Progress Report 5: April 1, 2011 – September 30, 2011
Accessing Brownfield Sustainability: Lifecycle Assessment and Carbon Footprinting
The Western Pennsylvania Brownfields Center at Carnegie Mellon, in collaboration with the Pennsylvania Downtown Center
US Environmental Protection Agency Brownfield Training Research and Technical Assistance Grant
Award: TR – 83417301 – 0
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A. Background

The primary purpose of this project is to develop the methodology and subsequent tools that stakeholders can use to assess the sustainability of Brownfield development as measured through carbon footprinting, pollutant emissions and energy impacts. The research is intended to apply innovative analytical techniques (such as economic input-output life cycle analysis) to estimate the carbon emissions, pollutant emissions and energy impacts associated with Brownfield development; while documenting the drivers of these impacts given alternative Brownfield development scenarios.

Training and technical assistance efforts complement the primary research purpose. Through training, we intend to educate and disseminate information that will allow the members of the community to better understand the public health risks of unattended Brownfields and the benefits of alternative remediation strategies. Through technical assistance, we intend to provide targeted communities with a prioritization tool that will allow for fair, transparent and equitable Brownfield development decisions.

Our work has been divided into 3 primary Activities:

- *Activity 1: Training – Empowerment Through Knowledge*. Enhance Pennsylvania Downtown Center's (PDC) webpage for Brownfield relevant information, participate in annual PDC events to provide Brownfield related content, and conduct topic specific seminars. As the project proceeds, the target group for training will be expanded beyond PDC's current membership.

- *Activity 2: Research – Quantifying the Sustainable Brownfield*. Develop a life cycle assessment model, including footprinting, for comparison of Brownfield development relative to greenfield development, beta test the tool on sites (preferably) selected in cooperation with PDC members, finalize and validate the model, develop a computer based tool, train PDC members to use the tool, and coordinate with US Environmental Protection Agency to develop strategy for transferring the tool to other Brownfield stakeholders.

- *Activity 3: Technical Assistance – Site Selection Through Prioritization*. Assist PDC members in developing inventories of sites, beta test the Site Prioritization tool with select PDC members, finalize Site Prioritization tool, distribute Tool to remainder of PDC members, and coordinate with the Pennsylvania Department of Environmental Protections and the USEPA to develop strategy for transferring both tools to other Brownfield stakeholders.

B. Overall Progress

The official date of the award was March 12, 2009. Pre-award approval from the USEPA Project Officer allowed our work to commence in October 2008 and our first Progress Report was submitted on October 1, 2009. Progress Report 2 addressed the time period between October 2009 and March 2010. Progress Report 3 addressed the time period between April 1 and September 30, 2010. Progress Report 4 addressed the time period between October 1, 2010 and March 31, 2011. And, Progress Report 5 addresses the time period between April 1, 2011 and September 30, 2011.

Carnegie Mellon personnel working on technical aspects of the project during the period addressed in Progress Report 5 include Professor Chris Hendrickson, Dr. Deborah Lange, graduate students Amy Nagengast and Yeganeh Mashayekh, and undergraduate student Zhe (Mark) Zhuang. PDC personnel working on the project include Executive Director Bill Fontana and Eddy Kaplaniak; as well as members of the Keystone CORE Services (KCS) group.

Overall progress with respect to each Activity is summarized as follows:

Activity 1: Training – Empowerment Through Knowledge – The Pennsylvania Downtown Center (PDC) provides education and technical assistance to local revitalization organizations including the members of their board of directors and their professional staff. These local boards and staff come from many diverse educational and experiential backgrounds, and many of them have both a lack of knowledge and an organizational aversion (fear) of entering the arena of real estate development, let alone environmentally challenged real estate projects. The efforts of PDC throughout this project have been to impart critical information to these organizations so that they may take steps, however tentative, to begin to address these "small site brownfield projects" by providing both direct information to our program managers at our annual managers meetings (3), annual conference (1), revitalization academy (1), and indirectly through continuous upgrades to the brownfields section of the PDC web site. In addition, we are moving toward the creation of sub-set of the larger PDC membership network that has come to express an interest in this topic and to impart more advanced information to this real estate/brownfields network.

Activity 2: Research – Quantifying the Sustainable Brownfield –A paper based on the comparison of 12 brownfield/greenfield pairs has been published (based on the research of Amy Nagengast) by the Journal of Urban Planning and Development, American Society of Civil Engineers in the September 2011 edition (See Appendix A). Ongoing research involves using travel demand models and traffic analysis zones to examine the effect of residential brownfield developments on the reduction of vehicle miles traveled (VMT) and the resulting costs (including the cost of driving time, fuel, and external air pollution costs). A paper based on this research is under review with the Journal of Urban Planning and Development, American Society of Civil Engineers – a draft of this paper was included in Progress Report 4. Furthermore, a third paper has been written on the analysis of residential brownfield developments if they are developed as LEED certified new developments (LEED ND) and their impact on travel patterns. This third paper further examines the cost effectiveness of the brownfield developments as VMT reduction strategy in comparison with other VMT reduction strategies. This paper (draft included as Appendix B) will be submitted to Journal of Urban

Planning and Development, American Society of Civil Engineers upon acceptance of the second paper.

During this quarter, the research team presented research at the following conferences:

- USEPA National Brownfields Conference, held in Philadelphia, Pennsylvania April 2011 (2 presentations given):
  1- Partnering 101: Working with Universities; Ways of effective collaboration between universities and the public and private sectors were discussed in a roundtable session.
  2- Western Pennsylvania Brownfields Center at Carnegie Mellon (Appendix C).
- The National Association of Environmental Professionals Conference, held in Denver, CO in April 2011 (Presentation: Evaluating Environmental Emissions of Pittsburgh Brownfields, Appendix D)
- Engineering Sustainability 2011 Conference co-sponsored by the Mascaro Center for Sustainable Innovation at the University of Pittsburgh and the Steinbrenner Institute for Environmental Education and Research at Carnegie Mellon(similar presentation found in Appendix E)
- Annual poster session of the Steinbrenner Institute for Environmental Education and Research at Carnegie Mellon, held in Pittsburgh, PA in April 2011(2 poster presentations).
  1- Title: Brownfield's Travel Patterns
  2- Assessing Brownfield Sustainability: Life Cycle Analysis and Carbon Footprinting
- 2011 International Society of Industrial Ecology -Science, Systems and Sustainability held in Berkeley, CA (June 2011) (2 presentations given).
  1. Title: Transportation and Environmental Benefits of Developing Underutilized Industrial Sites: Brownfields. (Appendix F)
  2. Title: Analyzing the Environmental Impacts from Residential Brownfield and Greenfield Developments (Appendix E)

Status of Tool Development: Using the detailed case analyses on 4 residential developments (two brownfield and two greenfield) in the SW Pennsylvania Region as well as the 12 pairs of brownfields/greenfields studied in the Nagengast research, we are preparing a spreadsheet-based tool to assess the environmental emissions associated with the remediation phase (for a brownfield) and the residential use phase (for both the brownfield and the greenfield.) The tool, and associated paper, is in a preliminary stage of development.

Activity 3: Technical Assistance – Site Selection Through Prioritization – Activity 3 is based on the implementation of a multi-attribute decision making tool that was in development at the Western Pennsylvania Brownfields Center prior to receipt of the TRTA grant. During the time period covered by the Period 5 report, we have worked with the Keystone CORE Services Group of PDC and engaged 79 communities in a beta test of the multi-attribute decision making tool.

C. Efforts and Accomplishments by Activity

Activity 1: Training – Empowerment Through Knowledge

Managers Meetings: Since the inception of the implementation of the subcontract between PDC and CMU, PDC has, as a regular part of its three yearly manager meetings, provided updates and additional information on the status of the CMU small sites brownfield projects to meeting attendees. In the 2010-2011 program year this included meetings in Allentown, PA (October 13, 2010 - 67 attendees), Uniontown, PA (October 20, 2010 - 49 attendees), and Harrisburg, PA (March 22, 2011 - 166 attendees).

Annual Conference: As an integral part of its annual revitalization conference, PDC includes at least one session dedicated specifically to brownfield and vacant/abandoned property reclamation. The conference this year was held in Scranton, Pennsylvania from September 6 through September 9. This year's conference coincided with the heavy rains and subsequent flooding associated with the remnants of Hurricane Irene that impacted central and northeastern Pennsylvania. Despite the challenges presented by these weather-related conditions, the conference was well attended, as was the brownfields session. The title of this session was *Keystone CORE Services and the CMU Brownfields Project.* The session was attended by 22 conference participants. The presenters included Chris Brown, a landscape architect with Derck and Edson and president of the Keystone CORE Services board of Directors; Bill Fontana, Executive Director of the Pennsylvania Downtown Center (PDC) and; Ed Brennan, an attorney from Pottsville, PA with particular expertise in the area of Pennsylvania's new Conservatorship Act. The session focused on: 1) the progress being made by Keystone CORE Services (KCS) , a non-profit subsidiary of PDC in providing both technical and financial assistance to communities with vacant and environmentally challenged properties; 2) the processes and procedures being utilized by PDC and KCS to developed a prioritized list of projects for implementation based upon the CMU site analysis tool; and 3), the new tools available to municipalities and non-profits to assist them with taking control and mitigating bighting influences, including environmental contamination. As a result of this session, PDC/KCS has already been contacted by 2 additional communities, not included in the CMU brownfields project, with request to use the CMU tool on various sites in Franklin County and for help on a specific site in Schuylkill County.

Revitalization Academy: PDC conducts an annual revitalization academy consisting of five (2) two-day sessions. Each session includes eight individual classes. PDC has devoted one of the eight classes specifically to brownfield and vacant land reclamation. The course is designed to provide new, first year revitalization professionals, many of whom lack any in-depth knowledge of brownfield and vacant property reclamation, with basic understanding of the laws, programs, processes and procedures involved in the reclamation and if necessary remediation of vacant, blighted and environmentally challenged properties. In the course of the 2010-2011 project year, this session was held on Wednesday, February 24, 2011. The session was attended by 26 new Main Street and Elm Street Managers. (Also mentioned in Progress Report 4.)

Web Site: PDC continues to host a section on small site brownfield revitalization on its web site. This site was developed over the last two program years and is due for an additional upgrade during the 2011-2012 program year.

Real Estate – Brownfields Network: As a result of the CMU project and the interest express by those communities with a more intense organizational interest in the topic of small site brownfield and vacant property reclamation, PDC/KCS expects to establish a “network” of these communities and to deliver more focused education, technical assistance and training to those communities in the network. The educational sessions, technical assistance, and other network benefits will be developed and initial implementation take place during the 2011-2012 program year.

Activity 2: Research – Quantifying the Sustainable Brownfield

We are pursuing two sub-activities within Activity 2. In Activity 2A, we evaluate the sustainability of brownfields through a life-cycle approach. In Activity 2B, we estimate all vehicular transportation of residents for a number of brownfield/greenfield pairs using regional travel demand models. Beyond transportation analyses, we began to gather and analyze data on water and electricity usage.

Activity 2A: Life Cycle Impacts of Brownfield and Greenfields

In Activity 2A, we are examining the overall life cycle costs and greenhouse gas (GHG) emissions resulting from residential brownfield redevelopments relative to more traditional developments. Our analysis is based upon census and zonal transportation travel demand models information for a sample of brownfield and greenfield developments, coupled with information from literature on remediation; infrastructure and building costs, maintenance costs and residential utility usage.

We find that brownfield redevelopments incur environmental remediation costs, but they have lower life cycle transport demand (due in large part to closer proximity to center cities) and higher residential densities. On balance, we find that brownfield redevelopments have lower life cycle costs and greenhouse gas emissions than greenfield developments, but individual development impacts will differ based upon specific details.

The deliverables from this sub activity are a peer-reviewed paper (ASCE Journal), other papers in review and the development of an analysis tool. A fourth paper, or the 'summary' paper, was submitted to Engineering Research Letters titled "Estimation of Comparative Life Cycle Costs and Greenhouse Gas Emissions of Residential Brownfield Redevelopments" in June 2011. Currently, we are revising the paper based on the reviewer's comments.

The excel-based analysis tool is under development. The tool compares brownfields to conventional greenfields through travel, remediation, utility and maintenance components. These components are evaluated from an economic and greenhouse gas perspective. For both the brownfields and the greenfields, the following information is to be collected:

Basic	Size
	Distance to City Center
	Number of Dwelling Units
	Development Density
	Population Density
	Walkability Index
Building Utility	Water Cost
	Electricity Cost
	Natural Gas Cost
	Total Utility Cost
Maintenance	Maintenance Cost
Travel	Annual Personal VKT
	Percentage of Freeway
	Percentage of Arterial

In addition, the following information is collected for a brownfield:

Remediation	Remediation Cost
	Discount Rate
	Time Horizon

The values provided by the potential user of the tool are compared to higher, average and lower bound reference values as determined though the Nagengast and case study research. Then based on default values, for the determination of green house gas emissions associated with each of the inputs, the overall impact of the development is determined. The tool (in MS Excel workbook format), includes instructions, a glossary and references. The tool is about 80% complete and will be finalized during Report Period 6. During Period 6, we will also plan to beta test the tool with members of the Pennsylvania Downtown Center.

Activity 2B – Yeganeh Mashayekh, a graduate student in Civil and Environmental Engineering and Engineering and Public Policy at Carnegie Mellon has planned her PhD studies around this topic. Upon finishing the travel pattern comparison analysis of eight brownfields and eight comparable greenfields in four cities of Chicago, Baltimore, Minneapolis and Pittsburgh, her next level of analysis was to compare the travel patterns of brownfield development and LEED certified brownfield developments. Furthermore, the analysis looked at brownfield developments and LEED certified brownfield developments as a VMT reduction strategy and compared the cost effectiveness of these two types of developments with other VMT reduction strategies such as telework, transit improvement, and pricing.

This analysis considers the cost-effectiveness of LEED certified brownfield developments as a VMT and greenhouse gas (GHG) emission reduction strategy in comparison with other VMT and GHG reduction alternatives. Results show that with minimal implementation cost incurred by transportation authorities (about 75 to 95 percent less than other VMT reduction strategies), brownfield developments as well as LEED certified brownfield developments that have earned VMT reduction points are a beneficial travel demand strategy and an environmentally viable option to assist federal, state, and local governments with their greenhouse gas emission reduction goals. Compared with conventional Greenfield developments, residential brownfield developments can reduce VMT and its consequential environmental costs by about 52 and 66 percents respectively. LEED certified residential brownfield developments can have an additional 1% to 12% VMT reduction and a 0.03% to 3.5% GHG reduction compared with conventional greenfield developments. Comparing residential brownfield developments and LEED residential brownfield developments with other VMT reduction strategies cost of implementation is significantly less in most cases while net benefits are comparable with most other VMT reduction strategies. Results of this study show that effective collaboration between transportation and environmental agencies to select those brownfield sites with the highest cost saving potentials can assure a favorable outcome when it comes to decreasing VMT and GHG emissions. Furthermore, providing incentives and guidance to private developers of brownfields can expedites the VMT and GHG reduction goals set by the public sector while assisting developers and owners to construct a LEED certified development.

A paper (Appendix B) on this research will be submitted to Journal of Urban Planning and Development, American Society of Civil Engineers upon acceptance of the second paper submitted.

Additional Activities:

- Currently, the research team is exploring options to add the retail and commercial components of brownfield developments to the analyses conduced thus far. The team is in the process of literature and existing database review to develop the most feasible and effective way of adding this non-residential component and associated travel patterns.

- During the 14th National Brownfield Conference cosponsored by EPA, we participated in a panel discussion named "Partnership 101: Working with Universities". Yeganeh Mashayekh from Carnegie Mellon/Western Pennsylvania Brownfields Center was on the panel. Each panelist discussed what they do and what the challenges are. Through an interactive discussion with the audience the panel was able to identify some of the issues related to partnership with universities and discuss some potential solutions.

- From April 26th to April 29th of 2011, Yeganeh Mashayekh attended the National Association of Environmental Professionals 36th Annual Conference in Denver, CO. Yeganeh was speaker presenting some of the work we have done as part of the EPA brownfield project. The title of the presentation was "Evaluating Environmental Emission of Pittsburgh Brownfields" covering an overview of the environmental footprint analysis of the brownfield developments in Pittsburgh compared with Greenfield developments.

- Both Mashayekh and Nagengast presented papers at the 2011 International Society of Industrial Ecology -Science, Systems and Sustainability held in Berkeley, CA (June 2011)

Activity 3: Technical Assistance – Site Selection Through Prioritization

The first phase of the revised outreach strategy with Keystone CORE Services has been completed. Main and Elm Street Managers, associated with the Pennsylvania Downtown Center, were asked to complete a site profile (Appendix G) on properties within their respective community that were abandoned, blighted, and/or underutilized. A total of 79 properties from 17 communities were submitted. The profiles span the real estate spectrum from old commercial buildings to churches to gas stations. KCS's Board of Directors reviewed each profile and after some thoughtful and lively discussion chose 30 sites, representing 16 communities, to move to the second phase: project attribute review. The 30 sites were selected on the basis of criteria that were determined to be consistent with the mission of the KCS. Those criteria included: size (smaller sites were preferred), geography (to obtain a representation of sites across the state), intuitive likelihood of success, whether or not a Phase I Assessment had been performed, the existence of a cooperative property owner, and whether or not the site was determined to be underutilized.

During the subject project period, KCS worked one-on-one with the chosen communities to complete an attribute review (Appendix H) of each selected site. Typically, a local non-profit revitalization organization or redevelopment authority, not a municipal official nor an owner, completed the questionnaire in order to minimize bias. The 23 returned questionnaires were reviewed and the responses scored based on a 'Key,' included as Appendix I. It should be noted that the KCS Board questioned some of the reasoning behind the scores and there was much discussion regarding questions related to the environment (i.e. should a poor environmental condition score high or low?) and demographics (i.e. should high unemployment score high or low?). Values were assigned for the KCS purpose but, as part of future work, such questions will be revisited to remove ambiguity.

Concurrently, Carnegie Mellon worked with 4 members of the KCS Board of Directors to develop 'weights' for all of the indicator categories and the questions within each. As a reminder, the primary- and sub-indicator categories are as follows:

(1) Development Driver/Champion

- Developer Champion
- Municipal or NGO Interest

(2) Development Potential

- End Use
- Funding
- Time
- Property Ownership
- Community Support
- Quality of Life

(3) Environmental Factors

- Contamination

• Previous Use of Site

• Public Utilities

(4) Market Information

• Labor Market

• Property and Wage Values

• Environmental Justice

• Location

• Infrastructure Indicator

Along with PDC Executive Director Bill Fontana, Deborah Lange facilitated a discussion among the board members to assure that all understood a similar definition for each indicator prior to 'secret ballot' voting by each member. The weights (percentages) suggested for each indicator were as follows:

	BOARD MEMBER				
	A	B	C	D	AVE
Primary Indicator					
1 - Champion	25%	30%	15%	40%	27.5%
2 – Development Potential	30%	40%	25%	15%	27.5%
3 – Environmental Factors	10%	20%	50%	20%	25%
4 – Market Information	35%	10%	10%	25%	20%
Total	100%	100%	100%	100%	100%

The 'average' values seemed to be tightly clustered and through a subsequent discussion, members of the Board explained their respective weights to others on the board. A second 'secret ballot' followed with these results:

	BOARD MEMBER				
	A	B	C	D	AVE
Primary Indicator					
1 - Champion	10%	35%	25%	35%	26.2%
2 – Development Potential	40%	40%	30%	20%	32.5%

3 – Environmental Factors	20%	10%	35%	25%	22.5%
4 – Market Information	30%	15%	10%	20%	18.8%
Total	100%	100%	100%	100%	100%

Because the first and second set of results demonstrated some 'dynamic' thinking among the Board members, a pair-wise comparison was also performed:

Primary Indicator	1	2	3	4
1 - Champion	X	--	--	--
2 – Development Potential	2	X	--	--
3 – Environmental Factors	1	2	X	
4 – Market Information	1	2	3	X

From this exercise, it was clear that the Board members rank the indicators in the following order and the values noted in (parentheses) were the final assigned weights:

- ❖ Primary Indicator 1: Development Driver/Champion (25%)
- ❖ Primary Indicator 2: Development Potential (40%)
- ❖ Primary Indicator 3: Environmental Factors (20%)
- ❖ Primary Indicator 4: Market Factors (15%)

Except for the 'Development Driver' indicator (which only has 2 sub indicators), a similar exercise of pair-wise comparisons was performed to weight the sub-indicators found within each of the primary categories. The results were as follows:

(1) Development Driver/Champion

- Developer Champion – 20%
- Municipal or NGO Interest – 80%

(2) Development Potential

- End Use – 30%
- Funding – 14%
- Time – 3%
- Property Ownership – 7%
- Community Support – 26%

- Quality of Life – 20%

(3) Environmental Factors

- Contamination – 50%
- Previous Use of Site – 34%
- Public Utilities – 16%

(4) Market Information

- Labor Market – 5%
- Property and Wage Values – 10%
- Environmental Justice – 15%
- Location – 30%
- Infrastructure Indicator – 40%

It should be noted that the dialogue/voting/dialogue exercise performed by the KCS Board resulted in 'weights' to be input into the multi-attribute decision-making tool. The unexpected outcome, however, was the value of the facilitated discussion that allowed to Board members to: a) better understand the priorities of one another; and, b) better define the mission of KCS.

