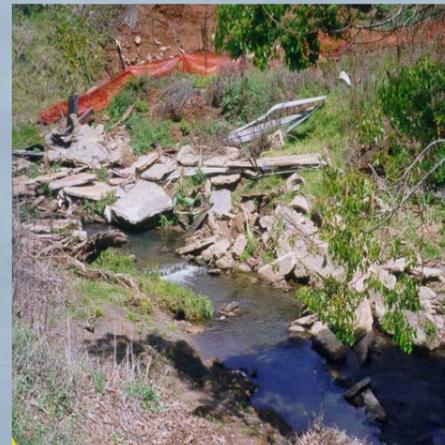
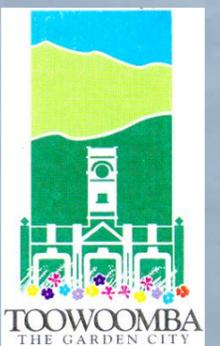


GOWRIE CREEK Toowoomba

CATCHMENT MANAGEMENT STRATEGY
NOVEMBER 1998



HASSELL



Gowrie Creek Catchment Management Strategy

by

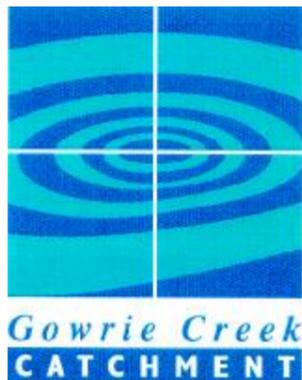
WBM OCEANICS AUSTRALIA

AND

HASSELL

for

Toowoomba City Council



HASSELL



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GOWRIE CREEK Toowoomba
INTRODUCTION AND STUDY BACKGROUND

1 INTRODUCTION AND STUDY BACKGROUND

1.1 INTRODUCTION

This report presents the findings of a study aimed at developing a Management Strategy for the catchment and major tributaries of Gowrie Creek (*East and West Creeks and Black Gully*). The report will form the basis of a subsequent Gowrie Creek Catchment Management Plan, which will result in the implementation of a range of key management actions within the catchment, including:

- generic planning policies for the catchment;
- possible changes to Development Control Plan No. 4 (*DCP4*) for Gowrie Creek;
- specific Local Area Plans (*LAP*);
- a defined capital and on-going maintenance works program; and
- community education and participation projects.

This process is illustrated in Figure 1.1.

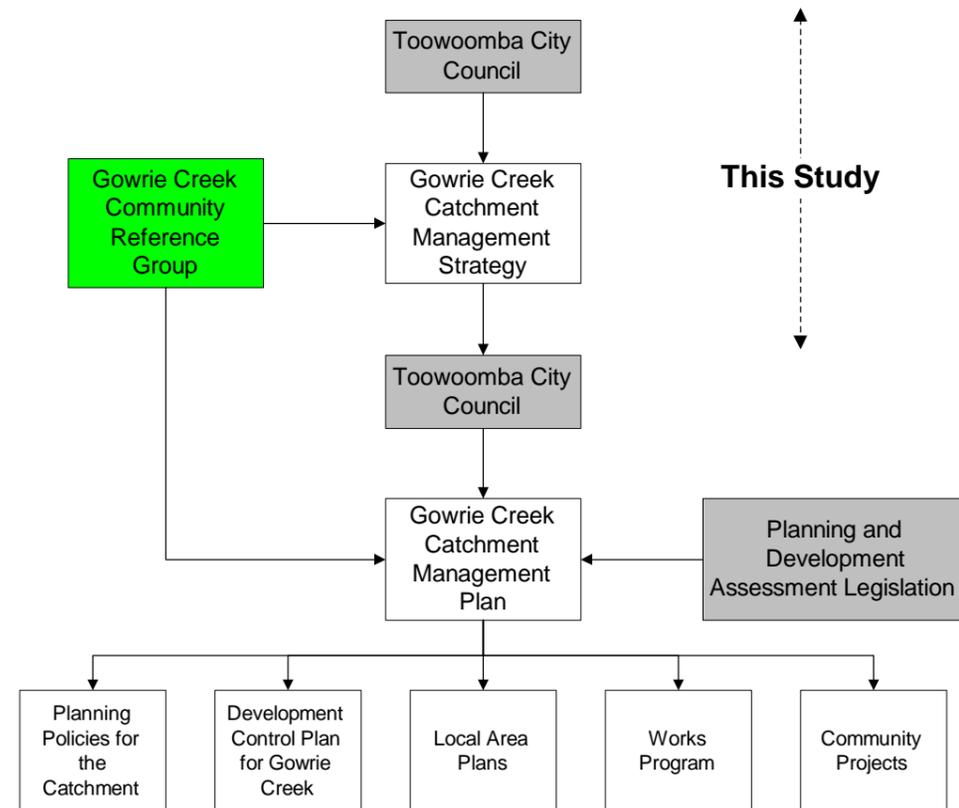


Figure 1.1 - Overall Gowrie Creek Management Process

The study has been undertaken with significant and valuable input from Council and State Government officers, concerned local residents and business people and the general community of Toowoomba.

1.2 STUDY BACKGROUND

Gowrie Creek and its' tributaries have been a subject of concern to the community, Toowoomba City Council, landowners along the creek and State Government agencies for many years, primarily for reasons of flooding and severe bank and bed erosion. Figures 1.2 and 1.3 present relevant newspaper clippings in this regard dating back to the early 1970's.



Figure 1.2 - Relevant Newspaper Clipping (1/11/73)

Figure 1.3 - Relevant Newspaper Clipping (29/1/85)

GOWRIE CREEK: WHAT A MESS!

Gowrie Creek sampling is the latest part of the Downs Dairy Association's plan in Brook Street.

A week after heavy storm rain on Thursday night runs within eight metres of the association's worst off an-cabin sewage building.

Downs Cooperative Dairy general manager Mr Don McNamara said the problem was being caused by possibly of filling to the opposite bank. This was allowing the gradually pushing the creek further west.

"In fact, it is filling fast and we are watching the situation."

In Friday, Mr McNamara asked a complaint with the Water Resources Commission.

"We are no longer going to be by city and the filling must be," he said yesterday.

"Someone has to accept responsibility and do something. We want urgent action."

"In recent years there has been a tremendous amount of

filling of the eastern side of the creek, and it is pushing the creek further and further westward towards Brook Street."

"If something is not done about the filling work's taking place, the creek's up and storage room is going to end up under water one day."

Mr McNamara said storm runoff from a nearby street entrance" signs of the filling, which consisted of heavy and light materials.

Concrete steps and walls have finished on mid-storm, after Thursday night's storm causing severe flooding in the western bank of the swollen creek, west of the creek's entrance.

Mayor A Teriman Clive Bergin, and council Works Committee chairman Alferman Zoss Miller recently inspected the creek from a bridge in Brook Street.

City Engineer Mr Ray Moore inspected it again on Friday afternoon, together with an officer from the Water Resources Commission.

IT'S TIME FOR A CLEAN-UP

By Graham Meredith
You won't find a cleaner, tidier, more beautiful, healthy Gowrie Creek in Toowoomba's Gowrie Creek.

Instead, there is evidence of the by-products of modern industrial society.

Judging from the junk in the watercourse, there must be a large amount of rubbish.

It looks unhealthy, too. In the sections not hidden by thick undergrowth on the banks.

For the unprepared, it

counts as something of a shock to see the ugly reality of Gowrie Creek.

And to realize the water it carries is Toowoomba's contribution to larger stream and river systems in the Downs and further afield.

The waterway is littered with debris and in places carries the stench of industrial dumping.

Storm erosion, scouring and silting complicates the picture.

And it's not a pretty one!



GOWRIE CREEK, showing debris on the east bank and scouring (foreground) on the west. Heavy concrete structural steel beams, supplied by crane in the middle foreground, are a sign to prevent further scouring away of the west bank. They were originally part of fill in the opposite bank, but ended up in midstream after heavy storm rains last Thursday night.

This led to the then Minister for the Department, the Honourable Howard Hobbs, and departmental representatives meeting in July 1996 with the Toowoomba City Council Mayor, Councillors and affected landowners regarding the flooding and erosion problem and deterioration of Gowrie Creek.

Thereafter, a small project team comprising the Toowoomba and Region Environment Council (TREC) and officers from the City Council and DNR had discussions on rehabilitating Gowrie Creek. These discussions centred on what could be achieved for the creek, related constraints and possible tasks required to be undertaken. It was recognised during these discussions that the Mort Street route besides Gowrie Creek would become one of the major entrances to the City following the future construction of a second range crossing, and that Gowrie Creek in its existing condition was not an 'attractive' feature statement upon entering Toowoomba.

The likely activities identified as being necessary to understand the problems with the creek included an audit of available information, and additional studies which would investigate environmentally sensitive restoration and protection options as well as the 'hard engineering' options examined previously. It was also identified during discussions that there was a need for the establishment of a means for overseeing the development and implementation of a management plan for the creek.

The project team identified that the activity of prime importance was to determine what the community wanted for the creek before formulating a plan. The attitudes of the community towards the creek were to drive the approach made in putting together a plan to address the problems such as flooding, erosion, weeds, rubbish and poor water quality affecting the creek.

Thus, it was proposed to undertake carefully planned community consultation. In the first instance, a survey and invitation to attend a community meeting was sent to possibly interested persons. An open invitation to the community to attend the meeting and participate in the survey was also issued in the media.

At the meeting, nominations were called to represent the various interest groups, and the Gowrie Creek Community Reference Group (referred to in this report as the Reference Group) was formed to provide future direction and leadership in the rehabilitation of the creek. This group was instrumental in the development and facilitation of the study process illustrated in Figure 1.1.

The Gowrie Creek system has been the subject of several major technical studies over the last decade, all with the basic aim of reducing or managing the magnitude of flooding and erosion. Principal studies in this regard have included the following:

- West Creek Flood Retardation and Improvement Study - Sinclair Knight and Partners (1987)
- Gowrie Creek Flood Study - Creedon Reid and Associates (1988)
- Study to Underground West Creek to Facilitate Toowoomba CBD Revitalisation - Sinclair Knight Merz (1995)

Progress on the recommendations of these earlier studies has been minimal because of the lack of an integrated strategy, supported by the community, that addressed all key issues comprehensively, and was able to be realistically implemented.

In May 1996, several business operators along Gowrie Creek approached the Department of Natural Resources (DNR) seeking a remedy for flooding that was contributing to bank instability along the Creek. The Department was also petitioned by local residents who had concerns regarding both the erosion of their properties and the general state of Gowrie Creek in their area. Representations were made to the Member for State Parliament, the Honourable Graham Healy.

1.3 CATCHMENT DESCRIPTION

1.3.1 General

This study encompasses the entire catchment of Gowrie Creek located within the boundary of Toowoomba City Council, an area of some 51.3km². Gowrie Creek is located at the headwaters of the catchment of the Condamine River, which subsequently flows into the Murray-Darling system, as illustrated in Figure 1.4. Activities within the catchment that affect Gowrie Creek by way of flooding, pollutant export and environmental degradation are important both on a local and regional context as:

- storm runoff and baseflow from the Gowrie Creek catchment is an important source of environmental flows downstream of Toowoomba and supplies water for irrigators along the Gowrie/Westbrook Creek system; and
- Toowoomba is the largest city on the Darling River system, and one of the largest on the Murray-Darling, and hence has potential to affect this system especially through non point source pollutant inputs to the river system.

Figure 1.5 illustrates Toowoomba City Council's boundary, the catchment limits of Gowrie Creek, and other salient topographic features.

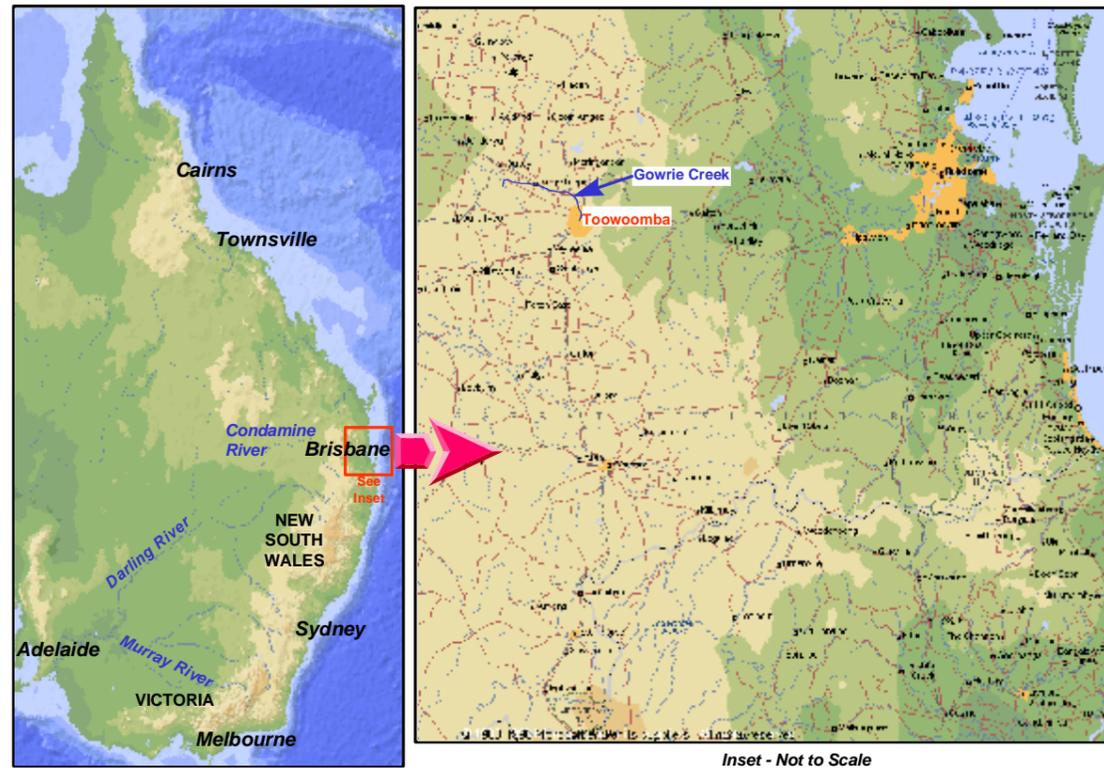


Figure 1.4 - Study Area Locality Plan

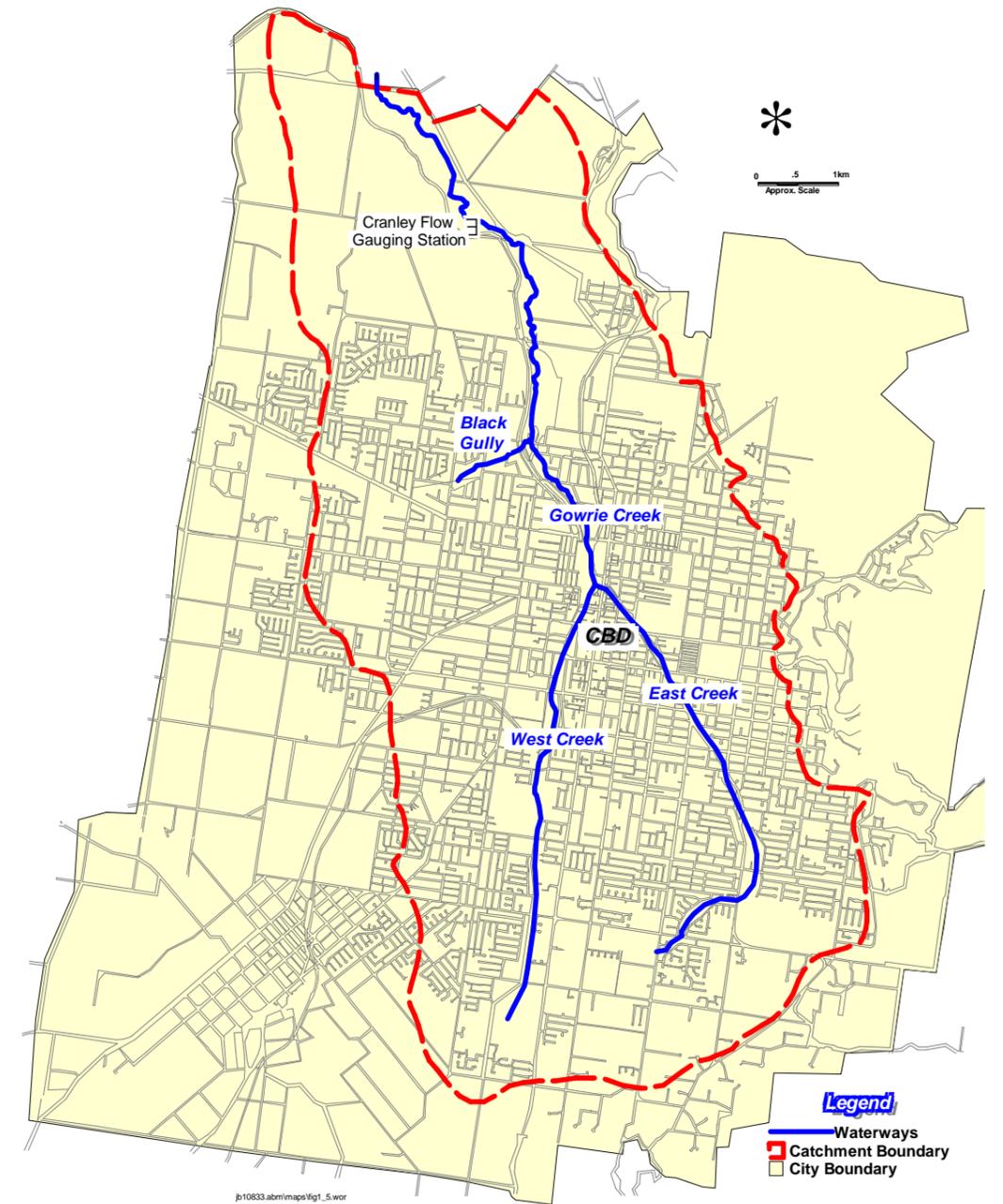


Figure 1.5 - Catchment Extent and Key Topographic Features

1.3.2 Key Waterways

The Gowrie Creek catchment is drained by four key waterways with a combined length of approximately 20km, as shown in Figure 1.5. East and West Creeks rise in the southern portion of Toowoomba City, and converge just to the north of the Central Business District (CBD), forming Gowrie Creek. Some 2km downstream of the commencement of Gowrie Creek proper, Black Gully joins the creek from the west.

Of a total area within the Toowoomba City Council boundary of some 51.3km², the respective sub-catchments of Gowrie Creek have the following approximate sub areas.

Waterway	Area (km ²)
West Creek	16.2
East Creek	14.6
Black Gully	7.3
Gowrie Creek	13.2

1.3.3 Historical Background

At the time of European settlement of the Toowoomba region, the Gowrie Creek system comprised a long, narrow swamp, full of aquatic reeds with fringing stands of major vegetation (*presumably eucalypts*). Along the centre of the swamp ran a narrow watercourse, with intermittent broad and deep waterholes. The swamp areas were fringed on both sides with melaleuca (*tea-tree*) and leptospermum tree species.

Upon the establishment and growth of Toowoomba in the mid 1800's, there were major changes to the swamps. Removal of the tree cover and associated vegetation, and the churning action of the hooves of horses and cattle, turned the swamps into bogs. The local water tables also began to rise.

The presence of livestock, and waste from the settlers themselves, also had significant effects on water quality. By the early 1860's, the swamps had widened to up to 160m in some places, and were noxious and unappealing. There were also a number of public health 'scars', typically ascribed to the quantity and quality of water in the swamps.

Consequently, action was undertaken in 1874 to drain Toowoomba's swamps. Channels were cut into all main swamps and, within a period of 1-2 years, complete drainage of these areas had occurred. This included the establishment of an artificial drainage channel passing along the lower reaches of East and West Creeks to their confluence at Gowrie Creek, and subsequently for some distance along Gowrie Creek itself.

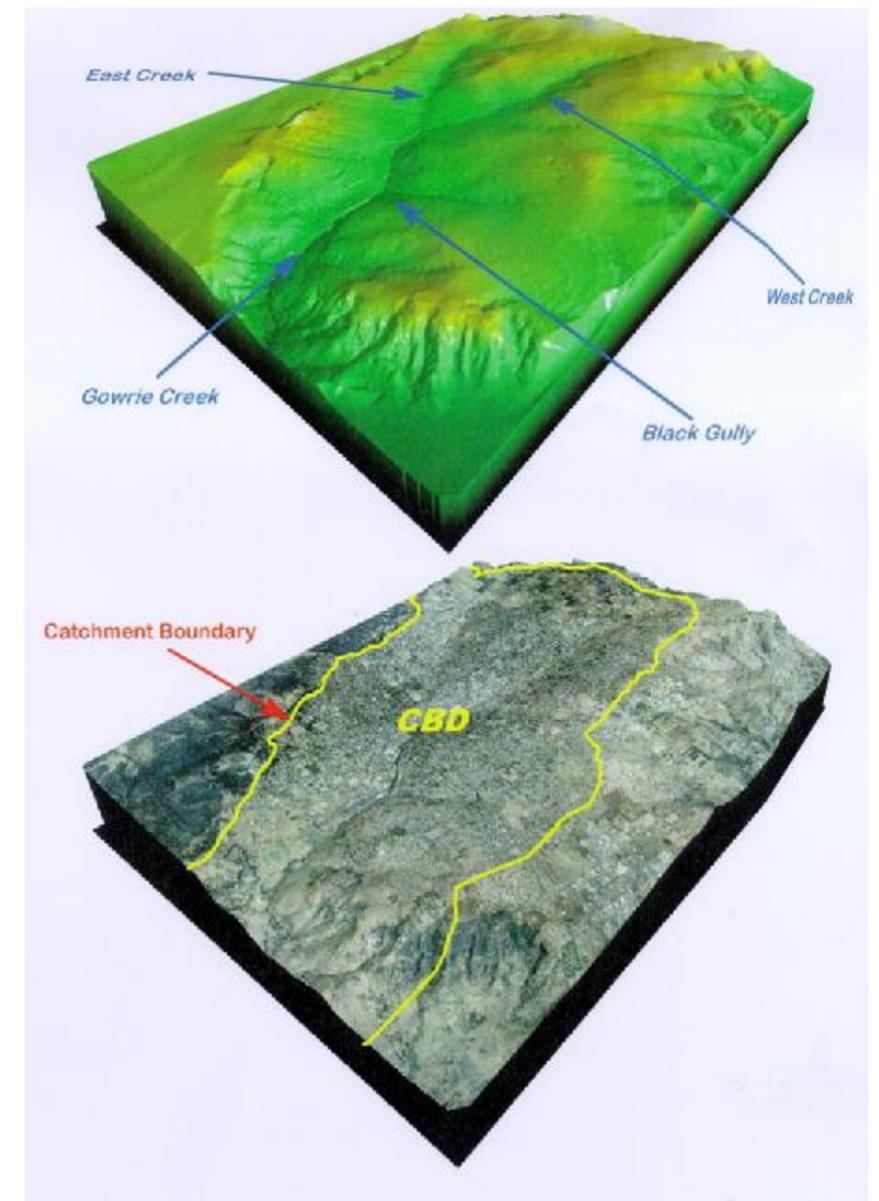
It is believed that the change in flood flows caused by the draining of the Toowoomba swamps (*ie. without the storage effect of these swamps, upstream floods passed along the creek at a much higher rate*), together with increased runoff caused by catchment development, are the principal reasons why Gowrie Creek is presently experiencing major erosion problems.

1.3.4 Topography

In comparison to most other streams in Queensland, Gowrie Creek has a steep main channel gradient. The catchment is also quite steeply sloping. Typical grades of the catchment draining towards the waterways of East, West and Gowrie Creeks and Black Gully are of the order of 3-

5%, with longitudinal grades of the waterways themselves of the order of 0.5-2%. Figure 1.6 provides a three-dimensional representation of the Gowrie Creek catchment, while Figure 1.7 presents long-section profiles for each creek.

Figure 1.6 - Three-Dimensional Catchment Plan



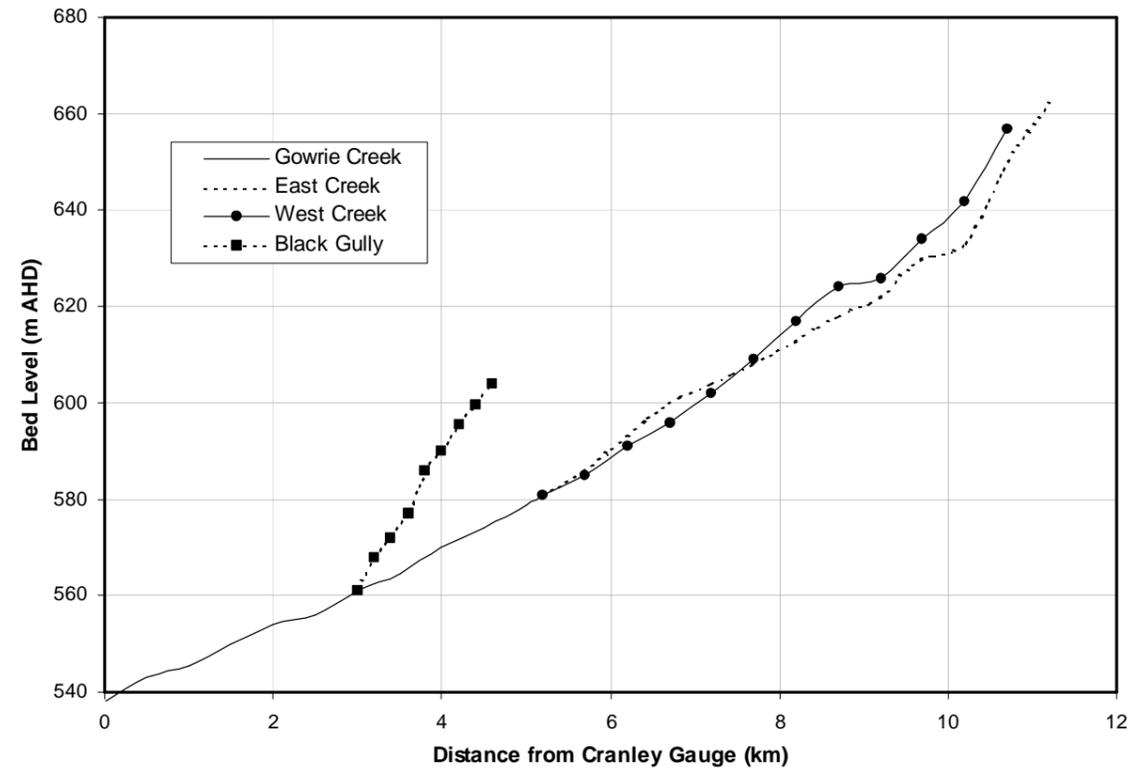


Figure 1.7 - Waterway Long Section Profiles

1.3.5 Soils/Geomorphology

There are significant soil, geological and geomorphological differences between East, West and Gowrie Creek and Black Gully. The nature of underlying soils varies depending on location within the catchment with

- Krasnozems (*Ferrosols - red soils*)
- Xanthozems (*Ferrosols - the dark soils with yellow clay subsoils and large amounts of iron and manganese*); and
- Prairie soils/black earths (*Dermosols/vertosols - dark brown to black over yellow to brown subsoils on basalt*) associated with Gowrie Creek at the northern (*downstream*) extent of the study area.

The red soils are freely draining. The ferrosols with yellowish clay subsoils are poorly drained and generally associated with perched or intermittent water tables. The black clay soils are generally younger soils with slow drainage and good moisture retention.

Significant issues for Gowrie Creek, and to a lesser extent East and West Creeks and Black Gully, are current and past geomorphic changes in creek section/profiles. These changes reflect active responses of the creeks to past land use changes such as catchment clearing and urbanisation and changes to channel form as a result of infilling and urban development. These responses are clearly marked by a series of bed level controls of a strongly resistant nature (*ie. rock bars or concrete debris structures*) and by upstream migrating knick points in the softer clayey materials of the channel bed.

There are significant groundwater inflows to the upper reaches of East and West Creeks which result from interactions between fractured basalt aquifers beneath the upper catchment areas and alluvial blankets of limited permeability clay in the valleys. This situation contributes to a perennial baseflow in East and West Creeks, and was the main reason for the swampy conditions which existed along the creeks before the city was developed.

1.3.6 Stream Hydrology

Gowrie Creek is one of few perennial waterbodies in Queensland, with the last recorded zero flow reading having occurred for several days in May 1995. This consistent flow is caused by two mechanisms, as follows:

- seepage of groundwater into Gowrie Creek from major fractured rock aquifers underlying much of the upper catchment; and
- a major (*approx. 0.5 ML/day*) cooling water/trade waste discharge into West Creek from the Mauri Foods Factory.

The average minimum flow at the Cranley Gauge, located toward the bottom of the catchment (*see Figure 1.5*), has ranged between 5 and 6 ML/day in recent years.

Due to the steep nature of the catchment and creek, the critical storm duration for peak storm flows in Gowrie Creek is quite short, between 2 and 3 hours. Peak predicted flood flows at the Cranley Gauge for existing and fully developed catchment conditions (*with no flow mitigation measures*) are provided in Table 1.1 below.

