Estimating Multiple Benefits from Stormwater Capture Projects- Why and How

Water Reuse Action Plan Action 3.3

September 7, 2021

Building Capacity to Capture and Reuse Stormwater

Water Reuse Action Plan (2020)

- WRAP partnerships help advance integrated water management and recycling
- 45+ actions with implementation plans
- Action 3.3 focuses on advancing stormwater capture and use

Understanding SCU Opportunities & Challenges

- Webcast series to explore key issues affecting SCU
  - 4 webcasts and 1 technical meeting 2021
- ***Today's webcast focuses on evaluation of multiple benefits***
- National meeting at Johnson Foundation at Wingspread September 2021
- Meeting report and followup actions

Today's Webcast

Introductions

Multiple Benefits As The Springboard
- Anne Thebo, Pacific Institute

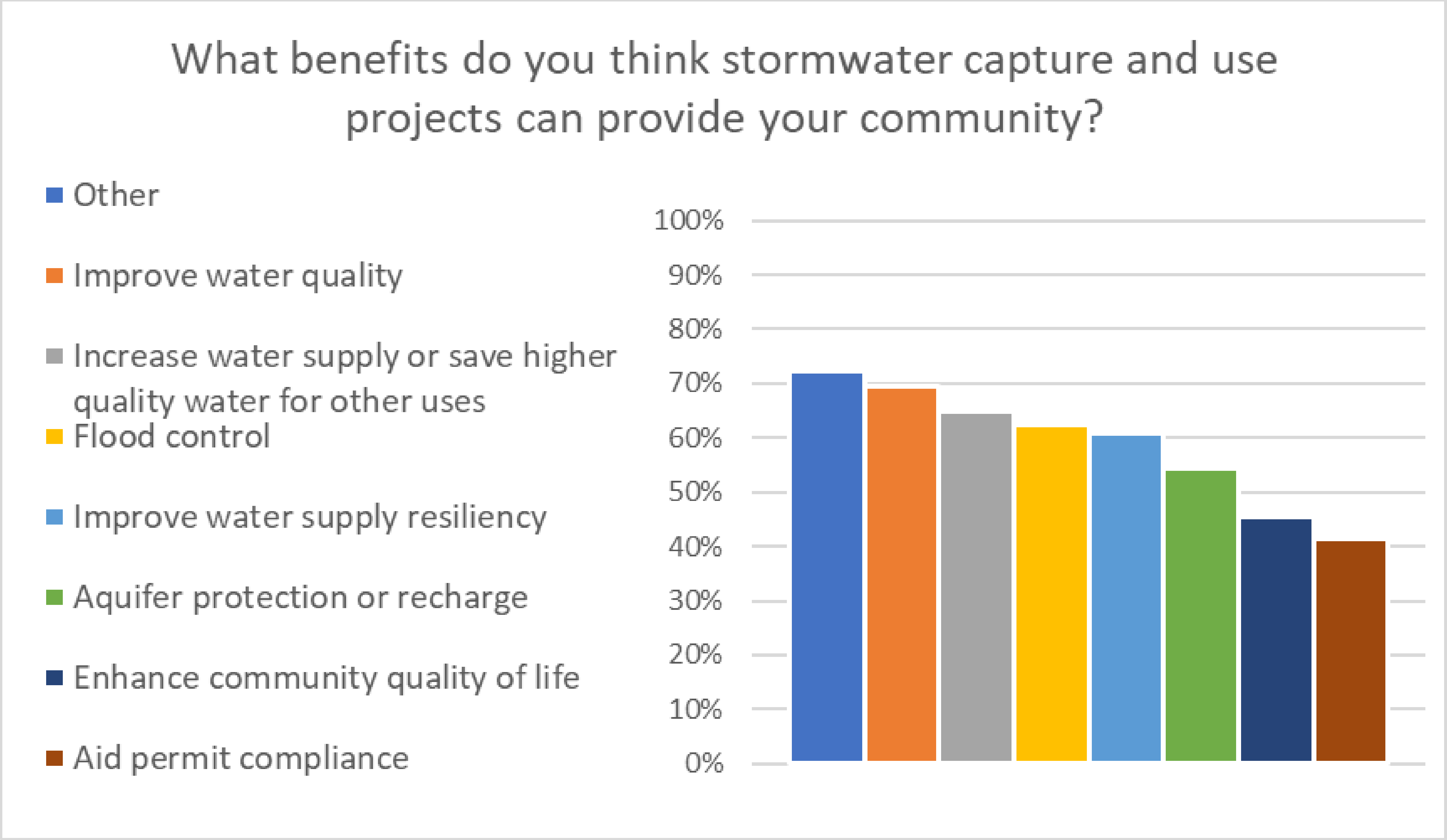
Current Approaches to Evaluating Benefits
- T.J. Moon, Los Angeles County
- Spencer Joplin, CA State Water Resources Control Board

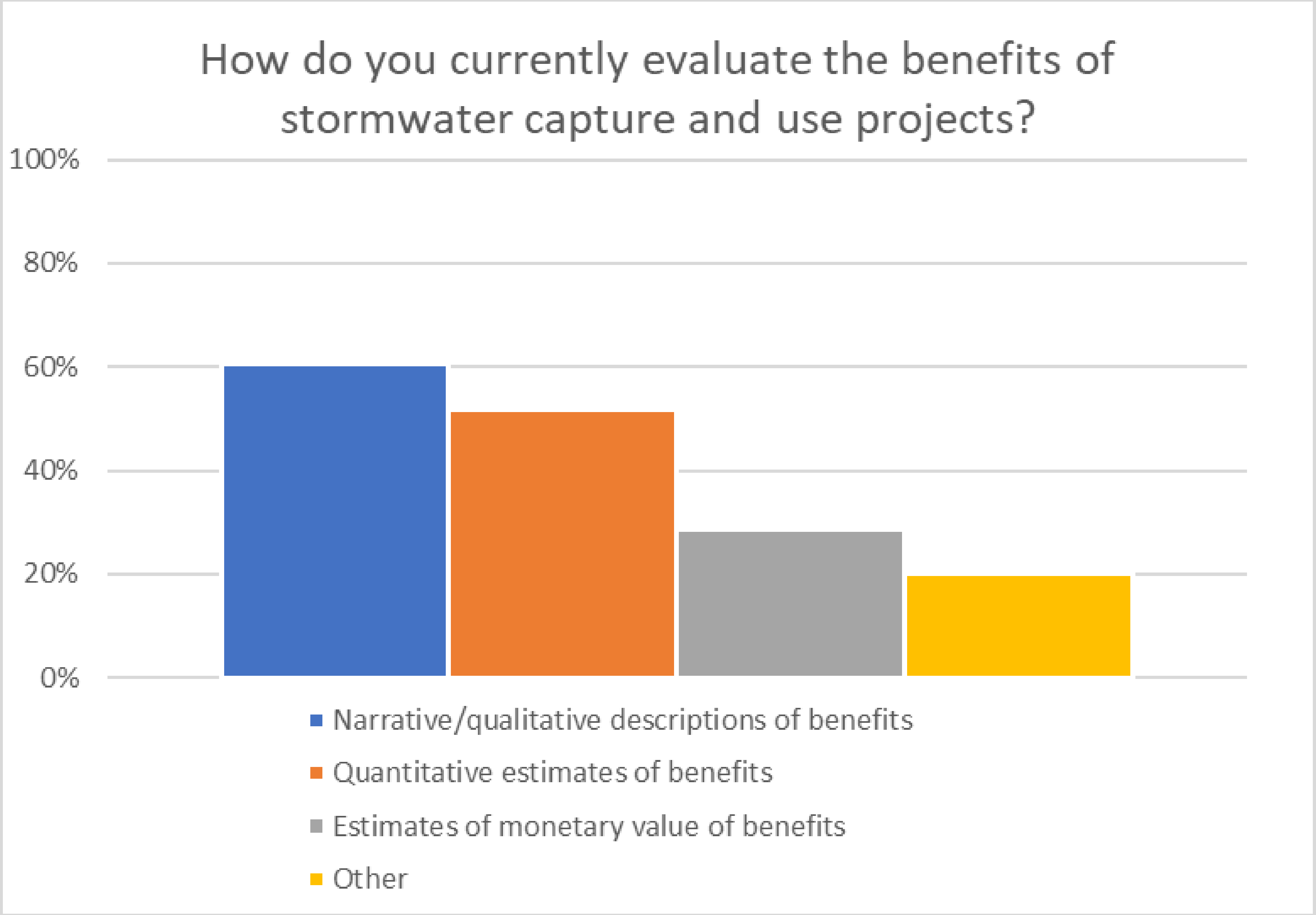
How Can We Estimate Multiple Benefits?
- Sybil Sharvelle, Colorado State University
- Janet Clements, Corona Environmental
- Katie Spahr, Water Research Foundation

Where Do We Go From Here?

What We Heard From You

- About 400 Registrants
- > Half from West, 10% each from East, South, Southwest
- Quarter each from local agencies, states, and consultants
- 2/3 from water limited areas
- Most want several kinds of help with benefits evaluation:
  - Examples of how others do it
  - Matching benefits methods with different audiences
  - New benefit evaluation tools


What benefits do you think stormwater capture and use projects can provide your community?
Other
Improve water quality
Increase water supply or save higher quality water for other uses
Flood control
Improve water supply resiliency
Aquifer protection or recharge
Enhance community quality of life
Aid permit compliance
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%

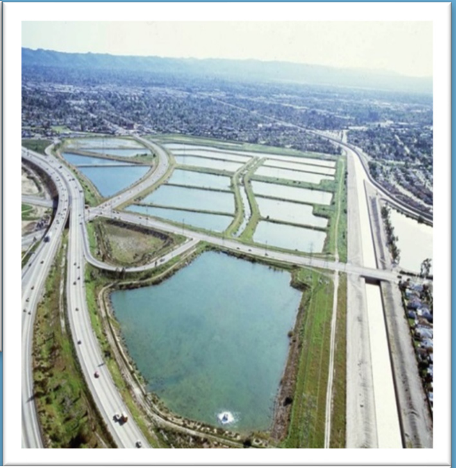

How do you currently evaluate the benefits of stormwater capture and use projects?
100%
80%
60%
40%
20%
0%
Narrative/qualitative descriptions of benefits
Quantitative estimates of benefits
Estimates of monetary value of benefits
Other

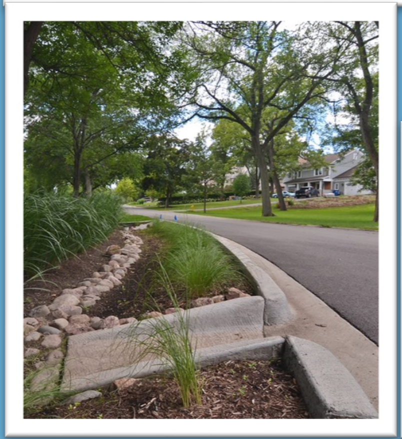
Estimating Multiple Benefits from Stormwater Capture Projects – Why and How?

Multiple Benefits as the Springboard

EPA Webinar Series
September 7, 2021

Anne Thebo, Ph.D.
Senior Researcher, Pacific Institute





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Today's Webinar

Why Should We Look at the Multiple Benefits?

Current Approaches to Evaluating Benefits

How Can We Estimate Multiple Benefits?

Where Do We Go From Here?

Why Should We Look at the Multiple Benefits of Stormwater Capture and Use?

- Benefits motivate action, but costs are a common barrier
- Benefits can build public support, motivate integrated approaches, and build co-funding opportunities

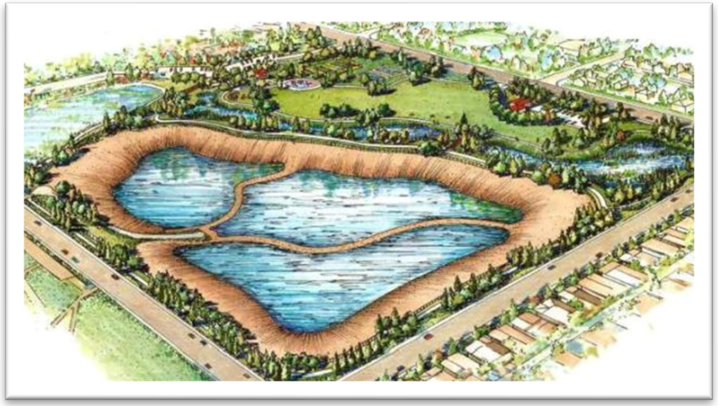
What do we mean by ‘stormwater capture’?

Decentralized

Centralized

Household Raingarden
(Portland, OR)
Source: City of Portland

Bioretention Bed in Greenstreet
(Queens, NY)
Source: NYC Parks



Rory M. Shaw Wetlands Park
(Los Angeles County)
Source: Maven’s Notebook

Tujunga Spreading Grounds
(Los Angeles County)
Source: LADWP

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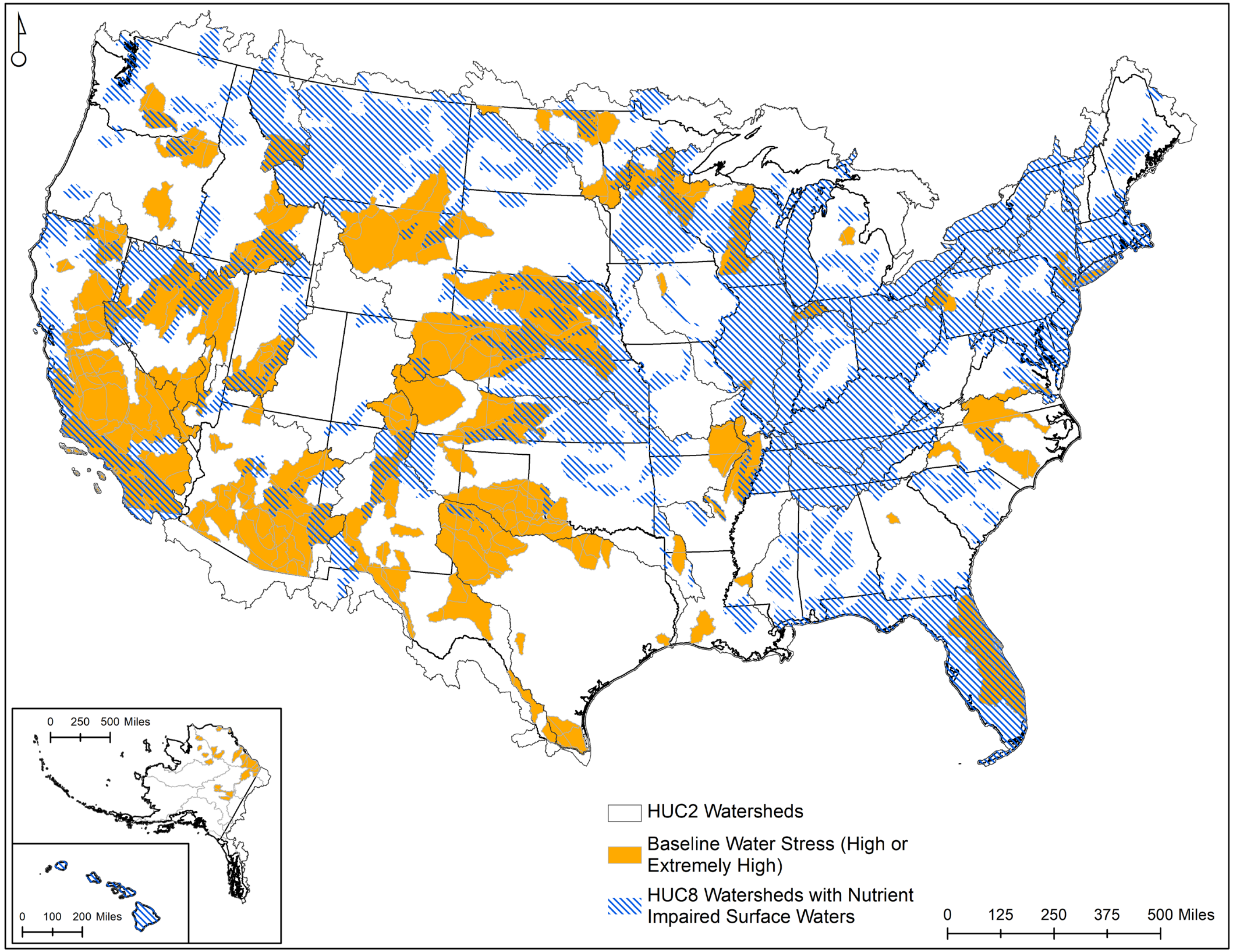
Multiple Scales, Direct and Indirect Reuse, Wide Ranging Geographies, and

Diverse Project Drivers

What Benefits Have Historically Motivated Stormwater Capture?

