Innovative approaches
Practical results
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Trinity River Vision Storm Drain Master Plan
Volume III: Mass Grading

Prepared for:

City of Fort Worth

October 2014

FREESE AND NICHOLS, INC.
TEXAS REGISTERED ENGINEERING FIRM F-2144
4055 International Plaza, Suite 200
Fort Worth, Texas 76109
817-735-7300

TSC08309

FREESE AND NICHOLS

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STATE OF TEXAS
SCOTT K. HUBLEY
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PROFESSIONAL ENGINEER

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FREESE AND NICHOLS, INC.
TEXAS REGISTERED ENGINEERING FIRM F-2144
4055 International Plaza, Suite 200
Fort Worth, Texas 76109
817-735-7300

TSC08309

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1.0 MASS GRADING INTRODUCTION

Freese and Nichols, Inc. (FNI) is under contract with TranSystems to provide planning and design services for municipal stormwater utilities associated with construction of the proposed Trinity River Vision (TRV) Bypass Channel. The purpose of this report is to identify and size storm drain infrastructure required to support the redevelopment of the Panther Island area as envisioned by a mass grading plan developed by Kimley-Horn and Associates, Inc. FNI produced previous iterations of this report in January 2011 and August 2013; this May 2014 report supersedes all previously provided information.

For this report, FNI developed a set of potential stormwater strategies for the Panther Island area, with the underlying assumption that the water quality of storm runoff is a critical factor in the success of this project. As the Panther Island area is redeveloped, this report is expected to serve as a planning tool to guide future development practices. Finally, this report serves as technical backup for FNI's *TRV Storm Drain Master Plan – Volume IV: LID Strategies for Panther Island*, dated February 2014, which is a graphical representation of the potential LID controls that could be employed in the Panther Island area to contribute to water quality treatment goals.

1.1 DATA SOURCES

A mass grading plan to facilitate redevelopment of the Panther Island area was developed by Kimley-Horn and Associates, Inc. and provided to FNI in March 2013. The mass grading plan includes three CAD files depicting (1) a comprehensive plan showing the bypass channel, street layout, and development pad locations; (2) a grading plan for the streets and canals; and (3) a grading plan depicting a potential range of finished floor elevations for each development pad. This data was used as a basis for FNI's storm drain analysis, including the establishment of drainage area boundaries, flow paths, and outfall locations. A workmap depicting the mass grading plan is provided in Appendix G.

The southwest area of Panther Island includes the Henderson Street and White Settlement Road bridges over the proposed bypass channel. FNI used the final bridge plans for Henderson Street and 90% bridge plans for White Settlement Road as a basis for drainage area boundaries in this area.

2.0 LID CONTROL MODELING

2.1 LID SCENARIOS

The Trinity River Vision Authority (TRVA) has developed water quality standards for stormwater runoff in the TRV project area, requiring all stormwater runoff to be treated prior to entering the canals and/or lakes. Because water quality is a major focus for success of the Panther Island development, FNI investigated three combinations of low-impact development (LID) controls that contribute to meeting the criteria of 100% water quality treatment. These LID controls include rain gardens (a form of biofiltration) and green roofs, both of which limit the pollutant level of storm runoff. In addition, these LID controls may also reduce the peak runoff rate, allowing the installation of smaller-diameter, less expensive storm drain infrastructure. Refer to the iSWM Fact Sheets for Bioretention (Rain Gardens) and Green Roof in Appendix B for additional background information regarding these types of LID controls.

FNI developed conceptual sizing, layouts, and cost estimation for storm drain trunk lines under four different scenarios. While all scenarios are based on the same mass grading plan, each scenario represents a different level of implementation of low-impact development (LID) controls, ranging from a "traditional" development with no LID controls to a development with extensive use of rain gardens and green roofs. Each of the LID scenarios, described below, is cumulative and includes LID controls from previous scenarios. Refer to *Volume IV: LID Strategies for Panther Island* for renderings of each scenario.

1. **Traditional Design** – Runoff from the right-of-way and all development pads is collected in street curb inlets and routed through storm drain lines to an outfall into the nearest canal or lake. Runoff is treated at each outfall by a structural end-of-pipe treatment system. No storm runoff from any development is allowed to drain directly to the canals because of water quality treatment requirements. Therefore, under this scenario, all development must drain to the road where it can be collected in a storm drain system and then treated before entering the canals in order to meet water quality treatment criteria.
2. **Right-of-Way Response** – Runoff from the right-of-way and all development pads is routed through 5-ft-wide rain gardens along the right-of-way. Rain gardens, a form of biofiltration, intercept a portion of the runoff, filter it, and discharge directly to storm drain lines in the right-of-way. This response reflects water quality measures that are within the greatest control of the public authorities. While this scenario promotes green infrastructure within the right-of-way, it does not allow development to direct untreated storm runoff directly into the canals. Each

development is still required to drain to the road and continue through traditional closed-pipe systems prior to discharge in the canals.

3. **Open Space Response** – This response assumes that 10-ft-wide rain gardens are located within the view corridors, and that 10-ft-wide terraced rain gardens line the canals. Adding this treatment mechanism along the canal boundaries allows development pads adjacent to the canals to discharge storm runoff directly into the canals. TRVA has indicated that they would have some control over the development of view corridors and canals and may use incentives to successfully implement this scenario. In accordance with this new discharge pattern, approximately half of the runoff from development pads along canals is assumed to be collected in rain gardens along the canals and view corridors and then discharged into the canals. The remainder drains to the right-of-way and is collected in the right-of-way rain gardens and traditional closed-pipe systems as described in the previous scenario. This is a significant change in drainage patterns. Allowing sites to discharge directly to the canals or lakes reduces the drainage area contributing to storm drain systems by 35%. A corresponding reduction in storm drain pipe sizes in the streets is achieved with this alternative.

4. **Architectural Response** – This response classifies an average of 25% of each building footprint, as depicted in the mass grading plan, as a green roof. Green roofs intercept a small portion of runoff, filter it, and discharge to roof drains which connect to public drainage systems. The remainder of runoff is collected as described in the Open Space Response scenario. It is assumed that the addition of green roofs is entirely dependent on construction by the development community. Incentives would be required to successfully implement this scenario.

In order to develop the required storm drain infrastructure for each of the four LID scenarios, FNI performed four separate hydrologic and hydraulic analyses of the Panther Island area as described in Sections 3.0 and 4.0. Certain hydrologic parameters are dependent upon the water quality treatment characteristics of each LID control. Therefore, FNI first calculated the water quality effects of each LID scenario as described in the following subsection.

2.2 WATER QUALITY CALCULATIONS

The NCTCOG iSWM Technical Manual defines the water quality protection volume as runoff resulting from the 85th percentile storm event, which carries the majority of pollutants into drainage systems. For North Central Texas, this corresponds to 1.5 inches of rainfall. This rainfall corresponds to a certain volume of runoff as described by the volumetric runoff coefficient R_V, where $R_V = 0.05 + 0.009(I)$ and I is the percentage of impervious cover. Therefore, for the 96% impervious Panther Island area, the water quality protection volume is $1.5 \times (0.05 + 0.009 \times 96) = 1.37$ inches of runoff.

The rain gardens and green roofs included in the LID scenarios described previously are capable of treating a certain maximum volume of water during each storm event. This treatment is achieved by capturing the water and filtering it through the LID controls. The volume of treatment is assumed to be equal to the total available storage for each LID control. Plan view extents of the Right-of-Way Response rain gardens were delineated based on the assumption that all right-of-way street trees shown on the comprehensive plan would be converted to rain gardens. Similarly, Open Space Response rain gardens were delineated based on tree areas shown in view corridors and based on area adjacent to canals and lakes. These assumptions are depicted graphically in Volume IV. Finally, the aggregate area of the green roofs in the Architectural Response was calculated based on 25% of the building footprint area.

FNI also calculated the average ponding, soil, and drain rock storage depths in the rain gardens and green roofs, based on assumed typical sections for these controls. FNI then used the measured areas and assumed depth characteristics to calculate maximum storage volumes for each LID control across the Panther Island area. These maximum storage volumes are assumed to become saturated with water over the course of a rainfall event. The storage volumes were then divided by the total drainage area to obtain the volume treated represented as depth of runoff. Relevant assumptions and supporting calculations are documented in Appendix A, *LID Control Water Quality Calculations*, and are summarized in Table 1 below.

Table 1. Water Quality Volume Treated

	Volume Treated	Pct. of WQ Volume Treated
Traditional Design	0.00 in	0 %
Right-of-Way Response	0.32 in	23.4 %
Open Space Response	0.69 in	50.0 %
Architectural Response	0.79 in	57.5 %

Note that these LID controls contribute toward the criteria of 100% water quality treatment. The remaining treatment to reach 100% will be achieved through a combination of structural treatment systems at the storm drain outfalls or by additional LID controls employed by site development.

3.0 HYDROLOGIC MODELING

For each of the LID scenarios, FNI delineated drainage areas (subbasins) and flowpath geometry, and used these to calculate peak flow rates in the storm drain trunks. Horizontal alignments for the storm drain trunks were set based on the provided mass grading plan. FNI used InfoWorks SD software to calculate hydrologic losses with the SCS curve number method, and to generate hydrographs with the SWMM method. FNI then adjusted initial abstraction and routing parameters to model the particular hydrologic effects of each LID scenario. Rainfall was modeled using a 24-hour, 100-year return event storm as described in the *City of Fort Worth iSWM Criteria Manual for Site Development and Construction* dated August 1, 2012.

3.1 DRAINAGE SUBBASIN DELINEATION

For the Traditional Design and Right-of-Way Response scenarios, FNI delineated each subbasin to the lowest adjacent street intersection, assuming that all development pad areas would drain to the storm drain in the right-of-way. Development pads were bisected by subbasin boundaries where the mass grading plans indicated multiple nearby low points.

For the Open Space and Architectural Response scenarios, FNI delineated a separate set of subbasins. These subbasins reflect the assumption that each development pad adjacent to a lake or canal will drain half its area directly to the lake or canal by way of a rain garden, with the remaining area draining to the street. This is a significant change in drainage patterns, reducing the drainage area contributing to storm drain systems by 35%. Therefore, the subbasins draining directly to the lake or canals were disregarded in FNI's hydrology calculations for the storm drain trunk design.

3.2 FLOWPATH DELINEATION

FNI delineated the flow path for each subbasin from the high point (usually on the far corner of a development pad) to the nearest adjacent low point in the street. Elevations for the starting and ending points of each flow path were assigned from the provided mass grading plan, using proposed contours or pad elevations, as applicable. FNI used the maximum elevation given for each development pad to produce a conservative estimate for each subbasin's slope parameter. To obtain each subbasin's width parameter required by the SWMM method, FNI divided the subbasin area by the flowpath length. These slope and width parameters were entered into the InfoWorks SD model, and are provided in Appendix C.

3.3 HYDROLOGIC LOSS AND ROUTING PARAMETERS

Each subbasin in the model was assigned an average impervious area of 96% based on future land use and a curve number of 69 for the predominant hydrologic soil group B. For the Traditional Design scenario, the impervious surface was modeled using an initial loss of 0.1 inches, which represents a minimal amount of ponding, and a Manning's n value of 0.011 for hydrologic routing. The pervious surface in the Traditional Design scenario was modeled using an NRCS initial abstraction factor of 0.2 and a Manning's n value of 0.24 for hydrologic routing. The impervious surface's initial loss and weighted Manning's n parameters were then incrementally increased for each LID scenario according to FNI's water quality analysis as described in the next section.

3.4 ADJUSTMENT OF PARAMETERS FOR LID SCENARIOS

Rain garden and green roof LID controls are designed to improve water quality by treating the pollutant-loaded "first flush" of runoff. In addition, these controls alter the hydrologic properties of each subbasin. FNI adjusted the base hydrologic parameters when modeling each LID scenario as described in the following two subsections.

3.4.1 Initial Abstraction

As described previously in section 2.2, the water quality volume treated by LID controls can be expressed as a depth of runoff. The aggregate LID control storage volume is assumed to hold water until the peak of the storm has passed, and can therefore be represented as an initial abstraction from a hydrologic modeling perspective.

In each respective LID scenario model, FNI added that scenario's cumulative initial abstraction to the base initial abstraction parameter of 0.1 inches used in the Traditional Design scenario. This modeling technique allows each hydrologic model to account for the storage effects provided by its LID controls. Increasing this initial abstraction parameter has a negligible effect on 100-year peak flows and would not impact pipe sizes. This is because the LID controls are only designed to treat the first flush of such large storm events.

3.4.2 Hydrologic Routing

Flow velocity of storm runoff through rain gardens and across green roofs is lower than the flow velocity through concrete gutters and pipes. This results in a longer travel time for storm runoff in each subbasin and therefore results in lower peak flow rates in the storm drain. To model this impact, FNI made adjustments to the SWMM impervious Manning's n parameter for each LID scenario. Because only one Manning's n can be applied to the impervious area in SWMM methodology, a length-weighted Manning's n for a typical flow path was used.

Flow paths from six representative drainage areas were split into length along rooftops, length along pavement, and length along the right-of-way and/or open space. As described previously, a Manning's n of 0.011 for concrete was used for all three of these lengths in the Traditional Design scenario.

For the Right-of-Way and Open Space Responses, the length along the right-of-way and/or open space was given a Manning's n of 0.035 for channelized flow in a vegetated rain garden. Length-weighted Manning's n values were then calculated for each of the six representative flow paths and averaged to obtain a typical Manning's n value of 0.025 for the watershed. This typical value was then entered into the SWMM impervious Manning's n parameter for the Right-of-Way and Open Space Response hydrologic model.

For the Architectural Response, the length along rooftops was given a weighted Manning's n of 0.0683. This represents a 75% weight of n=0.011 for sheet flow on concrete, plus a 25% weight of n=0.24 for sheet flow on a vegetated surface. This reflects FNI's assumption of 25% green roof coverage on Panther Island buildings. Manning's n for the flow path length along the right-of-way and/or open space remained at 0.035, as in previous LID scenarios. Total weighted Manning's n values were then calculated for each of the six representative flow paths and averaged to obtain a typical weighted Manning's n value of 0.039. This typical value was entered into the SWMM impervious Manning's n parameter for the Architectural Response hydrologic model.

These average hydrologic routing values are summarized in Table 2 on the next page.

Table 2. Hydrologic Routing Parameters

	SWMM Impervious *n* value
Traditional Design	0.011
Right-of-Way Response	0.025
Open Space Response	0.025
Architectural Response	0.039

Increasing this hydrologic routing parameter has a significant effect on 100-year peak flows, as depicted in the Peak Flow Rates table provided in Appendix D. Adding these LID controls slows the time of concentration of runoff to the subbasin outlets, decreasing 100-year peak flows and allowing for smaller storm drain trunk lines.

4.0 STORM DRAIN HYDRAULICS

4.1 STORM DRAIN ALIGNMENTS

FNI used Innovyze InfoWorks SD 14.0 software, version 14.0, to size the storm drain trunks for each LID scenario. The horizontal alignment of each storm drain trunk follows the street system, collects the subbasins, and outfalls to the nearest canal or lake. The model has each subbasin contributing directly to the storm drain trunk; no inlets or laterals were modeled. Where possible, priority was given to alignments that allowed for the use of existing infrastructure during phased implementation. Exhibit 5, attached, shows the impacts to existing infrastructure. For example, storm drain alignments along 6th Street and 7th Street are allowed to drain into the existing Calhoun trunk until Canal D is constructed.

Each storm drain trunk follows the general slope of the grading plan while maintaining a minimum cover of 3 feet and outfalls at the nearest lake or canal. The mass grading plan indicates that 521 is the bottom elevation of the canal, and that the normal pool is 525; therefore, FNI set each outfall at 521 and limited the height of storm drain trunk lines to 4 feet so that storm drain outfalls would not be visible above the water level.

Note that each of the pipe alignments and sizes described in this volume were set based upon ultimate conditions, after the TRV project and mass grading are completed. These sizes represent the minimum sizes needed for ultimate development conditions. Larger-diameter pipes may or may not be required during interim periods, depending on construction phasing of the TRV project. These potential interim alignments and sizes are described in Volume II of this report.

4.2 DESIGN CRITERIA

To obtain ground levels above each storm drain, FNI created a TIN surface from the provided mass grading data and imported this surface into InfoWorks. Each length of storm drain trunk was then sized in order to keep the peak 100-year hydraulic grade line at least 2 feet below ground level. This conservative design criterion allows for additional hydraulic losses through laterals, inlets, and offsite drainage. In addition, compared to an HGL equal to the ground level, this criterion generally only requires an incremental increase in storm drain trunk size, e.g. a 48” pipe rather than a 42”. Sizes and flowlines for storm drain shown in the final bridge plans for Henderson Street and in the 90% bridge plans for White Settlement Road were input to match the plans. A Manning’s n roughness value of 0.015 was used for all concrete pipe. Headlosses along the trunk line were estimated as 0.35 times the velocity head at the upstream section of each major pipe length.

4.3 ALTERNATIVE STORM DRAIN SCENARIOS

FNI executed the hydraulic models using the 100-yr rainfall event and sized each length of storm drain pipe according to the criteria described previously. For each LID scenario, horizontal alignments of storm drain remained the same; only pipe sizes were changed. Storm drain alignments and sizes for each LID response alternative are shown in Exhibits 1-4, attached. In most cases, the alignments used are consistent with proposed alignments for the TRV project, as discussed in Volume II.

4.4 COST ESTIMATES

FNI developed planning-level cost estimates for each storm drain line under each LID scenario, excluding the pipe shown on the Henderson and White Settlement bridge plans. These estimates are based on the following assumptions:

1. Unit costs of storm drain trunk line were estimated based on TxDOT average low bids plus an escalation contingency.
2. Lateral quantities were estimated based on an average of two 60-foot lengths of 24” pipe at 200-foot increments along each storm drain trunk line.
3. Unit costs of rain gardens per square foot were estimated based on aggregate unit costs of concrete walls, drain pipe, filter media, sodding, plantings, etc., and represent an incremental cost increase compared to street trees shown in the comprehensive plan.

4. The cost of green roofs is expected to be assumed by development and was not estimated.
5. Appurtenances (inlets and manholes) were estimated as 20% of the pipe cost under the traditional design alternative. Because curb inlets are replaced by rain gardens and thus not necessary under each LID response scenario, this estimate was lowered to 10% of the pipe cost for these alternatives.
6. To satisfy TRVA water quality requirements, a structural end-of-pipe treatment system was included at each outfall under the traditional design alternative. To account for the water quality benefits of each LID control, the cost of this treatment system was reduced by half for the LID response scenarios.
7. A 30% contingency was applied to each estimate.

In general, the cost of each storm drain line remains approximately the same as more LID controls are added. While the LID controls themselves add costs to the project, they lower 100-year peak flows, which permits the use of smaller storm drain pipes. Additionally, the higher quality of storm runoff permits the use of smaller structural end-of-pipe treatment systems.

A summary of these costs is provided in Table 3 on the next page. Each storm drain system's cost represents the total cost of implementing a particular LID scenario for that system. More detailed opinions of probable construction costs are included in Appendix E.

The decrease in total cost from the Traditional Design to the Right-of-Way Response is driven by the lower cost of smaller storm drain trunks, which offset the increased cost of rain gardens in the right-of-way. The increase in total cost from the Right-of-Way to the Open Space Response can be attributed to a much greater area of rain gardens along the canals and lakes, which outweigh the decreased in cost from smaller storm drain trunks. The decrease in total cost from the Open Space to the Architectural Response is entirely due to smaller storm drain trunks, because the increased cost of implementing green roofs would be assumed by developers.

Table 3. Opinion of Probable Construction Cost Summary

	Traditional	ROW	Open Space	Architectural
8th Street	$ 741,000	$ 699,000	$ 701,000	$ 689,000
7th Street	$ 888,000	$ 881,000	$ 1,026,000	$ 992,000
6th Street	$ 798,000	$ 845,000	$ 1,051,000	$ 918,000
White Settlement North	$ 1,166,000	$ 1,155,000	$ 1,284,000	$ 1,269,000
4th Street	$ 666,000	$ 695,000	$ 758,000	$ 758,000
Throckmorton Street North	$ 200,000	$ 164,000	$ 209,000	$ 209,000
Throckmorton Street South	$ 416,000	$ 372,000	$ 423,000	$ 412,000
Street F at 7th	$ 251,000	$ 231,000	$ 269,000	$ 269,000
Street F at White Settlement	$ 354,000	$ 331,000	$ 469,000	$ 469,000
Street F at 4th	$ 217,000	$ 178,000	$ 305,000	$ 305,000
Street F at 3rd	$ 336,000	$ 330,000	$ 316,000	$ 313,000
Calhoun Street	$ 217,000	$ 195,000	$ 287,000	$ 281,000
White Settlement Mid	$ 209,000	$ 175,000	$ 334,000	$ 334,000
White Settlement South	$ 488,000	$ 540,000	$ 506,000	$ 506,000
Street A North	$ 309,000	$ 317,000	$ 344,000	$ 344,000
Street A South	$ 693,000	$ 658,000	$ 804,000	$ 790,000
Street B	$ 262,000	$ 229,000	$ 331,000	$ 331,000
Totals	**$ 8,211,000**	**$ 7,995,000**	**$ 9,417,000**	**$ 9,189,000**

4.5 BUSINESS CASE EVALUATION

In partnership with Verdunity, Inc., FNI also estimated the benefits associated with each LID response. These estimations are based on green infrastructure Business Case Evaluator (BCE) software, developed by Impact Infrastructure, LLC. The benefits calculated for each LID response reflect the net present value of long-term economic benefits associated with improved water quality, including incremental increases in property value, recreational use value, tax revenue, and other factors. The software also accounts for the costs of long-term operations and maintenance (O&M) of LID elements.

Table 4 below summarizes the net present value of major economic elements for the Right-of-Way and Open Space Responses. Each of the costs or benefits presented in Table 4 represents an incremental increase over the Traditional Response scenario discussed previously. (For example, the capital cost of the Right-of-Way Response is $216,246 lower than that of the Traditional Response, and the capital cost of the Open Space Response is $1,206,000 higher than that of the Traditional Response.) As shown, the higher capital and O&M costs of each LID response is offset by increases to tangible benefits, i.e. sales and property taxes, and to intangible benefits, i.e. the subjective value of water and air quality.

For a detailed presentation of the BCE methodology and results, please refer to Verdunity's full BCE report, provided in Appendix F.

Table 4. Business Case Evaluation Summary

	Right-of-Way Response	Open Space Response
Costs:		
Capital	(-$216,246)	$1,206,000
Operations and Maintenance	$202,412	$442,325
Total	(-$13,834)	$1,648,325
Benefits:		
State/Local Sales Tax	$290,383	$580,767
Water Quality	$298,665	$371,184
Residential Property Tax (City/County)	$2,919,612	$5,717,190
CO2 Emissions	-	$142,858
Air Pollution	-	$199,981
Total	$3,460,785	$7,011,980
Net (Benefits - Cost)	$3,474,619	$5,363,655

5.0 CONCLUSION

The water quality of storm runoff is a critical factor in the success of the Panther Island project. Traditional curb-and-gutter development techniques convey storm runoff to a body of water as quickly as possible, missing the opportunity to treat water before it is concentrated in a public storm drain infrastructure. Rain gardens and green roofs increase the water quality of storm drain runoff but can also decrease peak flows in storm drain infrastructure, allowing for smaller, less expensive storm drain trunk lines. As additional LID controls are implemented, the water quality of storm runoff is appreciably increased with no impact or moderate impact to overall project cost.

In describing the storm drain infrastructure required to support each level of LID implementation, this report is anticipated to provide guidance for future development and improved water quality as the Panther Island area is redeveloped.

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Updated: September 2014

EXHIBIT 2

CITY OF FORT WORTH

TRV STORM DRAIN MASTER PLAN
CONTRIBUTING DRAINAGE AREAS
RIGHT-OF-WAY RESPONSE

LEGEND

- Pipes
- Pipes (Size Decrease)
- Proposed ROW
- Proposed Lakes and Canals

North Drainage Areas

- 8th Street
- 7th Street
- 6th Street
- White Settlement North
- 4th Street
- Calhoun Street
- Clear Fork Gate
- Throckmorton Street North
- Throckmorton Street South
- Street F at 7th
- Street F at White Settlement
- Street F at 4th
- Street F at 3rd

South Drainage Areas

- White Settlement Mid
- Street A North
- Street A South
- White Settlement South
- Street B

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Updated: September 2014

#	DESCRIPTION
1	Pipes to remain and drain through proposed Grand Ave. outfall
2	Pipe to be removed with Channel Zone 3
3	Outfall to be relocated to NE 8th St
4	Pipe abandoned with Grand Ave. realignment
5	Pipe to be removed with Main St Bridge
6	Pipes to be incrementally replaced as required by development
7	Conflicts with Canal D
8	Unnecessary pipes to be abandoned after construction of canals
9	Outfall to remain
10	Pipe to be removed with Henderson Bridge
11	Conflicts with Development and Canal A
12	Outfall unnecessary with upstream development
13	Pipe to be replaced with Channel Zone 4
14	Pipe to be removed with Channel Zone 4
15	Outfall and storm drain to remain

EXHIBIT 5

CITY OF FORT WORTH

TRV STORM DRAIN MASTER PLAN
EXISTING CONFLICTS

LEGEND

- Existing Storm Drain Upsized with Future Development
- Existing Storm Drain to Remain
- Existing Storm Drain Removed During Central City Project
- Existing Storm Drain Incompatible with Future Development
- Proposed ROW
- Proposed Lakes and Canals

This exhibit represents preliminary conceptual alignments for the stormwater masterplan based on the KHA Grading Plan received March 6, 2013.

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Updated: August 2013

Appendix A
LID Control Water Quality Calculations

LID Control Water Quality Calculations

The calculations below are in support of the water quality treatment capacity of each LID scenario. As described in Section 2.2, the storage capacity of each LID scenario was calculated after delineating the total square footage of each LID control according to the provided comprehensive plan. These square footages are represented below as "Total area, sq ft." Each LID control was assumed to have a particular depth of ponding, depth of soil storage, and depth of drain rock storage. The total volume of storage is obtained by multiplying each LID control's square footage by its depth, porosity, and expected maximum saturation level that occurs during a rainfall event.

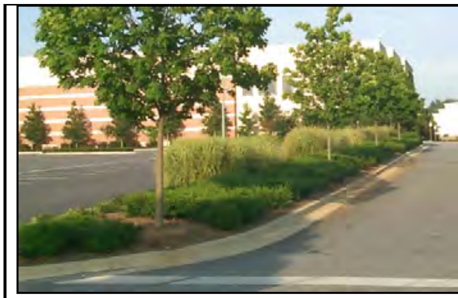
Because each LID scenario is cumulative and includes LID controls from previous scenarios, the cumulative volume for each scenario is divided by the total project area, 329.8 acres, to obtain the cumulative initial abstraction in inches. This cumulative initial abstraction represents the portion of the water quality volume that is treated.

Right-of-Way Response Storage *(5-ft-wide Rain Gardens Along ROW)*					
Total area, sq ft	277,878				
	Depth (in)	Porosity	Saturation	Volume (ft^3)	
Ponding	6	100%	100%	138,939	
Soil storage	42	30%	75%	218,829	
Drain rock storage	6	25%	75%	26,051	
	54			383,819	Total volume
				383,819	Cumulative volume
				0.32	**Cumulative initial abstraction (in)**
Open Space Response Storage *(10-ft-Wide Rain Gardens in Open Space)*					
Total area, sq ft	316,120				
	Depth (in)	Porosity	Saturation	Volume (ft^3)	
Ponding	6	100%	100%	158,060	
Soil storage	42	30%	75%	248,945	
Drain rock storage	6	25%	75%	29,636	
	54			436,641	Total volume
				820,460	**Cumulative volume**
				0.69	**Cumulative initial abstraction (in)**
Architectural Response Storage *(Green Roofs Covering 25% of Building Area)*					
Total area, sq ft	1,154,394				
	Depth (in)	Porosity	Saturation	Volume (ft^3)	
Ponding	0	100%	100%	-	
Soil storage	4	30%	75%	86,580	
Drain rock storage	2	25%	75%	36,075	
	6			122,654	Total volume
				943,114	**Cumulative volume**
				0.79	**Cumulative initial abstraction (in)**

Appendix B
iSWM Fact Sheets
Bioretention/Rain Gardens and Green Roofs

2.0 Bioretention

Structural Stormwater Control



Description: Shallow stormwater basin or landscaped area that utilizes engineered soils and vegetation to capture and treat runoff.

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Maximum contributing drainage area of 5 acres (< 2 acres recommended)
- Often located in "landscaping islands"
- Treatment area consists of grass filter, sand bed, ponding area, organic/mulch layer, planting soil, and vegetation
- Typically requires 5 feet of head

ADVANTAGES / BENEFITS:

- Applicable to small drainage areas
- Good for highly impervious areas, flexible siting
- Good retrofit capability
- Relatively low maintenance requirements
- Can be planned as an aesthetic feature

DISADVANTAGES / LIMITATIONS:

- Requires extensive landscaping if in public area
- Not recommended for areas with steep slopes

MAINTENANCE REQUIREMENTS:

- Inspect and repair/replace treatment area components

POLLUTANT REMOVAL

80%	**Total Suspended Solids**
60/50%	**Nutrients** - Total Phosphorus / Total Nitrogen removal
M	**Metals** - Cadmium, Copper, Lead, and Zinc removal
No Data	**Pathogens** - Coliform, Streptococci, E. Coli removal

STORMWATER MANAGEMENT SUITABILITY

P	**Water Quality Protection**
S	**Streambank Protection**
S	**On-Site Flood Control**
	Downstream Flood Control

Accepts Hotspot Runoff: Yes (requires impermeable liner)

S - in certain situations

IMPLEMENTATION CONSIDERATIONS

M	**Land Requirement**
M	**Capital Cost**
L	**Maintenance Burden**

Residential Subdivision Use: Yes

High Density/Ultra-Urban: Yes

Drainage Area: 5 acres max. (< 2 acres recommended)

Soils: Planting soils must meet specified criteria; No restrictions on surrounding soils

Other Considerations: Use of native plants is recommended

L=Low **M**=Moderate **H**=High

23.0 Green Roof

Structural Stormwater Control

Description: A green roof uses a small amount of substrate over an impermeable membrane to support a covering of plants. The green roof slows down runoff from the otherwise impervious roof surface as well as moderating rooftop temperatures. With the right plants, a green roof will also provide aesthetic or habitat benefits. Green roofs have been used in Europe for decades.

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Relatively new in North America
- Potential for high failure rate if poorly designed, poorly constructed, not adequately maintained Minimum length to width ratio for the pond is 1.5:1

ADVANTAGES / BENEFITS:

- Provides reduction in runoff volume
- Higher initial cost when compared to conventional roofs, but potential for lower life cycle costs through longevity

DISADVANTAGES / LIMITATIONS:

- Requires additional roof support
- Requires more maintenance than regular roofs
- Special attention to design and construction needed
- Requires close coordination with plant specialists
- Potential for leakage due to plant roots penetrating membrane.

POLLUTANT REMOVAL

85%	**Total Suspended Solids**
95/16%	**Nutrients** - Total Phosphorus / Total Nitrogen removal
25%	**Metals** - Cadmium, Copper, Lead, and Zinc removal
No Data	**Pathogens** - Coliform, Streptococci, E. Coli removal

STORMWATER MANAGEMENT SUITABILITY

P	**Water Quality Protection**
S	**Streambank Protection**
☐	**On-Site Flood Control**
☐	**Downstream Flood Control**

IMPLEMENTATION CONSIDERATIONS

L	**Land Requirement**
L	**Capital Cost**
H	**Maintenance Burden**

Residential Subdivision Use: No

High Density/Ultra-Urban: Yes

Drainage Area: No restrictions.

Soils: No restrictions.

