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Long-Term Stewardship of Schools Built on Remediated Sites

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Long-Term Stewardship of Schools Built on Remediated Sites

by

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Date: December 16, 2010

SZT

Project Number: 41-SZT-002

LONG-TERM STEWARDSHIP OF SCHOOLS BUILT ON REMEDIATED SITES

An Interactive Qualifying Project Proposal

submitted to the Faculty of

WORCESTER POLYTECHNIC INSTITUTE

in partial fulfillment of the requirements for the

Degree of Bachelor of Science

by

Freshta Abedi

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Date: December 16, 2010

Professor Seth Tuler, Advisor

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Executive Summary

In 1985, The Government Accountability Office estimated that there were about 425,000 contaminated sites in the country (GAO, 1985). Only 19,400 of these sites were identified by the Environmental Protection Agency (EPA) and a proper list of all contaminated sites did not exist. The number of contaminated sites has not fluctuated much in the last twenty years (Scorecard, 2005).

The federal government has several programs to carry out remediation of contaminated sites. One such program is the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), which has lead to the analysis and remediation of thousands of these contaminated sites within the last twenty years (EPA, 2006). In addition, states have programs to address the tracking and cleanup of contaminated sites that have not been addressed by the federal programs (Scorecard, 2005).

After a site has been remediated, the land can be reused for other purposes. A common reuse of remediated sites is construction of schools. According to the Massachusetts waste site database, a total of 38 school sites have been built on remediated sites since 1995 (Mass.gov, 2010). Reuse of remediated sites for school construction inspires more public concerns than other forms of land use since children are one of the most vulnerable members of our society.

Due to budget constraints, the nature of the contaminant, or a lack of technology, remediated sites are not necessarily "clean". Thus, sites that have been remediated by the state or the federal government have periodic protocol associated with them to ensure the protection of human health and the environment. Long-term stewardship (LTS) is the term used to describe the management of remediated sites (NRC, 2003).

Though remediated school sites may have been in compliance with state and federal standards when the schools were built, schools that lack a long-term stewardship plan may fall out of compliance with required regulations. Thus, municipalities often take a lead role to ensure LTS functions are carried out appropriately (NRC, 2003).

The National Research Council published a report which presented various issues relating to Long-term Stewardship and made recommendations on how it should be carried out. Using this report as background knowledge and by studying schools in Massachusetts, we identified how LTS is carried out in schools and determined best practices. We studied the practices in schools by conducting interviews with officials that we felt were most knowledgeable, drawing out their perspectives and insights on matters regarding budget constraints and funding, various monitoring options, and health risks posed by the contaminants present.

We then offered recommendations relating to implementation of LTS functions in schools and suggested possible areas for further research. Our chief recommendations include the following:

- Provide training and information on LTS issues to school staff

- Adapt LTS plans as needed to account for deterioration of engineered controls over time
- Develop immediate response plans in case of lapses in maintenance and rises in contamination levels
- Allocate budgets for schools so as to ensure that LTS requirements never lack funding
- Educate the community about LTS activities in schools

We hope that this project presents useful insights about LTS practices at schools and provides background knowledge for possible areas of further research.

Abstract

This report investigates long-term stewardship (LTS) of schools built on remediated sites in Massachusetts. Through a combination of archival research and interviews with city, state, and school officials, the project team determined various issues and constraints in the implementation of LTS. Using case studies, the team provided key recommendations to mitigate concerns on school sites. Specifically, the team suggested possible improvements for LTS systems in schools and identified relevant areas for further research on schools and LTS functions.

Authorship Page

This report was written as a collaboration of the project group members: Freshta Abedi, Hiral Dutia, David Muchene, and Rohit Mundra. While some sections were primarily written by one individual, each group member read and revised all sections to increase clarity and ensure that the views presented in the report were the views of the group as a whole.

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Disclaimer

This report represents the work of WPI undergraduate students submitted to the faculty as evidence of a degree requirement. WPI routinely publishes these reports on its web site without editorial or peer review. For more information about the projects program at WPI, see http://www.wpi.edu/Academics/Project.

All human subjects were offered a confidentiality waiver before proceeding with any interviews. They had the option to either remain anonymous or allow the project team to cite them as sources of information. The names of all subjects that chose not to waive their confidentiality are undisclosed.

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List of Acronyms

AUL	Activity and Use Limitation
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
DPH	Department of Public Health
ECRA	Environmental Cleanup Responsibility Act
EPA	Environmental Protection Agency
GAO	Government Accountability Office
HVAC	Heating, Ventilating, and Air Conditioning
IC	Institutional Control
KMS	Keith Middle School
LSP	Licensed Site Professional
LTS	Long-Term Stewardship
LTMMIP	Long-Term Monitoring and Maintenance Implementation Plan
MassDEP	Massachusetts Department of Environmental Protection
NBHS	New Bedford High School
NPL	National Priority List
NRC	National Research Council
OSWER	Office of Solid Waste and Emergency Response, US Environmental Protection Agency
PCB	Polychlorinated Biphenyls
ppm	Parts per million
RCRA	Resource Conservation and Recovery Act
RLF	Revolving Loan Fund
SVOCs	Semi-volatile Organic Compounds
TBA	Targeted Brownfield Assessment

TSCA	Toxic Substances Control Act
UTS	Universal Treatment Standards
VOCs	Volatile Organic Compounds

1. Introduction

In 1985, The Government Accountability Office estimated that there were about 425,000 contaminated sites in the country (GAO, 1985). Only 19,400 of these sites were identified by the Environmental Protection Agency (EPA) and a proper list of all contaminated sites did not exist. The number of contaminated sites has not fluctuated much in the last twenty years (Scorecard, 2005).

The federal government has several programs to carry out remediation of contaminated sites. One such program is the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), which has led to the analysis and remediation of thousands of these contaminated sites within the last twenty years (EPA, 2006). Sites which CERCLA has identified as most hazardous have been placed on the National Priority List (NPL); a total of 31 sites in Massachusetts have been listed as such (EPA, 2006). In addition, states have programs to address the tracking and cleanup of contaminated sites that have not been addressed by the federal programs (Scorecard, 2005). For instance, a remediation initiative taken by the Massachusetts Brownfield Program offers incentives to buyers of contaminated lands, provided that appropriate action is taken to remediate them (MassDEP, 2005).

After a site has been remediated, the land can be reused for other purposes. In Boston, Massachusetts, an electric generating station was built in the 1890s next to a

series of abandoned warehouses that were used for residential, industrial, and commercial purposes. This site is now under renovation and will be used for offices and residential areas in order to "create a new and revitalized community" (Wilk, 2008). Schools are often located on remediated sites. According to the Massachusetts waste site database, a total of 38 school sites have been built on remediated sites since 1995 (Mass.gov, 2010).

Due to budget constraints, the nature of the contaminant, or a lack of technology, remediated sites are not necessarily "clean". In the case of Keith Middle School in New Bedford, Massachusetts, limited funding did not allow official to carry out a thorough cleanup. Thus, sites that have been remediated by the state or the federal government have periodic protocol associated with them to ensure the protection of human health and the environment. Long-term stewardship (LTS) is the term used to describe the management of remediated sites (NRC, 2003).

Though remediated school sites may have been in compliance with state and federal standards when the schools were built, schools that lack a long-term stewardship plan may fall out of compliance with required regulations. Thus, municipalities often take a lead role to ensure LTS functions are carried out appropriately (NRC, 2003).

To prevent human exposure of any contaminants remaining on-site, LTS activities typically include two components: engineered barriers and institutional controls (EPA, 2006). Engineering controls and physical barriers are effective in the short term, but may deteriorate over an extended period of time. For instance, impermeable liners and landfill soil caps, two commonly used physical barriers, can develop cracks and leaks where gaseous toxins can enter the building (Siegel, 2009). Thus, institutional controls are put

into place to ensure continuous monitoring of those engineered barriers. Activity and Use Limitations (AULs) are one such control utilized at remediated sites. AULs are deed restrictions that regulate all activity on-site and permit only Licensed Site Professionals (LSPs) to carry out any cleanup work (EPA, 2006).

Successful LTS programs comprise several roles distributed between different actors involved in executing LTS functions. These roles include a guardian who is responsible for stopping activities that could harm the site, a watchman who monitors the land to catch issues, a land manager who deals with the ecological processes, a repairer who fixes failures in the engineering controls, an archivist who keeps a database of knowledge, an educator to teach the community about the site, and a trustee to acquire the necessary funds (NRC, 2003).

The goal of this project was to understand and assess how LTS is implemented in schools. Specifically, we aimed to review institutional controls, implementation entities, authorities, and the resources necessary to ensure that the integrity of schools on remediated sites is not compromised. We conducted case studies by interviewing state, city, and school officials in Massachusetts. We studied how the different elements of LTS, such as inspection of engineering controls and reporting of information, are implemented in specific municipalities. We recommended a model for long-term stewardship of schools using a combination of the literature review and the findings of our research.

2. Background

The purpose of this chapter is to discuss key topics about long-term stewardship (LTS), LTS of schools, its importance, contaminants and some general and specific concerns at brownfields. First we start off by discussing the types of contaminants found on various sites. Various aspects such as where they are found and their known effects are also discussed. Secondly, we explore how children and adults are vulnerable to the various toxins found at contaminated sites. We look at the regulatory bodies that handle environmental issues discuss the type of programs they have established to clean up the contaminations. We move on to discuss long-term stewardship in general. In looking at LTS we address a status report published by the National Academies Press in 2003, which goes into depth about the concept of long-term stewardship (LTS) and how it is incorporated into environmental management. Finally, we discuss how schools are constructed on remediated sites. We analyze the reasons that lead decision makers to commission schools on remediated sites and discuss what is needed after the schools are built. The archival research we performed in this chapter was utilized in deciding best practices for LTS.

2.1 Contaminants Found

The types of contamination found on sites prior to remediation vary based on the type of activities carried out on the site. The activities carried out usually relate to agriculture, battery recycling and disposal, chemical and dye manufacturing, municipal and industrial landfills, etc. Generally, contaminants relating to such activities can be chemically categorized into Halogenated VOCs (Volatile Organic Compounds), Non-halogenated VOCs, Halogenated SVOCs (Semivolatile organic compounds), Non-halogenated SVOCs, Fuels, Metals and Metalloids, and Explosives (Brownfields TSC, 2010). These chemical categories directly relate to hydrocarbon spillages, solvents, pesticides, tributyltins and asbestos, and heavy metals such as lead.

