Engineers & Planners

REPORT

LAUDERDALE STORMWATER DRAINAGE ASSESSMENT

Project No. J111164CH

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Johnstone McGee & Gandy
incorporating **Dale P Luck & Associates**

APPROVED COMPANY
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CONTENTS

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1. INTRODUCTION

JMG have been engaged by Clarence City Council to provide a concept for stormwater drainage to suit changes in land zoning associated with the Lauderdale Structure Plan recently prepared by Council. This report examines the existing drainage infrastructure and streamflow paths for the catchments affected by the rezoning changes and outlines a drainage concept for the new lots proposed under the Structure Plan. The future impacts of continuing land fill and rising sea levels are also assessed.

2. PURPOSE AND SCOPE OF REPORT

The purpose of the report is to prepare a drainage design concept for the proposed urban and commercial lots proposed in the Lauderdale Structure Plan. The new residential lots are located along Ringwood Road and Mannata Street and the new commercial area extends the commercial zoning into 438/456 and part of 488 South Arm Road. These areas are shown on pages 9 and 13 of the Lauderdale Structure Plan and included in this report as Appendix A.

The extent of the study is limited to the catchment that incorporates the new lots. Only hydrological and civil engineering design aspects of the drainage system have been examined. The existing drainage systems, both natural and constructed have been examined and adequacies and inadequacies described. To carry out this analysis the catchment was divided into its two main subcatchments. Firstly, a catchment of 185 Ha that flows through the Lauderdale Lagoon and across Mannata Road and secondly, a smaller catchment of 83 Ha that flows across Ringwood Road and through Roches Beach Retirement Village. The catchments join at 526 South Arm Road and flow into Ralphs Bay through a single 900 and twin 600 concrete pipes under South Arm Road. These catchments are shown in Figure 1

The hydrology of sub catchments has been examined to determine runoff volumes, and review the flow capacities of existing structures at road crossings.

3. LAUDERDALE STRUCTURE PLAN

3.1 STATUS OF PLAN

The Plan has been approved by Council and a Planning Scheme Amendment has been initiated by Council responding to the relevant recommendations of the structure plan. The amendment (A-2011/10) is currently before the Tasmanian Planning Commission awaiting its final determination.

3.2 STRUCTURE PLAN EXECUTIVE SUMMARY

The following text has been extracted from the Plan to outline its purpose and highlight the key elements intended for the growth of Lauderdale.

"This structure plan is a long term plan for the use and development of Lauderdale. It is specifically a spatial plan and deals with issues in a broad framework. It is not intended to provide the level of detail you would expect in a detailed urban design masterplan, a social plan, landscape plan or the like.

This plan provides a framework for actions, some of which may require further project work involving detailed investigation and design, before they can be implemented.

Broadly then this structure plan builds on several important reports and plans to provide a framework for the following key elements in the growth of Lauderdale:

- Expansion of the urban growth boundary and associated planning scheme modifications.
- Provision for a neighbourhood activity centre with a large supermarket and associated speciality shops to serve the Lauderdale community and surrounding suburbs, from Acton Park to Opossum Bay.
- Provision for expansion of the residential area along the main collector linking the South Arm Highway to Bayview Road.
- Improved movement systems, including public transport, bicycles and pedestrian access, improved connections between commercial properties and to public land.
- Enhanced streetscapes to provide a high standard of residential and commercial amenity.
- Climate change responses for public land, including managing beaches as well as supporting development controls to protect buildings from inundation and coastal erosion events in the future.
- Development coordinated with the supply and connection of reticulated services."

4. EXISTING STORMWATER DRAINAGE

4.1 CATCHMENT DESCRIPTION

The area included in this investigation has a total catchment Area of 268 Ha (2.68 km^2) with two main subcatchments. Refer Figure 1.

Main Catchment - North Terrace 1 (NT1)

The catchment area is 185 Ha with a primary stream length of 4090m. The upper reaches are steeply sloping rising to 245m. These slopes reduce significantly however beyond the rear of rural properties on Acton Road with 64% of the catchment at less than 4.5m elevation with slopes reducing to grades of less than 1:2000.

Whilst the upper section of the catchment (above Acton Road) has natural drainage paths, drainage of the lower area is characterised by several formally constructed channels, lagoons and barriers including roads and filled land.

The lower areas of the catchment, where slopes are low, provide for significant retention of stormwater runoff through minor undulations, thick grass coverage, access tracks and roads impounding. Additionally there is a lagoon system known as the Lauderdale Wetlands through which all upstream runoff flows from Catchment NT1. The Wetlands have been formalised into a series of interconnected lagoons with a pump station removing water from the lowest lagoon, pumping to a shallow grass lined channel at the end of Balook Street.

86% of the catchment is upstream of Ringwood Road/Mannata Street, the proposed land for rezoning and development.

The majority of the catchment upstream of the proposed development is rural with some horticultural development but with a very low density of development overall. There is an area of main Lauderdale urban development to the east, comprising about 190 lots west of Bangalee Street. The urban lots along North Terrace slope to the catchment at their rear. Elsewhere there are about 25 residences or buildings scattered through the balance of the catchment. It is estimated there is 120,000m^2 of roofs and impervious areas (hardstand and roads including compacted gravel areas). This comprises less than 7% of the catchment. It should be noted that approximately 83% of the 120,000m^2 is located in the urban area. This urban area is generally positioned over highly permeable sandy soils which will reduce surface runoff. (Refer section on Geology below).

Secondary Catchment - North Terrace 2 (NT2)

The catchment area is 83 Ha with a primary stream length of 2340m. The upper reaches are steeply sloping rising to 220m. As with catchment NT1, these slopes reduce significantly beyond the rear of rural properties on Acton Road with 56% of the catchment at less than 4.5m elevation with slopes reducing to grades of less than 1:2000.

These lower areas of the catchment, where slopes are low, again provides for retention of stormwater runoff through minor undulations, thick grass coverage, access tracks and roads impounding runoff. This is to a lesser extent than catchment NT1 however with 80% of the catchment being upstream of Ringwood Road/Mannata Street.

The overall impervious area for the catchment is again very low at approximately 37,000m^2, 4.4% of the catchment area.

A summary of catchment areas is provided in Table 1 below.

Table 1 – Catchment Area Summary

Description	*NT1*	*NT2*
Catchment Area	185 Ha	83 Ha
Area >4.5m AHD	66.5Ha	36.7Ha
Area <4.5m AHD	118.5Ha	46.3ha
Downstream Balook Street	28.5Ha	N/A
D/S Mannata St / Ringwood Rd	19.2Ha	19.6Ha
Area of Recent Fill (Refer Fig 3)	3.9Ha	1.4Ha*

*Excludes filling on Roches Beach Living (RBL) Complex

Lower Catchment Areas

The lower lying areas of both catchments (areas downstream of Ringwood Road and Mannata Street) are subject to inundation during flood events and are subject to backflow of seawater during extreme high tide events. There is a significant portion of land downstream of Ringwood Road and Mannata Street which has a level of 1m or less and these areas are affected by seawater inundation demonstrated by the presence of saltmarsh. Maximum High Water for Hobart is 1.16m AHD. Note that Table 2.4 of the WRL Technical Report 2011/05 "Roches Beach Coastal Hazard Lines Reassessment – September 2011" defines the 100 year ARI (1% AEP) tide level for year 2000 as 1.44m AHD.

Formalised drains and excavated channels aid drainage in these lower reaches. The main drain in catchment NT1 has a concrete invert channel. There have also been some channel improvements carried out by Council in catchment NT2.

Development in lower areas that have been subject to inundation have been either undertaken on fill or placed on naturally occurring high areas within lots. Recent filling has occurred in some areas and this is discussed further below.

A detailed assessment to identify flood prone houses has not been undertaken.

4.2 HYDROLOGY

Localised ponding and barriers to natural flow paths are characteristic of both the major subcatchments as evidenced by aerial photography of the July 1974 flood event. (Refer Figure 5 of WRL/SGS Integrated Report – Climate Change Impacts on Clarence Coastal Areas).

For Catchment NT1, there are three major constrictions that can attenuate flood events.

1. Balook Street 3 x 375 RCP's and Access to Lots 146,148 & 150 Balook Street.
2. 3 x 375 RCP's under Mannata Road (once Balook Street is overtopped).
3. 2 x 600 RCP & 1 x 900 RCP under South Arm Highway

For Catchment NT2, there are two major constrictions that can attenuate flood events.

1. 1 No. 600 x 300 Box Culvert under Ringwood Road.
2. 2 x 600 RCP & 1 x 900 RCP under South Arm Highway (in conjunction with flows from Catchment NT1).

Analysis has been carried out to establish the flows through these restrictions before overtopping of the tracks or roads they pass under. A stage discharge relationship for overtopping has also been determined. Upstream flood volumes have then been determined based on LIDAR contours to quantify the effect these barriers have on floods of high magnitudes. The lack of any hydrologic data for the catchment means the analysis is subject to a number of assumptions and should therefore be considered as guidance only. It has been included however to demonstrate the potential impacts of higher return period flood events and possible effects of rising sea levels and land filling. The analysis is covered in Section 6 – Hydrology and Sea Level Rise below.

4.3 EASEMENT WIDTHS

The existing easements are shown on the plan attached in Appendix B. Easements are either 3.02m wide (NT1 main drain) or 1.83m wide (RBL drain)

4.4 COMMERCIAL

The catchment for the Commercial area covering the Nursery, doctors surgery, Tavern and shopping area is separate from catchments NT1 and NT2 and drains direct to Ralphs Bay through a piped drainage system.

5. GEOLOGY AND GROUNDWATER

5.1 REFERENCE REPORT

An overview of the Geology of the area is provided below. The information has been extracted from a report prepared by W C Cromer Pty. Ltd for the Lauderdale Sewerage Scheme (*Geotechnical Report, Lauderdale Sewerage Infrastructure, Lauderdale – Rokeby – January 2009*).

5.2 GENERAL DESCRIPTION

Lauderdale is underlain by unconsolidated Quaternary- and probably Tertiary-age sediments including beach and Aeolian sand, near-shore marine sands, and backswamp and estuarine sand, silt and clay. Lower ground is underlain by Tertiary-age sediments, and the higher ground is underlain by Permian-age sandstone and siltstone intruded by Jurassic-age dolerite.

The unconsolidated sediments at Lauderdale comprise:

- two upper units up to about 6m thick (and locally more) of loose grey sand and shelly sand over loose to stiff, bright olive green sand, clayey sand, silt and clay over
- at least two lower units of mottled orange and grey, stiff to hard, clay, silty clay and clayey silt.

The combined thickness of the four units is at least 24m, but may be much more. The uppermost units includes the Aeolian and beach sands which form an arcuate strip bordering Roches Beach, and extending up to 200m or so inland. This strip and the boundary line with the estuarine silty sands and clays is shown in Appendix C (Figure 4 from the Geotechnical Report – Lauderdale Sewerage Infrastructure). Of importance to surface runoff from the areas is the significant difference in permeability with catchment west of the boundary line being significantly less permeable than the Aeolian and beach sands to the east.

5.3 GROUNDWATER

The hydrogeology of the Lauderdale area was studied extensively in the 1990's firstly as part of the environmental management plan to extend the Lauderdale tip, and later to assess the impact, if any, of domestic wastewater disposal on groundwater quality north of the canal. These and other investigations are summarised by Cromer (2006)[2].

Groundwater is present at shallow depth throughout the unconsolidated Quaternary sediments at Lauderdale, and in the adjacent Tertiary sediments near the Lauderdale School. It is also probably present in the older Permian sediments and Jurassic dolerite, but at greater depths.

