ATTACHMENT D
Site Based Stormwater Management Plan

98 Glenmore Drive,
Bonogin QLD 4213
Lot 1 on RP218875

August 2026

Urban Planning | Urban Design
Project Management | Development Advice

Legend Consultants
Efficiency • Innovation • Quality

STORMWATER MANAGEMENT PLAN

Proposed Rural Subdivision
98 Glenmore Drive, Bonogin

Lot 1 on RP218875

For Salt Development Projects
6 August 2026
File No: LC5079-0002-SWMP-A

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Synopsis: This *Stormwater Management Plan* describes the existing site characteristics, and corresponding stormwater quantity and quality management controls to be implemented during the operation phase of the development.

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Appendix B Legend Consultants Plan of Development (Ref: LC25079.C001.G)
Appendix C Legend Consultants Pre-Development Catchment Plan (Ref: LC25079.C401.B)
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1.0 INTRODUCTION

1.1 Background

Legend Consultants Pty Ltd has been appointed by Salt Development Projects to prepare a Stormwater Management Plan (SWMP) in support of a combined Development and Operational Works Application (COM) to the City of Gold Coast for the proposed Rural Subdivision located at 98 Glenmore Drive, Bonogin.

This report is based on updated development plans and maintains the site's Lawful Point of Discharge (LPOD) to Bonogin Creek

The development site is described as Lot 1 on RP218875 and has a total site area of 12.352ha.

1.2 Scope of Report

This SWMP describes the planning, layout and strategy of the stormwater management infrastructure for the construction and operational stages of the proposed development.

This SWMP endeavours to:

- Determine the necessary criteria assessing both the existing and proposed stormwater quantity and quality enhancement systems.
- Present the design of the stormwater infrastructure including stormwater quality enhancement devices and stormwater quantity management controls.
- Establish the modelled post-development stormwater quality flowing from the site does not negatively affect the water quality and ecological values of downstream watercourses and systems.
- Determine that stormwater runoff is transmitted through the site to a Lawful Point of Discharge (LPOD) in accordance with the Queensland Urban Drainage Manual (QUDM), and
- Provide reporting and monitoring procedures to ensure the execution of the proposed system can be evaluated to enable detection of corrective actions/modifications required to ensure the intended objectives are upheld.

This SWMP has been compiled in accordance with the IEAust *Australian Runoff Quality: Guide to Water Sensitive Urban Design, Queensland State Planning Policy 2017*, IPWEA *Queensland Urban Drainage Manual (QUDM) Fourth Edition (2017)* and City of Gold Coast (CoGC), SC6.11 City Plan Policy – Land Development Guidelines*)*.

2.0 SITE DESCRIPTION

2.1 Site Location

The relevant site is located at 98 Glenmore Drive, Bonogin. The site fronts Glenmore Drive to the west, Bonogin Creek to the east, and rural residential lots to the south and north. The site includes a total combined area of 12.352ha, with details as provided in Table 1 and as per the locality shown in Figure 1.

Table 1: Site Description

Client	Lot and Property Description	Street Address
Salt Development Projects	*Lot 1 on RP218875*	*98 Glenmore Drive, Bonogin*

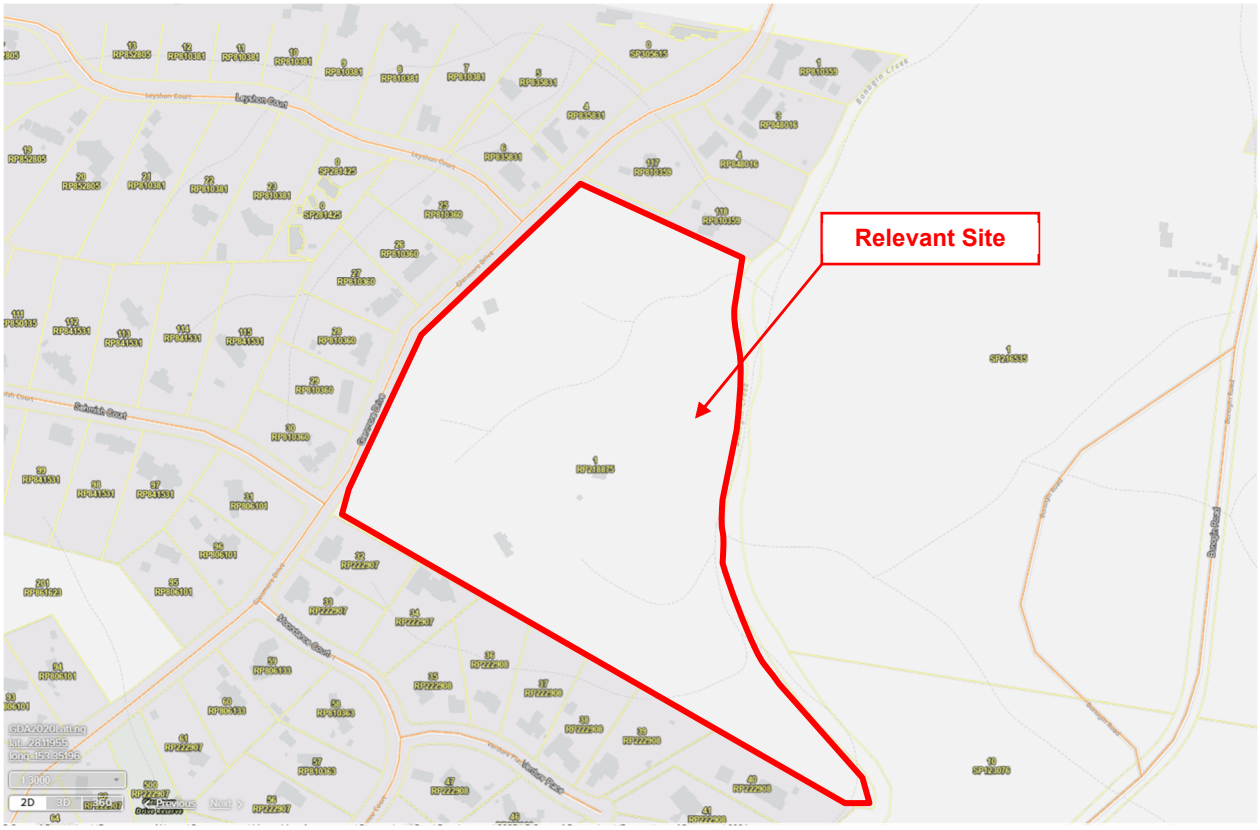


Figure 1: Locality Plan (Source: Queensland Globe)

2.2 Site Characteristics

The existing site generally grades from southwest to northeast steep with spot heights ranging from approximately RL 68.0m AHD to RL 22.5m AHD. The site generally slopes towards the Bonogin Creek that forms the eastern boundary of the site. Based on the provided survey and aerial information, any stormwater runoff from ground surfaces drains overland to the existing Lawful Point of Discharge (LPOD) in the northeast area of the site.

Further information of the site survey has been provided by Andrews & Hansen Topographic Survey (Ref: 181151-2A-270126) included as Appendix A.

2.3 Existing Vegetation and Use

The subject site presently comprises three existing dwellings and associated buildings with informal driveways. This site is covered by primarily by bush and scattered trees with open areas being grassed. Access for the site is obtained from the Glenmore Drive.

An aerial image taken on the 17 Nov 2025 of the subject site is included in Figure 2.

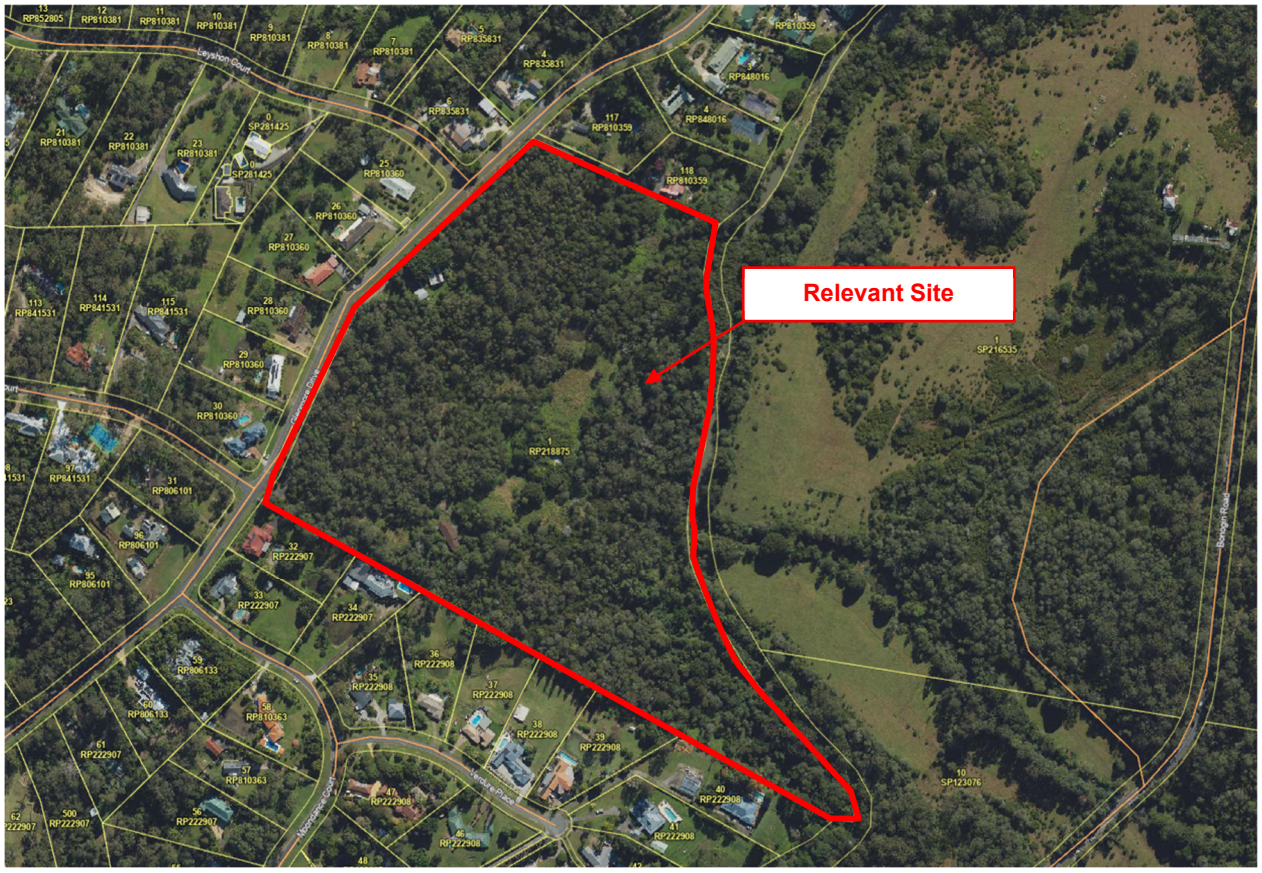


Figure 2: Aerial Image of the Site (Source: MetroMap)

2.4 Proposed Development

The proposed development for the site consists of a 17-lot rural residential subdivision, associated driveways, footpaths, internal road and landscaped grounds. The proposed development at time of writing this report has provided a detail landscaping plan with adequate landscaping footprints as per Council's requirements.

Access to the site is gained via a new internal road connection to Glenmore Drive along the western boundary. This proposed new road will connect to individual residential lots and private driveways constructed to IPWEA standards.

Refer to Appendix B for further architectural details prepared by Legend Consultants Plan of Development (Ref: LC25079.C001.G) included in Appendix B.

2.5 Proposed Drainage Concept

It is proposed that each residential lot will provide with a 5 kL rainwater tank to capture and store roof runoff. Overflow from the rainwater tanks will be conveyed via the proposed stormwater pipe network for lots 7, 8, 9, 10 and 17, while lots 1 to 6, and 11 through 16 will be discharged through level spreaders to promote sheet flow and minimise the potential for downstream erosion.

It is also proposed that runoff from the proposed internal road network will be collected by the underground stormwater drainage system and conveyed through a proposed Enviro Filter Stormwater Quality Improvement Device (SQID) for stormwater quality treatment. The treated runoff will then be conveyed to a combined underground detention tank designed to attenuate post-development peak flows for all events to pre-development levels prior to discharge to the site's lawful point of discharge (LPOD).

2.6 Rainfall Data

Rainfall intensity data has been acquired from the Australian Bureau of Meteorology's 2016 Design IFD Rainfall System. The data has been obtained for the nearest grid cell at Latitude 28.112 (S) and Longitude 153.362 (E). The IFD data and average rainfall intensities utilized in this report are in accordance with the techniques outlined in Geosciences Australia, Australian Rainfall and Runoff 2019.

3.0 STANDARDS AND DATA REFERENCES

The following provides the data references which have been utilised in order to prepare this report for the site:

- Detailed site survey provided by Andrews & Hansen Topographic Survey (Ref: 181151-2A-270126) included as Appendix A.
- Proposed site plan provided by Legend Consultants Plan of Development (Ref: LC25079.C001.G).
- LIDAR data for the development site obtained from Australian Government Elevation and Depth Foundation Spatial Data (ELVIS), Date Source: 2014, DEM Data.
- Rainfall and Meteorological 2016 IFD Data by the Australian Bureau of Meteorology.
- Information Extracted from CoGC Infrastructure Assets Mapping.
- Aerial photography from Queensland Global (Accessed on 24 March 2026), and
- MUSIC data sourced from Rainfall Station 40606 (UPPER MUDGEERABA WATER).

4.0 SITE HYDROLOGY

4.1 Background

The subsequent segments of this report delineate the approach and parameters employed in the hydrological analysis of the site, aiming to create a simulation of the expected flow patterns and maximum discharge at the Lawful Point of Discharge (LPOD). Additionally, a Rational Method calculation is presented for comparative analysis.

The Rational Method, as outlined in Section 4.3 of the Queensland Urban Drainage Manual (QUDM 2017), proves to be a suitable estimation technique due to its flexibility in data requirements. It is capable of generating reliable estimates for peak site discharges with the following data inputs:

- specific intensity frequency duration (IFD) data.
- length/type of flow path.
- contributing catchment areas, and
- coefficient of discharge.

4.2 Pre-Development

4.2.1 Lawful Point of Discharge and Defined Catchments

The analysis of the pre-development site has been conducted as a single internal catchment, with a contributing area measuring 12.352ha. Any stormwater on ground surfaces is conveyed as sheet flow through the development site towards to the northeast corner boundary discharged to the existing LPOD.

The existing LPOD for the development site (for analysis in accordance with QUDM), is the existing overland flow adjacent to the northeast corner of the site.

The catchment area and LPOD for the development site are shown on Legend Consultants Pre-Development Catchment Plan (Ref: LC25079.C401.B) included as Appendix C.

4.2.2 Coefficient of Discharge

The pre-development coefficient of runoff (C year) was calculated using the fraction impervious method outlined in QUDM. According to the survey data, the pre-development catchment features impervious surfaces covering 0.247 hectares, resulting in a fraction impervious (fi) of 2%. With a one-hour, ten-year rainfall intensity (1I10) set at 70 mm/hr, the pre-development catchment adopts a C10 value of 0.70.

The pre-development coefficients of runoff, as presented in Table 2, have been selected in alignment with QUDM Table 4.5.2. These coefficients correspond to the frequency factors associated with standard Annual Exceedance Probability (AEP)

design storms at 63%, 39%, 18%, 10%, 5%, 2%, and 1%. These percentages correspond to the 1, 2, 5, 10, 20, 50, and 100-year Average Recurrence Interval (ARI) storms, respectively.

Table 2: Pre-Development Coefficient of Discharge

Catchment	C1	C2	C5	C10	C20	C50	C100
Pre	0.56	0.60	0.67	0.700	0.74	0.81	0.84

4.2.3 Time of Concentration

The Time Of Concentration for the predevelopment catchments has been calculated in accordance with QUDM Table 4.6.4 – Recommended maximum length of overland sheet flow and Table 4.6.5 – Surface roughness or retardance factors. The pre-development catchment will have a time of concentration that will incorporate 20.26minutes as overland flow.

4.2.4 Design Discharge

Pre-development peak flow rates for the selected storms have been calculated utilizing design rainfall intensities sourced from the Bureau of Meteorology IFD Data. The estimation of design peak flow rates for the pertinent site has been conducted using the Rational Method (Q = 2.78 x 10-3 CIA). The resulting pre-development peak flows for the development site are detailed in Table 3.

Table 3: Estimated Pre-Development Peak Discharges – Rational Method

Pre								
Annual Exceedance Probability	AEP	63%	39%	18%	10%	5%	2%	1%
Coefficient of Runoff	C	0.56	0.60	0.67	0.70	0.74	0.81	0.84
Area of Catchment (ha)	A	12.352	12.352	12.352	12.352	12.352	12.352	12.352
Average Rainfall Intensity (mm/h)	I	55	69	106	122	139	161	178
Peak Flow Rate (m^3/s)	**Q**	**1.049**	**1.401**	**2.427**	**2.937**	**3.511**	**4.450**	**5.132**

4.3 Post Development

4.3.1 Catchment Definition and Lawful Point of Discharge

The post-development scenario has been analysed a singular internal catchment similar to the pre-development scenario and has a contributing area of 12.352ha.

Stormwater collected from the roofs, carparks, driveway and ground areas shall be conveyed via an internal network of pits and stormwater pipes, sized to capture the major AEP events, and conveyed to the proposed quality treatment devices. The captured flows within the tank are connected to the site's LPOD.

The post development catchment area and LPOD are detailed on Legend Consultants Post Development Catchment Plan (Ref: LC25079.C402.B) and Music Catchment Plan (Ref: LC25079.C403.B) included as Appendix D.

4.3.2 Coefficient of Discharge

The post-development coefficients of runoff (C year) were established through the application of the fraction impervious method, as stipulated in QUDM.

According to the provided architectural plans, the Post 01 catchment encompasses roughly 0.865 ha of impervious surfaces, resulting in a fraction impervious (fi) of 11%. With a one-hour, ten-year rainfall intensity (1I10) set at 70 mm/hr, the post-development catchment adopts a C10 value of 0.7.

The post-development coefficients of runoff, as indicated in Table 4, have been selected in accordance with QUDM Table 4.5.2. These coefficients align with the frequency factors associated with standard Annual Exceedance Probability (AEP) design storms at 63%, 39%, 18%, 10%, 5%, 2%, and 1%. These percentages correspond to the 1, 2, 5, 10, 20, 50, and 100-year Average Recurrence Interval (ARI) storms, respectively.

Table 4: Post Development Coefficient of Discharge

Catchment	C1	C2	C5	C10	C20	C50	C100
Post	0.56	0.60	0.67	0.70	0.74	0.81	0.84

4.3.3 Time of Concentration

The Time Of Concentration for the post development catchments has been calculated in accordance with QUDM Table 4.6.4 – Recommended maximum length of overland sheet flow and Table 4.6.5 – Surface roughness or retardance factors. The post-development catchment will have a time of concentration that will incorporate 11.40minutes as overland flow.

4.3.4 Design Discharge

Post-development peak flow rates have been computed for the selected storms by utilizing design rainfall intensities obtained from the Bureau of Meteorology 2016 IFD Data. The Rational Method (Q = 2.78 x 10-3 CIA) has been employed to estimate the necessary design peak flow rates for the respective site. The resulting post-development peak flows for the development site are outlined in Table 5.

Table 5: Estimated Post Development Peak Discharges – Rational Method

Post								
Annual Exceedance Probability	AEP	63%	39%	18%	10%	5%	2%	1%
Coefficient of Runoff	C	0.56	0.60	0.67	0.70	0.74	0.81	0.84
Area of Catchment (ha)	A	12.352	12.352	12.352	12.352	12.352	12.352	12.352
Average Rainfall Intensity (mm/h)	I	72	90	140	160	183	212	234
Peak Flow Rate (m^3/s)	**Q**	**1.383**	**1.832**	**3.285**	**3.854**	**4.623**	**5.854**	**6.739**

4.4 Change in Discharge

The variance in peak flow rates, computed for the entire pre and post-developed site, has been assessed using The Rational Method. The outcomes are given in Table 6.

Table 6: Estimated Change in Peak Discharges– Rational Method at LPOD

Annual Exceedance Probability	AEP	63%	39%	18%	10%	5%	2%	1%
Pre-Developed Peak Flow Rate (m^3/s)	Q	1.049	1.401	2.427	2.937	3.511	4.450	5.132
Post-Developed Peak Flow Rate (m^3/s)	Q	1.383	1.832	3.285	3.854	4.623	5.854	6.739
Change in Peak Flow Rate (m^3/s)	**Q**	**+0.334**	**+0.431**	**+0.858**	**+0.917**	**+1.112**	**+1.404**	**+1.607**

As demonstrated in Section 4.2 and Section 4.3 and Table 6, due to the increase of impervious area, discharged peak flow rate at LPOD is higher than the existing condition. On-site detention measures will be required for this LPOD of the development.

4.5 External Catchments

The subject site and the surrounding area were examined to determine if any localised external catchments will contribute to the subject site. The site is deemed to not contain any influencing localised external catchments for the following reasons.

To the west of the site along Sehmish Court the contours along Sehmish Court indicate flows along Sehmish Court in the direction of the site. However, at the eastern end of Sehmish Court immediately before the intersection with Glenmore Drive there is a series of four large gully pits (two either side of the road). Refer Figure 3.

In conjunction with the gully pits, Sehmish Court contains a sag in the longitudinal alignment before the intersection with Glenmore Drive. The sag grades laterally to the west resulting in the remaining runoff at surface in Sehmish Court flowing north across Sehmish Court and north down the western side of Glenmore Drive. Flows from Sehmish Court do not discharge into the subject site.

Glenmore Drive along the site frontage drains to the northwest outside the western boundary of the site.

At the southern boundary of the site there is a ridge line resulting in external runoff to the south discharging away from the southern boundary due to the existing topographical watershed formation along the southern boundary. Please also refer to plan LC25079.C402 which provides the site and surrounding areas contours and flow directions following both survey and site inspections.

There is an area of inflow to the subject site at the eastern area of the site in proposed lot 11, however where this external catchment inflow is located no development works are proposed and no alteration to the overland flow from the external catchment will occur.



Figure 3: Sehmish Court Gully Pits and Intersection with Glenmore Drive

5.0 STORMWATER QUANTITY ASSESSMENT

5.1 Background

The land development is anticipated to augment peak flow rates originating from the development site, primarily attributed to the expansion of impervious areas and a decrease in the surface roughness of the site. Consequently, the forthcoming section of this report offers initial particulars about a proposed On-Site Detention (OSD) system. The purpose is to illustrate that there will be no escalation in nuisance flows and adverse impacts, stemming from potential increased post-development runoff. This demonstration aims to address concerns related to neighbouring properties, downstream waterways, and the stormwater infrastructure of relevant authorities.

5.2 Objective

Aligned with the stipulations of City of Gold Coast and typical industry-standard practices, the subsequent objective has been established for the post-development stormwater discharge from the site:

- Ensure there is no net increase in peak flows originating from the development site for all events up to the 1% Annual Exceedance Probability (AEP) design storm event in the post-developed condition.

To verify this objective, a suitable hydrologic and hydraulic modelling package will be employed. This demonstration will involve the containment of site runoff from the development site within the proposed buried detention tank.

5.3 Hydraulic Model

A calculation of the necessary detention volume to counteract any rise in total site discharge rates has been conducted using the DRAINS software program, in adherence to the Australian Rainfall and Runoff 2019 (ARR 2019) Guideline.

At the preliminary planning stage, a DRAINS model has been employed to ensure a more confident estimation of the detention volume. Given that finished site levels are preliminary but grounded in topographic site survey data, this initial calculation serves as an estimate with sufficient accuracy to advance the design confidently.

The model was formulated by simulating the layouts of the pre-development, post-development, and mitigated catchments, comparing the peak flow rates generated from each scenario. The mitigated catchment encompasses the 1% Annual Exceedance Probability (AEP) runoff from the entire site, encompassing roofs, ground areas, and driveways. This configuration ensures ample mitigation to demonstrate that there is no increase in peak flow rates exiting the site compared to the pre-development scenario.

It is important to highlight that the design of roof gutters and the site drainage system aims to channel the significant 1% Annual Exceedance Probability (AEP) event into the detention tanks.

A comprehensive analysis was conducted for a variety of storm events, extending up to the 1% AEP design storm event, covering standard durations ranging from 5 minutes

to 360 minutes. The DRAINS model was utilized to calculate the combined peak discharge rates for the site in both scenarios. The results are presented in Table 7.

The pre and post-development catchment area and LPOD are detailed on Legend Consultants Pre-Development Catchment Plan (Ref: LC25079.C401.B) and on Legend Consultants Post Development Catchment Plan (Ref: LC25079.C402.B) and Music Catchment Plan (Ref: LC25079.C403.B) included respectively as Appendices C and D.

The Q100 Rational Method calculation result was used as sanity check with DRAINS output and shown in Table 7.

Table 7: Peak discharge Rational method vs DRAINS Model (m³/s)

Catchment ID	Q100 Peak Flow Rate Discharge (m³/s)		
	Rational Method	DRAINS	Different (%)
Pre	5.132	4.620	-10.0
Post	6.739	5.970	-11.4

Table 8: Anticipated Peak Site Discharge Rate – Extracted from DRAINS Model (m³/s)

Annual Exceedance Probability	63%	39%	18%	10%	5%	2%	1%
Pre-Development Peak Flow Rate (m³/sec)	0.968	1.600	2.210	2.740	3.550	3.940	4.620
Unmitigated Peak Flow Rate (m³/sec)	1.390	1.820	2.970	3.640	4.480	5.340	5.970
Change in Peak Flow Rate (m³/s)	+0.422	+0.220	+0.760	+0.900	+0.930	+1.400	+1.350

The DRAINS assessment for the proposed development indicates an anticipated increase in peak flow rates discharging from the site. Consequently, the implementation of On-Site Detention (OSDs) is considered necessary to mitigate flows and maintain conditions comparable to pre-development levels.

5.4 Detention Volume

It is proposed that each lot will be provide a 5 kL rainwater tank to capture and store roof runoff. In addition, five (5) Atlan detention tanks (50 m² × 1.46 m) are proposed to capture runoff from the internal road and driveway areas of five lots.

The following detention storage parameters were adopted to achieve the target pre-development flow rates by mitigating the post-development peak flows. The detention storage parameters and low flow, high flow configurations are presented in Table 9 and Table 10.

Table 9: Rainwater Tanks Parameters

Rainwater tank	Parameters
Low Flow (@0.0m of Storage Depth)	60mm Ø Orifice
High Flow (@1.66m of Storage Depth)	150mm Ø Orifice

Table 10: Adopted Atlan Detention Tanks Parameters

Detention tank	Parameters
Low Flow (@0.0m of Storage Depth)	Orifice: 800mm(W)x200mm(H)
High flow weir (@1.26m of Storage Depth)	1.8m length
Minimum Detention Volume required:	73m^3

The 1%AEP 10-minute - temporal pattern number 07 design storm was determined as the critical storm duration for determining the required volume within the detention tanks. A comparison of the pre-development and mitigated flow rates based on the arrangement as shown in Table 11.

Table 11: Comparison of Pre-Development and Mitigated Flow Rates – Extracted from DRAINS

Annual Exceedance Probability	63%	39%	18%	10%	5%	2%	1%
Pre-Development Peak Flow Rate (m^3/sec)	0.968	1.600	2.210	2.740	3.550	3.940	4.620
Mitigated Peak Flow Rate (m^3/sec)	0.915	1.440	2.200	2.510	3.300	3.870	4.520
Change in Peak Flow Rate (m3/s)	-0.053	-0.160	-0.010	-0.230	-0.250	-0.070	-0.100

As evident from the outcomes presented in Table 11, the detention configuration is observed to proficiently alleviate the post-development flows during the critical design storm Annual Exceedance Probability (AEP) events that have been adopted.

The hydraulic analysis using the DRAINS model has determined that a minimum total detention volume of 73 m³ is required to attenuate runoff from the proposed internal road network. In addition, each residential lot will be provided with a 5 kL rainwater tank to capture and store roof runoff. The detention tank is to be fitted with an outlet pipe configuration (low and high flow outlets) as detailed in Table 9 and table 10 to satisfy the mitigation requirements. Refer to the Legend Consultants Stormwater Management Plan (Ref: LC25079.C404.B) and Tank Details (Ref: LC25079.C405.B) provided in Appendix E for details of the tank's arrangement and indicative location.

The final location onsite and construction levels will be determined at the detailed design stage.

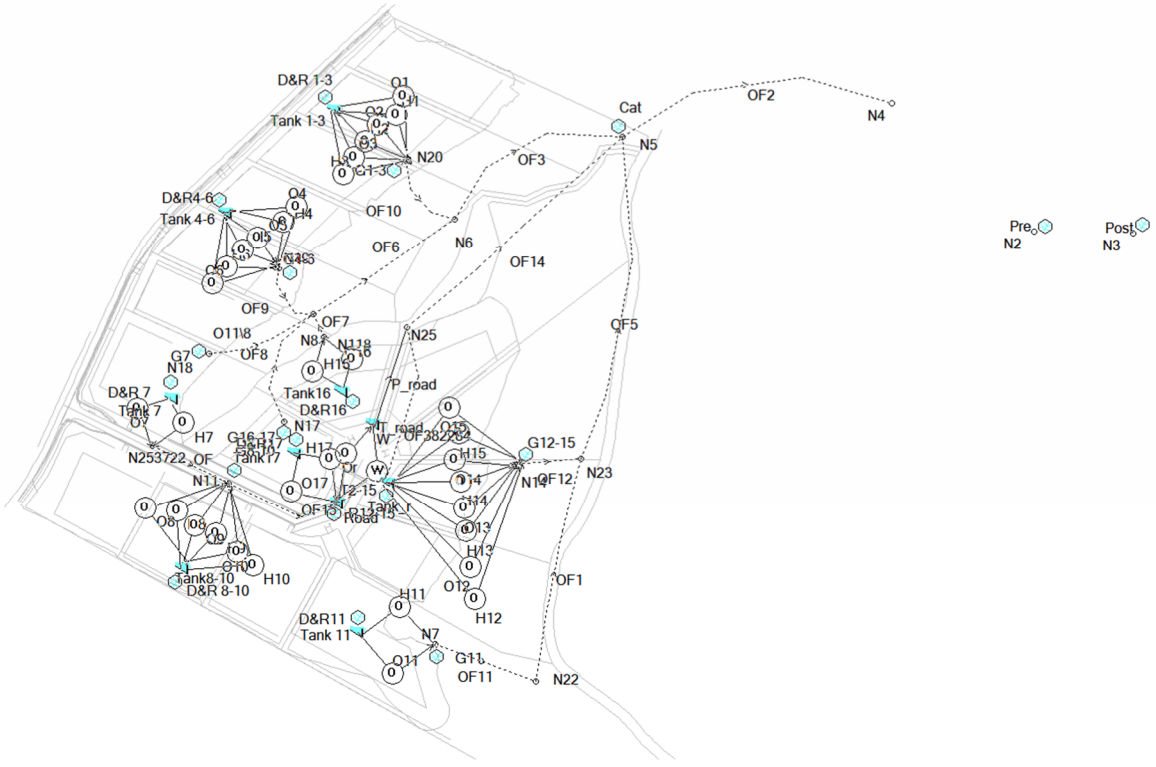


Figure 4: DRAINS Model

A copy of DRAINS model used in this report can be made available to council upon request.

6.0 STORMWATER QUALITY ASSESSMENT

6.1 Background

The land development poses a risk of augmenting pollutant loads in stormwater runoff and downstream watercourses. Construction activities during the development phase could lead to notable disturbances to the existing ground, potentially causing a significant rise in sediment loads entering downstream drainage systems and watercourses. Moreover, the operational phase of the development may potentially contribute to an increase in the amounts of sediments and nutrients washing from the site.

The subsequent sections describe the construction and operational phase controls and water quality modelling of the proposed treatment train in compliance with Council guidelines.

6.2 Construction Phase

The construction phase of the site poses a significant risk of stormwater pollution primarily due to erosion and the transport of sediment off-site into the receiving environment. This heightened risk is mainly attributed to construction activities that disturb the site, leading to exposed areas of soil vulnerable to the erosive effects of the environment.

The subsequent section of this report delineates the procedures essential for minimizing erosion and effectively controlling sediment during construction, adhering to the guidelines outlined in the International Erosion Control Association (IECA) Best Practice ESC Document.

6.2.1 Main Contaminants

The main contaminants have been identified for the Construction Phase of the development.

Table 12: Key Pollutants, Construction Phase

Pollutant	Sources
Litter	Paper, construction packaging, food packaging, cement bags, material offcuts.
Sediment	Exposed soils and stockpiles during earthworks and building works.
Hydrocarbons	Fuel and oil spills, leaks from construction equipment and temporary car park areas.
Toxic Materials	Cement slurry, asphalt primer, solvents, cleaning agents, and wash waters (e.g., from tile works).
Acids or Alkaline substances	Acid sulphate soils, cement slurry and wash waters.

6.2.2 Erosion and Sediment Controls

Erosion and Sediment Control (ESC) devices implemented on the site will be designed and constructed following the guidelines outlined in the International Erosion Control Association (IECA) Best Practice ESC Document, as indicated in Legend Consultants Erosion and Sediment Control Plan (Ref: LC25079.C250.B) included as Appendix F.

Prior to Construction

- Implement a stabilized access/exit onto Local internal road to the west.
- Install sediment fences around the perimeter of the site.
- Install a sediment trap on the western part of the site.
- If necessary, install dust fencing.
- Conduct education sessions for site personnel to ensure understanding and adherence to the Erosion and Sediment Control Plan requirements.

Start of Construction

- Ensure the maintenance of construction access/exit points, sediment fencing, dust fences, and all other existing controls as needed.
- Build diversion drains to channel runoff from disturbed areas to temporary sediment traps.
- Confine construction activities to specific stages to minimize the extent of disturbance at any given time.

During Construction

- Ensure ongoing maintenance of construction access/exit, sediment fencing, dust fences, diversion drain, and all other necessary existing controls.
- Implement progressive revegetation of completed areas where applicable.
- Divert runoff from undisturbed areas around disturbed zones.
- Provide protection for drainage structures such as field inlets and gully pits.

During the construction phase, all sections with exposed soils that may lead to dust generation must undergo appropriate treatment. These treatments involve soil covering and watering. Regular cleaning of road accesses is imperative to prevent soil transmission on vehicle wheels and eliminate the accumulation of common road dirt and tire dust from delivery vehicles.

Furthermore, it is essential to establish and maintain adequate waste disposal facilities on the site to handle all types of waste materials, including litter, hydrocarbons, toxic substances, as well as acids or alkaline substances.

6.2.3 Water Quality Monitoring and Inspections

In order to verify compliance with water quality objectives throughout the construction phase, water quality monitoring is mandatory. This monitoring process will involve the use of a calibrated probe or sampling and subsequent testing at a laboratory registered with the National Association of Testing Authorities (NATA).

Location: LPOD as shown on Legend Consultants Pty Ltd, *Erosion and Sediment Control Plan* (Ref: LC5079.C250.A).

