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Linking advanced public service learning and community participation with environmental analytical chemistry: lessons from case studies in Western New York

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1. Introduction

Partnerships involving service learning or clinical field work in environmental science, engineering, public health and law and policy are common and growing. National evidence of this is the examination of environmental justice (1) in the 1990's, which led the National Institutes of Environmental Health Sciences (NIEHS) to incorporate public participation and community partnerships within major grants for environmental public health studies. The experiences of these projects and others provide lessons about the complexities of government involvement in service learning partnerships from the environmental sphere.

In Erie and Niagara counties in western New York (WNY), the major cities of Buffalo and Niagara Falls, with many other municipalities have provided a fertile region to explore environmental service learning opportunities. In this chapter, a review of case studies from WNY serves to illustrate the nexus of interactions at multiple levels. Efforts in WNY are heavily influenced by the history of Love Canal (2,3). Further, the continued efforts have resulted in the integration of efforts in multiple universities and colleges, among many academic schools, departments and disciplines. Figure 1 summarizes the organizational relationships and identifies some of the participant organizations exemplified in the case studies that are reviewed here.

A particular focus is the experience that results from dealing with the overlapping regulatory and policy responsibilities of various government institutions.

On important service learning vehicle has been the lead author's efforts in aligning an advanced undergraduate chemistry course entitled "Analytical chemistry of pollutants" (4). Beginning in 1994, course revisions for service learning built on the existing academic chemistry framework, which involved students working in teams to design and execute field studies, including sampling, analysis and reporting. These were married to structure and action based on common models of public service learning (5,6). The resulting twelve years of work has had broad impact on teaching, research and service in environmental analytical chemistry at UB and in Western New York.

A special focus of this chapter is the illustration of the multiple complex relationships between these environmental service learning projects and the host of (sometimes) overlapping government agencies. Environmental and environmental public health agencies operate at all levels of government, including federal, state, local, school districts, towns, cities, counties, and their interactions with service learning initiatives, from the university, faculty and students, is both interesting and successful and fraught with difficulties. The exemplars provided in this chapter should illustrate all aspects of those types of relationships.

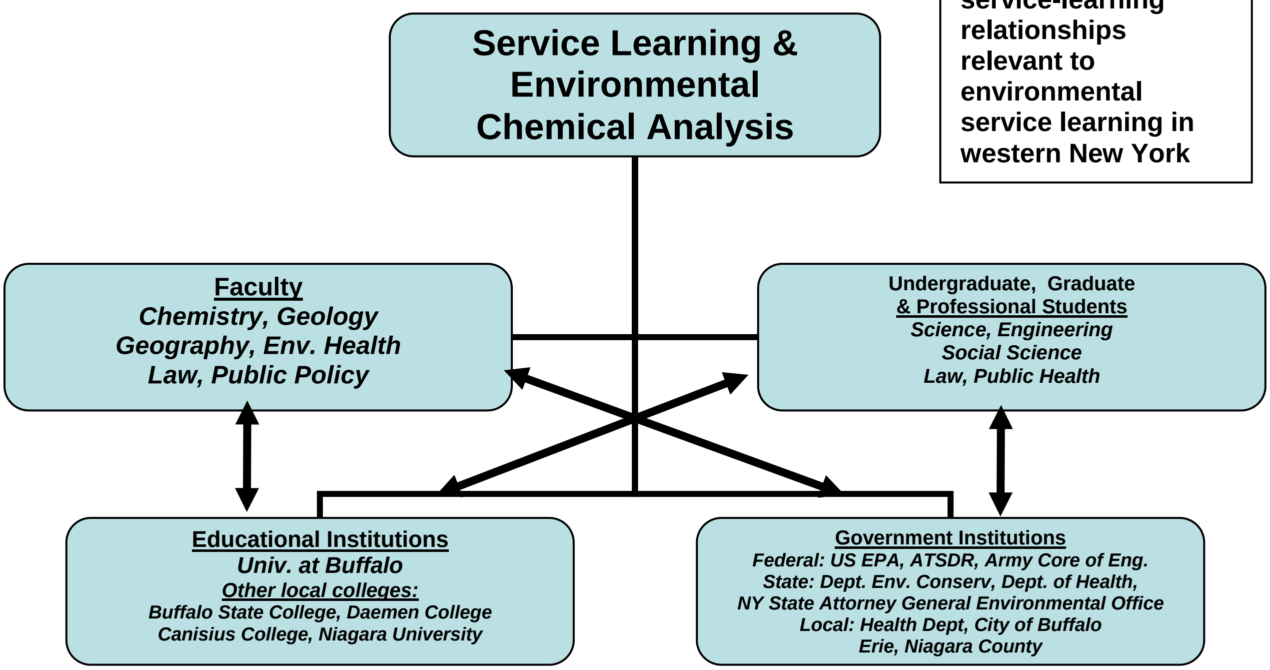


Figure 1: Nexus of service-learning relationships relevant to environmental service learning in western New York

2. Background

Mindful of George Santayana's famous dictum (7), many lessons from the lead author's undergraduate experiences in environmental pollution analysis in service to community needs were captured in the projects. At Oakland University, in Rochester Michigan, through the 1970s, Professor Paul Tomboulian, of the Chemistry Department, led groups of undergraduates in research programs responding to community needs, while working with elected officials in local government. One major focus of that work was environmental sampling in rural, suburban and urban areas, mainly in water quality and environmental microbiology. One project of the lead author's was the identification of illegal connections of human sewage lines to storm sewers in Lake Orion, Michigan, polluting Paint Creek, a stream that connects Lake Orion to Rochester (8,9). Working with community elected leaders and public agency personnel, the experiences led to lessons about basic analytical chemistry, environmental analysis, interdisciplinary work, the public communication of science and science journalism, and the state of standard methods in environmental analysis.

One particular example involved a response from the local health department in Oakland County. Studies of creek water by the students at Oakland were publicized in the local press. The identification of human waste input into Paint Creek was challenged by the health department, who offered the opinion that the waste was due to animal sources, given the rural nature of the majority of the land that the creek flowed through. A joint sampling and split analyses by both the college and Health Department laboratories were agreed upon. However, upon collection of analyses, we learned that the critical (standard method) test that distinguished between animal and human waste sources for the microbes detected in the water was not available to the Health Department. Thus, the conclusion that the source was animal waste was based on limitations, not on results of testing. This exposed the author to key aspects of government regulatory work in the environment, and to the potential for narrow interpretations based on minimal compliance. It set the basis for many of the preparations for government collaborations in the service learning projects over the past 13 years.

Working with this history, we set out to modify the UB Chemistry course and align it to community needs; at a time when attention to service learning opportunities in science were increasing (4-6, 10-14). Service learning in undergraduate chemistry classes has had a distinct environmental focus, led by nationally recognized faculty such as Professors Alanah Fitch of Loyola University of Chicago (11) and Edward Eyring of the University of Utah (12), one focus is lead analysis in communities. Many other faculty at colleges and universities (10,13,14) have developed innovative field courses in environmental analysis that study environmental indicators of pollution and bring student skills into expertise for their communities.

3. Issues affecting government environmental efforts

A first issue involves the regional environmental history. The lead author came to Buffalo in 1982, near the end of the initial phase of the impact of Love Canal. Love Canal (2,3), where buried toxic waste began leaking into residences, causing community concerns about public health impacts, and resulting in the first instance of federal (indeed, presidential orders for) emergency relocation and demolition of housing also led to the development of so called Superfund legislation, where a tax on industry was used to create an emergency relocation and remediation fund, with identification of responsible parties and reimbursement to the government after immediate action. In New York, both federal EPA and state Department of Environmental Conservation (DEC) have funded Superfund programs, that are available to deal with identification of toxic sites with potentially significant health impacts on surrounding communities.

Love Canal has a more immediate local impact in the minds of WNY residents, professionals in public environmental agencies and university and college faculty. The two most important lessons that one can glean from working with Western New Yorkers steeped in Love Canal lore are

- community activism is required to get industry and government to respond to environmental pollution based problems (residents), regardless of the advances in regulatory efforts and
- some local, state and federal health and environmental agency representatives lack respect for and some actually fear community activism; these people see it as a lack of knowledge about chemical exposure, toxicology and relative risk.

It is important to identify the impact of this community context into preparing students for public participation in the course.

