Water Cycle Management Plan

PROPOSED REZONING
FOR
RESIDENTIAL USES

Lot 8, DP 816552

5 Anderson Road, Glenning Valley

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1.0 INTRODUCTION

This report was prepared by ACM Landmark and commissioned by Andrews Neil on behalf of Pyoand Pty Ltd, the owners of Lot 8, DP 816552 – 5 Anderson Road, Glenning Valley.

The report provides a conceptual Water Management Plan for the proposed rezoning and redevelopment of the land for urban uses.

Together with the accompanying plans, this report provides an assessment of the various issues affecting a water cycle management plan including existing and proposed site conditions, water cycle controls, ongoing maintenance, proposed management plan strategy. The report provides an assessment of a possible design solution to support the future development of the land for urban uses.

The report considers a number of development options and the suitability of those options to provide for water quality for the use of the land for urban purposes. The options proposed meet Wyong Shire Councils guidelines, criteria and framework for water quantity and quality.

2.0 SITE DETAILS

2.1 LOCATION AND DESCRIPTION

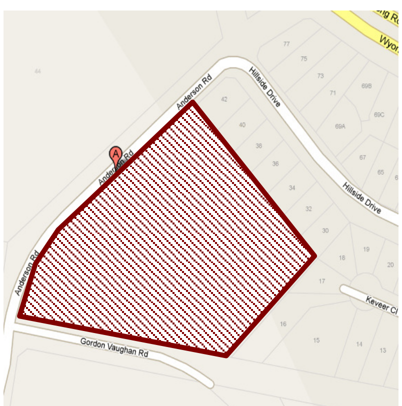


Figure.1 – *Site Location Extract from Google Maps*

The subject site defined as Lot 8, DP 816552 – 5 Anderson Road, Glenning Valley; is located on the eastern side of Anderson Road, Glenning Valley and has a site area of approximately 19,110m^2. Figure 1 shows the site location being slightly to the north east of Quondong Gully, a tributary to Berkeley Creek.

2.2 TOPOGRAPHY

The surrounding land falls towards the south western corner of the site and Anderson Road. The gradient is mainly uniform and there is generally a shallow central depressions visible from the site contours, the central depression generally directs stormwater flows through the site within the contributing catchment to the south west.

The site is located at the top reaches of the Quondong Gully drainage catchment and although some adjacent land holdings fall towards the subject site, the existing drainage paths in the form of road side kerb and gutter/drainage and inter-allotment drainage lines within DP 816552 means that the catchment associated with the drainage of the site will consist solely of the subject site with little to no upstream contribution. Appendix A shows the subject site, drainage catchment and details associated with the proposed water management plan.

2.3 EXISTING LAND USE AND ZONING

Presently remnant natural vegetation exists along the southern and eastern boundaries of the subject site however the remainder of the site has been previously cleared of vegetation having previously been used for agricultural purposes. The site is vacant and there are no existing site improvements other than fencing. The land is well maintained by regular mowing.

Photo – *Subject Site Looking North*

The site is currently zoned 7(c) – Scenic Protection Small Holdings Zone in accordance with Councils Local Environmental Plan (LEP). It is proposed to rezone the land from zone 7(c) to Residential 2(a) to allow the future subdivision of the site for urban purposes.

2.4 SCOPE OF STRATEGY ASSESSMENT

The stormwater management plan as part of this assessment has addressed the subject site which is bounded by Anderson Road to the west, Gordon Vaughan Road to the south and existing residential development to the east and north.

Photo – *Anderson Road and Gordon Vaughan Road Intersection.*

It is noted that site drainage from the adjacent residential land is either conveyed directly to Hillside Drive street drainage or via inter-allotment drainage lines to Anderson Road street drainage. This results in stormwater runoff external to the site bypassing the subject site.

3.0 WATER CYCLE MANAGEMENT CONTROLS

The preparation of a stormwater and water cycle management plan must address the anticipated increase in stormwater runoff from the site and provide appropriate controls as part of a treatment train for the site.

The assessment of natural systems planning and controls to identify their functionality as part of a suitable treatment train for the subject site will help determine an appropriate methodology for addressing key water quality and quantity matters. A number of potential source, conveyance and discharge controls have been discussed to determine their suitability for the subject site.

3.1 NATURAL SYSTEMS PLANNING

The assessment of natural systems as they currently exist and the effect any development proposal will have on the adjustment or augmentation to the natural systems is essential to allow an effective management strategy to be established which works with existing natural systems rather than against such systems.

The proposed development should consider natural systems planning by incorporating the following developmental elements.

- Nominating roads to match into existing surface levels where possible reducing cut and fill and site impacts.

- Minimising piped drainage as part of the development to retain and improve any existing informal drainage paths located within the subject site.
- Retain existing vegetation fronting Anderson Road and Gordon Vaughan Road as urban enhancement.
- Consider infiltration to retain groundwater.

3.2 SOURCE CONTROLS

Source controls are implemented at the start of water cycle systems. In terms of the potential future development of the subject site this will generally occur where increased stormwater runoff will occur such as dwelling roofs, courtyard areas, road pavement etc from impervious areas.

Source controls can include the following.

- Individual allotment rainwater tanks for collection of roof stormwater runoff (compliance with BASIX).
- Individual allotment retention trenches/tanks for detainment and dispersion/reuse of stormwater runoff.
- Site grey water reuse to minimise release of contaminants into the water cycle and to minimise individual reticulated water usage.
- Direct infiltration trenches/tanks on individual allotments for detainment and dispersion of stormwater runoff.
- Site contouring and regrading to form localised depressions for collection and infiltration of stormwater.
- Selective vegetation planting to minimise demand for water use, fertilisers and herbicides and encourage infiltration of potential contaminants by creating meandering water paths around and through planted areas.

3.3 CONVEYANCE CONTROLS

Conveyance controls collect and direct stormwater runoff from a source to a central or trunk drainage system point. This can consist of the following types of conveyance controls.

- Localised depressions such as grassed swales or dish drains for water polishing (filtration in grass swales) and transportation.
- Existing natural drainage channels within gullies and depressions.
- Constructed grassed swale drains to improve water quality and filter out pollutants.
- Kerb & guttered road network for transfer of overland stormwater flow.
- Kerb inlet pits and piped drainage network for collection and transfer of stormwater flows.

- Inter-allotment drainage (IAD) lines for collection and transfer of stormwater flows.
- Provision of gross pollutant traps to remove coarse and medium pollutants as well as sediments.

The above conveyance controls can be described as hard or soft depending on the effect they have on the conveyed stormwater flows. Soft options include the use of grassed swales, natural drainage channels and other methods which help to reduce pollutant loads and encourage infiltration of stormwater into the soils. Hard options are those options which do not encourage infiltration, do not reduce nutrient loading and exist only to convey stormwater flow away from the source. These are generally constructed from concrete or other impervious materials and their role is purely conveyance and stormwater control.

3.4 DISCHARGE CONTROLS

Discharge controls collect stormwater runoff via the conveyance controls for detainment, infiltration and pollutant removal purposes. Examples of typical discharge controls include the following.

