Connell Wagner

# ericho Town Flood Mitigation Study

*inal Report - Volume 1*

*ericho Shire Council*


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# Jericho Town Flood Mitigation Study
# Final Report – Volume 1
# For Jericho Shire Council

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# 1. Introduction

### 1.1 General

Connell Wagner was engaged on 18 June 2001 by Jericho Shire Council to undertake a detailed assessment of Jordan Creek flooding and to determine a range of mitigation options aimed at reducing the impact of flood events upon the town. The town of Jericho lies on the Capricorn Highway approximately 54 km west of Alpha and 85 km east of Barcaldine as shown on Figure 1. The town also is on the main Central Railway to Longreach and is located at the junction of the Yaraka/Blackall Branch Railway.

Jericho lies on a low floodplain with the ridge of the Great Divide some thirty kilometres to the east. Jordan Creek, which flows along the eastern side of town, originates approximately sixty kilometres to the south with a catchment area of over 2000km$^2$ to Jericho. After leaving Jericho, Jordan Creek joins the Alice River, which then flows to the west to join the Barcoo River.

Severe flooding of Jericho has occurred on a number of occasions. In 1990 the town was completely inundated except for a small section of the railway line at the north-eastern end of the town, where the Capricorn Highway crosses the Central Railway line. The town has experienced six to seven major floods in the past century. The most recent flood in 1999 did not enter the town.

### 1.2 Study Scope

Jericho Shire Council has received funding through the Department of Emergency Services (DES) under the Natural Disaster Risk Management Studies Program (NDRMSP) to evaluate the current floodplain situation, identify the potential of continuing flood losses, and to recommend a program of short and long-term measures that will alleviate the impacts of flooding in Jericho.

The Natural Disaster Risk Management Studies Program is a program initiated by the Commonwealth Department of Finance and Administration. NDRMPS seeks to provide financial support for the reduction of community loss and suffering caused by natural disasters through the conduct of studies that lead to the development of disaster mitigation initiatives. The Queensland Government, through the Department of Emergency Services is responsible for the administration of the NDRMPS in Queensland. Projects are based on community benefit, relevance of study and likelihood of success. Jericho Shire Council was responsible for the submission of a detailed project plan and formulating a Study Working Group, which includes the Counter Disaster and Rescue Services District Manager as a representative.

The Study scope includes the development of a detailed 2 dimensional (2d) hydraulic model of Jordan Creek and its floodplain. The model has been calibrated against two historical flood events – April 1990 and February 1997 – both of which inundated the town. Using the calibrated model the impacts of the existing infrastructure, in particular the Capricorn Highway and Central Railway, on flooding have been quantified. Mitigation works and drainage improvements have been determined and considered in terms of physical, economic and social benefit for the community. Consequently the Study not only entails hydrologic and hydraulic studies, economic and cost/benefit analysis but also community consultation. Consultation with the Study Working Group and local residents has been undertaken throughout the project with input and feedback sought at key stages of the project.

# 2. Background

## 2.1 General

The key features in Jericho are Jordan Creek located to the east of the town, the north-facing main street with the hotel and several shops which serve the local community and tourists travelling the Capricorn Highway. The town has approximately 150 buildings including Shire offices, a public hall, Hotel, several shops and a number of residences some dating back 100 years. Most of the residences are lowset.

The Central Railway line approaches Jericho from the east and departs to the west. The Capricorn Highway swings north-west to cross Jordan Creek and then approaches the town directly from the north before crossing the railway line and entering the town through a right turn into the main street as shown on Figure 2. Immediately to the east of the town is Jordan Creek with a weir in the stream to provide a recreational water area. Historically the weir was used to provide water to Queensland Rail. To the west of the town there is a rail junction and the branch line to Yaraka and Blackall.

The region is a mixture of grasslands and is lightly timbered with a mixture of ironbark and eucalypti. The soils are sandy alluvial soils from the Quaternary (2myBP) derived from siltstones and mudstones.

## 2.2 Flooding Mechanisms

Flooding generally follows the Jordan Creek floodplain, ie from south to north (refer to Figure 3). To the south of Jericho, the principle floodplain is on the western side of Tumbar Road. Flow enters this floodplain through a major breakout on the western bank of Jordan Creek. This breakout is approximately 4km south of Jericho, downstream of the 'Burgoyne' residence. A smaller breakout occurs upstream of the 'Burgoyne' residence, travelling west around the property to join the major breakout.

The flow continues north until it intercepts the existing levee and is diverted west. Most of the diverted flow crosses the Yaraka/Blackall Railway and Blackall/Jericho Road and heads north-west to intercept the Central Railway. The railway embankment presents a significant restriction to the flow, which results in ponding upstream of the railway. Two three-span rail bridges and some smaller culverts allow water to pass through to the Capricorn Highway, which creates additional restriction. After passing through a number of culvert structures under the highway or flowing over the road, the floodwaters continue north to eventually meet up with the Alice River.

The portion of flow diverted along the levee that does not cross the Yaraka/Blackall Railway, travels north along the western edge of town. This is one source of flooding in the Jericho township.

Another source of flooding comes from a breakout at a hairpin bend in Jordan Creek, approximately 2km upstream of Jericho. This water travels between the Tumbar Road and Jordan Creek and fills the swampy area behind the cemetery. Floodwaters enter the south-east corner of town from the swampy area and continue, generally north-west, through residential and commercial properties. The flow leaves the north west corner of town and crosses the Central Railway and Capricorn Highway, continuing north-west to join other floodwaters.

A third source of flooding in the town occurs when floodwaters break the banks of Jordan Creek near the town weir. The water generally travels west until it joins other floodwaters at the north-west corner of town.

Further breakouts occur on the eastern banks of Jordan Creek. These travel north to the Capricorn Highway and flow across the Central Railway and Capricorn Highway east of Jericho. These floodwaters do not appear to affect flooding within the town.

# 3. Data Collection and Review

An extensive amount of data was collected during the early stages of the project. This included material held by Jericho Shire Council (JSC), the Bureau of Meteorology (BoM), the Department of Main Roads (DMR), Queensland Rail (QR), the Department of Natural Resources and Mines (DNRM), George Bourne & Associates (GBA) and the local residents of Jericho. The contribution of all organisations and individuals is gratefully acknowledged.

The data provided was reviewed and provided vital input to the Flood Study. Details of the data collected are summarised below.

**Previous Studies**
The following relevant reports were obtained for use in the Flood Mitigation Study:

- Western Queensland Towns Flood Study – Volume 1 (Scott & Furphy January, 1991);
- Western Queensland Towns Flood Study – Volume 2 (Scott & Furphy January, 1991); and
- April 1990 Floods Inland Queensland (Bureau of Meteorology, 1990).

**Historical Flood Event Information**
Jericho has experienced a number of large flood events in recent times. The most significant events occurred in April 1990 and February 1997, with substantial inundation of the town. A further event took place in March 1999, with no flood waters in the town but inundation of the highway occurring. From discussions with residents it was noted that other large events occurred in 1950, 1969, 1974.

A range of information regarding historical events has been collected and includes:

- Oblique photography (Western Queensland Towns Flood Study, Scott & Furphy Report, 1990) from aircraft during the 1990 event;
- Photographs of 1997 and 1999 flood events showing inundation throughout Jericho;
- Surveyed flood level marks on a number of houses and buildings throughout Jericho;
- Advice from local residents and the Study Working Group regarding upstream breakout paths, and flood depths, velocities and flowpaths of flood waters through Jericho; and
- Photographs from various flood events courtesy of Mr Henry Masters.

**Aerial Photography**
Two sets of aerial photography were taken as part of this project. The first set covered the town of Jericho and immediate surrounds. This was used to assess the requirements of the flood study.

The second set, taken by Aerometrex Pty Ltd, involved flying two adjacent runs. Each run covered an area from approximately 11km upstream of Jericho to approximately 2km downstream. Eight photographs were taken on each run. This data was used to generate the Digital Terrain Model (DTM).

**Survey Data**
Survey data was acquired from a number of sources. It was used to construct the hydrologic and hydraulic models and to assist with calibration exercises and flood damage estimates. The following survey data was collected for this study:

- DTM derived from the aerial photography (Airesearch Mapping Pty Ltd). The DTM incorporated a regular grid of spot levels at 10m spacing as well as breaklines at changes in grade. Other features were also extracted through the photogrammetry including roads and railways. The photogrammetric survey was reported to have a vertical accuracy of ±200mm;
- Aerial Photography Survey Control (AJ & MK Hoffmann Pty Ltd);

- Floor Levels and Flood Marks (AJ & MK Hoffmann Pty Ltd);
- Jericho Flood Data Locations (circa 1998) DMR – Plans and cross-sections, identifying structures along floodpaths and levee details; and
- Topographic maps – Jericho SF 55-14 and Tambo SG 55-2.

**Cross-Drainage Structure Details**

To enable an accurate hydraulic model to be constructed, it was important to obtain accurate details of hydraulic structures, such as culverts and bridges. The following data was sourced:

- Capricorn Highway design drawings (circa 1995) (DMR);
- Jericho Flood Data Locations (circa 1998) DMR – Plans and cross-sections, identifying structures along floodpaths and levee details;
- Emerald to Longreach Railway design drawings (circa 1964) (QR);
- Jericho Drainage Structures spreadsheet (2000) QR – This data was collected and supplied by QR following a request for information; and
- Jericho Spot Levels (circa 1989) (GBA).

**Rainfall Data and URBS Model**

Daily rainfall and pluviograph data for various nearby gauging stations was sourced from the Bureau of Meteorology (BoM).

An URBS hydrologic model for the catchments downstream of Jericho was also sourced from the BoM. This was used to assist in the joint calibration process.

In addition to the above data, the Study Team Project Leader undertook a thorough site inspection of the Jericho township, Jordan Creek and the surrounding area. This provided first-hand knowledge of a number of items including:

- Key features and local flowpaths through town;
- Examination and assessment of breakout flowpaths from Jordan Creek in the area upstream of Jericho;
- Review of the type and density of vegetation on the Jordan Creek floodplain; and
- Examination of road and rail links and state of existing cross-drainage structures.

**Statistical Information**

Council provided various statistics regarding the Jericho township, population and economic trends for use on the project.

# 4. Consultation Activities

Consultation is a key element of this project, with local residents and Study Working Group members providing valuable input to all stages of the project. A range of activities has been undertaken as detailed below.

## 4.1 Study Newsletters

Newsletters were utilised as a method of conveying study information to members of the community, and interested stakeholders. They were designed to inform the community of the study and its objectives and ensure the community is updated regarding the study progress.

Thee newsletters were sent to residents and interested stakeholders throughout the project. Copies of these are included in Appendix A.

## 4.2 Public Meetings

In addition to the newsletters, public meetings were held as another forum for keeping the community informed. The meetings also served as a mechanism for the community to provide input into the study. Two public meetings were conducted, the first on 10 July 2001, the second on 12 March 2002 and the third on 17 June 2002.

Valuable information was obtained from local residents and recorded by way of survey forms, completed by residents individually or by a member of the Study Team. A copy of the survey forms can be found in Appendix B.

## 4.3 Open Day

An open day was arranged to coincide with the first of the public meetings. Designed as an informal forum, members of the community were able to speak with members of the Study Team to discuss relevant matters or concerns.

## 4.4 Study Working Group Workshops

The Study Working Group consists of the following parties:

- Members of the Community;
- Jericho Shire Council;
- George Bourne & Associates;
- Department of Main Roads;
- Department of Emergency Services;
- Queensland Rail; and
- Department of Natural Resources and Mines.

Three workshops with the Study Team (Connell Wagner) and the Study Working Group were undertaken. The first was designed to coincide with the first of the Public Meetings. At this workshop the Study Working Group was briefed on the proposed project methodology and the impending Public Meeting. The group also advised the study team of the issues and mitigation options, thought to be relevant to the project. The group also provided valuable insight into flowpaths of historical events.

The second meeting coincided with the second Public Meeting. The Study Working Group was informed of the study progress, and the Interim Report was presented. The Study Team received feedback on the proposed mitigation options from the Study Working Group.

A final public meeting and Study Working Group Meeting was held at the completion of the Draft Report. At this meeting the Study Team presented the Draft Report and briefed the local residents and Working Group on the study outcomes. Feedback on the report contents was provided.

### 4.5 Public Display

A large poster presenting key features and results of the project was placed on display in the local store at Jericho for four weeks. A copy of the Draft Report and associated drawings were also available for local residents to examine and provide feedback on forms provided. No feedback was received during this period.

### 4.6 Key Issues

A number of issues were identified during the initial consultation processes with the community and stakeholders. These have been addressed in this study and include:

- The impact of the Capricorn Highway on flooding;
- The impact of the Central Railway on flooding;
- Mitigation measures to reduce flooding in the town;
- The impact that mitigation measures may have on surrounding properties; and
- The extent to which commercial activities and residences are at risk from future flooding and the impacts/benefits of structural and non-structural mitigation works.

Suggestions on measures to mitigate the effects of floods, provided by residents during consultation activities included:

- Increasing the size of culverts at the north west corner of town;
- Increasing the size of culverts under Capricorn Highway and Central Railway;
- Extending the existing levee;
- Constructing new levees;
- Filling swamp near cemetery;
- Redirecting Jordan Creek;
- De-silting the town weir; and
- Raising affected dwellings above appropriate flood level.

Where possible, the suggestions and issues raised have been addressed in the study outputs. The community consultation process as a whole should be considered a success.

# 5. Hydrologic Model Development

## 5.1 URBS Modelling Package

The hydrologic modelling of the Jordan Creek catchment has been carried out using the URBS model (Version 3.9). The URBS program is a runoff-routing program developed by Brisbane City Council and the Department of Primary Industries (Water Resources). Two different routing models are available to model the sub-catchment and channel storage routing behaviour. These are the URBS Basic and Split models. The Split model has been used for hydrological modelling of the Jordan Creek catchment to provide compatibility with the BoM URBS models.

In the Split model, rainfall on the sub-areas is firstly routed to the creek channel and then along the creek channel. The inflow from the sub-catchment into the channel is assumed to occur at the centroid of the sub-catchment with the lag of the sub-catchment storage assumed to be proportional to the square root of the sub-catchment area. The catchment routing parameter of the Split model can be optionally modified to include the effect of catchment slope on the catchment response.

The time it takes for the flow to travel from the sub-catchment perimeter to the centroid can be modified to allow for the effects of urbanisation or forestation. The urbanisation/forestation factors are only applied to the sub-catchment routing component with channel flows unaffected by local sub-catchment urbanisation or forestation. This model is therefore suitable for representing large creeks or rivers where the main channel hydraulic properties are largely unaffected by the extent of catchment urbanisation or forestation.

The URBS modelling package is used by the Bureau of Meteorology for its flood forecasting/warning models and therefore was the ideal choice the Jordan Creek catchment. The resulting URBS model can be provided to BoM. Advice was sought from the BoM during the development of the model to ensure that the model remains compatible with the BoM models. Accordingly, the optional parameters of channel slope, catchment slope, urbanisation and forestation were not used and the mandatory parameters of catchment area and stream length were adopted.

## 5.2 Model Setup

The URBS model of the Jordan Creek catchment consists of 17 sub-catchments as shown in Figure 4. Sub-catchment boundaries, areas and reach lengths were determined using the available 1:25,000 topographic maps. The number of sub-areas was selected to ensure proper definition of the creek system and accurate results at key locations.

Discussions were held with Mr Terry Malone, Senior Engineer Hydrology and Flood Warning (BoM), regarding appropriate model parameters for catchments in Western Queensland. BoM operates an URBS flood warning model for the Alice River, into which Jordan Creek flows. The BoM URBS model consisted of two sub-catchments upstream of Jericho, as the main points of interest were downstream, particularly where stream gauges are located, eg at Barcaldine Weir. To assist in the calibration process, the detailed URBS model upstream of Jericho was incorporated into the BoM Alice River URBS model. This allowed model parameters to be adjusted and a check of the URBS model results at the Barcaldine Weir stream gauge to be used to confirm the overall model calibration.

Table 1 presents the sub-catchment details as used in the URBS model.

**Table 1 – URBS Sub-Catchment Parameters**

| Sub-Catchment | Area (Ha) |
|---|---|
| 1 | 164.6 |
| 2 | 49.6 |
| 3 | 170.6 |
| 4 | 151.7 |
| 5 | 230.0 |
| 6 | 45.5 |
| 7 | 117.7 |
| 8 | 42.9 |
| 9 | 19.8 |
| 10 | 240.8 |
| 11 | 180.6 |
| 12 | 29.8 |
| 13 | 116.3 |
| 14 | 134.3 |
| 15 | 100.4 |
| 16 | 120.4 |
| 17 | 119.1 |
| **Total** | **2034.1** |

# 6. Hydraulic Model Development

## 6.1 MIKE 21 Modelling Package

Modelling for this investigation was undertaken using the Danish Hydraulic Institute's (DHI) MIKE 21 package. MIKE 21 is a comprehensive modelling system for two dimensional free surface flows where stratification can be neglected. MIKE 21 simulates the water level variations and flows in response to a variety of forcing functions in floodplains, lakes, estuaries, bays and coastal areas. The water levels and flows are resolved on a rectangular grid covering the area of interest when provided with the bathymetry (topography), bed resistance coefficients, wind field, hydrographic boundary conditions etc.

MIKE 21 solves the vertically integrated equations of continuity and conservation of momentum in two horizontal dimensions using implicit finite difference methods. The following effects are included in the equations:

- Convective and cross momentum;
- Wind shear stress at the surface;
- Barometric pressure gradients;
- Coriolis forces;
- Momentum dispersion ("eddy");
- Sources and sinks (both mass and impulse); and
- Evaporation.

A MIKE 21 generated model has only three calibration factors, namely bed resistance, wind friction and momentum dispersion. Using these factors alone, calibration of a model is normally quite easy. In practice, the calibration of a model depends far more on the accuracy of the data, eg topography and boundary conditions.

The MIKE 21 data requirements for this project included the following:

- **Basic Model Parameters**
  - Model grid size and extent;
  - Time step and length of simulation; and
  - Type of output required and its frequency.
- **Topography**
- **Calibration Factors**
  - Bed resistance; and
  - Momentum dispersion coefficients.
- **Initial Conditions**
  - Water surface level; and
  - Flux densities in x and y directions.
- **Boundary Conditions**
  - Water levels or flow magnitude; and
  - Flow direction.

The data used for each of the above parameters are detailed in the following section.

### 6.2 Jordan Creek Model Development

The first step in the development of the MIKE 21 model of Jordan Creek was to use the terrain modelling package '12D' to review the DTM and prepare the data in a format suitable for input into MIKE 21. The extent of modelling is shown in Figure 5.

In the DTM, the river was aligned approximately 67° west of north. In order to minimise model computations and hence run-time, it is appropriate to align the river with one axis of the MIKE 21 grid. The DTM was therefore rotated 67° clockwise within the MIKE 21 software to produce a grid with the river generally flowing parallel to the y-axis.

A 10 metre grid spacing was adopted – this gave large, but acceptable file sizes and good detail in the model, particularly in the vicinity of Jericho and the Jordan Creek breakout points. The topography used in the model is presented in Figure 6. To satisfy stability criteria a timestep of 3 to 5 seconds was adopted.

A roughness map for the model extent was prepared using information gained from the site inspection, photographs of the creek and the aerial photograph.

The main channel consisted of mainly a gravelly/rocky base, with some relatively thick riparian vegetation, generally giving way to grasslands. The grasslands consist of sparse trees, with felled timber remaining on the ground. Surrounding the town is a large tract of heavily forested land. Other areas include cleared grasslands, road reserves and habitable areas within town. The roughness values presented in Table 1 were used to represent each of these distinct areas.

**Table 2 - MIKE 21 Manning's Roughness Values**

| Location | Mannings 'n' |
|---|---|
| Channel with Vegetated Riparian Band | 0.08 |
| Grasslands with Felled Timber | 0.12 |
| Forested Land | 0.08 |
| Cleared Grasslands | 0.08 |
| Road Reserves | 0.04 |
| Habitable areas | 0.08 |

The Manning's 'n' value of 0.08, used for habitable areas, was adopted to account for the impedance to flow caused by buildings, fences and other obstructions.

The eddy viscosity for the model extent was generally set at a (velocity based) value of $0.5m^2/s$. Wind shear stress was neglected for all cases. The boundary conditions for the MIKE 21 model consisted of a flux density (ie inflow hydrograph) across the upstream boundary of the model and a fixed tailwater level of RL 345m AHD along the downstream boundary. The tailwater of 345m was adopted to improve model computational stability. As the downstream boundary is approximately 2km downstream of the town, changes in tailwater were thought to have minimal effect.

In order to improve the MIKE 21 model stability, trenches were introduced into the topography at the upstream and downstream ends of the model, as shown in Figure 6.

# 7. Calibration of Models

## 7.1 Selection of Calibration Events

The selection of calibration events for a joint calibration process requires specific data for each event including:

- Rainfall Depths (eg. daily rainfall data);
- Rainfall Distribution (eg pluviograph data); and
- Recorded Flood Levels for the event.

Rainfall and pluviograph data was sourced from the BoM and DNRM for available rainfall stations close to Jericho. A summary of the available data is shown in Table 3.

**Table 3 – Rainfall and Pluviograph Data**

| BOM Station | Data Type | 1990 | 1997 | 1999 |
|---|---|---|---|---|
| 'Glencoe' | Daily Rainfall | ✗ | ✓ | ✓ |
| Alpha | Pluviograph | ✗ | ✓ | ✓ |
| | Daily Rainfall | ✓ | ✓ | ✓ |
| Yalleroi | Daily Rainfall | ✓ | ✗ | ✗ |
| Jericho | Daily Rainfall | ✓ | ✗ | ✓ |
| Richmond Hills | Daily Rainfall | ✓ | ✓ | ✓ |
| Rosedale | Daily Rainfall | ✓ | ✓ | ✓ |
| Chesterton | Pluviograph | ✓ | ✓ | ✓ |
| | Daily Rainfall | ✓ | ✓ | ✓ |
| Tiree | Pluviograph | ✓ | ✗ | ✗ |
| | Daily Rainfall | ✓ | ✗ | ✗ |
| Tumbar | Daily Rainfall | ✓ | ✗ | ✗ |

*(Note: ✓= data available ✗= data unavailable or incomplete)*

It can be seen from Table 3 that data was unavailable at a number of locations. In some cases this was due to the station being closed. In other cases, however the station was flooded and the data was either not recorded or was destroyed during the flood event.

### *7.1.1 April 1990 Event*

Daily rainfall for Jericho was considered appropriate for modelling the 1990 event. The 'Glencoe' station would have been more appropriate as it is located centrally within the Jordan Creek catchment, however the 'Glencoe' station was establish following and as a result of the 1990 event. Figure 7 shows the daily rainfall recorded at Jericho for the 1990 event.

Ordinarily it would be considered appropriate to use the closest pluviograph station in Alpha to obtain a rainfall distribution profile, however this station was inundated during the 1990 event and the pluviograph data was destroyed. The next two closest stations to Jericho were Chesterton and Tiree. It was decided to adopt the rainfall distribution at Chesterton as this best matched the daily rainfall pattern. Figure 8 shows the pluviograph data for Chesterton.

During the calibration process, the BoM provided additional data from their rainfall distribution models. This enabled varying rainfall to be applied to the URBS sub-catchments based on their location.

#### *7.1.2 February 1997 Event*

The daily rainfall data for 'Glencoe' was adopted for the 1997 event, as this station is centrally located within the Jericho catchment. No daily rainfall data was available for Jericho in 1997. Figure 9 shows the recorded daily rainfall at 'Glencoe' for the 1997 event.

The pluviograph data for both Chesterton and Alpha was considered. There did not appear to be any clear relationship between them, so the Alpha distribution was adopted, being the closest pluviograph station to Jericho. Figure 10 shows the pluviograph data recorded at Alpha during the 1997 event.

Similarly to the 1990 event, the BoM provided additional data from their rainfall distribution models to assist with the calibration process. This enabled varying rainfall to be applied to the URBS sub-catchments based on their location.

#### *7.1.3 March 1999 Event*

The 'Glencoe' daily rainfall data was considered the most appropriate source for the 1999 event and can be found in Figure 11.

It appears that rainfall during the 1999 flood event was not as widely spread as the 1990 and 1997 events, making the selection of rainfall distribution difficult. Pluviograph data for both Chesteron and Alpha were initially considered. The daily rainfall patterns for these centres did not match the rainfall within the Jordan Creek catchment, making it almost impossible to apply a distribution to the rain.

It was decided to omit the 1999 event from the calibration process, due to the difficulties in modelling the hydrology and the fact that the flood did not enter the town.

The 1990 and 1997 flood events were select for the joint calibration exercise. Both floods inundated the town and occurred recently. Calibration of the MIKE 21 model requires that reliable peak flood heights be available. Numerous peak flood levels were available for the 1990 event and sufficient were available for the 1997 event to permit calibration.

The 1999 event was not considered for the calibration process, as it did not enter the town. There was also insufficient flood height data available to calibrate against this event.

Events occurring prior to 1990 were also disregarded for calibration, as there was insufficient flood data available.

### 7.2 Joint Calibration Exercise

Joint Calibration involved adjusting the model parameters for both the hydrologic (URBS) and hydraulic (MIKE 21) models to achieve modelled results that closely match the recorded flood heights.

Calibration of the URBS model was achieved by comparing the model results against the recorded stream gauge using BoM's Alice River URBS model downstream of Jericho to the Barcaldine weir. The weir has a calibrated rating curve and a stream gauging station to record river levels. The URBS model, routed runoff to the Barcaldine weir and a level was generated from the rating curve. This was checked against the recorded values at the weir.

Calibration of the URBS model is generally undertaken by varying model parameters including the rainfall loss parameters. Initially an Initial/Continuing loss model was adopted for the URBS model of Jericho, however following discussions with BoM, it was decided to adopt an Initial/Proportional Loss model, consistent with BoM's approach in catchments of this nature.

The rainfall loss parameters were adjusted such that a good match was achieved between the modelled levels and the recorded flood levels at the weir. Figures 13 and 14 show the recorded and calculated levels at the Barcaldine Weir. Table 4 shows the loss parameters adopted for the relevant storm events. Advice from the BoM indicated that it is not unusual to use different loss parameters on the same URBS mode under different storm events, particularly when the sizes of the storms vary substantially.

**Table 4 – Table of URBS Loss Parameters**

| Event | Initial Loss (mm) | Proportional Runoff (%) |
|---|---|---|
| 1990 | 0.0 | 32 |
| 1997 | 0.0 | 20 |

The runoff values in Table 4 were adopted following consultation with BoM. While the proportional runoff fraction may appear low, it is not uncommon to use values of this order in western catchments, such as the Jordan Creek catchment.

With the URBS model calibrated, at Barcaldine, the hydrograph at Jericho was extracted and used as the inflow for the MIKE 21 model. Flood levels resulting from the MIKE 21 model were then compared with the recorded values for each event. Calibration limits for flood heights where no official stream gauge data exists are generally ±200 to 300mm. Figures 15 and 16 show the MIKE 21 calibration results for the 1990 and 1997 events respectively. It can be seen that the results are within the acceptable limits.

Following the 1990 flood event, stream height gauges were installed, adjacent to the rail bridge at Jordan Creek. The recorded peak level on this gauge was used in the 1997 calibration process.

It is believed that an acceptable calibration has been achieved. The results of the calibration exercise were presented to the Study Manager, who accepted the model calibration.

# *8. Evaluation of Current Floodplain Situation*

## 8.1 Flood Hazard Mapping

With agreement from the Study Manager, return periods were nominated for small, medium and large events. Flood hazard mapping was undertaken for these events. The Probable Maximum Flood (PMF) was also modelled to assess an extreme event. It should be noted that the PMF event was estimated using the approximate techniques outlined in AR&R Book 6. More accurate assessment for the PMF can be obtained from the BoM at additional cost. It was considered that the AR&R approximate techniques were appropriate for this assessment. The adopted events and corresponding design return periods are shown in Table 5.

**Table 5 – Selected Design Events**

| Event | ARI |
|---|---|
| Small | 5 Years |
| Medium | 20 Years |
| Large | 100 Years |
| Extreme | PMF |

Inundation and velocity maps, covering the entire floodplain, were produced for each of the above events and are presented in Figures 21 to 24.