Other Considerations:

- Hotspot Areas

L=Low **M**=Moderate **H**=High

Appendix C
Hydrologic Parameters by LID Scenario

Hydrologic Parameters – Traditional Design & Right-of-Way Response

Subbasin	Area (ac)	Slope (%)	Width (ft)	Subbasin	Area (ac)	Slope (%)	Width (ft)
2	3.074	0.5	309.4	67	4.379	0.9	230.6
3	7.007	0.3	421.7	68	6.871	0.5	457.2
4	1.242	0.3	101.6	69	1.753	0.6	107.9
5	5.399	0.2	271.5	70	3.281	0.5	242.1
6	1.254	0.2	146.8	71	2.07	0.6	258
7	2.344	0.6	160	72	3.266	0.5	241
8	1.088	0.5	153.3	73	4.862	1.6	239.3
9	0.947	0.6	102.4	75	1.477	0.7	97.2
10	2.249	0.7	199.7	76	3.987	1.1	212
11	7.174	0.3	291.1	78	0.629	0.9	105.2
12	2.876	0.5	190.1	79	5.977	0.4	395
13	1.169	0.6	116	80	2.314	0.4	166.6
14	2.256	0.3	291.1	81	3.287	0.5	250.7
15	1.275	0.4	162.8	83	2.048	0.6	108.2
18	3.555	3.2	89.5	84	1.662	1.1	120.8
21	2.586	0.5	163	86	3.263	3.3	178.1
22	3.009	0.3	210.8	87	0.882	3.3	48.1
23	2.121	3	149.5	88	2.212	2.2	215
24	1.498	0.5	179.6	89	6.708	0.3	307.1
25	2.557	0.5	295.3	90	4.49	1.5	369.8
26	1.852	0.5	155.7	91	1.546	2.2	145.5
27	4.84	3.2	119.3	92	1.632	2.1	130.9
28	1.98	0.6	193.3	93	2.662	0.4	210.4
29	2.067	0.6	201.8	94	2.626	0.6	225.6
31	2.822	1	220.6	96	3.617	0.4	216.8
32	2.52	1	206.9	97	9.557	1.3	413.3
33	1.943	3.1	154.5	98	9.985	1.5	434.1
34	0.644	0.6	99.5	99	3.283	0.4	109.7
36	3.813	0.9	238	100	2.112	0.6	206.6
37	1.339	0.9	181.4	101	4.357	0.5	195.4
40	2.81	0.7	279.2	102	3.528	0.4	254.7
41	0.953	0.8	129.1	106	3.905	1.9	320.1
42	0.797	0.6	123	107	3.339	0.6	277.4
43	2.178	0.6	181.8	108	4.603	2	303.7
44	3.718	1	196.8	110	1.989	0.9	146.8
45	3.768	0.8	256.8	111	1.047	1.4	145.6
46	2.977	0.9	220.9	112	1.245	0.7	127.5
47	1.132	0.5	137.6	113	6.098	2.3	303.5
48	0.73	0.5	88.6	114	1.928	0.7	200.5
49	2.609	0.6	234.9	115	4.389	1.7	220.7
50	0.847	0.5	89.8	116	2.012	0.2	124.2
52	0.97	0.7	140.5	117	3.952	1.6	205.8
53	3.801	0.9	212.5	118	3.941	0.6	290.5
54	3.896	1.2	239.6	120	4.674	1.3	237.4
55	3.139	0.5	221.9	121	4.571	0.9	251.6
56	1.792	0.8	158.1	122	2.57	3.7	146.9
57	3.699	0.5	284.4	126	7.294	0.3	273.4
58	1.337	0.6	170.8	130	2.657	0.6	182.6
59	3.389	0.8	215.6	131	1.123	0.9	140.2
60	2.776	0.5	212.3	132	1.669	0.6	151.8
61	4.445	0.8	233.3	136	2.243	0.3	272.5
62	6.497	1	224.3	138	1.341	5.6	90.7
63	2.391	0.6	156.5	140	1.96	1.5	162.7
65	1.983	0.7	158.7	141	1.257	1.1	104.8
66	3.709	1.9	258.9				

Hydrologic Parameters – Open Space & Architectural Responses

Subbasin	Area (ac)	Slope (%)	Width (ft)
2	1.416	0.4	115.5
3	2.268	0.6	254.5
4	1.242	0.3	101.6
5	5.399	0.2	271.5
6	1.254	0.2	146.8
7	1.139	0.7	102.6
8	1.088	0.5	153.3
9	0.443	0.8	64.5
10	0.641	0.7	56.9
11	5.562	0.3	225.7
12	0.796	0.7	70.3
13	0.505	0.6	50.1
14	2.256	0.3	291.1
15	0.57	0.4	72.8
18	3.065	3.2	77.1
21	0.948	0.8	94.7
22	1.206	0.3	84.5
23	0.735	4.1	71.3
24	0.608	0.5	72.8
25	0.214	0.5	24.7
26	1.427	0.5	120
27	3.682	3.2	90.8
28	0.801	0.6	78.2
29	0.849	0.6	82.9
31	1.874	1.6	231.7
32	1.647	1.5	205.5
33	1.155	3.1	91.8
34	0.644	0.6	99.5
36	2.467	1	183.2
37	0.494	0.9	67
40	1.711	0.7	170
41	0.362	0.8	49
42	0.587	0.6	90.6
43	1.212	0.6	101.1
44	3.718	1	196.8
45	3.768	0.8	256.8
46	2.155	0.9	159.9
47	0.376	0.5	45.7
48	0.337	0.5	40.9
49	1.212	0.6	109.1
50	0.495	0.5	52.5
52	0.632	0.7	91.6
53	3.801	0.9	212.5
54	3.896	1.2	239.6
55	0.876	0.7	88.9
56	1.154	0.8	101.8
57	1.787	0.5	137.3
58	0.302	0.6	38.6
59	3.389	0.8	215.6
60	1.478	0.5	113
61	4.445	0.8	233.3
62	6.497	1	224.3
63	1.065	0.8	99.1
65	1.109	0.7	88.8
66	3.709	1.9	258.9

Subbasin	Area (ac)	Slope (%)	Width (ft)
67	4.379	0.9	230.6
68	3.4	0.7	334.3
69	0.913	0.8	66.3
70	1.414	0.5	104.3
71	2.07	0.6	258
72	1.445	0.5	106.6
73	4.862	1.6	239.3
75	0.793	0.8	62.3
76	3.987	1.1	212
78	0.335	0.9	56.1
79	2.784	0.6	269.8
80	2.314	0.4	166.6
81	1.327	0.5	101.2
83	2.048	0.6	108.2
84	1.662	1.1	120.8
86	3.263	3.3	178.1
87	0.882	3.3	48.1
88	2.212	2.2	215
89	1.759	0.6	142.4
90	2.036	1.5	167.7
91	1.546	2.2	145.5
92	1.632	2.1	130.9
93	0.87	0.6	117.5
94	0.583	0.7	60.9
96	1.275	0.6	101.7
97	3.043	1.6	171.4
98	4.987	2	282.5
99	1.513	0.6	71.9
100	1.201	0.7	148.8
101	2.297	0.6	113.4
102	1.896	0.6	195.4
106	3.905	1.9	320.1
107	1.843	0.6	153.1
108	4.603	2	303.7
110	1.093	1.4	128.5
111	1.047	1.4	145.6
112	1.245	0.7	127.5
113	6.098	2.3	303.5
114	1.928	0.7	200.5
115	4.389	1.7	220.7
116	1.271	0.2	82.9
117	3.952	1.6	205.8
118	1.997	0.6	147.2
120	0.494	2.8	54.5
121	2.559	0.9	147.7
122	2.57	3.7	146.9
126	4.244	0.3	171.2
130	2.657	0.6	182.6
131	0.173	0.9	21.6
132	0.66	0.8	72.9
136	2.243	0.3	272.5
138	1.341	5.6	90.7
140	1.96	1.5	162.7
141	1.257	1.1	104.8

Appendix D
Peak 100-yr Flow Rates by LID Scenario

Peak 100-yr Flow Rates by LID Scenario (cfs)

Subbasin	Traditional	Right-of-Way	Open Space	Architectural	Subbasin	Traditional	Right-of-Way	Open Space	Architectural
2	29.5	25.5	10.5	9.2	67	39.9	33.3	32.4	28.1
3	59.0	47.1	19.2	17.2	68	61.5	50.8	28.4	25.4
4	10.9	8.9	8.7	7.6	69	16.0	13.3	7.2	6.4
5	41.9	33.4	32.3	28.4	70	30.2	25.4	10.6	9.3
6	11.5	9.7	9.4	8.2	71	20.6	18.3	17.8	16.1
7	21.5	18.0	9.4	8.4	72	30.1	25.2	10.9	9.5
8	10.9	9.8	9.5	8.6	73	45.9	39.2	38.1	33.6
9	9.3	8.2	4.1	3.7	75	13.6	11.5	6.4	5.7
10	21.8	19.0	5.3	4.7	76	37.2	31.5	30.6	26.8
11	53.9	43.1	32.3	28.1	78	6.5	6.0	3.1	2.9
12	26.1	21.7	6.5	5.8	79	52.9	43.3	22.9	20.4
13	11.4	9.9	4.2	3.7	80	20.8	17.2	16.7	14.5
14	21.7	18.8	18.2	16.2	81	30.4	25.5	10.0	8.7
15	12.5	11.0	4.8	4.3	83	18.0	14.7	14.3	12.5
18	31.9	26.3	22.1	19.1	84	16.1	14.1	13.7	12.2
21	23.0	18.9	8.0	7.2	86	32.6	29.2	28.4	25.7
22	26.3	21.3	8.3	7.3	87	8.8	7.9	7.7	7.0
23	21.6	19.7	7.1	6.7	88	22.8	21.1	20.5	19.0
24	14.7	13.0	5.1	4.6	89	53.7	42.6	13.9	12.3
25	25.1	22.1	1.8	1.6	90	45.0	40.2	17.7	16.1
26	17.5	14.9	11.2	9.8	91	15.9	14.6	14.2	13.2
27	43.1	35.5	26.3	22.8	92	16.6	15.0	14.6	13.4
28	19.3	16.8	6.6	5.9	93	24.2	20.1	7.7	7.0
29	20.1	17.6	7.0	6.3	94	25.1	21.6	5.0	4.5
31	27.5	24.1	17.5	16.3	96	31.5	25.6	9.9	8.7
32	24.6	21.6	15.3	14.3	97	87.0	72.5	24.8	22.0
33	20.0	18.4	10.7	9.9	98	92.1	77.4	41.5	37.1
34	6.6	6.0	5.8	5.4	99	24.4	19.6	10.1	8.9
36	35.7	30.3	20.3	18.1	100	20.5	17.8	10.6	9.6
37	13.7	12.5	4.5	4.1	101	36.4	29.0	15.6	13.7
40	27.6	24.3	14.4	12.9	102	31.9	26.4	15.8	14.2
41	9.7	8.8	3.3	3.0	106	39.5	35.7	34.8	31.8
42	8.1	7.4	5.3	4.9	107	31.8	27.3	14.7	13.0
43	20.6	17.6	9.5	8.4	108	45.7	40.7	39.6	35.7
44	34.4	28.9	28.1	24.6	110	19.1	16.4	10.1	9.3
45	35.5	30.2	29.4	25.8	111	10.9	10.2	9.9	9.2
46	28.5	24.6	17.3	15.4	112	12.3	10.9	10.6	9.5
47	11.2	9.9	3.2	2.9	113	59.1	51.5	50.1	44.6
48	7.2	6.4	2.9	2.6	114	19.1	16.9	16.4	14.8
49	25.2	21.8	9.9	8.8	115	41.8	35.8	34.9	30.8
50	8.3	7.2	4.1	3.7	116	16.2	12.8	7.9	7.1
52	9.9	8.9	5.7	5.2	117	37.6	32.3	31.4	27.7
53	35.0	29.4	28.6	25.0	118	36.9	31.2	15.4	13.5
54	37.2	32.1	31.2	27.6	120	43.7	37.1	4.7	4.4
55	28.5	23.7	7.4	6.6	121	42.0	35.2	19.5	17.1
56	17.5	15.3	9.6	8.6	122	26.0	23.4	22.8	20.8
57	34.4	29.1	13.6	11.9	126	53.1	42.5	24.7	21.5
58	13.4	12.0	2.6	2.4	130	24.5	20.5	19.9	17.4
59	31.5	26.6	25.8	22.6	131	11.4	10.3	1.6	1.4
60	25.8	21.8	11.3	9.9	132	16.1	14.0	5.7	5.2
61	40.3	33.5	32.6	28.2	136	21.3	18.3	17.7	15.7
62	55.3	44.4	43.1	38.2	138	13.9	13.0	12.6	11.8
63	21.8	18.2	9.0	8.1	140	19.7	17.7	17.2	15.6
65	19.0	16.4	8.9	7.9	141	12.4	10.9	10.6	9.5
66	37.0	32.9	32.0	29.0					

Appendix E
Opinions of Probable Construction Cost

Trinity River Vision Conceptual Storm Drain
Opinion of Probable Construction Cost
Traditional Design Alternative
Trinity River Vision Authority

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
TSC08309	JGJ	SKH	August 21, 2013

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
8th Street					
	48" RCP	270	LF	$170	$45,900
	7'x4' RCB	680	LF	$450	$306,000
	Laterals (24" RCP)	570	LF	$70	$39,900
	Appurtenances	20	%	$78,360	$78,360
	Structural End of Pipe Treatment System	1	EA	$100,000	$100,000
	Contingency	30	%	$171,048	$171,048
				8th Street Subtotal	$741,000
7th Street					
	48" RCP	300	LF	$170	$51,000
	7'x4' RCB	780	LF	$450	$351,000
	36" RCP	190	LF	$110	$20,900
	Laterals (24" RCP)	770	LF	$70	$53,900
	Appurtenances	20	%	$95,360	$95,360
	Demo Existing Pipe	560	LF	$20	$11,200
	Structural End of Pipe Treatment System	1	EA	$100,000	$100,000
	Contingency	30	%	$205,008	$205,008
				7th Street Subtotal	$888,000
6th Street					
	48" RCP	330	LF	$170	$56,100
	5'x4' RCB	560	LF	$340	$190,400
	6'x4' RCB	220	LF	$380	$83,600
	30" RCP	210	LF	$90	$18,900
	Laterals (24" RCP)	800	LF	$70	$56,000
	Appurtenances	20	%	$81,000	$81,000
	Demo Existing Pipe	1,400	LF	$20	$28,000
	Structural End of Pipe Treatment System	1	EA	$100,000	$100,000
	Contingency	30	%	$184,200	$184,200
				6th Street Subtotal	$798,000
White Settlement North					
	30" RCP	870	LF	$90	$78,300
	48" RCP	620	LF	$170	$105,400
	7'x4' RCB	820	LF	$450	$369,000
	Laterals (24" RCP)	1,390	LF	$70	$97,300
	Appurtenances	20	%	$130,000	$130,000
	Demo Existing Pipe	830	LF	$20	$16,600
	Structural End of Pipe Treatment System	1	EA	$100,000	$100,000
	Contingency	30	%	$268,980	$268,980
				White Settlement North Subtotal	$1,166,000

Trinity River Vision Conceptual Storm Drain
Opinion of Probable Construction Cost
Traditional Design Alternative
Trinity River Vision Authority

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
TSC08309	JGJ	SKH	August 21, 2013

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
4th Street					
	4'x4' RCB	560	LF	$220	$123,200
	36" RCP	280	LF	$110	$30,800
	6'x4' RCB	300	LF	$380	$114,000
	24" RCP	210	LF	$70	$14,700
	Laterals (24" RCP)	810	LF	$70	$56,700
	Appurtenances	20	%	$67,880	$67,880
	Demo Existing Pipe	260	LF	$20	$5,200
	Structural End of Pipe Treatment System	1	EA	$100,000	$100,000
	Contingency	30	%	$153,744	$153,744
				4th Street Subtotal	$666,000
Throckmorton Street North					
	24" RCP	400	LF	$70	$28,000
	Laterals (24" RCP)	240	LF	$70	$16,800
	Appurtenances	20	%	$8,960	$8,960
	Structural End of Pipe Treatment System	1	EA	$100,000	$100,000
	Contingency	30	%	$46,128	$46,128
				Throckmorton Street North Subtotal	$200,000
Throckmorton Street South					
	24" RCP	200	LF	$70	$14,000
	42" RCP	440	LF	$140	$61,600
	48" RCP	380	LF	$170	$64,600
	Laterals (24" RCP)	620	LF	$70	$43,400
	Appurtenances	20	%	$36,720	$36,720
	Structural End of Pipe Treatment System	1	EA	$100,000	$100,000
	Contingency	30	%	$96,096	$96,096
				Throckmorton Street South Subtotal	$416,000
Street F at 7th					
	36" RCP	510	LF	$110	$56,100
	Laterals (24" RCP)	310	LF	$70	$21,700
	Appurtenances	20	%	$15,560	$15,560
	Structural End of Pipe Treatment System	1	EA	$100,000	$100,000
	Contingency	30	%	$58,008	$58,008
				Street F at 7th Subtotal	$251,000
Street F at White Settlement					
	42" RCP	640	LF	$140	$89,600
	30" RCP	200	LF	$90	$18,000
	Laterals (24" RCP)	510	LF	$70	$35,700
	Appurtenances	20	%	$28,660	$28,660
	Structural End of Pipe Treatment System	1	EA	$100,000	$100,000
	Contingency	30	%	$81,588	$81,588
				Street F at White Settlement Subtotal	$354,000

FREESE AND NICHOLS

Trinity River Vision Conceptual Storm Drain

Opinion of Probable Construction Cost

Traditional Design Alternative

Trinity River Vision Authority

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
TSC08309	JGJ	SKH	August 21, 2013

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
Street F at 4th					
	30" RCP	420	LF	$90	$37,800
	Laterals (24" RCP)	260	LF	$70	$18,200
	Appurtenances	20	%	$11,200	$11,200
	Structural End of Pipe Treatment System	1	EA	$100,000	$100,000
	Contingency	30	%	$50,160	$50,160
				Street F at 4th Subtotal	$217,000
Street F at 3rd					
	48" RCP	540	LF	$170	$91,800
	30" RCP	130	LF	$90	$11,700
	Laterals (24" RCP)	410	LF	$70	$28,700
	Appurtenances	20	%	$26,440	$26,440
	Structural End of Pipe Treatment System	1	EA	$100,000	$100,000
	Contingency	30	%	$77,592	$77,592
				Street F at 3rd Subtotal	$336,000
Calhoun Street					
	24" RCP	210	LF	$70	$14,700
	36" RCP	210	LF	$110	$23,100
	Laterals (24" RCP)	260	LF	$70	$18,200
	Appurtenances	20	%	$11,200	$11,200
	Structural End of Pipe Treatment System	1	EA	$100,000	$100,000
	Contingency	30	%	$50,160	$50,160
				Calhoun Street Subtotal	$217,000
White Settlement Mid					
	30" RCP	210	LF	$90	$18,900
	24" RCP	200	LF	$70	$14,000
	Laterals (24" RCP)	250	LF	$70	$17,500
	Appurtenances	20	%	$10,080	$10,080
	Structural End of Pipe Treatment System	1	EA	$100,000	$100,000
	Contingency	30	%	$48,144	$48,144
				White Settlement Mid Subtotal	$209,000
White Settlement South					
	48" RCP	290	LF	$170	$49,300
	5'x4' RCB	440	LF	$340	$149,600
	Laterals (24" RCP)	440	LF	$70	$30,800
	Appurtenances	20	%	$45,940	$45,940
	Structural End of Pipe Treatment System	1	EA	$100,000	$100,000
	Contingency	30	%	$112,692	$112,692
				White Settlement South Subtotal	$488,000

Trinity River Vision Conceptual Storm Drain
Opinion of Probable Construction Cost
Traditional Design Alternative
Trinity River Vision Authority

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
TSC08309	JGJ	SKH	August 21, 2013

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
Street A North					
	42" RCP	340	LF	$140	$47,600
	4'x4' RCB	200	LF	$220	$44,000
	Laterals (24" RCP)	330	LF	$70	$23,100
	Appurtenances	20	%	$22,940	$22,940
	Structural End of Pipe Treatment System	1	EA	$100,000	$100,000
	Contingency	30	%	$71,292	$71,292
				Street A North Subtotal	$309,000
Street A South					
	42" RCP	710	LF	$140	$99,400
	4'x4' RCB	320	LF	$220	$70,400
	6'x4' RCB	350	LF	$380	$133,000
	Laterals (24" RCP)	830	LF	$70	$58,100
	Appurtenances	20	%	$72,180	$72,180
	Structural End of Pipe Treatment System	1	EA	$100,000	$100,000
	Contingency	30	%	$159,924	$159,924
				Street A South Subtotal	$693,000
Street B					
	36" RCP	270	LF	$110	$29,700
	4'x4' RCB	150	LF	$220	$33,000
	Laterals (24" RCP)	260	LF	$70	$18,200
	Appurtenances	20	%	$16,180	$16,180
	Demo Existing Pipe	220	LF	$20	$4,400
	Structural End of Pipe Treatment System	1	EA	$100,000	$100,000
	Contingency	30	%	$60,444	$60,444
				Street B Subtotal	$262,000
				Project Total	**$8,211,000**

Note: The unit cost of rain gardens represents an incremental increase over the cost of street trees shown in the comprehensive plan dated March 2013.

FREESE AND NICHOLS

Trinity River Vision Conceptual Storm Drain

Opinion of Probable Construction Cost

Right-of-Way Response

Trinity River Vision Authority

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
TSC08309	JGJ	SKH	August 21, 2013

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
8th Street					
	42" RCP	270	LF	$140	$37,800
	7'x4' RCB	680	LF	$450	$306,000
	Laterals (24" RCP)	570	LF	$70	$39,900
	Appurtenances	10	%	$38,370	$38,370
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way	13,120	SF	$5	$65,600
	Contingency	30	%	$161,301	$161,301
				8th Street Subtotal	$699,000
7th Street					
	42" RCP	300	LF	$140	$42,000
	6'x4' RCB	560	LF	$380	$212,800
	7'x4' RCB	220	LF	$450	$99,000
	30" RCP	190	LF	$90	$17,100
	Laterals (24" RCP)	770	LF	$70	$53,900
	Appurtenances	10	%	$42,480	$42,480
	Demo Existing Pipe	560	LF	$20	$11,200
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way	29,900	SF	$5	$149,500
	Contingency	30	%	$203,394	$203,394
				7th Street Subtotal	$881,000
6th Street					
	42" RCP	330	LF	$140	$46,200
	5'x4' RCB	780	LF	$340	$265,200
	30" RCP	210	LF	$90	$18,900
	Laterals (24" RCP)	800	LF	$70	$56,000
	Appurtenances	10	%	$38,630	$38,630
	Demo Existing Pipe	1,400	LF	$20	$28,000
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way	29,450	SF	$5	$147,250
	Contingency	30	%	$195,054	$195,054
				6th Street Subtotal	$845,000
White Settlement North					
	30" RCP	870	LF	$90	$78,300
	42" RCP	620	LF	$140	$86,800
	6'x4' RCB	820	LF	$380	$311,600
	Laterals (24" RCP)	1,390	LF	$70	$97,300
	Appurtenances	10	%	$57,400	$57,400
	Demo Existing Pipe	830	LF	$20	$16,600
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way	38,060	SF	$5	$190,300
	Contingency	30	%	$266,490	$266,490
				White Settlement North Subtotal	$1,155,000

Trinity River Vision Conceptual Storm Drain

Opinion of Probable Construction Cost

Right-of-Way Response

Trinity River Vision Authority

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
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ITEM / DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
4th Street				
4'x4' RCB	560	LF	$220	$123,200
36" RCP	280	LF	$110	$30,800
5'x4' RCB	300	LF	$340	$102,000
24" RCP	210	LF	$70	$14,700
Laterals (24" RCP)	810	LF	$70	$56,700
Appurtenances	10	%	$32,740	$32,740
Demo Existing Pipe	260	LF	$20	$5,200
Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
Rain Gardens in Right-of-Way	23,910	SF	$5	$119,550
Contingency	30	%	$160,467	$160,467
			4th Street Subtotal	$695,000
Throckmorton Street North				
24" RCP	400	LF	$70	$28,000
Laterals (24" RCP)	240	LF	$70	$16,800
Appurtenances	10	%	$4,480	$4,480
Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
Rain Gardens in Right-of-Way	5,450	SF	$5	$27,250
Contingency	30	%	$37,959	$37,959
			Throckmorton Street North Subtotal	$164,000
Throckmorton Street South				
24" RCP	200	LF	$70	$14,000
42" RCP	820	LF	$140	$114,800
Laterals (24" RCP)	620	LF	$70	$43,400
Appurtenances	10	%	$17,220	$17,220
Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
Rain Gardens in Right-of-Way	9,380	SF	$5	$46,900
Contingency	30	%	$85,896	$85,896
			Throckmorton Street South Subtotal	$372,000
Street F at 7th				
36" RCP	510	LF	$110	$56,100
Laterals (24" RCP)	310	LF	$70	$21,700
Appurtenances	10	%	$7,780	$7,780
Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
Rain Gardens in Right-of-Way	8,420	SF	$5	$42,100
Contingency	30	%	$53,304	$53,304
			Street F at 7th Subtotal	$231,000
Street F at White Settlement				
36" RCP	310	LF	$110	$34,100
42" RCP	330	LF	$140	$46,200
24" RCP	200	LF	$70	$14,000
Laterals (24" RCP)	510	LF	$70	$35,700
Appurtenances	10	%	$13,000	$13,000
Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
Rain Gardens in Right-of-Way	12,300	SF	$5	$61,500
Contingency	30	%	$76,350	$76,350
			Street F at White Settlement Subtotal	$331,000

Trinity River Vision Conceptual Storm Drain
Opinion of Probable Construction Cost
Right-of-Way Response
Trinity River Vision Authority

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
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ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
Street F at 4th					
	24" RCP	420	LF	$70	$29,400
	Laterals (24" RCP)	260	LF	$70	$18,200
	Appurtenances	10	%	$4,760	$4,760
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way	6,890	SF	$5	$34,450
	Contingency	30	%	$41,043	$41,043
				Street F at 4th Subtotal	$178,000
Street F at 3rd					
	42" RCP	540	LF	$140	$75,600
	30" RCP	130	LF	$90	$11,700
	Laterals (24" RCP)	410	LF	$70	$28,700
	Appurtenances	10	%	$11,600	$11,600
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way	15,300	SF	$5	$76,500
	Contingency	30	%	$76,230	$76,230
				Street F at 3rd Subtotal	$330,000
Calhoun Street					
	24" RCP	210	LF	$70	$14,700
	30" RCP	210	LF	$90	$18,900
	Laterals (24" RCP)	260	LF	$70	$18,200
	Appurtenances	10	%	$5,180	$5,180
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way	8,670	SF	$5	$43,350
	Contingency	30	%	$45,099	$45,099
				Calhoun Street Subtotal	$195,000
White Settlement Mid					
	24" RCP	410	LF	$70	$28,700
	Laterals (24" RCP)	250	LF	$70	$17,500
	Appurtenances	10	%	$4,620	$4,620
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way	6,730	SF	$5	$33,650
	Contingency	30	%	$40,341	$40,341
				White Settlement Mid Subtotal	$175,000
White Settlement South					
	48" RCP	290	LF	$170	$49,300
	5'x4' RCB	440	LF	$340	$149,600
	Laterals (24" RCP)	440	LF	$70	$30,800
	Appurtenances	10	%	$22,970	$22,970
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way	22,540	SF	$5	$112,700
	Contingency	30	%	$124,611	$124,611
				White Settlement South Subtotal	$540,000

Trinity River Vision Conceptual Storm Drain
Opinion of Probable Construction Cost
Right-of-Way Response
Trinity River Vision Authority

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
TSC08309	JGJ	SKH	August 21, 2013

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
Street A North					
	42" RCP	340	LF	$140	$47,600
	48" RCP	200	LF	$170	$34,000
	Laterals (24" RCP)	330	LF	$70	$23,100
	Appurtenances	10	%	$10,470	$10,470
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way	15,800	SF	$5	$79,000
	Contingency	30	%	$73,251	$73,251
				Street A North Subtotal	$317,000
Street A South					
	42" RCP	310	LF	$140	$43,400
	48" RCP	320	LF	$170	$54,400
	36" RCP	400	LF	$110	$44,000
	5'x4' RCB	350	LF	$340	$119,000
	Laterals (24" RCP)	830	LF	$70	$58,100
	Appurtenances	10	%	$31,890	$31,890
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way	21,110	SF	$5	$105,550
	Contingency	30	%	$151,902	$151,902
				Street A South Subtotal	$658,000
Street B					
	36" RCP	270	LF	$110	$29,700
	48" RCP	150	LF	$170	$25,500
	Laterals (24" RCP)	260	LF	$70	$18,200
	Appurtenances	10	%	$7,340	$7,340
	Demo Existing Pipe	220	LF	$20	$4,400
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way	8,220	SF	$5	$41,100
	Contingency	30	%	$52,872	$52,872
				Street B Subtotal	$229,000
				Project Total	**$7,995,000**

Note: The unit cost of rain gardens represents an incremental increase over the cost of street trees shown in the comprehensive plan dated March 2013.

FREESE AND NICHOLS

Trinity River Vision Conceptual Storm Drain

Opinion of Probable Construction Cost

Open Space Response

Trinity River Vision Authority

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
TSC08309	JGJ	SKH	August 21, 2013

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
8th Street					
	42" RCP	270	LF	$140	$37,800
	5'x4' RCB	680	LF	$340	$231,200
	Laterals (24" RCP)	570	LF	$70	$39,900
	Appurtenances	10	%	$30,890	$30,890
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	29,880	SF	$5	$149,400
	Contingency	30	%	$161,757	$161,757
				8th Street Subtotal	$701,000
7th Street					
	42" RCP	300	LF	$140	$42,000
	6'x4' RCB	560	LF	$380	$212,800
	7'x4' RCB	220	LF	$450	$99,000
	24" RCP	190	LF	$70	$13,300
	Laterals (24" RCP)	770	LF	$70	$53,900
	Appurtenances	10	%	$42,100	$42,100
	Demo Existing Pipe	560	LF	$20	$11,200
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	53,060	SF	$5	$265,300
	Contingency	30	%	$236,880	$236,880
				7th Street Subtotal	$1,026,000
6th Street					
	42" RCP	330	LF	$140	$46,200
	5'x4' RCB	780	LF	$340	$265,200
	24" RCP	210	LF	$70	$14,700
	Laterals (24" RCP)	800	LF	$70	$56,000
	Appurtenances	10	%	$38,210	$38,210
	Demo Existing Pipe	1,400	LF	$20	$28,000
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	62,090	SF	$5	$310,450
	Contingency	30	%	$242,628	$242,628
				6th Street Subtotal	$1,051,000
White Settlement North					
	30" RCP	670	LF	$90	$60,300
	42" RCP	620	LF	$140	$86,800
	5'x4' RCB	560	LF	$340	$190,400
	6'x4' RCB	260	LF	$380	$98,800
	24" RCP	200	LF	$70	$14,000
	Laterals (24" RCP)	1,390	LF	$70	$97,300
	Appurtenances	10	%	$54,760	$54,760
	Demo Existing Pipe	830	LF	$20	$16,600
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	63,670	SF	$5	$318,350
	Contingency	30	%	$296,193	$296,193
				White Settlement North Subtotal	$1,284,000

Trinity River Vision Conceptual Storm Drain

Opinion of Probable Construction Cost

Open Space Response

Trinity River Vision Authority

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
TSC08309	JGJ	SKH	August 21, 2013

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
4th Street					
	48" RCP	860	LF	$170	$146,200
	30" RCP	280	LF	$90	$25,200
	24" RCP	210	LF	$70	$14,700
	Laterals (24" RCP)	810	LF	$70	$56,700
	Appurtenances	10	%	$24,280	$24,280
	Demo Existing Pipe	260	LF	$20	$5,200
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	52,110	SF	$5	$260,550
	Contingency	30	%	$174,849	$174,849
				4th Street Subtotal	$758,000
Throckmorton Street North					
	24" RCP	400	LF	$70	$28,000
	Laterals (24" RCP)	240	LF	$70	$16,800
	Appurtenances	10	%	$4,480	$4,480
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	12,320	SF	$5	$61,600
	Contingency	30	%	$48,264	$48,264
				Throckmorton Street North Subtotal	$209,000
Throckmorton Street South					
	24" RCP	200	LF	$70	$14,000
	30" RCP	440	LF	$90	$39,600
	36" RCP	380	LF	$110	$41,800
	Laterals (24" RCP)	620	LF	$70	$43,400
	Appurtenances	10	%	$13,880	$13,880
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	24,500	SF	$5	$122,500
	Contingency	30	%	$97,554	$97,554
				Throckmorton Street South Subtotal	$423,000
Street F at 7th					
	30" RCP	510	LF	$90	$45,900
	Laterals (24" RCP)	310	LF	$70	$21,700
	Appurtenances	10	%	$6,760	$6,760
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	16,520	SF	$5	$82,600
	Contingency	30	%	$62,088	$62,088
				Street F at 7th Subtotal	$269,000
Street F at White Settlement					
	30" RCP	310	LF	$90	$27,900
	36" RCP	330	LF	$110	$36,300
	24" RCP	200	LF	$70	$14,000
	Laterals (24" RCP)	510	LF	$70	$35,700
	Appurtenances	10	%	$11,390	$11,390
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	37,090	SF	$5	$185,450
	Contingency	30	%	$108,222	$108,222
				Street F at White Settlement Subtotal	$469,000

Trinity River Vision Conceptual Storm Drain

Opinion of Probable Construction Cost

Open Space Response

Trinity River Vision Authority

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
TSC08309	JGJ	SKH	August 21, 2013

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
Street F at 4th					
	24" RCP	420	LF	$70	$29,400
	Laterals (24" RCP)	260	LF	$70	$18,200
	Appurtenances	10	%	$4,760	$4,760
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	26,510	SF	$5	$132,550
	Contingency	30	%	$70,473	$70,473
				Street F at 4th Subtotal	$305,000
Street F at 3rd					
	36" RCP	470	LF	$110	$51,700
	24" RCP	130	LF	$70	$9,100
	42" RCP	70	LF	$140	$9,800
	Laterals (24" RCP)	410	LF	$70	$28,700
	Appurtenances	10	%	$9,930	$9,930
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	16,800	SF	$5	$84,000
	Contingency	30	%	$72,969	$72,969
				Street F at 3rd Subtotal	$316,000
Calhoun Street					
	24" RCP	210	LF	$70	$14,700
	30" RCP	210	LF	$90	$18,900
	Laterals (24" RCP)	260	LF	$70	$18,200
	Appurtenances	10	%	$5,180	$5,180
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	22,720	SF	$5	$113,600
	Contingency	30	%	$66,174	$66,174
				Calhoun Street Subtotal	$287,000
White Settlement Mid					
	24" RCP	410	LF	$70	$28,700
	Laterals (24" RCP)	250	LF	$70	$17,500
	Appurtenances	10	%	$4,620	$4,620
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	31,290	SF	$5	$156,450
	Contingency	30	%	$77,181	$77,181
				White Settlement Mid Subtotal	$334,000
White Settlement South					
	48" RCP	290	LF	$170	$49,300
	4'x4' RCB	440	LF	$220	$96,800
	Laterals (24" RCP)	440	LF	$70	$30,800
	Appurtenances	10	%	$17,690	$17,690
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	28,900	SF	$5	$144,500
	Contingency	30	%	$116,727	$116,727
				White Settlement South Subtotal	$506,000

Trinity River Vision Conceptual Storm Drain

Opinion of Probable Construction Cost

Open Space Response

Trinity River Vision Authority

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
TSC08309	JGJ	SKH	August 21, 2013

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
Street A North					
	42" RCP	540	LF	$140	$75,600
	Laterals (24" RCP)	330	LF	$70	$23,100
	Appurtenances	10	%	$9,870	$9,870
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	21,230	SF	$5	$106,150
	Contingency	30	%	$79,416	$79,416
				Street A North Subtotal	$344,000
Street A South					
	30" RCP	710	LF	$90	$63,900
	42" RCP	320	LF	$140	$44,800
	48" RCP	350	LF	$170	$59,500
	Laterals (24" RCP)	830	LF	$70	$58,100
	Appurtenances	10	%	$22,630	$22,630
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	63,850	SF	$5	$319,250
	Contingency	30	%	$185,454	$185,454
				Street A South Subtotal	$804,000
Street B					
	36" RCP	270	LF	$110	$29,700
	42" RCP	150	LF	$140	$21,000
	Laterals (24" RCP)	260	LF	$70	$18,200
	Appurtenances	10	%	$6,890	$6,890
	Demo Existing Pipe	220	LF	$20	$4,400
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	24,950	SF	$5	$124,750
	Contingency	30	%	$76,482	$76,482
				Street B Subtotal	$331,000
				Project Total	**$9,417,000**

Note: The unit cost of rain gardens represents an incremental increase over the cost of street trees shown in the comprehensive plan dated March 2013.

