Memorandum

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To: Jonathan Doherty, NPS
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From: Rebecca Winer-Skonovd, Dave Hirschman, Hye Yeong Kwon and Chris Swann
Center for Watershed Protection

Re: Synthesis of Existing Cost Information for LID vs. Conventional Practices

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This memorandum quantifies some of the economic cost information for low impact (LID) development through the examination of case studies from around the United States. The case studies selected compare the costs and benefits of LID practices against the costs of conventional stormwater treatment and control practices. When possible, actual development costs are provided for comparison, although cost comparisons may be based on modeling efforts. In other case studies, the benefit information presented is focused on LID or conservation designs that have resulted in significant environmental benefits. These environmental benefits can come in many forms, including natural areas (forest or wetland) preservation, reduced stormwater runoff, protection of aquatic habitat, and reduction in pollutant loads in runoff. The third type of case study provides economic data on the benefits of LID projects, but offers no cost comparison with conventional development.

The case studies presented are only a sampling of the many LID projects that have been or are currently being implemented nationwide. The examples selected concentrate on projects that have been implemented in the Chesapeake Bay region that include economic data comparisons or quantifiable impacts. Other case studies from around the country are included where economic cost comparison information is available.

For each case study presented below, a brief description of the project is provided followed by monetary benefits, other benefits and source of information. The studies are summarized in the conclusion and the additional resources section will point the reader to additional case studies not included in this technical memorandum.

Laurel Springs Jackson, WI

Laurel Springs is a residential subdivision with 110 lots and seven duplex condominiums that was developed using conservation design principles. This included clustering houses to help preserve open space and minimize grading and paving, as well as incorporating the use of bioretention and vegetated swales for stormwater management. The design also reduced impervious cover through a reduction in the amount of road pavement.

Monetary Benefits

The developer, Bielinski Homes, estimated the cost savings realized by comparing conservation design costs with the estimated cost of developing the site with conventional practices (see Table 1). The total savings realized with conservation design were just over $629,000, which is approximately 20% of the estimated costs for conventional construction. The largest savings came from reduced costs associated with stormwater management infrastructure. The use of on-lot detention eliminated much of the need for storm sewer pipes, catch basins, inlets, and cleanout structures, resulting in a 46% reduction in costs to the developer.

Table 1. Cost Comparison for Laurel Springs Development

Item	Conventional	Conservation	Cost Savings
Site Preparation (grading)	$441,600	$358,500	$83,100
Paving	$335,665	$255,760	$79,905
Concrete (sidewalks and curbs)	$271,800	$259,995	$11,805
Landscaping	$65,000	$120,000	($55,000)
Utilities	$270,000	$161,280	$108,720
Water Lines	$412,460	$384,240	$28,220
Stormwater Management	$439,956	$204,100	$235,856
Sanitary Sewers	$415,600	$385,280	$30,320
Finance Costs	$548,000	$441,400	$106,600
Total	$3,200,081	$2,570,555	$629,526

Other Benefits

Benefits to Developers:

- Averaging $400,000 in infrastructure savings per community.
- Greater "site appeal" of conservation design may garner premiums up to 25 to 30 % per lot.
- Total costs are typically 15 to 25 % less, despite landscape expenses that can be more than three times conventional development budgets.

Source(s)

- Builder, Oct 2003, p 244, by Christina B. Farnsworth.
http://www.greenclips.com/03issues/226.htm

- Conservation Research Institute. 2005 . Changing Cost Perceptions: An Analysis of Conservation Design, Page 31.
http://www.nipc.org/environment/sustainable/conservationdesign/cost_analysis/

SEA Streets Seattle, WA

The Seattle Public Utilities (SPU) implemented a retrofit program that utilizes alternatives to traditional street drainage design to help address impacts to their urban watersheds from runoff and transport of non-point pollution. The goal of the Natural Drainage Systems (NDS) program is to provide drainage that more closely mimics the natural landscape prior to development than traditional piped systems. As part of this effort, the SPU initiated a pilot effort on 2.3 acres in north Seattle called Street Edge Alternative, or 'SEA Street' (Figure1). A 660- foot block of 2nd Avenue was redesigned to incorporate several low impact development (LID) techniques, including open drainage swales or bioswales, to replace curb and gutter. Streets were narrowed to reduce imperviousness and an abundance of diverse plants and trees were placed in the street right of way. The neighborhood participated in the development of the street design with city staff, garnering public support for the project.

