LOW-IMPACT DEVELOPMENT STRATEGIES AND TOOLS FOR LOCAL GOVERNMENTS

BUILDING A BUSINESS CASE

REPORT LID50T1

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Low-Impact Development Strategies and Tools for Local Governments: Building a Business Case
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Executive Summary

Municipal managers need a life-cycle cost (LCC) analysis method for evaluating low-impact development (LID) projects as an alternative to, or as part of, conventional stormwater controls. They need a framework for assessing which design alternative (LID or conventional) fulfills the performance requirements of the typical municipal land development project (such as runoff retention or pollutant removal) while having the lowest LCC and, in some cases, additional benefits.

LID techniques attempt to mimic a site's predevelopment hydrologic regime, using distributed landscape features and engineered devices such as bioretention, grass swales, vegetated rooftops, rain barrels, and permeable pavements to reduce runoff, minimize pollutant discharges, decrease erosion, and maintain base flows of receiving streams. LID focuses on capturing and infiltrating the stormwater into the soil as close as possible to the point at which it hits the ground, thus reducing runoff. It differs from conventional stormwater management approaches, which typically aim to move water away from a site as quickly as possible via impervious surfaces (gutters, pipes, and paved ditches) to a central retention and treatment device.

LID is a relatively new and innovative stormwater engineering and design approach that has economic and environmental benefits that conventional techniques lack. Proponents assert that some LID techniques can achieve sediment retention and pollutant removal goals at a lower initial cost than conventional systems, in part because they require less pipe and underground infrastructure. In cases where LID designs have had higher initial costs than traditional approaches, proponents point to lower maintenance and operating costs and other savings that result in lower LCCs than traditional approaches. Proponents also assert that LID techniques have additional benefits such as enhanced pollutant removal rates, increased open space, reduced downstream flooding, increased property values and redevelopment potential, public health protection, reduced automobile traffic and fuel consumption, habitat preservation, erosion prevention, and improved quality of life for a community.[1] However, the collection of empirical data supporting claims of cost savings and other benefits is in its early stages.

We recommend an approach to applying LCC to LID and a means to estimate some of its benefits. Our approach identifies further technical research needs, including compiling actual cost figures for LID design, construction, and operation and maintenance. It also suggests further research topics concerning benefits. For example, research into the monetary benefits of LID, such as a study on increases in property value directly caused by LID, would be useful.

Regardless of the available cost and benefit information, decision makers are regularly making stormwater management decisions. The decision to use LID often comes down to the bottom line—is it the most affordable option? In many cases, LID is indeed the least costly choice on a life-cycle basis, even if the upfront capital costs are higher than for traditional stormwater alternatives. Affordability should be defined as a measure of the overall LCCs of a project, with benefits properly recognized.

A common challenge to gaining support for LID is the perception that it is new, not well understood, and more difficult and expensive to design and construct. These criticisms can be overcome with a better understanding of LID, coupled with a grasp of its longer-term advantages. Managers should approach the option of LID as a business matter and work to show that, in many cases, it is the most cost-effective option.

Some cost and many benefit components of LID projects are not easily quantified, but a manager can still build an economic case to support LID by using our recommended approach. Specifically, the manager should complete the comprehensive cost estimation worksheet, consider whether LID provides the listed benefits, and use the examples of LID benefits as data sources for the project in which they are interested.

Funds or resources for estimating full LID benefits are unlikely to be available at the municipal level. We recognize this and suggest that our recommendation to create factors to represent the relative level of effectiveness will help simplify the process, yet provide useful information.

[1] CH2M HILL, Inc., *Pierce County Low Impact Development Study*, April 2001.

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Chapter 1
Introduction

This report discusses a life-cycle cost (LCC) analysis method for evaluating low-impact development (LID) projects as an alternative to, or a part of, conventional stormwater controls at a development site. It also describes other benefits that municipal managers can garner using various LID techniques instead of conventional controls. The purpose is to give city managers or planners a framework for assessing which design alternative (LID or conventional) fulfills the performance requirements of a municipal land development project (such as runoff retention or pollutant removal) while having the lowest LCC and, in some cases, other benefits.

LID techniques attempt to mimic a site's predevelopment hydrologic regime, using distributed landscape features and engineered devices such as bioretention, grass swales, vegetated rooftops, rain barrels, and permeable pavements to reduce runoff, minimize pollutant discharges, decrease erosion, and maintain base flows of receiving streams. LID focuses on capturing and infiltrating the stormwater into the soil as close as possible to the point at which it hits the ground, thus reducing runoff. It differs from conventional stormwater management approaches, which typically aim to move water away from a site as quickly as possible via impervious surfaces (gutters, pipes, and paved ditches) to a central retention and treatment device such as a stormwater retention pond.

LID is a relatively new and innovative stormwater engineering and design approach that has economic and environmental benefits that conventional techniques lack. Proponents assert that some LID techniques can achieve sediment retention and pollutant removal goals at a lower initial cost than conventional systems, in part because they require less pipe and underground infrastructure. In cases where LID designs have had higher initial costs than traditional approaches, proponents point to lower maintenance and operating costs and other savings that result in lower LCCs than traditional approaches. Proponents also assert that LID techniques have additional benefits such as enhanced pollutant removal rates, increased open space, reduced downstream flooding, increased property values and redevelopment potential, public health protection, reduced automobile traffic and fuel consumption, habitat preservation, erosion prevention, and improved quality of life for a community.[1] However, as with many new techniques, the collection of empirical data supporting claims of cost savings and other benefits is in its early stages.

Without strong supporting cost and operational data, municipal managers are often reluctant to recommend new land development techniques such as LID for

[1] CH2M HILL, Inc., *Pierce County Low Impact Development Study*, April 2001.

municipal capital projects. Because of their tight budgets, municipalities may not implement LID techniques, when considered, because their higher initial cost overshadows their lower LCC. Other LID benefits are rarely included in the analysis, in part because they are difficult to quantify. This shortsightedness can result in procurement decisions that do not select the most cost-effective option.

