Changing Cost Perceptions:
An Analysis of Conservation Development

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Executive Summary

While the environmental benefits of conservation approaches to development are well known, cost-sensitive municipalities and developers are often reticent to try a conservation approach. A common concern about alternative development approaches is the perception of increased cost. A project group, spearheaded by the Conservation Research Institute, came together to investigate this issue. Developers, local officials, policy analysts and staff from several development consulting firms helped to fill information gaps on the costs of conservation development.

This project was conceived to support the implementation of the Chicago Wilderness Biodiversity Recovery Plan, by informing players about the feasibility of development alternatives that can minimize damage to the ecosystems of the Midwest. The project set out to answer the following questions: Does conservation development, which helps to address the issue of environmental protection, have the potential to help mitigate the problem of the high cost of development? Or, does it exacerbate the current trend of rising costs, especially for stormwater management?

The conservation approach addresses stormwater on-site by distributing the water across the landscape, thereby mimicking or restoring the historical hydrological regime. The result is a range of environmental benefits: groundwater recharge, improved surface water hydrology, improved water quality, habitat protection, and others. On the other hand, conventional practices such as engineered stormwater ponds or concrete-lined drainage ditches have sometimes shown negative environmental impacts not present with conservation tools, such as increased flooding or decreased water quality.

To compare the stormwater management costs of conservation with conventional development, this project undertook three studies: a literature review, an analysis of built-site case studies, and a cost analysis of hypothetical conventional and conservation design templates, or layouts.

Literature Review

The literature consistently raised examples of how conservation development methods can save money in both construction and maintenance, from the broad metropolitan scale down to the site level, and further down to a comparison of specific Best Management Practices (BMPs). Here is a brief summary of conclusions from the literature:

1. Public infrastructure costs are higher when a development is built within the context of urban sprawl, as compared to smart growth patterns that conserve land.
2. At the site level, significant cost savings can be achieved from clustering, including costs for clearing and grading, stormwater and transportation infrastructure, and utilities.
3. Installation costs can be between $4,400 and $8,850 cheaper per acre for natural landscaping than for turf grass approaches.
4. Maintenance cost savings range between $3,950 and $4,583 per acre per year over ten years for native landscaping approaches over turf grass approaches.
5. Better site design can reduce paving costs.
6. While conventional paving materials are less expensive than conservation alternatives, porous materials can help total development costs go down, sometimes as much as 30%, by reducing conveyance and detention needs.
7. Swale conveyance is cheaper than pipe systems, by some claims as much as 80%.
8. The literature is not clear enough to resolve the cost differences between discrete detention and retention tools by themselves.
9. Costs of retention or detention cannot be examined in isolation, but must instead be analyzed in combination with conveyance costs, at which point conservation methods generally have a cost advantage.
10. Green roofs are currently more expensive to install than standard roofs. Yet costs are highly variable and going down. Green roofs also have significant cost advantages when looking at life-cycle costs.
11. Several specific conservation tools can actually have multiple positive economic effects by themselves, both directly and indirectly.

Perhaps the most significant theme gleaned from the literature is that, by *combining* multiple tools, such as clustering

with native landscaping, bio-swales, and other practices, deeper cost savings can be achieved from the resulting opportunities to downsize the infrastructure. When techniques are applied together, the individual benefits of specific tools cannot be separated from the overall benefits of a complete site design, but the cumulative economic benefits of site design can be impressive. Across ten case studies examined here, holistic conservation design treatments saved an average of 36% over conventional practices.

Built-Site Cost Analysis

Built-site analyses provide case studies from the real world to complement the lessons from the literature research. By analyzing engineering data and construction costs from actual built projects, this report compared specific aspects of development costs more closely to find from where cost-savings are derived between conventional and conservation developments.

Mill Creek and Sunset Prairie are similar subdivisions in Kane County, Illinois. Sunset Prairie was built conventionally, whereas Mill Creek used several conservation practices. Based on the cost results, about $3,700 per foot was saved in the conservation development relative to the conventional approach. Approximately 53% of the savings came from stormwater management construction costs and 21% come from site preparation costs.

Three Bielinski Homes residential subdivisions from Southeastern Wisconsin were analyzed for their estimated conventional cost scenarios and for actual cost of conservation construction. Total cost savings ranged from $563,764 to $1,288,646 and averaged $876,913 across the three Wisconsin sites. Overall, every item in construction cost less under conservation development except for landscaping costs, which were higher in Auburn Hills and Laurel Springs. Overall site preparation saved 23 to 32% of conventional development costs when built with conservation techniques. Savings ranged from 47 to 69%, or about $2,500, to $3,300 per unit where vegetated swales or bioswales substituted for storm sewers.

At Prairie Crossing, in Grayslake, Illinois, cost savings generated from conservation development were found in several areas: stormwater management, curb and gutter, site paving, sidewalks, and landscaping. Conservation development savings were $3,798 per lot for construction.

Prior to construction of a conservation designed corporate campus, Tellabs, in Naperville, Illinois, compared costs between conservation and conventional scenarios on the same site. In this case, earthwork, stormwater management, and landscaping were the design components that drove most of the differences between conventional and conservation scenarios. Total savings for capital costs were $564,473, or just over 12 percent. Savings of site preparation from conservation development were as much as $214,500 (or $3,900 per acre) less than the conventional scenario, and the conservation design preserved six more acres with minimum disturbance. Integrated stormwater management and landscaping in conservation site design helped save money in the beginning because of the combined integrity present by concurrent installation of the bioswales, wetlands, and native landscaping.

Seattle's Street Edge Alternatives program used natural drainage systems in an urban residential retrofit context to allow infiltration and detention as part of their stormwater management system. Seattle's conservation streets cost $217,253 less than a conventional street would have on overall construction costs, which is equivalent to $329 savings per foot. Savings resulted from use of conservation alternatives for conveyance, detention, paving, and street design.

The largest cost savings across all built-site case studies were mainly derived from site preparation, stormwater management, site paving and sidewalks. Two conservation techniques appear to have the most direct and significant influence on cost savings: clustered site design and naturalized stormwater management systems.

Template Cost Analysis

These cost evaluations were prepared as a follow-up to the recent Blackberry Creek Watershed Alternative Futures Analysis project, where templates, or design models, were developed to illustrate the differences between conservation and conventional site design and stormwater management approaches. The templates were based on a hypothetical forty acre site in the Blackberry Creek Watershed in northern Illinois. This cost analysis compared the capital costs associated with developing a land parcel using a conservation design template versus a conventional one, using real unit-costs from the Midwestern development industry. The design templates were categorized by land use and reflected the same densities for both the conservation and conventional designs within each category. Conservation and conventional template costs were compared for four land-uses: moderate density residential, rural residential, estate residential, and commercial/industrial.

For a Moderate Density Residential land use, overall capital cost savings from conservation were 15% of conventional. The conventional form exhibited wide roads, no public open space, storm sewers, and turf detention basins, whereas the conservation template had narrow streets, integrated natural stormwater system, clustering and open space.

Rural Residential Development cost slightly less for the conservation alternative. The conventional form included cul-de-sacs, drained with traditional roadside swales and culverts into a detention basin. The conservation alternative had narrower drives, naturalized stormwater system, trails and open space.

The Estate Residential Conservation template saved 40% of conventional costs. Both had the same cul-de-sac pattern, lot lines, and open swale systems. In the conservation alternative, natural areas beyond the building footprint were preserved or restored, and driveways shortened.

The Commercial/Industrial alternatives were nearly equivalent, except for a “premium” conservation alternative, which added a green roof, thereby increasing costs over conventional. The conventional form was an auto-access strip mall with two single-story big box retail, isolated outlets, parking and detention. The conservation template also had big box retails, but in a “main street” retail setting with plaza, permeable paving and bioswales.

A majority of the conservation template designs are cost competitive or even more economical than the conventional forms. Plus, the land-uses show a general correlation where, as density decreases, the percentage of capital cost savings for conservation design increases. The largest potential cost savings are in stormwater management infrastructure.

Cumulative Discussion and Recommendations

By looking across all three analyses, a set of common conclusions can be offered. Perhaps most importantly, these results contradict the notion that conservation design is always more expensive than conventional practices. Not only do the three analyses show conservation is cost-competitive, but they also raise many situations where conservation methods can save the developer significant expense that translates directly to their bottom lines. In terms of overall approaches then, a gentle footprint on the land will reduce construction costs. Clustering and minimal site disturbance go a long way to cut infrastructure costs significantly, especially for stormwater management.

These conclusions call out for significant consideration of conservation development across the spectrum of development forms. Yet, even in the light of these conclusions, it is critical to point out that favorable cost comparisons are only one reason to consider conservation development. Ecological and social reasons should also be considered and, while not components of this study, they can complement and in some cases may even outweigh cost considerations.

Given the wide variety of conservation approaches that can be used in isolation or combination, the analyses reveal that there is a continuum of choices; in other words conservation design is not all or nothing. A spectrum of approaches and mixes of conservation tools can be considered for every budget and every site. BMPs, such as rain gardens and infiltration trenches, are more easily adapted to suburban and rural development sites. Tools such as porous pavements and green roofs may be more appropriate for urban sites, where land area is at a much greater premium and cannot be utilized economically for stormwater detention basins.

Further research work is needed on several fronts. The next steps should include:

- Gathering and analyzing information on operation and maintenance costs of conservation development, where possible, using life-cycle cost analyses as a method of comparison to conventional methods.
- Taking into account systematically both cost and effectiveness in future analyses of conservation design alternatives.
- Analyzing conservation development costs in a higher-density context where tools such as porous pavement and green roof are generally perceived to be more competitive.
- Conducting more economic benefit studies that can provide information on the economic values obtained by conservation development, as guidance for planning efforts.

Even where costs are competitive, incentives for conservation development should be offered by municipalities and governing agencies two reasons: 1) to help communities and developers overcome market inertia that can become entrenched, even when they have supporting information for change; 2) to enable financing mechanisms to pilot innovative approaches in new locations, especially as part of larger municipal stormwater management programs.

The project team recommends outreach and dialog with municipalities and developers. Use of the Internet could provide this cost information and new reports as they become available in the form of a clearinghouse for costs and benefits. Such a website could include a relational database that helps users tailor the information to their needs.

Introduction

In 2002, Chicago Wilderness provided funding support to Conservation Research Institute (CRI) for a "Cost Analysis of Conservation versus Conventional Development in Northeastern Illinois and Northern Indiana." The project was motivated by the need to explore the potential roles for development as a risk to, and opportunity for, protection of biodiversity in the Chicago Region, and conceived specifically to provide information to support the implementation of the Chicago Wilderness Biodiversity Recovery Plan.

This report is unprecedented. Developers, local officials, policy analysts and staff members from several development consulting firms came together to advise the work of filling information gaps on the costs of conservation development. The advisors were of one mind that good development practices require good cost information placed in the hands of developers and municipalities.

Carefully implemented conservation developments are of interest to advocates for biodiversity conservation for a range of reasons. They can protect open space and natural areas, recharge groundwater, complement ecological restoration efforts with native landscaping, reduce downstream stormwater damage, and help preserve or re-establish historical hydrological regimes to which native species are adapted.

Across the country, municipalities face at least three stormwater-related problems with development:
1) Flood waters are an increasingly significant stressor on biodiversity and property. Rural and suburban areas that feel significant growth pressure face increasing environmental and property costs from the stormwater that accompanies that growth;
2) At the same time, through the 1990s, the costs of providing a cubic-foot of stormwater pond storage climbed by over 30% after inflation (Schueler and Holland, p. 401); and
3) Maintenance costs for traditional stormwater controls have become a significant cost burden for local governments and communities, in some cases equaling or exceeding the initial construction cost (Prince George's County (a), p. 4.5).

For developers, these bottom-line cost realities, understandably, can outweigh any marginal environmental improvements from alternative development methods as they consider their stormwater management choices. They need to act based on the cost realities of the available options.

This project tries to answer the questions: Does conservation development, which helps address the issue of environmental protection, have the potential to mitigate the problem of the high cost of development? Or does it exacerbate the current trend of rising costs, especially for stormwater management? Many advocates quote widely-used cost savings figures from specific pilot conservation developments such as Village Homes, in Davis, California (e.g., Browning and Hamilton). Such summary information has been trickling out through various avenues. But there has been very little detailed information to answer whether or not such savings are exceptions or the general rule. Developers and planners need to see data, assumptions, and analyses to judge whether or not it is worthwhile to consider alternatives to what have become standard practices.

Conservation Development, also called Low-Impact Development (LID), represents a suite of those alternative methods. The conservation approach addresses stormwater on-site by distributing the water across the landscape, thereby mimicking or restoring the historical hydrological regime. The result is a range of environmental benefits: groundwater recharge, improved surface water hydrology (i.e., less flooding and higher low-flows), improved water quality, habitat protection, and others. Yet cost-sensitive municipalities and developers are often reticent to try these approaches, in part, because of the perceived premium price tag for these fairly new methods.

On the other hand, engineered stormwater ponds are a popular conventional approach. While most people agree that some detention is better than nothing, conventional practices have sometimes shown negative environmental impacts not present with conservation tools, such as unnatural water temperatures, hydrological disruption, and loss of stream reaches and wetlands (Schueler and Holland, Article 79). This approach conveys water to storage areas where it can be detained long enough to dispose of into local streams and rivers at a legally-acceptable rate.

To compare the costs of conservation with conventional development, this project undertook three studies: a literature review, an analysis of built-site case studies, and a cost analysis of hypothetical conventional and conservation land-use development templates. This report presents all three products as separate chapters. The three analyses are followed by a discussion of some overall conclusions and recommendations for further work. Also included are a bibliography and several appendices with more detailed information relating to the three analyses.

To the extent possible, the three approaches focused attention similarly on both construction costs and operation and maintenance costs (where such costs were available). However, the information available for these studies differed substantially, resulting in different emphases in each product. The project concentrated as much as possible on information sources tailored to a Midwestern audience. This was not possible throughout the analyses, and national information was added, where appropriate, to increase the depth of analysis. A glossary is provided in Appendix 1.

This project did not compare the effectiveness of conservation and conventional development in meeting environmental goals. Rather, this report shines a spotlight on cost as a concern, so that perceptions about cost can be either confirmed or changed in order for municipal planners, designers, and developers to consider alternative methods. Also, several practices that address only water quality, such as sweeping and sand filters, are not covered in this report. Instead, the analyses are concentrated on Best Management Practices (BMPs) that have an impact on runoff rate and volume. This makes sense given our targeted audience, when the literature includes evidence for claims such as: “In general, about a third of every dollar spent on stormwater pond construction was devoted to water quality control, with the remainder spent on flood control storage.” (Schueler and Holland, p. 401.) Also, because strategies to decrease runoff volumes are also effective in addressing water quality, a focus on hydrology has broad ranging benefits.

Yet, the effectiveness of each tool in pollution control also needs to be considered by municipalities and developers in addition to just costs. While water quality effectiveness is not covered by this report, there is growing evidence that many of the LID or Conservation Development alternatives to conventional methods can be equally or more effective in achieving water quality goals (e.g., Schueler and Holland, pp 515-520; Liptan and Brown; Schueler 2000).

The focus on costs also implies the team did not intend to deal comprehensively with benefits, although they are touched on occaisionally. Similarly, off-site costs and benefits to downstream interests and the broader community should be considered to complete the picture of comparison.

Also left out of this analysis is the cost of overcoming local misperceptions, reticence by zoning officials, and changes in ordinances that sometimes prohibit or at least discourage innovation. Today, in many places, many innovative tools cannot be utilized even if they are better and cheaper. Changing ordinances requires a steady stream of information on cost and environmental effectiveness of conservation techniques, as well as information on the many community benefits of these innovative alternatives. Both additional research and increased outreach to developers and municipal officials are needed to show that the tools work before anyone can revise the rules of the game.

Literature Review

Regional Context and Approaches

A large body of smart growth literature from the past ten years compares costs of conventional, sprawling growth patterns to smart growth forms at the regional level. They show higher costs for the conventional patterns as compared to smart growth across watersheds and metropolitan areas. (For smart growth principles, see ICMA). Many reports describe the cost inefficiencies of sprawling development patterns in comparison with managed growth (e.g., Bank of America; Ewing, et al.; Hulsey; Burchell; Brabec, 1992). These studies generally focus on public infrastructure for roads and water, as well as municipal services, and do not delve into construction or maintenance costs of specific methods (for smart growth literature, visit www.smartgrowth.org).

For example, the Southeast Michigan Council of Governments compared resource consumption for current low-density sprawl versus compact development patterns at the scale of multiple communities within a metropolitan context. Costs compared are not site-specific technologies, but at a broad level of analysis for population, housing, and broad infrastructure trends. Infrastructure savings from compact development were estimated at 25 percent for roads, and 15 percent for utilities, including water supply and sewer. (SEMCOG).

Some literature points to immense cost savings of implementing conservation techniques at this regional scale (US Water News). For example, in the Atlanta metro region, 20 percent loss of trees and natural vegetation, and their replacement with urban manmade structures, produced a 4.4 billion cubic foot increase in stormwater runoff. It would cost at least $2 billion to build containment for this amount of excess water.

Notably, some conservation developments pay close attention to site aspects only to miss taking advantage of smart growth principles in terms of where the development is located at a regional scale.

At the municipal scale, Bellevue, Washington considered on-site techniques as components in their system-wide stormwater management approaches. They decided to "augment natural drainage systems to handle urban stormwater, rather than build extensive new underground piped systems." The City estimated its open space system, which uses on-site methods applied across the whole watershed, cost the City 75% less to construct than underground storm sewers (Girling).

Other cities have also recognized the value of open space preservation for stormwater management at a regional level. The potential for cost savings over enhancements to highly engineered systems is not lost on financially-strapped local governments. The City of Milwaukee has been identifying and protecting open spaces that can prove helpful in this regard. (O'Leary).

Regional Context Conclusion

The literature describes higher costs for public infrastructure, when built within the context of urban sprawl, as compared to smart growth development patterns.

Site Context and Approaches

The site component generally refers to the placement of buildings, how the site is managed, and the consequences of those decisions. A traditional development layout often spreads the buildings equally across the landscape, and primarily applies turfgrass everywhere in between. Conservation development tends to cluster the buildings in one area to minimize the disturbance to the site as a whole. Clustering and open space management are often used interchangeably in the literature. Building in this manner provides perhaps the largest cost savings of all the conservation tools. The differences between clustering and traditional site layout receive more attention in the smart growth literature than any of the other techniques analyzed here. There are two basic cost-saving themes: 1) Clearing and Grading, and 2) Infrastructure and Services, with a good deal of literature discussing the cumulative savings that can occur.

Clearing and Grading

Citing earlier work, Schueler and Holland claim that cluster development can reduce the need to clear and grade by 35 to 60 percent from the upper range of conventional costs, and provide $5,000 per acre in savings from erosion control at the same time. (Schueler and Holland, p 174). A USEPA case study corroborates this view. By preserving natural existing site contours, clustering decreased site preparation costs and at the same time reduced need for stormwater control measures. (USEPA(b) p. 24).

Infrastructure and Services

The Center for Watershed Protection (CWP) used a simple model to compare several conventionally-built sites with a redesign of the same site using better techniques (preserving more open space). The techniques used in the redesign resulted in reduced impervious surface area and therefore reduced stormwater amounts. Total infrastructure costs included stormwater management, storm drainage, paving, sidewalk, curb and gutter, landscaping and reforestation, water, sewer and septic systems. (Sanitary sewer and water supply costs savings are explored further in the built-site and template cost analysis.) The biggest cost savings came from the use of clustering, with the resulting reduction in road and stormwater management conveyance costs. Estimated infrastructure cost savings ranged between 12% and 64%. (Zielinski, et al, pp. 202-203). The following table illustrates this point:

Residential Development	Construction Savings (%)	Notes
Remlik Hall [1]	52	Includes costs for engineering, road construction, and obtaining water and sewer permits
Duck Crossing [2]	12	Includes roads, stormwater management, and reforestation
Tharpe Knoll [3]	56	Includes roads and stormwater management
Chapel Run [3]	64	Includes roads, stormwater management, and reforestation
Pleasant Hill [3]	43	Includes roads, stormwater management, and reforestation
Rapahannock [2]	20	Includes roads, stormwater management, and reforestation
Buckingham Greene [3]	63	Includes roads and stormwater management
Canton, Ohio[4]	66	Includes roads and stormwater management
CWP(a). Cited Sources: [1] Maurer, 1996; [2] CWP, 1998; [3] Delaware DNREC, 1997; [4] NAHB, 1986		

TABLE 1. Estimated Infrastructure Cost Savings Between Conventional and Conservation Developments

By reducing road lengths, clustering means that costs for utilities such as gas, water and electricity can also be decreased. Maintenance costs would decrease correspondingly (CWP, 1998, p. 99; Brabec, 1992; Dreher and Price, p. 48). Schueler and Holland estimate that cluster development can reduce the capital cost of residential subdivision development by 10-33% by reducing the length of infrastructure needed (citing NAHB 1986, Maryland Office of Planning 1989, and Schueler 1995).

Summarizing the work of others, Schueler states that at least 60% of development costs are variable, related directly to the length and layout of roads. The result is that clustering large-lot developments saves 25% or more (the size was not specified), with smaller savings of 10% when smaller (e.g., half-acre) lots are clustered (Schueler, 1995, p. 64).

By minimizing natural-area clearing and grading, clustering also saves in stormwater management costs through decreasing the volume of runoff generated. The literature supports the idea that such savings are amplified when other conservation methods are used in tandem. When a cluster project combines such infrastructure savings with the results from clearing and grading, and other conservation tools, the benefit to the bottom line can add up. Dreher and Price make this point, also citing the NAHB 1986 report. They point to a case study where 34 percent savings were achieved when combining costs of a whole suite of development components: street pavements, curbs, gutters, trees, driveways, drainage, water distribution, sanitary sewer, grading, clearing, sidewalks for a site in Ohio (Dreher and Price, p. 49).

Similarly, according to the Stormwater Center's Open Space Design Fact Sheet, benefits from clustering, or open space design, "can be amplified when it is combined with other better site design techniques such as narrow streets, open channels and alternative turnarounds."

Maintenance

Maintenance costs for clustering should also be lower because of reduced infrastructure, lawn areas, streets, etc. (Dreher and Price, p 49). However, no literature was found that compares specific maintenance costs between conventional and conservation methods at the site level.

Site Context Conclusions

At the site level, the literature points to significant cost savings from clustering for clearing and grading activities, as well as for the costs of supplying infrastructure for stormwater, transportation, and utilities.

Best Management Practices

Landscaping

One of the clearest distinctions made between conventional and conservation methods is in the landscape forms they employ. Conventional landscaping generally implies site design and preparation (e.g., grading) to enable the use of turfgrass lawns, while conservation landscaping implies preservation of any existing natural areas and installation of native landscaping instead of lawns. Schueler and Holland cite a 1992 WHEC study showing corporate land owners can save between $270 to $640 per acre by reserving their open lands for natural areas instead of turfgrass campuses. But even where preserving natural areas is not an option, currently-available information points to cost savings obtained for both installation and maintenance of native landscaping.

Installation

Some detailed cost information is available for the Midwest. In 2001, Conservation Design Forum (CDF) compared the installation costs for 10 acres of corporate landscape with native landscaping versus traditional turf-based landscaping methods. That comparison breaks out specific labor, materials, monitoring, and design costs:

	Sustainable (Native)	**Traditional** (Turf)	**Note**
Up-Front Installation	$141,000*	269,000	The difference is mostly in direct construction costs that include grading, irrigation system, etc.

