Guidelines for stormwater harvesting on Melbourne Water drainage assets

Design, construction and maintenance of diversion structures

Table of contents

Table of contents continued

Table of contents continued

Table of contents continued

Document Control

Current Document

Document Name	Guidelines for stormwater harvesting on Melbourne Water drainage assets
Version Number	2
Last Review Date	February 2016
Frequency of Review	5 years
Next Review Due Date	February 2020
Groups	Diversion Team
Responsible Officer	Tim Donovan
Approved by	Steve Hosking

Document History

Version No.	Amendments	Authorised by	Date
1	New document	Steve Hosking	October 2012
2	Revised document	Steve Hosking	February 2016
3			

Melbourne Water
990 Latrobe Street, Docklands 3008
PO Box 4342 Melbourne Victoria 3001
Telephone 131 722 melbournewater.com.au

ISBN 978-1-921911-22-4 (Print)
ISBN 978-1-921911-23-1 (Web)

Section 1 - Introduction

Stormwater has been identified as a relatively untapped water resource with potential to be utilised more productively to substitute existing demands on potable water supplies and to meet the water needs of new developments. Also, use of stormwater is a prerequisite for the protection or restoration of urban waterways.

Extractions of water from waterways or works of Melbourne Water have been capped at current allocation levels since October 2006 to protect security of supply and environmental values. However, the Government has recognised that urban stormwater is a potential resource to be utilised in favour of potable supply for purposes such as irrigation of race courses, golf courses, sporting ovals and public parks and gardens. This recognition was reinforced in the Central Region Sustainable Water Strategy which identified large volumes of stormwater available across the urban area.

The Government has adopted the following allocation rules for stormwater in urban areas as referred to in the Central Region Sustainable Water Strategy 2006:

- If stormwater is flowing to the sea via a drain, all of the stormwater may be harvested
- If stormwater is flowing to a stream from an existing development, assume up to 50 per cent of existing stormwater can be harvested for consumptive use and 50 per cent is reserved for the environment. If there is a scheme to harvest more than 50 per cent of the resource a study is required to assess the implications for the environment
- If stormwater is generated from a new development, all of it is available for consumption with the aim of the development having no impact on catchment run–off
- All diversions from waterways will continue to require a Section 51 licence under the *Water Act 1989.*

Stormwater proposals must be considered in the context of the entire catchment, recognising the intrinsic value of rainfall in replenishing surface water flows and groundwater recharge and with consideration towards the environmental and social/aesthetic values of urban waterways.

Availability of water will vary from catchment to catchment depending on a range of issues including:

- Catchment characteristics (level of urbanisation, environmental significance of waterways within the catchment)
- Receiving environment (bay, estuary, freshwater system)
- Existing demands (urban and rural).

The frequent discharge of polluted stormwater has been implicated as a major driver of stream degradation (Walsh et al., 2005). Reducing the frequency and volume of stormwater delivered to receiving waters is thus a prerequisite for their protection or restoration (Walsh et al., 2012). However, in some systems stormwater plays an important part in providing water for flow–stressed rivers. Therefore, any proposals to harvest stormwater must consider the implications for river health.

Proposals for stormwater use need to consider both the quality and quantity of stormwater extraction and will therefore require a case by case assessment of the impacts on each of these areas to ensure that extraction is sustainable.

Melbourne Water approval must be obtained for stormwater harvesting projects if the connection is to a drain, watercourse or open channel controlled by Melbourne Water. Licenses for the take and use of water and associated works components must be in place prior to works or extraction.

As the licensing authority and waterway manager for urban waterways within the Melbourne region, Melbourne Water has developed guidelines for stormwater harvesting and is continuing to develop principles and rules relating to the volume, rate of harvest and location of stormwater harvesting. These rules and principles form an important part of the overall allocation framework for stormwater in this region.

To assist stormwater harvesting proponents Melbourne Water has developed standard drawings and associated technical guidelines for the design, construction and maintenance of diversion structures for stormwater harvesting on Melbourne Water assets. These drawings and guidelines will:

- assist proponents and applicants in developing a suitable design likely to be supported by Melbourne Water
- ensure that Melbourne Water’s operational and environmental requirements are met and the outcome is therefore consistent with our stormwater harvesting principles.

Melbourne Water's basic principles for diversion structures:

- To pass required base low flows downstream to receiving waterways where they are providing for social and ecological benefits
- To minimise any interface and impact on existing Melbourne Water drainage assets
- To prevent adverse maintenance / operation conditions within the Melbourne Water drainage assets
- To prevent any adverse impact on the hydrologic function of the waterway, channel or pipeline
- To promote access to stormwater during rain events and higher flow periods.

Where the urban storm water harvesting can occur

Stormwater can only be harvested within urban areas where significant development has occurred resulting in increased water run off into drains and waterways above what would naturally occur in the catchment if still undeveloped. To meet the criteria for harvesting, proposals need to be within the Urban Growth Boundary (Port Phillip & Western Port) as defined in the Melbourne 2030 strategic document and contained in council planning provisions.

The table below can be used as a preliminary screening tool to determine if Melbourne Water is likely to support potential schemes. We suggest that Applicants contact Melbourne Water in the preliminary stages of scheme development and obtain an in principle supporting letter prior to undertaking the formal design. We also recommend the proponent undertake monitoring of flow rates and water quality in the proposed diversion drain as part of the planning process in advance of constructing any scheme.

Source	In principle support
Melbourne Water underground pipe drain	Yes
Melbourne Water constructed channel drain	Possible. Based on case by case assessment. Depends on upstream and downstream environmental values.
Natural waterways	No
Modified waterway	Possible. Based on case by case assessment. Depends on waterway values
Constructed wetland on waterway	No
Constructed wetland on drain	Possible. Based on case by case assessment. Scheme must not compromise wetland function
Constructed wetland off line	Possible. Based on case by case assessment. Scheme must not compromise wetland function
Natural wetland	No
Retarding basin on waterway	Possible. Based on case by case assessment. Depends on waterway values
Retarding basin on drain	Yes
Aesthetic dam or lake on waterway	Possible. Based on case by case assessment. Depends on impacts of drawdown and passing flows.
Aesthetic dam or lake off waterway or on drain	Yes

Table 1 *Preliminary screening tool*

NOTE:
Stormwater harvesting directly from wetlands is likely to interfere with the Extended Detention Depth (EDD) and possibly Normal Water Level (NWL) of the wetland. Both EDD and NWL are vital for the ongoing viability of the planted marshes which provide the tertiary treatment in wetlands. Consequently, in most cases harvesting from wetlands is unlikely to be supported unless it can be demonstrated by the applicant that the scheme will not adversely impact on the wetlands treatment, environmental or aesthetic functions.

Stormwater harvesting could be acceptable from wetland outfall pits where it does not affect the EDD or NWL in the wetland and will provide flows that have a degree of primary, secondary and tertiary treatment (litter, sediment and nutrient treatment). The discharge from the outfall structure can be directed to an offline pump well with the necessary consideration for base flows to the 'receiving waters'.

For further information on requirements for stormwater harvesting please refer also to Melbourne Water's Guidelines for Stormwater harvesting available on our website at the following link : Stormwater-harvesting-guidelines

Constructed wetlands design manual

Constructed wetlands are shallow, densely-planted man-made wetlands which regularly fill and drain. They provide a natural way to treat stormwater and remove pollutants before stormwater enters our creeks, rivers and oceans. Wetlands usually have a series of planted ponds to help filter water through physical and biological processes.

Further information on the design, construction and establishment of constructed wetlands can found on the following link :

Constructed-Wetlands-Design-Manual

Section 2 – Guidelines Overview

General

This document is designed to provide proponents and engineering practitioners with guidance on Melbourne Water's requirements and recommended options for the design, construction, operation and maintenance of diversion structures for stormwater harvesting constructed on Melbourne Water (MWC) drainage assets.

Design and construction of stormwater diversion structures consistent with these guidelines and standard drawings will enable a smoother licensing and approval process. Variation to these requirements will be considered on a case by case basis but the proposed design must be able to demonstrate how it meets the overarching principles in respect to hydraulic impacts, maintenance, passing flows, etc.

Typical functional requirements for diversion structures

1. Allow for the reliable diversion of designed flow rates and volumes to the usage/treatment/storage component
2. Uniform diversion rate control – e.g. there should not be a significant increase in the flow to treatment/storage component during the overflow
3. The hydraulic impact of the new diversion structure on the existing drainage system should be minimal
4. The operation should be fully automatic where feasible (e.g. no need for manual interference during operation)
5. The design should avoid any complication likely to lead to unreliable performance (e.g. no moving parts)
6. The chamber should be self-cleansing with minimal risk of blockage
7. It should have minimum maintenance requirements
8. It should allow safe access for inspection, maintenance and cleaning
9. Allowance on the diversion pipe for flow calibration and metering
10. Structural integrity of the existing drainage system must not be compromised
11. It should not be in operation until the prescribed flow is being passed through (environmental and/or self-cleansing flows)
12. Diversion structures should have the ability to be isolated or shut off in case of maintenance requirement or pollution incident.

Guidelines structure

These Guidelines consist of three essential parts:

1. Introduction and overview
    a. Assets ownership
    b. Safety in Design requirements
    c. Base low flows requirements
2. Detailed Requirements
    a. Hydraulics assessment
    b. Construction
    c. Operation & Maintenance
    d. Licensing and flow meters
3. Recommended options including drawings.

These guidelines should be read in conjunction with other relevant Melbourne Water standard drawings and example construction specifications contained in the MWC Land Development Manual at: http://melbournewater.com.au/Planning-and-building/Pages/planning-and-building.aspx

Asset Ownership

Commonly in stormwater harvesting proposals the diversion of stormwater from the Melbourne Water drainage system will require construction of an appropriate diversion structure within the Melbourne Water asset. Most schemes will require a manhole chamber to be incorporated in the design and upon completion the structure will be an on-line component of the drainage system.

Diversion structures (DS) for stormwater harvesting constructed on Melbourne Water (MWC) drainage assets must be constructed in accordance with Melbourne Water requirements. The Diversion structure once completed will become a MWC asset following the successful commissioning and defects liability/proofing by the proponent/contractor.

Ongoing responsibility for the structure and maintenance will rest with Melbourne Water unless a separate maintenance agreement is entered into. Licensing fees may incorporate a maintenance fee to cover costs of ongoing inspections and maintenance or alternatively licence conditions may require the licensee to meet the direct costs of MWC maintenance undertaken on the diversions structure. Any future access or works must be undertaken in accordance with Melbourne Water requirements and approvals.

The scheme proponent / licence holder will be responsible for the offtake / diversion pipe and all other harvesting works components downstream of the Diversion structure.

Additional information on works licensing can be obtained from MWC Diversion Management team at 131 722.

Safety in Design

The concept of Safety in Design encourages designers to “design out” risks during design development in an effort to improve the safety of the project and end product.

1 Legislative Requirements

Sections 27 and 28 of the *Occupational Health and Safety Act* 2004 place obligations on designers of plant, buildings and structures to ensure that as far as reasonably practical, their products are designed to be safe and without risks to health if used for a purpose for which it was designed.

2 What is Safe Design?

Safe Design involves the integration of hazard identification and risk assessment methods early in the design process to eliminate or minimise safety risk throughout the life of the product, structure or system being designed. For designers, this means applying systematic risk management techniques and consulting the operators, maintainers and health & safety professionals when making choices about design, materials and methods of manufacture or construction to enhance safety.

3 Who needs to consider safe design?

Safe Design is based on the idea that each person with control or influence over the design of products, items or systems of work has some responsibility for their safety throughout its lifecycle (including conception, redevelopment and disposal). People who are considered to be designers for the purposes of this procedure include architects, drafters, building designers, engineers, interior designers, industrial designers and contractors. Also fundamental to safe design is the continual transfer and feedback of information between all people involved in design, manufacture and end use of the product.

4 Design Safety Risk Management

- **Overview**

Design safety risk management covers risk identification, analysis, evaluation and control. The typical steps are identified in the following table:

	Process
1	Preliminary Hazard Analysis (leading to Safety in Design Plan) • Identify hazards and risks that need addressing in the design • Identify required hazard identification processes • Identify suppliers of third party design for inclusion in assessment processes • Identify stakeholders to be consulted
2	Develop Safety in Design plan
3	Perform hazard identification processes
4	Analyse risks (risk allocation, evaluation and ranking)
5	Risk control and management
6	Melbourne Water risk acceptance
7	Provide Safety in Design Report

Table 2 *Safety risks management process.*

The level of detail in a risk assessment should be broadly proportionate to the risk.