In addition to having to recommend priorities for municipal capital investments, municipal managers must comply with the Government Accounting Standards Board (GASB) Statement 34, which requires that a municipality annually present

- its capitalization policy,
- an inventory of its infrastructure assets (including stormwater infrastructure),
- a description of the asset's condition,
- the estimated cost of maintaining the assets in the previous budget period,
- the actual costs and the reasons for any difference, and
- a brief explanation of procedures used to ensure that government infrastructure is well maintained into the future.[2]

As a result, as municipalities move to implement LID, managers need better information resources and methods to estimate a LID technique's expected life, initial costs, and operation and maintenance (O&M) costs.

In this report, we offer municipal managers an approach for estimating and comparing the LCCs of conventional and LID techniques and incorporating LID's benefits into project evaluation methods. Managers can use this approach as a starting point for building a business case for LID. Properly documented benefits and LCCs will prove LID the best option in many situations.

[2] In accordance with GASB 34, municipalities must select pollution control strategies that have the lowest LCCs. Government Accounting Standards Board, *Statement 34 Resource Center*, http://www.gasb.org/repmodel/index.html.

Chapter 2
Project Evaluation Techniques

To evaluate LID techniques, a municipal manager, planner, or engineer must properly assess whether they are more cost-effective than alternative stormwater management techniques. Whatever the situation, someone implementing a LID project probably will have to defend that decision.

Project evaluation traditionally uses one of the following techniques:

- Initial project cost estimation
- LCC estimation
- Cost-effectiveness analysis
- Cost-benefit analysis.

In this chapter, we evaluate each technique's potential use by municipal managers for evaluating project alternatives. We selected these particular methods because they are well established and reasonably cover the scope of methods in actual use today.

PROJECT LIFE CYCLE

The typical public facility construction and maintenance process has sequential or life-cycle phases (Figure 2-1):

- *Planning*. During this initial phase, municipal managers, often with architect and engineering (A-E) consultants, translate demands for new facilities into planning and financial justification documents. They evaluate design alternatives (such as LID or conventional stormwater controls), select a design concept, assess regulatory requirements, estimate initial project costs, and seek project approval and financing. Once a project is approved and financing is arranged, they proceed to the design phase.

- *Design*. The A-E firm works with the municipal manager to articulate requirements in detailed construction plans and specifications. The municipal manager often submits these plans with a construction bid and selects a construction contractor. The A-E investigates the site and revises construction and site development specifications. Also during this phase, the municipal manager or A-E firm completes any regulatory requirements for the project.

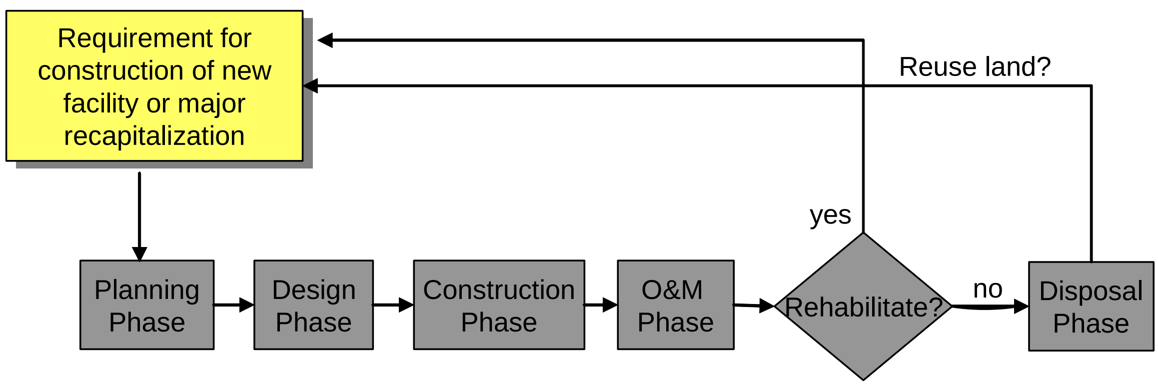
- *Construction*. The construction contractor works with the municipal manager to acquire the labor and equipment to implement the approved plans to the required specifications. Contractors often have to obtain and comply with environmental permits.

- *Operation and maintenance*. Once a facility is built and occupied, maintenance begins. The municipality and contractors operate and maintain a facility throughout its useful life. Costs in this phase can include energy, water, and maintenance.

- *Recapitalization*. At the end of the expected life of an asset or facility, municipal managers determine whether they should significantly rehabilitate or dispose of the facility. A decision to recapitalize the facility translates into a new requirement for either a major repair or renovation project, and the process recycles to the first phase. This can include the installation of a LID technique instead of rehabilitating existing conventional stormwater structures.

- *Decommission*. A decision to dispose of the facility leads to this final phase, in which the facility can be decommissioned and the land offered to other federal, state, local, or private owners.

Figure 2-1. Typical Life Cycle for Municipal Construction Project



Initial Project Cost Estimation

Initial project cost estimation calculates the costs to plan, design, and construct a new system or project. The estimates typically take one of two forms: (1) a detailed estimate of the direct and indirect costs associated with planning, designing, and constructing a project; or (2) a general cost estimate based on historical costs for similar projects.

An established reference for developing a detailed estimate using unit costs for some LID techniques is *Green Building: Project Planning & Cost Estimating*.[1] It contains cost information for LID techniques such as vegetated roofs, rainwater harvesting systems, vegetated swales, plants, ponds, and pavers. RSMeans also offers other construction catalogs that contain cost information on traditional construction techniques. RSMeans provides the following cost components for calculating each step of the initial project cost:

- *Direct costs.* Outlays made directly to suppliers of project inputs. Four elements of direct costs are outlays for professional labor, craft labor, material items, and construction equipment.
- *General conditions costs.* Outlays for necessary tasks associated with a project, such as travel and per diem, permits, taxes, professional labor personnel, and supervision.
- *Overhead costs.* Outlays for contract labor overhead and any home office expense.
- *Profit.* A fee—in addition to direct costs, general conditions costs, and overhead costs—paid for use of capital and risk bearing.[2]

For example, an estimate of the initial cost to install a bioretention cell would only include the costs to design the cell, purchase the plants and materials, prepare the site, and construct the cell. Initial costs typically do not include sunk costs, such as the original cost to purchase the land, or any future costs, such as O&M, sampling and analysis, or demolition costs.