A MS Excel spreadsheet was constructed and populated with the scores from the 23 returned questionnaires to perform the weighting calculation. Final weights ranged from 27 to 70, with a distribution as follows:

Weight Range	Number of Sites
Greater that 67	2
63-67	4
56-62	8
44-55	3
33-42	5
Less than 33	1

Upon review of this data, the KCS Board agreed that there is merit to ranking the sites on the basis of the 'overall' score, but perhaps there is also merit to parsing the data to look at scores within the 'Primary Indicator' areas; particularly 'Environmental Factors,' and 'Development

Potential.' This recognition strengthens the value in the tool by suggesting that once the data is collected, there are alternate analyses that can be performed, with the intent to best serve the needs of the communities that have brownfields and the mission of the decision-maker.

For instance, the KCS Board would like to 'reward' at least one site in each of their 3 geographic regions: west, central and east. The data can be sorted by region, sites within that region can be ranked, and the needs (financial, technical guidance, feasibility studies, etc.) can be assessed.

To test the accuracy of the multi-attribute decision-making tool, the KCS Board gathered for an exercise to compare their 'intuitive' ranking of the 23 sites to the 'calculated' ranking of the sites based on the tool. The comparison was at best anecdotal but the exercise forced the members of the Board to express their reasons for selection; and this brought a higher level of transparency to the decision-making. As an example of the intuitive process, sites were selected for the following reasons:

- Site is representative of other sites in other Main and Elm Street Communities, such as gas stations.
- The community may have positive redevelopment activity and the potential for strategic partners.
- Site seems for be consistent with the mission of Keystone CORE.

Action Steps

1) PDC/KCS will respond to 23 questionnaire participants.
2) PDC/KCS will determine appropriate rewards for sites that completed the questionnaire and ranked higher than peers. KCS would like to 'reward' a site in each of the 3 geographic regions of Pennsylvania but also recognize that all participants may value from some level of input from the KCS Board of Directors.
3) Primary indicators have been modified and an 'Infrastructure' indicator has been created by removing 'Public Utilities' from 'Environmental Factors' and 'Location' and 'Infrastructure' from the 'Market Information' indicator. Weights were modified accordingly.
4) Ambiguities in the scoring system (as seen in the KEY) need to be addressed.

D. Progress vs Proposed Milestones

The proposed milestones for Years 1, 2 and 3 (presented in our application package) are summarized in the following table. Note that this report is intended to summarize the activities of Year 3, however, our Year 3 funding was not yet received from the USEPA until the end of the subject period.

Completion YEAR	Activity 1: Training – Empowerment through Knowledge	Activity 2: Research – Quantifying a Sustainable Brownfield	Activity 3: Technical Assistance – Site Selection through Prioritization
1	.Participate in PDC regional events .Update PDC webpage with Brownfield related content .Nat'l Brownfields Conference (Fall 2009)	Develop framework and scope for life cycle assessment and carbon footprinting tool	Complete inventories in select Main Street/ Elm Street Communities
2	As above with webpage updates including additional case studies	Finalize transportation, building, electricity and water analysis modules	Initiate ranking process select Main Street/ Elm Street Communities
3	As above with webpage updates including additional case studies .Nat'l Brownfields Conference (Spring 2011)	Demonstrate, troubleshoot and validate model and tool	Complete ranking process select Main Street/ Elm Street Communities

Our progress to date (through Year 3) can be summarized as follows:

Activity 1: We continue to work with PDC is their regional events. PDC webpage is active and we will need to focus on assuring the accuracy of the information on the webpage and adding case studies. We note that we have also shared the results of our research in a number of additional local and national conferences, as noted above.

Activity 2: We continue to look for publicly available sources of data that can be used to understand environmental emissions particularly related to the items that differentiate brownfield from greenfield development: remediation, utility consumption (of residents), and transportation behavior (of residents). We have a better understanding of transportation behavior associated with brownfield development vs. greenfield development and during this period of performance we have identified sources for data on utility usage. We will explore additional sources for supporting data this Project Period 6 while continuing the development of a MS Excel based assessment tool. Furthermore, the retail and commercial component of brownfield developments will be added to the travel patterns.

Activity 3: We are working with Keystone CORE Services to engage PDC's Main Street and Elm Street managers and have completed a 'beta test' of the ranking process using the multi-attribute decision making tool. KCS will determine the best method for communication back to the participants. In addition, we have identified a number of improvements to the tool and will look to address these improvements in the next period of performance.

E. Actual vs, Proposed Expenditures

Our original budget assumed that we would spend $500,000 through Year 3. In fact, we spent approximately $366,000 because distribution of the Year 3 funding was delayed. At the end of Period 5, we received $150,000 for Year 3, $50,000 less than proposed. As of September 31, 2011, we have approximately $84,000 remaining. We will calibrate our efforts to work within this limit and will not exceed this amount until we understand the status of funding for Years 4 and 5 of the grant.

F. Lessons Learned and Goals by Activity

Activity 1: Training – Empowerment Through Knowledge

We will continue to improve the webpage and participate in PDC regional and statewide events. Interest in brownfield development seems to be growing based on the interest exhibited in the regional and annual PDC events. The formation of Keystone CORE and the exercise with the multi-attribute decision making tool is also generating interest among the Main and Elm Street managers.

Activity 2: Research – Quantifying the Sustainable Brownfield

To date, our research suggests that the environmental impact of residential brownfield development is primarily differentiated from residential greenfield development on two fronts: efforts expended during site remediation and the transportation behavior of the residents. Other aspects of the development phase (such as infrastructure improvements and housing construction) and use phase (such as residents' utility consumption) seem to be relatively equivalent. For this reason our research and tool development have tended toward the understanding of travel behavior.

As we expand the research to look at commercial and retail developments, we will tend to focus in transportation as well, based on the findings of the research focused on residential developments.

Activity 3: Technical Assistance – Site Selection Through Prioritization

Keystone CORE has provided the incentive (either financial or in-kind support) for communities to participate in the beta testing of the multi-attribute decision making tool. Through this strategy, 79 communities participated in the program and 23 will receive some level of support.

We note that Progress Report 6 will include efforts performed between October 1, 2011 and March 31, 2012.

Respectfully submitted,

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APPENDIX A

Commuting from U.S. Brownfield and Greenfield Residential Development Neighborhoods

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Abstract: Whereas brownfield development is of widespread interest, there is scant literature on the environmental impacts of brownfield developments relative to conventional developments. We assembled a set of two residential brownfield and two conventional greenfield developments for a sample of U.S. cities including Baltimore, Chicago, Milwaukee, Minneapolis, Pittsburgh, and St. Louis. Using the travel time and modes of transportation information from the 2000 U.S. Decennial Census, we analyzed the long-term commuting impacts from the two types of developments. Relative to greenfield development neighborhoods, we find that the brownfield development neighborhoods are closer to center cities, have higher public transportation use for commuting, comparable average travel times to work, and lower energy and greenhouse gas emissions for commuting. Future work will extend these results to consider other differential impacts of the two types of developments. **DOI: 10.1061/(ASCE)UP.1943-5444.0000072.** *© 2011 American Society of Civil Engineers.*

CE Database subject headings: Energy Consumption; Public Transportation; Travel Time; Travel Modes; Brownfields; Emissions; Life Cycles; Residential location.

Author keywords: Energy consumption; Public transportation; Travel time; Travel modes; Brownfields; Greenhouse gas emissions; Life-cycle assessment.

Introduction

With population growth and urban sprawl on the rise, cities are paying special attention to effective use of limited available land. The Environmental Protection Agency's Smart Growth program aims to "help communities grow in ways that expand economic opportunity, protect public health and the environment, and create and enhance the places that people love" (U.S. EPA 2010). Furthermore, the U.S. Department of Transportation's (DOT) Livability Initiative promotes the integration of quality transportation to areas that enrich citizens and communities (U.S. DOT Federal Highway Administration 2010). This multidisciplinary focus of these federal agencies reflects the importance of sustainable development through the interrelationships between land use and transportation.

One example of land and mobility intersections can be examined through brownfield development sites. Brownfields are properties with the presence (or suspected presence) of hazardous substances or contaminants (U.S. EPA 2009). Brownfield remediation and development are intended to improve environmental quality and reduce pressure for development of green spaces. A variety of grants and support programs are available to spur brownfield development in the United States at the federal, state, and local levels (Wernstedt et al. 2006; Lange and McNeil 2004). Brownfield development requires assessment of environmental risks and, in most cases, remediation activities before development is possible. However, brownfield development might take advantage of existing infrastructure such as water and sewer distribution and collection networks, roads, and power supply. Furthermore, brownfield development results in significant benefits to the surrounding citizens through reduced health risks, neighborhood improvement, and transportation externalities (De Sousa 2002).

Transportation is an integral component of sustainable development. The topic is now expanding beyond mobility into discussions surrounding human health and ecosystem protection (Deakin 2001). To help understand the role of transportation in sustainable growth, we compare the travel time, energy, and greenhouse gas emission impacts of commuting from a sample of brownfield and greenfield development neighborhoods. Our intent is to investigate the various long-term effects of brownfield developments relative to conventional greenfield developments. Commuting is an important component of such long-term effects. Our analysis is based on U.S. Census tracts that include brownfield and greenfield residential developments as well as surrounding housing.

Sample of Brownfield and Greenfield Development Neighborhoods

Brownfield developments range widely in size and intended use. For example, numerous brownfield developments involve remediation and reuse of individual gasoline service stations; larger brownfield developments may be former industrial plants that are converted to office parks or golf courses.

For this study, we sought a sample of representative U.S. brownfield and greenfield developments. We restricted our sample to metropolitan areas for which knowledgeable local representatives could identify two relatively large brownfield developments and two comparable greenfield development areas. The chosen developments were to have occurred in the past 20 years and include approximately 100 or more housing units. Our final

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sample set is based on suggestions from local urban planners and community economic and development organizations that were contacted via e-mail and telephone. The final sample set includes developments in Baltimore, Chicago, Milwaukee, Minneapolis, Pittsburgh, and St. Louis.

The distance to center city for each development is listed in Table 1 for greenfields and Table 2 for brownfields. Distances to center city were obtained from online map directions and represent roadway distances with the shortest travel time. Additional information on the brownfield and greenfield developments can be found in the supplemental information.

Greenfield developments are, on average, 24 mi (38 km) from center city and six times further from the center city than the average for brownfields. This result is not surprising. Greenfield developments are built where land is available and relatively inexpensive, which typically means the outskirts of metropolitan areas. Brownfield developments occur where earlier development has already taken place and the property was subsequently vacated, so we expect they would be closer to the center city and supporting infrastructure.

With closer proximity to the urban core, we expect that brownfield residents may have fewer vehicle miles of travel (VMT) overall. Paull's analysis of the Maryland Historic Tax Credit Program notes that compact development has been correlated to a reduction of 20–40% in VMT compared to sprawl (Paull 2009). The Transportation Research Board (TRB) report on driving and the built environment also identified reductions in VMT for compact city development (National Research Council 2009). Shammin et al. (2010) found that compact living had roughly 18% lower energy intensity than sprawling developments.

Modal Shares and Commuting Time

At an aggregate level, commuting modal shares in the U.S. Census Bureau data (2000) are divided into: individual automobile, public transportation, motorcycle, bicycle, walked, and other modes (Fig. 1). Of the various modes in the census data, only the individual automobile, public transportation, and walking had substantial use in both brownfield and greenfield developments.

For individual vehicle transportation, residents of greenfield developments use their personal vehicles 97% of the time for travel to work, with 8% carpooling and 89% driving alone. In brownfield neighborhoods, the commute to work by personal automobile is substantially less, at 72%. Of those individuals who drive individual vehicles, almost twice as many carpool (15%) as compared to greenfields residents (8%). Commuting modal shares are summarized in Fig. 2, with the full analysis in the supplemental information.

The second main type of commuting mode is public transportation, responsible for 2% of the trips to work by residents in greenfield neighborhoods and 18% for brownfield neighborhoods. Finally, the share of commuting by walking is 1% for greenfields and 8% for brownfields. These transportation differences are likely a result of the greater attractiveness and availability of public

Table 1. Distance to Center City for Sample of Greenfield Developments

State	County	Development name	Distance to city center (mi)	Distance to city center (km)
PA	Butler	Cranberry Heights	28	44
PA	Washington	Peters Township	14	22
IL	Dupage	Woodland Hills Unit 11	35	56
IL	Dupage	Reflections at Hidden Lakes	25	39
MO	St. Louis	Villages at Liberty Gardens Addition	21	34
MO	St. Louis	Lafayette Trails	34	54
WI	Waukesha	Bristlecone Pines (Village of Hartland)	25	40
WI	Waukesha	Springbrook North (City of Waukesha)	38	61
MD	Howard	Waverly Woods	18	29
MD	Howard	RiverHill Village	24	38
MN	Dakota	Itokah Valley Townhomes 4th Addition	18	29
MN	Hennepin	Creekside Estates Apartments	9	14
		Average distance	24	38

Table 2. Distance to Center City for Sample of Brownfield Developments

State	County	Development name	Distance to city center (mi)	Distance to city center (km)
PA	Allegheny	Summerset at Frick Park	6	9
PA	Allegheny	Waterfront	6	10
IL	Cook	Homan Square	5	8
IL	Cook	Columbia Pointe	9	14
MO	St. Louis City	Lofts at the Highlands	5	8
MO	St. Louis City	Welsh Baby Carriage Phase 1	2	2
WI	Milwaukee	Trostel Square, Beerline Development	1	2
WI	Milwaukee	Cherokee Point	7	12
MD	Baltimore City	Clipper Mills	3	5
MD	Baltimore City	Camden Crossing/Koppers	2	2
MN	Hennepin	Heritage Park	2	4
MN	Hennepin	Mill City area	1	1
		Average distance	4	6

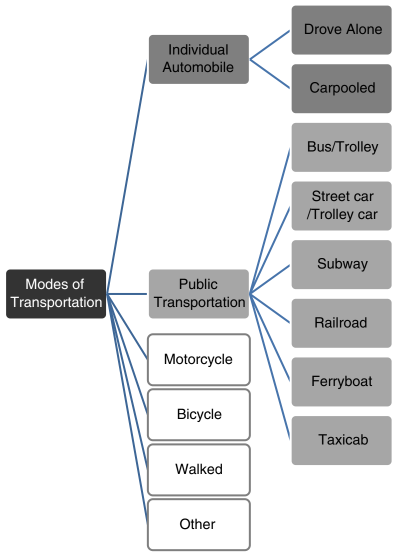

Fig. 1. U.S. Census modes of transportation categories and subcategories

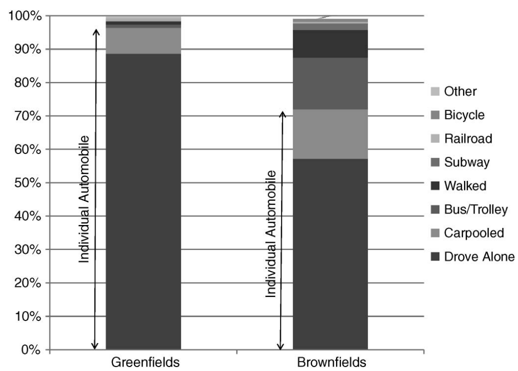

Fig. 2. Greenfield and brownfield disaggregated commuting modal shares

transportation closer to center cities, as well as shorter average commuting distances from brownfield developments. There might also be greater interest in carpooling, public transportation, and walking among residents choosing to live in a brownfield neighborhood. Fig. 2 shows the overall shares of commuting modes.

While the modal split of the two types of development neighborhoods are quite different (Fig. 2), the average travel time to work is quite similar with 28 min for greenfields and 27 min for brownfields (Tables 3 and 4).

It is helpful to look at the disaggregation of the travel time by mode for use in calculating energy consumption and greenhouse gas emissions of the various developments. These average travel times from the U.S. Census Bureau data can be disaggregated by mode into two broad categories: public transportation; and other, as

Table 3. Average Total Travel Time to Work One Way (min) and Disaggregated by Mode for Greenfield Neighborhoods Census Tracts

State	Greenfield name	Avg. across all modes	Avg. public	Avg. “other”
PA	Cranberry Heights	30	63	29
PA	Peters Township	28	55	27
IL	Woodland Hills Unit 11	32	75	30
IL	Reflections at Hidden Lakes	29	58	29
MO	Villages at Liberty Gardens Addition	25	44	24
MO	Lafayette Trails	28	0	28
WI	Bristlecone Pines (Village of Hartland)	21	20	21
WI	Springbrook North (City of Waukesha)	30	45	30
MD	Waverly Woods	32	64	32
MD	RiverHill Village	32	73	31
MN	Itokah Valley Townhomes 4th Addition	22	33	22
MN	Creekside Estates Apartments	21	36	20
	Average travel time (min)	28	47	27

Table 4. Average Total Travel Time to Work One Way (min) and Disaggregated by Mode for Brownfield Neighborhoods Census Tracts

State	Brownfield name	Avg. across all modes	Avg. public	Avg. “other”
PA	Summerset Phase 1	19	29	17
PA	Waterfront	26	38	24
IL	Homan Square[a]	50	23	54
IL	Columbia Pointe	30	44	23
MO	Lofts at the Highlands	19	19	19
MO	Welsh Baby Carriage Phase 1	24	48	23
WI	Trostel Square, Beerline Development	15	24	15
WI	Cherokee Point	20	41	20
MD	Clipper Mills	27	38	26
MD	Camden Crossing/Koppers	26	34	24
MN	Heritage Park	30	50	16
MN	Mill City area	31	41	24
	Average travel time (min)	27	36	24

[a]The U.S. Census tract containing the Homan Square brownfield neighborhood has reported travel times across all modes that are unusually high compared to the remaining brownfields and greenfields in Tables 3 and 4. Homan Square development also has a high carpooling rate. For this analysis, we have assumed two persons per vehicle for carpooling.

seen in Tables 3 and 4. The “other” category includes: individual automobile; motorcycle; bicycle; walking; and other (Fig. 1). Since the individual automobile is used by most residents (97% greenfields and 72% brownfields), we assumed that the average “other” travel time is representative of private vehicle travel times.

Energy Impacts of Commuting

Scope and Assumptions

In this energy impact analysis, our scope includes the upstream supply chain production of the transportation fuel and the combustion of the fuel during the vehicle use phase. We estimated supply chain fuel production and combustion data for individual automobile and public transportation separately. To calculate these impacts, commuting speed, automobile fuel efficiency, price of fuel and electricity, public transportation information, and upstream supply chain and combustion impacts were required.

Individual Automobile Transportation

Automobile Fuel Energy

In order to quantify the upstream energy required to produce automobile fuel, the economic input-output life-cycle assessment (EIOLCA) U.S. 2002 Producer Price model was chosen (Hendrickson et al. 2006; Carnegie Mellon University (CMU) Green Design Institute 2010). Within the model, we chose the "Petroleum Refineries" sector group for analysis. This specific sector accounts for "establishments primarily engaged in refining crude petroleum into refined petroleum" and associated upstream impacts (CMU Green Design Institute 2010). The EIOLCA model estimated that 31.7 TJ/$1 million resulted from the supply chain of fuel production (CMU Green Design Institute 2010). Assuming the average price of gasoline in 2001 was $1.53/gal. [Energy Information Administration (EIA) 2008a], the upstream energy impact translates to approximately 49 MJ/gal.

