

Planeación y Gestión Integral del Recurso Hídrico (IRMP)

Eduardo Behrentz, Ph.D.

behrentz@gmail.com

Instituto Colombiano de Aprendizaje
(INCAP)





AGRADECIMIENTOS Y REFERENCIAS



Rain City Strategy:

A green rainwater infrastructure and rainwater management initiative

City of Vancouver
November 5, 2019

A special thank you to...

The report authors:

Tugce Conger
Alex Couillard
Wendy de Hoog
Chris Despins
Timothy Douglas
Yette Gram
Jenikka Javison
Robb Lukes
Cameron Owen
Michelle Pollard
Jack Satzewich
Melina Scholefield

The Rain City Strategy Expert Panel:

Celia Brauer, False Creek Watershed Society
Crystal Campbell, Kerr Wood Leidal
Deborah Carlson, West Coast Environmental Law
Louis Conway, Architecture2, AIBC
Gamma Dunn, Iahka Consulting
Kathy Dunster, Kwantlen Polytechnic University
Sarah Gergel, University of British Columbia
Cynthia Girling, University of British Columbia SALA
Rob Larson, Eböwater
Kees Lokman, University of British Columbia SALA
Vicky Marlett, Simon Fraser University
Daniel Roehr, University of British Columbia SALA

We are also very grateful to the many more staff from the Green Infrastructure and Landscape Teams, the Buildings and Sites Working Group and across dozens of branches within Engineering Services, Planning, Urban Design, and Sustainability (PDS), Development, Buildings and Licensing (DBL), Real Estate Facilities Management (REFM), Finance, Risk and Supply Chain Management (FRS), and the Vancouver Board of Parks and Recreation who contributed their ideas, energy, and leadership to inform the Rain City Strategy and Action Plans.

The Rain City Strategy Staff Working Group:

Brad Biedal
Wendy de Hoog
Chris Despins
Eric Duvochel
Natalia Lubiw
Jordan McAuley
Chris Radzinski
Melina Scholefield
David Uyesugi

The Illustrator:

Matthew Thomson

Carmen Rosen, Still Moon Arts Society
Lisa Parker, Gilzon
Sara Four, Kerr Wood Leidal
Hans Schreier, University of British Columbia
Randy Sharp, Randy Sharp Landscape Architecture
Glen Shukhan, Urban Systems
Kim Stephens, Partnership for Water Sustainability
Louise Towell, Stream of Dreams
Jack Tupper, Hapa Collaborative
Ted van der Gulik, Partnership for Water Sustainability
Carlos Vargas, Nature-based Solutions Specialist
Christianne Wilhelmson, Georgia Strait Alliance



Article

Sustainable Rainwater Management Concept in a Housing Estate with a Financial Feasibility Assessment and Motivational Rainwater Fee System Efficiency Analysis

Izabela Godyn^{1,*}, Agnieszka Grela¹, Dominika Stajno² and Patrycja Tokarska²

- Faculty of Environmental and Power Engineering, Politechnika Krakowska, 31-155 Kraków, Poland; agnieszka.grela@pk.edu.pl
 - Master's Programme in Spatial Planning, Faculty of Environmental and Power Engineering, Politechnika Krakowska, 31-155 Kraków, Poland; dominikastajno@gmail.com (D.S.); ppatrycja.tokarska@gmail.com (P.T.)
- * Correspondence: izabela.godyn@pk.edu.pl; Tel: +48-12-628-28-92

Received: 23 November 2019; Accepted: 31 December 2019; Published: 3 January 2020



Abstract: Unresourceful usage of rainwater continues to be a serious problem as this type of natural resource is still treated as wastewater that most often ends up directly in the sewer system. The aim of the article is to present a concept of sustainable rainwater management within a completed housing estate in Cracow (Poland). Sustainable solutions are proposed, such as rain gardens, soakaways, permeable surfaces, and infiltration boxes, limiting the surface runoff, feasible for implementation in an existing development. Their efficacy was shown by estimating the runoff reduction and two financial assessments: (1) the required investment costs converted to costs per 1 m² of residential area and as per 1 household, and (2) the assessment of financial profitability by the rate of return and the payback period, which are the basic tool for making decisions by potential investors: developers and residents. On the cost side, investment costs are included, and on the benefit side, savings resulting from the reduction of national and municipal rainwater fees. The analysis also aims to examine the incentive nature of these fees. National rainwater drainage fees, which have been introduced to encourage rainwater retention, have low non-incentive rates and the potential benefits of reducing them maybe around 1% of investment capital, which gives a payback period of almost 100 years. Higher rates of municipal fees are more motivating for investors; the proposed concept of rainwater management can potentially bring savings of around 9% (rate of return), and investment can be recovered within 12 years.

