



**HORNSBY**  
SHIRE COUNCIL

# Catchments Remediation Program

2014 Annual Performance Report



## **HORNSBY SHIRE COUNCIL**

### **Catchments Remediation Rate Program**

2013 - 2014 Annual Report



**Plate 1 – Appletree Drive, Cherrybrook – Biofilter**

### **Acknowledgements**

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## Executive Summary

This report aims to provide both quantitative and qualitative commentary on a number of programs run as part of the Catchments Remediation Program, funded by the Catchment Remediation Rate and identified in the Sustainable Total Water Cycle Management Strategy. These programs include the water quality treatment and stormwater harvesting capital works, asset maintenance and monitoring, asset renewal, landfill and leachate remediation, street sweeping and catchment education.

The primary focus of the report is to provide quantitative data and analysis of the relative performance of different water quality treatment measures, including gross pollutant devices (GPD's), sediment basins, wetlands and biofilters that have been constructed to improve stormwater quality in Hornsby Shire. The results of the report will be used by stormwater and catchment managers to provide a better insight into determining the type of structures that are suitable for specific sites. Furthermore, the data provides valuable information about the costs (both capital and maintenance), benefits and device optimisation which can aid in the formulation of strategies to improve catchment and landuse practices by both structural and non-structural means.

Gross pollutant devices, sediment basins, wetlands and biofilters all come under the general description of Stormwater Quality Improvement Devices (SQUIDS). The principal objective of installing SQUIDS is to improve water quality by removing pollutants and in some instances retaining stormwater flows. In the 2013 - 2014 financial year, \$1,016,000 was spent on capital works with 9 new catchments remediation projects being initiated and completed, including two major upgrades of existing assets. These works involved the construction and/or installation of:

- Five end-of-pipe biofilters: Hornsby heights, Mount Colah, Cherrybrook (x3);
- One carpark bioswale: Pennant Hills;
- One upflow wetland: Thornleigh;
- One large graduated trash racks: Cherrybrook
- One net-tech (GPT): North Epping.

- 7,617 native plants at new and existing sites to replace weeds and help facilitate the process of water quality treatment

Additionally, the following works were also carried out on existing sites that involved either upgrading their water quality treatment and pollutant removal or instigating repair works:

- Upgrade of aerators, wall repair and sediment removal at the Lakes of Cherrybrook;
- Upgrade of Community Nursery water reuse system, Pennant Hills;
- Repair and upgrade of Foxglove Oval leachate treatment system, Mount Colah;
- Sediment removal from Laurence Street wetland: West Pennant Hills;

While these repair and maintenance works treat and remove pollutants directly, the Catchments Remediation Program also promotes and funds non-structural initiatives in the pursuit of improving water quality in the Shire's creeks, waterways and receiving waters. These include: monitoring, maintenance, street sweeping, riparian bush regeneration, environmental education, business auditing, compliance programs, pollution clean-ups and estuary management initiatives.

The collection of performance data over the 2013 - 2014 financial year has allowed Council to quantify the volume of gross pollutant (sediment, litter and organic matter) removal from Council's 438 water quality improvement assets. The data show that 930 cubic metres of sediment, litter and organic matter collectively was captured and prevented from entering the Shire's waterways during this period. In addition, modelling indicates that over 703kg of phosphorous and 2,094kg of nitrogen was removed by CRR funded initiatives which is of particular significance because of their known detrimental impact on aquatic ecosystems, such as creeks and estuaries.

The total cost to Council to maintain its water quality improvement devices and adjacent landscaped areas was approximately \$420,000 in the 2013-2014 financial year. This included \$165,000 for the cleaning of SQUIDS and disposal of waste and \$255,000 for landscape maintenance and bush regeneration at the sites. Other associated costs

included the monitoring and maintenance of leachate treatment facilities, tree work and staff wages.

The report also provides information on the design principles behind innovative stormwater treatment measures known as biofilters. A project of particular interest in 2013 - 2014 was a pilot project involving the installation of an up-flow wetland to clean base flows from the Thornleigh Industrial area (which are regularly highly polluted). This project was innovative in design in that it aims to treat flows within the creek itself by combining conventional engineering with biological processes. The performance of the asset will be monitored to determine whether similar systems can be rolled out across the Shire.

Overall, the findings of this report give stormwater managers a better insight into the cost-effectiveness and performance of water quality improvement structures and the management of life-cycle costs for individual stormwater treatment measures. The performance of these devices allows Council to both refine and modify the design of future water quality control measures and judge their appropriateness for proposed remediation sites based on catchment size and land use impact.

# 1. Introduction and Background

Hornsby is located 25 kilometres north-west of the Sydney CBD and is the Council base for a Shire covering approximately 50,990 hectares and serving the needs of an estimated 157,000 residents (Australian Bureau of Statistics, 2011). The Shire extends from Epping in the south to Brooklyn and Wisemans Ferry in the north fronting a large expanse of the Lower Hawkesbury River. A majority of the northern and central Shire consists of National Park and Nature Reserve. This unique natural character combined with the many creeks and estuaries has led to Council being termed the 'Bushland Shire'.

In an attempt to conserve the ecological value of the Shire's many natural waterways and to improve the quality of urban stormwater, Hornsby Shire Council has taken an integrated approach to stormwater quality management by developing a range of capital and non-capital (preventative) measures. This initiative includes all major catchments under the Stormwater Management Plan framework, together with more closely modelled sub-catchment plans. Council's progressive strategy has recognised the need to tackle these challenges using a broad approach to understanding and managing the total water cycle. This has led to the development of a Sustainable Total Water Cycle Management Strategy (2005).

This report focuses on the performance of different stormwater treatment measures, including gross pollutant traps, constructed wetlands, sediment basins, stream remediation, and biofilters that have been constructed under Council's Catchments Remediation Rate (CRR) Capital Works Program. The report also outlines Council's work on leachate treatment and stormwater harvesting schemes.

## 1.1 Report Objective

To provide quantitative data and an analysis of the relative performance of different stormwater and leachate quality improvement devices that have been implemented under the Catchments Remediation Rate Program. Specific reference will be made to those devices constructed and / or installed in the 2013 - 2014 financial year.

## 1.2 Background of the Catchments Remediation Program

### 1.2.1. Catchments Remediation Program

In response to general water quality degradation, including red algal blooms and fish kills in the Berowra Creek estuary in September 1993, Hornsby Council placed a moratorium on all development assessments within the catchments of the West Hornsby STP. To resolve this, the Minister for Planning established a Technical Working Party (TWP), comprising representatives of Council, the Water Board (Sydney Water) and the Department of Urban Affairs and Planning (DUAP) which are now known as The NSW Department of Planning. Representatives from the Environment Protection Authority (EPA) and the Hawkesbury-Nepean Catchment Management Trust joined the TWP in early 1994. The TWP confirmed that the two Sewage Treatment Plants (STP's) contributed to the poor water quality of the creek. Moreover, it highlighted the significant role of polluted urban stormwater, particularly runoff from developing and newly developed residential areas.

On 27 April 1994, the participating organisations of the TWP signed a Statement of Joint Intent (SoJI - also known as the Community Contract for Berowra Creek) agreeing to work together to achieve the ecologically sustainable development (ESD) of the Berowra Creek catchment and the recovery of the environmental health of the creek. The Community Contract, included agreements to upgrade the STP's and it bound the parties to the preparation and implementation of a Water Quality Management Strategy. It also required Council to prepare and implement a strategy to reduce stormwater nutrient ingress to Berowra Creek and to utilise water sensitive design in its consideration of future developments.

However, the level of pollutants and the urgent need for action was not confined to Berowra Creek. Water quality in the other major catchments within the Shire had also deteriorated as a result of urbanisation. Remedial works to reduce pollution and improve water quality were required throughout the entire Shire including relevant areas draining the Cowan Creek, Lane Cove River and the Hawkesbury River catchments.



In 1995, the Water Catchments Team initiated the first phase of the ongoing strategic planning for catchment management within the Shire. The result was the production of a Catchments Remediation Program Five-Year Plan which detailed the proposed expenditure of the Catchments Remediation Rate towards meeting the objectives of the Statement of Joint Intent and in turn improving water quality in the Shire's waterways. The Plan included financial forecasts of rate income over a five year period together with capital investment and non-capital expenditure including asset management.

It was hoped that Hornsby Shire Council's Catchments Remediation Program would give stormwater managers a better insight into the cost-efficiency and performance of individual devices, but more importantly, monitoring of devices would reflect the individual characteristics of sub-catchments and the associated point sources of pollution, which can be targeted through pollutant minimisation strategies. It was also seen that community and industry awareness projects are important to complement the Catchments Remediation Program, whilst Local Government can also review work practices and strategies in relation to sediment and erosion controls on building sites (and their enforcement), street sweeping, street tree planting, rubbish collections and kerbside recycling collections.

Additional objectives of the Catchments Remediation Program, which still apply today, aim to address:

- Innovative Products and Services – generate and use ideas to add value to the community as stakeholders, provide productivity improvements, continue leadership and management capabilities in local government
- Health and Safety – provide a safe and healthy aquatic environment for the community, council staff and contractors
- Performance – to better understand community needs and expectations and deliver reliable devices which maximise the cost / benefit of installed capital projects
- Reporting – detail expenditure through regular reporting to the community; and
- Service – protect and service assets and continually improve operations.

### 1.2.2. Catchments Remediation Rate (CRR) and Panel

Council's catchments remediation work up to 1997 was only partly funded by the CRR, with the majority of funding being at the expense of other traditional Council services e.g. Parks. However, the cost of Council's 'Statement of Joint Intent (SoJI) for Berowra Creek' obligations and remediation works in the other catchments was highlighted to be much more than was covered by the rate. The proposal to increase the CRR from 2% to a 5% levy on ordinary rates in 1997 was presented with the idea to accelerate remediation capital works and return resources to traditional services that had suffered funding cuts. The increased funding was intended for planning, design, construction, maintenance and management of remediation devices. The proposal to increase the CRR to 5% was adopted by Council on the 13th April 1997 and still applies today.

Approximately 50% of the CRR is directed to non-capital costs including project management and a series of studies, associated with meeting the SoJI objectives. These studies are designed to identify more precisely the cause and effect mechanisms of pollution generation in the Shire, develop effective longer term remedies for the problems, and establish appropriate technological and monitoring techniques to determine and report progress. The remaining 50% of CRR funding is allocated to on-ground capital remediation works and subsequent routine maintenance of all constructed devices. Current remedial environmental protection works include the design and construction of wetlands, SQUIDs, leachate control from old landfill sites, sediment basins and creek stabilisation / rehabilitation.

The Catchments Remediation Rate Expenditure Review Panel (the Panel) was established in July 1997 following community consultation on increasing the CRR from 2% to 5%. The Panel meets twice annually to review expenditure following the second and fourth quarters of each financial year and currently comprises six community members, relevant council staff and two nominated Councillors. The purpose of the Panel is to ensure accountability and transparency of expenditure of CRR funds.

The terms of reference for the Panel were to:

- note the criteria which enables costs to be eligible for CRR funding;

- assess the validity of funding decisions made by Council staff against the criteria;
- note information relevant to CRR funding, available from Council's accounts;
- determine, in consultation with Council and staff, if the CRR funds have been appropriately assigned; and
- report to Council on the Panel's determination.

### 1.2.3. Synergy with Council's Strategic Direction

#### Council's Community Plan 2013- 2023

The Hornsby Shire Community Plan has been prepared by Hornsby Shire Council in partnership with local residents, our business community, other levels of government, educational institutions, non-government community and cultural organisations and neighbouring councils.

The Hornsby Shire Community Plan sets the strategic direction for where the people of Hornsby Shire want to be in 2020. It's a long term plan to deliver the best possible services to the people of the Hornsby Shire.

The Community Plan is aligned to the Hornsby Shire 2020 Framework for a Sustainable Future which states that a sustainable future requires a successful combination of:

- Protection and enhancement of our natural environment
- A resilient local economy and sustainable resource use
- Enhanced social and community wellbeing
- Effective community infrastructure and services
- Leadership that is accountable and effective

These strategic themes are supported by key goals that will guide the Shire for the next 10 years. The Catchments Remediation Program has a key role to play in delivering Goal 1.2: Maintain healthy waterways and catchments, which emphasises protecting the landscapes and health of our waterways and catchments, including the Hawkesbury River, Berowra Creek and associated tributaries and applying a total water cycle management approach to maintain water quality in our creeks, wetlands and rivers. The strategy pursuant to this goal and related actions are identified below.

