,000	$17,000	$19,000
Existing Facility[d]	$38,000	$36,000	$36,000	$56,000	$42,000	$36,000	$39,000
#4 New Facility	$28,000	$24,000	$25,000	$47,000	$33,000	$25,000	$31,000
Existing Facility[e]	$50,000	$43,000	$43,000	$66,000	$56,000	$43,000	$48,000
#5 New Facility	$63,000	$64,000	$84,000	$141,000	$95,000	$70,000	$97,000
Existing Facility[f]	$117,000	$116,000	$134,000	$191,000	$150,000	$121,000	$147,000
#6 New Facility	$1,606,000	$1.568,000	$2,304,000	$4,140,000	$2,103,000	$1,894,000	$2,575,000
Existing Facility[g]	$3,404,000	$3,283,000	$3,930,000	$5,767,000	$3,807,000	$3,569,000	$4,186,000

a/ In 1991 dollars.
b/ The six "model" facilities are summarized in Exhibit 4-7.
c/ 30-percent contingency included.
d/ $27,000 of cost is for double bottom tank retrofit for three 10-foot diameter tanks.
e/ $23,000 of cost is for double bottom tank retrofit for two 12-foot diameter tanks.
f/ $81,000 of cost is for double bottom tank retrofit for three 12-foot diameter tanks and double bottom tank retrofit for one 40-foot diameter tank.
g/ $2,534,000 of cost is for double bottom tank retrofit for two 80-foot diameter, three 120-foot diameter, and four 200-foot diameter tanks.

Note: The retrofit costs for Model Facilities 1 and 2 do not include double bottom retrofit costs because the tanks at these model facilities are horizontal, saddle-mounted tanks (see Exhibits 4-1 and 4-2).

EXHIBIT 4-17

ANNUAL OPERATIONS AND MAINTENANCE COSTS

TYPE	IMPERVIOUS SOIL		CONCRETE		GEOMEMBRANES		
	Native Silty Clay	Modified Soil	Uncoated	Coated	Polymeric Sheets	Bentonite Mat	Polysulfide Spray On
Operational	Low	Low	Moderate	Low	Low	Low to High	Low
Liner System Repair	Low	Low	Moderate	High	High	Moderate	High

- Retrofitting of double bottoms occurs during a routine inspection and maintenance period when the tank has been drained, cleaned, and temporarily taken out of service.

- Soils with high permeability can be modified to produce an impervious soil liner by applying 3 pounds of bentonite to each square foot of soil. The liner is covered with 6 inches of soil that is seeded with grass, fertilized, and mulched.

- Tank foundation liners are installed at new, large and medium sized facilities. This involves installation of a HDPE liner, a 2-inch sand layer, cathodic protection, and an additional 2-inch sand layer. At existing facilities, additional equipment such as cranes and temporary tank pads are required for retrofitting undertank liners.

- Large facilities have roads within secondary containment structures. Crushed stone roads are constructed over a liner system consisting of a geomembrane and impervious soil layers. In the case of concrete liners, the concrete is thickened along the course of the road.

As indicated in Exhibit 4-16, for all liner systems, the cost to retrofit liners is higher than installing liners at new facilities because of the added difficulty and cost associated with working around existing tanks and appurtenances (e.g., piping). In addition, certain general conclusions are apparent from the table:

- Coated concrete was the most expensive alternative for all model facilities.

- Uncoated concrete, impervious modified soil, bentonite mat, and polysulfide spray-on liner systems were the least costly for retrofitting of existing facilities with total storage capacities of less than approximately 100,000 gallons.

- For a large facility (e.g., total storage capacity of greater than or equal to 1 million gallons), native soil and bentonite mat liner systems were the least costly alternatives.

- For all model facilities, the bentonite mat liner system was consistently one of the least expensive alternatives.

- For all model facilities, the costs for polymeric sheet liner systems were similar to the costs of other options; however, polymeric sheets were never the least expensive alternative.

