NARACOORTE LUCINDALE COUNCIL

Flood Inundation Mapping of Naracoorte Creek

Accompanying Report

November 2000 **Principal Contact**

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FLOOD INUNDATION MAPPING

OF NARACOORTE CREEK

ACCOMPANYING REPORT

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1. INTRODUCTION

Prior to this Study, there has been no hydrological investigations or floodmapping of Naracoorte Creek, Naracoorte undertaken.

This floodmapping Study has been commissioned by the Naracoorte and Lucindale Council in order provide information on the extent of flood inundation from the 20, 50 and 100 year average recurrence interval (ARI) floods. This mapping will also assist in identifying deficiencies in the existing channel hydraulics.

This Study will serve as a planning tool for use in assessing development near the creek within the township of Naracoorte. The Study findings will also provide data necessary for planning future drainage works discharging into Naracoorte Creek.

This Study Report accompanies the flood mapping presented and should therefore be read in conjunction with that mapping.

2. HYDRAULIC MODELLING

A set of floodplain maps which depict the 20, 50 and 100 year ARI floods have been produced. The extent of flood inundation has been represented as a line of inundation along the creek through the developed areas of Naracoorte township. In addition, flood elevation contours have been provided to show the calculated water surface levels of the floods.

The flood levels along the creek have been derived from a computer based hydraulic model of the creek compiled from cross-sectional ground survey data of the main channel, floodplain and hydraulic structures such as bridges and weirs in conjunction with the predicted flows.

The flows have been predicted from hydrological investigations of the creek's contributing catchment area.

The following provides detailed discussion of the key areas of the modelling.

2.1 Channel Geometric Detail

Ground survey was carried out by SOKKIA surveys. Channel cross-sections at a spacing of approximately 100m were taken over a creek length of approximately 5 kilometres. The cross-sections define the main channel shape together with a portion of the floodplain area and building outlines immediately adjacent to the creek. Appendix A contains the report prepared by the surveyors. The report shows photographs of the channel at survey station locations along the length of creek surveyed. These station numbers have been shown on the flood maps for reference to the photographs.

Bridges and in-line weir structures were detailed by the ground survey. Due to the controlling effect that bridges and culverts often have on the backwater curve of a major flood, additional level survey and hand measurement of the bridge openings was undertaken by Tonkin Consulting to ensure accurate representation of these controlling structures in the modelling.

2.2 Hydrology

A number of different hydrological methods have been considered for application to the Naracoorte Creek catchment. However, due to the difficulties in estimating the catchment storage together with the difficulties in identifying those portions of the catchment which contribute runoff for different rainfall events, it has been concluded that the most appropriate method of analysis was to carry out a flood frequency analysis of the available streamflow data.

A streamflow gauging station (AW239542) is located just north of the swimming lake and downstream of the junction of Naracoorte Creek and the Caves Road Drain outfall. All available gauging data (15 years) has been acquired from the Department of Environment, Heritage and Aboriginal Affairs (DEHAA) for analysis.

Annual peak flows were extracted from the 15 years of available streamflow data. This series was analysed using the FLIKE model. This model performs analysis for the following statistical distributions :

- 2 Parameter Log Normal
- Log Pearson III
- Gumbel
- GEV
- Generalised Pareto

The FLIKE model produces both text file information detailing the results of the analysis together with graphical plots which illustrate the fitting of each analysed distribution.

For Naracoorte Creek, the analysis was firstly performed for the full 15 years of annual peak flows and secondly for a reduced series which eliminated low flows that skew the results downward.

It was evident from the detailed analysis output files that the Gumbel distribution provided a consistently satisfactory fit for both the full and reduced data sets.

In reviewing the results, it should be noted that the Naracoorte Creek analysis has been based on only 15 years of gauged data for which the reduced series consisted of 10 observations. Given the relatively short period of gauged data, it was considered prudent to adopt flows nearer to the 90% confidence limit of the fitted Gumbel distribution. These flows are as shown in Table 2.2.

Table 2.2 Gumbel Distribution Naracoorte Creek Flows

ARI (years)	Flow (m^3/s)
20	22
50	27
100	31

The flat, swampy nature of the South-East catchments makes estimation of flows difficult since the contributing catchment area and catchment storage capacity is difficult to estimate. Therefore, as a cross-check and comparison of the above analysis, the FLIKE model has also been applied to annual peak flows for the adjacent catchments of Mosquito and Morambro Creeks which exhibit similar catchment characteristics and behaviour. The 100 year ARI results for both of these creeks are presented in Tables 2.3 and 2.4.

Table 2.3 Mosquito Creek (26 years of data)

Distribution	90% lower	Expected	90% upper
2 Parameter Log Normal	124	225	502
Log Pearson III	-	63	-
Gumbel	73	92	118
GEV	63	94	265
Generalised Pareto	63	67	75

Table 2.4 Morambro Creek (17 years of data)

Distribution	90% lower	Expected	90% upper
2 Parameter Log Normal	27	64	231
Log Pearson III	-	14	-
Gumbel	14	19	27
GEV	14	45	772
Generalised Pareto	13	16	23

Table 2.5 summarises the derived 20, 50 and 100 year ARI flows for each catchment based on the analysis of streamflow data. The flows and associated catchment areas have then been plotted to provide a regional relationship between flow and catchment area. The curves are presented in Figures 2.1 to 2.3.