In the unconsolidated Quaternary materials at Lauderdale four types of groundwater are recognised (Cromer 2006, cited above):

- **Type 1.** This is a low salinity water (electrical conductivity <2,000µS/cm) in the arcuate coastal Aeolian and beach sand bordering Roches Beach (encountered at Aragoon, Mannata and Balanada PS).
- **Type 2.** This groundwater is moderate salinity leachate (electrical conductivity <5,000µS/cm) beneath the former Lauderdale tip, which is on the southern side of the Lauderdale Canal and not in the area covered by this report.
- **Type 3.** This high salinity groundwater occurs beneath the low-lying salt marshes extending from the rear of the beach system west to Ralphs Bay. Near surface electrical conductivities may exceed 50,000µS/cm (compared to sea water conductivities around 35,000µS/cm) but probably decrease with depth. This groundwater type is present along the lower sections of the main drain (64,000µS/cm) with decreasing values upstream at the Main Sewage Pumping Station (13,100µS/cm).

[2] Cromer, W. C. (2003). *Lauderdale Marina Village: Hydrogeological considerations.* Report by William C Cromer Pty Ltd for Walker Corporation Pty Ltd and Tominex Holdings Pty Ltd (September 2003), in The Vision for Lauderdale Lauderdale Quay (June 2006). Submission to the Tasmanian Government by Walker Corporation.

- **Type 4.** This groundwater is a moderate salinity water (electrical conductivity 3,000 – 5,000µS/cm) present in the silt and clay sediments rising gently inland to the west from Roches Beach, and to the north from near the Lauderdale Tavern and north of Ringwood Road and Mannata Street.

6. HYDROLOGY AND SEA LEVEL RISE

6.1 CURRENT FLOOD LEVELS

The largest flood in recent years occurred in 1974. Peak levels from this flood were not formally recorded however these have been estimated from aerial photography and have been reported as 1.5m AHD in the lower catchment bounded by the South Arm Highway.

6.2 FLOOD ATTENUATION ANALYSIS

An analysis was undertaken to determine runoff rates and volumes using Boyds formula and the rational method. The flow capacities of culverts under Mannata Street (Catchment NT1), Ringwood Road (Catchment NT2) and the South Arm Highway (Catchment NT1 + NT2) were used to determine storage volumes (and associated levels) that would occur behind these structures for flood events. The culvert analysis was carried out using "Hydraflow" (CivilCAD 3D design package) which uses Mannings formula as its calculation basis (n=0.12). IDF curves for Lauderdale, obtained from the Bureau of Meteorology Website, were used in the analysis. Storage volumes were calculated for areas based on LIDAR level information. The levels of recent filling, as shown in Figure 3 were superimposed on the LIDAR information to calculate the volumes given below.

Table 2 - Summary of Flood Storage Volumes and Culvert Capacities

Location	**Upstream Storage Volume at overflow level**	**Culvert Size & Number**	**Culvert Capacity at overflow level**
Ringwood Road at RBL Culvert (NT2)	720 m^3	600 x 300	340 L/s
End Balook Street at entrance to 150 (NT1)	9000 m^3	3 x 375	580 L/s
Mannata Street at Main Drain (NT1)	Included in Volume below to 1.5m AHD	3 x 375	380 L/s
South Arm Highway & 40 North Terrace Discharges (NT1 & NT2)	*74000 m^3	900 / 2 x 600 1 x 375	*1040 L/s *190 L/s

* Values at 1.5m AHD

Runoff coefficients were varied between 0.05 and 0.5 for ARI events for 1 year to 100 years respectively.

Further details of hydraulic data are attached in Appendix D.

Upper Catchment Flooding

Figure 6 shows the inundation that occurs when water rises to the barriers caused by Ringwood Road and the raised ground that provides driveway access to 150 Balook Street.

With respect to sub catchment NT1, the above table shows that for flows up to 380 L/s, upstream runoff passes through culverts without overflowing. Above this flow rate water will overflow across Mannata Street. By the time this occurs, water is already spreading beyond the concrete spoon drain downstream of Mannata Street, rising to a depth of approximately 300mm and resulting in inundation of surrounding land.

The Lauderdale Lagoon attenuates the flood hydrograph, significantly reducing the frequency of overtopping. Theoretical flows from short duration storm events with frequencies of less than 1 year ARI will produce flows in excess of 380L/s however it requires a 20 year ARI 6 hour storm to cause overtopping at Mannata Street.

The drain under Ringwood Road that continues under RBL has a capacity of 150L/s and 340L/s before overtopping. Analysis shows that overtopping will occur relatively more frequently across Ringwood Road with a 1 in 5 year to 1 in 10 year event flooding the upstream storage area resulting in flow over the road. The capacity through RBL however is significantly greater but constraints do exist further downstream.

High Level Flooding

The event that causes overtopping of Mannata Street will produce a flood level of around 1.0m AHD in the downstream area bounded by South Arm Road and North Terrace. More extreme events will result in higher levels of flooding in this lower catchment area. Figure 5 shows the areas inundated for a flood level of 1.5m AHD. This was the estimated level of the 1974 flood. Whilst there is a significantly larger storage area compared with the upstream catchments, the channel capacities and drainage outlets to the catchment still constrain flow and raise the level within the storage area. As levels rise however the outflow from the catchment increases as head increases in the 900/600 RCP under South Arm Road and 375 RCP under North Terrace. This has a mitigating effect on flood levels.

Based on current culvert capacities and extent of filling, a 1 in 100 year ARI event will result in a flood level of 1.5m AHD.

An event between 1 in 20 year and 1 in 50 year ARI storm will result in a flood level of 1.2m AHD in the lower catchment.

These events will only be affected by the highest of tides and because they occur over periods of greater than 12 hours the tidal cycle will allow the catchment to drain.

6.3 SEA LEVEL RISE

Clarence City Council commissioned WRL to review and determine the potential inundation risks and produce hazard lines for Roches Beach. Table 23.1 from the WRL Report "Roches Beach Hazard Line Assessment – September 2011" is reproduced below and summarises sea levels for mid and high level sea level rise scenarios for the years up to 2100.

Table 3 - Sea Level Rise

Equivalent Present Day Average Recurrence Interval Risk) of Hobart Sea Level for Various Future Sea Levels and Future 100 year ARI event

Year	SLR(m)	100 year ARI Level	Equivalent present day ARI (years)
present	0.0	1.44	100
2050	(mid) 0.2	1.64	800
2050	(high) 0.3	1.74	2,000
2100	(mid) 0.5	1.94	15,000
2100	(high) 0.9	2.34	850,000

For the HIGH range scenario a rise of 900mm applies by 2100 across all return intervals. This will result in the twice daily high tides inundating the lower areas of the catchment, e.g. a current Tide Chart Height of 1.0m (0.17m AHD) will be equal to 1.07m AHD in 2100. The invert, where flow enters the stormwater pipes that pass under the South Arm Highway is 0.67m AHD. The impact on flood levels in 2100 will depend on the coincidence of flood and tide levels but will range from an increase of up to 0.4m for daily tide events and up to 0.87m increase for the 100 year tide event.

6.4 DEVELOPMENT IMPACTS FROM LSP

There will be approximately 63 lots created under the proposed Lauderdale Structure Plan. Whilst this will be approximately a 20% increase in urban lots for the catchment, it creates a relatively small overall increase in the impervious area of 0.9% (rising from 6.1% to 7.0%). Whilst local drainage to the new lots requires a formal system the impact of the development on overall catchment runoff is negligible.

The Commercial Development will substantially discharge stormwater direct to Ralphs Bay (outside of North Terrace Catchment area) and will have no impact on flood levels for the balance of the catchment.

The filling associated with the residential land development will affect current drainage paths and potentially cause local flooding of upstream properties. The implementation of the drainage concept as proposed below will eliminate the possibility for localised flooding. The reduction of storage area in the lower catchment by filling of land less than 1.5m elevation will however increase flood levels. The rise can be eliminated by improvements to drainage channels and culvert capacities. This is discussed further below.

6.5 IMPACTS OF DEVELOPMENT ELSEWHERE

As mentioned the catchment area is largely rural with significant attenuation of flood events due to high initial losses associated with retention of stormwater runoff through minor undulations, thick grass coverage, access tracks and roads impounding runoff and the Lauderdale Wetlands lagoon system. Large scale changes to land use that increase impermeable areas within the catchment will increase runoff. If this coincides with a reduction of areas downstream through land filling then drainage paths will require upgrading to deal with the increased flows.

The impact of stormwater runoff should be considered as part of the approval of any developments within the catchment.

7. LAND FILLING

7.1 FILLING PLAN

A walk through site inspection was made to identify areas of recent fill. These areas are shown in Figure 3. The approximate depth of fill was measured to the nearest 0.5m.

The total area of recent filling downstream of Mannata Street and Ringwood Road, as shown in Figure 3, is 53,000m^2 (5.3Ha). This area equates to 14% of the 37.7Ha catchment area downstream of Mannata Street and Ringwood Road but this is not equally divided. The table below shows the extent of filling within the catchments of the two main drains (NT1 & NT2).

Table 4 – Areas of Filling Downstream of Mannata Street and Ringwood Road.

Description	Percentage reduction in Area	Area of Fill
Extent of Filling for Catchment NT1	20%	38,500m^2
Extent of Filling for Catchment NT2	8%	15,300m^2
Extent of Filling in Catchment NT1 in area up to RL1.5m	23%	38,500m^2
Extent of Filling Below RL1.5m for Catchment NT2	4%	3,300m^2

The storage volume reduction will be the same percentage for floods up to 1.2m AHD and slightly less for floods to 1.5m AHD

7.2 EFFECT OF FILLING

Any reduction in volume of the storage areas shown in Figures 5 and 6 will result in an increase in the flood level for the same rainfall event. This is because the flood routing effect (attenuation) will be reduced to the storage effects in the channel only. The greater the amount of land filling, the higher the level, and frequency, of flooding that will occur.

At the extreme, it is assumed all the lower catchment is filled and the available storage volume is reduced to say 20,000m^3. For the 100 year ARI storm event, if the critical time of concentration for the catchment is 3 hours, the drain will require a channel and outlet culvert capacity of 4.3m^3/s, if the critical event is a 1 hour storm, a capacity of 6.4 m^3/s is required. The current capacity of the outlet culvert (at 1.57m AHD, i.e. 900 deep) is 1.23 m^3/s. A vertical sided concrete channel 3.7m wide and flowing approximately 900mm deep is required for a capacity of 4.3m^3/s (5.2m wide for 6.4 m^3/s).

Overflow Drainage Paths
During extreme flood events the water levels of the lower areas downstream of Ringwood Road and Mannata Street have combined to produce a single pool. It is recommended the connectivity between catchments is maintained and made a condition of any filling permits. This will assist in reducing the level of flooding in partial area storms where filling does not exacerbate flooding upstream.

8. NEW DRAINAGE CONCEPT

8.1 GENERAL DESCRIPTION

The residential area nominated for zone change is a strip either side of Ringwood Road and Mannata Street. The levels along this strip are in a range between approximately 1m, for land adjacent to the main drain of Catchment NT1 (26 Mannata Street), up to 2.5m for land opposite Roches Beach Living complex (61 Mannata Street).

Filling will be required along the residential strip both to provide a building platform for housing and to provide for drainage from and around the new housing lots.

A drainage concept plan is shown in Figure 4.

Due to the constraints imposed by the levels of existing drainage channels open channel drains are proposed at the front and rear of the properties. Both front and rear drainage will be dual purpose. The front drainage will provide road reserve and property drainage. The rear drainage channel will direct upstream runoff to the main drainage channels and again provide for property drainage.

8.2 MANNATA AND RINGWOOD ROAD RESERVES

It is assumed that the existing road levels will remain largely unaltered. The 18m width of the existing road reserve however will be insufficient to accommodate the improvements required to formalise the current drainage channels and provide for a cyclepath and footpath. Land requirements for each component of the road reserve are suggested below.