TABLE 2. Installation Cost of Native versus Turf Landscape at 10 Acre Corporate Campus (2001)
*No ranges were provided. The figures were based on estimated values using the firm's unit cost experience with landscaping projects. This information is not published, but is posted in detail at www.cdfinc.com

NIPC's 1997 natural landscaping report also provides a set of estimates to compare the costs per acre of turf-grass landscapes to native landscaping. This information was recently updated (see Appendix 2 for more detail). The sources are all local suppliers of natural landscaping services, and they agree that turf grass is more expensive for both installation and maintenance costs than more native systems. However, the direct experience of one developer reached for comment contradicts these conclusions. The difference perhaps is in assumptions about irrigation. For residential sites that do not include irrigation systems, seeded turf may be competitive, but for highly maintained corporate or residential landscapes that require irrigation systems to achieve a certain level of turf quality, native landscaping should be more cost competitive. Further analysis of assumptions and site-specific case studies is warranted.

Year 1 Dollar Costs Per Acre*			
Landscape Treatment	**Low End Estimate**	**High End Estimate**	**Note**
Turf Grass	$7,800	$14,825	Depends upon 1st year maintenance assumptions
Native Landscaping	$3,400	$5,975	Depends upon use of seed versus plugs, & 1st year maintenance assumptions
Difference (Savings from Native Landscaping)	$4,400	$8,850	

TABLE 3. Year 1 Installation Costs for Native versus Turf Landscapes (1997)
* Sources: Conservation Design Forum, Applied Ecological Services, Pizzo and Associates, through the Northeastern Illinois Planning Commission, 2004.

Maintenance

CDF's 2001 cost comparison of corporate campus landscapes also provided a comparative estimate of longer-term maintenance costs for ten acres:

	Sustainable (Native)	**Traditional** (Turf)	**Note**
Ten Years Maintenance Total	162,000	315,000	Native is slightly less in first 5 years. Significantly less thereafter, as site is more established. The only significant long-term management expense is annual burning.

TABLE 4. Total Long-Term Maintenance Costs for Native versus Turf Landscape (2001)

The NIPC sources provided a similar set of maintenance cost estimates (see Appendix 2 for details) over a series of years. The numbers fluctuate from year to year, depending upon the assumed activities (e.g., burning, aeration, and other scheduled maintenance). However, when looking at their numbers over the entire 10 years, they are surprisingly similar. They are averaged below:

10 Year Average Maintenance Cost per Acre*		
Landscape Treatment	**Low End Estimate**	**High End Estimate**
Turf Grass	$5,550	$6,471
Native Landscaping	$1,600	$1,788
Difference (Savings from Native Landscaping)	$3,950	$4,683

TABLE 5. 10-Year Maintenance Costs for Native versus Turf Landscapes
* Sources: Conservation Design Forum, Applied Ecological Services, Pizzo and Associates, through the Northeastern Illinois Planning Commission, 2004.

These documents and others attribute the lower maintenance costs for native landscapes to a number of factors, including higher maintenance costs for turfgrass landscapes because of the need to mow, irrigate, fertilize, and weed. Those costs generally include labor and materials. (See also CWP(a); Dreher and Price; USEPA(a).)

Landscaping Conclusions

NIPC's cost analyses show that installation costs can be between $4,400 and $8,850 cheaper per acre for native landscaping than for turf grass approaches. A ten-year average savings for maintenance ranges between $3,950 and $4,683 per acre per year for native landscaping approaches over turf grass methods.

Streets and Parking

The cost difference for streets and parking requires a little more explanation than for landscaping. Impervious surfaces are an inevitable part of all but the most innovative developments. However, conservation development techniques minimize the impervious surface areas of streets, sidewalks, and parking through 1) better site design, and 2) alternative materials. The direct cost implications relate to these two factors.

Designed Layout

The first comparison found in the literature is between the layouts of conventional designs and conservation design, which minimizes the amount of impervious surface by reducing the size or amount of roads or parking, Several conservation methods can decrease the square footage or area needed in pavement, thereby decreasing costs noticeably, regardless of the materials used. The conventional cost to treat an acre of impervious surface runoff for both quality and quantity can range from $30,000 to $50,000. So, by reducing impervious surface area, clustering can reduce costs for stormwater conveyance and treatment. (Schueler and Holland, pp174-7, 404-5). However, this strategy is not limited simply to clustering. It can also include designs that challenge the necessity of certain road widths and number of parking spaces.

Smart Growth and New Urbanism advocates claim that narrower roads can be designed to accommodate traffic and address safety concerns and emergency vehicles. Narrower pavement widths can also reduce impervious surfaces reduction and assist with traffic calming (Burden and Zykofsky).

Dreher and Price describe some of the cost savings from decreasing the lengths and widths of streets, driveways, and sidewalks. If the width of a typical residential street installation, which costs $20 per square yard, was reduced from 34 feet to 26, the cost savings would be $94,000 per mile, or $500 per 60-ft-frontage residence.

Similarly, a typical driveway installation is $13,000. Reducing the driveway length from 30 to 20 feet would save $230 per residence, based on a 16 foot width. Plus, reducing building setbacks lowers the length and cost of utility lines, especially for water and sanitary sewer services. Finally, when a typical sidewalk installation is $3.00 per square foot, reducing sidewalk width from five to four feet saves $180 per lot. Combined, these would save $910 per lot (Dreher and Price, p.40).

Such cost savings are also described in CH2M-Hill, 1993; Schueler, 1995; Schueler and Holland; CWP(a); USEPA(a), and USEPA(b). Again, when impervious cover is reduced by layout design, cost savings accumulate, not only in road-building, but also in storm drainage, and water/sewer service.

Reducing the number of parking spaces in a particular area will also reduce impervious surface. One case study showed that the required parking lot area for an Iowa City Shopping Center was only 74% full at its peak occupancy rate just before Christmas (USEPA(a), pp 50 – 51). By re-examining the assumptions and presumed needs for conventionally planned parking facilities, the Center for Watershed Protection finds that reductions in the office-parking space ratio are often justified (CWP(a), p. 63). Shared parking facilities are possible with mixed use developments where peak parking demand varies between uses. The savings from constructing a smaller lot can be significant. The cost of a single parking space can be $1,100. Additional costs savings would also accrue from lower storm drain, BMP, and land costs (Schueler 1995, p. 167). When maintenance is included, lifetime savings for each parking space eliminated can be $5,000 to $7,000 per space. (from CH2M-Hill,1993 in Schueler, 2000 Schueler and Holland, p. 175).

Materials

Conventional surfacing materials for roads and parking lots generally include asphalt or concrete. The conservation alternative is a range of porous pavement products that contribute to on-site water management. A simple comparison of these alternatives in the literature shows that conventional paving, most explicitly asphalt, is significantly cheaper per linear foot, or per acre, than porous paving.

Paving System	**Installation costs per square foot (quotes from suppliers)**
Asphalt	$0.50 - $1.00
Porous concrete	$2.00 - $6.50
Grass/gravel pavers	$1.50 - $5.75
Interlocking concrete paving blocks	$5.00 - $10.00

TABLE 6. Typical Paving Costs. Low-Impact Development Center (LIDC), 2002. Definitions were not provided.

Several sources raise the question of indirect cost implications – in this case, whether or not the material choice can contribute to cost reductions elsewhere on the project. When porous paving is used, the size of required stormwater detention facilities can be decreased. A smaller basin can then be built, thereby saving construction costs while making more land available for other uses (LIDC, 2002). Likewise, conveyance costs can be reduced, helping to offset the cost of porous paving choices further. (CWP, 1998, p. 77; USEPA(d), p. ii). LIDC describes even more potential savings by eliminating the need for underground storm drain pipes.

According to the LIDC, porous asphalt costs about 10% more than non-porous, yet it helps total costs decrease by 30% at favorable sites. So, when all factors are considered together as a system, permeable pavers can become cost-effective. (LIDC, 2002).

Paving System	**Installation costs per square foot (quotes from suppliers)**
A permeable paver stormwater management system (including drains, reinforced concrete pipes, catch basins, outfalls, storm sewer connections)*	$4.50 – 6.50
A conventional concrete stormwater management system. (including drains, reinforced concrete pipes, catch basins, outfalls, storm sewer connections)	$9.50-11.50

TABLE 7. Cost Comparison between Permeable Paving and Concrete Paving.
*(Presumably, less storm sewer infrastructure is needed in this system)

Operations and Maintenance

This is yet another category where little information exists in the literature, and the gap is often acknowledged.

Roads and Streets

Deductive reasoning was evidently applied in a few documents to make the point that less impervious surface means less direct maintenance of those remaining surfaces, and less cost for ongoing stormwater management as well. For example, USEPA claims there will be less maintenance and repair cost for roadways in their case study because of the lanes being reduced from four to two (USEPA(b), p. 34.)

Likewise, maintenance regimes for materials are only briefly mentioned (e.g., England; CWP(a), p. 90). Porous pavement should receive annual cleaning with a vacuum truck to unclog it from dirt and oil. Also, periodic replacement of fine gravel joint filler is recommended between pavers. However, no cost comparisons are made here.

The Stormwater Center's Alternative Pavers fact sheet compares maintenance costs for several alternatives (without explanation):

Material	Maintenance Cost
Conventional Asphalt/ Concrete	Low
Brick (in a loose configuration)	Medium
Natural Stone	Medium
Gravel	Medium
Wood Mulch	Medium
Cobbles	Medium

TABLE 8. Cost Comparison for Paving Maintenance. (Stormwater Center, citing the Bay Area Stormwater Management Agencies Association)

Rocky Mountain Institute provided a parking lot case study at a Connecticut mall expansion. With a one-million dollar estimate for a conventional detention pond, the builders instead used turf paving and an underground tank for water reuse. This technique was more expensive than asphalt for construction, but avoided the need for the original detention pond, saving $500,000. Plus, the grass paving and asphalt were equal in cost after five years, with the cost advantage tipping to grass beyond five years (Wilson, et al., p. 144).

There are some perceptions that permeable surfaces are difficult to maintain. For example, some have voiced concern about the ease of plowing snow on porous pavement. The current literature does not clearly address these concerns.

Streets and Parking Conclusions

Better site design can lower paving costs by reducing the length and area of impervious surfaces within a development. Conventional materials, however, are less expensive per unit than permeable paving. Yet, the use of porous materials can help total development costs go down, sometimes by as much as 30 percent, by contributing to conveyance and detention cost reductions.

Water Conveyance: Swales Versus Curb and Gutter

The search results for literature dealing with conveyance costs shows more obvious examples of savings. Here, the primary distinction is between the use of bio-swales in conservation development instead of the more conventional curb, gutter, and sewer pipe. The Stormwater Center's "Stormwater Management Fact Sheet: Grassed Channel" describes the conservation approach:

> The term 'swale' (a.k.a., grassed channel, dry swale, wet swale, biofilter) refers to a series of vegetated, open channel practices that are designed specifically to treat and attenuate stormwater runoff for a specified water quality volume. As stormwater runoff flows through the channels, it is treated through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils.

All the literature reviewed argued that conveyance by swale is cheaper than curb, gutter, and storm sewer. The qualification is that *where* they are used can significantly change the cost because of land values. In addition, bio-swales will have an added water quality benefit from filtering by the plant material. Piped conveyance systems do nothing to treat stormwater runoff.

Construction

According to both Fan et al., and Backstrom et al., swales are not necessarily practical in more urban settings. Costs will vary depending upon the price and availability of land. Land prices make swale systems more viable in areas where land prices are generally less than $9.70 per square meter. However, if swale alternatives can be accommodated within existing landscaping requirements, then the cost of land is irrelevant.

Backstrom et al. compared swale and pipe systems in Europe and showed pipe systems to be 34% to 80% more expensive than swale systems in areas with poor topsoils. The study compared stormwater pipe buried beneath a paved surface versus a grassed swale close to a paved surface. Curb and gutter components were not part of this analysis, which started from the inlet. Including curb and gutter would add even more cost to the conventional system. Pipe system costs included excavation, pipe, stormwater inlets, and pipe trench. Land costs were not included. Results showed:

- pipe system – previously undeveloped areas - $79/meter (or $24/foot)
- pipe system – replacing another pipe -- $106/m ($32/ft)
- swale system – poor soil area -- $59/m ($18/ft)
- swale system – good soil -- $17/m ($5/ft)

Estimates from EPA show seeded swales averaged $6.5 per linear foot, while sodded swales averaged $20 per linear foot. Capital costs for a swale or filter strip include mobilization, site preparation and development, inlet and outlet structures, design, legal and contingencies. (Ferguson, et al.)

On the other hand, a traditional structural conveyance system (curb and gutter with stormdrain inlet and pipe systems) costs $40-50 per running foot, 2-3 times more expensive than grass swales (USEPA(d), p. 7; CWP(a), p. 59). These reports undoubtedly used different methodologies and assumptions, but the rough comparison agrees with other literature.

USEPA's North Carolina campus case study shows construction cost savings added up to $500,000 by using grassy swales, water quality ponds and bioretention instead of curb and gutter with oil grit separators. (USEPA(b), p 34.)

More locally, Dreher and Price also argued that roadside swales with culverts at crossings are less costly than curb/gutter/sewers, but that the cost differential is reduced with more crossings. For a typical residential subdivision with ½ acre lots in Lake County, Illinois, the construction savings was estimated to be $70,000 per mile, or $800 per residence. But, while construction time is less, the vegetation may need more time to get established (Dreher and Price, pp. 14-15).

The literature sometimes blurs the distinction between conveyance, retention, and detention, especially in conservation developments which combine design elements that play multiple roles. This is discussed more under Detention and Retention (see below).

Maintenance

Dreher and Price also posited that the maintenance regime is probably less for swales than curb, gutter and sewer systems. And Backstrom agreed that pipe systems cost more for maintenance. In its fact sheets on vegetative practices, the Canada Mortgage and Housing Corporation provided the same perspective, noting that vegetative BMPs are cheap to establish and maintain, and that grassed swales are more economical than curb and gutter from both capital and operations perspective. Unfortunately, the maintenance literature for conveyance seems to be limited primarily to a handful of anecdotal claims.

Dreher and Price reported that replacement costs are virtually non-existent for swales -- that they generally do not need replacement. However, some professionals disagree with this view, claiming the eventual need for rehabilitation (personal communication with advisory team members). Culverts will occasionally need to be replaced, although the cost is typically borne by the property owner. Storm sewers may need replacement after roughly 100 years and curb/gutter/inlets every 50 years.

Today, the field is experiencing a further shift in innovation with the distinction between turf grass swales, and naturalized, or bio-swales. In rural settings, grass swales are the standard in actual practice, and the conservation alternative is naturalized swales, moving away from turf grass to more native species (personal communication with CDF). This distinction was not found in the literature, nor was there any cost information on naturalized swales. It is reasonable to presume that grass swales and naturalized swales compare similarly for construction and maintenance costs to the comparison between native landscaping and turfgrass lawns.

Conveyance Conclusions

The literature holds a significant degree of agreement that swale conveyance is cheaper than pipe systems, by some claims as much as 80 percent.

Retention and Detention

Separating out this function from conveyance is problematic because numerous methods accomplish both purposes at once. Because purposes are blurred between retention, detention, infiltration, and conveyance tools, the literature shows that there is, in fact, a continuum of approaches to detention/retention, from conventional to conservation. The conservation end of this continuum emphasizes more on-site retention, infiltration, native plants, and constructed wetlands used in combination with other tools. The other end is characterized by collection and conveyance to larger centralized stormwater detention basins systems.

The difference between conservation and conventional methods for this category stems largely from their different purposes. This difference is not expressed well in the literature reviewed for this study. Conventional water management treats stormwater as a nuisance or waste which needs to be disposed of as quickly as possible, as allowed by regulation. The conventional method temporarily stores the stormwater and moves it offsite and into the local watershed in accordance with the acceptable discharge rate.

Conservation methods, on the other hand, manage stormwater as close to the source as possible. These techniques restore or mimic natural hydrologic patterns, where stormwater has a chance to infiltrate into the ground or evapotranspirate through plant life back into the atmosphere. Generally, this means incorporating several tools throughout a site that will greatly decrease or even eliminate the need for conventional detention or retention facilities. For example, bioretention or rain gardens are sometimes installed as a system together with bioswales, porous pavement, green roofs, natural landscaping, and other methods to slow, cleanse, infiltrate, and evapotranspire stormwater. Bioretention is a conservation approach that relies on plants for added efficiency in retention, for infiltration and transpiration, as well as cleansing. Typical bioretention methods include naturalized swales with or without infiltration trenches, constructed wetlands, rain gardens, and green roofs.

A great deal of literature compares conventional methods with each other, but it does not include conservation approaches. Further complicating these comparisons in a significant amount of literature is that they use units of measurement not easily comparable, and in regions not necessarily comparable (e.g., the cost of an acre-foot of detention storage in Maryland cannot easily be compared with the cost of a linear foot of swale in the Midwest). Few studies, if any, compare costs across the whole continuum of alternatives. Different assumptions and unit measurements make comparisons between studies difficult.

The combination of tools and overlap of functions contributes as well to the difficulty of comparing costs by discrete tools, and that is reflected by the brevity of sources in the literature. Instead, the literature has several examples of site-specific, whole-system comparisons, which are discussed below.

Not surprisingly, the complexity of this issue results in different cost conclusions across the literature, often without enough explanation to draw conclusions between studies.

Construction

Only a few studies claim explicitly that conservation alternatives cost less than conventional approaches. For example, according to Dreher and Price, a natural wet bottom detention basin should cost less than a conventional wet basin. Conventional basins use riprap ($11/ft) for shorelines, naturalized basins uses perennial plantings ($1.5/ft). Wetland shelves can reduce excavation costs, $35, 000 in savings was shown in one study for a 40-acre residential development. Overall estimated costs (minus land) for constructing a naturalized wet detention basin is about $22,000 per acre-foot of active detention storage. A natural design could save approximately $275 per household for a wet basin in a 40-acre residential development. Costs for constructed wetland or dry bottom basins are less than for wet bottom basins because permanent pools require more excavation. The cost of constructing a shallow marsh wetland detention basin is $17,000 per acre foot of active detention storage. The estimated cost to construct a dry detention basin is $7, 200 per acre-foot, not including cost of underdrains which are sometimes required. Dry basins cost less to excavate, but need more land area due to the volume lost to the 2% bottom slope –

approximately 50 percent additional land, relative to a wet or constructed wetland detention basin. So, depending upon land costs, a constructed wetland basin may be less than or equal to cost of a dry basin.(Dreher and Price pp. 20-21)

However, more documents concentrate on the indirect cost savings of conservation retention, especially in terms of reduced pipe and sewer costs. The main point is that bioretention reduces the need for storm sewers, so retention cannot be examined in isolation, but must instead be analyzed in combination with conveyance costs. While a common perception may be that onsite management is more expensive than management offsite at a regional facility, bioretention facilities and other onsite facilities can significantly reduce the need for storm sewers, thus reducing stormwater infrastructure costs. (CWP, 1998, p. 88)

Other reports support this, arguing that the construction of bioretention and rain gardens costs less than conventional methods (e.g., CWP(a) p. 88; Hager; Liptan and Brown) because of savings in conveyance infrastructure. A case of bioretention at a medical office in Prince George's County reduced the amount of storm drain pipe required from 800 feet to 230 feet, thereby saving $24,000 (50%) of overall drainage costs (USEPA(d), p. 5).

Hager claims that bioretention's overall LID costs are at the most equal to conventional stormwater management. She describes a case where planned storm sewers and detention ponds would have cost $300,000 more than the rain gardens that were used instead. The savings were due to the elimination of curbs, sidewalks and gutters.

But cost savings vary widely depending upon site conditions. Greater efficiencies are achieved when bioretention is integrated into the landscaping. For residential and commercial sites, 10 to 25% savings have been achieved (Coffman and Winogradoff, p. 263). Other lot-level approaches that use bioretention have shown cost reductions of 25-30% in decreased site development, stormwater fees, and residential site maintenance. And the Somerset development in Maryland installed rain gardens whose implementation cost of $100,000 compared to $400,000 for planned detention ponds (Hager).

Some literature conflicts with this lower-cost message about conservation forms. Stormwater Center fact sheets claim extended detention wet ponds are the most cost effective ($0.96 per cubic foot storage), with bioretention more expensive ($6.80 per cubic foot storage). However, the fact sheets do not provide enough information to judge the accuracy of this view, and the comparison is limited to specific detention tools, not whole-site designs.

Such lower-cost claims for conventional ponds are based generally on economies of scale arguments, i.e., the bigger the pond, the cheaper per unit of storage. In 1996, the Center for Watershed Protection surveyed 73 stormwater practices in the Mid-Atlantic area for cost information, gathering estimates from 14 private engineering firms and public agencies in Maryland and Virginia. In comparing 41 different pond systems, both dry and wet, with bioretention, they concluded that ponds do have economies of scale, whereas bioretention areas do not; they are sized based on a flat percentage of site area. Unfortunately, that study did not actually compare the costs of these two techniques, and different units were used to describe both. While the paper concludes that ponds are the most cost-effective option for stormwater quantity and quality control, it also stresses that ponds are not effective for smaller sites, where needed detention often has to go underground. (Schueler and Holland, pp. 401-405).

As with conveyance, bioretention may be placed in underutilized spaces such as setbacks, parkways, and traffic islands, and allowing the inclusion of other features to property or development of space that would otherwise have been dedicated to a stormwater pond (CWP(a), p 88; Stormwater Management Center Bioretention Fact Sheet).

All these sources also acknowledge the point made earlier, that overall savings result from looking beyond the comparison of retention/detention tools by themselves.

The US Department of Transportation (USDOT) lies in-between the two extremes of cost conclusions. The Department compares costs for stormwater BMPs in urban settings or areas directly connected to roadways. While lacking definitional clarity, this report shows bioretention to be comparable to detention ponds in capital costs. However, some of this chart contradicts information elsewhere in the literature (e.g., porous pavement is generally not considered to have low capital costs).

BMP	Capital costs
Infiltration trench	Moderate to high
Infiltration basin	Moderate
Bioretention	Moderate
Detention ponds	Moderate
Wetlands	Moderate to high
Veg swales	Low
Veg filter strips	Low
Porous pavement	Low

TABLE 9. USDOT Costs for Stormwater BMPs.
Adapted from Young, et al, 1996; Claytor and Schueler, 1996; USEPA(c) and several others. The ranking conclusions were not explained. Only those BMPs that have an impact on quantity are listed here.

Maintenance

Conceptually, this report should include maintenance information as well as the expected life-span or effective life of the retention facility. Unfortunately, again, there is very little information comparing maintenance costs. Because low-impact development projects are often in pilot stages at this point, the full maintenance costs and lifespans have not been fully examined yet. The information currently available often consists of claims without citing rigorous study to support them, but a few sources do point to lower maintenance costs for some conservation methods. The Center for Watershed Protection, for example, claims that bioretention requires less maintenance when it is replacing detention basins with turfgrass (CWP(a), p. 88).

Also, the Canada Housing Information Center claims that operations and maintenance costs can be less than retention ponds and other conventional alternatives. Additionally, operations and maintenance costs for constructed wetlands, once established, can be lower than for the alternatives and are "generally less than $1,500/ha/year, including the cost of pumping, mechanical maintenance, and pest control."

Hager describes how lower bioretention costs often result from the owner paying for the maintenance. This raises the question of the consistency and quality of maintenance over time. Some LID site designs cost nothing for maintenance (e.g., maintaining existing sandy soils) but even when adding costs back in by adding bioretention, overall maintenance costs for LID are still equal to or less than conventional stormwater management.

No comparisons were found to claim that maintenance for conservation methods is more expensive than for conventional approaches. However, Stormwater Center fact sheets point out that infiltration basins have a fairly high failure rate when compared with other stormwater treatment practices, resulting in a shorter expected life span. Infiltration basin maintenance costs are estimated to be between 5 and 10 percent of construction costs, but dry extended detention ponds are estimated at 3 to 5 percent. The documents do not give a basis for these percentages.

USDOT's BMP comparison shows bioretention again to be comparable to detention ponds in O&M costs as well. However, their comparison shows a longer effective life for detention ponds than for bioretention. Swales and other bioretention tools are comparable to detention, and are listed separately, making it difficult to generalize from the findings.

