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The legacy of urbanization: historical land use and its impact on current health hazards at a community garden in Charlestown, Massachusetts

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Boston University
THE LEGACY OF URBANIZATION: HISTORICAL LAND USE AND ITS IMPACT ON CURRENT HEALTH HAZARDS AT A COMMUNITY GARDEN IN CHARLESTOWN, MASSACHUSETTS

by

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THE LEGACY OF URBANIZATION: HISTORICAL LAND USE AND ITS IMPACT ON CURRENT HEALTH HAZARDS AT A COMMUNITY GARDEN IN CHARLESTOWN, MASSACHUSETTS

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Abstract

Introduction: The Charlestown Sprouts Community Garden, one of Boston’s largest community gardens, comprises 105 plots—all producing food—located in the historic neighborhood of Charlestown. It serves mainly minority and recent immigrant member households who rely on the land as a source of fresh produce. To ensure the safety of food production at the garden, the coordinators sought assistance from the Department of Environmental Health at the Boston University School of Public Health (BUSPH) to: 1. conduct a historical survey identifying past land uses, 2. characterize potential contaminant exposures to gardeners, and 3. furnish health-protective recommendations to minimize gardener hazard exposures. In the process of meeting these aims, broader dimensions of food production in the urban environment emerged from the literature: soil safety for urban agriculture, environmental justice, food security, determining “safe”
levels of contaminants in urban soil, and the expansive policy implications that these issues engendered. For the work presented in this thesis project, the scope of interrelated topics were refined and lend contextual structure for a semi-quantitative characterization of human health risk from potential soil lead (Pb) exposures. This was accomplished by employing probabilistic modeling with the USEPA's Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) (2010).

Under specified assumptions of multimedia Pb exposures, the model predicts a theoretical young child’s probability of his or her lead blood concentration’s (PbB) exceeding a PbB cutoff. For this analysis, the recently promulgated CDC reference value of 5 μg/dL was used as a cutoff in addition to the model default of 10 μg/dL. The IEUBK was also employed to approximate a range of soil Pb concentrations that could be considered “acceptable,” based on a health-protective approach; that is, to estimate a soil Pb concentration that would not significantly contribute to the exceedance of PbB > 5 μg/dL as a result of exposures to lead in soil. In this evaluation, an acceptable soil Pb concentration is defined as a mean soil Pb concentration that is determined by consideration of minimizing human health risk and maximizing practicability of the means to achieve the soil criterion—a level that could be reasonably achieved and be safe for urban agriculture.

**Methods:** Research for the historical survey included, but was not limited to, consulting historical fire insurance maps, archived municipal and county records, environmental databases, geographic information systems (GIS), and gathering accounts from local
community members, historical societies, and multiple Boston city agencies to build a historical narrative about the garden land and the adjacent properties.

For the IEUBK model runs, multimedia exposure parameter values from Boston environmental data (air, water, and soil) were used as inputs for the IEUBK modeling runs in the absence of suitable site-specific data. Comparison runs were executed with soil Pb concentration data from compost sourced from the City of Boston Department of Public Works Leaf and Yard Waste composting program and from Boston-area private compost facilities.

**Results and Conclusions:** The garden was established at a site with a varied history of land uses from rail yard, to salt plant, to unknown activities. Community-member accounts, corroborated by photointerpretation data, suggest that the site was possibly an dumping grounds in the 1970’s-80’s. Based on the findings of the survey, it is likely that a number of potential contaminants exist at the garden, including lead, arsenic and/or polyaromatic hydrocarbons (PAHs). Based on visual inspection, point-source contamination of the soil is likely to be occurring at the garden, stemming from the treated rail ties that compose a majority of the garden plot constructions and of the plots inspected, the timbers appeared to be CCA-treated wood. The accumulation of site-specific knowledge gained through historical research, (GIS), and anecdotal evidence aided in determining what historical hazards were likely to pose a current risk to gardeners through gardening activities.
The IEUBK model predicted a geometric mean blood value of 2.73 μg/dL with an associated risk of a young child’s PbB exceeding 5 ug/dL as 9.9% using default parameter values. In comparison, to achieve a goal of less than 5% risk, the IEUBK modeling indicated that soil Pb would have to be less than 153 mg/kg.

Under the guidance of BUSPH faculty, the findings and consequent recommendations, differing in remediation technique and resource-intensiveness, were summarized in a document for the garden steering committee’s development of imminent renovation plans.
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<tr>
<td>ASTSWMO</td>
<td>The Association of State and Tribal Solid Waste Management Officials</td>
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<td>ACS</td>
<td>American Community Survey</td>
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<tr>
<td>ATSDR</td>
<td>Agency for Toxic Substances and Disease Registry, Division of Health and Human Services</td>
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<tr>
<td>AUL</td>
<td>Site Activity &amp; Use Limitations (AULs)</td>
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<tr>
<td>B&amp;L</td>
<td>Boston and Lowell Railroad</td>
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<tr>
<td>B&amp;M</td>
<td>Boston and Maine Railroad</td>
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<tr>
<td>BLL</td>
<td>Blood Lead Level</td>
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<td>BNAN</td>
<td>Boston Natural Areas Network</td>
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<td>BPHC</td>
<td>Boston Public Health Commission</td>
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<tr>
<td>BPL</td>
<td>Boston Natural Areas Network</td>
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<td>BRA</td>
<td>Boston Redevelopment Authority</td>
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<td>BUSPH</td>
<td>Boston University School of Public Health</td>
</tr>
<tr>
<td>CCA</td>
<td>Chromated Copper Arsenate</td>
</tr>
<tr>
<td>CDC</td>
<td>Centers for Disease Control</td>
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<tr>
<td>CHS</td>
<td>Charlestown Historical Society</td>
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<tr>
<td>CLPPP</td>
<td>Childhood Lead Poisoning Prevention Program</td>
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<tr>
<td>COB</td>
<td>City of Boston</td>
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<tr>
<td>Acronym</td>
<td>Full Form</td>
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<tr>
<td>Deeds</td>
<td>Suffolk County Deeds</td>
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<tr>
<td>DEP</td>
<td>Department of Environmental Protection</td>
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<tr>
<td>DND</td>
<td>City of Boston Department of Neighborhood Development</td>
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<tr>
<td>DPW</td>
<td>City of Boston Department of Public Works</td>
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<tr>
<td>EBLL</td>
<td>Elevated Blood Lead level</td>
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<td>EJ</td>
<td>Environmental Justice</td>
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<tr>
<td>GMB</td>
<td>Geometric Mean Blood</td>
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<tr>
<td>GSD</td>
<td>Geometric Standard Deviation</td>
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<tr>
<td>HOB</td>
<td>Health of Boston</td>
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<tr>
<td>IEUBK</td>
<td>Integrated Exposure and Uptake Biokinetic Model</td>
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<tr>
<td>ICP-AES</td>
<td>Inductively coupled plasma atomic emission spectroscopy</td>
</tr>
<tr>
<td>ISD</td>
<td>City of Boston Department of Inspectional Services</td>
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<tr>
<td>IVBA</td>
<td>In Vitro Bioaccessibility</td>
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<tr>
<td>MADPH</td>
<td>Massachusetts Department of Public Health</td>
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<td>MassDEP</td>
<td>Massachusetts Department of Environmental Protection</td>
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<td>MassDOT</td>
<td>Massachusetts Department of Transportation</td>
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<tr>
<td>MassGIS</td>
<td>Massachusetts Geographical Information System</td>
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<td>MassHEIS</td>
<td>Massachusetts Health and Environment Information System</td>
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<td>MCP</td>
<td>Massachusetts Contingency Plan</td>
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<td>MIT</td>
<td>Massachusetts Institute of Technology</td>
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<tr>
<td>MOA</td>
<td>Mode of Action</td>
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<td>MRC</td>
<td>Mystic River Corporation</td>
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<td>MWRA</td>
<td>Massachusetts Water Resources Authority</td>
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<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>NHANES</td>
<td>National Health and Nutrition Examination Survey</td>
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<td>NTP</td>
<td>National Toxicology Program</td>
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<td>PAHs</td>
<td>Polycyclic Aromatic Hydrocarbons</td>
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<td>Pb</td>
<td>Chemical Symbol for Lead</td>
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<td>PbB</td>
<td>Lead Blood</td>
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<td>PCB</td>
<td>Polychlorinated Biphenyl</td>
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<td>PFC</td>
<td>Public Facilities Commission</td>
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<td>R-55</td>
<td>BRA Urban Renewal Plan for Charlestown</td>
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<td>RAM</td>
<td>Release Abatement Measure</td>
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<td>Schools</td>
<td>City of Boston Department of Schools</td>
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<td>SSL</td>
<td>Soil Screening Level</td>
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<td>TRW</td>
<td>Technical Review Workgroup of the United States Environmental Protection Agency</td>
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<tr>
<td>UARI</td>
<td>Urban Agriculture Rezoning Initiative</td>
</tr>
<tr>
<td>UMASS</td>
<td>University of Massachusetts Extension Soil and Plant Tissue Testing</td>
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<tr>
<td>USEPA</td>
<td>United States Environmental Protection Agency</td>
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<tr>
<td>USGS</td>
<td>United States Geological Survey</td>
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<tr>
<td>WPA</td>
<td>Waterfront Protection Act</td>
</tr>
<tr>
<td>WTTC</td>
<td>Wind Turbine Testing Center of Charlestown</td>
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<td>XRF</td>
<td>X-ray Fluorescence</td>
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Introduction

Currently, Boston is home to hundreds of community gardens, with some deeded lots held in perpetuity (BNAN, 2012) but urban agriculture has not yet been secured zoning within the City. In Boston, in addition to various non-governmental groups, urban agriculture has direct support from the Mayor Thomas Menino’s Urban Agriculture Initiative whose objectives include increasing access to affordable and healthy food, promotion of economic opportunity and greater self-sufficiency for people in need, and increasing education and knowledge about healthy eating and food production” (BRA, 2012).

Urban Agriculture is used in this work to mean, quite simply, activities associated with the growing of food in an urban environment. Generally, this may encompass the raising of livestock, but animal husbandry will not be addressed here (in part because this is not currently legal in Boston due to local zoning laws). Community gardening can be viewed as a relational term since some of its activities can include the growing of food, but is not restricted to that activity alone, nor to urban environments. Indeed, there are community gardens in suburban and rural (and agricultural) areas on sanctioned and unsanctioned land that are used for varying purposes e.g., horticulture, beekeeping, which are guided by community needs and local regulations such as zoning.

Strictly speaking, it could be viewed as more appropriate to recategorize activities that take place in an urban community garden under the umbrella of “urban horticulture.” However, since the term urban agriculture is in currency today, it will be used in this work.
with the functional definition stated above, and the terms urban agriculture and community gardening will be used interchangeably throughout this text.

The Boston Redevelopment Authority’s (BRA) Urban Agriculture Rezoning Initiative (UARI) is one of several city initiatives supporting the growth of urban agriculture in Boston. The UARI views urban agriculture as governing activities of potential commercial scale of food production (BRA, 2012a), and can include the sale of its products to others. In contrast, a community garden serves to benefit, precisely as its name suggests, the community or group of individuals who grow and harvest food for personal consumption.

Benefits of urban agriculture

At a community meeting held by the BRA earlier this year to kick off the UARI, attendees were asked to break into small visioning groups to discuss and share how they thought urban agriculture impacted them (transcripts of public comment are available online through the BRA website). In summary, these themes were often stated by many of the groups (BRA, 2012a; personal notes): 1) positive health influence, 2) community building, 3) environmental sustainability, 4) crime prevention, and 5) neighborhood improvement.

From a review of the published literature, it is apparent that there is a body of scholarly work that substantiates the holding of the attendees’ perceptions above. Draper and Freedman (2010) performed a comprehensive review and analysis of existing peer-reviewed and scholarly studies and found this to be true. Litt, et al (2011) cite greater consumption of produce among community gardeners than home gardeners; Morris, et al (2002) found that a nutrition curriculum enhanced by hands-on gardening activities yielded a significant increase in food awareness, and subsequent healthful food
choices among fourth graders who participated in the program and those who did not; Been and Voicu (2006) reported that opening a community garden has a significant positive impact on neighboring property values and that the greatest impact is in the most economically disadvantaged neighborhoods.

**Brownfield Sites—Reclamation of Land**

Urban agriculture by way of community gardening is not a new phenomenon. Boston’s Fenway Victory Gardens was established 70 years ago. It is the only remaining Victory Garden in America (“Fenway Victory Gardens: Our History,” n.d.)—a vestige of the Roosevelt administration’s efforts to increase food production during World War II. Since then, the urban and human ecologies of community gardening have transformed. Today, where un- or under-developed land in cities is scarce, especially in the Northeast (Pagano & Bowman, 2000) potential community garden sites range from “former auto-manufacturing sites, industrial complexes, and whole neighborhoods, down to small individual lots, including commercial and residential areas” (USEPA, 2011).