Required Road Reserve Width

Reserve Component	
Roadside Swales 2 x 4m	8m
Road Pavement	7.4m (Minor Collector)
Road Verges	1.2m
Shared Path	2.5m
Footpath	1.5m
Sides to paths 4 x 0.3m	1.2m
Total	21.8m minimum

Council's standard road reserve widths are 15m, 18m and 24m. With a minimum required width of 21.8m a 24m wide reserve is recommended.

Drainage Path Crossings of Residential Lots, Ringwood Road and Mannata Street
Stormwater crossings of the road reserve (and adjacent lots) will be either piped or in open channels. There are three crossings to consider.

NT1 Main Drain at 26 Mannata Street - The Structure Plan's designated green belt channel crossing of Mannata Street may need widening to ensure it does not become a restriction and raise flood levels upstream. A significant factor in this assessment is the impact of filling of adjacent residential lots. An alternative to widening would be to provide additional culverts under the road.

Drain at 66 Mannata Street - The catchment area for this drain crossing is relatively small and can be accommodated within a piped system.

NT2 Main Drain at RBL - The area upstream of the culvert under Ringwood Road has no defined channel and has been subject to inundation during flood events. The owners of the rural lots immediately behind the new residential lots are likely to be concerned the residential development will aggravate this flooding. The culvert under Ringwood Road is 600 x 300 and has a capacity of 150L/s before backing up behind the road. This culvert should be increased in size to match downstream channel capacity. Should there continue to be concerns an overflow path both south west towards the drainage system that flows under the Commercial lots of the Tavern and adjacent Shopping Area and southeast along Mannata Street to catchment NT1 can be provided to further mitigate against extreme flood levels.

8.3 INFRASTRUCTURE AND LAND FILLING

To be regarded as a "permitted" development, the strips of land each side of the road will require filling to provide a building platform to satisfy Council's development conditions and ensure a floor level of 3.2m. The area of filling associated with the new lots is 46,800m^2, with 11,800m^2 below the 1.5m AHD level increasing the area of current land filling from 41,800m^2 to 53,700m^2 (and consequential reduction of the flood storage volume). The extent of fill in the areas below 1.5m AHD will increase from 23% to 29% of Catchment NT1 and increase from 4% to 4.5% for Catchment NT2. The effect of this reduction in storage volume will increase the level and frequency of flooding but can be corrected by increasing channel and culvert capacities.

To ensure the integrity of the drainage concept the proposed drainage channels should be constructed in their entirety prior to any subdivision occurring. This is to ensure that development of individual lots is not obstructed or disrupted by undeveloped sections downstream and to ensure the drainage concept is implemented across the current title boundaries. It would also be preferable to carry out filling activities in conjunction with drainage works to ensure damage does not occur to the drainage system.

The road side swales can be grass lined as these will be readily accessible and subject to regular maintenance. It is recommended however for the drains at the rear of properties to be concrete lined. Concrete lining is recommended to ensure obstructions such as trees and shrubs do not block the drainage path and to mitigate the risk of lot owners altering the path. The style of drain can be similar to existing infrastructure and be either a 1m wide concrete shallow spoon drain with grassed batters (similar to the main drain crossing 26 Mannata Street) or the rectangular concrete channel recently constructed through 506 South Arm Road. The widths and levels of the drain would be determined during detailed design.

Easements of appropriate widths will be required over the drainage channels on private land. Controls over fencing between properties will also be required. Locating the open channel in the larger rural zoned lots will assist in this regard.

FIGURES

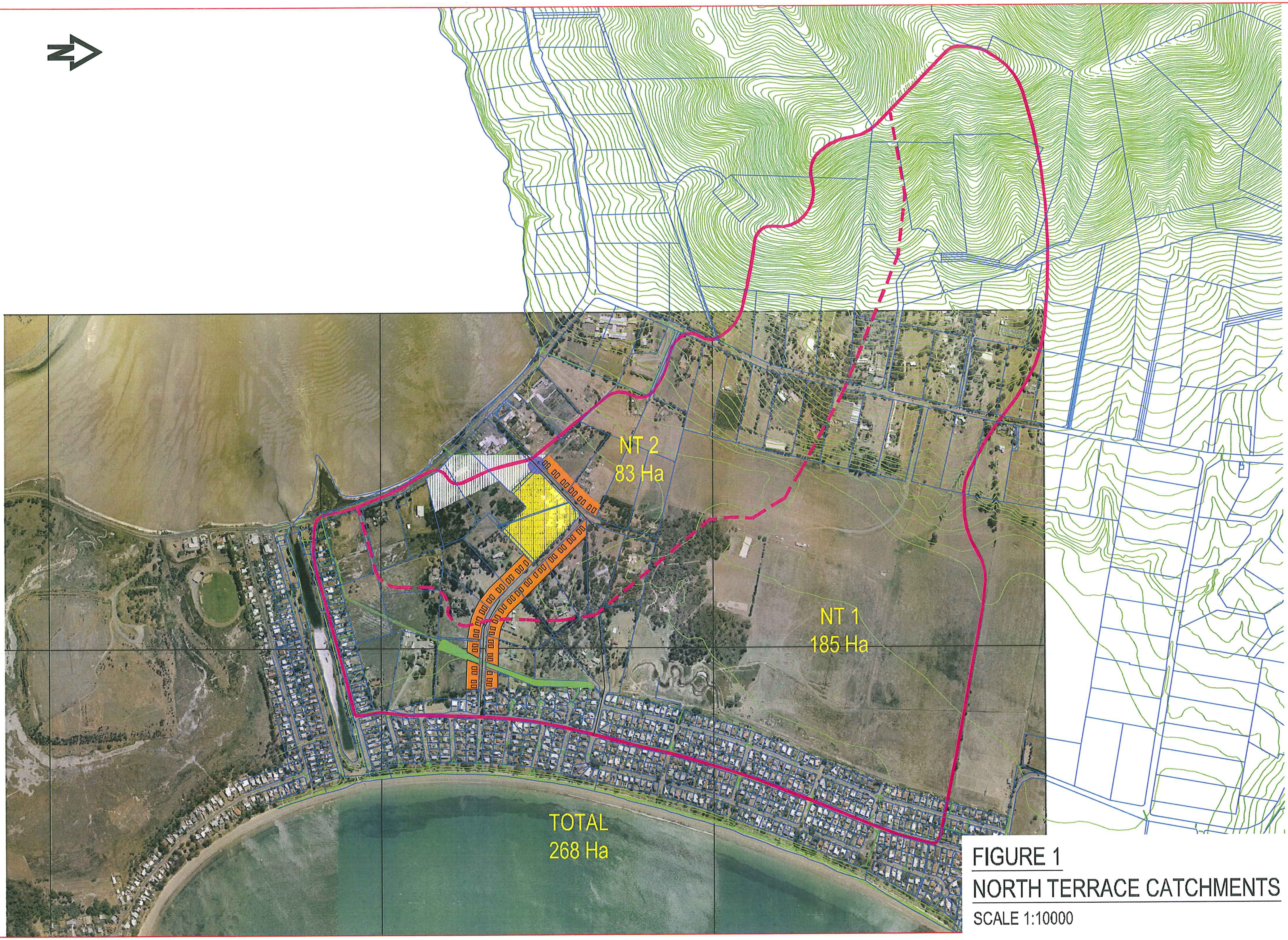


FIGURE 1
NORTH TERRACE CATCHMENTS
SCALE 1:10000

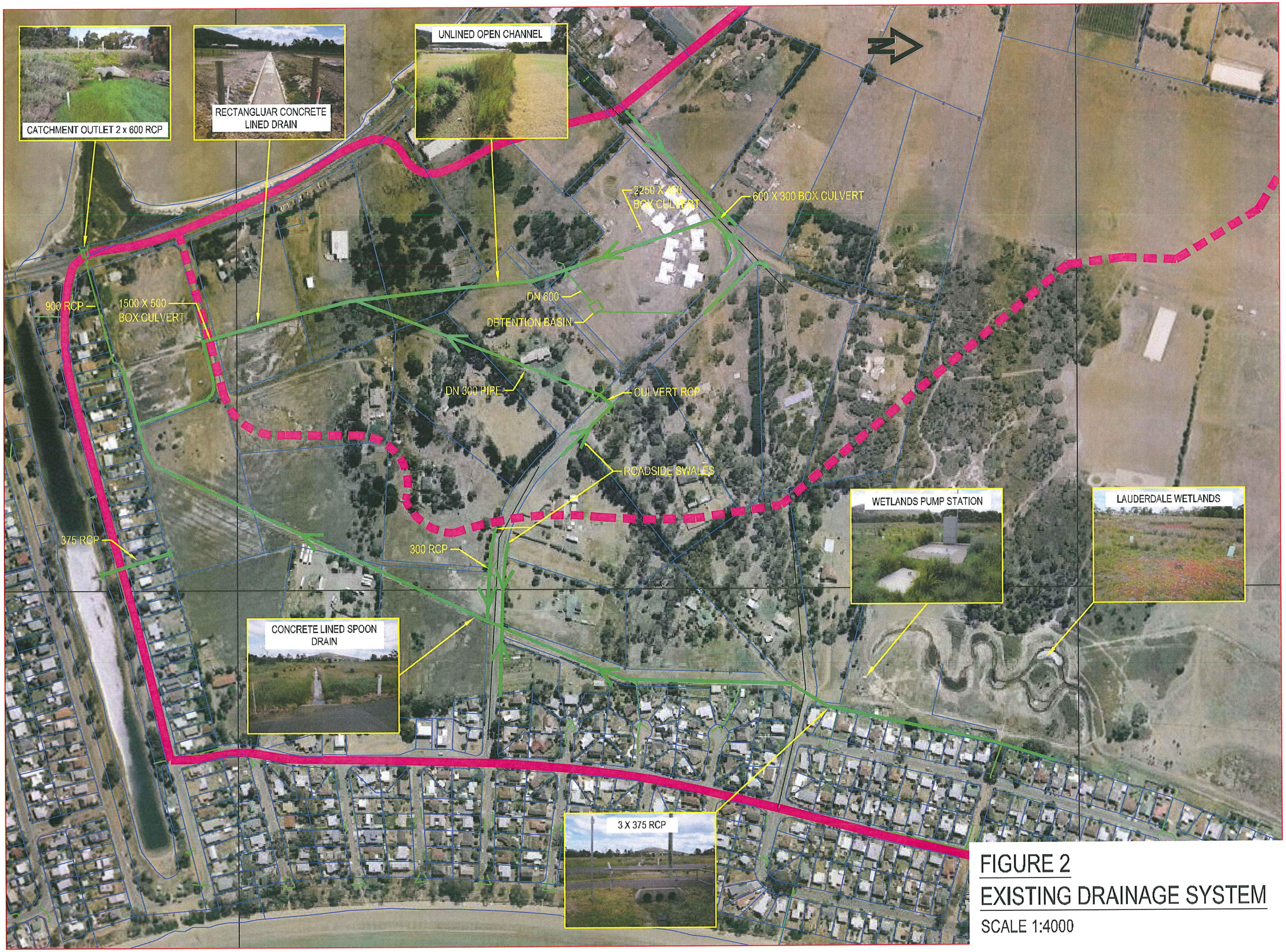
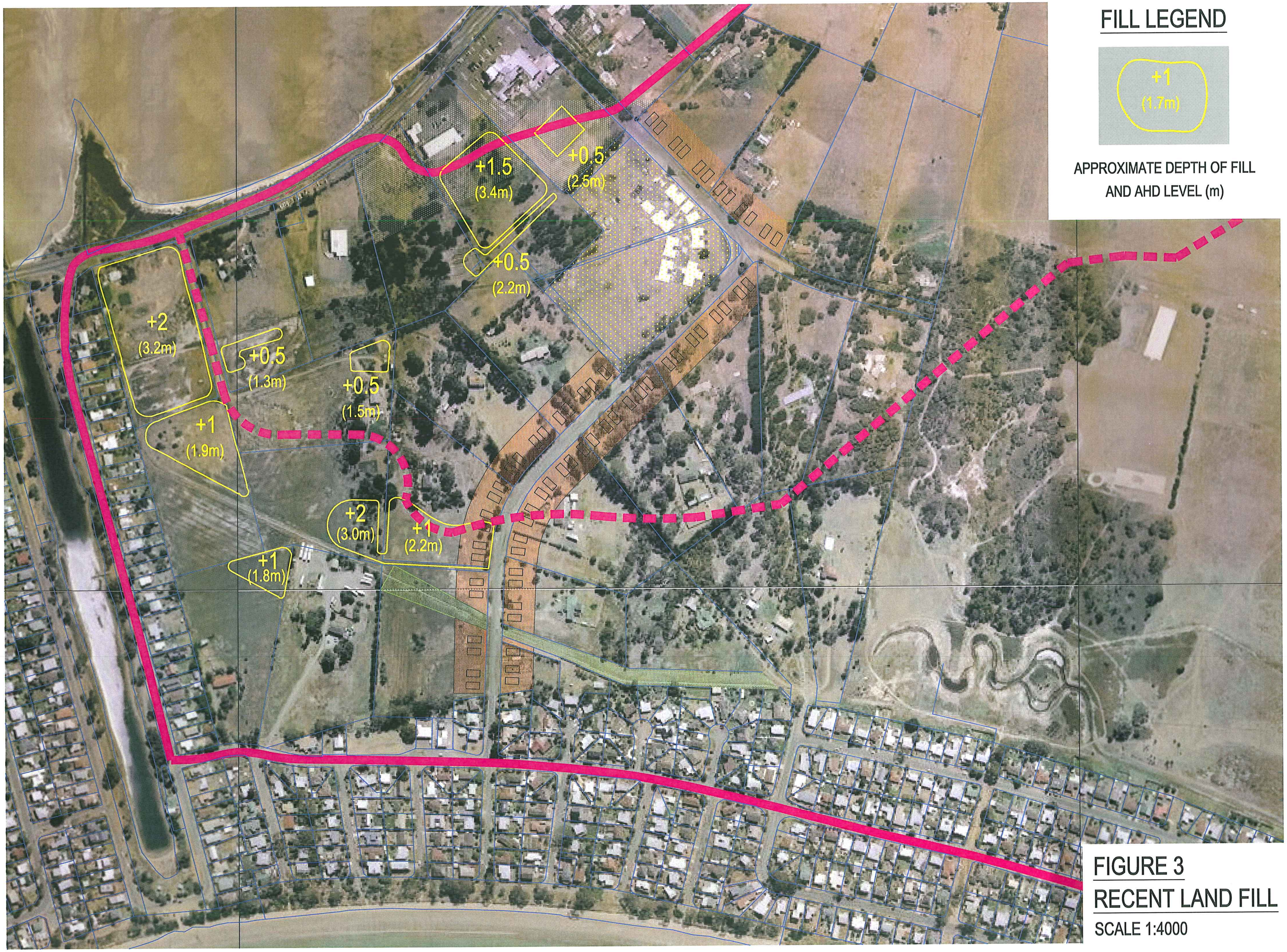