Table 2.5 Summary of Derived ARI Flows*

Catchment	Area (km^2)	20 yr ARI	50 yr ARI	100 yr ARI
Morambro Creek	329	13.46	16.7	19.15
Naracoorte Creek	740	12.11	15.16	17.45
Mosquito Creek	1130	65.76	80.89	92.23

*Gumbel Distribution Results

Figure 2.1 20 yr ARI Curve Fitting

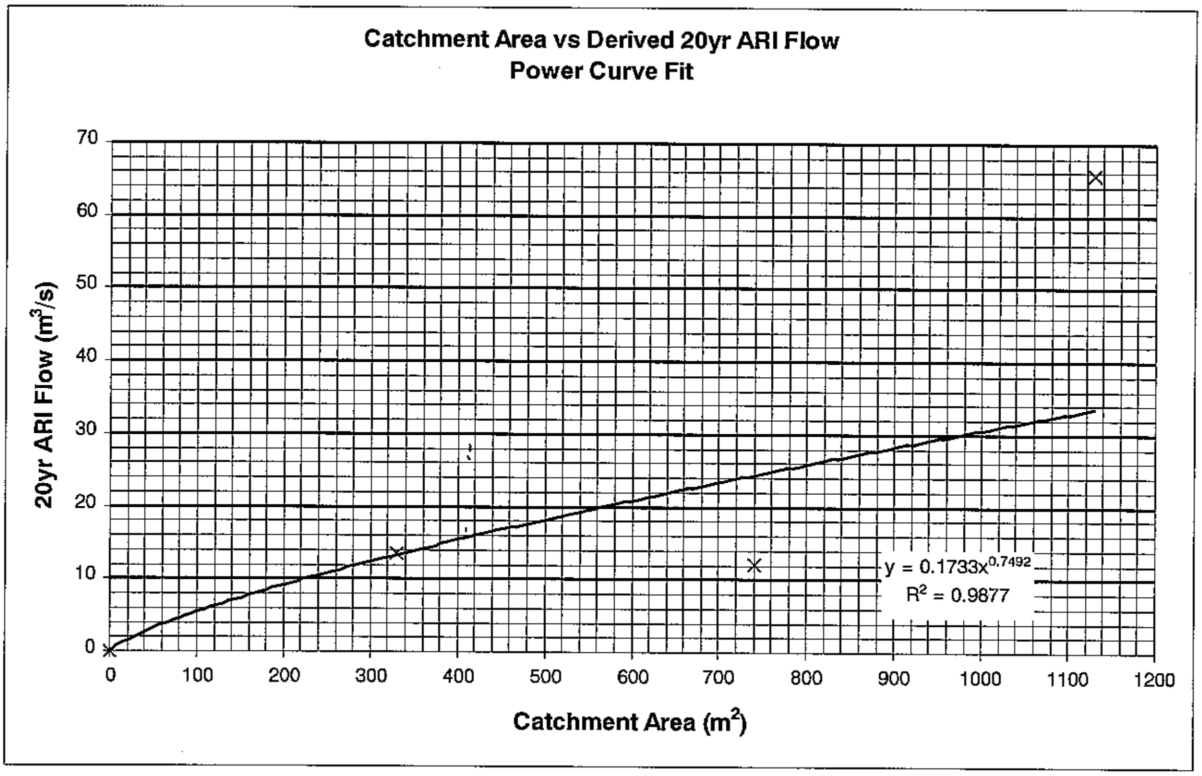


