(Appendix 1)

Record No 06-9344
File No PL160092

Shire of Dardanup

Crooked Brook Structure Plan

Hydrological Review

June 2005

JDA Consultant Hydrologists

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1. INTRODUCTION

The Crooked Brook Structure Plan is part of the Dardanup Settlement Node Planning Strategy which has been prepared as a settlement proposal in the Local Planning Strategy of the Shire of Dardanup.

The objectives of the Structure Plan are to facilitate the provision of rural residential lots varying in size within the constraints and opportunities of the land, to make provision for public amenity and infrastructure and to ensure that the drainage infrastructure serving farming properties continues to operate effectively.

The Structure Plan was prepared in 2004 by Graham Houghton, Town Planning Consultant to the Shire.

In preparation of the Structure Plan, discussions were held with Officers of Department of Environment with respect to appropriate drainage infrastructure. The use of swales rather than detention basins was recommended to maintain the hydrological balance of the area. The Shire has concerns regarding the effectiveness and maintenance of such swales and has engaged JDA Consultant Hydrologists to provide independent assessment of the Structure Plan drainage requirements.

This report represents Stage 1 of JDA's scope including the following tasks:

- Obtaining and reviewing original PW drain designs, if available.
- Obtaining and reviewing DoE monitor bore data
- Calculation of detention basins, storage requirements.
- Liaison with DoE regarding drainage design criteria.
- Preparation of draft drainage strategy to support the Structure Plan.

This report is effectively a desk-top assessment following two site visits by JDA staff. No additional survey to better define topography or gradient of drains has been performed. This may be required to finalise the drainage strategy or at detailed design stage.

2. EXISTING HYDROLOGY AND DRAINAGE

2.1 Setting

The Structure Plan area is on the eastern side and adjacent to the Preston River approximately 4 kms east of Dardanup (Figure 1).

2.2 Topography

The Structure Plan area slopes gently from east to west towards the Preston River. Maximum and minimum elevations are 37 and 15 m AHD respectively and typical gradients are less than 1:500. Only 5 m contours are available for the whole of the Structure Plan area. One metre contours over part of the Structure Plan area are contained in Koltasz Smith (2003).

2.3 Soil Mapping

The soil-landscape units have been mapped and described by Barnesby et al. (1998) and comprise the Pinjarra Plain and Bassendean Systems (see Figure 2).

The Pinjarra Plain System consists primarily of two subsystems distinguished by the depth of permeable sand and loamy sand overlaying a clay subsoil that has low permeability. Subsystem Pj1b consists of moderately deep sands or sandy loams (50 to 100 cm) over clay. Subsystem Pj2 has shallower sands or sandy loams of less than 50 cm over clay. The Pinjarra Plain System is characterised by poor drainage such that during wetter months waterlogging and inundation is likely.

The Bassendean System (Bs) consists of very low sand rises or dunes of deep leached grey sands with high permeability. Interdunal sandy and clay swamps (Bs3) have low permeability. Figure 2 shows that the Pinjarra Systems (Pj1b and Pj2) comprise most of the Structure Plan area. The Bassendean sub-system comprises perhaps 20% of the area.

The duplex soils of Pinjarra Plain system are prone to saturation following rainfall. Lower permeability sub-soil clays prevent downward infiltration and lead to waterlogging and surface inundation.

2.4 Wetlands Mapping

Figure 3 shows that the majority of the Structure Plan area is mapped as wetland, as opposed to dry land. Wetlands are generally defined as areas where saturation of the soil profile occurs, such that the land is either waterlogged or inundated at the surface for part of the year. These definitions generally apply to average rainfall years rather than the drier climate experienced since approximately 1975 in the SW of Western Australia.

All three geomorphic categories (Channel, Basin & Flatlands) are represented within the Structure Plan area (Figure 3):

- North-south drain between Dardanup West Road and Ford Road as a channel wetland.

- A large part of the western half of the Structure Plan area as palusplain, being flat wetland.
- A large part of the eastern half of the study area being basin wetland.

With respect to Wetland Management Categories, Figure 4 shows the vast majority of the mapped wetland to be Multiple Use Category, where the management objective is to plan for use, develop and management "in the context of ecologically sustainable development and best management practice catchment planning through landcare".

Figure 4 shows one Resource Enhancement Category wetland where the management objective is "for management, restoration and protection" with a view of restoring the wetland to Conservation Category.

Figure 4 shows one wetland having Conservation Category, the objective of which is the "preservation of wetland attributes and functions through various mechanism including reservation... protection under Environmental Protection Policies and ... covenants..". These areas are to be protected from development. The Preston River (beyond the western boundary of the Structure Plan Area) is also classified as Conservation Category wetland.

The Conservation Category wetland is an EPP lake and subject to the provisions of the Environmental Protection Policy (Swan Coastal Plain Lakes) Policy 1992. This wetland forms part of a Water Corporation rural drain, which drains a large part of the Plan area.

2.5 Groundwater

As discussed above, a large part of the Structure Plan Study area becomes waterlogged or inundated particularly during winter months.

Figure 5 shows the location of DoE groundwater monitoring bores.

Figure 6 shows time series of these DoE monitor bore water levels indicating a seasonal variation of approximately 1 m and maximum levels approximately 1-2 m below natural surface. Onsite investigation confirmed a summer minimum of 2 m below natural surface, indicating a winter maximum of 1 m below natural surface. This would suggest that the regional water table does not reach the ground surface and cause the observed waterlogging and inundation.

Rather it appears that saturation of the shallow soil profile occurs in winter leading to the development of the perched water table several metres above the regional water table which results in waterlogging and surface inundation.

The regional water table contours are confirmed by regional mapping by Commander (1984).

2.6 Surface Drainage

The natural drainage system comprises the lower parts of the landscape where the perched water table intercepts the natural surface resulting in inundation and slow drainage generally towards the Preston River or basin wetlands.

Waterlogging and inundation would have restricted agriculture in the past. Artificial drainage channels have been created to remove excess surface water. There are two principal drainage channels, both of which are Water Corporation rural drains.

Figure 7 shows the location of Water Corporation rural drains. These are sub branches A and B of the Gavins Gully drain. Water Corporation is responsible for drainage structures associated with these rural drains.

Figure 8 shows the catchment boundaries associated with the existing surface drains based on available mapping and our site visits.

Private farm drains and local authority road drains discharge into the Water Corporation drains or into the Preston River itself. The two Water Corporation drains discharge into the major Gavins Gully Drain which discharges into the Preston River.

The Water Corporation rural drains were constructed in 1950's only to remove surface water and prevent pasture demise caused by waterlogging. In general a "three day inundation" rule was applied, such that if landholders experienced paddocks having more than three days surface water, the (then) Public Works Department would seek to construct a drain to reduce the period of inundation.

It follows that the existing drainage was not intended for rural residential or higher density settlement.

3. PRE DEVELOPMENT DRAINAGE

The existing catchments were modelled in XP-STORM to estimate peak runoff rates for the 5, 10 and 100 year ARI storm events. The estimated catchment areas, slopes and lengths were estimated from the topological contours of the site, and are shown in Table 1.

TABLE 1: SUMMARY OF SURFACE WATER CATCHMENT AREAS

No.	Sub Catchment	Catchment Area (ha)	Slope (m/m)	Length (m)
1	**Sub B Drain (upstream of Garvey Rd)**	339.7	0.0043	2700
2	Sub B Drain (main branch upstream of Dardanup West Road)	130.0	0.0047	1600
3	Sub B Drain (main branch between Garvey Rd and West Dardanup Rd)	26.1	0.0018	1100
4	Sub B Drain (South West catchment)	26.5	0.0040	550
5	Sub B Drain (South catchment)	135.2	0.0040	2000
6	Sub B Drain (East catchment)	21.9	0.0050	1000
	Sub A Drain (Upstream of Garvey Rd)	182.2	0.0033	2800
7	Sub A Drain (Downstream of Garvey Rd)	19.5	0.0037	540
8	Sub A Drain (Between Dardanup West Rd and Garvey Rd)	51.5	0.0031	1250
9	Sub A Drain (East catchment)	15.8	0.0044	510
10	Sub A Drain (South East catchment, upstream of Dardanup West Rd)	43.8	0.0040	1400
11	Sub A Drain (South catchment, upstream of Dardanup West Rd)	71.2	0.0027	1900
12	Garvey West Catchment (outlet into Preston River near Garvey Rd reserve)	24.7	0.0060	880
13	Padbury West catchment (outlet into Preston River near Padbury Rd reserve)	18.0	0.0049	700
14	Mid catchment (outlet into Preston R between Garvey West & Padbury West catchments)	18.7	0.0029	900
15	Dardanup West Rd catchment (outlet into Preston R south of Dardanup West Rd)	50	0.0046	1400

Note: 1. Sub B Drain (upstream of Garvey Rd) combines all catchments upstream, ie main branch, South West, South and East.
2. Sub A Drain (upstream of Garvey Rd) combines all catchments upstream, ie between Garvey and Dardanup West Rds, East, South East and South.