The various historical land uses of the vacant lots that now host community gardens could have left a legacy of contamination. The reclaiming of potentially contaminated vacant land, or brownfield site, for productive purposes can be subject to state cleanup laws and standards, based on intended reuse type of the land. Of the different land use types, i.e., commercial and industrial, residential reuse cleanup is scrutinized most stringently due to the assumptions regarding the potential exposures incidental to residential activity. However, neither urban agriculture nor community gardening is categorized for these cleanup laws and standards.
Importance of the Project

In May of 2012, BUSPH was contacted by the garden coordinators of Charlestown Sprouts Community Garden, herein referred to as "the Site" to conduct a historical survey of the land occupied by the garden for the purpose of characterizing the soil and for identifying potential contaminants and hazards present in the garden’s soil. The results of the survey would facilitate the focus for creating a soil sampling plan for the garden and to develop best practices recommendations tailored for the garden’s membership.

This thesis project was born out of ongoing work for the garden, and the process and results of the historical survey with accompanying public health based recommendations are presented here as a case study. The significance of a historical survey helps hone the potential contaminants for further examination based on historical land use of a site and to assess the risk to human health these chemicals would pose from potential exposures to them.

Work from this project seeks to advance the development of a risk assessment framework for urban agriculture in the U.S., which should include the articulation of risk-based soil contaminant concentrations for urban agriculture, especially for contaminants most likely to be of highest concern, and guidance for soil sampling and analysis.

Exposure Risk to Populations

Despite the multiple benefits of community gardening, there are underlying potential risks to human health that must be addressed, given that many urban community gardens are built on abandoned lots of which their past uses are uncertain. This uncertainty coupled with other factors, such as the age of housing stock in the area or
activities e.g., burning of refuse on the land may have resulted in the contamination of the soil contained in the lots. Lead-based paint for example, was historically used in homes, and is suggested in the literature to be one of the greatest contributors to lead exposure hazards (J. S. Litt et al., 2002; Mielke et al., 2004). The impact of these factors will be discussed in further detail later in this work.

Understanding the exposure pathways, or the ways in which a contaminant reaches and enters the human body is essential to assessing those risks. The relevant exposure pathways associated with urban gardening are: incidental soil ingestion, ingestion of plants grown in soil, inhalation of soil particles, and dermal exposure to soil. Of these pathways, the most significant are incidental soil ingestion, i.e., ingestion of soil clinging to vegetables even after washing or through eating with unwashed hands after working with soil; inhalation of the fine particulate dusts; and the ingestion of plants that have taken up contaminants from the soil.

One commonly identified hazard in Boston gardens is lead. In a study of Boston backyards through the Lead Safe Yards Program (USEPA, 2012a), Litt et al (2002) state, “Lead’s persistence in the environment, its widespread use in industry, its presence in older homes, and its remnants in soil from leaded gasoline and deteriorating exterior paint on aging homes make it a public health threat in aging urban neighborhoods.” And that “Low-income and minority families, those living in older housing, those living in older urban areas…still suffer from excess exposures to lead in the environment” (Litt et al., 2002). Within these environments, the most vulnerable populations of persons at risk from the health effects of exposure to lead would be young children and pregnant women. Children in particular are susceptible to exposures to lead
because of their habits, i.e., hand-to-mouth behaviors, crawling, and in addition, are most sensitive to the health effects of potential lead exposures due to their stage of development. Therefore, much of the discussion to follow identifies lead as a key contaminant of impact to children’s health.
Objectives

This work integrates and adds to the existing body of knowledge associated with community gardening. The main objective driving this work is to develop sound public health recommendations based on available information from geochemistry, urban planning, sociology, environmental health, and regulatory frameworks to assess human health impacts of urban agriculture. This will be accomplished using Charlestown Sprouts Community Garden, located in Boston, Massachusetts, as a case study. Questions that this work seeks to answer are:

- What tools do those in public health and laypersons have at their disposal to identify potential contaminants? And how would they be adopted?
- What contaminants can we expect to find at the Charlestown Sprouts community garden based on the historical survey?
- What are the ranges of lead levels expected from different local sources of compost that could be used for the garden or urban agriculture?
- What are concentrations of lead in compost and soil that are health protective and reasonably achieved?
- How can modeling be used to approximate risk of health impacts of lead at a community garden site in the absence of reliable site-specific data?
- What remedial recommendations or alternatives could be proposed to the Charlestown community garden members and leadership based on the findings of the historical survey such that gardening activities can continue at the site?
Charlestown Sprouts Community Garden: A Case Study

Charlestown is Boston’s oldest neighborhood, founded in 1629, even before the City of Boston itself. Following the famous Battle of Bunker Hill (fought on Breed’s Hill) in 1775, British troops burned down much of Charlestown. In 1874, the town was annexed to Boston and joined Suffolk County. It is situated on a peninsula located on Boston’s Inner Harbor, with the Mystic River to the north, and its advantageous location had made it a hub of industry and rail and ocean transport. However, its industrial legacy was slowly encroaching on parts of the neighborhood had left it less than fertile for residential inhabitants. By the latter part of the 20th century, Charlestown became a prime candidate for urban renewal (BRA, n.d.; “Charlestown Historical Society,” n.d.).

In the 1950’s the newly formed Boston Redevelopment Authority drew plans for Charlestown’s Urban Renewal Plan (BRA, 1965) at a at a time when other parts of Boston were also slated for revitalization to prevent further deterioration of areas blighted
by neglect and crime. The BRA’s objective for Charlestown was: “to stimulate and to facilitate public, private and institutional development efforts in the area in such a way as (1) to preserve the neighborhood, (2) to assure the public health and safety, (3) to strengthen the physical pattern of neighborhood activities, (4) to reinforce the fabric of family and community life, and (5) to provide a more wholesome framework of environmental conditions better suited to meet the requirements of contemporary living“ (BRA, 1965).

Today, Charlestown is a neighborhood with an estimated population of 18,236 (BRA ACS 2005-2009). The BRA ACS reported that Charlestown had the highest median income of all Boston neighborhoods at $83,926 (adjusted for 2009 inflation dollars). Despite this, 16.6% of families reported an annual income at below poverty level— the highest percentage among the neighborhoods with the greatest median incomes (Back Bay, West Roxbury, North End) (BRA, 2011).

The population of Charlestown is diverse: 21.7 percent of the population self-identifies as minority or mixed-race. The percentage of the population born outside of the U.S. is 14.5% (includes those born in Puerto Rico, US Islands, or born of American parents). One-third of these residents have entered the U.S. in the year 2000 or later. Among foreign-born residents, the majority was born in China (31.5%), Dominican Republic (23.3%), Russia (4.6%), and Canada (3.1%). Other countries reported include Turkey, India, and Honduras (BRA, 2011).
Background

The Charlestown Sprouts community garden was founded by community activist Oren McCleary, at the current location after the relocation of the Boys and Girls Club garden here in 1997. At its founding, 75 garden plots were established on “previously debris-filled [land] that held the remnants of neighborhood buildings that had been torn down” (Lamboy, 2011). In 2009 Boston Natural Areas Network (BNAN) in partnership with Nubia, a refugee gardening program, built 30 new plots on the premises as well as installing new water lines. Today, Charlestown Sprouts is one of Boston’s largest community gardens totaling 105 total plots, each serving one household. Of note, this location was featured in the film “the Town” starring Ben Affleck.

As of the past 2012 growing season, 95 of the plots were active and all were used for growing food for consumption—a vital source of family produce (Lamboy, personal communication). Garden members are a diverse group of persons, most (approximately 75%+) of whom are limited English-speakers, and who are from the Chinese, Vietnamese, Cape Verdean, Afghani, Somali and Nubian refugee communities. To be sure, a sampling of the produce being cultivated represents a mixture of ethnic and garden-variety vegetables and fruits.

The garden coordinators, through informal survey measures, approximate that 80% of members live in low or moderate income households, with a large number currently living in affordable housing units (Lamboy, 2011) located within a quick walking distance of the garden. Spatialization of 2000 census data (MassGIS, 2003) shows that the area around the garden is categorized as an environmental justice (EJ) community—classified by the Massachusetts Executive Office of Environmental Affairs as
communities with high minority, non English speaking, low-income, and foreign-born populations—who would bear a disproportionate burden of environmental injustices (MassGIS, 2003).

Figure 2: Environmental Justice Map of Charlestown

The garden is now led by two volunteer garden coordinators and a steering committee of gardeners who manage issues regarding garden policy and implementation, and operations of the garden while actively engaging garden stakeholders. The current condition of the garden is in need of repair, as many of the original garden beds are constructed out of weathered rail ties. The gardeners are seeking to develop and implement a design plan for renovating, and possibly expanding, the garden. To meet this goal, the garden coordinators contacted Boston University
School of Public Health (BUSPH) to investigate the current conditions of the Site, i.e., possible contaminations, based on historical land use research and to help develop remediation and renovation recommendations to the Steering Committee and garden stakeholders based on our findings.

The issues and challenges that the Charlestown Sprouts Community Garden now faces have provided an opportunity for real-world application of my academic and practical skills drawn from my graduate studies at BU. As a case study, conducting a historical survey for the Charlestown Sprouts Community Garden represents a complex example of what a practitioner may face in the field.

The purpose of the survey is to understand and assess the contribution of soil contamination at the Site from the historical land uses of the current and adjacent sites. My collaborative work for the garden will be presented in a separate document for the garden coordinators’ review. The methods and results of the work for the garden will be presented in the following sections. The recommendations based on the Site Survey follow in the Discussion section.
Figure 3: Site Locus
Source: MassGIS, 2012a

Site Description

Charlestown Community Sprouts Garden (the “Site”) is located at 49 Terminal Street on a manmade peninsular landmass in Charlestown (Y: 42.381866 Latitude X: -71.058302 Longitude), formerly known as Mystic Wharf. The garden is reported to comprise 0.37 acres of an 11.7 acre parcel currently owned by the City of Boston (COB,
However, measurement of the garden boundaries using satellite imagery suggests that the actual area is approximately 0.9 acres (MassGIS, 2012b).

The parcel (City of Boston Assessor’s Parcel # 0202735000, See Appendix A) is zoned as an Open Space District and protected under Massachusetts General Law Chapter 91 and the Wetlands Protection Act (COB, 2008). The Site is surrounded by commercial and industrial zoning. The nearest surface body of water is directly due south, the Little Mystic Channel. Further south across the water is a residential area. The land at the Site is currently being used for gardening and growing food, and will be used for those purposes for the foreseeable future.

Figure 4: Satellite imagery of garden environs. Garden site outlined in green. Note the salt piles covered by the black tarp. Source: Google Maps, 2012

The Site is bounded to the east by an area owned by the BRA called the Little Mystic Access Area that includes a boat launching ramp and a surface-level parking lot. To the
west, the Site abuts the Charlestown High School athletic fields, which are composed of a baseball diamond, a football field, and spectator area. These adjacent sites are part of the same assessor’s land parcel. The Little Mystic Channel bounds the Site to the south, an open body of surface water. The Site is bounded to the north by Terminal Street, a two-laned asphalt road.

Just beyond Terminal Street, due north, there are tarped piles of road salt belonging to International Salt (headquartered in Clarks Summit, Pennsylvania), which leases the land from Massport. The leased land is part of the Moran Terminal Container Port, a Massport-owned property of approximately 80 acres (Suffolk Deeds, 2011) entirely zoned for industry, which is home to the newly built Wind Turbine Testing Center. Part of Moran Terminal has been leased by the Boston Autoport, LLC who has operated the Autoport, which has decreased operations over the years since the volume of shipped cars has dramatically fallen.

Site Inspection

As part of the Site Investigation, an inspection of the Site was conducted on May 14th, 2012 to the record general conditions of the garden. The visit occurred in the afternoon while two gardeners were present. The garden plots at the Site vary in size and shape. There is a visible mound upon which some of the older plots are built, which appears to take up more than half of the area of the garden used for growing. Most plots seem to be growing food for consumption. Newer plots are located south of the mound in a more organized fashion. The community garden site comprises 107 plots maintained by garden members.
Many of the older plots are in disrepair, and held together with weathered timber and bric-a-brac such as pipes and granite curbstone. Behind the area of the mound, the rear, or north side of the garden, evidence of construction debris is apparent. During the visit, reinforcement steel and construction equipment were also present at the Site (See Appendix B for photographs taken during the site visit).

Gardeners at the Site generally are restricted to growing in their household plot within the larger garden area, though the garden coordinator noted instances where unauthorized planting occurred outside of allotted plots. The plant material was promptly disposed of and education for the members followed.