Monetary Benefits

The SEA Street project was funded completely by SPU who used money collected from drainage fees. Estimates for the final total project cost are approximately $850,000, compared to estimates of $870,000 for conventional drainage methods and street improvements. The Sea Street cost estimates also included substantial expenditure for community outreach and coordination as well as design modifications to address community concerns. It is expected that research, design, and communications budgets for future SEA Street projects will be much lower, making the approach even more economical and competitive. Table 2 contains a comparison of the costs for the LID retrofit to the estimated costs of a traditional street retrofit.

Table 2. Cost Comparison for Seattle SEA Street

Item	Traditional Street	SEA Street	Cost Savings
Site Preparation	$65,084	$88,173	($23,089)
Stormwater Management	$372,988	$264,212	$108,776
Site Paving and Sidewalks	$287,646	$147,368	$140,278
Landscaping	$78,729	$113,034	($34,305)
Misc. (mobilization, etc.)	$64,356	$38,761	$25,595
Total	$868,803	$651,548	$217,255

Much of the savings for the project came from reductions in expenditure for stormwater infrastructure and site paving. Landscaping and site preparation cost increased for the SEA Street design, since additional plantings and removal of existing impervious cover had to occur.

The city of Seattle has found that the implementation of natural drainage systems is more cost effective than traditional systems. SPU estimates that natural drainage systems cost 25 % less than traditional roadside development. SPU also estimates that NDS capital costs are less expensive than traditional drainage systems, and that a significant life-cycle savings is realized by using natural drainage systems. A life cycle cost comparison (construction, maintenance, risk and replacement) indicates a 13 to15 % savings by using a natural drainage system approach.

This cost reduction does not factor in environmental services such as increased carbon sequestration through the planting of trees, cleaner waterways, and replenished groundwater.

Other Benefits

The final project also provided numerous environmental benefits. These included:

- The final constructed design reduced imperviousness by more than 11 %.
- Tests and monitoring of the project have indicated that the total volume of stormwater leaving the street has been reduced by 98% for a 2-year storm event.
- Based on estimates for a street drainage system design according to City of Seattle conventions, the SEA Streets alternative reduces runoff discharged to Pipers Creek in the wet months by a factor of 4.7 relative to the conventional street.
- The project added over 100 evergreen trees and 1100 shrubs to a street right-of-way where no trees were present.

Source(s)

- Seattle Public Utilities – Street Edge Alternatives (SEA Streets) Project. http://www.seattle.gov/util/About_SPU/Drainage_&_Sewer_System/Natural_Drainage_Systems/Street_Edge_Alternatives/index.asp

- Natural Resources Defense Council. Stormwater Strategies. Chapter 12 Low Impact Development. http://www.nrdc.org/water/pollution/storm/stoinx.asp

Figure 1. Seattle SEA Street Bioswale (Source: Seattle SPU)

Rivergate Alexandria, VA

Rivergate is a 58-unit townhouse urban "infill" development in Alexandria in a high-density, open space design. Located on the banks of the Potomac River, the 4.2 acre parcel historically housed industrial facilities and was formerly the site of the Norton Rendering Plant. A comparison was done of the actual design of the site (as built) which employed techniques to limit impervious cover, provide better protection of sensitive areas, and treat stormwater at the source, to a hypothetical site plan where more conventional site design was used (status quo). The purpose of the comparison between the two design variations was to quantify the relative reduction in impervious cover and clearing and to document the preservation of native vegetation.

The actual Rivergate site design used several techniques to reduce its impacts. Houses were clustered at one end of the site through shorter setbacks and frontages, as well as narrower easement widths. This allowed the site to retain 47% of the parcel next to the Potomac River as common open space (Figure 2). Common walkways, narrower streets, and reduced surface parking also help to minimize impervious cover and reduce runoff. Finally, rooftop runoff from the site is captured and treated in an underground sand filter located adjacent to the property.