**Table 1-1 - Link to Council's Community Plan**

Goal	Strategy	Actions for Council
Maintain healthy waterways and catchments	<b>Strategy 1.2.1:</b> Protect and improve the catchments in the Shire by providing support and direction to the water catchments program	Construct water quality remediation devices as per the Catchments Remediation Rate (CRR) 10 year capital works program  Undertake the Estuary Management Program
	<b>Strategy 1.2.2:</b> Identify and implement innovative water conservation and sustainable water cycle management practices	Implement the Total Water Cycle Management Strategy  Implement water conservation and reuse projects
	<b>Strategy 1.2.3:</b> Work with the community to care for, protect, enjoy and enhance the health of waterways in the Shire	Provide education to the community on the importance of waterways and estuaries
	<b>Strategy 1.2.4:</b> Provide a water quality monitoring service using methods that are reliable, professional and contemporary	Monitor and report environmental conditions, including water quality, at creeks and estuaries

### **Total Sustainable Water Cycle Management Strategy**

Council has shown leadership in successful water quality management since the break out of algal blooms in Berowra Creek in the early 1990s with the implementation of the Berowra Creek Water Quality Management Strategy. However, the Water Catchments Team recognised the need to expand traditional thinking of water quantity and quality, to include an understanding of the total water cycle which culminated in the adoption of the Sustainable Water Cycle Management Strategy 2005.

Council's recognition of the need to tackle these challenges using a strategic approach places it at the forefront of sustainable water cycle management and provides the inspiration for this project. The continuation of the Catchments Remediation Program is critical to the successful implementation of this strategic approach to total water cycle management.

### **Stormwater Drainage Asset Management Plan 2005-2025**

The Stormwater Drainage Asset Management Plan (SDAMP) 2006 formalises the process for the financial and physical requirements for a 20 year long-term performance of Council's stormwater and water quality infrastructure assets. The Plan demonstrates responsible stewardship as well as defines and articulates how the stormwater and water quality infrastructure assets are and will be managed to achieve Council's objectives. The Plan also identifies the future service delivery funding requirements for the adopted levels of service, future demand for infrastructure, current asset performance, asset failure, risk, required works and funding constraints.

#### **1.2.4. Statutory Considerations**

It should be noted that the Hornsby Shire Local Environment Plan (LEP), 1994, permits Council to undertake the construction or maintenance of stormwater drainage and water quality treatment devices, bush regeneration and landscaping without obtaining development consent. The proposals for construction are assessed under Part V of the Environmental Planning and Assessment Act, 1979, which requires Council to prepare a Review of Environmental Factors (REF). This identifies and evaluates the impacts of an activity to determine whether the impacts are likely to significantly affect the environment. The REF must also consider impacts of the activity on critical habitat or

threatened species, populations or ecological communities or their habitat, under section 5A of the EP&A Act.

The Threatened Species Conservation Act (TSC Act) 1995 specifies a set of seven factors which must be considered by decision makers in assessing the effect of a proposed activity on threatened species, populations or ecological communities, or their habitats. These factors are collectively referred to as the seven part test of significance.

The outcome of any threatened species assessment should be that activities are undertaken in an environmentally sensitive manner, and that appropriate measures are undertaken to minimise adverse effects on threatened species, populations or ecological communities, or their habitats.

#### **1.2.5. Asset Auditing and Lifecycle Management**

##### **Lifecycle Management**

Lifecycle management enables Council to plan interventions, whether its maintenance or renewal, at the optimum stage of an asset's deterioration to enable cost effective extensions of its useful life. There are a number of activities considered in lifecycle management:

- **Operations:** those activities that have no effect on asset condition but are necessary to keep the asset appropriately utilised.
- **Maintenance:** the day to day work required to keep assets operating at agreed service levels. This falls into two broad categories: planned (proactive) maintenance which are maintenance activities planned to prevent asset deterioration; and unplanned (reactive) maintenance which are maintenance activities to correct asset malfunctions and failures on an as required basis (e.g. emergency repairs). Maintenance work is required to maintain the asset's ability to provide the agreed service level but does not extend the life of the asset. Operations and Maintenance expenditure are considered an "Expense" for Council's financial accounting purposes. A key element of asset management planning is determining the most cost-effective mix of planned maintenance in order to reduce unplanned maintenance to a minimum.

- **Renewal work:** the substantial replacement of the asset, or a significant asset component, to its original size and capacity. This work generally aims to return the asset to a condition or state similar to the original asset.
- **Reconstruction (or upgrades):** are those projects that are created for the extension or upgrading of assets required to cater for growth or to maintain or improve on the levels of service.

The Stormwater Drainage Asset Management Plan (SDAMP) 2006 was prepared to provide a financial forecast for water quality assets in the Shire over a 20 year period. Cumulative operating expenditure identified in the Plan includes the cumulative operation / maintenance expenditure and asset renewals and upgrades associated with assets reaching their optimum life or age. To ensure responsible financial management the assumptions made in the modelling were very conservative. Hence, both renewal and projected maintenance cost were set at a high level to allow for unforeseen circumstances or unpredictable rises in costs.

The key feature of these financial projections is that it is envisaged that operational and renewal costs will take an increasingly larger proportion of CRR funds in future years as the number of assets increases. The life cycle analysis modelling of the catchments remediation program, as with Council's Asset Management Plans, will be reviewed at

regular intervals to allow for the input of monitoring and knowledge gained over time.

#### **Asset Auditing**

Over the previous two financial years Council's Environmental Scientist Catchment Remediation Officer has concentrated on assets auditing. By the end of the 2012-2013 period all of the 400 + assets had been audited. The audits were undertaken using a risk assessment approach which included assessing:

- Public Safety, resulting in:
  - An action register
  - Signage requirements
- Performance – both functionality and structural integrity
- Contractor and Staff OH&S requirements

This proactive auditing regime will be ongoing as it provides a much more realistic assessment of asset condition and hence the requirement for renewal and repair than lifecycle modelling. The information gained from this auditing process along with careful tracking of the costs associated with maintenance, renewal and repair have shown that at present there is little need for a CRR sinking fund for asset renewal/repair. The next round of audits is scheduled for the end of 2014.

## 2. Catchments Remediation Rate Capital Works Program

### 2.1 Delivery of Capital Work

The selection and implementation of structural stormwater quality improvement devices involves numerous steps. These include: site identification and prioritisation; determination of treatment objectives; development of treatment train; concept design; comparison of potential treatments (modelling); detailed design; review of environmental factors; notification and authority to commence construction.

#### 2.1.1. Project Management and Construction

Due to the varying degrees of expertise in different fields the Divisions of Environment and Human Services and Infrastructure and Recreation have forged a partnership approach to deliver CRR capital works projects. The Infrastructure and Recreation Division's Design and Construction Branch now incorporate the design, construction and project management responsibilities associated with CRR capital works routinely into their annual civil works improvement program.

There are a number of benefits to both Divisions and to the Council as a whole as a result of this partnership. Some of these are:

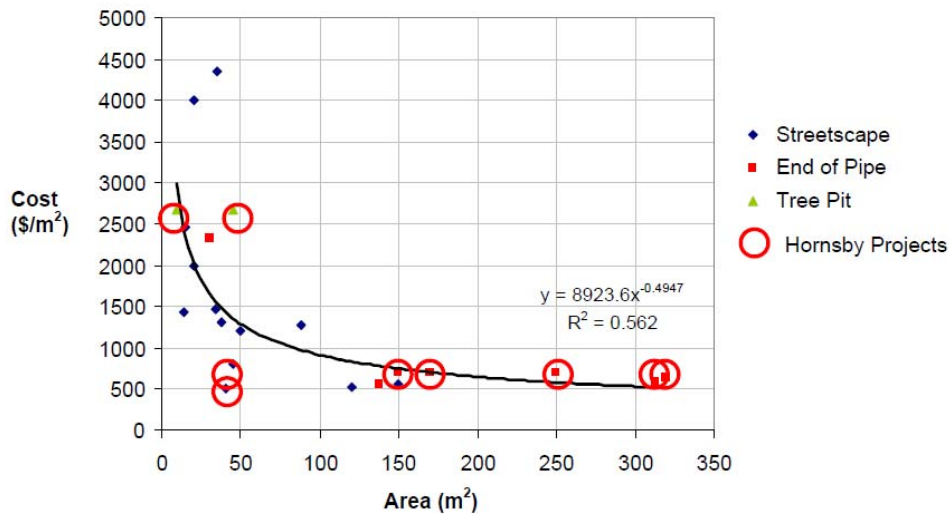
- Projects are developed ensuring compatibility with local engineering and environmental standards, and making sure that all issues are addressed;
- Experience and knowledge from involvement in these projects is utilised in all Council works so that Council sets the standard for developers / builders to follow;

- Opportunities for the Infrastructure and Recreation Division staff to be involved in environmentally "cutting edge" technologies;
- Involvement of staff in the Infrastructure and Recreation Division in an area of environmental management, with a flow-on effect resulting in better understanding of sustainability issues;
- Opportunities for Environment and Human Services Division staff to become more aware of engineering issues in the development of projects;
- Expansion of the core business of the Infrastructure and Recreation Division; and
- Flexibility during the construction phase not necessarily afforded in contractual arrangements.

The combination of the push towards competitive tendering and the need to seek specialised engineering and contractor services results in the contracting out or tendering of some of the design and construction activities. At present a small proportion of the works is contracted out (usually low-risk remediation projects such as stream remediation works and small scale gross pollutant devices) together with specialised design and consulting services.

To date the Environment and Human Services Division has been satisfied with the quality of work achieved and the cost-benefit involved. To reaffirm this, Council has benchmarked the cost of constructing biofilters against other Sydney Councils. As **Figure 2.1** illustrates the in-house arrangement represents good value for money.





Comparative costs of construction of bioretention systems for Sydney Councils

Figure 2-1 - Comparative construction of biofilters (Knights *et al*, 2010)

### 2.1.2. Work Health and Safety (WHS) and Risk Management

All contractors are required by Council to have a WHS Policy in accordance with the Work Health and Safety Act 2011 and The Work Health and Safety Regulation 2011 which aim to secure and promote the health, safety and welfare of people at work. Employers and supervisors of staff and contractors have a duty of care under the Act to protect employees and demonstrate due diligence in their WHS Management Systems. Council and contractor policies must address:

- certificates of currency for public liability, third party motor vehicle insurance and workers compensation;
- safe work practices and procedures (hazard identification and risk analysis per site / device);
- induction and safety training (Green or White card);
- corrective actions and documentation;
- incident / accident recording and investigation; and
- personal protective equipment (PPE).

By ensuring these requirements are met by both Council staff and contractors the risks identified

during the cleaning and maintenance process can be analysed, evaluated and risk treatment plans implemented in accordance with AS / NZS 4360 Risk Management.

## 2.2 Types of Stormwater Quality Improvement Assets

### 2.2.1. Objective of Stormwater Treatment

Historically, the principal objective of stormwater treatment measures was to improve the quality of stormwater by removing pollutants, including litter, sediment, nutrients, metals and associated bacterial contamination. Stormwater treatment can be grouped into three categories: primary, secondary and tertiary (Refer to **Table 2.1** and **Section 2.2.2**).

Recent research suggests that to further protect stream ecosystems stormwater management systems should be designed to retain water from small-to-moderate rain events. By doing this the disturbance or damage caused by frequent events can be reduced (Walsh *et al* 2004).

With this in mind Council's Catchments Remediation Program has been implementing and providing funding to projects which retain and use stormwater, e.g., biofilters (through plant evapotranspiration) and stormwater harvesting schemes (through sports field irrigation).

