Naracoorte Lucindale Council

Naracoorte Drainage Study

Stage 3

Principal Contacts
Drew Jacobi

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ADELAIDE
TONKIN CONSULTING
5 Cooke Terrace
Wayville SA 5034
T +61 8 8273 3100
F +61 8 8273 3110
adelaide@tonkin.com.au

MOUNT GAMBIER
JONES TONKIN
1 Krummel Street
Mount Gambier SA 5290
T +61 8 8723 5002
F +61 8 8723 5004
mtgambier@tonkin.com.au

www.tonkin.com.au

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1. Introduction

The Naracoorte Lucindale Council commissioned a hydrological study to provide a review of the existing drainage and upgrade options for individual catchments within the Naracoorte township.

Stage 1 of this process involved field investigations and liaison with Council staff to develop a skeleton plan of the township drainage in its current condition. Information was also collected from Council staff on the locations where flooding has occurred in the past. Catchment areas were determined from topographical maps and information gathered on site. These catchment areas were used to identify other possible drainage problems in the town and to divide the town into a suitable number of smaller areas for future studies. Twelve catchments were identified for investigation.

The findings of Stage 1 enabled priorities to be assigned to individual catchments to undertake a detailed design. The catchments with the highest priority were the Town Centre and Gare Swamp Precincts, which were addressed in Stage 2 of the review.

Stage 3 involved reviewing the existing drainage and developing upgrade options for the remaining nine catchments within the township.

The key elements of this study include,

- Evaluation of the standard of existing underground drainage.
- Identification of areas where the existing underground drainage system is deficient.
- Recommendations for upgrading the drainage system to achieve the required level of protection.

This report documents the findings of the study, including a preliminary costing of the works recommended to upgrade deficient drainage systems.

2. Catchment Description

The extent of the nine study catchments is shown in Appendix A. The area of each of these catchments is shown in Table 2.1. The underground drainage systems within these areas were investigated as a part of this study.

Based on a field inspection of flow directions, each catchment was divided into smaller sub-catchments to an individual entry pit level, as shown in Appendix A.

Table 2.1 Catchment Areas

Location	Catchment Number	Area (Ha)
Gum Avenue	1	34.75
Cameron Street	2	52.4
Sandstone Ave / Park Tce	3	21
Sandstone Ave/ Artaud Tce	4	10.25*
TAFE	5	12.6
Town Centre	6	60.2
Gare Swamp	7	77.5
Butler Tce / McCoy St	8	47.6
Deviation Rd / Butler Tce	9	62.5
Deviation Road	10	1.2
Wheeler Court	11	5.25
Schinckel Road	12	105

* - Excludes external catchment, upper Caves Road system not modelled.

2.1 Land Use

Existing land use information was derived from site observations and inspection of Council development plans. These plans indicate that ultimate development within the study catchments will be predominantly residential. Areas not zoned residential include:

- Recreational area (North Parklands) to the north of Park Terrace.
- Commercial areas along the western end of MacDonnell Street and along Stewart Terrace immediately north of the railway line.
- Town Centre along Smith Street backing onto the eastern end of Livingston Street.
- Commercial/Industrial area within the showgrounds and along Gordon Street between Alexander and Atchison Avenue.
- Industrial zoned areas along Deviation Road extending to sections along Butler Terrace and another along the western end of Smith Street.

- Mixed use area along Livingston Street.
- Country living area to the west of Gordon Street.

The land use of each of the nine catchments was found to reflect the nominated development plan zoning, hence hydrological analysis for each catchment has been undertaken using this as the basis for determination of runoff coefficients. Exceptions to this rule include the TAFE grounds as part of catchment of 5 and the Naracoorte Hospital as part of catchments 8 and 12.

2.2 Existing Stormwater Infrastructure

The study catchments are served by various underground drainage systems. Naracoorte Creek is used as an outfall by systems draining the northern catchments. Catchments to the west and north-west indirectly drain to Naracoorte Creek by first discharging to the Caves Road open drain. Drainage systems within the remaining catchments to the south and south-east utilise end-of-line basins to soakaway/evaporate stormwater. The majority of these basins have an outfall to an open drain passing through paddocks running northwards along the railway line. One basin, however, does not contain an outfall and thus relies on the infiltration and evaporation of stormwater.

3. Hydrological Modelling

3.1 Introduction

Hydrological modelling was performed to determine peak flows occurring in drainage systems throughout the catchment for a range of average recurrence interval events. Comparing these peak flows against the known capacity of each system allows evaluation of existing standards, and identification of problems requiring future improvement.

3.2 Drain Data

Drain data, including type, size and location were taken from recent work undertaken that developed a database of existing drainage.

Drain grades were not available from the database, and thus were estimated from For these drains, grades were determined from surface contours on Department of Lands maps. Physical grades were reduced by a factor of 0.25 (ie. such that pipe grades were equal to 75% of the longitudinal surface grade), in order to allow for pit and box losses. The estimated grade was used in the hydrological model to determine pipe capacity and despite the possible discrepancy between the modelled and physical pipe grade, the resultant capacity was considered to be valid as the surface grade closely resembles the maximum available hydraulic gradient. Minor losses in the pipes due to junction boxes and other structures were accounted for by reducing the effective hydraulic gradients applied to each pipe segment.

Recognising that some existing Council records are limited, any subsequent detailed design work may need to be based on field inspection and survey, particularly when providing connections into existing drains.

3.3 Catchment Data

The catchment was analysed at an individual entry pit level, where sub-catchments to each side-entry pit were determined from field inspection and Department of Lands maps. Field inspections identified sub-catchment modifications such as spoon drains and verified road and gutter drainage patterns and the existence, location and specifications of side-entry pits.

Time of concentration for each sub-catchment was calculated based upon the gutter slope and maximum gutter flow length to the inlet. An additional 5 minutes was adopted to account for drainage of stormwater from the property roof to the street water table.