Figure 2.2 50 yr ARI Curve Fitting

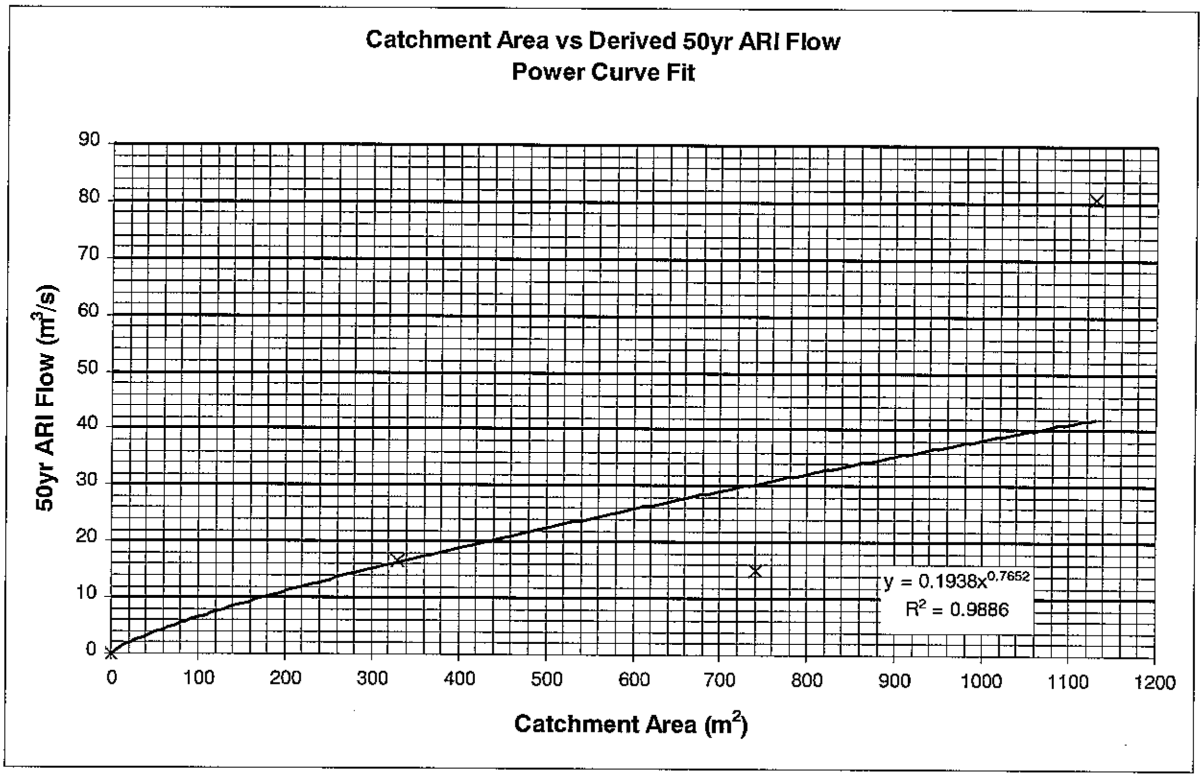
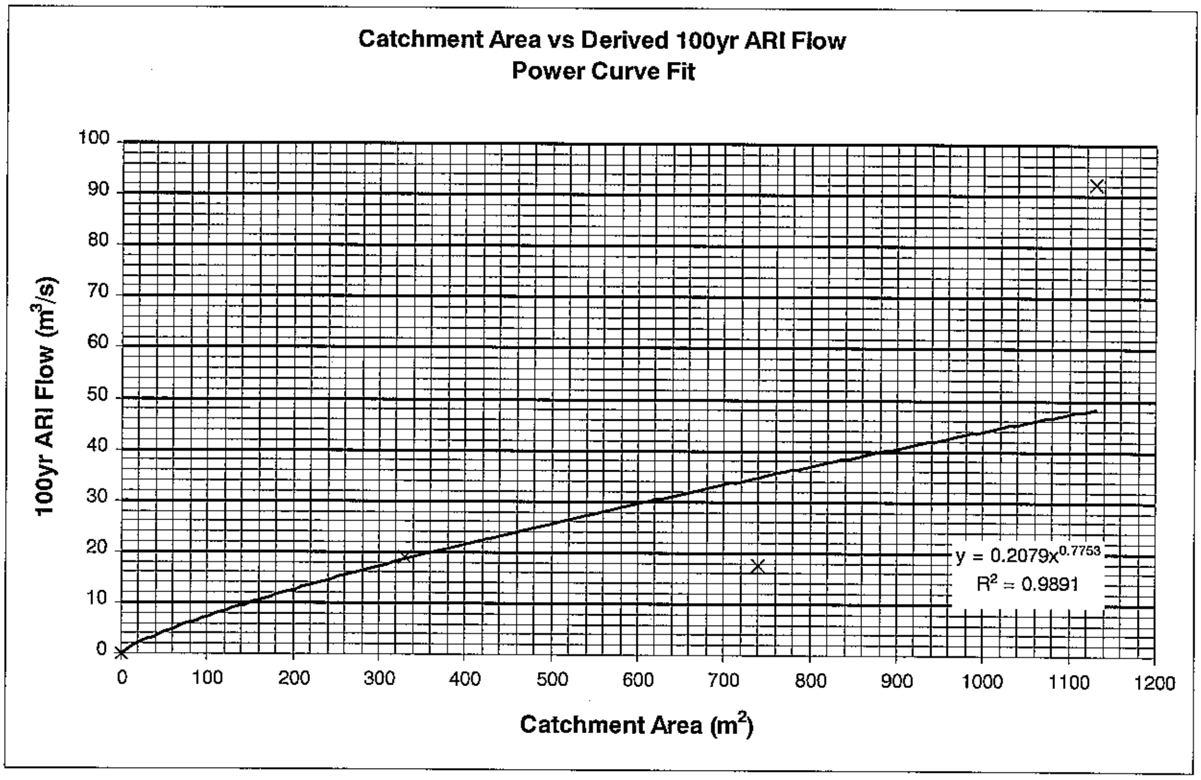


Figure 2.3 100 yr ARI Curve Fitting



From the regional relationships presented in the above figures, estimations of the Naracoorte Creek 20yr, 50yr and 100 year ARI design flows have been read and are presented in Table 2.6.