Access to the site is unrestricted and open to the public. There is chain-link fencing along the western border of the garden, separating the athletic fields and the garden, and along the northern perimeter. Physical barriers do not restrict the eastern and southern perimeters. There are no paved walkways in the garden. A concrete walkway borders the garden to the south and follows the southern/southeast boundary of the garden. From the garden, beyond a high wall of wooden fencing, the tops of the salt piles can be viewed. During the site visit, black tarps were covering the salt piles. During the winter season, it is unknown if they are continuously covered.

**Topography**

As the contour lines on the map below demonstrate, the garden’s topography is variable. Some areas are relatively flat, but the highest points demarcated on the map are associated with the “mound” in the garden that was observed during the Site Inspection (See Appendix B) and was stated to be 10 feet high at the garden’s founding. The elevations at the Site range from 15-22 feet above sea level.
Figure 5: Topographical Map of Charlestown Sprouts Community Garden. Adapted from Camp Dresser & McKee, Inc. (CDM, May 2007)

Geology

Much of the land of Boston is composed of fill, and Charlestown is no exception (Seasholes, 2003). The land upon which the garden was built had originally been salt situated in the Mystic River. In 1852, despite strong opposition, permitting for the filling of the land was granted. Building of this land began in 1859, with the construction of a 20-foot seawall along the north side of the channel, and subsequent filling of the several
acres of the flats behind the seawall. By 1887, most of the Mystic Wharf, known today as the Moran Container Port, was completed (Seasholes, 2003).

While soil boring data were not available for the Site specifically, the composition of the abutting parcel was reported to “miscellaneous fill composed of sand, gravel, silt, cobbles and rubble varying in depth from 2-16 feet…[overlying] a compact sandy gravel varying in depth from 4 to 14 feet” (BRA, 1967a).

**Historical Survey Methods**

The overall methodology of how data for the historical survey was collected is outlined below in Table 1. It is not an exhaustive account enumerating the sequence and steps of the research, but is intended to detail the various places sought out during the process to bridge the gaps in the knowledge of the Site’s history of land use.

The initial steps in performing the historical survey involved consultation of Sanborn Fire Insurance maps, which were published since 1888 for the purpose of relaying information about businesses, industry, and residences for a city or town for use by insurance needs. These comprehensive maps detail the construction materials of buildings, type of business conducted (or not, if it was a residential building) and who owned it. The Sanborn Fire Insurance maps were particularly helpful in developing a skeleton for building a historical use narrative of the Site and of the adjacent properties. The table below reviews the different methods employed to gather information about the history of the Site.

For researchers needing information on Boston local government and agencies, the City Archives website has an excellent review of the history of each agency, with specific information about when it was active, and if it still exists, but under a new name, or
underwent structural changes. This was the case for the Public Facilities Commission (PFC), to whom BRA transferred the garden land parcel in 1988, now known as the Department of Neighborhood Development (DND), as per the website (COB, 2012). However, after a discussion with a Records Manager at DND, I learned that the PFC still exists, but its functions are different from those of 20 years ago.

**Table 1: Detailed Methods for Historical Survey**

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<th>Materials Reviewed/ Accessed</th>
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<td>2009, 2010 Sampling Data</td>
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<td>City Directories</td>
<td>BPL</td>
<td>Sporadic Years to check operation of a business</td>
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<td>Boston City Archives Website</td>
<td>DND history Schools history ISD history Parks history</td>
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<td>Phone call In-person</td>
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<td>Parks Commissioner via liaison</td>
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<th>How/Where Found</th>
<th>Materials Reviewed/ Accessed</th>
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<td>In-person</td>
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<td>Reported releases near the Site</td>
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</table>

| Who/What                  | How/Where Found                          | Materials Reviewed/ Accessed                                                                 |


Historical Survey Results

Examining the historical uses of land can reveal the potential hazards that existed in the past that may even persist to present day. It is of high importance to conduct due diligence in applying traditional methods of inquiry, but also by utilizing informal methods, which may bridge gaps of knowledge. Despite the information gleaned from various sources, knowledge of all the past uses of the Site is incomplete. The Sanborn insurance maps along with other historical maps provided a composite for further investigation, indicating the businesses that had historically operated on and near the Site. Many of the surrounding parcels had been used for industrial and commercial purposes.

Site History Narrative

*Building of Mystic Wharf (1859-1892)*

The entirety of the peninsular landmass upon which the garden land is situated is man-made. Its formative construction began in 1859 by the Mystic River Corporation (MRC) and spanned three decades, as the tidelands in the Mystic River were progressively filled with dredged material. Much of the filling was undertaken by the Boston and Lowell Railroad (B&L) lessee to MRC, who by 1886 purchased all of MRC’s property. In 1887, B&L was taken over by Boston and Maine (B&M) and by 1892, most of the project had been completed (Seasholes, 2003).

*Site Land Uses*

The following represent the summation of information gleaned by the collection of both official and firsthand accounts of the activities and uses that occurred at the site.
1. **1870s-mid 1960s Railroad Spurs and Rail yard**—In the early 1870’s Boston & Lowell (B&L) built a track along the waterfront of the newly constructed land (Seasholes, 2003). In 1883, B&L leased the land from the Mystic River Corporation and later purchased it in 1886. A year later, B&L was taken over by Boston and Maine Railroad (B&M). (Seasholes 2003). B&M owned the land until the mid-1960s when Massport took the land over. One spur, closest to the garden area is extant, but not in use (Massport, 2012 Personal Communications with D. Hadden). Mystic Wharf “soon became one of the major shipping terminals of the harbor” and supported the commercial and industrial uses over the years (Seasholes, 2003).

2. **1900’s-1922 Lumber Yard**—A lumber yard appears on the maps (see Appendix C ), which was possibly operated by Holt and Bugbee lumber distributors, or operated by B&M. By 1922 (Bromley maps, Mapjunction), the Lumber Yard was no longer labeled. A “Lumber Yard and Storage Shed” was recorded in the Assessor’s archived tax records (COB, 1930).

3. **1920s-1968 Salt Plant and Distribution**—International Salt and Eastern Salt, a subsidiary of International Salt Co., operated at the Site until 1968. The Sanford map indicates that Eastern Salt was in operation at the Site location by 1927 and does not appear in the Bromley map from 1922.

   An aerial photo of the garden site from 1955 demonstrates that there were substantial structures at the site, presumably belonging to Eastern Salt (See Figure A-
15, Appendix D). In July 1959, B&M Railroad sold 186,549 square feet to Eastern Salt Co (Suffolk Deeds, 1959a) and the plan map (Suffolk Deeds, 1959b) depicts a foundation of an old building present at the site. A permit filed that same month allowed the company to erect a business garage (ISD, 1959) at the recorded address of 41 Terminal Street. The land use in 1963 was reported to be “Industrial Plant” (Larry Smith & Co., 1963).

4. 1968-1988 Unknown Uses

4.1 BRA taking of land from Eastern/International Salt

According to a “Letter of Understanding” between BRA and Eastern Salt referenced by another document (BRA, 1967b), Eastern Salt was to have vacated the land on April 1, 1968. The Urban Renewal Program R-55 (BRA, 1965) outlined the taking of Eastern Salt’s land as part of Parcel P-8, which was designated by the Program to be Open Space (Appendix E). Under the provisions of the Housing Authority Law, the BRA took this land (as part of Parcel P-8) under eminent domain in 1975 (Suffolk Deeds, 1975). Parcel P-8 currently comprises the Charlestown H.S. Athletic fields, the Community center and the garden site. It was stated in the Order of Taking in 1975, that the owner of the parcel was unknown at the time.

4.2 Waste Disposal?

Land use in 1971 from photointerpretation results visualized through Massachusetts’ Geographic Information System (MassGIS) data (MassGIS, 2002) suggest that the garden land was part of an area of mixed use for the purposes of transportation, waste disposal (primarily in the area of the current H.S. football field) and recreation (See
Figure in Appendix F). Between 1971 and 1985, the Site area was still used for transportation and recreation, but no longer for waste disposal. These uses appear to have remained generally the same through 1999, and by 2005, the entirety of the garden land was interpreted as having been used for transportation (MassGIS, 2009). In 1988, the BRA transferred the land to the Public Facilities Commission (PFC), an agency of the City of Boston (Deeds, 1988). At some point after that date, PFC may have transferred the land to Schools, but inter-agency transfers are not documented.

Verification as to what activities occurred here during the 1970’s up until the founding of the garden in 1998 was difficult through review of documentation. The Sanford maps also did not indicate any businesses were in operation at the Site. However, anecdotal reports point to dumping, possibly illegal, at the Site during this period.

4.3 Anecdotal Accounts of Historical Uses of Site

Anecdotal evidence from distinct sources revealed undocumented disposal practices that would have otherwise been missed in the course of the research for the historical survey. In attempt to corroborate among the accounts, a search for historical and active of industrial waste and construction and demolition (C&D) wastes was performed. According to the a report prepared for the USEPA, List of Industrial Waste Landfills and Construction and Demolition Waste Landfills (Eastern Research Group, Inc., 1994), the Site was not listed as an active C&D or industrial waste in the mid 90’s.

According to a historian and former resident of Charlestown, “Your site of interest, according to my memory, lying between athletic facilities and the boat ramp, had no clear use and was blighted by illegal dumping of construction waste such as dirt,
concrete and brick rubble by rogue contractors” [italicized for emphasis]. Similarly, another long-time Charlestown resident recounts that the lot was used as a “city yard” to which materials from construction and physical improvements where hauled by City workers. These materials were said to be removed after some time. This resident also stated that soil from an adjacent property (3-4 feet deep) was moved to the garden (date unverified).

The statements above were consistent with a third Charlestown resident’s whose account mentioned that when construction of Charlestown High School was complete, large concrete barriers (concrete boxes-not jersey barriers) that were used were dragged to the garden area. Over time, they were left there to fill with natural debris. In constructing the garden (late 1990’s), he explained that soil was brought in to add to the tops of the concrete barriers. And in fact, two truckloads of soil were transported from his home’s yard to the garden location.

4.4 Other Relevant Findings

Implementation of the Charlestown Plan by the BRA entailed, “portions of the western edge of the Channel...be land-filled in order to create an embankment as well as to create land for some of the recreation facilities” (BRA, 1967b). The status of the parcel in 1969 was reported by the BRA as having been filled and left to settle for one year (BRA, 1969). This was confirmed by a GIS datalayer that showed the progressive filling within the last century (MassGIS, 2012;) and by superimposing historical maps from different periods through GIS.
As mentioned earlier, the question as to which COB agency currently oversees the Garden Site has still not been definitively answered. As per their institutional policies, the School Committee should have retained records of a formal vote of the parcel’s transfer from Public Facilities to the School Department (Schools). At the time of writing, this action could not be confirmed. It was confirmed through visits to various city agencies that BRA, DND, or Parks does not oversee the land. It has been opined by city agents that it is Schools. The following information presents evidence of transfer of ownership from PFC to Schools.

- ISD records from 1998-1999 indicate that the lessee/licensee as (ISD, 1999) Boston Community Schools (at 1010 Mass Ave) and others as DND (1998) of parcel 2735. The ISD records were for 29 Terminal St, application for temporary tennis court structure. The ISD application for construction on an existing concrete foundation was signed by DND in July 1998.

- In a letter dated April 3, 2000, from Superintendent of Boston Public Schools Thomas Payzant to Oren McCleary, it is clear that Schools owned the garden property at the time, which was related to the building of the Charlestown High School (Payzant, 2000). Multiple attempts at verifying current ownership through Schools by direct phone, email, and in-person visit have not yielded satisfactory results.
Abutting Parcels (within 500 feet of Site)

SOUTH

Little Mystic Channel (also known as South Channel) is a body of surface water.

NORTH

Massport currently owns the land north of Terminal Street known previously as Mystic Wharf, and has leased it to various businesses. B&M had operated on this land from the late 19th century and various cargo was transported including coal and gypsum.

Historical Uses

1. 1870's? Rail yard -- As mentioned during the Site narrative, B&L and later B&M operated at the Site, in addition to this area, north of the current garden site. The historical maps reviewed indicate that this area has been full of tracks. To date, some these spurs are still in place (conversation with D. Hadden) but are not in use, with the nearest being approximately 100 feet away from the garden.

2. 1969-1985 Scrap Metal Yard -- Schiavone & Sons leased the land from B&M, and operated a metals scrapyard from 1969 to 1985. Massport took over the property in 1987. Prior to 1969, the property was used as a coal import terminal (MassDEP, 1986). In 1986, a Site Investigation completed by the MassDEP (1986) reported this area as vacant land on which automotive scrap and scattered battery casings were observed. Piles of railroad ties were reported to be found, with some “oozing creosote” (MassDEP, 1986), along with piles of brick and concrete rubble with rebar—materials all observed
during the Field Investigation at the Garden Site. The map below shows which area of the former Schiavone property that was under investigation. The street address recorded for this property was 60 Terminal Street.

