GREEN RAINWATER INFRASTRUCTURE & NATURAL ASSETS:

Cost-effective approaches for climate resilience & water quality

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Burrard Inlet Science Symposium | May 13, 2019

Climate Adaptation & Water Quality

HOT OFF THE PRESS… EVERY DAY, A NEW STORY ABOUT CLIMATE CHANGE IMPACTS & URBAN WATER POLLUTANTS

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ANALYSIS | 'We are not well prepared': An expert's view of climate change and the next big storm

The federal government has struck an expert panel to consider adaptation

By Aaron Wherry, CBC News · Posted: Sep 03, 2017 5:00 AM ET | Last Updated: Sep 03, 2017 5:00 AM ET

A woman gets out of her car to check it in floodwater in Toronto back in 2013. (Frank Gunn/Canadian Press)

WEATHER August 30, 2017 10:39 am

Vancouver breaks 50-year-old temperature record and hot weather will return for long weekend

By Amy Judd

Online News Producer Global News

Comments 7 | Facebook 1.8k | Twitter | Email | Print | ...

Government must declare 'climate and biodiversity' emergency

Children may have to be taught about life forms 'in the past tense', claims Senator

Mon, May 6, 2019, 17:50 | Updated: Mon, May 6, 2019, 19:44

Kevin O'Sullivan Environment & Science Editor

Vancouver

Untreated sewage pollutes water across the country

By AINSLIE CRUICKSHANK StarMetro Vancouver

Wed., April 11, 2018

Nearly 120 million cubic metres of untreated sewage and runoff entered Canadian waterways in 2016, StarMetro has learned.

ORCAS

Human and animal fecal matter may impact the health of Southern Resident orcas

Scientists want to know how microbes in wastewater flows are affecting the Southern Resident orcas.

Author: Alison Morrow
Published: 7:21 PM PDT May 3, 2019
Updated: 7:50 PM PDT May 3, 2019

SEATTLE — Wastewater flows into Puget Sound in both treated and untreated forms, and in both, microbes like bacteria, fungus and other parasites make it into the marine environment. Scientists

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British Columbia

Potent drugs found in West Coast sewage threaten chinook salmon, study reveals

Antidepressants can make smolts 'bold,' less afraid of predators, says Seattle toxicologist

Yvette Brend · CBC News · Posted: Aug 06, 2018 6:00 AM PT | Last Updated: August 6

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Politics

Billions of litres of raw sewage, untreated waste water pouring into Canadian waterways

Conservatives introduced new rules in 2012, but problem was actually worse last year

Elizabeth Thompson · CBC News ·
Posted: Dec 12, 2016 5:00 AM ET | Last Updated: December 12, 2016

Resilience

Climate change impacts

'Coastal Cities at Risk' project ranked Metro Vancouver **11th** most vulnerable in the world for exposed assets

