

## **CIVIL ENGINEERING SERVICES**

# **Tower B, St Leonards: Stage 2 Design and Construction – Medical Specialist Suites and Associated Allied Health Uses Development Application Report**





## DOCUMENT CONTROL

01	5 <sup>th</sup> December 2017	Development Application
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## APPROVALS

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# CIVIL ENGINEERING SERVICES

## 1. INTRODUCTION

Warren Smith and Partners (WS+P) has been engaged by Savills to prepare a development application report for the Tower B, St Leonards: Stage 2 Design and Construction - Medical Specialist Suites and Associated Allied Health Uses. This report outlines a stormwater strategy plan associated with the proposed development at St Leonards. This report aims to address the following: -

- Proposed On-site Detention (OSD) and stormwater drainage works;
- Existing and proposed connections to Council drainage;
- Water quality requirements and proposed treatment system, and;
- Sediment and erosion control.

### 1.1 BACKGROUND

The existing site is located at 1 Westbourne Street, St Leonards, NSW, approximately 8km north of the Sydney CBD. The development site is bound by Westbourne Street to the south, Reserve Road to the west, Frederick Street to the north and commercial properties to the east. Please refer to Figure 1 below which shows the extent of the development site area in which the proposed works will be carried out.

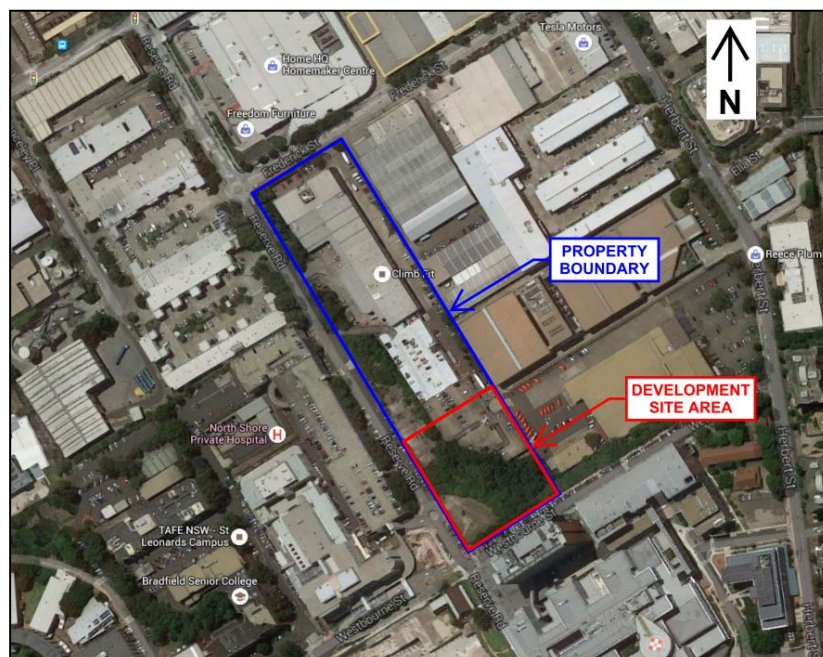


Figure 1: Aerial View of Development Site Area (Source: Google Earth)

## 2. EXISTING STORMWATER INFRASTRUCTURE

A site inspection was carried out in order to determine the existing drainage infrastructure within the development site. The inspection revealed the following: -

- The development area grades in a northerly direction. The southern section of the development area grades at approximately 8.8% towards an embankment which grades towards the existing warehouse building at a steeper grade of approximately 54%.
- An existing drainage channel runs along the south of the warehouse in an east to west direction. This channel has a number of existing stormwater pits which reticulate from the western corner of the development area in a north westerly direction to connect into the existing stormwater system in Frederick Street.
- Another existing pit and pipe system also runs from the northern corner of the development area in a north westerly direction to connect into the existing stormwater system in Frederick Street.

Please refer to Figure 2 below for an illustration of the site grading and the location of the existing stormwater infrastructure.

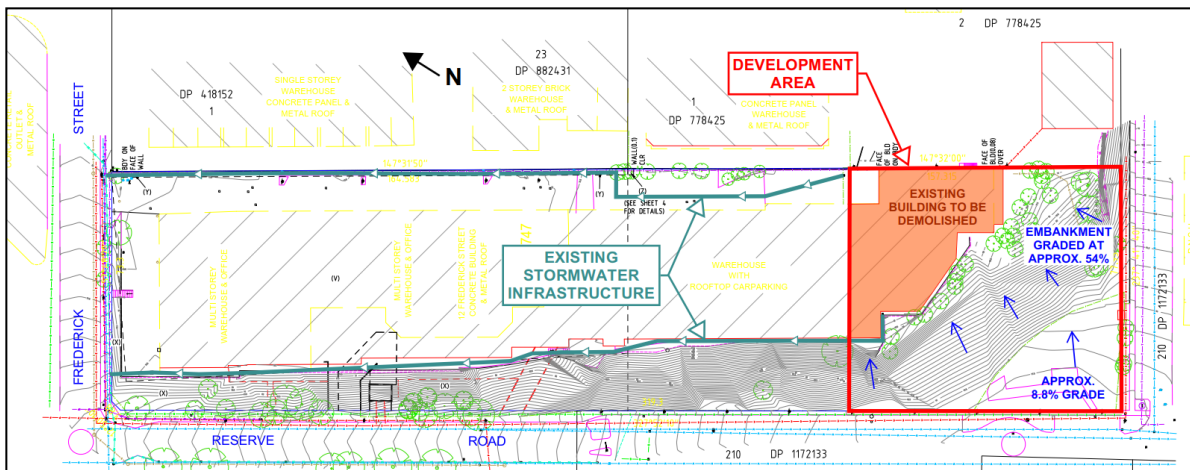


Figure 2: Survey of Property and Development Area

### 3. AUTHORITY AND REGULATORY REQUIREMENTS

#### 3.1 WILLOUGHBY CITY COUNCIL

With reference to the *Willoughby City Council Development Control Plan (DCP)*, dated 21 August 2006, the council requirements are as follows: -

##### 3.1.1 STORMWATER DRAINAGE AND ON-SITE DETENTION (OSD) REQUIREMENTS

- All stormwater drainage pipe systems must be designed in accordance with the Willoughby City Council DCP *Attachment 19 Stormwater Design Elements*.
- OSD and permissible site discharge (PSD) calculations shall be in accordance with Table 1 and Table 2 from the Willoughby City Council DCP *Attachment 20 On-Site Detention Technical Standard No. 1*.
- An overland flow route shall be provided and must be capable of carrying flows for a 1 in 100 year ARI storm event.
- A minimum freeboard of 300mm must be provided to all habitable floor levels above the maximum design storage water surface level.

##### 3.1.2 WATER SENSITIVE URBAN DESIGN (WSUD) REQUIREMENTS

The stormwater treatment objectives set out in the Willoughby City Council DCP *Attachment 24 Water Quality Technical Standard No. 5* are presented in Table 1 below.

**Table 1: Water Quality Requirements**

Pollutant Type	Target Reduction Percentage (%)
Gross Pollutants	70%
Total Suspended Solids	80%
Total Phosphorus	45%
Total Nitrogen	45%

## 4. PROPOSED STORMWATER DRAINAGE SYSTEM

The development site has a total catchment area of approximately 0.6194 Ha. The breakdown of the proposed catchment is presented in Table 2 below.

**Table 2: Breakdown of Total Site Catchment**

Catchment Areas	Area (Ha)	Percentage of Total Area (%)
Roof	0.4040	65.2
Driveways and Open Space	0.1912	30.9
Western Bypass Area	0.0242	3.9
<b>Total</b>	<b>0.6194</b>	<b>100</b>

### 4.1 PROPOSED DRAINAGE SYSTEM

It is proposed that a total area of 0.5952 Ha will capture rainfall and reticulate to the OSD tank located below the lower ground carpark in Basement 5. This area includes the roof and the driveways.

The remaining area totalling 0.0242 Ha, located along the western side of the proposed development, will bypass the stormwater drainage and OSD system and discharge on to Reserve Road. The bypass amounts to 3.9% of the total development area which is classed as minimal.

It is proposed that the OSD tank will have a total volume capacity of 237.6kL. The stormwater drainage and OSD systems have been designed in accordance with AS3500.3: 2015 and the Willoughby City Council requirements.

## 4.2 ON-SITE DETENTION & PERMISSIBLE SITE DISCHARGE

The required on-site detention (OSD) volume and permissible site discharge (PSD) have been calculated in accordance with the Willoughby City Council's DCP, August 2006, *Attachment 20, OSD Technical Standard No.1*. Please refer to *Schedule 1* for the Willoughby City Council OSD Checklist.

### 4.2.1 OSD CALCULATION

The proposed development area has a total site area of approximately 6,194 m<sup>2</sup>.

The minimum volume of OSD storage has been calculated to be approximately 235.37 m<sup>3</sup> and is in accordance with the OSD Technical Standard, *Table 1 – Site Storage Requirements per impervious area*. Please refer to Table 3 below for a summary of the OSD calculation.

**Table 3: Option A - OSD Calculations**

Zone	Volume of Storage Required per Cubic Metre (m <sup>3</sup> /100m <sup>2</sup> )	Area of Site (m <sup>2</sup> )	OSD Volume Required (m <sup>3</sup> )
3	3.8	6,194	235.37

### 4.2.2 PSD CALCULATION

The PSD has been calculated to be approximately 111 L/sec and is in accordance with the OSD Technical Standard, *Table 2 – Permissible Site Discharge per impervious area*. Please refer to Table 4 below for a summary of the PSD calculation.

**Table 4: Option A - PSD Calculations**

Zone	Permissible Site Discharge per Cubic Metre (L/sec/Ha)	Area of Site (Ha)	Maximum PSD (L/sec)
3	180	0.6194	111.49

The proposed OSD tank will be constructed with a sediment sump and a trash screen located immediately upstream of the outlet pipe. It is proposed that a minimum area of 0.60m x 0.60m and a minimum depth of 0.2m below the invert level of the outlet pipe will be provided for the sediment sump.

### 4.3 CONNECTION TO EXISTING DRAINAGE

It is proposed that stormwater will be discharged from the OSD tank, via a 226mm diameter orifice. The orifice size was calculated using the following equation.

$$\text{Orifice Dia. (mm)} = 21.8 \times \sqrt{(\text{PSD} / (\sqrt{\text{Head of Water (m) over the centreline of the orifice}}))}$$

$$\text{Orifice Dia. (mm)} = 21.8 \times \sqrt{(111 / (\sqrt{1.07}))}$$

$$\text{Orifice Dia. (mm)} = 225$$

The discharge released through the orifice plate will reticulate via a new pit and pipe system. This pit and pipe system will reticulate through the adjacent property to the north of the development site, to connect into existing Council drainage infrastructure in Frederick Street. Please refer to the WS+P DA Drawing Package for further details. The new pit and pipe system has been designed to cater for the uncontrolled flows emanating from the development during the 1% AEP storm event, as required by DA Condition.

### 4.4 FLOODING ASSESSMENT

With reference to the WS+P letter, dated 21 December 2016, an overland flow path study was undertaken by Lyall and Associates to assess the patterns of overland flow paths within the vicinity of No. 12 Frederick Street. A total of three (3) HEC-RAS models were undertaken to assess the depth of flooding that would occur along the roads that border the property, specifically: -

- Reserve Road West;
- Reserve Road East (which extends along the southern side of Frederick Street), and;
- Westbourne Street

The findings of this study concluded that all overland flow would be contained within the road reserve and therefore not discharge into the property for storm events up to, and including, the 1% AEP storm event. Please refer to *Schedule 2* for the WS+P letter and Lyall and Associates overland flow study.

### 4.5 FREEBOARD

As per the Lyall and Associates flood information provided in Schedule 2, the maximum probable flood levels adjacent to the site vary between 95.50 mAHD and 97.31 mAHD from north-west to south-east along Reserve Road East, and 92.59 mAHD and 97.11 mAHD from north east-to south-west along Westbourne Road. The commercial areas within the development have been designed with a minimum floor level of 98.05 mAHD, thus allowing for the 0.3m freeboard tolerance required as per Willoughby City Council requirements.

## 5. WATER QUALITY MANAGEMENT

In order to follow Willoughby City Council requirements for the adequate treatment of stormwater runoff, treatment solutions have been provided to remove suspended solids and nutrients prior to being discharged from site.

### 5.1 POTENTIAL POLLUTANTS GENERATED

The pollutants that could be potentially generated as a result of the development use are as follows:-

- Litter;
- Sediment; and,
- Nutrients (Nitrogen and Phosphorus)

The development has been modelled to demonstrate the performance of the stormwater treatment system utilising a program called MUSIC (Model for Urban Stormwater Improvements Conceptualisation). MUSIC models the proposed stormwater treatment devices and estimates their respective performance against the performance targets of the project. The pollutants modelled in MUSIC are Gross Pollutants, Total Suspended Solids (TSS), Total Phosphorus (TP) and Total Nitrogen (TN).

### 5.2 RAINFALL

The rainfall data used in the MUSIC model was based on the Bureau of Meteorology data and is presented in Table 5 below.

**Table 5: Rainfall Data for MUSIC Modelling**

Rainfall Station	Rainfall Period	Rainfall Period Dates	Time Step
Sydney Observatory 066062	5 Years	1 Jan 1981 – 31 Dec 1985	6 minutes

The average potential evapotranspiration (PET) data used in the MUSIC model was based on the average Sydney PET and is presented in Table 6 below.

**Table 6: Monthly Evapotranspiration Data for MUSIC Modelling**

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PET (mm)	180	135	128	85	58	43	43	58	88	127	152	163

### 5.3 RAINFALL RUNOFF PROPERTIES

In accordance with the Draft NSW MUSIC Modelling Guidelines, dated August 2010, the following Table 7 and Table 8 presents the rainfall runoff properties which have been used in the MUSIC model.

**Table 7: MUSIC Rainfall Runoff Properties**

Parameter	Unit	Value
<b>Impervious Area Parameters</b>		
Rainfall Threshold	mm	1.0 (for roads/paths etc.) 0.3 (for roofs)
<b>Pervious Area Parameters</b>		
Soil Storage Capacity	mm	120
Initial Storage Capacity	%	25
Field Capacity	mm	80
Infiltration Capacity co-efficient a		200
Infiltration Capacity co-efficient b		1.0
<b>Groundwater Properties</b>		
Initial depth	mm	10
Daily recharge rate	%	25
Daily base seepage rate	%	5
Daily seepage rate (%)	%	0

**Table 8: Pollutant Concentration Parameters for MUSIC Source Nodes**

Land Use Category		Concentration (mg/L-log <sub>10</sub> )					
		Total Suspended Solids		Total Phosphorus		Total Nitrogen	
		Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow
General Urban (incl public open space)	Mean	2.43	1.20	-0.30	-0.85	0.34	0.11
	Standard Deviation	0.32	0.17	0.25	0.19	0.19	0.12
Roofs	Mean	1.30	*	-0.89	*	0.30	*
	Standard Deviation	0.32	*	0.25	*	0.19	*

\*Base flows are only generated from pervious areas; therefore these parameters are not relevant to impervious areas.

## 5.4 MUSIC MODEL CATCHMENT AREA

The MUSIC model's total catchment area to be treated is 5,952m<sup>2</sup>, with the remaining area of 242m<sup>2</sup> bypassing the treatment system. Please refer to Figure 3 below for an illustration of the extent of the MUSIC model catchment areas.

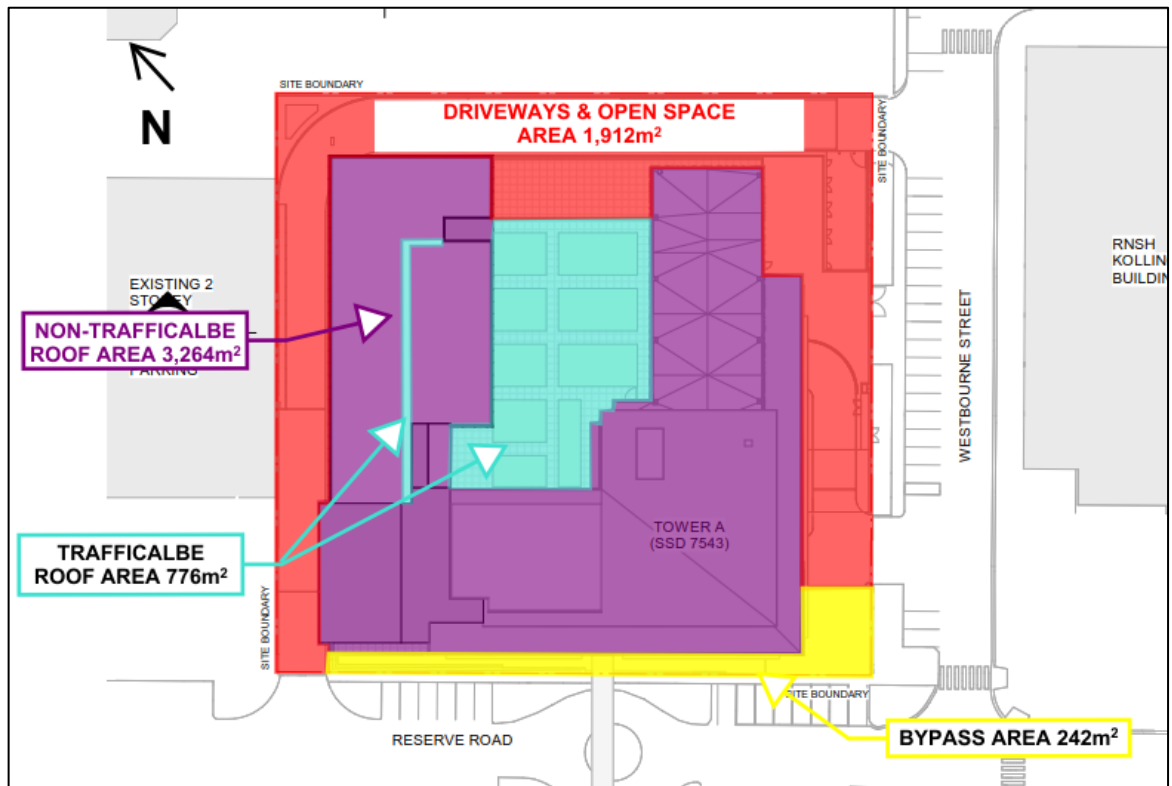
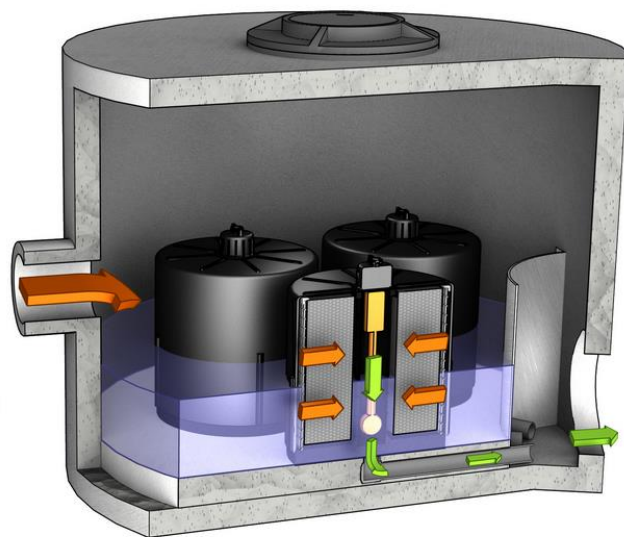


Figure 3: Extent of MUSIC Model Catchment

## 5.5 RAINWATER TREATMENT PLAN

It is proposed that the stormwater discharge from the development site will pass through a treatment system in order to provide treatment to the stormwater runoff prior to it entering the existing stormwater system.

It is proposed that twenty-seven (27) Psorb Stormfilter cartridges, supplied by Stormwater 360, be installed within the OSD to provide treatment to the stormwater. A Psorb Stormfilter cartridge system is provided to remove any suspended sediments and nutrients which have entered the stormwater system, please refer to Figure 4 below for an illustration of a typical Psorb Stormfilter.



**Figure 4: Typical Psorb Stormfilter**

## 5.6 MUSIC RESULTS

The stormwater quality treatment system has been modelled using the MUSIC software, please see Figure 5 below for the treatment plan.

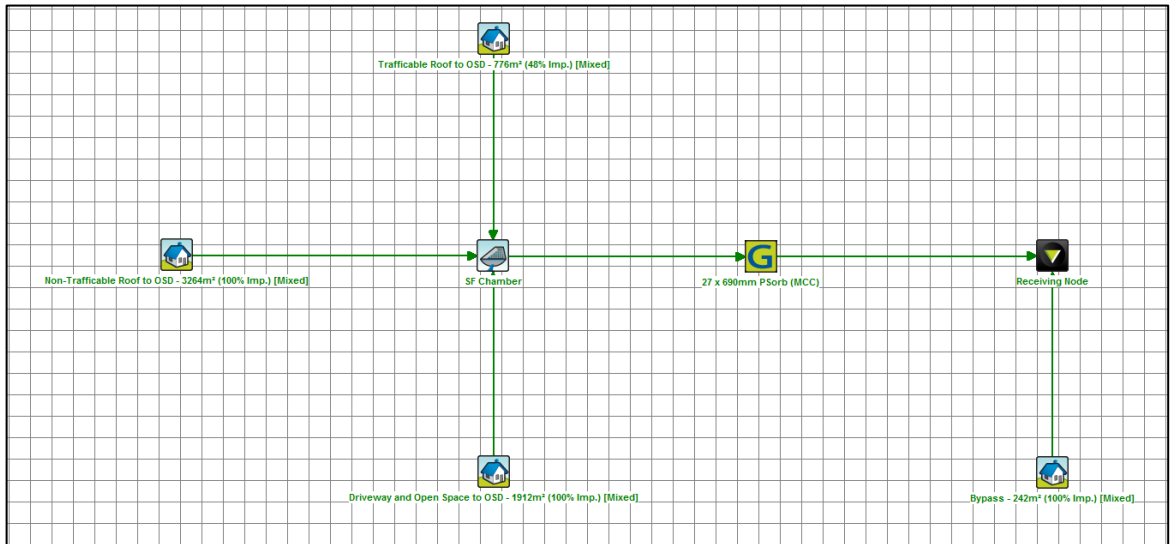


Figure 5: MUSIC Model Treatment Plan

Please refer to *Schedule 3* for the MUSIC results and Table 9 below for a summary of the results.