Basing initial cost estimates on unit or assembly costs, such as those presented in the RSMeans catalogs, can be tricky. Every case has a variety of site-specific factors, project assumptions, and uncertainties, which affect the actual project costs. Furthermore, cost categories are often ignored or only partially included in the estimate. As a result, initial cost estimates vary in accuracy. For example, an English study showed that many government departments frequently underestimated project costs by more than 50 percent.[3]

Beyond the unit and assembly cost information contained in RSMeans, data specifically documenting initial LID costs are scarce. In 2003, Sample, et al.,

[1] Seiglinde K. Fuller, et al., *Green Building: Project Planning & Cost Estimating, A Practical Guide for Constructing Sustainable Buildings*, RSMeans, 2003, http://www.rsmeans.com/bookstore/detail.asp?sku=67338.

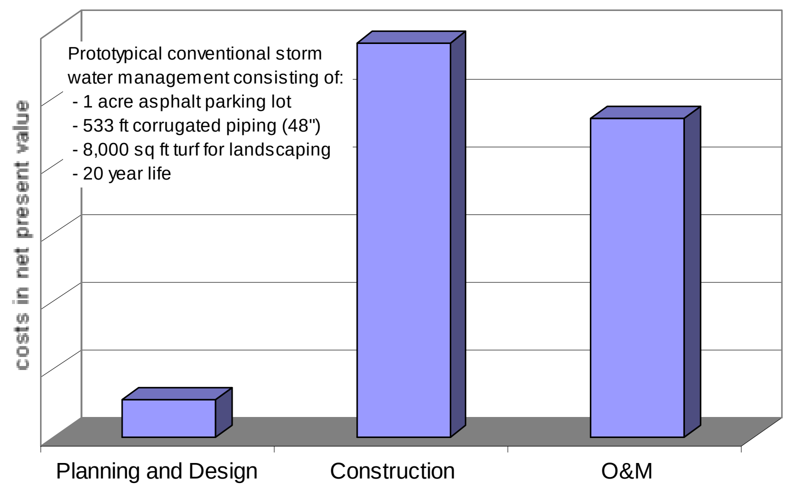
[2] See Note 1.

[3] Office of Government Commerce, UK, *Achieving Excellence in Construction, Procurement Guide 07: Whole-life costing and cost management*, 2003.

discussed the lack of availability of data on best management practices (BMPs).[4] However, as researchers complete more work on the actual costs of LID, managers will have better information for estimating the initial costs of future LID projects.

As stated, initial capital costs cover only a portion of the total costs of a project. The problem with relying only on initial costs when evaluating design alternatives is that O&M costs generally are a significant portion of total costs considered in terms of net present value.[5] Figure 2-2 depicts a typical 20-year LCC distribution for a conventional stormwater management system associated with a prototypical 20,000-square-foot administrative building built to common standards.

Figure 2-2. Cost by Phase of Conventional Stormwater Management System



Source: Department of Energy, Federal Energy Management Program, *The Business Case for Sustainable Design in Federal Facilities*, 2003.

Public agencies typically have a "fire-and-forget" mentality—evidenced by the substantial attention that goes into planning new construction, but minimal attention on planning, execution, and funding for maintenance and recapitalization. LCC analysis is an approach that considers a project's entire costs.

Life-Cycle Cost Analysis

LCC analysis is a method of project evaluation that considers all project costs arising from planning, designing, constructing, operating, and ultimately disposing of an asset. LCC is particularly suitable for the evaluation of

[4] BMPs help reduce the degradation of water bodies from pollution from the land. They use the same concepts as LID, but LID is an advancement on BMP techniques, incorporating features such as landscape architecture in the design. For more information, see http://www.epa.gov/region01/assistance/univ/bmpcatalog.html.

[5] Net present value, in this context, is an equivalent measure of the sum of current and future expenditures after taking into account (discounting for) the time value of money.

stormwater system design alternatives that satisfy a required level of performance (including pollutant removal and stormwater retention rates) but that have different initial costs, O&M costs, and life spans.[6] This approach is critical in estimating LID costs because often its O&M costs are significantly lower than conventional approaches. Admittedly, LCC analysis can require a substantial amount of supporting information and be difficult to apply in practice. Future costs are inherently difficult to predict, and LID projects can be long-lived.

The subjective nature of determining the planning horizon for the project life cycle (such as 20 or 50 years) complicates LCC analysis. To fairly analyze the LCC of different alternatives, the estimator must use the same life cycle. For practical purposes, the planning horizon should be prospective and not include sunk (previously spent) costs for any alternative.[7] It should, however, span the expected life of the major system components.

Determining the reach of the costs considered also complicates LCC analysis. Some methods look at the broader societal costs, and others focus strictly on the direct project costs. For the purpose of evaluating project design alternatives, we recommend restricting the costs to those realized by the project owner (in this case the municipality), but including the costs realized by the subordinate office running the particular project. For example, consider the environmental sampling costs of different alternatives, even if the municipality's environmental office, rather than the municipal office in charge of capital planning, would realize those costs. Again, to fairly analyze the LCC of different alternatives, the estimator must use the same assumptions of cost reach for each.

The concept of LCC analysis has matured over time and within different fields. The *Standard Handbook for Civil Engineers* describes LCC as initial and O&M costs, with no mention of the disposal or recycling costs or gains.[8] In some cases, however, disposal is a significant cost issue. In addition, because LID techniques tend to have a low disposal cost compared with more infrastructure-intensive approaches, disposal costs should be considered in LID analyses.

The basic steps in an LCC analysis are as follows:

- Identify feasible alternatives.
- Establish assumptions and parameters to use in all alternatives.
- Estimate each cost component and its timing.

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[6] Sieglinde Fuller and Stephen R. Petersen, *Life-Cycle Costing Manual for the Federal Energy Management Program*, NIST Handbook 135, February 1996, http://fire.nist.gov/bfrlpubs/build96/PDF/b96121.pdf.

[7] See Note 5.

[8] Frederick S. Merritt, *Standard Handbook for Civil Engineers*, third edition (New York: McGraw-Hill Publishing Company, 1983).