Secondly, there is great complexity of responsibilities in different agencies. In Figure 1, we illustrate a range of government agencies involved at all levels of government. At the federal level the US Environmental Protection Agency (EPA) and the US Army Corp of Engineers (USACE) are involved in a variety of ongoing projects, and provide first line environmental work. For public health issues related to the environment, the Center for Disease Control's Agency for Toxic Substances and Disease Registry is often a resource on public health impacts of environmental issues, and is involved in studies of health impacts in cooperation with EPA. At the state level, typical of most states, New York has both an active environmental function in the state Departments of Health (NYS DOH) and a fully functional Department of Environmental Conservation (NYS DEC), along with an environmental action bureau in the Office of the New York State Attorney General. At the local level, city and county health departments and environment and planning functions are common, along with school districts, which often are involved in environmental issues from the perspective of protecting children and staff.

In each case study below, we will focus on the roles of participants from government in terms of regulatory requirements and public participation requirements, since the role of this service learning initiative has been focused on engaging community with the public's right to know and understand environmental issues.

All agency staff at all levels tread a fine line in responding to community involvement and encouraging public participation, including participants from college students and professors. Often, they try to balance a tension between listening and answering questions and demands from community groups, from established block clubs to hastily constructed residential groups, with answering to sometimes conflicting priorities set by elected officials. Agency officials often grow impatient with attempting to "validate" the relevance and credentials of what constitutes a community stakeholder and defer instead to answering to elected officials as the appropriate "representative of the people".

This dilemma can be detrimental to defining the support of service learning to community involvement. It is not unique to environmental community controversies, however, and is a longstanding tension in American democracy. Princeton Professor of History, Sean Wilentz, in his book, "The Rise of American Democracy, Jefferson to Lincoln" (15) describes the historic American roots of the tension between public participation in government decisions and elected officials making decisions for the public. Wilentz discusses the origins of the tension at the earliest stages of American democracy, in George Washington's administration, to de Tocqueville's descriptions of early 1830's American society, through to Lincoln's expanded definition of democratic rights for a broader spectrum of Americans. Wilentz presents the idea that "sovereignty rightly belongs to the mass of ordinary individual and equal citizens," represented a new departure in the Western Tradition.

Of relevance to the present dilemma in environmental public participation, Wilentz traces the rise of two overlapping but distinct groups pressing for greater popular participation in public affairs--rural democrats, attuned to local self-government and fearful of centralized political power, and city artisans, who demanded a say in urban affairs but proved willing to support a powerful national government such as that created by the federal Constitution. Such city artisans are a forerunner of community groups established to deal with local environmental issues.

Indeed, even in the earliest days of the American democracy, critics of George Washington's Administration established Democratic-Republican societies, which insisted on the right of the people to debate public issues and organize to affect public policy. Washington, who saw the government, not private associations, as the authentic voice of the people, condemned the societies as "self-created." But Wilentz insists this was precisely what made them democratic-- unlike most previous political groups, they were not formed by political leaders, yet they claimed the right to scrutinize and criticize the conduct of elected officials. The parallels of Wilentz' work on the rise of American democratic structures are directly relevant to the balance between community groups as stakeholders and elected officials played out in many environmental issues. An understanding of this dilemma can help frame community involvement in service learning, where government agencies, and their staff juggle the difficult decision to serve multiple interests.

4. The Course

Chemistry 470, the Analytical Chemistry of Pollutants, has been taught at UB since the 1970s. At that point, the course involved a lecture component focused on environmental statistics and analytical methodology for detection of pollutants in air, water, soil, sediment and solid wastes. A field study project involved students writing a proposal and work plan for field sampling and analysis, and execution and reporting of a sampling, analysis and reporting project. The projects that were accomplished often relied on a significant fraction of the students who had experience or were working part time in commercial or government environmental laboratories, and often utilized laboratory resources from those sites.

The revision of the course (Table 1) in the mid 1990s occurred with four steps. First, new content was added to prepare students for community involvement and the work with government agencies, including standard methodology (Table 2) and efforts in case studies. The lecture components focused on analytical methodology for various media (air, water, soil, solid waste, sediment) were also adapted to real world case study approaches, based on the infrastructure at UB as the National Center for Case Study Teaching in Science (16, 17). Original case studies were developed by the lead author to complement the basic methodology lecture material. Subject areas for case studies are listed in the table.

The third step involved shifting the course emphases as they related to the development of the public service environmental analysis projects. The old field study requirement involved small groups of two to four students, focused often on evaluating new measurement technologies. This requirement was evolved to the design of larger, class based projects that necessitated not just collection of data but method and data validation. The studies have potential to be used to make recommendations to the public, elected officials, industry representatives and environmental agency professionals. A university laboratory that is used for student education and research is unlikely to meet Good Laboratory Practice (GLP) standards, or be able to achieve EPA or New York State certification for environmental data collection and validation. Thus, we first shifted the emphasis of analytical methodology in the course to focus on the strengths and limitations of ***standard methods.*** This meant infusing concepts of standardization, and the need for standard methods in the environmental testing industry. While the rise of new analytical technology is still a focus of lecture material, analytical performance of standard methodology is stressed, as those methods are set up, validated and used in the community based testing. Standard methods are commonly used in two areas, elemental analysis of metals and semivolatile organic compounds (SVOC) in soils (e.g. using EPA methods series 6000 and 8270), and air pollution analysis of volatile organic compounds (VOCs) adapting NIOSH methods TO1 and TO2.

Topic	Weeks	Lecture topics Case Study Materials Problem Sets
Statistics for Environmental Analysis	1-2	Statistics Definitions Crummit, et. al., Anal. Chem., 1980. (18) Problem Set 1 Applications/Issues
Thermodynamics of Pollutant Movement	3-4	Transport in water, sediment, soil, air Equilibrium predictors: e.g. octanol water Kinetic predictors Problem Set 2
Analysis of Natural Water Systems	5-7	Metals in water Chemical transformations Elemental Analysis methods Case Study: Organophosphate pesticides in water: degradation products
Analysis of Soil/Solid Waste	8-11	Volatile and Semivolatile organics in soil, Partitioning in soil, sediment, solid waste GC, LC, GC-MS Organochlorine Pesticides Dioxin Analysis
Analysis of Air Pollution	12-14	FTIR methodology Remote sampling Source sampling Particulate sampling Ozone Hole Chemistry Global Warming
Project Reports & Presentations	15	

In addition, while statistical analysis of data has always been emphasized throughout the core of analytical chemistry syllabi, a stronger emphasis on data quality for environmental measurements was introduced. For this, the “Guidelines for Data Acquisition and Data Quality Evaluation in Environmental Chemistry” (18), are used. This document was first published in 1980 by the American Chemical Society Committee on Environmental Improvement and the subcommittee on Environmental Analytical Chemistry. An emphasis in reviewing analytical performance, data quality evaluation and quality assurance has also been added to the course, through review of the field study after introduction to environmental applications of experimental statistics.

The fourth and final change involved the work of transforming the field study into projects that responded to community requests and concerns. This was accomplished in two steps. In the initial step, a project was developed in response to a request from the City of Buffalo Office of the Environment. The project examined potential soil contamination in areas adjacent to Houghton (nee Stachowski) Park, an urban park along the Buffalo River in the Kaisertown neighborhood of Buffalo. Adjacent to the park is a site presently used as if it were an extension of the park.

However, this land had been a popular dumping ground through the 1970's for waste for the City Parks Department, along with local industries, who were also suspected of illegal dumping. The New York State Department of Environmental Conservation (NYS DEC) had identified contaminants and surface soils similar to combustion residue, but without a single potentially responsible party, the site was removed from lists (aka "delisting") for state funded remediation.

Table 2: Analytical Methods developed for adapted course

Technology	***EPA or other Standard Methods***	***Target Analytes***
Atomic Absorption (AA) with Graphite Furnace	**Prep: 3050A, 3005 Anal: 6010A**	**Lead, Heavy Metals at low concentrations**
Inductively Coupled Plasma (ICP) Atomic Emission	**Prep: 3050A, 3005 Anal: 6010A**	**Metals, esp. Arsenic, other related elements,**
Gas Chromatography-Electron Capture Detection (GC-ECD)	**Prep: 3500, 3550 Anal: 8081**	**Pesticides, Chlorinated Compounds, e.g. PCB's**
GC-Mass Spectrometry (GC-MS)	**Prep: 3500, 3550 Anal: 8270A, 8260** **NIOSH TO1, TO2**	**Semivolatiles, PAH's, PCBs, Pesticides** **Volatiles, Benzene, Toluene, others**

The class of 26 students was divided into four teams, involving 1) planning and reporting, 2) sampling, 3) sample workup for metals and semi-volatiles and 4) chemical analysis. Soils were tested and compared to the park and to adjacent and nearby housing, and elevated levels of heavy metals, PAH's and chlorinated pesticide residues were quantified. Testing results were supported by split samples analyzed by a commercial certified environmental laboratory. With a detailed report in hand, the local City Councilman was able to obtain federal block grant funding for remediation of the lot. While the program was successful from the standpoint of implementation of the methodologies, validation of the results, and in fact, the outcome of the student's work, no community members, groups or block clubs had been engaged in the planning and reporting.

