Aspen Group

Lot 2 Nettleton Rd, Byford

Local Water Management Strategy

September 2009

JDA
Consultant Hydrologists

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1. INTRODUCTION

1.1 Background

This local water management strategy (LWMS) has been prepared by JDA Consultant Hydrologists on behalf of the Aspen Group for the development of Lot 2 Nettleton Road, Byford (herein referred to as the Study Area, Figure 1).

This document has been prepared to support the Local Structure Plan prepared by Taylor Burrell Barnett for the abovementioned property in accordance with State Planning Policy 2.9. The relationship of this document to the planning process is shown in Table 1.

The LWMS provides a framework for the application of total water cycle management to the Study Area, consistent with Department of Water (DoW) principles of Water Sensitive Urban Design (WSUD) as detailed in the Stormwater Management Manual (DoW 2007). It aims to integrate stormwater drainage, nutrient and pollutant management, and stormwater conservation, and is based on the principles of WSUD (Whelans et al. 1993).

The LWMS provides an understanding of the existing surface water and shallow groundwater for the Study Area and provides advice on seasonal groundwater variation, stormwater drainage, water quality considerations and flood management.

This document has been prepared to be in accordance with the requirements of the Byford Townsite Drainage and Water Management Plan (BDWMP) (DoW, 2008). A copy of the LWMS Checklist for Developers is included as Appendix A to assist the Shire and DoW in review of this document.

TABLE 1: INTEGRATED PLANNING AND URBAN WATER MANAGEMENT PROCESS

Planning Phase	Planning Document	Urban Water Management Document and Status
District	Byford Structure Plan	Byford Townsite Drainage and Water Management Plan (DoW) **ISSUED SEPTEMBER 2008**
Local	Lot 2 Nettleton Rd Local Structure Plan	Lot 2 Nettleton Rd Local Water Management Strategy **THIS DOCUMENT**
Subdivision	Subdivision Application	Urban Water Management Plan (required for individual stages of development) **FUTURE PREPARATION**

1.2 Key Design Principles and Objectives

This LWMS employs the following key documents to define its content, key principles and objectives:

- Engineering Standards for Subdivisional Development (Shire of Serpentine Jarrahdale, 2003)
- Byford Urban Stormwater Management Developer Guidelines (Parsons Brinckerhoff, 2005)
- Model for Integrating Urban Water Management and Use Planning

  (Essential Environmental Services 2005)
- Peel Harvey WSUD Local Planning Policy (Peel Development Commission 2006)
- Stormwater Management Manual for Western Australia (DoW 2007)
- Draft Byford Townsite Drainage and Water Management Plan (DoW 2008)

A summary of the key design principles and objectives from these documents is provided in Table 1 and summarised below in chronological order.

1.2.1 SSJ Engineering Standards for Subdivisional Development 2003

The Shire of Serpentine Jarrahdale (SSJ) Standards for Subdivisional Development (SSJ, 2003) provide details of the Shire requirements regarding stormwater drainage management. The document provides both general guidelines at the strategic conceptual design level and also more specific detailed criteria for design of drainage systems (pipe diameters, grades, runoff rates, subsoil drainage etc).

At the strategic level addressed in this LWMS, key design guidelines are detailed as follows:

- Water sensitive design principles and practices shall be incorporated into the proposed subdivision and in accordance with the Stormwater Management Manual (DoW, 2007)
- The SSJ is the authority responsible for future care, control and management of stormwater drainage infrastructure.
- Calculations are to be consistent with Australian Rainfall and Runoff (Institution of Engineers Australia, 1987).

Specific criteria in relation to stormwater/groundwater are detailed as:

- Residential minor stormwater drainage should be designed to the 5 year ARI.
- Flow paths for 100 year ARI storms are to be identified and designed to minimise the risk of damage to private property or public assets
- Outfalls to significant waterways shall have a suitable treatment train for the purpose of protecting the waterway from pollution.

1.2.2 Byford Urban Stormwater Management Strategy 2005

On behalf of SSJ, Parsons Brinckerhoff prepared the Byford Urban Stormwater Management Strategy (BUSMS) in June 2005 to provide water-related objectives for urban development. BUSMS was intended to provide urban water management in accordance with the Byford Structure Plan and address planning for local waterways and the shallow groundwater table present in most of the area.

Guidelines and recommendations provided in BUSMS have now been superseded by the Byford Townsite Drainage and Water Management Plan, prepared by GHD on behalf of DoW (Section 1.2.6).

1.2.3 Model for Integrating Urban Water Management & Land Use Planning 2005

The guideline document Proposed Model for Integrating Urban Water Management and Land Use Planning (Essential Environmental Services, 2005), focused primarily on process integration between land use and water planning and specifying the level of investigations and documentations required at various decision points in the planning process, rather than the provision of any specific design objectives and criteria for urban water management.

This report prepared as an LWMS is consistent with this process.

1.2.4 Peel Harvey WSUD Local Planning Policy 2006

The *Peel Harvey WSUD Local Planning Policy* (Peel Development Commission 2006) was developed through the Federal Governments Coastal Catchments Initiative and endorsed by the Environmental Protection Authority (EPA). It aims to assist local government to help integrate catchment management objectives with land and resource planning in urban landscapes.

The policy identifies broad policy objectives against which strategic and statutory proposals can be assessed. WSUD principles, in order of priority, are outlined below:

- Provide protection to life and property from flooding that would occur in a 100 year Average Recurrence Interval (ARI) flood event

- Manage rainfall events to minimise runoff as high in the catchment as possible. Use multiple low cost ‘in-system’ management measures to reduce runoff volumes and peak flows (for example, maximise infiltration from leaky pipes and stormwater pits installed above pollutant retentive material)

- Retain and restore existing elements of the natural drainage system, including waterway, wetland and groundwater features and processes, and integrate these elements into the urban landscape, possibly through a multiple use corridor

- Minimise pollutant inputs through implementation of appropriate non-structural source controls (such as town planning controls, strategic planning controls, pollution prevention procedures, education and participation programs and regulatory controls) and structural controls (that manage the quantity and quality of stormwater runoff and prevent or treat stormwater pollution)

- Maximise water use efficiency, reduce potable water demand, and maximise the re-use of water harvested from impermeable surfaces

Water quantity management principles and objectives are provided based on post-development discharges being maintained relative to predevelopment levels. Criteria are provided for both ecological protection (1 in 1 year events), and flood protection (1 in 100 year events). Water quality management principles and objectives are based on maintaining or improving water quality relative to existing conditions.

Specific water quality guidelines are provided in the document including limitations on developments where average input rates of nutrients exceed 15 kg/phosphorus/ha per annum or 150 kg/nitrogen/ha per annum.

In addition, stormwater management is stated as having to provide (as compared to a development that does not actively manage stormwater quality):

- At least 80% reduction of total suspended solids
- At least 60% reduction of total phosphorus
- At least 45% reduction of total nitrogen
- At least 70% reduction of gross pollutants

The policy is consistent with the *Decision Process for Stormwater Management in WA* (DoE and Swan River Trust 2005) which is appended to the policy and is consistent with the objectives of the Environmental Protection Policy (Peel Inlet – Harvey Estuary) 1992.

This policy is stated as holding no legal standing and envisages each local government in the Peel Harvey catchment will customise the model policy to suite its own specific requirements.

At the time of preparing this LWMS, it is understood no customisation of this policy has been undertaken by the SSJ.

1.2.5 Stormwater Management Manual for Western Australia 2007

The Water and Rivers Commission (now Department of Water, DoW) released *A Manual for Managing Urban Stormwater Quality in Western Australia* in 1998 to define and practically describe Best Management Practices (BMP’s) to reduce pollutant and nutrient inputs to stormwater drainage systems. The Manual also aimed to provide guidelines for the incorporation of water sensitive design principles into urban planning and design, which would enable the achievement of improved water quality from urban development.

The document was released to provide a guideline for best planning and management practices and was intended for use by Water and Rivers Commission, but also by other State and Local Government Authorities and sectors of the urban development industry.

DoW has recently completed a major review of the Manual in consultation with a working team comprising industry and government representatives. The Manual was officially launched in August 2007.

DoW’s current position on Urban Stormwater Management in Western Australia is outlined in Chapter 2: Understanding the Context of the Stormwater Management Manual for Western Australia (DoW 2007), which details the management objectives, principles and a stormwater delivery approach for WA. Principle objectives for managing urban water in WA are stated as:

- Water Quality: To maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions
- Water Quantity: To maintain the total water cycle balance within development areas relative to the pre-development conditions
- Water Conservation: To maximise the reuse of stormwater
- Ecosystem Health: To retain natural drainage systems and protect ecosystem health
- Economic Viability: To implement stormwater systems that are economically viable in the long term
- Public Health: To minimise the public risk, including risk of injury or loss of life to the community
- Protection of Property: To protect the built environment from flooding and waterlogging
- Social Values: To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater
- Development: To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles

To provide a decision framework for planning and design of stormwater management systems and assist in meeting the objectives specified above, the Department of Environment (now Department of Environment and Conservation / DoW) and Swan River Trust released the Decision Process for Stormwater Management in WA in 2005.

A copy of the Decision Process is contained as Appendix B with key elements summarised in Table 2.

1.2.6 Byford Townsite Drainage and Water Management Plan 2008

GHD have recently completed the Byford Drainage and Water Management Plan (BDWMP) Report on behalf of DoW. The report aims to cover all aspects of total water cycle management as a means of a holistic approach to water management. The following aspects have been addressed:

- Protection of significant environmental assets within the Structure Plan area, including meeting their water requirements and managing potential impacts from development
- Water demands, supply options, opportunities for conservation and demand management measurements, and wastewater management
- Surface runoff, including both peak event (flood) management and the application of WSUD principles to frequent events
- Groundwater, including the impact of urbanisation, variation in climate, installation of drainage to reduce groundwater levels, potential impacts on the environment and the potential to use groundwater as a resource

- Water quality management, which includes source control of pollution inputs by catchment management, acid sulphate soil management, control of contaminated discharges from industrial areas and management of nutrient exports from surface runoff and groundwater through structural measures

The report also presents the proposed Arterial Drainage Scheme for the Byford Townsite in accordance with the responsibilities for Drainage Planning assigned to DoW by the State Government.

The LWMS is consistent with this report.

TABLE 2: SUMMARY OF LWMS DESIGN PRINCIPLES AND OBJECTIVES

Key Guiding Principles
• Facilitate implementation of sustainable best practice in urban water management • Encourage environmentally responsible development • Provide integration with planning processes and clarity for agencies involved with implementation • Facilitate adaptive management responses to the monitored outcomes of development • To minimise public risk, including risk of injury or loss of life • To maintain the total water cycle

Category	Principles	Objectives
Water Supply and Conservation	• Consider all potential water sources in water supply planning • Integration of water and land use planning • Sustainable and equitable use of all water sources having consideration of the needs of all users, including community, industry and environment • Maximise the reuse of stormwater	• Minimise the use of potable water where drinking water quality is not essential, particularly ex-house use. • Residential consumption target of 100 kl/person/yr including potable water use at 40-60 kL/person/yr • Promotion of rainwater tanks for ex-house use • Apply waterwise landscaping measures to open space areas to reduce irrigation demand • Native plants to constitute 35% of total POS plantings
Groundwater Levels and Surface Water Flows	• Retain natural drainage systems and protect ecosystem health • Protect from flooding and waterlogging • Implement economically viable stormwater systems • Post development annual discharge volume and peak flow rates to remain at predevelopment levels or defined EWR's • Minimise change in peak winter levels at groundwater dependent wetlands due to urbanisation • Ensure that stormwater management recognises and maintains social aesthetic and cultural values	• Use pipes, swales, living streams and ephemeral storage areas (buffers, POS, etc) to attenuate and infiltrate prior to discharge into Beenyup Brook • For ecological protection, 1 in 1 year ARI volume and peak flow rates maintained at pre-development conditions • Where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles consistent with DoW's requirements • For flood management, manage up to the 1 in 100 year ARI event within the development area to predevelopment peak flows unless otherwise negotiated with DoW • Post development end of winter operating levels at significant wetlands maintained at pre-development levels, unless otherwise determined by EWR's
Groundwater and Surface Water Quality	• Maintain or improve groundwater and surface water quality • Reduce the average annual load of stormwater pollutants discharged by development compared to if it used a traditional piped conveyance system. • Where waterways/open drains intersect the water table, minimise the discharge of pollutants from groundwater • Where development is associated with an ecosystem dependent upon a particular hydrologic regime, minimise discharge or pollutants to shallow groundwater and receiving waterway and maintain water quality in specified environment	As compared to a development which does not actively manage water quality, apply following targets (annual loads) : 80% reduction in TSS 60% reduction in TP 45% reduction in TN 70% reduction in Gross Pollutants or, alternatively construct vegetated bioretention systems sized at 2% of the constructed impervious area they receive runoff from • Where development associated with sensitive environment, refer to specific DoW requirements regarding water quality

2. PRE-DEVELOPMENT ENVIRONMENT

2.1 Location and Topography

The Study Area is approximately 32 ha in size and is located 35 km south-east of Perth CBD within the Shire of Serpentine-Jarrahdale (Figure 1). The Study Area is bounded by Beenyup Rd to the north, Nettleton Rd to the south and South Western Hwy to the west.

The existing topography of the Study Area, shown in Figure 2, rises gently from 60 to 89 mAHD in an easterly direction. Beenyup Brook traverses the site and flows through an exaggerated river valley. The floodplain for Beenyup Brook is approximately 50 m wide and its invert ranges from 60 to 62 mAHD.

2.2 Climate

The metropolitan region of Perth is characterised by a Mediterranean climate with warm dry summers and cool wet winters. Annual and monthly rainfall is shown in Figure 3. Rainfall data shown is predominantly from Wungong Dam station (Site No. 009044), with missing data replaced with records from nearby stations Armadale (Site No. 009039) and Cardup (Site No. 009137).

The long term average annual rainfall is 1183 mm (1914-2006). This average has decreased since 1975 to an average annual rainfall of 1019 mm, reflecting approximately a 6% reduction compared to the long term average.

The total rainfall distribution has also shifted since 1975 with a significant reduction of average monthly totals in the winter months, but an increase in monthly rainfall during the summer months (Figure 3).

The average annual pan evaporation is approximately 1898 mm (Luke et al. 1988).

2.3 Geology and Soils

The surface geology for the Study Area is shown in Figure 4.

The Armadale and Serpentine 1:50000 Environmental Geology map (Geological Survey of WA) indicates that the site, situated in the region at the foot of the Darling Scarp, is characterised by the Yogannup Formation made of Ridge Hill Colluvium. The majority of the Study Area is comprised gravelly sandy clay made of rounded gravel of colluvial origin, with lenses of silt and gravel. A small area located along the eastern boundary of the Study Area, comprises gravelly clayey sand made of decomposed bedrock and gravel rock fragments with fine clay minerals that may flocculate to silt or sand size.

A geotechnical investigation of the Study Area was performed on the 21 and 22 of February 2008 by Coffey Geotechnics (Coffey,2008). Coffey excavated a total of 35 test pits at depths varying from 1.9m to 2.4m below natural surface to determine the profiling of the soil. A generally defined sub surface profile was found to consist of four general layers as described below:

- SAND (Topsoil)- 0 to 0.1m thick, of loose sandy, fine to medium grained, grey to dark grey sand, traces of fines and root fibres

- SAND- 0 to 0.5m thick, fine to medium grained, off white, with some gravel, traces of fines and tree roots
- CLAYEY GRAVEL/CLAYEY SAND- a 0 to 0.7m thick, fine to medium grained, off white, low plasticity, traces of tree roots
- CLAYEY GRAVEL- >1.2m thick, fine to medium grained, brown mottled grey, low plasticity

Due to the presence of clays on the site, opportunities for infiltration are likely to be minimal and therefore hydraulic conductivity and infiltration capacity has not been assessed as part of this investigation.

2.4 Surface Water Hydrology

2.4.1 Existing Surface Drainage

The existing local drainage network in relation to the Study Area is shown in Figure 5.

The Study Area predominantly drains to Beenyup Brook via overland flow with the exception of the north eastern corner which drains north towards a small drain alongside Beenyup Rd. The Study Area also receives uncompensated flows from the rural residential development alongside the eastern boundary. Existing catchment areas are shown in Figure 5.

Beenyup Brook flows in a westerly direction through the middle of the site and has a catchment area of approximately 14.5 km^2 upstream of the Study Area. Beenyup Brook downstream of the Study Area typifies a constructed drain and eventually discharges into Birrega Main Drain which in turn drains into the Serpentine River System, and ultimately to the Peel Harvey Estuary.

Beenyup Brook is considered ephemeral with flow occurring during winter and spring. Beenyup Brook was observed on monitoring occasions as flowing during the winter months (June, July and August) at a maximum of approximately 40 L/s. Continuous flow recording stations have been recently installed by JDA on behalf of the Aspen Group at two locations in Beenyup Brook in November 2008.

The south side of the site is bordered by a shallow table drain alongside Nettleton Rd which flows in a westerly direction towards South Western Hwy before discharging to Beenyup Brook.

A cut-off drain is also present north of Beenyup Brook on the southern side of the Study Area which diverts the flow from a portion of the adjacent residential development and ultimately discharges into Beenyup Brook.

2.4.2 Peak Flow Estimates

Peak flow rates for main waterways within the Byford Structure Plan area have been presented in the Byford Drainage and Water Management Plan (BDWMP) (DoW, 2008).

The BDWMP provided peak flow estimates for Beenyup Brook downstream of South Western Hwy immediately downstream of Lot 2 Nettleton Rd. The 5 Year and 100 Year average recurrence interval (ARI) flows are 8 m^3/s and 31 m^3/s respectively.

2.4.3 Surface Water Quality

Surface water quality sampling for the Study Area was commenced by JDA in October 2007 at 2 locations along Beenyup Brook. Surface water quality monitoring site locations are shown in Figure 6. Samples were analysed for physical parameters and nutrients. Results from the pre-development monitoring program are included in Appendix C.

A summary of the water quality results are presented in Table 3 in relation to ANZECC (2000) guideline values, Australian Runoff Quality mean stormwater concentrations (IEA, 2006) and typical mean concentrations of urban runoff on the Swan Coastal Plain (Martens *et al*, 2004).

The BDWMP (DoW, 2008) gives a brief overview of the upstream and downstream surface water quality in Beenyup Brook. Total Nitrogen (TN) ranges from less than 1.2mg/L to greater than 3.0 mg/L and Total Phosphorus (TP) ranges from 0.065 mg/L to 0.20 mg/L.

TN and TP concentrations measured within the Study Area are comparable to the upstream results reported in the BDWMP (2008).

Overall, concentrations of TN and TP are below ANZECC guideline values.

Water quality in Beenyup Brook did not appear to deteriorate as it passed through the Study Area.

TABLE 3: PREDEVELOPMENT SURFACE WATER QUALITY SUMMARY

Parameter and unit of measurement	ANZECC Guideline Vaules[1]	Mean ARQ Urban Stormwater Concentration[2]	Typical Urban Stormwater Quality on Swan Coastal Plain[3]	Monitoring Sites (Site Averages)	
				S1	S2
Electrical conductivity (mS/cm)	0.12 – 0.30	-	0.6	0.47	0.57
pH	6.5 – 8.0	6.8	7	6.54	6.52
Total Suspended Solids	-	-	-	6.0	11.0
Total Nitrogen (mg/L)	1.2	2.7	1.1	0.89	0.74
Ammonia N (mg/L)	0.8	-	-	0.02	0.01
Nitrate/Nitrite NOx as N (mg/L)	0.15	-	-	0.65	0.52
Total Kjeldahl Nitrogen (mg/L)	-	-	-	0.24	0.23
Total Phosphorus (mg/L)	0.065	0.29	0.21	0.01	0.02
Filterable Reactive Phosphorus (mg/L)	0.04	-	-	0.005	0.005

1. Values adopted for Lowland River, South West Australia. ANZECC (2000a) trigger values for freshwater for a 95% level of protection (slightly to moderately disturbed ecosystem)
2. Institute of Engineers Australia (2006)
3. Martens et al (2004)

2.5 Groundwater Hydrology

2.5.1 Regional Hydrogeology

The superficial formation present at the Study Area is the Guildford Clay Formation (Davidson 1995). Within the Study Area the superficial aquifer has a saturated thickness of approximately 20 m.

Recharge is by direct rainfall infiltration but some from stream flow draining the Darling Range.

There is no clear presence of a confined aquifer underneath the Study Area due to its proximity to the Darling Scarp. There is some indication that the Cattamarra Coal Measures may be present underneath the Study Area at depths of 90m (Laz Leonard, DoW, pers comm.)

The Cattamarra Coal measures may be up to 1500m thick and consists of sandstones, siltstones and shales.

2.5.2 Groundwater Levels

To estimate groundwater levels for the Study Area, JDA installed a total of 16 groundwater monitoring bores (MW1 – MW16) within the Study Area (Figure 6); bores MW1 to MW13 were installed on 28 September 2007 and additional bores MW14 to MW16 were installed on 22 February 2008. All bores were installed by a 200 mm Air Core drill. The bores were constructed of 50 mm PVC capped at both end sand slotted into the water table. The bores were gravel packed and developed for water quality monitoring in addition to water level monitoring. Lithological logs for these bores are included in Appendix D and results of the pre-development monitoring program are included in Appendix C.

Natural surface and top of casing (TOC) levels for the bores were surveyed by Whelans to Australian Height Datum (AHD)

Table 4 provides a summary of survey data and groundwater levels recorded by JDA on 16/10/07 along with the levels in bore BDM12 previously installed by JDA for the approved Byford Main Precinct Local Urban Stormwater Management Strategy, (JDA, 2005).

Water levels in two nearby long term Department of Water (DoW) bores (SES21 and SED6) were also recorded by JDA on 16 October 2007. The locations of these bores relative to the Study Area are shown in Figure 6. Water levels measured in DoW bores and BDM12 were compared to their long term average annual maximum groundwater levels (AAMGL) based on the available historical data. The average correction for DoW bores from 16 October 2007 to AAMGL was +0.49 m (Table 5).

The Average Annual Maximum Groundwater Level (AAMGL) is used as a statistic term to provide an indication of winter water table levels for the Study Area. This level is then used to develop a controlled groundwater level (CGL) for the site in Section 4.3.

The AAMGL for bores MW13-MW16 was calculated by correcting the levels taken on 17 March 2008 to the average difference to AAMGL for bores MW1-MW12.

The calculated AAMGL for all bores are presented in Table 6 and shown as contours over the site in Figure 7. In summary, the average winter maximum groundwater levels ranges from approximately 82 mAHD on the eastern side of the site and falls to 62 mAHD on the west side of the site. Groundwater flow is generally in a westerly direction towards South Western Highway.

The depth to groundwater varies from about 0 m to 5.1m below natural surface (Figure 8).

TABLE 4: MONITORING SITES AND RECORDED GROUNDWATER LEVELS

Location	Location (GDA)[1]		Natural Surface (m AHD)	Top of Casing (m AHD)	Water Level Recorded 16/10/08 [3]	
	Easting	Northing			(m below TOC)[2]	(m AHD)
JDA Bores						
MW1	407264	6434440	79.46	80.16	0.48	79.68
MW2	407130	6434404	75.05	75.73	2.01	73.72
MW3	407064	6434194	70.07	70.74	1.14	69.60
MW4	406978	6434194	70.94	71.59	0.73	70.86
MW5	406929	6434183	67.12	67.81	1.00	66.81
MW6	406937	6433911	68.04	68.80	1.71	67.09
MW7	406838	6434220	65.84	66.57	0.78	65.79
MW8	406801	6434220	63.45	66.12	1.99	64.13
MW9	406715	64344220	63.51	64.22	0.94	63.28
MW10	406652	6434489	61.34	62.02	1.16	60.86
MW11	406601	6434324	61.06	61.79	1.05	60.73
MW12	406571	6434229	61.26	61.89	1.13	60.77
MW13	406540	6434114	61.29	61.99	0.74	61.25
MW14	407496	6434515	86.70	87.27	6.90	79.80
MW15	407428	6434450	86.14	86.75	7.99	78.15
MW16	407394	6434508	83.84	84.42	6.37	77.47
BDM12	406253	6433849	-	56.07	0.66	54.40
Department of Water Groundwater Monitoring Bores						
SES21	407329	6434569	60.06	60.74	1.22	59.52
SED6	406351	6432721	81.31	81.55	2.72	78.83

1. GDA : Geocentric Datum of Australia
2. TOC : Top of Casing
3. MW14 – MW16 water levels shown are from 17 March 2008

TABLE 5: BORE AAMGL'S AND CALCULATION OF CORRECTION FACTOR

Bore	AAMGL 1988- present (mAHD)	Water Level (mAHD) 16/10/07	Difference (m)
SES21	60.04	59.52	0.52
SED 6	79.19	78.83	0.36
BDM 12	55.99	55.40	0.59
Average Difference to AAMGL : Correction Factor (m)			**0.49**

TABLE 6: ESTIMATED PRE-DEVELOPMENT GROUNDWATER LEVELS

Bore	Natural Surface Elevation (mAHD)	Calculated AAMGL (mAHD) [1]	Depth to AAMGL (m)
MW1	79.46	79.46	0.0
MW2	75.04	74.20	0.8
MW3	70.07	70.07	0.0
MW4	70.94	70.94	0.0
MW5	67.11	67.12	0.0
MW6	68.04	67.58	0.5
MW7	65.84	65.84	0.0
MW8	65.48	64.62	0.9
MW9	63.51	63.51	0.0
MW10	61.34	61.34	0.0
MW11	61.06	61.06	0.0
MW12	61.26	61.26	0.0
MW13	61.29	61.29	0.0
MW14	86.70	82.39	4.3
MW15	86.14	81.04	5.1
MW16	83.84	80.18	3.7

1. AAMGL has been corrected to natural surface, where correction results in ‘ponded‘ water above natural surface it is due to site topography (Figure 8).

2.5.3 Groundwater Quality

Groundwater quality sampling of the superficial aquifer was done by JDA monthly from October 2007 to September 2008 for monitoring bores MW1-MW13, and from March 2008 to September 2008 for monitoring bore MW14-MW16. Samples were analysed for physical parameters and nutrients.

The pre-development monitoring program commenced in October 2007 prior to the release of the BDWMP. At this time, Department of Water pre-development groundwater quality monitoring requirements consisted of physical parameters and nutrients and excluding testing for heavy metals. Results from the pre-development monitoring program are included in Appendix C and laboratory reports are provided in Appendix E.

A summary of the groundwater quality results are shown in Table 7 in relation to ANZECC (2000) guideline values, Australian Runoff Quality mean stormwater concentrations (IEA, 2006) and typical mean concentrations of urban runoff on the Swan Coastal Plain (Martens *et al*, 2004).

Summarising the monitoring results:

- Across the site, the groundwater samples were slightly acidic with a pH between 4.5 and 6. The mean pH across the site was 5.31. These values are slightly below ANZECC (2000) guideline of 6.5 – 8.
- The mean conductivity for the site was 1.93 mS/cm. Conductivity was generally higher than ANZECC guideline range of 0.12-0.3.

- Total Nitrogen was varied across the site with a site average of 2.00 mg/L and site median of 0.48 mg/L. Most bores were within ANZECC guidelines.
- Total Phosphorus levels were generally below 0.1 mg/L with the site average being 0.04 mg/L and majority of the samples comparable to ANZECC (2000) guidelines.

Table 7 also provides a comparison of groundwater quality monitoring data from the Study Area with typical mean concentrations of urban runoff on the Swan Coastal Plain based on local data (Martens *et al* 2004). Post-development stormwater quality for the Study Area is considered likely to be similar to Martens *et al* (2004).

2.6 Wetlands

The Department of Environment and Conservation (DoEC) Geomorphic Wetlands of the Swan Coastal Plain Wetland mapping shows the boundaries and locations wetlands in the Study Area (Figure 9).

The western side of the site is classified as a multiple use palusplain.

No Environmental Protection Policy (EPP) or Conservation Category wetlands are located within the Study Area.

2.7 Previous Land Use

An aerial photograph of the area is shown with topography in Figure 2.

The Study Area is predominantly pasture with the eastern corner consisting of native vegetation. Previously, there was a vacant house on the property which has been recently been removed due to safety concerns.

There are no existing infrastructure constraints on the land and no known source of contamination.

The subject land does not accommodate any site or building identified for protection in the Local Municipal Heritage Inventory or other heritage register. Beenyup Brook is to be protected within a foreshore reserve.

2.8 Water Resources

The Study Area is located in the Serpentine groundwater area and the Byford 3 groundwater sub area.

The Department of Water has advised that there is a considerable volume of unallocated groundwater available for abstraction from both the superficial and confined aquifers as of April 2008.

- Current quota in the superficial aquifer is 13,630,000 kL/yr of which 88% is available
- Current quota in the Leederville aquifer is 2,270,000 kL/yr of which 44% is available
- Current quota in the Cattamarra Coal Measures is 1,130,000 kL/yr of which 82% is available.

Opportunities for abstraction at the Study Area from these available water resources is discussed in Section 4.1.

TABLE 7: PREDEVELOPMENT GROUNDWATER QUALITY SUMMARY

	Parameter and Unit of Measure							
	EC (mS/cm)	pH	Total Nitrogen (mg/L)	Ammonia (as N) (mg/L)	Nitrate /Nitrite NOx as N (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Phosphorus (mg/L)	Filterable Reactive Phosphorus (mg/L)
GUIDELINE VALUES								
ANZECC Guideline Values ¹	0.12-0.30	6.5-8.0	1.2	0.8	0.15	-	0.065	0.04
Mean ARQ Urban Stormwater Concentration²	-	6.8	2.7	-	-	-	0.29	-
Typical Urban Stormwater Quality on Swan Coastal Plain³	0.6	7.0	1.1	-	-	-	0.21	-
STUDY AREA VALUES								
Site Average	1.93	5.31	2.00	0.04	1.51	0.50	0.04	0.007
MW1	0.87	5.45	0.24	0.05	0.02	0.22	0.05	0.005
MW2	1.81	4.66	0.28	0.01	0.13	0.15	0.04	0.005
MW3	1.66	5.22	0.96	0.05	0.60	0.36	0.03	0.006
MW4	1.70	5.52	0.22	0.01	0.06	0.18	0.03	0.007
MW5	2.13	6.00	13.12	0.02	11.42	1.72	0.03	0.006
MW6	0.63	5.07	1.35	0.02	0.89	0.46	0.04	0.007
MW7	0.84	4.66	0.42	0.02	0.05	0.38	0.03	0.005
MW8	0.30	5.22	2.78	0.02	2.21	0.58	0.04	0.006
MW9	4.85	5.29	0.54	0.05	0.08	0.46	0.04	0.006
MW10	0.31	4.95	2.13	0.02	1.73	0.41	0.05	0.005
MW11	4.82	5.72	5.49	0.05	4.43	1.06	0.04	0.005
MW12	3.00	5.26	0.47	0.03	0.15	0.33	0.02	0.005
MW13	3.88	6.01	0.72	0.06	0.38	0.34	0.03	0.006
MW14	1.43	5.77	0.67	0.05	0.14	0.53	0.18	0.038
MW15	0.49	4.84	0.25	0.08	0.02	0.23	0.03	0.005
MW16	0.80	5.38	0.41	0.12	0.05	0.36	0.03	0.005

1. Values adopted for Lowland River, South West Australia. ANZECC (2000a) trigger values for freshwater for a 95% level of protection (slightly to moderately disturbed ecosystem)
2. Institute of Engineers Australia (2006)
3. Martens et al (2004)

2.9 Acid Sulphate Soil

Regional Acid Sulphate Soil (ASS) mapping from Planning Bulletin no 64 (WAPC, 2003) identifies that the Study Area as low to moderate risk of ASS occurring at depths greater than 3m from the surface.

ASS investigations are being undertaken as a separate approval process to the LWMS as part of Contamination Sites work.

3. PROPOSED DEVELOPMENT

The proposed development of the Study Area is shown in Figure 10. Two distinct development areas are proposed, Aspen Villages (over 45's lifestyle) and Aspen Communities (retirement). Aspen Villages will be in two locations, on the scarp and on the south side of Beenyup Brook.

The Study Area will be comprised of approximately 580 independent homes average lot size of approximately 225-285 m^2 (~R40), a central community centre, community facilities and landscaped POS area.