Monetary Benefits

In Rivergate as-built, the larger parkland results in a higher landscaping cost. However, the increase in asphalt and utility lengths in the conventional site design results in a higher infrastructure cost than for the case study design. Also, the increased imperviousness of the status quo site design results in a higher volume of stormwater runoff to be treated, which in turn increases the BMP construction cost by 35%. Overall, the status quo site design is estimated to have total infrastructure construction costs that are about 50% higher than Rivergate as-built. Table 3 gives a breakdown of the estimated infrastructure cost for the development.

Table 3. Infrastructure Cost Estimates for Rivergate Development

	Status Quo	As Built	% Difference
Infrastructure Costs	$ 382,400	$ 190,000	50%
BMP Costs	$ 33,900	$ 21,900	35%
Landscaping / Reforestation	$ 1,600	$ 2,900	(81%)
Total Infrastructure Costs	$ 417,900	$ 214,800	49%

Other Benefits

Common open space covers a significant portion of Rivergate as-built, with 47% of the site preserved as parkland. The site also had no existing indigenous vegetation prior to development, and the open space design and landscaped park increased vegetation and incorporated native plants into the landscape plan.

The reduced impervious cover and increased parkland of the as built design resulted in a 30% reduction in volume of runoff and a 76% increase in volume of infiltration per year over the status quo site design scenario. These site characteristics also result in reduced nutrient loading.

Table 4 shows the reductions associated with the as built design versus hypothetical status quo design. Notably, annual nutrient loads from the status quo site design with a BMP (an underground sand filter) are comparable to the loads from the as built design even when the BMP is eliminated from the analysis.

Table 4. Stormwater Impacts of Comparison of Rivergate Design				
		Conventional (Status Quo)	**LID Design (As Built)**	**% Difference**
Runoff (inches/yr)		24.8	17.4	30%
Infiltration (inches/yr)		2.9	5.1	76%
Nitrogen Load (lbs/yr)	Without BMP	49.4	37	25%
	With BMP	37.8	29.6	22%
Phosphorous Load (lbs/yr)	Without BMP	6.0	4.3	28%
	With BMP	4.3	3.3	23%

Source(s)
Center for Watershed Protection. 2002. An Assessment of the Better Site Design Principles for Communities Implementing Virginia's Chesapeake Bay Preservation Act. http://www.cblad.virginia.gov/docs/pubs/bsd.pdf

Figure 2. Rivergate Walkway and Park (Source: CWP)

South Kingstown, RI

South Kingstown was the subject of an economic analysis of the benefits of conservation subdivision versus traditional design. The author's goal was a ranking of the profitability of conservation subdivisions relative to other designs through analysis of price premiums, improvement costs, and time on the market. The analysis was done considering three factors. First, the article considers whether there is a price premium for lots in conservation versus conventional subdivisions by comparing whether the natural and social features of conservation subdivisions carry more market value than the higher-density development that is a common feature of conservation developments. Second, the article examines whether lots in conservation subdivisions are truly less expensive to build than lots in conventional subdivisions, or whether requirements to build around the natural features of a parcel might increase the overall cost of conservation subdivisions, offsetting any premiums such lots may carry. Third, the article examines absorption rates for lots in conservation versus conventional subdivisions to determine if lots in conservation subdivisions sell at a faster rate.

South Kingstown has adopted open space preservation as a central feature of its land use policies. Conservation subdivisions, known as Flexible Design Residential Projects (FDRPs) in the town's Subdivision Regulations, are one tool for conserving open space. FDRP subdivisions are required to set aside a minimum of 30% to 70% of a parcel as open space. The 30% set aside applies only to smaller lot sizes (10,000 to 20,000 square feet), and larger lots are required to set aside between 50% and 70% of the parcel.