3.4 Rainfall Data

Rainfall data for the hydrological model were derived from Australian Rainfall & Runoff (Institution of Engineers Australia, 1987). Rainfall depths and temporal patterns were determined for ARIs between 1 and 100 years and storm durations between 5 minutes to 72 hours.

The parameters obtained to generate the rainfall data were taken at the Naracoorte Post Office.

3.5 Hydrological Model

Hydrological modelling of the catchment was undertaken utilising the ILSAX model, "Program for Urban Stormwater Drainage Design and Analysis" (O'Loughlin, 1993). ILSAX is a computer based rainfall-runoff routing program, combining flows through a drainage network and calculating appropriate pipe hydraulic capacities.

The hydraulic model incorporates equations for flow times and overflows and determines pipe and culvert capacities. Manning's Roughness Coefficients of 0.012 and 0.011 were used for culverts and pipes respectively. ILSAX can be configured to produce an output file which summarises each drain, reporting the maximum peak flow passing through it for a range of storm durations, for each recurrence interval investigated. he table summarises flows entering the drain from the surface, and any flood flows produced as a result of the drain capacity being exceeded.

ILSAX can be run to:

- Review existing drains;
- Design new drain sizes that will provide a level of protection equivalent to that recurrence interval;
- Upgrade existing drains to provide a new level of protection; and
- Design new drains that will duplicate existing drains in order to achieve a new level of protection.

ILSAX has been utilised by designers over a considerable period and has been accepted as an industry standard tool in analysing urban catchments.

3.6 Rainfall Loss Model

Runoff coefficients for each sub-catchment were estimated through inspection of the Naracoorte Lucindale Council Development Plans.

The majority of the residential zoned areas throughout the township are relatively old development and allotments are not directly connected to the street network. It was estimated that such areas have a direct and indirect impervious fraction of 0.18 and 0.1 respectively. For new residential developments along Playford Drive and within

Parkside Court the direct and indirect impervious fraction allocated was 0.27 and 0.05 respectively.

Typical values for direct and indirect impervious fractions in other development areas were as follows;

- Commercial 0.50-0.65 direct;
- Industrial 0.55 direct;
- Mixed Used 0.28 direct, 0.10 indirect;
- Hospital 0.40 direct; and
- TAFE grounds 0.30 direct.

Throughout the modelling process, an initial loss value of 1mm for the impervious areas was subtracted from the rainfall hyetograph, with the remaining rainfall considered to be runoff. An initial loss of 45mm and a continuing loss of 3mm/hr from the rainfall hyetograph were used to determine runoff from pervious areas of the catchment.

3.7 Model Calibration

The ILSAX model was initially used to investigate the performance of the existing drainage system for a range of recurrence intervals. The results indicated that flooding problems existed in many drainage systems throughout the catchment. In order to validate the accuracy of the model variables, known drainage problems and their frequency of occurrence, as indicated by Council staff, were compared with the model output. The information gathered from this process confirmed that the model results reflected known drainage problems. Some problems areas were also verified when a rainfall event occurred during a field inspection.

Information on the frequency of known flooding problems within each catchment is limited. Flooding problems due to insufficient drain capacities are likely to be unreported due to many roads having large gutter flow capacities providing an overflow path for floodwaters.

Despite the lack of comprehensive flooding records, the model is considered to reasonably reflect the behaviour of the catchment, provide findings on the performance of the existing system and be a consistent basis on which to provide recommendations on future upgrading of the drainage network.

4. Existing Drainage Assessment

This section describes the results of the hydrological modelling for the existing drainage systems within the modelled catchments. These results have been used to identify the level of protection provided to the community by each of the drainage systems, enabling an assessment to be made of locations where improvement to the level of protection is required. The existing drainage network for each catchment is shown in Appendix A.

Detailed output including flow information and existing pipe capacities are presented in Appendix B.

4.1 Pipe Capacity

Design flows for 1, 2, 5, 10, 20, 50 and 100 year ARI flood events were compared to the existing pipe capacities to determine the current standard of each drain element in each of the catchments. The design flows have been calculated based on the upstream pipe system being capable of carrying the design flow, i.e. no flood flows spill out of the catchment. The flow data provided in Appendix A assumes that flood flows in excess of the pipe capacity will spill out of the local catchment at points where this physically occurs along the system.

4.2 Inlet Capacity

The adequacy of the inlets in the drainage system were assessed by reviewing the surface flow arriving at the inlets from the sub-catchments. The inlet capacity is dependant on the size of the side-entry pit and the slope of the approach gutter. Typically an on-grade, double side-entry pit has a capacity of transferring flows from gutter into the underground drainage system in the range of 60-80L/s. Gutter flows in excess of the inlet capacity will bypass an on-grade inlet or pond at a trapped low point even if the pipe has sufficient capacity.

4.3 Drainage System Analysis

4.3.1 Catchment 2

All underground drainage within this catchment drains south to Naracoorte Creek. The major drainage system is located along Cameron Street extending upstream to Park Terrace. A significant portion of this particular system was found to have a less than 1 year ARI design standard which is of concern considering there is a trapped low point at the corner of Cameron and Freeling Street. Surface storage within the

roadway at this intersection must be just sufficient to provide protection to surrounding properties from low intensity rainfall events.

A soakage pit on the northern side of Park Terrace (shown in Figure 4.1 below) was observed to perform poorly during a very light rainfall event (~5mm).

Figure 4.1 Soakage Pit on Park Terrace

A small system at the eastern end of MacDonnell Street has a less than 1 year ARI design standard which also needs attention as there are no accessible overland flow paths to the creek. This poses a risk of flooding to adjacent businesses.

At the western end of MacDonnell Street the drainage system has a less than 1 year design standard, however an overland flow path exists south to the creek.

4.3.2 Catchment 3

The majority of the underground drainage within this catchment drains to Naracoorte Creek and is at an acceptable standard (greater than 5 year ARI). The drainage system located underneath the railway line at the intersection of Sandstone Avenue was found to have a 2 year ARI standard or less. This system has an outlet on the western side of Sandstone Avenue after which overland flow is possible to Naracoorte Creek.