Key elements of the structure plan related to stormwater management include:

- Use of linear POS areas for detention, retention, conveyance, and treatment of stormwater
- Use of locally distributed POS areas for stormwater retention and detention
- Remediation and protection of the Beenyup Brook foreshore reserve
- Use of higher density urban residential zonings to reduce landscape nutrient input at domestic scale
- Maintenance of existing surface water flow paths including for external contributing catchments
- Location of POS areas to maximise retention of existing significant trees
- Preservation of 3 ha of remnant vegetation in the north eastern corner of the site
- Proposed use of dry planted species in the Beenyup Brook foreshore reserve area to reduce nutrient input and conserve water resources
- Retained ownership of Aspen Villages and Aspen Community sites for ongoing maintenance of POS, and water supply and drainage infrastructure

4. LOCAL WATER MANAGEMENT STRATEGY

4.1 Water Use Sustainability Initiatives

4.1.1 Water Conservation

Development of the Study Area will lead to an increased demand for water for new residents as well as irrigation of public open spaces. Water conservation measures will be implemented to reduce scheme water consumption within the development will be consistent with Water Corporation's "Waterwise" land development criteria, and include:

- The use of higher density residential zoning and smaller lots to reduce garden use of water.
- Implementation of waterwise practices including water efficient fixtures and fitting (taps, showerheads, toilets and appliances, rainwater tanks, waterwise landscaping)
- All houses to be built to 5 star building standards
- Use of native plants in POS areas
- Proposed use of dry planted species in the Beenyup Brook foreshore reserve area
- Retention of existing natural vegetation to minimise irrigation requirements
- Maximising on site retention of stormwater (where practicable)

Agreed measures to achieve water conservation and will be detailed in the UWMP.

4.1.2 Water Balance & Non Potable Water Supply

No quantitative water balance at the district or regional scale were provided in the DWMP (DoW,2008).

A water balance at the LWMS stage is generally requested to support the identification of excess water generated by the development for potential use as a non potable water supply scheme.

While post development groundwater levels in the Study Area will be maintained at existing levels, development will lead to an increase of surface water volume discharge to the receiving environment. Peak flow rates for design events will however be maintained at predevelopment rates (Section 4.2.3) consistent with DWMP (DoW,2008) requirements.

Based on geotechnical investigations (Section 2.3) opportunities for infiltration (pre and post development) and storage of stormwater for reuse in the Study Area are limited. Furthermore, recharge and abstraction from the superficial aquifer for non potable use is considered unlikely due to the presence of Guilford clay. There is also no clear presence of a confined aquifer underneath the Study Area due to its proximity to the Darling Scarp (Laz Leonard, DoW, pers comm.).

As such, rainwater tanks have been identified as a potential non-potable source to be promoted as part of the domestic water supply to assist in reducing excess stormwater generation and minimise scheme water importation. Information regarding the appropriate sizes for rainwater tanks will be provided at UWMP stage, commensurate with requirements of building design and DoW (2007).

Consistent with UWMP guidelines a quantitative water balance at lot scale will be conducted at UWMP stage to demonstrate overall compliance with water use targets of the BDWMP (DoW, 2008).

4.2 Flood Management

4.2.1 Regional Flood Management

Regional flood modelling of Beenyup Brook was provided in the BDWMP (DoW, 2008). The report provided 100 year flood levels within the brook and delineated indicative floodways.

The modelling provided a 100 Year ARI flood level for Beenyup Brook of 61.4 mAHD adjacent to South Western Highway increasing to 64.7mAHD at the upstream boundary of the Study Area.

An indicative flood width for Beenyup Brook downstream of the Study Area of 40m is provided in the BDWMP (DoW, 2008). It should be noted that flood widths are provided by DoW as being “indicative only” and are prepared at regional scale. It is normal practice for an LWMS to revise these regionally calculated flood widths based on more detailed local survey, site appreciation, and local investigations.

The Beenyup Brook foreshore reserve delineated in Figure 10 has a minimum width of 50m and extends to in excess of 100m in the Study Area. This exceeds the indicative 40m width requirement provided in the BDWMP (DoW,2008)

Post development, the floodway will be contained within the Beenyup Brook foreshore reserve, with the minimum habitable floor level for areas adjacent to Beenyup Brook set 0.5 m above the 100 Year ARI flood level, consistent with DoW flood protection requirements.

4.2.2 Local Flood Management

Local stormwater management is proposed to be undertaken consistent with water sensitive design practices and meet key objectives and criteria as detailed in Table 2.

The local stormwater management system will consist of a series of pipes, swales, and ephemeral water storage areas to attenuate and infiltrate (where possible) peak surface water flows, and provide water quality treatment for the proposed development prior to discharge from the Study Area to the receiving environment.

The stormwater drainage system will be designed using a major/minor approach. The minor drainage system is defined as the system of underground pipes, swales, kerbs, gutters etc. designed to carry runoff generated by low frequency ARI storms, typically less than 5 year ARI. The major drainage system is defined as the arrangement of roads, drainage reserves, attenuation/infiltration areas and open space planned to provide safe passage of stormwater runoff from extreme events which exceeds the capacity of the minor system.

Dependent on localised conditions, stormwater runoff generated by the impervious areas of the road reserve will be collected in gully or side entry pits and then flow into a local piped (or swale) drainage system. Attenuation of flow will then be achieved through minimising runoff at source and use of detention storages and swales in Open Space areas.

Consistent with principles and objectives discussed in Section 1.2, stormwater will be attenuated to maintain 1 in 1 year ARI event post development discharge volumes and peak flow rates at predevelopment conditions.

While opportunities for roof drainage and road drainage to be connected to soakwells to promote at-source infiltration will be examined in detail at UWMP development stage, local site conditions, clayey soils and high water table may ultimately limit its implementation. The use of bottomless manholes for infiltration of road drainage (wherever practicable) will be adopted consistent with DoW stormwater management principles.

Detention/retention areas will generally be designed to attenuate runoff for storm events up to 100 year ARI, with basin outflow designed to not exceed predevelopment (existing) levels. The minimum habitable floor levels will comply with DoW requirements for a 0.5m clearance above the estimated 100 year ARI flood level for detention basins and swales.

4.2.3 XP-Storm Modelling

XP-Storm modelling was performed for the Study Area to determine flood storage requirements for local flood management post development and provide assessment of local structure plan areas for drainage purposes.

A schematic of the XP-Storm model is shown in Figure 11. Modelling was based on the proposed land use plan shown in Figure 10.

Post development design flows for the Study Area are calculated based on allowable catchment discharges provided in the BDWMP (DoW, 2008). The allowable pro-rata flow rates for the catchment in which the Study Area is located is specified in the BDWMP are 32 l/s/ha and 86 l/s/ha for the 5 and 100 year ARI storm events respectively. These design flows have been used as the basis for flood attenuation storage modelling.

Storage areas were designed to contain runoff from the 5 and 100 year ARI storm event, with discharge for the 5 and 100 year ARI event designed not to exceed estimated pre-development (existing) levels. Storage locations were determined based on existing topographic contours, depth to groundwater mapping, and POS and drainage areas specified in the local structure plan. Storage area side slopes of 1 in 6 (v:h) have been assumed above the storage invert for modelling purposes. Internal Study Area catchment boundaries were based on structure plan design and topography. Basin outlets for this modelling were set at AAMGL.

The design storms modelled by XP-Storm were calculated internally by the model with reference to the methodology in Australian Rainfall & Runoff (AR&R) (Institution of Engineers, Australia 2000). The rainfall temporal pattern was assumed to be spatially uniform across the catchment. Storm durations modelled ranged from 10 minutes to 72 hours with critical durations for the basins ranging from 1 hour to 12 hours. The following runoff coefficients applied for various land uses in and around the Study Area:

High Density Residential Lots	80%
POS & Detention Basin Areas	60%
Road & Road Reserve	90%
Community Centre/Community Facilities	50%

The proposed stormwater management system for the Study Area is shown in Figure 12, with modelled assumptions, flood storage volumes, areas, and flood levels for detention areas detailed in Table 8. Figure 13 details long section of the drainage design along key swale drains of the Aspen Villages site.

The total storage volume of 4290 m^3 shows good agreement with the Byford DWMP (DoW,2008) which provided an estimate storage requirement of 3700 m^3, based on 126 m^3/ha storage for the subcatchment in with the Study Area is located.

Storm volumes for the 1 hour 1 year ARI event are also provided in Table 8 and Figure 12 to provide a guide for storage requirements and areas for water quality treatment consistent with DoW requirements specified in the BDWMP (DoW,2008). Specific details of 1 in 1 year treatment measures and their design will be contained in the UWMP.

Note that storage shapes shown in Figure 12 are indicative only for determination of area requirements, and representation of storage areas required in relation to POS areas allocated in the structure plan. The final configuration (side slopes etc) and exact location of storage areas will be dependent on final earthworks, drainage, and road design levels for the development, and catchment areas shown in this report may change as a result.

4.3 Groundwater Management

Based on outcomes of the Geotechnical Investigation (Coffey, 2008, detailed in Section 2.3) and on site groundwater investigations by JDA (Section 2.5), groundwater management in the Study Area is proposed by the use of the following :

- Adoption of the average annual maximum groundwater level as specified in Figure 7 as the Controlled Groundwater Level (CGL) for the Study Area.
- In Aspen Communities land areas, clearance to groundwater will be achieved through the use of imported fill and subsoil drainage within road reserves to control groundwater rise post development. Subsoil drainage will be established at the CGL with fill imported to provide a 1.2m clearance above this CGL consistent with BDWMP (DoW,2008) requirements.
- In the Aspen Villages land areas, use of site responsive housing and subsoil drainage are predominately used to minimise earthworks and maximise tree retention consistent with Shire sustainability principles. It is acknowledged fill will still be required in some of the Aspen Villages land where groundwater is close to the surface to achieve adequate separation.

Where required, subsoil drainage will be installed at the higher of the CGL or clay layer. Given proposed lot sizes, this will result in a subsoil network at approximately 45m spacing over much of the Study Area, This is considerably closer that typical spacing of subsoil drainage for conventional residential development. It should be noted also that roads within the Aspen Village site have been aligned to assist with subsoil drainage performance in this area.

A summary of proposed groundwater management is shown in Figure 14, utilising this standard and widely adopted subsoil and fill approach to groundwater management.

This LWMS establishes criteria and the general approach for setting finished lot levels.

Finished lot levels and fill requirements are a detailed design issue and will addressed during preparation of the UWMP and submitted for council approval at this stage. Details submitted for council and DoW consideration at this time will include calculations detailing fill levels relative to mounding between subsoil drains for various ARI storm events to demonstrate compliance of the design to required standards and ensure adequate separation of development from groundwater.

TABLE 8: STORMATER MANAGEMENT CONCEPTUAL DESIGN

Post-Development Catchment [3]	C2	D1	Lower
Catchment Area (ha)	20.42	10.03	5.48
Catchment Data/Land Use			
POS Area	1.93	1.92	1.18
Village Lots	6.77	-	1.85
Community Lots	-	5.85	-
Community Facilities	0.41	0.75	1.75
Road & Road Reserve	1.93	1.52	0.69
Remnant Vegetation	3.13	-	-
Catchment Slope	0.04	0.03	0.04
Storage Data			
Side Slopes (v:h)	1:6	1:6	1:6
Storage Outlet Level (mAHD)	67.0	61.5	61.7
Storage Pipe Outlet Diameter (mm)	525	375	270
Outlet Pipe Length (m)	10	10	10
Water Quality Treatment Volumes/Areas			
1 year 1 hour (m^3)	1965	1250	610
2% of effective impervious area	0.24	0.15	0.07
5 Year ARI Flood Event Management			
Top Water Level Area (ha)	0.23	0.24	0.07
Flood Storage (m^3)[1]	1330	1300	290
Flood Rise (m)[2]	0.74	0.68	0.64
Peak Outflow (m^3/s)	0.63	0.30	0.13
Critical Duration (hrs)	12	12	12
100 Year ARI Flood Event Management			
Top Water Level Area (ha)	0.27	0.28	0.09
Flood Storage (m^3)[1]	1840	1990	460
Flood Rise (m)[2]	0.95	0.91	0.89
Peak Outflow (m^3/s)	1.73	0.77	0.36
Critical Duration (hrs)	1	1	1

1. Flood storage above basin base.
2. Flood rise refers to Top Water Level minus basin base.

4.4 Wetland Management

As previously discussed in Section 2.6, there are no Conservation Category wetlands or EPP lakes located within the Study Area.

4.5 Water Quality Management

With respect to water quality management the LWMS proposes the use of a treatment train approach including source control techniques. The proposed water quality management approach for the Study Area includes:

- **Non Structural Controls**
  Planning practices (POS locations, land use density, POS configuration)
  Construction practices (construction management, use of native and dry plantings)
  Maintenance practices (street sweeping, stormwater system, POS areas)
  Educational and participatory practices (community education)

- **Structural Controls**
  Retention and infiltration of frequent events where possible (soakwells, swales, bottomless manholes)
  Use of vegetated swales
  Creation of ephemeral retention/detention areas within POS areas
  Creation of Bioretention Areas for treatment of frequently occurring events
  Gross Pollutant Trapping device on storage outlets

- **Monitoring**
  Establishment of pre and post development monitoring network
  Annual monitoring program and reporting, including assessment of BMP's performance and suitability to provide ongoing guidance to DoW for future WSUD planning.

With respect to criteria for water quality, the principle of improving water quality in comparison to existing water quality will be adopted, and water quality targets will be developed based at the completion of predevelopment monitoring and detailed in the UWMP. Assessment of performance with targets will be through post development monitoring (refer Section 5.3).

Two percent of the equivalent impervious area of each catchment will be set aside for establishment of a bioretention system for water quality treatment of frequently occurring events as required by the BDWMP (DoW,2008). These areas and volumes are shown in Table 8 and shown schematically in Figure 12, to demonstrate sufficient area has been set aside in this LWMS for water quality treatment purposes.

Specific design of these areas will be undertaken during preparation of the UWMP to the satisfaction of the Shire and DoW.

4.5.1 Post Development Nutrient Input

NiDSS is a tool developed by JDA Consultant Hydrologists to assist in landuse management planning, and allow quantitative estimation of nutrient input rates and the potential reduction in nutrient input (including costings) for various combinations of water sensitive urban design (WSUD) water quality management measures. NiDSS focuses on the adoption of an integrated catchment approach to water quality management, including measures to minimise nutrient inputs at source, and provides a logical framework for the evaluation of the effectiveness of various best management practices for nutrient input management.

It calculates the total expected nutrient input for a particular development proposal based on aggregating individual nutrient inputs from different land uses (lots, POS, road reserves, conservation areas) prior to implementation of stormwater management measures. The impact of individual source and in-transit controls on nutrient input can then be determined by either turning on/off individual controls or varying the effectiveness of these measures. The results present information on:

- estimates of total phosphorus (TP) and total nitrogen (TN) application to an area;
- estimates of reductions due to source control measures (eg. education, native vegetation); and
- estimates of the cost of removal (in PV terms) for a selected WSUD program.

NiDSS was applied to the Study Area to model existing land use and the proposed Structure Plan land use. Nutrient application rates were adopted from the Southern River Urban Water Management Strategy (JDA, 2002), which based application rates on a nutrient input survey conducted by JDA of medium density residential areas, and on previous work of Gerritse *et al.* (1991, 1992a, 1992b) at CSIRO on rural residential lots.

Results of NiDSS modelling are presented in Appendix F. Summarising modelling results:

- Pre-development (existing) rural land use is estimated to have nutrient input loadings of 15 kg/ha/yr for TP and 45 kg/ha/yr of TN.
- With the proposed urban land use and assuming no WSUD, the Study Area is estimated to have comparable nutrient input loadings of 7 kg/ha/yr for TP and 41 kg/ha/yr of TN.
- With implementation of a typical WSUD program including :

  1. Education Campaigns (targeting fertiliser application rates and pet waste management)
  2. Focus on Native Plantings for Residential and POS Areas (and use of Phosphorus free fertilisers)
  3. Street Sweeping

  It is estimated nutrient input loadings will be 4 kg/ha/yr for TP and 25 kg/ha/yr of TN below pre-development input loadings which consist in about 75% and 45% reduction for both TP and TN respectively.

An example of the program and the nutrient balance calculations are detailed in Appendix F. Please note that the program presented is not a strict recommendation but an example of the outcomes a nutrient input reduction program will achieve, and assess the development relative to PDC(2006) requirements.

In summary, post development nutrient application rates for TP and TN will be well below PDC(2006) requirements of 15 kg/ha/yr TP and 150 kg/ha/year TN.

4.5.2 Assessment of Proposed Structural BMP's to Design Criteria

Table 9 details a summary from DoW's Stormwater Management Manual for Western Australia (2007) of expected pollutant removal efficiencies for vegetated swales and detention/retention systems in relation to the water quality design criteria specified in this BDWMP (DoW, 2008)). Expected nutrient input reduction via non structural measures calculated in Section 4.5.1 are also reported in Table 9.

While DoW (2007) does not provide expected pollutant removal efficiencies for all BMP's, application of a treatment train approach using a combination of non structural and structural measures detailed in Section 4.5 will therefore clearly achieve the design objectives for water quality.

Specific details on the location, scale of application, and responsibilities for individual BMP's are to be assessed for individual development areas within the Precinct during development of Urban Water Management Plan.

TABLE 9 : BMP WATER QUALITY PERFORMANCE IN RELATION TO DESIGN CRITERIA

Parameter	**Design Criteria via BDWMP** (required removal as compared to a development with no WSUD)	**Non Structural Controls** (refer Section 4.5.1) Nutrient Input Reduction	**Structural Controls** Nutrient Output Reduction ^{1}	
			Vegetated Swales	**Detention/ Retention Measures**
Total Suspended Solids	80%	-	60-80%	65-99%
Total Phosphorus	60%	50%	30-50%	40-80%
Total Nitrogen	45%	40%	25-40%	50-70%
Gross Pollutants	70%	-	-	>90%

1. Typical Performance Efficiencies via DoW (2007)

4.6 Construction Management

4.6.1 Dewatering

Dewatering will be required for some elements of subdivision construction. Given the depth of construction, dewatering will only be in the superficial aquifer.

As the volume of dewatering will be relatively minor, and water is to be infiltrated back into the superficial aquifer locally, the overall impact on the aquifer will be minimal.

Drawdown will occur at the dewatering site, and mounding where the water is infiltrated. It should be noted that there will be zero net loss of groundwater, as all water abstracted will be infiltrated (except for minor losses to evaporation).

Prior to the commencement of any dewatering, the construction contractor will apply for and obtain from DoW a “Licence to Take Water”. All dewatering will be carried out in accordance with the conditions of this licence.

Where possible, construction will be timed to minimise impacts on groundwater and any dewatering requirement.

4.6.2 Acid Sulphate Soil

Management of Acid Sulphate Soils (ASS) will be addressed separate study to this LWMS.

Details regarding the outcomes of this study will be included as part of the Urban Water Management Plan as these studies are being progressed as part of the “Contaminated Sites” work.

ASS will be investigated and managed in accordance with the applicable DEC Acid Sulphate Soil Guideline Series.

4.7 Water Management Strategy Summary

Table 10 also provides an overall summary of key elements of the strategy with an assessment in relation to DoW (2007) principle objectives for stormwater management in Western Australia (Section 1.2.1).

TABLE 10: ASSESSMENT OF PROPOSED LOCAL WATER MANAGEMENT STRATEGY

Principle	Key LWMS Elements
Water Quantity To maintain the total water cycle balance within development areas relative to the pre-development conditions.	• Maintain flow paths for existing catchments • Maintain 1 in 1 year ARI event post development discharge volume and peak flow rates relative to predevelopment conditions • Maintain 10 and 100 year ARI peak flows from the Study Area to at or below current discharge levels. • Installation of subsoil drainage at defined CGL. • Maximise infiltration opportunities (where possible) for frequent events.
Water Quality To maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions.	• Higher density land use to reduce nutrient input compared to typical urban development • Nutrient input in the Study Area below existing levels and PDC(2006) requirements. • Maintain 1 in 1 year ARI event post development discharge volume and peak flow rates relative to predevelopment conditions • Where/if possible infiltrate frequently occurring events using soakwells, open based manholes, and swales. • Use of treatment train approach to stormwater management • Application of source controls – street sweeping, education to reduce nutrient application, native/dry plantings, swales, passive POS areas, lot soakwells. • Application of structural controls – retention / detention areas, swales, GPT's • Ongoing monitoring programs and performance review processes • Foreshore buffers and rehabilitation of Beenyup Brook • Retaining 3 ha of existing vegetation in north western corner of the Study Area • Frequent event treatment areas consistent with BDWMP requirement of 2% of impervious area
Water Conservation To maximise the reuse of stormwater	• Implement water efficiency and demand management measures in and ex-house. • Maximise stormwater infiltration opportunities, and infiltrate 1 in 1 year event where/if possible. • Use of native/dry plantings within POS areas to minimise irrigation • Retention of existing significant trees
Ecosystem Health To retain natural drainage systems and protect ecosystem health	• Maintain flow paths for existing catchments • Foreshore buffers and rehabilitation of Beenyup Brook • Retention of frequently occurring storm events on site
Economic Viability To implement stormwater systems that are economically viable in the long term	• Use of proven structural WSUD technology • Use of source control techniques to minimise cost of nutrient management • Retained ownership and management by Aspen Villages and Communities
Public Health To minimise the public risk, including risk of injury or loss of life to the community	• Design in accordance with relevant design standards, best management practices, council regulations and government agency requirements.
Protection of Property To protect the built environment from flooding and waterlogging	• Provision of 100 year ARI flood protection for Study Area • Protection of downstream areas by restricting stormwater discharge to existing levels for storm events up to 100 year ARI. • Subsoil drainage to be implemented to control seasonal groundwater rise post development to defined CGL.
Social Values To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater	• Use of swales within POS areas for stormwater conveyance • Integration of drainage and POS functions
Development To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.	• Development of the LWMS in accordance with government agency guidelines and best management practice recommendations. • Reporting of outcomes of post development monitoring programs to assist in assessing system performance, with outcomes guiding future urban development water management.

5. IMPLEMENTATION

5.1 Roles and Responsibilities

Table 11 details the roles and responsibilities to undertake the implementation plan.

With respect to both Aspen Villages and Communities, the operation and maintenance of the stormwater management system will continue to be the responsibility of the owner as both sites will remain in private ownership.

Further detail is provided regarding each deliverable in the section outlined in Table 11 below.

TABLE 11: IMPLEMENTATION RESPONSIBILTIES

IMPLEMENTATION		**RESPONSIBILITY**	
LWMS Section	**Action**	**Landowner**	**Shire of Serpentine Jarrahdale**
5.1.1	Preparation of an Urban Water Management Plan	✓	-
5.1.2	Construction of stormwater system and 12 months maintenance post construction (defects period)	✓	-
5.1.2	Long term stormwater system operation and maintenance	✓	-
5.1.3	Monitoring program – 3 years post development	✓	-

5.1.1 Urban Water Management Plan

Processes defined in ESS (2007) and the BDWMP (2008) require an Urban Water Management Plan (UWMP) to be developed following from an LWMS and submitted together with an application for subdivision.

As detailed in the BDWMP (2008), the UWMP will re required to be prepared by the developer and address the following:

- Objectives as outlined in the BDWMP and this LWMS. Demonstration of compliance with these criteria and objectives should be achieved through appropriate assessment tools, calculations or assessments, to the satisfaction of the DoW.

- Agreed/approved measure to achieve water conservation and efficiencies of use including sources of water for non-potable uses and detailed designs, controls, management and operation of any proposed system including the use of rainwater tanks at the lot scale.

- Management of groundwater levels including locations of subsoil drainage and finished lot levels. Maintenance of ecosystem health and any proposed dewatering will be identified.

- Detailed stormwater management design including the size location and design of public open space areas, integrating major and minor flood management capability.

- Details regarding 1 year ARI stormwater treatment and storage and its role in the overall drainage design

- Specific structural and non-structural BMPs and treatment trains to be implemented including their function, location, maintenance requirements, expected performance and agreed ongoing management arrangements.

- Measures to achieve protection of waterways, remnant vegetation and ecological linkages.

- Adequacy of buffers proposed in the Local Structure Plan considering any controlled groundwater levels proposed.

- Management of subdivisional works (to ensure no impact on regional conservation areas, maintenance of any installed BMPs and management of any dewatering and soil/sediment transport or erosion, including dust).

- Management of disease vector and nuisance insects such as mosquitoes and midges.

- Management of acid sulphate soils

- Monitoring programs and/or contribution.

- Implementation plan including roles, responsibilities, funding and maintenance arrangements. Contingency plans will also be indicated where necessary.

5.1.2 Stormwater System Operation and Maintenance

For Aspen Villages and Communities, the operation and maintenance will continue to be the responsibility of the owner.

The surface and subsoil drainage system will require regular maintenance to ensure its efficient operation. It is considered the following operating and maintenance practices will be implemented periodically:

- removal of debris to prevent blockages

- street sweeping to reduce particulate build up on road surfaces and gutters

- stripping and removal of vegetation from basins

- cleaning of sediment build up an litter layer on the bottom of basins

- mowing of grassed open channel sections monthly and grass clippings removed
- application of slow release/low phosphorus fertilisers for maintenance of swales
- undertake education campaigns regarding source control practices to minimise pollutant runoff into stormwater drainage system
- checks on subsoil drainage function

5.1.3 Monitoring Program

The monitoring program has been designed consistent with Joint Australian/ New Zealand Standards (1998a,b,c) to allow quantitative assessment of hydrological impacts of proposed development within the Study Area. .

The post development monitoring program is designed to operate over a 3 year period to allow for time lag for impacts of development on the receiving environment to occur. The program will be periodically reviewed to ensure suitability and practicality. The program may need to be modified as data are collected to increase or decrease the monitoring effort in a particular area or alter the scope of the programme itself.

All water quality sample testing will be conducted by a NATA approved laboratory.

A summary of the proposed monitoring program and reporting schedule is shown in Table 12, with the frequency of water quality target review and the contingency action plan detailed in Table 13.

Figure 15 shows the proposed monitoring locations.

5.1.3.1 Surface Water

Surface water monitoring includes both quality and quantity parameters. This will enable and estimate of nutrient concentrations and loads discharging for the Study Area to be established.

Discharge at 5 locations throughout the Study Area are to be monitored over the first 3 years of development (Figure 15). Flow estimates will be taken from detention storage outflow points and continuous levels will be recorded within Beenyup Brook. Water quality samples will be taken monthly while flowing for laboratory analysis.

Monitoring of the following parameters is proposed consistent with requirements of the BDWMP (DoW,2008):

- pH, EC, TSS
- Nutrients- Total Phosphorus, Total Nitrogen (with components including FRP, TKN, Nitrate/Nitrite, Ammonia)
- Heavy Metals

5.1.3.2 Groundwater

Monthly monitoring of water levels and quarterly is proposed. Monitoring at a total of 12 groundwater sites is proposed using locations that correspond to pre-development monitoring sites (Figure 15).

Any of the bores disturbed during development will be replaced as near as possible to existing bore sites and re-surveyed to Australian Height Datum (AHD).

The depth to water table will be measured by electrical depth probe or an alternative suitable device. Water samples are to be taken after purging the bores to ensure a fresh sample is obtained.

Water quality parameters to be measured are as described above for surface water monitoring.

5.1.3.3 Reporting Mechanisms

The preparation of annual monitoring reports is to be coordinated by the developer and submitted to the DoW/SSJ for review. The report will compare the monitoring results with the design criteria and performance objectives and determine what, if any, further actions may be necessary consistent with contingency planning measures detailed in Table 13.

The proposed reporting schedule is detailed in Table 12.

TABLE 12: MONITORING SCHEDULE AND REPORTING

Monitoring Type	Parameter	Location	Method	Frequency, Timing & Responsibility	Reporting
Groundwater Level	Water Level (m AHD)	13 Monitoring Bores	Electrical depth probe or similar	Monthly for 3 years by Developer	Annual reports to be provided by Developer as part of regional post development monitoring will provided for a period of 3 years. Reports will be submitted to DoW/SSJ within 3 months of completion of the reporting period.
Surface Water Quantity	Flow	5 Locations within Study Area	Visual estimate continuous logger	Monthly when flowing	
Groundwater Quality	pH, EC, TSS Nitrogen Phosphorus Heavy Metals	13 Monitoring Bores	Pumped bore samples	Quarterly for 3 years by Developer	
Surface Water Quality	pH, EC, TSS Nitrogen Phosphorus Heavy Metals	5 Locations within Study Area	Collected grab samples	6 samples annually for 3 years by Developer Sampling to capture first flush (if possible), then 5 further samples from May to Oct	

TABLE 13: CONTINGENCY PLANNING

Monitoring Type	Criteria for Assessment	Criteria Assessment Frequency	Contingency Action 1. Assess if an isolated, development area or regional occurrence. 2. Determine if due to the development or other external factors. 3. Perform appropriate contingency action as required (examples provided below) 4. Record and report in the annual report any breach and action taken. 5. If necessary, inform residents of any required works and their purpose.
Groundwater Level	Groundwater levels not to exceed AAMGL plus 0.7m in areas of subsoil drainage.	After monitoring occasion	1. Review design and operation of subsoil and stormwater drainage system. 2. Perform maintenance as required.
Surface Water Quantity	Flow discharging from Study Area to be similar to interim targets established based on existing surface water flow estimates	Annual review of water quality targets	1. Review design and operation of detention storage areas 2. Perform maintenance as required
Groundwater Quality	Nutrient concentrations in shallow bores to be similar or better than interim targets established by predevelopment monitoring.	Annual review of water quality targets	1. Identify and remove any point sources. 2. Reinforce Community Education/Awareness program. 3. Review operational and maintenance (eg fertilising) practices. 4. Consider alterations to POS areas including landscape regimes and soil amendment. 5. Consider modifications to the stormwater system. 6. Consider initiation of community based projects.
Surface Water Quality	Water quality discharging from the Study Area to be similar or better than interim targets established based on existing surface water quality		

SJS TRIM IN09/13770

6. REFERENCES

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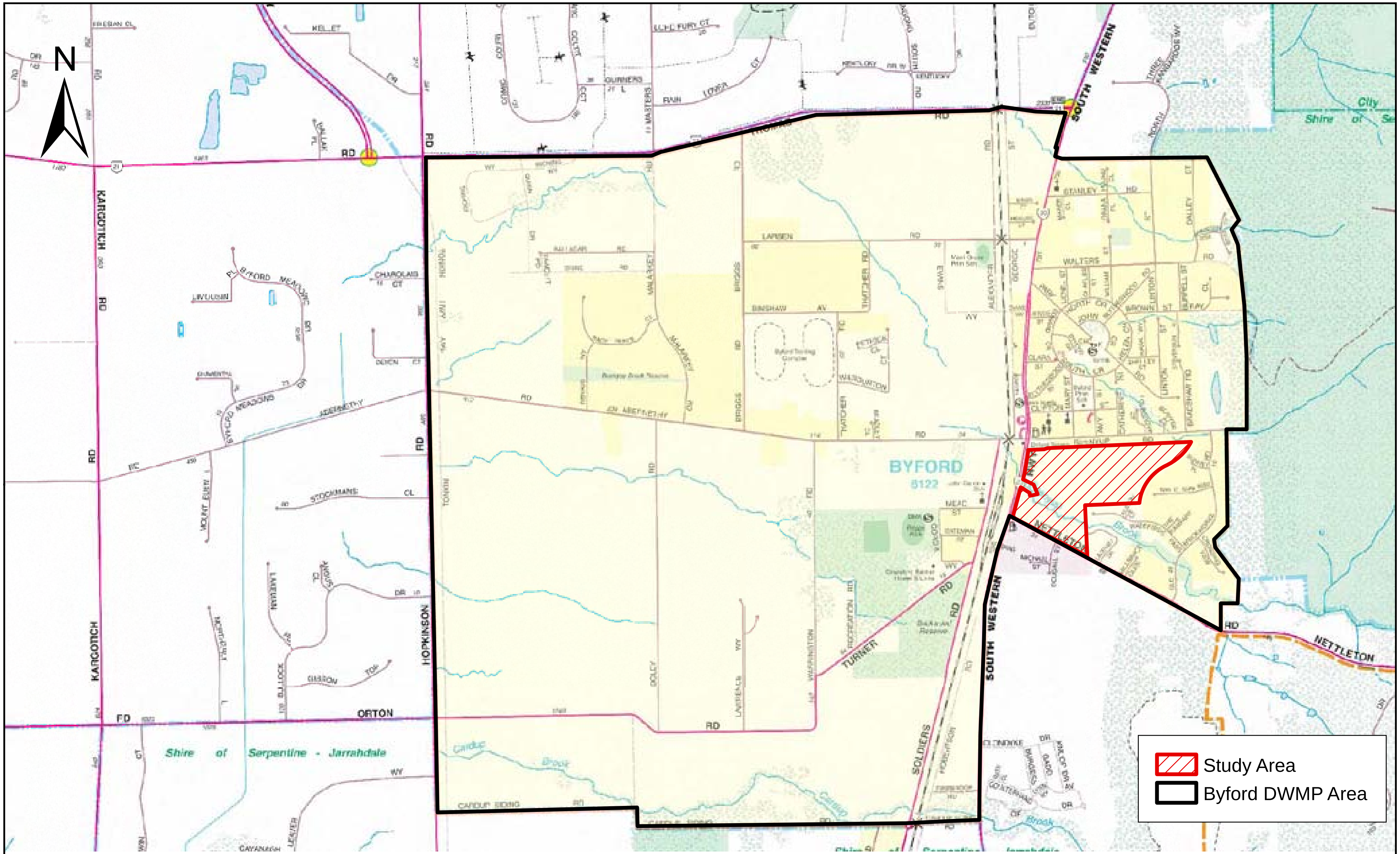
FIGURES