Table 9: Percentages Based Load Reduction in Pollutant Results

Pollutant Type	Source (kg/yr)	Residual Load (kg/yr)	Reduction % Achieved	Willoughby City Council Target Reduction %
Gross Pollutants	175	6.71	96.2	70%
Total Suspended Solids	1170	233	80	80%
Total Phosphorus	2.45	0.612	75	45%
Total Nitrogen	16.3	8.09	50.2	45%

## 6. SEDIMENT AND EROSION CONTROL

The Contractor for the works is required to provide Sedimentation and Erosion Control in accordance with the general requirements outlined below.

### 6.1 SITE PROTECTION MEASURES

It is proposed to provide the following in order to inhibit the movement of sediment off the site during the demolition and construction phases.

#### 6.1.1 SITE ACCESS

Construction vehicles leaving the site shall be required to pass over a Temporary Construction Vehicle Entry consisting of a 1.5m long by 3m wide 'cattle rack'.

#### 6.1.2 SEDIMENT CONTROL

All exposed earth areas where it may be possible for runoff to transport silt down slope shall be protected with a sediment and erosion control silt fence generally installed along the boundaries of the site.

The fence will be constructed in accordance with details provided by the Department of Conservation and Land Management incorporating geotextile fabric which will not allow suspended particles greater than 50mg/L non-filterable solids to pass through, and as such comply with the appropriate provisions of the Clean Waters Act 1970.

The construction of the silt fence will include the following: -

- Geotextile fabric buried to a maximum of 100mm below the surface;
- Overlapping any joins in the fabric;
- Turning up on the ends for a length of 1 metre in order to prevent volumes of suspended solids escaping in a storm event;
- Any Council owned road kerb entry and or gully pits will be protected by Atlantis Filter Bales and EcoSock. Additional protection will be provided by inserting Water Clean Filter Cartridges into the gully opening, and;
- Internal site drainage pits shall be protected by Sediment Traps consisting of hay bales.

### 6.1.3 TEMPORARY STORMWATER SYSTEM (WHERE REQUIRED)

Site runoff within the zones of the excavation will be drained into a central holding well within the excavation. Runoff will be allowed to settle out suspended particles and debris, and an acceptable water of 50mg per litre of Non Filterable Residues (NFR) is required to be achieved prior to discharge.

### 6.1.4 DUST CONTROL

The following dust control procedures will be adhered to:

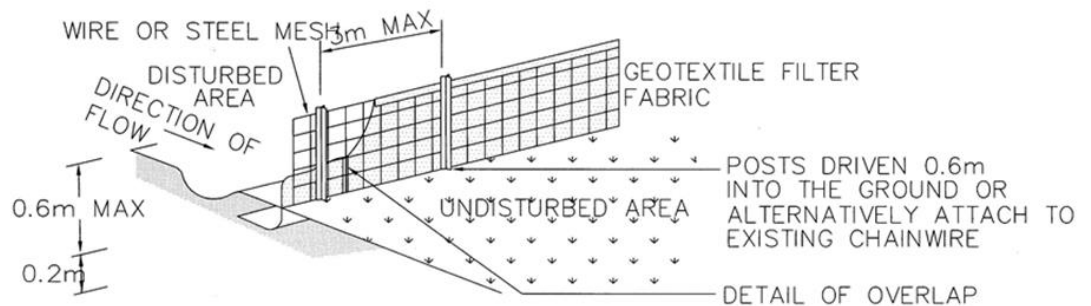
- Loose loads entering or leaving the site will be securely covered by a tarpaulin or like material in accordance with RMS and local Council Guidelines.
- Soil transport vehicles will use the single main access to the site.
- There will be no burning of any materials on site.
- Water sprays will be used across the site to suppress dust. The water will be applied either by water sprinklers or water carts across ground surfaces whenever the surface has dried out and has the potential to generate visible levels of dust either by the operation of equipment over the surface or by wind. The watercraft will be equipped with a pump and sprays.
- Spraying water at the rate of not less than three (3) L/s and not less than 700kPa pressure. The area covered will be small enough that surfaces are maintained in a damp condition and large enough that runoff is not generated. The water spray equipment will be kept on site during the construction of the works.
- During excavation all trucks/machinery leaving the site will have their wheels washed and/or agitated prior to travelling on Council Roads.
- Fences will have shade cloth or similar fabric fixed to the inside of the fence.

### 6.1.5 MAINTENANCE

- It will be the responsibility of the site foreman for the building contractor to ensure sediment and erosion control devices on site are maintained. The devices shall be checked daily and the appropriate maintenance undertaken as necessary.
- Prior to the closing of the site each day, the road shall be swept and materials deposited back onto the site.
- Gutters and roadways will be kept clean regularly to maintain them free of sediment.

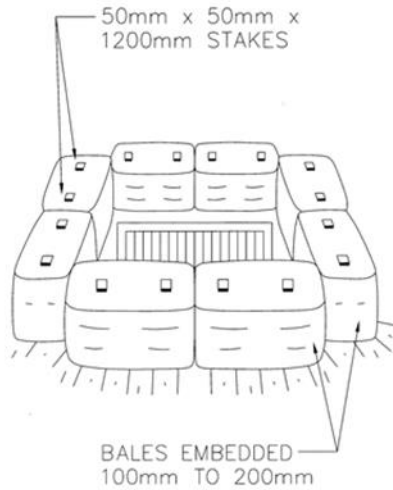
- Appropriate covering techniques, such as the use of plastic sheeting will be used to cover excavation faces, stockpiles and any unsealed surfaces;
- If dust is being generated from a given surface, and water sprays fail;
- If fugitive emissions have the potential to cause the ambient air quality to foul the ambient air quality;
- The area of soils exposed at any one time will be minimised wherever possible by excavating in a localised progressive manner over the site; and,
- Materials processing equipment suitable comply with regulatory requirements. The protection will include the covering of feed openings with rubber curtains or socks.

It is considered that by complying with the above, appropriate levels of protection are afforded to the site and the adjacent public roads, footpaths and environment.



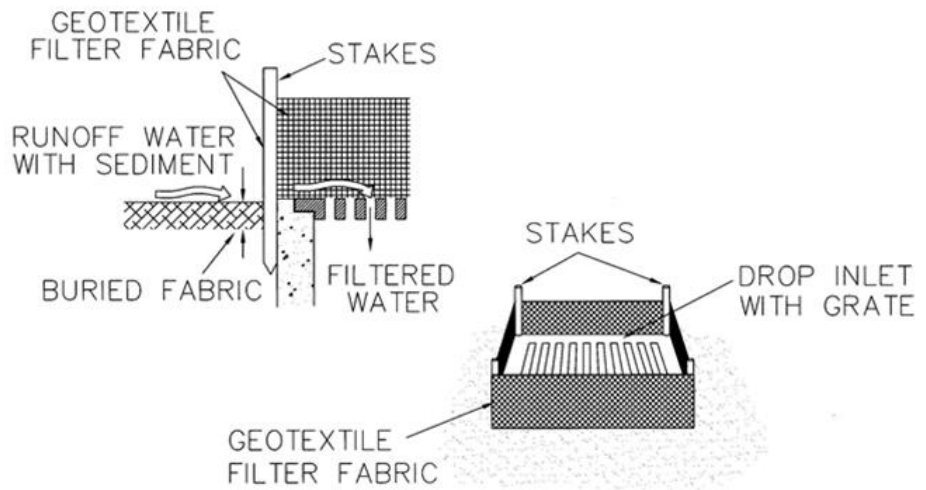
## SEDIMENT CONTROL FENCE

NTS



STORMWATER PIT  
SEDIMENT TRAP

NTS



GEOTEXTILE FILTER FABRIC DROP INLET  
SEDIMENT TRAP

NTS

## Atlantis Sediment Control Filter Bales



### What are FilterBales?

Water Clean FilterBales are a unique new patented 7 stage sediment filter device developed to substantially reduce the migration of sediment and contaminants into drainage systems while allowing filtered water to easily pass through. FilterBales reduce customers' time and money by providing solutions to comply with environmental and regulatory requirements.

#### ***Durable, Dependable, Reusable.***

Replacing hay bales and other inadequate attempts to stop sediment run-off, FilterBales are durable and re-useable, effectively stopping your money from "pouring down the drain". They are also lightweight and easy to handle. Replaceable Water Clean Filter Cartridges guarantee peak performance is maintained.

Ask your local FilterBales stockist about replacement frequencies in your area. Cartridges and filter covers should be changed when the infiltration rate decreases. Water Clean FilterBales are suitable for a wide range of sediment and water management situations and can be easily secured in place for long term use. The unique multi-directional filter system allows you to position Water Clean FilterBales in any direction without reducing performance.




Water Clean FilterBales can be fixed to concrete or bitumen surfaces using an epoxy mortar-binder or fixed to earth surfaces using 6-10 mm pegs or stakes. When positioning, the side with the red reflective marker should be facing traffic.





[www.atlantiscorp.com.au](http://www.atlantiscorp.com.au) 

1. **FilterBales frames** are a perforated plastic structure made from recycled wheelie bins, battery cases, milk bottles etc.
2. **Filter medium** (bio engineered soil media) used in the filter cartridges is made from a special blend of recycled organic (RO) materials from kerbside and vegetation drop off centres. The RO hosts enhanced naturally occurring micro-organisms. The blend also contains natural minerals to capture nutrients. The filter medium is as safe as normal soil.
3. **FilterBales** have a seven (7) stage filtration system:
  1. In through the filter bag
  2. Through the perforated plastic structure wall
  3. In through the filter cartridge bag
  4. Through the bio engineered filter medium
  5. Out through the filter cartridge bag
  6. Out through the perforated plastic structure wall
  7. Out through the filter bag
4. **The filter bag** is made from 300-micron (one third of a millimetre) pore size geotextile. This is the first stage that filters much of the sediment and other suspended solids from the run-off water. The geotextile is designed to stop sediment and reduce clogging but allow water to pass through easily. The filter cartridge bags are made from a similar geotextile.
5. **FilterBales** work effectively up to "a one-in-one-year 48 hours, 100 mm "storm events". This is the largest storm event experienced since the commercialisation of FilterBales. Having handled this easily, Filter Bales are considered capable of handling much greater "storm events". During these storm events FilterBales were used inside gully pits in one application and on the ground surrounding the gully pit in another application.
6. **EcoSocks** are made from a similar geotextile to the filter cartridge bags and contain the same bio engineered soil media as the FilterBales. They appear able to stand up to as much wear and tear as a sandbag.
7. **FilterBales** are much lighter (at around 15 kgs dry weight) than hay bales. This reduces exposure to Occupational Health and Safety problems

### Product Range

Item No.	Description	
HFB001	<b>High FilterBale</b> , suitable for high flow situations and higher retention time applications. Contains two standard size WaterClean Filter Cartridges in upright formation to treat contaminated waters. (605mm x 485mm x 460mm)	
LFB002	<b>Low FilterBale</b> , suitable for low flow situations and kerb & gutter applications. Multi-directional module containing two standard size WaterClean Filter Cartridges. (605mm x 485mm x 220mm)	
ESF004	<b>Directional EcoSock</b> , can be used in conjunction with FilterBales to direct water. Will also provide some sediment filtration from seepage through bio-remediating media contained within the EcoSock (1135mm x 160mm x 30mm)	

### Accessories

Item No.	Description	
FCR004	<b>WaterClean Filter Cartridges</b> contain a unique blend of fixating and bio-remediating products that treat common pollutants. To achieve maximum performance, each FilterBale uses two WaterClean Filter Cartridges. (440mm x 400mm x 100mm)	
HBC005 (High bale)	<b>Replaceable FilterBale covers</b> , made from specially designed geotextile. FilterBale covers have a standard aperture of 300 microns.	
HBC006 (Low bale)	<b>Replaceable FilterBale covers</b> , made from specially designed geotextile. FilterBale covers have a standard aperture of 300 microns.	

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V3-20/06/01

# SCHEDULE 1 – WILLOUGHBY CITY COUNCIL OSD CHECKLIST

## APPENDIX F

### WILLOUGHBY CITY COUNCIL

#### OSD DESIGN CHECKLIST

- |     |   |   |
|-----|---|---|
| 1.  | Has an overland flow route been provided?   | <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No |
| 2.  | Has the minimum freeboard been provided between habitable floor levels and the 1:100yr flood level? Refer to Section 10 of Council's Floodplain Management - Technical Standard No. 3 for information regarding freeboard requirements. | <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No |
| 3.  | Has a minimum of 300mm freeboard been provided between the habitable floor levels and the OSD design storage top water level?   | <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No |
| 4.  | For above ground storage maximum depths   |   |
|     | • over driveways and carparking   | N/A Mm  |
|     | • over landscaping or garden areas  | N/A Mm  |
|     | • minimum below ground storage  | N/A cu.m  |
| 5.  | Below ground OSD tanks must be accessible for maintenance purposes in accordance with AS 2865 – Safe Working in Confined Spaces.  |   |
|     | • Have step irons been provided for tanks deeper than 900mm?  | <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No |
|     | • Have 2 x 600mm x 900mm access grates been provided?   | Yes   |
| 6.  | Total impervious area including driveways, carports, pathways and swimming pools not incorporating high-level overflow system.  | 6,194 sq.m  |
| 7.  | Existing and proposed surface levels and contours have been provided (contours extend 5m beyond property boundary)  | <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No |
| 8.  | Location of all trees has been provided.  | <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No |
| 9.  | Calculated volume of storage according to Table 1.  | 235.37 cu.m   |
| 10. | Calculated permissible site discharge according to Table 2.   | 111.49 l/s  |
| 11. | Calculated orifice diameter (65mm minimum).   | 226 Mm  |
| 12. | Type of mesh screen provided?   | Maxi Mesh RH3030  |
| 13. | Details of an overflow spillway and overland flowpath have been provided?   | <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No |
| 14. | Direct connections to Council's drainage system have been checked against backwater effect?   | <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No |
| 15. | Is the base of the OSD tank graded flush with the orifice invert level?   | <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No |
| 16. | Has a minimum 125mm x 75mm RHS been provide for discharge through the street kerb?  | Yes/No/N/A  |
| 15. | All levels have been given to Australian Height Datum (AHD)   | <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No |

Design Engineer



Date 30/11/2017

Qualifications: [BEng in Civil & Transportation Engineering, 2011](#) and [BEng in Civil Engineering, 2009](#). TMIEAust No. 4449809

# SCHEDULE 2 – OVERLAND FLOW PATH STUDY

Tuesday, 21st December 2016



35 YEARS OF SERVICE

**Attention: Mr Mick O'Driscoll**

Donald Cant Watts Corke (NSW) Pty Ltd  
Level 1 14 Martin Place  
Sydney, NSW 2000

Project No. 2016-5320001

Dear Mick,

**RE: North Shore Private Hospital – 12 Frederick Street, St. Leonards  
DA-2016/211 – Stormwater Management**

Warren Smith & Partners has drafted this letter in response to Willoughby City Council's (Council) letter, dated 10<sup>th</sup> August 2016, in relation to the subject property. The items to be addressed are on-site detention (OSD) and overland flow as follows.

**1. ON-SITE DETENTION**

As it is intended to subdivide the site into two (2) lots, Council state that pursuant to Part C5 of Council's DCP and Technical Standards, an OSD system is required to be provided.

**1.1 LOT 1**

With reference to a meeting held with Council on 26<sup>th</sup> August 2016, it was noted that on-site detention (OSD) has been designed for the development within the Lot 1 sub-division and will be provided in the upcoming development application in accordance with Council's DCP and Technical Standards. Please find attached the following items: -

1. An extract from the development application report detailing the proposed OSD system for Lot 1, and;
2. Development application drawings C4.01 and C4.03 which provide further details on the proposed OSD system.

**1.2 LOT 2**

In relation to the Lot 2 sub-division, it was agreed that OSD requirements would be addressed by providing a concept OSD plan and that Council will consider and advise if a bond can be put in place in lieu of OSD. It was proposed that a bond be provided for a 3 to 5 year period and if the subdivision was not developed during this time, an OSD would subsequently be provided. Please find attached the following items: -

1. Lot 2 concept OSD calculations, and;
2. Concept sketch SK-01 illustrating an indicative layout for the OSD tank.

**Warren Smith & Partners Pty Ltd** Consulting Engineers **ABN** 36 300 430 126

**A** 1st Floor, 123 Clarence Street, Sydney 2000 NSW Australia **T** 02 9299 1312 **F** 02 9290 1295 [wsp@warrensmith.com.au](mailto:wsp@warrensmith.com.au) [www.warrensmith.com.au](http://www.warrensmith.com.au)

■ Hydraulic Services ■ Fire Protection ■ Civil Engineering ■ Sydney Water Accredited Water Servicing Co-ordinator - Design Project Management - Building Plan Approvals

## 2. OVERLAND FLOW

In order to protect the private property from damage by any potential overland flow, Council has requested that an overland flowpath study be undertaken. Lyall & Associates (Lyall) has undertaken an overland flowpath study to assess patterns of overland flow in the vicinity of No. 12 Frederick Street.

A DRAINS model was used to assess the capacity of the existing piped drainage system and to determine the magnitude of surcharge flow for storms up to the 1% AEP storm event. HEC-RAS modelling software was used to assess the depth at which the stormwater which surcharges the existing piped system will be conveyed in the roads that border the property. Please refer to the Lyall Overland Flowpath Study attached.

A total of three (3) HEC-RAS models were undertaken as follows: -

- Reserve Road West
- Reserve Road East which extend along the south side of Frederick Street
- Westbourne Street

Please refer to Figure 2 in the Lyall study for a plan illustrating the above HEC-RAS models.

### 2.1 HYDRAULIC MODELLING RESULTS

A summary of the key findings of the investigation area are as follows: -

#### RESERVE ROAD WEST

- Overland flow does not overtop the crown of the road and contribute to flow along the eastern side of Reserve Road.

#### RESERVE ROAD EAST

- As the overland flow along the western side of Reserve Road does not surcharge to the eastern side for storm events up to the 1% AEP, flow along the eastern kerbline of Reserve Road is generated entirely by the 0.3 Ha catchment shown in Figure 1 of the Lyall study.
- Depths of overland flow along the eastern kerbline of Reserve Road are not sufficient to surcharge the road reserve adjacent to the property.

#### WESTBOURNE STREET

- Depth of overland flow are not sufficient to result in surcharge of the road reserve.

### 2.2 CONCLUSION

The hydrologic and hydraulic modelling undertaken has demonstrated that overland flow will be contained within the road reserve and therefore not discharge into the property during storms up to and including the 1% AEP storm event.

Please call if you wish to discuss.

Regards,



Michael Cahalane

Director - Water and Civil Engineering

Phone: 02 8234 8640

Mobile: 0433 522 569

Email: michael@warrensmith.com.au

Attachments Enclosed: -

1. Lot 1 Development Application Report Extract
2. Lot 1 Development Application Drawings C4.01 and C4.03
3. Lot 2 Concept On-Site Detention & Permissible Site Discharge Calculations
4. Lot 2 Sketch SK-01 OSD Location Plan
5. Lyall & Associates Overland Flowpath Study

## 4. PROPOSED STORMWATER SYSTEM

The development site has a total catchment area of approximately 6,194 m<sup>2</sup>. The breakdown of the proposed catchment is presented in Table 2 below.

**Table 2: Breakdown of Total Site Catchment**

Catchment Areas	Area (m <sup>2</sup> )	Percentage of Total Area (%)
Roof	4,243	68.5
Impervious	1,839	29.7
Pervious	112	1.8
<b>Total</b>	<b>6,194</b>	<b>100</b>

### 4.1 PROPOSED DRAINAGE SYSTEM

It is proposed that a total area of 5,968m<sup>2</sup> will capture rainfall and reticulate to the OSD tank located below the lower ground carpark LG3. This area includes the roof, driveway and southern garden beds.

The remaining area totalling 226m<sup>2</sup>, located along the western side of the proposed development, will bypass the stormwater drainage and OSD system and discharge on to Reserve Road. The bypass amounts to 3.65% of the total development area which is classed as minimal.

It is proposed that the OSD tank will have a total volume capacity of 236kL. The stormwater drainage and OSD systems have been designed in accordance with AS3500 and the Willoughby City Council requirements.

## 4.2 ON-SITE DETENTION & PERMISSIBLE SITE DISCHARGE

The required on-site detention (OSD) volume and permissible site discharge (PSD) have been calculated in accordance with the Willoughby City Council's DCP, August 2006, *Attachment 20, OSD Technical Standard No.1*. Please refer to *Schedule 1* for the Willoughby City Council OSD Checklist.

### 4.2.1 OSD CALCULATION

The proposed development area has a total site area of approximately 6,194 m<sup>2</sup>.