Organization for economic co-operation and development (OECD), 2013

Image: King tide in 2012 at the Kitsilano pool, Vancouver

Models predict

Decrease in snowpack in drinking watersheds

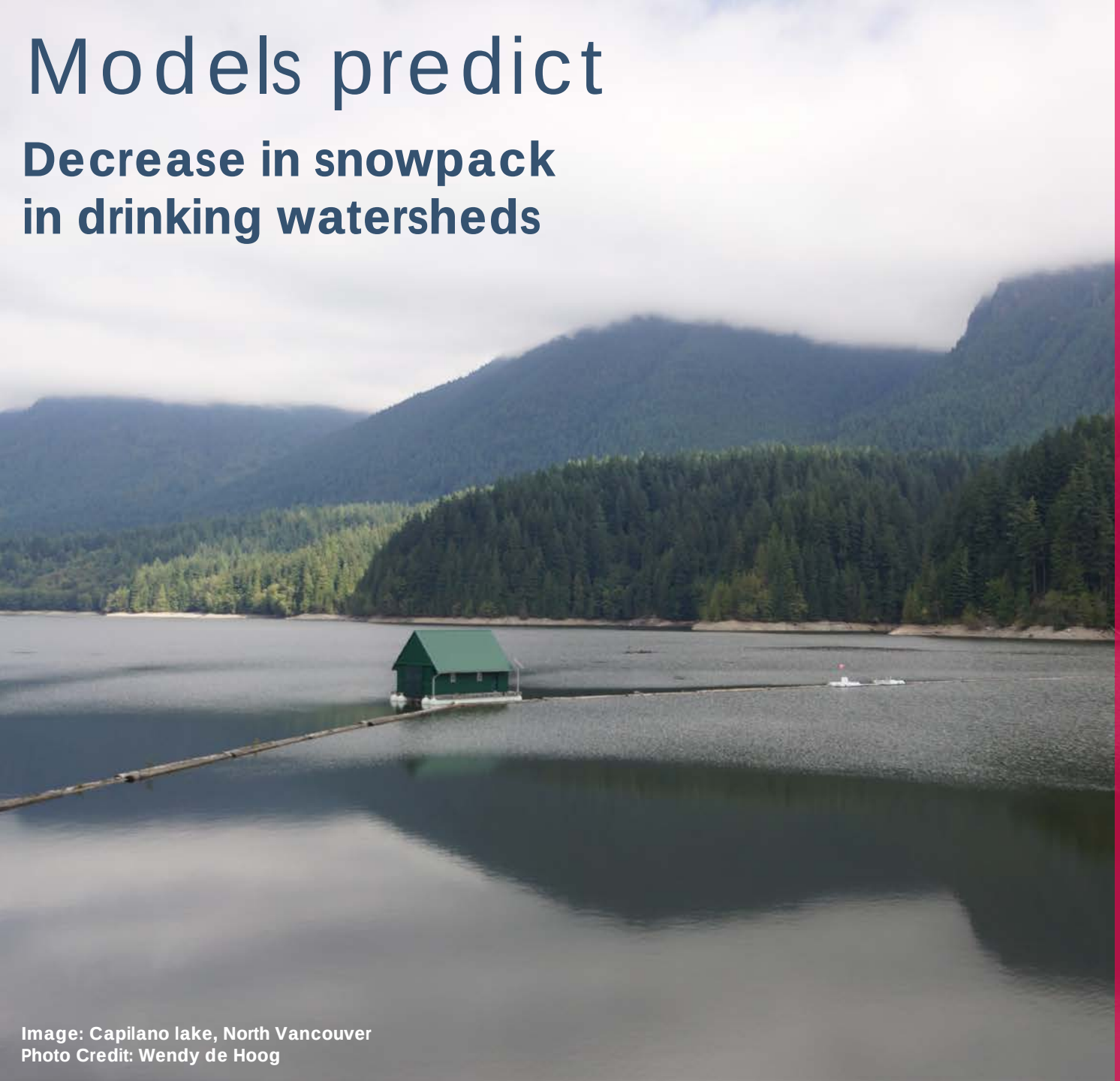


Image: Capilano lake, North Vancouver
Photo Credit: Wendy de Hoog

WARMER WINTERS

58% decrease in snowpack

WHICH MEANS

increased risk of summer drought

minimum temp goes up by 4.8°

29% reduction in home heating needs

increased risk of coastal flooding

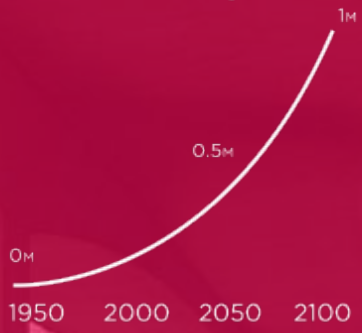
because of king tides and stormy weather

Models predict

Sea level rise of 1 meter by 2100 and 2 meters by 2200

HIGHER SEA LEVELS

Sea levels may rise 0.5 metres by 2050



Sea level rise contributes to increased flood risk

Coastal habitat for birds and fish may shrink

Image: Sea level rise public art underneath the Cambie bridge, Vancouver

Models predict

More intense rain storms like on October 12, 2017

Image: Flooding at Cambie St & W Broadway, Vancouver
Photo Credit: Alexandra Coulliard

WETTER AUTUMNS

heavy rain events **35%** more intense

21% more rain on the wettest days

WHICH MEANS

a higher flood risk

Models predict

More extreme heat

Image: Heat stress

WARMER SPRINGS

15% longer growing season

72% decrease in frost days

snow melts earlier

20% increase in April showers

HOTTER SUMMERS

more frequent heat waves

hottest days even hotter

twice as many days above 25°C

WHICH MEANS

increased health risks to vulnerable people

20% less rain

increased water restrictions

Vancouver's Rain City Strategy

Rain City Strategy

A high level, 30 year implementation plan that aims to manage rainwater sustainably through green infrastructure that