**Table 2-1 - Pollutant ranges for stormwater treatment measures (Engineers Australia, 2006).**

Particle Size Grading	Treatment Measures				Treatment Process
Gross Solids > 5000 µm	Gross Pollutant Traps				Screening
Coarse- to Medium-Sized Particulates 5000 µm – 125 µm		Sedimentation Basins (Wet & Dry)			Sedimentation
Fine Particulates 125 µm – 10 µm			Grass Swales & Filter Strips	Surface Flow Wetlands	Enhanced Sedimentation
Very Fine/ Colloidal Particulates 10 µm – 0.45 µm				Infiltration Systems	Adhesion and Filtration
Dissolved Particles < 0.45 µm				Sub - Surface Flow Wetlands	Biological Uptake

#### Typical Stormwater Pollutants and Contaminants

- **Gross pollutants** are typically those materials greater than 0.05mm, both degradable and non-degradable, which detrimentally impact physically, visually and bio-chemically on aquatic ecosystems.
- The deposition of **suspended solids** can block pipes, change flow conditions, decrease light penetration and disrupt the habitat of aquatic invertebrates and fish (e.g. by infilling pool habitat). Equally important is that they are associated with other contaminants such as heavy metals, hydrocarbons and phosphorus (Engineers Australia, 2006).
- Increased **nutrients** (phosphorous and nitrogen) levels may cause excessive and unbalanced growth of plants and algae leading to oxygen depletion. Sources of nutrients include atmospheric deposition, tree leaves, domestic and agricultural fertilisers, industrial waste, sewer overflows, animal droppings, detergents and lubricants (Engineers Australia, 2006).
- A wide variety of **heavy metals** are present in stormwater and toxic effects can occur once concentrations exceed certain levels.

#### 2.2.2. Biofilters

Biofilters or basins can be simply thought of as “vegetated sand filters”. Stormwater run-off is delivered, either directly or via a low flow diversion, to the biofilter where it is spread over the vegetated area and slowly percolates through a filter media. Pollutant removal is achieved through the interface of the vegetation and filter media as a result of enhanced sedimentation in the vegetation zone, mechanical filtration, sorption and other chemical processes in the filter media and plant and biofilm

uptake of pollutants (Hatt, et al 2006). An underdrain collects the treated water and delivers it to existing stormwater infrastructure or waterways.

Biofilters can be constructed at different locations within the catchment; they can be at-source within the streetscape (e.g. within traffic calming devices or tree pits) or at the “end-of-pipe” where stormwater infrastructure (pipes) run into bushland or waterways.

### **End-of-Pipe Biofilters**

These systems encapsulate the “treatment train” approach by providing primary, secondary and tertiary treatment through the one biofilter.

To provide optimal treatment both the vegetation type and filter media have been specified to comply with recent research findings. While the concept is simple, extensive research has refined the specifications to optimise performance of these systems.

**Primary Treatment:** Stormwater flows into sediment forebays which captures larger sediments. It then flows into a distribution swale where the stormwater is evenly spread across the basin surface to allow litter, leaves and finer sediment to be trapped on the surface of the filter media. Through the CRR maintenance program these larger litter items and accumulated sediment are removed on an as needs basis.

**Secondary Treatment:** After the stormwater has entered the biofilter it percolates down into the filter media where finer sediment and pollutants are retained by attaching to soil particles or becoming trapped within pore spaces.

**Tertiary Treatment:** Tertiary treatment also occurs as biofilms on the highly fibrous root system of the plants take up nutrients and metals. In addition, this system has been installed with the option to create a permanent saturated zone which assists in the depletion of available nitrogen through the process of denitrification.

### Innovation wetland design, Larool Crescent, Thornleigh

In June 2014, an up-flow wetland was constructed downstream of the Thornleigh industrial area as part of the Catchments Remediation Program. One of the main challenges using biological treatment (i.e. wetlands) to treat water pollution is the requirement for a large area of land (and subsequent large surface area) to effectively treat stormwater. This innovative design, while only a pilot project, aims to address this issue by carrying out treatment within the creek itself. The up-flow wetland operates by passing water up through filtration media (i.e. soil) which is planted with suitable plants. This combination provides treatment through fine filtration and biological uptake. The vegetation that grows in the filter media enhances its function by continuously breaking up the soil through plant root growth to prevent clogging and providing biofilms on plants roots that absorb pollutants. Council is optimistic that this design will improve the water quality of Larool Creek and the performance will be monitored to determine whether this treatment option can be used elsewhere in the Shire.



Plates 2-4: Larool Crescent, Thornleigh –  
Up-flow wetland during and after construction, June 2014.

### **2.2.3. Gross Pollutant Devices and Sediment Basins**

Gross Pollutant Devices (GPD's) and sediment basins can operate in isolation to protect immediate downstream receiving waters or as part of a more comprehensive treatment system. When acting in isolation they are used primarily to protect downstream waters from litter or to address specific issues such as excessive leaf drop. When maintained at a prescribed level they can be useful in retaining a significant proportion of all pollutant types.

In an integrated treatment system (or treatment train), they are the most upstream measure and are important in protecting the integrity of downstream treatments (such as wetlands and biofilters) by removing the coarse fraction of contaminants (e.g. litter, coarse sediment etc) (Engineers Australia, 2006, p8-2).

For the purposes of this report, GPD's take many forms including trash racks, litter baskets, channel nets, pit inserts and underground sumps. Some GPD's are fabricated to fit specific locations, whereas others are bought off the shelf (proprietary devices). At present over 437 stormwater treatment measures have been installed and / or constructed throughout the Shire.

Hornsby Shire Council maintains 68 sediment basins throughout the Shire. As with GPD's, proper maintenance is essential to ensure optimal performance, therefore, Council scheduled the cleaning of a number of established basins in the 2013 - 2014 period. It is important that sediment basins are cleaned at least biennially (or at 30% capacity) so as to prevent colonisation of weeds and the release of potentially bio-available contaminants caused by disturbance events (e.g. scour and re-suspension).



### The Lakes of Cherrybrook get an 'overhaul'

In December 2013, Council undertook sediment and organics removal from the bottom lake of The Lakes of Cherrybrook situated on Shepherds Drive. The Lakes are the receiving body for a large, highly impervious catchment. Hence, they collect high levels of urban runoff and associated pollutants. These works involved removing a thick layer of sulphurous and low oxygen detritus, resulting in the capacity of the Lakes being restored. Additionally, the wall of the top lake was repaired due to scour which occurred during high rainfall events. Aerators in the bottom lake were also upgraded to provide mixing of the water column to improve water quality.



**Plates 5-9: Cherrybrook Lakes, Cherrybrook – Bottom Lake cleanout showing during and after cleanout, before and after wall repair and aerators being deployed.**

#### 2.2.4. Constructed Wetlands

Natural wetlands are transitional environments between terrestrial and aquatic habitats. They are characteristically shallow environments that are cyclically, intermittently or permanently inundated by fresh, brackish or saline water. Wetlands provide habitat for biota such as emergent macrophytes, macroinvertebrates, fish, amphibians, reptiles and birds which are dependent on the inundation of the wetland.

In managing urban stormwater pollution of natural waterways, constructed wetlands are often built to mimic nature and to achieve improvements in stormwater quality through natural physical and chemical processes. Furthermore, they provide additional benefits through the provision of habitat for aquatic and terrestrial fauna, maximising biodiversity and enhancing aesthetics.

As shown in Plates 7-10, Ashleigh Madison Way, Mount Colah had high levels of sediment removed to ensure future capacity. Additionally, a constructed wetland had sediment removed at John Savage Crescent, Cherrybrook. Efforts were made to retain some native aquatic vegetation on its edges and to time the cleanout to reduce impacts on duck breeding in the waterbody.

#### 2.2.5. Stream Remediation

Many creeks become physically degraded when the natural hydrology of the catchment is altered. This most often results in creek bank scour and erosion which is accelerated through processes such as the clearing of riparian vegetation and increased stormwater runoff from impervious surfaces. This degradation can have a detrimental impact on water quality often resulting in an increase in sediment transport and associated sediment bound contaminates.

Aquatic flora and fauna are impacted through a loss of habitat, increased competition with weeds, poor light penetration into the water column due to increased turbidity levels and smothering of benthic organisms with increased sedimentation.

In the remediation of a degraded section of stream the following techniques are used:

- **Creek bank stabilisation** - Typically using locally sourced sandstone boulders that prevent the creek bank from eroding any further and provide habitat for fauna and flora on the rock surface and in cracks between rocks. A variety

of softer creek bank armouring strategies may also be incorporated, including the pinning or staking of jute mesh/matting, woven blankets, fallen logs and chain-wire mesh. These approaches are often combined with the planting of native plant cells or tubestock.

- **Use of meanders** - To aid in the reduction of flow velocities during storms.
- **Riffle zones and natural rock fall structures** - Are used to provide in-stream habitat, stabilise the creek bed, aerate the water and allow maximum UV light treatment from sunlight to destroy faecal bacteria.
- **Pool zones** - Are incorporated to create habitat for fauna and macrophytes and to dissipate flow velocities which allows sediments to drop out for later removal.
- **Revegetation of riparian zone** - This zone is planted with indigenous native tubestock to improve habitat, enhance faunal corridors and vegetation links, provide a food source for both terrestrial and aquatic organisms and to stabilise the banks.
- **Stabilising stormwater outlets** - Rock armouring around stormwater outlets reduces erosion and scour caused by high flows.

In addition, the majority of stormwater treatment measures discussed in this report also incorporate some stream remediation to stabilise banks around the devices and improve habitat immediately up and downstream. Although the environmental benefit of stream remediation works is difficult to quantify, the works provide a significant benefit in terms of a reduction in erosion and associated sediment loads moving to the lower reaches of creeklines and receiving waters, improved native riparian and aquatic habitat and enhanced visual aesthetics.



In early 2014, Council installed a biofilter at Pecan Close, Cherrybrook downstream of an existing sediment basin. This catchment receives high levels of leaf litter, from both deciduous and indigenous trees in the area, which are delivered to the basin via the stormwater system. For this reason a treatment train approach was used, including a net-tech gross pollutant trap, sediment basin and biofilter, to optimise the treatment efficiency of the system.



Plates 10-13: Pecan Place, Cherrybrook – Biofilter Works.

### 2.2.6. Projects Delivered in 2013 - 2014

In the 2013 - 2014 financial year, \$1,016,000 was spent on capital works with 9 catchments remediation projects being initiated and completed. These works involved the construction of:

- Five end-of-pipe biofilters: Hornsby heights, Mount Colah, Cherrybrook (x3).
- One carpark bioswale: Pennant Hills;
- One upflow wetland: Thornleigh;
- One large graduated trash racks: Cherrybrook
- One net-tech (GPT): North Epping.
- 7,617 native plants were planted at new and existing sites to replace weeds and help facilitate the process of water quality treatment.

Additionally, the following works were also carried out on existing sites that involved either upgrading their water quality treatment and pollutant removal or instigating repair works:

- Upgrade of the existing aerators, wall repair and sediment removal at the Lakes of Cherrybrook;

- Upgrade of Community Nursery water reuse system, Pennant Hills;
- Repair and upgrade of Foxglove Oval leachate treatment system, Mount Colah;
- Sediment removal from Laurence Street wetland: West Pennant Hills

Some sites combined a number of measures to provide optimal treatment of stormwater, referred to as a treatment train, whereas others focused on a specific type of treatment. Catchment characteristics, site conditions and constraints are the core factors in determining what type of measure is constructed. However, where possible, Council aims to provide primary, secondary and tertiary treatment to optimise benefits to the downstream environment.

Following this is **Table 2.2** which lists the locations and treatment measures for projects completed in 2013 - 2014. A full list of all devices managed by Hornsby Shire Council is detailed in Appendix A with projects from the 2013 – 2014 period defined in bold.

**Table 2-2 - Capital Works Projects 2013 – 2014**

**(1-main treatment 2- supplementary treatment, EP- End-of-pipe biofilter)**

Project Location	Biofilter	Carpark Bioswale	Upflow Wetland	GPT Installation
Spedding Road, Hornsby Heights <sup>1</sup>	1(EP)			
Appletree Drive, Cherrybrook	1(EP)			2
Murralong Road, Mount Colah <sup>2</sup>	1(EP)			
Gavin Place, Cherrybrook <sup>2</sup>	1(EP)			
Odney Place, Cherrybrook				1
Braidwood Avenue, North Epping <sup>3</sup>				1
Pecan Place, Cherrybrook	1(EP)			
Pennant Hills Park		1		
Larool Crescent, Thornleigh			1	

1. Initiated in 2012-2013

2. Upgrade of sediment basin to biofilter

3. Net-tech device installed on existing biofilter





**Plates 14-16: Biofilters completed in 2013-2014**  
**Spedding Road, Hornsby Heights**  
**Appletree Drive, Cherrybrook (with graduated trash rack)**  
**Murralong Road, Mount Colah (retrofit of a sediment basin to biofilter)**





## 3. Catchments Remediation Rates Asset Maintenance

### 3.1 CRR Asset Maintenance

#### 3.1.1. Cleaning and Maintenance of CRR Assets

Included within the CRR capital works budget is provision for monitoring and maintenance of all structures on a regular, recorded basis. Due to the current strain on Council's resources, the increasing number of structures being built and the resulting demand for timely and efficient maintenance, Council has continued to utilise contractors (on a 3 year contract) to undertake maintenance works under Council supervision.