Data Source: Street Express 2006

JDA

Job No. J4148

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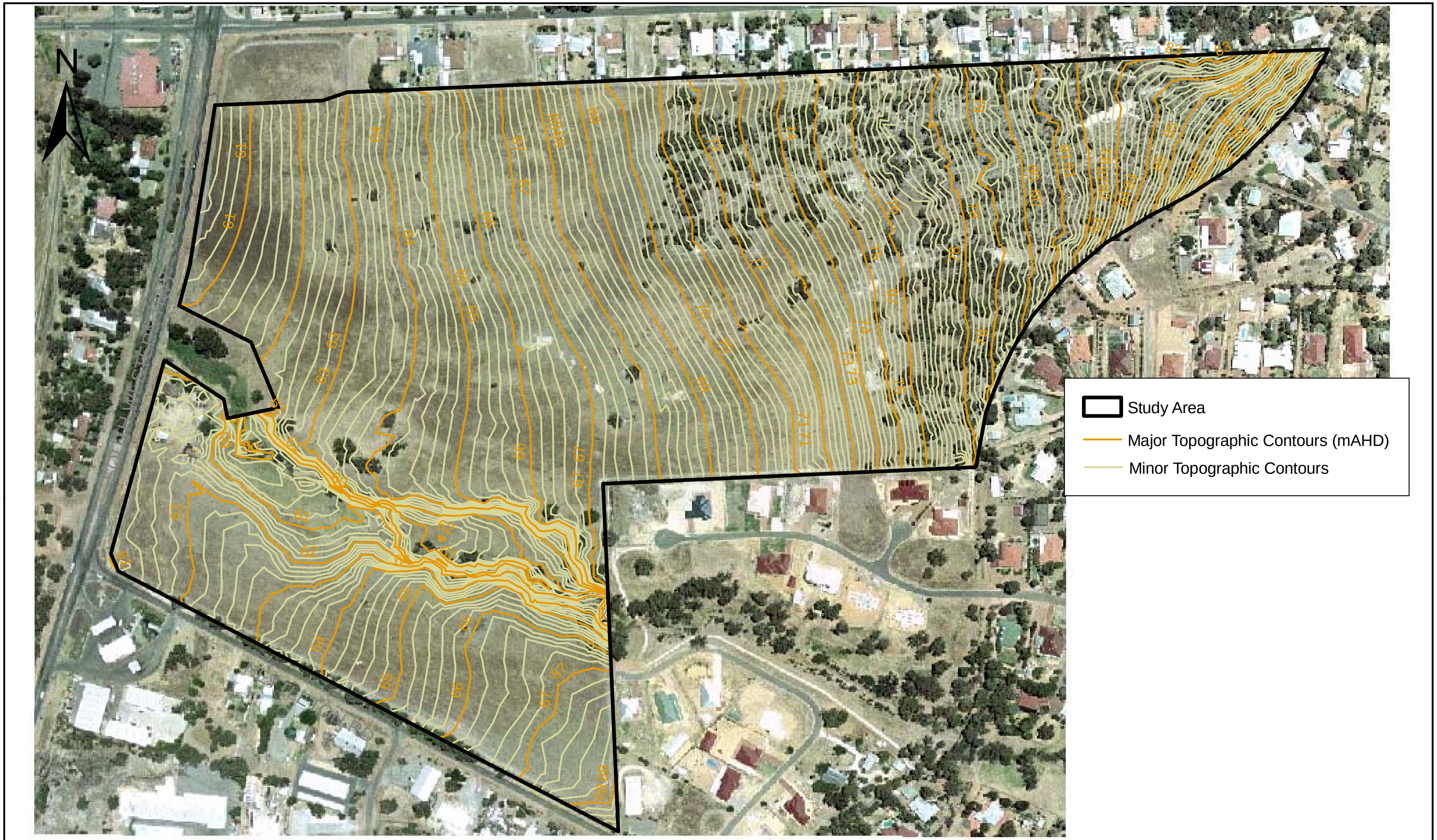
Aspen Group
Lot 2 Nettleton Rd, Byford: LWMS
Figure 1: Location Plan



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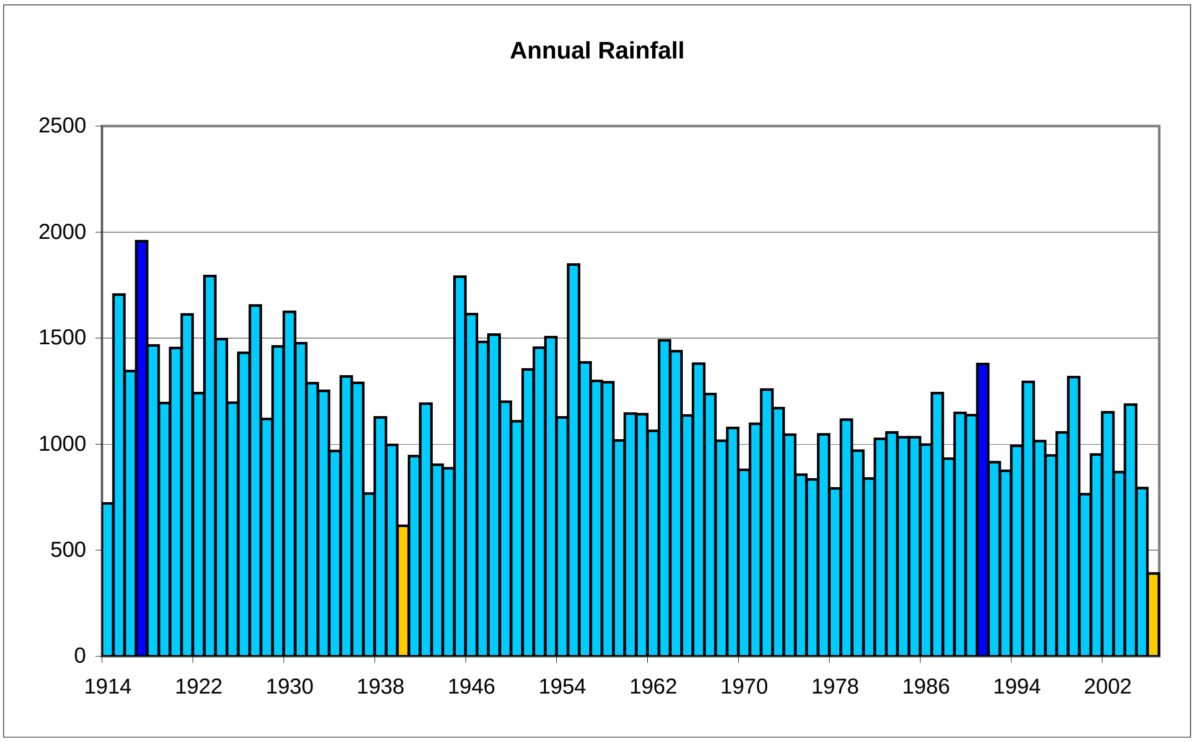
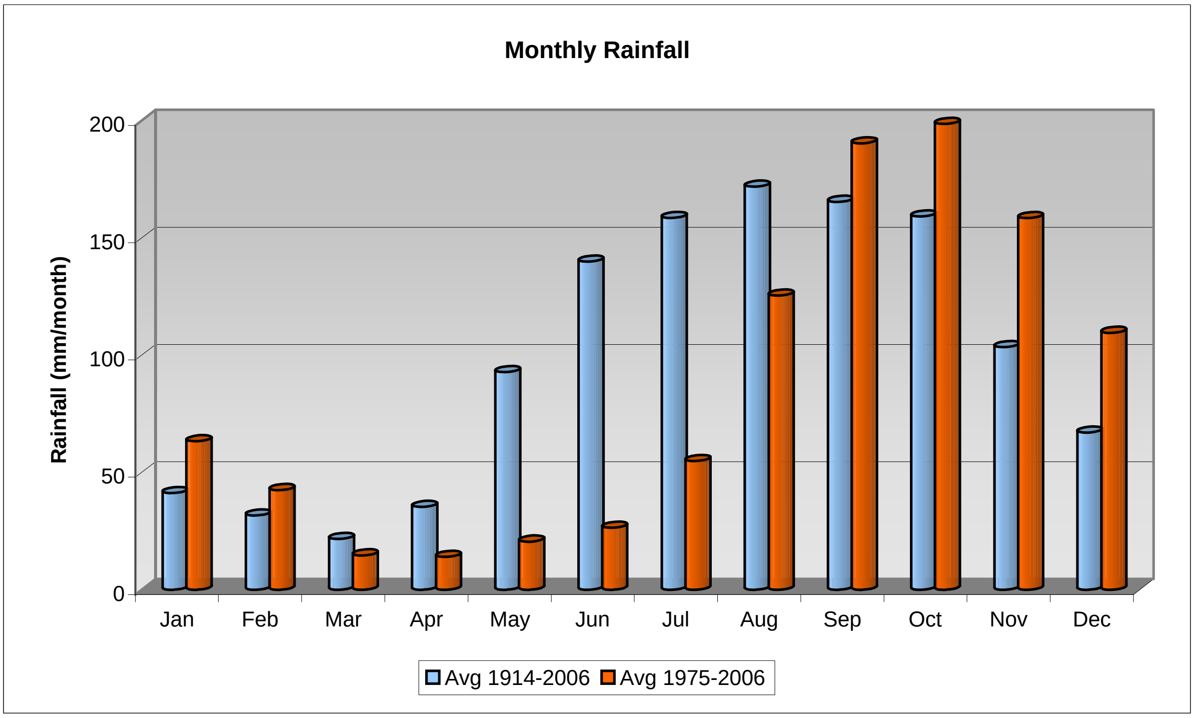
Aspen Group

Lot 2 Nettleton Rd, Byford: LWMS

Figure 2: Topography and Aerial Photo





Data Source: Bureau of Meterology (BoM) 2007

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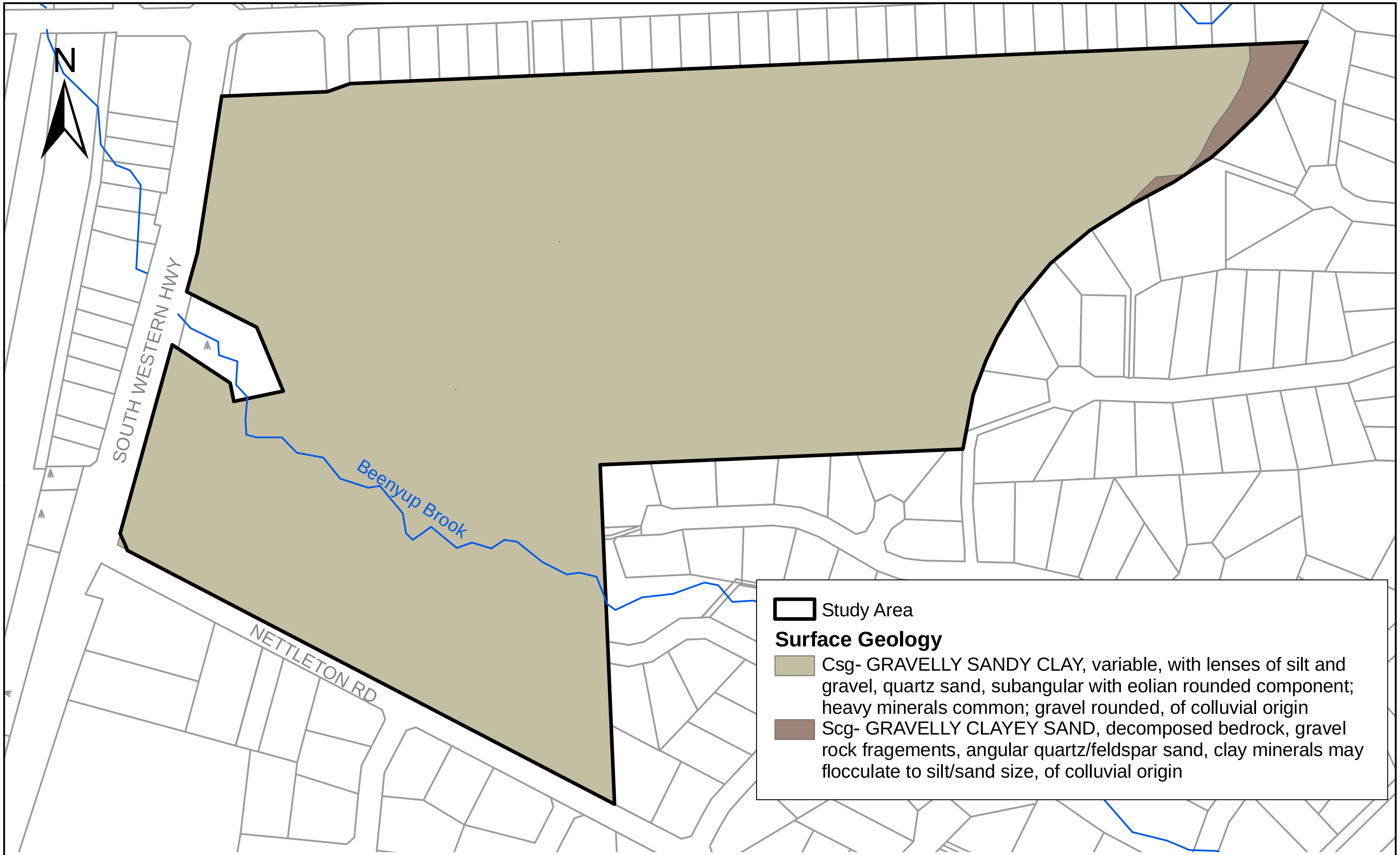
Aspen Group
Lot 2 Nettleton Rd, Byford: LWMS

Figure 3: Byford Annual and Monthly Rainfall



▭ Study Area

Surface Geology

🟫 Csg- GRAVELLY SANDY CLAY, variable, with lenses of silt and gravel, quartz sand, subangular with eolian rounded component; heavy minerals common; gravel rounded, of colluvial origin

🟫 Scg- GRAVELLY CLAYEY SAND, decomposed bedrock, gravel rock fragements, angular quartz/feldspar sand, clay minerals may flocculate to silt/sand size, of colluvial origin

JDA

Job No. J4148
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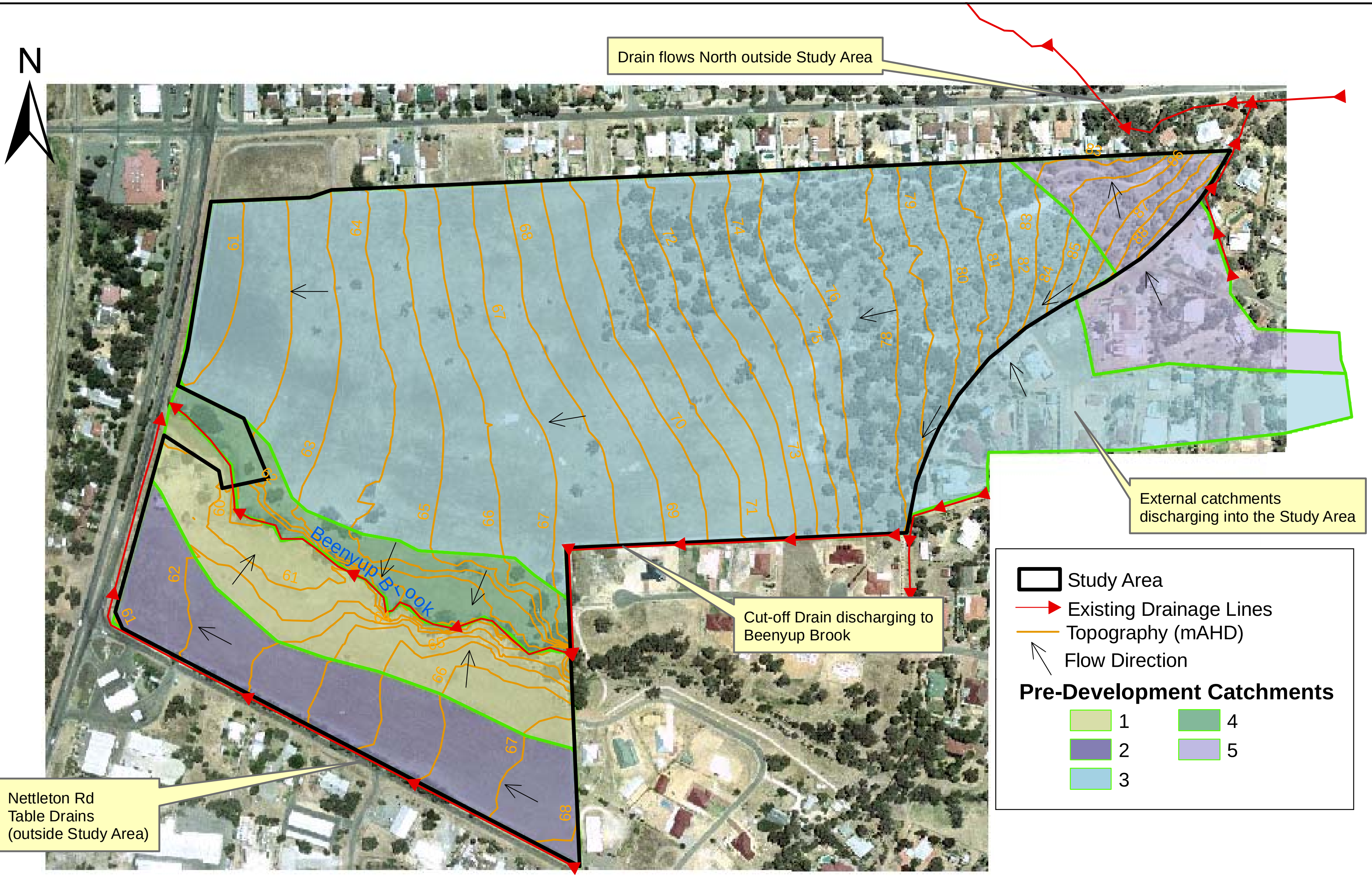
0 100 200 300 400 Meters

Aspen Group
Lot 2 Nettleton Rd, Byford: LWMS
Figure 4: Surface Geology



Data Source: Whelans (2007)

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Aspen Group
Lot 2 NettletonRd, Byford: LWMS
Figure 5: Existing Local Surface Drainage

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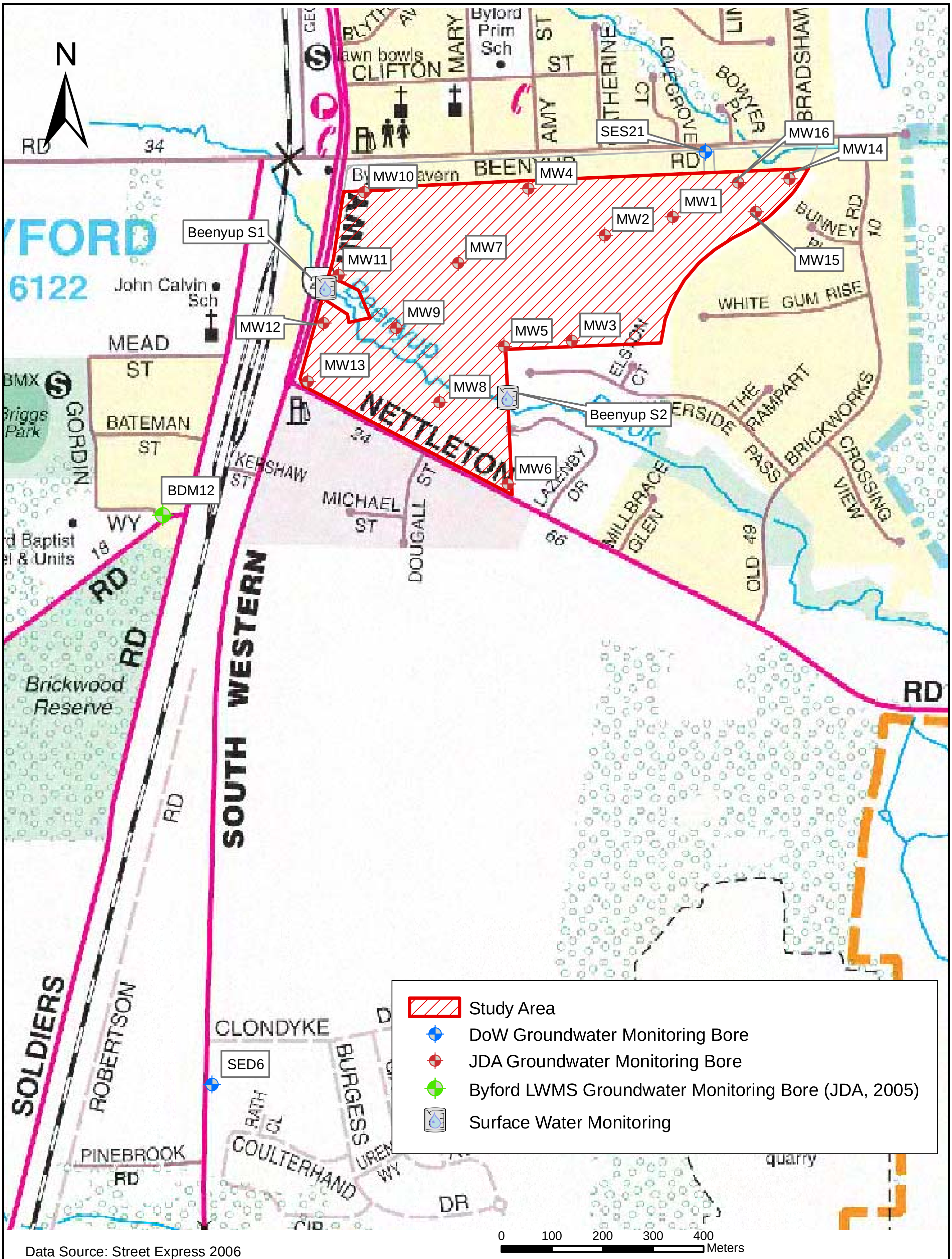

Data Source: Street Express 2006

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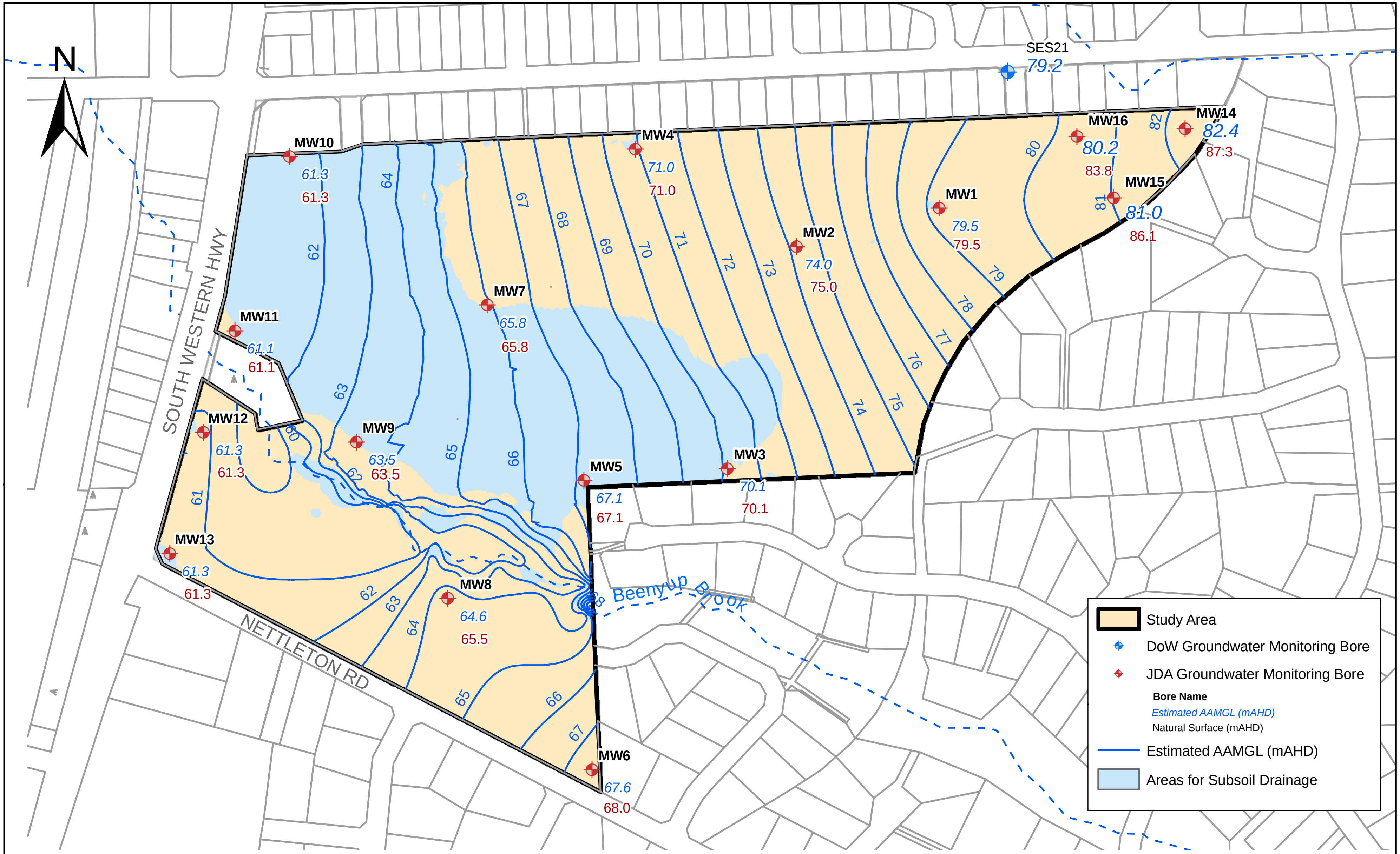
Aspen Group
Lot 2 Nettleton Rd, Byford: LWMS

Figure 6: Monitoring Locations



Data Source: DoW, 2007

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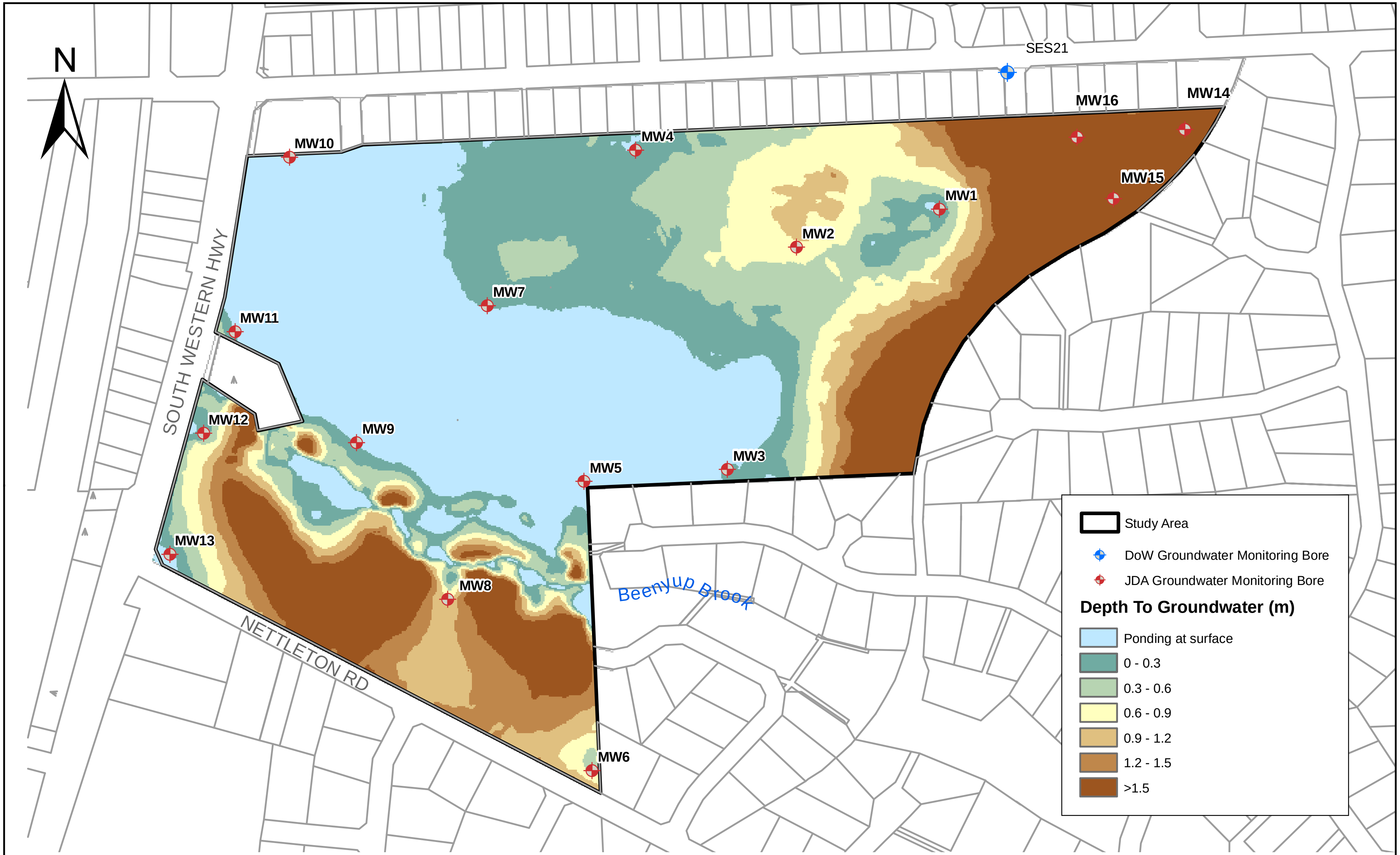
Aspen Group
Lot 2 Nettleton Rd, Byford: LWMS
Figure 7: Estimated Groundwater Levels