Further details of catchment hydrology are presented in Section 3.1 of this report and in the Study Technical Appendix.

Table 1.1 - Peak Flow Characteristics at Cranley Gauge

Flood ARI (years)	Peak Flow (m ³ /s)	
	Existing Land Use	Ultimate Land Use
1	83.7	90.6
2	111.1	122.7
100	253.1	292.6

1.3.7 Land Use

Most of the catchment of Gowrie Creek has been urbanised, with the majority of this development comprising moderate block size urban residential use. The existing land use attributes of the catchment are illustrated in Figure 1.8.

With the expansion of Toowoomba City over the next 15-20 years, significant portions of the presently undeveloped land will be converted to urban land use, especially in the upper reaches of the catchment. Some 600ha of currently rural usage land in this area has been identified for potential urban development. Approximate percentages of existing and ultimate residential/commercial and open space/rural/undeveloped land are provided in Table 1.2. There is considerable potential for this development to exacerbate the flooding and erosion problems being experienced by the Gowrie Creek system unless appropriate measures are implemented.

Table 1.2 - Approximate Catchment Land Use Characteristics

Condition	Residential/Commercial	Open Space/Rural/Undeveloped
Existing	34.1 km ²	17.2 km ²
Ultimate	39.7 km ²	11.6 km ²

As a result of historical development decisions, many of the areas of Gowrie Creek between the confluence of East and West Creeks and the confluence with Black Gully have an industrial land use character. This industrial land use was often allowed to develop to the edge of the creek. When upper catchment development and drainage works caused increases in creek flows, and the banks of the creek started to erode, any buffers that may have existed between these industrial lands and the creek itself were reduced. This often led to ad hoc actions such as piecemeal dumping of material, inadequate bank protection, etc, which have in many cases worsened erosion problems.

The presence of many of these existing structures and intensive land uses in close proximity to, but alienated from the creek, is incompatible with modern waterway and open space management.

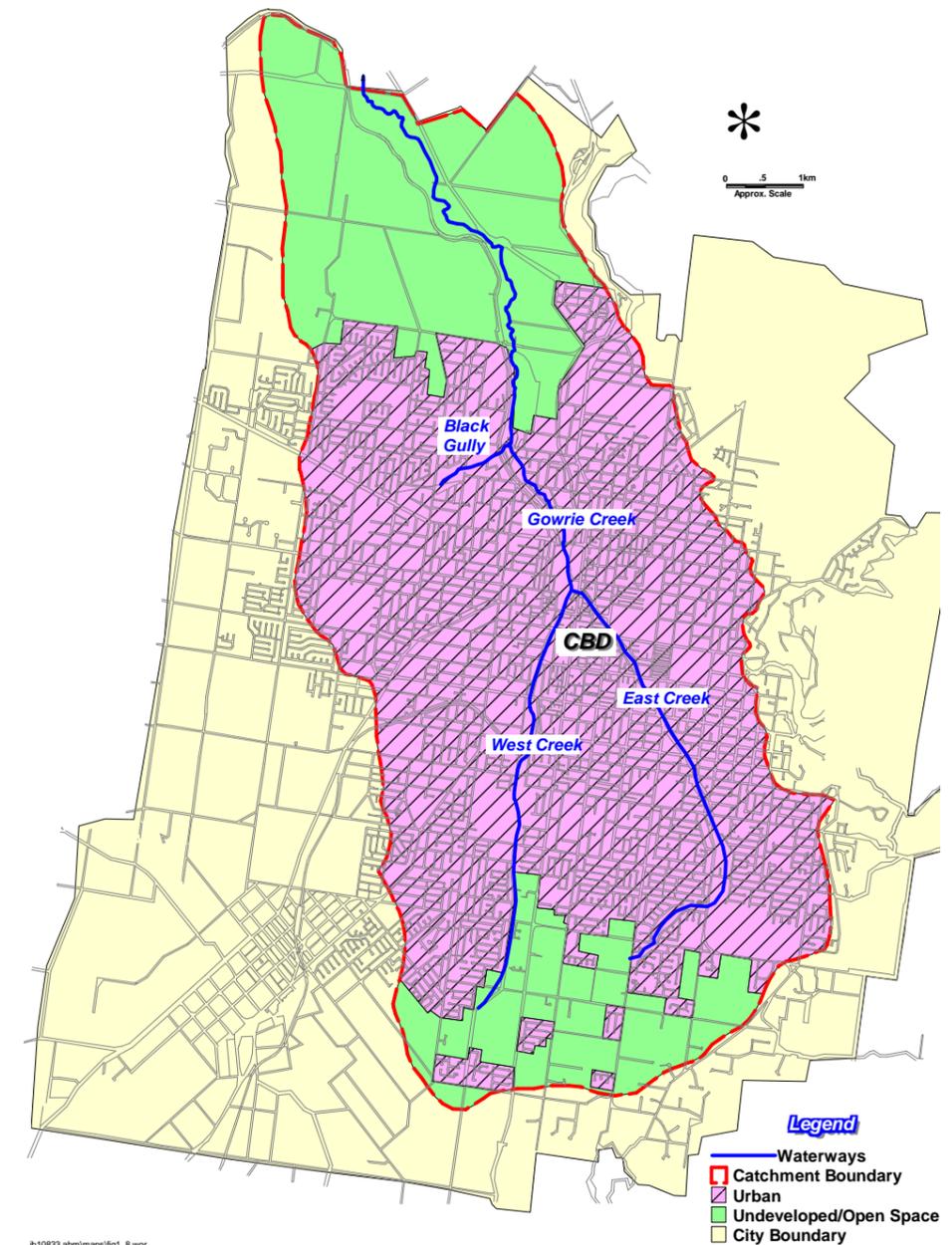
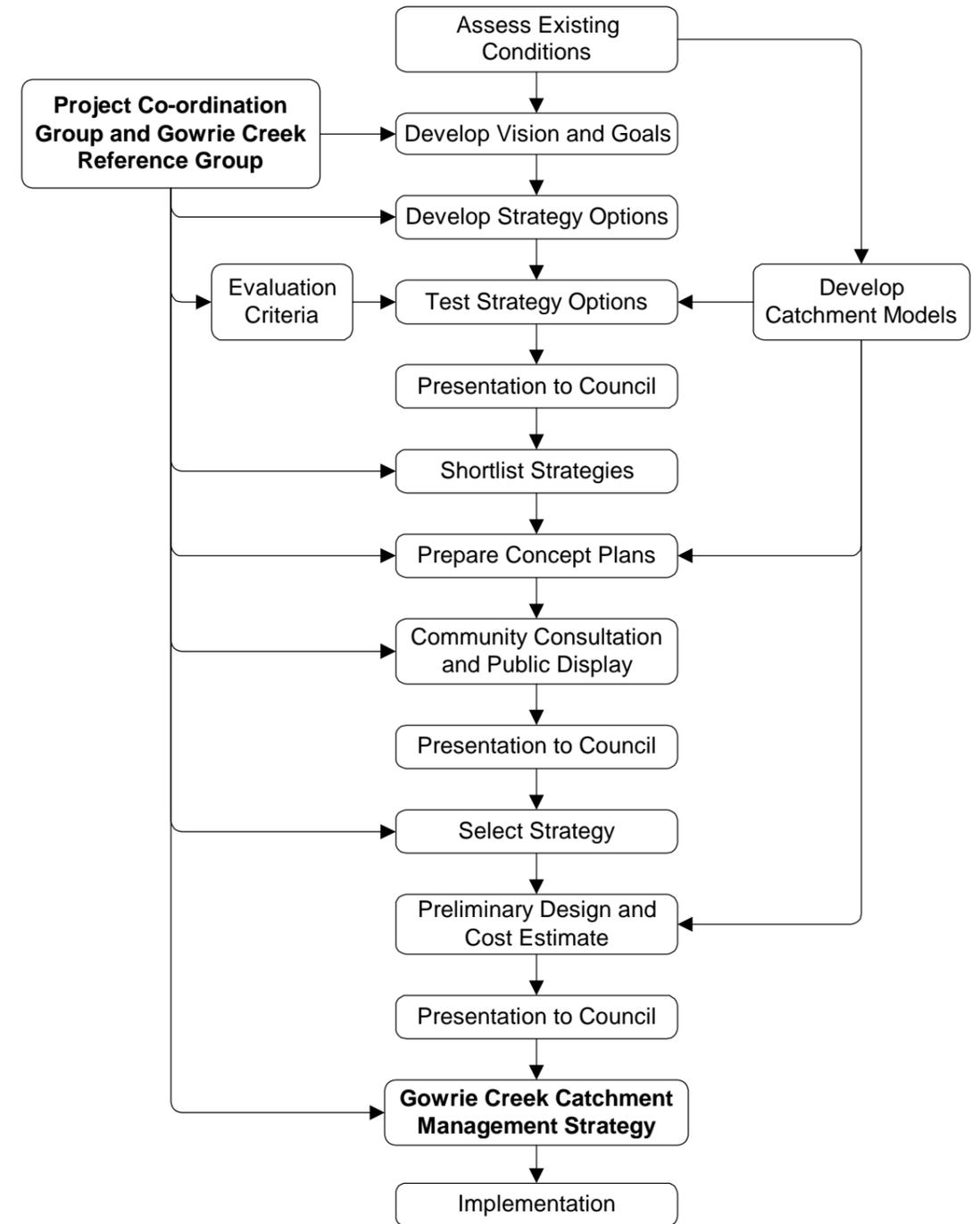


Figure 1.8 - Existing Catchment Land Use

1.4 STUDY PROCESS

The process adopted in developing the Gowrie Creek Catchment Management Strategy is illustrated in Figure 1.9. The process had several key elements, as follows:

- Close contact, liaison and opportunities for guidance and feedback were maintained with the Project Coordination Group and Reference Group.
- The ultimate management strategy resulted from a logical process with the following key stages:
 - ⇒ existing condition assessment;
 - ⇒ goal/vision setting;
 - ⇒ development, testing and shortlisting of a wide range of strategy options;
 - ⇒ community/reference group consultation to select a preferred strategy option; and
 - ⇒ development of all aspects of the preferred strategy option including cost estimates, implementation schedules, etc.
- Extensive public/community consultation over a 4 week period, comprising public and stakeholder meetings, public displays in Council offices, libraries and shopping centres, together with the opportunity to submit feedback/comment forms.
- Regular Toowoomba City Council liaison.



k:\jb10833.abm\report\00017949fig1-9.vsd

Figure 1.9 - Gowrie Creek Catchment Management Strategy Study Process

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GOWRIE CREEK Toowoomba
CATCHMENT VISION AND GOALS

2 CATCHMENT VISION AND GOALS

A key step in the study was to develop a Catchment Vision Statement and definitive Goals against which subsequently developed management options could be assessed. The Vision Statement and specific Goals were developed during the course of a number of Project Coordination Group and Reference Group meetings, and are presented below.

2.1 CATCHMENT VISION

The catchment, waterways and tributaries of Gowrie Creek will be transformed into a sustainable creek system that is a natural asset, and source of pride, to the local community. It will serve important ecological, recreational, drainage, cultural heritage and aesthetic roles of regional significance to Toowoomba, and build upon Toowoomba's image as a 'Garden City'. Community involvement and education will facilitate increased involvement and awareness of catchment and waterway management issues.

2.2 CATCHMENT GOALS

Category	Goals
Flooding/Erosion	Minimise flooding and unnatural erosion in the catchment through floodwater detention, within catchment management techniques and channel/bank modifications by using natural materials engineered to mimic natural stream processes.
Water Quality	Achieve water quality levels in the catchment that will preserve the natural ecosystem and allow primary contact recreation (<i>swimming</i>) at most times.
Ecology/Habitat	Provide a riparian (<i>riverbank vegetation and adjacent land</i>) zone, continuous if possible, that mimics natural conditions that existed prior to European settlement, using appropriate native species and natural materials.
Open Space, Recreation and Aesthetics	Provide a safe, continuous multi-use recreation, open space and cycle/pedestrian path corridor along the waterways that has various character attributes, active and passive recreational possibilities and opportunities for water play, interaction and appreciation. Maximise access, visibility, safety and use for all sectors of the community.
Land Use	Ultimately achieve landuses that are compatible with the creeks' ecological, flooding and recreational values.
Finance and Implementation	Produce a plan which Council can commit funding to, and which is cost effective with respect to its capital cost and annual maintenance commitment. The plan will source funding and support from the broad range of government, business and community groups.
Education and Awareness	Maximise opportunities for waterway revitalisation to foster community education, understanding of cultural heritage issues and water conservation.



(Vision for Gowrie Creek)

2.3 SPECIFIC OBJECTIVES

Within the gamut of the Catchment Vision and Goals identified above, during the course of the study a number of specific objectives were defined to both quantify the Catchment Goals and to ensure co-ordination and consistency of the Gowrie Creek study with other significant local and regional issues. These additional objectives were as follows.

- Flooding - contain the 100 year Average Recurrence Interval (*ARI*) flood within the banks of waterways in the Gowrie Creek system for full catchment development conditions, and reduce 2 year *ARI* flood velocities within eroding channel sections to less than 1.5 m/s.
- Water quality - ensure no worsening of catchment pollutant export, and ideally a reduction, for full catchment development conditions. Provide infrastructure to improve baseflow water quality sufficiently to comply with primary contact recreational requirements.
- Recreation - provide a continuous bikeway along study waterways.
- Ecology/habitat - maximise the ecological value of the catchment and waterways through the restoration/replanting of instream and companion habitat, within flooding and open space/recreational constraints.

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GOWRIE CREEK Toowoomba
**CATCHMENT ANALYSIS AND EXISTING
CONDITION ASSESSMENT**

3 CATCHMENT ANALYSIS AND EXISTING CONDITION ASSESSMENT

In the initial stages of the study, in consultation with the Reference Group and Project Coordination Group, a number of key issues were identified which require management within the Gowrie Creek catchment. These issues were as follows:

- flooding;
- creek bed and bank stability;
- water quality;
- ecology/habitat;
- open space and recreation;
- aesthetics; and
- land use.

In association with derivation of these issues, their relative importance was 'ranked'. With the exception of water quality and ecology, the issues were identified as having generally comparable importance. Water quality and ecology were issues highlighted as being of somewhat greater concern.

An analysis and discussion of each of these key issues is provided below.

3.1 FLOODING



(West Creek flooding upstream of Margaret Street - 1988)

Gowrie Creek and its tributaries experience frequent flooding in some locations due to the constrained nature of most of the waterways, and because most of the catchment is urbanised, causing flood flow rates which exceed the capacity of existing channels.

The creek can be broken into four separate sections with respect to flooding, as follows:

- **Upstream of the CBD** - In this part of the catchment, which includes both East and West Creeks, flooding causes few problems. The creeks generally have sufficient capacity to allow the passage of flood waters without causing property inundation, with the exception of an isolated area near the Toowoomba City Golf Course. In some areas, localised nuisance flooding of roads and parks occurs during heavy rainfall.
- **Within the CBD** - Frequent nuisance flooding and inundation of properties occurs along the creek in this area. In particular, there are problems in the vicinity of the Margaret and Russell Street Bridges and along Dent Street, where inadequate channel size in West Creek and flow constrictions caused by the bridges force floodwaters to leave the creek, flooding nearby commercial areas and roadways. The railway bridge crossing of West Creek just downstream of Herries Street also causes flooding problems along Dent Street.
- **Downstream of the CBD** - In this area there are no identified flood inundation problems.
- **Black Gully** - Flooding problems in Black Gully are generally associated with nuisance inundation in isolated areas such as the intersection of Bridge and Tor Streets.

Implications of flooding with respect to the defined study goals are as follows:

- flooding must be managed within the CBD area for economic and Business District revitalisation reasons. The frequency of flooding must be reduced to acceptable levels; and
- flooding contributes significantly to the erosion and environmental degradation problems experienced along Gowrie Creek. This effect must be reduced.

Details of modelling work undertaken to quantify existing flooding processes within the catchment are provided in the Study Technical Appendix. This modelling work comprised the following actions:

- set-up and calibration to four (4) historical events of a catchment hydrology (*rainfall runoff*) model;
- use of the calibrated hydrological model to simulate design event flood flows within the study area for existing and fully developed catchment conditions, and to assess proposed mitigation measures;
- set-up and calibration of a hydraulic model to predict peak flood levels within the catchment; and
- use of this model to assess design event flood levels within the study area for existing and developed catchment conditions, and to assess proposed flood and erosion mitigation measures.

Based on this modelling, the peak flood flows contained in Table 3.1 were predicted.

Table 3.1 - Peak Flood Flow (m³/s) Predictions - Existing and Developed Catchment Conditions

Location	Design Flood ARI					
	1 Year		2 Year		100 Year	
	Existing	Developed	Existing	Developed	Existing	Developed
East Ck upstream of Confluence	22.4	30	29.3	39.9	69.2	103.3
West Ck upstream of Confluence	35.7	43.3	48.6	57.7	104.2	131.9
Black Gully at Gowrie Creek	31.5	31.5	41.5	41.5	85.4	86.2
Gowrie Creek upstream of Black Gully	63.6	74.2	84.3	100.2	194.7	245.4
Gowrie Creek at Cranley Gauge	83.7	90.6	111.1	122.7	253.1	292.6

From the data presented in Table 3.1, it can be seen that with ongoing catchment development, existing flooding problems (*see below*) will continue to worsen.

Peak flood flows along East and West Creeks cause nuisance flooding at a number of road crossings. Property inundation occurs mainly within the CBD near West Creek, with some problems adjacent to the Toowoomba City Golf Club. The major area of flooding concern extends from Herries Street to the Confluence. Major obstacles to flood flows in this reach are as follows:

- Herries Street Culverts
- Railway Bridge Crossing
- Margaret Street Bridge
- Russell Street Bridge

Inadequate channel capacity along this reach also contributes to flooding problems.

Figures 3.1 and 3.2 illustrate predicted peak 2 year and 100 year flood levels for existing and developed catchment conditions for the section of West Creek between Herries Street and the Confluence. From these figures, it can be seen that;

- 2 year flood levels along West Creek within the CBD increase by up to 0.6m with ultimate catchment development, and no mitigating measures;
- bridge structures within the CBD remain flood immune for the 2 year event after catchment development, however the difference between peak water and structure levels is slight; and
- flooding under the 100 year event is considerably worse.

Flooding of this area presently occurs for events of between 5 year and 10 year ARI magnitude.

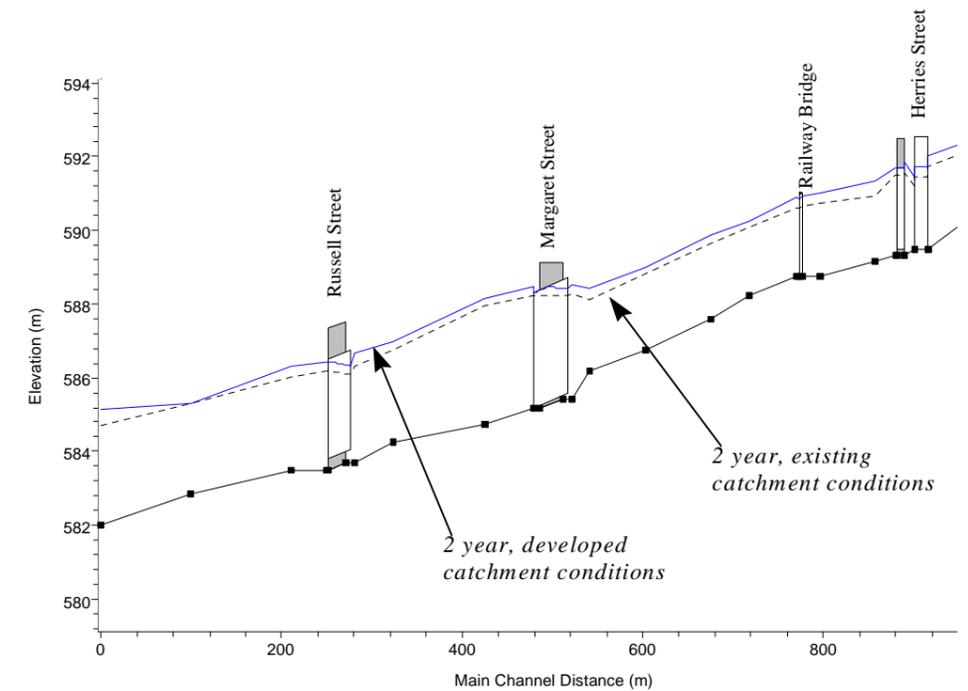


Figure 3.1 - Peak 2 year ARI Flood Levels - West Creek

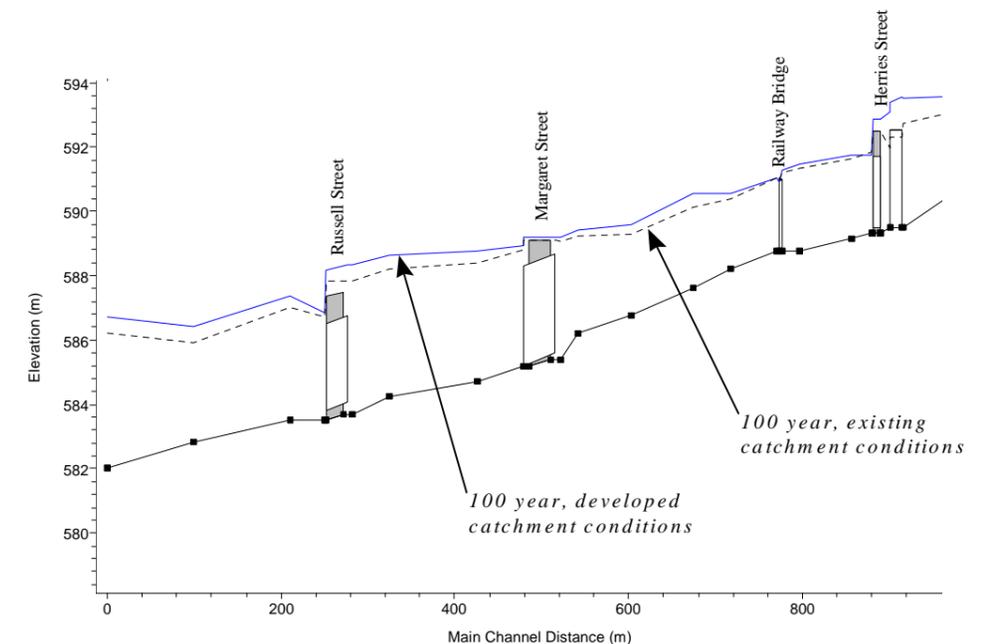


Figure 3.2 - Peak 100 year ARI Flood Levels - West Creek

3.2 CREEK BED AND BANK STABILITY



(Gowrie Creek upstream of Jellicoe Street - 1998)

Most of the soils in the catchment of Gowrie Creek are erodible by nature.

East and West Creeks upstream of the CBD, and Black Gully, are generally stable due to the provision of a wide grassed channel cross-section with gentle side slopes, and the presence of a concrete lined low flow channel (which prevents the initiation of erosion of the channel invert). Some areas of East Creek are experiencing gully type erosion of up to 2m depth and 5m width due to the lack of such a low flow channel.

Within the CBD, the creek channels are typically heavily grassed or concrete and rock lined, and are relatively stable.

In Gowrie Creek downstream of the CBD, there are many areas of creek bank that are extremely unstable. In these areas, the bank material is falling into the creek, where it is subsequently washed away by flood waters. The channel bed is also actively eroding in many areas. This bed and bank instability is caused by the joint influence of several factors, including the following:

- draining of the Toowoomba ‘swamps’ in the late 1800’s, altering the flood flow characteristics of the creek system. That is, flood flows entering the ‘swamps’ would formerly have been stored for a period of time, and released into Gowrie Creek at a lower rate, whereas these flows now pass rapidly along the creek;
- urbanisation of most of the catchment, with associated significant increases in total runoff volumes, and peak flow rates;
- piecemeal filling and ‘protection’ of many sections of the creek banks with unsuitable material, causing additional local turbulence and flow concentration. The resultant fill slopes in many of these cases are often too steep to be stable under the high flood velocities experienced in Gowrie Creek; and
- flow turbulence caused by the dumping of rubbish into the creek.

‘Typical’ channel cross-sectional profiles for East, West and Gowrie Creeks and Black Gully are illustrated in Figure 3.3. These profiles illustrate the steep banks experienced in Gowrie Creek downstream of the CBD.

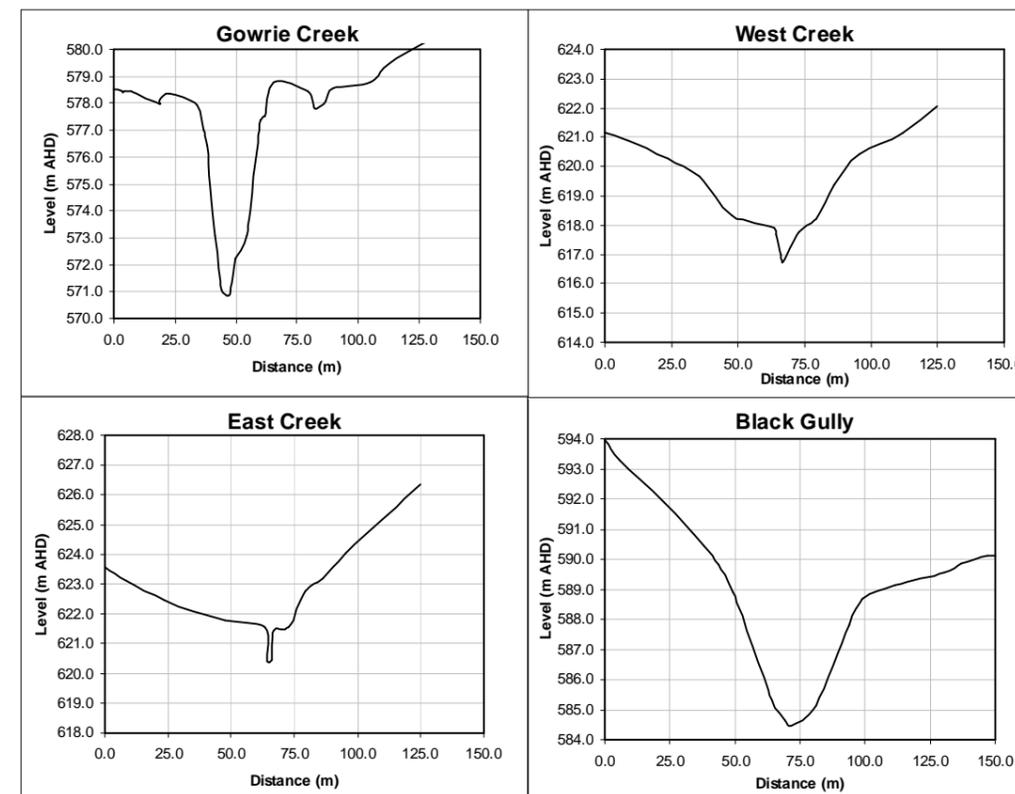


Figure 3.3 - ‘Typical’ Channel Cross-Sectional Profiles

Figure 3.4 presents indicative flood velocities predicted along the most severely eroding sections of Gowrie Creek (from Bridge Street to North Street) for the 2 year ARI storm, for both existing and developed catchment conditions. This figure shows the high velocities experienced in the creek, and also that these velocities are likely to increase with on going catchment development and no management action.

Solving creek bed and bank stability issues is important to achievement of the study goals because if they are not solved:

- they will preclude the development of viable open space corridors along the creek; and
- they will seriously affect the realisation of the potentially significant aesthetic and environmental benefits of the creek (eg. an unstable bank profile will preclude any revegetation and environmental enhancement works. Constant erosion also affects water quality).

