Hazardous Wastes Within the Transportation Planning Context

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In the 1980s hazardous wastes are everyone's concern. For the transportation planner, hazardous wastes have become a significant factor in the location and expansion of roadways and other transportation facilities. In order to examine the issue of potential hazardous waste problems, a preliminary screening study should be undertaken at the initial planning or location study phase. The goal of such a study is to identify the potential for hazardous waste problems with a view to their avoidance, which is the optimal solution from a transportation planning viewpoint. Although the data review and surface field investigation are an important part of a preliminary screening study, they generally fail to address the historic profile of land use adequately. In order to determine the potential of hazardous waste contamination from historic land uses, an important supplemental step in the preliminary screening process is to carry out a computerized aerial photographic (CAP) analysis, which is a powerful tool for looking into the past and has proved to be a very accurate predictor of hazardous waste contamination. When the cleanup of a hazardous waste site becomes necessary, there are two basic components to the design: a remedial investigation and a feasibility study. There are four special features unique to cleanup activities at hazardous waste sites. These include the need for a quality assurance-quality control (QA/QC) program, a health-andsafety plan, an emergency and contingency plan, and on ongoing monitoring program. The extensive requirements of hazardous waste site cleanups only reinforce the need for identification early in the planning phases of a transportation project so that, wherever possible, hazardous waste contamination problems can be avoided.

In the 1980s hazardous wastes are everyone's concern. For the transportation planner, hazardous wastes have become a significant factor in the location and expansion of roadways and other transportation facilities. If hazardous waste problems are not taken into account, substantial extra costs and time delays for transportation projects can result. There have already been, unfortunately, cases in which hazardous waste contamination discovered for the first time during the construction phase of a project has resulted in tens of millions of dollars of extra costs for cleanup and years of delay over the originally scheduled completion date for the project.

Clearly it is advantageous to address hazardous waste problems earlier rather than later in the transportation planning process. The earlier the issue is addressed, the greater the flexibility of response in the development of a solution, and the greater the flexibility, the less the resulting extra costs and time delays. This is shown graphically in Figure 1. In the planning or location phase of a project, when flexibility of response is

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greatest, it may be possible in many instances to avoid a potential or known hazardous waste site altogether. Avoidance is the solution of choice whenever feasible. If a hazardous waste problem is left unaddressed until the design phase, the flexibility of response may have been reduced to the point at which avoidance is no longer cost-effective or possible. In this case, minimization of impact through a minor shifting of alignment or an engineering design modification may be the optimal solution. If a hazardous waste problem is not addressed until the construction phase, flexibility of response is generally low. Often the only feasible solution is a full-scale cleanup. The extra costs and time delays of this least desirable solution will in all likelihood be dramatically greater than what would have been available at earlier stages in the transportation planning process.

Two aspects of hazardous wastes are examined: the most effective way of addressing hazardous waste problems in the location study and planning phase of a project (the time at which they ideally should be addressed) and, for those cases in which site cleanup becomes necessary, the basic steps involved in the design of a cleanup and the special factors that must be taken into account during cleanup activities.

PRELIMINARY SCREENING STUDY

The goal of a preliminary screening study is to identify the potential for hazardous waste problems with a view to their avoidance, which is the optimal solution from a transportation planning viewpoint. A preliminary screening study should be undertaken when the initial planning and location study phase begins. A preliminary screening study comprises six basic steps.

Step 1. Initial Classification of Risk by Land Use Category

The first step in a preliminary screening study is to classify land use within the project area into three groups: high, medium, and low risk. High-risk land use categories include all known hazardous waste sites, all landfills (which are automatically suspect), and industrial sites under Standard Industrial Classification (SIC) codes that have historically been associated with hazardous and toxic waste contamination. These would include the industries for paper products, oil refining, chemicals, metal fabricating, electrical machinery, and plastics, to name a few. The medium-risk group would include (a) hazardous waste sites that have been subject to cleanup but at which there has been no final determination of completeness of the cleanup and



FIGURE 1 Hazardous waste site cleanup.

(b) industrial sites under SIC codes that historically have shown themselves to be possible candidates for hazardous or toxic waste contamination. These would include such industries as automobile assembly, textiles, and wearing apparel. The low-risk group would include all other land use categories. This classification should then be refined according to the following steps.