Estimation of hazard involves a number of factors although a key component is stability. The primary factors affecting stability of both pedestrians and vehicles are flow velocity and depth of flow. The relationship between depth and velocity for each of the hazard categories varies depending on the person or vehicle involved. Plate 1 from *Floodplain Management in Australia* (CSIRO, 2000) describes each of the hazard categories as outlined in Table 6.

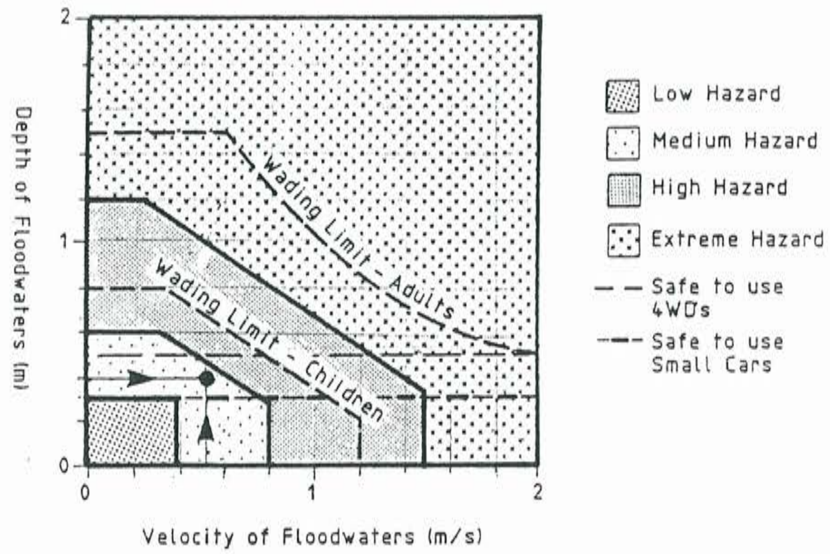



**Plate 1 – Flood Hazard Definition**

**Table 6 – Hazard Category Descriptions**

| Hazard Category | Description |
|---|---|
| Low | • There are no significant evacuation problems;<br>• If necessary, children and elderly people could wade to safety with little difficulty;<br>• Maximum flood depths and velocities along evacuation routes are low;<br>• Evacuation distances are short;<br>• Evacuation is possible by sedan-type motor vehicle, even a small vehicle;<br>• There is ample time for evacuation; and<br>• Evacuation routes remain open for at least twice the time required for evacuation. |
| Medium | • Fit adults can wade to safety, but children and elderly may have difficulty;<br>• Evacuation routes are longer;<br>• Maximum flood depths and velocities are greater;<br>• Evacuation by sedan-type vehicle is possible in the early stages of flooding, after which 4WD vehicles or trucks are required; and<br>• Evacuation routes remain trafficable for at least 1.5 times as long as the necessary evacuation time . |
| High | • Fit adults have difficulty in wading to safety;<br>• Wading evacuation routes are longer again;<br>• Maximum flood depths and velocities are greater (up to 1.0m and 1.5m/s respectively);<br>• Motor vehicle evacuation is possible only by 4WD vehicles or trucks and only in the early stages of flooding;<br>• Boats and helicopters may be required; and<br>• Evacuation routes remain open trafficable only up to the minimum evacuation time. |
| Extreme | • Boats and helicopters are required for evacuation;<br>• Wading is not an option because of the rate of rise and depth and velocity of floodwaters; and<br>• Maximum flood depths and velocities are over 1.0m and 1.5m/s respectively. |

Flood hazard maps covering the town area, under each event are presented in Figures 25 to 28. Where small areas of lower hazard were completely surrounded by a higher category, the highest category was selected. The PMF hazard map shows that extreme hazard occurs throughout the town and therefore this map may be redundant.

## 8.2 Flood Frequency Curve Development

Using the results of the design event runs a flood frequency curve was produced. The modelled flood levels, for all design events at the Jericho town weir, were plotted on a linear scale and a curve fitted. The levels for the 1990 and 1997 events were plotted on the curve to obtain an estimate of the approximate recurrence interval (refer Figure 29).

**Table 7 – Recurrence Interval for Historic Events**

| Event | Approximate Recurrence Interval (Years) |
|---|---|
| 1990 | 100 to 110 |
| 1997 | 5 to 10 |

At the outset of the project, DNRM provided estimates of the return period for the 1990 and 1997 events for Native Companion Creek. This creek is located upstream of Alpha and has a similar catchment area and terrain as Jordan Creek. The estimated return period for Native Companion Creek was 100 year ARI for 1990 and 10 year ARI for 1997. This corresponds well with the estimates derived from the modelling undertaken.

## 8.3 Impact of Existing Road and Rail Links

The hydraulic model was used to assess impacts of the Capricorn Highway and Central Railway on flooding within Jericho. By removing the road and/or rail embankments on either side of Jericho and modelling a range of design storm events, the effects of each could be considered in isolation. It was decided to model three physical scenarios:

- Base case (no road or rail link);
- Effect of rail only (no road link); and
- Effect of road only (no rail).

These cases were modelled for the small, medium and large design events. The results of this modelling is presented as difference maps in Figures 30(a, b & c) for the rail only case and Figures 31(a, b & c) for the road only case. The difference maps show the difference in flood levels between the respective case (rail only or road only) and the base case with no road or railway embankments.

The results show that the rail and road embankments, both east and west of Jericho, are providing minimal influence on flood levels in the town. This is the case for all of the flood events modelled. The rail link in isolation raises flood levels in town by up to 100mm, with more area affected under the large event (100 Year ARI) than under the smaller events. The road link has almost no impact in town, with some areas reporting a slight decrease in levels up to 100mm.

## 8.4 Environmental and Planning Considerations

An assessment of the current environmental conditions has been undertaken. The relevant statutes and guidelines have also been reviewed and are summarised in Table C1, Appendix C. The existing environmental condition of the floodplain is detailed in the following sections.

### *8.4.1 Climate and Rainfall*

Jericho experiences a summer rainfall pattern with the highest rainfall averages occurring in January and February. The average monthly maximum temperature range is 22°C in winter to 36°C in summer.

Rainfall is highly variable in incidence, total received, and reliability. All streams are characterised by extreme variation in discharge and flow duration.

### *8.4.2 Land Uses*

Jericho is a small regional town with a population of approximately 170. There are approximately 55 houses and 5 businesses in the town. A cemetery reserve is located in the south east corner of the town. Bushland is located immediately south of Jericho – this is freehold land (Town Common) under Council control. Grazing is the dominant land use surrounding the town.

According to the Planning Scheme, Jericho is divided into two zones, namely Town and Rural. The intent of the Town Zone is to provide for urban development, including residential, commercial, industrial, open space and recreational development.

### 8.4.3 Soils and Topography

Sandy, alluvial soils from the Quaternary period are the predominant soil types within the area. They are derived from silt and mud stones.

### 8.4.4 Surface Water Quality

The project area lies within the Cooper's Creek catchment. This catchment forms an integral part of the Lake Eyre Basin (approximately 297,000 $km^2$), which is recognised as one of the last remaining, relatively undamaged catchment systems in the world. The main waterway that lies within the project area is Jordan Creek. This waterway drains into the Alice River which in turn discharges into the Barcoo River and then Cooper Creek, and eventually into Lake Eyre.

No water quality data exists for Jordan Creek. However, two water quality studies undertaken in the Lake Eyre Basin (Bailey 2001 and DNR 1997) provide some insight into the project area's water quality conditions. In short, both studies revealed that most of the waterways within the Lake Eyre basin have low salinity, visual clarity and dissolved oxygen; and high pH, nutrients (total phosphorus and total nitrogen) and temperatures. However, the studies also revealed that water quality is highly variable within the basin and warned that any differences or trends identified could be strongly affected by the timing of sampling in relation to flooding, and by sample handling. The conclusions reached in both studies must therefore be treated with caution.

### 8.4.5 Groundwater Quality

The project area lies immediately above the Great Artesian Basin. Given the low rainfall/high evaporation conditions in this area, the groundwater obtained from this aquifer is an extremely valuable resource. The *Lake Eyre Basin Queensland Water Resource Assessment Report* (DNRM 1997) revealed that the groundwater within and immediately outside of the project area is of relatively good quality. Levels of Total Dissolved Solids and Fluoride were generally within 500mg/L and 1mg/L, respectively, indicating that the groundwater within the project area is fit for human consumption.

### 8.4.6 Flora

The project area has been heavily disturbed by human activities, particularly agricultural activities, roads and other infrastructure such as houses and sheds. Most of the vegetation within Jericho has been cleared. The vegetation type surrounding the town is mainly Poplar box woodland and Brigalow (DNRM Emerald, pers comm). These vegetation community types are not considered to be of any significance (DNRM Emerald, pers comm) but further investigation is required to confirm this.

A review of the ecosystem types based on Sattler and Williams (1999) has revealed that the site is located in the Alice Tableland province in the Desert Uplands. There are a number of regional ecosystems in this province that are listed as 'Of Concern' or 'Endangered' however based on verbal advice received from Department of Natural Resources and Mines, it is not likely that the values within the project area are representative of any of these ecosystems.

There are no known sites of National Environmental Significance, as defined under the Environmental Protection and Biodiversity Conservation (EPBC) Act, within or in the vicinity of the project area.

It is important to note that no vegetation survey has been undertaken for this project.

#### *8.4.7 Fauna*

Existing information on the fauna within and in the vicinity of the project area is non-existent.

A regional fish survey, undertaken by DNRM, recorded 14 species of fish within the Lake Eyre basin (Bailey and Long 2001). Fish monitoring of the upper reaches of the Barcoo River, which is immediately downstream of the Alice River and approximately 80km downstream of Jericho revealed that there are four major fish species within this river system. These are the Bony Bream, the Barcoo Grunter, Lake Eyre Yellowbelly and Hyrtl's catfish. These fish have evolved to cope with the ephemeral nature of the Lake Eyre stream/waterways system, with some species responding to a cycle of drought and flood by opportunistic migration, spawning and rearing strategies.

A site investigation of the bushland surrounding the project area has not been undertaken so it is not possible at this stage to comment on the habitat values of the remnant bushland. Given the extent of clearing that has occurred in the region, it is likely that a number of fauna species, particularly birds, would utilise the bushland surrounding the town.

While the presence of endangered, vulnerable and rare species is unlikely within the area, it is recommended that an ecologist confirm the conservation status of the vegetation prior to clearing.

#### *8.4.8 Air and Noise Quality*

Air and noise monitoring has not been undertaken within the project area. Given the predominant land use in the area (ie rural), no major air and noise issues are expected.

#### *8.4.9 Cultural Heritage*

An indigenous cultural heritage investigation has not been undertaken for this assessment. A search of the native title claimants register has also not been undertaken.

### 8.5 Scott and Furphy Report

The report entitled "*Western Queensland Towns Flood Study*", Scott and Furphy, (1991), contains a section reviewing the impact of the 1990 flood event upon Jericho. A copy of this report is provided in Appendix D. This report was used as reference material throughout the current study.

# 9. Existing and Continuing Flood Risks

## 9.1 Identification of Flood Risks

There are a number of parties that would be directly affected by the risk and severity of flooding from Jordan Creek. These include:

- Landholders and local residents;
- Local business owners;
- Federal government;
- State government;
- Local shire council;
- Industries/businesses;
- Bureau of Meteorology;
- Emergency services (fire, police, ambulance, SES);
- Department of Natural Resources and Mines;
- Queensland Rail; and
- Department of Main Roads.

The elements that are at risk during a large Jordan Creek flood event include:

- Individual people using the floodplain;
- Industries/businesses on the floodplain (ie flooding may affect production);
- Built assets and natural resources;
- Public property such as the airstrip and race track;
- Private property and infrastructure including residential and commercial properties;
- Public infrastructure including water supply, sewerage, roads, railway, electricity, telephone;
- Natural resources such as land and forests or bushland; and
- Floodplain ecology.

The potential risks include:

- Loss of life or injury;
- Risk to community health from contaminated flood waters;
- Isolation leading to inability to access medical help and supplies;
- Difficulty of evacuation and movement within the town;
- Damage to property, including houses and contents, sheds, business premises, equipment etc;
- Damage to local infrastructure including water supply, road and rail links, air strip etc;
- Health risks due to the inundation of septic tanks resulting in surcharging of these tanks; and
- Damage to the surrounding environment.

These existing risks will continue unless an appropriate mitigation option is selected to reduce flooding within the town. Damage to infrastructure outside the town, including the road and rail links, is likely to continue to be a risk during major flood events.

## 9.2 Flood Prediction and Warning Procedures

### *9.2.1 Existing Situation*

Prior to 1990 it is understood that flood warning for Jericho was based on the informal gathering of information from property owners upstream at 'Burgoyne' (about 6km upstream) and at Tumbar (about 55km upstream). The absence of gauge boards on the creek at Jericho hampered the recording of river level readings.

Subsequent to the 1990 event, the Bureau of Meteorology, in conjunction with Jericho Shire Council, initiated a formal flood warning station for Jericho by installing a manual Flood Warning Station at Jericho and an additional station approximately 12km upstream at 'Glencoe'.

### *9.2.2 Flood Warning Stations*

At typical Flood Warning Stations, volunteers observe daily rainfall and river height and forward the data to the BoM through a Remote Observer Terminal (ROT). A ROT is a small device attached to a normal telephone line. The observer calls a Freecall number and enters the data into the ROT. If river heights reach a predetermined threshold the observer may be required to increase the frequency of observations.

When the BoM receives the river height data, it is checked to determine if a flood warning should be issued. The data processing and subsequent issuing of flood warnings have been automated, enabling Counter Disaster Organisations to access the warnings within 30 minutes of the BoM receiving the data.

According to the BoM Flood Warning System Website the classifications of flood warnings are defined to be:

- **Minor** – causing inconvenience such as closing of minor roads, and the submergence of low level bridges and makes the removal of pumps located adjacent to the river necessary;
- **Moderate** – causing inundation of low lying areas requiring the removal of stock and/or the evacuation of some houses. Main traffic bridges may be closed to floodwaters; and
- **Major** – causing inundation of large areas, isolating towns and cities. Major disruptions occur to road and rail links. Evacuation of many houses and business premises may be required. In rural areas widespread flooding of farmland is likely.

When a flood warning is issued, the data is automatically uploaded to the Flood Warning System Website (*www.bom.gov.au/hydro/flood*). This is readily accessible by members of Counter Disaster Organisations and the public for both disaster planning and other preventative measures. It is important that members of the Jericho Counter Disaster Organisation are aware of this facility. Its many features could assist with the planning for impending floods.

**'Glencoe' Flood Warning Station**

The 'Glencoe' Flood Warning Station was established on 6 August 1991, with river height gauges located adjacent to the 'Glencoe' Station. A photograph of the 'Glencoe' height gauge is shown as Plate 2.


**Plate 2 – 'Glencoe' River Height Gauges**

(Photograph courtesy of Mr Terry Malone, Bureau of Meteorology)

The 'Glencoe' Flood Warning Station requires the first flood report to be issued when the river reaches 1.8m above the gauge datum. Recordings are then taken at 6.00am and 3.00pm until floodwaters recede. Table 8 identifies the flood heights that will trigger the various flood warning classifications.

**Table 8 – 'Glencoe' Flood Warning Classifications**

| Flood Warning Classification | Flood Depth (Height Above Gauge Datum) |
|---|---|
| First Report | 1.8m |
| Minor | 2.0m |
| Moderate | 2.5m |
| Major | 3.0m |

**Jericho Flood Warning Station**

The Jericho Flood Warning Station was also established on 6 August 1991, with river height gauges located adjacent to the railway bridge on the eastern side of town. The nominated observer for the Jericho station is the Police (Officer in Charge). Photographs of the Jericho river height gauges are shown as Plate 3 and Plate 4.


**Plate 3 – Lower Jericho River Height Gauge**

(Photograph courtesy of Mr Terry Malone, Bureau of Meteorology)

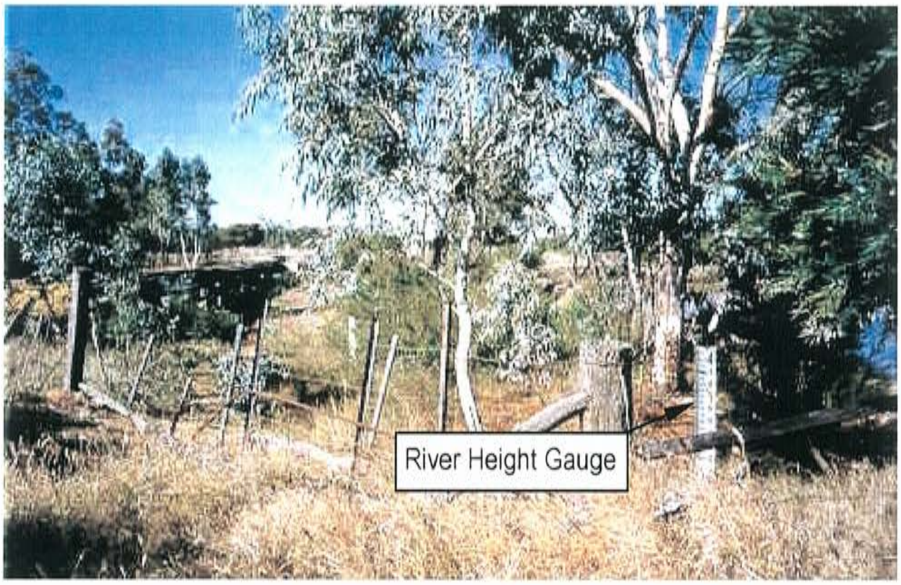
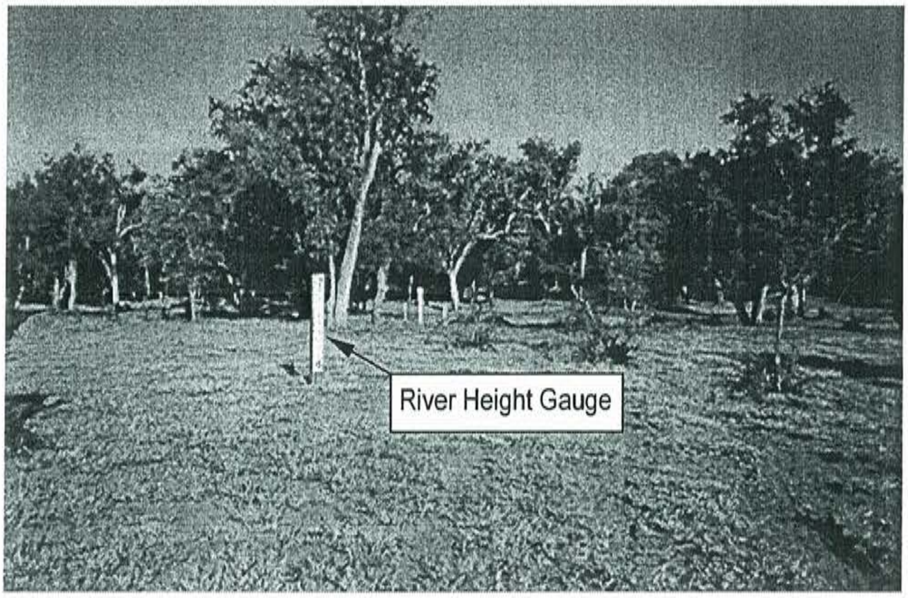



**Plate 4 – Upper Jericho River Height Gauges**

(Photograph courtesy of Mr Terry Malone, Bureau of Meteorology)

The Jericho Flood Warning Station requires the first flood report to be issued when the river reaches 1.8m above the gauge datum. Recordings are then taken at 6.00am and 3.00pm until floodwaters recede. Table 9 identifies the flood heights that will trigger the various flood warning classifications at Jericho.

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(Photograph courtesy of Mr Terry Malone, Bureau of Meteorology)

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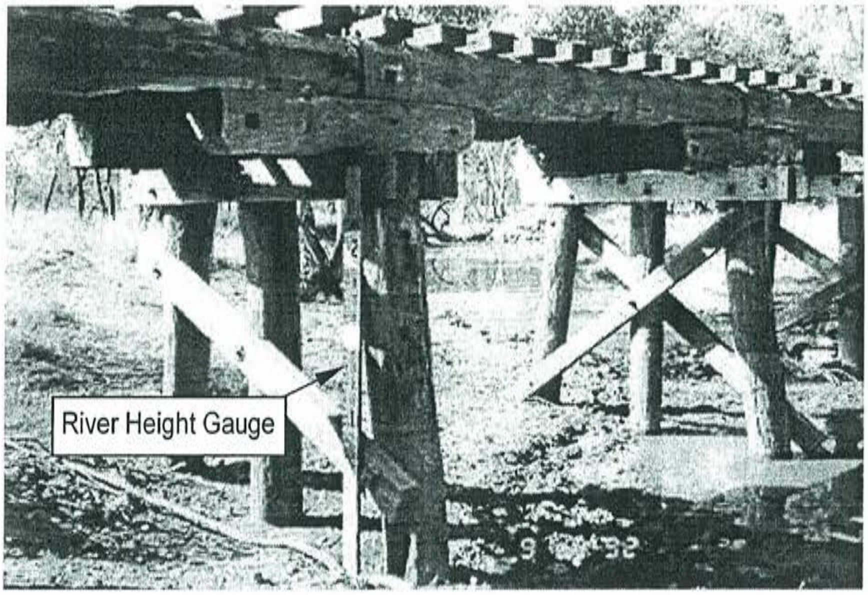



**Plate 3 – Lower Jericho River Height Gauge**

(Photograph courtesy of Mr Terry Malone, Bureau of Meteorology)

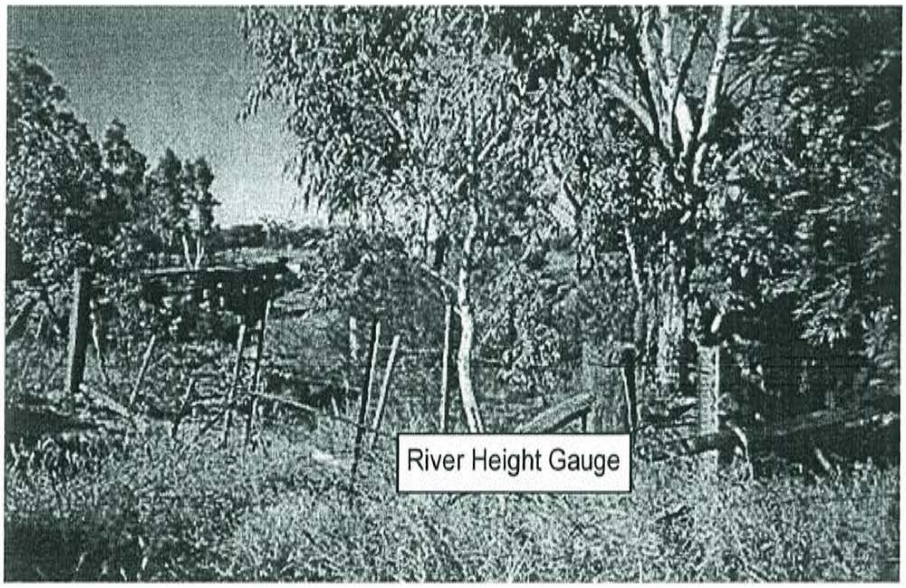



**Plate 4 – Upper Jericho River Height Gauges**

(Photograph courtesy of Mr Terry Malone, Bureau of Meteorology)

The Jericho Flood Warning Station requires the first flood report to be issued when the river reaches 1.8m above the gauge datum. Recordings are then taken at 6.00am and 3.00pm until floodwaters recede. Table 9 identifies the flood heights that will trigger the various flood warning classifications at Jericho.

**Table 9 – Current Jericho Flood Warning Classifications**

| Flood Warning Classification | Flood Depth (Height Above Gauge Datum) | Flood Level (AHD) |
|---|---|---|
| First Report | 1.8m | 348.3m |
| Minor | 2.0m | 348.5m |
| Moderate | 2.3m | 348.8m |
| Major | 3.0m | 349.5m |

Community response to flood events in Jericho is believed to have been adequate due to:

- Warning offered by upstream property owners;
- The relatively small number of inundated houses and businesses, enabling the Police to warn individual householders and business operators;
- The relatively shallow nature of the floodwaters; and
- Prior flood experience (it being understood that local flooding occurs quite frequently).

### 9.3 Flood Damage Assessment

Using the results of the flood modelling exercise and the surveyed floor levels of each property, properties that are inundated under small, medium and large events have been identified. The damage cost, in term of structural and contents damage, was determined using the program ANUFLOOD.

ANUFLOOD is an interactive computer package used to assess the cost of flood damage within an existing developed catchment. The program is based on research undertaken by the Centre of Resource and Environmental Studies (CRES) at the Australian National University. The program requires the following input to assess estimates for annual average damage:

- Stage/damage characteristics;
- Survey of ground and floor levels; and
- Flood frequency information.

Inspections of affected properties were undertaken during the second round of consultation and final damage costs have established. Survey of ground and floor levels was undertaken prior to the study and flood frequency data was prepared based on the results of the MIKE 21 modelling.

Costs associated with damage due to small, medium and large events are presented in Table 10. The stage-damage curves provided with ANUFLOOD are based on 1990/1991 prices. The figures in Table 10 have been indexed to 2002 prices, using CPI as an indicator.

**Table 10 - Damage Costs**

| Event (ARI) | Residential Damage | Commercial Damage | Total Damage |
|---|---|---|---|
| Small (5 Year) | $34,500 | $ 2,000 | $36,500 |
| Medium (20 Year) | $153,000 | $ 8,000 | $161,000 |
| Large (100 Year) | $234,000 | $ 83,000 | $317,000 |

The costs for the 100 year ARI event have been compared against the values estimated by Scott & Furphy for the 1990 flood event. The costs below compared favourably with the Scott & Furphy estimates taking into account the fact that Scott & Furphy adopted a uniform flood level throughout town and the latest analysis undertaken uses flood levels derived from the MIKE 21 analysis.

# 10. Assessment of Mitigation Options

## 10.1 Structural Measures

A range of structural measures, including those proposed by the Study Working Group and local residents, have been modelled to assess their effectiveness in reducing impacts of flooding within the town. The measures assessed are described in Table 11 and shown diagrammatically in Figure M0.

**Table 11 – Mitigation options modelled in MIKE 21**

| Option | Description |
|---|---|
| 1 | Remove Central Railway (embankment and structures) |
| 2 | Remove Capricorn Highway (embankment and structures) |
| 3 | Upgrade hydraulic structures under Central Railway and Capricorn Highway |
| 4 | Upgrade hydraulic structures under Blackall/Jericho Road and Yaraka/Blackall Railway |
| 5 | Upgrade the culverts at the north-western corner of town under Blackall and Barcaldine railway lines |
| 6 | Lower the town weir by 500mm |
| 7 | Extend existing town levee west to Yaraka/Blackall Railway |
| 8 | Construct a new levee following the western bank of Jordan Ck from the Central Railway, around the south-eastern corner of town and through to the existing levee on the southern side of town |
| 9 | Extend the existing town levee south-east along the Tumbar Road |
| 10 | Combination of Options 7 and 8 |
| 11 | Same as option 10, although it includes a levee around the property east of Jordan Creek, adjacent to the town. |
| 12 | Combination of Options 7 and 9, although it includes a levee around the bend in Jordan Creek at the south east corner of the town. |

The results of the MIKE 21 modelling of options 1 to 12 have been presented in Figures M1 to M12 respectively. These figures show difference in flood levels, with Figures prepared for select options to show the reduction in inundation within the town. Modelling was undertaken using the 50 year ARI design event.

It can be seen that Options 1 to 6 provide no significant benefit to flood levels within the town. This is significant in that it rules out some of the most costly mitigation options, including bridges and culverts upgrades, roadworks and rail construction. At the request of the Study Working Group model runs were undertaken to simulate a 1 year ARI design event upon the town area only. This was carried out to assess the benefit associated with increasing the culvert capacity under the railway and highway on the western side of town. The model was run for the existing case and that modelled under Option 5. The model showed that by providing substantially more culvert capacity in this area, peak water levels under a small local event can be dropped by up to 500mm. This is not the case under larger Jordan Creek events, rather it applies for local rainfall on the town. Further model runs would be necessary to refine these results and assess specific options.