Trinity River Vision Conceptual Storm Drain

Opinion of Probable Construction Cost

Architectural Response

Trinity River Vision Authority

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
TSC08309	JGJ	SKH	August 21, 2013

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
8th Street					
	36" RCP	270	LF	$110	$29,700
	5'x4' RCB	680	LF	$340	$231,200
	Laterals (24" RCP)	570	LF	$70	$39,900
	Appurtenances	10	%	$30,080	$30,080
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	29,880	SF	$5	$149,400
	Contingency	30	%	$159,084	$159,084
				8th Street Subtotal	$689,000
7th Street					
	36" RCP	300	LF	$110	$33,000
	6'x4' RCB	560	LF	$380	$212,800
	6'x4' RCB	220	LF	$380	$83,600
	24" RCP	190	LF	$70	$13,300
	Laterals (24" RCP)	770	LF	$70	$53,900
	Appurtenances	10	%	$39,660	$39,660
	Demo Existing Pipe	560	LF	$20	$11,200
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	53,060	SF	$5	$265,300
	Contingency	30	%	$228,828	$228,828
				7th Street Subtotal	$992,000
6th Street					
	42" RCP	330	LF	$140	$46,200
	4'x4' RCB	560	LF	$220	$123,200
	4'x4' RCB	220	LF	$220	$48,400
	24" RCP	210	LF	$70	$14,700
	Laterals (24" RCP)	800	LF	$70	$56,000
	Appurtenances	10	%	$28,850	$28,850
	Demo Existing Pipe	1,400	LF	$20	$28,000
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	62,090	SF	$5	$310,450
	Contingency	30	%	$211,740	$211,740
				6th Street Subtotal	$918,000
White Settlement North					
	30" RCP	670	LF	$90	$60,300
	42" RCP	620	LF	$140	$86,800
	5'x4' RCB	560	LF	$340	$190,400
	5'x4' RCB	260	LF	$340	$88,400
	24" RCP	200	LF	$70	$14,000
	Laterals (24" RCP)	1,390	LF	$70	$97,300
	Appurtenances	10	%	$53,720	$53,720
	Demo Existing Pipe	830	LF	$20	$16,600
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	63,670	SF	$5	$318,350
	Contingency	30	%	$292,761	$292,761
				White Settlement North Subtotal	$1,269,000

Trinity River Vision Conceptual Storm Drain

Opinion of Probable Construction Cost

Architectural Response

Trinity River Vision Authority

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
TSC08309	JGJ	SKH	August 21, 2013

ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
4th Street				
48" RCP	560	LF	$170	$95,200
30" RCP	280	LF	$90	$25,200
48" RCP	300	LF	$170	$51,000
24" RCP	210	LF	$70	$14,700
Laterals (24" RCP)	810	LF	$70	$56,700
Appurtenances	10	%	$24,280	$24,280
Demo Existing Pipe	260	LF	$20	$5,200
Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
Rain Gardens in Right-of-Way and Open Space	52,110	SF	$5	$260,550
Contingency	30	%	$174,849	$174,849
			4th Street Subtotal	$758,000
Throckmorton Street North				
24" RCP	200	LF	$70	$14,000
24" RCP	200	LF	$70	$14,000
Laterals (24" RCP)	240	LF	$70	$16,800
Appurtenances	10	%	$4,480	$4,480
Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
Rain Gardens in Right-of-Way and Open Space	12,320	SF	$5	$61,600
Contingency	30	%	$48,264	$48,264
			Throckmorton Street North Subtotal	$209,000
Throckmorton Street South				
24" RCP	200	LF	$70	$14,000
30" RCP	440	LF	$90	$39,600
30" RCP	380	LF	$90	$34,200
Laterals (24" RCP)	620	LF	$70	$43,400
Appurtenances	10	%	$13,120	$13,120
Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
Rain Gardens in Right-of-Way and Open Space	24,500	SF	$5	$122,500
Contingency	30	%	$95,046	$95,046
			Throckmorton Street South Subtotal	$412,000
Street F at 7th				
30" RCP	510	LF	$90	$45,900
Laterals (24" RCP)	310	LF	$70	$21,700
Appurtenances	10	%	$6,760	$6,760
Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
Rain Gardens in Right-of-Way and Open Space	16,520	SF	$5	$82,600
Contingency	30	%	$62,088	$62,088
			Street F at 7th Subtotal	$269,000
Street F at White Settlement				
30" RCP	310	LF	$90	$27,900
36" RCP	330	LF	$110	$36,300
24" RCP	200	LF	$70	$14,000
Laterals (24" RCP)	510	LF	$70	$35,700
Appurtenances	10	%	$11,390	$11,390
Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
Rain Gardens in Right-of-Way and Open Space	37,090	SF	$5	$185,450
Contingency	30	%	$108,222	$108,222
			Street F at White Settlement Subtotal	$469,000

Trinity River Vision Conceptual Storm Drain
Opinion of Probable Construction Cost
Architectural Response
Trinity River Vision Authority

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
TSC08309	JGJ	SKH	August 21, 2013

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
Street F at 4th					
	24" RCP	210	LF	$70	$14,700
	24" RCP	210	LF	$70	$14,700
	Laterals (24" RCP)	260	LF	$70	$18,200
	Appurtenances	10	%	$4,760	$4,760
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	26,510	SF	$5	$132,550
	Contingency	30	%	$70,473	$70,473
				Street F at 4th Subtotal	$305,000
Street F at 3rd					
	36" RCP	470	LF	$110	$51,700
	24" RCP	130	LF	$70	$9,100
	36" RCP	70	LF	$110	$7,700
	Laterals (24" RCP)	410	LF	$70	$28,700
	Appurtenances	10	%	$9,720	$9,720
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	16,800	SF	$5	$84,000
	Contingency	30	%	$72,276	$72,276
				Street F at 3rd Subtotal	$313,000
Calhoun Street					
	24" RCP	210	LF	$70	$14,700
	24" RCP	210	LF	$70	$14,700
	Laterals (24" RCP)	260	LF	$70	$18,200
	Appurtenances	10	%	$4,760	$4,760
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	22,720	SF	$5	$113,600
	Contingency	30	%	$64,788	$64,788
				Calhoun Street Subtotal	$281,000
White Settlement Mid					
	24" RCP	210	LF	$70	$14,700
	24" RCP	200	LF	$70	$14,000
	Laterals (24" RCP)	250	LF	$70	$17,500
	Appurtenances	10	%	$4,620	$4,620
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	31,290	SF	$5	$156,450
	Contingency	30	%	$77,181	$77,181
				White Settlement Mid Subtotal	$334,000
White Settlement South					
	48" RCP	160	LF	$170	$27,200
	48" RCP	130	LF	$170	$22,100
	4'x4' RCB	440	LF	$220	$96,800
	Laterals (24" RCP)	440	LF	$70	$30,800
	Appurtenances	10	%	$17,690	$17,690
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	28,900	SF	$5	$144,500
	Contingency	30	%	$116,727	$116,727
				White Settlement South Subtotal	$506,000

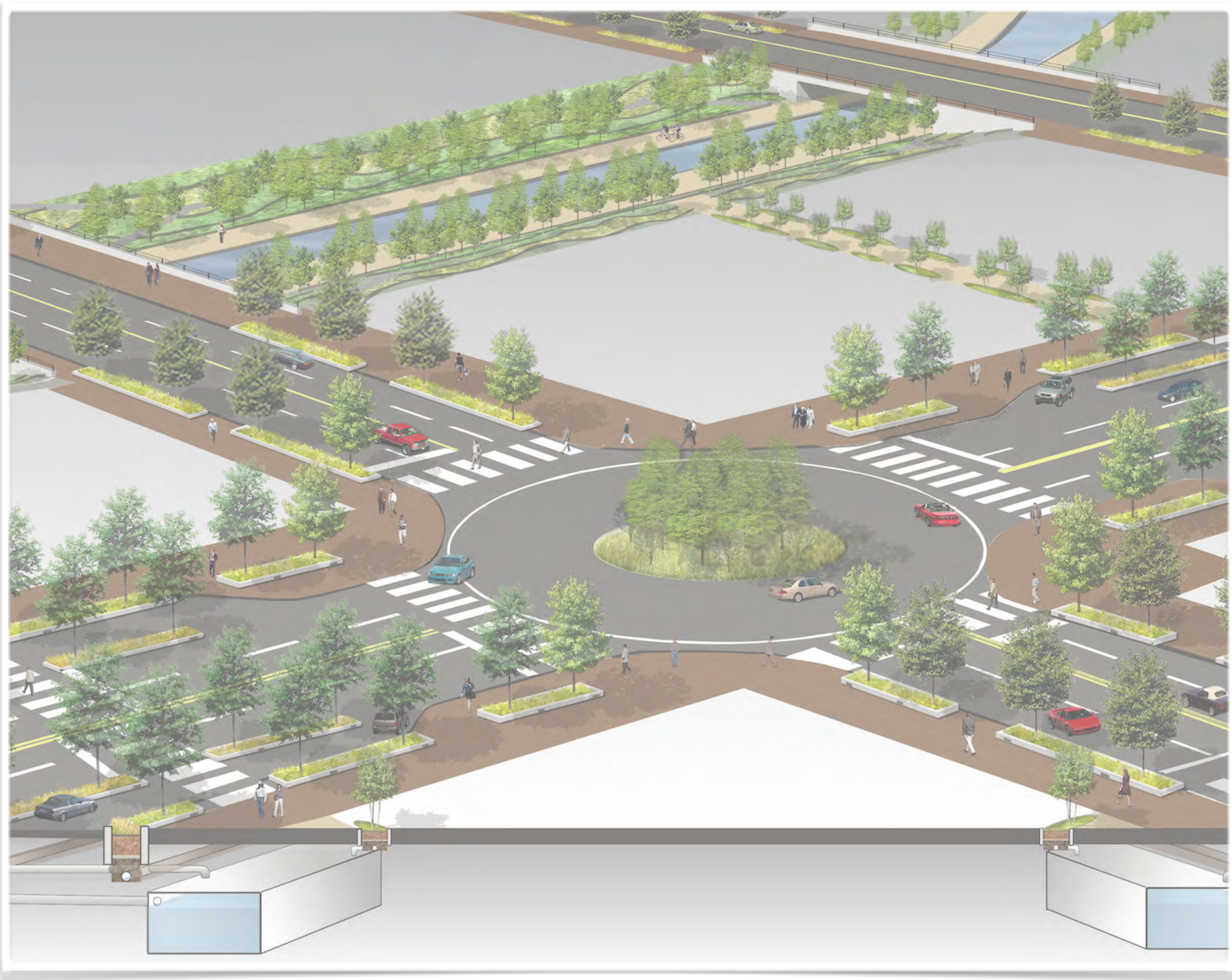
Trinity River Vision Conceptual Storm Drain
Opinion of Probable Construction Cost
Architectural Response
Trinity River Vision Authority

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
TSC08309	JGJ	SKH	August 21, 2013

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
Street A North					
	42" RCP	340	LF	$140	$47,600
	42" RCP	200	LF	$140	$28,000
	Laterals (24" RCP)	330	LF	$70	$23,100
	Appurtenances	10	%	$9,870	$9,870
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	21,230	SF	$5	$106,150
	Contingency	30	%	$79,416	$79,416
				Street A North Subtotal	$344,000
Street A South					
	30" RCP	310	LF	$90	$27,900
	36" RCP	320	LF	$110	$35,200
	30" RCP	160	LF	$90	$14,400
	30" RCP	240	LF	$90	$21,600
	48" RCP	350	LF	$170	$59,500
	Laterals (24" RCP)	830	LF	$70	$58,100
	Appurtenances	10	%	$21,670	$21,670
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	63,850	SF	$5	$319,250
	Contingency	30	%	$182,286	$182,286
				Street A South Subtotal	$790,000
Street B					
	36" RCP	270	LF	$110	$29,700
	42" RCP	150	LF	$140	$21,000
	Laterals (24" RCP)	260	LF	$70	$18,200
	Appurtenances	10	%	$6,890	$6,890
	Demo Existing Pipe	220	LF	$20	$4,400
	Structural End of Pipe Treatment System (Reduced)	1	EA	$50,000	$50,000
	Rain Gardens in Right-of-Way and Open Space	24,950	SF	$5	$124,750
	Contingency	30	%	$76,482	$76,482
				Street B Subtotal	$331,000
				Project Total	**$9,189,000**

Note: The unit cost of rain gardens represents an incremental increase over the cost of street trees shown in the comprehensive plan dated March 2013.

Appendix F
Business Case Evaluation
LID Implementation Levels for Panther Island (Verdunity)



Business Case Evaluation

LID Implementation Levels for Panther Island

Prepared for: Trinity River Vision Authority
307 W. Seventy St., Suite 100
Fort Worth, Texas 76102

Prepared by: Verdunity, Texas Registered Engineering Firm F-13496
Mikel Wilkins, PE, ENV-SP
March 13, 2014

EXECUTIVE SUMMARY

The report titled “Chapter IV - LID Strategies for Trinity Uptown” prepared by Verdunity and Freese and Nichols explored three increasing levels of implementation for LID and green infrastructure strategies within the Panther Island development area. The report compared implementation of rain gardens or biofiltration within the proposed development’s right of way, expanded implementation into the open spaces and ultimately expanding strategies into the individual development sites. The baseline strategy included only structural treatment of storm water runoff at the outfalls of the drainage systems. The report findings showed that the expansion of LID and green infrastructure strategies within the right of way and public open space would provide significant water quality benefits while potentially reducing the required size of underground grey infrastructure for storm water management. It also showed that this level of implementation would introduce significant up front capital costs for installation and would require additional financial commitments for on going maintenance.

Understanding that there were other advantages to the expanded implementation of LID and green infrastructure strategies in the Panther Island development related to quality of life and increased attractiveness of the area to new and relocating business, tourism and new residency, Verdunity has evaluated the three development scenarios using the green infrastructure Business Case Evaluator (BCE) that was developed by Impact Infrastructure, LLC. The BCE economic model evaluates infrastructure projects with varying levels of green infrastructure and LID implementation and determines the net present value of economic costs and benefits that can be expected over a specified life cycle and that are directly related to the selected strategies and extent of implementation.

The total value of benefits calculated for the Open Space Response Scenario which is attributable fully to the increased implementation of green infrastructure and LID strategies exceeds the total value of benefits expected by the traditional development scenario by a net present value of nearly $5.4 million. Many studies have shown that community developments with expanded implementation of LID and green infrastructure strategies will typically outperform traditional community developments in both economic performance, environmental performance and quality of life measurements. Many of the benefits related to improved quality of life such as improved general health within walkable and high quality landscaped communities as well as the overall attractiveness of the community to new and relocating businesses are not evaluated in the models but will positively impact the development’s economic performance. Based on the substantial increase in economic benefits that are expected with increased implementation of LID strategies and the relatively minor increase in capital expenses we recommend further exploration into the implementation of LID requirements into the development code for the Panther Island Development. Given the importance of maintaining a high level of water quality within the canals and lake and the estimated economic benefits that can be expected with the higher level implementations of LID strategies the additional capital expense should be considered a worthy and wise investment towards the future success of the Panther Island development.

BUSINESS CASE EVALUATION OF LID IMPLEMENTATION LEVELS FOR PANTHER ISLAND

Introduction

Storm water management for the quality and quantity of runoff from the Panther Island Development is a priority to protect the quality and usability of the proposed canals and the lake within the development. The report “Volume IV - LID Strategies For Trinity Uptown” investigated multiple levels of LID implementation and measured the effects of each on both quality and quantity of storm water runoff discharged into the canals and lake from the proposed redevelopment area. The levels of implementation investigated included:

1. Traditional Design: Runoff from the right-of- way and development pads collected in standard storm drainage systems and then treated at each outfall by a structural end of pipe system.

2. Right-Of-Way Response: Runoff from the right-of-way and development pads routed through bioretention systems prior to introduction into underground storm water conveyance system and then discharged into the canals and lake.

3. Open Space Response: This level of implementation includes the bioretention systems within the right-of-way and introduces additional systems within the view corridors and along the terraces adjacent to the canals and the lake.

4. Architectural Response: The final level of implementation incorporates LID measures such as green roofs within the redevelopment corridor assuming a total of 25% of building footprints utilizing this storm water management strategy.

The report detailed the level of water quality and quantity treatment that could be expected at each level of implementation. Freese and Nichols (FNI) prepared the report titled “Volume III: Mass Grading” based on these findings. The report included capital cost estimates for the first three scenarios. It was determined that a slight reduction in the size of underground infrastructure could result from each increased level of LID implementation and by allowing building sites to drain toward the canals. It also followed that with each increased level of LID implementation, the cost of green infrastructure increased and that there would be an associated operations and maintenance cost for those systems.

The benefits of the various levels of LID implementation are clear from a water quality and quantity perspective. The intent of this report is to further analyze the economic, environmental and social impacts associated with each level of LID implementation. The Business Case Evaluation tool (BCE), developed by Impact Infrastructure, LLC and released for public pilot testing via the Institute for Sustainable Infrastructure (ISI) in October 2013 was determined to be the preferred economic model for this evaluation. Verdunity pilot tested the system and worked with Impact Infrastructure providing feedback during the pilot testing period. During the review of the new system it became apparent that it would be a valuable tool for evaluating the different levels of LID implementation for the Panther Island development area and would provide valuable data for Trinity River Vision Authority and the City of Fort Worth as development guidelines are further refined for the area.

The BCE allows for a truly holistic life cycle analysis of a major infrastructure project, particularly one that incorporates a certain level of green infrastructure implementation. The system takes an economic valuation approach that provides a sensible comparison between green infrastructure and traditional grey infrastructure for storm water management facilities. The BCE relies on common metrics to combine engineering and economic methods into monetary quantities that can be used for effective decision making.

Questions that have hindered implementation of LID practices in the past are related to cost of installation and cost of maintenance. The BCE addresses these questions utilizing installation data from around the country along with cost information collected locally from LID installations within the North Texas region provided by the design engineer. The BCE greatly expands upon this information by evaluating this basic cost information along with a multitude of other benefits that can be quantified in dollar amounts over the life cycle of the infrastructure project. The benefits of LID implementation analyzed by the BCE tool include:

1. Increased revenues, change in subsidies and avoided costs.
2. Shadow wage benefit.
3. Recreational use value.
4. Property value benefit.
5. Reduced heat stress mortality benefit.
6. Water quality and habitat enhancement.
7. Wetland enhancement.
8. Emissions.

The results of the analysis of multiple levels of LID implementation and traditional infrastructure provides the necessary data for informed decision making and facilitated communication of the reasoning behind those decisions. A copy of the Business Case Evaluation Manual is provided as Appendix 1. It provides detailed descriptions and references for the analysis methodology and the key data that the BCE relies on.

Methodology and Assumptions

The BCE tool was utilized to evaluate three scenarios for comparison. The first scenario which is considered the baseline model evaluates the traditional storm water infrastructure design with the addition of end of system structural treatment for water quality. The second and third scenarios are based on the right-of-way response and open space response LID implementation levels.

The basis of each of the three scenarios is economic data from two previous studies, 'Economic and Fiscal Impacts of the Corps of Engineers' Trinity River Vision Project in Tarrant County Texas' by the Center of Economic Development and Research at University of North Texas (UNT) dated February 2005 and 'TRV Storm Drain Master Plan Volume III: Mass Grading' by Freese and Nichols dated August 2013. Projected state and local sales tax revenue for the development by five year period from Appendix II of the UNT report was utilized to determine a net present value of tax revenue estimated for the area over a 40 year build out period in which an estimated $672 million worth of residential construction and $480 million in commercial properties would occur. The data from the report was first adjusted to 2013 dollars and then the net present value to be used in the BCE was calculated. The adjusted data is shown in the following table:

Table 1

State and Local Tax Projections

Years	0 to 5	6 to 10	11 to 15	16 to 20	21 to 25	26 to 30	31 to 35	36 to 40
Mid-Year	2.5	7.5	12.5	17.5	22.5	27.5	32.5	37.5
Discount Factor	1.13	1.44	1.84	2.35	3.00	3.83	4.88	6.23
Value (2005)	$6,810,420	$3,405,210	$17,026,049	$6,810,420	$6,810,420	$10,215,629	$6,810,420	$10,215,629
Value (2013)	$8,166,924	$4,083,462	$20,417,310	$8,166,924	$8,166,924	$12,250,386	$8,166,924	$12,250,386
Discounted Value (2013)	$7,229,117	$2,832,101	$11,095,127	$3,477,329	$2,724,578	$3,202,167	$1,672,655	$1,965,853

TOTAL NET PRESENT VALUE FOR BASELINE, ESTIMATED: $34,198,929

The estimated present value costs for the the three levels of storm water infrastructure implementations; traditional, right-of-way response, and open space response were provided in the FNI report and are provided in the following table:

Table 2
Storm Water Infrastructure Capital Costs

Traditional	Right-of-Way Response	Open Space Response
$8,211,000	$7,995,000	$9,417,000

Note that these costs only include the cost of storm water infrastructure such as pipe, rain gardens and end of pipe treatment systems. These costs do not include water, sewer and pavement costs which are assumed to be equal for each of the scenarios and are not included in this study.

Business Case Evaluator Data Entry and Analysis

The set up of the BCE model requires input in ten distinct categories. Each category is described in the following with a discussion of the assumptions made for each scenario. The data used can be easily updated to reevaluate the scenarios based on input from TRVA.

Location and Project Dates

The location is set to Fort Worth, Texas and allows the model to draw from financial data specific to the municipality including prevailing wage rates, average home values and tax data. The project dates specify the time frame for construction, operations ramp up, full operations start and operations end. The schedule is the same for each of the project scenarios. The assumed project schedule is:

Construction Period: June 1, 2015 - June 1, 2023 (8 years)
Operations Ramp-Up: This is not applicable for this case evaluation
Operational Period: June 2023 - June 2073 (50 years)

The total cost of installation of the storm water management infrastructure for the Panther Island development is assumed to be spread over 8 years and is based on an estimated schedule for installing all of the right-of-way and open space infrastructure. It is understood that a 50% build out of mixed use developments is estimated to be completed within 40 years. Costs and revenues attributable to private development is not considered in the model with the exception of calculated increased residential property value attributable to increased LID implementation. The operational period of 50 years was selected as a standard time frame for the life cycle analysis.

Project Design Components

The data entry for this portion includes all of the green infrastructure components of each project scenario. The data for each scenario is shown in the following table.

Table 3
Project Design Components

Green Components	Traditional	Right-of-Way Response	Open Space Response
Area of Project	329 acres	329 acres	329 acres
Total Number of Trees Planted	1,990	1,990	3,104
Average Tree Diameter	6 to 10 inches	6 to 10 inches	6 to 10 inches
Rain Gardens	0 acre	6.32 acres	13.5 acres

The total project acreage of 329 acres was held the same for each project scenario. The estimated number of trees for the Traditional and Right-of-Way Response scenarios was calculated using the total landscaped area within the right-of-way and assuming a spacing of 28 linear feet between each new tree. The landscaped area is equal for each scenario but the right-of-way response landscaped area is assumed to be bioretention areas. The additional trees for the Open Space Response scenario was calculated in the same manner for the additional bioretention areas within the open space areas.

Capital Expenditures and O&M Costs

This portion of the BCE model data entry allows the user to input estimated costs for green infrastructure and grey infrastructure components. The values from the FNI report were used in this portion and are summarized in the following table. Costs for operation and maintenance are not entered because the BCE model utilizes EPA data to estimate O&M costs for the green infrastructure components based on the areas for each that were entered in the previous data set. The cost of trees were not included in the FNI report and are calculated by the BCE based on the quantities input in the previous data set. It is important to note that the calculated O&M costs in this study are only for the bioretention areas.

Table 4
Capital Expenditures

Capital Expenditure	Traditional	Right-of-Way Response	Open Space Response
Rain Gardens	$0	$1,376,250	$2,935,944
Hydrodynamic Structures	$1,700,000	$850,000	$850,000
Grey Components	$6,511,000	$5,768,504	$5,631,056
Total	$8,211,000	$7,994,754	$9,417,000

Revenues, Employees, Decommission

The data entered in this section is utilized to estimate differences in revenue generation, shadow wage benefits and decommissioning costs. Revenue related to the mixed use development was not included in this analysis nor were decommissioning costs as it is not applicable in these scenarios. Data is entered relevant to the projected number of construction employees during the 8 year construction period and the new full time employees that will be required to carry out operations and maintenance activities throughout the 40 year analysis of the project. The values were kept the same for each scenario as the project size stays the same and differences in projected values between scenarios is not feasible at this time. Substantial differences between construction workers and full time employees for operations are not likely between each scenario in this study and therefore there are no benefits shown for increased levels of LID implementation.

Funding, Subsidies, and Other

This data set is reliant on the funding mechanisms that will used to finance the construction of the storm water infrastructure. This data determines the weighted average cost of capital and directly influences the calculation of net present value and other economic benefits. The assumed structure of the funding mechanisms is described in the table below and can be adjusted according to suggested modifications by TRVA.

Table 5

Project Funding Distribution

Funding Information	
Primary Entity Served	Municipality
Taxes	15%
Grants/Donations	5%
Equity	30%
Nominal Rate of Return for Equity	10%
Debt	50%
Debt Financing Term Length	30 years
Rate of Interest for Debt Financing	4%
Weighted Average Cost of Capital	4.7%

The calculated net present value of the projected tax benefits, $34,198,929 is entered along with this data set as well.

Resource Usage and Waste

The resource usage and waste data set allows entry of resource consumption estimates that in some cases will vary depending on the LID strategies implemented. This study does not include detailed information on projected energy uses and material types and therefore this data was not incorporated into the evaluations. As more detailed design goals are created this information can be added to further calibrate the financial performance estimates.

Recreational Use

The recreational use data set is a series of questions related to the anticipated types and qualities of recreational uses within the development area and the proximity facilities with similar uses within the region. This data was maintained at the same level for each of the evaluated scenarios because it is not anticipated that the LID components would necessarily add new uses. The data entered for each scenario is listed below:

- 117 acres of recreational use area is equal to the open space area including the canals and lake.
- The facility does not have significant capacity for hunting and fishing.
- There are several general activities available such as cycling and jogging along with one high quality value activity such as boating/kayaking.
- There are many similar activities available within a one hour travel time and a few of them are within a thirty minute travel time.
- The future facilities that will support the activities will be optimum facilities with good access and have high aesthetic quality.

Water Quality and Wetlands

The driving force behind the consideration to implement higher levels of LID within the Panther Island development is to maximize the overall water quality in the canals and the lake. The level of water quality can be correlated to a monetary value known as Willingness To Pay (WTP). The WTP factor was developed by the USACE to assist in the financial evaluations of the recreational use of reservoirs. It is applied in the BCE model based on the selected average water quality expected for each scenario. The level of water quality is selected from Vaughan's (1986) Water Quality Ladder which is provided in Appendix 1. In order to calculate a conservative financial benefit for comparison between the scenarios it was assumed that the water quality for the traditional and Right-Of-Way response would be similar at a level of 6.0 which is described as acceptable for swimming and fishing. The expected water quality is only slightly increased for the Open Space Response to a level of 6.2. These minor differences reflect that the traditional level strives to address the quality of storm water runoff through structural means and that the quality of the runoff is projected to be similar in terms of the positive financial implications. Vaughn's Water Quality Ladder is provided in Appendix 1.

Emissions and Air Pollution

The environmental impact of trees and shading provides economic value to the development. The model estimates the total amount of carbon dioxide removed by the proposed trees over their estimated life span. The calculations are based on the iTree tools resource developed by the US Forest service. Based on this data set which was held constant for each scenario and combined with the projected number of trees planted for each scenario the BCE model calculates these financial benefits. The calculated benefits include carbon sequestration, heat island reduction, heat mortality reduction, increased energy efficiencies and improved air quality in general. The data set indicates that the project is in an urban environment and that any planted tree will have significant exposure to sunlight. The projected average lifespan of the trees is estimated to be 35 years. In each of these scenarios the quantity of trees are insufficient to create any substantial benefits in heat island reduction, heat mortality reduction nor increased energy efficiencies. In order for the development to realize some of these benefits it will be imperative to require sufficient landscaping and efficient building designs within the corridor.

Model Variable Values

The model variable data set allows the user to input specific values in lieu of the default model variables that are automatically populated based on other data entered into the BCE. Based on review of the default variable values for each scenario it was determined that the only required modifications were to adjust the average property values and the projected number of residential properties within the development.

Results and Conclusions

The results of the analysis for each scenario, Traditional, Right-of-Way Response and Open Space Response were evaluated and compared to determine the additional costs and the benefits associated with higher levels of LID/green infrastructure implementation. The analysis shows that although there is a higher capital cost and maintenance cost associated with the Open Space Response level of implementation, the present values estimated for the benefits of this level of implementation far exceed those of the traditional ‘business as usual’ development strategy. The results of the life cycle economic analysis for each LID/Green Infrastructure development scenario compared to the traditional development scenario are provided in Table 6. The values provided are net increases or decreases in costs and benefits as compared to the Traditional scenario.

Table 6

Costs and Benefits Compared to Traditional Response (Net Present Value)

	Right-of-Way Response	Open Space Response
Costs:		
Capital	(-$216,246)	$1,206,000
Operations and Maintenance	$202,412	$442,325
Total	(-$13,834)	$1,648,325
Benefits:		
State/Local Sales Tax	$290,383	$580,767
Water Quality	$298,665	$371,184
Residential Property Tax (City/County)	$2,919,612	$5,717,190
CO2 Emissions	-	$142,858
Air Pollution	-	$199,981
Total	$3,460,785	$7,011,980
Net (Benefits - Cost)	$3,474,619	$5,363,655

Capital expenditures and operations and maintenance costs are highest for the Open Space Response evaluation given that the LID implementation level is nearly double that of the Right-of-Way Response scenario. Capital expenditures for the Open Space Response scenario is approximately $1.6 million higher than that of both the Traditional and Right-Of-Way Response scenarios. The net present value of 40 years of operations and maintenance costs for the Open Space Response scenario is $442,325 which is $239,913 more than the costs for the Right-Of-Way Response scenario. Although the capital costs and operations and maintenance costs are significantly higher it is important to note the increased financial benefits attributable to the expanded implementation of LID in the Open Space Response scenario. The financial benefits related to the increased environmental benefits for the expanded implementation exceeds the expected environmental benefits of the Traditional Response by more than $5 million dollars net present value. This is directly related to the expected increase in property values and the incremental water quality improvements from doubling the surface drainage treatment coverage within the open spaces and view corridors. This very significant increase in benefits greatly outweighs the additional expenditure for the implementation of the LID concepts.

