CONDUCTING CONTAMINATION ASSESSMENT WORK AT DRYCLEANING SITES

State Coalition for Remediation of Drycleaners
Revised October 2010

State Coalition for Remediation of Drycleaners

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8. North Carolina Drycleaning Solvent Cleanup Act Program
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDIX

CONDUCTING CONTAMINATION ASSESSMENT WORK AT DRYCLEANING SITES

1. INTRODUCTION

According to the United States Department of Commerce 2007 Economic Census, there were 39,484 businesses in the United States that provide drycleaning and laundry services. This includes drycleaning facilities, coin-operated drycleaning and laundering facilities, linen supply, uniform rental and industrial laundering facilities (National Clothesline, 2009). Soil and groundwater contaminated by drycleaning solvent is likely associated with most of these facilities that utilized solvents. One study estimates that 75% of all drycleaning facilities are contaminated (Schmidt, et al, 2001). In addition to active drycleaning facilities, there are a large but unknown number of former drycleaning sites that are also contaminated. Since drycleaning facilities are located in urban areas, drycleaning solvent contamination has impacted a significant number of private and public water supply wells and threatens many other well fields. More recently, vapor intrusion has been identified as a significant environmental issue associated with VOC contamination. To address these problems, thirteen states – Alabama, Connecticut, Florida, Illinois, Kansas, Minnesota, Missouri, North Carolina, Oregon, South Carolina, Tennessee, Texas and Wisconsin have developed drycleaning solvent cleanup programs.

This paper was written by members of the State Coalition for the Remediation of Drycleaners (SCRD), an organization of the thirteen states, which have instituted drycleaning solvent cleanup programs. SCRD is sponsored by the U.S. E.P.A. Office of Superfund Remediation and Technology Innovation. The paper is intended to aid those engaged in conducting site characterization work at drycleaning sites.

In order to effectively conduct site characterization work at drycleaning facilities, it is necessary to have a basic understanding of drycleaning operations, including the drycleaning process, the equipment and chemicals utilized, the wastes generated by the drycleaning process and the historical waste management practices of the drycleaning industry. For additional information on these topics refer to the following papers/presentations posted on the State Coalition for Remediation of Drycleaners website at www.drycleancoaliton.org.

- Tour a Drycleaning Operation
- Regulatory/Compliance Issues at Perchloroethylene Drycleaners
- Glossary of Drycleaning Terms
- Chemicals Used in Drycleaning Operations
- Drycleaning Chemical Database (over 600 chemicals used in drycleaning)
- Chronology of Historical Developments in Drycleaning

2. DRYCLEANING EQUIPMENT AND DRYCLEANING OPERATIONS

2.1 Drycleaning Machines

In early drycleaning operations, the solvent was applied to the garment with a brush on a table and the garments were then rinsed in tubs filled with solvents and then the garments were hung to dry in a warm room. In the late nineteenth century washing machines were used in drycleaning. The Troy Laundry Machinery Company Ltd. reportedly manufactured washing machines that utilized petroleum naphtha as early as 1893 (Martin, 1958). But dryers or “tumblers” were not utilized until the 1920s. This marked the introduction of *transfer machines or “first-generation machines”* which were actually two or three machines including a washer (where the garments were washed), an extractor (where the solvent was extracted from the garments by centrifugal force), and a tumbler (where the garments were dried). Later transfer machines incorporated the extractor in the washing machine. In a transfer machine operation, the clothing is “transferred” from the washer to the tumbler (dryer). This clothing transfer results in solvent vapors escaping to the atmosphere. Some later transfer machine operations captured some of the solvent vapors using inductive fans and a carbon adsorption unit known as a “sniffer”.

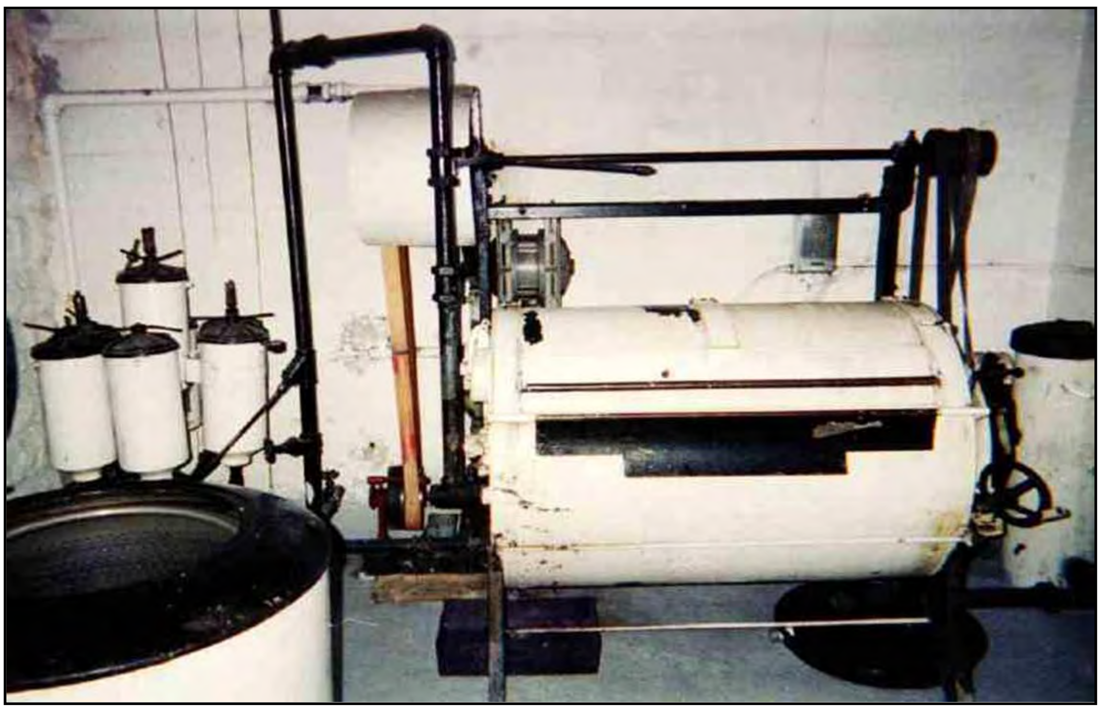

Figure 1. Petroleum Transfer Machine.
The washer, also known as a belly washer, rotates on a horizontal axis. After washing the clothes are transferred to an extractor (left foreground) where solvent is extracted by centrifugal force. Clothes are then transferred to a dryer or tumbler.

Figure 2. Transfer Machine and Solvent AST.
Tumbler on right, Solvent AST on left.

In the 1960s "dry-to-dry" machines were developed in Germany. In dry-to-dry machines, washing, extraction and drying of garments occur in the same machine. The garments go into the machine dry and come out dry, hence the name "dry-to-dry". The earliest dry-to-dry machines are also known as *"second-generation machines"* or the so-called *"vented dry-to-dry machines"*. Outside air is introduced into the machine during the drying cycle to cool the clothing and vapors in the machine and to help remove solvent vapors (deodorize). In early models, the air was vented to the atmosphere but in later models it was routed to a carbon adsorption unit, known in the drycleaning industry as a "sniffer", and then vented to the atmosphere.

Figure 3. Carbon Adsorption Unit (Sniffer).
Solvent vapors recovered from the transfer machine dryer or tumbler (left) are routed to the sniffer (lower center) where they sorb to the carbon. Periodically, solvent is desorbed from the carbon by passing steam through the sniffer. The steam/solvent mixture is routed to the condenser (large black cylinder on right) where the vapors are condensed and the PCE and water go to a water separator (steel cylinder below condenser) where the PCE and water are gravity separated.

A number of improvements have been made to dry-to-dry machines over the years to reduce solvent emissions and thus improve solvent mileage, the amount of fabric cleaned per a quantity of solvent. *Third generation machines* are dry-to-dry machines that utilize refrigerated condensers to recover solvent from vapors in the drycleaning machine. These machines were introduced in the late 1970s and are also known as closed-loop machines. Some second generation drycleaning machines have been retrofitted with refrigerated condensers. *Fourth generation machines*, introduced in the early 1990s are closed-loop machines that utilize refrigerated condensers and two different carbon adsorption units to reduce solvent vapor concentrations in the drum of the drycleaning machine to below 300 parts per million (ppm). The latest drycleaning machines, known as *fifth generation machines* are closed-loop machines that utilize carbon adsorption units and refrigerated condensers to reduce solvent emissions. They are also equipped with an inductive fan and internal solvent vapor monitoring devices and lockout devices that will not allow access to the machine until solvent vapor concentrations are below 300 ppm. These machines were introduced in the late 1990s.

It is estimated that perchloroethylene (PCE) transfer machines used approximately 82 pounds of solvent to clean 1,000 pounds of clothing compared to 34 pounds of PCE used by second-generation machines. The latest drycleaning machines, known as "fifth-generation machines" use approximately 10 pounds of PCE to clean 1,000 pounds of clothing (National Clothesline, 2002).

The Clean Air Act Amendments of 1990 identified PCE as a hazardous air pollutant. On December 9, 1991, the U.S. Environmental Protection Agency (EPA) proposed the National Emission Standards for Hazardous Air Pollutants (NESHAP). One consequence of these standards was the regulation of PCE emissions from drycleaning plants. On September 15, 1993, the EPA Air Office published the Final Air Standard for Perchloroethylene Drycleaners (University of Tennessee, 1995). These air regulations required record keeping, inspections and reporting as well as mandates for retrofitting or replacing certain types of drycleaning equipment based on PCE use. In short, these air regulations have had a greater impact than any previous regulations with regards to changes in drycleaning equipment, practices and solvent usage.

New PCE drycleaning machines have refrigerated condensers, carbon adsorption units, inductive fans and lockout devices, which prevent operators from performing certain operations until PCE concentrations in the air in the machine drum are below certain levels. Under the National Perchloroethylene Air Emissions Standards for Drycleaning Facilities (40 CFR Part 63), effective July 27, 2008, transfer machines can no longer be used in PCE drycleaning operations (EPA, 2006). However, transfer machines are still widely used in petroleum solvent drycleaning operations in many parts of the United States. Some of these petroleum transfer machines recover solvent from the dryers or tumblers. The first recovery petroleum dryers (reclaimers) were marketed in the early 1970s. One measurement of efficiency in the drycleaning industry is solvent mileage or solvent consumption, or the amount of solvent used to clean a given amount of fabric.

Below is a table comparing the solvent mileage for the various generations of PCE drycleaning machines.

Table 1. PCE Mileage per 1000 Kilograms of Clothing Cleaned	
Machine Generation	**PCE Consumption (kilograms)**
First Generation (transfer machines)	78 – 100
Second Generation (vented dry-to-dry)	77 – 94
Third Generation (closed-loop)	20 – 40
Fourth & Fifth Generation	10 – 20
(CARB, 1996)	

Coin-operated drycleaning machines were introduced in 1960 by Whirlpool (Kirk-Othmer, 1965). These are small capacity (8 – 12 pounds of clothing) dry-to-dry machines that use PCE or Freon 113. Spent solvent is purified by filtration. Although the early models had powder filtration systems, the later models used cartridge filters. These machines do not have distillation units. Most of these machines were manufactured in Europe and they are no longer being manufactured. The use of these machines has been banned in some states but some of the PCE machines are still being used in parts of the United States, primarily in Laundromats.

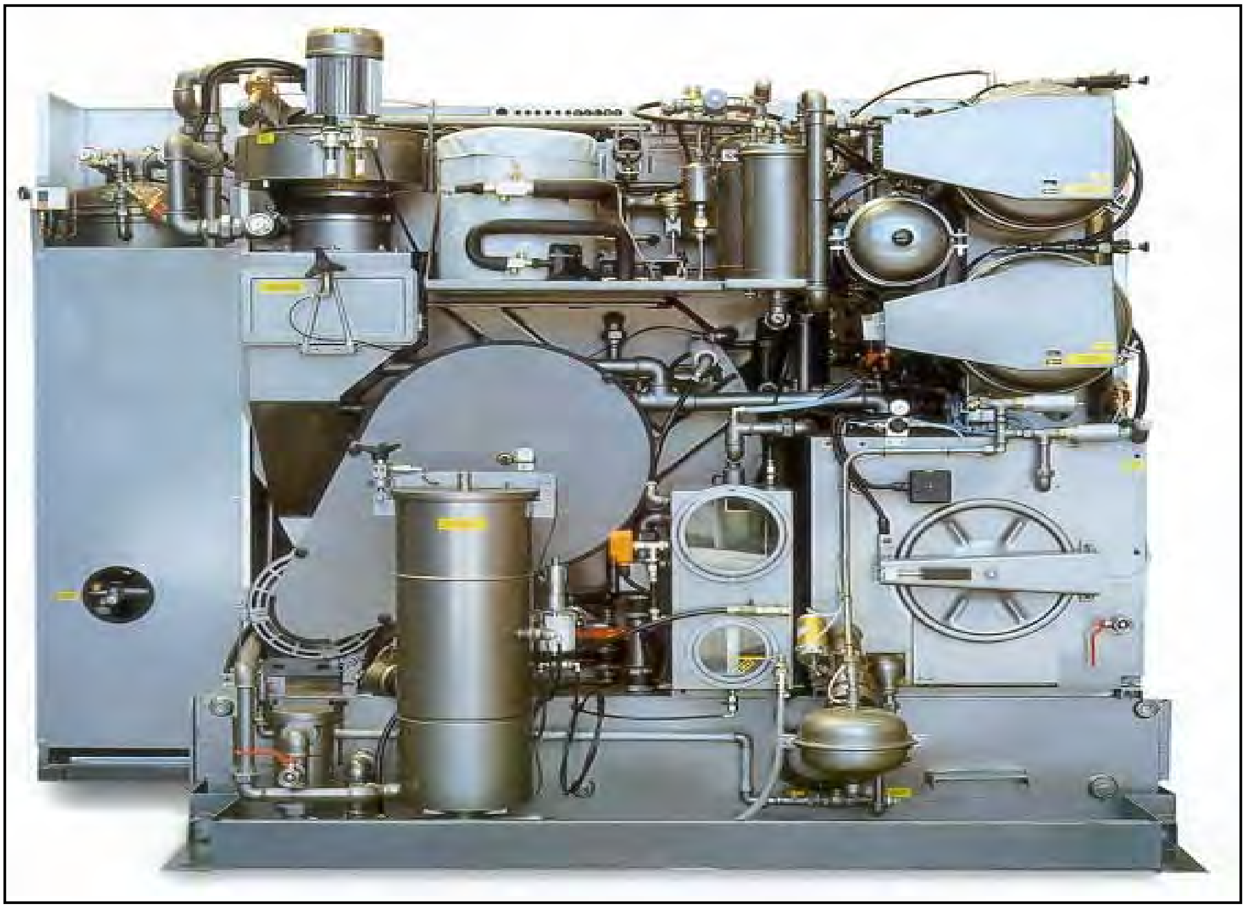

Figure 4. Back of Closed-Loop Dry-to-Dry Machine.

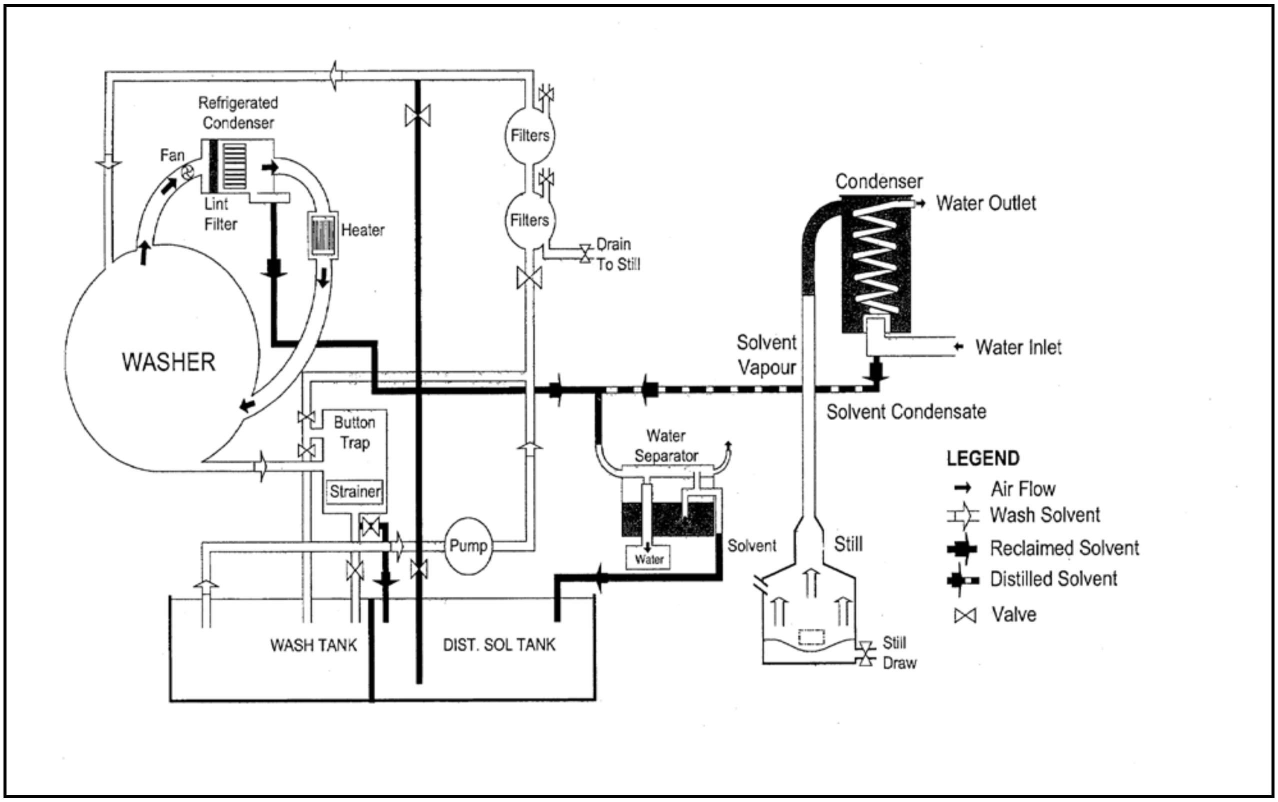

Figure 5. Dry-to-Dry Machine.
(Drycleaning Institute of Australia, 1998)

2.2 The Drycleaning Process

What happens to clothing after it is dropped off at a drycleaning facility? Access "Tour a Drycleaning Operation" on the State Coalition for Remediation of Drycleaners at http://drycleancoalition.org/tour for an illustrated tour of the process. Briefly, the following sequence of events occurs:

- The clothing is marked or tagged for identification.
- The garments are separated or classified on the basis of weight, color and type of fabric.
- If an item of clothing is stained or heavily soiled, it may be pre-cleaned or spot cleaned prior to placing it in the drycleaning machine.
- The clothing is placed into the drycleaning machine where it is washed and then the solvent is extracted from the drum of the machine. The clothing is then either transferred to a dryer (tumbler) in a transfer machine operation, or it is dried in the same machine if it is a dry-to-dry model.
- The garments are removed from the machine. If a garment is still stained, it will be spot-cleaned.

