TECHNICAL DOCUMENT

CLOSURE REQUIREMENTS FOR UNDERGROUND STORAGE TANK SYSTEMS

EFFECTIVE APRIL 1, 1998

STORAGE TANK PROGRAM

PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION

DEPARTMENT OF ENVIRONMENTAL PROTECTION

Bureau of Land Recycling and Waste Management

DOCUMENT NUMBER:	253-4500-601
TITLE:	Closure Requirements for Underground Storage Tank Systems
EFFECTIVE DATE:	April 1, 1998
AUTHORITY:	The Storage Tank and Spill Prevention Act (Act 32 of 1989, as amended, P.L. 169). 25 Pa. Code, Sections 245.451-455.
POLICY:	It is the policy of the Department of Environmental Protection to carry out the provisions of the Storage Tank and Spill Prevention Act.
PURPOSE:	The purpose of the attached guidance is the establishment of minimum standards that must be met in order to comply with the closure requirements for regulated underground storage tanks. These procedures include closure notification, tank handling and waste management and disposal, site assessment, sampling requirements, analytical requirements, release reporting and record keeping.
APPLICABILITY:	The attached guidance applies to the closure of all federally or state regulated underground storage tanks.
DISCLAIMER:	The policies and procedures outlined in this guidance document are intended to supplement existing requirements. Nothing in the policies or procedures will affect regulatory requirements. The policies and procedures herein are not an adjudication or a regulation. There is no intent on the part of the Department to give these rules that weight or deference. This document establishes the framework, within which DEP will exercise its administrative discretion in the future. DEP reserves the discretion to deviate from this policy statement if circumstances warrant.
PAGE LENGTH:	49
LOCATION:	Volume 5 Tab 66
DEFINITIONS:	Definitions for pertinent terms used in the guidance may be found in the Storage Tank and Spill Prevention Act and/or Pa. Code §245.1.
TECHNICAL GUIDANCE:	See attached.
APPENDICES:	The following appendices are included with the guidance: A. Pennsylvania Department of Environmental Protection, Environmental Cleanup Program, Storage Tank Section, and the Department of Environmental Protection, Regional Storage Tank Offices (3930-MP-DEP0061-Rev. 6/97). B. Planning for Permanent Closure Checklist (2530-FM-LRWM0126 4/96).

C. Underground Storage Tank System Closure Notification Form (2530-FM-LRWM0127 4/96).

D. Underground Storage Tank System Closure Report Form (2530-FM-LRWM0159), Rev. 11/97).

E. Standards/Action Levels for Confirmatory Samples Collected At Closure Site Assessments.

TABLE OF CONTENTS

I. INTRODUCTION

On August 5, 1989, the state Storage Tank and Spill Prevention Act (Act 32) became effective in Pennsylvania. This act provides authority for the Department of Environmental Protection to develop regulations establishing the: 1) requirements for closure of tanks by owners and operators to prevent future releases of regulated substances into the environment, 2) standards and procedures for removal and intended and completed closure of underground storage tank (UST) systems; 3) methods and procedures for the removal of USTs from service by the owner and operator, and 4) requirements for reporting by the owner or operator of intended and completed closure of any UST facilities. On September 20, 1991, in 25 Pa. Code §245.2, the department adopted by reference the federal closure regulation, 40 CFR Part 280, Subpart G - "Out-of-Service UST Systems and Closure", to satisfy the requirements of Act 32.

The principal objective of the federal closure requirements is to identify and contain existing contamination and to prevent future releases from UST systems no longer in service. These federal regulations became effective on December 22, 1988. Copies of the regulations may be obtained by writing the U.S. Environmental Protection Agency, Office of Underground Storage Tanks, P.O. Box 6044, Rockville, MD 20850, or by calling or writing the Division of Storage Tanks, Bureau of Watershed Conservation, Department of Environmental Protection, P.O. Box 8762, Harrisburg, PA 17105-8762, (1-800-42-TANKS in PA only, or 1-717-772-5599). This guidance sets forth the procedures for complying with the closure requirements for regulated underground storage tanks.

Also, the Pennsylvania State Police has the responsibility for enforcing closure regulations for storage tanks containing flammable and combustible liquids. The primary intent of these regulations is to prevent fire and explosion hazards. These regulations are contained in the "Pennsylvania State Police Fire Marshal Flammable and Combustible Liquids Handbook". Copies of the regulations may be obtained by contacting the Pennsylvania State Police, Fire Marshal Division, 1800 Elmerton Avenue, Harrisburg, PA 17110, telephone 717-783-5529. The regulations apply throughout Pennsylvania with the exception of Philadelphia and Allegheny Counties, which administer their own programs. In Philadelphia, contact the Commercial and Industrial Fire Unit, 1600 Arch Street, 9th Floor, Philadelphia, PA 19103, telephone 215-686-5150/5151/5152. In Allegheny County, contact the Office of the Fire Marshal, Allegheny County, 400 North Lexington Street, Pittsburgh, PA 15208, telephone 412-350-2552. For UST systems in the City of Pittsburgh, contact Fire Bureau/Public Safety, Fire Prevention Division, telephone 412-255-2863.

Since the effective date of the federal closure regulations for USTs and with the passage of the Storage Tank and Spill Prevention Act, there have been numerous inquiries regarding requirements and appropriate practices for the proper closure of USTs in Pennsylvania. The purpose of this document is to indicate what the department considers to be good practice for persons who are involved in the closure of regulated USTs. The department believes that adhering to this guidance will result in compliance with all applicable federal and state laws and regulations.

While this document is intended to acquaint regulated persons with good practices, it may not address all the actions that the department may determine are necessary at an individual site. Different or supplemental actions may be required in any individual case to achieve compliance with the applicable laws and regulations. Also, this guidance is not intended to address every closure situation. Discuss variations for site specific conditions with the appropriate DEP regional office. A map of the regional offices along with the appropriate contact person and telephone numbers for each region can be found in Attachment 1.

This guidance focuses on the proper procedures for tank closures, along with the observations and measurements necessary to determine if a storage tank site may be closed or subject to corrective action. This guidance does not address the corrective action requirements in any detail. This guidance document revises the "Closure Requirements for Underground Storage Tank Systems," document issued by the department that had an effective date of August 1, 1996.

II. APPLICABILITY

This guidance applies to all federally or state regulated USTs (including piping and/or ancillary equipment) when:

1. A federally regulated UST in operation on or after December 22, 1988, is being permanently closed by removal, closure-in-place or completing a change-in- service.

2. A state regulated UST (that is not a federally regulated UST) in operation on or after August 5, 1989, is being permanently closed by removal, closure-in-place or completing a change-in-service.

3. A federally regulated UST in operation on or after December 22, 1988, is being temporarily closed. (Section V only)

4. A state regulated UST (that is not a federally regulated UST) in operation on or after September 20, 1991, is being temporarily closed. (Section V only)

5. A federally regulated UST was permanently closed before December 22, 1988, and the department has reason to believe that the UST poses a current or potential threat to human health and the environment.

6. A state regulated UST (that is not a federally regulated UST) was permanently closed before August 5, 1989, and the department has reason to believe that the UST poses a current or potential threat to human health and the environment.

7. A state or federally regulated UST is being partially closed - these are closures of portions of regulated underground storage tank systems such as piping and/or dispensers, but do not include closure of other portions such as the tank.