Keywords: rainwater management; green infrastructure; rainwater fees; rate of return; payback



Water-Energy Nexus 3 (2020) 29–40



Contents lists available at ScienceDirect

Water-Energy Nexus

Journal homepage: www.keaipublishing.com/en/journals/water-energy-nexus/



Integration of green and gray infrastructures for sponge city: Water and energy nexus

Yongjun Sun^{a,*}, Li Deng^a, Shu-Yuan Pan^b, Pen-Chi Chiang^c, Shailesh S. Sable^d, Kinjal J. Shah^{a,e}

- ^a College of Urban Construction, Nanjing Tech University, Nanjing 211800, China
^b Department of Biomechanical Systems Engineering, National Taiwan University, Taipei City 10617, Taiwan
^c Carbon Cycle Research Center, National Taiwan University, Taipei 10672, Taiwan
^d Department of Civil and Environmental Engineering, University of Alberta Edmonton, Alberta T6G 1H9, Canada

ARTICLE INFO

Article history:
Received 6 November 2019
Revised 12 February 2020
Accepted 31 March 2020
Available online 8 April 2020

Keywords:
Green infrastructure
Sponge city
Water and energy
Evaluation

ABSTRACT

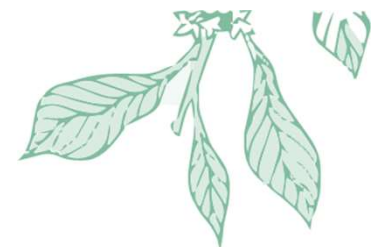
In the past few decades, urban flooding and water shortages caused by the rapid expansion of cities and the destructions of construction ecology have been harshly lost. The current ecological rainwater management system is based on the traditional gray infrastructure and cannot effectively solve the water problems of different scales. Sponge city, as an advanced rainwater management technology, plays a vital role in urban transformation and new construction. While building a sponge city, the gray infrastructure will be integrated to form a gray-green infrastructure integration, and the relationship between water and energy in the sponge city will be coordinated. This paper proposes the problems encountered in the transformation of the gray infrastructure of the sponge city to the green infrastructure and the measures to be taken. The integrated indicator system is used to comprehensively evaluate the integration of the gray-green facilities.
 © 2020 The Authors. Production and hosting by Elsevier B.V. on behalf of [Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License](http://creativecommons.org/licenses/by-nc-nd/4.0/).



Mauricio Herrera, Ph.D, P.Eng - 1er
Principal Consultant (Water Resources) at SRK Consulting
Vancouver, Columbia Británica, Canadá - [Información de contacto](#)

SRK Consulting





CONTEXTO





Adaptación, adaptación, adaptación

ARTÍCULO 3. EJES DE TRANSFORMACIÓN DEL PLAN NACIONAL DE DESARROLLO. El Plan Nacional de Desarrollo se materializa en las siguientes cinco (5) transformaciones:

1. Ordenamiento del territorio alrededor del agua. Busca un cambio en la planificación del ordenamiento y del desarrollo del territorio, donde la protección de los determinantes ambientales y de las áreas de especial interés para garantizar el derecho a la alimentación sean objetivos centrales que, desde un enfoque funcional del ordenamiento, orienten procesos de planificación territorial participativos, donde las voces de las y los que habitan los territorios sean escuchadas e incorporadas.

2. Seguridad humana y justicia social. Transformación de la política social para la adaptación y mitigación del riesgo, que integra la protección de la vida con la seguridad jurídica e institucional, así como la seguridad económica y social. Parte de un conjunto





DE VANCOUVER A MONTERÍA (Pasando por Pereira)





Para algunos, el agua es cuestión de practicidad. Para otros, el agua es un regalo, incluso sagrado. Para todas las especies vivas, el agua es vida.



**HUMAN RIGHTS TO
WATER AND SANITATION**





PLANEACIÓN INTEGRAL E INTEGRADA





La planeación integral del recurso hídrico comprende una visión **ambiciosa** para la **acción colectiva** en torno a la implementación de infraestructura verde de agua lluvia (**GRI**, por su sigla en inglés).





Requerimos un **enfoque renovado** hacia el mejoramiento de la **salud de los cuerpos receptores**, la reducción del **riesgo de inundaciones**, la creación de **espacios para el agua** en nuestra ciudad y el avance en la recolección y **reutilización**.

También un liderazgo y **responsabilidad compartidos**, que se extiendan más allá de **entidades e infraestructuras** públicas.