- Discount future costs to net present value using appropriate discount rates.
- Compute the LCC for each alternative.[9]

An excellent reference, which details methods for calculating LCC, is the *Life-Cycle Costing Manual for the Federal Energy Management Program*.[10] Each year the National Institute of Standards and Technology (NIST) computes the discount rate to be used in the analysis of federal energy and water conservation and renewable energy projects. In addition, it computes tables of discount factors and energy price indexes, which are based on this discount rate and on energy price projections made by the Department of Energy (DOE) Energy Information Administration for this purpose. These data are published each April in the Annual Supplement to Handbook 135 and in the life-cycle costing software. The tables and software are available in electronic form from the DOE Federal Energy Management Program (FEMP) website.[11] NIST also develops and distributes a computer program, the Building Life-Cycle Cost Program (BLCC5), to support LCC analysis of buildings. This source contains the up-to-date discount rates, inflation rates, and energy prices for calculating LCCs of competing building designs.

In addition to LCCs, secondary benefits, measurable but sometimes difficult to value, can be critical for municipal decision makers. We now turn to assessing these benefits.

COST-EFFECTIVENESS ANALYSIS

Cost-effectiveness analysis is a technique for determining a preferred option on the basis of costs and effectiveness. In its simplest form, the method assumes that all options result in the desired outcome and analyzes costs to determine the best value.[12] However, the more usual case is that different options have different levels of effectiveness. This is especially true in terms of environmental impact, protection, or remediation, where different options often have quite different environmental consequences.

Scholars have attempted to incorporate environmental impacts into projects or purchasing decisions and to determine the net present value of such projects.[13,14] Because of the difficulty of quantifying environmental factors, this approach can be difficult to implement in practice. For example, a project may protect the

[9] See Note 1.

[10] See Note 6.

[11] Department of Energy, *Federal Energy Management Program*, http://www.eere.energy.gov/femp/.

[12] Robert A. Corbitt, *Standard Handbook of Environmental Engineering*, (New York: McGraw-Hill Publishing Company, 1990).

[13] Net present value refers to the value of all factors, including the social and environmental components of a project or item.

[14] Tom Tietenburg, *Environmental and Natural Resource Economics* (Boston: Addison Wesley, 2003).

environment in several ways, each somewhat different from the others. Quantifying each may be difficult. Also, another project may protect the environment substantially in a few ways but not in others. When this is the case, the two projects may be difficult to compare.

Still, cost-effectiveness analysis is superior to LCC analysis alone because unbiased choice among project alternatives requires consideration of benefits. LID in particular offers several benefits, which can favorably tip the balance in some cases. We discuss the means to attach benefits to LID in the next chapter.

Finally, attaching monetary values to effectiveness facilitates comparisons among projects. We next turn to cost-benefit analysis, which compares costs and quantified benefits to select the best alternative.

COST-BENEFIT ANALYSIS

Cost-benefit analysis considers the costs of a project along with the economic value of its benefits. The two are compared to reach a decision whether the project is worth the cost. This is a useful technique for private-sector ventures, such as the building of a new restaurant or apartment complex. However, for projects involving environmental management, benefits generally will be more difficult to value. An ongoing discussion in the environmental economics field is how to value environmental benefits so that they can be included in analyses of alternatives.

A variety of methods exists to estimate such values, directly or indirectly. Direct estimation methods are based on actual market choices, or *stated preferences*. In contrast, indirect methods are based on inferred information, or *revealed preferences*.[15] Both indirect and direct valuation methods attempt to produce a dollar value of an environmental good or service. Though it is widely accepted that valuing environmental goods and services is useful, the appropriate techniques are far less established. These techniques, such as contingent valuation and hedonic pricing, are strong conceptually but limited in their applicability. Generally speaking, cost-effectiveness analysis is probably the best choice for most projects that involve substantial environmental components.

NIST has developed a method for comparing the economic and environmental considerations of alternative building products. It is supported by a database of building materials costs called “Building for Environmental and Economic Sustainability (BEES).”[16] The database contains approximately 200 building products and, although not necessarily complete, is a good place to begin.

[15] Clifford S. Russel, *Applying Economics to the Environment*, Oxford University Press.

[16] National Institute of Standards and Technology, *BEES Please*, http://www.bfrl.nist.gov/oae/software/bees/please/bees_please.html.

APPLICABILITY TO LID

LCC estimation is recommended for LID project evaluation, but it can be difficult and imprecise. Often, a detailed cost estimate requires extensive if not expensive analysis, relies on a host of assumptions, and is subject to a set of other variables difficult to quantify. In the next chapter, we offer a means for dealing with some of these issues.

Cost-effectiveness analysis can be an even more useful tool in judging between LID and other approaches to stormwater management. Costs should include LCCs, not just upfront capital costs, and benefits should be quantified and valued where possible and practical. Assessing the LID business case requires consideration of all of these factors, which allow proper comparison of the relative advantages and disadvantages of project alternatives.

Chapter 3
LID Business Case

In this chapter, we examine how to best construct a business case for a LID alternative. Our interest is to offer practical advice to a city manager who wants to know whether LID makes sense in a particular instance, either as a standalone project alternative or in combination with another approach.

Estimation of project lifetime costs and effectiveness is a complex process that requires training and expertise. Cost estimation, especially for non-established cost categories, can be extremely complicated and time-consuming. It can also be cursory or exhaustive, depending on the needs of a particular situation. Therefore, we offer only broad guidelines, which should be used as they apply to each specific situation. More particularly, these principles can be used to develop an approach for estimating and understanding LID costs and benefits.

PROJECT LIFE-CYCLE

In Chapter 2, we pointed out that projects are sometimes selected solely because they have lower upfront costs. Thus, for example, when two storm runoff alternatives are being considered, the option with the lowest initial costs may be selected regardless of long-term O&M or other costs.

This example has practical significance for LID. Designing and constructing bioretention cells may be more expensive upfront than installing a typical storm drain system, but they generally require less O&M and have virtually no rehabilitation or disposal costs. Over time, the storm drain system requires ongoing repair and cleaning and eventually replacement. When all of these costs are considered, the bioretention cells may yield a far higher return on investment than the conventional design and hence may be the more economical choice after all.