- Gross pollutant traps to collect and detain detritus, debris and pollutants.
- Vegetated filter strips and channels to improve water quality and pollutant removal.
- Dry detention basins which fill up temporarily during storm events and detain increased stormwater flows.
- Wet detention basins which remain partially filled with water and provide additional stormwater detention capacity above the existing or permanent water level.
- Constructed wetlands which are designed to improve water quality and remove sediment from stormwater discharge. These wetlands are usually combined with a wet detention basin to meet both water quality and quantity requirements for a site.

4.0 DESIGN WATER MANAGEMENT PLAN SOLUTION

The implementation of a suitable water cycle management plan should address and provide achievable objectives for improving water quality and can comprise the following key components.

- Reduce the reliance on potable water supplies.
- Harvest rainwater and urban stormwater runoff for reuse.
- Capture, treat and reuse wastewater where appropriate.
- Allow for the use of infrastructure which is compatible for both present and potential future water use.
- Identify general drainage patterns and flow details for all natural water course and water channels.

- Locate all points of discharge.
- Propose techniques to prevent soil movement and the siltation of local waterways.
- Provide onsite stormwater detention and retention measures to prevent the release of increased flows or raised flood levels.
- Minimise impervious areas and maximise onsite infiltration to reduce runoff to the stormwater system.
- Demonstrate the application of appropriate water sensitive urban design elements.
- Identify the quantity of potable water demand that can be reduced through the application of water saving devices.
- Detail proposed stormwater quantity and quality measures to be implemented.

These objectives are expected to be achieved through the implementation of a number of water cycle management controls which together will form the proposed design treatment train solution for the subject site. These controls are shown illustrated on the catchment plan in Appendix A and discussed in more detail under further sections of this report.

The establishment of an appropriate water cycle management plan however is dependent not only on the suitability of the proposed solution but also on the consideration and assessment of incompatible options.

The following strategies for addressing the water cycle requirements associated with the subject site and its contributing catchment were considered and are discussed in detail as follows.

4.1 STRATEGY ASSUMPTIONS AND CONCLUSIONS

Photo – *Existing Vegetated Swale Drain along Anderson Road*

The potential number of options available to provide a suitable water cycle strategy and design treatment train on the site was reduced by implementing the following base assumptions and conclusions.

- Upslope stormwater runoff from adjacent lots is captured and conveyed away from the site by either existing inter-allotment or drainage to the associated road reserves.
- Direct access to lots via Anderson Drive by vehicular traffic will not be permitted for the development. Thus retaining the existing vegetated swale.
- The retention of existing vegetation corridors along Anderson Road and Gordon Vaughan Road is considered a priority as part of any overall site development strategy.
- The subject site is not controlled by a regional constructed wetland in accordance with discussions between Council officers and ACM Landmark in November 2010.
- As the land parcel is located at the top of the Quondong Gully catchment and the site is small in relation to these catchments, the provision of water sensitive urban design solutions in lieu

of a site specific detention basin is preferred in accordance with discussions between ACM Landmark and Council officers.

- Development of the road network will require the provision of kerb & gutter to all internal roads. However to maintain the rural environment currently existing to the north, west and south west it is concluded that the existing swale drains to Anderson Road and Gordon Vaughan Road will be retained to allow polishing of stormwater leaving the site. Gordon Vaughan Road however will receive only limited stormwater from the retained vegetation areas.
- The concept subdivision arrangement shown on plans attached as Appendix A was used in establishing existing and proposed site discharge requirements for the site.
- The use of onsite detention storage of up to 30% of the total BASIX volume within the provided BASIX rainwater tanks was utilised to allow the application of water draw down and site reuse between rainfall events over the site. An anticipated BASIX rainwater tank of 5000 Litres was chosen for modelling purposes thereby resulting in an available onsite detention storage allowance of 1,500 Litres per tank per lot.

4.2 SOURCE CONTROL – RAINWATER TANKS

Rainwater tanks are a BASIX requirement associated with the construction of any new dwelling. They provide a means for the collection of stormwater runoff from roof surfaces for site reuse and thereby help decrease initial stormwater runoff from leaving residential sites.

It is proposed that BASIX requirements will determine a requirement to provide rainwater tanks of approximately 5,000 Litres to each future dwelling on each proposed lot. As previously discussed Council will allow up to 30% of the BASIX tank size requirement to be used for onsite detention purposes. A volume of 1,500 Litres for each of the proposed lots (totalling 19 lots) has been utilised as part of the overall catchment assessment.

Secondary to this allowance the tanks may also be oversized to provide additional detention storage in excess of the BASIX requirements for a site. A low flow bleed off valve can be provided to ensure drainage of the detention space occurs over time. Over sizing of rainwater tanks has not been proposed in this instance but is encouraged as this will provide additional onsite detention storage which may be utilised for future development as part of this strategy.

Source controls can be considered impractical and possibly unreliable as a critical component of an overall strategy for the following reasons.

- They generally consist of a series of individual systems which are highly dependent upon maintenance for correct operation generally by the owner of an allotment.

- Such systems can be poorly maintained and can fall into disrepair. However as these are within the presence of the land owner the asset is generally well maintained and used.
- The failure of one individual source control can impact the cumulative effect of the strategy.
- Such options do not make allowances for increased stormwater runoff from roads and other public areas meaning that separate source controls are required to be provided for these public assets.

Despite some source control disadvantages, the use of rainwater tanks is encouraged for inclusion and have been nominated in this instance as part of an overall water cycle strategy for the subject site.

4.3 SOURCE CONTROL – LANDSCAPE DESIGN

The use of appropriate plants, particularly native and indigenous plants as well as suitable planting locations can help improve water quality by encouraging infiltration of stormwater, requires less watering and reduces the application of nutrients and phosphates. This is often referred to as a rain garden.

Long, deep watering of plants encourages the growth of deep root systems which in turn helps support the soils and prevent erosion of sediments with stormwater runoff. Plants indigenous to the local environment are also to be proposed as they will require less fertilisers which are key generators of phosphates and other nutrients. This will therefore reduce the potential for these pollutants to enter the water systems.

Consideration of planting locations may also help reduce erosion when planting in steep areas and/or encourage infiltration of stormwater runoff within areas where grades are shallow or are slightly depressed.

In accordance with previously considered source controls, the implementation of these controls relies heavily on the continued maintenance by the end user, however opportunities exist within Council approval processes to apply landscaping requirements during planning and assessment processes which will achieve landscaping works to be provided on individual developments. These can also be included on 88B Instruments on the title to each lot in association with existing vegetation retention.

Photo –*Subject Site facing East*

4.4 CONVEYANCE CONTROL - PIPED DRAINAGE

Kerb & gutter supported by a pit & piped drainage network is a typical conveyance control employed as part of many urban residential subdivisions and has been nominated as a suitable conveyance control in this instance by Wyong Shire Council.