protects **restores** **mimics**

the natural water cycle

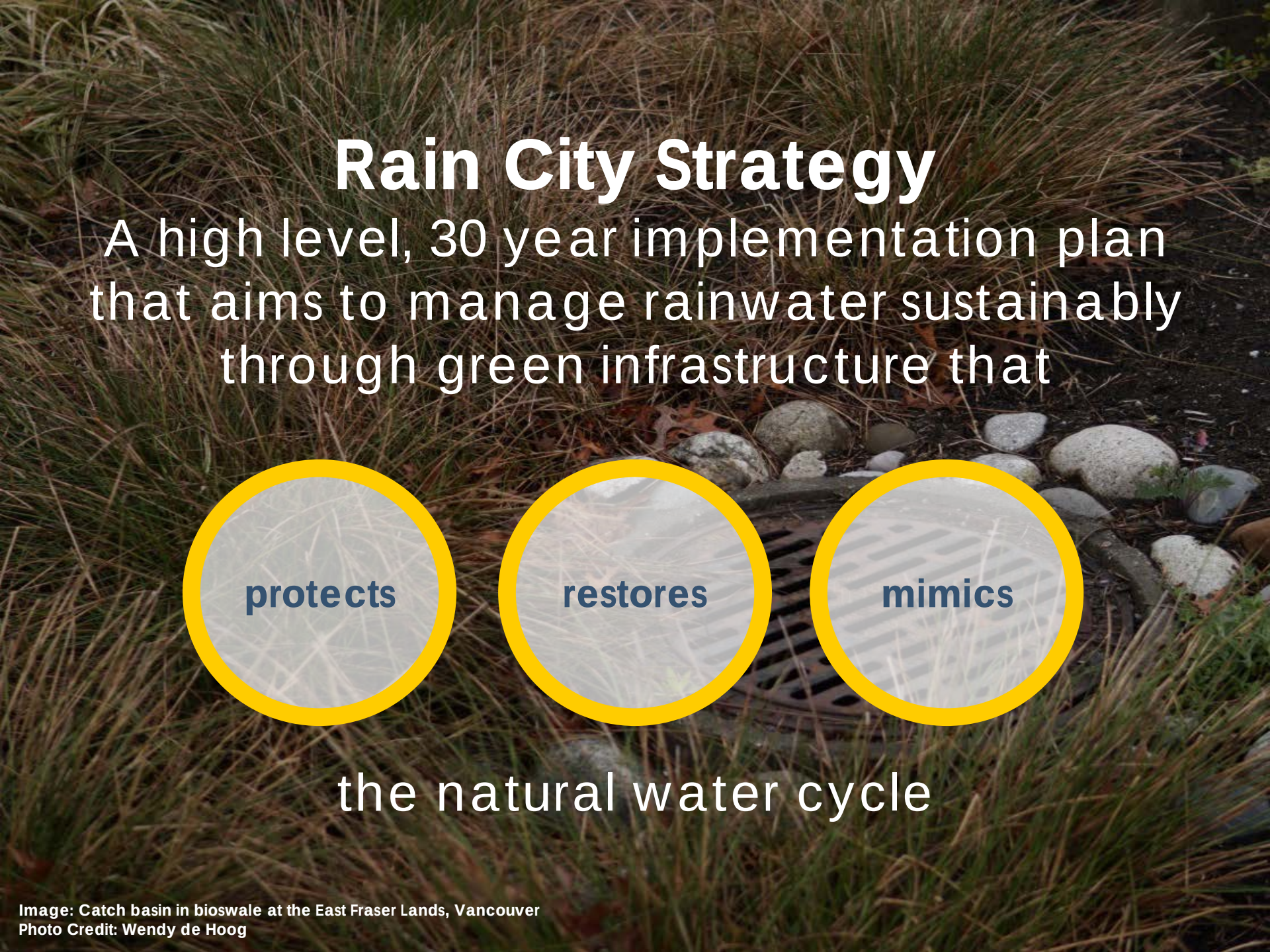


Image: Catch basin in bioswale at the East Fraser Lands, Vancouver
Photo Credit: Wendy de Hoog

Vision

Vancouver's rainwater is embraced as a valued resource for our communities and natural ecosystems

Image: Community garden, Vancouver
Photo Credit: Greenest City Action Plan update 2016-2017

Goals

Improve and protect Vancouver's **water quality**

Increase Vancouver's **resilience** through sustainable water management

Enhance Vancouver's **livability** by improving natural and urban ecosystems

Objectives

Image: Grasses at Van Dusen Gardens, Vancouver
Photo Credit: Wendy de Hoog

Scoping the implementation plan

- What tools should be applied:
  - Why (rationale)
  - Where
  - To what extent
  - When in next 30 yrs
- Who will take lead to deliver
- What resources will be needed

Mechanisms

- Policy
- Regulation
- Design standards
- Operating procedures
- Retrofit & enabling programs
- Incentives
- Community partnerships

Economics of green infrastructure investments

MANY CITIES ARE RETHINKING THEIR APPROACH:
Economic imperatives for green investments
(Chicago, Philadelphia and Washington DC examples)

Forbes Billionaires Innovation Leadership Money Consumer Industry Lifestyle

5,023 views | Jan 22, 2013, 07:52pm

Smart Communities will Build Green Infrastructure

The communities of the future will be smarter about their use of resources. That seems inevitable. More investment is flowing to

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METROPOLIS

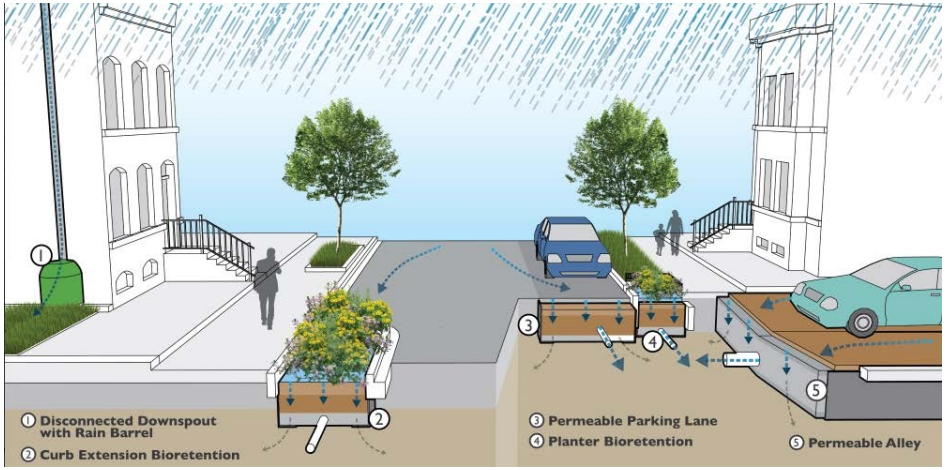
Tunnel Vision

Chicago tried to dig its way out of urban flooding decades before climate change made it a national crisis. Did the city, and its imitators, pick the wrong solution?

By HENRY GRABAR JAN 02, 2019 • 5:50 AM

WAMU | FEB 22

How D.C. Is Keeping Raw Sewage Out Of Rock Creek By 'Greening' The City



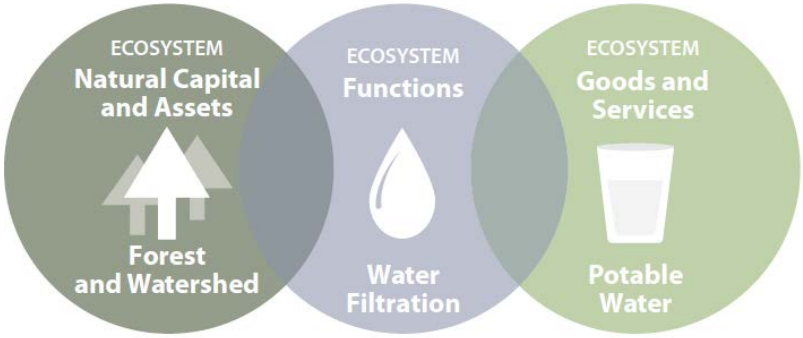
With a Green Makeover, Philadelphia Is Tackling Its Stormwater Problem

In a major initiative, Philadelphia is building an extensive network of rain gardens, green roofs, wetlands, and other infrastructure to capture stormwater. The goal is to prevent runoff from overwhelming sewers and polluting waterways and to help green America's fifth-largest city.