Table 2 shows the estimates of peak flood flows for the existing catchments.

The peak flow from the Sub A branch of Water Corporation Gavins Gully Main Drain upstream of downstream boundary is estimated as being 2.46 m^3/s for the 100 yr ARI event and 1.81 m^3/s for the 10 yr ARI event.

The peak flow for the Sub B branch of the Gavins Gully Main Drain upstream of Garvey Rd is estimated as being 3.86 m^3/s for the 100 yr ARI event and 2.85 m^3/s for the 10 yr ARI event.

In addition to these flows into the Water Corporation Main Drain, there are also catchments flowing directly into the Preston River, with total peak flows of 2.15 m^3/s for the 100 yr ARI event and 1.56 m^3/s for the 10 yr ARI event.

TABLE 2: ESTIMATES OF PEAK FLOWS IN DRAINS (m^3/s)

No.	Sub Catchment	5 Year ARI	10 Year ARI	100 Year ARI
	Sub B Drain (upstream of Garvey Rd)	**2.55 (36)**	**2.85 (36)**	**3.86 (6)**
2	Sub B Drain (main branch upstream of Dardanup West Road)	1.23 (36)	1.38 (36)	1.91 (6)
4	Sub B Drain (South West catchment)	0.32 (36)	0.36 (36)	0.50 (6)
5	Sub B Drain (South catchment)	1.18 (36)	1.31 (36)	1.80 (6)
6	Sub B Drain (East catchment)	0.30 (36)	0.33 (48)	0.46 (6)
	Sub A Drain (Upstream of Garvey Rd)	**1.38 (36)**	**1.54 (36)**	**2.09 (6)**
7	Sub A Drain (Downstream of Garvey Rd)	0.24 (36)	0.27 (36)	0.37 (6)
8	Sub A Drain (Between Dardanup West Rd and Garvey Rd)	0.49 (36)	0.55 (36)	0.76 (6)
9	Sub A Drain (East catchment)	0.22 (36)	0.24 (48)	0.33 (6)
10	Sub A Drain (South East catchment, upstream of Dardanup West Rd)	0.49 (36)	0.54 (36)	0.75 (6)
11	Sub A Drain (South catchment, upstream of Dardanup West Rd)	0.60 (36)	0.67 (36)	0.92 (6)
12	Garvey West Catchment (outlet into Preston River near Garvey Rd reserve)	0.35 (48)	0.40 (48)	0.55 (6)
13	Padbury West catchment (outlet into Preston River near Padbury Rd reserve)	0.25 (48)	0.28 (48)	0.39 (6)
14	Mid catchment (outlet into Preston R between Garvey West & Padbury West catchments)	0.20 (36)	0.24 (36)	0.33 (6)
15	Dardanup West Rd catchment (outlet into Preston R south of Dardanup West Rd)	0.58 (36)	0.64 (36)	0.88 (6)

Note: 1. Brackets indicate the critical duration, in hours
2. Sub B Drain (upstream of Garvey Rd) combines all catchments upstream, ie main branch, South West, South and East.
3. Sub A Drain (upstream of Garvey Rd) combines all catchments upstream, ie between Garvey and Dardanup West Rds, East, South East and South.

4. STRUCTURE PLAN DRAINAGE PROPOSAL

The Structure Plan took as its objectives for water quality and quantity from WRC (2003) as follows:

- Water Quantity – to maintain the total water cycle balance within development areas relative to the pre-development conditions.
- Water Quality – to maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions.

The Structure Plan used the following principles:

- Retain and restore natural drainage systems – retain and restore existing valuable elements of the natural drainage system, including waterways, wetland and groundwater features and processes.
- Implement non-structural source controls – minimise pollutant inputs principally via planning, organisational and behavioural techniques, to minimise the amount of pollution entering the drainage system.
- Minimise runoff – infiltrate or reuse rainfall as high in the catchment as possible. Install structural controls at or near the source to minimise pollutant inputs and the volume of stormwater.
- Use of "in-system" management measures – includes vegetative measures, such as swales and riparian zones, and structural quality improvement devices such as gross pollutant traps (Interim Position Statement – Urban Stormwater Management in WA, Principles & Objectives, Water & Rivers Commission, 2003).

The Structure Plan adopted the additional principle that artificial drainage channels should continue to drain farmland to ensure long term effective drainage of that land.

For rural residential lot and road design the Structure Plan stressed the need for drainage mechanisms to take into account the existing drainage characteristics:

- Low infiltration for much of the year;
- water detention in inundation areas and in the soil profile;
- fairly rapid discharge of overflow water into man-made drains;
- the slow discharge of soil profile water into lower elevation areas, maybe areas of inundation, and into man-made drains;
- the limited capacity in the off-site drains; and
- the need to ensure that, where necessary, the drains function effectively on farming property.

The need for maintaining the water balance was identified. Sub-soil drainage was considered "not permitted", on the basis it would significantly modify the water balance causing environmental impacts.

The Structure Plan noted the increase in amount of runoff that would need to be discharged compared to pre-development agricultural conditions as a result of impervious roads and access tracks, house pads and other built-up areas. It was identified that this additional water could be difficult to manage given the environment of low infiltration and limited capacity of the off-site discharge drains.

It was noted that several of the existing drains feeding directly into the Preston River which are west of the alignment of the Water Corporation north/south rural drain.

It was considered that this direct discharge is not "environmentally satisfactory" and it was proposed to allow stormwater discharge into swales in the proposed river foreshore.

The Structure Plan noted that some properties may remain as farming while others will convert to rural residential lots. The rural residential development should not prevent effective draining of the farmland.

The Structure Plan noted there is little existing roadside drainage along Garvey Road and Dardenup West Roads which would need to be upgraded at the sub-dividers expense. Roadside swales were proposed for internal sub-division roads to collect and slowly channel water towards the discharge point. The swales were to act as detention areas to attenuate the peak flow so that post-development flows do not exceed existing pre-development flows. It was noted that waterlogging would continue to occur over several months of winter and a notification on new titles created would be required to the effect that waterlogging and inundation may be experienced.

Existing flow paths into basins and from basins into drainage channels were proposed to be modified to create swales. Similarly swales along the Preston River Foreshore were proposed to discharge water into the river by pipes to lower erosion risk over the steep river banks.

It was proposed that at the sub-division stage the sub-divider would be required to construct the swales including the individual lot swales and revegetate the land to avoid the risk of soil erosion.

Swale design was to be to the satisfaction of Council and DoE with the guideline of depth to top width ratio of 1 in 6 or greater.

The depth of swales would be limited by the depth to the sub-surface clay layer such that it is not penetrated. It was envisaged that to do so would significantly alter the water balance. The issue of acid sulphate soils was also raised as the basin wetlands are particularly considered high risk areas and disturbance could result in ASS mobilisation. The created swales would be protected by easements.

With respect to water quality source controls to minimise pollutant inputs were recommended rather than nutrient stripping basins. The Structure Plan therefore did not recommend any new drains to be constructed to drain to the Preston River to alleviate the present waterlogging and inundation issues. Rather the philosophy was to create shallow surface drains (swales) which would slowly discharge surface water and provide flood storage during times of heavy rainfall.

