Technical Assistance Services for Communities
Contract No.: EP-W-07-059
TASC WA No.: TASC-4-HQ-OEJ
Technical Directive No.: CARE-Providence

Technical Assistance Services to Communities
Summary and Review of
Rhode Island Department of Environmental Management
Draft Five-Year Review Report
Anthony Carnevale Elementary School and Del Sesto Middle School

This report pertains to a review of documents regarding environmental conditions at the Anthony Carnevale Elementary School and Del Sesto Middle School, which were constructed between 1999 and 2000. The location of the schools was used as a landfill during the late 1960s and early 1970s. Prior to construction of the schools, environmental testing identified the presence of approximately 200,000 cubic yards of solid waste. Three major "constituents of concern" were identified from initial soil, ground water and air samples. These were lead, arsenic and total petroleum hydrocarbons (TPH). At an earlier time, Rhode Island Department of Environmental Management (RI DEM) also found polychlorinated biphenyls (PCBs) on the Site.[1] Ongoing monitoring and maintenance activities are conducted to protect those who occupy the buildings and use the property from exposure to harmful substances.

This report is provided by the U.S. Environmental Protection Agency (EPA)'s Technical Assistance Services for Communities (TASC) program, which is implemented by independent technical and environmental consultants. Its contents do not necessarily reflect the policies, actions or positions of EPA. TASC activities are meant to empower community members to more effectively participate in environmental decision-making processes within their communities.

At the request of the Environmental Justice League of Rhode Island, the TASC team completed the following activities:

- Reviewed RI DEM's *Draft Five-Year Review (FYR) Report, Anthony Carnevale Elementary School and Del Sesto Middle School*.
- Reviewed key documents upon which remedial actions were based, including the 1999 Site Investigation report (SI), Supplemental SI reports, and Remedial Action Work Plan (RAWP) and Order of Approval.
- Reviewed periodic monitoring reports.
- Reviewed the court order establishing the FYR.
- Conducted a site visit with community representatives.
- Prepared written comments on the RI DEM Draft FYR, including any recommendations for changes to the approved remedial actions for the Site.

[1] The "Site" is the 9.91-acre site upon which the Anthony Carnevale Elementary School (50 Springfield Street) and Del Sesto Middle School (152 Springfield Street) are located.

This report summarizes these activities and provides TASC recommendations for improving the Draft FYR and for making changes to the remedial actions for the Site. The purpose of the report is to provide the Environmental Justice League of Rhode Island and community members in Providence, Rhode Island with an understanding of the technical merit of the FYR and an independent review of the remedial activities so that they have sufficient information to provide their own comments to RI DEM during a public comment period for the Draft FYR report.

This report is organized into the following sections:

I. Draft FYR Report Compliance with the *Second Assented to Supplemental Order*
- I.A. Summary of the Second Assented to Supplemental Order
- I.B. TASC Review of the FYR's Compliance with the Second Assented to Supplemental Order

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- III.A. 1999 Site Investigation (SI)
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IV. TASC Site Visit, December 2011

V. Summary of 2011 FYR

VI. TASC Summary and Recommendations

[Note: outline above is hyperlinked to sections below.]

This report is accompanied by a shorter fact sheet discussing TASC's observations and recommendations. This longer report provides the reader with additional supporting information to the fact sheet.

I. Draft FYR Report Compliance with the *Second Assented to Supplemental Order*

The *Second Assented to Supplemental Order* is a court order issued to RI DEM requiring FYRs at the Site. The *Second Assented to Supplemental Order* states that every five years, RI DEM "shall conduct a review of the approved remedial action at the Springfield Schools Site to assure that human health and the environment are being protected by the remedial action being implemented."

I.A. Summary of the *Second Assented to Supplemental Order*

The *Second Assented to Supplemental Order* identifies seven orders to which the RI DEM Plaintiffs and Defendants consented. The orders are copied below with some re-phrasing for readability:

1. Conducting FYRs
2. Providing written notice at the start of each FYR

3. Including the following topics in each FYR
    a. Introduction/Site Conditions: This section shall include a discussion of the Site's history and a synopsis of the contaminants of concern and impacted media at the Site.
    b. Historical and Current Document Review: DEM shall summarize its review of key documents relating to the Site in the agency's file (e.g., site investigation report, any public comments, correspondence, etc.) and data contained in periodic monitoring reports since date of the prior FYR.
    c. Site Visit and Interviews: DEM shall conduct a site visit to look for any conditions indicating changes in the potential for adverse ecological or human health risks resulting from any impacted site media; interview personnel responsible for maintenance of soil gas systems, monitoring wells, methane meters, etc. and any other persons DEM deems necessary to interview; and summarize the information obtained during the site visit and interviews.
    d. Statement of Protectiveness: DEM shall make a statement stating either that the remedy is functioning as designed and will continue to be protective of the remedy, or that further steps need to be taken by the City of Providence to restore the protectiveness of the remedy. The statement shall also include answers to the following questions:
    i. Is the remedy still functioning as designed?
    ii. Is there any reason to believe that exposure assumptions, toxicity data and remedial objectives used at the time of remedy selection are not still valid?
    iii. Has any new information come to light that may impact the protectiveness of the remedy?
    e. Review Summary/Recommendations: DEM shall report any significant information that DEM gathers from the site interviews, site visit, and/or document and data review that may impact the protectiveness of the remedial action since the prior FYR and make recommendations (together with implementation timeframes) to address them. These recommendations may include revisions to the remedial actions approved to date by DEM. Also, DEM will indicate how it addressed any issues or concerns raised by persons responding to the written notice sent at the start of the FYR
4. Allowing for a comment period for the FYR
5. Compiling written comments received during the review period
6. Extending the review period if agreed upon by the plaintiffs and DEM
7. Allowing the Site Agreement to remain in full force and effect

I.B. TASC Review of the FYR's Compliance with the *Second Assented to Supplemental Order*
As part of this review, TASC provides an assessment of the completeness of the FYR report as described by the third order in the *Second Assented to Supplemental Order*.

a. Introduction/Site Conditions

- *Discussion of the Site's history*: Section 2 adequately discusses the Site's history.
- *Synopsis of contaminants of concern and impacted media*: Section 2 adequately discusses the contaminants of concern in the soil, including arsenic, lead and TPH which exceeded the applicable Residential Direct Exposure Criteria.

  The concentration of volatile organic compounds (VOCs) in ground water samples collected by an environmental consulting firm, ATC Associates, Inc. (ATC), were reportedly less than

the applicable RI DEM GB Ground Water Objectives. The ground water beneath the Site is classified as GB. GB ground water is not suitable for public or private drinking water use. GB ground water areas are typically located beneath highly urbanized areas, permanent waste disposal areas and the areas immediately surrounding the permanent waste disposal areas. The nearest GA[2] ground water area is located approximately 900 feet south of the Site. Based on the results of previous environmental investigations performed at the Site, the depth to ground water beneath the Site ranges between approximately 6 to 18 feet below grade, depending on seasonal fluctuations.