Parameters: Site discharge criteria.

Frequency: Following at least 30 mm of rainfall in a 24-hour period.

The contractor assumes responsibility for inspecting and maintaining all erosion and sediment control devices. In response to the findings from the monitoring program mentioned earlier, the contractor must implement additional controls and review existing ones as necessary.

6.2.4 Reporting

After each water quality monitoring session, a written inspection report must be prepared by a suitably qualified and experienced scientist/engineer. The report should include the following details:

- Inspector Name, development site address, and real property description.
- Council file reference number (if available).
- Locations of Monitoring points.
- Performance requirements.
- Results for each monitoring location, highlighting any violations of performance requirements.
- Proposed corrective actions and additional erosion and sediment controls, where necessary.
- These inspection reports must be provided to the contractor for their review and compilation in an on-site register.

If the contamination limits are exceeded and downstream monitoring stations indicate substantial worsening from upstream results (where applicable), the contractor must implement all recommendations from the inspection report within one (1) working day of receiving the report.

6.3 Operational Phase

The subsequent sections offer detailed information regarding the proposed Stormwater Quality Improvement Devices (SQIDs) for the operational phase of the development. Legend Consultants Stormwater Management Plan (Ref: LC25079.C404.B) and Tank Details (Ref: LC25079.C405.B) in Appendix E provides the locality and extent of the proposed SQID's.

6.3.1 Stormwater Quality Objectives

In accordance with the City Plan Policy – Land Development Guidelines, the proposed development has been assessed against the stormwater quality management criteria applicable to rural residential development. As the total impervious area is approximately 11%, stormwater quality treatment is only required for runoff generated from the proposed internal road network. Runoff from residential roof areas will be managed separately through individual 5 kL rainwater tanks, with controlled overflows discharged via level spreaders. Consequently, the MUSIC model has been developed to assess and demonstrate compliance for the internal road drainage system only.

The Stormwater Quality and Flow management Guideline provide a framework to ensure development for urban purposes with Gold Coast Council helps to achieve the outcomes of the State Planning Policy 4/10 and the Southeast Queensland Regional Plan 2009-2031 (SEQ Regional Plan).

Best Management Practices (BMPs) are mandated for demonstration in all Development Applications within the Gold Coast Council, and developers are encouraged to implement them. Whenever feasible, the incorporation of methods such as first flush devices and directing stormwater to landscaped/grassed areas before discharge to the LPOD should be integrated into the site's stormwater strategy, provided the opportunity exists.

When evaluating the post-development treatment train (comparing the unmitigated developed case versus the developed mitigated case), the following load reduction targets must be achieved:

- 80% reduction in Total Suspended Sediment (TSS)
- 60% reduction in Total Phosphorus (TP)
- 45% reduction in Total Nitrogen (TN)
- 90% reduction in litter (sized 5 mm or greater)

6.3.2 Post Development MUSIC Modelling

To evaluate the expected quantities of pollutants discharged from the site, the water quality modelling package 'Model for Urban Stormwater Improvement Conceptualization' (MUSIC) V6.3 by eWATER has been employed. Parameters for MUSIC modelling and delineated data have been obtained from Water by Design, MUSIC Modelling Guidelines, and, whenever feasible, through online MUSIC Link data.

Rainfall data has been acquired from Rainfall Station 40606 (UPPER MUDGEERABA WATER) within the date range from 2000 to 2009 utilizing a 6-minute time step, as per the specified requirements of City of Gold Coast. The rainfall runoff parameters are presented in Table 13.

Table 13: Rainfall Runoff Parameters

PARAMETER	SOURCE NODES
Land use	Urban Residential
Rainfall threshold (mm)	1
Soil storage capacity (mm)	500
Initial storage (% capacity)	10
Field capacity (mm)	200
Infiltration capacity coefficient a	211
Infiltration capacity coefficient b	5.0
Initial depth (mm)	50
Daily recharge rate (%)	28
Daily baseflow rate (%)	27
Daily deep seepage rate (%)	0

The adopted MUSIC catchment areas for the development site are as provided in Table 13.

Table 14: Adopted MUSIC Catchment Areas

Catchment	Area (ha)	% Impervious
Road 1	0.427	60
Road 2	0.086	60

The pollution source node parameters were adopted as recommendation of MUSIC modelling Guideline.

Table 15: Pollutant Export Parameters

LAND USE	FLOW TYPE	TSS (LOG10 MG/L)		TP (LOG10 MG/L)		TN (LOG10 MG/L)	
		MEAN	ST. DEV.	MEAN	ST. DEV.	ST. DEV.	MEAN
Ground	Baseflow	1.00	0.34	-0.97	0.31	0.20	0.20
	Stormflow	2.18	0.39	-0.47	0.31	0.26	0.23
Road	Baseflow	1.00	0.34	-0.97	0.31	0.20	0.20
	Stormflow	2.43	0.39	-0.30	0.31	0.26	0.23
Roof	Baseflow	N/A	N/A	N/A	N/A	N/A	N/A
	Stormflow	1.30	0.39	-0.89	0.31	0.26	0.23

6.3.3 *Stormwater Quality Improvement Devices*

The Enviro H-SERIES filter chamber is recommended for low impact catchments such as residential estates, and commercial and industrial activities are carried out. The unique single chamber and multi zone function design reduce size and cost.

Enviro filter chambers - Stormwater Quality Improvement Devices (SQID) – will be utilised to treat stormwater runoff from the site as it is deemed more suitable for the

proposed site use. The Enviro Filter H45 will be installed to treat stormwater flow internal road.

The proposed SQIDs have been provided for modelling purposes only and are subject to council approval. Accordingly, similar alternative devices may be adopted with council review and approval.

Runoff generated from the road/driveways will be collected by grated inlets and stormwater pipes and discharged to the Enviro Filter Chambers.

An illustration of the MUSIC model of the adopted operational treatment train for the post-development site has been provided in Figure 5.

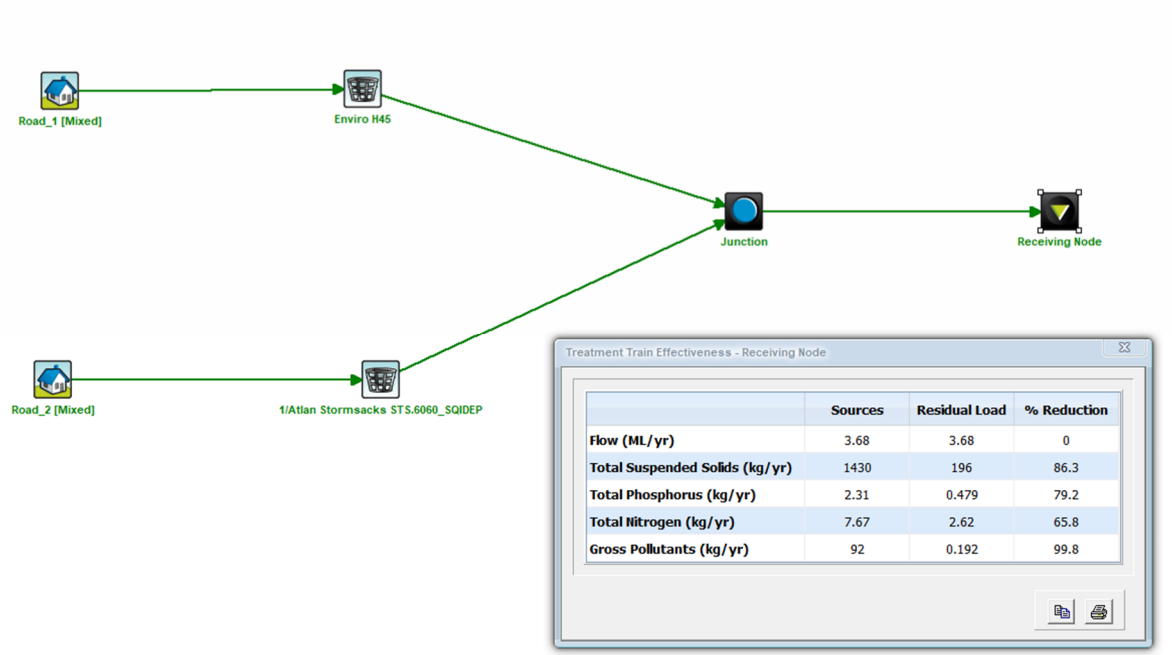


Figure 5: Operational Phase Treatment Train

6.3.4 *Design Parameters of the Stormwater Quality Improvement System*

The intricate design of the stormwater treatment train will adhere to the specifications outlined in the Water Sensitive Urban Design (WSUD), Technical Design Guidelines for South-East Queensland – Version 1 (June 2006).

Enviro Filter Chambers

According to the H-Series Technical Summary, it is proposed that the site will need install: Chamber model H45 which has the total flow rate of 66L/s to provide enough capacity to treat the Q3-month standard. For details of the proposed H45, refer to Appendix G *Enviro Technical Manual Version 5 and H-series Technical Summary*.

6.3.5 Post Development Modelling Results - Mitigated

The modelled Stormwater Quality Improvement Devices (SQIDs) have proven effective in reducing the discharge of sediments and nutrients from the proposed residential development. Table 16 provides a visual representation of the effectiveness of the SQIDs within the treatment train for the development.

Table 16: Treatment Train Effectiveness at Receiving Node

Parameter	Post	Post Mitigated	Reduction Achieved	Water Quality Objectives
Flow (ML/yr)	3.68	3.68	**3.6**	-
TSS (kg/yr)	1,430	196	**86.3**	80 %
TP (kg/yr)	2.31	0.479	**79.2**	60 %
TN (kg/yr)	7.67	2.62	**65.8**	45 %
Gross Pollutants (kg/yr)	92	0.192	**99.8**	90 %

The outcomes reveal that the proposed Stormwater Quality Improvement Devices (SQIDs) successfully meet the targeted Water Quality Objectives for Gross Pollutants, Suspended Solids, Phosphorous, and Nitrogen levels, aligning with the requirements set forth by the City of Gold Coast.

7.0 OPERATIONAL PHASE MAINTENANCE REQUIREMENTS

The proposed stormwater management devices will necessitate regular maintenance and monitoring to ensure they operate as intended. The following section outlines the essential maintenance tasks for the proposed devices.

7.1 Enviro H Filter Chamber

Standard Inspection

Standard inspections are conducted at regular four-month intervals. At this time, an approved trained maintenance officer or Enviro H representative shall undertake all measures outlined in Maintenance Procedure, Standard Inspection.

General Cleaning

At the end of each standard inspection, trigger measures will identify if general cleaning is required. General cleaning will need to be executed immediate during standard inspections if the follow triggers are satisfied:

- Build-up of debris/pollutants within the chamber.
- Accumulation of debris/pollutants on the outlet chamber of the detention tank.
- After large storm events the flooding impacts at the request of the owner.

Filter Chamber Maintenance

Stormwater treatment is dependent on the effectiveness of the Enviro H filter chamber. As the filter chamber ages, pollutants will inundate the cartridge and ultimately reduce the treatment flow rate. At this point, inspection and maintenance of the filter chamber will be required to restore functionality.

Mechanical damage to the filter chamber may require replacement if the damage is affecting safety aspects or function of the filter chamber. Based on the [site] concept modelling (MUSIC) and previous industry experience, the filter chamber with proper maintenance is estimated to have an indefinite life span. As a minimum requirement, the filter chamber should be thoroughly maintained once a year.

8.0 ASSET MANAGEMENT TRANSFER

The proposed stormwater quality devices shall be dedicated to the owner/body corporate following the time of practical completion for the proposed development. An Asset Management Transfer Checklist is provided as Table 17 as a guideline for the necessary steps to be taken prior to the end of the maintenance period.

Table 17: Asset Management Transfer Checklist

Asset Location:		
Construction By:		
Maintenance Period:		
Treatment:	**Y**	**N**
Actual treatment performance equivalent to design:		
Maintenance:		
Maintenance Plans Provided:		
Inspection and maintenance undertaken as per maintenance plan:		
Inspection and maintenance forms provided:		
Asset inspected for defects:		
Asset Information:		
Design assessment checklist provided:		
As constructed plans provided:		
Copies of all permits provided:		
Digital files provided:		

9.0 CONCLUSIONS

Legend Consultants Pty Ltd, on behalf of Salt Development Projects, has undertaken the preparation of a Stormwater Management Plan (SWMP) to support a combined Development and Operational Works Application (COM) for the proposed Rural Residential Development at 98 Glenmore Drive, Bonogin. This SWMP establishes an optimized stormwater management system that aligns seamlessly with the intended site use.

The plan outlines the planning, layout, and design of the stormwater management infrastructure for both the construction and operational phases of the development, ensuring compliance with City of Gold Coast Land Development Guidelines.

Based on a hydrological analysis, it has been determined that the expected post-development peak flow rates from the site are increased compared to the pre-development rates. Consequently, on-site stormwater detention will be incorporated into the site design.

Legend Consultants Pty Ltd has embraced a Water Sensitive Urban Design (WSUD) approach, aligning with the State Planning Policy, to effectively manage stormwater runoff from the proposed development. This approach includes treatment of stormwater runoff from the internal road network through an Enviro Filter SQID. The SQID arrangement adopted in the MUSIC model is subject to Council approval and may be substituted with an equivalent approved treatment device during detailed design.

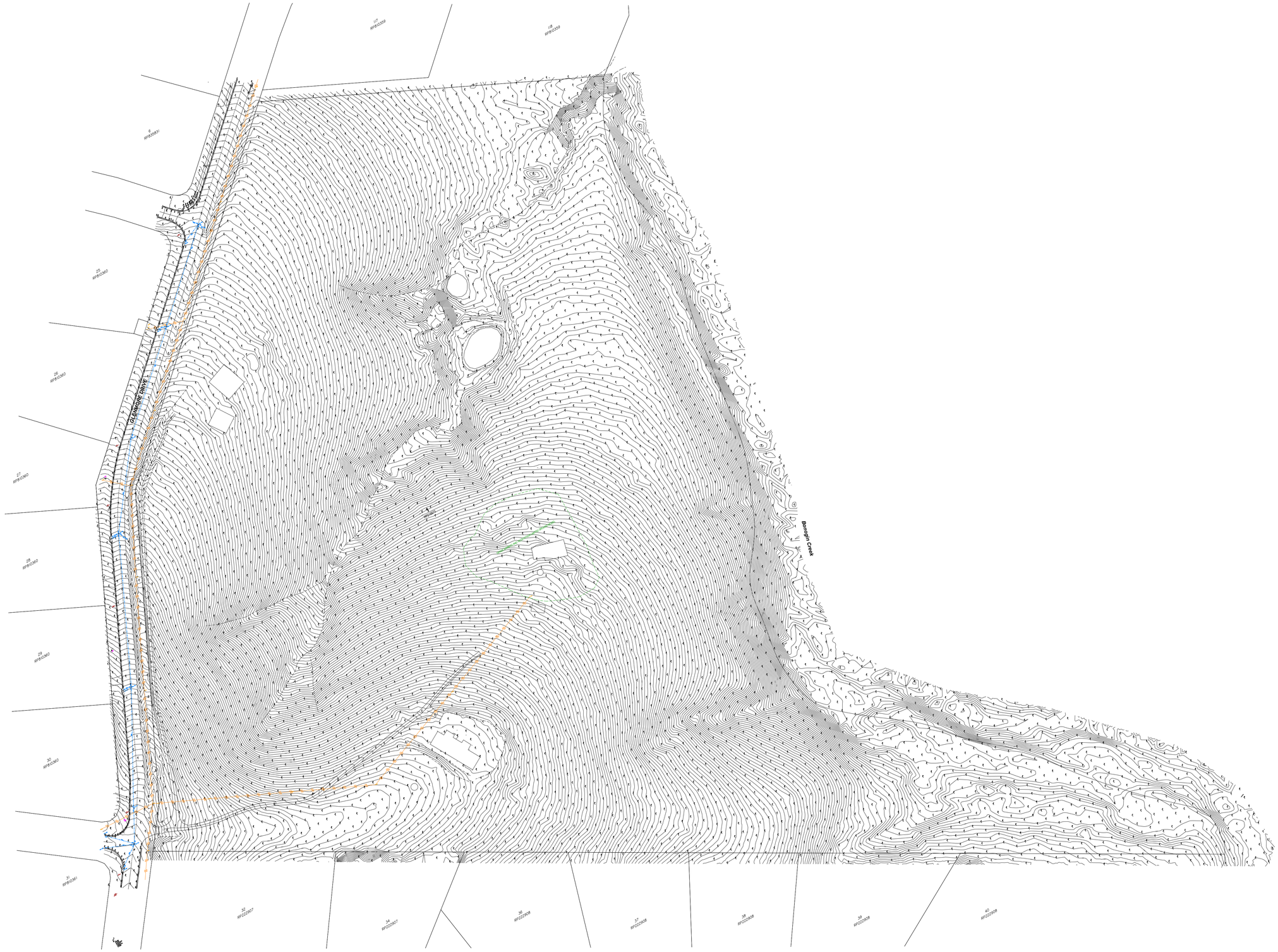
The SWMP includes a comprehensive monitoring and maintenance plan for the proposed infrastructure. Additionally, an erosion and sediment control plan has been outlined for the construction phase, with implementation responsibilities assigned to the contractor and developer.

This stormwater quality strategy has been formulated to fulfill the preliminary requirements and layout of the proposed development, ensuring compliance with the State Planning Policy 2017 and the Gold Coast City Council Planning Scheme's Stormwater Quality Management requirements.

APPENDIX

A

Andrews & Hansen Topographic Survey (Ref: 181151-2A-270126)



AH SURVEY PTY LTD
Consulting Surveyors
Head Office: 21/39 LAWRENCE DRIVE, NERANG QLD 4211
Correspondence: PO BOX 2130, NERANG DC QLD 4211
Phone: (07) 55962150 Fax: (07) 55960657
Email: admin@ahsurvey.com.au

TOPOGRAPHIC SURVEY
LOT 1 on RP218875
98 GLENMORE DRIVE
BONOGIN

Prepared for	SALT DEVELOPMENT PROJECTS		Scale 1 : 1000 @ A1
Vertical datum	AHD Derived OPM110581 RL69.429		
Locality	BONOGIN	Drawn by RP	Date 19/06/2026
Local Government	GOLD COAST CITY	Surveyed by RP	Drawing No. 181151 - 2 A

Notes : This plan is prepared for the client from a combination of Field Survey and existing records The survey has been carried out using techniques and to the scope of works as agreed between AH Survey Pty Ltd and the client at the time of instruction and not to be used by any other person or corporation or for any other purposes.

Information depicted on this plan is subject to the following limitations:

This survey has been completed with aerial LiDAR survey equipment and has been processed using industry-stand methods but is limited to:
- Vegetation, water surfaces, and reflective objects may reduce data reliability.
- Hidden or obstructed features may not be represented.
- While reasonable care has been taken, the accuracy of LiDAR-derived data is influenced by factors such as flight conditions, vegetation cover, ground reflectivity, GPS/IMU performance, and processing methodology. Localised variations in elevation and feature position may occur.
- Survey control has been completed by GNSS RTK observations.

The title boundaries as shown hereon have been derived from minimal connections to existing monuments and original plan dimensions. The positions shown have not been derived by a Cadastral Survey as defined under the Survey and Mapping Infrastructure Act and should not be interpreted as a boundary defined under that Act. Positions shown on this plan should not be relied upon for works on or near a boundary or for purposes of determining land tenure or position of features relative to it. Prior to any construction works on or near the boundary, an Identification Survey should be carried out which may result in changes to the boundary determination.

Any dimensions, grid lines, control lines, recovery marks and bench marks shown on this plan should be verified and confirmed by future contractors and any discrepancies be clarified in writing with the Surveyor prior to commencement of any future construction.

APPENDIX

B

Legend Consultants Plan of Development (Ref: LC25079.C001.G)



DEVELOPMENT SUMMARY

TOTAL SITE AREA:	12,354 ha
TOTAL LOTS:	17 LOTS
TOTAL AREA OF NEW ROAD	0,5150 ha
LENGTH OF NEW ROAD	230 metres
PARK RESERVE AREA :	0,4534 ha
NET DEVELOPMENT AREA :	11,3856 ha

LEGEND:

LOT NUMBER	LOT 16
LOT AREA	12261m²
BUILDING ENVELOPE AREA	BE 4296m²
BUILDING ENVELOPE	
ENVIRONMENTAL PROTECTION AREA	
FLOOD LEVEL CONTOUR	
PROPOSED BOUNDARY	
STORMWATER EASEMENT BOUNDARY	
NEW ROAD PAVEMENT	
EXISTING CADASTRAL	
WATERWAY CENTRELINE	

BUILDING ENVELOPE SETBACKS:

FRONT	6m
SIDE	3m
REAR	3m (OR ENVIRONMENTAL PROTECTION AREA LINE)

PRELIMINARY ISSUE
NOT FOR CONSTRUCTION

Legend Consultants
Efficiency • Innovation • Quality
16 ANDORRA PLACE, VARSITY LAKES, QLD, 4227

A1 THE SCALE SHOWN IS ORIGINAL DRAWING SCALE

REV	DATE	REVISION DETAILS	APPROVED
G	11.06.26	LAYOUT CHANGED	JW
F	30.03.26	EASEMENTS ADDED	JW
E	12.02.26	FOR SUBMISSION	JW
D	09.02.26	WITH BUSHFIRE AND BUILDING ENVELOPES	JW
C	04.02.26	BUFFER ADJUSTMENT	JW
B	03.02.26	LAYOUT AMENDED	JW
A	11.12.25	ORIGINAL ISSUE	JW

PROJECT
98 GLENMORE DRIVE, BONOGIN
PROPOSED RURAL
RESIDENTIAL DEVELOPMENT

DRAWN	TV
DESIGNED	TV
CHECKED	JW
APPROVED	JW
DATE	DEC 25
GRID REF.	AHD

CLIENT
SALT DEVELOPMENT
PROJECTS

TITLE
CONCEPT DEVELOPMENT
LAYOUT PLAN

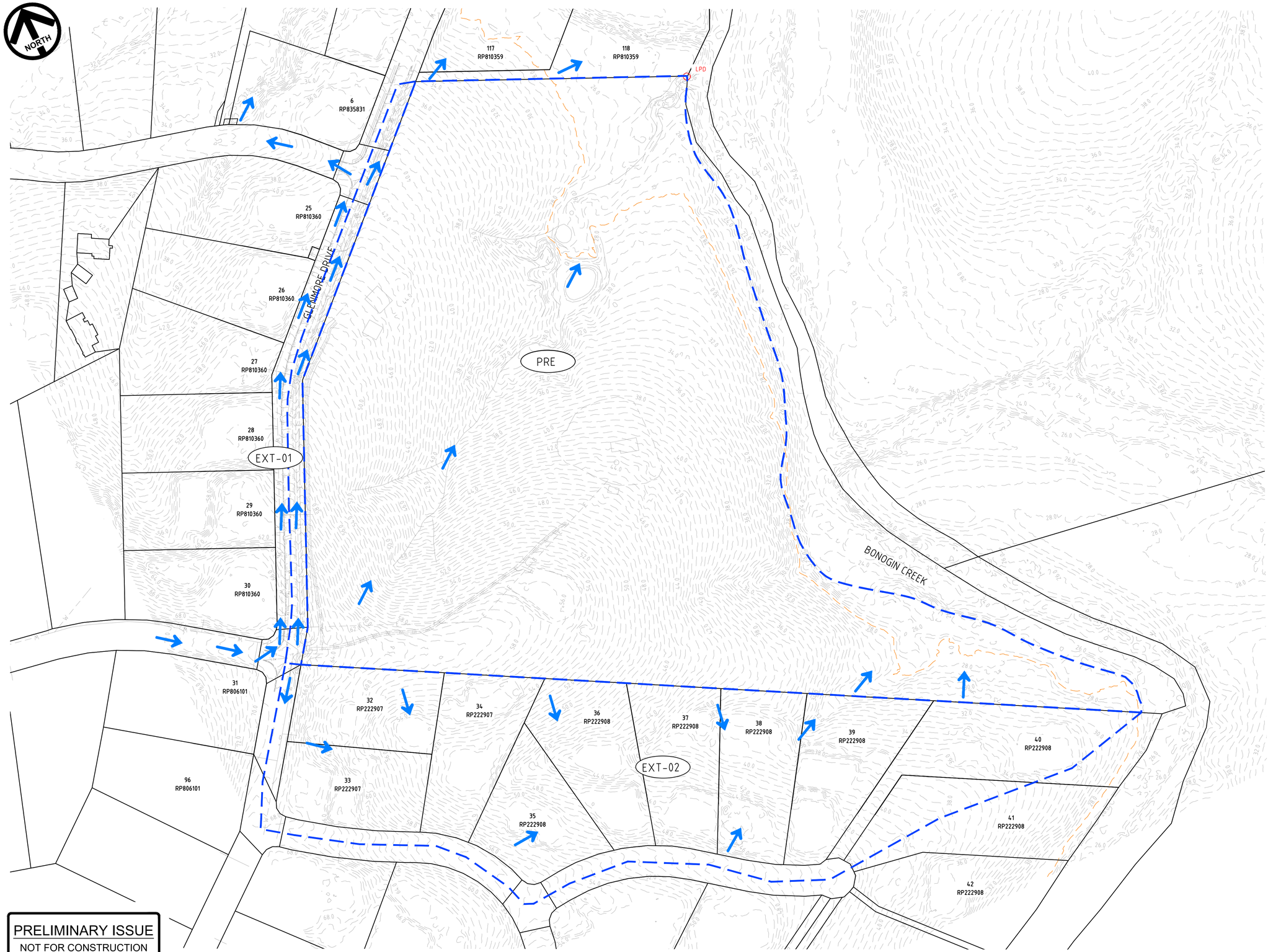
DRAWING NO. LC25079.C001

REV. G

APPENDIX

C

Legend Consultants Pre-Development Catchment Plan (Ref: LC25079.C401.B)



LEGEND:

- EXISTING CONTOUR (0.2m INTERVAL)
- CATCHMENT BOUNDARY
- EXISTING BUILDING
- EXISTING ROAD EDGE OF BITUMEN
- EXISTING KERB
- EXISTING GARDEN
- EXISTING ELECTRICITY
- EXISTING REGIONAL FLOOD EXTENT
- LEGAL POINT OF DISCHARGE
- LEGAL POINT OF DISCHARGE

CATCHMENT:

CATCHMENT	AREA (ha)
PRE	12.352
EXT-01	0.415
EXT-02	5.803

PRELIMINARY ISSUE
NOT FOR CONSTRUCTION

PRE DEVELOPMENT CATCHMENT PLAN

SCALE: 1:1250

1:1250 0 10 20 30 40 50m

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75 Barden Ridge Road, Reedy Creek, QLD 4227

REV	DATE	REVISION DETAILS	APPROVED
B	14.07.26	LAYOUT UPDATED	JW
A	27.03.26	ORIGINAL ISSUED	JW

A1 THE SCALE SHOWN IS ORIGINAL DRAWING SCALE

RPEQ No. 31580
J.WEBSTER
06-08-2026

PROJECT
PROPOSED 17 LOT RURAL RESIDENTIAL SUBDIVISION
98 GLENMORE DRIVE, BONOGIN

DRAWN	HN
DESIGNED	MN
CHECKED	JW
APPROVED	JW
DATE	Jul 26
GRID REF.	AHD

CLIENT
SALT DEVELOPMENT SERVICES

TITLE
PRE DEVELOPMENT CATCHMENT PLAN

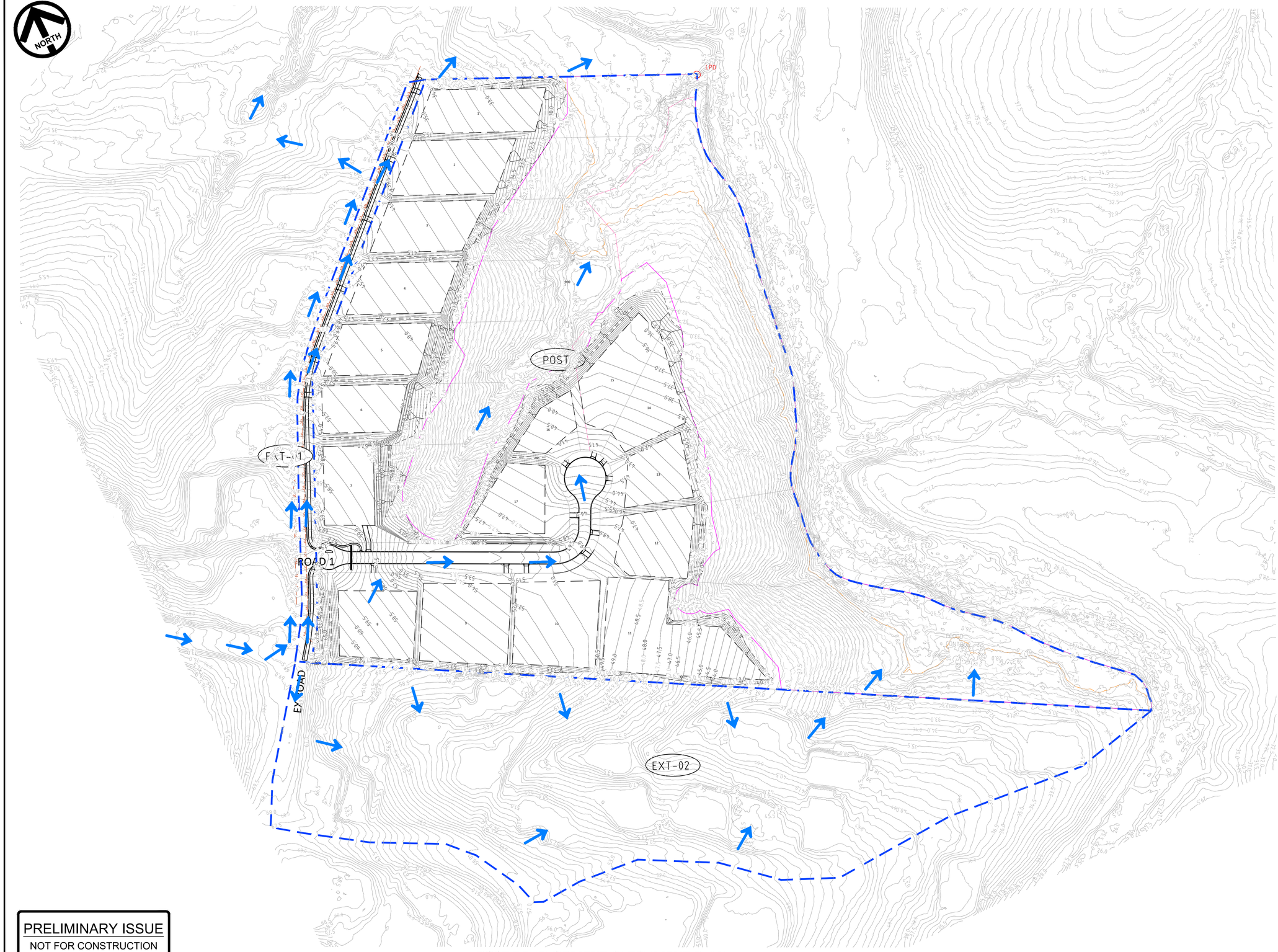
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REV. B

APPENDIX

D

Legend Consultants Post Development Catchment Plan (Ref: LC25079.C402.B) and Music Catchment Plan (Ref: LC25079.C403.B)



LEGEND:

- DESIGNED CONTOUR (0.5m INTERVAL)
- CATCHMENT BOUNDARY
- EXISTING BUILDING
- EXISTING ROAD EDGE OF BITUMEN
- EXISTING KERB
- EXISTING GARDEN
- EXISTING ELECTRICITY
- EXISTING REGIONAL FLOOD EXTENT
- LPD — LEGAL POINT OF DISCHARGE
- LEGAL POINT OF DISCHARGE

CATCHMENT:

CATCHMENT	AREA (ha)
POST	12.352
EXT-01	0.415
EXT-02	5.803

PRELIMINARY ISSUE
NOT FOR CONSTRUCTION

POST DEVELOPMENT CATCHMENT PLAN
SCALE: 1:1250

1:1250 0 10 20 30 40 50m

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A1 THE SCALE SHOWN IS ORIGINAL DRAWING SCALE

REV	DATE	REVISION DETAILS	APPROVED
B	14.07.26	LAYOUT UPDATED	JW
A	27.03.26	ORIGINAL ISSUED	JW

RPEQ No. 31580
J.WEBSTER
06-08-2026

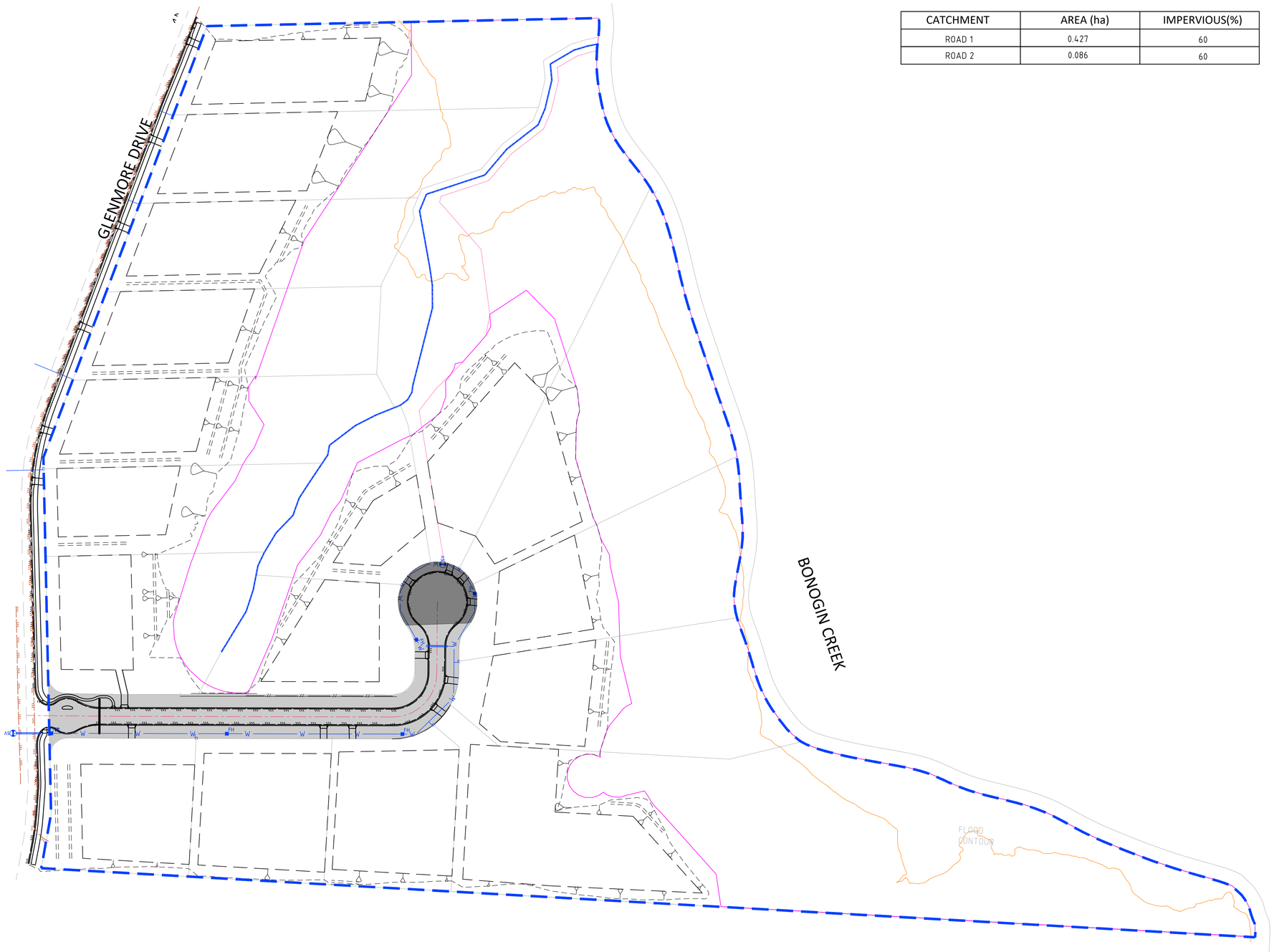
PROJECT
PROPOSED 17 LOT RURAL RESIDENTIAL SUBDIVISION
98 GLENMORE DRIVE, BONOGIN