- Water Supply
- Water Quality Improvement
- Flood Management



Data: Water Stress Indicator (WRI AQUEDUCT v3.0); 303(d) Listed Waters (USEPA)

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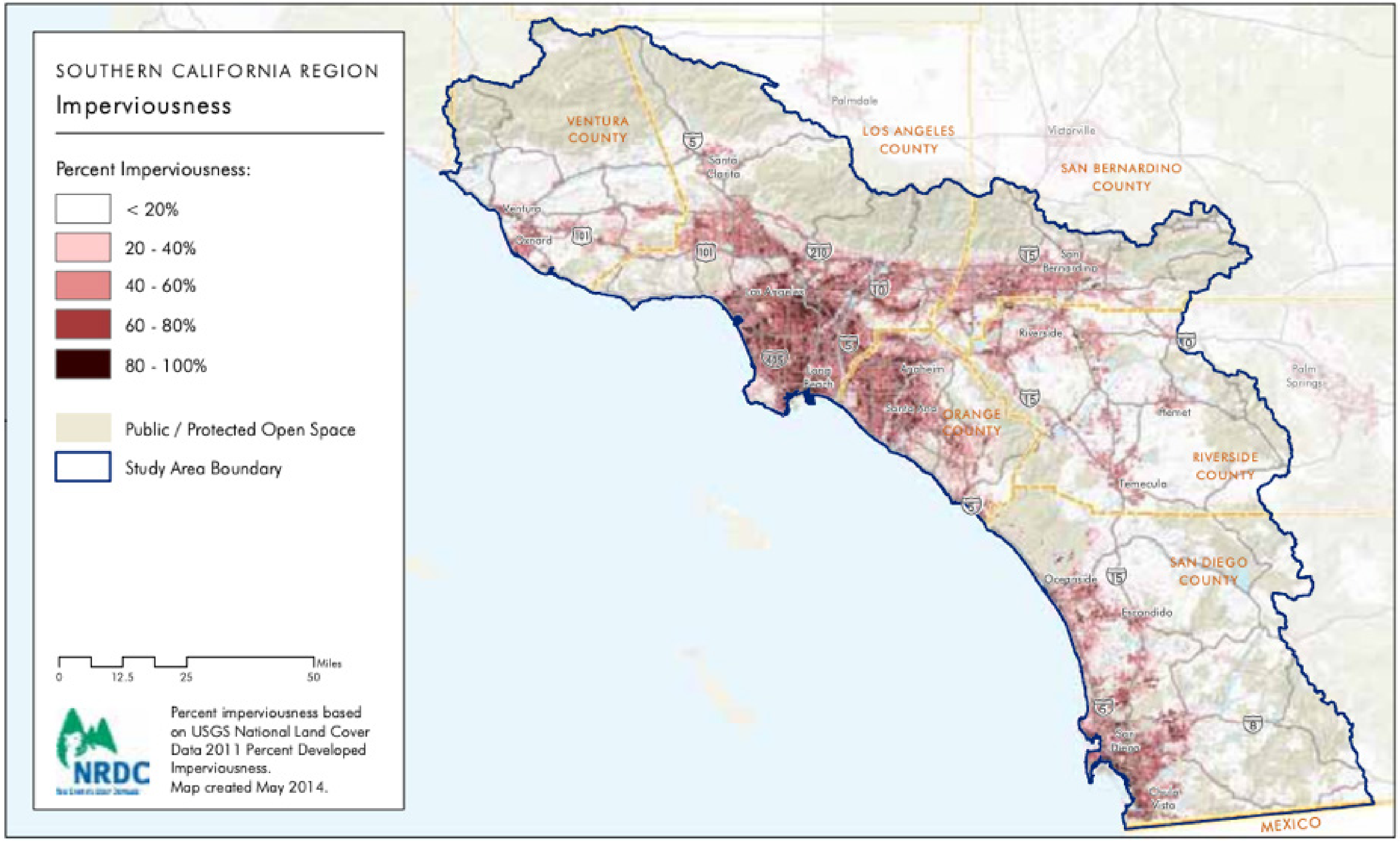
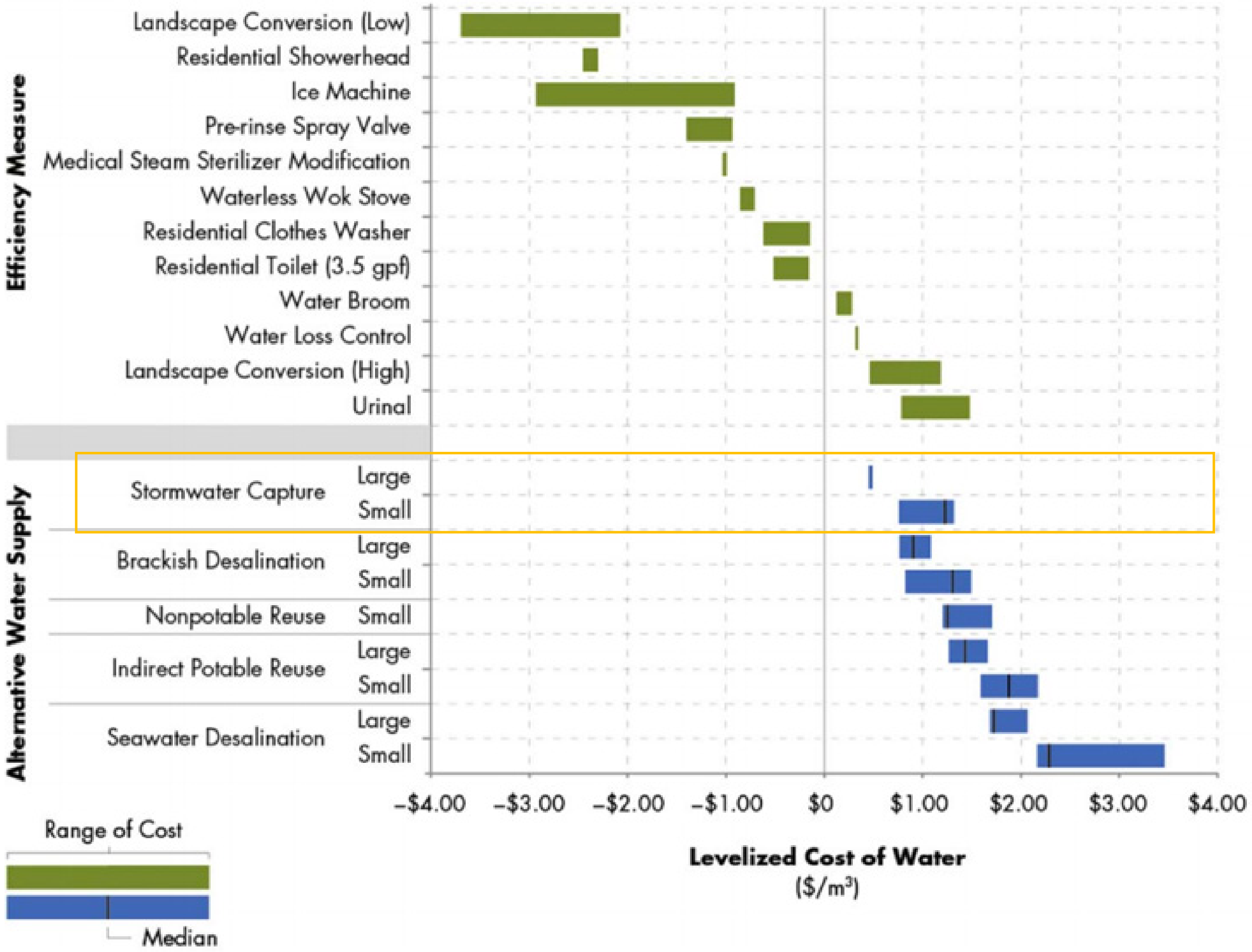
Abundant, but Underrealized Opportunities for Stormwater Capture

- Opportunity for 420,000 to 630,000 AFY in Bay Area and Southern California (NRDC and Pacific Institute 2014)
- Up to 34,000 MAFY stormwater potentially available for capture in the U.S. (EPA 2004; Aguilar and Brown 2020)
- U.S. Urban Water Use is Approximately 47,000 MAFY (USGS 2020)



Source: NRDC and Pacific Institute. Stormwater Capture Potential in Urban and Suburban California. June 2014.

Stormwater Can Be Less Expensive than Other Alternative Supplies



Median Costs per Acre-Foot

Cooley, et al. (2019)

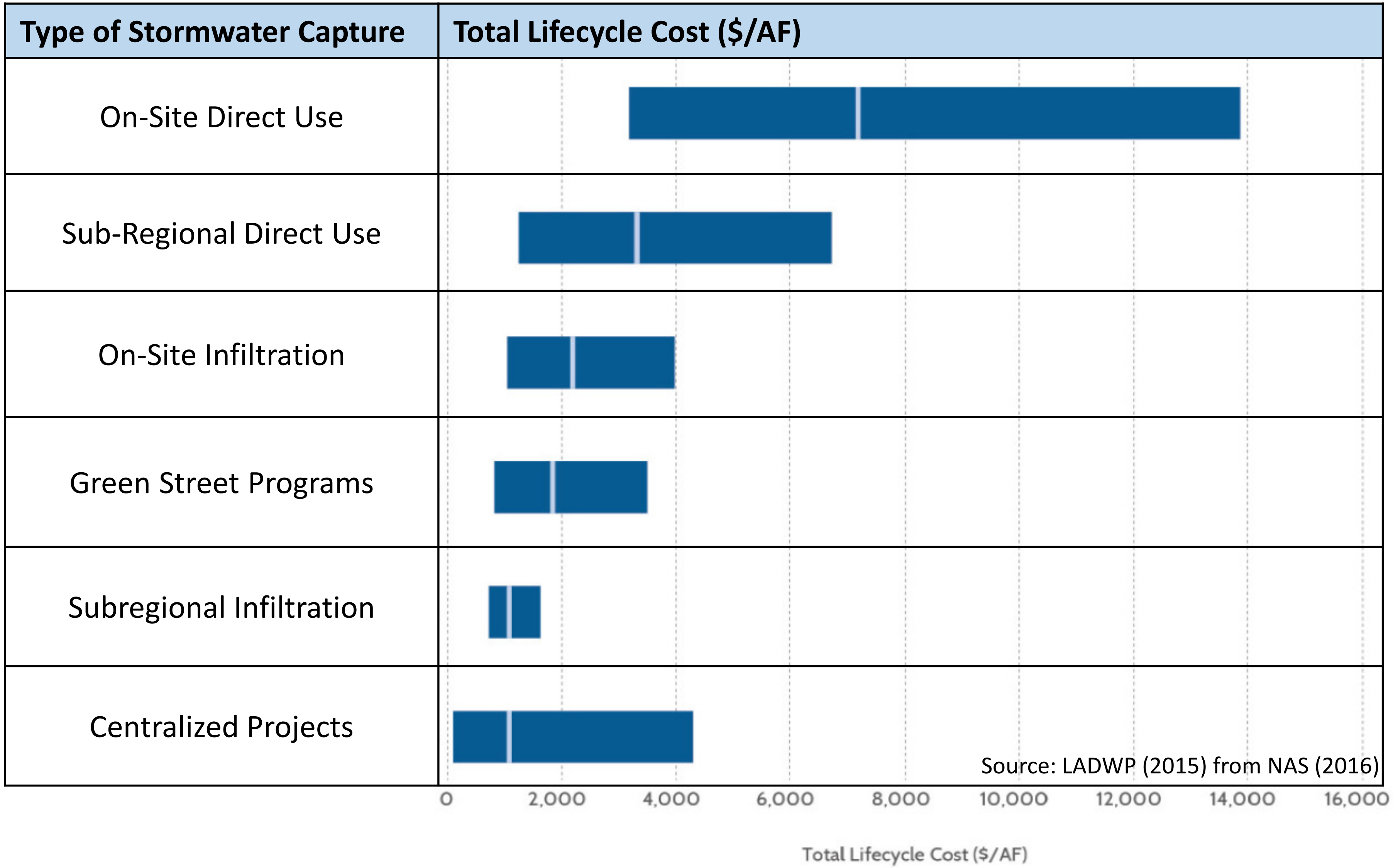
- Large (> 6,500 AFY): $590 / AF
- Small (< 1,500 AFY): $1,500 / AF

Perone and Rohde (2016)

- Managed aquifer recharge: $1,550 / AF (between $410 to $2,660 / AF)

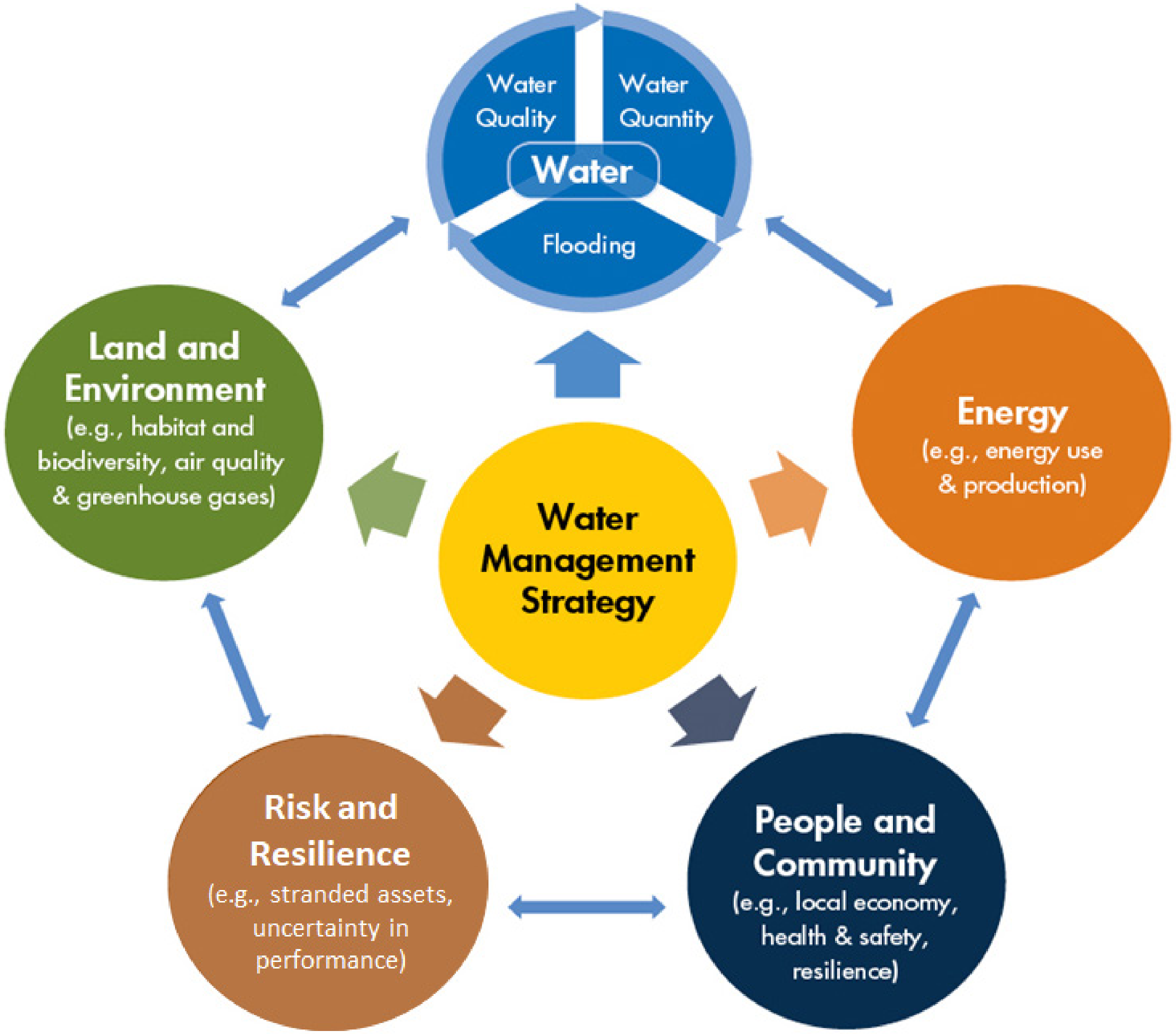
Sources: Cooley, et al. (2019) Environ. Res. Commun. and Perone and Rohde. (2016) SF Est and Wtrshd Sci.

Lifecycle Costs Vary Across Different Types of Stormwater Capture



Stormwater Capture Exists as Part of the Broader Water System

To accurately compare water projects, we need to systematically evaluate the benefits and costs of each water management option, as well as understand who benefits and who pays.