The kerb & gutter provides a method of collecting and diverting overland flow to a network of pits and pipes which then convey the collected stormwater runoff to a suitable discharge location. During minor storms up to the 1 in 5 year average recurrence interval in urban areas the piped drainage is designed to convey the majority of the stormwater whilst during larger storm events the pipes and kerb & gutter work in tandem to convey stormwater runoff to a nominated point of discharge.

There are two proposed points of discharge for pipe drainage to outlet from the subject site and both are to be located on Anderson Road slightly to the south east of the intersecting access road connecting to Anderson Road and toward the south west of the site.

Prior to the pipe outlets will be located a gross pollutant trap which will collect course litter sediments and the like. This would be a proprietary system sized for the contributing catchment.

At each piped outlet from the gross pollutant trap a concrete headwall and scour protection is to be provided in accordance with Councils Engineering Requirements for Development to allow transition between the pipe outlets and the downstream swale drains.

The use of other types of conveyance controls internal to the site has not been proposed for the following reasons.

- Sealed roads with kerb & gutter are required for urban residential subdivisions within the Wyong Shire Council area.
- The installation of grassed swales internal to the site is not appropriate given the urban nature of the site and limited footpath width within the anticipated road corridor.
- There are no natural channels currently existing on the site.
- Minimal inter-allotment drainage is anticipated as being required as part of a future subdivision due to the proposed subdivision layout and site topography.
- A road pit and piped drainage network internal to the site is considered the most practical solution given the subject site location at the top of the catchment.

4.5 CONVEYANCE CONTROL – SWALE DRAIN

Once site drainage is directed to Anderson Road stormwater flow will be conveyed within the existing vegetated swale drains located adjacent to the site within Anderson Road for discharge as part of Councils street drainage system.

Discharge is proposed to undergo treatment via the existing downstream swale drains from the piped outlets through the polishing of existing water quality to help remove pollutants and nutrients from the stormwater runoff. This will be achieved by encouraging infiltration of the stormwater runoff into the swale drain and slowing flow velocities within the vegetated drains which would also help remove any remaining pollutants that may be suspended within the stormwater runoff.

The base of the swale drains could be reworked to provide bio-remediation however this has not been proposed in this instance as the swale drains are existing and this would affect the established drains operation, albeit temporarily until vegetation regenerates within the channel. Similarly subsoil drainage may be incorporated to the base of the swale drains if considered appropriate in accordance with Councils Engineering Requirements for Development.

The use of other types of conveyance controls external to the site has not been proposed for the following reasons.

- The swales currently exist and it is proposed to utilise this existing natural feature rather than remove them.
- The land surrounding the site to the north and west is zoned Conservation Zone (7a) or Scenic Protection: Small Holdings Zone (7c) and the retention of swale drains rather than the construction of kerb & gutter help enhance the rural nature of the surrounding landscape
- The use of vegetated swale drains as a soft conveyance option external to the site is preferred over the application of hard options like piped drainage and kerb & gutter works.

5.0 SITE HYDROLOGICAL ANALISIS

The contributing catchment associated with the hydrological analysis of the design water cycle strategy solution consists solely of the subject site. The catchment associated with the strategy solution has an area of approximately 19,111m^2 and is shown in Appendix A.

Analysis of the contributing catchment for the site including the assessment of upstream runoff was undertaken using the Rational method as specified in Wyong Shire Council's "Engineering Requirements for Development" and in accordance with the Australian Rainfall & Runoff 1987 (AR&R).

5.1 DESIGN SOLUTION EXISTING SITE ANALYSIS

The site was assessed in accordance with Wyong Shire Council's "Engineering Requirements for Development" predominately Section 7 – Stormwater Drainage.

Fraction Impervious

The subject site in its existing form does not support any land improvements which would contribute an impervious area to the existing catchment.

Land Use	Area (m2)	Impervious Area (m2)	Total Imp %
Existing Contributing Catchment Area	19,111	0	0.0

Table 1 – Impervious Values for Existing Site Assessment

Coefficient of Runoff

These values were established in accordance with Councils Engineering Requirements for Development and Chapter 14.5 of AR&R for the relevant annual recurrence interval.

Time of Concentration

The time of concentration for the catchment was established using the Bransby-Williams formula (equation 1) for the existing rural catchment.

$$t_c = \frac{58.5(L)}{A^{0.1}S^{0.2}} \qquad (1)$$

Determination of Site Discharge

$$Q = \frac{CIA}{360} \qquad (2)$$

Utilising the previous theory the following times of concentration, rainfall intensities, runoff coefficients and existing site discharge values (equation 2) was determined for the catchment and summarised as follows. Detailed calculations can be found in Appendix B.

Bransby Williams Equation for Rural Catchments

L = 0.149 km
A = 0.019196 km^2
S = 134.23 m/km

$$\therefore \quad t_c = \frac{58.5(0.149)}{0.019196^{0.1}134.23^{0.2}} = 4.9 \text{ min}$$

A minimum time of concentration of 5.0 minutes was adopted as the established time of concentration was less than 5.0 minutes.

ARI (years)	tc (minutes)	I (mm/hr)	C	Q (L/s)
1 in 1	5.0	100.37	0.44	235.77
1 in 5	5.0	160.00	0.53	446.30
1 in 10	5.0	178.03	0.55	522.73
1 in 20	5.0	202.43	0.58	624.09
1 in 100	5.0	257.57	0.66	907.53

Table 2 – Existing Site Summary Details

5.2 DEVELOPED SITE ANALYSIS

Developed discharge for the site was calculated using the same methodology as established for the existing site. The catchments and the runoff were adjusted to suit the proposed future development of the site.

Areas based on a potential subdivision arrangement for the catchment are summarised as follows.

Land Use	Area (m2)	Fraction Imp %	Impervious Area (m2)	Total Imp %
Normal Residential Lot	11,820	50	5,910	
Potential Roof Area with tank	0	1	0	
Road Reserve Corridors	3,800	85	3,230	
Total Site Area 19,110	**15,620**		**9,140**	**59%**

Table 3 – Impervious Values for Developed Site Analysis

The establishment of the potential roof area is based on the assumptions established under section 4.1 of this report. Namely, that each of the proposed residential lots will support a house with a roof area of 200m^2 and a BASIX rainwater tank of 5,000 Litres capacity of which 30% (1,500 Litres) can be used for onsite detention storage capabilities.

Utilising the established theory the following times of concentration, rainfall intensities, runoff coefficients and existing site discharge values were determined for the catchment and summarised as follows. Detailed calculations can be found in Appendix B.

ARI (years)	tc (minutes)	I (mm/hr)	C	Q (L/s)
1 in 1	15.1	64.34	0.60	156.80
1 in 5	13.3	110.64	0.71	320.19
1 in 10	13.0	124.97	0.75	380.70
1 in 20	12.6	144.49	0.79	462.18
1 in 100	11.9	189.36	0.90	692.23

Table 4 – Developed Site Analysis Summary Details Excluding Tanks

The established time of concentration for the developed catchment was longer than the time of concentration for the existing catchment because the development of the site will result in the regrading of the land and diversion of stormwater flow within the nominated road corridors.