During inspections of the site it was noted that some culverts, particularly under the rail lines, were in need of significant maintenance. Some were partially silted and others, as shown in Plate 6, were in a dilapidated condition.

**Plate 5 – Culverts (Shutes) under railway**

**Plate 6 – Culvert in need of repair**

While modelling has shown that augmenting these culverts has little benefit during a Jordan Creek flood event, the blocked and damaged culverts are likely to worsen flooding from local events, where overtopping of the embankment is not expected. It is a recommendation of this report that all drainage structures, under road and railway embankments be the subject of a regular maintenance program with additional inspections/maintenance following periods of significant rainfall.

Options 7, 8 and 9 involve a range of mitigation measures incorporating levees. It can be seen that these provide significant benefit to various parts of the town with the exception of Option 9, which reports a reduction in flood levels of less than 100mm.

As a result of these findings and following discussion with the Study Manager, another two options were considered namely Option 10 and Option 11. These incorporate the best of the levee options into one option. The results indicate a significant benefit to the town, in that flooding is eliminated in most parts of the town for the 50 year ARI event.

Introducing a levee around the majority of the town to prevent inundation does have an impact on the upstream side of the levee. The estimated increase in peak water levels is presented in Figures M10 and M11 and some concentration of flow over the road and rail line on the eastern side of town occurs. Under the 50 year ARI event, at peak, there is an increase in depth of up to 210mm and an increase in velocity of approximately 0.1 to 0.2 m/s across the road.

The MIKE 21 models for both the unmitigated case and Option 10 were interrogated at three locations to quantify the expected impacts to inundation of the Capricorn Highway. The 50 year ARI design event was selected and is indicative of the type of flooding that might occur. Three locations were chosen:

- West – Capricorn Highway, approximately 800m west of town;
- Creek Crossing - Capricorn Highway, at Jordan Creek Bridge; and
- East – Capricorn Highway, approximately 800m east of town.

**Table 12 –Time of Inundation due to Option 10 under 50 Year ARI event**

| Depth of Flow Over Road (mm) | Time of Inundation (Hours) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | West | | | Creek Crossing | | | East | | |
| | Unmitigated Case | Option 10 | Variation | Unmitigated Case | Option 10 | Variation | Unmitigated Case | Option 10 | Variation |
| 100 | 113 | 94 | -19 | 50 | 65 | 15 | 86 | 77 | -9 |
| 200 | 72 | 62 | -10 | 24 | 50 | 26 | 43 | 14 | -29 |
| 300 | 34 | 26 | -8 | - | 38 | 38 | - | - | N/A |
| 400 | - | - | N/A | - | 18 | 18 | - | - | N/A |
| 500 | - | - | N/A | - | - | N/A | - | - | N/A |

The results in Table 12 indicate an increase in time of inundation at the Capricorn Highway crossing of Jordan Creek and a decrease in time of inundation both west and east of town. It should be noted that no assessment of road inundation has been considered beyond the extents of the MIKE 21 model.

In addition to the impacts on road inundation times, there are two properties located on the eastern side of the creek, one upstream of the railway and highway and the second between the railway and highway that may be affected by increased water levels. The first property appears to be elevated already and the second property does not appear to be inhabited. The adverse impacts on these properties need to be discussed further with the property owners prior to the introduction of any mitigation works.

During the second meeting with the Study Advisory Group it was requested that an additional option be considered to incorporate another combination of levees. Option 12 was modelled and included the extension of the existing levee west to the Blackall rail, extension of the existing levee south-east along

Tumbar Road and a new levee at the bend in Jordan Creek, at the south east corner of town. The results of Option 12 did not provide significant reduction in water levels on the eastern side of the town.

It should be noted that an inherent risk of adopting levees for protection from floodwaters is that breach of the levee may occur under events larger than the design event adopted. In some cases, a levee breach can cause the collapse of the levee, resulting in floodwaters entering the town with damaging velocities that would not have been experienced without the levee. Design guidelines now exist for levee structures that require a spillway to be included in the structure. This low point allows waters to spill over the levee in a controlled and safe fashion.

In addition to the modelled options, another structural measure could be to raise affected structures above the level of a pre-determined flood (Option 13). This would provide a solution that has no noticeable impact on surrounding properties or road/rail access. A visual assessment of the affected structures was carried out during the site visit of 12 March 2002 and approximate costs to undertake this work are included in this report.

## 10.2 Non-Structural Measures

A number of non-structural measures could be considered to minimise the impact of flooding on the town. These include:

- Option 14 – Initiating an automated flood warning system;
- Option 15 – Augmenting existing flood warning system;
- Option 16 – Developing a community flood awareness program; and
- Option 17 – Implementing planning procedures to prevent development in flood prone areas.

While these measures may not prevent flooding or reduce flood levels in the affected areas, they will help to minimise the effects of flooding.

### *10.2.1 Option 14 – Automated Flood Warning System*

An automated flood warning system could be installed to enhance the current warning for imminent flooding. Recent discussions have indicated that the BoM would consider monitoring gauging stations and include the data in their Flood Warning Systems, although the infrastructure, communications and maintenance costs would have to be borne by others. The BoM's recommendation would be to install two automated gas purge gauging stations, one at Jericho, and the other further upstream, possible at 'Glencoe'. Plate 7 shows a typical example of an automated gauging station. This would also enable the URBS model to be calibrated on a gauge closer to the site of interest, as opposed to the current calibration gauge at Barcaldine.

The principle advantage of an automated station over the current flood height gauges is that the automated station does not rely on a manual reading of the gauge. Currently, if the persons nominated to record the gauges are not in the area during a flood event, then the readings would not be received by the BoM's flood warning system. An automated system would eliminate this uncertainty from the flood warning procedure.

The detailed URBS model of the Jordan Creek catchment, developed during this study, has been incorporated into BOM's Alice River flood forecasting model. This will assist in providing a more accurate forecast of potential flooding.

**Plate 7 – Typical Gauging Station**

(Photograph courtesy of Mr Terry Malone, Bureau of Meteorology)

#### *10.2.2 Option 15 – Augmenting Existing Flood Warning System*

From feedback during the final Working Group Meeting it was established that the 'Glencoe' property was frequently unattended or may only have one person in attendance. This means that there is a possibility that early notification of potential flooding would not occur. The augmentation suggested was to install a manual gauge at the 'Burgoyne' property. This property is located approximately 6km upstream of the town and whilst it will not give a substantial warning time, someone would be in residence all the time and be able to notify the town of advancing floodwaters.

#### *10.2.3 Option 16 – Community Awareness and Training*

Community awareness should be considered important for a town subject to frequent flooding. It should not be assumed that all residents were around for the last major flood and may not be aware of the nature or extent of flooding. Maintaining community awareness will ensure that all residents, and in some cases visitors, have procedures in place in the event of an impending flood. This may serve to reduce damage or possibly injury or death. Community awareness can be increased through the preparation and release of a flood warning brochure to residents and holding local information sessions.

It has also been identified that training may be required for the members of the disaster response organisation in Jericho, particularly in regard to the interpretation of flood warning information forwarded from the BoM. The information from the BoM can be important in the planning of the response to impending flooding and those responsible for coordinating evacuations etc. should be fully aware of the available forecasting tools.

### *10.2.4 Option 17 – Planning Control Measures*

Planning procedures could be implemented to prevent new development in areas subject to flooding. As much of the area surrounding Jericho is subject to inundation, preventing all development may not be practical. Filling of lots could create significant nuisance by redirecting flood waters. In this case, development approval may include conditions to facilitate the passage of floodwaters without inundation to floorspace.

## 10.3 Cost Considerations

It is important to not only review the mitigation options in terms of impact on flooding, but also in terms of infrastructure cost. The following table has been prepared to provide indicative costs for the above options. Detailed costing is beyond the scope of this report and the costs presented in Table 12 are shown for the purposes of ranking the possible mitigation options.

**Table 13 – Indicative Cost Estimates**

| Mitigation Option | Indicative Cost |
|---|---|
| 1 – Remove Central Railway | N/A |
| 2 – Remove Capricorn Railway | N/A |
| 3 – Upgrade hydraulic structures under Central Railway and Capricorn Highway | $ 1,393,000 |
| 4 – Upgrade hydraulic structures under Blackall Road and Railway | $ 289,000 |
| 5 – Upgrade culverts on north-west corner of town | $ 197,000 |
| 6 – Lower the town weir by 500mm | $ 28,000 |
| 7 – Extend existing levee west to Blackall Railway line | $ 106,000 |
| 8 – New levee along west bank of Jordan Creek from Central Railway south to meet existing levee | $ 363,000 |
| 9 – Extend existing levee south-east along Tumbar Road | $ 302,000 |
| 10 – Combination of options 7 and 8 | $ 408,000 |
| 11 – Same as option 10 plus levee around property east of Jordan Creek | $ 529,000 |
| 12 – Combination of options 7 and 9 plus levee on bend in Jordan Creek on south-east corner of town | $ 514,000 |
| 13 – Raise affected structures above a pre-determined flood level | $ 315,000 |
| 14 – Initiate an automated flood warning system | $ 60,000 |
| 15 – Augment existing flood warning system | $ 5,000 to 10,000 |
| 16 – Develop community flood awareness program | $ 42,000 |
| 17 – Implement development planning procedures | N/A |

The following applies to the above indicative costs:

- The upgrade of the rail bridge in Option 3, assumes that the entire structure will be replaced, due to the difficulty matching existing timber construction with current design standards;

- The costs for levee options assumes that material for the levees will be won from sites adjacent to the levee and that this material will be suitable for levee construction;
- The levee is assumed to be an average 1.5m high, have a 2m wide crest and have 1 on 10 side batters;
- A contingency of 40% has been allowed; and
- Since Connell Wagner has no control over the cost of labour, materials, equipment or services furnished by others, or over contractors' methods of determining prices, or over competitive bidding or market conditions, any estimate of costs is made on the basis of Connell Wagner's experience and qualifications and represents its best judgement as an experienced and qualified professional engineer, familiar with the construction industry; but Connell Wagner cannot and does not guarantee that proposals, bids or actual construction cost will not vary from Connell Wagner's opinion of cost.

A more detailed breakdown of costs is provided in Appendix E.

## 10.4 Environmental Impacts

A range of potential environmental impacts associated with the construction and operation phases of the proposed measures has been assessed and is discussed below.

### 10.4.1 Land Use

The proposed mitigation options will reduce the risk of flooding within the town but may have a minor detrimental impact along the major roads and railway track. In general the flood mitigation options will have no impact on the land uses within the Study Area.

### 10.4.2 Soils and Topography

The construction of bank levees south-west and south-east of Jericho will alter the project area's topography. However, alterations to the topography are expected to be minimal as the bank levees will only be approximately 2m high.

The culvert and railway bridge upgrades will not impact on the project area's topography.

During construction of bank levees, culverts and railway bridges, the existing soils will be disturbed which may lead to erosion if suitable erosion and sediment control measures are not implemented. If suitable erosion control measures are implemented during construction, the potential impact on the soil environment is expected to be low.

The following are recommended management strategies:

- Limit soil disturbance during construction phase;
- Revegetate disturbed areas progressively and as soon as practicable with native species;
- Avoid earthworks when it is raining or while the soils are saturated; and
- Install and maintain temporary erosion and sediment control measures.

### 10.4.3 Water Quality

If erosion occurs during the construction phase the existing water quality may be reduced slightly as sediment enters the water. This is expected to be insignificant as regional water quality studies suggest that surface water bodies in the broader region currently have high turbidity levels.

Other potential impacts on surface water quality during the construction phase are as follows:

- Hydrocarbon pollutants from vehicles and machinery;
- Toxic materials such as asphalt prime, solvents and cement slurry; and
- Litter.

Changes to water quality conditions during the operational phase are not expected to be significant.

The following are recommended mitigation strategies:

- Temporary erosion and sediment control measures to be implemented;
- Revegetation as soon as practicable using native species;
- Cover and/or bund toxic materials and waste; and
- Provide on-site waste receptacles.

#### *10.4.4 Flora and Fauna*

The construction of levee banks and the upgrade of culverts and railway bridges may result in the direct removal of trees. Weeds may also be spread across the site during the construction phase.

The floodwater ecology of the area west of the proposed bank levees may be impacted upon during the operational phase. However, given the relatively small size of the impacted area, this impact is not expected to be significant within the broader area.

The following mitigation measures should be implemented:

- Undertake a flora survey prior to finalising the flood mitigation options;
- Limit clearing and disturbance;
- Rehabilitate disturbed areas as soon as practicable;
- All machinery is to be washed down prior to arriving on site, to avoid importing weeds from other areas;
- Any fill used on site should also be confirmed as being weed and seed free; and
- Remove declared weed species from the project area where practicable.

#### *10.4.5 Air Quality*

During construction, the air quality in the area may decrease slightly due to dust from construction. If dust suppression measures are implemented the impact is not expected to be significant.

No change in air quality is likely during the operational phase of the project.

The impact from dust during construction can be reduced through dust suppression measures. The following recommendations should also be implemented:

- Watering of the site and stockpiles;
- Limiting the amount of site open at once;
- Revegetating as early as possible;
- Informing residents of when dust producing activities will be undertaken;
- Stockpile sites to be located where they will not impact on residences; and
- Avoiding dust producing activities on high wind days.

#### *10.4.6 Noise*

Noise levels are likely to increase during the construction phase, due to the construction machinery involved. However, the impact from this is expected to be very low, as most of the works will be carried out along the perimeter of the town.

The following are recommended management strategies:

- Impacts from noise can be reduced by the use of the most appropriate machinery for the task, ie a smaller piece of machinery may be appropriate;
- Silencing equipment to be fitted to the machinery;
- Consultation with residents; and
- No nightworks, without prior consultation with residents.

#### *10.4.7 Cultural Heritage*

An indigenous cultural heritage investigation and native title claimants search have not been undertaken as part of this study. If the search reveals that native title claims have been lodged for the area, then Council will be required to notify all native title claimants of the proposed works, as specified under section 24KA of the *Native Title Act 1993.*

Prior to construction commencing it is recommended that a search be undertaken of the cultural heritage and native title claimants register.

### 10.5 Social Impacts

Given the extensive existing impacts of regular flood events on the township of Jericho, it is important to consider the social impacts of the various mitigation options being explored. While considering both potential positive and negative impacts issues examined include:

- Existing patterns of movement in the community, including access to education, businesses, medical facilities and emergency services;
- Impacts on capacity to increase population and/or local development; and
- Continued use of local facilities and services, including transport infrastructure.

Overriding issues such as 'down' time of the town, the economic and psychological cost of damage, and adequacy of warnings also raise social impact considerations.

An assessment of social impacts is summarised in Appendix F for each of the proposed options.

### 10.6 Recommended Mitigation Options

Modelling the proposed mitigation options under the 50 year ARI design event allowed the benefits of each option to be assessed under a moderate flood. It can be seen from the difference maps that upgrades to the road and rail structures has little significance to flood levels in town. Similarly, there is no significant benefit in upgrading the culverts at the north-east corner of town or in lowering the town weir. The modelling does however show that there is a significant benefit in extending the existing levee and constructing new levees.

The results in Figure M10 show the results of extending the existing levee and providing a new levee along the eastern side of town and around the south-eastern corner of town. It can be seen that this case provides significant benefit, almost eliminating inundation to the town area. The model results indicate that a levee, approximately 1.5m high, may be appropriate the 50 year ARI design event, allowing for 0.5m freeboard. Although the 100 year ARI design event was not modelled, a levee height in the order of 1.8m is anticipated to provide immunity to this event. If 100 year ARI immunity was ultimately required, the levee height should be confirmed with additional modelling.

It can also be seen that the levees would increase flood levels downstream and to the east of town.

This increase (afflux) appears to affect two properties on the eastern side of Jordan Creek. Mitigation measures could be employed to reduce the impact on these properties. These may include:

- Constructing a levee around the buildings on this property (refer Figure M11); or
- Raising the levels of the buildings above the expected flood level for a design ARI of possibly 100 years.

To assist in the selection of the most appropriate option, an evaluation matrix was prepared as presented in Table 14.

Table 14 - Mitigation Option Evaluation Matrix

| Option Number | Description | Hydraulic Benefit | | Cost Benefit | | Social Benefit | | Env. Impact | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Weight | 4 | Weight | 2 | Weight | 2 | Weight | 2 | | |
| | | Raw Score | Weighted Score | Raw Score | Weighted Score | Raw Score | Weighted Score | Raw Score | Weighted Score | Raw Score | Weighted Score |
| 1 | Remove Central Railway embankment and structures east and west of town | 1 | 4 | 1 | 2 | 1 | 2 | 1 | 2 | 4 | 10 |
| 2 | Remove Capricorn Highway embankment and structures east and west of town | 1 | 4 | 1 | 2 | 1 | 2 | 1 | 2 | 4 | 10 |
| 3 | Upgrade hydraulic structures under Central Railway and Capricorn Highway | 1 | 4 | 1 | 2 | 1 | 2 | 5 | 10 | 8 | 18 |
| 4 | Upgrade hydraulic structures under Blackall/Jericho Road and Yaraka/Blackall Railway | 1 | 4 | 1 | 2 | 1 | 2 | 5 | 10 | 8 | 18 |
| 5 | Upgrade the culverts at the north-western corner of town under highway and rail | 1 | 4 | 1 | 2 | 1 | 2 | 5 | 10 | 8 | 18 |
| 6 | Lower the town weir by 500mm | 1 | 4 | 1 | 2 | 1 | 2 | 3 | 6 | 6 | 14 |
| 7 | Extend existing town levee west to Yaraka/Blackall Railway | 3 | 12 | 3 | 6 | 4 | 8 | 3 | 6 | 13 | 32 |
| 8 | Construct a new levee following the western bank of Jordan Ck from the Central Railway, around the south-eastern corner of town and through to the existing town levee | 4 | 16 | 3 | 6 | 4 | 8 | 3 | 6 | 14 | 36 |
| 9 | Extend the existing town levee south-east along the Tumbar Road | 1 | 4 | 1 | 2 | 2 | 4 | 3 | 6 | 7 | 16 |
| **10** | **Combination of Options 7 and 8** | **5** | **20** | **4** | **8** | **5** | **10** | **3** | **6** | **17** | **44** |
| 11 | Same as option 10, although it includes a levee around the property east of Jordan Creek, adjacent to the town. | 5 | 20 | 3 | 6 | 5 | 10 | 3 | 6 | 16 | 42 |
| 12 | Combination of Options 7 and 9, although it includes a levee around the bend in Jordan Creek at the south west corner of the town. | 3 | 12 | 2 | 4 | 2 | 4 | 3 | 6 | 10 | 26 |
| 13 | Raise flood affected houses | 1 | 4 | 3 | 6 | 3 | 6 | 5 | 10 | 12 | 26 |
| 14 | Automated flood warning system | 1 | 4 | 3 | 6 | 5 | 10 | 3 | 6 | 12 | 26 |
| 15 | Augment existing flood warning system | 1 | 4 | 4 | 8 | 5 | 10 | 3 | 6 | 13 | 28 |
| 16 | Community awareness campaign regarding flood related issues | 1 | 4 | 5 | 10 | 5 | 10 | 5 | 10 | 16 | 34 |
| 17 | Amend planning controls | 1 | 4 | 5 | 10 | 5 | 10 | 5 | 10 | 16 | 34 |

Note: *Options are rated on a scale 1 to 5 with 1 being lowest benefit or least desirable and 5 being highest benefit or most desirable.*
*The option with the highest total score is most desirable*

As can be seen from the Evaluation Matrix, several options rated highly including both structural and non-structural measures. The best structural measure (Option 10) includes construction of a new levee bank around the majority of the upstream side of the town, linking into the existing levee bank. Option 11 rates very closely to Option 10, with protection of the property on the eastern bank being included. The type of works proposed for this property would need to be discussed with the property owner but may include house raising or other protection measures.

The best non-structural measure that rates highly (compared to the structural measures) is the introduction of a community awareness campaign. This would update residents and appropriate disaster management personnel on the current flood warning system and procedures.

Based on the outcomes of this investigation, it is recommended that the above options be considered for implementation at Jericho.

# 11. Economic Assessment of Recommended Mitigation Option

## 11.1 General

The hydraulic modelling for the Jericho Town Flood Mitigation Study has identified and assessed a number of structural flood mitigation options from which a preferred option has been refined and costed.

The objective of this economic assessment is to determine whether the cost of the preferred option can be justified economically against the proposed benefits accruing to Jericho Town from eliminating or minimising potential flood damage to dwellings, commercial structures and public infrastructure.

The geographic scope of the assessment is limited to the town as surrounded by the Capricorn Highway, Central Railway Line, Yaraka to Blackall Railway Line and the line and the existing levee to the south of the town.

Flood Damage Cost Estimates (for April 1990)
The town of Jericho comprises a population of approximately 170 people, 54 houses and 6 commercial/industrial premises. Significant public infrastructure is located in the town including state controlled and local roads, railway related infrastructure, services and utilities infrastructure. The following costs have been reported in Western Queensland Towns Flood Study (Scott and Furphy Pty Ltd January 1991) using ANUFLOOD.

### *11.1.1 Dwellings*

Records from the April 1990 flood identify that 20 houses were inundated with flood water with five of the above houses suffering major damage. The cost of flood damage for a flood of the April 1990 magnitude has been previously estimated at $200,000 for all affected household.

### *11.1.2 Commercial/Industrial*

Flood damage, which resulted to the commercial/industrial premises from the April 1990 flood has been estimated at $130,000.

### *11.1.3 Indirect*

Indirect damage, which includes personal effects and other consumables, was estimated at $100,000.

### *11.1.4 Other Damage*

Flood damage related costs were also incurred on transport infrastructure, services infrastructure (ie wastewater, water, electricity, etc), social infrastructure (eg schools, etc) vehicles and clean up tasks. State Government departments (eg Education, DMR and DES) and other state-owned corporations (eg QR, Ergon Energy, etc) and Jericho Shire Council are primarily responsible for these costs.

Jericho Shire Council estimated that $415,000 was expended in repairing public infrastructure under its responsibility in Jericho town. Damage repair was required for Jericho town streets, footpaths, fencing, showground, racetrack, tennis courts, community buildings and swimming pool. In particular, it is understood that the rail infrastructure at Jericho incurred significant damage with the railway line being in the natural flow path in the floodplain.

In addition to damage rail track and structures, QR would have incurred some operating losses through disruption to passenger and freight services during the flood period.

The flood damage to infrastructure could conceivably have an adverse impact on the effective life of the asset and on the timing of major maintenance. These costs are difficult to quantify in the absence of detailed asset registers and/or local maintenance plans, and any advice from the infrastructure owners. These infrastructure costs would be significant and are mentioned for information only.

#### *11.1.5 Total Damage Costs*

It is estimated that the total cost of quantifiable flood damage to Jericho town was approximately $845,000 in 1990/91 prices if the above residential, commercial/industrial and indirect damage costs are taken into consideration. These costs are underestimated because they do not include state government incurred costs.

Using changes in the Consumer Price Index (CPI) to escalate these recorded 1990/91 costs to 2000/01 prices, the resulting total damage costs would be equivalent to approximately $1.1 million in today's prices. Over this 10 year period, the CPI has risen by 27.5 percent for Brisbane prices and this has been used for the Jericho town context.

### 11.2 Recommended Flood Mitigation Option

The preferred option which has been identified from the hydraulic modelling involves the construction of additional levee to the east and south west of the town (estimated cost is $408,000) and the raising of one dwelling (estimated cost is $15,000). The total capital costs of this option is $423,000 in 2002 prices. The option is described in detail elsewhere in this project.

For the purposes of this analysis, it would be expected that the new levees when constructed would have a minimum life of 20 years providing effective and periodic maintenance is undertaken by Jericho Shire Council. It is more than likely that the effective life of the levees will extend beyond the 20 year time horizon.

### 11.3 Assessment of Recommended Mitigation Option

Assuming one flood incident to the extent of the 1990 flood over the 20 year life of the proposed new levees, the one-off capital costs of the recommended option totalling $423,000 will eliminate flood damage in the order of $1.1 million for dwellings, commercial/industrial and Council indirect related costs. This result alone for one incident, which involves known damage costs, will return a net benefit.

When State Government agency incurred costs and charges for repairing and restoring public infrastructure are added to known damage costs, the net benefits accruing to the Jericho town community (including government) from the preferred option would be substantial.

Similarly if more than one flooding incident occurred over the same 20 year period then the net benefit return would increase two fold.

Therefore on economic grounds (using the above assumption on flood incidence), the recommended option is justified and will provide net benefits to the community of Jericho town.

There may be a negative economic impact on the road and rail, east of town due to an increase in water levels and inundation times, however this is difficult to quantify and may be offset by a corresponding reduction in flooding west of town. Additional costs would also be incurred to repair damage following an event greater than the immunity offered by a levee.

# 12. Conclusions and Recommendations

The Jericho Town Flood Mitigation Study commenced with an extensive data collection phase including compilation of meteorological records, maps, historical flood records, anecdotal accounts, photographs, reports, survey and statistics. This information was collated and used at various stages throughout the project.

A number of consultation activities were undertaken as part of the study. The consultation served a number of purposes including:

- Informing residents of the study aims, progress and outcomes;
- Collection of anecdotal information from witnesses of flood events or damage; and
- Maintaining community awareness of flooding and flood related issues.

The consultation activities included newsletters, public meetings, displays and questionnaires. The consultation process was considered a success, with positive feedback received from residents and valuable information obtained to assist with the technical components of the study.

An URBS hydrologic model was developed for the Jordan Creek catchment upstream of Jericho as this is the model used by the BoM's flood forecasting system. This model was subsequently incorporated into the BoM's model to enable calibration at the Barcaldine weir, downstream of the subject area. The 1990 and 1997 flood events were modelled to obtain flows at the Jericho township for calibration purposes. Following calibration, design events were also modelled.

Aerial photogrammetry, undertaken prior to this project, was used to develop the 2 dimensional MIKE 21 hydraulic model. A joint calibration exercise was undertaken with both the URBS and MIKE 21 models using the 1990 and 1997 flood events. Flood levels for these events were surveyed prior the study and were used to confirm the calibration of the models. Final calibration levels were considered to be within an acceptable range from the recorded flood levels. Residents who had witnessed these events confirmed that the modelled flood behaviour generally represented conditions during the event.

Following calibration, the 5, 20 and 100 year ARI and PMF design events were run in the MIKE 21 model to assess the current floodplain situation. Hazard maps were produced for each of these events to enable the disaster response organisations to better assess evacuation routes and safe areas. This information will further enhance the flood warning system already in operation.

An assessment was also made as to the effects of the road and rail embankments either side of Jericho, with respect to flooding in the town. A comparison was made between the base case, with no road or rail embankments, and the cases with the road and rail in isolation and combined. It was concluded that the upstream rail embankment caused the most significant afflux, however the impact on properties within the town was negligible. It was therefore concluded that upgrading of hydraulic structures under these embankments would not serve to significantly lower flood levels in town.

Following the assessment of the existing floodplain situation a number of structural and non-structural mitigation options were developed. The structural options were modelled in MIKE 21 to assess the impacts on flooding within the town. Options considered included:

- Upgrading hydraulic structures;
- Extension of the existing levee;
- Construction of new levees;
- Lowering of the town weir; and
- Various combinations of the above.

It was concluded that the most significant reduction in flood levels within the town would be achieved with the construction of levees. Another structural mitigation option was to raise the flood prone structures above the 100 year ARI flood level. This could not be modelled in MIKE 21 and was therefore considered in terms of benefit and cost only. This was considered to an effective option for structures currently elevated above ground level. Slab-on-ground structures would not be suitable for raising.

Non-structural options were also considered, including:

- Automated flood warning system;
- Augmenting the existing flood warning system;
- Community awareness campaign; and
- Town planning considerations.

The most import of these options was considered to be the community awareness campaign. This is a low cost option that would result in residents becoming familiar with procedures for flood related activities including evacuation plans. A campaign should also involve training of disaster management personnel.