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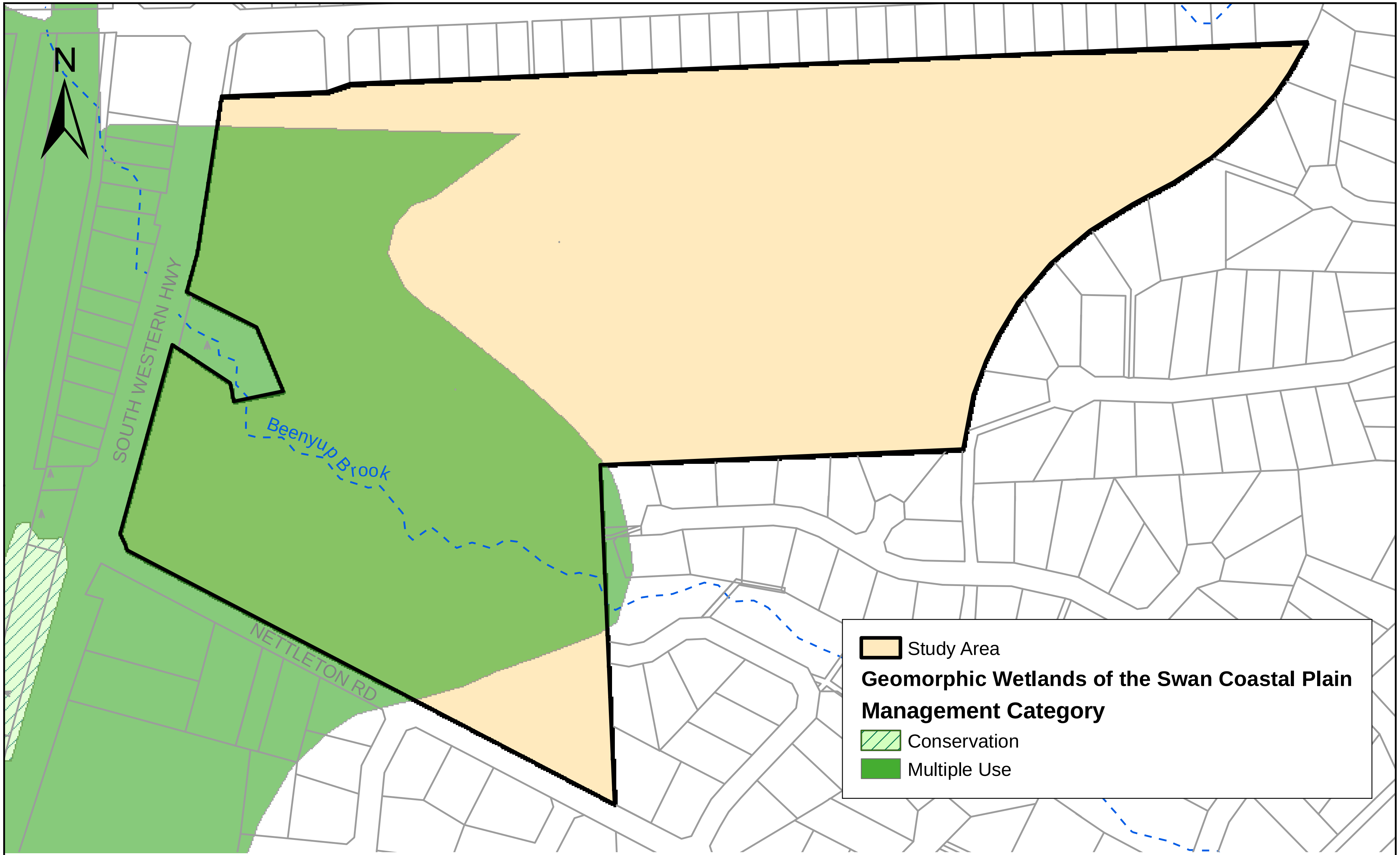
Aspen Group
Lot 2 Nettleton Rd, Byford: LWMS
Figure 8: Depth to Estimated Groundwater



Data Source: DoEC (2009)

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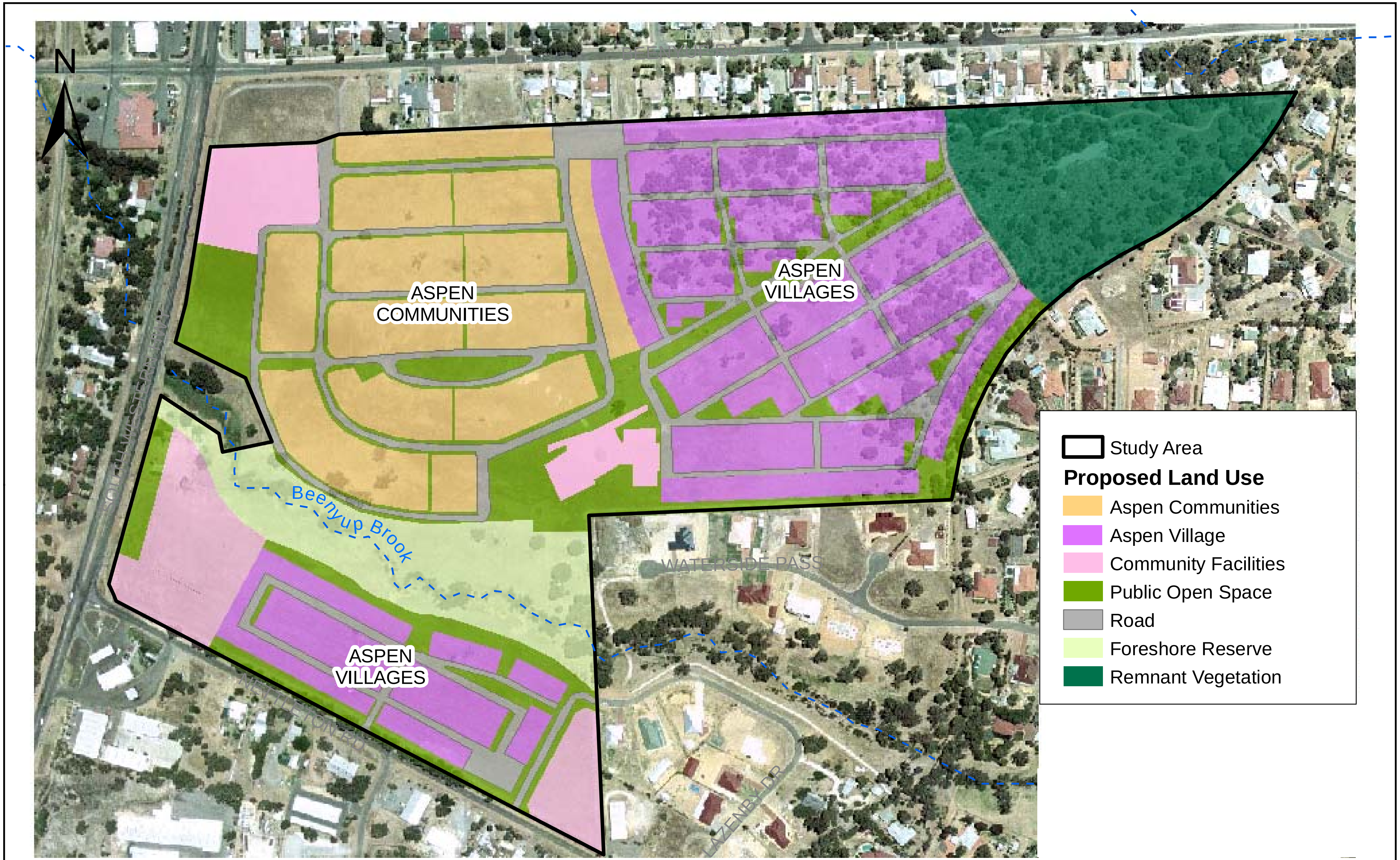
Aspen Group
Lot 2 Nettleton Rd, Byford: LWMS
Figure 9: DoEC Wetland Mapping



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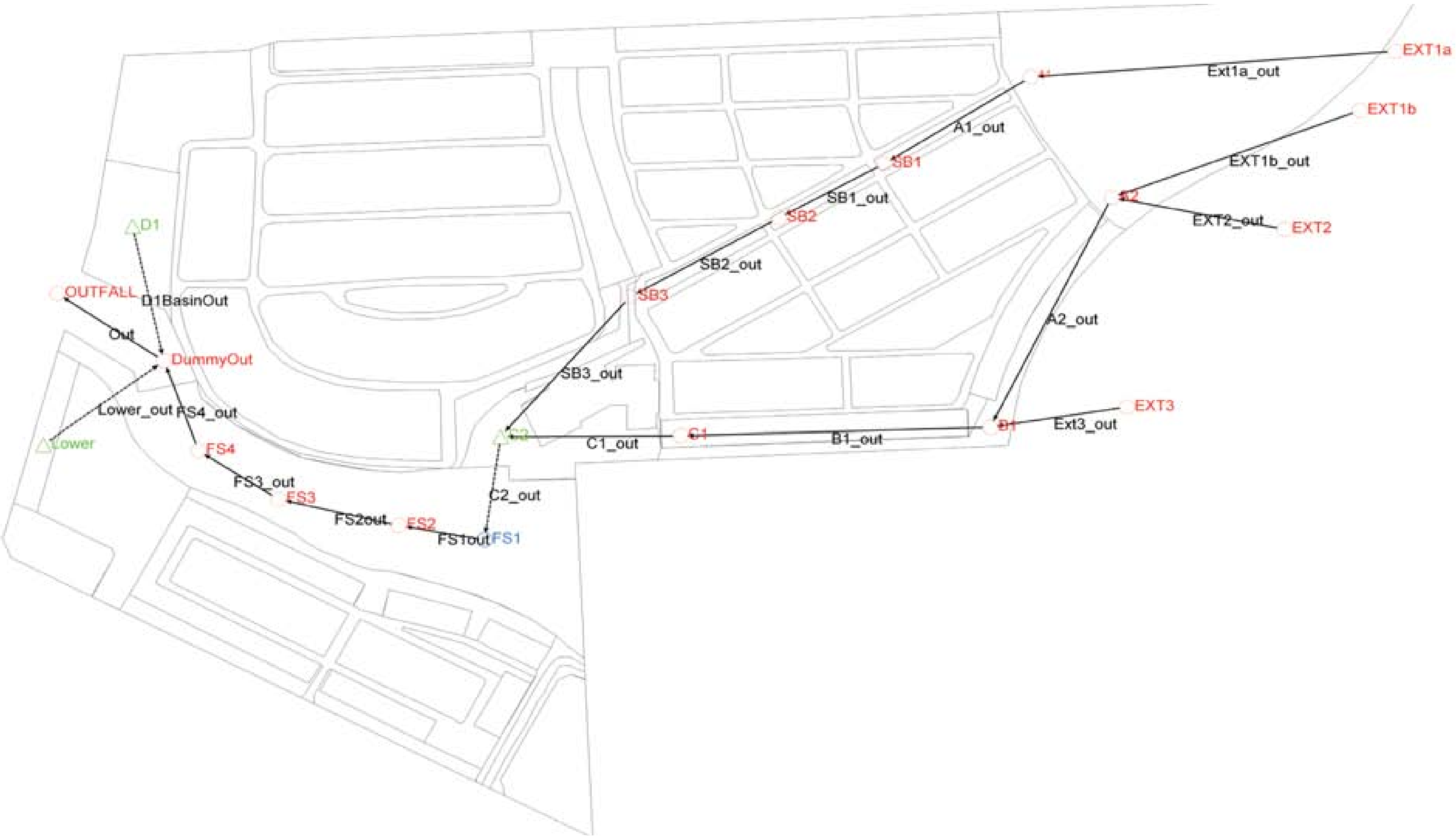
Aspen Group

Lot 2 Nettleton Rd, Byford: LWMS

Figure 10: Proposed Land Use



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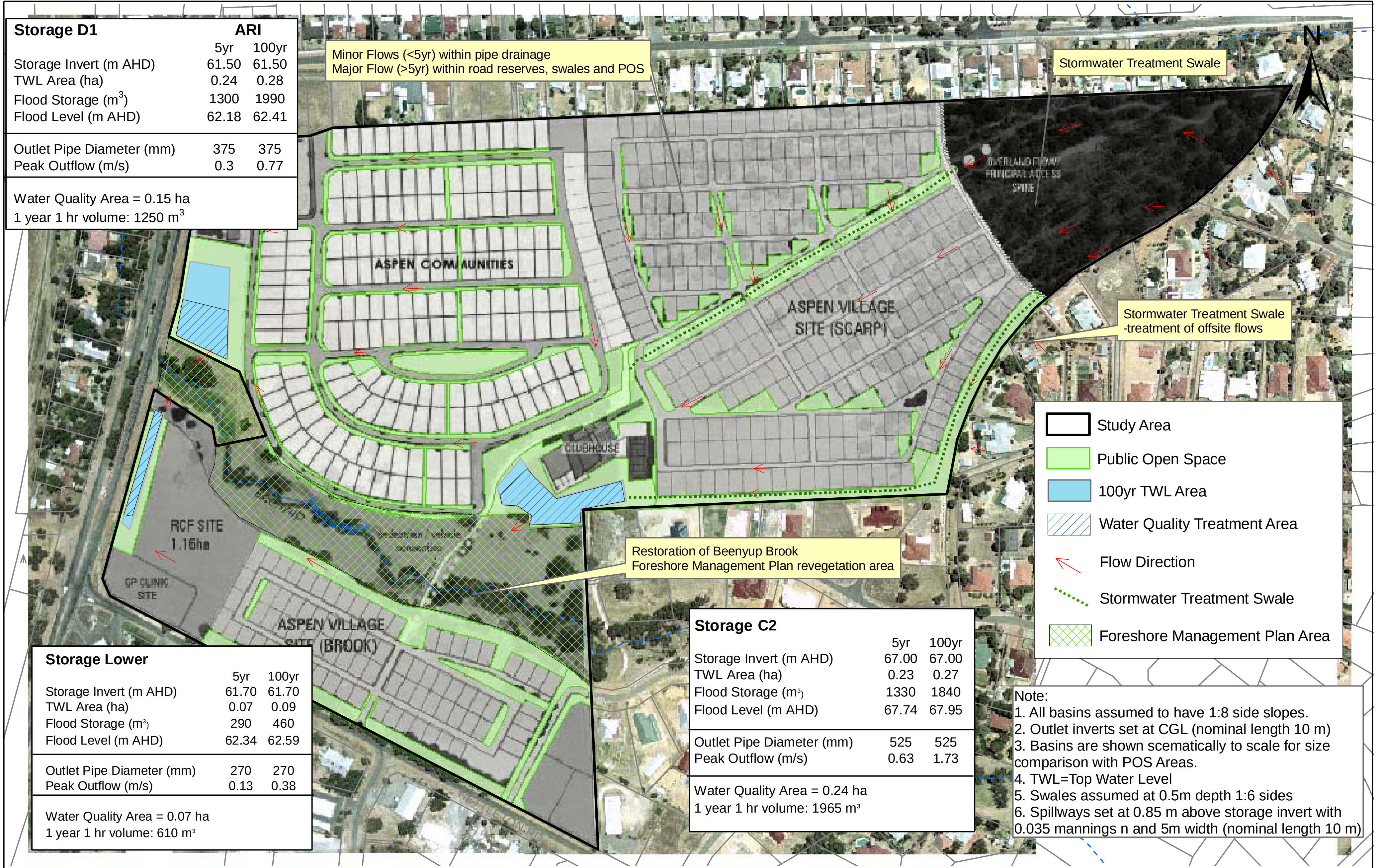
Aspen Group
Lot 2 Nettleton Rd, Byford: LWMS
Figure 11: XPStorm Schematic Model



Minor Flows (<5yr) within pipe drainage
Major Flow (>5yr) within road reserves, swales and POS

Stormwater Treatment Swale

Stormwater Treatment Swale
-treatment of offsite flows

Restoration of Beenyup Brook
Foreshore Management Plan revegetation area

Storage D1

	ARI	
	5yr	100yr
Storage Invert (m AHD)	61.50	61.50
TWL Area (ha)	0.24	0.28
Flood Storage (m^3)	1300	1990
Flood Level (m AHD)	62.18	62.41
Outlet Pipe Diameter (mm)	375	375
Peak Outflow (m/s)	0.3	0.77

Water Quality Area = 0.15 ha
1 year 1 hr volume: 1250 m^3

Storage Lower

	5yr	100yr
Storage Invert (m AHD)	61.70	61.70
TWL Area (ha)	0.07	0.09
Flood Storage (m^3)	290	460
Flood Level (m AHD)	62.34	62.59
Outlet Pipe Diameter (mm)	270	270
Peak Outflow (m/s)	0.13	0.38

Water Quality Area = 0.07 ha
1 year 1 hr volume: 610 m^3

Storage C2

	5yr	100yr
Storage Invert (m AHD)	67.00	67.00
TWL Area (ha)	0.23	0.27
Flood Storage (m^3)	1330	1840
Flood Level (m AHD)	67.74	67.95
Outlet Pipe Diameter (mm)	525	525
Peak Outflow (m/s)	0.63	1.73

Water Quality Area = 0.24 ha
1 year 1 hr volume: 1965 m^3

☐	Study Area
🟩	Public Open Space
🟦	100yr TWL Area
▨	Water Quality Treatment Area
↖	Flow Direction
⋰	Stormwater Treatment Swale
▩	Foreshore Management Plan Area

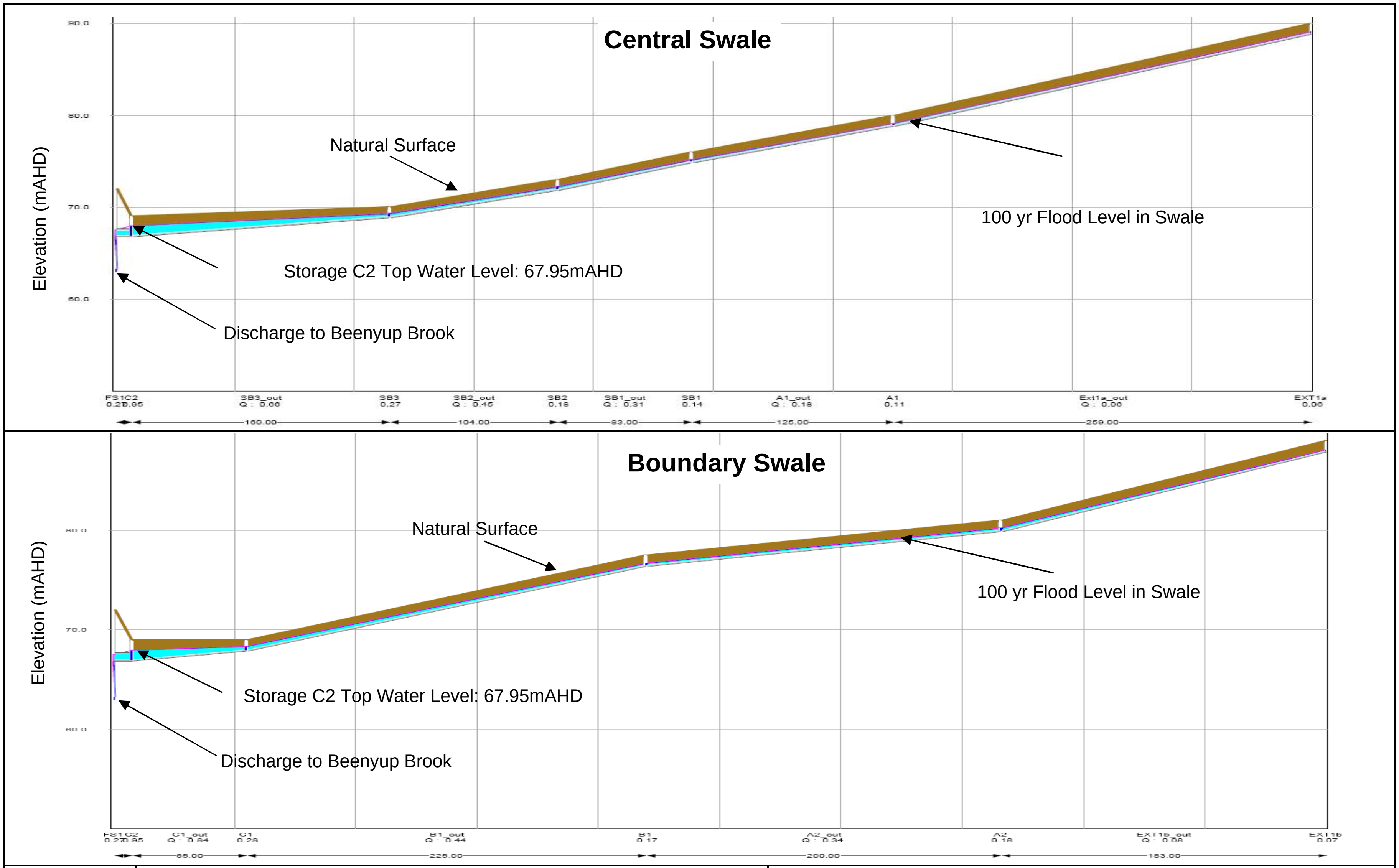
Note:
1. All basins assumed to have 1:8 side slopes.
2. Outlet inverts set at CGL (nominal length 10 m)
3. Basins are shown scematically to scale for size comparison with POS Areas.
4. TWL=Top Water Level
5. Swales assumed at 0.5m depth 1:6 sides
6. Spillways set at 0.85 m above storage invert with 0.035 mannings n and 5m width (nominal length 10 m)

Data Source: Aspen Group

JDA

Job No. J4148
Scale: 1:3,000

Aspen Group
Lot 2 Nettleton Rd: LWMS
Figure 12: Proposed Stormwater Management System

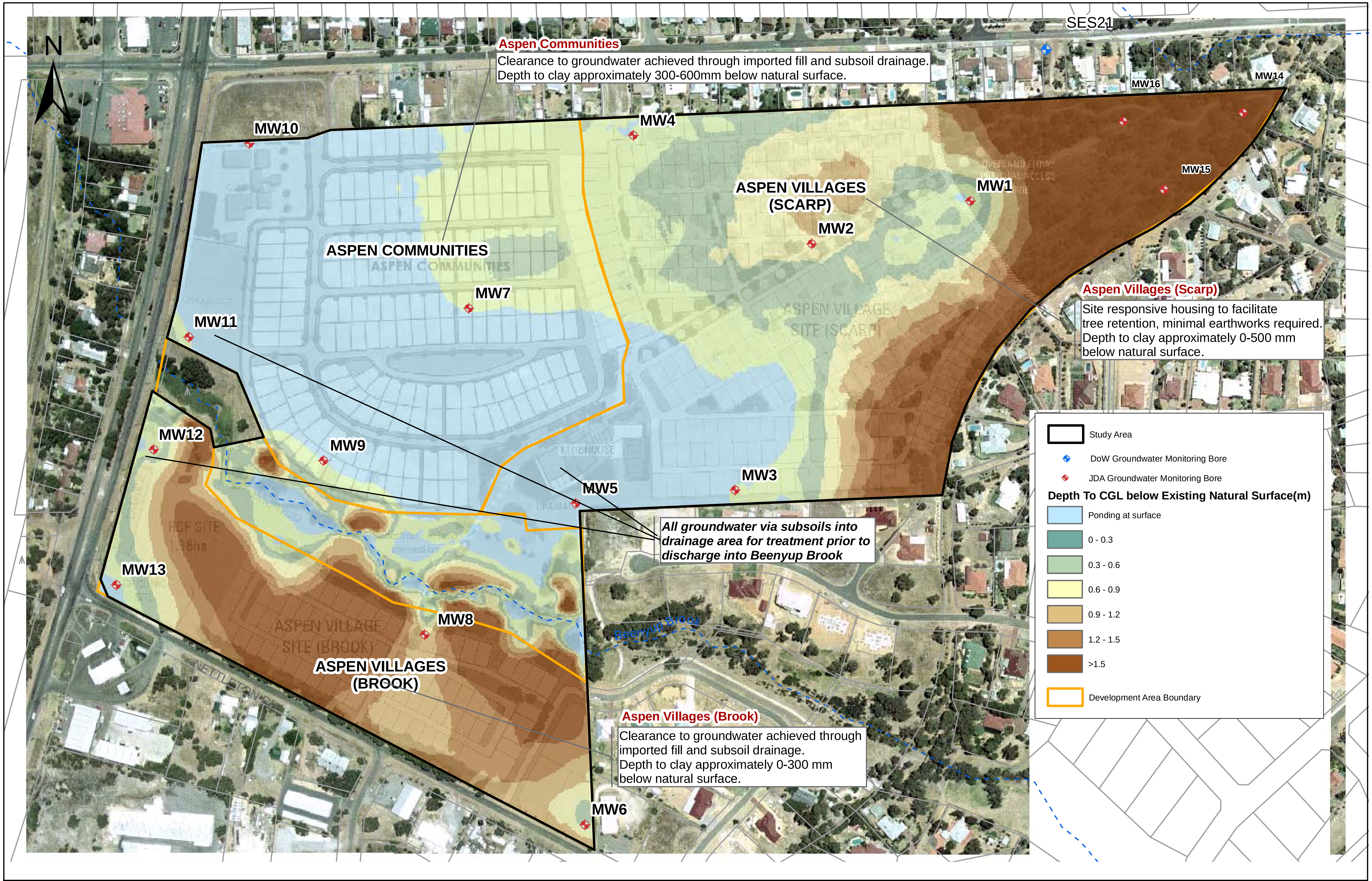


JDA Consultant Hydrologists

Job No. J4148

Aspen Group
Lot 2 Nettleton Rd, Byford: LWMS

Figure 13: Long Section of Proposed Swale Drain



Aspen Communities

Clearance to groundwater achieved through imported fill and subsoil drainage.
Depth to clay approximately 300-600mm below natural surface.

Aspen Villages (Scarp)

Site responsive housing to facilitate tree retention, minimal earthworks required.
Depth to clay approximately 0-500 mm below natural surface.

All groundwater via subsoils into drainage area for treatment prior to discharge into Beenyup Brook

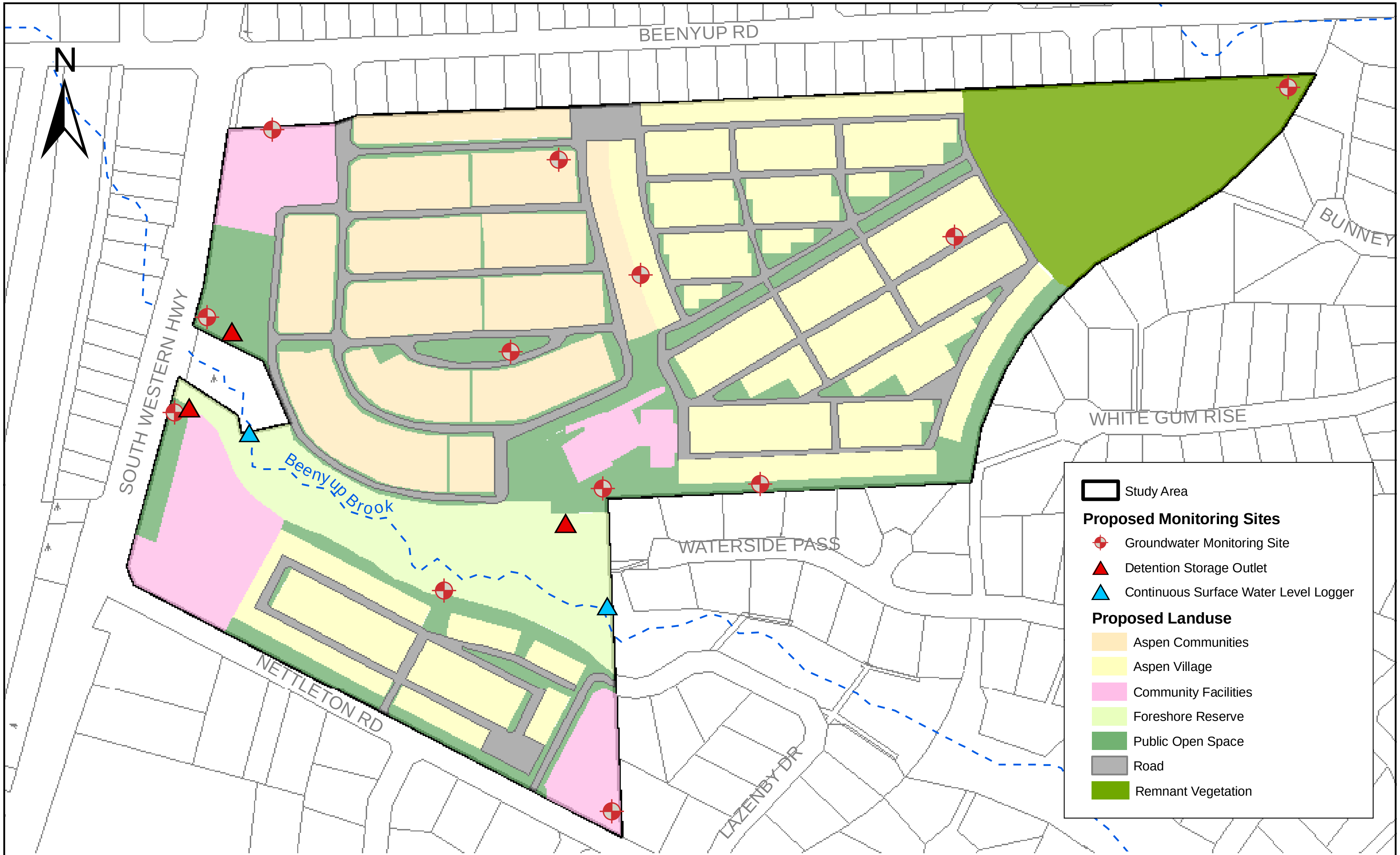
Aspen Villages (Brook)

Clearance to groundwater achieved through imported fill and subsoil drainage.
Depth to clay approximately 0-300 mm below natural surface.

Job No. J4148
Scale: 1:3,000

0 100 200 300 400 Meters

Aspen Group
Lot 2 Nettleton Rd, Byford: LWMS
Figure 14: Proposed Groundwater Management Plan



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Aspen Group
Lot 2 Nettleton Rd, Byford: LWMS
Figure 15: Proposed Post-Development Monitoring Sites

APPENDIX A

Local Water Management Strategy: Checklist for Developers

Local Water Management Strategy : Checklist for Developers

The checklist provides a summary of items to be addressed by developers in the preparation of local water management strategies for assessment by the Serpentine Jarrahdale Shire when an application for a local structure plan is lodged. The checklist must be completed and signed by a suitably qualified professional and submitted to council together with the local water management strategy.

Applicant: **Aspen Group**
Name of structure plan: **Lot 2 Nettleton Rd Byford**

Contact**: Sasha Martens, Principal Engineering Hydrologist, JDA Consultant Hydrologists**
Address: **Suite 1, 27 York St Subiaco WA 6008**
Telephone number: **9388 2436** Email: **sasha@jdahydro.com.au**

Date: **24 September 2009**

	Item	**Submission**		**Assessment**	
		LWMS Ref [1]	**Comment** [2]	**Compliance**	**Comment**
1.0	**Introduction**	Chapter 1	-		
1.1	Drainage and water management principles and design objectives for this structure plan	Section 1.2, Table 2 Section 4.7, Table 9 Appendix B	Table 2 details principles and objectives and Table 9 summarises measures adopted to meet DoW principle objectives for WSUD		
1.2	Planning background (subject land)	Section1 1.2.1 to 1.2.6	Water related planning background described in Sections Section 1.2.1 to 1.2.6. Planning context detailed in Section 1.1		
1.3	Previous studies (related to drainage and water)	Section1 1.2.1 to 1.2.6	Details previous overarching drainage planning studies affecting the LWMS		
2.0	**Proposed development**	Chapter 3, Figure 10	Description in LWMS focuses on stormwater management aspects of local structure plan. Other specific details contained in local structure plan document.		
2.1	Key elements of structure plan	Chapter 3, Figure 10	General description of Structure Plan included. Description in LWMS focuses on stormwater management aspects of local structure plan.		