The energy input for direct gasoline fuel combustion was assumed to be 132 MJ/gal. (EIA 2009). Thus, the total energy for fuel was the sum of upstream (supply chain) and direct use, $49 + 132 = 181$ MJ/gal.

Individual Automobile Combustion Energy Impacts

To estimate the combustion energy of fuel used per commuter in each development, we included the number of people who use individual automobiles, commuting travel time, average commuting speed, automobile fuel efficiency, and the energy in motor gasoline. The number of residents who used individual automobiles and the commuting travel time was from the U.S. Census tract information (U.S. Census Bureau 2000). We assumed those residents who carpooled had only two commuters per vehicle. We modeled the average commuting speed based on the 2009 Annual Urban Mobility Report published by the Texas Transportation Institute for an industry wide car and light truck stock having a fuel efficiency of 20.3 mi/gal. (Schrank and Lomax 2009; U.S. EPA 2005). The average commuting speeds are reported by city and by roadway type for 2007. For this analysis, we assume that the cities commuting time is the average speed based on freeway and arterial street information (Table 5).

Energy used for a vehicle trip is calculated from the average travel time to work (Tables 3 and 4), average travel speed in each city (Table 5), the average vehicle fuel efficiency (20.3 mi/gal.), and the automobile fuel energy (181 MJ/gal.)

$$\mathrm{EVT}_i = t_i \times v_i \times 181/20.3 \qquad (1)$$

where EVT_i = energy per vehicle trip for development i; t = average travel time; and v = average speed. An example calculation for the individual automobile energy intensity per vehicle trip for Cranberry Heights, located near Pittsburgh, is provided in Fig. 3. For this paper, a vehicle trip represents a resident's commuting distance to work one way.

On average, vehicle trips from greenfield developments consume 150 MJ of energy per vehicle trip (0.14 million BTU/year) compared to 130 MJ of energy per vehicle trip (0.13 million BTU/year) from brownfield developments. This difference is directly linked to the variation in individual automobile commuting time and speed, as shown in Tables 3–5. These numbers assume commuters use individual automobiles to and from work

Table 5. Average Commuting Speeds for Cities in 2007 (Schrank and Lomax 2009)

		2007 Traffic speed estimates (mph)		
State	City	Freeway	Arterial street	Average
PA	Pittsburgh	56	32	44
IL	Chicago	41	25	33
MO	St. Louis	53	30	42
WI	Milwaukee	50	32	41
MD	Baltimore	44	28	36
MN	Minneapolis	46	29	38

Table 6. Public Transit Authorities Annual Energy Type Consumption Distribution (NTD 2001)

	Diesel	Gasoline	CNG[a]	Electricity
Chicago	52%	0%	0%	48%
Baltimore	70%	0%	0%	30%
Minneapolis	100%	0%	0%	0%
St. Louis	84%	0%	< 1%	16%
Pittsburgh	90%	0%	0%	10%
Milwaukee	100%	0.3%	0%	0%

[a]CNG = compressed natural gas.

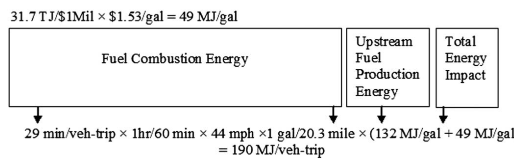

Fig. 3. Individual automobile vehicle trip total energy impact example calculation for Cranberry Heights (near Pittsburgh)

260 d/year. In addition, the energy intensity results for all developments can be found in the supplemental information.

Public Transportation

The other primary mode of commuting besides individual automobile is by public transportation. We estimated energy impacts per public transportation passenger. The National Transit Database (NTD) for 2001 provided annual energy consumption reported in gallons and kW·h and annual ridership information on the six cities' transit authorities containing the paired brownfield and greenfield developments. The distribution of fuel consumption by city can be seen in Table 6.

Public Transportation Fuel Energy

The fuel consumption information from the NTD was first combined with diesel gasoline, motor gasoline, and natural gas emission coefficients from the EIA data to obtain the combustion impacts (EIA 2009). Second, the upstream impacts from fuel and electricity production were calculated using the EIOLCA model identified previously. For fuel production impacts, the same initial EIOLCA factor of 31.7 TJ/$1 million, as described herein in the "Individual Automobile Transportation" section, was used and scaled by the corresponding 2001 consumer prices for diesel, gasoline, and natural gas (EIA 2008a, b, c).

The energy impact for direct diesel fuel combustion was assumed to be 146 MJ/gal. (EIA 2009). Thus, the total energy for diesel fuel was the sum of upstream (supply chain) and direct use $49 + 146 = 195$ MJ/gal.

The upstream energy impacts from electricity production used the EIOLCA "Power Generation" sector group for analysis. The model output for the power generation sector resulted in 114 TJ/\$1 million from the supply chain of electricity production (CMU Green Design Institute 2010). The model output was scaled by the average retail residential price of electricity in 2001 of \$0.09/kW · h (EIA 2008d).

Public Transportation Combustion Energy Impacts

After the upstream supply chain energy impact of fuel and electricity are calculated, the total energy consumed by fuel combustion must be added. For electricity, input energy to produce the electricity is in the supply chain, so direct use consumption is not included because it would be double counting. The use phase of fuel for public transportation agencies is reported by the NTD in gallons per year or kW · h/year for each energy source. The fuel and electricity consumption distribution percentages from the public transit authorities can be seen in Table 6. The NTD annual energy sources are converted into MJ/year, using the EIA emission coefficients (EIA 2009).

Lastly, the total of annual passenger trips given by the NTD, seen in Fig. 4, is used to compare the public transportation energy intensities per passenger across cities.

Energy used for a passenger trip is calculated from the public transportation agency fuel mix (Table 6), the fuel source energy intensity (EIA 2009), and public transportation annual ridership

$$\mathrm{EPT} = (\Sigma f_i \times e_i)/p \quad (2)$$

where EPT_i = energy per passenger trip for city i; f = fuel type consumption; e = energy intensity of fuel; and p = annual ridership. Assuming a passenger uses public transportation twice a day for 260 d/year gives an annual energy impact for each passenger. Milwaukee has the lowest annual energy impact for each passenger at 6,700 MJ/passenger/year (6.3 MBTU/passenger/year, and Pittsburgh has the highest at 16,000 MJ/passenger/year (15 MBTU/passenger/year. The results for all cities can be seen in Fig. 5. The wide range results from differences in annual public transportation passenger ridership (Fig. 4) and public transportation vehicle energy source distributions (Table 6).

Energy Impacts for All Transportation Modes

Combining both individual automobile transportation and public transportation energy impacts consumed by travel to work gives a more complete picture of the differences between greenfield

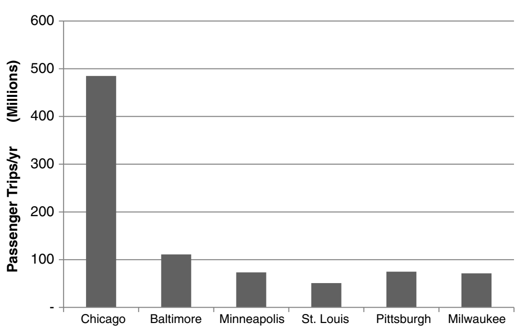

Fig. 4. Public Transportation Authority annual ridership (NTD 2001)

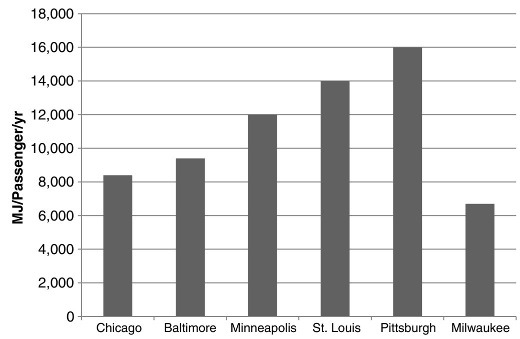

Fig. 5. Public Transit Authority annual energy impact per passenger

and brownfield developments. The energy use per commuter is calculated as a weighted average of the energy impacts for each mode, with the weights equal to the modal shares

$$\mathrm{EUC}_i = \Sigma_m\{ms_{mi} \times em_{mi}\} \quad (3)$$

where EUC_i = average energy use per commuter for development i; ms_{mi} = modal share fraction for mode m in development i; and em_{mi} = energy use per commuter for mode m and development i. We assumed those residents who carpooled had only two commuters per vehicle trip.

On average for commuting patterns, the greenfield developments consume 75,000 MJ/commuter/year (71 MBTU/commuter/year versus 47,000 MJ/commuter/year (45 MBTU/commuter/year) for brownfields. Therefore, the brownfield developments consume approximately 37% less commuting energy per resident annually than the studied greenfields (Fig. 6). The lower energy requirements are a result of differences in modal share (more walking, carpooling, and public transportation for brownfield commuters) and somewhat shorter travel times for use of private vehicles. Note that the Homan Square brownfield development is an outlier with high travel times and corresponding relatively high energy requirements.

Greenhouse Gas Emission Impacts of Commuting

The same method as presented previously for energy impacts of commuting was recalculated for greenhouse gas (GHG) emissions. The only variations were for upstream GHG emissions for fuel and electricity production and the corresponding emission factors. These upstream impacts were calculated through the same EIOLCA model and sectors described previously in the "Individual Automobile Transportation" and "Public Transportation" sections. The analysis resulted in 2,380 metric tons (t) of $C0_{2e}$/\$1 million (5.2 million lb $C0_{2e}$/\$1 million) for upstream fuel production and 9,160 t of $C0_{2e}$/\$1 million (20 million lb $C0_{2e}$/\$1 million) for upstream electricity production. The combustion GHG emission factors used for fuel and electricity were from the Energy Information Administration–Voluntary Reporting of GHG program (EIA 2002, 2009). An example calculation of the upstream impacts of diesel and electricity for public transportation for Pittsburgh can be seen in Fig. 7.

Individual automobile use by greenfield residents results in 11,000 lb $C0_2$ per auto commuter per year, which, on average, is approximately 36% higher than brownfields developments. The average greenhouse gas emissions from public transportation

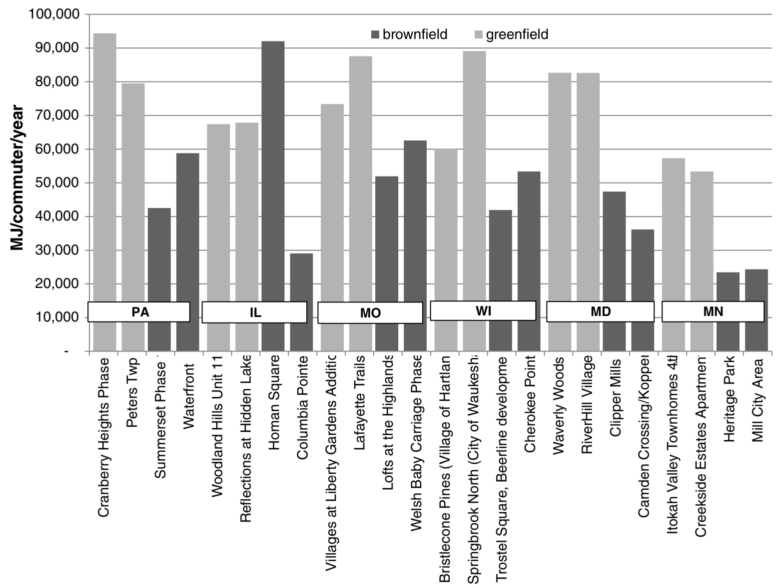

Fig. 6. Total greenfield and brownfield development energy impacts from commuting

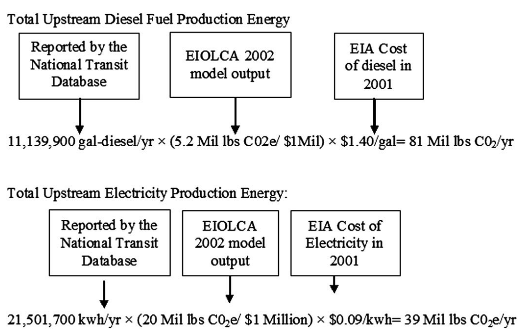

Fig. 7. Public transportation total $C0_{2e}$ upstream supply chain example calculation for Pittsburgh Transit Authority

averaged across all six studied cities is 2,000 lb $C0_2$ per bus passenger per year. Incorporating both individual automobile and public transportation travel into greenhouse gas impacts of commuting by residents, the greenfield developments average 11,000 lb $C0_2$/commuter/year, and the brownfield developments average 7,000 lb $C0_2$/commuter/year ; these results can be seen in the supplemental information.

Conclusion

This research analyzed energy consumption and greenhouse gas emissions impact differences from commuting for greenfield and brownfield developments for six cities: Baltimore, Chicago, Milwaukee, Minneapolis, Pittsburgh, and St. Louis. Greenfields are six times further from the center city, on average, than are brownfields (4 mi). On average, including both individual automobile and public transportation, the greenfield development commuters consume 75,000 MJ/commuter/year (71 MBTU/commuter/year) versus 47,000 MJ/commuter/year (45 MBTU/commuter/year) for brownfields. In terms of greenhouse gas emissions, the greenfield development emits 11,000 lb $C0_2$/commuter/year compared to 7,000 lb $C0_2$/commuter/year for the brownfield development. Thus, brownfield commuters had on average 37% lower energy and 36% lower greenhouse gas emissions for their commuting trips. These differences are from variations in modal shares (with more walking, carpooling, and public transportation for brownfield residents) and slightly shorter private automobile commuting times.

Our results have some significant uncertainties. First, our sample was limited to 24 developments. Second, we used average metropolitan travel speeds and average impacts per public transportation passenger in our estimation. Third, there is considerable uncertainty in energy and greenhouse gas emission estimates. Fourth, the greenfield and brownfield developments include the surrounding neighborhoods as defined by the US Census tracts. Finally, we did not consider other travel, buildings, or other impacts of the developments. Nevertheless, there do appear to be substantial differences in the impacts of commuting for the two types of developments.

Acknowledgments

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Supplemental Data

The supplemental data files relating to this topic are available online in the ASCE Library (www.ascelibrary.org).

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APPENDIX B

LEED Certified Residential Brownfield Development as a Travel and Greenhouse Gas Emission Reduction Strategy

Yeganeh Mashayekh, Chris T. Hendrickson, H. Scott Matthews (Carnegie Mellon University)

INTRODUCTION

The transportation sector is the second largest source of greenhouse gas (GHG) in the U.S., after electricity generation (EPA 2009a). Over the last decade, US vehicle miles traveled (VMT) have been increasing at the annual rate of about 2 percent (FHWA 2008). The US Energy Information Agency forecasts that VMT will continue to rise at an average rate of 1.6 percent over the next twenty years (DOE/EIA 2008). This forecasted impact of VMT growth could outpace gains from improved fuel economy and alternative fuels, resulting in further increases of transportation GHG emissions (AASHTO 2008).

To reduce VMT, federal, state and local governments have initiated various policy goals and initiatives. The American Association of State Highway and Transportation Officials (AASHTO) wishes to reduce VMT growth rate to that of the population growth rate, one percent, by 2030. The Federal Surface Transportation Policy and Planning Act of 2009 has a mandate to reduce national per capita VMT annually and to reduce surface transportation's impact on GHG emissions by 40 percent by the year 2030 (US FSTPP 2009). To achieve these goals, transportation state and local authorities have been implementing various VMT reduction strategies with the objective of shifting travel activity to less carbon intensive modes of transportation such as walking and biking, reducing the number of trips per capita and increasing vehicle occupancy.

In addition, the Energy Independence and Security Act was introduced in 2007, mandating the Office of Climate Change and Environment, in coordination with the Environmental Protection Agency (EPA) and in consultation with the United States Global Change Research Program to identify solutions to reduce air pollution generated from the Nation's transportation system (DOT 2010). In response to this mandate, on April of 2010 the U.S. Department of Transportation (U.S. DOT) released a report to the U.S. Congress discussing strategies that would reduce the impact of the transportation sector on climate change (DOT 2010). As part of this study the U.S. DOT examined five major categories of VMT reduction strategies: 1) pricing 2) transit, non-motorized and intermodal travel 3) land use and parking 4) commute travel reduction and 5) public information campaigns. The goal of the study was to objectively evaluate these strategies and their potentials to reduce transportation GHG emissions. While brownfield developments were briefly mentioned in the U.S. DOT (2010) report within the land use category, they were not fully assessed within the scope of the report.

With the Leadership in Energy and Environmental Design (LEED) certification system developed by the United States Green Building Council (USGBC) gaining rapid popularity and recognition over the past decade, brownfields redeveloped in combination with achieving the LEED travel reduction credits can help achieve VMT and GHG reduction goals effectively and at a faster rate.

This paper builds upon a previous study conducted by Mashayekh et. al (2011) analyzing travel patterns of sixteen residential brownfield and conventional developments in the U.S. In this paper, we examine the cost-effectiveness of 1) residential brownfield developments and 2)

LEED certified brownfield developments, as a VMT and GHG reduction strategy compared with conventional Greenfield developments. Assuming these two alternatives (residential brownfield developments and LEED certified residential brownfield developments) can be used as a VMT reduction strategy, we then compare their cost-effectiveness with other VMT reduction strategies including transit, teleworking, biking, and pricing. Finally we discuss how brownfield redevelopments that are combined with VMT reducing LEED credits not only lower the impact of the transportation sector on the environment, but can encourage cooperation between agencies across various public and private sectors to achieve a common goal: alleviating climate change.

BENEFITS AND COSTS OF BROWNFIELD DEVELOPMENTS AS A VMT REDUCTION MEASURE

Estimates show there are between 450,000 to 1,000,000 brownfield sites across the U.S. (U.S. GAO 2004). According to the U.S. Environmental Protection Agency (U.S. EPA), "brownfields are properties for which expansion, reuse or redevelopment may be complicated by the presence or suspected presence of contaminants, hazardous materials or pollutants." (EPA 2009b). To develop a brownfield site, an assessment usually followed by remediation is necessary. While remediation cost varies significantly depending on the type of contaminants, level of exposure and level of clean up (EPA 2001b, Rast 1997), Chicago (2003) reports a range of $24,000 to $550,000 per acre ($59,000 to $1,400,000 per hectare) with a median remediation cost of $190,000 per acre or $470,000 per hectare.

VMT reduction benefits of brownfield redevelopments include time, fuel and automobile maintenance savings that are the direct result of less travel activity. Furthermore, reduction in VMT results in external environmental cost savings. Mashayekh (2011) categorizes brownfield VMT reduction cost savings into groups of direct (time and fuel) and indirect (external environmental costs) cost savings. Table 1 shows the annual travel reduction and its consequential cost saving percentages from conventional developments to brownfield developments based on Mashayekh (2011). Reductions shown in Table 1 are results of an analysis of eight residential brownfield and eight residential greenfield sites in four cities of Chicago, Baltimore, Pittsburgh and Minneapolis (Mashayekh 2011). Travel demand models for the actual brownfield and Greenfield sites in these four cities were used to analyze travel patterns of the sites. VMT reductions are attributed to less number of trips per brownfield household (perhaps due to a better accessibility to transit and other facilities and also less number of people per household) and shorter trip distances (perhaps due to close proximity to city centers and places of work).

TABLE 1: Annual Travel Pattern Differences from Conventional to Brownfield Developments per Household; Mashayekh (2011)

	% Reduction from Conventional to Brownfield Developments
Vehicle Miles Traveled (VMT)	52
Number of Trips	28
Direct Cost of Time	60
Direct Cost of Fuel	60
Indirect Environmental Cost of Driving	66

Using pollution valuation data and cost of time and fuel, Mashayekh (2011) estimates direct cost savings of VMT reductions to be $2,630 per household per year and indirect environmental cost savings of VMT reductions to be about $450 per household per year. These figures are equivalent to a total average annual cost savings of about $3,100 per household or $1,300 per person. Automobile maintenance cost of $0.05 per mile, average density of 15 units per acre and an average household density of 2.4 people per dwelling unit was assumed. To compare the annual cost savings with the one time remediation cost of brownfield sites, the median cost of $190,000 per acre was annualized with a 5 percent discount rate for 30 years. Table 2 shows that, on average, brownfield developments can annually save individuals about $900.

