Beyond Stormwater Management: The Multiple Benefits of Using Green Infrastructure
Low Impact Development

18 June 09
Objectives

- What is Stormwater Management with Green Infrastructure - Really?
- How does This fit with NPDES Rules and Regulations?
LID Stormwater Management – what and why?

- Reduces land clearing and grading costs
- Reduces infrastructure costs (streets, curbs, pipes, sidewalks)
- Reduces storm water management costs (if you’re landscaping anyway….)
- Potentially reduces impact fees and increase lot yield
- Increases lot and community marketability
- Protects Site and Regional Water Quality
  - meets local post-construction water quality requirements

REMEMBER – “Reduces Costs” = Higher Profits

“Bundled” Economic Benefits

(Builder’s Guide to Low Impact Development)
We are all now well versed in MS4 Erosion and Sediment Control for Construction Activities. Now Comes Post Construction Water Quality.

It has been shown that increased volume of runoff and increased pollutant loads degrade stream quality. The essence of TMDL’s and 303(d) listings.

Traditional stormwater controls typically provide flood control for large storms but may not reduce or eliminate impact from smaller more frequent storms.

Majority of Water Quality Ordinances deal solely with Sediment. A good start, but change is coming.
• **Structural BMPs** include conveyances, infiltration devices, storage devices, filters, proprietary devices, etc. Things that get **built**.

• **Non Structural BMPs** include pollution prevention activities, development policies, education and regulations. Things that you **do**.

• Studies and models show that Non Structural BMPs can not sufficiently meet pollution reduction goals without Structural BMPs.
Non-Structural BMPs

- Many City and County ordinances require both, with SWPPP, pollution prevention, performance criteria and pollutant removal requirements combined with water quality BMP structure technical requirements.

- As an example, Boone County recognizes LID goals via Ordinance Chapter Four, Stormwater Pollution Prevention for Construction Sites, Section 2.A. “Minimize the potential for soil erosion by designing a development that fits the topography and soils of the site.....natural contours should be followed as closely as possible.”
Levels of Environmental Protection

• **LEVEL 1** – US EPA/Clean Water Act Mandated
  • Waters of the US – Wetlands
  • Waters of the US - TMDLs (It has begun!)
  • Riparian Corridor Protection
  • Pre & Post Construction NPDES Water Quality

• **LEVEL 2** – Mandates Above and Beyond US EPA Regulations
  • Multi-Jurisdictional (e.g. watershed conservancy districts)
  • State, County & City Standards

• **LEVEL 3** – Non-mandated Best Management Practices
  • Specific Green Stormwater Management Applications
  • Owner Goals - LEED or Other “GREEN” Certification
Range of Development Patterns

Low Density
- Primarily residential use
- Smaller detached buildings
- Pitched roofs
- Larger setbacks
- Curvilinear streets
- Informal landscaping
- Parks & greens
- More land at lower cost per acre

Medium Density
- Flexible use
- Larger attached buildings
- Flat roofs
- Shallow setbacks
- Grid street and alleys
- Formal/Urban landscaping
- Plazas and squares

High Density
- Larger attached buildings
- Flat roofs
- Shallow setbacks
- Grid street and alleys
- Formal/Urban landscaping
- Plazas and squares

Town Center
- Flexible use
- Larger attached buildings
- Flat roofs
- Shallow setbacks
- Grid street and alleys
- Formal/Urban landscaping
- Plazas and squares
**Typical Stormwater Management by Density**

<table>
<thead>
<tr>
<th>Best Management Practices (BMPs)</th>
<th>Low Density</th>
<th>Medium Density</th>
<th>High Density</th>
<th>Town Center</th>
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<tbody>
<tr>
<td>Vegetated Swale (&amp; Linear Basin)</td>
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<td>Rain Garden</td>
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<tr>
<td>Underground Storage</td>
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<td>Manufactured Systems</td>
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<tr>
<td>Green Roof</td>
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</table>
Traditional Stormwater Controls

- Wet/Dry Detention Basins
- Underground Storage
- Manufactured Water Quality Systems
- Media Filters
- Sediment Traps
Attributes

• Multiple use as a temp sediment basin during construction
• Aesthetics, Land value and Recreation
• Meets most Local stormwater codes
• Provides storage to reduce peak flow
• Can provide irrigation water for landscape, LEED credit

Considerations

• Public safety, swimming, ice, etc
• The land area for a basin can be significant.
• Thermal impacts to streams in the summer.
• Geese control
Underground Detention