- **Considerations**

Hazard identification and assessment of risks shall be performed during the design process for all design aspects of the project life cycle including:

- Design for safe construction / erection and installation; identify and control risks in the construction / erection and installation stages of the projects
- Design to facilitate safe use: Design controls, and document operating procedures
- Design to facilitate physical and psychological characteristics of users; apply ergonomic principles to minimise physical and mental demands on users, and to minimise human (cognitive) errors
- Design for intended use and reasonably foreseeable misuse; consider risks associated with both use, and potential misuse of the product. Assume people will make errors during the use of the product and plan for it
- Design for safe maintenance; consider risks relating to cleaning, isolating, servicing and repairing products
- Design for safe failure; consider types of failure or malfunction and design the product to fail in a safe manner
- Design for safe alterations; consider risks associated with minor alterations to the product, and
- Design for safe removal, demolition or decommissioning.

- **Hazard/Risk Management Process**

Risk Management is the overall approach of risk identification, analysis, evaluation and mitigation. A summary of the steps is as follows:

- The process begins with hazard identification using one or more tools
- Each hazard is entered into the risk register along with risk assessment information
- Risks are analysed to determine:
- Frequency of occurrence (likelihood) of hazardous event, and
- Consequence of impact of hazardous event expressed as a Consequence level
- Risk evaluation determines the risk rating based on the frequency of occurrence and severity level of the consequences
- Risk control and management shall be applied, where necessary to reduce the risk rating to "as low as reasonably practical" (ALARP) using the hierarchy of controls approach, and
- Residual risk acceptance (by Melbourne Water) - based on ALARP principles.

- **Hazard/Risk Identification Processes and Tools**

The Designer shall consider using one, or a range, of the following tools during the design process to ensure they fulfil their obligations to eliminate or minimise as low as reasonably practical all hazards. These tools will assist in hazard identification and risk assessment, based on the specific product and the nature of the expected hazards:

- Preliminary Hazard Identification
- Construction Hazard Assessment Implication Review (CHAIR)
- Hazard and Operability Studies (HAZOP, CORP GOV 028)
- Controls Hazard and Operability Studies (CHAZOP)
- Event Tree Analysis (ETA)
- Fault Tree Analysis (FTA)
- Fault Mode Effects Analysis (FMEA)
- Failure Modes, Effects and Criticality Analysis (FMECA)
- Human Reliability Assessment (HRA)
- Melbourne Water's Hazard Identification (HAZID, CORP H&S 027) process
- Melbourne Water's Management of Change (MOC, CORP GOV 051) process, and
- Others as necessary.

- **Melbourne Water Likelihood, Consequence and Risk Rating Tables**

The Designer is required to utilise the following references tables for the assessment of all risks :

- Likelihood Rating
- Consequence Rating
- Control Effectiveness
- Risk Rating Matrix, and
- Risk Management Classification Diagram.

- **Risk Control Measures**

In controlling risks, designers shall give consideration to the 'Hierarchy of Control' below, with preference given to elimination and substitution of risks:

- Elimination
- Substitution
- Isolation
- Administration, and
- Personal Protective Equipment.

- **ALARP**

Melbourne Water is required to reduce risks to As Low As Reasonably Practicable (ALARP).

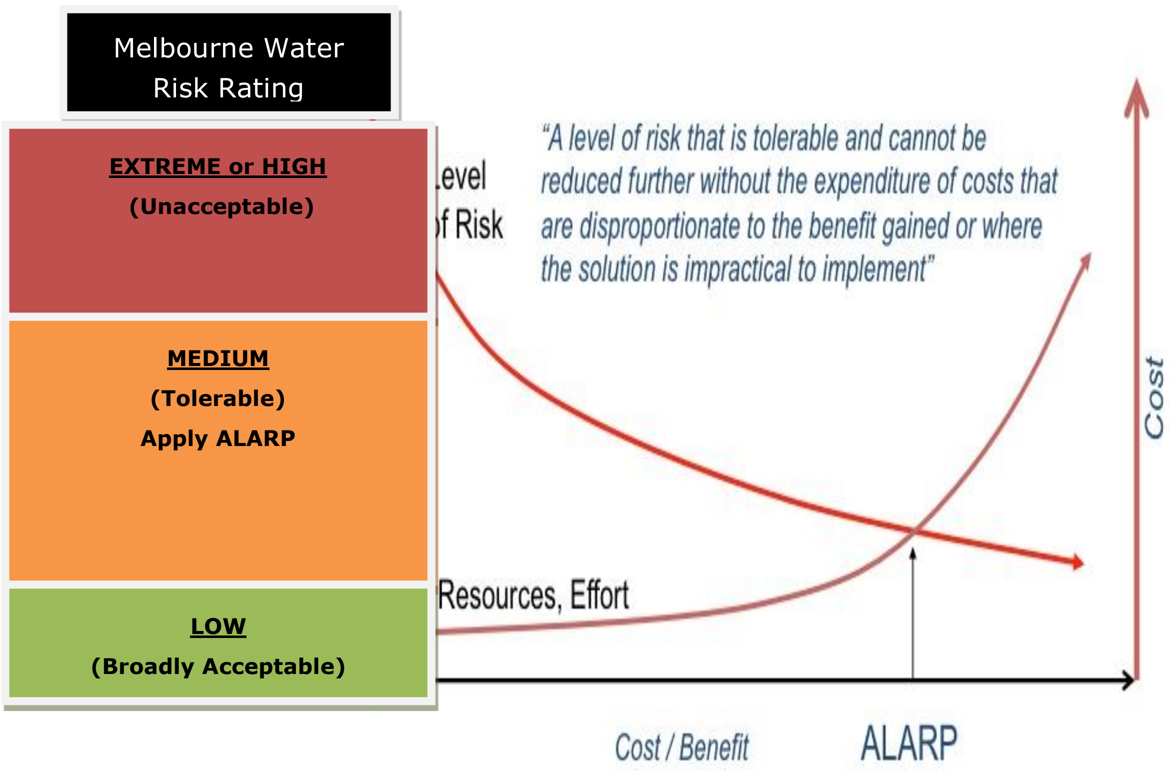
'Reasonably practicable' is a narrower term than 'physically possible'. A decision must be made by Melbourne Water in which the degree of risk is placed on one scale and the sacrifice involved in the proposed controls for averting the risk (whether in money, time or trouble) is placed in the other and weighing if there is a gross disproportion between them.

In essence, making sure a risk has been reduced ALARP is about weighing the risk against the sacrifice needed to further reduce it. The decision is weighted in favour of health and safety because the presumption is that Melbourne Water should implement the risk reduction measure. To avoid having to make this sacrifice, Melbourne Water must be able to show that it would be grossly disproportionate to the benefits of risk reduction that would be achieved.

Thus, the process is not one of balancing the costs and benefits of measures but, rather, of adopting measures except where they are ruled out because they involve grossly disproportionate sacrifices. An <u>extreme</u> example might be:

- To spend $1M to prevent one staff member suffering bruised knees is obviously grossly disproportionate, but
- To spend $1M to prevent a major explosion capable of killing 150 people is obviously proportionate.

ALARP in the context of Melbourne Water's Risk Rating



The Designers approach should be to provide designs with no "high" or "extreme" risks or risks above a rating of 7. For risks below 7, the risk control approach should be weighed against the value of implementing the control measure (i.e. apply ALARP principals).

5.0 Reports

The Design Safety Report should include:

- Description of overall process and tools used and stakeholders consulted
- Detailed report on outcomes from all hazard identification studies and risk assessment/evaluation
- Report on status of all actions (closed, open etc.)
- Complete risk register as at completion of design, and
- Demonstration of ALARP.

More information on the Victorian Occupational Health and Safety Act 2004 requirements is available on the Worksafe VIC website Worksafe Vic

Low- flow hydrology and environmental flow requirements

Under the Water Act 1989, Melbourne Water is the designated caretaker of river health for the Port Phillip and Westernport region, and has responsibility for waterway management, major drainage systems and floodplain management and the management of the environmental water reserve. As the waterway, drainage and floodplain authority for the Port Phillip and Westernport region, Melbourne Water is a statutory referral authority under the Planning and Environment Act 1987 for planning applications that may affect waterways. Melbourne Water therefore has responsibility for ensuring that the rivers, wetlands and estuaries within the Port Phillip and Westernport region are protected and improved on behalf of the community.

The Port Phillip and Westernport region spans more than 12,800sqkm, with more than 24,000km of rivers, creeks and estuaries and a range of natural and constructed wetlands across the Werribee, Maribyrnong, Yarra, Dandenong and Westernport catchments and contains a variety of waterways, from iconic rivers such as the Yarra to local wetlands, such as the Edithvale-Seaford Wetlands, that provide a haven for a variety of animals and plants to breed and thrive.

The Victorian Government's Our Water Our Future program recognized the impacts water extractions have had on river health and put in place actions to increase flows and restore river health.

More sophisticated resource management requires detailed water supply assessment and modelling techniques to better align yields and environmental flow models and ensure that sustainable outcomes are achieved. This will also require the development of detailed rules for the operation, release and keeping of accounts for water harvesting and environmental flows.

The Healthy Waterways Strategy (HWS) document Healthy-Waterways-and-Stormwater-Strategies outlines the role Melbourne Water will play, in partnership with the community, our customers and stakeholders, in managing rivers, estuaries and wetlands in the Port Phillip and Westernport region to ensure their value to the community is protected and improved.

Some of the targets and objectives outlined in the HWS are:

- Continuing to build knowledge and to ensure environmental flow regimes in urban waterways are improved through the sustainable management and licensing of stormwater
- Developing frameworks for the sustainable allocation of all sources from an environmental water perspective
- Environmental water management shall be robust under all water availability scenarios
- Assess new diversion applications as well as applications for trade or transfer to ensure catchment allocation caps are not exceeded
- Promote and manage stormwater harvesting schemes consistent with government objectives and refinement of policy

The flow regime is of fundamental importance to the ecology of streams and its components influence stream structure and function. Stream biota has evolved to depend on natural flow regimes and there is widespread agreement that natural flow regimes are essential to the ecological integrity of streams (Poff et al., 1997).

Many human activities alter natural flow regimes with urban land use being one of the most striking alterations. Urbanisation most commonly increases the frequency and magnitude of peak flows in response to rain events, resulting in an increase in the annual runoff volume. In addition to altering high-flow hydrology, urbanisation changes low-flow hydrology, albeit with a less consistent response. Covering the landscape with impervious surfaces (e.g. roofs and roads) reduces infiltration, which consequently decreases contributions to baseflow and thus to low-flow condition in receiving waterways.

The changes to hydrology associated with urbanisation are a primary degrader of stream ecosystems (Walsh et al., 2005). The protection and restoration of urban streams requires approaches to urban stormwater management which will not compromise remaining environmental values and aim to *restore or preserve appropriate flow regimes* (in addition to water quality). To ensure an equitable balance between protecting critical instream flows and stormwater harvesting can be achieved, MWC need to ensure that stormwater harvesting across the region is assessed and controlled against objective measures of impacts on low-flow regimes.

Many harvesting schemes propose to divert low-flows flows from drains or streams outside of wet weather events. Such proposals do not strictly fit the definition of stormwater harvesting and may not be supported by Melbourne Water on the basis that:

1. Diverting base low flows from drains or streams exacerbates the reduction in low-flows caused by urbanisation.
2. The schemes rely less on the harvesting of wet-weather stormwater flows; the flows that degrade urban stream ecosystems and often cause flooding.
3. The practice precludes future opportunities to successfully restore urban streams.

MWC in partnership with Melbourne University's Waterway Ecosystem Research Group has sourced gridded rainfall-runoff data (Australian Water Availability Project; http://www.csiro.au/awap/) to predict regional low-flow hydrology in the Port Phillip and Westernport region. These predictions provide an estimate of pre-development low-flows in urban streams which can be used to derive catchment-specific passing flow thresholds for stormwater harvesting in urban areas. The basis and methodology of the predictions are contained in the report which can be made available upon request.