The nature of development in the South East region is such that it is likely that in the future, peak flows will increase as new drainage works are carried out in the catchment. These new drainage works may take the form of culvert upgrades or drainage of swamp areas for increased agricultural activity. The result of this kind of development will be that the catchment storage may reduce and the catchment area contributing may effectively increase. As such, the adoption of the slightly higher peak flow estimates is considered justified.

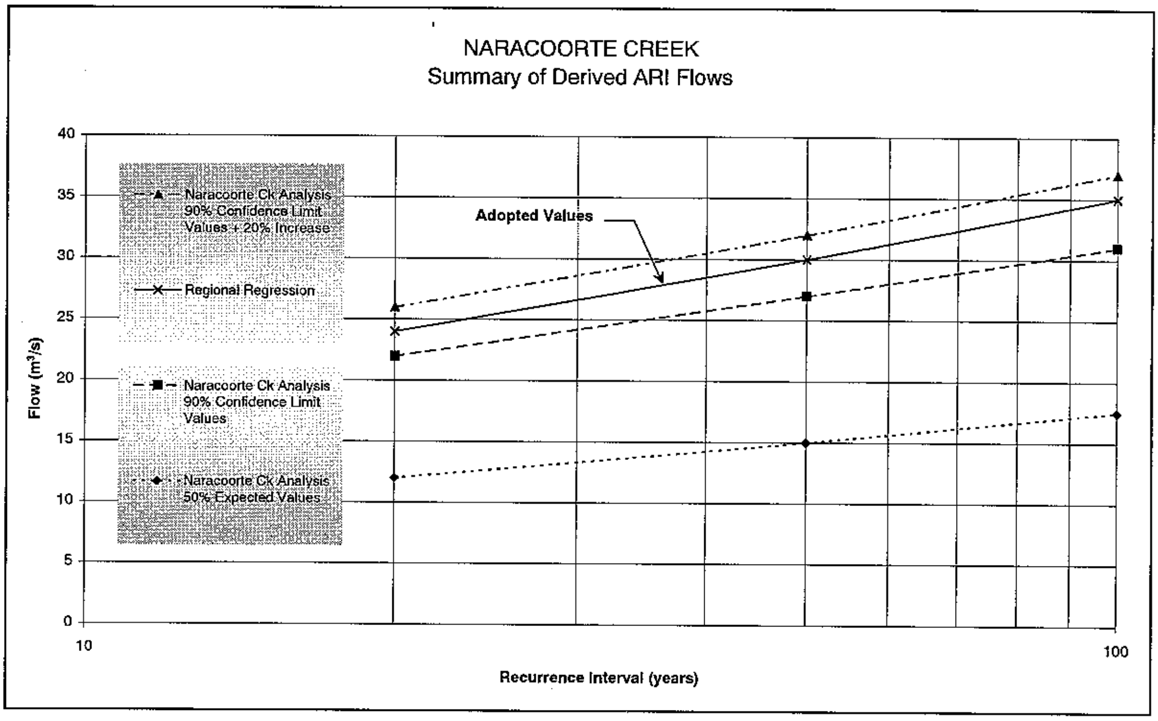
The analysis undertaken yields the sets of data for Naracoorte Creek presented in Table 2.6.

Table 2.6 Summary of Derived ARI Flows

	Naracoorte Ck Streamflow Analysis – Gumbel Distribution		3 Adjacent Creeks – 50% Confidence Limit Gumbel Distribution
ARI	90% Gumbel Distribution Confidence Limit (m^3/s)	90% Gumbel Distribution Confidence Limit (m^3/s) **+20%**	**Regional Relationship (m^3/s)**
20 year ARI	22	26	**24**
50 year ARI	27	32	**30**
100 year ARI	31	37	**35**

The values presented in Table 2.6 have been charted in Figure 2.4.

Figure 2.4 Summary of Derived Flows



It is evident from Figure 2.4 that the regional relationship yields peak flows similar to the Gumbel Distribution 90% confidence limit +20% increase. Hydraulic modelling of the creek has shown that the calculated water surface levels are relatively insensitivity to a +20% increase in flow. Given the likelihood of continuing development and construction of drainage works within the catchment and the resultant higher flows, the regional relationship flows have been adopted for use in this Study.

2.3 Manning's Roughness Values

Manning's Roughness value is a modelling parameter which describes the hydraulic roughness of the creek waterway. In this instance, the cross-sections used in the modelling are divided into three parts, the left floodplain overbank, the main channel and the right floodplain overbank.

The entire Study area was inspected on foot by members of the project team. This inspection showed that the main channel was generally clean with some reaches affected by the growth of reeds. The floodplains accommodate development such houses, commercial premises and sheds. On the outskirts of the township the floodplain is typified by open space and areas of native vegetation and paddocks.