Soil vapor samples were reported to contain concentrations of VOCs and/or typical landfill gases, including methane and carbon dioxide, which exceeded laboratory reporting limits.

b. Historical and Current Document Review

- *Summary of review of key documents related to the Site (e.g. site investigation report, any public comments, correspondence)*: Section 2.2 adequately discussed the Phase I Environmental Site Assessment (ESA), the RAWP, the Long-Term Operation and Maintenance (O&M) Plan, previous FYR, and public comments received from the distribution of public notices for the current FYR.
- *Summary of review of data contained in periodic monitoring reports since date of prior FYR*: Section 3.2 adequately discusses results of monitoring activities from 2006 through 2011, including frequent and isolated exceedances.

c. Site Visit and Interviews

- *Summarize site visit (look for any conditions indicating changes in the potential for adverse ecological or human health risks resulting from any impacted site media)*: The site inspection is adequately discussed in Section 3.3. Observations on the site grounds as well as the building interiors are included in this section.
- *Summarize interviews of personnel responsible for maintenance of soil gas systems, monitoring wells, methane meters, etc. and any other persons DEM deems necessary to interview*: Section 3.4 appears to adequately discuss interviews conducted with maintenance personnel, the City of Providence's monitoring consultant and school medical staff. Issues from the site inspection as well as recent occurrences appear to be identified in this section.

d. Statement of Protectiveness

- *A statement stating either that the remedy is functioning as designed and will continue to be protective, or that further steps need to be taken by the City of Providence to restore the protectiveness of the remedy*: Section 4 states "the report describes that these non-conformance issues have not significantly diminished the effectiveness of the overall monitoring program at evaluating performance of the remedial actions nor have they resulted in significantly increased risk posed to site users."
- *Answers to the following questions:*
    - *Is the remedy still functioning as designed?*
    - *Is there any reason to believe that exposure assumptions, toxicity data and remedial objectives used at time of remedy selection are not still valid?*

[2] Class GA ground water is known or presumed to be suitable for drinking water use without treatment. Approximately 70 percent of the state of Rhode Island overlies ground water classified as GA.

- *Has any new information come to light that may impact the protectiveness of the remedy?*

The protectiveness statement appears to answer these questions, although not explicitly. It would be helpful to the FYR reader if the questions were listed in the FYR and specifically addressed.

e. Review Summary/Recommendations

- *Report of any significant information that DEM gathers from the site interviews, site visit, and/or document and data review that may impact the protectivenesss of the remedial action since the prior FYR and make recommendations (together with implementation timeframes) to address them*: Section 4 adequately discusses conclusions and recommendations from the FYR by discussing issues discovered during the FYR process. The document provides recommendations for addressing the issues. These issues are discussed in terms of compliance with operations and monitoring requirements and effectiveness of remedial actions (soil cap and sub-slab ventilation systems).
- *Discuss how DEM addressed any issues or concerns raised by persons responding to the written notice sent at the start of the FYR:* Section 2.1.2 includes discussions of the two comments received upon distribution of the public notices. A response is provided for each comment that is relevant to the FYR. The responses appear to adequately respond to each comment.

II. Draft FYR Comparison to EPA Superfund Guidance for FYR Reports

The EPA Superfund Comprehensive FYR Guidance (2001) states, "the purpose of a five-year review is to evaluate the implementation and performance of a remedy in order to determine if the remedy is or will be protective of human health and the environment." The draft FYR for the Anthony Carnevale Elementary and Del Sesto Middle School generally follows the EPA guidance and includes discussion of most of the key areas needed in order to evaluate protectiveness. The draft FYR report provides background on the site, including the physical setting; the history of contamination; a description of the remedial action; and an update on the issues and recommendations of the previous FYR. The FYR process included public notifications, document review, data review and evaluation, a recent site inspection, interviews, an evaluation of the remedial components, and identification of issues and recommendations related to long-term effectiveness. However, the draft FYR is lacking in three areas:

- There is no discussion of the terms and current status of the Environmental Land Usage Restriction. This is listed in Section 2.2 as a component of the overall remedy and therefore its effectiveness is expected to be discussed in Section 4.
- Monitoring data is not presented quantitatively in the report. Monitoring data is discussed qualitatively in Section 3.2.1 as exceedances and summarized in Table 2. It would be useful for the reader of the FYR to have information about the quantitative extent of exceedances.
- There is no discussion of the validity of 1999 RAWP action levels for indoor air and soil gas screening identified in the O&M Plan. The report discusses data based on exceedances of the O&M thresholds, but a discussion of current standards or screening levels is needed to confirm that the O&M thresholds remain protective.

III. Review and Summary of 1999 Site Investigation and Quarterly Monitoring Reports

III.A. 1999 SI[3]

III.A1. SI Report Section I SI Results

The SI Report details the various environmental investigations performed at the Site, denoted in the SI as the Springfield Avenue Lots. The SI was performed in accordance with the scope and limitations of ASTM[4] Practice E 1527 which provides standard practice for Environmental Site Assessments. The SI was performed as part of the City of Providence's due diligence assessment of the Site. The SI Report documents the results of the: soil and water material sampling, ground water sampling and soil gas sampling. A summary of key information from the SI Report is presented below. The SI section and page number are provided for those who may want additional information.

SI Report Section 3.0, page 2

The Site was used for disposal of solid waste, primarily between 1965 and 1970. DEM conducted a limited sampling program to evaluate allegations of disposal of **auto fluff** at the Site. The date for this evaluation is not specified in the SI report. The SI report states that the DEM results indicated that auto fluff was disposed at the Site and PCBs were detected.

Auto fluff is the non-metallic material that remains after junked automobiles are stripped and then shredded to recover their metal (primarily iron compounds) and other valuable components. The composition of auto fluff varies, however, it is generally comprised of scrap metal (wire, molding, etc.), plastic, vinyl, leather, cloth, sponge, foam, glass and other noncombustibles. Traces of lead, cadmium, chromium and mercury can be present in this material along with organic compounds, such as oil, antifreeze, transmission and brake fluids, and PCBs.

SI Report Section 6.0, page 6

Two to three thousand cubic yards of solid waste were excavated while extracting sand and gravel for use on the Site. The solid waste was buried in the excavation hole. It was reported that the sand and gravel contained "no reportable concentrations of contaminants of concern." The report indicates that the sand and gravel were to be used for fill during construction activities at the Site.

SI Report Section 9.0, page 7

Section 9 of the SI report states that, "Based on the results of this study, it is not likely that abutting properties have been impacted by the release at this site." The basis for this determination is not clear. TASC recommends an updated evaluation of the potential for releases of landfill gas into nearby residences.

SI Report Section 10.0, page 8

The ground water at the Site is classified as GB and there are no surface water bodies within 500 feet of the Site.

[3] The SI Report is available at this website: http://www.dem.ri.gov/programs/benviron/waste/springfd.htm.

[4] ASTM is an international standards organization that develops and publishes voluntary consensus technical standards for a wide range of materials, products, systems and services.

SI Report Section 11.0, pages 8-9 (and Appendices C and D)

Test pits were dug to determine the nature of the waste buried at the Site. Soil samples taken during test pit operations were analyzed for eight metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium and silver), VOCs, PCBs, and TPH. Eleven of the test pit soil samples contained arsenic and lead above the applicable Rhode Island Method 1 Residential **Direct Exposure Criteria**. Three contained arsenic only above the exposure criteria. One contained lead only above the exposure criteria. One contained arsenic, lead and TPH above the exposure criteria. The findings for each test pit at different depths below ground surface are presented in Appendix C of the SI. In general, "garbage," including bottles, cans, etc. is reported being found in test pits from 1 to 12 feet below ground surface. No "garbage" was found in four of 15 test pits.

> **Direct Exposure Criteria** shall mean the concentrations of Hazardous Substances in soil protective of human health and the environment from exposures including but not limited to ingestion…
> *Remediation Regulations (DEM-DSR-01-93, Amended February 2004)*

SI Report Section 11.0, page 9-11

Surface soil samples were taken from the southern portion of the Site, south of the proposed location for the elementary school. Four of seven surface soil samples contained arsenic, lead, and TPH above the applicable exposure criteria.