Monetary Benefits

This study utilized data from 184 randomly selected vacant developed lots in South Kingstown built and sold between 1993 and 2002.The lots represent the finished product that was sold by developers. Regression models and variance analysis were used to test the price of developed lots, the improvement costs, and the time to sell for three different lot types (conventional, conservation, and minor subdivisions). Together, the results show that conservation subdivisions are more profitable to developers than conventional subdivisions. The results show that lots in conservation subdivisions carry a premium, are less expensive to build, and sell more quickly than lots in conventional subdivisions. The following results were derived from the study:

- Developed lots in conservation subdivisions carry additional value ranging from 12% to 16% per acre over lots in conventional subdivisions.
- Developed lots in the three subdivision types are significantly different from each other. Analysis shows that lots in conservation subdivisions sold had premiums ranging from $13,000 to $18,000 per acre over lots in conventional subdivisions.
- Lots in conservation subdivisions cost on average about $7,400 less to produce than lots in conventional subdivisions.
- Lots in conservation subdivisions sold in about half the time (9.1 months) than lots in conventional subdivisions (17.0 months).
- The study indicates that buyers of lots in conservation subdivisions would pay less for additional lot size and more for amenities associated with conservation subdivisions.

The author suggests that the results of this study have implications for subdivision design and open space. Three main differences emerge from this study regarding the incorporation of open space into subdivision design:

1. Concentrating open space in one or a few locations matters: In contrast to open space that is laid out such that each household gets to "claim" a small portion, conservation subdivisions provide concentrated open space accessible to a maximum number of households and discourage claims of individual ownership.
2. Communal ownership is important: When the ownership of open space is ambiguous, it may not be as well appreciated as when ownership, rights, and responsibilities are clear.
3. High density can be acceptable: Americans can be comfortable with higher density subdivisions provided that other environmental, aesthetic, and communal concerns are addressed. The relatively large value of the coefficient obtained in this research suggests that the utility of additional land falls faster when open space is available than when it is not. The size of the coefficient reflects the intuition that there is little value to additional yard space given the existence of concentrated open space in conservation subdivisions (and nearby scenic districts).

Other Benefits

Other benefits were not quantified.

Source(s)

Rayman Mohamed. January 2006. Economics of Conservation Subdivisions. http://www.landchoices.org/Economics%20of%20Conservation%20Subdivisions%20(1).pdf

Wetland Studies and Solutions Office Building Gainesville, VA

The Wetland Studies and Solutions Inc. (WSSI) headquarters is located in Gainesville, VA on a five acre site. The commitment of the organization to the protection of the environment led them to decide to showcase low impact development (LID) techniques for managing stormwater and environmentally friendly design and construction practices. WSSI set the following goals for the project:

- To reduce the post-development curve number to the pre-development curve number by using permeable paving surfaces.
- To minimize the effect of increased runoff volume on downstream waters by reducing the post-developed runoff rate below the pre-developed forested rate through increased storage and time of concentration.
- To demonstrate compliance with Chesapeake Bay Preservation Ordinance and stormwater management ordinance regulations without a conventional stormwater management facility.

The techniques implemented included three different types of pervious pavement in the parking lot, a green roof on a portion of the building, a rain garden and underground cistern, water-quality swale, and a gravel bed detention system to collect and filter runoff. Extensive measures were also taken during construction to reduce erosion and avoid site disturbance as much as possible. The building is also notable in that it is the first Leadership in Energy and Environmental Design (LEED) Gold Certification in Virginia. This certification measures the extent to which a building incorporates environmentally friendly design and construction practices.

Monetary Benefits

The WSSI new headquarters cost nearly $6.1 million to design and construct. The use of the variety of LID features cost more than the typical curb-and-gutter approach to stormwater management. WSSI calculated the total cost to install all the LID techniques was $620,705. In comparison, the company estimates that a standard asphalt parking lot with curbs and gutters would have cost $360,115. Table 5 has a breakdown of installation costs.

Table 5. Costs for Installation of WSSI LID Features

Item	$/ft^2 impervious	Cost
Rain Garden	$2.60	$90,000
Cistern	$1.23	$31,000
Green Roof	$31.80	$115,316
Pervious Concrete Pavers	$7.90	$39,000
Gravel Pavement	$4.32	$5,500
GravelPave2 System	$6.00	$143,500
Gravel Bed Detention	$0.32	$24,000
Swale	$3.68	$46,525
Native Landscaping and Drip Irrigation	N/A	$125,864
Total LID		$620,705
Standard Asphalt / Curb and Gutter Estimate		$360,115

On an overall cost basis, the GravelPave2 System used in the pervious parking are cost the most to install. However, on a cost per square foot of impervious surface treated basis, the green roof by far cost the most to install at a total cost of $31.80 per square foot, more than four times the cost of the next most expensive cost per square foot item, the pervious concrete pavers. WSSI believes that as suppliers and contractors become more familiar with LID techniques, the costs associated with the approaches they used will decrease.