III. METHODS OF CLOSURE

A. Temporary Closure -- Placing an UST out-of-service for a limited period of time.

B. Permanent Closure

1. Removal -- Placing an UST out-of-service by removing it from the ground.

2. Closure-in-Place -- Placing an UST out-of-service by filling the tank with an inert, solid, non-shrinking material. Foam is not an acceptable material unless approved by the State Police Fire Marshal. Note that local regulations may prohibit closure-in-place or the use of certain types of materials for in-place closures.

3. Change-in-Service -- Placing an UST out-of-service by discontinuing use of the tank to store a regulated substance, but continuing to use the tank to store a non-regulated substance or using the tank in a manner that results in the tank no longer being regulated.

IV. ELEMENTS OF CLOSURE

Closure may involve three specific types of activities:

A. Tank handling activities

Tank handling activities during closure may involve such tasks as hazard recognition and abatement; removal and handling of vapors, product, wastewaters, and accumulated sludges from the UST system; overseeing cleaning of the UST system; leaving the UST system in the ground and filling the UST with an inert, solid, non-shrinking material; removing the UST system from the ground; excavating soil from around the UST system; and initial, onsite staging of excavated soil.

Tank handling activities must be conducted or directly supervised by a DEP-certified installer (which includes remover) who must be on-site during the tank handling activities. The certified installer must have certification in the appropriate category to conduct the activities. A list of DEP-certified tank handling companies is available from the Bureau of Watershed Conservation, Division of Storage Tanks, P.O. Box 8762, Harrisburg, PA 17105-8762, telephone 800-42-TANKS (in PA only) or 717-772-5599; or Environmental Cleanup Program, Storage Tank Section, in each regional office (see Attachment 1).

B. Waste management and disposal activities

Various wastes are generated during closure. It is the responsibility of the tank owner to ensure that these wastes are managed and disposed of in accordance with all applicable regulations and policy. (See Section VI.B., page 7)

C. Site assessment activities

The purpose of a site assessment is to determine if contamination is present around each storage tank system as a result of any leaks and/or spills which may have occurred during the operation of the current or any previously existing storage tank system.

The DEP does not certify, nor recommend, specific individuals or companies to perform site assessments. It is highly recommended that the owner or operator acquire the services of qualified and experienced professionals in the environmental field to conduct the site assessment. The person(s) conducting the site assessment should be familiar with proper soil and water sampling and handling procedures. Because many site assessments result in the need for corrective action, it may be advantageous to hire professionals who are capable of proceeding with any necessary corrective action.

V. TEMPORARY CLOSURE

A. When an UST system is temporarily closed, owners and operators must:

- Continue operation and maintenance of corrosion protection;
- Continue operation and maintenance of any release detection, unless the UST system is empty. An UST system is empty when all materials have been removed using commonly employed practices so that no more than 2.5 centimeters (one inch) of residue, or 0.3 percent by weight of the total capacity of the UST system, remain in the UST system;
- Submit an <u>amended</u> "Registration of Storage Tanks" form to the Bureau of Watershed Conservation, Division of Storage Tanks, P.O. Box 8762, Harrisburg, PA 17105-8762, indicating that the UST or USTs have changed status from currently in-use to temporarily out-of-use;

- Where there is an indication of a release of regulated substances, initiate and complete an investigation as soon as practicable, but no later than 7 calendar days, after the indication of a release, in accordance with 25 Pa. Code Chapter 245, Subchapter D, Section 245.304 (relating to investigation of suspected releases); and

- Notify the appropriate regional office of the department as soon as practicable, but no later than 2 hours, after the confirmation of a reportable release, in accordance with 25 Pa. Code Chapter 245, Subchapter D, Section 245.305 (relating to reporting releases), and immediately initiate corrective action. The appropriate release reporting telephone number(s) for each region can be found in Attachment 1.

B. When an UST system is temporarily closed for 3 months or more, owners and operators must also:

- Leave vent lines open and functioning; and

- Cap and secure all other lines, pumps, manways and ancillary equipment.

C. When an UST system is temporarily closed for more than 12 months, owners and operators must:

- Permanently close the UST system if it does not meet either performance standards for new USTs or the upgrade requirements for existing USTs, unless the department provides an extension of the 12-month temporary closure period. Owners and operators must complete a site assessment in accordance with Section VI.C. of this document before such an extension can be applied for. Extension requests must be submitted in writing to the appropriate regional office of the department.

VI. PERMANENT CLOSURE

A. Planning For Permanent Closure

Where the owner and operator intends to permanently close an UST system, the following pre-closure planning steps should be taken:

1. If the tank(s) are required to be registered and they are not, submit a "Registration of Storage Tanks" form, with a fee of $50.00 per tank, to the appropriate regional office of the department. On the form, complete information for <u>all</u> regulated storage tanks at the facility, including those to be permanently closed.

2. Hire a DEP-certified installer who has UMR certification to conduct tank handling activities.

3. Make sure that the certified installer and any of their subcontractors have:

   a. A <u>Site-Specific Health and Safety Plan</u> which includes:

      (1) Familiarity with and adherence to all applicable Occupational Health and Safety Administration (OSHA) and National Institute for Occupational Safety and Health (NIOSH) regulations and recommendations. A complete discussion of OSHA and NIOSH requirements that may be applicable to closure activities is beyond the scope of this guidance. However, the following closure procedures may be relevant:

         - OSHA 2226 - Excavations

- OSHA, 29 CFR Part 1926, Occupational Safety and Health Standards-Excavations
- OSHA, 29 CFR Part 1910, Occupational Safety and Health Standards
- The NIOSH "Criteria for a Recommended Standard*** Working in Confined Space" may be used as guidance for conducting safe closure procedures at some hazardous substance tanks.

(2) Locating underground utilities prior to excavation or drilling. Prior to beginning any excavation or drilling activities the person(s) conducting the closure should be familiar with the location of buried utilities as well as other tanks and piping that may be present at the facility. The Underground Utility Line Protection Law (Act 172 of 1986) requires that anyone planning excavations or borings call Pennsylvania ONE-CALL at 1-800-242-1776 at least three, but not more than ten business days, prior to conducting excavation or drilling activities. Once notified, if there are public utilities in the area of the planned excavation or drilling activity, the utilities will mark their lines.

(3) Procedures or provisions to avoid contact with overhead utility lines by heavy equipment.

(4) Restricting site access from vehicular or pedestrian traffic by utilizing fencing, similar barriers, security patrols or warning signs.

(5) Monitoring for and mitigating flammable vapors.

(6) Elimination of ignition sources by not smoking and utilizing hand tools (shovels, wrenches, hammers) made of spark-proof materials such as beryllium, power tools which are explosion proof and flashlights which are intrinsically safe.

(7) The availability of a fire extinguisher at the job site which is capable of extinguishing all types of fires.

(8) The provision for the wearing of appropriate personnel protective equipment.

(9) Procedures for addressing emergency situations such as fire or explosion, injury and environmental incident. Include a map showing directions to the nearest hospital as well as emergency telephone numbers.

b. Made provisions for Tank Cleaning and Waste Handling which includes:

(1) A plan for containing small spills from disconnecting piping.

(2) A method for purging or inerting the tank.

(3) A method for cleaning the tank if performed on site.