Maintenance typically involves regular cleaning of SQUIDs and periodic maintenance of sediment traps and wetlands in terms of sediment removal and bank repair. Fundamental design principles allow ease of draining / flow bypass and access for maintenance of all water quality control devices which results in efficient and cost-effective maintenance techniques in the long term. The cleaning / maintenance contract was re-let for another three-year period from July 2013.

The existing contracts stipulate the contractor's responsibilities. These are outlined as follows:

- Contractors are required to dispose of waste material to a nominated landfill or a privately operated screening operation that offers a competitive rate per tonne. The only exception being the liquid / solid mix waste removed by vacuum from wet sump devices. This waste shall be disposed of to an approved location at Council's expense; and
- That the contractor has a proven record of Work Health and Safety (WHS) commitment, training and record keeping.

The frequency of maintenance varies between treatment measures and a majority of SQUIDs need regular inspections and maintenance after each significant rainfall event. In 2013 - 2014 Hornsby Shire recorded approximately 21 large events (>10mm of rainfall in the previous 24hrs) and no very large events (>50mm in the previous 24hrs) which has resulted in lower yields than in previous years (refer to Appendix B for statistical data).

Larger wet vault SQUIDs are inspected and maintained on a quarterly basis, whilst constructed wetlands and leachate treatment systems are maintained on a more regular schedule. Sediment basins are inspected regularly and maintained as required biennially. These basins need periodic maintenance in terms of sediment removal, bank repair or minor structural repairs. The scope of these works is based on additional quotations for specific works and upon joint inspection by Council's Environmental Scientist Catchment Remediation Officer and the Contractor (Refer to **Table 3.1**).

- To maintain existing water quality remediation structures to ensure optimal functioning and a weed-free surrounding landscape of many devices;
- To ensure quality control / assurance throughout the maintenance process incorporating:
  - Minimal pollution of the site during cleaning and transport of materials; and
  - Efficient, accurately documented records of contents removed and / or actions taken.
- Contractors are required to provide both a status and cleanout report sheet for each structure after maintenance. Council requires this to evaluate SQUID performance and device accountability;

**Table 3-1 - Maintenance Operations for Stormwater Treatment Measures**

<b>Stormwater Treatment Measure</b>	<b>Inspection Frequency</b>	<b>Maintenance Frequency</b>	<b>Waste Destination</b>	<b>Reporting</b>
<b>GPD (end-of-pipe)</b>	Storm event (>10mm in 48hrs)	Selective based on inspection (within 5 working days)	Council nominated site.	<b>Within 2 weeks from completion</b>
<b>GPD (wet vault)</b>	No inspection. Quarterly empty as scheduled	Quarterly empty as scheduled	Council nominated site. Liquid fraction decanted to passive open space or to an approved facility	<b>Within 2 weeks from completion</b>
<b>GPD (pit insert)</b>	Quarterly or after a Storm Event (>10mm in 48hrs) Monthly	Selective based on inspection (within 5 working days)	Council nominated site	<b>Within 2 weeks from completion</b>
<b>Constructed wetlands, Leachate treatment, Biofilter</b>	Biannually or after a storm event (depending on magnitude)	Scheduled monthly or as required	Weed material composted onsite or disposed of to an approved facility. Sediment disposed of to a Council nominated site	<b>Monthly</b>
<b>Sediment basins, Creek remediation</b>	Biannually or after a storm event (depending on magnitude)	Selective based on inspection (within 10 working days)	Weed material composted onsite or disposed of to an approved facility. Sediment disposed of to a Council nominated site	<b>Within 2 weeks from completion</b>

**Table 3.2** presents the efficiencies in terms of cubic metre of waste collected against the cost of maintenance in the July 2013 – June 2014 financial year for each type of device. The total clean cost for each device and average clean cost of devices emptied during this period are also presented. The table shows that reasonable efficiencies can be achieved with minimal fiscal input for devices such

as Pit Inserts, Ski-Jumps and Trash Racks. Higher costs are associated with Net-Tech devices due to the fact that these devices can often release with minimal waste capture. Higher empty rates are also associated with vaults due to being reasonably labour intensive and requiring specific trucks and equipment.

**Table 3-2 - SQID comparative costs from July 2013 - June 2014**

Device	Total Clean Cost / Total m <sup>3</sup>	Total Clean Cost for 2013-2014	Average Clean Cost of Devices Emptied
Net-Techs (Proprietary Net), (n=51)	\$98.62/m <sup>3</sup>	\$3,570	\$70.00
Proprietary Underground Vaults <sup>1</sup> (n=79)	\$306.83/m <sup>3</sup>	\$19,450	\$246.00
Litter Baskets (n=34)	\$156.32/m <sup>3</sup>	\$2,720	\$80.00
Channel Nets (Proprietary Net), (n=166)	\$127.23/m <sup>3</sup>	\$12,145	\$73.00
Trash Racks (n=48)	\$38.66/m <sup>3</sup>	\$9,440	\$197.00
Ski-Jumps (Proprietary Device), (n=7)	\$97.99/m <sup>3</sup>	\$1,460	\$208.00
Pit inserts (n=284)	\$132.90/m <sup>3</sup>	\$5,680	\$20.00

<sup>1</sup>Note: Proprietary Underground Vaults include Rocla, CDS and Humeceptor Vaults.  
n: number of device empties

### 3.1.2. Bush Regeneration, Landscape and Wetland Maintenance

Due to the increasing number of devices being built and the resulting demand for timely and efficient maintenance, Council has continued to engage bush regeneration contractors on a 3 year basis with an optional additional 1 year. The contracts are annually renewed based on a performance evaluation of the previous year's work and compliance with the conditions of the contract. The key objectives of the contract are:

- to maintain planted native vegetation around water quality structures and nominated wetlands, using methods that have minimal environmental impact on aquatic organisms and water quality;
- treatment and eradication of any riparian and aquatic weeds giving priority to the treatment of categorised noxious weeds, applying herbicide according to manufacturers specifications and in

a responsible and recorded manner (in terms of both environmental and personal safety); and

- to provide a maintenance report for each site after treatment, including a more detailed maintenance report for the wetland sites which is required to assess the extent of plant growth and site recovery from weed infestation.

In 2013 - 2014, contractors were responsible for landscape maintenance of seventy eight sites at a cost of \$255,000 (approximately 6121 hours) which covered bush regeneration activities on approximately 69,000m<sup>2</sup> of land managed under this contract. This involved weeding and spot spraying of the immediate area surrounding each water quality control asset including landscaped areas that have been mulched and planted with local native species. Some replacement planting and staking of existing tubestock is also required. Newly constructed devices will also require planting of terrestrial tubestock and in some cases, aquatic (macrophyte) plantings, with the majority of plant

stock being supplied by Council's nursery. Maintenance reports and invoices are submitted to Council on a fortnightly basis. Targeted terrestrial weed species include - Privet, Camphor Laurel, Lantana, Blackberry, Turkey Rhubarb, Castor Oil plant, Balloon Vine, Madeira Vine, Honeysuckle, Morning Glory, Asparagus Fern, Mist Flower, Crofton Weed, Ochna, Ginger, Wandering Jew and other herbaceous weeds and grasses such as Kikuyu and Paspalum.

Wetland maintenance involves the weeding / spraying of riparian areas and removal of weeds and nuisance plants within the shallow wetland ponds. In 2013 - 2014, contractors were responsible for maintaining 16 wetland sites carrying out 1,825 maintenance hours at a cost of \$73,000 (this includes four wetlands not built using funding from the CRR budget) and covered works on approximately 46,000 m<sup>2</sup> of land and wetland under this contract. Of this, 56% was dedicated to Council's four largest wetlands (Wallumeda, Laurence Street, Hastings Road and Clarinda Street). Time is also allocated to the removal of stormwater litter / rubbish strewn throughout the pond and edge areas. Replacement planting with macrophytes is also carried out, including occasional wetland establishment at new sites. A wetland maintenance sheet is required to be completed when conducting

works within wetlands, as Council requires this information for wetland condition monitoring.

Target aquatic weed species include Typha (Bullrush), Barnyard Grass, Milfoil, Watercress, *Cyperus eragrostis* and other undesirable or noxious water plants (e.g. *Ludwigia peruviana*, Alligator Weed and Salvinia). If a W1 Noxious Weed category plant is found onsite, the Contractor is to immediately notify Council as required under the Noxious Weeds Act 1993.

### 3.1.3. Total Maintenance Costs

The total cost to Council to maintain its water quality improvement devices including cleaning, landscape and wetland maintenance was approximately \$420,000 in the 2013 - 2014 financial year. This included \$165,000 for the cleaning of SQUIDS and disposal of waste to landfill and \$255,000 for wetland maintenance and bush regeneration at the sites. Other associated costs included the monitoring and maintenance of leachate treatment facilities, tree work and staff wages.

## 4. Catchments Remediation Rates Assets Performance

### 4.1 Rainfall Measurement

Daily rainfall data is obtained from the Bureau of Meteorology at eleven sites across the Shire. This data is used to examine the relationship between total yields of gross pollutants and rainfall. In 2013 - 2014 the Hornsby Council area recorded less than half the rainfall received in 2012 - 2013 (Refer to Appendix B for statistical data).

### 4.2 Pollutant Removal Trends

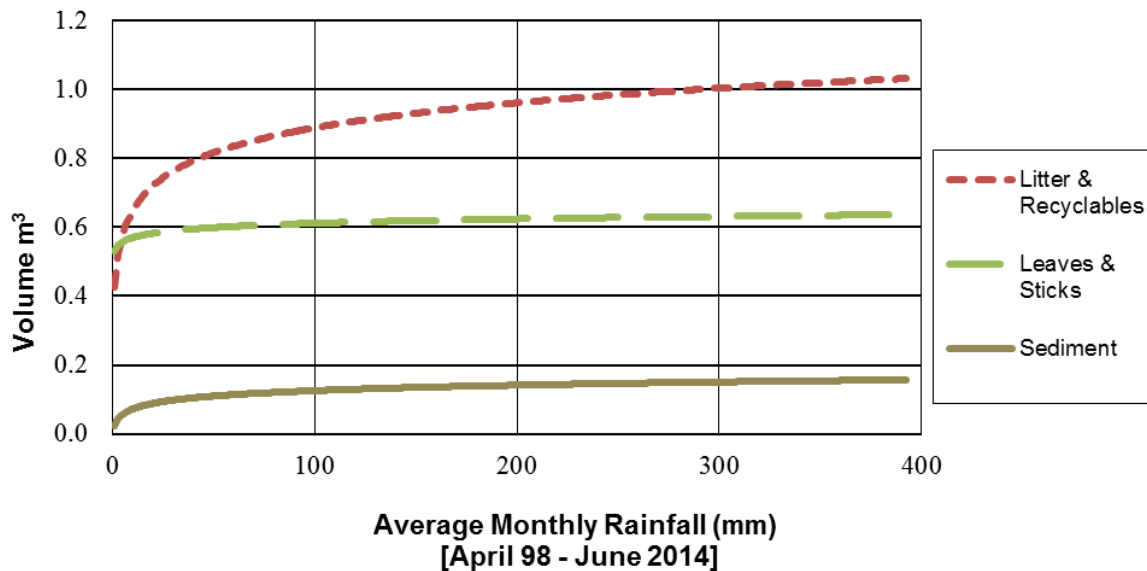
The collection of performance data over the 2013 - 2014 financial year has allowed Council to examine the indicative maintenance costs and gross pollutant removal trends for the 433 water quality improvement devices in the LGA. The results indicate that in 2013 - 2014, SQIDs have served to remove approximately 930 cubic metres collectively of sediment, litter and organic matter from the Shire's waterways.