A range of costs (expressed in dollars per gallon of storage capacity) to install new and retrofitted liners at the six model facilities is presented in Exhibit 4-18. These ranges are based on the least and most expensive liner cost estimates presented in Exhibit 4-16. Generally, the larger the facility, the lower the price per gallon of capacity to construct a liner system because, for most secondary containment structures of typical proportions, the volume of the secondary containment structure increases at a faster rate than its area. Because secondary containment structures are designed to hold the entire contents of the largest tank or aggregate volume of tanks permanently manifolded together within the structure, the volume of the structure is typically roughly equivalent to the storage capacity of the tank or tanks within that structure. Because the increase in surface area results in costs roughly equivalent to the incremental material and installation cost of liners (which cover the surface area of the secondary containment) and the increase in volume corresponds with the additional amount of available storage capacity, the ratio of available storage volume to surface area increases with tank size. This, in turn, translates into declining cost per gallon of storage capacity. For example, if two facilities have secondary containment areas of 50,000 square feet, and one has a dike height 6 inches higher than the other, the difference in height would add very little to the cost of installing a liner (the increase in lined surface area would be approximately 45 to 50 square yards), but the facility could store as much as 180,000 more gallons of oil.

As shown in Exhibit 4-18, the cost for installing a liner system at an AST with a nominal capacity at a small end-user facility (Model Facility 1) is estimated to range from $1.50 to $4.50 per gallon of storage capacity. A liner system at a large oil terminal facility (Model Facility 6) is estimated to cost approximately $0.03 to $0.11 per gallon of capacity. In general, the costs to install liner systems at facilities would be better represented in dollars per gallon of throughput rather than dollars per gallon of storage capacity since throughput is a better representation of the economical value of the tank; however, EPA lacks sufficient data on average throughput to present costs in this manner.

Existing ASTs are assumed to be retrofitted with double bottoms to prevent undertank discharges. The cost of retrofitting ASTs with double bottoms is proportional to the area of the tank bottom. These retrofits were found to vary from $15 to $115 per

EXHIBIT 4-18

ESTIMATED LINER CAPITAL COST PER GALLON OF STORAGE CAPACITY

MODEL FACILITY	COST FOR RETROFIT INSTALLATION (DOLLARS/GALLON)		COST FOR NEW INSTALLATION (DOLLARS/GALLON)	
	Low	High	Low	High
1	$2.00	$4.50	$1.50	$4.00
2	$0.46	$1.00	$0.38	$0.92
3	$0.80	$1.24	$0.36	$0.62
4	$0.41	$0.63	$0.23	$0.45
5	$0.36	$0.59	$0.19	$0.43
6	$0.07	$0.11	$0.03	$0.08

square foot, depending on the tank size, with the higher cost per square foot associated with smaller tanks. New installations of undertank liners can be completed for approximately $4 to $34 per square foot, depending on tank size.

Annual O&M costs were examined qualitatively in the analysis. They are generally low for impervious soils and geomembrane liners (except for bentonite mats, which must be hydrated regularly). Operational costs for coated concrete are lower than uncoated concrete; however, the costs to repair cracks, deteriorated expansion joints, and sealants for coated concrete systems are greater. Although liner manufacturers rated operational costs for bentonite mats as low, facility owners and operators who had installed these types of liners stated that the operating costs were high. Exposed geomembrane liners are susceptible to damage from vandalism and accidents, and any needed repairs may be costly.

EPA determined that there is not sufficient information to quantify the number, size, and costs associated with releases that liner usage may prevent. However, initial research does indicate that the cost of remediating oil releases will vary greatly depending on the characteristics of the oil (e.g., viscosity), characteristics of the soil and ground-water (e.g., depth to ground water, velocity of flow, depth of saturation, and effects from nearby pumping), external factors such as weather, and remediation technique used. Preliminary analysis suggest that remediation costs can range up to greater than $100 per gallon of oil released.

4.5 LEAK DETECTION METHODS

Current technology has produced a variety of leak detection systems including alarms, inventory control, acoustic emissions testing, volumetric measurement, and interstitial space monitoring, and industry is aggressively developing technology to make leak detection more reliable. EPA has found that leak detection systems are part of an effective liner system for ASTs, serving to bring a leak or spill to the owner's or operator's attention while the liner prevents leaks and spills from reaching soil or ground water.