Making these determinations requires LCC analysis because the technique incorporates the costs of the project over its lifetime. Table 3-1 breaks the project life cycle further down. Stormwater project cost estimates should include all of these specific cost components.

Table 3-1. Typical Cost Components of Project Life Cycle by Phase

Cost Component	Plan	Design	Construction	O&M	Rehabilitation	Disposal
Direct costs						
Professional labor	X	X	X	X	X	X
Craft labor			X	X	X	X
Materials			X	X	X	
Construction equipment			X	X	X	X
Indirect costs						
Administrative support	X	X	X	X	X	X
Overhead	X	X	X	X	X	X
Other costs						
Permitting fees			X	X	X	X
Real estate costs (land opportunity costs)	X		X			X
Energy/water/other utility costs				X		
Landscaping			X	X	X	X
Sampling and analysis				X		X
Disposal fees			X	X	X	X

In some cases, LCC analysis includes more cost components than those presented in Table 3-1. Our literature review suggests that LCC is not often used on a small scale, the likely category of many LID projects. Still, the principle holds. All phases of a project's costs should be considered.

The cost data needed to populate the above table can be found in a number of different sources. As stated, the RSMeans *Green Building Guide* is a respected reference for cost data and includes many elements of LID designs. Also, NIST's *Life-Cycle Costing* guides and BLCC5 software provide guidance and tools to estimate the LCC of alternative projects given cost data. However, the specifications of a LID design tend to be site specific—also true for conventional stormwater projects. Therefore, the best cost data are likely to be available from local sources (equipment vendors, A-E firms, and construction contractors). Also, our research shows that cost data for LID are highly varied and not standardized. A manager or planner has to make assumptions and use the best available data to develop estimates. As more information about the long-term maintenance costs of LID becomes available, cost estimation of this alternative will become easier to accomplish and more precise. Furthermore, the approach we describe in this report will become more widely accepted as longer term data are more readily available.

EFFECTIVENESS AND SECONDARY BENEFITS

Determining the costs of the various elements and stages of the project life cycle is one critical step. However, as stated, LID offers benefits not reflected in Table 3-1 that also need to be considered. We next turn to a means of incorporating effectiveness into the analysis.

For the purposes of this study, we define effectiveness as the ability of a design to bring about the desired effect. In terms of stormwater controls, the desired effect is normally to eliminate excess stormwater and to reduce flooding.

Specifically, stormwater management seeks to

- minimize the discharge of pollutants into receiving waters,
- reduce the frequency and severity of flooding events,
- decrease soil erosion,
- maintain downstream habitat, and
- eliminate illicit discharges into the stormwater system.

Varying techniques accomplish these goals in different ways. LID seeks to bring the landscape closer to its natural state to allow the natural absorption of rainwater into the ground. When water does not absorb into the ground because the surface is impervious, it flows along the surface until it reaches an area where it can be absorbed or where it can flow into receiving waters. Consideration of LID alternatives should take into account their ability to reduce the discharge of pollutants into receiving waters, flooding, and reduce, if not eliminate, illicit discharge into the local stormwater system.

Quantifying the direct and secondary benefits of LID techniques and other project alternatives is challenging, making cost-effectiveness assessment more difficult. However, the concept still applies. To simplify, we suggest an approach that first quantifies the ability of each alternative to meet or exceed a particular system performance objective and then quantifies their secondary benefits. This approach also provides a checklist to walk managers through a process of articulating the specific goals of the project and assessing whether the alternatives meet them. This simple idea is illustrated in our comprehensive cost estimation worksheet (Table 3-2). Though these data do not quantify environmental impacts in terms of pollutants removed or runoff reductions, they still enable the quantification of project effectiveness and secondary benefits that may be quite useful in judging project alternatives.

Table 3-2. Comprehensive Cost Estimating Worksheet

Title of Project:							
Describe Option (LID or conventional?):							
Estimate Life-Cycle Cost							
Cost by Project Phase	**Planning**	**Design**	**Construct**	**O&M**	**Rehab**	**Disposal**	
	green shading indicates that the cost is expected in that phase						
Direct Project Costs (i.e., professional labor, craft labor, materials, equipment, overhead)							
Indirect Project Costs							
Permitting fees							
Real estate costs							
Energy/utility costs							
Landscaping							
Sampling and analysis							
Disposal fees							
Other costs							**Life-cycle cost**
Total Quantifiable Cost (use current year dollars)							
Calculate Effectiveness Factor							
3 = will exceed the objectives 2 = will meet objective 1 = will not meet objective	*Effectiveness is difficult to quantify. Therefore, enter a description of the goals of your project. You may add additional lines as necessary. Identify whether the project will accomplish the objectives over its lifetime.*						
State objective #1 of the project:							
	How well will the project meet objective 1?						
State objective #2 of the project:							
	How well will the project meet this objective 2?						
State objective #3 of the project:							
	How well will the project meet this objective 3?						**Effective-ness factor**
	Total (higher score = more effective)						
Calculate Secondary Benefits Factor (Answer yes or no for each question)							
	Increases usable space (e.g., lot yield)						
	Increases green space						
	Reduces pollutant discharges offsite						
	Reduces site run-off						
	Provides regulatory credits						
	Encourages economic development						
	Improves or protects local/downstream habitat						
	Improves aesthetic value						**Benefits factor**
	Total # of Y answers						
Comments:							

Directions: Fill out one worksheet for each option under consideration. You should use total life-cycle cost estimates, effectiveness factors, and benefits valuation to make a decision.

Complete the worksheet as follows:

- *Estimate Life-Cycle Cost*. Insert cost data for each phase and component of the project using the best available information. The table presents the typical cost components for each phase of the project. Considering all the components and entering the net present value for future investments using an appropriate discount factor are critical. As a simplified approach, consider all dollars in current year value, negating estimates of price escalation or discounting. Add the costs up from each phase to determine the LCCs.