As part of its assessment of stormwater harvesting applications, MWC will use these predictions to determine a low-flow threshold for each application. Any urban related flow diversion scheme will only be allowed to divert water in excess of these modelled low-flows. Applicants should contact Melbourne Water in the preliminary stages of scheme development so that the low-flow threshold can be determined for input into the detailed design of the scheme and diversion offtake.

The application of flow thresholds is consistent also with existing historic licensing across the catchment where minimum environmental flow triggers have been established on all licences to protect low flow conditions and downstream environmental values. For extractions from waterways and channels, pump operations must comply with existing nominated flow triggers for the specific catchment.

For stormwater pipe harvesting, the flow threshold will be determined at site level as detailed above and will need to be engineered into the diversion structure to prevent harvesting occurring at lower levels.

Application of MWC triggers will apply to most applications. In accordance with direction specified in the CRSWS, exemptions will apply only to stormwater schemes on pipelines that discharge directly to the sea with no downstream waterway environment.

Maintenance flows and self-cleansing velocities allowance

For all new diversion structures constructed on Melbourne Water drainage assets, allowance should be made to pass low/base flows through the system both prior to and during times of flow diversion in order to avoid sediment deposition and associated maintenance problems in the drainage network.

The minimum self-cleansing velocities for the design of these flows must be calculated on a case by case basis using the boundary shear stress approach as described in these design guidelines. These calculations shall demonstrate that the design solution allows for the continuation of base flows through the system and that these flows produce the boundary bottom shear stress equal to or exceeding the pre-set minimal boundary bottom shear stress of $\tau \geq 1.5$ ***Pa.*** More information on the minimal boundary bottom shear stress calculations is provided in Appendix 1 of these guidelines.

Melbourne Water at its discretion may accept reduced requirements for the maintenance flow in the Diversion Structure design if it can be demonstrated that sufficient self-cleansing velocities are generated in the downstream section on the main drainage line as a result of additional inflows into the drainage system from other contributing drains in close proximity.

Low flows quantification and assessment

To assist stormwater harvesting proponents, Melbourne Water upon the receipt of an application and supporting technical data will determine the case - specific low flow threshold using the CSIRO’s gridded rainfall-runoff predictions (AWAP). These flows will then be compared to the maintenance flow requirements estimate and in most cases – the largest number adopted as a minimum flow trigger for stormwater harvesting diversion.

Section 3 – Hydraulic Assessments Requirements

General

A diversion structure as part of a stormwater harvesting system receiving water from Melbourne Water drainage assets should be designed to:

- Collect the agreed volume of urban runoff from the contributing catchment(s). The volume of water permitted for collection should be as per requirements of the diversion license issued by Melbourne Water.
- Make allowance for low/base flows to continue through the system prior to and at the time of flow diversion in order to:
  - avoid sediment deposition and associated maintenance problems in the drainage network (refer to operational requirements for more detail)
  - provide for flow requirements in receiving waterways downstream.
- Avoid any adverse impact on the hydraulic capacity of the existing drainage system. Diversion structure design must ensure no negative hydraulic impacts on adjacent properties when design capacity of the underground drainage system is exceeded during extreme rainfall events. Negative hydraulic impacts can be classified as increases in flood levels, overland flows and/or impact on public safety. Where deemed necessary, the hydraulic impact of proposed installation is to be checked, documented and presented to Melbourne Water for approval prior to works commencement.
- Provide minimal/negligible head loss to the satisfaction of Melbourne Water.
- Ensure no increased risk of blockage to Melbourne Water's drainage assets.
- Avoid any increased risk of detrimental impact on flooding of private properties or public safety.

Hydraulic impact assessment

Base Theory

Calculation of head losses at diversion structures, represented by changes in energy and hydraulic grade lines, are required to adequately describe flow behaviour and assess its impact on the original hydraulic capacity of the drainage system.

Flow through diversion structures can be relatively complex due to unsteady full and part-full pipe flow conditions in stormwater drainage systems. Diversion structures are nearly always larger than incoming and outgoing pipes and the expansion of pipe flows entering the structure, the flow diversion impact and the effects of downstream water levels create complex flow conditions, with energy losses and local increases in water levels that in extreme situations could reduce performance and cause overflows.

Complexity comes from the almost infinite variety of conditions that can occur. Some relate to the system geometry. For a typical diversion structure this can involve:

a) various numbers of pipes entering the structure (1 to 3 or more)
b) the angles of the inlet pipes relative to the outlet pipe in the horizontal plane
c) the various heights of the invert pipes and drops in the structure
d) the pipe diameters and slopes
e) whether incoming pipe inflows are opposed, so that jets will interfere with each other
f) whether jets from inlet pipes are directed into the outlet pipe, or against a wall/weir
g) type of diversion mechanism (e.g. transverse weir, side weir, drop etc.)
h) the size and shape of the structure
i) whether benching or deflectors are placed in the structure.

Also important are flow characteristics, including:

j) the flow rates in the inlet pipes and the diversion flow rate
k) whether the pipes are running full or part-full, supercritical or subcritical
l) the effect of tailwater level and the water level in the pit
m) in the case of junctions with two or more upstream pipes, time-dependent flow ratios, as contributing hydrographs in upstream pipes pass through the diversion structure.

Requirements for hydraulic impact assessment

The type and geometry of a diversion structure should be selected with due consideration of its hydraulic impact on the conveyance capacity of the original drainage system for the full range of expected flows.

Stormwater proponents should contact Melbourne Water's Asset Management Team in order to obtain existing asset information to inform the design of a diversion structure.

Based on the assets information available, the following hydraulics parameters should be established in consultation with Melbourne Water:

- Pipe/culvert geometry incl. cross section(s) and gradient(s),
- Hydraulic capacity of the original drainage network at the proposed location of diversion structure (typically Q_{system} in m^3 /sec),
- Energy and Hydraulic grade lines for the original drainage system at/in the vicinity of the proposed diversion structure,
- Governing flow regime in the drainage network at Q_{system} (e.g. sub-critical free flow)

Based on the above parameters the maximum allowable hydraulic impact of the proposed diversion structure should be determined in consultation between the proponent and Melbourne Water on a case-by-case basis.

In cases of minimal risk of negative hydraulic impacts to private property and/or public safety, some localized hydraulic impacts may be acceptable subject to consultation with Melbourne Water.

In cases of hydraulically sensitive areas where there is tangible risk of negative hydraulic impacts to private property and/or public safety, the applicant must ensure no negative hydraulic impacts due to the diversion structure and will be required to demonstrate through hydraulic modelling how impacts will be mitigated to the satisfaction of Melbourne Water.

The designer of the proposed stormwater harvesting works will be required to prepare and submit sufficiently detailed calculations to demonstrate that for the specified range of flows (typically up to and including the Q_{system}) the hydraulic impact of the proposed installation is kept within the agreed limits.

These calculations are expected to address both the localised hydraulic impact and the propagation of this local impact further upstream of the proposed diversion structure to the extent determined in consultation with Melbourne Water.

Adjustment and calibration

The diversion structure (DS) design should have allowance for further adjustments and calibration (e.g. base flow passage rates, diversion rates etc.) where practicable.

Example of hydraulics operations of the diversion structure – DS with transverse weir

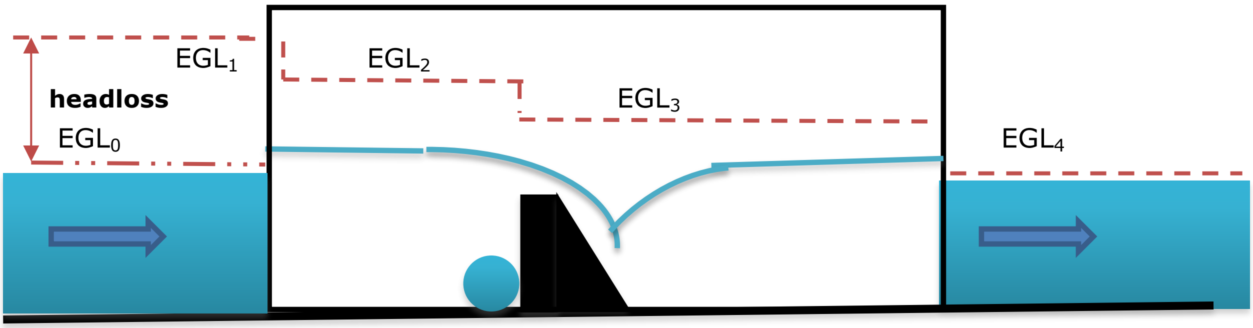


Diagram A *Typical weir operation under the system flow (Q_{sys}) - Section*

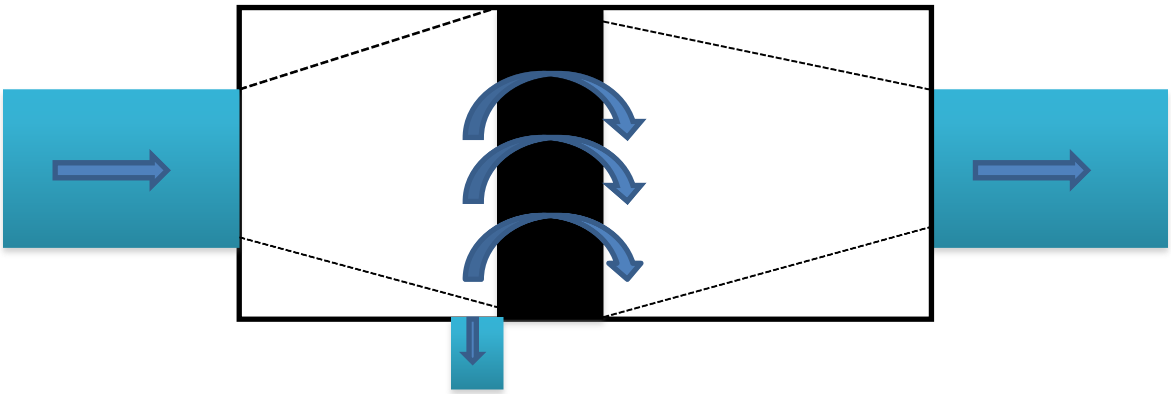


Diagram B *Typical weir operation under the system flow (Q_{sys}) - Plan*

Abbreviations:

Weir

pipes

EGL (energy grade line) for the system flow (Q_{sys}) with the DS installed

EGL (energy grade line) prior to the DS installation at the system flow

Indicative water profile in the DS at the system flow (Q_{sys})

Flow direction arrow

Headloss Headloss for the installed DS at the system flow (Q_{sys}) expressed as the difference in EGL's pre and post DS installation

Many diversion structures employ the transverse weir to:

- Divert the specified flow (Q_{div}) into the stormwater harvesting component
- Pass the specified system flow (Q_{sys}) through with agreed hydraulic impact on the Energy Grade Line (EGL)

Typical operation of the transverse weir diversion structure is shown in Diagrams A&B.

The assessment of the impact of these diversion structures on the existing hydraulic capacity of the drainage system would typically comprise the following steps:

1. In consultation with Melbourne Water establish the hydraulic capacity of the existing drainage system, typically expressed by the Design System Flow rate(Q_{sys}), and the Energy Grade Line (EGL) for the Q_{sys}
2. In consultation with Melbourne Water establish the maximum allowable hydraulic impact of the proposed diversion structure, typically expressed as headloss (Δh)
3. Assess the impact of the diversion structure on the EGL for the Q_{sys} (refer Diagram A) and compare the Δh with the agreed max headloss

The following components would typically contribute to the total headloss (Δh) imposed by the installation of the transverse weir diversion structure:

- Flow expansion headloss (Δh_{exp})
- The weir headloss (Δh_{weir})
- The contraction headloss (Δh_{con})

The hydraulic assessment would normally start with establishing the flow regime in the drainage system under the (Q_{sys}) conditions, typically subcritical or supercritical flow regime.

For subcritical flow regime the local headlosses in the DS can propagate upstream, while for the supercritical flow regime the effect of local losses is rather kept within the local reach, however the potential for high turbulence and hydraulic jumps and its effects under the supercritical flow regime have to be properly considered.