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Austin’s Rain Catcher Pilot Program

<u>Project Goals</u>

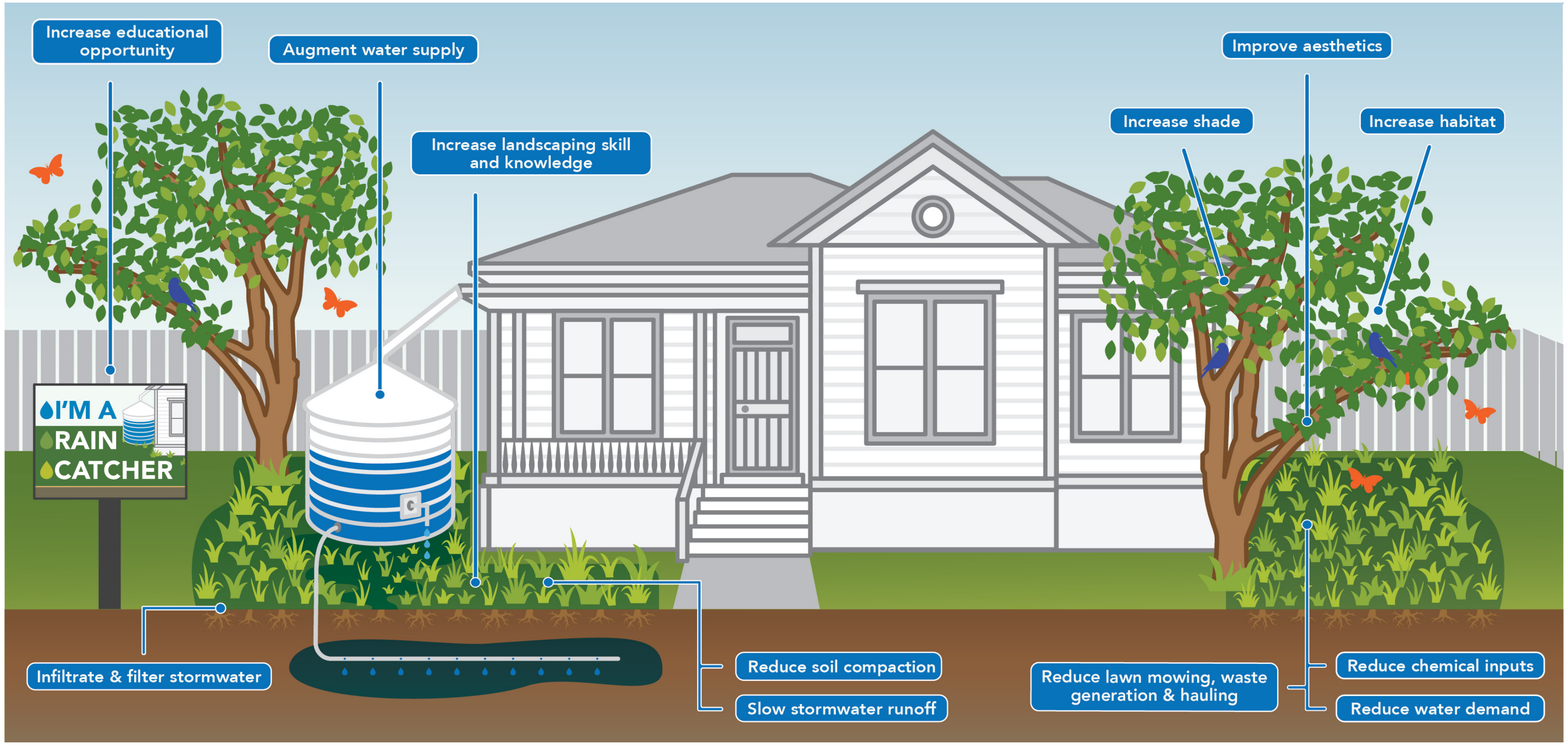
Reduce erosive events, improve instream flows, engage with residents

<u>Project Options</u>

Rain cisterns, rain gardens, trees

<u>Project Partners</u>

Austin Water
Austin WPD
Local NGOs



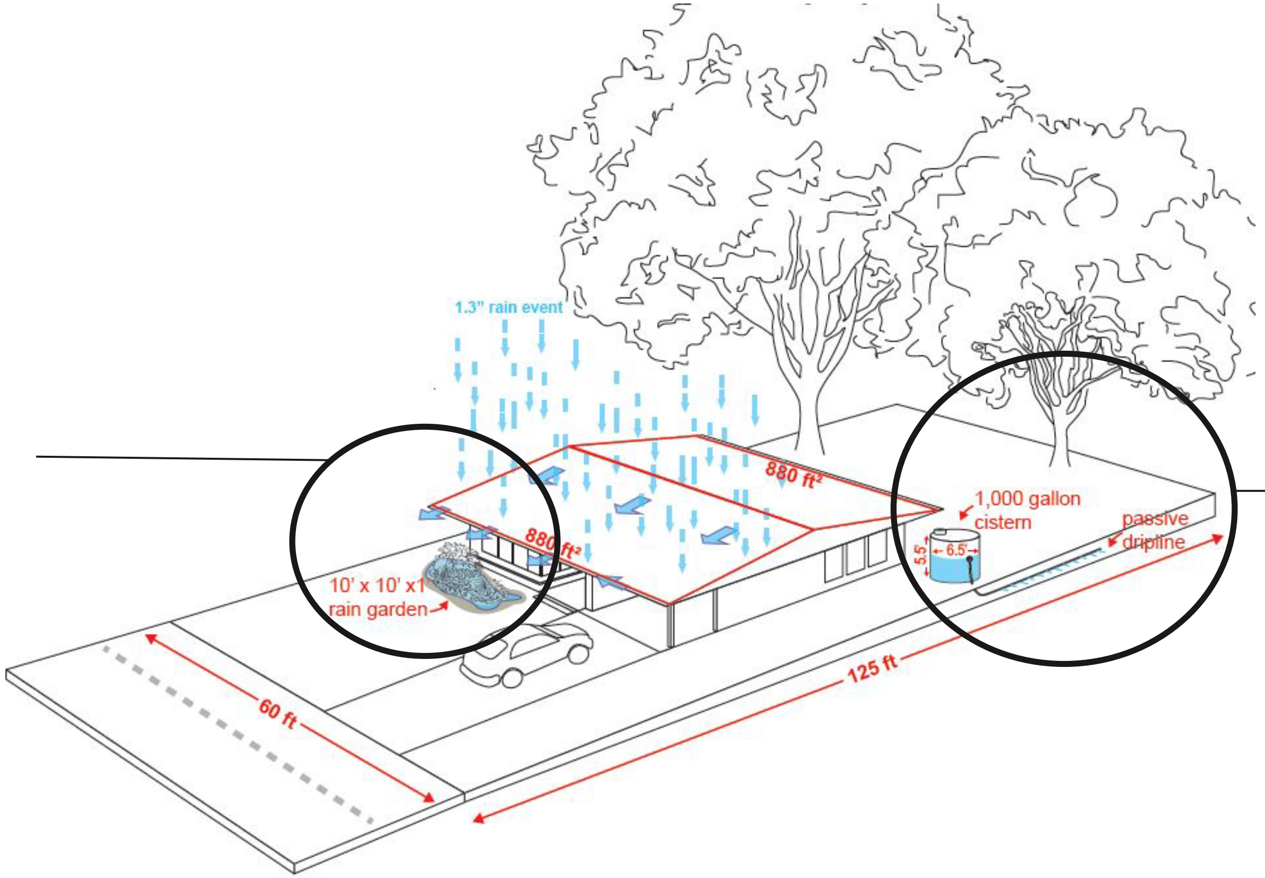
How can multiple benefits increase engagement with other city departments, homeowners, and local NGOs?

Connecting Benefits with Beneficiaries

Theme	Benefit	Stakeholder Interested
Water	Minimize erosive events	WPD
	Reduce nuisance flooding on-site	WPD, residents
	Reduce water pollution	WPD
	Reduce water demand	Austin Water, residents
	Augment water supply	Austin Water, residents
Energy	Energy for water treatment and delivery	Austin Energy, Austin Water
	Energy related to heating/cooling buildings	Austin Energy, residents
Land and Environment	Improve habitat and biodiversity	Environmental NGOs, Development Services Department (Forestry), WPD, Office of Sustainability, Parks and Recreation Department
	Improve air quality	Office of Sustainability, Austin Health Department, Austin Energy, Environmental NGOs
	Improve in-stream flows, extend hydrograph	WPD, Environmental NGOs
	Greenhouse gas emissions reduction and sequestration	Office of Sustainability, WPD, Environmental NGOs
Community Benefits	Reduce urban heat island effect	Parks and Recreation Department, Development Services Department (Forestry), Public Works Department, Office of Sustainability, WPD, Environmental NGOs, residents

Rain Catcher Rebates from Two City Departments

Austin Water's
Rainscape Rebate
$0.30 per sq. ft.
PLUS
Austin WPD
stormwater rebate
$1 per gallon



Austin Water's
Rainwater Harvesting
Rebate
$0.5 - $1.00 / gallon
PLUS
Austin WPD
stormwater rebate
$1 per gallon

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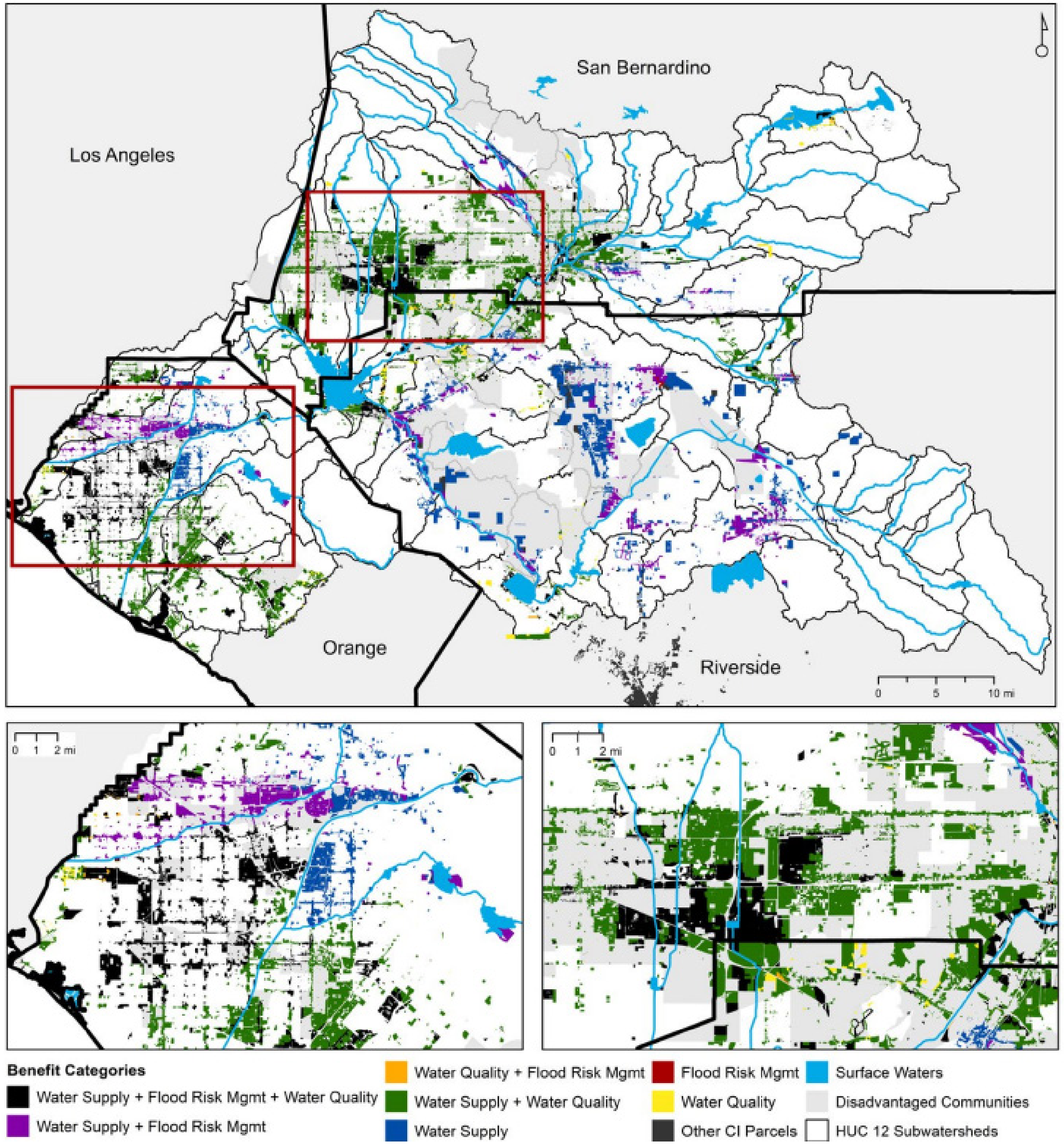
Can Multiple Benefits Help Motivate Private Sector Investment in Landscape Improvements (Including Stormwater Capture)?

Analysis at watershed and parcel scale:

- Water supply
- Water quality
- Flood risk mitigation
- Disadvantaged communities



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Incorporating Multiple Benefits Into Funding Programs

Benefits of Stormwater Capture Cited In California Prop 1E and 84 Proposals

Benefit	Benefit Metric (2018 USD)
Water Supply	• Avoided cost of purchasing imported supplies • Cost savings for water users relative to the status quo • Revenue from sales of water to other users • Avoided operations and maintenance costs
Flood Damage Reduction	• Avoided flood damage to residential and non-residential properties • Avoided loss of revenue and wages from flood disruptions to business • Avoided emergency response costs • Reduced insurance premiums • Avoided public safety and health impacts
Water Quality	• Avoided cost of water treatment
Energy and/or Electrical Savings	• Avoided or reduced energy use from groundwater pumping or surface water transfers
Community Benefits	• Added public active and passive recreation space (acres of space) • Increased property values
Habitat	• Economic value of ecosystem services of wildlife habitat • Value of in stream flows
Greenhouse Gases Avoided	• Avoided greenhouse gas emissions (metric tons of CO2e per year) • Carbon sequestration (metric tons of CO2e per year)
Avoided Costs	• Avoided lowest-cost project alternative • Avoided operations and maintenance, including groundwater pumping

https://doi.org/10.1371/journal.pone.0230549.t004

Source: Diringer et al. 2019

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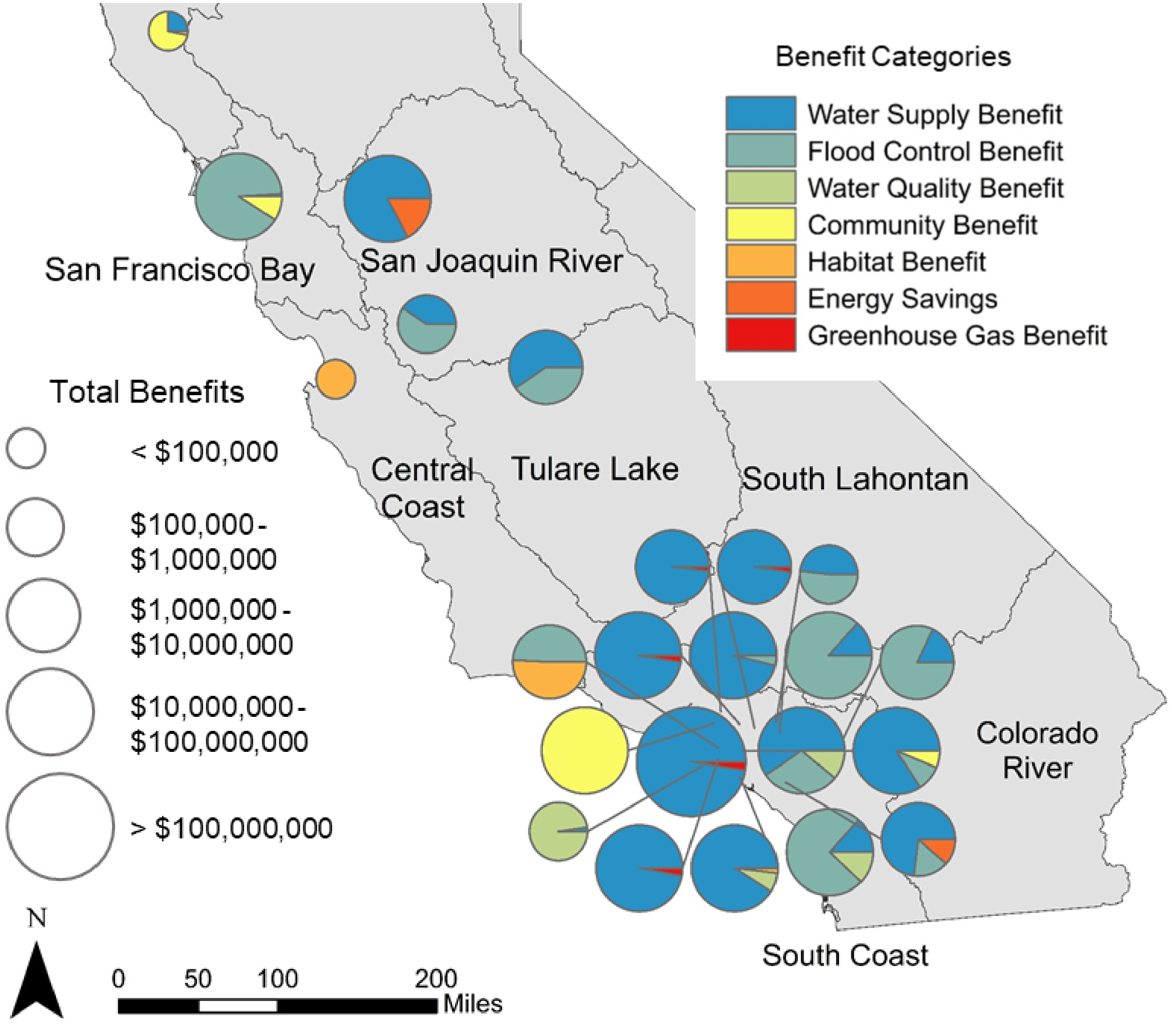
Value and Diversity of Stormwater Capture Related Benefits Identified in Prop 84 and 1 Proposals