Leak detection methods are typically classified as either continuous or periodic systems, although many current technologies may be configured to provide either type of operation. Continuous leak detection provides uninterrupted monitoring and, consequently, instant notification of tank failure or an oil discharge. Examples of continuous systems are overfill alarms, overfill sumps, tell-tale drains, interstitial space monitors, and horizontal wells with electronic fluid-flow indicators. These systems are most effective in preventing adverse environmental impacts of discharges when integrated with leak *containment* systems because leak detection systems by themselves only alert facility operators to the existence of the discharge. For example, when used in conjunction with double tank bottoms, interstitial space monitoring may consist of a hydrocarbon sensitive tape lying between a tank's external bottom and its internal double bottom. Use of tell-tale drains on ASTs also is common at facilities that have installed double bottom retrofits. Tell-tale drains are used to check the integrity of the double bottom by providing a drain path for any liquid that has accumulated in the space between the two bottoms. While overfill alarms and sumps are a form of leak detection, they do not provide notification of tank bottom failure.

Periodic leak detection involves checks or tests at regular intervals to determine the occurrence of oil discharges or tank bottom failure. The type of system used generally depends on the type and size of the tank being monitored. Periodic systems include: internal/external visual inspections; pressure/vacuum testing of tanks and piping; volumetric precision testing of the tank; inventory record and measurement reconciliation; acoustic emissions testing; and chemical gas detection methods. OSCs agreed that visual inspection is the most common form of leak detection at AST facilities. When visual leak detection is used, daily records need to be maintained, interpreted, and reviewed to provide the most sensitive leak detection threshold possible. The most significant drawback to visually inspecting vertically mounted tanks is the inability to examine the tank bottom while the tank is in service.

Periodic leak detection systems are generally required in States that regulate ASTs; however, these methods are not adequate in certain situations. For example, visual inspections cannot be conducted for the bottom or internal area of vertical ASTs without the removal of stored product. In such circumstances, other non-invasive periodic methods (i.e., those that do not require tank entry) such as acoustic emissions testing and precision volumetric detection, must be used. These methods can have detection thresholds as low as one gallon of leaking product per hour.

Intrusive methods of leak detection have an extremely high detectability rate because areas that are suspected to have failed can be examined by other means of integrity testing (i.e., ultrasonic, radiographic, dye penetrant, magnetic particle, and vacuum box testing). Internal inspections can be expensive and result in significant tank down-time; consequently, intervals between tests have historically been as long as 20 years. Internal inspections alone may not be adequate to identify tank bottom failures because of the long time between bottom failure and leak discovery given the average time between tests.

Other non-invasive methods of leak detection such as inventory reconciliation can be useful at detecting large leaks; however, inventory checks may not detect slow, continuous leaks because of the normal margin of error in making measurements and the effects of temperature-related expansion of product volume in the tank. Although the types of systems described in the paragraphs above are effective for detection of smaller leaks, their expense can be significant.

5. RECOMMENDATIONS

This chapter presents the Agency's recommendations. The recommendation of this Report to Congress is based primarily on the results of EPA's study of liners as well as insights the Agency has gained over the past 20 years into the problems posed by onshore AST facilities. As a first step toward addressing the potential risks to public health and the environment as a result of contamination from AST facilities located near navigable waters, the Agency recommends initiating, through a *Federal Register* notice or stakeholder workgroups, a process involving broad public participation to develop a voluntary program. This process would give stakeholders the opportunity to share new or additional data and information to characterize the sources, causes, and extent of soil and ground-water contamination and efforts underway to address contamination at AST facilities nationwide. Such data are critical to determining the most appropriate and effective means to reduce contamination.

As envisioned by EPA, the voluntary program would be designed to encourage facility owners or operators, through incentives such as technical assistance, cost savings, and public recognition, to identify and report contamination, take actions to prevent leaks and spills, and remediate soil and ground-water contamination. This program would complement the Agency's efforts to develop cleaner, cheaper, and smarter approaches to environmental problems through innovative solutions that depart from the traditional regulatory approach. The Agency favors a voluntary, rather than regulatory, approach at this time in order to provide greater flexibility in addressing contamination at the vast range of oil storage facility types, sizes, and locations. A voluntary program could focus more directly on facilities that may pose the greatest hazard to public health and the environment. For example, the program may initially focus on larger, older facilities, and facilities located near waters, sensitive areas, or populations. In addition, a voluntary approach could allow implementation of the most appropriate prevention and cleanup activities for each facility. The program would look for incentives for industry to implement reasonable and cost-effective measures to address existing problems and help prevent future ones.