4.3.3 Catchment 4

This catchment contains three small drainage systems directing stormwater into an open channel, Caves Road drain, adjacent to Playford Drive. A portion of the system along Sandstone Avenue is at a 2 year ARI standard or less.

4.3.4 Catchment 5

The majority of this catchment drains to two inlets located at a low point on Gordon Street, these inlets discharge into a retention basin located within the TAFE grounds. This drainage system was found to be at or less than a 2 year ARI design standard. The approximate volume of the basin is 75m^3. An analysis of the basin determined its capacity to be approximately 4mm of rainfall over the catchment (assuming no infiltration). This corresponds to a rainfall less than a 1 year ARI event of 1 hour duration. As a result there is a reliance on high infiltration rates to soakaway water arriving in the basin.

Two inlets are located at the low point along Foster Street, details of the underground drainage are unknown and therefore it was not possible to determine the existing design standard of this system.

A soakage pit is located at a low point along Loveday Street, this is thought to be effective in dealing with existing local flows.

4.3.5 Catchment 8

This catchment contains a single major underground system running west along Butler Terrace, down McCoy Street discharging into Naracoorte Creek. The majority of the system has a less than 1 year ARI design standard. There is a known problem of ponding at the corner of McCoy and Livingston Street. Due to the length of this system flooding is more likely due to poor inlet capacity resulting in a significant amount of overland flow. New drainage in Butler Terrace was designed in 1999 but has not been constructed.

4.3.6 Catchment 9

The major system has a 2 year ARI design standard or less between the round-about at Smith Street and the outlet at Naracoorte Creek. Flooding is likely to be an issue at the round-about as no overflow path exists over the railway line to the north. Overflows will likely spill into the road reserve area thus posing no risk to properties. However, north of the railway line there is potential of flooding to adjacent properties as gutter flows will not be able transferred to the underground system due to the low capacity of the drainage system. Upstream sections of this system along Butler Terrace were also found to have 1 year ARI or less design standard. An overflow path does exist north-west along Butler Terrace.

The southern most drainage system along Gordon Street which drains to a swale/basin located within the road reserve along Deviation Road was found to have a 2 year ARI design standard or less. The capacity of this swale/basin is approximately 75m³ which is equivalent to less than 1mm of rainfall over the catchment. This corresponds to less than a 1 year ARI design standard. A low point exists at the upstream end posing a flood risk to adjacent properties as there is no safe overland flow path.

4.3.7 Catchment 10

This catchment drains to an open channel which runs westward parallel to Moyhall Road. This basin discharges into a retention basin as part of the new industrial estate The drainage system located within this catchment was found to have a 10 year ARI design standard or above.

4.3.8 Catchment 11

This catchment drains north to Naracoorte Creek. There are two underground systems located within this catchment, drains were found to have a 10 year ARI or above design standard except for one section of less than 1 year ARI. The inlets are located at a low point, overflows will most likely spill over to the grassed area and away to the creek, thus posing little flood risk.

4.3.9 Catchment 12

This catchment has three separate underground drainage systems with each system connected into separate detention basins located on the western side of Gordon Street.

A significant portion of the system at the western end of Schinckel Road has a less than 1 year ARI design standard or less. This is due to large surface flows arising from the very large sub-catchment area draining to this point, more than half of the catchment drains to this particular system. A low point exists along this system whereby there is potential of flooding to adjacent properties. However, overflows will likely spill into the large road reserve area thus posing little risk of flooding to adjacent properties. The end-of-line detention basin has an outfall to a open drain running along the railway line and thus overtopping of this basin does not pose a risk of flooding to adjacent properties.

The second system which extends from McLachlan Crescent down Atchison Avenue has a 5 year and above ARI design standard through the majority of the system reducing to a 2 year standard through the most downstream portion. An overflow path exists at the downstream end northwards along Gordon Street. The capacity of the end-of-line retention basin was found to be approximately 12mm of rain falling over the catchment which corresponding to a 1 year ARI design storm of 1 hour duration (assuming no infiltration). This basin, providing retention for 400m³ of runoff, relies on high infiltration rates to reduce the risk of flooding to adjacent properties.

The third system extends from Cedar Avenue down Lochiel and Bibury Avenue. The majority of this system has a 2 year ARI design standard with a portion upstream at 1 year or below. A low point exists at the downstream end, at the corner of Gordon Street and Bibury Avenue. The overland flow path from this low point is through the properties located on the western side of Gordon Street. The end-of-line detention basin has an outfall again to the open drain running along the railway line and thus overtopping of this basin does not pose a risk of flooding to adjacent properties.

5. Proposed Drainage Master Strategy

5.1 Introduction

This section outlines the preferred works for each system. The standard of each existing drainage system was reviewed and upgrade options were assessed for the systems that were found to be inadequate.

5.2 Design Standard

The Naracoorte Lucindale Council generally require a 5 to 10 year ARI design standard for underground drainage systems. Stage 2 established a target level of drainage performance which was adhered to in this stage of the investigation:

- 5 year ARI underground drainage where safe overland flow paths for 100 year ARI event are available;
- Increased underground drainage capacity where a safe overland flow path is not available such that property is not inundated for the 100 year ARI event.

5.3 Proposed Drainage Upgrade Works

The layout of the proposed drainage networks for each of the nine catchments are shown in Appendix A. The upgraded drainage systems are considered adequate to provide the desired standard.

The alignment of the proposed drains have been selected using the general criteria of maximising the use of existing drainage (thus minimising costs), provision of interception drains to alleviate flows in existing undersized drains, relatively high gutter flows and use of public rather than private land.

Detailed output, including flow information and design pipe sizes for each drain element, is presented in Appendix B.

