Air and Water Quality Impacts of Brownfields Redevelopment

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This fact sheet describes an approach to quantifying the environmental impacts of Brownfields reuse and provides estimates of impacts on air and water quality of multiple revitalization projects in five municipal regions. [1]

Overview

A number of previous studies compared the environmental performance of specific brownfield redevelopments with similar projects built on undeveloped greenfield sites. These studies examined single brownfield/infill developments and entailed extensive site-specific analysis. The comparison sites generally accommodated the same number of residential units and commercial square footage, but typically occupied more acreage per employee or residence and were less location efficient. A review of 12 of these studies concluded that brownfield/infill development results in significant environmental benefits when compared to their greenfield counterparts. However, making broader quantitative assessments applicable to brownfield redevelopment around the country requires a methodology that is more easily transferable. This study tests an analytical approach to quantifying the environmental impacts of multiple redevelopment projects in a given municipal area in a manner that can be replicated in other regions. The method was applied to five cities and their surrounding areas—Seattle, WA, Baltimore, MD, Minneapolis-St. Paul, MN, Emeryville, CA, and Dallas-Fort Worth, TX.

Study Approach

For each of the five cities, all known brownfield sites that benefited from U.S. EPA Brownfields Program assistance and that have redevelopment completed or under way were identified. Most of these properties are in close-in, high density areas. The study also identified alternative development locations for each of the brownfield sites, based on prevailing development trends in the area. That is, it was assumed that had the development not occurred on the brownfield, it would have gone to these locations. The environmental performance of both sets of locations were measured and compared, using metrics such as vehicle use per capita, air pollutant emissions per capita, personal vehicle energy use per capita, and stormwater runoff and pollutant loads. The environmental performance measures were developed with data from regional transportation demand models, a watershed management model, and INDEX, a geographical information system (GIS)-based analytical tool. [2, 3]

Development on suburban/exurban sites consumes more acreage per resident or employee than urban core project areas. Most but not all of the alternative sites were located outside the urban core. The study assumed that these projects were sited on greenfields and would require 2-4 times the acreage typically used for development on brownfield sites. This assumption, believed to be conservative, is derived from factors drawn from literature on land use patterns by type of use as well as experience in the Puget Sound area. Nearly all alternative locations identified for this study would require more land to accommodate the same type of development on brownfield sites.

Five Municipal Areas Included in Study

The five municipal areas (see table) were selected based on several factors, including: the existence of a significant number of brownfield properties that met the aforementioned criteria, the availability of information about the status of redevelopment on the brownfield sites, the availability of data that could be used as indicators of local environmental performance, and ecoregion stratification to provide precipitation profile diversity for the stormwater analysis.

Municipal Areas Studied

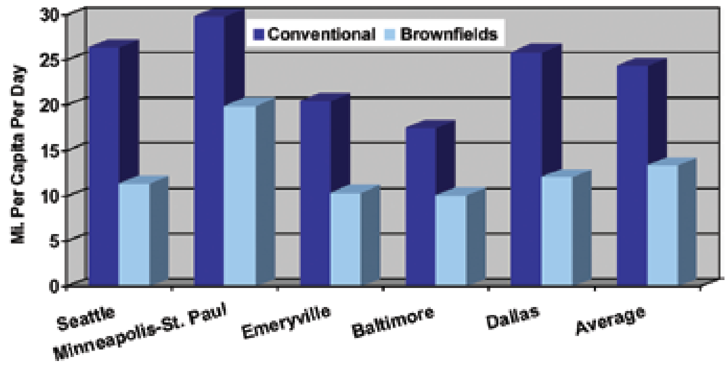
City	No. of Brownfield Properties	Brownfield Acreage	Planning Area	Population in Planning Area (millions)
Seattle	25	87	4-county area	3.6
Minneapolis-Saint Paul	37	80	7-county area	2.9
Emeryville	39	183	9-county area	5.1
Baltimore	37	322	5 counties & Baltimore City	2.5
Dallas-Ft. Worth	25	266	12-county area	6.5
Total	163	938		

