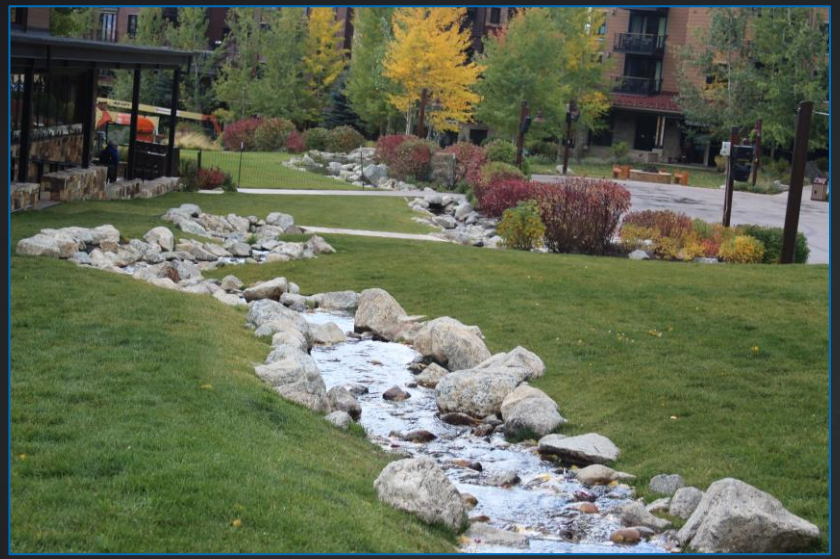
THE $GREEN BENEFITS OF WATER SENSITIVE DESIGN



A Matrix for identifying the Ancillary Benefits of WSD

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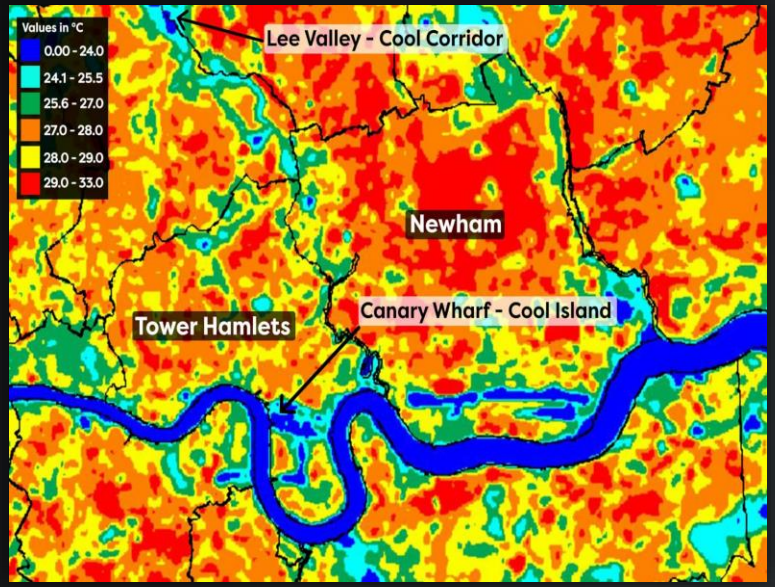
Ancillary benefits of WSUD that can provide clean, safe, resilient, and vibrant communities.

Benefits include:

- Reduction of urban heat island effect
- Improved air quality
- Lower carbon emission & increased energy efficiency
- Reduced flood risk and sewer overflows
- Healthy water courses
- Greater biodiversity
- Increased property values
- Improved health & well-being
- Reduced crime & violence
- Increased economic performance
- Inclusion of te mana o te wai
- Educational opportunities

Reduced Urban Heat Island Effect



COST SAVINGS FROM WSUD = $1.4 million/ha/50 years

Replacing vegetation with concrete and asphalt, alters the thermal properties of the landscape

The impermeable surfaces within the built environment absorb heat causing surface temperatures to rise.

In summer the city of Los Angeles is 2.75 ^{o}C warmer than the surrounding more vegetated areas

Green roofs, trees, rain gardens, vegetated swales, wetlands, and flood basin parks lower the ambient air temperature through evapotranspiration and shading.

The City of Toronto, Canada estimates that a widespread use of green roofs in the city could lower the air temperature in the city by as much as 5^{o} C.