BMP	Maintenance	O&M	Effective Life*
Infiltration trench	sediment/debris removal	Moderate	5-10
Infiltration basin	mowing	Moderate	5-10
Bioretention	mowing/plant replacement	Low	5-20
Detention ponds	annual inspection	Low	20-50
Wetlands	annual inspection/plant replacement	Moderate	20-50
Veg swales	mowing	Low	5-20
Veg filter strips	mowing	Low	20-50
Porous pavement	semi-annual vacuum cleaning	Moderate	15-20

TABLE 10. USDOT BMP Maintenance Cost Comparison.
*"Effective life" is not defined in the document, but it assumes "regular maintenance, occasional removal of accumulated materials, and removal of any clogged materials." (USDOT)

Retention/Detention Conclusions

Wetlands are raised in several publications as a BMP. But this literature does not generally distinguish between existing natural wetlands and constructed wetlands. Yet, from a biodiversity perspective, this distinction is critical. While society increasingly recognizes the value of wetlands, the biodiversity found in remaining natural wetlands will be lost if those wetlands are subject to inundation from polluted surface runoff for detention. Conservation Development stresses that natural area wetlands should be protected from increased runoff. The only "wetlands" that should be used as part of a stormwater management system are facilities specifically constructed for that purpose (personal communication with Conservation Design Forum).

The literature is not clear enough to resolve the cost differences between specific storage methods. Instead, it sends the message that costs of retention or detention cannot be examined in isolation, but must instead be analyzed in combination with conveyance costs. Except for a handful of sources that point to economies of scale for conventional detention, most claim that construction costs for bioretention are less than, or at the most the same as, conventional methods when factoring in the savings in conveyance infrastructure. There is almost no information comparing maintenance costs because low-impact development projects are still young and the full maintenance costs and life-spans have not yet been fully examined.

Roofing Systems

Because conventional roofs account for such a large proportion of imperviousness in more urban settings, they can provide a sizable contribution to stormwater runoff. Therefore, roofing alternatives can have a significant impact on the rate and volume of stormwater runoff. Green roofs, or vegetated roof systems, are a conservation alternative to conventional roofing that has been growing rapidly in the past five years. However, because of the infancy of the American green roof industry, there are only a handful of professional papers (in English) on green roof costs. A good deal of the existing information on green roofs is from the green roof industry itself. Nevertheless, there is enough information to make some observations. The green roof literature surveyed here covers climates from Singapore to northern Europe, Canada, and the Pacific Northwest.

Conventional roofing often consists of asphalt shingles for residential developments, and a membrane with gravel ballast for commercial roofs. A green roof generally consists of a light-weight growing medium over a drainage layer and waterproofing. Plant species are selected for their tolerance of the climatic extremes found in roof-top environments. The literature distinguishes between extensive roofs, which generally consist of low-lying, drought tolerant plants in a thin growing medium, and intensive roofs, sometimes called rooftop gardens, which have deeper substrates and more plant diversity, even to the point of including trees (e.g., Liptan and Strecker).

Installation Costs

Green roofs are generally more expensive to install than standard roofs. According to Liptan and Strecker, extensive green roof, or "ecoroof," costs are highly variable, from $5-12 per square foot for new construction and $7-20 for retrofits. They point out that standard roofs are also highly variable from $2-10 per square foot for new, and $4-15 for retrofitting. Scholz-Barth provides a higher estimate for extensive roofs in the US, from $15 to $20 per square foot. The cost difference is primarily from additional material needs over a conventional ballast roof and labor for the installation of those materials.

In one of the few European articles in English, a five cm gravel layer is 5 Euros per square meter versus a 12 cm extensive roof layer, which approaches 20 Euros per square meter. (Giesel). Greenroofs.com explains that initial extra capital costs include structural preparation, soil media preparation, and planting.

While conventional roofing systems tend to be cheaper than green roofs for up-front costs, the green roof market in the US is quite young and construction prices are falling (personal communication with Conservation Design Forum; Scholz-Barth). As the market matures, and competition increases, it is reasonable to expect the upfront costs of green roofs to fall to more comparable levels.

Maintenance and Life-Cycle Costs

Initial, higher short term capital costs for green roofs can be offset most significantly through long-term energy and maintenance savings. A green roof can extend the lifespan of a roof membrane by two to three times (greenroofs.com). Wong, et al., computed a life-cycle cost analysis for extensive green roofs which supports this claim. Life-cycle costs for extensive green roofs, even without considering energy costs, are lower than those of exposed flat roofs in Singapore, despite higher initial costs. In Europe, Giesel calculates that, from a life-cycle perspective, a green roof prolongs the life of the sealing membrane from 20 to at least 40 years with a total savings in repair costs of 31,500EUR. Maintenance is primarily annual weed removal.

Intensive roof gardens require more irrigation and maintenance, so on-going costs tend to be greater than for extensive green roofs or standard roofs (Liptan and Strecker).

Other Benefits and Cost Offsets

The indirect benefits of green roof systems mentioned in the literature can be so significant that they should not be ignored when comparing costs with conventional roofs. Liptan and Strecker, Scholz-Barth, and Greenroofs.com all describe multiple benefits – reduction of stormwater infrastructure needs, energy savings, mitigation of heat island effects, aesthetics, habitat enhancements, increased property value, and others. These benefits are hard to estimate and do not necessarily accrue to the developer.

Giesel describes extra cost savings in Germany that come from the effective thermal insulation effect of green roofs. But, the German example may not be indicative of the degree of savings from reduced energy use in the United States because energy costs are significantly lower here.

Giesel's life cycle analysis concludes that an extensive green roof saves about 30% of total costs over 40 years, when compared with a gravel roof. However, most of that cost reduction is due to savings in stormwater disposal fees, which are also more significant in Germany than the United States.

Wong, et al showed that, in Singapore, the project payback period was 10 years for extensive roofs, when energy savings was included. This stresses the importance of including energy savings in any life-cycle analysis. It also stresses the need for more locally-derived studies.

Reduced heating and cooling costs may point to niche markets that make more immediate sense for green roof installation. The National Research Council Canada suggests targeting hospitals and industries with high cooling costs.

Unfortunately, at the time of this literature analysis, there was not much rigorous information on these benefits. Many sources only listed such benefits without providing any quantitative support. However, any literature search attempted today should produce a new crop of studies, as information on green roofs seems to be rapidly expanding with real-world examples that highlight the benefits for a domestic audience.

Roofing Conclusions

Green roofs are currently more expensive to install than standard roofing. Yet, costs are highly variable and going down. The literature also shows that green roofs have significant life-cycle cost advantages. For example, they can extend the life of the roof membrane by two or three times.

Discussion of Literature

Much of the literature warns that all costs are site-specific. Both cost and performance efficiency depend upon many site-specific variables, including soil types, climate, surrounding land use, cost of land and property values, regulatory requirements, other methods also in use, and a host of other factors. An ideal study might be to compare a specific set of alternatives and their costs for a suite of locations one site at a time. Are conservation costs calculated for covering the same size area as the conventional developments they are compared with? Are they at similar points on the urban-suburban continuum? No rigorous studies were found in the literature that have accounted systematically for these kinds of site variables. The built-site analysis, which follows, attempts to do this for a few cases.

The Blackberry Creek templates used in the template cost analysis (see below) did not include a higher-density iteration. Yet, denser urban and redevelopment situations can result in very different costs because of higher land prices and increased imperviousness for each site.

The literature search did not provide much comparative cost information either, for the higher-density context (a couple of exceptions are USDOT, and Sear and Bay). But where it is raised, land cost becomes the primary driver. In such a setting, several conservation development approaches, such as porous pavement and green roofs, may become increasingly relevant. Porous pavement can become cost-effective where underground vaults are the only alternative for stormwater detention. In such cases, rights-of-way are usually minimized, making space even more limited (USDOT, Section 2.2.4). When such expensive alternatives are being considered, conservation tools such as green roofs or porous pavement, which likely have higher first costs in a suburban setting, may become cost-competitive on first costs alone. According to Landphair, "when land costs and construction variations required to meet site conditions are factored in, costs can quickly escalate making some seemingly expensive solutions more cost-effective for a particular situation" (Landphair, p.91).

As reflected in the discussions above, specific conservation tools can have multiple economic effects by themselves. To review this point, the best examples are clustering and green roofs. Multiple cost savings are summarized in the following table:

Tool	Multiple Effects
Clustering (e.g., Schueler, 1995)	· Decreased impervious surface costs · Lower storm drain and sewer line costs · Less grading costs · less clearing · less erosion control · decreased lengths of utility lines · increased land value
Green Roof (e.g., Scholz-Barth)	· increased insulation · decreased heat island effect · decreased stormwater volumes and rates · decreased long-term replacement costs · increased property value · downsizing HVAC

TABLE 11. Economic Effects of Conservation Tools

Furthermore, as shown in the retention literature, comparing discrete tools can be misleading, even when accounting for their multiple effects. By combining multiple tools, such as clustering with native landscaping, bio-swales, and

other practices, deeper cost savings can be achieved from the resulting opportunities to downsize significantly the infrastructure. Some are cheaper in construction only if used in concert with a suite of tools at a specific site. Zielinski describes how the cumulative benefits of site design can be impressive. But when techniques are applied together, the individual benefits of specific tools cannot be separated from the overall benefits of a complete site design. The literature is rich with case studies that underscore this point. For example, stressing the multifunctional nature and the cumulative benefits of their features, Coffman and Winogradoff present case studies that show at least 25%in reductions to site development and maintenance costs achieved by less grading, pipes, ponds, curbs and paving. Their Somerset example saved $4,500 per lot, or $900,000 overall by eliminating need for curbs, ponds, and drainage structures.

The Center for Watershed Protection (d) used four actual development sites to compare conventional and innovative design techniques. The first comparison was between two medium-density residential site plans for the same site (a typical Virginia Piedmont site) with the same number of units (108). One is a conventional design with uniform lots, wide streets, and a dry extended detention facility. The other is an “innovative” open space design that incorporates clustering, avoidance of natural features, buffering, shorter and narrower streets, bioretention with a wet extended detention pond, and minimization of turf and other features. The result showed a conservation benefit of about $300,000 (20%):

Costs	Conventional Design	Innovative
Infrastructure	1,390,198	992,780
BMPs	149,100	245,020
Landscaping/Reforestation	-- (??)	951
Total	1,539,298	1,238,751
Savings		$300,547 (20%)

TABLE 12. Medium Density Residential Comparison

Low density residential site designs were also compared for an eight lot development, typical of Maryland’s Eastern Shore. The conventional design included large lots, septic, no open space, wide streets, curb and gutter, turf. The innovative design included clustering, sharing septic fields with sand filters, sharing driveways, bioretention and dry swales.

Costs	Conventional Design	Innovative
Infrastructure	102,769	77,768
BMPs	2,421	16,502
Landscaping/Reforestation	2,363	960
Septic	36,000	31,200
Total	143,553	136,430
Savings		$7,123 (5%)

TABLE 13. Low Density Residential Comparison

Retail designs were also compared for a site with two large retail stores, another retail space, a gas station and a bank. The conventional retail center is a strip development, with large paved parking areas. The innovative alternative preserves open space and reduces impervious cover, with fewer parking spaces, pervious overflow areas, and buildings positioned to reduce walking distances.

Costs	Conventional Design	Innovative
Infrastructure	708,064	643,452
BMPs	72,000	100,556
Landscaping/Reforestation	2,388	2,263
Total	782,452	746,270
Savings		$36,182 (5%)

TABLE 14. Retail Comparison.

Designs for a commercial office park were also compared. Again, the site was typical for the Chesapeake Bay watershed. 12.2 acres held two five-story buildings covering 1.37 acres. The conventional building was surrounded by parking, with almost no natural open space, and two stormwater detention ponds. The innovative design moved buildings closer to the road, reduced the parking space ratio and the number of spaces (because of transit nearby). Overflow parking was designed with porous paving. Bioretention and dry swales were used in combination with a wet retention pond.

Costs	Conventional Design	Innovative
Infrastructure	856,242	631,164
BMPs	88,441	153,859
Landscaping/Reforestation	4,217	3,409
Total	948,900	788,432
Savings		$160,468 (17%)

TABLE 15. Commercial Comparison.

These holistic examples would probably save even more than indicated, because the comparisons did not include grading, erosion and sediment control costs, which are anticipated to be less for conservation approaches.

In an often-quoted paper, Liptan and Brown presented several holistic site comparisons for conventional versus low-impact, or what they refer to as "water-quality" designs, for estimated or actual construction cost savings. The following chart summarizes these case studies, which illustrate the combinations of tools in site-specific conditions.

Case Study	Conventional	Water-Quality	Savings
6-Acre Commercial Parking Lot	Landscape medians designed to shed runoff.	Landscape medians re-designed as swales to accept runoff and filter pollutants. Eliminated manholes, pipes, trenching and catch basins.	About $78,000
2-Acre Light Industrial Site	Site built with mounded medians and landscapes, pipe, catch basins, curb and gutter to convey runoff into city storm drain system.	Water Quality site plan included bioswales and depressions instead of mounds, regrading to drain pavement into bioswales, reduction of catch basins, roof configuration to drain into bioswale, native vegetation.	Over $10,000, despite higher excavation costs.
Residential Community (Village Homes)	Conventional approach with curb and gutter, piping, catch basins.	Meandering vegetated swales feeding into a city detention pond.	$800 per unit
2-Acre Office & Parking Garage	Inlet and pipes.	Landscape Swales.	0 (equal cost)
3.2 Acre Office and Parking lot	Catch basins and pipes.	Reduced piping and catch basins, conversion of landscapes to swales.	$24,000 or 71%
2.2 Acre Educational Facility & Parking	Piping, catch basins and mounded landscape.	Swales with minimal piping and catch basins.	$21,000 or 68%
Four row houses on 0.2 acres	Soakage trench with catch basin and piping to city storm drain.	Smaller trench and catch basin in front, adding landscape filtration area in rear of lot.	$4,000 or 44%
5-acres with 31 homes + 3 acres riparian area	Significant piping and some bioswales.	Open channel bioswales replacing piping for conveyance.	$21,000 ($680/unit, 27%)
One acre parking lot	lot sloping to drain through catch basin and pipe to an on-site infiltration drywell. $10,000 added costs.	Drainage to perimeter landscapes designed to accept water and allow infiltration. No added costs.	$10,000 or 100%

TABLE 16. Cost Comparisons for Conventional versus Low-Impact Developments

Although detailed evidence is lacking, conservation tools often compare favorably in the literature from a Life-Cycle Analysis perspective (e.g., USEPA(e); USEPA(g); Prince George's County(a); Wilson). One notable exception is the infiltration basin, described previously. Because of the reliance on natural areas and native plantings, maintenance costs can be significantly low for some of these techniques.

For maintenance costs, Liptan and Brown chronicled a six-acre commercial parking lot facility that includes maintenance of swales as part of their landscape costs and resulted in no more costs than for other areas. However, some poorly-constructed curb cuts required modification. And for a two-acre light industrial site, they estimated conventional and water quality approaches to be about the same. The water-quality approach would have reduced costs for catch basin inspections and maintenance, and would have reduced landscaping costs for native plants, but it would have increased costs for sediment removal (Liptan and Brown).

Life cycle cost analysis is a critical tool for selling such green technologies because there are many broad claims that significant savings may occur over time, whether or not first costs are less. These claims need to be supported. This literature review faced a large gap in information along these lines. Rigorous life cycle analyses, both economic and ecological, can go a long way to provide rigorous information on all these time-dependent factors.

Costs cannot be judged fairly without the context of benefits, and the literature discusses numerous benefits of conservation development, which are not necessarily shared with conventional tools. While details on these benefits are outside the scope of this project, a partial list of benefits here provides a flavor of the additional selling points for developers and communities.

Benefit	Sampling of References
Higher Property Values—increased sales, higher sale & resale prices, shorter time on market, etc.	Schueler and Holland; Trust for Public Land; Haugland; Brabec, 1992; Gilroy; Ewing; Center for Watershed Protection 1995; Farnsworth; Emmerling-Dinovo, 1995; Lacey and Arendt; USEPA(h)
Increased tourism and recreation	Trust for Public Land; Gilroy; Brabec & Kirby
Increased tax revenue	Trust for Public Land; Brabec, 1992
Downstream Economic Benefits (reduced flooding damages, treatment costs, increased property values, etc.)	Braden & Johnston; Braden, Johnston & Price; Stormwater Center Open Space Design Fact Sheet; Trust for Public Land; Gilroy
Land released back to developer for additional returns	Prince George's County (a)
Reduced needs for infrastructure project bonding	Prince George's County (a)

TABLE 17. Benefits of Conservation Development and References.

Literature Analysis Conclusions

The literature consistently raises examples of how conservation development methods can save money in construction and maintenance costs from the metropolitan scale to the site level and down to a comparison of specific BMPs. Here is a summary of conclusions:

1. Public infrastructure costs are higher when a development is built within the context of urban sprawl, as compared to smart growth patterns.
2. At the site level, significant cost savings can be achieved from clustering, including costs for clearing and grading, and for stormwater and transportation infrastructure, as well as utilities.
3. Installation costs can be between $4,400 and $8,850 cheaper per acre for natural landscaping than for turf grass approaches.
4. Maintenance cost savings range between $3,950 and $4,583 per acre per year over ten years for native landscaping approaches over turf grass approaches.
5. Better site design can reduce paving costs.
6. While conventional paving materials are less expensive than conservation alternatives, porous materials can help total development costs go down, sometimes as much as 30%, by reducing conveyance and detention costs.
7. Swale conveyance is cheaper than pipe systems, by some claims as much as 80%.
8. The literature is not clear enough to resolve the cost differences between discrete detention and retention methods. Yet, costs of retention or detention cannot be examined in isolation, but must instead be analyzed in combination with conveyance costs, at which point conservation methods generally have a cost advantage.
9. Green roofs are currently more expensive to install than standard roofs. Yet costs are highly variable, and going down. Green roofs also have significant cost advantages when looking at life-cycle costs.

Finally, time and again the literature stresses that, by combining multiple conservation tools at a single site, even deeper cost savings can be achieved, creating impressive cumulative benefits. Across ten of the case studies examined here (see Tables 12 - 16), holistic design treatments with a mixture of conservation tools saved an average of 36% over conventional practices.

BUILT-SITE COST ANALYSES

These built-site analyses provide case studies from the real world to complement the lessons from the literature research and the template cost estimates (see below). By analyzing actual engineering data on construction costs, they compare specific aspects of development costs more closely to understand from where the exact cost-savings and benefits are derived between conventional and conservation developments. In addition, examples from the Midwest can help local governments, developers, homeowners, and other interest groups to learn about, compare, and examine the feasibility of conservation development in the region.

Both residential and commercial case studies are provided. The residential cases include Mill Creek and Sunset Prairie subdivisions in or near the city of Geneva, Illinois, Prairie Crossing in Grayslake, Illinois, and three Bielinski Homes developments in Wisconsin. Tellabs Corporation in Naperville, Illinois, provides an example of a commercial/industrial development. Finally, the Street Edge Alternative Streets project in Seattle, Washington, illustrates retrofitting of urban streetscapes with conservation stormwater management strategies.

This analysis used two approaches: first, compare two different sites when one represents conventional development and the other conservation development; second, compare two scenarios on the same site. In the first approach, criteria for selecting sites included: the degree of comparability between sites, the availability of data, and the representative nature of the project types. When comparing two locations, several aspects were taken into account, including similarity of environmental context, density, size, and construction periods, to minimize the number of variables in play. When the same site was estimated for both conservation and conventional scenarios, the comparison relied on actual construction bidding and budget documents for the two forms, when the conservation scenario was eventually built.

FIGURE 1. Mill Creek subdivision plat.

FIGURE 2. Mill Creek Subdivision Site Photos. Images courtesy of Conservation Design Forum

CASE STUDY 1: Mill Creek Subdivision vs. Sunset Prairie Subdivision

Background

Kane County suffered a serious flood in the Blackberry Creek Watershed area in 1996 when thousands of homes filled with water and millions of dollars washed away. At the same time, the county has been experiencing population growth, the third most rapid in the state, behind Will and DuPage Counties (U.S. Census). To address water quality, open space protection, and urban sprawl, the Kane County 2020 Land Resource Management Plan and several watershed and resources management plans were developed to control growth and negative development-related impacts by designating conservation development as a preferred alternative.

The Mill Creek development is located in unincorporated Kane County, Illinois near the City of Geneva. The neighborhood is in the Batavia School and Park Districts. Sunset Prairie subdivision is located in the City of Geneva about one mile from Mill Creek and is in the Geneva School District and the Geneva Park District.

The Mill Creek development is a large-scale, planned community with large area of contiguous open space, a wide range of housing types, neighborhood retail centers, and recreation amenities. It embodies many of the conservation planning principles espoused by the 2020 Plan. Its adjacent land uses are primarily farmlands. The Sunset Prairie subdivision is approximately 5 miles due west of downtown Geneva and is a typical single family residential development for many areas of Kane County that are within the corporate limits of municipalities. Public parks are adjacent to the south and east of the Sunset Prairie subdivision.

Method

To strengthen the comparability of the two sites using available data, this case study selected only a portion of each subdivision with similar gross density. Sunset Prairie's Subdivision Unit 1 consists of 55 lots in 30.6 acres and is equivalent to a gross density of 1.7 units per acre or 25,600 square feet per lot. Mill Creek's Neighborhood U has a gross density of 1.6 units per acre or 27,400 square feet per lot, calculated from 66 lots on 41.5 acres, which is only a portion of the roughly 1,500 acres and 2,000 homes in the entire development.

The following summarizes background information for both sites:

Site:	Sunset Prairie Subdivision	Mill Creek Subdivision
Model Type:	Conventional Development	Conservation Development
Location:	About 5 miles west of downtown Geneva, Illinois	About 5 miles west of downtown Geneva, Illinois
Surrounding Land Uses	Subdivisions, Parks	Farmlands
Density:	1.7 unit/acre or 25,600 sf/lot	1.6 unit/acre or 27,400 sf/lot
Size:	30.6 acres	41.5 acres
# of Lots:	52	66
Construction Year:	2002	2002

TABLE 18. Sunset Prairie and Mill Creek Subdivision Site Data.

The cost analysis was generated from probable construction costs provided by the project civil engineers, Cemcon, Ltd., for Sunset Prairie, and Sheaffer & Roland, Inc. for Mill Creek. In an effort to analyze roughly comparable items, cost items that are present in one project but not in the other or categories where differences were so great it was obvious that they did not cover the same items were eliminated. For example, earthwork improvements for Sunset Prairie included earth excavation, tree removal, grading, and topsoil strip and placement that totaled about $255,000. In Mill Creek, topsoil re-spreading was the only item listed under excavation and cost about $35,000. Because of the extreme cost mismatch, the item of earthwork improvements was not included in this analysis.