Results

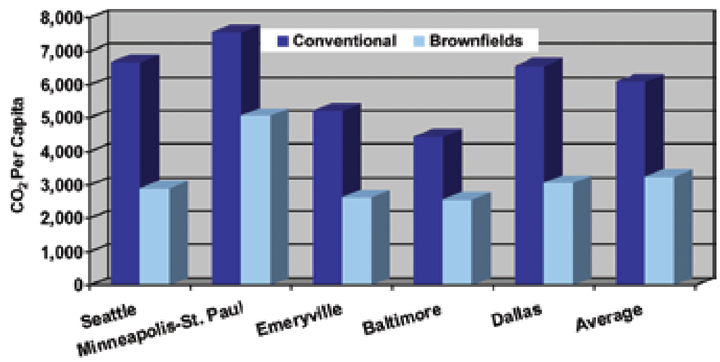
Indicators of environmental performance were estimated for each of the 163 brownfield sites that met the above criteria and their hypothetical counterparts. The values varied widely from site to site, as would be expected given the wide range of characteristics of the various locations. Nevertheless, for 90-95% of the sites, the brownfield locations had superior environmental performance to their conventional/greenfield counterparts. The results were averaged for each municipal area and are shown in the attached table. Average results for the five municipal areas indicate that:

- On average, automobile use by residents and employees at brownfield locations is estimated to be substantially lower than at the alternative locations:
    - Daily vehicle miles traveled per capita would be 32 – 57% lower.
    - Daily vehicle trips per capita would be 16 – 38% lower.
    - Personal vehicle energy use per capita would be 32 – 57% lower.
- Brownfield redevelopments produce 32 – 57% less carbon dioxide (CO_2) emissions per capita relative to conventional developments.
- Brownfield redevelopments produce 32 – 57% less air pollutant emissions per capita relative to conventional developments.
- Stormwater runoff for brownfield redevelopments is estimated to average 43 – 60% less than the greenfield alternatives.
- Brownfield redevelopments also produce substantially lower loads of all pollutants studied, averaging 9 – 80% for conventional pollutants and 59% to 72% for metals. These estimates do not include the potential reduction in pollutant loads from cleanup of the brownfield properties, nor some of the pollution from contaminated properties that would remain undeveloped if the redevelopment had occurred on the greenfields instead.
- Based on a literature review, it is estimated that brownfield sites typically accommodate the same number of homes and businesses on about ¼ (maximum impact result) to ½ (minimum impact result) the land typically used at corresponding conventional sites. The table at the end of this fact sheet provides additional detail about these estimates.

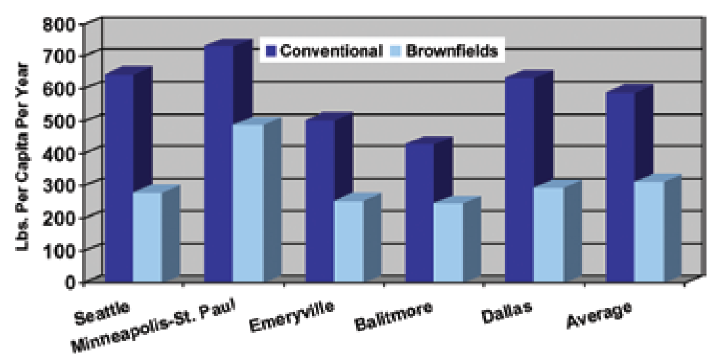
Vehicle Miles Traveled
(Miles Per Capita Per Day)