Although the cost of installing LID techniques was higher than that estimated for traditional stormwater management using curb and gutter, it should be noted that the overall cost did not include a calculation for a stormwater management facility for the traditional design. This is because the site was already served by an existing stormwater management pond, and all the techniques employed at the site were optional installations that WSSI chose to do because of their environmental ethic. If the cost for development of a stormwater management pond were included in cost estimates, it is likely that the final total cost numbers would be closer to the LID numbers.

Other Benefits

There were a number of environmental benefits realized from the use of the low impact techniques employed. These included:

- The green roof included two small wetland areas with native vegetation.
- 1.17 acres of native vegetation was left undisturbed at site.
- Impervious area was reduced 28.8%.
- Peak runoff rate was reduced 15.7%.
- LID technologies removed 51.3% of phosphorus from the runoff.

Source(s)

- Stormwater Magazine. Laboratory for LID. Volume 7, Number 7. October 2006. http://www.stormh2o.com/sw_0610_toc.html

- Wetland Studies and Solutions Inc. LID at Wetland Studies and Solutions Inc. http://www.wetlandstudies.com/docUpload/WSSI_LID_2006.pdf

Pembrook Woods Emmitsburg, MD

The Pembrook Woods Subdivison is a ½ acre residential development located in northern Frederick County, Maryland. Pembrook Woods was originally designed as a ¼ - acre lot conventional subdivision with 97 lots, two stormwater management ponds and closed section streets. The original design also called for most of the wooded site to be cleared. The site was redesigned using site foot-printing techniques that preserved approximately 50 % of the site in undisturbed wooded condition, helping to maintain pre-development hydrologic conditions. Site foot-printing also enabled the developers to gain two additional lots, increasing the site yield from 68 to 70 individual ½ acre lots.

Developers also reduced impervious cover and saved money by converting approximately 3,000 linear feet of road from an "urban road" section to a "rural road." The conversion allowed them to replace curbs and gutters with vegetated swales and reduce paving width of the road from 36 to 30 feet. The use of LID practices and principles throughout the development also enabled developers to eliminate the use of the two stormwater management ponds required in the conventional design.

Monetary Benefits

The site redesign resulted in a number of monetary benefits to the developer. These included:

- Addition of 2 lots added roughly $100,000 in additional value to the project.
- Elimination of the two stormwater management ponds resulted in a savings in infrastructure costs of roughly $200,000.
- The use of swales saved the developers $60,000 in infrastructure construction
- The reduced road width lowered paving cost by 17%.
- Estimated savings of $160,000 from reduced need for clearing and grading.

Other Benefits

From an environmental and market perspective, a number of benefits were derived from the use of LID practices. These included:

- The developer preserved two-and-a-half acres of undisturbed open space and wetlands, which aids in the control of stormwater runoff and avoided some wetlands mitigation impacts.
- Homes sold 60% faster than surrounding developments.

Source(s)

- Ecosite, Inc. No date. Case Study: Pembrook Woods Low Impact Development (LID) Residential Subdivision.

http://www.ecosite.biz/Pembroke%20LID.pdf

- Buckeye Development. No date. Pembrook Woods Webpage.

http://www.buckeyedevelopment.net/gallery5.htm

Somerset Prince George's County, MD

The Somerset subdivision is an 80-acre site consisting of nearly 200 homes. The development was built with approximately one half using low impact development (LID) techniques, and the other half using curb-and-gutter design with detention ponds for stormwater management. The LID portion uses 300- to 400- square foot rain garden (bioretention cells) on each of the 0.25-acre lots and vegetated swales to replace conventional stormwater infrastructure. Sidewalks were also eliminated from the design, but local transportation department concern that roadside parking would damage the swales caused roads to be widened by ten feet to accommodate parking.