- As part of the finishing process the garments are pressed.
- Finally, the clothing is placed on a hanger and covered with a plastic bag.

2.3 Pre-cleaning/Spotting

At a drycleaning operation, cleaning of stained or heavily soiled garments prior to the normal drycleaning operation is generally performed on a spotting board (see Figure 6). The spotting board is served by steam, water, compressed air and a vacuum line. Delivery of steam, water and compressed air is via a steam/air gun and controlled by foot pedals located at the base of the spotting board. The working surface of the spotting board is shaped similar to the top of an ironing board. At one end of the board is a tray or series of bowls where spotting agents can be stored. The tip or nose of the spotting board has a screen. Under the screen is a vacuum ring. Garments can be held in place by placing them over the nose of the board and pressing the vacuum pedal. Spotting chemicals are applied to stained garments on the board. Various tools (brushes, etc.) can be used to apply mechanical action with the chemicals to removed stains/soils. Wet or dry steam can be applied with the air gun to assist in stain removal. Excess liquid wastes from the spotting process are routed to a drain receptacle (semi-circular steel cylinder) mounted at the base of the spotting board. For a discussion of the chemicals used in spotting and pre-cleaning operations please refer to *Chemicals Used in Drycleaning Operations*, available at the State Coalition for Remediation of Drycleaners website: http://drycleancoalition.org/chemicals/ChemicalsUsedInDrycleaningOperations.pdf.

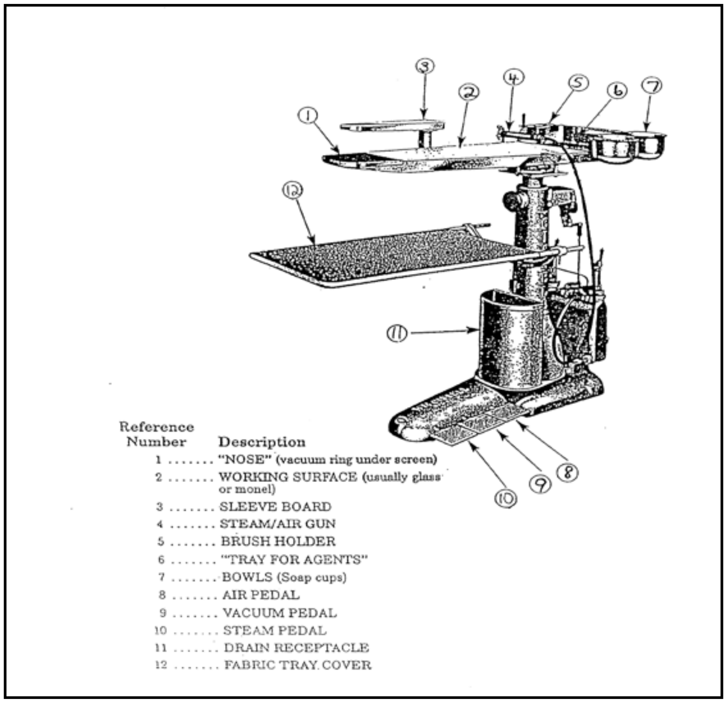

Figure 6. Conventional Spotting Board.
(Concord Custom Cleaners, 1994).

In a modern drycleaning operation, the drycleaning of clothing begins with the placement of the clothing in the drum of the machine. The machine is then "charged" with a synthetic detergent (surfactants) and solvent. Generally the detergent constitutes 1 to 2% of the charge by volume. Some drycleaners add a small amount of water to the detergent to form an emulsion and to remove water-soluble soil. However, sufficient moisture is generally present in the clothing from humid air and the addition of water is not necessary. After the solvent is added to the drum the clothes are tumbled in the solvent for approximately five minutes. During this time, clean solvent is added to the drum and dirty solvent is withdrawn and filtered. At the end of the wash cycle, the solvent is drained from the drum and then extracted from the garments in the spin cycle. The drum is refilled with clean solvent and the clothes are rinsed for approximately three minutes. Then the solvent is drained and extracted as earlier. The clothing is then dried for approximately 12 minutes with air heated to approximately 140 F. During the drying cycle, solvent-laden air is routed to a refrigerated condenser to remove solvent from the air. Cool air is then circulated in the drum for approximately 12 minutes and then routed to a carbon adsorption unit to remove the solvent from the air. The entire drycleaning cycle lasts for 39 – 45 minutes (Eastern Research Group, 2005).

2.4 Solvent Clarification

Historically, drycleaners have clarified or purified dirty solvent (removed soils and impurities) by five different processes: distillation, settling, centrifugal force, chemical treatment and filtration. Distillation was reportedly first used to purify drycleaning solvents in the United States in the early part of the twentieth century (Martin, 1958). Figure 7 is a drawing of an early distillation unit (circa 1909) used to purify petroleum naphtha drycleaning solvent. In the distillation process the spent solvent is vaporized in the distillation unit or "still" by heating with steam. The boiling point of PCE is 250 F, however, water will be present with the PCE and an azeotrope is formed which has a lower boiling point, 190 F. The solvent/water vapors are routed to a condenser leaving nonvolatile residues and impurities behind in the distillation unit. The solvent vapors are cooled in the condenser by the circulation of chilled water through the condenser coils, which lowers the temperature of the solvent/water vapor to below the solvent's dew point causing the solvent and water vapors to condense. The liquid resulting from condensation is a mixture of solvent and water and any other compound that was present in the still that has a boiling point lower than the temperature generated by the distillation unit. The distillation unit is incorporated into modern drycleaning machines. In some older operations it is a separate piece of equipment. The solvent is recovered by gravity separation in a water separator. Distillation units used in conjunction with drycleaning machines that use powder filtration systems are called "muck cookers".

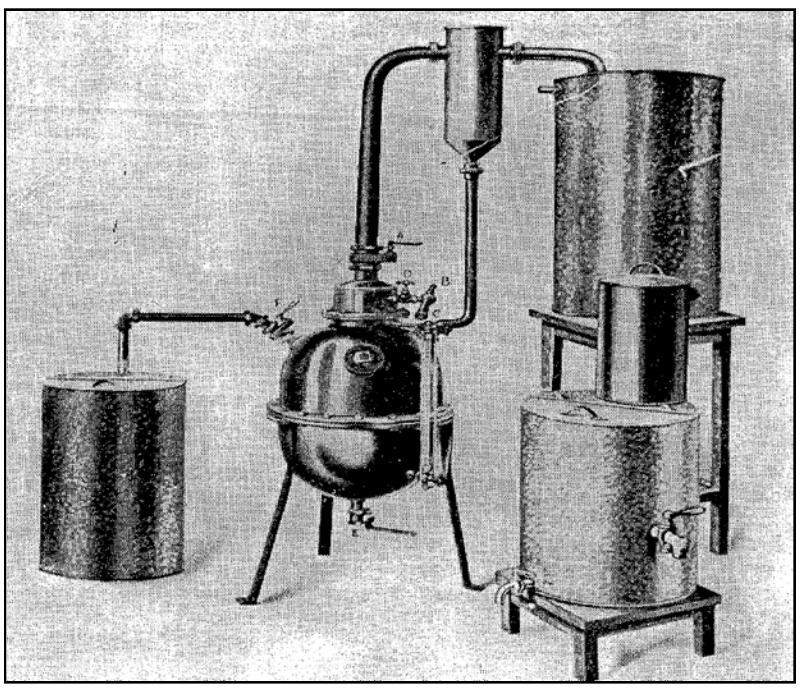

Figure 7. Drycleaning Petroleum Naphtha Distillation Unit. Circa 1909 (Michelsen, 1957)

Petroleum drycleaning solvent is a mixture of many petroleum compounds. Reportedly over 200 compounds are present in Stoddard solvent. Petroleum solvent has a boiling range of from 300 to 410 F (Caplan, 1981). Distillation of petroleum solvent at high temperatures presents a fire hazard and high distillation temperatures can breakdown or "crack" some of the petroleum compounds with lower boiling points. Therefore distillation of petroleum drycleaning solvents is performed in a sealed unit under a vacuum (normally 27 – 29 inches). The higher flash point petroleum solvents require higher steam pressure for still operation. Many petroleum drycleaners do not perform distillation. Instead they use filtration to purify the dirty solvent.

Settling tanks were used to purify dirty solvent as early as 1905. Dirty solvent was routed to tanks where the impurities were allowed to settle to the bottom of the tank and the solvent (petroleum solvent) was skimmed from the top of the tank or recovered for re-use after it flowed over the top of a series of baffles (Lohman, 2001). Sludge with associated waste solvent was discarded. Physical separation of solvent and soil/wastes was accomplished in a much shorter period of time by the introduction of *centrifuges*. Centrifuges allowed for the segregation of soils or wastes via centrifugal force while solvent was continuously circulated through the washing machine.

In addition to the physical separation of impurities from solvent, chemicals were sometimes used in the clarification process. Two different types of chemical treatment were utilized: *alkali treatment* and *sulfuric acid treatment*. Caustic soda (a.k.a. sodium hydroxide or lye) was the alkali most commonly used to treat dirty petroleum solvent. Other alkalis have been used including sodium metasilicate, sodium sesquisilicate and sodium orthosilicate. The main function of the alkali treatment was to saponify or convert fatty acids from solvent soluble compounds into water soluble compounds (Randall, 1940). Generally, an 8-10% solution of caustic soda (sodium hydroxide) was mixed with or bubbled through the dirty solvent to facilitate removal of impurities. Although not as common, dirty solvent was sometimes treated with sulfuric acid to remove unsaturated fatty acids from the solvent that could not be removed by alkali treatment. Generally 2 to 3 quarts of concentrated sulfuric acid was used to treat 100 gallons of solvent (Randall, 1940). Clarified solvent was routed to a dump tank that was often located beneath the floor of the facility.

Activated carbon was generally used in conjunction with the alkaline and acidic clarification processes to remove color or dyes from the solvent. Since this first application of filtration, a wide variety of filter types have been used in drycleaning operations to purify solvents, including bag filters, flat screen filters, rigid-tube filters, flexible tube-filters, cartridge filters, and spin disc filters. Filters were reportedly first used to purify drycleaning solvent in the United States in the early 1920s (Lohman, 2001).

Filtration

Early filter systems used powder filtrate materials, typically diatomaceous earth or diatomite (a siliceous powder), or a combination of diatomite and granular activated carbon. The spent solvent was filtered through these materials, which were applied as a coating to bags, wire screens or metal tubes. The earliest of these filters were known as *bag filters*. These were a series cloth bags mounted on frames hung in a cylinder. The cloth utilized was generally a heavy canvas. Powder filtrate material (diatomite) was pumped with the solvent and formed a coat or filter cake on either the outside or inside of the bags. The dirty solvent was purified as it flowed through the powder filtrate material and cloth bags which trapped soil particles. The solvent flow held the filtrate material on the bags. These types of filters are therefore also known as constant pressure filters. Periodically, the bags were removed for cleaning. Some solvent was recovered from the spent filtrate material, known as muck, via distillation, or the spent filtrate material was discarded.

Flat screen filters were introduced in the 1940s (Lohman, 2002). They were constructed of fine mesh Monel metal wire mounted on a rectangular frame. The filters were mounted in a vertical position with nipples feeding into a manifold. The powder filtrate material was deposited directly on the screen filter. Solvent was purified by flowing through the filtrate material and screens. Another type of flat screen filters consisted of circular screens mounted in a horizontal plane with brushes mounted between the screens. The screens were cleaned by rotating the brushes.

In the 1950s, tube filters were introduced in drycleaning operations (Lohman, 2002). Two types of tube filters have been utilized in drycleaning operations: *rigid tube filters* and *flexible tube filters.* Rigid tube filters are constructed of a fine metallic wire. The tubes were suspended vertically from a plate within a cylinder. Powder filtrate material was deposited on the outside of the tubes and the dirty solvent was filtered by passing through the filtrate material and wire mesh material and out of the tops of the tubes. When the filtrate material was spent it was washed off the outside of the tubes by reversing the solvent flow, a process known as *backwashing*.

Flexible tube filters were constructed of fine-mesh Monel wire and were flexible. They functioned much like rigid tube filters. However, the flexibility of the filter tubes allowed the spent filtrate material to be discharged from the tubes by mechanical action referred to as *flexing or bumping*.

Bag filters, flat screen filters and tube filters have been replaced by cartridge filters and spin disc filters in modern drycleaning operations. *Cartridge filters* were first utilized in drycleaning operations in the early 1960s (Caplan). Cartridge filters generally consist of an outer perforated metallic shell enclosing a pleated paper filter element that surrounds a perforated canister filled with activated carbon, activated clay or a combination of activated carbon and activated clay. Solvent flows through the outer shell of the filter through the pleated paper (generally treated with a phenolic-formaldehyde resin). The pleated paper removes most insoluble soil. The solvent then flows through a perforated inner shell which encases activated carbon or activated carbon and activated clay. After passing through the carbon or carbon-clay core, the solvent exits through a center or outlet tube composed of laminated paper or perforated metal. This tube is wrapped with polypropylene or nylon. Cartridge filters are mounted in series in filter tubes or housings (see Figure 21). Felt washers are placed between cartridge filters and on the outside of the first and last filters in the filter housings. These washers function as absorbent seals (Caplan, 2003). *Polishing filters,* or *final filters,* a type of cartridge filter, utilize resin-bonded fibers, a spiral cotton element or pleated paper as the filter medium. The function of a polishing filter is to remove "the last traces of insoluble soil from well filtered solvent and to catch any accidental soil particles during a sudden breakthrough of soil in the main filters" (IFI, 1995).

Cartridge filters are available in a range of sizes (from 7 5/8 inches in diameter x 14 ¼ inches in length to 13 1/4 inches in diameter to 18 1/8 inches in length). A standard cartridge filter (7 5/8 inches x 14 1/4 inches) contains 2.5 pounds of activated carbon. The primary function of the cartridge filters with carbon cores is to remove fugitive dyes. The adsorptive cartridge filters contain activated carbon and activated clay (typically attapulgite or montmorillonite). In addition to the removal of fugitive dyes from the solvent, these filters will sorb water, alcohol, acids, aldehydes, ketones, olefins, natural esters, aromatics, cyclo-paraffins, and paraffins. The jumbo full-size adsorptive cartridge filters contain 8 pounds of activated carbon and 14 pounds of activated clay (Caplan, 2003). The adsorptive cartridge filters are often used in drycleaning machines where distillation is not utilized. These are commonly petroleum solvent drycleaning machines.

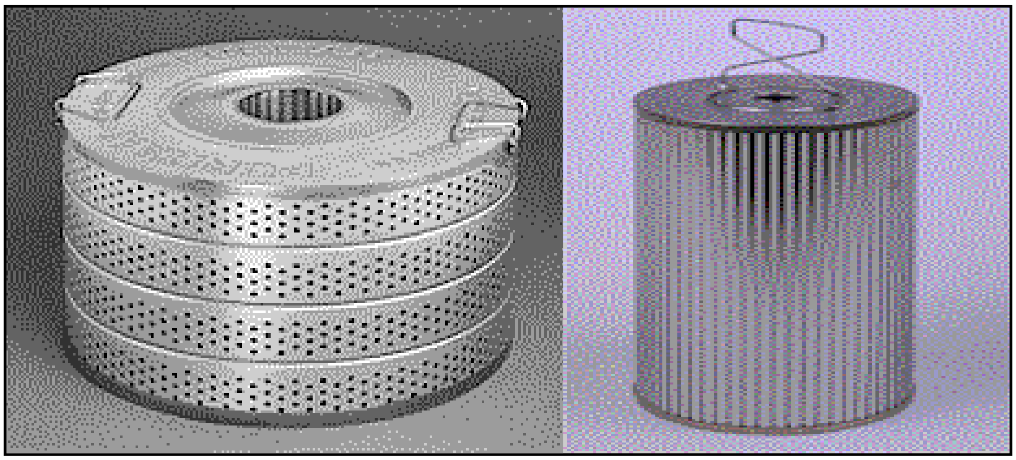

Figure 8. Cartridge Filters.

Spin disc filters were introduced to drycleaning in the 1980s and are now the primary filtration systems employed in most new drycleaning machines. A spin disc filter is a device containing a series of discs covered with finely-woven polyester mesh (to filter impurities) mounted on a hollow central shaft with a motor drive to spin the shaft. Solvent is pumped into the central filter housing and flows through the polyester discs (see Figure 9). Two types of spin disc filter systems are in use. One uses filter powder (diatomite or a combination of diatomite and activated carbon), which coats the surface of the discs. Soils are trapped in the filtrate material and on the polyester mesh. In these types of systems the openings in the polyester mesh are generally 60 microns in size. In the powderless spin disc filters, the mesh openings are smaller, typically 30 microns. No filter powder is used and the impurities are trapped on the polyester mesh. After passing through the polyester discs, the solvent is routed through holes in the central shaft for re-use.

Periodically, solvent pumping is stopped and the hollow shaft is rotated, spinning the polyester discs (*hence the name spin disc*). The resulting centrifugal force discharges the soils to the bottom of the filter housing through a pipe to the distillation unit. In general, spin disc filter systems generate less waste, particularly the powderless systems, and minimize waste handling.

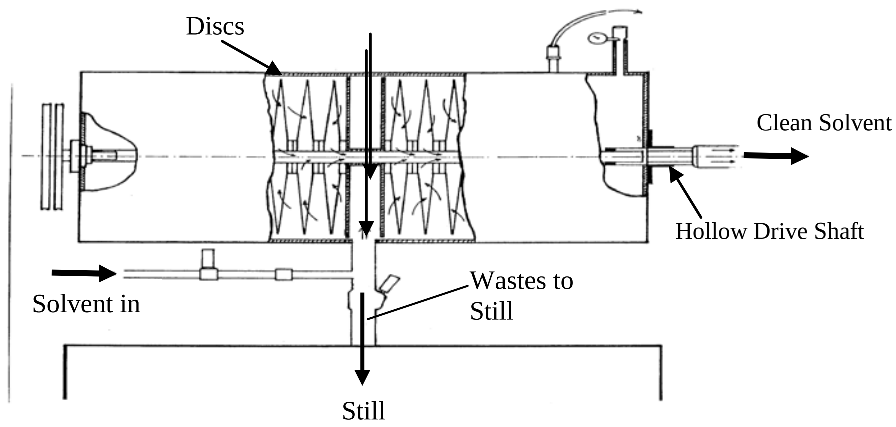

Figure 9. Spin Disc Filter System.

3. WASTES GENERATED IN DRYCLEANING OPERATIONS

A variety of wastes are generated during the drycleaning process. In chlorinated solvent drycleaning operations, most of these wastes are hazardous. Discharges of these wastes have caused soil and groundwater contamination at drycleaning sites. Prior to November 21, 1980, when the Resource Conservation Recovery Act (RCRA) was promulgated, there was little regulation of wastes generated at drycleaning operations. The notification deadline for small quantity generators of hazardous waste under the Hazardous and Solid Waste Amendments (HSWA) to RCRA was in September 1986. Most drycleaners did not contract hazardous waste haulers for disposal of hazardous waste prior to the mid-1980s.

3.1 Contact water

Contact water is any water that has come into contact with drycleaning solvents or drycleaning solvent vapors. Contact water will contain some concentration of dissolved solvent. There are several types of contact water generated by drycleaning operations: separator water, vacuum water, mop water and process water.