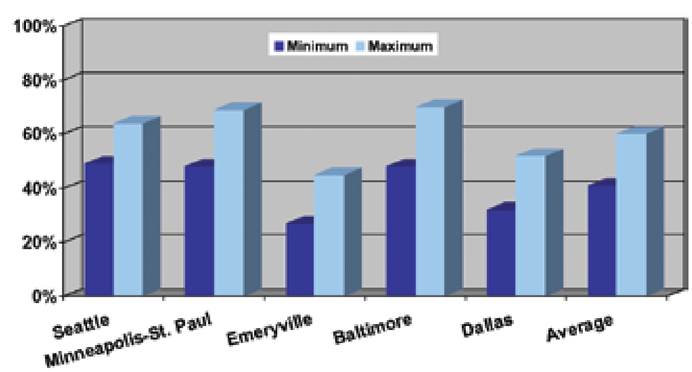
Carbon Dioxide Emissions
(Pounds Per Capita Per Year)



Air Pollutant Emissions
(NOx, CO, HC: Pounds Per Capita Per Year)



Stormwater Runoff
(Percent Reduction for Brownfields)



The table at the end of this fact sheet provides additional detail about these estimates.

Discussion

The air quality results are consistent with the land use patterns and urban form measures for the areas studied. On average, neighborhoods where the brownfield sites are located had higher development density (population, dwelling units, and employees per gross acre), more travel accessibility (in terms of distance and travel time) to other areas, and better access to transit than the areas where the hypothetical conventional counterparts are located. For example, the Seattle neighborhoods where the brownfields are located have more than twice the population density of the conventional counterpart areas. In addition, the percentage of houses or jobs within ¼ mile of transit in the brownfield neighborhoods is more than double that of the conventional locations, on average.

The results are also in line with other studies that compare the environmental performance of brownfield/infill development with conventional development. Furthermore, the results are consistent with evaluations of the relationship between urban built environment and vehicle use and air emissions using data for wider geographic areas, such as counties and metropolitan statistical areas. A well-researched summary of this literature is included in the report *Growing Cooler: The Evidence of Urban Development and Climate Change*.[4] The study estimated that, with more compact development, people drive 20 to 40% less per year.

Another study using the 1999 Puget Sound Household Travel Survey and land use measures concluded that residents make travel choices based on several factors, most of which are related to time spent traveling, including wait times, which are, in turn, related to land use patterns.[5] Increased levels of mixed-use development, retail density, and street connectivity were associated with lower per capita emissions and an increased tendency to walk.

Although the results for each city show significant positive environmental outcomes from building on brownfields, the estimates vary from city to city. This variation is not always empirically explained by a direct comparison of the average urban form indicators used in this study, such as population density, employment density, dwelling units per gross acre, and accessibility measures. Direct comparisons of these variables are confounded by the fact that the results are first differences between the conventional and brownfield scenarios (i.e., conventional scenario less brownfield scenario) and that there are many factors that vary among cities, such as geographical barriers, socioeconomic characteristics, existence and effectiveness of mass transit, physical form of existing greenfield areas, and economic growth. For example, because Seattle is surrounded by many bodies of water and mountains, some of the outlying areas are accessible to the central city or other destinations only by bridge, ferry, or circuitous routes. This may explain why the results for the Puget Sound area indicate considerably greater reductions in vehicle miles traveled and emissions under the brownfields redevelopment scenario than for the other cities.

The estimated percentage reductions in stormwater runoff and pollutant loads are dependent on precipitation, soil type, and land use type, which vary within each region as well as across regions. Generally, the percentage runoff reduction is greatest when the alternative greenfield site is on forest land, lower for pasture, and even lower for agricultural land. The percentage reduction also varies positively with the ratio of greenfield acreage to brownfield acreage used for the same type and amount of development. Except for a few pollutants on agricultural lands in some locations, all the brownfield development scenarios yielded substantially lower pollutant loads.

While the study properties account for a relatively small portion of total development acreage in these regions, their development has been important to the communities in overcoming obstacles to redevelopment. Brownfields and infill redevelopment have significant positive environmental impacts on water resources and air quality, particularly greenhouse gas emissions.