FIGURE 2
EXISTING DRAINAGE SYSTEM
SCALE 1:4000



FILL LEGEND

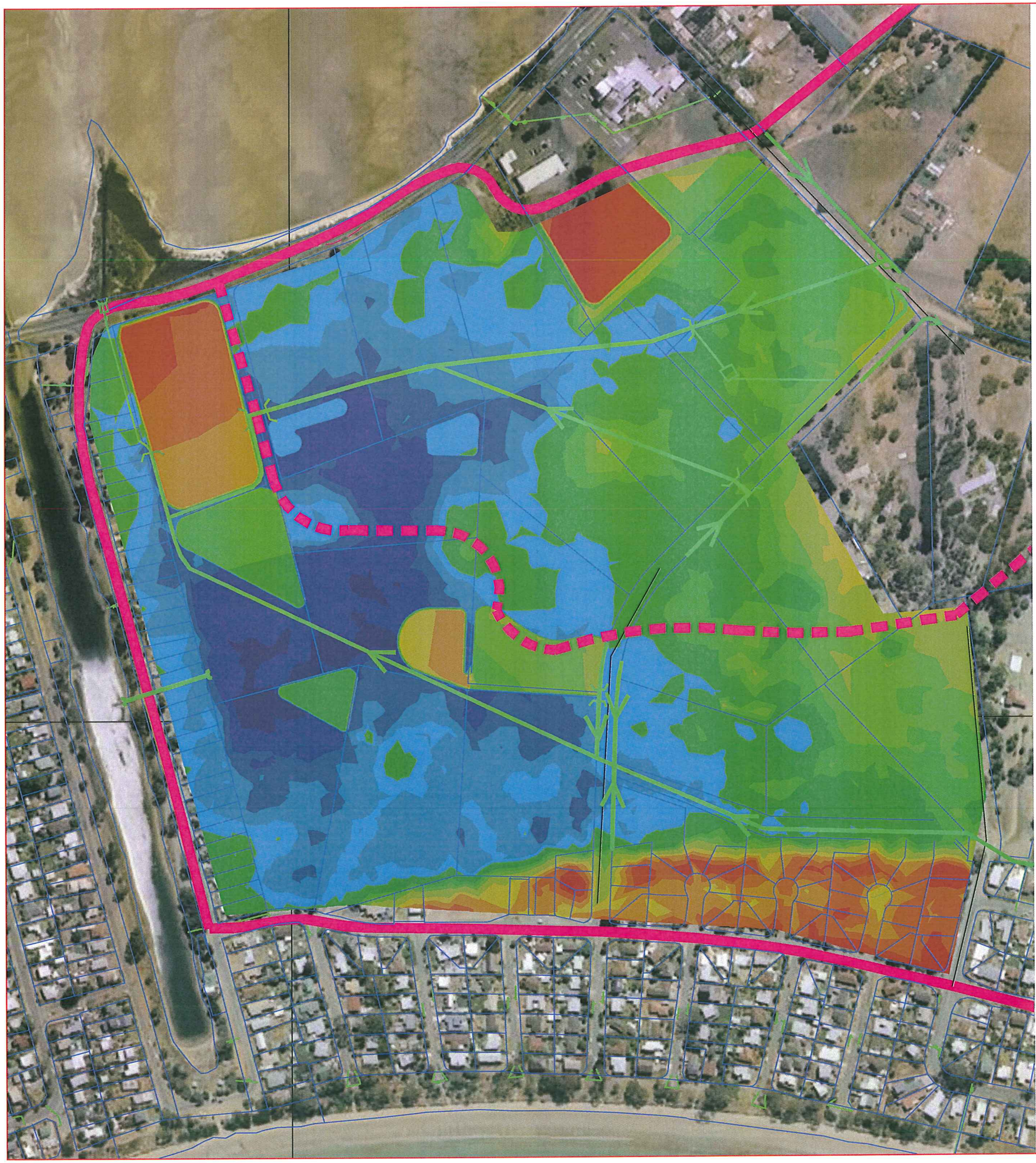
+1
(1.7m)

APPROXIMATE DEPTH OF FILL AND AHD LEVEL (m)

FIGURE 3
RECENT LAND FILL

SCALE 1:4000

FIGURE 4
PROPOSED DRAINAGE PATHS
SCALE 1:4000



SURFACE ELEVATION DATA

ELEVATION RANGE		COLOR
3.7	3.5	
3.5	3.3	
3.3	3.1	
3.1	2.9	
2.9	2.7	
2.7	2.5	
2.5	2.3	
2.3	2.1	
2.1	1.9	
1.9	1.7	
1.7	1.5	
1.5	1.3	
1.3	1.1	
1.1	0.9	
0.9	0.7	
0.7	0.5	

*AREAS SHADED BLUE, INDICATE THE EXTENT OF INUNDATION SHOULD WATER LEVEL REACH 1.5m AHD IN A FLOOD EVENT.

FIGURE 5
FLOOD INUNDATION
(LOWER CATCHMENTS)
SCALE 1:4000

SURFACE ELEVATION DATA

ELEVATION RANGE		COLOR
5.0	4.8	
4.8	4.6	
4.6	4.4	
4.4	4.2	
4.2	4.0	
4.0	3.8	
3.8	3.6	
3.6	3.4	
3.4	3.2	
3.2	3.0	
3.0	2.8	
2.8	2.6	
2.6	2.4	
2.4	2.2	
2.2	2.0	
2.0	1.8	
1.8	1.6	
1.6	1.4	
1.4	1.2	
1.2	1.0	
1.0	0.8	

*AREAS SHADED BLUE, INDICATE THE EXTENT OF PONDED WATER BEFORE ROAD SPILLAGE OCCURS INTO LOWER CATCHMENTS (2.0m AHD).