With this experience, and a certain naïveté about how the process could be successful, we undertook the second phase, incorporating community consultation into projects in subsequent years. In the second phase, students in the course were organized into groups of four to five students, focusing on a particular analytical project within an area of concern. So, unlike the first year, where the entire class focused on one soil analysis project, in subsequent years, student groups might be involved in soils analysis and air analysis but all involved in the same community problem. Rather than distributing the work across the entire class, the group projects were focused on a particular analytical problem, and the group had to organize all facets for the project (design, sampling, analysis and reporting/validation), within their group.

Finally, a key issue in public service learning is the need to sustain collaborations with communities beyond semester based experiences. In all experiences with the course, as it has been modified, it has also served as a vehicle for recruiting students into longer term undergraduate and graduate research projects. This creates both unique opportunities to expand the development of the course materials, but also sustain the interactions with communities.

Grading in the course has several components. First, there are problem sets, mid-term and final exams on the class lecture/case study material. The project reports consist of a fully documented report, with data tables, and a presentation that is provided to the community, and serves as a document for grading. Besides the homework, exams and oral presentations and final report, the students are asked to prepare self and group evaluations. Using methods of self assessment, journals and self reflection common in service learning courses (5,6,10), the students are required to review their contribution to the project, and their team members, in a narrative essay. That material serves as a means to assign distribution of credit in the project and to have the students critique their participation in the project.

5. Public Participation

An outcome of the past twelve years of work has been critical and evolving approaches to preparing students for the process of community participation, especially when it involves collaboration or interaction with government agencies. The work is not simply a matter of providing “expert” advice as a consultant, to people who do not know what questions to ask. In fact, our observation is that community members ask sophisticated, complex and difficult questions. We also know that many parties are involved, community members, industry, government agencies and elected officials. Many times, while on the surface, our efforts are “welcomed” by all involved, there are clear tensions that develop among other professionals; industries, agencies and elected officials. The lead author has been involved in many pitched political battles as an outcome of these experiences; however, some clear advice and training for students involved in these studies has been developed. The key ideas are captured in the six “Rules of Engagement” in Table 3. These are a short hand for students to think about information and process in working in the community. Open communication is critical, obviously. But more than that is needed for science and engineering students, many who have not likely been prepared for the process of political debate and public communication. Much of what is developed for students must be guided by the research in community engagement and public policy. For public participation (as opposed to public notification), the International Association for Public Participation (IAP2, www.iap2.org) has particular relevance for environmental decision making. Their core values are given in Table 4.

Table 3: Rules of Engagement

Rules of Engagement for Academic/Community Interactions	**Key Questions and Comments for Students and Faculty**
Define the Problem	What does each stakeholder want to achieve?
Define the Players	What are the specific roles and responsibilities of all participants and stakeholders? Which are driven by statutory or regulatory concerns?
Consult the Community (Listen)	How can all voices be heard and respected? Learn to develop collaborative methods for agendas, meetings, hearings Don't accept conventional wisdom from agency, industry or community experts without listening to all voices.
Get the Data	What are the relevant measurements? How do these measurements relate to regulated measurements? What information is not being collected by standard measurements and monitoring? Can the community design the measurement strategies?
Interpret, Make Decisions	Define the results of the measurements to the community. Use collaborative techniques to answer further questions from the community.
Make Recommendations	Make clear reports that address specific recommendations to the community, industry, elected officials and government agencies.

Table 4: Public participation IAP2 (www.iap2.org) core values
The public should have a say in decisions about actions that affect their lives.
Public participation includes the promise that the public's contribution will influence the decision.
The public participation process communicates the interests and meets the process needs of all participants.
The public participation process seeks out and facilitates the involvement of those potentially affected.
The public participation process involves participants in defining how they participate.
The public participation process provides participants with the information they need to participate in a meaningful way.
The public participation process communicates to participants how their input affected the decision.

It is interesting to note that the IAP2 framework has been utilized by the NYS DEC Environmental Justice training, state wide. In fact, the lead author was asked to help with local (WNY) training opportunities using his experience and familiarity with public participation. It is also interesting to note that the training has limited effect on day to day operations; while some of those staff trained in environmental justice and public participation view this as a tool to engage the public, the tension between public engagement and elected officials is not overcome. Further, the demands of the IAP2 core values are quite high; asking that communities engage in planning and execution of work, that they be given the right to influence the work that is done. In practice, regulatory compliance driven efforts often limit the

6. Role of Research

Besides the efforts to engage the public, a key effort has been to translate data into forms and formats that effect the understanding of the public and serve to simplify the data. Geographic Information Systems (GIS) and Geographic Information Analysis (GIA) can serve this role, and a special effort to transform GIS information for public consumption is a major effort in the GIS community. So called Public Participation GIS (PPGIS) is an active area of study.

Often, with environmental data, a lack of geographic awareness is evident in the general populace and also with policy makers. In this era of IT domination, GIS holds the key to multi-disciplinary solutions of many socio-environmental problems that have so far been inadequately addressed within a non-geographic framework. As Seiber (19) writes GIS can assume the ubiquitous role as a technology to "present a visually compelling image of an issue and quickly analyze data from disparate sources. However, GIS are such flexible technologies that they assume different roles (e.g. cartographic tools, spatial databases, decision making tools, education assets etc.) depending on the context of use. For the purposes of the work presented here, GIS is primarily used as a portal to spatial awareness—i.e., teaching general populace to appreciate that "*where-ness*" matters in most social and environmental investigations. The public however need not care about the specific spatial technology in use, as long as they ask the right spatial questions and maintain a healthy rate of geographic information consumption.

Taking advantage of the research strengths of GIS and GIA complements government agency efforts in data analysis; providing a level of data analysis for the community that is often better than agency capabilities, and empowering the community with information that government or industry does not have.

7. Case Studies

A. Overview Over the past 11 years we have developed long standing relationships and collaborations with six different communities identified on Figure 2. Table 5 summarizes the studies that have taken place in each neighborhood.