All of the options have been evaluated in terms of hydraulic impact, cost, environmental impact, social benefit and economic impact. An evaluation matrix was prepared to assist in the selection of preferred options. The Evaluation Matrix assisted in confirming that the following options should be considered for implementation at Jericho:

- **Option 10** – Extension of the existing town levee west to Yaraka/Blackall Railway and construction of a new levee following the western bank of Jordan Ck from the Central Railway, around the south-eastern corner of town and through to the existing town levee. In addition, adverse impacts from these proposed works should be addressed for the property on the eastern bank of the creek.

- **Option 14** – Introduction of a community awareness campaign regarding flood related issues and updated training for disaster management personnel.

# 13. References

Bailey, V (2001), *Western Streams Water Quality Monitoring Project*. Department of Natural Resources and Mines, Brisbane.

Bailey, V and Long, P (2001), *Wetland, Fish and Habitat Survey in the Lake Eyre Basin, Queensland, Final Report*. Department of Natural Resources and Mines, Brisbane.

Council of the Shire of Jericho Planning Scheme (1999).

Counter Disaster and Rescue Services (2000), *Disaster Risk Management*.

CSIRO (2000), SCARM Report 73 – *Floodplain Management in Australia – Best Practice Principles and Guidelines*.

Department of Emergency Services, *State Planning Policy on Land Use Planning for Natural Mitigation and Development Assessment* – discussion paper 2001.

DNR (1997), *Lake Eyre Basin Queensland Water Resource Assessment Report*. DNR, Brisbane.

Institution of Engineers, Australia (1998), *Australian Rainfall and Runoff*.

Sattler, P and Williams R (1999). *The Conservation Status of Queensland's Bioregional Ecosystems*. Environmental Protection Agency, Queensland.

Scott & Furphy (1991), *Western Queensland Towns Flood Study*.

## *Figures – refer Volume 2*

# *Appendix A*

***Newsletters***

# Jericho Town Flood Mitigation Study

**Newsletter No 1** July 2001

## Introduction

***Council is planning for the future. The town of Jericho has historically been subjected to periods of flooding which have had a major impact on the local community. A study is being conducted to investigate options for reducing the impact of flooding on Jericho. The study area focuses on the town of Jericho and the surrounding Jordan River Floodplain located approximately 220km west of Emerald and west of the Great Dividing Range.***

## Study Aim

*Connell Wagner has been commissioned to conduct a Flood Mitigation Study. The key aims of this study are to:*

- *Identify the current issues and concerns about flooding;*
- *Assess the future risk of flood related losses in the area; and*
- *Recommend ways of reducing the impacts of flooding on the local community.*

## Study Scope

*The following tasks will be conducted as part of the study:*

- *Issues and options identification in relation to flooding in the area;*
- *Evaluation of current floodplain situation including an investigation of the town weir, the flood levee, and the existing road and rail embankments;*
- *Determination of existing and continuing flood risks;*
- *Assessment and evaluation of ways to reduce the impacts of flooding;*
- *Two public meetings and one open day in Jericho;*
- *Regular newsletters throughout the study; and*
- *1800 Free Call Study Information Line.*

## Study Program

*The study consists of four stages that will be conducted over the next few months. Throughout the study there will be a number of opportunities for the local community to become involved. Residents of Jericho will be able to raise issues about flooding in Jericho and suggest ways to reduce the impact of flooding on the area. Residents will also have opportunity to view and comment on the various draft outcomes produced as part of the study process.*

Shire of Jericho

Connell Wagner

# How to be Involved

*An important part of the study is the involvement of the local community. Residents of Jericho are invited to participate in study activities and to pass on their local knowledge to the study team. There are various way to become involved:*

*Attend the first Public Meeting on Tuesday 10 July 2001 in the Jericho Town Hall starting at 7pm to help identify key issues and concerns about flooding in Jericho and to discuss ways to reduce the impact of flooding;*

*Call the free call study information line 1800 500 667 for further information or to discuss any issues or concerns with a member of the study team;*

*Read the study newsletters to stay informed about the progress of the study; and*

*Visit the Open Day on Wednesday 11 July 2001 in the Jericho Town Hall between 9am and 1.30pm and speak one-on-one to a member of the study team.*

**Free Call Study Information Line**
**1800 500 667**

Connell Wagner


Jericho Town Flood Mitigation Study

# Jericho Town Flood Mitigation Study

**Newsletter No 2** Feb 2002

## Update

***Since the issue of the first newsletter and the public meeting, the Flood Study has progressed significantly. Modelling of Jordan Creek has been completed and a range of mitigation options aimed at reducing the impact of flooding in Jericho have been assessed. We are now seeking your feedback on the outcomes of this assessment.***

## Mitigation Options

*The following mitigation options have been considered:*

- *Upgrading culverts under the Capricorn Highway;*
- *Upgrading bridge structures under the Central Railway;*
- *Upgrading culverts under the Blackall/Jericho Road;*
- *Upgrading culverts under the Yaraka/Blackall Railway;*
- *Upgrading culverts under the road and rail at north-western corner of town;*
- *Extending levee to the Blackall/Jericho Road;*
- *Extending Levee south along the Tumbar Road;*
- *Extending levee along the eastern side of town; and*
- *Lowering the town weir.*


## Public Meeting

***Come along to the next public meeting:***

When: ***Tuesday 12 March***

Time: ***7.00pm***

Where: ***at Jericho Town Hall***

***Your feedback and comments on the mitigation options will be used to determine an overall option to reduce flooding in Jericho. These will be presented in the Draft Report to be released in April.***

Connell Wagner

# How to be Involved

*An important part of the study is the involvement of the local community. Residents of Jericho are invited to participate in study activities and to pass on their local knowledge to the study team. There are various way to become involved:*

*Attend the next Public Meeting on Tuesday 12 March 2002 in the Jericho Town Hall starting at 7pm.*

*Call the free call study information line 1800 500 667 for further information or to discuss any issues or concerns with a member of the study team.*

*Read the study newsletters to stay informed about the progress of the study.*

**Free Call Study Information Line**
**1800 500 667**

Connell Wagner

JERICHO TOWN FLOOD MITIGATION STUDY

# Appendix B

*Consultation Feedback Forms*

Connell Wagner

## Activity One: Overview of Flood Issues

Name (optional): ____________________

1. Using the map as a guide, comment on flood related issues for both the Town of Jericho and surrounding areas.

2. Comments should include consideration of:

- Path or direction of flood waters (please mark on map)
- Duration of flooding
- Depth of flood waters
- Damage to property, township and surrounding areas (eg Affected properties, significant erosion, road or rail damage,)
- How often does flooding occur and where are the commonly affected areas

3. Record your comments either below or on the map provided.

Duration of 97 99 Flood.
5 - 6 days

Depth 15 inches - Top End
Varying reports - Deeper - South End
Out the front of the pub Foot + a half.
Floods flow slow 97, 99
Carpets + Furniture to low places
One's raised were O.K
last flood 4 homes damaged.
Rail washed away - Western side
No significant erosion 97 99 - Straight over the weir

Rocky. 4~~9~~384584

hydrolyic person in Wallace — Ian

1990 - 1 in 50

1997, 99 - 1 in 5

Priority

COMMUNICATION PLANNER

Name: File:

Company: Subject:

Position: Delegate to:

Address: Return to:

www.

E-Mail:

Bus.: Fax: Res.: Cell.:

| Type ✓ | Date/ Note | Time/ Seq. | Subject | Response | Follow-up Date |
|---|---|---|---|---|---|

-> Flooding & QR

(1) - nothing could be done about flooding in 1990 event.
- however 1997 event was an event that flooded houses. Investigations showed large drop in head through rail culverts as culverts were not clean (full of blue metal)
ie maintenance of culverts on Yaraka Blackall Line.

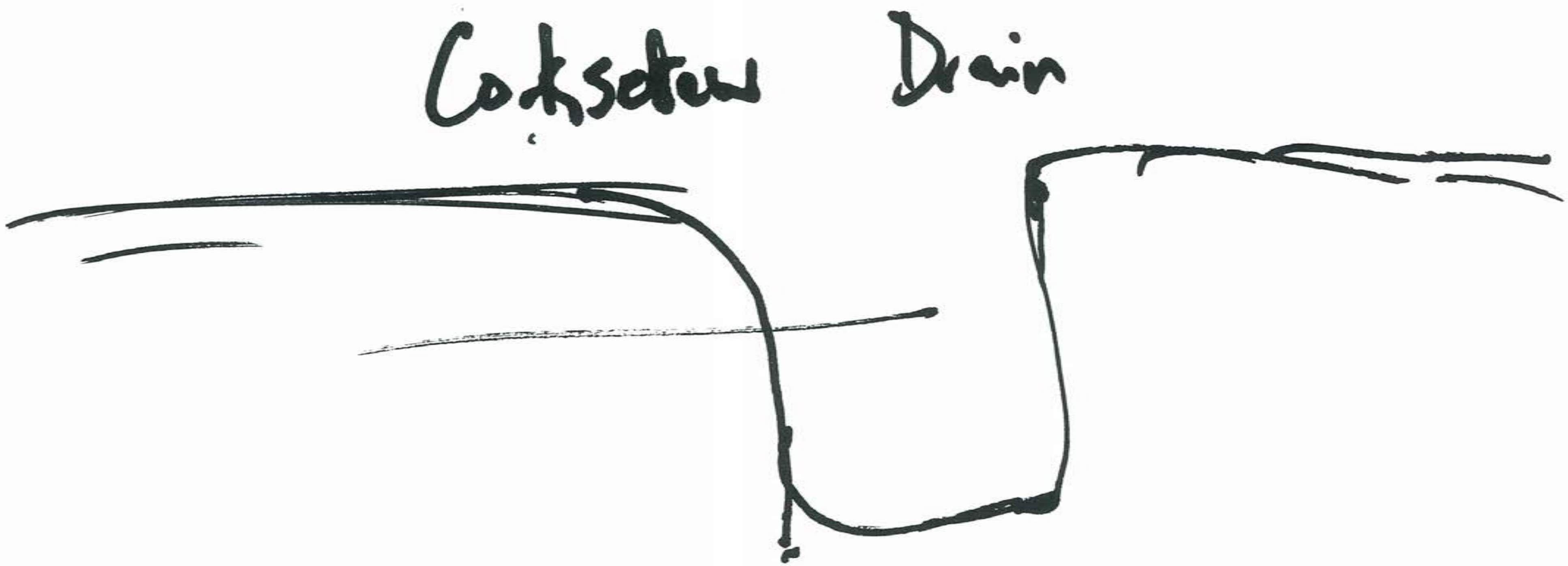
(2) Grade of streets in town falls to western end (away from river bank) there is a drain @ western end flowing S to N.

~~-> The~~

Over



Type: O = Outgoing Call I = Incoming Call M = Meeting
E = E-Mail C = Correspondence F = Facsimile


Drain

Connell Wagner

## Activity One: Overview of Flood Issues

Name (optional): ____________________

1. Using the map as a guide, comment on flood related issues for both the Town of Jericho and surrounding areas.

2. Comments should include consideration of:

- Path or direction of flood waters (please mark on map)
- Duration of flooding
- Depth of flood waters
- Damage to property, township and surrounding areas (eg Affected properties, significant erosion, road or rail damage,)
- How often does flooding occur and where are the commonly affected areas

3. Record your comments either below or on the map provided.

Resmchran btwn Blackhall R Dam & end of levee. – significant erosion.
Breakout (Burgoyne) happens before flooding into town. → then flooding of town → once it drops – breakout flow still occurs.
1997 – Blackall - Jericho Road – under area. for about 1 week.
1990, 1997, 1999

1990 – Central Railway washed away, reconstructed since then.

Levee bank raised since 1990

1990

→ Blackwell end of Davies St - scow

& junk yard - all through town.

1990 to 1997 ~ 1ft diff in flood levels.

Connell Wagner

## Activity One: Overview of Flood Issues

Name (optional): ____________________

1. Using the map as a guide, comment on flood related issues for both the Town of Jericho and surrounding areas.

2. Comments should include consideration of:

- Path or direction of flood waters (please mark on map)
- Duration of flooding
- Depth of flood waters
- Damage to property, township and surrounding areas (eg Affected properties, significant erosion, road or rail damage,)
- How often does flooding occur and where are the commonly affected areas

3. Record your comments either below or on the map provided.

1990 → land on Burgoyne pulled

→ trees on ground

* Raughers.

(1)

Connell Wagner

## Activity Two: Survey of Residents

Name (optional): Ruth Bonham

Using the Town Map, identify your property or place of residence by making a cross on the map attached.

Complete the questions below as they related to your property or place of residence.

1. How long have you been at this address? 25 Years

2. Is the property

   [✓] Residential?
   [ ] Commercial ?
   [ ] Both residential and commercial
   [ ] Other (please specify) ______________

3. Have you experienced flooding problems at this address? [✓] Yes [ ] No

4. If so, what was the worst event?

   1990

5. Are you aware of any other large flood events? [✓] Yes [ ] No

6. If so, please provide details (eg. Year)

   1950, 1969, 1974, 1997

7. Do you have any flood marks for any flood events that could be surveyed?

[ ] Yes
[✓] No

8. If so, for which flood/s? ______________

**The remaining questions relate to the worst flood event described in Question 4**

9. For the worst event, what parts of your property were flooded and approximately to what depth (you may circle more than one answer)

[ ] Yard ( m)
[ ] Garage/Shed ( m)
[✓] Building ( 1 m)

10. How long did the flooding last? 4 days or _________ hours

11. How much warning did you receive before the flood hit? MINIMAL hours

12. Did you require evacuation? [✓] Yes [ ] No

13. If so, how were you evacuated and by which organisation?
we took ourselves

14. Was access cut to your property? [✓] Yes [ ] No

15. If so, on what road, approximately where, and for how long?
ALL AROUND TOWN

16. Where was the water flowing from and to?

17. Was the water following fast or slow? [✓] Fast [ ] Slow

Estimated speed: ______________ metres/second TO FAST TO NEGOTIATE ON FOOT SAFELY

18. How quickly did the water rise? [✓] Fast [ ] Slow

Estimated speed: ______________ metres/minute

19. Using the town map would you please draw where the flood or stormwater flowed or reached in relation to your property?

within the town area there was no dry land.

20. Do you have any photographs, videos or other information about flooding in your area, which you would be prepared to make available (on loan?

[ ] Yes
[✓] No

21. Do you have any information, such as flood marks, which would help us identify water levels at particular times through the most recent flood?

[.] Yes
[ ] No

If you have relevant information or if you have any other relevant information, please provide your telephone number so that we may contact you.

Telephone number: 46514171

Other comments

In 1997 the flood water reached high enough to touch the edge of our car shed floor.

Thank you completing this survey

DARWIN ST
PASTEUR ST
PLAYFAIR ST
EDISON ST
TYNDALL ST
FARADAY ST
DAVY ST
BESSEMER ST
LYON ST
HUXLEY ST
JERICHO
BUSINESSES
HOUSES

(2)

Connell Wagner

## Activity Two: Survey of Residents

Name (optional): KINCT

Using the Town Map, identify your property or place of residence by making a cross on the map attached.

Complete the questions below as they related to your property or place of residence.

1. How long have you been at this address? 12 Years

2. Is the property

[✓] Residential?
[ ] Commercial ?
[ ] Both residential and commercial
[ ] Other (please specify) ______________

3. Have you experienced flooding problems at this address? [✓] Yes [ ] No

4. If so, what was the worst event?

1990

5. Are you aware of any other large flood events? [✓] Yes [ ] No

6. If so, please provide details (eg. Year) "1950" * "1997"

7. Do you have any flood marks for any flood events that could be surveyed?

[✓] Yes
[ ] No

8. If so, for which flood/s? 1990

**The remaining questions relate to the worst flood event described in Question 4**

9. For the worst event, what parts of your property were flooded and approximately to what depth (you may circle more than one answer)

   [✓] Yard ( m)
   [✓] Garage/Shed ( m)
   [ ] Building ( m) HIGH SET HOUSE

10. How long did the flooding last? 2 days or ________ hours ← 1997 Event

11. How much warning did you receive before the flood hit? ________ hours

12. Did you require evacuation? [ ] Yes [✓] No

13. If so, how were you evacuated and by which organisation?

    ________________________________________

    ________________________________________

14. Was access cut to your property? [ ] Yes [ ] No

15. If so, on what road, approximately where, and for how long?

    ________________________________________

    ________________________________________

16. Where was the water flowing from and to?

    ________________________________________

    ________________________________________

17. Was the water following fast or slow? [ ] Fast [✓] Slow

    Estimated speed: ____________ metres/second

18. How quickly did the water rise? [ ] Fast [✓] Slow

    Estimated speed: ____________ metres/minute

19. Using the town map would you please draw where the flood or stormwater flowed or reached in relation to your property?

20. Do you have any photographs, videos or other information about flooding in your area, which you would be prepared to make available (on loan?

[✓] Yes
[ ] No

21. Do you have any information, such as flood marks, which would help us identify water levels at particular times through the most recent flood?

[✓] Yes
[ ] No

If you have relevant information or if you have any other relevant information, please provide your telephone number so that we may contact you.

Telephone number: ________________

Other comments

______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________

Thank you completing this survey

VIDEO OWNED BY GREG GIBSON


DARWIN ST
PASTEUR ST
PLAYFAIR ST
EDISON ST
TYNDALL ST
FARADAY ST
DAVY ST
BESSEMER ST
LYON ST
HUXLEY ST
JERICHO
BUSINESSES
HOUSES

Connell Wagner

## Activity Two: Survey of Residents

Name (optional): Joan BYRNE

Using the Town Map, identify your property or place of residence by making a cross on the map attached.

Complete the questions below as they related to your property or place of residence.

1. How long have you been at this address? 30+ Years

2. Is the property

   [✓] Residential?
   [ ] Commercial ?
   [ ] Both residential and commercial
   [ ] Other (please specify) ______________

3. Have you experienced flooding problems at this address? [✓] Yes [ ] No

4. If so, what was the worst event?
   1990. FLOOD

5. Are you aware of any other large flood events? [ ] Yes [ ] No

6. If so, please provide details (eg. Year)
   1959 1974

7. Do you have any flood marks for any flood events that could be surveyed?

[✓] Yes
[ ] No

8. If so, for which flood/s? 1990
   1997

**The remaining questions relate to the worst flood event described in Question 4**

9. For the worst event, what parts of your property were flooded and approximately to what depth (you may circle more than one answer)

[✓] Yard ( 1 m)
[ ] Garage/Shed ( m)
[ ] Building ( m)

10. How long did the flooding last? _______ days or _______ hours Away

11. How much warning did you receive before the flood hit? _______ hours Away

12. Did you require evacuation? [ ] Yes [ ] No Away

13. If so, how were you evacuated and by which organisation?

_______________________________________________

_______________________________________________

14. Was access cut to your property? [✓] Yes [ ] No

15. If so, on what road, approximately where, and for how long?
Pasteur St

_______________________________________________

16. Where was the water flowing from and to?
From Pasteur St through yard to yard backing in Darwin St

17. Was the water following fast or slow? [ ] Fast [ ] Slow

Estimated speed: _______________ metres/second

18. How quickly did the water rise? [ ] Fast [ ] Slow

Estimated speed: _______________ metres/minute

19. Using the town map would you please draw where the flood or stormwater flowed or reached in relation to your property?
away at time of flood - Result of passage of water was scouring through length of yard. Undermining of blocks of House to make a lean of 15 cm's from front corner of house to diagonal back corner of house
1997 Water came through but only to height of ½ metre -

20. Do you have any photographs, videos or other information about flooding in your area, which you would be prepared to make available (on loan?

[ ] Yes
[✓] No

21. Do you have any information, such as flood marks, which would help us identify water levels at particular times through the most recent flood?

[✓] Yes
[ ] No

If you have relevant information or if you have any other relevant information, please provide your telephone number so that we may contact you.

Telephone number: 0746571230

Other comments

above flood level access in town as. helipad. as roads ar cut both sides of town & airship is under w.

Thank you completing this survey


DARWIN ST
PASTEUR ST
PLAYFAIR ST
EDISON ST
TYNDALL ST
FARADAY ST
DAVY ST
BESSEMER ST
HUXLEY ST
LYON ST
JERICHO
BUSINESSES
HOUSES

(6)

Connell Wagner

## Activity Three: Flood Mitigation Options

Name (optional): ____________________

How can the impact of flooding on the Town of Jericho be reduced? Comment on the following ideas and suggest any others.

| Mitigation Option | (Please Tick) Agree | Disagree | Unsure | Comments |
|---|---|---|---|---|
| Changes to existing or new Levee bank/s | | | ✓ | |
| Upgrading road/rail creek and waterway crossings | | | ✓ | |
| Changes to road and rail links | ✓ | | | |
| Desilting of town weir | ✓ | | | |
| Development and implementation of flood warning system | ✓ | | | |
| Raising of house levels | | | ✓ | |
| Other | | | | |

9
9
6
8
6
5
2

Connell Wagner

10

## Activity Three: Flood Mitigation Options

Name (optional): KING

How can the impact of flooding on the Town of Jericho be reduced? Comment on the following ideas and suggest any others.

| Mitigation Option | (Please Tick) | | | Comments |
|---|---|---|---|---|
| | Agree | Disagree | Unsure | |
| Changes to existing or new Levee bank/s | ✓ | | | |
| Upgrading road/rail creek and waterway crossings | ✓ | | | |
| Changes to road and rail links | | | | |
| Desilting of town weir | ✓ | | | |
| Development and implementation of flood warning system | ✓ | | | |
| Raising of house levels | | | | |
| Other<br>PROTECT CEMETRY WITH LEAVE | | | | |

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## Activity Three: Flood Mitigation Options

Name (optional): ____________________

How can the impact of flooding on the Town of Jericho be reduced? Comment on the following ideas and suggest any others.

may not help as water curves around at end of weir

| Mitigation Option | (Please Tick) | | | Comments |
|---|---|---|---|---|
| | Agree | Disagree | Unsure | |
| Changes to existing or new Levee bank/s | | | ✓ | • Link two levees? • ~~Link~~ Levee b/w cemetery hill + high bank of river? • Point of concern of intensity b/w cemetery & high bank (north of cemetery) |
| Upgrading road/rail creek and waterway crossings | | | | |
| Changes to road and rail links | | | | |
| Desilting of town weir | | ✓ | | |
| Development and implementation of flood warning system | | | | |
| Raising of house levels | | | | |
| Other DIVERTING THE RIVER – | | | ✓ | channel from upstream of out~~back~~ reaks down to past race course. Not to divert all flow but to split up flow |

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Connell Wagner

## Activity Three: Flood Mitigation Options

Name (optional): Chris

How can the impact of flooding on the Town of Jericho be reduced? Comment on the following ideas and suggest any others.

| Mitigation Option | (Please Tick) | | | Comments |
|---|---|---|---|---|
| | Agree | Disagree | Unsure | |
| Changes to existing or new Levee bank/s | ✓ | | | Current Levee helps ; consider other Levee's on East & west side of town. |
| Upgrading road/rail creek and waterway crossings | ✓ | | | culvents under railway to west need to be made much larger and maintained. |
| Changes to road and rail links | | ✓ | | |
| Desilting of town weir | | | | |
| Development and implementation of flood warning system | | | | |
| Raising of house levels | | | | |
| Other | | | | |

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## Activity Three: Flood Mitigation Options

Name (optional): ____________________

How can the impact of flooding on the Town of Jericho be reduced? Comment on the following ideas and suggest any others.

| Mitigation Option | (Please Tick) | | | Comments |
|---|---|---|---|---|
| | Agree | Disagree | Unsure | |
| Changes to existing or new Levee bank/s | | | | Existing Levee is Doing its Job. |
| Upgrading road/rail creek and waterway crossings | | | | Existing Railway Culverts are inadequate & not maintained. |
| Changes to road and rail links | | | | |
| Desilting of town weir | | | | |
| Development and implementation of flood warning system | | | | |
| Raising of house levels | | | | |
| Other | | | | OPEN Drain at North West of Town. is Weird Design Stoping Flow of Water. |

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**Activity Three: Flood Mitigation Options**

Name (optional): Mick Wells

How can the impact of flooding on the Town of Jericho be reduced? Comment on the following ideas and suggest any others.

| Mitigation Option | (Please Tick) | | | Comments |
|---|---|---|---|---|
| | Agree | Disagree | Unsure | |
| Changes to existing or new Levee bank/s | ✓ | | | LENGTHEN LEVIE SOUTH ALONG WEST SIDE TUMBAR Rd. |
| Upgrading road/rail creek and waterway crossings | ✓ | | | 1990 RAILLINE WASHED AWAY AND LET WATER AWAY 1997 WATER STAYED IN TOWN LONGER. |
| Changes to road and rail links | ✓ | | | MORE DRAINAGE BLACKALL & BARCALDINE ROAD AND RAIL. |
| Desilting of town weir | | | | |
| Development and implementation of flood warning system | | | | |
| Raising of house levels | | ✓ | | |
| Other | | | | DRAINAGE UNDER RAIL NTH WEST CR TOWN THE WHOLE TOWN DRAINS THROUGH ONE 4' CULVERT. |

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**Activity Three: Flood Mitigation Options**

Name (optional): ___________________

How can the impact of flooding on the Town of Jericho be reduced? Comment on the following ideas and suggest any others.

| Mitigation Option | (Please Tick) | | | Comments |
|---|---|---|---|---|
| | Agree | Disagree | Unsure | |
| Changes to existing or new Levee bank/s | ✓ | | | |
| Upgrading road/rail creek and waterway crossings | ✓ | | | |
| Changes to road and rail links | ✓ | | | |
| Desilting of town weir | ✓ | | | |
| Development and implementation of flood warning system | | ✓ | | |
| Raising of house levels | | ✓ | | |
| Other | | | | |

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**Activity Three: Flood Mitigation Options**

Name (optional): Al Masters

How can the impact of flooding on the Town of Jericho be reduced? Comment on the following ideas and suggest any others.

| Mitigation Option | (Please Tick) | | | Comments |
|---|---|---|---|---|
| | Agree | Disagree | Unsure | |
| Changes to existing or new Levee bank/s | ✓ | | | Levee at 3 mile to Rail |
| Upgrading road/rail creek and waterway crossings | ✓ | | | more culverts & Pipes |
| Changes to road and rail links | | | | |
| Desilting of town weir | ✓ | | | |
| Development and implementation of flood warning system | | ✓ | | |
| Raising of house levels | | ✓ | | |
| Other<br>Sandy Bend<br>Swamp near cemetry - Filling this area | | | | Needs to be ~~desilting~~ desilted (on Tumbar Rd) area<br>Test in modelling |

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Connell Wagner

## Activity Three: Flood Mitigation Options

Name (optional): ____________________

How can the impact of flooding on the Town of Jericho be reduced? Comment on the following ideas and suggest any others.

| Mitigation Option | (Please Tick) | | | Comments |
|---|---|---|---|---|
| | Agree | Disagree | Unsure | |
| Changes to existing or new Levee bank/s | ✓ | | | EXTEND EXISTING LEVY SOUTH AND WEST PUT ANOTHER ONE FURTHER TO THE SOUTH TO |
| Upgrading road/rail creek and waterway crossings | ✓ | | | DIVERT MAIN OUTBREAKS INTO 3 MILE CREEK. |
| Changes to road and rail links | ✓ | | | |
| Desilting of town weir | | ✓ | | |
| Development and implementation of flood warning system | | ✓ | | |
| Raising of house levels | | ✓ | | |
| Other | | | | |

Connell Wagner

**Activity Three: Flood Mitigation Options**

Name (optional): ____________________

How can the impact of flooding on the Town of Jericho be reduced? Comment on the following ideas and suggest any others.

| Mitigation Option | (Please Tick) | | | Comments |
|---|---|---|---|---|
| | Agree | Disagree | Unsure | |
| Changes to existing or new Levee bank/s | | | | |
| Upgrading road/rail creek and waterway crossings | | | | |
| Changes to road and rail links | | | | |
| Desilting of town weir | | | | |
| Development and implementation of flood warning system | | | | |
| Raising of house levels | | | | |
| Other<br>Drainage outlet from town.<br>Railway Creek | | | | → Needs to be upgraded.<br>Consider inflow from this side tributary |

(Quick response time on catchment)

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**Activity Three: Flood Mitigation Options**

Name (optional): A BONHAM

How can the impact of flooding on the Town of Jericho be reduced? Comment on the following ideas and suggest any others.

| **Mitigation Option** | **(Please Tick)** | | | **Comments** |
|---|---|---|---|---|
| | **Agree** | **Disagree** | **Unsure** | |
| Changes to existing or new Levee bank/s | ✓ | | | EXTEND LEVEE BOTH ENDS OR LEVEE BANK & NEW BANK IN BURGOYNE |
| Upgrading road/rail creek and waterway crossings | ✓ | | | MORE BRIDGES & CULVERTS UNDER ROAD & RAIL |
| Changes to road and rail links | | | | AS ABOVE |
| Desilting of town weir | ✓ | | | |
| Development and implementation of flood warning system | ✓ | | | |
| Raising of house levels | | | | |
| Other | | | | |

Connell Wagner

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## Activity Three: Flood Mitigation Options

Name (optional): Joan BYRNE

How can the impact of flooding on the Town of Jericho be reduced? Comment on the following ideas and suggest any others.

| Mitigation Option | (Please Tick) Agree | Disagree | Unsure | Comments |
|---|---|---|---|---|
| Changes to existing or new Levee bank/s | | | | Upgrade |
| Upgrading road/rail creek and waterway crossings | ✓ | | | |
| Changes to road and rail links | ✓ | | | More culverts under rail + road. |
| Desilting of town weir | ✓ | | | |
| Development and implementation of flood warning system | | | | |
| Raising of house levels | | | | New houses to be sited on stumps or raised soil. |
| Other<br>Helipad | ✓ | | | |

C W BRISBANE

25 MAR 2002

REFER TO TDS. 25/3

FILE No. 030002

# Jericho Flood Management Study – Mitigation Options
## Community Feedback

| Name: S/Const MASON | Contact Details: OFFICER IN CHARGE JERICHO POLICE STATION |
|---|---|
| **Mitigation Option 1 – Remove Central Railway (embankments and structures)**<br><br>*Rating*<br>(1) 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |
| **Mitigation Option 2 – Remove Capricorn Highway (embankment and structures)**<br><br>*Rating*<br>(1) 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |
| **Mitigation Option 3 – Upgrade hydraulic structures under Central Railway and Capricorn Highway**<br><br>*Rating*<br>(1) 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |
| **Mitigation Option 4 – Upgrade hydraulic structures under Blackall/Jericho Road and Yaraka/Blackall Railway**<br><br>*Rating*<br>(1) 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |
| **Mitigation Option 5 – Upgrade the culverts at the north-western corner of town**<br><br>*Rating*<br>1 2 3 4 5 6 7 (8) 9 10<br>Undesirable Desirable Very Desirable | Comments: |
| **Mitigation Option 6 – Lower the town weir**<br><br>*Rating*<br>1 2 3 4 5 (6) 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |

# Jericho Flood Management Study – Mitigation Options

## Community Feedback

joanne.taylor@qr.com.au

| | |
|---|---|
| Name: Joanne Taylor | QR 30 Oak Street Barcy. Contact Details: 46515237 (Ph) 46512112 (Fax) |
| **Mitigation Option 1 – Remove Central Railway (embankments and structures)**<br>*Rating*<br>(1) 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | **Comments:**<br>No decrease in the flooding of the town. |
| **Mitigation Option 2 – Remove Capricorn Highway (embankment and structures)**<br>*Rating*<br>(1) 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | **Comments:**<br>No decrease in the flooding of the town. |
| **Mitigation Option 3 – Upgrade hydraulic structures under Central Railway and Capricorn Highway**<br>*Rating*<br>(1) 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | **Comments:**<br>No decrease in the flooding of the town. |
| **Mitigation Option 4 – Upgrade hydraulic structures under Blackall/Jericho Road and Yaraka/Blackall Railway**<br>*Rating*<br>(1) 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | **Comments:**<br>No decrease in the flooding of the town. |
| **Mitigation Option 5 – Upgrade the culverts at the north-western corner of town**<br>*Rating*<br>(1) 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | **Comments:** No great decrease in the water levels in town. Do these culverts need to have one way flood gates to prevent the water coming back in to the north west corner of town. Will this increase the localised flooding from local (town) water |
| **Mitigation Option 6 – Lower the town weir**<br>*Rating*<br>(1) 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | **Comments:**<br>No decrease in the water levels in town. |

18 MAR 2002

REFER TO: TDG | TDG 13/3

FILE No. 03000 ...