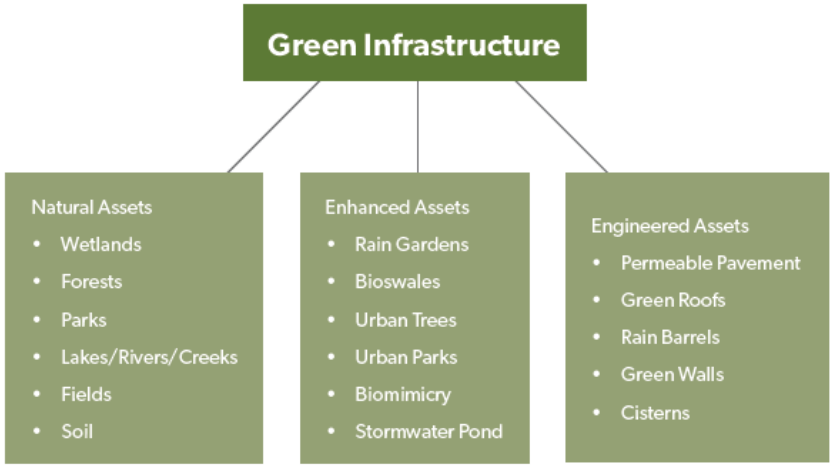
BY BRUCE STUTZ • MARCH 29, 2018

ECONOMICS OF NATURAL ASSETS:
Cost-effective services and making nature count
(District of West Vancouver example)

Link between natural capital & services

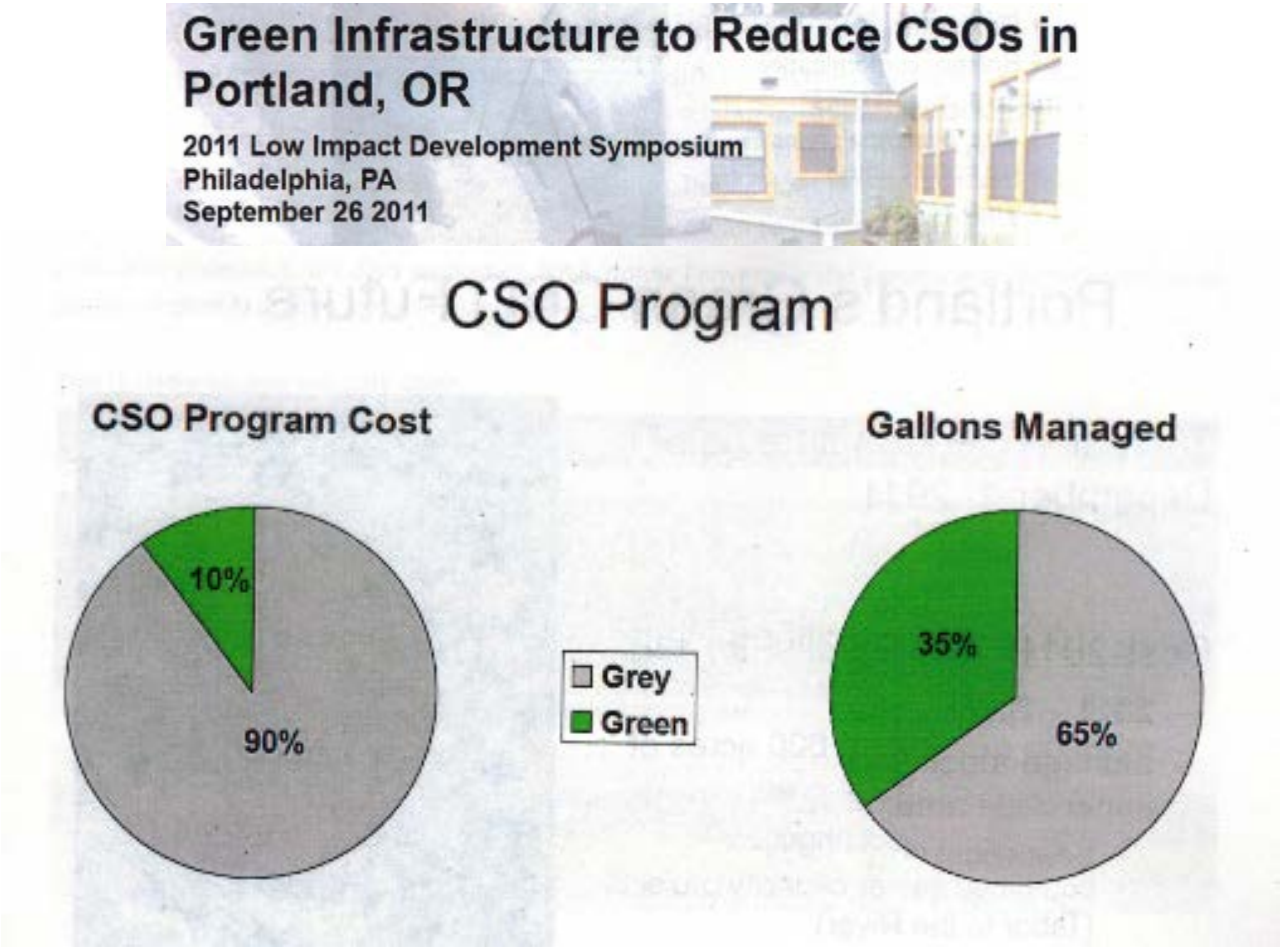


Source: Municipal Natural Assets Initiative (MNAI). 2017. *Defining and Scoping Natural Assets*. Available at https://mnai.ca/media/2018/02/finaldesignedsept18mnai.pdf