2.1.1 Effects of Contaminants

The effects of such pollutants are both cancerous as well as noncancerous. For example, tributyltins relate directly with gene activity problems causing obesity and imposex in certain animals (Iguci & Katsu, 2008). Pesticides cause problems such as non-Hodgkin lymphoma, leukemia, neurological birth defects, fetal death, and neurodevelopment disorders (Bassil, Vakil, Sanborn, Cole, Kaur & Kerr, 2007). Exposure to asbestos relates to many cancers, especially mesothelioma (Marbbn, 2009). Solvents are known to have potential long-term problems that affect the nervous system, reproductive system, liver and kidney damage, respiratory impairment, cancer and dermatitis (US Dept. of Labor, 2007).

2.1.2 Human Vulnerability to Contaminants

These effects can be life threatening to human beings, but in younger members of the society these effects can be more pronounced. Children's organs are developing until adolescence. For example, air sacs in the lung, where oxygen enters the blood stream, increase in number until adolescence (Landrigan and Needleman, 1994). Children's immune systems also behave differently from those of adults. This is mostly because of the significant difference in organ growth and development. Occasionally, this gives children the ability to deal with toxins better than adults; however, they are usually more vulnerable than adults (Landrigan, 1998). For example, children absorb about 50% of the lead to which they are exposed, while adults absorb only 10-15% (Landrigan and Needleman, 1994).

Apart from differences because of biological factors such as age and metabolism, children are also more susceptible to environmental threats because of their psychological growth. They do, after all, behave like children. They do not have the ability to understand what does or does not pose a chemical or biological threat to their lives. Their natural curiosity and tendency to explore can pose a significant health risk to them on a contaminated site. Thus, this only makes the assessment of remediation processes at schools more important.

However, remediation alone is not sufficient to ensure safety at brownfields. For instance, at Springfield Street School – a middle school built on a remediated site – a report identified holes adjacent to the foundation of the middle-school building. These holes were later repaired by Providence School Department and verified by an

environmental analyst/inspector as a part of their LTS program (Crawford, 2010). The dangers posed by toxins require both that contaminated land be remediated and that the remediation methods are protected and maintained.

2.2 Programs for Cleanup

Federal and state governments have established regulations and programs to ensure that sites are remediated and that the integrity of the remediation is maintained. It is important to know the different tasks and responsibilities that different agencies (both federal and state) take on to ensure that contaminated sites are well cleaned up. Environmental laws and policies differ from state to state, however since our project is concerned with Massachusetts, we will give an overview of federal laws and laws pertaining to Massachusetts.

2.2.1 Federal and Regulatory Agencies

The Environmental Protection Agency (EPA) is the federal agency responsible for ensuring that everyone in United States is protected from significant risks to human health and the environment they live and work. The EPA is responsible for making sure that federal laws protecting human health and the environment are enforced fairly and effectively (EPA, About EPA, 2010). Congress writes the laws, however, it is EPA's responsibility to implement the laws by writing regulations and, sometimes, to set national standards that states and tribes enforce through their regulations (EPA, About EPA, 2010).

2.2.1.1 EPA Cleanup Programs

The EPA categorizes contaminated lands so that appropriate action can be taken to make them usable again. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) was passed on December 11, 1980 in response to tragic events such as a fire in chemical-waste treatment facility that left six dead and thirty five hospitalized (EPA 2006). As part of the program a list of the most serious sites identified for possible long-term cleanup was created. There are currently about 1200 sites on the list called the National Priorities List (NPL). In general, the cleanup process involves assessing sites, placing them on the NPL if appropriate, and establishing a long-term cleanup plan. In addition, the EPA also treats emergency cases, enforces against responsible parties, ensures community involvement, and involves states in the cleanup process.

The EPA has delegated responsibilities to various offices within the Superfund program. For example, oversight of the Superfund program is handled the EPA's Office of Solid Waste and Emergency Response (OSWER) in Washington, DC. Within the OSWER, the Office of Emergency Management is responsible for short-term responses, while the Office of Superfund Remediation and Technology Innovation, and the Federal Facilities Response and Reuse Office manage the long-term cleanup and reuse of contaminated sites. The EPA has also divided states into regions and the ten regional offices handle the implementation of the Superfund programs in those regions.

Other programs and regulations that play an important role in remediation and cleanup of the contaminated sites are Resource Conservation and Recovery Act (RCRA),

Universal Treatment Standards (UTS), Environmental Cleanup Responsibility Act (ECRA) and State Hazardous Waste Program. Table 1 summarizes the nature of these programs.

Table 1. Regulations impacting remediation activities in the US

Name of Regulation / Program	Nature or Impact
RCRA	Requires corrective action upon shutdown or permitted treatment, storage or disposal facility
Superfund (through the CERCLA)	Requires investigation and remediation of sites placed on the NPL
USTs (regulated under RCRA and by individual states)	Requires remediation of soil and groundwater contaminated by hazardous chemicals or petroleum products leaking from tanks.
ECRA (employed by New Jersey; similar programs are used in 17 other states	Requires cleanup of property upon change of ownership
State Hazardous Waste programs (patterned after the CERCLA)	Requires investigation and remediation of sites not on the NPL.

(Cairney & Hobson, 1998)

One of the most effective cleanup programs is the EPA's Brownfields Program, which, according to the EPA, has grown to be a result-oriented program. Brownfields are abandoned sites that have been previously used for industrial or commercial purposes. The main function of the Brownfields Program is to authorize and allow states, communities and stakeholders to work together to prevent, assess and safely clean up a Brownfield and in turn allow the reuse of the cleaned up site. Another goal of the program is to provide states, communities, and other stakeholders with funds, which help create jobs as well as assist to prevent, assess, safely clean up and sustainably reuse brownfields (EPA, Brownfields Program Activities under the Recovery Act, 2010).

2.2.1.2 Cleanup and Remediation laws in Massachusetts

While the federal government has established agencies and programs to deal with environmental issues, states also often have their own regulations and cleanup programs that suit needs that are particular to them. Furthermore, since not all contaminated sites can be addressed by the federal programs states need their own guidelines in order to further protect their residents.

In Massachusetts, the state agency responsible for environmental matters is Massachusetts Department of Environmental Protection (MassDEP). Their objective is to ensure that clean air, water and safe environments are provided for everyone (MassDEP, 2010). According to MassDEP, it is their responsibility to ensure the safe management of toxics and hazards, the recycling of solid and hazardous wastes, the timely cleanup of hazardous waste sites and spills and the preservation of wetlands and coastal resources.

Under Massachusetts General Laws Chapter 21E, the MassDEP is responsible for taking all action that is appropriate to secure the benefits of CERCLA and other pertinent federal laws. The law states that MassDEP should promulgate regulations that it deems necessary for the implementation of federal and state laws. It goes on to state that the Department should adopt these regulations establishing classes of sites and response actions.

An example of regulations that MassDEP has established is the Activity and Use Limitations (AUL). AULs are legal restrictions to limit human exposure to contaminants remaining in soils at a disposal site. Elements of AULs include written restriction to provide notice and a record at the Registry of Deeds. An AUL on a property would alert

future owners that the property they will be occupying has potential risk for exposure. In addition to AULs, the Department has established other programs such as the Brownfields Program to accomplish their missions.

The Massachusetts Brownfields Act was signed into law in 1998 and was meant to give financial incentives and liability relief for parties undertaking cleanup of Brownfields. A brownfield in the context of the law is a contaminated site which is either abandoned or for sale. The program gives incentives to sellers and buyers of contaminated lands provided there is a commitment towards cleanup and redevelopment.

2.3 Five Stages of Remediation

The implementation of remediation takes place in five stages, as shown in Figure 1 (EPA, 2002). Brownfields must be remediated to meet state and federal environmental regulations before they can be redeveloped to remove the chance of human exposure to toxins in the future. This process begins with a licensed environmental analyst examining the site.

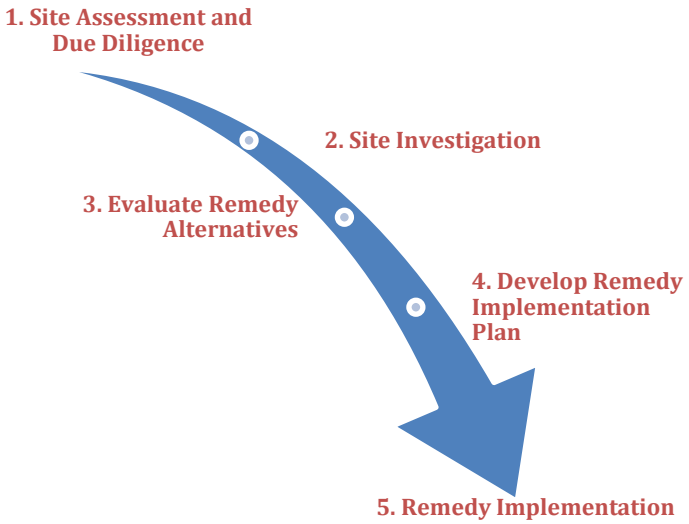

Figure 1.Technical Approaches to Redeveloping Brownfield Sites, EPA

After a site's background information has been obtained, the environmental analyst identifies the following factors in the first step of remediation, which is assessing a site for:

- Potential contaminants that remain in and around a site
- Likely migration pathways that the contaminants may move along
- Potential risks to the environment and human health that exist along the migration pathways
- Potential legal and regulatory requirements and risks
- Preliminary cost estimates for property purchase, engineering, taxation and risk management
- Market viability of a redevelopment project

If a high level of contamination is detected and the viability of project is reassessed, the second phase of remediation begins. This phase, called site investigation, consists of the following:

- Sampling of the site and identification of the type, quantity, and extent of the contamination
- Establishing cleanup and reuse goals
- Determining length of time required to reach cleanup goals
- Determining post-treatment care needed and costs

The analyst gathers data by sampling soil, water and air. In this process, they can use previous knowledge or background information of the site if it is available. In order to minimize the cost, they conduct limited sampling in the beginning (EPA, 2002).

The third step in the process is the evaluation of remedial alternatives; the following actions are taken in this process:

- Establishing remediation goals
- Selecting an appropriate and feasible remedy, determined by factors such as:
    - Federal, state, local or tribal requirements
    - Community surroundings
    - Available funding
    - Time frame
- Developing a list of potential remedial options by researching existing technologies
- Narrowing the list of potential remedies

- Selecting the best remedial option

The fourth phase of remediation is developing the selected remedy plan, which includes the following steps:

- Coordinating with stakeholders to design a remedy implementation plan
- Ensuring compliance with applicable federal and state regulatory guidelines
- Developing a plan that incorporates the selected remedial alternative, which includes:
    - A schedule of completion and sources of available funds
    - Procedures for community participation, such as community advisory boards
    - Contingency plans for possible discovery of additional contaminants

Once a remediation plan is developed and designed, the next major step is the implementation of the selected management option, which is the fifth step exhibited in Figure 1. This step may require the involvement of federal, state and city officials to ensure that the procedures for long-term monitoring on the site are taking place as planned, if they are needed (EPA, 2002). The officials' roles in remediating brownfields and implementing long-term stewardship are discussed in later sections.