Monetary Benefits

Implementation of LID techniques was estimated to save more than $300,000 in capital costs over conventional stormwater management methods. This estimate comes from a comparison of the cost to install a rain garden versus a conventional detention pond. An approximate cost of $100,000 was required to install rain gardens at Somerset (swale construction was an additional cost). Each rain garden had a cost of about $150 for excavation and about $350 for plants. In comparison, nearly $400,000 was needed to install conventional detention ponds, which did not include the expense of curbs, gutters, and sidewalks. Six additional lots were also developed in the LID half of Somerset due to the elimination of the need for a stormwater pond. The elimination of the stormwater pond also translated into a cost savings of more than $4,000 per lot. The cost comparison for the traditional and LID portions of the site are shown in Table 6.

Table 6. Cost Comparison for Somerset Subdivision

	Conventional Design	LID Design	% Savings
Total Cost	$2,456,843	$1,671,461	32%

Other Benefits

The environmental benefits of using the LID approach were highlighted in a paired watershed study done by Prince George's County. The study found the following:

- The average annual runoff volume from the LID watershed was approximately 20 % less than that from the conventional watershed.
- The number of runoff-producing rain events in the LID watershed also decreased by 20 %.
- Metal content of runoff also significantly decreased in the LID area. Concentrations of copper were 36 % lower, lead concentrations were 21 % lower, and zinc concentrations were 37 % lower in the LID watershed runoff.
- Homeowner response to the bioretention cells was positive, with many perceiving the management practices as a free landscaped area.

Source(s)

Nonpoint Source News Notes. Low Impact Development Pays Off. May 2005, #75.
http://www.epa.gov/owow/info/NewsNotes/issue75/75issue.pdf

Jordan Cove Waterford, CT

The Jordan Cove Watershed Study was a "paired watershed" study to evaluate water quality from a traditional subdivision on 10.6 acres of land and a 6.9-acre site that employs a low impact development (LID) approach. The study began in 1995 and was monitored extensively for ten years. The primary goals of the project were to compare runoff quality and quantity between traditional and LID developments and to demonstrate the effectiveness of urban best management practices (BMPs).

Several LID techniques (Figure 3) were employed during development of the BMP watershed to reduce impervious area. These included clustering of homes (zero lot line setbacks, reduced front setbacks), elimination of curb and gutter and sidewalks, and the use of alternative paving materials. Stormwater management was provided through bioretention cul-de-sac, swales and gardens. Small lawns and the use of low- and no-mow areas were also employed. The comparison study was also done on driveway surfaces and lawn nutrients, as well as a homeowner education program study regarding pet waste management, nutrient management, and yard waste management (composting).

Monetary Benefits

Since the focus of this study was on water quality benefits, there is little cost comparison data available. A presentation from the staff of the Jordan Cover Watershed Project provides some details on the costs for employing LID on a per lot basis (Table 7).

Table 7. Cost Comparisons - per Lot for Traditional vs. LID Watersheds

	Traditional	LID
Driveways	$1,318	$7,896
Planning design	$ 400	$1,300
Plantings	$ 500	$ 650
Rain gardens	$ 0	$1,600

Other Benefits

The environmental benefits of the LID techniques used were examined over a ten year period both during construction and post-construction. The study indicates that LID has the ability to improve water quality and reduce the amount of stormwater runoff at a site. Among the benefits documented by the study:

- Stormwater runoff, and associated pollutant loading, is significantly less from the BMP neighborhood than from the traditional neighborhood.
- During construction, a significant decrease in peak flow and flow volume was observed in the BMP watershed.
- BMP installation costs were offset by less maintenance and greater property value.
- Stormwater flow decreased 107%.
- Peak flows from BMP neighborhood lagged behind traditional and control areas by average of 24 minutes.
- Post construction monitoring in the BMP watershed indicates that pollutant concentrations increased 59%-83%, but mass export of pollutants decreased.