# Jericho Flood Management Study – Mitigation Options
## Community Feedback

| Name: RUTH BONHAM | Contact Details: P.O. BOX 16 JERICHO 4728 HOME 46514171 A/H. |
|---|---|
| **Mitigation Option 1 – Remove Central Railway (embankments and structures)**<br>*Rating*<br>(1) 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | **Comments:**<br>NOT REALLY FEASABLE |
| **Mitigation Option 2 – Remove Capricorn Highway (embankment and structures)**<br>*Rating*<br>(1) 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | **Comments:**<br>AS ABOVE |
| **Mitigation Option 3 – Upgrade hydraulic structures under Central Railway and Capricorn Highway**<br>*Rating*<br>1 2 3 4 5 (6) 7 8 9 10<br>Undesirable Desirable Very Desirable | **Comments:**<br>MAY REDUCE TIME ROAD IS CLOSED |
| **Mitigation Option 4 – Upgrade hydraulic structures under Blackall/Jericho Road and Yaraka/Blackall Railway**<br>*Rating*<br>1 2 3 4 5 (6) 7 8 9 10<br>Undesirable Desirable Very Desirable | **Comments:**<br>MAY HELP MITIGATE FLOODING FROM LOCAL RAIN IN N.W. CORNER OF TOWN. |
| **Mitigation Option 5 – Upgrade the culverts at the north-western corner of town**<br>*Rating*<br>1 2 3 4 5 (6) 7 8 9 10<br>Undesirable Desirable Very Desirable | **Comments:**<br>AS ABOVE |
| **Mitigation Option 6 – Lower the town weir**<br>*Rating*<br>(1) 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | **Comments:** |

# Jericho Flood Management Study – Mitigation Options
## Community Feedback

| Name: | Contact Details: |
| --- | --- |
| **Mitigation Option 1 – Remove Central Railway (embankments and structures)**<br><br>*Rating*<br>1 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |
| **Mitigation Option 2 – Remove Capricorn Highway (embankment and structures)**<br><br>*Rating*<br>1 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |
| **Mitigation Option 3 – Upgrade hydraulic structures under Central Railway and Capricorn Highway**<br><br>*Rating*<br>1 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |
| **Mitigation Option 4 – Upgrade hydraulic structures under Blackall/Jericho Road and Yaraka/Blackall Railway**<br><br>*Rating*<br>1 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |
| **Mitigation Option 5 – Upgrade the culverts at the north-western corner of town**<br><br>*Rating*<br>1 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |
| **Mitigation Option 6 – Lower the town weir**<br><br>*Rating*<br>1 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |

# Jericho Flood Management Study – Mitigation Options
## Community Feedback

| Name: | Contact Details: |
|---|---|
| **Mitigation Option 1 – Remove Central Railway (embankments and structures)**<br><br>*Rating*<br>1 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |
| **Mitigation Option 2 – Remove Capricorn Highway (embankment and structures)**<br><br>*Rating*<br>1 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |
| **Mitigation Option 3 – Upgrade hydraulic structures under Central Railway and Capricorn Highway**<br><br>*Rating*<br>1 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |
| **Mitigation Option 4 – Upgrade hydraulic structures under Blackall/Jericho Road and Yaraka/Blackall Railway**<br><br>*Rating*<br>1 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |
| **Mitigation Option 5 – Upgrade the culverts at the north-western corner of town**<br><br>*Rating*<br>1 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |
| **Mitigation Option 6 – Lower the town weir**<br><br>*Rating*<br>1 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |

| | |
|---|---|
| **Mitigation Option 7 – Extend existing levee west to Yaraka/Blackall Railway**<br><br>*Rating*<br>1 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |
| **Mitigation Option 8 – Construct a new levee following the western bank of Jordan Ck from the Central Railway, around the south-eastern corner of town through to the existing levee**<br><br>*Rating*<br>1 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |
| **Mitigation Option 9 – Extend the existing levee south-east along the Tumbar Road**<br><br>*Rating*<br>1 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |
| **Mitigation Option 10 – Combination of Options 7 and 9**<br><br>*Rating*<br>1 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |
| **Mitigation Option 11 – Same as Option 10 but including levee round property to east of Creek**<br><br>*Rating*<br>1 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | |
| **Preferred Mitigation Option:** | Comments:<br>AL BONHAM<br>DAVY ST |
| **Other Suggestions/Comments:** | JERICHO |

# Jericho Flood Management Study – Mitigation Options
## Community Feedback

4983 8743.

| Name: Scott Meyn | Contact Details: Main Roads - Emerald |
|---|---|
| **Mitigation Option 1 – Remove Central Railway (embankments and structures)**<br><br>*Rating*<br>(1) 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | **Comments:** |
| **Mitigation Option 2 – Remove Capricorn Highway (embankment and structures)**<br><br>*Rating*<br>(1) 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | **Comments:** |
| **Mitigation Option 3 – Upgrade hydraulic structures under Central Railway and Capricorn Highway**<br><br>*Rating*<br>(1) 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | **Comments:**<br>Has little improvement for works. |
| **Mitigation Option 4 – Upgrade hydraulic structures under Blackall/Jericho Road and Yaraka/Blackall Railway**<br><br>*Rating*<br>1 (2) 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | **Comments:** |
| **Mitigation Option 5 – Upgrade the culverts at the north-western corner of town**<br><br>*Rating*<br>1 2 (3) 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | **Comments:** |
| **Mitigation Option 6 – Lower the town weir**<br><br>*Rating*<br>1 (2) 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | **Comments:** |

MICK WELL

# Jericho Flood Management Study – Mitigation Options

## Community Feedback

| Name: | Contact Details: |
|---|---|
| **Mitigation Option 1 – Remove Central Railway (embankments and structures)**<br><br>*Rating*<br>1 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |
| **Mitigation Option 2 – Remove Capricorn Highway (embankment and structures)**<br><br>*Rating*<br>1 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |
| **Mitigation Option 3 – Upgrade hydraulic structures under Central Railway and Capricorn Highway**<br><br>*Rating*<br>1 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |
| **Mitigation Option 4 – Upgrade hydraulic structures under Blackall/Jericho Road and Yaraka/Blackall Railway**<br><br>*Rating*<br>1 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |
| **Mitigation Option 5 – Upgrade the culverts at the north-western corner of town**<br><br>*Rating*<br>1 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |
| **Mitigation Option 6 – Lower the town weir**<br><br>*Rating*<br>1 2 3 4 5 6 7 8 9 10<br>Undesirable Desirable Very Desirable | Comments: |

# Appendix C

*Statutory Obligations*

## Table C1: Statutory Obligations

| Legislation | Description | Relevance | Licence/Permit |
|---|---|---|---|
| *Environmental Protection Act 1994* | All persons have a general environmental duty not to cause environmental harm, and to report any harm that does occur. | The project must comply with the Act and not cause environmental harm. | All activities will need to ensure they do not cause environmental harm. |
| | From July 2002, construction activities will become an environmentally relevant activity (ERA). A licence to carry out the proposed works may therefore be required. | Construction activities undertaken in the project area may be ERAs and a licence may therefore be required. | If an ERA is occurring on site, a licence under the *Environmental Protection Act 1994* may be required after July 2002. |
| | The provisions for contaminated land are included in this Act. | A search of the contaminated land and environmental management registers must be undertaken in order to determine whether there are any registered sites within the project area. | If the site is registered, then a soil investigation needs to be undertaken in order to determine whether the soil is contaminated. If the tests reveal that the soil is contaminated, then a disposal permit from the EPA is required. |
| *Environmental Protection (Water) Policy 1997* | This policy applies to all activities that have the potential to impact on water quality. Sections 31 and 32 of the policy prohibit the deposit or release of material such as building waste, cement or concrete, rubbish and oil into a stormwater drain and water body or a place where it could be washed into these places. | The project may impact upon this issue and therefore this policy must be adhered to. | No licence is required but compliance with the relevant provisions is required. |
| *Environmental Protection (Noise) Policy 1997* | Section 11 of the policy sets acoustic quality objectives whilst Part 3 deals with the evaluation procedure and the approval of a Draft Environmental Management Program. Part 4 of the policy deals with abatement of unreasonable noise and is intended to provide measures for nuisance noise controls. Part 6 sets out details of the procedures and equipment suggested for making noise assessment. Schedules 1 and 3 of the policy outline planning levels and prescribe information for particular noise generating works. | The project may impact upon this issue and therefore this policy must be adhered to. | No licence is required but compliance with the relevant provisions is required. |

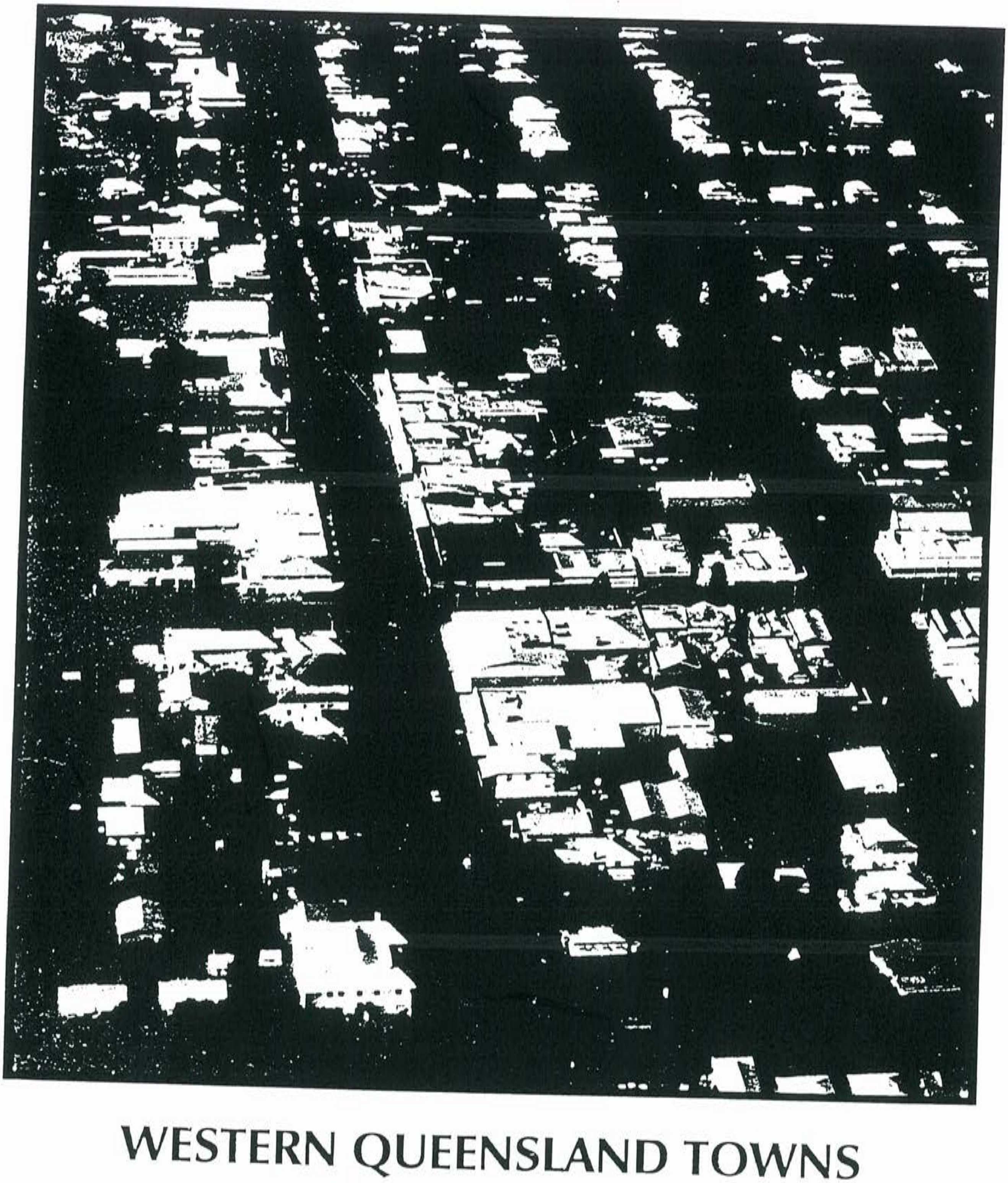
| Legislation | Description | Relevance | Licence/Permit |
|---|---|---|---|
| *Environmental Protection (Air) Policy 1997* | Part 3 of the policy covers environmental management decisions and air pollution dispersion modelling and monitoring of releases. Part 4 covers management of certain sources of contamination with Part 5 requiring a whole-of-government approach to managing the air environment. Schedule 1 states air quality indicators for carbon monoxide, lead, nitrogen dioxide, ozone, particulates and sulphur dioxide. Goals for each of these pollutants are also stated. | The project may impact upon this issue and therefore this policy must be adhered to. | No licence is required but compliance with the relevant provisions is required. |
| *Environmental Protection (Waste Management) Regulation 2000* | The regulation provides for offences for littering and waste dumping. It also provides for a waste tracking system which tracks specified waste and obtains data on the generation, transportation and treatment/disposal of these wastes within Queensland and interstate. | The project will generate waste during the construction phase. | Compliance with the relevant provisions is required. |
| *Environmental Protection (Nuisance) Regulation 2000* | The environmental nuisance laws aim to strike a balance between protecting our quality of life and the reasonable pursuit of activities that have the potential to annoy others. The laws specify conditions, hours of operation and noise levels for activities, including building works and construction sites. | Noise will most likely be generated during the construction phase of the project. | Compliance with the relevant provisions is required. |
| *Environment Protection and Biodiversity Conservation Act 1999* | This Act establishes a Commonwealth administrated environmental assessment and approval system that will operate in addition to but separate from the Queensland system. Approval is required under the Act for matters of national environmental action that will have or is likely to have a significant impact on a matter of national environmental significance. | Preliminary investigations have revealed that the project area does not contain any flora/fauna species and ecosystems that are of national environmental significance, as defined under the Act. | Not applicable. |

| Legislation | Description | Relevance | Licence/Permit |
|---|---|---|---|
| *Water Act 2000* | This Act provides, among other things, for the allocation and sustainable management of water. It affirms that all rights to the use, flow and control of all water in Queensland are vested in the State (s.19). It also provides that a person may take or interfere with overland flow water for any purpose unless there is a moratorium notice or a water resource plan that limits or alters the water that may be taken or interfered with (s.20(6)). 'Overland Flow Water' includes floodwater (Schedule 4). | A Water Resource Plan has been prepared for the Cooper Creek Catchment. Section 9 of the Plan refers to environmental principles and provides that water resources for ecologically significant areas, including for example landscapes and wetlands, must be protected.<br>It is not known at this stage whether the plan restricts the interfering with overland flow. | Currently under investigation. |
| *Floodplain Management In Australia – Best Practice Principles and Guidelines* | This is a non-statutory document which provides a set of best practice principles and guidelines for the management of risks associated with flooding. It is primarily directed to flood hazard management. | The principles and guidelines within this document may have some relevance to the design and implementation of the proposed flood mitigation measures. | This document has no statutory force but it is recommended that the principles and guidelines outlined within the document be considered during the design and implementation of the proposed flood measures. |
| *Nature Conservation Act 1992* and *Nature Conservation Regulation 1994* | The Act provides for the conservation of nature in two ways – the declaration and management of protected areas, and the protection of native wildlife that is not found within a protected area. Section 89 of the Act restricts the taking of protected plants other than under a conservation plan applicable to the plan; a licence, permit or other authority issued or given under a regulation; or an exemption under a regulation. | The proposed works may impact upon a protected plant. | If future ecological studies indicate that the proposed works will involve the taking of a protected plant, then a clearing permit under the *Nature Conservation Regulation 1994* will be required. |
| *Native Title Act 1993* | The Native Title Act applies to all lands where a Native Title claim has been lodged. | A claim may have been lodged over the area. | A review of claims lodged will need to be undertaken to determine if consultation with Native Title claimants is required. |

# Appendix D

***Scott and Furphy Report***

WATER RESOURCES COMMISSION



# WESTERN QUEENSLAND TOWNS FLOOD STUDY

## Volume 1 - Report

SCOTT & FURPHY PTY. LTD.

January 1991

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WATER RESOURCES COMMISSION

# WESTERN QUEENSLAND TOWNS FLOOD STUDY

## Volume 1 - Report

January 1991

SCOTT & FURPHY PTY. LTD.

**WESTERN QUEENSLAND TOWNS FLOOD STUDY**

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**VOLUME 1 – REPORT**

Cover Photograph – Charleville Central Business District during April 1990 flood

# 10. JERICHO

## 10.1 INTRODUCTION

Jericho is situated on the Capricorn Highway 53km west of Alpha and 83 km east of Barcaldine. The Rockhampton to Longreach railway passes through the town. The location of the township is shown on Figure 1.1 and the map of the town showing the extent of inundation in the April 1990 flood is given in Figure 10.1.

The population of Jericho is about 170. There are about 55 houses and 5 businesses most of which are located in Darwin Street. In the April 1990 flood 20 houses were inundated (overfloor flooding), 5 suffering major damage.

The whole township is located in the floodplain of Jordan Creek which flows in a northerly direction along the eastern edge of Jericho. A weir has been constructed on Jordan Creek immediately upstream of the railway crossing to provide town water and originally to provide water for railway locomotives. The weir crest is at about 348.5 AHD, about 3m above creek bed level.

The town generally slopes away from the river bank so once overbank flow is initiated, rapid inundation follows. Natural drainage is impeded by the railway line which although being only slightly elevated above natural level has very restricted culvert capacity, suitable for local drainage only.

Jordan Creek flows north from Jericho before turning west to flow into the Alice River north east of Barcaldine.

## 10.2 FLOOD MECHANISM

Flooding is caused by levels in Jordan Creek on the eastern side of Jericho exceeding bankfull. The crest level of the weir is at 348.5m AHD and floodwaters first enter the town when water levels rise to 349.6m AHD, only 1.1m AHD above weir crest level.

Floodwaters first enter the town at the south east corner of Davy Street between Bessemer and Lyon Streets. This water is from the old meander forming a previous river course and not directly from the current course. This breakout water flows north-westerly towards the lowest point (Playfair/Darwin Streets), the northern section of the Playfair Street reserve being a drain. The slope of the town is such that the ground surface falls away from the river bank, so that once overflow occurs from the river, the township is rapidly inundated. Furthermore, the Playfair Street drain has very little outlet capacity, only 2 very small culverts under the railway. Thus ponding occurs until the railway is overtopped.

Floodwaters pass over the railway flowing north back towards the creek.

During major floods as occurred in 1990, floodwaters are extensive, both east and west. Some of the floodwaters pass south of Jericho to join up with Woololla and Mistake Creeks. There were extensive washouts on the railway line west of Jericho due to floodwaters in the latter creeks, which far exceeded waterway capacity.

General overtopping along the properties between Lyon Street and the river occurs at about 350m AHD.

A partial levee system was constructed some time in the past but has fallen into disrepair and is ineffective in excluding floodwaters from the township.

## 10.3 APRIL 1990 FLOOD

### 10.3.1 General

The flood of April 1990 was the highest since settlement of Jericho. There is currently no official flood gauge at Jericho, but post-flood surveys have indicated a peak water level adjacent to the creek of 350.3m AHD, compared to the previous highest level of approximately 350.0 AHD recorded in 1950.

Widespread heavy rain caused flooding in Woololla and Mistake Creeks causing closure of the Capricorn Highway at the crossings of these creeks from 18th April.

Very heavy rain in the Jordan Creek catchment (see Chapter 2) caused rapid rise in levels, with the result that breakout flow was initiated at the eastern end of Davy Street at about 5.30am on 19th April 1990. Continued river rise led to overflow occurring northwards from this point along the entire Lyon Street creek frontage as far as the weir, with peak level being reached about 6.00pm on 19th April.

As stated previously the town slopes away from the river bank, so flooding was widespread. Deeper flooding occurred in the northwest corner, made worse by the damming effect of the railway at this point where culvert capacity is inadequate. Overtopping of the railway through the town and both east and west of the town occurred as the floodwaters flowed northerly back towards the river channel. Subsequent railway reconstruction using rock material in the embankment means these are less likely to washout in the future but this could transfer problems to other points.

The entire township was inundated, the only spot above water being the railway level crossing at the east end of town.

Floodwaters also pass westerly across the southern edge of the town being partly diverted away from the town by the existing levee. The absence of detailed plans of the levee means that this role cannot be determined accurately at this time.

### 10.3.2 Flood Levels and Depths

As discussed above, the entire township was inundated with minimum depth occurring near the river bank, and maximum depth up to about 1m occurring in the north west corner of the town.

The extent of flooding is shown on Figure 10.1. The flood levels were established by post-flood surveys (Dept. of Transport and George Bourne & Associates) and the peak level, near the weir was 350.3m AHD compared to the previous record depth of about 350.0m AHD in 1950.

Data on flood levels and depths are only available from the following sources.

- post–flood surveys of peak flood levels;

- flood depths estimated as the difference between water surface levels and ground levels ascertained from the available contour mapping.

Approximate maps of water surface levels and flood depth have been prepared and are given in Figures 10.2 and 10.3.

### 10.3.3 Flow Direction

Flow directions have been determined from the following:

- debris on fences;
- photographic evidence;
- eye–witness evidence (Police, residents);
- hydraulic evidence from flood levels.

The best interpretation of the flow direction of the floodwaters from the available evidence is given in Figures 10.3. The flow was generally north westerly from the river through the town and discharging over the railway line.

### 10.3.4 Velocity of Flow

In the absence of discharge data, it has not been possible to quantify estimates of velocity.

However, velocities are known to have been such as to cause washout of the railway line and other scouring. This indicates that velocities of the order of 2m/s or more occurred at least locally. Local effects such as flow between houses, or even around vehicles, can cause critical velocity to be exceeded even when the average velocity is substantially less.

Velocities can also be higher during the recession phase when depths are reducing and typically much of the scour can occur at that time.

## 10.4 HYDRAULIC MODELLING

In the absence of any records on discharges and formal records of water levels, and due to the extensive nature of the flooding around Jericho, it was not possible to carry out any hydraulic model studies.

## 10.5 FLOOD WARNING AND COMMUNITY RESPONSE

### 10.5.1 Flood Warning

Flood warning for Jericho is currently based on the informal gathering of information from property owners upstream at Burgoyne (about 5km upstream) and at Tumbar (about 55km upstream).

The absence of gauge boards on the river at Jericho hampers the recording of river level readings.

Information on upstream river levels is currently gathered by the Jericho Police. Jericho Shire operates a system of Yellow, Blue and Red alerts.

The Bureau of Meteorology in conjunction with Jericho Shire Council are currently planning to initiate a formal flood warning station for Jericho by installing a river level station at Jericho and an additional station upstream at Glenco which is situated about 10km upstream. As this would be expected to provide only a few (2-4) hours warning, consideration should also be given to installation of a station further upstream, say at Tumbar in order to increase the warning time to 8-12 hours.

### 10.5.2 Community Response

Community Response in Jericho is believed to have been adequate due to; the relatively small number of houses and businesses inundated enabling the Police to warn individual householders and business operators; the relatively shallow nature of the floodwaters; and prior flood experience (it being understood that local flooding occurs quite frequently).

### 10.5.3 Recommendations

Those factors pertaining to the actual procedures for evacuation in the event of major flooding relating to preparation of the Local Counter Disaster Plan and the level of equipment available are outside the scope of this Report.

However, there are a number of factors which have adversely impacted on the effectiveness of the flood warnings and their dissemination to the public, and which should be addressed. These are:

| Problem | Recommended Action |
|---|---|
| Currently no official warnings for Jericho | Upgrade flood warning system as recommended by CBM plus further station upstream |
| Local warnings of a qualitative nature only - gives low level of credibility and makes warnings difficult to interpret | Develop hydrologic model to enable issue of quantitative warnings |

| | |
|---|---|
| Warnings contain insufficient detail | Residents need to know flood level at their own property and along exit routes. |

It is recommended that public awareness to flooding be raised and that future warnings are made more meaningful. In order to achieve this the following actions are proposed:

- production of public awareness leaflet which should include the following:

  - brief explanation of the nature and extent of flooding in Jericho;
  - a simple explanation of flood probability so that residents realise that a major flood can occur at any time, and that having had a recent flood does not give immunity for years to come;
  - a map showing flood extent and depth (as given in this Report);
  - brief explanation of flood warnings, how to relate the warning to flood levels at each house, and how to respond;
  - brief explanation of evacuation procedures.