2.4 Long-term Stewardship

Remediation is complete when the site has been cleaned up according to federal or state standards, which can include controlling groundwater contamination and sealing off toxic materials and landfills. Even after sites have undergone extensive cleanup, they

may require long-term management because the engineering controls used to prevent human exposure to contaminants degrade over time. Consequently, long-term monitoring may begin immediately after remediation, a concept that is known as long-term stewardship (EPA, 2006).

Long-term stewardship (LTS) is comprised of several aspects, which include monitoring, maintenance, land-use controls, and information management. The best way to carry out LTS functions is to compartmentalize the execution of tasks. That is, different actors should be responsible for carrying out the different functions of LTS. Table 2 shows a brief description of what each role entails (NRC, 2003).

Table 2. Roles of Long-Term Stewardship

Role	*Description*
Guardian	Halts any potential dangerous activities
Watchman	Monitors the land to catch issues as they originate
Land manager	Assists ecological processes and responsible human use
Repairer	Fixes physical structures as failures arise
Archivist	Keeps a database of knowledge
Educator	Teaches nearby communities the history and dangers of the site
Trustee	Guarantees the finances necessary to maintain the site

The first role is that of a **guardian**. The guardian must stop any dangerous activities that could cause any engineering controls in place to fail. This role works in conjunction with that of the **watchman**, who must actively monitor the site by coming up

with innovative ideas for using available technologies and best utilizing human resources. Together, they should have an immediate plan of action ready in case a problem emerges, so that they can simultaneously rectify the problem and inform the necessary parties. For example, if an impermeable liner develops leaks and allows toxic gases to escape into the school's atmosphere, the watchman's monitoring system should be quick enough to catch that, and the repairer must quickly act on fixing the problem (NRC, 2003).

The **land manager** has to facilitate both ecological processes and human uses to work symbiotically. The natural environment at any site will change as time goes by. The human changes being made to the land must not harm natural communities and processes. Any engineered barriers that are built should be done so that they can support nature, not work against it (NRC, 2003).

A **repairer** fixes failures as they are found in engineering and institutional controls on the site. They also determine when re-remediation is needed and plan to execute that. Unforeseen events will take place over long periods of time. Each remedy will not last forever, and repairers must analyze the costs and benefits of implementing new remedies and making the most informed decision when an engineered barrier fails so that the new one lasts longer and the same problems do not occur (NRC, 2003).

The **archivist** maintains a database of knowledge about the site, such as what contaminants or pollutants have been present on the land and what remediation efforts have taken place. This ties in closely with acting as **educator**, one who not only knows the history of the site, but makes sure that community residents know the history as well as how it affects them in their lives. The community, as well as future generations, must

have the information and the resources to safely use and take care of the site. Lastly, a **trustee** must guarantee that finances are secure enough to continue to maintain the site as intended (NRC, 2003).

In the case of schools, LTS functions like those described above can be carried out by school administrators, parent organizations at schools, city officials, and state and federal regulatory agencies. Each actor should have a clearly defined role to maximize the efficiency of a long-term stewardship system.

2.5 Schools on Remediated Sites

Reuse of remediated sites for school construction inspires more public concerns than other forms of land use. The reasons for the concerns include the fact that children are more physically vulnerable to harm from toxic exposures, that school attendance is obligatory, and that most schools are publicly owned (Siegel, 2009).

There are many factors that lead to the construction of schools on remediated sites. These include budget constraints, undocumented history of sites, and a lack of available land in the community.

2.5.1 Budget Constraints

The decision makers involved in the process of siting a school with budget constraints face a dilemma where they have to compromise on certain aspects of the school. For instance, a decision maker may have to choose between a school on an expensive site with minimal facilities and a school on a remediated site with abundant facilities. New schools usually mean smaller class sizes, new computers, and more

resources for children and staff. This often leads decision makers to construct the school on the remediated site figuring it to be the lesser of two evils. This decision could potentially put all the people involved such as students, faculty, staff and parents, at risk. For example, in 1978, the groundbreaking school siting controversy broke out in Niagara Falls, New York, over schools built next to a 21,800-ton toxic waste dump known as Love Canal. When the matter was investigated, it was found that the company that previously owned the land, Hooker Chemical, was reluctant to sell the land to the members of the school board in 1953. In fact, the company also demonstrated to members of the school board how toxic the land was, however, the school board remained insistent and bought the land because of budget constraints (Zuesse, 1981). Twenty-five years later, outraged parents gathered to question their children's safety, especially in light of the hazardous materials that were leaching, exposing their children to toxic chemicals. Two schools were eventually closed down, unearthing a new awareness of contaminated school properties and the demand for a strictly regulated school siting process (Eckardt, 1979). This is only one of many instances where a school was built on or around a contaminated site because of budget constraints.

2.5.2 Proximity to Target Community and Resources

Another reason why brownfields are used for the construction of schools is because of the proximity of available land around the target community and other resources. This problem is more prominent in urban areas where ever rising enrollment and lack of available land are known issues. For instance in January of 2000, the City of Providence Rhode Island announced that they were building a 400-pupil elementary school on a site where a mill was burned down by an arson fire. At the time, the city was

trying to replace a school, which was at a location not within the neighborhood of most of its students (Tsongas, 2006).

2.5.3 Rising Enrollment

Schools have rising enrollment but available land is hard to find. In March of 1999, the Providence City Council Finance Committee voted on a proposal to build an elementary and middle school on land that was formerly the city dump. The $30 million plan was to build a 450-pupil elementary school and an 800-pupil middle school**.** At the time, Providence was in dire need of new schools, but lacked the space to build them. The schools were at 98 percent capacity and the school department had even started opening up makeshift classrooms in some schools to accommodate new students (Davis, 1999).

The New Bedford school district was in a similar predicament when the need for a new middle school and a lack of space meant that they had decided to build the school on a contaminated site. In addition, the school district had to also clean up the high school that was built before they knew that the site was contaminated. The construction of Keith Middle School and the cleanup of New Bedford High School began in 2005. Most of the area is now remediated but the City has much work left to ensure the integrity of the remediation remains (Spillane, 2010).

2.6 Long-term Stewardship of Schools

Since remediation does not guarantee a completely risk free environment, schools built on remediated sites need an LTS plan which details the methods they will use to

ensure that the integrity of the remediation is not compromised. The plan has to distribute responsibilities efficiently and have accountability mechanisms in place to make sure that the responsibilities are addressed. Specifically, the plan has to make sure that all of the functions of LTS as described by the NRC report (guardian, watchman, land manager, repairer, archivist, educator, and trustee) are properly performed. These are areas that are not addressed in detail in current literature; therefore, we developed methods to obtain this information.

3. Methodology

The goal of our project was to identify and improve the way schools built on remediated sites perform long-term stewardship and analyze how the various functions of LTS are implemented in specific schools. Additionally, we aimed to recommend a model with which schools can comply with in order to ensure the most efficient management. In order to accomplish our goals, we decided to focus on two case studies in New Bedford.

3.1 Research Questions

Our first task towards accomplishing our goals was to split the original problem into several research questions. The research questions focus on learning how schools performed LTS and establishing which areas need to be improved. Our goals require that we not only know how LTS is being implemented in specific schools, but that we also know why these schools chose to implement it in the manner they did. We established the different actors involved in LTS, such as school administrations, city officials, state officials, federal officials, and the public. We also considered critical factors leading to actors' satisfactions, available monitoring options, roles within LTS systems, sources and constraints of funding, and implementation of school curricula on LTS.

- **What information do the actors know, and how do they obtain their information?**

In order to determine the effectiveness of LTS programs, we needed to ask what people know. When the actors are informed of the situation, they might be more likely to create

a driving force to carry out LTS functions. We can then analyze whether the amount that actors know is associated with the efficiency of the LTS systems.

- **What are the critical factors that cause the lead actors to be satisfied or unsatisfied with the current system?**

One aspect of measuring how well the current system of LTS is working is to determine whether those involved are satisfied with the way things are run. If they are, the critical factors can help us determine elements of a good model to recommend to schools. If they are not, we can determine how to improve the implementation of LTS systems.

- **What are the different options for monitoring? What are the important criteria in assessing which option is the most appropriate to conduct at a particular site?**

We wanted to know the different monitoring technologies, and how satisfied schools were with the choice they made. To this end, we inquired about the options for LTS schools considered. To further understand their choice, we asked what criteria they based their choices on, such as accuracy, reliability, ease of interpretation, cost, and trade-offs with other long-term management functions.

- **What should be the roles of the different actors in the LTS system? Are these roles clear to the different actors and are there any accountability mechanisms in place?**

According to the National Research Council report, an efficient LTS system has the roles of guardian, watchman, land manager, repairer, archivist, educator, and trustee clearly

defined. LTS plans should clearly designate roles to the actors involved, and they should know their responsibilities. We also wanted to know about any accountability mechanisms in place to ensure that the roles are executed as intended.

- **What are the sources of funds for long-term management, and what are the constraints in obtaining them?**

In order to implement LTS systems in a regular manner and according to plan, schools need to have the budget required for annual monitoring. As such, we wanted to learn the budgetary constraints schools face in carrying out LTS because our recommendations will face the same constraints.

- **What are the opportunities and constraints to implementing high school curricula on long-term management of contaminated sites? What are ways to overcoming these constraints?**

One of the issues we wanted to address was whether introducing curricula on long-term stewardship as part of an environmental studies course or series of course would be beneficial. Greater awareness on the students' parts may lead to increased involvement in implementing LTS.

3.2 Selecting Case Studies

We looked for schools by searching through newspaper articles online and the MassDEP database of sites scheduled for cleanup. The database search results yielded a list of 38 schools which had AULs associated with them (see Appendix B). Eight of these schools' AULs had been terminated, so we chose to focus on the remaining 30 schools.

We chose to contact schools based on the type of contamination they had and how much relevant information we could find about the school. For instance, we chose to ignore the schools that had small contamination events such as oil spills because problems of that nature are not long-term and therefore did not fit our criteria.

Initially, we searched the Rhode Island Department of Environmental Management database with the same criteria that we used for Massachusetts schools. We found four schools located on or near the Providence city dump. When we contacted these schools, we were directed to the Providence Public School District, who asked us to fill out a lengthy research application. This application would not have been reviewed until after the anticipated completion of our project. These schools held promise as a wealth of information; however, using these schools for our case studies was beyond the scope of our project, so we chose to focus on schools in Massachusetts (see Table 3).