Estimates of Manning's roughness values have been based on field observations, reference material (ref 1,3) and the combined experience of the Study team.

Calibration of the hydraulic model requires that a recorded flood mark can be assigned a flow for a known channel geometry. Whilst there was ample photographic evidence of flooding within the reach of interest, much of the documented flooding was associated with channel geometry which has changed and/or the flow in the creek at the time of the photograph was unknown. Only one historical flow and flood level at the streamflow gauge was useful in calibrating the upstream end of the hydraulic model. This historical event was only partially useful in verifying the chosen Manning's Roughness values.

2.4 Computer Models

2.4.1 HECRAS

HECRAS is an industry standard model developed by the US Army Corps of Engineers to perform one-dimensional, steady state hydraulic calculations for a network of channels. It has become the replacement program to the earlier backwater curve program, HEC-2 as used in the earlier Study.

Steady flow water surface profiles can be produced for subcritical, supercritical and mixed flow regimes. The computational procedure is based on the solution of the one-dimensional energy equation. The software manual (ref 1) states that energy losses are evaluated by Manning's equation for friction losses and contraction/expansion coefficients multiplied by the change in velocity head. Obstructions such as bridges, culverts and floodplain obstructions can be modelled and considered in the computations.

2.4.2 BOSS RMS for AutoCAD, HECRAS Interface Module

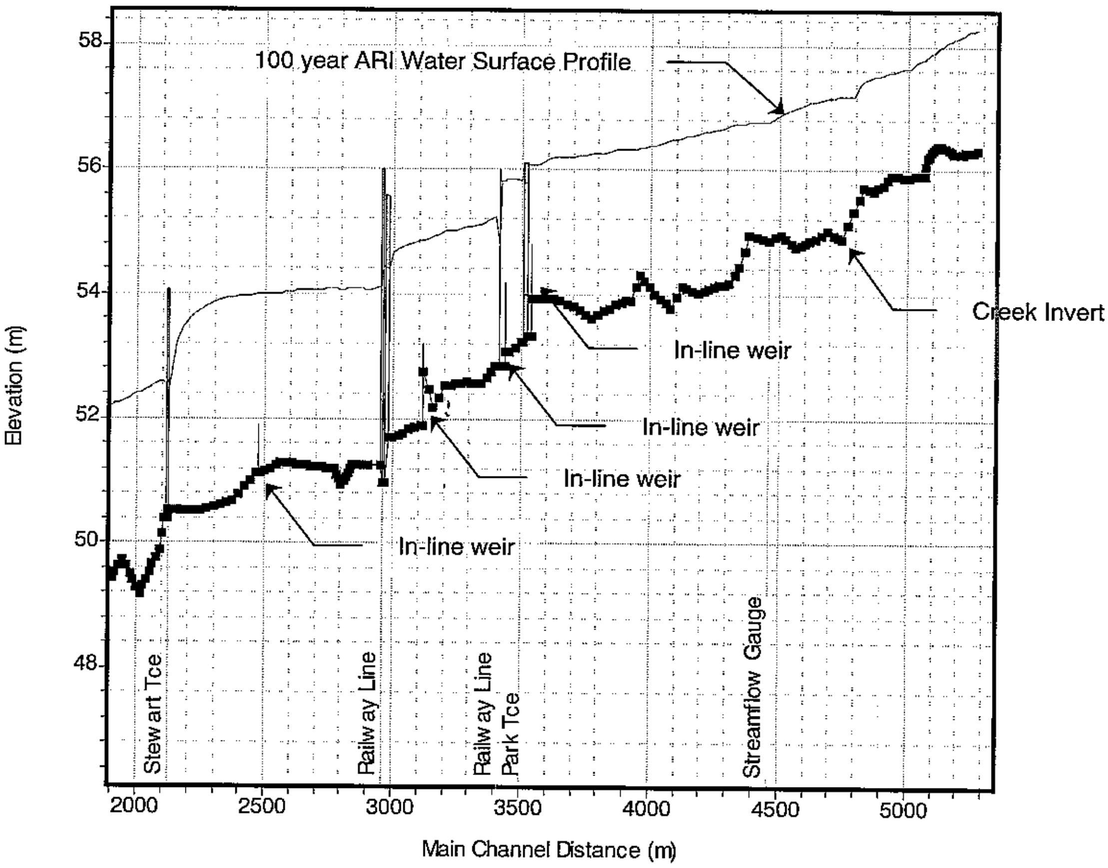
The HECRAS interface module for BOSS RMS for AutoCAD is an AutoCAD application which provides a graphical interface for the HECRAS model. As such, a 3-dimensional AutoCAD drawing can be used to graphically build an equivalent HECRAS model. Furthermore, the resulting water surface levels as calculated by the HECRAS analysis engine can be mapped within the AutoCad environment. In this case, the survey information described above provided the basis for the analysis and mapping of the required floodplain although some manual adjustment of the flood inundation line has been performed to account for omissions in the available contouring.