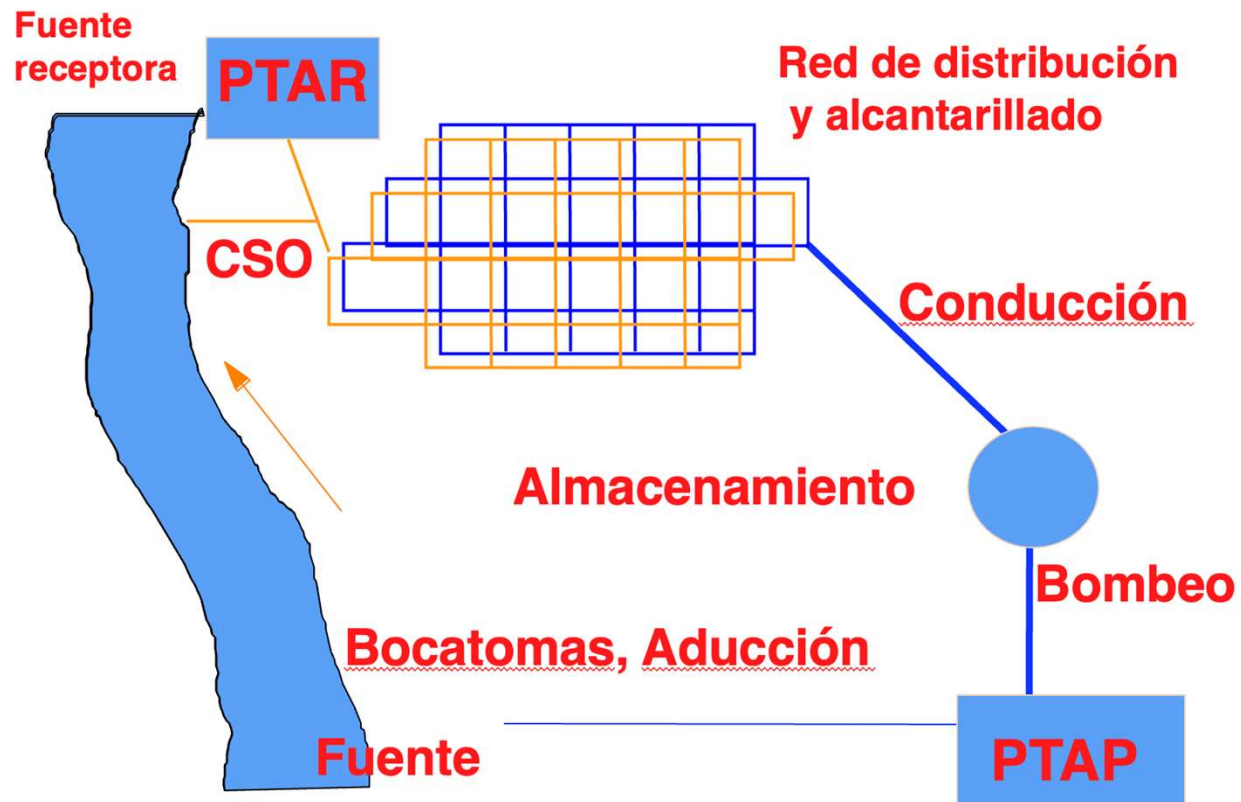




Nuevo paradigma: el recurso hídrico y los ecosistemas son entendidos como activos de la comunidad



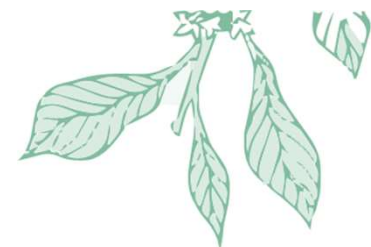
Visión Tradicional de Saneamiento





- 25% de la población mundial consume agua proveniente de fuentes contaminada.
- 700 millones de personas no tienen acceso a agua potable residencial.





PRINCIPIOS





1er Congreso
Camacol Verde
Sostenibilidad en Construcción

PRIMER PASO



- Entender al agua como recurso, **no como una amenaza**.
- Reducir demanda de agua potable (promoción de **uso sostenible**).
- Restaurar el **rol de las cuencas** urbanas para proteger los ecosistemas locales y lograr un buen manejo del agua.

Las mejores prácticas en la gestión del recurso hídrico



DISEÑAR LA CIUDAD...

- ... como **cuenca** de abastecimiento de agua.
- ... y su infraestructura para brindar **servicios ecosistémicos**.
- ... para la resiliencia, **adaptabilidad** y flexibilidad del agua.
- ... para fomentar la acción colaborativa y promover **comportamientos sabios** respecto al agua.
- ... para apoyar un **futuro equitativo** en cuanto al agua.





¿CÓMO SE LOGRA?