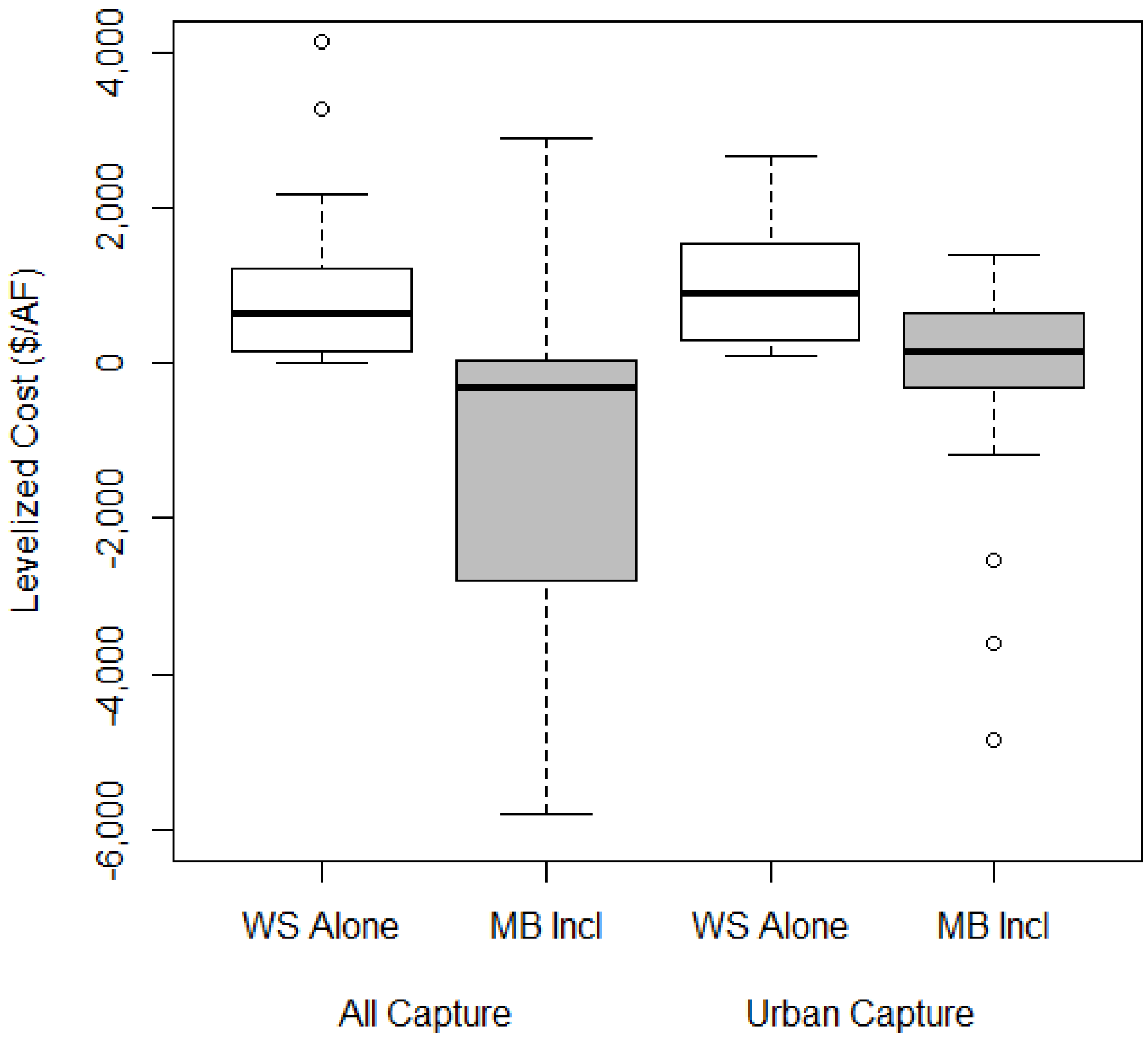


Stormwater capture is economically feasible, but prioritizing projects that yield the greatest benefits is challenging.

Incorporating multiple benefits provides opportunities to:

- Develop standardized project proposals,
- Allow funders to determine the net benefits,
- Co-fund projects,
- Optimize investments in water.

Including a Greater Range of Benefits in Benefit-Cost Analyses Can Reduce the Effective Cost of Stormwater Capture



Source: Diringer et al. 2019

Stormwater capture costs decreased when multiple benefits were included

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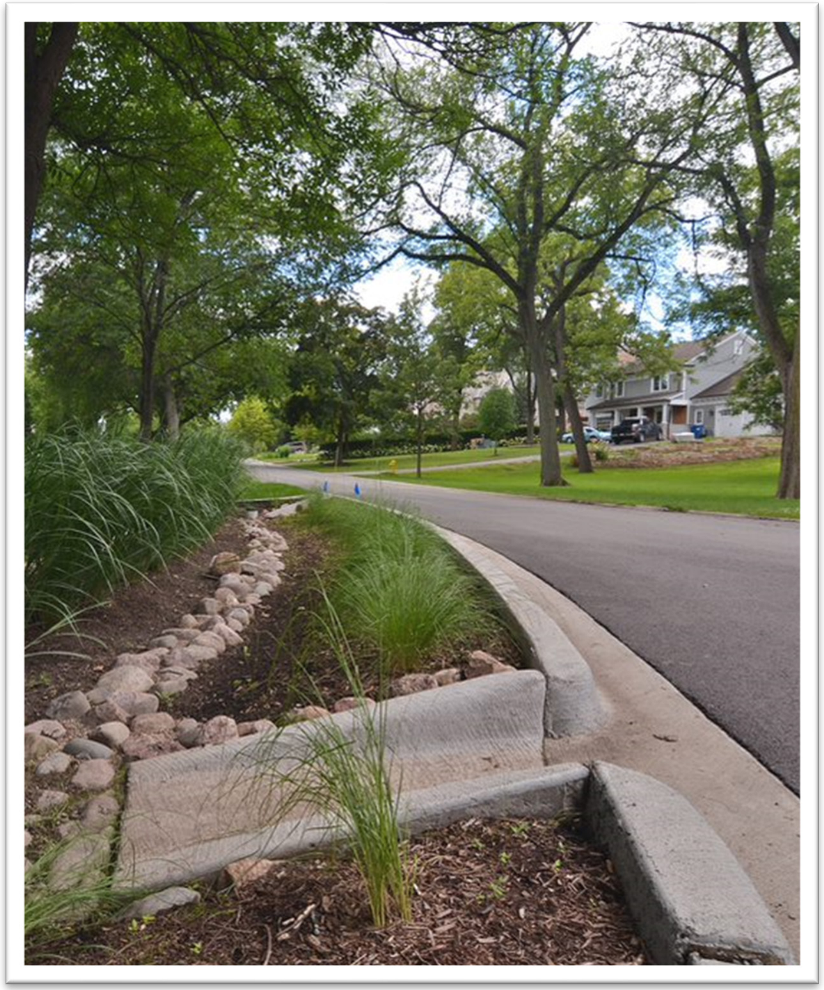
Incorporating multiple benefits can improve decision making

- $ Optimize investment of time, money, and resources
- Identify opportunities to share costs
- Building community support for a project or program
- Minimize adverse and unintended consequences
- Promote equitable and transparent decisions



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Thank You!

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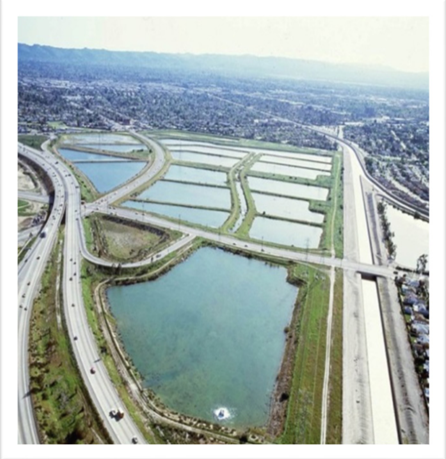

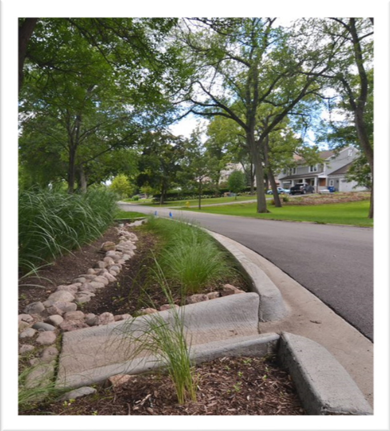

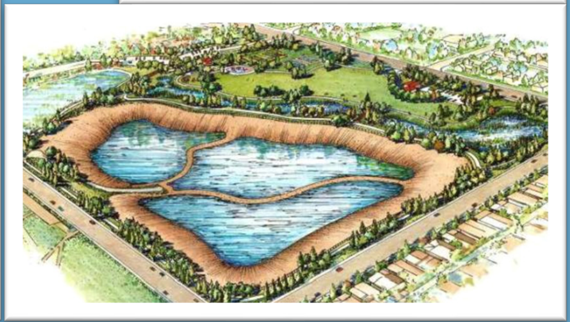

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Public Works
LOS ANGELES COUNTY

Evaluating Stormwater Capture Project Benefits in Los Angeles County

September 7, 2021

Evaluating Benefits

- 2012 Los Angeles MS4 Permit encouraged the development of multi-benefit, regional stormwater capture projects
- How do you balance all the potential multi-benefits?
    - Water Quality
    - Water Supply
    - Community Enhancements
- Can you assign monetary value?
- Is one formula appropriate for all projects

Safe Clean Water Program – Scoring Criteria

- Stakeholder Advisory Group consisting of environmental groups, water supply, MS4 agencies, regulators developed scoring criteria in 2017-2018
- Watershed Management Modeling System (WMMS) – Water Quality model developed by LA County was instrumental in determining metrics to evaluate most benefits
- November 2018 – Safe Clean Water Program passed
  - Generates ~$280M towards stormwater capture projects
- Scoring Committee has evaluated over 120 Multi-Benefit Projects

Safe Clean Water Program – Scoring Criteria

Water Quality

- Cost Effectiveness – 24-hour Capacity (acre-feet) / Construction Cost
  - Ratio of 1 or greater was determined to be optimal
- Performance Effectiveness – WMMS generated pollutant reduction results

Water Supply

- Cost Effectiveness – Total Life-Cycle Costs / Total Water Supply Benefit (ac-ft)
- Water Supply – Annual Water Supply Benefit (ac-ft) generated by WMMS

Community Investments

- Metrics - Flooding, recreational, access
- Community Support

Ladera Park Stormwater Capture Project

Water Quality
- Capacity 5.1 ac-ft (Infiltration)
- Construction Cost: $5.9 M
- Ratio: 0.86

Water Supply
- No Recharge Potential (Near Coast)
- Dry Weather runoff (1 cfs) is used for water harvesting/treatment

Community Enhancements
- Bioswales
- Demonstration Garden/ Shade Structure
- Education Outreach

Total Score: 69

Roosevelt Park Stormwater Capture Project

Water Quality
- Capacity – 8.0 ac-ft (Infiltration)
- Construction Cost: $9.7 M
- Ratio: 0.82

Water Supply
- Recharge Potential in Los Angeles River – 80 ac-ft/year

Community Enhancements
- Education Garden
- Bioswales/Native Landscaping
- Exercise Equipment
- Skate Park
- Soccer Field

Total Score: 67

Gates Canyon Park Stormwater Capture Project

Water Quality

- Capacity – 3.5 ac-ft (On-site Treamtent)
- Construction Cost: $8.9 M
- Ratio: 0.39 (Not Cost-Effective in comparison)

Water Supply

- No recharge potential due to geological constraints
- Water Harvesting System (35 ac-ft/year)

Community Enhancements

- New park amenities
- Reduced irrigation costs

Total Score: N/A. Didn't meet base score

County of Los Angeles Stormwater Projects

Project Name	Type	Note	Construction Costs	24- hour Capacity (ac-ft)	Water Supply (ac-ft/year)	Safe Clean Water Program Score
Ladera Park	Infiltration Wells & Irrigation Reuse	No Recharge Potential	$5.9M	5.1	22	69
Roosevelt Park	Infiltration Wells & Gallery	Recharge Potential	$9.7M	8.0	80	67
Gates Canyon Park	Infiltration Wells & Irrigation Reuse	High Treatment Cost	$8.9M	3.5	35	N/A

Conclusions

1. Every project has different challenges/opportunities
   - Geotechnical constraints & Water Supply Opportunities vary
   - Water Treatment Projects are most expensive
   - Dry Weather vs. Wet Weather Projects
   - Difficult to use a singular formula that applies to all projects
2. Recommend comparing similar projects per region
   - Project in areas where groundwater recharge is possible provide “more” benefit compared to areas that don’t recharge
3. Community Enhancements are difficult to compare/evaluate
   - Need further stakeholder engagement to develop agreed upon quantification
   - Metrics are being developed by Safe Clean Water Program team – expected in June 2022
4. Developing stormwater BMP models help evaluate benefits

Questions

TJ Moon
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Funding Perspective on Project Benefits

Presenter: Spencer Joplin, P.E.
Water Resource Control Engineer

CALIFORNIA
Water Boards

Outline

- Grant Program Requirements (for Project Benefits)
- How benefits are presented in an application
- How benefits are evaluated by the Grant Program Staff

Grant Program Requirements

MULTI-BENEFITS

PRIMARY BENEFIT

- Only one (1) Primary Benefit per Project
- Water Supply/Quality – Preferred/Incentivized
- Must be a quantifiable benefit

SECONDARY BENEFIT(S)

- Up to two (2) Secondary Benefits per Project (for scoring purposes)
- Not required to be a quantifiable benefit; However, quantification expected (when feasible) depending on the type of benefit claimed

Examples of quantifiable benefits

Benefit	Example	Metric Units
Water Quality while contributing to compliance with applicable permit and/or TMDL requirements	• Increased filtration and/or treatment of runoff • Nonpoint source pollution control • Reestablished natural water drainage and treatment	• Load Reduction: lb/day, kg/day. • Concentration: mg/l, µg/l, MPN/ml. • Unit cost: $/lb, $/kg, $/MPN. • Treatment capacity: MGD, AFY.
Water Supply through groundwater management and/or runoff capture and use	• Water supply reliability • Water conservation • Conjunctive use	• Volume Captured: MGD, AFY • Unit Cost: $/AF (along with volume)
Flood Management	• Decreased flood risk by reducing runoff rate and/or volume • Reduced sanitary sewer overflows	• Rate: CFS. • Area protected: acres. • Volume: CF, AF • Storm: x-year storm, inches in 24 hours.

Environmental	• Environmental and habitat protection and improvement, including:
	  • wetland enhancement/creation;
	  • riparian enhancement; and/or
	  • instream flow improvement
	• Increased urban green space
	• Reduced energy use, greenhouse gas emissions, or provides a carbon sink
		Size and/or Rate
		• acres
		• cubic feet per second (cfs)
		• carbon sequestration (megagrams of carbon per area)
		Other
		• area units of landscape and buffer
		• measure of improved hydrology
		• number of biotic structure
		• number of physical structures
		• reduced temperature (degrees)

Community	• Enhanced and/or created recreational and public use areas • Community involvement • Employment opportunities provided	• Size • size of population served • number of people • number of jobs • acres

How are Benefits presented in an Application?

Annual Benefit Quantities Analysis

- Driving force behind projects
  - (i.e. water shortages, WQ impairments)
- Methodology for quantifying claimed Benefits and supporting documentation
- Description of Non-quantifiable Benefits
- Table Summary of Primary and Secondary Benefits (including quantification)

Cost-Benefit Analysis

INPUT:

- Itemized volumetric benefit quantities for each BMP Type (amount captured, treated, infiltrated/used)
- Estimated Useful Life of each BMP Type
- Capital Costs of each BMP Type
- Annual O&M Costs of each BMP Type

OUTPUT:

- Unit (Dollar/Acre-Foot) Cost

Typical Quantification Methods

- Water Balance
- Modeling Tools or Software
- Calculations

How are Benefits evaluated?

- Scoring of Benefits driven by the scoring criteria/rubric within the Program Guidelines (Adopted by the Board)
- Do claimed benefits address Program preferences/priorities?
- Are benefits quantified (when applicable) and supported with technical analysis?
- Geographical scale of benefits
  - (i.e. project addressing regional or watershed scale issues vs. local issues)
- Unit Cost-Benefit in comparison with other proposals

CONTACT INFORMATION

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Colorado State University

Co-Benefits Assessment in the CLASIC tool

Sybil Sharvelle

Co-Benefits Assessments – Spectrum of Analysis

Lists of Co-Benefits

Qualitative

Monetary estimates

Quantitative

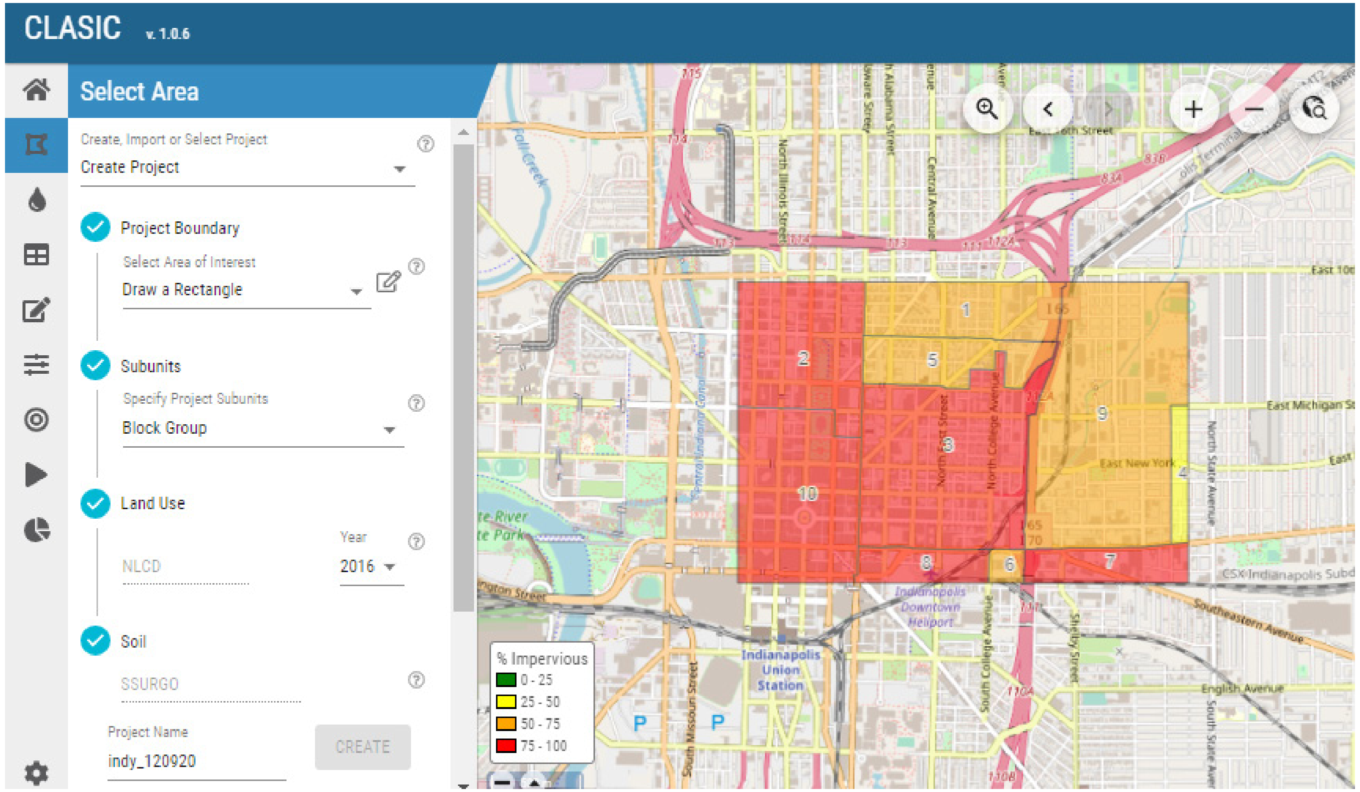
Low input data needed
Local considerations less important

Complex input data needed
Local considerations very important

Vision of CLASIC Decision Support System

The CLASIC tool is a user-informed screening tool which utilizes a lifecycle cost framework to support stormwater infrastructure decisions on extent and combinations of green, hybrid green-gray and gray infrastructure practices.