TABLE 2: Brownfield Developments' Cost Savings per Household and per capita

Annual Cost/Savings	*Cost of Fuel Saved*	*Cost of Time Saved*	*Cost of Maintenance Saved*	*Total Direct Savings*	*External Environmental Costs Saved*	*Total Savings*	*Cost of Remediation*	*Net Savings*
$/household	425	1925	280	2,630	450	3,080	(900)	2,180
$/person	180	800	120	1,100	190	1,300	(400)	900

Other studies (EPA 1999, EPA 2001a, EPA 2002, EPA 2010a, NRDC 2003, Schroeer 1999, IEC 2003, USCM 2001) support brownfield developments' impact on reducing VMT from 30 to 80 percent. Nagengast (2010) reports a 36 percent decrease in brownfield developments' greenhouse gas emissions due to less commute travel. Section 4 of this paper discusses how the benefits and costs of brownfields compare with other VMT reduction strategies.

BENEFITS AND COSTS OF LEED CERTIFIED BUILDINGS AS A VMT REDUCTION MEASURE

The types of buildings included in a brownfield development are design decisions on the part of constructors and owners. These design decisions can choose energy efficient buildings but also include features that can further reduce VMT. Since brownfield development VMT reductions shown in Table 1 are for residential developments only, in this section we consider travel reduction credits in the LEED new residential development (LEED® for Homes) and LEED™ for Neighborhood Development (ND) standards. The goal is to gauge the additive impact of VMT reduction LEED credits, when they are incorporated into the design of brownfield developments.

USGBC LEED certification is the most popular green building standard in the US. The certification is obtained by amassing a prescribed number of credits for each new development, with different levels of certification corresponding to different levels of credits obtained. The brownfield site VMT reductions shown in Table 1 occurred without LEED certification.

In the LEED® for Homes Rating System report (USGBC 2008), there are two sections providing points that could potentially reduce VMT: 1) Sustainable Site (SS) and 2) Location and Linkages (LL).

Under the SS section, SS 6 category called "compact development" provides a minimum of 2 and a maximum of 4 points (moderate, high and very high density) while potentially reducing VMT. The objective of SS 6 category is to preserve land while increasing transportation efficiency and walkability. Multi housing units with average density of 7 to 20 or more residential units can earn LEED points under this category (USGBC 2008).

Under the LL section of LEED® for Homes, six measures shown in Figure 1 can provide a maximum of 10 LEED points. If LL1 is satisfied, LL2-6 cannot be used and vice versa.

To earn LL points under LL1, the development should be certified as LEED™ for Neighborhood Development (ND) (USGBC 2009a). A neighborhood development should earn a minimum of 40 points out of 110 points possible to be certified as LEED ND. Of the 110 points possible under LEED ND a maximum of 41 VMT reduction points can be acquired.

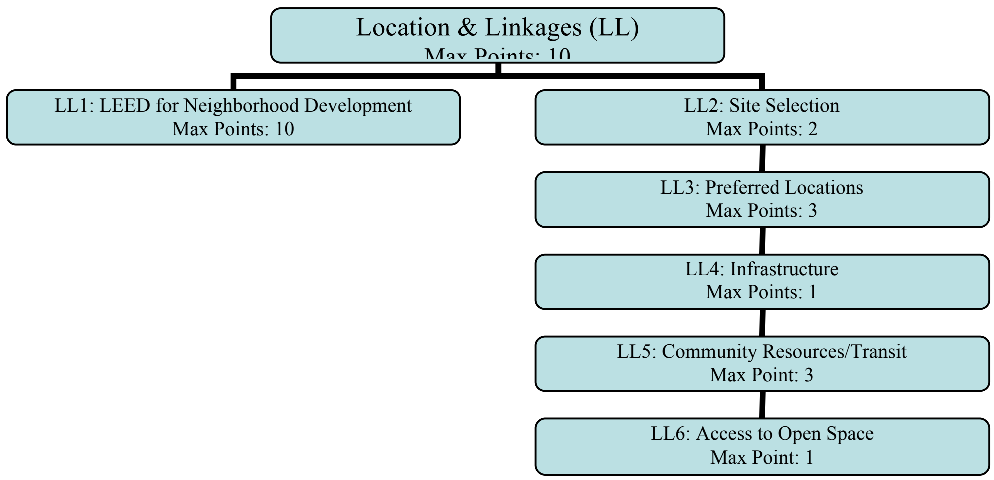

FIGURE 1: Location and Linkages Category under LEED for Homes Rating System (USGBC 2008)

In the case that a residential brownfield redevelopment is not LEED ND certified, a maximum of 10 points from LL2 to LL6 categories (Figure 1) can be credited. In that case LL5 is the only measure that can potentially result in VMT reduction:

LL5: Community Resources/Transit with an objective of promoting less VMT for a maximum of 3 points (USGBC 2008).

- Select a site that is located within ¼ a mile of 4 to 11 basic community resources such as banks, daycare centers, school, restaurants, etc.
- Or select a site that is located within ½ a mile of 7 to 14 basic community resources.
- Or select a site that is located within ½ a mile of transit services that offer 30 to 125 transit rides per weekday (bus, rail and ferry combined)

In summary a LEED certified multiunit residential brownfield development can have up to seven VMT reduction points under LEED® for Homes SS6 and LL5 categories or up to ten points under LEED® for Homes LL1 category, which is equivalent to LEED™ ND certification. Therefore LL1 can leverage all of the VMT reduction points assumed under LEED™ ND.

To assess the impacts and cost-effectiveness of VMT reduction measures under any of the two LEED systems (i.e. LEED™ ND, LEED® for Homes), we categorize them into the following three types of measures:

1- Measures reducing VMT due to high density or compact nature of the development. (e.g. SS6)
2- Measures reducing VMT due to accessibility to transit and community resources. (e.g. LL5)
3- All other measures (e.g. measures under LEED ND such as walkable streets)

Given that brownfield sites are typically within the urban core of the cities, where land is scarce and public transportation and community centers are most accessible, it is unlikely that type 1 and type 2 measures have additive impacts to VMT reductions already calculated as part of brownfield developments in the previous section. Brownfields are typically built at a higher density and their location within the city centers assures reasonable accessibility and close proximity to transit, community, civic and recreational facilities.

Type 3 measures however can have some additive impacts to the already calculated residential brownfield VMT reductions shown in Table 1. A LEED certified development can satisfy the following four LEED ND points (type 3 measures):

1- Bicycle Network and Storage
2- Walkable Streets
3- Reduced Parking Footprint
4- Transportation Demand Management

For the first two measures the Center for Clean Air Policy (CCAP) suggests 1-5% VMT reduction for bicycle improvements and 1-10% VMT reduction for pedestrian improvements (CCAP 2011). Some of these improvements are already accomplished through the compact and mixed-use nature of brownfield developments, since residents of brownfields have better accessibility to various facilities and live in close proximity of them. However, design factors such as providing connectivity through building sidewalks and bike paths, illumination of streets, sidewalks and bike paths as well as providing scenery and shade can be incorporated within the developments to further encourage biking and walking. Although separating the impacts of the design factors from the effects of mixed use and high density developments is not an easy task, there are some literature attempting to do so. A study of fifty developments done by Cervero (2001) found that each doubling of connectivity design factor reduced VMT by 3 percent. LUTAQ (2005) analyzed VMT in Puget Sound area finding that residents living in communities with the most interconnected street networks drive 26 percent less. Boarnet (2001) found that pedestrian environmental factors have a significant impact on increasing non-work travel at the neighborhood level. Case studies in Davis, California and Boulder, Colorado further show that providing bike networks and walkable streets can decrease driving from 1 to 10 percent (CCAP 2011). Summarizing what was found in the literature, given that reduction of VMT due to the compact and high density nature of brownfields is already incorporated into the brownfield VMT reduction calculations in Table 1, we assume 1 to 5 percent of additive VMT reduction impact due to pedestrian and bicycle design factors.

CCAP suggests the VMT reduction from reduced parking footprint of 5 to 25 percent. These parking management programs could include car sharing programs, unbundling of parking and rent prices, providing transit passes, incorporating maximum parking limits, providing cash out incentives to employers, and others. Most of these programs (e.g. cash out incentives) are more feasible for retail and commercial developments. For residential developments, providing car sharing programs and unbundling of pricing seem to be most feasible. Based on the literature, VMT reduction from car sharing varies significantly and no study on impacts of unbundling could be found. Steininger (1996) suggests that car sharing reduces urban VMT by 2.7%. Shaheen (1998) reported VMT reduction of 37% and 58% in Netherlands and Germany respectively due to car sharing. Copper (2000) shows 7.6% VMT reduction with the use of car sharing programs. Litman (2000) and Lane (2005) forecasted that the impact of car sharing would be a reduction of privately owned vehicles by 6 to 12 percent. Cervero (2004) assumes that car share users would reduce their VMT by 25%. Based on the literature review, for the residential brownfield development we use a market share of 20% (Shaheen 2007) meaning that 20% of residents enroll in a car share program and the range of 7 to 12 percent for VMT reduction of those enrolled.

Under Transportation Demand Management LEED point the following five options are possible (One point for every two options for a maximum of two points (USGBC 2009a)):

TABLE 3: LEED Transportation Demand Management Options

Options	*Description*	*Feasibility*
TDM Program	Create a program that reduces weekday peak period VMT by at least 20%.	Very Low
Transit Passes	Provide transit passes for at least a year, subsidized to be half of regular price or cheaper.	Low
Developer Sponsored Transit	Provide year-round, developer sponsored private transit service from at least one central point in the project to other major transit facilities.	Low
Vehicle Sharing	Locate the project such that 50% of the dwelling units entrances are within one quarter of a mile walk distance of at least one car sharing program.	Moderate to High
Unbundling of Parking	To sell or rent parking spaces separately from the dwelling units.	Moderate to High

In Table 3 under the third column the following rationale was used to rate the feasibility of each option: In a residential brownfield development that is already reducing VMT due of its compact and high density characteristics, the feasibility of creating other TDM programs that could reduce VMT by an additional 20 percent is very low. This is also due to the fact that LEED^{TM} ND states (USGBC 2009a), "Any trip reduction effects of Options 2, 3, 4, or 5 may not be included in calculating the 20% threshold." Providing transit passes and developer sponsored transit services not common within residential developments are practiced more often within mixed use developments with commercial and retail components. The additive impact of vehicle sharing and unbundling parking although more feasible to implement is already calculated as part of the Reduced Parking Footprint category. Therefore, under the vehicle sharing option no additive VMT reduction impact is considered.

In summary the additive VMT reduction impacts of implementing LEED points ranges between 1 to 12 percent for reducing VMT through bike paths, walkable streets, unbundled parking and car sharing programs. To benefit from these VMT reduction percentages and to credit LEED points associated with these reductions, owners and developers need to incorporate these measures in the design and planning of any brownfield development project. Two important factors should be considered while conducting benefit and cost analysis of LEED certified buildings:

1) The probability of achieving VMT reduction through LEED points decreases as percent VMT reduction goes up. In other words there is a higher chance of achieving 1 percent VMT reduction through LEED points than achieving 12 percent VMT reduction through LEED points.

2) In some cases although LEED measures are implemented and a building is LEED certified, energy savings and GHG emission reductions may actually not be achieved (Scofield 2009). The same may occur for VMT reductions.

On the cost side, a LEED certified development incurs a higher cost of construction compared with a conventional development plus an additional soft cost of documentation, review fees and commissioning. USGBC (2009b) report looked at 110 projects in New York City of which 63 were LEED certified. Results show that on average LEED certified high-rise residential buildings on average cost $175,000 per acre more than non-LEED buildings (USGBC 2009b). According to Kats (2009), green buildings cost about 2 percent more to construct than conventional buildings. Kats reports that the construction cost of green buildings is $3-$5/ft^2 higher than conventional buildings (approximately $130,000 to $220,000 per acre). An older study, NEMC (2003), reports LEED certification adds 4 to 7 percent to a project's construction cost. In addition NEMC (2003) reports the cost of documentation as low as $10,000 and as high as $60,000 per project. For the cost side of this analysis we use a range of $175,000 per acre assuming our residential brownfield redevelopment is LEED certified (USGBC 2009b). Higher ratings of LEED certification (i.e. Silver, Gold) would probably increase the cost of construction. However this paper analyzes costs and benefits of minimum required points for certification only. To qualify for compact developments under LEED, density should be between 7 to 21 dwelling units per acre. We assume an average density of 15 dwelling units per acre, and 5 percent discount rate for 30 years.

Adding percent reductions to the VMT that was already reduced by moving from a conventional development to a brownfield development (Table 4), and updating cost data so that it includes the cost of remediation and LEED certification, the following cumulative annual cost savings can be expected.

TABLE 4: Per Household and per Capita Annual Cost Saving Ranges of Brownfield Redevelopments when Combined with VMT Reducing LEED Points

Annual Cost/Savings	*Cost of Fuel Saved*	*Cost of Time Saved*	*Cost of Maintenance Saved*	*Total Direct Savings*	*External Environmental Costs Saved*	*Total Savings*	*Remed. + LEED*	*Net Savings*
$/household	430-	1,940-	280-300	2,650-	450-480	3,100-	(1500)	1,600-
$/person	180-	800-870	120-125	1,100-	190-200	1,300-	(600)	700-800

Table 4 shows that when a brownfield site is developed as a residential multiunit development, incorporating and implementing LEED VMT reduction measures - including bicycle network and storage, walkable streets, unbundling and car sharing programs – can potentially save each household up to an extra $200 and each person up to an extra $100 a year on the direct costs (time, fuel and maintenance). However since cost of LEED certification adds about 70% to the original cost of brownfield remediation, the net savings are less in the case of LEED brownfield developments compared with non-LEED brownfield developments. Percent VMT reduction from LEED points need to increase to 30% in order for the net savings to be the same as non-LEED brownfield developments (Table 1).

As mentioned previously, this paper only includes residential developments. Therefore only LEED points that pertain to residential developments were included in the analysis. Brownfield developments often have commercial and retail components to them. In case that a commercial brownfield development is being analyzed, LEED for New Construction (LEED NC) points are more favorable to be used for the analysis. LEED NC includes the following three potential VMT reduction measures (USGBC 2011):

1- Alternative Transportation: Public Transportation Access
2- Alternative Transportation: Bicycle Storage and Changing Rooms
3- Alternative Transportation: Parking Capacity

Of these three measures, public transportation access (as mentioned previously) will not have much of an additive impact since brownfields are already located in urban cores with a better access to transit. The next two measures, bicycle storage and changing rooms as well as parking capacity, are common in all LEED standards and have already been accounted for in the analysis of brownfield residential developments. Therefore, if commercial components are added to brownfield residential developments, we do not anticipate a significant cost saving from any additional LEED VMT reduction measure.

LEED CERTIFIED BROWNFIELD DEVELOPMENTS VS. OTHER VMT REDUCTION MEASURES

In recent years a number of studies have been conducted to quantify benefits and costs of various VMT reduction strategies (CCAP 2011, CSI 2009, Ewing 2008, NRC 2009). The U.S. DOT (DOT 2010) report to the U.S. Congress combines results of many of these studies to show how various VMT reduction strategies can be environmentally effective. To compare brownfield redevelopments and LEED certified brownfield redevelopments with other travel reduction strategies, the same definitions and assumptions as DOT (2010) were used to generate the cost-effectiveness estimates for this part of the study: for direct implementation cost, remediation cost and the cost of LEED certification are considered. For the net benefit, direct implementation costs as well as cost savings from fuel use, externalities and vehicle operation were included. For consistency between this study and the DOT report, all direct costs are reported in present year real dollars without any inflation or discounting. Calculating net benefits however, future year operating cost savings were discounted using the rate of 7 percent. Results are shown in Table 5.

TABLE 5: Comparison of Various VMT Reduction Strategies*

Strategy	*Key Assumptions*	*Cost Effectiveness* Implementation Cost ($/tonne CO_2e)	*Cost Effectiveness* Net Benefit ($/tonne CO_2e)**
Brownfield Redevelopments (this study)	Brownfield redevelopments in 4 cities of Pittsburgh, Minneapolis, Chicago and Baltimore resulting in an average of 52% VMT reduction.	16-30	250-700
LEED Certified Brownfield Redevelopments (this study)	Brownfield redevelopments mentioned in the previous row plus LEED certification including LEED VMT reduction points.	28-57	200-450
VMT Fee	VMT fee of 2 to 5 cents per mile	20-280	650-950
Pay As You Drive Insurance	Require states to permit PAYD insurance (low)/Require companies to offer (high)	30-90	920-960
Congestion Pricing	Maintain level of service D on all roads (average fee of 65 cents/mile applied to 29% of urban and 7% of rural VMT)	300-500	440-570
Cordon Pricing	Cordon charge on all U.S. metro area CBDs (average fee of 65 cents/mile)	500-700	530-640
Transit	2.4-4.6% annual increase in service; increased load factors	1200-3000	(1000)-900
Non-Motorized Modes	Comprehensive urban pedestrian and bicycle improvements implemented	80-210	600-700
Land Use	60-90% of new urban growth in compact, walkable neighborhoods (4,000+ persons/sq mi or 5+ gross units/acre)	10	700-800
Tele-Working	Doubling of current levels	1200-2300	180

*Source: A sample of VMT reduction strategies from the Report to Congress by U.S. Department of Transportation (with an exception of numbers for brownfield redevelopments and LEED certified brownfield redevelopments (first two rows)).
**A positive number shows net savings, a negative number (xx) represents increased cost. All benefits were reduced by 14% to account for the induced demand resulting from the implementation of each VMT reduction strategy. The report does not specify the type of externalities included in these estimates and the method used to estimate the externalities.

The result of this comparison shows while land use in general and brownfields in particular have the lowest implementation cost, the net benefit of brownfield developments is comparable with all other measures. Furthermore, constructing a LEED certified brownfied project that has earned the VMT reduction points under bike network, walkable streets, unbundling and car sharing within the LEED system although increases the implementation cost by 75 to 90 percent compared with a non-LEED certified brownfield development, the cost of implementation is still lower than most other VMT measures (in some cases like transit or tele-working less than 1 percent of the cost). This result further shows the net benefit of LEED certified brownfield redevelopments are in most cases comparable with other VMT measures.

DISCUSSION

From the governmental standpoint, especially state and local transportation authorities, brownfield developments and in particular LEED certified brownfield developments can serve as a cost-effective VMT reduction strategy compared to most other strategies. Table 6 shows some of the potential costs and benefits that brownfield development stakeholders might incur.

TABLE 6: Stakeholders' Benefits and Costs of Brownfield Developments

Who?	*Potential Benefits*	*Potential Costs*
Local Residents	Reduced Health Risks – Increased Home Values– Reduced Crime	Increased Tax – Noise Congestion
Brownfield Residents	Saved Time – Saved Fuel Improved Health	Safety Concerns Lower Quality of School
Developers	Existing Infrastructure - Zoning Differentiation - Funds and	Remediation Cost - Timing Issues
Society at Large	Improved Health Reduced Emission	Tax
The City	Property Tax – Employment Opportunities – Other Income	Negligible
Government	Achieving Emission Reduction Goals Various Fees	Funding - Subsidies
Transportation Authorities	Achieving VMT Reduction Goals – Increasing Cost Effectiveness of	Negligible

Most stakeholders incur some sort of a cost when it comes to brownfield redevelopments. However transportation authorities have a minimal cost since most of the cost of brownfield developments are either paid by a developer or environmental agencies such as the U.S. EPA, which provides funding and incentives for the initial remediation cost of the sites. Therefore results of this benefit cost analysis should encourage metropolitan planning organizations and state and local transportation governments as well as the transportation policy makers to consider brownfield redevelopments and especially LEED certified brownfield redevelopments as a VMT reduction strategy by encouraging and providing additional funding and incentives to other brownfield stakeholders. Furthermore, transportation authorities should join efforts with the U.S. EPA to identify and provide incentives brownfield sites that would result in an increased modal shift, such as those that are in close proximity of transit infrastructures and services. In cooperation with the cities and planning departments, transportation authorities can also provide incentives and grants that would encourage developers and planners to implement smart growth principles such as diversity and interconnectivity.