Ground water samples were collected and analyzed on site using a portable gas chromatograph. None of the organic compounds detectable by the gas chromatograph were detected. Thirteen different VOCs are listed as commonly detectable in Appendix A (Field Analysis Method) of the SI report. Five ground water samples were sent for laboratory analysis for VOCs. Naphthalene and dichlorodifluoromethane (Freon 12) were detected at 53.2 micrograms per liter (µg/L) and 2.6 µg/L, respectively, in one sample. Naphthalene has a chronic lifetime health advisory threshold of 100 µg/L and Freon 12 has a health advisory of 1,000 µg/L.[5]

SI Report Section 14.0, pages 13-14

Ground water was encountered at 6 to 10 feet below ground surface and within the waste in the northern portion of the landfill. Deep borings completed at the Site indicate that there is a 3 to 4 foot thick peat layer underlying the waste. Underlying the peat layer is a sand/gravel unit. The report indicates that the peat is compressed and may be acting as a partial **aquitard**. The ground water identified in the fill material is likely to be perched above the compressed peat layer. However, the peat is not extensive throughout the Site and the ground water in the waste material is likely in contact with the ground water in the lower sand/gravel unit below the peat layer. Also, buried sewer lines through the Site may be acting as conduits for contaminant migration. Ground water under the Site is classified as GB and is not used for drinking water.

> An **aquitard** is a layer of silt or clay that slows the movement of water to or from an adjacent aquifer.

[5] United Stated Environmental Protection Agency. Drinking Water Standards and Health Advisories Table. November 2009. http://www.epa.gov/region9/water/drinking/files/DWSHATv09.pdf

The report states that it is likely that regional ground water flow is to the north. The report also states that subsurface pipes likely influence the flow of the ground water in the uppermost aquifer and flow is likely southeasterly to easterly.

SI Report Section 15.0, page 15
The SI states that although the Federal Emergency Management Agency, Flood Insurance Rate Map depicts the Site to be within a 100-year flood plain, the SI report states that the current elevation of the ground surface of the Site is above the base flood elevation due to filling of the wetland that existed on the Site.

SI Report Section 16.0, pages 15-16
Methane was detected at 0.2% concentration at only one soil gas monitoring point. Oxygen concentrations in the soil gas ranged from 12.8% to 20.5%. The report states that the oxygen concentrations indicate that if microbial decomposition of waste materials is occurring, it is aerobic (with oxygen). Bacteria that produce methane cannot survive in the presence of oxygen. Therefore, large quantities of methane are typically not produced from decomposing materials when oxygen is present in the subsurface. Instead, bacteria that do not produce methane are decomposing the materials.

SI Report Section 17.0, page 16
The report states that there was little storm water runoff from the Site and most rainfall infiltrated to the subsurface.

III.A2. SI Report Section II Development of Remedial Alternatives
Three alternatives were evaluated:

1. *NoAction/Natural Attenuation* was evaluated as ineffective because arsenic and lead will not be removed through natural attenuation and the alternative will fail to comply with remediation regulations. Under this alternative, no action would be taken to remediate the site or site contaminants.

2. *Remove the Solid Waste Present at the Site and Replace the Solid Waste with Clean Fill* was evaluated as too costly to be practical. This alternative would involve the use of large equipment and heavy trucks to dig up and haul away the waste materials on the Site.

3. *Engineered Cover Coupled with Soil Gas Collection Systems* was chosen as the preferred alternative. The report explains this alternative: "Under this option, approximately 2 feet of clean fill will cover the non-building areas of the site. Some areas will receive less than two feet of clean fill where an asphalt surface will be located. Under the Elementary School building solid waste material will be excavated and removed from the site, thus reducing the need for a soil gas collection system. Timber piles installed to approximately 40 feet below the ground surface will support the middle school foundation, and a soil gas collection system will be placed under the building to prevent the migration of gas through the foundation."

III.A3. TASC Comments on the 1999 SI Report

TASC observations specific to the SI report are presented in this section. Also supplemental information that may be useful for the Environmental Justice League of Rhode Island members' understanding of technical issues is provided in this section.

Observations about the Cap Design

The engineered cover is only designed to prevent people coming into direct contact with contaminated soils and waste materials in the subsurface. A clay cap and/or barrier layers to prevent infiltration of rainwater and migration of contaminants into ground water is not discussed. Without such a cap, contamination of ground water remains a possibility. Ground water is classified as GB in this area, which is likely why a cap to prevent rainwater infiltration was not required.

Observations and Supplemental Information about Landfill Gas Infiltrating Indoor Air

Direct contact with contaminated soil is a valid concern and a clean soil cap is needed to prevent direct contact. However, the most concerning issue with placing school buildings on top of a landfill is the potential for landfill gas to accumulate in the indoor air.

The EPA report, *Guidance For Evaluating Landfill Gas Emissions from Closed or Abandoned Facilities* (2005) states:

> "Asphyxiation and explosion are the two most commonly recognized health risks associated with landfill gas (LFG). … LFG is a complex mixture of gases, including methane, carbon dioxide, and trace constituents of volatile organic compounds (VOC), hazardous air pollutants (HAPs), and hydrogen sulfide. ...."[6]

The ongoing sub-slab ventilation system and indoor air monitoring program at the Site screens for these potential LFGs: methane (CH_4), carbon dioxide (CO_2), oxygen (O_2), VOCs, hydrogen sulfide (H_2S), and carbon monoxide (CO).

Table 1-3 from the same EPA guidance document (below) lists specific contaminants of potential concern that are commonly found in LFG. The laboratory analyses for soil and soil gas attached to the SI Report include most of the substances in EPA's Table 1-3. However, sulfur-containing substances, carbon disulfide, methyl mercaptans, and hydrogen sulfide were not included as analytes in the laboratory reports attached to the SI report. This may have been an oversight in the initial investigation, as hydrogen sulfide is now included in soil gas and indoor air field screening. TASC recommends that RI DEM review whether quarterly soil gas sample analyses should also include analyzing for carbon disulfide, methyl mercaptans, and hydrogen sulfide.

[6] Environmental Protection Agency. *Guidance for Evaluating Landfill Gas Emissions From Closed or Abandoned Facilities*. September 2005. Page ES-1.

Table 1-3. Contaminants of Potential Concern Commonly Found in LFG [a]

1,1,1-Trichloroethane (Methyl Chloroform)	1,1,2,2- Tetrachloroethene
1,1-Dichloroethane (ethylidene dichloride)	1,1-Dichloroethene (vinylidene chloride)
1,2-Dichloroethane (ethylene dichloride)	1,2-Dichloropropane (propylene dichloride)
Acetone	Acrylonitrile
Benzene	Bromodichloromethane
Carbon disulfide	Carbon tetrachloride
Chlorobenzene	Chloroethane
Chlorofluorocarbons	Chloroform
Chloromethane	Dichlorobenzene
Dichloromethane (Methylene Chloride)	Hexane
Hydrogen sulfide	Methyl ethyl ketone
Methyl isobutyl ketone	Methyl mercaptans
Tetrachloroethylene (perchloroethylene)	Toluene
Trichloroethylene	Vinyl chloride
Xylenes	

[a] Constituents associated with carcinogenic and/or chronic noncarcinogenic health effects that are routinely measured; Source: SWANA 2000.

Source: Environmental Protection Agency. *Guidance for Evaluating Landfill Gas Emissions from Closed or Abandoned Facilities*. September 2005. Pages 1-5.

III.B. Quarterly Monitoring Reports

The online Site document repository[7] contains 39 quarterly monitoring reports. The first report is dated June 7, 2000 and the most recent report is dated November 11, 2011. TASC reviewed the most recent quarterly monitoring report in detail because this report is most relevant to site conditions today. TASC then randomly selected 18 additional reports to briefly review. Each of these efforts is summarized in the sections below.

III.B1. November 11, 2011 Quarterly Monitoring Report

The November 11, 2011 quarterly monitoring report states that the City of Providence's contractor, ARCADIS, conducted monitoring of soil gas, indoor air, the sub-slab ventilation system, and the cap between the dates of September 28, 2011 and October 3, 2011. The report also states that new and existing ground water monitoring wells were sampled by ARCADIS on October 3, 2011.