(4) A plan for the handling of tank liquids and sludges.

(5) A process to excavate, identify and properly stockpile uncontaminated and contaminated soil.

(6) A plan for tank system removal.

4. Make sure that the person(s) conducting the Waste Management and Disposal activities has/have:

   a. If the tank is to be cleaned off-site, a plan for transporting the tank to a permitted processing, treatment, storage or disposal facility, and complying with PennDOT regulations.

   b. A plan for the management and disposal of tank liquids and sludges.

   c. A plan for transportation of the cleaned tank after removal and the disposition of the tank.

   d. A plan to remediate and/or dispose of contaminated soil.

5. Determine who is going to conduct the site assessment.

6. Make sure that the person(s) conducting the site assessment has/have:

   a. A Site Assessment Plan which includes:

      (1) Visual assessment procedures.

      (2) Field test and field instrument procedures.

      (3) Sample collection procedures and sample preservation methods, including chain-of-custody procedures and documentation.

      (4) Decontamination procedures used on sampling and drilling equipment.

7. At least 30 days prior to initiating permanent closure of state and federally regulated UST systems, notify the department of the intent to permanently close utilizing the "Underground Storage Tank System Closure Notification" form found in Attachment 3. A copy of this form must also be sent to the Pennsylvania State Police, Fire Marshal Division, or to the appropriate agency in Philadelphia or Allegheny County, if the tank is governed by their flammable and combustible liquid regulations.

8. Use as much product in the tank as possible.

9. Identify and comply with any local ordinances governing UST system closures.

A "Planning for Permanent Closure Checklist" can be found in Attachment 2. This checklist is intended to assist the owner and operator in the closure planning process.

B. Tank Handling/Waste Management and Disposal Activities

Where possible, the department recommends that all UST systems be removed from the ground. However, the department recognizes that closure-in-place may be necessary where an UST system is under a permanent structure and removal would damage that structure. Certified installers and tank owners and operators are referred to the following tank handling procedures when permanently closing an UST system:

- American Petroleum Institute Recommended Practice 1604, "Removal and Disposal of Used Underground Petroleum Storage Tanks"

- American Petroleum Institute Publication 2015, "Cleaning Petroleum Storage Tanks"

These publications are available from the American Petroleum Institute (API), 1220 L Street, Northwest, Washington, DC 20005, telephone 202-682-8375.

In addition to the API publications, certified installers and tank owners and operators should be aware of the following:

1. Soil Excavation

If an UST system is being permanently closed by removal from the ground, the certified installer should initially excavate only that amount of soil and backfill material necessary to remove the tank and piping. Once the tank system is removed from the ground, removal of any soil beyond three feet from the tank and piping in any direction will be considered as remedial activity and will not require the use of a certified installer.

Excavated soils must be segregated (i.e. obviously contaminated, not suspected to be contaminated). This may be accomplished by visual observation and by field screening the soils as they are excavated through the use of field instruments such as photoionization detectors, flame ionization detectors, portable gas chromatographs and other appropriate field measurement procedures. Segregation of soils during excavation will facilitate laboratory testing, treatment and disposal. **Note, however, where soil has been segregated into presumably contaminated and uncontaminated piles, the soil, which is presumably uncontaminated, must be sampled prior to reuse on-site in order to confirm that it is uncontaminated. See Section VI.C.1.d.(5), page 21, "Soil Pile Sampling."** It is also recommended that excavated soils be segregated from concrete and asphalt material.

2. Classification of Wastes

The wastes associated with the permanent closure of UST systems include residual and possibly hazardous wastes. Wastes may include the tank itself, along with any associated piping, unusable product, sludges and sediments, condensation water, wastewater associated with cleaning the tank, and contaminated soil removed from the excavation.

A classification of these wastes as either residual or hazardous should be made based on the following:

a. Tank, Piping and Contents

Emptied and Cleaned - A storage tank is considered "empty" when no more than 1 inch (or .3 percent by weight of its total capacity) of residue remains in the tank. A tank and piping is considered "cleaned" when all remaining residue has been removed using applicable industry standards to clean that type of storage unit. A tank and piping which has been emptied and cleaned is considered scrap metal and, if it is to be recycled or reused, is specifically excluded from being a hazardous waste (25 Pa. Code §261.4(a)(21), relating to exclusions) or residual waste (25 Pa. Code §287.1, relating to definition of coproduct and waste). An emptied and cleaned tank which will not be recycled or reused, but is destined for disposal in a landfill, is regulated as a residual waste.

Emptied but not Cleaned - A petroleum storage tank, which meets the above definition of "empty", but has not been cleaned, is excluded as a hazardous waste, provided the tank and contents do not fail the test for any characteristic from D001 through D017 (see 25 Pa. Code §261.4(a)(17)). If excluded as a hazardous waste, the tank and contents are a residual waste. Most petroleum storage tanks, with the exception of those containing gasoline residues, which may fail the test for ignitability (D001) or lead (D008), fall into the category of petroleum contaminated media and debris and are excluded as hazardous waste and regulated as a residual waste.

In the case of a tank which stored a hazardous substance, or a petroleum storage tank which contains a substance that fails the test for any characteristic from D001 through D017, the tank contents are not subject to regulation as a hazardous waste until the waste exits the tank in which it was generated, or remains in the tank for a period of more than 90 days after the tank ceased to be operated as a storage tank (see 25 Pa. Code § 261.3(e)).

Not Empty - A petroleum or hazardous substance storage tank and its contents are not subject to regulation as a hazardous waste for a period of 90 days after closure or until the waste exits the storage tank, whichever comes first (25 Pa. Code § 261.3(e)). The classification of the contents upon exit from the tank or after 90 days has elapsed is dependent on the results of a hazardous waste determination provided the contents are not usable product. When it is not immediately possible to determine if a material is a hazardous waste, the material must be managed as a hazardous waste until a determination is made which indicates it is not (25 Pa. Code § 261.3(g)).

b. Unusable product, sludges and sediments, tank bottoms and wastewater - These wastes from inside the storage tank are hazardous if they meet any of the hazardous waste criteria in Chapter 261. If the tank contained gasoline it should be assumed the wastes are hazardous. If the wastes are determined to be non-hazardous, they are subject to regulation as a residual waste.

c. Contaminated Soil - Petroleum contaminated soil is regulated as a residual waste (25 Pa. Code §287.2(c)(4), relating to scope) provided it does not meet any of the hazardous waste criteria in Chapter 261 or if it is specifically excluded from regulation as a hazardous waste (25 Pa. Code §261.4(a)(17)). Soils contaminated with products that appear on the hazardous waste lists of commercial chemical products are subject to regulation as a hazardous waste.

d. Recovered or reclaimed product - Any virgin product recovered directly from the tank, if used, is considered a product and is not regulated as a waste. In addition, any material reclaimed from tank bottoms that qualifies as a coproduct, is not regulated as a waste.