The volume of OSD storage has been calculated to be approximately 236 m<sup>3</sup> and is in accordance with the OSD Technical Standard, *Table 1 – Site Storage Requirements per impervious area*. Please refer to Table 3 below for a summary of the OSD calculation.

**Table 3: Option A - OSD Calculations**

Zone	Volume of Storage Required per Cubic Metre (m <sup>3</sup> /100m <sup>2</sup> )	Area of Site (m <sup>2</sup> )	OSD Volume Required (m <sup>3</sup> )
3	3.8	6,194	235.37

### 4.2.2 PSD CALCULATION

The PSD has been calculated to be approximately 111 L/sec and is in accordance with the OSD Technical Standard, *Table 2 – Permissible Site Discharge per impervious area*. Please refer to Table 4 below for a summary of the PSD calculation.

**Table 4: Option A - PSD Calculations**

Zone	Permissible Site Discharge per Cubic Metre (L/sec/Ha)	Area of Site (Ha)	Maximum PSD (L/sec)
3	180	0.6194	111.49

The proposed OSD tank will be constructed with a sediment sump and a trash screen located immediately upstream of the outlet pipe. It is proposed that a minimum area of 0.60m x 0.60m and a minimum depth of 0.2m below the invert level of the outlet pipe will be provided for the sediment sump.

## 4.3 CONNECTION TO EXISTING DRAINAGE

It is proposed that stormwater will be discharged from the OSD tank, via a 168mm diameter orifice. The orifice size was calculated using the following equation.

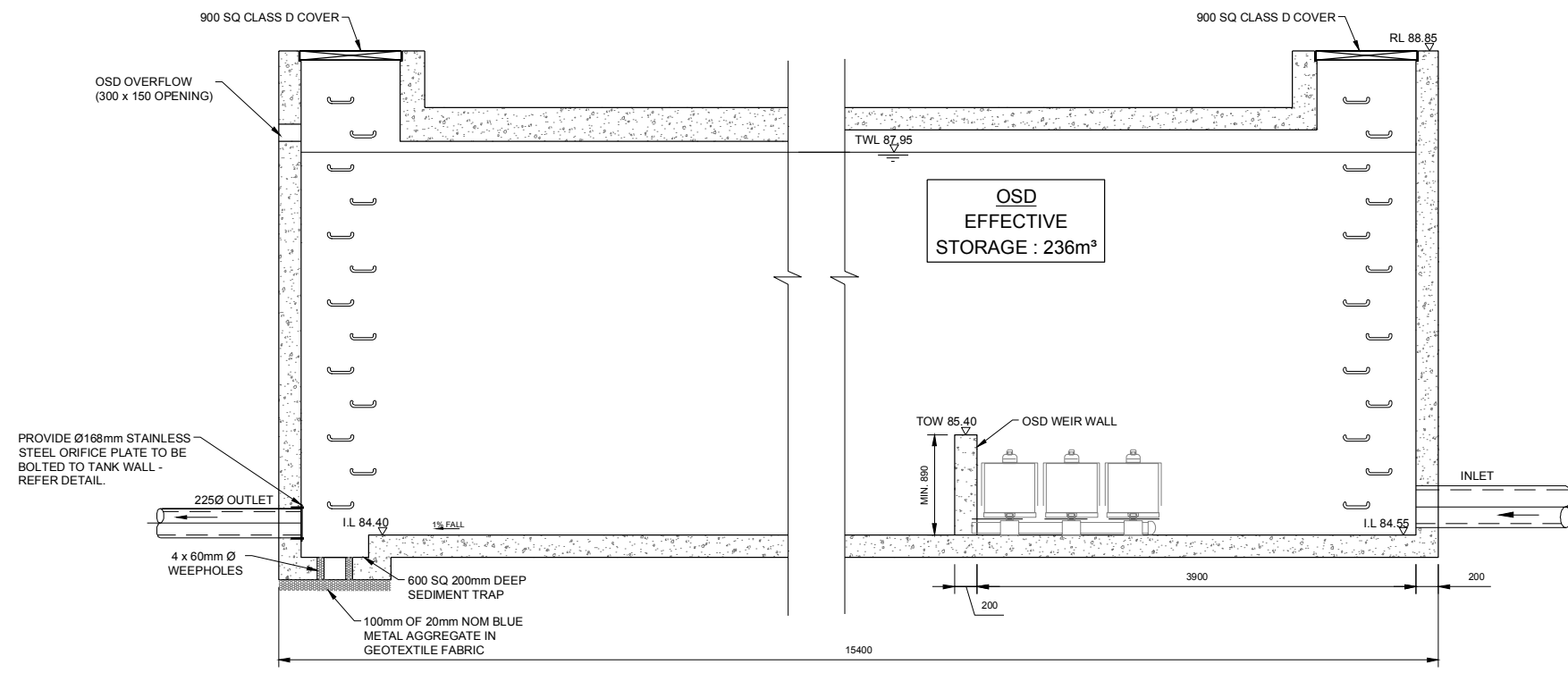
$$\text{Orifice Dia. (mm)} = 21.8 \times \sqrt{(\text{PSD} / (\sqrt{\text{Head of Water (m) over the centreline of the orifice}}))}$$

$$\text{Orifice Dia. (mm)} = 21.8 \times \sqrt{(111 / (\sqrt{3.466}))}$$

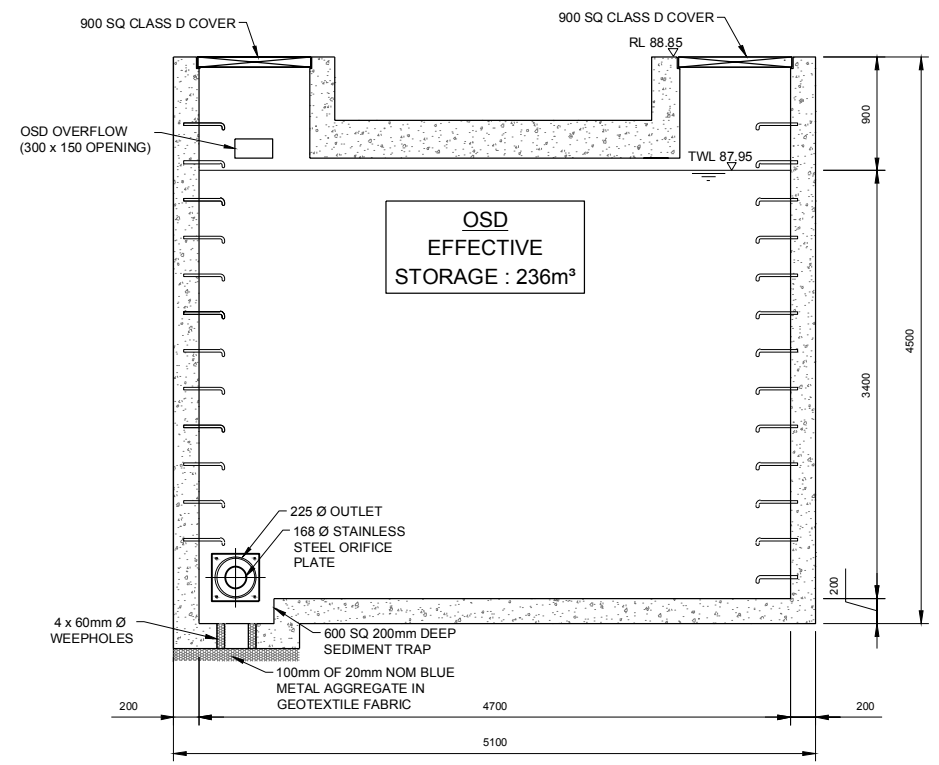
$$\text{Orifice Dia. (mm)} = 168$$

The discharge released through the orifice plate will reticulate via a new pit and pipe system connecting into an existing pit located at the norther eastern corner of the development area. This existing pit reticulates to the existing Council drainage infrastructure in Frederick Street via a pit and pipe system which runs along the eastern side of the property. Please refer to the WS+P DA Drawing Package for further details.

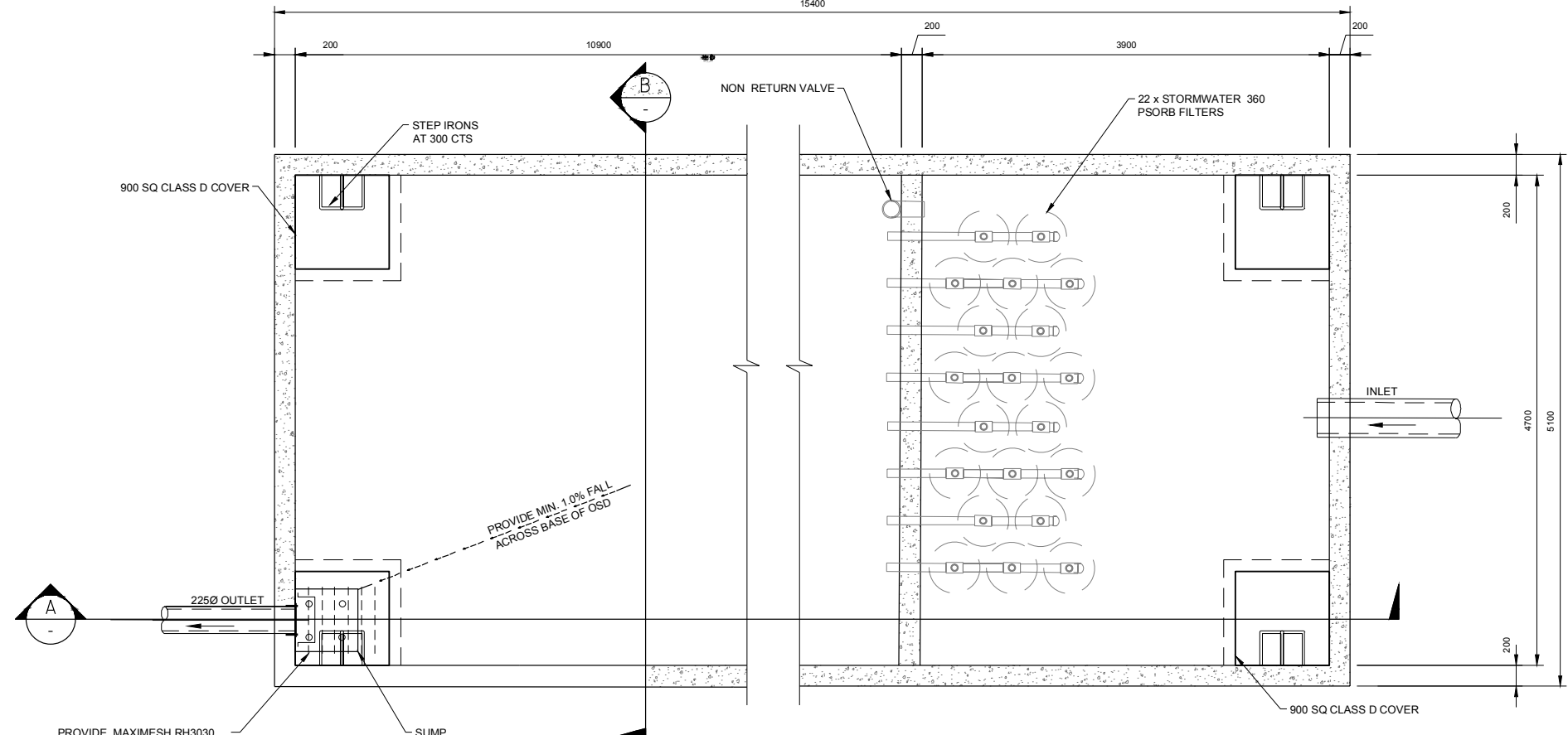




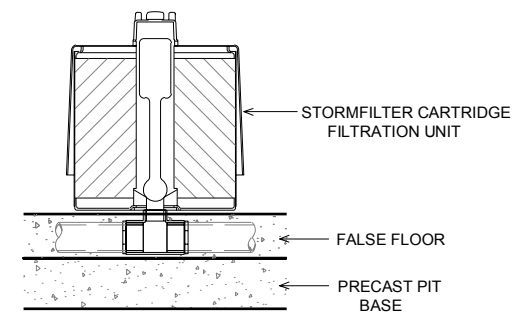
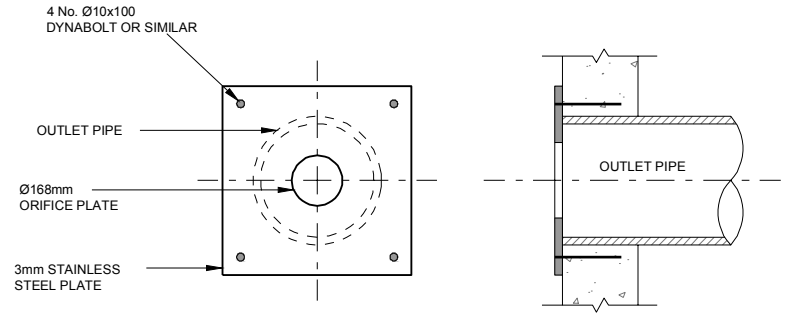
**SECTION A-A**  
SCALE 1:30



**SECTION B-B**  
SCALE 1:30



**PLAN**  
SCALE 1:30



**STORMFILTER CARTRIDGE DETAIL**  
NOT TO SCALE

DO NOT SCALE FROM DRAWINGS. CHECK & VERIFY ALL DIMENSIONS & LEVELS BEFORE COMMENCEMENT OF ANY WORK.  
THIS DRAWING IS NOT TO BE COPIED IN PART OR WHOLE WITHOUT WRITTEN PERMISSION FROM WARREN SMITH AND PARTNERS.

ISSUE	AMENDMENT	DATE	ISSUE	AMENDMENT	DATE
A	PRELIMINARY ISSUE	09/05/16			

CLIENT  
**DEXUS**  
PROPERTY GROUP

PROJECT  
**NORTH SHORE PRIVATE HOSPITAL**

**Warren Smith & Partners**

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CONSULTING ENGINEERS  
Hydraulic Services Fire Protection Civil Engineering  
Sydney Water Accredited Water Servicing Co-ordinator  
Design Project Management - Building Plan Approvals

SERVING THE CONSTRUCTION INDUSTRY SINCE 1981.

TITLE  
**ON SITE DETENTION DETAILS**

SCALE	DRAWN	DESIGNED	CHECKED	APPROVED
AS SHOWN	P.G	L.S	L.S	M.C.
JOB No. <b>5320001</b>		DRAWING No. <b>C4.03</b>		ISSUE <b>A</b>
DATE 09/05/2016		STATUS DEVELOPMENT APPLICATION		

## LOT 2 CONCEPT ON-SITE DETENTION & PERMISSIBLE SITE DISCHARGE

The required on-site detention (OSD) volumes and permissible site discharge (PSD) for Lot 2 have been calculated in accordance with the Willoughby City Council's DCP, August 2006, Attachment 20, *OSD Technical Standard No.1*.

### 1.1 OSD CALCULATION

The sub-division Lot 2 area has a total site area of approximately 18,810 m<sup>2</sup>.

The volume of OSD storage has been calculated to be approximately 715 m<sup>3</sup> and is in accordance with the OSD Technical Standard, *Table 1 – Site Storage Requirements per impervious area*, please refer to Table 1 below for a summary of the OSD calculations.

**Table 1: Option A - OSD Calculations**

Zone	Volume of Storage Required per Cubic Metre (m <sup>3</sup> /100m <sup>2</sup> )	Area of Site (m <sup>2</sup> )	OSD Volume Required (m <sup>3</sup> )
3	3.8	18,810	714.78

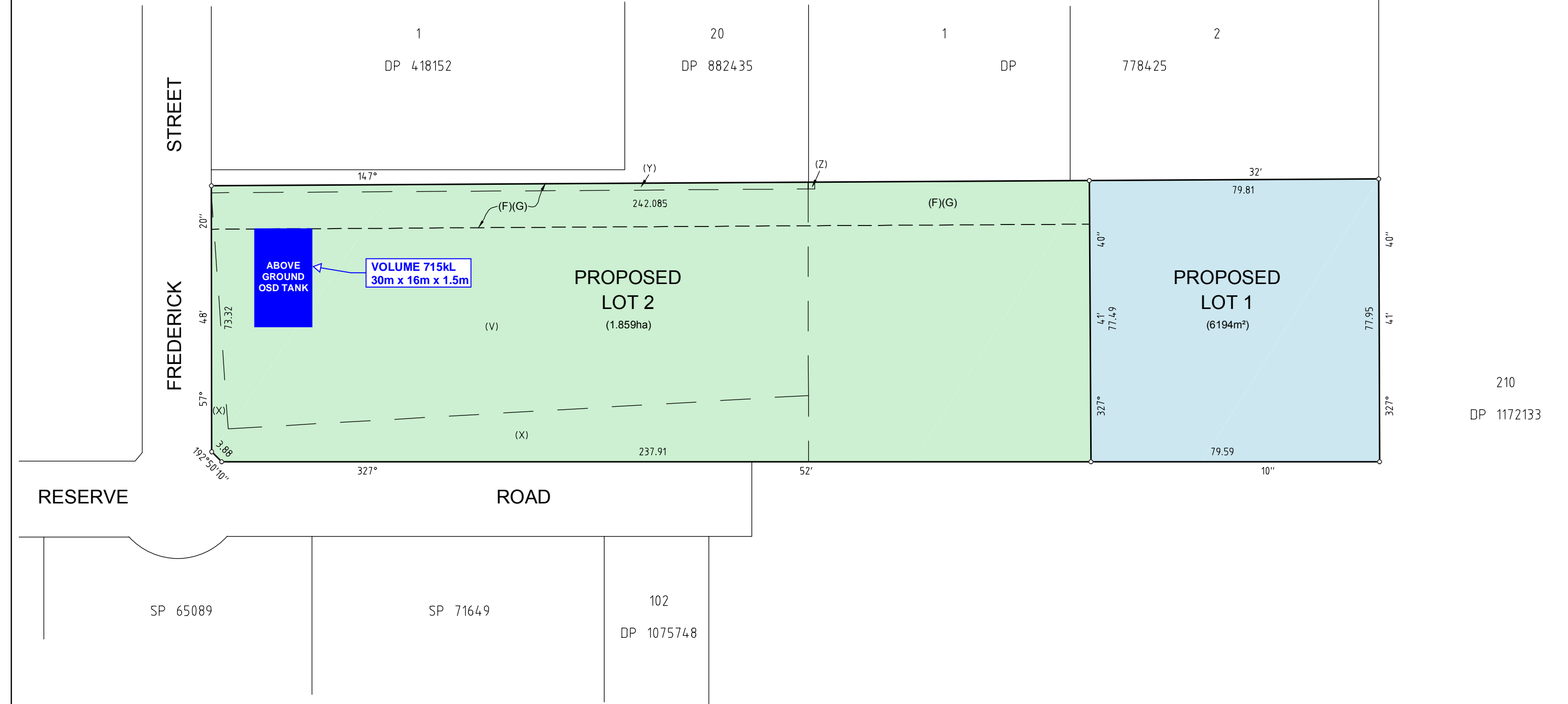
### 1.2 PSD CALCULATION

The PSD has been calculated to be approximately 338 L/sec and is in accordance with the OSD Technical Standard *Table 2 – Permissible Site Discharge per impervious area*, please refer to Table 2 below for a summary of the PSD calculations.

**Table 2: Option A - PSD Calculations**

Zone	Permissible Site Discharge per Cubic Metre (L/sec/100m <sup>2</sup> )	Area of Site (m <sup>2</sup> )	Maximum PSD (L/sec)
3	1.8	18,810	338.58

**PROJECT: NORTH SHORE PRIVATE HOSPITAL SUB-DIVISION**  
**TITLE: LOT 2 CONCEPT OSD LOCATION PLAN**  
**DATE: 13 DECEMBER 2016**  
**ENGINEER: L. SHAUGHNESSY**  
**NOT TO SCALE**



**EXISTING EASEMENTS**  
(V) COVENANT (DP 591747 & H 542568)  
(X) EASEMENT FOR SUPPORT (DP 591747 & H 542567)  
(Y) EASEMENT FOR DRAINAGE (DP 591747 & H 542568)  
(Z) EASEMENT FOR DRAINAGE (DP 591747)

**PROPOSED EASEMENTS**  
(F) EASEMENT FOR ACCESS 12 WIDE  
(G) EASEMENT FOR SERVICES 12 WIDE

Surveyor: JOSEPH MONARDO  
Date of Survey: ....., 2016  
Surveyor's Reference: 42243-42857DP

PLAN OF SUBDIVISION OF LOT 1 IN DP 591747 AND  
EASEMENTS OVER LOT 210 DP 1172133

LGA: WILLOUGHBY  
Locality: ST LEONARDS  
Subdivision No:  
Lengths are in metres. Reduction Ratio 1: 750



DP DRAFT  
ISSUE B: 12/05/2016  
FOR DA PURPOSES

Warren Smith & Partners  
1<sup>st</sup> Floor, 123 Clarence Street  
SYDNEY NSW 2000

Job No. AR269.020

**Attn: Mr Michael Cahalane**

20 December 2016

**Re: Proposed Subdivision of 12 Frederick Street, St Leonards**

Dear Sir,

This report sets out the findings of an investigation that has been undertaken by Lyall & Associates (**L&A**) to assess patterns of overland flow in the vicinity of No. 12 Frederick Street, St Leonards (**Property**), being Lot 1 in DP 591747.