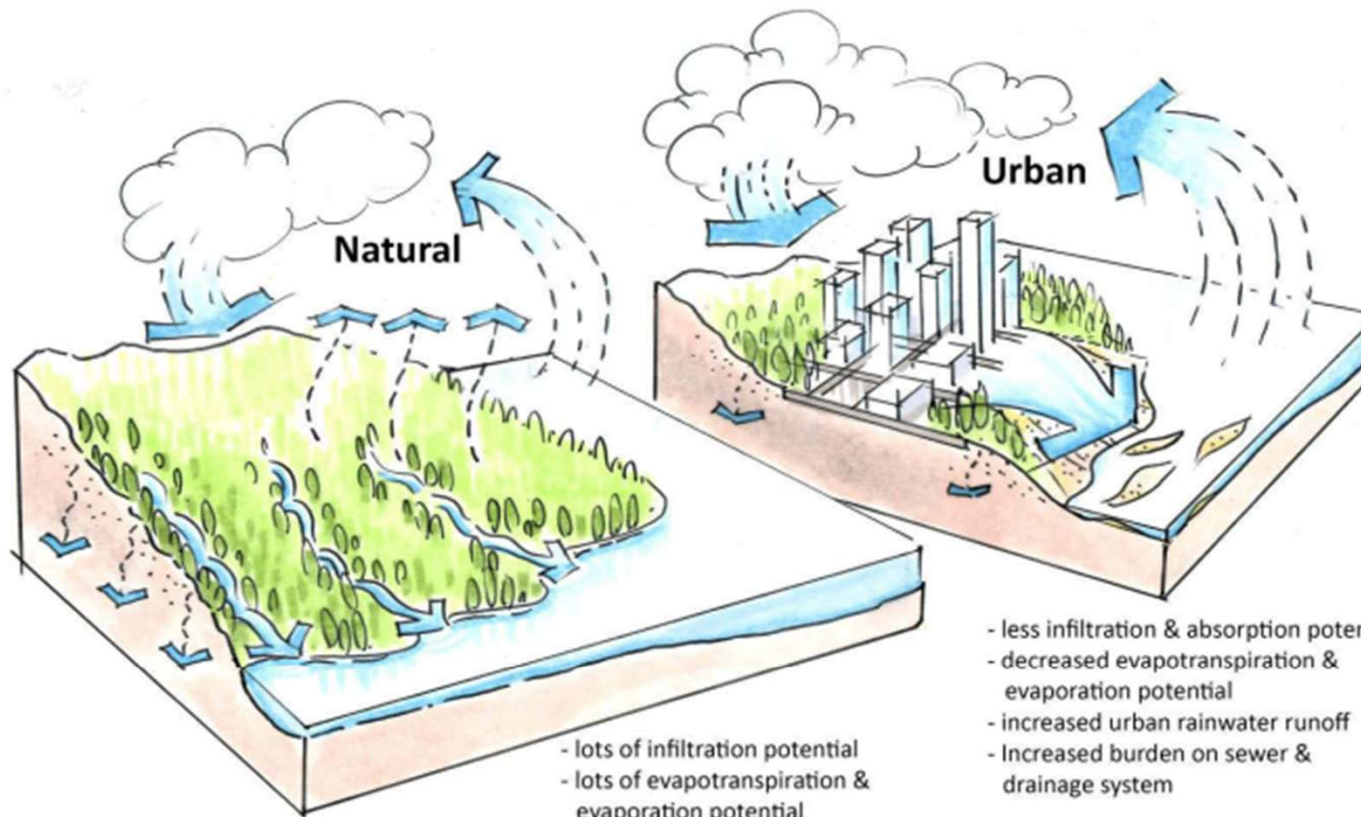




La implementación de GRI implica una aproximación **holística** en la prestación de **servicios públicos** de agua, protege la **calidad del agua**, respalda la **resiliencia** y mejora la habitabilidad y **equidad**.

También esencial en la **reivindicación de derechos** de habitantes ancestrales.





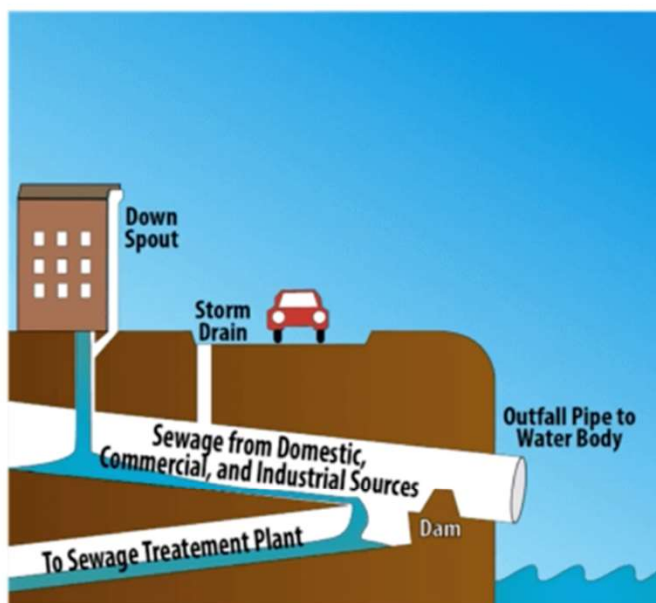
- lots of infiltration potential
 - lots of evapotranspiration & evaporation potential by plants and trees

- less infiltration & absorption potential
- decreased evapotranspiration & evaporation potential
- increased urban rainwater runoff
- Increased burden on sewer & drainage system





