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ISSUE 503 BULLETIN

Meridian Energy Building, Wellington

Rainwater harvesting in commercial and industrial buildings

October 2008

A significant quantity of mains-supplied potable water is used in the commercial and industrial sector.

Much of this water, particularly for non-potable uses, could be replaced by rainwater harvested on-site.

This bulletin gives an overview on the design and construction of rainwater harvesting systems for commercial and industrial buildings.

1.0 INTRODUCTION

1.0.1 While there is no overall shortage of rainfall in New Zealand, there are water shortages in some parts of the country at certain times of the year. Local authorities also spend millions of dollars each year collecting, treating and supplying potable (drinkable) water to their communities. Part of this cost passes directly to building owners though their general rates or, more frequently for commercial buildings, by direct charging for water on a volumetric basis.

1.0.2 Collecting rainwater to supplement the potable water supply in the urban environment is a fairly new concept, but is starting to have a greater uptake. This is especially true for new buildings or those being substantially renovated that aim for an environmental rating, such as NZ GreenStar, which includes water sustainability and the reduction of potable water use through on-site supply in its rating criteria.

1.0.3 In the Auckland region around 25% of potable water supplied is used by the commercial and industrial sectors. Many of these end uses do not require potable water, but can be covered by collecting rainwater instead. This option not only reduces the strain on the water distribution network, but also decreases the amount of stormwater discharge and building running costs due to reduced water bills.

1.0.4 Before considering rainwater harvesting, water use should be made as efficient as possible through, for example, using water-efficient fixtures such as low-flush toilets. This can allow for smaller collection tanks, which lowers overall system costs.

2.0 WATER USE IN COMMERCIAL AND INDUSTRIAL BUILDINGS

2.0.1 There is not a lot of information in New Zealand on water use distribution in commercial and industrial buildings. However, a significant amount of water is used for toilet flushing and urinals, especially in office buildings, and this does not require high quality potable water. Industrial processes may also consume large amounts of water.

2.0.2 Large roof areas on many commercial buildings, such as supermarkets and warehouses, offer a huge potential for harvesting rainwater. Table 1 shows the average annual rainfall in urban centres throughout the country, and the potential volumes that can be collected. The table assumes 80% efficiency, accounting for loss through evaporation, spills and first flush diverters (devices which divert the first amount of rainfall and sweep much of the dust, dirt etc off the roof away from the storage tank).

3.0 RAINWATER COLLECTION COMPONENTS AND DESIGN

3.0.1 Whether for new or renovated buildings, the design and installation of rainwater harvesting systems needs to be addressed at the beginning of the design stage, especially if the system is to be integrated into the building and the rainwater is to be used for indoor purposes such as toilet flushing.

3.0.2 If the collected rainwater is to be used for potable water applications such as dishwashing, or for certain industrial uses, additional treatments such as UV-treatment, filtration, ultrafiltration, chlorination or other systems may need to be installed. Most treatment systems normally require regular maintenance such as changing filters. Treatment system manuals should be followed. However, where a water mains connection is available, the Ministry of Health recommends that any potable uses are supplied from mains water.

3.0.3 Incorporating systems just for non-potable uses is much simpler and less costly.

3.1 COLLECTION AREAS

3.1.1 A major component in rainwater collection is the collector area. Roofs are the most common, but not the only, option. Rain can also be harvested from paved areas such as carparks, roads and footpaths, but this is not common in New Zealand, and these surfaces tend to have higher levels of pollutants, such as animal faeces and oils, requiring treatment before the water can be used, especially for indoor purposes.

3.2 THE ROOF

3.2.1 When rainwater is to be collected from the roof, roof material is an important factor in reducing contamination, especially if drinking water is to be collected.

3.2.2 Roof materials that can be used for rainwater collection without particular treatment include:

- steel (galvanised, factory-painted, zinc- or aluminium-coated, stainless steel)
- clay tiles
- factory-painted tiles
- slate
- glass.

3.2.3 Roofs newly-painted with acrylic paints need weathering before water collection can begin.

3.2.4 Some composite asphalt roof systems or concrete tiles can leach chemicals and particles that affect the quality of the water that passes over them. Although butyl can be used, black butyl rubber will oxidise as it weathers.

3.2.5 Materials which should not be used include:

- lead – whether in the roof itself, flashings or solder, nail caps or paint
- asbestos cement sheets or tiles
- bituminous materials.