Web Based Decision Support System: clasic.erams.com



GIS Interfaced for automated data collection of CLASIC inputs (area characteristics)

Three Basic Outputs for User Allows for Integrated Assessment

Life-Cycle Cost

- Rigorous comparison of life cycle costs associated with technologies particularly compared to similar gray infrastructure

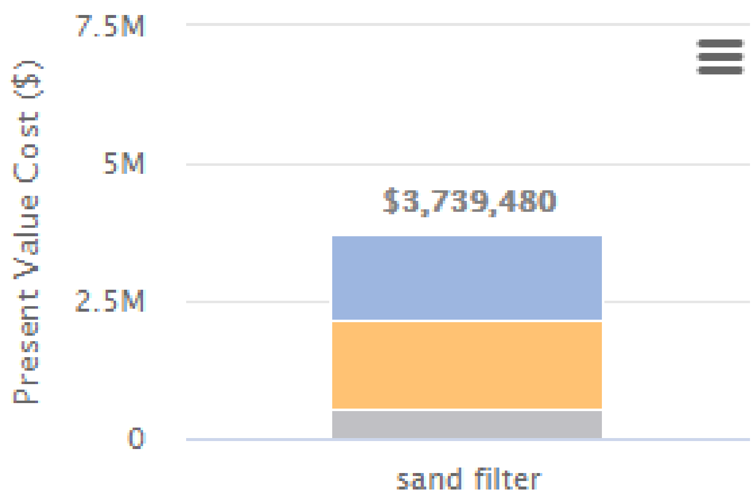
Performance

- Runoff Volume Reduction
- Peak Flow Reduction
- Pollutant Load Reduction

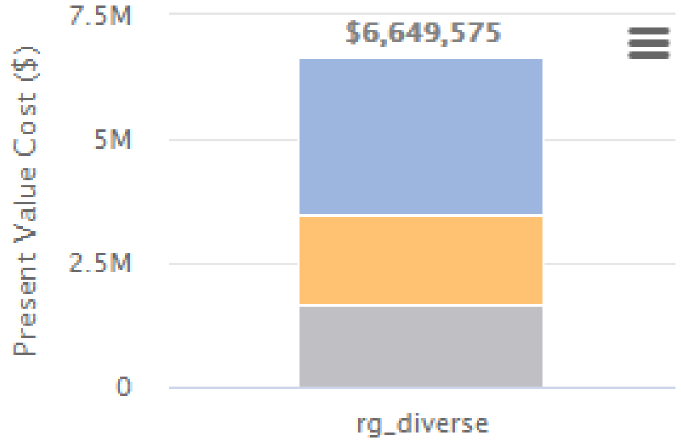
Co-Benefit Analysis

- Score for economic, social, and environmental co-benefits based on multicriteria decision analysis

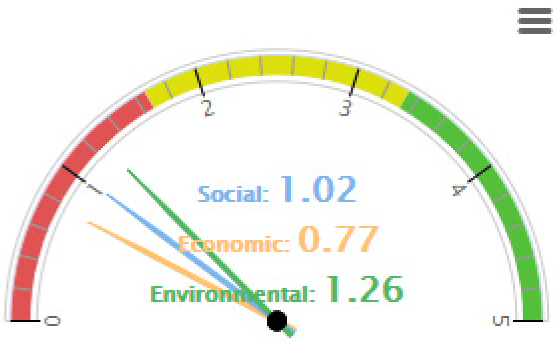
Sand Filter

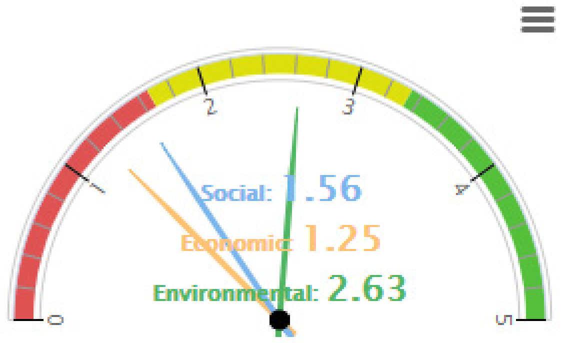


Rain Garden with Diverse Vegetation



Construction Maintenance Rehabilitation





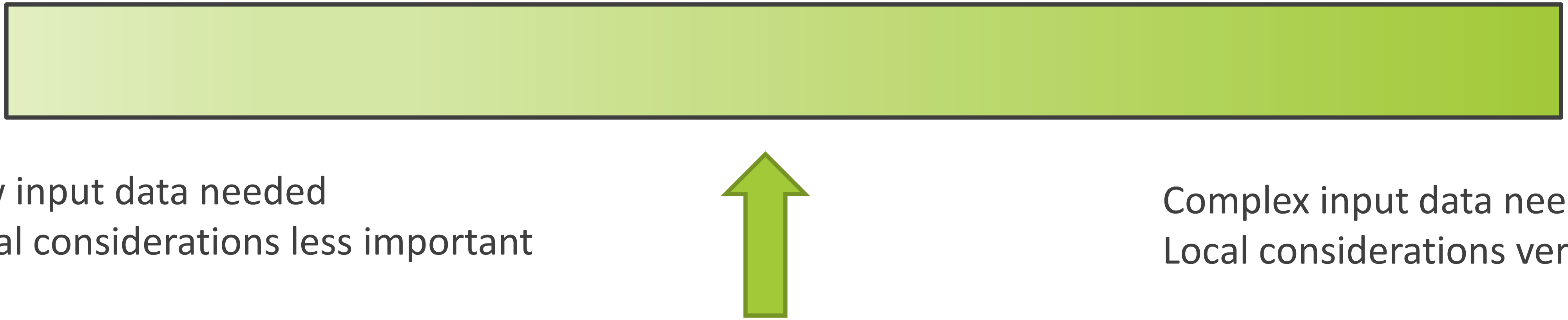
Co-Benefits Assessments – Spectrum of Analysis

Lists of Co-Benefits

Qualitative

Monetary estimates

Quantitative

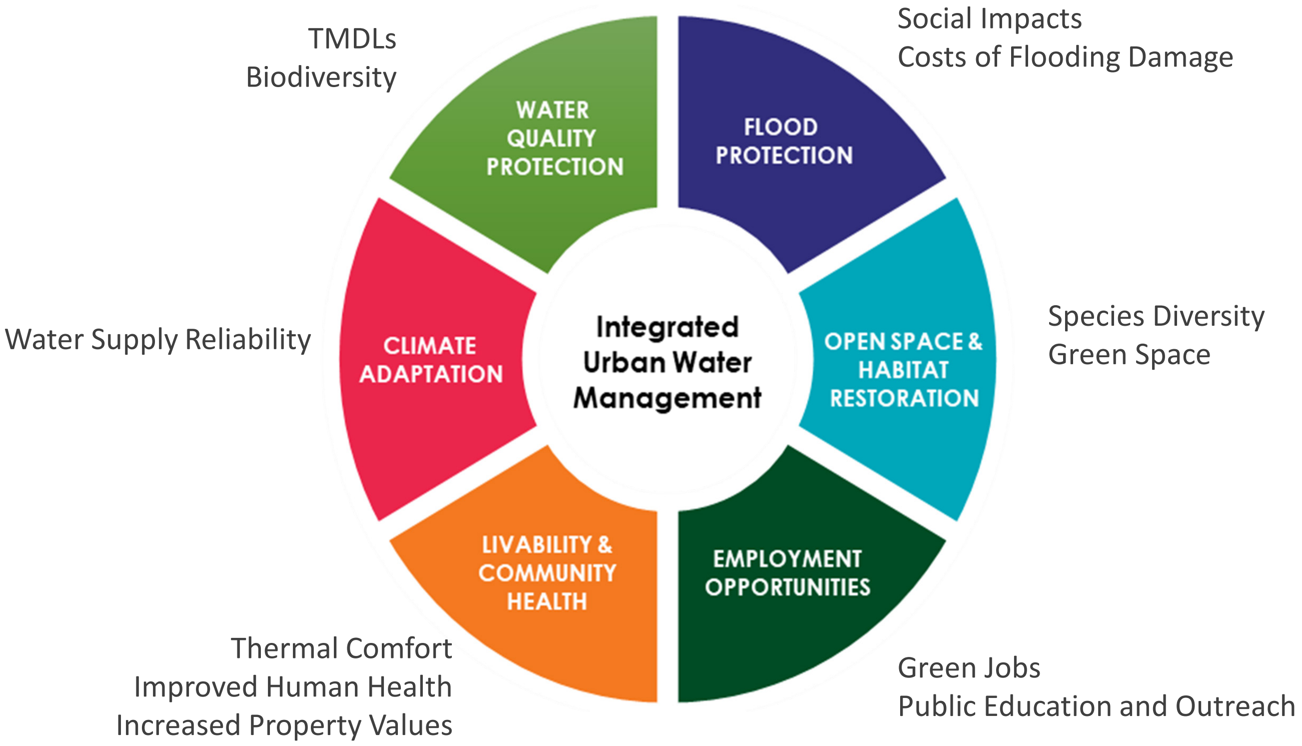


Low input data needed
Local considerations less important

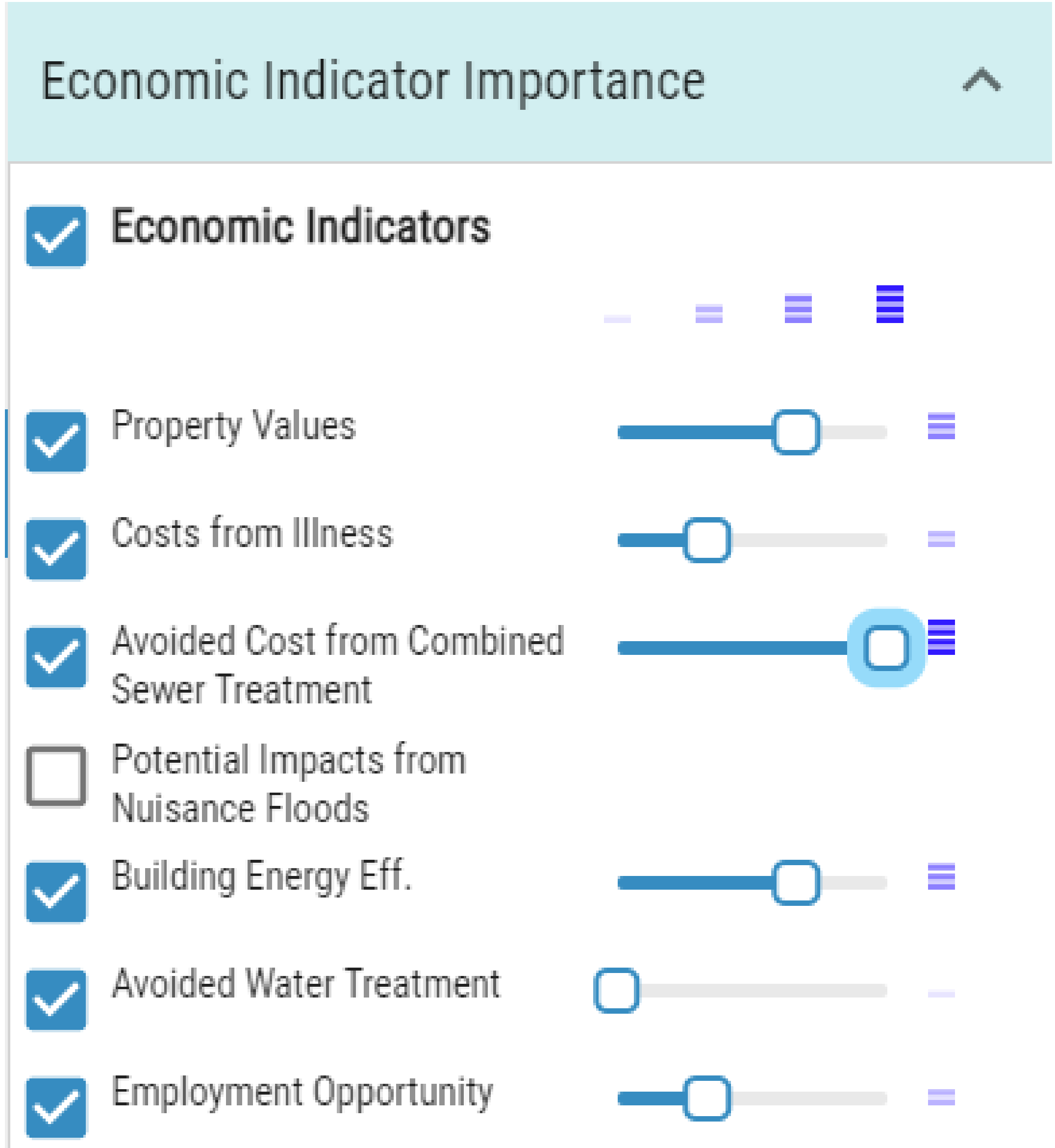
Complex input data needed
Local considerations very important

CLASIC

Co-Benefit Analysis in CLASIC Tool



User selects importance factors (1 – 4) for each indicator

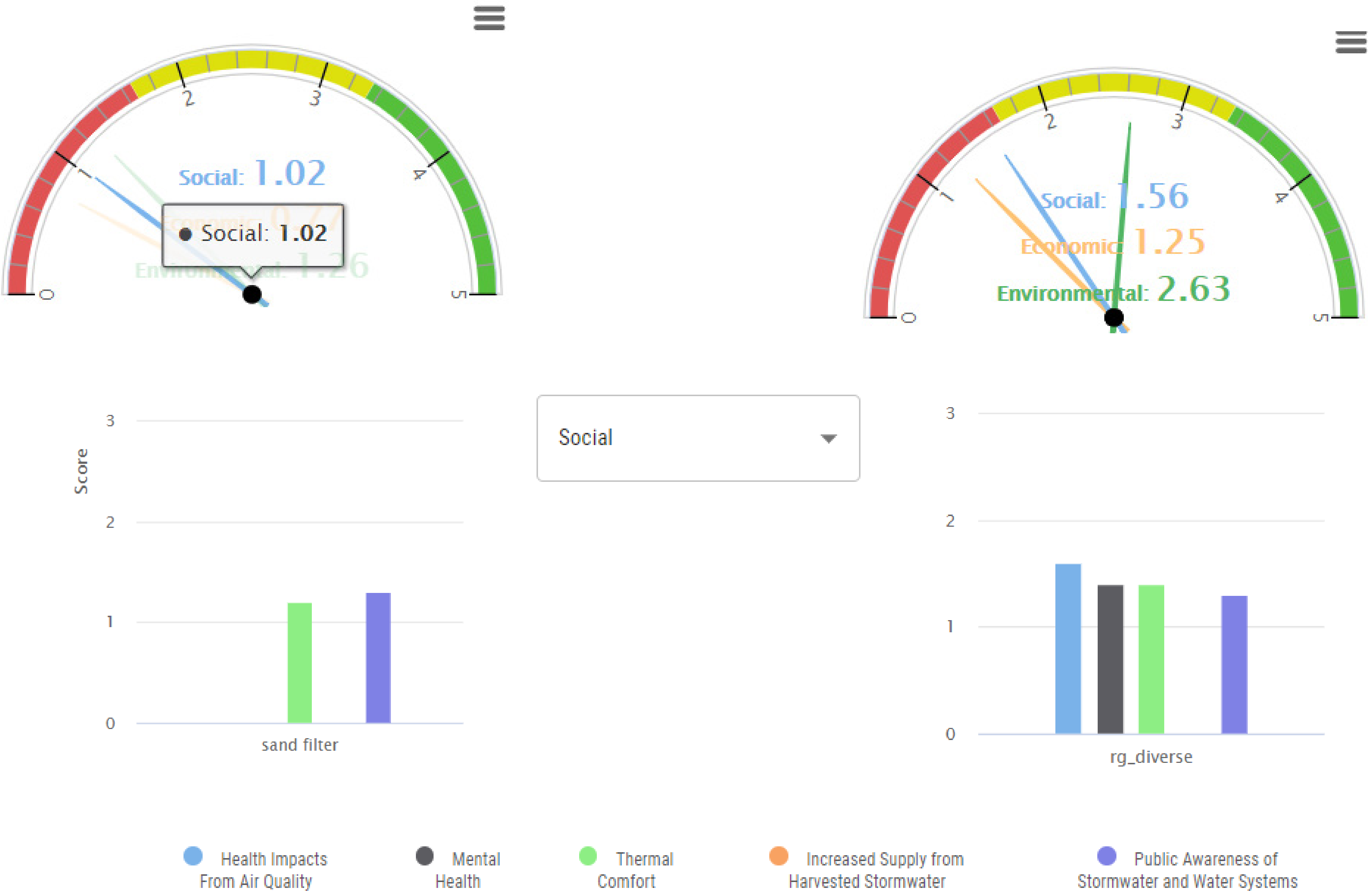


Quantitative Data used to Assign Indicator Ratings

For each indicator, relative rating between 1 - 5 is assigned to enable a comparative analysis between scenarios