Separator water is generated during the distillation and solvent recovery processes. As discussed earlier, vapors from the distillation process are condensed into a liquid – a mixture of solvent and water. The solvent is separated from the water by gravity separation in a water separator (see Figure 10). The recovered separator water is generally routed to a five-gallon plastic bucket, located behind the drycleaning machine. The separator water is saturated with respect to solvent. At room temperature, approximately 150 milligrams per liter PCE will be dissolved in the separator water. In PCE drycleaning operations, some free-phase PCE is generally found in the bottom of the separator water bucket. The condenser in a PCE drycleaning machine should operate at a temperature of less than 45 F. If not, some of the separation of solvent and water will occur in the plastic collection bucket rather than in the condenser.

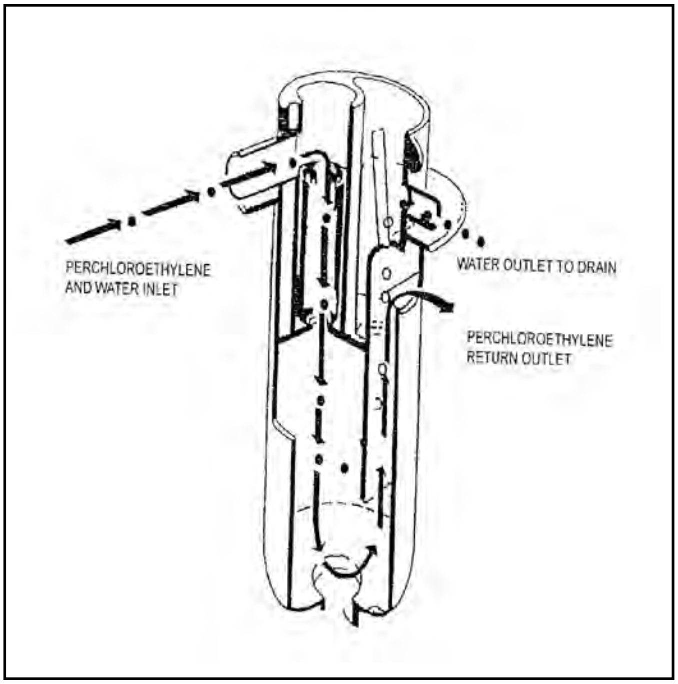

Figure 10. PCE Water Separator.

Vacuum water samples collected from PCE drycleaning operations generally contain PCE in concentrations in the tens of parts per billion range, but PCE has been detected in some vacuum water samples in concentrations exceeding 100 parts per billion.

Mop Water is a commonly overlooked source of contact water at drycleaning facilities. Mop water can collect solvent from vapors, lint and still bottoms at a drycleaning facility. It is not uncommon, during the operation of some drycleaning machines, to splash still bottoms or cooked powder residues when cleaning out the distillation unit or muck cooker. When these distillation residues are mopped up they can saturate the mop water with solvent.

Conventional Laundry Waste Water
If clothing is pre-cleaned or spot-cleaned with solvents prior to conventional laundering or if drycleaned clothing containing residual solvent is conventionally washed, drycleaning solvent will be present in the wash water.

Vacuum water is also known as *press-return water*. Drycleaned clothing will retain some residual drycleaning solvent. When the drycleaned clothes are steam pressed, some of the drycleaning solvent retained in the clothing will be dissolved into the steam and steam condensate. The contaminated steam and condensate from this operation is collected in a *vacuum unit*. The vacuum unit is composed of a small tank with a vacuum pump mounted on the top (see Figure 11).

Figure 11. Vacuum Unit.
Vacuum water is stored in the tank. It is drawn off at the valve at the base of the tank. A vacuum pump is mounted on the top of the unit.

Process Water – Some drycleaners have steam-cleaned drycleaning machines. The steam condensate generated by these operations is contact water.

Boiler blow down water – In order to prevent scale buildup, water/steam is normally purged daily from boilers through a process known as blowdown. Normally, boiler blowdown water is not contact water. However, some drycleaners have utilized separator water in their boilers.

Solvent can also be introduced to the boiler from the distillation unit. After the distillation process, some solvent is still present in the still bottoms. Some drycleaners recover some of this solvent through azeotropic distillation. In this process, the distillation unit is allowed to cool and then water or live steam is introduced into the distillation unit. Introduction of live steam to the distillation unit is referred to as steam sweeping. The still bottoms water/steam mixture is then slowly distilled to recover additional solvent. If not properly conducted, steam sweeping can result in a steam/solvent mixture back-flowing into the boiler.

3.2 Still Bottoms/Muck/Cooked Powder Residues

The waste product generated from the distillation process is known as either still bottoms or cooked powder residues (from powder filtration systems). Still bottoms contain grease, oil, detergent, dyes, sizing, waxes, filter materials and other non-volatile residues. A study of wastes generated at Canadian drycleaning plants found PCE concentrations as high as 75% by weight in still bottoms and as high as 56% by weight in cooked powder residues (Beak Consultants, 1990). Not all drycleaners perform distillation. This is particularly true of many petroleum solvent drycleaning operations, which sometimes purify solvent by filtration alone. If these operations use powder filtration systems, the filter waste generated, known as "muck", can contain considerable solvent.

Figure 12. Distillation Residues.
Distillation residues or still bottoms drawn off the still into the blue bucket, white bucket collects separator water.

3.3 Spent Cartridge Filters

Spent jumbo cartridge filters can contain up to one gallon of solvent. Some of this solvent can be recovered if the filters are allowed to drain before they are changed. Standard cartridge filters should be drained in the machine for 24 hours prior to being removed, and adsorptive cartridge filters be should be drained in the machine for 48 hours prior to being removed from the drycleaning machine. Additional solvent can be recovered from the spent cartridge filters in a steam cabinet.

Figure 13. Spent Cartridge Filters.
Filters place in boxes behind drycleaning Facility.

3.4 Spent Solvent

At drycleaning facilities that waterproofed garments, PCE was commonly used as the carrier for the waterproofing agent. Garments were waterproofed by immersion in a dip tank that was filled with the waterproofing agent. Oils, fats, lint and other non-volatile residues from the garments would accumulate in the dip tank and periodically the spent waterproofing agent, containing solvent (generally up to 30 gallons or more) would have to be discarded (Albergo, 1997). In extreme cases, PCE solvent has become so acidic that it has to be discarded. Petroleum drycleaning solvent that has gone rancid (biodegraded) and acquired a sour odor also must be discarded.

3.5 Spotting Residues

These are wastes that are generated during the pre-cleaning or spotting process. They can contain a variety of chemicals: solvents, acids, enzymes, bleaches, bases, enzymes, detergents etc. Spotting wastes are collected by a vacuum line at the spotting board and routed to the vacuum unit or to a drain receptacle mounted at the base of the spotting board.

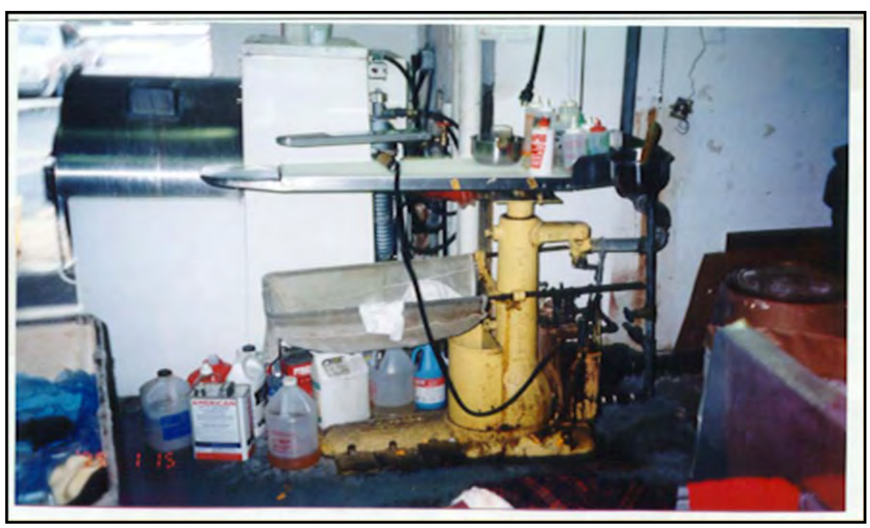

Figure 14. Spotting Board. Note spotting chemical containers on top of board and on floor near the spotting board.

3.6 Lint

Lint accumulates in the button trap, pump strainer, the dryer bag filters and on the fins surrounding the condensing and heating coils of the drycleaning machine. Lint generated from drycleaning operations contains drycleaning solvent. The lint collected from the button trap and pump strainer is saturated with solvent.

4. HISTORIC OPERATIONAL PRACTICES AT DRYCLEANING FACILITIES

4.1 Solvent Delivery/Storage/Transfer

Although much of the PCE drycleaning solvent being used today is delivered to the drycleaning facility via closed-loop/direct couple delivery systems (see Figure 15), these systems have only been available since 1993 (Dawson, 2007). Historically drycleaning solvent has been delivered to the drycleaning facility in drums and by tank trucks. Some drycleaning wholesale supply facilities receive solvent deliveries via railroad tank cars. Numerous instances of solvent discharges, associated with these deliveries, have been documented including:

- Discharge of solvent during transfer from railroad tank car to an above ground storage tank (drycleaning wholesale supply facility).
- Discharge of solvent when delivery hose uncoupled from tank truck
- Overfilling of solvent storage tanks.
- Discharge of solvent to the floor of the drycleaning facility or ground when the solvent delivery hose from tank truck was reeled in.
- Discharge of solvent from drums dropped during delivery.
- Discharge of solvent when withdrawing solvent from an AST or transferring solvent to a drycleaning machine.
- Discharge of solvent from overfilling drycleaning machine.
- Discharge of solvent via vandalism of solvent AST.
- Discharge of solvent during movement of drycleaning machine.

Due primarily to the industry conversion to more efficient drycleaning machines, PCE use by drycleaners in the United States has declined dramatically**.** A recent survey conducted by the Textile Care Allied Trade Association found that PCE use by drycleaners in the United States in 2006 was 24.1 million pounds compared to 260 million pounds used in 1985 – a decrease of over 90%. The primary reason for the large decline in PCE use in drycleaning is the increased efficiency of today's fourth and fifth generation drycleaning machines. Less solvent is used and less solvent is stored at drycleaning facilities. Most facilities store drycleaning solvent in the base tanks in the drycleaning machine. In the past, additional solvent was often stored in storage tanks, primarily aboveground storage tanks (ASTs) for PCE and both aboveground and underground storage tanks (USTs) for petroleum solvents (see Figure 23). There have been solvent discharges associated with these storage tanks from leaks (valves, flowlines and tanks) and from spills or discharges of solvent, during both tank filling and solvent withdrawal.

A study of reported solvent leaks, spills and discharges at 334 drycleaning facilities and 14 drycleaning wholesale supply facilities located in Florida found that the largest average solvent spill volumes were associated with solvent transfer and storage (Linn, 2002).

Figure 15. Closed-Loop Direct Couple Solvent Delivery System.

4.2 Drycleaning Equipment Operation and Equipment Failures

Approximately 20.9% of the solvent and solvent-contaminated waste discharges reported in the Florida study were due to equipment operation problems including still boilovers, clothing caught in the machine door, loose cartridge filter housings, filter blowouts due to excessive soil buildup, overflow of water separator, and open valves. The largest number of reported spills/discharges (39.2%) were associated with equipment failure, including leaking gaskets, seals, valves, ruptured hoses, failed couplings, and equipment corrosion (Linn, 2002).

The Florida study found that 13.8% of the reported discharges were associated with equipment maintenance, including spills associated with filter changes, still cleanouts, button trap cleanouts and servicing the solvent pump (replacing seals and packing or cleaning out the pump strainer).

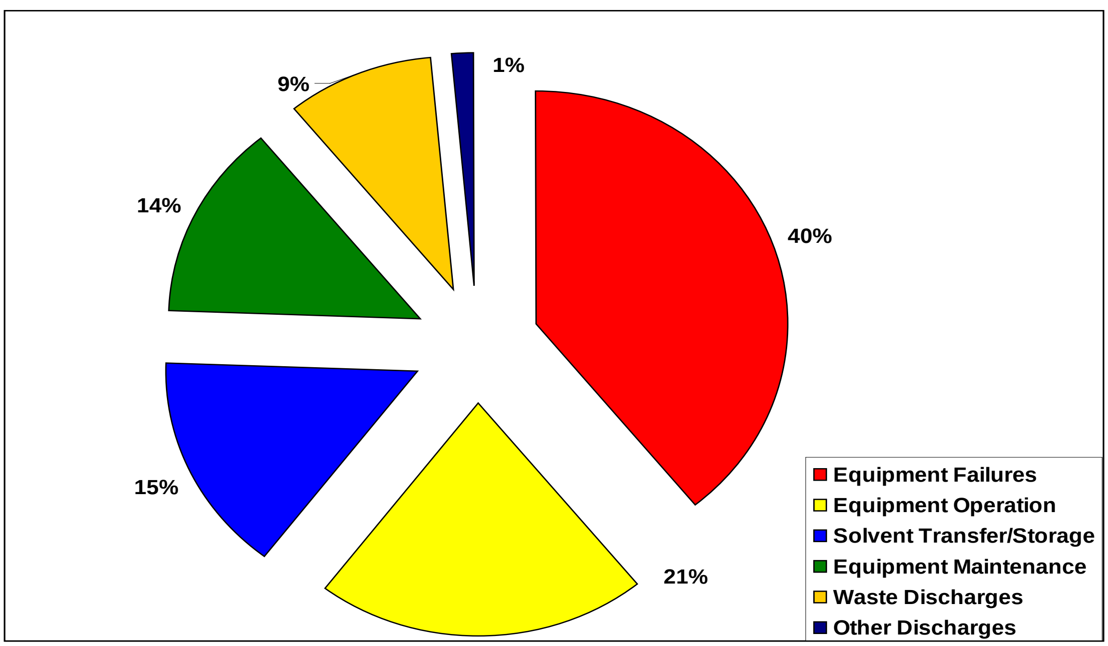

Figure 16. Sources of Drycleaning Solvent/Waste Discharges.

4.3 Contact Water

In 1988, the International Fabricare Institute conducted a study of drycleaning equipment and plant operations, including waste disposal practices. Over 70.7% of the 909 drycleaning operations that responded to the survey indicated that separator water was being discharged to either a sanitary sewer or a septic tank (IFI, 1989). It is reasonable to conclude that historically, sanitary sewers and septic tanks have been the most common disposal points for contact water – separator water, vacuum water and mop water. A study of drycleaning solvent contamination in California concluded, “The main discharge point for drycleaners is the sewer line” (Izzo, 1992). Studies conducted in California have found evidence of the presence of free-phase PCE in sewer lines serving drycleaning plants.

Other contact water disposal/discharge practices include: overflow from separator water collection bucket, discharge onto the ground, discharge into storm sewers and soakage pits, and discharge to blind drains. Contact water has reportedly been discharged to cooling towers and used in boilers at drycleaning facilities. Separator water is used by some drycleaners as a spotting or pre-cleaning agent. Separator water has also been used to mop floors.

Evaporation has been a common means of disposing of separator water. More recently, equipment has been developed to treat and dispose contact water on site. The contact water (primarily separator water) is most commonly treated using granular activated carbon. Polymer filters have also been utilized. The treated water is disposed of either by evaporation, by misting the treated water through an atomizer or disposal to the sanitary sewer. Some drycleaners utilize a hazardous waste hauling firm to dispose of separator water.

4.4 Still Bottoms/Cooked Powder Residues

Still bottoms and cooked powder residues from chlorinated solvent drycleaning operations are hazardous wastes – regulated under RCRA. Still bottoms and cooked powder residues from petroleum drycleaning operations are hazardous wastes if their flash point is less than 140^{o} F or if they are characteristically hazardous. Prior to the mid-1980s, most still bottoms/cooked powder residues were either disposed of in landfills or were discharged onto the ground.

Many petroleum drycleaning solvent facilities do not perform distillation. If powder filtration systems are utilized in these operations, the muck is a waste product. Much of the muck generated in these operations was historically disposed of in landfills or discharged onto the ground.

Figure 17. Separator Water Treatment (Misting) Unit.

4.5 Spent Filters and Muck

As noted earlier, spent cartridge filters should be allowed to drain in the drycleaning machine prior to being replaced. This practice is not always followed and spent solvent is often spilled during filter changes and residual solvent bleeds from the spent filters during storage/disposal. Historically, spent cartridge filters were discarded to the trash. A common storage point for spent cartridge filters was a cardboard box stored inside the drycleaning facility or on the ground outside the facility near the service door.

Figure 18. Still Bottoms Discharges. Note the still bottoms spilled onto the floor and splattered on wall behind drycleaning machines.

4.6 Spotting and Pre-cleaning Agents and Spotting Wastes

A greater variety of chemicals are used at the spotting board than at any other location in a drycleaning plant. Sometimes spotting agent containers are temporarily stored on the spotting board (see Figure 14). In addition to splashing and other discharges during the spotting process, containers of spotting agents have leaked or have been spilled around the area of the spotting board. The drain receptacle (semi-circular cylinder) located at the base of the spotting board, which receives steam condensate and spotting wastes will tend to corrode over time and will eventually leak. Some operators have replaced these receptacles with cans or plastic containers, but some operators have allowed these wastes to discharge to the floor or to a floor drain. Containers of spotting agents at drycleaning facilities are sometimes stored on shelves or on the floor rather than in a secondary containment structure. Spotting board wastes have been discharged to floor drains (sanitary sewer), septic tanks and onto the ground.

4.7 Lint

Historically, lint from drycleaning operations has been disposed of with trash and in some cases discharged onto the ground outside the facility. Lint is collected in the pump strainer, the button trap, the machine cylinder air flow system and at a point before the carbon adsorber (sniffer). Lint from a drycleaning machine contains solvent and lint extracted from the button trap or the pump strainer will be saturated with solvent.

5. PLANNING FOR THE ASSESSMENT - PRELIMINARY SITE CHARACTERIZATION

The key to a successful site assessment is preparation. Preliminary site assessment work involves a review of existing data, a desk top review, and a site reconnaissance. The objectives of the preliminary assessment phase include:

- Identification of potential contaminant point sources and environmental concerns at the site;
- Identification, in a preliminary manner, of the subsurface conditions at and near the site vicinity to develop a site conceptual model; and
- Establishment of a framework for subsequent site investigation work. (Waterloo, 1994)

5.1 Desk Top Review

In the desk-top review, existing data for the site and site area are reviewed. These data may include the following:

- Regulatory and compliance data including records of regulatory inspections, warning letters, consent orders, etc. from state, county and local regulatory agencies;
- Environmental property audits;
- City directory searches to determine historical land use and other potential contaminant source areas in the site vicinity;
- Review of historical aerial photographs;
- Review of topographical maps;
- Historical maps and fire insurance records (such as Sanborn® Fire Insurance maps)
- Review of assessment/remedial work at nearby sites (particularly service stations);
- Review of facility as-built drawings; and
- Utility records, including videos of sewer lines and pressure testing of sewer lines.