References

1. U.S. EPA 2010. Air and Water Quality Impacts of Brownfields Reuse, Office of Solid Waste and Emergency Response, Office of Brownfields and Land Revitalization, EPA-560-F-10-232, July 2010.

2. Allen, E., 2008. "Clicking Toward Better Outcomes: Experience with INDEX 1994 to 2006," Eliot Allen, in Planning Support Systems for Cities and Regions, 139-166, Ed. Richard Brail, Lincoln Institute of Land Policy, Cambridge, MA, 2008.

3. U.S. EPA 2001. EPA's Smart Growth Index in 20 Pilot Communities: Using GIS Sketch Modeling to Advance Smart Growth, EAP 231-R-03-001, August 2001.

4. Ewing et al., 2008. Growing Cooler: The Evidence on Urban Development and Climate Change, Reid Ewing, Keith Bartholomew, Steve Winkelman, Jerry Walters, Don Chen, Urban Land Institute, 2008.

5. Frank, L., 2005. Travel Behavior, Emissions & Land Use Correlation Analysis in the Central Puget Sound, Lawrence Frank, James Chapman, Mark Bradley, T. Keith Lawton, prepared for the Washington State Department of Transportation, June 2005.

Comparison of Environmental Performance Measures for Five Regions

		Percent Difference for Brownfields as Compared to Conventional/Greenfields (Conventional Less Brownfields Scenarios as a Percent of Conventional)					
Environmental Indicator	Units	Seattle Area	Twin Cities Area	Emeryville Area	Baltimore Area	Dallas-Fort Worth Area	Average
Air and Energy							
Home based vehicle miles traveled	mi/capita/day	67%	32%	53%	37%	NA	45%
Non-home based vehicle miles traveled	mi/capita/day	37%	34%	45%	53%	NA	43%
Total vehicle miles traveled	mi/capita/day	57%	32%	49%	42%	53%	47%
Home based vehicle trips	mi/capita/day	11%	13%	36%	NA	NA	20%
Non-home based vehicle trips	mi/capita/day	29%	19%	40%	NA	NA	30%
Total Vehicle trips per capita	Trips/capita/day	19%	16%	38%	NA	24%	24%
Personal vehicle energy use	MMBtu/capita/yr	57%	32%	49%	42%	53%	47%
Residential structural energy use	MMBtu/capita/yr	6%	NA	NA	NA	NA	NA
Carbon dioxide (CO_2) emissions	lbs/resident/yr	57%	32%	49%	42%	53%	47%
Air Pollutants (NOx, HC, & CO)	lbs/resident/yr	57%	32%	49%	42%	53%	47%
Land and Water							
Land consumption	Acres	50 to 75%	50 to 75%	50 to 75%	50 to 75%	50 to 75%	50 to 75%
Stormwater runoff	Acre Feet/yr	49 to 64%	48 to 69%	27 to 45%	48 to 70%	43 to 52%	43 to 60%
Nitrogen	lbs/yr	57 to 71%	75 to -17%	53 to 69%	1 to 74%	66 to -48%	9 to 71%
Phosphorous	lbs/yr	64 to 78%	81 to -36%	77 to -113%	79 to -13%	77 to -55%	-31 to 78%
Suspended solids	lbs/yr	65 to 79%	26 to 83%	79 to -11%	30 to 80%	79 to -3%	21 to 80%
Biological oxygen demand	lbs/yr	64 to 78%	67 to 83%	54 to 77%	65 to 78%	59 to 78%	62 to 79%
Chemical oxygen demand	lbs/yr	65 to 79%	71 to 84%	60 to 77%	61 to 78%	66 to 79%	65 to 79%
Oil and grease	lbs/yr	65 to 79%	71 to 84%	60 to 77%	65 to 80%	67 to 80%	66 to 80%
Metals (lead, copper, zinc, cadmium, chromium, nickel)	lbs/yr	60 to 74%	65 to 78%	53 to 64%	62 to 77%	54 to 68%	59 to 72%

Full report available at: www.epa.gov/brownfields/sustain.htm