## 1. Site Description

**Figure 1** shows that the Property is bounded by Westbourne Street to its south, Reserve Road to its west, Frederick Street to its north and existing commercial development to its east. **Figure 1** also shows the proposed subdivision of the Property into two lots, denoted Proposed Lot 1 and Proposed Lot 2.

The Property comprises an existing multi-storey factory building containing eleven units on the ground floor accessible by the Frederick Street Entrance and two units on the roof top accessible by the Upper and Lower Reserve Road Entrances. The finished floor levels of the ground floor units range between RL 75.81 m AHD and RL 77.03 m AHD.

The survey plan provided by the Applicant (refer copy contained in **Annexure A**) shows that there is about a 20 m fall in levels internal to the Property along the Reserve Road and Westbourne Road frontages.

Reserve Road falls at a grade of about seven per cent from an elevation of about RL 97.80 m AHD at a location approximately 45 m north of its intersection with Westbourne Street to about RL 80.60 m AHD at its intersection with Frederick Street.

Frederick Street also falls at a grade of about seven per cent from an elevation of about RL 80.60 m AHD at its intersection with Reserve Road to about RL 75.10 m AHD adjacent to the northern boundary of the Property. A sag point is located in Frederick Street approximately 50 m to the east of the Property and has an elevation of about RL 74.20 m AHD.

Westbourne Street falls at a slightly steeper grade of approximately nine per cent from an elevation of about RL 97.60 m AHD at its intersection with Reserve Road to about RL 92.55 m AHD adjacent to the eastern boundary of the Property.

## 2. Existing Drainage System

**Figure 1** shows the extent of the catchments that contribute to flow in the existing piped drainage system that controls surface runoff discharging to the roads which border the Property, while **Figure 2** shows the key features of the existing piped drainage system in the immediate vicinity of the Property.

Runoff from the 2.7 ha and 0.3 ha catchments that contribute to flow on the western and eastern sides of Reserve Road, respectively is controlled by a 525 mm diameter pipe that runs in an easterly direction toward the sag point in Frederick Street, while runoff from the 0.2 ha catchment that lies to the south of the Property is controlled by an existing piped drainage system (the dimensions of which are unknown) that runs in an easterly direction along Westbourne Street.

Runoff that cannot enter the existing piped drainage system will be conveyed around the Property in the adjacent road reserves which act as overland flow paths. Plates contained in **Annexure B** show the key features of these overland flow paths in the immediate vicinity of the Property.

## 3. Assessment of Drainage Patterns – Present Day Conditions

### 3.1 Development of Hydrologic and Hydraulic Models

A hydrologic (DRAINS) model that was developed as part of a previous Local Government Area (LGA) wide screening study that was undertaken by L&A on behalf of WCC in 2009 was used as the starting point for defining patterns of overland flow in the vicinity of the Property.

The structure of the DRAINS model was updated to incorporate additional sub-catchments (refer **Figure 1**), the outlets of which corresponded with the location of existing stormwater inlet pits. The surface roughness applied to each sub-catchment was also updated to reflect the findings of more recent studies that have been undertaken in the LGA.

Details of the existing piped drainage system in Reserve Road and Frederick Street were incorporated into the DRAINS model. Council's stormwater asset database was used to determine pipe dimensions, while the ground survey data provided by the Applicant were used to determine pipe invert levels where available. Pit types were defined by visual inspection.

The DRAINS model was used to assess the capacity of the existing piped drainage system and determine the magnitude of surcharge flow for design storms with Average Recurrence Intervals (ARI's) of 5, 20 and 100 years<sup>1</sup>.

The HEC-RAS modelling software was used to assess the depth at which stormwater which surcharges the existing piped drainage system will be conveyed in the roads that border the Property. **Figure 2** shows the layout of the three HEC-RAS models which were developed as part of the present investigation (denoted the "**Westbourne Street, Reserve Road East and Reserve Road West HEC-RAS Models**").

The **Reserve Road West HEC-RAS Model** comprises ten cross sections which are located along the western side of Reserve Road, noting that overland flow in the western kerbline of Reserve Road at its intersection with Frederick Street will continue in a northerly direction toward the intersection of Campbell Street and Reserve Road.

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<sup>1</sup> Note that the DRAINS model does not incorporate pit and pipe data in Westbourne Street as there is no existing piped drainage system in this area.

The **Reserve Road East HEC-RAS Model** comprises ten cross sections along Reserve Road and four cross sections along Frederick Street. Overland flow in the eastern kerbline of Reserve Road will turn into Frederick Street where it will discharge in an easterly direction toward the sag point which is located about 50 m to the east of the Property.

The **Westbourne Street HEC-RAS Model** was developed to confirm if runoff generated from the adjacent 0.2 ha catchment will be contained within the road reserve.

### 3.2 Hydraulic Model Results

**Annexure C** contains a tabulated set of results for the **Reserve Road West HEC-RAS Model**, as well as cross sections showing depths of overland flow along the western side of Reserve Road. The key findings of the investigation in relation to flow along the western side of Reserve Road were as follows:

- There is a reduction in flow downstream of cross section *RR\_W\_7* as the overland flow in the western kerbline is intercepted by the existing piped drainage system immediately upstream of cross section *RR\_W\_6*.
- The peak 100 year ARI flow of 0.92 m<sup>3</sup>/s at cross section *RR\_W\_1* is confined to the western side of Reserve Road.
- Overland flow will not overtop the crown of the road and contribute to flow along the eastern side of Reserve Road.

**Annexure D** contains a tabulated set of results for the **Reserve Road East HEC-RAS Model**, as well as cross sections showing depths of overland flow along the eastern side of Reserve Road and the southern side of Frederick Street. The key findings of the investigation in relation to flow along the eastern side of Reserve Road and the southern side of Frederick Street were as follows:

- As the overland flow does not surcharge the western side of Reserve Road for storm events up to 100 year ARI, flow along the eastern kerbline of Reserve Road is generated entirely by the 0.3 ha catchment shown on **Figure 1**.
- The majority of flow along the eastern kerbline of Reserve Road is intercepted by the existing piped drainage system immediately downstream of cross section *RR\_E\_1*. Flow along the southern kerbline of Frederick Street is therefore relatively minor in nature.
- Flow overtops the crown of the road in a 100 year ARI storm event, contributing to flow on the western side of Reserve Road adjacent to cross section *RR\_E\_1*<sup>2</sup>.
- Depths of overland flow along the eastern kerbline of Reserve Road are not sufficient to surcharge the road reserve adjacent to the Property.

**Annexure E** contains a tabulated set of results for the **Westbourne Street HEC-RAS Model**, as well as cross sections showing depths of overland flow along the southern side of Westbourne Street. The key finding regarding flow along the southern side of Westbourne Street is that depths of overland flow are not sufficient to result in surcharge of the road reserve.

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<sup>2</sup> The **Reserve Road West HEC-RAS model** was rerun assuming the 0.13 m<sup>3</sup>/s from the eastern side of Reserve Road contributes to the total flow in the western side of the road. Even with the additional flow (i.e. total flow of 1.05 m<sup>3</sup>/s at cross section *RR\_W\_1*), depths of overland flow along the western kerbline of Reserve Road are not sufficient to result in surcharge of the road reserve during a 100 year ARI storm event.

**Figure 3** shows the computed 100 year ARI hydraulic grade line along the existing piped drainage system where it runs between Pits 1 to 5 (refer **Figure 2** for location of pits). By inspection of **Figure 3**, the existing piped drainage system is not surcharged by a 100 year ARI storm event. This is principally due to the capacity of the existing inlet pits limiting the rate at which surface runoff can enter the piped drainage system.

#### **4. Concluding Remark**

Hydrologic and hydraulic modelling undertaken as part of the present investigation has demonstrated that overland flow will be contained within the road reserve and therefore not discharge to the Property for storms with ARI's up to 100 years.

We trust that the findings presented in this letter report will assist you in obtaining an approval for the proposed subdivision. Please do not hesitate to contact the undersigned should you require any further advice in relation to the above assessment.

Yours faithfully

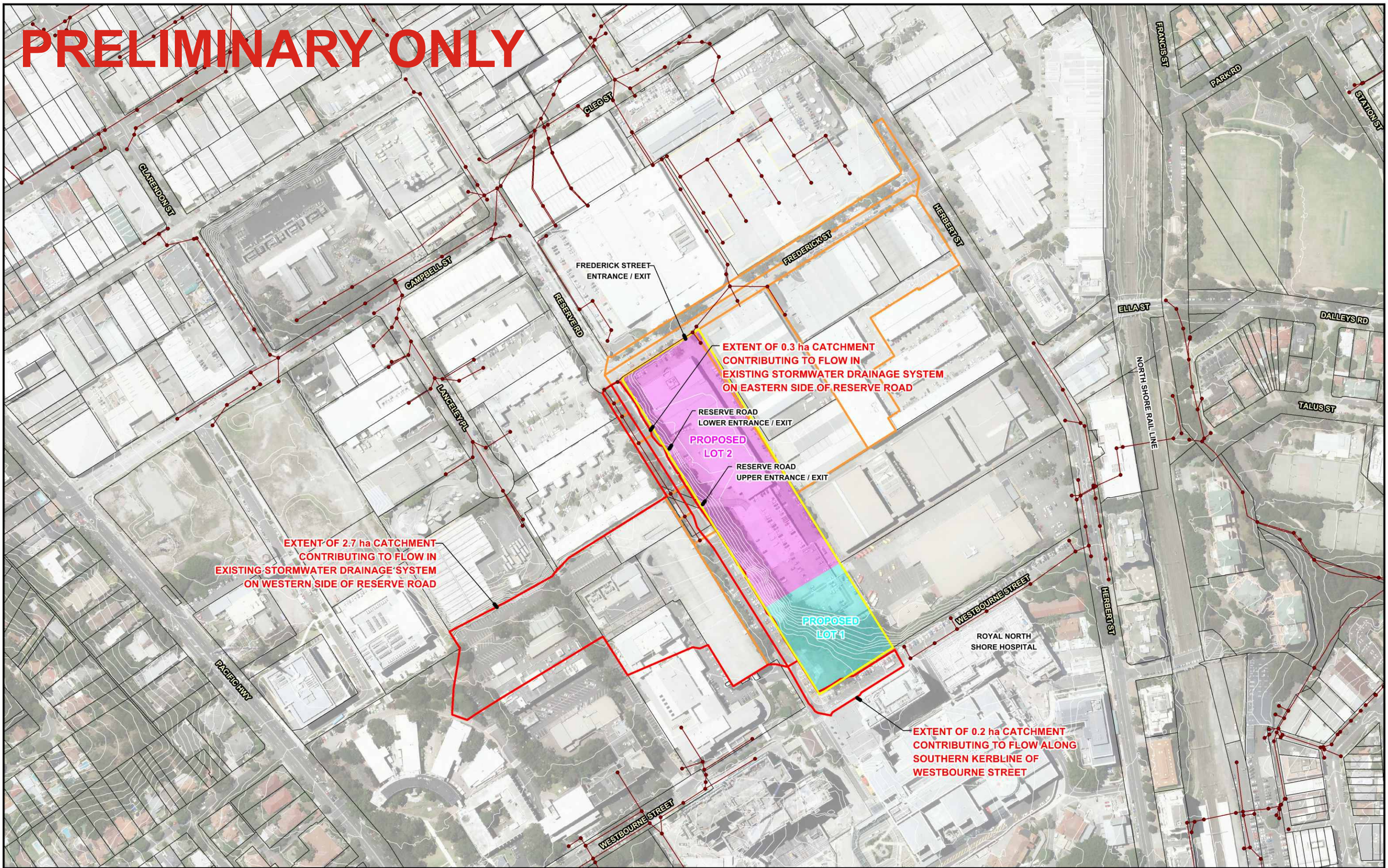
**Lyll & Associates Consulting Water Engineers**

**Scott Button**

**Principal**

DRAFT FOR CLIENT REVIEW

# PRELIMINARY ONLY



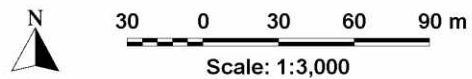
EXTENT OF 2.7 ha CATCHMENT CONTRIBUTING TO FLOW IN EXISTING STORMWATER DRAINAGE SYSTEM ON WESTERN SIDE OF RESERVE ROAD

EXTENT OF 0.3 ha CATCHMENT CONTRIBUTING TO FLOW IN EXISTING STORMWATER DRAINAGE SYSTEM ON EASTERN SIDE OF RESERVE ROAD

EXTENT OF 0.2 ha CATCHMENT CONTRIBUTING TO FLOW ALONG SOUTHERN KERBLINE OF WESTBOURNE STREET

RESERVE ROAD LOWER ENTRANCE / EXIT  
**PROPOSED LOT 2**  
 RESERVE ROAD UPPER ENTRANCE / EXIT

**PROPOSED LOT 1**



**Lyall & Associates**

**LEGEND**

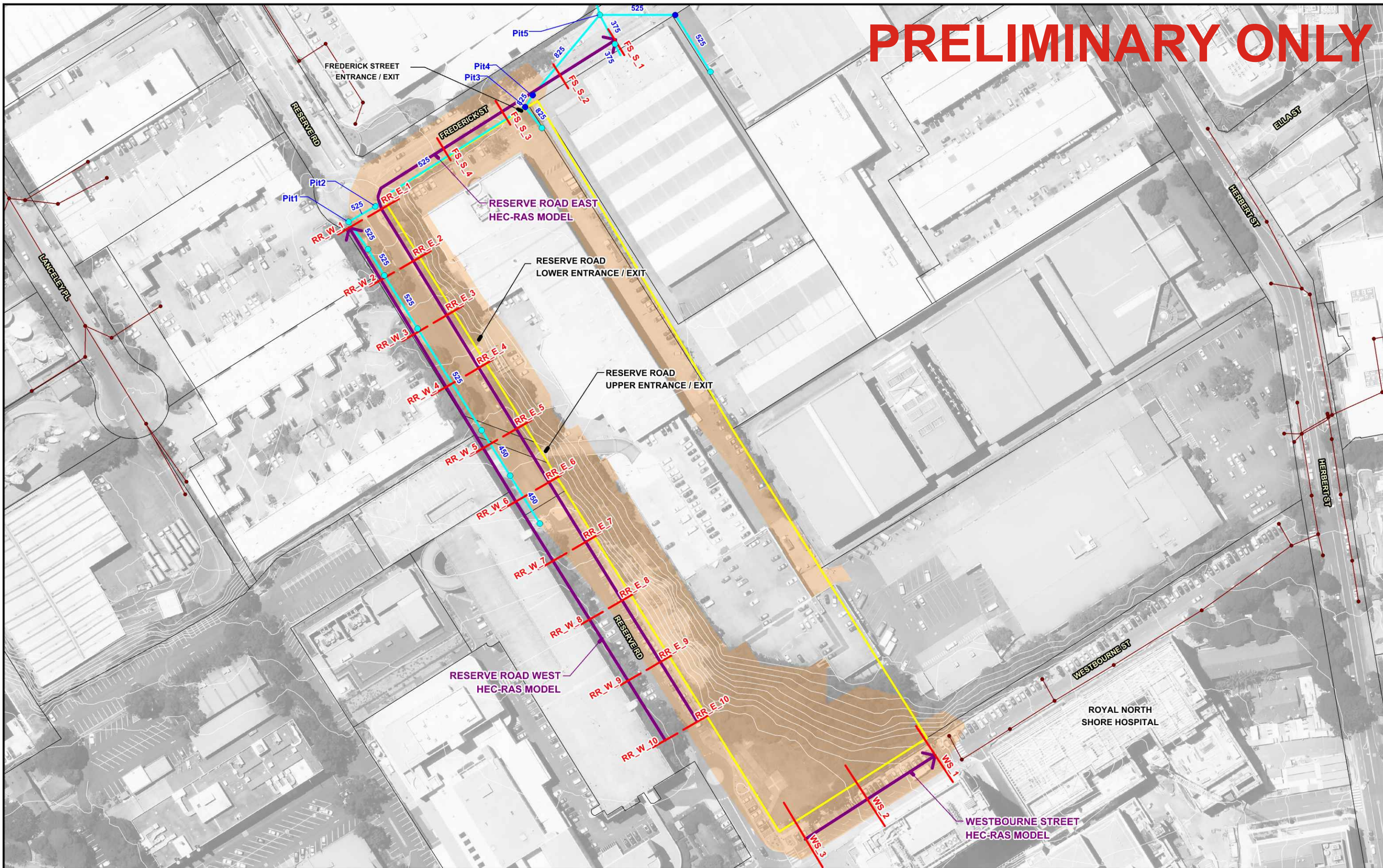
- Sub-catchment Boundary
- Catchment Boundary
- Property Boundary
- Existing Stormwater Drainage Network

**12 FREDERICK STREET, ST LEONARDS FLOODING ASSESSMENT**

Figure 1

CATCHMENT PLAN AND EXISTING STORMWATER DRAINAGE SYSTEM

# PRELIMINARY ONLY



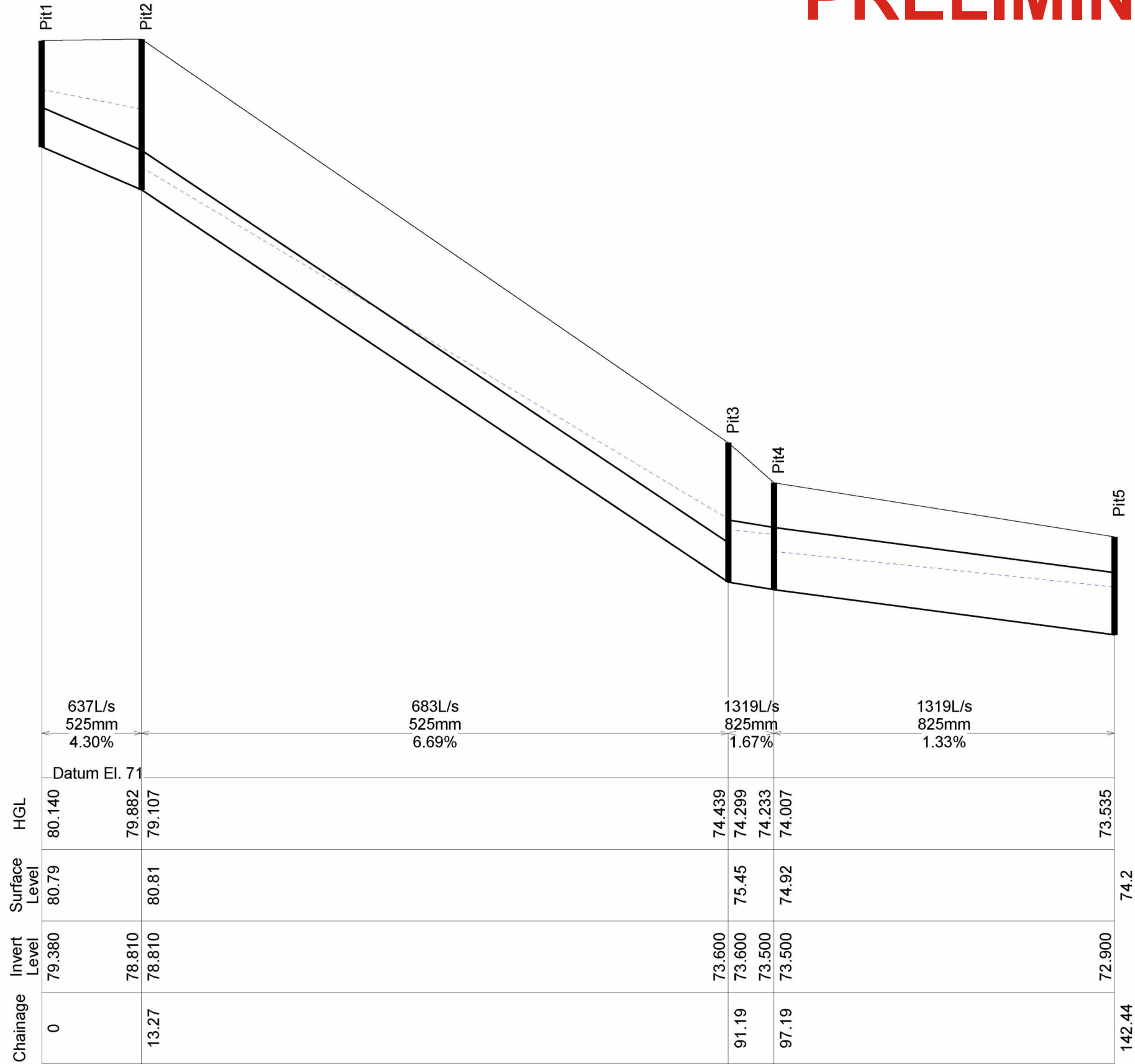
LEGEND	
	Overland Flow Path HEC-RAS Model
	HEC-RAS Cross-section and Identifier
	Property Boundary
	Extent of Detailed Ground Survey Data
	Inlet Pit
	Junction Pit
	Existing Stormwater Pipe and Diameter (mm) (only shown in vicinity of Property)
	Existing Stormwater Drainage Network

