

1

Benefits of GSI

LID can help communities more efficiently and effectively manage stormwater and protect their water resources.

- Reduces flooding and protects property.
- Assists municipalities in meeting stormwater standards & regulations
- Reduces municipal infrastructure costs
- Provides a cost-effective alternative to traditional development (less land clearing, reduced infrastructure, etc.)
- Promotes smart growth



2

Co-Benefits of GSI

- Increase the appearance and aesthetics of community.
- Increase public safety (traffic calming).
- Protects the environment (water quality, ecologic and carbon footprint).
- Protects human health (recreational and drinking water quality).
- Assist with LEED certification and/or Sustainable Sites Initiatives.
- Good for the economy (eco-friendly development, eco-tourism, cost effective, energy savings, increased land worth and tax base).



3

Green Infrastructure Benefits and Practices

This section, while not providing a comprehensive list of green infrastructure practices, describes the five GI practices that are the focus of this guide and examines the breadth of benefits this type of infrastructure can offer. The following matrix is an illustrative summary of how these practices can produce different combinations of benefits. Please note that these benefits accrue at varying scales according to local factors such as climate and population.

Benefit	Reduces Stormwater Runoff					Increases Available Water Supply					Improves Air Quality					Improves Community Livability				
	Reduces Water Treatment Needs	Improves Water Quality	Reduces Grey Infrastructure Needs	Reduces Flooding	Increases Available Water Supply	Increases Groundwater Recharge	Reduces Salt Use	Reduces Energy Use	Improves Air Quality	Reduces Atmospheric CO ₂	Reduces Urban Heat Island	Improves Aesthetics	Increases Recreational Opportunity	Reduces Noise Pollution	Improves Community Cohesion	Urban Agriculture	Improves Habitat	Cultivates Public Education Opportunities		
Practice																				
Green Roofs	●	●	●	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
Tree Planting	●	●	●	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
Bioretention & Infiltration	●	●	●	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
Permeable Pavement	●	●	●	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
Water Harvesting	●	●	●	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○		

● Yes ◐ Maybe ○ No



4

Additional Commercial Economic Benefits (NRDC)

- In many cases, LID (green systems) are MORE economical than conventional (grey systems)
- Less capital costs
- Less maintenance costs
- ...or BOTH!
- Additional benefits



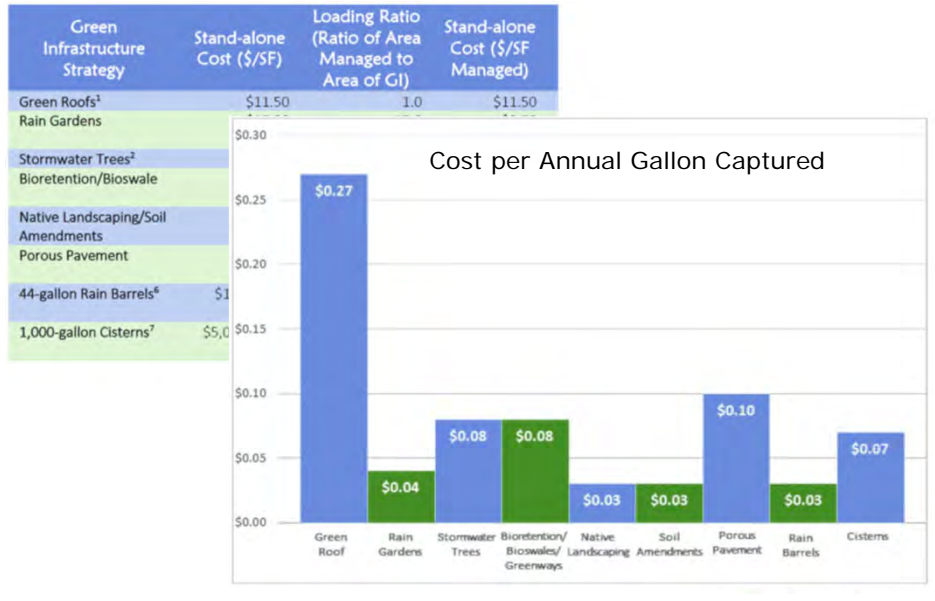
5

NRDC – GI Creates Value



6

GI Cost - MMSD



7

Maintenance Considerations

- Must be Continuous
- During Construction
- After Construction



8

Maintenance After Construction

- Owner Responsible?
- Inspections Frequency?
- Maintenance Agreement?