5. JDA DRAINAGE PROPOSAL

JDA considers that there is an excess of surface water created largely by a perched water table reaching the surface in winter, which needs to be dealt with by additional drainage outlets to the Preston River.

Such new outlets should discharge safely after attenuation in detention basins to prevent erosion of Preston River banks.

JDA has identified two possible locations which should both be considered for further analysis.

These are:

- Westward extension of road drain along Garvey Road to the Preston River.
- Westward extension of road drain along Dardanup West Road to the Preston River.

Both of these possible new drains are indicated on Figure 9 together with the surface catchments which they would serve. Also indicated on Figure 9 are tentative locations for surface water flood detention basins.

The drain along Dardanup West Road would capture all the catchments south of Dardanup West Road that currently drain to the Gavins Gully A Sub Branch. The drain along Garvey Road would capture all catchments between Garvey Rd and Dardanup West Rd and catchments east of Dardanup West Rd.

There are seven possible detention basin site, three for the southern Dardanup West Rd drain, and four for the central Garvey Rd drain. An eighth may be required for the northern section of the Gavins Gully A Sub Branch, and other smaller basins maybe required for the catchments discharging directly to the Preston River.

The proposed drainage system has been modelled in XP-STORM. Basins were sized so that no overflow occurs in basins or channels for the critical 10 yr ARI storm event. The downstream basins were sized so that post development outflow is less than or equal to pre development outflows. The proposed detention basin sizes are summarised in Table 3. Channels were assumed to be "V" channels with 1 in 3 side slopes, with maximum depth of 1 m. Exact profiles and geometry of the new drains will need to be considered at detailed design stage.

These proposed drains will not lower the perched water table on which the wetlands depend but rather slowly remove excess surface water from the landscape.

This will protect rural residential roads base course from saturation and reduce the areas of surface water within the newly created properties, while protecting wetland water balance.

JDA does not consider that such drains should only be within the sand horizon but that they could extend into the clay subsoil of the Pinjarra land system.

Long sections of natural surface and proposed drain inverts of the Garvey Road and Dardanup West Road are shown in Figure 10, together with detention basin invert and overflow pipe to allow complete drainage.

Protection works or drop structure within the Preston River foreshore reserve will be required to minimise erosion.

Acid sulphate soil assessment would be required to verify the acceptability of this proposal.

JDA considers the attenuation of surface flow in detention basin to be at least comparable with attenuation in swales and to be an acceptable and proven method in other parts of the southwest of WA.

Table 4 compares the estimates of flood flows from the Study Area for pre development and the proposed post development.

TABLE 3: PROPOSED DETENTION BASIN CHARACTERISTICS

Basin	Area (ha)	Depth (m)	Volume (m^3)	Base Elevation (mAHD)	Outlet Pipe (mm)	Peak Outflow Rate (m^3/s)		Peak Basin Water Depth (m)	
						10 yr ARI	100 yr ARI	10 yr ARI	100 yr ARI
A	2.96	1.0	27,600	24.0	450	0.43	0.55	0.70	0.94
B	1.49	1.0	13,500	21.0	525	0.64	0.80	0.78	1.00[1]
C	2.96	1.0	27,600	20.3	525	0.42	0.58	0.71	0.91
D	1.74	1.0	15,900	19.0	900	1.49	2.10	0.81	0.87
E	0.3	1.0	2,300	18.0	750	1.51	1.83	0.79	1.00[1]
F	1.49	1.0	13,500	22.0	450	0.49	0.57	0.86	1.00[1]
G	1.49	1.0	13,500	20.0	450	0.36	0.46	0.61	0.79
H	0.3	1.0	2,300	18.0	750	1.61	1.70	0.90	1.00[1]

Note: 1. Basins overflows during 100 yr ARI event.

TABLE 4: COMPARISON OF PRE AND POST DEVELOPMENT RUNOFF RATES (m^3/s)

Outlet	Pre Development		Post Development	
	10 yr ARI	100 yr ARI	10 yr ARI	100 yr ARI
Sub A Drain	1.81	2.46	0.38	0.51
Sub B Drain	2.85	3.86	0.19	0.27
Garvey Outlet	0.40	0.55	1.51	1.83
Dardanup West Rd	0.64	0.88	1.61	1.70
Padbury Outlet	0.28	0.39	0.30	0.40
Mid Outlet	0.24	0.33	0.26	0.34
Total	**6.38**	**8.47**	**4.25**	**5.05**

6. CONCLUSIONS

- The Structure Plan area is subject to waterlogging and inundation associated with a perched water table due to low permeability clay sub-soils. Much of the area is mapped as wetland, supported by this perched water table.

- The perched water table rises to the surface and results in considerable surface inundation and flow in existing drainage channels.

  This surface drainage has limited conveyance routes to the Preston River due to lack of maintenance on Water Corporation rural drains over the years and the limited number of outlets to the Preston River.

- The Structure Plan describes surface water management in shallow swales in an attempt to protect the existing water balance. The plan does not recommend new surface drainage outlets to the Preston River.

- JDA considers that new surface water outlets to the Preston River are required to facilitate better surface water management in the context of land use change from agriculture to rural residential with associated road infrastructure.

- JDA's proposal is therefore new drainage outlets to the Preston River with reduction of peak flow rates in detention basins and erosion control structures at outlets.

7. REFERENCES

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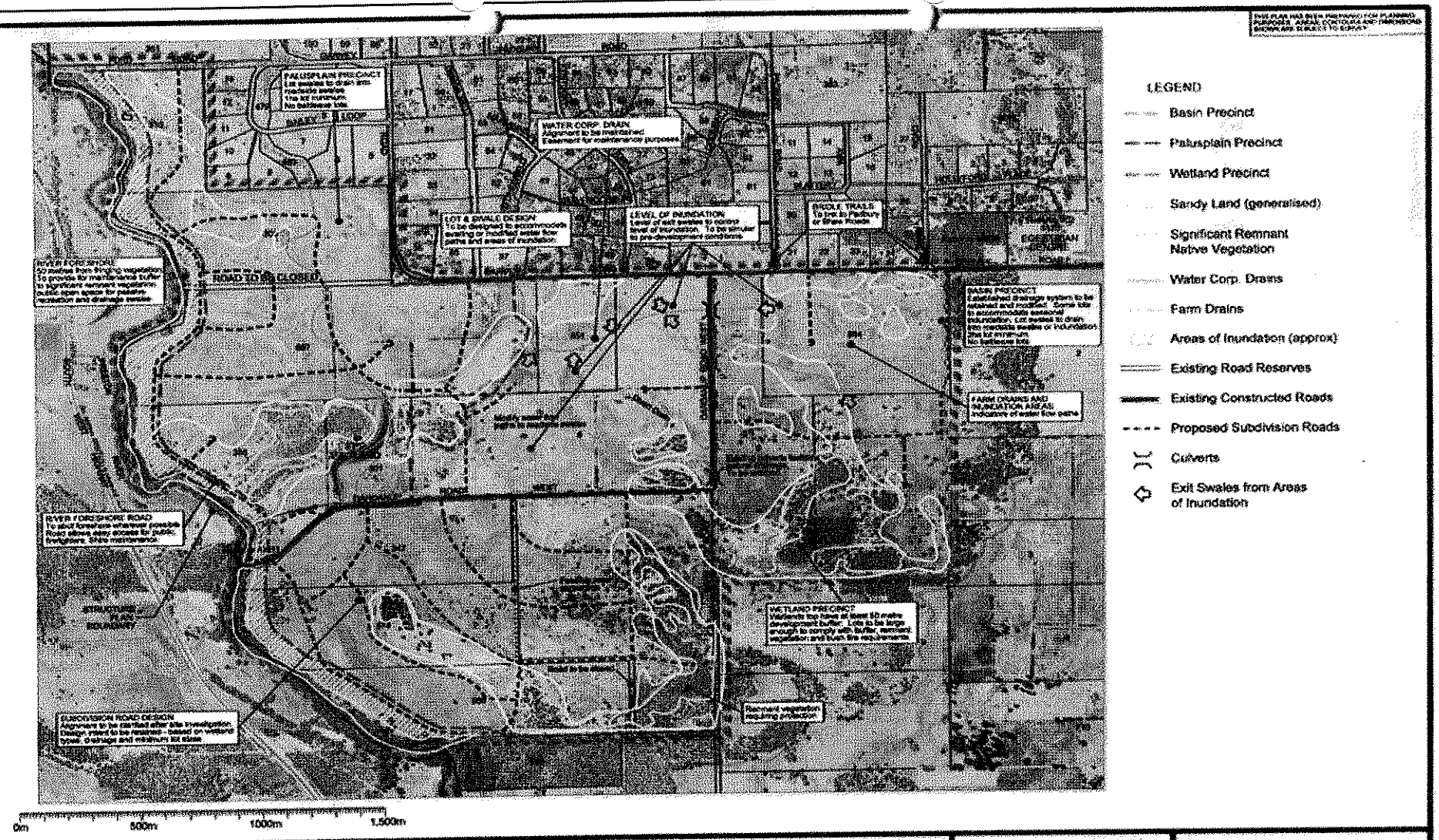
FIGURES