Stormwater runoff from the proposed roof surfaces to the nominated rainwater tanks was routed to establish the runoff (if any) from the tanks. The anticipated runoff from one tank was multiplied across the total proposed number of lots with the following values established for stormwater runoff from the tanks.

ARI (years)	tc (minutes)	I (mm/hr)	C	Q (L/s)
1 in 1	15.1	64.34	0.90	60.15
1 in 5	13.3	110.64	0.90	105.11
1 in 10	13.0	124.97	0.90	118.72
1 in 20	12.6	144.49	0.90	137.27
1 in 100	11.9	189.36	0.90	179.90

Table 5 – Developed Site Analysis Summary Details For Tanks

ARI (years)	Tc (minutes)	Site Q (L/s)	Tank Q (L/s)	Total Q (L/s)
1 in 1	15.1	156.80	60.15	229.01
1 in 5	13.3	320.19	105.11	449.93
1 in 10	13.0	380.70	118.72	528.70
1 in 20	12.6	462.18	132.27	634.99
1 in 100	11.9	692.23	179.90	925.38

Table 6 – Developed Site Analysis Summary Details Including Tanks

Comparison of anticipated post development flows shows that the development of the site and the implementation of rainwater tanks for onsite detention requirements will result in a reduction of peak discharges from the site of up to 2.9% for the 1 in 1 year storm with a maximum increase in flows from the site of 1.8% in the 1 in 100 year storm. Other storm events are consistent with pre development flows.

As outlined previously local overall onsite detention of the increased stormwater is not proposed in this instance due to the small size of the subject site, the location of the site at the top of a catchment and that the established discharge rates are expected to be less than or consistent with the existing rates. The use of water sensitive urban design features to help encourage site water reuse and infiltration works is preferred in lieu of a site specific detention basin.

5.3 DOWNSTREAM SWALE DRAIN ASSESSMENT

A swale drain is proposed to convey stormwater from the subject site along Anderson Road verge towards the existing road culvert under Anderson Road and thence the natural flowpath of Quondong Gully.

The existing swale drains beside the road have been modelled using the approximation shown below.

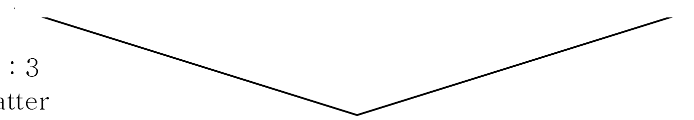


Figure 2 – Proposed Swale Drain Parameters

Calculations identifying the estimated depth of water within the channel based on the anticipated post-development discharge levels from the subject site using Manning's Equation can be found in Appendix B and are summarised below for convenience.

ARI (years)	Q (L/s)	Water Height in Channel (mm)	Flow Width in Channel (m)	Velocity in Channel (m/s)	V * d Value (m^2/s)
1 in 1	229.72	252	1.513	1.20	0.30
1 in 5	447.43	324	1.942	1.42	0.46
1 in 10	524.41	344	2.062	1.48	0.51
1 in 20	628.34	368	2.206	1.55	0.57
1 in 100	910.00	422	2.535	1.70	0.72

Table 7 – Subject Site Discharge in Swale Drain

The use of the channel section previously drawn and the calculations established above have been proposed based on the following considerations.

- The existing swale drain beside Anderson Road has used an approximated batter slope of 1:3. In some instances the batter slopes may steeper than the nominated 1:3.
- Although Councils preferred maximum batter slopes is 1:6, the use of 1:3 slopes is considered acceptable because the swale drains are existing.
- The swales will be located beside trafficable road carriageways and will therefore be accessible to the public and need to meet safety criteria for flow depth by velocity products for minor storm events although in the rural areas there are no pedestrian footpaths.

- The swale drains are to be maintained as short grass thereby allowing the use of the Manning's "n" co=efficient of 0.033.
- Warning signs can be installed warning of the potential danger of the swale drains during periods of heavy rainfall if required.
- Preferred velocities within grass lined swales generally range around 0.5m/s. Scour protection or armouring may need to be provided to reduce the impact of stormwater flows within the swales particularly during large storm events.

The existing swale drain in some instances may require additional works to ensure the drain is in accordance with the statements and calculations previously provided. Detailed design of the subdivision should identify where such deficiencies may exist and proposed remediation works as required.

A freeboard allowance within the swale drain is also required to ensure that additional overland flow or blockages within the swale will not affect the conveyance of stormwater within the swale drain.

Given the flow depths of approximately 420mm, Councils specified freeboard requirement of an additional 300mm above the established top water level is considered onerous for the proposed subdivision.

It is considered that a freeboard of approximately 100mm be proposed as this represents a further 60% capacity of the swale drain to allow for additional site runoff and conveyance in the event of upstream drainage structure failure or blockage of the swale drain.

It should be noted that should the swale drain capacity exceed then those excess flows are accommodated within Anderson Road as is currently the case. Therefore the reduced freeboard is considered appropriate.

ARI (years)	**Q (L/s)**	**Water Height in Channel (mm)**	**Flow Width in Channel (m)**	**Velocity in Channel (m/s)**	**V * d Value (m^2/s)**
1 in 100	1365.01	492	2.951	1.88	0.93

Table 8 – Upstream & Developed Site Discharge in Swale Drain

Based on the above calculations to assess the discharge parameters for a further 60% capacity it is considered that a swale drain be adopted based on the channel cross-section shown below for conveyance of discharge from the subject site along Anderson road and Gordon Vaughan Road towards Quondong Gully.

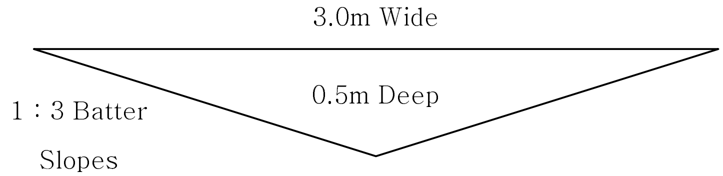


Figure 3 – Nominated Swale Drain Dimensions

5.4 DOWNSTREAM FLOODING EFFECTS

A number of previous reports have been prepared which consider the effects of flooding from the Berkeley Creek and Quondong Gully catchment and its tributaries.

Information provided by Council previously to ACM Landmark Pty Ltd shows that the land to the north west of Anderson Road is flood effected for short durations however the extents of flooding within the 1 in 100 year storm event do not cross Anderson Road and generally reach to approximately R.L. 16.00 AHD.

The site has levels ranging from R.L. 22.00 at the western (lower) corner of the site to R.L. 42.00 along the southern boundary these levels are highter than the identified flood level and therefore the site is not affected by flooding. This includes the drainage works which can be designed to discharge at levels above the 1%AEP thereby eliminating any possible back water effects upon the drainage design.

The subject site will discharge stormwater towards the natural catchment as identified previously. As the site catchment is small in size, located at the top of the catchment and post development flows are similar in quantity to the established existing discharge rates it is considered that the effect of this minor increase in stormwater within the 20 year Average Recurrence Interval (ARI) will have on downstream flooding is minimal. It is proposed to allow the stormwater to flow unrestrained apart from that detention within the BASIX tanks from the site so that the stormwater can flow through the downstream natural catchment at generally pre development levels before the critical time of concentration associated with the major flooding events within the catchment is reached.