For the subcritical flow regime the hydraulic assessment would typically start with the calculations of the EGL in the downstream conduit. The next step would be the calculation of the contraction headloss (Δh_{con}) caused by the installation of the DS. Typically the Δh_{con} is calculated as:

$$\Delta h_{con} = k \times \frac{V^2}{2g}$$, where:

V is the velocity in the downstream pipe (m/sec)

k is the headloss coefficient for the particular type of pipe/DS connection (e.g. smooth, rough, rounded etc.)

g is the acceleration of gravity (m/sec^2)

By adding the Δh_{con} to the EGL_4 in the downstream conduit the EGL_3 downstream of the diversion weir can be established. Then, based on EGL_3 the effect of backwater should be assessed to determine whether the weir will be free flowing or submerged during its operation under the system flow (Q_{sys}).

Then the appropriate formulae can be used to establish the Energy Grade line location upstream of the weir. The formulas that could be used for these calculations are:

A) Submerged weir

$$Qs/Q = [\ 1.0 - (Hs/H)^n\ ]^{0.385}$$ (Villemonte 1947), where:

Qs –discharge over submerged weir (m^3 /sec)

Q – discharge over the weir for free flowing situation (m^3 /sec)

Hs - tailwater depth above the weir crest (m)

H – head upstream of weir (m)

n – coefficient, for sharp crested weir n = 1.50

B) Free flowing weir

$$Q = CwLH^{3/2}$$, where:

Q – discharge over weir (m^3 /sec)

Cw – weir discharge coefficient (typically Cw = 1.73)

H – head on weir (m); and L – effective length of weir (m)

Once the EGL_2 is established upstream of the weir – the expansion headloss should be calculated as follows:

$$(\Delta h_{exp}) = \frac{(V_{us} - V_{ds})^2}{2g} \text{ where,}$$

V_{us} is the velocity in the upstream conduit (m/sec)

V_{ds} is the velocity in the diversion structure upstream of the weir (m/sec), and

g is the acceleration of gravity (m/sec^2)

Finally, the EGL_1 upstream of the installed DS can be established and compared with the original Energy Grade Line (EGL_0) in view of calculating the resultant headloss due to the DS installation as follows:

$$\Delta h = EGL_1 - EGL_0$$

Expansion and Contraction hydraulic losses coefficients[1]

Expansion of flow

Flows from the upstream pipe entering the diversion structure will normally[2] decelerate thus causing the hydraulic energy loss typically called the *expansion headloss* or $\Delta h_{exp.}$

The expansion headloss could be calculated in one of the two ways:

<u>Option 1:</u>

$$(\Delta h_{exp}) = \frac{(V_{us} - V_{ds})^2}{2g} \text{ where,}$$

V_{us} is the velocity in the upstream conduit (m/sec)

V_{ds} is the velocity in the diversion structure upstream of the weir (m/sec),and

[1] Please note that the methodology presented in this document is only applicable under the subcritical flow regime in the drainage system and should not be used in situations when the flow regime in the existing drainage system is supercritical

[2] This is applicable when the velocity in the diversion structure is lower than the velocity in the upstream pipe either due to the difference in size/area and/or the effect of the downstream obstruction e.g. weir

g is the acceleration of gravity (9.81 m/sec^2)

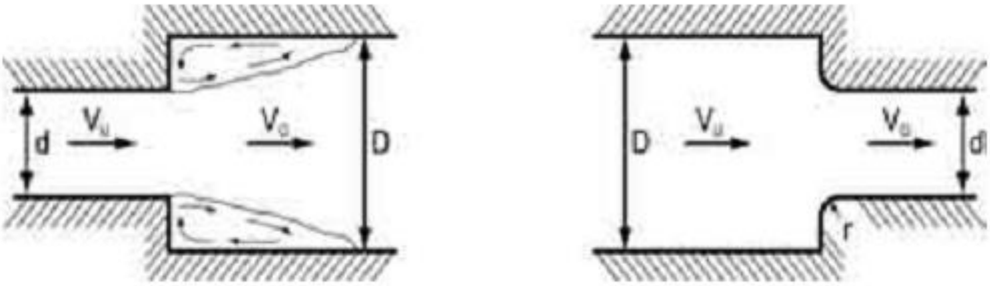


Diagram C *Expansion and Contraction losses in the diversion structure*

Option 2:

$$\Delta h_{exp} = k \times \frac{Vus^2}{2g}$$, where:

V_{us} is the velocity in the upstream pipe (m/sec)

k is the headloss coefficient for the particular type of pipe/DS connection and benching (refer Table 1)

g is the acceleration of gravity (9.81 m/sec^2)

A_U/A_O or A_O/A_U	d/D	Sharp expansion [2]	Contraction [3]				
			Sharp edge	r/d = 0.02	r/d = 0.04	r/d = 0.06	r/d = 0.1
1	**1.000**	0.000	0.000	0.000	0.000	0.000	0.000
0.8	**0.894**	0.081	0.079	0.058	0.043	0.036	0.027
0.6	**0.775**	0.200	0.248	0.165	0.121	0.091	0.060
0.4	**0.632**	0.377	0.371	0.255	0.187	0.137	0.077
0.2	**0.447**	0.659	0.442	0.324	0.234	0.169	0.086
0.1	**0.316**	0.833	0.471	0.353	0.245	0.180	0.087
0	**0.000**	1.000	0.500	0.376	0.250	0.185	0.087

Notes:

[1] Sourced from Miller (1990).

[2] Energy loss coefficient (K_{exit}) relative to upstream velocity head ($V_U^2/2g$).

[3] Energy loss coefficient (K_{entry}) relative to downstream velocity head ($V_o^2/2g$).

Table 3 *Expansion and Contraction K factors (source Queensland Urban Drainage manual, 2007)*

Contraction of flow

The *contraction headloss* or Δh_{con} in diversion structures is normally associated with the need to generate the (additional) energy to direct the required flow rate from the diversion structure (typically with lower velocity of flow) into the downstream conduit (typically higher velocity of flow). Therefore, the Δhcon in any particular situation will depend largely on the local geometry of entry (rounding/benching) and the need for velocity acceleration (V_{us}/V_{ds}). Typically the Δh_{con} is calculated as:

$$\Delta h_{con} = k \times \frac{Vds^2}{2g}$$, where:

V_{ds} is the velocity in the downstream pipe (m/sec)

k is the headloss coefficient for the particular type of pipe/DS connection (e.g. smooth, rough, rounded etc. refer to Table 1)

g is the acceleration of gravity (9.81 m/sec^2)

Effect of benching on local hydraulic losses in diversion structures

It is noted that the appropriate benching within the diversion structure could reduce the flow expansion losses at the upstream pipe entry into the structure as well as the flow contraction losses at the exit into the downstream pipe. The effect of the benching could be accounted for by the application of the reduction factor to the "no-benching" scenario headloss coefficient referenced from the Table 3.

It is recommended that for the purpose of hydraulic calculations for the diversion structure on Melbourne Water assets - the reduction factors applied to the contraction/expansion headloss coefficients (k_b) should be in the range of 30% or 0.30 for the half-pipe benching to 100% or 1.0 for no benching (applied on the sliding scale).

The headloss calculations formula could then be adjusted as:

$$\Delta h = k \times k_b \times \frac{V^2}{2g}$$, where:

Δh is the local headloss either expansion or contraction (m)

k is the headloss coefficient with no benching referenced from Table 1, and

k_b is the reduction factor due to benching (in the range 0.3 for half pipe benching to 1.0 for no benching).

Section 4 – Requirements for Construction of Diversion Works

General Scope

All works carried out to / on Melbourne Water assets, including diversion structures which will become the responsibility of Melbourne Water must be undertaken in accordance with standards outlined in this section.

The scope for construction of diversion structures shall generally include, but not be limited to:

- Site preparation
- Site temporary fencing, gates and security
- Access roads
- Temporary pavement for construction access road
- Excavation
- Condition /dilapidation survey
- Surface treatment/soil stabilisation (if applicable)
- Dewatering (if applicable)
- Water proofing
- Formwork
- Reinforcement
- Concrete and structural works
- Sealing
- Spoil disposal
- Suitable back filling material
- Include the provisions for access stairs, services lift opening and major refurbishment opening in the roof structure.
- Ground level structure provisions for drainage, sumps, pits and bunds.
- Services and piping connection valve pits
- Soiling, grassing and landscaping
- Making good access paths and roads.

Governing Standards

The following Australian Standards shall be deemed to govern requirements for relevant materials and workmanship:

- AS 1319 Safety signs for the occupational environment.
- AS 1170 Structural design actions.
- AS 1345 Identification of the contents of pipes, conduits and ducts.
- AS 1939 Degrees of protection provided by enclosures for electrical equipment.
- AS 1940 The storage and handling of flammable and combustible liquids.
- AS 2700 Colour standards for general purposes.
- AS 2845 Water supply - backflow prevention devices
- AS 3000 Electrical installations (known as the Australian/New Zealand Wiring Rules).
- AS 3500 National plumbing and drainage code.
- AS 3600 Concrete Structures.
- AS 3996 Access covers and grates
- AS 4087 Metallic flanges for waterworks purposes
- WSA 01 Polyethylene Pipeline Code.

All work shall meet all the requirements of national and local authorities and shall also be in accordance with the following in so far as they apply to the work:

- Structure Code of Australia
- MRWA specification No: 04-03-1
- All applicable Australian Standards
- Melbourne Water requirements
- Local government requirements
- Workcover requirements
- All Health Authority Requirements
- Metropolitan Fire Brigade requirements
- the *Water Act* 1989
- Occupational Health and Safety Act
- *Melbourne Water* requirements for *confined space entry and permit to works system*
- The Aboriginal *Cultural Heritage Act*

Design Life

All diversion structures on Melbourne Water assets should be designed for the following design life:

Concrete structures	50 years
Pipework	50 years
Mechanical work	25 years
Metal work	25 years

Concrete exposure classification and loading

Exposure classification	- in accordance with table 4.3 in AS 3600
Traffic loading	- to W7, T44, HLP 320 and SM 1600 and other relevant design code and standards

Concrete durability

Minimum concrete strengths and associated minimum nominal concrete cover shall comply with AS3600. The structures shall be designed to be waterproof from both internal and external sources. The concrete mix for the structure shall be developed to achieve the minimum design strength of 32 MPa in accordance with the durability requirements.

Lower strength concrete can be considered for use in non-structural applications (e.g. benching). The concrete properties to be used in the design shall be calculated in accordance with AS3600.

Consideration shall be given to the effects of shrinkage and creep in concrete structures. The characteristics of different types and different ages of concrete shall be considered. These effects shall be included in the ultimate and serviceability limit states using the appropriate load factors in accordance with AS5100.

Concrete joints and waterproofing

The structure shall be waterproof from both internal and external water. Joints in the structure shall be made continuous where feasible to minimise areas potentially vulnerable to water leakage.

Water resisting measures shall be adopted, in particular:

- Roof slab to wall construction joints and roof slab construction joints shall be detailed with suitable bars, hydrophilic seals or similar.
- If the base slab is monolithic and integral with the wall for structural reasons, the floor to wall construction joints shall be detailed as for water-retaining structures.

The diversion structure shall be designed and detailed in accordance with AS3735 and AS3600. The design and detailing of construction joints shall be such that the number of construction joints will be as few as practicable. Where significant for design, the locations of construction joints and the construction sequence shall be clearly indicated on the drawings.

In terms of construction, the concrete pour length shall be limited by the Contractor to ensure the structure is fully water proof and suitable to be a water retaining structure.

Formwork

Generally, the finish to walls and slabs shall be in accordance with AS3610.
Design and construct formwork so that the concrete, when cast in the forms, will have the required dimensions, shape, profile, location and surface finish. Allow for dimensional changes, deflections and cambers resulting from the application of prestressing forces (if any), applied loads, temperature changes and concrete shrinkage and creep.

Formwork shall be watertight and of sufficient strength to prevent excessive deflection under loads during placement and compaction of fresh concrete.

Structural Steel and Connections

All structural steelwork shall be Australian Steel Sections with minimum Grade 300 and designed using ultimate limit state method in accordance with AS4100.

The design method adopted shall be clearly stated at the start of the calculations. Unless otherwise shown, structural bolts shall be designed in accordance with AS 1252. Capacities of bolts shall be based on the assumption that threads are in the shear plane. Bolts shall be installed in accordance with AS4100. Lock nuts shall be used in the vicinity of vibrating equipment.

Where necessary, slotted holes shall be used to allow for thermal expansion and contraction. All connections shall have a minimum of 2 bolts except for minor connections. The minimum fillet weld size shall be 6 mm unless otherwise approved by Melbourne Water. All welding for structural components shall be minimum grade SP in accordance with AS1554.