EPA views such a program as a cooperative effort among EPA, State governments, industry, and environmental groups. Based on this study's findings, EPA believes the program should include commitments from facilities to:

- Address known contamination and to assure that existing contamination will not be allowed to migrate offsite;

- Report to appropriate government agencies the status of facility contamination and actions underway to address any problems;

- Adopt the most protective appropriate prevention standards and upgrade equipment as necessary; and

- Monitor and/or implement leak detection to ensure that new leaks are addressed.

Provided stakeholders commit to the voluntary approach, a successful program will entail the identification of specific actions for participating facilities to undertake and include means for objectively measuring results.

EPA has evaluated the feasibility of conducting a voluntary program to address the problem of AST releases and concluded that a voluntary program is worth pursuing for the following reasons:

- The universe of large AST facilities is relatively easy to define and is represented by several large trade associations.

- The program is consistent with the Agency's goal of developing and promoting innovative approaches to achieve environmental goals.

- Clear, achievable goals are apparent (e.g., to mitigate the spread of existing contamination and to prevent future releases).

- Flexible approaches (i.e., numerous technological options and management practices) are available to address the problem, thus allowing participants to implement the program in a tailored manner appropriate to their circumstances.

- EPA is committed to providing technical assistance as well as other incentives.

- There are established industry and state practices and standards that can be used as a basis for constructing a comprehensive program.

EPA identified several characteristics shared by successful voluntary programs. These include:

- <u>The program must have goals that are clearly defined up front</u> – This assures that participants are working toward the same objectives and provides a framework that increases efficiency.

- <u>The program must have achievable goals</u> – The goals of the program must be realistic in order to ensure widespread participation and avoid wasting resources.

- The program must offer useful incentives – Successful voluntary programs offer benefits to attract and maintain the interest of participants. Such incentives have included:

  - Cost savings/long-term profits/more efficient operations (release prevention reduces product loss);
  - Publicity (newsletters, press releases, etc.);
  - Recognition (certificates of participation and achievement);
  - Technical assistance (advice and sources of information);
  - Reducing or eliminating the need for regulations; and
  - Other types of assistance, such as assistance in identifying Federal/State/private financial options (i.e., information on insurance programs, State grant programs, etc.).

  EPA will vigorously pursue other incentives, and will work with interested parties over the coming months to help identify them.

- The program must have a structure in place to work with all potentially affected and interested parties and promote continued participation – We believe it is imperative that a voluntary program ensure broad participation and be structured so that all involved can affect the decision-making process.

- The program must effectively track progress and disseminate success stories – Project tracking enables the Agency to determine whether the program is successful, identify areas where adjustments are needed, resolve issues, and plan future goals. Success stories help foster new involvement.

- The program must have the support of the lead agency, the public, and participants – For a program to be successful, it needs a real and strong commitment of those involved.

In keeping with the Agency's initiatives to develop innovative, common-sense approaches to environmental problems, EPA supports a voluntary prevention and cleanup program as a first step in addressing the environmental problem presented by contamination from AST facilities. Industry representatives have expressed their support for such a program as a more cost-effective, flexible alternative than traditional regulation. EPA fully supports such an attempt, and believes it will be successful, provided that it has the full commitment of those involved. The Agency believes it is essential that stakeholders have the opportunity to participate in the development and execution of this voluntary program and will establish an open process for public input into the program's design and implementation.

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APPENDIX A: STATE REGULATIONS

EPA reviewed current and proposed AST regulations for the 50 States to gather information on liner systems and to estimate the number of facilities currently required to use liners as a result of State regulation. Exhibit A-1 summarizes the results of this review. The following components of AST regulatory programs were examined:

- Status of AST requirements (i.e., full AST regulations, NFPA or other fire codes only, proposed AST regulations with NFPA or other fire codes, or proposed AST regulations only);
- Status of liner requirements (current, proposed, or none);
- Status of spill data collection (full AST regulations, some spill data collection, AST data base started but is not extensive or easy to access, or spill data collected but not required by regulation); and
- Whether a cost/benefit data analysis was performed.

Section 3.1.2 provides a more detailed discussion of the nine States (AK, CO, FL, MO, NJ, NY, RI, SD, and WI) that have promulgated or proposed regulations specifying the use of "impermeable" secondary containment systems, liners, or other diversionary structures and systems.