5.3.1 Catchment 2

Cameron Street

A safe overland flow path is not available for the Cameron Street drainage system such that property is not inundated for the 100 year ARI event. The following upgrade is therefore proposed:

- 20 year ARI design standard underground drainage;

- Provide additional inlets;
- Allow 100 year ARI gap flow to pond in the low point;
- Manage floor levels within the area for future developments ensuring allotments will not be inundated in a 100 year ARI event;

In addition to this it is proposed to remove the soakage pit located on the northern side of Park Terrace. A field gully will be provided at this location with a connection into the existing side entry pit on the southern side of Park Terrace.

MacDonnell Street

An upgrade of the system located at the eastern end of MacDonnell Street is proposed to achieve a 100 year ARI design standard. This is necessary as a safe overland flow path is not available.

The western most system running south along Stewart Terrace is proposed to be upgraded to achieve a 5 year ARI design standard.

5.3.2 Catchment 3

Drainage under the intersection of Sandstone Avenue and the railway line is proposed to be upgraded to achieve a 5 year ARI design standard. Initially it is recommended that this system be cleaned out as most of the inlets and the downstream channel were found to be blocked. A regular maintenance program should be implemented to ensure the capacity of the drainage is not compromised.

5.3.3 Catchment 4

Underground drainage at the northern end of Sandstone Avenue is proposed to be replaced to achieve a 5 year ARI design standard.

5.3.4 Catchment 5

Gordon Street

The drainage system along Gordon Street is located at a low point, hence there is the potential of flooding of adjacent properties. It is therefore proposed to upgrade the drainage draining to the retention basin within the TAFE grounds to achieve a 20 year ARI design standard. This upgrade will include the construction of additional inlets to transfer the large gutter flows into the underground system and into the basin.

A volume of 1360m^3 is required to retain the amount of runoff produced from the catchment during a 100 year ARI event of 2 hours duration. The existing basin is reported to empty over a number of days which considered to be appropriate. This equates to an area of approximately 45m long by 15m wide by 2m deep being set aside for a retention basin. This is in excess of the existing basin dimensions (approx

75m³). Council will have to obtain an easement of such size so as to provide adequate retention storage at this location. Further assessment may allow for a reduced basin area to be required, should storage of some floodwaters on Gordon Street be feasible.

Foster Street

The drainage system along Foster Street is located at a low point resulting in a risk of flooding to adjacent properties. It is therefore proposed to also upgrade this system to achieve a 20 year ARI design standard. The proposal is to direct water from the existing pits through an easement over the TAFE grounds into the basin located along Gordon Street.

5.3.5 Catchment 8

It is proposed to replace the existing underground drainage system to achieve a 5 year ARI design standard. In conjunction construction of additional inlets is proposed to more effectively transfer the excessive existing gutter flows. This proposed system will incorporate an earlier concept design by Tonkin Consulting (1999). It should be noted that this design will require an amendment to reflect the new design flows calculated by this study. New drainage was proposed in the 1999 Study for Smith Street to connect into this system. Hence this was incorporated in the current study.

Due to the long length of underground drainage a staged approach is proposed to undertake the replacement.

The three stages proposed are as follows:

1. Replacement of the main drain between the intersection of Magarey Crescent and Butler Terrace and the outlet at Naracoorte Creek.
2. Construction of lateral pipes along Smith Street connecting into the main drain.
3. Replacement of the remaining main drain between the round-about at Jenkins Terrace and the intersection of Magarey Crescent and Butler Terrace.

Completion of the three stages will provide the system with a 5 year ARI standard. Each stage has been designed is such a way that they can be progressively built to achieve the standard as funding becomes available.

5.3.6 Catchment 9

A two staged approach is proposed for the necessary upgrades along Butler Terrace aimed at addressing flooding issues in the short term and long term.

1. Construction of additional inlets along Butler Terrace aimed at addressing flooding in the short term, its role being to transfer excessive gutter flows into the drain downstream where an acceptable standard was found.
2. Replace existing upstream drainage to achieve a 5 year ARI design standard.

It is further proposed to replace the existing drainage between the Smith Street round-about and Naracoorte Creek to achieve a 5 year ARI design standard. Additional inlets will be constructed along this reach of drainage.

An upgrade of the drainage along Gordon Street between the intersection of Adelaide Avenue and Deviation Road is also proposed to achieve a 5-100 year ARI design standard. A safe overland flow path is not available for this system drainage system such that property is not inundated for the 100 year ARI event. As a result a 100 year ARI design standard is necessary on the downstream portion.

There is a need to manage development within the industrial zone such that any development does not lead to the capacity of the existing drainage system being exceeded. For example, if the industrial zone is currently 20% developed and if in the future development occupies 50% of the zone, internal stormwater measures will need to be required to ensure that the amount of stormwater reaching the kerb and gutter matches the existing development level.

The southern most drainage system along Gordon Street currently drains to a retention swale/basin located within the road reserve along Deviation Road. A volume of 5400m^3 is required to retain the amount of rainfall produced from this portion of the catchment during a 100 year ARI event of 2 hours duration. This volume assumes 'ultimate development' within a catchment that currently is largely undeveloped. This equates to an area of approximately 55m long by 50m wide by 2m deep being set aside for a retention basin which is in excess of the current dimensions (75m^3). Council will have to obtain an easement of such size so as to provide adequate retention storage at this location. It is not possible to fit such a basin into the road reserve, hence it is recommended that council acquire some land to the east of Deviation Road to construct the basin within.

5.3.7 Catchment 10

No upgrades are necessary within this catchment as an acceptable standard was found for the drainage system.

5.3.8 Catchment 11

It is proposed to upgrade the existing drainage system located at the western end of Wheeler Court to achieve a 5 year ARI design standard. This involves replacing the existing underground drainage and providing additional inlets.

5.3.9 Catchment 12

Lochiel Avenue

The following is proposed for the Lochiel Avenue drainage system:

- Replace existing upstream drainage to achieve a 5 year ARI design standard;
- Provide additional inlets; and
- Replace downstream drainage to achieve a 100 year ARI design standard.