## 12 FREDERICK STREET, ST LEONARDS FLOODING ASSESSMENT

Figure 2

HYDROLOGIC AND HYDRAULIC MODEL LAYOUT

# PRELIMINARY ONLY



12 FREDERICK STREET, ST LEONARDS  
FLOODING ASSESSMENT

Figure 3

HYDRAULIC GRADE LINE  
100 YEAR ARI

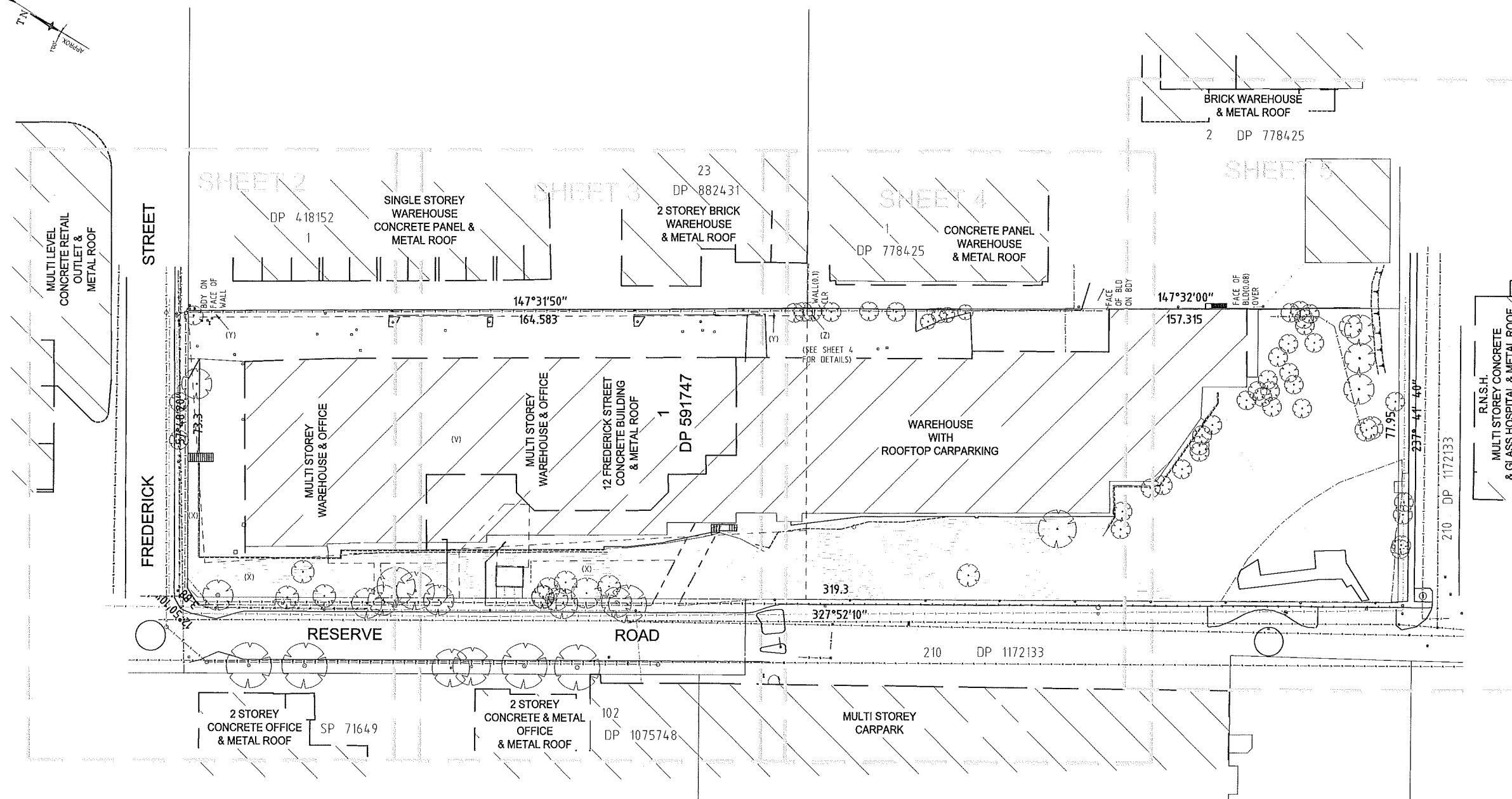
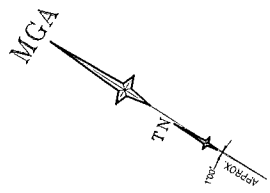


**NOTE:**  
Where available details of the existing stormwater drainage system have been taken from detailed ground survey provided by the Applicant (refer Annexure A for copy).

**ANNEXURE A**

**SURVEY PLAN**

DRAFT FOR CLIENT REVIEW

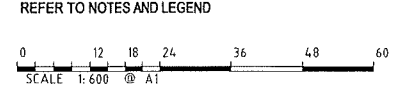


**LEGEND**

BENCH MARK	▲
OPTUS PIT	OP
TELSTRA PILLAR	TP
COMIS PIT	COM
TELSTRA PIT	TEL
ELECTRIC LIGHT POLE	ELP
ELECTRIC LIGHT BOLLARD	LB
ELECTRICITY PIT	EPIT
ELECTRICITY BOX	EL
POWER POLE	PP
SERVICE PIT	PIT
PIT WITH CONCRETE LID	CLID
PIT WITH METAL LID	MLID
TRAFFIC LIGHT	TL
STREET SIGN	SS
BOLLARD	BOL
ROAD TRAFFIC AUTHORITY	RTA
GRATED INLET PIT	GIP
KERB INLET PIT	KIP
SEWER INSPECTION POINT	SIP
SEWER MANHOLE	SMH
STOP VALVE	SV
HYDRANT	HYD
FIRE HYDRANT	FH
FIRE SERVICE	FBST
WATER METER	WM
WATER VALVE	WV
GAS VALVE	GV
GAS VALVE	GS
VEHICLE CROSSING	(VC)
PRAM CROSSING	(PC)
WINDOW	W
DOOR	D
HEAD/SILL	H/S
GAS (DBYD)	g
TELSTRA (DBYD)	t
WATER (DBYD)	w
STORMWATER (DBYD)	—
SEWER (DBYD)	s
ELECTRICITY (OVERHEAD)	p
ELECTRICITY (UGROUND) (DBYD)	e
NATIONAL BROADBAND NETWORK (DBYD)	nbn
GAS (DETECTED)	g(d)
TELSTRA (DETECTED)	t(d)
OPTICAL FIBRE (DETECTED)	of(d)
WATER (DETECTED)	w(d)
STORMWATER (DETECTED)	—
SEWER (DETECTED)	s(d)
ELECTRICITY (DETECTED)	e(d)
UNKNOWN SERVICE (DETECTED)	u(d)

- NOTES**
1. THE BOUNDARIES HAVE NOT BEEN MARKED
  2. ALL AREAS AND DIMENSIONS HAVE BEEN COMPILED FROM PLANS MADE AVAILABLE BY THE OFFICE OF LAND & PROPERTY INFORMATION (NSW) AND ARE SUBJECT TO FINAL SURVEY
  3. ORIGIN OF LEVELS ON A.H.D. IS TAKEN FROM **SSM38990 R.L. 76.645** (A.H.D.) IN HERBERT STREET
  4. CONTOUR INTERVAL **0.5m**
  5. CONTOURS ARE INDICATIVE ONLY. ONLY SPOT LEVELS SHOULD BE USED FOR CALCULATIONS OF QUANTITIES WITH CAUTION
  6. ONLY SPOT LEVELS SHOULD BE USED FOR CALCULATIONS OF QUANTITIES WITH CAUTION
  7. KERB LEVELS ARE TO THE TOP OF KERB UNLESS SHOWN OTHERWISE
  8. FLOOR LEVELS SHOWN ARE THRESHOLD LEVELS. NO INVESTIGATION OF INTERNAL FLOOR LEVELS HAS BEEN UNDERTAKEN
  9. NO INVESTIGATION OF UNDERGROUND SERVICES HAS BEEN MADE. SERVICES HAVE BEEN PLOTTED FROM RELEVANT AUTHORITIES INFORMATION AND HAVE NOT BEEN SURVEYED. ALL RELEVANT AUTHORITIES SHOULD BE NOTIFIED PRIOR TO ANY EXCAVATION ON OR NEAR THE SITE
  10. 8/4/7 DENOTES TREE SPREAD OF 8m, TRUNK DIAMETER OF 0.4m & APPROX HEIGHT OF 7m
  11. SHOWS APPROXIMATE POSITION OF ROAD LINEMARKING AND IS INDICATIVE ONLY
  12. BEARINGS SHOWN ARE MGA (MAP GRID OF AUSTRALIA) ADD APPROX. 1°00' FOR TRUE NORTH

- EASEMENTS**
- (V) - COVENANT (DP 591747 & H 542568)
  - (X) - EASEMENT FOR SUPPORT (DP 591747 & H 542567)
  - (Y) - EASEMENT FOR DRAINAGE (DP 591747 & H 542568)
  - (Z) - EASEMENT FOR DRAINAGE (DP 591747)

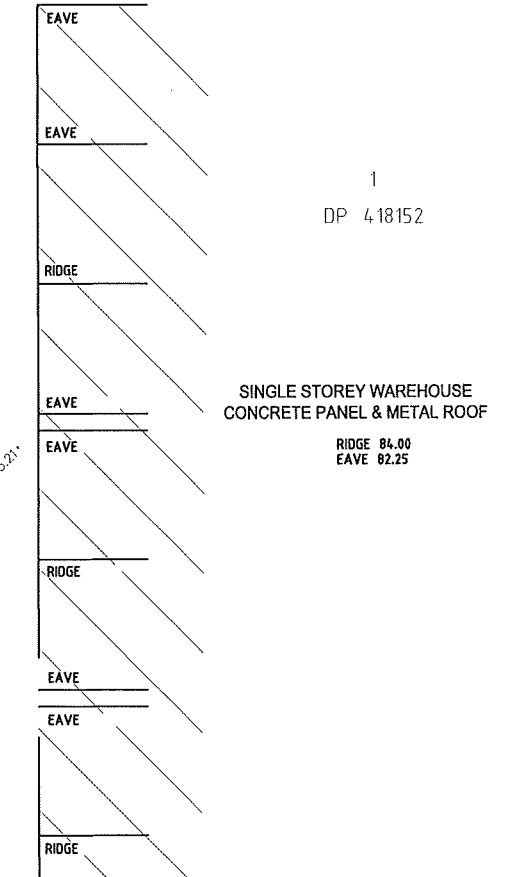
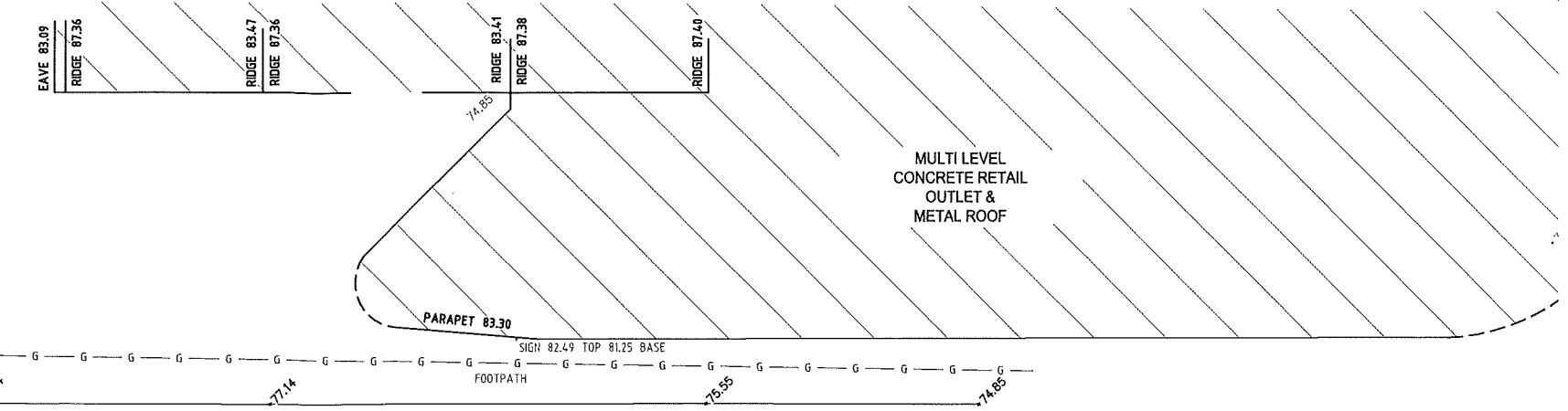
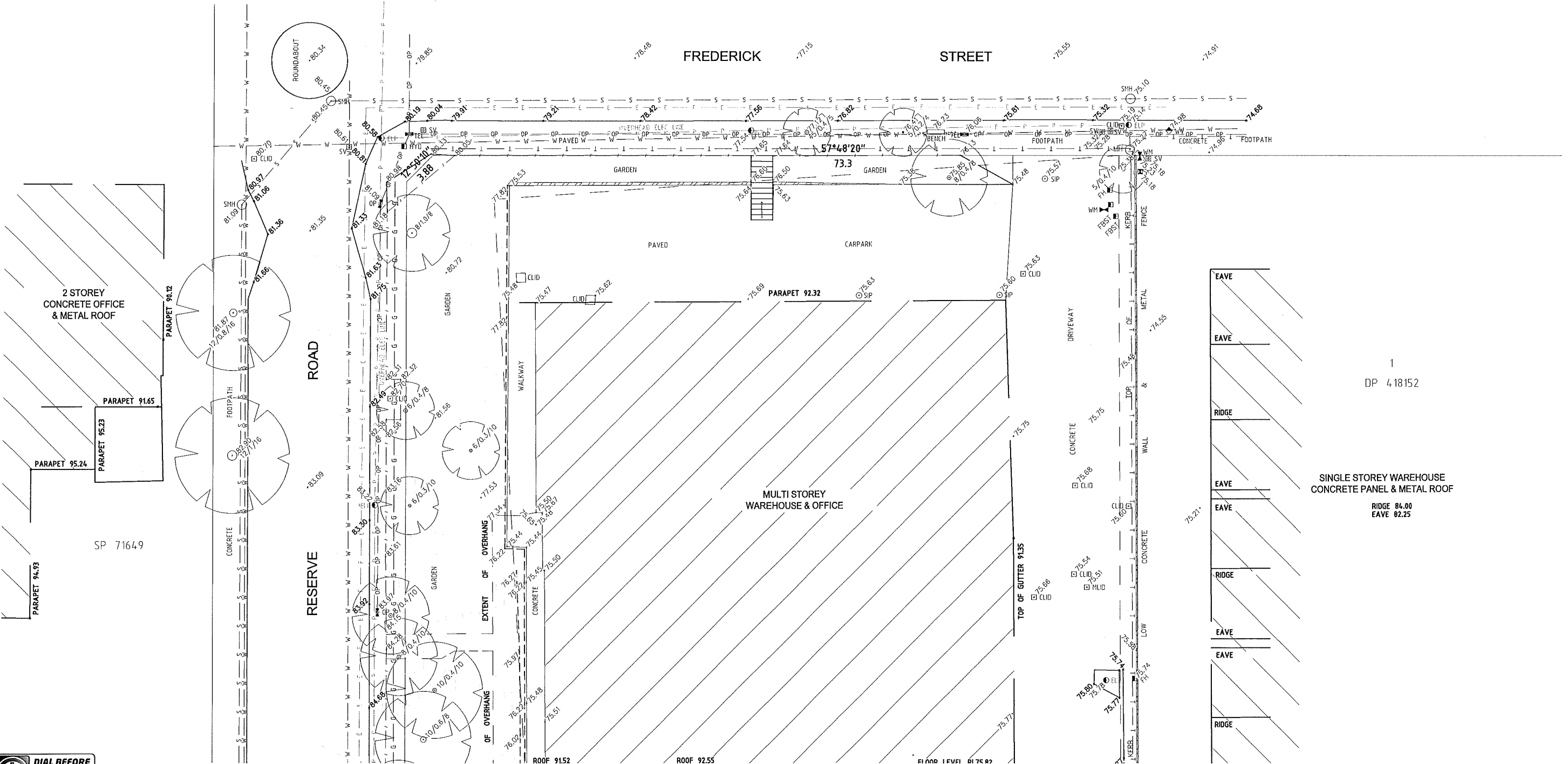
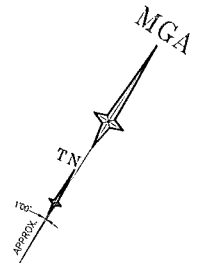


Revision	Date	Description	Reference
D	00/00/00	-	00
C	00/00/00	-	00
B	00/00/00	-	00
A	03/08/15	Initial draft plan completed	00

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 Registered Surveyor NSW  
**LTS**  
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 Registered Surveyors NSW  
 www.lts.com.au  
 Suite 1, Level 1  
 810 Pacific Highway  
 Gordon NSW 2072  
 Locked Bag 5  
 Gordon NSW 2072  
 P 1300 587 000  
 F 02 9499 7760

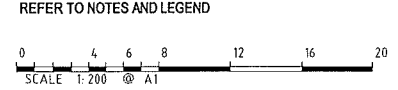
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 Drawing title  
**PLAN OF DETAIL AND LEVELS OVER LOT 1 IN DP591747 KNOWN AS 12 FREDERICK STREET ST LEONARDS**

datum **AHD** project number **42243DT - UNTOUCHED\_A3**  
 site Area **2.478ha** scale **1:600 @A1** date of survey **30/08/15**  
 LGA **WILLOUGHBY** SHEET **1** OF 7 SHEETS



1  
DP 418152

SINGLE STOREY WAREHOUSE  
CONCRETE PANEL & METAL ROOF  
RIDGE 84.00  
EAVE 82.25



REFER TO NOTES AND LEGEND SEE SHEET 1 FOR NOTES AND LEGEND

Revision	Date	Description	Reference
D	00/00/00	-	00
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B	00/00/00	-	00
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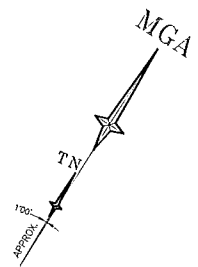
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Registered Surveyor NSW



Suite 1, Level 1  
810 Pacific Highway  
Gordon NSW 2072  
Locked Bag 5  
Gordon NSW 2072  
P 1300 587 000  
F 02 9499 7700

Client DEXUS PROPERTY GROUP  
Drawing title  
PLAN OF DETAIL AND LEVELS OVER LOT 1 IN DP591747  
KNOWN AS 12 FREDERICK STREET ST LEONARDS

datum AHD	project number -	reference number 42243DT - UNTOUCHED_A3
site Area 2.478ha	scale 1:200 @A1	date of survey 30/08/15
LGA WILLOUGHBY	SHEET 2 OF 7 SHEETS	

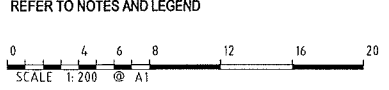
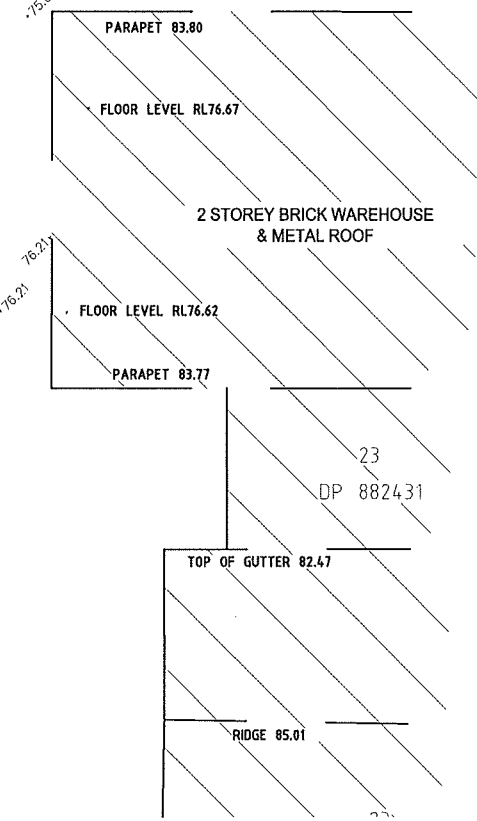
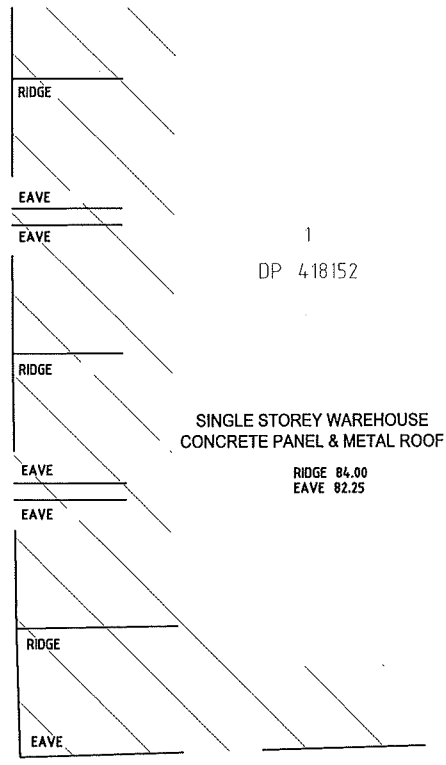
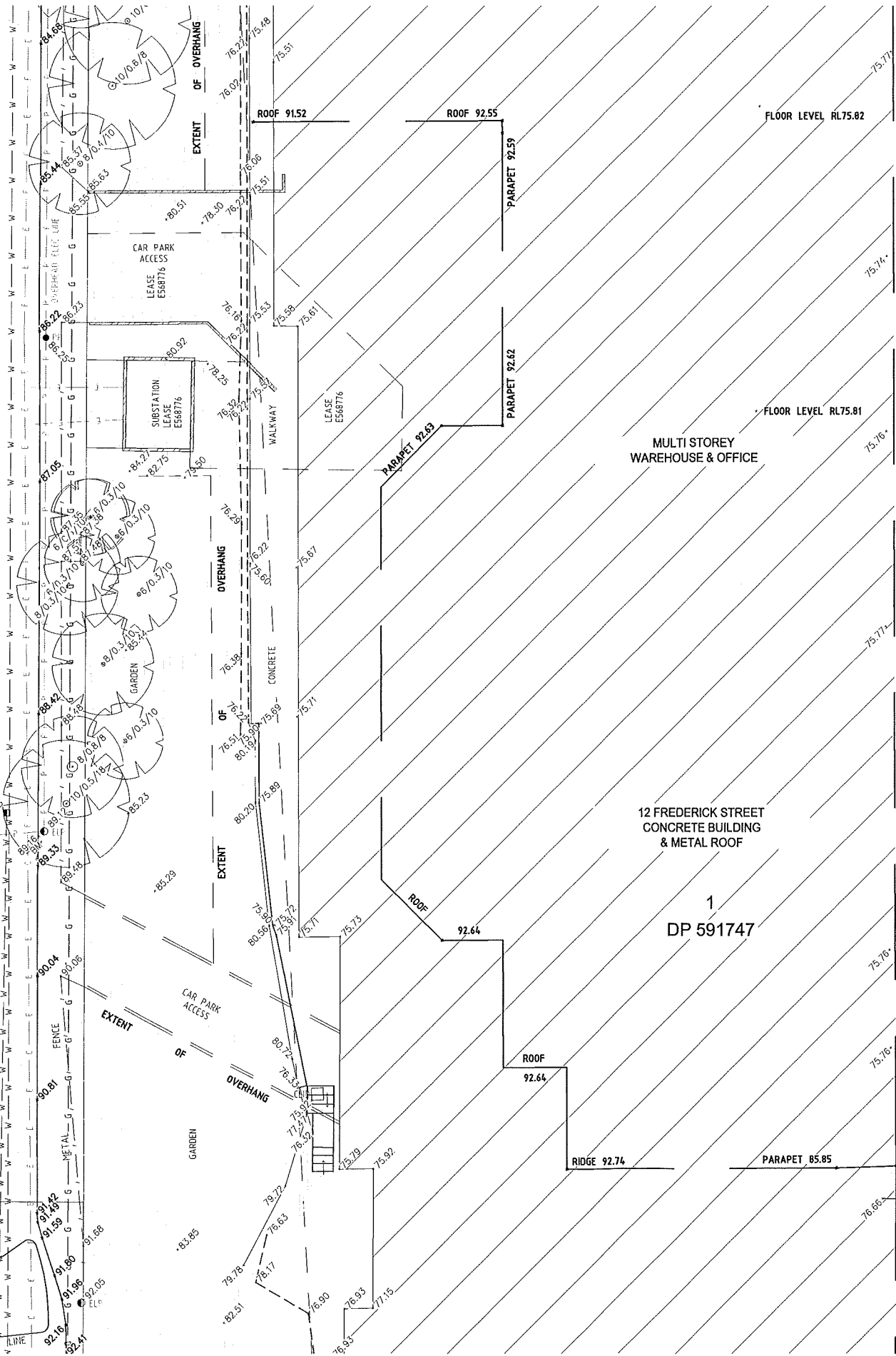