Table 3. Select List of Schools Built on Remediates sites in Massachusetts

School	Location	Regional Office
Keith Middle School	New Bedford, MA	Southeast
New Bedford High School	New Bedford, MA	Southeast
John M. Tobin School	Cambridge, MA	Northeast
Abby Kelley Foster Charter Public School	Worcester, MA	Central
Florence-Roche Middle School	Groton, MA	Central
Wilmington High School	Wilmington, MA	Northeast

3.3 Selecting Interviewees

Once we narrowed our focus to this list of schools, we proceeded to contact potential interviewees. For our first step, we contacted the principals of each of these schools. We then contacted the MassDEP offices that handled cases in each school's region. MassDEP has four offices in the state – one each for the western, central, southeast, and northeast regions. To optimize the communication process, we created a list of the people we needed to contact with a rubric that marked our progress in scheduling interviews. We collaboratively updated this list each time we attempted to contact the prospective interviewees. We created our interviewing schedule based on the responses we received.

Prior to arranging interviews, we sent an email to every potential interviewee. This email explained who we are, gave a brief overview of our project, and requested that they speak with us (see Appendix C). If they agreed to an interview, we arranged one at a time that was most convenient for them. We then prepared questions for the interview based on the interview guide (see Appendix D) and what we had learned about them during the literature review. For later interviews, we included additional questions, which were based on what we had learned from the previous interviews.

Based on the responses we received, we chose to conduct interviews with individuals focusing on two particular schools: New Bedford High School and Keith Middle school, both of which were built on the Parker Street dump in New Bedford. We picked these as case studies because they exemplified the LTS problem well. Despite being built on the same site, these schools represent two very different methods of LTS.

As New Bedford High School was built before the city knew the site contained residual contamination, it does not have an explicitly laid out LTS plan. Conversely, Keith Middle School was required to create an LTS plan. These schools face the same issues – PCB and some VOCs contamination – but their strikingly different approaches to handling the same problem assisted us in comparing and contrasting efficient and non-efficient ways of implementing long-term stewardship.

3.4 Conducting Interviews

The interviews were semi-structured and qualitative, each lasting approximately 45 minutes. We gave each interviewee a consent form, on which they could choose to keep or waive their confidentiality. Two of the four individuals we interviewed chose to waive their confidentiality. They are:

- Richard Desrosiers, Principal of Keith Middle School
- Molly Cote, Environmental Analyst, MassDEP Southeast Region

The other two individuals we interviewed are city officials responsible for ensuring compliance with environmental laws and regulations in New Bedford. They wish to remain unnamed.

All of the interviewees consented to recording the interviews, so a team member recorded each interview and took down key points as the interviews progressed. At the end of interviews, we requested all interviewees to refer us to individuals who would potentially know more about the subject. Both Desrosiers and Cote were instrumental in assisting us secure interviews with New Bedford city officials.

With Desrosiers, we discussed school-specific details, such as the history of the site and how information on LTS is transferred to community members, which include school faculty and staff, parents, and the public. With Cote, we spoke of general issues regarding both New Bedford High School and Keith Middle School, such as the frequency of monitoring and implementation plans for the schools. With city officials, we conversed about the responsibilities of the city toward each school. A broader study of the subject would have involved interviews with parent organizations involved at each school, as well as interested members of the community. However, due to time and resource limitations, we narrowed our interview focus to these individuals.

3.5 Analyzing Data

Following the interviews, we transcribed all of the interviews. We then organized information as it related to our research questions. As is the nature of personal interviews, we did not receive responses to only one question at a time. Though our interview guide closely followed a logical progression similar to that of our research questions, the individuals we interviewed gave us an assortment in no particular order. We received a variety of information from the interviewees on a range of topics such as the history of the schools, the current plans in place, the frequency of monitoring, and what information is available to the actors. To proceed with our discussion and recommendations in a coherent manner, we organized this information according to our research questions.

We also extracted pertinent information from the documents we received, which included the Environmental Fact Sheet for Keith Middle School, issued by the city of New Bedford, and the Long-term Monitoring and Maintenance Implementation Plan for

Keith Middle School, prepared for the city of New Bedford by BETA Group, Inc. We used these documents to complement our findings from the interviews.

Once the data were organized, we were able to understand how each school operated their LTS systems. We then compared our findings to the ideas of LTS functions of guardian, watchman, land manager, repairer, archivist, educator, and trustee as presented in the National Research Council report. Finally, we analyzed all of our findings to provide several recommendations.

4. Findings

This chapter discusses the results of our research and analysis. We used techniques such as archival and database research and conducting interviews. First, we discuss briefly the existing LTS systems in the two New Bedford schools. Later, we discuss our findings individually and justify them with factual reasoning.

In the current LTS plan in New Bedford, Keith Middle School hires private companies to periodically perform tests around the area. By the guidelines laid out by the NRC, these private companies play the role of the watchman. After completing a test, the company performing it will write a report detailing their findings. The City publishes their report in a public database thereby fulfilling the archivist role. The reports generally feature results from testing the various engineering controls, or recent sampling of the air or soil. Problems found are taken of and information is posted on the database. New Bedford publishes information about its schools, and the Parker waste site in general on a public database as well. In addition to the monitoring reports, New Bedford also publishes fact sheets, which summarize everything that has been done to make the schools safe. The fact sheets lay out every step the City has taken in a very clear manner and even provide a glossary of terms people might be confused about. The sheets are intended to provide an easy way for members of the community who do not understand scientific jargon to know what is going on with their school. Although these databases are quite comprehensive, they do not feature any of the budgetary information regarding the cleanups.

Budget constraints play a large role in determining the direction a city takes when doing long-term management of these sites. The Keith Middle School project was allocated $103.6 million by the city, $78 million of which has been used thus far for construction and remediation. The cleanup costs would be much higher if all of the contaminated soil was to be excavated as some activists have suggested, so the city decided to try other methods. These methods included excavating 56,000 tons of soil, installing a cap over the remaining soil, and installing a ventilation system in the school. New Bedford is lucky in that the state provided them with $90 million under the Massachusetts school reimbursement program (Spillane, 2010). The city also plans to sue several companies it deemed responsible for the contamination (Anderson, 2010).

4.1 Responsibilities of Actors

This section illustrates our findings on how the State and City carry out certain responsibilities such as notification of audits, staff training sessions, etc.

4.1.1 Finding #1: Notice of Audits

State audits of schools are preceded by a notification to the City Council, and the results of such audits are publicly available.

When MassDEP conducts audits on schools built on remediated sites, they notify City officials that they will be carrying out an inspection. The City's LSP meets a representative from the DEP. The DEP representative reviews the documentation for the site, and walks the entirety of the property to see if the benchmark conditions are met. They fill out a checklist, after which DEP issues a notice of audit findings to the city. No

matter what type of site the audit is conducted at, the letter is copied to the local Board of Health, the Chief Municipal Office, the Mayor, and any individual who wishes to be copied (Cote, 2010). When inspections are carried out, the results are sent to the Mayor's office and are publicly available (Desrosiers, 2010).

4.1.2 Finding #2: Staff Training Sessions

The City conducts annual staff training sessions to make them aware of the Activity and Use Limitation in effect on the property.

New staff members must attend, while returning members are required to undergo refresher training (Undisclosed, 2010). The staff training is primarily held for those who directly deal with the ground, both on the interior and exterior of the building. This involves mainly custodians and those doing landscaping work. Described as the "first line of defense" by a representative from New Bedford's City Hall, these individuals will be the first to see any cracks in the foundation, as they encounter the ground on a daily basis (Undisclosed, 2010).

When questioned about whether the administration and faculty of a school should have more knowledge and/or input on the long-term stewardship of the school, a city representative stated, "I would hope that everybody's aware" (Undisclosed, 2010).

4.1.3 Finding #3: Public Involvement Meetings

The City holds public forums for members of the community.

One of the provisions in the Massachusetts Contingency Plan is that residents can request that a site be designated as a public involvement plan site. To receive permission to build Keith Middle School, the City was required to organize regular meetings. Thus, the City holds public forums for members of the community (Cote, 2010). Members from City Hall work with the school department in planning these meetings. They meet with school staff, both at Keith Middle School and at New Bedford High School when they are so requested. They also talk to parents during meetings.

Keith Middle School, in particular, holds public involvement meetings with the interested public. The frequency of these meetings ranges between bi-weekly to quarterly, depending on the events that are taking place. The school uses what is called the "Eye Alert" – a reverse 911 phone messaging system that automatically calls all parents and guardians of every student in the building, informing them of public forums held in the auditorium or the community room of the school (Desrosiers, 2010). They also inform the public by putting notices in multiple newspapers, including the *Standard Times*, and the Spanish and Portuguese newspapers, as both communities have large ethnic populations concentrated in the area. In addition, they advertise the meetings on the radio as well as create fact sheets (Cote, 2010). Another thing the City does is utilizing Spanish and Portuguese translators for that component of the population. They attempt to have the same people; so as to establish a routine, familiarizing the translators with the project and the terminology as the discussion is often technical (Undisclosed, 2010).

4.1.4 Finding #4: City Website and Fact Sheets

City officials create fact sheets detailing several portions of the project, both when the school is constructed and after any audits are conducted.

The Office of Environmental Stewardship has committed itself towards a significant improvement in the way they communicate information starting in February 2010. The City posts every document they prepare for the site on the City's website. Within the site, there is a section specifically devoted to Keith Middle School (Undisclosed, 2010). Over the past few months, the City's website has undergone thorough reorganization. Upon accessing the site, one would encounter a long list of documents; now, the same information is presented in a more organized format, making it easier for any interested public to find a specific document (City Hall).

The city creates fact sheets detailing major portions of the project, such explaining the components of the engineered cap under Keith Middle School, and what type of remediation is ongoing at New Bedford High School. Similar fact sheets exist for the wetlands adjacent to Keith and Walsh Field (Undisclosed, 2010).

City officials believe it is important that as many people have access to as much information as possible. One interviewee told us:

"If people don't have access to the information, then there's sometimes a temptation to fill in the blanks with what they believe to be true, and sometimes that breeds misinformation. So the more people that understand about it, the more equipped they are to make their own decisions about how they want to deal potential exposure. It

can heighten people's concerns sometimes, but we really don't have an option when it comes to getting this information out. It needs to be out there."

4.2 Criteria for Satisfaction with Current LTS System

On any site with an industrial past, the public and local officials will have vital, legitimate concerns about how the site is being handled and how it affects public safety. Richard Desrosiers, Principal of Keith Middle School, says there are no health-risks present to anyone on the site, nor have there been any recent, controversial issues related to remediation/contamination issues. He justified this by saying that there were no health-related incidents that were reported.

4.2.1 Finding #5: Health Risks Present

Contaminants under the land of the school do not pose any health risks to the surrounding community.