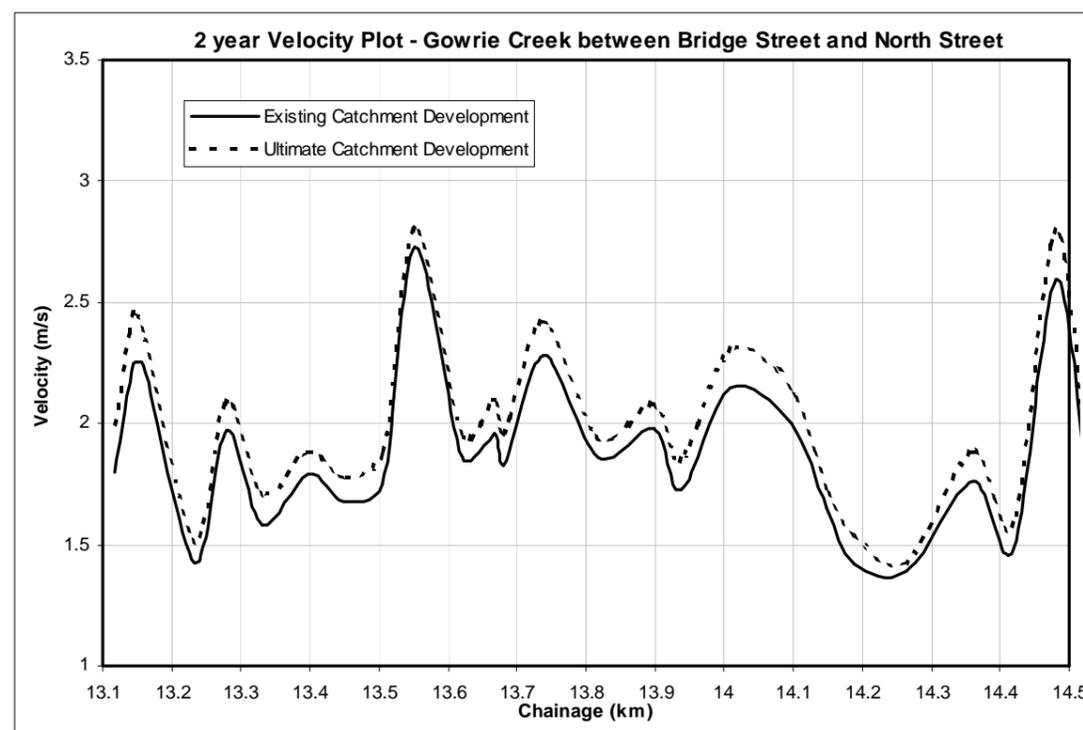


Figure 3.4 - Gowrie Creek Flood Velocities

3.3 WATER QUALITY

During periods of moderate to heavy rain, there is considerable soil erosion from the catchment, which consequently turns the waters of the creek an unattractive red/brown colour due to high levels of suspended solids in runoff waters. This effect can persist for several days or weeks after major rainfall. Outside periods of rainfall, substantial baseflows in Gowrie Creek are generated from groundwater entering the creek system from 'springs' along the creek. Although the water quality is visually appealing during these low flow periods, leakage from sewer mains, and other polluted urban runoff are affecting water quality. This problem was identified by the interpretation of the results of a monthly water quality sampling and analysis program conducted by Council in the northern reaches of the creek (WBM Oceanics Australia, 1997).

As well as sediment inflows, the Gowrie Creek system also receives inflows of potentially contaminated stormwater runoff from urban areas throughout the city. These stormwaters contain elevated levels of heavy metals, nutrients and other toxicants. In addition, there may be overflows from some of the city's older sewers under high rainfall conditions.

In order to quantify existing dry and wet weather water quality conditions in the creek, the results of an earlier study (WBM Oceanics Australia 1997) were reviewed. In this study, available water quality data at the Cranley Grange was separated into dry and wet weather conditions. The data, which extended from 1994 to 1996, enabled the results contained in Table 3.2 to be derived.



(Discharge to West Creek upstream of Margaret Street - 1998)

Table 3.2 - Ambient Gowrie Creek Water Quality Levels

Constituent	ANZECC (1992) Guidelines	Dry Weather	Wet Weather
Faecal Coliforms (<i>org/100mL</i>)	1000 ⁽¹⁾ /150 ⁽²⁾	2524	2258
Enterococcus (<i>org/100mL</i>)	230 ⁽¹⁾ /35	585	703
Chloride (<i>mg/L</i>)	100 ⁽³⁾	155±46	138±48
Nitrite (<i>mg/L</i>)	10 ⁽⁴⁾	0.03±0.01	0.03±0.00
Nitrate (<i>mg/L</i>)	30 ⁽⁴⁾	0.40±0.36	0.34±0.28
Phosphate (<i>mg/L</i>)	0.015 ⁽⁵⁾	0.29±1.17	0.05±0.04
Total P (<i>mg/L</i>)	0.1 ⁽⁵⁾	0.14±0.14	0.28±0.12

- (1) recreational waters - secondary contact
- (2) recreational waters - primary contact
- (3) irrigation waters
- (4) livestock watering
- (5) protection of aquatic ecosystems

From Table 3.2, it can be seen that:

- both dry and wet weather bacterial levels in Gowrie Creek are quite high. This is of some concern with respect to 'use' of the waters of Gowrie Creek by residents of Toowoomba; and
- nutrient levels are comparable in dry and wet weather flows, with both flow categories having higher than desirable phosphorus levels. This is of concern with respect to the downstream Condamine-Balonne and Murray-Darling Basin environmental management 'obligations' of Toowoomba.

WBM Oceanics Australia (1997) also estimated wet and dry weather mass loads from the catchment for a three year 'typical' rainfall period. These loads, for the key bacterial and phosphorus water quality constituents, were as follows:

Table 3.3 - Gowrie Creek Water Quality Mass Loadings

Constituent	Dry Weather	Wet Weather
Faecal Coliforms (10^{12} organisms/yr)	77	105
Enterococcus (10^{12} organisms/yr)	18	33
Total P (tonnes/yr)	0.35±0.06	1.08±0.62

From the above data, the importance of managing/treating *both* dry weather and wet weather flows to achieve generally acceptable recreational water quality levels, and reduced downstream pollutant loadings is apparent.

Pollutant export modelling undertaken by the study, described further in the Study Technical Appendix, showed that nutrient loads from the catchment with future development could increase by up to 10% with no management action. Bacterial loads could also be expected to increase.

Water quality must therefore be addressed as:

- it affects the goal of primary contact recreation in the creek;
- it affects the potential aesthetic and environmental benefits of the creek;
- it could prevent the realisation of study ecological goals via impacts on:
 - ⇒ instream life; and
 - ⇒ habitat creation
- the amenity goals of the study may not be achieved if the creek waters are unattractive (*either due to sediment, algae or litter*); and
- it affects the downstream management obligations of Toowoomba City Council.

With respect to the latter of the above, Toowoomba City Council recognises that runoff from the city contributes to the effective pollutant load in the Murray Darling system, and that any actions to reduce this load will be of benefit to areas downstream of the city.

3.4 ECOLOGY/HABITAT



(Gowrie Creek downstream of Griffiths Street - 1998)

There are no major areas of existing ecological or habitat value (*ie. the presence of areas of rare and endangered vegetation or faunal species, or significant habitat, in the catchment*) within the study area which restrict opportunities for waterway enhancement or catchment management activities along the waterways of Gowrie Creek.

Some sections of waterway have isolated stands of existing vegetation and ponded water that provide valuable local habitat, and the aim of the strategy should be to protect and enhance these areas. For example, in the vicinity of Hermitage Road, toward the northern limit of the study area, there is a significant vegetated area of Crown Land commonly referred to as Cranley Wood, which has ecological value. Similarly, the Waterbird Habitat on East Creek is worthy of protection and enhancement.

Cleared areas of the creek require revegetation in order to re-establish a continuous habitat link. On a regional scale, the eastern uplands of the Condamine catchment have been denuded, and the re-establishment of this creek corridor habitat will compliment the few remaining intact stands of vegetation in the region.

Ecological and habitat issues are imperative to achievement of the study goals and must be addressed by the strategy as:

- they affect the river bank stability objectives of the study;
- the provision of a suitably vegetated waterway corridor can assist with achieving the water quality goals of the study by promoting a healthy ecosystem and also by filtering lateral runoff into the creek from its' immediate catchment; and
- they affect the potential aesthetic and environmental benefits of the creek.

Ecological and habitat issues need to be addressed by the study as nature conservation has been identified as a high priority strategy in both the Condamine and Queensland Murray Darling Basin Strategic Plans. Hence, the strategy will need to develop a vegetated corridor along the creek system, using appropriate local species, to eventually restore the creek habitat to a form

similar to that which existed prior to European settlement. Such habitat re-establishment and corridor provision will require major replantings along the creek corridor. In association with in-stream habitat enhancements, this would provide the Gowrie Creek Catchment with far greater biodiversity than is presently the case.

3.5 OPEN SPACE AND RECREATION



(Existing wetland on West Creek - 1998)

Upstream of the CBD, the waterways of East and West Creek contain generous reserves of open space, of up to 100m width in some areas providing an extensive, yet under utilised open space and recreation system. While some of these areas display a significant cover of mature trees, the majority of the open space reserves are open grassed areas with limited tree planting. A number of active and passive recreation facilities exist within the open space reserves, providing numerous community focal points along the waterway, interconnected by an extensive, although sometimes fragmented, network of pedestrian and cycle pathways.

Within and downstream of the CBD, Gowrie Creek presently has no open space or recreational value due to limited open space and the dominance of adjacent industry. Over recent years, ongoing land filling carried out by adjacent industrial land owners has contributed to the serious creek bank erosion problems, directly affecting open space and recreational amenity as follows:

- steep banks combined with the close proximity of industrial development or private land prevent any physical pedestrian access;
- a lack of public land fronting the creek, combined with a lack of adjacent development oriented towards the creek, reduces public safety and willingness for the public to use the creek;
- heavy debris in the creek, with steep eroded banks void of vegetation, is unattractive and further reduces use of the creek for recreation; and
- a lack of any facilities gives people no reason to use this space.

Black Gully provides similar open space and recreational value to that of East and West Creeks upstream of the CBD.

3.6 AESTHETICS/CHARACTER



(Black Gully - 1998)

Upstream of the CBD, both East and West Creek are associated with generous, wide reserves of open space. Most of the waterway corridor above the CBD is under developed in terms of aesthetic value. In many areas, the open space is void of significant trees or shrub planting and consists of open expanses of grassland, offering the user minimal visual variety. Certain areas along East and West Creeks offer visual stimulation, in particular the Waterbird Habitat, Garnett Lehmann Park, Lake Annand and the waterway features on West Creek upstream and downstream of Stenner St. However, the waterway lacks a continuous and sequential visual experience made up of a variety of elements including tree and shrub planting, natural rock riffles, water bodies and even appropriate community art.

Within the CBD and down to the confluence of East and West Creeks, the waterways are less attractive due to the more constrained and highly modified nature of the creek bed and banks. Downstream of the confluence of East and West Creek, severe bed and bank erosion and the accumulation of rubbish and concrete debris within the creek channel result in Gowrie Creek having minimal to no aesthetic value.

Black Gully provides similar aesthetic opportunities to those of East and West Creek upstream of the CBD.

In areas where the creek has eroded such that adjacent industrial areas are affected, and where haphazard fill placement and rubbish dumping has occurred, further loss of aesthetic value and waterway character exists.

3.7 LAND USE



(Gowrie Creek looking downstream to North Street Road Bridge- 1998)

Landuses within the catchments of East Creek, West Creek, Gowrie Creek and Black Gully are highly developed, with predominantly residential, commercial, industrial and associated community facility landuse types. The only remaining portions of land which are currently undeveloped are situated in the extreme upper and lower portions of the overall catchment. Portions of land in the upper catchment are currently undergoing development for a variety of residential and ancillary purposes. This process is likely to continue until full catchment development is achieved in around 15 years (say 2011 to 2015).

The waterways of both East and West Creek and Black Gully run through developed areas of residential use and are immediately adjoined by generous reserves of open space offering continuous public access. Provided adjacent development faces the creek, and adequate links to the waterways and associated open space are provided and maintained, these adjacent land uses are generally compatible with a multiuse waterway corridor. Potential exists to incorporate catchment performance policies and development criteria into the City-wide Strategic Plan or any Local Area Plans for the undeveloped areas to ensure catchment constraints, opportunities and linkages are taken into account in all future development assessments.

Downstream of the CBD however, existing land uses adjacent to Gowrie Creek are not orientated towards or compatible with a desirable waterway corridor function. The existing land uses result in the complete alienation of the waterway from any aesthetic appreciation, open space provision or recreational role. The waterways in these areas show signs of neglect associated with their inaccessibility. Re-development and new development opportunities exist throughout these CBD and downstream areas. Incorporation of catchment and Creek orientated performance criteria into the implementation of the current strategies and development assessments is desirable to reverse the current degree of neglect in particular locations.

In the lower reaches of Gowrie Creek, where adjacent land is undeveloped but zoned for industrial use, opportunities exist to adapt adjacent land use development potential to promote and establish a land use that can be integrated to suit functional and recreational aspects of the waterways. The establishment of the second range crossing through these lower reaches will present an opportunity to redistribute the City's industrial estates and to enhance the entry

statement to Toowoomba through maximising the Creek's assets and accessibility in this northern area.

3.8 SUMMARY

The future development of Toowoomba is aimed at ensuring that the City continues to respond to the needs of the Toowoomba and regional communities, while also ensuring that development is economically and environmentally sustainable as well as socially responsive for the long term benefit of the community.

The general thrust of Toowoomba City Council's Strategic Plan in this regard is to maintain a City with a convenient central location and which is of a comfortable size with good recreational, educational, cultural and health facilities and services for the benefit of its citizens and visitors.

The Gowrie Creek system provides a key element of the green and attractive "Garden City" environment, integral to the success of the Strategic Plan's vision. It is acknowledged that the catchments of the Gowrie Creek system will be developed to achieve the overall planning principles of liveability, economic development, environmental quality and social equity. Regulation of these planning principles throughout the catchment areas may not always achieve optimal benefits for the Gowrie Creek system, as envisaged in this Management Strategy, in all instances. However, development opportunities and constraints for areas in close proximity to, or directly impacting upon the creek system need to be recognised and incorporated in all future decisions.

Figures 3.5 to 3.7 summarise the existing conditions in the catchment as identified by this study.

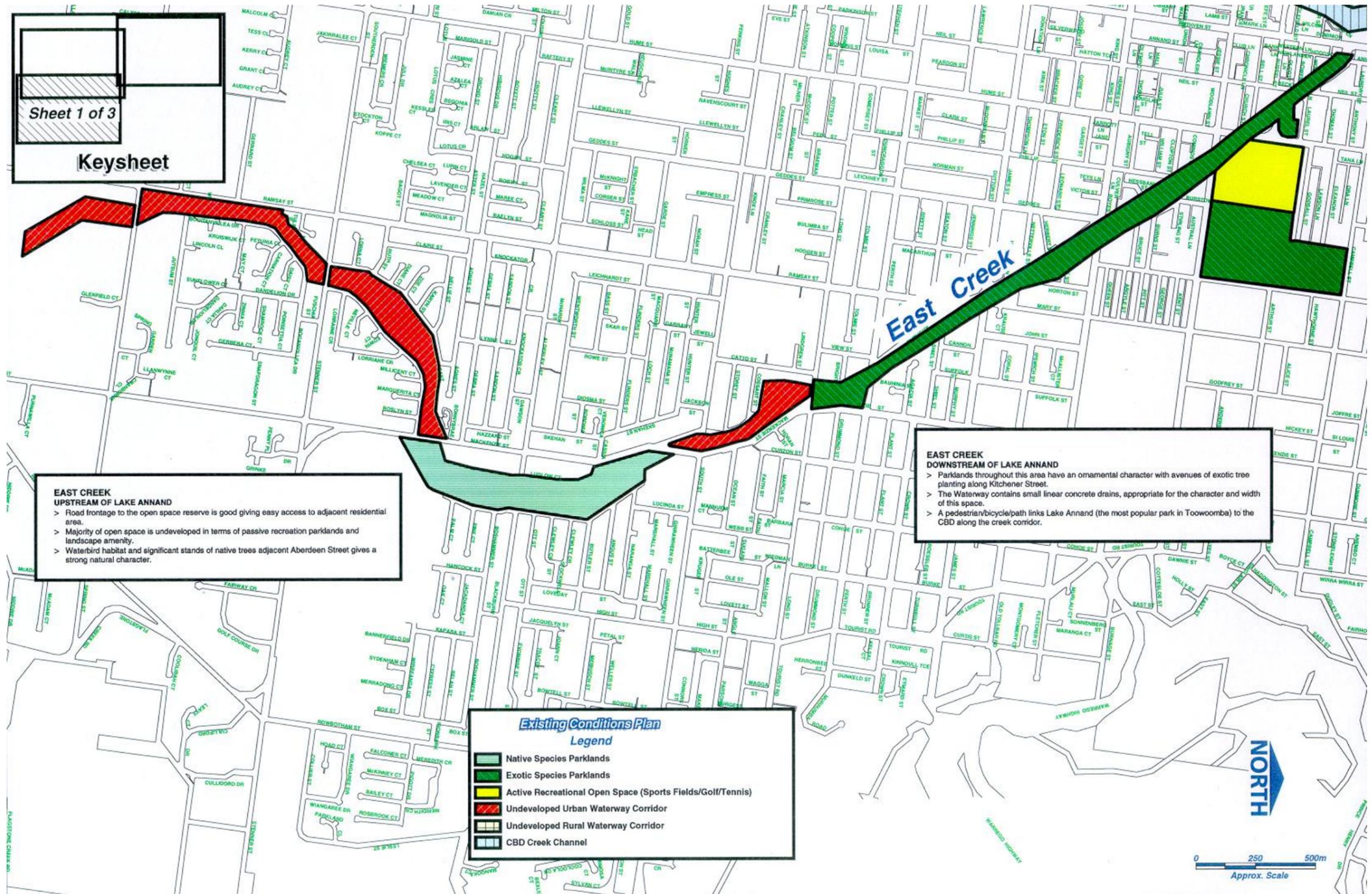


Figure 3.5 - Existing Condition Assessment - East Creek

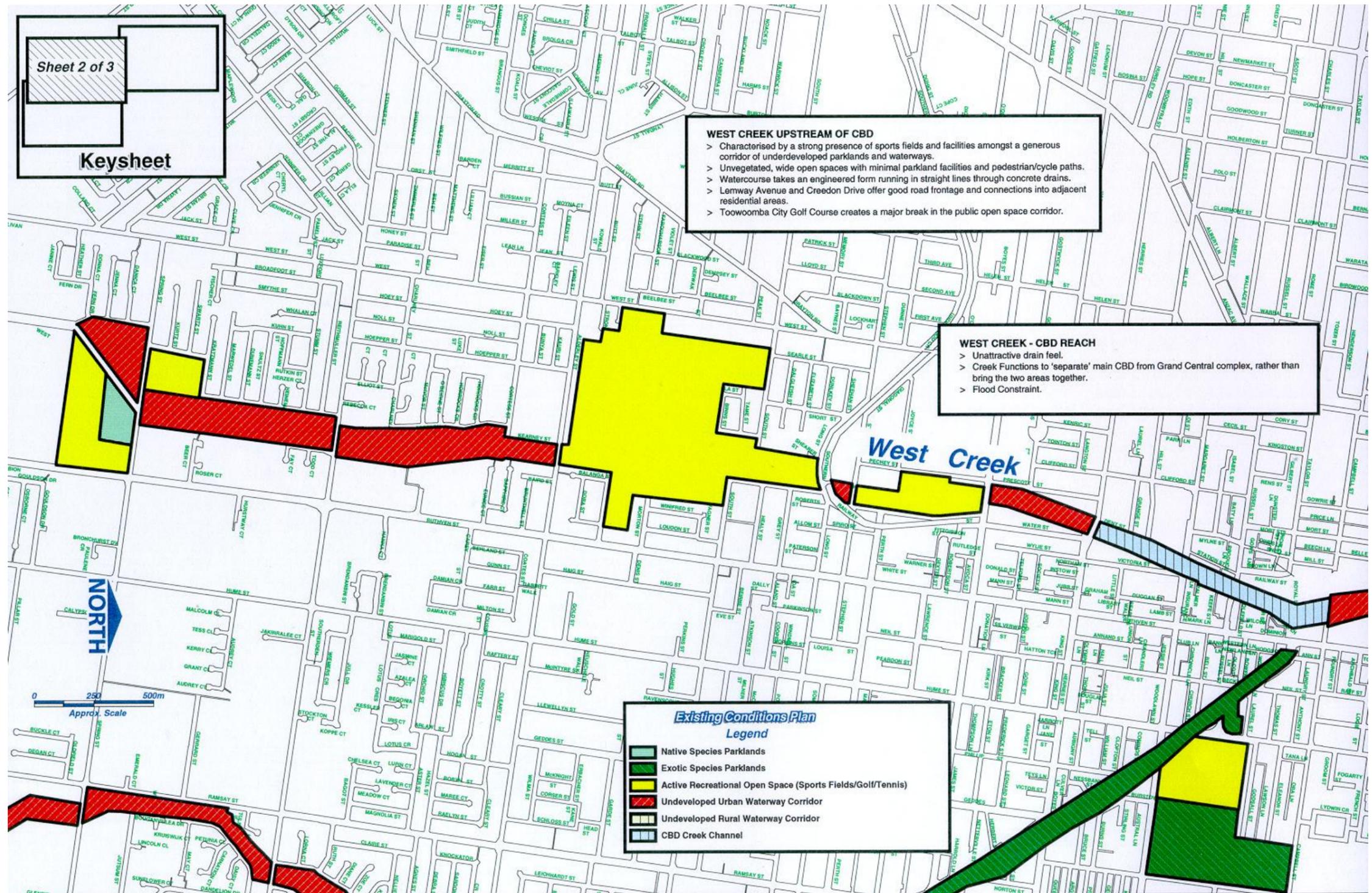


Figure 3.6 - Existing Condition Assessment - West Creek

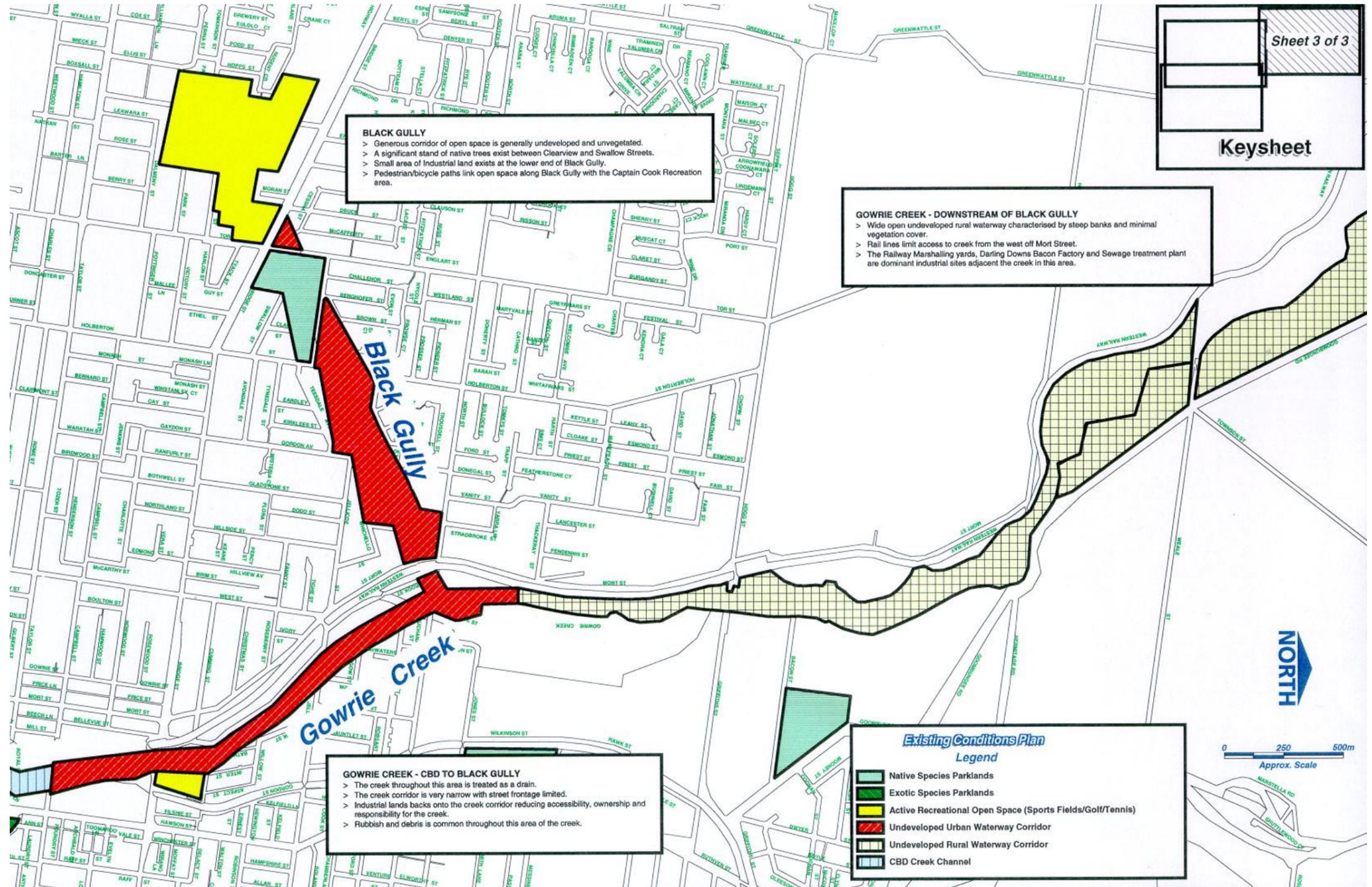


Figure 3.7 - Existing Condition Assessment - Gowrie Creek and Black Gully



GOWRIE CREEK Toowoomba
**MANAGEMENT OPTION FORMULATION AND
SHORTLISTING**

4 MANAGEMENT OPTION FORMULATION AND SHORTLISTING

Following on from the previously described Existing Condition assessment, the study considered the management options available to overcome the problems being experienced by Gowrie Creek. As a first step in this regard, Opportunity and Constraint plans were prepared summarising all possible factors which could affect the study. These plans are attached as Figures 4.2 to 4.4.

Following the Opportunity and Constraint assessment, it became apparent that there were a large number of potential management actions which could be considered in different sections of the Gowrie Creek catchment, and an even greater number of ways in which these disparate management actions could be combined. It became apparent in the early stages of this study that there were four 'areas' that had distinctly separate characteristics for which different management actions were required. Joint actions within these areas would work towards satisfying the Study Vision and Goals. These separate areas (Figure 4.1) were as follows:

- The whole of the catchment, outside the immediate waterway corridors; and
- Along the waterway corridors of:
 - ⇒ East and West Creeks and Black Gully;
 - ⇒ West Creek within the CBD;
 - ⇒ Gowrie Creek itself.

The approach whereby management actions for each of these areas were formulated, combined, shortlisted and from which a preferred study option/management scheme was formulated is discussed below.

4.1 OPTION FORMULATION

4.1.1 Whole of Catchment Actions

A wide range of 'whole of catchment' actions was initially proposed that would occur in addition/parallel to planned waterway management activities. Such actions (which are further described in Section 5.1 of this report) were as follows:

- revegetation along creek corridors with appropriate species;
- facilitation of community education and awareness on catchment management issues;
- investigation of opportunities for stormwater harvesting and reuse; and
- 'within catchment' measures to link with community awareness and other study actions including:
 - ⇒ the use of rainwater tanks;
 - ⇒ innovative stormwater management techniques;
 - ⇒ litter control measures;
 - ⇒ sediment and erosion control; and
 - ⇒ dog/cat faeces control measures.

These 'whole of catchment' actions, and study recommendations in this regard, are further discussed in Section 5.1 of this report.