- *Calculate Effectiveness Factor*. This section of the worksheet is a simple way to apply the concept of cost-effectiveness to the decision-making process and does not require the use of complex calculations. Specify the specific goals (or minimum requirements) of the project, adding rows to the worksheet if necessary. Use knowledge of conventional stormwater management and LID to determine whether the project will meet, exceed, or fall short of the objective. Enter the corresponding number into the appropriate field. The total of these numbers will provide an effectiveness factor. Each alternative must have the same objectives listed in this section of the sheet. Since these numbers simply represent a concept, they must be entered for each alternative to be comparable.

- *Calculate Secondary Benefits Factor*. A LID project often offers secondary benefits, such as increased green space, protected habitat, and other amenities. The secondary benefits portion of Table 3-2 lists a number of these, merely asking whether a particular project alternative offers them or not. The sum of "yes" answers represents a summation for these secondary effectiveness factors.

  In a few cases, it may be possible to quantify the value of some of these secondary factors (such as improved land values surrounding a LID alternative). Typically, however, quantifying environmental benefits (in terms of dollars) to analyze costs and benefits is difficult because few markets are available for obtaining the relevant values. In the next chapter (Table 4-1), we summarize this information on the benefits of LID and provide references. If value data can be applied to secondary benefits, the total should be considered in the decision-making process.

The worksheet in Table 3-2 represents a simplified approach to applying the concepts discussed in this report. This approach is designed to set the stage for an extensive, yet practical, analysis for LID projects.

Chapter 4
LID Benefits

When building a business case for LID, a manager should provide cost and benefit data and consider nonquantifiable benefits. Quantifying many LID benefits is difficult, but some information is available. In this chapter, we briefly describe research pertaining to LID benefits and give references that may help in building a better business case.

Economic, Environmental, and Social Benefits

Some research has quantified the environmental benefits of good stormwater runoff management. In 2003, Thurston, et al., proposed an approach for quantifying stormwater BMP effectiveness so that it could be traded on a market, similar to air quality permit trades.[1] This method would show the value of reducing the marginal cost of abating runoff. In addition, they proposed to create a value for protected land by establishing a value for protected endangered species habitat.

Such an approach might help in evaluating the benefits of LID. However, other, more specific references identify LID benefits:

- *Reduced downstream erosion and flood control*. By keeping runoff close to the source and preventing sediment loading, LID prevents streams from being overburdened with excess water during rain events that can cause flooding and severe erosion downstream, thereby preventing costly cleanup and stream bank restorations. In addition, LID protects floodplains, and creates economic benefits through open space, enhanced wildlife habitat, and farming.[2]

- *Increased property value and tax revenue*. Natural open space and trails are prime attractions for potential home buyers. Various LID projects and smart growth studies have found that clustered housing with open space appreciated in value at a higher rate than conventionally designed subdivisions. For example, in Amherst and Concord, MA, clustered housing sold at an average of $17,100 more than houses in conventional subdivisions. The clustered homes appreciated at an average annual rate of 22 percent compared with 19.5 percent in conventional subdivisions. These increases

[1] Hale W. Thurston, Haynes Goddard, David Szlag, and Beth Lemberg, “Controlling Storm-Water Runoff with Tradable Allowances for Impervious Surfaces,” *Journal of Water Resources Planning and Management ASCE*, September/October 2003, pp. 409–418.

[2] *Trust for Public Land*, “Publications,” http://www.tpl.org/tier3_cdl.cfm?content_item_id=1157&folder_id=727.

in property values translate directly into increased tax revenue.[3] Also, the Triangle Greenways Council found that the average home price next to green space is $5,000 more than houses located away from green space.[4]

- *Infrastructure and development costs.* LID techniques can reduce infrastructure requirements by decreasing the amount of pipes, roadways, etc. This translates to decreased development and maintenance costs and potential gains in lot yields. See Table 4-1 for further information.

- *Improved quality of life and public participation.* LID developments can reduce automobile traffic and fuel consumption by creating a community more open to walking. Placing water quality practices on individual lots provides opportunities to involve homeowners. This enhanced public awareness of water quality issues in a community can lead to overall improvement in its quality of life. An American Lives, Inc Real Estate Study found 77.7 percent of potential homeowners rated natural open space as "essential" or "very important" in planned communities. Community designs that offer quiet environments and low traffic levels were top ranked.[5]

- *Economic development.* A 2004 Brookings Institute smart growth report found that the cost of providing public infrastructure and delivering services can be reduced through thoughtful design and planning, which LID promotes. The study found regional economic performance is enhanced when areas are developed with community benefits and the promotion of vital urban centers in mind. In contrast, unplanned growth can degrade the environment and impair the local economy. Also, planning that keeps development in community centers leads to more efficient distribution of services and hence to lower property taxes.[6]

- *Regulatory compliance credits.* Many states recognize the benefits LID techniques offer, such as reduced wetland impacts. As a result, they offer regulatory compliance credits, easier permit processes, and further incentives similar to those offered for other green practices. In addition, a LID project can have less of an environmental impact than a conventional project, thereby resulting in lower impact fees.

- *Tax credits.* LID projects may be eligible for state energy tax credits. For example, in the state of New York, builders who meet energy goals and use environmentally preferable materials can receive a state tax deduction

[3] National Park Service, *Rivers, Trails and Conservation Assistance*, Fourth Edition, Revised, 1995, http://www.nps.gov/pwro/rtca/propval.htm#real.

[4] Triangle Greenways Council, "Increased Property Values," *Economic Growth*, http://www.trianglegreenways.org/econ.htm.

[5] See Note 3.