- A study of driveway runoff indicated that stormwater runoff and mass export of solids, nutrients, and metals was greater from asphalt than either the pavers or crushed stone driveways. In addition, concentrations of solids, nutrients, and metals were lower in runoff from the paver driveways than the asphalt driveways, and concentrations of total phosphorus and lead were lower in runoff from the crushed stone driveways than from the asphalt driveways.
- A study of lawn nutrients indicated that the BMP lawns being monitored have lower values than the non-BMP lawns**.**

Source(s)
University of CT, College of Agriculture and Natural Resources. No date. Jordan Cove Watershed Project.
http://www.canr.uconn.edu/jordancove/

Figure 3. Examples of LID Practices in BMP Watershed (Source: University of Conneticut)

Forest Ridge Palmyra, PA

Forest Ridge is a residential development located on 69 acres of forests in a rural setting in South Londonberry Township. The developer and excavator felt strongly about the importance of maintaining the forested character of the land, and preservation of the mountainous character of the land and wildlife corridors and habitat were paramount in the design. Development techniques such as selective clearing, soil protection, and development of a tree conservation plan prior to final design were utilized to accomplish this goal.

The commitment to forest preservation was evident in the extra efforts the developer implemented to retain trees:

- Each lot site was walked to determine placement of homes to maximize the preservation of the most trees.
- Minimal clearing was permitted on each site so that only a narrow path was cut in the trees around each house pad to accommodate the building.
- Two pieces of excavation equipment were purchased to accomplish tree preservation goals.
- Excavated soil was moved off site to protect tree roots and avoid soil compaction during construction, and then returned to the site for backfilling.
- Each prospective homeowner walked a lot with the developer, who emphasized the importance of the trees. If the prospective homeowner disagreed with the importance of preserving a lot's trees, they were shown a lot in a less wooded section and informed that deeds restricted tree removal.

Monetary Benefits

Despite the higher costs associated with walking the site and purchase of new, specialized equipment, the overall benefit of the forest conservation based design was reflected in the demand for houses in the Forest Ridge site. Evidence of the market benefits include:

- Phase one was a six month sellout, to the surprise of realtors who told the developer that the treed lots were overpriced for the area.
- Phase two has even heavier forest cover per homesite with just 10% of the lot cleared, and Phase 2 is becoming a record sellout.
- Lots in Phase 3 are selling for a higher premium due to success of Phases 1-2.
- Homes sold 75 % faster than nearby homes in traditional developments.

Other Benefits

The Forest Ridge design also resulted in benefits from a natural area preservation standpoint. These include:

- Deed restrictions were imposed by the developer to curtail the cutting of trees require that if a tree is taken down on a lot, it must be replaced on the lot.
- The Township holds the easement for 2 conserved areas, .9 acres set aside for a park and 2.6 acres set aside along the perimeter with a requirement that a minimum of 25% of entire site remains in trees.

Source(s)

Alliance for the Chesapeake Bay. 2005. Forest Friendly Development: Chesapeake Bay Case Studies.
http://www.acb-online.org/pubs/projects/deliverables-145-8-2005.pdf

Forest Brooke Manassas, VA

Forest Brooke is a 62 acre development site with 18 lots varying in size from 1 - 8 acres. Numerous forest conservation techniques were employed to reduce the impact of construction on forest resources, including minimizing clearing, building at low density, and consolidation of existing forest to protect wildlife corridors and habitat. For instance, the site was walked and mapped by a site engineer so that lots were complementary to terrain features such as slope and ravines, and homes were designed to blend into the natural forest setting and preserve as much forest as possible. Homes were re-situated as needed to take optimal advantage of the existing trees. As a result, sixty % of the site was left in trees, maintaining the surrounding forested corridor. Deed restrictions mandate tree conservation by individual homeowners, and homeowner education began in the pre-building phase while walking the site with new owners to determine placement of homes within the heavily treed lot.

Tree preservation was also achieved through a prohibition on mass clearing and grading which added to costs but was recouped by the increase in desirability and market value of homes. Smaller construction equipment was used to clear home footprints individually one tree at a time, to avoid damage to specific trees tagged for saving. This also helped avoid excessive soil compaction. The amount of impervious cover at the site was reduced through the use of an internal road that follows the natural topography and separates into two shared driveways.