Improved Air Quality

Urban areas suffer from poor air quality due to emission of:

Urban areas suffer from poor air quality due to emission of:

- nitrogen dioxide (NO_2)
- sulphur dioxide (SO_2)
- ground level ozone (O_3)
- particulate matter 10 µg/m (PM_{10}).

The NZ *Ministry for the Environment* states that poor air quality leads to:

- Increase in school absences
- Days off work
- Hospital admissions.

Table 1 - Pollutant uptake of WSUD

	NO_2	SO_2	O_3	PM_{10}
Medium Street Tree (McPherson et al, 2002)	77 g	31 g	122 g	132 g
Green Roof per 100 m² (US EPA 2014)	232 g	198 g	449 g	65 g
Rain garden & other green streetscapes per m² (Shakya, R., and Ahiablame, L. 2021)	64 g	55 g	124 g	18 g

COST SAVINGS FROM WSUD = $16,975 tonne/year

LOWER CARBON EMISSION & INCREASED ENERGY EFFICIENCY

Table 2- CO_2 Emissions of manufacture and transport

Stormwater Hardware	CO_2 Emissions Manufacture & Transport
225 mm diameter Concrete Pipe	17.17 kg per meter
1,200 mm diameter manhole	177 kg per meter of depth
660 mm x 460 mm Catchpit	75 kg

WSUD helps in lower carbon emissions in several ways:

- Swales, rain gardens and wetlands for stormwater reticulation reduces the need for pipes reducing embodied carbon.
- The grasses and trees, an essential part of WSUD, sequester CO2
- Parks, street trees and green roofs reduce the ambient air temperature, reducing the energy demands for cooling.
- Green roofs create more energy efficient buildings by improving thermal performance

Value = $55 tonne

Reduced Flood Risk & Sewer Overflows

- The 2023 flooding price tag for Auckland was $2 billion dollars in damages, the cost is the equivalent of $1,226 for every resident of Auckland.
- More frequent rainfall event contribute to sewer overflows into the harbour. The closure of beaches has an economic impact on communities like Ōrewa that receives 30% of its retail income from beach attendance.

- Blue green parks and wetlands designed to provide extended detention reduce flooding in extreme rainfall events.
- Conveying water overground using restored streams & roadside swales make the urban environment less reliant on the piped network.
- Planting stands of trees reduces runoff velocity, and volume, increases the time of concentration, as well as supports infiltration into the soil

Healthy Water Courses & Greater Biodiversity

Greater Biodiversity

Blue green parks, constructed wetlands, rain gardens and street trees provide habitat for native birds, insects, fish & nationally important plant species.

Value = $240/Ha/year

An Urban Example

The 2.73 ha green roof at the Jacob Javits Convention Center in the heart of Manhattan is home to 29 species of birds, 5 species of bats, 80,000 honeybees, other arthropods, and soil microbes.

Healthy Water Courses

Vegetated swales, rain gardens and wetlands remove pollutants upstream of the receiving environment, protecting and restoring natural waters.

Value = $55,000/km/year

Stream Bank Protection

In smaller rainfall events, rain gardens , tanks and wetlands protect stream banks from erosion, by providing detention enabling stream to better convey water and protecting stream habitats from degradation.

Increased Property Values & Greater Economic Performance

INCREASED RESIDENTIAL PROPERTY VALUES

In Seattle, the value of houses on streets with swales & rain gardens or green streets are 3% - 5% higher than those without.

Houses near parks have an increased value of between 8% - 19%

INCREASED ECONOMIC PERFORMANCE

Commercial property value can be increased by 15% near open spaces.
Shoppers stay longer and spend more in commercial districts which included Green WSUD .
According to the USEPA these environments result in a happier, more productive work force.

IMPROVED HEALTH & WELL-BEING

WSUD assets provide opportunities for exercise and recreational activities which improves physical health and mental well-being.

WSUD can also include urban gardens providing an opportunity to grow food

In a country that has a public health care system improved health and well-being can reduce healthcare costs.

REDUCED CRIME & VIOLENCE

For every 1% increase in high quality green space there is a 1.2% reduction in violent crime and a 1.3% reduction in property crime.
Interaction with nature can promote the ability to make better choices.
Well maintained green spaces that area part of WSUD can provide a walkable environment; increasing social interactions, reinforcing a sense of community, contributing to civic pride and provide inclusion.
WSUD reduces ambient air temperature , reducing aggressive behaviors.