EXHIBIT A-1

STATE REGULATIONS[33]

STATE	BASIS FOR AST REQUIRE-MENTS	LINER REQUIREMENT		Spill Data Collected	Cost/Benefit Data	Comments
		Current	Proposed			
Alabama	1			Some		Guidelines available
Alaska	X	X		★		Liners required at new facilities only
Arizona	1					
Arkansas	X					Working on draft regulations
California	X			★		
Colorado	• 1					Proposed AST regulations
Connecticut	• 1		X	★		Proposed AST regulations
Delaware	1			Some		
Florida	X	X		X	X	
Georgia	1					
Hawaii	1			Some		
Idaho	1			●		
Illinois	1					
Indiana	1					
Iowa	1			★		
Kansas	1					
Kentucky	1			★		Began data base in '92; no regulations; local control
Louisiana	1					

33 Information as of April 1994.

LEGEND

X = AST regulation
1 = NFPA or other fire codes
★ = data base started, but not extensive nor easy to access
o = spill data is collected, but not required by regulation
• = proposed AST regulation

STATE	BASIS FOR AST REQUIREMENTS	LINER REQUIREMENT		Spill Data Collected	Cost/Benefit Data	Comments
		Current	Proposed			
Maine	1			o		Some oil terminal regulations; proposed AST regulations currently under development
Maryland	X	X		X	X	
Massachusetts	X			X		Regulations only cover tanks > 10,000 gallons
Michigan	1			★		No regulations; local control
Minnesota	X			X	X	Cost/benefit data from the failed liner requirement available
Mississippi	1					
Missouri	1					
Montana	1					
Nebraska	1					Requires liners on a case by case basis
Nevada	1					
New Hampshire	1			★		
New Jersey	X	X		X		
New Mexico	1					No regulations; local control
New York	X	X		X	X	
North Carolina	1			o		
North Dakota	1			o		
Ohio	1			o		Proposed regulations currently under development; no provisions available
Oklahoma	1					
Oregon	1			o		
Pennsylvania	X			★		New and retrofit must meet API standards

LEGEND

X = AST regulation
1 = NFPA or other fire codes
● = data base started, but not extensive nor easy to access
o = spill data is collected, but not required by regulation
• = proposed AST regulation

STATE	BASIS FOR AST REQUIRE-MENTS	LINER REQUIREMENT		Spill Data Collected	Cost/Benefit Data	Comments
		Current	Proposed			
Rhode Island	X	X		X		
South Carolina	1			o		
South Dakota	X	X				
Tennessee	1					No regulations; local control
Texas	X					
Utah	1					
Vermont	1			•		
Virginia	X					Regulation applies to facilities with AST capacity in excess of 25,000 gallons of oil. Requires installation of release prevention barriers either under or in the bottom of new or retrofitted tanks.
Washington	X					Only covers marine terminals
West Virginia	1					
Wisconsin	X	X				
Wyoming	1			•		

LEGEND

X	=	AST regulation
1	=	NFPA or other fire codes
★	=	data base started, but not extensive nor easy to access
o	=	spill data is collected, but not required by regulation
•	=	proposed AST regulation

APPENDIX B: MODEL FACILITIES

This appendix describes how EPA used previous analyses to determine how the model facilities developed for this analysis would represent the diversity of facilities with ASTs that do not have liner systems in place.

B.1 Allocation of AST Facilities into Size and Use Categories

As described in Chapter 2, the universe of AST facilities that currently is estimated not to have liners was divided into size categories based on their storage capacity and use categories (see Exhibit 2-6). This classification scheme has been used in a previous EPA analysis supporting revisions to the Oil Pollution Prevention regulation.[34] EPA's earlier analysis also estimated the storage capacity for typical (i.e., representative) facilities in eight of the nine size and use categories. (Because only a negligible number of large facilities were estimated to exist, no typical storage capacity was estimated for this category.) The results of the analysis are presented in Exhibit B-1.