The increased financial benefits for carbon dioxide and other air pollutants sequestration is directly related to the number of trees installed. The model estimates the tree canopy's life cycle removal capacity and associates the benefit with well established social costs of the major air pollutants. Many references for sources of these costs are provided in Appendix 1.

Many studies have shown that community developments with expanded implementation of LID or green infrastructure strategies will typically outperform traditional community developments in both economic performance and quality of life measurements. Many of the benefits related to improved quality of life such as improved general health within walkable and quality landscaped communities as well as the overall attractiveness of the community to new and relocating businesses are not evaluated in the models but clearly will positively impact the development's economic performance.

Multiple studies conducted across the United States have concluded that residential property values located adjacent to parks and open space areas and in particular, within LID communities are higher than those located within traditional developments. Studies have shown that property values located within full LID developments generally have property values 3.36% higher than properties located in non-LID developments. The Panther Island development is projected to have 10,500 residential units valued between $150,000 and $160,000. The Business Case Evaluator allows the user to enter a projected percentage of those residential units that will be directly impacted by enhanced landscaping and LID measures. It also allows for projections on the timing of the buildout and a lag time for the increased property values to show significant positive impact on city and county property tax collections. Economic uncertainty requires that the percentage of impacted residential units and the timing of the tax impact be estimated as a range of values. The exact values will be a measure of economic conditions in the future and the site plans for the individual developments within Panther Island. The projected positive impacts on property values and subsequently, the property tax revenue were based on the following assumptions and residential development projections within Panther Island provided by TRVA:

Right-Of-Way Response: 10% of the residential units were estimated to be impacted by this level of implementation.
Open Space Response: 25% of the residential units were estimated to be impacted by this level of implementation.

Based on these assumptions the model calculated the net present value of the increased city and county property tax revenue over the life cycle of the development and also calculates the total value added to property values due to the implementation of LID within the development. Only 50% of the calculated benefits are counted because property value estimates from the literature encompass a wide range of benefits associated with LID. The 50% factor is used to avoid double counting of benefits in within the projected property value increases. The results are provided in Table 7.

Table 7: Impact of LID Implementation Scenarios on Property Values and Tax Revenues

	Right-of-Way Response	Open Space Response
Total Residential Units	10,500	10,500
Average Value of Residential Unit (Non - LID Development)	$155,000	$155,000
LID Benefits:		
Number of Units Affected	2,100	4,200
Estimated Value Increase	3.36%	3.36%
Total Value Increase	$10,936,800	$21,873,600
50% Rule	-$5,468,400	-$10,936,800
Total Value Added By LID	$5,468,400	$10,936,800
NPV	$2,919,692	$5,717,190

Based on the substantial increase in economic benefits that are expected with increased implementation of LID strategies and the relatively minor increase in capital expenses we recommend further exploration into the implementation of LID requirements into the development code for the Panther Island Development. Given the importance of maintaining a high level of water quality within the development and the estimated economic benefits that can be expected with the higher level implementations of LID strategies the additional capital expense should be considered a valuable investment in the future success of the Panther Island development.

APPENDIX 1

BUSINESS CASE EVALUATOR DRAFT USER MANUAL

Business Case Evaluator

A Value and Risk Based Enhancement to Envision^{TM}

User & Documentation Manual

BCE 2.0 – 12/2013

Written By
John Parker and Ryan Meyers
Impact Infrastructure, LLC

Designed By
Dvorak Design, Ltd

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Published simultaneously in Canada.

For more information contact: Info@ImpactInfrastructureLLC.com

Co-Created By: Impact Infrastructure, LLC and The ISI Economics Committee

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Introduction

The Business Case Evaluator (BCE) has been developed to enhance the Envision™ rating system, adding the ability for the Envision™ system to provide value-based and risk-adjusted analyses of infrastructure projects. The current iteration of the BCE tool is designed to be applied to stormwater management projects. This document helps users apply the BCE tool to projects, while also explaining the capabilities and identifying the limitations.

The steps have been numbered. For the input pages, the numbered steps in this manual correspond to the numbers for each input on each input page in the Excel worksheets. For the output pages, screenshots have been taken, and the important components of each screenshot have been surrounded by red boxes and numbered.

Model Inputs

It is important to remember that not all inputs in the BCE need to be filled out in order to run the model.

For most projects, there will likely be several input categories that are not relevant. If this is the case, or the user does not have reliable information for a specific input, it can be left blank. For example, "Expected Number of Full-time Employees During Operations Stage" may not be relevant to a small stormwater management project, therefore this set of inputs could be left blank. As a general rule, the more inputs that are filled out with accurate information, the more reliable the results will be in reflecting the true costs and benefits of the project.

Most of the inputs include the capability of indicating a low, expected (or most likely), and high value for each variable. These ranges provide the basis for the risk assessment in the model, allowing the user to indicate uncertainty around values. If the user has a specific value for an input, they can simply enter a value for the "Expected Value", leaving the low and high value boxes blank. In the case that the user has only low and expected values, the high value can be set as equal to the expected value. Similarly, if the user has only the expected and high values, the low value can be set as equal to the expected value.

Input Risk Ranges

For each input that has the option of entering a range of values, the user can also indicate the "Distribution Type", around those values. The options in the BCE include "Normal, 95% CI", "Beta", and "Triangular" distributions.

The "Normal, 95% CI" option means that the Low and High values will surround a range containing 95% of the potential values for that input. In other words, there will be a 2.5% probability that the value for that input will be lower than the Low value, and there will be a 2.5% probability that the value for that input will be higher than the High value. This distribution is useful if a range can be identified with high confidence but without certainty. The distribution that is fitted to the three inputs will be a symmetrical, bell-shaped curve.

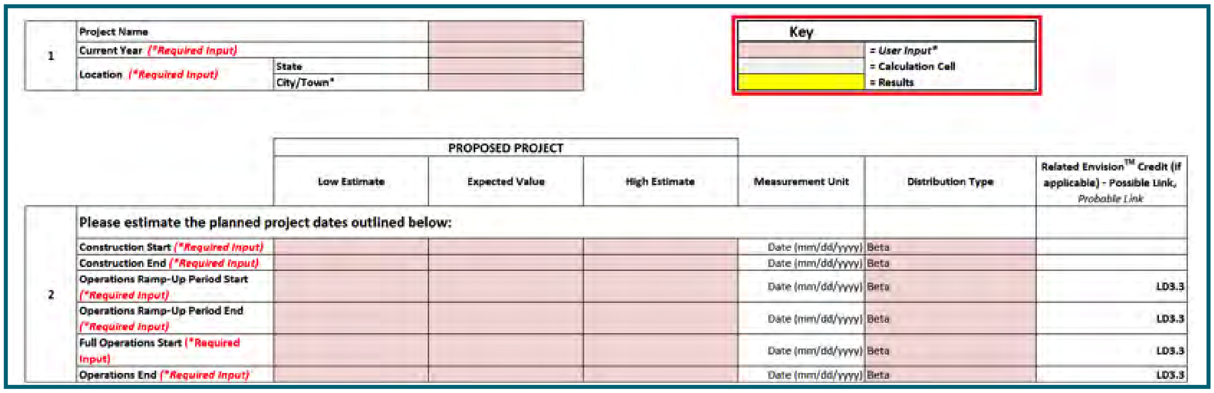
The second distribution type is the "Beta" distribution. The beta distribution is best to use when the user does not expect that the value of the input will ever be lower than the Low value indicated or higher than the High value indicated. Essentially, the beta distribution ensures that the Low and High values are the extremes and it assumes a 0% chance that the input will ever be outside of the contained range. This distribution is useful if a range can be identified with certainty. This distribution can be, but need not be, symmetrical. If the weight of evidence is towards the upper or lower inputs a skewed curve will be fitted.

The third distribution type is the "Triangular" distribution. Similar to the beta distribution, the triangular distribution is most appropriate when the value of the input is never expected to be lower than the low value indicated, nor higher than the high value indicated. The Triangular distribution can also be non-symmetric. The difference between the beta and triangular distributions is that the triangular distribution assumes equal weighting between the low, expected, and high values, while the beta distribution gives the expected value four times the weighting of the low and high values.

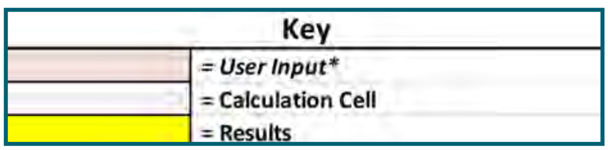
Spreadsheet Conventions and Navigation

There is a color coding scheme to the model that runs throughout all the spreadsheets. The key for this color coding scheme can be found at the top of the "Location and Project Dates" sheet. A screenshot of the key can be seen below:

Baseline Information – Location and Project Dates



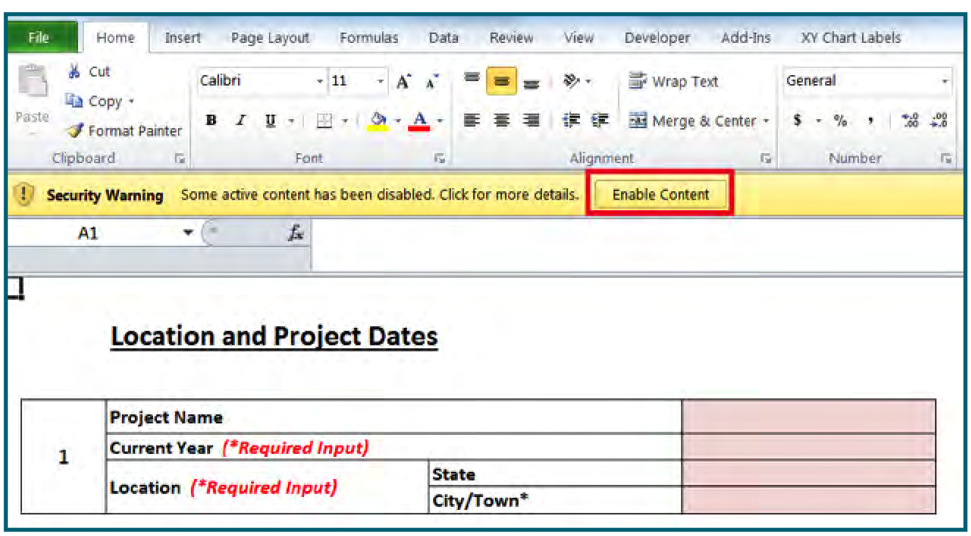
A closer look at the key can be seen below:



Any cell that is shaded in red is an input that can be modified by the user. In the results pages, important results are shaded in yellow, while calculations cells are shaded in grey. The only cells in the model that should be manipulated in any way by the user should be the cells shaded in red, unless otherwise specified.

Opening the Excel Workbook

When first opening the Excel workbook, it is important that editing and content are both enabled. This can be completed by selecting the "Enable Editing" and "Enable Content" buttons when prompted. These buttons are usually embedded in a yellow band near the top of the window, or they may popup in dialogue boxes that require your permission. An example of how this might look is shown in the screenshot below:



PART I: INPUTS PAGES

Page 1 ("Location and Project Dates")

1. The first set of inputs requires the user to enter the project's name, the current year, and the location of the project. The project's name has no limitations and is at the discretion of the user. The current year is important in determining value projections in current year values. For the location, it is important that the user inputs the state before indicating what city the project is in. The city list is contingent on the state selected. If the project's town or city is not included in the city dropdown list, please select the town or city that is closest to the project's location.

2. This is where the user can indicate the planned dates for the multiple stages of the project. Note that all dates are required inputs (at a minimum, an expected value for each date must be input for the model to run).

Page 2 ("Project Design Components")

3. The first, and potentially most important, set of inputs requires the user to indicate which Low Impact Development (LID), or green infrastructure components, are expected to be included in the proposed project. Some of these inputs require specific guidance, and are explained below:

   a. Area of project: this input requires the user to indicate the total number of acres of the entire project.

   b. Total number of new trees planted: this must be the net new trees planted as a result of the project. If trees are cut down or removed, these must be subtracted from the total number of new trees planted. This number is important in evaluating the project's impact on air pollution and carbon emissions.

   c. Average tree diameter at breast height (4′ 6″ high = diameter at breast height "D.B.H.") – This input refers to the average diameter of all of the new trees planted in this project, and it must be reported in inches. As with the "Number of new trees planted", this value is important in evaluating the project's impact on air pollution and carbon emissions.

Page 3 ("Cap Ex and O&M Costs")

4. This section provides the user with the opportunity to indicate the capital expenditure costs for the project. These capital expenditure costs can be listed either by component or as a total value. If the user is unsure of the capital costs, the model will estimate them based on stored cost estimates for different green components, incorporating the green components that are included in the project and how much of each one is expected to be included. If the user has a total cost estimate, but the value is not broken down by component, it is important that $0 is entered into the model for each component that is being included in the project. The total capital expenditure costs can then be entered into "Total other green construction costs" (located at the bottom of the table), or they can be entered into input 5, described below. Note that if the capital expenditure cells are left blank for a component that is listed as being included on the "Project Design Components" sheet, then the cost for that component will be automatically estimated by the model. Finally, cost values must be entered as positive numbers in the table. So, if a green roof will cost $50,000, it must be entered as $50,000, not -$50,000.

5. Since the table in input 4 allows the user to enter capital expenditure information for green components only, this fifth input group provides an input for the user to estimate any traditional infrastructure or "grey" construction components that will be included in the project. These grey components include any other capital expenditure costs that would not have been included in the input 4 table for green components; this may include piping, pavement or concrete, metal structures, or other components.

6. The user has two options for inputting the project's O&M costs: the costs can either be input for each green component individually, or the total O&M costs can be input. As with the capital expenditure costs, if the area of a green component is included in the project but its associated cells where its O&M costs can be input are left blank, then the O&M costs for that component will automatically be estimated by the model. Therefore, if the user chooses to input the total O&M costs at one time under "Total other annual operations and maintenance costs" (at the bottom of the input 6 table), it is important that $0 is entered into the model for each component that is being included in the project. If this is not done, costs that may be included in the total O&M costs may be double counted because the model will estimate each component's O&M cost as well.

7. Some sections in the BCE refer to "Current" costs (such as current O&M costs, current energy costs, etc.). These sections only need to be filled out if the proposed project is not a new piece of infrastructure. In other words, if the project is replacing or renewing an existing piece of infrastructure, then these sections need to be filled out as fully as possible. These inputs refer to the reference case, essentially providing baseline values for some of the costs or benefits. The reference case can also be thought of as the status quo or the "do nothing" scenario.

These "Current" inputs require the user to indicate what the operations and maintenance (O&M) costs are in the reference case, as well as their expected growth rates. This is important to estimate the true costs of the reference case, or maintaining the status quo. For example, the proposed project may be renewing a piece of infrastructure that is aging and falling apart. In this case, this input would allow the user to indicate the high level of O&M costs, as well as the associated annual growth rate in these costs, which may also be very high. Note that the growth rate in these costs is the nominal growth rate, hence it includes inflation.

Page 4 ("Revenues,Employees,Decommission")

8. This requires the user to estimate both revenues in the reference case and after the project is operational. The reference case, or current revenues value, sets a baseline so that if revenues for the proposed project are expected to change, the relative value can be assessed. If revenues are not relevant to the project, if they are unknown, or if they are not expected to change in the proposed project, then these inputs should be left blank.

9. This set of inputs gathers information about employees in the reference case, as well as information about expected employee costs during the operations phase of the project. This information includes the number of employees and the average employee's salary. If the number of employees will be changing relative to the reference case in the operations stage of the project, the user can input the number of employees during the operations stage. As with revenues, these inputs should be left blank if employee information is not relevant to the project, if the values are unknown, or if they are not expected to change in the proposed project.

   The user can also input information about the number of people employed during the construction phase of the project. This is important for estimating the shadow wage benefit of the project (the benefit of jobs from the project).

10. Input 10 allows the user to indicate what the decommissioning costs are expected to be. This value should be estimated in current year dollars. As with capital expenditures and O&M costs, the cost should be written as a positive number. So, a cost of $100,000 would be written simply as $100,000 rather than -$100,000.

Page 5 ("Funding, Subsidies, and Other")

11. The first input group in the "Funding, Subsidies, and Other" page refers to information about funding for the project. The purpose of this set of inputs is to determine the project's overall weighted average cost of capital (WACC). This is used in calculating the present value of all of the costs and benefits in the model.

There are four possible funding sources that are included in the table. They include taxes, grants/donations/fundraising, equity, and debt. The percent of funding that is coming from each source must be indicated for each source. When the table is completed, all funding sources should add up to 100%. If they do not add to 100%, there will be a highlighted row indicating that there are funds missing. A screenshot of this can be seen below:

Funding, Subsidies, and Other Costs/Benefits

11	**Funding Information**	
	Who is the primary party that this project is being built on behalf of?	Municipal, State, or Federal Government
	Please indicate what proportion of funding will come from the following	
	Taxes*	60%
	Grants/Donations/Fundraising*	0%
	Equity*	0%
		10%
	Debt*	50%
	What is the term length for the debt financing? (years)	40
	What is the expected rate of interest for the duration of the term for the debt financing?	3%
	Calculated Weighted Average Cost of Capital (WACC)	1.28%
	The total funding from the four sources currently adds to MORE than 100%.	

This warning automatically loses its shading and is modified to read, "The total funding for the four sources adds to 100%" when filled out correctly and completely.

For equity financing, the user must estimate what the required rate of return is expected to be. Similarly for debt financing, the user must indicate what the interest rate on the debt will be. Note that for taxes and grants/donations/fundraising, the required rate of return is assumed to be 0%.

After the table is filled out, the WACC, shown at the bottom of the table, will automatically calculate to the appropriate value and is then used throughout the model.

12. If the reference case includes the benefit of annual subsidies being collected, this input provides the opportunity for the user to indicate the value of these subsidies. This should be left blank if there are no subsidies being collected, if the value is unknown, or if they are not expected to change in the proposed project.

If any one-time subsidy will be gained from the construction of the new project, this can be indicated in this group of inputs. In addition, if any recurring subsidies are expected to be different after the project is in operation than in the reference case, the user can indicate the new expected recurring subsidies in the cell provided.

13. There may be direct financial costs or benefits that are associated with the project that were not captured by any of the other input groups. If this is the case, the present value of these costs or benefits can be input into this section. There is also an option to input a discount factor for the value of "Other Benefits" claimed from the project. This is in an effort to avoid double counting the benefits with other benefits in the model. As an example, the user could have attempted to quantify reduced noise pollution as a result of enhanced local green space. However, part of this benefit may already be counted in the "Property Values" benefit. Hence the user may apply a 30% discount factor to this, which would essentially mean that the value of that benefit would be input into the model at 70% of its face value.

Note that the description of the cost or benefit is for logging purposes only and is not incorporated into the output of the model.

Page 6 (“Resource Usage and Waste”)

14. Energy usage in the project is incorporated into the model in several costs and benefits, including direct financial costs of energy, the impacts on CO_2 emissions, and the impacts on air pollution. However, as with several of the other input groups, this information only needs to be provided by the user if it is going to be changing with respect to the reference case. If the project uses no energy or the usage is remaining the same for all energy sources, these inputs can be left blank. Note the units that energy usage must be logged in (e.g. MWh/year for electricity usage). In addition, costs need to be input as positive numbers.

15. If water costs are expected to be different after the project is in operation than in the reference case, the user can indicate the previous and expected costs in the cells provided.

16. If the costs of any materials required by the facility/project are expected to be different after the project is in operation than in the reference case, the user can indicate the previous and expected costs in the cells provided.

17. If the costs of waste treatment or disposal are expected to be different after the project is in operation than in the reference case, the user can indicate the previous and expected costs in the cells provided.

Page 7 (“Recreational Use”)

18. If any part of the facility or project is intended to be used for recreational purposes, the extent of recreational use can be indicated in this input group. The answers to the questions in this group of inputs are used to calculate the value of that recreational space, as perceived by its users.

Page 8 (“Water Quality and Wetlands”)

19. Water quality improvements are incorporated into the BCE by using Vaughan’s water quality ladder, which can be seen on the input page. If there is a large body of water in the local area and the project is likely to produce a change in water quality in that body of water, the user can indicate the expected extent of that change, as determined by the water quality ladder. Use of the sliding scales ranges from 0 to 10 with precision to one decimal place.

20. If wetlands are being created or restored as a part of the proposed project, the user must indicate the type of wetland, location (inland or coastal), if the created/restored wetlands are going to be a part of a larger system, and, the estimated acreage of the total wetlands system.

21. To most accurately value any wetlands being created or restored, the user must indicate the functions of the wetlands. If the functions of the wetlands are unknown or if none of the listed wetland functions are applicable, the user can simply indicate “No” for all wetland functions.

Page 9 ("Flood Risk")

22. The first set of inputs on the "Flood Risk" page pertain to the land use characteristics of the project's area both before and after project construction. There should be some overlap between the information required to complete this section with the information required to complete the "Project Design Components" page. The inputs have been left independent of each other to allow for unforeseen differences between the data. Note that the values input in this section must be the total acreage of each type before and after project construction.

This section also allows inputs pertaining to the soil types of any lawn, woods/trees/forest, and/or swales/gardens present on the project's site. This information is required to calculate the average curve number of the site. If the soil types are not known, selecting "Unknown" from the cell dropdown lists will default the model to averaging out the curve numbers that would be generated from each of the four soil types.

23. This input group allows the user to provide information on the project site's water retention and flow characteristics. This includes peak capacity (in cubic feet) of any detention basins, retention ponds, or cisterns on the site. Any other similar rainwater retention unit can be included in any one of these inputs.

The current and planned peak discharge of grey infrastructure are the final inputs on this page. They refer to the discharge from any stormwater drainage systems that would be directly removing water from the project site during a large storm event.

Page 10 ("Air Emissions")

24. The final inputs group relates to CO_2 emissions and air pollution. First, the user must indicate whether the project will be located in a dense urban, urban, or rural environment. Then, if trees are being planted, the user must indicate the estimated exposure to light for the trees. This requires the use of judgement, and it must be estimated on a scale of 1 to 5, with 1 representing a low exposure to light (e.g. a tree in a dense forest) and 5 representing maximum exposure to light. The last inputs require the user to estimate the average and maximum lifespan of trees planted, in years.

PART II: USER-DEFINED MODEL INPUTS

Page 1 – Model Variable Values (“Model Variable Values”)

The “Model Variable Values” page shows most of the default values in the spreadsheet and provides the ability for the user to modify the default values if they choose. For example, the default rate of inflation in the model is 2%. If the user inputs 3%, that is the new value that will be used throughout the model. This example can be seen in the screenshot below:

USER-DEFINED MODEL INPUTS

**Only modify default values if highly confident that the user-defined values will make the model more accurate.*

Impact Infrastructure, LLC
INFORMING IMPACT INVESTMENTS
BCE 2.0 – 12/2013

	Default Value	User-Defined Value	Value Used	Implied Real Rates
Rate of Inflation	2%	3.00%	3.0%	N/A
Nominal WACC	Calculated from "Funding Information" Section- default to values shown below if funding sources do not add up to 100%.		9.5%	6.31%
Nominal Discount Rate - Low*	6%			
Nominal Discount Rate - Medium*	9.5%		9.5%	6.5%
Nominal Discount Rate - High*	13%			
Nominal Social Opportunity Cost of Capital (SOCC) - Low**	3%			
Nominal SOCC - Medium**	6.1%		6.2%	3.12%
Nominal SOCC - High**	10%			
Corporate Tax Rate	15%		15.0%	N/A

Note that the default values should only be replaced by user-defined values after careful consideration.

PART III: RESULTS

Page 1 – Monte Carlo Simulation ("Results- Monte Carlo Simulation")

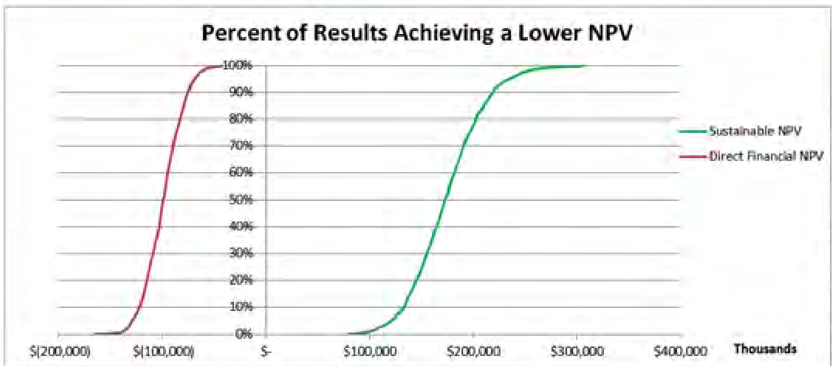
A screenshot of the key components on this worksheet can be seen below:

Run Fast Monte Carlo Simulation	○ Quick Monte Carlo
Run Detailed Monte Carlo Simulation 1.	◉ Detailed Monte Carlo

Run Full Monte Carlo Sim 2.

Clear Last Monte Carlo Results 3.

	$-NPV	Discounted Payback (yrs)	$-ROI	$-IRR
Ave:	$ 174,170,838.03	14.90	441.0%	10.3%
St Dev:	$ 34,262,600.02	2.73	90.1%	1.7%



Approximate Time for Detailed Simulation		
Run Length	Time	
Quick Monte Carlo	120	seconds
Detailed Monte Carlo	120	seconds

Probability of Achieving a Lower NPV		
Percentile and associated minimum Direct Financial NPV:	5%	-$ 129,102,840.46
	50%	-$ 98,957,612.75
	95%	-$ 68,536,133.44
Percentile and associated minimum Sustainable NPV:	5%	$ 120,695,548.05
	50%	$ 172,995,703.04
	95%	$ 234,697,581.00

1. The BCE has a Monte Carlo Simulation programmed into the model so that the results of the model can be risk-adjusted. Before running the Monte Carlo Simulation, the user must select whether they would like to run a "Quick Monte Carlo" or "Detailed Monte Carlo" simulation. The difference between the two is the number of iterations. The quick Monte Carlo simulation runs 100 iterations, while the detailed simulation runs 1,500 iterations, producing a more precise result. It is recommended that the model first be run using the quick Monte Carlo simulation as a test run. The table to the right of the chart, titled "Approximate Time for Detailed Simulation" will then estimate the total time for the longer simulation.

2. After indicating the desired length of the run, clicking on the button labeled "Run Full Monte Carlo Sim" will prompt a popup window. Pressing "Run" on the popup window will then initiate the simulation. Once the simulation is started, it will be required to run to completion before the spreadsheet will be active again. Avoid the use of other computer programs while the simulation is running.

3. A button labeled "Clear Last Monte Carlo Results" is also available to clear results from this worksheet if the user wants a fresh start to the page.

Page 2 – Summary ("Results – SUMMARY – Risk Adj")

There are no user inputs on this page. The cells and values on this page should not be manipulated by the user; they are for viewing purposes only. Results provided on this page include multiple different value metrics, a breakdown of value by stakeholder accounts, a breakdown of value by Envision™ Credits, and multiple charts outlining the costs and benefits pertaining to the proposed project.

Page 3 – Static Projections ("Results – Static Projections")

There are no user inputs on this page. As with the Summary Results page, the cells and values on this page should not be manipulated by the user; they are for viewing purposes only. Note that the values on this page are not risk adjusted; they assume that the expected values are used for every input in the model, and hence do not take into account any uncertainty in the values, as the other results do.

Page 4 – Multiple Stakeholder Accounts Analysis ("Multiple Account Costs&Benefits")

Scrolling down on the "Multiple Account Costs&Benefits" page will show a table where the user can indicate which costs and benefits can be allocated to each stakeholder account. A screenshot of this table can be seen below:

	Account			
	1. 1	2	3	Total NPV
Revenues	Direct Financial Value			3,474,747.09
Capital Expenditures	Direct Financial Value			-126,622,158.53
O&M Costs	Direct Financial Value			-36,187,088.85
Employee Costs	Direct Financial Value			0.00
Electricity Costs	Direct Financial Value			0.00
Natural Gas Costs	Direct Financial Value			0.00
Propane Costs	Direct Financial Value			0.00
Diesel Costs	Direct Financial Value			-334,121.06
Other Energy Costs	Direct Financial Value			0.00
Change in Waste Costs	Direct Financial Value			0.00
Change in Water Costs	Direct Financial Value			0.00
Change in Materials Costs	Direct Financial Value			0.00
Change in Other Costs (Present Val	Direct Financial Value			2,531,108.99
One Time Subsidies/Grants	Direct Financial Value			0.00
Recurring Subsidies/Grants	Direct Financial Value			58,204,213.29
Shadow Wage Benefit	Economic or Business Activity	Government or Taxpayer		0.00
Recreational Use Value	Community or Other			47,428,738.79
Flood Risk Value	Community or Other	Government or Taxpayer		6,047,980.11
Change in Property Values - Reside	User / Target-Beneficiary or Customer Service			7,158,088.47
Change in Property Values - Gov's F	Government or Taxpayer			0.00
Heat Stress Mortality	Community or Other	Government or Taxpayer		7,421,889.28
Water Quality and Habitat Enhance	Environmental	Government or Taxpayer		2,603,082.64
Wetland Enhancement	Environmental	Government or Taxpayer		199,227,297.11
CO2 Emissions	Environmental	Government or Taxpayer		-120,618.04
Air Pollution	Environmental	Government or Taxpayer		387,085.87
Residual Value of Assets	Direct Financial Value			0.00
Decomissioning Costs	Direct Financial Value			0.00
				Total Value

1. Each cost and benefit can have a maximum of three different stakeholder accounts allocated to it. There are already default values in the model, however the user has the ability to modify which stakeholders benefit from, or are responsible for, each benefit and cost, respectively. An important consideration is that a simple equal allocation mechanism is used. So, if another stakeholder account is added to a cost or benefit, the value from that cost or benefit is divided amongst all the stakeholder accounts allocated to it. For example, the "Residual Value of Assets" is automatically allocated as only "Direct Financial Value", so 100% of its value is allocated to the "Direct Financial Value" account. However, if "Government or Taxpayer" was added, then 50% of its value would be allocated as "Direct Financial Value", while the other 50% would now be allocated as "Government or Taxpayer" value.

Page 5 - Envision™ Credits Value Allocation ("Envision Credit Costs&Benefits")

Scrolling down on the "Envision Credit Costs&Benefits" page will show a table where the user can indicate which costs and benefits can be allocated to each Envision™ Credit. A screenshot of this table can be seen below:

	Account			
	1. 1	2	3	Total NPV
Revenues	*Financial or Market Valuation*			4,179,599.68
Capital Expenditures	*Financial or Market Valuation*			-116,079,094.25
O&M Costs	*Financial or Market Valuation*			-13,762,582.51
Employee Costs	*Financial or Market Valuation*			53,274,359.70
Electricity Costs	*Financial or Market Valuation*	*Resource Allocation*	*Climate*	0.00
Natural Gas Costs	*Financial or Market Valuation*	*Resource Allocation*	*Climate*	0.00
Propane Costs	*Financial or Market Valuation*	*Resource Allocation*	*Climate*	0.00
Diesel Costs	*Financial or Market Valuation*	*Resource Allocation*	*Climate*	-382,421.25
Other Energy Costs	*Financial or Market Valuation*	*Resource Allocation*	*Climate*	0.00
Change in Waste Costs	*Financial or Market Valuation*	*Leadership*	*Resource Allocation*	0.00
Change in Water Costs	*Financial or Market Valuation*	*Resource Allocation*		0.00
Change in Materials Costs	*Financial or Market Valuation*			0.00
Change in Other Costs (Present Value	*Financial or Market Valuation*			2,283,809.92
One Time Subsidies/Grants	*Financial or Market Valuation*			0.00
Recurring Subsidies/Grants	*Financial or Market Valuation*			68,754,448.42
Shadow Wage Benefit	*Quality of Life*			-10,190,319.52
Recreational Use Value	*Quality of Life*	*Natural World*		91,700,277.47
Flood Risk Value	*Leadership*	*Natural World*	*Climate*	7,316,997.04
Change in Property Values - Resident	*Other*			6,830,597.55
Change in Property Values - Gov't Po	*Other*			0.00
Heat Stress Mortality	*Quality of Life*	*Climate*		8,513,204.58
Water Quality and Habitat Enhancem	*Natural World*	*Resource Allocation*		3,046,505.15
Wetland Enhancement	*Natural World*	*Climate*		64,675,019.93
CO2 Emissions	*Resource Allocation*	*Climate*		144,898.61
Air Pollution	*Quality of Life*	*Climate*		527,781.15
Residual Value of Assets	*Financial or Market Valuation*			0.00
Decomissioning Costs	*Financial or Market Valuation*	*Resource Allocation*		0.00

1. Similar to the Multiple Accounts Costs and Benefits page, each cost and benefit can have a maximum of three different Envision™ Credits allocated to it. There are already default values in the model, however the user has the ability to modify which credits gain the value from each cost or benefit.