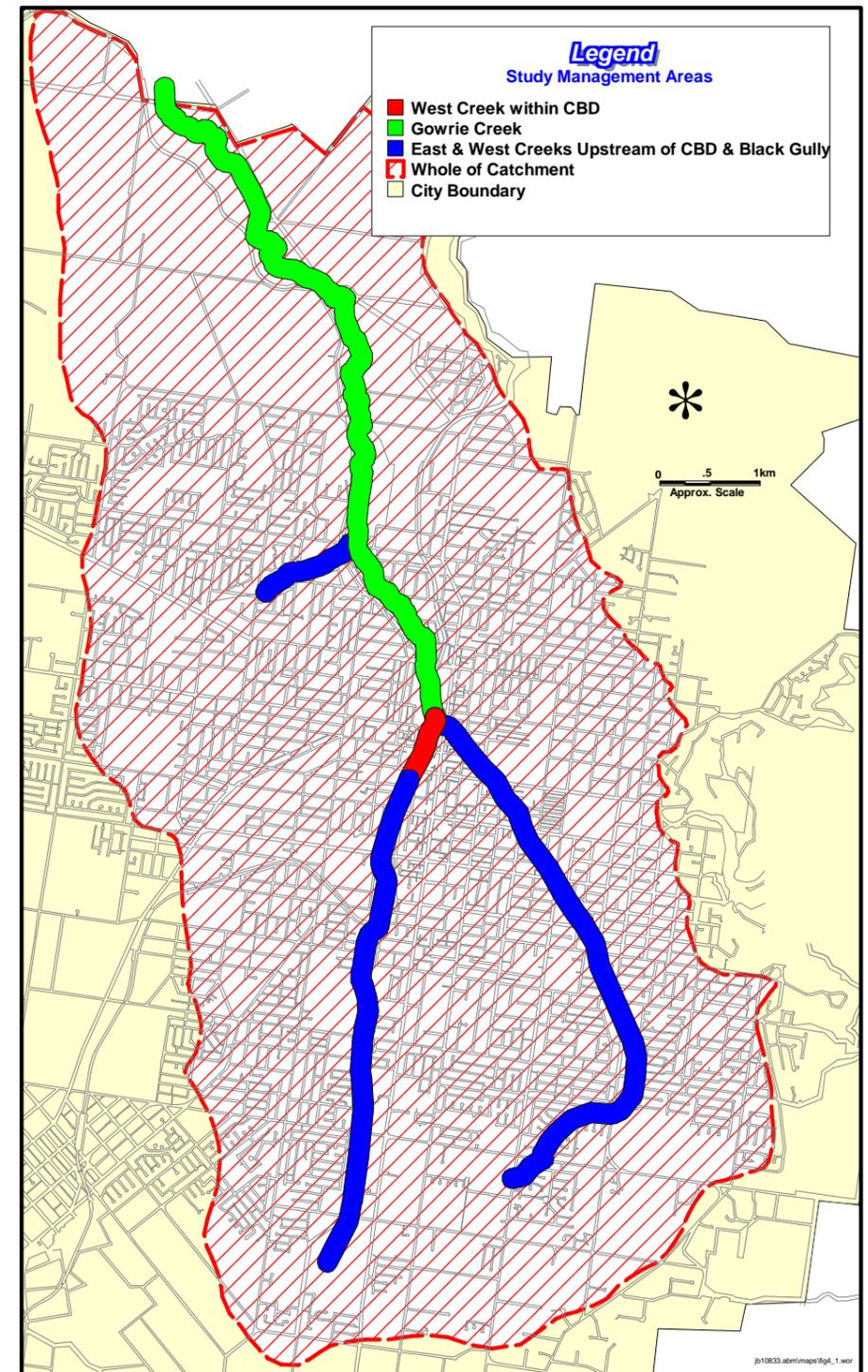


Figure 4.1 - Defined Study Management Areas

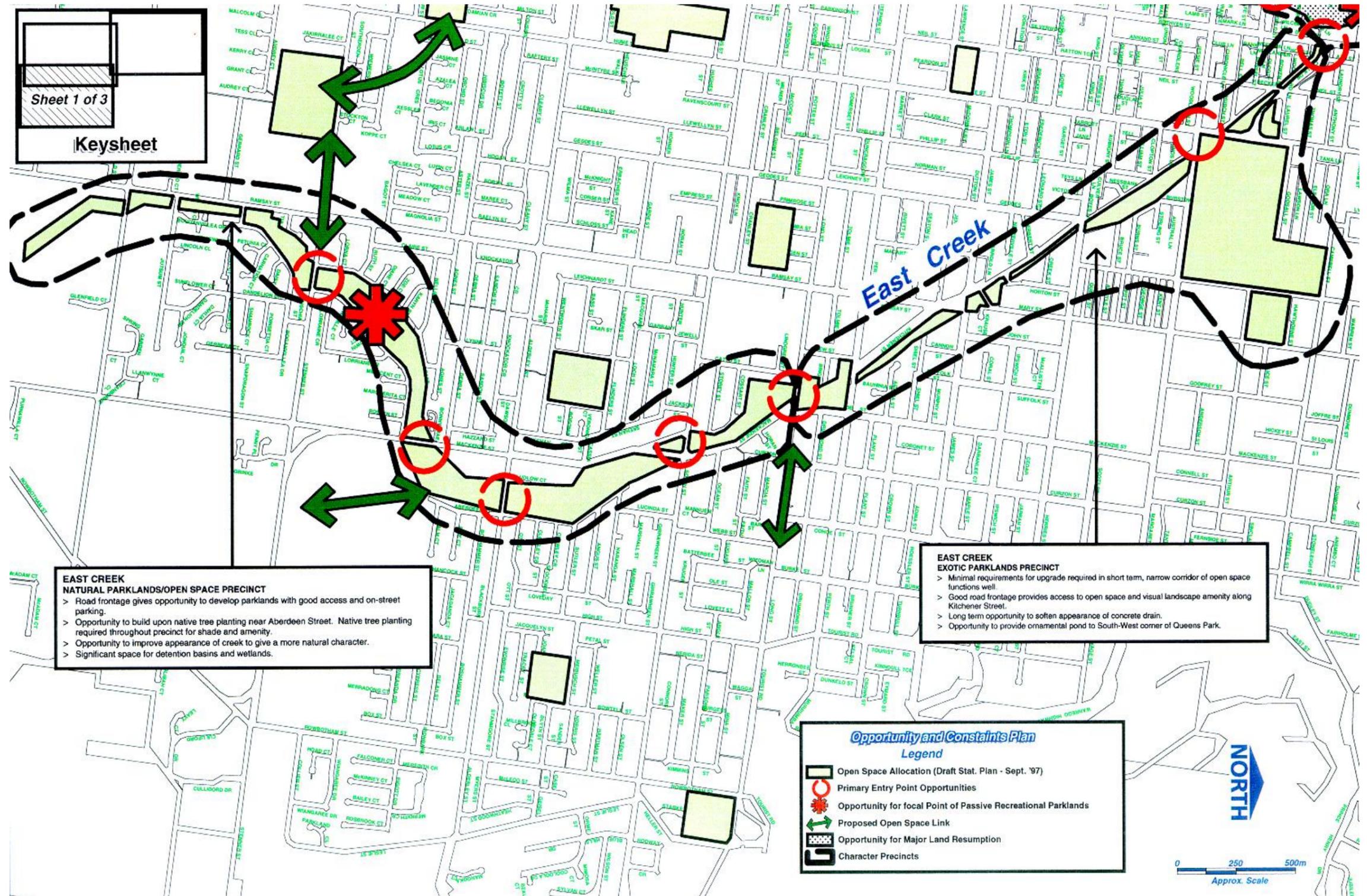


Figure 4.2 - Opportunity and Constraint Assessment - East Creek

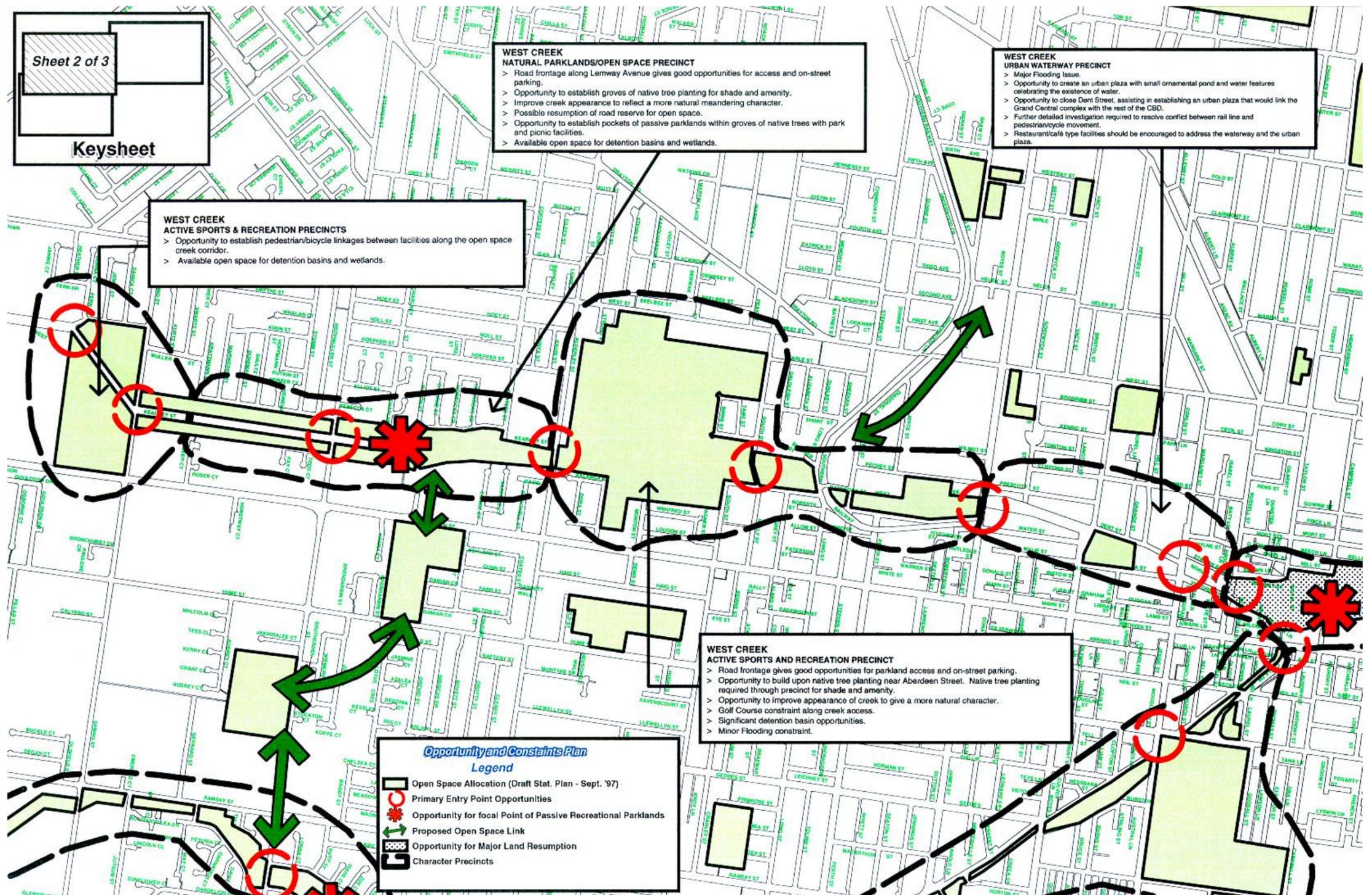


Figure 4.3 - Opportunity and Constraint Assessment - West Creek

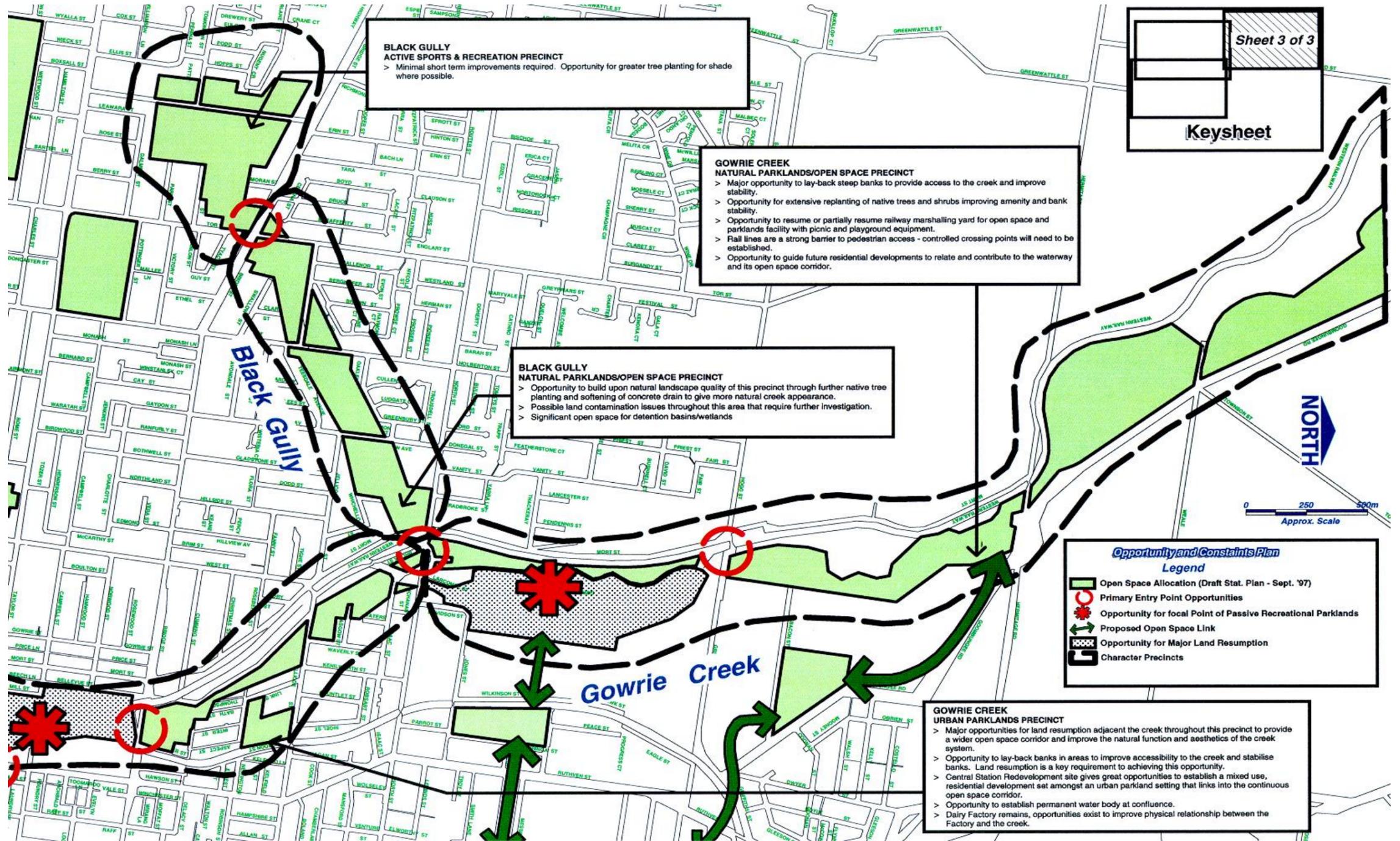


Figure 4.4 - Opportunity and Constraint Assessment - Gowrie Creek and Black Gully

4.1.2 West and East Creeks and Black Gully

Four management actions were initially identified in this area for consideration by the study, as follows:

- do nothing;
- flood detention structures;
- flood retention structures (eg. lakes); and
- wetlands.

In all cases, the 'do nothing' option was included to provide a baseline against which to compare the other options. Flood detention structures, or dry detention basins, would control downstream flooding and assist with reducing bank erosion. Flood retention structures, or wet detention basins, would serve a similar flood/erosion control role to the dry basins with additional water quality and aesthetic/open space benefits. Wetlands would control flooding and reduce bank erosion in a similar manner to detention basins, and would have significant additional water quality, aesthetic and environmental values.

4.1.3 CBD Reach

Four management actions were initially identified in this area for consideration by the study, as follows:

- do nothing;
- complete 'undergrounding' of West Creek;
- partial 'undergrounding' of West Creek, with additional channel improvements; and
- channel improvements alone.

'Undergrounding' refers to a previous proposal to construct a major culvert structure (3 of 3.6 x 3.6m box culverts) along West Creek from Herries Street to below the Confluence, sufficient to convey the 100 year Average Recurrence Interval (ARI) flood. This undergrounding was proposed for both flood mitigation reasons, and as a way of allowing road construction between Chalk Drive and Russell Street. Partial undergrounding refers to a possible option to use small culverts to convey say the 2-5 year ARI event, and to supplement this with channel improvements along West Creek to convey larger events via overland flow without causing local property inundation. The 'channel improvement alone' option relied on upstream detention measures to reduce peak flood flows such that by upgrading the channel of West Creek between Herries St and the Confluence, floodwaters would be able to be safely conveyed along the creek.

For the CBD Reach, in the 'Do Nothing' option, channel 'undergrounding' between Chalk Drive and Russell Street was assumed to be required for traffic conveyance reasons. The 'Do Nothing' description effectively applies throughout the remainder of the study area.

4.1.4 Gowrie Creek

Five management actions were initially identified in this area for consideration by the study, as follows:

- do nothing;
- minimal land acquisition, lay back banks and channel stabilisation;

- construction of drop structures or an artificial pool and riffle sequence;
- construction of additional retention and detention structures along the creek; and
- more extensive land acquisition and greater/flatter bank reprofiling.

The main management issue requiring attention for this section of the creek is the unstable nature of the creek banks. For this reason, one of the proposed actions was to lay back the banks at a stable slope (say 1 vertical: 4 horizontal) and to undertake necessary channel stabilisation (either by vegetative or 'hard' engineering measures). In order to enable this action to occur, it would be necessary to gradually and voluntarily acquire certain properties along the creek.

One other way in which creek stability could be enhanced would be to construct a series of 'drop' structures (see Section 5.2.4) along the eroding section of creek, thus creating a series of slower flowing pools and energy dissipating riffles along the creek. There may also have been merit/value in the use of additional retention and detention structures along the creek. One final management action that was identified was to undertake more extensive land acquisition along the creek, thus enabling greater bank re-profiling, and the provision of a more significant open space and recreational corridor along the creek.

4.2 INITIAL SHORTLISTING

Initial evaluations were made of the previously described management actions, and the following decisions were made by the study team in consultation with the Reference Group and Project Coordination Group:

- additional retention/detention measures in Gowrie Creek downstream of the Confluence were shown to be ineffective due to the volume/rate of floodwater passing through the creek in this reach, and also due to the limited available area; and
- drop structures and pool/riffle sequences would be required in association with all management options for this area to achieve the desired flow velocities, and hence would not be considered separately.

Given the above, an initial list of nineteen possible waterway management options were formulated, as illustrated in Table 4.1.

There was a need to refine the possible waterway management options presented above to a more reasonable set for detailed assessments. In this regard, the following approach was taken to define a preferred set of initial waterway management options:

- the 'do nothing' option was selected as a baseline against which all options should be assessed;
- the 'hardest', or most engineered, option (Option 2) was selected;
- the 'softest', or most natural, option (Option 19) was selected;
- the likely least cost option (Option 8) was selected; and
- the likely most expensive option (Option 13) was selected.

Table 4.1 - Possible Waterway Management Options

Downstream of CBD	CBD Reach	West Ck/East Ck/ Black Gully	Option No.
Do Nothing	Undergrounding from Russell Street to Chalk Drive only for traffic reasons	Do Nothing	1
Minimal land acquisition and layback banks	Complete Undergrounding	Detention	2
		Retention	3
		Wetlands	4
	Partial Undergrounding	Detention	5
		Retention	6
	Wetlands	7	
Channel Improvements	Detention	8	
	Retention	9	
	Wetlands	10	
More extensive land acquisition for creek and side parks layback banks	Complete Undergrounding	Detention	11
		Retention	12
		Wetlands	13
	Partial Undergrounding	Detention	14
		Retention	15
		Wetlands	16
	Channel Improvements	Detention	17
		Retention	18
		Wetlands	19

The adopted initial Waterway Management base cases are presented in Table 4.2 below.

The study was also requested to investigate a ‘no detention’ option which considered complete undergrounding through a section of the CBD and channel stabilisation (e.g. stone pitching, concrete lining) of eroding sections of Gowrie Creek, without flood flow mitigation measures in the upper parts of the catchment.

Table 4.2 - Initial Waterway Management Options

Description	Downstream of CBD	CBD Reach	West Ck/ East Ck/ Black Gully	Option No.
<i>Do Nothing</i>	Do Nothing	Undergrounding from Russell Street to Chalk Drive only for traffic reasons	Do Nothing	1
<i>‘Hardest’ Option</i>	Minimal land acquisition and layback banks	Complete Undergrounding	Detention	2
<i>Minimum Cost Option</i>	Minimal land acquisition and layback banks	Channel Improvements	Detention	8
<i>Maximum Cost Option</i>	More extensive land acquisition for creek side parks and lay back banks	Complete Undergrounding	Wetlands	13
<i>Maximum Community Benefit</i>	More extensive land acquisition for creek side parks and lay back banks	Channel Improvements	Wetlands	19
<i>No Detention</i>	Stabilise Channel	Complete Undergrounding	Do Nothing	-

Subsequent to the formulation of these initial options, more detailed assessments of each option were performed to assist in further shortlisting. The approach/findings of these assessments are described below.

Firstly, hydrological and hydraulic modelling (refer Study Technical Appendix) showed that with the construction of a reasonable number of detention basins (or wetlands) upstream of the CBD, that flood flows for existing and ultimate catchment conditions could be acceptably conveyed through the CBD. Consequently, Options 2 and 13 presented in Table 4.2 were eliminated.

Technical, environmental/open space, social and financial assessments were subsequently undertaken by the study team, in consultation with the Reference Group and Project Coordination Group. The results of these assessments are summarised in Tables 4.3 to 4.6 below.

Table 4.3 - Technical Summary

Element	Base Case			
	Do Nothing	No Detention	Minimum Cost	Maximum Community Benefit
Prevent CBD Flooding	ú	ú	ú	ú
Reduce Flood Flows	ú	ú	ú	ú
Reduce Flood Velocities	ú	ú	ú	ú
Reduce Pollutant Export	ú	ú	ú	ú

Table 4.4 - Environmental and Open Space Summary

Element	Base Case			
	Do Nothing	No Detention	Minimum Cost	Maximum Community Benefit
Improve Water Quality	ú	ú	ú	ú
Enhance Riparian Zone	ú	ú	ú	úú
Improve Aesthetics of Creek Corridor	ú	ú	ú	úú
Achieve Open Space/ Recreation Potential	ú	ú	ú	úú

Table 4.5 - Social Benefit Summary

Element	Base Case			
	Do Nothing	No Detention	Minimum Cost	Maximum Community Benefit
Creek Accessibility & Safety	ú	ú	ú	ú
Compatible Land Use along Creek Corridor	ú	ú	ú	ú
Additional Public Space	ú	ú	ú	úú

Table 4.6 - Financial Summary

Element	Base Case (*)			
	Do Nothing	No Detention	Minimum Cost	Maximum Community Benefit
Flood Damage and Clean-up Costs	\$1,911,000	-	-	-
Undergrounding	\$10,933,000	\$21,000,000	\$7,000,000	\$7,000,000
Detention Basins and Lakes/ Wetlands	-	-	\$10,000,000	\$11,600,000
Land Acquisition	-	\$4,500,000	\$4,500,000	\$11,000,000
Rock Riffles/Pools	-	-	\$2,000,000	\$2,000,000
Bank Stabilisation/Re-Profiling	-	\$11,044,000	\$1,841,000	\$3,700,000
East Creek Channel Works	-	\$500,000	\$300,000	\$300,000
Indirect Costs	\$709,000	\$315,000	\$236,000	-
TOTAL	\$13,553,000	\$37,359,000	\$25,877,000	\$36,600,000

Indicative costs only.

With respect to the information presented in Table 4.6, the following assumptions were made:

- costs are a net present worth estimate
- 50 year time period
- 6% discount rate
- 'indirect' costs refer to estimated costs of:
 - ⇒ ongoing sediment and pollutant export (\$10,000/yr)
 - ⇒ lost environmental opportunities (\$10,000/yr)
 - ⇒ lost open space opportunity (\$10,000/yr)
 - ⇒ lost aesthetic value opportunity (unattractive creek corridor along new Range Crossing) (\$15,000/yr)
- flood damage and clean-up costs combine estimated costs of:
 - ⇒ property clean up within CBD (\$10,000/yr)
 - ⇒ annual costs for general bank restoration downstream of confluence (\$35,000/yr)
 - ⇒ occasional major bridge repair (\$1,000,000 at year 15)
 - ⇒ building undermining repair every 5 years (\$200,000 at years 5, 10, 15, ...)
 - ⇒ annual cost to repair ongoing East Creek Scour problems (\$10,000/yr)

Based on the information summarised in Tables 4.3 to 4.6, the following general comments can be made with respect to the four study options.

- the 'do nothing' option has substantial costs associated with it, with no environmental or social benefit, CBD flooding upstream of Russell Street would continue to be a problem (as undergrounding was assumed to commence at Russell Street), and would in fact worsen;

- the 'no detention' option will manage CBD flooding, and has some environmental and open space benefits, however it is very expensive, would appear very heavily engineered and unnatural and would be subject to the well recognised potential for failure of engineered works in a natural waterway;
- the 'minimum cost' option is considerably less expensive than the 'no detention' case, and has significant additional benefits in terms of environmental, social and open space improvements of the Gowrie Creek system; and
- the 'maximum community benefit' option is comparable in cost to the 'no detention' case, and of much greater benefit to the environmental, social and open space characteristics of Gowrie Creek. It would provide an attractive corridor through the centre of Toowoomba.

Given the above, and a review of the Catchment Goals and Visions defined earlier in this study, the recommendation was made to proceed with a more detailed appraisal, including Community Consultation, of two (2) study management options, as follows:

- minimum cost; and
- maximum community benefit.

This recommendation was presented to, and endorsed by, both the Reference Group and Council. The study then moved into a Community Consultation Phase, as described in Section 4.3.

The results of detailed mathematical modelling, and other desktop assessments, were used as part of the process described above in order to verify the capacity of the various proposed management measures to achieve the defined catchment goals. A summary of these assessments, presented in more detail in the Study Technical Appendix, is presented below:

- Hydrology - In total, 20 detention basins are proposed in both the Minimum Cost and Maximum Community Benefit options at various locations along East and West Creeks (as detailed in the Study Technical Appendix). The impacts of these basins on peak flood flows for a range of design flood events are summarised below.

Table 4.7 - Peak Design Event Flows (m³/s) for Ultimate Catchment Development with Detention Basins

Location	1 yr ARI	2 yr ARI	100 yr ARI
East Creek upstream of confluence with West Creek	23.4 (0%)	30.6 (4%)	64.5 (-7%)
West Creek upstream of confluence with East Creek	21.7 (-39%)	28.3 (-42%)	56.2 (-46%)
Black Gully at junction with Gowrie Creek	27 (-19%)	36.6 (-12%)	84.2 (-1%)
Gowrie Creek upstream of junction with Black Gully	50.3 (-21%)	64.5 (-23%)	141.1 (-28%)
Cranley Gauge	76.6 (-8%)	96.6 (-13%)	217.2 (-14%)

Note - values in brackets are changes in peak flow rates compared to **existing** catchment conditions.

- Flooding - The reduced peak flows in West Creek through the Toowoomba CBD enable the 100 year ARI event to pass along West Creek without causing any out of channel flooding. This flooding improvement is illustrated in Figure 4.5.

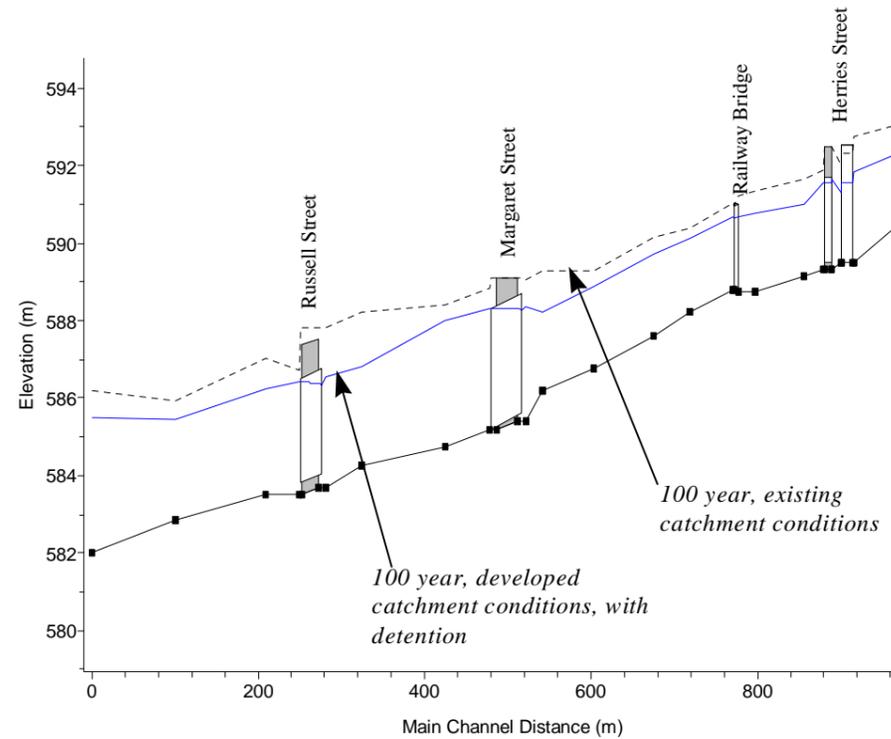


Figure 4.5 - 100 year Flood Level Profile - CBD Reach - with Detention Basins

- Bank/Bed Erosion - The reduced peak Flood Flows, channel modifications and pool/riffle structures proposed along Gowrie Creek have a significant effect on flow velocities along the creek, which is the key cause of existing erosion problems. The changes in critical 2 year ARI flood flow velocities in Gowrie Creek between Bridge Street and North Street for the minimum cost option (with minimal bank reprofiling) are illustrated in Figure 4.6. Average 2 year flow velocities in critical reaches of Gowrie Creek change as illustrated in Table 4.8 and Figure 4.7 with the implementation of catchment management measures.