  These leaflets should be initially distributed to each household, and then periodically, say on issue of the annual rates notice, and should be readily available for non-ratepayers from the Shire Office, Library, etc.

- Preparation and mounting of a large scale map of flood extent and depth in a prominent position in the town.

- The erection of permanent notices throughout the town showing the record flood level. These should be prominent signs attached to telephone/power poles or other appropriate street furniture to act as a constant reminder and to rapidly educate newcomers. future flood warnings can then refer to expected level relative to 1990 level in a meaningful way.

- The development of tables giving the depth of inundation for each flood liable property for any forecast flood height. This could be carried out as an extension of the data base developed during the current Study (as given in Appendix B). This information could then be used to determine needs and priorities for evacuation during future floods.

## 10.6 OPTIONS FOR FUTURE FLOOD MANAGEMENT

### 10.6.1 General

Both structural and non-structural options have been considered in the range of options for future flood management in Jericho.

After a general consideration of options, greater detail is given regarding those options considered feasible.

### 10.6.2 Structural Measures

Structural flood mitigation options for Jericho must be considered in the context of the extensive flooding which occurs, with the joining of floodwaters from adjacent catchments to both east and west. This situation results in a number of mitigation options not being feasible.

The following options have been considered:

- Storage – not feasible due to the large flood volumes, lack of suitable storage sites and the extensive regional flooding which would result in inundation of Jericho even if peak flows in Jordan River could be reduced.

- Levee construction – due to Jericho being located not only in the floodplain of the Jordan Creek but also liable to inundation from adjacent waterways, a levee would essentially be of a 'ring' levee type, with the railway line forming one side of the levee. There is room to construct a levee behind the properties in Lyon Street, to be tied in to the railway line near the existing weir. This would extend along the edge of the old channel near Davy Street to exclude flood waters where breakout flows first occur, then south of Hadley Street and west of Playfair Street to tie into the Jericho–Blackall railway line. The railway line in this area would need to be raised to match the levee crest height. A road crossing will need to be constructed on the Blackall–Jericho Road and on Faraday Street.

  The location of the levee is shown on Figure 10.4.

  Provision for drainage from within the levee would be required, and this would necessitate additional drainage capacity under the railway to allow drainage to the north.

  In the absence of hydraulic model studies it is not possible to estimate the effect of the levee on flood levels outside, but due to the extensive nature of the flood waters, this is expected to be minor.

- Channel enlargement and clearing – not applicable.

- Flood diversion – a flood diversion is potentially possible to the east ofJericho but this would only be effective in minor floods – in major floods the extent of floodwaters would render such a diversion ineffective.

- Weir reconstruction – the existing fixed weir causes a significant increase in flood levels locally. This could be offset by constructing a diversion channel fitted with a flood gate section which could be opened during flood periods to reduce flood levels. However, this again is likely only to be successful for minor floods, as during major floods the extensive nature of the floodwaters will reduce the effectiveness of this measure.

- Housing raising and flood proofing of commercial premises would reduce flood damages without impeding the passage of floodwaters.

- Enhanced drainage capacity – existing local drainage within the township is restricted to a small number of small capacity culverts under the railway. According to residents, these are inadequate to cope with even local drainage and severely impede the passage of floodwaters. Significantly increasing the drainage capacity under the railway, possibly by the use of trestle sections, would result in lower flood levels in the town.

### 10.6.3 Non-Structural Options

Non-structural options include the following:

- Upgrading of the flood warning system as suggested by CBM plus an additional station upstream as noted in 10.5.1. This could include flood modelling to enable quantitative forecasting.

  The usefulness of the warnings to the general public should also be improved as discussed in Section 10.5.

- Planning controls - as the whole town is built on the floodplain there is little to be done in this regard unless no further building is allowed. However, it is recommended that any new building be raised at least 0.5m above 1990 flood level, or say 1.5m above ground level.

- Public awareness - the installation of markers in each street to indicate the 1990 flood level is recommended as an immediate measure. This will provide a high level of awareness even after memories dim, and for new residents with no flood experience.

### 10.6.4 Selected Options

Of the options considered above, the following are considered worthy of further consideration.

- Levee construction in conjunction with enhanced drainage capacity.

- House raising and flood proofing of commercial premises.

The above are in addition to upgrading of the flood warning system, improving public flood preparedness and the use of planning control to prevent the future construction of low set buildings.

a) Levee construction

Figure 10.4 shows a sketch of the possible location of the levee. This is indicative only at this stage and does not constitute a firm proposal, but rather illustrates the possibility of protecting the town from future major flood events.

The levee would essentially form a 'ring levee' with the railway line forming one side of the 'ring' which would be completed by construction of a levee round the town tied into the railway at both ends. The section of railway forming part of the levee will need to be raised to the levee crest level.

As the flood waters are extensive, the reduction in flow area resulting from this is not large and a significant increase in flood level is not expected. There would be no requirement for demolition of any houses, although some land acquisition would be required where the levee passes behind the houses in Lyon Street. Road crossings would be required on Faraday Street and Davy Street. Some improvement of drainage capacity under the railway would be beneficial in preventing pondage of local runoff behind the levee.

The levee would be provided with spillways at two or more locations, in order that controlled flooding of the town can occur should the design flood be exceeded. These spillways would be set about 0.6m below levee crest level, so that under these extreme conditions the town would flood relatively slowly. This is to avoid the catastrophic nature of flooding which would occur if the levee overtopped along its entire length with subsequent erosion damage. The 2 spillways mentioned above would be the minimum required, and detailed studies may recommend additional spillway capacity.

The levee would be formed from local clay/loam material assuming this to be available within a reasonable distance from the town. Design studies would need to include geotechnical studies of available material to determine suitable borrow areas and to determine acceptable side slopes. In the absence of this information, it has been assumed for the current purpose of preparing an indicative cost estimate that side slopes of 1 vertical to 4 horizontal are appropriate with a 4m crest width. These shallow side slopes are necessary to avoid undue erosion damage. It will also be necessary for a good grass cover to be established on the levees and maintained in good condition by irrigating from the weir pool. This is essential to prevent erosion damage occurring during flood.

On the above basis, the following indicative cost estimate has been derived.

| | |
|---|---|
| Levee construction including grassing $60,000m^3$ @ $10 | $ 600,000 |
| Railway raising say | $ 200,000 |
| Roadway over levee crossing say | $ 30,000 |
| Spillways, outlet structures say | $ 50,000 |
| Damage improvements, say | $ 50,000 |
| Land acquisition say | $ 50,000 |
| | $ 930,000 |
| Contingency, say 10% | $ 70,000 |
| TOTAL | $1,000,000 |

b) Flood proofing/house raising (all unraised timber/fibro houses)

| | |
|---|---|
| 26 houses @ say $20,000 | $ 520,000 |
| 6 businesses @ say $20,000 | $ 120,000 |
| plus additional railway drainage capacity, say | $ 200,000 |
| | $ 840,000 |

## 10.7 FLOOD DAMAGE STUDIES

### 10.7.1 Residential Damage

Residential flood damage (potential) was estimated both for the 1990 flood and for a range of floods using ANUFLOOD.

The basic statistics of the housing stock included in the survey is given in Tables 32 and 33.

TABLE 32

SUMMARY STATISTICS OF HOUSING STOCK – JERICHO
(Flood liable areas only)

| Description | | Number |
|---|---|---|
| Total number of premises flood liable | | 54 |
| Number single storey | | 54 |
| Number not raised (<0.5m) | | 26 |
| Number raised | | 28 |
| Construction material | – weatherboard/timber | 21 |
| | – fibro | 22 |
| | – brick, masonry | 1 |
| | – metal | 10 |
| | – other | 0 |
| Number non-raised and capable of being raised | | |
| | – weatherboard/timber | 5 |
| | – fibro | 14 |
| | – metal | 6 |

TABLE 33

FREQUENCY ANALYSIS OF HOUSE GROUND AND FLOOR HEIGHTS
JERICHO
(Heights relative to Australian Height datum)

| Height Range m | No. with height above ground in range | No with ground height in range | No. with floor height in range |
|---|---|---|---|
| 0 -0.25 | 26 | | |
| 0.25-0.5 | 5 | | |
| 0.5-0.75 | 5 | | |
| 0.75-1.0 | 0 | | |
| 1 -1.25 | 1 | | |
| 1.25-1.5 | 0 | | |
| 1.5-1.75 | 8 | | |
| 1.75-2.0 | 6 | | |
| 2-2.25 | 3 | | |
| 348-349 | | 34 | 11 |
| 349-350 | | 16 | 22 |
| 350-351 | | 4 | 19 |
| 351-352 | | | 2 |

About 50% of the flood liable houses are not raised significantly above ground level (the 'not raised' category includes houses raised up to 0.5m).
Also, all but one of the 26 unraised houses are of weatherboard/timber, fibro or metal construction so could be raised. Raising of these properties (and possibly further raising of already raised houses) is an option for reducing damages from future floods.

Mean annual residential flood damage was estimated, using ANUFLOOD, to be $5,000. This figure is only approximate as it has been necessary to assume the shape of the stage-probability curve in the total absence of data. Damages for floods of a range of magnitudes are estimated as given in Figure 10.5, with that for 350.3m AHD as reached in April 1990 being about $200,000. These estimates are of low accuracy as they are sensitive to the stage-probability curve which has been assumed. This does not affect the damage estimation for various levels of flooding.

### 10.7.2 Commercial Damage

Summary statistics for commercial premises are given in Tables 34 and 35. There are only 6 commercial premises 4 of which have floor level raised 0.25m or more above ground level. All are of fibro or metal construction.

The mean annual commercial flood damage is estimated at $4,000 and again is only approximate due to the assumed slope of the stage probability curve. The damage for the 1990 flood is estimated at $130,000. Values for a range of flood heights are given in Figure 10.5.

**TABLE 34**

**SUMMARY STATISTICS COMMERCIAL/INDUSTRIAL - JERICHO**

| Description | Number |
|---|---|
| Total number of commercial/industrial premises | 6 |
| Number single storey | 6 |
| Number raised (above 0.5m) | 4 |
| Construction material - weatherboard/timber | 0 |
| - fibro | 1 |
| - brick/masonry/stone | 0 |
| - metal | 5 |
| - other | 0 |

TABLE 35

FREQUENCY ANALYSIS OF GROUND HEIGHTS COMMERCIAL
JERICHO
(Heights relative to Australian Height Datum)

| Height Range m AHD | No. with Ground Height in Range |
|---|---|
| 348-348.5 | 2 |
| 348.5-349 | 3 |
| 349-349.5 | 1 |

### 10.7.3 Total Damage

The above values give a total mean annual direct flood damage of about $9,000 (residential plus commercial), excluding government damages and indirect damages. As stated previously, this figure is put forward to illustrate the relative magnitude of damages compared to flood mitigation works and is not regarded as being of high accuracy. Increasing the direct damage estimates to allow for indirect damages (residential 15%, commercial 55%) brings the total to $12,000 p.a.

The total direct damage for the 1990 flood is estimated to be $0.33 million, and including indirect damages (but excluding government damage, infrastructure damage and vehicle damage) this increases to $0.43 million.

### 10.7.4 Effect of Mitigation Works on Damages

ANUFLOOD was used to investigate the effects of various flood mitigation works on mean annual flood damages and the results are given in Table 36, again with the qualification on accuracy referred to above.

Assuming a real discount rate of 5% (as typically used for public works), the average annual estimated direct and indirect damage cost of $12,000 pa. has a present value of $230,000. This can be compared with the estimated capital cost of the proposed works, assuming these to be completed in a single year.

The levee option, giving protection to 1m above 1990 flood level results (assuming minimal afflux) in a reduction in mean annual flood damages of 87%, so has a present worth benefit of $200,000 (based on a discount rate of 5%) compared to an estimated capital cost of $1.0 million. Hence, this scheme is not economically viable (benefit/cost ratio 0.2) on the basis of residential and commercial damages alone. When government losses and social losses are included, this ratio would increase somewhat, but this figure is still low.

Raising all properties and flood proofing commercial properties at a cost of about $840,000 (26 timber/fibro houses @ $20,000 and plus flood proofing 6 commercial premises at say $20,000 plus additional railway drainage capacity) also has a benefit cost ratio of 0.2 (benefit present value 78% of $0.23 million i.e. $0.18 million) and would not be justifiable on purely economic terms.

## TABLE 36

### EFFECT ON ANNUAL AVERAGE FLOOD DAMAGE FOR A RANGE OF MITIGATION OPTIONS - JERICHO

| Option | Residential $x1000 | Residential Reduction% | Commercial $x1000 | Commercial Reduction | Total Direct $x1000 | Total Direct Red% |
|---|---|---|---|---|---|---|
| Nil | 5 | 0 | 4 | 0 | 9 | 0% |
| Levee giving protection to | | | | | | |
| 350m AHD | 4.4 | 10% | 3.3 | 12% | 7.7 | 15% |
| 350.3m AHD | 2.8 | 44% | 2.1 | 46% | 4.9 | 45% |
| 351.3m AHD | 0.7 | 86% | 0.5 | 88% | 1.2 | 87% |
| Raising all unraised premises by 1m | 3.1 | 37% | 3.2 | 16% | | |
| 2m | 2.0 | 60% | N/A | | | |
| Flood proofing to 1m | N/A | | 1.5 | 60% | | |
| to 2m | N/A | | 0 | 100% | | |
| Raising residential to say 1m above 1990 level & flood proofing commercial to 2m | 2.0 | 60% | 0 | 100% | 2.0 | 78% |
| Relocating all premises below | | | | | | |
| 348m AHD | 5 | 0% | 4 | 0% | 9.0 | 0% |
| 349m AHD | 5 | 0% | 4 | 0% | 9.0 | 0% |
| 350m AHD | 0.6 | 88% | 0 | 100% | 0.6 | 93% |

In terms of relocation, all buildings below 350m AHD would have to be relocated, virtually the entire town, to significantly reduce mean annual damages by 93%. This would involve some 50 houses at a cost per property of say $80,000 (new land and building say $60,000, infrastructure costs say $10,000 per dwelling, demolition say $10,000 per dwelling) giving a total of about $4.0 million i.e. and 5 commercial premises say an average of $100,000 i.e. $0.5 million giving a total of $4.5 million, against a benefit present value of only $0.21 million (benefit/cost ratio 0.05). This is clearly not viable.

Even though the above costs are indicative only, it is apparent none of the above options are viable on a purely economic basis, and could be justified only if social and other intangible losses are taken into account. As the levee option and flood raising/flood proofing have similar cost benefit ratios, the former is preferred as it provides an improved level of protection to infrastructure compared to house raising/flood proofing and also results in less social disruption during flood events.

## 10.8 SUMMARY OF FACTORS IN 1990 FLOOD

The 1990 flood was the highest on record, and resulted in the whole town being inundated.

The main points may be summarised as below:

a) Event probability

The rainfall event producing the flood was estimated to have an AEP of about 0.4% (ARI of 250 years), but in the absence of discharge data this should be regarded as indicative only.

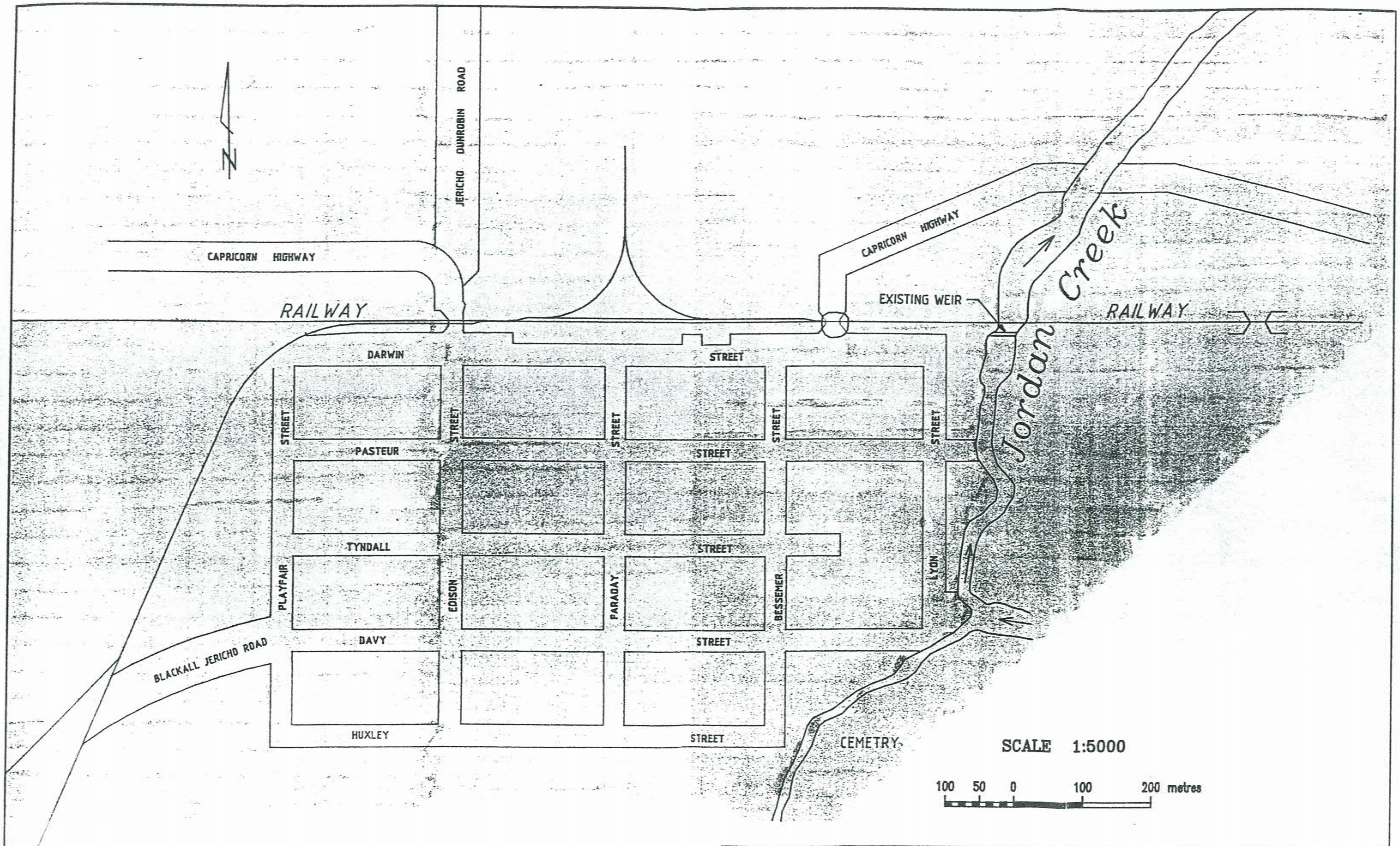
b) Damage Costs

The damage costs were moderate as flood depths and velocities were not great. There was sufficient warning time to allow lifting of goods and the small size of the community facilitated dissemination of flood warnings.

## 10.9 RECOMMENDATIONS

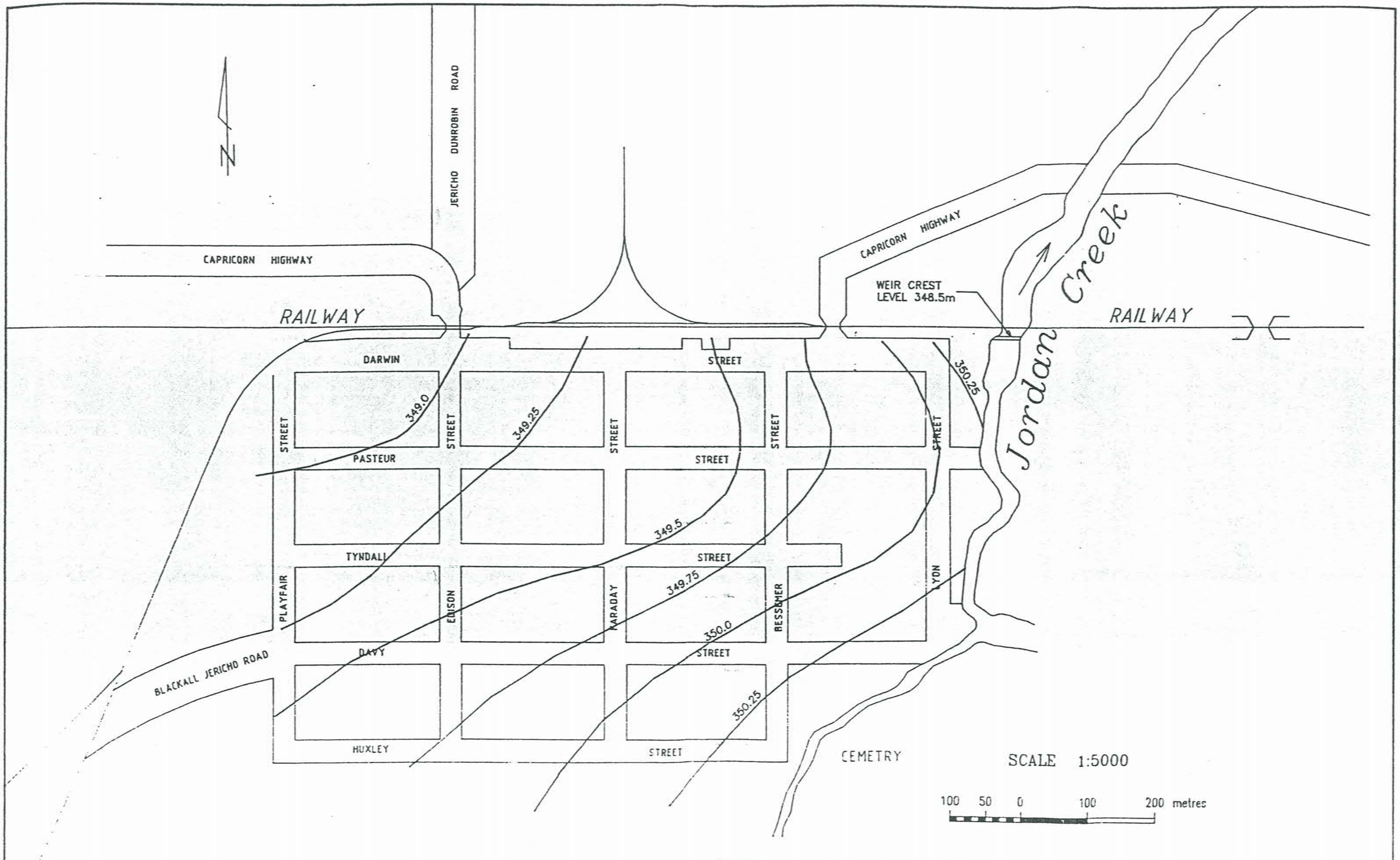
The following recommendations are made in regard to future flood management for Jericho.

- Commission an aerial survey to produce an accurate contour map of the town, the creek channel and a significant surrounding area in order to facilitate detail consideration of the levee option, to accurately survey existing partial levees, and to enable accurate determination of flood flow paths. This should extend to cover the whole flood plain to Woololla and Mistake Creeks which together with Jordan Creek act as a single system during flood.
- Commission detail consideration of levee option. This will require geotechnic and materials inputs in addition to more detailed hydraulic, engineering investigations together with investigation of social and environmental impacts, and an economic study to determine appropriate design criteria as outlined in Section 4.6.5
- Installation of flood markers throughout town and issue maps/leaflet showing flood depths to increase community preparedness for future floods.
- Development of tables of flood depth for a range of flood heights for each property.
- Installation of official flood warning system to include headwaters.
- Development of flood warning models.
- Improve drainage under railway. In the case of the levee option being proceeded with, railway drainage should be improved to enable passage of local drainage flows from within the levee. Should the levee option not be proceeded with, railway drainage should be singificantly augmented in order to allow improved passage of floodwaters.




JERICHO
Flood Inundation April 1990

Figure 10.1




NOTE: Flood surface contours in metres (AHD).