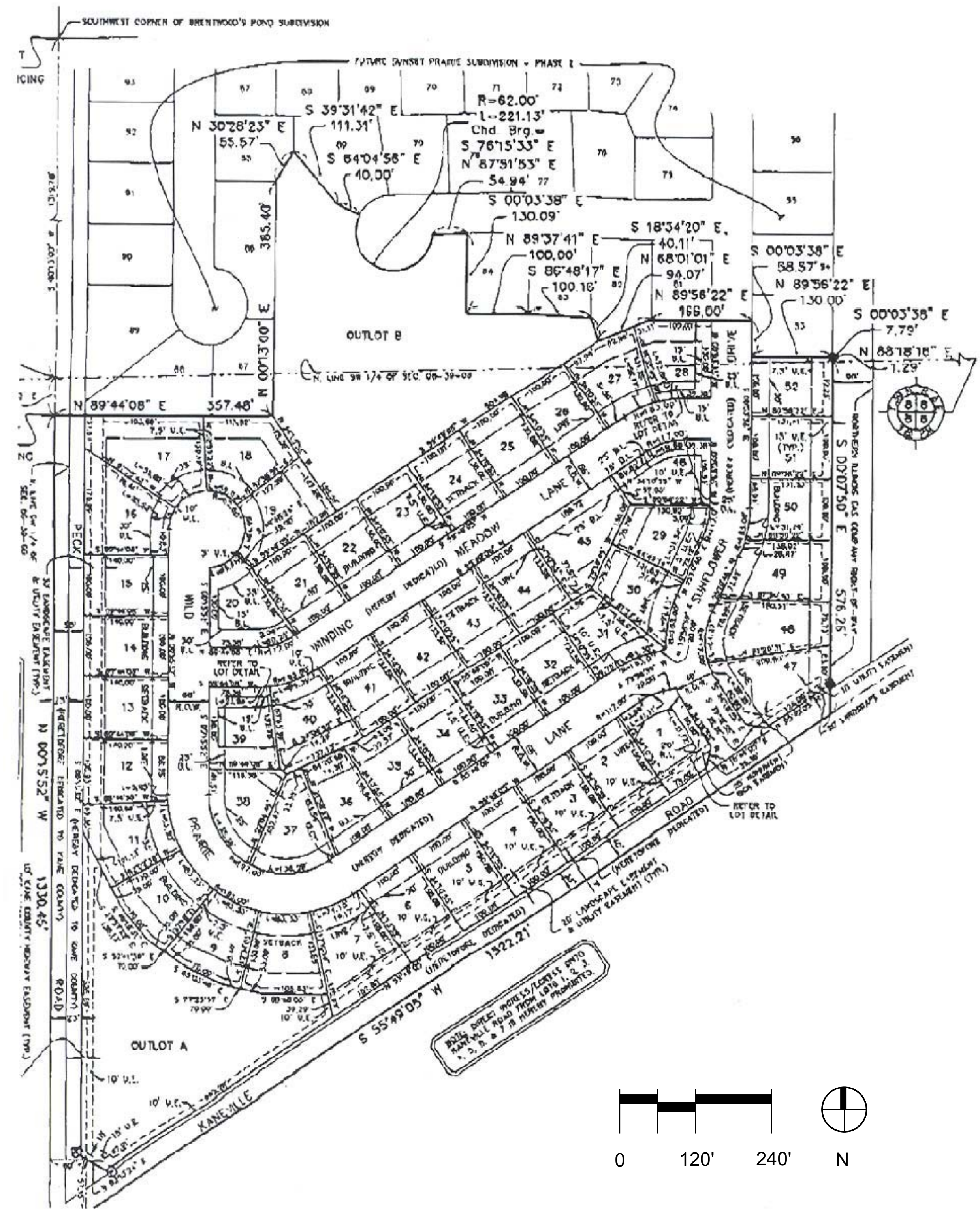


FIGURE 3. Sunset Prairie Subdivision Plat.

Nevertheless, it is worth noting that such cost reductions are typically found in conservation developments.

Also, to clarify the comparison, the costs are shown both as a total and per lot. The detailed cost analysis can be found in Appendix 3.

Results & Discussion

The analysis results are summarized in Table 19. Based on per-lot cost results, about $3,700 per lot is saved in the conservation development relative to the conventional approach. Approximately 53% of the savings came from stormwater management construction costs and 21% come from site preparation costs. The following describes and discusses the results of each item.

Site Preparation

Site preparation included topsoil removal and stockpiling and erosion control. As shown in Table 19, construction costs for erosion control (silt fence and temporary seeding) did not differ significantly between conservation and conventional developments whereas topsoil removal and stockpiling was more than double for the Sunset Prairie development relative to Mill Creek. In this case, conservation development shows that a fair amount of topsoil removal (871 cubic yard per lot) was avoided. Topsoil removal was reduced from 1,118 cubic yards to 247 cubic yards per lot, and saved $960 per lot from the conservation development. Based on the literature findings, conservation design is intended to minimize grading, site excavation, topsoil removal, and earth work, and thus save construction costs for site preparation. This result implies that more lands were preserved from disturbance for open space.

Stormwater Management

As shown in Table 19, conservation methods of stormwater management contributed to the greatest savings with more than half (53%) of the total savings per lot. To look closely, installation of storm sewers and sump pump connections was reduced from 164.2 linear feet to 85.2 linear feet per lot and thus saved $1,623 per lot. Plus, trench backfill was reduced from 20 cubic yards per lot to 3.7, saving $232 per lot. Additional infrastructure costs in the conventional development included catch basins, slope inlet boxes, and cleanout structures, which totaled $23,783, or $457 per lot.

In accordance with literature, this case showed significant reductions in stormwater sewer pipes and associated infrastructure costs, making up more than half of the total savings.

Sanitary Sewer

Sanitary sewer includes piping and bedding, sanitary manholes, trench backfill, and other related infrastructures. As can be seen in Table 19, lump sum cost-savings per lot were as much as $579, which represents 17% of the total savings.

The total cost of sanitary sewer (8” in diameter PVC pipe) was similar in both subdivisions although cost per individual lot was higher in the conventional development, due to the greater length of the infrastructure (74 linear feet per lot versus 58 linear feet per lot). In addition, $257 per lot was saved from the operation costs of trench backfill in the conservation development (23 versus 5 cubic yard per lot). This supports the literature claims that clustering design can reduce street length, and thus reduce required sanitary pipe length, thereby lowering costs.

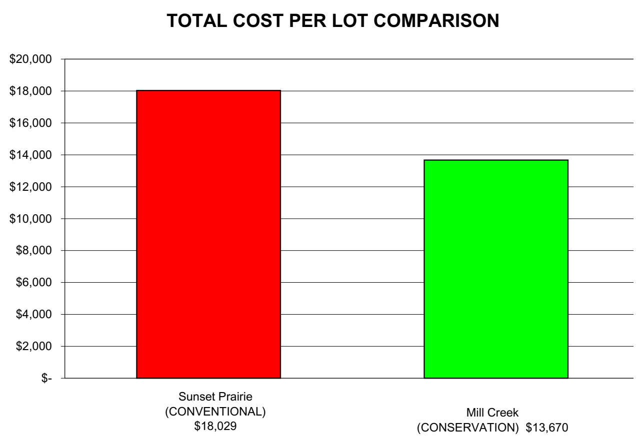
Water Distribution

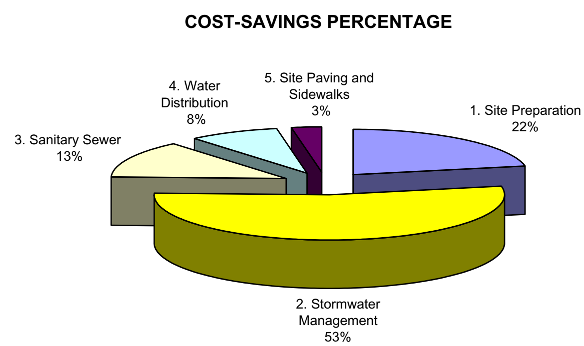
Water distribution includes water main, hydrant, valve in vault, water service pipes, trench backfill, and connections to the existing water main. The results demonstrated that conservation development saved $369 per lot. Although the Mill Creek subdivision presented about $14,000 more in this item, fourteen more lots resulted in lower costs per lot.

Again, the results of this case study agree with literature findings that the clustering at Mill Creek did save money on water distribution infrastructure costs.

		Sunset Prairie (CONVENTIONAL)			Mill Creek (CONSERVATION)				
COST	ITEM	cost per item	cost per item per lot[2]	% per total cost	cost per item	cost per item per lot[2]	% per total cost	cost-savings per lot	cost-savings percentage
CAPITAL COSTS[1]	1. Site Preparation[3]	$ 106,350	$ 2,045	11%	$ 71,690	$ 1,086	8%	$ 959	22%
	2. Stormwater Management[4]	$ 235,826	$ 4,535	25%	$ 145,486	$ 2,204	16%	$ 2,331	53%
	3. Sanitary Sewer	$ 144,477	$ 2,778	15%	$ 145,156	$ 2,199	16%	$ 579	13%
	4. Water Distribution	$ 142,498	$ 2,740	15%	$ 156,492	$ 2,371	17%	$ 369	8%
	5. Site Paving and Sidewalks	$ 308,338	$ 5,930	33%	$ 383,418	$ 5,809	42%	$ 120	3%
TOTAL		$ 937,489	$ 18,029	100%	$ 902,241	$ 13,670	100%	$ 4,358	100%

NOTES:
[1] Exclude offsite improvements, landscaping costs, and construction contingency cost
[2] Based on 52 lots for Sunset Prairie Subdivision and 66 lots for Mill Creek Subdivision
[3] Earthwork costs that are not available for Mill Creek were excluded from both sites in the table
[5] Detention cost is not available for Mill Creek and were excluded from both sites in the table
[5] Acreage for Sunset Prairie is 30.56 acres whereas Mill Creek is 41.5 acres
[6] Property values varies upon location of sites and design of the site. Locality is often the major driving force for property values; however, if comparing site design only, conservation development would have greater property values than conventional one as a result of open space and community benefits derived from conservation planning and design.





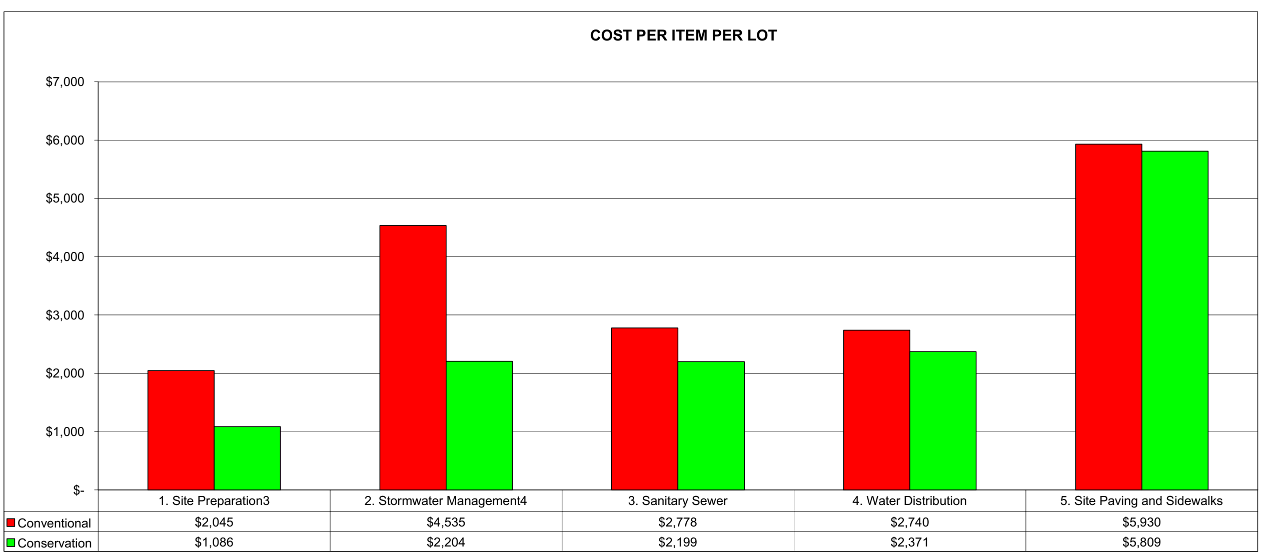


TABLE 19. Sunset Prairie versus Mill Creek Cost Comparison Summary.

Site Paving and Sidewalks

Table 19 shows that conservation development resulted in $120 less per lot from site paving and sidewalk construction costs, representing 3% of the total savings.

Construction costs for asphalt paving were $226 per lot less in the conservation development. In addition, $113 per lot was saved by reducing 42 linear feet of sidewalk per lot in the conservation development. The cost of street paving was lower for Mill Creek due to both reduced street length and width relative to Sunset Prairie. Costs of curb and gutter, conversely, increased 35 linear feet per lot in conservation development, or about $219 per lot. However, a cost increase on curb and gutters implies that other unknown factors of design may be concealed in this case, thus limiting the comparison results.

Sidewalks were put on both sides of the streets in both subdivisions, making the results comparable for length of sidewalk per lot and associated cost-savings derived from the site design. Shorter sidewalk lengths per lot is evidence of clustered design in Mill Creek and magnified the savings on construction costs from conventional development.

Property Values

Marketing information from both subdivisions shows that lot prices vary according to location within the subdivision and proximity to open space, recreational facilities, train stations, and downtown facilities. In Neighborhood U at Mill Creek, a $3,000 premium occurs when lots are adjacent to walking/biking trails, and $10,000 or $17,500 premiums apply when lots are adjacent to or have views of open space.

In Sunset Prairie, Phase I, the only open space on the site is a detention pond in the middle of the overall development and a turf lawn at one of the street intersections. Surrounding parks and a biking trail between adjacent subdivisions, however, allow Sunset Prairie to borrow views as well as recreational uses of nearby amenities. For this reason, premium lots are generally distributed around the detention pond and adjacent to the biking trail. The lot premiums ranged from $5,000 to $39,000.

Open Space

Within 1,500 acres, 40 percent of the land is designated as open space in Mill Creek, of which 27 acres are a public golf course, 127 acres are forest preserve with quality wetlands, 195 acres are public parks, and 15 miles of walking/biking trails are placed in the 123 acres of roads, trails and easements.

As alluded to in the literature analysis, open space not only increases aesthetic values and provides recreational facilities but also helps to protect significant natural features from further development. In addition, conservation development that integrates stormwater management into open space can help to reduce stormwater runoff volume and improve water quality as well. Furthermore, residents feel safe and possess convenient access to open space near by.

Conclusion

Cost savings of $3,700 per lot were estimated for the conservation approach, with 53% from stormwater management as the largest contributing factor to those savings.

Although there are differences, this comparison is as close to an apples-to-apples look at identical sites as can be found practically. Similarities include: proximity to downtown and transit, adjacent land uses, timing of construction, and the overall planning and design for the entire subdivision.

Although some uncertainty is inherent in this case study, it still provides a valuable demonstration of real world costs. The comparison between Sunset Prairie and Mill Creek supports the proposition that conservation developments in residential subdivisions can save money during construction, especially in site preparation and the installation of stormwater management infrastructures.

FIGURE 4. Auburn Hills subdivision plats. Image courtesy of Bielinski Homes

CASE STUDY 2: Bielinski Homes- Auburn Hills, Laurel Springs, and Prairie Glen Subdivisions

Background
Three residential subdivisions, built by Bielinski Homes, were analyzed for actual conservation costs in relation to estimated conventional costs. Prairie Glen, in Germantown, Wisconsin, is considered a national model for Conservation Communities by the Conservation Fund. 59 percent of the land was preserved as open space, with native plants and wildlife habitat reintroduced. Hiking trails and site layout were designed for easy access to the natural areas. Street widths were minimized to reduce runoff, and wetland areas were created to help manage the stormwater.

Auburn Hills, also in southwestern Wisconsin, is one of Bielinski Homes' Conservation Neighborhoods that provides common open space, which preserves 40 percent of the site from development, and includes wetlands, natural plant landscaping and green space, along with a network of walking paths. And Laurel Springs, a residential subdivision in Jackson, Wisconsin, is a third low impact conservation design, which preserved open space, minimized grading, paving and stormwater sewer systems.

Method
In this case study, three subdivisions were analyzed respectively for their estimated conventional costs and for actual cost of conservation development. Cost comparisons are analyzed separately, and then discussed together.

According to Bielinski Homes, infrastructure costs were divided into nine categories. To make this case study comparable to the template cost analysis, comparison items were reorganized as: 1) Site Preparation, including grading and miscellaneous (demolition, erosion control, etc.); 2) Stormwater Management, which refers to storm sewer; 3) Sanitary Sewer; 4) Water Distribution, which refers to watermain; 5) Utilities; 6) Site Paving and Sidewalks, including paving and concrete; and 7) Landscaping.

As a developer, Bielinski Homes compared costs not only in construction but also development-related finances, such as impact or permit fees required by municipalities or counties, professional expenses for site analyses and site planning and design, financing expenses such as loans and legal fees, and real estate taxes that developers are required to pay. Because impact fees are so site-specific and require more in-depth study, they were considered outside the scope of this limited analysis. For similar reasons, land costs were not included in this analysis.

Results & Discussion
Table 20 summarizes cost comparisons and percentage savings of each item among the three sites while their detailed cost analyses are included in Appendix 4. The following discussion details each category of construction costs as well as overall costs.

Site Preparation
This case study supports the literature analysis findings that clearing and grading can be reduced when cluster design is applied. Overall site preparation costs for conservation development were reduced by 23 to 32% of conventional development costs. Within those savings, grading contributed almost 100%, as miscellaneous costs of demolition and erosion control were the same or less than ten percent of total savings.

Stormwater Management
Among the cost analysis items, stormwater management is the largest area of cost savings for conservation development. Savings ranged from 47 to 69%, or about $2,500 to $3,300 per unit where vegetated swales or bioswales substituted for storm sewers. This also agrees with the conveyance literature analyzed previously as being one of the greatest cost savings, thereby endorsing the use of this incentive by real world examples from a developer's point of view.

FIGURE 5. Laurel Springs subdivision plats. Image courtesy of Bielinski Homes

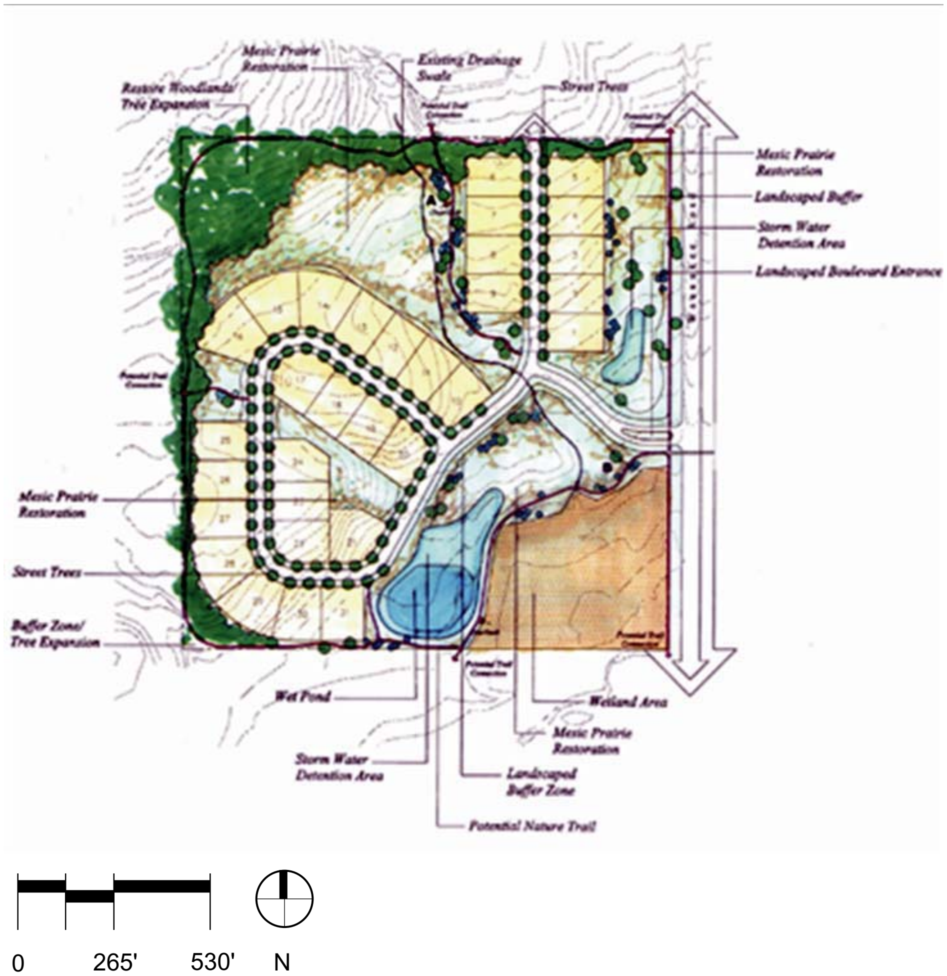


FIGURE 6. Prairie Glen subdivision plat. Image courtesy of Bielinski Homes

Description	Auburn Hills			Laurel Springs			Prairie Glen			Comments
	Conventional Cost	Conservation Cost	Cost Savings %	Conventional Cost	Conservation Cost	Cost Savings %	Conventional Cost	Conservation Cost	Cost Savings %	
Site Preparation	$699,250	$533,250	24%	$441,600	$342,000	23%	$277,043	$188,785	32%	reduced lot grading for conservation
Stormwater Management	$664,276	$241,497	64%	$439,956	$136,797	69%	$215,158	$114,364	47%	storm sewers vs. treatment swales
Sanitary Sewer	$671,020	$485,520	28%	$415,600	$385,280	7%	$189,402	$166,827	12%	reduced street lengths
Water Distribution	$858,670	$777,160	9%	$412,460	$384,240	7%	$166,260	$146,868	12%	
Utilities	$290,510	$177,920	39%	$270,000	$161,280	40%	$64,790	$39,680	39%	
Site Paving and Sidewalks	$771,859	$584,242	24%	$607,465	$515,755	15%	$463,547	$242,707	48%	reduced street lengths and widths
Landscaping	$225,000	$240,000	-7%	$165,000	$155,000	6%	$50,100	$53,680	-7%	
Construction Cost Subtotal	**$4,180,585**	**$3,039,589**	27%	**$2,752,081**	**$2,080,352**	24%	**$1,426,300**	**$952,911**	33%	
Impact Fee / Permits	$80,000	$47,500	41%	$51,500	$35,000	32%	$33,100	$17,600	47%	
Professional Services	$218,750	$217,600	1%	$192,500	$184,400	4%	$90,000	$82,500	8%	
Financing Expenses	$358,000	$244,000	32%	$244,000	$159,000	35%	$154,425	$87,050	44%	
Real Estate Tax	$69,500	$69,500	0%	$60,000	$63,000	-5%	$54,560	$54,560	0%	
Finance Cost Subtotal	**$726,250**	**$578,600**	20%	**$548,000**	**$441,400**	19%	**$332,085**	**$241,710**	27%	
Total Costs	**$4,906,835**	**$3,618,189**	**26%**	**$3,300,081**	**$2,521,752**	**24%**	**$1,758,385**	**$1,194,621**	**32%**	
Summary	10138 l.f. of roads in conservation vs. 11500 l.f. in conventional			6560 l.f. of roads in conservation vs. 6860 l.f. in conventional			3125 l.f. of roads in conservation vs. 3450 l.f. in conventional			
	Construction Cost per foot of roadway: $357 conventional vs. $427 conservation			Construction Cost per foot of roadway: $384 conservation vs. $481 conventional			Construction Cost per foot of roadway: $357 conservation vs. $475 conventional			
	Construction Cost per unit: $26,030 conservation vs. $38,943 concentional			Construction Cost per unit: $20,337 conservation vs. $27,501 conventional			Construction Cost per unit: $35,790 conservation vs. $52,879 conventional			
	113 lots/13 duplex condos in conservation vs. 126 lots conventional			110 lots/7 duplex condos in conservation vs. 120 lots conventional						
				On-site detention in conservation vs. 5 acre off-site lot in conventional						

Date: 11/4/2003
Source: Bielinski Homes
Edited by: CDF

TABLE 20. Cost Comarison Summary of Auburn Hills, Laurel Springs, and Prairie Glen Subdivisions.

Sanitary Sewer

Sanitary sewer cost savings range from 7% to 28%. These savings may have resulted from the reduced street length in the clustering design, which then reduced the length of infrastructure. 1,878 linear feet of 8-inch diameter sanitary sewer pipes were saved in the Auburn Hills subdivision, 250 linear feet were saved in Laurel Spring, and 893 linear feet of 15" and 8" sanitary sewer pipes combined were saved in Prairie Glen.

Water Distribution

Though clustering design differs from site to site, in general, these case studies provide evidence that conservation development helps to save on water distribution infrastructure costs. Yet, cost savings from water mains are relatively low when compared to other construction cost items. Around 9% to 12 % of the conventional costs are saved with conservation design. 2,300 linear feet of 8" water main pipe are saved in Auburn Hills, while 300 and 460 linear feet of 8" and 12" water main pipes combined are saved in Laurel Spring and Prairie Glen respectively. The cost of water distribution infrastructure also depends on the length of roads, so that clustering design helps to save these construction costs.