Step 2. Review of Available Data

The second step in the preliminary screening study is to make a detailed review of all data available at federal, state, and local levels that may provide information as to potential or actual sources of toxic and hazardous waste contamination for the land use within the project area. At the federal level, Environmental Protection Agency (EPA) files on Superfund sites and facilities under the Resource Conservation and Recovery Act of 1976 (RCRA) should be consulted. At the state level, the equivalent of a division of waste management within the state's department of environmental protection would be the best source. At the local level, regional authorities, counties, and municipalities should be canvassed regarding pertinent information they may have on file.

Step 3. Preliminary Field Investigations

The third step in the preliminary screening study is to make a visual surface examination within the project area in an effort to identify any apparent or possible problem areas with regard to hazardous waste contamination. It is during this preliminary field investigation that illegal dumping activities may be discovered. For example, it is not altogether improbable that a stack of metal drums, for example, may be found partially buried in a remote wooded area within a project area.

Step 4. Computerized Aerial Photographic (CAP) Analysis

Although the data review and surface field investigation are important refinements to the initial classification of risk by land use category, they alone are insufficient for a comprehensive screening because they generally fail to address the historic profile of land use adequately. What may appear on the surface to be only a vacant lot or grassy field may very well be the site of hazardous waste contamination that occurred decades earlier. To assume that what appears to be benign on the surface is in fact benign is to invite an unpleasant surprise later, when flexibility of response may be severely curtailed.

In order to address the issue of historic land use and the potential for hazardous waste contamination from such use, a fourth step in the preliminary screening process is to carry out a CAP analysis. This computerized analytic procedure is highly cost-effective and has proved to be an accurate predictor of the location of hazardous waste contamination. Because of its high utility and widespread applicability to transportation planning, it is useful to outline the steps of a CAP analysis in some detail. The basic steps are as follows.

Collect Aerial Photos

The first step in the CAP analysis is the collection of standard 9×9 -in. aerial photographs for as many different years as

possible for the entire project area in question. These aerial photographs, which have a standard scale of 1 in. = 2,000 ft or 1 in. = 1,000 ft, are available from a variety of sources, including the U.S. Geological Survey, the U.S. Army Corps of Engineers, state departments of environmental protection, county planning boards, and local aerial photography firms, to name the more common sources. In previous applications of CAP analysis it has generally been found possible to obtain 9×9 -in. aerial photographs dating back as far as 50 to 60 years and at intervals of one every 10 years or less up to the present time. In other words, it has generally been possible to obtain an excellent profile of land use over time, usually going back as far as the 1920s, that includes a time series of 6 to 10 aerial photographs for the entire project area.

Identify Suspect Uses

Once the aerial photographs have been collected, a trained aerial photographic interpreter examines them to identify areas of suspect use. In this regard it should be noted that stereoscopic pairs of aerial photographs are significantly easier for photointerpretation than single aerial photographs. The principal tool used for aerial photointerpretation is a stereoscope, which enables the aerial photointerpreter to view the photographed surface in three dimensions and to magnify areas of interest. In addition, using an attachment called a stereometer, the aerial photointerpreter can measure heights of objects in the photographs.

Through stereoscopic photograph interpretation, features can be recognized as having positive relief (located above ground level), negative relief (below ground level), or zero relief (at ground level). Assuming that stereoscopic pairs are available, which is generally the case, a trained aerial photointerpreter can readily identify sources of potential hazardous waste contamination, including landfills, lagoons, dump storage areas, tank storage areas, and even spills, whether accidental or intentional. The following are some of the major characteristics of these sources of contamination.

Industrial Activity Buildings and other industrial structures identified exhibit positive relief. Ground outlines of former building sites (zero relief) and excavations (negative relief) can be distinguished. Other signs of industrial activity are parking lots, smokestacks, incinerators, site roads, and trucks and other vehicles.

Drum Storage Drums and barrels are identified on the basis of positive relief, shape, and grouping. Ground stains are usually present when drum storage is identified.

Tank Storage Tank storage facilities are usually associated with a large industrial operation (refinery, utility, chemical company). They exhibit positive relief.