One factor that matters to actors is whether any health risk is associated with the contamination present under the schools. Molly Cote of DEP says, "There is no health risk associated with the Keith Middle School as far as the contamination that's there." Though residual contamination still exists at New Bedford High School, she maintains it is "safe to attend school there from a health perspective. They monitor the indoor air for PCBs to see if there's anything in the indoor air, and all of the monitoring indicates that it is safe to breathe the indoor air of the high school." This suggested that she was confident that the land which Keith Middle School is built on does not pose any health hazards to the community that interacts with it.

When the City did the initial round of sampling of the indoor air at the high school in 2006, they identified high levels of PCBs in the indoor air that needed addressing. Four classrooms were closed down in order to address this anomaly. After sampling, they realized that the operation and maintenance of the heating and ventilation system was not carried out every year after the opening of the school (Undisclosed, 2010).

School sites have the strictest standards in the state for PCBs. Neither school has exceeded any groundwater standards for PCBs. There have been PCBs detected in the sediment in the wetland but the levels are lower and adjacent to a capped site (Cote, 2010).

The Massachusetts Department of Public Health has done a couple of studies targeting health risks connected to living or working near PCB-contaminated land. They did a PCB serum study of people who lived and worked at the high school or middle school, or live in the neighborhood (Cote, 2010). The results of this study are, however, only available to the participants. Department of Public Health is also doing an indoor air quality assessment and analyzing the results of that (Undisclosed, 2010).

4.2.2 Finding #6: Implementation of Monitoring Plan

New Bedford High School has had lapses in maintenance with the HVAC system, and the school department is entirely responsible for the upkeep of that.

The monitoring plan is a "living document," as described by a City employee. It is used as a base line. The plan calls for indoor air monitoring in the school three times a year. When the school first opened, the City tested on a monthly basis, as there was much

concern among parents about indoor air quality. The plan is used as a minimum standard. Based on what they observe, they can increase and decrease the frequency of monitoring as long as it is equal to or above the base line (Undisclosed, 2010).

Another issue is how well the HVAC system is running. According to City employees, the HVAC system at Keith is very advanced as compared to other school systems. As long as the school staff carries out routine maintenance to ensure the system is operating as designed and at maximum efficiency, the lead actors should be satisfied (Undisclosed, 2010).

New Bedford High School has had lapses in maintenance with the HVAC system, and the City had to go in and take actions to fix that. Everyone wants assurances that will never happen again. The school department is directly and entirely responsible for the upkeep of that. The City can only encourage them to do so (Undisclosed, 2010).

4.2.3 Finding #7: Lapses in Maintenance

The lack of a well-defined LTS system in New Bedford High School has been the cause of lapses in maintenance in the past.

The high school still contains PCBs in ballasts and fluorescent light fixtures. Initially, the City had been informed that all but those in custodial and maintenance areas had been replaced. It turns out that upon closer examination, ballasts in one of the common room areas that students frequent were riddled with PCBs. As a result, the City did a full inventory of all 7,000 light fixtures in the school to confirm that they had been replaced; if they had not, the remaining ones were identified. The only event in which

PCB-contaminated light fixtures remain permissible to use is if they are not leaking and they are maintained; however, the City wants to replace all of them regardless (Undisclosed, 2010).

The middle school was built on the conditional approval that a monitoring plan would be implemented. The high school was built on a dumpsite, which meant that the City would sample soil at the New Bedford High School campus and conduct indoor air sampling. They discovered PCBs in building materials such as caulking, adhesives, paint. There is a laminate, countertops, and cabinets in classrooms, all of which are secured to plywood with adhesive. After a thorough mapping of all the potential sources, the City found that the highest concentrations of PCBs in a bulk material was present in the accumulation of dust in the HVAC system at 31 ppm, which was a large contributor to PCB-ridden air being distributed around the entire building. A full cleaning of the HVAC system ensued; all the filters were changed, faulty ventilation units were replaced, and the system started generating fresh air within the building, which resulted in a greater air exchange rate within the building. The next step is working on the laminate, the adhesives, the cabinets, and the wall. To do that they removed entire cabinets, ripped down a couple of walls, and replaced all of that material. They then found ventilation units that contained asbestos and PCBs, and 31 of those units were replaced (Cote, 2010).

4.2.4 Finding #8: Addressing Concerns

Even though contaminants have not posed a health risk on these sites in the past, parents are still concerned about the site's history.

Walsh field is a sports ground adjacent to Keith Middle School. Parents have questions as to whether or not it is safe for their child to play sports at Walsh Field. The Office of Environmental Stewardship in New Bedford believes that as long as the City addresses the parent's concerns, they will be satisfied (Cote, 2010). However, without a proper survey of the parents and other community members about their level of satisfaction, these claims cannot be verified.

Last December, higher-than-expected VOC levels were discovered during routine sampling in the mechanical room of the school, the source being the groundwater that enters the building. The discovery triggered an immediate response action by the City, which is currently working on this in conjunction with DEP. The consultant is investigating a few locations, one being the mechanical room and the other being the front of the school near the flagpole area. A City representative said, "We are still investigating those and coming up with steps to resolve them."

Many people are concerned about PCBs in soil, but the high concentrations are generally not at the surface. Fill material and loam seeded into the ground serves as a barrier to prevent people coming into direct contact with PCBs. It is neither an ideal solution nor a permanent one, but steps are being taken to remediate the remaining areas.

As summed up by City employees, “We have removed all of the building materials that we know of that contained PCBs that are greater than 50 ppm, which is the threshold where it’s regulated under TSCA. TSCA allows building materials that contain PCBs to remain in place if they are in use – if they are in good condition and the concentration is less than 50 ppm.”

4.3 Different Options for Monitoring

This section discusses our findings in the important criteria (accuracy, reliability, ease of interpretation, particulars of information, and trade-offs with other long-term management functions) in assessing which option is the most appropriate to conduct monitoring at a particular site.

4.3.1 Finding #9: Where to Monitor

An LSP is mandatory to carry out any soil sampling done on-site. If the sampled results are above certain standards, the EPA must be notified immediately.

According to the Long-Term Monitoring and Maintenance Implementation Plan (LTMMIP) for Keith Middle School, the top one and half to four feet of soil are of concern for residential and school use, because that is what the average student or resident will come into contact with on a daily basis. An LSP must supervise any work completed under four feet of soil (Cote, 2010).

The action levels for PCBs work in the following manner: If levels of PCBs are at 2 ppm or higher, state regulations apply and DEP must oversee any remediation being done. If PCB levels are at 50 ppm or higher, both state and federal regulations apply, and

that is when DEP and EPA must be involved. In the case of these two schools, both regulatory agencies are involved because the highest PCB concentrations found were well over 50 ppm (LTMMIP, 2006).

The City's risk assessors have calculated two regulatory standards for PCBs in indoor air. One of them is 0.03 $\mu g/m^3$, which is the standard at which the city must look for potential sources contributing to that in indoor air. The second standard 0.05 $\mu g/m^3$, which calls for immediate action, which can be evacuating or closing the school, or introducing fresh air to reduce the contamination while identifying the source (LTMMIP, 2006).

4.3.2 Finding #10: Frequency of Monitoring

Inspections are carried out every two years at the minimum, and more often if any problems start to arise.

The City carries out an inspection every two years at the minimum. They can do them more frequently should any type of concern arise. The site AULs and long-term plans dictate how often inspections have to be done, and then the City must submit reports to DEP. There are different types of inspections – the cap is monitored quarterly and the indoor air at Keith is monitored semi-annually (LTMMIP, 2006).

4.3.3 Finding #11: Monitoring Technologies

The city uses multiple technologies to make the assessments comprehensive and accurate.

4.4.3.1 High Volume and Low Volume Samplers

The City uses high volume samplers, which monitor conditions over a 24-hour period. The benefit of this type of equipment is that it is not just capturing a snapshot of time, but monitoring over a longer period of time, which will obtain the average PCB concentrations. Additionally, high volume samplers are one of the few available sampling methodologies for PCBs in indoor air. High volume samplers draw a volume of air through a polyurethane foam cartridge, which is the media that is sent to a lab to be analyzed. The other option is low volume samplers but they are slower and for a shorter period of time, and a lower volume sampler is less accurate and cause you to miss PCBs (Undisclosed, 2010).

4.4.3.2 Summa Canisters

The VOCs are sampled with Summa Canisters, which are evacuated, pre-cleaned stainless steel. Those also remain open for 24 hours so as to collect aggregate data for a day (Undisclosed, 2010).

4.4.4 Finding #12: Financial Concerns

The City carries out budget cuts whenever LSPs identify that results or yield does not change significantly at a high cost.

The schedule for proposing changes to monitoring practices varies. The City reviews information with third-party engineering consultants and LSPs, and asks if the monitoring they are doing makes sense. It must be adequate and fulfill the requirements of the plan. However, indoor air sampling is fairly expensive, and the City is willing to incur the expense provided the schools receive tangible benefits. "If we are seeing the same results month after month and we're expending a significant amount of taxpayer money doing that, we need to ask ourselves, is this really a wise use of taxpayer money and should we be looking at ways that we can reduce that expense?" explained an Office of Environmental Stewardship representative. So in that case, they do look at other areas where they can improve. For example, in 2009, the City identified areas where taxpayer money expenditure could be reduced significantly, by reducing the frequency of certain tests, such as indoor air VOC samplings (TRC, 2009).

4.4.5 Finding #13: Sampling Conditions

Due to its extensive nature, sampling is carried out in worst-case situations and during school vacations.

The sampling events are done in worst-case conditions. Thus, they have to take place during school vacation periods, when the building is sealed and people are not entering and exiting the building. During vacations, the HVAC systems are not running, so the air is more stagnant and fresh air is not being pumped through the building like it usually is. This also ensures a more accurate reading of any possible PCB and VOC levels. Though sampling only during the summer makes it difficult for the City because they have to work in eight-week windows of time, it also means that the students are not

disturbed during school hours. Remedial work at New Bedford High School has taken place over the last four summers. The HVAC system was cleaned in 2007. In 2008, they mapped the areas still requiring remediation, and removed contaminated materials in 2009. In 2010, they replaced the unit vents. No work can be done during any other time during the year because the students' breaks are not long enough – for example, winter breaks are only one week long (Undisclosed, 2010).

4.5 Actors in LTS and Their Roles

4.5.1 Finding #14: Definitions of Responsibilities in KMS

Roles and responsibilities are mostly clearly defined in Keith Middle School. New Bedford High School, however, is still developing an LTS plan and does not have most functions of LTS defined.