Utilities

Utilities included electricity and cable television infrastructure in this case study. Cost savings on this item are about 40% across the three sites.

Site Paving and Sidewalks

Paving and concrete cost savings range from 15% to 48%, or nearly half the conventional development. In Auburn Hills, 1,312 linear feet of road are saved, which equals $70 per foot of roadway, or $91,840 total savings. 300 linear feet of road or $97 per foot are saved in Laurel Springs, and 325 linear feet or $118 per foot are saved in Prairie Glen.

Costs for concrete included curb and gutter for all three sites and sidewalks in both Laurel Springs and Prairie Glen. Curbs with gutters are 3,224 and 600 linear feet less in Auburn Hills and Laurel Springs respectively, whereas the costs stay the same for both scenarios in Prairie Glen. As for sidewalks, Laurel Springs saved 2,970 square feet while 61,824 square feet were saved in Prairie Glen.

Total cost savings from concrete are not significant except in Prairie Glen where a substantial amount of sidewalks (72%) were added in the conventional development. Cost savings on street paving, on the other hand, appears more consistent among the three sites. Again, those savings were derived from the reduced street length and width in the clustering design.

Landscaping

Landscaping costs include site landscaping (including native landscape restoration in the conservation development cases) and street cleaning. Overall, unlike other cost items, landscaping costs were slightly more in the conservation developments, due to the increased amount of community green space that must be landscaped. As shown in the detailed cost analyses (in Appendix 4), street cleaning costs more (about 70%) in the conventional development. Site landscaping costs about 29% more in both Auburn Hills and Prairie Glen, whereas the costs were the same in Laurel Hills.

Conclusion

Total cost savings ranged from $563,764 to $1,288,646 and averaged $876,913 across the three Wisconsin sites, and the average percentage savings was 27%. Overall, every category of construction costs is lower under conservation development except for landscaping costs, which were higher in Auburn Hills and Laurel Springs. Those savings trends are in agreement with findings in the literature analyses where costs of clearing and grading, infrastructure (including sanitary sewer, water main, and utilities), stormwater management, and street paving are less as a result of clustering design. Conservation design principles that minimize disturbance on site, reduce street length and width, and employ bioswales instead of storm sewer piping contribute a significant amount of savings during construction.

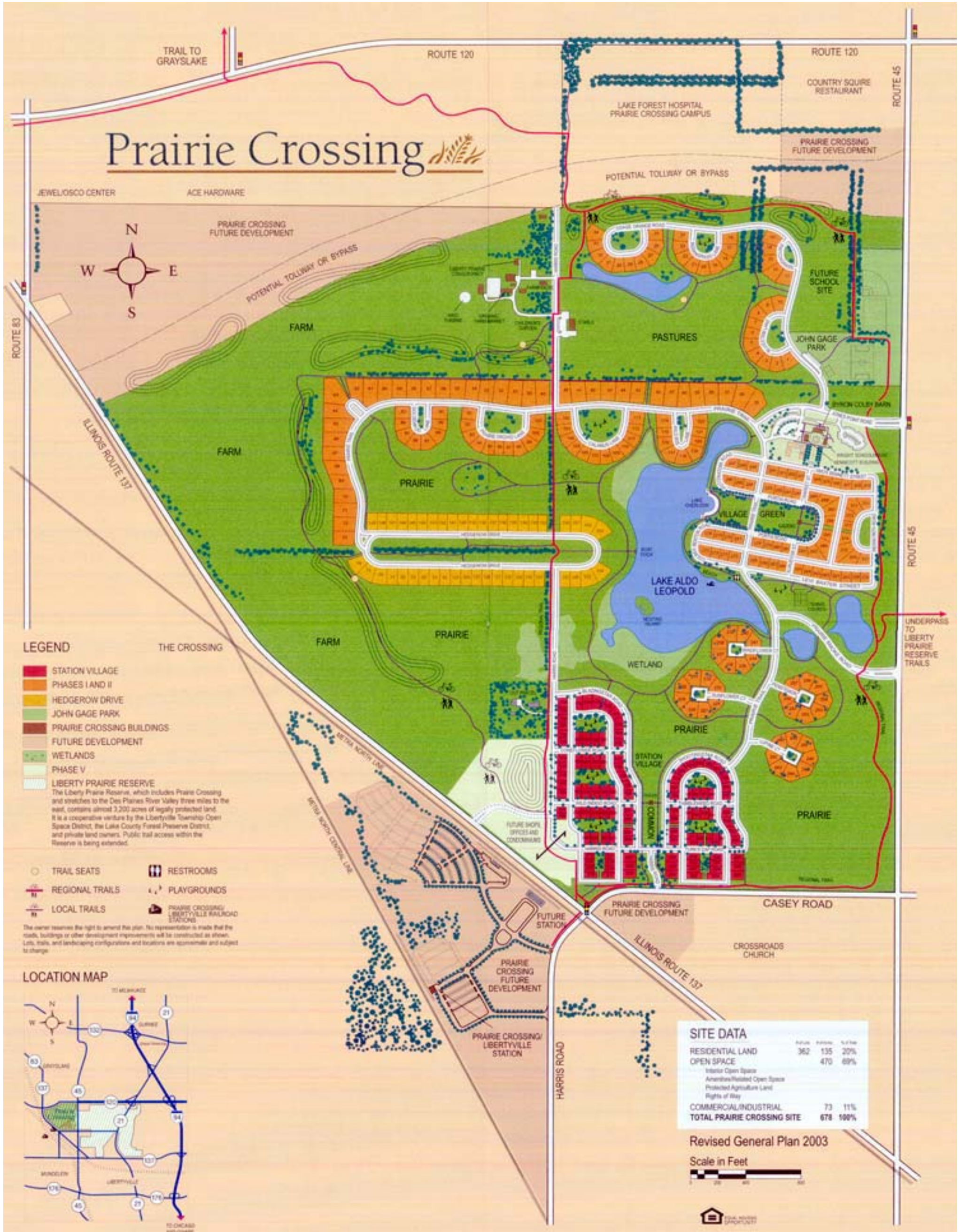


FIGURE 7. Prairie Crossing Subdivision Master Plan. Image courtesy of Prairie Crossing.

FIGURE 8. Prairie Crossing Subdivision Site Photo. Image courtesy of Prairie Crossing

CASE STUDY 3: Prairie Crossing

Background

The Prairie Crossing Subdivision, in Grayslake, Illinois, was initiated by a group of visionary landowners who saw an alternative development that would celebrate community and provide a high quality of life. They planned for 362 homes on 678 acres with 470 acres of open space and 73 acres of commercial space, accompanied by schools, a community center, an organic farm, a lake and beach, biking trails, and two commuter train stations across the street. After nearly a decade, Prairie Crossing has become one of the best known examples of conservation development in the Midwest.

Method

The data acquired from Prairie Crossing are not broken out by the construction categories used elsewhere in this report. Rather, an estimated lump sum cost savings was completed in 1993 for the two different construction approaches, conventional and conservation. The assumptions for these data are:

- Both conventional and conservation development cost summaries assume the same layout.
- Storm sewers are sized per village code and Lake County Stormwater Management Commission requirements (alternative stormwater management techniques such as bioswales for water conveyance are employed in the conservation development).
- Curb and gutter are installed for all streets and alleys (curb and gutters are avoided when sheet flow applies and open swales are used in the conservation development).
- Street width meets village codes (27 and 36 feet wide according to codes, versus 16, 18, 20, 24, and 32 feet wide in conservation development).
- Sidewalks are installed in front of every house (portions of sidewalks are replaced with alternative pedestrian and biking trails in the conservation development).
- Open space areas are planted with turf (or in the conservation development, native prairie and wetland species are planted or restored).

In addition to construction costs, the data also compares maintenances costs. Turf grass expenses included costs of seed, mulch, and fertilizers, and maintenance costs over five years include the expenses of mowing, fertilizer application, irrigation system, municipal water, and aerating or de-thatching (every other year). Expenses for native prairie included expenses of seeding, plugs, and mulching while its maintenance requires mowing in the first two years, spot herbicide treatment over five years, and prescribed burn in the second, third, and fifth year.

Results & Discussion

Since the layout of both scenarios is the same, they shared the same street length and an equal amount of open space. Therefore, this case study focused on construction costs when alternative stormwater management and grading design approaches are applied. Cost savings generated from conservation development were found in four areas: stormwater management, curb and gutter, site paving, and sidewalks. Total net savings from these construction items were estimated at $1,375,000 (approximately $3,798 per lot or $2,028 per acre) for the overall site (see Table 21).

Stormwater Management

The amount of reduced storm sewer pipes saved a total of $210,000 in the conservation development, which agrees with the literature analyses that shows conservation methods are responsible for significant savings in conveyance costs.

Curb and Gutter

Alternative street edge treatment that apply open water conveyance systems and replace curb and gutter contributed a quarter of the total estimated savings over the conventional approach, equaling $339,000. (See also Case Study 5 for Street Edge Alternative projects).

Site Paving

Reduced street width alone made up $178,000 or $263 per acre cost savings in the conservation development,

SAVINGS	ITEM	Savings Per Item	Savings Percentage
NET SAVINGS	Reduced Road Width[1]	$ 178,000	12.9%
	Curb and Gutter[2]	$ 339,000	24.7%
	Sidewalk[3]	$ 648,000	47.1%
	Storm Sewer[4]	$ 210,000	15.3%
TOTAL SAVINGS		**$ 1,375,000**	**100.0%**
	Total Savings Per Lot	**$ 3,798**	
	Total Savings Per Acre	**$ 2,028**	
LANDSCAPING SAVINGS From Prairie (Conservation) v.s. Turf (Conventional)	Year One per acre	$ 4,695	27.6%
	Year Two per acre	$ 2,275	13.4%
	Year Three per acre	$ 2,015	11.8%
	Year Four per acre	$ 5,365	31.5%
	Year Five per acre	$ 2,680	15.7%
TOTAL SAVINGS	**Average Savings Per Year Per Acre**	**$ 3,406**	**100.0%**
	Total Prairie Landscaping Savings Per Year	**$ 572,889.2**	

Data source: Prairie Crossing

Assumptions for Conventional comparison:

[1] Street widths to meet village code in Conventional Scenario

[2] Curb and gutter for all streets and alleys in Conventional Scenario only

[3] Assume sidewalks in front of all houses and along roads in Conventional Scenario versus trails systems are developed in Conservation Scenario

[4] Storm sewer sized per village code and Lake County Stormwater Management Commission requirements in Conventional Scenario versus natural drainage and stormwater management system are established in Conservation Scenario

Site Data		# of Lots	# of Acres	% of Total
Residential Land		362	135	20%
Open Space			470	69%
	agriculture	116	25%	
	lawn	28	6%	
	prairie	168	36%	
	wetland	28	6%	
	Hedgerow	16	3%	
	Other	114	24%	
Commercial/Industrial			73	11%
Total Site			**678**	**100%**

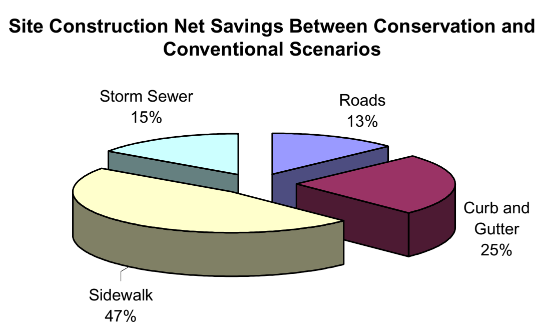


TABLE 21. Prairie Crossing Estimated Savings Between Conventional and Conservation Scenarios.

confirming the cost-effectiveness of conservation design principles on this issue.

Sidewalks

Table 3 shows that cost savings for sidewalks contributed the greatest amount among the construction items analyzed (nearly half of the total cost savings). This reduced cost may be attributable to alternative paving materials such as the replacement of concrete sidewalks with crushed limestone trails.

Landscaping

As shown in Table 21, landscaping cost savings range from $2,000, with prescribed burns on native prairie, to $5,400, when burning is not required. Over five years, the native prairie landscaping can save $7,990,000 in total open space area (or $1,598,000 annually), which equals $17,000 per acre over five years or $3,400 per acre annually.

Irrigation systems and water bills can create excessive installation expenses as well as maintenance expenses. Additionally, mowing represents about half of the overall expenses in the subsequent years after installation and continues to be a substantial expense over time. On the other hand, the native prairie landscapes of this site cost less up front as well as for subsequent maintenance. Installation of prairie cost about half (56%) of the turf installation, primarily as a result of the difference of irrigation costs. As for maintaining prairie landscapes, the only major expense is from prescribed burning that has been done every year or two.

Conclusion

Conservation development savings at Prairie Crossing were $3,798 per lot for construction. Unfortunately, detailed cost comparison data was not available at the time of this project so that cost savings from specific items could not be analyzed. Furthermore, since this development did not count clustering design as an alternative approach in the scenario comparisons, site planning and design factors could not be analyzed and the study compares only construction costs for different approaches.

This case supports the argument that the alternative design strategies of conservation development do indeed help to reduce construction costs up front, and save dollars in the long run in terms of maintenance for landscaping. These findings agree with the literature analyses that stormwater conveyance, site paving, and sidewalks are significant cost saving-factors.

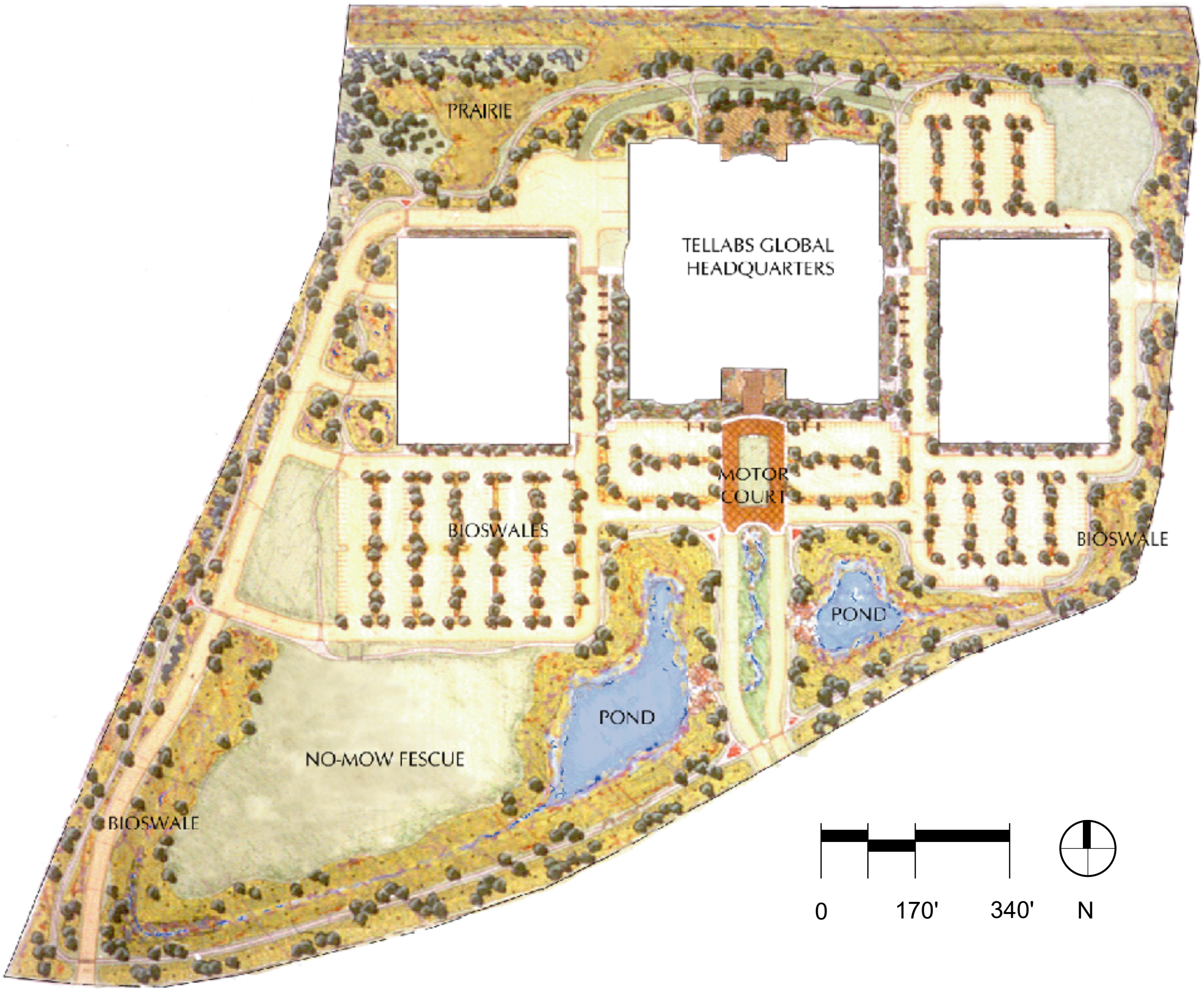


FIGURE 9. Tellabs Master Plan. Image courtesy of Conservation Design Forum

FIGURE 10. Tellabs Site Photo. Image courtesy of Conservation Design Forum.

CASE STUDY 4: Tellabs Corporate Campus

Background
Located in Naperville, Illinois, Tellabs Headquarters campus consists of 332,500 square feet of office space situated on a 55 acres site. At the beginning of the planning process for the new campus, the engineering and landscape architecture consultants undertook cost comparisons between conservation and conventional scenarios on the project site. Based upon the data, Tellabs chose the conservation approach for the campus design, especially after they compared its construction and maintenance costs to other campuses that had been constructed conventionally in the region. As a result, the conservation design was built, making Tellabs a valuable case study of commercial/office/industrial conservation development possibilities in the region.

Method
In this case, earthwork, stormwater management, and landscaping were the design components that drove most of the differences between conventional and conservation scenarios. Therefore, construction costs of other design elements such as sanitary sewer, water distribution, and site paving and sidewalks were omitted from this section. The detailed cost analysis can be found in Appendix 5.

National Survey & Engineering provided construction costs for the conventional scenario. Conservation Design Forum, as the landscape architecture and ecological engineering consultant, produced the actual cost figures for conservation development and compared them to the conventional costs.

Results & Discussion
The results are shown in **Table 22.**

Site Preparation
Site preparation included mass earthwork, grading, tree removal/relocation, and retaining walls for grading and elevation differences. Total savings of site preparation from conservation development were as much as $214,500 (or $3,900 per acre) less than the conventional scenario, and conservation preserved six more acres with minimum disturbance.

Conservation design principles minimized earthwork and followed natural drainage and topography as much as possible, providing much of the savings on grading and earthwork. Unit cost differences were $35,000 per acre in grading. Six fewer acres graded, therefore, reduced the overall grading costs by $210,000. Although retaining walls were required in the conservation scenario (slopes in some areas were preserved, leaving elevation differences), savings from earthwork remained greater than the cost for construction of those walls.

Stormwater Management
Stormwater management in the conventional scenario included storm sewer piping, bedding, and excavation of a detention pond. Conservation development included the costs of stormwater infiltration techniques such as level spreaders, parking lot bioswales, and overland bioswales. Associated construction costs for the bioswales included mass earthwork for excavation to accommodate the overland flow, native vegetation plugs in the bioswales, and a bridge across an overland swale.

Total savings from conservation development in this case were $62,910, mainly by eliminating 920 linear feet of storm sewer pipe. The total construction cost for the parking lot bioswales was $104,400 (or $29 per linear foot) and the total cost for an overland bioswale was $135,500 (or $45,167 per acre-foot). The parking lot bioswales were designed as part of the stormwater management system in the conservation development. This difference is shown in the following landscaping section.

COST	ITEM[1]	CONVENTIONAL	CONSERVATION
CAPITAL COSTS	1. Site Preparation	$ 2,178,500	$ 1,966,000
	2. Stormwater Management	$ 480,910	$ 418,000
	3. Sanitary Sewer	$ 71,750	$ 71,750
	4. Water Distribution	$ 155,900	$ 155,900
	5. Site Paving and Sidewalks	$ -	$ -
	6. Landscape Development	$ 502,750	$ 316,650
	Construction Contingency[2]	$ 847,453	$ 732,075
	Design Contingency[3]	$ 338,981	$ 351,396
TOTAL CAPTIAL COST		**$ 4,576,244**	**$ 4,011,771**
PER SQ FT RETAIL[4]		**$ 10**	**$ 8**

NOTES:

[1] Cost for items 3-Sanitary Sewer, 4-Water Distribution, and 5-Site Paving and Sidewalks are assumed the same for both scenario

[2] Assumed25% for both scenarios.

[3] Assumed 10% for conventional scenario and 12% for conservation scenario.

[4] Based on 332,500 sf multi-use retail space.

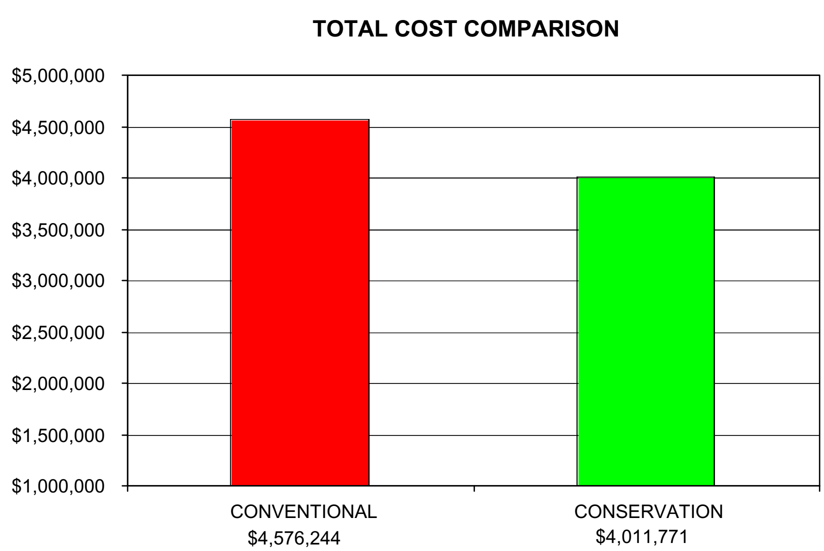


TABLE 22. Tellabs Cost Analysis Summary.

One of the major cost additions in the conservation scenario was for an ornamental footbridge to cross the main bioswale. This cost was not directly related to the stormwater management function, but necessary due to Tellabs' desire to allow their employees and guests to enjoy the ability to walk and jog amongst the restored landscape.

Landscaping

The most visible difference between the conservation and conventional site development approaches is in the landscape. The conservation landscape that was installed at Tellabs includes areas of native prairie and wetland restoration, complimented with transitional areas and stormwater landscapes that are more naturalized. Areas adjacent to the building and pavement are more manicured to keep a neat, intentional appearance consistent with Tellabs' corporate image. The majority of the landscape is passive, low-maintenance naturalized or native planting, in contrast with the typical conventional approach that would include acres of high-maintenance turf grass lawns, clipped shrubs, and annual flowers. Both scenarios included landscaping for the parking lot islands. In the conventional scenario, the islands were strictly ornamental, and their cost is included under the landscape category only. In the conservation scenario, the islands served as both ornamental landscape and as a bioswale stormwater management feature. Thus, the excavation and gravel and soil backfill required for the stormwater aspect are included under stormwater and the planting is included under landscape.

Landscaping in this case also included a 0.47-acre wetland mitigation. The cost for the purchase of off-site wetland mitigation credits was avoided because the conservation scenario offered the option of integrating wetland re-creation and pond edge enhancement that would meet the mitigation requirements into the overall landscape scheme for the site. Since the wetland mitigation was integrated into an overland swale of the conservation scenario, earthwork for creating the wetland area was included in overall site preparation and planting, which was included in the overall landscape budget. Incorporating the wetland mitigation into a naturalized drainageway of the site was acceptable from a regulatory standpoint only because the runoff received pre-treatment in the bioswales before discharging to the wetland swale.