DRAWN	HN
DESIGNED	MN
CHECKED	JW
APPROVED	JW
DATE	Jul 26
GRID REF.	AHD

CLIENT
SALT DEVELOPMENT SERVICES

TITLE
POST DEVELOPMENT CATCHMENT PLAN

DRAWING NO. LC25079.C402
REV. B



CATCHMENT:

CATCHMENT	AREA (ha)	IMPERVIOUS(%)
ROAD 1	0.427	60
ROAD 2	0.086	60

LEGEND:

- CATCHMENT BOUNDARY
- ROAD 1
- ROAD 2

PRELIMINARY ISSUE
NOT FOR CONSTRUCTION

POST DEVELOPMENT CATCHMENT PLAN

SCALE: 1:1000

1:1000 0 10 20 30 40 50m

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A1 THE SCALE SHOWN IS ORIGINAL DRAWING SCALE

REV	DATE	REVISION DETAILS	APPROVED
B	14.07.26	LAYOUT UPDATED	JW
A	27.03.26	ORIGINAL ISSUED	JW

RPEQ No. 31580
J.WEBSTER
06-08-2026

PROJECT
PROPOSED 17 LOT RURAL RESIDENTIAL SUBDIVISION
98 GLENMORE DRIVE, BONOGIN

DRAWN	HN
DESIGNED	MN
CHECKED	JW
APPROVED	JW
DATE	JUL 26
GRID REF.	AHD

CLIENT
SALT DEVELOPMENT SERVICES

TITLE
MUSIC CATCHMENT LAYOUT PLAN

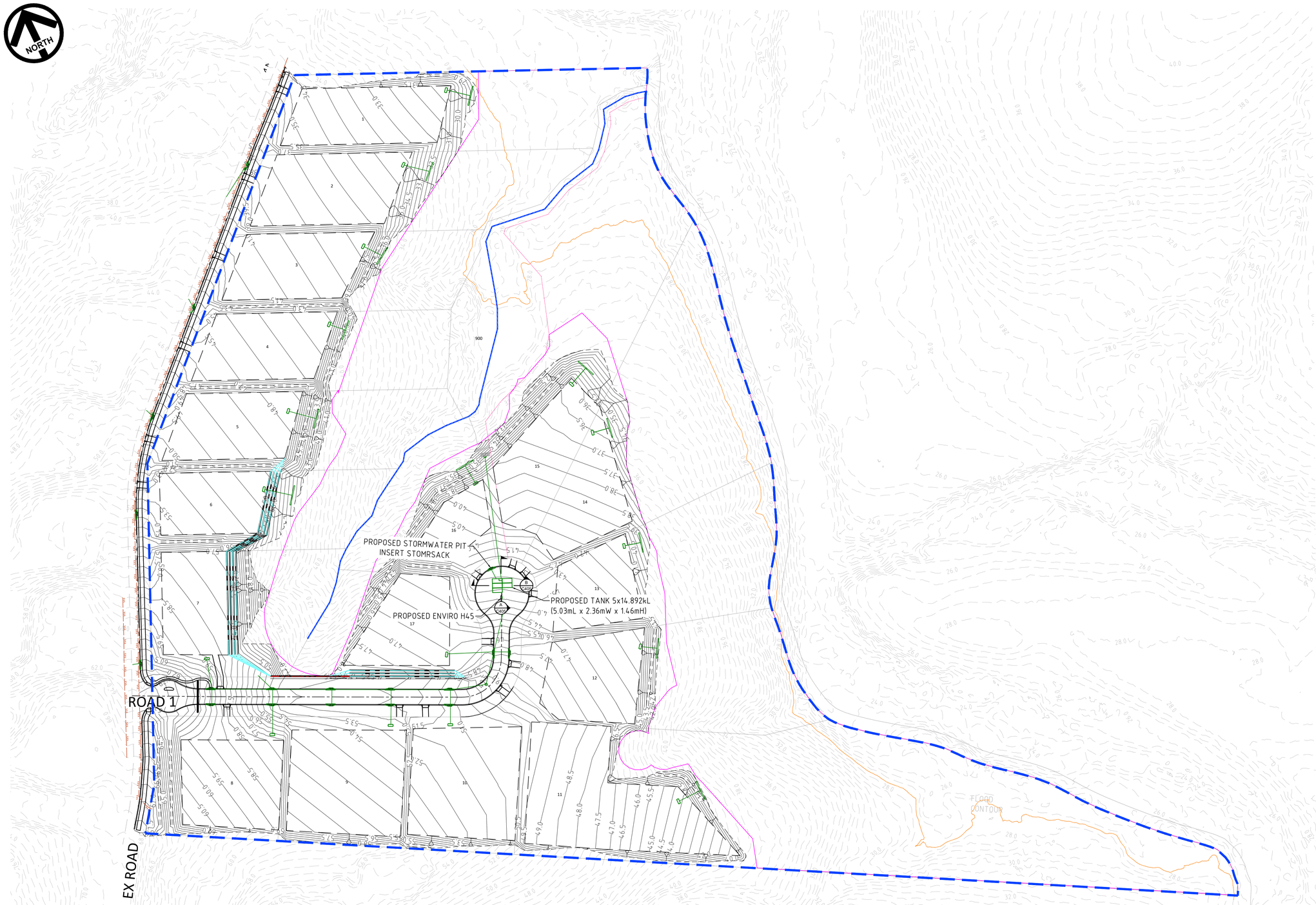
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REV. B

APPENDIX

E

Legend Consultants Stormwater Management Plan (Ref: LC25079.C404.B) and Tank Details (Ref: LC25079.C405.B)



PRELIMINARY ISSUE
NOT FOR CONSTRUCTION

CONCEPTUAL STORMWATER MANAGEMENT PLAN

SCALE: 1:1000

1:1000 0 10 20 30 40 50m

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A1 THE SCALE SHOWN IS ORIGINAL DRAWING SCALE

REV	DATE	REVISION DETAILS	APPROVED
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A	27.03.26	ORIGINAL ISSUED	JW

RPEQ No. 31580
J.WEBSTER
06-08-2026

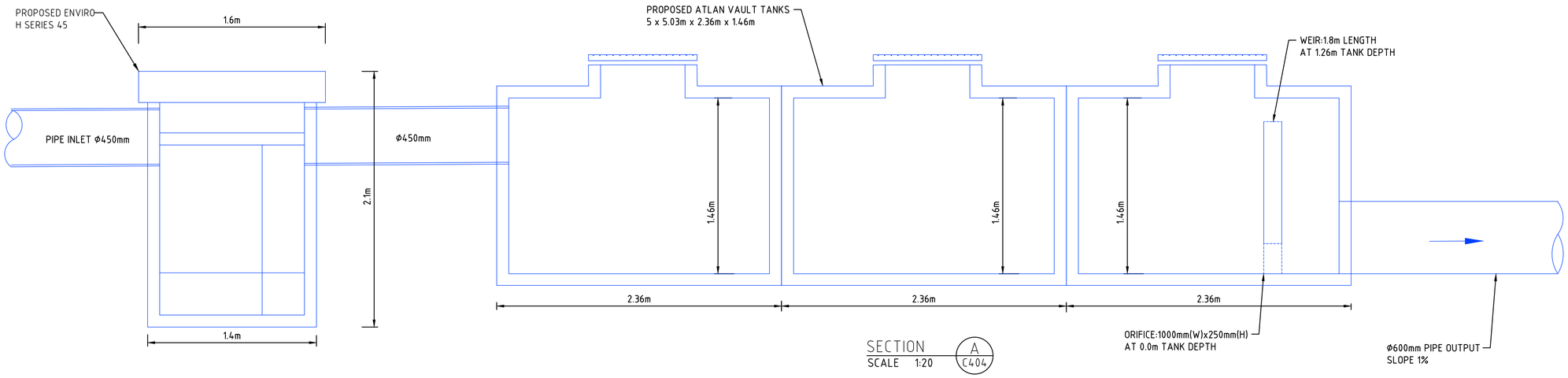
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PROPOSED 17 LOT RURAL RESIDENTIAL SUBDIVISION
98 GLENMORE DRIVE, BONOGIN

DRAWN	HN
DESIGNED	MN
CHECKED	JW
APPROVED	JW
DATE	JUL 26
GRID REF.	AHD

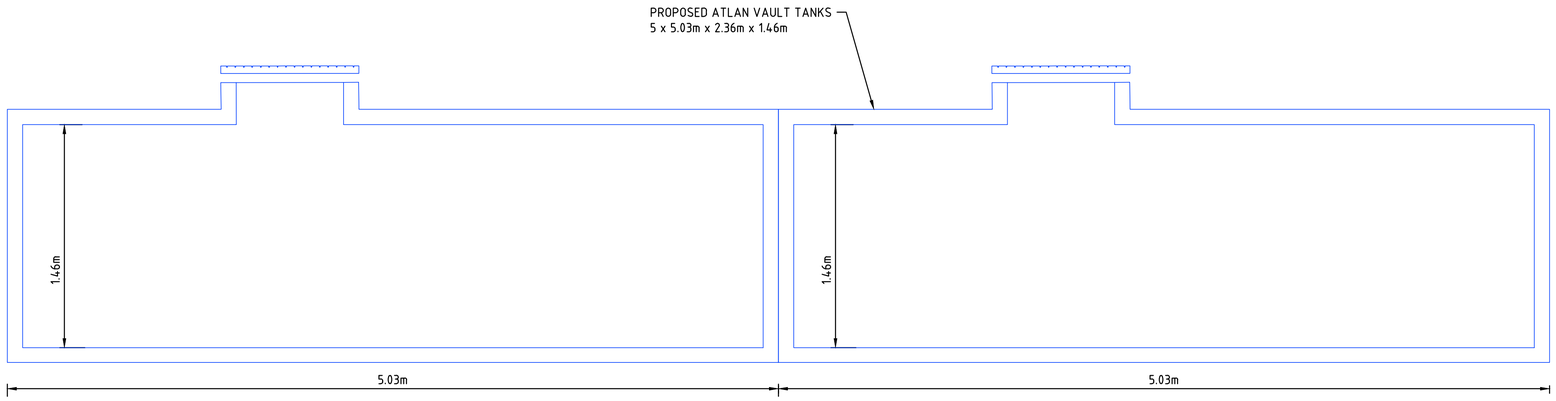
CLIENT
SALT DEVELOPMENT SERVICES

TITLE
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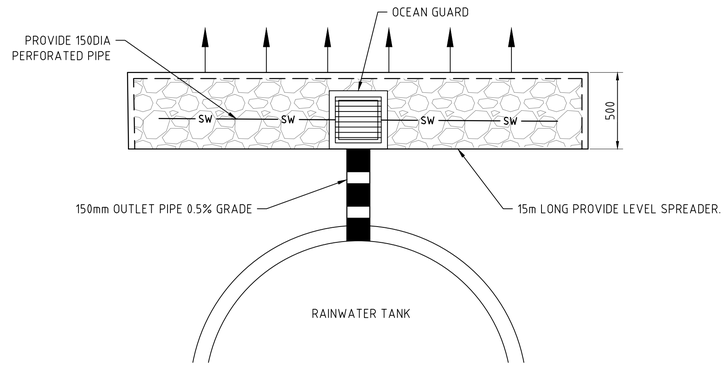
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REV. B



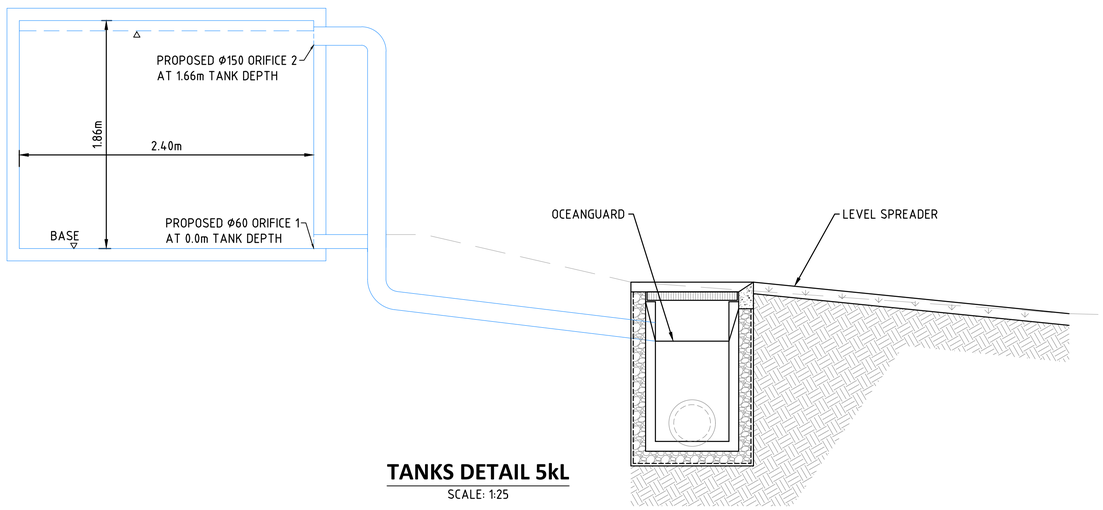
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SCALE 1:20 C404



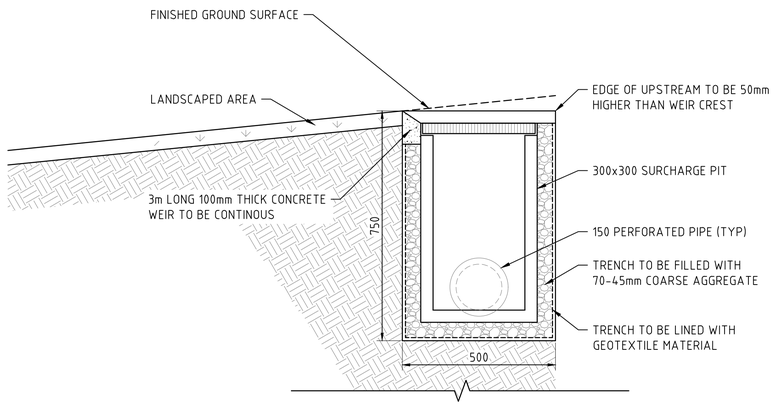
SECTION B
SCALE 1:20 C404



LEVEL SPREADER PLAN
SCALE 1:20



TANKS DETAIL 5kL
SCALE: 1:25



LEVEL SPREADER SECTION
SCALE 1:10

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A1 THE SCALE SHOWN IS ORIGINAL DRAWING SCALE

REV	DATE	REVISION DETAILS	APPROVED
B	14.07.26	LAYOUT UPDATED	JW
A	27.03.26	ORIGINAL ISSUED	JW

RPEQ No. 31580
J.WEBSTER
06-08-2026

PROJECT
PROPOSED 17 LOT RURAL
RESIDENTIAL SUBDIVISION
98 GLENMORE DRIVE, BONOGIN

DRAWN	HN
DESIGNED	MN
CHECKED	JW
APPROVED	JW
DATE	JUL 26
GRID REF.	AHD

CLIENT
SALT DEVELOPMENT
SERVICES

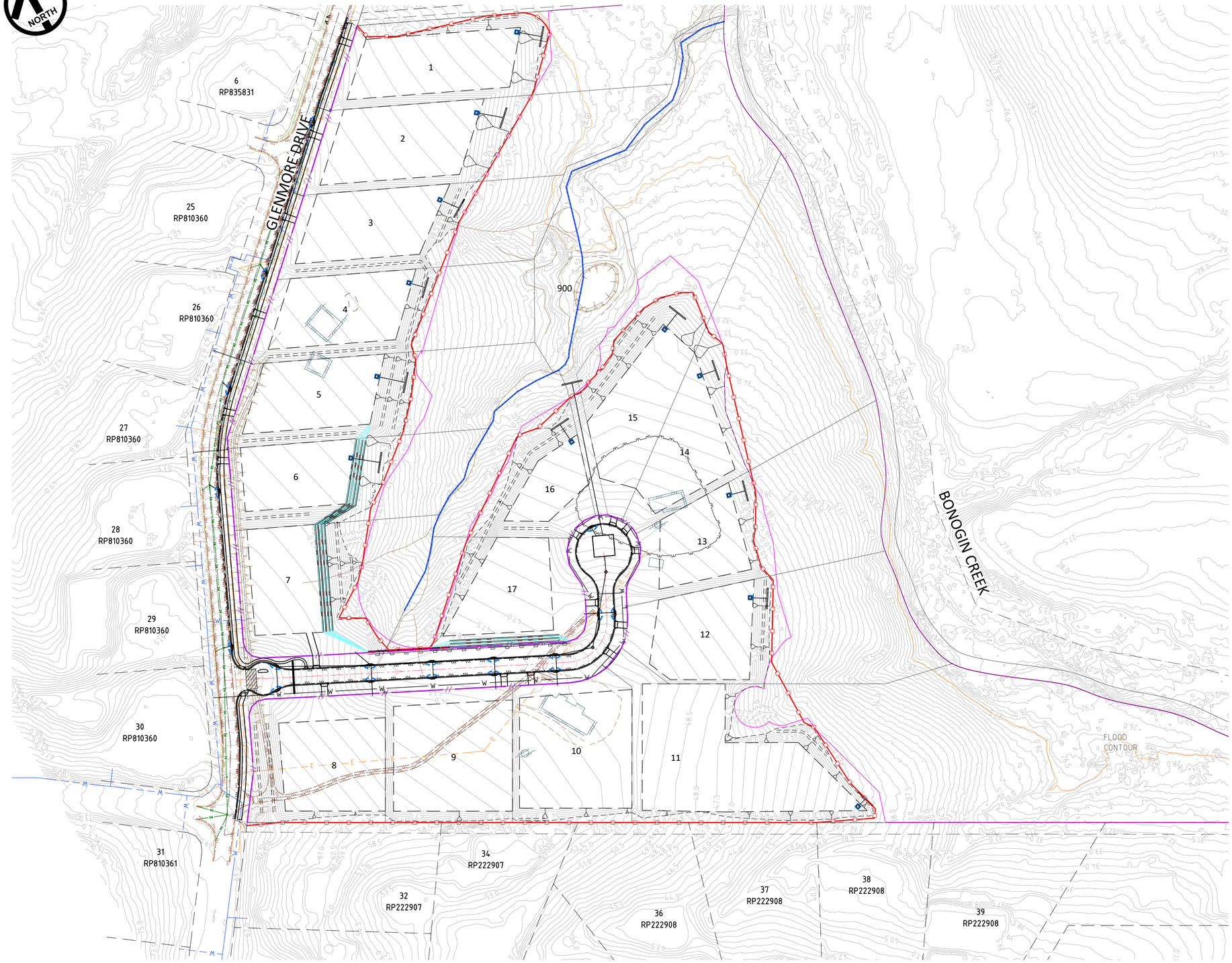
TITLE
TANKS DETAIL

DRAWING NO. LC25079.C405
REV. B

APPENDIX

F

Legend Consultants Erosion and Sediment Control Plan (Ref: LC25079.C250.B)



LEGEND:

- FINISHED CONTOUR (0.5m INTERVAL)
- EXISTING BOUNDARY
- EXISTING BUILDING
- EXISTING ROAD EDGE OF BITUMEN
- EXISTING KERB
- EXISTING GARDEN
- EXISTING ELECTRICITY
- EXISTING ELECTRICITY POLE
- EXISTING TOB/BOB EARTHWORK
- EXISTING WATERWAY
- PROPOSED BATTER
- PROPOSED CONTROL LINE
- PROPOSED BDY
- PROPOSED 1.5m MAX RETAINING WALL
- PROPOSED 7.0m MAX RETAINING WALL
- SHAKE DOWN AREA
- PROPOSED SEDIMENT FENCE
- PROPOSED DUST FENCE
- PROPOSED FILTER ROLL
- PROPOSED STORMWATER INLET SEDIMENT TRAP

EROSION AND SEDIMENT CONTROL LAYOUT PLAN

SCALE 1:1000

DETAILED DESIGN
NOT FOR CONSTRUCTION

1:1000 0 10 20 30 40 50m

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A1 THE SCALE SHOWN IS ORIGINAL DRAWING SCALE

REV	DATE	REVISION DETAILS	APPROVED
B	06.07.26	LAYOUT UPDATED	JW
A	25.03.26	DETAILED DESIGN	JW

RPEQ No. 31580
J.WEBSTER
25-03-2026

PROJECT
PROPOSED 18 LOT RURAL RESIDENTIAL SUBDIVISION
98 GLENMORE DRIVE, BONOGIN

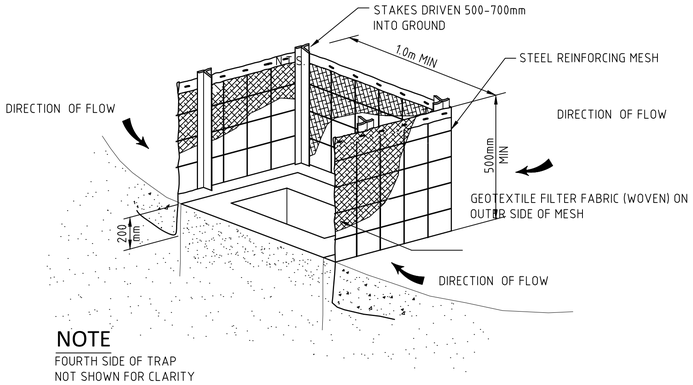
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DESIGNED	TV
CHECKED	JW
APPROVED	JW
DATE	FEB 26
GRID REF.	AHD

CLIENT
SALT DEVELOPMENT SERVICES

TITLE
EROSION AND SEDIMENT CONTROL LAYOUT PLAN

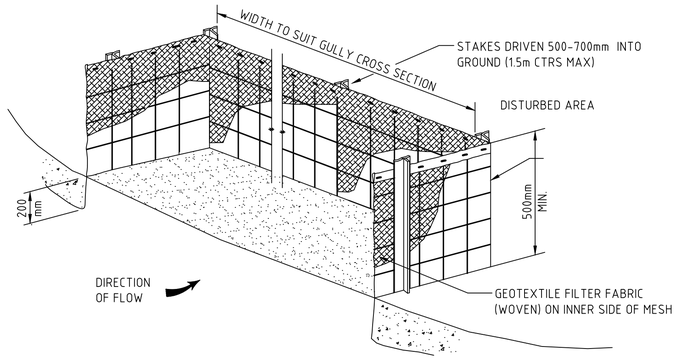
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REV. B

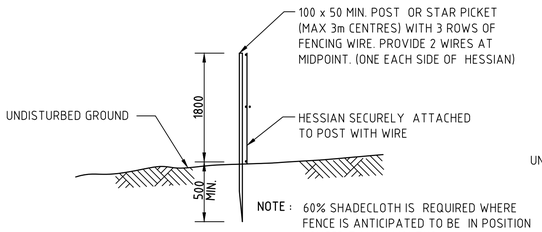


NOTE
FOURTH SIDE OF TRAP NOT SHOWN FOR CLARITY

STORMWATER INLET SEDIMENT TRAP
N.T.S.



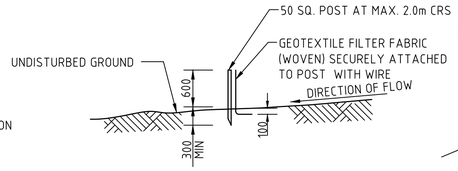
DRAINAGE GULLY SEDIMENT TRAP
N.T.S.



NOTE : 60% SHADECLOTH IS REQUIRED WHERE FENCE IS ANTICIPATED TO BE IN POSITION LONGER THAN 6 MONTHS

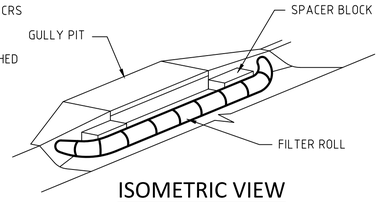
DUST CONTROL FENCE
N.T.S.

NOTE: DUST CONTROL FENCE TO BE PLACED AS DIRECTED ON-SITE BY SUPERINTENDENT.

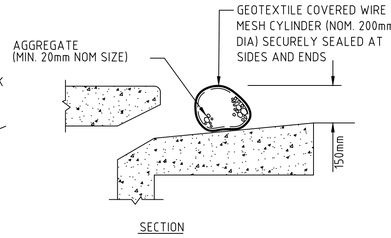


SEDIMENT FENCE
N.T.S.

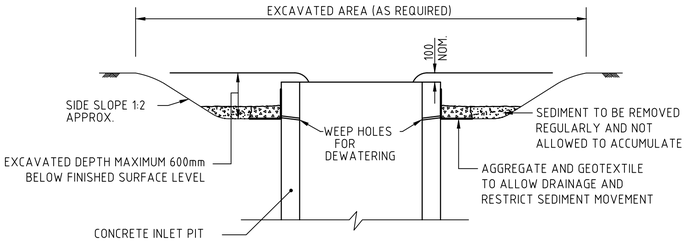
NOTE : SILT FENCE TO HAVE TURNOUTS AT 50m MAX INTERVALS.



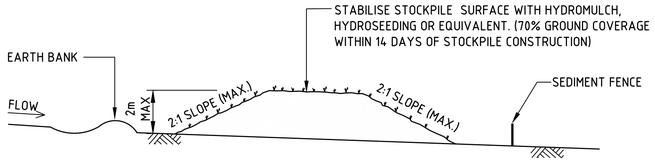
ISOMETRIC VIEW



FILTER ROLL
N.T.S.



EXCAVATED INLET ARRANGEMENT
N.T.S.

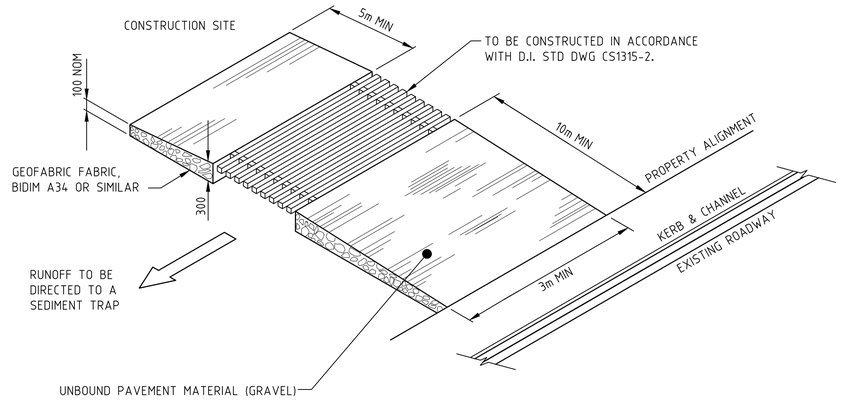


TYPICAL STOCKPILE CONFIGURATION
N.T.S.

NOTES
1. LOCATE STOCKPILES AT TOP OF CATCHMENT ON FLAT GROUND AND NOT WITHIN 5m OF CONCENTRATED FLOW PATHS.
2. STOCKPILES SHOULD HAVE EARTHBANKS UPSLOPE FOR DIVERSION OF UPSTREAM WATER AROUND STOCKPILE AND SEDIMENT FENCES PLACED 1-2m DOWNSLOPE.

SEDIMENT AND EROSION CONTROL NOTES

1. THIS DRAWING HAS BEEN PREPARED AS A GUIDE. IT IS THE CONTRACTOR'S RESPONSIBILITY TO MANAGE SITE SEDIMENT AND EROSION CONTROL MEASURES AND DURING THE CONSTRUCTION PERIOD INSTALL ADDITIONAL MEASURES WHERE SCOUR OR SEDIMENT TRANSPORT IS LIKELY TO OCCUR.
2. DELAY CLEARING, GRUBBING AND TOPSOIL STRIPPING UNTIL NECESSARY.
3. COMMENCE WORK ON SITE ONLY AFTER SEDIMENT AND EROSION CONTROL MEASURES ARE IN PLACE.
4. MANAGE SITE ENTRY/EXIT POINTS TO ENSURE SEDIMENT IS NOT TRACKED OFF SITE.
5. SHAKEDOWN AREA: PROVIDES FOR CONSTRUCTION, SERVICE AND STAFF VEHICLES ENTERING PUBLIC ROADS. CONTRACTOR SHALL LOCATE TO SUIT SITE ACTIVITIES. CONSTRUCTED AS 250mm THICK LAYER OF COARSE (150mm -200mm) RIVER GRAVEL OVER A SINGLE LAYER OF HIGH STRENGTH GEOTEXTILE (15m x 5m).
6. THE CONTRACTOR SHALL INSTALL EITHER STORMWATER INLET SEDIMENT TRAPS OR EXCAVATED INLET ARRANGEMENT AT ALL STORMWATER STRUCTURES DURING THE CONSTRUCTION.
7. FILTER ROLLS SHALL BE INSTALLED AT GULLY PITS IMMEDIATELY AFTER GULLY PIT CONSTRUCTION AND LEFT IN PLACE DURING THE MAINTENANCE PERIOD. OPERATION OF ROLLS DURING PERIODS OF HEAVY RAIN TO BE MONITORED TO PREVENT FLOODING AND EROSION DAMAGE ELSEWHERE.
8. ARRANGE FOR EROSION CONTROL MEASURES TO BE INSTALLED AS CLOSE AS POSSIBLE TO THE SOURCE OF EROSION.
9. ENSURE STOCKPILED TOPSOIL AND EARTHWORKS ARE NOT ERODED BY WIND AND STORMWATER RUN-OFF AND ARE PROVIDED WITH A SILT FENCE AROUND THE LOW SIDE.
10. SILT FENCES HAVE BEEN ESTABLISHED UNDER BULK EARTHWORKS CONTRACT. ERECT SILT FENCES IF REQUIRED, GENERALLY ALONG THE LOW SIDE OF THE CONSTRUCTION SITE AND ALONG A LINE OF CONSTANT LEVEL. AS AN ALTERNATIVE TO BURYING THE SILT FENCE LOWER EDGE, THE CONTRACTOR MAY ELECT TO PLACE 200mm OF THE FABRIC ON THE GROUND UP-SLOPE OF THE FENCE AND COVER WITH 100mm MIN LAYER OF AGGREGATE.
11. TO PREVENT EROSION, TOPSOIL AND SEED IMMEDIATELY AFTER COMPLETION OF BULK EARTHWORKS TO FINISHED PROFILES.
12. PROVIDE TURF STRIP ADJACENT TO KERB FOR FULL LENGTH OF NEW ROAD AND TURF STRIP PLACED AT 90° TO KERB EVERY 10m FOR FULL WIDTH OF VERGE.
13. PRIOR TO COMPLETION OF CONSTRUCTION OF PAVEMENT AND SEALING, PLACE SANDBAGS AT 45° TO ARREST SCOUR AGAINST KERB AND CHANNEL AS FOLLOWS:
    ROAD GRADE 0.5% - 5% - 25m MAX CRS.
    5% - 10% - 10m MAX CRS.
    10% - 15% - 15m MAX CRS.
    15% - 20% - 5m MAX CRS.
14. SWEEP EXTERNAL ROADS WHERE SEDIMENT HAS BEEN DROPPED FROM CONSTRUCTION VEHICLES. DO NOT WASH SILT INTO THE STORMWATER SYSTEM.
15. ALL SEDIMENT AND EROSION CONTROL STRUCTURES, TRENCHES ETC. SHALL BE REGULARLY MAINTAINED AND INSPECTED FOR EFFECTIVENESS.
16. THE USE OF POTABLE WATER IS NOT PERMITTED IN SITE EARTHWORKS OPERATIONS, ROAD AND PAVEMENT CONSTRUCTION OR DUST SUPPRESSION. RECYCLED WATER IS REQUIRED TO BE USED AND IS TO BE IN ACCORDANCE WITH C.o.G.C GUIDELINES.



TEMPORARY CONSTRUCTION ENTRY/EXIT
N.T.S.

DETAILED DESIGN
NOT FOR CONSTRUCTION

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A1 THE SCALE SHOWN IS ORIGINAL DRAWING SCALE

REV	DATE	REVISION DETAILS	APPROVED
B	06.07.26	LAYOUT UPDATED	JW
A	25.03.26	DETAILED DESIGN	JW

RPEQ No. 31580
J.WEBSTER
25-03-2026

PROJECT: PROPOSED 18 LOT RURAL RESIDENTIAL SUBDIVISION 98 GLENMORE DRIVE, BONOGIN

DRAWN	TT
DESIGNED	TV
CHECKED	JW
APPROVED	JW
DATE	FEB 26
GRID REF.	AHD

CLIENT: SALT DEVELOPMENT SERVICES

TITLE: EROSION AND SEDIMENT CONTROL NOTES AND DETAILS

DRAWING NO. LC25079.C251

REV. B

APPENDIX

G

Enviro Technical Manual Version 5 and H-series Technical Summary



FLOW RATES BASED AT 1% PIPE GRADIENT:-

TREATED FLOW..... 66 L/SEC
GROSS FLOW..... 362 L/SEC

MASS:

(BASED ON "D" CLASS COVERS)

TOTAL MASS (FOR MINIMUM INVERT):4.500 TONNE

Enviro H45

General Notes

The Enviro 'H' series is an Australia Designed and Manufactured Device for the removal of pollutants including oils from run-off water. The Enviro 'H' Series is normally installed in-line within new or existing drainage pipes and can be adapted to be installed in an open channel if required. The device does not require any power, utilising the energy in the water flow to separate and contain pollutants for periodical removal by evacuation equipment. Internal surface can be inspected and washed as required, whilst screens can be removed and also cleaned if and as required.

The Enviro 'H' Series are a unique oil/water Separator as well as a Stormwater Quality Improvement Devices (SQID's) which has undergone extensive performance stress testing by independent authorities. These tests indicate compliance with Environmental Protection Authority (EPA) Legislation and Guidelines which prohibit the discharge of pollutants into stormwater. The aim of the Enviro 'H' Series is to restore water quality to a safe and environmentally sustainable state, which pre-existed urbanisation. The application is aimed at any catchment, where an oil spill risk may exist.