Dry Weather



Wet Weather

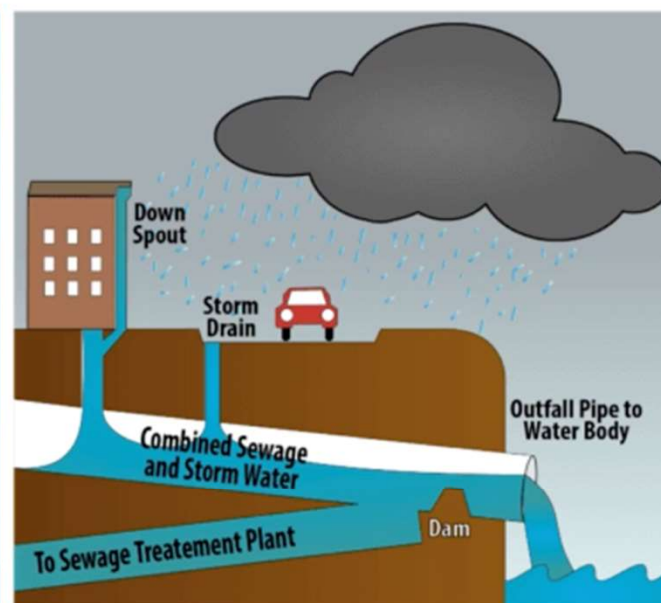


Image Credit: Sewerequipment.com





- GRI es un campo emergente que **mezcla la ingeniería con el conocimiento de los ecosistemas** para proteger, restaurar e imitar el **ciclo natural** del agua.
- Emplea suelos, plantas, árboles y **estructuras construidas** (v.g., techos verdes, trincheras de árboles, jardines pluviales) para **capturar** (infiltración, evapotranspiración, reutilización), **almacenar y limpiar el agua lluvia** antes de su absorción o entrega a un receptor.







Viabilidad y **beneficio-costo** han sido ampliamente demostrados en Norteamérica, Europa y Asia.



The value of the world's ecosystem services and natural capital

[Robert Costanza](#), [Ralph d'Arge](#), [Rudolf de Groot](#), [Stephen Farber](#), [Monica Grasso](#), [Bruce Hannon](#), [Karin Limburg](#), [Shahid Naeem](#), [Robert V. O'Neill](#), [Jose Paruelo](#), [Robert G. Raskin](#), [Paul Sutton](#) & [Marjan van den Belt](#)

Nature **387**, 253–260 (1997) | [Cite this article](#)

179k Accesses | **11695** Citations | **864** Altmetric | [Metrics](#)

Abstract

The services of ecological systems and the natural capital stocks that produce them are critical to the functioning of the Earth's life-support system. They contribute to human welfare, both directly and indirectly, and therefore represent part of the total economic value of the planet. We have estimated the current economic value of 17 ecosystem services for 16 biomes, based on published studies and a few original calculations. For the entire biosphere,

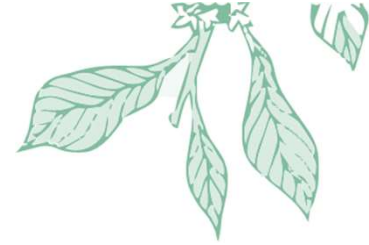
Según Costanza et. al. (2014), el valor de los **servicios ecosistémicos** a nivel global es de **140 millones de millones de dólares** anuales, es decir el doble del producto interno bruto combinado **de todos los países** del mundo.

Esto incluye **capacidad de producción y regulación hídrica**, recirculación de nutrientes, diversidad genética y captura de carbono atmosférico.

Siendo Colombia una región de **alta biodiversidad**, es esperable que en nuestro caso la proporción sea aún más favorable en el sentido del valor económico de nuestros recursos naturales.

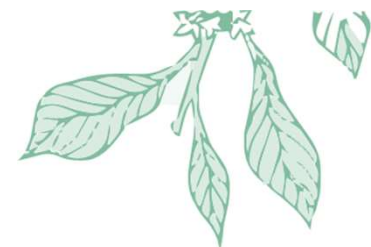
!Calculemos el **beneficio-costo!**

GESTIÓN ADAPTATIVA



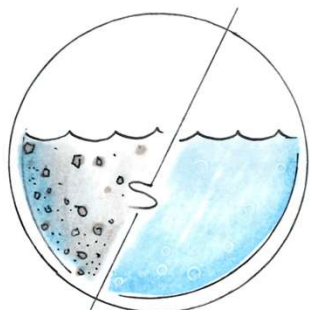
- Las técnicas GRI requieren **curiosidad**, innovación y el coraje de **aprovechar las lecciones**, tanto de éxitos como de fracasos.
- Aprender y compartir lecciones a través de proyectos y asociaciones entre niveles de gobierno, empresas, academia y otras organizaciones, permitirá la **capacidad colectiva** para ajustar los programas.