Site landscaping included all the trees, shrubs, perennials, lawns, and prairies (in conservation only). The total for plant materials alone in the conservation development was $44,150 more than the conventional total. However, in the conservation development, irrigation systems are not required because stormwater is allowed to infiltrate onsite directed to planted areas and the native prairie plants tolerate drought conditions. The irrigation systems required in the conventional scenario cost an extra $150,000, in addition to plants. As a result, the overall cost savings from conservation development for landscaping was $105,850.

Landscaping in parking lot islands cost $72,750 in the conventional scenario. As discussed earlier, parking lot islands in the conservation case were replaced by bioswales as a part of stormwater management (The built cost within that context was $104,400.)

Landscape Maintenance

The literature analysis described significant savings from conservation development for landscape maintenance. In this case, Tellabs monitored annual costs spent on maintaining conventional lawn versus a conservation landscape over ten years for the same 27 acres. As shown in **Table 23**, a traditional landscape would have required $842,000 for maintenance, whereas the native prairie landscape in a corporate setting needed only $437,100. After ten years, a traditional landscape would require an average of $81,000 per year to maintain the campus, when only $14,715, or 18% of the conventional landscape cost, is needed for the conservation landscape.

	Conventional Landscape	Conservation Landscape
Year 1	$81,000	$51,000
Year 2	$89,000	$86,400
Year 3	$89,000	$45,900
Year 4	$89,000	$81,000
Year 5	$89,000	$40,500
Year 6	$81,000	$35,100
Year 7	$81,000	$13,500
Year 8	$81,000	$35,100
Year 9	$81,000	$13,500
Year 10	$81,000	$35,100
Ten-Year Total	**$842,000**	**$437,100**
Subsequent Years	$81,000	$14,715

TABLE 23 Annual Landscape Maintenance Fees. (source: Tellabs)

The lower-cost figures arrived at by Tellabs supports the proposition that conservation development is not only cost-effective but also affords room for additional amenities that are truly beneficial. The landscape development for Tellabs included a number of programs and features to enhance the ability to appreciate the campus. Aesthetic embellishments such as pedestrian paths, bridges, and overlooks provide the opportunity for employees and visitors to enjoy naturalized walking trails and preserved trees and open space.

Conclusion

Total savings in capital costs were $564,473, or just over 12% in favor of the conservation design. Complete conclusions from Tellabs' conservation development data are somewhat limited due to the lack of detailed civil engineering estimates of the construction costs for the conventional scenario. For this reason, certain construction costs were not analyzed in this case study (e.g., water distribution, site paving and sidewalks, and other utilities).

The Tellabs case study does show that commercial developments can certainly benefit from conservation development cost savings, especially from earthwork, stormwater management, and landscaping. In this case, the multiple functions of the integrated stormwater management and landscaping in the conservation site design, which included bioswales, wetlands, and native landscaping, helped save up-front construction costs and long-term maintenance liabilities. Conservation development also provided substantial ecological and environmental benefits by providing clean site water, stable hydrology, and habitat for a wide diversity of plants and animals.

Before

After

FIGURE 11. SEA Street Project Before and After Photos.

CASE STUDY 5: Street Edge Alternatives Streets

Background

For nearly a decade, the City of Seattle has researched alternative street edge treatments, which use natural drainage systems to allow infiltration and detention as part of their stormwater management system. The momentum began when the City was renovating 2nd Avenue. The costs for alternative street edge and stormwater management designs were compared to traditional stormwater piping systems. As a result, an effort known as the Street Edge Alternatives (SEA) Streets Project was born.

Method

Seattle Public Utilities provided cost data for the SEA Streets project (conservation streets) and the traditional pipe alternative (conventional streets) based on a 660-foot block. In both scenarios, the same drainage area and goals for stormwater detention and water quality were applied. Both scenarios envisioned the replacement of the street and sidewalk paving. Original data includes not only construction costs but also costs for planning, design, and close-out phases (see Appendix 6). The following focuses on construction costs only.

Results & Discussion

The results of the cost analysis are shown in Table 6. It shows that Seattle's conservation streets cost $217,253 less than a conventional street would have on overall construction costs, which is equivalent to $329 savings per foot.

Site Preparation

For this category, site preparation included temporary erosion and sediment control (TESC), and removals and adjustments. Conservation streets cost $88,173, or $134 per foot, in comparison with $65,084 for preparation costs, or $99 per foot, for a conventional street. The $35 per foot difference may be due to aesthetic enhancements.

Stormwater Management

In this case, stormwater management refers to drainage. Conservation streets saved $165 per foot and $108,776 in total on this item. Instead of storm sewer piping, SEA Streets applied vegetated swales and an interconnected underground detention and drainage system to allow infiltration and help to store stormwater volumes. The cost savings from reduced pipes was one of the primary contributions to the overall cost savings.

Site Paving and Sidewalks

The conservation streets cost $223 per foot, in comparison with $436 per foot for conventional streets, for a reduction of $213 per foot. The higher cost for conventional streets is likely related to wider paving for more total paved surface. Sidewalks were planned on both sides of the conventional street and just one side of the conservation street.

Landscaping

The conservation streets cost $52 per foot more for landscaping than the conventional streets. In the conventional street landscape, trees, sod, and minimal plantings were designed as required by city codes, whereas the conservation street landscape design included more diversity of native plants for both aesthetic reasons and for stormwater cleansing functions. The selection and higher maturity of plants needed to achieve those functions resulted in greater installation costs.

Miscellaneous

Miscellaneous costs included mobilization and traffic control. The conservation streets cost only 60% of conventional street costs, which saved $39 per foot. Traffic control for streets may include various traffic calming strategies such as speed bumps, curves, varying paving materials, planting islands, etc. For SEA Streets, the conservation street design employed winding or curved edges so that standard traffic control devices were deemed unnecessary.

COST	ITEM[1]	CONVENTIONAL[1]	CONSERVATION[2]
CAPITAL COSTS	TESC Measures	$ 20,621	$ 27,273
	Removals and Adjustments	$ 44,463	$ 60,900
	Drainage	$ 372,988	$ 264,212
	Paving	$ 287,646	$ 147,368
	Landscaping	$ 78,729	$ 113,034
	Misc. (mobilization, traffic control)	$ 64,356	$ 38,761
TOTAL CAPTIAL COST		**$ 868,802**	**$ 651,549**

NOTES:

[1] Swales providing detention and water quality treatment.

[2] Drainage area comparable to SEA Streets.

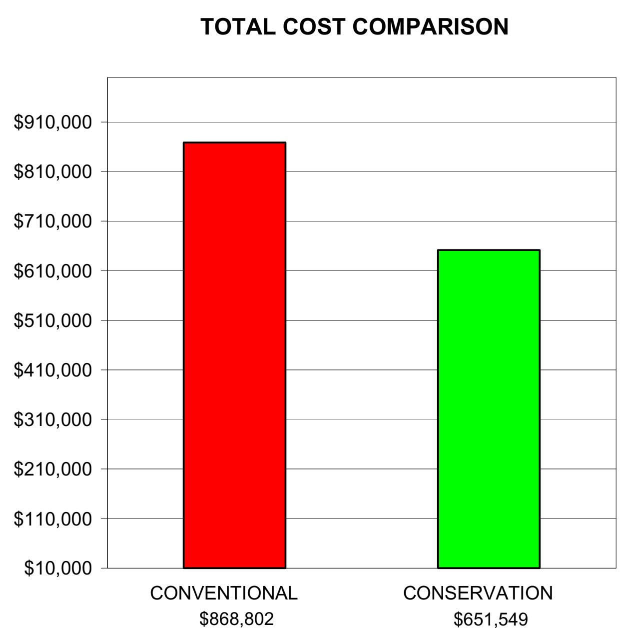


TABLE 24. SEA Street Cost Analysis.

Limitations
Since the SEA Streets project is on the west coast, it may be questionable to directly transfer conclusions to the Midwest, although this is not meant to imply that the alternative street edge treatment cannot be implemented in the Midwest. Further assessment should be conducted on codes and ordinances and the applicability of these stormwater management techniques in a Midwestern climate.

Conclusion
In this case, construction of the conservation design saved $217,253, or $329 per foot over the conventional costs. The SEA Streets success has helped to change people's perceptions about conventional storm sewer design by showing conservation BMPs with naturalistic streetscapes actually functioning for stormwater management. Not only were construction costs reduced with conservation BMPs, but water quality was improved (see Horner, et al.).

Built-Site Conclusions
The case studies provide a valuable view of real-world practices that support the proposition that conservation development can generally be cost-effective and result in other value-added benefits. The largest cost savings across all cases were mainly derived from site preparation, stormwater management, site paving and sidewalks. The benefits included long-term landscaping maintenance savings, potentially higher real estate values, the advantages of additional open space, and well-planned community-oriented site components and layouts. These cases suggest that the relative cost benefits are roughly similar for a wide range of development types and scales, whether they are moderate-density or rural residential, commercial, or streetscape (see also the following template analysis).

Two conservation techniques appear to have the most direct influence on cost savings: clustering design, which reduces street length and width, and stormwater management. In agreement with the literature review, the built-sites analysis shows that clustering design contributes a significant cost savings for site paving and sidewalks and for stormwater management. The degree of savings depends on the intensity of clustering, which is very site and project dependent.

The costs and benefits of conservation development also depend on how many "green" techniques are implemented on a particular site. These built-site cases primarily employed many of the more basic "green" techniques such as reduced street width and length, bioswales, and native landscaping. More "advanced" conservation design techniques such as porous paving and green roofs were not seen in these case studies (see the Literature Review and Commercial Template analyses). More case studies are needed to analyze the potential benefits and cost efficiencies of a broader suite of conservation techniques.

Finally, it is worth noting that conservation development is not limited to engineering for stormwater management, or to landscape practices. All methods of land and resource management that lead to a sustainable future, ranging from energy conservation to local organic farming to transportation alternatives should be considered for new developments because of the host of benefits they can provide to residents, business owners, and communities. While they were not directly a part of the built-site analysis, long-term maintenance and life-cycle analysis for conservation practices should also be considered.

Template Cost Analysis

These cost evaluations were prepared as a follow-up to the Blackberry Creek Watershed Alternative Futures Analysis project (Conservation Design Forum, 2003; hereafter, the BBC Watershed Analysis. See Appendix 7). A follow up question from this study was: What would these conceptual template designs cost a developer if they choose to implement these 'green' conservation-based designs?

Under the initial project, two density-neutral design templates were developed to illustrate the differences between conservation and conventional site design and stormwater management approaches. The conventional and conservation templates were then evaluated to estimate the differences in runoff response for each of four template land uses (commercial, moderate density residential, rural residential, and estate residential). Higher urban densities were not part of the initial project scope, and so could not be analyzed for costs in this study. "Conservation" for this study refers to techniques and best management practices (BMPs) that are based on ecologically-sensitive design and planning principles with a particular focus on stormwater management. Generally conservation templates use integrated, state-of-the-art technologies, designs, and site planning to achieve stormwater, habitat, livability, restoration, and other ecological goals.

As explained at the beginning of this report, conventional development refers to practices typical in land development and building construction today in northeastern Illinois. Even though conservation and conventional designs may both be allowed by code, conventional design techniques represent the default designs and practices for a majority of communities and developers.

This analysis compares costs between conventional and conservation construction for typical land uses in the region based on the previously published conceptual template site designs. For this study, stormwater management and water quality are the driving principals in the conservation design approach. Many other social and cultural benefits have been documented, but do not play a role in determining the template costs evaluated here.

The real-life research and actual built-site comparisons of the previous two sections reveal much about the costs and design trends associated with conservation design. However, due to the varying conditions of site and region, the review cannot directly compare the capital costs associated with developing a particular land parcel using one design approach versus another. Therefore, this analysis attempts to control for outside forces such as differing community benefits, agency regulations, topography and other site conditions, land costs that vary with location and construction time, associated traffic costs, and infrastructure connection costs.

The analysis attempts to: 1) compare similar infrastructure-based divisions within each set of templates, using real unit-costs in the Midwest; 2) determine the potential savings or additional expenses associated with the overall design concepts; and 3) determine which infrastructure divisions are shown to be most cost-effective. It hypothesizes that conservation design can generally be more economical, or similarly as affordable for the immediate capital construction costs for different land uses. The template analysis will, therefore, help determine and clarify the degree of cost-effectiveness for conservation design approaches in each land-use type.

Limitations

- This cost comparison is limited to the stormwater infrastructure and related systems of site design. All water entering into the system and leaving the system is considered. Building costs and auxiliary utilities have not been included.
- No effort was made to minimize costs. The Blackberry templates were intended to illustrate a maximum application of conservation approaches and practices. This is most evident in the commercial land-use template, where every attempt was made to prevent stormwater impacts for a traditionally impervious land use. As described in the Alternative Futures Analysis report, this goal was largely achieved. In reality, most new developments will implement a subset of the measures identified in the templates. That subset may not achieve the same level of benefits as illustrated in the Alternatives report. However, significant benefits can still be achieved and development costs mitigated.
- The cost analysis does not consider the actual value of the land. Land value is typically a greater factor in

higher density areas where land devoted to detention land requirements plays a larger factor in overall cost. Under current regulations prevalent in northeastern Illinois, the higher-cost techniques will be most cost-effective on such sites, where the space required for conventional detention is expensive and limits development potential.

- Due to the conceptual nature of these comparisons, a life-cycle cost analysis was too extensive to include. However, life-cycle cost analysis is a critical part of the forward thinking required to analyze true conservation design. As alluded to in the literature analysis, the importance of life-cycle analysis should not be diminished by its omission from this study.
- Unit costs for construction vary with season and demand. Typical unit costs for northeastern Illinois were used for comparison purposes. Unit costs were based on RS Means 2003 for much of the pricing, while local suppliers and local bid costs were also used. Pricing errors associated with the assumed unit cost should not have a significant impact on the relative cost of the conventional or conservation designs since most unit prices are transferable or similar in both cost estimates.
- The ecological and social benefits of ‘green’ design are significant driving factors for those who choose conservation design; however they are not addressed directly in this analysis.
- Costs associated with private driveways and private landscaping are not included in the residential templates.

Template Designs

Each template was designed for a hypothetical 40-acre site in the Blackberry Creek Watershed, due to its predominance as a common parcel size. The templates were categorized by land use according to the Kane County 2020 Land Use Plan. Costs were estimated for the following land uses:

Moderate Density Residential (identified as Urban Residential in the Kane County Plan; at 2.2 units per acre gross density),
Rural Residential (0.55 units per acre gross density),
Estate Residential (0.20 units per acre gross density), and
Commercial/Industrial.

Each of the four land use templates has two versions - a conventional and a conservation - for a total of eight templates. Both templates in each category are density neutral, using identical numbers of units, commercial square footage, etc., but are arranged and organized in different ways over the site to illustrate different stormwater management and landscaping techniques.

The conservation templates incorporated the following Environmental Design Principles:

1. Development should avoid, to the extent possible, natural features, including streams, wetlands, remnant natural areas, and critical habitats.
2. The site plan should respect site topography, utilizing natural drainage patterns to minimize site grading and the need for built infrastructure.
3. Clustering of built areas, a range of lot sizes, and other design techniques should be used to create views, privacy, and amenities for each home site. This also facilitates protection of site natural areas, efficient utilization of site topography, integration of naturalized storm-water management systems, and provision of common open space.
4. Created native landscapes should be integrated into the stormwater management system to utilize their natural filtration, infiltration, storage, and transpiration processes.
5. Where appropriate, engineered systems based on natural processes should be utilized as part of the stormwater management system for the purpose of enhancing groundwater recharge, stabilizing site and regional hydrology, and minimizing irrigation needs.
6. Stormwater should be managed as close to its source as feasible.

Cost Comparisons

This analysis includes: 1) a description of the proposed infrastructure for both conventional and conservation designs; 2) a cost estimate summary; 3) an evaluation of the cost and trends presented; 4) the conceptual illustration for each template; and 5) a detailed unit-cost based analysis (see Appendix 8).

Each cost comparison is organized by standard construction divisions related to site design and stormwater

infrastructure. Due to the different site layout and planning techniques used, the site hardscape and street layout will also differ. For this reason, water and sewer have been included due to their direct relation to street layout. A cost premium for green roof installation was used in the conservation template for commercial/industrial, since roofs are typically not included as part of site costs. Infrastructure divisions include:

- Site Preparation
- Stormwater Management
- Sanitary Sewer
- Water Distribution
- Site Paving and Sidewalks
- Landscape Development
- Green Roof (Commercial/Industrial Only)

Typical design cost for each development was assumed to be 10% of construction costs. However, for the Commercial/Industrial and Moderate Density templates, conservation designs were assumed to be 12% of construction costs. The greater costs were assumed because of two factors. First, additional time is typically required to educate local officials and work with existing code that is not structured to consider the benefits of conservation design and the related stormwater BMPs. This has not been found to prevent conservation design, yet it increases the amount of discussions and meetings, submittals, and back-up information required. As local officials and permit reviewers become more familiar with innovative stormwater techniques and the basis of conservation design, the time investment is expected to decrease and should become less of a factor.

Second, many still debate whether or not conservation construction reduces stormwater infrastructure cost. Therefore, this study assumes that site and stormwater design costs will increase slightly due to the increased need for information about the land and more complex modeling of the site that is often required.

FIGURE 12. Moderate Density Template- Conventional & Conservation. Image courtesy of Conservation Design Forum

Moderate Density Residential Templates

Moderate density residential development is defined for this project as having a gross density of approximately two units per acre with single family lot sizes ranging from 6,000 to 15,000 square feet which are planned to be served with municipal water and sewer services. As previously stated, the two template versions are density neutral with a total of 89 lots developed into each template site.

Conventional Description

The Conventional Template includes wider roads, no public open space, and storm sewers discharging into turf and/or rip-rap lined detention basins. Due to the impervious surfaces and infrastructure-based drainage systems, hydrology is shifted from groundwater dominated to surface water dominated.

Site Preparation

General site preparation techniques include clearing and grubbing and fine grading of the entire site as well as clearing and grading techniques that may balance, yet also flatten, the site for ease of construction.

Stormwater Management

Conventional Moderate Density Residential template development has been designed to direct runoff from streets, driveways, and lawns via piping to temporary detention basins before releasing it offsite. The entire development is served by curb, gutter, and storm sewer drainage. While detention is quite effective at controlling the rate of runoff, it does little to address the increased volume of runoff, and hence its effectiveness decreases with increasing watershed size.

Modeling conducted in the BBC Watershed Analysis determined that 15 ac-ft of detention must be provided. Detention basins were assumed to be edged with rip rap and do not create a recreation or aesthetic amenity for the neighborhood.

Sanitary Sewer

A traditional sanitary sewer system was laid out to serve all homes and assumed to require the same length of piping as road length with one connection to the existing sanitary trunk line.

Water Distribution

A traditional 8-inch water distribution system was laid out to serve all homes and assumed to require the same length of piping as road length and one connection to the existing water main. Fire hydrants were installed on the water main as required by code.

Site Paving and Sidewalks

Residential roadways were assumed to be 32-foot for both the local and collector roads. A 5-foot concrete sidewalk and curbing along both sides was included for all roads. Asphalt parking areas for residences are paved and include exterior parking space, with room for at least two cars per single family housing unit. This driveway layout was assumed to be identical for both templates and not included into the cost estimate.

Landscape Development

Public open space is often limited to road rights-of-way and small isolated park lands. Lot sizes were standardized with little variety. Street trees were placed on within the parkway approximately 50 feet apart based upon a typical subdivision code requirement. Seeded turf grass was assumed for all common spaces. The cost comparison did not include any on-lot landscaping, typically consisting of shrub, tree, lawn, and perennial plantings and irrigation.

COST	ITEM	CONVENTIONAL	CONSERVATION
CAPITAL COSTS	1. Site Preparation[1]	$ 938,000	$ 529,000
	2. Stormwater Management	$ 437,000	$ 395,000
	3. Sanitary Sewer	$ 309,000	$ 282,000
	4. Water Distribution	$ 330,000	$ 315,000
	5. Site Paving and Sidewalks	$ 873,000	$ 751,000
	6. Landscape Development	$ 109,000	$ 249,000
	Design Contingency[2]	$ 305,000	$ 309,000
TOTAL CAPITAL COST		**$ 3,350,000**	**$ 2,880,000**
PER LOT[3]	Not Including Building, Site Appurtenances, and Land Costs	**$ 38,000**	**$ 32,000**

NOTES:
[1] Assume less overall grading disturbance per acre.
[2] Design cost contingency assumed at 10% for Conventional and 12% for Conservation.
[3] Based on 89 lots per 40 acres.

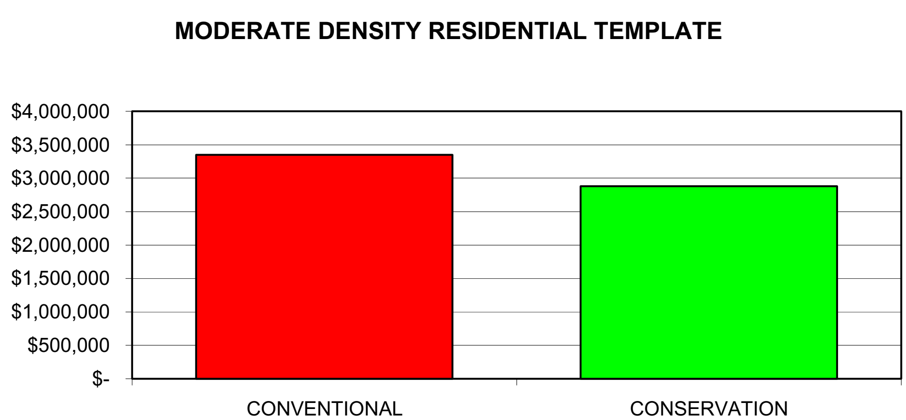


TABLE 25. Moderate Density Residential Template Summary.

Conservation Description

The Conservation template includes narrower streets and an integrated, naturalized stormwater system in community space that hosts public trails and locates each residential lot adjacent to open space. Conservation moderate-density residential developments can take to form of cluster housing, with varied lot sizes at the same gross density as the conventional development while preserving and/or creating ecological and stormwater corridors. Clustering creates opportunities to develop neighborhood amenities, including parks and recreation facilities.

Site Preparation

General site preparation techniques are also incorporated into conservation design. This, however, includes clearing and grubbing only 27 acres of the site due to the clustering of homes and restored conservation areas. Clearing and grading techniques to balance the site are reduced by designing with site topography in mind as well as a reduced area of disturbance.

Stormwater Management

The street and front yard runoff are directed to shallow street parkway bioswales, with an infiltration trench beneath. The excess surface runoff from the roadway bioswales, runoff from the backyards, and roof runoff are conveyed to the vegetated swale - rain garden in the common space. An area averaging 35-foot in width is planned between the trails to enhance adsorption of the runoff.

Modeling conducted for the BBC Watershed Analysis determined that 6 ac-ft of detention is needed. Detention areas are naturalized and designed to mimic natural wetlands and are part of a network of open space within and outside the development.

Sanitary Sewer

A traditional sanitary sewer system was laid out to serve all homes. It was assumed to require the same length of piping as road length with one connection to the existing sanitary trunk line.

Water Distribution

A traditional 8-inch water distribution system was laid out to serve all homes and assumed to require the same length of piping as road length and one connection to the existing water main. Fire hydrants were installed on the water main as required by code.

Site Paving and Sidewalks

Streets are narrowed to reduce traffic speeds and decrease impervious cover. Local residential roadways were narrowed to 27 feet wide while the collector remained at 32 feet wide.

A 5 ft sidewalk and a street cross section without curbing has been designed along both sides the 27 ft roadway. The streets were lined with stormwater conveyance swales. A secondary pedestrian system was designed with limestone screening pathways running within the internal open space parkway.

A 5 ft concrete sidewalk along one side and concrete curbing was designed along the main collector road.

Landscape Development

A natural area buffer and prairie/savanna restoration were planned for 17 acres of common space. Street trees were planned in the parkway spaced every 50 feet or so based upon typical subdivision code requirement.