Recommendations made in the Australian Run-Off Quality Guideline 2007 (ARQ) are adhered to. The 'H' models also comply with EN-858-1, Class 1 oil/water separators.

Specifications: -

1. Design service life 100 years for fixed parts and 25 years for replacement parts
2. Hydraulic Resistance k factor = 0.425
3. Inlet to outlet differential = 25mm
4. Concrete chamber, risers and cover slabs are designed and manufactured in accordance with AS3600-2009 and under Quality Assurance 9001.
5. Covers are designed and tested in accordance with AS3996 – 2006 Access Covers and Grates
6. Internal components are manufactured from high grade, stainless steel to comply with International Corrosion Standards. There is no welding used. This complies with advice from both the American and Australian Institute of Engineers warning that welded stainless steel exposed to bacterial charged water can result in early corrosion and failure.
7. 'H' Series performance testing verifies the following pollutant removal rates. The testing was performed across a range of concentrations and flow rates which replicated various run-off water conditions and confirmed: -

S.No	Pollutants	Minimum Reduction Required	Test Reduction Achieved
7.1	Total Suspended Soilds	80%	86%
7.2	Total Phosphorus	60%	97%
7.3	Total Nitrogen	45%	85%
7.4	Gross Pollutants	90%	100%
7.5	Total Hydrocarbons	99.95%	99.95%

8. The lower storage chamber has the capacity to hold the annual load discharged from a catchment based on the ARQ Section 3.7 recommended allowance of 1m3/ha/ann.
9. Treated flow through the Enviro 'H' Series is in compliance with EPA definitions, which require the entire catchment run-of to pass through a SQID, until sufficient flows have occurred to mobilise at least 90% of the potential pollutant load.
10. Particle size capture is set to retain all particles greater than 500µ and to then retain a majority of particles to less than 100µ.
11. Hydrocarbon retention occurs in a separate chamber which operates as a best practice oil and grease arrestor
12. Re-suspension of hydrocarbons and all retained materials is prevented by including separate chambers for separation from flow and retention.

REV.	DESCRIPTION	DATE	APPROVED
R2	Illustration Changed	29-Dec-22	LC
R1	Chamber Wall and Base Thickness Changed from 150mm to 100mm	21-MAY-2022	LC
0	Technical Specification Created	30-NOV-21	LC

REVISIONS

For further assistance: -
Technical Support Ph: .....+61 8 8564 2347
Email: info@enviroaustralis.com.au

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS

BENDING RADIUS	K - FACTOR
PREPARED BY	Logesh S
CHECKED BY	LR
APPROVED BY	LC
DATE	29-Dec-22

ENVIRO

TITLE:
ENVIRO H45
SPECIFICATIONS & TECHNICAL DATA

DRAWING NO: ENV-TEC-H45-000-1

MATERIAL: CONCRETE & S/STEEL

ASSEMBLY: H45

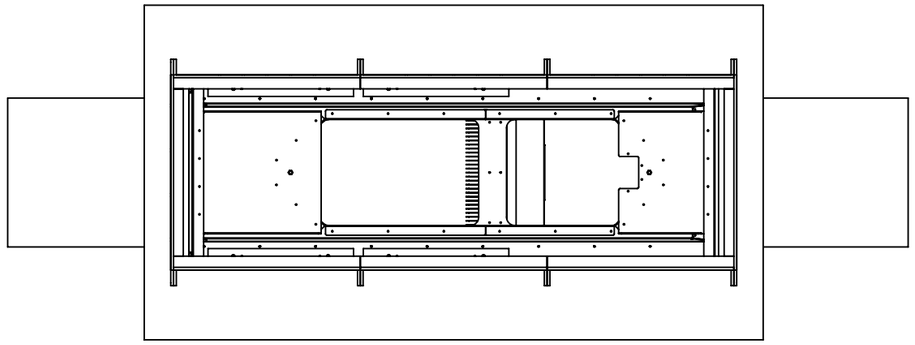
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REV: R2

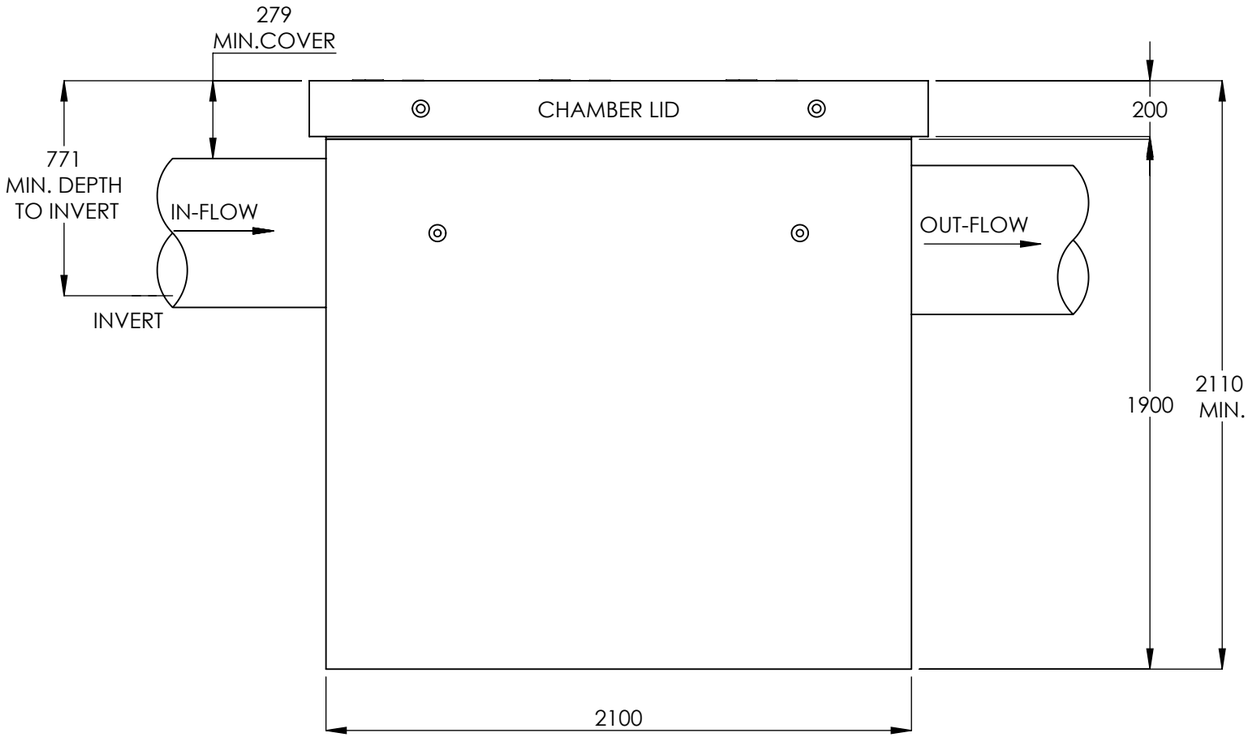
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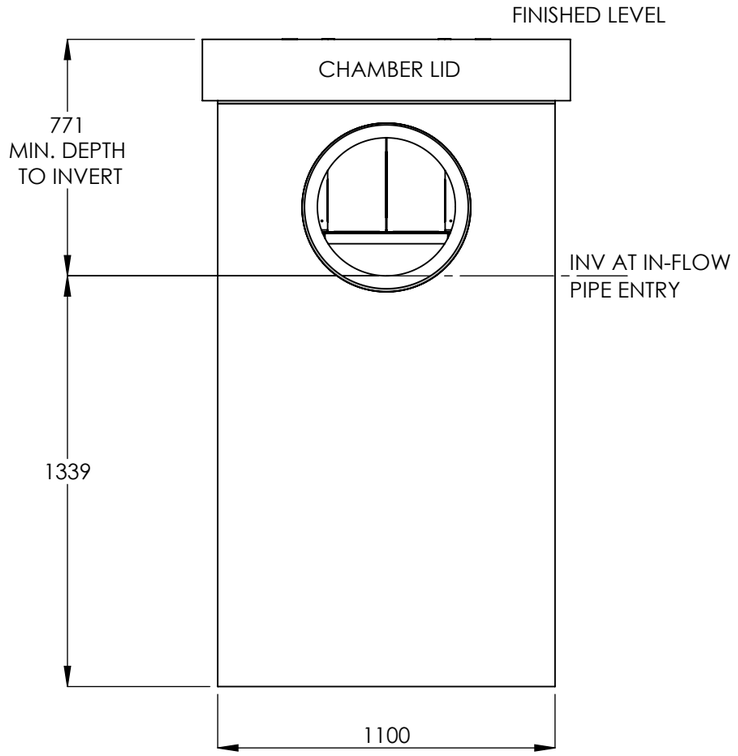
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SHEET 1 OF 4



VIEW AS SEEN THROUGH COVERS OPENING FOR
SERVICE AND INSPECTION





CLASS	OVERALL HEIGHT (MIN.)	MIN. DEPTH TO INVERT
'D' CLASS	2110	771

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PREPARED BY	Logesh S
CHECKED BY	LR
APPROVED BY	LC
DATE	29-Dec-22
MATERIAL: CONCRETE & S/STEEL	
WEIGHT: Kg	

ENVIRO

TITLE:
ENVIRO H45
GENERAL ARRANGEMENT

DRAWING NO: ENV-TEC-H45-000-2

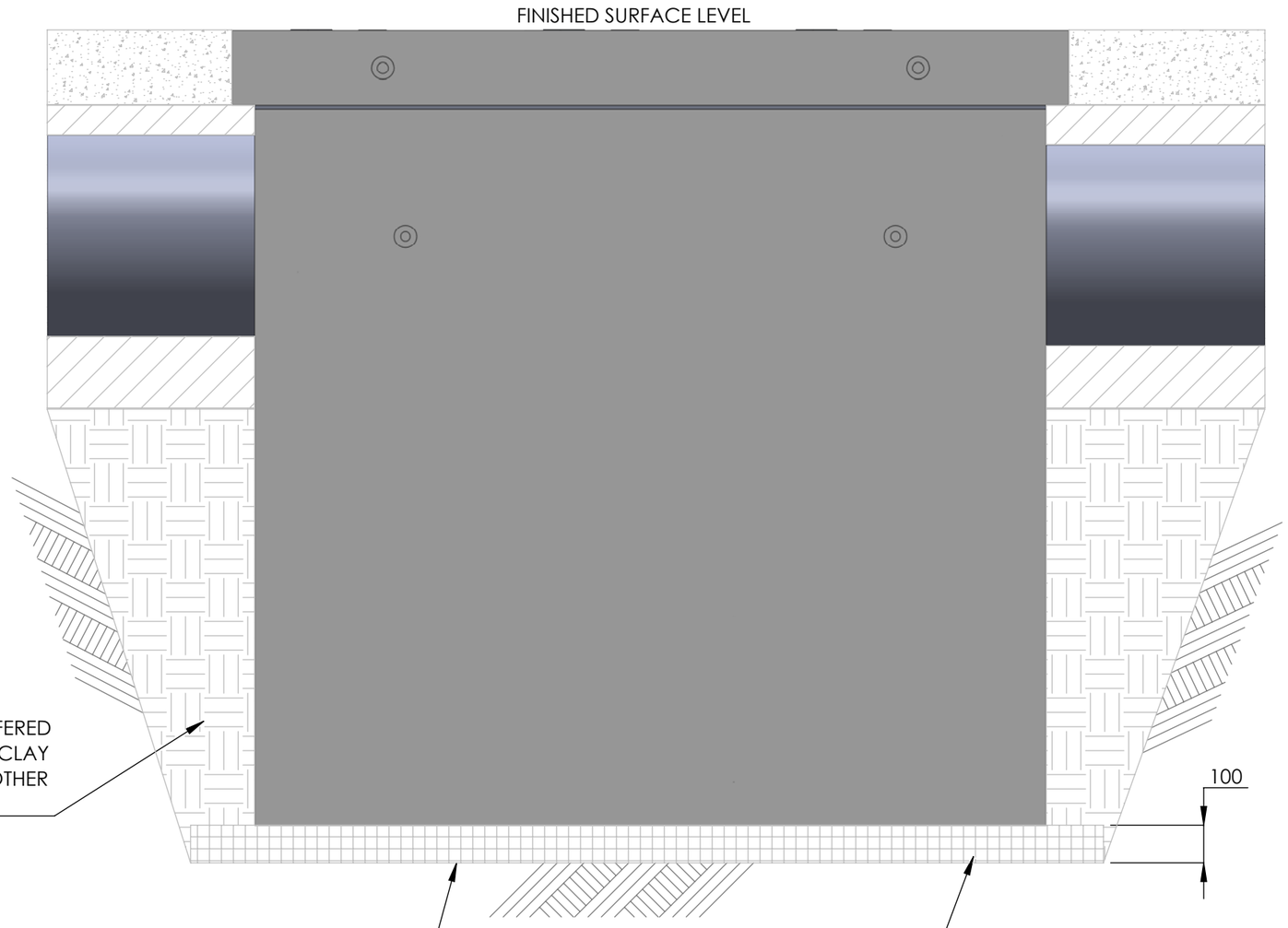
ASSEMBLY: H45

A3

REV: R2

SCALE: NTS

SHEET 2 OF 4



EXCAVATION VOLUME (WITHOUT RISER):

TOTAL EXCAVATION VOLUME - 18.64 m^3

BACKFILL VOLUME FROM CHAMBER BOTTOM TO PIPE INVERT = 5.58 m^3

BACKFILL VOLUME FROM PIPE INVERT TO TOP = 8.18 m^3

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS	
BENDING RADIUS	K - FACTOR
PREPARED BY	Logesh S
CHECKED BY	LR
APPROVED BY	LC
DATE	29-Dec-22
MATERIAL: CONCRETE & S/STEEL	
WEIGHT: Kg	

ENVIRO

TITLE: ENVIRO H45 SITE INSTALLATION

DRAWING NO: ENV-TEC-H45-000-3

ASSEMBLY: H45

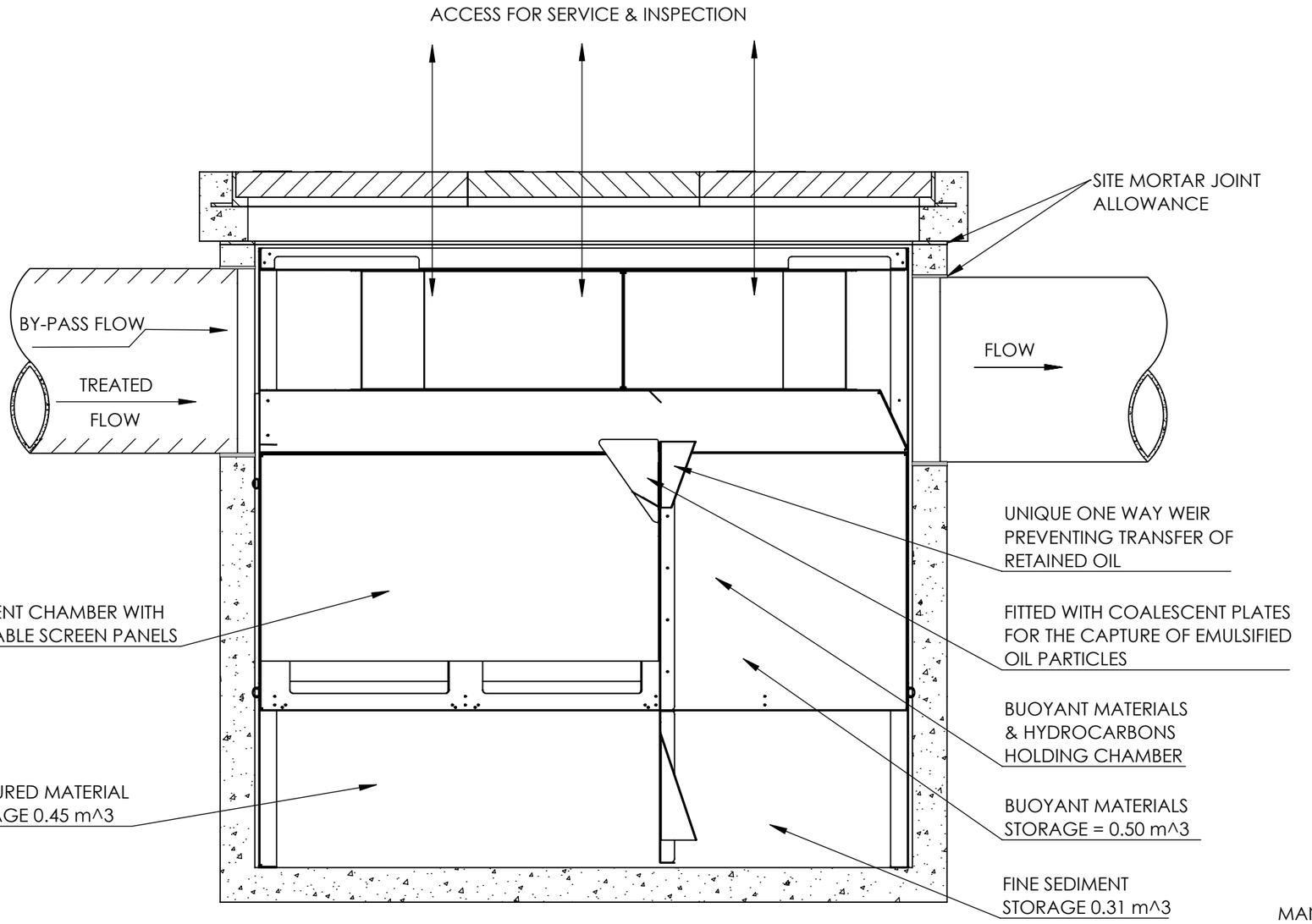
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REV: R2

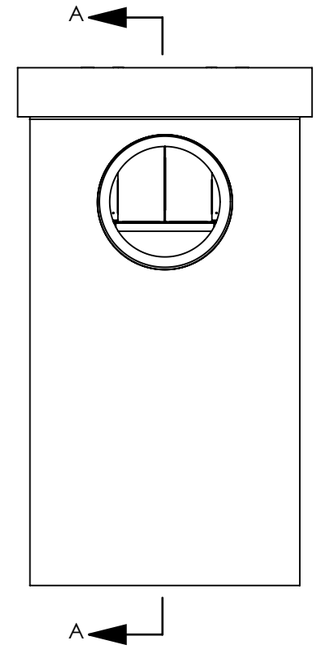
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SHEET 3 OF 4

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SECTION A-A



TOTAL STORAGE CAPACITY = 1.26 m^3

MANUFACTURING GENERAL SPECIFICATIONS
CONCRETE- 32 mpa (minimum)
REINFORCEMENT- SL81, CENTRAL
WALL THICKNESS- 100mm (minimum)

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS	
BENDING RADIUS	K - FACTOR
PREPARED BY	Logesh S
CHECKED BY	LR
APPROVED BY	LC
DATE	29-Dec-22
MATERIAL: CONCRETE & S/STEEL	
WEIGHT: Kg	

ENVIRO

TITLE: ENVIRO H45 GENERAL OPERATION

DRAWING NO: ENV-TEC-H45-000-4

ASSEMBLY: H45

A3

REV: R2

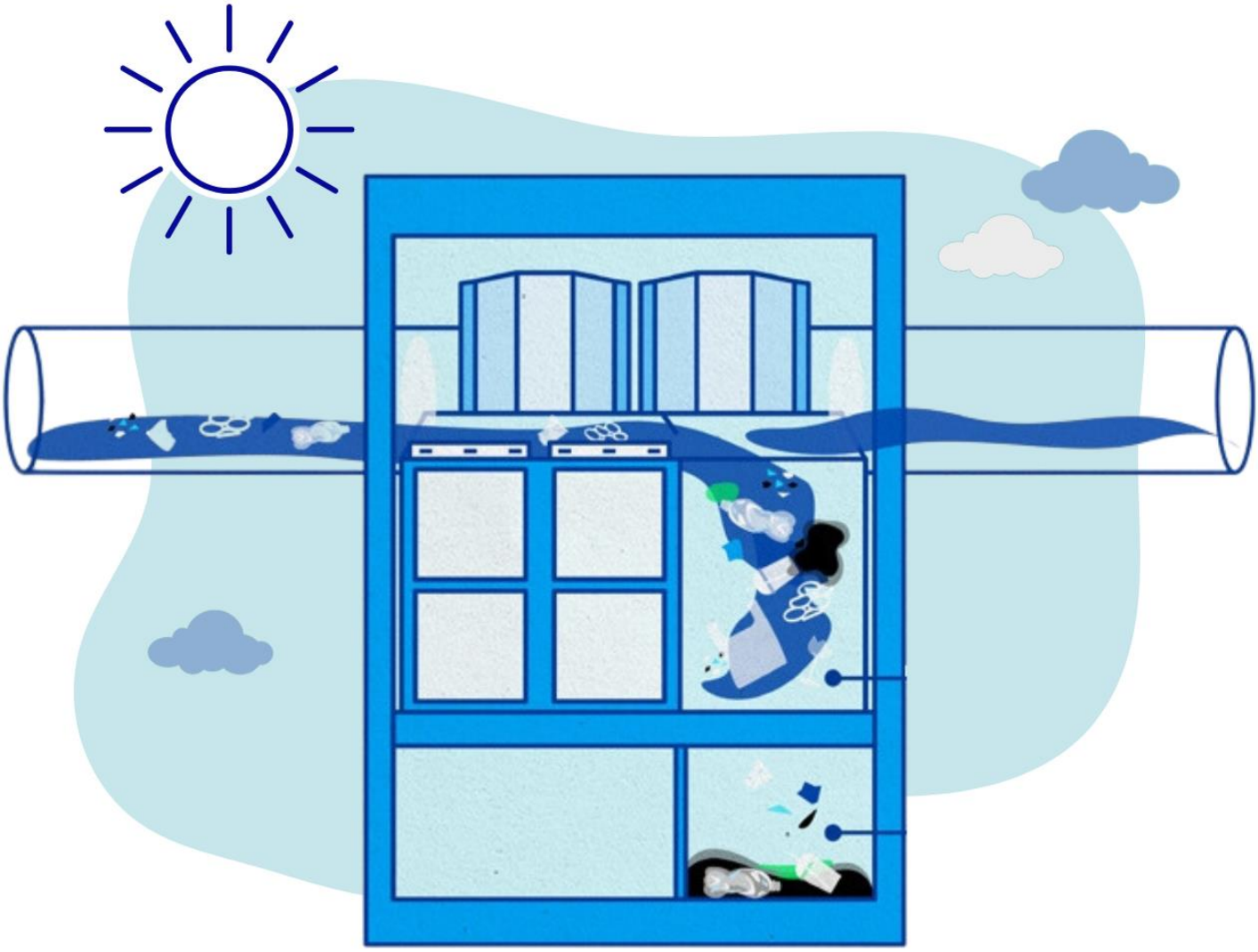
SCALE: NTS

SHEET 4 OF 4

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ENVIRO

STORMWATER TREATMENT SOLUTIONS



TECHNICAL MANUAL

GOOD DESIGN AWARD® WINNER

VERSION 5

About Enviro Australis

Enviro Australis Pty Ltd (Enviro) is a South Australian owned and operated company. Many years of research and considerable financial investment have resulted in the development of revolutionary fully integrated stormwater pollution control systems which remove the broad spectrum of pollutants and include devices specifically designed for oil/water separation for catchments where a risk of oil spillage exists.

Enviro is a passionate specialist company supplying Environmental Protection Systems that are compliant with current Australian and International legislation. Enviro prides itself on providing systems that are low cost to install, service and maintain. Enviro EPS are unique world-first integrated devices that replace a treatment train. One Enviro device can remove gross pollutants (trash and litter), sediments (fine and course), nutrients and oils. All Enviro systems are **independently tested** and **approved.** For example; the oil/water separation process that Enviro developed was independently certified to comply with the strictest European Standard EN858-1.

Australia has adopted the term “Gross Pollutant Trap” or “GPT” to describe stormwater treatment, but Enviro has taken a different approach. Enviro devices capture the full range of contaminants and have adopted the term “Environmental Protection System” or “EPS”, to differentiate from gross pollutant traps that represent only 30% of the pollutant spectrum. This is driven by recognising that Australian Environmental Protection Legislation lists pollutants that are deemed unlawful to discharge into stormwater drains.

Enviro also has solutions for the reduction of biological oxygen demand (BOD) and enrichment of dissolved oxygen (DO) in wetlands to support the principles of Water Sensitive Urban Design (WSUD).

Introduction

Enviro’s intention is to provide stormwater pollution control that is in line with environmental protection policy and legislation, i.e. the total pollution load (as defined in legislation) discharged from urban development must be reduced in accordance with set reduction targets.

Enviro EPS are designed to suit the type and load transported by storm water from a catchment. This is the primary selection criterion to determine the series required. The model within each series is then sized to suit treated flow, WSUD and structural duty.

The aim of this Technical Manual is to provide one source of reference material that encapsulates the research, development and testing conducted over more than ten years.

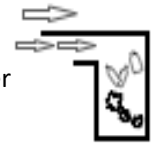
The manual describes:

- The application of Enviro EPS
- Performance testing and validation; and
- Some of the processes evaluated during the development phase.

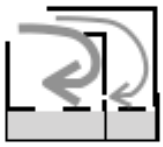
Supporting documents and references to substantiate the Enviro approach are included as appendices.

Major Benefits

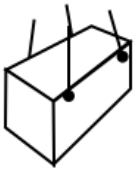
1. Permanently retain all buoyant materials via a one-way trap, not relying on a barrier



2. Separate materials and prevent churning



3. Ease of installation



4. Ease of service with one operator and vehicle



Environmental Protection Authorities (EPA) refer to the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) and have in turn enacted legislation that prohibits discharge of pollutants into stormwater. Each state is responsible for administering the legislation; however, the principles are common, and a list of pollutants is readily available. In principle, the aim of the legislation is to remove anthropogenic impact by requiring large reductions in synthetic materials in stormwater, while allowing some nutrients to be discharged at similar concentrations to natural background levels.

Enviro continues to refine and develop processes aimed at meeting current legislation and is passionate about the environmental impact of stormwater pollutants.

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1 Technical Manual Summary

The Enviro EPS is a fully integrated in-line range of devices for removal of pollutants from stormwater.

Environmental protection, under legislation and as part of our social responsibility, demands that anthropogenically generated pollutants are **removed before** run-off water enters receiving waters.

In the development phase Enviro's approach was to:

1. Define pollutants
2. Understand the nature of pollutants
3. Research the source and associated characteristics
4. Develop and test processes for removal, storage and safe handling of pollutants
5. Consider all of the above with regard to ease of manufacture, installation, service and life expectancy

1.1 The Final Result

With more than a decade of combined development and field experience, Enviro's range of Environmental Protection Systems (EPS) represents world-leading technology, backed by performance. Designed and manufactured in Australia, these systems are available nationally.

Pollutant groups extend well beyond gross pollutants, which are typically related to gross pollutant traps (GPTs).

The resulting Enviro EPS design removes the broadest range of pollutants that compromise aquatic ecosystems. Where required, Enviro can also supply solutions to reduce Biological Oxygen Demand (BOD) and increase Dissolved Oxygen (DO).

1.2 Enviro EPS Range

The Enviro EPS range is divided into three levels, providing systems that are suitable for anticipated load, being mindful of installation and service costs. The EPS series has multiple functions to suit catchment load discharge varying from low impact to high impact where oils (hydrocarbons) may spill.

Performance is validated through rigorous stress testing conducted by independent experts. This methodology aligns with industry standards that necessitate long-term proof of performance. The stress testing simulated worst-case scenarios over repeated events, effectively replicating the equivalent to two years of service.

Pollutant groups and test results are in the following table:

Oil removal as per EN858-1	**99.95%**
Gross pollutants	**100%**
Suspended solids	**86%**
Total Nitrogen	**85%**
Total Phosphorous	**97%**

The breakdown of catchment activities and the suitable EPS series is summarised as follows:

	EPS Series		
CATCHMENT	**H**	**E**	**G**
Residential housing – low to medium density	✓	✓	✓
Traffic, passenger vehicle – low density	✓	✓	✓
Residential – high density	✓	✓	
Discharge to sensitive water body or wetlands	✓	✓	
Transport vehicles	✓	✓	
Commercial and retail	✓	✓	
Industrial activity	✓	✓	
Transport terminal	✓		
Fuel handling and chemical process	✓		

The EPS range is primarily an "at source" stormwater pollution control system. The "at source" term refers to discharge generated from a new development that does not include extensive hinterland activity which may extend time lag periods from internal wetlands. The latter are accommodated by "end of pipe" solutions that are custom designed to suit the specific requirements and characteristics of the catchment.

2 Enviro Performance

A critical part of development of the Enviro EPS was understanding the source and nature of pollutants transported by stormwater run-off to the treatment location.

Some of the above is detailed in the publication, *Balanced Urban Development: Options and Strategies for Liveable Cities.* Enviro's Director of Engineering, Leo Crasti was a contributing author to this publication. Refer extract Appendix 1

The following summarises the research which is also illustrated in Fig 2.1

- "Gross pollutants" is a term that generally describes trash and litter. Enviro has determined that this category includes items sized down to 0.5mm and should be limited to a large size of 150mm in the minor dimension as this is the nominal opening of kerbside drains. If larger items may be transported, some custom designing can be applied.
    - **Trash** is defined as anthropogenic, in that it was not part of a natural environment and includes a wide range of materials such as polystyrene, PVC, cardboard etc. Most of these exhibit buoyant properties and are subject to breakdown, particularly if exposed to constant churning. The Enviro process is to separate these materials into a holding chamber, to avoid churning and breakdown.
    - **Litter** is defined as materials that are organic in nature, such as grass clippings and similar. Although these are mostly not recognised as pollutants, the excessive raw state overdoses receiving waters and stresses DO levels. Litter and animal excrement are also major contributors to nutrient overload. These materials also exhibit buoyant properties and are separated in the EPS (E and H Series) in a separate chamber to avoid churning, bio-release and remobilisation.
    - Testing showed 100% retention of this category.

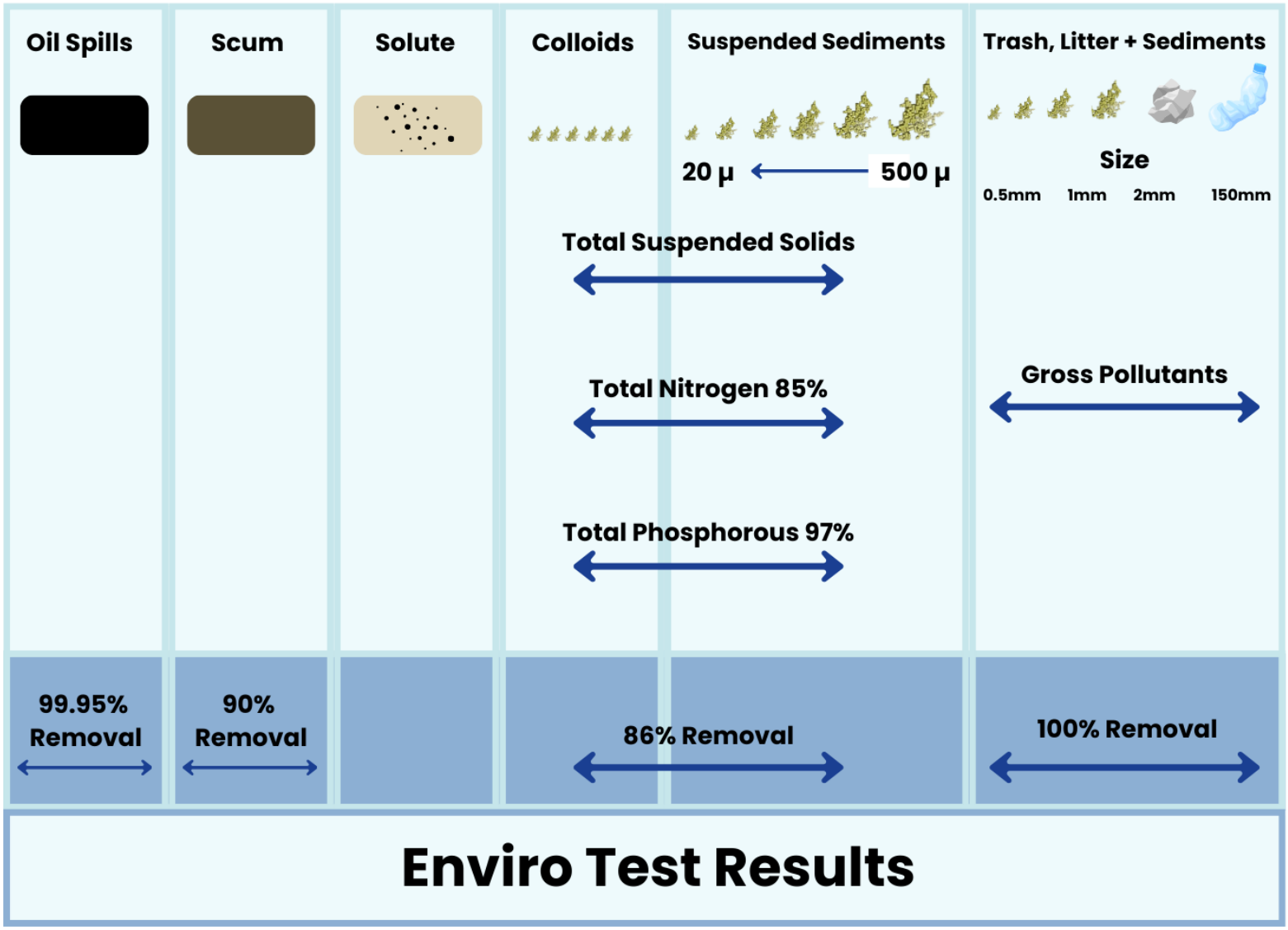
- **Sediment** covers a wide range of fine materials transported by stormwater. Although sediments in the natural environment produce rich alluvial soils, unfortunately sediment generated from an urban (built) environment are quite different. Rubber from tyres, dust from brake linings and particulates from industrial exhausts are some examples of the origin of sediment.

- Most of this particulate matter includes toxic chemicals and nutrients that need to be excluded from indigenous sediment beds created prior to urbanisation. Enviro has applied its best effort to reducing discharge of sediment and defined this particulate matter as less than 500 microns in size.
    - Removal of these fine sediments was tested at a size range where 90% was below 500 microns (Refer to Section 7).
    - Enviro's proprietary process utilises a combination of hydraulics and three-dimensional screening to separate fine particles from the flow and deposit these in a quiescent storage zone.
    - Very fine particles are transferred into a separate chamber where settlement may occur over an extended period of time.