2 STOREY  
CONCRETE & METAL OFFICE  
& METAL ROOF

102  
DP 1075748  
MULTI STOREY  
CARPARK

210  
DP 1172133

ROAD  
RESERVE



SEE SHEET 1 FOR NOTES AND LEGEND

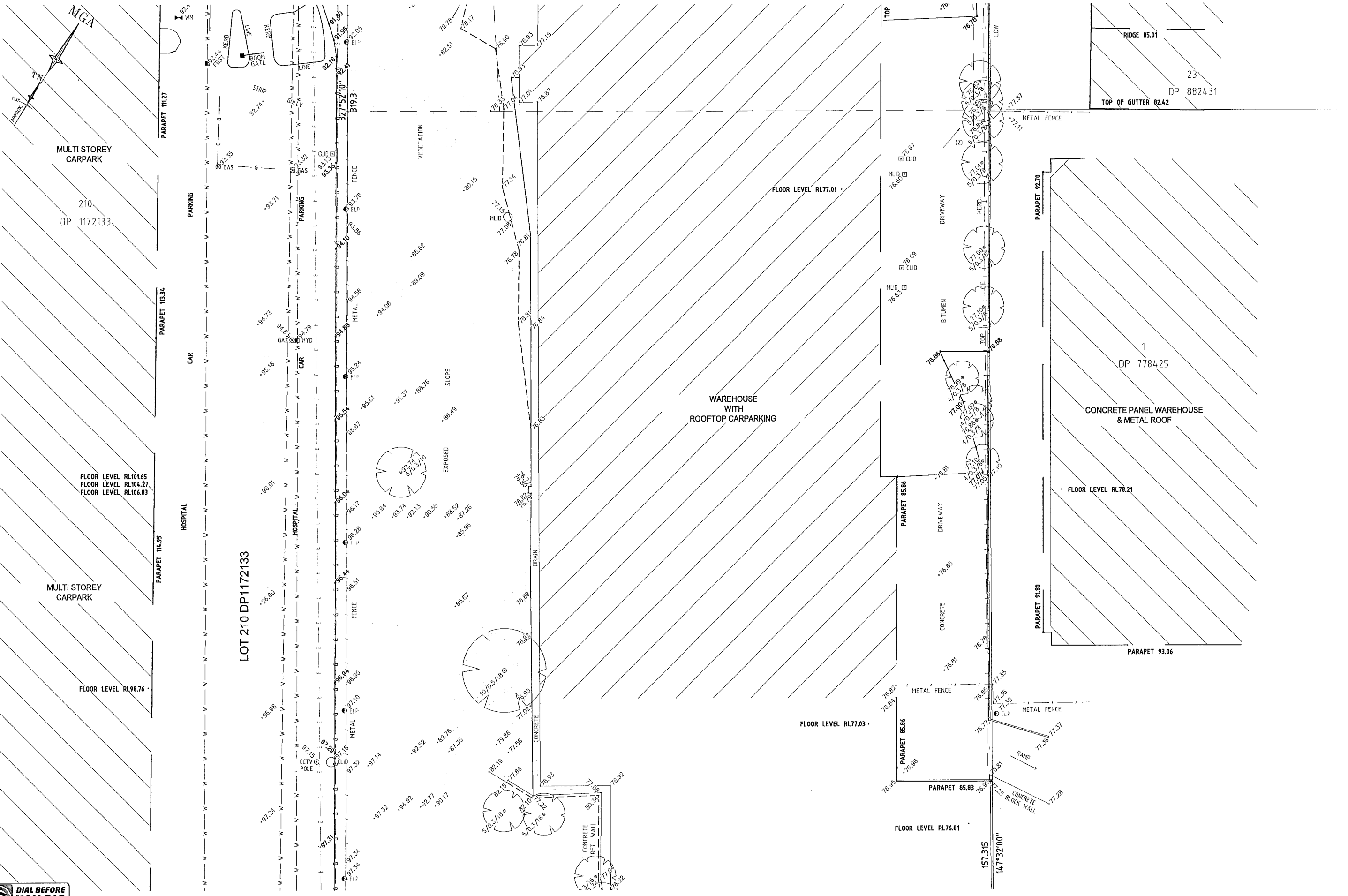
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Drawing title  
PLAN OF DETAIL AND LEVELS OVER LOT 1 IN DP591747  
KNOWN AS 12 FREDERICK STREET ST LEONARDS

datum AHD	project number -	reference number 42243DT - UNTOUCHED_A3
site Area 2.478ha	scale 1:200 @A1	date of survey 30/08/15
LGA WILLOUGHBY	SHEET 3 OF 7 SHEETS	



LOT 210 DP1172133

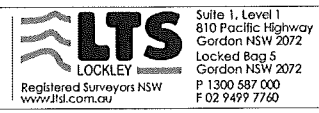


REFER TO NOTES AND LEGEND  
 SCALE 1:200 @ A1  
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SEE SHEET 1 FOR NOTES AND LEGEND

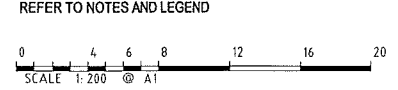
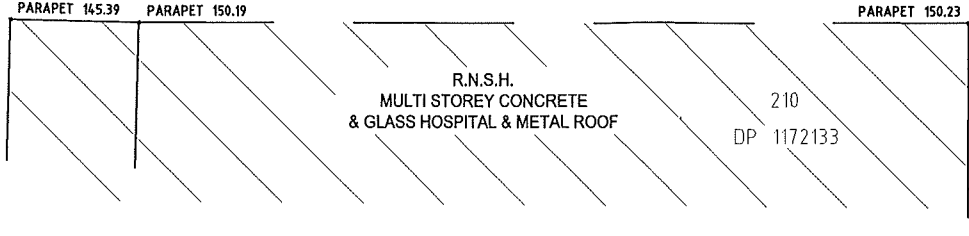
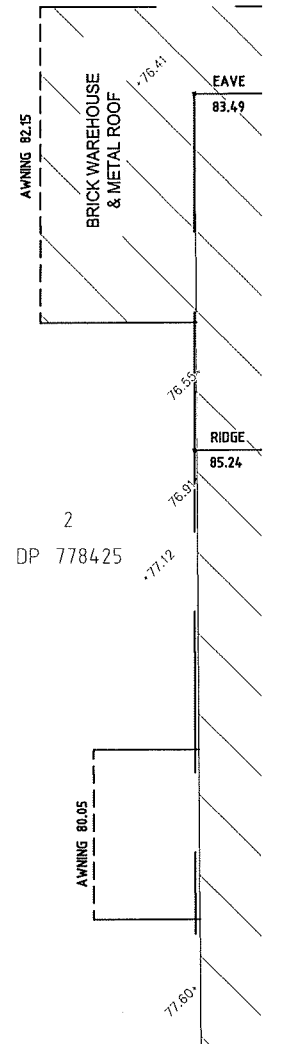
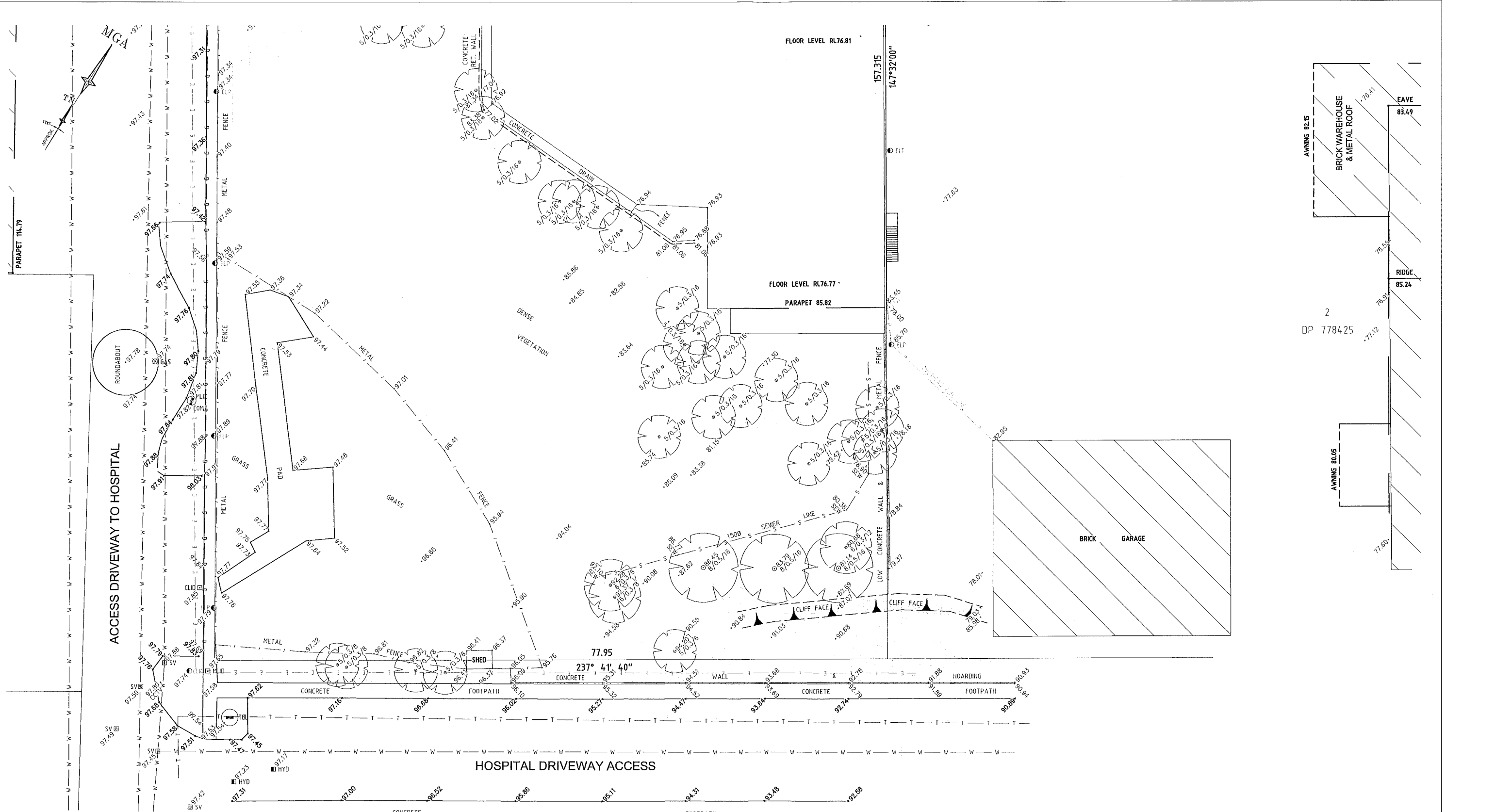
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Client DEXUS PROPERTY GROUP  
 Drawing title PLAN OF DETAIL AND LEVELS OVER LOT 1 IN DP591747 KNOWN AS 12 FREDERICK STREET ST LEONARDS

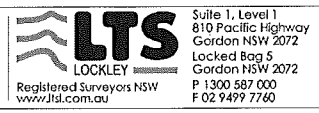
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site Area 2.478ha	scale 1:200 @A1	date of survey 30/08/15
LGA WILLOUGHBY	SHEET 4 OF 7 SHEETS	



SEE SHEET 1 FOR NOTES AND LEGEND

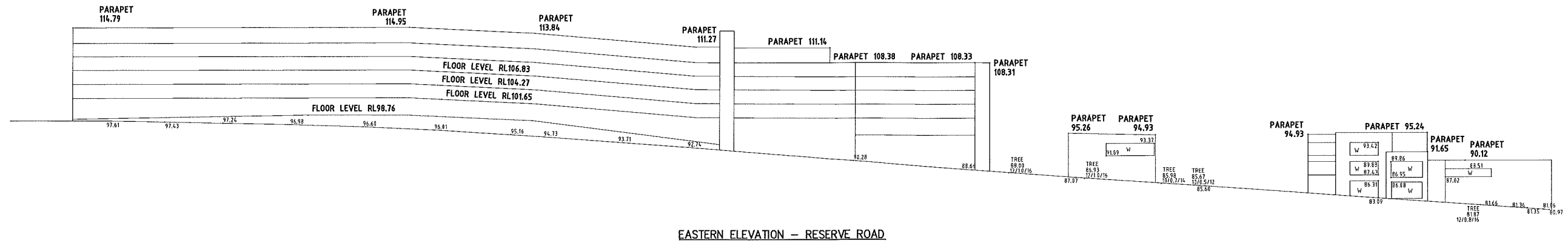
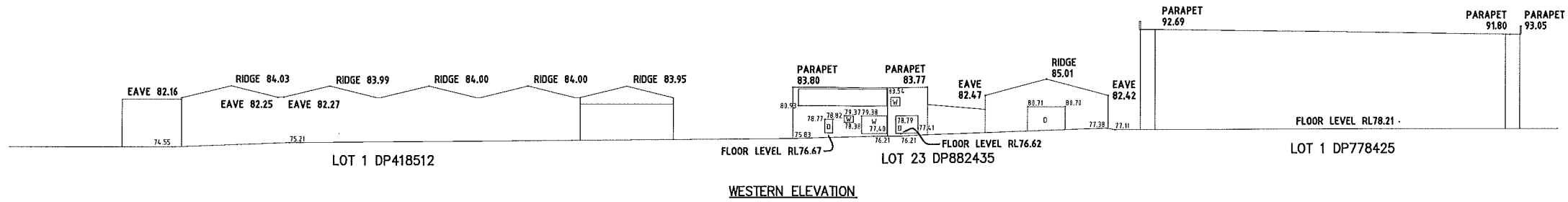
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Client: DEXUS PROPERTY GROUP  
Drawing title: PLAN OF DETAIL AND LEVELS OVER LOT 1 IN DP591747 KNOWN AS 12 FREDERICK STREET ST LEONARDS

datum: AHD  
project number: 42243DI - UNTOUCHED\_A3  
site Area: 2.478ha  
scale: 1:200 @A1  
date of survey: 30/08/15  
LGA: WILLOUGHBY  
SHEET: 5 OF 7 SHEETS



REFER TO NOTES AND LEGEND



SEE SHEET 1 FOR NOTES AND LEGEND

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B	00/00/00	-	00
A	03/08/15	Initial draft plan completed	00

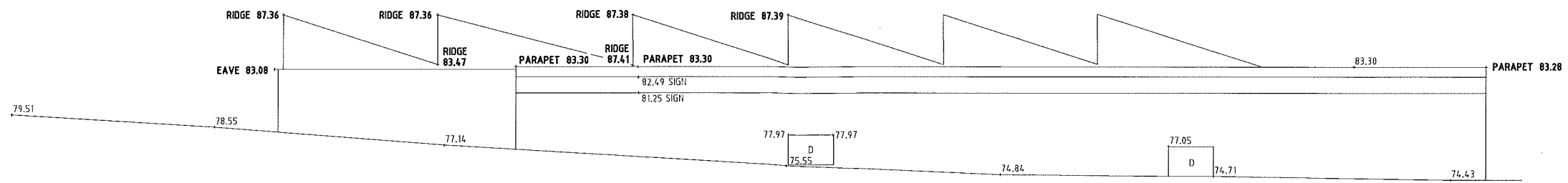
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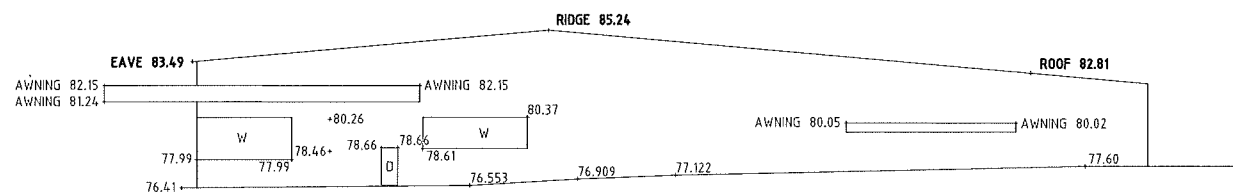
Suite 1, Level 1  
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 Gordon NSW 2072  
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 Gordon NSW 2072  
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 F 02 9499 7760

Client: DEXUS PROPERTY GROUP  
 Drawing title:  
**PLAN OF DETAIL AND LEVELS OVER LOT 1 IN DP591747  
 KNOWN AS 12 FREDERICK STREET ST LEONARDS**

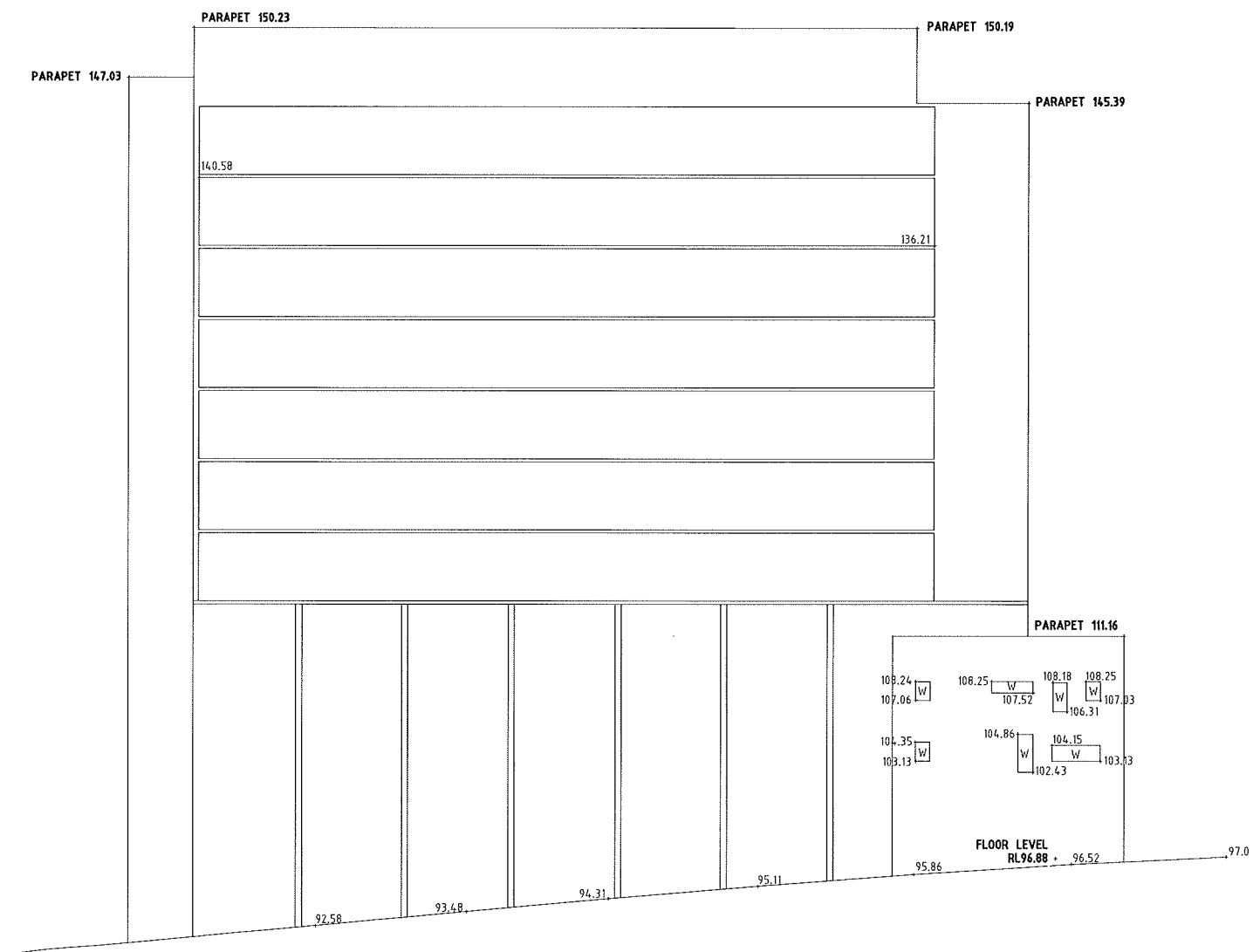
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site Area	2.478ha	scale	1:200 @A1	date of survey	30/08/15
LGA	WILLOUGHBY	SHEET	6 OF 7 SHEETS		6



NORTHERN ELEVATION - FREDERICK STREET



WESTERN ELEVATION (2) - LOT 2 DP778425



SOUTHERN ELEVATION - WESTBOURNE STREET



REFER TO NOTES AND LEGEND



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Client: DEXUS PROPERTY GROUP  
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file Area	2.478ha	scale	1:200 @A1	date of survey	30/08/15
LGA	WILLOUGHBY	SHEET	7 OF 7 SHEETS		

UNTOUCHED\_A3

**ANNEXURE B**

**PLATES SHOWING KEY FEATURES OF OVERLAND FLOW PATHS**

DRAFT FOR CLIENT REVIEW



**Plate 1:** Looking north (downstream) along eastern side of the Reserve Road from cross section *RR\_E\_9*.



**Plate 2:** Looking north (downstream) along the western side of Reserve Road from cross section *RR\_W\_7*.



**Plate 3:** Looking north (downstream) along the eastern side of Reserve Road from cross section *RR\_E\_7*.



**Plate 4:** Looking east (downstream) along the southern side of Frederick Street from its intersection with Reserve Road.