9

Six Key Elements to Maintain

Seattle Public Utilities (SPU)

Natural Drainage Systems (NDS) Maintenance Manual





<http://www.seattle.gov/util/my services/drainagesewer/projects/greenstormwaterinfrastructure/completedgsiprojects/operationsmaintenance/>



10

Landscape

Table I. Landscape and Vegetation Manual

Service Category	Service Level A (Excellent Effort)	Service Level B (Good Effort)	Service Level C (Moderate Effort)	Service Level D (Poor Effort)
Aesthetics (vegetation and trash)	<ul style="list-style-type: none"> Vegetation <ul style="list-style-type: none"> Healthy and attractive No bare spots Plant palette is working for facility At least 95% survival of establishing plants Weeds - Little or no weeds are present Aesthetics <ul style="list-style-type: none"> Clean, distinct edges Vegetation confined to planted areas No overgrown appearance/dead growth Mulch <ul style="list-style-type: none"> Evenly distributed & approximately 4" of arborist woodchip mulch. No evidence of erosion (stabilized surfaces) Limited shoulder compaction Homeowner is fully maintaining (where applicable) 	<ul style="list-style-type: none"> Vegetation <ul style="list-style-type: none"> Healthy with a good appearance Occasional bare spots Plant palette is mostly working for facility (At least 75%) Weeds - Small quantities of weeds are present Aesthetics <ul style="list-style-type: none"> Loose edges: grass/mulch encroaching on swale or vice versa Some vegetation overlapping into pedestrian areas Overgrown in isolated areas with some dead material Mulch <ul style="list-style-type: none"> 2"-4" layer of mulch is present Erosion likely unless maintenance improved Some shoulder compaction Homeowner is providing some maintenance (where applicable) Able to achieve Level A without complete retrofit 	<ul style="list-style-type: none"> Vegetation <ul style="list-style-type: none"> Poor vegetation health and appearance Bare spots are frequent Plant palette is not working for facility (75%-50%) Weeds - Weeds common Aesthetics <ul style="list-style-type: none"> No edges; Surrounding vegetation spills into swale and pedestrian areas Mulch <ul style="list-style-type: none"> Mulch is less than 2" Substantial eroded areas Shoulder compaction Homeowner is not maintaining swale (where applicable) Unable to achieve higher service levels without complete retrofit 	<ul style="list-style-type: none"> Vegetation <ul style="list-style-type: none"> Poor Planted vegetation health and appearance Bare spots are common Plant palette has failed Less than 50% Weeds - Weeds dominant Aesthetics <ul style="list-style-type: none"> No edges; surrounding vegetation spills into swale or vice versa Mulch <ul style="list-style-type: none"> Mulch is absent Substantial eroded areas Shoulder compaction Homeowner is not maintaining swale (where applicable) Unable to achieve higher service levels without complete retrofit
Vegetation	Lush vegetation, excellent appearance 	Mostly healthy vegetation with good appearance 	Mostly healthy vegetation with neglected appearance 	Poorly planted vegetation health and neglected appearance 

11

Stormwater System Functionality

Table II. System Functionality







Service Category	Service Level A (Excellent Effort)	Service Level B (Good Effort)	Service Level C (Moderate Effort)	Service Level D (Poor Effort)
SYSTEM FUNCTIONALITY				
Bioretention (vegetation & soils/substrate)	<ul style="list-style-type: none"> Vegetation <ul style="list-style-type: none"> 100% of swale bottom is covered with healthy, wetland vegetation No bare spots Infiltration <ul style="list-style-type: none"> Soil is well aerated, no evidence of compaction Water drains within 48 hours Maintenance <ul style="list-style-type: none"> No erosion, channelization or scouring No significant sediment or debris accumulation 	<ul style="list-style-type: none"> Vegetation <ul style="list-style-type: none"> At least 80% of swale bottom is covered with healthy, wetland vegetation Minimal bare spots 10% Infiltration <ul style="list-style-type: none"> Some evidence of compaction (2" of mulch) Most water drains within 24 hours, minimal long-term ponding Maintenance <ul style="list-style-type: none"> Some erosion, channelization or scouring Sediment or debris accumulation does not affect the function of the facility. 	<ul style="list-style-type: none"> Vegetation <ul style="list-style-type: none"> Between 60-80% of swale bottom is covered with healthy, wetland vegetation A few bare spots 10-20% Infiltration <ul style="list-style-type: none"> Compacted soils (Lack of Mulch) The presence of long-term ponding (> 72 hours) Maintenance <ul style="list-style-type: none"> Erosion, channelization or scouring Sediment and debris accumulations inhibit the water quality function of the facility without affecting conveyance 	<ul style="list-style-type: none"> Vegetation <ul style="list-style-type: none"> Less than 60% of swale bottom is covered with healthy, wetland vegetation Many bare spots Infiltration <ul style="list-style-type: none"> Compacted soils (Lack of Mulch) The presence of long-term ponding (> 72 hours) Maintenance <ul style="list-style-type: none"> Erosion, channelization or scouring Sediment and debris accumulations inhibit the water quality and conveyance of the system
Biofiltration (vegetation & soils/substrate)	<ul style="list-style-type: none"> Vegetation <ul style="list-style-type: none"> At least 80% of swale bottom covered with healthy, uniformed fine-stemmed vegetation at least 18 - 24 inches high No bare spots Maintenance <ul style="list-style-type: none"> No erosion, channelization or scouring No ponding No significant sediment or debris accumulation 	<ul style="list-style-type: none"> Vegetation <ul style="list-style-type: none"> Between 60-80% of swale bottom covered with healthy, uniformed fine-stemmed vegetation at least 18 - 24 inches high A few bare spots 10% Maintenance <ul style="list-style-type: none"> Some erosion, channelization or scouring No ponding Sediment and debris does not affect the function of the facility. 	<ul style="list-style-type: none"> Vegetation <ul style="list-style-type: none"> Between 60-40% of swale bottom covered with healthy, uniformed fine-stemmed vegetation, of at least 18 -24 inches high Many bare spots 10-30% Maintenance <ul style="list-style-type: none"> Erosion, channelization or scouring The presence of ponding Sediment and debris affect the water quality function of the facility with out affecting conveyance. 	<ul style="list-style-type: none"> Vegetation <ul style="list-style-type: none"> Less than 40% of swale bottom covered with healthy, uniformed fine-stemmed vegetation, of at least 18 -24 inches high Many bare spots Maintenance <ul style="list-style-type: none"> Erosion, channelization or scouring The presence of ponding Sediment and debris accumulations inhibit the water quality and conveyance of the system