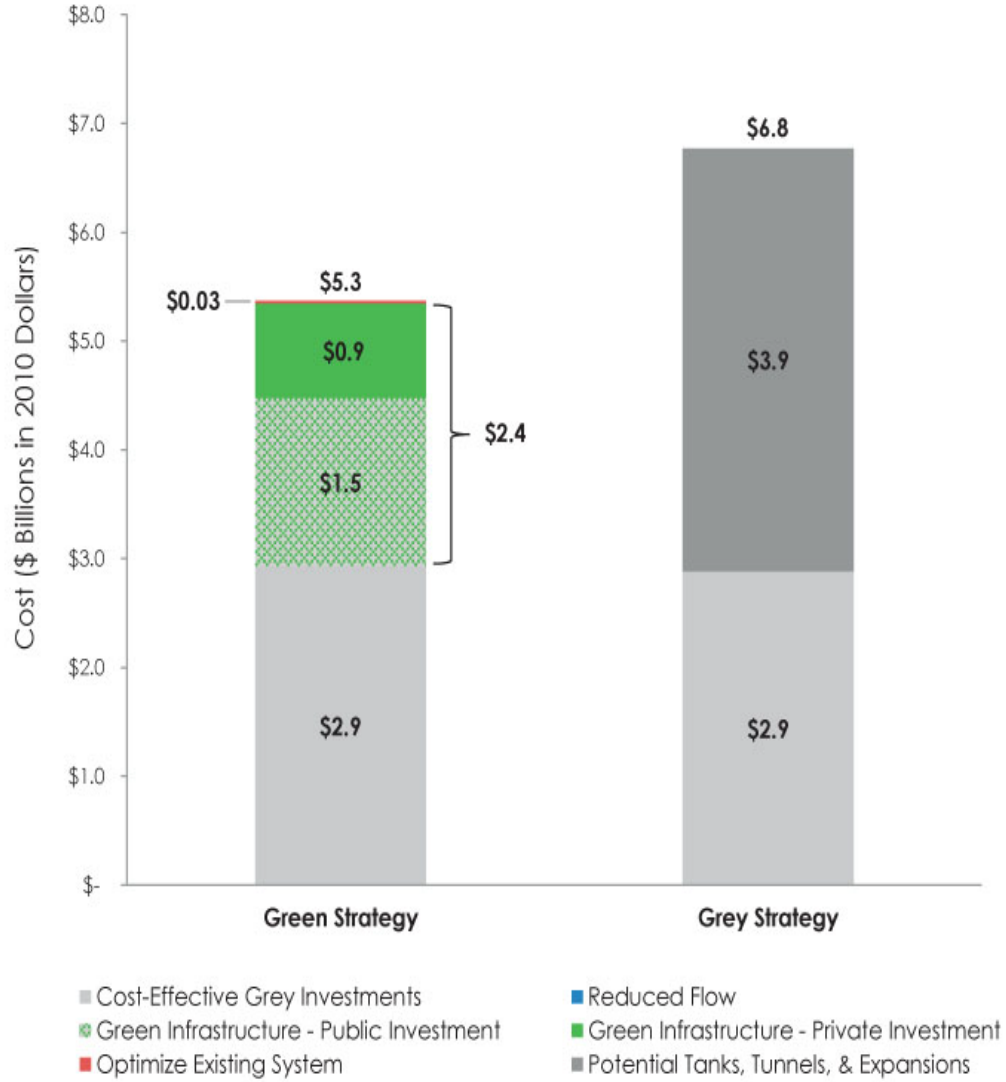
Source: Municipal Natural Assets Initiative (MNAI). 2018. *Primer on Natural Assets Management: FCM 2018 Sustainable Communities Conferences*. Available at https://mnai.ca/media/2018/01/FCMPrimer_Jan1_2018.pdf

COMBINED SEWER OVERFLOW (CSO) MITIGATION COSTS:
GI investments cost-effective & yield high performance
(City of Portland Example)