**Attributes**
- Maximizes developable space
- Can provide groundwater recharge or water harvesting opportunities
- Out of sight
- Increased level of public safety over open ponds

**Considerations**
- Costs that can approach $250,000 ac-ft
- Minimal water quality benefits unless they have recharge component
- Maintenance can be expensive
- Pretreatment device recommended and/or required
Manufactured Systems

Attributes
- Remove oil, greases and sediment
- Can be used as a pre-treatment device
- Removal efficiency can exceed 80% of heavy particulates

Considerations
- Can be expensive for service area
- Maintenance is difficult without proper equipment
- Does not attenuate peak flows or reduce runoff volume
- Low-to-no removal efficiency for nutrients and/or fine particulates
Attributes
- Remove oil, greases, bacteria and fine particulate sediment
- Can reduce peak flow velocity
- Can be underground

Considerations
- Expensive for service area
- More intensive maintenance required
- High solids will clog w/out pretreatment
- Certain designs maintain permanent pools
- Need high hydraulic head to push flow through various media
Green Stormwater Controls

- Bioretention (Distributed Storage)
  - Vegetated Swales (Rain Gardens in Series, conveyance, storage & BMP!)
  - Rain Gardens
  - Bioretention Areas
  - Streetscape Integration
- Permeable Pavement
- Water Harvesting
- Green Roofs
- Watercourse Buffers
- Stormwater Wetlands
Low Impact Development Stormwater Controls

**Bioretention** – includes Rain Gardens, using landscaping and soils for water quality and quantity control.

- Reduces runoff volume, metals, nutrients, and thermal impacts of runoff
- Can look identical to traditional landscaped areas
- Landscaping Costs can be higher than traditional site for native plants
- Is the answer

**Permeable Pavement** – are unit pavers, concrete or asphalt systems designed for storage, conveyance, and treatment of stormwater.

- Lower life-cycle costs vs. concrete or asphalt
- Upfront capital costs are higher
- Infiltrate up to 400 inches per hour!
- Construction sequencing is a big issue
- If installed correctly, catastrophic clogging and failure a myth! (Hunt, 2007)
What does it look like?  Bioretention
What does it look like - Permeable Pavement

Permeable Interlocking Concrete Pavers (PICP)

Pervious Asphalt

Concrete Grid Pavers (CGP)

Pervious Concrete

Invisible Structures™ Plastic Reinforcing Grid

Soil Filled for Grass Growth

Gravel Filled

Pervious Concrete w/ Hose Photo by Greg McKinnon from Puget Sound Online

The porosity allows pavement infiltration rate up to 400 in/hr. (Pilat, 2002)

The fear of catastrophic failure after *proper construction* is fictional. for any anticipated rain event. (Hunt, 2007)
Water Harvesting or Reclamation - a method of utilizing rain water for domestic and agricultural use.

- Seasonal concerns for redundant back up system plumbing.
- Regulatory concerns on need to drain enough for next event.

Green or White Roof – use of alternative roofing materials for storm, operation and maintenance efficiencies.

- Attenuates peak flows and reduces runoff volume
- Reduces size and footprint of detention facilities
- Building energy savings
- Cost per square foot of treatment is high
- Best suited for high density urban applications
Low Impact Development Stormwater Controls

**Watercourse Buffer/Stream Restoration** – provides natural protection and green space

- Re-creates more natural stream channel
- Preserves wildlife corridors
- Provides Greenway and Recreational Uses

**Stormwater Wetland** – engineered natural biological treatment systems

- Provides a high level of treatment
- Provides wildlife habitat areas and corridors
- Initial intensive maintenance until wetland species are established and to prevent clogging
Deep rooted native plants open up soils and can provide 5 to 13 inches per hour infiltration rates.

Iowa State University

Turf Grass

Turf Grass Roots

Root Systems of Prairie Plants

Conservation Design Forum, Inc.
Research shows that Green Stormwater techniques can be effective in reducing the volume of runoff to predeveloped levels.

Green Stormwater techniques do an excellent job of treating the annual pollutant load and runoff volume from storm events up to 1” +/- which comprises up to 90% of all annual rainfall events (and up to 80% of the pollutants!)