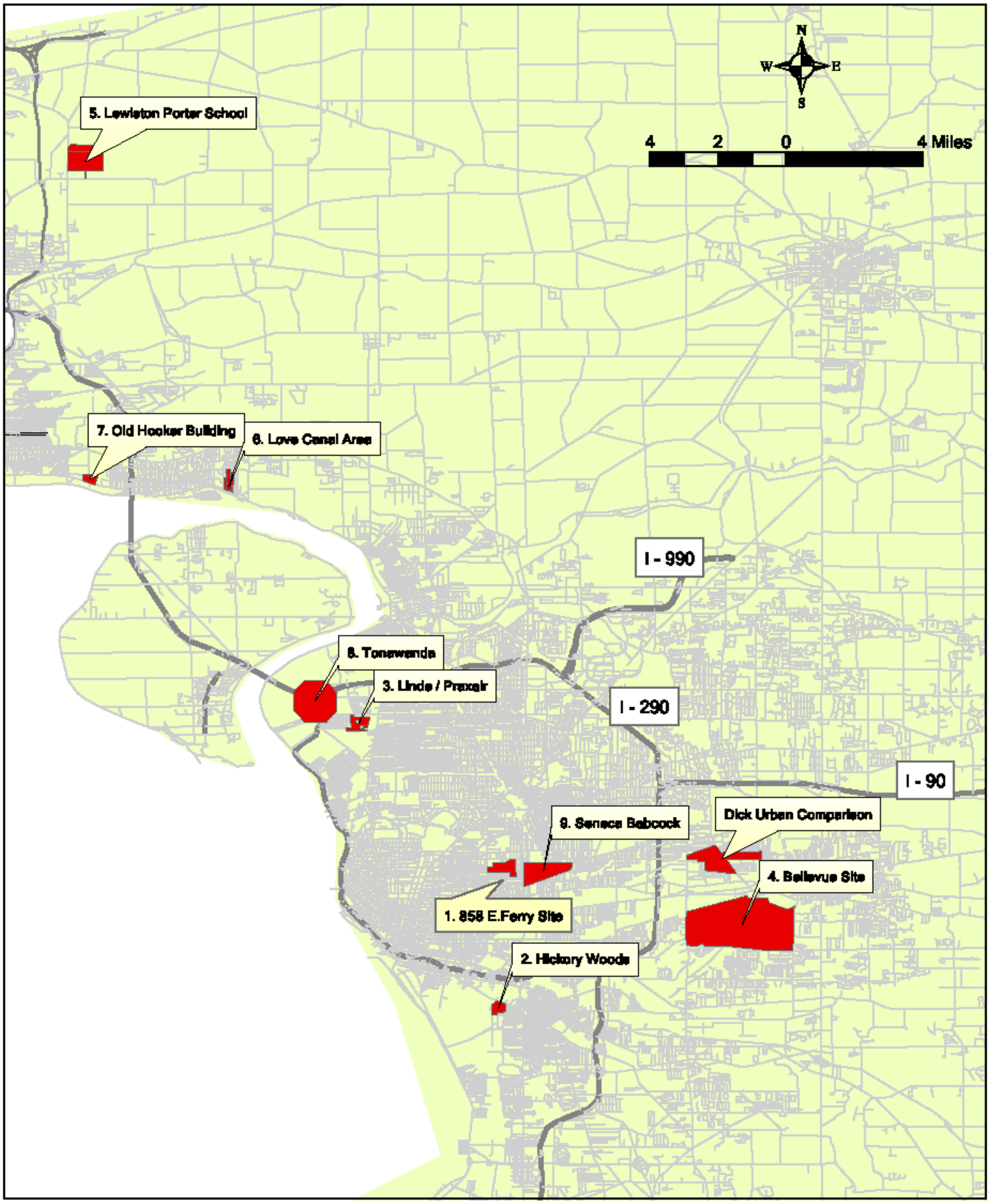
In Seneca Babcock, air emissions from chemical plants and soil contamination from local industry affects low income residents in the poorest neighborhood in Buffalo (per capita income = ca. $7000). Hickory Woods is a community of federal and state subsidized construction of new housing built adjacent to a former coke plant and steel mill, now a New York State Superfund site, and presently being remediated. Some of the housing was built on contaminated land with city knowledge, despite warnings from the New York State Department of Health to conduct a phase I

Table 5 Community projects with long term sustainable collaborations

Community Name	Studies underway or completed
Seneca Babcock (Buffalo)	• Air emission of indigo dye related pollutants • Soil study of neighborhood park with lead emissions
Hickory Woods (Buffalo)	• Soil studies of metals • PAH Source apportionment by multivariate statistics • GIS studies of soil contamination, location and sources
Bellevue (Cheektowaga) (Eastern Erie County)	• Air emissions from quarry • Comparative study of autoimmune disease prevalence and asthma prevalence
E. Ferry Street (Buffalo)	• Lead contamination outside of superfund site • GIS analysis of lead hot spots • Comparative public health studies of blood lead level, lupus prevalence and asthma prevalence in community
Tonawanda (Northwestern Erie County)	• Soil contamination at school adjacent to Manhattan project uranium processing plant • Air emissions from multiple industries
Lewiston Porter (Northwestern Niagara County)	• Soil contamination at school adjacent to WWII TNT plant, Radium storage site and Hazardous waste landfill • Community GIS evaluation of publicly accessible soil and groundwater pollution

environmental assessment. High levels of soil contaminants dominate the neighborhood. Bellevue/Cheektowaga is a community surrounded by an active quarry, emitting hydrogen sulfides and crystalline silica in air emissions, and three landfills, one cited for illegal dumping of hazardous waste. On E. Ferry street, in Buffalo, a lead smelter operated from the 1920s to 1972, when it was torn down. Extensive lead contamination in the soil exists over a large area, adjacent to a growing church community and public housing. 23 cases of lupus have been documented in the neighborhood, in the surrounding zip code New York State Department of Health reports the highest childhood blood lead levels in the state. In Tonawanda, an elementary school was built in the 1950s adjacent to a site where uranium processing occurred for the Manhattan Project, subsurface groundwater testing on the site shows significant uranium contamination, several radioactive contaminated buildings have been demolished in the past six years. Also, the community suffers from air emissions of carbon disulfide and petroleum products, and one of New York's highest emissions of mercury from a coal fired power plant. Fifty industrial sites within a 2 squre mile area are permitted for air emissions. In Lewiston-Porter, the schools were built on a buffer zone from the Lake Ontario Ordnance works (LOOW), a TNT plant from World War II, later used to store 2000 Curies of K65 (Radium) high level nuclear material, presently stored at the Niagara Falls Storage Site on the adjacent land. A portion of the "remediated" land was then sold to create New York State's only hazardous waste landfill.

Figure 2: Map of Erie and Niagara Counties in Western New York, with regions and neighborhoods where collaborative environmental sampling and analysis projects are ongoing.



The community concerns that exist because of community knowledge of this history and these issues are significant, and not trivial. The discussion of the four cases that follow exemplify a number of key issues for community participation in study design and execution, the need to identify preparation for students doing community work, the advocacy that follows a commitment to the long term, and the impact of the work in urban environments.

B. Seneca Babcock The Seneca Babcock community, a 1 square mile area within the city of Buffalo, just north of the Buffalo River, was built as employee housing for the first chemical plant in Western New York, the Schoellkopf Dye Works, later known as National Aniline Corporation. In 1972, National Aniline was acquired by Allied Chemical, and split into three companies, the Allied (now Honeywell) Buffalo Research Laboratories, Buffalo Color Corporation, which retained the indigo dye manufacturing components, and the PVS chemical corporation, which acquired the portion of the chemical facility that produced sulfuric acid and derivatives. Buffalo Color operated until 2002, when it went bankrupt due to overseas competition, leaving a federal Superfund site that is presently being remediated by the EPA. Three or more generations of chemical workers and their families still reside in the neighborhood, as noted above, among the poorest in Buffalo. Like many industrial neighborhoods, housing is interweaved with industrial sites, some operating, some abandoned, and in the 1950s, the New York State Thruway Authority built the southern portion of the US Interstate 190 ring highway for Buffalo through this neighborhood. Extensive railroad lines also crisscross the neighborhood.

In 1995, PVS Chemical emitted an extensive sulfur dioxide release, an air pollution event that stayed in the area for five days. After years of battling for better monitoring and attention, a community/industry coalition was developed according to Good Neighbor Planning projects that had been developed in Austin Texas, Chattanooga, Tennessee, and Philadelphia, Pennsylvania and with consideration of the (then) Chemical Manufacturers Association (now American Chemistry Council) Responsible Care™ programs for community advisory committees. In 1996, as an outcome of the first Stachowski Park project, the lead author was asked to join the Good Neighbors Environmental Committee, to help provide the neighborhood with better access to understanding of environmental contamination, air quality monitoring and communication between the companies and the community.

For the first four years of collaboration, a series of air and soil monitoring studies were undertaken with collaboration from the community. The first work involved developing and adapting personal air sampling badges for volatile organic compounds and a specific badge sampling for formaldehyde. This project was based on concerns from the residents about the nature of odors in the neighborhood. Using techniques of community sampling, the residents collected samples, which were extracted and analyzed using GC-MS. A series of studies identified typical VOCs that were detected in the neighborhood, but the data was supplemented by extensive sample notebooks kept by the residents. The residents also implemented personal air sampling pumps to develop better sensitivity and detection limits.

Among the most important study was one involving formaldehyde. The residents, industry representatives and local government were working with data from the US EPA Toxic Release Inventory (TRI) for Buffalo Color Corporation, the company that had the most extensive air emissions. Formaldehyde was often cited by industry representatives as a compound that would be present in household indoor air pollution, from a variety of sources, and their emissions, mainly part of a sewer permit, would not be the source for community exposures. To test the notion that community involvement works, we tested for formaldehyde using a specific test badge (20,21), and the NIOSH 3500 chromotropic acid/visible spectroscopy method. The results of over 80 badges were developed and reported by students to the community. The main result was that high formaldehyde exposures were limited to those who lived with or were 2 pack/day cigarette smokers. Thus, by the residents collecting their own data, they were able to validate what industry told them, but they only believed it when they had independently developed the conclusion.