Table 4.8 - Changes in 2 year Flood Velocities

Creek Reach	Existing	Developed	Developed + Catchment Management Measures
Bridge to North Streets	1.94 m/s	2.06 m/s	1.36 m/s
North to Griffith Streets	1.96 m/s	1.98 m/s	1.65 m/s

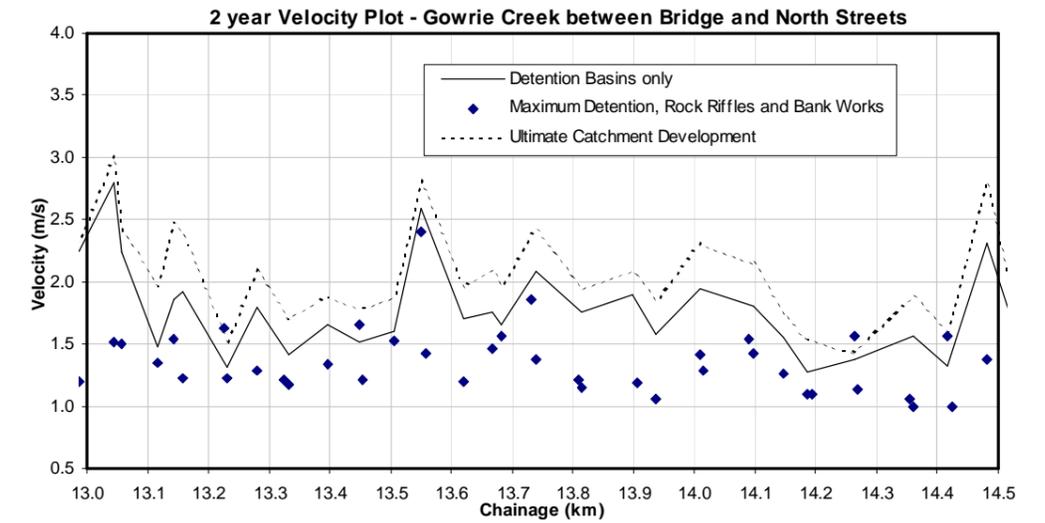


Figure 4.6 - Flood Velocity Profiles - Gowrie Creek - with Detention Basins

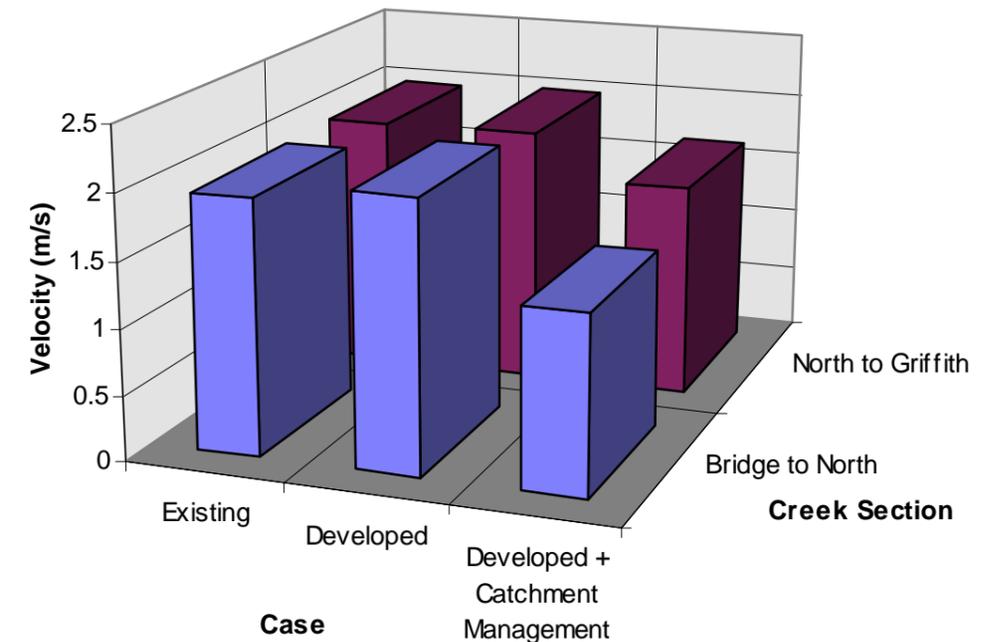


Figure 4.7 - Changes in Average 2 year Flood Velocities

- Pollutant Export/Water Quality - The Minimum Cost option would have only marginal benefits in terms of pollutant export from the catchment of Gowrie Creek. It would also only slightly improve baseflow water quality. With the Maximum Community Benefit option however, more substantial pollutant export/water quality benefits are likely to occur as:

⇒ stormwater flows will be detained for several hours/days in wetlands and lakes/wet basins, allowing the deposition of sediment and organic material; and

⇒ baseflows will be detained for several days in the series of wetlands, wet basins and pool/rifle structures, enhancing significantly the disinfecting effect of sunlight/UV penetration into the ponded areas.

The effect of the former of the above on catchment pollutant export was simulated in the models developed by the study, with the results of these predictions contained in Table 4.9.

Table 4.9 - Pollutant Export Predictions

Pollutant	Existing Land Use	Fully Developed Catchment	Fully Developed Catchment & Wetlands
Total Sediment	1.55 x 10 ⁶ kg	1.70 x 10 ⁶ kg	1.35 x 10 ⁶ kg
Total Nitrogen	1.35 x 10 ⁴ kg	1.53 x 10 ⁴ kg	1.40 x 10 ⁴ kg
Total Phosphorus	2.81 x 10 ³ kg	3.16 x 10 ³ kg	2.84 x 10 ³ kg

These predictions indicate that the proposed wetlands will significantly reduce sediment export, and produce a no-worsening situation for nutrient export following full catchment development.

With respect to base flow water quality improvement, the wetlands and pools along Gowrie Creek have a combined resident volume of in excess of 120 ML. For a typical baseflow of 5 ML/day, this will effectively detain baseflow for some 24 days. This detention will significantly improve the baseflow water quality, especially with respect to bacterial levels.

One other issue of concern to the Reference Group was evaporation from the wetlands, and the effect this may have on downstream users who rely on creek baseflows. Calculations indicated that the estimated average annual loss of baseflow in a dry year (*ie 30% below average rainfall*) due to evaporation is 0.24 ML/day, which represents 5%. This potential loss will be offset to a degree by the increased yield that will occur from the catchment due to further development, the improvements in water quality and alterations to the shape of the flood hydrograph caused by the flood flow detention basins.

4.3 COMMUNITY CONSULTATION

Following selection of the two shortlisted study options, an extensive community consultation process was undertaken. Key elements of this consultation were as follows:

- a 'stakeholder' meeting prior to commencement of the widespread consultation phase, to inform those residents and industries potentially affected by the study of what is proposed and seek their views;
- a 4 week public display period with two permanent displays located in one of Council's Administration Buildings and the City Library, and one mobile display which was respectively located for one week periods in the following Toowoomba shopping centres and venues:

- ⇒ Village Fair
- ⇒ Clifford Gardens
- ⇒ The 134th Royal Toowoomba Show
- ⇒ Toowoomba Kmart Plaza

The displays in these locations were continuously staffed by Council officers and members of the Reference Group.

- a public meeting was held toward the end of the consultation period to provide interested citizens with an opportunity to raise any queries and objections that they may have had with the study; and
- the provision at all of the above consultation activities of 'feedback' forms to enable participants/ interested persons to comment on the study.

For each of the above displays, a carefully designed series of text/picture panels describing the study was used, supported by a montage of landscape architect produced plans of the waterways of East, West and Gowrie Creeks and Black Gully. These plans illustrated the works proposed in each area for both the 'Minimum Cost' and 'Maximum Community Benefit' options.

Overall response from the community consultation was strong (*504 responses*), and generally favourable towards the strategy. 96% of respondents expressed either Support or Strong Support for the strategy. Support for one option over another was not however so apparent. There was greater support for the Maximum Community Benefit option within the CBD, however for the other study areas there was still considerable support for the Minimum Cost option. This sentiment was also apparent at the Stakeholder and Public Meetings.

Something that became apparent during the course of the Community Consultation phase was a concern that, even though most people favoured the Maximum Community Benefit Option, that the preferred approach could be a combination of certain elements of the two options. This combination of the "Minimum Cost" and "Maximum Community Benefit" approaches could satisfy many of the catchment goals, at a more affordable price.

The importance to future activity on this project of both the number of community responses (*504*) to the public displays, and the degree of support for the strategy (*96%*) must be highlighted. There was an obvious mandate provided to Toowoomba City Council by the citizens of the city to pursue implementation of works within the catchment of Gowrie Creek.

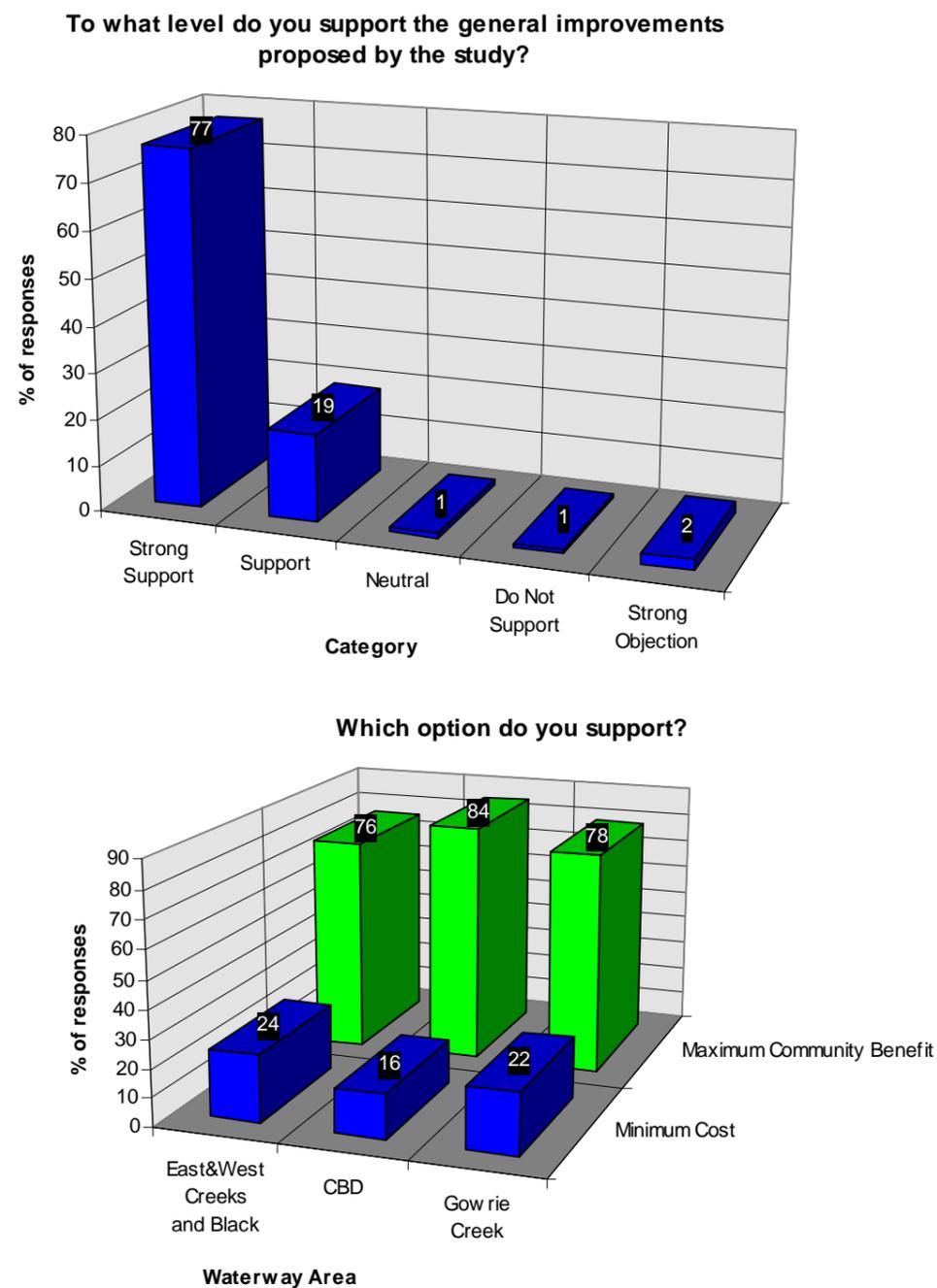


Figure 4.8 - Community Response Analysis - Preferred Strategy Option



(Example of community consultation material)

4.4 PREFERRED MANAGEMENT PLAN SELECTION

Based on a thorough review of the findings of the study Community Consultation phase, further analysis of the merits and disbenefits of the two options, and meetings with the Reference Group, Project Coordination Group and Council, the decision was made to adopt a preferred management plan configuration which was a modification of the Maximum Community Benefit option. Modifications were principally made along the section of Gowrie Creek from Bridge to Griffiths Streets, in which the Maximum Community Benefit option was likely to cause some distress to local residents and industries due to the extensive, though voluntary, land acquisition proposed for this area. Key changes that were made to the Maximum Community Benefit option to develop the recommended waterway management plans presented in Chapter 5 of this report were as follows:

- modify/fine tune the areas of identified land purchase downstream of the CBD;
- define this modified land requirement initially on the basis of the minimum channel section and land purchase required for channel bed/bank stability;
- investigate in detail land requirements downstream of the CBD for Open Space and Recreational requirements; and
- provide for key 'nodes' of activity and access requirements.

All elements of the recommended management plan for the catchment and waterways of Gowrie Creek are subsequently presented in Chapter 5 of this report.



GOWRIE CREEK Toowoomba
CATCHMENT MANAGEMENT PLANS

5 CATCHMENT MANAGEMENT PLANS

5.1 WHOLE OF CATCHMENT ISSUES

There are a wide range of whole of catchment issues and activities which need to be initiated by Council to compliment the works proposed along the waterways and to build a sense of ownership and responsibility for Gowrie Creek by the residents of Toowoomba. It is important to realise that without attention to these matters, the works proposed along the waterways will be less effective, and also that there may be conflicts with the desired study goals that could otherwise have been overcome. Examples of these issues are as follows:

- if catchment based stormwater management measures reduce the relative increase in peak storm flow associated with on going catchment development, then waterway based management measures (eg. *detention basins, wetlands*) will perform more efficiently; and
- attention to catchment based processes may actually facilitate the achievement of the desired study goals. For example, there is a desire for the waters of Gowrie Creek to be safe for people to swim in at most times. Without management of diffuse catchment processes such as sewer exfiltration, illegal stormwater connections and animal faecal matter deposition, this study goal may never be achieved.

In regard to ‘Whole of Catchment’ issues, we believe that there are eight (8) broad categories or areas in which Council should take action, as follows:

- community education;
- innovative stormwater management;
- management of illegal stormwater connections, sewer exfiltration and sewer overflows;
- erosion and sediment control;
- management of diffuse source pollution;
- fertiliser and pesticide use control;
- weed species control; and
- future planning and management of land uses.

These categories are discussed below.

5.1.1 Community Education

Gowrie Creek receives a wide range of pollutant inputs due to human activities in the catchment, ranging from washing paint brushes in drains to people illegally disposing of lawn and garden refuse into the creek. In isolation, these inputs may be small however when aggregated across the 60-80,000 people who live in the catchment of the creek, this total load could be quite large.

Community awareness and education programs have been shown (*Melbourne Water et al, 1998*) to be a valuable tool for changing community attitudes and behaviour, with commensurate improvements in stormwater quality, realising that these changes do not occur ‘overnight’. This is a long term process that needs ongoing resourcing. Source control education programs focus the responsibility squarely on the polluter. This can often lead to permanent solutions to stormwater pollution and waterway management problems, due to simple, though long term, changes in attitude and behaviour.

Toowoomba City Council and the Reference Group should develop a thorough community education program to complement other works in the area. This program should have both short and long term objectives, as follows:

- short term - to improve the understanding of residents in Toowoomba of:
 - ⇒ how the streets and stormwater system of Toowoomba and the Gowrie Creek system are interconnected;
 - ⇒ the relationship between people’s daily activities (eg. *washing the car, gardening*) and stormwater quality; and
 - ⇒ how actions within the catchment affect the ‘health’, ecology and biodiversity of the Gowrie Creek system.
- long term - to encourage a true sense of responsibility and ownership for the Gowrie Creek catchment including:
 - ⇒ increasing community participation in creek and catchment management; and
 - ⇒ a greater community appreciation of the creek system itself, and what environmental values it has to offer.

Examples (*Melbourne Water et al, 1998*) of simple messages that can be used in community catchment management education programs are provided below.

Painting clean-up

Never clean brushes or rinse paint containers into street gutters or drains. When using water based paints, paint out brushes on scrap materials and rinse into the garden or into an older container.

Car washing

Washing your car in the street can lead to soapy water flowing down the gutter and into Gowrie Creek. The increased nutrients from detergents will contaminate the creek, causing water plants and algae to grow in excessive quantities. By washing your car on a grassed area, you’ll help keep your local streets clean and Gowrie Creek free of detergent. Use an automotive or dishwashing liquid - laundry detergents can be quite alkaline, damaging the environment *and* your car’s paint work.

Fertiliser and pesticides

Avoid applying fertiliser and pesticides in areas where they could be easily washed into drains, particularly when storms are predicted. Use only the recommended application rates. Don’t overwater and lose phosphorus through run-off or leaching. High phosphorus levels in Gowrie Creek will assist the development of nuisance and possibly toxic algal blooms.

Landscaping and construction

Make sure soil and sand stockpiles are not covering street gutters. Protect stockpiles from wind and rain by storing under secured plastic sheeting or tarpaulins. Schedule grading and excavation projects for dry weather periods.

Sweeping

Don’t sweep waste into the kerb or channel in your street, onto the roadway, or into the nearest stormwater pit. All wastes should be picked up and disposed of properly - in the bin.

Grass clippings and leaves

Everyone can help by keeping street gutters and drain entrances clear of leaves. Start a

compost heap or use leaves as garden mulch. Debris can block drains and cause local flooding. Rotting organic matter pollutes waterways with excessive nutrients.

Bin it securely

Make sure litter cannot blow or fall out of bins or recycling containers. Stray litter can easily be washed into the stormwater drain system.

Dog wastes

It really helps if you clean up after your dog and flush droppings down the toilet or bury them in the garden. Dog droppings contain bacteria and nutrients.

There are a range of tools (*Melbourne Water et al, 1998*) that can be effectively used to facilitate community catchment management education. These include the following:

- **Printed material** (eg. newsletters, fact sheets, brochures and posters). Simple residential information sheets can quickly become monthly or quarterly publications containing a variety of information on the creek environment. Such publications should incorporate relevant logos and slogans, so that the material is easily associated with other community education material.
- **Use of the media** (eg. press releases, advertising and public service announcements) - Selected media activities can offer widespread publicity and the opportunity to relay the message repeatedly.
- **Signs** - Billboards and council vehicles present another opportunity for relaying a message related to catchment and waterway management.



- **Community programs** - (eg storm drain stencilling) - There is a wide choice of community based programs available, ranging from simple drain stencilling, to 'Friends of Gowrie Creek' type programs through to waterways monitoring and awareness programs. All offer potential to work with the community and its' resources. The short lead time and low maintenance costs of a storm drain stencilling program for example make it an attractive activity for local communities.

- **Displays** - Direct contact between

Council staff and the public can provide an excellent opportunity to relay the importance of the creek environment, and how catchment and waterway management can affect it. Environmental booths may be setup as static displays in well traversed areas or at special functions and festivals, or during periods of particular environmental significance, for example: Arbour Day or National Water Week.

- **Community water quality monitoring programs** - Encouraging community participation in environmental monitoring programs using the 'Waterwatch' approach provides an excellent means of 'hands-on' education.
- **Launches** - Attracting public attention through a launch is a great way to boost the profile of an education program. Guest speakers can be incorporated into the launch program to communicate important issues.
- **School Education Programs** - Developing environmental awareness from an early age is an effective long-term means of changing community behaviour and attitude. When developing a school education program, 'fun' is the key element. Start with the key environmental messages, then design fun and exciting activity programs to relay these messages. Facility

tours of the Wetalla wastewater treatment plant or municipal waste collection centres, or contests to develop posters and calenders are examples of fun ways to develop children's awareness of the creek and associated issues.

The responsibility for Community Education in the context of Gowrie Creek already rests with Toowoomba City Council Officers. It should be the role of Council Officers to continue existing community education activities in light of the above recommendations and to provide more opportunities for community involvement. This activity will require a long term commitment by Council, and may be able to be supported by external (eg. *State and Federal*) funding resources.

5.1.2 Innovative Stormwater Management

One of the major problems facing Gowrie Creek is the excessive rate of catchment floodwater runoff causing creek bed and bank erosion. This problem will worsen with continuing catchment development unless it is properly managed.

Toowoomba City Council should investigate the feasibility, initiate a range of test cases, and subsequently implement a wide range of 'innovative' stormwater management practices that will mitigate or overcome the effects of catchment development. These practices could include the following:

- **Aquifer Storage and Recovery** - Toowoomba is underlain by aquifers which could receive surface waterflow (*following suitable treatment*) for possible subsequent recovery at a later stage for reuse. This technique is used extensively in other parts of Australia and should be investigated in Toowoomba. Given the extensive existing pumping from bores across Toowoomba for potable water supply, particular care will have to be taken with any such aquifer storage and recovery systems to ensure that existing aquifers are not contaminated.
- **Minimisation of Directly Connected Impervious Areas** - Reducing impervious areas which are directly connected to stormwater drainage systems increases the opportunity for overland flow and infiltration over pervious surfaces such as grass and landscaping, thus reducing runoff volume. This practice also increases the entry time for runoff into the stormwater system and assists in reducing peak flow rates. By reducing the total effective impervious area, a reduction in runoff volumes can also be achieved. (*BCC, 1997*)
- **Water Sensitive Urban Design** - Toowoomba City Council is encouraged to require the application of Water Sensitive Urban Design (*WSUD*) techniques, with the objective of achieving a 'no-worsening' criteria for stormwater quantity and quality, from future subdivision developments within the catchment of Gowrie Creek. *WSUD (BCC, 1997, WA Dept of Planning and Urban Development et. al. 1994)* is a relatively new approach to urban planning and design which places emphasis in the urban area on:
 - ⇒ storage of stormwater, rather than conveyance;
 - ⇒ recycling/reuse of wastewater to conserve water;
 - ⇒ use of vegetation for filtering purposes;
 - ⇒ water conserving landscaping;
 - ⇒ protection of water related environmental, recreational and cultural values;
 - ⇒ localised water supply for irrigation purposes; and
 - ⇒ localised wastewater treatment systems, where practicable.
- **Leaky Wells/On-Site Infiltration** - For new and existing residential areas, Council is encouraged to investigate the viability of on-site stormwater infiltration measures such as 'leaky' wet wells, porous pavements etc. Recent developments in the design and operation of porous pavements in the United Kingdom may be of particular relevance to Toowoomba.

5.1.3 Illegal Connections

Illegal connections of sewer or tradewaste discharges to the stormwater system could be contributing substantial quantities of pollutants to the Gowrie Creek system. Council should initiate a program of investigations, possibly associated with ongoing monitoring (see Section 6.1.5) of illegal connections, and take necessary corrective action. A similar program should be considered for sewer exfiltration and sewer overflows.

5.1.4 Erosion and Sediment Control

The elevated suspended sediment concentrations in Gowrie Creek under high flow conditions (see photograph in Section 2.1) is evidence of the magnitude of erosion occurring from the catchment. Erosion and sediment control on construction sites across the catchment of Gowrie Creek will provide a significant reduction in sediment load. Techniques for the control of sediment/erosion during construction are well recognised and easily implementable, and include the application of techniques such as:

- sediment fences;
- temporary berms or swales;
- check dams/gravel filter weirs; and
- suitable site management practices.

Toowoomba City Council is in the process of developing a policy on sediment erosion from construction sites. This policy should adopt rigorous requirements and enforcement practices. Education of Council's workforce, contractors and landscapers in the principles of erosion control may be required.

Council should also review the implications of the Environmental Protection (*Water*) Policy 1997 on how sediment and erosion control measures are handled within the city.

5.1.5 Diffuse Source Pollution Control

There are 3 generic areas of diffuse source pollution control that are recommended as part of whole of catchment actions, as follows:

- Stormwater Pollution - pollution from developing portions of the catchment can be managed by Council adopting relevant Water Sensitive Urban Design and sediment and erosion control practices. For developed areas, the installation of water quality control measures is unlikely to be practical or cost effective (*due to space limitations*). The wet detention basins and wetlands proposed for construction within the waterways of East, West and Gowrie Creeks and Black Gully will improve water quality from these areas.
- Litter Control - gross pollutants and litter are an obvious problem in Gowrie Creek. The works proposed along the waterways of the creek system include gross pollutant traps, however the efficiency, and maintenance load, of these structures would be improved if litter loads to the creeks are reduced. Public education will assist in this regard, however Council may wish to consider the implementation and enforcement of a system of substantial fines for littering. Other measures such as the use of minor off-line trash bags on stormwater inlets (see photograph) are recommended.
- Animal Faeces - The entry of faecal material from animals into the waters of Gowrie Creek could cause unacceptably high bacterial levels, and public health concerns. Council is encouraged to consider the introduction of fines for unmitigated dog faecal pollution within

the vicinity of the waterways of Gowrie Creek. Appropriate receptacles should be provided for dog owners to dispose of animal droppings.

5.1.6 Fertiliser and Pesticide Use Control



Fertiliser and pesticide use controls (*eg. use of suitable chemicals, not applying chemicals before rain, not applying chemicals too close to waterways*) are voluntary control mechanisms which can be adopted by residents of Toowoomba who use these chemicals as part of their landscaping activities. Council Parks and Maintenance crews should also adopt these techniques by way of example. In the case of Toowoomba residents, use controls should be 'implemented' via the Community Education program discussed at Section 5.1.1. The general public should be made aware of the consequences of overuse of these chemicals, and of the financial implications to them of overusing and hence wasting these materials. Council work crews should also be made aware of these problems.

5.1.7 Weed Species Control

The Gowrie Creek catchment has extensive existing infestations of exotic 'weed' species. Of particular concern in the case of the waterway corridors are Privet and Willow. There is a need for ongoing activities to remove and replace these 'weed' species with non-spreading, preferably indigenous, species. These ongoing activities need to be gradual, and carefully initiated, for a number of reasons, as detailed below:

- Weeds can form a useful habitat for birds, reptiles and small mammals, albeit of lesser value than native flora.
- Weeds can facilitate bank stabilisation, particularly when they make up the predominant vegetation type in an area, through root penetration (*physically holding the banks together with their roots*) and flow protection (*deflecting and slowing water flow near banks, helping prevent erosion*).
- Careless weed removal can exacerbate the infestation problem by allowing propagules (*including fruit, tubers and cuttings*) to spread downstream.
- Careless weed removal can also harm the surrounding area, in terms of both damaging nearby natives and disturbing and/or compacting the soil.

A number of good references exist which provide excellent detailed instructions on weed removal and bush regeneration (eg. *Buchanan 1989*). The following principles should be noted as guidelines for any weed removal operation:

- Where possible, rehabilitate the most weed-free sites first to encourage natural regeneration before moving on to more heavily weed-infested areas.
- Clear weed-infested areas in staged or ‘spot’ fashion to allow recolonising/planted vegetation to become established, and to avoid complete removal of wildlife habitat from an area.
- Weed removal should preferably be undertaken manually, although limited use of glyphosate-based herbicides (eg. *Roundup*) may be appropriate in some areas.
- Where necessary, herbicides should be applied to specific weed plants (eg. *using a wand or a wick*), as seedlings of native species often occur within weed patches.
- Care should be taken to prevent herbicides being sprayed or washed into the waterways of the Gowrie Creek catchment, as this may pollute the water and potentially affect valued downstream vegetation.
- Prior to weed disturbance, remove any propagules (*such as seed heads*) present on the weeds, and place them in bags for removal from the site and disposal, to prevent spreading. For weeds such as Mother-of-millions (*Bryophyllum spp.*) this would involve bagging the entire plants to prevent the dropping and re-shooting of any part.
- When removing weeds, disturb as little soil as possible, and where possible place natural mulch over all disturbed soil surfaces.
- Once removed, weeds which will not re-grow from stems, tubers, etc. can be left to die and dry out, hung up on native vegetation on-site, and used as mulch later.

5.1.8 Future Planning and Management of Land Uses

The identification of preferred land uses on a City-wide or site specific basis can only be achieved through the reduction of diverse compatible and competing elements. The suitability and availability of land for such uses as commercial, industrial, special use and various densities of residential activity needs to take into account accessibility, infrastructure availability, existing and preferred land uses as well as specific criteria such as proximity to, and direct impact upon, the Gowrie Creek system.

Toowoomba of today is the result of many decisions taken over decades that established a framework, economy, culture and social fabric that characterises the present day City. The impact of point and non-point discharges from existing and proposed land-uses abutting onto, or affecting, the Gowrie Creek system is addressed elsewhere in this section.

The Strategic Plan for the City establishes a framework for growth management throughout the City which is generally compatible with the catchment management objectives of this Strategy. The criteria for development of the upper catchments of East and West Creeks and Black Gully are considered to be appropriate, subject to full implementation at the suitable time of all performance criteria.

The major issue to be addressed is the re-development of existing commercial and industrial areas situated in the lower Gowrie Creek area, as well as the development of vacant areas associated with the second range crossing and various vacant private and Crown land holdings adjacent to the Creek in this area. In general, the industrial designations directly abutting onto the Creek corridor could inhibit the full utilisation, accessibility and amenity of the creek if a suitable relationship to the creek corridor is not incorporated into future development or re-development decisions.

The preference is to encourage abutting land uses that attract usage of the creek area, increase accessibility and provide continual scrutiny of all sections of the creek. Industrial or commercial activities cannot fully meet these criteria in all instances. However, if such objectives and performance criteria are taken into account in any future planning and assessment procedures, the integrity of the proposed creek system could be achieved and appropriate access routes provided from the creek system to other areas of the City.