Notes

Business Case Evaluator

Documentation

Notes

DESCRIPTION OF ECONOMIC BENEFITS AND APPROACH TO VALUATION

Economic Valuation Approach

To make a sensible comparison between green infrastructure, or low impact development (LID), and traditional grey infrastructure, or pipe and water processing facilities, one needs a common metric. Engineering methods can often quantify the differences in gallons or litres of water or kWh of electricity saved; economic methods help to put a price on these quantities so that monetary equivalent value (price times quantity), or dollars, can be used in the decision-making.

Engineers have at their disposal tools to calculate water and energy saved from sustainable design. Valuation in terms of the social costs (the damage or benefit to human health, buildings, crops, animals, and the environment) of the improvements is the missing link to value the benefits of sustainable projects.

Because the economics is often similar across projects, we have codified the economics and made it available to designers and engineers so that they can understand the full economic value of their project. In this way engineers have access to tools that help them design the project right. Envision™ attempts to help the design process so that the project is done right from a sustainability perspective. It also helps to make sure that the right project is done.

To compare the value and make decisions regarding the right project, one also needs to understand the risks associated with the choices. The methodology adopted combines economic cost-benefit analyses with risk analysis so that risk adjusted values are calculated, allowing informed decision making.

Finally, infrastructure projects are complicated and affect stakeholders differently. The use of multi-account cost-benefit analysis provides a basis for understand who wins and who loses and what the basis is for cost, benefit or risk transfer. By identifying groups who, or sectors that, do not benefit from a project, multiple account cost-benefit analysis helps the right project, done right, get done.

> *"Urban planners are often faced with difficult choices concerning watershed development. While their primary focus may be flood control and water quality, many projects have spillover or "external" effects that can enhance economic value at a relatively low marginal cost. Choices concerning landscaping, management practices, and size and accessibility of open space may directly affect the value of the project or indirectly affect value through aesthetic improvements and/or increasing biodiversity. Spillover effects are external to the market and assessing their value can be a challenge."* [1]

BCE Links to Envision™ Credits

Most of the costs and benefits that are quantified in the BCE have links to credits in the Envision™ rating system. Some of these links are strong (e.g. Recreational Use Value's link to QL3.3 Enhance Public Space), and some of these links are possible but not always strong (e.g. Recreational Use Value's link to QL1.2 Stimulate Sustainable Growth and Development). The full detailed mapping of the links between the BCE and credits in the Envision™ system, along with the associated strength of each link, can be found in Appendix A.

[1] "Economic Values for Open Space, Landscaping, Biodiversity, and Best Management Practices Associated with Urban Watershed Improvements: A Conjoint Study" Mary Riddel and Keith Schwer, p. A-4 as reproduced in "User's Guide Watershed Management Techniques Economic Valuation Model", Revised March 2010, County of Los Angeles, Department of Public Works, Watershed Management Division

Sometimes the services green infrastructure provides have no price that can be directly observed as the outcome of market transactions. Economics uses several methods to value these non-market externalities. The table below shows how the various benefits from wetlands creation can be valued.

Table 1. Examples of Valuation Techniques for Wetland Services

Benefit Type	Valuation Method
Habitat for commercial species	Market prices for commercial species and productivity per acre
Habitat for wildlife and visual/cultural benefits	Prices paid by government agencies to protect wetlands
Wetland conservation	Opportunity costs; i.e., benefits of wetland conversion
Amenity or aesthetic value	Hedonic property price model i.e. the willingness to pay for an amenity that is reflected in property prices (holding other factors constant)
Recreation value	Travel cost method i.e. how much people pay to travel to a recreation facility; Participation model using unit-day values; Contingent valuation i.e. survey of willingness to pay by potential users
Flood control and shoreline anchoring	Damages avoided
Water purification	Reduced treatment costs by alternative methods
Non-use and option value	Contingent valuation (see above)

Table 1 Source: Adapted from David W. Pearce and R. Kerry Turner. 1990. Economics of Natural Resources and the Environment. Baltimore: Johns Hopkins University Press. pp. 226-235

While methodologies for valuation may not vary for similar projects, often the values themselves will vary by region of the country or by income or demographics of those affected. By using meta-analyses that synthesize many studies, we hope to produce accurate results through the inclusion of geographically specific variables that include, among others, local incomes, housing values, weather patterns, and water quality.

As shown in the table above, **non-market valuation methods** are used to value things that people may never use:

- **Revealed preference methods:** Infer the value of a non-market good or service using other market transactions. For example, the price of a house may be used to determine the value of transit services. Hedonic pricing methods start from the premise that the price of a good is a function of the service's characteristics. A regression model then determines the contribution of each characteristic to the market price.
- **Stated preference methods:** Contingent valuation studies survey people on how much they are willing to pay to get access to a good or service or how much they would be willing to accept as compensation for a given harm or lack of access.

Market-based methods are used to measure value from the perspective of what you would have spent had you taken another approach:

- **Avoided cost analysis:** This methodology looks at "the marginal cost of providing the equivalent service in another way. For example, rainfall retention and infiltration can offset a water utility's cost to capture, transport, treat and return each additional gallon of runoff." [2] Rather than the avoided cost of not building facilities, it may be more appropriate to consider the converse, what the cost would be of damages be if the project does not go ahead.

[2] The Value of Green Infrastructure - A Guide to Recognizing Its Economic, Environmental and Social Benefits, Center for Neighborhood Technology 2010, p. 14, downloaded from: http://www.cnt.org/repository/gi-values-guide.pdf January 22nd 2013. (referred to as CNT below)

Risk Analysis Approach

High, medium and low values from the literature are collected to reflect the range of uncertainty about inputs as well as their most likely values. A three-point estimation technique can then be used to construct a probability distribution representing the outcome of future events, based on limited information. These distributions are then an input into a Monte Carlo risk analysis following a cost-benefit approach. More information is provided in Appendix B.

Use of Envision™ Business Case Evaluator

The business case evaluator aims to, as much as possible:

- **Be a comprehensively exhaustive list of economic benefits (where data exists)**. Avoiding double counting and correctly defining the scope of the project and the benefits, costs and risks to be counted is crucial to ensuring that the calculation is credible.
    - To avoid error in the ultimate estimation of the total economic value associated with a given project, it will be important to avoid the potential error associated with counting a benefit associated with a given project more than once. We have tried to avoid the temptation to create a 'grab bag' of all possible benefits associated with these projects. We have focused attention on those benefits that are most readily monetized and where data is available. Economists often agonize over double counting and there are some rules of thumb that have emerged in cost benefit studies. For transit, for example, hedonic house price models that attempt to capture the benefit of access to transit that is embedded in houses prices might already be accounted for in travel time savings that are also counted as a benefit. In this case 50% of the property price increase is counted as incremental to the other benefits. The 50% rule has also been used for property uplift values in the Philadelphia stormwater management project evaluation. We have adopted the convention here as well.
    - There is a need to provide a clear definition of the boundary for measuring the 'project impact' in order to consistently measure benefit/credits across categories. For instance, is the boundary of impact spatial or non-spatial? A clear understanding/method for estimating the project boundary will be needed. This will directly impact the inclusion/exclusion of project benefits/credits.
- **Measure the risk associated with the business case costs and benefits.**
    - There are often many ways to measure the same benefit. Often, meta-analyses of benefits use studies that mix several techniques. In theory, willingness to pay (WTP) and willingness to accept (WTA) should give the same results but in experiments they have shown that measures of WTA greatly exceed measures of WTP. As meta-analyses have done, we average results over several methodologies (but also capturing the range that is produced from these methodologies too). For a particular benefit, one methodology for measurement and monetization may dominate and in another a range of methodologies may be used. The objective is to use the state of the art in measurement of these externalities. In this regard transparency trumps consistency of one particular method.
- **Be a reference document that documents the sustainable return of the infrastructure project.** The analysis is done relative to a reference case, which is equivalent to the status quo or a "do nothing" scenario. Often, refurbishment or increased operations and maintenance costs of an existing facility are required if a project does not go ahead. These expenditures should be included in the reference case. The evaluator also has the capacity for individual projects to be compared against each other, so that if a "do nothing" scenario is not a viable option, then results valuing different project options against each other may be obtained.

Each cost or benefit that is quantified in the business case evaluator has been included in the Green Infrastructure (GI) or Low Impact Development (LID) because it:

- Is significant on a list of costs and benefits that aims to be comprehensively exhaustive when describing the impacts of GI/LID projects,
- Has substantial literature surrounding its quantification so that reliable and consistent values can be obtained, even as the model is applied across different geographical regions.

Because of the risk and cost benefit framework, the use of the business case evaluator may fulfill some requirements for Envision™ credits.

Model Testing

The model was run with the same inputs as the Philadelphia stormwater study to compare the model's results against those from a 169 page, city-specific study using custom analyses on each cost or benefit. The Philadelphia stormwater study was a reference for the development of the Business Case Evaluator; hence all of the benefits that can be attributable to an LID project that are included in the Philadelphia stormwater analysis are also included in the Excel model. As a result, an apples to apples comparison could be conducted to provide an idea of the accuracy of the automated, broadly applicable Business Case Evaluator.

The inputs used in the model were matched up as much as possible to those used in the Philadelphia analysis. The Philadelphia analysis calculates the benefits of investing in Low Impact Development LID in several scenarios, including a "grey infrastructure" option, a 25% LID option, a 50% LID option, a 75% LID option, and a 100% LID option. The "50% LID" scenario was used as the comparison between the Business Case Evaluator and the Philadelphia analysis. Most of the values used as inputs in the Excel model were found in the study, although some assumptions were made due to insufficient information for some cost/benefit calculations. A full list of the inputs used in the Business Case Evaluator compared with those used in the Philadelphia stormwater analysis can be seen in Appendix C.

In addition to using the inputs specified in the study, some of the default calculation values used in the Excel model were adjusted to match the assumptions in the Philadelphia study. For example, the inflation rate was changed from the default value of 3% in the Excel model, to the assumed value of 4% in the Philadelphia study. A full table showing the changes of the Business Case Evaluator's variables can be seen in Appendix D.

The results from the comparison showed that the Business Case Evaluator produces cost and benefit values closely mirroring those from a large, custom, city-specific study. The net present value (NPV) of the benefits from investing in a 50% LID stormwater management project in Philadelphia was found to be $3.02 billion (2012 USD) in the Philadelphia stormwater analysis, while the Business Case Evaluator found that the investment would yield an NPV of $3.16 billion (2012 USD), a 4.87% difference. This close resemblance in values is despite differences in calculation methodologies, supporting the notion that the methodologies used in the Business Case Evaluator produce robust, accurate values.

	ii BCE (2012 USD)	Philadelphia Study (50% LID Option) (2012 USD)	% Difference	Difference as % of Total
Shadow Wage Benefit	$ 90,365,443	$ 133,665,944	-32%	1.37%
Recreational Use Value	$ 608,982,295	$ 561,311,350	8%	1.51%
Change in Property Values - Resident Portion	$ 758,713,730	$ -	N/A	N/A
Change in Property Values - Gov's Portion	$ 195,114,630	$ -	N/A	N/A
Change in Property Values - Total	$ 953,828,360	$ 616,425,810	55%	10.66%
Heat Stress Mortality	$ 995,670,496	$ 1,131,826,279	-12%	4.30%
Water Quality and Habitat Enhancement	$ 128,611,985	$ 360,009,796	-64%	7.31%
Wetland Enhancement	$ 3,921,705	$ 1,712,294	129%	0.07%
CO2 Emissions	$ 157,567,730	$ 22,687,894	595%	4.26%
Air Pollution	$ 225,426,776	$ 189,743,570	19%	1.13%
TOTAL	$ 3,164,374,791	$ 3,017,382,936	**4.87%**	

Table: Philadelphia stormwater study vs the Business Case Evaluator

Shown above: The full table showing a breakdown of the values of the costs and benefits between the Philadelphia stormwater study and the Business Case Evaluator.

[3] *Ibid.*

Low Impact Development (LID) or Green Infrastructure (GI) Initiative Descriptions

There are many stormwater control manuals available that have Low Impact Development (LID) or Green Infrastructure (GI) definitions. In the definitions below we have chosen a selection of these published by regulatory agencies, states and cities to provide both definitions for the LID/GI practices considered in the model and to provide a starting point for a researcher to investigate local regulations and best management practices (BMPs). Most of the links in the footnotes to these definitions have pictures and more extensive definitions than the summaries provided here. Also, each source has multiple LID/GI definitions; we have selected just one from each.

LID/GI Measure	Definition
New or Restored Private Forested Area or State-owned/Public Forested Area (Number and Size of New Trees Planted)	"Planting trees provides many services which have ecological, economic and social implications. Whether measured on a tree-by-tree basis or on a larger scale such as an urban forest, tree planting has a multitude of benefits. Reduces Stormwater Runoff ... Recharge ... Reduces Energy Use ... Improves Air Quality ... Reduces Atmospheric CO_2 ... Reduces Urban Heat Island ... Improves Community Livability ... Improves Habitat ... Cultivates Public Education Opportunities ..." [1] *from Center for Neighborhood Technologies*
Biofilter (Swales & Filter Strips) **or Grass Strip/Filter Strip/Urban Grass Buffers/Bioswale** (New or enlarged)	"Vegetative practices, also referred to as biofiltration, use various forms of vegetation to remove pollutants by encouraging infiltration into the ground, reducing runoff velocity and allowing particles to settle, thereby absorbing some pollutants. Such use of vegetation occurs in filter strips, grassed swales, riparian areas, and landscaping of wet, dry and infiltration basins. Vegetation is often employed as part of a BMP system, to remove particulates and slow runoff before it enters another treatment device." [2] *from Government of British Columbia* **Grassed swales** "Grassed swales are shallow grass-covered hydraulic conveyance channels that help to slow runoff and facilitate infiltration. The suitability of grassed swales depends on land use, soil type, slope, imperviousness of the contributing watershed, and dimensions and slope of the grassed swale system. In general, grassed swales can be used to manage runoff from drainage areas that are less than 4 hectares (10 acres) in size, with slopes no greater than 5 percent. Use of natural, low-lying areas is encouraged and natural drainage courses should be preserved and utilized." [3] *from U.S. Environmental Protection Agency* **Vegetated filter strips** "Filter strips are bands of dense vegetation planted downstream of a runoff source. The use of natural or engineered filter strips is limited to gently sloping areas where vegetative cover can be established and channelized flow is not likely to develop. Filter strips are well suited for treating runoff from roads and highways, roof downspouts, very small parking lots, and impervious surfaces. They are also ideal components for the fringe of a stream buffer, or as pretreatment for a structural practice." [4] *from U.S. Environmental Protection Agency* **Bioswale** "Bioswales are landscape elements designed to remove silt and pollution from surface runoff water. They consist of a swaled drainage course with gently sloped sides (less than six percent) and filled with vegetation, compost and/or riprap. The water's flow path, along with the wide and shallow ditch, is designed to maximize the time water spends in the swale, which aids the trapping of pollutants and silt. Depending upon the geometry of land available, a bioswale may have a meandering or almost straight channel alignment. Biological factors also contribute to the breakdown of certain pollutants. A common application is around parking lots, where substantial automotive pollution is collected by the paving and then flushed by rain. The bioswale, or other type of biofilter, wraps around the parking lot and treats the runoff before releasing it to the watershed or storm sewer." [5] *From Wikipedia, the free encyclopedia* **Urban Grass Buffers** "Buffer strips are vegetated areas that reduce sediment loads from water flowing through them. Buffer strips are aligned perpendicular to the water flow. They are commonly used in conjunction with swales, living streams and constructed wetlands." [6] *from the Government of Western Australia*
Bioretention (New - Suburban and Retrofit - Highly Urban)	"Bioretention areas, or rain gardens, are landscaping features adapted to provide on-site treatment of stormwater runoff. They are commonly located in parking lot islands or within small pockets of residential land uses. Surface runoff is directed into shallow, landscaped depressions. These depressions are designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems. During storms, runoff ponds above the mulch and soil in the system. Runoff from larger storms is generally diverted past the facility to the storm drain system. The remaining runoff filters through the mulch and prepared soil mix. The filtered runoff can be collected in a perforated underdrain and returned to the storm drain system." [7] *from U.S. Environmental Protection Agency*

LID/GI Measure	Definition
Chemical Control or Erosion and Sediment Control	"Soil erosion and sediment controls are measures which are used to reduce the amount of soil particles that are carried off of a land area and deposited in a receiving water." [8] *from U.S. Environmental Protection Agency* ***Sediment*** Fragmentary material that originates from weathering of rocks and is transported by, suspended in, or deposited by water. ***Erosion*** The wearing away of natural (earth) and unnatural (embankment, slope protection, structure, etc.) surfaces by the action of external forces. In the case of drainage terminology, this term generally refers to the wearing away of the earth's surface by flowing water. It can also refer to the wear on a structural surface by flowing water and the material carried therein." [9] *from IECA, International Erosion Control Association*
Detention Basin or Dry Detention Ponds (New/Dry) **Extended Detention Ponds** (New & Retrofit)	**Dry Detention Pond** "Dry extended detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, extended detention ponds) are basins whose outlets are designed to detain the stormwater runoff from a water quality "storm" for some minimum duration (e.g., 24 hours) which allow sediment particles and associated pollutants to settle out. Unlike wet ponds, dry extended detention ponds do not have a permanent pool. However, dry extended detention ponds are often designed with small pools at the inlet and outlet of the pond, and can also be used to provide flood control by including additional detention storage above the extended detention level." [10] *from The Stormwater Manager's Resource Center (SMRC)* **Detention Basin** "Wet detention basins have a permanent pool of water year-round. The permanent pool allows pollutant particles in stormwater runoff to settle out over an extended period of time, and nutrient uptake also occurs through biological activity. (1) Wet detention basins can be used to treat runoff from a single property or can be incorporated into a regional stormwater management plan where runoff from a large area discharges into a single basin or series of basins." [11] *from The Milwaukee River Basin Partnership*
Green Roof	"a green roof is an extension of an above grade roof, built on top of a human-made structure, that allows vegetation to grow in a growing medium and which is designed, constructed and maintained in accordance with the Toronto Green Roof Construction Standard. A green roof assembly includes, as a minimum, a root repellent system, a drainage system, a filtering layer, a growing medium and plants, and shall be installed on a waterproof membrane of an applicable Roof." [12] *from the City of Toronto*
Infiltration Basin	" A stormwater infiltration basin holds runoff and lets it soak into the ground. The basins are open facilities with grass or sand bases. They can either drain rapidly or act as permanent ponds where water levels rise and fall with stormwater flows. Infiltration facilities can be designed to handle all runoff from a typical storm but could overflow in a larger one. Since the facility is designed to soak water into the ground, anything that can clog the base will reduce performance and be a concern. Generally, infiltration basins are managed like detention ponds but with greater emphasis on maintaining the ability to infiltrate stormwater." [13] *from Stormwater Partners of SW Washington*
Infiltration Trench or Infiltration Practices w or w/o Sand, Veg. (New)	**Sand Filter** "A sand filter is a type of stormwater management facility designed to filter rainwater. It is typically a depression in the ground filled with sand that helps to manage polluted or excess rainwater. To the untrained eye, it may look like a sand box or volley ball court." **Infiltration Trench** An infiltration trench is a type of stormwater management facility designed to filter rainwater. Infiltration trenches are excavated channels filled with gravel that help to manage polluted or excess rainwater on your property. They can be designed to be located on the ground surface or buried." [14] *from Montgomery County, Maryland*
Manufactured Device (Multiple Types) **or Hydrodynamic Structures** (New)	"Hydrodynamic devices are designed to remove solids, oil/grease, floatables and other debris from stormwater runoff through gravitational trapping of pollutants. They are typically used in combination with other structural BMPs, such as a pre-treatment device." [15] *from Minnesota Pollution Control Agency*
Media Filter or Sand Filter/Filtering Practices (Sand, above and below ground)	"Stormwater media filters are usually two-chambered including a pretreatment settling basin and a filter bed filled with sand or other absorptive filtering media. As stormwater flows into the first chamber, large particles settle out, and then finer particles and other pollutants are removed as stormwater flows through the filtering media in the second chamber." [16] *from California Stormwater Quality Association*
Porous Pavement or Permeable Pavement w and w/o Sand, Veg. (New)	"Porous pavement is a permeable pavement surface with a stone reservoir underneath. The reservoir temporarily stores surface runoff before infiltrating it into the subsoil. Runoff is thereby infiltrated directly into the soil and receives some water quality treatment. Porous pavement often appears the same as traditional asphalt or concrete but is manufactured without "fine" materials, and instead incorporates void spaces that allow for infiltration." [17] *from Perkiomen Watershed Conservancy*

LID/GI Measure	Definition
Retention Pond/Basin	"Retention ponds, also known as stormwater retention basins or man-made lakes: • store rainfall runoff from streets and adjacent lands • are an efficient and cost-effective land drainage system, because fewer and smaller pipes can be used to carry runoff to the rivers • benefit our environment by acting as a natural filter – they help to remove sediment and chemicals before the water drains to our rivers • collect only land drainage, and not wastewater from homes or businesses" [18] *from The City of Winnipeg*
Wetland Basin or Wet Ponds/Wetland (New and Retrofit)	"Wet ponds (a.k.a. stormwater ponds, retention ponds, wet extended detention ponds) are constructed basins that have a permanent pool of water throughout the year (or at least throughout the wet season). Ponds treat incoming stormwater runoff by settling and algal uptake. The primary removal mechanism is settling while stormwater runoff resides in the pool. Nutrient uptake also occurs through biological activity in the pond. Wet ponds are amo ng the most cost-effective and widely used stormwater treatment practices. While there are several different versions of the wet pond design, the most common modifi cation is the extended detention wet pond, where storage is provided above the permanent pool in order to detain stormwater runoff in order to provide greater settling." [19] *from The Stormwater Manager's Resource Center (SMRC)*
Wetland Channel or Vegetated Open Channels	"The wet swale (or wetland channel) also consists of a broad open channel capable of temporarily storing the WQv, bu t does not have an underlying filtering bed.... The wet swale is constructed directly within existing soils and may or may not intercept the water table. Like the dry swale, the WQv (*water quality volume*) within the wet swale should be stored for approximately 24 hours. The wet swale has water quality treatment mechanisms similar to stormwater wetlands, which rely primarily on settling of suspended solids, adsorption, and uptake of pollutants by vegetative root systems. These systems are often called wetland channel systems since they are basically a linear shallow wetland system." [20] - editorial inset in *italics*. *from Iowa Department of Natural Resources*

1 *Center for Neighborhood Technology, 2010, The Value of Green Infrastructure A Guide to Recognizing Its Economic, Environmental and Social Benefits http://www.cnt.org/media/CNT_Value-of-Green-Infrastructure.pdf*

2 *Government of British Columbia, Ministry of Environment, Environmental Protection Division http://www.env.gov.bc.ca/wat/wq/nps/BMP_Compendium/Municipal/Urban_Runoff/Treatment/Vegetative.htm*

3 *U.S. Environmental Protection Agency, Stormwater Management Best Practices http://www.epa.gov/oaintrnt/stormwater/best_practices.htm#grassedswales*

4 *U.S. Environmental Protection Agency, Stormwater Management Best Practices http://www.epa.gov/oaintrnt/stormwater/best_practices.htm#vegetatedfilterstrips*

5 *Bioswale From Wikipedia, the free encyclopedia http://en.wikipedia.org/wiki/Bioswale*

6 *Government of Western Australia, Department of Water, Water sensitive urban design, Swales and buffer strips http://www.water.wa.gov.au/PublicationStore/first/99295.pdf*

7 *U.S. Environmental Protection Agency, National Pollutant Discharge Elimination System (NPDES), Bioretention (Rain Gardens) http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=72*

8 *U.S. Environmental Protection Agency, Sediment and Erosion Control http://www.epa.gov/region6/6en/w/sw/sediment.pdf*

9 *IECA, International Erosion Control Association, Terms and Acronyms http://www.ieca.org/resources/intropagedefinitionsacronyms.asp*

10 *The Stormwater Manager's Resource Center (SMRC) web site, Stormwater Management Fact Sheet: Dry Extended Detention Pond http://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool6_Stormwater_Practices/Pond/Dry%20ED%20Pond.htm*

11 *The Milwaukee River Basin Partnership, Protecting Our Waters, a guide to responsible development within the Milwaukee River Basin, Detention & Infiltration Basins http://clean-water.umwex.edu/plan/drbasins.ht*

12 *The City of Toronto, What is a green roof http://www.toronto.ca/greenroofs/what.htm*

13 *Stormwater Partners of SW Washington, Facilities, Infiltration basin http://www.stormwaterpartners.com/facilities/basin.html*

14 *Montgomery County, Maryland, Department of Environmental Protection, Stormwater Facility Maintenance Program, Surface Sand Filters and Infiltration Trenches http://www6.montgomerycountymd.gov/content/dep/downloads/water/NS_Sand_Filt_and_Infiltration_080912.pdf*

15 *Minnesota Pollution Control Agency, Minnesota Stormwater Manual, Hydrodynamic devices http://stormwater.pca.state.mn.us/index.php/Hydrodynamic_devices*

16 *CASQA California Stormwater Quality Association, California Stormwater BMP Handbook, January 2003, New Development and Redevelopment, Media Filter, TC-40 http://www.cabmphandbooks.com/Documents/Development/TC-40.pdf*

17 *Perkiomen Watershed Conservancy, Environmental Planning Section, Managing Stormwater: Best Management Practices http://www.greenworks.tv/stormwater/porouspavement.htm*

18 *The City of Winnipeg, Retention ponds, What are retention ponds? http://winnipeg.ca/waterandwaste/drainageFlooding/ponds.stm http://winnipeg.ca/waterandwaste/drainageFlooding/ponds.stm*

19 *The Stormwater Manager's Resource Center (SMRC) web site, Stormwater Management Fact Sheet: Wet Pond http://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool6_Stormwater_Practices/Pond/Wet%20Pond.htm*

20 *Iowa Department of Natural Resources, Iowa Stormwater Management Manual, Version 3; October 28, 2009 http://www.iowadnr.gov/Portals/idnr/uploads/water/stormwater/manual/part2i.pdf*

Economic Benefits

> *"Customized application of nonmarket valuation methods can be expensive and time consuming to perform. Contingent valuation, for example, can require conducting survey research; a hedonic pricing study may involve extensive data assembly."* [3]

While expensive, the preferred approach will always be for the use of directly measured benefits. To the extent that project, local, or regional data, are available and is consistent with the measurement of the benefit category, it should be used. An example may be that a survey is available of local residents that measures WTP for park space. Where information is not available the "benefits transfer" approach is used. This takes benefits calculated for other projects, perhaps in other areas or for different types of projects and uses the estimates for the current infrastructure project adjusted for local conditions and design. In design of the tool then we have adopted the philosophy that the user should always have the option of entering data to override defaults with more appropriate data.

The costs and benefits of low impact development, or green infrastructure, compared with traditional pipe and processing facilities, or grey infrastructure, are:

Table: Costs vs Benefits

Cost or Benefit Type	Group/Area Impacted
1. Increased revenues, change in subsidies, avoided costs (including capital expenditures, operations and maintenance costs, direct employee, energy, waste, water, or materials costs)	City
2. Shadow Wage Benefit	City
3. Recreational Use Value	City
4. Flood Risk	City
5. Property Value Benefit	City
6. Reduced Heat Stress Mortality Benefit	City (Population rather than local government)
7. Water Quality and Habitat Enhancement	River Basin (and Region and City)
8. Wetland Enhancement	River Basin (and Region and City)
9. CO_2 Emissions	All
10. Air Quality	City

[3] *Ibid.*

Increased Revenues and Avoided Costs

The first costs and benefits that are incorporated into the model's calculations are the direct costs and benefits, including capital expenditures, operations and maintenance costs, direct employee, energy, waste, water, and materials costs, and a change in subsidies obtained. The impacts of a project on employee, energy, waste, water, and materials costs, as well as subsidies, are all calculated using values that are input by the user that indicate what those costs would be in a status quo or "do nothing" scenario, as well as what those values are expected to be after the proposed project is in operation. An example of these user inputs for electricity usage can be seen below:

Table: Costs vs Benefits

Energy				
Electricity				
If applicable, will the project lead to a change in the amount of electricity used?				
If yes, what is the current annual cost of electricity?				Current USD
If yes, what is the current annual total electricity usage?				MWh
If yes, what is the expected annual cost of electricity?				Current USD
If yes, what is the expected annual total electricity usage?				MWh

Other costs, such as capital expenditures and operations and maintenance (O&M) costs can be determined either by using information provided by the user, or by estimating the costs based on components installed and cost data that is stored in the model. When inputting project attributes into the model, the user can indicate how many acres of each component are going to be included in the project. Examples of green stormwater management project components include Biofilters, Green Roofs, Infiltration Basins, Media Filters, and others. For each component, the user has the ability to input the expected capital expenditure costs (including installation), as well as the expected annual O&M costs. In the case that the user of the Business Case Evaluator does not know the capital expenditure or O&M costs, the model estimates those costs automatically. There are low, medium, and high values per acre for each component; the values have been adapted from multiple sources that include the EPA, the Philadelphia stormwater management analysis, a stormwater management analysis from Maryland, and an International Stormwater BMP Database. For a full list of sources, see the References section at the end of the document. In addition, tables showing the values used for each green stormwater infrastructure component can be found in Appendix E.

The final cost values are calculated by taking the number of acres of each component and multiplying that value by the expected cost per acre of the component. The expected cost per acre uses the distribution generated from the low, medium, and high values so that the cost values are also adjusted for uncertainty. Note that if the user has specified the known costs for a component of the project, the user-input value is used, not the automatically calculated value. This method is the same for both the capital expenditure costs and the operations and maintenance costs.

Jobs & Shadow Wage

Description: Poverty Reduction Benefits of Local Green Infrastructure Jobs

As noted in the Philadelphia Study: "Benefit-cost analysis of public infrastructure investment projects does not traditionally consider job creation as a category of project benefits. Although creating jobs is universally perceived as beneficial, it is reasoned that jobs created by public investment are no more beneficial than jobs created by the private sector."

Another way of looking at it is – with limited government funding resources, public investment in one project is likely to generate the same (or similar) number of jobs as another public investment (even if there are zero long-term efficiency gains (e.g., digging holes and filling them in). Thus, the construction jobs created by investment projects are typically not included in benefit-cost/ROI analyses as they are considered costs (rather than benefits). For example, a more expensive project is likely to generate more construction jobs even if it accomplishes the same benefits as a less expensive project.

This standard industry approach ignores a few key factors:

- What is the geographic jurisdiction for the return on investment (ROI) analysis? A city? County? Metro area? An entire country like the US? Job impacts may be a net benefit for a more local jurisdiction while simply a re-distribution at the national level.
- What is the shadow wage of labor in the area? The shadow wage is the social opportunity cost of labor; that is the cost of labor in its next best use. Extensive research has shown that the full cost of labor for construction (directly related to construction jobs) can be reduced by the shadow wage of labor. In this way, the "benefit" is actually applied as a reduction in costs.
- Sources of funding – is this a 100% public investment from funds within the geographic jurisdiction of study? Or does the project attract private or federal funds that otherwise would not be invested in the area?
- From Marvin Shaffer "Multiple Account Benefit-Cost Analysis" p.75
  $SOCL = p_u * v_u + (1 – p_u) * w$
  $NB – w – SOCL = p_u * (w - v_u)$ where
  - SOCL is the social opportunity cost of labour
  - p_u is the probability of hiring people who would otherwise be unemployed
  - v_u is the value of what the unemployed persons would otherwise be doing (the minimum they would have to be paid to willingly work at the new job)
  - w is the wages that are paid in the new or comparable existing job, and NB is the net benefit that is realized from the new job.
  - " . . . the net benefit of any employment generated by a project or policy will be greater, the greater is the probability of hiring persons who would otherwise be unemployed (p_u), and the greater is the difference between the wages paid in the new jobs (w) and the value of whatever those hired would otherwise be doing (v_u)."
- A recommended approach is to apply a customized shadow wage conversion factor (CF) to the labor cost portion of the investment to lower the costs of the project. A very conservative approach is to simply discount wages by the local/regional unemployment rate. The recommended equation by the European Union is to also take into account taxes and social security payments, resulting in an equation of: **SW = FW (1-u) (1-t)**, where SW is the shadow wage, FW is the financial (or market) wage, u is the local/regional unemployment rate, and t is social security and taxes. The European BCA Guide gives an example with an unemployment rate in 12% (too high for most of the US), and social security/taxes of 32% (perhaps also too high for the US). Their recommended SW ends up ranging from 0.6 to 1.0 depending on the type of market and mix of skilled labor.
- A further refinement could reflect the amount of net new investment entering a local/regional jurisdiction. This could be due to: a) a project that obtains competitive federal funding that would otherwise go to another region; and/or b) private investment to implement an infrastructure project that otherwise would go to another region. This could potentially be handled as a further reduction in costs (though that might be controversial) or as a separate calculation of net new jobs for the region (based on net new investment) but not "additive" to other benefits.