EJEMPLOS





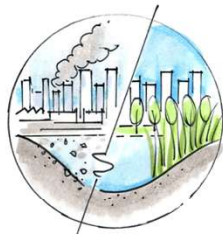
Goals: Improve and protect Vancouver's water quality



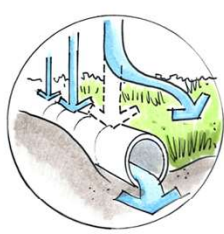
Increase Vancouver's resilience through sustainable water management



Enhance Vancouver's livability by improving natural and urban ecosystems



Objectives: Remove pollutants from water and air



Reduce volume of rainwater entering pipe system



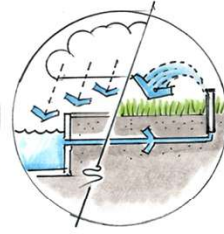
Increase managed impermeable area that treats urban rainwater runoff



Increase total green area that treats urban rainwater runoff



Mitigate urban heat island effect



Harvest and reuse water



METAS

- Mejorar y proteger la **calidad** del agua.
- Aumentar la **resiliencia** a través de una gestión sostenible del agua.
- Mejorar la **habitabilidad** mediante la mejora de los ecosistemas naturales y urbanos.



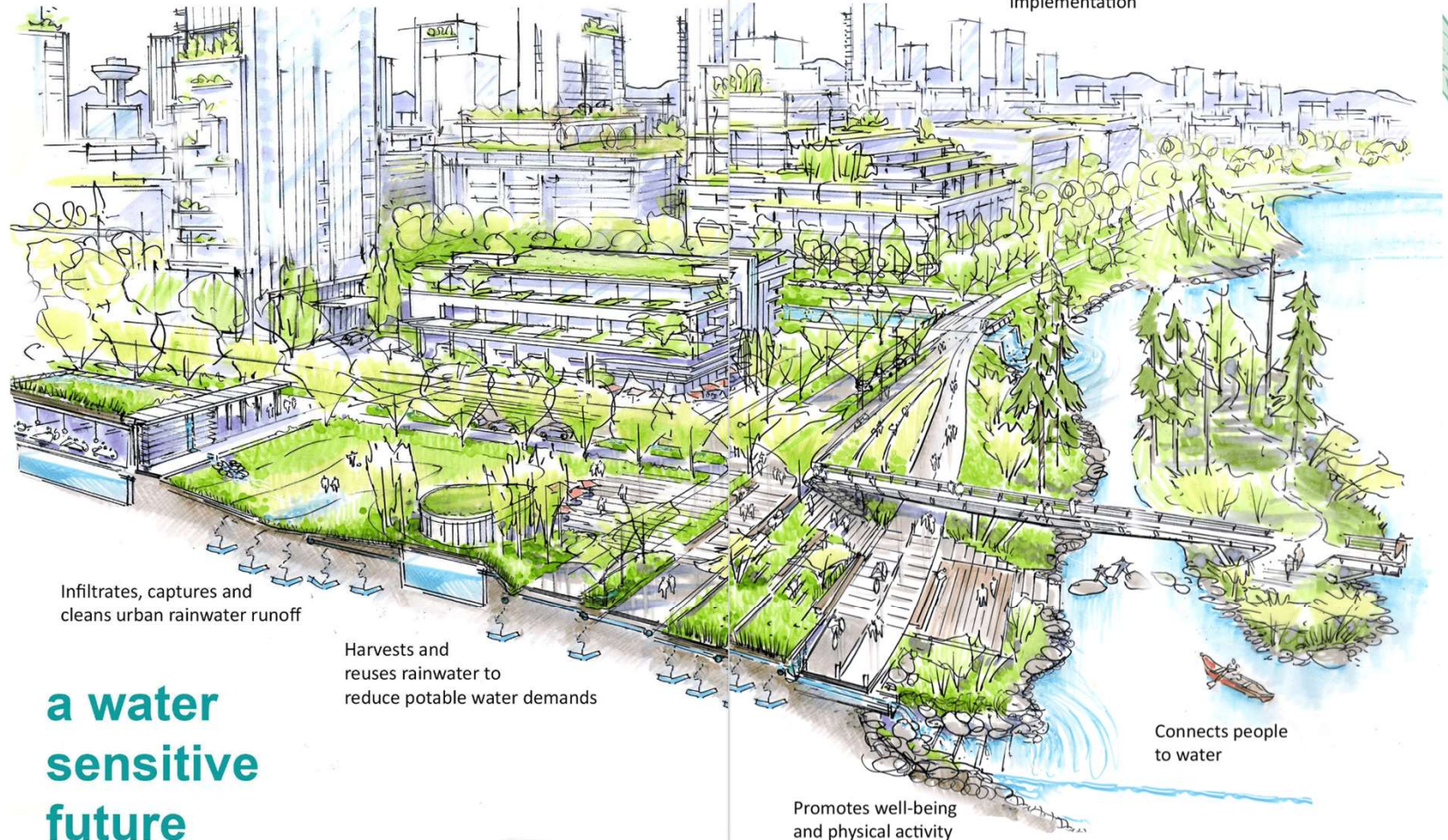
OBJETIVOS

- Eliminar **contaminantes** del agua y el aire.
- Aumentar el **área impermeable** gestionada.
- **Reducir volumen** de aguas lluvias que ingresa al alcantarillado.
- Recolectar y **reutilizar agua**.
- Mitigar el efecto de **isla de calor** urbana.
- Aumentar **área verde** total.