Of greater importance is the need to manage the placement of fill and the re-profiling of lands abutting the creek system. Under the Integrated Planning Act, such activities are now defined as “development” of land and should be subject to “material change of use” or “operational works” approvals depending on the provisions of the planning scheme in force. There have been difficulties in the past where inadequate referral processes between State agencies and the Council have resulted in inappropriate fill being placed in the beds and banks of the system without full concurrence of all relevant parties. It is believed that the combination of a “Memorandum of Understanding” between all parties together with implementation of the provisions of the Integrated Planning Act will ensure that the appropriate assessment manager has the full benefit of all referral or concurrence agencies before any further fill or excavation applications are approved.

The transitional provisions of the current planning scheme, including DCP-4, are considered to remain valid as a statutory planning mechanism, subject to incorporation of elements of this Strategy. The blanket 60m wide open space corridor outlined in DCP4 needs to be reconsidered to recognise the fluctuating nature and potential of areas along the system. While many of the objectives can be achieved by development negotiation and contribution, there will be instances where land acquisition is the only realistic means of obtaining the necessary sections of land. A Council policy on such a strategy may need to be prepared for full implementation of this Management Strategy.

As a general principle, the following are specific criteria that must be implemented with respect to land usage:

- adopt the Gowrie Creek Management Strategy as a Council Policy;
- review DCP4 to ensure compatibility of all elements;
- in the review of the City’s planning instruments, include provisions that require any works which materially raise the level of existing land that was flood affected in a Q100 event to become a development requiring impact assessment;
- support such development assessment elements with criteria related to the hydraulic performance of the system, environmental characteristics, recreational aspects, access and ongoing maintenance constraints and responsibilities;
- if creek bank erosion is, or continues to be, a development constraint, criteria could be incorporated and refined within the planning scheme that alter land so affected to a higher level of assessment; for example “code assessment” altered to “impact assessment”;
- any redevelopment or development of lots directly adjoining the Creek system must, where practicable, achieve pedestrian and cyclist access from surrounding areas, have a public frontage and provide exposure to the waterway system and associated parklands;
- the adoption of “Crime Prevention through Urban Design” principles such as 24 hour visibility of the creek areas, lighting and appropriate adjoining land uses to overlook the system.
- determine a land acquisition programme for any areas abutting the Creek system that constitute areas of significant or potential creek bank erosion;

- investigate provisions for incorporation into the City Planning Scheme to allow for innovative approaches to development, use and reconfiguration of land affecting the creek system to achieve best practice options to achieve the Management Strategy objectives; and
- review of the Management Strategy on a regular basis keeping the community informed of future development for regular input when significant issues arise.

5.2 WATERWAY MANAGEMENT PRACTICE, PLANNING AND DESIGN PRINCIPLES

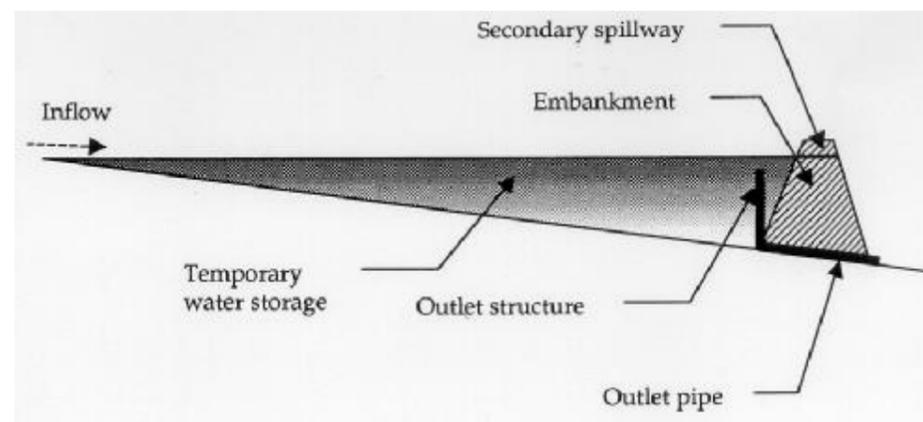
There are four major management practices that are recommended by this study at various locations along the waterways of Gowrie Creek and its' tributaries. These are:

- flood detention basins;
- artificial wetlands;
- bank reprofiling; and
- pool and riffle structures.

In addition, there are important generic planning and design principles which are recommended for application to the linear waterway parks of the Gowrie Creek system.

General descriptions of the nature of each of these management and planning practices are provided below.

5.2.1 Detention Basins



Development or urbanisation of a catchment results in the generation of increased runoff rates from storms due to the increased amount of impervious area, and because of the more hydraulically efficient drainage network that is typically installed. To counter these effects, it is necessary to detain or retard the passage of floodwaters from a catchment. One of the more efficient approaches in this regard is the application of floodwater detention basins. These basins act as a runoff storage area, collecting flows and releasing them at a controlled rate. They can be either 'dry' or 'wet' depending on whether or not the basin maintains a permanent storage of water.

Baseflows and small storms (<2-3 month storm) pass through these basins with no significant attenuation/storage. Also, the total volumes of water passing through the basins in larger storms will not be changed.

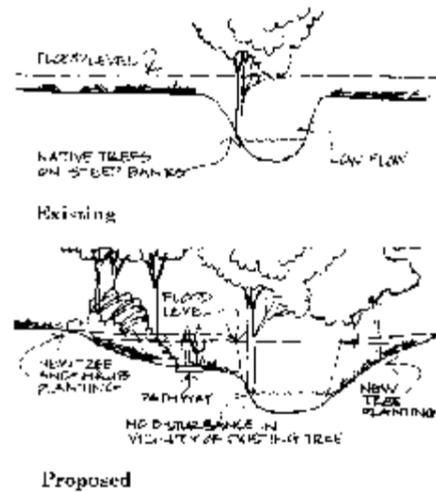
5.2.2 Wetlands

A constructed wetland system combines all the benefits of a detention basin in terms of flood mitigation with additional water quality, aesthetic and environmental/habitat attributes. The wetland system is essentially a detention basin as described above, with a permanent pool of water planted with suitable aquatic plant species.



The Waterbird Habitat on the upper reaches of East Creek and the wetland area on West Creek upstream of Stenner Street are excellent examples of what this study proposes in terms of constructed wetlands.

5.2.3 Bank Reprofiling



Bank reprofiling is a technique used to decrease the steepness of a bank slope, thereby preventing further slippage or slumping of the slope. This also results in a bank that does not present a safety hazard to people who may be present on the top of the bank. Such actions are recognised as being unlikely to be a ‘permanent’ solution to the problem of bank instability unless:

- the bank is further protected by revegetation or other techniques after reprofiling; and
- the initial cause of bank instability, typically excessive flood flow rates, is addressed.

The greater waterway area provided following reprofiling also enables floodwaters to pass along a creek at a slower velocity, reducing the erosive potential of these flows.

The ‘benefits’ of bank reprofiling are illustrated in Figure 5.1.

The visual ‘severity’ of a battered bank can be relieved by adding ledges and preserving and adding vegetation where possible. In extremely erosive cases, there may be a need to further protect lower portions of a reprofiled bank via hard methods such as gabions or rock protection.

It is important to realise that in order for bank reprofiling to both satisfy waterway stability and environmental enhancement objectives, particular care must be taken to ensure that proper channel edge configurations are developed, with in stream and riparian habitat issues being of particular concern. That is, rather than sloping at 1V:4H from the top of the creek bank to the bed, a defined low flow channel is required, possibly with steeper banks. This low flow channel should be planted with appropriate riparian vegetation (eg. *Lomandra* spp), with the nature of vegetation altering with distance from the water.

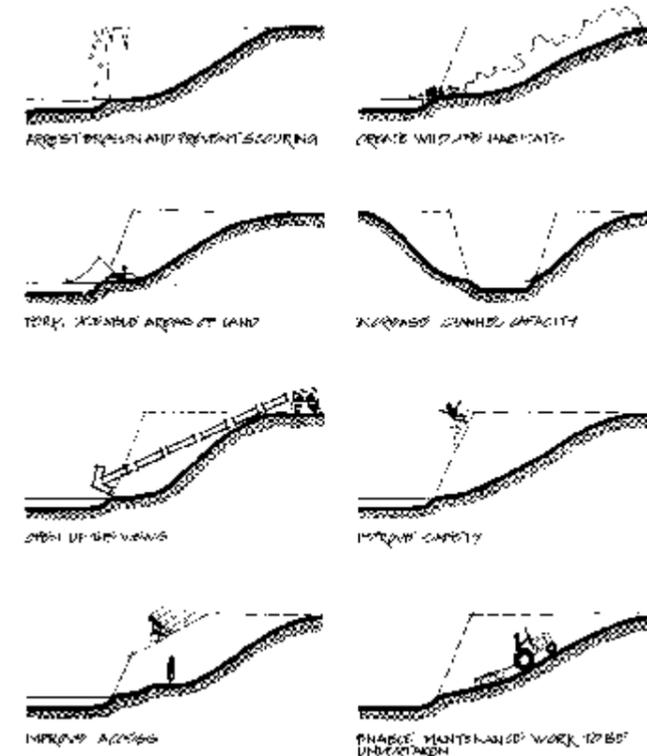


Figure 5.1 - Bank Reprofiling Benefits

5.2.4 Pool and Riffle Structures

Pools and riffles are normal features of natural streams, combining flat, relatively slow flowing sections of water (*pools*) with areas of shallow, turbulent water (*riffles*). Constructed pool and riffle sequences have been shown to be highly effective in controlling bed and bank erosion, provided the sequence of riffles in particular is suited to the waterway being managed. Research (*BCC undated*) has shown that pool/riffle spacing is reliant mainly on the channel width, with riffle sequences typically being some 5-7 channel widths apart.

It is apparent that Gowrie Creek is attempting to establish a natural pool and riffle sequence, as such features are visible in one form or another at approximately 100m intervals along the creek. In developing the recommended works programs for Gowrie Creek, the study team has taken the natural placement of these existing pool and riffle sequences into account, and built upon them.

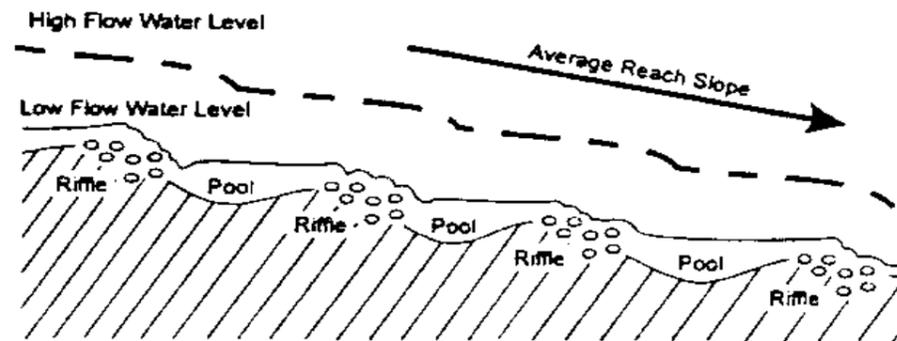


Figure 5.2 - Pool-Riffle Sequence

As well as assisting with controlling the bank erosion problems of Gowrie Creek, the proposed pool and riffle structures will be effective in providing habitat for in stream biota, such as fish and crustaceans, and will also improve water quality.

It must be realised that the pool and riffle structures proposed for Gowrie Creek will not simply be a few boulders. These structures will have to be carefully designed to ensure they are viable under the often high flows experienced in Gowrie Creek, and in some cases may be more appropriately considered as ‘drop’ structures. In particular, the first one or two of these structures that are built should be somewhat oversized, to ensure no failures, which could be a significant detraction from future progress with these measures.

5.2.5 Parks and Waterways Planning and Design Principles

This section outlines the planning principles which are intended to guide detailed design and implementation of the catchment strategy. The catchment management plan serves as a master plan. It will be necessary to develop detailed design briefs which integrate hydraulic, recreation, environment and landscape values for each section of the creek. Recreational needs in particular will require definition as the plans are indicative only in terms of these facilities.

- Landscape Character

- ⇒ the CBD will have a formal urban character responding to the proposed city and streetscape planting and materials. The creek channel and water features will be more urban and hard edged to support intensive public use. Lighting, extensive seating, shelters and other amenities should be provided. Due to limited space and intensive use, grass will not be appropriate - instead surfaces will be paved or planted out. Aquatic planting could be established in an ornamental manner in the CBD;
- ⇒ the lower reaches of East Creek have an exotic and historical character. This should be maintained and enhanced;
- ⇒ Gowrie Creek downstream of North Street will be developed as a bushland comprised mainly of native understory (say 80%) with limited areas of lawn (say 20%) and localised recreation facilities; and
- ⇒ other areas of East, West and Gowrie Creeks and Black Gully will have a predominant native woodland character with a riparian creek landscape with opportunities for exotic tree planting around recreation nodes, entries, and sporting facilities. Here, native understory would comprise say 30-40%, while open grass areas would comprise 60-70% of the total area. The creek channel should reflect a

natural meandering water course with continuous planted edges. The exception will be intensive use areas where grass, paving or a timber edge will allow access to the water.

- Recreation

- ⇒ there will be an emphasis on passive recreation opportunities to be developed in the linear park;
- ⇒ areas of active, structured recreation will be developed in broader, flatter areas of the linear park where appropriate;
- ⇒ an overall recreation plan should be prepared for Gowrie Creek or each individual tributary to serve as a brief for detailed design; and
- ⇒ the recreation brief should provide for a mix of local and regional facilities.

- Wildlife Habitat

- ⇒ prepare a species list comprised of local native riparian species with an emphasis on food/habitat value;
- ⇒ develop a wildlife corridor through establishment of wider areas of understory planting at frequent intervals;
- ⇒ create planting with different stratas of canopy heights;
- ⇒ define access to the creek in order to minimise public impact to habitat; and
- ⇒ create an irregular creek bank alignment with a variety of edge and depth conditions.

- Access

- ⇒ develop recreation nodes and parking with mainroad frontages to enhance visibility and access and to minimise impact on local residential streets;
- ⇒ establish road frontages to the park system wherever possible;
- ⇒ provide informal pedestrian creek crossings of stepping stones or low level timber walkways at key crossing points;
- ⇒ provide grade separated bikeway links under major roads;
- ⇒ create a continuous well-signed cycle/pedestrian path; and
- ⇒ develop open space links consistent with the citywide open space plan.

- Maintenance

- ⇒ limit the extent of mown grass and irrigation to intensive recreation use areas;
- ⇒ use ground cover, shrubs and dense tree planting wherever possible;
- ⇒ provide clear direct access to gross pollutant traps and other areas requiring frequent maintenance; and
- ⇒ maximise the extent of tree-planting to suppress grass and weed growth - particularly in the creek channel.

- Safety and Security

- ⇒ maximise overlooking of the park from adjacent roads and surrounding development;
- ⇒ provide adequate lighting within and around the park;

- ⇒ install warning signs to advise the public of the safety issues associated with the function of the detention basins; and
- ⇒ ensure safe gradients along creek banks and below water.
- Furniture and Structures
 - ⇒ prepare design guidelines for all facilities, furniture and structures to reflect the creek environment. This may involve simple adaptation of Council’s standard furniture to incorporate the Gowrie Creek logo for example;
 - ⇒ develop a suite of directional and interpretative signage; and
 - ⇒ initiate a public art strategy involving school and community groups.

5.3 WATERWAY STRATEGY PLANS

Detailed strategy plans for each of the waterway corridors of West, East and Gowrie Creeks and Black Gully are presented in subsequent sections of this chapter. In each case, a visual/plan description of works proposed for the section of waterway is provided, together with a description of the key issues in each section. Where appropriate, the plan and textual descriptions are supported with relevant sketches and photographs.

The attached Figures 5.3 and 5.4 introduce the diagrammatic tools used to illustrate the waterway management plans, and present the relationship of the individual areas covered by each waterway management plan with respect to the entire study area.

These plans are intended to form the basis for subsequent detail design and construction activities along the creek. It must be realised that they are ‘concept’ plans only, and are based on limited ground truthing. Some modifications to the works proposed in the plans are likely to occur when detailed design activities are undertaken.

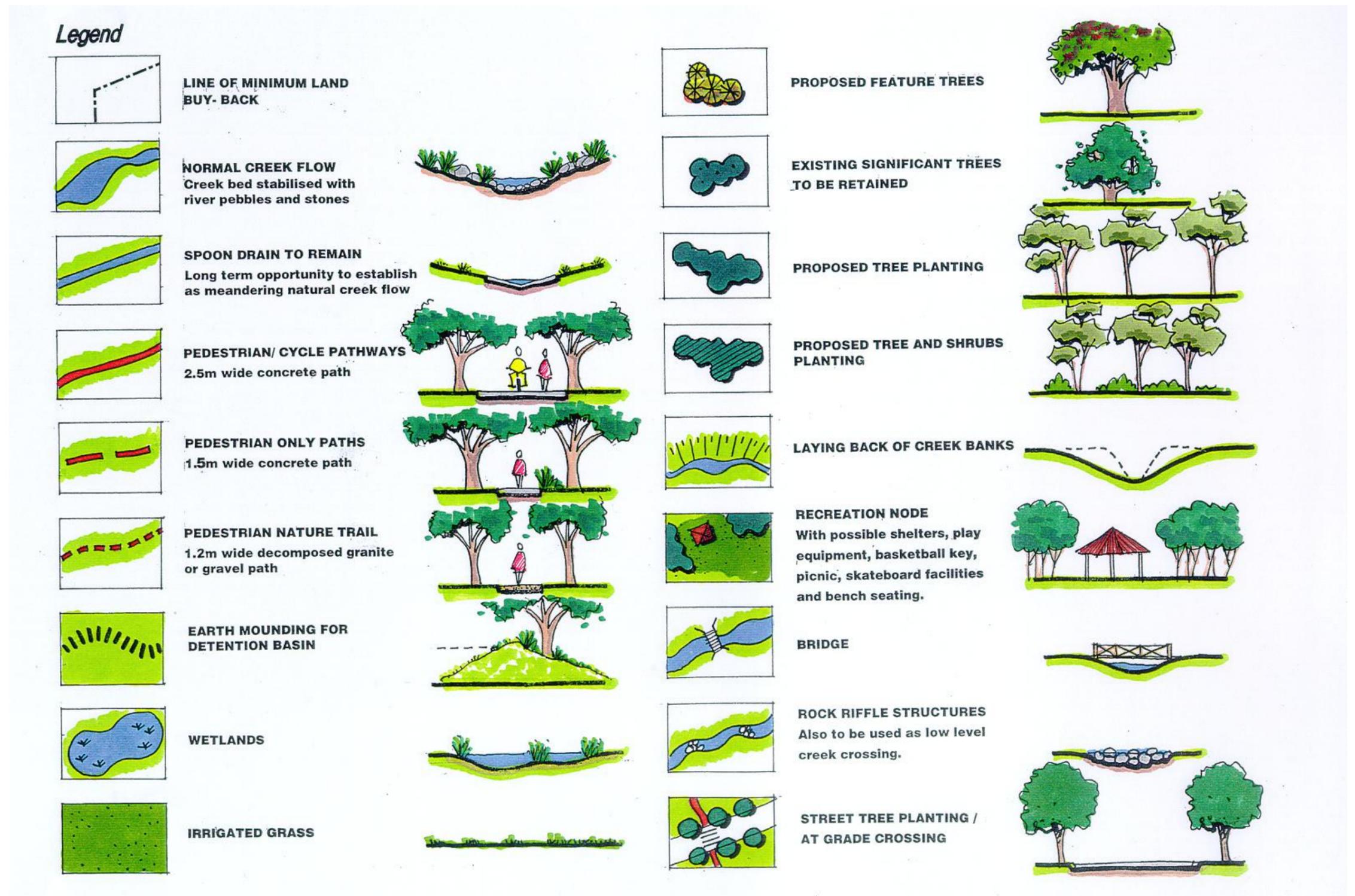


Figure 5.3 - Waterway Management Plan Legend

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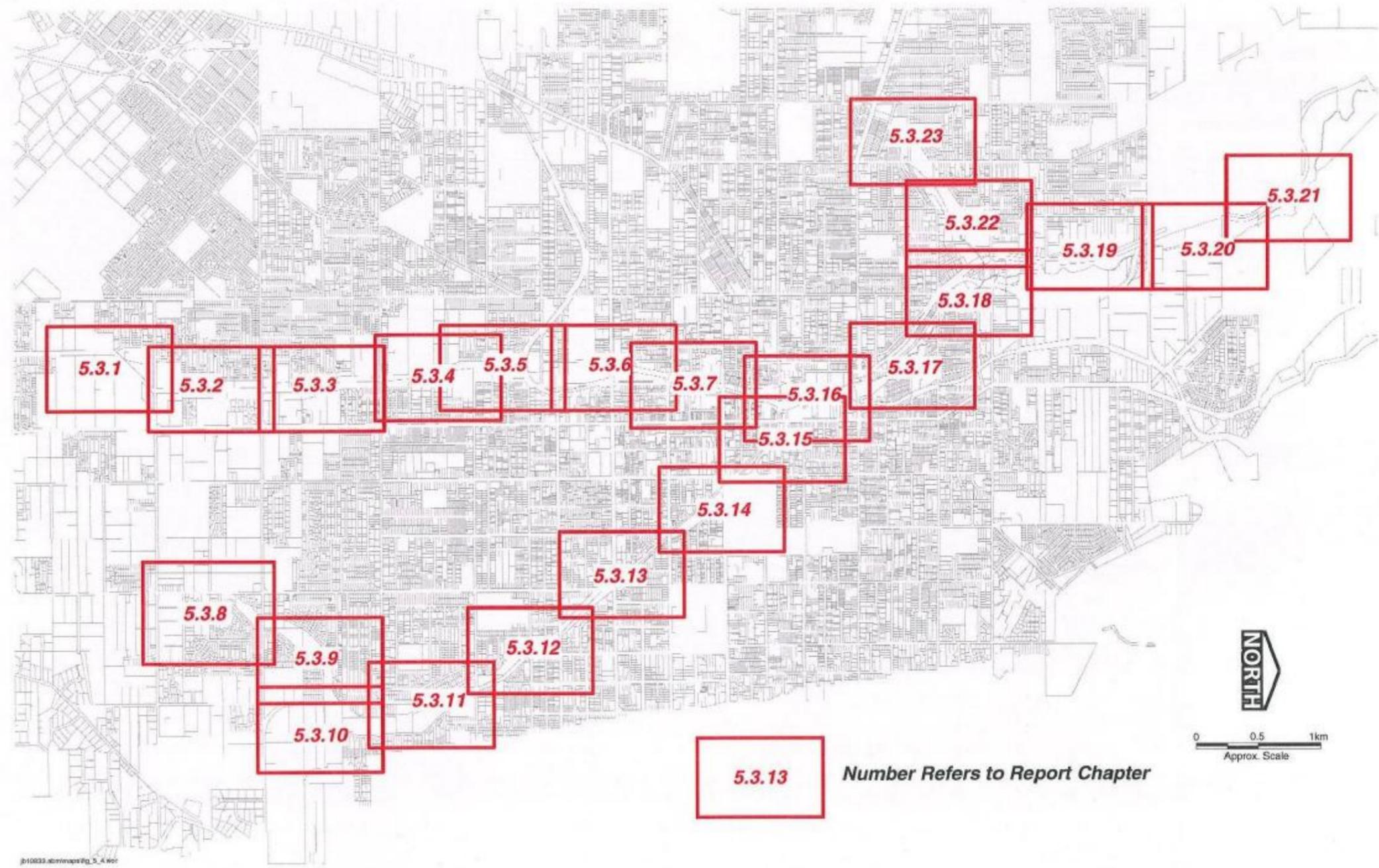
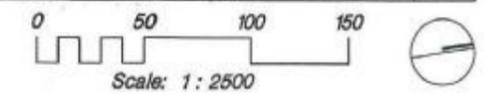


Figure 5.4 - Waterway Management Area Key Plan



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PBL 0503 / W-01



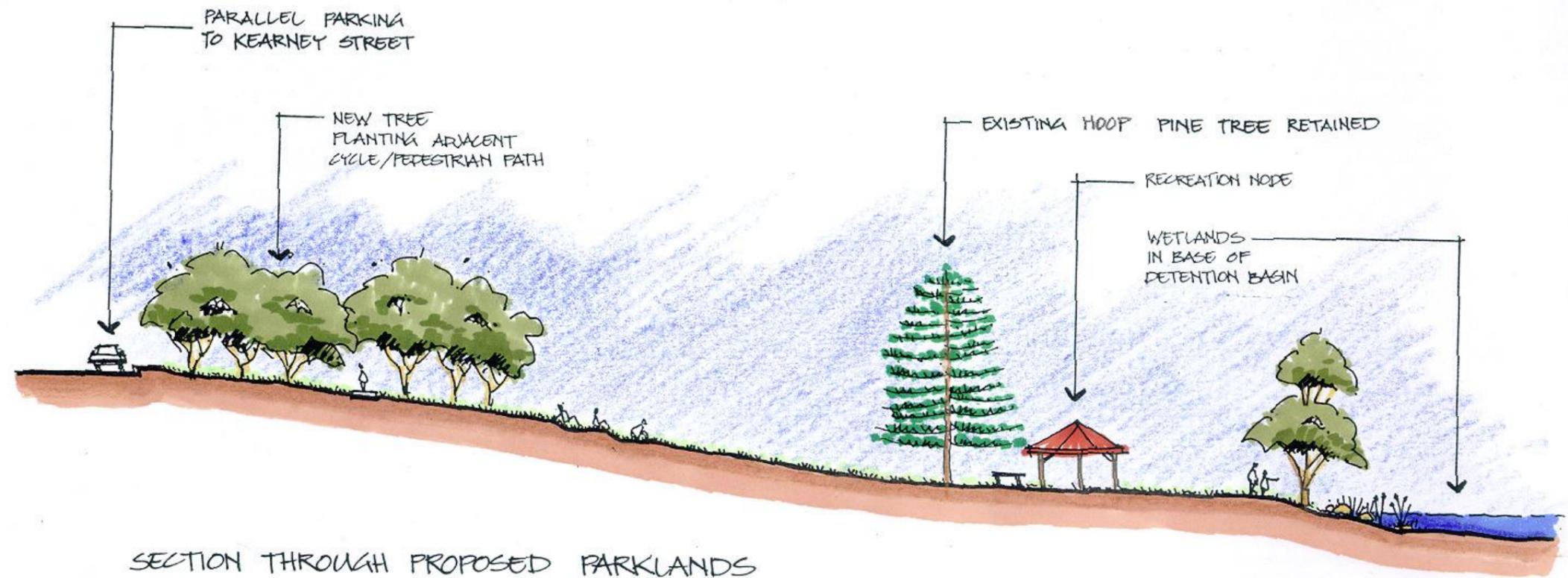
5.3.1 West Creek - Upstream of Spring Street

Issues

- Existing pedestrian/cycle path links Kearney Street and Spring Street.
- Existing sporting facilities at Kearney Spring Park are poorly linked to the existing bicycle path and the waterway corridor.
- The waterway south of Spring Street is naturally flat and marshy, offering a good opportunity for wetlands to be developed.
- Regular flooding of Spring Street is a serious issue that needs to be addressed.
- Electricity lines and associated power poles run adjacent to the creek and their service access must be considered in any future works in this area.
- A significant stand of native trees exists east of the bicycle path between Kearney Spring Park and Spring Street. With the exception of a few mature pine trees, the remainder of the waterway corridor is open grass.

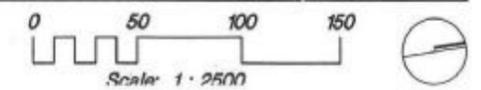
Recommendations

- Spring Street should be raised to improve flooding immunity, and to create the proposed detention basin wall.
- A small series of wetlands and open water can be established to provide a natural habitat, amenity and a focus for the proposed adjacent recreation area, while providing water quality benefits at the upper end of the creek.
- Raising of the road along Spring Street for flood immunity requirements, combined with some minor excavation, will establish a detention basin capable of detaining flood waters for a period of time to avoid flooding at Spring Street and to mitigate flooding and erosion further down the creek system.
- A recreation area is proposed adjacent to the wetlands with picnic facilities.
- Major planting of indigenous tree species should be carried out to provide both shade, amenity and aesthetic value.
- Pedestrian paths should link to Kearney Spring Park.
- Carparking would be on the street, however for major events overflow parking may occur on open grass areas of the park.