- Nutrients of concern are **nitrogen (N)** and **phosphorous (P)**. In nature, P exists in very low concentrations while N is abundant as it is used to form most of the bio-mass on the planet. The source of P in run-off is of anthropogenic origin and is mostly discharged through the sewer system. The source of N is wide-spread – (Refer to Section 8)
    - Although solute forms of N are readily available, the source should be limited, and therefore substantially reduced in the catchment design. These solute forms of N are transitional in the N cycle and should not appear in significant concentrations at a treatment location. Solute forms may well be generated once water flows into permanent water bodies where release will occur.
    - EPS performance does not include removal of solute forms of nutrients. Adsorption by media was found to be ineffective due to blinding by fine sediment. Removal of fine sediment proved to be more reliable for most catchments. Alternatives are available for removal of dissolved forms of nutrients as required.

2.1 Enviro Test Results

The diagram below shows test results achieved by Enviro for separation of the different pollutant groups. *Refer Appendix 2*



3 EPS Series Explanation

3.1 G Series – Low-cost device intended for low impact catchments such as Residential areas

- The Enviro G Series is an in-line single chamber device designed to remove the broad spectrum of pollutants transported by stormwater run-off water in low impact catchments, typically residential developments.
- The G Series as a single device that replaces the conventional GPT which is part of a treatment train.
- Suitable for low impact catchments, typically residential developments.
- Other aspects are as detailed in the E Series with exception of incidental oil removal.

Model	Pipe Size	Treated Flow and Storage Capacity	Plan Dimensions (external length x width)	Depth Below Invert	Mass	Excavation Volume
Enviro G30	Nominally 300 ID. Can be used for 375mm ID subject to gradient and velocity	22 litres/sec 0.25 m^3	1.2m x 0.9m	1.2m	2.6 tonnes	1.7 m^3
Enviro G45	450mm ID	66 litres/sec 0.52 m^3	1.5m x 1.2m	1.4m	4.6 tonnes	3.3 m^3
Enviro G60	600mm ID	142 litres/sec 0.87 m^3	2.2m x 1.2m	1.8m	7.5 tonnes	6.2 m^3
Enviro G75	750mm ID	258 litres/sec 3.2 m^3	2.85m x 1.95m	2.2m	13.3 tonnes	15.9 m^3
Enviro G90	Nominally 900 ID. Can be used for 1,050mm pipe size subject to gradient and velocity.	419 litres/sec 3.3 m^3	3.6m x 1.95m	2.0m	15.8 tonnes	18.3 m^3
Enviro G120	1200mm ID	902 litres/sec 3.0 m^3	3.6 m x 2.1m	1.8m	16.3 tonnes	10.3 m^3

Gross pollutants	100%
Suspended solids	94%
Total Nitrogen	85%
Total Phosphorous	97%
Other factors include:	
Treated flow of pipe diameter[1]	30%
Hydraulic resistance, k factor	0.425
Nominal service intervals [2 & 3]	1year
Maximum particle size by-pass	500µ
Nominal particle size capture	100µ
Design service life	100 years
Fully removable internal screens	

The above table shows the percentage reductions based on test results.



Note 1: Treatment continues after this level is exceeded enabling capture of higher density materials transported by increased energy in flow resulting from higher rainfall intensity.

Note 2: Additional storage of a further 1.4 m^3 is available before unit performance is compromised.

Note 3: Load volume allowance of 1m^3/ann based on ARQ section 3.7.

3.2 E Series – General-purpose device for Commercial and Industrial catchments

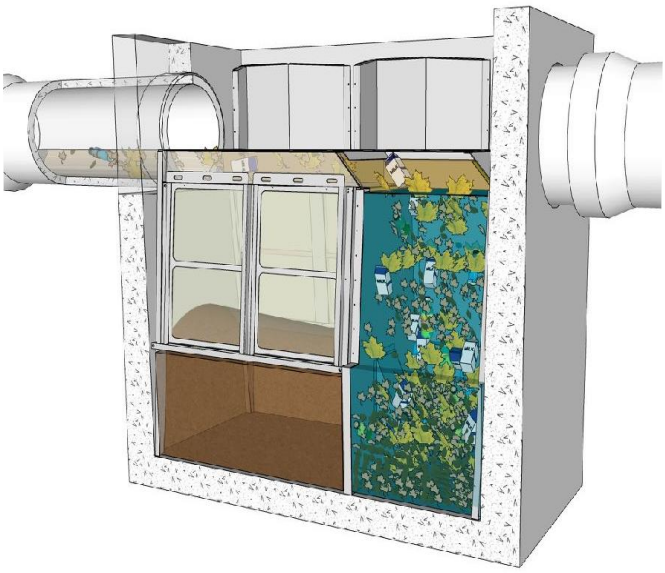
- The Enviro E series is an in-line multi-chamber device designed to remove the broad spectrum of pollutants transported by stormwater run-off water from high impact catchments, typically where commercial and industrial activities are carried out.
- Removes incidental oil/fuel spillage as well as gross pollutants, sediment and nutrients.
- Pollutant groups are separated and contained in separate zones for removal.
- Independently tested and accredited by University of South Australia, with supporting analysis and verification by University of Sydney.
- Compliant with all current required legislation.
- Arrives fully assembled, ready for easy installation.
- Minimal excavation and backfill required.
- No concrete slab or tie downs required.
- Multiple processes in one unit – replaces a conventional treatment train.
- Servicing and maintenance is required once per 12 months, with use of any local qualified contractor with vac truck.
- Removable screens for cleaning, and common to all systems.
- Separate waste storage location prevents scouring and remobilisation.
- Designed to store 12 months load in accordance with ARQ 3.7 for ease of maintenance and servicing.
- Hydraulic flow is managed to ensure particles do not become attached to the screens and settle into the lower chamber.
- Separate storage chamber below the processing section, in a quiet zone, prevents scouring and remobilisation.
- Personnel are not required to enter the device for cleaning, making Enviro a safer system. Entry into any device is defined as entering a confined space and requires specialist training and entry permits.
- Can be legally transported without special conditions.
- Internal components are not welded to avoid potential corrosion.

Model	Pipe Size	Treated Flow and Storage Capacity	Plan Dimensions (external length x width)	Depth Below Invert	Mass	Excavation Volume
Enviro E30	Nominally 300 ID. Can be used for 375mm ID subject to gradient and velocity	22 litres/sec 0.23 m^3	1.5m x 0.9m	1.2m	3.2 tonnes	2.2 m^3
Enviro E45	450mm ID	66 litres/sec 0.45 m^3	2.2m x 1.2m	1.4m	6.1tonnes	4.9 m^3
Enviro E60	600mm ID	142 litres/sec 0.85 m^3	2.8m x 1.2m	1.8m	9.3 tonnes	7.9 m^3
Enviro E75	750mm ID	258 litres/sec 3.1 m^3	3.6m x 1.95m	2.2m	16.1 tonnes	20.1 m^3
Enviro E90	Nominally 900 ID. Can be used for 1,050mm pipe size subject to gradient and velocity	419 litres/sec 3.2 m^3	4.35m x 1.95m	2.0m	18.6 tonnes	22.1 m^3
Enviro E120	1200mm ID	902 litres/sec 5.2 m^3	4.35m x 2.1m	1.8m	19.2 tonnes	22.0 m^3

Model	Pipe Size	Treated Flow and Storage Capacity	Plan Dimensions (external length x width)	Depth Below Invert	Mass	Excavation Volume
Enviro E130	1300 mm ID	1285 litres/sec 6.7 m^3	5.1m x 2.4m	1.7m	23.9 tonnes	25.0 m^3
Enviro E180	1800 mm ID	2570 litres/sec 13.4 m^3	9.5m x 5.1m	1.65m	87.3 tonnes	56.0 m^3

Gross pollutants	100%
Suspended solids	94%
Total Nitrogen	85%
Total Phosphorous	97%
Hydrocarbon removal	90%
Other factors include:	
Treated flow of pipe diameter[1]	30%
Hydraulic resistance, k factor	0.425
Nominal service intervals [2 & 3]	1year
Maximum particle size by-pass	500µ
Nominal particle size capture	100µ
Design service life	100 years
Fully removable internal screens	

The above table shows the percentage reductions based on test results.



Note 1: Treatment continues after this level is exceeded enabling capture of higher density materials transported by increased energy in flow resulting from higher rainfall intensity.

Note 2: Additional storage of a further 1.4 m^3 is available before unit performance is compromised.

Note 3: Load volume allowance of 1m^3/ann based on ARQ section 3.7.

3.3 H Series – High Impact catchment with risk of oil spillage and/or sensitive wetlands

- This is our optimal environmental protection system for **high impact catchments** where there is likelihood of oil spillage and/or downstream sensitive wetlands that need to be protected.
- The Enviro H series has been independently tested and certified in accordance with EN858 – 1 Class 1 by UniSA and process verification by Manly Hydraulics Laboratory.
  Refer test report Appendix 3
- This EPS is an in-line, multi-chamber and multi-zone system that includes oil/water separator functions.
- All other functions are as detailed in the E Series.

Model	Pipe Size	Treated Flow and Storage Capacity	Plan Dimensions (external length x width)	Depth Below Invert	Mass	Excavation Volume
Enviro H30	Nominally 300 ID. Can be used for 375mm ID subject to gradient and velocity	22 litres/sec 0.6 m^3	1.5m x 0.9m	1.2m	3.2 tonnes	3.2 m^3
Enviro H45	450mm ID	66 litres/sec 1.3 m^3	2.2m x 1.2m	1.4m	6.3 tonnes	6.1 m^3
Enviro H60	600mm ID	142 litres/sec 2.0 m^3	2.8m x 1.2m	1.8m	9.9 tonnes	9.3 m^3
Enviro H75	750mm ID	258 litres/sec 7.7 m^3	3.6m x 1.95m	2.2m	16.9 tonnes	16.1 m^3
Enviro H90	Nominally 900 ID. Can be used for 1,050mm pipe size subject to gradient and velocity	419 litres/sec 8.1 m^3	4.35m x 1.95	2.0m	19.2 tonnes	18.7 m^3

Oil removal as per EN858-1	99.95%
Gross pollutants	100%
Suspended solids	94%
Total Nitrogen	85%
Total Phosphorous	97%
Other factors include:	
Treated flow of pipe diameter[1]	30%
Hydraulic resistance, k factor	0.425
Nominal service intervals [2 & 3]	1year
Maximum particle size by-pass	500µ
Nominal particle size capture	100µ
Design service life	100 years

The above table shows the percentage reductions based on test results



Note 1: Treatment continues after this level is exceeded enabling capture of higher density materials transported by increased energy in flow resulting from higher rainfall intensity.

Note 2: Additional storage of a further 1.4 m^3 is available before unit performance is compromised.

Note 3: Load volume allowance of 1m^3/ann based on ARQ section 3.7.

3.4 OE Series – High Risk catchment with risk of bulk oil spillage

- High risk catchments typically include the handling, storage and dispensing of total petroleum hydrocarbons (TPH). This may also extend to other chemicals.
- The bulk spill volume can be adjusted to suit the assessed risk volume which may vary from 0.5 to 20kL in one (1) device. Larger bulk spill volume can be provided (M Series).
- The Enviro OE series includes the H Series oil/water separator insert which has been accredited to EN858–1.
- Included is a reservoir which functions as a secondary oil scum removal. A 2m deep water trap provides a secondary polishing process, reducing the potential for TPH presence in the outflow.
- The reservoir also acts to contain bulk oil spills by causing the oil to displace water, relying on the natural differential in density.
- The OE Series are full retention separators for the oily water stream. The remainder of catchments may also be treated by applying a flow control chamber ahead of the nominated device.
- The insert retains its feature of being a multi-chamber and multi-zone with an intermediate coalescent plate separator to achieve EN858-1 compliance.
- All other functions are as detailed in the H Series.

Model	Pipe Size	Treated Flow & Sediment Storage	Bulk Spill Capacity (Litres)	Plan Dimensions (external length x width)	Depth Below Invert	Mass	Excavation Volume
Enviro OE30	Nominally 160mm HDPE	22 litres/sec 0.33 m^3	11,242L	2,870m dia	2.15m	8.6 tonnes	16.9 m^3
Enviro OE45	Nominally 225mm HDPE	66 litres/sec 0.76 m^3	11,064L	2,870m dia	2.11m	9.6 tonnes	16.9 m^3
Enviro OE60	Nominally 315mm HDPE	142 litres/sec 1.33 m^3	10,471L	2,870m dia	2.02m	10.2 tonnes	16.9 m^3

Oil removal as per EN858-1 [2]	99.95%
Gross pollutants	100%
Suspended solids	94%
Total Nitrogen	85%
Total Phosphorous	97%
Total Secondary Oil Removal [3]	99.99%
Bulk Spill Containment	10,000L
Treated flow of pipe diameter [1]	100%
Hydraulic resistance, k factor	0.425
Nominal service intervals	1year
Maximum particle size by-pass	500µ
Nominal particle size capture	100µ
Design service life	100 years

The above table shows the percentage reductions based on test results



Note 1: The OE Series is a full retention separator with no bypass.

Note 2: The internal processing cartridge complies with EN858-1which acts as the primary oil/water separation function.

Note 3: Water discharging from the insert exits as a laminar flow allowing any residual scum to be captured by a 2m deep water trap acting as a secondary oil removing function. Typically, this will remove all residual oils.

4 Enviro Series and Size Selection Guide

The Enviro EPS range is divided into three catchment load/risk categories with the final model selected based on pipe size, treated flow and enclosure load requirements. There are other selection criteria to suit other stormwater issues such as OSD and other site related factors.

The following guide will assist in determining a recommended EPS. For further technical support contact Enviro's team of Engineers – info@enviroaustralis.com.au or via our website www.enviroaustralis.com.au

Project Details

- Project name and details

Catchment Characteristics

- The pollutant type and load concentration from the catchment will determine which EPS level of pollution control is required
- A brief description should define whether activities in the catchment would be regarded as being of low, medium or high impact on the downstream receiving waters

Select EPS Series

Enviro EPS System	H	E	G
Residential Housing Low/Medium Density	✓	✓	✓
Traffic, Passenger Vehicles, Low Density	✓	✓	✓
Residential, High Density	✓	✓	
Discharge to Sensitive Water Body or Wetlands	✓	✓	
Transport Vehicles	✓	✓	
Commercial and Retail	✓	✓	
Industrial Activities	✓	✓	
Transport Terminal	✓		
Fuel Handling and Chemical Process	✓		

Review Treated Flow

- Treated flow has no fixed parameter. It is defined as the volume of water that flows across a catchment and transports at least 90% of the pollutants; and preferably 100% of gross pollutants (*refer ARQ 2.4.2*)
  Refer to Section 5.1

Pipe Diameter

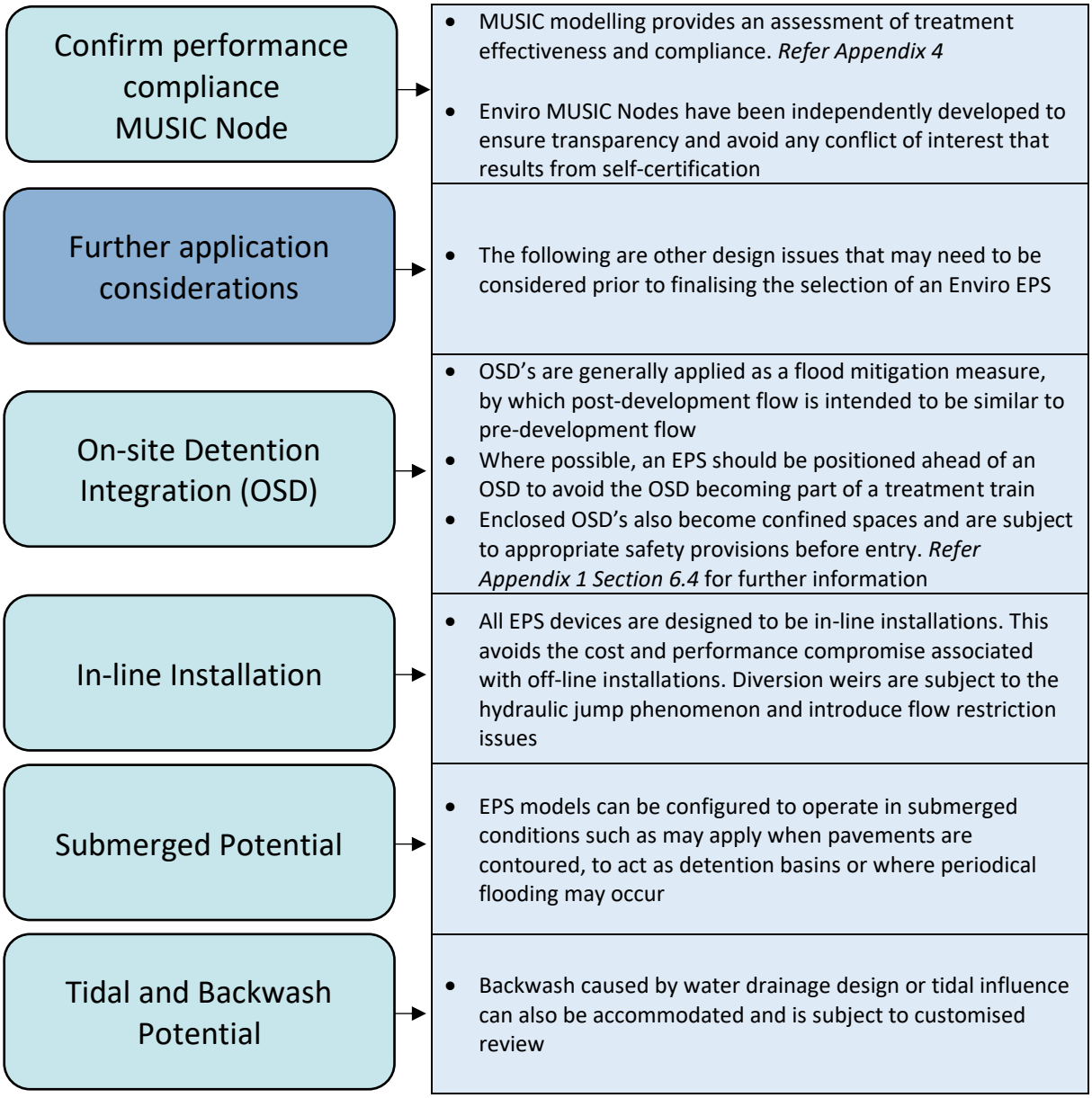
- All EPS models are initially sized on the pipe diameter
- Treated flow is set at 30% of pipe depth
- If the treated flow of the initial model selection is insufficient, select the next larger size with increased treated flow

Flow Rate

- Flow rate refers to the gross flow for 'as designed' pipe diameter and gradient. This will vary subject to flood design conditions for that catchment

Flow Velocity

- Flow velocity is also a consideration. The velocity should, where possible, be limited to 3m/sec. If flow velocity cannot be managed with the drainage system, some custom design may be required


Confirm performance compliance MUSIC Node
MUSIC modelling provides an assessment of treatment effectiveness and compliance. Refer Appendix 4
Enviro MUSIC Nodes have been independently developed to ensure transparency and avoid any conflict of interest that results from self-certification
Further application considerations
The following are other design issues that may need to be considered prior to finalising the selection of an Enviro EPS
On-site Detention Integration (OSD)
OSD's are generally applied as a flood mitigation measure, by which post-development flow is intended to be similar to pre-development flow
Where possible, an EPS should be positioned ahead of an OSD to avoid the OSD becoming part of a treatment train
Enclosed OSD's also become confined spaces and are subject to appropriate safety provisions before entry. Refer Appendix 1 Section 6.4 for further information
In-line Installation
All EPS devices are designed to be in-line installations. This avoids the cost and performance compromise associated with off-line installations. Diversion weirs are subject to the hydraulic jump phenomenon and introduce flow restriction issues
Submerged Potential
EPS models can be configured to operate in submerged conditions such as may apply when pavements are contoured, to act as detention basins or where periodical flooding may occur
Tidal and Backwash Potential
Backwash caused by water drainage design or tidal influence can also be accommodated and is subject to customised review

5 Treated Flow

5.1 The most important design parameter for determining size and type of SQID

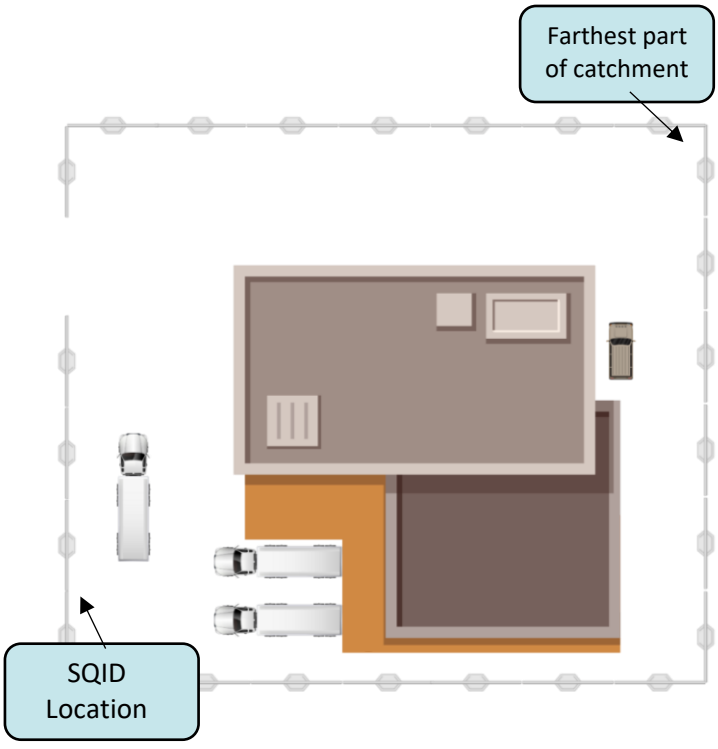
Treated flow is one, if not **the** most important design parameter in determining the size and type of a Stormwater Quality Improvement Device (SQID).

The following is a simple method of estimating treated flow:

1. Determine the longest drainage leg on a time basis
2. Calculate flow volume at the proposed SQID location factored by time lag
3. Apply that flow as the minimum flow that should be treated

The following diagrams illustrate the treated flow determination process. For further information *refer to Appendix 1 Section 6.2.2*

Fig 5.1.1 Illustrates a typical warehouse property with drainage lines servicing impervious yard and roof areas.



As rainfall begins, water level rises across the catchment and induces flow overland, gathering contaminants before flowing into drains.

Water volume collected at pit P1, P2 and P3 are approximately equal at this stage, subject to the area serviced by each pit. *Refer Fig 5.1.2.*

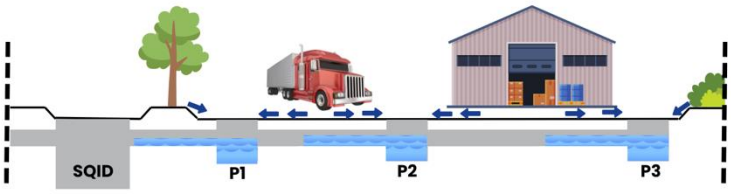


Fig 5.1.2

As rainfall continues, the volume of upstream water aggregates with P1 and P2 merging before water from P3 merges with P2 and ultimately to P1 and the SQID.

During the time lag for P3 water to reach the SQID, additional water volume has also been fed into the drainage system via P1 and P2. This defines the value of Treated Flow which needs to pass through the SQID to achieve the percentage reduction targets.

This latter flow rate needs to be the treated flow. *Refer Fig 5.1.3.*

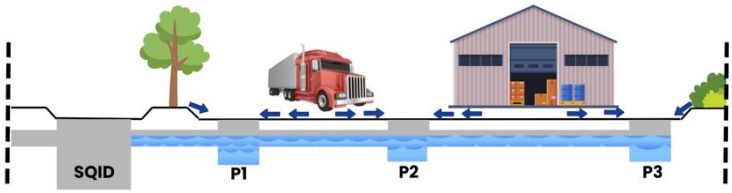


Fig 5.1.3

5.2 The Physics of Treated Flow

Fundamentally, treated flow occurs when there is sufficient energy in the water flow to transport the materials surrounded by that water.

If water falls on porous (pervious) surfaces, water is unlikely to surround those materials. The result would be wet stationary materials. This condition remains for as long as the rate of infiltration exceeds the rate of rainfall. Once the rate of rainfall exceeds infiltration, run-off begins.

The starting point for run-off will vary depending on the surface porosity (permeability), roughness and gradient.

The driving factor is to determine run-off energy. Energy is available in two forms.

Firstly, the explosive energy of rain drops striking the surface mobilises materials, in particular, smaller sized materials such as sediment.

The next available energy is wind, creating a horizontal force. The greater prevailing form of energy is gravitational energy, creating a force to cause water to flow, relative to gradient.

The final component of treated flow is duration (time) required for the flow to transport the material at source to the point of separation and retention.

Refer images 1,2 and 3 for flow stages example.

Treated flow determination is generally expressed in rainfall, as intensity and/or depth. Therefore, to determine treated flow, **both** factors need to be considered.

There is no fixed standard by which treated flow is determined. The range of variables are diverse, complex and unique to a catchment at the time of a rainfall event.

Engineers need to be mindful that they are ultimately responsible for compliance with Environmental Protection Legislation, that has provisions for prosecution. Though suppliers of Stormwater Quality Improvement Devices (SQID's) are responsible for performance claims, Engineers (designers/specifiers) are responsible for catchment related factors; and in particular treated flow.

Further information on treated flow and determination factors is available in Balanced Urban Development, Chapter 6, by Leo Crasti and the included references. *Refer Appendix 1.*



Image 1 **Image 2** **Image 3**

5.3 Treated Flow and Enviro EPS Devices

Enviro G Series are single chamber, in-line devices for capture and retention of pollutants as defined by the ARQ Section 8.5.

Enviro E Series are multi-chamber devices with increased storage capacity and ability to capture fine sediments below 53 microns, along with incidental oils.

One objective of Environmental Protection Authorities (EPA's) worldwide is to have all anthropogenically generated contaminants removed from catchment run-off. That expressed in other terms, is that the load from 100% of catchment should be reduced or removed. The percentage reduction targets are based on the whole catchment.

Treated flow is the portion of run-off that passes through a device and is therefore treated i.e. water quality is improved.

Stormwater quality improvement is defined as reduction of total load transported from a catchment on an annual basis, not just the reduction achieved through a device.

The Enviro EPS treated flow capacity is based on a 1 year, 5 min IFD, that also follows the recommendations made in the ARQ Section 2.4.2. The ARQ recognizes that a 1 year ARI is regarded as necessary to export up to 90% of the catchment load. This depth and rate based on the AR&R87 IFDs is charted as the 1EY, 5min event.

Note: The treatment of a lesser rainfall event is unlikely to reach 90% transport of pollutants, reducing effectiveness dramatically, and hence compliance of a device set at a lower ARI.

A 1-year ARI treated flow is typically required to compensate for the time lag in drainage pipe runs, enabling the farthest entry pit water to be treated **before** by-pass commences. This has been determined through a review of typical projects and analysis of national BOM data as *shown in Fig 5.3.1.*

	IFD, sample analysis of Australian Industrial Centres						
ARI, years	1	2	5	10	20	50	100
average, mm/hr	95	123	157	178	206	245	276
as % 100 yr ARI	34%	44%	57%	64%	75%	89%	100%

City	Suburb	Values shown are mm/hr, based on 5 min duration						
Sydney	Glendenning	77	99	128	145	167	196	218
Newcastle	Mayfield	86	110	140	157	179	209	232
Wollongong	Unanderra	116	147	182	202	228	263	288
Melbourne	Campbellfield	49	65	89	105	127	159	185
Adelaide	Wingfield	40	55	78	96	120	156	188
Perth	Welshpool	60	80	104	122	147	184	215
Darwin	Winnelle	151	191	229	252	286	331	367
Brisbane	Wacol	114	147	188	212	245	289	323
Cairns	Portsmith	127	163	207	233	269	315	351
Townsville	Bohle	115	149	195	222	259	306	343
Gladstone	West Gladstone	110	143	184	209	243	289	326

City	Suburb	values shown are % of 100 year, 5 min IFD						
Sydney	Glendenning	35%	46%	59%	67%	77%	90%	100%
Newcastle	Mayfield	37%	47%	60%	68%	77%	90%	100%
Wollongong	Unanderra	40%	51%	63%	70%	79%	91%	100%
Melbourne	Campbellfield	26%	35%	48%	57%	69%	86%	100%
Adelaide	Wingfield	21%	29%	42%	51%	64%	83%	100%
Perth	Welshpool	28%	37%	48%	57%	68%	86%	100%
Darwin	Winnelle	41%	52%	62%	69%	78%	90%	100%
Brisbane	Wacol	35%	46%	58%	66%	76%	89%	100%
Cairns	Portsmith	36%	46%	59%	66%	77%	90%	100%
Townsville	Bohle	34%	43%	57%	65%	76%	89%	100%
Gladstone	West Gladstone	34%	44%	56%	64%	75%	89%	100%

Data Supplied By: Australian Government, Bureau of Meteorology

Fig 5.3.1

Fig 5.3.1 is an analysis of rainfall IFD's published by BOM Australia across the major cities and suburbs that attract commercial development.

An assumption is that pipe sizes are set at 100-year 5min IFD. The conclusion drawn from this analysis is that on average, 1 year 5 min IFD is equivalent to 34% of a 100-year 5 min IFD.

Therefore, setting the diverter at a nominal 30% of pipe depth approximates the treatment volume (flow rate) necessary to capture 90% of the total catchment load.

5.4 Treated Flow and Bypass

The **Enviro G and E Series** have the same operating method for internal diversion of water into the treatment chamber. Both devices are in-line and are pre-set to treat approximately 30% of the pipe maximum flow capacity, before by-pass begins.

Fig 5.4.2 shows the flow entry exclusively passing into the process chamber. This is further illustrated in *Fig 5.4.2(a).* The lower portion of the pipe flow is diverted by a horizontal separator into the primary chamber. Materials are collected and deposited into the lower storage chamber where a quiescent state has been created.

Fig 5.4.2(a)

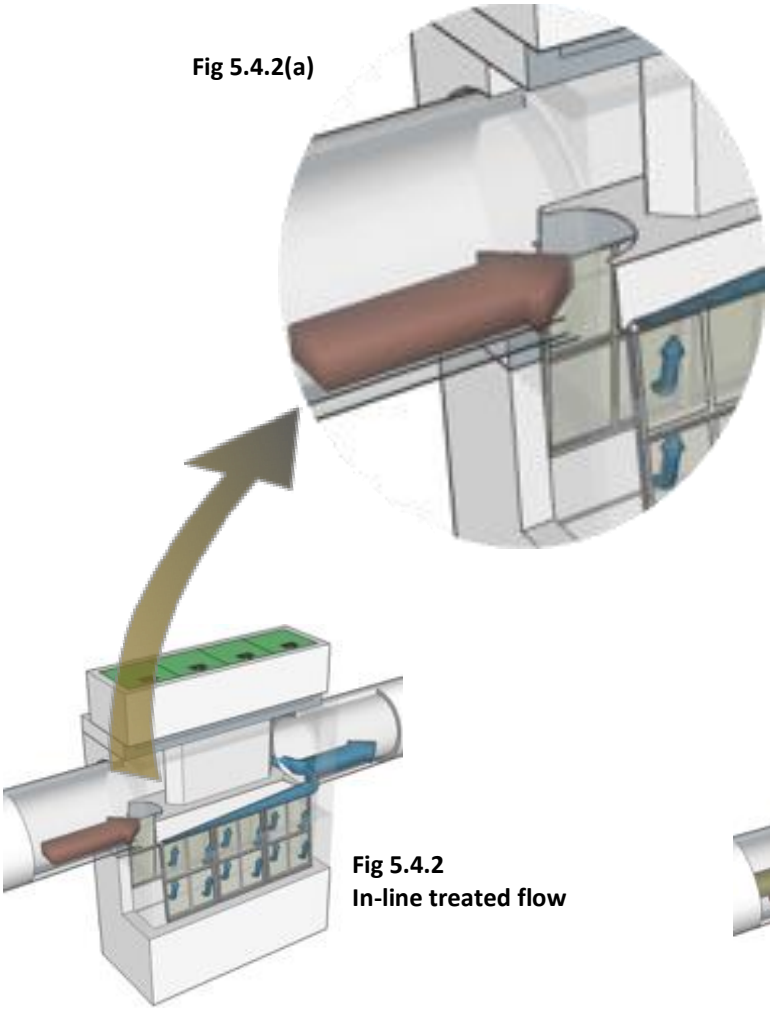


Fig 5.4.2
In-line treated flow

Fig 5.4.3 shows how the treatment of flow continues after by-pass commences. The fixed horizontal separator continues to divert the lower portion of the pipe as flow rate and velocity increases. This feature increases the treatment capacity allowing for capture of higher density materials that are transported by the increased energy of higher flow rates and velocity.

Fig 5.4.3(a) further illustrates the 'over' nature of the by-pass. Water flows around a central turret installed for ease of access to inspect and service.

Fig 5.4.3(a)

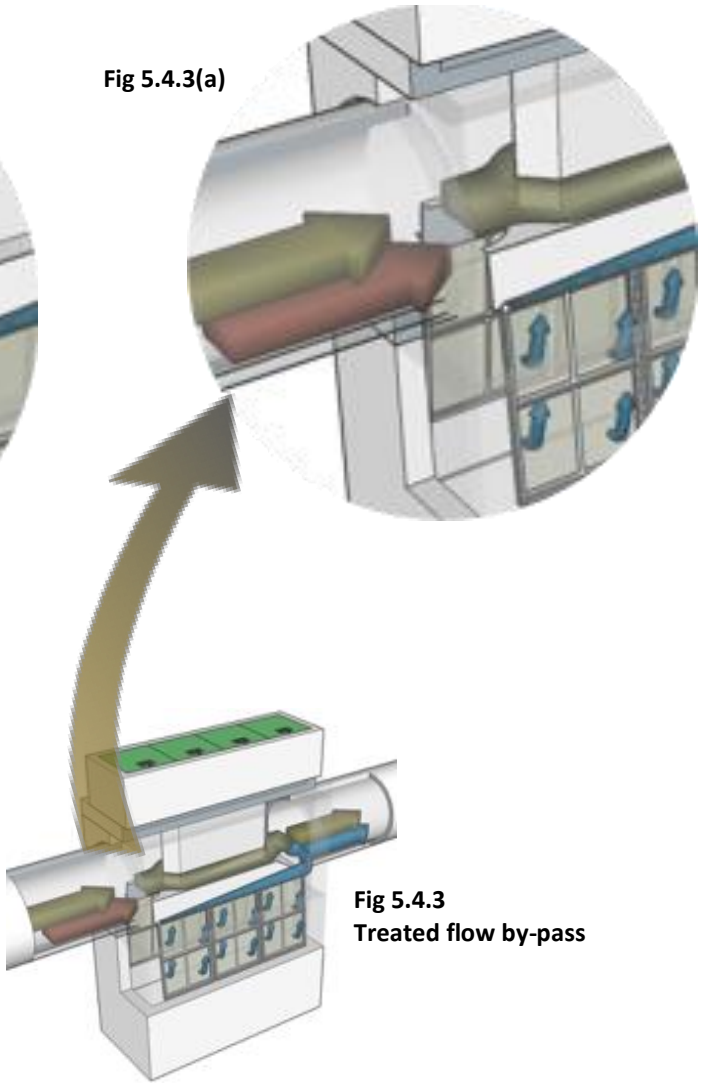


Fig 5.4.3
Treated flow by-pass

The area around the central turret is greater than the pipe area, eliminating hydraulic impedance. Even at trickle flows, re-suspension and remobilization does not occur due to the positive water flow. This feature was noted in the Manly Hydraulics Laboratory testing that reported 100% capture of gross pollutants and no re-suspension.