This was a powerful lesson for the community and industry; and on this basis, Buffalo Color industrial hygiene staff began a closer collaboration on the projects. Using TRI air pollution data and a collaborative risk evaluation and education project, the community developed a sampling plan for aniline and ammonia, two pollutants emitted with the highest risk for exposure. Buffalo Color was forthcoming in designing the sample points to be near their point source of emissions. The community was assuaged from concern about aniline emissions when extensive air sampling over several months could not detect aniline in the area. Thus, the conclusion that cigarette smoke and other exposures were more significant than that from TRI reported releases was made by the residents and students. This of course, confirmed the hypothesis and claims of government and company representatives, but it was done by the residents collecting the data themselves, not based on the claim of industry representatives with no data.

The lessons from Seneca Babcock were many; including the ability to build trust, help industry communicate with the community and empower citizens to collect their own air samples, with students providing the chemical analysis. Unfortunately, the successes of working with industry, government and community were short lived for the program, although they led to the request for the lead author to get involved with the Hickory Woods community.

C. Hickory Woods In 1988, construction of a few modest homes (selling for $50-60,000) in a small neighborhood that bordered an abandoned Republic steel mill and the Donner Hanna coke plant began as part of a novel public housing program to use federal and state housing funds to build subsidized new homes. In addition, grants were available to purchasers of older homes to make improvements. This strategy of public housing had been used successfully throughout Buffalo by the leadership of the (then) mayor and his housing and planning offices, and received nationwide recognition as a strategy to move away from high rise public housing, and encourage neighborhood development by private home ownership. The mayor, whose parents never owned their own home, sought to find a neighborhood for this development in his own home district of South Buffalo, and thus, Hickory Woods was developed from an older housing area, again bordering an abandoned industrial site. At the same time as the housing program developed, the steel mill and coke plant were demolished, leaving 219 acres designated later as a class 2 New York State superfund site. In 1992, building on his predecessor's successful home ownership strategy, a newly elected mayor began a second phase of home construction began in Hickory Woods. These were more expensive homes (selling for $100,000), and a large strip of land was given from LTV Steel (the owners of the Republic Steel/Donner Hanna plant) to the City of Buffalo, along Abby Street, which bordered the NYS Superfund site. The NYS DEC was responsible for testing and evaluation, and remediation planning for the site, west of Abby Street.

Concerns about potential soil contamination from the Superfund site were identified immediately, but despite a letter from the New York State Health Department in 1993, and the insistence of the developer, the City of Buffalo ignored their recommendation to pursue a phase 1 environmental assessment of the land. A new developer was engaged, and homes were constructed until 1999, when a city inspector was called to Abby Street to identify construction problems with a home foundation. The inspector identified liquid coke wastes on the site, high in carcinogenic polycyclic aromatic hydrocarbons (PAHs). Soil testing was pursued, and high levels of PAH's were detected in nine lots, five undeveloped and four with housing completed, three already with residents. The residents were moved out of the homes, and those lots were remediated. However, residents in the neighborhood began to raise other concerns, such as the identification of contamination hot spots, the sources of contamination found elsewhere in the neighborhood, the use of city trucks and city employees to transport soils from empty lots at 2am in the morning (caught on video!). They also wanted to know why the remediation was limited in scope. Finally, they asked why the fence lines of lots were magic. In other words, how could an extensively contaminated site 5 feet away be dangerous, but the lot next door, be safe?

In 2000, the city asked for help from EPA staff. Upon reviewing the data and information, EPA constructed a substantial soil study of the neighborhood (about 70 homes over just a few city blocks), taking six hundred soil samples at the surface and at multiple depths. The results clearly showed elevated levels arsenic, lead and PAH's in various regions of the neighborhood. At this time, no comprehensive remediation plan exists; several lots were remediated by the EPA, and a public park, the site of extensive arsenic contamination, a contaminant with no relation to the Superfund site, has been remediated. However, the residents are still left with their fundamental questions about hot spots and magic fences.

These questions were:

- What are the contaminants and how dangerous or toxic are they?
- Where are the hotspots in the neighborhood? ("hotspot" = elevated level of concentration of contamination plus geographic area (not property lines) and depth)
- Why are cleanups restricted to fencelines or property lines? and
- What is the source of contamination?

In the spring of 2001, we began to develop a geographic information systems and analysis (GIS or GIA) approach to categorizing and analyzing the soils data from the EPA studies and all previous studies that were publicly available. A key feature of the project was the lack of willingness of EPA, DEC or DOH to undertake a geospatial analysis of the large amount of data. Citing confidentiality issues, EPA and DOH declined to address the neighborhood concerns. The University study went door to door to obtain permission to use individual data sets from each residential lot to create the GIS database and provide mapping to answer fundamental questions about hot spots. The work has involved several masters level students and three Ph.D. students, several who started work by taking the CHE 470 course as undergraduates, two who then served as teaching assistants. The GIS/GIA approach has yielded a substantial, independent analysis of the soils data so that the community has prepared a remediation plan for the neighborhood. While many local and national news reports have focused on the issues of constructing housing on contaminated land, without careful testing, the neighborhood remains in negotiations over their "Three R's", relocation, remuneration and remediation. However, the approach to GIS/GIA has played a significant role in two other cases, and underpins all other public participation projects we undertake.

Extensive geographic information analysis has been accomplished (23-25) to define areas of contamination and the relationships between surface and subsurface contamination, and the relationships between the Superfund site contamination and that in the neighborhood. Three contaminants were of major concern, lead, arsenic (not related to the Superfund site) and polycyclic aromatic hydrocarbons (PAHs). The latter contaminant was directly related to the coke waste on the Superfund site; and the fact that land used for housing was part of the activities of the manufacturing on the site, despite the claim that the property line ended at a particular street. The controversy about the source, level and effects of the contamination is still continuing, as residents attempt to develop a plan for remuneration, relocation and remediation. In 2006, a newly elected city administration began working to develop a comprehensive cleanup plan and relocation/remuneration plan for those affected. After six years of effort, the City of Buffalo is finally utilizing the geographic information analysis first developed in 2001.

In this case, students developed extensive use of geographic information analysis, along with the design of soil sampling and testing, interpretation of results and working directly with residents on interpretation of the results for potential use for planning the extent, depth and geographic plan for remediation. This is an exciting example of new research driven results having a direct impact on a continuing political and environmental controversy. Residents have learned a great deal about soil sampling, soil chemistry, contaminant toxicology and geographic information analysis.

D. East Ferry Street Superfund Site This site was first identified as a hazardous site in 1997 by the City of Buffalo. The contamination resulted from an abandoned industrial complex housing a zinc and lead smelter and refining operation from the 1920s through the early 1970s, when the smelter building was demolished. The original site at 858 E. Ferry (the name the community knows as the site), a 3.32 acre empty lot, was used by the smelter to dump waste ash and slag. Adjacent to the site, at 856 E. Ferry, 2.3 acres, was the actual address of the smelter facility, according to City's 1939 Sanborn maps. The site investigations showed extensive lead contamination (subsurface "soil" values for lead content as high as 96,000 ppm (96 parts per thousand, or 9.6%!). Further, the true geographic extent of lead contamination was not defined in the early studies. Residents in this community were concerned about a variety of environmental health issues, and the link to this superfund site. The neighborhood is part of a zip code district with one of the highest incidences of elevated blood lead levels in children, according to New York State Department of Health data (26,27).

In the late 1990s, a local Baptist minister and community leader, purchased an abandoned supermarket site across the street at 907 E. Ferry. He converted it into a growing church community (now 4300 members), the True Bethel Baptist Church. Concerns in the community about environmental related illnesses led to the establishment of the Toxic Waste Lupus Coalition (TWLC) in 2000 (28). The TWLC was awarded a five year National Institutes of Environmental Health Sciences grant in 2001 to study the incidence of Lupus and other autoimmune diseases and asthma in environmentally impacted communities, in collaboration with the University at Buffalo.