4.5.1.1 Guardian

Keith has a Plant Engineer in the building to maintain the building and be in charge of tasks like changing the filters. New Bedford High School does not have a plan in place, but the two schools are under the same entity, the City of New Bedford (Desrosiers, 2010).

4.5.1.2 Watchman

When asked about who is responsible for monitoring the engineered cap at Keith, Cote explained, "The City of New Bedford School Department is required to carry out the long-term operation, maintenance, and monitoring under the direction of both EPA

and DEP." They are required to comply with the tenets set forth by the monitoring plan approved by EPA. The AUL on the property has rules for maintaining the grassy areas and paved areas, such as not digging through cap and preventing any exposure to the contamination. DEP audits all AULs in Massachusetts – they review each AUL, see which activities are permitted and which are not, what the property owners are responsible for. They go to the site themselves and inspect them. If the site is not in compliance, that is a violation under DEP and they can assess fines for that (Cote, 2010). These audits are carried out over a period of 4-6 weeks once every two years for sites. However, for sites with AULs, MassDEP can increase the frequency of the audits if they have reason to believe that the site may be posing hazards to the environment (MassDEP, 2010)

According to Keith's plan that was put in place upon the school's opening in 2006, several types of monitoring must happen annually. A soil cap was engineered over the contaminated land on the property, and the school was built on top of that cap. A timetable has been established for the city, and DEP looks over to see that the assigned environmental engineer is doing their job. The City's environmental consultant for the school conducts indoor air and foundation monitoring three times a year, conducts groundwater monitoring twice a year for the three wells on the property, inspects the engineered cap three times a year, and checks the wetlands once a year (Undisclosed, 2010).

The City has done much assessment, followed by fairly extensive remediation on the wetlands adjacent to Keith Middle School. One section is still not devoid of PCBs, which they discovered when they did resampling in 2008. They initially believed the area

had been re-contaminated, but then came to the conclusion that the contractor who did the remediation did not succeed in removing all of the contaminants the first time (Cote, 2010).

As another part of the City's requirement, the wetlands have been fenced off so as to prevent students and local children who live in the neighborhood out of the wetland. The City has yet to decide if they will go and dig out that part of the wetland to go and remediate it or attempt an alternative method. The reason they caught this is because they are required to resample annually (Cote, 2010).

4.5.1.3 Land Manager

For a school that has particularly complex issues, cities sometimes hire an environmental consultant, who is in charge of overseeing the entire remedial and monitoring process at that particular school. The advantage of this method is that the environmental staff person understands the nuances of the issues. Having a dedicated person trained in environmental issues is an efficient use of city resources, as opposed to trying to have the administration of schools assume more responsibilities. School principals do not necessarily understand the implications of contaminants such as PCBs, but as Cote elaborated, "People whose background is in chemistry, or public health, or environmental issues, probably have a better understanding and can probably explain it better" (Cote, 2010).

4.5.1.4 Repairer

As seen at Keith Middle School and New Bedford High School, the City fulfills the role of the repairer, and fixes engineered barriers if they fail (Cote, 2010). The schools do not have clearly outlined emergency response plans should an emergency arise.

4.5.1.5 Archivist

DEP does have an electronic centralized system for keeping files. When any DEP employee conducts an inspection, they submit an inspection and monitoring report that the DEP stores, so that new employees can acquaint themselves with a history of the site by examining old audits (Cote, 2010).

4.5.1.6 Educator

The school plays the role of educator in long-term stewardship. The principal of the building has to sit on the building committee for the construction and monitoring of the building, which meets every other month. The members of the committee include the people who represent the school in question, the contractors for the building, and the environmental agencies involved with monitoring. The information is shared between the different parties present and then conveyed to parents and interested community members at a public forum meeting so that everyone is notified of current goings-on (Desrosiers, 2010).

The school department has a copy of the Long-Term Monitoring and Maintenance Implementation Plan (LTMMIP), which holds the school responsible to communicate

information to the administration and faculty. Additionally, the City has met with staff at New Bedford High School regularly because of remediation issues taking place there (Undisclosed, 2010).

The DEP does not do any public education about remediated sites; that is entirely the responsibility of the City. The City is required to train any school staff who will directly be dealing with the cap or maintaining the HVAC system. That is one of the City's requirements by EPA for those particular schools (Cote, 2010).

4.5.1.7 Trustee

Keith Middle School secures funds under the school department, which receives its budget from the City annually. No individual is specifically assigned to fulfill the role of trustee. The school has no back-up plan in case the City has difficulty securing funds to continue implementation of the monitoring plan in a given year (Undisclosed, 2010).

4.6 Accountability Mechanisms

One of the things the City is working on is developing a maintenance and implementation plan for New Bedford High School (Undisclosed, 2010). Since this plan was not required as part of the approval for building the school, as was the case with Keith Middle School, there is another mechanism to make sure that the plan is being implemented. Under the Massachusetts Contingency Plan, anyone who undertakes any actions to do assessments or cleanup for a site has to prepare a report to submit to DEP for each aspect of the project. They must obtain approval for that particular phase before seeking approval for the next part of the project. This system did not work too efficiently in this case because the state does not have enough resources to absorb so much

information in so little time, because it was too cumbersome to have to wait for approval for each step of a project. They would sometimes take months to respond about drafts (Undisclosed, 2010).

The state came up with a more effective way to regulate sites – by using LSPs. They are licensed by Massachusetts to act in the capacity of DEP and are responsible for confirming that state regulations are followed. However, even though LSPs act as a liaison between school sites and DEP, the level of scrutiny on these two schools is such that the state thought it was better to have the state issue approvals for any and all plans the City submits for cleanup activity. So any time the City prepares a draft cleanup plan for any remediation aspect, they submit that draft to DEP. After a 20-day public comment period, they respond to the comments they receive. They prepare a final plan to submit to the state, who can then issue approval, a process that usually gets completed in two weeks or less (Undisclosed, 2010).

For example, recently the high school collected over 1000 soil samples, and testing revealed these that on discrete locations around the school, the soil has a PCB concentration of 76 ppm, much greater than the federal action level of 50 ppm. This must be remedied with state approval, and the remainder of the work will be done under state guidance. To do that, they will have to submit a plan to the state, receive DEP approval, and then implement that plan next year (Undisclosed, 2010).

Though this procedure takes more time at the beginning, the implementation of the public comment period makes the overall process more streamlined and prevents further delays. Instead of seeing the plan only after it is entirely finished, the DEP has had

the entirety of the comment period to review it, and they have been involved at each draft issue. This also helps in ensuring the City is going along the right approach in terms of methods for cleanup (Undisclosed, 2010).

4.7 Sources of Funds for LTS

Budgets are always a rather complex matter as there are multiple sources of funds that need to be identified. Furthermore, a lot of constraints are associated with funding. Here, we have identified the different sources of funds and the practical problems associated with funding.

4.7.1 Finding #15: Sources of Funds

No specific fund is set aside to meet the costs associated with LTS activities; however, the City is legally obliged to meet all necessary expenses for monitoring every annual budget cycle.

Keith Middle School was built with 90% state-funded money, and the City issued a bond for the rest of the money. The building's original budget was $115 million, but the City ended up using only $79 million of that (Desrosiers, 2010). The bond was used to fund all activities, including school construction, remediation, and monitoring. At some point, the bond will be exhausted and the school department, which is a department of the City, will take over the funding for the school. It will then be budgeted for as part of the City's annual budget by the school department administration, under Larry Oliveira, the business manager for the school department. Though no long-term fund has been specifically set aside to meet long-term stewardship requirement, the City is legally

obliged to fulfill and find a way to include all necessary expenses for monitoring in every budget cycle (Undisclosed, 2010).

4.7.2 Finding #16: Responsibility of Securing Funds

The City is responsible for securing funds for LTS carried out in schools. The school administration is not very involved with expense allocation for LTS.

School administration is not responsible for the costs of monitoring equipment. Desrosiers said, "I don't see the figures; I just know it's expensive." That responsibility rests with the Mayor's office, where all public documents are made available (Desrosiers, 2010). The responsibility of securing funds for long-term stewardship falls entirely upon the City. The DEP does not know how much it costs the City on an annual basis, but does reserve the right to fine the City if they do not comply with state environmental regulations (Cote, 2010).

4.7.3 Finding #18: Justification for Remediation and LTS Expenditures

Schools are often built on remediated land because of the low cost of land, so it is justified to spend money on LTS of the site to safeguard all community members and to maintain the integrity of the land.

Doing the cleanup for the school is justified because it costs much less than would building an entire new school. The total remediation costs thus far have totaled to around $3 million (Undisclosed, 2010). Costs of constructing a new school for 4,000-5,000 students – the capacity of New Bedford High School - would run upwards of $100 million today. The City of New Bedford would also need a clean site to construct the

school upon, and New Bedford doesn't have many clean, open spaces available as a remnant of its manufacturing history. It is also not possible to rebuild the school entirely on the current site, because the City still has the issue of educating all of the students currently enrolled in New Bedford High while construction for a new school is ongoing. Some have suggested rebuilding towards the south end of the site, where the athletic fields are located, but contamination issues have been known to exist there as well (Undisclosed, 2010).

4.8 Implementing LTS in High School Curricula

Neither the City nor DEP is responsible for implementing any sort of curricula in schools. At Keith Middle School, the students are not actively involved or notified of remediation and monitoring plans. The principal believes it is not important for them to know (Desrosiers, 2010).

5. Discussion

5.1 Comparing Schools

We can safely determine that Keith Middle School is carrying out most of the roles of LTS as intended in the long-term monitoring plan. They have a Plant Engineer to act as guardian, in addition to the environmental consultant's responsibilities as guardian. The City holds the duties of the watchman, while the land manager function is carried out by the school's environmental consultant. The City and DEP both act as archivist for all issues, and the school and City take on responsibility of educating the community.

However, KMS does not fully carry out the repairer and trustee roles. Though the City repairs engineering barriers in the event that they fail, the school does not have an immediate response plan in case levels of PCBs in indoor air rise above state and federally mandated standards. The money required to maintain monitoring options stems from the City's annual budget, but no specific trustee is designated to secure funds solely for the purpose of implementing LTS at Keith Middle School.

New Bedford High School is currently still undergoing remediation and therefore do not have a long-term stewardship plan as does Keith. They aim to complete remediation within the next year. The City is in the process of developing a monitoring plan similar to that of Keith Middle School's, and this plan will be implemented as soon as the site is fully remediated. Although some LTS functions are carried out at NBHS,

such as the City's frequent indoor air assessments, the City does not have an organized plan to fulfill every function of LTS.