CROOKED BROOK
STRUCTURE PLAN AERIAL (Figure E)

PREPARED BY GRAHAM HOUGHTON
TOWN PLANNING CONSULTANT
WITH THE SHIRE OF DARDANUP

SCALE	DRAWN
1:15 000	K. SHAW - TME
DATE	PLAN No.
8-3-2004	04064P-01

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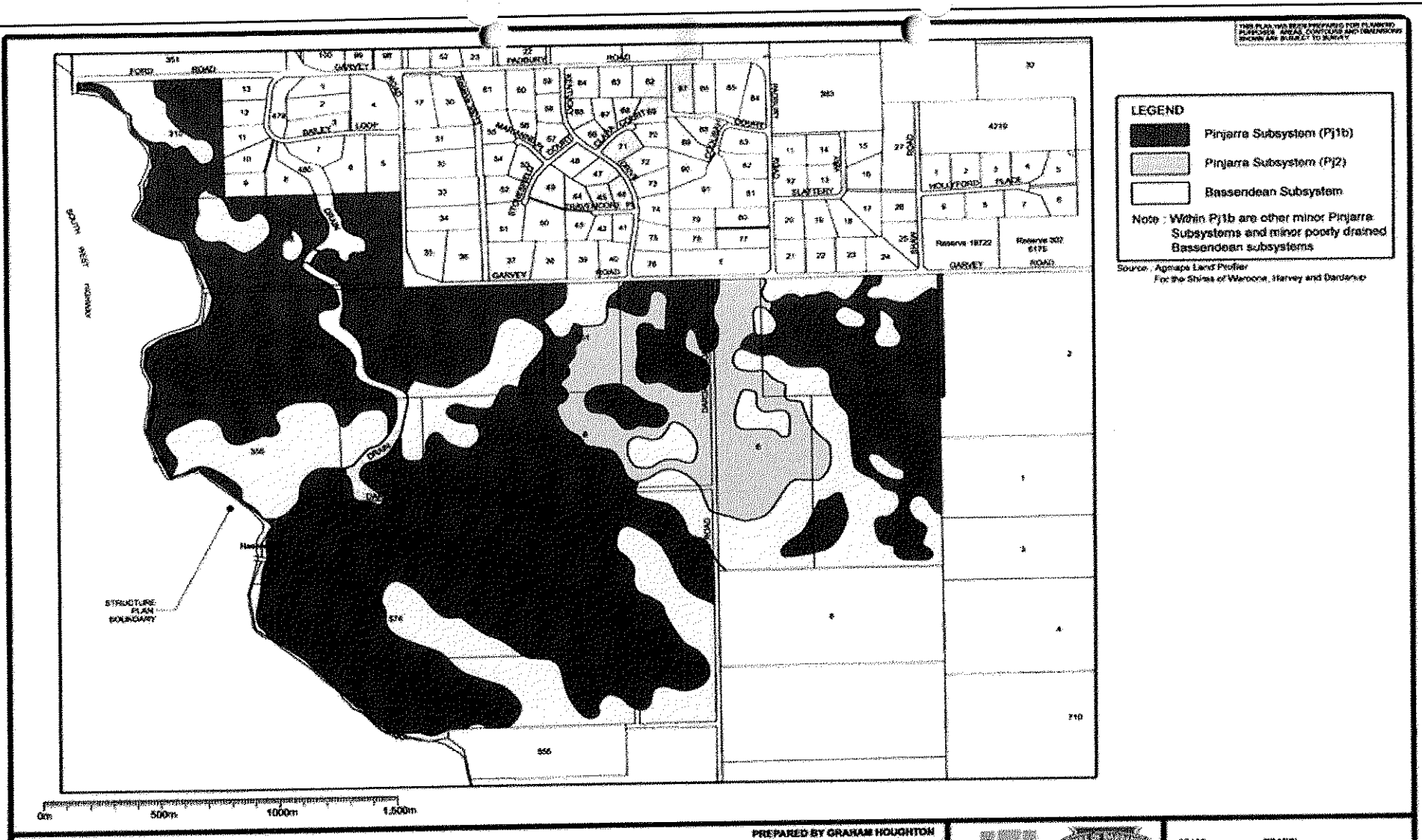
West Dardanup

Figure 1: Crooked Brook Structure Plan Aerial (reproduced from Figure E of Graham Houghton (2004))



CROOKED BROOK
SOIL AND LANDFORM UNITS (Figure B)

PREPARED BY GRAHAM HOUGHTON
TOWN PLANNING CONSULTANT
WITH THE SHIRE OF DARDANUP

SCALE 1:15 000 | DRAWN J. HARKNESS - TME
DATE 8-3-2004 | PLAN No. 04064P-02

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West Dardanup

Figure 2: Soil & Landscape Units (reproduced from Figure B of Graham Houghton (2004))