3. On-site Storage of Contaminated Soil

Contaminated soils removed from the excavation during a tank removal that are residual waste must be stored in accordance with applicable sections of 25 Pa. Code §§299.101-299.154 (relating to standards for storage of residual waste) of the residual waste management regulations and other applicable department regulations. In addition to the general requirements set forth in §299.131(a), 25 Pa. Code §245.308(d) (relating to on-site storage of contaminated soil) of the regulations to administer the storage tank and spill prevention program requires that contaminated soil piles be completely and securely covered, for the duration of the storage period, with an impermeable material of sufficient strength, thickness, anchoring or weighting to prevent tearing or lifting of the cover, infiltration of precipitation or surface water runon, and exposure of the soil to the atmosphere. In addition to the nuisance control requirements set forth in §299.115(b),

25 Pa. Code §245.308(d) also requires that appropriate steps be taken to deter public access to the storage area. This may include fencing, similar barriers, security patrols or warning signs.

Where excavated contaminated soil is stored on-site, 25 Pa. Code §245.308(c) requires that the excavated soil be disposed of or active treatment of the excavated soil be initiated, within 90 days from the first day of storage, unless extended by the department in writing. Extension requests must be submitted in writing to the appropriate DEP regional office. The department may require immediate removal of contaminated soil if the soil is not being properly stored or managed, or if the department determines that storage poses a threat to human health, safety or the environment (25 Pa. Code §245.308(e)).

Contaminated soils that are hazardous waste must be stored in accordance with 25 Pa. Code §262.34 (relating to accumulation) of the hazardous waste management regulations. Hazardous waste cannot be stored for more than 90 days without a permit from DEP's Bureau of Land Recycling and Waste Management. Extensions under Chapter 245.308(c) do not apply to hazardous waste.

4. Tank Cleaning

USTs may be cleaned at the closure site or moved to another location for cleaning. However, the department recommends that USTs be cleaned prior to removal from the excavation to eliminate the potential for releases. In either case, the tank owner is considered the generator of the wastes. If the wastes are hazardous, the owner must obtain a provisional generator I.D. Number from DEP's Division of Reporting and Fee Collection by telephoning 717-783-9258. If the USTs are cleaned at the closure site, use extreme care to safely and properly purge the USTs of explosive vapors prior to accessing the USTs for cleaning. If the USTs are to be moved to another location for cleaning, see the waste transportation requirements in Section VI.B.6. below.

5. Tank Removal

When a tank is to be removed from the ground, provisions should be made in order to safely lift it out of the excavation. One of the major dangers in tank removals is when the lifting chain is not properly attached to the tank and the chain snaps back under tension. The lifting chain should be attached to an existing lifting lug on the tank or a lifting plug (a threaded plug with an attached lifting lug) screwed into a center tank opening. It is also important that the machine (backhoe, excavator or crane) used to remove the tank be of sufficient lifting capacity to safely remove the tank. For example, a small backhoe could be damaged or tipped over while attempting to remove a large tank.

6. Waste Transportation Requirements

The wastes associated with the permanent closure of UST systems must be transported as follows:

a. Tank, Piping and Contents

Emptied and Cleaned - An underground storage tank and piping that is emptied and cleaned on-site is considered scrap metal. If it is to be recycled or reused, it is not subject to hazardous or residual waste management transportation regulations. If it is destined for disposal in a landfill, it is subject to the residual waste transportation requirements (25 Pa. Code §285.218 and §299.201-219).

Emptied but not Cleaned - A petroleum product storage tank containing a substance that does not fail the test for any characteristic from D001 through D017, which is empty

(contains no more than 1 inch or .3 per cent by weight of its total capacity), but has not been cleaned, is exempt from the department's hazardous waste transportation requirements. Residual waste transportation requirements as provided by 25 Pa. Code §285.218 and §299.201-219 apply.

In the case of a tank which stored a hazardous substance, which meets the definition of a hazardous waste, or a petroleum product storage tank which contains a substance that fails the test for any characteristic from D001 through D017, the tank contents are not subject to regulation as a hazardous waste until the waste exits the tank in which it was generated, or remains in the tank for a period of more than 90 days after the tank ceased to be operated as a storage tank (see 25 Pa. Code § 261.3(e)). Until 90 days has elapsed, the residual waste transportation requirements apply if the tank is to be transported, after which hazardous waste transportation regulations apply.

Not Empty - Any regulated storage tank containing more than 1 inch of residue (or more than .3 percent by weight of total capacity) may be transported according to the residual waste regulations for a period of up to 90 days, after which the hazardous waste regulations apply unless the residue contained in the tank is determined to be non-hazardous.

The Pennsylvania Department of Transportation (PennDOT) does have two additional requirements which tend to override DEP's regulations for transporting tanks that have not been thoroughly emptied and cleaned. These are:

- *If a tank stored a flammable liquid such as gasoline, it must be totally emptied, cleaned and purged on-site before being transported over the highway. If such a tank is only "empty" -- one inch of residue remaining -- that "empty" tank must be transported in a DOT-approved container. Since the transport of an underground storage tank inside another DOT-approved tank is impractical, the impact of this requirement is that tanks, which contained flammable liquids, must be emptied, cleaned and purged on-site prior to transporting them.*

- *If a tank stored a combustible liquid (petroleum products other than gasoline), the tank must be leak tight. This means that the remaining residue cannot leak out through holes, fittings, etc.*

For additional information pertaining to PennDOT requirements, contact PennDOT, Motor Carrier Enforcement Division, 717-787- 7445.

b. Unusable product, sludges and sediments, tank bottoms and wastewater - These wastes upon removal from inside the storage tank, if hazardous wastes, must be transported by a licensed hazardous waste transporter, under manifest. The transporter must ensure that Chapter 263 is being complied with.

If the wastes are not hazardous wastes, they must be transported in accordance with Chapters 285.218 and 299.201-219, as residual wastes.

c. Contaminated Soil - Petroleum contaminated soil that is a residual waste must be transported in accordance with Chapters 285.218 and 299.201-219.

Petroleum contaminated soil that is determined to be hazardous waste and soils contaminated with products that appear on the hazardous waste lists of commercial chemical products are subject to regulation as a hazardous waste and must be transported by a licensed hazardous waste transporter, under manifest. Chapter 263 must be complied with.

d. Recovered or reclaimed product - This is considered a product. Therefore, no licensed hazardous waste transporter is required. PennDOT regulations, however, apply.

7. Waste Disposal/Treatment Options

a. Empty product tank and piping - Once properly emptied and cleaned, a storage tank and piping may be recycled. If they are not recycled, these wastes, if hazardous wastes, must be taken to a permitted reclamation facility or permitted hazardous waste treatment, storage or disposal facility. If non-hazardous, the wastes can be disposed of at a facility permitted to accept the wastes.

b. Unusable product, sludges and sediments, tank bottoms and wastewater - These wastes, if hazardous wastes, must be taken to a permitted reclamation facility or permitted hazardous waste treatment, storage or disposal facility.

If non-hazardous, the solids can be disposed of at a facility permitted to accept the wastes. Tank bottoms and wastewater can be treated at a facility which is designated to treat tank bottoms and wastewater and has an issued NPDES permit and waste management permit or permit-by-rule which specifies the discharge of treated tank bottoms and wastewater. The product can be separated and recovered with the remaining wastes subjected to additional treatment processes prior to discharge.

It also may be possible to discharge non-hazardous liquids to a DEP permitted sanitary sewer system. However, prior written authorization must be received from the receiving sewer authority.

c. Contaminated Soil - Contaminated soil shall be used, treated or disposed of in accordance with department regulation and policy.