These volumes were less than the previous year which can be best explained by two anomalies:

- The lower levels of rainfall experienced during the 2013-2014 period compared to the 2012-2013 financial year which can translate to a lower mobilisation of organic matter downstream before cleaning can be completed; and
- The high yield of sediment and organic matter resulting from the cleaning out of a number of large sediment basins in the 2012-2013 period.

The following series of figures examine the performance of SQIDs in 2013 - 2014 and against previous years.

**Figure 4-1 - The relationship between average monthly volume of gross pollutants and average monthly rainfall**



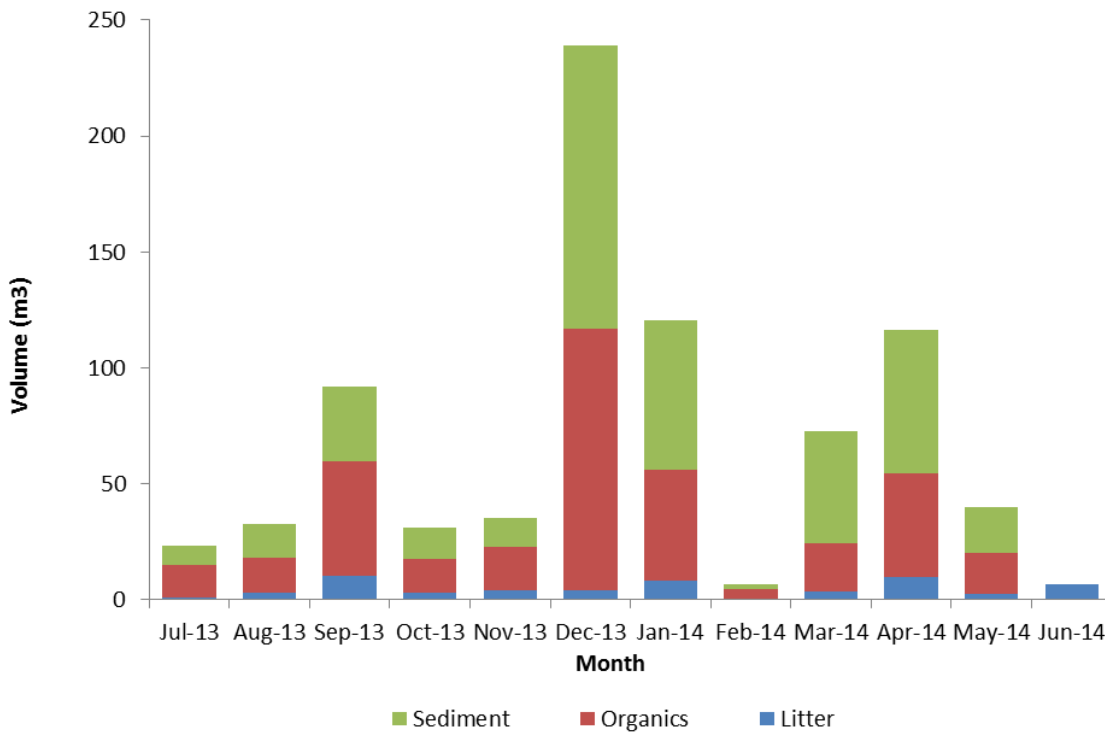
NOTE: Volume removed = total volume removed by all SQIDs across the Shire divided by number of SQIDs emptied.

When pollutant volume is analysed against average annual rainfall, all three categories of gross pollutants are mobilised and captured after only 10 mm of rainfall as evidenced in **Figure 4.1** by the evident rise in each curve. This phenomenon is referred to as the “first flush” effect, after which the volume captured continues to rise at a much slower rate in relation to rainfall volumes.

It can be seen that the load of litter recovered from all devices is relatively mobile when experiencing

only small levels of rain. This can be seen by the more steeply rising red dotted line. This is most likely due to the fact that litter is readily mobile and floatable in the formal drainage system (curb, gutter and pipes) and most of it will be flushed and collected in downstream SQIDs, even in small rain events. However, the fact that the curve for sediment has a gradual climb, proportional to rainfall, illustrates that after the initial flush the transport of sediment is directly proportional to stormwater volumes and associated energy.

**Figure 4-2 - Volumes of pollutants removed from SQIDs (2013 - 2014)**



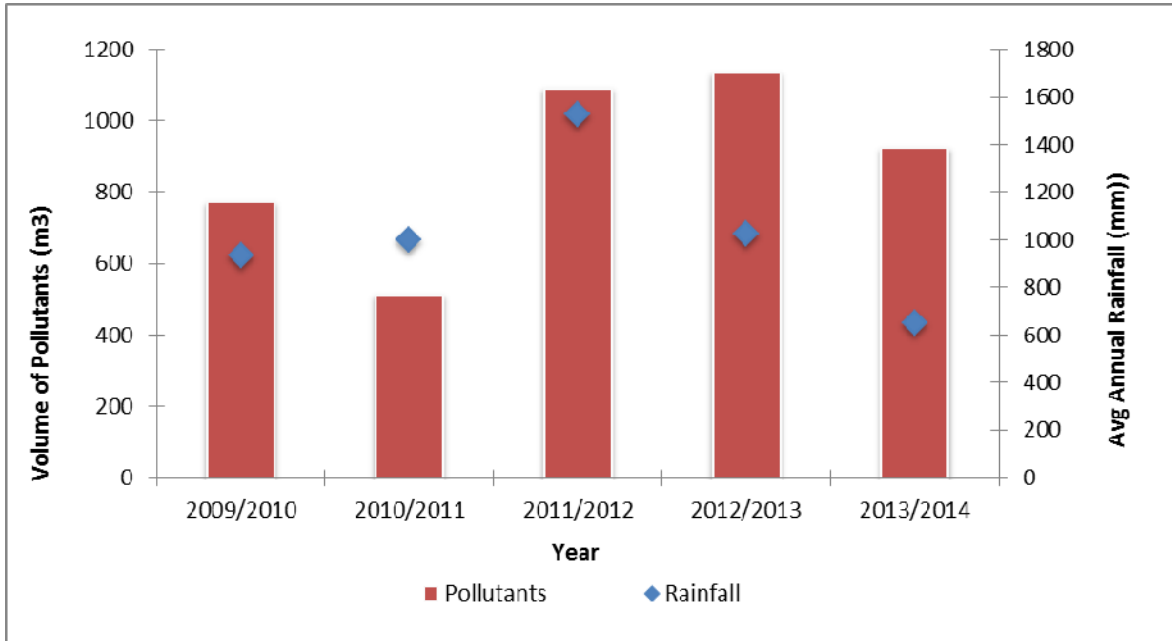
The actual volume of pollutants removed from month to month shown in **Figure 4.2** varied greatly in the 2013-2014 period. A clear correlation between monthly removal rates and rainfall cannot be made due to: 1) variable lag times between rainfall events and cleaning events, and 2) the disproportionately high volumes removed from sediment basins and wetlands evidenced in the December – January 2013 period, which are in addition to regular cleaning events.

However, a strong correlation is found between rainfall and pollutant yield from Council's SQIDs when viewed annually, as shown in **Figure 4.3**. With the lower rainfall levels experienced in the 2013 – 2014 period there is a reduction in stormwater run-

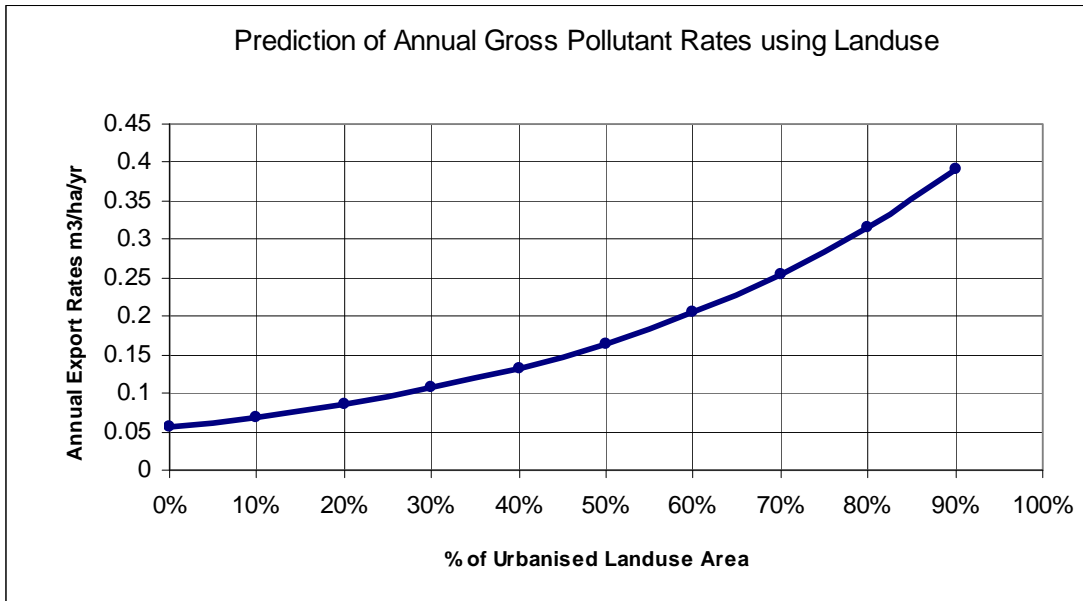
off into Council's drainage system that results in pollutants not being mobilised and therefore not transported and trapped by SQIDs. Fewer rainfall events also results in less SQID empties which reflects the lower yield in the 2013-2014 period (compared to 2012-2013). Some litter and organics may have also been captured by street sweeping vehicles from gutters due to not being delivered to the stormwater system. Additionally, lower rainfall levels can result in less mobilisation and scour of sediment from the upstream catchment due to the lower velocities experienced.



**Figure 4-3 - Pollutant volume (m3) removed from SQIDs against average annual rainfall July 2009 – June 2014**



**Figure 4-4 - Prediction of annual gross pollutant rates using landuse area**



Hornsby Shire Council is now at a stage where the data gathered from the various SQIDs can be used to predict the annual gross pollutant (export) rates on the basis of landuse. **Figure 4.4** shows how the annual export rate of pollutants exponentially increases with the amount of catchment that is urbanised (excludes bushland / open space). This information can be used when planning for future devices, in terms of expected export rates and known device capabilities. Stormwater managers can then compare actual pollutant export rates with

the predicted values in order to gauge the efficiencies of devices through time.

The high frequency of Hornsby Council’s inspection and cleaning of the devices combined with the unique trap designs for ease of maintenance, ensures that the pollutant trapping efficiency is optimum for each storm event and that materials do not decompose or stagnate causing additional problems with the release of pollutants into downstream receiving waters.

### 4.3 Wetland Performance

#### 4.3.1. Pollutant Removal Trends and Costs

The size of catchments draining to these constructed wetlands ranges from 15-400 hectares. The average pond surface area to catchment area ratio calculates at 0.23% which is below the minimum design size recommended by DLWC (1998) of 2% of the catchment area. It should be noted that this recommendation does not account for the variability associated with different catchment land uses, pollutant loads, peak flows, topography and soils. It is best used to determine preliminary wetland feasibility. Because the nature of Hornsby Shire is so topographically constrained (ridge top development that does not afford large areas for wetland construction) and contains significant remnant bushland, the wetland feasibility threshold is much lower than average.

Water quality monitoring of five separate systems managed by council over the past 10 years has shown that levels of total nitrogen, phosphorus, suspended solids and faecal coliforms are significantly reduced under base flow and small storm flow events. Monitoring results are based on both grab and load-based samples (and multi-probe analytes) obtained by Council over multiple rainfall events and inter-events.

#### 4.4 Assessment of Nutrient Removal by the CRR program

The principal objective of the CRR program is to improve water quality by removing pollutants. From the beginning of the program there has always been a particular focus on the removal and/or capture of nutrients because of their known impact on aquatic ecosystems, such as creeks and estuaries.

Quantitative data recorded to date on the performance of SQIDs has primarily looked at the mass and/or volume of gross pollutants removed through maintenance. While this provides a good data source the Natural Resources Operations Team has been looking at ways that give a better indication of the amount of nutrients removed from our waterways by the CRR program.