Liquid Storage Liquid storage facilities are also usually associated with a large industrial operation (refinery, etc.). They are a much greater potential source of contamination than tank storage facilities and are distinguished by the presence of liquid (which appears flat and is usually black), negative relief, and surrounding dikes (positive relief). **Standing Liquids** Standing liquids are usually associated with industrial or landfill operations. However, the accumulation is more likely to be unplanned. When it appears to be planned, it is usually confined to a ditch and a surrounding dike is not usually present. It is distinguished by the presence of liquid and negative relief.

Lagoon Lagoons are characterized by the same features as those for liquid storage, except that the purpose is for liquid disposal or runoff rather than industrial use.

Sludge Sludge is usually associated with large industrial operations and is characterized by a lighter color than liquids. Sludge has a negative relief and is typically found in the presence of surrounding dikes (positive relief).

Fill Fill is usually associated with grading operations. It is distinguished from undisturbed ground by its lighter color at inception (lack of vegetation) and positive relief. It is distinguished from landfill operations by its uniformity of color (generally light), smooth texture, flat surface, and lack of obvious waste.

Landfill A landfill is usually a sanitary landfill where municipal solid wastes and construction debris are permanently deposited. Characteristic features are positive relief, variable light and dark coloration, irregular texture, presence of waste piles, road network, trucks, incinerators, and leachate (lighter color) at extremities of the landfill. There may also be liquid storage, lagoons, and drum storage.

Waste Disposal Waste disposal is usually associated with an industrial facility. It can be recognized by variable light and dark coloration, irregular texture, and positive relief. It may be permanent disposal or temporary storage of waste material.

Digitize and Normalize Input

Following the identification of possible sources of contamination on the 9×9 -in. stereo pairs, the scales of the aerial photographs are enlarged to permit easy digitization, the process of translating paper drawings of photographs into computer images. Each photograph is enlarged to a scale of 1 in. = 200 ft to facilitate positive identification of minute features and to reduce the margin of error in the subsequent analytic process.

Digitization is then accomplished through the use of an electronic drafting board, called a digitizing tablet, with a defined coordinate system. The tablet is sensitive to the movement of a pointing device along its surface. The two most common pointing devices are the cursor and the light pen. Points, lines, or polygons from the photographs are translated into computer images by moving the pointing device over the digitizing tablet and pressing predefined buttons to define starting and ending points of the line constituting various shapes.

By so digitizing cultural, industrial, and environmental features, the resulting information can be readily readjusted for scale and displayed in a variety of useful formats for analytic purposes. The scales are also normalized during the digitization process for the sake of comparability in subsequent analysis.



FIGURE 2 Hazardous waste screening studies.

Generate Overlays

Once the digitized and normalized photographic information has been input into the computer, overlays are generated that identify known waste areas and industry site locations, transportation features, topographic features, and any type of information labeling desired. For ease of use, the information for different years is generally produced in different colors on the computer screen. The overlays can be mixed and matched in any combination of multiple sets and the overlay scales can be enlarged or compressed to provide more detail or to generalize features, depending on what is most useful. Figure 2 gives an example of a typical overlay that can be generated by the CAP analysis.

Flag Problem Areas

From the computer-generated overlays, potential problem areas can be flagged without difficulty and preliminary evaluations made regarding the ease of changing the corridor location or specific alignment of a proposed transportation facility in order to avoid such problem areas.

Step 5. Reclassification of Rlsk

Based on the foregoing three refinement activities, a final reclassification of risk by land use category is prepared.

Step 6. Preliminary Testing

On the basis of the final reclassification of risk by land use category, all high-risk classifications and some or all of the medium-risk classifications should be subjected to subsurface testing for the standard range of hazardous wastes. The current EPA regulations require that groundwater and soil samples be tested for 129 priority pollutants plus the next 40 highest unknown peaks. The preliminary subsurface testing is carried out in an effort to verify the presence of contamination and, where it is present, to serve as a starting point for the subsequent determination of a contamination plume profile designating the spatial dimension of the contamination. Moreover, when there appear to be cost-benefit trade-offs requiring a decision between shifting a proposed project within a transportation corridor or from a specific alignment to avoid a hazardous waste problem area or holding to the originally proposed corridor or alignment with the possible requirement that a hazardous waste cleanup may be necessary, preliminary testing is of vital importance to the decision process.