5.2 Problems and Challenges in Implementing LTS

Both schools, but especially NBHS since it is still undergoing remediation, should have a better response system in case any physical barriers break and raise levels of contaminants. During our interviews, the individuals we spoke to were hesitant to say what would happen in case of an engineered control failing and causing human exposure to toxins. Though this hesitation may be due to the fact that they do not want to publicize such emergency or evacuation plans and cause unnecessary alarm among the students, parents, and community members, they should formulate more specific emergency or evacuation plans.

Additionally, both schools are funded by the City's school department, where the budget cycle runs annually. Each year, each school is given a budget to implement their monitoring requirements, but they do not have complete financial security. As stated by a City employee, monitoring these schools is not a discretionary spending, and the City will be fined by DEP if they do not comply. Monetary fines are a strong incentive for the City to comply with state regulations, but still do not guarantee finances. In the event the City budget cannot provide the finances needed to implement monitoring using the highest quality equipment or at the frequency which is needed, they do not have a back-up plan. In this case, it might be prudent to have the school department act a trustee and secure funds for the long-term. Keeping these problems and challenges in mind, we make several recommendations on conducting LTS functions in the next chapter.

5.3 Limitations and Constraints of Our Study

A better treatment of the subject would have included more case studies and interviews with parents and other members of the community. Unfortunately, due to time restrictions, we were not able to speak with everyone with whom we wanted to speak. Therefore, we were not able to address issues such as satisfaction of the public. The best resources we had to answer the question of whether or not the public had any concerns regarding remediation were newspaper articles and City officials. Journalists and City officials are not good representations of the public so we could not come to any conclusions regarding the public's concerns.

One of our initial goals of the project was to compare and contrast schools in Massachusetts and Rhode Island in terms of how they approached long-term stewardship. We were not able to accomplish this goal because of Rhode Island's regulations regarding studies on schools. Prior to interviewing any member of the Rhode Island public schools, the project has to be reviewed by a board that meets twice a year. The board did not meet at times that would allow us to complete the study in our intended time frame and therefore we did not study Rhode Island public schools.

The last question we wanted to explore was whether or not it was possible for teachers to include issues about remediation of schools in their courses. The school administrator we were able to speak with was not very keen on this idea. We would reach a better conclusion about establishing classes if we were able to work with more case studies. Investigating the details about how to create a curriculum for high school

students, how the public feels with regards to LTS, and how LTS plans differ from state to state could be areas of further research by another group of researchers.

6. Recommendations

Based on our literature review and the findings we obtained from our case studies, specifically the standards set by Keith Middle School's Long-Term Monitoring and Maintenance Implementation Plan, we present the following three types of recommendations for schools that have been built on remediated sites in Massachusetts. Cities can choose to implement each recommendation for long-term stewardship as they deem appropriate for each school under their jurisdiction. We also present recommendations for areas of future research on schools and recommendations on research methods for LTS studies.

6.1 Recommendations for long-term stewardship functions in schools

6.1.1 Guardian

Cities should hire a Plant Engineer to act as the guardian for schools that have complex and recurring issues. The Plant Engineer should work in conjunction with the site's Licensed Site Professional. These individuals will be the most knowledgeable and qualified to stop any potentially dangerous activities.

6.1.2 Watchman

The watchman function has two components. School personnel such as custodial staff should be the first ones to report any anomalies to the city, whose responsibility is to follow up on these observations. The City must also monitor the land and air to catch issues as they arise. If the City does not comply with the requirements of their long-term

monitoring plan, the DEP must act as an accountability mechanism and assess fines to the city. This includes, but is not limited to, the following responsibilities:

- Conducting audits according to the frequency the plan states. In special circumstances, the city should:
    - Increase auditing frequency if unusual contamination levels are seen in test results (i.e. groundwater quality), if schools have completed remediation within the last year in order to alleviate community concerns,
    - Reduce auditing frequency to base line standards as dictated by the school's monitoring plan if no contamination above acceptable state and federal standards has been found in a year.
- Maintaining the ventilation systems at each school according to their plan by use of the following methods:
    - Conducting base line number of checks a year (three per year is the standard set by Keith Middle School), and more should any contamination issues arise,
    - Monitoring indoor air quality using high-quality sampling devices to collect data over a period of time such as 24 hours to obtain the most accurate results and conducting these monitoring sessions in worst case conditions.

6.1.3 Land Manager

The DEP is responsible for environmental management throughout the state. The regional office manager should be responsible for ensuring responsible human use of the land.

They can do this working in conjunction with the school's environmental consultant when auditing school sites to ensure city compliance with state and federal standards.

6.1.4 Repairer

Cities must act as the repairer, and fix physical failures as they arise. As engineered measures age over time, cities should propose appropriate changes to the plan currently being implemented, such as, but not limited to:

- Increasing the frequency of monitoring
- Investing in newer, more accurate technologies for sampling indoor air and/or groundwater.

In addition to cities, schools should also act as the repairer and have at their disposal an immediate response plan in the event a lapse in maintenance causes contamination levels to rise unexpectedly. This plan can include, but is not limited to, the following:

- Evacuating or closing the school until potential sources of contamination are identified and remedied,
- Using appropriate technologies to introduce a greater amount of fresh air into the building so as to improve the quality of the indoor air to acceptable standards as determined by the state.

6.1.5 Archivist

The City should keep track of all documents they issue for specific school sites, which can include long-term monitoring and maintenance plans and any other related information. The DEP should be responsible for keeping records of all audits they

conduct. Both should ensure that any publicly available documents are accessible and navigable, in the case of websites.

6.1.6 Educator

Cities should provide training and information to the community at the site, which includes school staff and the interested public. Specifically, they should:

- Hold annual training on contamination issues for the entire custodial staff of schools, with refresher training provided to returning staff at the beginning of each year.
- Cities should disseminate information about their long-term monitoring plan to all new staff
- Keep the public informed of current monitoring efforts in conjunction with the school district or department, by:
    - Hiring a qualified webmaster to maintain an up-to-date, easily navigable website
    - Creating annual or semi-annual fact sheets
    - Holding quarterly public forums that are well-advertised through a variety of media, including online, print, and radio.

Schools are also responsible for playing the role of educator. Therefore, schools that do not have current issues with contamination and have not had any issues for at least ten years should consider implementing environmental studies courses focusing on long-term monitoring of remediated sites to expand upon their role as educators.

6.1.7 Trustee

School departments that secure funds from the City's annual budget should design a back-up plan should the City be unable to allocate the necessary funds in a given year.

6.2 Recommendations for future research on schools

- Researchers should further investigate how the trustee role is implemented in school departments, as this was a function not fully investigated in this study.
- Researchers should determine the feasibility of implementing high school curricula on long-term stewardship issues as part of environmental studies courses, as this could enhance schools' roles as educators of the community.
- Researchers should assess the possibility of conducting public surveys to determine public satisfaction in regards to LTS functions carried out by schools.

6.3 Recommendations for research methods on LTS

- Researchers should focus on contacting regional DEP offices and City officials, as they are much more involved with LTS functions than are school administrators. Both the DEP and the City will have a wealth of information, as well as a multitude of official documents readily available to the public.
- Researchers should interview individuals at the federal level. EPA employees will be knowledgeable of federal guidelines, which can be useful to compare to state guidelines. They also appoint specific employees within regions who are experts on specific contaminants; for example, EPA currently appoints an employee specifically to take care of PCB-related matters in the Northeast.

- Researchers should conduct more in-depth, longer-term projects to allow time to complete paperwork for research authorizations, as some schools require a more formal research proposal process, such as the Providence Public School District.
- Researchers should contact the Business Manager for cities' school departments to inquire about funding-related questions, as they are the most knowledgeable about financial issues.

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Appendix A: Remediation Technologies & Associated Costs

Applicable Technology	Technology Description	Contaminants Treated by this Technology	Limi	Cost
Containment Technologies				
Capping	• Used to cover buried waste materials to prevent migration.Consist of a relatively impermeable material that will minimize rainfall infiltration.Waste materials can be left in place.Requires periodic inspections and routine monitoring.Contaminant migration must be monitored periodically.	• MetalsCyanide	• Costs associated with routine sampling and analysis may be high.Long-term maintenance may be required to ensure impermeability.May have to be replaced after 20 to 30 years of operation.May not be effective if groundwater table is high.	• $11 to $40 per square foot.[1]
Sheet Piling	• Steel or iron sheets are driven into the ground to form a subsurface barrier.Low-cost containment method.Used primarily for shallow aquifers.	• Not contaminant-specific	• Not effective in the absence of a continuous aquitard.Can leak at the intersection of the sheets and the aquitard or through pile wall joints.	• $8 to $17 per square foot.[2]
Grout Curtain	• Grout curtains are injected into subsurface soils and bedrock.Forms an impermeable barrier in the subsurface.	• Not contaminant-specific	• Difficult to ensure a complete curtain without gaps through which the plume can escape; however new techniques have improved continuity of curtain.	• $6 to $14 per square foot.[2]

Applicable Technology	Technology Description	Contaminants Treated by this Technology	Limi	Cost
Slurry Walls	• Used to contain contaminated ground water, landfill leachate, divert contaminated groundwater from drinking water intake, divert uncontaminated groundwater flow, or provide a barrier for the groundwater treatment system.Consist of a vertically excavated slurry-filled trench.The slurry hydraulically shores the trench to prevent collapse and forms a filtercake to reduce groundwater flow.Often used where the waste mass is too large for treatment and where soluble and mobile constituents pose an imminent threat to a source of drinking threat to a source of drinking water.Often constructed of a soil, bentonite, and water mixture.	• Not contaminant-specific	• Contains contaminants only within a specified area.Soil-bentonite backfills are not able to withstand attack by strong acids, bases, salt solutions, and some organic chemicals.Potential for the slurry walls to degrade or deteriorate over time.	• Design and installation costs of $5 to $7 per square foot (1991 dollars) for a standard soil-bentonite wall in soft to medium soil.[3]Above costs do not include variable costs required for chemical analyses, feasibility, or compatibility testing.