It is necessary to upgrade downstream drainage to a 100 year ARI standard as a safe overland flow path is not available, as a result property on the western side of Gordon Street will be inundated in the 100 year ARI event. Alternatively, it may be viable to provide an overland flow path through existing allotments to the end-of-line detention basin.

Any upgrade to this system will need to account for the movement of the downstream detention basin which may occur due to the development of a new land division. Therefore an increase in the standard of the basin will also be appropriate to account for the land division. The basin currently has an outfall to an open drain to the west which runs northwards along the railway line. We recommend Council acquire control over the basin and the open drain. Currently there is no development to the west of the basin and as such there is no need to control the outfall. However, if in the future development is to occur there will be a need to accurately model the basin and its outfall to ensure any development is not flooded in a 100 year ARI event.

Atchison Avenue

It is proposed to replace the downstream portion of this system to achieve a 5 year ARI design standard. This will have the added effect of reducing the gutter flows arriving at the Lochiel Avenue system.

Careful management of the retention basin at the downstream end of this system will be crucial to the effectiveness of this system. Currently the retention basin is situated on private property. We recommend that Council acquire the basin site. To be effective in retaining a 100 year ARI event of 2 hours duration, a volume of approximately 1755m^3 is required. The existing basin is reported to empty over a number of days which is considered appropriate. This equates to an area of approximately 30m long by 30m wide by 2m deep being set aside for retention. This is in excess of the basins current capacity (approximately 400m^3).

Schinckel Road

Due to the large amount of the catchment draining to the existing Schinckel Road drainage system the proposed upgrade has been designed with an aim to break up the large sub-catchment. The proposed work is therefore to add a new system which runs along Gordon Street from Schinckel Road to Alexander Avenue then along Alexander to Grieve Avenue. This new system will also discharge into the basin located along Doolans Road. In conjunction with this work the existing drainage needs to be replaced to achieve a 5 year ARI level of protection.

Careful management of the detention basin at the downstream end of this system will be crucial to the effectiveness of this system. Currently the detention basin is situated on private property, again we recommend that Council acquire the site of the basin. The outfall for the basin is into an open drain to the west which runs northwards along the railway line. We also recommend Council acquire control of the open drain. Currently there is no development to the west of the basin and as such there is no need to control the outfall. However, if in the future development is to occur there will be a need to accurately model the basin and its outfall to ensure any development will not be inundated in a 100 year ARI event.

Scouring and silt deposition was noted within the Nature Reserve on the southern side of Attiwill Street. It is proposed to provide an improvement to the outlet by providing a sediment trap including some scour control measures.

6. Works Priorities and Costing

6.1 Priorities

The priorities for the works identified have been set below, according to the following,

- The significance in reduction of flood damages as a result of constructing the proposed works.
- The requirements for a proposed drain to be constructed so that the other proposed drains feeding into this drain can subsequently be constructed.
- Construction costs.

Application of the above criteria and incorporating those works proposed in Stage 2 of this Study and the 1999 Caves Road Drainage Study produced a preferred priority hierarchy for staging the construction of all projects as follows:

1. Hinckley Street
2. Caves Road – Open Channel Upgrade
3. Gum Avenue – Stage 1 Detention/Drainage
4. Cameron Street
5. Guernsey Street
6. Butler Terrace/McCoy Street/Smith Street
7. Schinckel Road
8. Lochiel Avenue
9. MacDonnell Street East
10. Gordon Street – Deviation Road
11. Railway Line/Sandstone Avenue – Drainage Clean Out
12. Memorial Drive
13. Atchison Avenue
14. Gordon Street (TAFE)
15. Foster Street
16. Caves Road – Racecourse Detention Basin
17. Smith Street round-about to Naracoorte Creek
18. Butler Terrace (Catchment 9)
19. Robertson Street – Additional Inlets
20. Gum Avenue – Stage 2 Pump
21. Sandstone Avenue
22. MacDonnell Street West
23. Wheeler Court
24. Railway Line/Sandstone Avenue – Drainage Upgrade

The Caves Road Drainage Study (1999) recommended that detention storage within the racecourse be used to throttle 100 year ARI flood flows to a flow which could be safely be transmitted by the existing open channel.

In the past modifications have been made to the Caves Road drain to stem the flooding problems experiences in the confines of the township area. A 300m section of open channel upstream of Mudge Street has been backfilled with the installation of a 300mm RCP. This is a significant restriction to flow with the upstream capacity of the open channel in the order of 1m^3/s.

It is therefore recommended to replace the 300mm drain and return this section of the Caves Road drain to open channel. As a second (later) stage, it is recommended that the capacity of the entire length of open channel be reviewed to determine whether a 100 year ARI capacity can be achieved.

6.2 Indicative Cost Estimates

Cost estimates for each of the proposed drainage systems have been prepared. A table of the cost estimates is shown in Appendix C. The estimated costs for the proposed drains include an allowance for regional area construction costs (15%), design (7.5%), alteration of existing services (5%) and contingencies (20%). The costs do not include GST.

These estimates are prepared for general information only. It is recommended that an appropriately qualified quantity surveyor be consulted to provide detailed advice regarding construction costs if a more definitive estimate is required. It is expected that further development of the design concepts is required to refine the estimates further. The acquisition and control of basin sites and overflow channels have not been costed

Table 6.1 Costing Summary

Proposed Upgrade	Reserves / Easements Required	Design ARI Standard	Indicative Cost Estimate	CMSS Eligibility
Hinckley Street		100	$1,510,000	$175,000
Caves Road – Open Channel Upgrade		-	$180,000	$90,000
Gum Avenue – Stage 1 Detention/Drainage	Y	20	$290,000	
Cameron Street		20	$325,000	
Guernsey Street		5	$310,000	
Butler Tce/McCoy St/Smith St		5	$1,430,000	$60,000
Schinckel Road	Y	5	$1,050,000	
Lochiel Avenue	Y	5, 100*	$290,000	
MacDonnell Street East		100	$45,000	
Gordon Street – Deviation Road	Y	5, 100*	$215,000	
Railway line/Sandstone Avenue Drain Clean		-	$10,000	
Memorial Drive		5	$240,000	
Atchison Avenue	Y	5, 100**	$70,000	
Gordon Street (TAFE)	Y	20, 100**	$55,000	
Foster Street	Y	20	$85,000	
Smith St round-about to Naracoorte Creek		5	$300,000	
Butler Tce (Catchment 9)		5	$100,000	
Robertson Street Additional Inlets		5	$35,000	
Gum Avenue – Stage 2 Pump		100	$230,000	
Sandstone Avenue		5	$45,000	
MacDonnell Street West		5	$40,000	
Wheeler Court		5	$15,000	
Railway line/Sandstone Avenue		5	$25,000	

* - 100yr ARI design standard where safe overflow path does not exist.
** - 100yr ARI design standard for retention basins.