12

Porous Pavement

Table IV. Porous Pavement Manual




Level of Service	Service Level B (Good Effort)	Service Level C (Moderate Effort)	Service Level D (Low Effort)	Recommended Maintenance Activities
Street	Infiltration rate of 20 +in/hr	Infiltration rate of 10 in/hr	Infiltration rate of 3 in/hr	based on peak flows for 100yr design storm 3 in/hr and excess capacity for localized failure
Sidewalk	Infiltration rate of 20 +in/hr	Infiltration rate of 10 in/hr	Infiltration rate of 1 in/hr	Test infiltration rates per SPU Materials Lab procedure.
				
	Pressure wash @2500 psi bi-annually	Pressure wash @ 2500 psi annually	Pressure wash @ 2500 psi annually	
				Pressure wash pavement with an industrial machine



13

Other Elements

Table V. Other Elements





Service Category	Service Level B (Good Effort)	Service Level C (Moderate Effort)	Service Level D (Low Effort)	Recommended Maintenance Activities
OTHER ELEMENTS	<ul style="list-style-type: none"> up to 10% blockage caused by organic matter, sediment, debris or trash irrigation system functions properly with no blockages or breaks in drip system ponding only to intended depth (varies by location) pond capacity is maintained no liner leakages reported 	<ul style="list-style-type: none"> between 10-30% blockage caused by organic matter, sediment, debris or trash irrigation system functions properly with no blockages or breaks in drip system ponding only to intended depth (varies by location) some sediment may reduce pond capacity no liner leakages reported 	<ul style="list-style-type: none"> more than 30% blockage caused by organic matter, sediment, debris or trash irrigation system has occasional blockages or breaks in drip lines ponding only to intended depth (varies by location) sediment buildup causes reduced pond capacity no leakages reported 	
□ Curb cuts	Curb is up to 10% blocked 	Curb is between 10-40% blocked 	Curb is above 40% blocked 	<input type="checkbox"/> remove trash and organic debris and dispose properly



14

Safety

Table VII. Safety, Spill Prevention and Response, and Pest Control

Service Category	Service Level A (Excellent Effort)	Service Level B (Good Effort)	Service Level C (Moderate Effort)	Service Level D (Low Effort)
SAFETY, MOBILITY, ACCESS	<ul style="list-style-type: none"> Vegetation causes no visibility (line of sight) or driver safety issues Infrastructure is always accessible and has clear access path Vegetation around infrastructure is maintained at height to prevent damage during routine maintenance Fire hydrant access clearly visible and accessible Vegetation does not impede pedestrian access 	<ul style="list-style-type: none"> Vegetation causes minimal visibility (line of sight) or driver safety issues Infrastructure is mostly accessible and has access path Most vegetation around infrastructure is maintained at height to prevent damage during routine maintenance Fire hydrant access clearly visible and accessible Vegetation does not impede pedestrian access 	<ul style="list-style-type: none"> Vegetation causes visibility (line of sight) or driver safety issues Infrastructure is not accessible and has clear access path Vegetation around infrastructure is will be damaged during routine maintenance Fire hydrant access clearly visible and accessible Vegetation does not impede pedestrian access 	<ul style="list-style-type: none"> Vegetation causes visibility (line of sight) or driver safety issues Infrastructure is not accessible and has clear access path Vegetation around infrastructure is will be damaged during routine maintenance Fire hydrant access clearly visible and accessible Vegetation does not impede pedestrian access
				
SPILL PREVENTION	<ul style="list-style-type: none"> Exercise spill prevention measures whenever handling or storing potential contaminants. Fertilizers, Herbicides, Fungicides and Insecticides are prohibited in GSI. 			



15

Climate Resiliency



16

LID Resources

- List of References



17

Challenges for GSI Implementation

Communities will face some challenges in implementing GSI.

- Public acceptance.
- Against status quo for contractors and developers.
- Engineers and land development firms need design tools.
- Maintenance requirements need to be better understood by municipalities, contractors and homeowners.
- Ordinances need to be re-written to allow LID or alternative methods for dealing with stormwater.

Education!



18



Questions?