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5.3.2 West Creek - Spring Street to Stenner Street

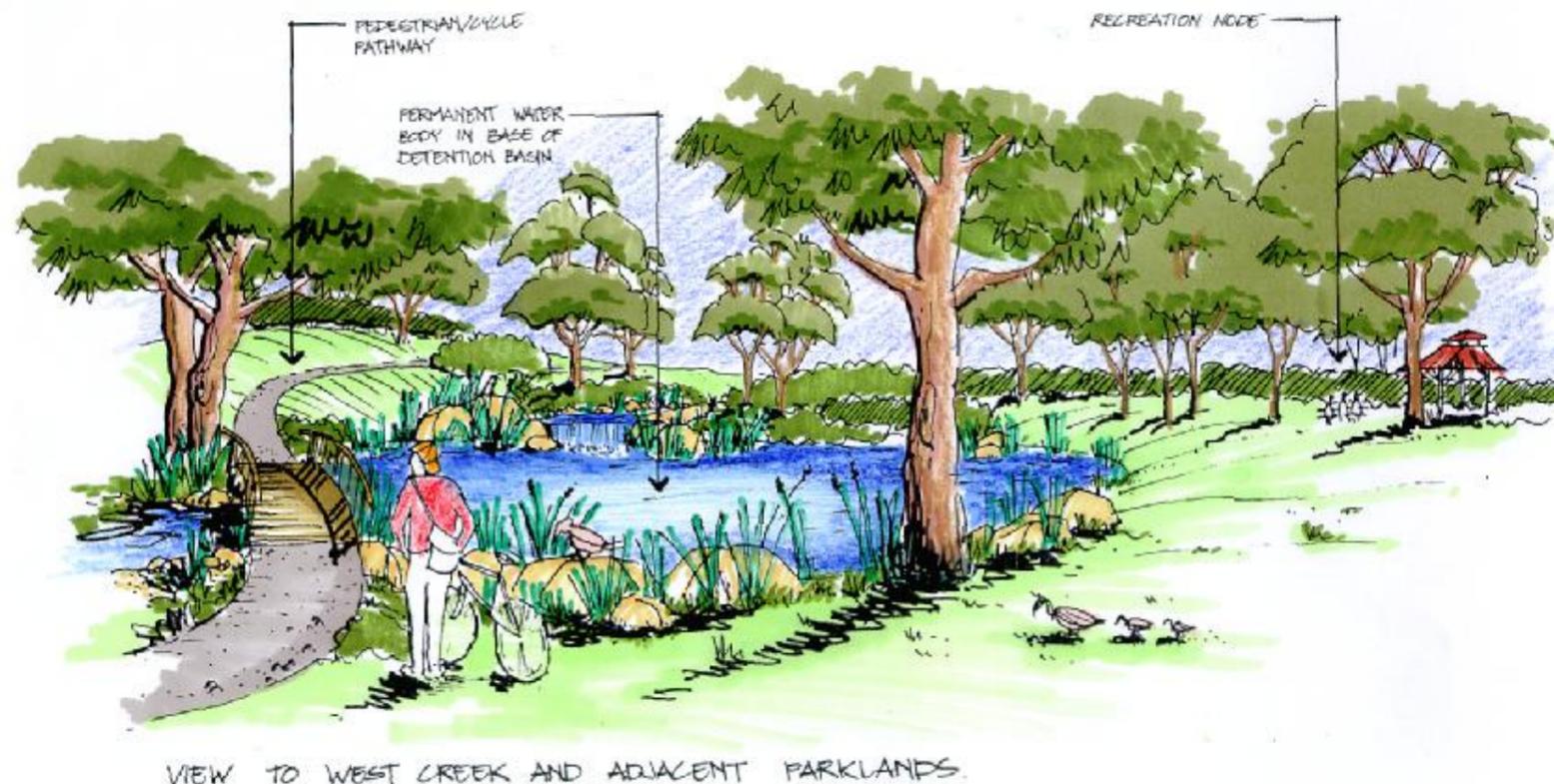
Issues

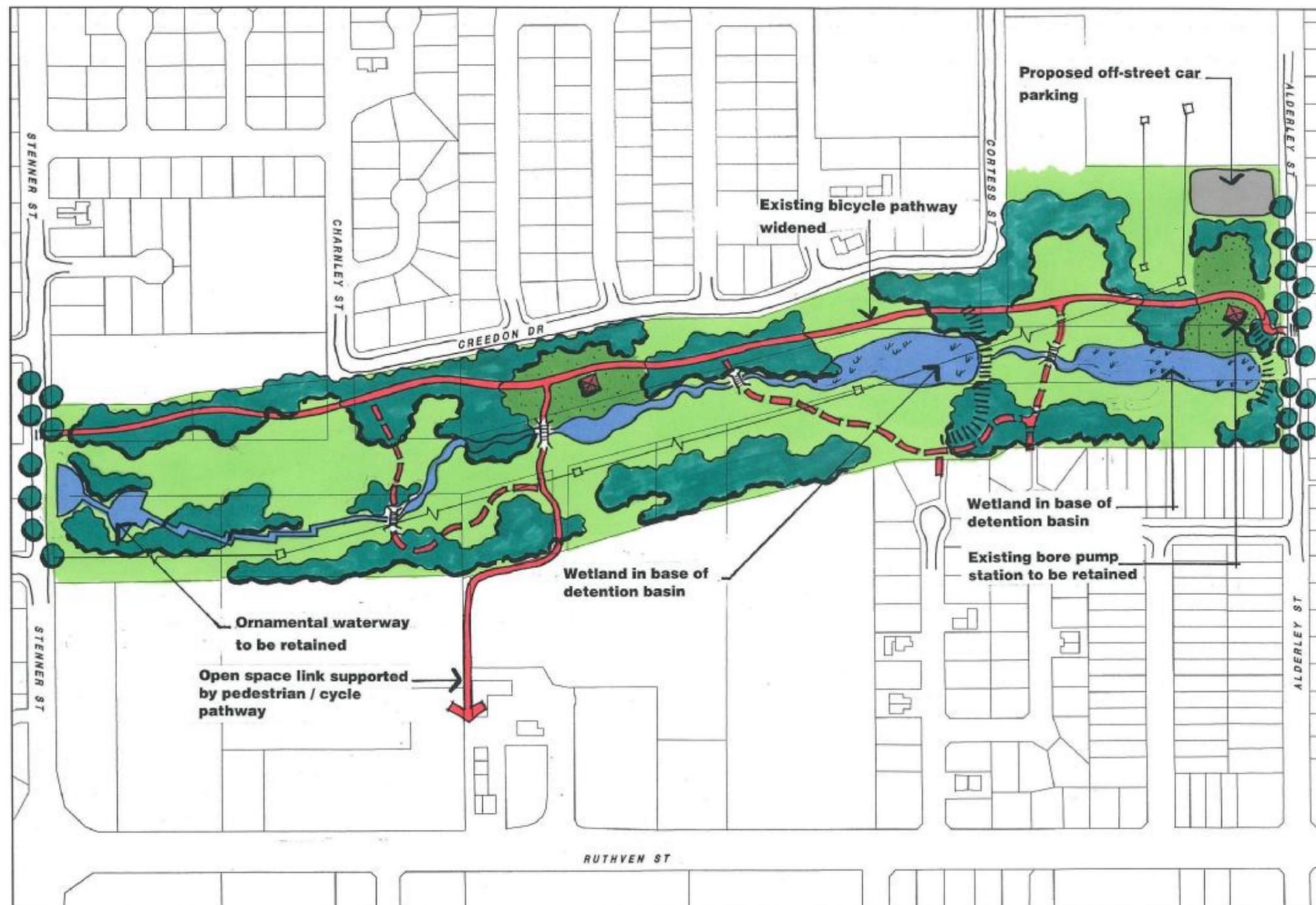
- The waterway easement immediately north of Spring Street is very narrow, and part of West Creek is running through private property.
- Lemway Avenue on the western side of the creek provides good public access with adjacent housing addressing the creek.
- Tree planting is minimal in this area, with the majority of the area open grass.
- An existing waterbody immediately south of Stenner Street (*one of the 'Wetlands of the World'*) provides a recreation focus and amenity.
- Existing overhead power lines cross the creek north of Spring Street.

Recommendations

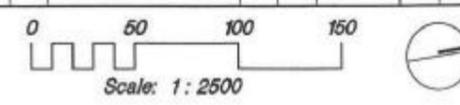
- The continuous pedestrian/cycle path should meander through the parkland linking existing access from residential areas and retirement village to the east.
- A series of three detention basins will assist in reducing whole of catchment flooding and bank erosion issues. Each detention basin will ultimately incorporate small bodies of permanent water in the form of wetlands to assist in water quality management and to provide a natural habitat area, visual amenity and interest. Large open areas of possibly irrigated lawn adjacent to these waterbodies will provide 'kick around' space for informal active recreation.

- The existing 'Wetland of the World' waterbody upstream of Stenner Street can provide a focus to this area of parkland and should incorporate picnic and playground facilities adjacent to it, establishing a significant recreational area accessible from both Stenner Street and Lemway Avenue. The outlet from this waterbody should be modified to improve detention properties under flood flow conditions.
- Ensure proposed planting activities along the creek are designed to incorporate this 'Wetland of the World' waterway.
- A clear easement, void of trees, should be maintained under the existing power lines.
- Major tree planting should be undertaken outside this easement to provide shade and amenity, creating pockets of open areas.
- Purchase of land north of Spring Street would help open the parklands to Spring Street and offer greater public accessibility and improved water quality. This is an optional recommendation as public access along this area is presently acceptable.





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5.3.3 West Creek - Stenner Street to Alderley Street

Issues

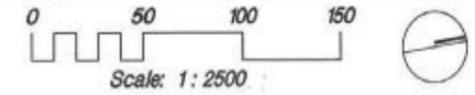
- Primary access to this area of waterway corridor is via Stenner Street, Alderley Street and Creedon Drive. Minor access ways connect to eastern residential areas.
- Overhead powerlines run through the middle of the open space affecting the placement of trees, waterbodies and some parkland facilities.
- Existing ornamental waterbodies and canals are largely incompatible with the proposed natural character of the waterway, but they can still be an attractive feature.
- Other existing permanent waterbodies east of Creedon Drive are a good example of the desired waterway character proposed along the whole of West Creek.
- An existing bicycle path provides a continuous link between Stenner and Alderley Streets.
- There has been a former proposal for a ‘Wetlands of the World’ development extending along West Creek from upstream of Stenner St to Alderley St. The existing waterbodies upstream and downstream of Stenner St are the only components of this project that have been developed to date.

Recommendations

- The existing ornamental waterbodies and canal should be retained to avoid major costs of removal, however some softening of the edge treatment should be considered by appropriate planting and landscaping. Other existing waterbodies should be retained and maintained in their present state.
- Two detention basins are proposed south of Alderley Street to assist in minimising flooding and erosion of the creek. Permanent waterbodies are proposed in the base of each basin to provide habitat, improve water quality, promote amenity and provide landscape and recreation features.
- Two recreational nodes are proposed, each adjoining a permanent body of water for added amenity.
- Off-street car parking is proposed adjacent to Alderley Street to provide greater accessibility to this area of the waterway and nearby recreational nodes.
- The existing cycle path should be widened to accommodate pedestrians as well as cyclists. Further pedestrian paths should be provided to link residential housing to the east with the parklands.
- Extensive indigenous tree planting should be undertaken to provide shade and amenity. Clustering of tree planting should create open pockets of parkland. Powerline easements should also be considered in this tree planting scheme.
- No further development of the ‘Wetland of the World’ projects should take place. Proposed ponded water areas along West Creek should be planted using native vegetation species and configured in a ‘natural’ manner.



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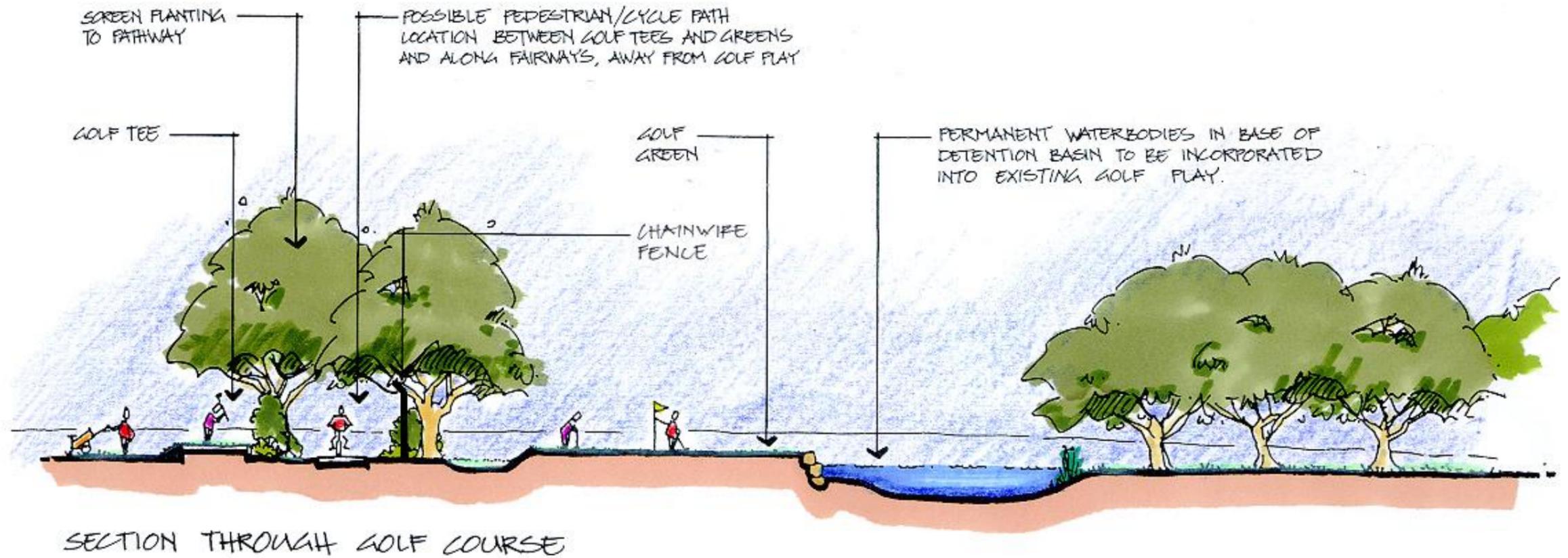
5.3.4 West Creek - Alderley Street to South Street

Issues

- West Creek between Alderley and South Streets runs through the Toowoomba City Golf Club.
- An existing bicycle path runs between Alderley and Pierce Streets. The cycle path requires a significant detour along Ruthven Street before returning to the creek at South Street to avoid the Golf Course. Properties along Klein St bordering West Creek are presently experience occasional flooding. The use of upstream detention measures will reduce the frequency of this flooding.
- Properties along Klein Street bordering West Creek presently experience occasional flooding. The use of upstream detention measures will reduce the frequency of this flooding.

Recommendations

- Detention basins are proposed within the Golf Course to prevent flooding further downstream. Tees and greens can be incorporated with necessary mounding for the detention basins. Permanent waterbodies are proposed along the creek and in the base of the detention basins, adding further interest and challenge to the golf holes.
- A pedestrian/cycle path is proposed through the middle of the Golf Course running alongside golf holes and between golf tees and greens. The acceptability of this bikeway to Council and the Toowoomba City Golf Club requires further investigation. There is a risk associated with such a bikeway, however the use of screening shrubs and fencing to buffer the public pedestrian/cycle path from the play of the Golf Course would significantly reduce this risk.
- Some golf holes may require minor changes to accommodate the possible bicycle pathways.





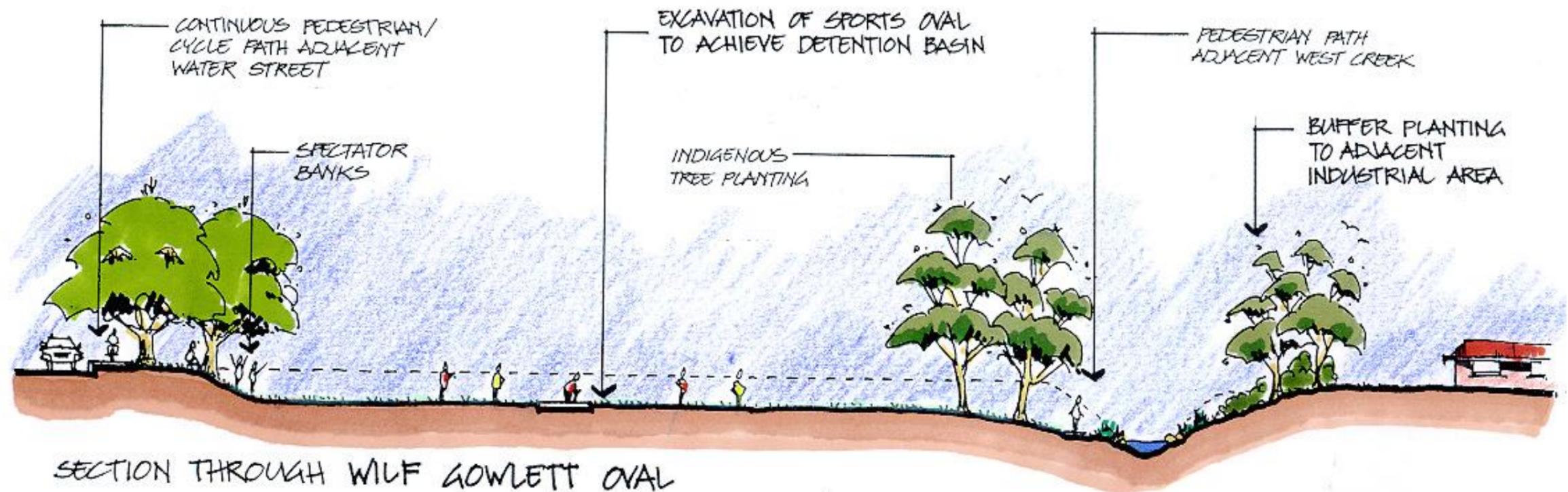
5.3.5 West Creek - South Street to Long Street

Issues

- Public access through and around this area is limited.
- The adjacent sporting oval does not address the waterway, with steep banks leading to the creek.
- North of Long Street, the creek comprises a large concrete channel.
- An existing bore water pump station and ancillary buildings are located in the parkland reserve, north of the Southern Railway line.

Recommendations

- The proposed continuous pedestrian/cycle path should run along South Street and down Water Street, crossing Long Street and continue under the Southern Railway line.
- Major excavation of the sporting oval will allow the area to function as a detention basin reducing flooding and erosion downstream. Following excavation, the area is recommended to still function as a sporting field. All top soil removed from the site should be reused in-situ if possible. Excavated banks along South and Water Street should be profiled to enable their use as spectator banks.
- A small permanent waterbody can be formed in the main flow channel within the detention basin offering amenity for the proposed adjacent sporting oval and a recreation area and a visual focus for views from Long Street.
- The existing pump station will remain and should be screened by tree and shrub planting.
- Extensive perimeter planting of relevant indigenous and exotic trees is required around the sporting oval to add amenity and shade.
- The existing channel should remain to reduce costs, however tree and groundcover planting along its edge will help to soften its appearance. Bridge crossings should be provided to increase connectivity.





5.3.6 West Creek - Long Street to Herries Street

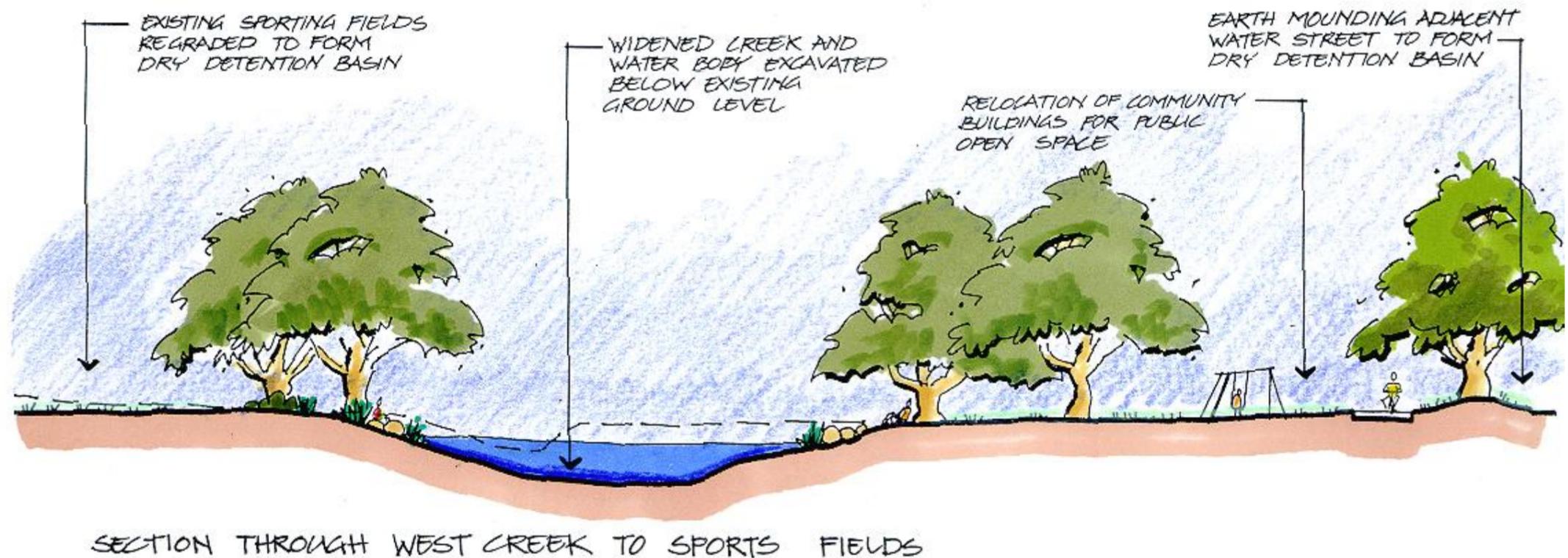
Issues

- Throughout this section, West Creek flows through a generous reserve with sports fields to the west and community facilities to the east.
- A number of community facilities exist along Water Street including community club buildings, tennis courts and the Police Citizen Youth Club.
- West Creek itself flows along a large concrete channel. The cost of removing this channel is considered prohibitive.
- The waterway corridor to the south of James Street has good access and frontage from Water Street, however the location of existing community buildings reduce accessibility and frontage.
- North of James Street the waterway corridor is less accessible isolated by development to the west and the rail line to the east. Access is via James Street, Herries Street and Goggs Street.

Recommendations

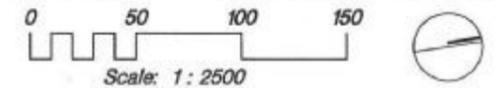
- Slight excavation of the Pechey Street sports fields, combined with earth mounding, is proposed to create a dry detention basin to mitigate flooding problems downstream. After excavation, use of the area as sporting fields should continue.
- To add interest and amenity, a permanent body of water is proposed in the base of the detention basin. Other than this waterbody, it is suggested that the concrete channel be retained to minimise costs, and be softened with planting.

- A number of small pedestrian bridges spanning the creek are proposed to allow movement between facilities on the east of the creek to sporting fields and other facilities on the western side of the creek.
- It is proposed that community buildings (*on land leased by Council*) along Water Street be relocated as their leases expire, to improve parkland frontage and access to Water Street. Existing tennis court facilities should remain and any design and construction of the adjacent detention basin should ensure no flooding or disturbance to this facility.
- The creek north of James Street should be reformed to reflect a more natural creek character.
- Significant planting of appropriate exotic and indigenous tree species should be carried out to increase amenity and provide shade.





Drawing No. :
PBL 0503 / W-07



5.3.7 West Creek - Herries Street to Russell Street

Issues

- As West Creek enters the CBD, its' formerly generous reserves of open space are reduced by encroaching development and the railway line.
- Dent Street provides good access to a thin corridor of open space which is presently unused and undesirable for use. This area is adjoined by the rail line on the eastern side.
- Community facilities (eg. library, aquatic centre) exist on the eastern side of West Creek, however they are isolated from Dent Street (a primary public access point) by the railway line.
- Between Margaret and Russell Streets, West Creek flows through a narrow corridor of open space. Development to the west faces away from the creek corridor and is isolated by the rail line. Fencing along Victoria Street isolates the creek corridor from the east, and access from Margaret and Russell Streets is also very poor.

Recommendations

- The narrow corridor of open space between Herries and Margaret Streets should be vegetated to promote visual and recreational amenity. The density of vegetation used in this area will need to be considered carefully to ensure no adverse flooding effects.
- The continuous pedestrian/cycle path should continue adjacent to Dent Street, to Margaret Street, and then following down Victoria Street to Russell Street.
- The east-west connection along Margaret Street between the CBD and the Grand Central complex is seen as a major opportunity. It is proposed that the civic square outside the Library be extended and reflected on the western side, outside the Myer Centre entry, aided by the possible future partial closure of Dent Street. A series of planted and paved terraces leading down to a series of permanent waterbodies will become the focal point of this space.

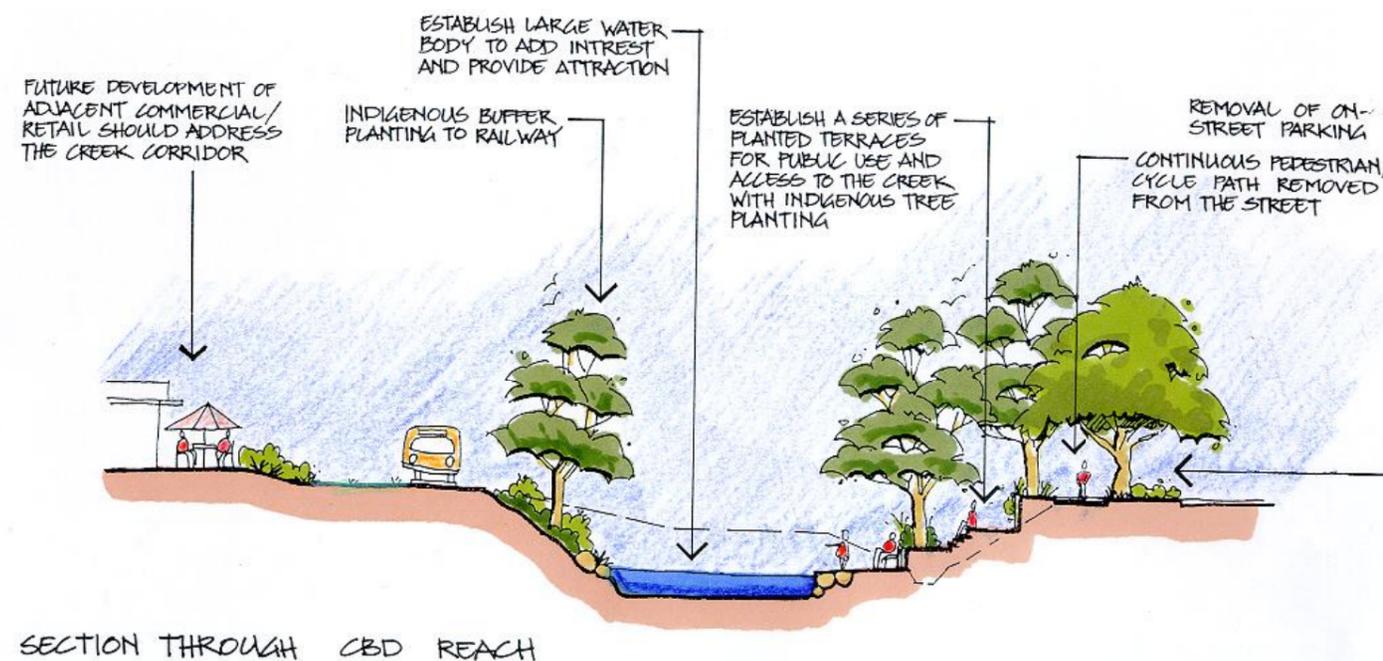
- North of Margaret Street, this theme of planted and paved terraces leading down to a series of open waterbodies should be continued. Access to these spaces should be via Victoria Street, through the rationalisation of on street parking.
- Development on either side of the creek should be encouraged to face the waterway to take



VIEW TO RUSSELL STREET FROM MARGARET STREET ALONG WEST CREEK

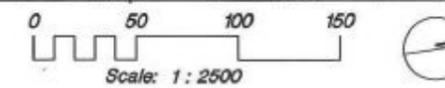
advantage of its improved visual amenity.

- Potential planting of more feature trees to accentuate the 'Garden City' image.





Drawing No. :
PBL 0503 / E-01



5.3.8 East Creek - Daffodil Street to Stenner Street

Issues

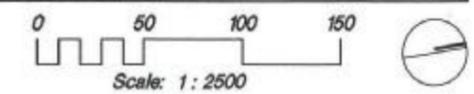
- This section of East Creek is supported by generous reserves and adequate road frontage and access.
- An existing bicycle path links Daffodil Street to Stenner Street, with a pedestrian pathway existing along Bouganvillea Drive.
- Minor scouring of the creek base caused by the eroding effect of consistent base flows, combined with a lack of mature trees, reduces the visual amenity sections of East Creek.
- Adjacent land use is residential, hence the open space areas should provide maximum recreational potential and aesthetic appeal.

Recommendations

- Two detention basins are proposed through this section to mitigate the problems of downstream flooding and erosion.
- Planting of indigenous tree species is suggested throughout the parklands with concentrated screening to those residential homes backing onto the park. Existing vegetation should be retained where possible.
- The existing bicycle path should be widened to accommodate shared use, and slightly re-routed to allow for the proposed detention basins.
- A recreation area comprising basic picnic facilities and informal 'kick around' space is proposed adjacent Stenner Street for ease of access and visibility.



Drawing No. :
PBL 0503 / E-02



5.3.9 East Creek - Stenner Street to Mackenzie Street

Issues

- Generous areas of open space again flank East Creek throughout this section, with road frontage on each side.
- A number of large Camphor Laurel trees line the creek, which provide shade and amenity.
- The creek is experiencing some erosion problems, with consistent low flow induced scouring of its bed resulting in vertical banks of up to two metres in some areas. Such steep banks constitute a potential safety hazard.
- The existing pedestrian path along Ballin Drive links to playground facilities in the middle of the park.