3. 2003-current Salt Piles --Through telephone calls to Highways and Massport, it was determined that the salt piles are owned by International Salt based out of Clarks Summit Pennsylvania, (personal communications) and is managed by Salt City, Inc. (verified via telephone to HQ). The land is sub-leased to International Salt. According to an official at Massport, salt piles have been stored at this location since the mid-2000s. The salt piles appear in aerial imagery from 2005 and 2008 (MassGIS), but absent in 2001. Through MassGIS, the current salt piles were measured to be about 32 meters away from the garden.
Figure 6: Boundaries of Schiavone & Sons Inc, Metal Scrapyard
Source: MassDEP, 1986
EAST

1. (1920s-1950s) Coal Distribution—The Sanborn Maps indicate that a coal distributor operated in the area east of the garden, some time in the 1920’s until the 1950’s. In a newspaper advertisement from 1953, Snider Fuel Corporation sold imported Welsh Anthracite with an ash content of 2.4%. The address listed in the advertisement for Snider Fuel was Mystic Wharf (Boston Globe, 1953).

2. 1972-current Boat Launching Ramp—The boat launching ramp and parking lot was built by the state in 1972 where it was reported that small power boats were launched from the ramp (BRA, 1975) and was a “constant source of vandalism” (BRA, 1984). From 1980-1983 the BRA leased the land to Matthew O’Neil to maintain a boat launching facility, but his attempts were unsuccessful (BRA, 1985b). In the tenant agreement dated (Suffolk Deeds, 1986), the address of these premises was recorded as 88 Terminal Street.

WEST

1. 1975-current Charlestown H.S. Athletic Fields—The Charlestown H.S. Athletic Fields are a part of the same land parcel (P8) as the garden and were constructed in 1975 (BRA, 1975). The current site of the athletic fields is thought to have been the possible site of a historical lead smelter based on the findings of the doctoral work of a student at George Mason University in 2001 {Citation}. This triggered response from the USEPA
and MassDEP. The MassDEP investigation (MassDEP, 2007) found polycyclic aromatic hydrocarbons (PAHs), lead, and arsenic in excess of reportable concentrations—maximum concentrations for regulated chemicals that require further action—which resulted in soil excavation and removal in 2007.

Subsequently, the risk assessment concluded that there was “no significant risk” to current and future users of the athletic fields. In 2007, renovations to the athletic fields culminated in its current configuration. Of note, the MassDEP status report (MassDEP, 2007) stated finding PAHs and “heavy metals in excess of reportable concentrations was not unexpected at this location since numerous other sites in Charlestown with urban soil fills, in particular Barry Playground and Ryan Playground, had both resulted in reporting conditions during prior investigations due to the quality of urban fill soil. The soil is typical of the old Boston waterfront fill.”

Further

1. Tobin Bridge--The Tobin Bridge was erected in 1950 and has been operated by Massport and by 1978, MassDOT. The Tobin spans the Little Mystic Channel from Charlestown to Chelsea and is located about 1600 feet from the garden. The bridge is currently undergoing renovation to its steel beams, which had been painted historically with lead-based paint. In 2004, land adjacent to the bridge was found to be contaminated with lead in excess of reportable concentrations (MassDEP, 2005). Currently an Activity and Use Limitation (AUL) is in place that limits current and future activity at the site to industrial and commercial uses and prohibits residential, agricultural, and recreational uses.
Potential Hazard Sources

The information gathered for the Historical Survey provides reasonable grounds for identification of potential contaminants at the Site and from nearby sources. There are two main modes of exposure to soil contaminants to a human gardener. Direct exposures include exposures that would occur as a direct result from gardening activities or any activities that would involve interaction with potentially impacted garden soil. Indirect exposures include those resulting from secondary pathways, i.e., plant uptake of soil contaminants, and the vegetable subsequently being consumed by a person.

The Site’s history aids in identifying sources of contamination and an initial characterization of the Site’s potential impact on human health. General historical and current uses of land that can pose possible contamination hazards include, “Former commercial and industrial properties, former orchards, former dump or landfill sites, former incinerator or smelter sites, as well as transportation corridors, ports, areas near bridges, historic residential neighborhoods constructed prior to 1978, and land adjacent to these areas” (ASTSWMO, 2012). Table 2 below reviews contaminants that are likely to be present at the Site, their general sources, and current Site-specific potential sources.

Contaminants at the Site can be expected to have pervaded the surficial soil, or the root zone, defined as the depth of the soil at which the plant roots are in direct contact with the soil matrix (typically up 0-1.5 feet). It is also possible that they may extend further into the soil, to the full extent of the fill portion. Based on boring data obtained from adjacent parcels (C.E. McGuire, P-3, etc.), fill depths in this area can range from 2-
16 feet. Depending on the root structure of a particular plant, contaminants may be taken up from soil depths greater than 3 feet.

**Table 2**: Potential Contaminants Based on Land Use

<table>
<thead>
<tr>
<th>Potential Contaminants</th>
<th>General Source(s)</th>
<th>Site-specific Source(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>Buildings (including residential) constructed prior to 1978. Although banned for residential use, lead-based paint is still available for some industrial uses on bridges, at ports, and in roadway striping. Water tanks, etc.</td>
<td>Urban fill Tobin Bridge Contamination found in adjacent and nearby properties.</td>
</tr>
<tr>
<td>Arsenic</td>
<td>Facilities treating lumber (pressure treated), railroad ties, telephone poles, furniture and flooring manufacture. Also residential use of railroad ties and treated lumber</td>
<td>Railroad Ties (CCA)</td>
</tr>
<tr>
<td>Asbestos</td>
<td>Residential, commercial, and industrial construction demolitions sites (structures erected pre-1989)</td>
<td>Purported demolition debris at Site</td>
</tr>
<tr>
<td>Volatile and Semi-volatile Organic Compounds (VOCs and SVOCs)</td>
<td>Any process occurring on industrial or commercial zoned property</td>
<td>Adjacent areas are commercially zoned, and in past, industrially?</td>
</tr>
</tbody>
</table>

1. **Potential Onsite Hazards — Point Sources of Contamination**

1.1 Treated Timbers of Older Garden Beds—During the Site visit, weathered wood beams were observed to be holding together the older garden beds, along with other materials of unknown origin. Based on the history of a railroad spur immediately north of the Site, and rail operations by B&M in adjacent areas, it is highly likely that these timbers at the Site were originally used as railroad ties. Gardens in Boston have historically found to use these timbers in the construction of garden beds (Heiger-Bernays et al, 2009).
Two types of treated wood are each a source of possible contamination. Creosote is one type, which contains a mixture of PAHs. The other possibility is that the beams are made of Chromated Copper Arsenate (CCA)-treated wood, which can release arsenic to the soil. Having both of these types of timber present at the Site is a likely scenario as well. Typically, creosote appears to be “crumbly” in appearance and can be differentiated from CCA-treated wood. Based on visual inspection of select plots, it is likely that CCA-treated wood is present in some plots, but does not exclude the presence of creosote in the rest of the garden. The newer plots did not appear to contain these treated timbers.

1.2 Reported Dumping Debris--Since dumping could not be verified from primary sources, it is not clear what kind of debris lies within and under the soil. It has been opined by community members that a part of the garden is situated atop demolition waste. It would be expected, in that case, that lead from lead-based paint and asbestos from construction debris could be present in the soil. Several anecdotal sources recalled some form of dumping, presumably illegal, occurred during the 1970’s and 80’s.

2. Potential Off-site Hazards (within 500 feet of Site)

2.1 Salt piles --The presence of salt piles directly north of the garden, across Terminal may be a source of windblown and runoff contamination. During the site visit, it was observed that salt was covered by black tarps, which would serve to minimize dissolution of the salt and fugitive salt dust. Historical accounts mention salt stored in this
area would blow into the neighborhood, corroding automobiles. The chemical components of road salt vary, but the common constituents are sodium chloride (NaCl), and an anti-caking agent such as ferric cyanide.

The primary physical characteristic of NaCl is its high solubility in water, which dictates its transport via overland flow on impervious surfaces. It may associate with suspended particulate matter or water droplets. However, the current topography and construction of the garden may preclude much runoff from reaching the plots. Wind-blown road salt particles could deposit onto the soil, after which, dissolution during watering or rainfall would occur and the chemical constituents of road salt could adsorb to soil particles.

2.2 Tobin Bridge (approximately 1600 feet away)--Previously applied lead-based paint that flaked or was blasted off from the Tobin Bridge could have contaminated adjacent properties over time. According to one resident, paint chips were found within a four block radius of the bridge. The original paint system specified lead-based primers and alkyd topcoats (Norton, 1986) at the time of construction in 1950. From 1950 up to 1977, multiple rounds of maintenance painting occurred using lead-based primers and open blasting. During the times when unchecked abrasive blasting of the bridge occurred, it is likely that lead dust migrated from the bridge to the garden and adsorbed onto soil particles, and persisted in the soil.

Painting activities in the 1980s involved extensive environmental controls (Norton, 1986), from blast debris containment to the temporary relocation of pregnant women, to minimize exposure to lead. Currently, the Tobin Bridge is currently undergoing
renovation (cleaning and painting the structural steel to the cost of 44.8 million dollars MassDOT 2012) with safety measures in place to protect residents and nearby areas. (MassDOT website).

2.3 B&M Rail yard --The Boston & Maine railroad would have carried a myriad of cargo. Coal, salt, lumber and gypsum were common materials carried to and from Mystic Wharf. Historical releases of hazardous materials traced to B&M could range from gasoline, arsenic, PAHs, and other metals, but this has not been established as affecting the garden site. One of the major concerns is that the rail yard was likely to be the source of railroad ties used in the garden.

Contaminants of Potential Concern

Below is a discussion on site-specific contaminants that were inexclusively determined to have a high likelihood of being present in the garden soil due to the history of land use and current exposure routes. Synthesis of Site History data, identification of sources of potential contamination and impact to human health culminates in a qualitative assessment of hazard. These potential constituents are discussed here in regard to potential human health hazard to the gardeners. It should be noted that mere presence of a contaminant at the Site is not grounds for hazard. The pathways should be complete, and there should be evidence that the chemical constituent under evaluation is toxic, based upon the weight of scientific evidence.
Lead

Lead (Pb) is a key contaminant that is frequently detected in urban fill. In the Boston area, “lead was detected in 98 percent of the more than 300 samples collected to characterize various urban park sites” (Swanson and Lamie, 2010). The ubiquity of lead in urban fill soils can be traced to natural occurrence, and human activity which includes historical use of “leaded gasoline, leaded paint on building construction materials (including steel beams), and its presence in pipes and in solder” (Swanson and Lamie, 2010).

By nature of the Site land being composed of urban fill, it is expected that lead be present in the soil at levels above what would occur naturally. There are additional sources of lead that would potentially impact the garden soil. Potential dumping of construction materials on site could release lead into the soil. Further away, the Tobin Bridge to which leaded paint has been applied, could have also contributed to lead soil if wind blown paint chips deposit onto the soil.

Once deposited onto soil particles, lead is likely to be immobile. Lead mobility is dependent on chemical speciation and a complex set of soil parameters. Different sizes of lead particles, what form of Pb; pH, chemical makeup of the soil, physical characterization of soil all are factors in the mobility of lead in soil. For instance, increased pH decreases Pb mobility due to the chemical interactions that Pb has with other constituents in the soil (Clark, et al, 2006).

The health effects resulting from lead exposures are discussed in detail in the next section, Focus on Lead.
Arsenic

Arsenic is a heavy metal that occurs naturally in the soil. It is a common contaminant in urban fill, and the primary source in the urban environment is likely from widespread pesticide use (Swanson and Lamie, 2010). At the Site however, contamination is likely to be point-source from treated timbers once used as railroad ties from the nearby rail spurs.

Arsenic would be likely to found in topsoil. The results of a study conducted by Heiger-Bernays, et al (2009) on Boston gardens, were consistent with other study findings regarding the extent of contamination caused by treated timbers. Rahman et al’s study (2004) on soil adjacent to CCA-treated timbers from established garden beds (approximately 10 years old) reported that the “highest concentrations of arsenic in soil were found 0-2 cm from the wood with a steady decline of concentration at greater distances” (Rahman, 2004 et al as cited in Heiger-Bernays, 2009). In addition, age of the wood affects the leaching rate, which would be highest in the earliest years of exposure to the elements than that of later years (Heiger-Bernays, 2009).