All stainless steel components should be grade 316 or equivalent.

Miscellaneous components

All steelwork within the works space must as a minimum be heavy duty galvanised with appropriate attention to dissimilar metal corrosion; designed to conform to AS4100.

Exposed steelwork, including services supports, access platforms and hand railing, shall be hot dip galvanised to AS/NZS 4680 "Hot-dip galvanized (zinc) coatings on fabricated ferrous articles" with an average minimum coating thickness of 85 microns, or an equivalent level of protection.

Reference should be made to AS2312 "Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings". Durability requirements shall be 25+ years which is categorised as extra-long term. Atmospheric corrosivity shall be category C (Medium) which is typical for sewage treatment works.

Flotation

Stability of the structure against flotation shall be checked for all stages of construction and throughout the service life of the structure based on the design ground water levels and flood levels.

Construction loads

Permanent forces and effects introduced during construction shall be considered in the design. Allowance shall also be made for the weight of any false work, plant and any associated storage/stockpile loading of materials that may be carried by the structure resulting from the anticipated method or sequence of construction; this includes crane loads, compaction equipment during backfilling, etc.

Excavation

The excavation shall not extend past the defined works space (other than a nominal agreed amount to incorporate a temporary shoring system). Provide temporary supports, bracing, shoring, planking and strutting as required for excavation.

A preferred method of excavation is to bring excavated fill to ground level and finally into a truck for disposal/stockpiling. Where excavation exceeds the required depth, or deteriorates, reinstate to the required level and bearing value. Make allowance for compaction or settlement.

Prepare the excavated final level (i.e. remove materials such as loose material, debris and organic matter) before constructing ground slabs or load bearing elements.

At practical completion of construction, the final ground surface level shall be reasonably smooth and uniform, similar to its original state.

Excavation must make allowance for protection of any existing assets. Particular care must be taken around sensitive and/or an aged asset such as brick drains etc.

Earthworks

Compaction standards shall be expressed as a percentage of the materials standard Maximum Dry Density (MDD (std)) at its optimum moisture content as determined in accordance with AS1289.

The required degree of compaction shall be as follows:

- 95% for fill generally.
- 100% for a minimum depth of 300mm immediately under concrete slabs and footings placed on fill or the in-situ subgrade.

Embankments composed of engineered fill and cuts in existing site material shall be excavated in accordance with recommendation provided by geotechnical investigation report commissioned by the contractor and/or consultant and approved by Melbourne Water.

Backfill Material Specification

The Contractor shall employ suitable methods to compact backfill of excavation and to comply with the approved project specification and prevent collapse or settlement. Where fill is placed around the structure, the fill shall be placed and compacted evenly to prevent displacement.

Care shall be taken to place and compact the fill evenly around the structure in thin layers, to avoid unbalanced lateral loading. High compactive effort shall not be used against structures to ensure damage to the structure is prevented. Particular care must be taken to adjacent retaining walls. The project specific recommendations on the suitable backfill should be determined in consultation with Melbourne Water based on a site specific geotechnical report commissioned by the Contractor/Consultant.

Topsoil

At practical completion of construction, the site topsoil shall support plant life and be safe for human life, contain organic matter and be free from unwanted matter (i.e. stones over 25mm diameter, clay lumps, weeds and tree roots, sticks and rubbish, material toxic to plants, etc).

Soil shall be tested in accordance with AS4419. Soil placement shall be by wheel barrow, conveyor or bucket excavated to avoid excessive compaction.

Spread topsoil on the prepared subsoil and grade evenly making the necessary allowances to permit the following:

- Required finished levels and contours may be achieved after light compaction
- Grassed areas may be finished flush with adjacent hard surfaces such as kerbs and foot paths.

Compact lightly and uniformly in 150 mm layers. Compact by hand or by light rolling. Between each layer, cultivate to a depth of approximately 25mm to avoid the formation of interface problems. Avoid differential subsidence and excess compaction and produce a finished topsoil surface which has the following characteristics:

- Finished to design levels
- Smooth and free from stones or lumps of soil
- Graded to drain freely, without ponding, to catchment points
- Graded evenly into adjoining ground surfaces
- Ready for planting.

All backfill and compaction works are to be designed and executed in accordance with the MRWA specification No: 04-03-1 – Backfill specification.

Access covers, step irons and ladders requirements

General

Access arrangements for the diversion structures shall be in accordance with Melbourne Water Access Covers, Platforms and Walkways Standard CORP AM S020 version 2, August 2014 and AS1657 – 2013 Fixed platforms, walkways, stairways and ladder – Design, construction and installation.

- Minimum access shaft diameter - 0.90 m
- All materials to be Stainless Steel grade 316 or equivalent
- All fixing to be Stainless Steel grade 316 or equivalent

Step irons

Step irons and ladders must conform to Melbourne Water Access Covers, Platforms and Walkways Standard CORP AM S020 version 2, August 2014 AS 1657-2013 and be located and fixed in the structure in accordance with the approved drawings.

The access step irons must be cast in-situ. Step irons used for other purposes may be installed in drilled holes using a dry packed mortar or epoxy compound.

All bolts must be placed in the formwork before pouring the concrete. Care must be taken to ensure that step irons remain in place and are properly aligned after pouring.

Access covers

All covers must conform to AS 3996-2006 and be Heavy-duty Gatic Type BV or equivalent and fixed flush with the pavement or finished surface level, or in accordance the Drawings and Tolerances.

The Contractor must prevent distortion of cast iron frames during fixing and replace any distorted cover or frame. Cast iron covers must be filled with M25 Grade concrete. The identification, cover locating marks and numbering pad must be left exposed.

The covers and frames must be cleaned and greased after completion of the section of the Works.

Weepholes

Where site conditions require the use of weepholes, they shall be placed in accordance with Drawing 7251/8/403 in Melbourne Water's Land Development Manual. The holes must be a minimum diameter of 38 millimetres. The outlets must be clean and flush with the outer face of the structure.

Weephole formwork must be set in place before concrete is poured. Hollow weephole formwork must be temporarily filled and covered with bituminous paper or plastic film before pouring to prevent concrete entering the cavity.

Pipe penetrations

Pipe penetration cut-outs should be round holes and should be no larger than the pipe diameter plus 25mm. Make cuts using a saw with a masonry or diamond grit blade. Do not use an axe or other impact type tools.

Protection of site assets

The Contractor shall ensure all site assets are protected at all times. Any damage incurred as a result of works undertaken by the Contractor as part of contract shall be immediately reported and repaired to the satisfaction of Melbourne Water, at the Contractor's expense.

Location and protection of all services underground and above ground is the responsibility of the Contractor and locations shall be verified on site prior to commencing work.

The Contractor shall protect trees and site vegetation at all times during the construction works. If the Contractor damages vegetation, remedial works must be undertaken to the satisfaction of Melbourne Water.

Temporary hoarding and fencing

All works must be enclosed with suitable temporary barriers and protection which prevents the entry of unauthorised persons onto the site, and prevent injury, damage, vandalism or theft. The Contractor is responsible to supervise openings and access points to the Works during working hours and to ensure the safety and security of the Works during non-working hours

The Superintendent may require additional barriers and protection at no additional cost to Melbourne Water.

Melbourne Water may require additional barriers and protection be provided. Barriers and protection adjacent to roads and paths shall be fitted with night reflectors, orange plastic bunting and lighting as required for safety.

Barrier types shall include as appropriate:

- Chain mesh fencing, not less than two metres high
- Fluorescent para-webbing
- Temporary rails and bunting, one metre high
- Screens of continuous plastic sheeting, taped edges, to restrict dust and moisture
- Existing fences, if approved by the Superintendent
- Other suitable barrier types approved by the Superintendent.

Traffic and Access

The Contractor shall prepare a Traffic Management Plan for review by Melbourne Water. The traffic management plan shall identify all disruptions to traffic movement and public access to the site and adjacent properties and all safety barriers and equipment to be used.

The traffic management plan should also address issues regarding access and loading. The traffic management plan shall be submitted to the local council's traffic management department. Works shall not commence until the traffic management plan has been approved.

Adjacent roads, paths and land:

The Contractor will be responsible to:

- Provide and maintain continuous access to adjacent properties and public areas for pedestrians and vehicles. Do not close or obstruct any road or path unless required by the approved works permit and carried out in accordance with the requirements of the relevant authorities.
- Make arrangements with Melbourne Water and other relevant authorities / land owners for access to and from the site for personnel, goods and materials, and constructional plant and equipment. Provide required temporary roads, crossings

over existing roads and paths, in accordance with the requirements of the relevant authorities, and remove when no longer required.

- Provide traffic control equipment as required from time to time or by the relevant authority. Traffic control equipment shall include vehicle barricades, signs, traffic lights and the like.
- Ensure all existing infrastructure to be retained is protected from damage.
- Ensure all temporary access roads are dismantled at the completion of construction works and the affected surfaces reinstated to the standards acceptable by Melbourne Water and the landowner.

Security

The Contractor shall be responsible for all activities on the Site including providing access for authorised persons and restricting the access of unauthorised persons. The Contractor shall take all necessary precautions to secure the site, works, materials, plant and equipment during working and non-working hours from the date of commencement on-site to 4.00pm on the Date of Practical Completion.

Services

Identification and protection of existing services.

It is the responsibility of the Contractor to carry out all investigations necessary (including utilising Dial Before You Dig Melbourne One Call Service and physically detecting services on site using suitable electronic equipment) to locate and mark the location of all services within the works area and to retain and protect those services throughout the Contract period.

Any damage to existing services caused by the Contractor must be repaired or rectified at the Contractor's expense to the satisfaction of Melbourne Water and the responsible authority.

The Contractor must not excavate by machine within 1m of existing underground services.

Continuity of Services

No services shall be interrupted unless agreed in writing by Melbourne Water or the service provider

Telephone services shall be maintained in continuous operation. Where service disruption is required, disconnect services at nearest stop valve, or switchboard, before cutting or opening service pipes and conduits. Provide temporary or permanent sealing as required where fittings are removed.

The Contractor shall:

- Before disconnecting or interrupting services, give not less than 48 hours' notice directly to the Superintendent and provide an estimate of the duration of disruption. Keep disruption of services to a minimum. Submit copies of notices.
- Advise Melbourne Water at least 48 hours before shut down of any reticulated services (such as main electrical power, natural gas, cold water supply, and fire services) and reinstate each working day.
- Provide required warning signs and carry out appropriate safety procedures when working on services.

Temporary Services

The Contractor is responsible to provide all temporary services required for the Works, including electricity, water, sewerage, storm water disposal, telephone and the like. Make applications to the relevant authorities, pay all connection and consumption charges, comply with conditions, provide connections, equipment and reticulation, and remove entire installation and make good when no longer required or at Practical Completion.

Reticulate temporary power to required work areas. Comply with all safety requirements and notify all site personnel of safety procedures.

Site condition and maintenance

Progressively:

The Contractor will be required to keep the Works, adjacent common areas and adjacent properties affected by the Works, clean and tidy at all times. Clear and remove dirt and debris from the site progressively. Provide sufficient personnel and equipment for cleaning operations.

Provide and regularly empty disposal containers for demolished materials, debris, discarded and surplus goods and materials generated by the Works. Locate containers as close as practicable to the relevant work area.

Containers shall not be located on public roads or paths unless approved by the relevant authority and all required permits have been obtained and fees paid.

Melbourne Water may require any area to be immediately cleaned during the construction period at no additional cost.

The Contractor will be required to remove all dirt and debris attributable to the Works from adjacent roads, paths and properties in accordance with the requirements of the relevant authorities.

Vehicles and transportation:

The Contractor will be required to use trucks that will not spill or deposit dirt or debris on adjacent public roads, paths or properties. Clean the tyres and underside of trucks before leaving the site. Provide and maintain effective truck wash down and silt retention where required.

Completion:

Before arranging handover inspections, finish, clean, and make good the Works including:

- Clear and remove surplus materials, dirt, debris and the like
- Repair damage and defects to adjacent properties resulting from the Works
- Repair damage, stains and blemishes, or replace work where required.
- Clean all surfaces
- Commission, test and ensure services and equipment are connected and operating properly

Risks Assessment

The Contractor shall prepare and submit a Risk Assessment prior to commencing the Works. The Risk Assessment Form shall be used to record the risk assessment and risk control methods to be employed by the Contractor.