To do so, Council has used the modelling software MUSIC (Model for Urban Stormwater Improvement Conceptualisation) and modelled all urban sub-catchments within the LGA. However, Council has found the continuous updating of these models cumbersome and that they don't truly represent all nutrient capture from GPT's and do not include the benefits of other non-structural initiatives such as street sweeping.

Consequently, Council commissioned the formulation of a tool to provide a simplified and rapid assessment of the mass of nutrients captured by the CRR Program, which explicitly included estimates of the pollutant loads captured by GPT's and street sweeping. The findings have been encouraging with the tool indicating that over 703kg of phosphorus and 2,094kg of nitrogen was captured and removed from our waterways in the 2013-2014 period. Furthermore, it shows that in areas where concerted catchment remediation initiatives, e.g. on-ground works and frequent street sweeping have been rolled-out the overall pollution reduction that has been achieved is relatively good (Refer to **Table 4.2**).

This will prove to be an effective tool for Council in reporting on water quality improvements over time as well as aiding in future decisions on the most appropriate devices for specific areas and situations. This will enable Council to make cost savings by choosing the best management options and will provide greater clarity as to the areas contributing the most nutrient input to the waterways.

**Table 4-1 - Constructed wetland annual costs and monitoring records to end of June 2014**

Wetland (Year Built)	Capital Cost \$	Pond Surface Area (m <sup>2</sup> )	Pond Surface Area to Catchment Area (%)	Cost per m <sup>2</sup> of pond (\$/m <sup>2</sup> )*	Average Annual Maint. Cost <sup>2</sup> (\$/yr)	Monitoring Data (year/s)
<b>Asquith</b>						
Baldwin Avenue (2005)	38,000	123	0.46	326	2,050	Nil
<b>Beecroft</b>						
Lamorna Ave (2005)	134,000 <sup>4</sup>	400	0.44	349	5,512	Nil
Midson Rd (2003)	252,000	1,220	0.03	209	2,533 <sup>3</sup>	Nil
Plympton Rd (2000)	305,000	350	0.06	878	2,254 <sup>3</sup>	Nov 99-Jun 2002
<b>Brooklyn</b>						
Brooklyn Rd (1997)	46,000	205	0.26	231	1,382 <sup>3</sup>	Nil
<b>Castle Hill</b>						
Hastings Park (2002)	445,000	1,500	0.60	301	6,280	Jul 2001-Aug 2003
<b>Cherrybrook</b>						
Cherrybrook Lakes (1988)	70,000	4,615	0.58	16	1,897	2007-Sep 2013
<b>Dural</b>						
Millstream Grove (1995)	60,000	1,014	1.06	62	2,369	Nil
<b>Galston</b>						
Salloway Rd (2000)	36,000	190	0.01	193	718	Nil
<b>Hornsby</b>						
Clovelly Rd (1999)	117,000	210	0.02	563	1,261	Nil
Clarinda St (2001)	241,000	1,550	0.82	159	5,580 <sup>3</sup>	Jul 2002-current
<b>Pennant Hills</b>						
Laurence St (1996)	135,000	225	0.06	621	4,699	Jun 1995-Jun 2002
<b>Thornleigh</b>						
Dartford Rd (2006)	80,000	250	2.27	326	1,593	Nil
<b>West Pennant Hills</b>						
Boundary Rd (1996)	288,000	1,875	0.14	159	10,310 <sup>3</sup>	Aug 1998-Jun 2002
John Savage Cres (2004)	203,000	1,050	0.09	195	2,090 <sup>3</sup>	Nil
<b>Mean</b>	<b>163,333</b>	<b>985</b>	<b>0.46</b>	<b>306</b>	<b>3,251</b>	NA
<p>1 Includes monthly grab sampling (wet / dry) and probe (total of 13 parameters). Analysis by NATA lab  2 Includes weeding/spraying, sediment / rubbish/debris removal, planting / mulching and replacement and reporting (excludes volunteer Bushcare labour)  3 Volunteer Bushcare present onsite  4 Capital costs incorporates up to 100m of stream remediation  *Cost/m<sup>2</sup> of pond is calculated using capital cost and average annual cost / year</p>						

**Table 4-2 - Capture of Nutrient Exports (CANUTE) in Hornsby LGA from July 2013 to June 2014**

Sub-catchments	Total Phosphorus				Total Nitrogen			
	Source	To Receiving Waters	Reductions		Source	To Receiving Waters	Reductions	
	(kg)	(kg)	(kg)	(%)	(kg)	(kg)	(kg)	(%)
Berowra Creek	3,490	3,059	431	19%	45,851	44,533	1,317	7.7%
Hornsby Creek / Cowan Creek	417	322	95.1	24%	3,978	3,565	413	13%
Hawkesbury River (local total)	3,993	3,465	1.3	3.8%	48,984	47,253	0.4	0.2%
Lane Cove River	1,115	940	175.1	16%	7,768	7,405	364	5%

## 5. Landfill and Leachate Remediation

The Catchments Remediation Program has also been responsible for funding the treatment of polluted leachate from two of the Shire's largest former municipal tip sites at Arcadia Park, Arcadia and Foxglove Oval, Mt Colah. Instead of using the traditional technologies available for the treatment of leachate, Council has looked to more sustainable and innovative methods that can achieve pollution reductions and serve as a model for leachate treatment at a local government, state and national level.

This work is significant by way of the methodology which mimics natural processes of nitrification and

denitrification. Council staff have worked together in a trans-disciplinary manner, together with specialised scientific consultants to design, construct and monitor both treatment systems. Council is committed to the long-term maintenance, monitoring and management of the two facilities in order to justify and apply the technological benefits to other landfills within the Shire.

Monitoring results illustrating the treatment levels achieved by the system can be viewed in the "Water Quality Monitoring Program 2013 – 2014 Annual Report".

## 6. Catchments Remediation Rate Environmental Education

Environmental education is delivered by Council's Catchment Remediation Education Officer to rate payers, residents, local business & industry, community groups, council staff, teachers and students within the Shire.

The definition of "environmental education" generally refers to organised efforts to teach about how natural environments function and, particularly, how human beings can manage their behaviour and ecosystems in order to live sustainably.

In the context of the Catchments Remediation Program, council's environmental education activities generally focus on promoting community awareness of:

- CRR-funded capital works program
- Stormwater quality improvement devices
- Hornsby's water quality monitoring program
- Hornsby's catchments, creeks and estuarine areas
- Total water cycle management
- Stormwater pollution
- Stormwater harvesting
- Water conservation
- Catchment care personal actions

Activities undertaken by the Catchment Remediation Education Officer have included:

- CRR Promotion at Community Events
- Hosting stalls and displays at various community events, such as
  - Bushland Festival
  - Berowra Woodchop Festival
  - Brooklyn Spring Fair
  - Hornsby's Christmas Spectacular
  - Hornsby TAFE Environmental Expo
  - Council's Native Plant Giveaways

- Media campaigns
- Promotional Material
  - developing print material and website content
  - preparing case studies of CRR devices
  - interpretive signage
- Catchment tours
- Guided tours promoting the CRR program and capital works installed
- Workshops
- Rainwater tank and grey water awareness workshops
- Schools program
- Hornsby Environment Network for Schools (HENS)
- School presentations
- Resource materials for school assignments
- Streamwatch water quality monitoring support
- Lane Cove River Catchment Day
- Grant funded projects
- Water for Life Council Partnership Kit (stormwater awareness)
- Catchment Connections (stormwater and catchment awareness)
- Tankscape – Rainwater Tanks in Schools Program
- Hornsby Creek Catchment Urban Sustainability Program





Environmental education is a learning process that increases people's knowledge and awareness about the environment and associated challenges, develops the necessary skills and expertise to address the challenges, and fosters attitudes, motivations, and commitments to make informed decisions and take responsible action (UNESCO, Tbilisi Declaration, 1978).

## Nature's Filter

Biofilters (also known as bioretention systems or raingardens) use the combination of plants and sand to filter and remove pollutants from stormwater run-off. Here's how they work:

- 1** Polluted stormwater from surrounding properties, footpaths and roads runs into the biofilter via street drainage.
- 2** Biofilters are customised for each site location and may include a gross pollutant trap to collect litter and leaves.
- 3** Stormwater flows into a sediment trap, which slows the flow of water, allowing sediment to drop out for later removal.
- 4** Water disperses over the surface of the biofilter maximising the volume of run-off to be treated. Native grasses, shrubs and trees are densely planted and selected on their proven capacity to absorb pollutants.
- 5** Run-off water is filtered as it percolates downwards through almost a metre of loamy sand. Biofilters remove pollutants (eg. nutrients and heavy metals) through physical, chemical and biological processes, including filtration, plant uptake and microbial activity.
- 6** Slotted drainage pipes collect the treated water and direct it into a collection pit. These pits also act as overflow points during heavy rainfall.
- 7** Cleaner, treated water flows to local creek and estuary.

These biofilters have been installed at key locations across the Shire funded by the Catchments Remediation Rate – a special rate used to improve and protect the health of Hornsby Shire's waterways and catchments.

Leaves, litter, dog poo, cigarette butts, car wash detergent, paint, engine oil, garden run-off (fertiliser and pesticide) and sediment from building sites all pollute our waterways. Please remember: the drain is just for rain!

Hornsby Shire Council... *protecting your local creek*

Plate 19-21 Educational Initiatives  
(top to bottom)  
Catchment Tour of CRR Biofilter  
Interpretive signage for Biofilter

## 7. Street Sweeping

Since 1997, the Catchments Remediation Rate (CRR) has funded a proportion of Council’s Street Sweeping Program at a total cost of \$233,000 per year. Street sweeping is an effective method by which gross pollutants (sediment, leaves and litter) can be collected at source by targeting problem leaf drop areas and high pollutant load land use areas, e.g. commercial and industrial.

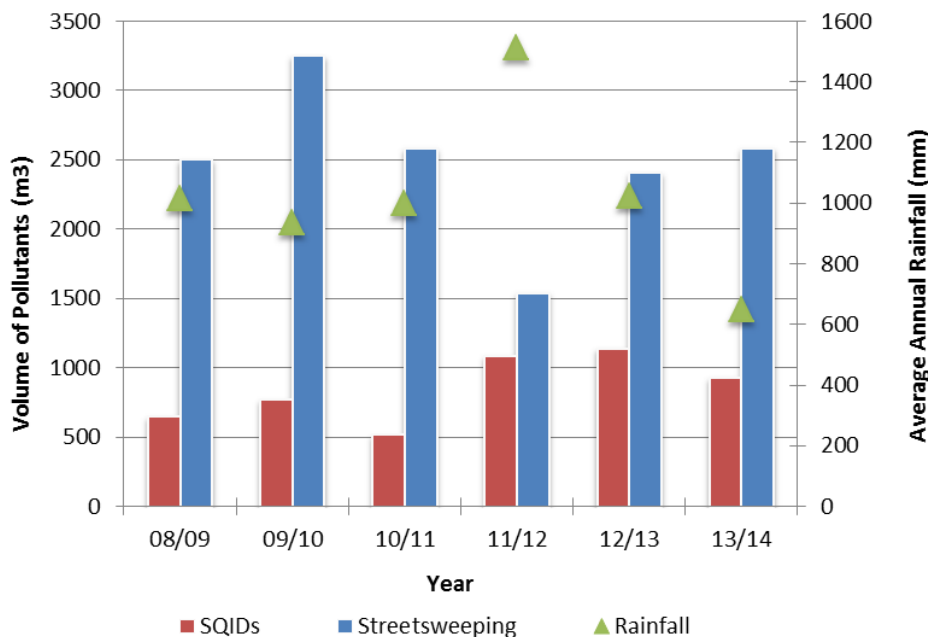
In 2013 - 2014, 926 cubic metres of material was collected from scheduled cleaning of roadside curb and guttering. This is a decrease on the 1,136 cubic metres collected in the 2012-2013 financial year potentially due to the lower level of rainfall during 2012-2013 resulting in a reduction in delivery of this matter into nearby stormwater drains and on to streams and creeks. This material may have been collected by street sweeping vehicles instead which is supported by an increase in street sweeper volumes compared to the 2012-2013 financial year totals.

**Figure 7.1** compares volumes extracted by SQIDs against street sweeping. Interestingly, when comparing street sweeping in 2012-2013 to that for 2013-2014, the lower rainfall experienced in 2013-2014 appears to have resulted in higher street sweeping collection. This may be attributed to an accumulation of leaf litter and sediment in gutters for longer periods resulting in greater capture of these pollutants by street sweeping vehicles.