Due to a lack of action by the New York state legislature and governor, funding for the New York State Superfund program was depleted in the late 1990s, and reauthorization took several years. Since the initial studies indicated that the geographic extent of lead contamination was not clearly delineated, residents, church members and the TWLC approached the authors in 2003 to consider the provision of additional lead soil data to provide answers to the geographic extent of pollution. Students first created GIS maps of the existing environmental data from New York State DEC analyses from the neighborhood (Figure 3). These maps, which included overlays of high resolution aerial maps, allowed the community to visualize the present level of knowledge of where samples had been taken and the geographic extent of lead contamination (along with other contaminants). Using these maps, residents and members of the community, along with 10 students, planned and collected 30 soil samples in summer 2003. These samples were taken from private residences, nearby public housing and the True Bethel Church property. Soil samples were analyzed by an EPA certified commercial laboratory for heavy metals. Data showed elevated lead levels (500-1000 ppm) in surface soil samples outside of the 856 and 858 E. Ferry sites (Figure 3b). As a result of this study, NYS DEC planned a much more extensive site sampling plan in 2003, and reported in 2004 (29) that the geographic extent of elevated lead contamination spread further to the west than first identified. Three additional industrial properties to 810 E. Ferry showed elevated lead levels and were targeted for cleanup. The residents worked with a newly funded New York State Superfund planning process to propose their own remediation plan, which was accepted by New York State DEC in 2005. Work began in late 2006 and is continuing to excavate and remediate the entire area, with significant cleanup to residential standards at 858 E. Ferry.

Students worked with community members for several years on development of maps that summarized and explained paper report data. These maps were used to plan where to take samples from the community in areas that included housing, which had not been sampled previously. The community learned about sample collection, chain of custody processes, data analysis and comparison of soil data from surface samples and subsurface data. Further, they had data that was outside of the public agencies control, which allowed them to learn how to use their questions and data to prepare their own remediation plan. NYS DEC representatives noted that this was among the few sites where community involvement actually created the accepted remediation action plan.

E. Lewiston- Porter Schools and the Lake Ontario Ordnance Site (LOOW) The Lewiston Porter Schools in Youngstown (Niagara county) NY were built on land adjacent to several sites which were developed from the former LOOW, a site that covers approximately 7500 acres (Figure 2). The former LOOW is a complex, controversial site whose history is not fully known. The use of this site by the Federal Government began in 1942, first as a TNT production facility and later in the Manhattan project, following with the storage of high level K65 radioactive materials from the late 1940s to the 1980s. Since the 1940s, the area has no longer been entirely Department of Defense (DOD) property; government and private landowners have used the property for various activities, such as high efficiency fuel plants, jet engine testing facilities, a NIKE missile facility, chemical and radioactive waste storage facilities, municipal and hazardous waste landfills, and testing of experimental communications equipment (30). Present uses are the Chemical Waste Management hazardous waste site and the Niagara Falls Storage Site (NFSS), for the high-level radioactive waste. A large number of remedial investigations to assess the environmental impact of these waste management facilities have been conducted in the past in this

Figure 3a: Development of mapping strategies for East Ferry (Buffalo, NY) site. a. Overlay of high resolution aerial photo identifying sites along East Ferry street and areas sampled by previous studies.

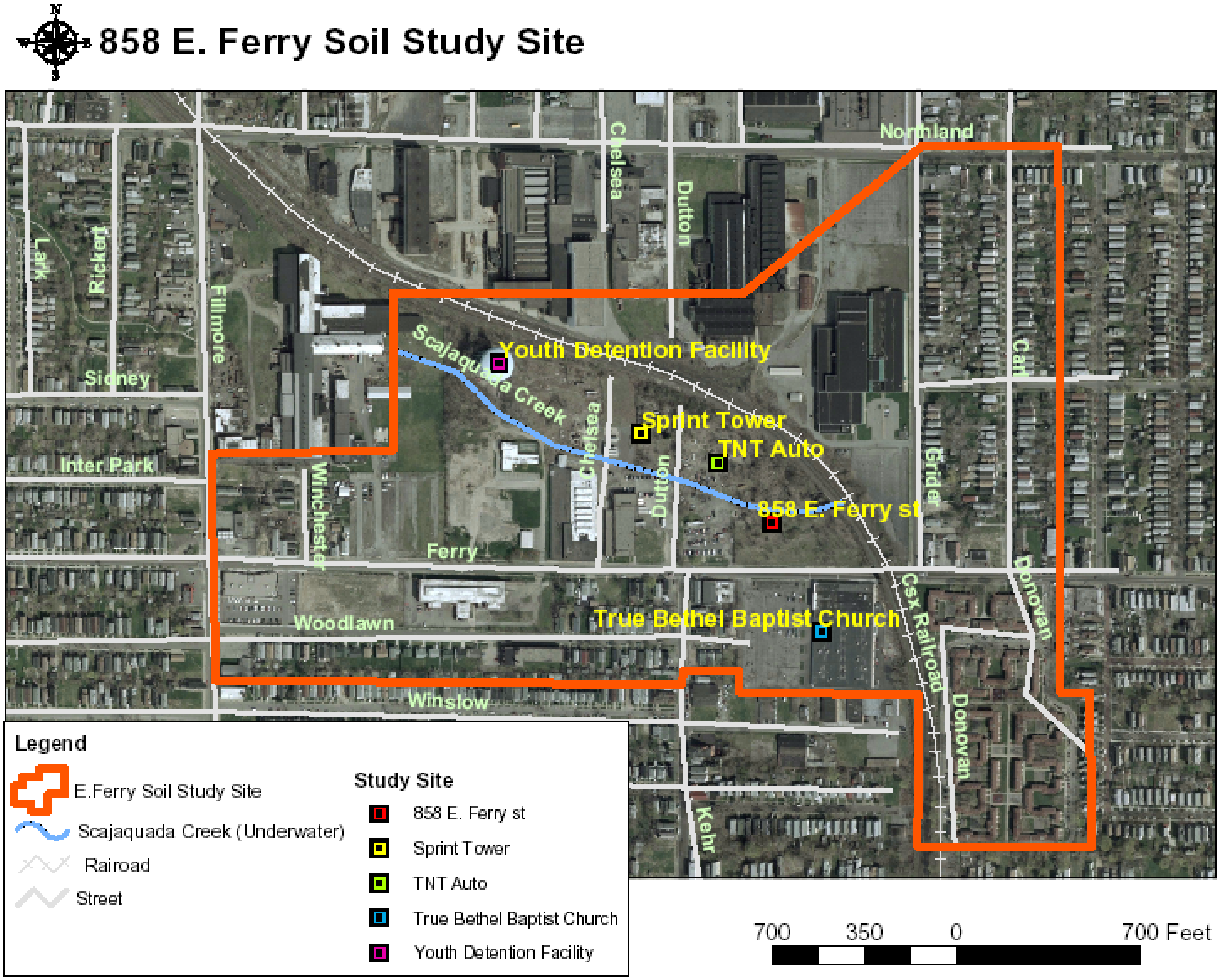
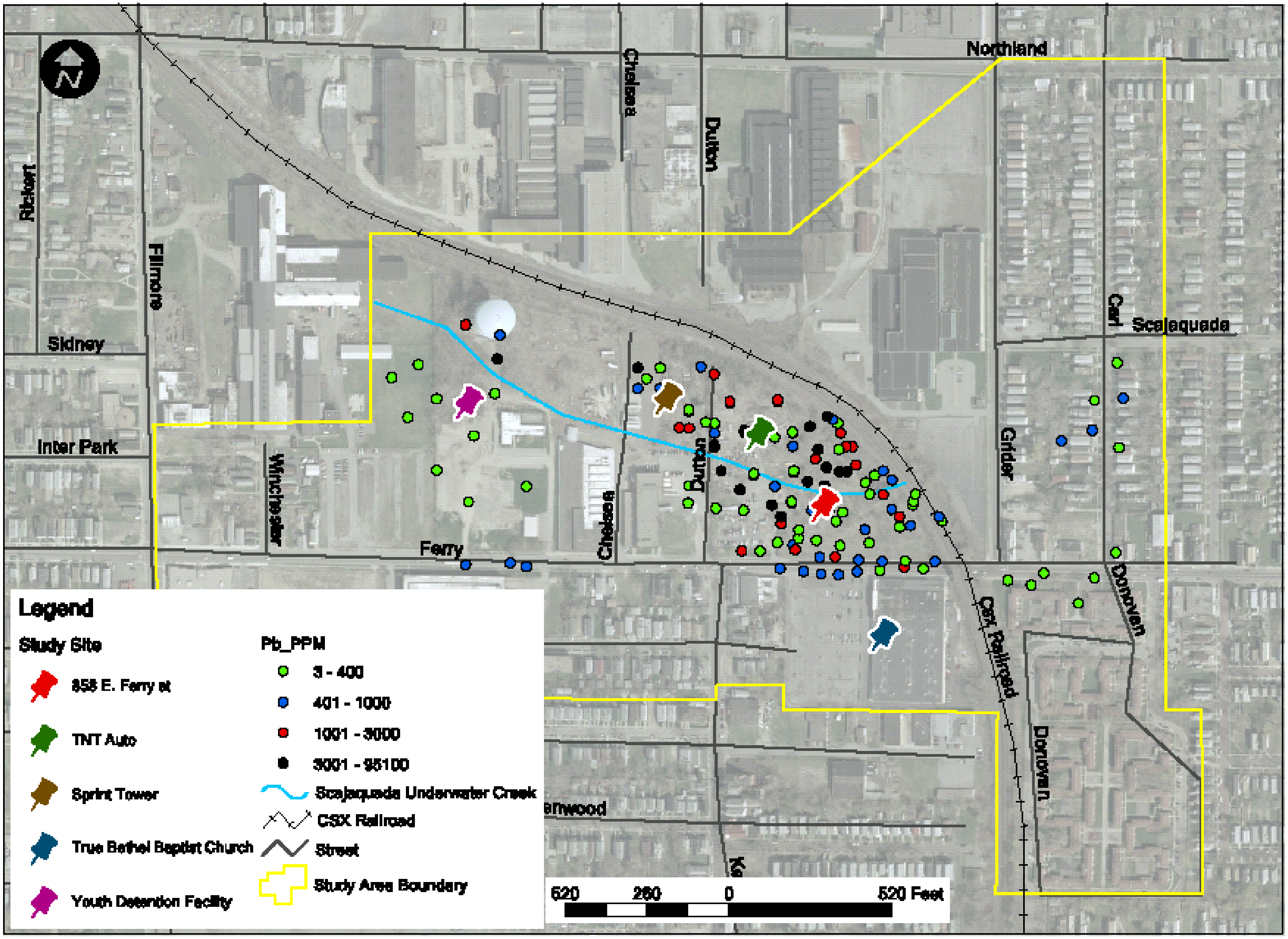