The strategies discussed here could also be augmented with additional measures to further reduce vehicle miles traveled and greenhouse gas emissions. For example, mixed use developments could further reduce overall travel demand. Energy efficient buildings could reduce GHG for heating, ventilation and cooling (Scofield 2009).

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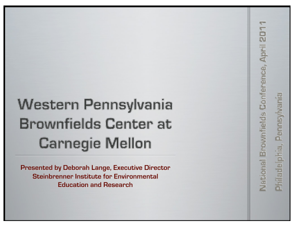
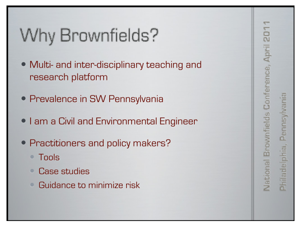
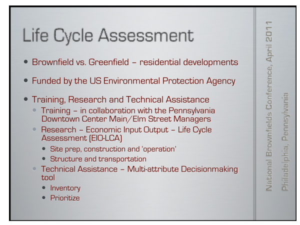
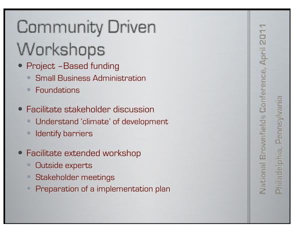
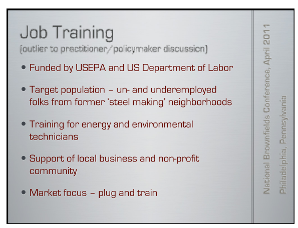
APPENDIX C

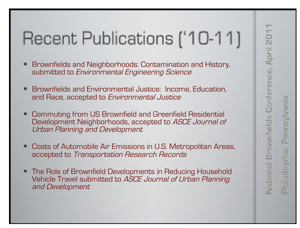

Western Pennsylvania Brownfields Center at Carnegie Mellon
Presented by Deborah Lange, Executive Director
Steinbrenner Institute for Environmental Education and Research
National Brownfields Conference, April 2011
Philadelphia, Pennsylvania

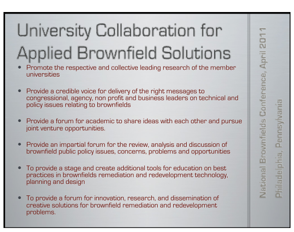

Why Brownfields?
Multi- and inter-disciplinary teaching and research platform
Prevalence in SW Pennsylvania
I am a Civil and Environmental Engineer
Practitioners and policy makers?
Tools
Case studies
Guidance to minimize risk
National Brownfields Conference, April 2011
Philadelphia, Pennsylvania


Life Cycle Assessment
Brownfield vs. Greenfield – residential developments
Funded by the US Environmental Protection Agency
Training, Research and Technical Assistance
Training – in collaboration with the Pennsylvania Downtown Center Main/Elm Street Managers
Research – Economic Input Output – Life Cycle Assessment (EIO-LCA)
Site prep, construction and 'operation'
Structure and transportation
Technical Assistance – Multi-attribute Decisionmaking tool
Inventory
Prioritize
National Brownfields Conference, April 2011
Philadelphia, Pennsylvania

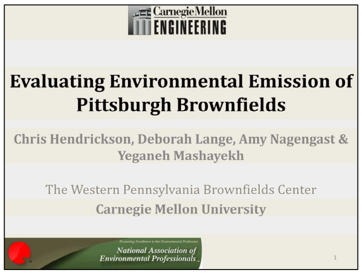

Community Driven Workshops
Project –Based funding
Small Business Administration
Foundations
Facilitate stakeholder discussion
Understand 'climate' of development
Identify barriers
Facilitate extended workshop
Outside experts
Stakeholder meetings
Preparation of a implementation plan
National Brownfields Conference, April 2011
Philadelphia, Pennsylvania


Job Training
(outlier to practitioner/policymaker discussion)
Funded by USEPA and US Department of Labor
Target population – un- and underemployed folks from former 'steel making' neighborhoods
Training for energy and environmental technicians
Support of local business and non-profit community
Market focus – plug and train
National Brownfields Conference, April 2011
Philadelphia, Pennsylvania


Recent Publications ('10-11)
Brownfields and Neighborhoods: Contamination and History, submitted to Environmental Engineering Science
Brownfields and Environmental Justice: Income, Education, and Race, accepted to Environmental Justice
Commuting from US Brownfield and Greenfield Residential Development Neighborhoods, accepted to ASCE Journal of Urban Planning and Development
Costs of Automobile Air Emissions in U.S. Metropolitan Areas, accepted to Transportation Research Records
The Role of Brownfield Developments in Reducing Household Vehicle Travel submitted to ASCE Journal of Urban Planning and Development
National Brownfields Conference, April 2011
Philadelphia, Pennsylvania


University Collaboration for Applied Brownfield Solutions
Promote the respective and collective leading research of the member universities
Provide a credible voice for delivery of the right messages to congressional, agency, non profit and business leaders on technical and policy issues relating to brownfields
Provide a forum for academic to share ideas with each other and pursue joint venture opportunities.
Provide an impartial forum for the review, analysis and discussion of brownfield public policy issues, concerns, problems and opportunities
To provide a stage and create additional tools for education on best practices in brownfields remediation and redevelopment technology, planning and design
To provide a forum for innovation, research, and dissemination of creative solutions for brownfield remediation and redevelopment problems.
National Brownfields Conference, April 2011
Philadelphia, Pennsylvania

APPENDIX D



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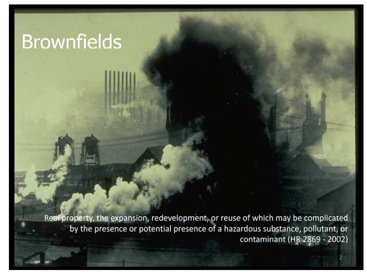
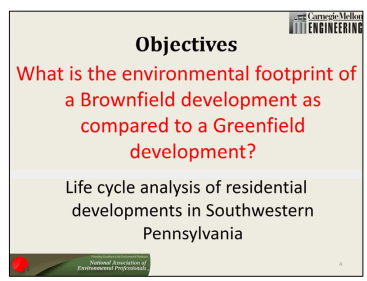


1) This is a 1947 photo of a steel making facility in Pittsburgh
2) This is a portion of the 'official' USEPA definition of a brownfield
3) Definition has wide interpretation from large industrial facilities to small local fabricators and gasoline stations
4) Total number of brownfields in the US (450,000).

2

Brownfields are desirable real estate resources from social perspective:
-Increase jobs
-Improve tax base
-Impact land value positively
-Improve health
However there are also barriers redeveloping them.

3



Given benefits and barriers of brownfield developments, in an era that climate change and global warming is one of the top concerns, how does redeveloping brownfields impact the environment?

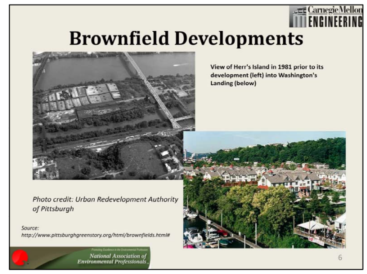
4

Location of many brownfield redevelopments in Pittsburgh. Summerset was chosen due to data availability and comparability with greenfields.
Site Selection Criteria:

- -Metropolitan Areas
- -Relatively Large Developments
- -Developed in the Past 20 Years
- -At Least 100 Housing Units

Residential Developments Only

5



Washington's Landing at Herr's Island

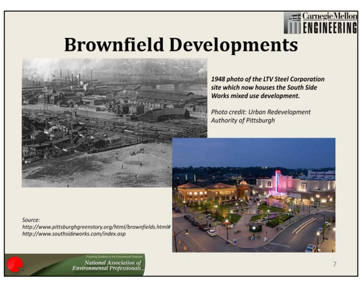
The first brownfield project undertaken was the former Herr's Island — now known as Washington's Landing — a 42-acre island located on the western bank of the Allegheny River.

For over 100 years, Herr's Island had been used as a rail stop for livestock and was a thriving regional meatpacking center. But by the mid-1970s, all that was left was an operating salvage yard and meat rendering plant. Abandoned stockyards, railroad tracks and other debris occupied over 34 acres. Noxious waste materials, traces of polynuclear aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs), and contaminated groundwater made the site virtually unusable.

After cleanup and a meticulous environmental remediation, the island was hazard-free by 1990 at a cost of approximately $2.5 million. Today, Washington's Landing is a unique waterfront resource — a center for commerce, manufacturing, recreation and upscale housing. The total development cost including public and private investment has exceeded $70 million and has created over 2,100 jobs. What was once a virtually taxless property now generates more than $1 million in revenues for the city.

Source: http://www.pittsburghgreenstory.org/html/brownfields.html

6



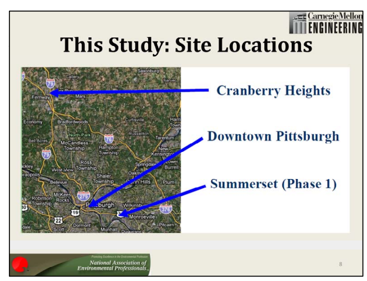
South Side Works

Directly across the Monongahela River from the Pittsburgh Technology Center and connected by a newly rehabilitated railroad bridge, sits a former LTV Steel site. In 1993 the city purchased the 123-acre site that housed a former finishing mill. While this site didn't pose the kind of environmental hazards found at the J&L site across the river, there were heavy concentrations of iron cyanide metals, and some evidence of PCBs. Based on its experience in remediating PCBs from Herr's Island, the Urban Redevelopment Authority removed these same contaminants from this site.

Now called the South Side Works, this exciting mixed use development includes entertainment, retail and office, housing, research, development, and distribution. When fully completed, the total private investment in this project is expected to reach $250 million and will create up to 5,400 jobs. Currently, the city receives almost $3 million in annual real estate taxes and will eventually receive over $8 million.

Source: http://www.pittsburghgreenstory.org/html/brownfields.html

7



Summerset at Frick Park:

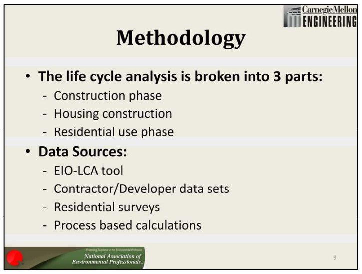
Nine Mile Run, formerly a 238-acre riverside slag dump for steel mills, is being transformed into a new traditional residential neighborhood called Summerset at Frick Park with 694 housing units on 138 acres of prepared land. Transforming the Nine Mile Run site posed three distinct challenges: grading and stabilization of 600,000 cubic yards of slag; reclamation and revegetation of 105 acres extending the adjacent Frick Park, thereby connecting it to the Monongahela River; and cleaning a polluted stream that bisects the site.

Extensive excavation to the site was required, including the addition of several feet of new soil and vegetation, but already, Summerset at Frick Park is becoming an exciting new community and one of the first new planned residential developments in the City of Pittsburgh in decades.The $243 million project will soon generate approximately $2.4 million of property taxes for the city. *Source: http://www.pittsburghgreenstory.org/html/brownfields.html*

Site locations: brownfield (Summerset) 6 miles to downtown Pittsburgh
Greenfield (Cranberry Heights) 28 miles to downtown Pittsburgh

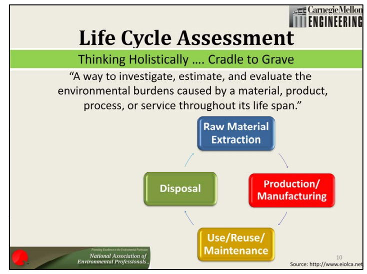
Development Comparison:
Population: BF (400), GF (900)
Number of Housing Units: BF(199), GF(244)
Land Area: BF(32acre), GF(270acre)

8



EIO-LCA:
- developed by Carnegie Mellon University (Green Design Institute).
-Estimates the greenhouse gas (GHG) emissions attributed to purchasing goods and services from a specific industry/economic sector given a specified dollar amount.
-2002 US National Producer Price Model
Contractor/Developer data sets:
-The data was organized as an array of line items specifying the materials and services purchased during the construction phase.
-Material line items detailed individual purchases, their unit price, the authorized quantity, and the total cost.
Residential Surveys:
- Household Data, Travel Behavior to Work and School, Total Annual Mileage, Monthly Household Utilities
Process Based calculations: itemizes inputs and outputs for a single step in product production

9

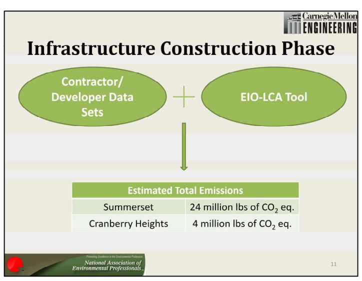


EIOLCA= "General interdependency" model: quantifies the interrelationships among sectors of an economic system
-Identifies the direct and indirect economic inputs of purchases, Assumes a linear, proportional production model in sectors, Can be extended to environmental and energy analysis. Use EIOLCA to estimate supply chain impacts for construction materials, electricity, natural gas, etc.

LCA is not perfect, but it is a helpful tool.

Sectors that Might be Applied to BF/GF Development:
Broad Sector: Construction
    Manufacturing and Industrial Buildings
    Highway, Street, Bridge and Tunnel Construction
    Water, Sewer and Pipeline Construction
Broad Sector: Professional and Technical Services
    Architectural and Engineering Services
    Environmental and Other Technical Consulting Services

10



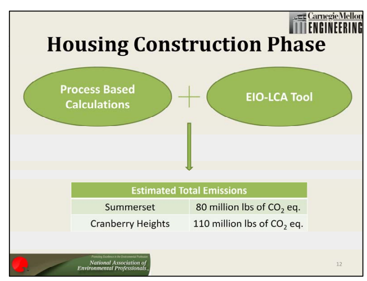
Economic Input Output - Life Cycle Assessment
Based on dollars spent in certain economic sector - data assembled by Dept of Commerce, Bureau of Economic Analysis
'Breakdown' construction costs into sectors that match BEA sectors
Environmental data also maps onto sectors
    Source: Environmental Protection Agency, Energy Information Administration

Infrastructure:
Connecting Roads
Waterlines
Power lines

Estimated Length –2 Miles

Scale construction phase emissions from the original 3.6 on-site miles, to represent 5.6 miles of total development.

11



Adjusted for both on-site and off-site construction.

Many process based values were obtained from the contractor of either Summerset or Cranberry Heights.

12

Residential Use Phase

Process Based Calculations + EIO-LCA Tool + Residential Survey

	Natural Gas	Electricity	Water	Private Vehicle	Public Transit	Total/ Capita
Summerset	18,600	27,200	1,400	15,300	1,300	32,000
Cranberry Heights	35,000	38,300	4,100	31,700	7,900	31,600

Emissions (lbs of CO_2 eq./year)

National Association of Environmental Professionals

13

The Residential Survey component asked questions regarding:

1. Household Data included the address, the move-in date, the number of residents and the months of occupancy for each residential home.
2. Travel Behavior included the job zip code for each working member of the house, along with the school zip code for each student. In addition to the zip codes, the Travel
3. Behavior also asked for the number of days the workers and students used a private vehicle, public transit, or walk/bike to their respective endpoint zip code.
4. Total Mileage required each household to report the total private vehicle miles traveled per year; as well as the total public transportation miles per week, and total non-leisurely walking/biking miles per week.
5. Household Utilities requested the typical low and high monthly utility bills for gas, electricity and water.

13

Analysis of Initial Emissions (lbs of CO_2 eq.)

		Total Development	Per Acre	Per Unit	Per Capita
Infrastructure Construction Phase	Summerset at Frick Park	24 million	750,000	120,000	60,000
	Cranberry Heights	6 million	23,000	25,000	7,000
Housing Construction Phase	Summerset at Frick Park	80 million	2.5 million	400,000	200,000
	Cranberry Heights	110 million	410,000	450,000	120,000

National Association of Environmental Professionals

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Results are given for the two developments. These results encompasses the raw material + manufacturing LCA phases.

Remember the details for the various developments.
Development Comparison:
Population: BF (400), GF (900)
Number of Housing Units: BF(199), GF(244)
Land Area: BF(32acre), GF(270acre)

The BF is more dense in population/acre and housing units/ acre.

However, BF has only 2 people/ Household while GF have almost 4 people/household. More families with children seem to be living in GF developments. These differences are some of the reasons why choosing a normalization is challenging.

The 244 developments of GF have approx. 2700 sq. ft of living space.

The BF has 5 types of housing units each with different living space (sq. ft).
Condo 1,500
Cottage 2,200
Townhome 2,400
Village 3,000
Estate 5,500

14

Analysis of On-Going Emissions (lbs of CO_2 eq./Year)

		Total Development	Per Unit	Per Capita
Utility Consumption	Summerset at Frick Park	9.4 million	47,000	24,000
	Cranberry Heights	19 million	77,000	21,000
Vehicle Usage	Summerset at Frick Park	3.3 million	17,000	8,000
	Cranberry Heights	9.7 million	40,000	11,000

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15

These results are for the Use phase of the Life Cycle are broken down in various metrics for comparison.

Finding an effective normalization for the results is challenging. There is not a standard metric (e.g. per captia, per unit, per development) in the industry for comparison. Suggestions are welcome!

Other normalizations could be (lbs of C02 eq./yr/ square foot of floor space)

15

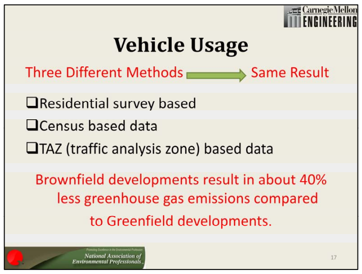
Observations

- Remedial efforts, added to the amount of construction required, results in greater environmental emissions for brownfields
- Use phase emissions:
  - Utility consumption: relatively equivalent
  - Vehicle usage: Greater for Greenfield developments

National Association of Environmental Professionals

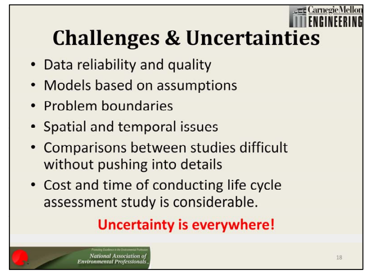
16

16



For vehicle usage two other methods were used:
1- Census based data to compare the commute between bf and gf developments.
2- Travel demand models were used to compare vehicle miles traveled between bf and gf developments.
All results show that greenfields generate more vehicle miles traveled and as a result more greenhouse gas emissions compared to brownfield developments.

17



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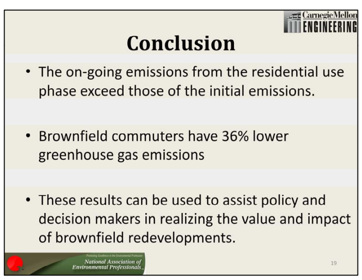


These results only reflect these two developments. Future case studies are needed before any wide conclusions can be drawn.

Brownfield commuters have 36% lower greenhouse gas emissions because they are typically closer to city centers and have higher public transportation use for commuting and comparable average travel times to work.

19

APPENDIX E

Analyzing the Environmental Impacts from Residential Brownfield and Greenfield Developments

Amy Nagengast
Carnegie Mellon University

June 10, 2011
International Society for Industrial Ecology 2011

What is a Brownfield?