3. MODELLING RESULTS

3.1 Review of Existing Channel Conditions

In reviewing the results of the hydraulic modelling, it is evident that the flow regime is strongly sub-critical. This means that the water surface profile through the creek will be largely controlled by the calculated water levels downstream. Furthermore, where there are controlling structures within the waterway such as bridges and weirs, the water surface levels associated with these features will tend to be projected upstream. Figures 3.1 illustrates the water surface profile associated with the calculated 100 year ARI flow.

Figure 3.1 100 Year ARI Water Surface Profile



From Figure 3.1, it can be seen that there are a number of restrictive features which significantly control the water surface levels along the creek.

The calculated water surface profiles associated with the 20, 50 and 100 year ARI design flows have been provided in Appendix B The following discussion provides an overview of the key reaches within the Study area, with particular reference to the 100 year ARI flood.

3.1.1 Downstream of Stewart Terrace

Downstream of Stewart Terrace the channel flows in a westerly direction for approximately 400 metres and then turns toward the north. Until the channel changes direction to flow north, the 100 year ARI flood plain is confined to a well defined valley. The 100 year flood plain spread is close to the existing houses but they remain clear of and above the flood. As the channel moves north parallel to Dartmoor Court, the floodplain is confined on the east bank by high ground. This high ground accommodates development which, from the survey, is above the 100 year ARI flood levels. To the west of the channel the land is undeveloped. The 100 yr ARI flood plain is contained until the creek turns west towards open space and paddocks. Survey information indicates that the 100 year ARI flood will just begin to spill towards the west at a point approximately in-line with Gum Avenue and flood paddocks to the west of the developed areas of the town.

3.1.2 Stewart Terrace to Oliver Street

The Stewart Terrace road bridge has sufficient capacity and is not overtopped by the 100 year ARI flood. This reach of creek is relatively narrow compared to the reach downstream of Stewart Terrace. From Figure 3.1 it is evident that the reach of channel immediately upstream of Stewart Terrace causes water surface levels to rise noticeably. Levee banks have been constructed on either side of the creek at this location to confine floodwaters although it is apparent that the 100 year ARI flood levels are such that the levee banks will not contain the 100 year ARI flood. The levee banks end at Oliver Street.

From the site inspection it is evident that Oliver Street originally had a road bridge over the creek which was high enough for the levee banks downstream to match into. Oliver Street to the south of the creek connects to Graham Street which runs gently uphill back to Stewart Terrace. All that exists of the Oliver Street bridge is the remains of the bridge abutments. The build up of the road to the south of the creek remains and continues to act as an extension of the levee banks. However, from preliminary ground survey where Oliver Street connects to Graham Street, there is a low point in the road which may compromise the effectiveness of the levee banks since it would appear that both the 50 and 100 year ARI water surface levels upstream of Oliver are higher than the low point in the road. This would permit floodwaters which build up, east of Oliver, to escape into the area behind the levee banks on the south side of the channel between Oliver and Stewart Terrace. The preliminary ground survey would suggest this is an area that requires review with the possibility of raising both the low point in the Oliver/Graham Street road and the levee banks. The extent of inundation of dwellings behind the existing levee banks has been estimated from the available broad contouring.

It is recommended that further investigations be undertaken to determine building floor levels in this area and identify the frequency for which dwellings will experience flood damage.

3.1.3 Oliver Street to MacDonnell Street

This reach of creek flows approximately parallel and to the south of MacDonnell Street. Light commercial development exists between the creek and MacDonnell Street. The ground levels fall away upstream of Oliver Street and are at their lowest in the vicinity of the former tyre outlet and the wool merchant premises near to the MacDonnell Street bridge. In this area and on the north side only of the creek the levee bank has been continued. However, the level of the bank and its general condition will not prevent the 100 year ARI flood from breaking out and flooding those premises mentioned above and possibly others along the south side of MacDonnell Street. Additional survey would be required to ascertain the extent of the flooding between MacDonnell Street and the creek.

The railway line lies south of the creek and tapers in where is crosses the creek just downstream of the MacDonnell Street bridge. The railway line grades gently uphill towards the east. In this reach, the track lies well clear of the 100 year ARI flood levels. The land lying between the creek and the railway line appears in the past to have accommodated works associated with the railways. This land is currently undeveloped and generally grades up to the railway line however there is a pocket of land close to Oliver Street which would pool flood waters and potentially provide the avenue for flood waters to escape into the area discussed in the previous section of this report between Oliver Street and Stewart Terrace behind the levee banks.

The railway line has capacity to convey the 100 year ARI flood without overtopping however both the railway line bridge and the MacDonnell street bridge do act to control the calculated backwater curve upstream (refer Appendix B).

3.1.4 MacDonnell Street to the Upstream Railway Crossing

This reach of channel flows parallel to and north of Riverside Drive. Immediately to the north, the creek is contained by the railway line embankment. Riverside Drive provides access and parking to the rear of the commercial premises which front Ormerod Street. These premises are part of the main commercial precinct of the town.