3.2.6 When specifying roof material, ask the manufacturer if they know whether a certain product or material is suitable for use where water is to be collected.

3.2.7 In an existing building being retrofitted with a collection system, catchment areas and gutters should be inspected during rain to judge how well the rainwater drains off. Areas where ponding occurs should be addressed to reduce moss growth.

3.3 GUTTERS AND DOWNPIPES

3.3.1 Common materials used for guttering and pipes include PVC, seamless extruded aluminium and galvanised steel.

3.3.2 Gutters and downpipes need to have sufficient flow capacity to accommodate storm flows. For large roof areas, where huge volumes of water can be collected in a short period of time, siphonic systems can drain the roof quickly. These systems use gravity to create a siphon effect, which speeds up water going to the tank and they can reduce pipe diameters substantially. The number of downpipes can also be reduced, which cuts back on the amount of plumbing required.

3.3.3 Pipes will need to be properly sloped to avoid water stagnation and ponding – a minimum 1:100 slope should be sufficient.

3.4 DIVERTERS AND SCREENS

3.4.1 Leaves, bird droppings and other unwanted debris should be kept out of the system. Methods include:

- leaf screens – these have a fine wire mesh which acts like a sieve. For larger systems, and where more leaves are expected, screening could be considered along the whole length of the gutters
- first flush diverters – these direct the first amount of rain (which washes the dust and other debris) away from the tank. The larger the roof, the bigger the first flush diverter needs to be. These devices are all readily available.

4.0 STORAGE TANKS

4.0.1 Rainwater needs to be stored for use when required and there is a wide selection of tank options. Materials include plastic, fibreglass, concrete and steel. If there are space restrictions, tanks can be fitted underground or included into the foundations of the building or carpark. Narrow wall-type systems and storage bladders are also available. Tanks can be bought off the shelf (up to 30,000 L capacity for plastic tanks) or constructed on-site.

4.0.2 For buried underground tanks, careful thought about siting and support is needed. Some tanks may have cracked, leading to contamination of the stored water. You also need to ensure that surface water cannot enter the tank and that it will not be subject to loads from vehicles. Ask your local authority about requirements and permit conditions for buried tanks.

4.0.3 To reduce algae growth, light should not enter the tank. Tank access should be secured (especially when at ground level) to prevent accidents.

4.1 TANK SIZE

4.1.1 The tank size is largely dependent on the overall building's water use, which depends on the number of occupants and types of end uses to be supplied. Other factors are the size of the collector area and the amount of rainfall.

4.2 SAMPLE CALCULATION

4.2.1 The following calculation is for an office building with: 1500 m^2 roof area in Wellington (1249 mm rain annually); 100 full-time employees (FTEs); 300 days' occupancy; rainwater to be used for toilet flushing (3/6 L toilets specified).

Rainwater supply:
0.8 x rainfall (mm) x collection area (m^2) = L/yr harvested

0.8 x 1249 mm x 1500 m^2 = 1,498,800 L (1499 m^3 per year)

Water demand (toilet flushing):
Assuming a toilet is flushed 5 times per day per employee
# of FTEs x (# of flushes/day) x average toilet volume (L) x (# of occupied days) = L/yr

100 FTEs x 5 flushes x 4.5 L x 300 days = 675,000 L (675 m^3 per year)

Balancing demand and supply:
Captured rainfall is more than sufficient to cover the whole water demand for toilet flushing by a factor of two, assuming the tanks are sized correctly.

An efficiency of 80% (runoff coefficient = 0.8) is assumed, as not all the rain that will fall onto the collector area will eventually enter the tank. Losses occur due to first flush diversion, evaporation, spillage, roof pitch, and absorption of collector material.

4.2.2 What is discussed here is an approximate calculation which doesn't account for seasonal variations. The PURRS model (Probabilistic Urban Rainwater and wastewater Reuse Simulation) can be used to give a more accurate assessment. (See Coombes PJ and G Kuczera, *Rainwater tank design for water supply and stormwater management*, Stormwater Industry Association 2001 Regional Conference, Port Stephens, NSW. 2001.)

4.3 PUMPS/GRAVITY FEED

4.3.1 The water from the storage tanks needs to be reticulated to its point of use either by gravity or by a pump. This depends largely on the site conditions. Generally tanks are located at ground level, in the basement or underground and hence require pumping. The pump size is dependent on the amount of water required at any one time and the building's height (highest point of water use).