INCLUSION OF TE MANA O TE WAI

Value = Priceless

Including Mana Whenua values as part of the WSUD process provides for :

- The well-being of people.
- Increased social harmony with the inclusion of Te Mana o te Wai as it is a vehicle for cross cultural understanding.
- Enhanced civic engagement across cultures, promoting democracy and social capital.
- The inclusion of all groups reduces social stresses and has a positive impact on mental health.

EDUCATIONAL OPPORTUNITIES

Teaching the next generation the value of water is critical to New Zealand's Future.

WSUD provides educational opportunities from primary to tertiary level including:

- STEM.
- Urban ecology.
- Nature photography .
- A living laboratory.

Table 3 Benefits of various WSUD assets

	Rain gardens	Swales	Street Trees	Permeable paving	Green Roofs	Flood Basin Parks	Wetlands	Rain Tanks
Reduction of Urban Heat Island Effect	✓	✓	✓	✓	✓	✓	✓	
Improved Air Quality	✓	✓	✓		✓	✓	✓	
Lower Carbon Emission		✓			✓			
Increased Energy Efficiency					✓			✓
Reduced Flood Risk	✓	✓				✓	✓	✓
Reduction of Sewer Overflows	✓	✓	✓		✓	✓	✓	✓
Healthy Water Courses	✓	✓	✓		✓	✓	✓	
Greater Biodiversity	✓	✓	✓		✓	✓	✓	
Increased Property Values	✓		✓			✓	✓	
Improved health and well-being	✓		✓			✓	✓	
Reduced crime and violence			✓			✓	✓	
Increased economic performance	✓		✓		✓	✓	✓	
Inclusion of Te Mana o te Wai	✓	✓				✓	✓	
Educational Opportunities	✓				✓	✓	✓	

Table 4 - Beneficiaries of WSUD by stakeholder and project type.

	Civic Building	Commercial Development	Council / Govt Project	Private Housing Development	Kāinga Ora Development	Single House Site
Reduction of Urban Heat Island Effect	✓	✓	✓	✓	✓	
Improved Air Quality	✓	✓	✓	✓	✓	
Lower Carbon Emission	✓	✓	✓	✓		
Increased Energy Efficiency	✓	✓	✓		✓	✓
Reduced Flood Risk	✓	✓	✓	✓	✓	✓
Reduction of Sewer Overflows			✓			
Healthy Water Courses			✓	✓	✓	
Greater Biodiversity			✓			
Increased Property Values		✓		✓		✓
Improved health and well-being	✓		✓		✓	
Reduced crime and violence	✓		✓		✓	
Increased economic performance	✓	✓				
Inclusion of Te Mana o te Wai	✓		✓		✓	
Educational Opportunities	✓		✓		✓	

Table 5- Dollar values for WSUD secondary benefits.