Figure 3b. combination of aerial photograph and geographic information analysis of lead contamination results from all studies.



area by the US Army Corp of Engineers (USACE), the US Department of Energy (USDOE), Chemical Waste Management Inc. (CWM), Modern Disposal Inc. and the Town of Youngstown. Some important aspects of the LOOW site are:

- A storage silo located on the former LOOW site was used to store high activity K65 radium, thorium and uranium radioactive residues from 1949 until 1983 when transfer of the residue commenced until completed in 1985 (31, 32). During that time, the local community was exposed to concentrations of radon gas far above acceptable levels (33).
- The Niagara Falls Storage Site (NFSS) contains a interim waste containment structure including 250,000 cubic yards of residual radioactive material including high-level K-65 residue and “radium, thorium, and uranium” (32, 34).
- Radioactive waste, which would not fit in storage, was dumped on the ground on the NFSS in the 1940’s. The dumping area is 100 feet from a sizeable central drainage ditch that extends throughout the former LOOW site (33).
- The NFSS is bounded on two sides by major waste disposal facilities, CWM and Modern Landfill. (32)

In the summer of 2003, at the request of the Lewiston Porter Board of Education, we prepared a plan to survey the Lewiston Porter Schools campus for potential soil contamination and to involve the public in evaluation, analysis and public outreach about the testing and results. The plan took advantage of previous soil sampling projects accomplished by the District, and cooperation from the US Army Corp of Engineers (USACE) in coordinating results from this study with previous data taken off the campus. Public participation was managed by a stakeholders listening group, evaluating community concerns and developing plans for soil sampling. Following that consultation process, soil samples were taken from 40 spots on and near the school campus. The lead author, the Superintendent and members of the Board of Education met several times and identified six tasks for the Lewiston Porter Schools project.

1. review the testing and results that have been done to date by the district;
2. survey the community with the help of a stakeholder listening group, including residents, parents, staff and teachers about specific knowledge and concerns regarding the Holmes site:
3. meet with US Army Corp of Engineers regarding the Lake Ontario Ordnance Works (LOOW) site and Niagara Falls Storage Site (NFSS) monitoring programs.
4. advise the district concerning the gaps that are presented in our knowledge and prioritize and identify the testing that should be done;
5. advise the district as to what labs or other parties would be appropriate for the particular testing at issue;
6. help interpret the results of the testing for the Board and community.

Student teams were critical to the success of the planning and execution of the project. One MPH student managed the public input and design program. Two geography GIS students managed to global positioning work and GIS development, including the interactive map designs. Chemistry students managed the sampling plan, collection of samples with experts from a EPA certified laboratory, and interpretation of the results. During this project, GIS proved to be an enabling technology by integrating modern surveying data with historical evidence and anecdotal information collected from the local residents. Citizens developed a soil sampling plan to detect surface contaminants and then we ensured a transparent communication of results through easily interpretable thematic maps. This is novel for the community, since partly because of the technical nature of contaminant studies, and partly due to monolithic traditional agency-wide regulations and personnel attitudes, none of the previous studies had considered using a public participation model for remedial investigations. Public health issues were raised by the community throughout this project but were considered outside the scope of the work, and have been a focus of follow up work. The project workflow is presented in Figure 4.

One map of results (Figure 5) highlights an area where elevated levels of Arsenic and PAHs were detected near the northernmost building on campus, the Community Resource Center. Interestingly the presence of Arsenic could not be attributed to the NFSS or LOOW sites; hence it was suspected that it was residue from pesticides used for an apple orchard that may have been present before the land was donated to the school. The evidence for such a farm is however not conclusive. A second stage sampling was planned and accomplished (inset, Figure 4), and results have been used to define a remediation zone near the Community Resource Center.

Concentrations of PCBs and other organic compounds, such as pesticide residues, were below detection limits in a majority of samples, and were detected at trace levels mainly in roadside samples. Other priority pollutants of concern (heavy metals, organic compounds) were detected at typical soil background levels. Lithium (a marker used by the USACE for LOOW activity) was detected at various concentrations across campus, and became a second mapping project of concern to the community, as what constituted background levels is not clearly defined. Further discussion of the lithium results is provided below.

Extensive public consultation was done in the months following the release of results, to design maps of the key results. There were concerns about PCBs being deposited by CWM; however results showed that the campus had non-detectable PCB levels. Since Lead levels were high only alongside roads they were attributable to leaded gas emissions from road traffic and not considered for remediation. The areas of contamination were not located on athletic fields. This assuaged the concerns of the District because they were planning on constructing a new athletic field.

The results from the Lithium analysis are a good case example of the community participation in the follow up to the analysis results. Community members had expressed concern about the information from Lithium concentrations to the USACE. The Army Corp provided extensive databases of their analyses of soil contamination on the two sites that they monitor and other sites where they had taken data near the schools. These data were integrated into the mapping results and allowed us to determine that arsenic levels were elevated compared to the sites outside the campus.

Lithium results were important as a measure of activity on the LOOW site; yet, lithium itself is not a priority pollutant or health concern. Background levels for this element are not well established and the USACE proposed background level had not gained confidence in the community. Thus, we set out to establish i) the background level of lithium, ii) what constituted an elevated level, and iii) whether there were elevated levels on campus. The results showed a distribution of higher lithium concentrations on the eastern part of campus. But consultative meetings with the stakeholders listening group and the USACE staff and a review of existing literature established

Figure 4. Project flow plan for public participation program in Lewiston Porter Schools project.