The accompanying flood maps show that the water surface levels in this reach are controlled by the downstream railway line bridge and the MacDonnell Street bridge although neither of these bridges are overtopped by the 100 year ARI flood. However, the 100 year ARI flood flows close to the underside of the MacDonnell Street bridge. Whilst it is evident that the 100 year ARI flood spills south of the channel towards the commercial buildings backing onto Riverside Drive, the water levels are such that these buildings are generally safe from flooding. However, at the downstream end of this area near the MacDonnell Street bridge, the ground level on the south side of the creek falls away significantly. Immediately upstream of the bridge on the south side there is a small park area between the creek and the first commercial building (Video Hire outlet) on Ormerod Street. The northern property boundary accommodates a low wall which rises up to approximately the building floor level. This wall acts to contain the flood waters however the natural ground levels fall away significantly behind the garden machinery outlet and around the carpet warehouse buildings. These buildings are not protected from floodwaters and whilst some building floor levels may be safe from inundation these buildings may be isolated in the event of a 100 year ARI flood.

There is a small institute building fronting Ormerod Street west of the carpet warehouse/shop (see flood maps). The ground levels at the rear of this building rise in comparison with those around the carpet buildings and 100 year ARI flood waters, whilst conveyed by Riverside Drive, would not inundate buildings in this area. Closer to the upstream railway crossing, the bank on the south side of the creek adjacent to the Ford/Subaru dealer is high enough that the floodwaters would be contained to the main channel.

It is recommended that further investigations be undertaken to determine building flood levels in and around the low lying land in order to identify the frequency for which buildings will be inundated.

3.1.5 Upstream Railway line Crossing to Park Terrace

This is a short reach of channel which accommodates a man made lake adjacent to the scout hall oval. The lake has been formed by the construction of a low in-line weir which acts to contain a pool of water behind it.

The 20 year through to 100 year ARI flood flows prime the bridge opening however the bridge is not shown to overtop.

To the east of the channel, residential development has been established on ground which is just clear of the 100 year ARI floodplain. It is recommended that development in this general area proceed cautiously and that when approving development, a building floor level (inclusive of 500mm freeboard) is specified to ensure habitable dwellings are safe from the 100 year ARI flood.

The accompanying 100 year ARI flood maps show that the water surface levels in this reach are controlled largely by the railway bridge and its embankment. The 100 year ARI flood levels upstream of the railway line plateau at approximately 55.8 mAHD which results in shallow flooding across the north-western bank. The available survey together with checks of spots levels suggests that this flood level would be contained to the oval area and not extend significantly along the northern side of the railway embankment.

3.1.6 Upstream of Park Terrace

Park Terrace represents the upstream most bridge in the reach of Naracoorte Creek under consideration in this Study. The Park Terrace culverts acts as a control of the water surface levels and cause flood levels upstream to rise. The 100 year ARI flood will overtop the culverts creating shallow flooding over the road at this location. After a short distance upstream the water surface profile is controlled by the channel geometry.

To the north-west of the creek lies the caravan park, swimming lake and playing fields. These areas are on high ground and not threatened by the 100 year ARI flood. To the east of the creek, the flood plain spreads across undeveloped paddocks which lie at the rear of properties which front Sandstone Avenue. Whilst not currently developed, should an application be received to sub-divide this area, careful consideration should be given to :

- The setting of building floor levels inclusive of 500 mm freeboard,
- The impact on upstream water levels that filling and encroaching onto the flood plain may have.

In order to review a development application in this area, additional survey may be required.

3.1.7 North of the Swimming Lake

The areas north of the swimming lake are bounded on the east side by largely undeveloped cleared land and on the west side by pine plantation forest. There is a significant discharge of inflow from the outfall of the Caves Road drain, however in terms of the flows used in the mapping, the inflow from this drain is not significant and the timing of the peak flow from Caves Road would not coincide with the main Naracoorte Creek flow.

The area of most interest is that to the east of the channel, as it is understood that this area may be opened up to development in the future. The area outside of the main creek channel grades gently towards the creek and therefore there is a wide expanse of land which could be regarded as floodplain. The cross-sectional data used in the modelling is adequate for estimating the design water surface levels however the survey was not wide or detailed enough to satisfactorily depict the contouring of this large area of land.

With the above in mind it is recommended that when considering development of this area, building floor levels safe from of the 100 year ARI floodplain are specified with allowance for freeboard. Depending on the proximity of the development to the main channel, the encroachment effect that the development may have on the upstream flood levels should be reviewed.

As indicated on the floodmaps, the extent of the floodplain in this reach is only approximate. The noted water surface level contours are however accurate since the cross-sections used are considered wide enough to enable satisfactory calculation of the water surface levels. Should this area require accurate depiction of the line of inundation of any of the floods, wider cross – sections and contouring of this area would be required.