	Value	Comment / Sources
Reduction of Urban Heat Island Effect	$1.4 million/ha/50 years	Street trees, wetlands and green space can take time to demonstrate health and social benefits. This figure represents a decrease in healthcare costs and increased social benefits. (adapted from Johnson et al. 2021)
Improved Air Quality	$16,975 tonne/year	Total health benefits resulting from improved air quality. (adapted from Horton et al. 2019)
Lower Carbon Emission	$55.00 / tonne	Carbon price as of April 2024. Carbon credits can be gained through the construction of 2 ha of green space and other monetary benefits can be gained through lowering carbon emissions on a project.
Increased Energy Efficiency	$16.00/1% decrease/100 m^2	Based on BRANZ energy uses and current retail kWh costs. A green roof can reduce electricity consumption by 13.65% on 1000 m^2 building the energy savings are $2,185/year.
Reduced Flood Risk	$3,093 / year/ household	Reducing the flood risk from events greater than the 10-year storm to events greater than the 100-year storm weighted annual average damage savings estimates based on probability (adapted from Horton et al. 2019).
Reduction of Sewer Overflows	$33,000/overflow	Based on lost revenue from recreational fishing, swimming and food gathering resulting from red water conditions and based on the cost estimates of the larger events. There is significant statistical analysis that needs to be undertaken here.
Healthy Water Courses	$55,000 km/year	The improvement of water quality in rivers, lakes and streams increases recreational opportunities, improves fisheries, and improves coastal waters. Bank stabilisation and water channel improvements allow for better conveyance of runoff in storm events (adapted from Horton et al. 2019)
Greater Biodiversity	$240 /ha/year	Increase biodiversity helps support NZ biodiversity targets and restores natural capital. Greater biodiversity improves recreational opportunities and contributes to a sense of well-being. (adapted from Horton et al. 2019)
Increased Property Values	10% Residential 3-15% Commercial	Based on RICS 2007 and others. There seems to be global agreement around 10%.
Improved health and well-being	local green space $38.00 / visit View of greenery $317/person/yr.	These figures are based on increased emotional well-being and increased physical activity reducing health care costs and costs associated with depression and mental health. (adapted from Horton et al. 2019)
Reduced crime and violence	$1,644 /100 households/ 1% addition of greenery	Based on the per person crime rate of NZ as published by the word band the 1.2% reduction in crime for every 1% of greenery added as predicted by Venter, Z. S. et al. (2022)
Increased economic performance	57% increase in retail sales Increased employee productivity and reduced absenteeism	Based on the Center for Neighborhood Technology (CNT) and American Rivers (2010). There is a global acceptance of better employee outcomes where an office building incorporates green infrastructure. The percentages vary widely based on the quality of that infrastructure and the type of employment.
Inclusion of Te Mana o te Wai	$ unknown	Embedding Indigenous knowledge in WSUD creates engagement and fosters democracy and understanding. Placing a dollar value on this is problematic. However, the NZ government has committed to the inclusion of Mana o te Wai. This category should be considered a requirement for the relevant stake holders identified in Table 3.
Educational Opportunities	$42.00 per educational trip	This is an estimate of the educational benefits provided by trips which include lessons about nature, catchments, flooding and WSUD. (adapted from Mourato et al. 2010)

Worked Examples

A Convention center with a 5,500 m^2 green roof– Potential Cost Benefits from WSUD = $1.42 million / 50yr

- 13.65% energy reduction = $12,012 year (NZ current price)
- Removal 0.052 tonnes of air borne pollutants = $881/year
- Increased biodiversity = $132/year
- Reduction to Urban Heat Island Effect =$770,000 /50 year design life

In Total:

- $600,000 in energy saved at current prices.
- $44,050 worth of air borne pollutant removal.
- $6,600 biodiversity values.
- $770,000 value in the reduction of urban heat island effects.

WORKED EXAMPLES

High Density Public Housing – Potential Cost Benefits from WSUD = 55 million over the 50yr design life

5 ha of land is available for a public housing development with a density of 36 units/ha including roads and parks.

<u>108 street trees would provide the following ancillary benefits:</u>

- **0.039 tonnes of air pollutant uptake per year = air quality improvements worth $662 per year.**
- **Trees create 1% of green space -= Crime & violence reduction of $1,775 per year.**

<u>1 km of 2 m wide roadside bioretention swales with a 1% AEP capacity would add</u>:

- **0.522 tonnes of air pollutant uptake per year = air quality improvements worth $8,860.95 per year.**
- **Bioswales create 4% additional green space = additional crime and violence reduction = $7,100 per year.**
- **Reduced flood risk = $334,044 per year.**
- **A 20 tonne reduction kg CO2 emissions due to a reduced pipe network**

<u>Creating a 1 ha flood basin park at the centre of the development adds:</u>

- **2.61 tonnes of air pollutant uptake per year = air quality improvements wort $44,304.75 per year.**
- **The park creates an additional 20% of green space = An additional crime and violence reduction of $35,510 per year**
- **292 residents visit the park once a week & 100 residents have direct view = Improved health and well-being valued at $669,429**

CONCLUSIONS

THE IMPLEMENTATION OF WSUD HAS THE POTENTIAL TO :

- Improve water quality,
- Reduce flood risk,
- Improve air quality,
- Lower carbon emissions,
- Increase property values,
- Create greater biodiversity,
- Promote physical and mental health,
- Reduce crime,
- Boost economic performance, and
- Align with Mana Whenua values.

Using the tables presented here allows us to customise designs to appeal to different stakeholders based on their desired outcomes. Placing a monetary value on the secondary benefits of WSUD will help in creating a robust business case for its adoption.
Ultimately, the incorporation of WSUD has the potential to bring significant secondary benefits to the community, and its widespread implementation could lead to positive environmental, economic, and social outcomes.

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THANK YOU!

QUESTIONS? PATAI?

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