(Multi-Criteria Decision Analysis)

Co-Benefit Indicators	Approach	CLASIC parameters used for estimation
ECONOMIC		
Property Values	Directly correlated to area of added green space	SCM area (acre) only when vegetated is selected and technology is added to captured impervious
Costs from Illness	Ozone, PM10, nitrogen dioxide, sulfur dioxide, and carbon monoxide removal by each herbaceous plants and trees is estimated. Pollutant removal is used in conjunction with cost of illness treatment associated with each pollutant.	Diverse Vegetated SCM area (acre); Number of trees added; Area of Green Roof
Avoided Costs from Combined Sewer Treatment	Runoff volume	Average annual precipitation that becomes runoff (in/yr)


Social: 1.02
Social: 1.02
0
2
3
4
5
Social: 1.56
Economic: 1.25
Environmental: 2.63
0
2
3
4
5
Social
Score
3
2
1
0
sand filter
3
2
1
0
rg_diverse
Health Impacts From Air Quality
Mental Health
Thermal Comfort
Increased Supply from Harvested Stormwater
Public Awareness of Stormwater and Water Systems

Summary

- Co- Benefits Analyses range from qualitative to quantitative (monetary)
  - More extensive data inputs required for monetary estimate
- CLASIC utilizes multi-criteria decision analysis approach to provide relative comparisons of co-benefits between scenarios with few user inputs

Welcome to the GSI TBL Tool
This Tool allows you to quantify and monetize the Triple Bottom Line (TBL) benefits of Green Stormwater Infrastructure (GSI).

In subsequent tabs, you will provide inputs necessary to develop the GSI scenario you would like to evaluate. You will also enter key inputs necessary to quantify and monetize the GSI benefits relevant to your community. Each benefit is represented by a separate tab/benefits module.

Throughout this Tool, only enter values into Cells shaded in GREEN. Generally, you should not enter values into cells shaded in GRAY **(although there are exceptions).** Results are shown in cells that are shaded in ORANGE.

To successfully navigate the Tool, the **MACROS ASSOCIATED WITH THIS FILE MUST BE ENABLED.** Simply hit the Enable Content button at the top of the screen to enable macros.

Framework and Tool for Quantifying the Triple Bottom Line Benefits of Green Stormwater Infrastructure

Enter TBL GSI Tool

THE Water Research FOUNDATION

CORONA ENVIRONMENTAL CONSULTING

Kennedy/Jenks Consultants

Janet Clements
Director, Water Economics and Planning
Corona Environmental Consulting
September 7, 2021

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Project Objective

Develop economic framework and Excel-based tool to help practitioners ***quantify*** and ***monetize*** the ***Triple Bottom Line benefits*** of GSI and compare them to ***costs***.

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What is Triple Bottom Line Analysis?

Comprehensive **benefit-cost analysis** that accounts for:

- *financial*
- *social*
- *environmental*

benefits and costs of a project or program **over time,** and to **whom they accrue**.

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Economic Aspects of GSI

A broader *economic* (TBL) perspective can reveal that GSI provides greater benefits for communities.

Social

- ✓ Reduced urban heat stress
- ✓ Flood risk reduction*
- ✓ Increased property values
- ✓ Improved recreational opportunities
- ✓ Green job creation
- ✓ Water supply

Financial

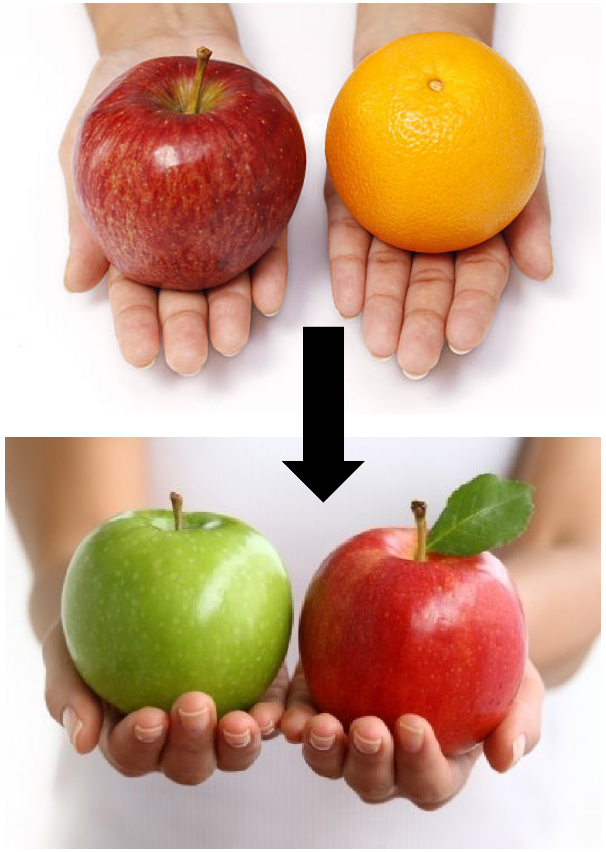
- ✓ Avoided infrastructure costs
- ✓ Asset life extension
- ✓ Utility energy savings

Environmental

- ✓ Improved air & water quality
- ✓ Improved habitat/ecosystem
- ✓ Carbon reduction

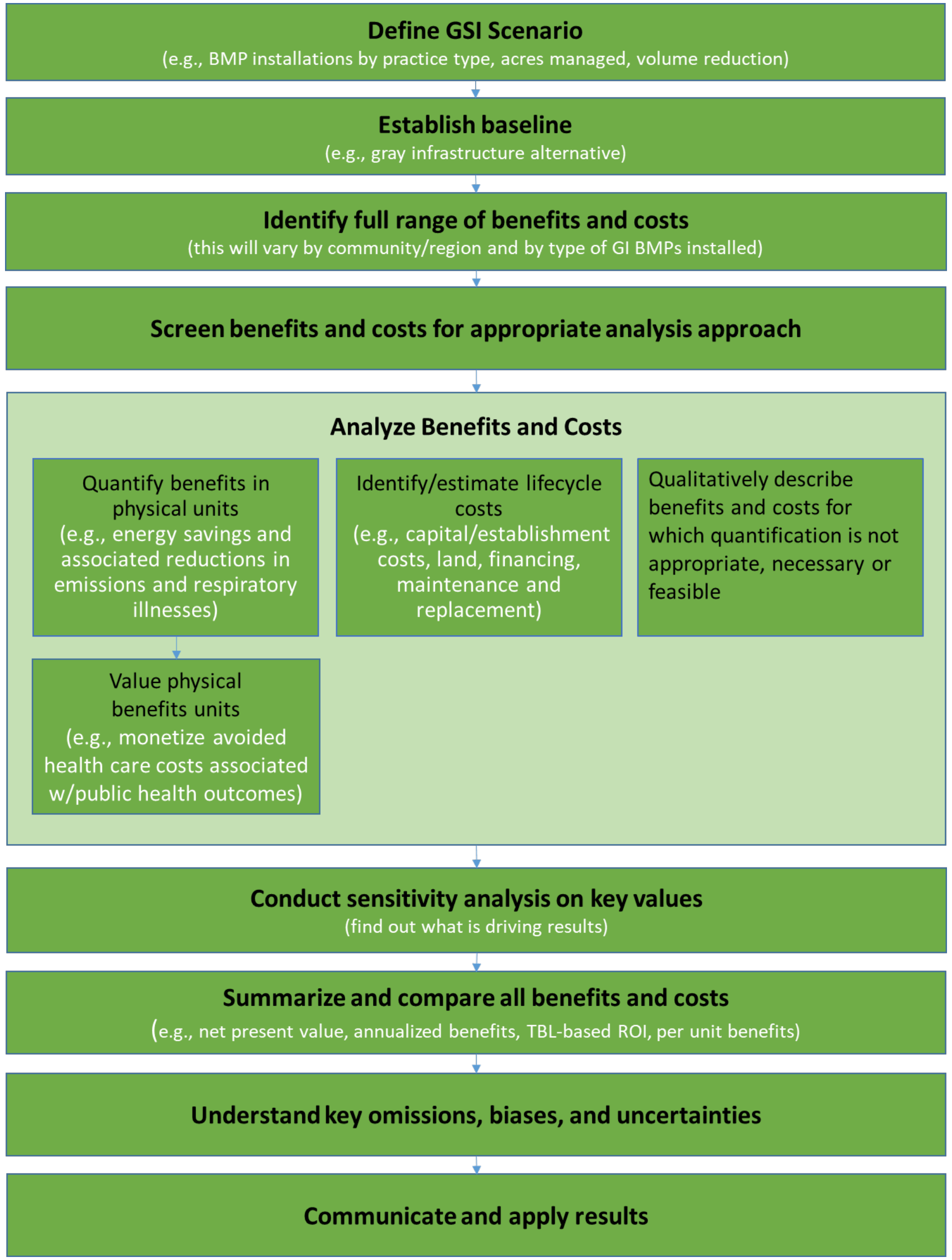
Why is Quantitative/Monetized TBL Information Needed?

- Build support for GI internally
- Identify stormwater management alternatives that maximize community value
- Compete for scarce funding
- Leverage private capital and alternative funding
- Support alternative project delivery models
- Gain community support and buy-in



Framework and Tool

- Standard economic valuation methods
- Default (regional) values/allows for user customization
- Neighborhood, city, watershed scale
- Excel-based Tool, guidance, report, extensive technical documentation



Establishing a GSI Scenario

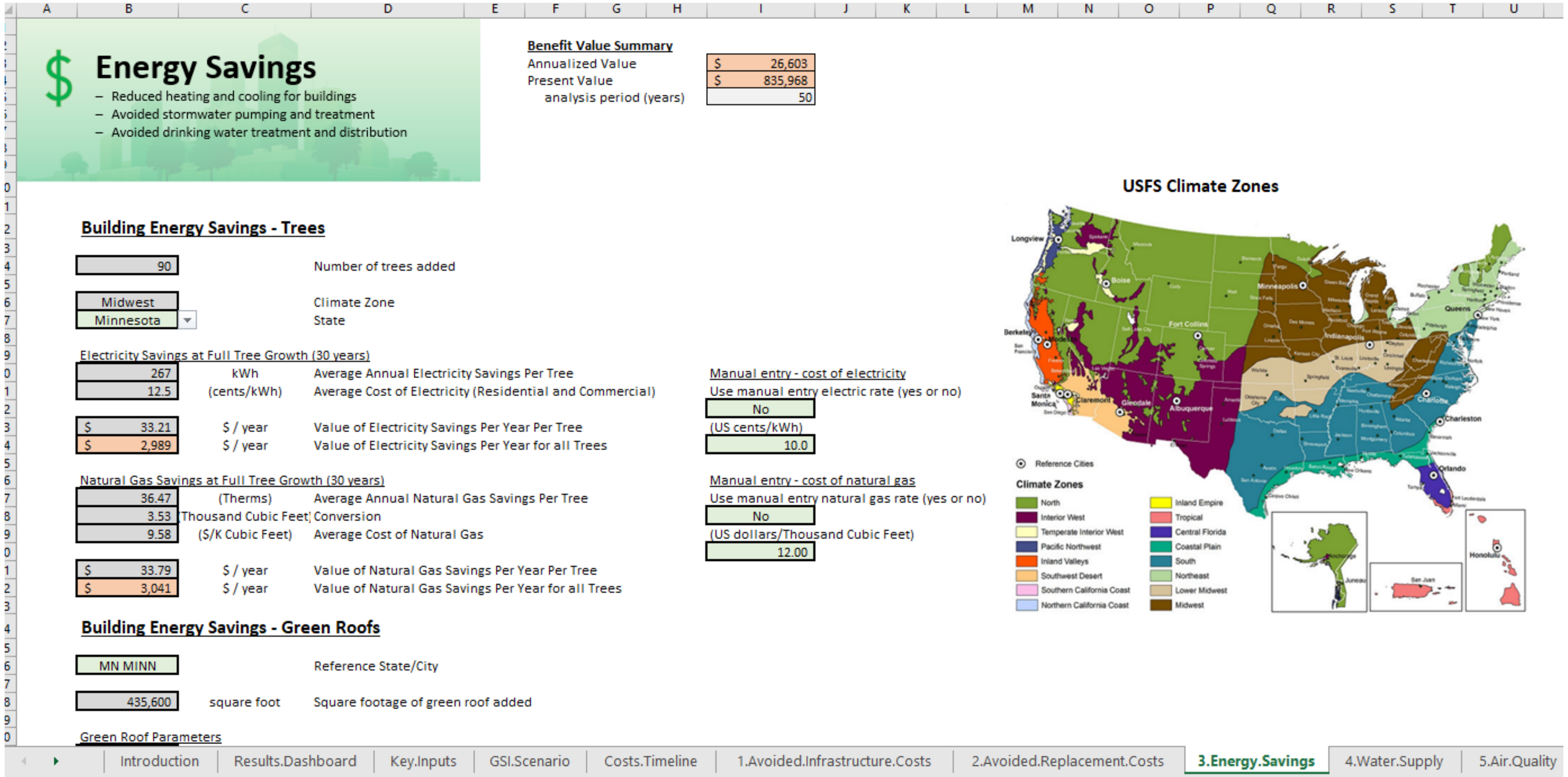
GSI Practices - Enter Acres Managed or Number of BMPs

GSI Practice (BMP)	CLASIC BMP Name	Effective Impervious Acres Managed (acres)	Number of BMPs	Volume Capacity by BMP type (cft)	Calculated BMP Area (Footprint) (square feet)	Annual Runoff Volume (cft)
Rain gardens	Rain gardens		-	-	-	-
Bioretention facilities	Infiltration trenches	708.4	802	2,520,062	4,408,272	79,279,098
Green roofs	Green roofs	57	598	202,505	2,987,534	6,370,642
Tree planting/street trees	*	151.2	118,000	548,700	82,962,564	16,916,421
Permeable pavement	Permeable pavement	329	329	1,170,385	7,165,620	36,819,344
Cisterns - rainwater harvesting	Rainwater harvesting	8.29	45	30,080		927,373
Rain barrels - rainwater harvesting	Rainwater harvesting	11.48	1,000	7,352.9		1,284,583
Constructed wetland	*		-	-	-	-
Wet ponds	Wet pond		-	-	-	-
Biofiltration/grass or vegetated swale	Grass swale		-	-	-	-
		1,265		4,479,085		141,597,462

* CLASIC does not address "Tree planting/street trees" or "constructed wetland"

Benefit Modules: Energy Savings

- Building energy savings (trees and green roofs)
- Avoided stormwater pumping and treatment
- Avoided drinking water treatment and distribution



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GSI Benefit/Cost Results

- Benefits by Triple Bottom Line (TBL) category
- Benefits over time

Analysis Assumptions

Analysis Period	28	Years
Discount Rate	4.0%	

Present Value - All Benefits and Costs

	Total over study period	Annualized values
Benefits	$ 27,893,556	$ 1,673,975
Costs	$ 21,532,600	$ 1,292,235
Benefit-Cost Rati	1.295	

Benefit Categories

Financial

- ☐ Avoided infrastructure and treatment costs
- ☑ Avoided replacement costs
- ☑ Energy savings

Environmental

- ☑ Water quality improvements
- ☑ Carbon emissions reduction and sequestration
- ☑ Ecosystem benefits