5.5 Off Line Diversion: Issues to be Considered

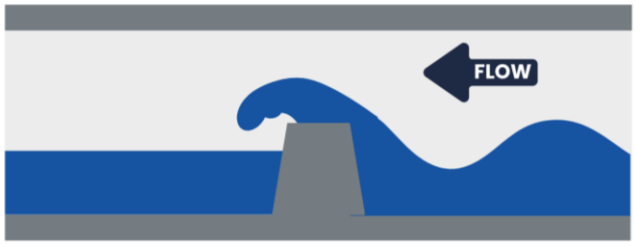
Though off-line diversion may be used in large custom designed installations, the Enviro EPS standard range are exclusively in-line installations.

Weirs used to divert water are well known to exhibit hydraulic jump properties and subsequent draw through. This is illustrated in *Fig 5.5.1 and 5.5.2*

Fig 5.5.1



Fig 5.5.2



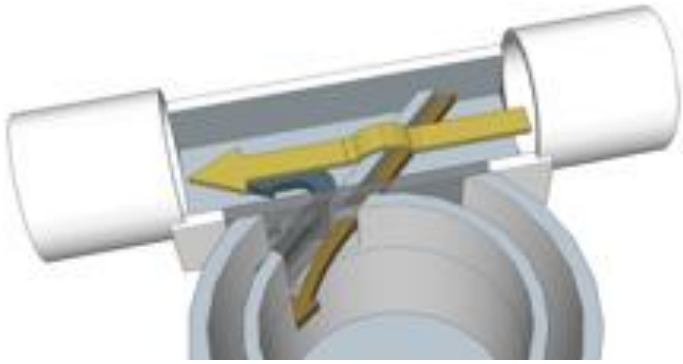


Fig 5.5.4
By-pass begins

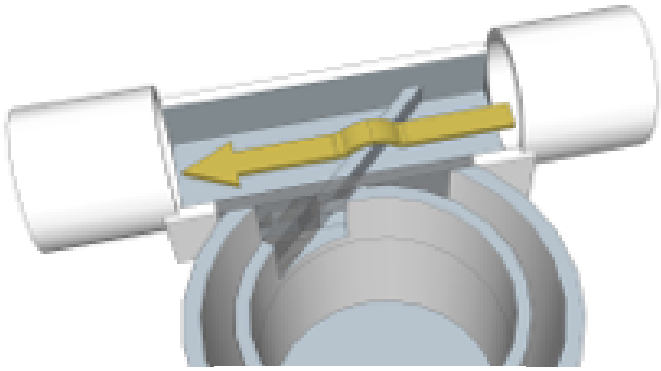


Fig 5.5.5
Total by-pass occurs

Hydraulic resistance within off-line devices will also influence the critical flow at which hydraulic jump occurs. *Figs 5.5.3, 5.5.4 and 5.5.5* illustrate where elevated hydraulic impedance may occur, as the outflow from an off-line device is returned back to the downstream side of the weir.

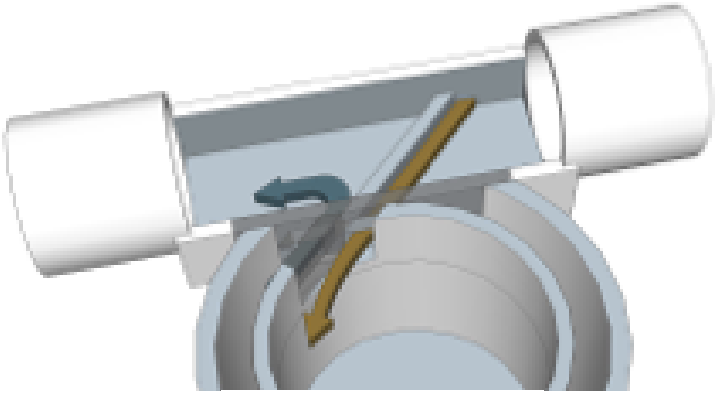


Fig 5.5.3
Off-line treated flow

Figs 5.5.4 and 5.5.5 illustrate the flow path that is generated as flow increases. The initial stage diverts the flow, however hydraulic resistance of the greater flow path, plus the energy change at the weir causes the main flow height to rise immediately prior to the weir.

A factor often overlooked is that as the flow increases, the differential height across the weir reduces, creating competing factors.

When the hydraulic jump starts, some diversion continues. However, when critical flow is reached, often at 70% of the weir height, the diversion effectively stops, and all flow continues along the main conduit.

6 Gross Pollutants

6.1 A Minor Part of the Pollutant Load Consisting of Trash and Litter

In Australia, removal of gross pollutants has been the focus of stormwater quality improvement devices (SQIDs) for some time. This category of pollutants remains important to be removed, as it is the source of various pollution-related issues that compromise water quality; such as micro-plastics and increased biological oxygen demand (BOD) in receiving waters. Receiving waters need to include natural waterways and water bodies as well as constructed wetlands designed as part of water sensitive urban design (WSUD).

Enviro has divided gross pollutants into two constituents: trash and litter. The reason for this sub-division is to more clearly understand the impact of the two pollutant types.

Trash is not organic by definition. These materials are of anthropogenic origin, consisting mostly of package materials that do not breakdown in a sustainable manner. Plastics now pollute most ocean waters and have been found at depths of 11km. Micro-plastics have now become part of the wider food chain that includes birds and mammals. *Refer Appendix 5*

Litter on the other hand is organic and can be broken down by decomposition that relies on bacterial action. In nature this occurs in leaf litter, soil, ground water and finally in streams, rivers and estuaries before entering oceans.

The urban (built) environment displaces natural surfaces and processes with impervious surfaces causing an overdose of BOD in receiving waters, including oceans. The demand on dissolved oxygen (DO) is extreme, due to the difference between atmospheric availability at 20% and aquatic DO of 5ppm.

Gross pollutants are generally regarded as representing 30% of the gross load discharged from a catchment.

Enviro has classified gross pollutants as being larger than 1.0mm. The process employed to remove particles greater than 1.0mm by default, produced tested results of 100% of both trash and litter removal when the correct level of treated flow has been applied in accordance with the Enviro model selection process.

The photos included *(right)* were taken on 9 January 2019 in Adelaide, South Australia and show the presence of gross pollutants that have bypassed up-stream removal systems i.e. GPTs. Obviously, these have been ineffective.









In 2015, Enviro's Engineering Director, Leo Crasti met with Professor Emma Johnson at the Sydney Institute of Marine Science (SIMS) to express concern about micro-plastics and fibers. Reports on recent research found micro pollutants were accumulating inside the gut of fish removed from Sydney Harbour confirming the need for concern.

Other research also showed the presence of similar pollutants in the intestinal tract of sediment dwellers (benthic organisms) which form the base of the aquatic food pyramid.

In conclusion, the widespread acknowledgment of the need to remove trash and litter larger than 1mm from waterways has significantly influenced the development of the Enviro EPS system. Its innovative multi-chamber design effectively separates these materials from sediments, enhancing environmental cleanup efforts.

6.2 Microplastics Warning

National Geographic posted a warning that microplastics (pieces of plastic smaller than 5mm) are in the food chain and are now regularly detected in food for human consumption.

Microplastics are being studied by various institutions and environmental groups with findings such as:

- Micro plastics float (travel) in ocean currents and carry bacteria from region to region, altering the micro-organism population.
- They become micro-sponges attracting chemicals that accumulate in lower food chain organisms. Hence, it may not necessarily be plastic in the food chain that is harmful, it may be the chemicals around and within the particles.
- *Refer to Appendix 5* for further insight

Enviro has taken this into consideration and has applied the principle that if possible, all trash should be removed at source.

Enviro systems are designed to **remove all particles**, at minimum 0.5mm and greater. Smaller micro beads are present in waste water; generally present in cosmetics and household products. The risk of plastics entering oceans via storm water will be eliminated with an Enviro EPS applied at source.



Image: Micro plastics found on beaches

7 Sediment

7.1 The Major Transporter of Toxic Chemicals and Nutrients

Enviro has researched sediment and identified the importance of removing sediment generated from urban catchments.

Historically, in an undisturbed environment, sediment which has eroded from land surfaces, is transported to form deep beds of rich alluvial plains and fertile marine beds. This process is gradual and involves integrated processes of organic matter conversion by microorganisms and plants that produce low levels of nutrient content in the sediment.

However, in urban catchments (built environments) comprising of impervious surfaces, run-off water and the content of sediment has changed. Sediment includes raw un-processed organic material and chemicals, previously not present in these types of areas.

The photos opposite, were taken on 20 January 2019 in Adelaide, South Australia, showing the presence of gross pollutants mixed with substantial deposits of sediment. There are clear indications of nutrient release as water levels diminish and water temperature elevates. The presence of increased algal activity with raised water temperature and reduced depth is mostly misunderstood. The cause, or trigger is a combination of:

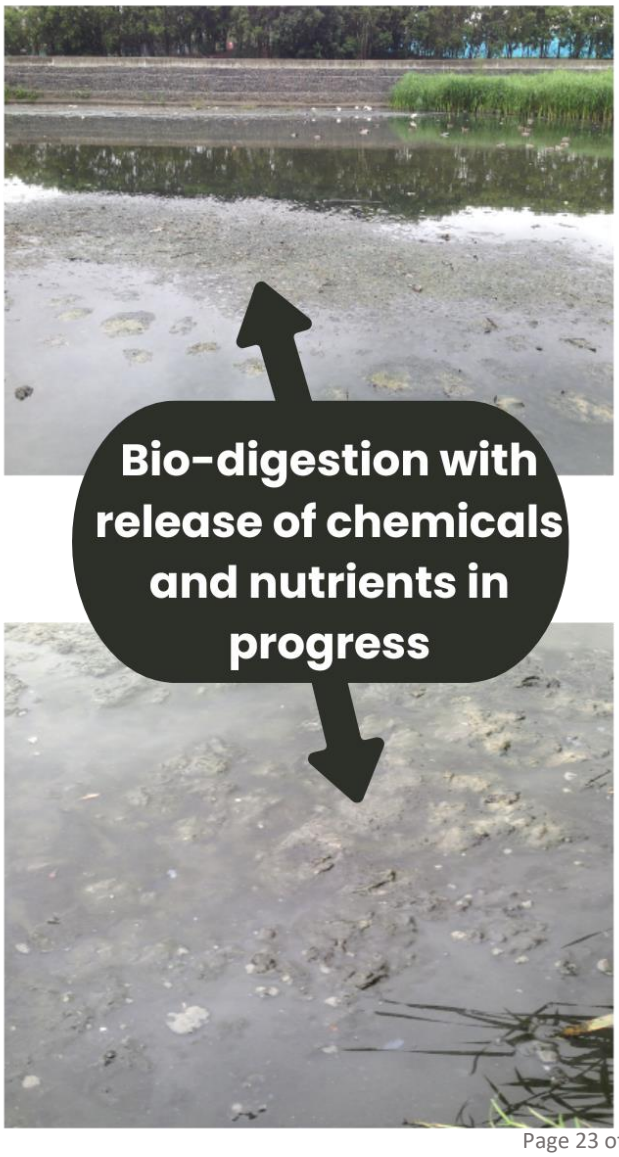
- Increased nutrient levels
- Reduced DO as a result of elevated water temperature due to natural reduced saturation as water temperature increases
- Stagnation, preventing DO replenishment

It is estimated that sediment accumulation in this catchment discharge stream exceeds 100 tonnes per annum.

Remediation, in the form of dredging will need to be carried out in the foreseeable future unless accumulation is mitigated.

Enviro's technology has been designed to remove sediment, reduce biological oxygen demand (BOD) and increase dissolved oxygen (DO) in catchments such as that shown in the photos to the *right*.





7.2 The Nature of Particles

Prior to undertaking full-scale testing, Enviro engineers worked closely with Sydney University to understand the particle bonding mechanism and the strength of these bonds measured in release-rate vs time.

Professor Federico Maggi has independently researched the nature of particles and constructed a method of filming microscopic particles. A 3D diagram of a 40-micron particle is illustrated in *Section 7.3*.

At the same time professor Maggi supervised a study of particulate matter gathered from the Sydney CBD. Analysis of that particulate matter showed high affinity to nutrients, heavy metals and other toxicants.

Visualisation of the particle and grouping of sub-micro particles *(Section 7.3)* provides evidence to demonstrate that the level of particle capacity to bond with various chemical compounds is potentially far higher than previously anticipated.

As illustration *7.3.2* and *7.3.3* show, the particle has three levels of bonding mechanism. *Refer Appendix 6*.

Electrostatic attraction is high as a result of the large surface area created by aggregation of micro particles. Again, driven by the large surface area is the high potential for chemical attraction. Mechanical entrapment also occurs as sub-particles aggregate.

This created an understanding of why sediment beds have such high capacity to trap and retain nutrients and toxicants.

In parallel with particle imaging, Sydney University with assistance from the Australian Mathematical Sciences Institute (AMSI), created a working model of the particle separation process and analysed the mechanism at play. A complex mathematical model was also created using known hydraulic and pore theories and compared the actual performance with the mathematical prediction.

It was demonstrated that the particle separation process was supported by known mechanisms, with the model being used as the basis for future design and is currently embedded in the modelling process used to determine Enviro system size.

Studies were conducted to determine the relationship between nutrient release into solute form vs catchment transport time. The aim was to determine whether during the relatively short time that material is wetted and transported; that nutrient would transfer from bonded to solute form.

Two studies were conducted in parallel. One focused on **phosphorous** and the other focused on **nitrogen**.

The results of the nitrogen release study showed that nitrogen remained bonded to particulate matter and concluded that early removal of urban debris and associated particulate matter was a means of preventing nutrification of urban waterways.

The overall conclusion reached by both studies was that early capture and retention of fine particles was a reliable method of removing the majority of nutrient from storm water flows.

The final process of the Enviro system is the holding of particulate matter in a quiescent state. This process utilises entrapment as observed in nature, where sediment beds capture and hold nutrient and toxicants as mentioned earlier. During the MHL testing, various concentrations and flow rates were monitored while allowing captured materials to aggregate in the storage zone. This was used as a method of replicating actual, real world conditions.

Accumulation of materials during tests that replicated two years of rainfall events showed no evidence of scouring, resuspension and mobilisation of captured materials. All tests were conducted using a known influent mass of pollutants while monitoring discharge water quality. At the completion of testing the materials collected were recovered and assessed to ascertain the net balance of pollutant materials captured.

While developing the current Enviro multi-chamber multi-zone device, process reviews, analysis and prototype testing was conducted using various configurations and methods. Some of these are cited in *Section 11*.

7.3 The Importance of Particle Removal and "The Particle"

Our findings show that timely capture of fine particles is directly proportional to the retention of toxic chemicals and nutrients.

This conclusion was reached as a result of several studies in collaboration with University of Sydney students, mentored by Professor Federico Maggi. The studies included:

- Screening efficiency testing, modelling and computer analysis. *(Fig 7.3.1)*
- Particle column filming and creation of a 3-dimensional model. *Fig 7.3.2* is a photographic image of a 40-micron particle. *Fig 7.3.3* shows an animation of the particle. This research confirmed that particles are compacted micro structures and not solid. The 3D model in *Fig 7.3.3* reveals a complex structure with a large surface area to volume and a high capacity to bond chemicals via electrostatic attraction, chemical and mechanical bonding.
- Field and laboratory data gathering, measuring the release rates of nutrients to solute forms.
- Field studies of wetlands and existing installations.

The research conducted supported the hypothesis, that particles exhibit an ability to retain nutrients and unwanted chemicals to a greater level than expected. This was verified by student field studies that measured the time rate of release of nutrients from accumulated bio-mass in a typical suburban catchment. These field studies were carried out in Sydney's northern suburbs. *Refer Appendix 7*

Results confirmed that negligible release occurred for at least 30 minutes after wetting, confirming that early capture of particles, is a practical method of reducing nutrient and toxic chemical discharge in run-off water.

This research then led to a greater understanding of pollutant categories and characteristics and gave rise to development of the **Enviro E Series**.

Details of this research are available on request, together with an independent review by UniSA.

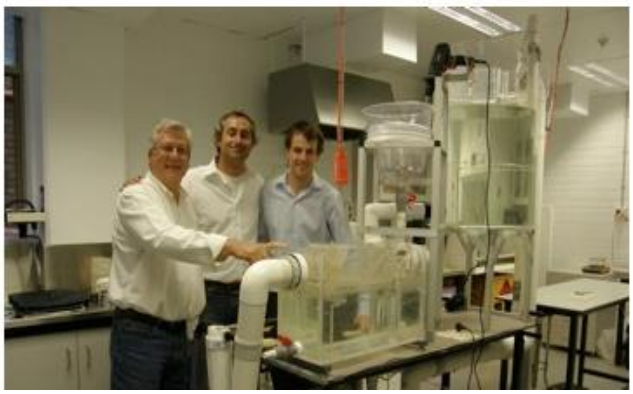


Fig 7.3.1 Laboratory modelling

AMSIIntern
An Innovative University and Industry Collaboration

The University of Sydney program supported by Leo Crasti and mentored by Dr Federico Maggi, created a laboratory simulation of rainfall and pollutant load. This resulted in creation of a world-first mathematics model that is now the basis of the Enviro operating process.

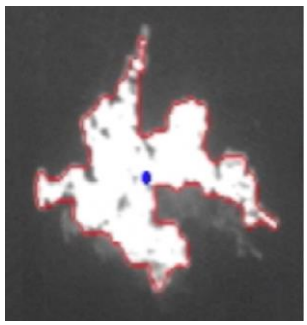


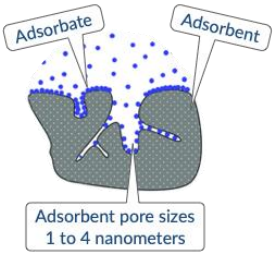
Fig 7.3.2 Photographic image of particle



Fig 7.3.3 40-micron particle model

8 Nutrients

The functionality of media is typically based on adsorption, which operates as illustrated *below*.



For that functionality to operate, influent water must be removed of particulate matter, which if present would cause the media to clog and for the adsorption process to be compromised. In stormwater conditions where the presence of solute chemicals is anticipated, Enviro can supply tertiary treatment modules comprising a suitable media for attracting the predicted solute chemicals from solution.

It is well-recognised that stormwater is the major transporter of anthropogenic pollutants into fresh and marine water environments.

Nutrients are depleting oxygen levels and spawning algal blooms resulting in over-nutrification in many locations.

Nutrients in relation to stormwater are noted as Phosphorous (P) and Nitrogen (N), both of which stimulate algal blooms in marine and freshwater aquatic environments. The major concern is N as this is a significant part of biomass. In an undisturbed environment the N cycle operates in balance, with most remineralization occurring in soil and therefore land-based biomass. The introduction of large impervious areas forces that process downstream into the aquatic environment where the availability of oxygen is greatly reduced.

The aim of pollution reduction targets is to reduce the total load of N, hence the reference to Total Nitrogen as TN. The definition of TN is Total Kjeldahl Nitrogen (TKN = Ammonia (NH_4/NH_3) + Organic Nitrogen) + Nitrite (NO_2) + Nitrate (NO_3). *Refer Appendix 8*

Nutrients in the form of N and P form part of the natural food chain. The ARQ, table 2.5 suggests guideline levels for Total Nitrogen (TN) at <0.5mg/L and for Total Phosphorous (TP) at a level of <0.05 mg/L.

The Phosphorous cycle is simple as it is regarded as the predominant trigger in marine species of algae. Environmental Phosphate is present in low concentrations in rocks, soil and sediment. The urban built environment introduces excess Phosphates in similar input paths as Nitrogen.

Phosphates are released via decomposition, or direct discharge from waste.

The Nitrogen cycle is more complex, where N moves from gas to bio-mass, then breaks down via decomposition to be released as gas or returned to bio-mass. *Fig 8.1* shows the Nitrogen Cycle.

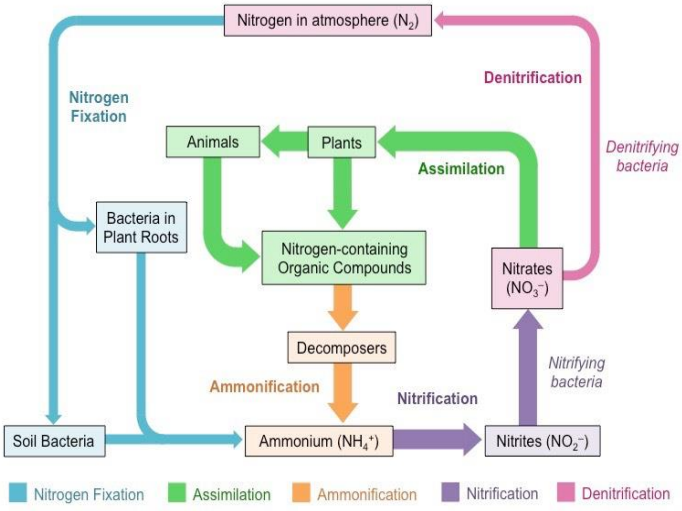


Fig 8.1

We live in an atmosphere that is 78% nitrogen (N_2). N_2 is an inert gas and is not taken up by water, otherwise rainfall would be charged with N_2.

N_2 is converted by bacteria for assimilation by plants, and in turn animals. These are the fixation and assimilation phases.

Decomposition and assimilation have an internal cycle of unstable Nitrogen species converted by bacteria in a balanced process with some N_2 returned to the atmosphere.

Soil bacteria are the organisms responsible for the conversion process.

In atmospheric conditions decomposition is relatively fast due to the availability of Oxygen (O_2), which is approximately 20% of air. In aquatic environments the availability of O_2 is limited to a few parts per million (ppm) typically, 5pmm. Therefore, the rate of decomposition requiring Oxygen is very slow in an aquatic environment.

Though discharge of readily available, N and P stimulates immediate depletion of DO. The receiving of N and P that is part of other biological matter such as Chlorophyll and Protein, still has the same result over an extended period of time. *Refer Fig 8.2*

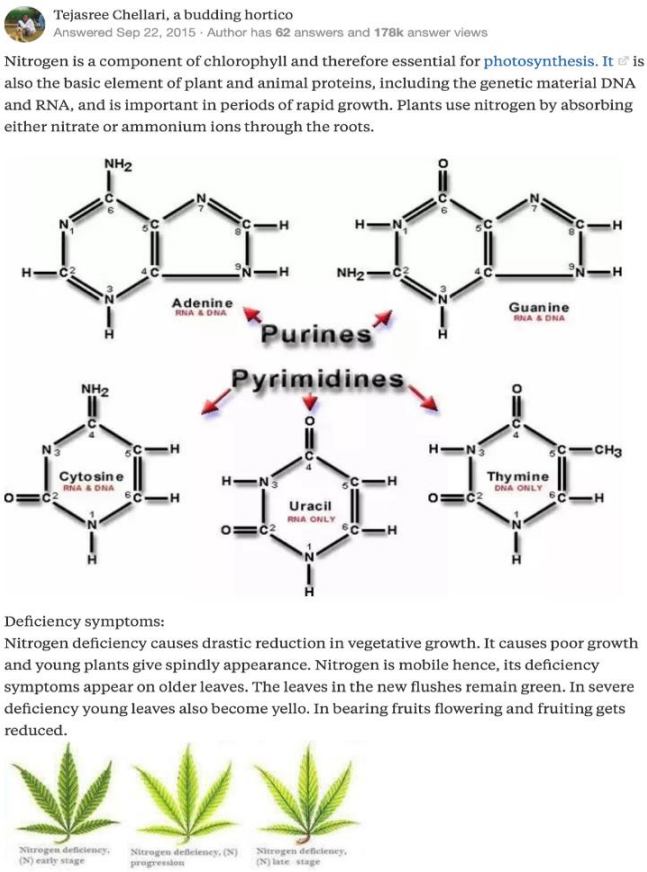


Fig 8.2

Enviro has adopted the principle of removing as much of the source N and P as possible within acceptable constraints determined by the physics and economics of stormwater treatment.

The principles relied upon are:

1. In the case of P that it is bonded to other particles and its origins are typically products that have P associated with its chemistry. P in nature is a rare mineral present in very low concentrations.

2. The presence of N is far more prolific, and the forms vary. All plant and animal matter rely upon N as a critical ingredient. N is not taken up by water except in certain circumstances, since the atmosphere is 78% N. Fortunately this does not occur, because if it did, water in storage tanks would be toxic. Acid rains have been caused by uptake of chemicals by rain in the atmosphere, however these chemicals are present in atmospheric suspension as fine particles.

Urban environments have disrupted the natural relationship between rainfall, organic matter, decomposition and conversion to biomass. In an undisturbed environment a small amount of N is utilised as nutrient for aquatic organisms. The urban environment creates large impervious surfaces and pollutant load is transported by stormwater down drains into the aquatic environment which receives an overdose. That overdose is now defined as pollutants. It is this overdosing that is to be reduced.

8.1 Pre-Urbanisation

In an undeveloped environment, leaf litter, plants and animals are broken down (decompose) due to the high availability of Oxygen from the atmosphere. Various organisms participate in the process. As matter decomposes, N in various forms is produced and converted by bacteria, typically in the presence of water in the soil where plants assimilate Nitrates; or it is returned to the atmosphere as N_2.

Farmers and gardeners are well aware that Nitrates are readily taken up by plants and stimulate growth. In a well-balanced natural environment, the Ammonia through Nitrite to Nitrate phases are relatively short. A walk in any natural bushland reveals layers of leaf litter, compost and sweet-smelling soil.

Fig 8.1.1 illustrates the pre-urbanisation passage of water that delivers low concentrations of refined nutrients to the aquatic ecosystem.

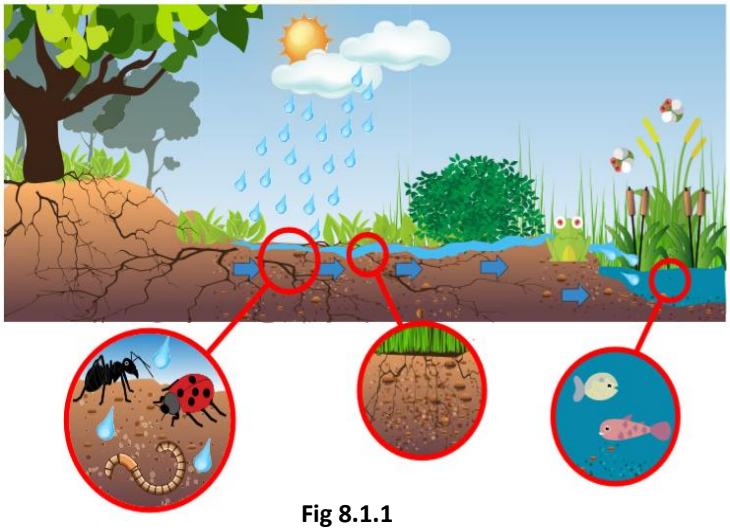


Fig 8.1.1

8.2 Post-Urbanisation

Urbanisation dramatically alters the Nitrogen cycle, removing the environment that enables decomposition to occur over time – weeks, months and years. Raw unprocessed biological material is transported within minutes directly to receiving waters.

This bypass of the natural decomposition phase also brings a compounding effect, due to availability or lack of Oxygen (O_2). Decomposition previously had access to air, which is approximately 20% O_2. In the aquatic environment O_2 is reduced to an average of 5 ppm.

Fig 8.2.1 illustrates water run-off in an urban area.

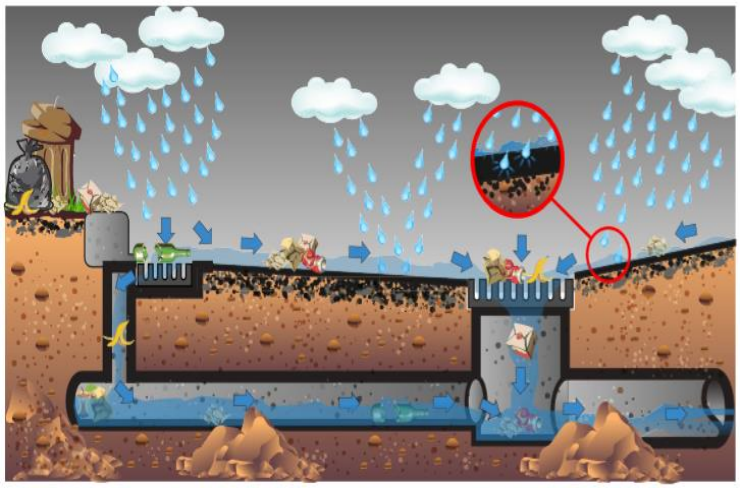


Fig 8.2.1

Most urban catchments have impervious areas representing approximately 50% of the total surface area. Rainfall on these surfaces has higher energy and greater capacity to mobilise load into stormwater drains. Most stormwater drains are round pipes, which are favoured as they convey water at very low gradients, a factor in fluid dynamics associated with flow, hydraulic gradient and velocity.

Flat gradients cause materials to accumulate during low flow conditions due to flow energy being insufficient to mobilise the material. As flow increases, materials are suddenly mobilised, creating short-term high concentrations. All of these conditions compromise sample methods described in *Section 10*.

The urban-built environment alters the cycle through many factors, mainly:

- Removal of soil habitats where plants grow, and bacteria exists.
- Increased load density of organic matter that will decompose.
- Introduction of pre-processed matter, such as sewage discharge and animal waste.
- Addition of other forms of Nitrogen via fertilisers, waste, and consumer products, etc.

Allowing these to enter water bodies drives eutrophication and depletion of Dissolved Oxygen, compromising aquatic bio-diversity.

8.3 Removal of Nutrients – Nitrogen and Phosphorous

Removal of TP and TN is fundamental to improving water quality in fresh and marine ecosystems.

Environmental Protection Authorities nominate reduction targets of:

- TN reduction - 45%
- TP reduction - 65%

Enviro systems are designed to comply with reduction targets by removing the major source of TN and TP; being fine particles, defined as suspended solids. It is an established principle that both TN and TP are primarily transported by these fine particles. Nutrient tests carried out by UniSA in February 2020 show that the EPS removes 85% of N and 97% of P.

References:

- Email from Baden Myers, Research Fellow UniSA. *Refer Appendix 9*
- UniSA report on Nutrient Reduction.
- *Refer Appendix 10*
- Suspended solids, various articles and studies

  https://www.sciencedirect.com/topics/earth-and-planetary-sciences/suspended-sediment

The urgency for reduction in nutrient discharge is emphasized in a science report published in January 2015 (*refer* https://science.sciencemag.org) that analysed the planet's sustainability factors and identified over-nutrification having reached critical levels adjacent to many high population areas.

The Enviro method of removing nutrients is based on the following principles:

1. Anthropogenic pollutants include litter and other organic matter including Nitrogen.

2. Sediments, which are more closely aligned to soil and detritus in the sub 1.0mm size range include banded forms of N and P.

3. The presence of solute forms of nutrient varies by catchment but is not a usual occurrence in catchments that are newly designed and constructed. This would require permanent water bodies to be included, and these are repositories for organic matter that induces high presence of BOD and low DO.

4. If solute forms of N are present, Enviro has measures available to compliment the natural process of conversion, release to gas or conversion to bio-mass.

Enviro Engineers in developing the EPS processes, referred to existing contemporary understanding and in-house research to establish a cost-effective method of removing nutrients from stormwater flows to meet nominated reduction targets.

These reduction targets are achieved by removing particulate matter to sizes defined as fine sediment within the Enviro multi chamber EPS. The processes included in the EPS are separation, settlement and consolidation awaiting recovery.

The following is an explanation of development, research and principles employed as well as some reference material. Further reference material is available upon request. Alternatively, more evidence can be found by conducting personal website research.

Current accepted science is that Phosphorous is mostly bonded to particles. There is little evidence that solute forms are present in stormwater discharge. Phosphorous is naturally an exotic mineral that is present in very low concentrations. Phosphorous is currently recognised as the major trigger for algal blooms and phytoplankton.

Nitrogen in its various forms, however, is readily available in the environment and there has been much concern that solute forms of Nitrogen need to be removed from storm water as a priority.

Studies conducted over recent years have concluded that particle bonded Nitrogen is the major form transported in storm water drains. Therefore, meeting the 45% reduction target is best achieved by removing fine particles, as test results confirm. *Refer Dissolved Organic Nitrogen:*

https://www.sciencedirect.com/science/article/pii/S0048969717331649
and
https://www.sciencedirect.com/topics/earth-and-planetary-sciences/dissolved-organic-nitrogen

The eWater MUSIC model also assumes that N and P are transported by particulate matter.

Refer MUSIC Manual
https://wiki.ewater.org.au/display/MD6

8.4 Further Discussion

Solute forms of Nitrogen are difficult to remove as these are in the size realm of < 1 micron and more likely 0.2 microns. N.O.G. Jorgensen has written and defined properties of N in various forms as detailed in his article. *Refer Fig 8.4.1*

In nature, solute forms are readily taken up by vegetation and converted by bacteria that typically occurs in natural wetlands.

Although the application of adsorption media can reduce the level of solute forms, in practice, media performance quickly declines as a result of blinding caused by fine particles. Therefore, if adsorption media were to be used, removal of fine sediment is a precursor.

The ARQ defines fine sediment as particles of < 62 microns. Other studies have created a definition of suspended solids as being < 500 microns. *Refer sediment and bedload discussion papers at:*

https://www.fondriest.com/environmental-measurements/parameters/hydrology/sediment-transport-deposition/

These studies point out that larger particles should be considered as bed-load and should not be taken into account as part of the totally suspended solids (TSS) reduction target which is typically 80%.

Organic Nitrogen

N.O.G. Jørgensen, in Encyclopedia of Inland Waters, 2009

Definition of Nitrogen Pools

Organic nitrogen in aquatic environments consists of truly dissolved organic nitrogen (DON) and particulate organic nitrogen (PON). DON is defined as material that can pass a 0.2-μm filter, while PON is the material that is retained on the filter. This means that PON includes both dead organic matter and living organisms that are larger than 0.2 μm. The definition of DON as material being smaller than 0.2 μm is a practical, operational term rather than a biologically or chemically well-defined term. DON includes a variety of organic molecules and compounds, ranging from small molecules like urea and amino acids, to peptides and proteins, but does also include viruses and small bacteria.

Another important nitrogen pool in all aquatic environments is dissolved inorganic nitrogen (DIN), which consists of ammonium, nitrate, and nitrite. Thus, the content of total dissolved nitrogen (TDN) is made up by DIN and DON.

Concentrations of DON in rivers and lakes have been found to vary from 3 μM N in low-productive, oligotrophic waters to about 100 μM N in eutrophic rivers and lakes. Higher concentrations (>300 μM N) have been measured in waters receiving a high input of nitrogen such as tropical fish ponds. A large portion of DON in lakes and rivers typically originates from release by algae and phytoplankton. Since the biomass of both algae and phytoplankton varies with season and depth, DON concentrations will often show seasonal variations and will also vary with depth in lakes. Further, DON can be transported by rivers and streams into lakes and introduce large local variations in concentrations.