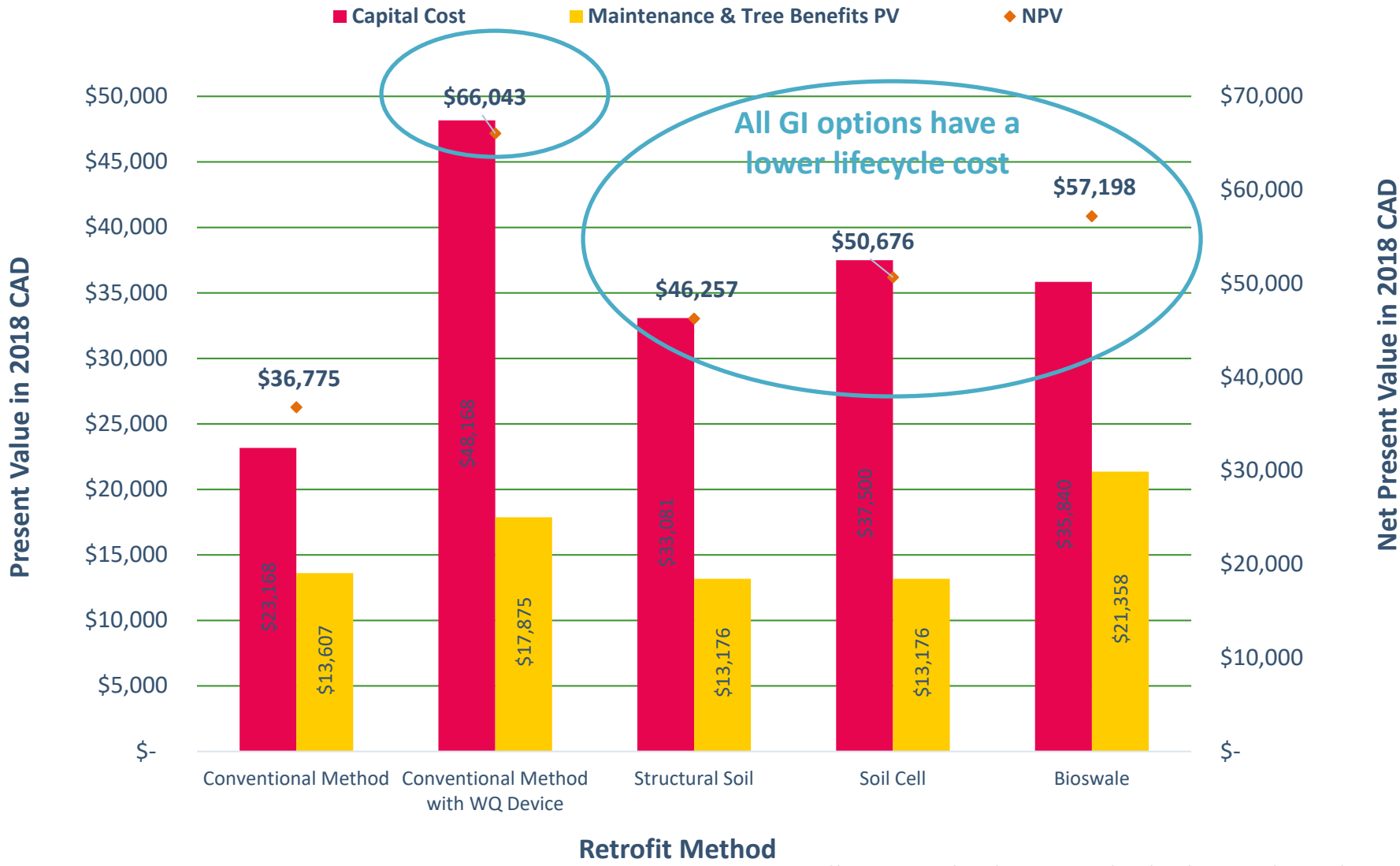


Source: Ville de Montreal Guide Technique en hydrologie Urbaine (Lasalle NHC Inc.). 2018. *Rapport d'étape-revue de littérature technique Annexe - préliminaire*.

CSO MITIGATION COSTS:
Green-Gray vs. All Gray
(New York City Example)



PUBLIC REALM GREEN INFRASTRUCTURE:
Stormwater Tree Trench Life cycle cost comparison



Source: Vega, O. 2018. *Application of Stormwater Tree Trenches in the City of Vancouver*. Available at https://sustain.ubc.ca/sites/sustain.ubc.ca/files/GCS/2018_GCS/Reports/2018-52%20Application%20of%20Stormwater%20Tree%20Trenches%20in%20the%20City%20of%20Vancouver_Vega.pdf

PUBLIC REALM GREEN INFRASTRUCTURE:
Stormwater Tree Trench Life cycle cost comparison

Practice	Stormwater Direct Benefits		Stormwater Indirect Benefits					
	Stormwater Water Quality Treatment	Stormwater Water Volume Reduction	Heat Island Effect Reduction	Groundwater Recharge	Downstream Waterbody Protection	Tree Soil Volume ($15m^3$)	Supports Greenest City Action Plan	Supports Healthy City Strategy
Conventional - No Treatment	No	No	No	No	No	No	No	No
Conventional - With Treatment	Yes	No	No	No	Yes	No	Partially	No
Structural Soil	Yes	Yes	Yes	Yes	Yes	Partially[3]	Yes	Yes
Soil Cell	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bioswale	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: Vega, O. 2018. *Application of Stormwater Tree Trenches in the City of Vancouver*. Available at https://sustain.ubc.ca/sites/sustain.ubc.ca/files/GCS/2018_GCS/Reports/2018-52%20Application%20of%20Stormwater%20Tree%20Trenches%20in%20the%20City%20of%20Vancouver_Vega.pdf

GI FOR WATER QUALITY & ECONOMIC DEVELOPMENT:
The economic impacts of '*Green City, Clean Waters*'
(City of Philadelphia example)

sbn Sustainable Business Network of Greater Philadelphia

"[Green infrastructure approaches] are simultaneously environmentally sustainable, **positive for the local economy** and beneficial to neighborhoods throughout the City"

City of Philadelphia: Green city, Clean Waters' Trip Bottom Line Benefits		
Economics	Environment	Equity
Green infrastructure is more cost-efficient than gray infrastructure and circulates more dollars with the local business community	Green infrastructure is less energy intensive than gray infrastructure	Green infrastructure creates more neighborhood benefits and more accessible employment/business opportunities than gray infrastructure