Arsenic may act under several proposed mechanisms of action, targeting ubiquitous enzyme reactions. It can cause neurological, gastrointestinal, renal, hepatic, dermal, reproductive, cardiovascular, hematopoietic, respiratory, and immune system defects (USEPA, 1998). The USEPA classifies arsenic as a Class A human carcinogen, strongly associated with lung and skin cancers and to a lesser extent, other cancers (USEPA, 1998).
Road Salt

Wind-blown particles from the salt piles, although currently covered can have migrated to the garden. Anecdotal evidence from residents suggests that historically, cars in the area would have their paint corroded by the salt (Anecdotal Account). The road salt currently stored is likely to contain the anti-caking agent ferric cyanide—a requirement by contractors—that is regulated under the Clean Water Act.

Neither chloride nor sodium has a MassDEP S1 soil standard, which indicates it is not regulated in the State of Massachusetts. Cyanide does appear on the list of chemicals for S1 standards. In 1995, Environment Canada placed road salt on its Priority Substances List in 1995 of placing salt on its Priority Substances List for assessment under the Canadian Environmental Protection Act, and, in 2004, it released a Code of Practice for the Environmental Management of Road Salts.

Sodium and chloride may not be hazards to human health, but may be toxic to vegetation, stunting or killing plant growth, and affecting the cation ion exchange of the soil (NH, 2007). This is likely to decrease the soil pH and in turn, mobilize other metals in the soil. It can be assumed that some fraction of the salt stored across Terminal Street migrates to the garden, but exposure risk to free cyanide would be minimal. The two pathways that the salt would reach the garden are by runoff and deposition of salt particles. Further discussion on mitigating potential exposure to road salt and its constituents is included in Recommendations and Summary section of this work.
Focus on Lead

Lead is a naturally occurring metal that is found ubiquitously in various environmental media such as soil, water, and air. The greatest source of lead in the environment is traced to anthropogenic uses, mainly from historical use in gasoline and paint. Residential lead-based paint was banned in the U.S. in 1978, but it was continued to be used in commercial applications. Lead was an additive used in gasoline as an anti-knock compound until it was banned by the Clean Air Act in 1996.

Lead is a particular contaminant of concern in urban soils. “In urban areas, soil is a key sink for Pb in the environment and a major site for human exposure “ (Clark, et al 2006). In soil, lead is deposited on and bound to soil particles and can persist in this medium for many years. Isotopic analyses of lead in Boston garden soils in the communities of Roxbury and Dorchester suggest that lead-based paint and leaded gasoline are sources of significant Pb contamination of these inner-city garden soils (Clark et al, 2006). Some key determinants of Pb soil contamination are age of housing stock, which used the application of lead-based paint, lead pipes, and interior dust (Litt et al, 2002). The flow chart below (Figure 7) demonstrates the sources, sinks, and exposure pathways of Pb through which humans are exposed to lead the urban environment.
Chronic exposures to lead have been primarily associated with neurological, developmental, hematological, renal, and reproductive effects in humans (CDC, 1991; ATSDR, 2007). According to the EPA, the degree of uncertainty about the health effects of lead is quite low. It is “one of the most extensively studied environmental toxicants, with more than 28,900 publications on health effects and exposure in the peer reviewed literature” (NTP, 2012). The body of evidence on lead exposure indicates that elevated childhood exposures to lead are associated with diminished intelligence and impaired neurobehavioral development (ATSDR, 2007a; USEPA, 2004), and
neurological adverse effects are the most sensitive health endpoints for lead exposure. Mazumdar, et al, suggest that the impact of child exposures to lead for a known health effect like compromised neurological activity, is far-reaching. For an individual child that has been exposed to lead and has a higher level of blood lead concentration (PbB), the IQ may be diminished as an adult (Mazumdar, et al 2011).

Lead bioaccumulates in the human body, and is found primarily in bone (USEPA, 2004). But due to the relative difficulty of obtaining measurements for bone Pb, blood is a far more widely used reliable biomarker of lead exposure. Soil has been associated to high PbB in young children. One major factor may be the behavioral differences like hand-to-mouth behavior that may result in higher exposure. Among other environmental media, soil and dust are most strongly intercorrelated with PbB (Rabinowitz, et al, 1985).

Further, it has been noted in the literature that soil is a significant contributor to indoor dust, which a child can be exposed through the oral or inhalation exposure pathways. Paustenbach suggests up to a 50% contribution by soil to indoor dust levels based on analysis of previous studies. Indoor dust has been implicated as a key source of Pb exposure resulting in elevated PbB (Paustenbach, et al, 1997).

**CDC Changes Blood Level of Concern**

At the behest of a federal Science Advisory Board panel, in May 2012, the Centers for Disease Control (CDC) changed the “Blood Level of concern” (BLL—now termed “reference value”) for children for the first time in 20 years from 10 μg/dL to 5μg/dL (CDC, 2012). In the intervening time, the CDC had acknowledged that there was uncertainty in the 10μg/dL value since there was a growing body of knowledge that negative health effects occurred below PbB 10μg/dL (CDC, 2009; NTP, 2012).
Lanphear’s work, based on The National Health and Nutrition Examination Survey (NHANES III) suggests that cognitive development may be affected in children with PbB as low as 2.5 μg/dL (Lanphear, 2000). The new CDC BLL threshold (5 μg/dL), intended to sufficiently protect young children, may still underestimate the risk of a child’s encountering adverse effects from Pb exposure. However, the change reflects a shift in CDC public health strategy in regard to PbB that “emphasizes preventing lead exposure rather than responding after exposure has taken place” (CDC Response, 2012a).

The implications of such a change are extensive. The former BLL of concern, 10 μg/dL, was a number that and definition of “elevated” PbB (PbB >10μg/dL), the upper limit of an acceptable PbB range, and has been the basis of long-standing policy decisions and epidemiological analyses. In June 2012, NTP released the prepublication copy of the Monograph on the Health Effects of Low Level lead which details the extensive evaluation of epidemiological studies that focused on adverse health effects associated with low level Pb exposures indicated by PbB 5-10 μg/dL. The NTP concluded that there is sufficient evidence that lead does have deleterious health effects on both children and adults with PbB at that range.

One measure recommended by the advisory board was that the definition of elevated blood level or “lead poisoned” be changed. On that recommendation, the CDC will no longer be using the term “blood lead level of concern” (BLL) in its literature and communications (CDC 2012a). The means to implement structural changes based on this policy change, CDC mentions, is limited (CDC 2012a). Future revisions to this reference value is possible, as new NHANES data emerge over the years, and the CDC will continue to review the PbB of the upper 2.5% of children to derive a PbB reference
value, and update it every four years using the latest two NHANES survey data (CDC 2012b, website).

Since this change has occurred very recently, analysis in this project was modified to reflect the change in definition and management strategy for a blood level that would represent a PbB above which 2.5% of the population of children would exhibit. At the time of writing many health agency websites understandably, still employed the term “blood level of concern” (December 2012). Implementation of these policy changes on the regional and state level will be on hold until 2013 (CDC, 2012b). CDC PbB surveillance data has recently included a new category for 5 μg/dL for the latest 2010 PbB data. At the time of writing, county level data were only available through 2009.

The Boston Public Health Commission (BPHC) published the results of the 2009 childhood PbB surveillance data in its publication “Health of Boston 2010” (BPHC, 2010) which reported that of the children screened, 1% had elevated blood lead levels, or PbB greater than 10 μg/dL (BPHC, 2011). More recent data published by BPHC, show a further decline in prevalence rate in Boston overall from 2009 to 2010 (1.2 to <1.0%) (BPHC 2010). Data used in the HOB 2011 Report could not be obtained from the BPHC for the purpose of re-analysis with the new reference value for this work, as it is protected health information (BPHC, personal communications).
As shown in Table 3 below, the latest county-level for PbB screening data (CDC, 2009) in Suffolk County Massachusetts (includes Boston, Chelsea, Revere, and Winthrop) suggest a higher prevalence of elevated PbB among Boston city children compared to their counterparts in Suffolk county, and statewide. Note that the prevalence of confirmed cases of PbB > 10 μg/dL among children in Charlestown is lower than in all geographic levels.
Table 3: 2009 Child PbB Screening Community to State-level Data

<table>
<thead>
<tr>
<th></th>
<th>Charlestown (9-47 months)</th>
<th>Boston (&lt;72 months)</th>
<th>Suffolk County (&lt;72 months)</th>
<th>MA (9-47 months)</th>
<th>MA (&lt;72 months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child pop</td>
<td>N/A</td>
<td>N/A</td>
<td>53,284</td>
<td>218,022</td>
<td>463,357</td>
</tr>
<tr>
<td>N= Children Screened</td>
<td>447</td>
<td>23,514</td>
<td>29,269</td>
<td>182,049</td>
<td>225,469</td>
</tr>
<tr>
<td>Percent Screened</td>
<td>81.2-99.9%</td>
<td>N/A</td>
<td>55%</td>
<td>83.5%</td>
<td>49%</td>
</tr>
<tr>
<td>Confirmed EBLL</td>
<td>0*</td>
<td>278</td>
<td>137</td>
<td>908</td>
<td>977</td>
</tr>
<tr>
<td>Prevalence</td>
<td>0%</td>
<td>1%</td>
<td>0.47%</td>
<td>0.51%</td>
<td>0.43%</td>
</tr>
</tbody>
</table>

1. Adapted from combined data BPHC (2010) and MADPH (2012). 2009 data across all regions were used for consistency; the latest published data available on the city level are from 2010 (BPHC, 2011)

2. Data are collected by the MA Department of Public Health, Bureau of Environmental Health, Childhood Lead Poisoning Prevention Program.

2b. Intercensal year population estimates created by linear interpolation of Geolytics data.

*BPHC reports this to be N<5, an insufficient sample size, so no prevalence rate was calculated for their report (BPHC, 2010)
Methods

IEUBK Methods

The IEUBK (USEPA, 2010) is a robust statistical modeling tool developed by the USEPA to help inform for risk assessors and managers about lead hazards at a site. It is risk-based pharmacobiokinetic model that predicts lead blood concentrations (PbB) in children as environmental lead exposures are modified by the user. The IEUBK uses a log-normal probability distribution to characterize variability in PbB due to differences in behavior, household characteristics, and individual levels of lead uptake and biokinetics (EPA, 2007). This investigation interprets the output of the model as a best estimate of a plausible range of PbBs for a theoretical child.

In regard to the specific application of the IEUBK for assessing soil used for urban agriculture, the USEPA does not provide official guidance on how to manipulate the model (IEUBK, 2012a). However, detailed guidance and technical documents for understanding the foundations of the model and its applications are available at the EPA website (Please see relevant citations in under References) such that modifications can be made. Understanding the underpinnings of the model is crucial to its use and interpretation. The figure below schematically outlines the components and the compartmental Pb flows in the IEUBK, providing a visual overview of the model.
Figure 9: Biokinetic Compartments in the IEUBK
(Source USEPA, 1994a)
Exposure Assumptions

The overall aim of modeling was to calculate risk probability estimates intended to assess lead exposure impact on human health. Therefore, when applicable, conservative or health-protective, exposure parameter values were assumed and inputted for the IEUBK runs. The explicit purpose of modeling was to evaluate the differential risks posed by modifying Pb concentrations in soil, air, and water. The manipulation of these parameters are detailed in this section. Ideally, use of site-specific data to approximate actual exposures would have increased the predictive power of the model.

In the absence of the availability of site-specific data, other environmental data that were most geographically proximal to the Site were used as surrogate values. This was under the assumption that the surrogate data were qualitatively similar to those that would have been obtained from the site.

Soil data (total bulk lead) determined which sets of other environmental data were used to modify the air and water parameters. This method allowed for consistency; for instance, environmental media data from 2009 were used as inputs, since one of the purposes of the modeling was to calculate risk based on the 2009 Pb soil data from BNAN. The various inputs for the model runs are summarized in Table 4 below, followed by explanation of the exposure assumptions:
**Table 4: IEUBK Exposure Assumptions**

<table>
<thead>
<tr>
<th>Run#</th>
<th>Soil Pb (mg/kg)</th>
<th>Source</th>
<th>Air Pb (µg/m³)</th>
<th>Source</th>
<th>Water Pb (µg/L)</th>
<th>Source</th>
<th>BLL Cutoff µg/dL</th>
<th>Age Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>3a</td>
<td>200</td>
<td>default</td>
<td>0.1</td>
<td>default</td>
<td>4</td>
<td>default</td>
<td>10</td>
<td>default</td>
</tr>
<tr>
<td>3b</td>
<td>200</td>
<td>default</td>
<td>0.1</td>
<td>default</td>
<td>4</td>
<td>default</td>
<td>5</td>
<td>default</td>
</tr>
<tr>
<td>4</td>
<td>400</td>
<td>USEPA SSL</td>
<td>0.016</td>
<td>[1]</td>
<td>2</td>
<td>[4]</td>
<td>5</td>
<td>default</td>
</tr>
<tr>
<td>9</td>
<td>92**</td>
<td>C1</td>
<td>0.025</td>
<td>[2]</td>
<td>1</td>
<td>[5]</td>
<td>5</td>
<td>default</td>
</tr>
</tbody>
</table>
The following are the explanations of the sources for the Pb assumptions in the various media parameters modified.