This theory is further supported by the low levels collected in the 2011-2012 financial year and the correspondingly high levels of rainfall. This seems to suggest that this high rainfall delivered leaf litter and sediment to the stormwater system before street sweepers could collect it.

SQIDs would also be prone to missing some pollutants in high rainfall periods due to devices being designed to bypass in high flows to reduce the risk of flooding.

**Figure 7-1 - Pollution yield (m<sup>3</sup>) extracted by SQIDs and street sweeping against average annual rainfall July 2008 – June 2014**



## 8. Total Water Cycle Management

The Sustainable Total Water Cycle Management Strategy provides actions and integrates existing programs for managing the natural and urban water cycle in an ecologically sustainable manner. Urbanisation has altered the way water flows through a catchment resulting in poor water quality and aquatic ecosystem health. Broadly the actions outlined in the Strategy aim to minimise the urban impact on the natural water cycle, including water quality. This is based on the premises that by managing the urban water cycle as a whole a more efficient use of resources can be achieved providing not only economic benefits but also improved social and environmental outcomes.

The enhancement of water quality treatment, through the Catchments Remediation Program, and water re-use has been the main focus of the Strategy. To achieve this goal biological treatment of polluted water and stormwater harvesting has become an effective and environmentally viable option to reduce pollution and potable water use in urban areas.

### 8.1 Stormwater Harvesting

The harvesting of stormwater involves the collection, treatment, storage and use of stormwater run-off from urban areas. The process differs from rainwater harvesting as the runoff is collected from drains or creeks rather than roofs.

Benefits associated with stormwater harvesting include:

- engagement of water conservation practices;
- cost savings from reusing water;
- reduce and reuse the volume of stormwater/irrigation water leaving the site;
- water quality treatment of stormwater;
- reduced pollution loads to waterways;
- reduce wastewater flows;
- apply water resource sustainability practices;

- minimise the dependency on potable water;
- enhancing playing field condition and
- promote social interaction, and a healthier community.

### 8.2 Stormwater Harvesting Projects

Stormwater harvesting facilities have been constructed at Greenway Park, Berowra Oval, Epping Oval, Nth Epping Oval, Somerville Oval, Foxglove Oval, Pennant Hills Nursery and Thornleigh Oval. The benefits derived from these works have included, reusing water to irrigate the parks in a sustainable and cost effective way and to reduce pollution downstream ecosystems. These works have also provided social benefits to the community by enhancing playing field condition and promoting social interaction. Typically urban stormwater contains high levels of gross pollutants and suspended solids that alter flow conditions, decrease light penetration and effect habitat of aquatic ecosystems. Nutrients and bacteria are also associated with urban pollution which causes excessive growth of plants and alga leading to oxygen depletion.

#### • Greenway Park

Greenway Park is located in Cherrybrook. The stormwater harvesting facility was completed in 2009. The facility has a storage capacity of 400kL (i.e. four underground 110 kL tanks).





**Plates 22 Water quality testing of harvested stormwater, Thornleigh Biofiltration/stormwater harvesting system**

- **Berowra Oval**

Berowra Oval is situated north of Hornsby in Berowra. The stormwater harvesting facility was completed in October 2009. Water storage consists of a 90kL concrete belowground tank located adjacent to Gully Rd.

- **Epping Oval**

Epping Oval was completed in 2011. The facility has a storage capacity of 400kL's consisting of two underground tanks (i.e.100kL's and 300 kL's).

- **Nth Epping Oval**

North Epping Oval was completed in 2011. The project includes 100kL's and 300kL's below ground storage tanks.

- **Somerville Oval**

Somerville Oval was completed in 2010. The facility has a belowground storage capacity of 400kL

- **Foxglove Oval**

Foxglove Oval was a landfill site. The oval was compacted, capped and converted to Foxglove Oval in 1985. A water quality treatment facility was installed to reduce the impacts of the leachate coming from the site. The treatment process involves a two-cell natural soil-based shallow wetland and a nitrification-filter to treat water to a level compatible with standards for irrigation reuse. A harvesting system was completed in June 2010 to reuse the effluent to irrigate the oval.

In 2014 the recycling system was upgraded to a three phase stainless steel pump and a monitor protection system. The monitor system will protect the pump from power surges and electrical malfunctions.

- **Thornleigh Oval**

The Thornleigh oval stormwater harvesting scheme was completed in 2013. The facility is located at Dawson Ave, Thornleigh. Stormwater flows are captured into a primary 100kL's stormwater storage biofiltration tank.

Water is pumped via a rising main along Ferguson Ave to a 20kL header tank located at Thornleigh Oval ready for distribution.



**Plates 23 & 24 Thornleigh Biofiltration/stormwater harvesting system (during and after construction)**

- **Pennant Hills Nursery Cottage**

The nursery cottage stormwater harvesting scheme was completed in 2003. Flows discharge into a primary 107kL's primary storage tank. Water is then treated and stored in a 110kL's tank ready to be used for irrigation.

The facility was upgraded in 2014. The works included: cleaning and renewal of all drainage



pipework, pits; seal and repair of water leakages; renewal of biological media; cleaning of storage tanks; servicing of pumps and electrical panels.

facilities. The preventative maintenance program includes a six monthly service for each facility. The program commenced in 2014 for a term of three years.

### 8.3 Stormwater Harvesting Facilities Preventative Maintenance

Council has implemented a preventative maintenance program for the stormwater harvesting. The program will also ensure public health safety by preventing equipment failures and decrease system downtime by replacing suspect defective worn components. The outline of the preventative maintenance work requirements is shown in Table 8-1.

The program will mitigate the consequences of equipment failure by preventing downtime through a planned maintenance program. Accordingly, the preventative maintenance program will improve equipment reliability by inspecting and replacing suspect worn components and will include partial or complete service at specified periods.

**Table 8-1 - Stormwater Harvesting preventative maintenance program**

Process	Function	Preventative Maintenance
Raw Water Collection	<b>Pump well</b>	Dewatered and de-sludge.
	<b>Rising main pumps</b>	Clean, replace seals, O rings, oil and test.
Storage Tanks	<b>Raw Storage</b>	Empty, inspect, clean and de-sludge as required.
	<b>Transfer Pumps</b>	Clean, replace seals. O rings ( as per manufactures requirements)
Filtration	<b>Backwash screen filter</b>	Clean screen filter and inspect and replace worn components as per manufactures requirements (i.e. O rings , pawl and reverser)
	<b>Media Filter</b>	Check valves, water quality (turbidity), pressure and increased frequency of backwash. Media to be replaced every 5 years.
Tertiary Treatment	<b>UV Disinfection</b>	Clean / replace lamps and test as per manufacturer requirements.
Electrical Systems	<b>Control Panel</b>	Clean sensors and calibrate all functions to ensure true accurate readings.
Plant Room	<b>Mechanical</b>	Check lines and fitting connections for leaks and wear.
Header Tank	<b>Treated Storage</b>	Inspect and clean as required.

## 9. Conclusions

This report has aimed to provide quantitative data and analysis of the relative performance of different water quality treatment measures, including GPD's, sediment basins, wetlands and biofilters that have been constructed to improve stormwater quality in Hornsby Shire. The results of the report can be used by stormwater and catchment managers to provide a better insight into determining the type of structure and suitability for specific sites. Furthermore, the data provides valuable information about the costs (both capital and maintenance), benefits and device optimisation which can aid in the formulation of strategies to improve catchment / landuse practices by both structural and non-structural means.

Overall, the findings of this report should give stormwater managers a better insight into the cost-effectiveness and performance of water quality improvement structures and the management of life-cycle costs for individual stormwater quality assets. The performance of these devices has allowed Council to both refine and modify future designs, and judge their appropriateness to proposed remediation sites based on catchment size and land use impacts.

## 10. References

Australian Bureau of Statistics (2011). Population Estimates by Local Government Area, 2001 to 2010. Report 3218.0.

Brisbane City Council (2006). Water Sensitive Urban Design – Technical Design Guidelines for South East Queensland. Version 1 released June 2006.

Collins, A. (2005). Stormwater Reuse Issues and Experiences – Hornsby Shire Council. Stormwater Industry Association 2005 Regional Conference, Port Macquarie, NSW, 20-22 April (12pp).

Cooperative Research Centre for Catchment Hydrology (2003). Model for Urban Stormwater Improvement Conceptualisation (MUSIC). Version 2 released December 2003.

Walsh et al (2004) Urban Stormwater and Ecology of Streams Cooperative Research Centre Freshwater Ecology and Catchment Hydrology

DLWC (1998). The Constructed Wetlands Manual – Volumes 1&2.

EPA (1999). Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-Liquid Wastes.

Engineers Australia (2006) Australian Runoff Quality Engineers Media

Hatt, B et al (2006) Filter media for stormwater treatment and recycling: the influence of hydraulic properties of flow on pollutant removal Water, Science and Technology IWA Publishing

Hornsby Shire Council (1997). Catchments Remediation Program Five Year Plan (Revised Edition). Report prepared by The Water Catchments Team.

Hornsby Shire Council (2013). Catchments Remediation Rate Capital Works Program 2012 – 2013 Annual Report. Prepared by The Water Catchments Team, October 2013.

Hornsby Shire Council (2013). Water Quality Monitoring Program 2012 – 2013 Annual Report. Prepared by The Water Catchments Branch, October 2013.

Hornsby Shire Council (2006). Draft Stormwater Drainage Asset Management Plan. Prepared by the Water Catchments and Assets Branches, May 2006.

Rocla CDS<sup>®</sup> Technologies Pty Ltd, Gross Pollutant Traps Product Brochure, November 2007.

University of Technology, Sydney (2004). Environmental Assessment of HydroCon Stormwater Infiltration Systems at Hornsby. Faculty of Engineering.

Victoria Stormwater Committee (1999). Urban Stormwater: Best practise environmental management. CSIRO

WBM Oceanics (2005). Maintenance Guidelines for Stormwater Treatment Measures. Final Report January 2005. Prepared for Hornsby Shire Council under NSW Stormwater Trust funding.

Knights, D, Beharrell, D Jonasson, J (2010) What does it cost to build a water quality treatment system? Findings from Council retrofits in Sydney. Stormwater Industry Association 2010 National Conference, Sydney, NSW July 2010

## Appendix A - SQUID Site Locations

### Stormwater Quality Improvement Devices Non - Proprietary (36)

#### Waste Racks (4)

Cherrybrook  
Flametree Crescent (2)  
**Appletree Close**  
**Odney Place**

#### Trash Racks (21)

Beecroft  
Norwood Avenue

Berowra  
Berkeley Close  
The Gully Road

Berowra Heights  
Warrina Street

Castle Hill  
Belltree Place

Cheltenham  
Castle Howard Road

Cherrybrook  
Woodgrove Road

Epping  
Beecroft Road

Glenorie  
Tekapo Road

Hornsby  
Northcote Road  
Water Street  
Clarinda Street  
Malsbury Road  
Old Berowra Road

Mt Kuring-gai  
Hamley Road

Normanhurst  
Denman Parade

Pennant Hills  
Bellamy Street

Thornleigh  
The Comenarra Parkway  
Larool Crescent

West Pennant Hills  
New Farm Road  
Wilga Street

#### Litter Baskets (11)

Asquith  
Mittabah Road

Beecroft  
Sutherland Road

Berowra  
Bambil Road x 3

Berowra Heights  
Berowra Waters Road

Cherrybrook  
Shepherds & Macquarie  
Drives

Hornsby  
Clovelly Road  
Sherbrook Road

Thornleigh  
The Comenarra Parkway  
Janet Avenue

### Stormwater Quality Improvement Devices (SQIDs) - Proprietary (275)

#### Underground Vaults (25)

Asquith  
Dudley Street  
Gardenia Street

Beecroft  
Jacinta Avenue

Berowra  
The Gully Road

Berowra Heights  
Woodcourt Road

Berowra Waters  
Dusthole Bay

Brooklyn  
Dangar Road  
George Street

Castle Hill  
Foley Place

Cheltenham  
Castle Howard Road

Cherrybrook  
Greenway Park  
Millbrook Place  
Monterey Place  
Rosemary Place

Dural  
Lockyer Close

Eastwood  
Blaxland Road (Somerville  
Park)