Fig 8.4.1

8.5 Development of Enviro Systems

The Enviro systems have been developed based on a similar conclusion, i.e. particle removal is biased to < 500 microns. During full-scale testing at Manly Hydraulics Laboratory (MHL) the Enviro process was stress tested using sediment recovered from discharge of a sediment basin at the Blacktown International Sports Park.

The sediment profile was 90% below 500 microns and 35% below 53 microns. Removal rates exceeded 80%. *Refer to Process and Performance Testing at Section 3* of this manual. This particle size distribution profile follows very closely the profile of particles found to be the major transporter of TN.

8.6 The Enviro Final Design

The final design has taken two separation principles into account:

The first separation principle is that floatables need to be separated from sediments. Floatables are directed from gross influent materials into a secondary chamber via a one-way weir preventing further breakdown and remobilisation. This enables sediments to be removed from the flow and retained in a separate storage sump.

The second separation principle is the screening of fine particulate matter while eliminating the tendency for screen blinding. This has been achieved by Enviro after substantial hydraulic in-house testing and with University assistance. Design and construction of this remains part of intellectual property associated with EPS performance.

In summary, the process was tested and proven to reliably remove particulate matter < 20 microns without compromising screen performance. In addition to the unique design, particles are directed into a lower quiescent storage zone. *Refer Fig 8.6.1*

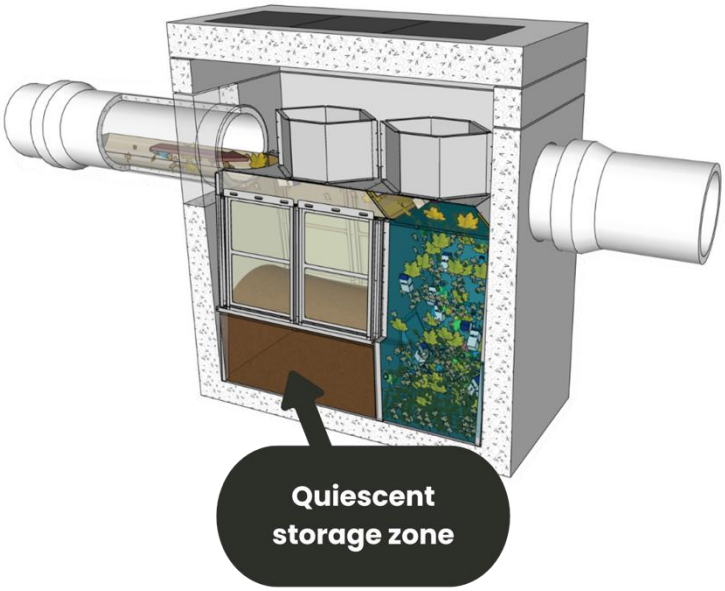


Fig 8.6.1

9 Testing

Enviro has adopted empirical testing methods where full-scale systems are exposed to in-field flow rates that can be dosed with known pollutants at pre-determined concentrations. *Refer 8.2 Post-Urbanisation.*

The outflow volume is completely captured and then filtered to determine the composition and quantity of by-pass. This provides an absolute measure of performance across variables of flow, pollutant mix and concentrations.

9.1. Enviro Testing and Proof of Performance

The following summarises results and conclusions derived from university research and independent testing which included Ecological Consultants Australia, SESL (NATA Certified Laboratories) and Manly Hydraulics Laboratory (MHL) in Sydney. *Fig 9.1.1* shows the testing facility at MHL.



Fig 9.1.1

A full-scale model equivalent to the Enviro E45 was tested. Over 1.0 megalitre of water was processed, simulating about 38 rainfall events with varying concentrations of pollutants.

The published test results are in summary:

1. Gross pollutant removal……100%
   Construction of the Enviro devices includes proprietary screening with apertures of 1mm or less. The entry is one-way - reverse flow is impossible - and the configuration does not allow re-suspension.
2. Sediment removal……86%
   Testing utilised a PSD with a bias towards fine sediment where 90% were less than 500 microns and 35% of the particles were less than 53 microns. Removal rate achieved was 81% to 86% across a range of flow rates and concentrations.
3. Nutrient removal, potentially ……80%
   The fact that sediments are the major transporters of TN and TP is well established. This only varies for discharge from wetlands where release has occurred. Sydney University students researched the release rate of both N and P from catchment materials and concluded that wetted durations of greater than 10 minutes were required, to achieve significant release. These studies confirmed that early capture of particles represented a viable method of substantial nutrient export.

Enviro, in conjunction with Civilmart, established a world first testing facility, that can mimic rainfall events and provide proof of performance. *Refer 9.1.2 and 9.1.3*

In October 2018, the Enviro H model was tested in accordance with EN 858-1 to confirm oil/water separation in addition to the removal of stormwater pollutants and in February 2020 the EPS was tested for nutrient removal. These tests were conducted by UniSA.

The oil/water separation tests included continuous dosing of raw diesel oil into the influent for 20 minutes. After this duration of accumulated oil, discharge water samples were collected and tested.

The results proved that 99.95% of the oil was separated and collected. Only 4.1 ppm was detected in the out-flow samples.

Nutrient testing involved dosing the inflow with leaf litter, grass clippings, soil and potting mix



Fig 9.1.2

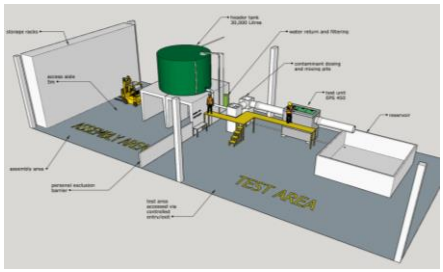


Fig 9.1.3

10 Field Validation

10.1 Sampling

Stormwater is difficult to sample in the field, predominantly because of flow infrequency and the constraints of retrieving samples.

Sampling methods proposed by industry associations are based on the use of automatic samplers retrieving small and infrequent samples for analysis. Analysis is then limited to dissolved fractions and some fine particulate matter that may be drawn into the sampling tube. These samples only provide an indicative measure and it is therefore not convincing for them to be used to substantiate broad spectrum pollution removal performance.

Enviro has investigated sampling methods associated with key suppliers such as Sigma and ISCO water samplers. *Refer 10.1.1*

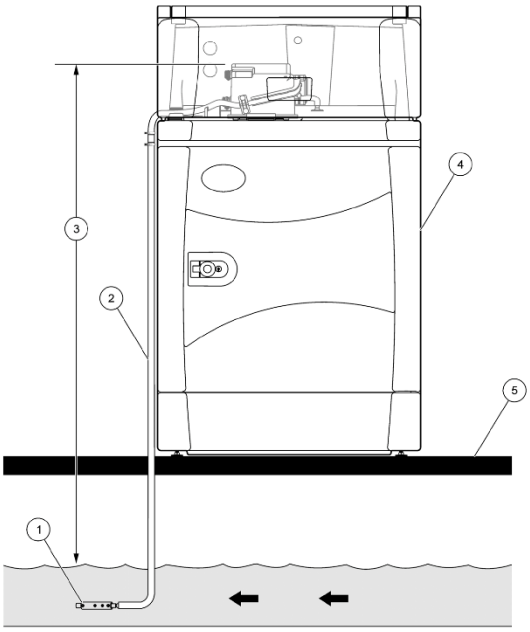


Figure 8 Mounting configuration

1	Strainer	4	All weather refrigerated sampler
2	Intake tubing	5	Mounting surface
3	Vertical lift		

Fig 10.1.1
Automatic water sampler

Samplers from these providers operate on similar principles i.e. the use of a pump to draw a set of samples from pipe water into sample bottles. Limitations of these devices are:

- A small diameter tube (6-10mm) is used to draw a sample.
- The tube nominally faces downstream.
- A strainer is attached to the tube to prevent particles from being drawn into the tube as the pump method operates on a peristaltic principle.
- Samples are relatively small, typically, 1-5L.

There are various factors that will alter validity of samples taken in this manner, such as:

- The position of suction points relative to a location within a pipe, noting that obstructions, changes of direction, pipe joints etc. alter flow patterns and potentially create accumulation of debris. *Fig 10.1.2*

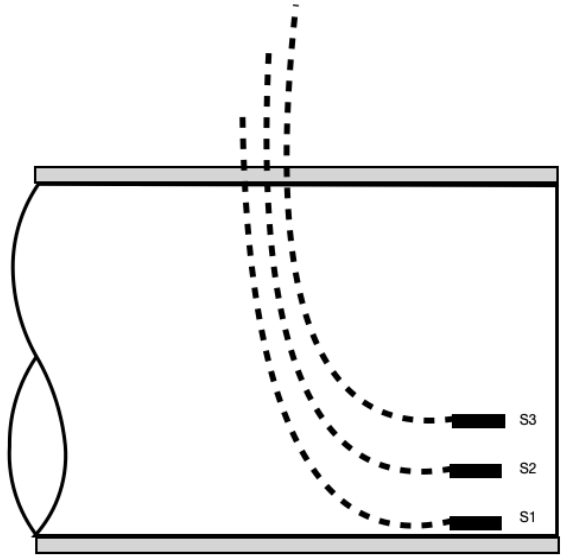


Fig 10.1.2

- Timing of samples is an issue e.g. if the first sample is taken at a trickle flow the sample may include air and compromise the sample itself as well as the sampling mechanism. *Refer 10.1.3*

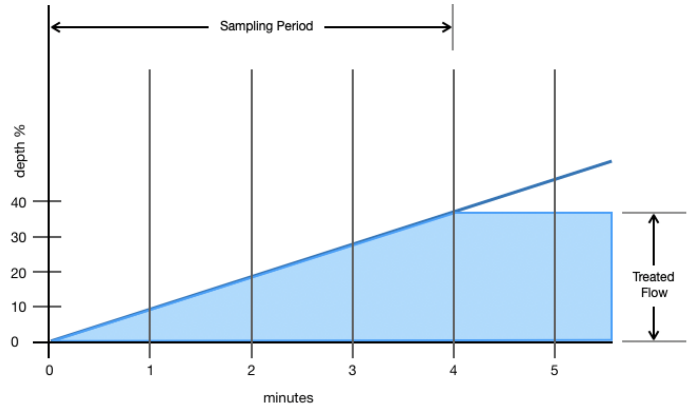


Fig 10.1.3

- The concentration of material may be heavily biased with depth, which causes concern as to where the sample be taken within the pipe diameter.
  Refer Fig 10.1.4

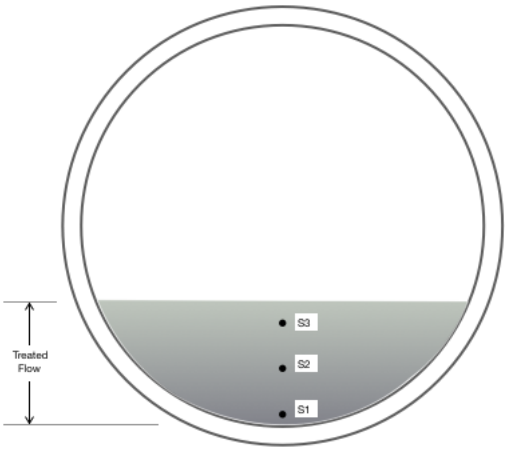


Fig 10.1.4

- The sample may not be as representative as what would occur in a water body that is reasonably homogenous. The constituents within a stormwater drain flow vary substantially by time and may never be replicated.

Suppliers of samplers refer to testing in water bodies such as streams and lakes. There does not appear to be reference to sampling conducted in stormwater drains with intermittent flow.

11 Methods Reviewed and Rejected by Enviro

11.1 Enviro Hydraulic Process Review

During the development of the current Enviro multi-chamber process, various hydraulic flow control methods were trialed.

The following details some of those methods. Enviro discarded most as unsuitable for broad spectrum separation and containment of pollutants.

11.2 Hydro-Cyclones

Hydro-cyclones are circular screens where cyclonic or vortex action is encouraged, with materials captured on the inside of a cylinder allowing water to escape outwards. *Refer Fig 11.2.1*

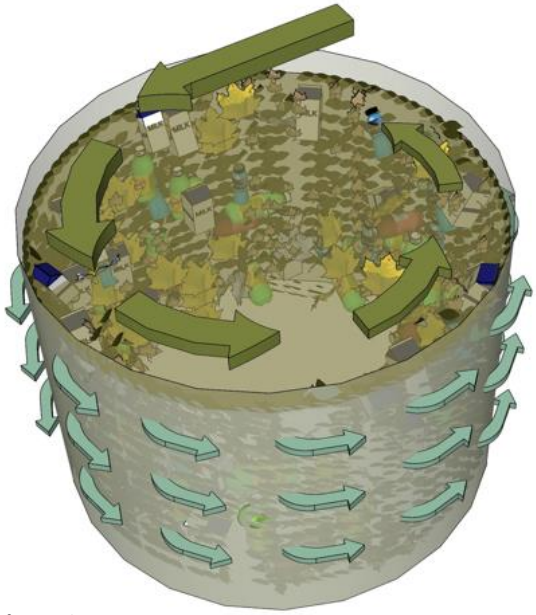


Fig 11.2.1

This process is contrary to normal centrifugal based cyclones where heavy matter is projected to the outside while clean fluid is drawn from the centre. Floatable materials contribute substantially to a grating effect which causes fine sediments to pass through the screen. Organic matter, particularly resident from previous rainfall events, breaks down and by-passes the screen. The observation was documented by Professor Gavin Birch. *Refer research article:*

http://dx.doi.org/10.1080/15730620902807056

Infiltration or media was also tested as a potential process in a treatment train after larger (gross pollutants) were removed. This method was discontinued as the life expectancy of media was limited and replacement caused high service costs.

Hydro-cyclones *(Fig 11.2.2)* are widely used to remove sediment in pipe lines. Efficiency is directly related to flow velocity generating a centrifugal force *(Fig 11.2.3)*, which causes materials to be thrown to the outside, while clean water flows from the centre of the vortex.

This same principle is used in dust extractors *(Fig 11.2.4)*. The main factors that caused Enviro to disqualify this method from serious consideration are the variable flow velocities in a drainage system, coupled with awkward configuration of pipe work.

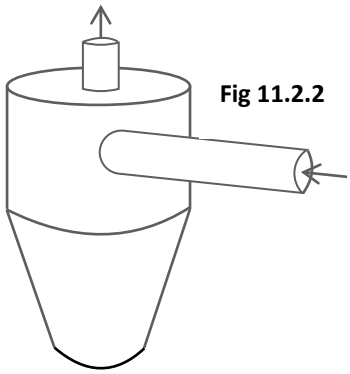
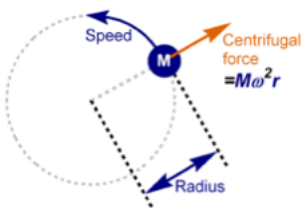


Fig 11.2.2

Fig 11.2.3



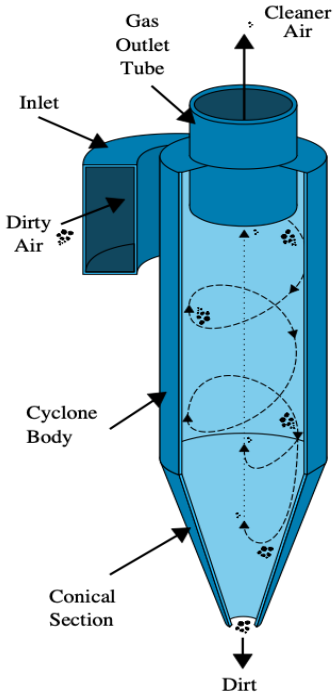


Fig 11.2.4

11.3 Screened Chamber

Enviro reviewed a simple attack screen where water passed directly through a screen causing the screen to act as a sieve. As expected, the sieve principle is limited by the area and size of pores. As pores fill, the aperture reduces and there is accelerated tendency for the sieve to further blind.

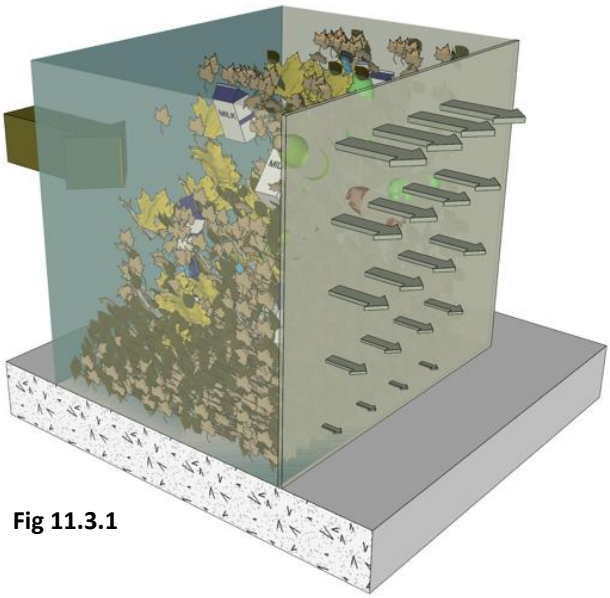


Fig 11.3.1

Fig 11.3.1 shows the principle sometimes employed with an attack screen. Though initially successful, short term blinding of the screen requires servicing immediately prior to a rainfall event. Constant churning during a rainfall event causes particulate matter to be drawn through the mesh and for organic matter to breakdown and be drawn through also.

Fig 11.3.2 shows a chamber where the flow is caused to divert vertically under a weir and pass through an attack screen. Though claims of some oil retention is possible, the main function of gross pollutant and sediment capture is limited because:

1. The weir could not cause buoyant materials to submerge. Floatables accumulated and were eventually drawn through as the volume allowed for floatables was relatively small.
2. Some heavy sediments were captured and settled; however lighter sediments were not captured, and some were retained by the screen openings. As the screen is in an attack orientation, a dramatic loss in screen-through volume compromised performance and caused pre-mature by-pass.
3. Scouring was also found to occur with subsequent flow, as materials in the sump broke down and became suspended by gaseous discharge.

Use of this principle required introduction of a primary floatable chamber or pit inserts, and an extended chamber size to create extended settlement periods.

A quiescent chamber *(Fig 11.3.3)* coupled with a skimming weir is the principle used in oil separators and grease arrestors. The principle was also tested for sediment and gross pollutant retention.

Conclusions:

- Suitable for low flow rates and velocities only. Excessive volume and velocity create turbulence and re-suspension.
- Sediment removal occurs via settlement, which is particle size and time related. Medium to fine particles may take 1 to 2 hours to settle. This is impractical in this type of device as it requires a large chamber to hold the entire catchment run-off volume to be stored for the settlement period.

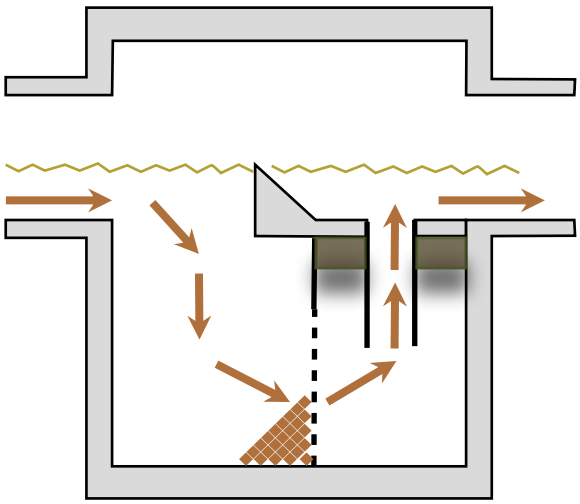


Fig 11.3.2 Diversion through attack screen

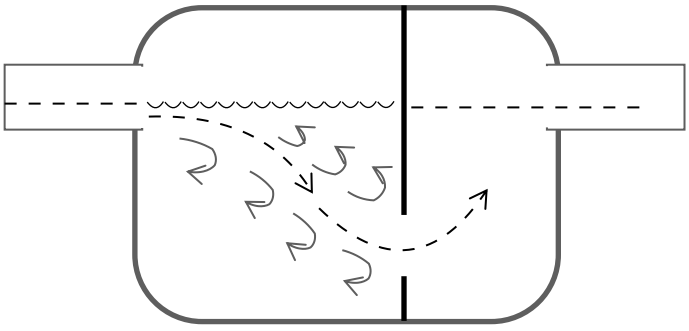


Fig 11.3.3 Quiescent Chamber

11.4 Inverse Vortex

Inverse vortex *(Fig 11.4.1)* is used by some manufacturers of stormwater devices. These systems are not true vortex/centrifuges in that retained material is mobilised towards a screen, compromising efficiency. Other factors that limit performance are:

- The process chamber needs to be off-line, requiring a diversion weir which is subject to the hydraulic jump phenomenon as water flow rates increase to 1m/sec.
- Hydraulic impedance is high, as water flow direction needs to be reversed to rejoin the main pipe conduit.
- Trickle and low flow tend to pass through the screen until sufficient flow velocity generates a vortex.

The illustration *(Fig 11.4.2)* shows the outcome of tests where the material tend to orbit the chamber, either impeding flow as velocity increases or fragmenting to smaller sizes and bypassing.

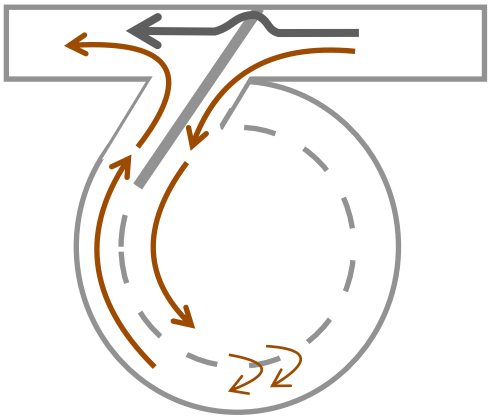


Fig 11.4.1 Inverse vortex

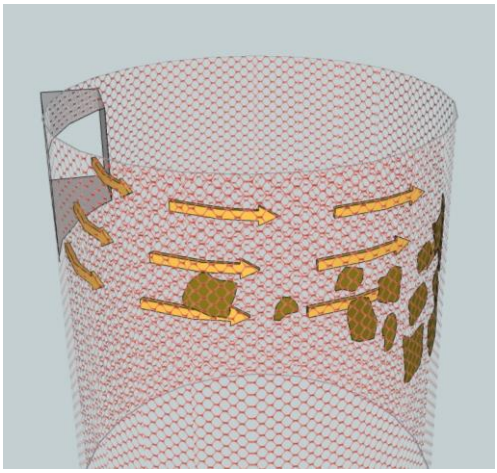


Fig 11.4.2

11.5 Solute Forms of Nutrients – Removal Process

Artificial or tertiary treatment methods that may be applied to remove Dissolved Nutrients, and in particular Dissolved Organic Nitrogen (DON), have physical limitations. DON is defined as being smaller than 0.2 microns *(Refer Fig 8.4.1)*. It therefore follows that removal of suspended sediment is a pre-curser to the implementation of DON removal media.

In simple terms, if fine media is required, that media will very quickly blind if exposed to suspended solids that are present in the influent.

The practical conclusion therefore is, that removal of the prime carrier, being suspended solids smaller than 500 microns, is critical to artificial and natural methods that occur in wetlands. Natural methods involve interaction between plants and bacteria where Dissolved Nitrogen is a ready source of nutrient and is converted to biological material.

The illustration below demonstrates the tendency for media beds similar to those used in bio filtration, to attract a layer of surface material inhibiting the infiltration process. *Fig 8.8.1*

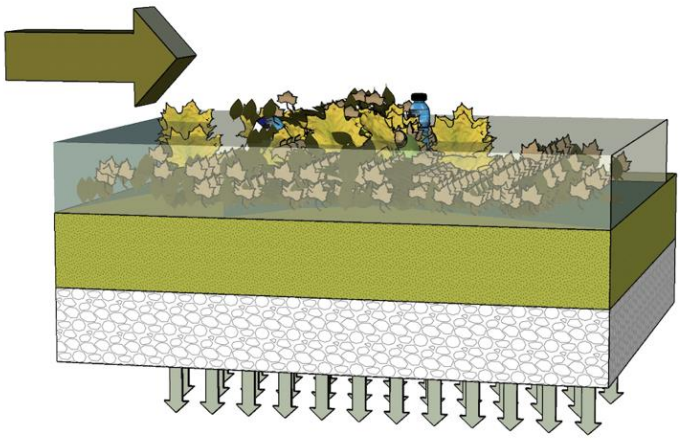


Fig 8.8.1

12 Design Service Life

12.1 Design Life Expectancy

Enviro systems are designed with a service life of 100 years for fixed components and 25 years for replaceable parts.

The main materials used are:

1. Precast reinforced concrete designed and manufactured in accordance with AS3600, exposure classification Table 4.3, 4(b)(i) permanently submerged in sea water.
2. Marine grade stainless steel, either 304L or 316, for the internal processing cartridge.
3. Polypropylene (PP) is used for screens, taking advantage of resistance to chemicals and fatigue. PP resists microbial attack and prevents fatigue failure from vibration and flexing under flow conditions.

12.2 Stainless Steel - Microbially Influenced Corrosion (MIC)

Stainless steel is vulnerable to MIC around heat affected zones, particularly welds.

Enviro utilises stainless steel, with no heat applied and no welding. Materials are processed by cold cutting (laser), mechanical punching and riveting. By avoiding welding and heating processes, the creation of an environment that would harbour and induce microbial attack is avoided.

Concerns with MIC date back over 30 years. In 2007, MIC was the topic of a two-day International Symposium in Perth (WA) when growing awareness of the nature and danger of MIC was brought to the attention of marine, mining and industrial applications of stainless steel. This conference followed a Nickel Institute 2005 paper that warned about MIC in all grades of stainless steel exposed to bacterially active water e.g. well water, surface water and raw water. *(NI reference book series No. 11 026, page 11).*

MIC is caused by bacteria harbouring within micro cracks, where their excreta builds up and creates a localised acidic environment.

Refer to a publication by Susan Borenstein, August 2002, "Susceptibility of Stainless-Steel Weldments to Microbiologically Influenced Corrosion"

https://www.researchgate.net/publication/231975642_Susceptibility_of_Stainless_Steel_Weldments_to_Microbiologically_Influenced_Corrosion

Susan Borenstein has over 30 years of metallurgical and corrosion engineering experience for the petrochemical, utility and chemical industries.

Professional Registrations

Registered Engineer, Texas - 87474
Registered Corrosion Engineer, California - CR 1059
Registered Mechanical Engineer, Rhode Island - 6953
Registered Professional Engineer, Delaware - 11654

Austral Wright Metals, one of the larger suppliers of stainless steel in Australia include the above mentioned warning in their technical data.

https://www.australwright.com.au/wp-content/uploads/2012/07/Types-Myths-of-SS1.pdf

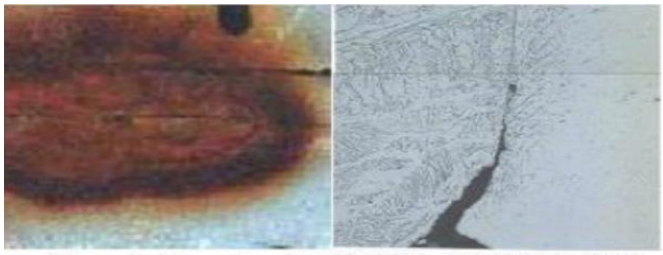
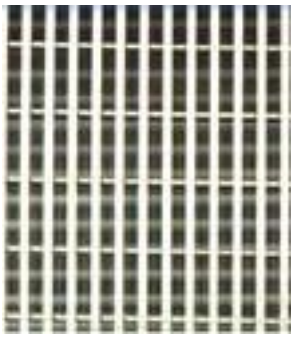


Figure 1—Overview of pit on corroded 304L stainless steel weld

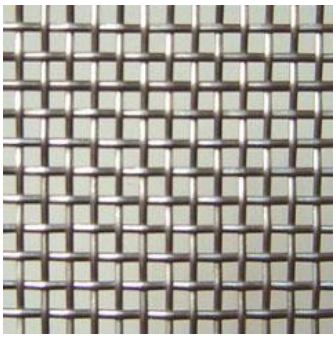
Figure 2—Closeup showing deep crevice adjacent to weld bead/base metal interface

Extract image from research paper by Susan Borenstein

12.2 Screen Selection



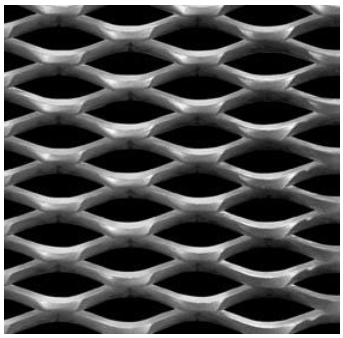
1. Trapezoidal wire



2. Woven mesh



3. Punched sheeting



4. Expanded mesh

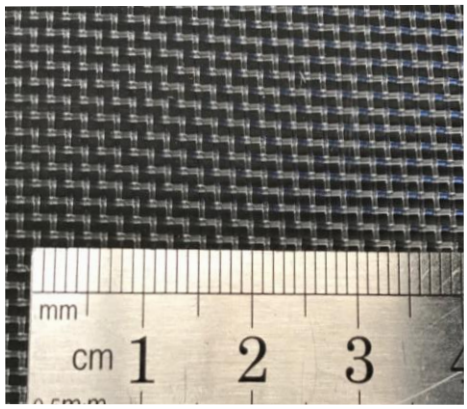
During development of Enviro systems, substantial research and testing of screening methods and materials were conducted. All of the above screen example materials were analysed and discarded as unsuitable or partially suitable. Each are shown at approximate full size.

The following are summary comments only, greater detail is available upon request.

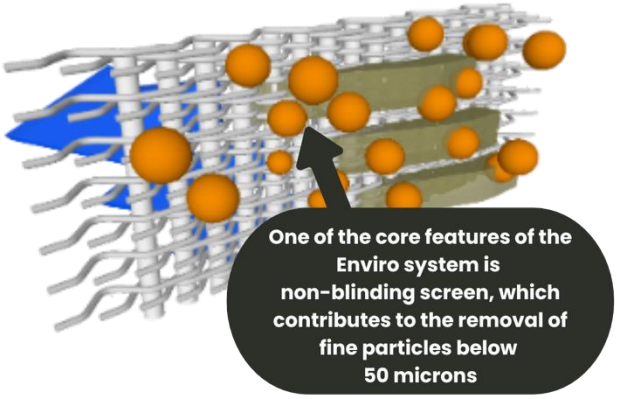
1. **Trapezoidal wire** often used in waste water screens is limited to aperture size.
2. **Woven mesh** can be used where larger apertures may be tolerated. The wire laps tend to gather fibrous materials.
3. **Punched sheeting** is bi-directional and is expensive. Flow rates are relatively slow requiring large screen surfaces.
4. **Expanded mesh** is limited to large apertures of 6 to 10mm. If smaller apertures are used, the burred and sharp edges together with the twisted nature of the expanding process accumulates fibrous materials.

The Enviro solution is a specially woven high strength fabric, mounted on stainless steel frames for ease of service and replacement as required. This follows common practices in many filtering applications.

The fibres are also pretreated to a smooth finish to prevent attraction of fibrous materials. High resistance to bio-filming occurs as a result of the smooth surfaces.



Typical Enviro Screen



12.3 Enviro Systems can be Offered with a De-Watered Sump Feature

A de-watered sump can be environmentally important for the following reasons:

Photos 3 and 4 where taken inside two separate systems to demonstrate the actions of bio-digestion. The enlarged section of *Photo 3* shows bubbles rising to the surface generated by decomposition of organic material in retained water. The gas generated is similar to the anaerobic process used in waste water treatment. The output includes Carbon Dioxide, Methane and potentially, Hydrogen Sulphide. **Some of these gases are toxic and potentially life threatening.**

Of further concern is the bacterial conversion of bonded chemicals and nutrients such as Nitrogen and Phosphorus into solute forms. These toxic chemicals easily enter the food chain, while over-nutrification depletes available Dissolved Oxygen (DO).

Nutrients cause spontaneous generation of algal blooms, some of which are toxic. The greater issue is that algae takes up the available DO and starves all other aquatic flora and fauna.

Often it is difficult to appreciate the importance of DO to aquatic sustainability. On Earth we live in a Nitrogen atmosphere which has 20% Oxygen (O_2). This is also a ready source of O_2 for the decomposition process. Transfer this into an aquatic environment, and the availability of O_2 is vastly less. DO levels vary around 10 to 15 ppm depending on temperature and other factors, therefore the conversion and breakdown of organic matter takes a long time and many exchanges of DO when compared to atmospheric exposed conversion.

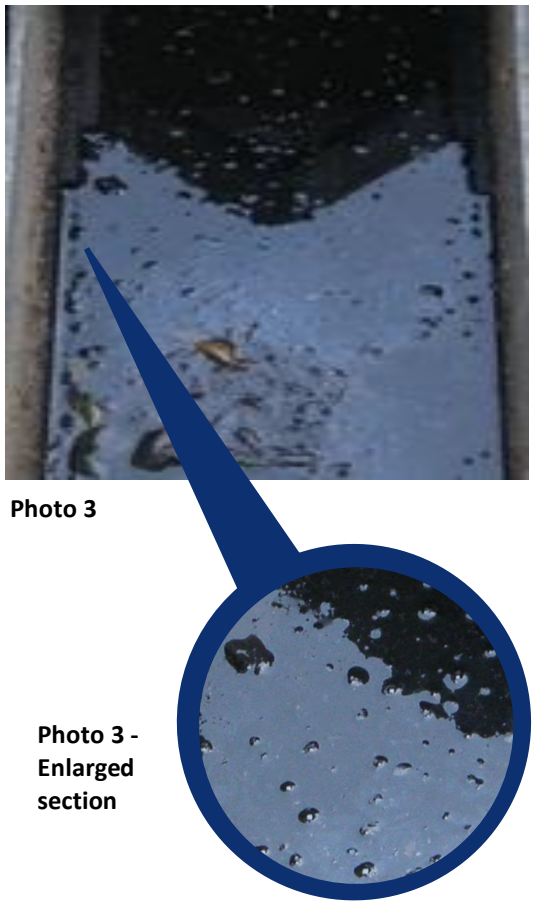


Photo 3

Photo 3 - Enlarged section



Photo 4

12.3.1 Service Costs are Greatly Reduced

By eliminating the free water, service evacuation does not have to include the cost of on-site treatment if this is possible or transfer to a waste plant for final processing.