Southside Works
Pittsburgh, Pennsylvania

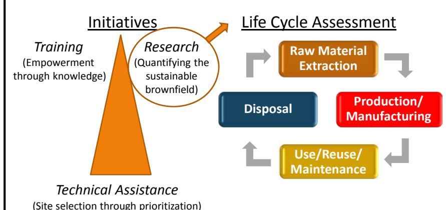
"Brownfields are properties with the presence (or suspected presence) of hazardous substances or contaminants"

Brownfields: Benefits & Barriers

Benefits
- Location
- Existing Infrastructure
- Public Health and Safety
- Economic Growth
- Job Creation
- Local Tax Generation

Barriers
- Cleanup Costs
- Development Costs
- Liabilities
- Collaboration among Stakeholders
- Permitting
- Limited data on previous projects

Assessing Brownfield Sustainability: Life Cycle Analysis and Carbon Footprinting

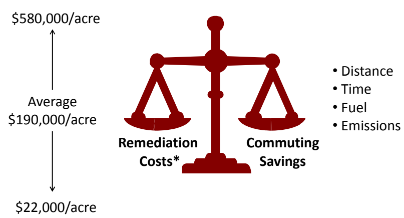


What could be different with BF and GF?

- Construction Costs-Remediation
- Travel to Work
  - Distance & Time
  - Modal Choice
- Housing Characteristics
  - Housing type (single family, multifamily)
  - Population density
- Infrastructure (roads, pipes, electricity)
- Occupant Factors
  - Income
  - Education
- Walkability-Amenities in a close proximity

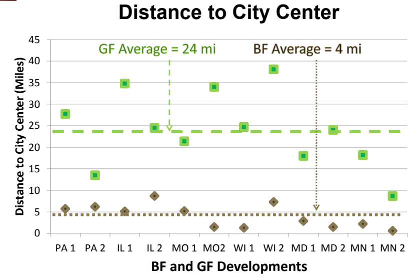
Brownfield and Greenfield Locations

Brownfield Trade Offs

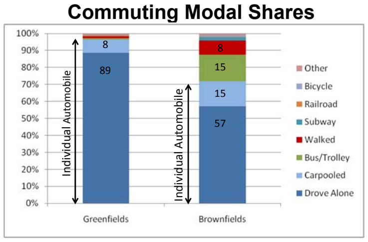


Source: Mashayekh, Yeganeh, Chris Hendrickson, and H. Scott Matthews, (2011), The Role of Brownfield Developments in Reducing Household Vehicle Travel, ASCE J. of Urban Planning and Development (in review).

Distance to City Center

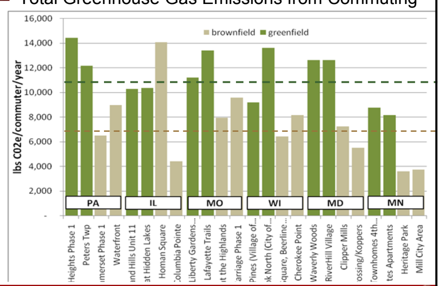


Commuting Modal Shares



Largest differences are in Individual Automobile, Public Transportation and Walking categories

Total Greenhouse Gas Emissions from Commuting

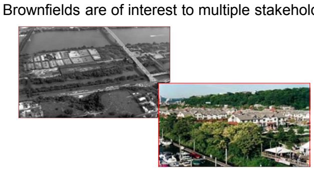


Preliminary Results

Category	Annual Savings ($/year/person)	Annual Greenhouse Gas Emission Savings (kg CO2E/year/person)
Remediation	(250)	(60)
Building Utility Energy	10	400.
Travel Costs	200	700.
Value of Travel Time	900	-
Sum	**860**	**1,000**

Conclusions

- Remediation costs and commuting savings are important in economic and GHG calculations
- Brownfield redevelopment can be an avenue to reduce transportation congestion.
- Brownfields are of interest to multiple stakeholders.



Acknowledgements

Special Thank You to:

- Chris Hendrickson, Professor, Dept. of Civil and Environmental Engineering, Carnegie Mellon University
- Deb Lange, Executive Director, Steinbrenner Institute for Environmental Education and Research (SEER), Carnegie Mellon University
- US EPA Training, Research and Technology Assistance Grant EPA-560-F-08-290
- Western Pennsylvania Brownfields Center
- Green Design Institute

Questions?

Contact Information

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Website: https://www.andrew.cmu.edu/~anagenga/

APPENDIX F

Transportation and Environmental Benefits of Developing Unutilized Industrial Sites: *Brownfields*

Chris Hendrickson, Deborah Lange, Scott Matthews, Yeganeh Mashayekh

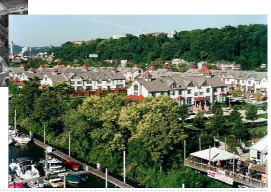
International Society of Industrial Ecology 2011, Berkeley, California

Agenda

- Introduction
- Methodology
- Results
- Discussion
- Conclusion

2

Brownfield Developments

View of Herr's Island in 1981 prior to its development (left) into Washington's Landing (below)

Photo credit: Urban Redevelopment Authority of Pittsburgh

Source: http://www.pittsburghgreenstory.org/html/brownfields.html#

3

Brownfield Redevelopment - Barriers

- Cost of remediation and lack of funding
- Uncertainty over cleanup standards
- Concerns over liability
- Land assembly issues
- Reluctance to invest in distressed communities

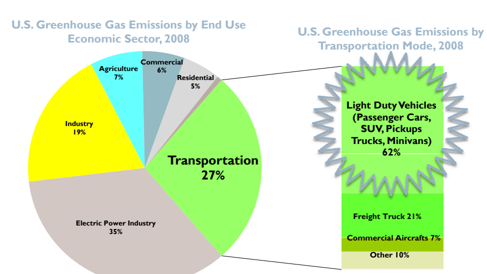
4

Brownfield Redevelopment - Benefits

- Use existing infrastructure
- Keep green spaces intact
- Increase cost-effectiveness of transit (depending on the development location)
- Provide greater opportunities for physical activity
- Generate of local tax revenue
- Reduce vehicle miles traveled and the consequential emissions

5

Transportation System's Impact on Greenhouse Gas Emission



Source: U.S. EPA. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 to 2008, April 2010

6

Transportation GHG Reduction Policy Goals

Energy Independence and Security Act 2007 – Section 1101(c)

Transportation System's Impact on Climate Change

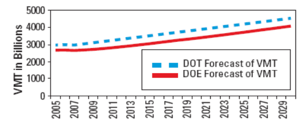
American Association of State Highway and Transportation Officials (AASHTO) Goal

Reduce rate of growth in VMT to approximately rate of population growth (about 1% per year)

Vehicle Miles Traveled (VMT)

37% Increase in VMT by light duty motor vehicles (1990 – 2008)
~15,000 miles/person

Forecasted VMT growth will outpace gains from improved fuel economy and alternative fuels.



Sources: U.S. DOE, *Annual Energy Outlook 2006, Revised Early Release (March 2006)*
FHWA, *2006 Conditions and Performance Report.*

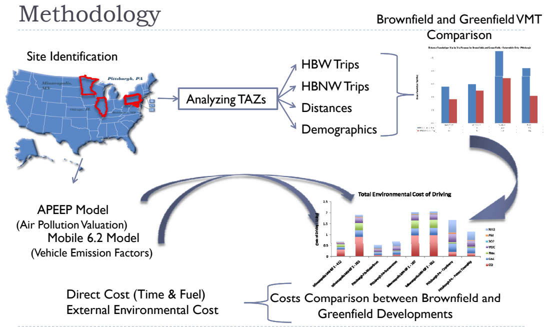
Motivating Questions

- Do Brownfield Developments reduce VMTs? What are the contributing factors for such reduction?
- Would the environmental cost savings resulted from VMT reduction offset the extra initial infrastructure development costs (i.e. remediation) of Brownfield Developments?

Agenda

- Introduction
- **Methodology**
- Results
- Discussion
- Conclusion

Methodology



Agenda

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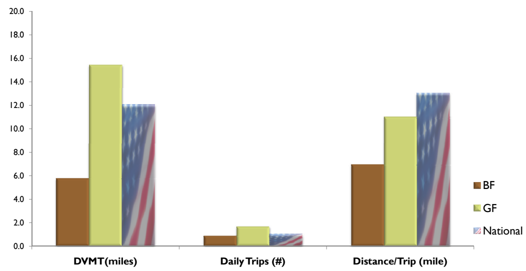
VMT Comparison Results
Brownfield and Greenfield Developments' Travel Pattern Comparisons
Home-Based Work Auto Trips per Household



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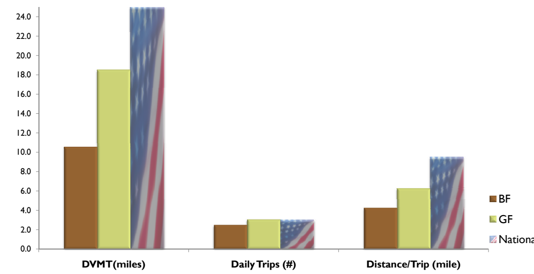
VMT Comparison Results
Brownfield and Greenfield Developments' Travel Pattern Comparisons
Home-Based Non-work Auto Trips per Household



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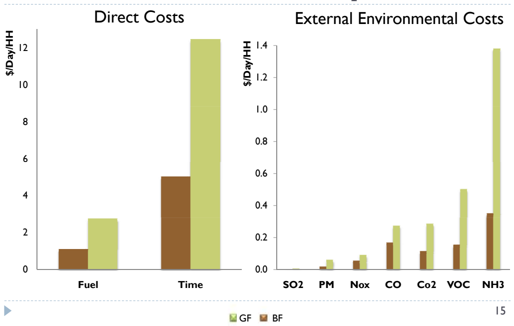
Cost Comparison Results
Brownfield and Greenfield Developments



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Annual Reductions per Household

	Greenfield Developments	Brownfield Developments	% Reduction
Vehicle Miles Traveled (miles)	8,800	4,200	52
Number of Trips	1,200	870	28
Direct Cost of Driving ($)	4,000	1,600	60
Environmental Cost of Driving ($)	680	230	66

Remediation Cost of Brownfield Developments: $190,000/Acre*
Brownfield Unit Density: 65 Units/Acre

Initial Cost: $2,900 per Household
Benefit: $2,900 per Household per Year

Source: Various Literature (mainly Chicago Brownfield Initiatives, R.S. Mean)

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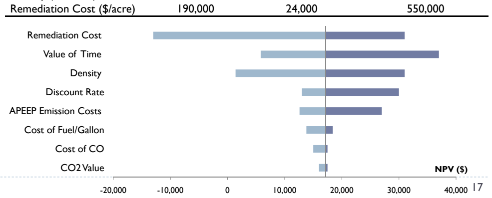
Uncertainty Analysis – 20 Year Period

	Base Case	Best Case	Worst Case
CO2 Value	$30/ton	$10/ton	$85/ton
Cost of CO ($/t)	520	1	1050
Cost fuel ($)/Gallon	2.80	Min (2008-2010)	Max (2008-2010)
APEEP Emission Costs	County Specific	Lowest County Costs	Highest County Costs
Discount Rate	7%	3%	9%
Cost of Time ($)	15.5	8.25	30.0
Density (HH/acre)	12	100	6
Remediation Cost ($/acre)	190,000	24,000	550,000



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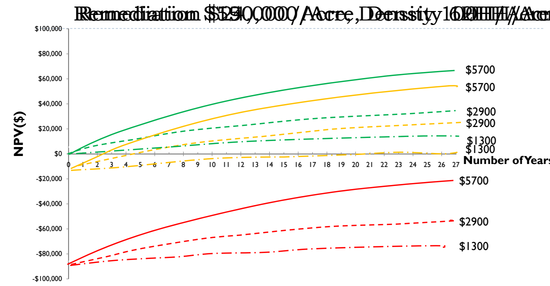
Net Present Value – [illegible] Scenario —
Remediation $[illegible]/Acre, Density [illegible] HH/Acre



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Agenda

- Introduction
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- Conclusion

Brownfield vs. Other VMT Reduction Strategies

Strategy	Cost Effectiveness: Implementation Cost ($/tonne CO_2e)	Cost Effectiveness: Net Included Benefit ($/tonne CO_2e)
This Study	14-16	260-750
VMT Fee	20-280	650-910
Pay As You Drive Insurance	30-90	920-960
Congestion Pricing	300-500	440-570
Cordon Pricing	500-700	530-640
Transit	1200-3000	(1000)-900
Non-Motorized Modes	80-210	600-700
Land Use	10	700-800
Tele-Working	1200-2300	180

Source: Department of Transportation, Report to Congress, April 2010

Agenda

- Introduction
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In Summary…

- Brownfield Developments generate less VMT:
  - Shorter distances to city centers result in shorter distance/trip especially for commuters
  - Fewer trips, possibly due to better accessibility to transit
- Total cost of driving for Brownfield developments lower than for Greenfield developments
- Cost savings from Brownfield developments offset initial remediation costs in a short period of time (assuming median remediation cost and density)
- Brownfield developments can be a cost-effective strategy to reduce VMT in long term (depending on the nature of the stakeholders)

Stakeholders' Benefits and Costs of Brownfield Redevelopment

Who?	Potential Benefits	Potential Costs
Local Residents	Reduced Health Risks - Increased Home Values- Reduced Crime Rate	Increased Tax - Noise - Congestion
Brownfield Residents	Saved Time - Saved Fuel - Improved Health	Safety Concerns - Lower Quality of School
Developers	Existing Infrastructure - Zoning Differentiation - Funds and Subsidies	Remediation Cost - Timing Issues - Liability Concerns
Society at Large	Improved Health - Reduced Emission	Tax
The City	Property Tax - Employment Opportunities - Other Income	★
Government	Achieving Emission Reduction Goals - Various Fees	Funding - Subsidies
Transportation Authorities	Achieving VMT Reduction Goals - Increasing Cost Effectiveness of Transit	★

Policy Implications

Quantitative results should encourage MPOs, DOTs and transportation policy makers to consider Brownfield redevelopments as a VMT reduction strategy:

- Provide incentives and funding to other stakeholders
- Cooperate with other agencies such as EPA to select sites that would result in more VMT reduction (i.e. proximity to transit)
- Guide and provide incentives to developers and planners to implement smart growth principles (i.e. diversity and interconnectivity)
- Facilitate and encourage cooperation between agencies on a federal, state and local levels to work at cross purposes

Acknowledgments

- Dr. Chris Hendrickson, Dr. Scott Matthews, Dr. Deborah Lange
- Green Design Reading Group
- Steinbrenner Institute
- NSF Grant No. 0755672
- U.S. EPA Brownfield Training and Technical Assistance Grant
- The Southwestern Pennsylvania Commission
- Chicago Metropolitan Agency for Planning
- Baltimore Metropolitan Council
- Minneapolis Metropolitan Council

Thank You

Questions & Comments

Outstanding Issue – Future Work

- Expansion of the analysis to include more sites and especially those that will help with the combination of VMT reduction strategies
- Expansion of the analysis to include other aspects of Brownfield Developments including commercial and retail facilities
- Including congestion and transit environmental costs

Liability Issues

- Small Business Liability Relief and Brownfields Revitalization Act - mostly for Superfunds (2002)
- Economic Development Agency, Fiduciary and Lender Environmental Liability Protection Act (1995- Pennsylvania)
- Ohio and Illinois

The Paradox of Intensification

Ceteris paribus, urban intensification which increases population density will reduce per capita car use, with benefits to the global environment, but will also increase concentrations of motor traffic, worsening the local environment in those locations where it occurs.

Source: http://en.wikipedia.org/wiki/Compact_City

Remediation Cost Based on Various Documentations

Study	Remediation Cost ($/acre)	Note
Chicago 2003	25,000-530,000	Various Projects
Auld 2010	580,000	Pittsburgh
Lehr 2004	250,000-500,000	Capping
CUED 1999	57,000	-
R.S. Mean 2010	45,000	Capping (18")
Terry 1999	22,000	Phytostabilization
Terry 1999	56,000	Soil Capping
Terry 1999	65,000	Asphalt Capping

Brownfield and Greenfield Developments' Travel Pattern Comparisons

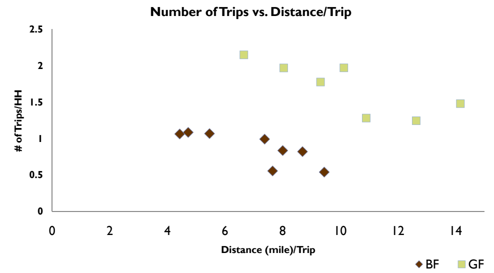
HBW

Type	Average VMT (mile/HH)	Average Distance (miles/trip)	Average # of Trips/HH
Brownfield (BF)	6.0	7.0	0.9
Greenfield (GF)	15.0	11.0	1.7
National	12.0	13.0	1.0
Reduction (GF to BF)	60%	36%	47%

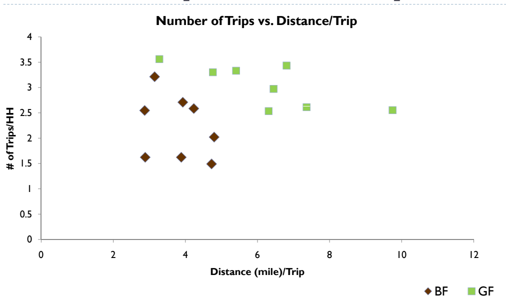
HBNW

Type	Average VMT (mile/HH)	Average Distance (miles/trip)	Average # of Trips/HH
Brownfield (BF)	11.0	4.2	2.5
Greenfield (GF)	19.0	6.3	3.0
National	25.0	9.5	3.0
Reduction (GF to BF)	42%	33%	17%

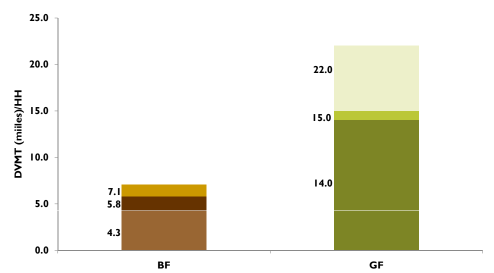
HBW Auto Trips – BF & GF Comparison



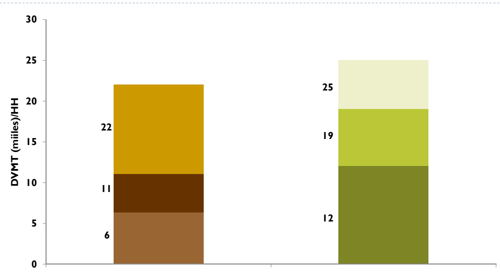
HBNW Auto Trips – BF & GF Comparison



DVMT/HH Range Comparison – BF & GF – HBW Auto Trips



DVMT/HH Range Comparison – BF & GF – HBNW Auto Trips



Comparison of Direct & Indirect Average Daily Costs/HH between Brownfield & Greenfield Sites

	Average Direct Costs ($/Day)		Average Indirect External Environmental Costs ($/Day)							
Area	Time	Fuel	CO_2	NO_x	VOC	CO	SO_2	PM	NH_3	Total
Brownfield (BF)	5.0	1.1	0.1	0.06	0.2	0.2	0.002	0.02	0.4	0.9
Greenfield (GF)	12.0	2.8	0.3	0.09	0.5	0.3	0.005	0.06	1.4	2.6
% Reduction (GF to BF)	60	60	60	40	70	40	60	70	75	67

Sources of Ammonia Emissions:

Agriculture is by far the biggest source of ammonia emissions.

Livestock farming and animal waste account for the biggest percentage of total ammonia emissions which are due to the decomposition of urea from large animal wastes and uric acid from poultry wastes.

Livestock – contributes more than 50% of all emissions

Fertilizer application

Oceans

Vegetation

Biomass burning

Source: http://www.tropical-rainforest-animals.com/Air-Pollutants.html

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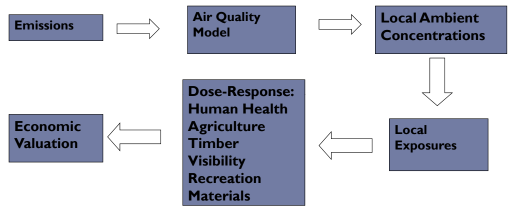
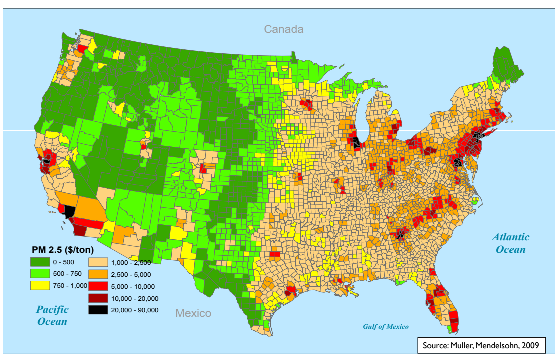
Non-Climate Damages via Air Pollution Emissions Experiments and Policy Analysis Model (APEEP)



Uses NEI - All emissions of NH_3, $PM_{2.5}$, PM_{10}, SO_2, NO_x, VOC in the contiguous U.S.