	Item	Submission		Assessment	
		LWMS Ref [1]	Comment [2]	Compliance	Comment
2.2	Previous land use and potential sources of contamination	Section 2.7, Figure 2	Land is vacant land. No known source of contamination.		
2.3	Finished lot levels – (determined by greater of 100 year flood protection criteria or minimum separation of building foundations to MGL or CGL)	Section 4.2.1 Section 4.3 Section 5.1.1	LWMS establishes criteria and approach for set finished lot levels. Finished lot levels is a detailed design issue and is not normally addressed until preparation of a UWMP. Commitment to provide at UWMP stage detailed. At the launch of the DWMP JDA raised concerns with DoW that the proposed checklist which was not provided to stakeholders for review contained a number of issues (including fill levels) which are not addressed until considerably later in the development process. These concerns were noted by DoW and are common to the preparation of LWMS's for other regions also.		
2.4	Assessment of risk undertaken	Section 2.3, 2.4.3, 2.5.2, 2.5.3, 2.6, 2.7, & 2.9 Section 4.6.2	Based on an assessment of surface and groundwater, geotechnical studies, existing and historical land use, and existing WAPC ASS mapping, no major risk are identified. ASS investigations are being undertaken as a separate process to the LWMS as part of Contamination sites work.		
3.0	**Existing site characteristics**	Chapter 2	-		
3.1	Topography and landform identified	Section 2.1	Based on detailed site surveys undertaken by Whelans and McMullan Nolan and Partners Surveyors		
3.2	Environmental geology of the site identified (including soil types, ASS and PASS)	Section 2.3, 2.9, Figure 4 Section 4.6.2	Environment Geology described and related to site specific investigations. WAPC ASS mapping referred to. Site specific ASS investigations are being undertaken as a separate process to the LWMS as part of contaminated sites work as detailed in Section 4.6.2.		
3.3	Soil hydraulic conductivity and infiltration capacity of the site identified	Section 2.3	Based on geotechnical investigations, lithological logs, Environmental Geology mapping, and experience at nearby Byford by the Scarp indicates there is limited infiltration capacity at the site. Section 2.3 explains that further		

	Item	Submission		Assessment	
		LWMS Ref [1]	Comment [2]	Compliance	Comment
			investigation of soil properties such as hydraulic conductivity and infiltration capacity was therefore not warranted.		
3.4	Groundwater levels, flows and quality of the site mapped (include identification and monitoring of any local or regional groundwater bores)	Section 2.4 Section 2.5, Tables 4,5, & 7, Figures 6,7 & 8, Appendices C and D	Based on a comprehensive ongoing monthly predevelopment monitoring program commenced in October 2007. Pre-development groundwater monitoring program results to date have been included in Appendix C and water quality results recorded in Section 2.4.3 and 2.5.3		
3.5	Surface water flows and quality of the site identified (include flow monitoring of existing drainage)	Section 2.4, Table 3, Figure 5 Appendix C	LWMS identifies key catchment areas, external catchments, and drainage flow paths related to the development. The LWMS includes peak flow estimates from the final BDWMP. Results for Total Suspended Solids included in Table 3. Pre-development monitoring program results included in Appendix C.		
3.6	Environmental assets and water-dependent ecosystems mapped	Section 2.6, Figure 9, Figure 10	No conservation category wetlands in Study Area. Proposed foreshore reserve for Beenyup Brook addressed in Foreshore Management Plan as a separate process.		
3.7	Indigenous sites identified	Section 2.7	Addressed in local structure plan document. The subject land does not accommodate any site or building identified for protection in the Local Municipal Heritage Inventory or other heritage register. Beenyup Brook is to be protected within a foreshore reserve.		
3.8	Existing infrastructure and constraints to design identified (include management strategies for any identified constraints)	Section 2.7, Section 2.8	Site is vacant land – no infrastructure constraints, dilapidated house was removed. Water resource constraints identified.		
3.9	Site water balance pre-development and postdevelopment identified	Section 4.1.2	Lot scale water balance committed to be performed at UWMP stage based on agreed measures.		
3.10	Water Sustainability Initiatives	Section 4.1, & Section 4.5.1	Water sustainability initiatives are provided as overarching objectives. Commitment to implement various initiatives is provide in Section 4.1.		

	Item	Submission		Assessment	
		LWMS Ref [1]	**Comment** [2]	**Compliance**	**Comment**
			Detailed design and investigations are to be undertaken at UWMP stage (including rainwater tank sizing)		
4.0	**Stormwater management**	Section 4.2	-		
4.1	Pre- and post-development hydrology (1 year, 5 year and 100 year ARI events)	Section 4.2.3 Table 8, Figure 13	The LWMS refers to pre and post development hydrology presented in the BDWMP as basis for design		
4.2	1 year ARI event managed for ecological protection in accordance with *Drainage and water management plan* section 6.2	Section 4.2.2, & Section 4.2.3, Table 8 Figure 12	The LWMS identifies that sufficient area is set aside in land use planning for drainage as shown in Figure 12. Aras and volumes provided.		
4.3	5 year ARI event managed for serviceability in accordance with *Drainage and water management plan* section 6.2	Table 8 Figure 12	The LWMS provides 5 and 100 year ARI modelling results.		
4.4	100 year ARI event managed for flood protection in accordance with *Drainage and water management plan* section 6.2 (include flow paths and emergency access routes and fully identify flood plain and protection measures)	Section 4.2.2, & Section 4.2.3, Table 8 Figure 12 Figure 13	The LWMS details 100 year ARI storage area requirements for major event flood protection and how they influence structure planning. Modelling results are consistent with discharge rates presented in the DWMP. Overland flow paths are shown in Figure 12. Long Section of proposed swale drains included in Figure 13.		
4.5	Finished lot levels at minimum of 0.5m above 100-year ARI flood levels.	Section 4.2.2 Section 5.1.1	LWMS establishes criteria and approach for set finished lot levels. Finished lot levels is a detailed design issue and is not normally addressed until preparation of a UWMP. Clearly identified in LWMS as an issue to be addressed in a UWMP		
4.6	POS credits identified	Table 8	Areas for 5 year ARI and area of overall POS detailed in Table 8 for assessment if required.		
4.7	Water quality management BMPs to achieve design targets: Vegetated bioretention systems sized at 2% of the constructed impervious area they receive runoff from OR to achieve: at least 80% reduction of total suspended solids at least 60% reduction of total phosphorus at least 45% reduction of total nitrogen at least 70% reduction of gross pollutants	Section 4.5 Table 9 Figure 12	Water quality management approach in LWMS targets more than simply a bioretention system. Areas set aside in the LWMS for water quality treatment are shown in Figure 12. Bioretention systems are to be sized and designed as part of the UWMP - refer Byford by the Scarp UWMP for example of detail to be provided. BMP performance is described in Section		

	Item	Submission		Assessment	
		LWMS Ref [1]	Comment [2]	Compliance	Comment
			4.5.2 and outlined in Table 9.		
5.0	**Groundwater management**	Section 4.3	-		
5.1	Groundwater level management strategy	Section 4.3, Figure 14	-		
5.2	Bio-retention system, subsurface drainage and drainage inverts	Section 4.3 Figure 14	Drainage inverts, subsoil design and bioretention system design are detailed design issue. Will be addressed in preparation of a UWMP. The use of subsoil drainage in the proposed development is described in section 4.3		
5.3	Subsurface drainage design	Section 4.3	Drainage inverts, subsoil design and bioretention system design are detailed design issue and are not normally addressed until preparation of a UWMP. These issues are not addressed until considerably later in the development process. At the launch of the DWMP JDA raised concerns with DoW that the proposed checklist which was not provided to stakeholders for review contained a number of issues (such as subsurface design) which are not addressed until considerably later in the development process. These concerns were noted by DoW and are common to the preparation of LWMS's for other regions also. The use of subsoil drainage in the proposed development is described in Section 4.3. Detail requested will be provided in the UWMP		
5.4	Groundwater management strategies to achieve: at least 60% reduction of total P at least 45% reduction of total N	Section 4.3, Section 4.5	No proposed export of groundwater as no subsoil below specified CGL (defined as annual average maximum water table) proposed.		
5.5	Discharge to water-dependent ecosystems	-	None specified in DWMP.		
5.6	Specifications for imported fill (where proposed)	Section 4.3	Fill specification a UWMP issue. The use of fill to achieve separation from groundwater addressed in Section 4.3		
5.7	Finished lot levels at a minimum of 0.8 m above the phreatic line	-	Finished lot levels and fill requirements are a detailed design issue and will addressed during preparation of the UWMP and submitted for council approval		

	Item	Submission		Assessment	
		LWMS Ref [1]	Comment [2]	Compliance	Comment
			at this stage. Details submitted for council and DoW consideration at this time will include calculations detailing fill levels relative to mounding between subsoil drains for various ARI storm events to demonstrate compliance of the design to required standards.		
6.0	**Monitoring**	Section 2.4.3, 2.5.2, 2.5.3, & 5.3 Table 4, 7, 10 &11 Figure 15	-		
6.1	Monitoring programs commenced 2 years prior to proposed development	Section 2.4.3, 2.5.2, 2.5.3, Tables 3 & 7, Appendix C & Appendix D	Predevelopment monitoring program commenced in October 2007, with a view to 18 months predevelopment data, consistent with previous DoW specifications. Previous DoW advice (Bill Till pers comm.) has stated the recently increased length of predevelopment monitoring period and extended parameters will not be applied to areas retrospectively that have undertaken monitoring programs on the basis of previous DoW requirements. Pre-Development monitoring program results included in Appendix C		
6.2	Monitoring/sampling to follow Australian Standards	Section 5.1.3	-		
6.3	Monitoring/sampling locations	Chapter 5.3 & Figure 15	-		
6.4	Water quality parameters to be monitored (refer to section 9.5 of *Drainage and water management plan*	Section 5.3.1 & Section 5.3.2 Table 12	Re water quality parameters, historically DoW has required only nutrients to be monitored and not metals – this has formed the basis of the pre development monitoring program. Previous DoW advice (Bill Till pers comm.) has stated the recently increased length of predevelopment monitoring period and extended parameters will not be applied to areas retrospectively that have undertaken monitoring programs on the basis of previous DoW requirements. Monitored parameters in the post-		

	Item	Submission		Assessment	
		LWMS Ref [1]	Comment [2]	Compliance	Comment
			development monitoring program will include the parameters outlined in the BDWMP.		
6.5	Monitoring program to include a contingency action plan to manage risk	Section 5.3.3 & Table 11	-		
7.0	**Implementation**	Section 5	-		
7.1	Commitments	Section 5.1	-		
7.2	Maintenance schedules	Section 5.1.2	-		
7.3	Roles and responsibilities (for pre-development, during construction and all periods postdevelopment)	Section 5.1	Summary table of roles and responsibilities included in Section 5.1		
7.4	Funding	Section 5.1	Summary table of roles and responsibilities included in Section 5.1		
7.5	Review	Section 5.1.2 & Section 5.1.3.3, Table 12	Includes maintenance, review of system performance, reporting requirements		

1 Identify the section in the local structure plan in which this item has been addressed. It is possible that some items are not applicable and if this is the case, please put an explanation in the comments section.

2 Please make comments as to the applicability of this criterion.

APPENDIX B

WA Stormwater Management Objectives, Principles, and Delivery Approach (DoE, 2004) & Decision Process for Stormwater Management in WA (DoE and SRT,2005)

Western Australian Stormwater Management Objectives

Water Quality
To maintain or improve the surface and groundwater quality within the development areas relative to pre development conditions.

Water Quantity
To maintain the total water cycle balance within development areas relative to the pre development conditions.

Water Conservation
To maximise the reuse of stormwater.

Ecosystem Health
To retain natural drainage systems and protect ecosystem health.

Economic Viability
To implement stormwater management systems that are economically viable in the long term.

Public Health
To minimise the public risk, including risk of injury or loss of life, to the community.

Protection of Property
To protect the built environment from flooding and waterlogging.

Social Values
To ensure that social, aesthetic and cultural values are recognised and maintained when managing stormwater.

Development
To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.

Western Australian Stormwater Management Principles

- Incorporate water resource issues as early as possible in the land use planning process.
- Address water resource issues at the catchment and sub-catchment level.
- Ensure stormwater management is part of total water cycle and natural resource management.
- Define stormwater quality management objectives in relation to the sustainability of the receiving environment.
- Determine stormwater management objectives through adequate and appropriate community consultation and involvement.
- Ensure stormwater management planning is precautionary, recognises inter-generational equity, conservation of biodiversity and ecological integrity.
- Recognise stormwater as a valuable resource and ensure its protection, conservation and reuse.
- Recognise the need for site specific solutions and implement appropriate non-structural and structural solutions.

Stormwater Delivery Approach for WA

Protect water quality
Stormwater remains clean and retains its high value

Implement best management practice on-site.
Implement non-structural controls, including education and awareness programs.
Install structural controls at source or near source.
Use in-system management measures.
Undertake regular and timely maintenance of infrastructure and streetscapes.

Protect infrastructure from flooding and inundation
Stormwater runoff from infrequent high intensity rainfall events is safely stored and conveyed

Safe passage of excess runoff from large rainfall events towards watercourses and wetlands.
Store and detain excess runoff from large rainfall events in parks and multiple use corridors.
Safely convey excessive groundwater to the nearest watercourse.

Minimise runoff
Slow the migration of rainwater from the catchment and reduce peak flows

Retain and infiltrate rainfall within property boundaries.
Use rainfall on-site or as high in the catchment as possible.
Maximise the amount of permeable surfaces in the catchment.
Use non-kerbed roads and carparks.
Plant trees with large canopies over sealed surfaces such as roads and carparks.

Maximise local infiltration
Fewer water quality and flooding problems

Minimise impervious areas.
Use vegetated swales.
Use soakwells and minimise use of piped drainage systems.
Create vegetated buffer and filter strips.
Recharge the groundwater table for local bore water use.

Make the most of nature's drainage
Cost effective, safe and attractive alternatives to pipes and drains

Retain natural channels and incorporate into public open space.
Retain and restore riparian vegetation to improve water quality through bio-filtration.
Create riffles and pools to improve water quality and provide refuge for local flora and fauna.
Protect valuable natural ecosystems.
Minimise the use of artificial drainage systems.

Minimise changes to the natural water balance
Avoid summer algal blooms and midge problems and protect our groundwater resources

Retain seasonal wetlands and vegetation.
Maintain the natural water balance of wetlands.
No direct drainage to Conservation Category Wetlands or their buffers, or to other conservation value wetlands or their buffers, where appropriate.
Recharge groundwater by stormwater infiltration.

Integrate stormwater treatment into the landscape
Add value while minimising development costs

Public open space systems incorporating natural drainage systems.
Water sensitive urban design approach to road layout, lot layout and streetscape.
Maximise environmental, cultural and recreational opportunities.

Convert drains into natural streams
Lower flow velocities, benefit from natural flood water storage and improve waterway ecology

Create stable streams, with a channel size suitable for 1 in 1 year ARI rainfall events, equivalent to a bankfull flow.
Accommodate large and infrequent storm events within the floodplain.
Create habitat diversity to support a healthy, ecologically functioning waterway.

Note: Selection of appropriate methods should be determined by site conditions.

Decision Process for Stormwater Management in WA
(Department of Environment and Swan River Trust, 2005)

Preamble

The *Decision Process for Stormwater Management in WA* provides a decision framework for the planning and design of stormwater management systems. The methodology outlined in the decision process will result in minimising potential changes in the volume of surface water flows and peak flows which, if not managed, would lead to adverse impacts on water regime, water quality, habitat diversity and biodiversity in receiving water bodies[1] resulting from land development (i.e. residential, rural-residential, commercial and industrial). The process also addresses the management of flood events for the protection of properties. The decision process sits within the objectives, principles and delivery approach outlined in the *Stormwater Management Manual for Western Australia* (DoE, 2004). This includes: minimising risk to public health and amenity; implementing systems that are economically viable in the long term; and ensuring that social, aesthetic and cultural values are maintained.

A significant stormwater management measure is to minimise the 'effective imperviousness' of a development area. Effective imperviousness is defined as the combined effect of the proportion of constructed impervious surfaces in the catchment, and the 'connectivity' of these impervious surfaces to receiving water bodies. The purpose of minimising effective imperviousness is to reduce the transportation of pollutants to receiving water bodies and to retain the post development hydrology as close as possible to the pre-development hydrology. This is achieved by 'disconnecting' constructed impervious areas from receiving water bodies and by reducing the amount of constructed impervious areas.

To retain the pre-development hydrology of a site, the order of management priorities is: the magnitude of peak flows; the volume of catchment run-off; and the seasonality of catchment run-off.

Rainfall, for the majority of events occurring each year, should be retained[2] or detained[3] on-site (i.e. as high in the catchment and as close to the source as possible, subject to adequate site conditions). Runoff from constructed impervious areas (e.g. roofs and paved areas) should be retained or detained through the use of soakwells, pervious paving, vegetated swales or gardens. For detention systems, the peak 1 year Average Recurrence Interval (ARI[4]) discharge from constructed impervious areas should be attenuated to the pre-development discharge rate. Events larger than 1 year ARI can overflow 'off-site'.

For larger rainfall events (i.e. greater than 1 year ARI events), runoff from constructed impervious areas should be retained or detained to the required design storm event in landscaped retention or detention areas in public open space or linear multiple use corridors. Any overflow of runoff towards waterways and wetlands should be by overland flow paths across vegetated surfaces. Further detention may be required to ensure that the pre-development hydrologic regime of the receiving water bodies is largely unaltered, particularly in relation to peak flow rates and, where practical, discharge volume.

---

[1] Water bodies are defined as waterways, wetlands, coastal marine areas and groundwater aquifers.

[2] Retention is defined as the process of preventing rainfall runoff from being discharged into receiving water bodies by holding it in a storage area. The water may then infiltrate into groundwater, evaporate or be removed by evapotranspiration of vegetation. Retention systems are designed to prevent off-site discharges of surface water runoff, up to the design ARI event.

[3] Detention is defined as the process of reducing the rate of off-site stormwater discharge by temporarily holding rainfall runoff (up to the design ARI event) and then releasing it slowly, to reduce the impact on downstream water bodies and to attenuate urban runoff peaks for flood protection of downstream areas.

[4] ARI is defined as the average, or expected, value of the periods between exceedances of a given rainfall total accumulated over a given duration. For further information, refer to *Australian Rainfall & Runoff* (IEA, 2001) and the Bureau of Meteorology website via <www.bom.gov.au/hydro/has/ari_aep.shtml>.

Urban pollutants, whether in particulate or soluble forms, are conveyed by stormwater almost every time a storm event occurs. Studies in urban areas have shown that there is no general trend of increased concentrations of contaminants such as nutrients and metals with increasing storm sizes. Figure 1 shows that most hydraulic structures can be expected to treat over 99% of the expected annual runoff volume when designed for a 1 year ARI peak discharge. Unlike flood mitigation measures, stormwater quality treatment devices do not need to be designed for rainfall events of high ARI to achieve high hydrologic effectiveness (i.e. the percentage of mean annual runoff volume subjected to treatment) and therefore a high level of beneficial environmental outcomes.

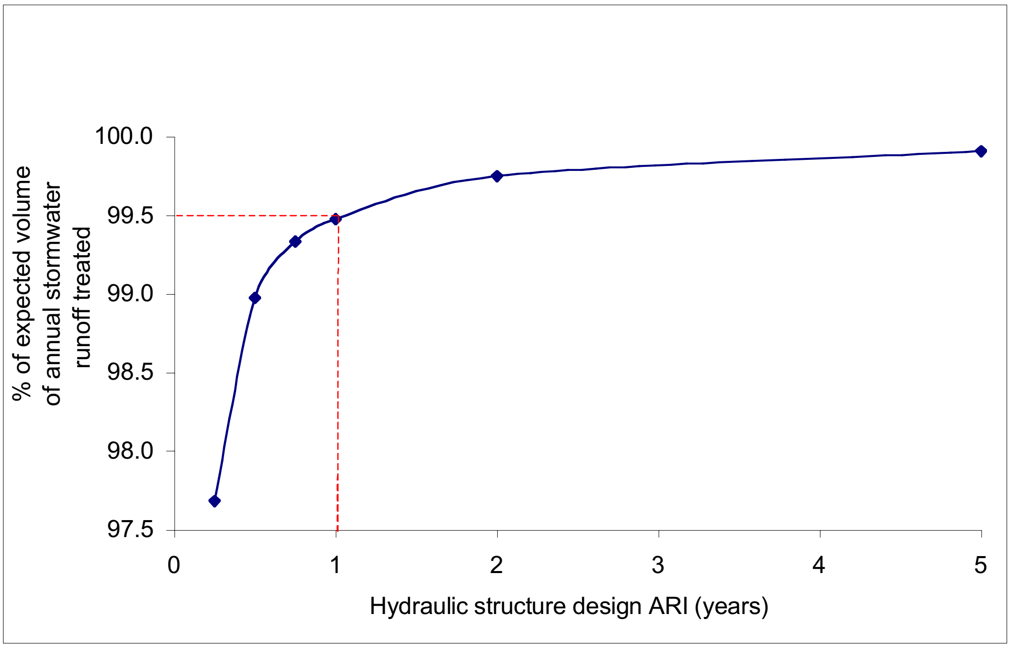

Figure 1. Treatment efficiency of stormwater hydraulic structures for Perth, Western Australia (adapted from Wong, 1999)

Stormwater management systems should be based on adequate field investigations and the conditions of the site. Prior to design, developers should consult with the Department of Environment, local government authority and other relevant stakeholders. For further information, refer to the *Decision Process for Stormwater Management in WA* flow chart.

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Decision Process for Stormwater Management in WA (DoE and SRT, 2005)

1. Stormwater management systems shall be designed in accordance with the objectives, principles and delivery approach outlined in the *Stormwater Management Manual for Western Australia* (DoE, 2004). This includes: minimising risk to public health and amenity; protecting the built environment from flooding and waterlogging; implementing systems that are economically viable in the long term; and ensuring that social, aesthetic and cultural values are maintained.
2. Prior to design, developers shall consult with the Department of Environment (DoE), local government authorities and other relevant stakeholders. Maintenance requirements should be considered at this stage.
3. Adequate field investigations shall be undertaken to determine the appropriate hydrologic regime for the site and potential site constraints, such as contaminated sites, acid sulfate soils or highly elevated nutrient levels in groundwater. Baseline and/or ongoing monitoring of groundwater and surface water quality and quantity may be required.
4. Stormwater management systems may be subject to additional design and performance criteria if they have the potential to impact on sensitive receiving environments. Sensitive receiving environments include (but are not limited to) conservation areas or reserves, wetlands and waterways with conservation values, Waterways Management Areas, the Swan River Trust Management Area, Environmental Protection Policy areas, and some areas of native vegetation. Sensitive native vegetation includes (but is not limited to) Declared Rare Flora, Priority Species, Threatened Ecological Communities, Threatened Fauna Habitat and vegetation identified in *Bush Forever* (WAPC, 2000), including vegetation located east of the Southern River Vegetation Complex on the Swan Coastal Plain.

Water quantity management

1. Is the proposal completely or partly within a known contaminated site (i.e. a contaminated site listed on the contaminated sites register, or identified through adequate field investigations) or high acid sulfate soil risk area?
2. Does the soil or groundwater contain *highly elevated* nutrient levels? A definition for highly elevated nutrient levels has not been provided, as nutrient breakthrough is highly variable and is dependent on the soil type (e.g. organic, clay and iron oxyhydroxide content) and local wetting and drying cycles.

Yes (to either question)

Avoid mobilisation or disturbance of the in-situ contaminants

If yes to question 1 - seek further advice from the DoE.

If yes to question 2 - consult with the DoE about best management practices to minimise nutrient leaching through the soil profile (i.e. structural and non-structural controls suitable to the site conditions).

No (most situations)

1. Maintain the pre-development hydrologic regime and meet the ecological water requirements of the receiving environment.
2. Hydraulic requirements shall be determined by ecosystem requirements and the hydrologic form of the local and downstream environment. Physical survey measurements and a biological survey should be undertaken.
3. Hydrologic and hydraulic analyses, modelling and design shall incorporate the recommendations and methodology of *Australian Rainfall and Runoff, A Guide to Flood Estimation* (IEA, 2001).
4. The effective imperviousness of a development shall be minimised. The process for achieving this is outlined below:

Less than and up to 1 year ARI events

Generally, rainfall from 1 year average recurrence interval (ARI) events should be retained or detained on-site (i.e. as high in the catchment and as close to the source as possible), unless it can be clearly demonstrated that achievement of this objective is impractical due to site conditions.

Generally, for detention systems, preserve the pre-development 1 year ARI peak discharge rate. Use best management practices (structural and non-structural) to treat water quality.

Greater than 1 year and up to 100 year ARI events

Mitigate runoff from constructed impervious areas for greater than 1 year ARI events, in landscaped retention or detention areas in public open space or linear multiple use corridors. Any overflow of runoff towards waterways and wetlands shall be by overland flow paths across vegetated surfaces.

Design for greater than 1 year and less than 10 year ARI events

Minor system conveyance (i.e. swales and pipes).

Design for 10 year to 100 year ARI events

Major system conveyance (i.e. via overland flow).

Water quality management

1. On-site field investigations are required to determine the appropriate water quality management measures for the site, including consideration of potential pathways of nutrients towards receiving water bodies. Receiving water bodies are defined as waterways, wetlands, coastal marine areas and groundwater aquifers.
2. The components of the water quality treatment train must be designed so that their combined effect meets the water quality management objectives as specified in the relevant regional water quality management targets (e.g. local government stormwater management plans, the Regional Natural Resource Management Strategy, *Swan-Canning Cleanup Program Action Plan* (SRT, 1999) and the *Environmental Protection (Peel Inlet-Harvey Estuary) Policy 1992* (EPA, 1992)). The requirements for demonstration of compliance shall depend upon the scale of the proposed land development. Demonstration of compliance may be achieved by the use of appropriate assessment methods, to the satisfaction of DoE.

Protect waterways and wetlands

1. Retain and restore waterways and wetlands. For waterways, the approach should be consistent with the *River Restoration Manual* (WRC, 1999-2003), *Draft Waterways WA - A Policy for Statewide Management of Waterways in Western Australia* (WRC, 2000), *Foreshore Policy 1 - Identifying the Foreshore Area* (WRC, 2002) and, in the Swan and Canning Catchments, the *Environmental Protection (Swan and Canning Rivers) Policy 1998* (EPA, 1998). For wetlands, the approach should be consistent with the *Environmental Protection of Wetlands Position Statement No. 4* (EPA, 2004) and the *Wetlands Conservation Policy for WA* (Government of WA, 1997). On the Swan Coastal Plain, the approach to managing wetlands should also be consistent with the *Environmental Protection (Swan Coastal Plain Lakes) Policy, 1992* (EPA, 1992) and the *Position Statement: Wetlands* (WRC, 2001).
2. There shall be no new constructed stormwater infrastructure within Conservation category wetlands and their buffers, or other conservation value wetlands and their buffers, or within a waterway foreshore area (e.g. no pipes or constructed channels within these wetlands and their buffers, or within waterway foreshore areas), unless authorised by the DoE or the Environmental Protection Authority. For Resource Enhancement and Multiple Use category wetlands, stormwater management shall be consistent with the objectives outlined in the *Position Statement:Wetlands* (WRC, 2001).
3. The creation of artificial lakes or permanent open water bodies generally will not be supported when they involve the artificial exposure of groundwater (e.g. through excavation, or lined lakes that require groundwater to maintain water levels in summer) or the modification of a wetland type (e.g. converting a dampland into a lake). Where water conservation (e.g. summer water supply) and environmental and health concerns (e.g. hydrology, water quality, mosquitoes, midges, algal blooms, acid sulfate soils and iron monosulfide minerals) can be adequately demonstrated to be addressed through design and maintenance, consideration may be given to the creation of artificial lakes/ponds. Seasonal wet infiltration areas or approved constructed waterways (i.e. ephemeral 'Living Streams') are preferred options.

Management of groundwater levels

1. Any proposals to control the seasonal or long-term maximum groundwater levels through a Controlled Groundwater Level (CGL) approach shall demonstrate through adequate field investigations, to the satisfaction of the Department of Environment, that local and regional environmental impacts are adequately managed.
2. The CGL may be defined as the controlled (i.e. modified) groundwater level (measured in metres Australian Height Datum) at which the DoE will permit drainage inverts to be set. The CGL must be based on local and regional environmental water requirements, determined in accordance with the *Environmental Water Provisions Policy for Western Australia* (WRC, 2000) and the *Urban Development and Determination of Ecological Water Requirements of Groundwater Dependent Ecosystems* (DoE, in preparation).
3. Where appropriate, field investigations must be undertaken to identify acid sulfate soils (ASS). Any reduction in groundwater level should not expose ASS to the air, as this may cause groundwater contamination. Refer to the ASS Guideline Series, including *Identification and Investigation of Acid Sulfate Soils* (DoE, 2004). If field investigations identify ASS, seek further advice from DoE.

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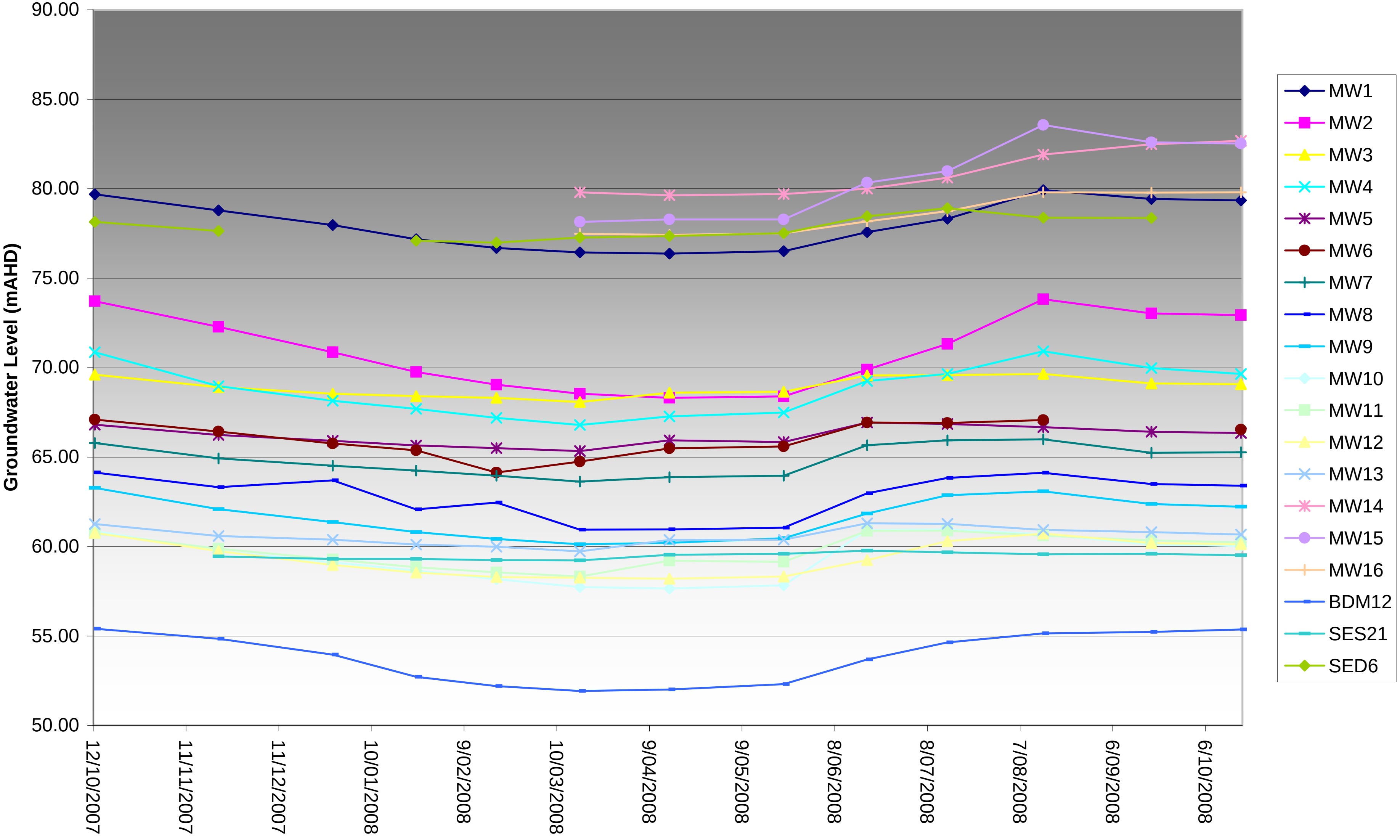
Department of Environment

SWAN RIVER TRUST

Swan-Canning Cleanup Program

APPENDIX C

Pre-Development Monitoring Program Results



Data Source:

Job No. J4148

N

Aspen Group
Lot 2 Nettleton Rd, Byford: LWMS
Groundwater Monitoring Bore Hydrographs