The completed Risk Assessment shall be submitted to Melbourne Water for review and approval prior to the commencement of Works.

Site Environmental Management plan

To manage risks, and in accordance with Melbourne Water's Environmental and Public Health Management System, a Site Environmental Management Plan (SEMP) must be developed for the proposal and must clearly indicate measures to be employed during construction for the management of the site.

The SEMP should be prepared as part of the works application.

The SEMP should include generic construction related aspects including noise, dust, erosion and sediment control, waste and chemicals use as well as specific aspects such as Flora and fauna and archaeological/heritage impacts.

The temporary management/diversion of drainage flows during the site works should be sufficiently detailed in the SEMP.

Designs of the environmental protection measures to be used on site, shall be included in the SEMP.

Design measures may include:

- Access Point
- Water Diversion Structures
- Stabilisation Measures
- Sediment Retention Structures
- Vehicle Cleaning Mechanisms
- Waste Containment Measures
- Bunding
- Flora and Fauna Protection Mechanisms
- Archaeological/ Heritage Protection Mechanisms
- Other Relevant Designs.

Sediment retention and water diversion structures should be designed to cater for a one in two year storm event (two-year ARI with intensity of six hours). Contingency measures such as stabilised bypasses should be put in place to cater for extreme storm events.

Additional guidance on assessing risk and possible environmental protection measures may be found within:

- EPA's publication 480 "Environmental Management Guidelines for Major Construction Sites" (available online: www.epa.vic.gov.au, Link- Publications and Legislation)

- EPA's Publication 275 "Construction Techniques for Sediment and Pollution Control" (available online: www.epa.vic.gov.au, Link- Publications and Legislation).

Cultural and Heritage Requirements

In 2006, the Victorian Government introduced the Aboriginal Heritage Act 2006. This Act replaces Part 11A of the Commonwealth Aboriginal and Torres Strait Islander Heritage Protection Act 1984 and the State Archaeological and Aboriginal Relics Preservation Act 1972.

As part of the design and construction of stormwater harvesting infrastructure the proponent will need to appoint a suitably qualified aboriginal heritage archaeological consultant to determine whether a Cultural and Heritage Management Plan (CHMP) is required for the execution of works.

A CHMP is required for an activity if:

- All or part of the activity area is an area of cultural heritage sensitivity, and
- All or part of the activity is a high impact activity.

Definitions for an area of cultural heritage significance, significant ground disturbance and high impact activity are described in the Aboriginal Heritage Act 2006.

It is the responsibility of the applicant to provide appropriate documentation to address the requirements of the Aboriginal Heritage Act 2006 as part of the proponent's application to Melbourne Water.

Assets Handover on completion of construction

This section provides the user(s) with detailed information with respect to procedures, documents and references that are required for the DS handover process.

Asset Ownership

All diversion structures constructed on MWC assets once completed will become a MWC asset following the successful commissioning and defects liability/proofing by the proponent/contractor.

Ongoing responsibility for the structure and maintenance will rest with Melbourne Water unless a separate maintenance agreement is entered into. Licensing fees may incorporate a maintenance fee to cover costs of ongoing inspections and maintenance or alternatively licence conditions may require the licensee to meet the direct costs of MW maintenance undertaken on the diversions structure.

The scheme proponent / licence holder will be responsible for the offtake / diversion pipe and all other harvesting works components downstream of the Diversion structure (DS).

Melbourne Water will endeavour to inform scheme owners when undertaking any maintenance or works on the diversions structure that may impact on harvesting potential or operations.

MWC Personnel involved in the handover process

The teams involved in the DS assets handover process include Diversions, Civil and Strategic Asset Management, Maintenance and Operations and Asset Planning groups.

The following MWC personnel should be involved in the handover of DS:

1. The Project Officer (Diversions team)
2. Works Surveillance Officer (Developer Project Works)
3. Asset owner (Drainage Asset Management)
4. Maintenance coordinator (Regional Delivery)

The Project Officer (Diversions) manages the project from the receipt of stormwater diversion application through detailed design and construction approval. The Works Surveillance Officer (Developer Project Works) then manages the works construction surveillance process including handover of assets to Melbourne Water under a quality assurance process.

The Works Surveillance Officer will also set-up handover certificates using MWC internal workflows.

MW Asset – http://livelink/livelink/livelink.exe/open/11466501

Handover procedures and staging

There will be two stages of Handover certificate for assets constructed under Melbourne Water surveillance as detailed below.

The MWC Asset Owner (Drainage Asset Management) accepts the asset on the Handover workflow internal process (initiated by the Works Surveillance Officer) at stage 1 handover.

The MWC Asset Owner (Drainage Asset Management) records on the handover workflow that works will be a MW asset after defects (usually in 3 months' time), identifies any possible maintenance issues that may not have been captured during detailed design and lists these in comments section or memo. Typically at each stage of the handover process a site meeting/inspection is organised with assets owners and proponent / contractor attending.

Stage 1 – Handover

- Initiated at Practical Completion of the asset by the Works Surveillance Officer (Developer Project Works)
- Completed for assets owned by Melbourne Water
- The handover document summarises the project and directs the internal MW teams to associated documentation, namely project files, as-constructed drawings
- At this stage, the Proponent maintains the asset. Responsibility typically lasts for 3 (three) months until the Final certificate is issued.
- The Works Surveillance Officer is able to arrange for an onsite visit to review the constructed asset and plan for future maintenance budgeting.
- There is some opportunity to modify the works at this stage as the works are still on defects liability but it is limited to minor modifications only.

Stage 2 Handover

- Initiated at Final Completion of the asset following expiry of the defects period
- Ensure all comments from the Stage 1 handover have been addressed
- At this stage, MWC will permanently maintain the asset

Relationship of Practical Completion and Final Completion with handover

Once works are at 100% completion and all Quality Assurance documentation is received, the MWC project officer grants Practical Completion (PC) to the Contractor. After Practical Completion, the works are in their Defects Liability Period (DLP). The purpose of the defects liability period is to ensure that there are no major problems with the asset before it is handed over to Melbourne Water. At this stage, the Developer, Consultant and Contractor for the asset are still required to maintain the works if there are any problems.

Defects Liability Period

The Defects Liability Period is determined by the type of works (i.e. civil, earthworks) and is outlined in the Works contract and in the Stage 1 handover form. Typically the defects period is 3 (three) months for pipelines and concrete structures including DS.

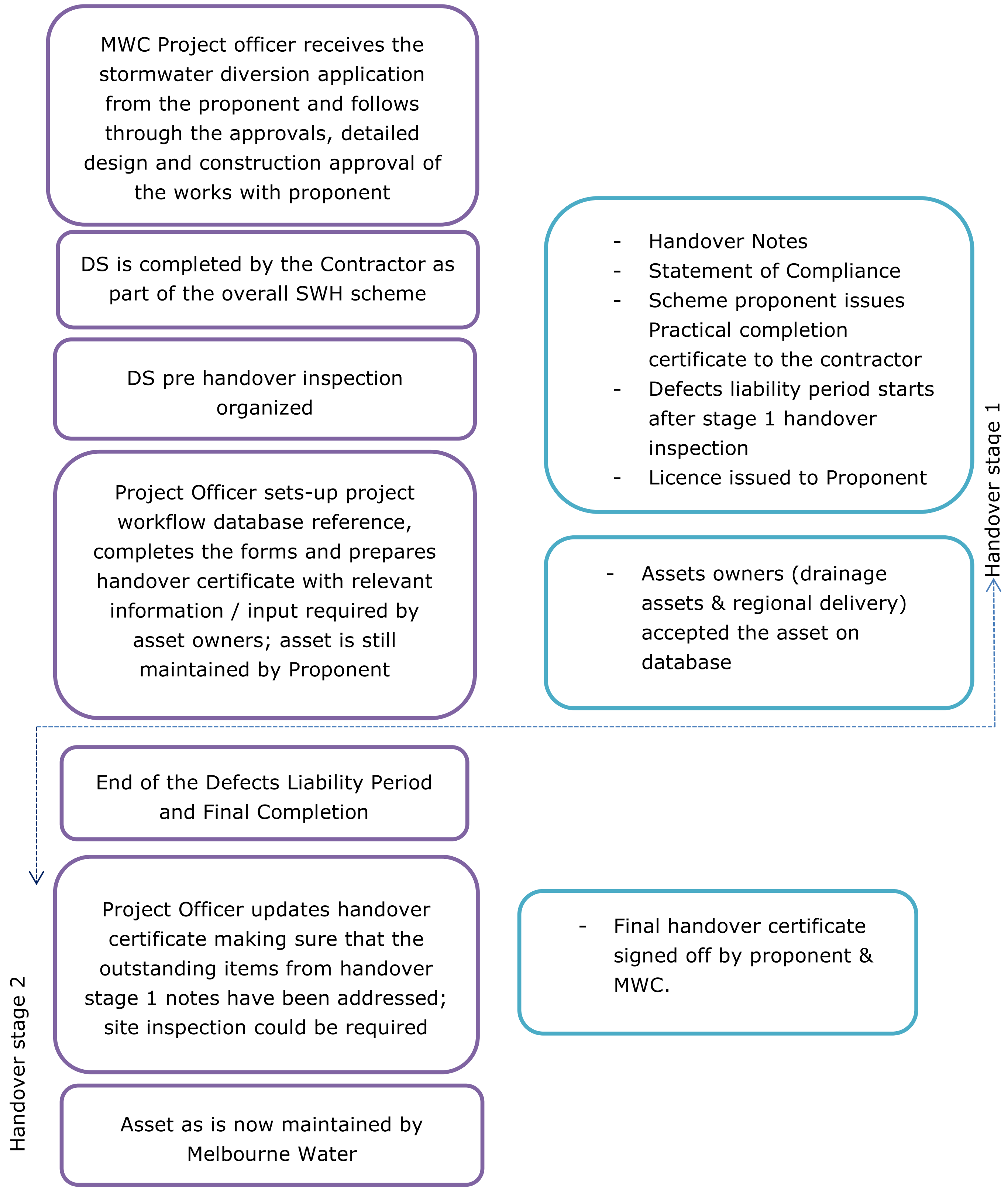
Documentation:

The documentation required for the handover is comprised of (but not limited to) the following:

Document category/title	*Hand over stage*	*Issued / collected by*
Statement of Compliance	Stage 1	Project Officer (PO)
Handover Certificate	Stage 2	PO
Construction certificates (material/warrantee, testing/plumbing certificates etc.)	Prior to Stage 1 handover	Works Surveillance Officer (WSO)
Quality Assurance documentation	Prior to and at Stage 1	WSO and PO
As Constructed drawings		WSO and PO
Licence to harvest stormwater	Stage 1, following MWC approvals of works and PC issue	PO

Table 4 *Documentation in support of handover*

Flowchart – assets handover



Special Melbourne Water requirements

- Any works carried out on Melbourne Water "live "drainage assets must be carried out by a Registered Contractor, subject to Melbourne Water registration requirements
- Construction of the Works must conform to the design approved by Melbourne Water
- Melbourne Water may require that Works be modified, removed or replaced at the Owner's cost if they:
  - are not completed strictly in accordance with the final design
  - do not meet a construction standard acceptable to Melbourne Water
- The construction of the Works must be carried out taking into account these guidelines, relevant Melbourne Water Standard Drawings and Standard Specifications A Buildover /Lease agreement is required for any constructions over Melbourne Water land or easements. Refer to the Assets Services Team for a copy of the Buildover agreement.
- The proposed diversion structure should be designed and constructed in a manner that does not load the existing conduit
- Melbourne Water must still have access to its assets at all times, including during construction.
- No services (e.g. electrical or plumbing) may be constructed within the Melbourne Water drainage conduits
- Any works to be conducted in the vicinity of existing drainage assets shall be undertaken in a manner that protects the assets (i.e.: minimum vibration, loading, saw cut of pipe instead of using a jack hammer, etc.).
- Any damage caused to an asset due to the stormwater harvesting works shall be paid for by the proponent/contractor
- Before commencement of construction, the proponent may be required to undertake a pre- and post- construction inspection of the existing assets to verify no damage has been caused as a result of construction or existence of the stormwater structure.
- When the construction is completed, "as constructed" drawings shall be supplied to Melbourne Water for future record.
- No contractors are allowed to enter Melbourne Water drainage assets unless prior arrangement is made through the Drainage Area Co-ordinator or through the Diversion Team by the application of a Permit to Work and a current Confined Space Entry ticket is held.
- It is the contractor's responsibility that the location of the assets is proven on site before any construction works commence.