Source: *National Research Council Report , Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use Presentation by Dr. Jared Cohon and Dr. Scott Matthews, Carnegie Mellon University, Departments of Civil & Environmental Engineering / Engineering & Public Policy*

APEEP Marginal Damages ($/ton): $PM_{2.5}$ Area Sources



VMT Reduction – Other Strategies

Strategy	Typical Reduction %*
Commute Trip Reduction Programs	10-30%
Congestion Pricing	10-20%
Pay as you Drive	10-12%
Transit and Rideshare Improvements	10-30%
Walking and Cycling Improvements	5-15%

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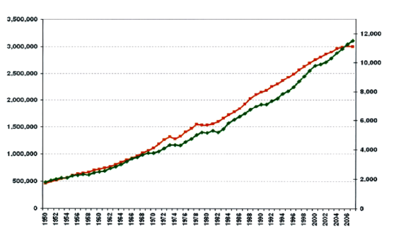
**Transportation Emission Reduction Strategies, Todd Litman, July 2010*

Correlation does not prove causation!

Vehicle Miles Traveled (VMT) and Gross Domestic Product (GDP) are extremely closely correlated:

Since 1950, the cumulative correlation rate between VMT and Real GDP, calculated using Pearson's R, is .9946. This is an extraordinarily strong correlation even when calculating the R-square value of 98.9% which indicates the predictive value between the two variables (VMT or GDP).



Source: HUA 2009

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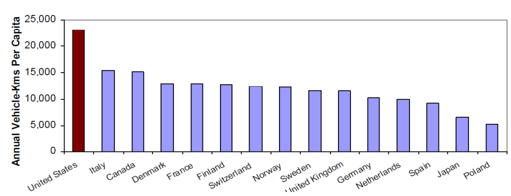
Per Capita Annual Vehicle Travel Per Country



Wealthy countries such as Switzerland, Norway and Sweden drive half as much as U.S. due to policies and planning practices that increases transport system efficiency!

Source: OECD 2009

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Typical Steps in the Redevelopment Process

Source: Anatomy of Brownfield Redevelopment, EPA 2006

Mode Share Depending on Distance from Public Transit Stop

	From station: home distance/work distance Subgroups		
	3C 1 mi/1mi (%)	2B 0.5 mi/0.5 mi (%)	1A 0.25 mi/0.25 mi (%)
Walk	6	8	9
Bike	3	4	3
POV	58	45	40
CTA/Pace Bus	8	10	9
CTA Train	11	17	27
Metra Train	10	12	9
Other	4	4	3

Source: Relationship between proximity to transit and ridership for journey-to-work trips in Chicago
Marshall Lindsey, Joseph L. Schofer, Pablo Durango-Cohen, Kimberly A. Gray
Transportation Research Part A, July 2010

Sample Calculations

$$FU_{(a)} = (FE_i * DVMT_{i(a)}) + (FE_j * DVMT_{j(a)})$$
$$FC_{(a)} = (FU_{(a)} * P)/C$$

$FU_{(a)}$ = Fuel use for site a (MJ/day);
FE = Fuel energy (MJ/Mile);
$FC_{(a)}$ = Fuel cost for site a ($/day);
P = Price of gas ($2.8/gallon);
C = 121.3 MJ/gallon of gasoline
$DVMT_{(a)}$ = Daily vehicle miles traveled for site a (mile/day);
i and j represent freeway and arterial respectively.

$$C_{i(a)} = DVMT_{(a)} * EF_i * C_i$$

$C_{i(a)}$ = Cost of pollutant i for development a ($/day);
$DVMT_{(a)}$ = Daily vehicle miles traveled for development a (mile/day);
EF_i = Emission factor for pollutant i (gram/mile); and
C_i = Cost factor for pollutant i ($/1000gram).

Direct Cost

$$FU_{(a)} = (FE_i * DVMT_{i(a)}) + (FE_j * DVMT_{j(a)})$$
$$FC_{(a)} = FU_{(a)} * P$$

Where:
- $FU_{(a)}$: Fuel use for site a (MJ/day);
- FE: Fuel energy (MJ/Mile);
- $FC_{(a)}$: Fuel cost for site a ($/day);
- P: Price of gas ($2.8/gallon);
- $DVMT_{(a)}$: Daily vehicle miles traveled for site a (mile/day); and
- i and j represent freeway and arterial respectively.

External Environmental Cost

$$C_{i(a)} = DVMT_{(a)} * EF_i * C_i$$

Where:
- $C_{i(a)}$: Cost of pollutant i for development a ($/day);
- $DVMT_{(a)}$: Daily vehicle miles traveled for development a (mile/day);
- EF_i: Emission factor for pollutant i (gr/mile); and
- C_i: Cost factor for pollutant i ($/kg).

Strategies to Reduce Greenhouse Gas Emissions of Transportation Sector

- Type of Fuel (Low–Carbon)
- Fuel Economy (Increase)
- Improving Transportation Efficiency (Management and Operations)
- Reducing Travel Activity (Vehicle Miles Traveled)

Components

- Site Selection Criteria:
  - Metropolitan Areas
  - Relatively Large Developments
  - Developed in the Past 20 Years
  - At Least 100 Housing Units
- Residential Developments Only
- 2010 TDM Models
- Only Automobile Trips
- Arterial vs. Freeway Miles: TTI Urban Mobility Report (2009)
- Speed: Freeways (65mph); Arterials (35mph)
- Distances are based on shortest paths.

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Strategy	Key Assumptions	Cost Effectiveness Implementation Cost ($/tonne CO_2e)	Cost Effectiveness Net Included Cost ($/ tonne CO_2e)
This Study	Explained throughout this presentation	14-16	260-750
VMT Fee	VMT fee of 2 to 5 cents per mile	20-280	650-910
Pay As You Drive Insurance	Require states to permit PAYD insurance (low)/Require companies to offer (high)	30-90	920-960
Congestion Pricing	Maintain level of service D on all roads (average fee of 65 cents/mile applied to 29 percent of urban and 7 percent of rural VMT)	300-500	440-570
Cordon Pricing	Cordon charge on all U.S. metro area CBDs (average fee of 65 cents/mile)	500-700	530-640
Transit	2.4-4.6% annual increase in service; increased load factors	1200-3000	(1000)-900
Non-Motorized Modes	Comprehensive urban pedestrian and bicycle improvements implemented	80-210	600-700
Land Use	60-90% of new urban growth in compact, walkable neighborhoods (4,000+ persons/sq mi or 5+ gross units/acre)	10	700-800
Tele-Working	Doubling of current levels	1200-2300	180

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Travel Demand Models

- Step 1 • Trip Generation
- Step 2 • Trip Distribution
- Step 3 • Mode Choice
- Step 4 • Assignment

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Comparison of VMT and GHG Reductions with Various Studies

Study	Geographic Area	Type of Land-Use	Average Reduction in VMT	Range of Reduction in VMT	Range of Reduction in GHG & Air Pollutants
This Study	Baltimore, Pittsburgh, Chicago, Minneapolis	Brownfield	52%	38% - 63%	35%- 75%
EPA 2010a	Seattle, Minneapolis, St. Paul, Emeryville, Baltimore, Dallas	Brownfield	47%	32% - 57%	32% - 57%
EPA 2001a, EPA 2002, EPA 1999, NRDC 2003, Schroeer 1999, IEC 2003	12 cities: Atlanta, Baltimore, Boston, Charlotte, Denver, Dallas, Nashville, Sacramento, San Diego, Montgomery, Wes Palm Beach, BCD	Brownfield	61%	39% - 81%	-
US Conference of Mayors (USCM), 2001	Baltimore and Dallas	Brownfield	-	23% - 55%	36%-87%
EPA 2006	Atlantic Station, Atlanta	Brownfield	73%	14%-52%	-
CSI 2009,	U.S.	Compact	40%	20%-60%	20%-60%
NCR 2010	U.S.	Compact	-	5%-25%	5%-25%
Ewing 2008,	U.S.	Compact	30%	20%-40%	18%-36%

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Travel Time Comparisons with National Averages – Auto Only

	TAZ Based		Census Based*		Survey Based **		NHTS 2009
	BF	GF	BF	GF	BF	GF	
HBW Travel Time (min)	12.0	16.0	20.0	24.0	15.0	17.0	24.0
HBNW Travel Time (min)	19.0	26.0	-	-	-	-	18.0

**Commuting from US Brownfield and Greenfield Residential Development Neighborhoods, Amy Nagengast, Chris Hendrickson and Deborah Lange*
***A Life Cycle Assessment Case Study of a Brownfield and a Greenfield Development: Cranberry Heights and Summerset Pennsylvania, Ronell Auld, Chris Hendrickson, and Deborah Lange*

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Brownfield Sites - Facts

- 450,000 Brownfield sites in the U.S.
- Abandoned or underutilized
- Desirable real estate resources from social perspective:
  - Increase jobs
  - Improve tax base
  - Impact land value positively
  - Improve health

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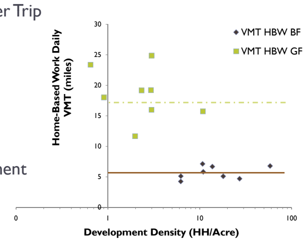
Contributing Factors to VMT Reductions

- Distance to City Center:
  - Shorter Distances per Trip
  - Fewer Trips
- Design:
  - Walkability
  - Access to Transit
- Diversity:
  - Mixed-use Development
- Density:
  - High vs. Low



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APPENDIX G

PDC'S PROPERTY PROFILE

Complete on per property - fill in as much information as possible.

GENERAL INFORMATION Date: ____________________

Name and title of person completing the profile: ____________________

Name of organization: ____________________

Address: ____________________ Phone number: ____________________

E-mail: ____________________

PROPERTY OWNER

Name of site (if applicable): ____________________

Address: Street: ____________________

City: ____________________ Zip: ____________________

County: ____________________ E-mail: ____________________

Is the owner open to redevelopment options? Yes__ No___ Not sure___

SITE INFORMATION

Name of site (if applicable): ____________________

Address: Street: ____________________

City: ____________________ Zip ____________________

County ____________________

Municipality: ____________________

Tax parcel ID# ____________________ Tax millage rate: ____________________

Are there any tax liens currently on the property? Yes__ No___ Not sure___

SITE INFORMATION (CONTINUED)

Are there any ongoing operations on the property? Yes___ No___ Not sure___

Size of property (acres):_______________ Zoning:____________________

Is the property more the 25% vacant? Yes___ No___ Not sure___

Number of structures on the property: 0____ 1-5 ____ 5+

Condition of structures: good (#_____) fair (#_____) poor (#_____) NS___

Age of structures: < 10 yrs:_____ 10 to 20 yrs: _____ >20 yrs: _____

NS:__

Does the property have historical value? Yes___ No___ Not sure___

Has a phase I ESA been preformed? Yes___ No___ Not sure___

Has a phase II ESA been preformed? Yes___ No___ Not sure___

Has there been any US EPA or PA DEP environmental response to the site?

Yes___ No___ Not sure___

If YES please explain: ____

____

____

____

Describe surrounding uses/neighborhood:________________________________

____

____

____

Please include pictures of the site, and if available, site plan, floor plan, and other report that might be available.

APPENDIX H

Site Attribute Questionnaire

Pennsylvania Downtown Center and The Western Pennsylvania Brownfields Center at Carnegie Mellon is designing a multi-attribute decision making tool to assist in prioritizing sites in Core Communities for redevelopment. The tool will allow Keystone C.O.R.E Services (KCS) to optimize their site selection process by weighting criteria of local and immediate interest as they determine where to allocate **environmental assessment and predevelopment** funds.

KCS first develops a weighting system to emphasize what is important to them. Then the tool uses a comprehensive list of factors to measure a site's redevelopment potential and assigns each site a score. These scores are adjusted according to the weighting scheme dictated by KCS. The weighted scores are then ranked to determine which sites would yield the greatest benefit.

For your convenience, the survey has been split into two parts; the first part was the property profile you completed which is necessary for a score to be calculated. The second part is the site attribute questionnaire which is attached. The questionnaire asks for information which is publicly available. KCS will work with the community to fill out the questionnaire as completely as possible. The community's participation and input will help us to improve the questionnaire and prepare it for broad distribution.

Thank You,

Eddy Kaplaniak

Keystone C.O.R.E. Services

Before you begin

Omitted Answers

This questionnaire was designed to be as user friendly as possible; to that end there is the option to submit a "not sure" response. Please submit this answer if you are unsure instead of leaving the question blank.

It is important to remember that there is no right or wrong answer to each question, the questionnaire is meant to evaluate the situation, not test your knowledge of the site. Please only select one answer per question.

For some quantitative questions, the answers are split into sections, for example "5-10 years". If you know the exact answer, please write that down.

Understanding the "actors"

There are several key people in this prioritization process.

The decision maker – They use the tool to prioritize the sites and decide how the assessment/predevelopment funds will be allocated. The decision maker is the entity that has access to funding. In this case the decision maker is Keystone C.O.R.E. Services

The information provider – He or she completes the questionnaire for specific sites. This person is unbiased towards the site and understands the role the site plays in the community.

The site owner –It is not necessary for the site owner to be involved in the data collection or prioritization process unless their data is needed to provide an accurate survey of the site. Should their site be ranked among the top and chosen for fund allocation, then the owner should be notified and further steps can be taken.

Indicator Questions

A. Development Driver/Champion Indicator

The champion is an entity, preferably an individual, who takes on the role of the organizer, the instigator, the cheerleader and the connecter. He or she "drives" the redevelopment effort. They might be part of a private sector developer, a community-based organization, or a local redevelopment authority.

1. To what level has a developer (or other private sector investor) expressed an interest in the site?
    - € Interested, and has funds for redevelopment
    - € Interested, but does not have adequate funding
    - € Somewhat, but only has a preliminary interest
    - € No one has expressed an interest

2. OPTIONAL QUESTION 2: To what level has the municipality or other non-profit NGO expressed an interest in the site?
    - € Interested, and has funds for redevelopment
    - € Interested, but does not have adequate funding
    - € Somewhat, but only has a preliminary interest
    - € No one has expressed an interest

B. Development Potential Indicator

This indicator assesses the likelihood that a site will be redeveloped. There are five sub-indicators within development potential: end use, funding, time, labor market and property ownership. Using your answers, we will be able to assess what sites stand a better chance of redevelopment.

End Use

The end use plan is a realistic plan that integrates important details like current land use, demographics, community master plans, historical development patterns, etc… The existence of an end use plan indicates that site champions have put some level of thought into the site.

3. How consistent is the proposed end use with the surrounding land use?
    - € Very consistent
    - € Consistent

- € Somewhat consistent
- € Inconsistent
- € No end use has been determined

4. Given today's economic and development climate in the area, how beneficial will the proposed end use be to the community?
   - € Very beneficial
   - € Beneficial
   - € Neither beneficial nor detrimental
   - € Detrimental
   - € No end use has been determined

5. How many long term jobs would be supported on this site?

   € 0 – 25 € 26 – 50 € 51 – 75 € 76 – 100 € 100 +

Funding

Finding sufficient funding for a project can be challenging due to a variety of reasons, including the lenders' fear of environmental liabilities. However, there are a variety of available funding sources – both public and private – that are specifically targeted at brownfields.

6. Are there at least partial funds for the environmental investigation?

   € Private € Public € Both € None € Completed
7. Are there at least partial funds for the environmental remediation?

   € Private € Public € Both € None € Completed
8. Are there at least partial funds for pre-development costs; such as engineering and permitting?

   € Private € Public € Both € None € Completed
9. Are there at least partial funds for construction costs?

   € Private € Public € Both € None € Completed

Time

Please answer the following questions as if the necessary funds were available.

10. If the environmental investigation would begin today, how long would it take to complete? (in months)

    € 0 – 6 € 7 – 12 € 13 – 18 € 18 – 24 € 25 +

11. Estimated time to complete the remediation (in months)

€ 0 – 6 € 7 – 12 € 13 – 18 € 18 – 24
€ 25 +

12. Estimated time to complete the infrastructure (in years)

€ 0 – 1 € 2 € 3 € 4 €
5 +

Property Ownership

The number of owners a piece of property potentially influences the ease of property acquisition. Getting permission from the owner(s) to assemble all sites and/or occupy them can be challenging.

13. How many entities own the property of interest?

€ 0 € 1 € 2 € Multiple €
Unknown

14. Has a plan that includes site acquisition, site assembly, etc. been completed?

€ Yes € No € Not sure

Community Support

Brownfields have been shown to be an integral component of the fabric of the communities in which they sit. Historically, community involvement has an obstructionist reputation – especially in federally influenced redevelopment activities. But due to the complexity of the site histories, legal and financial issues and environmental contamination, community engagement is very important to brownfield redevelopment.

15. How supportive is the surrounding community of the redevelopment plan for this specific site **(generally speaking)**?

€ Very supportive
€ Supportive
€ Indifferent
€ Unsupportive
€ Very unsupportive
€ No current redevelopment plan exists

16. How interested is the community in promoting brownfield development **(generally speaking)**?

€ Very interested
€ Interested
€ Indifferent

- € Uninterested
- € Very uninterested

Quality of Life

Many times, and especially in older communities, the land occupied by brownfields can be a key asset to the community.

17. If the end use is determined, will the redevelopment provide more recreational opportunities for the community?
    - € Many more recreational opportunities
    - € Some recreational opportunities
    - € No recreational opportunities
    - € No end use has been determined

18. If the end use is determined, will the redevelopment provide more green space for the community?
    - € Much more green space
    - € Some green space
    - € No green space
    - € No end use has been determined

C. Environmental Indicator

The environmental indicator is designed to estimate both the likelihood and magnitude of environmental contamination of a site, either real or suspected. It is often very difficult and laborious to get site specific environmental data related to potential contamination, so we used the following qualitative metrics to assess the potential level of environmental impact and implications for public health.

Contamination

19. Is there any perceived contamination on the site?

    € Yes € No

    If YES, please check all relevant Hazardous/Petroleum products
    - € Controlled Substances
    - € Asbestos
    - € PCBs - Polychlorinated Biphenyls (see appendix A for more information)
    - € VOCs -Volatile Organic Compounds (see appendix A for more information)
    - € Lead
    - € PAHs - PPolycyclic Aromatic Hydrocarbons (see appendix A for more information)

€ Radioactive materials
€ Other Metals: ______________________
€ Other Contaminants: _________________

20. Please give the number of documented releases of contaminants from the site:
€ 0 € 1 € 2 € Multiple € Unknown

Previous Use of Site

Identifying and documenting the historical uses of the site can play an important role in estimating the source and type of contamination with the eventual goal to determine an appropriate remediation strategy.

21. Please check the types of activities that the site has been used for:
€ Industrial – What type of industry? ____
€ Residential
€ Commercial - What type of commercial? ____
€ Green Space
22. Is the previous/current owner a documenter polluter?
€ Yes € No € Not sure
23. How long has the site been vacant? (in years)
€ 0 € 1 – 5 € 6 – 10 € 11 – 15 € 16 +
24. How long has the site been underutilized? (in years)
€ 0 € 1 – 5 € 6 – 10 € 11 – 15 € 16 +
25. Are there any deed restrictions on the property?
€ Yes € No € Not sure

Public Utilities

Does the site have curb connection/access to the following?
26. Municipal water:
€ Yes € No

27. Power grid:
€ Yes € No

28. Sewage system:
€ Yes € No

29. Septic:

€ Yes € No

30. Cable/DSL:

€ Yes € No

31. Phone:

€ Yes € No

32. Cellular service:

€ Yes € No

33. Fiber Optic:

€ Yes € No

D. Market Information

Labor Market

The population that is available for the 'labor market' is defined as the population that is between ages 16 and 64.