SJS TRIM IN09/13770

J4148 Lot 2 Nettleton Rd, Byford: Groundwater Levels

mAHD	TOC	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08
Date Monitored		**12/10/2007**	**21/11/2007**	**28/12/2007**	**24/01/2008**	**19/02/2008**	**17/03/2008**	**15/04/2008**	**22/05/2008**	**18/06/2008**	**14/07/2008**	**14/08/2008**	**18/09/2008**	**17/10/2008**
MW1	**80.16**	79.68	78.78	77.96	77.18	76.68	76.44	76.37	76.51	77.57	78.32	79.92	79.42	79.35
MW2	**75.73**	73.72	72.28	70.87	69.76	69.05	68.54	68.32	68.39	69.90	71.33	73.82	73.03	72.94
MW3	**70.74**	69.60	68.90	68.53	68.40	68.31	68.07	68.59	68.64	69.56	69.57	69.64	69.11	69.07
MW4	**71.59**	70.86	68.97	68.15	67.70	67.19	66.80	67.27	67.49	69.25	69.64	70.91	69.97	69.64
MW5	**67.81**	66.81	66.23	65.90	65.64	65.49	65.33	65.93	65.83	66.93	66.85	66.67	66.41	66.34
MW6	**68.80**	67.09	66.42	65.76	65.38	64.13	64.75	65.48	65.59	66.93	66.90	67.07	NM	66.54
MW7	**66.57**	65.79	64.92	64.51	64.24	63.95	63.63	63.87	63.96	65.66	65.93	65.99	65.24	65.26
MW8	**66.12**	64.13	63.31	63.69	62.07	62.46	60.94	60.95	61.05	62.97	63.83	64.12	63.49	63.40
MW9	**64.22**	63.28	62.09	61.36	60.80	60.42	60.12	60.20	60.46	61.85	62.86	63.08	62.37	62.23
MW10	**62.02**	60.86	59.74	59.11	58.64	58.17	57.73	57.65	57.83	60.91	60.95	60.68	60.11	60.02
MW11	**61.78**	60.73	59.87	59.27	58.84	58.55	58.32	59.21	59.14	60.87	60.88	60.61	60.33	60.23
MW12	**61.90**	60.77	59.74	58.97	58.54	58.30	58.26	58.20	58.32	59.23	60.30	60.73	60.19	60.13
MW13	**61.99**	61.25	60.58	60.38	60.11	59.99	59.73	60.37	60.38	61.30	61.27	60.92	60.80	60.67
MW14	**86.70**	Bore Not Yet Installed					79.80	79.63	79.70	80.00	80.61	81.91	82.48	82.67
MW15	**86.14**						78.15	78.28	78.28	80.34	80.98	83.56	82.59	82.52
MW16	**83.84**						77.47	77.42	77.51	78.17	78.75	79.79	79.78	79.80
BDM12	**56.06**	55.40	54.84	53.96	52.72	52.19	51.92	52.00	52.30	53.68	54.64	55.15	55.22	55.36

DoW Bore	TOC	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08
Date Monitored		**12/10/2007**	**21/11/2007**	**28/12/2007**	**24/01/2008**	**19/02/2008**	**17/03/2008**	**15/04/2008**	**22/05/2008**	**18/06/2008**	**14/07/2008**	**14/08/2008**	**18/09/2008**	**17/10/2008**
SES21	60.74	NM	59.44	59.30	59.30	59.24	59.22	59.53	59.59	59.77	59.67	59.57	59.59	59.51
SED6	81.55	NM	78.14	77.64	NM	77.10	76.99	77.27	77.35	77.52	78.46	78.91	78.37	78.36

NM: not measured

J4148 Lot 2 Nettleton Rd: Groundwater Quality Results

🟧 Not measured
🟨 Results below limit of detection

EC	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08
Date	**12/10/2007**	**21/11/2007**	**28/12/2007**	**24/01/2008**	**19/02/2008**	**17/03/2008**	**15/04/2008**	**22/05/2008**	**18/06/2008**	**14/07/2008**	**14/08/2008**	**18/09/2008**
MW1	1.00	0.83	0.94	0.87	0.88	0.82	0.9	0.91	0.88	0.770	0.94	0.760
MW2	1.00	0.90	10.70	1.06	0.97	1.05	1.1	1.12	1.29	0.940	0.78	0.780
MW3	1.21	0.55	1.63	2.37	2.91	2.21	1.9	1.38	2.02	0.460	2.49	0.820
MW4	1.72	1.42	1.27	1.61	1.88	1.81	2.0	1.77	1.90	1.100	2.06	1.860
MW5	0.79	0.57	4.39	4.41	4.10	2.26	1.4	2.36	0.98	1.030	1.18	2.04
MW6	0.78	0.73	0.71	0.63	0.26	0.63	0.6	0.73	0.67	0.540	0.75	🟧
MW7	0.93	0.85	0.87	0.81	0.81	0.81	0.8	0.87	0.81	0.760	0.97	0.76
MW8	0.33	0.23	0.22	0.21	0.63	0.24	0.3	0.25	0.49	0.260	0.34	0.08
MW9	6.79	6.52	4.39	3.92	3.92	3.72	3.8	3.83	4.41	4.950	5.76	6.22
MW10	0.35	0.34	0.36	0.28	0.36	0.38	0.3	0.40	0.30	0.16	0.31	0.15
MW11	1.64	7.81	8.83	8.63	10.56	10.28	2.3	1.56	1.47	1.090	1.61	2.07
MW12	4.04	3.15	2.88	2.83	3.40	4.27	2.9	2.55	2.44	2.30	2.73	2.53
MW13	3.44	3.82	3.90	3.83	3.72	3.71	3.7	3.91	4.18	3.960	4.36	4.08
MW14	Bore not Yet Installed					1.38	1.4	1.52	1.51	1.460	1.45	1.30
MW15						0.57	0.5	0.55	0.53	0.460	0.33	0.45
MW16						0.81	0.8	0.90	0.89	0.780	0.69	0.73

pH	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08
Date	**12/10/2007**	**21/11/2007**	**28/12/2007**	**24/01/2008**	**19/02/2008**	**17/03/2008**	**15/04/2008**	**22/05/2008**	**18/06/2008**	**14/07/2008**	**14/08/2008**	**18/09/2008**
MW1	5.66	5.71	5.50	5.72	5.23	5.31	6.00	5.05	5.34	5.240	5.35	5.300
MW2	5.36	4.92	4.74	4.74	4.50	4.71	4.95	4.28	4.26	4.480	4.48	4.480
MW3	5.99	5.69	5.29	5.29	4.93	5.01	5.45	4.95	4.78	5.280	4.89	5.090
MW4	5.66	5.65	5.45	5.69	5.47	5.56	5.90	5.43	5.34	4.890	5.51	5.630
MW5	6.65	6.10	5.81	5.78	5.63	5.77	6.25	5.79	6.15	6.160	5.99	5.94
MW6	5.83	5.35	5.21	5.09	4.97	4.71	5.40	4.64	4.69	4.930	4.91	🟧
MW7	4.73	4.72	4.42	4.83	4.46	4.72	4.85	4.42	4.75	4.680	4.63	4.700
MW8	5.49	5.42	5.46	5.36	4.65	4.61	5.60	4.52	5.29	5.300	5.53	5.37
MW9	5.87	5.67	5.47	5.22	5.12	5.05	5.55	5.11	5.02	5.270	5.03	5.150
MW10	5.78	5.20	5.34	5.14	4.45	4.63	5.25	4.36	4.58	4.77	5.00	4.88
MW11	6.50	5.93	5.710	5.67	5.37	5.21	5.95	5.48	5.77	5.700	5.64	5.76
MW12	5.88	5.72	5.54	5.38	5.10	5.05	5.50	4.86	4.81	5.04	5.05	5.19
MW13	6.31	6.26	6.16	5.88	5.81	5.79	6.10	6.15	5.75	6.060	5.89	6
MW14	Bore not Yet Installed					5.73	6.10	5.63	5.58	5.780	5.72	5.83
MW15						5.20	5.25	4.49	4.37	4.700	5.09	4.76
MW16						5.66	5.65	5.22	5.10	5.280	5.5	5.28

Total Nitrogen (mg/L)	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08
Date	**12/10/2007**	**21/11/2007**	**28/12/2007**	**24/01/2008**	**19/02/2008**	**17/03/2008**	**15/04/2008**	**22/05/2008**	**18/06/2008**	**14/07/2008**	**14/08/2008**	**18/09/2008**
MW1	0.19	0.440	0.050	0.16	0.150	0.260	0.9	0.050	0.49	0.050	0.050	0.06
MW2	0.28	0.260	0.050	0.09	0.130	0.280	0.3	0.050	0.09	0.050	1.1	0.66
MW3	4.3	0.480	0.050	0.47	0.490	0.340	0.2	0.080	0.31	2.700	1.5	0.55
MW4	0.32	0.860	0.050	0.21	0.080	0.290	0.2	0.050	0.05	0.430	0.050	0.06
MW5	17	14.00	2.50	0.56	5.400	6.700	16.0	5.300	23	25.000	27.00	15.00
MW6	1.3	0.77	1.00	1.20	1.400	2.600	1.7	1.600	1.2	1.000	1.10	Dry
MW7	0.3	0.25	0.06	0.22	0.230	0.460	0.4	0.050	2.3	0.090	0.10	0.55
MW8	3.2	3.70	3.00	3.20	3.400	3.400	1.9	1.000	2.4	2.600	2.90	2.70
MW9	0.42	0.45	0.33	0.89	1.600	0.680	0.5	0.210	0.69	0.140	0.40	0.23
MW10	2.3	2.50	2.10	2.40	1.700	2.10	1.8	1.70	2.3	2.20	2.30	2.10
MW11	8.7	2.30	3.00	3.40	0.960	0.390	8.2	7.900	8.7	6.500	7.70	8.10
MW12	0.52	0.19	0.09	1.40	0.27	0.65	0.4	0.06	1	0.54	0.30	0.28
MW13	6.2	0.270	0.210	0.64	0.220	0.220	0.1	0.150	0.15	0.050	0.2	0.2
MW14	Bore not Yet Installed					0.800	1.9	0.340	0.940	0.140	0.3	0.24
MW15						0.660	0.3	0.300	0.150	0.050	0.2	0.05
MW16						0.240	0.5	1.300	0.210	0.070	0.4	0.15

J4148 Lot 2 Nettleton Rd: Groundwater Quality Results

🟧 Not measured
🟨 Results below limit of detection

Nox_N (mg/L)	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08
Date	**12/10/2007**	**21/11/2007**	**28/12/2007**	**24/01/2008**	**19/02/2008**	**17/03/2008**	**15/04/2008**	**22/05/2008**	**18/06/2008**	**14/07/2008**	**14/08/2008**	**18/09/2008**
MW1	0.053	0.005	0.005	0.010	0.009	0.006	0.005	0.005	0.041	0.005	0.005	0.062
MW2	0.14	0.005	0.007	0.019	0.063	0.018	0.073	0.005	0.005	0.005	0.83	0.36
MW3	3.1	0.005	0.007	0.013	0.008	0.024	0.073	0.005	0.045	2.300	1.2	0.44
MW4	0.041	0.540	0.005	0.011	0.010	0.042	0.005	0.005	0.005	0.005	0.005	0.024
MW5	14	12.000	1.10	0.200	4.500	6.100	11.000	5.100	18	25.000	24.00	16.00
MW6	0.91	0.350	0.29	0.970	1.300	1.200	1.500	1.400	0.72	0.340	0.82	🟧
MW7	0.1	0.010	0.02	0.028	0.110	0.160	0.054	0.005	0.04	0.035	0.005	0.03
MW8	3	3.000	1.50	2.800	2.500	1.900	1.600	0.930	2.3	1.900	2.40	2.70
MW9	0.11	0.005	0.01	0.170	0.036	0.033	0.035	0.005	0.049	0.090	0.25	0.15
MW10	2.1	2.000	1.10	1.900	1.400	1.20	1.400	1.40	2.1	2.10	2.00	2.10
MW11	8.6	1.700	2.70	0.630	0.42	0.150	6.000	7.900	7.4	5.700	4.90	7.00
MW12	0.18	0.005	0.05	0.030	0.044	0.017	0.140	0.005	0.87	0.005	0.28	0.21
MW13	4.3	0.005	0.010	0.010	0.009	0.015	0.027	0.005	0.04	0.005	0.053	0.06
MW14	Bore not Yet Installed					0.140	0.100	0.130	0.200	0.005	0.2	0.18
MW15						0.006	0.005	0.005	0.015	0.005	0.069	0.02
MW16						0.025	0.005	0.005	0.005	0.005	0.3	0.03

TKN (mg/L)	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08
Date	**12/10/2007**	**21/11/2007**	**28/12/2007**	**24/01/2008**	**19/02/2008**	**17/03/2008**	**15/04/2008**	**22/05/2008**	**18/06/2008**	**14/07/2008**	**14/08/2008**	**18/09/2008**
MW1	0.14	0.440	0.050	0.150	0.140	0.250	0.870	0.050	0.45	0.050	0.050	0.050
MW2	0.14	0.260	0.050	0.070	0.070	0.260	0.220	0.050	0.09	0.050	0.22	0.3
MW3	1.2	0.480	0.050	0.460	0.480	0.320	0.160	0.080	0.27	0.370	0.34	0.11
MW4	0.28	0.320	0.050	0.200	0.07	0.250	0.180	0.050	<0.05	0.430	0.050	0.05
MW5	2.7	1.80	1.40	0.360	0.810	0.630	4.800	0.190	4.3	0.080	3.50	0.05
MW6	0.39	0.42	0.75	0.200	0.100	1.400	0.200	0.160	0.43	0.680	0.30	🟧
MW7	0.2	0.24	0.05	0.190	0.120	0.300	0.39	0.050	2.3	0.060	0.12	0.52
MW8	0.25	0.64	1.50	0.390	0.870	1.500	0.300	0.090	0.11	0.680	0.52	0.05
MW9	0.31	0.45	0.33	0.720	1.500	0.650	0.460	0.210	0.64	0.050	0.11	0.08
MW10	0.24	0.51	0.98	0.570	0.360	0.95	0.43	0.29	0.19	0.050	0.35	0.05
MW11	0.14	0.58	0.34	2.800	0.540	0.240	2.200	0.050	1.2	0.780	2.80	1.00
MW12	0.34	0.19	0.05	1.400	0.230	0.63	0.22	0.06	0.15	0.54	0.050	0.07
MW13	1.9	0.270	0.200	0.630	0.21	0.210	0.070	0.150	0.11	0.050	0.18	0.14
MW14	Bore not Yet Installed					0.660	1.800	0.210	0.740	0.140	0.08	0.07
MW15						0.650	0.320	0.300	0.140	0.050	0.11	0.05
MW16						0.220	0.470	1.300	0.210	0.070	0.08	0.15

NH_4_N (mg/L)	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08
Date	**12/10/2007**	**21/11/2007**	**28/12/2007**	**24/01/2008**	**19/02/2008**	**17/03/2008**	**15/04/2008**	**22/05/2008**	**18/06/2008**	**14/07/2008**	**14/08/2008**	**18/09/2008**
MW1	0.005	0.100	0.005	0.068	0.073	0.033	0.160	0.005	0.1	0.005	0.017	0.010
MW2	0.005	0.005	0.005	0.013	0.021	0.005	0.005	0.005	0.042	0.005	0.007	0.01
MW3	0.005	0.037	0.005	0.074	0.069	0.077	0.056	0.058	0.09	0.005	0.036	0.05
MW4	0.005	0.005	0.005	0.017	0.031	0.007	0.006	0.005	0.016	0.005	0.018	0.01
MW5	0.005	0.080	0.005	0.056	0.028	0.005	0.005	0.005	0.012	0.005	0.005	0.01
MW6	0.005	0.013	0.09	0.021	0.011	0.005	0.062	0.005	0.009	0.005	0.005	🟧
MW7	0.005	0.015	0.03	0.029	0.022	0.005	0.011	0.005	0.13	0.005	0.034	0.01
MW8	0.005	0.015	0.07	0.035	0.006	0.005	0.005	0.005	0.009	0.005	0.005	0.10
MW9	0.005	0.022	0.13	0.063	0.066	0.045	0.098	0.053	0.06	0.033	0.005	0.01
MW10	0.005	0.018	0.10	0.029	0.009	0.01	0.005	0.005	<0.005	0.031	0.016	0.01
MW11	0.005	0.068	0.26	0.079	0.072	0.051	0.005	0.005	0.005	0.005	0.006	0.01
MW12	0.005	0.021	0.005	0.058	0.07	0.08	0.04	0.028	0.027	0.017	0.021	0.01
MW13	0.093	0.150	0.005	0.079	0.075	0.025	0.065	0.04	0.11	0.029	0.032	0.01
MW14	Bore not Yet Installed					0.096	0.065	0.017	0.070	0.013	0.024	0.09
MW15						0.320	0.055	0.042	0.083	0.005	0.030	0.01
MW16						0.120	0.130	0.270	0.130	0.061	0.050	0.08

J4148 Lot 2 Nettleton Rd: Groundwater Quality Results

🟧 Not measured

🟨 Results below limit of detection

Tot. Phosphorous (mg/L)	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08
Date	**12/10/2007**	**21/11/2007**	**28/12/2007**	**24/01/2008**	**19/02/2008**	**17/03/2008**	**15/04/2008**	**22/05/2008**	**18/06/2008**	**14/07/2008**	**14/08/2008**	**18/09/2008**
MW1	0.02	0.13	0.010	0.080	0.100	0.030	0.02	0.010	0.21	0.010	0.020	0.010
MW2	0.02	0.05	0.020	0.100	0.130	0.010	0.10	0.020	0.01	0.010	0.010	0.010
MW3	0.02	0.05	0.010	0.100	0.020	0.010	0.01	0.010	0.01	0.010	0.010	0.05
MW4	0.02	0.04	0.010	0.140	0.080	0.010	0.03	0.040	0.01	0.010	0.01	0.01
MW5	0.02	0.04	0.04	0.110	0.030	0.010	0.02	0.020	0.01	0.010	0.010	0.01
MW6	0.02	0.04	0.05	0.090	0.090	0.010	0.04	0.050	0.01	0.010	0.010	🟧
MW7	0.02	0.06	0.010	0.050	0.040	0.010	0.04	0.010	0.09	0.010	0.010	0.01
MW8	0.02	0.02	0.03	0.060	0.140	0.010	0.02	0.020	0.01	0.010	0.050	0.10
MW9	0.02	0.04	0.02	0.250	0.110	0.010	0.02	0.020	0.01	0.010	0.010	0.01
MW10	0.02	0.03	0.03	0.090	0.110	0.010	0.07	0.05	0.01	0.010	0.100	0.01
MW11	0.02	0.03	0.01	0.200	0.050	0.010	0.05	0.050	0.01	0.010	0.010	0.01
MW12	0.02	0.03	0.010	0.030	0.04	0.010	0.01	0.01	0.01	0.010	0.010	0.01
MW13	0.03	0.02	0.010	0.190	0.020	0.010	0.02	0.020	0.01	0.010	0.030	0.01
MW14	Bore not Yet Installed					0.120	0.32	0.310	0.190	0.120	0.14	0.09
MW15						0.020	0.05	0.070	0.01	0.010	0.020	0.01
MW16						0.010	0.04	0.080	0.01	0.010	0.010	0.08

PO_4_P (mg/L)	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08
Date	**12/10/2007**	**21/11/2007**	**28/12/2007**	**24/01/2008**	**19/02/2008**	**17/03/2008**	**15/04/2008**	**22/05/2008**	**18/06/2008**	**14/07/2008**	**14/08/2008**	**18/09/2008**
MW1	0.005	0.005	0.005	0.011	0.005	0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.003
MW2	0.005	0.005	0.006	0.011	0.005	0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.003
MW3	0.005	0.005	0.005	0.013	0.005	0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.003
MW4	0.005	0.005	0.005	0.018	0.005	0.005	0.013	<0.005	<0.005	<0.005	0.005	0.01
MW5	0.005	0.005	0.010	0.014	0.006	0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.003
MW6	0.005	0.005	0.007	0.011	0.006	0.005	0.022	<0.005	<0.005	<0.005	<0.005	Dry
MW7	0.005	0.005	0.005	0.010	0.005	0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.003
MW8	0.005	0.005	0.005	0.013	0.005	0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.003
MW9	0.005	0.005	0.005	0.013	0.005	0.005	0.005	<0.005	<0.005	<0.005	<0.005	0.00
MW10	0.005	0.005	0.005	0.008	0.005	0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.003
MW11	0.005	0.005	0.005	0.011	0.005	0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.003
MW12	0.005	0.005	0.005	0.011	0.005	0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.003
MW13	0.005	0.008	0.005	0.010	0.006	0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.003
MW14	Bore not Yet Installed					0.034	0.009	<0.005	0.063	0.026	0.05	0.08
MW15						0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.003
MW16						0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.003

J4148 Lot 2 Nettleton Rd: Surface Water Quality Results

🟧 **Not measured**

Results below limit of detection

Estimated Flow (L/s)	**Oct-07**	**Nov-07**	**Dec-07**	**Jan-08**	**Feb-08**	**Mar-08**	**Apr-08**	**May-08**	**Jun-08**	**Jul-08**	**Aug-08**
Date Monitored	**12/10/2007**	**21/11/2007**	**28/12/2007**	**24/01/2008**	**19/02/2008**	**17/03/2008**	**15/04/2008**	**22/05/2008**	**18/06/2008**	**14/07/2008**	**14/08/2008**
Beenyup Bk S1	112	Dry	Dry	Dry	Dry	Dry	Dry	dry	20	🟧	37
Beenyup Bk S2	80	0.20	Dry	Dry	Dry	Dry	Dry	2.00	12.00	🟧	35.00

EC (uS/CM)	**Oct-07**	**Nov-07**	**Dec-07**	**Jan-08**	**Feb-08**	**Mar-08**	**Apr-08**	**May-08**	**Jun-08**	**Jul-08**	**Aug-08**
Date Monitored	**12/10/2007**	**21/11/2007**	**28/12/2007**	**24/01/2008**	**19/02/2008**	**17/03/2008**	**15/04/2008**	**22/05/2008**	**18/06/2008**	**14/07/2008**	**14/08/2008**
Beenyup Bk S1	0.51	Dry	Dry	Dry	Dry	Dry	Dry	Dry	0.49	0.40	0.47
Beenyup Bk S2	0.46	0.85	Dry	Dry	Dry	Dry	Dry	0.86	0.39	0.41	0.45

pH	**Oct-07**	**Nov-07**	**Dec-07**	**Jan-08**	**Feb-08**	**Mar-08**	**Apr-08**	**May-08**	**Jun-08**	**Jul-08**	**Aug-08**
Date Monitored	**12/10/2007**	**21/11/2007**	**28/12/2007**	**24/01/2008**	**19/02/2008**	**17/03/2008**	**15/04/2008**	**22/05/2008**	**18/06/2008**	**14/07/2008**	**14/08/2008**
Beenyup Bk S1	6.71	Dry	Dry	Dry	Dry	Dry	Dry	Dry	6.23	6.49	6.71
Beenyup Bk S2	6.75	6.45	Dry	Dry	Dry	Dry	Dry	6.27	6.45	6.43	6.74

Total Nitrogen (mg/L)	**Oct-07**	**Nov-07**	**Dec-07**	**Jan-08**	**Feb-08**	**Mar-08**	**Apr-08**	**May-08**	**Jun-08**	**Jul-08**	**Aug-08**
Date Monitored	**12/10/2007**	**21/11/2007**	**28/12/2007**	**24/01/2008**	**19/02/2008**	**17/03/2008**	**15/04/2008**	**22/05/2008**	**18/06/2008**	**14/07/2008**	**14/08/2008**
Beenyup Bk S1	0.65	Dry	Dry	Dry	Dry	Dry	Dry	Dry	1.8	0.42	0.7
Beenyup Bk S2	0.59	0.48	Dry	Dry	Dry	Dry	Dry	0.78	1.6	0.40	0.60

NOx_N (mg/L)	**Oct-07**	**Nov-07**	**Dec-07**	**Jan-08**	**Feb-08**	**Mar-08**	**Apr-08**	**May-08**	**Jun-08**	**Jul-08**	**Aug-08**
Date Monitored	**12/10/2007**	**21/11/2007**	**28/12/2007**	**24/01/2008**	**19/02/2008**	**17/03/2008**	**15/04/2008**	**22/05/2008**	**18/06/2008**	**14/07/2008**	**14/08/2008**
Beenyup Bk S1	0.31	Dry	Dry	Dry	Dry	Dry	Dry	Dry	1.4	0.35	0.53
Beenyup Bk S2	0.31	0.14	Dry	Dry	Dry	Dry	Dry	0.37	1.50	0.35	0.46

TKN (mg/L)	**Oct-07**	**Nov-07**	**Dec-07**	**Jan-08**	**Feb-08**	**Mar-08**	**Apr-08**	**May-08**	**Jun-08**	**Jul-08**	**Aug-08**
Date Monitored	**12/10/2007**	**21/11/2007**	**28/12/2007**	**24/01/2008**	**19/02/2008**	**17/03/2008**	**15/04/2008**	**22/05/2008**	**18/06/2008**	**14/07/2008**	**14/08/2008**
Beenyup Bk S1	0.34	Dry	Dry	Dry	Dry	Dry	Dry	Dry	0.35	0.07	0.19
Beenyup Bk S2	0.28	0.34	Dry	Dry	Dry	Dry	Dry	0.41	0.17	0.05	0.15

NH_4_N (mg/L)	**Oct-07**	**Nov-07**	**Dec-07**	**Jan-08**	**Feb-08**	**Mar-08**	**Apr-08**	**May-08**	**Jun-08**	**Jul-08**	**Aug-08**
Date Monitored	**12/10/2007**	**21/11/2007**	**28/12/2007**	**24/01/2008**	**19/02/2008**	**17/03/2008**	**15/04/2008**	**22/05/2008**	**18/06/2008**	**14/07/2008**	**14/08/2008**
Beenyup Bk S1	0.005	Dry	Dry	Dry	Dry	Dry	Dry	Dry	0.060	0.01	0.022
Beenyup Bk S2	0.005	0.033	Dry	Dry	Dry	Dry	Dry	0.01	0.019	0.01	0.013

Tot. Phosphorous (mg/L)	**Oct-07**	**Nov-07**	**Dec-07**	**Jan-08**	**Feb-08**	**Mar-08**	**Apr-08**	**May-08**	**Jun-08**	**Jul-08**	**Aug-08**
Date Monitored	**12/10/2007**	**21/11/2007**	**28/12/2007**	**24/01/2008**	**19/02/2008**	**17/03/2008**	**15/04/2008**	**22/05/2008**	**18/06/2008**	**14/07/2008**	**14/08/2008**
Beenyup Bk S1	0.02	Dry	Dry	Dry	Dry	Dry	Dry	Dry	0.01	0.01	0.01
Beenyup Bk S2	0.02	0.02	Dry	Dry	Dry	Dry	Dry	0.03	0.01	0.01	0.01

PO_4_P (mg/L)	**Oct-07**	**Nov-07**	**Dec-07**	**Jan-08**	**Feb-08**	**Mar-08**	**Apr-08**	**May-08**	**Jun-08**	**Jul-08**	**Aug-08**
Date Monitored	**12/10/2007**	**21/11/2007**	**28/12/2007**	**24/01/2008**	**19/02/2008**	**17/03/2008**	**15/04/2008**	**22/05/2008**	**18/06/2008**	**14/07/2008**	**14/08/2008**
Beenyup Bk S1	0.005	Dry	Dry	Dry	Dry	Dry	Dry	Dry	0.01	0.01	0.01
Beenyup Bk S2	0.005	0.005	Dry	Dry	Dry	Dry	Dry	0.01	0.01	0.01	0.01

TSS	**Oct-07**	**Nov-07**	**Dec-07**	**Jan-08**	**Feb-08**	**Mar-08**	**Apr-08**	**May-08**	**Jun-08**	**Jul-08**	**Aug-08**
Date Monitored	**12/10/2007**	**21/11/2007**	**28/12/2007**	**24/01/2008**	**19/02/2008**	**17/03/2008**	**15/04/2008**	**22/05/2008**	**18/06/2008**	**14/07/2008**	**14/08/2008**
Beenyup Bk S1	6	Dry	Dry	Dry	Dry	Dry	Dry	Dry	🟧	🟧	🟧
Beenyup Bk S2	2	25.00	Dry	Dry	Dry	Dry	Dry	6.00	🟧	🟧	🟧

Estimated Flow (L/s)	**Oct-07**	**Nov-07**	**Dec-07**	**Jan-08**	**Feb-08**	**Mar-08**	**Apr-08**	**May-08**	**Jun-08**	**Jul-08**	**Aug-08**
Date Monitored	**12/10/2007**	**21/11/2007**	**28/12/2007**	**24/01/2008**	**19/02/2008**	**17/03/2008**	**15/04/2008**	**22/05/2008**	**18/06/2008**	**14/07/2008**	**14/08/2008**
Beenyup Bk S1	112	Dry	Dry	Dry	Dry	Dry	Dry	dry	20	🟧	37
Beenyup Bk S2	80	0.20	Dry	Dry	Dry	Dry	Dry	2.00	12.00	🟧	35.00

APPENDIX D

Lithological Logs

JDA Consultant Hydrologists
Suite 1, 27 York Street
Subiaco WA 6008
Tel: 9388 2436
Fax: 9381 9279

LITHOLOGICAL LOG

Client:	Aspen Group Pty Ltd	Job No:	J4148
Project:	Lot 2, South Western Hwy	Hole commenced:	28/09/07
Bore location:	407265E 643440N	Hole completed:	28/09/07
Datum:	MGA94/AHD	Logged by:	WG/LM
Bore Name:	MW1	Total Depth: 12m	
Drill type:	Air Core	R.L. TOC: 80.16 mAHD	
Hole diameter:	200mm	Natural Surface: 79.64mAHD	

method	1 2 3 penetration	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
		50mm PVC (Class 9)				Light Grey	Coarse	Sand	Low	Dry	
					1.0m	Light Brown		Clayey Sand		Moist	Cemented Grey Clay with Fine Gravel
					2.0m					Dry	Cemented Grey Clay
								Sandy Clay			Cemented Grey Clay with Fine Gravel
					3.0m	Red Brown					Some Gravel
					4.0m						Cemented Clay
					5.0m	White/Red	Fine	Clay			Clay Mottles
					6.0m			Sand			
						Orange/White	Medium	Clayey Sand			Clay Mottles
					7.0m	Orange					
							Fine	Sandy Clay		Slightly Moist	Cemented Grey Clay
					8.0m	Grey		Clay			Cemented Clay
										Moist	
						Grey/Red/Orange					Clay Mottles
						Red/Orange					
			▽		9.0m					Saturated	
						Orange/Grey					
					10.0m 11.0m 12.0m	Red					Grey Cemented Clay
											End of Hole

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 28/09/07

WL below TOC …….