Monetary Benefits

Initial project expenditures were higher because of the choice to preserve forest and wildlife corridors. For example, about 30-60% more time was spent in site preparation due to individual tree clearing, and clearing expenses cost $5800-$6000 more in time and equipment costs than traditional clear cutting. However, the overall extra prepping costs were recouped in the increased value of each home and in added selling points and overall owner satisfaction. Some construction expense was lowered through the use of shared driveways, narrower roads and no sidewalks that reduced overall paving costs.

Other Benefits

The site design produced a number of market and environmental benefits. These include:

- Recurring septic problems seen in other nearby developments were avoided by bringing public sewer and water into the development at an additional cost.
- The market value increased substantially from forest setting, and the value of each home recouped the extra time spent in site preparation and clearing.
- Homes sold 30-50% faster than a traditional subdivision located less than a mile away.

Source(s)

Alliance for the Chesapeake Bay. 2005. Forest Friendly Development: Chesapeake Bay Case Studies.
http://www.acb-online.org/pubs/projects/deliverables-145-8-2005.pdf

Conclusion

The ten case studies presented show that low impact development (LID) practices can reduce project costs and improve environmental performance when compared to conventional development. In many cases, significant savings were realized during the development and construction of a project due to reduced costs for site preparation, stormwater infrastructure, and landscaping. Estimates of total cost savings ranged from 12 to 50 % with the application of LID methods over conventional techniques such as curb and gutter. Table 8 provides a summary of the estimated economic benefits of the use of LID versus conventional development. A 👍 indicates that the case study shows that the use of LID techniques cost less, whereas a 👎 shows that conventional development techniques cost less. As the use of LID techniques increases, it is expected that costs for the use of these practices will continue to fall as demand increases and the number of professionals capable of designing and installing these alternate practices grows.

In the few cases where capital cost may have been higher for LID designs, other benefits derived from the use of these techniques must be considered. The environmental benefits and increased market value in many cases offset the initial capital cost expenditures. Benefits such as aesthetics, recreational opportunities, increased property values due to the desirability of the lots (premiums) and their proximity to open space, increased number of total units developed, and the value of increased marketing potential and faster sales are not accounted for when conducting a cost-benefit analysis of a project. Additional research is needed to determine how to accurately place an economic value on the improved environmental performance, reductions in long-term operation and maintenance costs, and downstream benefits realized through the reduction of peak flows, discharge volumes and pollutant loadings from sites incorporating LID techniques.

Table 8. Summary of Cost Benefits of LID vs. Conventional from Case Studies

Case Study	Clearing and Grading	Infrastructure	House Value	Overall Project Savings
Laurel Springs	👍	👍	👍	👍
SEA Streets	👎	👍	--	👍
Rivergate	--	👍	--	👍
South Kingstown	--	--	👍	👍
WSSI	👎	👎	--	--
Pembrook Woods	👍	👍	👍	👍
Somerset	👍	👍	👍	👍
Jordan Cove	--	👎	--	--
Forest Ridge	--	--	👍	--
Forest Brooke	👎	👎	👍	👍

👍 - Indicates that LID techniques cost less
👎 - Indicates that the use of conventional development techniques cost less
--: study did not examine this benefit

Additional Resources

The following resources provide many other case studies from around the country that illustrate the benefits of the use of LID practices. Together with the sources cited after each case study, they represent a good synopsis of the economic information currently available on LID vs. conventional development cost comparisons.

Tetra Tech. 2006. Economic Benefits of Low Impact Development Practices. Draft submitted to EPA Office of Water, Nonpoint Source Branch.

Center for Watershed Protection. 1998. Nutrient Loading from Conventional and Innovative Site Development. CWP, Ellicott City, MD.

Minnesota Sustainable Communities Network. Residential Conservation Design Saves Money. http://www.nextstep.state.mn.us/res_detail.cfm?id=1268

Smart Communities Network. Green Development Success Stories. http://www.smartcommunities.ncat.org/greendev/stories.shtml

Maryland Environmental Design Program. http://www.dnr.state.md.us/ed/

Tetra Tech. 1996. Green Development Literature Search: Summary and Benefits Associated with Alternative Development Approaches. Prepared for the U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Washington, DC. EPA Contract #68-C3-0303. http://www.smartgrowth.org/bibliographies/greenlit_search/case_examples.html