4.4 BACKFLOW PREVENTION

4.4.1 If there is an interconnection between harvested water and mains supply water (for example, the storage tank is topped up by mains water if empty), adequate backflow prevention measures are required. This can be from installation of a specific backflow prevention device such as a double check valve, or from a design where harvested water can never enter pipes carrying mains water.

4.5 NZ GREENSTAR AND BUILDING RATING TOOLS

4.5.1 Water efficiency, including rainwater collection, makes up part of a building's rating under the NZ GreenStar accreditation process and other international rating tools. A rainwater harvesting system is fairly easy to implement, if included right from the design stage, compared to some other sustainability features.

5.0 DESIGN REQUIREMENTS

5.0.1 A rainwater collection system must meet the requirements of the New Zealand Building Code including E1 Surface water and G12 Water supplies.

5.0.2 The local authority consent requirements vary considerably around the country. Check what rules apply in your area. A consent is required for all sanitary plumbing works.

The system should be designed in a way for the user to be able to temporarily disconnect the system, if maintenance is required for example. It should be possible to drain the tank, but at the same time prevent it from supplying water to its end use(s) and re-filling. Dealing with overflow – for example by connecting to the stormwater system or to a raingarden – must also be considered.

6.0 CASE STUDIES

NZ POST BUILDING (HAMILTON)

The NZ Post building in Hamilton collects rainwater for toilet flushing from a 840 m^2 roof area. The water is stored in three tanks, totalling 75,000 L of storage. Potentially 990,000 L of rainwater can be reclaimed annually, which easily covers the 750,000 L required for toilet flushing per year. Due to the large roof area, the building's first flush diverter has a volume of 500 L.

CONSERVATION HOUSE (WELLINGTON)

Rainwater supplies 77% of the total non-potable demand (toilets, cleaning, servicing of pools on roof) to the newly renovated Conservation House in Wellington. The system was designed using monthly rainfall data and estimated water uses. Instead of a conventional first flush diverter, a rain sensor is used, which redirects the first 5 mm of rainfall away from storage. Two separate filtering systems are used before the end uses are supplied. Total storage is 65,000 L.

TABLE 1. COLLECTED RAINWATER (M^3) FOR SELECTED LOCATIONS AND VARYING COLLECTION AREAS ASSUMING 80% EFFICIENCY

	Rainfall/year (mm)	Collected rainwater (m^3/year)			
LOCATION		100 m^2	200 m^2	500 m^2	1,000 m^2
NEW PLYMOUTH	1432	115	229	573	1146
ROTORUA	1401	112	224	560	1121
WELLINGTON	1249	100	200	500	999
AUCKLAND	1240	99	198	496	992
TAURANGA	1198	96	192	479	958
HAMILTON	1190	95	190	476	952
INVERCARGILL	1112	89	178	445	890
TAUPO	1102	88	176	441	882
GISBORNE	1050	84	168	420	840
PALMERSTON NORTH	966	77	155	386	773
QUEENSTOWN	913	73	146	365	730
DUNEDIN	812	65	130	325	650
NAPIER	803	64	128	321	642
CHRISTCHURCH	648	52	104	259	518
Average	1080	86	173	432	864

LANDCARE RESEARCH BUILDING – (TAMAKI, AUCKLAND)

Rainwater from the roof is stored in two 25,000 L tanks. Water is used for toilet and urinal flushing and irrigating glasshouse and gardens. An additional 25,000 L tank acts as an overflow, releasing water slowly into the rain garden. A reverse osmosis machine treats water for use in laboratories. The pump is powered by a wind generator to fill up the roof tank. The pervious carpark surface allows rainwater to infiltrate underlying soil and flows into a rain garden where contaminants are removed.

MERIDIAN ENERGY BUILDING (WELLINGTON)

The new Meridian building on the Wellington waterfront makes use of a 16,000 L water tank for flushing its toilets.