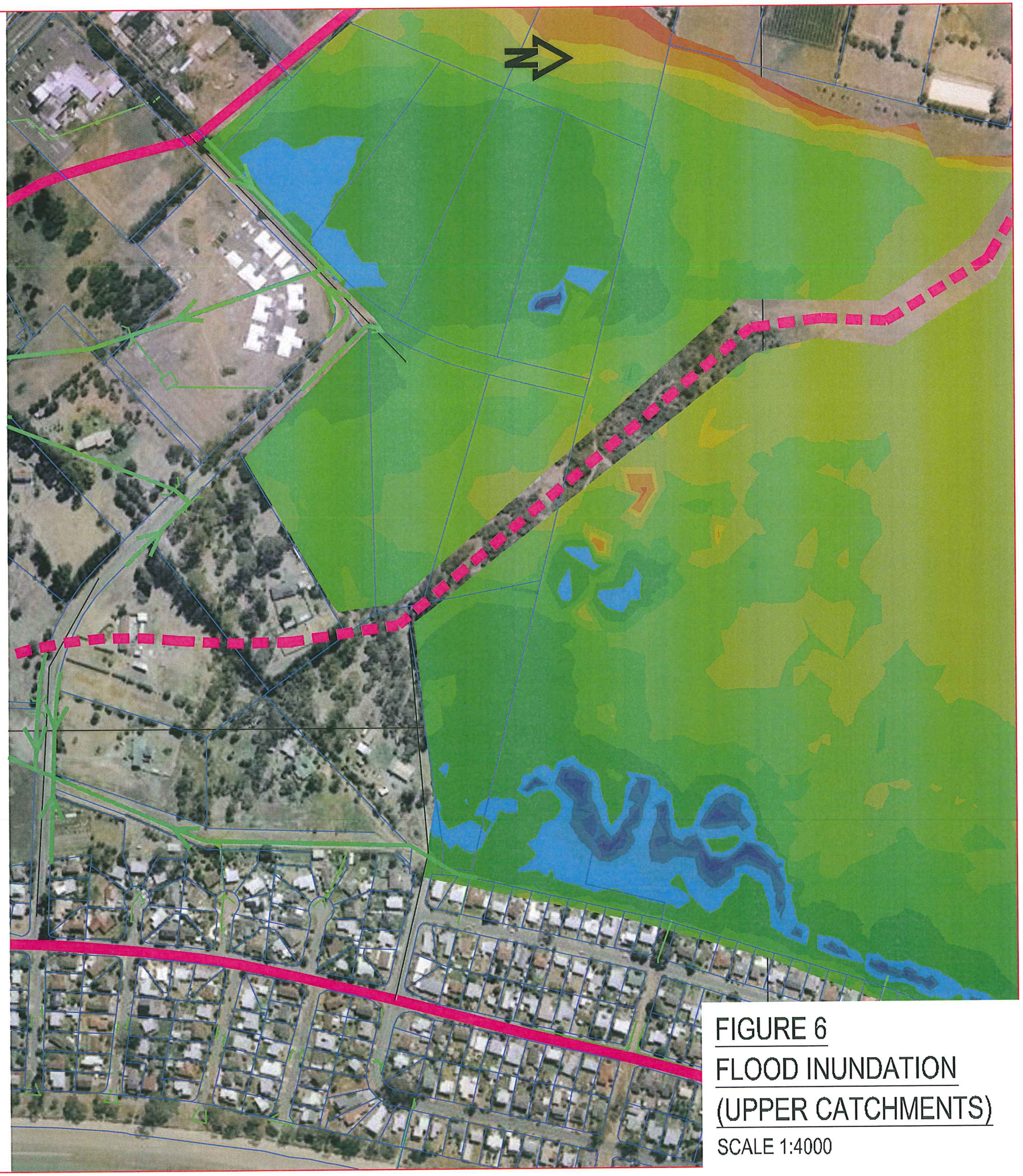
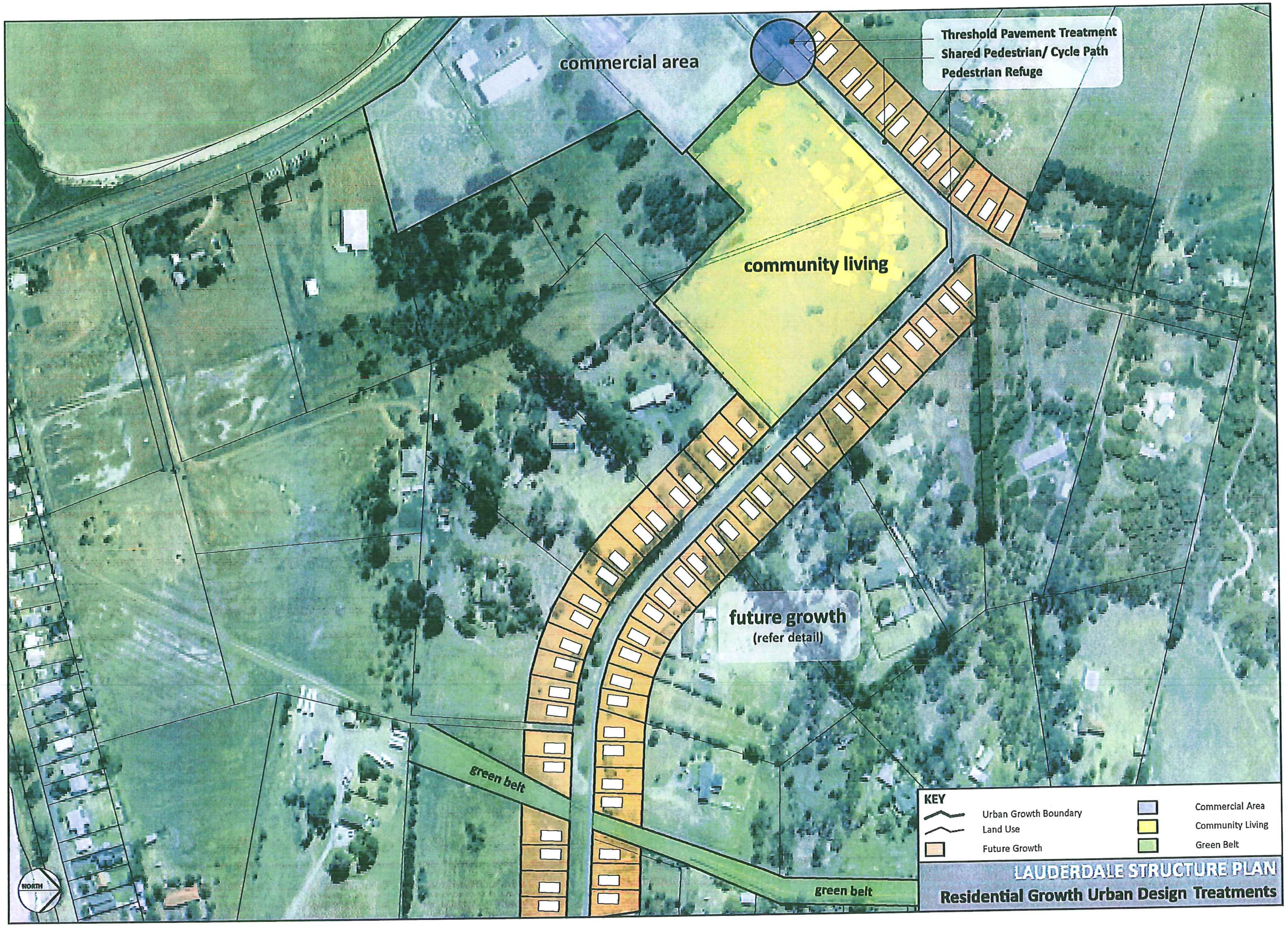
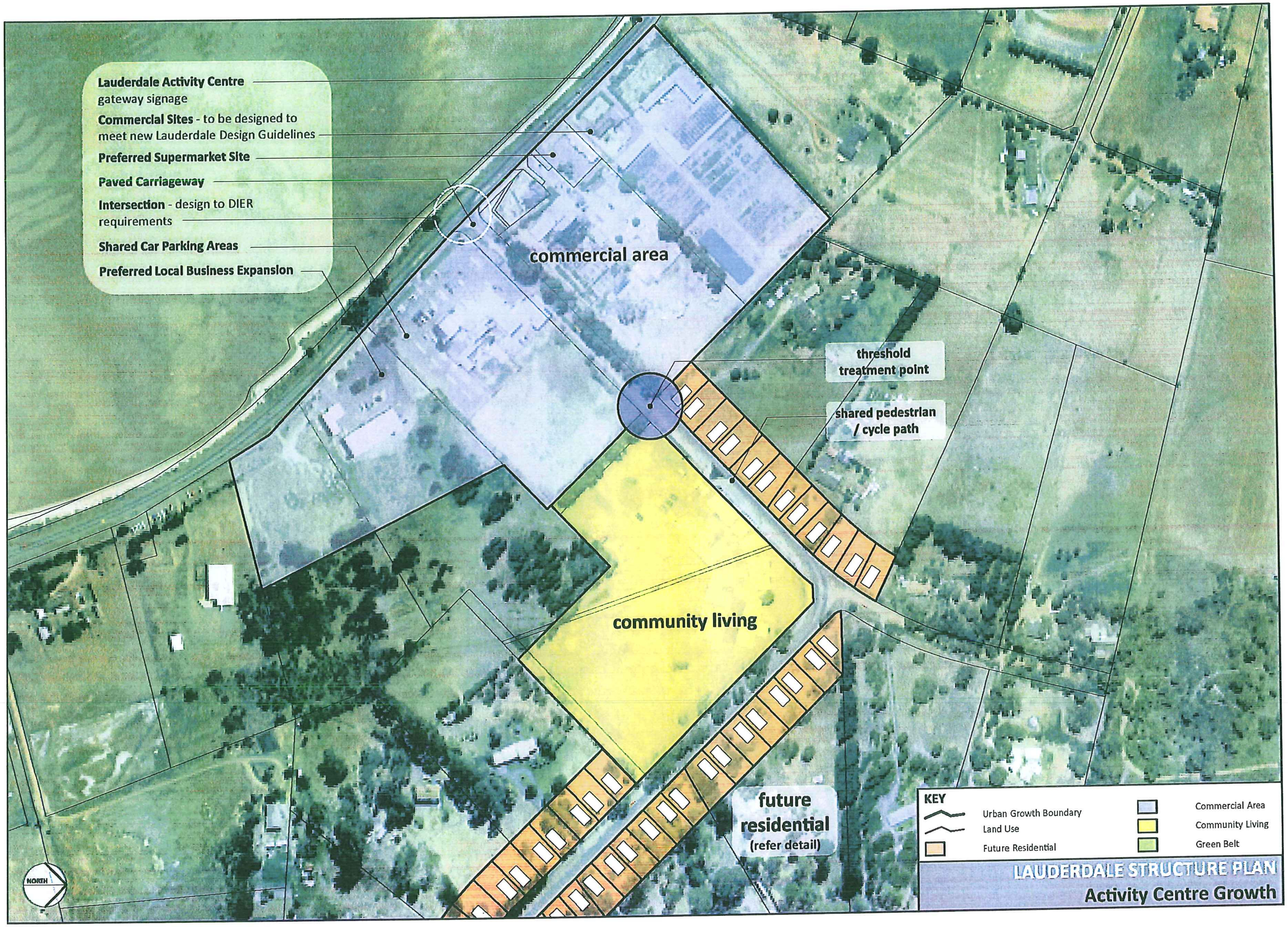


FIGURE 6
FLOOD INUNDATION
(UPPER CATCHMENTS)
SCALE 1:4000

APPENDIX A

LAUDERDALE STRUCTURE PLAN


commercial area
Threshold Pavement Treatment
Shared Pedestrian/ Cycle Path
Pedestrian Refuge
community living
future growth
(refer detail)
green belt
green belt
NORTH
KEY
Urban Growth Boundary
Land Use
Future Growth
Commercial Area
Community Living
Green Belt
LAUDERDALE STRUCTURE PLAN
Residential Growth Urban Design Treatments


Lauderdale Activity Centre gateway signage
Commercial Sites - to be designed to meet new Lauderdale Design Guidelines
Preferred Supermarket Site
Paved Carriageway
Intersection - design to DIER requirements
Shared Car Parking Areas
Preferred Local Business Expansion
commercial area
threshold treatment point
shared pedestrian / cycle path
community living
future residential (refer detail)
KEY
Urban Growth Boundary
Land Use
Future Residential
Commercial Area
Community Living
Green Belt
LAUDERDALE STRUCTURE PLAN
Activity Centre Growth
NORTH