[1] “Highest” measurement reported from BNAN 2009 Sampling Event. Note: this was not likely to be a composite sample.

[2] DPW Compost mean concentration

[3] Compost Facility 1 mean concentration

[4] Compost Facility 2 mean concentration

[5] Compost Facility 3 mean concentration

[4] The maximum detected measured concentrations in 2009 between both monitors was used as the input for the parameter (MassDEP)

[5] The maximum detected concentration in 2010 was used as the input for the parameter


[8] 2010 50th Percentile Water Pb for MWRA Communities (MWRA 2011)

Run 1 represents a conservative “worst-case” scenario to evaluate potential past exposures using the highest measures of environmental exposure data from 2009. All other parameter values were maintained. Runs 2a-2d differed in the age range examined, since stage of development can affect PbB. Other model runs assumed various values to test the sensitivity of the model, and for comparison. Run 3 assumes the default value of soil, 200 μg/g, which is considered to be a “plausible value for many
urban settings” (USEPA, 2007b) which still exceeds the MassDEP background concentration of 100 mg/kg.

The final runs: 6,7,8,9 (Runs C1-C3), represent the probabilities of a young child’s PbB exceeding the cutoff of 5 μg/dL as a result of exposure scenario where low level Pb was introduced in compost added to the garden. Run 9 In particular was a run to see if there was an appreciable difference in Geometric Mean Blood (GMB) and probability risk between two runs if the indoor air parameter was changed from a default value of to a constant value of 200 mg/kg. As mentioned earlier, indoor dust is thought to be a major source of exposure to Pb.

In addition to the runs presented above, two run modes of “Find Soil PbB” carried out. This mode calculates a Pb soil concentration that is determined by user-modified cutoff and percent probability of exceeding the cutoff for a specified age range. Pb soil concentration is based on what the other media Pb concentrations are contributing. Two runs were completed in this mode, modifying only the cutoffs; all other parameters were set to default values.

**Bioavailability**

In a discussion about human exposure to contaminants, it is important to define the term bioavailability at this juncture, which can mean different things across disciplines. Here, the USEPA’s definition for bioavailability is adopted since regulatory testing and modeling is overseen by the USEPA. According to the USEPA, bioavailability is defined as: “The fraction of an ingested dose that crosses the gastrointestinal epithelium and becomes available for distribution to internal target tissues and organs” (USEPA, 2007a).
“The bioavailability of Pb in soil has two important implications: the impact on human exposure Pb and the potential of various remediation schemes. The role of diet as a pathway of exposure to the human system, particularly produce grown in contaminated soil, is not well quantified” (Clark, et al 2006).

Homogeneity of bioavailability of a metal should not be assumed for a particular site since the bioavailability of a metal could very well vary within a site due to different conditions of the soil and of the contaminant such as lead (Clark et al 2006). These differences may be due to soil characteristics, metal concentrations, form of metal, aging, land use, or other factors (USEPA 2007a).

Physiologically, the bioavailability of lead may vary with parameters of individuals exposed such as age, nutritional status, gastric pH, and transit time (IEBUK Guidance Ch 4). All of these elements mentioned above make assessing bioavailability an intricate process, which would introduce uncertainty within this analysis.

The figure below presents suggested mechanisms of how lead gets absorbed by the gut, and made bioavailable:
Figure 4-1. Schematic drawing of the enterocyte showing possible mechanisms for lead absorption. Possible mechanisms include: (1) an active or facilitated component; (2) a transcellular component perhaps involving pinocytic mechanisms; and (3) a diffusion-driven paracellular route across tight junctions.


Figure 10: IEUBK Proposed mechanisms for gut absorption.
Source: USEPA 2007e, as adapted by Mushak (1991) and Morton et al (1985)

Sampling and Analysis Methods

BUSPH Sampling Plan and Preparation for Compost

The BUSPH team collected samples of Department of Public Works (DPW) compost, as described below, on February 23, 2012 at the DPW facility. The sources for the DPW compost were leaf yard waste collected by the City. On March 12th and March 15th 2012, a team from BUSPH conducted one sampling event each at three composting
facilities (C1, C2, C3) located within 30 miles north of the Boston area. The facilities all differed in functional operations. C1 operated as a farm, with no livestock on premises. C2 was the largest facility, and solely dedicated to composting. C3 was a medium-sized operation relative to C1 and C2. The compost testing was carried out at the request of the City of Boston, for the purpose of exploring suitable options for procuring compost for the City’s newly launched Urban Agriculture Initiative.

The following sampling plan and preparation steps were followed for the February and March sampling events. Members of the BUSPH team visually divided a compost pile into four quadrants of approximately the same size, about the surface of the pile. Within each quadrant, four sampling sites were identified, from which first, a shallow sample, then, a deep sample were obtained. One quadrant produced a total of four shallow samples, which were then mixed to create a composite shallow sample. The four deep samples were also mixed in this manner. These steps were reproduced for each quadrant, which yielded a total of eight samples per compost pile (one shallow, one deep sample per quadrant). Figure 11 below demonstrates the sampling plan graphically.

The composite samples of the February and March sampling events underwent discrete X-ray fluorescence (XRF) analysis for metals at BUSPH. The composite samples from the sampling events were prepared and submitted for analysis under chain-of-custody to the University of Massachusetts Extension Soil and Plant Tissue Testing (UMass) and Alpha Analytical laboratories. Each sample that was prepared for the off-site laboratories was a mixture of the eight composite samples from each composting site.
Soil sampling from the Site

In the summers of 2009 and 2010, BNAN conducted one sampling event each year of the soil in the garden. The soil samples were sent to UMass for analysis. Only lab reports from the UMass Plant and Laboratory were obtained. The field notes were
unavailable for review and therefore how the sampling plans were executed could not be
determined. This point value was used for IEUBK modeling, with the major constraint of
methodological uncertainty. Therefore, the results were interpreted with a low degree of
confidence in the data, and were used for comparison purposes, rather than to make a
statement about actual risk at the Site.

BUSPH XRF

Compost samples were dried and prepared by the BUSPH team after sample
collection for analysis by X-ray Fluorescence (XRF). Measurements of total metals were
obtained using the Innov-X Systems model Alpha-6500 XRF analyzer and test stand.
The team documented proper calibration, quality assurance, sample presentation
measures for testing, as outlined by the Innov-X manual (Innov-X, 2005) and EPA
guidelines for Method 6200 (USEPA, 2007c).

A subsample obtained from each composite sample was placed into a sealed plastic
bag, laying flat, to a minimum of 0.5 inches, for XRF analysis. XRF readings were
obtained in triplicate, from three discrete locations of the bagged subsamples, with a
thirty second live time (testing time). The soil was mixed in between measurements to
maintain homogeneity of the sample. Detection limits for lead were low enough for the
XRF results to be useful for data analysis. However, the level of detection was not low
enough for all metals analyzed and those data were not included in this analysis.

ALPHA ANALYTICAL LABORATORY

All compost samples were submitted under chain-of-custody to Alpha Analytical
Laboratory, for analysis of semivolatile organic compounds (SVOCs) by EPA method
8270C (USEPA, 1999) and of lead by EPA method 3050B/6010B (USEPA, 1996). Of note, these methods have been approved and evaluated by the USEPA. The data produced by these EPA methods can be used legal cases since the lab complied with regulatory criteria.

**UMASS**

Many residential gardeners nationally and locally send samples to UMass Extension Plant and Tissue Laboratory for analysis of their garden soil. It provides a key service to gardeners who need their soil analyzed expediently and affordably. UMass Soil Testing Lab screens nutrients and metals (P, K, Ca, Mg, Fe, Mn, Zn, Cu, B, Al and Pb) as part of routine testing, using a Modified Morgan extracting solution: dilute glacial acetic acid (0.25 N CH₃COOH at pH 4.8) and ammonium hydroxide (0.62 N NH₄OH) to extract a fraction of the total bulk lead of a sample.

The “extractable” lead is a measure of the reactive lead of the sample—the fraction of total lead that is contained in a sample that could potentially impact physiological processes. The UMass laboratory estimates total bulk lead on the basis of the extractable lead component. UMass cites that the correlation the between the two measurements has been established by previous analysis of over 300 soil samples with both the Modified Morgan’s extractant solution and “a more rigorous total soil digestion [procedure]” (UMass, 2012). Extracted metals are then analyzed by inductively coupled plasma atomic emission spectroscopy (ICP-AES). The purpose of the Modified Morgan’s test is to assess the concentration of bulk lead that would, in the human body, be of impact to physiological processes. The UMass Method is currently not a recognized as a regulatory method.
Data & Analysis

The datasets represent compost measurements from DPW Compost and the compost facilities for the samples collected by BUSPH for the City of Boston, and City compost.

**BUSPH Sampling Results**

*DPW Compost*

The results of the Feb 2012 COB DPW compost sampling event and XRF data indicate that one-third of the XRF measurements (N=24) exceeded the MassDEP Soil category S1 standard (See Appendix H), 300 mg/kg, associated with unrestricted use. The range of concentrations was reported 200-413 mg/kg, and the mean concentration, 283 mg/kg. The analysis of the samples submitted to Alpha Analytical yielded concentration measurements of 200 and 240 mg/kg (N=2, mean 220 mg/kg). Both mean concentrations were below S1 standards, however, the both exceeded the recommended interim lead concentration for compost of 150 mg/kg (Heiger-Bernays, 2012).

*Boston-Area Compost Facilities - BUSPH XRF*

BUSPH testing involved only XRF for metals. The largest facility (C2) had the highest mean level lead, which was expected due to visual evidence of a wide range of compost feedstock (sources for compost) during the site visit. In addition, there was a distinct nitrogenous odor from the pile sampled, despite expecting the absence of biosolids in the pile. The smallest facility (C1) yielded the lowest mean lead concentration. The results of the lead analysis are summarized in the table below:
**Table 5:** Compost Sources C1-C3 XRF Pb Results (BUSPH). Mean concentrations in bold.

<table>
<thead>
<tr>
<th>SITE</th>
<th>SPECIFIC CONCENTRATION FOR IEUBK MODELING</th>
</tr>
</thead>
</table>

The results of the analysis by UMass of the soil samples of the 2009 and 2010 sampling events conducted by BNAN at the were used in the IEUBK modeling to emphasize the uncertainty with which these soil Pb were obtained. Since it can not be determined where in the garden these samples were taken, assuming reasonable worst case
scenario is warranted to use as site-specific input for the soil lead parameter value of the IEUBK. Central tendency measurement would not be appropriate in this case since it cannot be ruled out that there are in fact, higher concentrations of lead existing in soil of the garden. As stated in previously, lead concentrations cannot be assumed to be heterogeneous throughout the soil matrix.

IEUBK Results

The IEUBK model outputs that were interpreted for analysis included calculated PbB associated with a 5 μg/dL and 10 μg/dL cutoffs with 1.6 Geometric Standard Deviation (GSD), and less than 5% probability of exceeding the cutoff—a USEPA health protection goal for clean up at contaminated sites. The two different cutoffs yielded very different results. The predicted soil Pb with all other inputs held at parameter default values yielded the following values:

1. With all defaults, at the 5 μg/dL cutoff (5% health protection goal), the Soil Pb concentration is **153 ppm**
2. With all defaults, with the 10 μg/dL cutoff (5% health protection goal), the Soil Pb concentration is **418 ppm**

Table 6 below summarizes all the results of the model runs.
### Table 6: IEUBK Assumptions and Results

<table>
<thead>
<tr>
<th>Run#</th>
<th>Soil Pb (mg/kg)</th>
<th>Source</th>
<th>Air Pb (µg/m³)</th>
<th>Source</th>
<th>Water Pb (µg/L)</th>
<th>Source</th>
<th>BLL Cutoff µg/dL</th>
<th>%above</th>
<th>GMB (µg/dL)</th>
<th>Age Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>2a</td>
<td>283</td>
<td>2009 BNAN</td>
<td>0.016 [1]</td>
<td>2</td>
<td>[4]</td>
<td>10</td>
<td>0.847</td>
<td>3.255</td>
<td>default</td>
<td></td>
</tr>
<tr>
<td>3a</td>
<td>200</td>
<td>default</td>
<td>0.1 default</td>
<td></td>
<td>4</td>
<td>default</td>
<td>10</td>
<td>0.287</td>
<td>2.73</td>
<td>default</td>
</tr>
<tr>
<td>3b</td>
<td>200</td>
<td>default</td>
<td>0.1 default</td>
<td></td>
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<td>default</td>
<td>5</td>
<td>9.889</td>
<td>2.73</td>
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<tr>
<td>6</td>
<td>92</td>
<td>C1</td>
<td>0.025 [2]</td>
<td>1</td>
<td>[5]</td>
<td>5</td>
<td>0.377</td>
<td>1.424</td>
<td>default</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>105</td>
<td>C3</td>
<td>0.025 [2]</td>
<td>1</td>
<td>[5]</td>
<td>5</td>
<td>0.633</td>
<td>1.549</td>
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</tr>
<tr>
<td>9</td>
<td>92**</td>
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<td>4.492</td>
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<td></td>
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</tbody>
</table>
In comparison, Run 3, which used all default parameter values, including soil Pb of 200 ppm, the model calculated a 9.9% probability of exceeding a 5 μg/dL cutoff at the default Pb soil; and 0.287% for 10 μg/dL. This indicates a significant difference between the theoretical exposures for Charlestown, and those assumed by the default parameters.