5.2 Site Reconnaissance

Conducting a site reconnaissance is absolutely necessary prior to mobilization for the site assessment. At active drycleaning facilities, the following individuals should be interviewed: real property owner, drycleaning business owner/operator and, employees. These interviews are an important means of gathering information on facility operations and waste management practices. Long-term employees are generally an excellent information source. Consultants are generally much more successful at collecting useful information from interviews than are regulatory personnel. Valuable information is often obtained from employees during the actual assessment activities. Drycleaning facility employees are generally very curious about the site assessment activities and useful information on waste management practices and contaminant source areas can be gleaned in informal conversations with these employees. During these interviews and an inspection of the site the following information needs to be collected:

- *Sensitive receptors:* Document the locations of nearby sensitive receptors: nearby residences, day care centers, hospitals, nursing homes, schools, water supply wells, etc.

- *Facility operation dates and location(s):* It is not uncommon for the drycleaning business to relocate within a strip mall or shopping center. If the shopping mall has been in existence for a long period of time, it's likely that a drycleaning business has had more than one owner/operator. It is also possible that more than one drycleaning business has operated on the property. Given the frequency that strip malls and shopping centers change ownership, do not expect the current property management firm to be knowledgeable about businesses that operated at the site in the past. At some shopping centers/strip malls, addresses for the bays within the mall/shopping center have changed over the years. The owners/operators of businesses that have occupied the strip mall/shopping center for a long period of time are good sources for information on past occupants.

- *Historical information on businesses that occupied the facility and nearby businesses that may use or have used solvents and other chemicals:* Note that a variety of businesses use or have used chlorinated and/or petroleum solvents. Both chlorinated solvents and petroleum solvents have been used in the printing and publishing industry including PCE, TCE, TCA, Freon 113 and mineral spirits – all of which have been utilized as drycleaning solvents (EPA, 1995). Other businesses that use or have used chlorinated and/or petroleum solvents include: auto repair facilities (PCE is the solvent of choice for brake cleaning and the most common parts washer is mineral spirits.), uniform rental/linen supply businesses, paint dealers, circuit board manufacturers, telephone companies, textile manufacturers in scouring operations, machine shops, metal plating operations, furniture strippers, power stations, boat dealerships and elevator service companies. The largest use of PCE today is as a chemical intermediary in the manufacture of other chemicals.

  Small coin-operated drycleaning machines have been utilized at laundromats. It is prudent to determine if any nearby laundromats use or have used these machines.

- *Solvents and chemicals used at the facility:* Note that if the drycleaning facility operated prior to the early 1960s, it is possible that petroleum solvent was formerly used as the primary drycleaning solvent. At drycleaning facilities where there have been changes in the business owner/operator, the current operator is often not very knowledgeable about past operations.

  PCE and its daughter products are commonly found as contaminants at facilities that use or have used petroleum drycleaning solvent. There are several possible sources for the PCE: bacterial inhibitor in soaps, spotting agents, and as a carrier in sizing and in waterproofing operations. Petroleum drycleaning has been the preferred method of cleaning coats and these facilities have traditionally offered waterproofing services (Albergo, 1997). If the facility has had more than one operator, it's always possible that a former operator used PCE or some other drycleaning solvent.

- *Drycleaning equipment locations:* Create a facility layout drawing that shows the current/former locations of drycleaning equipment, including the drycleaning machine, distillation unit, solvent storage tanks, waste storage areas, spotting board, vacuum unit, boiler, air compressor, ASTs, USTs, floor drains, access points, waste storage areas, dumpsters/trash cans, etc. Note the locations of active and plugged floor drains. Note dimensions of access points so access limitations are known when planning assessment work.

- *Historical waste management practices:* Determine the types of wastes that are/were generated by the drycleaning operations: contact water, filters, distillation residues, spotting wastes, lint, etc. and how the wastes were managed.

- *How is/was solvent delivered to the facility?* Was it in drums, via tank truck or by a closed-loop direct couple system? Where was the solvent delivered? Where did the tank truck park? Where are/were the solvent and spotting chemicals stored?

- *How and where was the drycleaning machine filled with solvent?* Was the machine filled via the door of the machine, button trap door or a filling port?

- *History of leaks, spills and discharges of chemicals at the facility:* When? Where? How? How much?

- *How is wastewater managed at the facility?* Is or was the facility ever served by a septic tank/drainfield? Note that chlorinated solvents have been used to clean out septic lines and grease traps. Where is/was the tank/drain field located? If it was abandoned, what was the abandonment date and how was the system abandoned? Or, is the facility served by a sanitary sewer? If so, where are the lines located and what is the flow direction in the lateral and main lines? Are there any lift stations located nearby?

- *Note the locations of all discharge piping/vents on the outside walls of the building.* Follow the piping inside the facility to its source and determine what is/was being discharged. If there are active discharges from any of these sources during the assessment work, sample the discharged fluids.

Figure 19. Discharge Piping/Hoses.
Discharge sources need to be identified.

- *Are there expansion joints and/or cracks in the facility floor slab located near solvent storage, solvent transfer, solvent use, or waste storage area?*

- *Types of utilities that serve the facility and their locations*. Note heights of any overhead utility lines and consider how this may limit equipment access during the assessment.

- *Regulatory/Compliance information:* What violations have been documented at the facility and how were the violations addressed? Note dates of actions. If pictures were taken during the inspection or maps/sketches were drawn, note the equipment layout of the facility.

- *Secondary containment:* Check for the presence and integrity of secondary containment structures in solvent use, solvent storage and waste storage areas. When was secondary containment installed?

- *Site drainage:* Determine how storm water is drained from the site (storm sewers, soakage pits, drainage ditches). This is best done during a major rain event at the site.

- *Water supply wells:* Determine locations and construction details of the nearest water wells. How is the water utilized?

Refer to the ***Drycleaning Site Visit Checklist*** included in as an appendix in this document. The Checklist is designed as an aid to conducting a thorough pre-assessment reconnaissance of drycleaning sites.

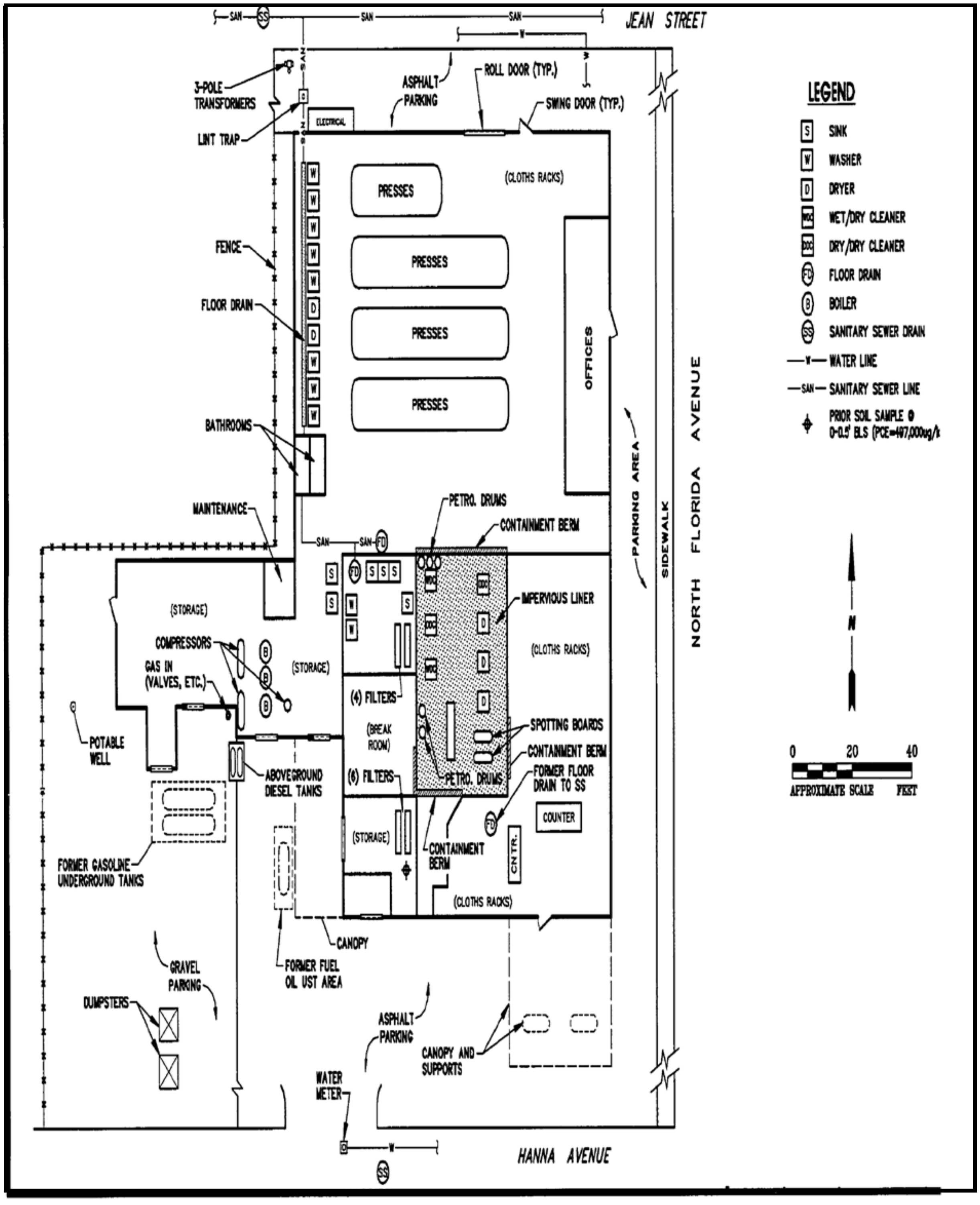

Figure 20. Drycleaning Facility Layout Diagram.

5.3 Development of a Site Conceptual Model

Based on the desktop study, the site reconnaissance and experience working in the area, a site conceptual model should be developed to guide the assessment work. The elements of the site conceptual model should include:

- Geologic setting;
- Surface and groundwater flow, including local conditions that alter the flow;
- Identification of preferential pathways for contaminant migration;
- Identification of potential receptors; and
- Characteristics of the contaminants (Waterloo, 1994).

6. CONDUCTING THE SITE ASSESSMENT

The approach and technologies utilized in conducting assessment work at a particular drycleaning site will depend on site-specific conditions (lithology, depth to water, access), regulatory requirements (permitting, local ordinances, and state regulations), the type of drycleaning solvents used and the available budget. Some of the investigation-derived wastes generated during drycleaning site investigations may be hazardous wastes. This is particularly true at PCE drycleaning sites. Knowing this, consideration should be given to using technologies and sampling techniques that minimize waste generation such as direct push technology, microwells, low-flow purging, passive sampling devices, etc. In general, some overall objectives of the site assessment should be to identify and characterize the contaminant source areas, define the extent of contamination in affected media, determine the properties of the affected media, identify receptors, and make recommendations for appropriate actions. If remediation is warranted, collect data necessary to design a remedial system.

In general, chlorinated solvent contaminant plumes are larger (deeper and of greater areal extent) than contaminant plumes associated with petroleum contamination. Chlorinated solvent plumes often extend off the property of origin. Obtaining off site access for sampling can be problematic. Most adjacent or offsite property owners do not want contamination documented on their property. One approach to this problem is to obtain access on road rights-of-way. This requires obtaining permits from local or state government agencies and sometimes involves long lead times. In addition to this, drycleaning facilities are located in urban areas with active businesses. Business owners do not want their businesses disrupted. Therefore, assessment work must sometimes be conducted after business hours or on weekends. Effective communication, meeting schedules and restoring properties to pre-assessment conditions are keys to maintaining good relations with business and property owners.

Prior to conducting drilling or probing operations, buried utilities should be identified and marked out. Generally, onsite utility identifications and mark outs are performed by commercial services and utility companies provide the locations of public utilities. It is recommended, however, that post holing be conducted to check for utilities at every drill/direct push location prior to conducting drilling operations.

An early step in the site assessment should be defining the site stratigraphy. Which zones are preferential flow paths? Which zones inhibit flow? What is the areal extent of these zones? This can be achieved with lithology borings but if the site lithology is amenable to utilization of the soil conductivity probe, a combination of lithological borings and soil conductivity probe logging is an excellent technique to define the site stratigraphy.

At some sites, the building that formerly housed the drycleaning operation has been razed. In some cases, the old building plans can be obtained from local governments. Historical aerial photographs are another method used to determine the location of the building. However, even if building plans and aerial photographs are available, the exact location of the building and the former locations of utilities may not be clear and the former locations of drycleaning equipment within the building are often unknown. Being off by a few feet may mean missing a contaminant source area. At these types of sites, active or passive soil gas surveys are useful tools in locating contaminant source areas. For a discussion of soil gas techniques refer to the Assessment Technologies Section of the paper.

One approach to contamination assessment at DNAPL sites has been the outside-in approach, or the collection of samples, particularly groundwater samples in areas out away from known chemical use/disposal areas and then gradually working in towards the source area(s). Generally, this approach is used to avoid breaching any confining units that could result in the downward migration of contaminants in groundwater. While this is still an important consideration, a different approach is to install soil borings out away from known or suspected contaminant source areas to determine site stratigraphy and then, utilizing that knowledge, begin sampling in known or suspected contaminant source areas, working outward from these areas until the contaminant plume is defined – an inside-out approach.

6.1 Contaminant Source Areas – *Where to Sample*

In general sampling to verify/delineate contaminant source areas should occur in areas where solvents were delivered, stored, and used and where solvent wastes were stored and disposed. This generally involves sampling beneath and in near proximity to the building that houses or formerly housed the drycleaning operation. These contaminant source areas include:

Drycleaning machine

The drycleaning machine was found to be the most common contaminant source area based on data collected from contamination assessments performed at 300 drycleaning sites in Florida. Only 8.8 % of the active drycleaning facilities that applied to the Florida Drycleaning Solvent Cleanup Program had some form of secondary containment at the time of application (Linn, 2008). Discharges of solvent and solvent-contaminated wastes are associated with solvent transfer, solvent storage, and machine operation and maintenance. Prior to the development of closed-loop direct-couple solvent delivery systems, solvent was added to drycleaning machines by opening the door of the machine and pouring or pumping the solvent into the machine drum or through the button trap door, located at the back of the machine. Solvent discharges are associated with overfilling the machine, leaking door gaskets, cleaning out the button trap, replacing seals on the solvent pump, changing filters, cleanout of the distillation unit and equipment failures. A bucket used to collect separator water is normally located behind the drycleaning machine. If the bucket is not emptied on a regular basis the separator water will overflow to the facility floor. This has been a common occurrence at drycleaning facilities.

If drycleaning is no longer performed at the facility and the former locations of the drycleaning equipment in the building are unknown, look for cut off lag bolts protruding from the concrete floor slab. The drycleaning machines were anchored into the floor with these bolts. Sometimes the bolts have been removed and their former locations are marked by concrete or mortar patches. Sometimes the floor at a former drycleaning facility is covered with carpet or floor tile and the former drycleaning machine location is unknown. As a general rule, in strip shopping centers, the drycleaning machine is most often, though not always, located in the rear portion of the bay occupied by the drycleaning facility. In the older petroleum drycleaning plants the drycleaning machines were located in “explosion proof” rooms. These rooms had brick or concrete block walls.

If feasible, sampling should be conducted beneath the facility floor slab at the front and back of the drycleaning machine, and near expansion joints or cracks in the floor slab near the drycleaning machine, sampling should be focused in these areas.

Figure 21. Filter Housings located adjacent to the drycleaning machine.
Note the sludge/staining on the front of the housings from filter blowout.

Although distillation units are built into the newer drycleaning machines, they are sometimes a separate piece of equipment in drycleaning facilities. A common operational problem with distillation units is overfilling (when too much spent solvent or muck is placed in the still/muck cooker) and subsequent boilover of distillation residues – resulting in the discharge of still bottoms or cooked powder residues to the facility floor. Boilover can also be caused by excessive operating temperatures. In early drycleaning operations, due to the strong solvent odors generated during the distillation process, stills were sometimes located in a separate room or even outside the facility in a covered area. Former still locations can often be identified by dark brown colored staining on facility floors or walls adjacent to the still cleanout. This staining is associated with either boilover of still bottoms or from splashing or spilling of still bottoms or cooked powder residues during cleanout of the distillation unit. The area around the still is a prime sampling location at drycleaning facilities (see Figure 22).

Figure 22. Distillation Unit. Note the distillation residues on the side of the unit. The result of a boilover.

Service Door

Historically, solvents have been delivered to the facility and wastes have been stored and discharged outside the service door of the drycleaning facility. If the drycleaning solvent was delivered to the facility by tank truck, find out where the solvent delivery truck parked during deliveries. If solvents were delivered by tank truck there were likely incidental spills or discharges associated with the solvent transfer. If the delivery area is paved with asphalt, sample in areas where the asphalt is deteriorated/dissolved or patched. The area outside the service door has also been a favorite discharge area for contact water and a storage area for spent cartridge filters. Very commonly, the area outside the service door opposite the side to which the door opens is a prime sampling area. If there are several doors in the facility, the door located nearest the drycleaning machine/distillation unit was the most likely waste disposal point.

Sanitary Sewer - Septic Tank/Drainfield

As stated earlier, the sanitary sewer and septic tank/drainfield have historically been popular disposal points for contact water and in some cases still bottoms. In fact some older drycleaning machine service manuals prescribe hard-piping the separator water discharge water to floor drains (Izzo, 1992). Sewer lines in urban areas can be constructed from a wide variety of materials, and within a city, several different kinds of sewer piping may be utilized depending on the time the sewer lines were installed. Older sewer lines were made of cast iron, vitrified clay and Orangeburg pipe (fiber conduit). Newer lines have been constructed from concrete or most recently thermoplastic. Manholes have been constructed of brick/mortar and concrete. Some early sewer line joints were sealed with mortar or bituminous compounds. Neither of these materials is liquid tight and through subsequent settling, dissolution and cracking have provided pathways for contaminant migration. Many local sewer authorities specify permissible leakage rates for newly-constructed sewer lines "of approximately 500 gallons per inch diameter per day per mile" (Siler, 1994).

Contact water, free-phase solvent and solvent vapors can leak from sewer lines through cracks, joints or breaks. Contact water and free-phase solvent can also leach through sewer piping. Studies conducted at drycleaning sites in California detected higher PCE concentrations in wastewater samples collected from sewer lines after the sewer lines were flushed with water. The higher PCE concentrations are attributed to PCE liquid or sludges that settle to the low spots in the sewer line. The higher PCE concentrations after line flushing are attributed to free-phase PCE and PCE in sludges dissolving into the flushing waters (Izzo, 1992).

Wastewater/sludge samples should be collected from sewer lateral lines during the site assessment. Wastewater and sludge samples should be collected from septic tanks that serve drycleaning facilities. Soil gas sampling along sewer lines can be used to delineate contamination associated with leaking sewer lines. Sanitary sewers and particularly septic tanks offer favorable conditions for reductive dechlorination of PCE. Samples of wastewater and sludge collected from sewer lines and septic tanks often contain PCE degradation products as well as PCE. Sometimes groundwater samples collected at drycleaning sites contain PCE daughter products even though aerobic conditions exist in groundwater. This may indicate that a leaking sewer line or septic drainfield is a contaminant source area at the site.