1) In Pennsylvania, the statewide average unemployment rate is 8.5%[i]. How would you describe your municipality's unemployment rate?

   € lower € approximately the same € higher

2) If you know the unemployment rate for your municipality, please provide it here:_______________%

3) The percentage of Pennsylvanian residents, 25 years of age and older, with at least a high school diploma is 81.9%. The percentage of your municipality's population, 25 years and older, with at least a high school diploma is…

   € lower € approximately the same € higher

Property and Wage Values

In order to better understand the surrounding community in which the brownfield site is located, please provide answers to the comparisons of this site with other (non-brownfield) properties in the area.

4) What is the difference in the surrounding property values from that of this site?
   a) Surrounding property values are significantly higher than site's

b) Surrounding property values are moderately higher than site's
c) Surrounding property values are slightly higher than site's
d) Surrounding property values are comparable to site's
e) Surrounding property values are lower than sites

5) What is the difference in potential tax revenue from surrounding sites from that of this site?
a) Surrounding properties have significantly higher tax revenue than site's
b) Surrounding properties have moderately higher tax revenue than site's
c) Surrounding properties have slightly higher tax revenue than site's
d) Surrounding properties tax revenue is comparable to site's
e) Surrounding properties have lower tax revenue than site's

Environmental Justice

As defined by the EPA, environmental justice "will be achieved when everyone, regardless of race, color, national origin or income, enjoys the same degree of protection from environmental and health hazards and equal access to the decision-making process to have a healthy environment in which to live, learn, and work"Redeveloping brownfields may be a step towards achieving environmental justice.

6) In Pennsylvania, the statewide percent of people identified as non-white is 14.3%. How would you describe your municipality's percentage of non-white people?
€ lower € approximately the same € higher
7) In Pennsylvania, the statewide percent of residents below the poverty line is 11.6%. How would you describe your municipality's percentage of residents below the poverty line?
€ lower € approximately the same € higher
8) In Pennsylvania, the statewide percent of rental units is 28.7%. How would you describe your municipality's percentage of rental units?
€ lower € approximately the same € higher

Location

The locations referred to in the following series of questions are all centers of human activity and/or important resources for the community. The distance that contamination lies away from these locations may dictate the urgency of remediation. **Note that if all of the brownfields you are comparing are in the same area geographically, the answers to the below questions would all be the same and so it is unnecessary to fill them out.**

9) Please give the shortest distances (in miles) to each as accurately as possible.

Distance to:
a) Schools: ______________________ miles
€ 0 – 2 € 3 – 5 € 6 – 8 € 9 – 11 € 12 +

b) Public recreation areas ______________________ miles
€ 0 – 2 € 3 – 5 € 6 – 8 € 9 – 11 € 12 +

c) Properties with high market value: __________________miles
€ 0 – 2 € 3 – 5 € 6 – 8 € 9 – 11 € 12 +

d) Residential neighborhoods: _________________________ miles
€ 0 – 2 € 3 – 5 € 6 – 8 € 9 – 11 € 12 +

e) Closest water source (river, lake, stream): __________________________ miles
€ 0 – 2 € 3 – 5 € 6 – 8 € 9 – 11 € 12 +

Infrastructure Indicator

The infrastructure indicator estimates the availability of infrastructure adjacent to a site. A great benefit of redeveloping brownfields instead of greenfields is that brownfields will often have existing infrastructure. The required resources for creating new infrastructure on a greenfield may be saved and used to improve other areas of a brownfield. **Note that if all of the brownfields you are comparing are in the same area geographically, the answers to the below questions would all be the same and so it is unnecessary to fill them out.**

10) Please give the distances (in road miles) to each as accurately as possible. Distance to:

a) Interstate
€ 0 – 2 € 3 – 5 € 6 – 8 € 9 – 11 € 12 +

b) Highway
€ 0 – 2 € 3 – 5 € 6 – 8 € 9 – 11 € 12 +

c) Railway
€ 0 – 2 € 3 – 5 € 6 – 8 € 9 – 11 € 12 +

d) River
€ 0 – 2 € 3 – 5 € 6 – 8 € 9 – 11 € 12 +

e) Airport
€ 0 – 2 € 3 – 5 € 6 – 8 € 9 – 11 € 12 +

f) In what condition are the access roads?
€ Excellent € Good € Fair € Poor

Thank you for completing the WPBC Brownfield Prioritization Method Questionnaire

What happens next?

You're done!

Thank you so much for the time and effort that you've put into this part.

The information's journey

The information gathered will be scored and weighted according to the preferences KCS has defined. The final score will ultimately be ranked against the scores of yours and other sites. You will receive a report of the final scores.

Thank you for your patience and continued support. In the near future, the questionnaire and tool will be put online for your convenience. Feel free to contact us if you have any questions or concerns.

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Appendix A

Polychlorinated Biphenyls
Although no longer commercially produced in the United States, PCBs may be present in products and materials produced before the 1979 PCB ban. Products that may contain PCBs include:

- Transformers and capacitors
- Other electrical equipment including voltage regulators, switches, reclosers, bushings, and electromagnets
- Oil used in motors and hydraulic systems
- Old electrical devices or appliances containing PCB capacitors
- Fluorescent light ballasts
- Cable insulation
- Thermal insulation material including fiberglass, felt, foam, and cork
- Adhesives and tapes
- Oil-based paint
- Caulking
- Plastics
- Carbonless copy paper
- Floor finish

The PCBs used in these products were chemical mixtures made up of a variety of individual chlorinated biphenyl components, known as congeners. Most commercial PCB mixtures are known in the United States by their industrial trade names. The most common trade name is Aroclor. *– U.S. EPA website*

Volatile Organic Compounds
VOCs are organic compounds that can be isolated from the water phase of a sample by purging the water sample with inert gas, such as helium, and, subsequently, analyzed by gas chromatography. Many VOCs are human-made chemicals that are used and produced in the manufacture of...

- paints
- adhesives,
- petroleum products
- pharmaceuticals
- refrigerants

They often are compounds of

- fuels
- solvents
- hydraulic fluids
- paint thinners
- dry-cleaning agents

VOC contamination of drinking water supplies is a human-health concern because many are toxic and are known or suspected human carcinogens. - *U.S. Geological Survey, 2005*

Polycyclic Aromatic Hydrocarbons
PAHs are a group of chemicals that are formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances, such as tobacco and charbroiled meat. There are more than 100 different PAHs. PAHs generally occur as complex mixtures (for example, as part of combustion products such as soot), not as single compounds. PAHs usually occur naturally, but they can be manufactured as individual compounds for research purposes; however, not as the mixtures found in combustion products. As pure chemicals, PAHs

generally exist as colorless, white, or pale yellow-green solids. They can have a faint, pleasant odor. A few PAHs are used in medicines and to make dyes, plastics, and pesticides. Others are contained in asphalt used in road construction. They can also be found in substances such as crude oil, coal, coal tar pitch, creosote, and roofing tar. They are found throughout the environment in the air, water, and soil. They can occur in the air, either attached to dust particles or as solids in soil or sediment.

Although the health effects of individual PAHs are not exactly alike, the following 17 PAHs are considered as a group in this profile:

- acenaphthene
- acenaphthylene
- anthracene
- benz[a]anthracene
- benzo[a]pyrene
- benzo[e]pyrene
- benzo[b]fluoranthene
- benzo[g,h,i]perylene
- benzo[j]fluoranthene
- benzo[k]fluoranthene
- chrysene
- dibenz[a,h]anthracene
- fluoranthene
- fluorene
- indeno[1,2,3-c,d]pyrene
- phenanthrene
- pyrene

These 17 PAHs were chosen to be included in this profile because (1) more information is available on these than on the others; (2) they are suspected to be more harmful than some of the others, and they exhibit harmful effects that are representative of the PAHs; (3) there is a greater chance that you will be exposed to these PAHs than to the others; and (4) of all the PAHs analyzed, these were the PAHs identified at the highest concentrations at NPL hazardous waste sites. – *Center of Disease Control - Agency for Toxic Substances and Disease Registry*

[i] U.S. Bureau of Labor Statistics, February 2011

APPENDIX I

Site Attribute Questionnaire - KEY

Indicator Questions

A. Development Driver/Champion Indicator

The champion is an entity, preferably an individual, who takes on the role of the organizer, the instigator, the cheerleader and the connecter. He or she "drives" the redevelopment effort. They might be part of a private sector developer, a community-based organization, or a local redevelopment authority.

1. To what level has a developer (or other private sector investor) expressed an interest in the site?
   - € Interested, and has funds for redevelopment 5
   - € Interested, but does not have adequate funding 3.66
   - € Somewhat, but only has a preliminary interest 2.33
   - € No one has expressed an interest 1

2. OPTIONAL QUESTION 2: To what level has the municipality or other non-profit NGO expressed an interest in the site?
   - € Interested, and has funds for redevelopment 5
   - € Interested, but does not have adequate funding 3.66
   - € Somewhat, but only has a preliminary interest 2.33
   - € No one has expressed an interest 1

B. Development Potential Indicator

This indicator assesses the likelihood that a site will be redeveloped. There are five sub-indicators within development potential: end use, funding, time, labor market and property ownership. Using your answers, we will be able to assess what sites stand a better chance of redevelopment.

End Use

The end use plan is a realistic plan that integrates important details like current land use, demographics, community master plans, historical development patterns, etc… The existence of an end use plan indicates that site champions have put some level of thought into the site.

3. How consistent is the proposed end use with the surrounding land use?
   - € Very consistent 5
   - € Consistent 4
   - € Somewhat consistent 3
   - € Inconsistent 2
   - € No end use has been determined 0

4. Given today's economic and development climate in the area, how beneficial will the proposed end use be to the community?
   - € Very beneficial 5
   - € Beneficial 4
   - € Neither beneficial nor detrimental 3
   - € Detrimental 2
   - € No end use has been determined 0

5. How many long term jobs would be supported on this site?
   € 0 – 25(1) € 26 – 50(2) € 51 – 75(3) € 76 – 100(4) € 100 +(5)

Funding

Finding sufficient funding for a project can be challenging due to a variety of reasons, including the lenders' fear of environmental liabilities. However, there are a variety of available funding sources – both public and private – that are specifically targeted at brownfields.

6. Are there at least partial funds for the environmental investigation?
   € Private(3) € Public(2) € Both(4) € None(1) € Completed(5)
7. Are there at least partial funds for the environmental remediation?
   € Private(3) € Public(2) € Both(4) € None(1) € Completed(5)
8. Are there at least partial funds for pre-development costs; such as engineering and permitting?

€ Private(3) € Public(2) € Both(4) € None(1) € Completed(5)

9. Are there at least partial funds for construction costs?

   € Private(3) € Public(2) € Both(4) € None(1) € Completed(5)

Time

Please answer the following questions as if the necessary funds were available.

10. If the environmental investigation would begin today, how long would it take to complete? (in months)

    € 0 – 6(5) € 7 – 12(4) € 13 – 18(3) € 18 – 24(2) € 25 +(1)

11. Estimated time to complete the remediation (in months)

    € 0 – 6(5) € 7 – 12(4) € 13 – 18(3) € 18 – 24(2) € 25 +(1)

12. Estimated time to complete the infrastructure (in years)

    € 0 – 1(5) € 2(4) € 3(3) € 4(2) € 5 +(1)

Property Ownership

The number of owners a piece of property potentially influences the ease of property acquisition. Getting permission from the owner(s) to assemble all sites and/or occupy them can be challenging.

13. How many entities own the property of interest?

    € 0(0) € 1(5) € 2(3.66) € Multiple(2.33) € Unknown(1)

14. Has a plan that includes site acquisition, site assembly, etc. been completed?

    € Yes(5) € No(1) € Not sure(0)

Community Support

Brownfields have been shown to be an integral component of the fabric of the communities in which they sit. Historically, community involvement has an obstructionist reputation – especially in federally influenced redevelopment activities. But due to the complexity of the site histories, legal and financial issues and environmental contamination, community engagement is very important to brownfield redevelopment.

15. How supportive is the surrounding community of the redevelopment plan for this specific site **(generally speaking)**?

- € Very supportive (5)
- € Supportive (5)
- € Indifferent (3)
- € Unsupportive (1)
- € Very unsupportive (1)
- € No current redevelopment plan exists (0)

16. How interested is the community in promoting brownfield development **(generally speaking)**?

- € Very interested (5)
- € Interested (5)
- € Indifferent (3)
- € Uninterested (1)
- € Very uninterested (1)

Quality of Life

Many times, and especially in older communities, the land occupied by brownfields can be a key asset to the community.

17. If the end use is determined, will the redevelopment provide more recreational opportunities for the community?

- € Many more recreational opportunities (5)
- € Some recreational opportunities (3)
- € No recreational opportunities (1)
- € No end use has been determined (0)

18. If the end use is determined, will the redevelopment provide more green space for the community?

- € Much more green space (5)
- € Some green space (3)
- € No green space (1)
- € No end use has been determined (0)

C. Environmental Indicator

The environmental indicator is designed to estimate both the likelihood and magnitude of environmental contamination of a site, either real or suspected. It is often very difficult and laborious to get site specific environmental data related to potential contamination, so we used the following qualitative metrics to assess the potential level of environmental impact and implications for public health.

Contamination

19. Is there any perceived contamination on the site?

€ Yes (5) € No (1)

If YES, please check all relevant Hazardous/Petroleum products

€ Controlled Substances
€ Asbestos
€ PCBs - Polychlorinated Biphenyls (see appendix A for more information)
€ VOCs -Volatile Organic Compounds (see appendix A for more information)
€ Lead
€ PAHs - PPolycyclic Aromatic Hydrocarbons (see appendix A for more information)
€ Radioactive materials
€ Other Metals: ____________________
€ Other Contaminants: ________________

20. Please give the number of documented releases of contaminants from the site:

€ 0 (1) € 1(2) € 2 (3) € Multiple (5)
€ Unknown (4)

Previous Use of Site

Identifying and documenting the historical uses of the site can play an important role in estimating the source and type of contamination with the eventual goal to determine an appropriate remediation strategy.

21. Please check the types of activities that the site has been used for:

€ Industrial – What type of industry? ______________________________________ (5)
€ Commercial - What type of commercial? __________________________________(3.66)
€ Residential (2.33)
€ Green Space (1)

22. Is the previous/current owner a documenter polluter?

€ Yes (5) € No (1) € Not sure (3)

23. How long has the site been vacant? (in years)

€ 0 (1) € 1 – 5 (2) € 6 – 10 (3) € 11 – 15 (4)
€ 16 +(5)

24. How long has the site been underutilized? (in years)

€ 0 (1) € 1 – 5 (2) € 6 – 10 (3) € 11 – 15 (4)
€ 16 +(5)

25. Are there any deed restrictions on the property?

€ Yes (5) € No (1) € Not sure (3)

Public Utilities

Does the site have curb connection/access to the following?

26. Municipal water:

€ Yes(5) € No(1)

27. Power grid:

€ Yes(5) € No(1)

28. Sewage system:

€ Yes(5) € No(1)

29. Septic:

€ Yes(5) € No(1)

30. Cable/DSL:

€ Yes(5) € No(1)

31. Phone:

€ Yes(5) € No(1)

32. Cellular service:

€ Yes(5) € No(1)

33. Fiber Optic:

€ Yes(5) € No(1)

D. Market Information

Labor Market

The population that is available for the 'labor market' is defined as the population that is between ages 16 and 64.

1) In Pennsylvania, the statewide average unemployment rate is 7.4%[i]. How would you describe your municipality's unemployment rate?

   € lower(1) € approximately the same(3) € higher(5)

2) If you know the unemployment rate for your municipality, please provide it here:_____________%

3) The percentage of Pennsylvanian residents, 25 years of age and older, with at least a high school diploma is 86.5%. The percentage of your municipality's population, 25 years and older, with at least a high school diploma is…

   € lower(5) € approximately the same(3) € higher(1)

Property and Wage Values

In order to better understand the surrounding community in which the brownfield site is located, please provide answers to the comparisons of this site with other (non-brownfield) properties in the area.

4) What is the difference in the surrounding property values from that of this site?
   a) Surrounding property values are significantly higher than site's (5)
   b) Surrounding property values are moderately higher than site's (4)
   c) Surrounding property values are slightly higher than site's (3)
   d) Surrounding property values are comparable to site's (2)
   e) Surrounding property values are lower than sites (1)

5) What is the difference in potential tax revenue from surrounding sites from that of this site?
   a) Surrounding properties have significantly higher tax revenue than site's (5)
   b) Surrounding properties have moderately higher tax revenue than site's (4)
   c) Surrounding properties have slightly higher tax revenue than site's (3)
   d) Surrounding properties tax revenue is comparable to site's (2)
   e) Surrounding properties have lower tax revenue than site's (1)

Environmental Justice

As defined by the EPA, environmental justice "will be achieved when everyone, regardless of race, color, national origin or income, enjoys the same degree of protection from environmental and health hazards and equal access to the decision-making process to have a healthy environment in which to live, learn, and work"Redeveloping brownfields may be a step towards achieving environmental justice.

6) In Pennsylvania, the statewide percent of people identified as non-white is 14.3%. How would you describe your municipality's percentage of non-white people?
   € lower (1) € approximately the same (3) € higher (5)
7) In Pennsylvania, the statewide percent of residents below the poverty line is 11.6%. How would you describe your municipality's percentage of residents below the poverty line?
   € lower (1) € approximately the same (3) € higher (5)
8) In Pennsylvania, the statewide percent of rental units is 28.7%. How would you describe your municipality's percentage of rental units?
   € lower (1) € approximately the same (3) € higher (5)

Location

The locations referred to in the following series of questions are all centers of human activity and/or important resources for the community. The distance that contamination lies away from these locations may dictate the urgency of remediation. **Note that if all of the brownfields you are comparing are in the same area geographically, the answers to the below questions would all be the same and so it is unnecessary to fill them out.**

9) Please give the shortest distances (in miles) to each as accurately as possible.

   Distance to:

   a) Schools: ____________________ miles
      € 0 – 2 (5) € 3 – 5 (4) € 6 – 8 (3) € 9 – 11 (2) € 12 + (1)

   b) Public recreation areas ____________________ miles
      € 0 – 2 (5) € 3 – 5 (4) € 6 – 8 (3) € 9 – 11 (2) € 12 + (1)
      €

   c) Properties with high market value: ________________miles
      € 0 – 2 (5) € 3 – 5 (4) € 6 – 8 (3) € 9 – 11 (2) € 12 + (1)

   d) Residential neighborhoods: ______________________ miles
      € 0 – 2 (5) € 3 – 5 (4) € 6 – 8 (3) € 9 – 11 (2) € 12 + (1)

   e) Closest water source (river, lake, stream): _______________________ miles
      € 0 – 2 (5) € 3 – 5 (4) € 6 – 8 (3) € 9 – 11 (2) € 12 + (1)

Infrastructure Indicator

The infrastructure indicator estimates the availability of infrastructure adjacent to a site. A great benefit of redeveloping brownfields instead of greenfields is that brownfields will often have existing infrastructure. The required resources for creating new infrastructure on a greenfield may be saved *and used to improve other areas of a brownfield.* **Note that if all of the brownfields you are comparing are in the same area geographically, the answers to the below questions would all be the same and so it is unnecessary to fill them out.**

10) Please give the distances (in road miles) to each as accurately as possible. Distance to:

a) Interstate
€ 0 – 2 (5) € 3 – 5 (4) € 6 – 8 (3) € 9 – 11 (2) € 12 + (1)

b) Highway
€ 0 – 2 (5) € 3 – 5 (4) € 6 – 8 (3) € 9 – 11 (2) € 12 + (1)

c) Railway
€ 0 – 2 (5) € 3 – 5 (4) € 6 – 8 (3) € 9 – 11 (2) € 12 + (1)

d) River
€ 0 – 2 (5) € 3 – 5 (4) € 6 – 8 (3) € 9 – 11 (2) € 12 + (1)

e) Airport
€ 0 – 2 (5) € 3 – 5 (4) € 6 – 8 (3) € 9 – 11 (2) € 12 + (1)

f) In what condition are the access roads?
€ Excellent (5) € Good (3.66) € Fair (2.33) € Poor (1)

Thank you for completing the WPBC Brownfield Prioritization Method Questionnaire