6.0 MAINTENANCE, MONITORING AND PERFORMANCE EVALUATION

The implementation of a suitable water cycle management plan requires continued monitoring and maintenance to ensure performance of the strategy. Assessment on the suitability of the strategy should focus on the following key components.

- Minimise both water and wind erosion over the site.
- Reduce the transference of sediments from upstream and through the site.
- Control pollutants emanating from the site by reducing their initial application and providing methods for the treatment of collected pollutants.

6.1 OPERATION AND MAINTENANCE

The controls and systems proposed are designed to be generally low maintenance controls which do not require continual maintenance. However it is imperative that any problems are quickly indentified and maintenance is carried out as expediently as possible to:

- Ensure that the design parameters of the controls are maintained through the systems life.
- Allow maintenance staff to check the effectiveness of the system on a regular basis.
- Identify through the regular inspections of the system any possible faults or issues that may arise and allow the rectification of these issues as soon as practicable.

Operation and maintenance activities are to be implemented through the use of a maintenance schedule or inspection checklist for the site controls. As a minimum, the controls associated with this site should be checked in accordance with the maintenance schedule shown in Appendix C as well as additional checks after either a major storm event or any other event which may have a significant effect on any or all of the site controls.

An inspection checklist which details the key components of each system control implemented on the site has been attached in Appendix D for use during maintenance inspections.

6.2 RESPONSIBILITIES

The responsibility for the inspection, operation and maintenance of the subject site and its implemented controls will vary depending on the location of the control and the stage of development the site is currently experiencing. Responsibilities for the inspection, operation and maintenance of the applicable site controls are set out in the following table.

Stage of Development	Controls	Responsibility
Pre-Construction	All	Land owner
Construction Phase	All	Construction contractor and/or supervising site manager
Post-Subdivision Phase	Rainwater Tanks	Land Owner
	Landscaping	Land Owner
	Piped Drainage	Council
	Gross Pollutant Traps	Council
	Downstream Swale Drain	Council

Table 9 – Responsibilities for Inspection, Operation and Maintenance

6.3 PERFORMANCE EVALUATION

The evaluation of the performance of any control within the nominated treatment train is assessed via pass or fail. If any control is not performing as required then that control is deemed to have failed and requires rectification. The Inspection checklist included as Appendix D of this report is designed to identify any deficiencies within the controls and allow works to be undertaken on the control to correct any problems which may arise.

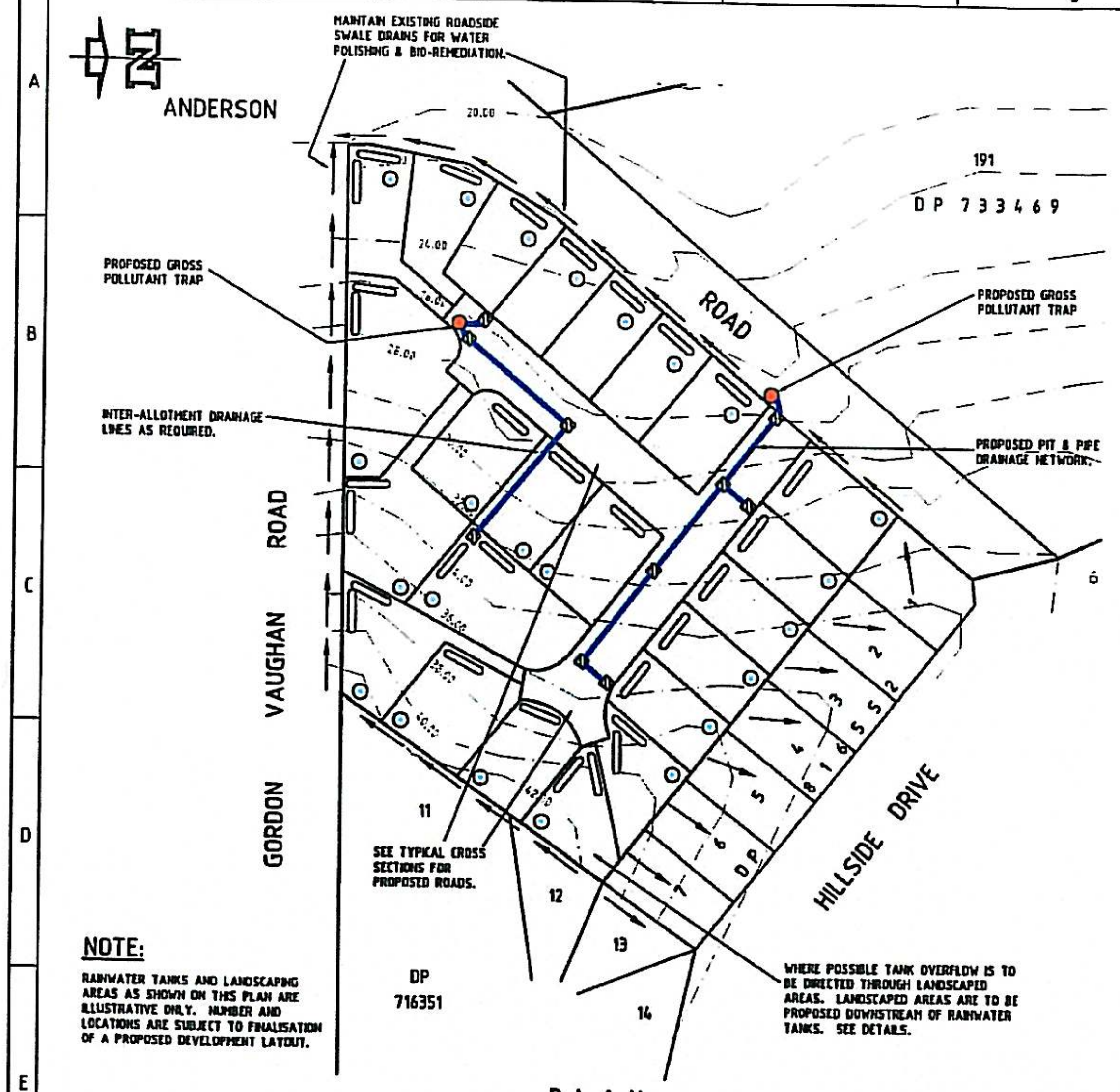
7.0 CONCLUSION

The assessment of the subject site has established existing pre development and proposed developed flows for the treatment of water quality and quantity. The flows leaving the site following development can meet pre-development targets and reduce the potential for impacting on downstream development.

A water management plan involving the assessment and implementation of a number of controls as part of an overall treatment train has been nominated which is considered suitable for the subject site and contributing catchment to allow the rezoning of the site for urban development.

APPENDIX A

Stormwater Catchment and Water Management Plan



NOTE:

RAINWATER TANKS AND LANDSCAPING AREAS AS SHOWN ON THIS PLAN ARE ILLUSTRATIVE ONLY. NUMBER AND LOCATIONS ARE SUBJECT TO FINALISATION OF A PROPOSED DEVELOPMENT LAYOUT.