- Melbourne Water reserves the right to impose additional conditions upon the receipt of design information from the proponent.

The contractor is required to submit a work method statement and tasks risk assessment (TRA) to Melbourne Water's Diversion Services team for approval prior to commencement of construction.

Section 5 – Operational & Maintenance Requirements

General

- The stormwater harvesting diversion structure should be designed to have minimal operational and maintenance requirements.
- The requirement for regular personnel access into the underground structure to perform maintenance activities should be avoided or minimised.
- Use of mechanical equipment and moving parts should be avoided where practicable.
- The operational and maintenance requirements for the diversion structure should be included in an Operational & Maintenance Manual prepared for the stormwater harvesting scheme with a copy provided to Melbourne Water for approval.
- The recommended diversion structure options detailed on drawings 7251/10/001 - 7251/10/011 included in Appendix 2 to this report provide further detail on the operational & maintenance requirements.

Minimum size of diversion pipeline

The minimum size of the pipeline from the diversion structure into the harvesting system should be 375 mm nominal bore to minimise blockage risks.

Base/low flows and self-cleansing velocities allowance

For all new diversion structures installed on Melbourne Water drains, allowance should be made for low/base flows to continue through the system prior/at the time of flow diversion in order to avoid sediment deposition and associated maintenance problems in the drainage network.

It is recommended that the minimum self-cleansing velocities for the design of these flows are calculated on a case by case basis using the boundary shear stress approach as described in these design guidelines. The design calculations shall prove that the design solution allows for the continuation of base flows through the system and that these flows produce the boundary bottom shear stress equal to or exceeding the pre-set minimal boundary bottom shear stress of $\boldsymbol{\tau \geq 1.5}$ ***Pa.***

Refer to Appendix 1 for more detail on the boundary bottom shear stress calculations.

Melbourne Water at its discretion may accept reduced requirements for the maintenance flow in the Diversion Structure design if it can be demonstrated that sufficient self-cleansing velocities are generated in the downstream section on the main drainage line as a result of additional inflows into the drainage system from other contributing drains in close proximity.

Flow isolation devices

The design of diversion structures should allow for the temporary isolation of the harvesting component from the diversion structure and associated drainage flows. This will allow for maintenance activities on the scheme downstream of the harvesting structure and for isolation in the case of emergency. To facilitate this, a sliding drop board arrangement within the DS is recommended as detailed on drawing 7251/10/011 included in Appendix 2 of these guidelines.

For the temporary isolation of the entire diversion structure from the main drainage line methods such as sandbagging and flow bypass or similar may be used on an as required basis.

Maintenance frequency

The diversion structure should be designed with minimal requirements for maintenance.

The following maintenance frequency/procedures are typical:

- Visual inspection (typically twice a year)
- Cleaning by suction truck (as determined by inspection not more than once a year)

Maintenance access

The design should allow for adequate and safe access to the installed diversion structure for maintenance and operation (e.g. cleaning).
This should include:

- access road with turn-around circle for maintenance vehicles (e.g. suction track/crane) providing sufficient reach to the installed structure
- access for personnel entry/ inspection (min access shaft diameter 900 mm)

Only suitably qualified personnel with appropriate training and qualification/ certification in OHS and confined spaces entry procedures should be involved in the maintenance of the diversion structures.

Entries into Melbourne Water assets are subject to Melbourne Water confined spaces entry and permit to work systems. Permits must be arranged through the Drainage Area Coordinators.

The recommended options for the diversion structures outlined in the standard drawings forming part of these guidelines incorporate provisions for the routine maintenance (e.g. open/close flow isolation device, cleaning with vacuum truck etc.) to be conducted from the ground level without the need to enter the DS. However safe access into the DS is still required for any major maintenance, alterations and emergencies.

Adjustment and Calibration

The diversion structure design should have allowance for further adjustments and calibration (e.g. base flow passage rates, diversion rates etc.) where practicable.

Exclusions and Clarifications

1. Melbourne Water at its discretion may accept reduced requirements for the low flow/self-cleansing velocities in the Diversion Structure design if it can be demonstrated that sufficient self-cleansing velocities are generated in the downstream section on the main drainage line as a result of additional inflows into the drainage system from other contributing drains in close proximity.

2. If the stormwater harvesting scheme (or part of) becomes decommissioned –the scheme operator in consultation with Melbourne Water must perform the works deemed necessary for the decommissioning or alteration of the diversions structure to ensure the continued safe and reliable operation of the drainage assets. Such works to be performed at the scheme operator’s cost.

Section 6 – Licensing and Flow Meter Requirements

Licence requirement

The harvesting of water from Melbourne Water's drains and waterways requires a licence under Section 51 of the *Water Act* 1989.

Licences require a resource assessment to determine whether sufficient water is available to satisfy the licence volume without impacting on existing users or the environment. The licence proponent will be required to provide supporting evidence to Melbourne Water as part of their application which demonstrate the catchment modelling and water availability calculations undertaken in support of the harvesting scheme.

Base low flow in drains and waterways is not considered urban stormwater. Urban stormwater is the increase in storm runoff resulting from an increase in imperviousness of an urban catchment. Applications will need to demonstrate how they are making allowance for passage of base flows in the drainage system.

The construction work on Melbourne Water Assets will require a Works Licence. All works must be carried out to Melbourne Water standards. Works licences may contain a range of conditions including requirements for the proponent to:

- engage suitably qualified contractors
- undertake recipient training for work on MWC assets
- obtain necessary permits to work
- hold appropriate confined space licences, etc.
- pay appropriate fees and bonds
- undertake asset handover processes.

To make application for both a stormwater licence and associated works licence Melbourne Water will require the following:

- A stormwater application form completed in full and signed by the party who will hold the licence. Application forms are available from Melbourne Water or on the website at http://www.melbournewater.com.au/diverters
- A cheque or equivalent made out to Melbourne Water Corporation for the relevant application fees.

- Hydrologic analysis and modelling of the proposal. The modelling should be undertaken for the catchment upstream of the off take location and for the overall catchment and should show current flows along with expected change in flow condition as a result of the harvesting proposal. It should be undertaken showing an average and a dry year and be conducted to a weekly (or more frequent) time scale.
- Works Plans for proposed works including proposed operation and maintenance. These should be properly engineered drawings detailing the works and include locality plan, detail plans and suitable cross sections.
- Copy of title(s) for the property where water will be used.
- Irrigation and Drainage Plan detailing the irrigation requirements and scheduling of application as well as drainage and runoff controls to be put in place on the site.
- Details of existing or proposed storages.
- Digital Photos of proposed pump / works locations.
- Demonstrated evidence that the applicant has obtained permission or consent from the owner of any land on which the works are, or will be, situated.

The maximum volume of a licence will be determined by Melbourne Water after considering the volume of water available at the new location, and the water needs of existing licence holders and the environment. Applications are subject to assessment in accordance with the provisions of the Water Act (section 53) and are referred both internally and externally to potentially affected parties to comment on impacts. Determinations consider all inputs and decisions may be subject to appeal at VCAT.

Additional information on licensing can be obtained from MWC's Diversion Management team at 131 722.

Flow meters

Accurate measurement of water supplied and accounting for water use against a customer's entitlement is a focus of the Australian Government under the Australian Standard AS 4747 "Meters for non-urban water supply".

These standards sit alongside the metering provisions of the National Water Initiative Agreement (NWI) which specifies the need to develop national standards for meter design and installation for consistent measurement of usage. All state governments have signed onto the National Agreement.

All stormwater harvesting schemes proposed to be installed on Melbourne Water drainage assets will require metering. It is a requirement of the diversion licence that an approved flow meter be installed within the works in order to:

- Provide an accurate record of volumes diverted
- Monitor actual usage to ensure it falls within individual licensed allocated volumes
- Provide water use data for State-wide reporting

Installation of the meter will be at the licensee's cost and Melbourne Water shall not be liable for any damage to customer infrastructure due to meter installation. Meters will be supplied by Melbourne Water at the cost of the applicant and will remain the property of Melbourne Water Corporation. All new meters are to be pattern approved according to AS4747.

There is a need to undertake an assessment of proposed works in order to gather certain information before an informed choice can be made regarding the water meter to be installed. The information relates to the type of diversion structure and associated stormwater harvesting infrastructure proposed including size, type of pipe and general pumping plant set-up. This assessment determines the most suitable type of meter for the project as well as enabling the calculation of the likely range of flow rates to be metered and discussion with the stormwater harvesting proponent on preferred location.

The proponent will need to make suitable allowance in the works design to provide for meter installation and smooth flow leading into and out of the meter. This will mean providing spacings before and after the meter as per the manufacturer's specifications. There should be no valves, bends or other flow interference in this space.

Melbourne Water may also require a data logger i.e. smart meter technology to be fitted to meters in certain circumstances to monitor harvesting. This requirement will be discussed with proponents at the time of application.

Certified Meter Validators

- Only Certified Meter Validators can undertake any works on Melbourne Water irrigation meters.

- Training is available via Irrigation Australia (www.irrigation.org.au) or other accredited training institutions.

Access to meters

In designing a stormwater scheme, proponents should also ensure adequate allowance has been made for the required access to the meter for reading and maintenance purposes:

- The meter installation site must be accessible to vehicles and machinery wherever practical.
- The meter should be installed above ground wherever possible and free from other obstructions.
- Safe access must be provided to meters (e.g. provision of covers, steps, platforms and handrails etc.) and comply with the requirements of relevant Health and Safety Acts and be in accordance with relevant Australian Standards.

All meter installations shall be configured and tested as soon as practicable upon completion of each installation. It is a requirement that all meter installations undergo configuration and testing to ensure that they meet the requirements of the specification.

Section 7 – Recommended Design Options

General

In summary of the major components in these guidelines the following set of design parameters for diversion structures on Melbourne Water drainage assets has been established:

The diversion structure should:

- Collect the agreed volume of urban runoff from the contributing catchment(s); the volume of water permitted for collection should be as per requirements of the diversion license issued by Melbourne Water.
- Make allowance for base low flows to continue through the system prior to and at the time of flow diversion in order to avoid sediment deposition and associated maintenance problems in the drainage network.
- Pass required base flows downstream to receiving waterways where they are providing for ecological benefits prior to and at the time of flow diversion.
- Not cause any adverse impact on the hydraulic capacity of the existing drainage system. The hydraulic impact of the proposed installation should be checked, documented and presented to Melbourne Water for approval prior to works commencement.
- Be designed to have minimal operational and maintenance requirements.
- Be designed to avoid or minimize the requirement for personnel access into the underground structure.
- Avoid where practicable the use of mechanical equipment and moving parts.
- Include an Operational & Maintenance Manual prepared for the stormwater harvesting scheme and the diversion structure, a copy of which should be provided to Melbourne Water for approval.
- Have a minimum size of pipeline from the diversion structure into the harvesting system of 375 mm nominal bore to minimize blockage risks.
- Have arrangements in place for the temporary isolation of the harvesting component from the main diversion structure for maintenance.
- Make allowance for adequate and safe access to the installed diversion structure for maintenance and operation purposes.

- Make allowance for further adjustments and calibration (e.g. base flow passage rates, diversion rates etc.) where practicable.

A number of preferred Diversion Structure design options have been developed that address these requirements with three options selected for inclusion in this document as Melbourne Water recommended options.

The three recommended options are further described in the following sections of this document with engineering drawings contained as appendices in Appendix 2.

Option 1

Option 1 has been specifically developed for stormwater harvesting diversions where limitations on the headloss/hydraulic impact are of particular importance and where there are defined requirements for continuous base/environmental flows passage.

This option is based on a low/base flow channel and an overflow side weir arrangement. The details of this option are provided on the drawings 7251/10/002, 7251/10/003 and 7251/10/004 included in Appendix 2.

The design rationale for this option is as follows:

- The pre-determined base/maintenance flows pass through the DS via the low/base flow channel unhindered; the volume / flow rate for these flows is determined by the size and height of the channel
- When the flow rate in the incoming conduit reaches the predetermined value - the diversion into the stormwater harvesting component commences via the side weir while the required low flows are still being passed through the DS into the receiving environment
- When the stormwater harvesting storages are full the water level in the DS rises to the top of side weir and all the incoming flows are passed straight through the DS and into the downstream drainage system
- During large flow events – provided that the stormwater harvesting scheme can still accept inflows – the DS should be able to provide both the harvesting of flows and passage of the excess flow into the downstream drainage system functions.