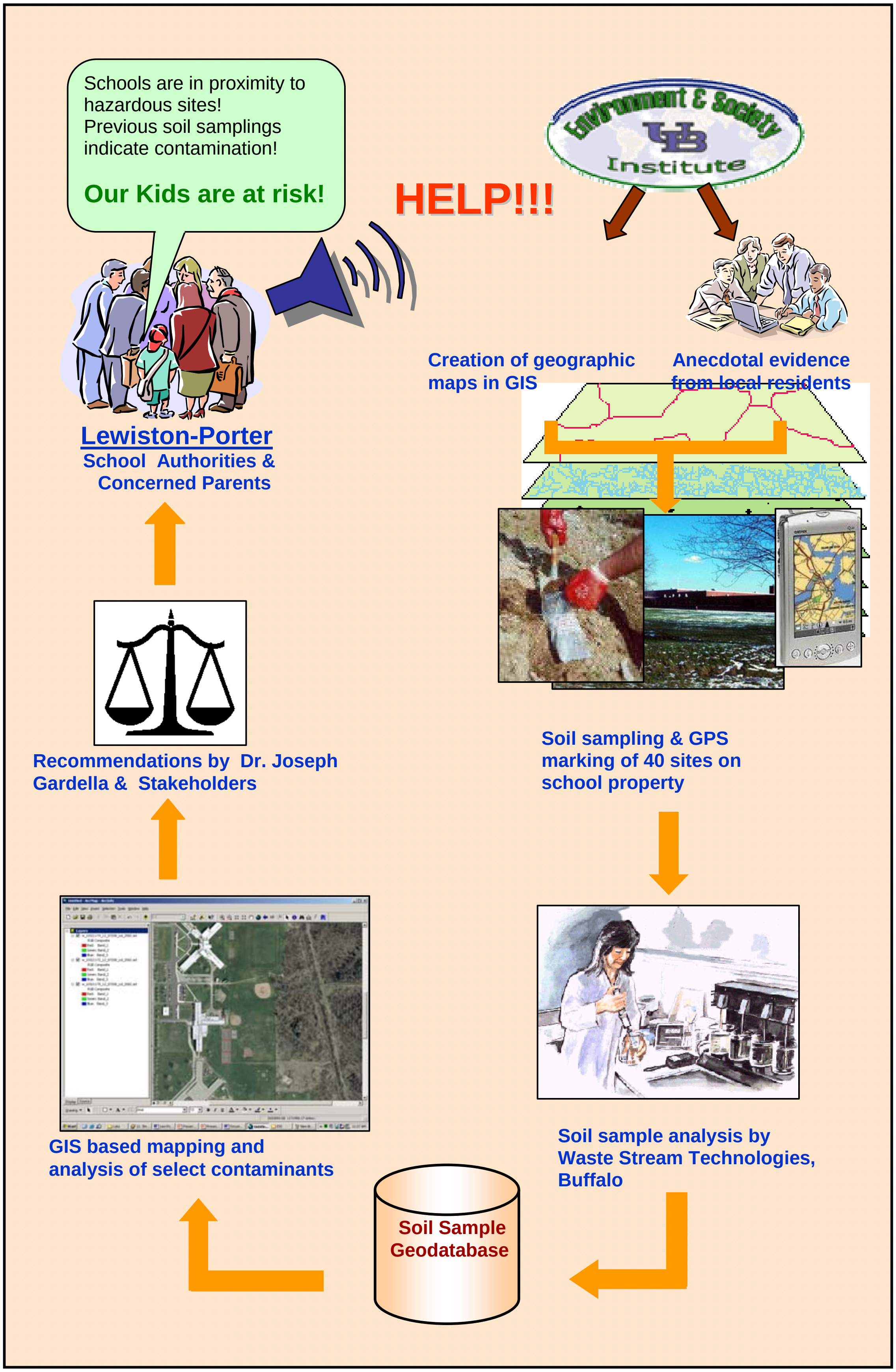
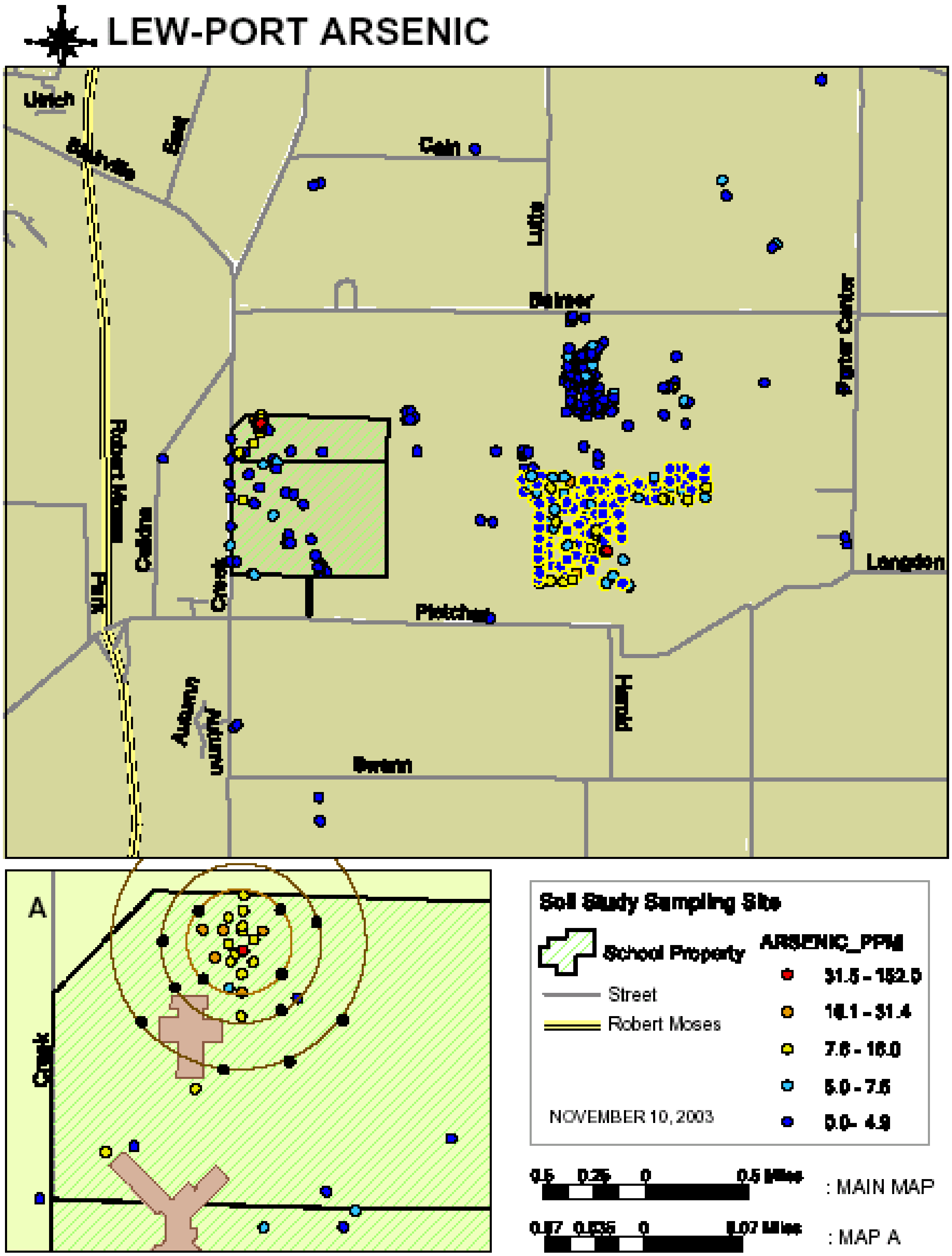


Figure 5. Results from integration of data from USACE NFSS and LOOW site data for arsenic concentrations near the Lewiston Porter Schools with results from the Lewiston Porter schools sampling project. Inset shows area of elevated arsenic concentration, and follow up sampling plan for localized



identification of region of contamination remediation ediation.

that all observed Lithium values were at background level. We concluded therefore that there was no region with elevated lithium levels on the campus. This fact combined with the lack of detection of boron and cesium, allayed concerns about K-65 or LOOW activities leaving residual contamination on the portions of campus that were analyzed.

This case was the first we used to proactively use GIS methods to plan a sampling and to interact with the community members in public participation of the entire study. The ability of students to work directly with community members created a longstanding relationship, presently involved in a collaborative effort, led by the Niagara County Health Department, funded by New York State and US federal funds, to account for environmental studies related to the LOOW site and determine what is known, geographically, and what is not known. The lead author also is a member of the USACE Restoration Advisory Board Steering and Chemical Committees for the LOOW site, representing the Lewiston Porter Schools.

8. Conclusions

In all the cases, the government interactions with service learning made for complex relationships and tensions between service learning collaborators, the community and government agency staff. Some tensions were resolved positively, as in East Ferry. In particular, the use of geographic information analysis has evolved into a serious research and public service effort.

The outcome of this work is a different view of the role of analytical chemistry in environmental public policy for students; rather than simply interpreting or implementing regulations, students see the limits of policy and regulation and the ability to influence new public policy and regulations. A key example is the use of geographic information analysis to set remediation and cleanup limits; rather than property line or fence line decisions. The students and faculty at UB have contributed to a broader discussion of remediation where pollution exists, rather than on specific sites with boundaries decided by a street or fence.

As is the case for most environmental work, science, public policy and regulation intersect with economic and political decisions. For students and the faculty involved, immersion in political processes can only be healthy, as more science should be used in public policy and environmental decision making.

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