Venting or low temperature stripping of contaminated soils may not be conducted without the express prior consent of DEP's Bureau of Air Quality. In general, such approval will not be granted without the provision of control measures, which are subject to prior review.

Petroleum contaminated soil that is a residual waste may be disposed of at any facility permitted to accept this type of waste. Other options include, but are not limited to, low temperature stripping and bioremediation. The department encourages alternatives to landfill disposal, however, prior review is required.

Petroleum contaminated soil that is determined to be hazardous waste and soils contaminated with products that appear on the hazardous waste lists of commercial chemical products are subject to regulation as a hazardous waste and must be taken to a permitted reclamation facility or permitted hazardous waste treatment, storage or disposal facility.

8. Release Reporting

An owner or operator must notify the appropriate regional office of the department as soon as practicable, but no later than two hours, after the confirmation of a reportable release, in accordance with 25 Pa. Code Chapter 245, Subchapter D, Section 245.305(a)(4), and immediately initiate corrective action. See Attachment 1 for the appropriate release reporting telephone numbers.

In addition, certified installers must report to the department, utilizing the "Notification of Contamination" form, a release of regulated substance or confirmed or suspected contamination from regulated substances observed while performing tank handling activities. This reporting is required by 25 Pa. Code Chapter 245, Subchapter B, Section 245.132(a)(4) (relating to standards of performance).

C. Site Assessment

The purpose of a site assessment is to determine if contamination is present around each storage tank system as a result of any leaks and/or spills which may have occurred during the operation of the current or any previously existing storage tank system. It is important to remember that the storage tank system includes all underground piping and ancillary equipment. Subsurface piping should be exposed and the trench it was laid in carefully examined for signs of obvious contamination wherever access to the piping is possible. The tank system closure is not complete until a site assessment has been performed.

A site assessment is not required if:

- A properly installed, calibrated, operated and maintained vapor or ground water monitoring system is operating as a release detection method up to the time of permanent closure and the system has given no indication that a release has occurred (The specific requirements for vapor and ground water monitoring release detection systems are found at 40 CFR Part 280, Subpart D - Release Detection, Sections 280.43(e) and (f), respectively); and
- A release does not occur during tank system closure; and
- No obvious contamination is observed during tank system closure.

In certain instances, the owner of an UST system may wish to close only a portion of the system. This "partial" closure of the UST system is a permanent closure and requires a site assessment of the portion(s) of the system that is/are to be closed (e.g. product delivery lines, dispensers, remote fills).

In completing the site assessment for a partial UST system closure, perform the site assessment for the part(s) of the system being closed according to the following sections for closure-by-removal or closure-in-place, depending on the option that is chosen.

Note that closure operations which pull or lift piping out of the ground are considered closure-in-place for purposes of site assessment, as they do not allow a thorough inspection and visual evaluation of the conditions in the vicinity of the piping.

In cases where the tank is located over a concrete pad, the decision to sample beneath the pad or at the edges of the pad and the specific locations where to take confirmatory samples is effected by factors such as the areal extent, condition, and thickness of the pad, and whether there is any slope or surface irregularities to the pad that could influence the direction of liquid flow through or off the pad. Because of the variability of conditions that may be encountered, the regional office should be contacted for specific requirements when tanks on concrete pads are encountered during removal or closure-in-place.

1. Tank System Removed from the Ground (See diagram on page 16)

If the storage tank system is going to be removed from the ground, the site assessment will be performed during the removal from service activities. Therefore, the person(s) conducting the site assessment must be present during the excavation of any material necessary to remove the tank system. The recommended site assessment procedures are as follows:

a. Excavate Soil/Backfill

Begin by excavating only that amount of soil and backfill material necessary to remove the tank system from the ground while observing for evidence of obvious contamination. (Once the tank system is removed from the ground, removal of any soil more than three feet beyond the tank system in any direction, will be considered as remedial activity and will not require the use of a certified installer.) Obvious contamination includes, but is not limited to:

(1) Product stained or product saturated soil or backfill,

(2) Ponded product in the excavation,

(3) Free product or sheen on the water in the excavation.

Obviously contaminated soils must be segregated from soils not suspected to be contaminated during excavation. This may be accomplished by visual observation and by field screening the soils as they are excavated using field instruments such as photoionization detectors, flame ionization detectors, portable gas chromatographs and other appropriate field measurement procedures. The document "Field Measurements: Dependable Data When You Need It," (EPA/530/UST-90/003) prepared for the U.S. Environmental Protection Agency, September 1990, describes a number of analytical field procedures.

Segregation of soils during excavation will facilitate laboratory testing, treatment and disposal. Also, excavated soils should be segregated from concrete and asphalt material. Soils should be stored in accordance with Section VI.B.3, page 9.

If obvious contamination is observed, the owner or operator must proceed as in Section "b." below. If obvious contamination is not observed, the owner or operator must proceed as in Section "c".

b. Obvious Contamination

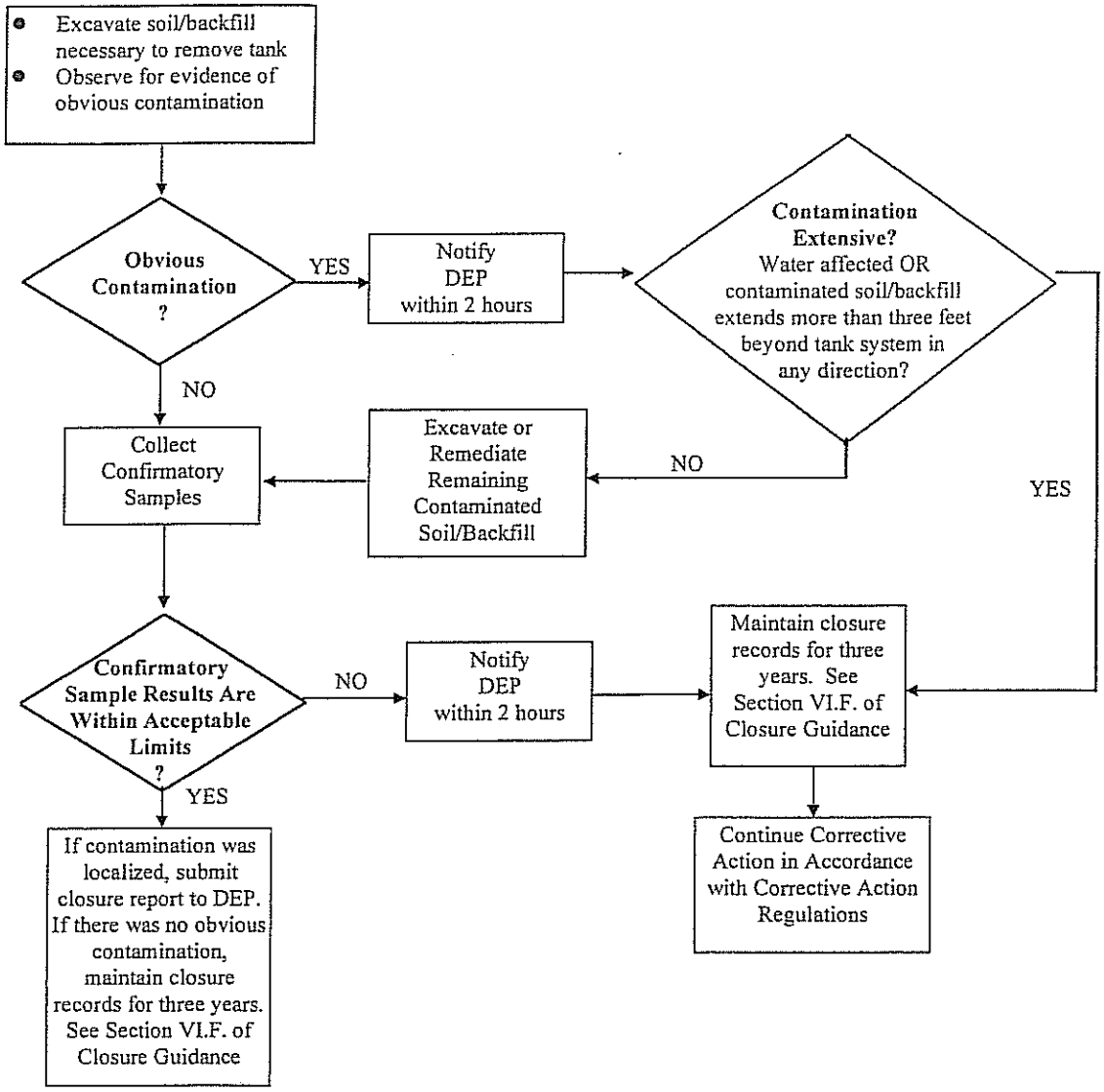
If obvious contamination is observed, the owner or operator must notify the appropriate regional office of DEP within two hours. See Attachment 1 for release reporting telephone numbers.