7. Summary

Hydrological modelling has been undertaken for the drainage systems within the remaining catchments in Naracoorte for the Naracoorte Lucindale Council not modelled previously in Stage 2 of the drainage study.

The standard of the existing drainage infrastructure varies greatly, with some systems having a 10 year ARI standard, while other systems have a less than 1 year ARI standard. According to Council requirements, the underground drainage systems were upgraded to a 5 year ARI standard and 20-100 year ARI standard from a low point.

Works are required at the locations listed below with the associated indicative cost estimates. It is suggested that they be carried out in order according to the relative priority as specified below. A detailed cost estimate will require further design work and assessment by an appropriately qualified quantity surveyor.

1. Hinckley Street	$1,510,000
2. Caves Road – Open Channel Upgrade	$180,000
3. Gum Avenue – Stage 1 Detention/Drainage	$290,000
4. Cameron Street	$325,000
5. Guernsey Street	$310,000
6. Butler Terrace/McCoy Street/Smith Street	$1,430,000
7. Schinckel Road	$1,050,000
8. Lochiel Avenue	$290,000
9. MacDonnell Street East	$45,000
10. Gordon Street – Deviation Road	$215,000
11. Railway Line/Sandstone Avenue – Drainage Clean out	$10,000
12. Memorial Drive	$240,000
13. Atchison Avenue	$70,000
14. Gordon Street (TAFE)	$55,000
15. Foster Street	$85,000
16. Smith Street round-about to Naracoorte Creek	$300,000
17. Butler Terrace (Catchment 9)	$100,000
18. Robertson Street Additional Inlets	$35,000
19. Gum Avenue Stage 2 Pump	$230,000
20. Sandstone Avenue	$45,000
21. MacDonnell Street West	$40,000
22. Wheeler Court	$15,000
23. Railway Line/Sandstone Avenue	$25,000

In addition to the works described above a number of basin sites and overflow channels, currently in private ownership, have been identified for strategic purchase by Council. These include;

- TAFE retention basin;
- Atchison Avenue/Gordon Street retention basin;
- Doolans Road (Schinckel Road drainage system) detention basin;
- Lochiel Avenue/Gordon Street detention basin; and
- Deviation Road retention basin.

The current sizes of the detention basins are not an issue as they each outfall into an undeveloped area of the township. However, it is essential council gain control over these sites to ensure they are able to control their sizing given future development. It is also essential that council gain control of the retention basin sites as they are each currently under sized. It will be necessary to upgrade these basins to achieve a 100 year ARI design standard.

Under the catchment management subsidy scheme, the proposed Butler Terrace/McCoy Street/Smith Street drainage system, Hinckley Street drainage system and the Caves Road open channel upgrades are eligible for a subsidy. The cost amounts listed in Table 6.1 is the amount of works eligible under the 50% subsidy.

8. References

Institute of Engineers Australia (1987) "Australian Rainfall & Runoff."

O'Loughlin, G. (1993) "The ILSAX Program for Urban Stormwater Drainage Design and Analysis", University of Technology, Sydney.

Tonkin Consulting (2005) "Naracoorte Drainage Study – Stage 2."

Tonkin Consulting (1999) "Caves Road Drainage Study for the District Council of Naracoorte."

Appendix A

Existing and Proposed Drainage

Note: Refer to loose plot

Appendix B

Existing and Proposed Drainage Hydrology Output

Appendix B - Proposed Drainage Hydrology

* Bold print denotes proposed underground drainage

	Total Flows to this Point (m^3/s)		Pipe Diameter (Existing/**Proposed**) (mm)		Grade Capacity (m^3/s)	ARI Design Standard (Years)
	5yr ARI	100yr ARI				
AAA 001	0.031	0.064	375		0.207	
AAA 002	0.063	0.131	375		0.207	
AAA 003	0.063	0.131	300		0.207	
AAB 001	0.044	0.093	375		0.207	
AAB 002	0.1	0.211	400		0.246	
AAC 001	0.016	0.035	300		0.114	
AAA 004	0.198	0.406	500		0.446	
AAA 005	0.198	0.404	500		0.864	
AAD 001	0.064	0.133	300*	**300**	0.109	20
AAD 002	0.096	0.201	300*	**375**	0.198	20
AAE 001	0.081	0.17	300		0.114	
AAE 002	0.142	0.297	300	**375**	0.198	5
AAE 003	0.179	0.373	300	**525**	0.485	100
AAE 004	0.179	0.372	300	**525**	0.485	100
AAF 001	0.051	0.112	300		0.114	
AAF 002	0.074	0.161	300		0.114	
AAF 003	0.074	0.16	450		0.337	
AAE 005	0.248	0.519	Open Channel		-	
AAG 001	0.345	0.788	Open Channel		-	
AAH 001	0.375	0.856	Open Channel		-	
AAG 002	0.711	1.636	Open Channel		-	
AAE 006	1.397	2.83	600x300	**825**	1.621	5
AAE 007	1.45	2.941	Open Channel		-	
AAI 001	0.067	0.141	300		0.14	
AAJ 001	0.222	0.465	225	**525**	0.485	100
AAK 001	0.027	0.057	225		0.053	
AAJ 002	0.362	0.753	300	**675**	0.951	100
AAL 001	0.019	0.039	300		0.114	
AAL 002	0.042	0.089	300		0.114	
AAL 003	0.054	0.114	300		0.114	
AAL 004	0.056	0.123	300		0.114	
AAM 001	0.021	0.046	300		0.114	
AAN 001	0.04	0.089	300		0.114	
AAM 002	0.061	0.134	300		0.242	
AAL 005	0.116	0.252	300		0.242	
AAO 001	0.032	0.073	300		0.114	
AAL 006	0.145	0.312	300		0.242	
AAP 001	0.038	0.081	300		0.114	
AAL 007	0.18	0.391	300		0.242	
AAQ 001	0.01	0.022	300		0.114	
AAR 001	0.014	0.031	300		0.114	
AAL 008	0.201	0.433	300		0.242	
AAS 001	0.003	0.007	300		0.114	
AAT 001	0.006	0.015	300		0.114	
AAL 009	0.21	0.45	300		0.242	
AAU 001	0.039	0.084	300		0.114	
AAL 010	0.248	0.527	300	**375**	0.42	5
AAV 001	0.021	0.043	450		0.337	
AAV 002	0.021	0.043	450		0.337	
AAV 003	0.054	0.113	450		0.462	