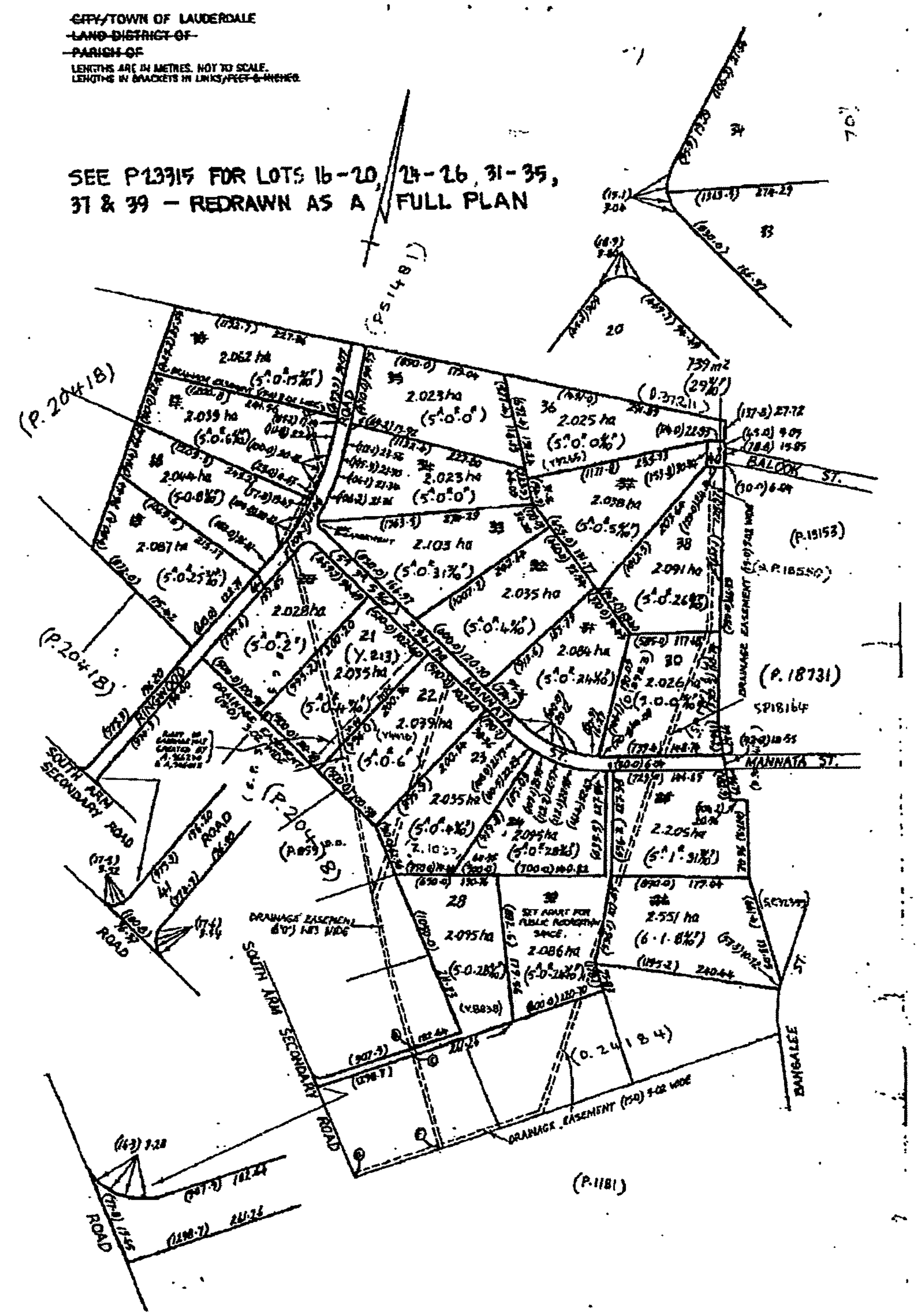
APPENDIX B

EASEMENT PLAN

APPROVED FROM 13 APR 1981 ... ACTING DEPUTY RECORDER OF TITLES	CONVERSION PLAN	REGISTERED NUMBER P. 15614
FILE NUMBER Z.1030 (LOT 23)	GRANTEE PARTS OF 700 ACRES LOCATED TO E.S.P. BEDFORD, 35 ACRES D. STANFIELD & 225 ACRES GTD TO D. STANFIELD	DRAWN 11/2/77

SKETCH BY WAY OF ILLUSTRATION ONLY

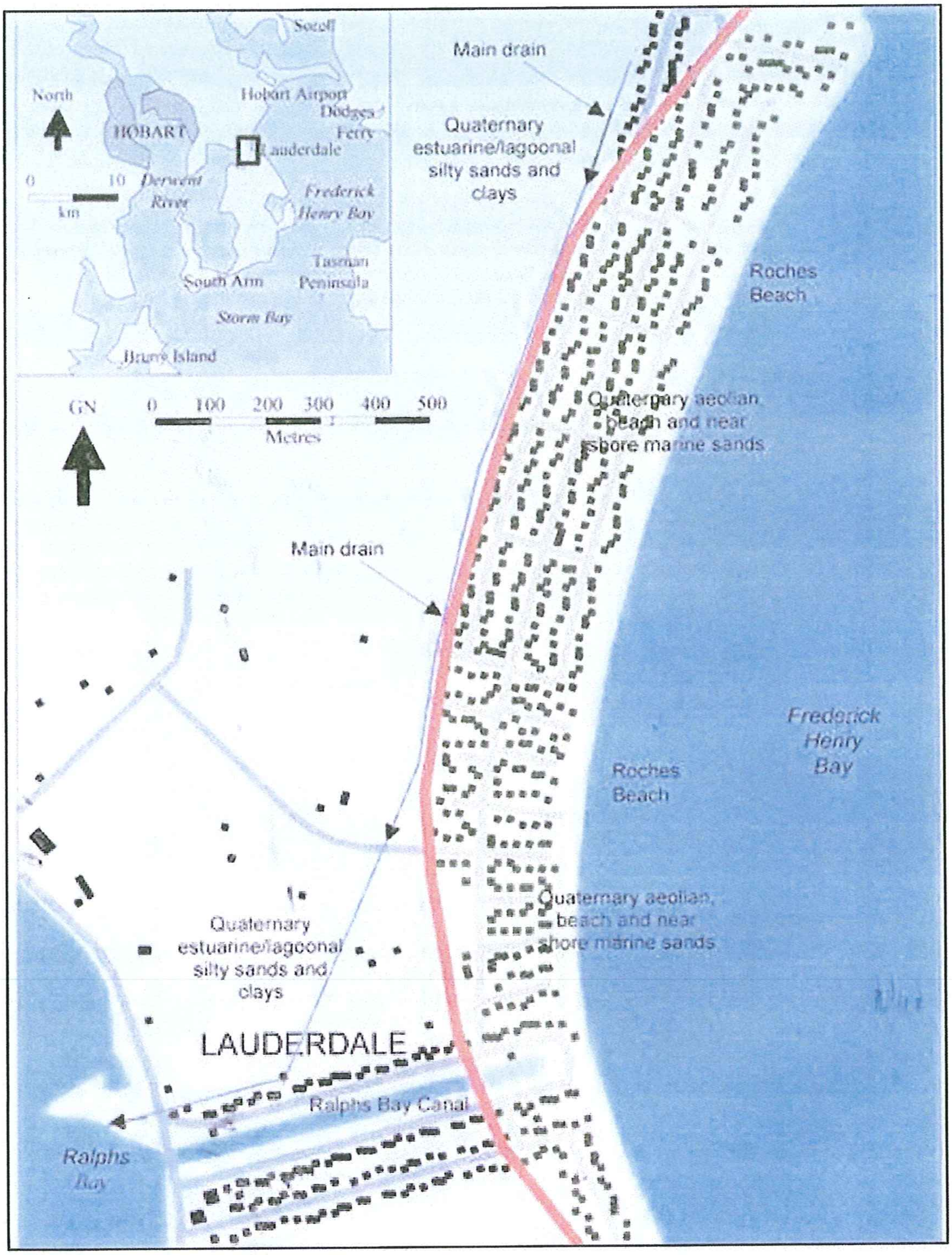
~~CITY~~/TOWN OF LAUDERDALE
~~LAND DISTRICT OF~~
~~PARISH OF~~
LENGTHS ARE IN METRES. NOT TO SCALE.
LENGTHS IN BRACKETS IN LINKS/~~FEET & INCHES~~.



APPENDIX C

GEOTECHNICAL REPORT - LAUDERDALE SEWERAGE INFRASTRUCTURE - FIGURE 4

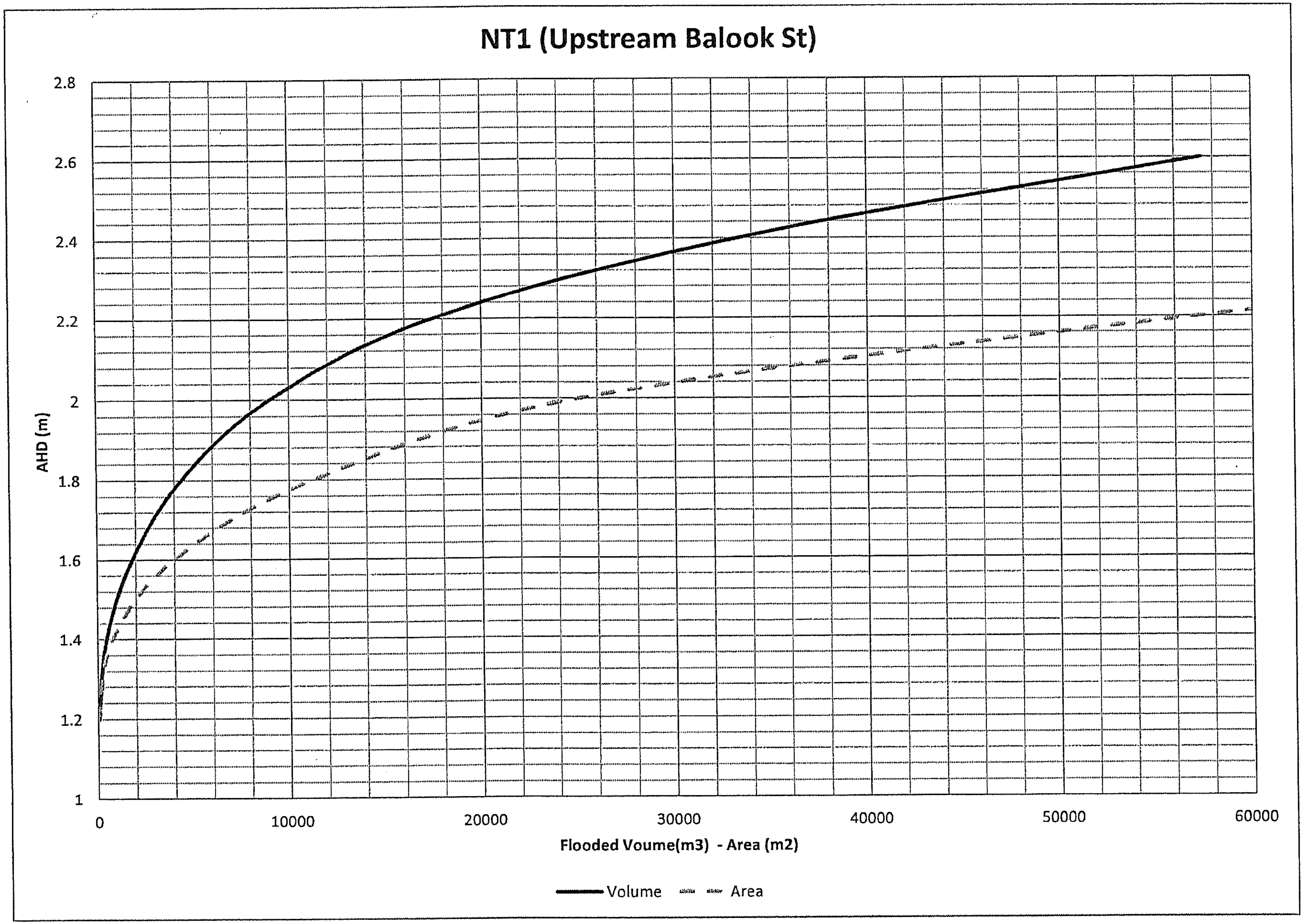
Figure 4 **Boundary (red line) between Quaternary aeolian and beach sand (to the east) and finer grained estuarine and lagoonal materials (to the west) at Lauderdale (modified from Cromer, 2001)[3]**