Sampling should also be conducted near floor drains. If solvent wastes are discharged down floor drains plumbed with PVC piping, PCE can dissolve the PVC. The elbow joints and low portions of the lines are particularly susceptible to dissolution. Floor drains are commonly located in the boiler room at drycleaning facilities. In older facilities, floor drains are/were often located adjacent to the drycleaning machine.

ASTs/USTs

At modern drycleaning plants drycleaning solvent is stored in base tanks located within the base of the drycleaning machine. In the past, it was common practice to store drycleaning solvent in ASTs or USTs. There were discharges associated with this storage including spills associated with filling the tank, tank and valve leaks and spills associated with collecting solvent in containers from the tank to fill the drycleaning machines. These PCE ASTs were commonly located just outside the service door or just inside the service door near the drycleaning machine. These are important sampling areas.

Although petroleum drycleaning solvent is commonly stored in USTs, most of the storage tanks associated with PCE drycleaning operations were ASTs. A study of drycleaning equipment and plant operations conducted by International Fabricare Institute in 1988 found that only 96 of 809 solvent storage tanks (11.9 %) reported in the survey were USTs. Only 2 of these 96 USTs were used to store PCE (IFI, 1989). USTs and ASTs are also used to store fuel oil (boiler fuel) and gasoline for facilities that operate vehicles to transport clothing to and from the dry drop-off stores/main plant. The discharge of drycleaning wastes to former solvent or fuel USTs has been documented at several drycleaning sites. Sampling should be conducted adjacent to the storage tanks and along any flow lines associated with the storage tanks.

Figure 23. Solvent AST (in corner) inside drycleaning facility.
Note spilled solvent on floor.

Storm Sewers

Storm sewers, particularly those located near the service door of a drycleaning facility, have been historical waste discharge points at drycleaning facilities. Sediment and wastewater samples should be collected from these sewers.

Dumpsters/Trash Cans

Prior to the advent of hazardous waste haulers, some of the wastes generated by drycleaning operations were disposed to waste containers, including filters, muck, and lint. Sampling should be conducted in these areas. It is important in interviews to determine where the waste containers were formerly located.

Other Source Areas

Other contaminant source areas include the spotting board, blind drains, and storage buildings. In transfer machine operations where non-recovery tumblers were utilized, solvent vapors and solvent-contaminated lint were discharged from vents. At some drycleaning plants these vents were mounted on the roof of the facility. Some separator water treatment units have been piped to discharge to the roof of the facility. The discharge point for separator water treatment units is often mounted on an exterior wall (see Figure 24). Rainwater contacting these vapors forms contact water and discharges from downspouts. If the filter in the separator water treatment unit is not changed, the untreated separator water may be saturated with solvent. Collect samples near the downspout discharge points. Although vacuum water or press return water has only low concentrations of dissolved solvents, this contact water has historically been discharged to the ground. Locate the vacuum unit. If there is piping leading from the base of the unit, follow the piping to find the discharge point.

Figure 24. Separator Water Treatment (Mister) Discharge Point.

6.2 Analytical Methods

Sample analysis can be performed onsite during the investigation using a portable gas chromatograph or a mobile laboratory or samples can be sent to a fixed laboratory for analysis. The advantage of onsite sample analysis is that it offers real time data. Using these data, the scope of work of the assessment can be changed and the assessment can be completed in a shorter time period (fewer mobilizations, fewer document reviews). Refer to the discussion on mobile laboratories under the Assessment Technologies Section.

At drycleaning sites that use/used chlorinated solvents the two most commonly utilized analytical suites are E.P.A. Method 8021, which is a gas chromatography method and E.P.A. Method 8260, which is a gas chromatography/mass spectrometry method. Both of these methods analyze for aromatic and halogenated volatile compounds that include PCE (and its degradation products), carbon tetrachloride (and its degradation products), 1,1,1-trichloroethane (and its degradation products), benzene, toluene, ethylbenzene, xylenes, and naphthalene. If requested, 1,1,2-trichlorotrifluoroethane (Freon 113) can be reported in these analyses.

Analytical methods that have been utilized at petroleum solvent drycleaning sites include total recoverable petroleum hydrocarbon (TRPH) methods, analysis for polynuclear aromatic hydrocarbons, using either E.P.A. Method 8310 or E.P.A. Method 8270 SIM. E.P.A Method 8270 has been utilized. E.P.A. Method 8021 or Method 8260 has been used at PCE sites as discussed above. As discussed earlier, chlorinated solvent contamination is commonly found at sites that used petroleum solvent as the primary drycleaning solvent. The origin of the chlorinated compounds may be spotting operations, use as a bactericide, water proofing operations or the facility used PCE, carbon tetrachloride or 1,1,1-trichloroethane as a primary solvent under a previous operator. Even relatively low concentrations of chlorinated solvent compounds in soil and or groundwater can be the driver in remedial operations at petroleum solvent drycleaning sites.

6.3 Monitor Well Installation

When choosing locations and screen intervals for monitor wells, consider the future function of the wells. Are the wells to be utilized for compliance monitoring or for performance monitoring of remedial systems? All too often, remedial design personnel focus strictly on the design and installation of a remedial system and fail to prescribe the installation of performance monitoring wells. In effect the monitor wells installed during the assessment are accepted by default. The wells installed during the site assessment are often not adequate for performance monitoring. Even monitor well locations and screen intervals selected on the basis of the analysis of groundwater samples collected via direct push vertical profiling on closely-spaced vertical intervals can miss thin high permeability zones where contaminant concentrations are an order of magnitude or more higher than in any groundwater samples collected during the assessment. Where applicable, these types of sites are good candidates for membrane interface probe logging. Refer to the membrane interface probe technology description. Minimal membrane interface probe logging will aid in selection of locations and screen intervals for monitor wells and for injection intervals for in situ remedial work.

6.4 Collecting Data for Remedial Design

At most environmental consulting firms, geologists plan and conduct site assessments and engineers design and supervise the installation and operation of remedial systems. At some firms, the geologists present the contamination assessment report to the engineers after the contamination assessment has been "completed". Engineers do not always receive the data that they need to properly design an effective remedial system. A better approach is to include the remedial design personnel in the site assessment planning process. This should ensure that, whenever possible, the data necessary to design a remedial system is collected during the site assessment. These data may include geotechnical parameters such as: soil bulk density, porosity, and moisture content, fraction of organic carbon, samples for oxidant demand studies, groundwater geochemical sampling, sampling for natural attenuation parameters such as: total organic carbon, total iron, ferrous iron, sulfate, hydrogen sulfide, nitrate, nitrite, chloride, carbon dioxide, alkalinity, methane, ethene, ethane, microcosm studies, and polymerase chain reaction (PCR) testing for *Dehalococcoides ethenogenes.*

6.5 Other Considerations

Commingled Contaminant Plumes: As stated earlier, drycleaning facilities are generally located in urban areas, often in close proximity to other businesses that use or have used solvents. Commingled solvent plumes are often present in older urban areas. In the case of the same solvent or solvents or similar daughter products it may be difficult to differentiate between or determine the limits of the various plumes. It is important during the assessment planning stage to try to identify properties located near the subject assessment property that used similar solvents. Time spent researching city directories, fire insurance maps and conducting interviews of longtime business owners can pay dividends in limiting the scope of the assessment. Chasing someone else's contaminant plume can quickly deplete your resources. Environmental forensics techniques have been utilized to differentiate or apportion these plumes. These techniques include analysis for various impurities in the solvents or additives to the solvent; analysis for compounds associated with a release, such as methylene blue active substance (MBAS); plotting the ratios of PCE and its daughter products versus distance from the source and isotopic analysis to differentiate contaminant sources and in some cases dating the release (Morrison, 2009).

Compliance Issues at Active Drycleaning Operations: Some of the drycleaning sites being assessed are still active drycleaning operations. Remediation will be conducted at many of these sites. It is true that transfer machines are no longer being used in PCE drycleaning operations; that today's new dry-to-dry machines have low emissions compared to older drycleaning machines and that the amount of PCE used in drycleaning continues to decline. However, discharges of solvent and wastes containing solvent still occur at some drycleaning operations. Secondary containment for drycleaning solvent storage, solvent use and solvent-containing waste areas, is not required by all states. Similarly, closed loop, direct-couple PCE delivery systems are also not required by all states. The drycleaning business is very competitive and operator turnover can be frequent. Not all drycleaning business owners have the knowledge and proper training required to successfully operate a drycleaning business. Finally, hazardous waste disposal can be a significant business expense.

It is important to consider these facts when performing assessment work and in designing and operating a remedial system at an active drycleaning facility. During the site reconnaissance, copies of regulatory compliance information should be provided to the drycleaning operator and owner and to the real property owner. Any questions on regulatory compliance should be directed to the appropriate state agency. Regulators and consultants should receive training on drycleaning operations and drycleaning regulatory compliance issues so that they can recognize ongoing regulatory/compliance problems or potential problems in the field and any detrimental operational practices can be stopped or prevented. Compliance monitor wells, screened across the water table should be installed in historical contaminant source areas such as adjacent to the drycleaning machine and outside the delivery door of the facility. These wells can provide an early warning system for any new discharges.

6.6 Vapor Intrusion Related to Drycleaning Operations

Background

Volatile organic compounds (VOCs) are a class of chemicals that readily evaporate at room temperature. Gasoline, degreasing agents (solvents), paint thinners and drycleaning solvents are several examples of products that contain these compounds. Most of the historical and currently used drycleaning solvents and their daughter products are volatile organic compounds, including the petroleum drycleaning solvents, carbon tetrachloride, 1,1,1-trichloroethane, trichloroethylene, 1,1,2-trichlorotrifluorethane, n-propyl bromide and the most widely used drycleaning solvent since 1961, perchloroethylene or PCE. PCE is a chlorinated VOC and has been found in soil and/or groundwater due to spills, discharges, improper storage, and poor housekeeping practices at drycleaner operations as well as other industries. PCE, and its degradation products are recalcitrant compounds and generally tend to persist in the environment. When PCE is released into the environment, it can penetrate through the soil and into the groundwater. Once in the groundwater, the dissolved portion is dispersed in a hydraulically down gradient direction from the source of the spill, causing the contaminant plume to expand.

Drycleaning operations are typically located close to residential properties. Also, drycleaning operations are commonly located in the same building with other businesses, in strip malls and shopping centers. For this reason, PCE contaminant plumes related to drycleaning operations sometimes extend beneath active businesses and residential properties, apartments and homes. There are several scenarios for PCE or solvent vapors migrating into buildings:

- The original contaminant release is located directly below or adjacent to a building.
- Solvent vapors migrate from contaminated soil to nearby buildings.
- Solvent vapors partition from contaminated groundwater.
- Solvent vapors migrate through preferential pathways, such as utility corridors.
- Solvent-contaminated groundwater enters a building via sumps or building foundation drains.

There are three primary concerns associated with contaminant migration into indoor air. Chemical vapor intrusion poses the greatest immediate threat to health when there is a potential for fire and explosion. The second concern is for a high concentration, acute chemical exposure that could result in immediate health symptoms. The third concern is the possible cancer and non-cancer effects caused by chronic long-term exposure to contaminants in indoor air. The fire and explosion hazard is by far the least likely to occur, while concerns regarding long-term exposure are the most common. For this reason many states require an evaluation of the potential for vapor intrusion into buildings where there has been a discharge of a VOC. This is generally referred to as a vapor intrusion evaluation.

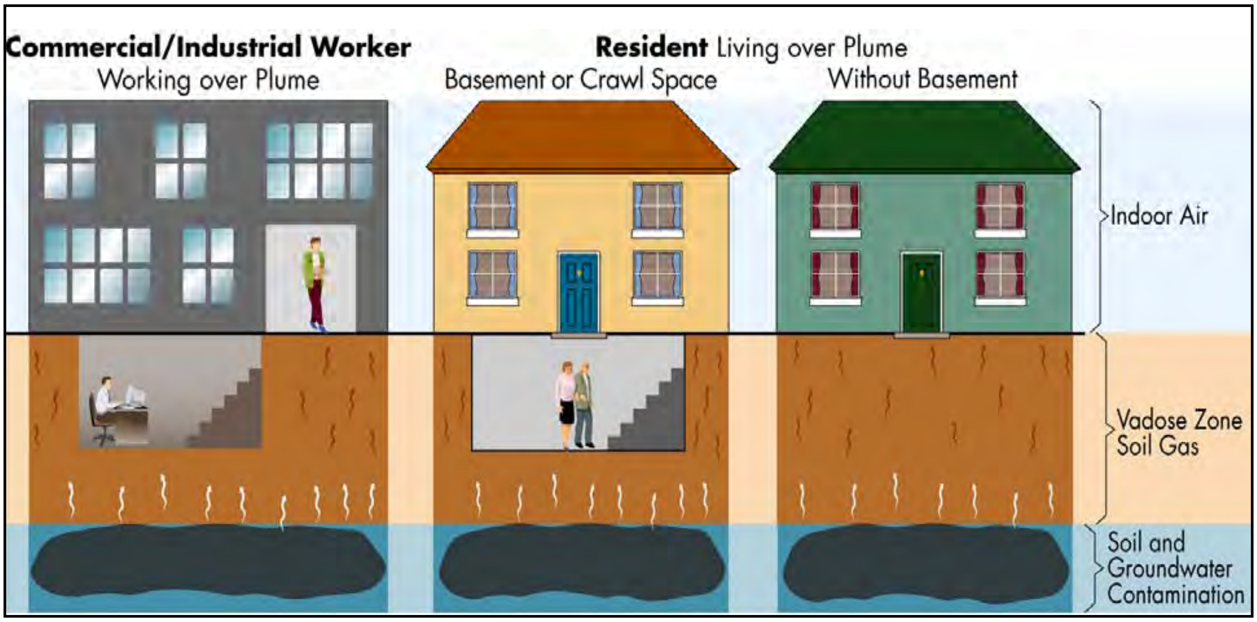

Figure 25. How Vapors Can Intrude into Different Building Structures.
(Courtesy Interstate Technology and Regulatory Council)

Vapor Intrusion Evaluation

The first step in these evaluations is to determine if there is a potential for a vapor intrusion to occur. Many states have established screening criteria to determine whether investigation of the vapor intrusion pathway is necessary. These screening criteria may involve contaminant concentrations in ground water, distance between the contaminant source and nearby buildings, the presence of free phase product, the potential for vapor migration through preferential pathways such as utility lines, etc. Failing any of the screening criteria triggers a more thorough investigation of the vapor intrusion pathway. Site specific conditions will determine the best investigative approach to evaluate vapor migration emanating from a drycleaner. Sub-slab vapor sampling is the most common approach to defining the risk for vapor intrusion at specific buildings. Other approaches, including Risk-based Corrective Action (RBCA) screening and use of the Johnson and Ettinger (J&E) model are acceptable in some states. The foundation floor of the structure is inspected to determine if there are any obvious pathways through which vapors could seep into the building such as cracks or sumps. If the result of the sub-slab evaluation indicates that indoor air may have been impacted, several states require that indoor air samples be collected.

To prevent any interference with the indoor air sample, VOC sources already located within the building need to be identified and removed if possible. Sources of interference that could affect the test include gasoline containers, paint thinners, nail polish remover and even recently drycleaned clothing that can emit enough PCE to interfere with the test and give false positive readings.

Figure 26. Air Sampling Equipment.
Summa Canister, Evacuation Chamber, Air Sampling Pump w/ Sorbent Tubes,
Tedlar® Gas Sampling Bag, & Glass Sampling Tube
(Courtesy New Jersey Department of Environmental Protection)

Mitigation

Vapor mitigation may be necessary if the contaminant concentrations in an indoor air sample exceed the action levels established by the state regulatory agency and it is determined that the source of the vapor intrusion is from subsurface vapors, as opposed to a source within the structure. If indoor air is affected by subsurface vapor intrusion, mitigation is typically required. A number of vapor intrusion mitigation approaches are available. The installation of a sub-slab depressurization system aka “radon” mitigation system is the most common remedy for vapor intrusion because it is inexpensive, readily available and immediately addresses potential health impacts to human receptors. Most states will also require cleanup of the contaminant source in order to remove the long-term threat of vapor intrusion.

There are several other methods that can be used to address vapor intrusion at a structure. For new construction, a vapor barrier can be installed that will prevent vapors from entering a structure from beneath its foundation. A passive vapor ventilation system can be installed that will use natural atmospheric pressure differences to maintain a neutral pressure in the soil beneath the building.

Figure 27. Active Venting System with Fan.
(Courtesy Kansas Department of Health and Environment)

An active vapor ventilation system can be installed that will create negative pressure in the soil beneath the building. This system, which is typically used for most residential properties, is similar to the system used to address radon (a naturally occurring radioactive gas) contamination. After a hole is drilled through the building floor slab, a ventilation pipe is inserted into the hole, and the pipe is sealed in place. The ventilation pipe is extended to the outside of the structure and discharges above the roofline (see figure, left). A fan installed in the vent pipe system creates a negative pressure under the slab. Soil vapor extraction systems may also be used to effectively mitigate structures.

During 2009/2010, the USEPA conducted an assessment of the correlation between indoor air concentrations and the triggers currently being used to identify when further investigation should be conducted. These triggers consist of groundwater contaminant concentrations, sub-slab soil gas concentrations and near slab soil gas concentrations.

Depending on what the results of this study indicate, there may be revisions to the U.S. E.P.A. Vapor Intrusion Guidance. A good general source for information on vapor intrusion is the Interstate Technology & Regulatory Council at www.itrcweb.org. Many states also have vapor intrusion guidance, which should be consulted for specific sites.

7. ASSESSMENT TECHNOLOGIES

Following are some examples of assessment technologies that have been utilized in drycleaning site characterization work. More detailed descriptions of these technologies can be found at the following websites:

- U.S. EPA CLU-IN - http://clu-in.org
- Interstate Technology & Regulatory Council – www.itrcweb.org/homepage.asp
- Geoprobe® Systems - www.geoprobe.com

7.1 Soil Gas Surveys

Soil gas surveys can be a useful tool to identify contaminant source areas at drycleaning sites. Two of the primary applications for soil gas surveys at drycleaning sites are where the building that housed the drycleaning facility has been razed and the location of the traditional contaminant source areas (drycleaning machine, distillation unit, solvent storage and waste storage areas) is unknown and in identifying contaminant sources associated with leaking sewer lines. There are two types of soil gas surveys – passive and active.

Passive soil gas surveys utilize a sorbent material (granular activated carbon or zeolites) contained in a sampling chamber. The sampling chamber is placed in a shallow borehole, which is sealed at the surface, and the sampling chamber is left in the ground for a period of time which varies from one day to two weeks. The sampling chamber is then retrieved, sealed and sent to a laboratory for analysis. Passive soil gas surveys can be successfully conducted in lower permeability soils. The drawbacks to passive soil gas sampling are that two site mobilizations are required and there is a waiting period for laboratory analysis.