If obvious contamination is observed and the obviously contaminated soils are not segregated from soils not suspected to be contaminated, the excavated soils may not be placed back in the excavation without treatment and/or testing. **If the obviously contaminated soils are segregated from soils not suspected to be contaminated, the believed to be "uncontaminated" soil pile must be sampled in accordance with Section "d.(5)" before being placed back in the excavation or reused on-site.**

(1) Localized Contamination

Localized contamination is defined as contamination that does not extend more than three feet beyond the tank system in any direction, and does not impact water in the excavation.

SITE ASSESSMENT
TANK REMOVAL



In order to check if contamination is localized, proceed with the excavation of up to three feet of soil extending from the tank system. If, after excavation, soil and any water in the excavation appear visibly uncontaminated, proceed with the confirmatory sampling protocol (Section "d"). Submit the closure report form (Attachment 4) or other report satisfying the requirements of §245.310(b) within 180 days of reporting the release (see Section VI.F., page 31). Note that the confirmatory sample locations in section "d" do not apply if the excavation has extended more than three feet from any part of the tank system being closed.

While it is advisable to leave the excavation open until the sample analysis results are known, safety considerations may warrant that the excavation be backfilled once the samples are obtained. In such a case, however, where sample results indicate unacceptable levels of contamination, additional corrective action will be required.

(2) Extensive Contamination

Extensive contamination is defined as contamination which extends more than three feet beyond the tank system in any direction, or impacts water in the excavation. Additional site characterization and corrective action will be required in cases of extensive contamination. In this circumstance, the requirements of the corrective action process regulations must be followed.

Where contamination is extensive, confirmatory samples need not be obtained. However, it may be desirable to take samples for purposes of beginning the site characterization. Records of the closure site assessment must be maintained in accordance with Section VI.F.

c. No Obvious Contamination

If obvious contamination is not observed, proceed with the confirmatory sampling protocol (Section "d."). Records of the closure site assessment must be maintained in accordance with Section VI.F.

If obvious contamination is not observed, the soil pile from the excavation does not have to be sampled if the soil is being reused on-site. However, if the confirmatory sampling performed in accordance with Section "d." reveals contamination exceeding the department's statewide standards/action levels, the department may require sampling of the soil pile.

While it is advisable to leave the excavation open until the sample analysis results are known, safety considerations may warrant that the excavation be backfilled once the samples are obtained. In such a case, however, where sample results indicate unacceptable levels of contamination, additional corrective action will be required.

d. Confirmatory Sampling Protocol/Tank System Removal (See table on page 19)

This sampling protocol applies only where there is no obvious contamination, or where there is localized contamination. Where extensive contamination has been established, and a site characterization must be performed, a site-specific sampling protocol must be developed to determine the magnitude and extent of the contamination.

All confirmatory samples (with the exception of "uncontaminated" soil pile sampling) must be discrete samples collected in the native soil, one foot below the product delivery

line and two feet below product dispensers, tanks and remote fills. Where bedrock and backfill interface, samples of the backfill may be collected. Where water is encountered, both soil and water samples must be collected. Soil samples are to be taken just above the soil/water interface.

Samples must be collected from all of the following locations for each tank system:

(1) Product Dispensers: one sample below each product dispenser, including dispensers which distribute multiple products.

(2) Product Delivery Lines: one sample from within the piping trench below the product delivery line, directly below a swing joint, flex connector or pipe elbow, if one exists. In cases where there is no swing joint, flex connector or pipe elbow, one sample must still be taken. The exact location of the sample should be chosen by the person conducting the site assessment at a location which in their judgment is most likely to indicate any release of regulated substance. If product delivery lines to different tanks lie within two feet of each other and carried the same product (e.g. gasoline), the piping runs may be sampled as if only one product delivery line was present.

Closure operations which involve pulling or lifting the piping out of an unexposed or unexcavated trench are to be considered closure-in-place as they do not allow a thorough inspection and evaluation of the soil conditions in the vicinity of the piping. See Section VI.C.2.e.(2), page 22.

The location of the sample along the piping run must be shown on the sampling plot plan. Photographs showing the exposed piping trench should be included with the closure records.

(3) Tanks:

Where water is not encountered in the tank excavation, soil samples must be collected as follows:

- For tank capacities up to and including 1,000 gallons, one sample below the bottom of the tank directly below the fill connection and one sample below the bottom of the tank directly below the product.

CONFIRMATORY SAMPLING PROTOCOL
TANK REMOVAL
Number of Samples

NO WATER ENCOUNTERED					
	TANKS*		PRODUCT DISPENSERS	DELIVERY LINES	REMOTE FILL (IF PRESENT)
	<= 1000 GAL	1001-20000 GAL			
SOIL**	2	3	1	1***	1
COMMENTS	Take Samples 2 Ft. Below Bottom of Tank-See Section d. (3), Pages 18 and 20 For Specific Locations		Take 1 Sample Per Dispenser, 2 Ft. Below Surface Directly Under Dispenser	Take 1 Ft. Below Line	Take 2 Ft. Below Fill Opening

WATER ENCOUNTERED					
	TANKS*		PRODUCT DISPENSERS	DELIVERY LINES	REMOTE FILL (IF PRESENT)
	<= 1000 GAL	1001-20000 GAL			
SOIL**	2	2	1	1***	1
WATER	1	2	****	****	****
COMMENTS	Take Soil Samples Just Above Soil/Water Interface Along Each Long Wall Of Excavation-Take Water Samples From Water Surface In Excavation		Take 1 Sample Per Dispenser, 2 Ft. Below Surface Directly Under Dispenser	Take 1 Ft. Below Line	Take 2 Ft. Below Fill Opening

* For tanks in excess of 20,000 gallons, contact the DEP Regional Office responsible for the county in which the tank is located.