Stickup above NS: 0.6m

WL ……. below NS

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LITHOLOGICAL LOG

Client:	Aspen Group Pty Ltd	Job No:	J4148
Project:	Lot 2, South Western Hwy	Hole commenced:	28/09/07
Bore location:	407130E 6434404N	Hole completed:	28/09/07
Datum:	MGA94/AHD	Logged by:	WG/LM
Bore Name:	MW2	Total Depth: 10.5m	
Drill type:	Air Core	R.L. TOC: 75.73mAHD	
Hole diameter:	200mm	Natural Surface: 75.04mAHD	

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
						COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
		50mm PVC (Class 9)				Grey	Medium	Sand	Medium	Dry	
					1.0m	Cream	Coarse		Low	Moist	Rocks and Perched Water Layer
						Orange	Fine	Sandy Clay		Slightly Moist	
					2.0m			Clay			
					3.0m	Orange/Red					Clay Mottles
						Red/Orange/Grey					
					4.0m	Orange/Light Brown	Medium	Sandy Clay		Dry	
						Light Brown		Clay			
					5.0m	Orange/Grey/Red	Fine			Slightly Moist	Clay Mottles
						Orange/Grey				Moist	
					6.0m		Coarse	Clayey Sand		Dry	
							Fine	Clay		Moist	
				▤	7.0m	White	Medium	Silcrete Clay		Dry	Silcrete Layer or Colluvial Boulder
					8.0m	Cream	Fine	Clay	Low	Moist	
					9.0m	Grey	Coarse	Clayey Sand		Slightly Moist	
			▽			Cream	Fine			Saturated	Grey Cemented Clay
					10.0m		Medium	Sandy Clay			
						Cream/Orange					
											End of Hole

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 28/09/07

WL below TOC ……………..……

Stickup above NS: 0.62m

WL …………….. m below NS

JDA Consultant Hydrologists
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Tel: 9388 2436
Fax: 9381 9279

JDA Consultant Hydrologists

LITHOLOGICAL LOG

Client:	Aspen Group Pty Ltd	Job No:	J4148
Project:	Lot 2, South Western Hwy	Hole commenced:	28/09/07
Bore location:	407065E 6434195N	Hole completed:	28/09/07
Datum:	MGA94/AHD	Logged by:	WG/LM
Bore Name:	MW3	Total Depth: 9m	
Drill type:	Air Core	R.L. TOC: 70.74mAHD	
Hole diameter:	200mm	Natural Surface: 70.07mAHD	

method	1 2 3 penetration	**support**	**water**	**Slot / Screen Depth**	**Depth (metres)**	**SOIL CHARACTERISTICS**					
						COLOUR	**PARTICLE SIZE**	**TEXTURE**	**ORGANIC CONTENT**	**MOISTURE**	**COMMENTS**
		50mm PVC (Class 9)				Dark Grey	Coarse	Sand	High	Dry	Quartz Sand
						Grey			Low		
					1.0m					Slightly Moist	Quartz Rocks
						Light Brown/Grey				Moist	Gravel
					2.0m	Brown		Sandy Clay			Orange/Grey Clay Mottles
							Medium	Clay		Dry	
					3.0m		Coarse	Sandy Clay		Moist	Grey Clay Mottles with Fine Gravel
					4.0m		Fine	Clay		Slightly Moist	Orange/Grey Clay Mottles
					5.0m	Orange/Grey				Moist	Clay Mottles
					6.0m	Yellow	Medium	Sandy Clay			Grey Sand with Quartz Rocks
							Fine/Medium				Grey Sand
					7.0m					Saturated	
						Grey	Fine	Clay		Slightly Moist	
			▽		8.0m	Yellow	Coarse	Sandy Clay		Moist	Grey Sand
						Grey	Medium			Saturated	Fine Gravel
						Orange	Coarse				Grey Sand
					9.0m 10.0m						*End of Hole*

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGI

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSI

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……………………………

WL below TOC ……………………

Stickup above NS: ………….m

WL …………….. m below NS

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Subiaco WA 6008
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LITHOLOGICAL LOG

Client:	Aspen Group Pty Ltd	Job No:	J4148
Project:	Lot 2, South Western Hwy	Hole commenced:	28/09/07
Bore location:	406979E 6434496N	Hole completed:	28/09/07
Datum:	MGA94/AHD	Logged by:	WG/LM
Bore Name:	MW4	Total Depth: 10.5m	
Drill type:	Air Core	R.L. TOC: 71.59mAHD	
Hole diameter:	200mm	Natural Surface: 70.94mAHD	

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
						COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
		50mm PVC (Class 9)				Grey	Coarse	Sand	Low	Dry	
					1.0m	Light Brown		Clayey Sand		Slightly Moist	Gravel
					2.0m	Orange		Sandy Clay		Dry	
						Light Brown/Red/Grey					
					3.0m	Red/Orange/Grey					
					4.0m		Fine	Clay			Clay Mottles
					5.0m	Orange/Grey				Slightly Moist	
											Fine Gravel
					6.0m	Grey	Coarse	Clayey Sand			
						Cream	Fine	Sandy Clay		Saturated	Cemented Clay
				▤	7.0m	Light Brown/Grey		Clay		Slightly Moist	
			▽	▤	8.0m	Cream/Grey/Green				Saturated	
				▤	9.0m	Cream	Coarse	Sandy Clay			
				▤	10.0m	Grey	Fine	Clay			
											End of Hole

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown,	Red,	Orange,	Yellow,	Grey,	Blue	Tones : solid colour, blemish or mottle
Medium :	Brown,	Red,	Orange,	Yellow,	Grey,	Blue	
Light :	Brown,	Red,	Orange,	Yellow,	Grey,	Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: ……………………………

WL below TOC ……………..……

Stickup above NS: …………m

WL …………….. m below NS

JDA Consultant Hydrologists
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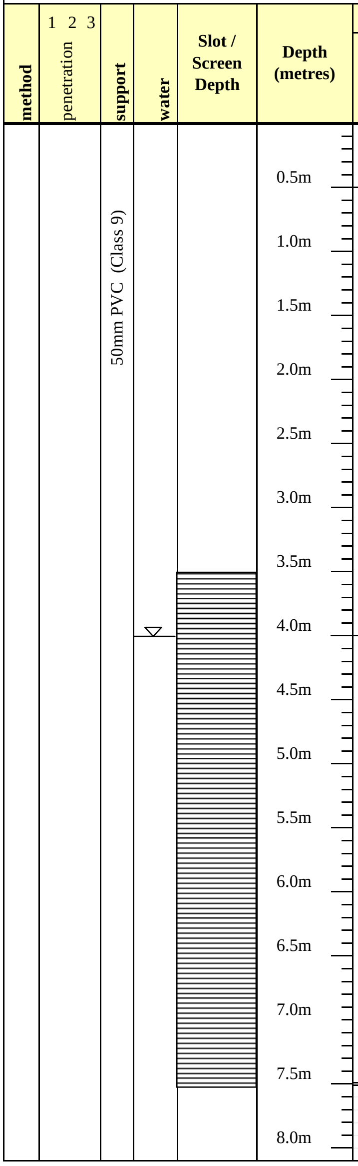
LITHOLOGICAL LOG

Client:	Aspen Group Pty Ltd	Job No:	J4148
Project:	Lot 2, South Western Hwy	Hole commenced:	02/10/07
Bore location:	406930E 6434184N	Hole completed:	02/10/07
Datum:	MGA94/AHD	Logged by:	Proline Drilling
Bore Name:	MW5	Total Depth: 7.5m	
Drill type:	Air Core	R.L. TOC: 67.81mAHD	
Hole diameter:	200mm	Natural Surface: 67.11mAHD	



SOIL CHARACTERISTICS

COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
Grey	Fine/Medium	Sand	Low	Dry	
Yellow Brown	Medium/Coarse	Sandy Clay		Moist	
	Fine	Clay		Moist/ Saturated	Fine/Coarse Gravel with Cobbles of Granite
Blue Grey				Saturated	Yellow Brown Clay Mottles with Fine/Medium Gravels
					End of Hole

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: ……………………………

WL below TOC ………….……

Stickup above NS: ………….m

WL …………….. m below NS

SJS TRIM IN09/13770

JDA Consultant Hydrologists
Suite 1, 27 York Street
Subiaco WA 6008
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JDA Consultant Hydrologists

LITHOLOGICAL LOG

Client:	Aspen Group Pty Ltd	Job No:	J4148
Project:	Lot 2, South Western Hwy	Hole commenced:	02/10/07
Bore location:	406938E 6433911N	Hole completed:	02/10/07
Datum:	MGA94/AHD	Logged by:	Proline Drilling
Bore Name:	MW6	Total Depth: 9m	
Drill type:	Air Core	R.L. TOC: 68.80mAHD	
Hole diameter:	200mm	Natural Surface: 68.04mAHD	

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
						COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
		50mm PVC (Class 9)			0.5m	Grey Brown	Fine/Medium	Sand	Low	Dry	Massive Laterite at Surface Nearby
					1.0m	Orange Brown	Fine	Clay		Moist	Fine/Medium Laterite Gravels
					1.5m						
					2.0m						
					2.5m						
					3.0m						
					3.5m	White Grey	Fine	Sandy Clay		Dry	Hard Layer, Moderately Cemented, Possibly Silcrete
					4.0m						
					4.5m	Orange Brown	Fine/Medium	Sandy Clay		Moist/ Saturated	Some Laterite Gravels
				▤	5.0m						
					5.5m						
					6.0m						
					6.5m						
					7.0m						
			▽		7.5m						
					8.0m	Blue Grey				Saturated	
					8.5m						
					9.0m						
					9.5m						*End of Hole*

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGI

		Tones : solid colour, blemish or mottle
Dark :	Brown, Red, Orange, Yellow, Grey, Blue	
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSI

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……………………………

WL below TOC ………….……..

Stickup above NS: 0.6m

WL …………….. m below NS

JDA Consultant Hydrologists
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Subiaco WA 6008
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JDA Consultant Hydrologists

LITHOLOGICAL LOG

Client:	Aspen Group Pty Ltd	Job No:	J4148
Project:	Lot 2, South Western Hwy	Hole commenced:	02/10/07
Bore location:	406839E 6434349N	Hole completed:	02/10/07
Datum:	MGA94/AHD	Logged by:	Proline Drilling
Bore Name:	MW7	Total Depth: 7.5m	
Drill type:	Air Core	R.L. TOC: 66.57mAHD	
Hole diameter:	200mm	Natural Surface: 65.84mAHD	

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
						COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
		50mm PVC (Class 9)			0.5m 1.0m 1.5m	Orange Brown	Fine	Clay	Low	Moist	Fine/Medium Laterite Gravels
					2.0m 2.5m 3.0m	Orange Brown/Grey	Fine/Coarse	Clayey Sand		Slightly Moist	Gravel with Clay Mottles: Patchy Ironstone Cementing
			▽	▤	3.5m 4.0m 4.5m 5.0m 5.5m	Red Brown		Ferricrete/ Mottled Ironstone		Moist/ Saturated	Cobble Layers of Well Cemented Ferricrete
				▤	6.0m 6.5m 7.0m 7.5m	Grey/White	Medium /Coarse	Sandy Clay		Saturated	
					8.0m						*End of Hole*

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATEE

STATIC WATER LEVEL

Date: ……………………………

WL below TOC ………..……

Stickup above NS: …………m

WL …………….. m below NS

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LITHOLOGICAL LOG

Client:	Aspen Group Pty Ltd	Job No:	J4148
Project:	Lot 2, South Western Hwy	Hole commenced:	02/10/07
Bore location:	406802E 6434072N	Hole completed:	02/10/07
Datum:	MGA94/AHD	Logged by:	Proline Drilling
Bore Name:	MW8	Total Depth: 9m	
Drill type:	Air Core	R.L. TOC: 66.12mAHD	
Hole diameter:	200mm	Natural Surface: 65.48mAHD	

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
						COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
		50mm PVC (Class 9)				Dark Brown	Fine/Medium	Sand	Low	Moist	Fine Laterite Gravels
					0.5m 1.0m 1.5m 2.0m 2.5m	Orange Brown	Fine	Clay			
					3.0m 3.5m 4.0m		Fine/Medium	Sandy Clay		Slightly Moist	Fine/Medium Laterite Gravels with Layers of Well Cemeted Ironstone
			▽	▤	4.5m 5.0m 5.5m	Grey/Red Brown				Moist	Fine/Coarse Laterite Gravels with Well Cemented Ironstone
				▤	6.0m 6.5m 7.0m	Yellow Grey		Clayey Sand		Saturated	
				▤	7.5m 8.0m	Grey		Sandy Clay			Very Well Cemented Layers of Sandy Clay, Fragments of Red/Brown Ferricrete
				▤	8.5m 9.0m	Blue Grey					
					9.5m						*End of Hole*

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGI

Dark :	Brown,	Red,	Orange,	Yellow,	Grey,	Blue
Medium :	Brown,	Red,	Orange,	Yellow,	Grey,	Blue
Light :	Brown,	Red,	Orange,	Yellow,	Grey,	Blue

Tones : solid colour, blemish or mottle

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSI

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……………………………

WL below TOC ……………………

Stickup above NS: 0.6 m

WL …………….. m below NS

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JDA Consultant Hydrologists

LITHOLOGICAL LOG

Client:	Aspen Group Pty Ltd	Job No:	J4148
Project:	Lot 2, South Western Hwy	Hole commenced:	02/10/07
Bore location:	406716E 6434220N	Hole completed:	02/10/07
Datum:	MGA94/AHD	Logged by:	Proline Drilling
Bore Name:	MW9	Total Depth: 7.5m	
Drill type:	Air Core	R.L. TOC: 64.22mAHD	
Hole diameter:	200mm	Natural Surface: 63.51mAHD	

method	1 2 3 penetration	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
						COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
		50mm PVC (Class 9)			0.5m	Brown	Fine	Clay	Low	Moist	Fine Gravel
					1.0m		Medium/Coarse	Sandy Clay		Slightly Moist	
					1.5m						
					2.0m						
					2.5m						
					3.0m						
				▤	3.5m		Fine	Clay		Moist/ Saturated	Fine/Coarse Gravel with Cobbles of Quartz
				▤	4.0m						
				▤	4.5m						
				▤	5.0m						
				▤	5.5m						
			▽	▤	6.0m						
				▤	6.5m					Saturated	Medium/Coarse Cobble Size Patches of Well Cemented Ironstone
				▤	7.0m						
				▤	7.5m	Blue Grey					
					8.0m						*End of Hole*

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: ……………………………

WL below TOC ……………..…….

Stickup above NS: ………….m

WL …………….. m below NS

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LITHOLOGICAL LOG

Client:	Aspen Group Pty Ltd	Job No:	J4148
Project:	Lot 2, South Western Hwy	Hole commenced:	03/10/07
Bore location:	406653E 6434489N	Hole completed:	03/10/07
Datum:	MGA94/AHD	Logged by:	Proline Drilling
Bore Name:	MW10	Total Depth: 7.5m	
Drill type:	Air Core	R.L. TOC: 62.02mAHD	
Hole diameter:	200mm	Natural Surface: 61.34mAHD	

method	1 2 3 penetration	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
						COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
		50mm PVC (Class 9)			0.5m 1.0m	Light Brown	Fine/Medium	Sand	Low	Saturated	Fine/Medium Laterite Gravels
					1.5m 2.0m 2.5m 3.0m	Grey	Fine	Clay		Moist	Orange Brown Clay Mottles
			▽		3.5m 4.0m 4.5m 5.0m 5.5m 6.0m	Red Brown				Moist/ Saturated	Cobble Size Grey Clay Mottles
					6.5m 7.0m 7.5m	Grey/Red Brown				Saturated	
					8.0m 8.5m 9.0m 9.5m						*End of Hole*

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGI

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSI

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……………………………

WL below TOC ……..m

Stickup above NS: 0.6m

WL …………….. m below NS

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LITHOLOGICAL LOG

Client:	Aspen Group Pty Ltd	Job No:	JXXXX
Project:	Lot 2, South Western Hwy	Hole commenced:	02/10/07
Bore location:	406601E 6434325N	Hole completed:	02/10/07
Datum:	MGA94/AHD	Logged by:	Proline Drilling
Bore Name:	MW11	Total Depth: 7.5m	
Drill type:	Air Core	R.L. TOC: 61.78mAHD	
Hole diameter:	200mm	Natural Surface: 61.06mAHD	

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
						COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
		50mm PVC (Class 9)			0.5m	Brown	Fine	Clay	Low	Moist	Fine/Medium Laterite Gravel
					1.0m	Orange Brown				Slightly Moist	Fine/Medium Gravel with Clay Mottles
					1.5m						
					2.0m						
					2.5m		Medium/Coarse	Sandy Clay			
					3.0m						
				▤	3.5m						
				▤	4.0m						
			▽	▤	4.5m	Blue Grey	Fine	Clay		Saturated	Orange Brown Clay Mottles
				▤	5.0m						
				▤	5.5m		Medium	Sandy Clay			Quartz Gravels and Ironstone Fragments
				▤	6.0m						
				▤	6.5m		Medium/Coarse				
				▤	7.0m						
					7.5m						*End of Hole*
					8.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATEᗡ

STATIC WATER LEVEL

Date: ……………………………

WL below TOC ………….……

Stickup above NS: ………….m

WL …………….. m below NS

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LITHOLOGICAL LOG

Client:	Aspen Group Pty Ltd	Job No:	J4148
Project:	Lot 2, South Western Hwy	Hole commenced:	03/10/07
Bore location:	406572E 6434229N	Hole completed:	03/10/07
Datum:	MGA94/AHD	Logged by:	Proline Drilling
Bore Name:	MW12	Total Depth: 9m	
Drill type:	Air Core	R.L. TOC: 61.90mAHD	
Hole diameter:	200mm	Natural Surface: 61.26mAHD	

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
					0.5m	Brown	Fine/Medium	Sandy Clay	Low	Moist	
		50mm PVC (Class 9)			1.0m 1.5m 2.0m 2.5m 3.0m 3.5m	Yellow Brown	Fine	Clay			Fine/Medium Gravel with Clay Mottles
					4.0m 4.5m	Grey	Fine/Medium	Sandy Clay			Moderately Cemented
				▤	5.0m 5.5m	Yellow Brown				Moist/ Saturated	Mottled Grey White Clay with Gravels and Cobbles of Ironstone
			▽	▤	6.0m 6.5m 7.0m 7.5m 8.0m 8.5m 9.0m	Grey				Saturated	Brown Clay Mottles
					9.5m						*End of Hole*

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGI

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSI

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……………………………

WL below TOC ……………………

Stickup above NS: 0.6m

WL …………….. m below NS

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LITHOLOGICAL LOG

Client:	Aspen Group Pty Ltd	Job No:	J4148
Project:	Lot 2, South Western Hwy	Hole commenced:	02/10/07
Bore location:	406540E 6434115N	Hole completed:	02/10/07
Datum:	MGA94/AHD	Logged by:	Proline Drilling
Bore Name:	MW13	Total Depth: 9m	
Drill type:	Air Core	R.L. TOC: 61.99mAHD	
Hole diameter:	200mm	Natural Surface: 61.29mAHD	

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
						COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
		50mm PVC (Class 9)			0.5m	Grey	Fine/Medium	Sand	Low	Saturated	
					1.0m 1.5m 2.0m 2.5m 3.0m 3.5m	Brown	Fine	Sandy Clay		Moist	Laterite Gravels
					4.0m 4.5m	Grey				Slightly Moist	Weakly Cemented, Yellow Brown Clay Mottles
				▤	5.0m 5.5m 6.0m 6.5m 7.0m 7.5m	Yellow Brown/Brown	Fine	Clay		Moist	Fine/Medium Gravels of Quartz and Ironstone
			▽	▤	8.0m 8.5m 9.0m	Grey/Blue Grey	Fine/Medium	Sandy Clay		Saturated	
					9.5m						*End of Hole*

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……………………………

WL below TOC ……………………

Stickup above NS: 0.6m

WL …………….. m below NS

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LITHOLOGICAL LOG

Client: Aspen Group Pty Ltd
Project: Lot 2, South Western Hwy
Bore location:
Datum: MGA94/AHD
Job No: J4148
Hole commenced: 22/02/08
Hole completed: 22/02/08
Logged by: AB

Bore Name: MW14
Drill type: Air Core
Hole diameter: 200mm
Total Depth: 13.4m
R.L. TOC:
Natural Surface:

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
						COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
		50mm PVC (Class 9)				Light Grey	Coarse	Sand	Low	Dry	
											Cemented Grey Clay with Fine Gravel
					1.0m 2.0m 3.0m	Light Brown					
					4.0m	Light brown/grey		Clayey Sand			Cemented Grey Clay with Large colluivial Gravel
				Bentonite							Grey mottles and fine quartz
					5.0m 6.0m	Light grey/brown		Sand			Cemented Grey Clay with gravel and fine quartz
					7.0m	Light grey/brown		Sandy Clay			Cemented Grey Clay with large gravel and fine quartz
					8.0m	Light brown/Orange/grey		Clayey Sand		Slightly moist	Grey mottles
					9.0m	grey	Medium-coarse				
						Grey/Red	Medium-Fine				Red/grey mottles
						Red					
					10.0m	Light Brown	Coarse			Moist	Red/grey mottles with gravel
					11.0m		Medium-Fine				
					12.0m 13.0m					Saturated	Red/grey mottles with large gravel
											End of hole

APPENDIX E

Laboratory Reports

LAB 17(2).

Analytical Report

Job No : **083317**

Lab Id Units LQL	External Idents	TSS mg/L 1	NOx_N mg/L 0.005	PO4_P mg/L 0.005	Tot P mg/L 0.01	TKN mg/L 0.05	Tot N mg/L 0.05	NH4_N mg/L 0.005
083317-001	JDA J4148 MW1	NA	<0.005	<0.005	0.01	<0.05	<0.05	<0.005
083317-002	JDA J4148 MW2	NA	<0.005	<0.005	0.02	<0.05	<0.05	<0.005
083317-003	JDA J4148 MW3	NA	<0.005	<0.005	0.01	0.08	0.08	0.058
083317-004	JDA J4148 MW4	NA	<0.005	<0.005	0.04	<0.05	<0.05	<0.005
083317-005	JDA J4148 MW5	NA	5.1	<0.005	0.02	0.19	5.3	<0.005
083317-006	JDA J4148 MW6	NA	1.4	<0.005	0.05	0.16	1.6	<0.005
083317-007	JDA J4148 MW7	NA	<0.005	<0.005	<0.01	<0.05	<0.05	<0.005
083317-008	JDA J4148 MW8	NA	0.93	<0.005	0.02	0.09	1.0	<0.005
083317-009	JDA J4148 MW9	NA	<0.005	<0.005	0.02	0.21	0.21	0.053
083317-010	JDA J4148 MW10	NA	1.4	<0.005	0.05	0.29	1.7	<0.005
083317-011	JDA J4148 MW11	NA	7.9	<0.005	0.05	<0.05	7.9	<0.005
083317-012	JDA J4148 MW12	NA	<0.005	<0.005	0.01	0.06	0.06	0.028
083317-013	JDA J4148 MW13	NA	<0.005	<0.005	0.02	0.15	0.15	0.040
083317-014	JDA J4148 MW14	NA	0.13	<0.005	0.31	0.21	0.34	0.017
083317-015	JDA J4148 MW15	NA	<0.005	<0.005	0.07	0.30	0.30	0.042
083317-016	JDA J4148 MW16	NA	<0.005	<0.005	0.08	1.3	1.3	0.27
083317-017	JDA J4148 Beenyup S2	6	0.37	<0.005	0.03	0.41	0.78	<0.005
083317-001-DUP	JDA J4148 MW1	NA	<0.005	<0.005	0.01	<0.05	<0.05	<0.005

NA Indicates analysis not requested

Date Printed **4/06/2008**

Analytical Report

Job No : **082314**

Lab Id **Units** **LQL**	**External Idents**	**EC** **uS/cm** **1**	**pH** **-** **0.05**	**NOx_N** **mg/L** **0.005**	**Tot N** **mg/L** **0.05**	**TKN** **mg/L** **0.05**	**NH4_N** **mg/L** **0.005**	**Tot P** **mg/L** **0.01**	**PO4_P** **mg/L** **0.005**
082314-001	JDA J4148 MW1	870	6.00	<0.005	0.87	0.87	0.16	0.02	<0.005
082314-002	JDA J4148 MW2	1100	4.95	0.073	0.29	0.22	<0.005	0.10	<0.005
082314-003	JDA J4148 MW3	1900	5.45	0.073	0.23	0.16	0.056	0.01	<0.005
082314-004	JDA J4148 MW4	2000	5.90	<0.005	0.18	0.18	0.006	0.03	0.013
082314-005	JDA J4148 MW5	1400	6.25	11	16	4.8	<0.005	0.02	<0.005
082314-006	JDA J4148 MW6	550	5.40	1.5	1.7	0.20	0.062	0.04	0.022
082314-007	JDA J4148 MW7	820	4.85	0.054	0.44	0.39	0.011	0.04	<0.005
082314-008	JDA J4148 MW8	320	5.60	1.6	1.9	0.30	<0.005	0.02	<0.005
082314-009	JDA J4148 MW9	3800	5.55	0.035	0.49	0.46	0.098	0.02	<0.005
082314-010	JDA J4148 MW10	340	5.25	1.4	1.8	0.43	<0.005	0.07	<0.005
082314-011	JDA J4148 MW11	2300	5.95	6.0	8.2	2.2	<0.005	0.05	<0.005
082314-012	JDA J4148 MW12	2900	5.50	0.14	0.36	0.22	0.037	0.01	<0.005
082314-013	JDA J4148 MW13	3700	6.10	0.027	0.09	0.07	0.065	0.02	<0.005
082314-014	JDA J4148 MW14	1400	6.10	0.10	1.9	1.8	0.065	0.32	0.009
082314-015	JDA J4148 MW15	530	5.25	<0.005	0.32	0.32	0.055	0.05	<0.005
082314-016	JDA J4148 MW16	830	5.65	<0.005	0.47	0.47	0.13	0.04	<0.005
082314-001-DUP	JDA J4148 MW1	880	6.05	<0.005	0.79	0.79	0.15	0.02	<0.005

Date Printed **22/04/2008**

Analytical Report

Job No : 081656

Lab Id Units LQL	External Idents	NOx_N mg/L 0.005	Tot N mg/L 0.05	TKN mg/L 0.05	NH4_N mg/L 0.005	Tot P mg/L 0.01	PO4_P mg/L 0.005
081656-001	JDA J4148 MW1	0.006	0.26	0.25	0.033	0.03	<0.005
081656-002	JDA J4148 MW2	0.018	0.28	0.26	<0.005	<0.01	<0.005
081656-003	JDA J4148 MW3	0.024	0.34	0.32	0.077	<0.01	<0.005
081656-004	JDA J4148 MW4	0.042	0.29	0.25	0.007	<0.01	<0.005
081656-005	JDA J4148 MW5	6.1	6.7	0.63	<0.005	<0.01	<0.005
081656-006	JDA J4148 MW6	1.2	2.6	1.4	<0.005	<0.01	<0.005
081656-007	JDA J4148 MW7	0.16	0.46	0.30	<0.005	<0.01	<0.005
081656-008	JDA J4148 MW8	1.9	3.4	1.5	<0.005	<0.01	<0.005
081656-009	JDA J4148 MW9	0.033	0.68	0.65	0.045	<0.01	<0.005
081656-010	JDA J4148 MW10	1.2	2.1	0.95	0.010	<0.01	<0.005
081656-011	JDA J4148 MW11	0.15	0.39	0.24	0.051	<0.01	<0.005
081656-012	JDA J4148 MW12	0.017	0.65	0.63	0.084	<0.01	<0.005
081656-013	JDA J4148 MW13	0.015	0.22	0.21	0.025	<0.01	<0.005
081656-014	JDA J4148 MW14	0.14	0.80	0.66	0.096	0.12	0.034
081656-015	JDA J4148 MW15	0.006	0.66	0.65	0.32	0.02	<0.005
081656-016	JDA J4148 MW16	0.025	0.24	0.22	0.12	0.01	<0.005
081656-001-DUP	JDA J4148 MW1	0.006	0.25	0.24	0.031	0.03	<0.005

Date Printed 11/04/2008

Analytical Report

Job No : 081026

Lab Id Units LQL	External Idents	EC uS/cm 1	NOx_N mg/L 0.005	PO4_P mg/L 0.005	Tot P mg/L 0.01	TKN mg/L 0.05	Tot N mg/L 0.05	NH4_N mg/L 0.005
081026-001	JDA J4148 MW1	NA	0.009	<0.005	0.10	0.14	0.15	0.073
081026-002	JDA J4148 MW2	NA	0.063	0.005	0.13	0.07	0.13	0.021
081026-003	JDA J4148 MW3	NA	0.008	<0.005	0.02	0.48	0.49	0.069
081026-004	JDA J4148 MW4	NA	0.010	0.005	0.08	0.07	0.08	0.031
081026-005	JDA J4148 MW5	NA	4.5	0.006	0.03	0.81	5.4	0.028
081026-006	JDA J4148 MW6	NA	1.3	0.006	0.09	0.10	1.4	0.011
081026-007	JDA J4148 MW7	NA	0.11	<0.005	0.04	0.12	0.23	0.022
081026-008	JDA J4148 MW8	NA	2.5	<0.005	0.14	0.87	3.4	0.006
081026-009	JDA J4148 MW9	NA	0.036	<0.005	0.11	1.5	1.6	0.066
081026-010	JDA J4148 MW10	NA	1.4	<0.005	0.11	0.36	1.7	0.009
081026-011	JDA J4148 MW11	12000	0.42	<0.005	0.05	0.54	0.96	0.072
081026-012	JDA J4148 MW12	NA	0.044	<0.005	0.04	0.23	0.27	0.065
081026-013	JDA J4148 MW13	NA	0.009	0.006	0.02	0.21	0.22	0.075
081026-001-DUP	JDA J4148 MW1	NA	0.009	<0.005	0.10	0.13	0.14	0.071

NA indicates analysis not requested

SJS TRIM IN09/13770

Date Printed 26/02/2008

Analytical Report

Job No : **080444**

Lab Id Units LQL	External Idents	Tot N mg/L 0.05	TKN mg/L 0.05	NOx_N mg/L 0.005	NH4_N mg/L 0.005	Tot P mg/L 0.01	PO4_P mg/L 0.005
080444-001	JDA J4148 MW1	0.16	0.15	0.010	0.068	0.08	0.011
080444-002	JDA J4148 MW2	0.09	0.07	0.019	0.013	0.10	0.011
080444-003	JDA J4148 MW3	0.47	0.46	0.013	0.074	0.10	0.013
080444-004	JDA J4148 MW4	0.21	0.20	0.011	0.017	0.14	0.018
080444-005	JDA J4148 MW5	0.56	0.36	0.20	0.056	0.11	0.014
080444-006	JDA J4148 MW6	1.2	0.20	0.97	0.021	0.09	0.011
080444-007	JDA J4148 MW7	0.22	0.19	0.028	0.029	0.05	0.010
080444-008	JDA J4148 MW8	3.2	0.39	2.8	0.035	0.06	0.013
080444-009	JDA J4148 MW9	0.89	0.72	0.17	0.063	0.25	0.013
080444-010	JDA J4148 MW10	2.4	0.57	1.9	0.029	0.09	0.008
080444-011	JDA J4148 MW11	3.4	2.8	0.63	0.079	0.20	0.011
080444-012	JDA J4148 MW12	1.4	1.4	0.030	0.058	0.03	0.011
080444-013	JDA J4148 MW13	0.64	0.63	0.010	0.079	0.19	0.010
080444-001-DUP	JDA J4148 MW1	0.17	0.16	0.009	0.066	0.07	0.010

Date Printed **30/01/2008**

Analytical Report

Job No : 077921

Lab Id	External Idents	Tot N	TKN	NOx_N	NH4_N	Tot P	PO4_P
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
LQL		0.05	0.05	0.005	0.005	0.01	0.005
077921-001	JDA J4148 MW1	<0.05	<0.05	<0.005	<0.005	<0.01	<0.005
077921-002	JDA J4148 MW2	<0.05	<0.05	0.007	<0.005	0.02	0.006
077921-003	JDA J4148 MW3	<0.05	<0.05	0.007	<0.005	<0.01	<0.005
077921-004	JDA J4148 MW4	<0.05	<0.05	<0.005	<0.005	<0.01	<0.005
077921-005	JDA J4148 MW5	2.5	1.4	1.1	<0.005	0.04	0.010
077921-006	JDA J4148 MW6	1.0	0.75	0.29	0.086	0.05	0.007
077921-007	JDA J4148 MW7	0.06	<0.05	0.018	0.026	<0.01	<0.005
077921-008	JDA J4148 MW8	3.0	1.5	1.5	0.066	0.03	<0.005
077921-009	JDA J4148 MW9	0.33	0.33	<0.005	0.13	0.02	<0.005
077921-010	JDA J4148 MW10	2.1	0.98	1.1	0.10	0.03	<0.005
077921-011	JDA J4148 MW11	3.0	0.34	2.7	0.26	0.01	0.005
077921-012	JDA J4148 MW12	0.09	<0.05	0.053	<0.005	<0.01	<0.005
077921-013	JDA J4148 MW13	0.21	0.20	0.010	<0.005	0.01	<0.005
077921-001-DUP	JDA J4148 MW1	<0.05	<0.05	<0.005	<0.005	<0.01	<0.005

Date Printed 10/01/2008

Analytical Report

Job No : 077226

Lab Id	External Idents	TSS	NOx_N	NH4_N	Tot P	PO4_P	Tot N	TKN
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
LQL		1	0.005	0.005	0.01	0.005	0.05	0.05
		+	+	+	+	+	+	+
077226-001	MW1	NA	<0.005	0.10	0.13	<0.005	0.44	0.44
077226-002	MW2	NA	<0.005	<0.005	0.05	<0.005	0.26	0.26
077226-003	MW3	NA	<0.005	0.037	0.05	<0.005	0.48	0.48
077226-004	MW4	NA	0.54	<0.005	0.04	<0.005	0.86	0.32
077226-005	MW5	NA	12	0.008	0.04	<0.005	14	1.8
077226-006	MW6	NA	0.35	0.013	0.04	<0.005	0.77	0.42
077226-007	MW7	NA	0.010	0.015	0.06	<0.005	0.25	0.24
077226-008	MW8	NA	3.0	0.015	0.02	<0.005	3.7	0.64
077226-009	MW9	NA	<0.005	0.022	0.04	<0.005	0.45	0.45
077226-010	MW10	NA	2.0	0.018	0.03	<0.005	2.5	0.51
077226-011	MW11	NA	1.7	0.068	0.03	<0.005	2.3	0.58
077226-012	MW12	NA	<0.005	0.021	0.03	<0.005	0.19	0.19
077226-013	MW13	NA	<0.005	0.15	0.02	0.008	0.27	0.27
077226-014	Beenyup S2	25	0.14	0.033	0.02	0.005	0.48	0.34
077226-001-DUP	MW1	NA	<0.005	0.11	0.13	<0.005	0.45	0.45

NA indicates analysis not requested
'+ indicates sample received outside holding time recommended by AS/NZ 5667.1:1988