**Plate 5:** Looking east (downstream) from the Frederick Street Entrance/Exit towards the sag point in Frederick Street.



**Plate 6:** Looking east (downstream) along Westbourne Street from its intersection with Reserve Road.

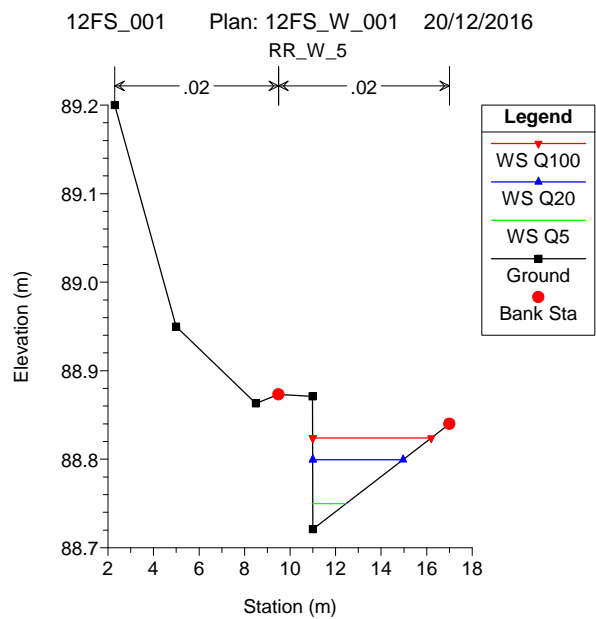
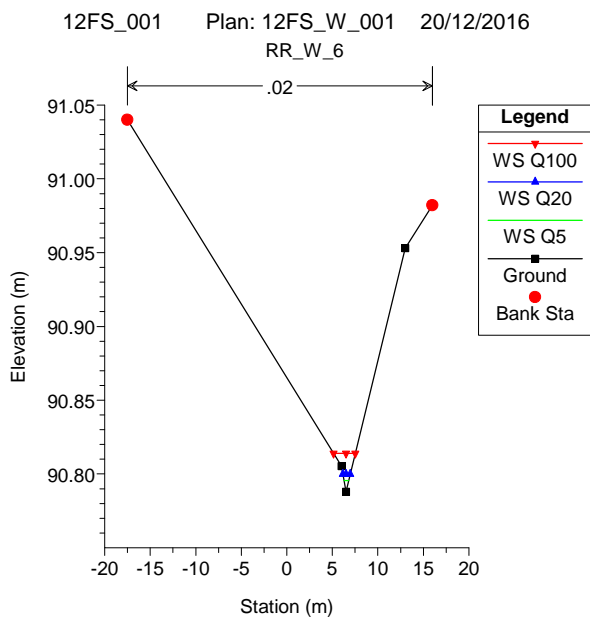
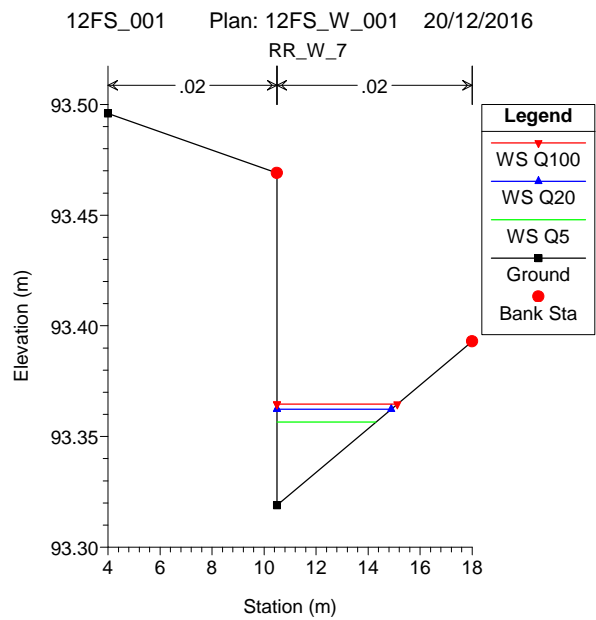
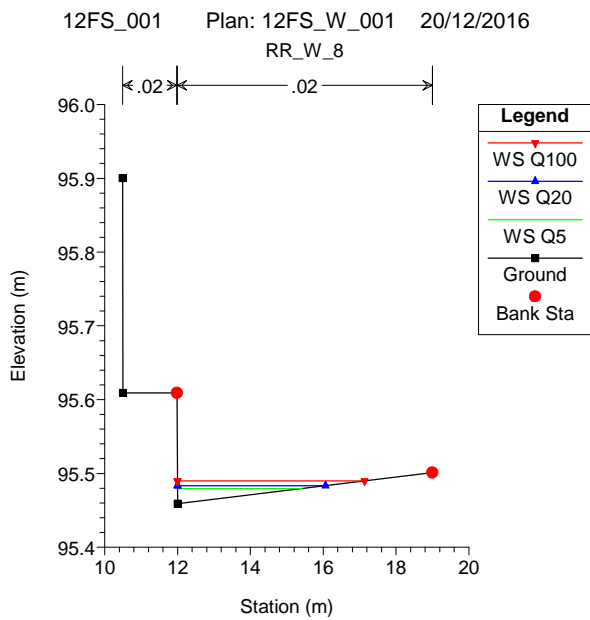
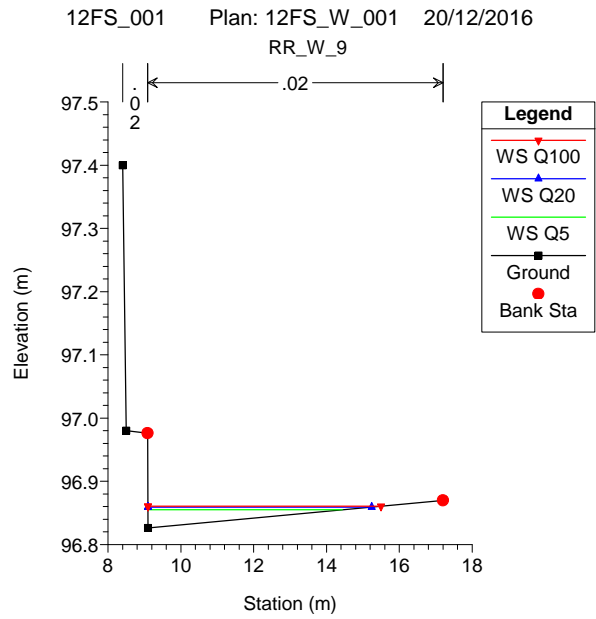
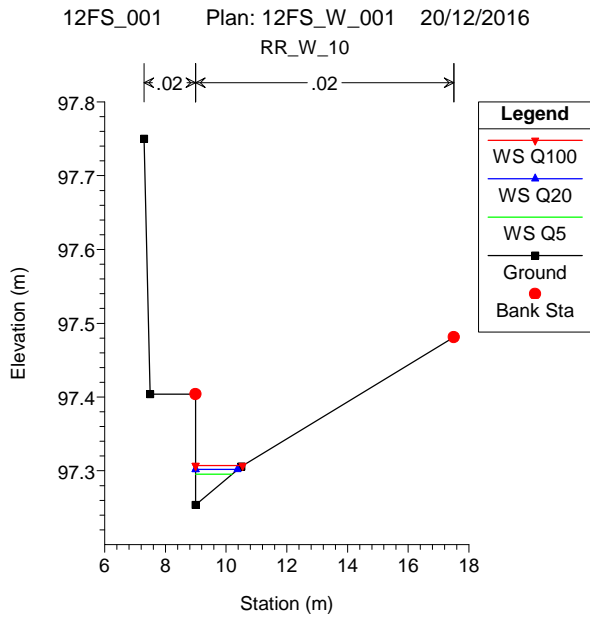
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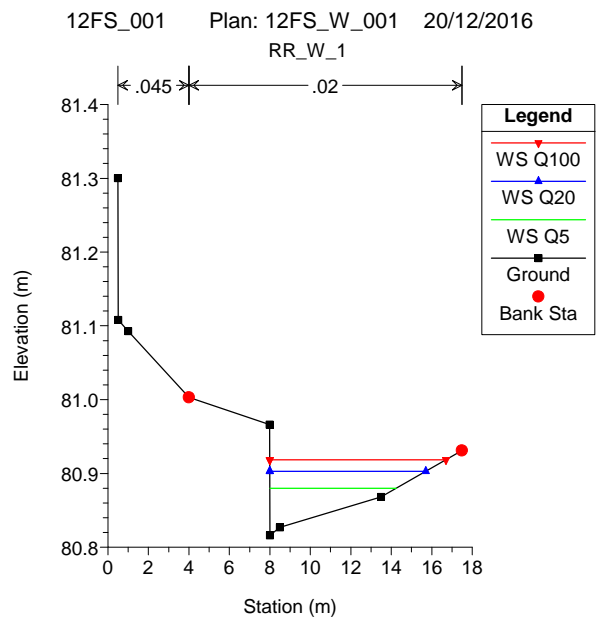
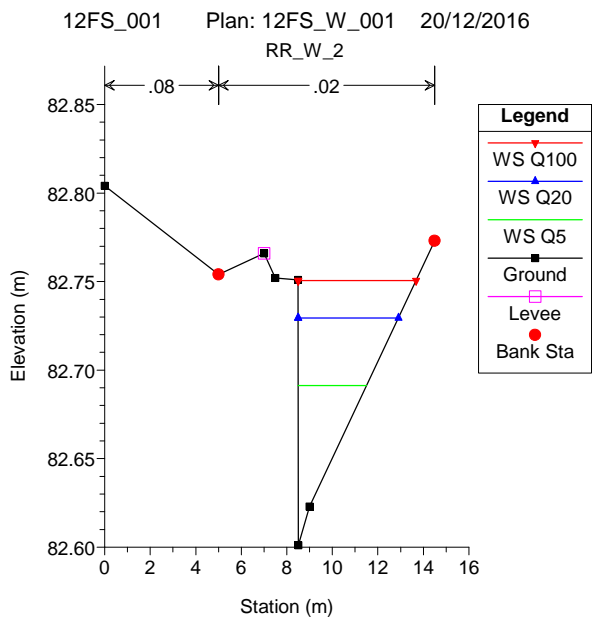
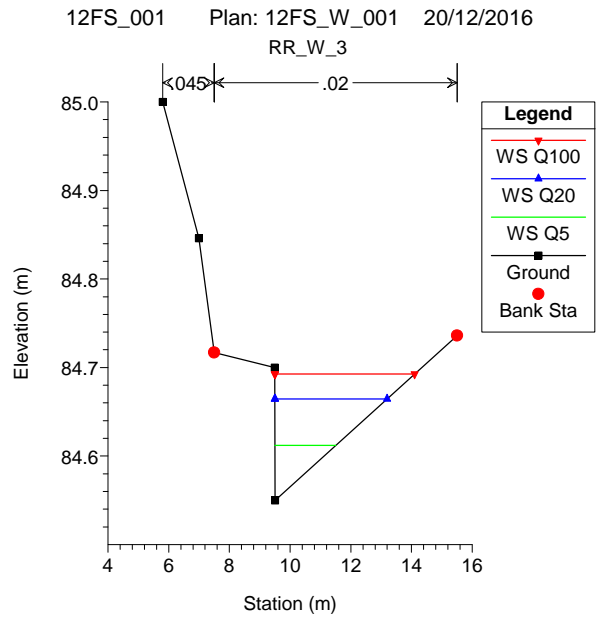
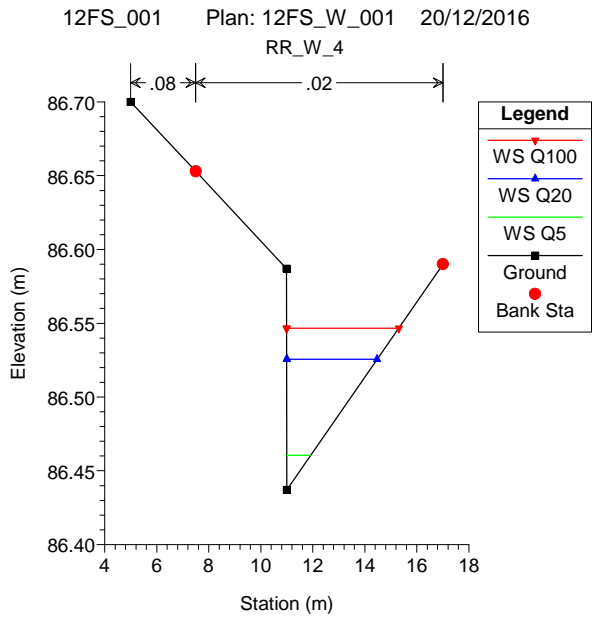
**RESERVE ROAD WEST HEC-RAS MODEL RESULTS**

DRAFT FOR CLIENT REVIEW

HEC-RAS Plan: 12FS\_W River: 12FS Reach: Reserve\_Rd

Cross-section	Profile	Gutter Level (m AHD)	Max. Water Surface Elevation (m AHD)	Peak Flow (m <sup>3</sup> /s)	Flow Velocity (m/s)
RR_W_10	5 year ARI	97.25	97.3	0.01	0.52
	20 year ARI	97.25	97.3	0.02	0.57
	100 year ARI	97.25	97.31	0.03	0.61
RR_W_9	5 year ARI	96.83	96.86	0.03	0.34
	20 year ARI	96.83	96.86	0.04	0.37
	100 year ARI	96.83	96.86	0.05	0.46
RR_W_8	5 year ARI	95.46	95.48	0.04	1.09
	20 year ARI	95.46	95.48	0.06	1.15
	100 year ARI	95.46	95.49	0.08	0.96
RR_W_7	5 year ARI	93.32	93.36	0.05	0.72
	20 year ARI	93.32	93.36	0.08	0.8
	100 year ARI	93.32	93.36	0.1	0.96
RR_W_6	5 year ARI	90.79	90.8	0.01	4.05
	20 year ARI	90.79	90.8	0.02	3.57
	100 year ARI	90.79	90.81	0.04	1.43
RR_W_5	5 year ARI	88.72	88.75	0.01	0.57
	20 year ARI	88.72	88.8	0.25	1.6
	100 year ARI	88.72	88.82	0.47	1.76
RR_W_4	5 year ARI	86.44	86.46	0.01	1.11
	20 year ARI	86.44	86.53	0.25	1.62
	100 year ARI	86.44	86.55	0.47	2
RR_W_3	5 year ARI	84.55	84.61	0.08	1.2
	20 year ARI	84.55	84.66	0.4	1.88
	100 year ARI	84.55	84.69	0.69	2.11
RR_W_2	5 year ARI	82.6	82.69	0.2	1.56
	20 year ARI	82.6	82.73	0.54	2.01
	100 year ARI	82.6	82.76	0.84	2.04
RR_W_1	5 year ARI	80.82	80.88	0.25	1.29
	20 year ARI	80.82	80.9	0.6	1.7
	100 year ARI	80.82	80.92	0.92	1.86