- It is also possible for infrastructure investments to result in long-term job gains to a region due to more efficient, cost-effective infrastructure that enhances the competitiveness of businesses or attracts new companies to the region. In most cases, this kind of longer-term economic development benefit is in some way accounted for in other benefits, such as property values or other direct cost savings. That is particularly frequent in fixed guideway transit investments that have transit oriented development/property value benefits in excess of measurable transportation benefits. In some cases, like highway projects, the key issue is the extent to which "induced" demand benefits are already accounted for in the analysis. Good discussions of this potential benefit are in various USDOT/FHWA research and UK guidance on wider economic benefits, with recommended values of a freight logistics/supply chain premium of 5 to 15% of direct freight user benefits.
- The Philadelphia stormwater management study approach focuses on poverty reduction due to jobs to unskilled workers rather than infrastructure that would require skilled labor (and unions). They argue these workers would otherwise be unemployed and apply various dollar values of reduced government spending on the unemployed/poor. Conceptually interesting, this approach is potentially controversial and not an "industry accepted standard" approach, further it requires significant information and assumptions about the kinds of jobs beyond what can be expected on most projects.

See the References section at the end of the document for a full list of sources.

Approach: Shadow Wage Conversion Factor (CF)

Apply CF to labor cost component of construction costs as well as employee costs during the operations stage, in order to reduce those aspects of costs, as recommended by multiple Benefit Cost Analysis (BCA) guides, literature, etc. The CF is determined by the unemployment rate in the relevant jurisdiction and taxes/social security The following equation is used in calculating the Net Shadow Wage Benefit:

Net Shadow Wage Benefit = Market Wage – Social Opportunity Cost of Labour (SOCL)

Where SOCL = Market Wage * (1 – u)(1 – t)

And u = the local unemployment rate and t = the local tax and social security rates

The Shadow Wage Benefits from both the construction and operations stages are calculated and compared against the Shadow Wage Benefits from the Reference Case (the status quo or "do nothing" scenario). These values are used to determine the project's Net Shadow Wage Benefit, as can be seen below:

	Social Opportunity Cost of Labour, Multiplier	Social Opportunity Cost of Labour, Value (current USD)	Net Benefit
Reference Case	0.81	$ -	$ -
Construction Phase	0.81	$ -	$ -
Operations Phase	0.81	$ -	$ -

Construction Phase, Wages Benefit to Society	$ -
Operations Phase, NET Wages Benefit to Society Vs. Baseline	$ -

Components:

1. Market/financial wage for construction workers and for employees during operation
2. Tax rate
3. Unemployment rate

Includes: Economic value of jobs created for those who would otherwise consume social services

Excludes: Jobs created for those already in the workforce

Recreational Use Benefit

Description:

"Green infrastructure has been shown to increase recreational opportunities (for example, walking the dog, walking or jogging on sidewalks, bench sitting or picnicking) when increased vegetation and treed acreage is added within a community. The value of added recreational opportunities is measured by the increase in recreational trips or "user days" gained from urban greening. Use values can then be assigned to the various recreational activity trips." [4]

". . . although the protection of public space and provision of recreational amenities are typically not "priced", they nevertheless have significant value to society, and economists have developed sophisticated analytical techniques to derive monetary values for these types of goods." [5]

The Business Case Evaluator uses the Philadelphia study's methodology for the value of recreational use of green space (from US Army Corps of Engineers) but it incorporates the low and high ranges from the original source study.

The range used in the risk analysis is important because the valuation of how much people are willing to pay for a recreation experience is uncertain. The model allows users to change the values to refelect the increased recreational opportunities associated with their green infrastructure alternatives. A screenshot of the questions referring to Recreational Use can be seen below:

Recreational Use	
Does this facility have the capacity for hunting or fishing? Note: If there are wetlands being restored or created as part of this project, this question EXCLUDES any capacity of the wetlands for hunting or fishing.	Yes
If yes, does this facility have the capacity for specialized fishing and/or hunting? Examples of this include big game hunting or marine fishing for salmon or steelhead.	No
Does this facility have the capacity for specialized recreation? Examples of this include white water rafting or wilderness backpacking trips.	No
What is the recreation experience expected to be in the area? Note: General activities include those that are common to the area and are of normal quality. These activities may include picnicking, camping, hiking, riding, cycling, and fishing and hunting of normal quality. A high quality activity is one that is not common to the area and is of high quality.	Several general activities
What is the local availability of the opportunity? In other words, what is the availability of equal quality activities at other sites in the area?	Several within 1 hour travel time; none within 30 minutes travel time
What is the expected carrying capacity of the facility?	Adequate facilities to conduct without deterioration of the resource or activity experience
How accessible is the facility and what are the quality of roads around and within the facility?	Good access, high standard roads to site; good access within site
How are the environmental and aesthetic features of the facility?	Above average aesthetic quality; any limiting factors can be reasonably rectified

[4] CNT Op. Cit.
[5] "User's Guide Watershed Management Techniques Economic Valuation Model", Revised March 2010, County of Los Angeles, Department of Public Works, Watershed Management Division, p. 24

The approach uses a points-to-dollars system that has been developed by the US Army Corps of Engineers, producing a range of WTP values that are largely based on the responses to "Recreation Use" questions in the Excel model.

Conversion of Points to Dollars

Points	General Recreation Values	General Fishing and Hunting Values	Specialized Fishing and Hunting Values	Specialized Recreation Values Other than Fishing and Hunting	4
0	$ 3.80	$ 5.46	$ 26.58	$ 15.43	
10	$ 4.51	$ 6.17	$ 27.29	$ 16.38	
20	$ 4.98	$ 6.65	$ 27.77	$ 17.56	
30	$ 5.70	$ 7.36	$ 28.48	$ 18.99	
40	$ 7.12	$ 8.07	$ 29.19	$ 20.17	
50	$ 8.07	$ 8.78	$ 32.04	$ 22.78	
60	$ 8.78	$ 9.73	$ 34.89	$ 25.16	
70	$ 9.26	$ 10.21	$ 37.03	$ 30.38	
80	$ 10.21	$ 10.92	$ 39.87	$ 35.36	
90	$ 10.92	$ 11.16	$ 42.72	$ 40.35	
100	$ 11.39	$ 11.39	$ 45.09	$ 45.09	

Low	Medium	High	Expected	St Dev	Alpha	Beta
$ 8.07	*$ 8.40*	*$ 8.78*	*$ 8.41*	*$ 0.12*	*$ 3.77*	*$ 4.20*

WTP:	$ 8.41

Shown above: The range of WTP values produces a distribution of input values that monetize the recreational benefit for the potential project.

Approach:

Estimate the WTP of users, and multiply by the total user days expected after the project is constructed. The increase in user days per year is estimated using a three-point beta distribution. The low value is set to zero, taking into account the possibility that no users may use the project area for recreation (for example, installing an infiltration basin right next to a highway may not provide much recreational use value). The middle value takes the average population density of the city or town where the project is being constructed to estimate the number of users per year per acre. The model then assumes that each user would use the facility 30 times per year, to approximate the new user days per acre per year for the facility. The high value is based on the estimations of new recreational user days per acre from the Philadelphia stormwater study, which estimated user days per acre for new green space at 1,344 each year. From these three values, a beta distribution is used to produce an expected value that is multiplied by the calculated WTP value to determine the total Recreational Use value from the project.

Components:

1. Direct use value (user days * WTP)
   a. Local population density
   b. Number of acres of increased green space
   c. Project recreational use characteristics

Includes: Stream restoration | Riparian buffer improvements | Creekside recreation space | Non-creekside recreation space in vegetated areas | Increased urban greenways | Water-based recreation

Excludes: Wetlands-related recreational value

Flood Risk

Description:

Reduced flood risk due to a smaller volume of runoff from the project's property during storm events. This can be caused by increased green acreage, water storage capacity, stormwater drainage capacity, or reducing the surface area covered by impervious land.

Approach:

1. Calculate the city's total property value at risk in 5, 10, 25, 50, and 100 year storm events
   a. Determine the total property value in the city/town
      i. Median value per house * Number of houses in the city/town
   b. Determine the percent of residential property value at risk
      i. (Flood damage per year per state from 1955 - 2003) * (Total property value for each year for each respective state from 1955 - 2003)
2. Calculate flood risk mitigated (as a percentage of total flood risk) due to the design of the project ((Reduction in flood volume due to project) / (Total city-wide flood volume))
   a. Determine total city-wide flood volume during storm events
      i. Find expected precipitation (in inches) from 5, 10, 25, 50, and 100 year storms
         - Used daily precipitation data from 6000+ weather stations across the United States from 1950 to 2013 to determine maximum 24 precipitation annually over that time period
         - Fit a Generalized Extreme Value (GEV) Distribution to each dataset to determine the distribution of precipitation for each weather station
         - Determined storm event precipitation depths using 80th, 90th, 96th, 98th, and 99th percentile values from the distribution to represent the 5, 10, 25, 50, and 100 year storms
      ii. Using estimated city average curve number, estimate ground absorption of water in large storm events
      iii. Using user-defined input "Strongest storm event that does not cause flooding", calculate the average stormwater drainage capacity of the city
      iv. City-wide flood volume = (City surface area * Storm depth) – (City surface area * Ground absorption rate) – (Average percent of max drainage rate during storm * City's maximum stormwater drainage capacity)
   b. Determine reduction in flood volume due to project
      i. Use expected precipitation (in inches) from 5, 10, 25, 50, and 100 year storms
      ii. Calculate runoff from the project's site before the project is built during storm events
         - (Site's runoff (depth) based on current curve number * Site surface area) – (Current average percent of max site drainage rate during storm * Site's current maximum stormwater drainage capacity)
      iii. Calculate runoff from the project's site after project construction during storm events
         - (Site's runoff (depth) based on expected curve number * Site surface area) – (Expected average percent of max site drainage rate during storm * Site's expected maximum stormwater drainage capacity)
      iv. Reduction in flood volume = (Current site runoff during storms) – (Expected site runoff during storms)
3. Total Annual Flood Risk Mitigation Value = (Total Value at Risk in City) * (Total Flood Risk Mitigated from Project)

Components:

1. Total acres of each land type (e.g.: lawn, forest, impervious), both currently and after project construction
2. Stormwater drainage capacity of the project's site, both currently and after project construction
3. Total square mileage of town/city where project is being constructed
4. Average curve number of town/city
5. Maximum stormwater drainage capacity of town/city
6. Distribution of maximum 24 hour precipitation depths for each year, using 6000+ weather stations and daily weather data from 1950 to 2013
7. Distribution of damage from flood events for the state (as a percent of total property value), using data from 1955 to 2003
8. Total property value in the town/city

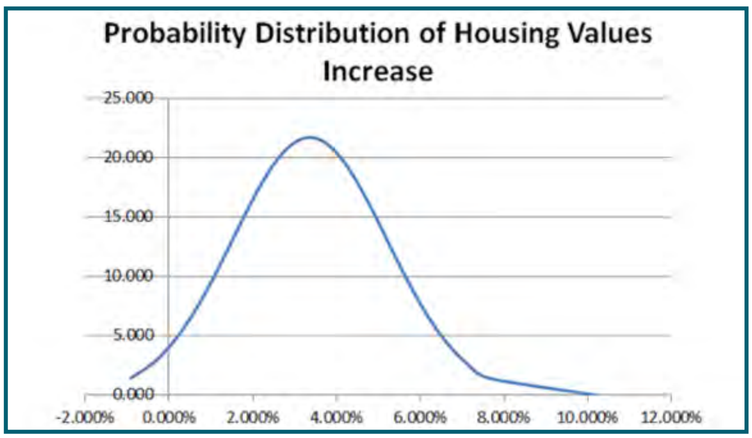
Neighbourhood Quality – Property Value

Description:

> *"This measure provides a value estimate based on a benefit category that directly affects market prices. Most commonly this value is derived from variations in housing prices, which in some part reflect the value of local environmental attributes. In this study the value for trees is based in part on increases in property values resulting from trees that are located in parks or nearby public spaces."* [6]

Property values can be positively influenced by LID projects. Increased value can be attributed to the temperature moderating effects of vegetation, thereby decreasing energy costs, reduced risk of flooding, improved air quality, or improved aesthetic value of the local area. Many studies have quantified the potential impacts of LID projects on property prices. The impacts on property prices as a result of LID projects that are used in the model can be found in Appendix F.

The values from these studies are used to develop a distribution of inputs that quantify the estimated impacts on local housing prices. An example of a probability density function of these values can be seen below:



Approach:

Estimate property value increases, and then multiply by 50% to account for possible double counting with other benefits included.

Components:

1. Property value baseline
   a. Number of properties in city or town where the project is being constructed
   b. Average housing price in city or town where the project is being constructed
2. Estimated property value increase from hedonic house price studies for 100% LID projects
3. Percent increase in green acreage in city or town that the project is being built in, providing the project's percent LID
   a. Total new green acres installed as a result of the project as a percentage of the total area of the city or town where the project is being constructed

Includes: New use for vacant property in shrinking urban centers | Enhanced aesthetics | Reduced risk of flooding | Reduced energy costs for air conditioning and heating due to the temperature moderating effects of increased vegetation

Excludes: Changes in non-residential property values | Changes in residential property values not attributed to LID. The 50% factor is an attempt to avoid double counting. Property value estimates from the literature encompass a wide range of benefits associated with LID. Many of these are not distinct from other benefits captured here. "For example, a property in an area with good air quality should sell for a higher amount relative to another property in an area with low air quality, all else equal. Thus, to simply add property value benefits with the benefits from improved air quality would be double-counting.

[6] *"User's Guide Watershed Management Techniques Economic Valuation Model", Revised March 2010, County of Los Angeles, Department of Public Works, Watershed Management Division, p. 24*

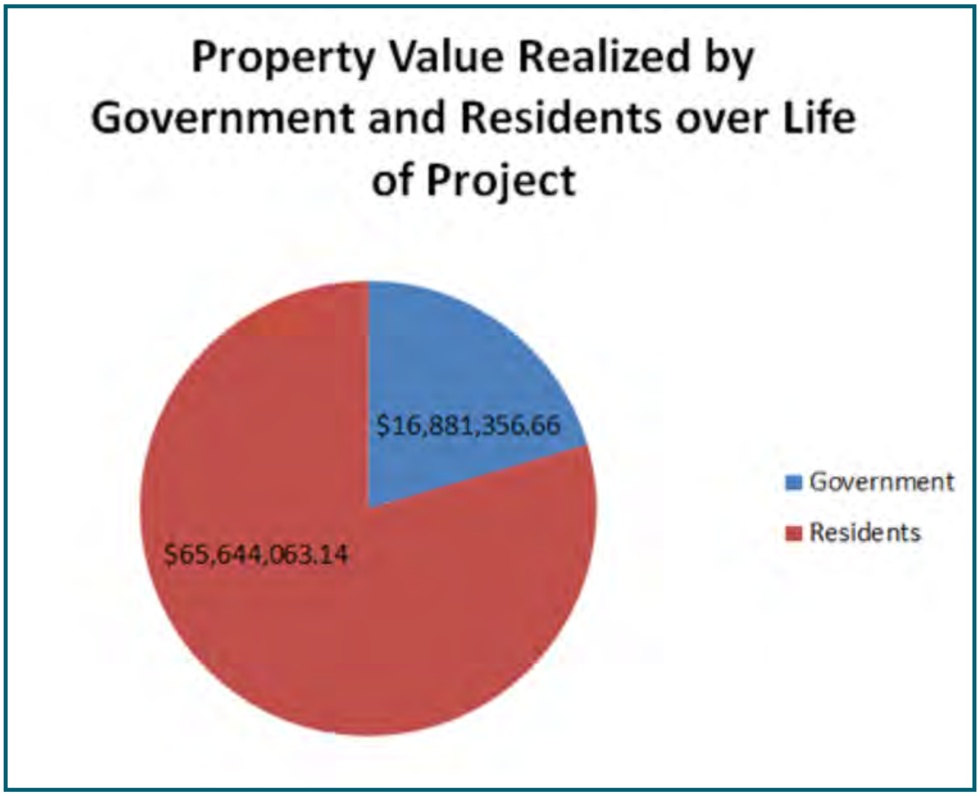
Additional Local Property Taxes Collected

Description:

An increase in property values also leads to an increase in taxes collected each year. The total amount that the government gains as a result of the project can be estimated over the life of the project.

Approach:

Tax rate * property value increase * years of project operation, discounted to estimate the net present value of the government's portion. An example of this breakdown can be seen in the pie chart below:



Components:

1. Local property tax rates
2. Property value increments

Includes: Increased property tax collected as a result of increased property value

Excludes: Potential changes in the local property tax rate over the life of the project

Heat Stress and Related Premature Fatalities Avoided

Description:

"Heat waves are a fixture of summers in Philadelphia, including some severe enough that they have resulted in over 100 premature deaths (for example, the summer of 1993). These events may be more frequent and severe in the future due to climate change. Green infrastructure (for example, trees, green roofs, and bioretention sidewalks) reduces the severity of extreme heat events in three ways - by creating shade, by reducing the amount of heat absorbing pavement and rooftops, and by emitting water vapor – all of which cool hot air. This cooling effect will be sufficient to actually reduce heat stress-related fatalities in the city during extreme heat wave events."

"The urban heat island (UHI) effect compromises human health and comfort by causing respiratory difficulties, exhaustion, heat stroke and heat-related mortality. . . Various studies have estimated that trees and other vegetation within building sites reduce temperatures by about 5°F when compared to outside non-green space. At larger scales, variation between non-green city centers and vegetated areas has been shown to be as high as 9°F." [7]

Approach:

1. Link LID to reduced temperatures
    a. Determine total acres of increased vegetation, and divide by the total acres in the town/city that the project is being built in to calculate an overall percentage increase in vegetation
    b. Link 10% increase in vegetation to reductions in temperatures (0.39 to 0.70 ^{0}F, according to multiple studies determining the impacts of LID projects on urban temperatures); see Appendix F for the values used in the model
    c. Calculate the overall reduction in temperature as a result of the project
2. Link reduced temperatures to avoided death
    a. Calculate the reduction in the average annual mortality rate based on local weather, the local mortality rate, and the local temperature threshold at which the impacts of heat on mortality can be detected (called the Minimum Mortality Temperature, or MMT)
        i. Calculate the change in the days each year when the city is over the MMT, as well as the change in the average temperature for the days that are still over the MMT after the project is implemented
        ii. Use the change in days over MMT and the change in the temperature for days over the MMT to calculate a new average annual mortality rate
        iii. Calculate annual lives saved from the project
3. Use the Value of Statistical Life to quantify the benefit of reduced heat mortality rates; see Appendix F for a list of values used.

Components:

1. Total acres of vegetation installed or restored in the project
2. Total acres in the town/city where the project is being installed
3. Local mortality rate
4. Longitude of location so that the approximate MMT can be calculated (the MMT has been found to correlate with latitude, so more southern locations have a higher MMT and more northern locations have a lower MMT).
5. Local weather patterns/history – daily data from 1981-2010 Climate Normals for ~1,500 weather stations across the United States were used to determine a distribution of temperature values for each city for every month of the year.
6. Population of town/city where the project is being installed
7. Value of statistical life - Value of a statistical life seems to be widely used in the regulatory impact analysis and cost benefit studies for federal government cost benefit analyses (e.g. safety improvements in rail and roadways). A range of $5-$13 million with a median around $9 million seems to be accepted.

Includes: Urban heat island mitigation

Water Quality

Description:

Increased acres of vegetation, including forest or wetlands, can positively influence the water quality in a local area. In addition, using LID for stormwater management can reduce the stormwater volume that must be managed by grey infrastructure, reducing the frequency and volume of overflowing sewer systems in large storm events. The impact of this is that the local water areas have improved water quality. This improvement can be quantified by assessing the WTP of local households for improvements in water quality.

Approach:

WTP is the amount of money people are willing to forego to have the item of interest. As shown in auctions, people have different WTP values for the same item. Value or WTP is often estimated by implementing a Stated Preference Survey. In such a survey, a detailed explanation is provided as to what is being proposed is described and the respondent is given a series of choices where trade-offs have to be made. There are two main types: Contingent Valuation and Conjoint Analysis. In a simple world, all prices would be revealed. By simulating a hypothetical (and plausible) market, estimates can be derived by surveying people to collect their evaluation of changes in the level of environmental quality, health and safety. Asking people outright how much would they pay produces highly optimistic and unlikely values as people tend to provide answers they feel are socially expected. The stated preference approach avoids this pitfall and has gained acceptance by academics and policy makers.

Uncertainty in the WTP for water is handled similarly to other benefits. The model is based on a meta-analysis of surveys that is linked to state-specific income and the magnitude of water quality improvements. Meta-analyses measure WTP for increases in water quality from studies that may account for regional differences or differences in methodology so that the meta-analysis results can be used to produce useful data like "In Texas, people are willing to pay x dollars per year for water to be improved from boatable to being suitable for game fishing". In the model users can choose how the project will affect water quality using a simple boatable, fishable, swimmable, drinkable scale:

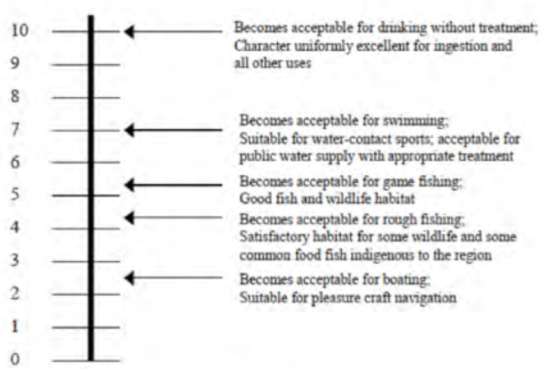


Figure D.1. Vaughan's (1986) water quality ladder.

Table D.1. Water quality characteristics for 5 classes of water use

	Fecal coliform (no./100 mL)	Dissolved oxygen (mg/L)	5-day BOD (mg/L)	Turbidity (NTU)	pH
Acceptable for drinking without treatment	0	7.0	0	5	7.25
Acceptable for swimming	200	6.5	1.5	10	7.25
Acceptable for game fishing	1,000	5.0	3	50	7.25
Acceptable for rough fishing	1,000	4.0	3	50	7.25
Acceptable for boating	2,000	3.5	4	100	4.25

Source: Russell et al., 2001.

[7] CNT Op. Cit.

Users can choose expected water quality improvements, as shown below:

Water Quality Improvements	
If water quality in streams, rivers, ponds, lakes, or any other bodies of water will be affected by this project, what is the current average water quality? Use the Water Quality Ladder below to determine this value. (Scale of 0-10)	4.8
Using the same Water Quality Ladder, below, what is the expected average water quality in the same body of water after the project is in full operation? (Scale of 0-10)	6.2

The model uses a meta-analysis of studies of water quality changes and WTP to determine the value of water quality changes as the result of a LID project being constructed in a region. Note that the recreational use value is captured in the recreational use benefit and habitat/ecosystem value is also captured in a separate benefit. The functions used in the model are adapted from a 2007 study by Van Houtven et. al. Two functions are used to determine WTP:

1. A semi-log model, and
2. A log-linear model.

Both functions are included in the model because each function carries its own benefits and drawbacks. The semi-log model has the highest R^2 value, at 0.61. This is compared with the log-linear model, with an R^2 value slightly lower, at 0.59. However, the log-linear model produces more reasonable results when the water quality changes in a region become very small. A project's influence over local water quality may be very large, but most often water quality changes will be incremental improvements. In these cases, the log-linear model produces results that are more intuitively accurate, as the WTP for water quality improvements from the log-linear model approaches zero as the water quality improvement approaches zero. In contrast, even an infinitesimally small change in water quality still yields a $10 WTP value for the semi-log model. For these reasons, both models are incorporated into the model so that the most accurate estimation can be obtained.

A distribution of values is created by incorporating Worst Case, Medium Case, and Best Case scenarios for each function. The Worst Case values assume that the initial water quality is rated as 1 point higher (on the scale of 1-10) than the user indicates, while also assuming that the overall water quality change due to the project is 1 point lower (on the same scale) than what the user indicates. At the same time, the Medium Case value takes the users inputs and uses them with no modifications to produce a WTP value. Finally, the Best Case assumes that initial water quality is 1 point lower than the user indicates, while the overall water quality change due to the project is projected to be 1 point more than what the user indicates.

The ranges for both models are used to create beta distributions for both the semi-log and log-linear functions. A mini Monte Carlo simulation, consisting of 100 iterations, is conducted, producing risk-adjusted WTP values for each function. The overall risk-adjusted values for each function are then averaged to determine the project's average WTP value.

After the overall WTP value is calculated, it is multiplied by the number of houses that use the local water to determine the total value of the project that can be attributed to water quality improvements. This value becomes an input into the Monte Carlo simulation of the overall project relative to the base case.

Components:

1. Water quality of local bodies of water before and after project construction
2. Number of households receiving benefits
   a. Number of households in the local area
   b. Percent of households that would use the body of water after project construction

Includes: All households experiencing benefits, including those located outside of the immediate LID zone | Improved channel stability | Reduced undesirable plants and vegetation | Reduced Biochemical Oxygen Demand | Restored predevelopment hydrology | Reduced sediments | Restored natural landscape features| Reduced Combined Sewer Overflows | Reduced digestive ailments caused by coliforms | Improved protection of drinking water sources | Improved ability to replenish groundwater | Reduced algae, lowering cost to treat drinking water

Excludes: Habitat value and creation outside the LID zone | recreational use and value

Habitat /Ecosystem

Description:

Wetland Enhancement and Creation

"The value measure for wetlands is based on a number of beneficial functions that wetlands serve, including the following: flood control, water supply, water quality, recreation, commercial fisheries, and habitat (Allen, et al. 1992)." [8]

"Many vegetated green infrastructure features can improve habitat for a wide variety of flora and fauna. Rain gardens and other vegetated infiltration features hold particular value in this regard insofar as they perform best when planted with native species. . . Habitats are typically economically valued using either contingent valuation methods (especially where the conservation of an endangered species is concerned) or using the market price of traded goods that are harvested at the habitat in question (or of traded goods that are harvested elsewhere but for which the relevant habitat provides breeding and/or nursery grounds). The latter method can be useful, for example, in the case of coastal estuaries that provide nurseries for commercially harvested fish, but this approach is less applicable to the relatively small-scale urban vegetated features in question here." [9]

Approach:

Determine acreage of newly created and restored wetlands, indicate the functions of the wetlands being created or restored (e.g.: flood reduction, recreational fishing, bird watching), and then determine the economic value of the wetland based on meta-analyses.
A screenshot of the user inputs for wetland value enhancement [10] can be seen below:

Wetland Value Enhancement	
What type of wetland is being created/restored?	Freshwater Marsh
Is the wetland created/restored inland or coastal?	Inland
If the wetland is joining a system of other wetlands, what is the approximate number of acres of the total wetlands in the area?	
Wetland Functions	
Which of the following wetland functions is the created/restored wetland expected to possess?	
Flood Reduction	No
Storm Buffer	No
Reduced Water Purification Costs (improved water quality)	No
Increased Water Quantity	No
Improvement in Recreational Fishing, on or off site	No
Improvement in Commercial Fishing, on or off site	No
Bird Hunting	No
Bird Watching	No
Amenity Value Provided by Proximity to the Environment	Yes
Nonuse Appreciation of Species Living in Wetland	Yes

Components:

1. Acres of wetlands created and/or restored
2. Type of wetland, location, and total acres of the greater wetlands system
3. Main functions of the wetlands being created and/or restored
4. Meta-analytical function to determine value per acre of wetland

Includes: Improved water quality | groundwater recharge | shoreline anchoring | flood control | wildlife habitat | enhanced aesthetics | some recreational use (if not captured under recreational use benefit)

[8] *"User's Guide Watershed Management Techniques Economic Valuation Model", Revised March 2010, County of Los Angeles, Department of Public Works, Watershed Management Division, p. 30*

[9] *CNT Op. Cit.*

[10] *The estimates draw from a meta-analysis of more than 70 US valuation studies estimating wetland value, willingness to pay for improvements in surface water quality, and the benefit for terrestrial habitat services. See Ayuna Borisova-Kidder, 2006 in the Wetland Value Enhancement References Section.*

Carbon Footprint

Description:

Avoided CO_2 equivalent (CO_2e) emissions due to the project, as well as increased CO_2 sequestration.

Green infrastructure reduces energy use, and to the extent it obviates the need for fossil fuel use, reduces carbon emissions. Relative to traditional grey infrastructure (pipes and water treatment infrastructure), low impact development may also have less embodied energy. Consider the embodied energy in manufacturing and constructing water treatment and conveyance facilities versus tree cultivation and planting. Planting new trees can also sequester carbon from the atmosphere, reducing the impacts of climate change.

> *"First, the cooling effects of trees and plants shade and insulate buildings from wide temperature swings, decreasing the energy needed for heating and cooling. Second, rain is managed where it falls in systems of soil and plants, reducing the energy needed for traditional systems to store, pipe, and treat it. Growing trees also act as carbon 'sinks,' absorbing carbon dioxide from the air and incorporating it into their branches and trunks."* [11]

Approach:

1. Calculate the change in carbon emissions relative to the base or reference case. This can be the reduced emissions from materials used in construction and from the operations phase.
   a. Determine the amount of cement expected to be used in the project, and calculate the greenhouse gas (GHG) emissions emitted in the construction phase
      i. (Tonnes of concrete) * (kg CO_2e / tonne of concrete used)
   b. Calculate avoided electricity or other fuel consumption for the project, determine the carbon intensity of the local fuel mix, then calculate lifetime avoided GHG emissions
2. It can also be the tons of carbon removed by green infrastructure:
   a. Total sum for all years of project operation: (Number of planted trees still living) * (Size & age-specific carbon absorption rate per tree each year)
      i. Number of planted trees still living: combination of healthy trees, poor trees, critical trees, and dying trees
      ii. Size and age-specific carbon absorption rate per tree each year: the weighted average diameter of trees planted increases each year as the trees grow, while aging trees tend to have lower growth rates, with carbon absorption rates reducing to zero just before tree death
3. Calculate the avoided GHG emissions from O&M, construction, and sequestration
4. Convert GHGs to CO_2e
5. Apply a social cost of carbon; for a list of values used, see Appendix F.

Components:

1. Lifetime (material, construction, operation, maintenance, demolition/reuse/recycle) energy use
2. Carbon intensity of local fuel mix
3. CO_2e conversion factors
4. Carbon absorption rate of trees at different life stages and at different sizes
5. Social cost of carbon (see Appendix F)

Includes: Reduced carbon emissions due to lower energy use | Increased carbon sequestration | Health, climate, environmental, and damage components of the social cost of carbon.

Excludes: Reduced carbon emissions due to reduced energy consumption from local buildings

[11] *Philadelphia Combined Sewer Overflow Long Term Control Plan Update, Supplemental Documentation, Volume 2. Triple Bottom Line Analysis, October 1, 2009 http://www.phillywatersheds.org/ltcpu/Vol02_TBL.pdf, downloaded January 15, 2013.*

Air Quality

Description:

LID projects can reduce air pollution emissions due to lower operational energy usage, as well as air pollutant removal from added vegetation.

> *". . . quantifies the direct (uptake and deposition) and indirect (avoided emissions) air quality impacts of green infrastructure and provides instructions for valuing these impacts in monetary terms. The criteria pollutants addressed here are nitrogen dioxide NO_2), ozone (O_3), sulfur dioxide (SO_2) and particulate matter of aerodynamic diameter of ten micrometers or fewer (PM-10) Practices that provide a direct benefit of uptake and deposition include green roofs, trees and bio-infiltration."* [12]

Approach:

1. Calculate the change in air pollution relative to the base or reference case. This includes reduced emissions from the operations phase, due to lower energy requirements.
   a. Calculate avoided electricity or other fuel consumption for the project, determine the air pollution emitted from energy usage, and calculate lifetime avoided air pollution emissions.
2. Calculate the change in air pollution due to increased pollutant absorption as a result of new vegetation:
   a. Total sum for all years of project operation:
   (Number of planted trees still living) * (Size and age-specific pollutant absorption rate per tree each year)
      i. Number of planted trees still living: combination of healthy trees, poor trees, critical trees, and dying trees
      ii. Size and age-specific air pollution absorption rate per tree each year: the weighted average diameter of trees planted increases each year as the trees grow, while aging trees tend to have lower growth rates, with pollution absorption rates reducing to zero just before tree death
3. Calculate the avoided air pollution emissions from the O&M phase and from sequestration
4. Apply a social cost of air pollution to convert air pollution reductions to a dollars value (see Appendix F for a full list of values used)

Components:

1. Lifetime (material, construction, operation, maintenance, demolition/reuse/recycle) energy use
2. Air pollution from electricity generation
3. Air pollution absorption rate of trees at different life stages and at different sizes
4. Social cost of different air pollutants (see Appendix F)

Includes: Health benefits from reduced criteria air contaminants (CACs) and ozone | Health benefits from avoided CACs and ozone from reduced direct energy consumption

Excludes: Health benefits from avoided CACs and ozone from reduced energy consumption from local buildings

[12] *CNT Op. Cit.*

Other possible benefits were considered by the ISI Economics Committee but were not quantified. These included community cohesion, urban agriculture, and noise pollution.