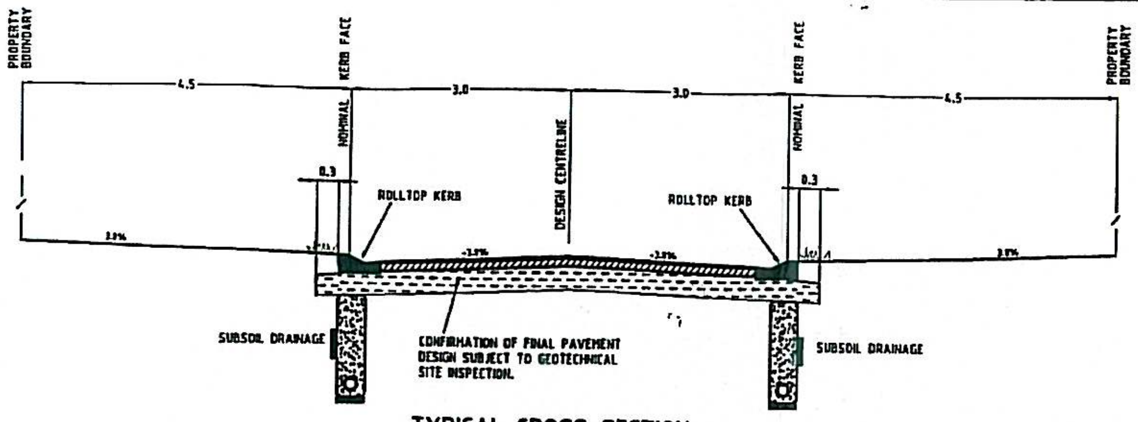
PLAN:

SCALE 1:1000 (A1)
CONTOUR INTERVAL 2.0m

LEGEND:

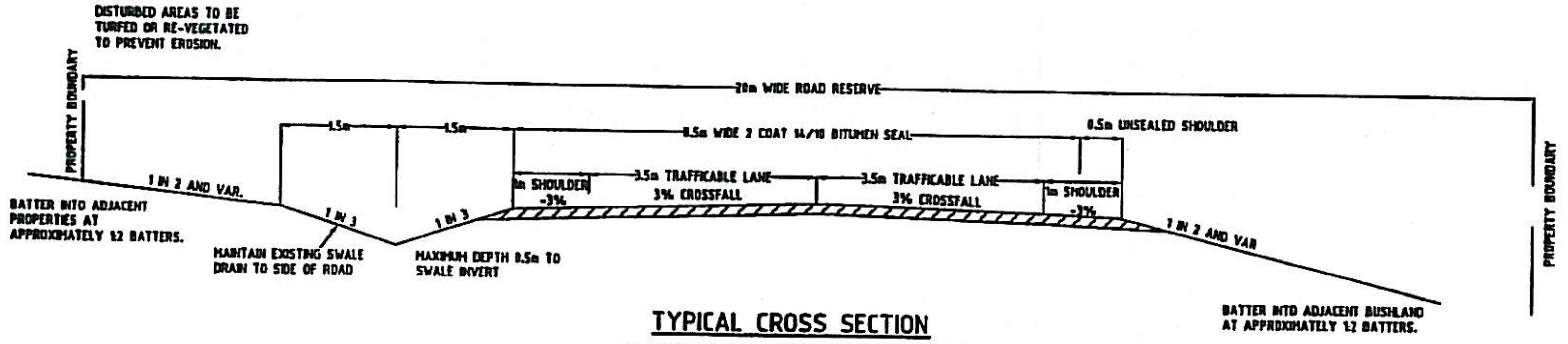
- SUBJECT SITE & CATCHMENT
- RAINWATER TANK
- EXISTING UPSTREAM DRAINAGE PATHS
- EXISTING & PROPOSED GRASS SWALES FOR BIO-REMEDIATION
- LANDSCAPED AREA
- PROPOSED PIPED DRAINAGE LINES & PITS
- GROSS POLLUTANT TRAP

LAND USE	AREA (m^2)
PROPOSED RESIDENTIAL AREAS	16,216
ROAD RESERVE CORRIDORS	2,980
TOTAL	19,196



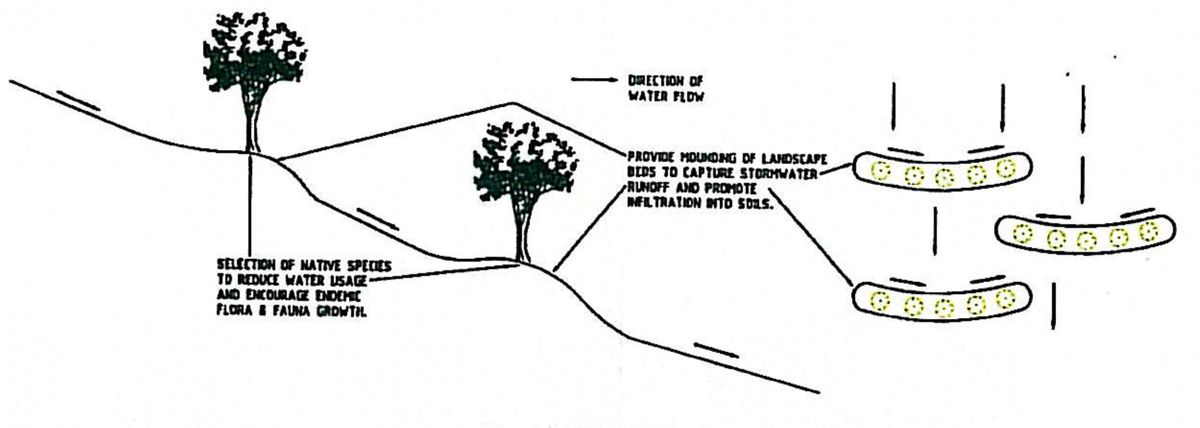
TYPICAL CROSS SECTION

PROPOSED STREET - 15.0m WIDE (4.5-6.0-4.5)
SCALE 1:50



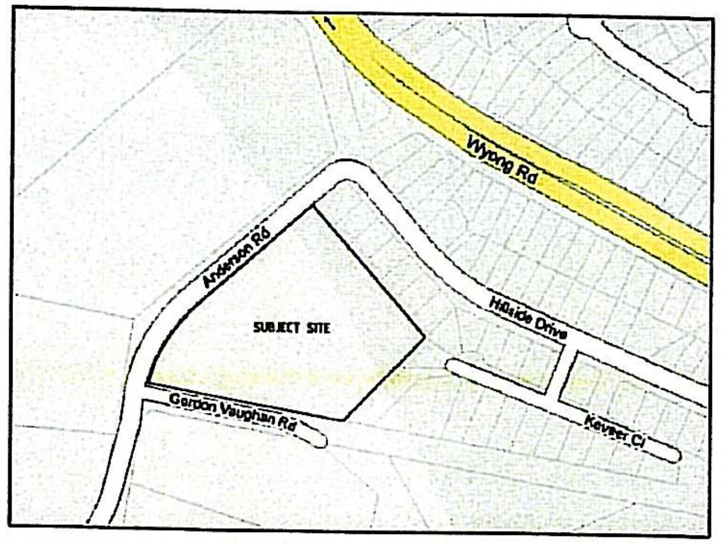
TYPICAL CROSS SECTION

ANDERSON ROAD - 20.0m WIDE (4.5-7.0-4.5)
N.T.S.