Appendix B: Schools in Massachusetts with Activity & Use Limitations

Site Name/Location Aid	City/Town	Release Address	Date
GRANVILLE CENTER SCHOOL	GRANVILLE	RTE 57	5/25/2001
AUL terminated on 09/14/2004			
AUL received on 09/14/2004			
AUL received on 05/25/2001			
HIGH SCHOOL BOILER ROOM A TANK	WEST SPRINGFIELD	425 PIPER RD	8/29/1996
AUL received on 08/29/1996			
KITTREDGE SCHOOL	HINSDALE	80 MAPLE ST	10/31/1997
AUL received on 10/31/1997			
REID MIDDLE SCHOOL	PITTSFIELD	950 NORTH ST	7/27/2001
AUL received on 12/22/2003			
AUL terminated on 12/22/2003			
AUL received on 07/27/2001			
SMITH VOCATIONAL HIGH SCHOOL	NORTHAMPTON	80 LOCUST ST	6/27/2002
AUL terminated on 11/01/2005			
AUL received on 11/01/2005			
AUL received on 06/27/2002			
RIVER BROOK SCHOOL	STOCKBRIDGE	4 ICE GLEN RD	2/28/2002
AUL terminated on 12/01/2003			
AUL received on 12/01/2003			
AUL received on 02/28/2002			
FORMER MAGNET MIDDLE SCHOOL	HOLYOKE	325 PINE ST	11/6/2006
AUL received on 05/18/2010			
AUL confirmed on 06/16/2009			
AUL received on 08/22/2008			
56 SCHOOL ST PROPERTY	ATHOL	56 SCHOOL ST	8/7/1995
AUL received on 08/07/1995			
MILFORD HIGH SCHOOL	MILFORD	31 WEST FOUNTAIN ST	11/4/1999
Legal notice posted on 04/22/2002			
AUL received on 11/04/1999			
UPSALA SCHOOL	WORCESTER	36 UPSALA ST	3/19/1996
AUL amended on 12/15/2006			
AUL received on 03/19/1996			
DOUGLAS SCHOOL DISTRICT	DOUGLAS	21 DAVIS ST	1/9/2006
AUL received on 01/09/2006			
ABBY KELLEY FOSTER CHARTER SCHOOL	WORCESTER	10 NEW BOND ST	12/9/2008

AUL received on 02/17/2010			
WILMINGTON HIGH SCHOOL	WILMINGTON	159 CHURCH ST	3/19/2003
AUL received on 04/16/2010			
Legal notice posted on 04/16/2010			
AUL terminated on 01/20/2004			
AUL received on 11/19/1997			
TOBIN SCHOOL	CAMBRIDGE	197 VASSAL LN	3/10/1999
AUL amended on 11/06/2002			
Legal notice posted on 11/01/2002			
Legal notice posted on 10/30/2002			
AUL received on 03/09/1999			
NATIONAL SCHOOL BUS SERVICE	BOSTON-DORCHESTER	30 WEST HOWELL ST	12/11/2000
AUL received on 12/11/2000			
CHARLES BERNAZZANI ELEM SCHOOL	QUINCY	701 FURNACE BROOK PKWY	6/21/1999
AUL received on 06/21/1999			
BRIMMER & MAY SCHOOL	BROOKLINE	69 MIDDLESEX RD	3/19/2001
AUL received on 10/15/1997			
BROOKLINE HIGH SCHOOL	BROOKLINE	46 TAPPAN ST	3/27/1995
AUL received on 03/27/1995			
HAYDEN SCHOOL	BOSTON-DORCHESTER	21 QUEEN ST	3/29/1999
Legal notice posted on 07/28/2005			
Legal notice posted on 07/28/2005			
AUL terminated on 07/27/2005			
AUL received on 03/29/1999			
WILLIAMS SCHOOL	CHELSEA	170-180 WALNUT ST	8/28/1998
AUL amended on 01/23/2007			
Legal notice posted on 01/23/2007			
AUL received on 08/28/1998			
HIGHLAND ELEMENTARY SCHOOL	DANVERS	190 HOBART ST	4/19/1996
AUL received on 04/19/1996			
BENJAMIN HAMILTON SCHOOL	NATICK	14 EAST EVERGREEN	8/12/2002
AUL amended on 09/05/2003			
Legal notice posted on 09/06/2001			
AUL received on 08/22/2001			

NEWTON COUNTRY DAY SCHOOL	NEWTON	785 CENTER ST	5/24/2007
AUL received on 05/24/2007			
CORNER OF SCHOOL ST AND ROCK ST N SIDE	LOWELL	294 SCHOOL ST	3/1/2007
Legal notice posted on 03/05/2007			
AUL received on 03/01/2007			
WITCHCRAFT SCHOOL OFF PURITAN RD	SALEM	1 FREDERICK ST	9/30/2005
AUL received on 09/30/2005			
PROPOSED MIDDLE SCHOOL	LOWELL	225 MT VERNON ST	3/1/2007
Legal notice posted on 03/05/2007			
AUL received on 03/01/2007			
PROPOSED MIDDLE SCHOOL	LOWELL	294 SCHOOL ST	3/1/2007
Legal notice posted on 03/05/2007			
AUL received on 03/01/2007			
SPRAGUE SCHOOL ATHLETIC FIELDS	WELLESLEY	79 OAK ST	6/7/2004
Legal notice posted on 09/23/2010			
AUL amended on 08/31/2010			
Legal notice posted on 08/27/2009			
AUL received on 08/20/2009			
PROPOSED RUMNEY MARSH SCHOOL	REVERE	101 SCHOOL ST	5/3/2007
AUL received on 12/09/2009			
MATIGNON HIGH SCHOOL	CAMBRIDGE	1 MATIGNON RD	10/30/2007
Legal notice posted on 11/15/2007			
AUL received on 10/30/2007			
POWER PLANT WRENTHAM STATE SCHOOL	WRENTHAM	EMERALD ST	3/21/2003
AUL terminated on 05/14/2004			
AUL received on 05/14/2004			
Legal notice posted on 05/14/2004			
Legal notice posted on 04/01/2003			
AUL received on 03/21/2003			
CORNER SCHOOL	STOUGHTON	49 ROSE ST	9/30/1994
AUL amended on 05/14/2002			
OLD HIGH SCHOOL	MATTAPOISETT	135 MARION RD	10/2/2002
Legal notice posted on 06/13/2002			
AUL terminated on 05/20/2002			
AUL received on 07/25/1995			

CONLEY SCHOOL	WHITMAN	FOREST ST	8/16/2005
Legal notice posted on 11/09/2005			
AUL amended on 08/29/2005			
AUL received on 12/13/2000			
AUL terminated on 12/13/2000			
CONLEY SCHOOL	WHITMAN	FORREST ST	3/5/1996
AUL received on 03/05/1996			
LITTLE RED SCHOOL HSE	WRENTHAM	944 WEST ST	6/11/1999
AUL received on 06/11/1999			
FOXBORO STATE SCHOOL	FOXBOROUGH	CHESTNUT ST	10/26/2006
AUL received on 12/14/2006			
SCHOOL MEADOW AT BROOK WELLFIELD	WALPOLE	1303 WASHINGTON ST	2/4/2000
AUL received on 02/04/2000			

Extracted from: http://db.state.ma.us/dep/cleanup/sites/SearchResults.asp.

Appendix C: Letter to Potential Interviewees

Dear XX,

We are a group of students from Worcester Polytechnic Institute who are conducting a research project about the long-term management and maintenance of schools that have been built on land contaminated by toxic chemicals. We are writing to you with the hope that you will agree to talk with us about your experiences working with xx school.

The following is an overview of our project:

The primary objective of this project is to study how activities set-up to ensure the safety and health of students and school staff and faculty are organized and the challenges faced by municipalities with such schools. We think of long-term management as including the activities involved with monitoring and maintenance of institutional controls (activity and use limitations), physical barriers, and on-going treatment systems that are required to ensure health and safety. This study is being conducted as part of our degree requirement. All WPI undergraduates must complete a group research project that addresses the connections between technology and society. Professor Seth Tuler, who has a project funded by the National Science Foundation to investigate factors that support long-term stewardship of contaminated sites, sponsors the study. The project is not an evaluation of past activities or how well schools are performing in regards to long-term management.

This study will involve interviewing key government officials and stakeholders who have a role in the long-term management of a school that is built on land that is contaminated by toxic chemicals and requires long-term monitoring and maintenance. We anticipate studying 2-4 schools in Massachusetts and Rhode Island. The interview questions will generally be about different peoples' roles in long-term management. We want to understand how the different responsibilities of management are distributed and how people think about creating management systems that ensure important functions such as coordination, financing, inspection and evaluation, and public notification. We are also interested in learning how people think about future needs and challenges.

It is our hope that after these interviews, we will be able to understand the methods school districts use to ensure that their students and faculty are safe and the challenges that they are anticipating from long-term obligations for monitoring and maintenance of the required institutional controls, physical barriers, and on-going treatment systems. At the end of our project, we will write a report that includes recommendations for possible improvements, and we will be happy to share this report with you.

Again, as part of our project we would like to interview you. We want to learn from your experiences at xx school. If possible, we would like to schedule an interview during the week of Monday, November 15 at a time that is convenient for you. We understand that you might be busy and it may not be possible for us to interview you. If this is the case, we would appreciate it if you could direct us toward someone who could assist us with this project.

If you have any questions about our project, please contact us. Our contact information, as well as the contact information of our advisors, is below.
We will be looking forward to speaking with you and thank you very much for your time.

Sincerely,

Freshta Abedi
Hiral Dutia
David Muchene
Rohit Mundra

Appendix D: Sample Interview Guide

1. **What are the continuing health risks to students and school staff?**
   a. What is being done about this?
   b. What are the goals of the activities to address the health risks? (Is it a goal to address people's fears?)

2. **Who are the key actors (organizations) involved?**
   a. What are each of their responsibilities?
   b. What is the role of parents?
   c. Specifically, what are your responsibilities for addressing the ongoing health risks?

3. **What monitoring and inspection (or auditing) practices are currently in place?**
   a. What are the purposes of the monitoring (i.e. satisfy regulatory requirements, inform parents and others, etc.)?
   b. Which of the following criteria is most important when considering monitoring options? (accuracy, reliability, ease of interpretation, particulars of information, trade-offs with other long-term management functions, finances, whether it affects students)
   c. What are requirements for independent inspections or auditing?
      i. Who is responsible for doing them?
      ii. Who gets information about the results?
   d. Is it important to do any sort of public/parent education about these issues?
   e. Is the monitoring and inspection (auditing) adequate?
      i. What criteria do you consider when making this judgment? (i.e. whether/how students are affected)
   f. If problems are found, what are common methods to address them?
   g. How effective do you think this plan will be a few years from now?

4. **How much does it cost to carry out this monitoring – can you give us actual budget figures for this?**
   a. What are sources of funds for long-term monitoring?
   b. Who is in charge of securing these funds?
   c. What happens if these funds cannot be secured from that particular source(s)?
      i. Are you worried about maintaining the funding?
      ii. Do you have a back-up plan?

5. **Implementing high school curricula**
   a. As an educator, how do you feel about developing high school curricula on this subject?
   b. Do you think it would be worthwhile for students to be involved in LTS?
   c. Are there instructors available to teach curricula on the monitoring of reused contaminated sites?
   d. How do you think students can get involved in LTS?
   e. If no, then who are actors that are currently not involved that could be involved?

6. **Who else do you think we should contact about this topic? (Town officials, city and state health boards, school districts, parent teacher organizations, etc.)?**