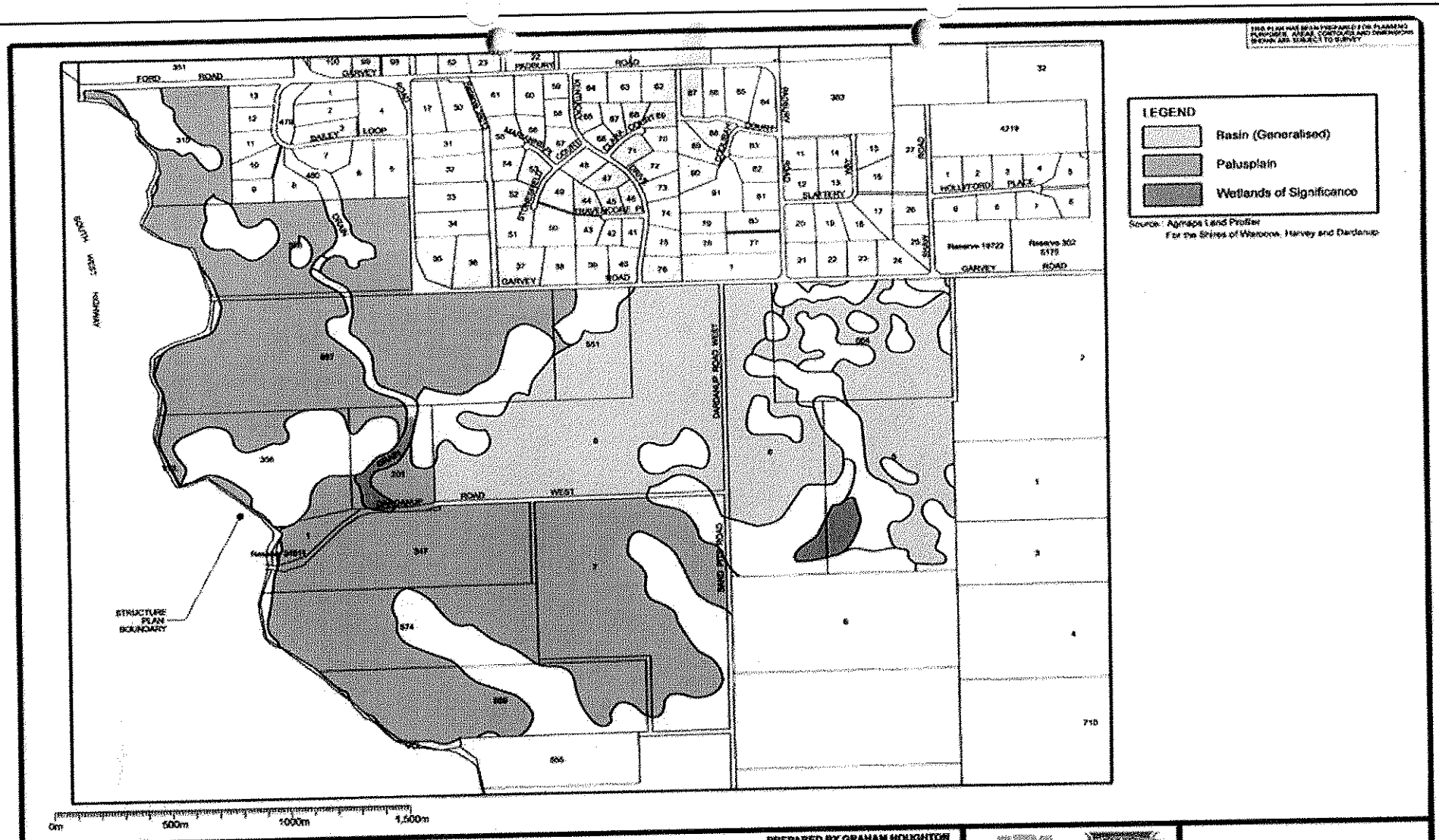

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Figure 3: Wetland Types (reproduced from Figure C of Graham Houghton (2004))

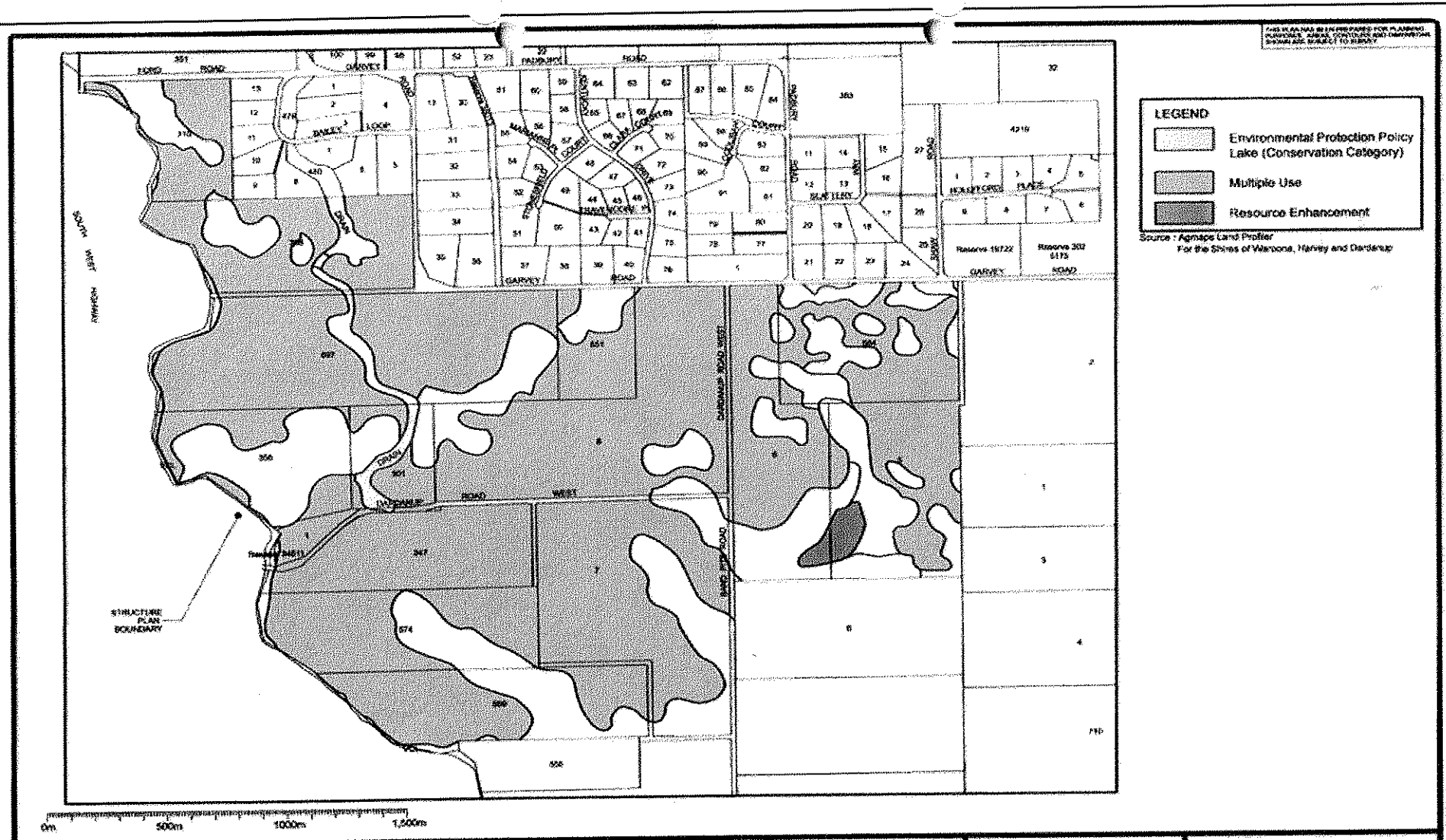

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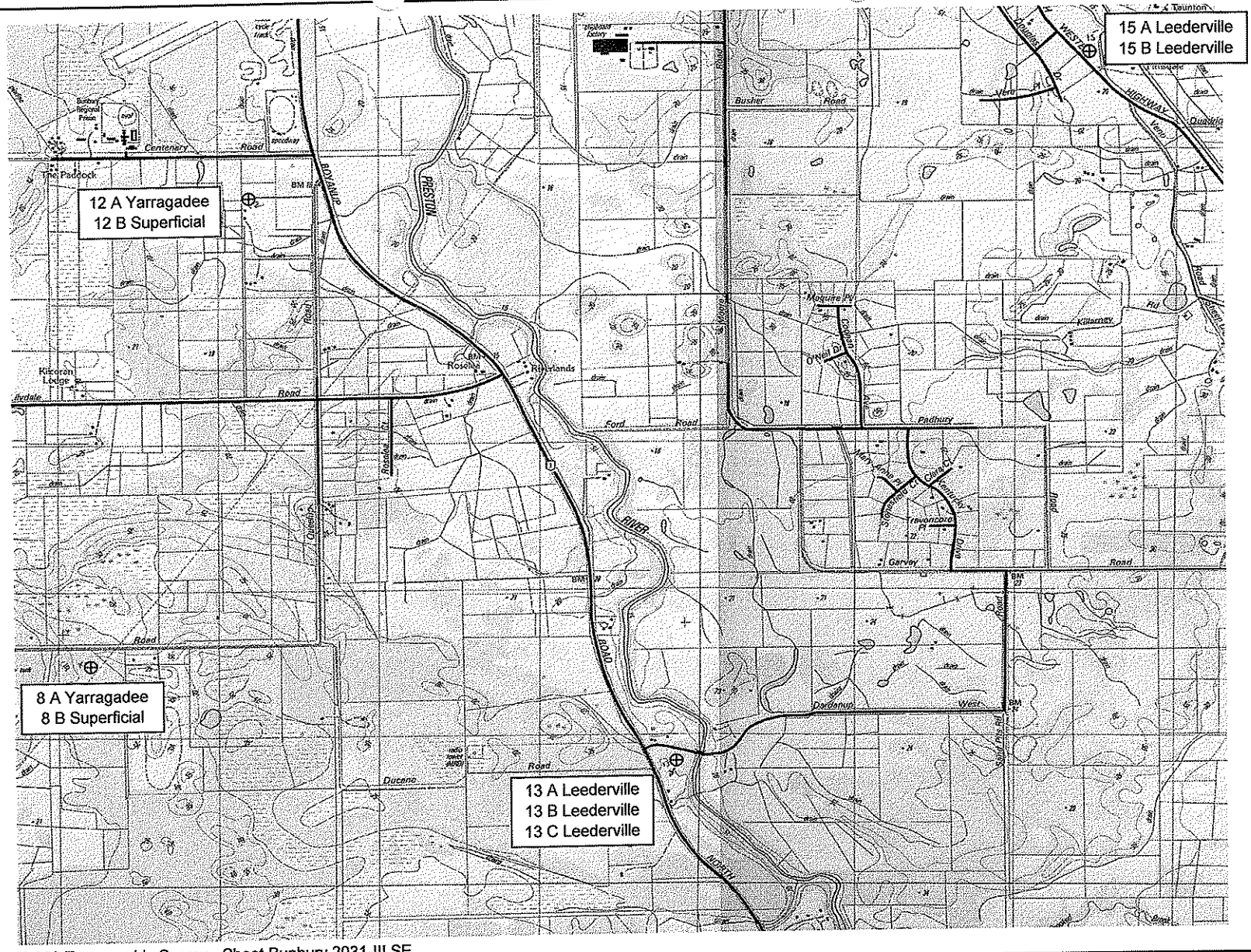
Figure 4: Wetland Management Categories (reproduced from Figure D of Graham Houghton (2004))