Possible Other Benefits – Community Cohesion

"One way that green infrastructure can make communities better places to live is through its effect on 'community cohesion'– improving the networks of formal and informal relationships among neighborhood residents that foster a nurturing and mutually supportive human environment (Sullivan, Kuo and Depooter 2004). A study done by the Landscape and Human Health Laboratory at the University of Illinois at Urbana/Champaign (UIUC) found that, "Exposure to green surroundings reduces mental fatigue and the feelings of irritability that come with it. . . Even small amounts of greenery. . . helped inner city residents have safer, less violent domestic environments." (Kuo and Sullivan 2001b). Another study documents a link between increased vegetation and the use of outdoor spaces for social activity, theorizing that urban greening can foster interactions that build social capital (Sullivan, Kuo and Depooter 2004). Related to this effect, a further study found a meaningful relationship between increased greenery and reduced crime (Kuo and Sullivan 2001a)." [13]

Possible Other Benefits – Urban Agriculture

"As urban populations grow and the costs associated with rural food production and distribution continue to increase, urban agricultural systems are being considered in order to address concerns related to food security and cost (Argenti 2000). According to the USDA, 15 percent of the world's food supply is currently produced in urban areas (AFSIC 2010). Green infrastructure practices such as green roofs and tree planting can provide increased opportunities for urban agriculture and urban foraging. Urban agriculture can include a multitude of benefits to urban areas, including economic development, recreational and community building activities, educational opportunities for youth and increased habitat within the urban ecosystem." [14]

Possible Other Benefits – Noise Pollution

"Green infrastructure, particularly vegetative practices and permeable pavement, have the added benefit of reducing noise pollution. Planes, trains and roadway noise are significant sources of noise pollution in urban areas sometimes exceeding 100 decibels, which well exceeds the level at which noise becomes a health risk. A study in Europe using porous concrete pavement found a reduction in noise level of up to 10 decibels (Olek et al 2003; Gerharz 1999). Likewise, the British Columbia Institute of Technology's Centre for the Advancement of Green Roof Technology measured the sound transmission loss of green roofs as compared to conventional roofs. The results found transmission loss increased 5–13 decibels in low– and midfrequency ranges, and 2–8 decibels in the high frequency range (Connelly and Hodgson 2008). Hedonic pricing studies assessing the impact of road and aircraft noise on property values find average reductions in property value per one decibel increase in noise level of 0.55 percent and 0.86 percent, respectively (Navrud 2003)." [15]

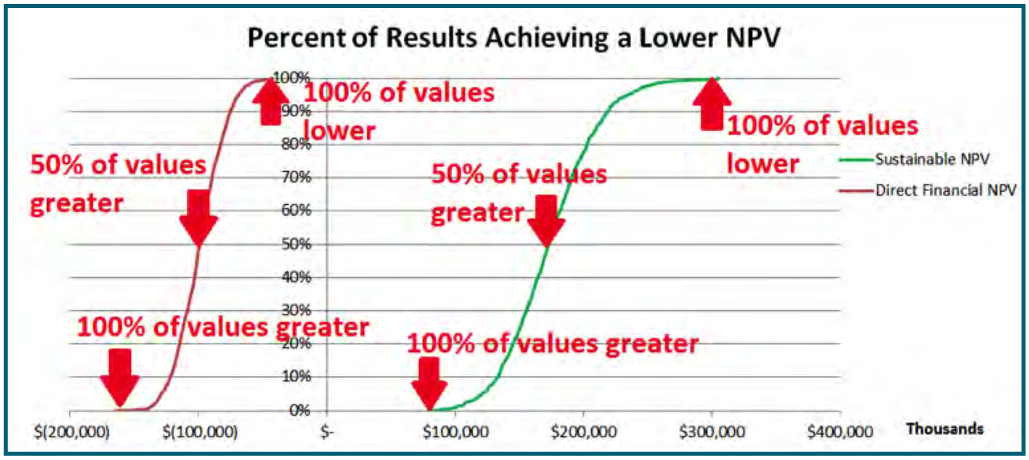
[13] CNT Op. Cit.
[14] CNT Op. Cit.
[15] CNT Op. Cit.

RESULTS AND OUTPUTS OF THE BUSINESS CASE EVALUATOR

Monte Carlo Simulation

The Business Case Evaluator contains multiple results pages that present the results using several different formats and features. The first page is the "Results- Monte Carlo Simulation" sheet, where the Monte Carlo Simulation is run. The user can select whether they want to run a "Quick" (100 iterations) or "Detailed" (1500 iterations) Monte Carlo Simulation. It is recommended that the "Quick" simulation be run initially to ensure that all inputs have been entered correctly and to get a quick snapshot of how the results may look.

When the run is complete, many different results are able to be viewed on this sheet. The first is a chart showing the "Percent of Results Achieving a Lower NPV". The two curves are in red and green; the red curve represents the probability distribution of the results for the Direct Financial Net Present Value (NPV), while the green curve represents the probability distribution of the results for the Sustainable NPV. This may be useful in viewing the direct financial returns from a project in contrast with the total returns, with the externalities of the project taken into account.



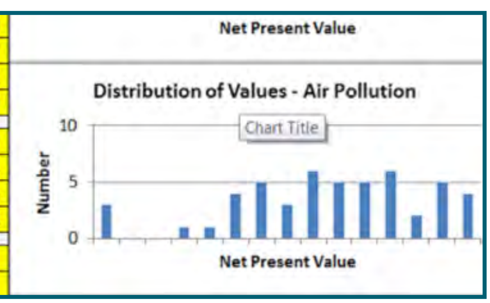
Shown above: An example of the results from the Monte Carlo simulation in the Business Case Evaluator.

The two curves can be useful in understanding what the minimum direct financial and sustainable net present values of the project are likely to be. For example, the above chart can be interpreted in the following way: there is almost a 100% probability that the project will yield an S-NPV greater than $100 million, with approximately a 50% probability of yielding an S-NPV greater than ~$175 million, and there is almost a 0% probability of producing an S-NPV greater than $300 million.

Other results available on the sheet include a summary of the NPV, breakeven (in years), Sustainable Return on Investment (S-ROI), and Sustainable Internal Rate of Return (S-IRR) for the project. The summary includes both averages and standard deviations for the project analyzed.

Finally, a summary of the value attributable to each cost or benefit is also shown on the sheet. For each cost or benefit, the average risk-adjusted values from the Monte Carlo distribution are shown, along with the standard deviation of the results, and the 95% confidence interval. A chart showing the distribution of the results is also provided. An example of these results can be seen in the screenshot, below:

CO2 Emissions	Average Value from Monte Carlo		$	325,770,272.20
	Standard Deviation		$	16,307,550.57
	95% Confidence Interval	Low	$	293,808,060.42
		High	$	357,732,483.99
Air Pollution	Average Value from Monte Carlo		$	199,612,213.17
	Standard Deviation		$	51,332,215.64
	95% Confidence Interval	Low	$	99,002,919.26
		High	$	300,221,507.08
	Average Value from Monte Carlo		$	-
	Standard Deviation		$	-



Results Summary

The results summary page contains charts and metrics so that the user can evaluate the value of the proposed project. The first charts that can be seen on the page are two pie charts, one showing a breakdown of the value from the benefits, and the second showing a breakdown of the value from the costs. These charts enable the user to view a quick visual representation of what most of the costs and benefits are attributed to.

Below the charts, there is a full breakdown of the results by "account". These accounts include the following:

1. Direct financial value
2. Government or taxpayer
3. User/target-beneficiary or customer service
4. Economic or business activity
5. Environmental
6. Community or other

The methodology for how the values are allocated to each account can be found in the "Multiple Account Costs and Benefits" section of this document.

Similar to the multiple account breakdown, the results are also broken down by Envision™ Credit. Note that, unlike the stakeholder account breakdown that was shown above it, the sum of value attributed to the Envision™ credits do not necessarily add up to the total NPV of the project. This is because some of the costs and benefits are direct financial costs or benefits, hence they do not fit in any of the Envision™ credit buckets. The full methodology for how the values are allocated to each account can be found in the "Envision Credit Costs&Benefits" section of this document.

There are multiple metrics are provided to determine the financial viability of the proposed project. These include the profitability indices, discounted payback period, net present value, return on investment, internal rate of return, modified internal rate of return, and net present values of each individual cost or benefit.

Static Results

The static results page shows the projected cash flows annually over the life of the project, broken down by each cost or benefit. The dates of project construction and project operation are taken into account, so that capital expenditure costs are paid when the project is under construction, while operations costs and benefits are only counted when the project is in operation. Inflation is also taken into account in the calculations.

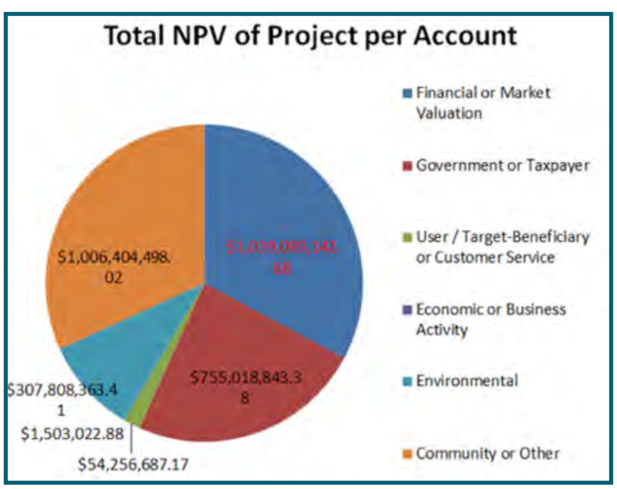
The values on the Static Results page are not "risk adjusted". These values automatically use the Expected Values or mid-point values for each input in the model to create estimated projections over the life of the project.

Multiple Account Costs and Benefits

The Multiple Account Costs and Benefits worksheet serves two purposes: 1. it provides definitions of, and a clear breakdown of the cost and benefit values allocated to, each account type (e.g. financial or direct financial value, government, economic, etc.), and 2. it allows the user to allocate a cost or benefit to multiple accounts or to a different account than is set by default in the model. A screenshot showing the table enabling this feature is shown below:

	Account		
	1	2	3
Revenues	*Direct Financial Value*		
Capital Expenditures	*Direct Financial Value*		
O&M Costs	*Direct Financial Value*		
Employee Costs	*Direct Financial Value*		
Electricity Costs	*Direct Financial Value*		
Natural Gas Costs	*Direct Financial Value*		
Propane Costs	*Direct Financial Value*		
Diesel Costs	*Direct Financial Value*		
Other Energy Costs	*Direct Financial Value*		
Change in Waste Costs	*Direct Financial Value*		
Change in Water Costs	*Direct Financial Value*		
Change in Materials Costs	*Direct Financial Value*		
Change in Other Costs (Present Valu	*Direct Financial Value*		
One Time Subsidies/Grants	*Direct Financial Value*		
Recurring Subsidies/Grants	*Direct Financial Value*		
Shadow Wage Benefit	*Economic or Business Activity*	*Government or Taxpayer*	
Recreational Use Value	*Community or Other*	Direct Financial Value	
Flood Risk Value	*Community or Other*	Government or Taxpayer	
Change in Property Values - Residen	*User / Target-Beneficiary or (*	User / Target-Beneficiary or Customer Ser	
Change in Property Values - Gov's Po	*Government or Taxpayer*	Economic or Business Activity Environmental	
Heat Stress Mortality	*Community or Other*	Community or Other *Government or Taxpayer*	
Water Quality and Habitat Enhancem	*Environmental*	*Government or Taxpayer*	
Wetland Enhancement	*Environmental*	*Government or Taxpayer*	
CO2 Emissions	*Environmental*	*Government or Taxpayer*	
Air Pollution	*Environmental*	*Government or Taxpayer*	
Residual Value of Assets	*Direct Financial Value*		
Decomissioning Costs	*Direct Financial Value*		

There are a maximum of three accounts that can share each cost or benefit. If there is only one account allocated to a cost or benefit, the full value of that cost or benefit is added to that account. However, if there are two accounts sharing one cost or benefit, the value is shared equally between the two accounts. Similarly, if three accounts share one cost or benefit, the value is shared equally between the three accounts. For example, if the net present value of the Air Pollution benefit is $120,000 and the benefit is shared between the "Environmental" account and the "Government or Tax Payer" account, then $60,000 will be added to each account as a result of Air Pollution. If the user were to decide that "Community or Other" should also be gaining from a reduction in air pollutants, they can add that account as the third account sharing that benefit. As a result, each account would then each gain $40,000 from the Air Pollution benefit.



Shown above: an example of a pie chart showing the breakdown of value between key accounts.

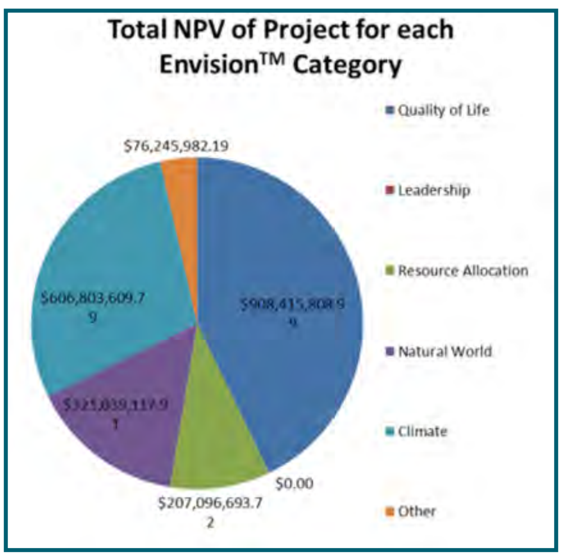
The total value of each account is calculated, and a pie chart is then created that shows a breakdown of the value between all the accounts.

Envision^{TM} Credit Costs and Benefits

The Envision^{TM} Credit Costs and Benefits worksheet serves two purposes: 1. it provides definitions of, and a clear breakdown of the cost and benefit values allocated to, each Envision^{TM} Credit category (e.g. financial or market valuation, quality of life, leadership, etc.), and 2. it allows the user to allocate a cost or benefit to different credits than is set by default in the model. A screenshot showing the table enabling this feature is shown below:

	Account		
	1	2	3
Revenues	Financial or Market Valuation		
Capital Expenditures	Financial or Market Valuation		
O&M Costs	Financial or Market Valuation		
Employee Costs	Financial or Market Valuation		
Electricity Costs	Financial or Market Valuatio	Resource Allocation	Climate
Natural Gas Costs	Financial or Market Valuatio	Resource Allocation	Climate
Propane Costs	Financial or Market Valuatio	Resource Allocation	Climate
Diesel Costs	Financial or Market Valuatio	Resource Allocation	Climate
Other Energy Costs	Financial or Market Valuatio	Resource Allocation	
Change in Waste Costs	Financial or Market Valuatio	Resource Allocation	
Change in Water Costs	Financial or Market Valuatio	Resource Allocation	
Change in Materials Costs	Financial or Market Valuatio	Resource Allocation	
Change in Other Costs (Present Valu	Direct Financial Value		
One Time Subsidies/Grants	Direct Financial Value		
Recurring Subsidies/Grants	Direct Financial Value		
Shadow Wage Benefit	Quality of Life		
Recreational Use Value	Quality of Life	Natural World	
Flood Risk Value	Other	Financial or Market Valuation	
Change in Property Values - Resident	Other	Quality of Life Leadership	
Change in Property Values - Gov's Po	Other	Resource Allocation	
Heat Stress Mortality	Quality of Life	Natural World	
Water Quality and Habitat Enhancem	Natural World	Climate Other	
Wetland Enhancement	Natural World	Climate	
CO2 Emissions	Resource Allocation	Climate	
Air Pollution	Quality of Life		
Residual Value of Assets	Financial or Market Valuation		
Decommissioning Costs	Financial or Market Valuatio	Resource Allocation	

As with the Multiple Account Costs and Benefits section, there are a maximum of three accounts that can share each cost or benefit. If there is only one account allocated to a cost or benefit, the full value of that cost or benefit is added to that account. However, if there are two accounts sharing one cost or benefit, the value is shared equally between the two accounts.



Shown above: an example of a pie chart showing the breakdown of value between the credits.

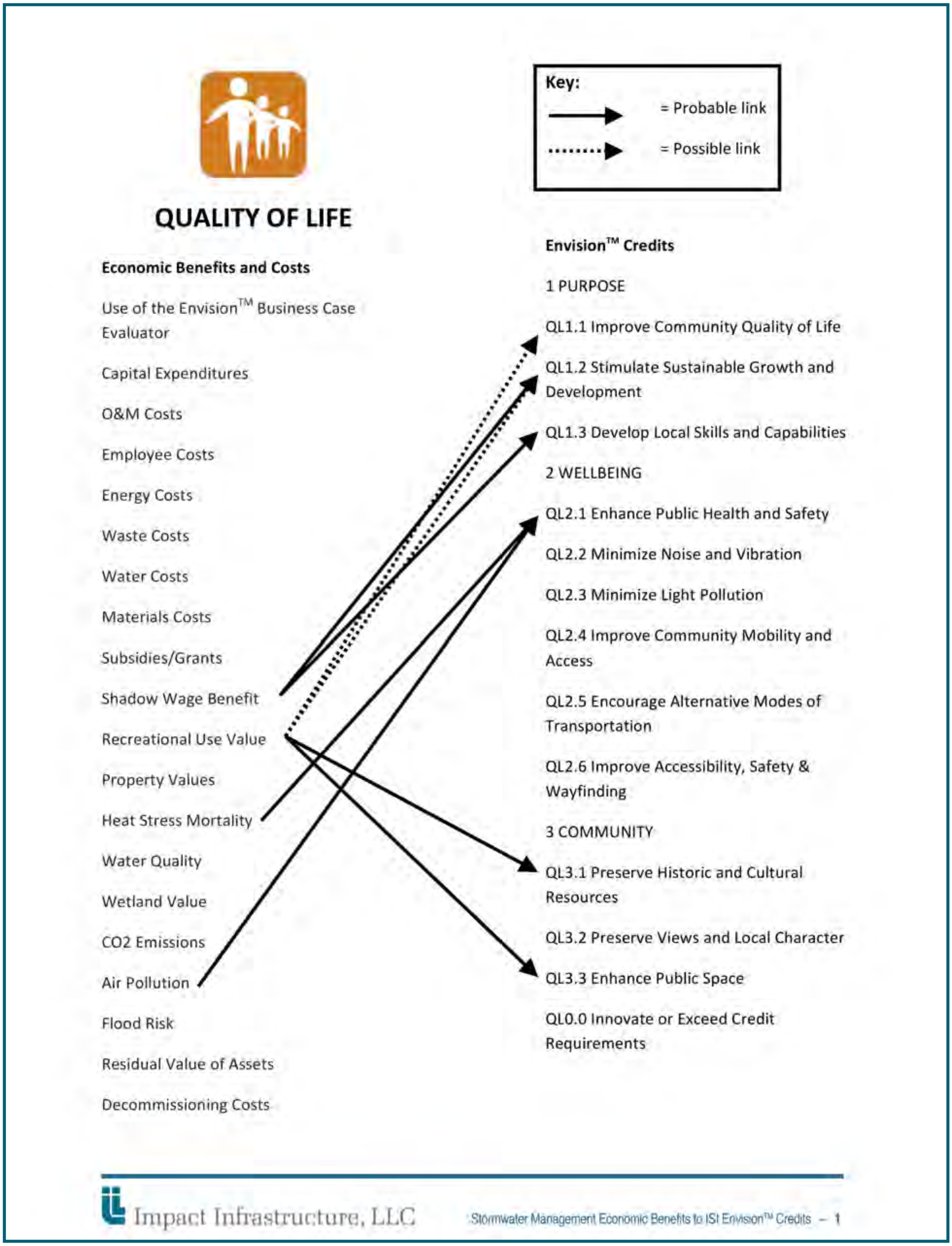
The total value of each credit is calculated, and a pie chart is then created that shows a breakdown of the value between all the Envision^{TM} credits. The default allocation of Envision^{TM} credit categories to BCE costs and benefits is based on the maps linking the BCE to the Envision^{TM} rating system, found in Appendix y.

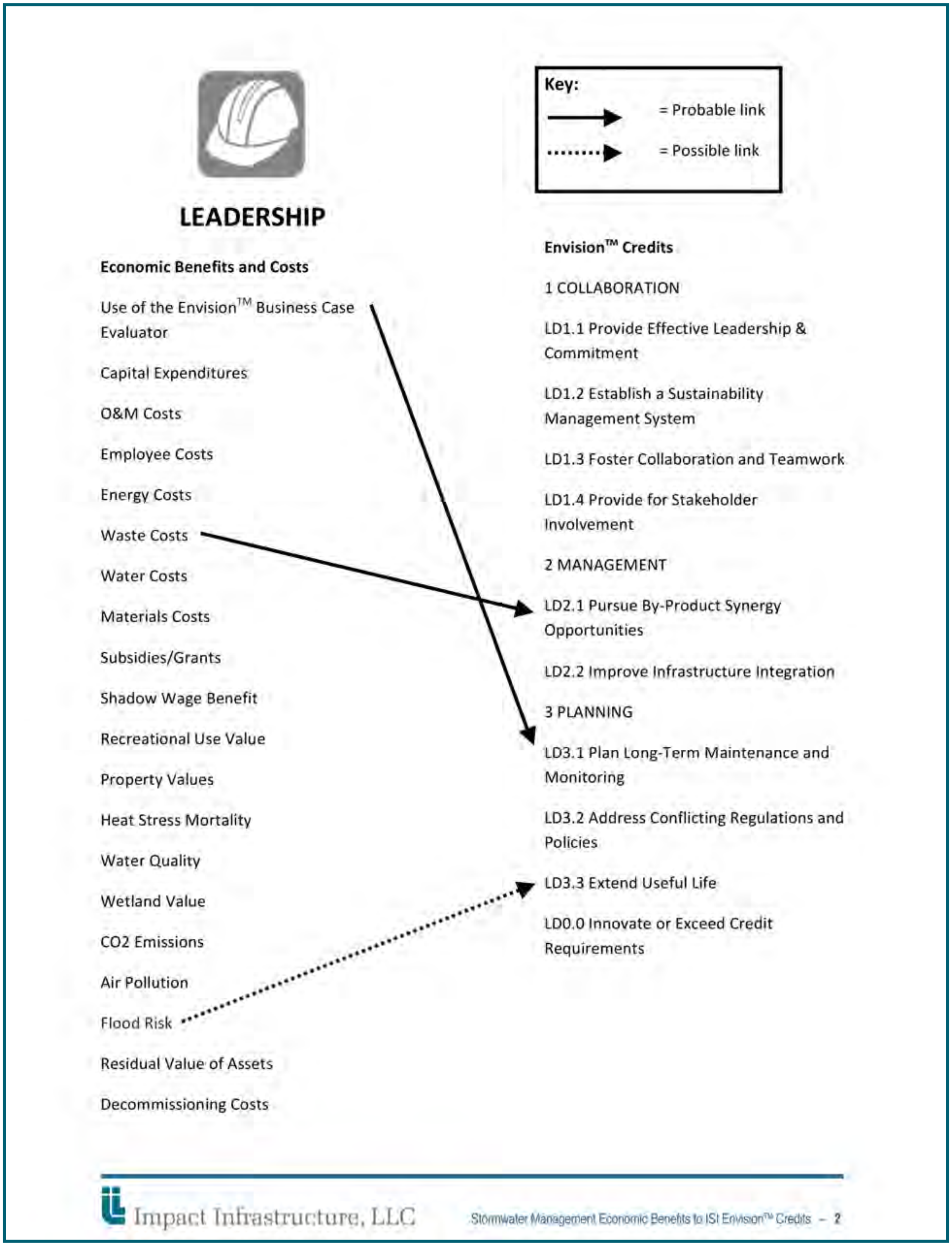
Notes

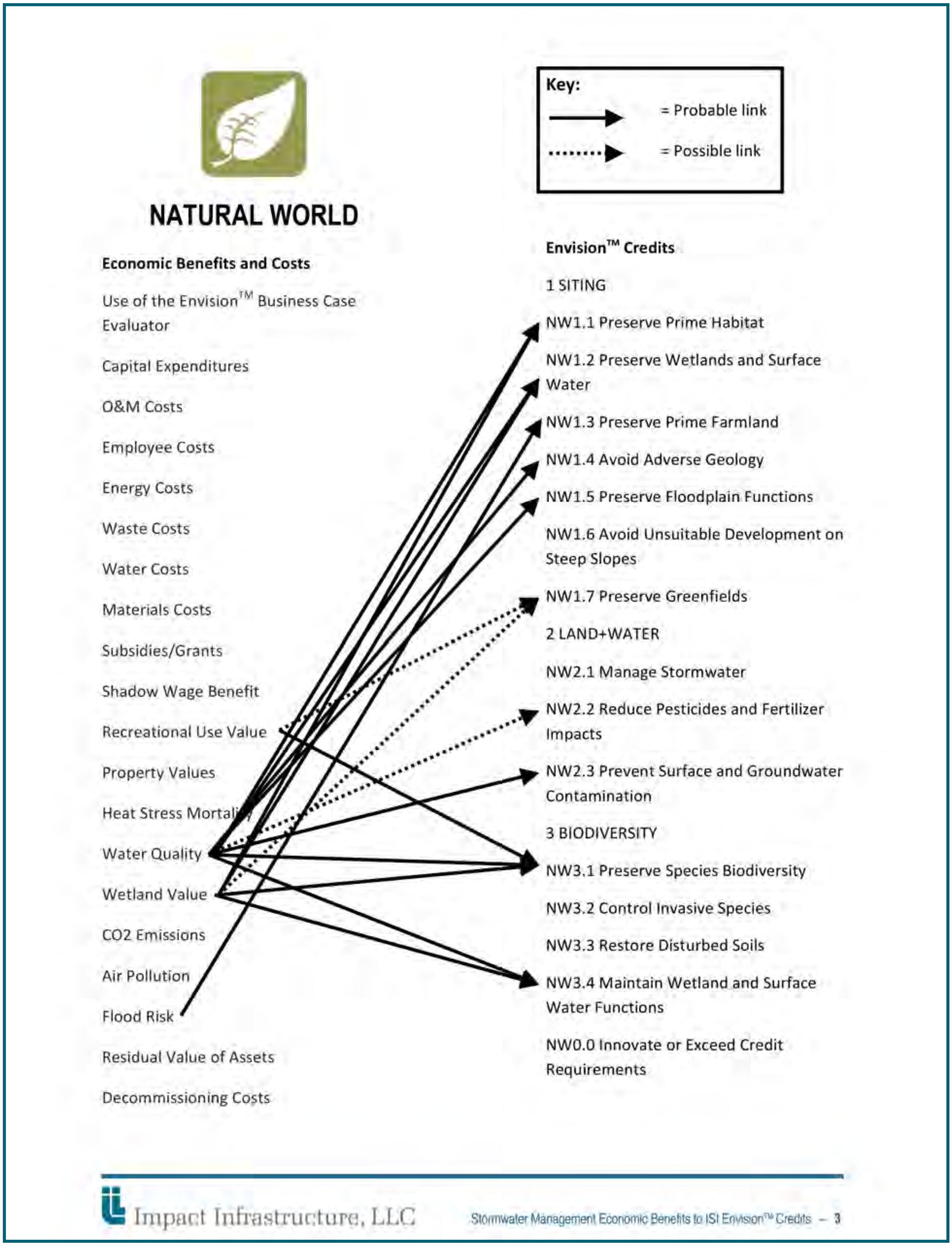
Business Case Evaluator

Appendices

Appendix A – BCE Cost & Benefits to Envision™ Credits Mapping




LEADERSHIP
Key:
= Probable link
= Possible link
Economic Benefits and Costs
Use of the Envision™ Business Case Evaluator
Capital Expenditures
O&M Costs
Employee Costs
Energy Costs
Waste Costs
Water Costs
Materials Costs
Subsidies/Grants
Shadow Wage Benefit
Recreational Use Value
Property Values
Heat Stress Mortality
Water Quality
Wetland Value
CO2 Emissions
Air Pollution
Flood Risk
Residual Value of Assets
Decommissioning Costs
Envision™ Credits
1 COLLABORATION
LD1.1 Provide Effective Leadership & Commitment
LD1.2 Establish a Sustainability Management System
LD1.3 Foster Collaboration and Teamwork
LD1.4 Provide for Stakeholder Involvement
2 MANAGEMENT
LD2.1 Pursue By-Product Synergy Opportunities
LD2.2 Improve Infrastructure Integration
3 PLANNING
LD3.1 Plan Long-Term Maintenance and Monitoring
LD3.2 Address Conflicting Regulations and Policies
LD3.3 Extend Useful Life
LD0.0 Innovate or Exceed Credit Requirements
Impact Infrastructure, LLC
Stormwater Management Economic Benefits to ISI Envision™ Credits – 2


NATURAL WORLD
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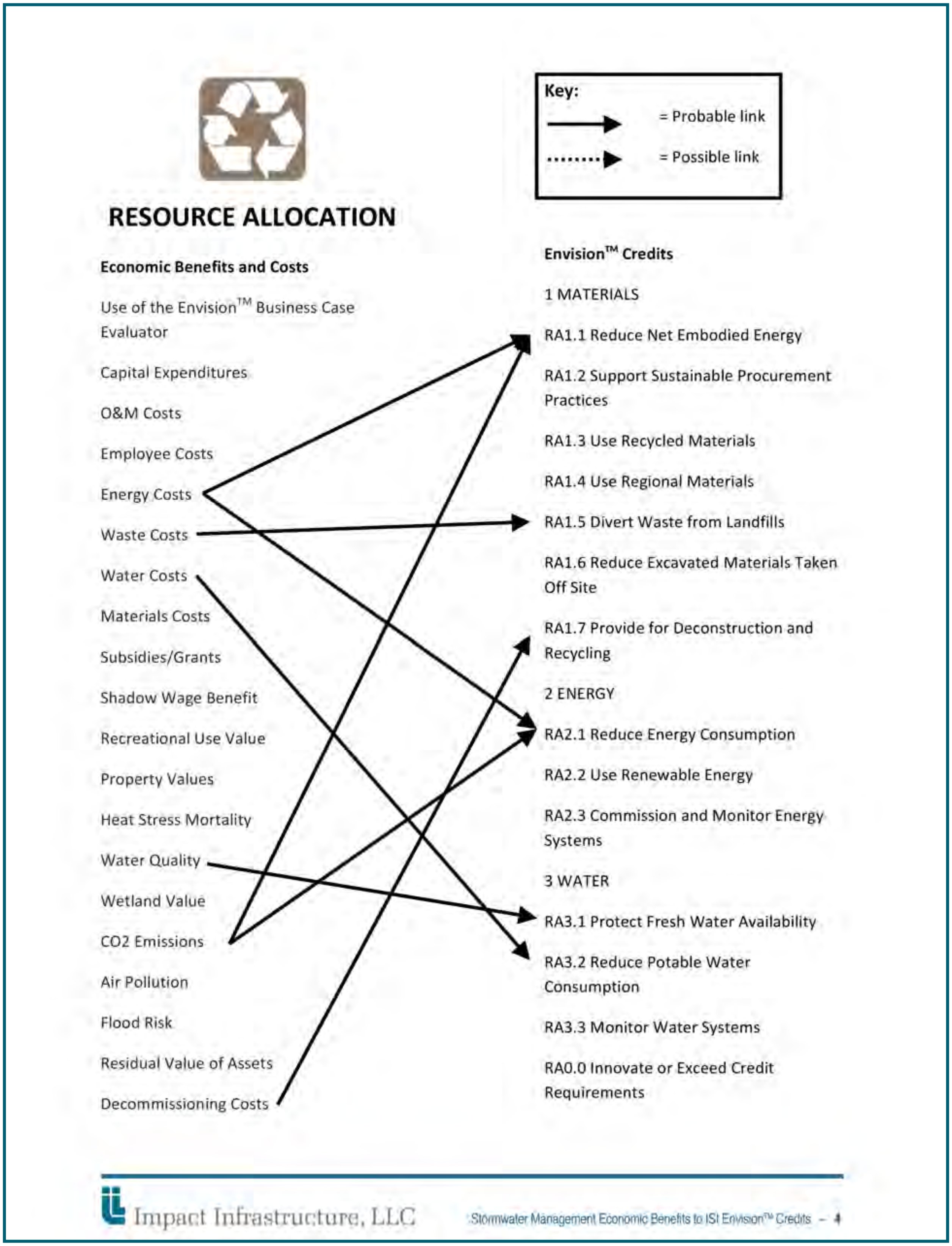
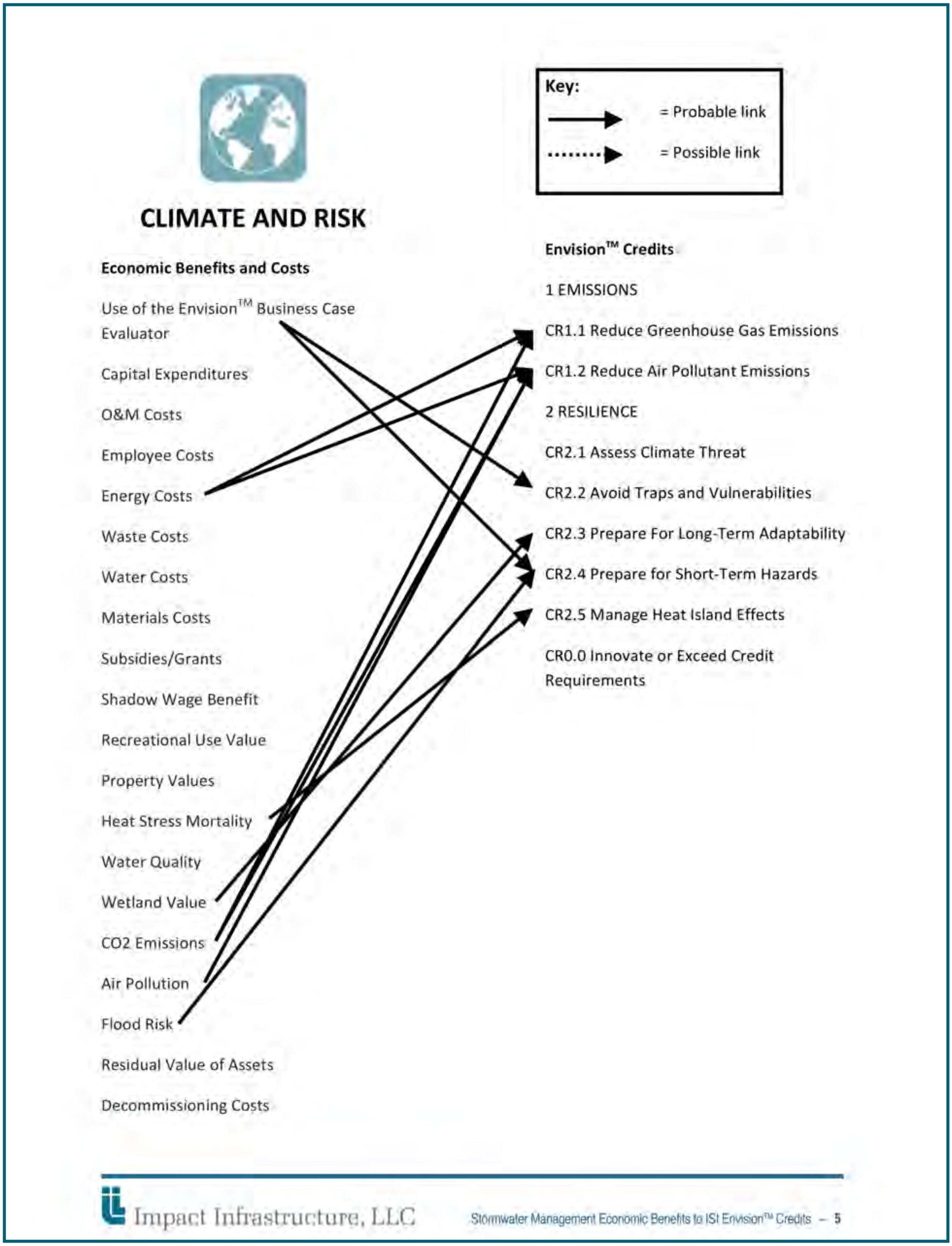
Economic Benefits and Costs
Use of the Envision™ Business Case Evaluator
Capital Expenditures
O&M Costs
Employee Costs
Energy Costs
Waste Costs
Water Costs
Materials Costs
Subsidies/Grants
Shadow Wage Benefit
Recreational Use Value
Property Values
Heat Stress Mortality
Water Quality
Wetland Value
CO2 Emissions
Air Pollution
Flood Risk
Residual Value of Assets
Decommissioning Costs
Envision™ Credits
1 SITING
NW1.1 Preserve Prime Habitat
NW1.2 Preserve Wetlands and Surface Water
NW1.3 Preserve Prime Farmland
NW1.4 Avoid Adverse Geology
NW1.5 Preserve Floodplain Functions
NW1.6 Avoid Unsuitable Development on Steep Slopes
NW1.7 Preserve Greenfields
2 LAND+WATER
NW2.1 Manage Stormwater
NW2.2 Reduce Pesticides and Fertilizer Impacts
NW2.3 Prevent Surface and Groundwater Contamination
3 BIODIVERSITY
NW3.1 Preserve Species Biodiversity
NW3.2 Control Invasive Species
NW3.3 Restore Disturbed Soils
NW3.4 Maintain Wetland and Surface Water Functions
NW0.0 Innovate or Exceed Credit Requirements
Impact Infrastructure, LLC
Stormwater Management Economic Benefits to ISI Envision™ Credits – 3