Clustering and decreased lot sizes allowed for every lot to adjacent to naturalized open space and/or turf park land that is also part of the drainage system. Common area parks and naturalized

open space were designed with an interwoven pattern across the entire development to connect habitats, provide stormwater infiltration and conveyance, and provide recreational opportunities to residents.

Typical on-lot landscaping was not included in the cost comparison (e.g., shrub, tree, perennial plantings and irrigation).

Results and Discussion

This cost comparison shows that the incorporation of conservation design into developed sites like the Moderate Density Residential template will result in overall capital cost savings consistent throughout most of the cost divisions. The general per-lot site cost for the conventional development is $38,000 per lot versus $32,000 for the conservation approach, a savings of just over 15 percent. This cost savings trend is comparable to, but not as high as the overall cost saving in the Bielinski Home Case Study (see the Built Site Analysis).

Site preparation for the moderate density residential site is expected to be less for the conservation design, since nearly 13 acres of site are minimally disturbed due to the reduced land requirements for clustering of homes. Savings can be achieved by minimizing the required clearing and grading by designing around the grades and fitting the site plan to the land.

Stormwater management systems are nearly similar for conventional and conservation design. Cost savings due to the reduction of detention and buried infrastructure are slightly greater than the increased cost of localized and naturalized stormwater management practices. Only 60% of the conventional detention volume is required for the conservation design due to localized stormwater management techniques.

Sewer and Water infrastructure costs vary with the degree of clustering and length of roadway. Both sanitary sewer and water infrastructure costs range from slightly less to nearly similar for both conventional and conservation development.

Even with the added pedestrian corridors, recreational limestone paths and improved sidewalk access, Site Paving and Sidewalk costs were less for the conservation design. Savings can be attributed to the narrowed streets and reduction of curbing throughout all residential streets.

Landscape costs for the conservation design were greater than for the conventional design due to the increase in the amount of common space that is a development cost, as opposed to on-lot landscape costs, which are generally borne by the home purchaser. These common areas were planned with native prairie plantings, and naturalized plantings in rain gardens and swales.

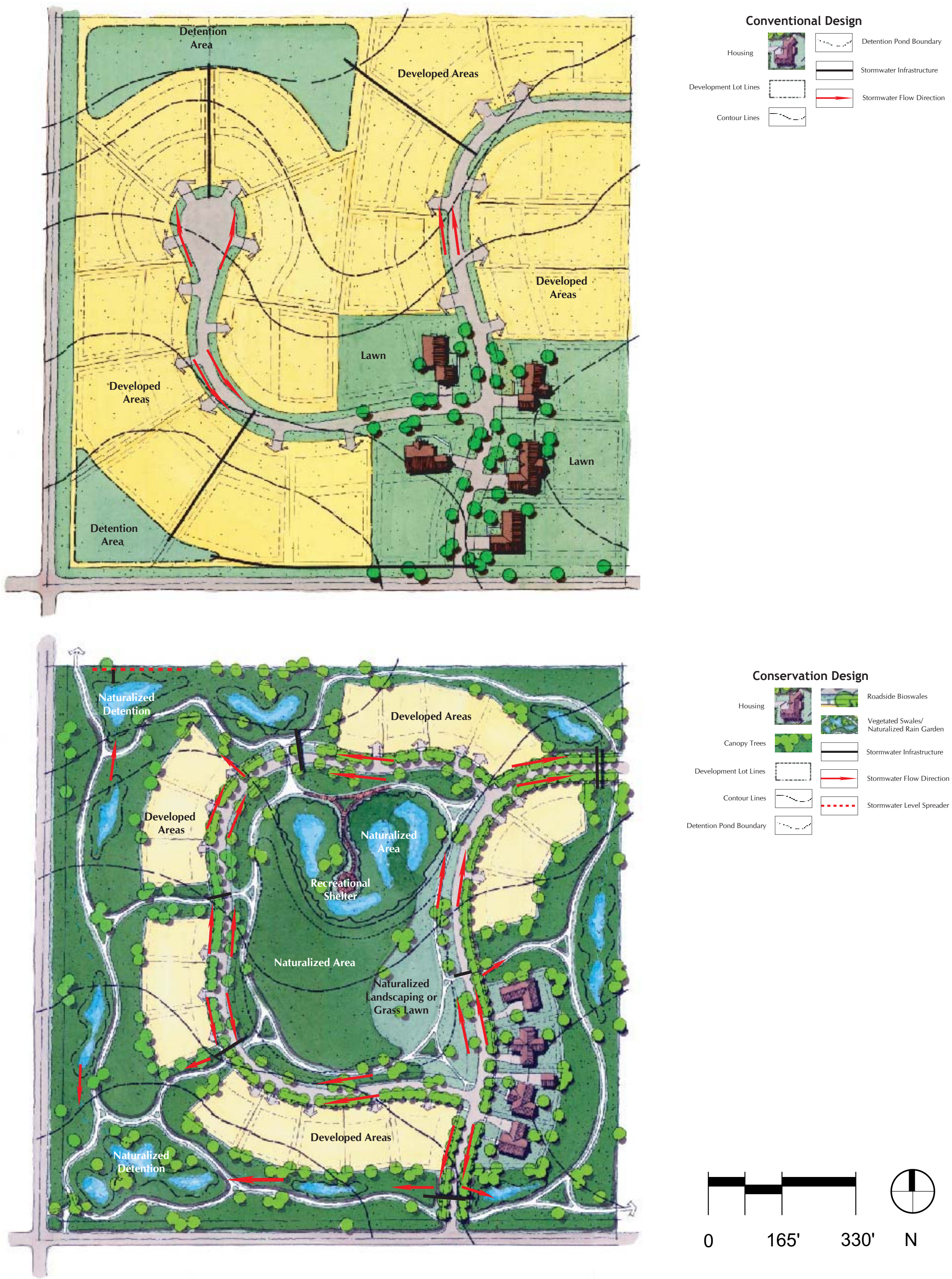


FIGURE 13. Rural Residential Template- Conventional & Conservation. Image courtesy of Conservation Design Forum

Rural Residential Templates

The Rural Residential Templates have single family lots which average approximately 1.25 acres, and a gross density of 0.55 units per acre. It is assumed that on-site water supply and wastewater treatment will be necessary. A total of 22 lots are shown in each version.

Conventional Description

The Conventional Rural Residential Template is planned with a cul-de-sac drained with traditional roadside swales and storm culverts discharging into large detention basins.

Site Preparation

General site preparation techniques include clearing and grubbing and fine grading of 36 acres of the site. Typically most of the site will be disturbed. Clearing and grading techniques may balance, but tend to flatten the developed portion of the site for easy construction.

Stormwater management

Many developments at this density are served by open drainage systems, yet many large-lot developments within municipalities have been increasingly using curb and gutter drainage with storm sewers. For this study, the development is assumed to be served by traditional road side swale systems with storm culvert drainage for consistency between templates.

The detention basins are assumed at the edge of the development with turf and rip rap reinforcement at the shoreline. Modeling conducted in the BBC Watershed Analysis determined that 10 ac-ft of detention volume must be provided.

Sanitary Sewer

Individual septic systems have been assumed to serve all 22 homes.

Water Distribution

Individual private wells have been assumed to serve all 22 homes.

Site Paving and Sidewalks

In these relatively low-density subdivisions, winding streets with cul-de-sacs and few connections to major collector roadways are the commonly used planning idiom. These plans are often criticized for issues that are beyond the scope of this study, such as the creation of disjointed neighborhoods, resulting in traffic congestion. As is common with this density, roads are also generally wider than necessary for the traffic they support, increasing stormwater runoff and encouraging higher speeds. This template assumed a 27-foot residential road with a 32-foot collector.

Although sometimes sidewalks are included in conventional large lot developments, typically they are not unless required by code. Therefore no sidewalks were included here. Setbacks are large, necessitating long paved driveways which further increases impervious cover.

Landscape Development

Lot sizes were standardized with little variety. Street trees were planned based on typical subdivision code requirements. Seeded turf grass was planned as landscape cover for the common open spaces. Typical on-lot landscaping (e.g., shrubs, trees, perennial plantings and irrigation) was not included in the cost comparison.

Conservation Description

The Conservation Rural Residential Template includes narrower drive lanes and a naturalized stormwater system

COST	ITEM	CONVENTIONAL	CONSERVATION
CAPITAL COSTS	1. Site Preparation[1]	$ 609,000	$ 353,000
	2. Stormwater Management	$ 227,000	$ 102,000
	3. Sanitary Sewer[2]	$ 99,000	$ 200,000
	Constructed Wetland Premium		*$ 101,000*
	4. Water Distribution	$ 98,000	$ 98,000
	5. Site Paving and Sidewalks[3]	$ 253,000	$ 358,000
	6. Landscape Development	$ 102,000	$ 184,000
	Design Contingency[4]	$ 142,000	$ 133,000
TOTAL CAPITAL COST		**$ 1,570,000**	**$ 1,470,000**
PER LOT[5]	Not Including Building, Site Appurtenances, and Land Costs	**$ 71,000**	**$ 67,000**

NOTES:
[1] Assume clearing grubbing non-open space areas only and less overall grading disturbance per acre.
[2] Traditional septic versus constructed wetland with land application.
[3] Includes community enhancing site amenities such as secondary limestone paths, sidewalks and boardwalk.
[4] Design cost contingency assumed at 10% for Conventional and 12% for Conservation.
[5] Based on 22 lots per 40 acres.

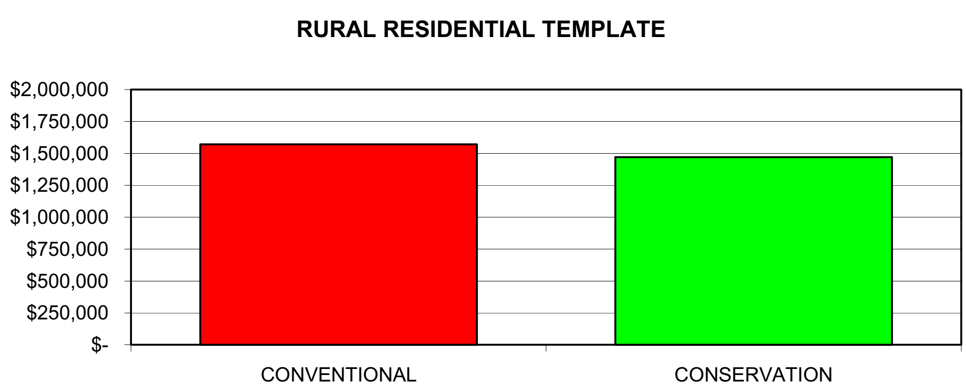


TABLE 26. Rural Residential Template Summary.

using the landscape to filter, evapotranspire, and absorb runoff. The layout includes walking/ biking trails for greater pedestrian use. The conservation rural residential development has the same gross density as the conventional development template. However, reduced lot sizes and clustering are employed to create shared common open space, and conservation easements are used to protect natural areas and create native landscape-based habitat and stormwater infiltration corridors.

Site Preparation

General site preparation techniques are also incorporated into the conservation design. This includes clearing, grubbing and fine grading of only 18 acres of the 40 acre site due to the clustering of homes and created conservation areas. Clearing and grading techniques to balance the site are also reduced by minimizing the impact to the site by designing with site topography in mind.

Stormwater management

The objective of the stormwater system is to utilize the significant amount of common open space to filter and absorb runoff and replicate the natural site hydrology. Stormwater is conveyed via naturalized roadside bioswales. Detention areas are naturalized, enhancing overall ecological integrity, while at the same time improving the aesthetic quality and rural character of the site.

Both the interior and perimeter roads were drained with prairie-vegetated swales. Detention areas were naturalized and designed to mimic natural wetlands. Modeling conducted for the BBC Watershed Analysis determined that 2.5 ac-ft of detention volume is required.

Sanitary Sewer

The wastewater system consists of individual septic tanks that flow to a common treatment system incorporating subsurface constructed wetlands with land application. This system is one of a variety of on-site wastewater recycling and reuse technologies that have been installed and operated in the Midwest as an alternative to individual septic fields and create the opportunity for clustered development in an ecologically sound fashion.

Water Distribution

Individual private wells have been assumed to serve all 22 homes.

Site Paving and Sidewalks

Roads in low density conservation developments are generally narrower on average, are designed at a more human scale, and for slower, safer speeds for neighborhoods. Road widths have been shown at 24 feet for the residential and 27 feet for the collectors. Sidewalks are included along all roadways for pedestrian access.

Several site amenities have been included in the conservation approach to improve community connection between neighbors and their land. Trail systems are located in the natural areas and roadways. A boardwalk into the naturalized area has been included into the design as a central feature.

Landscape Development

Street trees were planned in the parkway based upon typical subdivision code requirements. Seeded turf grass was planned for the central park common area. Typical on-lot landscaping (shrubs, trees, perennial plantings and irrigation) was not included in the cost comparison.

Wildlife habitat, native landscaping, and common space occur on over 21 acres in the central space and in the perimeter, visible from the front and rear of all of the homes. Over 50 percent of the entire parcel is set aside for common space. Most of the common areas were planned as restored

prairie and swales with the exception of a small community turf play area. This centralized area of the site is also required for the constructed wetlands and disposal fields (leach/drip irrigation). Since these areas have been set aside for common space, the planting costs are assumed as development expenses in this template.

Results and Discussion

This analysis shows that development costs for this conservation design are slightly less than the costs associated with typical conventional design for Rural Residential sites. Additionally, the conservation design approach assumes many community amenities that have not been included in the conventional approach. These amenities include added sidewalks, pathways, a nature boardwalk, community spaces, and views of restored prairie.

Savings are realized in site preparation and stormwater management, and can be attributed to: 1) improved stormwater quality through naturalization; 2) enhanced wastewater treatment leading to improved groundwater quality; and 3) increased community and pedestrian circulation. The general per-lot costs for the conventional development are shown to be $71,000 per lot versus $67,000 per lot for the conservation approach, a savings of 5.6 percent.

Site preparation costs have been assumed to be consistent with the other land-use templates. While these costs are relative based upon existing conditions, they are generally reduced from conventional to conservation in the rural templates, due to the additional 18 acres that have been set aside for prairie restoration and open space, thereby greatly minimizing the disturbed parcel area. Savings are again seen by minimizing the required clearing and grading in the disturbed areas by designing with the grades and minimizing fine grading.

Over 50% cost savings are realized for a conservation stormwater management system. These large cost savings are due to the 75% reduction of detention volume requirement and minimized piping costs by using localized stormwater management BMPs. This reduction of cost is complimented by the improved aesthetic aspects of the design, which are arguably more “rural” in character, and therefore create greater real estate value.

Both sanitary sewer and water infrastructure costs would be expected to be nearly similar for both conventional and conservation development if they utilized identical systems. However, an enhanced naturalized wastewater treatment design was included in the conservation template to allow clustering and create an ecologically superior water treatment approach. Yet, even with a doubling of the cost for enhanced onsite wastewater treatment, the overall site development cost is nearly the same. While the cost for individual well and septic fields is typically borne by the home builder or buyer, the lot price of the collective system in the conservation approach could reflect the benefit of already having these systems in place. An expected savings in overall cost of $101,000 (over ten percent) over a conventional approach could be realized by implementing the conservation approach. This result matches conservation designs presented in the Built Site Analysis Section.

Site Paving and Sidewalk costs are increased for conservation design because pedestrian corridors were added to the basic construction and planning practices assumed by the conventional template. Also, due to the large amounts of land in common space in the conservation approach, which are planned to be restored into prairie and wetland, landscape costs are greater than for the conventional approach. These are both value-added aspects that could be marketed for premiums and/or increase sales velocity over conventional subdivisions.

FIGURE 14. Estate Residential Template- Conventional & Conservation. Image courtesy of Conservation Design Forum

Estate Residential Template

The Estate Residential Templates are planned with single family lots averaging approximately 2.5 acres in size, or approximately 0.2 units per acre, which are served by private well and septic systems. A total of eight lots are shown on the parcel. Both conventional and conservation templates have been laid out with essentially the same cul-de-sac road pattern and lot lines. Open swale drainage systems were used in both versions of the Estate Residential Template.

Conventional Description

The Conventional Template has typical house placements centered in the lots, resulting in generally longer driveways. The lots are primarily landscaped with manicured lawns.

Site Preparation

General site preparation techniques include clearing, grubbing and fine grading for the entire site. Clearing and grading is minimal for each, however it has been assumed that the developed portion of the site has been leveled for ease of construction. Fine grading is required over the entire site devoted to lawn landscape.

Stormwater management

Requirements for stormwater detention are met through the provision of turf grass depressions and/or constructed ponds. Stormwater is conveyed via roadside turf swales and culverts to the detention pond. Roads are to be drained by turf swales approximately 10 feet wide. The required detention pond has been modeled with eight acre-feet of volume.

Sanitary Sewer

Individual septic systems have been assumed to serve all 8 homes.

Water Distribution

Individual private wells have been assumed to serve all 8 homes.

Site Paving and Sidewalks

The cul-de-sac roadway has been shown as 24’ wide. No sidewalks or curbs are required or included for this type of development. Driveways in conventional estate residential developments tend to be long and paved with standard impermeable asphalt and may include a drop off area and several outdoor parking spaces.

Landscape Development

Turf lawns are the dominating landscape feature of these subdivisions and have been assumed for the entirety of the lots based upon conventional practice. Irrigation was assumed for front yards and landscaped areas, or 10% of the site. The cost does not include typical shrub, tree and perennial plantings.

Conservation Description

The Conservation Estate Residential development is laid out in a similar pattern to the conventional template, but is very different ecologically. Although the same gross density is maintained and actual lot sizes are the same, the area impacted by development is much smaller as only the ground necessary for structures and septic systems is disturbed by equipment. The remaining areas are preserved or restored to a native landscape. The template has shorter driveways and uses native plantings and conservation easements.

COST	ITEM	CONVENTIONAL	CONSERVATION
CAPITAL COSTS	1. Site Preparation[1]	$ 548,000	$ 329,000
	2. Stormwater Management	$ 158,000	$ 29,000
	3. Sanitary Sewer	$ 36,000	$ 36,000
	4. Water Distribution	$ 36,000	$ 36,000
	5. Site Paving and Sidewalks	$ 63,000	$ 91,000
	6. Landscape Development	$ 570,000	$ 256,000
	Design Contingency[2]	$ 145,000	$ 81,000
TOTAL CAPITAL COST		**$ 1,590,000**	**$ 900,000**
PER LOT[3]	Not Including Building, Site Appurtenances, and Land Costs	**$ 200,000**	**$ 110,000**

NOTES:
[1] Assume less overall grading disturbance per acre.
[2] Design cost contingency assumed at 10% for Conventional and 12% for Conservation.
[3] Based on 8 lots per 40 acres.

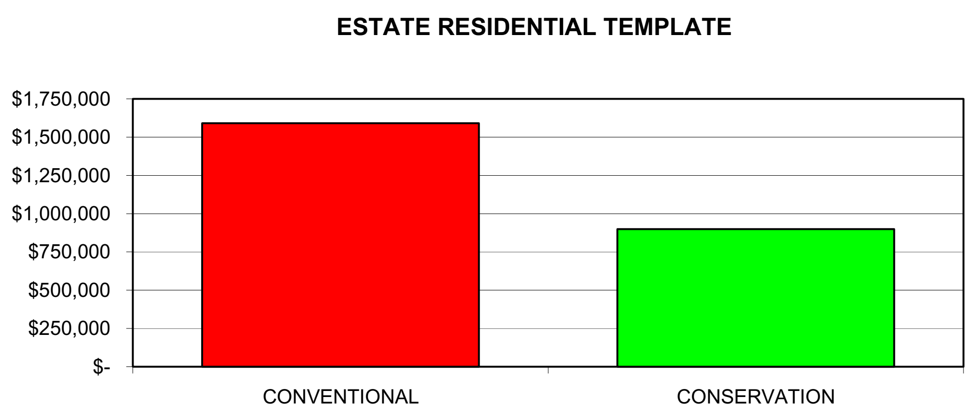


TABLE 27. Estate Residential Template Summary.

Site Preparation
General site preparation techniques include clearing and grubbing of 18 acres of the site and with fine grading for only 8.5 acres, since fine grading is not required for prairie restoration and natural buffer areas. Clearing and grading are balanced and minimal.

Stormwater Management
The goal for stormwater is to preserve and replicate the natural site hydrology. This is achieved by minimizing disturbed areas, using existing natural drainageways, and utilizing native landscapes to filter and retain runoff. Retention areas are designed as natural elements of the overall landscape. The road was assumed to be drained by prairie-vegetated swales with an interior cul-de-sac rain garden. The vegetated swales drain to the detention areas via wide prairie areas with minimal piping.

Sanitary Sewer
Individual septic systems were assumed to serve all 8 homes.

Water Distribution
Individual private wells were assumed to serve all 8 homes.

Site Paving and Sidewalks
The conservation estate road system is similar to the conventional, but the cul-de-sac has been designed with a vegetated island in the middle as part of the stormwater retention system. No curbs are incorporated into this plan (or in the convention version). Limestone screening paths are incorporated into pedestrian easements, which allow low-impact access to natural areas and other nearby neighborhoods.

Landscape Development
Design features are used to enhance the conservation estate development. Structures are moved slightly closer to the road to increase the amount of contiguous conservation easement land in the rear of lots.

Turf grass is included and limited to lawn areas immediately surrounding the home, while deep-rooted native plants occupy outer lawn areas and restored prairie conservation easements to the perimeter. One quarter of the non-impervious front yard was assumed to be planted in prairie vegetation and the remainder was assumed to be turf. Three quarters of the back yard was assumed to be prairie. Irrigation was included as lush green lawn is still assumed for this real estate market segment. Since the total area of lawn is much smaller, only 20 percent of the front lawn area is irrigated.

Costs do not include typical shrub, tree and perennial plantings, or other on-lot landscape expenses.

Results and Discussion
This cost analysis shows that the conservation design could save about 45% over conventional design for Estate residential sites. Savings are realized in stormwater management, site preparation, and landscape development. The general per-lot site costs for conventional is $200,000 per lot vs. $110,000 for the conservation approach.

As consistent with the previous templates, site preparation, is expected to be reduced for conservation. Fine grading is minimized due to the natural area buffer and prairie. Also, savings are seen because the required clearing and grading is minimized by designing around the grades and preserving open space.

The stormwater management system for the conservation approach is around one-fifth the cost as would be required

for conventional practices. These significant cost savings are due to detention volume requirements that were reduced by a factor of eight. Localized stormwater management BMPs reduce cost and increase the natural aesthetics of the neighborhood.

Both sanitary sewer and water infrastructure costs were identical for both conventional and conservation versions.

However, site paving and sidewalk costs were over 40% higher for the conservation template, due to the basic community-based design approach and the added pedestrian corridors with recreational limestone paths and use of sidewalks. This cost increase is may be offset by the perceived aesthetic and recreation value of the homesites of a standard subdivision.

Turf and irrigation cost for conventional design is over twice the cost of conservation design landscaping, due to the traditional aesthetic need for large-expansive-green lawns for estate residential. The conservation aesthetic incorporates nearly 33 acres of land into prairie and savanna restoration or conservation easements for recreational use and pleasure. Both approaches assume full ground cover landscaping and partial irrigation as part of the development costs. While on-lot landscape for rural subdivisions is normally borne by the home builder or buyer, these costs could be included in the home purchase price, or the naturalized landscapes could be required to be installed by whoever is building the home.