13 Service and Maintenance

Enviro G, E and H series are designed to minimise service and maintenance costs as a result of the following features:

1. The storage chamber located below the processing chamber is designed to be easily inspected and serviced. Based on the ARQ extrapolation of 1m^3/ann/ha from typical urban catchment, the large storage volume provides for extended service intervals. In most installations, service intervals are nominally 1 year (12 months).
2. Service is by evacuation. *(Refer Fig 1)*. The volume of water contained in the process chamber is minimised to reduce evacuation costs. This water can be pumped out as the first stage of service, avoiding evacuation and the cost of disposal. A dry sump option is available on request.
3. All surfaces inside the Enviro series are visible from the service covers, eliminating the need for personnel to enter the device and perform longer term wash downs. *(Refer Fig 2)*
4. If required, screens can be removed manually, without entering the device. This facilitates inspection, cleaning or replacement, without additional labour or equipment. *(Refer Fig 3)*
5. During the construction phase, i.e. before hand over to the client, screens can be removed enabling the device to act as a sediment trap. This allows the constructor to clean out the device and handover to the client an unused unit, eliminating disputes over device condition.

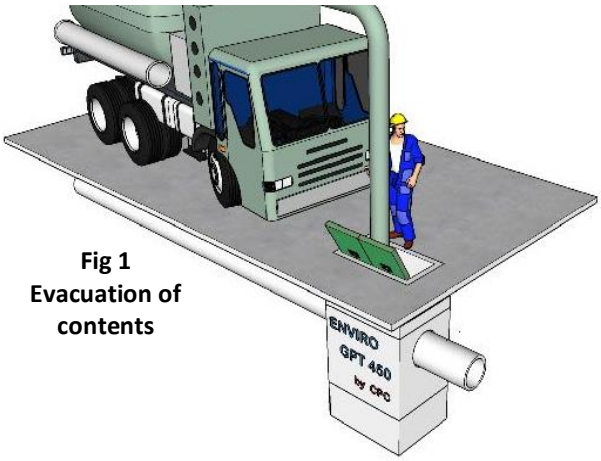


Fig 1
Evacuation of contents

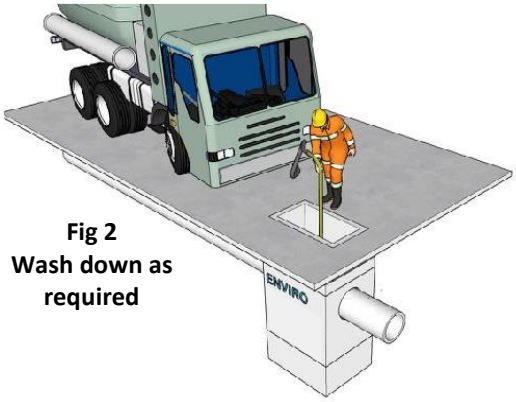


Fig 2
Wash down as required

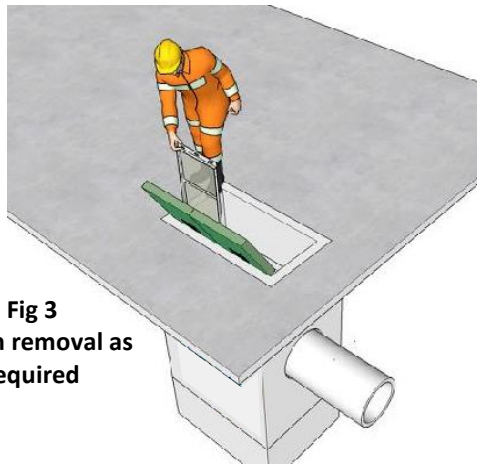


Fig 3
Screen removal as required

Appendices

(Appendices are prepared as a separate folder)

Number	Title	Author
1	Balanced Urban Development: Options and Strategies for Liveable Cities Chapter 6	Leo Crasti
2	Enviro Process Testing Summary	Leo Crasti
3	Performance Testing of Enviro Australis Oil/Water Separator	Australian Flow Management Group School of Natural and Built Environments University of South Australia Research Fellow: Dr Baden Myers
4	MUSIC Node	Australian Flow Management Group School of Natural and Built Environments University of South Australia Research Fellow: Dr Baden Myers
5	Deep Sea Pollution paper - Human footprint in the abyss: 30-year records of deep-sea plastic debris	Sanae Chiba, Hideaki Saito, Ruth Fletcher, Takayuki Yogi, Makino Kayo, Shin Miyagi, Moritaka Ogido, Katsunori Fujikura
6	Adsorption of Nutrients to Particles in Urban Stormwater Systems	Nicola Hayes supervised by Professor Federico Maggi University of Sydney
7	Particle Removal Efficiency from Stormwater	Scott Manning supervised by Professor Federico Maggi University of Sydney
8	Nutrient Discharge to Stormwater	Mason Bonacci peer reviewed by Simon Sharp EPA Victoria
9	Email: Relationship between Nutrients and Particles in Runoff	Australian Flow Management Group School of Natural and Built Environments University of South Australia Research Fellow: Dr Baden Myers
10	Performance testing of the Enviro EPS – Nutrient removal	Australian Flow Management Group School of Natural and Built Environments University of South Australia Research Fellow: Dr Baden Myers

APPENDIX

H

Healthy Waters Code Response

City Plan code response

This code template supports the preparation of a development application against either the acceptable outcome(s) or performance outcome(s) contained in the code. Development assessment rules are outlined in **Section 5.3.3** of the City Plan.

Please note:

Note: In accordance with Section 2.1 of City Plan, an assessment against State interest - Water quality (policies 4 and 5) of the State Planning Policy 2017 is required as the Healthy water development code does not fully integrate this State interest. A response table for policies 4 and 5 have been included below.

For assessment against the overall outcomes, refer to the appropriate code.

Note: The whole of the planning scheme is identified as the assessment benchmark for impact assessable development. This specifically includes assessment of impact assessable development against this strategic framework. The strategic framework may contain intentions and requirements that are additional to and not necessarily repeated in zone, overlay or other codes. In particular, the performance outcomes in zone codes address only a limited number of aspects, predominantly related to built form. Development that is impact assessable must also be assessed against the overall outcomes of the code as well as the strategic framework.

9.4.5 Healthy waters code

9.4.5.1 Application

This code applies to assessing material change of use, reconfiguring a lot or operational work for development where indicated within:

(1) **Part 5 Tables of assessment**; and

(2) **Table 9.4.5.1-1: Development triggers for applying the Healthy waters code.**

Table 9.4.5.1-1: Development triggers for applying the Healthy waters code

Topic	Assessment triggers	Applicable assessment benchmarks
Erosion and sediment control	All development.	For accepted development subject to requirements: **RO1, RO2**
		For assessable development: **PO1, PO2**
Stormwater quality and	For residential land uses involving one or more of the following:	For accepted development subject to requirements:

Topic	Assessment triggers	Applicable assessment benchmarks
waterway stability	(a) 3 or more dwellings; or (b) a land area greater than 1,200m^2; or (c) a newly constructed road (previously unformed road) exceeding 30m in total length; or (d) 200m^2 or more of uncovered new or refurbished car park area including parking bays and circulation driveways; or (e) the creation of high polluting outdoor activities (including Bulk landscape supplies, Garden centres, Tourist parks, Transport depots, Warehouses and Wholesale nurseries).	**RO3, RO5** For assessable development: **PO3, PO4, PO8 – PO13**
	For non-residential land uses involving one or more of the following: (a) a land area greater than 1,200m^2; or (b) a newly constructed road (previously unformed road) exceeding 30m in total length; or (c) 200m^2 or more of uncovered new or refurbished car park area including parking bays and circulation driveways; or (d) the creation of high polluting outdoor activities (including Bulk landscape supplies, Garden centres, Tourist parks, Transport depots, Warehouses and Wholesale nurseries).	For accepted development subject to requirements: **RO4, RO5** For assessable development: **PO3, PO4, PO8 – PO14**
Stormwater quantity	For residential activities, development associated with the creation of 3 or more dwellings, resulting in either: (a) an increase in the total impervious area; or (b) an alteration of upstream conveyance or change to existing discharge location or condition.	For accepted development subject to requirements: **RO3, RO6, RO7** For assessable development: **PO5 – PO14**
	For all other land uses, development that results in either: (a) an increase in the total impervious area; or (b) an alteration of upstream conveyance or change to existing discharge location or condition.	For accepted development subject to requirements: **RO4, RO6, RO7** For assessable development: **PO5 – PO14**
Woongoolba flood mitigation catchment area	Development that is code or impact assessable, on land within the 'Woongoolba flood mitigation catchment area' on the **Water catchments and dual supply system area overlay map**.	For assessable development: **PO15**

This code does not apply in the following instances:

(1) where the development involves internal works or minor building works to a lawfully established building; or

(2) a sales office.

When using this code, reference should be made to **Section 5.3.2** and, where applicable, **Section 5.3.3**, in **Part 5**.

9.4.5.2 Purpose

(1) The purpose of the Healthy waters code is to:

(a) protect the quality of the city's waters and watercourses by managing the impacts of development on quality and quantity of surface and ground water runoff; and

(b) ensure that development does not cause adverse impact on people and/or property.

(2) The purpose of the code will be achieved through the following overall outcomes:

(a) Total water cycle management and water sensitive urban design (WSUD) principles are:

(i) implemented to contribute to biodiversity areas and green space values within the city and promote co-location of assets; and

(ii) integrated into the landscape so as to maintain watercourse health, biodiversity and ecosystems.

(b) Development avoids or minimises disturbance to existing landforms, surface drainage, watercourses and groundwater.

(c) Impacts to public health and safety hazards are minimised.

(d) Adverse impacts to people and/or property are prevented and stormwater is safely managed within urban areas.

(e) Development protects existing overland flow paths and watercourses of environmental value.

(f) Development limits the quantity of key pollutants discharged in stormwater to protect the quality of receiving waters.

(g) Development avoids adverse impacts to downstream properties or environmental value from stormwater peak discharge.

(h) Development avoids or minimises adverse impacts on the environmental values of receiving waters from the release and mobilisation of nutrients and sediments.

(i) The drainage capacity of the Woongoolba Flood Mitigation Scheme Area for rainfall events up to 1 in 10 year 72 hours is maintained (contained within the Scheme drains within a 4 day period) and this capacity is not to be eroded due to cumulative impact of development.

9.4.5.3 Specific benchmarks for assessment

PART B – ASSESSABLE DEVELOPMENT BENCHMARKS

Table 9.4.5-3: Healthy waters code – for assessable development

Performance outcomes	Acceptable outcomes	Does the proposal meet the acceptable outcome? If not, justify how the proposal meets either the performance outcome or overall outcome	Internal use
Erosion and sediment control			
PO1 Stormwater discharge from a development site achieves the construction phase water quality objectives of **SC6.12 City Plan policy – Land development guidelines**, **Section 4 – Stormwater drainage and water sensitive urban design standards**.	**AO1** No acceptable outcome provided.	**COMPLIES -** The Stormwater Management Plan (SWMP) prepared for the proposed Rural Residential Subdivision located at 98 Glenmore Drive, Bonogin details the proposed mitigation measures to be implemented to ensure compliance with SC6.11 City Plan policy – Land development guidelines. Please see Legend Consultants Stormwater Management Plan Ref: LC25079-0002-SWMP prepared for the proposed development.	
PO2 Erosion, sediment and dust is appropriately managed during the construction phase.	**AO2** The level of risk for soil erosion and sediment pollution to the environment is determined by an erosion hazard assessment, completed by a suitably-qualified person in accordance with the criteria in **Table 9.4.5-4: Erosion hazard assessment**. Where the erosion hazard assessment has a risk score of: (a) less than or equal to 10: A deemed to comply report is prepared by a suitably qualified person for Council approval, including conceptual location and design drawings of each treatment measure in plan and section views, in accordance with the *Best Practice Erosion and Sediment Control: International Erosion Control Association, (IECA) 2008, Australasia Chapter 2008.*	**COMPLIES – PLEASE REFER TO THE ESC PLANS PROVIDED IN THE STORMWATER MANAGEMENT PLAN LC25079-0002-SWMP**	

	(b) greater than 10 or developments involving multiple stages of disturbance or more than 1.25 ha of land: (i) For material change of use or reconfiguring a lot, a conceptual erosion and sediment control plan (ESCP) is prepared by a suitably-qualified person for Council approval in accordance with **SC6.12 City Plan policy – Land development guidelines, Section 4 – Stormwater drainage and water sensitive urban design standards**, and the *Best Practice Erosion and Sediment Control: International Erosion Control Association (IECA) 2008, Australasia Chapter 2008*. (ii) For operational work, a detailed ESCP is prepared by a suitably-qualified person in accordance with **SC6.12 City Plan policy – Land development guidelines, Section 4 – Stormwater drainage and water sensitive urban design standards**, and *Best Practice Erosion and Sediment Control: International Erosion Control Association (IECA) 2008, Australasia Chapter 2008*. The ESCP is to detail appropriate treatment measures for the construction phase of development, demonstrating how the minimum design objectives in **Table 9.4.5-5: Stormwater design objectives** are achieved, including: (a) measures to ensure the release of sediment-laden stormwater for the		

Performance outcomes	Acceptable outcomes	Does the proposal meet the acceptable outcome? If not, justify how the proposal meets either the performance outcome or overall outcome	Internal use
	nominated design storm are minimised when the design storm is exceeded; (b) detailed design, installation, construction, monitoring and maintenance requirements of all approved proprietary products in accordance with local conditions and manufacturer's recommendations; and (c) details of how the ESCP aligns with the approved development staging plan.		
Stormwater quality			
PO3 Development appropriately manages stormwater quality to: (a) protect natural ecosystems; (b) protect water quality; (c) reduce runoff and peak flows; and (d) meet the water quality objectives and environmental values for Queensland waters. **Note: Water quality objectives and environmental values for Queensland waters are contained within *Schedule 1* of the *Environmental Protection (Water) Policy 2009*. Water quality objectives are locally specific and vary between and within river catchments.** **Note: A stormwater quality management plan prepared by a suitably qualified person in accordance with SC6.12 City Plan policy – Land development guidelines, Section 4 – Stormwater drainage and water sensitive urban design standards, is Council's preferred method for addressing this performance outcome.**	**AO3.1** For post developed sites, the following minimum pollutant reduction targets are achieved: (a) Gross pollutants (>5mm) – 90%; (b) Total Suspended Solids (TSS) – 80%, (c) Total Phosphorus (TP) – 60%; and (d) Total Nitrogen (TN) – 45%.	**COMPLIES -** The Stormwater Management Plan (SWMP) prepared for the proposed Rural Residential Subdivision located at 98 Glenmore Drive, Bonogin details the proposed mitigation measures to be implemented to ensure compliance with SC6.11 City Plan policy – Land development guidelines. Please see Legend Consultants Stormwater Management Plan Ref: LC25079-0002-SWMP prepared for the proposed development.	
	AO3.2 For development on land less than 1.25ha, a deemed to comply solution for stormwater quality is achieved in accordance with **Table 9.4.5-6: Stormwater quality deemed to comply solutions**.	-	
	AO3.3	**COMPLIES -** The Stormwater Management Plan (SWMP) prepared for the proposed Rural Residential Subdivision located at 98 Glenmore Drive, Bonogin details the proposed mitigation measures to be implemented to ensure compliance with SC6.11 City Plan policy – Land development guidelines.	

Performance outcomes	Acceptable outcomes	Does the proposal meet the acceptable outcome? **If not, justify how the proposal meets <u>either</u> the performance outcome or overall outcome**	Internal use
	For development on land greater than 1.25ha, a stormwater quality management plan is to be prepared by a suitably qualified person in accordance with **SC6.12 City Plan policy – Land development guidelines**, **Section 4 – Stormwater drainage and water sensitive urban design standards**, is required.	Please see Legend Consultants Stormwater Management Plan Ref: LC25079-0002-SWMP prepared for the proposed development.	
Waterway stability			
PO4 In-stream erosion, downstream of urban development is prevented by controlling the rate (or magnitude) and duration of sediment transporting flows.	**AO4** Post-development peak 0.632 Annual Exceedance Probability (AEP) event discharge within receiving waterway is limited to pre-development peak 0.632 AEP event discharge and is in accordance with **SC6.12 City Plan policy – Land development guidelines**, **Section 4 – Stormwater drainage and water sensitive urban design standards.**	**COMPLIES -** The Stormwater Management Plan (SWMP) prepared for the proposed Rural Residential Subdivision located at 98 Glenmore Drive, Bonogin details the proposed mitigation measures to be implemented to ensure compliance with SC6.11 City Plan policy – Land development guidelines. Please see Legend Consultants Stormwater Management Plan Ref: LC25079-0002-SWMP prepared for the proposed development.	
Stormwater quantity control			
PO5 Stormwater quantity management outcomes demonstrate no adverse impact on stormwater flooding or the drainage of properties external to the subject site.	**AO5** The following is achieved external to the development site: (a) no increase in peak flood flow rate from the development site for all events up to and including the 1% AEP; (b) no increase in peak flood velocities from the development site for all events up to and including the 1% AEP; (c) no increase in peak flood level from the development site for all events up to and including the 1% AEP; and	**COMPLIES -** The Stormwater Management Plan (SWMP) prepared for the proposed Rural Residential Subdivision located at 98 Glenmore Drive, Bonogin details the proposed mitigation measures to be implemented to ensure compliance with SC6.11 City Plan policy – Land development guidelines. Please see Legend Consultants Stormwater Management Plan Ref: LC25079-0002-SWMP prepared for the proposed development.	

Performance outcomes	Acceptable outcomes	Does the proposal meet the acceptable outcome? If not, justify how the proposal meets either the performance outcome or overall outcome	Internal use
	(d) stormwater outfalls or discharge is located to avoid conflict with existing usage of downstream land or impacts on existing watercourse or drainage.		
Lawful point of discharge			
PO6 Development ensures the stormwater systems are designed to not cause actionable nuisance that would adversely affect adjoining (upstream or downstream) properties.	**AO6** A lawful point of discharge must be identified and demonstrated that all discharge point/s from the development are in accordance with **SC6.12 City Plan policy – Land development guidelines**, **Section 4 – Stormwater drainage and water sensitive urban design standards**.	**COMPLIES**	
Overland flow paths			
PO7 Development must not obstruct free open surface flow of stormwater through a site.	**AO7** Overland flowing stormwater is allowed free open surface flow between the street and any waterway at the rear or sides of a property, in accordance with the provisions of the *Building Code of Australia*.	**COMPLIES**	
Whole of life costs			
PO8 Stormwater infrastructure is designed and constructed to: (a) remain fit for purpose for the life of the development and maintains full functionality in the design flood event; (b) be cost effective to maintain; and (c) ensure no structural damage to existing stormwater infrastructure.	**AO8** No acceptable outcome provided.	**COMPLIES**	
Landscape integration			
PO9	**AO9.1**	**COMPLIES -** The Stormwater Management Plan	

Performance outcomes	Acceptable outcomes	Does the proposal meet the acceptable outcome? If not, justify how the proposal meets either the performance outcome or overall outcome	Internal use
Stormwater treatment devices and stormwater infrastructure are designed to: (a) integrate with the urban design and landscape outcomes of the development; (b) complement natural environments, wetlands and watercourses; (c) protect environmental values; (d) enhance visual amenity; and (e) incorporate CPTED principles in accordance with **SC6.12 City Plan policy – Land development guidelines, Section 4 – Stormwater drainage and water sensitive urban design standards**.	Where stormwater treatment devices and stormwater infrastructure are integrated into public open space, a Statement of Landscape Intent is to be prepared by a suitably qualified person, for approval by Council. The plan is to demonstrate that the operation of stormwater infrastructure does not compromise the function of any co-located uses and reflect the design principles within **SC6.12 City Plan policy – Land development guidelines**, **Section 4 – Stormwater drainage and water sensitive urban design standards.** **Note: A Statement of landscape intent is to be prepared in accordance with SC6.13 City Plan policy – Landscape work.**	(SWMP) prepared for the proposed Rural Residential Subdivision located at 98 Glenmore Drive, Bonogin details the proposed mitigation measures to be implemented to ensure compliance with SC6.11 City Plan policy – Land development guidelines. Please see Legend Consultants Stormwater Management Plan Ref: LC25079-0002-SWMP prepared for the proposed development.	
	AO9.2 Stormwater treatment devices are located offline to any upstream catchment. **Note: This provision relates to the integration of stormwater treatment devices and stormwater infrastructure into the landscape. Development identified on the Environmental significance – wetlands and watercourse overlay map will still require assessment against the Environmental significance overlay code.**	**COMPLIES**	
	AO9.3 All stormwater outlets that are located adjacent to watercourses, creeks and drainage paths are aligned at a maximum of 45 degrees to the downstream direction of flow, and energy dissipation measures installed to minimise scour.	**COMPLIES – PROPOSED OUTLET LOCATIONS ARE NOT WATERWAYS, CREEKS OR RIVERS**	
Public safety			

Performance outcomes	Acceptable outcomes	Does the proposal meet the acceptable outcome? If not, justify how the proposal meets either the performance outcome or overall outcome	Internal use
PO10 Stormwater treatment devices and stormwater infrastructure minimise impacts on public health and safety.	**AO10** All stormwater quantity control measures are designed in accordance with **SC6.12 City Plan policy – Land development guidelines**, **Section 4 – Stormwater drainage and water sensitive urban design standards**.	**COMPLIES**	
Maintenance access			
PO11 Maintenance access is provided for all stormwater management systems and considers: (a) the type of vehicle or machinery needed to service particular assets; and (b) the need to ensure a safe working environment for maintenance personnel and the public.	**AO11.1** All weather vehicle access is to be provided to inlet zones of the stormwater treatment systems in accordance with **Table 9.4.5-7: Maintenance access requirements (slope).**	**COMPLIES**	
	AO11.2 Maintenance access is to be provided around the perimeter of all stormwater treatment systems in accordance with **Table 9.4.5-8: Maintenance access requirements (size).**	**COMPLIES**	
	AO11.3 A maintenance buffer is provided around the perimeter of all stormwater treatment devices and adjoining private property equal to: (a) 1m in width; or (b) the width of a perimeter maintenance access, as delivered in AO11.2, plus 0.5m. The maintenance buffer is measured from the adjacent allotment boundary to the top of batter around the treatment measure. The maximum slope on the maintenance buffer is 1 in 10.	**COMPLIES**	

Performance outcomes	Acceptable outcomes	Does the proposal meet the acceptable outcome? If not, justify how the proposal meets either the performance outcome or overall outcome	Internal use
Fauna movement			
PO12 Stormwater conveyance structures and channels are designed to ensure the safe movement of native fauna and provide for terrestrial and aquatic passage.	**AO12.1** Stormwater drainage structures and channels minimise impacts on aquatic fauna and associated habitats and provide opportunities for beneficial habitat uses of structures in accordance with the *Department of Primary Industries and Fisheries – Fisheries guidelines for Fish-friendly structures (2006).*	**COMPLIES**	
	AO12.2 Stormwater drainage structures allow for the safe movement of terrestrial fauna in accordance with: (a) the Queensland Government Fauna Sensitive Road Design Manual Volume 2: Preferred Practices; and (b) the Queensland Government Koala-Sensitive Design Guidelines.	**COMPLIES**	

Performance outcomes	Acceptable outcomes	Does the proposal meet the acceptable outcome? If not, justify how the proposal meets either the performance outcome or overall outcome	Internal use
Wastewater management			
PO13 Development does not discharge wastewater to receiving waters or areas external to the site unless demonstrated to be the best-practice environmental management for that site and takes into consideration: (a) the applicable water quality objectives for the receiving waters; and (b) the potential adverse impact on ecosystem health of receiving waters.	**AO13** Where the development involves the discharge of wastewater, a Wastewater Management Plan (WWMP) is prepared, demonstrating compliance with the performance outcome, by a suitably qualified person and submitted to the Council, detailing all of the following: (a) wastewater type; (b) climatic conditions; (c) water quality objectives; (d) best-practice environmental management; (e) waste management hierarchy; and (f) the WWMP provides for the management of wastewater in accordance with a wastewater management hierarchy that: (i) avoids wastewater discharge to watercourses; or (ii) if wastewater discharge to the environment cannot practicably be avoided wastewater discharge to watercourses is minimised through re-use, recycling, recovery and treatment for disposal to sewer, surface water and groundwater.	**N/A**	
Dewatering management			
PO14 Dewatering occurs in accordance with an approved Dewatering management plan.	**AO14** No acceptable outcome provided.	**N/A**	

Performance outcomes	Acceptable outcomes	Does the proposal meet the acceptable outcome? If not, justify how the proposal meets either the performance outcome or overall outcome	Internal use
Woongoolba flood mitigation catchment area			
PO15 In the Woongoolba flood mitigation catchment area, shown on the **Water catchments and dual supply system area overlay map**, peak outflow and its timing for Q2, Q5 and Q10 for rainfall events up to 72 hours does not change as a result of development.	**AO15** No acceptable outcome provided.	**N/A**	

State Planning Policy July 2017

Policies	Demonstrate how the proposal meets the policy?	Internal use
State interest – water quality		
ASSESSMENT BENCHMARK 4 (POLICY 4): At the construction phase, development achieves the applicable stormwater management design objectives in table A (appendix 2) of the State Planning Policy.	**COMPLIES -** Please see Legend Consultants Stormwater Management Plan Ref: LC25079-0002-SWMP prepared for the proposed development.	
ASSESSMENT BENCHMARK 5 (POLICY 5): (5) At the post-construction phase, development: a) achieves the applicable stormwater management design objectives on-site, as identified in table B (appendix 2) of the State Planning Policy; or b) achieves an alternative locally appropriate solution off-site that achieves an equivalent or improved water quality outcome to the relevant stormwater management design	**COMPLIES -** Please see Legend Consultants Stormwater Management Plan Ref: LC25079-0002-SWMP prepared for the proposed development.	

Policies	Demonstrate how the proposal meets the policy?	Internal use
objectives in table B (appendix 2) of the State Planning Policy.		

Table 9.4.5-3: Erosion hazard assessment

Controlling factor	Points	Score
Average slope of the whole site prior to operational works		
Slope less than 2%	0	
More than or equal to 2% but less than 5%	1	
More than or equal to 5% but less than 10%	2	2
More than or equal to 10% but less than 15%	4	
More than or equal to 15%	5	
Soil type (to be disturbed)		
Gravels and sandy soils	1	1
Sandy loam	2	
Clays on flood plains	3	
Shallow soils on slopes	4	
Clays on slopes greater than 5%/imported fill or untested fill	5	
Anticipated duration of site disturbance		
Duration less than 2 weeks	0	
More than 2 weeks but less than 3 months	2	
More than 3 months but less than 6 months	4	4
More than 6 months	5	
Anticipated erosive rainfall risk during site disturbance		
Low (monthly average rainfall less than 45 mm)	0	
Moderate (monthly average rainfall 46 - 100 mm)	1	
High (monthly average rainfall 101 - 225 mm)	2	2
Very high (monthly average rainfall 226 - 1500 mm)	4	
Extreme (monthly average rainfall more than 1500 mm)	5	

Off-site sediment control (down-slope of the soil disturbance)		
Score 1 point if there is no purpose-built sediment trap (e.g. sediment basin, gross pollutant trap or purpose-built wetland).	1	0
Run-off entering the site		
Score 1 point if stormwater run-off is not diverted from entering the site or away from soil disturbance.	1	0
Extent of site disturbance		
Score 2 points if the building works requires reshaping of the ground surface.	2	2
Total Score **Note: High erosion risk - if score 11 or greater, or five for any factor.**		11

This Erosion Hazard Assessment form is adapted from the *Best Practice Erosion and Sediment Control, International Erosion Control Association (Australasia), IECA 2008 Appendix H - Building Sites, the Brisbane City Council Erosion Hazard Assessment Form* and *Attachment 2 to the QDC Draft Part 16 Erosion and Sediment Control*.

Table 9.4.5-5: Stormwater design objectives

Construction phase stormwater design objectives	Notes
Drainage control	
Design life and design storm of temporary drainage works: (1) Disturbed area open for less than 12 months - 1 in 2 ARI. (2) Disturbed area open for 12-24 months - 1 in 5 ARI. (3) Disturbed area open for more than 24 months - 1 in 10 ARI.	• ARI = Average Recurrence Interval (see Engineers Australia document Australian Rainfall and Runoff). • Design capacity excludes minimum 150mm freeboard. • A higher drainage design objective may be required for temporary drainage structures upslope of occupied properties. • A revised drainage design storm may be required if these design objectives are found to be impracticable.
Erosion control	
(1) Stage clearing and construction works to minimise the area of exposed soil at any one time. (2) Effectively cover or stabilise exposed soils prior to predicted rainfall. (3) Prior to completion of works for the development, and prior to removal of sediment controls, all site surfaces must be effectively stabilised using methods which will achieve effective short-term stabilisation. (4) Avoid or minimise large construction activities in the 'wet season'. (5) Divert water run-off from undisturbed areas around disturbed areas. (6) Use erosion risk ratings to determine appropriate erosion control measures.	• 'Wet season' means the high rainfall months, e.g. the four highest rainfall months. • For point 6, determine the erosion risk rating using local rainfall erosivity, rainfall depth, or soil loss rate or other acceptable method. A rating scale such as very low, low, moderate, high, extreme should be applied. Such ratings should reflect the local area. Example ratings may be shown in local council guidelines or detailed in best-practice guidelines.
Sediment control	
(1) Use soil loss rates to determine appropriate sediment control measures. (2) Direct runoff from exposed site soils to sediment controls that are appropriate to the extent of disturbance and level of erosion risk.	• For point 1, surrogate determinations may be used such as monthly erosion or average monthly rainfall.

(3) All exposed areas greater than 2500 metres must be provided with sediment controls which are designed, implemented and maintained to a standard which would achieve at least 80% of the average annual runoff volume of the contributing catchment treated (i.e. 80% hydrological effectiveness) to 50mg/L Total Suspended Solids (TSS) or less, and pH in the range (6.5–8.5).	• A commonly used design storm for basin sizing is 80th percentile five-day event. Depending on the settling characteristics of local soils, a higher 'operational' design storm can be achieved with chemical dosing operated in flow-through mode in a large storm with rainfall-activated auto-flocculent dosing, and advanced hydraulic efficiency features such as floating off-takes, and a sediment forebay. • TSS = Total Suspended Solids. Turbidity measurements (e.g. 60 Nephelometric Turbidity Units (NTU)) could be used; however, for accuracy, a site-specific relationship should be developed between turbidity and TSS.

Table 9.4.5-6: Stormwater quality deemed to comply solutions

The following deemed to comply solutions are to be documented within a Stormwater quality management plan prepared by a suitably-qualified person in accordance with **SC6.12 City Plan policy – Land development guidelines**, **Section 4 – Stormwater drainage and water sensitive urban design standards**.

Development type			**Stormwater treatment train**		**Land ownership[2]**
Land use	**Scenario**	**Scale**			
Residential	>2 lots up to 20 lots	N/A	Tank Volume per dwelling: • Detached 5 kl • Attached 3 kl	Bio retention[3] @ 1.3% of impervious catchment area.[1]	Public and/or Private
			No Tanks	Bio retention[3] @ 1.8% of impervious catchment area.[1]	Public and/or Private
			Tank Volume per dwelling: • Detached 5 kl • Attached 3 kl	Wetland @ 5% of impervious catchment area.	Public and/or Private
			No Tanks	Wetland @ 7% of impervious catchment area.[1]	Public and/or Private
	> 2 dwellings (Townhouse style up to 2 storeys	≤ 12,500m^2	Tank Volume per dwelling: • Detached 5 kl • Attached 3 kl	Bio retention[3] @ 1.3% of impervious catchment area.[1]	Private
			No Tanks	Bio retention[3] @ 1.8% of impervious catchment area. [1]	Private
			Tank Volume per dwelling: • Detached 5 kl • Attached 3 kl	Wetland @ 5% of impervious catchment area.[1]	Private
			No Tanks	Wetland @ 7% of impervious catchment area.[1]	Private

	High density multiple dwelling apartments (flats, high-rise)*	≤ 12,500m^2	Tank Volume per dwelling: • Detached 5 kl • Attached 3 kl	Bio retention[3] @ 1.8% of impervious catchment area.[1]	Private
			No Tanks	Wetland @ 7% of impervious catchment area.[1]	Private
Commercial, Industrial and Retail (including retail at the bottom floors of high rise)[4]	Commercial and/or Industrial uses	≤ 12,500m^2	Tank Volume per dwelling: • Detached 5 kl • Attached 3 kl	Gross pollutant management (GPT) + Bio retention[3] @ 1.8% of impervious catchment area.[1]	Public and/or Private
			No Tanks	Gross pollutant management (GPT) + Wetland @ 8% of impervious catchment area.[1]	Public and/or Private

[1] For developments that results in an increase in less than 15% imperviousness (i.e. roof and ground level impervious), then stormwater management to focus on the impervious areas only.

[2] Ultimate owner of the device and responsible for maintenance.

[3] For bioretention basins larger than 800m^2, an inlet pond will be required.

[4] The City requires gross pollutant management for these land uses. It is preferred that these are located on private property, but in larger scale Reconfiguring a lot applications it is logical to have a single gross pollutant trap for the site. The City will not accept proprietary devices for nutrient management on public/City land.

Table 9.4.5-7: Maintenance access requirements (slope)

Treatment type	Access track slope	Material and width
Stormwater inflows where pipe is 450mm or greater (where there is no forebay or inlet pond)	1 in 4 or flatter	2.5m wide minimum Gravel or reinforced turf from inlet
Coarse sediment forebay	1 in 4 or flatter	2.5m minimum Reinforced concrete in accordance with *IPWEAQ standard drawing RS-051*

		Concrete paver (subject to City approval), cement treated gravel 250mm thick may be accepted by the City through negotiation.
Inlet pond (wet) for retention or wetland Sediment basins	1 in 4 or flatter	3m wide Reinforced concrete in accordance with Heavy Vehicle Crossing Industrial (*refer IPWEAQ standard drawing RS-051*). Where this access crosses perpendicular to pedestrian paths, the path must be 200mm thick, double reinforced and 42MPa.
Proprietary devices	1 in 4 or flatter	Reinforced concrete in accordance with Heavy Vehicle Crossing Industrial (refer *IPWEAQ standard drawing RS-051*).

Table 9.4.5-8: Maintenance access requirements (size)

Treatment type	Size	Maintenance access requirements (all paths 1 in 10 cross fall or less and maximum 1 in 4 longitudinal grade)
Bioretention	< 500m^2	Access path to > 40% of perimeter. ≥ 0.75m wide. Grass, mulch, gravel or concrete suitable for access on foot.[1]
	≥ 500m^2	Access path to > 40% of perimeter. ≥ 2.5m wide. Reinforced grass, gravel or concrete for light vehicles.[1] Remainder of perimeter as per < 500m^2 bioretention.
Wetland	<1000m^2	Access path to > 40% of perimeter.

		≥ 0.75m wide. Grass, mulch, gravel or concrete suitable for access on foot.
	≥ 1000m^2 to < 5000m^2	Access path minimum 40% of perimeter. ≥ 2.5m wide. Reinforced grass, gravel or concrete for light vehicles.[1] Remainder of perimeter ≥ 0.75m wide.
	≥ 5000m^2	Access path 100% of perimeter. ≥ 2.5m wide. Cement treated gravel 200mm or concrete for large vehicles.

[1] Determine access path treatment based on slope, maintenance vehicle and the surrounding landscape. For example, turf is not appropriate where the treatment system is located against conservation open space, and where revegetation for the treatment system complements the surroundings, the use of gravel or concrete is preferred.