The IEUBK findings are consistent with the HOB 2010 and 2011 reports (BPHC, 2010 and 2011) for Boston overall. Boston ELLs were compared to the IEUBK results since Charlestown count was less than 5 cases BPHC 2011 and 2010. However, the interpretation of the IEUBK modeling should not be misconstrued to be generalizable to the population of Boston children (USEPA, 1994a).

In meeting one component of the objectives stated from the outset of this work, the results of modeling were used to back-calculate a range of acceptable levels of lead in soil. To reach the health goal of less than 5% probability of PbB exceeding 5 μg/dL, soil Pb would have to be no greater 153 ppm mean soil Pb. Based on the PbB screening data for Charlestown, it is expected that chronic garden exposures to soil Pb do not contribute significantly to the blood lead burden of a hypothetical child since the results of the IEUBK modeling indicate 2.3% risk of exceeding 10 μg dL (see results of Run 2c), whereas actual PbB screening indicates 0% prevalence, as discussed earlier.

Based on the model trial outputs, the highest predicted GMB (2.3 μg/dL) was demonstrated by Run #4, which employed 400mg/kg for soil Pb, the USEPA soil screening level (SSL). With the exception of soil Pb, Run 4 employed environmental Pb
concentration assumptions that were substantially below those that were used for the default run (Run 3). The default run was for reference. A twofold rise in soil Pb resulted in a one and a half times increase in GMB and almost a fourfold increase in affected population.

**Compost Pb**

The probability of exceeding PbB of 5μg/dL with compost from the non-DPW ranged from 0.38-1.13%. For DPW-sourced compost, was approximated at 16.9%, using the same parameters. Changing the indoor dust to 200 (constant) resulted in a substantial increase from 0.38 to 4.5 and GMB 1.4 to 2.3 for 93 mg/kg soil Pb from C1. This run illustrates the importance of limiting exposures to indoor dust. Had C1 compost been brought into the garden, and that level was maintained, even exposure to Pb at concentrations less than “natural” soil (100 ppm) could result exceeding 5μg/dL.

In 2012, the City of Boston consulted BUSPH faculty for interim recommendations for acceptable ranges of lead in soil and compost for screening purposes. Based on their request, BUSPH responded with a memo that suggested interim goals of 100 mg/kg for soil and 150 mg/kg for compost. Furthermore, the memo recommended that “Compost or soil with [bulk] lead concentrations >200 mg/kg (200 ppm) or arsenic concentrations >10 mg/kg (10 ppm) should be rejected” (BU Letter Recommendations, 2012). The memo also acknowledged that there are other mitigating factors, such as soil pH as to why bulk lead is not the strongest indicator of bioavailable lead.
Discussion

Limitations and Uncertainties

Site History
Assessing historical point-sources for contaminants that are ubiquitous, especially in an urban area with documented commercial and industrial activity such as the Mystic waterfront, is difficult. However, this uncertainty is not likely to affect the overall characterization of risk of the Site since it is assumed that it is probable that other sources would have contributed to overall lead contamination of the garden soils.

Compost Sampling & Analysis
According to the XRF device manufacturer, arsenic measurements may have had a loss in precision due to high Pb concentration, which would cause overlapping in spectral peaks (Innov-X, 2005). The accompanying software does correct the interference, but not without some precision error.

BNAN Soil Testing
One major limitation was the uncertainty involved in the soil measurements from 2009 and 2010 since there was no knowledge of the sampling plan or the rationale behind it. Therefore, these data were not used to make a statement about potential exposures at the Site due to the lack of confidence in the data.
IEUBK limitations

The IEUBK is based on relatively recent exposures, limited usefulness in real-life setting because of clearing time in blood. A blood value for a six year old will not be indicative of possible high exposures to, or adverse effects of, lead when he was an infant. While modeling allows some estimate, or concept of risk to a human receptor, this measurement would be more accurate with site-specific readings. This would require the input of actual soil Pb data and other environmental media.

As recommended by the IEUBK Guidance, all other default model parameters were left intact. In doing so, the model runs reflect multi-media (soil, dust, air, diet, water) lead exposures. The run outputs demonstrate higher risks than those posed solely by soil exposure alone. The use of default parameters is justified since cumulative exposures across media are likely to produce a more realistic approximation of risk faced by the theoretical young child. The predictive power of the model would be more accurate if site-specific sampling data of air, dust, water, bioavailability, drinking water, and other adjustable parameters had been obtained for model inputs.
IEUBK Environmental Inputs Uncertainties

Air: The location of the TSP sampler to measure airborne lead levels changed midyear from Kenmore Square to Harrison Ave (Dudley Square) due to the renovation of the Kenmore Square monitoring station. The maximum detected concentration in 2009 between both monitors was used as the input for the parameter (MASSDEP, 2010) for Run 1a and 1b. This is likely to overestimate risk. In addition, the value was the maximum concentration between the 2009 and 2010 data, there is uncertainty in the measurement due to the placement of the monitor at a different location.

Water: The larger of the two 90th percentile of water Pb measurements was used in Run 1 to indicate an upper estimate of probability. One limitation of these historical lead data is that the water samples were collected from individual MWRA households that were most at risk of being exposed to high lead levels. Additionally, sampling at a resident’s home occurred on stagnant water, which would have a high concentration of lead.

The water input assumes that 100% of a person’s water source comes from a home tap. Realistically, this would not be the case. Through communication with the MWRA, it was confirmed that tested households in Charlestown did not exhibit extraordinary lead levels differing from those reported for Boston during the years examined (Personal Communication). The sample set for Boston water results was larger, with 26 data points, in comparison to only 2 households from Charlestown. It seemed prudent to use the larger dataset, while losing geographical specificity since the Boston water data was assumed to be more representative of actual risks.
EBLL screening rates (BPHC, CDC, MADPH)

The PbB screening data reported are solely related to the screened population. While it is mandatory to screen for PbB in Massachusetts of school-age children, it is possible that adherence to screening may not be actually done. In the case of implementation from practitioners or caretakers, this compliance could affect those screened. With an n<5 for Charlestown, this is good news for the population. However, it must be mentioned that utilization of pediatric health services among immigrant families varies (Flores and Tomany-Korman, 2008).

Future directions

Current work is being conducted to characterize bioavailability of urban soil. Determining a range of bioavailabilities of lead and other common urban soil contaminants over different residential areas would contribute to our understanding the connection between exposure and potential health effects and their associated risks. In turn, this would guide practitioners in their recommendations to the public.

More imminent and concrete, is the effect of the new reference value on other federal agencies as limited funding is available for implementation of changes based on the lowered PbB. It was stated in the CDC response that the CDC will work with the to ACCLPP, HUD and EPA, local departments of health, clinicians in the next fiscal year, and that full implementation will be contingent on funding (CDC, 2012a). In Fiscal Year 2012 and Fiscal Year 2013, the CDC will work with federal agencies that may also be affected by these recommendations including, but not limited to, HUD and the
Environmental Protection Agency (EPA). The goal of the summit will be to develop primary prevention strategies. In FY 2012, funding is not available for state and local CLPPPs.”

As climate-related weather patterns change, we may have to rethink risk-management procedures. With the case of regional planning, it would be prudent to have risk management plans in place before events occur. For example, an urban farm in Red Hook, Brooklyn located near the waterfront, was submerged under two and a half feet of water during Hurricane Sandy (Added Value, 2012). In its wake, there was definitive destruction. But what if families depended on these plots for food production, as is the case at Charlestown Sprouts? Sediment contaminant deposition from flooding poses a potential hazard and is worthy of consideration.
Summary & Recommendations

The recommendations to the Steering Committee of the Charlestown Sprouts Community garden are guided by these health-protective and resource-sensitive principles: 1) to reduce risk of potential contaminant-related adverse effects by reducing exposure to soil contaminants and 2) to balance the cost of soil sampling with a physical remediation technique, such as capping suspected contaminated soil with a physical barrier method, such as geotextile.

Other factors to consider for renovation design are timeframe, environmental effects, accessibility, and effectiveness for agriculture (RUAF 2006, as cited in EPA 2010) that weighing the options within a risk-benefit schema will be helpful to determine which recommendations are best for the community and the garden stakeholders. Specifically, the coordinators of Charlestown Sprouts Community Garden, guided by the work presented here, may decide to test selectively for certain contaminants due to their limited budget. Based on available data, literature; site-specific and stakeholder concerns, the primary recommendations for Charlestown Sprouts are as follows:

Primary Recommendations
1. Minimize gardeners’ exposure to possible soil contaminants, and thus reducing hazard risk by educating gardeners about garden best practices, which could be implemented almost immediately with minimal resources.
2. Remove all treated timber suspected to contain creosote or CCA, and dispose of properly. Educate gardeners and ensure that railroad ties and other debris not be used in the garden for any purpose. This point is especially important because such materials can be a point source of contamination.

3. Assume from the outset that contamination levels of the soil in situ are above what we would expect for urban fill. Based on that presumption, it is construct new raised beds filled with clean imported soil and/or compost on top of the native soil, with the two layers separated by a physical root barrier such as geotextile. Alternatives to (3) are outlined further below in this document.

**Rationale of Recommendations**

*Benefits of raised beds*

From a fiscal and public health perspective, the optimum recommendation would be to assume contamination exists at the Site and forgo in situ soil testing. This is a precautionary approach that takes into consideration many factors, and driven by the uncertainty of contaminant presence at the Site. Since the cost structure of testing can be prohibitive, and especially dependent on which contaminants are being tested for, it is recommended here to test once each time new soil or compost is brought in for bed fill material. This plan would feasibly entail only one initial testing cost, and whenever new soil or compost is needed to refill the garden beds. Some benefits of raised beds are noted below:
- Can improve water drainage
- Control over soil quality. Tested clean fill should remain clean. Amendments to the soil are also contained in the fixed volume of soil. Because the soil is contained above possibly impacted soil,
- Soil will be less compacted since foot traffic is minimal.
- Raised beds can be more accessible to those with mobility issues or those who find it difficult to maneuver i.e., knee/back problems around a traditional garden bed. Raised beds can also make gardening accessible for those in wheelchairs.

**Gardening Best Practices**

Garden Best Practices encompass steps that an individual gardener or managing group can take to reduce exposure to potential soil contaminants to the gardener and consumer of garden-grown produce. Best Practices are emphasized for children, who tend to exhibit a high degree of hand-to-mouth behavior, thus increasing potential exposures through the ingestion pathway. These practices for the gardeners and gardening Committee are listed below:

*For Gardeners*

- Wash all produce from the garden thoroughly before storing or consuming raw, or using for cooking. While high heat may kill off pathogens, contaminants such as heavy metals do not get “boiled off” under those conditions.
- Wash hands thoroughly after contact with the garden soil. Wearing gloves minimizes contact with soil and is recommended.

- Minimize tracking in garden dirt by leaving gardening shoes outside the home. Regularly launder clothes worn during gardening.

- Peel root crops such as carrots, beets, and potatoes after washing or scrubbing to physically remove possible contaminants that may have adhered to the root vegetable. They are particularly in greater contact with soil than other vegetables. Remove the outer leaves of leafy vegetables.

- Avoid using pesticides and or chemical applications whose chemical content is unknown, especially if not from U.S.

_Garden Governing Body_

- Do not permit garden in untested areas/plots

- Don’t bring in fill from unknown sources

- Regulate the use of materials and chemicals that may potentially impact soil quality
**Alternative Assumptions**

Based on how the stakeholders would like to proceed with testing, the following alternative assumptions about the quality of the potentially contaminated native soil are offered below. In all cases, gardeners should be educated on best practices to reduce potential contaminant exposure to reduce total body burden. Additional testing may be necessary to determine the extent of contamination in the soil.

Alternative 1. Soil is not assumed to be contaminated. Native soil is tested for a wide range of chemicals including lead, arsenic, etc. Based on the results of testing, the Committee and coordinators can decide on how to proceed with renovations, construction and possible remediation.