Social

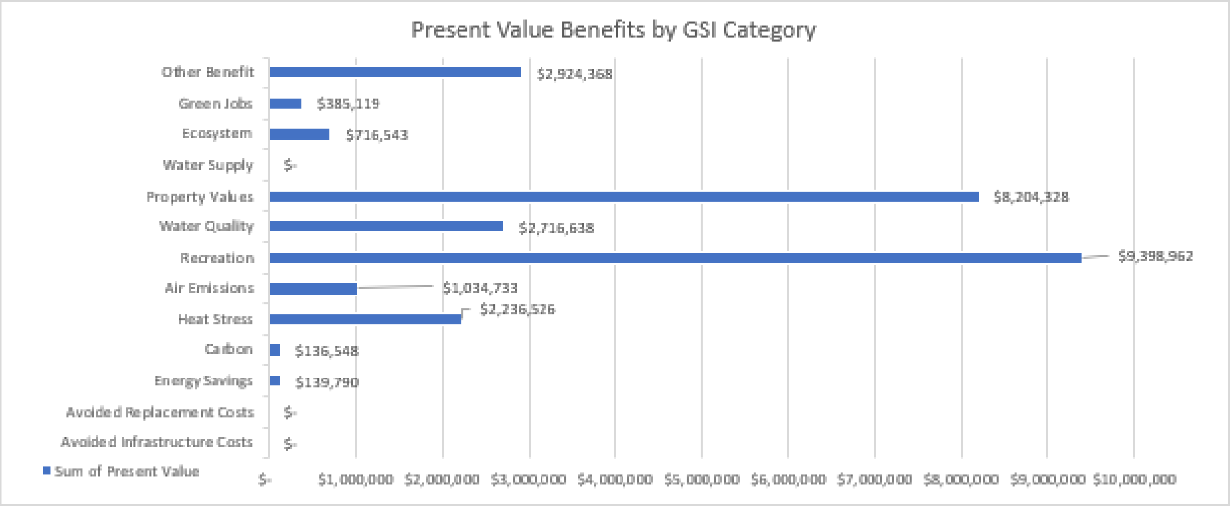
- ☑ Improved air quality
- ☑ Water supply benefits
- ☑ Improved aesthetics (property values)
- ☑ Reduced heat stress
- ☑ Increased recreation
- ☑ Green job creation

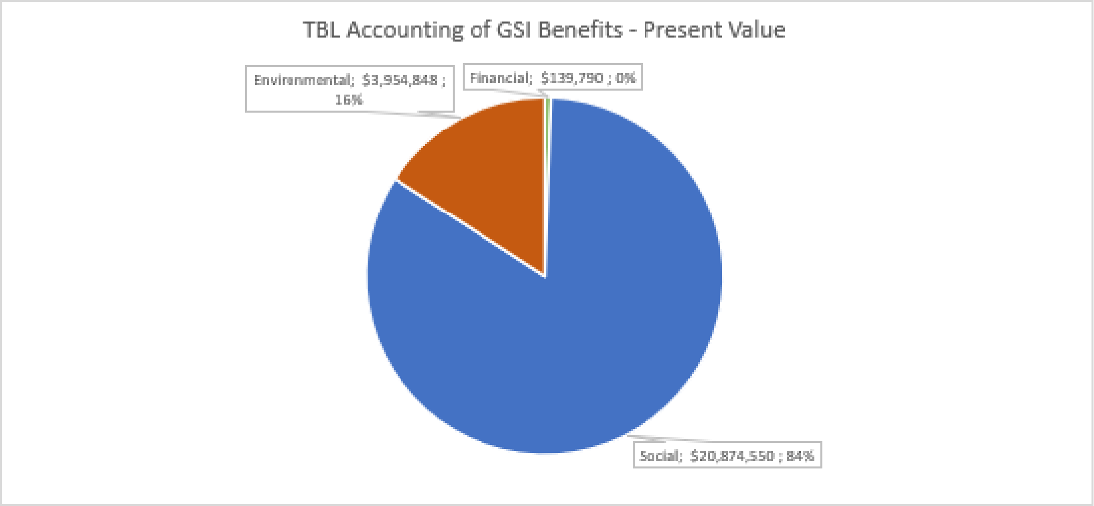
Other

- ☑ Other benefits (enter to the right)

Benefits Calculated Outside Tool

Average annual (non-discounted)	TBL Benefit Type
$ 175,500	Other





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Case Studies

- **St. Paul (MI)** – Green/Gray Alternatives evaluation; 34-acre site; Autocase comparison
- **Lancaster (PA)** – Citywide Stormwater Management Plan; CNT/AR comparison
- **Seattle (WA)** – Neighborhood Improvement; Incorporates MODA analysis
- **Cleveland (OH)** – 9 grant-funded projects

	Saint Paul, MN	Lancaster, PA	Seattle, WA	Cleveland, OH
Description	Compares benefits and costs of two alternatives – gray- and GSI-based approaches – for mixed-use, 134-acre redevelopment site.	Evaluates benefits and costs of a citywide GSI-based stormwater management plan implemented over 25-years.	Examines benefits and costs of three ROW bioretention projects in high priority watershed.	Evaluates benefits and costs of multiple grant funded GSI projects in combined sewer are of District.
Project proponents	Capitol Region Watershed District/City of Saint Paul	City of Lancaster	Seattle Public Utilities	Northeast Ohio Regional Sewer District.
Key highlights	Results compared to similar analysis using Autocase tool. Compares incremental costs / benefits of gray and GSI scenario.	Results compared to a similar analysis developed using *CNT/American Rivers Guide.*[a]	Incorporates MODA[b] framework that SPU uses to assess GSI project priorities / benefits.	Includes customized property value analysis and analyzes distributed projects.
GSI scenario	Centralized GSI corridor; 4.8 acres of bioretention; 300 trees, large retention pond / wetland system; 10-acres of green space. Stream restoration links development site to recreation/natural area.	Manages 1,265 IA / 1,060 MG of runoff/year through GSI: bioretention (56%)[c]; permeable pavement (26%); trees (13%)[d]; green roofs (4.5%); RWH (1%).	ROW bioretention projects managing 6 impervious acres; includes 89 trees, pedestrian/safety improvements, and community gathering space.	Nine distributed projects including bioretention, permeable pavement, and underground systems.
Avoided infrastructure		★		★
Avoided maint./replace.		★		★
Energy savings	★	★	★	★
Water supply		★		★
Air quality	★	★	★	★
Heat stress	★	★		
Recreation	★	★	★	
Enhanced aesthetics	★	★	★	★
Green job creation	★	★	★	★
Water quality/habitat	★		★	
Carbon reduction	★	★	★	★
Terrestrial ecosystem	★	★	★	★
Flood risk reduction	★			
Total PV benefits ($M)	$27.9 (GSI); $15.1 (gray); (28-year PV)	$521.8 (50-year PV)	$8.98 (50-year PV)	$3.49 (40-year PV)
Total PV costs ($M)	$21.5 (GSI); 18.8 (gray) (28-year PV)	$241.5	$5.87	2.40
Benefit-cost ratio	1.3 (GSI); 0.8 (gray)	2.16	1.53	1.455

Key Research Gaps and Next Steps

- Quantification: Flood risk reduction, habitat creation, urban heat stress benefits
- How to design, locate, and implement GSI to achieve benefits
- Incremental benefits and costs
  (what are the price points for achieving benefits?)
- Informing/integrating with funding and financing options/
  alternative project delivery models
- Equity implications
- Alternative frameworks for non-quantified benefits

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Assessing Co-benefits and Moving Towards Multi-functional Design

KATIE SPAHR, PH.D., P.E.
RESEARCH PROGRAM MANAGER, THE WATER RESEARCH FOUNDATION
PRESENTING GRADUATE WORK PERFORMED UNDER
DR. TERRI HOGUE, COLORADO SCHOOL OF MINES

Integrated Decision Support Tool (i-DST) Project

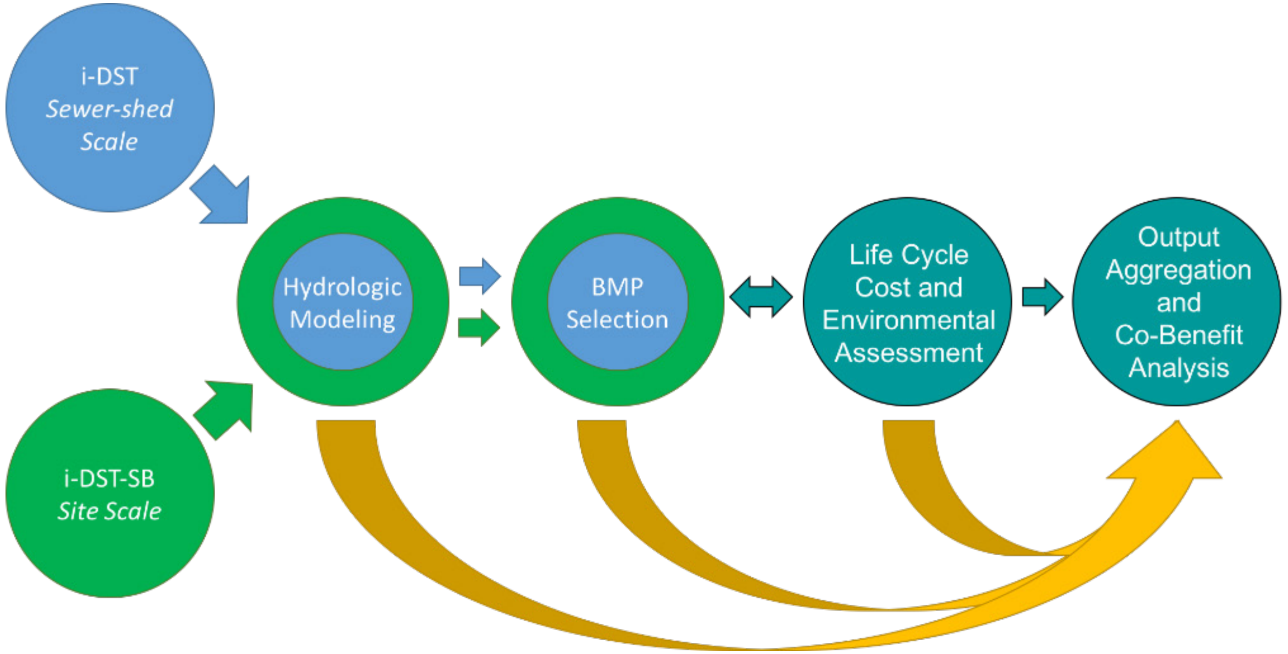
Develop an integrated, scalable, decision support tool (called **i-DST**) for grey, green, and hybrid infrastructure for nation-wide implementation

Planning-level tool – suitable for project prioritization (not design)

EPA National Priorities: Life Cycle Costs of Water Infrastructure Alternatives (RFP: EPA-G2015-ORD-D1)

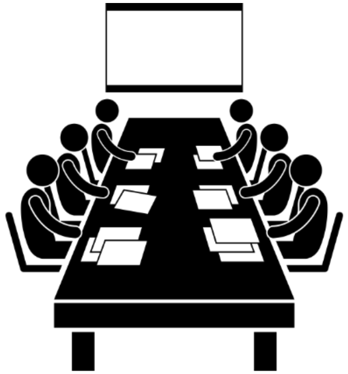
idst.mines.edu

Board Image from the Noun Project



Conceptual model of tool components

Multi-institutional collaboration



Science Advisory Board

State of the co-benefit literature

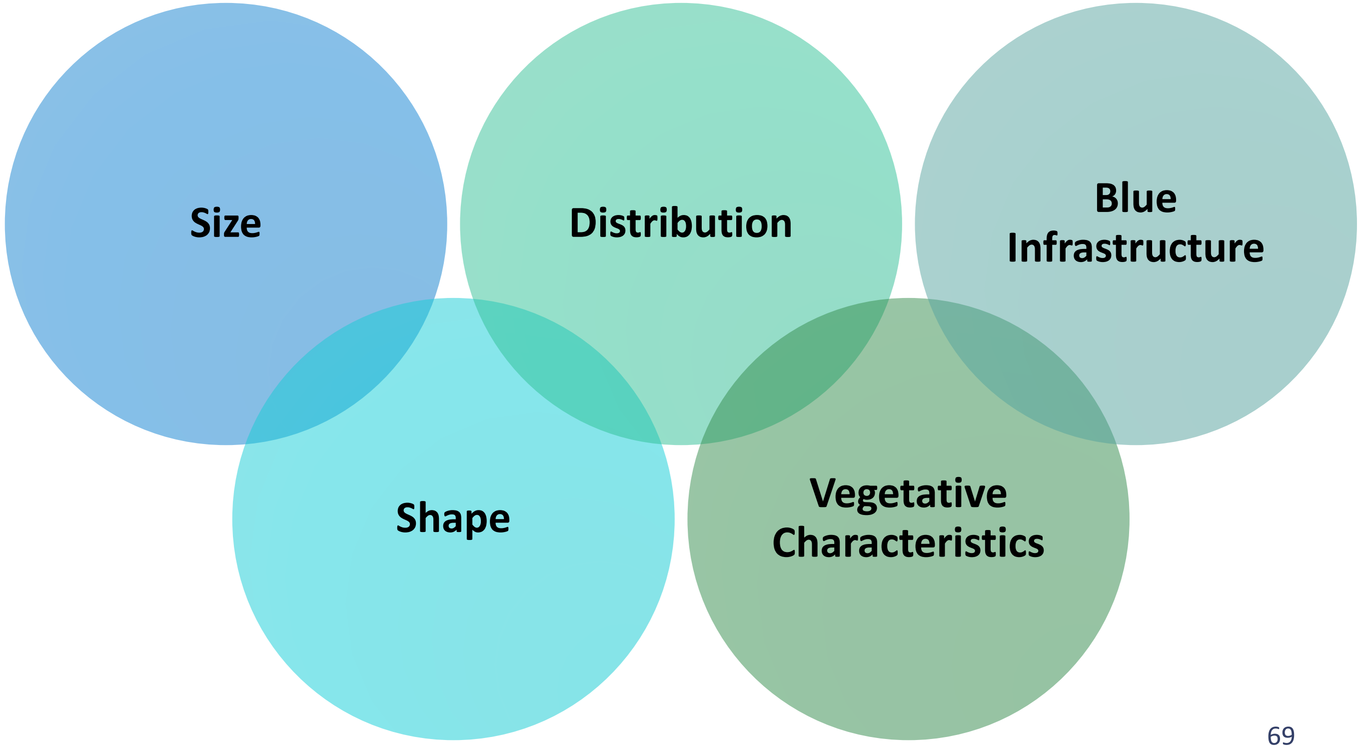
"This global systematic review highlights the **<u>minimal evidence on human health and social well-being</u>** relating to green infrastructure for stormwater and flood management"

-Venkataramanan et al. (2019)

"In small parks … pollutant removal by vegetation is **<u>unlikely to make the major contribution to improved air quality</u>** in their interiors"

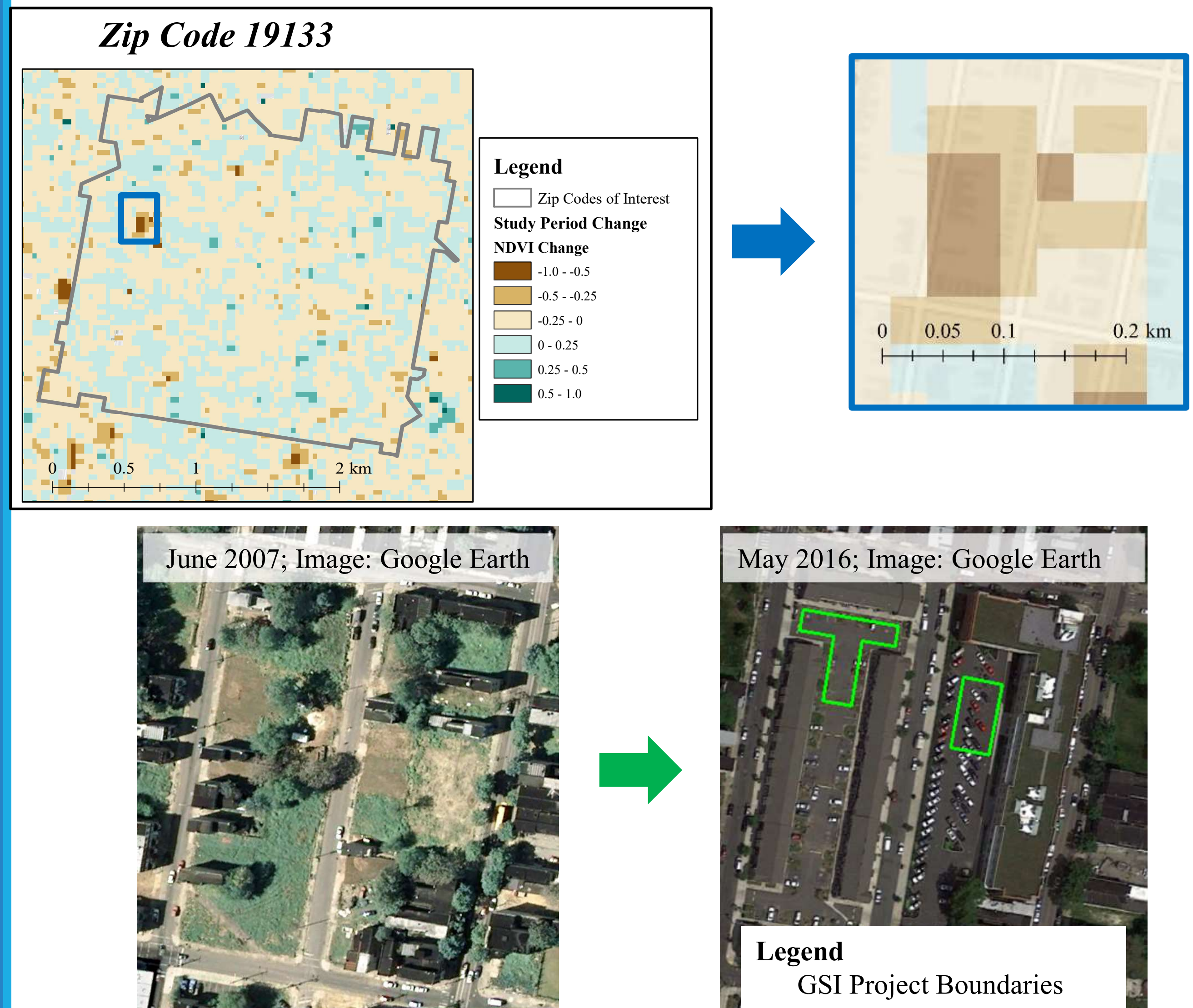
-Xing & Brimblecombe (2020)

Benefit	Reference
Improved air quality	(Xing & Brimblecombe, 2020)
Human health and well-being	(Venkataramanan et al., 2019)
Property values	(Mazzotta, Besedin, & Speers, 2014)
Urban cooling	(Yu et al., 2020)



Previous work using high resolution vegetation modeling showed that GSI installation is not offsetting development in Philadelphia.