Active soil gas surveys collect soil gas from a screened point driven into the ground or from vapor extraction wells. These samples can be analyzed onsite utilizing a portable gas chromatograph or mobile laboratory or, the sample can be sent to a fixed laboratory. A qualitative evaluation can be obtained onsite by utilizing colorimetric tubes. Active soil gas data analyzed in the field is real-time data and the scope of the survey can be adjusted to pinpoint “hot spots” and collect additional data during one mobilization. Active soil gas surveys are not suitable in low permeability soils and are limited at sites with very shallow water tables.

Figure 28. Conducting a Modified Active Soil Gas Survey. Technician is using a portable blower and an OVA.

Another form of active soil gas sampling, known as modified active gas sampling (MAGS™), involves the installation of vapor extraction wells and the extraction of soil gas at a relatively high rates (up to 100 cfm) by utilizing a portable regenerative blower. During sampling, wellhead vacuums are adjusted utilizing a valve at the wellhead. The discharge rate is measured for each wellhead vacuum. Vacuum measurements are taken from surrounding piezometers in order to estimate the area affected by each sampling point. Samples can be analyzed utilizing organic vapor analyzers, a portable gas chromatograph or a mobile laboratory. Confirmatory soil gas samples can be sent to a fixed laboratory. Source areas can be pinpointed by utilizing multiple sampling points (Lewis, 2004).

The advantage of this method of active soil gas sampling is that it provides a much larger coverage area than conventional active soil gas sampling. The effective radius of influence of this technique in a sandy soil can be greater than 30 feet. It provides an estimate of the average soil vapor contaminant concentration and therefore the available contaminant mass in the sampled area. The method also provides useful information for designing soil vapor extraction systems. The Florida Drycleaning Solvent Cleanup Program has used this technique at many drycleaning sites

AQR Color-Tec Analysis

AQR Color-Tec is a field-based analytical method which combines the use of colorimetric gas detector tubes with sample purging to detect very low (<3 µg/L or µg/Kg) concentrations of chlorinated volatile organic halocarbons (CVOHs) in liquid and solid samples. Samples are analyzed by purging the volatile compounds from a groundwater or soil sample through the colorimetric tube, which is designed to produce a distinct color change when exposed to chlorinated compounds. Estimated sample concentrations are obtained by comparing the tube readings to a conversion table based on comparing Color-Tec and GC/MS split sample data.

The AQR Color-Tec method is ideal for locating soil and groundwater source areas by combining low level detection of all chlorinated compounds with low per sample cost to allow for significant expansion of sampling coverage compared to assessment approaches where only definitive analytical (laboratory) methods are employed to locate source areas. Definitive laboratory analysis provides high analytical accuracy, but sampling quantity is often limited to control costs, resulting in data gaps, sampling uncertainty, and low overall data quality. The low per-sample cost of The AQR Color-Tec® method offers a 5:1 increase in analysis volume over laboratory methods, allowing for five times the sampling coverage for the same cost. Using the Color-Tec method used in conjunction with groundwater profiling allows for immediate decisions regarding subsequent vertical and lateral sampling locations. The method is also highly cost effective when used to evaluate surface water bodies impacted by groundwater plumes. In this application, large quantities of sediment pore water samples can be quickly evaluated. For detailed information about this method download the method manual at http://www.aqrcolortec.com/images/CT_Manual_1-2010.pdf.

AQR Soil Gas Method

AQR Soil Gas is an active soil gas sampling method, which combines the use of an innovative soil gas probe and field-based analysis using colorimetric gas detector tubes to detect concentrations of total chlorinated volatile organic halocarbons (CVOHs) to 0.1ppmV or 0.67 mg/m^3 in soil gas. Active soil gas sampling is accomplished by driving a small-diameter probe into the subsurface unsaturated soil to the desired sampling depth and purging a small volume of soil gas, which is analyzed using a colorimetric detector tube. This direct-analysis method offers low level detection of compounds suspended in the unsaturated soil matrix near the sampling point. Multiple sampling points are used to provide wide sampling coverage to quickly locate source areas and hot spots. The AQR soil gas analysis method provides fast, easy, and low cost collection and analysis of shallow (up to 40-inches below ground surface) samples. The method is easily modified to collect deeper soil gas samples when used in conjunction with direct push sampling rigs. Once the soil gas sampling/analysis results have identified areas of concern, soil matrix samples may be collected to confirm and quantify the impacts to soil. At sites with shallow water tables, contaminant vapor released from contaminated groundwater is often detectable in the overlying unsaturated soils using the AQR soil gas analysis method.

The AQR Soil Gas method is ideal for locating chlorinated solvent source areas in unsaturated soil by combining low level detection of total chlorinated compounds with low per sample cost to allow for significant expansion of sampling coverage compared to assessment approaches where only soil matrix samples are collected and analyzed. AQR Soil Gas screening can also be used in conjunction with groundwater profiling to screen soil gas samples from targeted sampling intervals. For detailed information about this method download the method manual at: http://www.aqrcolortec.com/images/AQR_Soil_Gas_Method_MANUAL.pdf

7.2 Passive Sampler Technologies

As defined in *Technology Overview of Passive Sampler Techno*logies (ITRC, 2006), passive samplers include "… devices that recover a grab sample, devices that rely on diffusion of the analytes to reach equilibrium between the sampler and the well water… and … devices that rely on diffusion and sorption to accumulate analytes in the sampler." The ITRC document describes twelve (12) different passive sampling technologies. The document can be found at http://www,utrcweb,irg/Documents/DSP_4.pdf. Most of these technologies are applicable for sampling the VOCs found at contaminated drycleaning sites.

One of the chief advantages offered by these technologies is that no purging is required. Investigation-derived wastes are reduced or eliminated and sampling times are reduced. Also, these technologies allow for the collection of groundwater samples from low yield aquifers. One disadvantage regarding passive diffusion bags is that they require two mobilizations, one to install the bags and one to retrieve them. Many of these technologies cannot be utilized in small diameter monitor wells (microwells). Some of the technologies yield small sample volumes. Many state regulatory agencies do not accept the sampling results of these devices to demonstrate site closure.

A useful application for passive diffusion bag samplers is in monitor or recovery wells with long screen intervals. By placing a series of the samplers across the screen, differences in contaminant concentrations or contaminant distribution can be determined.

7.3 Direct Push-Installed Monitor Wells (Microwells)

A significant portion of the costs of site assessment work is associated with monitor well installation and managing the investigation-derived wastes (drill cuttings, development water, purging and decontamination water) associated with well installation, development and sampling. Wastes generated during drycleaning site investigations often contain hazardous constituents and waste disposal can be expensive. Waste minimization should be an integral part of any site investigation. Utilization of microwells as permanent monitor wells in drycleaning site investigations can result in significant cost savings in both the investigations and subsequent groundwater monitoring events. Some state regulatory agencies do not accept sampling results from microwells to demonstrate site closures.

Microwells are small diameter (inner casing diameters of one-half, three quarters, or one inch) PVC monitor wells. These wells are generally installed utilizing direct push technology. If direct push sampling is conducted at a site and sample analysis is performed on site (e.g. utilizing a mobile laboratory, portable GC or Color-Tec screening); microwells can be installed upon completion of contaminant plume delineation saving time and the expense of an additional mobilization. Additionally, no drill cuttings are generated during installation and wastewater generated through well development and purging is minimized. Minimal purge water is generated during groundwater monitoring events. Where applicable, a considerable cost savings can be realized by the installation of monitor well clusters by installing multiple microwells in a single conventionally drilled borehole rather than drilling a separate borehole for each well.

An early argument against the use of microwells was that their small diameter precluded slug testing. This is no longer true. *Pneumatic slug testing* can be performed in microwells or in direct push groundwater samplers to obtain accurate hydraulic conductivity data. In pneumatic slug testing, a pressure transducer is placed within the water column of the well casing or the direct push probe rods. The well is sealed and the water level in the well/sampler is depressed by increasing the air pressure in the casing above the water. When the water table stabilizes, a valve is opened releasing the air pressure and the water level in the well/probe rods recovers and the recovery is recorded via the pressure transducer and data logger (Geoprobe® Systems, 2002).

A study comparing groundwater samples collected from microwells to those collected from conventional monitor wells installed utilizing hollow stem augers found that "… no significant performance differences were observed between the direct-push wells and hollow-stem auger drilled wells. More significantly, the chemical variability among the different well types was less than that displayed by spatial heterogeneities associated with well screen depth differences and temporal variability." (Kram, 2001).

7.4 Sonic Drilling

A sonic or roto-sonic drilling rig utilizes high frequency mechanical oscillations to transmit resonant vibrations and rotary power to the drill string. Sonic drilling offers some advantages over the more traditional mud-rotary and air rotary drilling. No drilling fluids are circulated in the borehole. A continuous core is obtained during drilling methods. The drilling process generates a minimum amount of waste. Since an outer casing is advanced during drilling, groundwater samples can be collected as the borehole is being advanced utilizing an inflatable packer for isolation. At sites where direct push technology cannot be used or where contamination has reached depths below direct push capabilities, sonic drilling can be utilized along with a portable gas chromatograph or mobile laboratory to collect real-time data and delineate the contaminant plume thereby minimizing site mobilizations.

The disadvantages of using sonic drilling are its higher cost (though, this should be weighed against the minimal amount of investigation-derived wastes generated by this technology) and its non-availability in some areas of the U.S. The early sonic rigs were fairly large and had access limitations. In the last several years, however, smaller sonic rigs have been developed. These so-called mini-sonic rigs can access some buildings.

Figure 29. Mini-Sonic Drilling Rig. Note rig is being operated in a strip mall bay formerly occupied by a drycleaning facility.

7.5 Soil Conductivity Probe

A soil conductivity profile provides a continuous reading of the conductivity of the soil/sediment (including fluids). The device is advanced using a direct push unit or a cone penetrometer. By collecting conductivity data at several borings installed across a site, a transect or transects can be developed. At least one probe point should be advanced adjacent to a borehole where a continuous core has been collected. The conductivity data can then be correlated with the lithological data to ground-truth the conductivity transects. At most drycleaning sites a day or two of conductivity profiling will be sufficient to develop the stratigraphic framework for the subsurface. Utilizing these data, groundwater sampling points can be selected, *particularly at breaks or changes in lithology*, to accurately characterize groundwater contamination at the site. The cost savings realized by collecting fewer but more representative direct push groundwater samples and strategically locating monitor well screen intervals will more than pay for the conductivity probe work. These data will also pay dividends during site remediation by focusing remedial efforts in areas where the predominant portion of the contaminant mass is located.

7.6 Mobile Laboratories

The iterative process practiced in conducting site assessments in the past involved multiple mobilizations that generated multiple reports and work plans requiring multiple reviews. Long delays occurred in the cycle. Additional data had to be acquired and reviewed because the original data was old and obsolete. Mobile laboratories offer an alternative to the older process. The mobile laboratory has become a fixture in many site assessment programs. Coupled with direct push sampling, mobile laboratories offer an efficient means to provide accurate real-time data that allows field personnel to adjust the scope of work during the assessment and therefore minimize the number of mobilizations needed to complete a site assessment. Mobile laboratories can also be utilized to analyze confirmatory soil samples during remedial excavations. Onsite soil analysis allows excavations to be completed in one mobilization.

Mobile laboratories offer laboratory-grade gas chromatograph or gas chromatograph/mass spectrometer detectors. Some states require certification of mobile laboratories by the National Environmental Laboratory Accreditation Program (NELAP). Many mobile laboratories have two and sometimes three gas chromatographs, allowing for faster sample run times. Typically, in drycleaning work, an abbreviated analytical suite is utilized to reduce sample run times. For a PCE drycleaning site this would include tetrachloroethene, trichloroethene, cis 1,2-dichloroethene, trans 1,2-dichloroethene, 1,1-dichlroethene and vinyl chloride. The BTEX suite is also typically included in the analysis. Some mobile laboratories offer extractables analyses. Mobile laboratories that offer these analyses would be able to perform a total petroleum hydrocarbon analysis that may be suitable for evaluating sites that use or used petroleum drycleaning solvents.

7.7 Membrane Interface Probe

The membrane interface probe (MIP) is a device used to detect volatile organic compounds (VOCs) in the subsurface. It has been described as a “semi-quantitative, field-screening device” (EPA, 2009). The probe is advanced using direct push or cone penetrometer technology at a rate of approximately one foot per minute. The probe contains a soil conductivity device, which is used to characterize the subsurface lithologies. The MIP contains a fluorocarbon membrane mounted on the side of the drive point. The membrane is heated (from 100 - 120 C) and VOCs partition from the soil, soil gas or groundwater across the membrane where they are transported to the surface by a carrier gas (Griffin, 2002). At the surface the vapors are analyzed in a truck-mounted laboratory using one or more detectors. For assessment work at drycleaning sites, normally three detectors are utilized: a flame ionization detector (FID), photoionization detector (PID) and the electron capture device (ECD). The FID is used primarily to detect petroleum compounds. The PID is most sensitive to aromatic compounds and the ECD is used to identify chlorinated compounds.

The MIP provides continuous profiling offering real-time data. It is effective in both the saturated and unsaturated zones and in clays. Since the MIP generates semi-quantitative data it cannot delineate contamination to regulatory standards. The detection limit for the PID is reportedly 1 ppm. The ECD is reported to have a detection limit of 2.5 ppb (EPA, 2009). However, for practical purposes, the resolution for the tool is approximately 100 ppb. Nonetheless, the MIP can be a highly effective tool in site characterization work at contaminated drycleaning sites. The primary application of the tool at drycleaning site assessment work would be to provide a picture of the distribution of contaminants in source areas. At highly contaminated sites where remediation is anticipated, one to three days of MIP work performed in and near the contaminant source(s) area can delineate the distribution of the predominant portion of the contaminant mass. These data will prove to be invaluable in remedial design, particularly where in situ remediation is being considered. Coupled with lithology borings and the soil conductivity data the MIP logs can be used to aid in choosing strategic locations and screen intervals for monitor wells to evaluate the performance of the remedial system. MIP data can also be used to select injection intervals for in situ remedial systems. The MIP has also been used as a post-injection evaluation tool at in situ chemical oxidation sites.

Figure 30. Membrane Interface Probe. The membrane block is the white rectangular block grasped by the man's right hand.

7.8 Assessing Sanitary Sewer Lines

As previously noted, sanitary sewers have been a favorite disposal point for drycleaning wastes. Leaking sewer lines serving drycleaning facilities are often point sources for drycleaning solvent contamination of soil/groundwater. Sewer line investigations are an integral part of contamination assessment work at drycleaning sites. Techniques that have been used to identify leaks in sewer lines include smoke testing, running a video camera down the line, and pneumatic pressure testing. During the site assessment, it is important to note the locations and flow directions for the sanitary sewer lateral and main lines.

In smoke testing, a section of the sewer line is generally partially blocked. Smoke is generated with either a smoke bomb or liquid smoke. A large fan is used to force the smoke into the sewer line. Exiting smoke plumes are generally marked and the locations are mapped.

A video camera survey is the most common method used to assess leaks in sanitary sewer lines. A variety of equipment is available from push systems that employ small cameras that can access 1-inch diameter cleanouts to crawler systems that can be used to inspect large diameter sewer mains. If blockages are present, the sewer line may need to be cleaned or jetted out prior to running the camera. Small blockages can sometimes be breached or pushed aside by the sewer camera.

These services offer a closed circuit television inspection. Videos are available in color and these are recommended over black and white. Generally, the footage run and the time are recorded and are presented on the video. Some of the services offer an audio narration by the operator. An experienced operator is a necessity. It is recommended that the camera be stopped, backed up and re-run in sections of the pipe where there are lateral line intersections, cracks, parted joints, sags or settled pipe joints, root passages etc. Also recommended is that these surveys be conducted during non-peak business hours when wastewater flows are at a minimum. Useful data cannot be collected when there are large discharges to the sewer line, such as the release of wastewater from washing machines.

Small sewer line leaks cannot always be identified by video cameras. Pneumatic pressure testing of sewer lines can identify these leaks. In this method, packers are used to isolate small sections of the sewer line and then air is introduced under low pressure into the isolated section and any decline in air pressure is logged.

8. STATE APPROACHES TO SITE ASSESSMENT WORK

8.1 Site Assessment Approach – Alabama

The Alabama Program is a voluntary reimbursable program, which is managed by the Alabama Department of Environmental Management (ADEM) and the Alabama Drycleaning Environmental Response Trust Advisory Board (Board). The Assessment Section of the ADEM Environmental Services Branch provides regulatory and project management, while the ADEM Groundwater Branch provides technical review of the documents submitted. The Board approves contactors for the assessment and remediation activities, as well as oversees the Drycleaning Trust Fund.

All participating drycleaners must register with the Alabama Department of Revenue and operating sites must pay a two percent of gross income fee in order to be reimbursed for assessment work associated with a release of contaminants from a drycleaning facility. Once a release has been confirmed, the Responsible Party should hire a contractor from the approved contractors (ADEC) list. These approved ADEC are designated into three categories based on experience and professional personnel. The contractor should, at that time, submit plans and cost proposals for site assessment and/or remediation. All costs for work are approved by the Board at quarterly meetings. Test methods typically used for analyzing drycleaning contaminants are EPA 8260 or 8021 for soil and water. Alabama has established Preliminary Screening Values for both soil and water, and also utilizes a risk-based approach for every site.

Lessons Learned

- Since approval of the ADEC is based on work experience and professional personnel, it is imperative to obtain the appropriate personnel involved as soon as possible for development of any corrective actions, if necessary. Some of the ADECs are only approved for initial assessments, and not for remediation.

- Having the costs for site activities approved on a quarterly basis sometimes hinders site assessment and remediation. Having cost proposals and plans authorized in a timelier manner would be advantageous for expedited site remediation. This is a matter the Board will have to address.

- There are no regulatory guidelines in the Drycleaner Act in regard to enforcement activities since this is a voluntary program.

8.2 Site Assessment Approach – Florida

The Hazardous Waste Cleanup Section of the Florida Department of Environmental Protection manages the Florida Drycleaning Solvent Program. Information on the Program can be found at (www.dep.state.fl.us/waste/categories/drycleaning). It is a state lead program, utilizing private contractors to perform site assessment and remedial work. Assessment work began at Program sites in early 1997 and through 2009; contamination assessments had been completed at over 300 drycleaning sites. Program objectives relative to site assessment are:

- Performance of site assessments in an efficient and timely manner with emphasis on minimizing the number of site mobilizations;

- Minimization of investigation-derived wastes and waste disposal costs; and

- Collection of data necessary to develop an accurate site-specific model and an appropriate remedial design.

Most drycleaning sites are assessed using direct push technology with onsite analysis of samples utilizing certified mobile laboratories. These laboratories are equipped with laboratory-grade gas chromatographs (GC) or gas chromatographs/mass spectrometers (GC/MS). At PCE drycleaning sites an abbreviated Method 8021 or Method 8260 is run for PCE, its degradation products and BTEX compounds. Based on analysis of the real-time data, the scope of work is adjusted in the field to delineate the contaminant plume and complete the assessment. An inside-out approach is used, collecting samples in known or suspected contaminant source areas: drycleaning machine, distillation units, service door, sanitary sewer lines (particularly near line junctions), sewage lift stations, septic tanks/drain fields, etc and then moving outward from the source areas to define the extent of contamination.