Soil Gas Monitoring

Appendix B of the quarterly monitoring report indicates that 38 analytes were included in the laboratory analysis of two soil gas samples. The laboratory list of analytes included most of the compounds listed in EPA's list of contaminants of potential concern commonly found in LFG (see EPA's Table 1-3 above).

[7] Available at: http://www.dem.ri.gov/programs/benviron/waste/springfd.htm.

The following contaminants of potential concern were not included in the list of soil gas analytes for the Site:

1. Acetone
2. Acrylonitrile
3. Bromodichloromethane
4. Carbon disulfide
5. Hexane
6. Methyl ethyl ketone
7. Methyl isobutyl ketone
8. Methyl mercaptan

TASC recommends that RI DEM review whether quarterly soil gas sample analyses should also include analyzing for these common LFG contaminants.

The list of soil gas analytes in the November 11, 2011 quarterly monitoring report also does not include hydrogen sulfide. Because hydrogen sulfide has been detected above 2 parts per million (ppm) in indoor air of both schools at various times and hydrogen sulfide causes health effects at low concentrations (See World Health Organization Table 2 below), TASC recommends that soil gas samples be analyzed for hydrogen sulfide. Early detection of increasing concentrations of hydrogen sulfide in the soil gas will be beneficial information for avoiding potentially hazardous indoor air conditions.

Table 2 of the World Health Organization's report on human health effects of hydrogen sulfide is included below only to inform the reader. Please note that hydrogen sulfide has not consistently been measured in the indoor air of the two schools. When hydrogen sulfide has been detected, it has been at very low concentrations in only some areas, i.e. less than 10 milligrams of hydrogen sulfide per cubic meter of air (mg/m^3) in the quarterly reports reviewed by TASC (see indoor air monitoring sections below).

Table 2: Human health effects at various hydrogen sulfide concentrations.

Exposure (mg/m^3)	Effect / observation	Reference
0.011	Odour threshold	Amoore & Hautala, 1983
2.8	Bronchial constriction in asthmatic individuals	Jappinen et al., 1990
5.0	Increased eye complaints	Vanhoorne et al., 1995
7 or 14	Increased blood lactate concentration, decreased skeletal muscle citrate synthase activity, decreased oxygen uptake	Bhambhani & Singh, 1991; Bhambhani et al., 1996b, 1997
5–29	Eye irritation	IPCS, 1981
28	Fatigue, loss of appetite, headache, irritability, poor memory, dizziness	Ahlhorg, 1951
>140	Olfactory paralysis	Hirsch & Zavala, 1999
>560	Respiratory distress	Spolyar, 1951
≥700	Death	Beauchamp et al., 1984

Note: 1 ppm = 1.39 mg/m^3.

Source: World Health Organization. Geneva. Concise International Chemical Assessment Document Number 53. *Hydrogen Sulfide: Human Health Aspects*. 2003.

Indoor Air Monitoring

The November 11, 2011 quarterly monitoring report states that indoor air monitoring was conducted on September 28, 2011 using a QRAE plus multi-gas meter (for methane, hydrogen sulfide and oxygen), a Mini Rae photoionization detector (PID; for organic vapors), and a Fluke 975 Airmeter (for carbon dioxide and carbon monoxide). These types of air monitors provide real time screening results for target gases. However, there are limitations to the ability of the equipment to detect specific substances in air and limits on the concentrations that can be detected. This is discussed further below for each type of equipment reported to be used during the sampling event for the November 2011 quarterly report. Following the discussion of equipment is a discussion of the indoor air monitoring results.

Equipment

Manufacturer's literature indicates that the QRAE plus multi-gas meter is capable of detecting combustible gas (methane) at 0% to 100% of its lower explosive level with a resolution of 1%; oxygen at 0% to 30% in air with a resolution of 0.1%; and hydrogen sulfide at 0 to 100 parts per million (ppm), with a resolution of 1 ppm.[8]

A PID is commonly used to measure organic (carbon-containing) compounds in air. A PID is a very sensitive monitor and can measure organic compounds in air at low (ppm) concentrations. However, a PID cannot distinguish between different organic compounds. Therefore, a PID cannot tell the user what organic compound is in the air, only that an organic compound is present. PIDs are calibrated using a calibration gas, such as isobutylene, the PID reports measurements of organic compounds as if every compound is the calibration gas. When the PID user knows what compound has been released into the air, a calibration factor can be applied to accurately measure the concentration of the specific compound in air. Also, if a compound released into the air has an ionization potential (IP) greater than the electron-volts (eV) produced by the ultraviolet (UV) lamp of the PID, then the PID cannot detect that compound. For example, a PID with a 9.8 eV can detect benzene, styrene and methyl ethyl ketone, but it cannot detect ethylene, vinyl chloride or carbon tetrachloride.[9]

In the November 11, 2011 quarterly monitoring report, the eV of the PID used for monitoring was not reported. Therefore, it is not possible to discuss what specific organic vapors are within the detection range of the PID used for monitoring.

For future field monitoring activities, TASC recommends that the UV lamp of the PID be chosen so that the VOCs detected by laboratory analysis in previous soil gas samples are also detectable by the PID, if possible. Also, TASC recommends that the quarterly report list any VOCs previously detected in laboratory samples that the PID is not expected to detect.

Manufacturer's literature indicates that Fluke 975 Airmeter is capable of detecting carbon dioxide at 0 to 5,000 ppm and carbon monoxide at 0 to 500 ppm with resolutions of 1 ppm.[10]

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[8] http://www.geotechenv.com/pdf/air_quality/qrae_plus.pdf

[9] RAE PID Systems Training Outline. http://v2010.raesystems.com/~raedocs/App_Tech_Notes/App_Notes/AP-000_PID_Training_Outline.pdf

[10] http://assets.fluke.com/Catalog/1274458S_w_Pg22.pdf?view=FitB&scrollbar=1&toolbar=1&messages=1&navpanes=1

Results
The quarterly monitoring report states that, "all readings were below the RAWP Action Levels. Methane, carbon monoxide, hydrogen sulfide, and organic vapors were not detected, and carbon dioxide was within the expected range for an occupied building."

Indoor air methane and hydrogen sulfide action levels specified in Appendix C of the May 9, 1999 RAWP are lower than indicated in Table 2 of the November 11, 2011 quarterly monitoring report (see the table below). TASC recommends that future quarterly monitoring reports be revised to reflect the actual indoor air RAWP action levels for methane (500 ppm) and hydrogen sulfide (5 ppm), and appropriate actions should be taken if the specified RAWP action level is exceeded.

Parameter	**1999 RAWP Action Level**	**Quarterly Report Action Level**
Methane	500 ppm	0.5% (5,000 ppm)
Carbon Monoxide	9 ppm	9 ppm
Hydrogen Sulfide	5 ppm	10 ppm
Carbon Dioxide	1,000 ppm	1,000 ppm
Volatile Organic Compounds	5 ppm	5 ppm

Because the World Health Organization has observed that asthmatic individuals may experience bronchial constriction with exposure to 2.8 mg/m^3 (about 2 ppm) of hydrogen sulfide in air, it would be prudent to set the action level for hydrogen sulfide in indoor air at less than 2 ppm.

Carbon dioxide concentrations in occupied buildings are expected to be higher than concentrations in outside air because people expel carbon dioxide when they breathe. When carbon dioxide concentrations in buildings are higher than recommended, it is usually the result of poor air circulation and adjustments to the heating/air conditioning ventilation system is usually needed. The Wisconsin Department of Health and Family Services, Division of Public Health reports the following information.