POTZDAMER PLATZ, BERLIN – DAIMLERCRYSTLER AREA – LARGE-SCALE RAINWATER AND STORMWATER MANAGEMENT

Around 23 million L (23,000 m^3) of rainwater per year is harvested from 19 buildings, 10 streets and a central plaza in the centre of Berlin. Facts:

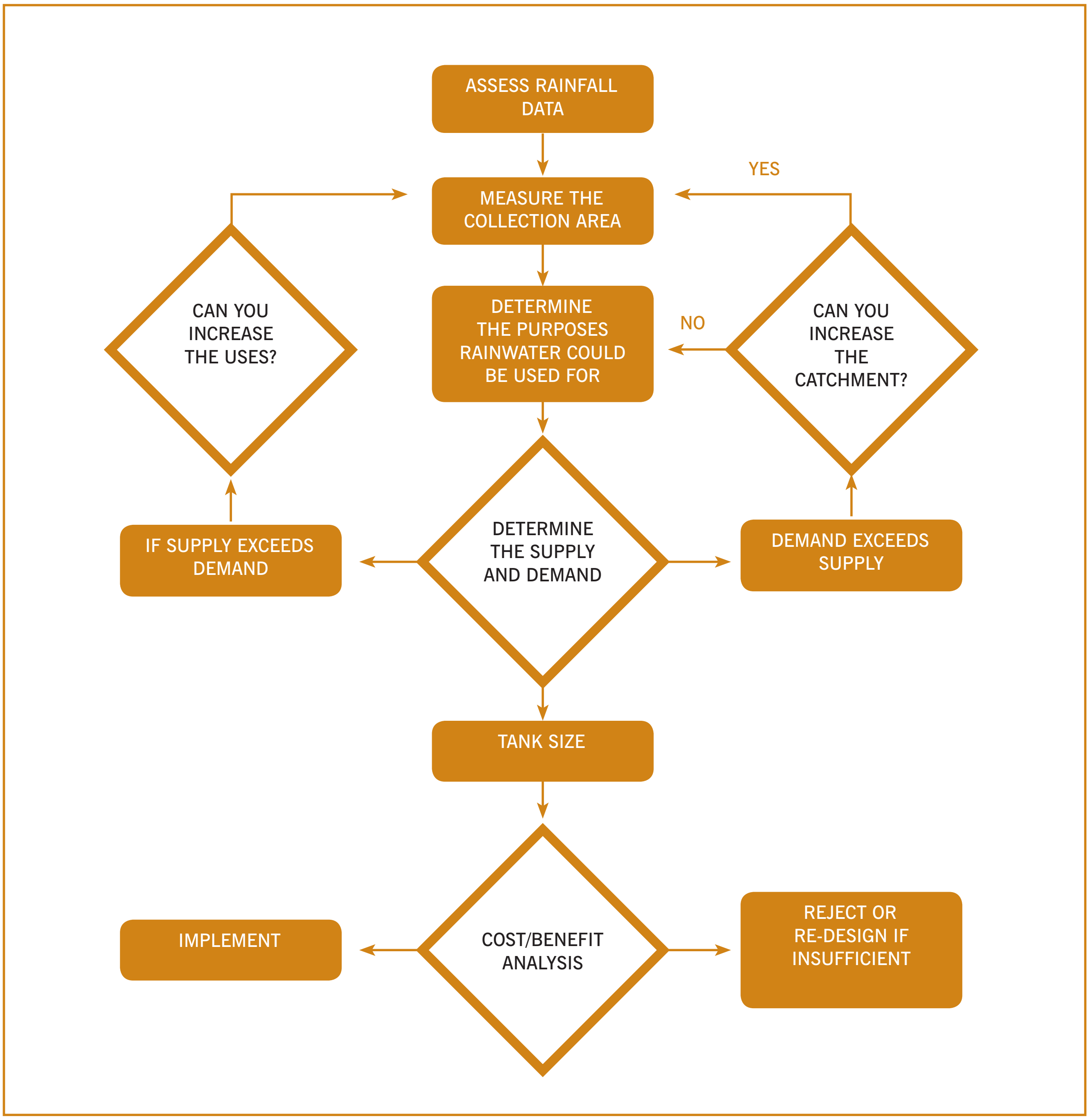
12,000 m^2 of green (i.e. planted) roofs

32,000 m^2 of conventional roofs

530 mm yearly precipitation (very low when compared to Auckland which has 1,240 mm)

water is used for toilet flushing, irrigation, artificial lakes and wetlands

2,600 m^3 total storage tanks



Flow chart: Assessing demand, supply and cost/benefit.

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FUNDED BY THE BUILDING RESEARCH LEVY BUILDING RESEARCH

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ISSN 1170-8395
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