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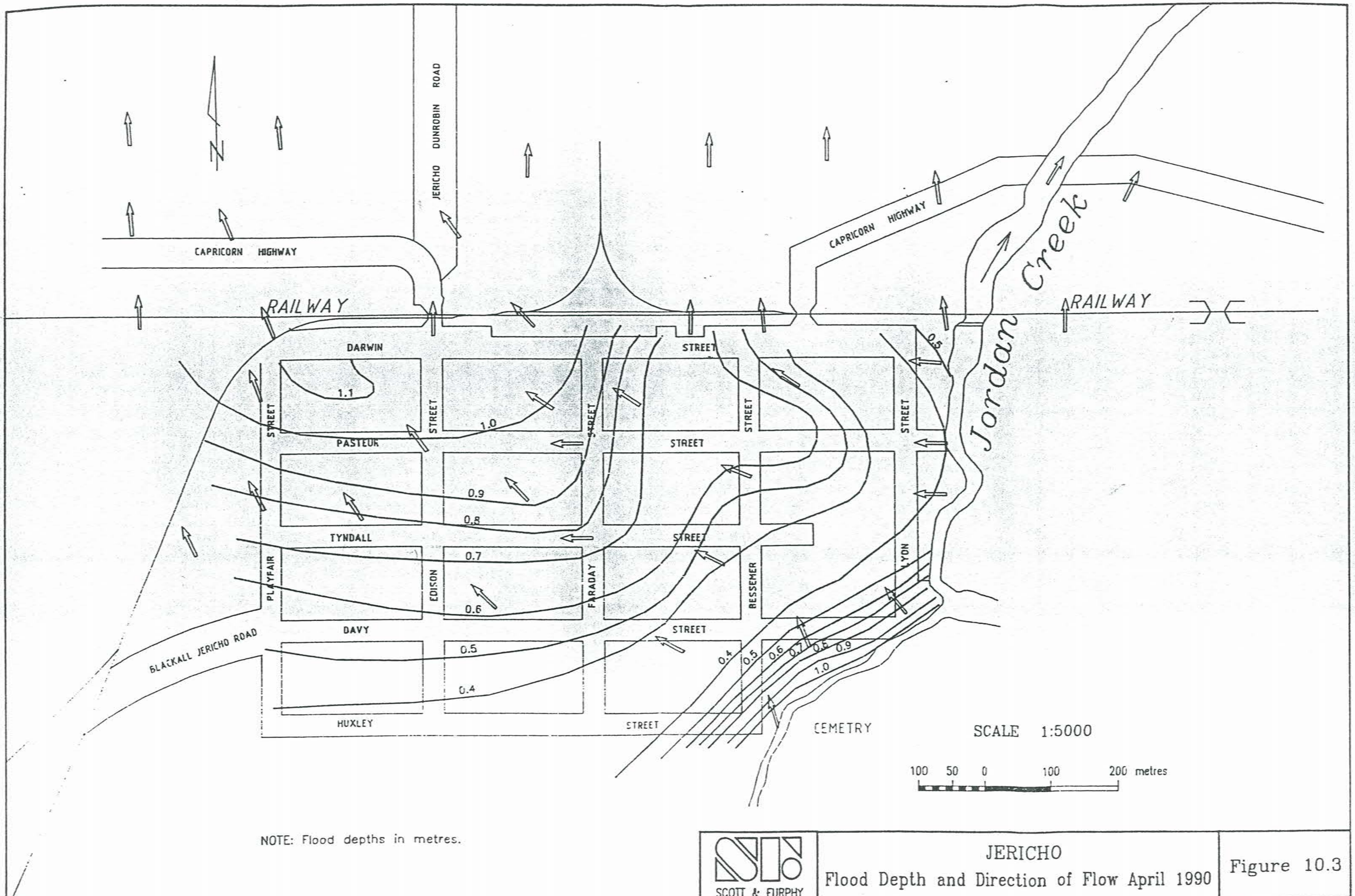
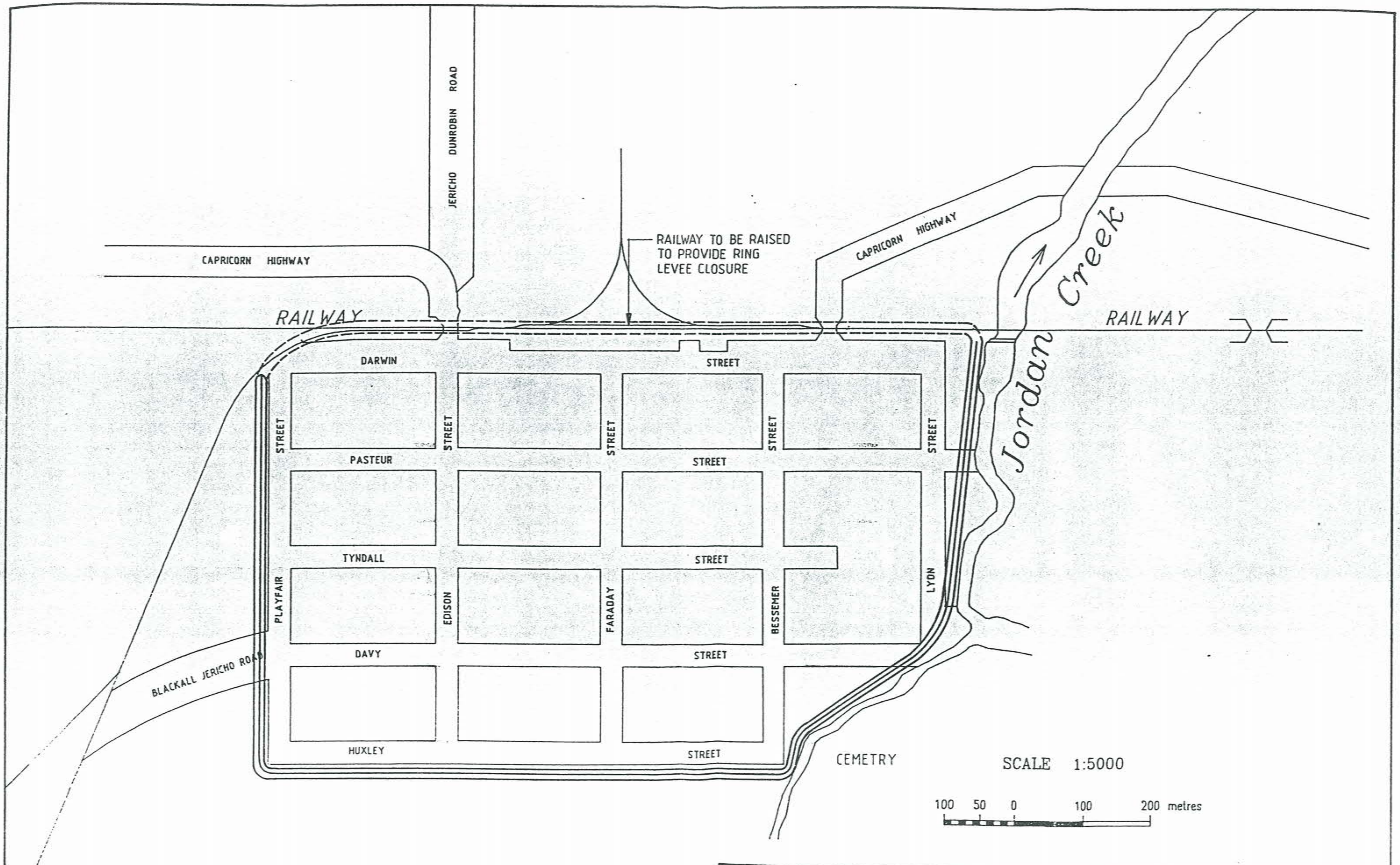
JERICHO
Water Surface Levels April 1990

Figure 10.2




JERICHO
Flood Depth and Direction of Flow April 1990

Figure 10.3

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JERICHO
Outline of Levee Option

Figure 10.4

**Table C1: Statutory Obligations**

| Legislation | Description | Relevance | Licence/Permit |
|---|---|---|---|
| *Environmental Protection Act 1994* | All persons have a general environmental duty not to cause environmental harm, and to report any harm that does occur. | The project must comply with the Act and not cause environmental harm. | All activities will need to ensure they do not cause environmental harm. |
| | From July 2002, construction activities will become an environmentally relevant activity (ERA). A licence to carry out the proposed works may therefore be required. | Construction activities undertaken in the project area may be ERAs and a licence may therefore be required. | If an ERA is occurring on site, a licence under the *Environmental Protection Act 1994* may be required after July 2002. |
| | The provisions for contaminated land are included in this Act. | A search of the contaminated land and environmental management registers must be undertaken in order to determine whether there are any registered sites within the project area. | If the site is registered, then a soil investigation needs to be undertaken in order to determine whether the soil is contaminated. If the tests reveal that the soil is contaminated, then a disposal permit from the EPA is required. |
| *Environmental Protection (Water) Policy 1997* | This policy applies to all activities that have the potential to impact on water quality. Sections 31 and 32 of the policy prohibit the deposit or release of material such as building waste, cement or concrete, rubbish and oil into a stormwater drain and water body or a place where it could be washed into these places. | The project may impact upon this issue and therefore this policy must be adhered to. | No licence is required but compliance with the relevant provisions is required. |
| *Environmental Protection (Noise) Policy 1997* | Section 11 of the policy sets acoustic quality objectives whilst Part 3 deals with the evaluation procedure and the approval of a Draft Environmental Management Program. Part 4 of the policy deals with abatement of unreasonable noise and is intended to provide measures for nuisance noise controls. Part 6 sets out details of the procedures and equipment suggested for making noise assessment. Schedules 1 and 3 of the policy outline planning levels and prescribe information for particular noise generating works. | The project may impact upon this issue and therefore this policy must be adhered to. | No licence is required but compliance with the relevant provisions is required. |

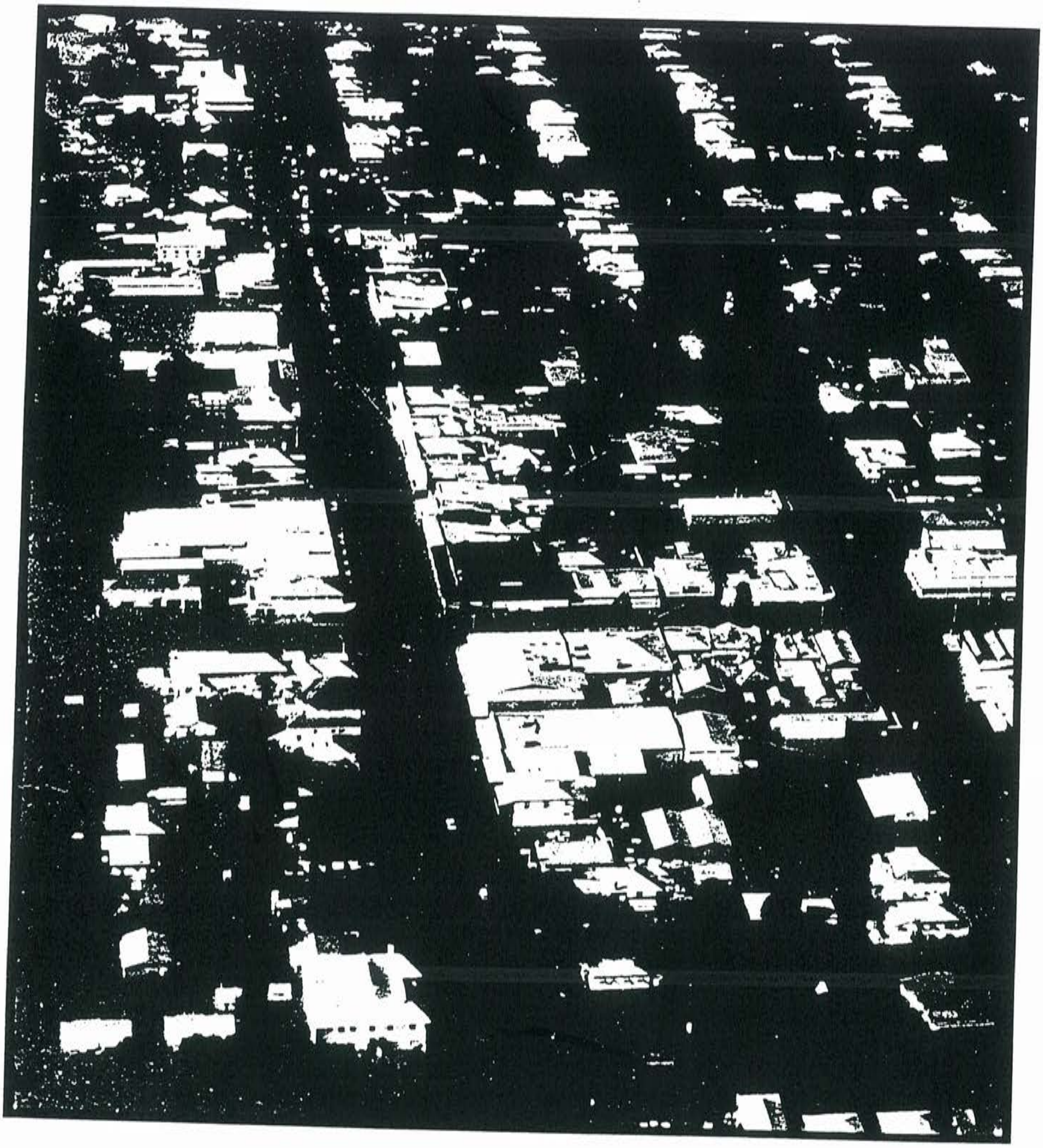
| Legislation | Description | Relevance | Licence/Permit |
|---|---|---|---|
| *Environmental Protection (Air) Policy 1997* | Part 3 of the policy covers environmental management decisions and air pollution dispersion modelling and monitoring of releases. Part 4 covers management of certain sources of contamination with Part 5 requiring a whole-of-government approach to managing the air environment. Schedule 1 states air quality indicators for carbon monoxide, lead, nitrogen dioxide, ozone, particulates and sulphur dioxide. Goals for each of these pollutants are also stated. | The project may impact upon this issue and therefore this policy must be adhered to. | No licence is required but compliance with the relevant provisions is required. |
| *Environmental Protection (Waste Management) Regulation 2000* | The regulation provides for offences for littering and waste dumping. It also provides for a waste tracking system which tracks specified waste and obtains data on the generation, transportation and treatment/disposal of these wastes within Queensland and interstate. | The project will generate waste during the construction phase. | Compliance with the relevant provisions is required. |
| *Environmental Protection (Nuisance) Regulation 2000* | The environmental nuisance laws aim to strike a balance between protecting our quality of life and the reasonable pursuit of activities that have the potential to annoy others. The laws specify conditions, hours of operation and noise levels for activities, including building works and construction sites. | Noise will most likely be generated during the construction phase of the project. | Compliance with the relevant provisions is required. |
| *Environment Protection and Biodiversity Conservation Act 1999* | This Act establishes a Commonwealth administrated environmental assessment and approval system that will operate in addition to but separate from the Queensland system. Approval is required under the Act for matters of national environmental action that will have or is likely to have a significant impact on a matter of national environmental significance. | Preliminary investigations have revealed that the project area does not contain any flora/fauna species and ecosystems that are of national environmental significance, as defined under the Act. | Not applicable. |

| Legislation | Description | Relevance | Licence/Permit |
|---|---|---|---|
| *Water Act 2000* | This Act provides, among other things, for the allocation and sustainable management of water. It affirms that all rights to the use, flow and control of all water in Queensland are vested in the State (s.19). It also provides that a person may take or interfere with overland flow water for any purpose unless there is a moratorium notice or a water resource plan that limits or alters the water that may be taken or interfered with (s.20(6)). 'Overland Flow Water' includes floodwater (Schedule 4). | A Water Resource Plan has been prepared for the Cooper Creek Catchment. Section 9 of the Plan refers to environmental principles and provides that water resources for ecologically significant areas, including for example landscapes and wetlands, must be protected.<br><br>It is not known at this stage whether the plan restricts the interfering with overland flow. | Currently under investigation. |
| *Floodplain Management In Australia – Best Practice Principles and Guidelines* | This is a non-statutory document which provides a set of best practice principles and guidelines for the management of risks associated with flooding. It is primarily directed to flood hazard management. | The principles and guidelines within this document may have some relevance to the design and implementation of the proposed flood mitigation measures. | This document has no statutory force but it is recommended that the principles and guidelines outlined within the document be considered during the design and implementation of the proposed flood measures. |
| *Nature Conservation Act 1992* and *Nature Conservation Regulation 1994* | The Act provides for the conservation of nature in two ways – the declaration and management of protected areas, and the protection of native wildlife that is not found within a protected area. Section 89 of the Act restricts the taking of protected plants other than under a conservation plan applicable to the plan; a licence, permit or other authority issued or given under a regulation; or an exemption under a regulation. | The proposed works may impact upon a protected plant. | If future ecological studies indicate that the proposed works will involve the taking of a protected plant, then a clearing permit under the *Nature Conservation Regulation 1994* will be required. |
| *Native Title Act 1993* | The Native Title Act applies to all lands where a Native Title claim has been lodged. | A claim may have been lodged over the area. | A review of claims lodged will need to be undertaken to determine if consultation with Native Title claimants is required. |

# Appendix D

***Scott and Furphy Report***

WATER RESOURCES COMMISSION



# WESTERN QUEENSLAND TOWNS FLOOD STUDY

## Volume 1 - Report

SCOTT & FURPHY PTY. LTD.

January 1991

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WATER RESOURCES COMMISSION

# WESTERN QUEENSLAND TOWNS FLOOD STUDY

## Volume 1 - Report

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WESTERN QUEENSLAND TOWNS FLOOD STUDY

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Cover Photograph – Charleville Central Business District during April 1990 flood

# 10. JERICHO

## 10.1 INTRODUCTION

Jericho is situated on the Capricorn Highway 53km west of Alpha and 83 km east of Barcaldine. The Rockhampton to Longreach railway passes through the town. The location of the township is shown on Figure 1.1 and the map of the town showing the extent of inundation in the April 1990 flood is given in Figure 10.1.

The population of Jericho is about 170. There are about 55 houses and 5 businesses most of which are located in Darwin Street. In the April 1990 flood 20 houses were inundated (overfloor flooding), 5 suffering major damage.

The whole township is located in the floodplain of Jordan Creek which flows in a northerly direction along the eastern edge of Jericho. A weir has been constructed on Jordan Creek immediately upstream of the railway crossing to provide town water and originally to provide water for railway locomotives. The weir crest is at about 348.5 AHD, about 3m above creek bed level.

The town generally slopes away from the river bank so once overbank flow is initiated, rapid inundation follows. Natural drainage is impeded by the railway line which although being only slightly elevated above natural level has very restricted culvert capacity, suitable for local drainage only.

Jordan Creek flows north from Jericho before turning west to flow into the Alice River north east of Barcaldine.

## 10.2 FLOOD MECHANISM

Flooding is caused by levels in Jordan Creek on the eastern side of Jericho exceeding bankfull. The crest level of the weir is at 348.5m AHD and floodwaters first enter the town when water levels rise to 349.6m AHD, only 1.1m AHD above weir crest level.

Floodwaters first enter the town at the south east corner of Davy Street between Bessemer and Lyon Streets. This water is from the old meander forming a previous river course and not directly from the current course. This breakout water flows north-westerly towards the lowest point (Playfair/Darwin Streets), the northern section of the Playfair Street reserve being a drain. The slope of the town is such that the ground surface falls away from the river bank, so that once overflow occurs from the river, the township is rapidly inundated. Furthermore, the Playfair Street drain has very little outlet capacity, only 2 very small culverts under the railway. Thus ponding occurs until the railway is overtopped.

Floodwaters pass over the railway flowing north back towards the creek.

During major floods as occurred in 1990, floodwaters are extensive, both east and west. Some of the floodwaters pass south of Jericho to join up with Woololla and Mistake Creeks. There were extensive washouts on the railway line west of Jericho due to floodwaters in the latter creeks, which far exceeded waterway capacity.

General overtopping along the properties between Lyon Street and the river occurs at about 350m AHD.

A partial levee system was constructed some time in the past but has fallen into disrepair and is ineffective in excluding floodwaters from the township.

## 10.3 APRIL 1990 FLOOD

### 10.3.1 General

The flood of April 1990 was the highest since settlement of Jericho. There is currently no official flood gauge at Jericho, but post-flood surveys have indicated a peak water level adjacent to the creek of 350.3m AHD, compared to the previous highest level of approximately 350.0 AHD recorded in 1950.

Widespread heavy rain caused flooding in Woololla and Mistake Creeks causing closure of the Capricorn Highway at the crossings of these creeks from 18th April.

Very heavy rain in the Jordan Creek catchment (see Chapter 2) caused rapid rise in levels, with the result that breakout flow was initiated at the eastern end of Davy Street at about 5.30am on 19th April 1990. Continued river rise led to overflow occurring northwards from this point along the entire Lyon Street creek frontage as far as the weir, with peak level being reached about 6.00pm on 19th April.

As stated previously the town slopes away from the river bank, so flooding was widespread. Deeper flooding occurred in the northwest corner, made worse by the damming effect of the railway at this point where culvert capacity is inadequate. Overtopping of the railway through the town and both east and west of the town occurred as the floodwaters flowed northerly back towards the river channel. Subsequent railway reconstruction using rock material in the embankment means these are less likely to washout in the future but this could transfer problems to other points.

The entire township was inundated, the only spot above water being the railway level crossing at the east end of town.

Floodwaters also pass westerly across the southern edge of the town being partly diverted away from the town by the existing levee. The absence of detailed plans of the levee means that this role cannot be determined accurately at this time.

### 10.3.2 Flood Levels and Depths

As discussed above, the entire township was inundated with minimum depth occurring near the river bank, and maximum depth up to about 1m occurring in the north west corner of the town.

The extent of flooding is shown on Figure 10.1. The flood levels were established by post-flood surveys (Dept. of Transport and George Bourne & Associates) and the peak level, near the weir was 350.3m AHD compared to the previous record depth of about 350.0m AHD in 1950.

Data on flood levels and depths are only available from the following sources.

- post-flood surveys of peak flood levels;

- flood depths estimated as the difference between water surface levels and ground levels ascertained from the available contour mapping.

Approximate maps of water surface levels and flood depth have been prepared and are given in Figures 10.2 and 10.3.

### 10.3.3 Flow Direction

Flow directions have been determined from the following:

- debris on fences;
- photographic evidence;
- eye-witness evidence (Police, residents);
- hydraulic evidence from flood levels.

The best interpretation of the flow direction of the floodwaters from the available evidence is given in Figures 10.3. The flow was generally north westerly from the river through the town and discharging over the railway line.

### 10.3.4 Velocity of Flow

In the absence of discharge data, it has not been possible to quantify estimates of velocity.

However, velocities are known to have been such as to cause washout of the railway line and other scouring. This indicates that velocities of the order of 2m/s or more occurred at least locally. Local effects such as flow between houses, or even around vehicles, can cause critical velocity to be exceeded even when the average velocity is substantially less.

Velocities can also be higher during the recession phase when depths are reducing and typically much of the scour can occur at that time.

## 10.4 HYDRAULIC MODELLING

In the absence of any records on discharges and formal records of water levels, and due to the extensive nature of the flooding around Jericho, it was not possible to carry out any hydraulic model studies.

## 10.5 FLOOD WARNING AND COMMUNITY RESPONSE

### 10.5.1 Flood Warning

Flood warning for Jericho is currently based on the informal gathering of information from property owners upstream at Burgoyne (about 5km upstream) and at Tumbar (about 55km upstream).

The absence of gauge boards on the river at Jericho hampers the recording of river level readings.

Information on upstream river levels is currently gathered by the Jericho Police. Jericho Shire operates a system of Yellow, Blue and Red alerts.

The Bureau of Meteorology in conjunction with Jericho Shire Council are currently planning to initiate a formal flood warning station for Jericho by installing a river level station at Jericho and an additional station upstream at Glenco which is situated about 10km upstream. As this would be expected to provide only a few (2-4) hours warning, consideration should also be given to installation of a station further upstream, say at Tumbar in order to increase the warning time to 8-12 hours.

### 10.5.2 Community Response

Community Response in Jericho is believed to have been adequate due to; the relatively small number of houses and businesses inundated enabling the Police to warn individual householders and business operators; the relatively shallow nature of the floodwaters; and prior flood experience (it being understood that local flooding occurs quite frequently).

### 10.5.3 Recommendations

Those factors pertaining to the actual procedures for evacuation in the event of major flooding relating to preparation of the Local Counter Disaster Plan and the level of equipment available are outside the scope of this Report.

However, there are a number of factors which have adversely impacted on the effectiveness of the flood warnings and their dissemination to the public, and which should be addressed. These are:

| Problem | Recommended Action |
| --- | --- |
| Currently no official warnings for Jericho | Upgrade flood warning system as recommended by CBM plus further station upstream |
| Local warnings of a qualitative nature only - gives low level of credibility and makes warnings difficult to interpret | Develop hydrologic model to enable issue of quantitative warnings |

| | |
|---|---|
| Warnings contain insufficient detail | Residents need to know flood level at their own property and along exit routes. |

It is recommended that public awareness to flooding be raised and that future warnings are made more meaningful. In order to achieve this the following actions are proposed:

- production of public awareness leaflet which should include the following:
  - brief explanation of the nature and extent of flooding in Jericho;
  - a simple explanation of flood probability so that residents realise that a major flood can occur at any time, and that having had a recent flood does not give immunity for years to come;
  - a map showing flood extent and depth (as given in this Report);
  - brief explanation of flood warnings, how to relate the warning to flood levels at each house, and how to respond;
  - brief explanation of evacuation procedures.

  These leaflets should be initially distributed to each household, and then periodically, say on issue of the annual rates notice, and should be readily available for non-ratepayers from the Shire Office, Library, etc.
- Preparation and mounting of a large scale map of flood extent and depth in a prominent position in the town.
- The erection of permanent notices throughout the town showing the record flood level. These should be prominent signs attached to telephone/power poles or other appropriate street furniture to act as a constant reminder and to rapidly educate newcomers. future flood warnings can then refer to expected level relative to 1990 level in a meaningful way.
- The development of tables giving the depth of inundation for each flood liable property for any forecast flood height. This could be carried out as an extension of the data base developed during the current Study (as given in Appendix B). This information could then be used to determine needs and priorities for evacuation during future floods.

## 10.6 OPTIONS FOR FUTURE FLOOD MANAGEMENT

### 10.6.1 General

Both structural and non-structural options have been considered in the range of options for future flood management in Jericho.

After a general consideration of options, greater detail is given regarding those options considered feasible.

### 10.6.2 Structural Measures

Structural flood mitigation options for Jericho must be considered in the context of the extensive flooding which occurs, with the joining of floodwaters from adjacent catchments to both east and west. This situation results in a number of mitigation options not being feasible.

The following options have been considered:

- Storage - not feasible due to the large flood volumes, lack of suitable storage sites and the extensive regional flooding which would result in inundation of Jericho even if peak flows in Jordan River could be reduced.

- Levee construction - due to Jericho being located not only in the floodplain of the Jordan Creek but also liable to inundation from adjacent waterways, a levee would essentially be of a 'ring' levee type, with the railway line forming one side of the levee. There is room to construct a levee behind the properties in Lyon Street, to be tied in to the railway line near the existing weir. This would extend along the edge of the old channel near Davy Street to exclude flood waters where breakout flows first occur, then south of Hadley Street and west of Playfair Street to tie into the Jericho-Blackall railway line. The railway line in this area would need to be raised to match the levee crest height. A road crossing will need to be constructed on the Blackall-Jericho Road and on Faraday Street.

  The location of the levee is shown on Figure 10.4.

  Provision for drainage from within the levee would be required, and this would necessitate additional drainage capacity under the railway to allow drainage to the north.

  In the absence of hydraulic model studies it is not possible to estimate the effect of the levee on flood levels outside, but due to the extensive nature of the flood waters, this is expected to be minor.

- Channel enlargement and clearing - not applicable.

- Flood diversion - a flood diversion is potentially possible to the east ofJericho but this would only be effective in minor floods - in major floods the extent of floodwaters would render such a diversion ineffective.

- Weir reconstruction - the existing fixed weir causes a significant increase in flood levels locally. This could be offset by constructing a diversion channel fitted with a flood gate section which could be opened during flood periods to reduce flood levels. However, this again is likely only to be successful for minor floods, as during major floods the extensive nature of the floodwaters will reduce the effectiveness of this measure.

- Housing raising and flood proofing of commercial premises would reduce flood damages without impeding the passage of floodwaters.

- Enhanced drainage capacity - existing local drainage within the township is restricted to a small number of small capacity culverts under the railway. According to residents, these are inadequate to cope with even local drainage and severely impede the passage of floodwaters. Significantly increasing the drainage capacity under the railway, possibly by the use of trestle sections, would result in lower flood levels in the town.

### 10.6.3 Non-Structural Options

Non-structural options include the following:

- Upgrading of the flood warning system as suggested by CBM plus an additional station upstream as noted in 10.5.1. This could include flood modelling to enable quantitative forecasting.

  The usefulness of the warnings to the general public should also be improved as discussed in Section 10.5.

- Planning controls - as the whole town is built on the floodplain there is little to be done in this regard unless no further building is allowed. However, it is recommended that any new building be raised at least 0.5m above 1990 flood level, or say 1.5m above ground level.

- Public awareness - the installation of markers in each street to indicate the 1990 flood level is recommended as an immediate measure. This will provide a high level of awareness even after memories dim, and for new residents with no flood experience.

### 10.6.4 Selected Options

Of the options considered above, the following are considered worthy of further consideration.

- Levee construction in conjunction with enhanced drainage capacity.

- House raising and flood proofing of commercial premises.

The above are in addition to upgrading of the flood warning system, improving public flood preparedness and the use of planning control to prevent the future construction of low set buildings.

a) Levee construction

Figure 10.4 shows a sketch of the possible location of the levee. This is indicative only at this stage and does not constitute a firm proposal, but rather illustrates the possibility of protecting the town from future major flood events.

The levee would essentially form a 'ring levee' with the railway line forming one side of the 'ring' which would be completed by construction of a levee round the town tied into the railway at both ends. The section of railway forming part of the levee will need to be raised to the levee crest level.

As the flood waters are extensive, the reduction in flow area resulting from this is not large and a significant increase in flood level is not expected. There would be no requirement for demolition of any houses, although some land acquisition would be required where the levee passes behind the houses in Lyon Street. Road crossings would be required on Faraday Street and Davy Street. Some improvement of drainage capacity under the railway would be beneficial in preventing pondage of local runoff behind the levee.

The levee would be provided with spillways at two or more locations, in order that controlled flooding of the town can occur should the design flood be exceeded. These spillways would be set about 0.6m below levee crest level, so that under these extreme conditions the town would flood relatively slowly. This is to avoid the catastrophic nature of flooding which would occur if the levee overtopped along its entire length with subsequent erosion damage. The 2 spillways mentioned above would be the minimum required, and detailed studies may recommend additional spillway capacity.

The levee would be formed from local clay/loam material assuming this to be available within a reasonable distance from the town. Design studies would need to include geotechnical studies of available material to determine suitable borrow areas and to determine acceptable side slopes. In the absence of this information, it has been assumed for the current purpose of preparing an indicative cost estimate that side slopes of 1 vertical to 4 horizontal are appropriate with a 4m crest width. These shallow side slopes are necessary to avoid undue erosion damage. It will also be necessary for a good grass cover to be established on the levees and maintained in good condition by irrigating from the weir pool. This is essential to prevent erosion damage occurring during flood.

On the above basis, the following indicative cost estimate has been derived.

| | |
|---|---|
| Levee construction including grassing $60,000m$^3$ @ $10 | $ 600,000 |
| Railway raising say | $ 200,000 |
| Roadway over levee crossing say | $ 30,000 |
| Spillways, outlet structures say | $ 50,000 |
| Damage improvements, say | $ 50,000 |
| Land acquisition say | $ 50,000 |
| | $ 930,000 |
| Contingency, say 10% | $ 70,000 |
| TOTAL | $1,000,000 |

b) Flood proofing/house raising (all unraised timber/fibro houses)

| | |
|---|---|
| 26 houses @ say $20,000 | $ 520,000 |
| 6 businesses @ say $20,000 | $ 120,000 |
| plus additional railway drainage capacity, say | $ 200,000 |
| | $ 840,000 |

## 10.7 FLOOD DAMAGE STUDIES

### 10.7.1 Residential Damage

Residential flood damage (potential) was estimated both for the 1990 flood and for a range of floods using ANUFLOOD.