"The levels of CO_2 in the air and potential health problems are:

- 250 - 350 ppm – background (normal) outdoor air level
- 350 - 1,000 ppm - typical level found in occupied spaces with good air exchange.
- 1,000 – 2,000 ppm - level associated with complaints of drowsiness and poor air.
- 2,000 – 5,000 ppm – level associated with headaches, sleepiness, and stagnant, stale, stuffy air. Poor concentration, loss of attention, increased heart rate and slight nausea may also be present.
- >5,000 ppm – Exposure may lead to serious oxygen deprivation resulting in permanent brain damage, coma and even death." [11]

[11] Wisconsin Department of Health and Family Services, Division of Public Health. 2005. http://www.dhs.wisconsin.gov/eh/chemFS/pdf/CarbonDioxide.pdf.

Table 2 of the November 11, 2011 quarterly monitoring report lists carbon dioxide concentrations ranging from 532-836 ppm in the elementary school and 379-639 ppm for various locations in the middle school. These are typical levels found in occupied spaces with good air exchange.[12]

Sub-slab Ventilation System Monitoring
The quarterly monitoring report states that the sub-slab ventilation system was inspected by ARCADIS on September 28, 2011, and the two elementary school blowers and the two middle school blowers were operating normally.

ARCADIS collected samples of influent and effluent (before and after the carbon canisters) air at each blower and analyzed for methane, carbon dioxide, oxygen, carbon monoxide, hydrogen sulfide and organic vapors using a GEM2000 Plus and a MiniRae 2000. "The GEM2000 Plus portable LFG analyzer is designed for monitoring LFG extraction systems in cases where carbon monoxide and hydrogen sulfide monitoring capabilities may be necessary."[13] The MiniRae 2000 is a portable PID, as described above in the indoor air monitoring section.

Methane, carbon monoxide, hydrogen sulfide and organic vapors were not detected in any of the ventilation system samples. Carbon dioxide was detected at a concentration of 0.3% to 0.5% (3,000 ppm to 5,000 ppm), which is greater than the RAWP action level of 1,000 ppm (0.1%), for five of the seven samples. The quarterly monitoring report states that the presence of carbon dioxide in soil gas is an indicator of subsurface bacterial activity and does not represent a threat to users of the property. TASC agrees that the high levels of carbon dioxide in soil gas are indicative of bacterial action in the subsurface. TASC's opinion is that carbon dioxide levels may be elevated due to decomposition of waste materials buried on site.

Cap Inspection
The quarterly monitoring report states that ARCADIS conducted a visual survey of the Site on September 28, 2011 for evidence of significant soil cover erosion, or for any areas where the orange snow fencing indicator barrier was visible. The report indicates that ARCADIS did not observe any areas where the orange indicator barrier was visible. There was no discussion in the report of significant soil cover erosion, depressions in the cover, or areas where additional fill was needed.

Ground water Monitoring
The quarterly monitoring report states that new and existing ground water monitoring wells were sampled by ARCADIS on October 3, 2011. The number and location of new wells is not discussed. However, Figure 2 shows four unusable monitoring wells (HP1-2, ATC-2, ATC-3 and ATC-5) and three new monitoring wells (MW-6, MW-7 and MW-8) installed on April 25, 2011, along with two previously existing monitoring wells (ATC-1 and ATC-4). Ground water monitoring results are summarized in Table 3 of the quarterly monitoring report for sampling events occurring between February 2001 and October 2011.

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[12] Wisconsin Department of Health and Family Services, Division of Public Health. 2005. http://www.dhs.wisconsin.gov/ch/chemFS/pdf/CarbonDioxide.pdf
[13] Equipco. http://www.equipcoservices.com/sales/landtec/gem2000_plus.html

For the samples taken in October 2011, chloroform was detected in MW-6 at a concentration equal to the laboratory detection limit of 2.0 µg/L. There is no RI DEM GB Ground Water Objective for chloroform. Trichloroethylene was detected in well ATC-4 at 1.1 µg/L, significantly below the RIDEM GB Ground Water Objective of 540 µg/L. No other target analytes were detected in any of the ground water samples. Laboratory reports are provided in Appendix B of the quarterly monitoring report. Ground water samples were tested for 76 different analytes.

III.B.2 Overview of Other Quarterly Monitoring Reports

This section contains TASC observations from briefly reviewing 18 randomly selected quarterly monitoring reports. Each report was examined for completeness regarding the topics that should be covered. More detailed examinations of different segments of the reports were randomly conducted. These detailed examinations are discussed below for the report topics of soil gas monitoring, indoor air monitoring, sub-slab ventilation system monitoring, cap inspection and ground water monitoring.

Completeness

Early quarterly monitoring reports (calendar years 2000 – 2001) do not document the sampling dates precisely. Also, some of the early reports seem to cover more than one quarterly reporting period. No second quarter reports were found for the calendar years of 2003 and 2005. Only two quarterly reports were found for the calendar year of 2002. These were for monitoring activities completed in February and December. For the past six years (2006 to September 2011), all quarterly monitoring reports are available in the online Site repository. The reports covering the time period of 2006 through 2011 that TASC examined appeared to be complete.

The FYR provides a good summary of quarterly monitoring results from first quarter 2006 through second quarter 2011, with the exception of two reports (second quarter of 2006 and fourth quarter of 2009) that were not available online at the time of the FYR.

Soil Gas Monitoring

A review of the quarterly monitoring reports indicates that the same 38 analytes are included in laboratory testing of soil gas samples for each reporting period. The quarterly monitoring reports reviewed indicate that two soil gas samples are taken and sent to a laboratory for analysis for VOCs. Low concentrations of several different VOCs have been detected in sample results for each quarterly report reviewed. No trend of increasing or decreasing VOC concentrations in soil gas is noted in the quarterly monitoring reports or FYR report. The concentrations of substances detected in the soil gas are compared to Occupational Safety and Health Administration (OSHA) **Permissible Exposure Limits** (PELs) in the quarterly monitoring reports, and no exceedances of OSHA PELs were reported in the quarterly monitoring reports reviewed by TASC.

> The **Permissible Exposure Limit** (PEL) is the maximum airborne concentration of a substance to which a worker may be legally exposed. Most PELs have been defined for substances that are dangerous when inhaled, but some are for substances that are dangerous when absorbed through the skin or eyes.

TASC notes that OSHA PELs may not be appropriate exposure limits for children because PELs are primarily developed to protect adult worker health in the workplace. Also, not all substances have PELs. However, TASC does not have an alternative recommendation.

There are several years of soil gas laboratory analyses. TASC recommends that the City or DEM create a graphical display of laboratory results for each soil gas analyte over time to evaluate any decreasing or increasing trends.

Indoor Air Monitoring

The earliest quarterly monitoring report (June 7, 2000) and the March 20, 2001 quarterly monitoring report both state that continuous monitors for methane were installed in the elementary school and that direct read instruments were used in the middle school to test for carbon monoxide, hydrogen sulfide and methane. More recent quarterly monitoring reports indicate that continuous methane monitors are installed at both schools.

Direct monitoring for oxygen, carbon dioxide, methane, carbon monoxide, hydrogen sulfide and organic vapors is done quarterly. Carbon monoxide and carbon dioxide were sometimes detected above RAWP action levels. The list below gives examples of indoor air monitoring results that were above RAWP action levels:

April 7, 2003	Carbon monoxide is above the RAWP action level of 9 ppm for some locations, but still within the range reported as normal for indoor air.
May 18, 2006	Carbon dioxide was detected at 0.2% at one location.
June 30, 2010	All readings were below the RAWP action levels except for four carbon dioxide readings in the Middle School.
March 22, 2011	Two carbon dioxide readings were above the RAWP action level of 1000 ppm.

Hydrogen sulfide was reported in indoor air as being below the RAWP action level in some quarterly monitoring reports, when in fact, the levels were above the RAWP action level. The indoor air RAWP action level for hydrogen sulfide is erroneously reported as 10 ppm in the quarterly monitoring reports reviewed by TASC. The actual indoor air RAWP action level is 5 ppm. Some examples of hydrogen sulfide concentrations measured in indoor air are listed below:

February 17, 2003	Hydrogen sulfide measurements varied from 0 to 7 ppm.
April 7, 2003	Hydrogen sulfide measurements varied from 0 to 3 ppm.
March 30, 2004	Hydrogen sulfide measurements varied from 0 to 1 ppm.
May 18, 2006	Hydrogen sulfide measurements varied from 2 to 3 ppm.
December 23, 2008	Hydrogen sulfide measurements varied from 2 to 7 ppm.