EXHIBIT B-1

TYPICAL STORAGE CAPACITIES FOR FACILITIES FROM PREVIOUS EPA ANALYSIS

Size and Use Category	Production	Storage/Distribution	Storage/Consumption
Small	37,800 gallons	10,000 gallons	2,000 gallons
Medium	96,600 gallons	250,000 gallons	205,000 gallons
Large	Not Applicable	21,400,000 gallons	4,028,000 gallons

To ensure consistency in its analyses, EPA used the typical storage capacities from this earlier analysis to determine which model facilities developed in this analysis best represented each size and use category. Specifically, EPA compared the typical storage capacities used in the previous analysis (and presented in Exhibit B-1) with the assumed storage capacities of the model facilities developed for this report. If a single model facility from this report closely agreed with the storage capacity from the earlier analysis, then that model facility was assumed to represent all of the AST facilities that currently do not have liners in that size and use category (as presented in Exhibit 2-6). For

[34] U.S. EPA, Emergency Response Division, "Regulatory Impact Analysis of Revisions to the Oil Pollution Prevention Regulation (40 CFR 112) to Implement the Facility Response Planning Requirements of the Oil Pollution Act of 1990", June 1994.

example, Model Facility 1 has an assumed storage capacity of 2,000 gallons, which equals the typical storage capacity of small storage/consumption facilities from EPA's earlier analysis. Consequently, all 198,529 small storage/consumption facilities are considered to be represented by Model Facility 1.

Where the typical storage capacity of facilities in a size and use category did not closely agree with a single model facility from this report, two model facilities were used to represent that size and use category. The allocation of facilities between the two model facilities generally was based on the difference between the typical storage category, as presented in Exhibit B-1, and the assumed storage capacities of the model facilities. For example, small storage/distribution facilities are estimated to typically have a total storage capacity of approximately 10,000 gallons, for which no single model facility in this report corresponds closely. Therefore, small storage/distribution facilities are best represented by a mix of Model Facilities 1 and 2, which are assumed to have 2,000 and 24,000 gallons of storage capacity, respectively. As the "typical" small storage/distribution facility (10,000 gallons) is closer in storage capacity to that of Model Facility 1 (2,000 gallons) than Model Facility 2 (24,000 gallons), facilities were allocated disproportionately to Model Facility 1. Of the estimated 4,554 small storage/distribution facilities, 2,898 facilities are estimated to be best represented by Model Facility 1, and the remaining 1,656 facilities are estimated to be best represented by Model Facility 2. The model facilities selected to represent each size and use category and the allocation ratios are presented in Exhibit B-2.

EXHIBIT B-2

CATEGORIZATION OF FACILITIES NOT CURRENTLY REQUIRED TO INSTALL LINERS

Size and Use Category	Production	Storage/Distribution	Storage/Consumption
Small	Model Facility 2 (34%) Model Facility 3 (66%)	Model Facility 1 (64%) Model Facility 2 (36%)	Model Facility 1 (100%)
Medium	Model Facility 4 (100%)	Model Facility 3 (41%) Model Facility 5 (59%)	Model Facility 4 (54%) Model Facility 5 (46%)
Large	Not Applicable	Model Facility 6 (100%)	

In the case of medium storage/distribution facilities, however, an alternative formula was used. The medium storage/distribution category of facilities includes gasoline service stations with ASTs. Historically, most gasoline service stations stored product in USTs; however, where land limitations require or building codes allow, ASTs are used at these facilities for product storage. Model 3, with a storage capacity of 45,000 gallons, is an effective representation of such medium-sized gasoline service stations. As shown in Exhibit 3-2, there are an estimated 5,967 medium-sized gasoline service stations. Therefore, 5,967 of the 14,681 medium storage/distribution facilities are represented by Model 3, and the remaining 8,714 are represented by Model 5, whose assumed storage capacity of 325,000 gallons is closest to the typical storage capacity of facilities in this size and use category (i.e., 250,000 gallons).

To determine the total number of facilities that each model facility represents, the percentages in Exhibit B-2 were multiplied by the estimated number of AST facilities in the corresponding size and use category in Exhibit 2-6 and the amounts were summed by model facility:

• Model Facility 1:	201,427	2,898 small storage/distribution facilities All small storage/consumption facilities
• Model Facility 2:	49,296	1,656 small storage/distribution facilities 47,640 small production facilities
• Model Facility 3:	97,277	91,310 small production facilities 5,967 medium storage/distribution facilities
• Model Facility 4:	55,623	All medium production facilities 5,880 medium storage/consumption facilities
• Model Facility 5:	13,663	8,714 medium storage/distribution facilities 4,949 medium storage/consumption facilities
• Model Facility 6:	3,927	All large storage/consumption facilities
	421,213 facilities	