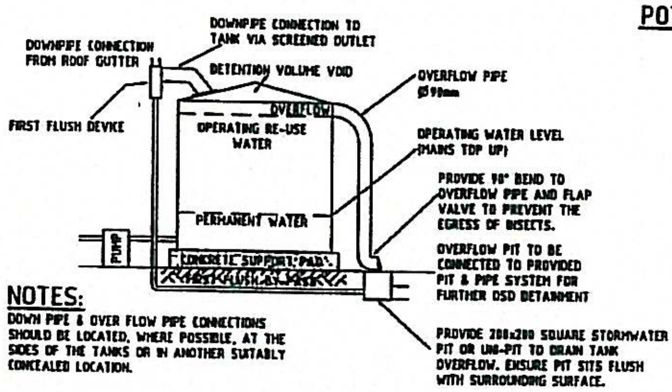
POTENTIAL LANDSCAPING ARRANGEMENT

NOT TO SCALE



SITE LOCATION:

SCALE: NTS



NOTES:

DOWN PIPE & OVER FLOW PIPE CONNECTIONS SHOULD BE LOCATED, WHERE POSSIBLE, AT THE SIDES OF THE TANKS OR IN ANOTHER SUITABLY CONCEALED LOCATION.

WATER TANK DETAIL

NOT TO SCALE

DIAL 1100 BEFORE YOU DIG

FOR APPROVAL

AutoCAD FILE.
F:/ACM DOCUMENTS/PA/C/1157/CADRAW/1/1157-1001-A.dwg
CIVILCAD FILE.

No.	Date	Amendment Details	Initial
A	15.12.13	ORIGINAL ISSUE FOR APPROVAL.	CP

ACM LANDMARK
LAND DEVELOPMENT CONSULTANTS

Client: ANDREWS NEIL URBAN DESIGN GROUP

Surveyed by:	-		
Geotechnical by:	-		
Datum:	ASSUMED	Coord:	
Designed:	CP	Checked:	CP
Drawn:	JM	Approved:	CP

Job Name: PROPOSED SUBDIVISION
LOT 8, DP 816552
5 ANDERSON ROAD, GLENNING VALLEY

Title: STORMWATER CATCHMENT & WATER MANAGEMENT PLAN

Scale: AS SHOWN | Drawing No. 1157-1001 | Sheet No. 1 of 1 | Amdt. A

APPENDIX B

Hydrological Calculations

ID - 1157 5 ANDERSON ROAD, GLENNING VALLEY 7/03/2011

OSD Drainage Assessment

Existing Catchment Assessment - Subject Site					Value	Units		
Total Site Area					19110	m^2		
Existing Impervious Area					0	m^2		
Fraction Impervious (%)					0.0%	%		
Rural Catchment Flow t_c - Bransby Williams								
Mainstream length					149	m		
Height Difference					20	m		
Mainstream slope					134.23	m/km		
$t_c = (58.5*L)/(A^{0.1*}S^{0.2}) =$		Where A is in km^2, L in km and S in m/km						
10 yr ARI 1 hr storm IFD for		Glenning Valley			59.07	mm/hr		
C110 = 0.1+0.0133*(10I1-25) =					0.55			
C10 = 0.9*f+C110*(1-f) =					0.55			
ARI	(Years)	1	2	5	10	20	50	100
tc	(min)	4.9	4.9	4.9	4.9	4.9	4.9	4.9
tc Used	(min)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
I	(mm/hour)	100.37	127.88	160.00	178.03	202.43	233.91	257.57
C		0.44	0.47	0.53	0.55	0.58	0.64	0.66
Existing	Q (L/s)	235.77	319.16	446.30	522.73	624.09	789.83	907.53

Developed Catchment Assessment - Subject Site					Value	Units		
Catchment 1			Area	Imp fract	Imp Area			
Normal residential Lot			11820	0.5	5910			
Roof Areas with Tanks			0	1	0			
Half Width Road Reserve			3800	0.85	3230			
Industrial Areas			0	0.9	0			
Parkland, Public Reserve				0.1	0			
Total Site Area		**19110**	**15620**		**9140**		**0.59**	
							Tot Site Imp %	
10 YR ARI Storm IFD for		Glenning Valley		59.07				
C110 = 0.1+0.0133*(10I1-25) =				0.55				
C10 = 0.9*f+C110*(1-f) =				0.76				
Co-eff of Runoff								
ARI	(years)	1	2	5	10	20	50	100
Co-eff		0.60	0.64	0.72	0.76	0.79	0.87	0.91
Sheet Flow t_c - Kinematic Wave								
Sheet Flow Length					30.6	m		
Height Difference					4.5	m		
Slope					14.71%	%		
roughness "n" - refer to Table 6.3.7					0.35			
$t_c*I^{0.4} = 6.94(L*n)^{0.6}/S^{0.3} =$					51.17			
Concentrated Flow t_c - Bransby Williams								
Mainstream length					174	m		
Height Difference					16	m		
Mainstream slope					91.95	m/km		
ARI	(Years)	1	2	5	10	20	50	100
tc - Sheet	(min)	8.8	7.9	7.1	6.7	6.3	5.9	5.7
tc - Concentrate	(min)	6.2	6.2	6.2	6.2	6.2	6.2	6.2
tc - total	(min)	15.1	14.1	13.3	12.9	12.5	12.1	11.9
I	(mm/hour)	64.34	85.17	110.64	124.97	144.49	169.80	189.36
C		0.60	0.64	0.72	0.76	0.79	0.87	0.91
Discharge	Q (L/s)	168.86	237.50	344.82	409.98	497.73	640.60	745.48