Data Source: 1:25,000 Topographic Survey - Sheet Bunbury 2031-III SE

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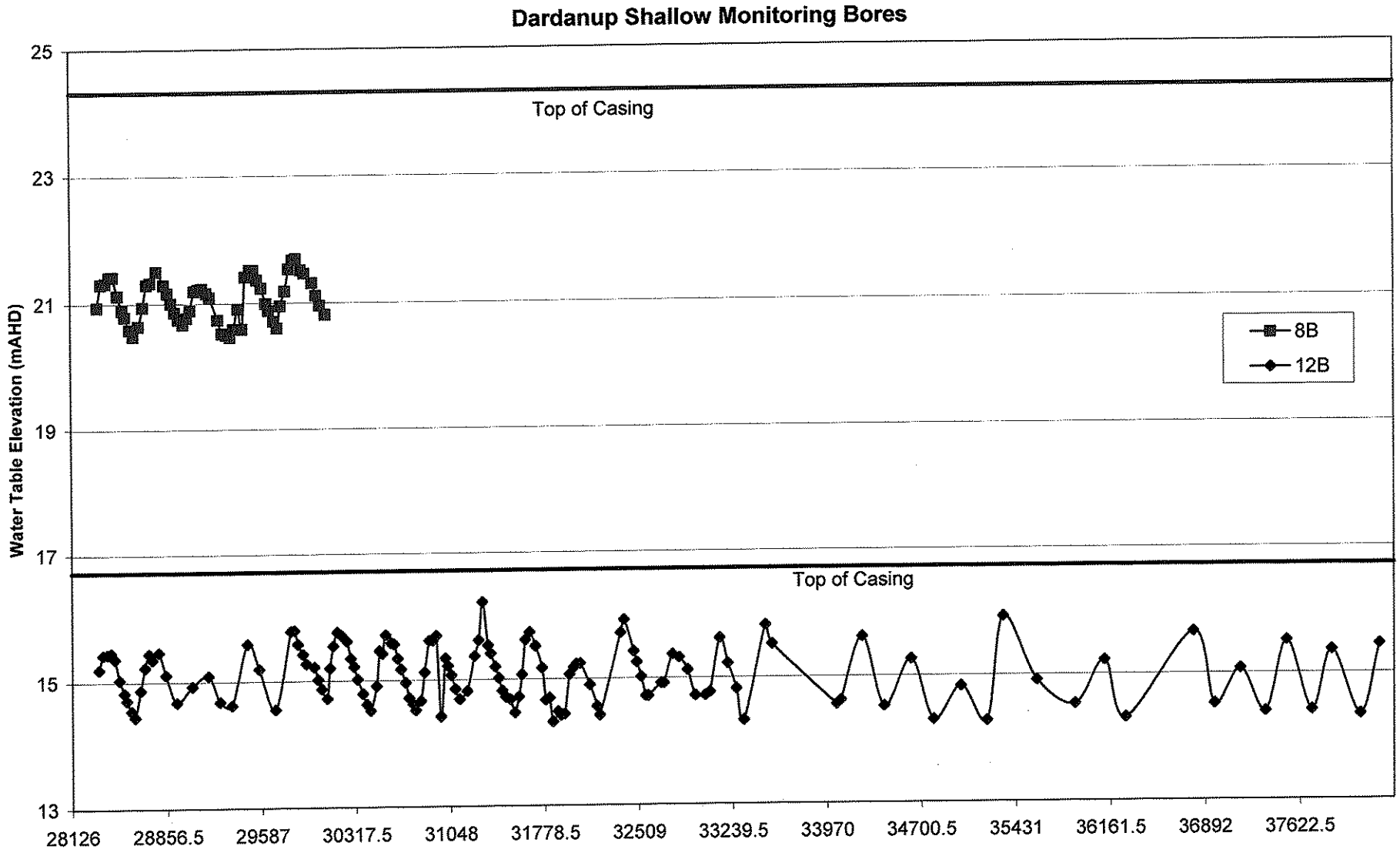
Not to Scale

Shire of Dardanup

West Dardanup - Crooked Brook

Figure 5: Groundwater Monitoring Bore Locations



Data Source: DoE

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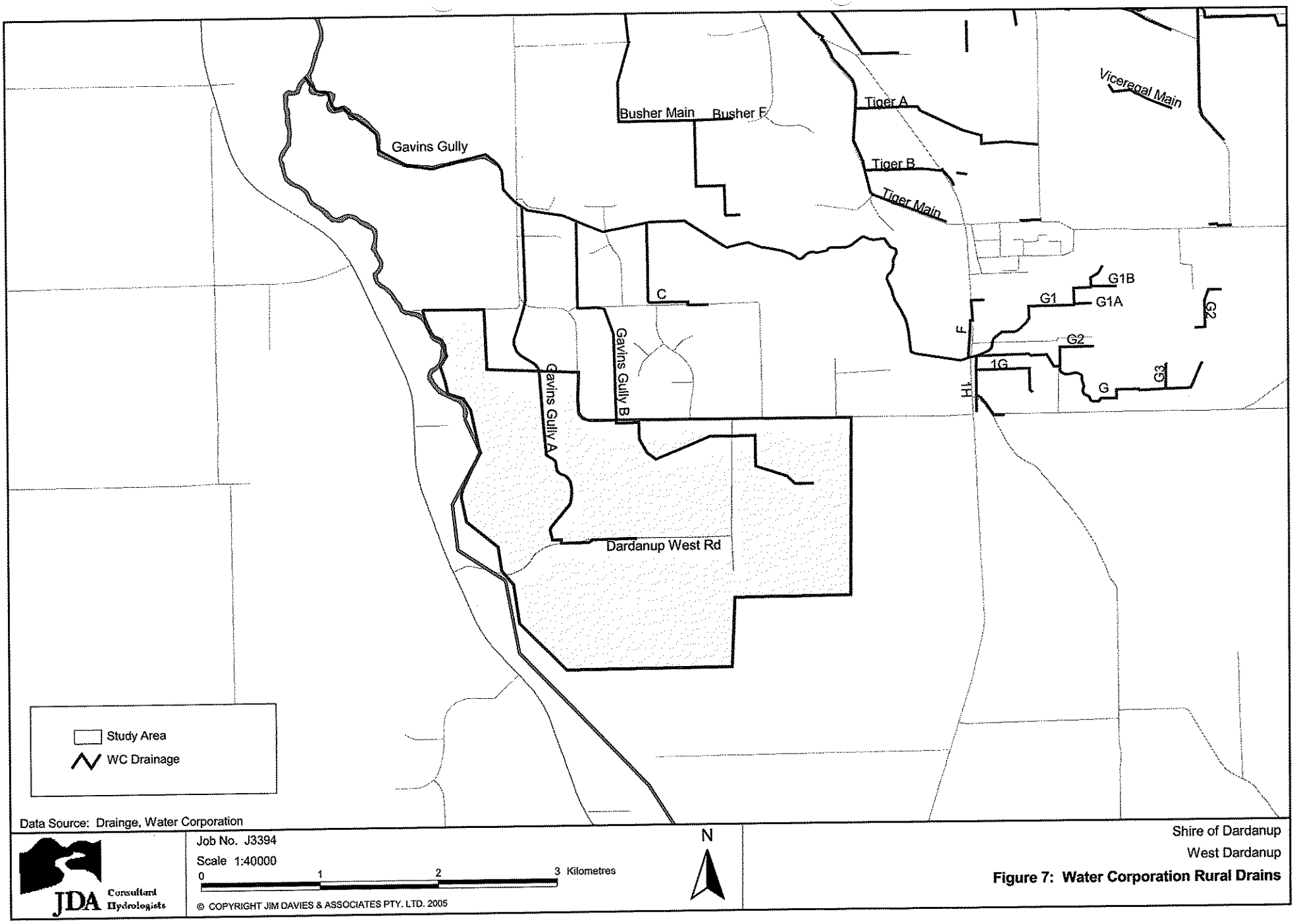
Shire of Dardanup