Helps to cool down urban environments and enhances biodiversity through trees and plants

Reduces pollution and urban flooding through GRI implementation



Infiltrates, captures and cleans urban rainwater runoff

Harvests and reuses rainwater to reduce potable water demands

Connects people to water

Promotes well-being and physical activity












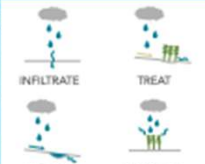
a water sensitive future







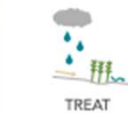




Camacol Verde

Sostenibilidad en Construcción



TOOL		IMPACTS ON WATER	BENEFITS
Absorbent Landscapes			<ul style="list-style-type: none"> intercept and clean rainwater through soil pores, allowing gradual infiltration into subsoils to recharge groundwater
Infiltration Swales			<ul style="list-style-type: none"> reduce runoff volume and increase water quality by capturing, detaining, treating, and conveying stormwater
Rain Gardens & Infiltration Bulges			<ul style="list-style-type: none"> reduce runoff volume and improve water quality by infiltrating, capturing, and filtering stormwater an overflow conveys extreme rainfall volumes
Pervious Paving			<ul style="list-style-type: none"> reduce runoff volume and improve water quality by infiltrating and treating stormwater while still providing a hard, drivable surface
Green Roofs			<ul style="list-style-type: none"> reduce stormwater peak flows and volume, depending on depth of growing medium benefit buildings by providing insulation and by reducing the heat island effect provide urban habitat
Tree Well Structures			<ul style="list-style-type: none"> adequate soil volume will retain excess stormwater and help to remove pollutants from stormwater runoff support a healthy tree canopy which intercepts rainfall



TOOL		IMPACTS ON WATER	BENEFITS
Rainwater Harvesting		 DETAIN CAPTURE & REUSE	<ul style="list-style-type: none"> runoff from roof surfaces can be captured, stored and used for non-potable uses like landscape irrigation, laundry, and toilets, subject to approval of authorities having jurisdiction.
Infiltration Trenches		 INFILTRATE DETAIN	<ul style="list-style-type: none"> reduce the volume and rate of runoff by holding and infiltrating water into subsurface soils water quality pre-treatment is advisable
Water Quality Structures		 TREAT	<ul style="list-style-type: none"> capture petroleum hydrocarbons, coarse grit and coarse sediment provide some water quality benefits except for soluble nutrients and pollutants
Detention Tanks		 DETAIN	<ul style="list-style-type: none"> reduce flooding and in-stream erosion by collecting and storing stormwater runoff during a storm event, and releasing it at controlled rates to the downstream drainage system
Daylighted Streams & Channel Improvements		 DETAIN HABITAT TREAT	<ul style="list-style-type: none"> may provide in-stream detention, water quality improvements, and essential habitat for aquatic life contribute to the liveability of an area and establish a sense of place if properly designed
Constructed Wetlands		 DETAIN HABITAT TREAT	<ul style="list-style-type: none"> provide detention, storage, habitat, and treat stormwater runoff through natural processes prior to discharging it into the downstream drainage system



BIORETENTION



RESILIENT ROOFS



RAINWATER TREE TRENCHES



SUBSURFACE INFILTRATION



LARGE SCALE PRACTICES



DOWNSPOUT DISCONNECTION



Downspout disconnection, Portland, OR

NON-POTABLE SYSTEMS



Hassalo and 8th District Blackwater Treatment, Portland, OR

ABSORBENT LANDSCAPES



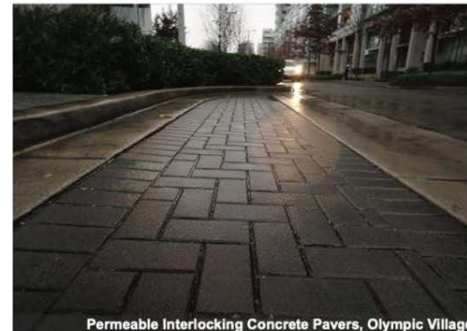
Grange Park Absorbent Landscaping, Toronto