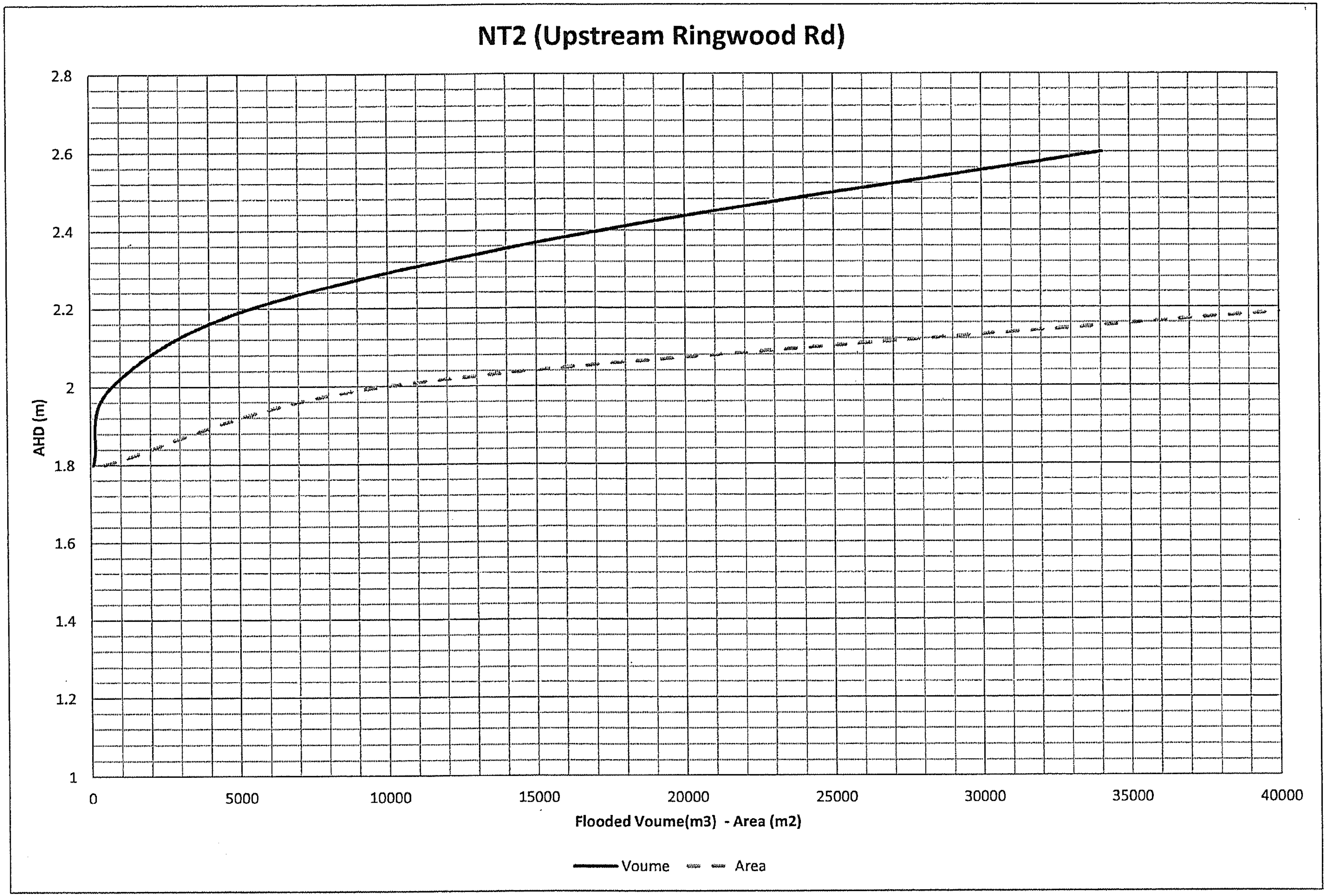


[3] Cromer, W. C. (2001). Treating domestic wastewater in an unconfined coastal sand aquifer near Hobart, in Patterson, R. (ed) Proceedings of the Onsite 01 conference, Armidale, 2001. Landfax Laboratories

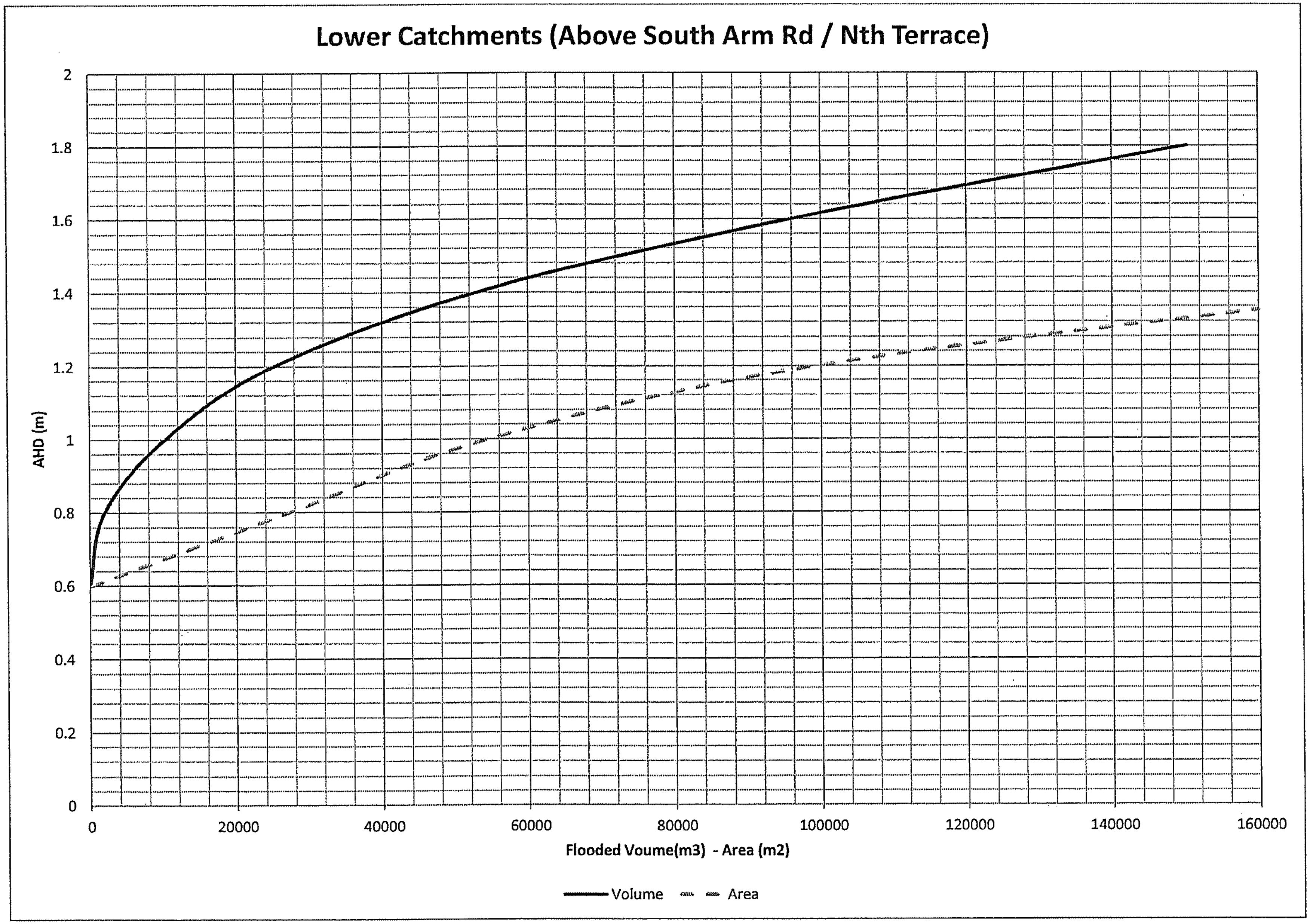
APPENDIX D

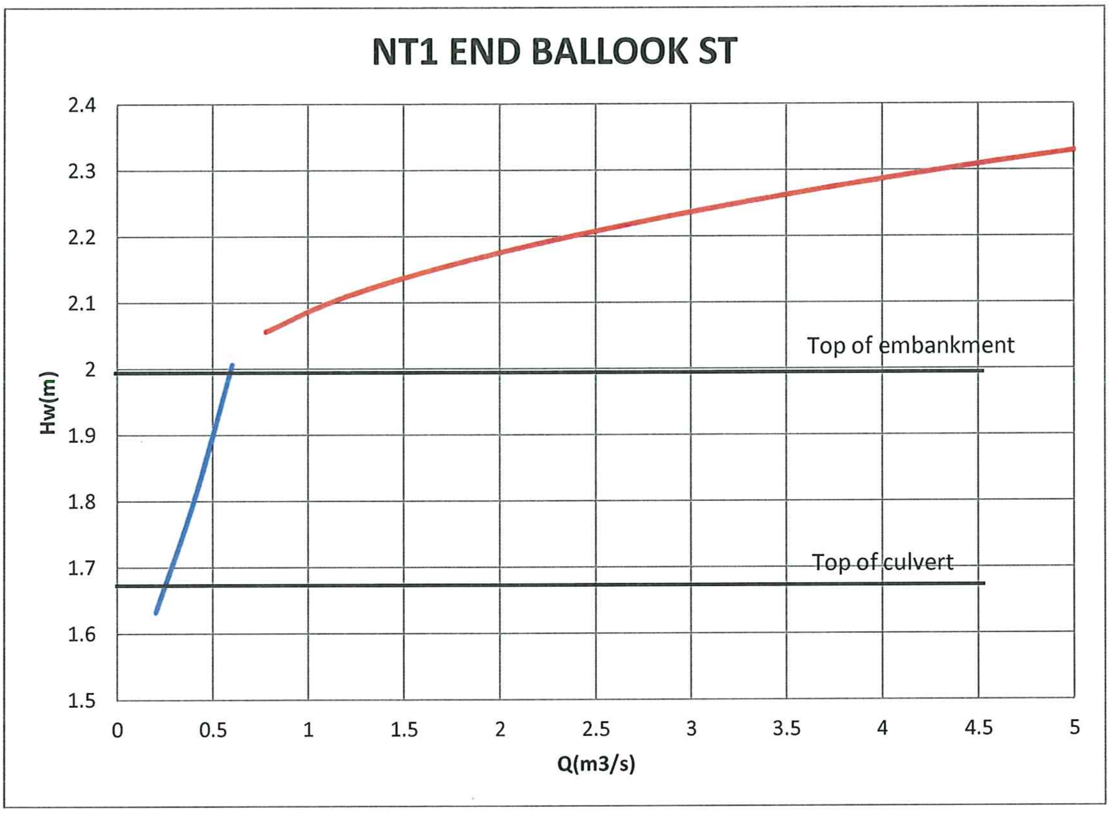
HYDRAULIC ANALYSIS DATA SHEETS

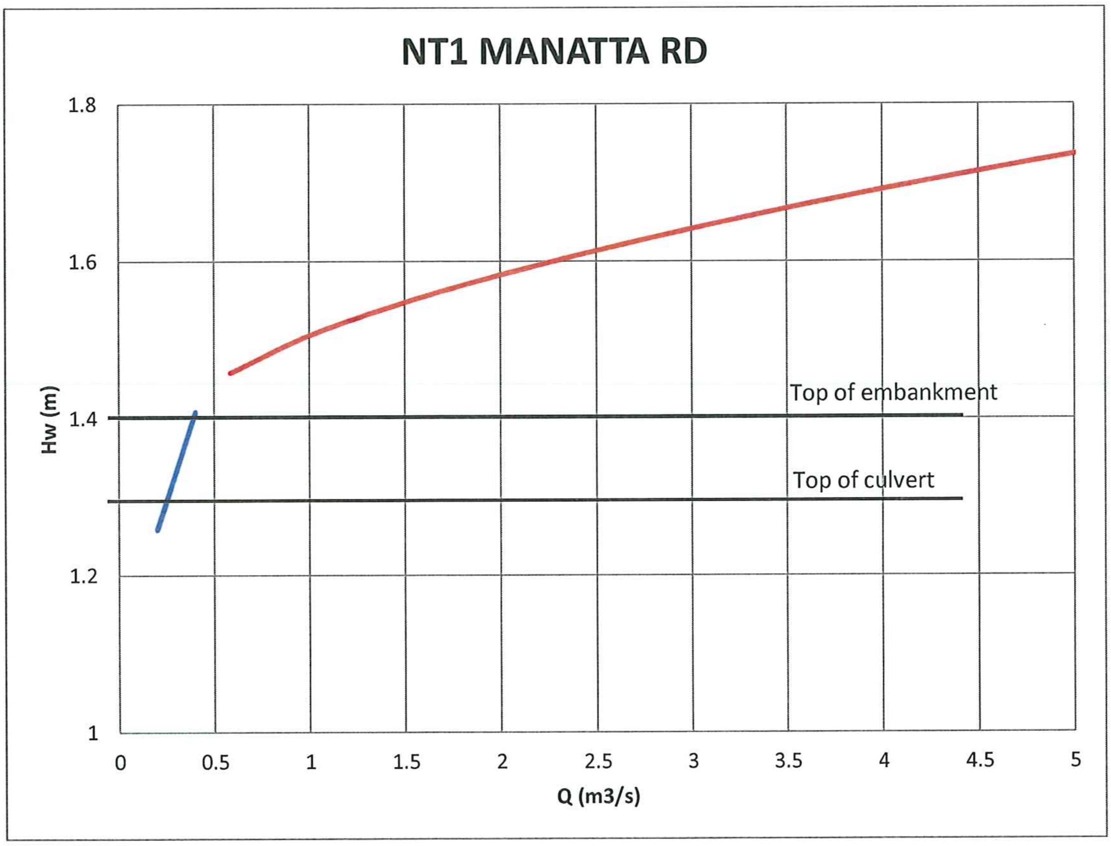

NT1 (Upstream Balook St)
AHD (m)
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0
10000
20000
30000
40000
50000
60000
Flooded Voume(m3) - Area (m2)
Volume
Area



NT2 (Upstream Ringwood Rd)
AHD (m)
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0
5000
10000
15000
20000
25000
30000
35000
40000
Flooded Voume(m3) - Area (m2)
Voume
Area


Lower Catchments (Above South Arm Rd / Nth Terrace)
AHD (m)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
20000
40000
60000
80000
100000
120000
140000
160000
Flooded Voume(m3) - Area (m2)
Volume
Area


NT1 END BALLOOK ST
Hw(m)
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Q(m3/s)
Top of embankment
Top of culvert


NT1 MANATTA RD
Hw (m)
1.8
1.6
1.4
1.2
1
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Q (m3/s)
Top of embankment
Top of culvert

Culvert Report

Ringwood Road 600 x 300.