When runoff does not leave or get discharged from the BMPs, neither do any pollutants in the water.
Effectiveness of Low Impact Development BMPs

- **Direct Environmental Benefits**
  - Decrease scouring velocities of offsite discharges
  - Reduce thermal impact from post developed property
  - Treats soluble and/or dissolved nutrients
  - High sediment removal capacity
  - Many effectively treat bacteria (e coli)
  - Groundwater recharge
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<th>LID Measure</th>
<th>TSS</th>
<th>N</th>
<th>P</th>
<th>Metals (Cu,Zn,Pb)</th>
<th>BOD</th>
<th>Hydro-carbon</th>
<th>Organics</th>
<th>Bacteria</th>
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<tr>
<td>Bioretention/Rain Gardens</td>
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<td>50-85</td>
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<td>80-99</td>
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Effectiveness of Low Impact Development BMPs

Burnsville, MN

Rain Gardens retrofitted throughout neighborhood
17 out of 25 houses participated

Photos courtesy of Barr Engineering
Effectiveness of Low Impact Development BMPs

Burnsville, MN Rain Gardens in Series Performance

Pre-Construction Runoff Data
June 6, 2003

Post-Construction Runoff Data
May 29, 2004

0.50-in

0.71-in

Data courtesy of Barr Engineering
Water Quality Focus

- Most local ordinances are beginning to recognize green stormwater infrastructure BMP’s as a holistic alternative approach to stormwater management. Most do not actively promote them, yet.

- Communities that want to promote Green Stormwater techniques are beginning to provide developers with incentives
  - Storm water utility rate credits
  - Flexibility in traditional stormwater requirements
  - Faster Permit Approval Process

- Many communities have concerns about long-term maintenance and effectiveness of pervious pavement, bioretention basins, and other LID BMP’s.
  - Who maintains? Who Funds? HOA? Home owners?
  - Can BMP’s be located on private property?
• Groundwater recharge or stay-on (Water Quality Retention Volume) requirements are a common method of “encouraging” developers to consider green stormwater development strategies, i.e. States of Wisconsin, New Jersey, and Ohio.

• Federal, State and Local Regulators are beginning to focus on the detrimental impacts to stream water quality from post construction site runoff then solely on impervious related flood control.

Remember the TMDLs?
Table 1 - Water Quality Volume - (WQv)

<table>
<thead>
<tr>
<th>Bioretention ID</th>
<th>Contributing Basins</th>
<th>Water Quality Volume Required WQv (ac-ft)</th>
<th>Water Quality Volume Provided WQv (ac-ft)</th>
<th>Water Quality Volume Net WQv (ac-ft)</th>
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<td>BR3</td>
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Design courtesy of INDOT, Synthesis Architects, EMH&T
Parking Lot Redirected to basin retrofit
West Columbus Street – Porous Concrete
West Columbus Street – Porous Concrete
Conventional to Alternative Ultra Urban Re-development

INDIANAPOLIS GREEN INFRASTRUCTURE

Redevelopment Design Example

Prepared by: EMHT

Cupped Landscaping vs. Conventional Mound

Pervious Concrete

Bioretention

NEXT GENERATION GREEN
innovative designs that make business sense
| The Real project has 0 discharge into the CSO system.... 100% removal! Currently at no cost to the City!? |

**TABLE 1 - Existing, Conventional and Green Integrated Site Design Comparison**

<table>
<thead>
<tr>
<th></th>
<th>Existing Site</th>
<th>Conventional</th>
<th>Green Integrated</th>
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<tbody>
<tr>
<td>Total Site (sq. ft.)</td>
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<tr>
<td>Impervious (sq. ft.)</td>
<td>41,901</td>
<td>38,177</td>
<td>23,615</td>
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<td>Pervious (sq. ft.)</td>
<td>988</td>
<td>4,712</td>
<td>19,274</td>
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<tr>
<td>% Green (pervious) Space</td>
<td>2%</td>
<td>11%</td>
<td>45%</td>
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<tr>
<td>Average Curve Number</td>
<td>97.1</td>
<td>93.9</td>
<td>77.7</td>
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<td>Cost ($/ Sq. Ft.)</td>
<td>n/a</td>
<td>$ 3.03</td>
<td>$ 3.86</td>
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<tr>
<td>Discharge Rate (cfs)</td>
<td>2.11</td>
<td>2.10</td>
<td>1.10</td>
</tr>
</tbody>
</table>

**Volume of Stormwater Removed from Combined Sewer System**

- 1" Storm (gal.): 0 / 0 / 26,703
- Annual Total (gal): 0 / 0 / 650,000

**Potential Combined Sewer Cost Savings (per Acre)**

- Annual Operation: $0 / $0 / $6,500
- CSO Storage Reduction**: $0 / $0 / $18,692

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*estimated from Indianapolis Rain Data, 2001-2005
**estimated 20% total volume reduction for peak detention