Modified active soil gas sampling (MAGS™) is being utilized early in the assessment process to identify contaminant source areas (Refer to technology discussion.). Based on soil gas results, soil samples are collected and analyzed in the mobile laboratory with some splits sent to a fixed laboratory. Lithology borings are installed as necessary to determine site stratigraphy. Based on site stratigraphy, groundwater samples are collected via direct push technology vertical profiling, where feasible. Groundwater samples are analyzed in the onsite mobile laboratory. To facilitate remedial design, groundwater samples are collected on a relatively tight spacing, both laterally and vertically, in source areas where the bulk of the contaminant mass resides. As sampling proceeds out away from the contaminant source area(s), sampling locations are spaced further apart with the objective of determining the lateral and vertical extent of contamination. Based on these data, the locations and screen intervals for monitor wells are chosen. Where applicable, small diameter (up to 1-inch) monitor wells (microwells) are installed via direct push technology. Pre-packed well screens are generally utilized for these wells. Approximately two-thirds of the monitor wells installed at Program drycleaning sites have been microwells.

Where conditions are unfavorable for direct push technology, conventional monitor wells are installed. Sonic drilling or roto-sonic drilling rigs are commonly used to complete the assessment. Sonic drilling offers many advantages versus well installation using mud rotary drilling (Refer to technology discussion).

Groundwater samples collected from monitor wells are analyzed in a fixed laboratory. At PCE drycleaning sites, a full Method 8021 or Method 8260 is run. At sites that used petroleum drycleaning solvent in addition to a full Method 8021 or Method 8260, a TRPH method and Method 8310 are run to analyze for petroleum hydrocarbons and poly-nuclear aromatic hydrocarbons.

When applicable and wherever feasible, data is collected during the assessment to aid in the remedial design. This may include geotechnical data such as soil porosity, bulk density and fraction of organic carbon, soil samples for oxidant demand studies, groundwater field parameters and general groundwater geochemical parameters, as necessary. Sampling for natural attenuation parameters is common at most sites, including: total organic or dissolved carbon, nitrates, nitrites, sulfates, sulfides, chlorides, alkalinity, carbon dioxide, ferrous iron, total iron, methane, ethene and ethane, as applicable and necessary.

Membrane interface probe (MIP) logging (Refer to technology discussion.) is generally conducted at highly contaminated sites (groundwater PCE concentrations >10% of aqueous solubility). This work normally involves two to three days of MIP profiling in and near the contaminant source areas to determine the distribution of the bulk of the contaminant mass, better define the site stratigraphy and develop a more accurate site-specific model. Additional performance monitoring wells are generally installed based on MIP results.

Lessons Learned

- Active soil gas surveys are superior to soil sampling to characterize contaminant mass distribution in unsaturated zone source areas.

- Include remedial design personnel early in the assessment process and whenever possible, collect the data necessary for designing a remedial system during the assessment.

- There never seem to be enough performance monitoring (source area) wells and based on vertical profiling alone, they are often not screened in the right intervals. This is where MIP logging pays dividends.

- Install monitor wells screened across the water table in all contaminant source areas. This is especially important at sites where drycleaning operations are still being conducted and future solvent discharges are always a possibility.

8.3 Site Assessment Approach – Illinois

The Illinois Drycleaner Environmental Response Trust Fund (Fund) was enacted in 1997 to provide financial assistance to drycleaners where soil and groundwater contamination issues need to be addressed. One of the requirements for the drycleaners to receive cleanup benefits from the Fund was to document the presence of solvent contamination and file a claim for remedial program benefits by June 30, 2006. Remedial program benefits are to reimburse the drycleaner for eligible cleanup costs incurred in remediating historical drycleaning solvent contamination.

Overall Scope of Work for Site Investigation

The site investigation activities of the Illinois Fund program can be categorized by the following three (3) phases. The first phase (or "initial" stage) of site investigation involved a minimal scope of work and was needed to meet the June 30, 2006 remedial claim-filing deadline. This initial stage investigation identified drycleaning facilities with historical drycleaning solvent contamination. The general scope of work for the initial phase site investigation was the installation of 4-6 soil borings down to 12-20 ft and the installation of 1-3 groundwater monitoring wells. As a part of the site investigation requirements, samples were collected in the area of the former and current hazardous waste containers, waste water vaporizer, drycleaning machine, back door of the drycleaning facility and along the sanitary sewer lateral where contamination was most likely to be found. At a minimum, two (2) samples were collected per soil boring at varying depths and one (1) sample per monitoring well (if possible) were required. A total of 754 drycleaning facilities went through this initial site investigation. As a result, drycleaning solvent contamination above the Illinois Tier I level of contamination was discovered at 685 out of 754 drycleaning facilities.

Second phase was the "risk-based closure" stage which identified drycleaning facilities that could be closed via risk-based closure without active remediation. The main focus of the site investigation during this stage was to delineate the outer boundary of the contamination plume via the installation of 5-40 additional soil borings and the installation of 10-20 additional groundwater monitoring wells. As a result, a focused no further remediation (NFR) letter via risk-based corrective action (RBCA) was issued at 336 out of 685 drycleaning facilities as of May 2010.

The third phase is the "active cleanup" stage in which the site investigation focus was mainly hotspot delineation. The scope of work for the site investigation during this stage was the installation of 5-25 additional soil borings and monitoring wells although the scope of work varies significantly depending on the severity of the contamination and availability of a groundwater usage prohibition ordinance (or groundwater ordinance). Note that many of the monitoring wells installed during this stage are also being used as injection points during the remediation process (in situ chemical oxidation and/or bioremediation).

Although there are some overlaps between the three phases, the facilities in the Illinois Fund program followed the site investigation phases described above.

Number of Samples & Sampling Depth for Soil Boring and Screen Length for Monitoring Wells

The screen length of the monitoring wells and number and depth of soil sampling depends on the vertical soil type profile and field PID readings. In the first and second phases of the site investigation, the screen length for monitoring wells were typically 10-15 feet and soil samples were based on field PID readings. In soil borings without distinctive PID readings, soil samples were collected near the surface (0-4 feet) and the bottom of the soil boring column (12-16 feet).

For the third phase of the site investigation (which focused on hotspot delineation necessary for later remedial action), the screen length for monitoring wells is typically 5-10 feet. Spacing between the monitoring wells ranged from 2-8 feet depending on the severity of contamination and soil type at the drycleaning facility.

Sampling Methods, Protocols, Analytical Requirements

Depending upon the type of solvent used at the drycleaning facility, VOCs and/or SVOCs analysis of each sample were required. The analysis of only VOCs was required at the majority of the drycleaning facilities since PCE was the only solvent used at approximately 93% of the drycleaning facilities. All soil samples were collected via direct push technology and VOC samples are required to be collected via SW-846 Method 5035.

For analytical purposes, Method 8260 for VOCs and Method 8270 for SVOCs are required. The Illinois Fund requires all analytical methods to include a minimum of PCE and its daughter products such as TCE, DCEs, VC, etc and BTEX compounds. All samples were required to be analyzed at accredited fixed analytical laboratories.

Lessons Learned.

- Installing monitoring wells with screen lengths greater than 10 ft may not provide accurate information regarding the groundwater contamination.

- The process of collecting groundwater samples is very important. The groundwater table in Illinois is about 3-7 feet according to the field data and the monitoring well depths are 16-20 feet at most drycleaning facilities. Once monitoring wells are installed, they need to be purged, allowed to recharge, and then sampled. Since the majority of the monitoring wells have a water column of 8 feet or more, if the groundwater sample is collected near the top of the groundwater table, especially at the drycleaning facility with free product present, it can significantly underestimate the groundwater contamination level since DNAPLs sink.

- In most cases, there is no such a thing as "too much site investigation" especially in the hotspot area. Our experience has shown a detailed hotspot delineation will save both time and money in completing the cleanup.

- Following the soil type classification protocols in the field is often very difficult, resulting in soil type classification which seems quite subjective. After all, what is the difference between sandy clay, clayey sand, sandy silt, etc? If the consultant designing and executing the remediation plan was not involved during the site investigation phase, it is recommended that limited additional site investigation be conducted by the consultant prior to completing the remedial design in order to get a sense of the site specific vertical and horizontal soil type.

8.4 Site Assessment Approach – Kansas

The Kansas Drycleaning Facility Release Trust Fund (DFRTF) was established in 1995 to provide funding for implementation of the Kansas Drycleaner Environmental Response Act. The DFRTF is administered by the Kansas Drycleaning Program, within the Kansas Department of Health and Environment (KDHE), as a state-lead corrective action program. Assessment, remedial design, remediation implementation, and remediation operation and maintenance (O&M) activities are conducted through a team effort with a KDHE project manager serving as the lead for the project and the environmental consultant providing technical expertise and field work.

The initial site assessment activities include the following as part of an Expanded Site Assessment (ESA):

- Site history information compilation;

- On-site reconnaissance activities; and,

- Field sampling to identify the nature and vertical/horizontal extent of contamination.

Prior to site mobilization the available information concerning the site is compiled from available sources, including county appraiser records or web sites, informal title searches, city directories and Sanborn® Fire Insurance Maps, available information describing geologic and hydrogeologic conditions, and the review and documentation of current and historical aerial photographs.

The initial site reconnaissance is performed to inspect the site and adjacent property for potential source areas by researching past and present activities or operations at the site. The site is visited and owner/operators, managers, and/or facility employees are interviewed to identify the location of drycleaning machines, USTs, ASTs, entrances, disposal methods, sewers, dumpsters, special waste areas, waste types, spills, leaks, location of trenches, equipment storage, buried utilities, overhead obstructions such as utility lines and trees, etc. The reconnaissance is also used to identify potential receptors and sensitive environments.

KDHE often uses the site reconnaissance to perform sewer line camera surveys to locate private lines and identify potential contaminant discharge locations from broken lines. In addition, soil gas surveys using passive soil gas samplers are used to identify areas to focus sampling during the field sampling activities.

Upon the completion of these tasks, sufficient information has been collected to identify specific locations for implementing field-sampling activities. In an effort to minimize investigation-derived waste (IDW), most sites are assessed, whenever possible, using direct push technology. KDHE has used both on-site mobile and fixed laboratories, but most sites use fixed laboratories for soil and groundwater analyses. When a mobile laboratory is used, 20 percent of the samples are confirmed at a fixed laboratory. Groundwater samples are required to use a fixed laboratory for analysis. The sample locations are guided by the previous reconnaissance data collection activities and proceed from suspected source areas outward to define the extent of contaminant migration, both vertically and laterally. Direct push conductivity logging is also frequently used to supplement site hydrogeologic understanding (i.e. water-bearing zones and stratigraphic changes).

Once adequate data have been collected to identify suitable locations and depths for permanent monitoring wells, the wells are installed. Monitoring well installation is typically performed using standard drilling techniques in Kansas. Portions of the state are amenable to well installation via hollow stem auger drilling while other areas require the use of air or mud rotary or rotosonic techniques. Various methods are required due to depth to groundwater and site stratigraphy (presence of bedrock, etc.). Due to great depth to groundwater in the western portions of Kansas, KDHE has been utilizing HydraSleeve™, or equivalent, no purge groundwater samplers to collect groundwater samples after the initial round of sampling. However, these samplers are not allowed to support site closure. Where depth to groundwater is more suitable, low-flow sampling methods are utilized to collect groundwater samples.

While every effort is taken to minimize site re-mobilizations, it is not uncommon upon the completion of the initial ESA field activities and the reduction and analysis of the data, to identify areas that require more data collection to refine the conceptual site model to better represent the site contaminant migration. KDHE has procedures in place to perform these follow-up investigations, as needed, through a source investigation and/or a supplemental site assessment.

Throughout the assessment activities, KDHE and their consultants work together to consider the potential remediation for the site. KDHE has often performed assessment and remediation activities in or near a site area and uses this knowledge to collect additional data to support potential remedial designs during the assessment activities.

Lessons Learned

- Sewer lines are often a primary contaminant source;
- Soil contaminant concentrations can vary considerably within a few feet;

- Site assessment sampling must include sampling inside the facility;

- Vertical migration pathway zones must be identified for monitoring purposes; and,

- Third party wells must be identified and located since they often impact groundwater flow.

8.5 Site Assessment Approach – New Jersey

The State of New Jersey does not have a funding program specifically for the remediation of drycleaner sites. The assessment of drycleaner sites in New Jersey is conducted in the same manner as any other potentially contaminated site. All aspects of the remediation of drycleaner sites are managed under the Site Remediation Program within the New Jersey Department of Environmental Protection (Department) and are guided under several regulations. These include the Site Remediation Reform Act which covers administrative requirements, the Remediation Standards, and any necessary guidance documents. The Technical Requirements for Site Remediation is the most important guidance document dictating the technical procedures for conducting the assessment, investigation, and remedial actions at a site.

Due to a large number of sites in the Site Remediation Program, a backlog developed which could not be properly addressed under the existing protocols. In an effort to address this backlog, a Licensed Site Remediation Professional (LSRP) program was initiated. The LSRP program requires that environmental consultants, through a Department certification program, obtain a license to oversee work on contaminated sites in New Jersey. By obtaining the license, the environmental professional has both the authority and responsibility to make environmental decisions without prior Department approval. After the LSRP completes the investigation and remediation of the site, he/she has the authority to issue a Remedial Action Outcome (RAO) which is equivalent to a No Further Action decision issued by the Department. The Department will conduct an audit of a percentage of the mandatory documents and RAO's. It is the intent of the Department that by only having to review a percentage of the submitted documents and outcomes, and not requiring prior approval of these documents, that the remediation of many more sites in the backlog will be expedited.

8.6 Site Assessment Approach – North Carolina

The North Carolina Dry-Cleaning Solvent Cleanup Act (DSCA) Program is administered by the State's Division of Waste Management in the NC Department of Environment and Natural Resources. The DSCA Program consists of a Remediation Unit and a Compliance Unit, and is funded by taxes on drycleaning solvent and services. The majority of the DSCA Fund is earmarked for assessment and remediation of contaminated drycleaning sites. This work is performed by the Program's independent State-lead contractors and overseen by the Remediation Unit. Since inception of the Program in 1997, 248 sites have been certified into the DCSA Program; of these, 122 have been fully assessed.

As a voluntary program, DSCA has in the past relied on property transactions or referrals from other regulatory agencies to prompt petitioners to seek entry into DSCA. To help increase participation from the many hundreds of drycleaners and property owners of former drycleaners, the Program sought and obtained statutory authority to spend annually up to 1% of the Fund balance to conduct limited preliminary investigations at sites where we had a reasonable belief that a release had occurred. This reasonable belief is based on owner or operator knowledge or, in the case of a PCE cleaner, if the facility operated prior to RCRA Subtitle C (Hazardous Waste) regulations for handling spent solvent. Site conditions dictate the scope of this limited investigation, but in most cases it involves the collection of a minimum of 3-4 soil samples, 3-4 direct push groundwater samples, and samples from areas of concern specific for the site. These samples are typically analyzed for VOCs per Method 8260, and in cases where SVOCs are a concern, Method 8270 as well. If no contamination is found, then the limited investigation is done at no cost to the property owner. If contamination is found, the owner or operator is eligible to join the DSCA Program; however, if the site is contaminated and the owner/operator opts not to enter DSCA, the state has statutory authority to seek cost recovery for the costs of the limited investigation. Of the 33 sites certified into the DSCA Program during 2009, 19 were brought in using these limited investigations.

Once a site is certified into the DSCA Program, the first phase of the site investigation is the prioritization assessment. The purpose of the prioritization assessment is to gather sufficient data to establish a receptor-based priority for the site. Typically this phase involves collecting on-site groundwater, soil, and vapor intrusion (soil gas, sub-slab vapor, or indoor air) data to define the magnitude of contamination and the migration direction. When feasible and appropriate, direct push methods and mobile lab analyses are utilized during the prioritization assessment, however, the local geologic conditions may necessitate the use of hollow-stem auger or air rotary equipment. A receptor survey is also conducted during the prioritization assessment to identify potential exposure pathways at the site (e.g., drinking water wells, surface waters, or indoor air). Since the vast majority of sites in the DSCA program are current and former PCE cleaners, sample analyses commonly target PCE and its breakdown products. Site circumstances, such as neighboring UST incidents will often necessitate the inclusion of a larger list of analytes to evaluate the contribution of and risk posed by the non-drycleaning related contamination. Historically, the NC DSCA Program has been sufficiently funded to address all the sites in the program, but due to the high cost of remediation and the decrease in receipts, the prioritization of sites has become critical in determining where to spend the limited funds.

As a general approach to conducting site assessments, the NC DSCA Program addresses source properties with an "inside-out" approach. In other words, we presume the release or discharge of drycleaning solvent emanated at the surface (either inside the drycleaner building, or in close proximity outside the cleaners), and the assessment focuses on locating and delineating the highest soil and groundwater concentrations at the source property. At non-source properties, the Program takes an "outside-in" approach. Impacts at non-source properties are most commonly due to the migration of contaminated groundwater. The resulting assessment at non-source properties focuses on finding contamination in the subsurface and determining if any exposures pathways are complete by assessing the path between the contamination and the receptor. For example, to determine if a resident down gradient of a drycleaner were at risk, we would first determine if their groundwater was impacted; if so, we would be sure they were provided clean drinking water. If the groundwater contaminant concentrations indicate that there may be an indoor air concern, near slab soil gas (at multiple depths, if possible) would be collected to determine if vapors in the vadose zone pose a potential risk. If so, and depending on the construction of the home, sub-slab vapor, crawl space, and/or indoor air samples may be collected to further evaluate the possible exposure.

In 2009, the DSCA Program amended its site assessment approach for PCE cleaners to include the evaluation of vapor intrusion at the source property early in the assessment process. At source properties that are no longer drycleaners or dry drop-off stores, the revised assessment includes the collection of indoor air and sub-slab vapor samples analyzed for PCE and its breakdown products during the initial phase of assessment. These air and sub-slab vapor samples are typically collected with SUMMA canisters. However recent developments have shown promising results for a passive sampler known as the Radiello sampler. While the Radiello sampler has some limitations, the DSCA Program is increasingly using them for indoor and ambient air samples due to their lower cost, simpler deployment, longer sampling time, and excellent correlation with traditional SUMMA methods. For source properties where PCE cleaning occurs (or PCE cleaned clothes are handled), the revised assessment approach directs the Program to initially collect sub-slab vapor samples only. If sub-slab vapor samples at a stand-alone building exceed the appropriate screening level then the owner is notified that when operations cease, there may be an indoor air issue due to the subsurface conditions. When sub-slab vapor samples exceed the appropriate screening level at a PCE cleaner that is co-located with other businesses (e.g., share a common roof), then the Program collects sub-slab vapor and indoor air samples at the adjacent spaces to evaluate the vapor intrusion pathway.