Hydraflow Express Extension for AutoCAD® Civil 3D® 2012 by Autodesk, Inc. — Thursday, Jan 12 2012

@ RBL

Box Culvert

Invert Elev Dn (m)	= 0.0001
Pipe Length (m)	= 10.0000
Slope (%)	= 0.2990
Invert Elev Up (m)	= 0.0300
Rise (mm)	= 300.0
Shape	= Box
Span (mm)	= 600.0
No. Barrels	= 1
n-Value	= 0.012
Inlet Edge	= Projecting
Coeff. K,M,c,Y,k	= 0.0145, 1.75, 0.0419, 0.64, 0.5

Embankment

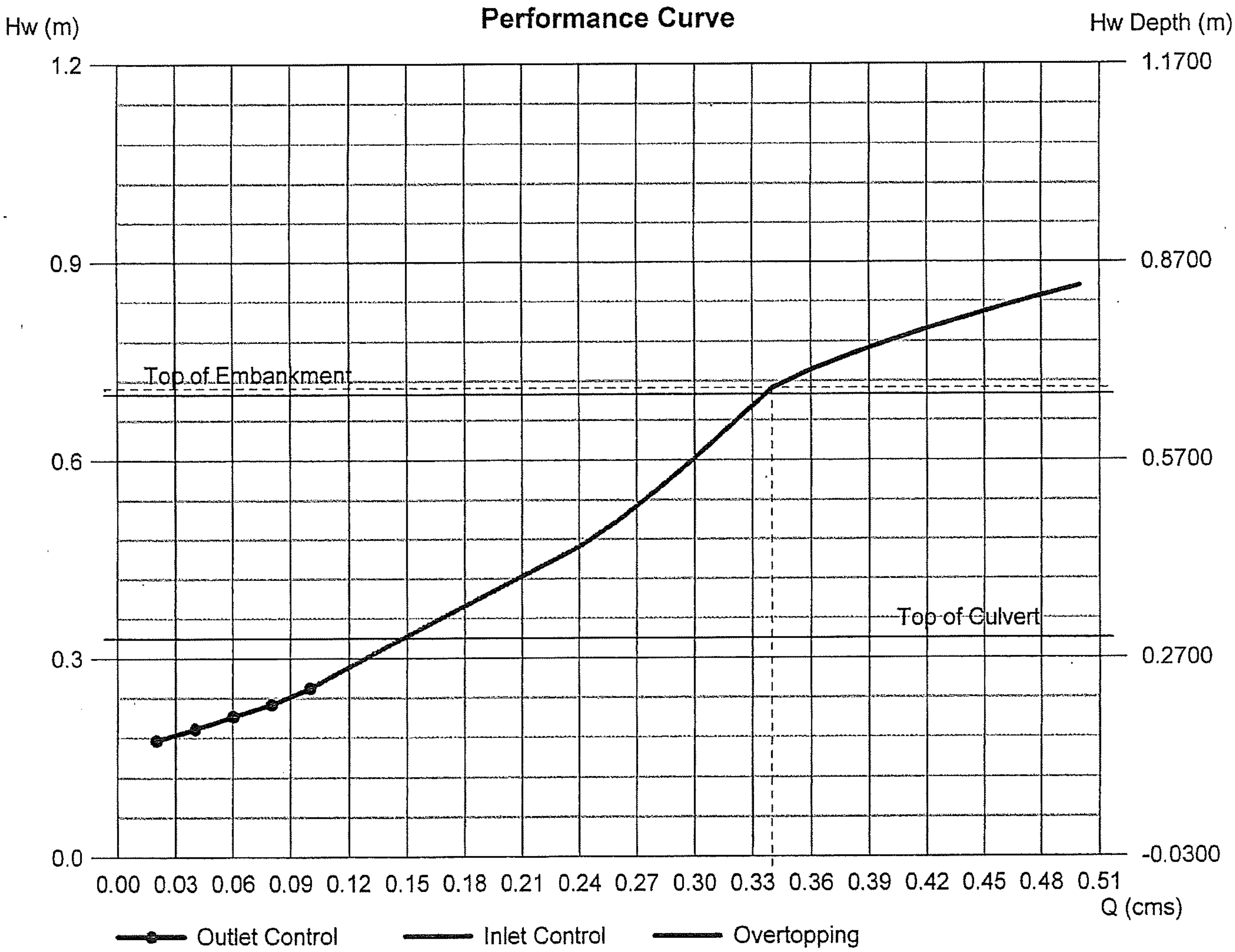
Top Elevation (m)	= 0.7000
Top Width (m)	= 9.9000
Crest Width (m)	= 1.0000

Calculations

Qmin (cms)	= 0.0000
Qmax (cms)	= 0.5000
Tailwater Elev (m)	= (dc+D)/2

Highlighted

Qtotal (cms)	= 0.3400
Qpipe (cms)	= 0.3391
Qovertop (cms)	= 0.0009
Veloc Dn (m/s)	= 1.8837
Veloc Up (m/s)	= 1.8837
HGL Dn (m)	= 0.3001
HGL Up (m)	= 0.3300
Hw Elev (m)	= 0.7093
Hw/D (m)	= 2.2644
Flow Regime	= Inlet Control



Culvert Report

Hydraflow Express Extension for AutoCAD® Civil 3D® 2012 by Autodesk, Inc.

Friday, Jan 13 2012

40 Nth Terrace (1 x 375)

Invert Elev Dn (m)	= 0.3500
Pipe Length (m)	= 80.0000
Slope (%)	= 0.5000
Invert Elev Up (m)	= 0.7500
Rise (mm)	= 375.0
Shape	= Cir
Span (mm)	= 375.0
No. Barrels	= 1
n-Value	= 0.012
Inlet Edge	= Beveled
Coeff. K,M,c,Y,k	= 0.0018, 2.5, 0.03, 0.74, 0.2

Embankment

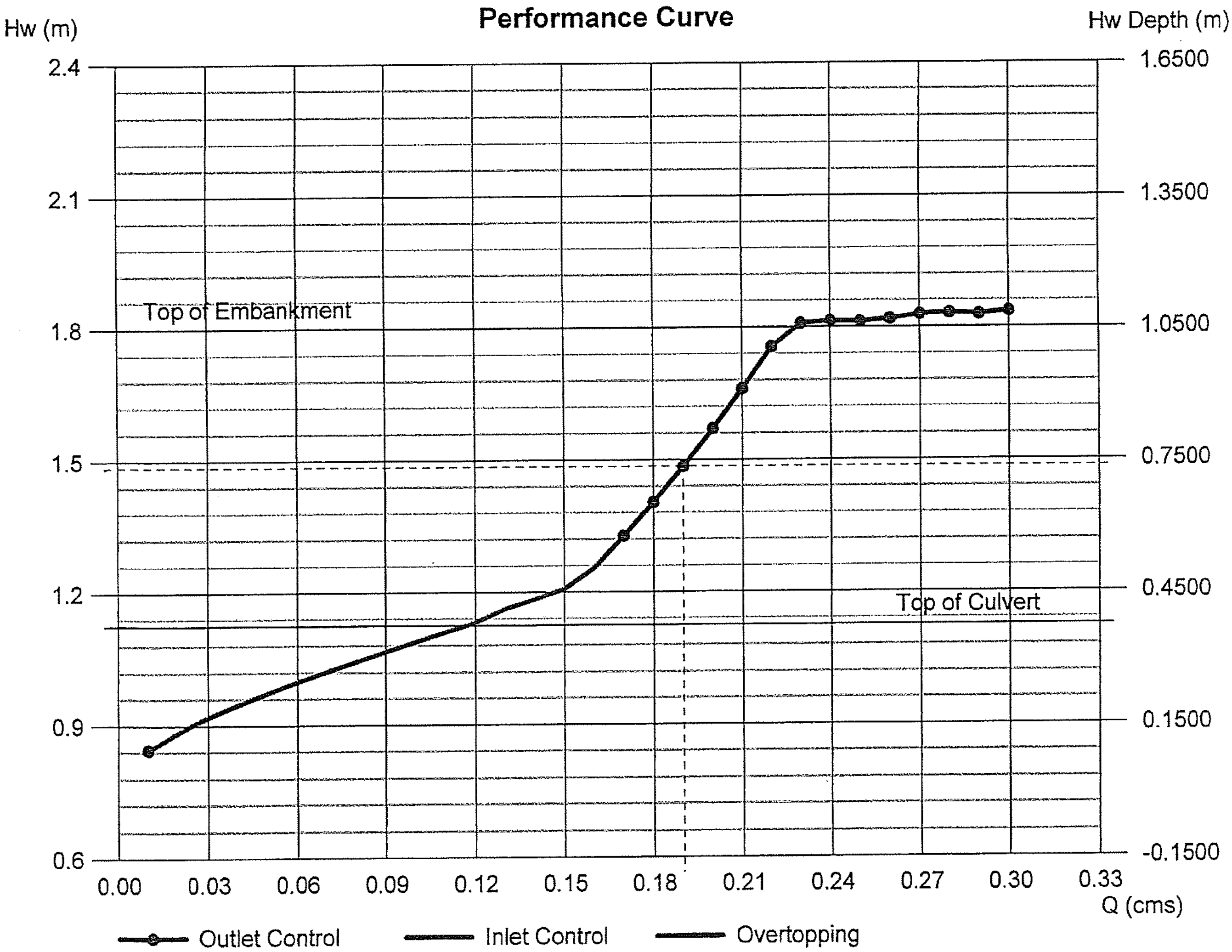
Top Elevation (m)	= 1.8000
Top Width (m)	= 79.0000
Crest Width (m)	= 5.0000

Calculations

Qmin (cms)	= 0.0000
Qmax (cms)	= 0.3000
Tailwater Elev (m)	= (dc+D)/2

Highlighted

Qtotal (cms)	= 0.1900
Qpipe (cms)	= 0.1900
Qovertop (cms)	= 0.0000
Veloc Dn (m/s)	= 1.7812
Veloc Up (m/s)	= 1.7203
HGL Dn (m)	= 0.6968
HGL Up (m)	= 1.4552
Hw Elev (m)	= 1.4853
Hw/D (m)	= 1.9609
Flow Regime	= Outlet Control



1x900 Culvert Performance Report