West Dardanup - Crooked Brook

Figure 6: DoE Monitoring Bore Data


Gavins Gully
Busher Main
Busher F
Tiger A
Tiger B
Tiger Main
Vicereqal Main
C
Gavins Gully B
Gavins Gully A
F
G1B
G1
G1A
G2
G2
1G
G
G3
1H
Dardanup West Rd
Study Area
WC Drainage
Data Source: Drainge, Water Corporation
Job No. J3394
Scale 1:40000
0
1
2
3 Kilometres
N
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Shire of Dardanup
West Dardanup
Figure 7: Water Corporation Rural Drains

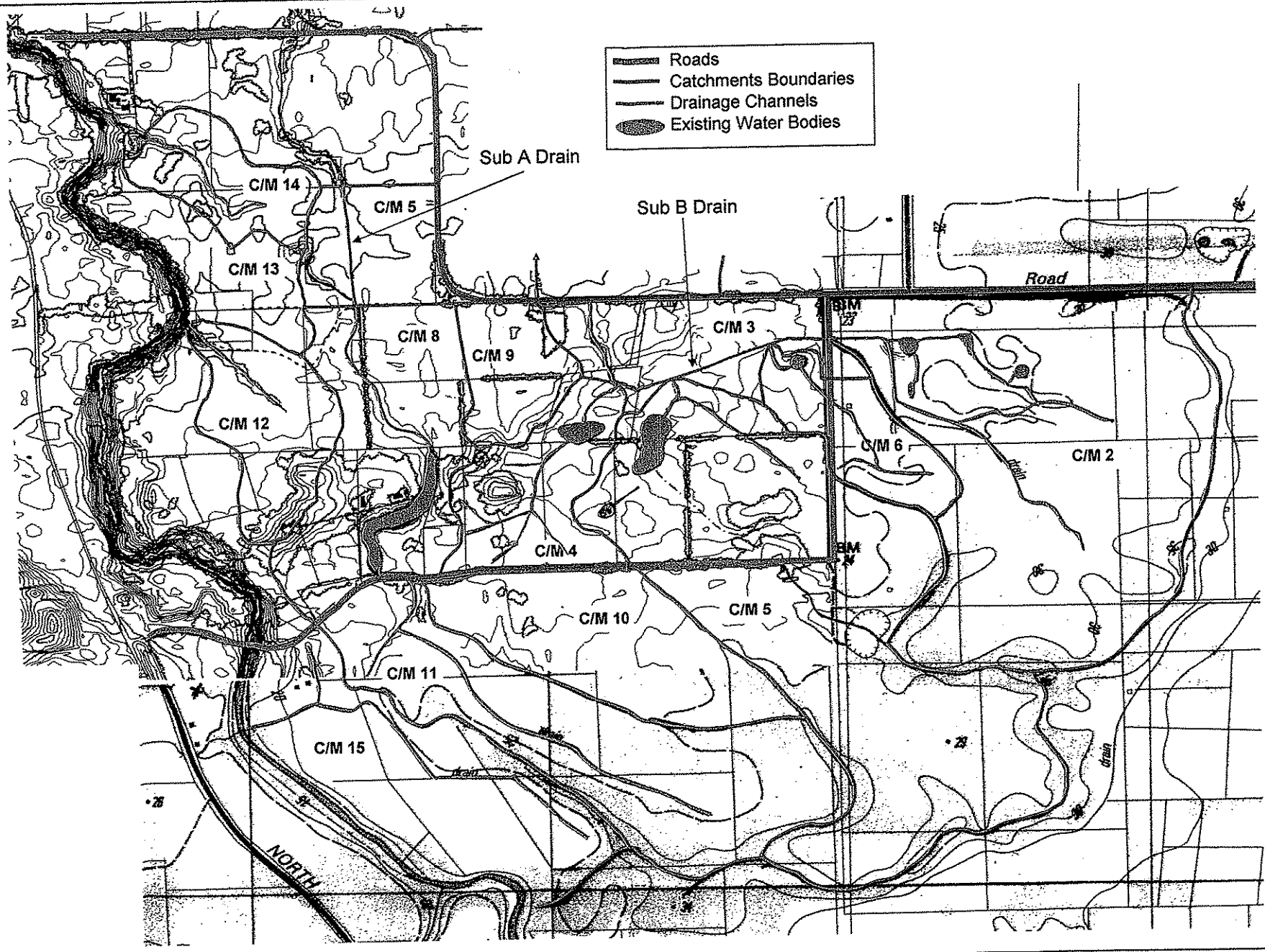

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Figure 8: Existing Drainage

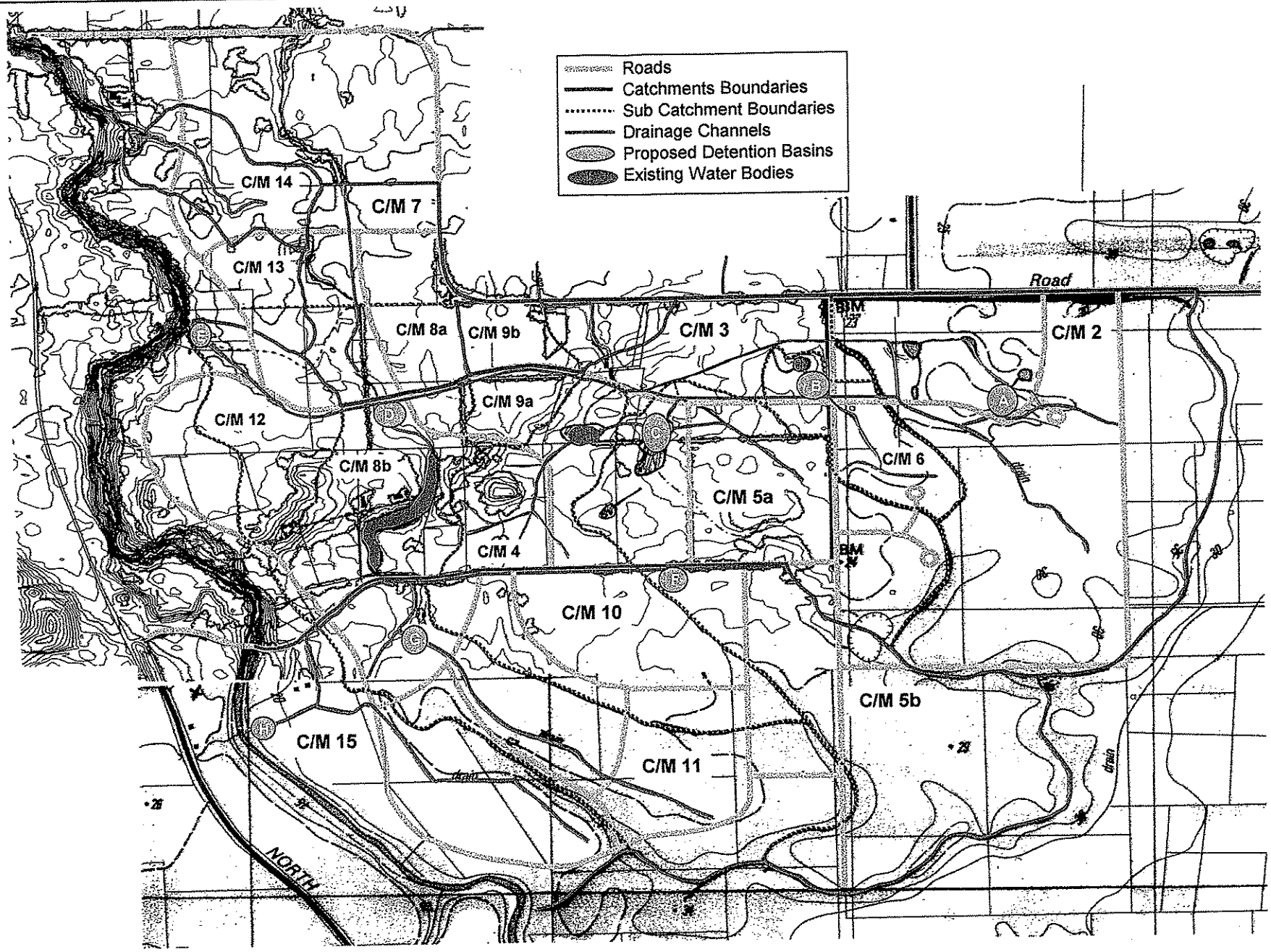

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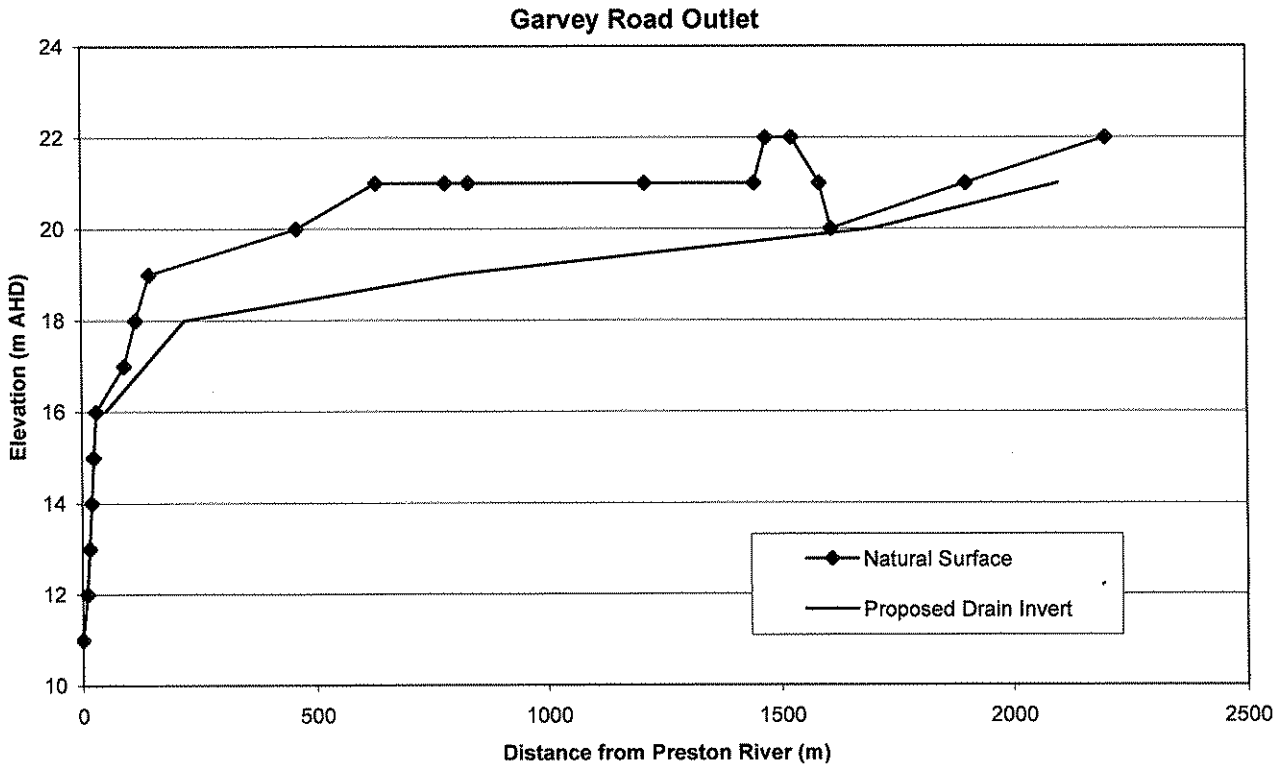
Figure 9: Proposed Post Development Drainage



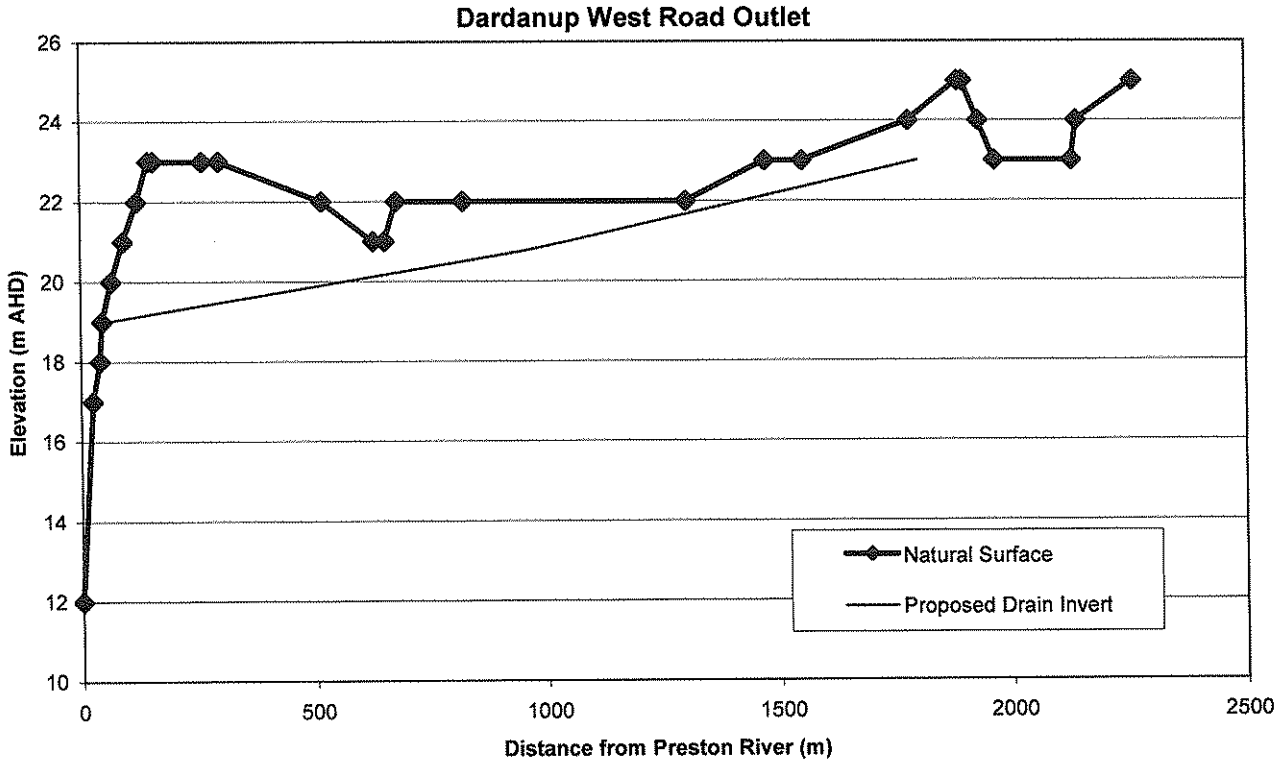


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Figure 10: Proposed Drain Long Sections - Garvey Rd & Dardanup West Rd