The basic statistics of the housing stock included in the survey is given in Tables 32 and 33.

**TABLE 32**

**SUMMARY STATISTICS OF HOUSING STOCK - JERICHO**
**(Flood liable areas only)**

| Description | | Number |
|---|---|---|
| Total number of premises flood liable | | 54 |
| Number single storey | | 54 |
| Number not raised (<0.5m) | | 26 |
| Number raised | | 28 |
| Construction material | - weatherboard/timber | 21 |
| | - fibro | 22 |
| | - brick, masonry | 1 |
| | - metal | 10 |
| | - other | 0 |
| Number non-raised and capable of being raised | | |
| | - weatherboard/timber | 5 |
| | - fibro | 14 |
| | - metal | 6 |

**TABLE 33**

**FREQUENCY ANALYSIS OF HOUSE GROUND AND FLOOR HEIGHTS**
**JERICHO**
**(Heights relative to Australian Height datum)**

| Height Range m | No. with height above ground in range | No with ground height in range | No. with floor height in range |
|---|---|---|---|
| 0 -0.25 | 26 | | |
| 0.25-0.5 | 5 | | |
| 0.5-0.75 | 5 | | |
| 0.75-1.0 | 0 | | |
| 1 -1.25 | 1 | | |
| 1.25-1.5 | 0 | | |
| 1.5-1.75 | 8 | | |
| 1.75-2.0 | 6 | | |
| 2-2.25 | 3 | | |
| 348-349 | | 34 | 11 |
| 349-350 | | 16 | 22 |
| 350-351 | | 4 | 19 |
| 351-352 | | | 2 |

About 50% of the flood liable houses are not raised significantly above ground level (the 'not raised' category includes houses raised up to 0.5m).
Also, all but one of the 26 unraised houses are of weatherboard/timber, fibro or metal construction so could be raised. Raising of these properties (and possibly further raising of already raised houses) is an option for reducing damages from future floods.

Mean annual residential flood damage was estimated, using ANUFLOOD, to be $5,000. This figure is only approximate as it has been necessary to assume the shape of the stage-probability curve in the total absence of data. Damages for floods of a range of magnitudes are estimated as given in Figure 10.5, with that for 350.3m AHD as reached in April 1990 being about $200,000. These estimates are of low accuracy as they are sensitive to the stage-probability curve which has been assumed. This does not affect the damage estimation for various levels of flooding.

### 10.7.2 Commercial Damage

Summary statistics for commercial premises are given in Tables 34 and 35. There are only 6 commercial premises 4 of which have floor level raised 0.25m or more above ground level. All are of fibro or metal construction.

The mean annual commercial flood damage is estimated at $4,000 and again is only approximate due to the assumed slope of the stage probability curve. The damage for the 1990 flood is estimated at $130,000. Values for a range of flood heights are given in Figure 10.5.

TABLE 34

SUMMARY STATISTICS COMMERCIAL/INDUSTRIAL - JERICHO

| Description | Number |
|---|---|
| Total number of commercial/industrial premises | 6 |
| Number single storey | 6 |
| Number raised (above 0.5m) | 4 |
| Construction material - weatherboard/timber | 0 |
| - fibro | 1 |
| - brick/masonry/stone | 0 |
| - metal | 5 |
| - other | 0 |

TABLE 35

FREQUENCY ANALYSIS OF GROUND HEIGHTS COMMERCIAL
JERICHO
(Heights relative to Australian Height Datum)

| Height Range m AHD | No. with Ground Height in Range |
|---|---|
| 348-348.5 | 2 |
| 348.5-349 | 3 |
| 349-349.5 | 1 |

### 10.7.3 Total Damage

The above values give a total mean annual direct flood damage of about $9,000 (residential plus commercial), excluding government damages and indirect damages. As stated previously, this figure is put forward to illustrate the relative magnitude of damages compared to flood mitigation works and is not regarded as being of high accuracy. Increasing the direct damage estimates to allow for indirect damages (residential 15%, commercial 55%) brings the total to $12,000 p.a.

The total direct damage for the 1990 flood is estimated to be $0.33 million, and including indirect damages (but excluding government damage, infrastructure damage and vehicle damage) this increases to $0.43 million.

### 10.7.4 Effect of Mitigation Works on Damages

ANUFLOOD was used to investigate the effects of various flood mitigation works on mean annual flood damages and the results are given in Table 36, again with the qualification on accuracy referred to above.

Assuming a real discount rate of 5% (as typically used for public works), the average annual estimated direct and indirect damage cost of $12,000 pa. has a present value of $230,000. This can be compared with the estimated capital cost of the proposed works, assuming these to be completed in a single year.

The levee option, giving protection to 1m above 1990 flood level results (assuming minimal afflux) in a reduction in mean annual flood damages of 87%, so has a present worth benefit of $200,000 (based on a discount rate of 5%) compared to an estimated capital cost of $1.0 million. Hence, this scheme is not economically viable (benefit/cost ratio 0.2) on the basis of residential and commercial damages alone. When government losses and social losses are included, this ratio would increase somewhat, but this figure is still low.

Raising all properties and flood proofing commercial properties at a cost of about $840,000 (26 timber/fibro houses @ $20,000 and plus flood proofing 6 commercial premises at say $20,000 plus additional railway drainage capacity) also has a benefit cost ratio of 0.2 (benefit present value 78% of $0.23 million i.e. $0.18 million) and would not be justifiable on purely economic terms.

## TABLE 36

### EFFECT ON ANNUAL AVERAGE FLOOD DAMAGE FOR A RANGE OF MITIGATION OPTIONS – JERICHO

| Option | Residential $x1000 | Residential Reduction% | Commercial $x1000 | Commercial Reduction | Total Direct $x1000 | Total Direct Red% |
|---|---|---|---|---|---|---|
| Nil | 5 | 0 | 4 | 0 | 9 | 0% |
| Levee giving protection to | | | | | | |
| 350m AHD | 4.4 | 10% | 3.3 | 12% | 7.7 | 15% |
| 350.3m AHD | 2.8 | 44% | 2.1 | 46% | 4.9 | 45% |
| 351.3m AHD | 0.7 | 86% | 0.5 | 88% | 1.2 | 87% |
| Raising all unraised premises by 1m | 3.1 | 37% | 3.2 | 16% | | |
| 2m | 2.0 | 60% | N/A | | | |
| Flood proofing to 1m | N/A | | 1.5 | 60% | | |
| to 2m | N/A | | 0 | 100% | | |
| Raising residential to say 1m above 1990 level & flood proofing commercial to 2m | 2.0 | 60% | 0 | 100% | 2.0 | 78% |
| Relocating all premises below | | | | | | |
| 348m AHD | 5 | 0% | 4 | 0% | 9.0 | 0% |
| 349m AHD | 5 | 0% | 4 | 0% | 9.0 | 0% |
| 350m AHD | 0.6 | 88% | 0 | 100% | 0.6 | 93% |

In terms of relocation, all buildings below 350m AHD would have to be relocated, virtually the entire town, to significantly reduce mean annual damages by 93%. This would involve some 50 houses at a cost per property of say $80,000 (new land and building say $60,000, infrastructure costs say $10,000 per dwelling, demolition say $10,000 per dwelling) giving a total of about $4.0 million i.e. and 5 commercial premises say an average of $100,000 i.e. $0.5 million giving a total of $4.5 million, against a benefit present value of only $0.21 million (benefit/cost ratio 0.05). This is clearly not viable.

Even though the above costs are indicative only, it is apparent none of the above options are viable on a purely economic basis, and could be justified only if social and other intangible losses are taken into account. As the levee option and flood raising/flood proofing have similar cost benefit ratios, the former is preferred as it provides an improved level of protection to infrastructure compared to house raising/flood proofing and also results in less social disruption during flood events.

## 10.8 SUMMARY OF FACTORS IN 1990 FLOOD

The 1990 flood was the highest on record, and resulted in the whole town being inundated.

The main points may be summarised as below:

a) Event probability

The rainfall event producing the flood was estimated to have an AEP of about 0.4% (ARI of 250 years), but in the absence of discharge data this should be regarded as indicative only.

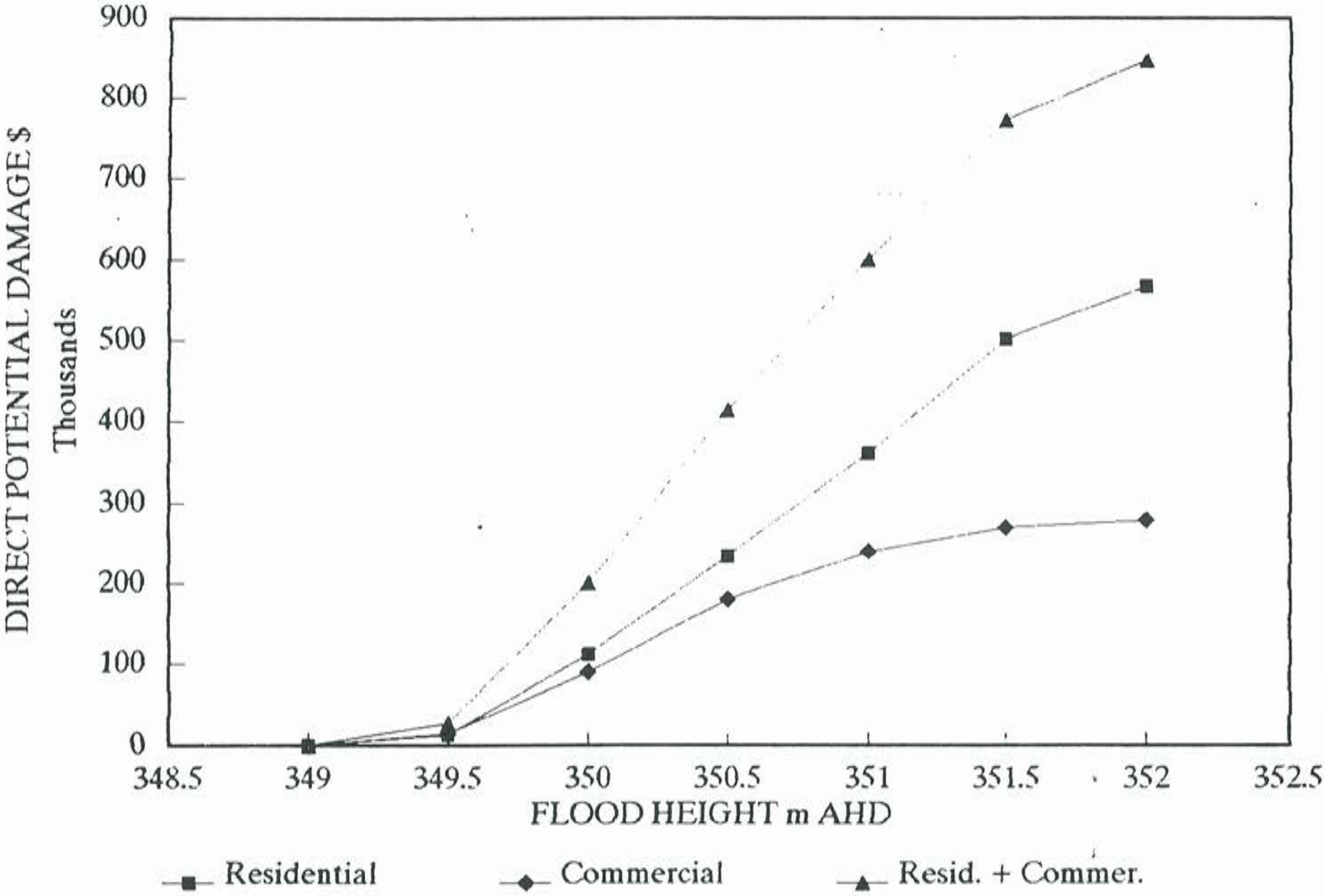
b) Damage Costs

The damage costs were moderate as flood depths and velocities were not great. There was sufficient warning time to allow lifting of goods and the small size of the community facilitated dissemination of flood warnings.

## 10.9 RECOMMENDATIONS

The following recommendations are made in regard to future flood management for Jericho.

- Commission an aerial survey to produce an accurate contour map of the town, the creek channel and a significant surrounding area in order to facilitate detail consideration of the levee option, to accurately survey existing partial levees, and to enable accurate determination of flood flow paths. This should extend to cover the whole flood plain to Woololla and Mistake Creeks which together with Jordan Creek act as a single system during flood.
- Commission detail consideration of levee option. This will require geotechnic and materials inputs in addition to more detailed hydraulic, engineering investigations together with investigation of social and environmental impacts, and an economic study to determine appropriate design criteria as outlined in Section 4.6.5
- Installation of flood markers throughout town and issue maps/leaflet showing flood depths to increase community preparedness for future floods.
- Development of tables of flood depth for a range of flood heights for each property.
- Installation of official flood warning system to include headwaters.
- Development of flood warning models.
- Improve drainage under railway. In the case of the levee option being proceeded with, railway drainage should be improved to enable passage of local drainage flows from within the levee. Should the levee option not be proceeded with, railway drainage should be singificantly augmented in order to allow improved passage of floodwaters.




SCOTT & FURPHY

DIRECT FLOOD DAMAGES
JERICHO

Figure 10·5

# Appendix E

***Mitigation Options Cost Estimates***

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# Indicative Costs for Mitigation options

## Option 3

| | | | | Subtotal | Contingency | Total |
|---|---|---|---|---|---|---|
| Central Rail Bridges | | | | | | |
| | Length | 45 | m | | | |
| | Width | 6 | m | | | |
| | Area | 270 | $m^2$ | | | |
| | Rate | 3000 | $\$/m^2$ | $ 810,000 | | |
| Capricorn Highway Culvert | | | | | | |
| | No of Cells | 16 | | | | |
| | Culvert Size | 1200x600 | | | | |
| | Length | 15 | m | | | |
| | Rate | 10240 | $/m | $ 153,600 | | |
| | Footing | | | $ 21,600 | | |
| | Endwalls/Wingwalls | | | $ 6,760 | | |
| | Miscellaneous | | | $ 3,000 | | |
| | Total | | | $ 994,960 | $ 397,984 | $ 1,393,000 |

## Option 4

| | | | | Subtotal | Contingency | Total |
|---|---|---|---|---|---|---|
| Blackall Road Culvert | | | | | | |
| | No of Cells | 15 | | | | |
| | Culvert Size | 1200x450 | | | | |
| | Length | 8 | m | | | |
| | Rate | 8850 | $/m | $ 70,800 | | |
| | Footing | | | $ 10,800 | | |
| | Endwalls/Wingwalls | | | $ 6,400 | | |
| | Miscellaneous | | | $ 3,000 | | |
| Blackall Rail Culvert | | | | | | |
| | No of Cells | 15 | | | | |
| | Culvert Size | 1200x450 | | | | |
| | Length | 8 | m | | | |
| | Rate | 13124 | $/m | $ 104,992 | | |
| | Footing | | | $ 1,080 | | |
| | Endwalls/Wingwalls | | | $ 6,400 | | |
| | Miscellaneous | | | $ 3,000 | | |
| | Total | | | $ 206,472 | $ 82,589 | $ 289,000 |

**Option 5**

| | | | Subtotal | Contingency | Total |
|---|---|---|---|---|---|
| No of Cells | 2 | | | | |
| Culvert Size | 1200x300 | | | | |
| Length | 15 | m | | | |
| Rate | 1200 | $/m | $ 18,000 | | |
| Footing | | | $ 2,700 | | |
| Endwalls/Wingwalls | | | $ 1,720 | | |
| Miscellaneous | | | $ 3,000 | | |
| | | | | | |
| No of Cells | 2 | | | | |
| Culvert Size | 1200x450 | | | | |
| Length | 10 | m | | | |
| Rate | 1300 | $/m | $ 13,000 | | |
| Footing | | | $ 1,800 | | |
| Endwalls/Wingwalls | | | $ 1,720 | | |
| Miscellaneous | | | $ 3,000 | | |
| | | | | | |
| No of Cells | 2 | | | | |
| Culvert Size | 900x450 | | | | |
| Length | 10 | m | | | |
| Rate | 1168 | $/m | $ 11,680 | | |
| Footing | | | $ 1,350 | | |
| Endwalls/Wingwalls | | | $ 1,720 | | |
| Miscellaneous | | | $ 3,000 | | |
| | | | | | |
| No of Cells | 2 | | | | |
| Culvert Size | 1200x900 | | | | |
| Length | 10 | m | | | |
| Rate | 1500 | $/m | $ 15,000 | | |
| Footing | | | $ 1,800 | | |
| Endwalls/Wingwalls | | | $ 1,720 | | |
| Miscellaneous | | | $ 3,000 | | |
| | | | | | |
| No of Cells | 4 | | | | |
| Culvert Size | 800x400 | | | | |
| Length | 10 | m | | | |
| Rate | 2334 | $/m | $ 23,340 | | |
| Footing | | | $ 1,200 | | |
| Endwalls/Wingwalls | | | $ 1,960 | | |
| Miscellaneous | | | $ 3,000 | | |
| | | | | | |
| No of Cells | 2 | | | | |
| Culvert Size | 1500x700 | | | | |
| Length | 10 | m | | | |
| Rate | 2000 | $/m | $ 20,000 | | |
| Footing | | | $ 2,250 | | |
| Endwalls/Wingwalls | | | $ 1,900 | | |
| Miscellaneous | | | $ 3,000 | | |
| | | | | | |
| Total | | | $ 140,860 | $ 56,344 | $ 197,000 |

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## Option 6

| | Subtotal | Contingency | Total |
|---|---|---|---|
| Allowance to lower weir by 500mm | $ 20,000 | | |
| Total | $ 20,000 | $ 8,000 | $ 28,000 |

## Option 7

| | | | Subtotal | Contingency | Total |
|---|---|---|---|---|---|
| Levee length | 350 | m | | | |
| Width | 3 | m | | | |
| Batter Slopes | 6 | 1 in X | | | |
| Height | 1.5 | m | | | |
| Volume | 4725 | $m^3$ | | | |
| Rate | 16 | $\$/m^3$ | | | |
| | | | $ 75,600 | $ 30,240 | $ 106,000 |

## Option 8

| | | | Subtotal | Contingency | Total |
|---|---|---|---|---|---|
| Levee length | 1200 | m | | | |
| Width | 3 | m | | | |
| Batter Slopes | 6 | 1 in X | | | |
| Height | 1.5 | m | | | |
| Volume | 16200 | $m^3$ | | | |
| Rate | 16 | $\$/m^3$ | | | |
| | | | $ 259,200 | $ 103,680 | $ 363,000 |

## Option 9

| | | | Subtotal | Contingency | Total |
|---|---|---|---|---|---|
| Levee length | 1000 | m | | | |
| Width | 3 | m | | | |
| Batter Slopes | 6 | 1 in X | | | |
| Height | 1.5 | m | | | |
| Volume | 13500 | $m^3$ | | | |
| Rate | 16 | $\$/m^3$ | | | |
| | | | $ 216,000 | $ 86,400 | $ 302,000 |

## Option 10

| | | | Subtotal | Contingency | Total |
|---|---|---|---|---|---|
| Levee length | 1350 | m | | | |
| Width | 3 | m | | | |
| Batter Slopes | 6 | 1 in X | | | |
| Height | 1.5 | m | | | |
| Volume | 18225 | $m^3$ | | | |
| Rate | 16 | $\$/m^3$ | | | |
| | | | $ 291,600 | $ 116,640 | $ 408,000 |

**Option 11**

| | | | Subtotal | Contingency | Total |
|---|---|---|---|---|---|
| Levee length | 1750 | m | | | |
| Width | 3 | m | | | |
| Batter Slopes | 6 | 1 in X | | | |
| Height | 1.5 | m | | | |
| Volume | 23625 | $m^3$ | | | |
| Rate | 16 | $\$/m^3$ | | | |
| | | | $ 378,000 | $ 151,200 | $ 529,000 |

**Option 12**

| | | | Subtotal | Contingency | Total |
|---|---|---|---|---|---|
| Levee length | 1700 | m | | | |
| Width | 3 | m | | | |
| Batter Slopes | 6 | 1 in X | | | |
| Height | 1.5 | m | | | |
| Volume | 22950 | $m^3$ | | | |
| Rate | 16 | $\$/m^3$ | | | |
| | | | $ 367,200 | $ 146,880 | $ 514,000 |

**Option 13**

| Raise Affected Houses | | | Subtotal | Contingency | Total |
|---|---|---|---|---|---|
| No of Houses | 15 | | | | |
| Rate | 15000 | $ ea | $ 225,000 | | |
| | | | $ 225,000 | $ 90,000 | $ 315,000 |

**Option 14**

| Community awareness Campaign | Subtotal | Contingency | Total |
|---|---|---|---|
| Allowance | $ 30,000 | | |
| Total | $ 30,000 | $ 12,000 | $ 42,000 |

**Option 15**

| | Subtotal | Contingency | Total |
|---|---|---|---|
| Gas Purge Recording Station | | | |
| Supply and Install (allowance) | $ 20,000 | | |
| Communications (allowance) | $ 20,000 | | |
| Maintenance (1 year) | $ 3,000 | | |
| Total | $ 43,000 | $ 17,200 | $ 60,000 |

# Appendix F

**Social Impact Summary**

## Appendix F – Social Impact Summary

An assessment of social impacts is summarised below for each of the proposed options:

| Option | Summary of Social Impact | Stakeholders Affected | Positive Benefits | Potential Risks |
|---|---|---|---|---|
| 1 | No significant benefits to flood levels. | All members of the community | Slight increase in positive public perception that "something" is being done about local flooding issues. | Continued impacts associated with flooding, such as safety, community health, isolation, access to medical services, damage to property and continued operation of local business.<br><br>Necessity to undertake additional flood mitigation works locally which would include additional local resources. |
| | | Queensland Rail | Nil Identified | Cost to Queensland Rail and consequent impacts on local use of rail services – both short and long term.<br><br>Environmental impacts of alternatives to existing rail infrastructure.<br><br>Disruption to local rail transport services. |
| 2 | No significant benefits to flood levels. | All members of the community | Slight increase in positive public perception that "something" is being done about local flooding issues. | Continued impacts associated with flooding, such as safety, community health, isolation, access to medical services, damage to property, continued operation of local business.<br><br>Necessity to undertake additional flood mitigation works locally which would include additional local resources. |
| | | Department of Main Roads | Nil Identified | Cost to Main Roads and consequent impacts on local use of road services – both short and long term.<br><br>Environmental impacts of alternatives to existing road infrastructure.<br><br>Disruption to road transport services. |
| 3 | No significant benefits to flood levels. | All members of the community | Slight increase in positive public perception that "something" is being done about local flooding issues. | Continued impacts associated with flooding, such as safety, community health, isolation, access to medical services, damage to property and continued operation of local business.<br><br>Necessity to undertake additional flood mitigation works locally which would include additional local resources. |
| | | Department of Main Roads and Queensland Rail | Nil Identified. | Cost to Queensland Rail and Main Roads.<br><br>Disruption to road and rail transport services. |

| Option | Summary of Social Impact | Stakeholders Affected | Positive Benefits | Potential Risks |
|---|---|---|---|---|
| 4 | No significant benefits to flood levels. | All members of the community | Slight increase in positive public perception that "something" is being done about local flooding issues. | Continued impacts associated with flooding, such as safety, community health, isolation, access to medical services, damage to property and continued operation of local business.<br><br>Necessity to undertake additional flood mitigation works locally which would include additional local resources. |
| | | Department of Main Roads and Queensland Rail | Nil Identified | Cost to Queensland Rail and Main Roads.<br><br>Disruption to road and rail transport services. |
| 5 | No significant benefits to flood levels. | All members of the community | Slight increase in positive public perception that "something" is being done about local flooding issues. | Continued impacts associated with flooding, such as safety, community health, isolation, access to medical services, damage to property and continued operation of local business.<br><br>Necessity to undertake additional flood mitigation works locally which would include additional local resources. |
| | | Department of Main Roads and Queensland Rail | Nil Identified | Cost to Queensland Rail and Main Roads.<br><br>Disruption to road and rail transport services. |
| 6 | No significant benefits to flood levels. | All members of the community | Slight increase in positive public perception that "something" is being done about local flooding issues. | Continued impacts associated with flooding, such as safety, community health, isolation, access to medical services, damage to property and continued operation of local business.<br><br>Necessity to undertake additional flood mitigation works locally which would include additional local resources. |
| 7 | Significant reduction to flood levels. | All members of the community | Increased protection of local properties.<br><br>Decreased opportunity for disruption to provision of, and access to, services and facilities.<br><br>Minimise flood damage.<br><br>Maintains community cohesion.<br><br>Positive community perception that government is responding to local flooding issues. | Protection to the entire residential and business community is not guaranteed.<br><br>Levee may have an impact on local environmental aesthetics. |

| Option | Summary of Social Impact | Stakeholders Affected | Positive Benefits | Potential Risks |
|---|---|---|---|---|
| 8 | Significant reduction to flood levels. | All members of the community | Increased protection of local properties.<br><br>Decreased opportunity for disruption to provision of, and access to, services and facilities.<br><br>Minimise flood damage.<br><br>Maintains community cohesion. | Protection to the entire residential and business community is not guaranteed.<br><br>Levee may have an impact on local environmental aesthetics.<br><br>Increased flood levels and inundation times may impact on evacuation to the east. |
| 9 | Minimal reduction in flood levels. | All members of the community | Increased protection of local properties.<br><br>Decreased opportunity for disruption to provision of, and access to, services and facilities.<br><br>Minimise flood damage.<br><br>Maintains community cohesion. | Protection to the entire residential and business community is not guaranteed.<br><br>Levee may have an impact on local environmental aesthetics. |
| 10 | Significant reduction in flood levels. | All members of the community | Increased protection of local properties.<br><br>Decreased opportunity for disruption to provision of, and access to, services and facilities.<br><br>Minimise flood damage.<br><br>Maintains community cohesion. | Protection to the entire residential and business community is not guaranteed.<br><br>Levee may have an impact on local environmental aesthetics.<br><br>Increased flood levels and inundation times may impact on evacuation to the east. |
| 11 | Significant reduction to flood levels. | All members of the community | Complete protection of local properties.<br><br>Decreased opportunity for disruption to provision of, and access to, services and facilities.<br><br>Minimise flood damage.<br><br>Maintains community cohesion. | Levee may have an impact on local environmental aesthetics.<br><br>Increased flood levels and inundation times may impact on evacuation to the east. |

| Option | Summary of Social Impact | Stakeholders Affected | Positive Benefits | Potential Risks |
|---|---|---|---|---|
| 12 | Moderate reduction in flood levels. | All members of the community | Increased protection of local properties.<br><br>Decreased opportunity for disruption to provision of, and access to, services and facilities.<br><br>Minimise flood damage.<br><br>Maintains community cohesion. | Protection to the entire residential and business community is not guaranteed.<br><br>Levee may have an impact on local environmental aesthetics. |
| 13 | Significant reduction in individual residential property damage | All members of the community | Protection of flood affected residential premises in the town.<br><br>Increase in local resident satisfaction regarding personal protection from flood. | Business premises would still be affected by flooding, causing disruption to provision of, and access to, town services and facilities.<br><br>Residents will still be affected by flooding in terms of ability to access services and facilities and necessity to evacuate preceding flood events. |
| 14 | Significant increase in understanding of flooding and flood related issues. | All members of the community | Increased understanding of issues will enhance community capacity and ability to deal with flood related issues – consequently local social capital is enhanced. | Does not address physical impacts of flood, which result in property damage, evacuations, isolation and disruptions to community well being. |
| 15 | Significant improvement in provision of flood warning information. | All members of the community | Substantial improvement in delivery of flood warning messages to local residents and businesses.<br><br>Contributes towards the community's capacity to prepare for and response to flooding issues, such as damage mitigation, evacuation, provision of appropriate supplies, gathering of volunteers. | Does not address physical impacts of flood which result in property damage, evacuations, isolation, disruptions to community well being. |

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