During the course of assessment, DSCA focuses on identifying and assessing the areas where drycleaning solvent releases commonly occur, including the location of the drycleaning machines, waste and solvent storage areas, floor drains, dumpsters, and back doors. However, it is not uncommon to find that soil sampling does not clearly identify a source in the soil, even though ground water impacts suggests that there should be one. In these cases, DSCA has had success screening the sub-slab vapor with a sensitive, handheld photoionization detector (PID) that can detect volatile organic compounds (VOCs) at levels as low as 1 ppb to locate "hotspots" in the soil. The method is rapid and inexpensive, and utilizes small diameter holes drilled through the slab that are then screened with the PID to get a relative concentration of VOCs in the airspace below the slab. This screening presumes that there is nominal airflow below the slab so that the higher readings on the PID will be in close proximity to the higher soil concentrations. The PID has also helped the Program successfully identify specific pathways where vapor intrusion was actively occurring. The device was used to locate one specific floor crack in a former drycleaning plant (currently a neighborhood grocery store) where a significant vapor source was entering the building. At another former drycleaning site, the PID was used to identify an electrical conduit chase and gaps in the wall behind the baseboards as pathways for significant intrusion of vapors emanating from the soil into the building. In these cases, the PID aided in the identification of specific vapor intrusion pathways so the Program could better address the indoor air problems.

The DSCA Program's remedial actions have traditionally been focused on protecting impacted drinking water supplies and attaining ground water plume stability by reducing contaminant mass at the source. However, the Program's recent efforts to understand and address the vapor intrusion pathway have resulted in the recognition that the potential exposure to indoor air will likely be the driver behind many of the remedial actions that will be implemented as our Program moves forward. Given the growing recognition of the potential health concerns posed by the inhalation of PCE vapors, the assessment and mitigation of indoor air exposures will be a top priority.

8.7 Site Assessment Approach – Oregon

The Oregon Drycleaning Program (www.deq.state.or.us/lq/cu/drycleaner/index.htm) is managed by the Land Quality Division of the Oregon Department of Environmental Quality (DEQ). It is a state lead program, maintaining a pool of private contractors to perform site assessment and remedial work. DEQ staff sometimes conducts limited field monitoring. Assessment work began at Program sites in 1996, and through 2009 work has been conducted at over 30 drycleaning sites. Program objectives relative to site assessment are:

- Prioritize sites based on environmental risk. It is a priority to focus first on sites where there are data or other indications that the site may be a high priority threat to human health or the environment.
- Collect enough data to provide an initial assessment on the extent and magnitude of contamination and provide an initial screening of risk (screening data against DEQ's Risk-based Concentrations).
- Utilize funding sources in addition to the Drycleaner Environmental Response Account to pay for investigations at drycleaner sites, as available. This has been accomplished by using federal funds to conduct Preliminary Assessments at some sites or by using insurance to pay for investigation and cleanup.

Most drycleaning sites are assessed using direct push technology. For larger investigations, such as removal assessments, onsite mobile laboratories may be used. The use of mobile laboratories provides real-time data that help guide the investigation. The scope of work is adjusted in the field to delineate soil and groundwater contamination for a more complete assessment. Soil gas and sub-slab vapor sampling is becoming a bigger part of initial investigations; however mobile laboratory analysis of soil gas samples has not been as common as laboratory analysis of air samples. There is no reason why mobile laboratory analysis of soil gas and/or air sampling could not be used as part of investigations at drycleaner sites.

Sampling is typically started in known or suspected contaminant source areas (drycleaning machine, distillation units, area outside service door, along sanitary sewer lines, septic tanks/drain fields, etc.), moving outward from the source areas to define the extent of contamination.

Vapor intrusion has become a major factor affecting DEQ's course of action at drycleaner sites. DEQ published its *Guidance for Assessing and Remediation Vapor Intrusion in Buildings* in March 2010. DEQ is finding that risks from vapor intrusion into buildings quickly become a driving factor at most drycleaner sites. At operating cleaners still using PCE it can be difficult to assess current risk from vapor intrusion into the drycleaning shop itself, as it is often not possible to distinguish operational releases from historic environmental releases. DEQ does assess potential impacts to neighboring spaces if present. At former cleaner sites, or at cleaners that no longer use PCE, assessing the vapor intrusion pathway to indoor air is more straightforward. Vapor intrusion into building spaces adjacent to drycleaners is now recognized as an important problem to consider when investigating and cleaning up sites. Assessments now typically include a vapor intrusion assessment element, which might include sampling of soil gas and/or sub-slab vapors, as well as more traditional soil and groundwater sampling. These data help DEQ prioritize the site for future cleanup.

Groundwater monitoring wells are installed using direct push technology to install pre-packed, small diameter (typically less than 2-inch diameter) wells when possible. If geology or depth limits the effectiveness of direct push, conventional monitoring wells are drilled using various drilling methods, including hollow-stem auger, air rotary and sonic. Due to the high cost of deeper drilling and the limited funding of the Drycleaner Environmental Response Account, deep groundwater assessment and plume definition is sometimes deferred so that the Account's limited funds can be used to focus on cleanup and risk mitigation actions.

The DEQ Drycleaner law was modified in 2003 to require drycleaner owners and operators to investigate whether insurance policies are available that cover investigation and cleanup costs. If there is insurance covering the pollution, the owner or operator is required to make a claim of coverage for investigating and cleaning up the site. Using insurance, if available, can save the Drycleaner Environmental Response Account significant funds that can be allocated for use on sites without insurance. Insurance is also desirable, as the insurance coverage will typically provide for more thorough investigation and cleanup than is otherwise possible using the limited Drycleaner Program funding.

Lessons Learned

- Vapor intrusion is nearly always a key risk driver now when investigating drycleaner sites.

- Vapor intrusion may be of concern even though significant contaminant levels are not found in soil or groundwater.

- Collect soil gas and/or sub-slab vapor samples early on in the investigation.

- Using an on-site (mobile) laboratory can save time and cost when conducting comprehensive investigations (such as for a removal assessment).

- Utilize insurance, if coverage is available, for site investigation and cleanup to help offset spending of Program funds.

8.8 Site Assessment Approach – South Carolina

The Drycleaning Restoration and Technical Assistance Section of the South Carolina Department of Health and Environmental Control manages the South Carolina Drycleaning Restoration Trust Fund Program. It is a state lead program, utilizing private contractors to perform site assessment and remedial work. Assessment work began at eligible sites in late 1999 and to date, twenty-nine sites have been completely assessed and monitoring well networks have been installed. A comprehensive assessment approach was employed at these initial 29 sites using direct push technology with onsite analysis of samples utilizing certified mobile laboratories. A source-out assessment approach was used which involved collecting samples in known or suspected contaminant source areas and then moving outward from identified source areas to define the extent of contamination. Once sufficient data was obtained to support a remedial decision, the appropriate remedy was implemented.

During late 2006, the department initiated an abbreviated site assessment and receptor evaluation approach to accelerate the process of determining health risks associated with all program sites. These abbreviated site assessments, called Expanded Initial Assessments (EIA), are completed in ½ day of fieldwork per site, which includes limited soil and groundwater sampling and a receptor survey. The objectives of each EIA are as follows:

- Determine the magnitude of DC related impacts to soil and groundwater beneath the site.
- Determine the potential for offsite migration in the various impacted media.
- Determine whether any identified receptors have been impacted.
- Determine the potential for contaminants to impact identified receptors by managing/mitigating identified impacted receptors, including providing municipal tap or filtration for affected private wells, ensuring that affected public wells are taken off-line and conducting interim source removals (where feasible) at highly impacted sites.

Since December 2006, SCDHEC has completed 244 Expanded Initial Assessments and has mitigated several indentified impacted receptors such as private and public potable supply wells and highly contaminated surface soil discovered during the EIA process. Once the EIA approach has been completed at all program sites, with impacted receptors mitigated and human health receptor risk has been temporarily managed, the sites are re-prioritized based on proximity to receptors and magnitude of identified soil and groundwater impacts.

Program objectives for comprehensive site assessments following the EIA approach are:

- Performance of site assessments with emphasis on field-based analysis to minimize the number of site mobilizations;
- Minimization of investigation-derived wastes and waste disposal costs; and

- Collection of data necessary to develop an accurate site-specific model and an appropriate remedial design.

Most drycleaning sites are assessed using direct push technology with the field screening of samples utilizing the Color-TecMethod, which combines sample purging with colorimetric detector tubes to detect low concentrations of total chlorinated halocarbons in soil or water samples. At all drycleaning sites regardless of the type of solvent used 10% of the samples are sent to a South Carolina certified lab for analysis. Depending upon the solvent used Methods 8260B, 8270C or 524.1 (for drinking water) are used to determine the particular contaminants present. Based on the field screening in real-time, the scope of work can be adjusted while in the field using the Triad Approach to delineate the entire contaminant plume and complete the assessment. The assessment will begin at what is the expected source of contamination, usually as close to the drycleaning machine as possible, near dumpster areas, sewer lines, septic tanks or drains, any exposed soil adjacent to the drycleaning building. As contamination is confirmed the assessment will move further outward to delineate the plume. These can include the sampling of surface water in the area, or any drinking water wells both public and private.

Active soil gas sampling with field-based colorimetric analysis is utilized early in the assessment process to identify contaminant source areas. Based on soil gas results, soil matrix samples are collected and sent to a certified laboratory for analysis. Groundwater samples are collected with direct push technology using Color-Tec field screening. A small percentage of groundwater samples are sent to a certified laboratory to be analyzed. As sampling proceeds out away from the contaminant source area, sampling locations are spaced further apart to determine the lateral and vertical extent of contamination. Lithology borings are installed as necessary to determine site stratigraphy. Based on the field data and site stratigraphy, the locations and screen intervals for monitoring wells are chosen. Two-inch diameter monitoring wells are installed by conventional drilling techniques. Sonic drilling or roto-sonic drilling rigs are commonly used to complete the assessment. Sonic drilling offers many advantages versus well installation using mud rotary drilling (Refer to technology discussion). Pre-packed well screens are generally utilized for these wells. Groundwater samples collected from monitor wells are analyzed in a fixed laboratory. At PCE drycleaning sites, a full Method 8260B is run. At sites that used petroleum drycleaning solvent Method 8270C is run to analyze for petroleum hydrocarbons.

Lessons Learned

- Impacted receptors may exist at program sites that are awaiting assessment. An expedited, limited site evaluation approach is imperative for addressing potential human health risk on a program-wide basis.

- Active soil gas surveys are superior to soil sampling to characterize unsaturated zone source areas.

- Field-based analysis methods such as Color-Tec saves time and costs by providing real-time, decision quality data that is used to delineate the extent of soil and groundwater contamination allowing accurate placement of permanent wells.

8.9 Site Assessment Approach – Wisconsin

The Wisconsin Drycleaner Environmental Response Program (DERP) is managed by the Bureau for Remediation & Redevelopment in the Wisconsin Department of Natural Resources. State statute established a fund financed by fees on gross drycleaning receipts and solvent fees to reimburse drycleaner owner/operators their costs for cleaning up environmental contamination. While drycleaners must adhere to certain procedures (such as bidding site investigation work) in order to receive reimbursement, the process they follow to assess contamination is the same as that used at any other contaminated site in the state.

The DERP program in Wisconsin is now closed to new applicants. When applicants were admitted, they first undertook site discovery (basically a Phase1 and Phase 2 investigation) which consisted of site history (uses of the property, types of chemicals used, likely locations of release, etc.) and collection of soil and groundwater samples using direct push techniques. Environmental consultants were expected to target areas where contamination was most likely to be found, such as beneath the drycleaning machine, the back door, loading docks, etc. Environmental samples were usually analyzed at a fixed laboratory using standard methods (such as 8021 or 8260 for groundwater samples).

State statute requires responsible parties to report any contaminant release to the WDNR. The responsible party is then required to investigate and cleanup the contamination in accordance with State administrative rules. Refer to http://www.legis.state.wi.us/rsb/code/nr/nr700.html. NR 716, Site Investigations, requires the determination of degree and extent of contamination in all affected media.

In summary, most site investigations involve installing soil borings, using hollow-stem auger or other drilling techniques, collecting soil samples for classification and chemical analysis every 5 feet and installing 2-inch diameter monitoring wells screened at the water table and usually at depth below the water table (termed piezometers in Wisconsin). Consultants may choose to use direct push techniques to investigate soil contamination and may install small diameter temporary monitoring wells. However, according to state rules, monitoring wells used to assess the extent of contamination must be installed using 2 –inch diameter casing and well screens, and be properly constructed with sand packs, bentonite seals, surface seals, etc. All other information necessary to provide location maps, geologic cross-section and plan maps, water table and piezometric maps, etc. must be collected.

Besides determining the degree and extent of soil and groundwater contamination, investigators are also expected to assess the vapor intrusion pathway. At most drycleaners, this involves installing probes through the slab foundation of the building and collecting sub-slab vapor samples. If the drycleaner is located near other businesses or buildings, the vapor investigation may need to be extended to those businesses or homes. Wisconsin has drafted guidance and is currently writing rules that set out decision-making criteria for mitigating and remediating the vapor pathway.

Lessons Learned

- Improvement is needed in assessing the 3-dimensional degree and extent of groundwater contamination, particularly with DNAPL contaminants such as PCE.
- Site investigations at drycleaners should always include assessment of utility corridors, particularly sanitary sewers. While the WDNR has developed written guidance on utility corridor investigation, this evaluation is often not included in site investigation work.
- Soil vapor assessment appears to be more effective in identifying significant PCE soil contamination beneath buildings than soil matrix samples. Soil vapor is currently assessed primarily through sub-slab vapor samples.
- People are reluctant to grant access to their home/business for sub-slab vapor sampling. Close coordination and open communication between WDNR, WI Department of Health Services and property owner ease/address concerns.

8.10 Site Assessment Approach – Texas

The Texas Drycleaner Remediation Program (DCRP) is managed by the Texas Commission on Environmental Quality (TCEQ). It is a state lead program, utilizing private contractors to perform site assessment and remedial work. The assessment of DCRP sites began in 2005, and has been completed at 55 sites. Currently, assessment work is ongoing at 102 sites.

The Texas approach uses conventional investigation techniques, combined with field screening techniques to minimize mobilizations. Most investigation work is done using traditional drilling methods or direct push. Sampling begins onsite near typical source areas, and continues offsite if necessary. Two-inch diameter wells are commonly installed using hollow-stem auger, with continuous samples collected. Direct push methods may be used to collect soil samples, if conditions are suitable. Occasionally, 1-inch diameter wells are installed in direct push borings. Sampling inside buildings is done using a direct push rig, if access is available or using hand augers. The collection of air samples, membrane interface probe (MIP) logging, and geotechnical logging are performed occasionally, depending on site conditions.

If data is being collected for the first time at the site, samples are run in a fixed lab for the full suite of volatile organic compounds using EPA Method 8260/5035. If contamination at the site has been determined to consist only of PCE and it degradation products, a modified version of EPA Method 8260/5035 is run that includes only those compounds. During the investigation, data is often collected for remedial design considerations, or natural attenuation parameters.

Contingency borings and wells are often included, in an effort to avoid additional mobilizations. Samples are field screened using color-tec, and additional borings or wells are installed as necessary. It is important to have obtained offsite access to be able to install the contingency borings or wells.

The timely, cost effective disposal of investigative derived waste (IDW) is a concern for the Texas DCRP. IDW is generally stored in drums pending analysis and characterization before being disposed of offsite. To dispose of the waste cost effectively, a “milk run” is often done by the contractor to collect IDW from several sites. This occasionally results in drums being stored in public view for several months, which can lead to complaints. Alternatively, disposal of IDW immediately after the investigation, on a site-by-site basis, is more expensive.

Lessons Learned

- PCE can move in significant quantities through the first groundwater bearing unit, so investigation of the next lower unit is critical.

- Include field screening and contingency borings or wells to eliminate multiple mobilizations.

- Offsite access issues are often responsible for preventing quick assessment. It is never too early to start working on offsite access, and time should be budgeted for both the contractor and PM to contact property owners to obtain access.

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Appendix

Drycleaning Site Visit Checklist

Date: __/__/__

Site:____

Address:____
____

Contacts:
Real Property Owner_______________________________
Business Owner___________________________________
Business Operator_________________________________

Site History & Operations

Date initial drycleaning operations commenced:_______________________

Facility still active? (yes/no). If no, date closed & current use of facility______________

Have any other businesses occupied to building? If so, list types & dates of operation

____

Solvents used/dates: PCE, petroleum (type), Valclene, other (types):

____

Drycleaning equipment used: (e.g. transfer machine, dry-to-dry machine, distillation unit, spotting board, steam presses, vacuum unit, chiller, boiler, compressor, etc. Denote current and historical locations of equipment on facility layout diagram.

____

____

Conventional laundering performed (yes/no)?
If yes, was pre-cleaning/spotting performed prior to laundering (yes/no)?

How was the drycleaning solvent delivered to the facility?

____

Are or were ASTs/USTs ever present at the site (yes/no)?________
Denote contents, sizes & status of tanks.______________________
Show tank locations on facility layout diagram

If inactive, how and when were tanks abandoned______________________
____

Is or was the facility served by a septic tank/drain field?____________________________
Is the system active?________
If the system is inactive, how was it abandoned?____________________________
Show the location of the system on the facility layout diagram.

Does the facility have floor drains (yes/no)?_____________
Are the floor drains active or plugged?___________
Show the locations of the floor drains on the facility layout diagram.

Is there an onsite water supply well (yes/no)?____________
If yes, what are the construction details?______________________
What is the producing aquifer?______________________________
What is the use of the water?________________________________
Show location of the well on the facility layout diagram.

List the types of utilities that serve the facility and show their location on the facility layout diagram. ____
____
Show the flow direction for the sewer lines.
Show the location of sewer cleanouts and manholes on the facility diagram.

Facility Waste Management Practices

How are/were the following wastes disposed/managed?
____
Still Bottoms/Cooked Powder Residues:
____
Spent Filters (describe types):
____
Contact Water (separator water, vacuum water):
____
Lint:
____
Spotting & Pre-cleaning Residues;
____
Solvent/Spotting Agent Containers
____

Document any known spills, leaks or discharges of solvents or solvent-contaminated wastes. Include dates, estimated volumes and locations of discharges.

____

Potential Contaminant Source Areas: Describe the general condition of units or areas based on observations, historical operations, discussions with facility personnel, etc.

Drycleaning Machines

Solvent Storage Areas

Waste Storage Areas

Septic Tank/Drain Field

Sanitary Sewer Line

Floor Drains/Floor Cracks

Spotting Board

USTs/ASTs

Discharge Piping

Other

Document any regulatory enforcement/compliance issues, including dates, actions and regulatory agencies.

Secondary Containment

Has secondary containment been installed around and/or beneath:

Each machine that uses solvents (yes/no)?______________________

Solvent storage areas (yes/no)?___________________

Hazardous waste storage areas (yes/no)?_________________

Has the floor beneath the spotting board been sealed or rendered impervious (yes/no)?___
____

Site Drainage

Describe storm water drainage from the site (e.g. 0 storm water sewer, soakage pits/French drains, storm water catchment basins, ditches, etc. (Designate the locations and include designation of paved and unpaved areas on the site drawing).

Receptor Issues

Identify the locations (distances and direction from the drycleaning facility) of any nearby sensitive receptors (e.g. day care centers, schools, nursing homes, hospitals, etc.)

Identify the locations (direction and distance from the drycleaning facility) of any water supply wells and collect data regarding well construction details, producing aquifer and use.

Identify nearby buildings and businesses, including current and former use that used or may have used solvents.