FIGURE 15. Comercial Industrial Templates- Conventional & Conservation. Image courtesy of Conservation Design Forum

Commercial/Industrial Templates

Commercial/Industrial developments include retail, light industrial and offices in various scales from large scale "big box" retail stores and light industrial and office park development, to smaller scale restaurants, shops, and individual offices. The Commercial/Industrial Templates were evaluated for construction costs based on the two templates shown in the illustrations. For this land use only, a third cost analyses based on the original conservation design was conducted to evaluate a commercial site without the benefit or additional cost of green roofs (template not shown). All assumptions for these conservation templates are identical with exception to the green roof. The original conservation template has been designated 'Premium Conservation' and the conservation cost template without the green roof system has been designated 'Base Conservation'. The three analyzed templates are:

Conventional
Premium Conservation
Base Conservation (No Green Roof)

Like the other templates, the development units were held constant between the conventional and conservation versions of the commercial template. For this template, the square footage of commercial space and the number of parking spaces were held constant. However, because of the efficiency of the conservation template stormwater management systems, there is room within the conservation template for additional commercial space and parking. The value of this potential additional space was not factored into cost analysis due to the high degree of variability in rental rates based on location and use. However, this factor should be considered when evaluating the templates costs.

Conventional Description

The Conventional Template is laid out as a typical automobile-accessed strip mall, with two single-story "big box" retail stores, smaller shops, franchise outlots, and parking, landscaping and stormwater detention according to code. These sites typically have a large amount of surface parking, which often exceeds the needs of the businesses during the vast majority of hours of operation throughout the week and seasonally.

Site Preparation

General site preparation techniques include clearing and grubbing of the entire site, as well as clearing and grading techniques that may balance, yet also level the site for ease of construction.

Stormwater Management

Stormwater is conveyed via traditional storm sewer systems including one catch basin per developed acre and that discharge to large detention basins on the development fringe. Pipe sizing was estimated as a 12-inch average storm sewer size. Because of the large amount of impervious cover, water level fluctuations in the detention basins are often large and frequent, leading to the need for rip-rap to protect the shoreline from erosion. Modeling conducted in the BBC Watershed Analysis determined that 22 ac-ft of detention volume is required.

Sanitary Sewer

A traditional sanitary sewer system was laid out to serve all building structures using the most direct layout and two connections to the existing sanitary trunk line.

Water Distribution

A traditional 8-inch water distribution system was laid out to serve all building structures using the most direct layout and two connections to the existing water main. A fire loop was installed around the buildings with one hydrant every 400 feet.

Site Paving and Sidewalks

Typically, the perimeter outlots are developed for fast food, banks, and other businesses. These outlots generally have their own parking, and are not easily accessed by pedestrians, even those shopping in the same center. The site was designed with a 24-foot wide access road and a 32-foot delivery road to

the back of the buildings. All roadways and raised parking islands were designed with standard curbing. Sidewalks were assumed to be 5-foot within the site and 12-foot adjacent to the stores and malls. All drivable and parking surfaces were covered with asphalt. Curbing was used to edge all roadways, parking areas and islands.

Landscape Development
Landscaping was limited to raised islands at the ends of parking isles and the exterior landscape perimeter adjacent to the main roadway. Standard small-diameter shrub and tree plantings were assumed throughout the site as are typically required. Turf grass was shown around detention basins and within the strip between the access roads and the parking lot and the buildings. Irrigation use was limited to only the front roadway/mall buffer landscape areas for plant establishment and maintenance.

Roof
Commercial and industrial developments are typically installed with flat asphalt or membrane roofs.

Premium Conservation Description
The Premium Conservation Template also has two "big box" retail stores, but in the conservation design, green roofs have been installed on the main structures and are designed as part of a "Main Street" retail setting, with a pedestrian plaza and both on-street and off-street parking. Sustainable technologies and designs are incorporated into conservation commercial developments to minimize the impact of impervious surfaces. Permeable paving systems are used in the parking lots along with stormwater infiltration bioswales as part of a naturalized and landscaped stormwater system.

Interconnected street systems with pedestrian and bicycle connections and infrastructure throughout provide public access to a variety of transportation alternatives. Conservation commercial developments can potentially be designed to fit any scale, and mix uses to encourage trip linking, day and night activity and reduced peak parking demands.

Site Preparation
General site preparation techniques are assumed in this conservation template. This includes clearing and grubbing of the entire site; however, clearing and grading requirements to balance the site could be somewhat reduced by minimizing the average excavation impact to the site by respecting existing site topography.

Stormwater management
Green roofs, biofiltration swales, rain gardens, porous pavement, and naturalized detention ponds are incorporated into the stormwater management of this template. A bioswale running down the center of the "main-street" area of the template was assumed to treat runoff from the adjacent roofs, walks, and roads. Rain gardens in a number of locations were used to filter and absorb runoff from adjacent impervious areas. The runoff from the impervious patio areas behind the main-street buildings was assumed to drain to the large rain gardens on either side of the traffic circle. These rain gardens are actually much larger than was necessary to achieve the stormwater objectives. Thus, there would be an opportunity to reduce the area of these rain gardens to provide additional commercial or parking space.

Porous pavement has been utilized within the north and west parking lots along with parking island bio-infiltration swales to minimize the impact of stormwater runoff associated with typically large impervious areas. There is considerable runoff storage within the aggregate beneath the permeable pavers, leading to a significant reduction in the amount of conventional detention required to meet local stormwater release rate requirements.

Modeling conducted in the BBC Watershed Analysis determined that 12 ac-ft of detention volume would be needed, a reduction of nearly 50% as compared to the conventional approach. This reduction in conventional detention requirements is largely the result of the large amount of storage distributed throughout the site beneath the permeable paving and within the bio-infiltration swales. Naturalized detention ponds have been assumed using native plantings and natural erosion control techniques.

Sanitary Sewer

A traditional sanitary sewer system was laid out to serve all building structures using the most direct layout and two connections to the existing sanitary trunk line.

Water Distribution

A traditional 8-inch water distribution system was laid out to serve all building structures using the most direct layout and two connections to the existing water main. A fire loop was installed around the buildings with one hydrant every 400 feet.

Site Paving and Sidewalks

Most parking areas are assumed to be paved with interlocking permeable concrete pavers for infiltration. Pedestrian access through the site is improved through the increased use of 5-foot sidewalks. Larger 8-foot sidewalks adjacent to all storefronts have been shown. A large paved plaza is shown in the central shop area for pedestrian gathering and was assumed as half paving and half landscaping. Access and delivery roadways were narrowed where possible and shown as asphalt pavement. Concrete curbing is utilized throughout.

Interlocking permeable concrete pavers were specified for this template due to their longevity, maintainability, and resistance to surface coating with impermeable sealers. However, a lower capital cost option would be use of permeable asphalt. Permeable asphalt has been used in other northern climates with good results. Permeable asphalt's greatest drawbacks are reduced longevity relative to pavers (but same as conventional asphalt) and its potential for seal coating, rendering it impervious.

Landscape Development

Landscape costs assumed a similar intensity of shrub and tree plantings as the conventional version throughout the site. However all landscape buffer strips around detention basins and between the access roads and the parking lot and the buildings are planned with a naturalized planting approach. No irrigation is needed in these naturalized buffer areas.

Green Roof

Green roofs were planned into the two main commercial buildings to intercept and absorb a portion of the rainfall. The two largest buildings were assumed to have shallow extensive green roof systems installed (approximately 3" soil media depth). For cost comparison, the green roof was estimated as an additional cost premium above and beyond traditional roofing cost. This cost was incorporated into the site design due to the stormwater detention and retention capabilities of the system.

Base Conservation Description

The Base Conservation evaluation assumes an identical layout, site materials, and stormwater best management practices as the Premium Conservation Design with the exception of the green roof. The green roof was removed from the base design first-cost option to evaluate the effect of green roof on the overall cost, stormwater mitigation, and to offer a more economical option for conservation design for developer and property owners.

Site Preparation, Sanitary Sewer, Water Distribution, Site Paving and Sidewalks, and Landscape Development

All site items within these five (5) divisions have been assumed to be identical as the Premium Conservation design approaches.

COST	ITEM	CONVENTIONAL	PREMIUM CONSERVATION	BASE CONSERVATION
CAPITAL COSTS	1. Site Preparation[1]	$ 1,538,000	$ 1,229,000	$ 1,229,000
	2. Stormwater Management	$ 708,000	$ 495,000	$ 591,000
	3. Sanitary Sewer	$ 140,000	$ 127,000	$ 127,000
	4. Water Distribution	$ 229,000	$ 219,000	$ 219,000
	5. Site Paving and Sidewalks[2]	$ 2,550,000	$ 3,139,000	$ 3,139,000
	Machine Laid Porous Paving	*N/A*	*$ 2,020,000*	*$ 2,020,000*
	6. Landscape Development	$ 285,000	$ 178,000	$ 178,000
	7. Green Roof Premium[3]	$ -	$ 1,325,000	$ -
	Design Contingency[4]	$ 545,000	$ 805,000	$ 658,000
TOTAL CAPITAL COST	Base Costs	**$ 6,000,000**	**$ 6,195,000**	**$ 6,140,000**
	Green Roof Premium	**$ -**	**$ 1,325,000**	**$ -**
	TOTAL CAPITAL COST	**$ 6,000,000**	**$ 7,517,000**	**$ 6,141,000**
PER SQ FT RETAIL[5]	Not Including Building, Site Appurtenances, and Land Costs	**$ 18**	**$ 23**	**$ 18**

NOTES:
[1] Assume less overall grading disturbance per acre.
[2] Includes cost of machine laid interlocking permeable concrete pavers
[3] Green roof cost above and beyond traditional high reflective roofing cost.
[4] Design cost contingency assumed at 10% for Conventional and 12% for Conservation.
[5] Based on density neutral 332,500 sf multi-use retail space.

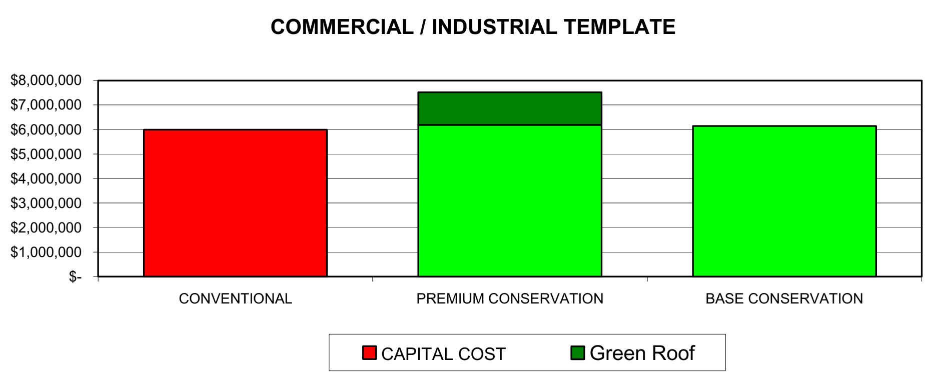


TABLE 28. Commercial/Industrial Template Summary.

Stormwater Management

Biofiltration swales, rain gardens, porous pavement, and naturalized detention ponds are incorporated into the stormwater management of the site. The green roof has been removed to reduce development capital cost. The removal of the green roof would increase the volume of detention required as presented in the premium design. Based on the NIPC BMP Course Manual detention sizing nomagraph, the overall required detention volume can be expected to increase to approximately 6 ac-ft.

Green Roof

Green roofs were removed from the two main commercial buildings, therefore reducing capital cost yet increasing runoff as compared with the Premium Conservation version.

Results and Discussion

This cost analysis shows that the Premium Conservation design for commercial or industrial sites will likely cost more to the developer or property owner (due to the green roofs on the large stores) than a conventionally-built development of similar scale. However, the Base Conservation approach as contrasted with the conventional design should be nearly equivalent in cost. So, in this hypothetical case, a highly-intensive green design may be more expensive for initial development and building construction costs. However, it is not conclusive as to which conservation approaches are beneficial and cost effective in all cases. A real-life development scenario would evaluate the relative costs and benefits and conclude the best combination for that situation. Land prices, local regulations, and other factors would weigh into those decisions. As stated previously, the conservation design practices incorporate storage throughout the site and therefore have the potential to provide additional developable square footage, which was not factored into the cost comparisons.

The site preparation for a commercial site is expected to be similar for both conventional and conservation designs since most, if not all, of the site would be heavily disturbed. Small but not insignificant savings are expected by minimizing the clearing and grading required by designing with greater respect to the existing grades and fitting the structure to the land. This practice has been relatively disregarded in most conventional commercial designs.

Stormwater management systems are shown to be greatly reduced in both the conservation designs due to the heavy reduction in buried infrastructure. Large amounts of money are saved due to a nearly 50% reduction in detention facility volume (Premium Conservation) and reduced conveyance piping. These cost savings are offset somewhat by the cost increase for localized stormwater BMPs and stormwater system planting to improve water quality (shown in the Landscape Development category).

Both sanitary sewer and water infrastructure costs can be expected to be similar for both conventional and conservation development. The costs for these templates show that the infrastructure cost is proportional to amount of clustering of buildings; the more spread out the structures, the higher the infrastructure piping costs.

Due to added pedestrian corridors, sidewalks, and a heavy premium on porous paving, Site Paving and Sidewalk costs are over double the cost for both conservation templates. Permeable interlocking concrete pavers, however, provide the benefits of stormwater mitigation, increased longevity, and improved aesthetics. The stormwater benefits could be retained while reducing construction costs if permeable asphalt was used instead of interlocking pavers. However, the longevity and aesthetic benefits would be lost when using permeable asphalt.

Landscape costs for both conservation design approaches are 40% less than the cost associated with conventional design. The cost for conventional turf installation and irrigation along the main buffers is much greater than the low maintenance native prairie buffer in the conservation designs that does not require irrigation and the associated water and energy infrastructure.

Roofing is the second largest cost variance (after porous pavement) for the conservation template. The comparison between the Premium and Base Conservation designs shows that it may be difficult to justify the increased cost of a green roof based on stormwater alone, at least for "greenfield" sites where available space and land costs are not

significant constraints. Where space is a restricted and the amount of required detention can reduce the amount of space available for development, green roofs can be very cost effective since the amount of detention required for green roofs can be as low as 20% of the volume required for conventional roofs. As discussed in the literature analysis, although a premium, green roofs have the benefits of stormwater quality improvement and mitigation, increased roof longevity, added aesthetics, reduced heating and cooling costs, and reduced heat island effects.

The general stormwater-based site costs for the Conventional and Base Conservation approaches are shown to cost per square-foot of retail space around $18 versus $23 for the Premium Conservation based approach. Although the costs for the premium conservation design are higher, there are several mitigating factors that have not been integrated into the design that would make the conservation approach more cost effective even with the green roof as part of the design.

- To illustrate a variety of stormwater management approaches, naturalized rain gardens were used to treat the runoff from the paved areas behind the main-street buildings. A more space-efficient approach would have been to use porous paving in these areas or a perimeter bioswale. If this approach were utilized the large areas associated with the rain gardens could have been utilized for additional building and/or parking. This variation would result in substantially greater leaseable space. It was the intention of the BBCW study to illustrate templates that had the same yield. Therefore, even though the Conservation versions could accommodate additional square footage, it was not shown, with the exception of possible second-story office or residential space above the Main Street stores.
- The design envisioned that the green roof areas would be accessible to an adjacent second story office space. Because of this outdoor space, it is likely that these units could be rented at a substantial premium. (A second story was not included in the analysis to retain the density neutral and identical footprint comparison)

Template Conclusions

Upon comparing the costs associated with each of the eight templates, this analysis raises observations on two topics: 1) land-use types most beneficial to conservation design, based strictly on capital cost; and 2) infrastructure concerns.

Land Use

Site preparation and mass grading can be a large cost on many site development projects. Costs can be reduced by using the existing topography as a basis to design the layout. Also, conservation easements and naturalized landscapes can reduce the amount of preparation and fine grading required since minimal land preparation is generally required to establish these landscapes.

A majority of the conservation templates, as designed for the BBC Watershed Analysis, are expected to cost the same or less with the exception of the 'Premium' Commercial/Industrial Template. The templates show a general correlation where, as density decreases, the percentage of capital cost savings for conservation design increases. However, as with all designs, each element and technique should be considered to support the overall project and community goals for whatever program, land use, or density is developed.

Commercial/Industrial

The Premium Conservation design is very much towards the green end of the development spectrum. As has been mentioned, each real-life project is unique, and must be planned according to the specific realities of the site, context, program, community, and other elements. Generally, conservation design can be cost competitive for dense and complete systems as long as a feasibility study is conducted to determine the cost-to-benefit ratio of the different components, and especially when long-term maintenance, energy use, employee satisfaction, and other factors are taken into account.

In the Commercial/Industrial template significant cost savings were associated with reducing the required detention volume by providing stormwater attenuation with green roofs, porous paving, and bioinfiltration swales. In reducing the required detention area by half, a sizable acreage of land could be freed development. The conservation template focused on increased stormwater quality and aesthetic value while maintaining a constant building square footage. Obviously, the ability to increase building square footage would increase the overall value of the development, and would be a preferred option for most developers.

Moderate Density, Rural and Estate Residential

These conservation design templates show a slight cost savings to the owner. In general, the cost saving associated with Moderate Density Residential and Rural Residential are comparable to the trends presented in the Built-Site Cost Analysis.

Estate Residential

The Estate Residential conservation template proves to be cost effective. This is largely due to the lower cost to establish natural landscape over the majority of the properties, rather than installing and maintaining manicured lawns throughout. The stormwater management costs are also greatly reduced.

Summary

The research and results derived from evaluating the costs to implement these specific designs help reinforce the evidence in the literature and built-site analyses that conservation design can be cost-effective. And, while highly intense green designs may not always be cost-effective in terms of initial capital costs, they can often be compared favorably with conventional forms using long term life-cycle costs, land value, marketing return, and desired aesthetic effects.

Infrastructure

Stormwater management infrastructure costs for the conservation templates are consistently more economical, ranging from a 10% to 80% reduction for Moderate Density Residential and Estate Residential, respectively. The added cost associated with swales, infiltration bioswales, and rain gardens is offset with cost savings associated with reduced stormwater infrastructure and reduced detention volume requirements. These costs do not include landscape planting in swale or detention ponds or costs associated with indirect BMPs such as green roofs and porous paving.

Both water supply and sanitary sewer systems can be expected to be similar for all conservation approaches. The exception is the example that uses enhanced waste water treatment on-site, which may or may not be economically viable depending upon the circumstances. Overall utility costs vary, depending on the clustering or spread of buildings and treatment level of wastewater. These decisions can be made between the owner and the regulatory agencies on a site-by-site basis.

Site paving and sidewalks are generally higher in cost for the choices made in the conservation templates, with the exception of the Moderate Density Development. Costs associated with asphalt paving in roadways and concrete curbing is often reduced due to roadway layout and width. However, the conservation design approach promoted increased pedestrian access through the incorporation of a network of sidewalks and secondary limestone chip paths. As shown in the literature, porous paving will increase the initial cost when directly compared to the use of asphalt, yet this cost increase will be somewhat mitigated through the reduced stormwater management costs and long term maintenance savings. Porous paving is not generally economical as a broad tool for all roadway applications, but can be extremely effective as a selective tool. Its cost-effectiveness depends in part on life-cycle benefits due to paver longevity and reduced maintenance.

Landscape development costs are generally higher for traditional land-use templates where large turf lawns and irrigation systems are installed. This is consistent with the Built Site Cost Analysis. Costs for low-maintenance, naturalized landscapes that perform multiple functions including stormwater cleansing and infiltration, passive recreation, and habitat restoration are generally lower that for highly maintained landscapes. However, the conservation templates typically include a higher ratio of common space as compared with conventional development. Therefore, there can be higher overall landscape establishment costs for the conservation alternatives. These discrepancies must be addressed in the overall site budget and the sale or lease price of the associated real estate in order to be cost competitive. The fact that some of the conservation site development techniques require greater up-front developer participation and a more sophisticated marketing and sales approach that conventional developments is perhaps one reason that it has taken longer for some of these ideas to become more prevalent.

Cumulative Discussion And Recommendations

By looking across all three analyses, a set of common conclusions can be offered. Perhaps most importantly, these results certainly contradict the notion that conservation design is always more expensive than conventional practices. Not only do the three analyses show conservation is cost-competitive, they also illustrate many situations where conservation methods can reduce development costs significantly compared to conventional techniques. In terms of overall approaches, a reduced footprint on the land will generally lower construction costs. Clustering and minimal site disturbance can go a long way to cut infrastructure costs significantly, especially for stormwater management.

These cost conclusions call out for significant consideration of conservation development across the spectrum of development forms. Yet, even in the light of these conclusions, it is critical to point out that favorable cost comparisons are only one reason to consider conservation development. Ecological and social reasons should also be considered. While not components of this study, such reasons can complement and in some cases can even outweigh cost considerations.

Given the wide variety of conservation approaches tried in isolation and in combination, the three analyses reveal that there is really a continuum of choices – conservation design is not all or nothing. A range of approaches and mixes of conservation tools can be considered for every budget and every site. BMP's such as rain gardens and infiltration trenches are more easily adapted to suburban and rural development sites. Tools such as porous pavements and green roofs may be more appropriate for more urban sites, where land area is at a much greater premium, and cannot be utilized economically for stormwater detention basins.

The literature review conflicts with the results of the template analysis on landscape costs. In the template analysis, landscape development costs are consistently higher for conservation, but this is mainly due to the increase in common space allocation. These areas are typically planted with prairie / savanna restorations or naturalized stormwater water management system plantings. However, cost figures presented from several sources in the literature use data that points to the cost effectiveness of native plantings. Further analysis is warranted to flesh out the assumptions and conditions behind these perspectives. Some of the difference in results may be related, either to the incorporation (or lack thereof) of irrigation systems into the template descriptions, or to whom the costs accrue, the land developer or the lot/home purchaser.

The amount and quality of information varies greatly across the development components analyzed. One concern raised about the literature, for example, is that there is a heavy reliance on a small group of sources (Center for Watershed Protection, Prince George's County, Portland, Northeastern Illinois Planning Commission) for information. This increases the significance of the built-site and template analyses because they provide new information to the field. However, those analyses were unable to augment the scant information on maintenance in the literature.

Further Research work is needed on several fronts:

- To gather and analyze information on operation and maintenance costs of conservation development, where possible, using life-cycle cost analysis as a method of comparison to conventional methods.
- To take into account systematically both cost and effectiveness in the future analyses of conservation design alternatives. One possible way to do this is reflected in the study by Sear and Bays, who created a production and cost function to analyze efficiency and cost together, i.e., minimizing cost for a fixed pollutant removal (looking only at Total Suspended Solids), or maximizing pollutant removal for a fixed cost. They compared five stormwater treatment technologies (street sweeping, dry bottom retention ponds, curb-cut swales, wet detention ponds, and wetlands) across 16 potential stormwater pond sites. Such an approach could be expanded to include volume and attention to the more innovative methods being addressed here. The problem with such quantitative analyses is that they occur in a vacuum, focusing on discrete tools for analytical ease. It would be too analytically cumbersome to include all the inter-relationships of conservation site approaches that use multiple tools in the holistic examples in this report.

- To analyze conservation development costs in a higher-density context where tools such as porous pavement and green roof are generally perceived to be more competitive.
- To conduct more economic benefit studies that can provide information on the values obtained by conservation development as guidance for planning efforts.
- To analyze the difficulties in trying to implement innovative projects, such as design fees, misperceptions, and variances, and seek ways to overcome or minimize them.

Even where conservation costs are competitive, municipalities and other governments should offer incentives to encourage conservation development for two reasons: 1) to help communities and developers overcome market inertia, which often exists even when they have information that supports change; and 2) to enable financing mechanisms for tools or combinations of tools to be piloted or implemented, especially as part of larger municipal stormwater management programs. Pagano and Weber discuss market incentives and financing for both public and private investment in green infrastructure for municipalities in the Chicago Region. When a package of conservation tools has higher capital costs for the developer, the benefits need to be illustrated more clearly. Those tools should be the target for incentive programs.

The project team recommends a second phase of this project that would concentrate on outreach and dialog with municipalities and developers. Use of the Internet could provide this cost information and new reports as they become available in the form of a clearinghouse for costs and benefits. Such a website could include a relational database that helps users tailor the information to their needs.

Yet, the most productive use for the information presented in this report is to share and discuss these findings face-to-face with developers and municipal officials as they begin to consider new developments.

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