[6] Mark Muro, *Investing in Better Future: A Review of Fiscal and Competitive Advantages of Smarter Growth Development Patterns*, The Brookings Institution Center on Urban and Metropolitan Policy, March 2004.

of up to $3.75 per square foot for interior work and $7.50 per square foot for exterior work.[7]

- *Improved groundwater recharge and drinking water and decreased treatment costs.* Keeping water clean is cheaper than cleaning it up after it has become polluted. The Trust for Public Land notes that Atlanta's tree cover has saved over $883 million by preventing the need for stormwater retention facilities. In 2002, a study of 27 water suppliers found that the more forest cover in a watershed, the lower the treatment costs. It also found the following:
  - Approximately 50 to 55 percent of the variation in treatment costs can be explained by the percentage of forest cover in the source area.
  - For every 10 percent increase in forest cover in the source area, treatment and chemical costs decreased approximately 20 percent, up to about 60 percent forest cover.[8]
- *Improved habitat.* Sustaining or improving natural habitat has numerous economic and social benefits. The cost of recovering or improving natural capital can be even more substantial. Any action that degrades, damages, or destroys ecosystems will reduce natural capital and thus the output of natural goods and services. LID can improve land value by addressing Endangered Species Act (ESA) requirements that may otherwise have to be mitigated if conventional stormwater treatment is used. For example, maintaining pre-site runoff conditions and habitat requires less mitigation than clearing the area, constructing a stormwater retention pond, and then providing separate mitigation for the critical habitat impacted.

BUILDING THE CASE: DEMONSTRATED BENEFITS

Realizing LID's full benefits requires the use of innovative site-specific approaches to minimize impervious surfaces, reduce stormwater volume, and maintain or improve natural ecosystem functions. Not all locations can effectively utilize LID techniques. Soil permeability, slope, and water table characteristics can limit the potential for local infiltration. LID requires precise engineering for soil characteristics, filtration rates, water tables, native vegetation, and other site features.

The most reliable source of information with regard to any particular site is an experienced LID management engineer. Such engineers have gained knowledge from experience to identify the hidden benefits, those difficult to quantify, and

[7] National Resources Defense Council, "New York's Green Building Tax Credit," *Cities & Green Living: Green Building*, http://www.nrdc.org/cities/building/nnytax.asp.

[8] The Trust for Public Land, *Economic Benefits of Parks and Open Space: How Land Conservation Helps Communities Grow Smart and Protect the Bottom Line*, 1999. See Note 2.

what works best for site specific situations. Therefore, participation of such a management engineer is critical from the earliest planning phases.

Reviewing other LID projects to glean some of their innovations and analysis can help in designing a LID approach. Table 4-1 identifies some of these projects and provides a resource that may prove helpful in quantifying the technique's benefits.

Table 4-1. Examples of LID Benefits

LID project/reference	Explanation	Savings/costs
General LID information		
Low Impact Development (LID) Practices for Storm Water Management, http://www.toolbase.org/tertiaryT.asp?TrackID=&CategoryID=1873&DocumentID=2007	• Contains resource list of organizations and companies that specialize in LID under contacts.	
Reduced development costs and gains in lot yield		
Somerset, MD, EPA Nonpoint Source News Notes, May 2005 Issue #75. http://www.epa.gov/owow/info/NewsNotes/issue75/75issue.pdf	• Used LID to eliminate need for stormwater ponds. • Gained 6 lots. • Viewed as free landscaping in purchasing home. Key part of subdivision's identity.	• Bioretention vs. stormwater pond = $300,000 savings • Cost savings per lot = $4,000>
Aberdeen, NC (1999), EPA Nonpoint Source News Notes, May 2005 Issue #75. http://www.epa.gov/owow/info/NewsNotes/issue75/75issue.pdf	• New apartment complex. Almost all of the conventional underground storm drains associated with curb and gutter projects eliminated.	• Savings of 72% of conventional stormwater construction costs = $172,000
Kensington Estates, WA (2001) EPA Nonpoint Source News Notes, May 2005 Issue #75. http://www.epa.gov/owow/info/NewsNotes/issue75/75issue.pdf	• LID residential development. Compares capital costs, maintenance costs, cost savings, and benefits for both LID and conventional for a site. Concludes with cost-benefit summary that considers education and outreach, maintenance agreements, and specific LID practice maintenance.	• If assume a stormwater fee of $118/year/lot, lots with LID would receive credit for on-site and would reduce fee by 75% down to $30/year • Capital cost comparison: conventional—$765,700 LID—1,502,900 • Without rooftop systems, $678,900 vs. $765,700 • Kensington Estates per lot conventional would cost $7,400/lot; LID = $14,590 cost savings per lot = $-7,150 • Garden Valley per lot conventional would cost $9,450/lot; LID = $7,690 cost savings per lot = $1,850
Sherwood Gap Creek, AK (2000), Toolbase Services Low Impact Development (LID) Practices for Storm Water Management, http://www.toolbase.org/tertiaryT.asp?TrackID=&CategoryID=1873&DocumentID=2007	• Project results on linear requirements saved using LID.	• Cost Per Lot Conventional $16,326, LID $11,507; cost savings per lot $4,819 • Higher lot yield 17 additional lots • Higher lot value ($3,000 more per lot than competition) • Enhanced marketability (80% sold in first year) • Added amenities 23.5 acres of green space • National, state, and professional group recognition • Estimate more than $2.2 million in savings • Kensington Conventional: $3,350 annually • LID = most of the O&M falls on the homeowner; $5,250 cost savings per lot = $-1,900 $35/year/household conv; $50/year/household LID • Garden Valley Conventional: $1,650 annually LID = most of the O&M falls on the homeowner; $2,240 cost savings per lot = $-700 $50/year/household conv; $70/year/household LID • If assume landscaping maintenance if removed, yearly maintenance cost for LID significantly lower