In addition to making sure that future quarterly monitoring reports use the correct indoor air RAWP action level for hydrogen sulfide, TASC also recommends that the action level for hydrogen sulfide in indoor air be lowered to no more than 2 ppm – the concentration that the World Health Organization reports as causing bronchial constriction in asthmatic individuals.

Sub-slab Ventilation System Monitoring

TASC's review of quarterly monitoring reports indicates that sub-slab ventilation system monitoring is occurring regularly. Screening for methane, carbon dioxide, oxygen, carbon monoxide, hydrogen sulfide and organic vapors was typically completed for 29 different

monitoring locations each quarter according to the reports that TASC reviewed. In examining a few quarterly monitoring reports, TASC notes that soil gas was screened in all 29 locations in July 2003, August 2007, February 2009, August 2010 and June 2011.

The April 10, 2002 quarterly monitoring report indicates that soil gas was tested at 27 locations with portable equipment for methane, carbon dioxide, oxygen, carbon monoxide, hydrogen sulfide and organic vapors. One of the monitoring wells was reported as destroyed (WB-5). No methane or carbon monoxide were detected. Less than 1 ppm of VOCs was detected at any location. Hydrogen sulfide was detected in every location at concentrations ranging from 0.2 to 2 ppm. Carbon dioxide was detected at every location at the RAWP action level of 1,000 ppm (0.1%) or higher.

There are several years of soil gas field monitoring results. TASC recommends the City or RI DEM create a graphical display of laboratory results for each of the six gases measured over time at each location to evaluate any decreasing or increasing trends.

Continuous operation of all the blowers for the sub-slab ventilation system is important to prevent migration of soil gas into the elementary and middle school buildings. In the reports examined by TASC, the problem of blowers not operating is reported in several different years from 2002 to 2011. Examples of blowers reported as not operating are listed below:

April 10, 2002	Blower located on western portion of middle school was not operating
November 15, 2005	Front shed middle school blower was not operating because the moisture knockout tank was full
March 18, 2009	Front middle school blower was not operating
September 16, 2010	Front middle school blower was off due to water in the knockout tank. Back middle school blower was not operating due to repairs to the carbon canister
March 22, 2011	The blower in the front shed was not operating because the knockout tank had filled with water, then the water froze in the tank.

Because the problem seems to be consistent over several years, TASC recommends that the sub-slab ventilation system be examined by a qualified engineer and appropriate equipment changes be made to solve the problem of frequent shutdown of the ventilation system blowers due to water accumulation in the knockout tanks (i.e., moisture separator tanks). Equipment changes could include adding a high water alarm in the knockout tanks or resizing the knockout tanks.

Cap Inspection

The quarterly monitoring reports examined by TASC indicate frequent need to fix pavement or add soil cover to repair the cap due to settling and erosion. Some examples of quarterly monitoring report findings are listed below:

October 30, 2003	No orange snow fencing indicator barrier observed; several areas identified as needing repair
September 21, 2007	No orange snow fencing indicator barrier observed; several areas identified as having been repaired
March 18, 2009	No orange snow fencing indicator barrier observed; previously identified areas were repaired; one hole identified as needing repair
September 16, 2010	No orange snow fencing indicator barrier observed; some small holes adjacent to the Middle School foundation identified as needing repair
July 29, 2011	No orange snow fencing indicator barrier observed; some holes identified as having been repaired

Quarterly reports indicate that the orange snow fencing indicator barrier is usually not visible during cap inspections, but holes frequently are found and filled to maintain the cap. TASC recommends a more frequent cap inspection/repair program.

Ground water Monitoring

Quarterly monitoring reports examined by TASC indicate that there are supposed to be five ground water monitoring wells on the Site, which are sampled quarterly. The more recent quarterly monitoring reports provide a summary of quarterly ground water test results beginning in 2001 to the date of the most recent sampling event. A cursory look at the most recent summary table does not suggest any trend towards increasing concentrations of specific contaminants in the ground water.

An early report, the April 10, 2002 quarterly monitoring report, states that five ground water monitoring wells were installed in December 2000 and these were sampled. Some of the earlier quarterly monitoring reports do not include the laboratory test results and only report summary data. For example, the reports dated March 20, 2001 and October 30, 2003 were examined by TASC and do not contain any laboratory reports.

Apparently, ground water monitoring wells are sometimes inaccessible. The March 18, 2009 quarterly monitoring report indicates that two ground water monitoring wells were inaccessible due to ice and snow on the date of sampling.

In the reports examined by TASC, the lists of analytes in the laboratory results for ground water samples somewhat consistent, with the number of analytes in the laboratory reports surveyed ranging from 68 to 80. No explanations were found for why the lists of analytes are not exactly the same for every sampling event.

IV. Site Visit

On December 23, 2011, Kirby Webster of Skeo Solutions and Steve Fischbach of Rhode Island Legal Aid toured the Site.[14] They walked the grounds surrounding both the middle school and elementary school. Both Ms. Webster and Mr. Fischbach met with Ms. Mari-Ellen Boisclair, principal of the elementary school, who showed them areas of interest at the school related to the FYR including: cracks in the floors, the large depression in the back parking lot, the vapor mitigation shed, the raised bed garden containing brought-in soil, methane detectors in the school

[14] Appendix A in this document contains photos from this site visit.

and the methane detector display panel in the front office. Ms. Webster and Mr. Fischbach were shown through the middle school by a custodial staff member. Related to the FYR, they viewed the methane detector display panel in the custodian office and the vapor mitigation shed in the front of the school toward Springfield Street. The vapor mitigation system was not operating at the time of the visit and the custodial staff member appeared unaware that the system was not operating. Ms. Webster and Mr. Fischbach had Site concerns similar to those identified in the FYR including:

- Cavities within the cap:
    - In the courtyard area at the northern end of the middle school along the foundation.
    - Near the electrical transformers behind the middle school and along the foundation behind the middle school.
- Pooling water:
    - In several locations behind the middle school in the "playing fields."
    - Near Springfield Street in the grassy area between the two schools.
    - In the parking lot behind the elementary school.
- Monitoring wells appeared to be locked, but none appeared to be labeled.
- One of the blowers in the front of the middle school was not operating.

Despite these concerns, no odors were observed within either school and methane detectors appeared to be in working condition based on appearance and readings observed in both the elementary school (in the front office) and the middle school (in the custodian office).

If not already occurring, TASC recommends that custodial staff and other appropriate school employees receive annual hazard recognition training with respect to Site conditions and sub-slab ventilation system operation from a qualified instructor.

V. Summary of 2011 FYR

This section of the report summarizes the 2011 FYR.

Section 1: Objective

This section describes that Fuss & O'Neill, Inc. was retained by RI DEM to assist in performing a FYR of the remedial action implemented at the Anthony Carnevale Elementary School and Del Sesto Middle School. The section explains that the FYR was performed in accordance with the *Second Assented to Supplemental Order*.

Section 2: Background

This section describes: the Site and physical setting; previous environmental investigations, remedial actions and the remedial design investigation; operations and monitoring requirements; and results of the previous FYR.

Site Description and Physical Setting

The Site is located on the west side of Springfield Street and the south side of Hartford Avenue in a residentially zoned section of the City of Providence, Rhode Island. The nearest surface water body, the Woonasquatucket River, is located approximately 2,000 feet northeast of the Site. The Woonasquatucket River is classified by RI DEM as Class B1. A Class B1 river is

designated for fish and wildlife habitat and primary and secondary contact recreational activities. The ground water beneath the Site is classified by RI DEM as GB. GB ground water is not suitable for public or private drinking water use. GB ground water areas are typically located beneath highly urbanized areas, permanent waste disposal areas and/or areas immediately surrounding permanent waste disposal areas.