It should be noted that, to date, when field verifications of preliminary testing have been carried out, the CAP analysis has demonstrated itself to be an accurate predictor of the existence of historic hazardous waste problems. It is this type of accuracy that makes CAP analysis a powerful technique for quickly examining the extent to which past industrial or other activities may have resulted in hazardous waste contamination problems. This six-step preliminary screening study should delineate where the hazardous waste problem areas may exist so that, when it is feasible, they can be avoided. When because of engineering or other environmental constraints, one or more potentially contaminated areas cannot be avoided, steps can be taken early in the transportation planning process to determine the type and extent of hazardous waste contamination that must be dealt with.

SITE CLEANUP

Basic Steps in Design

When the cleanup of a hazardous waste site becomes necessary in conjunction with a transportation project, either because it has been determined through a preliminary screening study that such cleanup cannot be avoided or because, in the absence of adequate preliminary screening, a hazardous waste site has been encountered for the first time during construction, there are two basic components to the cleanup design: a remedial investigation and a feasibility study.

Remedial Investigation

The first step in a remedial investigation is to posit a series of engineering operations typically known as unit operation scenarios (UOSs) and to evaluate them for appropriateness. UOSs encompass controls of surface water, groundwater, gas migration, and waste.

Common UOSs under each of the four basic controls that may be suitable and appropriate to the specifics of a particular hazardous waste site are as follows:

- · Surface water controls
 - -Regrading and diversion structure
 - -Surface sealing
 - -Revegetation
 - -Cutoff trench
 - -Basin ponds
 - -Containment berm
- Groundwater controls
 - -Bentonite slurry trench
 - -Grout curtain
 - -Sheet piling cutoff wall
 - -Grout bottom sealing
 - -Underdrain
 - -Well point system
 - -Deep well system
 - -Well injection system
- Gas migration controls
 - -Gas vent trench
 - -Gas extraction well
- Waste controls
 - -Treament of contaminated water
 - -Chemical fixation
 - -Chemical injection
 - -Excavation and reburial
 - -Leachate recirculation

It is possible that during this evaluation further testing may be required. For example, a gravel vent trench for gas migration control is generally only feasible to a depth of 20 to 30 ft. Beyond this depth a gas extraction well may be necessary for gas migration control. Further field testing may be necessary to determine the depth of gas production in the hazardous waste site.

Feasibility Study

In a feasibility study the UOSs are integrated into one or more conceptual designs, which are evaluated with respect to costeffectiveness. A final design is then prepared. For example, if a site cleanup involves drummed wastes, the final design may specify overpacking of some of the drums for further processing later and the bulking of the other drums for landfilling. The shelf life of the overpacked drums would have to be determined and compatibility requirements for the bulked drums specified.

In the preparation of the final design, it again may be necessary to carry out further subsurface testing. For example, if waste containment is the preferred alternative and a bentonite slurry trench is proposed, further testing may be necessary regarding soil porosity, permeability, and cation exchange to ensure that the properties of the bentonite remain unchanged over time when exposed to the specific leachate at the site.

Special Features

There are four special features unique to hazardous waste site cleanup activities. These include the need for a quality assurance-quality control (QA/QC) program, a health-and-safety plan, an emergency and contingency plan, and an ongoing monitoring program.

Quality Assurance–Quality Control (QA/QC) Program

The goal of a QA/QC program is to verify the accuracy and precision of the findings and completeness of the chain-ofcustody documentation. In a hazardous waste site cleanup activity, the verified accuracy and precision are a necessary part of the state or federal review agency's requirements in order to certify the completeness and adequacy of the cleanup.

Moreover, in any hazardous waste site cleanup activity, the agency or agents responsible for the cleanup (or both) are always only one step away from being drawn into litigation. Allegations that a site cleanup itself may have caused the inadvertent spread of contaminants, resulting in harm to third parties, are always a danger. (One of the most common areas of concern is contaminates present at the hazardous waste site in question.) It is imperative to designate a properly trained QA/QC officer with proper authority within his agency's or firm's organizational structure to specify the QA/QC program and to monitor its implementation throughout the cleanup.