RESOURCE ALLOCATION
Key:
= Probable link
= Possible link
Economic Benefits and Costs
Use of the Envision™ Business Case Evaluator
Capital Expenditures
O&M Costs
Employee Costs
Energy Costs
Waste Costs
Water Costs
Materials Costs
Subsidies/Grants
Shadow Wage Benefit
Recreational Use Value
Property Values
Heat Stress Mortality
Water Quality
Wetland Value
CO2 Emissions
Air Pollution
Flood Risk
Residual Value of Assets
Decommissioning Costs
Envision™ Credits
1 MATERIALS
RA1.1 Reduce Net Embodied Energy
RA1.2 Support Sustainable Procurement Practices
RA1.3 Use Recycled Materials
RA1.4 Use Regional Materials
RA1.5 Divert Waste from Landfills
RA1.6 Reduce Excavated Materials Taken Off Site
RA1.7 Provide for Deconstruction and Recycling
2 ENERGY
RA2.1 Reduce Energy Consumption
RA2.2 Use Renewable Energy
RA2.3 Commission and Monitor Energy Systems
3 WATER
RA3.1 Protect Fresh Water Availability
RA3.2 Reduce Potable Water Consumption
RA3.3 Monitor Water Systems
RA0.0 Innovate or Exceed Credit Requirements
Impact Infrastructure, LLC
Stormwater Management Economic Benefits to ISI Envision™ Credits – 4


CLIMATE AND RISK
Key:
= Probable link
= Possible link
Economic Benefits and Costs
Use of the Envision™ Business Case Evaluator
Capital Expenditures
O&M Costs
Employee Costs
Energy Costs
Waste Costs
Water Costs
Materials Costs
Subsidies/Grants
Shadow Wage Benefit
Recreational Use Value
Property Values
Heat Stress Mortality
Water Quality
Wetland Value
CO2 Emissions
Air Pollution
Flood Risk
Residual Value of Assets
Decommissioning Costs
Envision™ Credits
1 EMISSIONS
CR1.1 Reduce Greenhouse Gas Emissions
CR1.2 Reduce Air Pollutant Emissions
2 RESILIENCE
CR2.1 Assess Climate Threat
CR2.2 Avoid Traps and Vulnerabilities
CR2.3 Prepare For Long-Term Adaptability
CR2.4 Prepare for Short-Term Hazards
CR2.5 Manage Heat Island Effects
CR0.0 Innovate or Exceed Credit Requirements
Impact Infrastructure, LLC
Stormwater Management Economic Benefits to ISI Envision™ Credits – 5

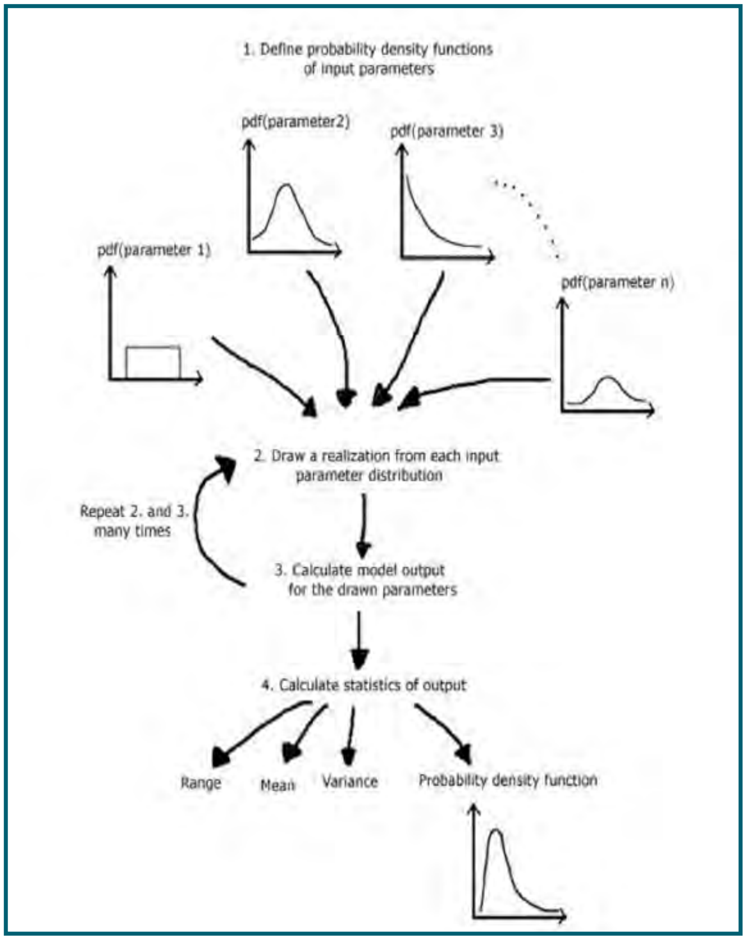
Appendix B - Risk Analysis Approach

As mentioned above, meta-analysis can provide a statistical confidence interval around a most like input into the analysis. The three-point estimation technique can then be used to construct a probability distribution representing the outcome of future events. This distribution is then an input into a Monte Carlo risk analysis.

In three-point estimation, three numbers are produced initially for every distribution that is required, based on the literature searches information that is stored in the database. Impact Infrastructure will use academic literature (especially meta-analyses) of social values to record three values that reflect the current science. These high, most likely and low estimates will be used to define the probability distributions used in the risk analysis. The values can be any defined to be three points on the distribution:

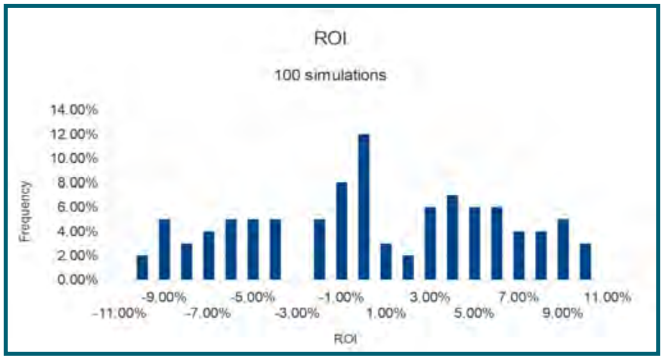
o = optimistic or a best-case estimate (such as maximum, 95%, 90%, 80%, etc.)
m = a most likely estimate (such as mean or arithmetic average, Median, Mode, or Geometric average)
p = pessimistic or a worst-case estimate (such as minimum, 5%, 10%, 20% etc.)

These values are combined to yield a full probability density. The model currently has three choices for probability distributions – a normal distribution for symmetric distributions, a triangular distribution for non-symmetric distributions, and a beta distribution for more flexible or less bell-shaped density distributions. This probability density function (pdf) is then an input into a Monte Carlo risk analysis:



Example of Monte Carlo Process from "Environmental Dynamics: An introduction to modeling anthropogenic impact on natural systems" Cvetkovic, V.; Martinet, P.; Baresel, C.; Lindgren, G.; Nikolic, A.; Molin, S.; Carstens, C.: http://www2.lwr.kth.se/grundutbildning/AE2202/Compendium_online_DES/ch02s02s03.html

For a trivial example of how the Monte Carlo analysis works, suppose the output is project return on investment (ROI) and it is calculated as return divided by investment. The return can be from -10 to +10 and the distribution is uniform (equal probability of each outcome between these numbers). The investment can range from 90 (0.1% probability) to 110 (99.9% probability) with a most likely value of 100 (50% probability) and the values are given by a normal distribution. Assume the return and investment are independent of each other. Pick at random a number between -10 and 10. Also pick a number at random from the normal distribution with mean 100 and standard deviation 3.3 (which gives 90 at 0.1% level and 110 as 99.9% level). Calculate the ROI (return/investment) for this pair of random numbers and save the result (and inputs). Then repeat the process 100 times and graph the resulting ROI distribution and calculate summary statistics.



Mean		-0.06%
Standard Deviation		5.58%
Maximum		10.80%
Minimum		-10.00%
Percentiles	0.1%	-9.98%
	1%	-9.85%
	5%	-9.11%
	10%	-7.93%
	20%	-5.84%
	50%	0.00%
	70%	3.33%
	80%	4.90%
	90%	7.22%
	95%	8.82%
	99%	10.47%
	99.9%	10.77%

Appendix C – Values Used in Comparison Against Philadelphia Stormwater Analysis

Recreational Use	Business Case Evaluator	Philadelphia Study
Does this facility have the capacity for hunting or fishing? Note: If there are wetlands being restored or created as part of this project, this question EXCLUDES any capacity of the wetlands for hunting or fishing.	Yes	Yes
If yes, does this facility have the capacity for specialized fishing and/or hunting? Examples of this include big game hunting or marine fishing for salmon or steelhead.	No	No
Does this facility have the capacity for specialized recreation? Examples of this include white water rafting or wilderness backpacking trips.	No	No
What is the recreation experience expected to be in the area? Note: General activities include those that are common to the area and are of normal quality. These activities may include picnicking, camping, hiking, riding, cycling, and fishing and hunting of normal quality. A high quality activity is one that is not common to the area and is of high quality.	Several general activities	Unspecified
What is the local availability of the opportunity? In other words, what is the availability of equal quality activities at other sites in the area?	Several within 1 hour travel time; none within 30 minutes travel time	Unspecified
What is the expected carrying capacity of the facility?	Adequate facilities to conduct without deterioration of the resource or activity	Unspecified
How accessible is the facility and what are the quality of roads around and within the facility?	Good access, high standard roads to site; good access within site	Unspecified
How are the environmental and aesthetic features of the facility?	Above average aesthetic quality; any limiting factors can be reasonably rectified	Unspecified

Water Quality Improvements	Business Case Evaluator	Philadelphia Study
If water quality in streams, rivers, ponds, lakes, or any other bodies of water will be affected by this project, what is the current average water quality? Use the Water Quality	4.3	Specified 4.3 as Base Case
Using the same Water Quality Ladder, below, what is the expected average water quality in the same body of water after the project is in	5.5	Specified a 2.5 point increase for the 100% LID option, implying a 1.25 point increase for the 50% LID option
Is the body of water rated above currently or potentially used for recreational activity? Examples may include swimming, boating, or fishing.	Yes	Yes
Approximately what percentage of the local community are users of the body of water rated above?	30%	0% - only counted non-use value

Wetland Value Enhancement	Business Case Evaluator	Philadelphia Study
What type of wetland is being created/restored?	Freshwater Marsh	Freshwater
Is the wetland created/restored inland or coastal?	Inland	Inland
If the wetland is joining a system of other wetlands, what is the approximate number of acres of the total wetlands in the area?		Unspecified
Wetland Functions	**Business Case Evaluator**	**Philadelphia Study**
Which of the following wetland functions is the created/restored wetland expected to possess?		
Flood Reduction	No	No
Storm Buffer	No	No
Reduced Water Purification Costs (improved water quality)	No	No
Increased Water Quantity	No	No
Improvement in Recreational Fishing, on or off site	No	No
Improvement in Commercial Fishing, on or off site	No	No
Bird Hunting	No	No
Bird Watching	No	No
Amenity Value Provided by Proximity to the Environment	Yes	Yes
Nonuse Appreciation of Species Living in Wetland	Yes	Yes
CO_2 EMISSIONS AND AIR POLLUTION	**Business Case Evaluator**	**Philadelphia Study**
Is this project being built in a rural, urban, or dense urban environment?	Urban	Urban
If there are any trees being planted, how much exposure will each tree have to sunlight? (Scale 1-5) Note: In denser areas, such as forests, exposure to light is often much lower than it is for a tree on the side of a street, for example.	3	Unspecified
If applicable, how long will the average lifespan be for new trees being planted?	50	Unspecified - Stated to be "Mature" after 25 years

Appendix D – Changes to Business Case Evaluator Default Values for Philadelphia Stormwater Management Study Comparison

	Default Value	User-Defined Value
Rate of Inflation	*3%*	*4.00%*
Discount Rate	*Calculated from "Funding Information" Section- default to 6% if funding sources do not add up to 100%.*	*4.88%*
PROPERTY MODEL		
	Default Values Used for 100% LID Project	**User-Defined Values for 100% LID Project**
Property Price Increase from 100% LID Project	3.36%	
Percent of Property Price Benefits Realized in Project	4.51%	50%
Number of Households Affected (based on population, town/city specific)	593777	
Average Value per Household (State specific)	$ 183,309.63	
CO_2 EMISSIONS		
	Default Values Used	**User-Defined Values**
Social Cost of Carbon	$33.96	12
Real Growth Rate of the Social Cost of Carbon (%, not including inflation)	3%	2.40%
Maximum Current USD Social Cost of Carbon	$100	$1,000
Lbs Carbon (C) Emitted per Short Ton of Concrete Used in Construction	510	

Appendix E – Capital Expenditure and Operations and Maintenance Cost Estimates for Green Stormwater Management Components

Capital Costs (Pre construction costs includes cost of site discovery, surveying, design, planning, permitting, geotechnical testing, legal fees, etc. Cost of constructing the BMP may include the cost of erosion and sediment control during construction.)

	Capital $/acre (2012 USD)		
Structural Items	Low	Med	High
Biofilter (Swales & Filter Strips) or Grass Strip/Filter Strip/Urban Grass Buffers	$ -	$ 12,874	$ 24,139
Biofilter (Swales & Filter Strips) or Grass Swale/Bioswale (New)	$ 921	$ 22,060	$ 42,869
Bioretention (New - Suburban and Retrofit - Highly Urban)	$ 15,793	$ 68,519	$ 187,553
Control or Erosion and Sediment Control	$ 26,538	$ 26,538	$ 26,538
Detention Basin or Dry Detention Ponds (New)/Dry Extended Detention Ponds (New & Retrofit)	$ 39,807	$ 54,352	$ 68,897
Green Roof	$ 235,440	$ 291,625	$ 347,810
Infiltration Basin	$ 3,948	$ 5,364	$ 6,394
Infiltration Trench or Infiltration Practices w or w/o Sand, Veg. (New)	$ 11,844	$ 85,100	$ 222,598
Manufactured Device (Multiple Types) or Hydrodynamic Structures (New)	$ 42,869	$ 42,869	$ 42,869
Media Filter or Sand Filter/Filtering Practices (Sand, above and below ground)	$ 7,380	$ 32,269	$ 57,159
Porous Pavement or Permeable Pavement w and w/o Sand, Veg. (New)	$ 51,797	$ 115,580	$ 346,546
Retention Pond/Basin	$ 2,632	$ 3,576	$ 4,263
Wetland Basin or Wet Ponds/Wetland (New and Retrofit)	$ 3,290	$ 4,470	$ 65,322
Wetland Channel or Vegetated Open Channels	$ 24,497	$ 24,497	$ 24,497
Street Trees or Urban Tree Planting	$ 17,658	$ 19,263	$ 20,869

Annual Operations and Maintenance Costs

	O&M $/acre (2012 USD)		
Structural Items	Low	Med	High
Biofilter (Swales & Filter Strips) or Grass Strip/Filter Strip/Urban Grass Buffers	$ 350	$ 605	$ 860
Biofilter (Swales & Filter Strips) or Grass Swale/Bioswale (New)	$ 50	$ 475	$ 900
Bioretention (New - Suburban and Retrofit - Highly Urban)	$ 858	$ 1,179	$ 1,500
Control or Erosion and Sediment Control	$ -	$ -	$ -
Detention Basin or Dry Detention Ponds (New)/Dry Extended Detention Ponds (New & Retrofit)	$ 29	$ 614	$ 1,200
Green Roof	$ -	$ -	$ -
Infiltration Basin	$ 11	$ 21	$ 32
Infiltration Trench or Infiltration Practices w or w/o Sand, Veg. (New)	$ 161	$ 518	$ 875
Manufactured Device (Multiple Types) or Hydrodynamic Structures (New)	$ 3,500	$ 3,500	$ 3,500
Media Filter or Sand Filter/Filtering Practices (Sand, above and below ground)	$ 738	$ 1,802	$ 3,228
Porous Pavement or Permeable Pavement w and w/o Sand, Veg. (New)	$ 2,178	$ 2,614	$ 3,049
Retention Pond/Basin	$ 86	$ 129	$ 172
Wetland Basin or Wet Ponds/Wetland (New and Retorfit)	$ 72	$ 407	$ 742
Wetland Channel orVegetated Open Channels	$ 600	$ 600	$ 600
Street Trees or Urban Tree Planting	$ 1,200	$ 1,200	$ 1,200

Appendix F – Default Values Used in Business Case Evaluator

Each cost or benefit has default values that are used to quantify the project's impact on the variable.
The key values used in the Business Case Evaluator are shown below:

Floor Risk Model

FLOOD RISK		
	Default Values Used	User-Defined Values
City average soil type (A, B, C, D, or Unknown)	Unknown	
Strongest storm* (expressed in terms of its return period) that can hit the town/city *without* causing flooding. In other words, what is the maximum storm strength capacity of the storm drainage infrastructure that is currently in place in the town/city, on average?	3	
Average Residual Volume in Detention Basin	30%	
Average Residual Volume in Retention Pond	30%	
Average Residual Volume in Cistern	30%	
Grey Infrastructure on Project Site's Average Percent of Maximum Peak Discharge Rate Over 24 Hours During Large Storm Events (10+ Year Return Periods)** - CURRENT	75%	
Grey Infrastructure on Project Site's Average Percent of Maximum Peak Discharge Rate Over 24 Hours During Large Storm Events (10+ Year Return Periods)** - PLANNED	75%	

**A 3 year storm is a storm that is likely to occur once in a three year period*

***The default vale of 75% means that the grey infrastructure on the project's site would average 75% of its maximum capacity flow over the 24 hours of a 10, 25, 50, or 100 year storm event*

Property Model

Author(s) and Year	Value Change From 100% Low Impact Design		
	Low	Expected	High
Ward et al. (2008)	*3.50%*	*4.3%*	*5%*
Shultz and Schmitz (2008)	*0.70%*	*1.1%*	*2.70%*
McPherson et al. (2006)	*3%*	*5.0%*	*7%*
Wachter and Wong (2006)		*2.0%*	
Anderson and Cordell (1988)	*3.50%*	*4.0%*	*4.50%*
Braden and Johnston (2003)	*0%*	*2.5%*	*5%*

Heat Mortality Model

		Reduction in Average T (F)	
Sailor (2003)	10% increase in urban vegetation	*0.39*	*(average T)*
		0.49	*(max T)*
Hudischewskyj et. al (2001)	10% increase in urban vegetation	*0.7*	*(max T, July 14, 1995)*
		0.4	*(max T, July 15, 1995)*

CO_2 Emissions Model

Greenhouse Gas	Probability Distribution	$/Metric Ton (2012 $)	Source	Expected Mean Value*
Carbon Dioxide - CO_2	*Most Likely*	*$23.88*	*IWGSCC (2010)*	***$33.96***
	Low	*$14.28*	*Nordhaus (2011)*	
	High	*$114.83*	*Stern Review (2006)*	
Real Growth Rate in Value of Metric Tonne of CO_2				**3.00%**
*Geometric mean used for calculation				

Air Pollution Model

Cost per Short Ton (2009 USD)			
	Low	Median	High
CO			
SO_2 (Rural)	$ 1,082.25	$ 3,083.82	$ 6,031.87
SO_2 (Urban)	$ 1,803.75	$ 16,693.56	$ 52,198.89
SO_2 (Dense Urban)	$ 10,378.99	$ 16,693.56	$ 104,397.77
NO_2	$ 360.75	$ 4,173.39	$ 17,198.40
PM10 (Rural)	$ 240.50	$ 1,322.75	$ 16,239.65
PM10 (Urban)	$ 3,968.25	$ 175,282.38	$ 287,093.87
PM10 (Dense Urban)	$ 107,490.00	$ 175,282.38	$ 574,187.74
O_3			

CO_2 Emissions and Air Pollution Model

Definitions:			Absorption Rate Adjustment
Healthy trees live to	75%	of max life	1
Poor trees live to	85%	of max life	0.76
Critical trees live to	95%	of max life	0.42
Dying trees live to	99.9%	of max life	0.15
Dead trees at 100% of max life.			0

The user has the ability to modify some of the values in the model, if they have values that they believe are more accurate for their project than the default values used. All the values that can be modified in the model are presented on the same page, for the convenience of the user. An example of this ability to modify the default values can be seen in the screenshot below:

CO_2 EMISSIONS		
	Default Values Used	User-Defined Values
Social Cost of Carbon	$33.96	
Real Growth Rate of the Social Cost of Carbon (%, not including inflation)	3%	
Maximum Current USD Social Cost of Carbon	$100	
Lbs Carbon (C) Emitted per Short Ton of Concrete Used in Construction	510	

Business Case Evaluator

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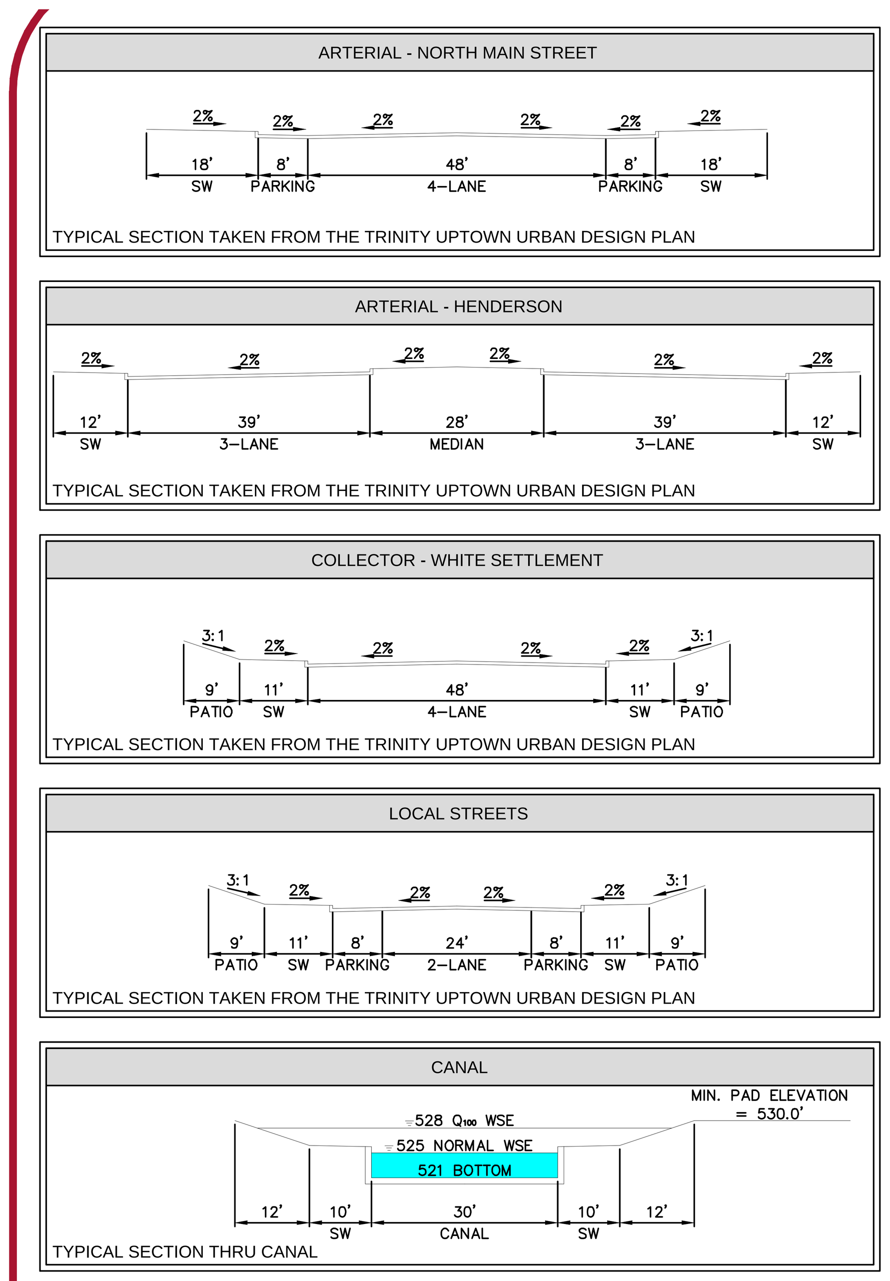
Impact Infrastructure, LLC
INFORMING IMPACT INVESTMENTS

Appendix G
Mass Grading Plan
(Kimley-Horn and Associates)



LEGEND	
CROSS SECTION	
PROPOSED CONTOURS	
EXISTING CONTOURS	
PROPOSED FINISHED GROUND ELEVATION	540.00 F.F. ELEV.
USACE 200' JURISDICTIONAL LINE	
PROPOSED RIVER FILL	
CANAL	

VOLUME (Cubic Yards)	
PROPOSED GROUND CUT	869,194
PROPOSED GROUND FILL	2,591,335
NET PROPOSED GROUND FILL	1,722,141

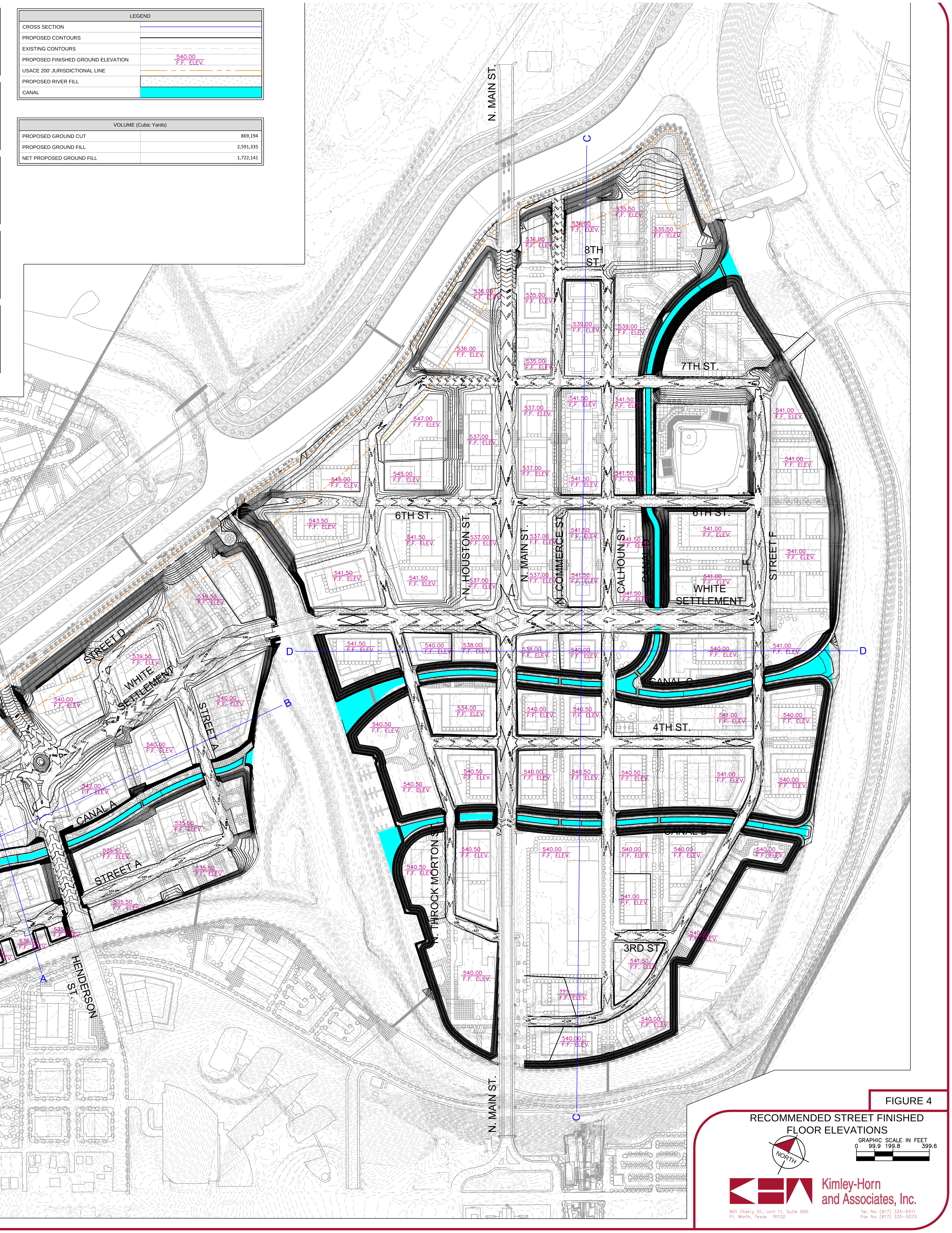


FIGURE 4

RECOMMENDED STREET FINISHED FLOOR ELEVATIONS

Kimley-Horn and Associates, Inc.
801 Cherry St., Unit 11, Suite 950
Ft. Worth, Texas 76102
Tel. No. (817) 335-6511
Fax No. (817) 335-5070