"Regulation has helped catalyze a best-in-class GSI industry cluster, with **meaningful consequences for the local economy**…and represents annual economic impact of almost $60 million within the city of Philadelphia, supporting 430 local jobs and generating nearly $1 Million in local tax revenues"

Source: Sustainable Business Network of Greater Philadelphia (Econsult Solutions Inc.). 2016. *The Economic Impacts of Green City, Clean Waters*. Available at http://planphilly.com/articles/2016/02/01/the-economic-benefits-of-green-city-clean-waters

GI ECONOMICS BLDGS & SITES:
Energy savings & avoided costs
(City of Philadelphia Example)

NRDC REPORT

DECEMBER 2013
R:13-11-C

The Green Edge: How Commercial Property Investment in Green Infrastructure Creates Value

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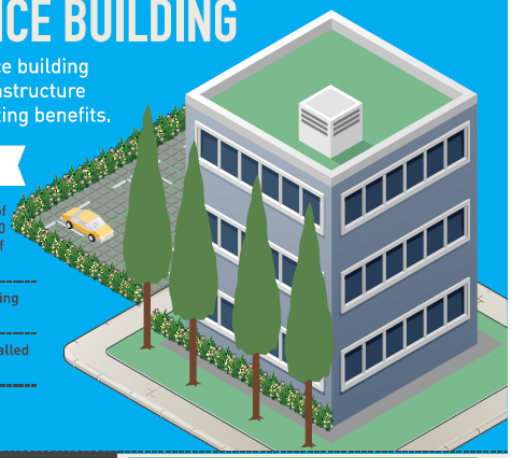
MEDIUM-SIZE OFFICE BUILDING

The figures below present the key office building assumptions, the proposed green infrastructure property improvements, and the resulting benefits.



GREEN INFRASTRUCTURE IMPROVEMENTS

17,900-sq.-ft. **green roof**, installed at the end of life of the existing conventional roof, with green covering 80 percent of the surface, or 14,300 sq. ft. (Remainder of roof is impervious area.)

20 strategically **planted trees**, 10 opposite a west-facing wall and 10 opposite an east-facing wall

10,000-sq.-ft. **permeable pavement** parking lot, installed at the end of life of the existing parking lot

Bioswales and **rain gardens** that manage 1 inch of runoff from 4,700 sq. ft. of adjacent impervious area

POTENTIAL BENEFITS

Energy savings due to reduced demand for heating and cooling	**$1,630** Annually
Avoided costs for conventional roof replacement	**$271,970** present value over 40-year analysis period
Tax credit	**$67,130** one-time credit in year of installation
Increased **rental income**	**$72,150** annually (assuming no vacancies)
Stormwater **fee reduction**	**$3,490** Annually (projected to increase 6% per year)
Total present value benefits (over 40-year analysis period)	**$1,863,000 +**

NON-QUANTIFIED BENEFITS

Increased **property values**	++
Reduced infrastructure costs due to use of permeable pavement system	+
Reduced crime	+/U
Improved **health and employee satisfaction**	+ (for tenants and employees)
Reduced costs associated with flooding	U

\+ would likely increase net benefits;
++ would increase net benefits significantly;
U direction of net change is uncertain.

BUILDING ASSUMPTIONS (BEFORE IMPROVEMENTS)

SIZE	53,600 sq. ft.
STORIES	3
ROOF SIZE	17,900 sq. ft.
LOT AREA	32,000 sq. ft.
PERMEABLE AREA (COVERED IN TURF)	1,000
ANNUAL RENT	$19.23 per sq. ft.

Present value benefits over 40-year period were estimated on the basis of a 6 percent discount rate, projected CPI, projected increase in electricity and natural gas prices in relation to CPI (based on historical relationship), and 6 percent annual increase in stormwater fees. Improvements assumed to be implemented in 2015. Avoided conventional roof replacement costs were added to net present value of other benefits. Tax credit and stormwater fee reductions are based on available credits and fee structure in Philadelphia; many other localities have similar incentives.

APARTMENT BUILDING

The figures below present the key multifamily building assumptions, the proposed green infrastructure property improvements, and the resulting benefits.

GREEN INFRASTRUCTURE IMPROVEMENTS

8,435 sq. ft. **green roof,** installed at the end of the life ofthe existing conventional roof, with green covering 90 percent of the surface, about 7,600 sq. ft.

12 strategically planted **large trees,** 6 opposite a west-facing wall and 6 opposite an east-facing wall

Bioswales and **rain gardens** that manage 1 inch of runoff from 2,635 sq. ft. of adjacent impervious area

POTENTIAL BENEFITS

Energy savings due to reduced demand for heating and cooling	**$1,780** Annually
Avoided costs for conventional roof replacement	**$128,160** present value over 40-year analysis period
Tax credit	**$52,720** one-time credit in year of installation
Increased **rental income**	**$77,720** Annually (assuming no vacancies)
Increased **property value**	**$37,500** one-time benefit to property owner at time of sale
Stormwater **fee reduction**	**$1,230** Annually (projected to increase 6% per year)
Total present value benefits (over 40-year analysis period)	**$1,740,000 +**

NON-QUANTIFIED BENEFITS

Reduced crime	+/U
Reduced costs associated with flooding	U

\+ would likely increase net benefits;
U direction of net change is uncertain.