** Where obvious contamination is observed, one composite sample per 100 cubic yards of the uncontaminated soil pile must be collected at a minimum depth of 12 inches, if it is intended to be reused on-site. Also, for up to 100 cubic yards, one discrete sample for each 50 cubic yards or fraction thereof, of the contaminated soil pile must be collected, if it is intended to be reused on-site. One discrete sample for each additional 100 cubic yards of contaminated soil must also be taken. The samples are to be taken from the most obviously contaminated areas based upon visual observation and field screening.

*** If piping is closed-in-place, see Section VI.C.2.e. (2), p. 22.

**** Assumes water is not encountered.

delivery line connection. In cases involving the removal of more than one tank from a single excavation, soil samples are to be collected for each individual tank.

- For tank capacities of 1,001 up to and including 20,000 gallons, one sample below the bottom of the tank directly below the fill connection, one sample below the bottom of the tank directly below the product delivery line connection, and one sample below the bottom center line of the tank away from the fill and product delivery line connection sampling locations. In cases involving the removal of more than one tank from a single excavation, soil samples are to be collected for each individual tank.

- For tank capacities over 20,000 gallons, additional samples may be required. Contact the appropriate regional office for further guidance.

In cases where more than two feet of soil has been removed from below the tank to remove localized contamination, take samples from the surface of the bottom of the excavation as soon as possible following tank removal.

Where water is encountered in the tank excavation, water samples must be collected in addition to soil samples, as follows:

- For tank capacities up to and including 1,000 gallons, one water sample from the water surface in the excavation and one soil sample from each long wall (total of two soil samples) just above the soil/water interface. In cases involving the removal of more than one tank (assuming each tank is 1,000 gallons or less in size) from a single excavation, the excavation may be sampled as if it contained only one tank. For example, if a single excavation was opened to remove three 1,000 gallon tanks, the sampling requirement would continue to be one water sample from the water surface in the excavation and two soil samples, one from each long wall of the excavation taken just above the soil/water interface.

- For tank capacities of 1,001 up to and including 20,000 gallons, two water samples from the water surface in the excavation and one soil sample from each long wall (total of two soil samples) just above the soil/water interface. In cases involving the removal of more than one tank (assuming at least one is 1,001 up to and including 20,000 gallons in size), from a single excavation, the excavation may be sampled as if it contained only one tank.

- For tank capacities over 20,000 gallons, additional samples may be required. Contact the appropriate regional office for further guidance.

(4) Remote Fills: if a remote fill is present, one sample below the fill opening.

(5) Soil Pile Sampling: In cases where obvious contamination was observed (either localized or extensive) and soil was segregated into "presumably contaminated" and "presumably uncontaminated" piles:

(a) One composite sample per 100 cubic yards of the "presumably uncontaminated" soil must be collected and analyzed prior to reuse of the soil on-site. Each composite sample should consist of four subsamples

of the soil pile collected at a minimum depth of twelve inches into the soil pile.

(b) For up to 100 cubic yards, one discrete sample for each 50 cubic yards or fraction thereof, of the "presumably contaminated" soil must be collected and analyzed prior to reuse of the soil on-site. One discrete sample for each additional 100 cubic yards of soil must also be taken. The samples are to be taken from the most obviously contaminated areas based upon visual observation and field screening. Sampling may be conducted prior to or following any treatment. Treatment and disposal options for contaminated soil are discussed in Section VI.B.7.c., page 13.

It is important to understand that soil which exhibits contaminant levels below the department's statewide standards/action levels provided in Attachment 5 is not necessarily considered "clean fill." This soil, which frequently contains some level of contamination, can be spread on the site or placed back in the excavation provided the "standards for reuse of soil on-site" values of Attachment 5 are met. **In addition, there must be no free liquids left in the soil based on visual inspection and the soil should not create any odor nuisance.** If off-site use of the soil is desired, the owner of the soil should contact the appropriate regional office waste management staff.

2. Tank System Closed-in-Place or Change-in-Service (See diagram on page 23)

The department does not recommend closure of tanks in-place. However, there may be certain instances where structural considerations or access problems prevent tank system removal. The recommended site assessment procedures are as follows:

a. Physically determine whether water will be encountered in the sampling process (i.e. between the ground surface and two feet below the bottom elevation of the tank).

b. If water is not encountered, samples must be collected in the native soil, one foot below the product delivery line and two feet below product dispensers, tanks and remote fills. Where bedrock and backfill interface, samples of the backfill may be collected. Samples are to be collected in accordance with Section "e." below.

c. If water is encountered, both soil and water samples must be collected. Soil samples are to be taken just above the soil/water interface. Samples are to be collected in accordance with Section "e." below.

Note: Where water is encountered between the ground surface and bottom elevation of the tank, sampling through the bottom of the tank should not be conducted. In this instance, tank sampling should be performed by conducting perimeter soil borings as in Section "e. (3)(b)" below. Perimeter soil borings are also necessary when performing a "change-in-service," regardless of water conditions.

d. In the conduct of determining depth to water, performing soil borings or obtaining soil or water samples, observe the soil or water for evidence of obvious contamination (i.e. product stained or product saturated soil, sheen or free product in the water sample).

e. Except where noted, samples must be collected from all of the following locations for each tank system (Also see table on page 25):

(1) Product Dispensers: one sample below each product dispenser, including dispensers which distribute multiple products.

(2) Product Delivery Lines:

Where product delivery lines are going to be left in-place, pulled or lifted from the ground such that the trench they were installed in cannot be thoroughly inspected and evaluated visually, the lines are to be considered as closed-in-place and the sampling protocol is as follows:

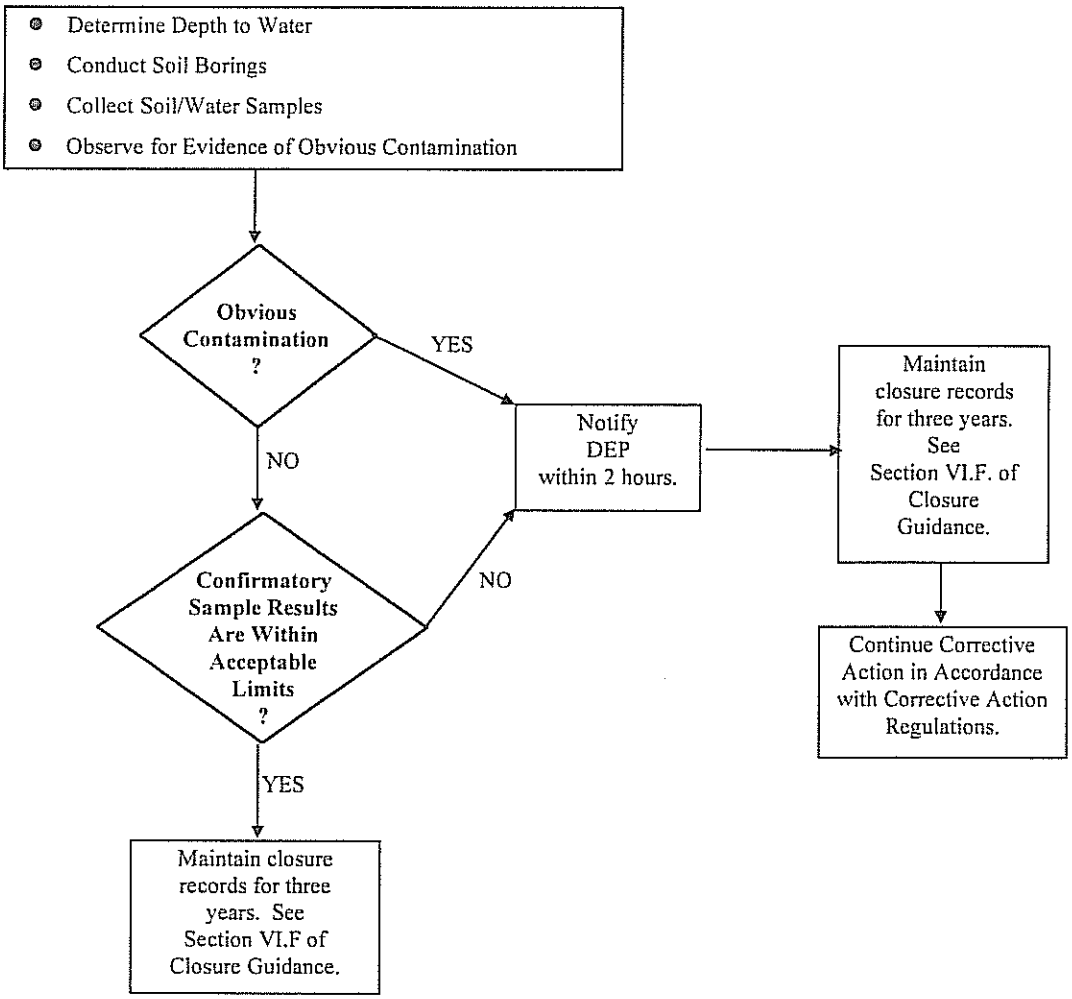
One sample every 20 linear feet below each product delivery line or portion thereof (one sample minimum) up to a maximum of five samples for 81-100 feet of piping. Where the product delivery line is less than 20 feet in length, one sample is still required. Sampling locations should be evenly spaced. Indicate total length of piping in Section III of the Closure Report Form. If product delivery lines to different tanks lie within two feet of each other and carried the same product (e.g., gasoline), the piping runs may be sampled as if only one product delivery line was present. If an individual product delivery line consists of more than 100 linear feet or if it is inaccessible because of a building or some other obstacle, contact the regional office responsible for the county in which the tank is located for site-specific guidance.

(3) Tanks:

(a) Where soils under the tank are accessible, samples are to be collected as follows:

- For tank capacities up to and including 1,000 gallons, one sample below the bottom of the tank directly below the fill connection and one sample below the bottom of the tank directly below the product delivery line connection.

SITE ASSESSMENT
TANK CLOSED-IN-PLACE OR CHANGE-IN-SERVICE



- For tank capacities of 1,001 up to and including 20,000 gallons, one sample below the bottom of the tank directly below the fill connection, one sample below the bottom of the tank directly below the product delivery line connection, and one sample below the bottom center line of the tank away from the fill and product delivery line connection sampling locations.

- For tank capacities over 20,000 gallons, additional samples may be required. Contact the appropriate regional office for further guidance.

(b) Where access to soils under the tank is restricted or where water is encountered between the ground surface and bottom elevation of the tank, samples are to be collected by conducting perimeter soil borings. The borings are to be located as close to the tank as possible, preferably within the backfill, at a distance no greater than five feet from the perimeter of the tank, as follows:

- For tank capacities up to and including 3,000 gallons, one boring along each of the four sides of the tank.

- For tank capacities of 3,001 up to and including 20,000 gallons, two borings along each long wall and one boring along each end wall of the tank.

- For tank capacities over 20,000 gallons, additional borings may be required. Contact the appropriate regional office for further guidance.

(4) Remote Fills: one sample below the fill opening.

f. If obvious contamination is observed, the owner or operator must notify the appropriate regional office within two hours. See Attachment 1 for release reporting telephone numbers. In this circumstance, the requirements of the corrective action process regulations must be followed. Site characterization will be required. Confirmatory samples and laboratory analysis are not necessary to complete the tank closure. Do not fill the tank with an inert, solid, non-shrinking material, until it has been determined that it will be unnecessary to remove the tank as part of the corrective action process. See Section VI.F., page 31, for options on submission and maintenance of closure site assessment records.

g. If obvious contamination is not observed, all samples collected must be quantified by a laboratory. Do not fill the tank with an inert, solid, non-shrinking material until the analytical results are received and it has been determined that corrective action will not be necessary. See Section VI.F., page 31, for options on submission and maintenance of closure site assessment records.

CONFIRMATORY SAMPLING PROTOCOL
CLOSURE-IN-PLACE OR CHANGE-IN-SERVICE
Number of Samples

SOIL UNDER TANK ACCESSIBLE - NO WATER ENCOUNTERED					
	TANKS*		PRODUCT DISPENSERS	DELIVERY LINES	REMOTE FILL (IF PRESENT)
	<= 1000 GAL	1001-20000 GAL			
SOIL	2	3	1	1**	1
COMMENTS	Take Samples 2 Ft. Below Bottom of Tank-See Section e. (3)(a), Pages 22 and 24 For Specific Locations		Take 1 Sample Per Dispenser, 2 Ft. Below Surface Directly Under Dispenser	Take 1 Ft. Below Line	Take 2 Ft. Below Fill Opening
SOIL UNDER TANK ACCESSIBLE - WATER ENCOUNTERED WITHIN 2 FEET OF TANK BOTTOM					
	TANKS*		PRODUCT DISPENSER	DELIVERY LINES	REMOTE FILL (IF PRESENT)
	<= 1000 GAL	1001-20000 GAL			
SOIL	2	3	1	1**	1
WATER	2	3	***	***	***
COMMENTS	Take Soil Samples Just Above Soil/Water Interface-Take Water Samples From Water Surface-See Section e. (3)(a), Pages 22 and 24 For Specific Locations		Take 1 Sample Per Dispenser, 2 Ft. Below Surface Directly Under Dispenser	Take 1 Ft. Below Line	Take 2 Ft. Below Fill Opening
SOIL UNDER TANK NOT ACCESSIBLE OR WATER ENCOUNTERED BETWEEN TANK BOTTOM AND GROUND SURFACE (Using Perimeter Borings)					
	TANKS*		PRODUCT DISPENSER	DELIVERY LINES	REMOTE FILL (IF PRESENT)
	<3000 GAL	3001-20000 gal			
SOIL	4	6	1	1**	1
WATER	4	6	***	***	***
COMMENTS	Take One Soil Sample And One Water Sample (If Water Encountered) Per Boring-If Water Encountered, Take Soil Samples Just Above Soil/Water Interface and Take Water Samples From Water Surface-See Section e. (3)(b), Page 24 For Specific Locations		Take 1 Sample Per Dispenser, 2 Ft. Below Surface Directly Under Dispenser	Take 1 Ft. Below Line	Take 2 Ft. Below Fill Opening

* For tanks in excess of 20,000 gallons, contact the DEP Regional Office responsible for the county in which the tank is located.

** If piping is also closed-in-place, see Section VI.C.2.e. (2), p. 22.

*** Assumes water is not encountered.