Previous Environmental Investigations, Remedial Actions, and Remedial Design Investigation
A Phase I Environmental Site Assessment of the Site was completed in March of 1999 showing that the Site was historically utilized as a municipal landfill from the mid-1960s until the mid-1970s. A Site Investigation Report and Site Investigation Report Addendum submitted in March and April 1999 documented the results of geophysical surveys, test pit excavations, and soil, ground water, and soil vapor sampling. A RAWP was submitted in April of 1999 describing a proposed remedial plan including:

- Excavation and off-site disposal of buried solid waste from the proposed building locations.
- Construction of an engineered cap.
- Placement of an orange snow fence at the interface of the cap and the existing ground surface to serve as a visible demarcation barrier.
- Recording of an Environmental Land Usage Restriction (ELUR) with the property deeds for the Site.
- Installation of sub-slab ventilation systems within both of the school buildings.
- Installation of interior methane sensors at multiple locations throughout both of the school buildings.

Operations and Monitoring Requirements
The April 1999 RAWP included a Long-Term O&M Plan which described monitoring and maintenance requirements for the engineered controls at the Site, as well as soil vapor and ground water sampling activities included as part of the long-term monitoring program. In accordance with the O&M Plan, the monitoring program is to be executed on a quarterly basis for a period of at least 20 years following the construction of the schools.

Results of Previous FYR
The previous FYR was conducted in 2006 and documented in a report entitled *Field Inspection Report*. The report discussed an inspection performed at the Site by personnel from the RI DEM Office of Waste Management on September 27, 2006. The report documented observations and deficiencies at the Site.

Section 3: 2011 FYR
Section 3 describes public notification activities and public comments received, results of past monitoring activities from 2006-2011, the Site inspection, and interviews with school maintenance personnel, school medical staff and the City of Providence's environmental monitoring consultant, Arcadis personnel.

Public Notification Activities

Public notices were distributed in June 2011 providing notice and a description of the current FYR. Public notification flyers were distributed to principal of both schools for distribution to students, teachers, and staff as well as a list of recipients identified in the FYR. Flyers were distributed in English and Spanish.

Upon distribution of public notices, RI DEM received comments from two individuals. Comments as well as responses to the comments are included in Section 3.1.2 of the FYR.

Results of Past Monitoring Activities: 2006-2011

Reports detailing the results of 20 quarterly monitoring events were reviewed as part of the FYR. The FYR describes activities including soil vapor sample collection, field screening and samples collected from each of the ventilation system legs, which were conducted during each sampling event.

Frequent and isolated contaminant standard exceedances are also discussed within this section. Carbon dioxide was the only constituent consistently detected during sampling at concentrations exceeding the applicable numeric threshold documented in the O&M Plan. Less frequent standard exceedances for other constituents were observed in quarterly monitoring reports including those for hydrogen sulfide, methane and carbon monoxide. Specific instances, activities surrounding the instances and supplemental field screening, if occurred, are discussed in the FYR.

Ground water sampling occurring during the quarterly monitoring activities is also discussed in this section. Results of ground water monitoring activities for the majority of the quarterly monitoring events indicated that one or more VOCs were detected in at least one ground water sample at concentrations exceeding laboratory reporting limits. Requirements for laboratory reporting limits are not discussed in the FYR. No detections of VOCs at concentrations exceeding the RI DEM GB Ground Water Objectives were reported for any of the ground water samples documented in any of the quarterly reports. However, not all substances detected have a GB Ground Water Objective.

Monitoring activities of the engineered cap were discussed. A number of deficiencies reported throughout the five-year time period were discussed. Visual observations of the orange snow fence demarcation barrier were not reported during any of the 20 quarterly monitoring events reviewed.

During each monitoring event, the blowers, which power the sub-slab ventilations systems, were inspected to evaluate their operating condition. One or more blowers were found to be inoperable during six monitoring events due to high water levels in the moisture separator tanks. In addition to interruptions in system operation due to water accumulation, four incidents were reported that impacted operation of the sub-slab ventilation systems. Each of these incidents was caused by either carbon dust emissions from the carbon canister or blower motors in need of repair or replacement. Additionally, four incidents involving operation of the methane sensors installed in the schools were also observed during the monitoring period. Methane sensors were recalibrated and/or faulty equipment was replaced in each case.

Site Inspection
A Site inspection was conducted on October 31, 2011. The Site grounds, portions of the interior ground levels of the school buildings, and the three sub-slab ventilation blower sheds at the Site were visually observed. Photographs taken during the inspection are included in Appendix C of RI DEM's draft FYR.

Specific concerns on the current conditions of the Site grounds and building interiors were noted in this section.

Interviews
Interviews were conducted with school maintenance personnel, City of Providence's monitoring consultants and school medical staff. Interviewees discussed their responsibilities, concerns and experiences over the past five years, and any observations that they have made pertaining to the maintenance of the grounds or the quarterly monitoring.

In one interview, a maintenance personnel at the middle school "observed a complete hole in the cap near the back of the middle school building which resulted in exposure of the orange snow fence at the base of the cap." Because this occurrence was not dated, TASC was unable to determine if it was reported appropriately.

Section 4: Conclusions and Recommendations
This section includes information on compliance with operations and monitoring requirements and effectiveness of remedial actions.

Compliance with Operations and Monitoring Requirements
Fuss & O'Neil identified the following issues of non-compliance with the operations and monitoring requirements:

- An incorrect, too high, threshold for hydrogen sulfide was used in the quarterly monitoring report reviewed for the FYR. The threshold for hydrogen sulfide in indoor air document in the O&M Plan is 5 ppm, however the threshold reported in the quarterly monitoring reports is 10 ppm. This resulted in exceedances at two locations detected, but not reported during one of the 20 monitoring events. Because the incorrect threshold was being used, exceedances were not specifically discussed in the corresponding quarterly report.
- There is a lack of laboratory analysis for LFGs in the monitoring reports. The monitoring reports indicated that soil vapor samples were submitted to the laboratory only for analysis of VOCs and analyzed for LFGs in the field with a portable field instrument. The O&M Plan indicates that two samples collected from soil vapor monitoring wells will be analyzed at a laboratory for VOCs and LFGs, however, the report explains that use of portable field screening instruments to evaluate concentrations of LFGs is a commonly-used and widely-accepted industry practice and is not anticipated to significantly affect the reliability of the resulting data.
- Some soil vapor monitoring wells were damaged and not sampled. The most recent monitoring reports indicate that soil vapor monitoring wells WB-5 and WB-7 have been destroyed.
- There was not an appropriate response to threshold exceedances for carbon dioxide. Carbon dioxide was detected in one or more samples at concentrations exceeding the threshold

during each of the 20 monitoring events. No indication of specified response actions for these exceedances was observed in the documentation reviewed as part of the FYR.

The report describes that these non-conformance issues have not significantly diminished the effectiveness of the overall monitoring program at evaluating performance of the remedial actions nor have they resulted in significantly increased risk posed to Site users.

Effectiveness of Remedial Actions

Soil Cap

The FYR revealed cavities that regularly develop within the thickness of the soil cap as a result of decomposition and shifting of underlying solid waste and soil. On one known occasion, this caused a complete hole in the cap and the orange snow fence present at the base of the cap was exposed, as reported in an interview with a maintenance personnel.

Fuss & O'Neill recommended increased frequency of grounds inspections (every two weeks instead of every four to six weeks) and that observed cavities should be repaired by filling and thoroughly compacting as soon as cavities are observed.