Table 4-1. Examples of LID Benefits

LID project/reference	Explanation	Savings/costs
		• Reduced stormwater utility fee $85/year/lot • Reduced water rates $88/year/lot; these cost savings are almost double the annual cost of maintenance
LID case studies to reference for state of WA	http://www.psat.wa.gov/Publications/LID_studies/new_redevelopment.htm	
Hydrologic and economic impacts of alternative residential land development methods	• Tries to quantify projected return on LID vs. traditional development using housing costs.	• Partial LID design profit is $0.25 million higher than traditional design and full LID option is $1.4 million lower
Bioretention and sand filters		
Austin TX (2004), EPA Nonpoint Source News Notes, May 2005 Issue #75. http://www.epa.gov/owow/info/NewsNotes/issue75/75issue.pdf	• Hill buffer redesign four bioretention areas.	• 4 bioretention areas = $65,000 ($450 per lot) vs. sediment-filtration pond $250,000 ($1,700 per lot) • Cost savings per lot $1,250 • Additional savings in storm drain pipe sizes and trenching depth
Chi-Yuan Fan, et. al. (2004), Costs of Urban Stormwater Control, Water Resources, ASCE.	• Presents information on the cost of stormwater pollution control facilities in urban areas, including collection, control, and treatment systems. Presents equations and costs to develop capital costs for sewer pipes, pump stations, settling tanks, sand filers, detention and retention ponds, and infiltration trenches and basins.	
CALTRANS BMP Retrofit Pilot Program (2004), http://www.dot.ca.gov/hq/env/stormwater/special/newsetup/_pdfs/new_technology/CTSW-RT-01-050.pdf	• The retrofit pilot program is thought to be the most comprehensive test of common stormwater management BMPs ever conducted, and the first significant evaluation in a climate of southern California's type. The study looks specifically at stormwater BMPs as they relate to highway management, in particular retrofits. Investigate media filters, extended detention basins, drain inlet inserts wet basin, infiltration, infiltration devices. Provides cost reduction strategies that are applicable to roads and development. Chapter 14 is just O&M estimates.	
Green roofs		
Nonpoint Education for Municipal Official's Green roofs, http://web.uconn.edu/nemo/reducing_runoff/green_roof.htm	• A technical paper with LID suggestions to consider when designing green roofs. Written for municipal officials.	No cost information
Hydrotech, http://www.hydrotechusa.com/START.HTM	• Includes a storm water retention calculator that tells you approximately how much water is retained by Hydrotech's Garden Roof® assembly (follow garden roof/benefits/stormwater).	
Roofscapes, Inc., http://www.roofmeadow.com/	http://www.roofmeadow.com/benefits2.html#top–benefits of roof gardens. http://www.roofmeadow.com/form.html is a form you can fill out to "assemble much of the information that the designer and installer will need to determine the appropriate system to fit your needs and to estimate costs."	
Pervious pavers		
Nonpoint Education for Municipal Official's Pavers, http://web.uconn.edu/nemo/reducing_runoff/index.htm	• Technical information on pervious pavers, specs, case studies, and links for further info.	

Table 4-1. Examples of LID Benefits

LID project/reference	Explanation	Savings/costs
Nonpoint Education for Municipal Official's Driveways, http://web.uconn.edu/nemo/reducing_runoff/driveways.htm	• A technical paper with LID suggestions to consider when designing driveways. Written for municipal officials.	No cost information
Nonpoint Education for Municipal Official's Sidewalks, http://web.uconn.edu/nemo/reducing_runoff/sidewalks.htm	• A technical paper with LID suggestions to consider when designing sidewalks. Written for municipal officials.	No cost information
Roads		
Nonpoint Education for Municipal Official's Roads, http://web.uconn.edu/nemo/reducing_runoff/roads.htm	• A technical paper with LID suggestions to consider when designing roadway systems. Written for municipal officials.	No cost information
Street Edge Alternatives Project, Seattle WA (2000), http://www.ci.seattle.wa.us/util/About_SPU/Drainage_&_Sewer_System/Natural_Drainage_Systems/Street_Edge_Alternatives/index.asp	• Reduced impervious surfaces to 11% less than a traditional street, provided surface detention in swales, and added over 100 evergreen trees and 1100 shrubs. • Total stormwater volume leaving street reduced by 98% for 2-year storm event.	• $850,000 that includes extensive design and communications budget due to the need to work closely with residents on the design: note that future projects will cost less than traditional street improvements
Parking areas		
Inglewood Demonstration Project, MD (2000), EPA Nonpoint Source News Notes, May 2005 Issue #75. http://www.epa.gov/owow/info/NewsNotes/issue75/75issue.pdf	• Retrofitted existing parking facility.	• $4,500 to construct • Traditional approach = $15,000–$20,000 with fewer environmental benefits and higher maintenance costs
Nonpoint Education for Municipal Official's Parking lots, http://web.uconn.edu/nemo/reducing_runoff/parking_lots.htm	• A technical paper with LID suggestions to consider when designing parking lots. Written for municipal officials.	• No cost information

Chapter 5
Conclusions

We initiated this study to develop a compendium of economic data and LCC analysis methods to help state and local managers compare the costs of LID with traditional stormwater options. The literature has many examples of the benefits of LID, but not much information quantifying them. We also could not find a concrete analysis showing that LID is the best choice among a set of project alternatives.

We provide an approach to applying LCC to LID and a means to estimate some of its benefits. We reference the limited data available and identify some that could improve the situation. Our approach identifies further technical research needs, including compiling actual cost figures for LID design, construction, and O&M. Our approach also suggests further research topics concerning benefits. For example, in-depth research into the monetary benefits of LID, such as a study on increases in property value directly caused by LID, would be useful.

Regardless of the available cost and benefit information, decision makers are regularly making stormwater management decisions. The decision to use LID often comes down to the bottom line—is it the most affordable option? In many cases, LID is indeed the least costly choice on a life-cycle basis, even if the upfront capital costs are higher than for traditional stormwater alternatives. Affordability should be defined as a measure of the overall LCCs of a project, with benefits properly recognized.

A common challenge to gaining support for LID is the perception that it is new, not well understood, and more difficult and expensive to design and construct. These criticisms can be overcome with a better understanding of LID, coupled with a grasp of its longer-term advantages. Managers should approach the option of LID as a business matter and work to show that, in many cases, it is the most cost-effective option.

Some cost and many benefit components of LID projects are not easily quantified, but a manager can still build an economic case to support LID by using our recommended approach. Specifically, the manager should complete the comprehensive cost estimation worksheet (Table 3-2), consider whether LID provides the listed benefits, and use the examples of LID benefits (Table 4-1) as data sources for the project in which they are interested.

Funds or resources for estimating full LID benefits are unlikely to be available at the municipal level. We recognize this and suggest that our recommendation to create factors to represent the relative level of effectiveness will help simplify the process, yet provide useful information.

Appendix A
Works Consulted

The following list of references may serve as a tool for local governments considering implementing LID. Many of the references contain information that fits into more than one category, we only list each reference once.

Cost Estimating/Valuation

General

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