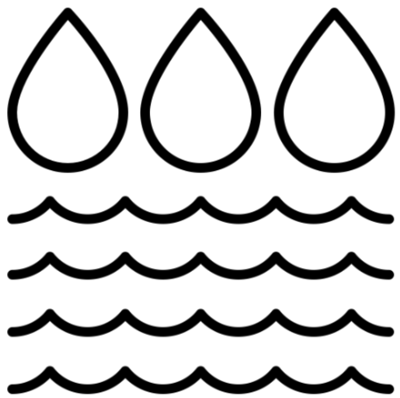
(Spahr et al., 2020)



For the i-DST, we focused on 13 benefits

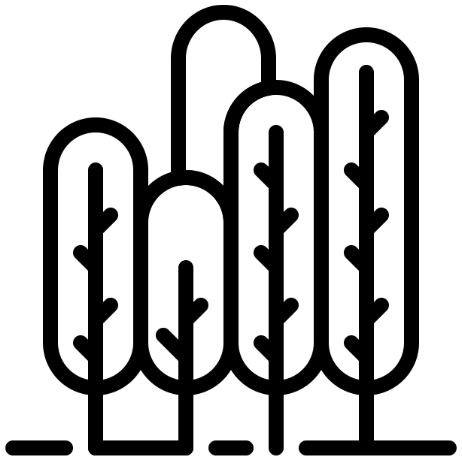
Benefits were analyzed by driver:

Hydrologic processes or vegetation



Hydrologic-process-based Benefits

- Improved water quality
- Reduced impacts from flooding
- Reduced burden on existing infrastructure
- Increased local groundwater resources
- Cistern-specific benefits
- Increased aquatic biodiversity

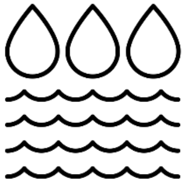


Vegetation-based Benefits

- Increased recreational opportunities
- Increased terrestrial biodiversity
- Increased property values
- Neighborhood beautification
- Human health and well social well being
- Improved air quality
- Neighborhood cooling

Images from the Noun Project

Different benefit drivers require different benefit assessments



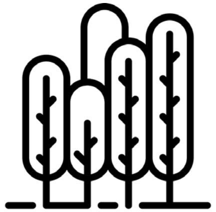
Hydrologic-process-based Benefits

Straightforward to measure through stormwater modeling

Benefit	Metric	Lower Value Preferred?	BR	IT	PP	UDS	UIS	VS
-	Total capital cost	Yes	1.00	0.06	0.54	0.48	0.26	0.00
Vegetated benefits	Total potential vegetated area	No	0.26	0.00	-	-	-	1.00
Reduced impacts from flooding	Flow exceedance frequency	Yes	0.32	0.39	0.39	1.00	0.61	0.00
Increased groundwater resources	Total groundwater recharge potential	No	0.00	0.12	0.07	-	1.00	0.65
Neighborhood Cooling	Total evapotranspiration	No	1.00	0.82	0.88	-	-	0.00
Improved water quality	Average annual load of total phosphorus at outlet	Yes	0.00	0.01	0.09	1.00	0.07	0.09

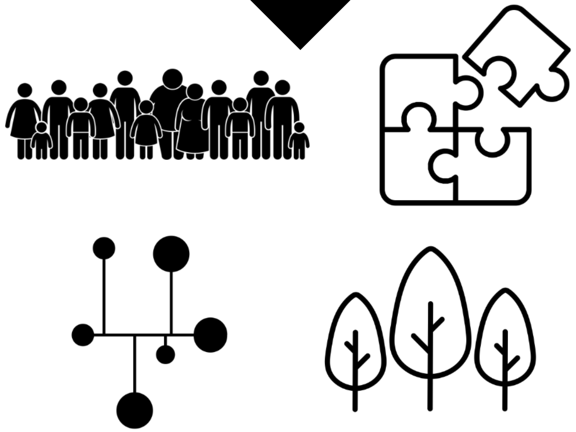
Key: ← More preferred ←

i-DST SUSTAIN



Vegetation-based Benefits

Require knowledge of surrounding urban green infrastructure



4 Cs: Community, context, connectivity, canopy

Images from the Noun Project

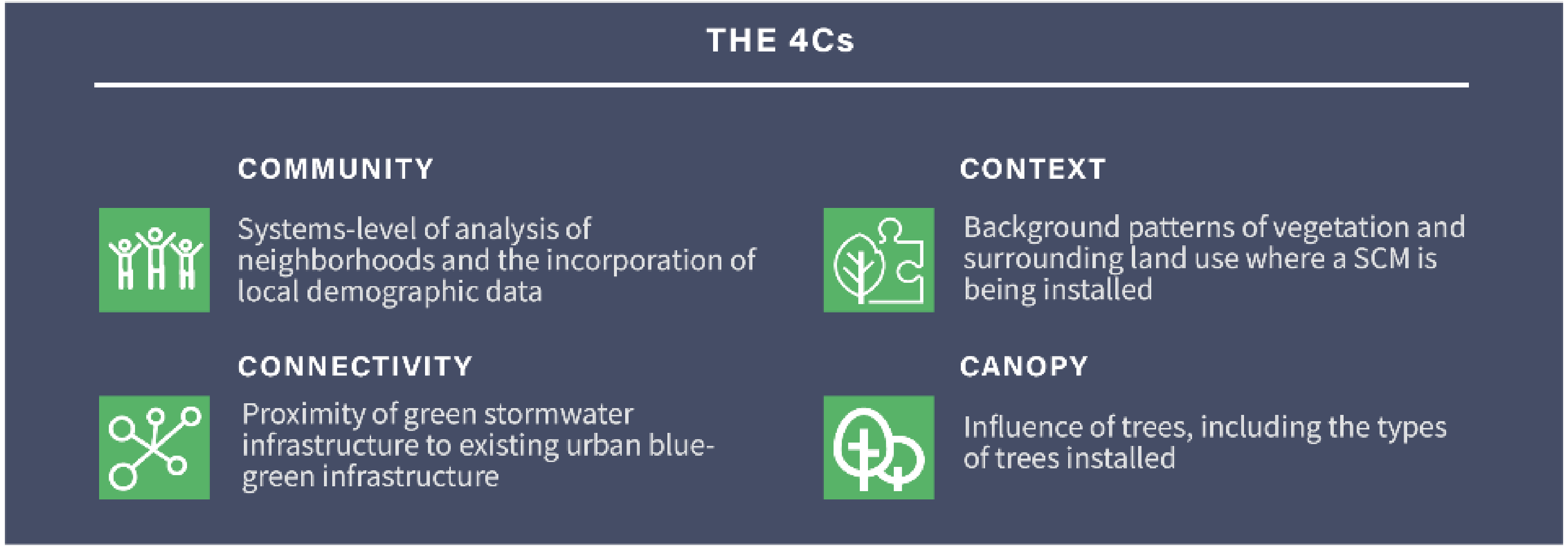
The 4Cs

Conceptual framework to be used to help practitioners assess trade-offs between benefits

Pulled from common themes in the vegetated benefit literature

Promotes and supports scientifically sound decisions and multi-functional planning

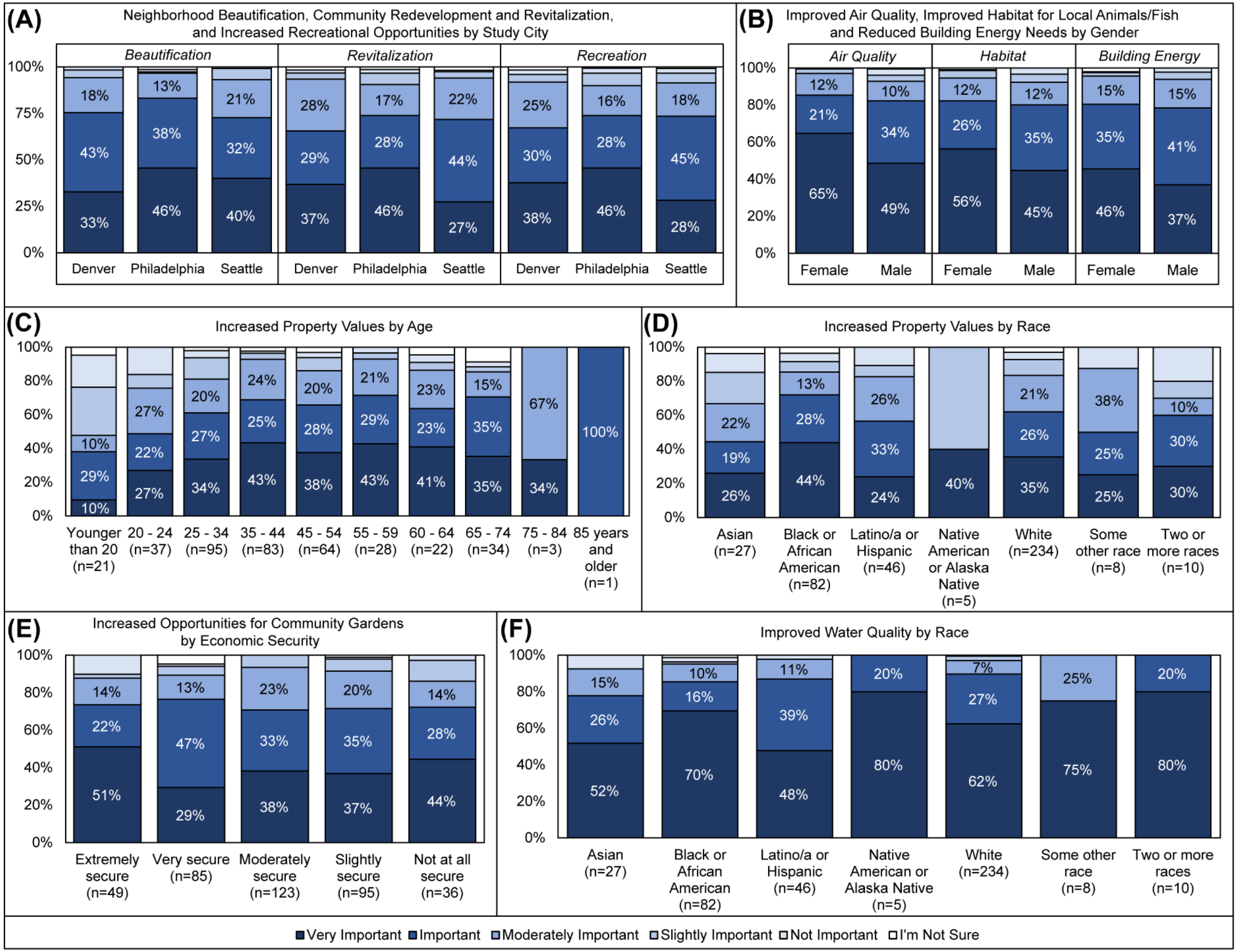
(Spahr et al., 2021)



i-DST Benefit Factsheets

- Summarize literature
- Identify trade-offs
- Jumping off point for stormwater managers
- Will be hosted on i-DST website

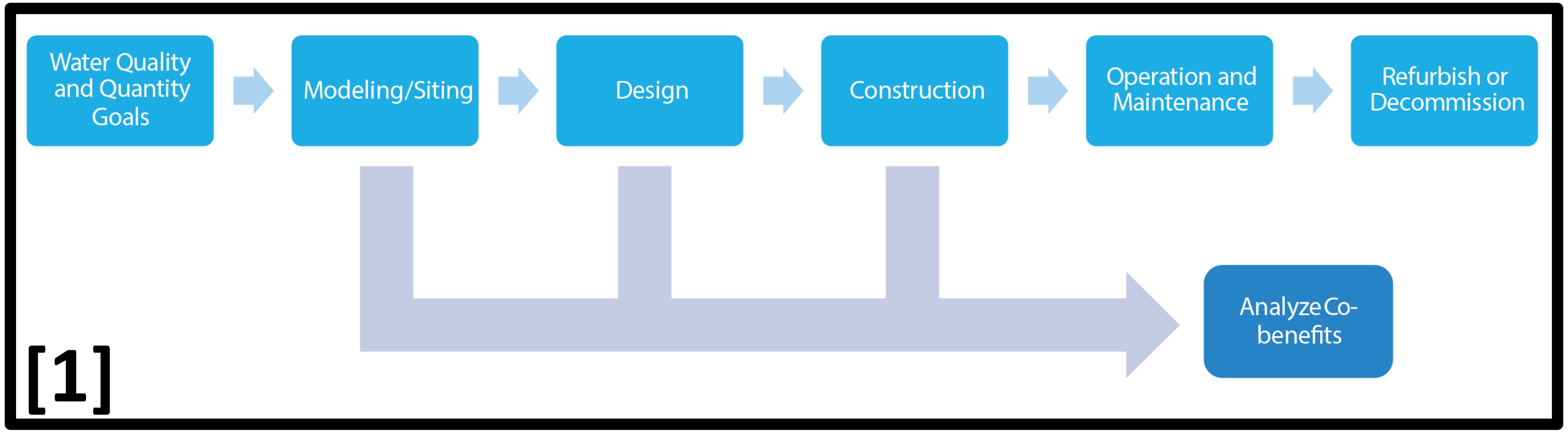
Preference for co-benefits varies over location and demographics.

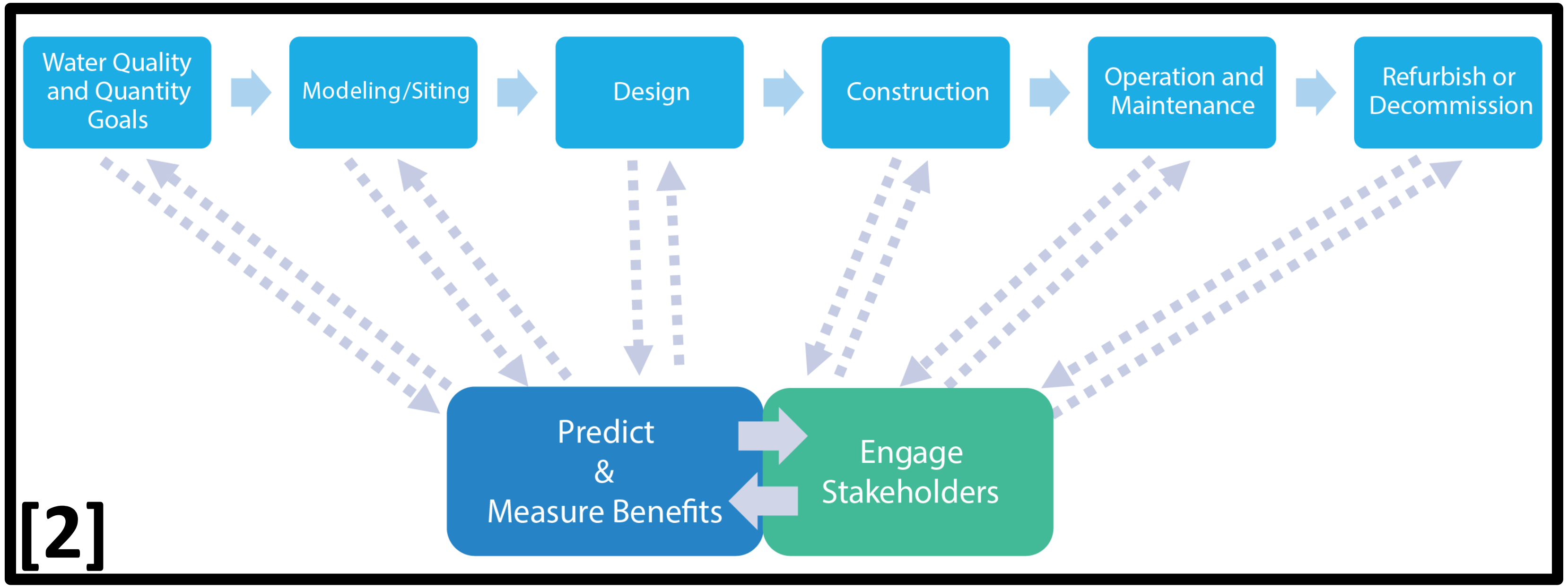


(Spahr et al., *In press*)

Shifting to Multi-functional Design

Moving away from post-processing analysis [1] to using benefit assessments to help each stage of the design process [2].





We need your help setting the research agenda for stormwater capture and use!

WRF Project 4841: Assessing the State of Knowledge and Research Needs for Stormwater Harvesting

Project Lead by Carollo Engineers

Please fill out this quick survey:

https://www.surveymonkey.com/r/stormwaterharvesting

Will drop link into the chat

References

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Where Do We Go From Here?

For more information, please visit:

> EPA’s Water Reuse Action Plan Home Page:
https://www.epa.gov/waterreuse/water-reuse-action-plan

> Action 3.3 page on the WRAP Online Platform:

https://www.epa.gov/waterreuse/national-water-reuse-action-plan-online-platform?action=3.3

Thank You For Joining Us!