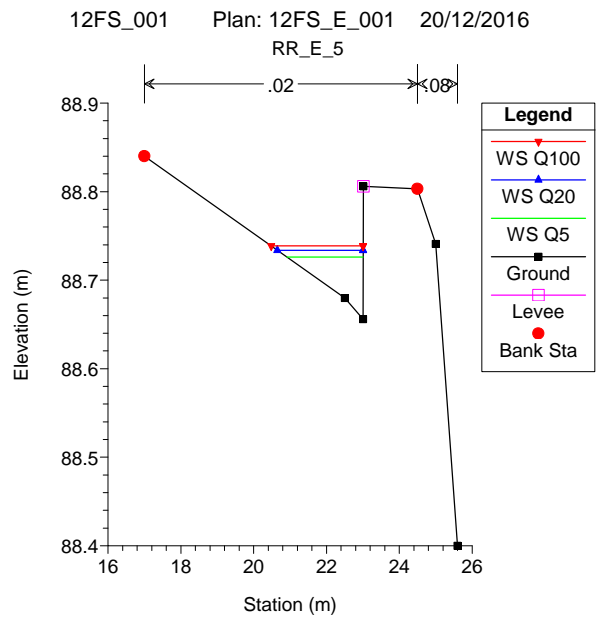
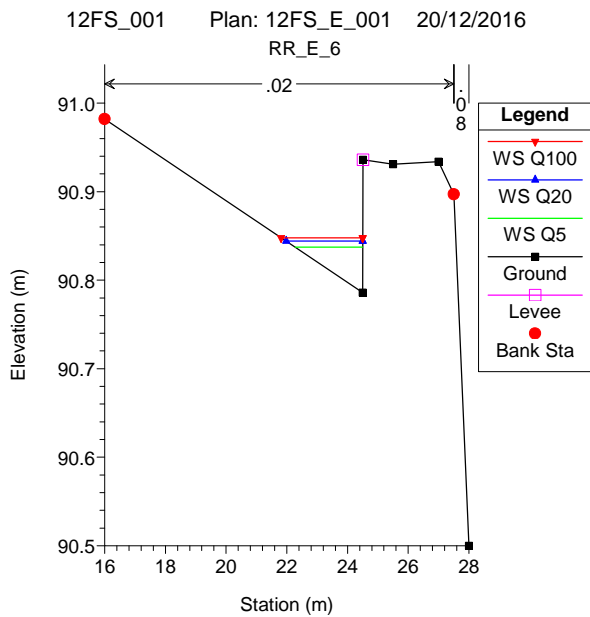
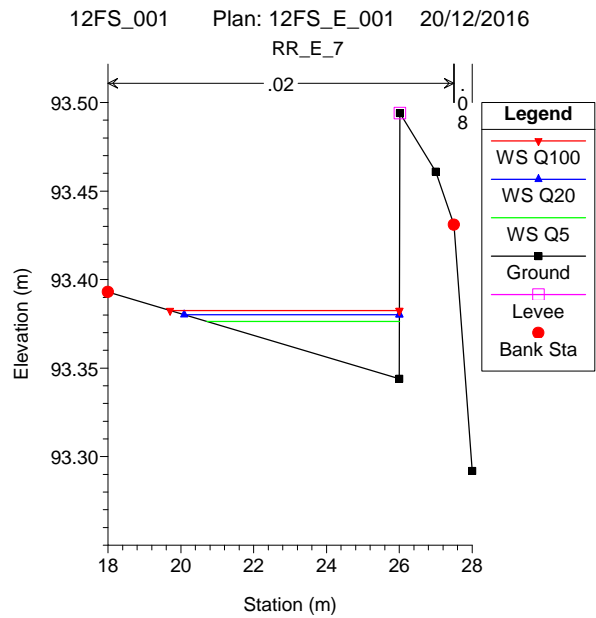
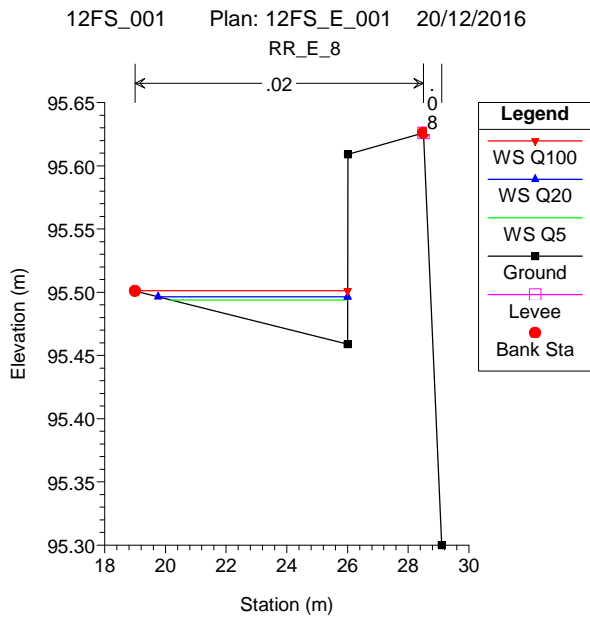
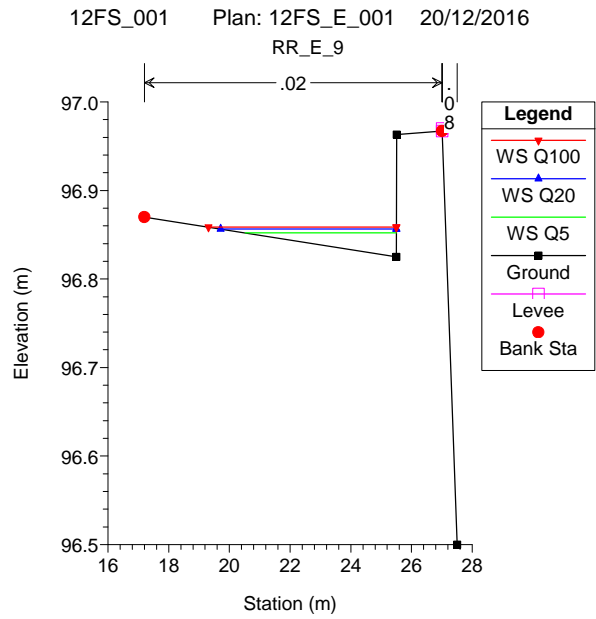
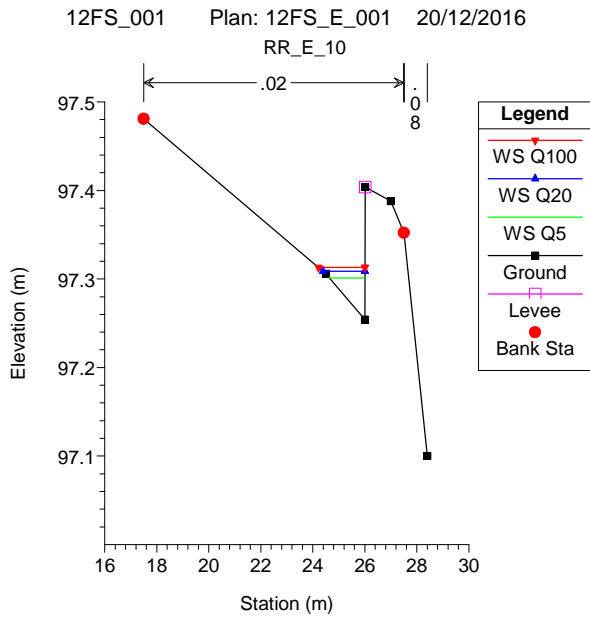
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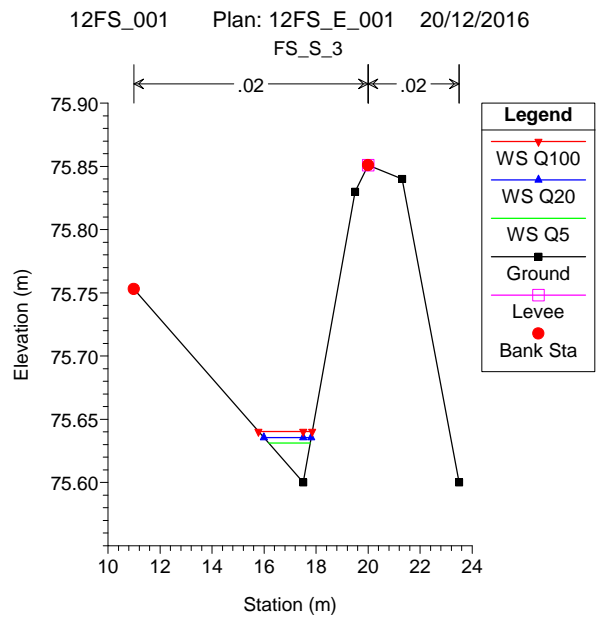
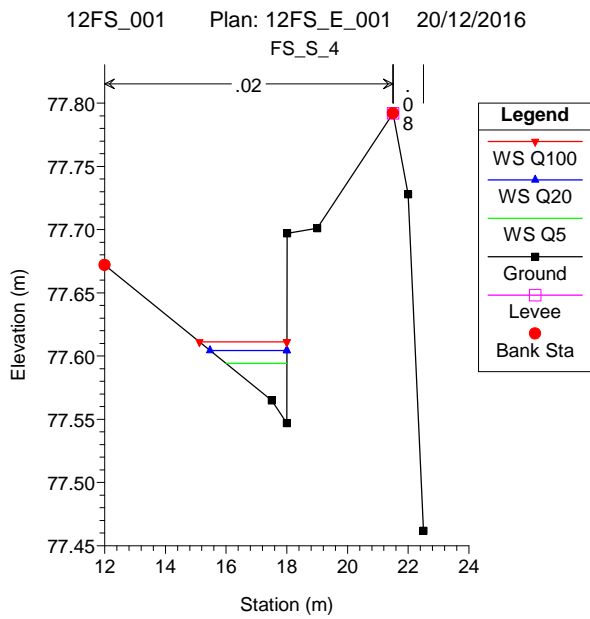
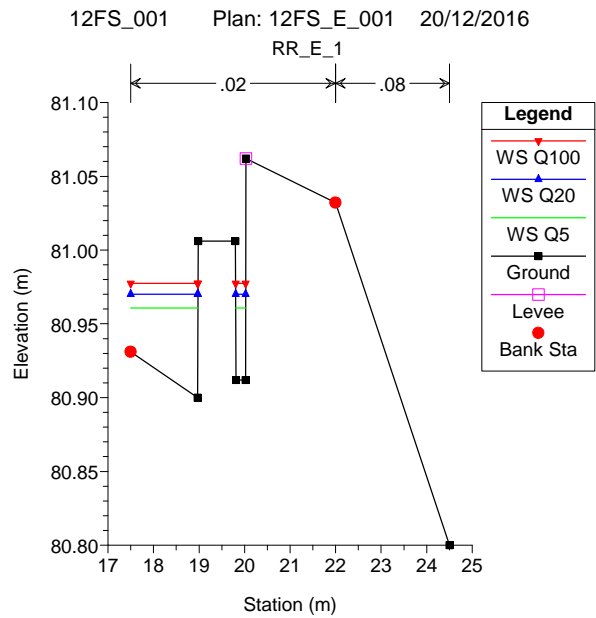
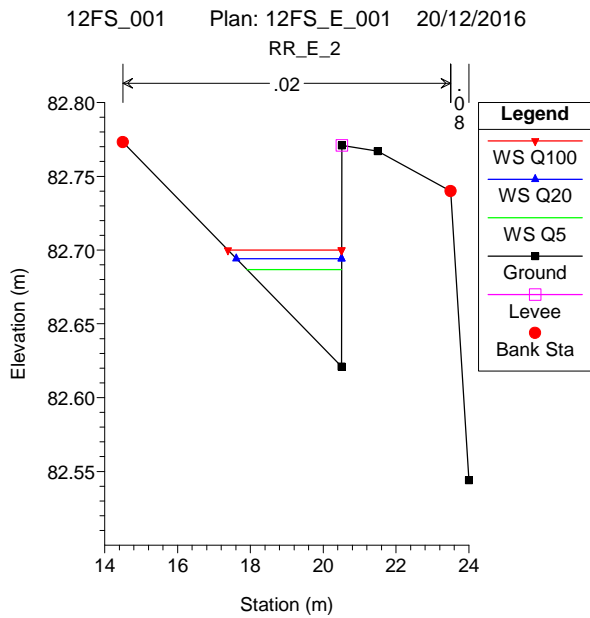
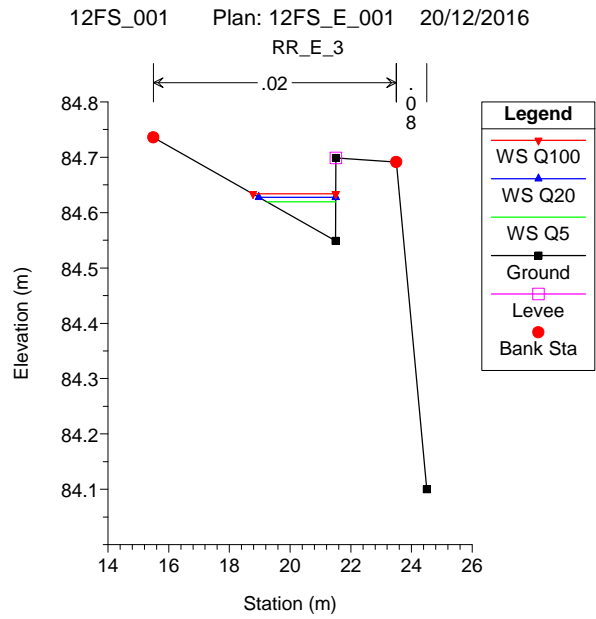
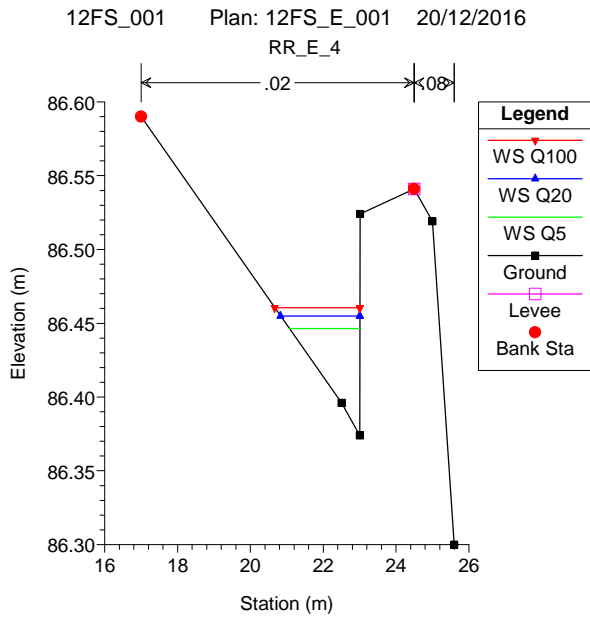
**RESERVE ROAD EAST HEC-RAS MODEL RESULTS**

DRAFT FOR CLIENT REVIEW

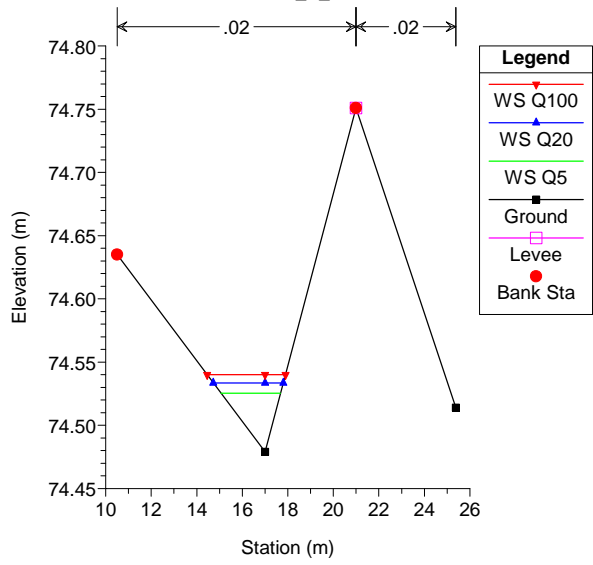
HEC-RAS Plan: 12FS\_E River: 12FS Reach: Reserve\_Rd

Cross-section	Profile	Gutter Level	Max. Water Surface Elevation	Peak Flow	Flow Velocity
		(m AHD)	(m AHD)	(m <sup>3</sup> /s)	(m/s)
RR_E_10	5 year ARI	97.25	97.3	0.01	0.4
	20 year ARI	97.25	97.31	0.02	0.41
	100 year ARI	97.25	97.31	0.02	0.44
RR_E_9	5 year ARI	96.82	96.85	0.03	0.39
	20 year ARI	96.82	96.86	0.04	0.4
	100 year ARI	96.82	96.86	0.04	0.41
RR_E_8	5 year ARI	95.46	95.49	0.04	0.38
	20 year ARI	95.46	95.5	0.05	0.45
	100 year ARI	95.46	95.5	0.06	0.44
RR_E_7	5 year ARI	93.34	93.38	0.05	0.61
	20 year ARI	93.34	93.38	0.07	0.66
	100 year ARI	93.34	93.38	0.09	0.71
RR_E_6	5 year ARI	90.79	90.84	0.05	0.9
	20 year ARI	90.79	90.84	0.07	0.96
	100 year ARI	90.79	90.85	0.09	1.03
RR_E_5	5 year ARI	88.66	88.73	0.07	1.02
	20 year ARI	88.66	88.73	0.09	1.1
	100 year ARI	88.66	88.74	0.11	1.16
RR_E_4	5 year ARI	86.37	86.45	0.07	1
	20 year ARI	86.37	86.45	0.09	1.07
	100 year ARI	86.37	86.46	0.11	1.13
RR_E_3	5 year ARI	84.55	84.62	0.08	1.02
	20 year ARI	84.55	84.63	0.11	1.09
	100 year ARI	84.55	84.63	0.13	1.15
RR_E_2	5 year ARI	82.62	82.69	0.08	0.95
	20 year ARI	82.62	82.69	0.11	1.03
	100 year ARI	82.62	82.7	0.13	1.08
RR_E_1	5 year ARI	80.9	80.96	0.08	1.05
	20 year ARI	80.9	80.97	0.11	1.18
	100 year ARI	80.9	80.98	0.13	1.26
FS_S_4	5 year ARI	77.55	77.59	0.02	0.48
	20 year ARI	77.55	77.6	0.03	0.48
	100 year ARI	77.55	77.61	0.04	0.5
FS_S_3	5 year ARI	75.6	75.63	0.02	0.79
	20 year ARI	75.6	75.64	0.03	0.95
	100 year ARI	75.6	75.64	0.04	1
FS_S_2	5 year ARI	74.48	74.53	0.02	0.33
	20 year ARI	74.48	74.53	0.03	0.37
	100 year ARI	74.48	74.54	0.04	0.4
FS_S_1	5 year ARI	74.24	74.28	0.02	0.38
	20 year ARI	74.24	74.28	0.03	0.43
	100 year ARI	74.24	74.29	0.04	0.46

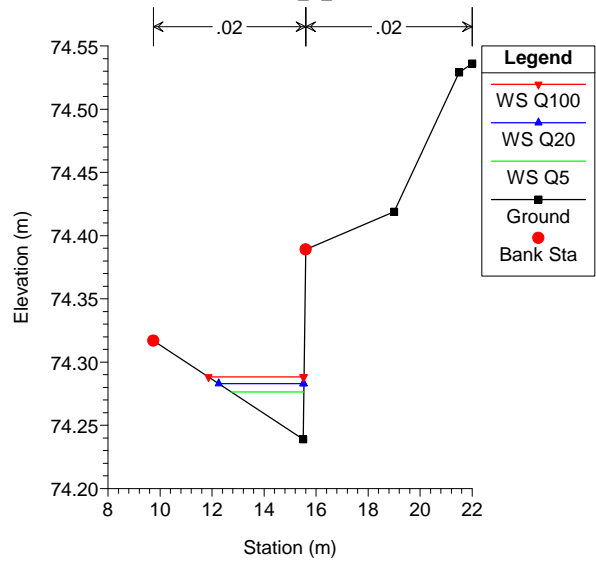




12FS\_001 Plan: 12FS\_E\_001 20/12/2016  
FS\_S\_2



12FS\_001 Plan: 12FS\_E\_001 20/12/2016  
FS\_S\_1



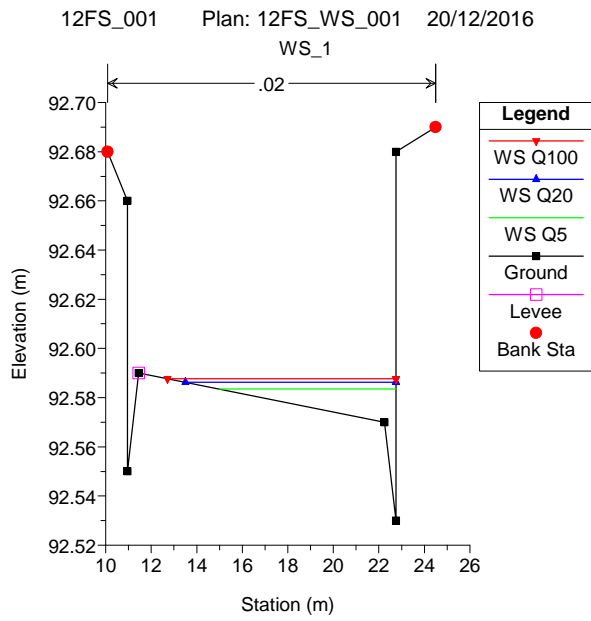
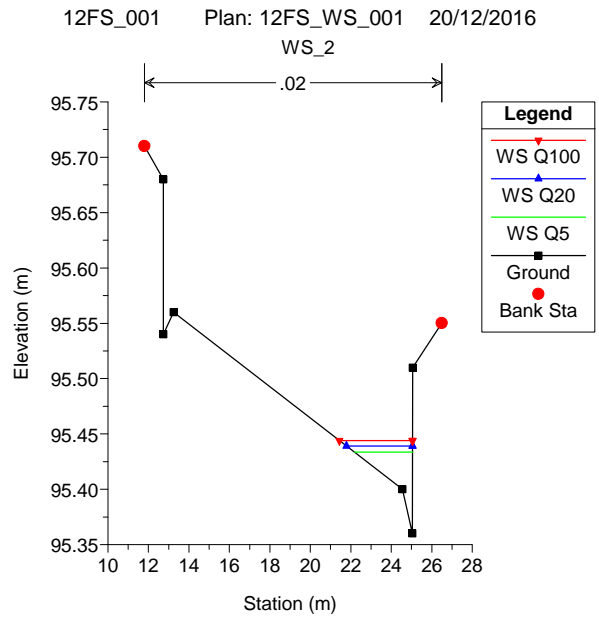
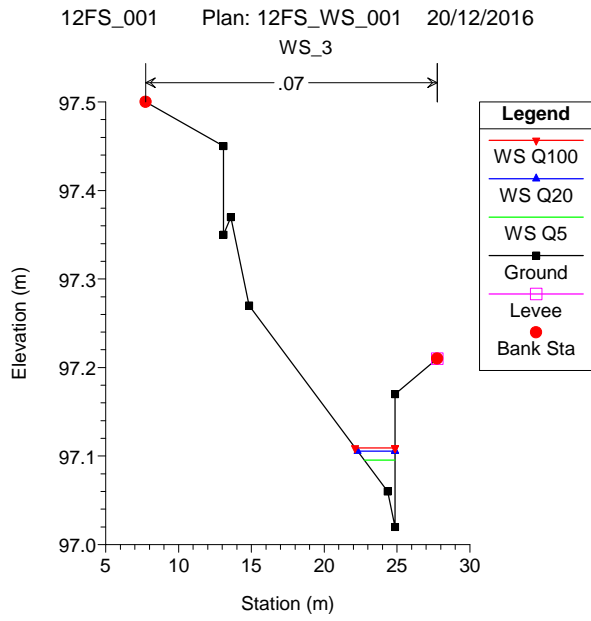
**ANNEXURE E**

**WESTBOURNE STREET HEC-RAS MODEL RESULTS**

DRAFT FOR CLIENT REVIEW

HEC-RAS Plan: 12FS\_WS River: Westbourne\_St Reach: Westbourne\_St

Cross-section	Profile	Gutter Level (m AHD)	Max. Water Surface Elevation (m AHD)	Peak Flow (m <sup>3</sup> /s)	Flow Velocity (m/s)
WS_3	5 year ARI	97.02	97.1	0.03	0.53
	20 year ARI	97.02	97.11	0.04	0.52
	100 year ARI	97.02	97.11	0.05	0.58
WS_2	5 year ARI	95.36	95.43	0.05	0.7
	20 year ARI	95.36	95.44	0.06	0.78
	100 year ARI	95.36	95.44	0.08	0.81
WS_1	5 year ARI	92.53	92.58	0.07	1.01
	20 year ARI	92.53	92.59	0.09	1.04
	100 year ARI	92.53	92.59	0.12	1.12



# SCHEDULE 3 – MUSIC RESULTS

# Receiving Node

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	Treatment Train Effectiveness				
	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	Gross Pollutants (kg/yr)
Sources	7.17	1.17E3	2.45	16.3	175
Residual Load	7.17	233	0.612	8.09	6.71
% Reduction	0.0	80.0	75.0	50.2	96.2