BUILDING ASSUMPTIONS (BEFORE IMPROVEMENTS)

SIZE	33,740 sq. ft.
STORIES	4
ROOF SIZE	8,435 sq. ft.
LOT AREA	12,435 sq. ft.
PERMEABLE AREA (COVERED IN TURF)	1,000 sq. ft.
NUMBER OF UNITS	32
MONTHLY RENT	$1,265 per unit

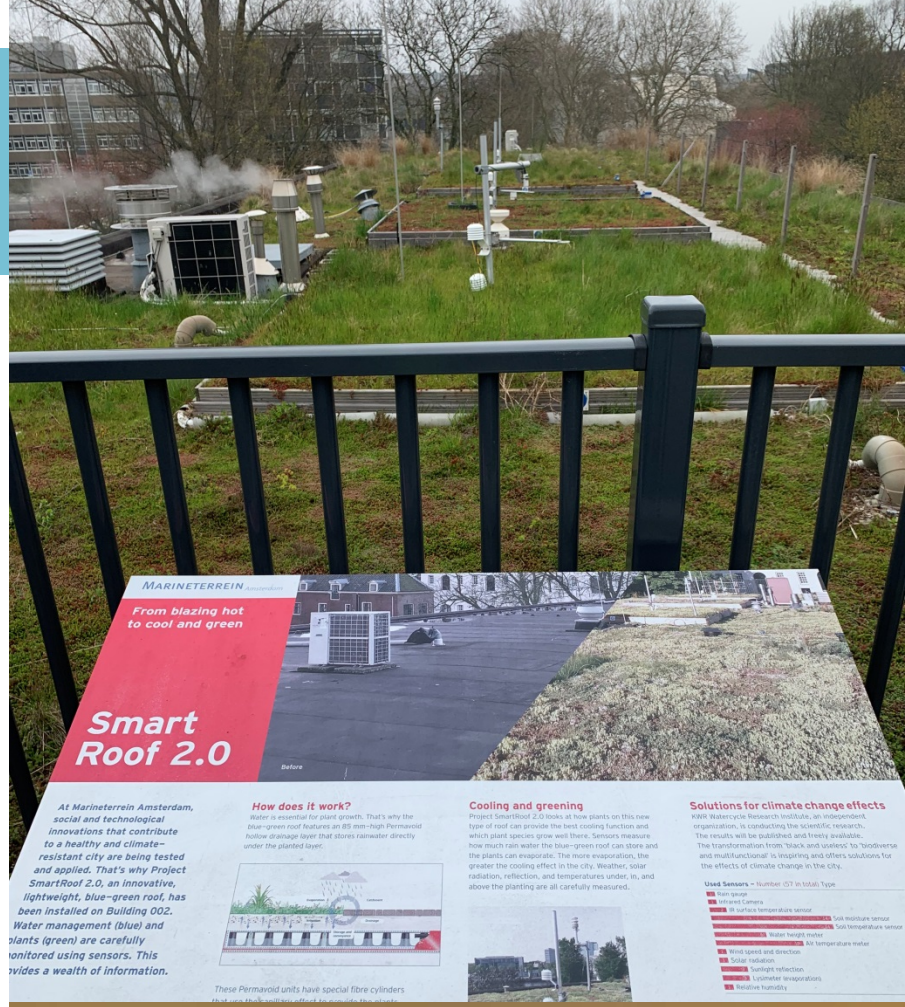
Present value benefits over 40-year period were estimated on the basis of a 6 percent discount rate, projected CPI, projected increase in electricity and natural gas prices in relation to CPI (based on historical relationship), and 6 percent annual increase in stormwater fees. Improvements assumed to be implemented in 2015. Avoided conventional roof replacement costs were added to net present value of other benefits. Tax credit and stormwater fee reductions are based on available credits and fee structure in Philadelphia; many other localities have similar incentives.

Source: Natural Resource Defense Council (NRDC). 2013. *The Green Edge: How Commercial Property Investment in Green Infrastructure creates Value*. Available at https://www.nrdc.org/sites/default/files/commercial-value-green-infrastructure-report.pdf

GI ECONOMICS BLDGS & SITES:
Smart Roof 2.0
(City of Amsterdam Example)

Blue-Green Roofs in Amsterdam are designed to manage between 60 and 150 mm of rainfall per 24 hrs

The air conditioning units were no longer needed with blue-green Smart Roof



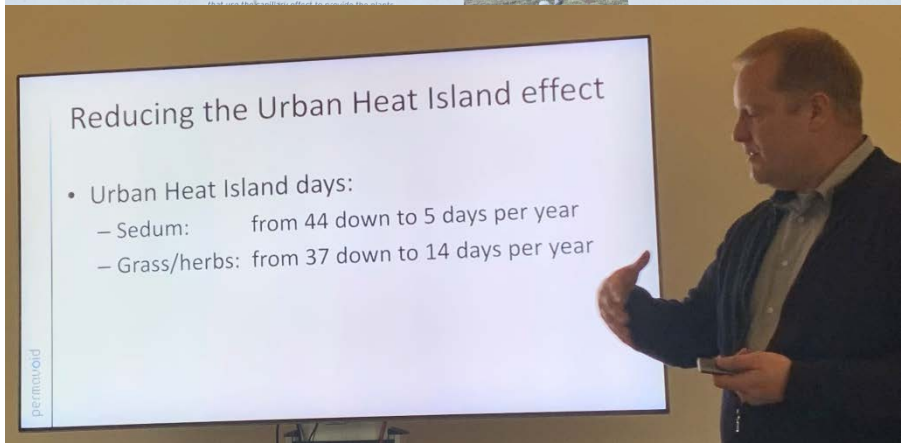


Photo credits: Melina Scholefield. More info:
https://www.marineterrein.nl/en/project/project-smartroof-2-0/

Thank you

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