Epping  
Somerset Street

Hornsby  
Hunter Street

Hornsby Heights  
Pike Road

North Epping  
Boundary Road

Thornleigh  
Dartford Road x 2  
Sefton Road

Waitara  
Unwin Road

West Pennant Hills  
Cardinal Avenue

**Net Techs / Pratten Nets / Channel Nets (75)**

Asquith  
Baldwin Avenue  
Stratford Place

Berowra  
Boundary Street x 3  
Ti Tree Crescent

Berowra Heights  
Currawong Road x 2  
Joalah Crescent

Castle Hill  
Childrey Place

Cheltenham  
Castle Howard Road x 2  
Kirkham Road x 2

Cherrybrook  
Gavin Street  
Glenoak Way  
Kenburn Avenue  
New Line Road x 5  
Pecan Close

Cowan  
Alberta Avenue

Dural  
James Henty Drive  
New Line Road x 3

Epping  
Bruceedale Road x 2  
Ridge Street  
Stanley Street

Hornsby  
Burdett Street x 8  
Clarinda Road  
Pacific Highway  
Rosemead Road x 2  
Sherbrook Road  
Binya Close

Hornsby Heights  
Galston Road x 5  
Raphael Drive

Mount Colah  
Jessica Place  
Murralong Road x 2  
Parklands Road

Mount Kuringai  
Gundah Road x 2  
Pacific Highway x 5

Normanhurst  
Hinemoa Avenue

North Epping  
**Boundary Road**

Pennant Hills  
Brittania Street x 2  
Morrison Place x 2

Thornleigh  
Blantyre Place x 2

Westleigh  
Duneba Drive x 3  
Russell Crescent

**Ski-Jump Litter Traps (3)**

Carlingford  
Anthony Street

Hornsby Heights  
Off Heights Place

Pennant Hills  
George Street

**Pit Inserts (172)**

Beecroft / Carlingford / Epping  
Various Locations (35)

Eastwood  
Blaxland Road (Somerville  
Park) (2)

Pennant Hills  
Commercial area (4)

Asquith  
Mills Park Tennis Carpark  
Wattle Street (3)

Glenorie  
Cairnes Road

Thornleigh  
Industrial / Commercial  
Zone (11)

Berowra  
Berowra Waters Road & Pacific  
Hwy (4)

Hornsby  
Hornsby Industrial area (20)  
Dural Street (3)  
CBD Various Locations (70)

Waitara  
Thomas and Orara Streets  
(6)

Berowra Waters  
Dusthole Bay

Mount Colah  
Pacific Highway  
Sue Place (2)

Westleigh  
Eucalyptus Drive

Brooklyn  
Brooklyn Road (5)

Normanhurst  
Denman Road (2)



## Biofilters, Bioswales, Streetscape Raingardens, Tree Pit Biofilter and Stormwater Reuse Biofilter (68)

### Biofilters/Bioswales (26)

Berowra  
Boundary Street

Berowra Heights  
Currawong Road

Cheltenham  
Castle Howard Road  
Lyne Road

Cherrybrook  
Appletree Close  
**Gavin Place**  
Lawson Place  
**Pecan Place**

Glenorie  
Tecoma Drive

Hornsby  
Stewart Avenue

Hornsby Heights  
Margaret Avenue  
Oorin Road  
Peter Close  
Spedding Road

Mount Colah  
**Murralong Road**  
Parish Place

Mount Kuringai  
Gundah Road

North Epping  
Belinda Crescent  
Malton Road  
Braidwood Avenue  
Eastcoate Avenue

Pennant Hills  
Albion Street  
Blackbutt Avenue  
**Pennant Hills Park**

West Pennant Hills  
Bellamy Street

Westleigh  
Apanie Avenue

### Streetscape Raingardens (21)

Berowra Heights  
Turner Road (6)  
Brooklyn  
George Street (4)

Epping  
Ray Road (4)  
Cowan  
View Street

Waitara  
Alexandria Parade (4)  
Galston  
Fagan Park (2)

### Tree Pit Biofilter (20)

Epping  
Oxford Street (16)

Hornsby  
Coronation Avenue (4)

### Stormwater Reuse Biofilter (1)

Thornleigh  
Dawson Avenue

### Sediment Basins (63)

Asquith (1)  
Beecroft (2)  
Berowra (6)  
Berowra Heights (1)  
Cheltenham (5)  
Cherrybrook (11)  
Cowan (1)

Dural (2)  
Epping (7)  
Epping North (1)  
Glenorie (1)  
Hornsby (3)  
Hornsby Heights (2)  
Mount Colah (3)

Mount Kuringai (2)  
Normanhurst (2)  
Pennant Hills (3)  
Thornleigh (4)  
West Hornsby (1)  
Westleigh (5)

### Constructed Wetlands (14)

Beecroft  
Lamorna Avenue  
Midson Road  
Plympton Road

Brooklyn  
Brooklyn Road

Castle Hill  
Hastings Park

Epping  
Ridge Street  
Galston  
Sallaway Road

Hornsby  
Clarinda Street  
Clovelly Road

Pennant Hills  
Laurence Street

Thornleigh  
Dartford Road  
**Larool Crescent**

West Pennant Hills  
John Savage Crescent  
Boundary Road

**Developer Constructed Wetlands (10)**

Berowra  
Summer Hill Way

Dural  
Millstream Grove\*\*

Thornleigh  
Huntingdale Way  
Wild Ash Avenue

Castle Hill  
Foley Place

Hornsby Heights  
Sydney Road\*\*  
The Outlook\*\*

Westleigh  
The Sanctuary

Cherrybrook  
Shepherds Drive (The Lakes)\*\*

Mount Colah  
Kalang Road\*\*

\*\* Council managed

**Stream Remediation Projects (47)**

<b>Berowra Creek Catchment</b>	<b>Hawkesbury River Catchment</b>
<u>Berowra</u> - Boundary Street - Gwandalan Crescent <u>Berowra Heights</u> - Wymah Road <u>Castle Hill</u> - Hastings Park <u>Cherrybrook</u> - Lakes of Cherrybrook - Woodgrove Road <u>Glenorie</u> - Tecoma Drive <u>Hornsby</u> - Clarinda Street - Reddy Park - Stewart Avenue <u>Hornsby Heights</u> - Heights Place <u>Mount Colah</u> - Murralong Road - Parrish Place - Parklands Road <u>Pennant Hills</u> - Albion Street - Laurence Street <u>West Pennant Hills</u> - John Savage Crescent - Wearne Avenue - Wilga Street <u>Westleigh</u> - Duneba Drive - Elouera Road	<u>Brooklyn</u> - Brooklyn Road  <b>Lane Cove River Catchment</b>  <u>Beecroft</u> - Fearnley Park - Lamorna Avenue - Midson Road - Norwood Avenue - Plympton Road - Ray Park <u>Carlingford</u> - Anthony Street <u>Cheltenham</u> - Castle Howard Road - Kirkham Street - Lyne Road <u>Cherrybrook</u> - Flametree Crescent <u>Epping</u> - Brucedale Avenue - Kent Street - Ridge Street (east) - Ridge Street (west) - Pembroke Road - Stanley Street - Essex Street <u>Normanhurst</u> - Hinemoa Avenue - Nicholas Crescent <u>North Epping</u> - Belinda Crescent <u>Pennant Hills</u> - Orchard Street <u>Thornleigh</u> - The Comenarra Parkway - Thornleigh Street
<b>Cowan Catchment</b>	
<u>Hornsby</u> - Sherbrook Road (Northcote end)	

## Appendix B - Rainfall Data for Hornsby LGA

### Location and Sources of Rainfall Data (BOM 2014)

Monthly / Annual Rainfall For Hornsby Shire (mm)												
Month	Berowra 67052	Cherrybrook 67062	Dural 67086	Hornsby Pool 67065	Glenorie 67010	Maroota 67014	Parramatta North 66124	Pennant Hills 66047	WP Hills 67089	Wisemans Ferry 61119	Wahroonga 66211	Monthly Average
Jul	4	24	5	10	11	8	19	12	29	13	10	13
Aug	11	8	10	13	11	10	10	10	7	10	15	11
Sep	26	19	14	21	15	20	17	23	18	19	26	20
Oct	30	16	18	23	19	22	15	20	11	32	24	21
Nov	164	257	273	301	146	177	174	270	212	141	262	216
Dec	34	34	36	36	28	27	36	36	33	22	2	29
Jan	23	32	17	21	22	33	22	31	28	32	1	24
Feb	89	85	81	89	95	84	67	86	82	106	34	82
Mar	135	181	179	146	126	155	18	162	137	139	172	141
Apr	34	53	48	60	33	67	47	60	47	42	75	51
May	14	10	10	9	10	8	9	10	6	8	14	10
Jun	27	28	30	44	27	26	31	30	34	23	45	31
<b>TOTAL</b>	<b>590</b>	<b>747</b>	<b>721</b>	<b>773</b>	<b>543</b>	<b>637</b>	<b>466</b>	<b>750</b>	<b>643</b>	<b>587</b>	<b>681</b>	<b>N/A</b>

**Note:** Shaded monthly totals have not been quality assured.

**WP:** West Pennant

**Average rainfall and average number of days exceeding 10mm and 50mm of rain for 11 sites across the Shire 2013 - 2014. (Note: Figures in brackets are for 2012 - 2013)**

<b>Month</b>	<b>Average Monthly Rainfall 2013 - 2014 (mm)</b>	<b>Average No. of Days &gt;10mm rain</b>	<b>Average No. of Days &gt;50mm rain</b>
<b>Jul</b>	13 (27)	0 (1)	0 (0)
<b>Aug</b>	11 (7)	0 (0)	0 (0)
<b>Sep</b>	20 (38)	1 (1)	0 (0)
<b>Oct</b>	21 (30)	0 (1)	0 (0)
<b>Nov</b>	216 (51)	7 (2)	0 (0)
<b>Dec</b>	29 (57)	1 (1)	0 (0)
<b>Jan</b>	24 (161)	0 (3)	0 (1)
<b>Feb</b>	82 (197)	3 (4)	0 (1)
<b>Mar</b>	141 (98)	7 (3)	0 (0)
<b>Apr</b>	51 (109)	1 (4)	0 (0)
<b>May</b>	10 (73)	0 (2)	0 (0)
<b>Jun</b>	31 (171)	1 (7)	0 (0)
<b>Total</b>	<b>NA</b>	<b>21 (29)</b>	<b>0 (2)</b>





**All Sites - Average Annual Rainfall vs 2013 - 2014 Annual Rainfall\***

<b>Sites</b>	<b>Maximums, Minimums and Average Annual Rainfall</b>	<b>2013- 2014 Annual Total</b>
<b>Berowra – 67052</b>	Since 1904 (Excluding 53 years of data) Maximum: 2078 Minimum: 708 Average: 1187	<b>590mm</b>
<b>Glenorie – 67010</b>	Since 1961 (Excluding 3 years of data) Maximum: 1681mm (1950) Minimum: 386mm (1944) Average: 987mm	<b>543mm</b>
<b>Hornsby Pool – 67065</b>	Since 2009 Maximum: 1349mm (2011) Minimum: 962mm (2009) Average: 1182mm	<b>773mm</b>
<b>Maroota – 67014</b>	Since 1926 (Excluding 30 years of data) Maximum: 1774mm (1950) Minimum: 354mm (1953) Average: 914mm	<b>637mm</b>
<b>Parramatta North - 66124</b>	Since 1966 (Excluding 2 years of data) Maximum: 1713mm (1990) Minimum: 513mm (1979) Average: 969mm	<b>572mm</b>
<b>Pennant Hills – 66047</b>	Since 1901 (Excluding 52 years of data) Maximum: 2036mm (1950) Minimum: 573mm (1941) Average: 1060mm	<b>750mm</b>
<b>Wahroonga – 66211</b>	Since 2011 (Excluding 0 years of data) Maximum: 1643mm (2011) Minimum: 1350mm (2012) Average: 1496mm	<b>681mm</b>
<b>Wisemans Ferry – 61119</b>	Since 1906 (Excluding 51 years of data) Maximum: 1498mm (1988) Minimum: 437mm (1906) Average: 587mm	<b>1004mm</b>

\*Note - Some data has been excluded as not quality assured by the BOM.