Photo: PFS Studio

PERMEABLE PAVEMENT



Porous Rubber, 10th Avenue Bikeway, Vancouver



Permeable Interlocking Concrete Pavers, Olympic Village

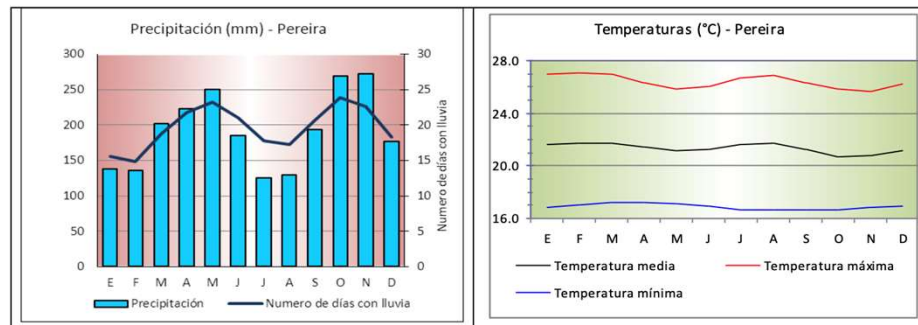


META

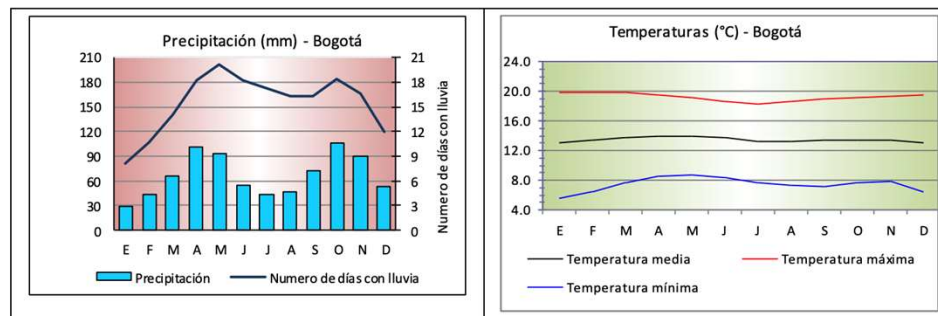
El **ambicioso** objetivo de Vancouver es **capturar y tratar** el **90% de la precipitación anual** de la ciudad, en un lugar cercano a dónde ésta ocurre (esto requiere desarrollar la capacidad de capturar hasta **50 mm** de precipitación al día)



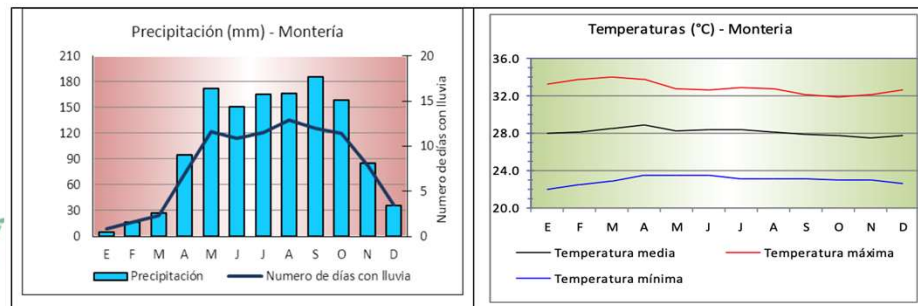
PEREIRA



BOGOTÁ



MONTERIA





¿Y EN NUESTRO CONTEXTO?



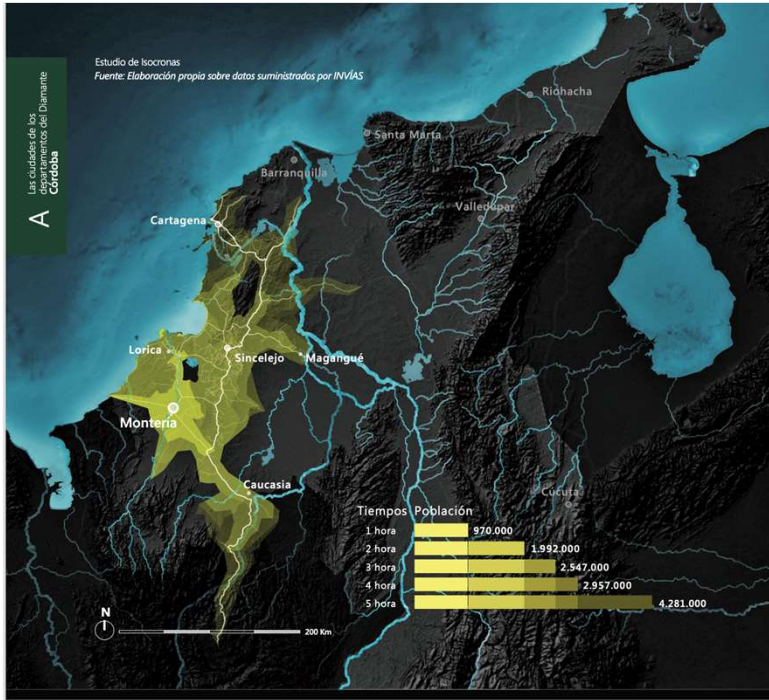


A Las ciudades de los departamentos del Diamante
Córdoba



Río Sinú a su paso por Montería







MENSAJE FINAL





SÍ SE PUEDE **(PROPUESTA PARA CAMACOL)**



!GRACIAS!

Eduardo Behrentz

behrentz@gmail.com

Instituto Colombiano de Aprendizaje
(INCAP)