N.B - CALCULATIONS HEREIN TO BE VIEWED IN CONJUNCTION WITH CONCEPT DRAINAGE PLANS AND SUBJECT TO FINAL DESIGN

ID - 1157

5 ANDERSON ROAD, GLENNING VALLEY
OSD Drainage Assessment

7/03/2011

Developed Site Assessment - Tanks on Subject Site					Value	Units		
ARI	(Years)	1	2	5	10	20	50	100
C		0.90	0.90	0.90	0.90	0.90	0.90	0.90
I		64.34	85.17	110.64	124.97	144.49	169.80	189.36
Tank Area	m^2	200	200	200	200	200	200	200
Tank Q	Q (L/s)	3.22	4.26	5.53	6.25	7.22	8.49	9.47
Calc tank Overflow as Unrestrained								
Tank Q	Q (m^3)	2.91	3.60	4.41	4.85	5.44	6.19	6.76
Runoff Volume								
Avail tank Storage		1.500	m3					
Tank Q	O/Flow (m3)	1.41	2.10	2.91	3.35	3.94	4.69	5.26
Q at point of overflow								
Tank 1	Q (L/s)	3.17	4.26	5.53	6.25	7.22	8.49	9.47
Times 19 lots		60.15	80.91	105.11	118.72	137.27	161.31	179.90
Total tank Overflow		60.15	80.91	105.11	118.72	137.27	161.31	179.90
Required Site Storage					Value	Units		
Developed Q	Q (L/s)	168.86	237.50	344.82	409.98	497.73	640.60	745.48
Tank Q	Q (L/s)	60.15	80.91	105.11	118.72	137.27	161.31	179.90
Total Q	Q (L/s)	229.01	318.41	449.93	528.70	634.99	801.91	925.38
Exsitng Q	Q (L/s)	235.77	319.16	446.30	522.73	624.09	789.83	907.53
Req'd Storage = tc*60*(Developed Q_n - Existing Q_n)/1000								
Req'd Storage	(m^3)	-6.11	-0.63	2.89	4.64	8.21	8.80	12.74
Swale Drain Asesessment					Value	Units		
Triangular Swale Drain								
0.5m deep channel								
Battered side slopes maximum 1:3								
				n =	0.033	For short grass		
$Q = (^1/_n)*A*R^{(2/3)}*S_o^{(0.5)}$				P =				
				R =				
				S_o =	0.025	2.50%		
Estimated height in channel for actual Q								
ARI	(Years)	1	2	5	10	20	50	100
Discharge	Q (L/s)	229.01	318.41	449.93	528.70	634.99	801.91	925.38
Height	ht (m)	0.25	0.28	0.32	0.34	0.37	0.40	0.42
Height	ht (mm)	252	285	324	344	368	401	422
Permieter	ht (m)	1.513	1.710	1.942	2.062	2.206	2.404	2.535
Flow Area	A (m2)	0.191	0.244	0.314	0.354	0.406	0.482	0.535
Flow Velocity	V (m/s)	1.20	1.31	1.43	1.49	1.57	1.66	1.73
V * d	(m2/s)	0.30	0.37	0.46	0.51	0.58	0.67	0.73
Calculations	Q (L/s)	229.7	318.5	447.4	524.4	628.3	790.1	910.0
Diff		0.71	0.07	-2.50	-4.29	-6.65	-11.80	-15.37

N.B - CALCULATIONS HEREIN TO BE VIEWED IN CONJUNCTION WITH CONCEPT DRAINAGE PLANS AND SUBJECT TO FINAL DESIGN

OSD Drainage Assessment

Swale Drain Asesessment - Freeboard assessment				Value	Units		
Triangular Swale Drain							
0.5m deep channel							
Battered side slopes maximum 1:3							
			n =	0.033	For short grass		
$Q = (^1/_n)*A*R^{(2/3)}*S_o^{(0.5)}$			P =				
			R =				
			S_o =	0.025	2.50%		
Estimated height in channel for additional 50% discharge							
ARI	(Years)	1	2	5	10	20	50	100
Discharge	Q (L/s)	344.58	477.72	671.14	786.62	942.51	1185.16	1365.01
Height	ht (m)	0.29	0.33	0.38	0.40	0.43	0.47	0.49
Height	ht (mm)	294	332	377	400	428	466	492
Permieter	ht (m)	1.761	1.991	2.261	2.400	2.568	2.799	2.951
Flow Area	A (m2)	0.258	0.330	0.426	0.480	0.550	0.653	0.726
Flow Velocity	V (m/s)	1.33	1.45	1.57	1.64	1.71	1.82	1.88
V * d	(m2/s)	0.39	0.48	0.59	0.66	0.73	0.85	0.93
Calculations	Q (L/s)	344.6	477.7	671.1	786.6	942.5	1185.2	1365.0
Diff		0.00	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX C

Water Management Plan

Maintenance Schedule

General Maintenance Schedule for Water Management Plan Objectives

Water Management Plan Control	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainwater Tanks												
Inspect roof gutters and flush downpipe system to clear blockages of debris as necessary.	●	●	●	●			●			●		●
Check for sediment and debris build up within overflow outlet discharge areas.	●			●			●			●		
Inspect and service pumps in accordance with manufacturers recommendations.	●			●			●			●		
Landscape Design												
Inspect garden beds for instability, erosion and rectify if required.	●			●			●			●		
Check for vegetation. Remove undesirable growth and/or replace dead vegetation.	●			●			●			●		
Kerb & Gutter and Piped Drainage												
Sweep kerb & gutter to remove sediment build up and other general litter (at least weekly)	●	●	●	●	●	●	●	●	●	●	●	●
Remove detritus and blockages from kerb inlet pits	●			●			●			●		
Flush stormwater pipes to remove blockages if any	●			●			●			●		
Inspect inlet and outlet pipes for damage at pits.	●			●			●			●		
Gross Pollutant Trap												
Check inlet and outlet pipes are operational	●			●			●			●		
Clear trash rack and empty collection bin of filtered gross pollutants	●			●			●			●		
Grassed Swale Drain												
Mow/slash undesirable vegetation growth within channel.	●	●	●	●			●			●		●
Clear swale of filtered gross pollutants (if any)	●			●			●			●		
Inspect embankments for slope instability, rectify if required	●			●			●			●		
Check and undertake as required sedimentation removal	●			●			●			●		

* All detention basin components are to be checked after a significant storm event or other event that may affect the functionality of the system (oil spill, fire, flood, etc)

APPENDIX D

Water Management Plan

Inspection Checklist

Inspection Checklist for Water Management Plan

Date / Time Inspected: **Inspected By:** **Signed:**

Overall Site Condition of Facilities

Management Component	Checklist		Comments	Action Taken (Dated)	Follow Up Required
	No Work Required	Work Required			
Rainwater Tanks					
Roof Gutters in good working order and clear of all debris					
Roof Downpipes clear of all blockages with no damage					
Overflow outlets clear of debris and sedimentation build-up					
Pumps working in accordance with manufacturers recommendations					
Landscaping					
Inspect garden beds for instability, erosion					
Check vegetation is alive and not dead					
Inspect recent growth for potential pruning					

Inspection Checklist for Water Cycle Strategy

Date / Time Inspected: **Inspected By:** **Signed:**

Overall Site Condition of Facilities

Management Component	Checklist		Comments	Action Taken (Dated)	Follow Up Required
	No Work Required	Work Required			
Kerb & Gutter and Piped Drainage					
Kerb & gutter clear of sediment build up and other litter					
Kerb inlet pits free of blockages					
Stormwater pipes free of blockages					
Inlet and outlet pipes free from damage					
Gross Pollutant Trap					
Inlet and outlet pipes are operational and free from blockages					
Trash rack empty of filtered gross pollutants					
Grassed Swale Drain					
Vegetation growth within channel is maintained					
Swale free of filtered gross pollutants and debris					
Embankments slopes stable and free from damage					
Evidence of sedimentation within swale is negligible					