Indoor Air

Fuss & O'Neill recommended that the heating, ventilation and air conditioning (HVAC) systems for the schools be checked regularly and maintained so that the systems are effectively balanced to ensure optimum indoor air quality, including carbon dioxide levels that are appropriate for occupied buildings.

Sub-Slab Ventilation Systems

Fuss & O'Neil stated that confirmation of a measurable vacuum in the subsurface environment throughout the Site would demonstrate that vacuum conditions exist beneath the buildings and would support a definitive conclusion that the systems are effectively preventing migration of subsurface vapors into indoor air. Therefore, regardless of the concentrations of constituents in subsurface soil vapor at the Site, risk posed to building occupants by intrusion of subsurface vapors would be mitigated.

Fuss & O'Neil stated that regular confirmation that the blowers powering the sub-slab ventilation are operating appropriately is paramount to ensuring the effectiveness of the ventilation systems. Fuss & O'Neill recommended that more frequent inspections of the operative condition of the blowers be required and /or the ventilations systems be adjusted to reduce the recurrence of shut downs due to high water levels in the moisture separator tanks. Alternatively, mechanical controls could be implemented to notify maintenance personnel of interruptions in operations. If any blower is found to be inoperative for any reason, effort should be made to restore operation of the blower as quickly as possible.

VI. TASC Summary and Recommendations

Landfill settling and potential for LFG infiltration into the school buildings will be an ongoing problems at this Site for many years. The soil cap and sub-slab ventilation system will continue

to require diligent monitoring and maintenance to protect children and adults from exposure to harmful substances.

TASC agrees with the recommendations in the FYR report. These recommendations include:

- Inspection of the soil cap every two weeks and repair of observed cavities by filling and thorough compaction of fill soil immediately.
- Regular inspections and maintenance of the HVAC systems for the schools to ensure optimum indoor air quality, including carbon dioxide levels.
- Confirmation of a measurable vacuum in the subsurface environment throughout the Site to support a definitive conclusion that the systems are effectively preventing migration of subsurface vapors into indoor air.
- Actions to reduce the recurrence of sub-slab ventilation system shutdowns. These actions could include more frequent inspections, adjustments to the ventilation system, resized equipment, mechanical controls or alarms.

TASC also recommends:

- That an updated evaluation of the potential for releases of LFG into nearby residences be conducted.
- Review of whether sulfur-containing substances (carbon disulfide and methyl mercaptans) should be added to quarterly laboratory analyses, as these are common LFGs. There is no record that these gases have ever been included in laboratory analyses of soil gases from the Site. Also, review if laboratory analyses should include the other 6 common LFGs listed and discussed on page 11.
- That quarterly laboratory analyses of soil gas samples include hydrogen sulfide.
- That future quarterly monitoring reports state whether or not the specific VOCs detected by laboratory analysis in previous soil gas samples are also detectable by the PID used for field screening of soil gas and indoor air.
- That future quarterly monitoring reports be revised to reflect the actual indoor air RAWP action levels for methane (500 ppm) and hydrogen sulfide (currently 5 ppm), and appropriate actions to be taken if the specified RAWP action level is exceeded.
- That the City or DEM create a graphical display of laboratory results for each soil gas analyte over time to evaluate any decreasing or increasing trends.
- That the RAWP action level for hydrogen sulfide in indoor air be lowered to no more than 2 ppm – the concentration that the World Health Organization reports as causing bronchial constriction in asthmatic individuals.
- That the City or DEM create a graphical display of laboratory results for each of the six gases measured over time at each location to evaluate any decreasing or increasing trends.
- Because the problem seems to be consistent over several years, TASC recommends that the sub-slab ventilation system be examined by a qualified engineer and appropriate equipment changes be made to solve the problem of frequent shutdown of the ventilation system blowers due to water accumulation in the knockout tanks (i.e., moisture separator tanks). Equipment changes could include adding a high water alarm in the knockout tanks or resizing the knockout tanks.

- If not already occurring, that custodial staff and other appropriate school employees receive annual hazard recognition training with respect to Site conditions and sub-slab ventilation system operation from a qualified instructor.
- That a review of RI DEM reporting requirements be given to appropriate school personnel. [In the section discussing maintenance personnel interviews, a maintenance personnel at the middle school "observed a complete hole in the cap near the back of the middle school building which resulted in exposure of the orange snow fence at the base of the cap." Because this occurrence was not dated, TASC was unable to determine if it was reported appropriately.]

With regard to improving the FYR report, TASC recommends:

- Specifically listing the questions required to be answered in terms of the statement of protectiveness and addressing each of these questions:
    - *Is the remedy still functioning as designed?*
    - *Is there any reason to believe that exposure assumptions, toxicity data and remedial objectives used at time of remedy selection are not still valid?*
    - *Has any new information come to light that may impact the protectiveness of the remedy?*
- Adding a discussion of the terms and current status of the Environmental Land Usage Restriction.
- Presenting monitoring data quantitatively in the FYR report. Tabulated data can be included in an appendix.
- Reviewing and discussing the validity of 1999 RAWP action levels for indoor air and soil gas screening identified in the O&M Plan.

<u>Additional Community Concerns</u>

TASC was asked to address the following concerns expressed by community members:

1. *Is it possible that contaminants in the subsurface are moving into the soil cap?*

TASC response: This is a reoccurring community concern because of probable direct contact of children with the surface soils. Movement of contaminants in the environment depends on the characteristics of the specific contaminants, as well as the characteristics of the soil, rocks and ground water in the subsurface. It is conceivable that certain contaminants may move in an upward direction if present in soil pore water or as gases. Solid contaminants are not likely to move upward into the clean soil cap. Although it seems unlikely that contaminants are moving upward into the clean soil cap, this concern could be alleviated by testing a few surface soil samples for chemicals of concern.

2. *Is it possible that contaminated ground water is interacting with areas of standing surface water frequently found on the Site between the two school buildings (see photo #5)?*

TASC response: This is an area of community concern because of probable direct contact of children with standing surface waters. It is unlikely that ground water is causing contamination of surface water by interacting with the surface water or by ground water coming to the surface. However, after large rain events under certain conditions, ground water can be forced to the surface. We do not know if this is happening at this Site. This community concern could be

alleviated by taking a grab sample of the standing surface water in the area between the two school buildings and testing the water for contaminants of concern.

3. *Is the weight of the buildings causing soil compression to the extent that it is causing an effect on the ground water in the perched aquifer on the Site?*

TASC response: While the weight of the building will cause some soil compression, it is unlikely that the weight of the building is affecting the perched aquifer.

4. Is tree death caused by the contaminants on the Site?

TASC response: This question is discussed in Section 3.1.2 of the FYR as a response to a public comment where maintenance personnel stated they believed that the incidents of dead plants may have been due to the lack of an irrigation system at the Site and insufficient watering. While TASC does not know the specific cause of the death of the trees on Site, it is unlikely that it is caused by interaction with the contaminants and more likely another cause such as lack of water or too much water.

5. Can cracks in the school foundation disturb the vacuum on the vapor mitigation system?

TASC response: It is unlikely that cracks in the foundation will impact the vacuum pressure of the vapor mitigation systems, as they are not gaping holes and likely are not entirely through the foundation material. As recommended in the FYR, confirmation of a measureable vacuum in the subsurface environment throughout Site would support a definitive conclusion that the systems are effectively preventing migration of subsurface vapors into indoor air and that cracks in the foundation are not disturbing the vacuum seal.

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Appendix A: Site Visit Photographs

#1: Cavity behind a bush along the foundation in the courtyard area of the middle school.

#2: Water pooled behind the middle school.

#3: Cavities around the electrical transformers behind the middle school.

#4: Cavity behind the middle school.

#5: Pooled water between the schools.

#6: Monitoring well behind the elementary school.

#7: Pooled water in the parking lot behind the elementary school.