1a. If contamination is present above recommended guideline levels (MASSDEP S-1; See Table xx) then remediate or build raised beds over geotextile. Remediation in this case can include excavation and removal of contaminated soil, and importing fill that has tested to be clean. This would be the most expensive of all options presented here.

1b. If contamination is present below these guidelines, proceeding with construction of regular (non-raised) garden beds would be acceptable.

Another round of testing should be carried out after any renovation. Since this alternative requires at minimum, two rounds of testing (once before and once after renovations) for a range of possible soil constituents, this would be the most costly option.
Alternative 2. Soil is not assumed to be contaminated. A tiered approach to sampling could be conducted. The first phase of sampling and analysis would include lead and arsenic—significant risk drivers—priority contaminants based on land use history and high level of hazard potential. The rationale for the initial testing of lead and arsenic is that these metals predominate in urban fill and it would be rare for other metals to play a significant role (Swanson and Lamie, 2010)

2a. If the measured total concentration of either metal is higher than recommended, then soil would be remediated, or raised beds should be constructed.

2b. If however, the sample results indicate neither chemical is present at levels above the recommended values, then a decision as to whether to test for other possible contaminants can be made. At this juncture, it would be prudent to consider the primary recommendation or steps listed for Alternative 1 can be followed, or listed above would be made. Again, testing would be costly, especially for PAHs. At that juncture, it would still be possible to assume contamination, and to build upward.

**Sampling and Analysis**

Based on the case history information presented in this project, it is critical that any future sampling plans reflect actual exposure areas in the garden. As a caveat, sound public health recommendations can not be predicated on one point estimate of contaminant concentration. The sampling plan should be constructed to be inclusive of different areas for future uses and spatial considerations. Sampling plans and collection should be well-documented. While the scope and type of testing may be limited by budget constraints, analysis should be rigorous and defensible.
The sampling plan should take into consideration the types of activities that will occur at an area of the garden. For instance, for gardening activities, exposure would feasibly happen at deeper depths in the soil, than for a child playing on the soil. This is a likely scenario. Another scenario would involve a child digging along side an adult gardener. At minimum, the extent of the soil depth being tested is relative to the activity associated with use.

Analysis should take into account potential contaminants based on known or most probable uses. Again, if the historical use of the land is not clear, then assumption of presence of a large scope is more prudent. The analytical criteria and soil parameters that would need to be included in testing will be driven by the decision of the garden coordinators and at what stage in renovation testing is being considered. At minimum, lead should be tested for.

*Excavation*

The current use of plots restricts growth to a household plot and so sampling of the soil within the plots should be tested. However, if additional areas are to be used in the future for growing, they should be tested as well. Testing each plot is not recommended. Rather, composite sampling is preferable, since there is a large scale of variability within soil. (Clark, et al 2008) and composite sampling is more likely to capture variability. For Charlestown Sprouts, one way to devise a sampling is to separate the areas of concern.
One or more composite samples could be from the newer plots, while another area could be subdivided to produce several composite samples.

Excavation costs have not been evaluated here, but according to the RAM document for Charlestown High School athletic fields, it was recommended by the Licensed Site Professional in that report that “eight feet excavation would capture the full depth of urban fill at this location” (MassDEP, 2007). Given the shared history of the athletic fields and the garden, it is probable that the LSP’s recommendation be applicable to the Site.

In the Charlestown garden where construction debris was documented during the site visit, every worker and gardener should be take precautionary measures and be aware of the hazards that may lie under the soil surface. Rebar, nails, glass, etc. were all materials present at the Site during the Site Investigation. For this reason (among others stated above), children should be closely supervised while at the garden during play or gardening activity.

**Importing Compost and/or Soil**

Compost and soil should be screened for contaminants before importing to the garden. The BUSPH Department of Environmental Health found that bulk lead in compost varied among different sources of compost in the Boston metro area. The analysis found compost from the City’s leaf and yard waste curbside composting program exhibited the highest levels of lead compared to private sources.
Testing can be accomplished at the compost source site, if it has been determined which pile has already been earmarked for the garden.

**Non-removal of timbers**

If the Committee decides to leave the treated timbers in place, for various reasons such as cost, it is recommended that planting in the area around the timbers be limited to non-edible plants to reduce possible exposures to PAHs.

**How clean is clean and how safe is safe?**

For urban fill, we would expect to find elevated levels of contaminants e.g. Lead, PAHs (mostly as a result of anthropogenic activity) above the concentrations found in “natural soil.” The Table from Appendix K is a list of regulatory concentrations (S-1) from the MassDEP that are applicable to the situation for testing. Results of IEUBK modeling data imply that a mean soil Pb of 153 mg/kg would yield an acceptable risk in the gardening scenario at Charlestown Sprouts.

To contextualize the cost of testing, a sample estimate from Alpha Analytical, (15 samples) would run upwards of $900. Analytical methods and fees included in this estimate are: Total arsenic (EPA 6010B), Total lead (EPA 6020B), Total Metal Prep, Total Solids (SM2540) and sample disposal fees. For a lot this size (.9 acres), about 20 samples are recommended. Obtaining samples for analysis can be carried out by trained persons or gardeners at the discretion of the Committee and coordinators.
Concerns to keep in mind after renovations or remediation:

Possible wind-blown salt (regardless of the construction of the beds), can redeposit after renovations. However, the raised beds will continue to protect any overland migration of the salt in water. In situ, the natural chemical balance (cation exchange) of the soil may have been affected by the past use. As stated earlier, the pH of the soil may also be affected, mobilizing other chemicals in the soil. Further impact of salt in the channel is likely to be minimal when considering Na Cl because of the water’s buffering capacity. However, since it is inconclusive as to whether fugitive dust is impacting the soil, due caution by following the recommendations above is to protect the health of the gardeners.

In summary, the best plan of action and its rationale has been outlined here. Alternatives and their rationales have also been presented. All options are offered, with the goal of limiting exposures to possible soil contaminants and the paramount objective of protecting gardeners’ health. With these aims in mind, any revisions to the sampling plan and renovations based on new knowledge is encouraged.
Appendices
Appendix A

Figure A-1: Assessor's Parcel #0202735000. Parcel boundaries are outlined in red.
Source: City of Boston EGIS Public Web Viewer version 1.0.0 © 2007
Figure A-2: Construction equipment found on premises. Note the bare soil pathway, which leads to the rear of the garden. And the bric-a-brac in the background that had been pulled out by the garden coordinators.
Appendix B

Figure A-3: Approach to Site. Photo taken in easterly direction.

Figure A-4: Approach to Site. Photo of seawall directly south of Site.
Appendix B

Figure A-5: Current conditions at Site. Note the granite curbstone in foreground.

Figure A-6: Rebar found at the grounds.

Figure A-7: A garden path toward rear plots.
Appendix B

Figure A-8: View of the Site from southwest corner of Site, facing northeast.

Figure A-9: View of the Site from southwest corner of Site facing north. Note the salt pile located behind the Site. In addition, the topography of the garden mound can be visualized in this photo.
Appendix B

Figure A-10: View of a garden plot. Note the various materials used to reinforce the construction of the bed.

Figure A-11: Same garden plot as above, view from the other side of the wall of ad-hoc materials.
Appendix B

Figure A-12: A plot located toward rear of garden, with various materials used to construct a supportive wall for garden bed.

Figure A-13: Debris found on Site grounds.
Appendix C

Figure A-14: 1912 Combined Bromley map of Mystic Wharf and Site area. Source: Mapjunction, BRA
Appendix D

Figure A-15: 1955 Aerial photograph of Site. Source: USGS, Mapjunction (BRA, 2012)

Figure A-16: 1973 Aerial photograph of Mystic Wharf with overlay of businesses in operation at that time. Source: C.E. Macguire, Inc., 1973.
Appendix E

Figure A-17: BRA Plan Map Charlestown Urban Renewal Proposed Land Uses (Source: BRA, 1964)
The maps presented here provide an overview of the land uses in the area over time from the period of 1971-1995.

**LEGEND:**
- Pink: SPECTATOR REC.
- Gray: TRANSPORTATION
- Yellow: WASTE DISPOSAL

**Figure A-18:** 2001 Orthographic image (Source: MassGIS Oliver)

**Figure A-19:** 1975-1985 Land Use (Source: MassGIS Oliver)

**Figure A-20:** 1985-1999 Land Use (Source: MassGIS Oliver)
Appendix G

Table A-1: Results of DPW Compost Sampling XRF (BUSPH)

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<td>7-Mar-12</td>
<td>Q4 - Shallow</td>
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277 Median
283 Mean
192-413 Range

Samples collected Feb. 21, 2012
## Appendix H

### Table A-2: PAHs and Metal Concentration Recommendations

<table>
<thead>
<tr>
<th>Chemical Analytes</th>
<th>Recommended Concentration (mg/kg)</th>
<th>Natural (mg/kg)</th>
<th>Background (mg/kg)</th>
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<td><strong>Metals</strong></td>
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</tr>
<tr>
<td>Arsenic</td>
<td>20; &lt;10 recommended</td>
<td>20</td>
<td>20</td>
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<tr>
<td>Cadmium</td>
<td>2</td>
<td>2</td>
<td>3</td>
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<tr>
<td>Chromium</td>
<td>30</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>Copper</td>
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<tr>
<td>Cyanide</td>
<td>100</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Lead</td>
<td>&lt;100 soil; &lt;150 compost</td>
<td>100</td>
<td>600</td>
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<td>Nickel</td>
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<td>20</td>
<td>30</td>
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<tr>
<td>Thallium</td>
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<td>0.6</td>
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<td>Zinc</td>
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<td>100</td>
<td>300</td>
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<td><strong>Polycyclic Aromatic Hydrocarbons</strong></td>
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<tr>
<td>Benzo(b)fluoranthenne</td>
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<td>1</td>
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<td>Chrysene</td>
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<td>Dibenzo(a,h)anthracen</td>
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<td>1</td>
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<td>Fluoranthene</td>
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</tr>
<tr>
<td>Pyrene</td>
<td>1,000</td>
<td>4</td>
<td>20</td>
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</tbody>
</table>

All values are MADEP S1 Standards except for lead. This reflects background levels and concentrations measured in compost and bulk soil.
References


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MWRA. 2012 Personal Communications


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Vita

BARAM KIM

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Born: 1979

EDUCATION

BOSTON UNIVERSITY Boston, MA
Graduate Medical Sciences, M.A. in Medical Sciences expected January 2013
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concentration in Environmental Health

BARNARD COLLEGE, COLUMBIA UNIVERSITY New York, NY
B.A. in Sociology October 2001

EXPERIENCE

BOSTON PUBLIC HEALTH COMMISSION Boston, MA

Integrated Pest Management Intensity Impact Study (IPMIIS)
Conducted multisite fieldwork of HUD sponsored community-based participatory research study at Boston public housing developments.

Duties encompassed: outreach; recruitment and enrollment of consented study subjects; administration and of survey tools; environmental (pesticide and allergen) sampling; and referral of subjects to appropriate services.

**CURRICULUM DEVELOPER**

**AND INSTRUCTOR**

**SEED LEARNING CENTER**

Bayside, NY


Taught high school students following disciplines: critical reading and writing, biology, chemistry, and mathematics at introductory through AP levels.

Developed logical reasoning/verbal skills enrichment and biology curricula

**RESEARCH COORDINATOR**

**WOMEN’S INTERAGENCY HIV STUDY (WIHS)**

Montefiore Medical Center and Mount Sinai Medical Center

Bronx, NY and New York, NY

July 2003 - July 2005

Responsible for identifying, tracking, and enrolling subjects from a pool of 500 participants for substudies of NIH national prospective women’s HIV study.

Communicated potentially sensitive abnormal health test results to subjects, and apprised them of WIHS follow-up procedures.

Organized and administered substudy clinics for subjects at two hospital sites.
REGIONAL PROGRAMS DEVELOPER

AGA KHAN HEALTH SERVICES, PAKISTAN

Lahore, Pakistan

July 2001 - Sept 2001

Conducted on-site operational research on efficiency of rural health centers in the Punjab and North West Frontier Regions

Counseled health care practitioners on the importance of preventative care and detailed documentation of patient medical history and demographics

OTHER EXPERIENCE

Volunteer Medic

COLUMBIA UNIVERSITY EMERGENCY MEDICAL SERVICES

New York, NY

Sept 1998-May 2001

CERTIFICATIONS AND SKILLS


AWARDS AND INTERESTS

Dean’s List (September 2000-May 2001); Columbia University King’s Crown Gold Leadership Service Award (May 2001); Urban Gardening/Agriculture, Climate Change Adaptation, Food Systems, Sustainable Development, Urban Planning for Health, Bicycling Advocacy; Cello and harmonica