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Analytical Report

Job No : 076096

Lab Id Units LQL	External Idents	NOx_N mg/L 0.005	PO4_P mg/L 0.005	Tot P mg/L 0.01	TKN mg/L 0.05	Tot N mg/L 0.05	NH4_N mg/L 0.005	TSS mg/L 1
076096-001	JDA J4148 MW1	0.053	<0.005	0.02	0.14	0.19	<0.005	NA
076096-002	JDA J4148 MW2	0.14	<0.005	0.02	0.14	0.28	<0.005	NA
076096-003	JDA J4148 MW3	3.1	<0.005	0.02	1.2	4.3	<0.005	NA
076096-004	JDA J4148 MW4	0.041	<0.005	0.02	0.28	0.32	<0.005	NA
076096-005	JDA J4148 MW5	14	<0.005	0.02	2.7	17	<0.005	NA
076096-006	JDA J4148 MW6	0.91	<0.005	0.02	0.39	1.3	<0.005	NA
076096-007	JDA J4148 MW7	0.10	<0.005	0.02	0.20	0.30	<0.005	NA
076096-008	JDA J4148 MW8	3.0	<0.005	0.02	0.25	3.2	<0.005	NA
076096-009	JDA J4148 MW9	0.11	<0.005	0.02	0.31	0.42	<0.005	NA
076096-010	JDA J4148 MW10	2.1	<0.005	0.02	0.24	2.3	<0.005	NA
076096-011	JDA J4148 MW11	8.6	<0.005	0.02	0.14	8.7	<0.005	NA
076096-012	JDA J4148 MW12	0.18	<0.005	0.02	0.34	0.52	<0.005	NA
076096-013	JDA J4148 MW13	4.3	<0.005	0.03	1.9	6.2	0.093	NA
076096-014	JDA J4148 Beenyup S1	0.31	<0.005	0.02	0.34	0.65	<0.005	6
076096-015	JDA J4148 Beenyup S2	0.31	<0.005	0.02	0.28	0.59	<0.005	2
076096-001-DUP	JDA J4148 MW1	0.052	<0.005	0.02	0.13	0.18	<0.005	NA

NA indicates analysis not requested

SJS TRIM IN09/13770

Date Printed 19/10/2007

APPENDIX F

Nutrient Input Modelling Results

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005
JDA Consultant Hydrologists
Report Date : 17-Jun-08

Lot 2 Nettleton Rd, Byford	
Total Nutrient Input - No WSUD (kg/yr)	**236**
Reduction due to WSUD (kg/yr)	**0**
Percentage Overall Reduction	**0.0%**
Pecentage Development Reduction	**0.0%**
Cost of Selected Program ($/kg/yr)	**$0**

● Total Phosphorus
○ Total Nitrogen

Catchment Name	Lot 2 Nettleton Rd, Byford	
Option Description	Post-Development Scenario	
Catchment Area	32	ha

Land Use Breakdown

Residential : ~R15	0.0%	lower density residential areas (excludes road reserve area)		
Residential : ~R35	53.0%	higher density residential areas (excludes road reserve area)		
Road Reserves : Minor	0.0%	maintainance of verge by landowners		
Road Reserves : Major	20.0%	maintainance of verge by local authority		
POS : Active	15.0%	grassed areas		
POS : Passive / Basins	7.0%	native vegetation		
Rural : Pasture	0.0%	general pasture		
Rural : Residential ~R2.5/R5	0.0%	low density	Total Residential	**53.0%**
Rural : Poultry	0.0%	specific high nutrient input land use	Total Area	**100.0%**
Commercial/Industrial	5.0%	town centre etc		

Nutrient Input Without WSUD

Residential	Garden	8.10	kg/net ha/yr	4.29	kg/gross ha/yr	137	kg/yr	58.1%
	Lawn	3.50		1.86		59		25.1%
	Pet Waste	0.00		0.00		0		0.0%
	Car Wash	0.13		0.07		2		1.0%
	Sub Total			6.22		199		84.2%
POS	Garden/Lawn	2.60	kg/ha POS/yr	0.39	kg/gross ha/yr	12	kg/yr	5.3%
	Pet Waste	3.80		0.57		18		7.7%
	Sub Total			0.96		31		13.0%
Road Reserve	Major Roads	1.04	kg/ha RR/yr	0.21	kg/gross ha/yr	7	kg/yr	2.8%
	Minor Roads	20.00		0.00		0		0.0%
	Sub Total			0.21		7		2.8%
Rural	Pasture	20.00	kg/ha Rural/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Poultry Farms	75.00		0.00		0		0.0%
	Residential (R2.5/R5)	4.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
			Total	**7.39**	kg/gross ha/yr	**236**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☐ Native Gardens (Lots - Garden) ☐ Native Gardens (Lots - Lawn) ☐ Native Gardens (POS) ☐ Street Sweeping
☐ Community Education : Fertiliser ☐ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness 0%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (POS)	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Fertiliser	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	0%	0.00	0	0.0%	$0	$0	$0.0
Totals		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	0%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	0%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input : Residential Area without WSUD	7.39	236	100.0%			
Nutrient Input : Rural Area	0.00	0	0.0%			
Removal via Source Control	0.00	0	0.0%	$0	$0	$0.0
Removal via In-Transit Control	0.00	0	0.0%	$0	$0	$0.0
Total Removal	0.00	0	0.0%	$0	$0	$0.0
Net Nutrient Input	**7.39**	**236**	**100.0%**			

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005
JDA Consultant Hydrologists
Report Date : 17-Jun-08

Lot 2 Nettleton Rd, Byford	
Total Nutrient Input - No WSUD (kg/yr)	**1,306**
Reduction due to WSUD (kg/yr)	**0**
Percentage Overall Reduction	**0.0%**
Pecentage Development Reduction	**0.0%**
Cost of Selected Program ($/kg/yr)	**$0**

○ Total Phosphorus
● Total Nitrogen

Catchment Name	Lot 2 Nettleton Rd, Byford	
Option Description	Post-Development Scenario	
Catchment Area	32	ha

Land Use Breakdown

Residential : ~R15	0.0%	lower density residential areas (excludes road reserve area)		
Residential : ~R35	53.0%	higher density residential areas (excludes road reserve area)		
Road Reserves : Minor	0.0%	maintainance of verge by landowners		
Road Reserves : Major	20.0%	maintainance of verge by local authority		
POS : Active	15.0%	grassed areas		
POS : Passive / Basins	7.0%	native vegetation		
Rural : Pasture	0.0%	general pasture		
Rural : Residential ~R2.5/R5	0.0%	low density	Total Residential	**53.0%**
Rural : Poultry	0.0%	specific high nutient input land use	Total Area	**100.0%**
Commercial/Industrial	5.0%	town centre etc		

Nutrient Input Without WSUD

Residential	Garden	17.70	kg/net ha/yr	9.38	kg/gross ha/yr	300	kg/yr	23.0%
	Lawn	23.10		12.24		392		30.0%
	Pet Waste	0.00		0.00		0		0.0%
	Car Wash	0.04		0.02		1		0.0%
	Sub Total			21.64		693		53.0%
POS	Garden/Lawn	73.40	kg/ha POS/yr	11.01	kg/gross ha/yr	352	kg/yr	27.0%
	Pet Waste	15.20		2.28		73		5.6%
	Sub Total			13.29		425		32.6%
Road Reserve	Major Roads	29.36	kg/ha RR/yr	5.87	kg/gross ha/yr	188	kg/yr	14.4%
	Minor Roads	132.00		0.00		0		0.0%
	Sub Total			5.87		188		14.4%
Rural	Pasture	60.00	kg/ha Rural/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Poultry Farms	175.00		0.00		0		0.0%
	Residential (R2.5/R5)	15.20		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
			Total	**40.80**	kg/gross ha/yr	**1,306**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☐ Native Gardens (Lots - Garden) ☐ Native Gardens (Lots - Lawn) ☐ Native Gardens (POS) ☐ Street Sweeping
☐ Community Education : Fertiliser ☐ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness 0%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (POS)	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Fertiliser	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	0%	0.00	0	0.0%	$0	$0	$0.0
Totals		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	0%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	0%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input : Residential Area without WSUD	40.80	1,306	100.0%			
Nutrient Input : Rural Area	0.00	0	0.0%			
Removal via Source Control	0.00	0	0.0%	$0	$0	$0.0
Removal via In-Transit Control	0.00	0	0.0%	$0	$0	$0.0
Total Removal	0.00	0	0.0%	$0	$0	$0.0
Net Nutrient Input	**40.80**	**1,306**	**100.0%**			

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005
JDA Consultant Hydrologists
Report Date : 17-Jun-08

Lot 2 Nettleton Rd, Byford	
Total Nutrient Input - No WSUD (kg/yr)	**480**
Reduction due to WSUD (kg/yr)	**0**
Percentage Overall Reduction	**0.0%**
Pecentage Development Reduction	**0.0%**
Cost of Selected Program ($/kg/yr)	**$0**

● Total Phosphorus

○ Total Nitrogen

Catchment Name	Lot 2 Nettleton Rd, Byford	
Option Description	Pre-Development Scenario	
Catchment Area	32	ha

Land Use Breakdown

Residential : ~R15	0.0%	lower density residential areas (excludes road reserve area)		
Residential : ~R35	0.0%	higher density residential areas (excludes road reserve area)		
Road Reserves : Minor	0.0%	maintainance of verge by landowners		
Road Reserves : Major	0.0%	maintainance of verge by local authority		
POS : Active	0.0%	grassed areas		
POS : Passive / Basins	25.0%	native vegetation		
Rural : Pasture	75.0%	general pasture		
Rural : Residential ~R2.5/R5	0.0%	low density	Total Residential	**0.0%**
Rural : Poultry	0.0%	specific high nutrient input land use	Total Area	**100.0%**
Commercial/Industrial	0.0%	town centre etc		

Nutrient Input Without WSUD

Residential	Garden	0.00	kg/net ha/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Lawn	0.00		0.00		0		0.0%
	Pet Waste	0.00		0.00		0		0.0%
	Car Wash	0.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
POS	Garden/Lawn	2.60	kg/ha POS/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Pet Waste	0.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
Road Reserve	Major Roads	1.04	kg/ha RR/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Minor Roads	20.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
Rural	Pasture	20.00	kg/ha Rural/yr	15.00	kg/gross ha/yr	480	kg/yr	100.0%
	Poultry Farms	75.00		0.00		0		0.0%
	Residential (R2.5/R5)	4.00		0.00		0		0.0%
	Sub Total			15.00		480		100.0%
			Total	**15.00**	kg/gross ha/yr	**480**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☐ Native Gardens (Lots - Garden) ☐ Native Gardens (Lots - Lawn) ☐ Native Gardens (POS) ☐ Street Sweeping

☐ Community Education : Fertiliser ☐ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness 0%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (POS)	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Fertiliser	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	0%	0.00	0	0.0%	$0	$0	$0.0
Totals		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	0%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	0%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input : Residential Area without WSUD	0.00	0	0.0%			
Nutrient Input : Rural Area	15.00	480	100.0%			
Removal via Source Control	0.00	0	0.0%	$0	$0	$0.0
Removal via In-Transit Control	0.00	0	0.0%	$0	$0	$0.0
Total Removal	0.00	0	0.0%	$0	$0	$0.0
Net Nutrient Input	**15.00**	**480**	**100.0%**			

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005
JDA Consultant Hydrologists
Report Date : 17-Jun-08

Lot 2 Nettleton Rd, Byford	
Total Nutrient Input - No WSUD (kg/yr)	**1,440**
Reduction due to WSUD (kg/yr)	**0**
Percentage Overall Reduction	**0.0%**
Pecentage Development Reduction	**0.0%**
Cost of Selected Program ($/kg/yr)	**$0**

○ Total Phosphorus
● Total Nitrogen

Catchment Name Lot 2 Nettleton Rd, Byford
Option Description Pre-Development Scenario
Catchment Area 32 ha

Land Use Breakdown

Residential : ~R15	0.0%	lower density residential areas (excludes road reserve area)
Residential : ~R35	0.0%	higher density residential areas (excludes road reserve area)
Road Reserves : Minor	0.0%	maintainance of verge by landowners
Road Reserves : Major	0.0%	maintainance of verge by local authority
POS : Active	0.0%	grassed areas
POS : Passive / Basins	25.0%	native vegetation
Rural : Pasture	75.0%	general pasture
Rural : Residential ~R2.5/R5	0.0%	low density
Rural : Poultry	0.0%	specific high nutrient input land use
Commercial/Industrial	0.0%	town centre etc

Total Residential **0.0%**
Total Area **100.0%**

Nutrient Input Without WSUD

Residential	Garden	0.00	kg/net ha/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Lawn	0.00		0.00		0		0.0%
	Pet Waste	0.00		0.00		0		0.0%
	Car Wash	0.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
POS	Garden/Lawn	73.40	kg/ha POS/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Pet Waste	0.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
Road Reserve	Major Roads	29.36	kg/ha RR/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Minor Roads	132.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
Rural	Pasture	60.00	kg/ha Rural/yr	45.00	kg/gross ha/yr	1,440	kg/yr	100.0%
	Poultry Farms	175.00		0.00		0		0.0%
	Residential (R2.5/R5)	15.20		0.00		0		0.0%
	Sub Total			45.00		1,440		100.0%
	Total			**45.00**	kg/gross ha/yr	**1,440**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☐ Native Gardens (Lots - Garden) ☐ Native Gardens (Lots - Lawn) ☐ Native Gardens (POS) ☐ Street Sweeping
☐ Community Education : Fertiliser ☐ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness 0%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (POS)	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Fertiliser	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	0%	0.00	0	0.0%	$0	$0	$0.0
Totals		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	0%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	0%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%
Nutrient Input : Residential Area without WSUD	0.00	0	0.0%
Nutrient Input : Rural Area	45.00	1,440	100.0%

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Removal via Source Control	0.00	0	0.0%	$0	$0	$0.0
Removal via In-Transit Control	0.00	0	0.0%	$0	$0	$0.0
Total Removal	0.00	0	0.0%	$0	$0	$0.0
Net Nutrient Input	**45.00**	**1,440**	**100.0%**			

NiDSS Core Data & Cost Calculations

Nutrient Input Decision Support System
Version 2.0 March 2005

Analysis Type (1,2)	1	TP	0%	% of total residential area as ~R15
Ave lots/net ha		0.0	0%	% of total residential Area as ~R35
Discount Rate	6%			

Community Education Information

"Who Cares About the Environment ?" (NSW EPA, 2000) Survey
17% stated environment one of two most important issues for govt to address
Of these 27% stated water as most important environmental issue
17% stated education most important issue to protect environment
Impact assumed to reduce fertiliser applications to minimum rates

Fertiliser Application Information/Assumptions

Lots assumed fertilised by property owner
Minor Road Reserves fertilised by property owner (verge assumed 40% road reserve)
Major Road Reserves fertilised by local authority (verge assumed 40% road reserve)
Active POS fertilised by local authority
Passive POS not fertilised
Rural Land Use and Poultry Farms have no reductions due to WSUD applied

Pet Waste

Data Source

Pets per lot and disposal via JDA Survey (2001)
TP & TN application via Gerritse at al (1991)
Cost Estimate via JDA. Distribution cost and frequency is for brochure, bag cost is for POS's

Application Rates

				Survey Results Pets Per Lot		
	TN (kg/yr)	TP (kg/yr)	TN or TP specified	R15	R35	R zoning specified
Cats	0.90	0.20	0.20	0.24	**0.16**	0.00
Sml Dogs	2.75	0.70	0.70	**0.12**	**0.16**	0.00
Med Dogs	5.50	1.40	1.40	**0.16**	**0.08**	0.00
Lge Dogs	8.25	2.10	2.10	**0.19**	0.00	0.00

Waste Disposal

	R15	R35	R zoning specified
Lot	35%	0%	0%
POS	6%	**12%**	0%
Bins	59%	88%	0%

Cost Data

Distribution	$1.00	per house
Frequency	2	years
Bag Costs	$2.50	per 100 bags

Cost Calculation

Total Residential Area	-	ha
Total Number of Lots	-	
Area to Apply	-	ha
Number of Lots to Apply	-	
Number of Dogs	-	
Disposing in POS	-	
POS bags per year	-	
Cost of bags per year	$0	
Cost of mailout per year	$0	
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Car Wash

Data Source

Frequency based on JDA Survey (2001)
TN/TP based on Polyglaze Autowash data via CRC for Freshwater Ecology (Canberra)
Cost Estimate via JDA. Distribution cost and frequency is for brochure

Application Rates & Washing Frequency

Car wash detergent			Washing Frequency (one car every x weeks)		
TN kg/wash	TP kg/wash	TN or TP specified	R15	R35	R zoning specified
0.00009	0.00033	0.00033	2	**4.5**	0.00

Cost Data

Distribution	$1.00	per house
Frequency	2	years

Cost Calculation

Number of Lots	-	
Cost of mailout	$0	per year
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Lot Fertiliser

Data Source

Mean Fertiliser Applications via JDA survey (2001)
% garden and lawns estimated via Aerial photography JDA(2001) for various suburbs with similar zonings
Minimum Fertiliser Applications via product recommended application data

Application Rates

	Fertiliser mean application		TN or TP
	kg TN/sqm/yr	kg TP/sqm/yr	specified
Garden	**0.059**	**0.027**	0.02700
Lawn	**0.033**	**0.005**	0.00500

	Fertiliser min application		TN or TP
	kg TN/sqm/yr	kg TP/sqm/yr	specified
Garden	0.010	0.003	0.00300
Lawn	0.009	0.001	0.00100

	Education Campaign Fertiliser Reduction		TN or TP	
	kg TN/sqm/yr	kg TP/sqm/yr	specified	% redn
Garden	0.049	0.024	0.02400	89%
Lawn	0.024	0.004	0.00400	80%

Garden and Lawn Areas

	R15	R35	R zoning specified
% garden	0.11	0.03	0.00
% lawn	0.28	0.07	0.00

Cost Data

Distribution	$1.00	per house
Frequency	2	years

Cost Calculation

Number of Lots	-	
Cost of mailout	$0	per year
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

POS Fertiliser

Data Source

Application rates based on City of Armadale application to active POS areas in years 1996-2000

Application Rates

	Fertiliser mean application		TN or TP
	kg TN/ha POS/yr	kg TP/ha POS/yr	specified
POS	73.4	2.6	2.60

NiDSS Core Data & Cost Calculations

Nutrient Input Decision Support System
Version 2.0 March 2005

Rural Land Use Fertiliser

Data Source Estimates via Gerritse et al (1992) for pasture

Application Rates

	Fertiliser mean application		TN or TP
	kg TN/ha Rural/yr	kg TP/ha Rural/yr	specified
Rural	60	20	20.00

Poultry Farms

Data Source
Estimates via Gerritse (et al) 1992
Based on 14000 hens on 42 ha property

Application Rates

	Fertiliser mean application		TN or TP
	kg TN/ha farm/yr	kg TP/ha farm/yr	specified
Poultry	175	75	75.00

Street Sweeping

Data Source
Street Sweeping Revisited - Nutrients and Metals in Particle Size Fractions of Road Sediment
from two major roads in Perth (Davies & Pierce 1999), Water 99 Joint Congress Brisbane
Cost based on Davies & Pierce (1998), $55/km

Estimated Removal Rate
(assumes no WSUD upstream)

	Potential Reduction (kg/gross ha/yr)		TN or TP	reduction due to upstream WSUD
	TN	TP	specified	
Sweeping	0.75	0.35	0.35	0%

Cost Data

Cost	$55.00	$/km
Frequency	6	times per year

Cost Calculation

Cost	$0	$/gross ha/yr
Area to Apply	0.0	ha
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Note : Street sweeping applied to developed areas only - not existing rural land use areas not to be developed

In-Transit Controls - Stormwater Nutrient Load

Data Source Nutrients in Perth Urban Surface Drainage Catchments Characterised by Applicable Attributes, Tan (1991)

Data Used to Calculate Nutrients in Stormwater Available for Removal by In-Transit Controls
Removal quantities are for no WSUD and are reduced in calcs based on upstream measures used

Estimated Stormwater Nutrient Load
(assumes no WSUD upstream)

Typical Phosphorus Stormwater Load (Perth Urban Areas)	0.40	kg/gross ha/yr
Typical Nitrogen Stormwater Load (Perth Urban Areas)	2.53	kg/gross ha/yr

TN or TP specified
0.40

Gross Pollutant Trap

Data Source
Approximate average retention value via JDA(2001) - GeoTrap Laboratory Test Report
Based on GeoTrap, Humesceptor, Downstream Defender, CDS
Cost of GPT's via CRC report 98/3 (Allison, Chiew and McMahon) April 1998

Estimated Removal Rate

	Percentage Removal		TN or TP
	TN	TP	specified
GPT	35%	50%	50%

Cost Data

Capital Cost	$1,880	per ha
Maintenance	$72	per ha/year

Cost Calculation

Area to Apply	0.0	ha
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Note : GPT's applied to developed areas only - not existing rural land use areas not to be developed

Water Pollution Control Pond

Data Source
TP removal efficiency and cost via Henley Brook Drive WPCP Conceptual Design (JDA,1997)
TN efficiency via Managing Urban Stormwater Treatment Techniques (NSW EPA 1997)

Estimated Removal Rate

	Percentage Removal		TN or TP
	TN	TP	specified
WPCP	35%	50%	50%

Cost Data

Capital Cost	$1,800,000	
Maintenance	$25,000	per year
Removal	34	kg TP/year

Cost Calculation

Cost per kg	$3,912	per kg
Removal	0.0	kg/year
Capital Cost	$0	
Operating	$0	
Total PV Cost	$0	

Note : WPCP's applied to developed areas only - not existing rural land use areas not to be developed

NiDSS Nutrient Removal Calculator

Nutrient Input Decision Support System
Version 2.0 March 2005

JDA

Analysis Type Total Phosphorus

Catchment Summary of Nutrient Removal due to Source Controls

Without WSUD 0.00 kg/gross ha/yr via developed area
480 kg/yr

Component	Checkbox Result	% Area to Apply Removal to	Level before Removal	Potential Removal	Adopted Removal (kg/gross ha/yr)
Native Gardens (Lots-Garden)	FALSE	0%	0.00	0.00	0.00
Native Gardens (Lots-Lawn)	FALSE	0%	0.00	0.00	0.00
Native Gardens (POS)	FALSE	0%	0.00	0.00	0.00
Education Campaign - Fertiliser	FALSE	0%	0.00	0.00	0.00
Education Campaign - Pet Waste	FALSE	0%	0.00	0.00	0.00
Education Campaign - Car Wash	FALSE	0%	0.00	0.00	0.00
Street Sweeping	FALSE	0%	0.00	0.00	0.00
Gross Pollutant Traps	FALSE	0%	0.00	0.20	0.00
Water Pollution Control Pond	FALSE	0%	0.00	0.20	0.00

Education Campaign Fertiliser Reduction

	Fertiliser Applied No WSUD kg/gross ha/yr	Removed due to Native Gardens kg/gross ha/yr	Available for further reduction	% applied reduction to min level	education campaign effectiveness	reduction kg/gross ha/yr
Garden	0.00	0.00	0.00	89%	0%	0.00
Lawn	0.00	0.00	0.00	80%	0%	0.00
Road Reserve Minor	0.00	0.00	0.00	80%	0%	0.00
					Total	0.00

Nutrient Removal via In-Transit Controls

Stormwater Load Available for Removal (ie no WSUD) 0.400 kg/gross ha/yr

	reduction due to WSUD upstream	adjusted rate to use
Gross Pollutant Traps	0.00%	0.400
Water Pollution Control Pond	0.00%	0.400

NiDSS : WSUD Option Summary

Nutrient Input Decision Support System
Version 2.0 March 2005

JDA Consultant Hydrologists

Report Date : 17-Jun-08

Catchment Name Lot 2 Nettleton Rd, Byford

Catchment Area 32 ha

Total Phosphorus Input : Summary of Options

								Reduction due to WSUD		Cost of
	Option	Development Input kg/year	Rural Input kg/yr	Total Input kg/yr	WSUD Reduction kg/yr	Net Input kg/yr	Input Rate kg/ha/yr	Overall Reduction %	Development Reduction %	Reduction $/kg/yr
1	Existing Land Use	45	5,882	5,927	0	5,927	17.1	0.0%	0.0%	$0.0
2	Proposed Land Use - No WSUD	5,843	288	6,131	0	6,131	17.7	0.0%	0.0%	$0.0
3	Proposed Land Use - With WSUD	5,843	288	6,131	2,864	3,267	9.4	46.7%	49.0%	$72.5

Total Nitrogen Input : Summary of Options

								Reduction due to WSUD		Cost of
	Option	Development Input kg/year	Rural Input kg/yr	Total Input kg/yr	WSUD Reduction kg/yr	Net Input kg/yr	Input Rate kg/ha/yr	Overall Reduction %	Development Reduction %	Reduction $/kg/yr
1	Existing Land Use	1,270	17,646	18,916	0	18,916	54.7	0.0%	0.0%	$0.0
2	Proposed Land Use - No WSUD	27,258	1,093	28,351	0	28,351	81.9	0.0%	0.0%	$0.0
3	Proposed Land Use - With WSUD	27,258	1,093	28,351	11,709	16,642	48.1	41.3%	43.0%	$19.1

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005
JDA Consultant Hydrologists
Report Date : 17-Jun-08

Lot 2 Nettleton Rd, Byford	
Total Nutrient Input - No WSUD (kg/yr)	**236**
Reduction due to WSUD (kg/yr)	**109**
Percentage Overall Reduction	**46.3%**
Pecentage Development Reduction	**46.3%**
Cost of Selected Program ($/kg/yr)	**$27**

● Total Phosphorus
○ Total Nitrogen

Catchment Name Lot 2 Nettleton Rd, Byford
Option Description Post-Development Scenario with WSUD
Catchment Area 32 ha

Land Use Breakdown

Residential : ~R15	0.0%	lower density residential areas (excludes road reserve area)
Residential : ~R35	53.0%	higher density residential areas (excludes road reserve area)
Road Reserves : Minor	0.0%	maintainance of verge by landowners
Road Reserves : Major	20.0%	maintainance of verge by local authority
POS : Active	15.0%	grassed areas
POS : Passive / Basins	7.0%	native vegetation
Rural : Pasture	0.0%	general pasture
Rural : Residential ~R2.5/R5	0.0%	low density
Rural : Poultry	0.0%	specific high nutient input land use
Commercial/Industrial	5.0%	town centre etc

Total Residential **53.0%**
Total Area **100.0%**

Nutrient Input Without WSUD

Residential	Garden	8.10	kg/net ha/yr	4.29	kg/gross ha/yr	137	kg/yr	58.1%
	Lawn	3.50		1.86		59		25.1%
	Pet Waste	0.00		0.00		0		0.0%
	Car Wash	0.13		0.07		2		1.0%
	Sub Total			6.22		199		84.2%
POS	Garden/Lawn	2.60	kg/ha POS/yr	0.39	kg/gross ha/yr	12	kg/yr	5.3%
	Pet Waste	3.80		0.57		18		7.7%
	Sub Total			0.96		31		13.0%
Road Reserve	Major Roads	1.04	kg/ha RR/yr	0.21	kg/gross ha/yr	7	kg/yr	2.8%
	Minor Roads	20.00		0.00		0		0.0%
	Sub Total			0.21		7		2.8%
Rural	Pasture	20.00	kg/ha Rural/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Poultry Farms	75.00		0.00		0		0.0%
	Residential (R2.5/R5)	4.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
			Total	**7.39**	kg/gross ha/yr	**236**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☑ Native Gardens (Lots - Garden) ☑ Native Gardens (Lots - Lawn) ☑ Native Gardens (POS) ☑ Street Sweeping
☑ Community Education : Fertiliser ☑ Community Education : Pet Waste ☑ Community Education : Car Wash

Education Effectiveness 30%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	50%	2.15	69	29.1%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	30%	0.56	18	7.5%	$0	$0	$0.0
Native Gardens (POS)	50%	0.20	6	2.6%	$0	$0	$0.0
Community Education : Fertiliser	30%	0.27	8	3.6%	$0	$89	$10.5
Community Education : Pet Waste	30%	0.05	2	0.7%	$0	$131	$79.9
Community Education : Car Wash	30%	0.01	0	0.1%	$0	$89	$437.1
Street Sweeping	100%	0.20	6	2.7%	$0	$2,640	$417.3
Totals		**3.42**	**109**	**46.3%**	**$0**	**$2,949**	**$27.0**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	0%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	0%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input : Residential Area without WSUD	7.39	236	100.0%			
Nutrient Input : Rural Area	0.00	0	0.0%			
Removal via Source Control	3.42	109	46.3%	$0	$2,949	$27.0
Removal via In-Transit Control	0.00	0	0.0%	$0	$0	$0.0
Total Removal	3.42	109	46.3%	$0	$2,949	$27.0
Net Nutrient Input	**3.97**	**127**	**53.7%**			

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005
JDA Consultant Hydrologists
Report Date : 17-Jun-08

Lot 2 Nettleton Rd, Byford	
Total Nutrient Input - No WSUD (kg/yr)	**1,306**
Reduction due to WSUD (kg/yr)	**495**
Percentage Overall Reduction	**37.9%**
Pecentage Development Reduction	**37.9%**
Cost of Selected Program ($/kg/yr)	**$6**

○ Total Phosphorus

● Total Nitrogen

Catchment Name	Lot 2 Nettleton Rd, Byford	
Option Description	Post-Development Scenario with WSUD	
Catchment Area	32	ha

Land Use Breakdown

Residential : ~R15	0.0%	lower density residential areas (excludes road reserve area)		
Residential : ~R35	53.0%	higher density residential areas (excludes road reserve area)		
Road Reserves : Minor	0.0%	maintainance of verge by landowners		
Road Reserves : Major	20.0%	maintainance of verge by local authority		
POS : Active	15.0%	grassed areas		
POS : Passive / Basins	7.0%	native vegetation		
Rural : Pasture	0.0%	general pasture		
Rural : Residential ~R2.5/R5	0.0%	low density	Total Residential	**53.0%**
Rural : Poultry	0.0%	specific high nutient input land use	Total Area	**100.0%**
Commercial/Industrial	5.0%	town centre etc		

Nutrient Input Without WSUD

Residential	Garden	17.70	kg/net ha/yr	9.38	kg/gross ha/yr	300	kg/yr	23.0%
	Lawn	23.10		12.24		392		30.0%
	Pet Waste	0.00		0.00		0		0.0%
	Car Wash	0.04		0.02		1		0.0%
	Sub Total			21.64		693		53.0%
POS	Garden/Lawn	73.40	kg/ha POS/yr	11.01	kg/gross ha/yr	352	kg/yr	27.0%
	Pet Waste	15.20		2.28		73		5.6%
	Sub Total			13.29		425		32.6%
Road Reserve	Major Roads	29.36	kg/ha RR/yr	5.87	kg/gross ha/yr	188	kg/yr	14.4%
	Minor Roads	132.00		0.00		0		0.0%
	Sub Total			5.87		188		14.4%
Rural	Pasture	60.00	kg/ha Rural/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Poultry Farms	175.00		0.00		0		0.0%
	Residential (R2.5/R5)	15.20		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
			Total	**40.80**	kg/gross ha/yr	**1,306**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☑ Native Gardens (Lots - Garden) ☑ Native Gardens (Lots - Lawn) ☑ Native Gardens (POS) ☑ Street Sweeping

☑ Community Education : Fertiliser ☑ Community Education : Pet Waste ☑ Community Education : Car Wash

Education Effectiveness 30%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	50%	4.69	150	11.5%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	30%	3.67	118	9.0%	$0	$0	$0.0
Native Gardens (POS)	50%	5.51	176	13.5%	$0	$0	$0.0
Community Education : Fertiliser	30%	0.91	29	2.2%	$0	$89	$3.1
Community Education : Pet Waste	30%	0.21	7	0.5%	$0	$131	$20.0
Community Education : Car Wash	30%	0.00	0	0.0%	$0	$89	$1,602.6
Street Sweeping	100%	0.47	15	1.2%	$0	$2,640	$173.8
Totals		**15.46**	**495**	**37.9%**	**$0**	**$2,949**	**$6.0**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	0%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	0%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input : Residential Area without WSUD	40.80	1,306	100.0%			
Nutrient Input : Rural Area	0.00	0	0.0%			
Removal via Source Control	15.46	495	37.9%	$0	$2,949	$6.0
Removal via In-Transit Control	0.00	0	0.0%	$0	$0	$0.0
Total Removal	15.46	495	37.9%	$0	$2,949	$6.0
Net Nutrient Input	**25.34**	**811**	**62.1%**			

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