AAW 001	0.016	0.035	275		0.091	
AAW 002	0.041	0.086	275		0.091	
AAX 001	0.016	0.034	600x250		0.248	
AAX 002	0.033	0.069	300		0.114	
AAY 001	0.055	0.114	300		0.114	
AAX 003	0.309	0.661	375	**450**	0.342	5
AAX 004	0.317	0.675	300	**450**	0.342	5
AAZ 001	0.054	0.113	160	**300**	0.119	5
AAZ 002	0.054	0.113	300		0.119	
ABA 001	0.011	0.024	475		0.389	
AAZ 003	0.065	0.135	475		0.389	
ABB 001	0.062	0.132	300		0.114	
AAZ 004	0.125	0.262	475		0.389	
AAX 005	0.457	0.972	700		1.164	
ABC 001	0.016	0.035	225	**300**	0.114	5
AAX 006	0.484	1.026	700		1.164	
ABD 001	0.019	0.04	225	**300**	0.114	5
ABE 001	0.018	0.041	300		0.114	
ABD 002	0.035	0.075	300		0.114	
ABF 001	0.044	0.098	300		0.114	
AAX 007	0.623	1.277	700		1.164	
ABG 001	0.072	0.153	160		0.021	
ABH 001	0.013	0.03	160		0.021	
ABG 002	0.103	0.219	375		0.207	
ABG 003	0.108	0.231	400		0.246	
ABG 004	0.316	0.72	Open Channel		-	
ABG 005	0.309	0.714	300	**450**	0.322	5
ABI 001	0.093	0.212	225	**300**	0.109	5
AAX 008	1.145	2.306	700		1.164	
ABJ 001	0.339	0.727	250x300	**450**	0.342	5
ABJ 002	0.372	0.789	450x300	**525**	0.485	5
ABJ 003	0.371	0.788	375	**525**	0.516	5
ABK 001	0.027	0.063	160	**300**	0.109	5
ABJ 004	0.421	0.873	375	**525**	0.516	5
AAX 009	1.554	3.168	700	**750**	1.779	5
ABL 001	0.021	0.044	300		0.114	
AAX 010	1.573	3.16	900		3.026	
ABM 001	0.17	0.354	250		0.151	
ABN 001	0.041	0.084	225		0.053	
ABN 002	0.052	0.109	225		0.053	
ABN 003	0.07	0.151	450		0.337	
ABO 001	0.141	0.303	300	**375**	0.198	5
ABO 002	0.203	0.435	300	**450**	0.322	5
ABO 003	0.208	0.444	300	**450**	0.322	5
ABP 001	0.053	0.113	300*		0.114	
ABQ 001	0.214	0.46	300*	**450**	0.322	20
ABQ 002	0.27	0.578	300	**525**	0.594	20
ABQ 003	0.27	0.58	375	**525**	0.665	20
ABR 001	0.06	0.13	300		0.114	
ABQ 004	0.325	0.703	450	**525**	0.726	20
ABS 001	0.014	0.03	300		0.114	
ABQ 005	0.338	0.722	475	**525**	0.726	
ABT 001	0.021	0.044	400x300		0.194	
ABT 002	0.04	0.085	500x450		0.452	
ABT 003	0.059	0.127	600x350		0.403	
ABT 004	0.144	0.301	400x250	**450**	0.322	20