4. RECOMMENDED ON-GOING ACTIONS

From the above discussion, the following summary recommendations have been compiled :

Downstream of Stewart Terrace
The occurrence of vacant land in this reach suggests that there may be pockets of on-going development taking place.

- Given that there are areas where the floodplain lies close to existing dwellings, it is recommended that as development proceeds in this area, due consideration be given to setting suitable floors levels above the 100 year ARI flood together with an assessment of the impact (if any) on the calculated floods levels.

Stewart Terrace to Oliver Street
This reach is currently protected by levee banks on either side of the creek however the levee is only effective in containing the 20 year ARI flood.

- It is recommended that the vulnerable areas behind the levee banks be investigated further to determine the floor levels of all buildings suspected of being inundated in these areas and establish the frequency with which these buildings are at risk of flood damage. Furthermore, measures aimed at protecting these areas should be developed such as raising the levee height and closing off the low areas adjacent to the levees which compromise the effectiveness of the levee banks. Any on-going development should be assessed for its protection from flooding.

Oliver to MacDonnell Street
It is evident from the floodmapping that the most vulnerable portion of this reach is that behind the hardware, wool merchant and former tyre outlet. The levee bank will be breached for a flood between the 50 and 100 year ARI.

- It is recommended that further investigations be undertaken to establish floor levels of buildings adjacent to the hardware to better refine the extent of the flood plain. This will also assist in determining whether the levee should be raised and/or extended towards the west.

MacDonnell Street to Park Terrace
Immediately upstream of MacDonnell Street, there is an area of low lying land adjacent to the carpet warehouse. The flood maps show that the 50 and 100 year ARI floods spread into this area and inundate and possibly isolate buildings for these large events.

- It is recommended that further investigations be undertaken to collect floor levels of the buildings in this area and determine the frequency of inundation. An assessment of the potential to construct levee banks or improve the downstream hydraulics to protect these building is suggested. Furthermore it is recommended that in the event that these buildings are redeveloped the new building floor levels are set above the 100 year ARI flood.

Upstream of Park Terrace
This area appears to be experiencing ongoing development. As such, any further development should be reviewed in terms of :

- Setting the new development above the 100 year ARI flood and
- Ensuring that the encroachment of the development on the floodplain does not adversely effect upstream water surface levels and increase the frequency of inundation for existing development.

5. GUIDELINES ASSOCIATED WITH DEVELOPMENT ALONG NARACOORTE CREEK

There are areas which are currently undeveloped adjacent to the creek. It is also understood that community groups may undertake beautification works along sections of the creek. In this regard, the following guidelines are offered when considering these sorts of works which may impact on the performance of the creek in conveying large floods.

- Any structures built in the waterway such as weirs or footbridges should be reviewed for their effect on the conveyance of large floods. Obstructions can result in raising flood levels most likely upstream of the structure and therefore upstream buildings and development may be at an increased risk of flood damage.
- In considering development within the floodplain, buildings should be reviewed for their effect on reducing the effective waterway area of the creek and subsequent impact on upstream flood levels.
- Where it has been shown that a building can be placed within the floodplain without adversely effecting upstream water surface levels, the building floor level should be set such that there is 500mm of freeboard above the calculated 100 year ARI flood level. Furthermore, access into and from the building in the event of a flood should be considered.
- The efficiency of the creek in conveying flood flows is often dependent on the hydraulic roughness (refer Section 2.3) of the creek. Vegetation such as reeds, weeds and deposition of silt can act to reduce the creek capacity in terms of both hydraulic roughness and physical waterway area. These items should be kept in check by periodic inspection and review of the creek, particularly those reaches which are prone to the build up these factors.

6. MISCELLANEOUS

This section describes observations made during the field inspection which may be of interest to the Council but are beyond the brief for this Study.

6.1 Water Quality

While inspecting the creek (January 2000) in the vicinity of the Park Terrace culverts and the man-made lake downstream thereof, it was noted that there were a significant number (30+) of dead fish floating in the lake. The odour associated with the decaying fish was strong.

This observation raises the following issues:

- The creek had been subjected to some form of contaminated inflow and may therefore continue to be receiving these inflows which are evidently detrimental to the creek ecology.
- The decaying fish present a source of contamination which may be unsafe for users of the creek water or those who come in contact with it.

6.2 Creek Water Reuse

During the site inspection, it was evident that water was being drawn from the creek for use elsewhere. A tanker was observed drawing water from the creek just upstream of the weir adjacent to Oliver Street. It is not known whether the practice of drawing water from the creek is permitted however, given the observations of dead fish at Park Terrace (Section 6.1), there may be water quality issues associated with the intended use of the creek water.

7. BIBLIOGRAPHY

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8. ACKNOWLEDGEMENTS

- Ground Survey by SOKKIA Survey
- Digital Cadastral Database information supplied by Naracoorte Lucindale Council
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- Digital, ortho corrected aerial photography supplied by the Department for Environment and Aboriginal Affairs.

APPENDIX A

SOKKIA Surveys Field Report