The grade of the base flows channel shall be the same as the gradient of the main drainage system in order to provide the smooth transition of flows and have minimal hydraulic impact.

The design of this DS specifies half pipe benching on the side opposite to the side overflow to minimize the hydraulic disturbance/headloss during high flow operations.

The minimum drop of 600 mm from the main drainage pipe to the collection chamber invert is recommended for this option based on the 375 ID diversion pipe into the stormwater harvesting component.

The DS incorporates an isolation device for the temporary isolation of the harvesting component from the main diversion structure during scheduled maintenance. Specific details on the recommended isolation arrangements can be found on drawing 7251/10/011 included in Appendix 2.

This option also allows for an access lid and shaft of 900mm x 900mm for ease of maintenance and access.

The DS should be designed making allowance for the routine maintenance (e.g. open/close flow isolation device, cleaning with vacuum truck etc.) to be conducted from ground level without the need to enter the DS. However safe access into the DS is still required for major maintenance, modifications and emergencies.

Note: Option 1 design can be used for diversion of flows under both sub-critical and super-critical flow regimes in the main drainage systems with reliable operation under both scenarios.

Option 2

Option 2 incorporates a low crest transverse weir (typ. 100 mm) and a small drop in the invert of the diversion structure (100 mm typ.) that, in combination, create sufficient head for the diversion of low harvestable flows from large drainage conduits with relatively flat grades.

The details of this option are provided on the drawings 7251/10/005, 7251/10/006 and 7251/10/007 included in Appendix 2.

The small weir is designed to overflow frequently and therefore there are no separate provisions for the self-cleansing / base flows passage in this option. Typically the low crest weir is designed to create the min head required for the diversion of the harvestable flows and it is therefore important that the designer minimises any backwater effects and/or headlosses in the diversion pipeline in order to secure the diversion of the designed volume for harvesting.

The weir should be positioned at a sufficient distance (min ½ pipe ID) from the incoming/outgoing main drainage pipe and concrete benching provided to allow for the smooth flow transition and minimisation of hydraulic losses within the DS.
The DS incorporates an isolation device for the temporary isolation of the harvesting component from the main diversion structure during scheduled maintenance.
Option 2 also allows for an access lid and shaft of 900mm x 900mm for ease of maintenance and access.

The DS should be designed making allowance for routine maintenance (e.g. open/close flow isolation device, cleaning with vacuum truck etc.) to be conducted from ground level without the need to enter the DS. However safe access into the DS is still required for major maintenance, modifications and emergencies.

Note: This option is best suited for the diversion of flows from large drainage pipes with sub-critical flow regime. The use of this option for the diversion of flows on steep grade/high velocity/super-critical flow drainage should be avoided.

Option 3

Option 3 combines a drop structure with a pre-screening grate as an entry point/inlet to the diversion pipe.

The details of this option are provided on drawings 7251/10/008, 7251/10/009 and 7251/10/010 included in Appendix 2.

The design rationale for this option is as follows:

- The pre-determined base/maintenance flows pass through the DS via the low/base flow channel incorporated into the grate design. The volume / flow rate for these flows is determined by the height of the channel. Also please note the need for benching to direct the base flows into the channel
- When the flow rate in the incoming conduit reaches the predetermined value (exceeds the flow capacity of the low flow channel) - the diversion into the stormwater harvesting component commences (via the side weirs/sides of the base channel and grate) while the required low flows are still being passed through the DS into the receiving environment

- When the stormwater harvesting storages are full the water level in the DS rises to the underside of the grate and all the incoming flows are passed straight through the DS and into the downstream drainage system
- During large flow events – provided that the stormwater harvesting scheme can still accept inflows – the DS should be able to provide both the harvesting of flows and passage of the excess flow into the downstream drainage system functions

The grate in Option 3 comprises of 32 NB pipes with min 25 mm gap contained in the rigid frame. The frame should be hinged for the ease of opening during maintenance operation.

Allowance should be made for the hinged section of the grate to be opened from the ground level with the use of a handle/hook arrangement as detailed on drawing 7251/10/011 included in Appendix 2.

The grate should be positioned such that the 32 NB pipes are parallel to the main drainage flow in order to minimize potential for grate blockage.

The grate and frame should be designed with adequate structural strength to allow for the dead and live loads associated with the maintenance personnel access during maintenance.

The provisions for base flow passage within the diversion structure are incorporated into the grate design (Enviro – channel profile).

The minimum drop of 600 mm from the main drainage pipe to the collection chamber invert is recommended for this option based on the 375 ID diversion pipe into the stormwater harvesting component.

The DS incorporates an isolation device for the temporary isolation of the harvesting component from the main diversion structure during scheduled maintenance.
Option 3 design also incorporates an access lid and shaft of 900mm x 900mm for the ease of maintenance and access.

The DS should be designed making allowance for the routine maintenance (e.g. open/close flow isolation device, open/close the grate, cleaning with vacuum truck etc.) to be conducted from ground level without the need to enter the DS. However safe access into the DS is still required for major maintenance, modifications and emergencies.

Note: Option 3 has been specifically developed for flow diversions on large drainage conduits including box culverts where large objects could be present in the incoming run off. The function of the grating in this option is to provide the pre-screening barrier to these large objects that could otherwise cause blockage of the diversion pipeline.

The effective area of the grating should be designed to cater for the secure passage of the design flows for the diversion/harvesting under the reduced area/"partially blocked" scenario (typically 50% blockage of the grate effective area).

Alternative Designs

While the options and designs above represent Melbourne Water's preferred outcomes, alternative or variations to these designs will be considered where they can demonstrate that they meet the design objectives outlined in these guidelines.

As-Constructed Diversion Pit

Section 8 – Abbreviations and References

Abbreviations

MWC	Melbourne water Corporation
WSUD	Water Sensitive Urban Design
IUWM	Integrated Urban Water management
LID	Low Impact development
SUDS	Sustainable Urban Drainage Systems
BMP	Best management Practice
GPT	Gross Pollutants Trap
DS	Diversion Structure
HGL	Hydraulics Grade Line
EGL	Energy Grade Line
Q_{sys}	System Flow
Q_{div}	Diversion Flow
Δh	Hydraulic Headloss
NB	Nominal Bore
MRWA	Melbourne Retail Water Authorities
SEMP	Site Environmental Management Plan
CHMP	Cultural & Heritage Management Plan
SFMP	Stream Flow Management Plan
AS	Australian Standard
WSA	Water Services Association
EPA	Environmental Protection Authority
EDD	Extended Detention Depth
NWL	Normal Water Level

References

Water Sensitive Urban Design: Basic Procedures for 'Source Control' of Stormwater - A Handbook for Australian Practice, Argue, J. R. (ed), Allen, M. D., Argue, J. R., Geiger, W. F., Johnston, L. D., Pezzaniti, D. and Scott, P. 2004, Urban Water Resources Centre, University of South Australia, Adelaide, South Australia

Hydraulics in Civil and Environmental Engineering, Chadwick and Morfett, third edition, 1998

Understanding Hydraulics, L. Hamill, MACMILLAN 1995

Wastewater Hydraulics, Willi J. Hager, Springer 1999

Queensland Urban Drainage Manual second edition, 2007

Algorithms for pit pressure changes and hydraulic losses in stormwater drainage systems, Geoffrey O'Loughlin & Bob Stack, conference paper abstract, 2007

Water Control Structures – Design for Natural Resources management on coastal floodplains, Ben Rampano, NSW Department of Industry & Investment, 2009

Environmental & Economic Assessment of Urban Water Services for a Greenfield development, A. Sharma, A. Grant, T. Grant, F. Pamminger, L. Opray, Environmental Engineering Science magazine, vol. 26, No 5 – 2009

Analysis of Climate Change Impact on the deterioration of concrete infrastructure, CSIRO National Research Flagship – 2010

Hydraulic design of Bosspipe lines, Water&Farr, 2005

Hydraulics Considerations for corrugated PE pipe, CPPA Association,2000

Sewerage Code WSA 02-2002-2.3 July 2004

Melbourne Water Access Covers, Platforms and Walkways Standard CORP AM S020 version 2, August 2014

Melbourne Water Handrail Standard CORP AM S021 version 1, August 2013

The Victorian Occupational Health and Safety Act 2004 – Section 28 "Duties of Designers of buildings & structures"

Burns, M.J., Fletcher, T.D., and Edwards, C. (2015). Low-flow hydrology in the Melbourne Water management region. April-2015. Melbourne Waterway Research-Practice Partnership Technical Report 15.1.

Poff, N. L., J. D. Allan, M. B. Bain, J. R. Karr, K. L. Prestegaard, B. D. Richter, R. E. Sparks and J. C. Stromberg (1997). "The natural flow regime: a paradigm for river conservation and restoration." BioScience **47**: 769-784.

Walsh, C. J., A. H. Roy, J. W. Feminella, P. D. Cottingham, P. M. Groffman and R. P. Morgan (2005). "The urban stream syndrome: current knowledge and the search for a cure." Journal of the North American Benthological Society **24**(3): 706-723.

Walsh, C. J., T. D. Fletcher and M. J. Burns (2012). "Urban stormwater runoff: a new class of environmental flow problem." PLoS ONE 7(9).

Appendix 1 Boundary shear stress calculations for maintenance flows

Sewers and storm water drains are designed to ensure minimum self-cleansing flow at more frequent flows when the conduit is typically flowing part full. Traditionally it is regarded that self-cleansing velocity is achieved at 0.5-0.75 m/s.

More accurate design for partially filled pipes is based on theory of fluid flow in open channel where the bottom (boundary) shear stress may be expressed as:

$$\tau = \rho.g.R.S$$

Where:

- τ is boundary shear stress, N/m^2 or Pa
- ρ is fluid density, kg/m^3
- g is gravitational acceleration, m/sec^2
- R is hydraulic radius of the drainage conduit, m
- S is hydraulic gradient/ slope, m/m

For a circular pipe flowing part full, since $R_{full\ pipe}$=d/4 equation 1 can be rewritten as:

$$\tau = \rho.g.{}^{d}\!/_{4}.{}^{R_p}\!/_{R_f}.S$$

The value of ***τ ≥ 1.5 Pa*** is generally regarded as a criterion of self-cleansing flow ensuring separation of fine sediment and grit.

Appendix 2 Design drawings

MWC Internal Inflo Link : http://inflo/inflo/llisapi.dll/open/32120843

Appendix 3 Glossary of Terms

Stormwater – Stormwater is considered the additional flows in a drain or waterway attributable to a rain event, above that which would naturally occur in an urban catchment if the catchment remained undeveloped. Stormwater excludes baseflows, environmental flows and rural catchment flows and is considered as the net increase in run-off and decrease in groundwater recharge as a result of the increase in impervious surfaces (such as roofs and roads) within an urban catchment.

Base flow – Base flow is considered to be the flow in drains and waterways from all other sources other than stormwater as defined above. These sources can include groundwater springs, catchment and rural runoff, urban wastage and mains leakage.

Drain - A drain is typically considered to be an artificial waterway or pipe that allows for water drainage, with minimum to no habitat, biodiversity, environmental flow or other environmental values.

Modified channel - The term modified channel can be used to describe a previously natural drainage system which has been modified and no longer exhibits the same drainage properties or environmental values of the natural drainage system and the values are now similar to that of a drain. For example, the channel may have been dug out and lined with concrete to increase the velocity at which water can drain away from an area, thus reducing flooding potential or straightened to increase hydraulic efficiency. Such channels may still retain elements of environmental value or social value due to the retention of some natural features and presence of adjoining open space or walking / bike trails.

Stormwater works:

(a) channels, drains or pipes or associated works, including box culverts, owned or operated for the purpose of collecting or conveying stormwater runoff from an urban area or development; and

(b) retarding basins or wetlands constructed or operated for the purpose of holding or treating stormwater runoff from an urban area or development; and

(c) works listed in MWC's asset register and used for the purposes of carrying out its regional drainage functions under Part 10 of the Act;

Waterway - A natural channel where water regularly flows whether or not the flow is continuous and includes all creeks, rivers and watercourses. References to waterways in this document should be taken as having the same definition as provided under section 3 of the Water Act 1989.