ABT 005	0.192	0.399	300	**450**	0.322	20
ABU 001	0.021	0.044	225	**300**	0.114	20
ABQ 006	0.541	1.139	300	**600**	0.953	20
ABV 001	0.054	0.115	450x100	**300**	0.109	20
ABV 002	0.191	0.407	450x100	**450**	0.322	20
ABW 001	0.089	0.187	300		0.114	
ABW 002	0.116	0.233	300	**375**	0.198	5
ABX 001	0.212	0.442	600x200	**450**	0.322	5
ABW 003	0.356	0.719	500x300	**450**	0.483	5
ABY 001	0.036	0.08	500x300		0.258	
ABZ 001	0.085	0.177	-	**300**	0.109	5
ABW 004	0.476	0.967	300	**450**	0.483	5
ACA 001	0.102	0.212	225	**300**	0.114	5
ACB 001	0.085	0.178	300		0.114	
ABW 005	0.646	1.352	300	**525**	0.728	5
ACC 001	0.034	0.072	-	**300**	0.109	5
ABW 006	0.674	1.41	300	**525**	0.728	5
ACD 001	0.005	0.012	300		0.114	
ACE 001	0.029	0.062	-	**300**	0.109	5
ABW 007	0.703	1.467	300	**525**	0.728	5
ACF 001	0.017	0.036	-	**300**	0.109	5
ABW 008	0.715	1.493	300	**525**	0.728	5
ACG 001	0.062	0.137	-	**300**	0.292	5
ACG 002	0.09	0.197	-	**300**	0.109	5
ACG 003	0.116	0.254	-	**375**	0.198	5
ABW 009	0.815	1.713	300	**675**	1.041	5
ABW 010	0.815	1.713	300	**825**	0.888	5
ACH 001	0.031	0.065	-	**300**	0.109	5
ACH 002	0.061	0.129	-	**300**	0.109	5
ACH 003	0.074	0.158	-	**300**	0.109	5
ACI 001	0.011	0.023	600x250	**300**	0.109	5
ABW 011	0.885	1.861	300	**900**	0.914	5
ACJ 001	0.011	0.023	-	**300**	0.109	5
ACJ 002	0.059	0.127	-	**300**	0.109	5
ACJ 003	0.163	0.347	225	**375**	0.198	5
ABW 012	0.991	2.12	400	**900**	1.324	5
ACK 001	0.021	0.045	-	**300**	0.109	5
ABW 013	1.004	2.149	400	**975**	1.216	5
ACL 001	0.023	0.049	-	**300**	0.109	5
ABW 014	1.016	2.189	800x375	**975**	1.216	5
ACM 001	0.067	0.146	-	**300**	0.109	5
ACM 002	0.11	0.234	-	**375**	0.198	5
ACN 001	0.19	0.419	-	**375**	0.258	5
ACN 002	0.203	0.443	-	**450**	0.305	5
ACO 001	0.087	0.182	-	**300**	0.109	5
ACM 003	0.397	0.848	-	**675**	0.521	5
ACP 001	0.098	0.205	-	**300**	0.109	5
ACQ 001	0.089	0.185	-	**300**	0.109	5
ACM 004	0.577	1.216	-	**675**	0.705	5
ACR 001	0.101	0.216	-	**300**	0.109	5
ACS 001	0.134	0.278	-	**375**	0.198	5
ACR 002	0.233	0.487	-	**600**	0.241	5
ABW 015	1.79	3.88	800x375	**975**	1.846	5
ABW 016	1.918	4.137	600	**1050**	2.248	5
ACT 001	0.011	0.023	150		0.018	
ACU 001	0.013	0.026	300		0.157	

ACV 001	0.102	0.212	225		0.065	
ACW 001	0.046	0.096	300		0.14	
ACX 001	0.008	0.016	300		0.14	
ACX 002	0.016	0.033	300		0.14	
ACY 001	0.028	0.066	225		0.053	
ACX 003	0.046	0.103	300		0.14	
ACZ 001	0.024	0.051	160		0.021	
ADA 001	0.147	0.34	375		0.207	
ADB 001	0.035	0.076	300		0.14	
ADC 001	0.036	0.082	225		0.053	
ADC 002	0.086	0.185	300		0.114	
ADE 001	0.073	0.155	450x200		0.126	
ADE 002	0.182	0.396	225	**375**	0.211	5
ADF 001	0.028	0.06	300		0.114	
ADF 002	0.046	0.1	300		0.14	
ADG 001	0.047	0.098	160	**300**	0.14	5
ADG 002	0.07	0.146	300		0.14	
ADH 001	0.022	0.049	300		0.361	
ADH 002	0.052	0.115	300		0.443	
ADI 001	0.06	0.126	275		0.091	
ADI 002	0.129	0.27	275		0.091	
ADJ 001	0.017	0.038	300		0.114	
ADJ 002	0.049	0.107	300		0.221	
ADK 001	0.042	0.089	300		0.114	
ADL 001	0.049	0.102	200	**300**	0.114	5
ADM 001	0.046	0.095	375		0.207	
ADN 001	0.023	0.051	300		0.114	
ADN 002	0.054	0.119	300		0.114	
ADO 001	0.109	0.231	300		0.114	
ADO 002	0.199	0.431	300	**450**	0.322	5
ADN 003	0.253	0.549	375	**450**	0.68	5
ADP 001	0.023	0.048	300		0.114	
ADN 004	0.294	0.63	375	**450**	0.68	5
ADN 005	0.346	0.73	375	**450**	0.68	5
ADN 006	0.373	0.788	375	**450**	0.68	5
ADQ 001	0.032	0.067	300		0.114	
ADN 007	0.41	0.863	475		0.754	
ADN 008	0.65	1.344	475		0.754	
ADN 009	0.648	1.341	475		0.754	
ADN 010	0.648	1.34	475		0.754	
ADN 011	0.659	1.359	475		0.754	
ADN 012	0.714	1.462	600		1.405	
ADR 001	0.065	0.137	225	**300**	0.114	5
ADR 002	0.065	0.136	500		0.446	
ADN 013	0.857	1.755	600	**675**	1.841	100
ADN 014	0.853	1.755	600	**675**	1.841	100
ADS 001	0.033	0.069	550x100		0.056	
ADS 002	0.091	0.191	300		0.114	
ADT 001	0.192	0.412	-	**375**	0.198	5
ADU 001	0.01	0.021	-	**300**	0.109	5
ADT 002	0.195	0.42	-	**375**	0.198	5
ADV 001	0.097	0.208	-	**300**	0.109	5
ADW 001	0.099	0.212	-	**300**	0.109	5
ADT 003	0.345	0.749	-	**525**	0.485	5
ADT 004	0.36	0.779	-	**525**	0.485	5
ADX 001	0.153	0.324	-	**375**	0.198	5

ADX 002	0.28	0.601	-	**450**	0.322	5
ADT 005	0.68	1.46	-	**600**	0.695	5
ADT 006	0.678	1.46	-	**600**	0.695	5
ADY 001	0.11	0.231	300		0.114	
ADY 002	0.137	0.288	650x550		0.837	
ADY 003	0.478	0.991	450	**525**	0.485	5
ADY 004	0.538	1.122	450	**600**	0.695	5
ADZ 001	0.103	0.219	375		0.44	
ADY 005	0.636	1.303	600		1.609	5

Appendix C

Cost Estimates