The QA/QC program must function during all phases of the site cleanup as well as during testing and design for all sampling procedures. There must be an accurate and complete documentation of all activities associated with sample acquisition in the field and sample analysis at the laboratory and transfer of custody of the samples in the field as well as at the laboratory. There must be training of all staff involved in the cleanup with regard to standard clearly specified procedures detailed in the QA/QC program. There must be provision for systemwide audits as well as random audits to check on the proper implementation of the QA/QC program. In addition, corrective procedures must be in place, both in terms of organizational responses and technical capability, to correct any deficiencies as soon as they are manifested.

Health and Safety Plan

The goal of the health and safety plan is to safeguard the wellbeing of all those engaged in the site cleanup activity as well as those populations adjacent to the site. At the outset, a health and safety officer must be designated to specify and monitor the health and safety plan for the cleanup. There is a series of steps that must be carried out in the development and application of the plan.

First, the health and safety officer must make a site evaluation for the cleanup in order to determine the major health and safety issues. Second, proper engineering safeguards must be installed, such as fencing, signing, and other controls, to ensure that only authorized personnel have access to contaminated or controlled areas on the site. In controlling the site the health and safety officer must delineate the four basic zones: exclusion, contamination reduction, support, and buffer.

The exclusion zone is the area in which the contamination has been located. This zone is off limits to all personnel except those who have been properly trained and who are wearing proper types of protective clothing. The contamination reduction zone is the ring around the exclusion zone in which the goal is to capture all of the contamination that may be coming out of the exclusion zone on equipment or clothing or through any other medium so that there is no spread of contamination beyond the immediate site. Cleanup equipment, health and safety equipment, and so on, are stored in the support zone. Finally, the buffer zone is designed to give an extra measure of protection to populations adjacent to the site.

For all personnel working on the site, there should be a medical surveillance program to determine antecedent medical conditions to use as a medical benchmark against which to measure exposure to any toxic or hazardous substances that have affected or may later affect their health and well-being. In this regard there should also be an ongoing site-monitoring program, particularly for explosive or toxic gases that may be released during site cleanup. In addition, the health and safety officer must specify the levels of personal protection that are appropriate to the site cleanup. These range from Level A, the so-called "moon suit," through Levels B, C, and D. Level-A protection provides complete insulation against respiratory as well as percutaneous hazards. The advantage of this level of protection is its completeness. The disadvantages are the expense of providing for equipment and the dramatic decrease in efficiency of workers enclosed in such protective gear. The efficiency rate for workers in Level-A protective clothing may decrease by a factor of 4 or 5 over that which would be achieved without any level of protection.

Emergency and Contingency Plan

The emergency and contingency plan should contain four basic procedures: evacuation, contact, containment, and remedial action. The evacuation procedures specify how the site is to be evacuated in the event of an emergency such as an accidental release of a toxic gas or liquid. The contact procedures specify what outside agencies are to be contacted, in what order, and for what type of emergency. Agencies typically contacted in such emergencies would include fire department, police department, ambulance, Federal Emergency Management Agency (FEMA), health officers, and the poison control center. The containment procedures specify what measures should be put in place immediately after the emergency has occurred in an effort to contain the further spread of the accidentally released toxic materials. Finally the remedial action procedures should specify the types of corrective measures to be put into place to eliminate the emergency situation so that cleanup activity can recommence.

Ongoing Monitoring Program

In most hazardous waste site cleanups, there is a requirement for postcleanup monitoring with regard to leachate and gas control. The purpose of these monitoring programs is to satisfy the appropriate review and regulatory agencies that the site cleanup is in fact adequate and complete and that the site has been stabilized. Stabilization of a hazardous waste site occurs when the reduction in the volume and characteristics of leachate or gas generated (or both) within the site reaches levels that will not endanger the environment adjacent to the site if and when the leachate or gas migrates across the site boundaries without further treatment or attenuation.

CONCLUSION

The extensive requirements of hazardous waste site cleanups reinforce the need for identification early in the planning phases of a transportation project so that, wherever possible, hazardous waste contamination problems can be avoided. The mission of departments of transportation is to provide for the safe and efficient movement of people and goods. It is the mission of other departments to deal with the problem of cleaning up the hazardous and toxic waste sites found throughout the country. The goal of a waste-screening study should be to keep these two missions separate.

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