(Example Creek Profile - River Torrens Adelaide)

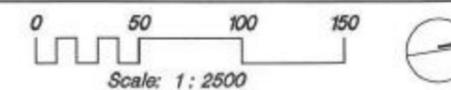
Recommendations

- A series of three detention basins is proposed through this section of the creek, aiding in relieving flooding and erosion problems further downstream.
- A series of permanent water bodies and wetlands proposed to be ultimately incorporated within these detention basins will help in slowing water flows, improving water quality, providing habitat and amenity, and in providing a focus and interest in the parkland.
- Creek banks should be reprofiled to reduce their steepness and increase accessibility of water flows in the creek. The creek bed outside ponded areas should be stabilised with concrete covered by river stone, or equivalent, to add a natural creek character.
- Major tree planting using indigenous or exotic species as appropriate should be carried out and located to form open pockets and recreational nodes with necessary parkland facilities.
- The proposed pedestrian/bicycle path should meander throughout the parklands linking with Amanda Drive and Ballin Drive and connecting with the existing path at Mackenzie Street.

The layout of the path should connect the proposed recreation nodes, and avoid dividing the open space areas along the creek.



Drawing No. :
PBL 0503 / E-03



5.3.10 East Creek - Mackenzie Street to Alderley Street

Issues

- The existing Waterbird Habitat makes up this section of East Creek. This series of wetlands is a good example of the waterbodies that are proposed throughout sections of both East and West Creeks.
- Pedestrian access is controlled by a large chain wire fence that surrounds the wetlands. While the fence helps in protecting this fragile environment from domestic animals, the fence detracts from its visual amenity and natural character setting.
- An existing bicycle path runs around the Waterbird Habitat, isolated from the open space by the above mentioned chain wire fence.

Recommendations

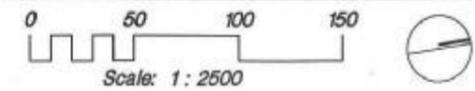
- Consideration should be given to either the removal of the perimeter fence, or replacement with a more attractive style of fence, to improve accessibility and amenity, also helping to promote the Waterbird Habitat as part of a larger wetland and waterbird environment along the whole of East Creek. Removal of the fence may have undesirable impacts on wildlife within the Waterbird Habitat due to exposure to domestic animals.
- The bicycle path should be widened to incorporate a separate pedestrian path and consideration given to incorporating the path more within the parklands.



(Example Waterway/Bikeway Corridor - River Torrens Adelaide)



Drawing No. :
PBL 0503 / E-04



5.3.11 East Creek - Alderley Street to South Street

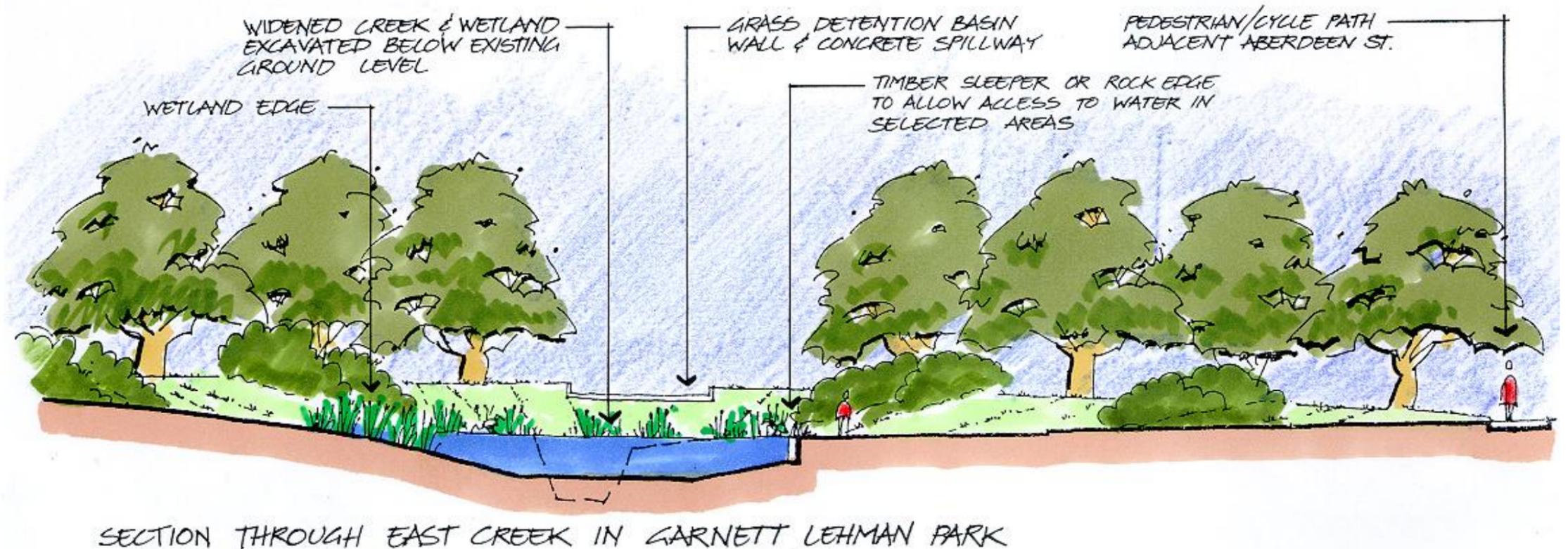
Issues

- This section of East Creek runs through Garnett Lehmann Park. This park supports a significant stand of semi-mature native trees, making it one of the more natural and pleasant areas along East Creek. However, there is little shrubbery and other vegetated layers, reducing the environmental value of the area.
- The creek bed is experiencing some erosion problems caused by base flows in the creek scouring the base of the creek, resulting in steep banks, with possible associated public safety problems.
- Access to this section of the parkland is good with street frontage to Mackenzie Street to the west and Aberdeen Street to the east.
- Small playground and picnic facilities exist in Garnett Lehmann Park north of Alderley Street.

Recommendations

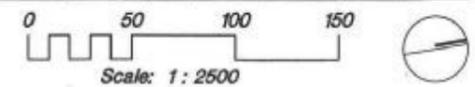
- Two large detention basins are proposed within Garnett Lehmann Park, helping to alleviate downstream flooding and erosion problems.
- A series of small permanent water bodies is also proposed to help in reducing the erosion problems of continuous low flows, and to provide habitat, aesthetic value and amenity to the parklands.

- Two recreation nodes are proposed. The first is adjacent Alderley Street, building upon existing facilities. The second is more centrally located within Garnett Lehmann Park, off Mackenzie Street.
- Steep creek banks should be reprofiled and the creek bed stabilised with the use of drop structures and river stones, or equivalent.
- Off-street parking from Ludlow Court is proposed to improve broader accessibility to Garnett Lehmann Park and its' facilities.
- The pedestrian/cycle path should continue throughout the park linking recreational areas and crossing major roads via level crossings.
- North of Mackenzie Street, the existing concrete spoon drain in East Creek should be retained and softened with river stones and pocket planting.





Drawing No. :
PBL 0503 / E-05



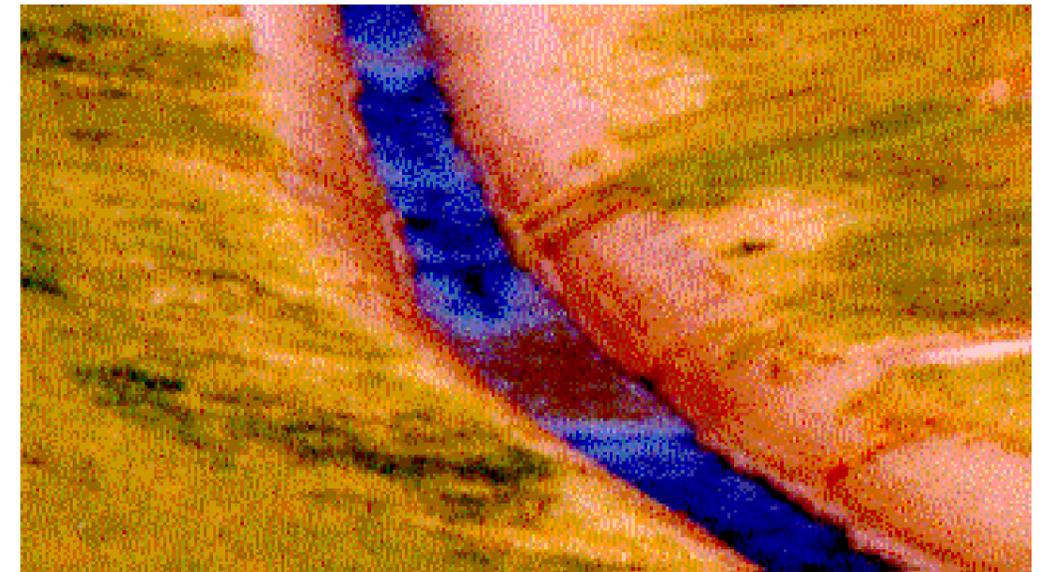
5.3.12 East Creek - South Street to Perth Street

Issues

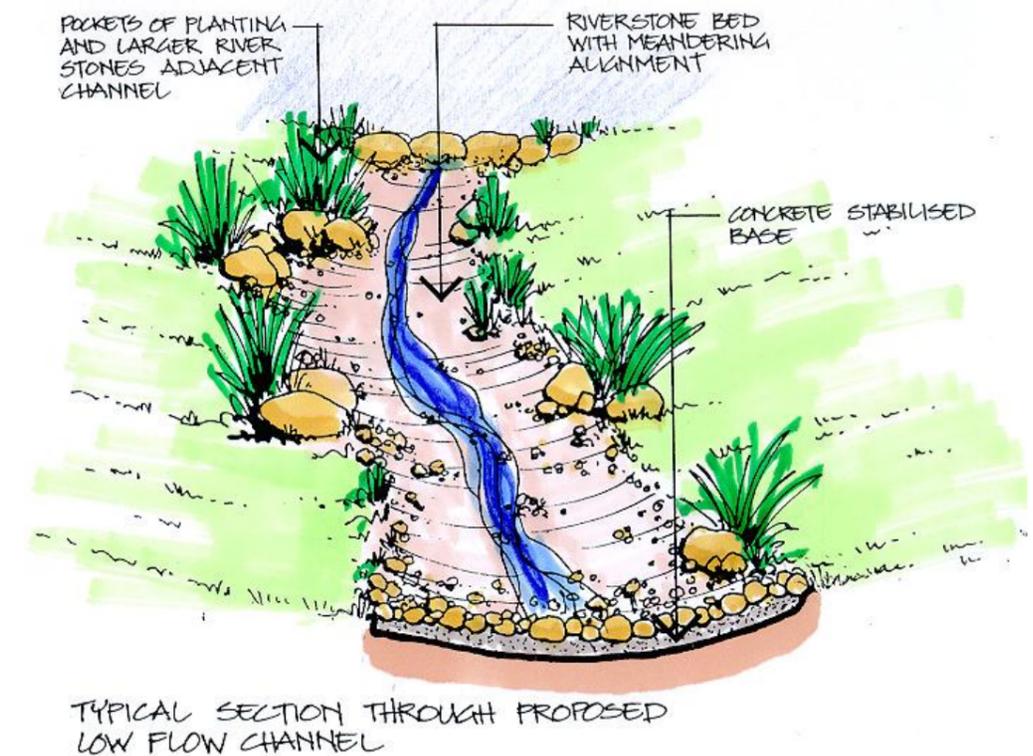
- Between South and Long Street, East Creek flows through an adequate corridor of open space, lacking significant tree cover however.
- Between Long and Perth Streets, the open space is centred on Lake Annand, one of Toowoomba's most popular passive recreation facilities.
- This section of East Creek also has good street frontage, ensuring high levels of visibility and potential public access.
- The creek through much of this section takes the form of a concrete lined spoon drain. Lake Annand takes a more urban character and form with exotic tree planting and hard, concrete edges to the lake. It will function as a sedimentation basin.
- There is an existing bore pump station facility and ancillary buildings to the north of South Street, which has heritage value.

Recommendations

- One new detention basin is proposed in this section of the creek, together with modifications to the outlet structure from Lake Annand, in order to reduce flooding and erosion further downstream.
- The concrete spoon drain within the creek should remain to help reduce costs, however it should be 'softened' with some planting and river stone placement along the drain.
- A permanent waterbody in the base of the proposed detention basin south of Long Street would provide attraction and habitat value to this space.
- The plan illustrates two recreational areas, the first as it exists at Lake Annand and the second south of Long Street, gaining access from both Mackenzie and Long Streets.
- Extensive planting of indigenous and exotic tree species as appropriate should be carried out to provide shade and add character/habitat value. Denser screen planting should be provided around the existing pump station.



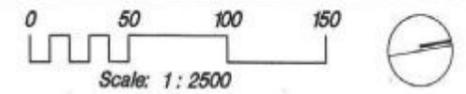
Section through Spoon Drain along East Creek - Before



Section through Spoon Drain along East Creek - After



Drawing No. :
PBL 0503 / E-06



5.3.13 East Creek - Perth Street to Herries Street

Issues

- Lake Annand marks a distinct change in the character of the waterway, parkland corridor and landscape planting of East Creek. Downstream of the lake, the parkland becomes more constrained and narrower, as reflected in the linear straight form of the concrete based creek line. The plant species present along this section reflect an exotic character with plantings of Willow, Camphor Laurel, Jacaranda and other exotic trees.
- Kitchener Street, while providing good street frontage and visibility into the linear waterway corridor, provides limited opportunities for stopping and parking.
- The majority of the open space throughout this section is unsuitable for larger nodes of recreation due to its narrow constricted form.
- At present the waterway corridor provides a link from one end to the other through the provision of a continuous bicycle path.

Recommendations

- Generally this section of the waterway corridor should be promoted as a linear pedestrian/cycle transport corridor, due to the lack of available space for any significant recreation nodes. The existing cycle path should be widened to accommodate pedestrian as well as bicycle use.
- Pedestrian linkages from adjacent residential streets to the west and east should also be provided.
- Gradual replacement of Willow species with other suitable exotic species to prevent downstream progression of willows.



Drawing No. :
PBL 0503 / E-07

5.3.14 East Creek - Herries Street to Hume Street

Issues

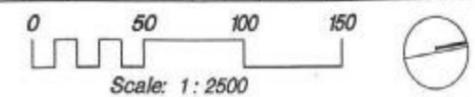
- Between Herries and Margaret Streets, the waterway corridor is generous and has road frontage on all sides giving good access and visibility to the area. Low to moderate flows in the creek itself are diverted underground, however the open space offers two ornamental lakes and various pedestrian paths throughout.
- East Creek between Margaret and Hume streets enters Queens Park, one of Toowoomba's most recognised parklands.
- Vegetation throughout this section of the waterway again displays a distinctive established streetscape exotic character that should be enhanced rather than destroyed.

Recommendations

- Little change is proposed to the waterway and associated open space between Herries and Margaret Streets. The waterway should remain underground to reduce costs, the primary pedestrian path should be widened to accommodate bicycle use, planting of a blend of native and exotic tree species should be undertaken and a recreation node created between Burstow and Margaret Streets with necessary parkland and picnic facilities.
- North of Margaret Street within Queens Park, the Catchment Management Plan has adopted the previously proposed Vera Lacaze Park Scheme. In addition, the pedestrian/cycle pathway should connect level crossings at Margaret Street and Hume Street in the most direct path possible. Further investigations into a large 'water feature' in Queens Park are warranted. This water feature could mitigate both flood flows and pollutant export from a major sub-catchment of East Creek, which has existing large culverts flowing through the park.



Drawing No. :
PBL 0503 / E-08



5.3.15 East Creek - Hume Street to Ruthven Street and the Confluence

Issues

- The creek corridor within this section of the waterway is very narrow due to Chalk Drive to the north-east and CBD development in the south-west. Access to the creek is difficult because of adjacent heavily trafficked roads, road crossings and nearby buildings.
- The creek itself takes the form of a straight channel with a concrete invert accommodating its narrow, linear easement.
- Immediately north of Hume Street there exists a small open air Council carpark. Directly opposite the carpark exists a recently constructed skateboard facility. It has been requested that both facilities be retained in any future scheme.
- There is little vegetation along this stretch of the waterway, and along both sides of Chalk Drive.

Recommendations

- The existing creek channel should be retained for economic and available space reasons, however extensive tree and shrub planting should be undertaken to help soften the concrete channel. This planting needs to be carefully designed to ensure that it does not excessively impede flood flows.
- The existing carpark should remain, however extensive shade trees should be planted to soften the space, buffer the carpark and provide needed shade.
- The continuous pedestrian/cycle path should cross Hume Street and continue adjacent Chalk Drive, isolated from the road by shrub planting and an avenue of trees.
- The existing skateboard facility should remain, and be incorporated into a parkland setting with tree and shrub planting and necessary facilities.

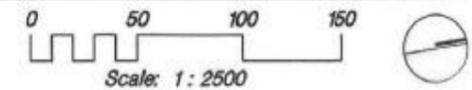
After



Before



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PBL 0503 / G-01



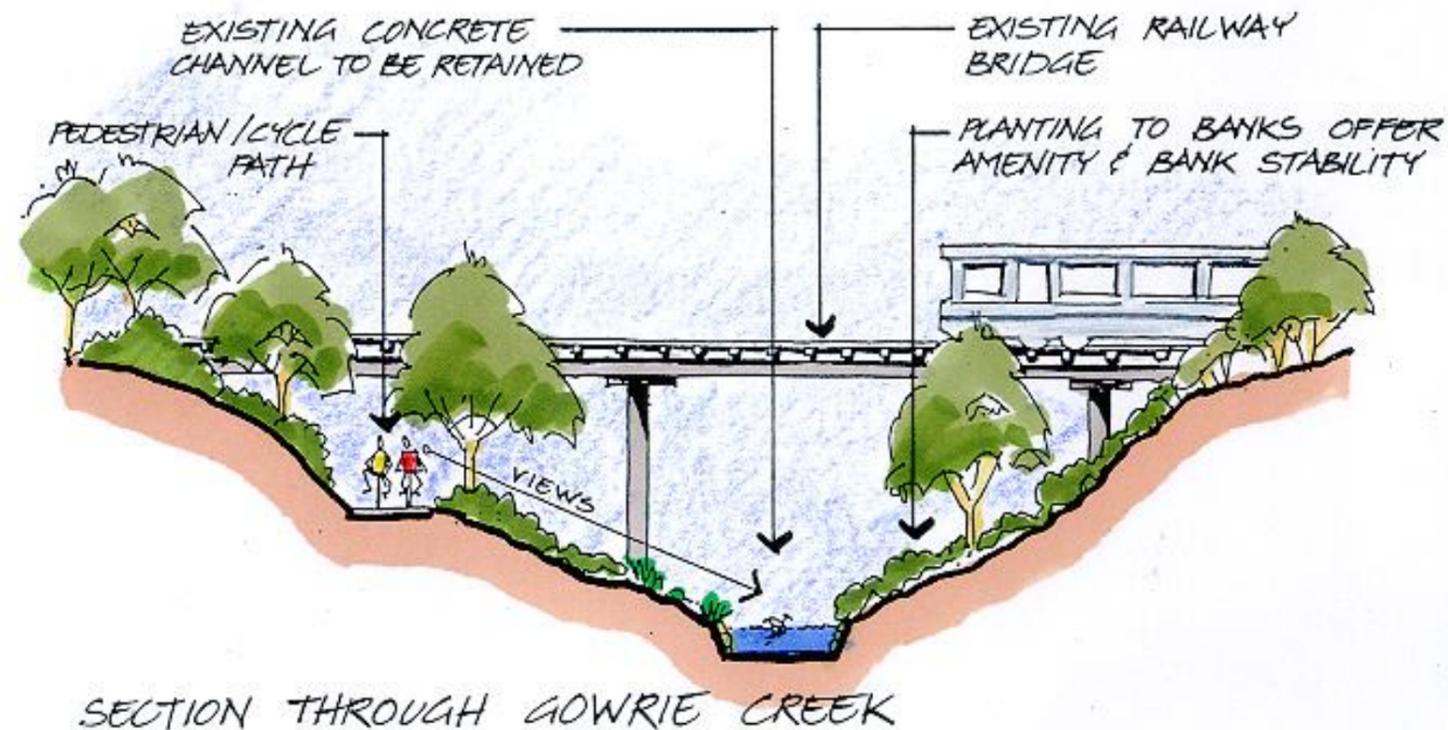
5.3.16 Gowrie Creek - East/West Creek Confluence to Bridge Street

Issues

- West Creek and subsequently Gowrie Creek between Russell and Bridge streets runs through Queensland Rail land, bordered by railway buildings and train lines to the west and industrial development to the east.
- Many of the railway buildings have Heritage value and should be retained in any future schemes.
- Access to the waterway corridor in this area at present is very difficult, however prime access could be provided from Russell Street, Ruthven Street (via an extension of Chalk Drive) and Bridge Street.
- Two existing railway bridges, immediately south of Bridge street, pass over Gowrie Creek. These bridges and their supporting pylons must be retained in any future scheme.
- West Creek flows through an open, degraded concrete lined channel from Russell Street to the confluence with East Creek, after which Gowrie Creek flows along a straight, steeply loping bluestone pitched trapezoidal channel to just upstream of the railway bridges upstream of Bridge Street. The stone pitched channel has some potential aesthetic value. It will require maintenance and repair in several areas where the stone pitching is beginning to deteriorate.

Recommendations

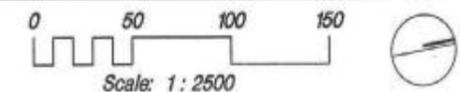
- It is proposed that Council negotiate with Queensland Rail to buy land between West and Gowrie Creek and the main railway line in this reach. Existing Heritage buildings should be retained and utilised for market type facilities and existing railway infrastructure such as rail lines and sleepers should be incorporated into the parklands as a cultural reference to the sites' history.
- From Russell Street to the confluence of East and West Creeks, a large water body is proposed to help reduce water flood flows and to add considerable interest and amenity to the area. It will also help to draw people into the proposed parklands between Russell & Ruthven Streets.
- The bluestone pitched channel north of the confluence of East and West Creeks should be repaired and retained and its' upper banks on the western side (*above the level of stone pitching*) reprofiled for easier access. Banks on the eastern side should be heavily vegetated with shrubs and trees to both provide habitat and assist with stabilising the banks and to screen views of adjacent industrial development. Further tree planting of indigenous species should be carried out to help screen views of the Western Railway line that will be retained for the foreseeable future.
- The pedestrian/cycle path from upstream of Russell Street should continue behind the proposed market building down to the creek and under the existing railway bridges through



to Bridge Street.



Drawing No. :
PBL 0503 / G-02



5.3.17 Gowrie Creek - Bridge Street to Jellicoe Street

Issues

- This section of Gowrie Creek is characterised by steep, highly unstable creek banks, narrow easements with industrial development on either side of the creek, and poor public access and safety.
- Immediately north of Bridge Street, bordered by Alexander Street, there is an existing sports field, leased by Council to a local Soccer Club. This sports field is constructed on an old municipal landfill site.
- Industrial development to the west of the creek is primarily comprised of the Dairy Factory, well established in the area with many permanent facilities located adjacent the creek. Many Dairy Factory buildings on the opposite side of Brook Street to Gowrie Creek are quite old and hold heritage value.
- Some vegetation exists along the creek, however it is predominantly made up of exotic and weed species.

Recommendations

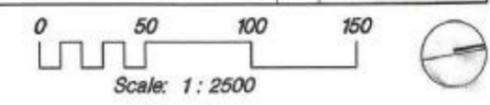
- The soccer club should be relocated from its current location and the site redeveloped as a major recreation node, with parkland facilities and 'kick around' space. The creek banks adjacent to this proposed recreation area should be reprofiled and terraced to give both views and accessibility to the creek, and to provide a more stable creek bank profile. The existing club house could remain and be utilised as a 'community' building.
- Investigations should be undertaken into the nature and extent of contamination of material beneath the playing fields and whether there is a significant leachate issue to be addressed. The results of these investigations should then be considered as a component of detailed design for the area.

- Council should negotiate with adjacent land owners to obtain identified land adjacent to the creek to increase the width of the waterway corridor, to allow for reprofiling the banks and to improve road frontage and visibility into the open space. These actions will jointly significantly improve creek corridor accessibility and useability.
- A second recreation node is proposed adjacent Link and Bath Streets, as a result of negotiated purchased land. This space provides a local gateway into the waterway corridor and offers passive recreation facilities for adjacent residents.
- Extensive clearing of weed species and removal of rubble and rubbish from the creek should be undertaken followed by major refurbishment of riparian vegetation with species endemic to the region to enhance local habitat value.
- Existing Dairy Factory buildings and facilities which are likely to be required to be retained on the western side of the creek make reprofiling of creek banks difficult in some areas. Therefore the continuous pedestrian / cycle path should remain on the eastern side of the creek. If it is not possible to reprofile the banks on the western side of the creek, it may be necessary to apply rock protection. Some compensation or contribution in regard to these works should be sought from the Dairy Factory.
- A series of artificial pools and rock riffles approximately 100 to 150 metres apart are proposed along the creek to reduce water flow velocities and provide ponded water for amenity, water quality improvement, habitat and aesthetic appreciation. The placement of these structures is very important with respect to natural geomorphological processes occurring in the creek.





Drawing No. :
PBL 0503 / G-03



5.3.18 Gowrie Creek - Jellicoe Street to North Street

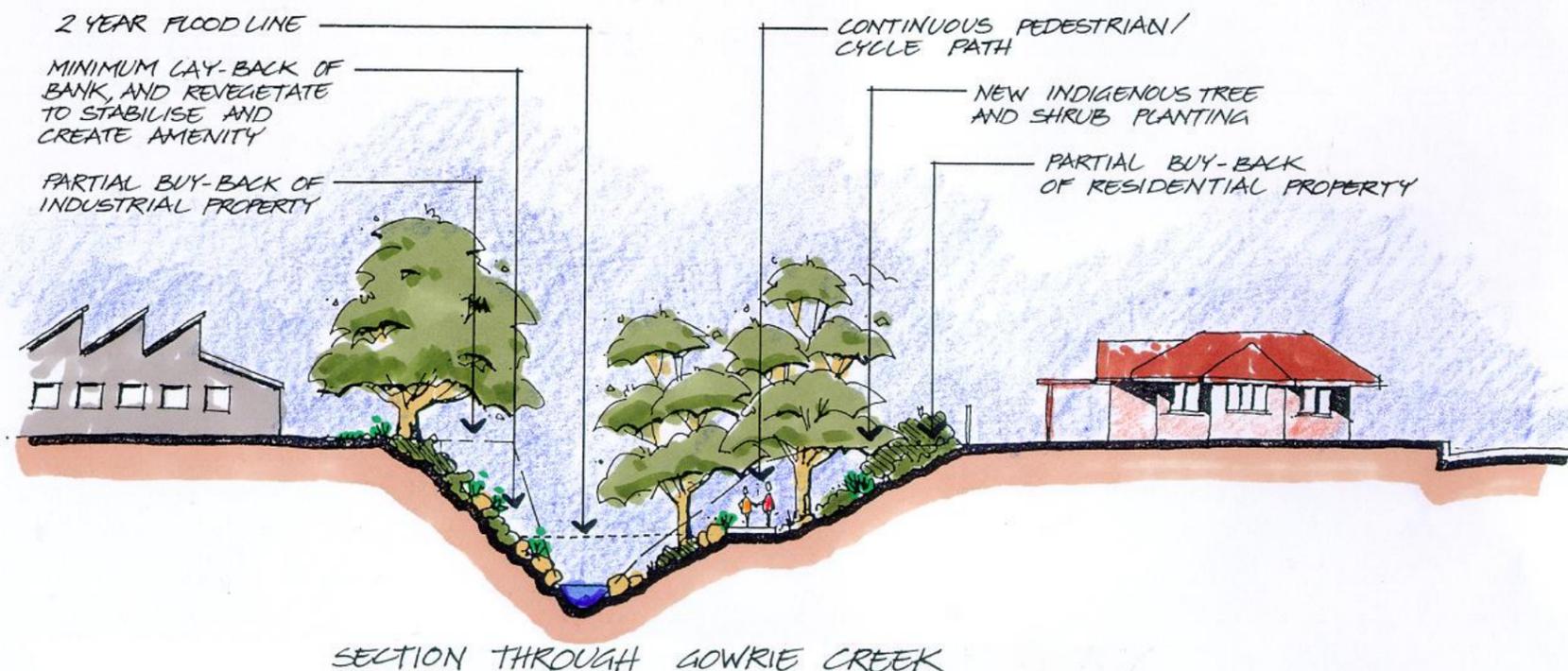
Issues

- This section of Gowrie Creek is again characterised by a narrow waterway corridor with steep eroding banks on both sides, adjoined by industrial development to the west and residential areas to the east. Public access is severely limited and presently undesirable for aesthetic and safety reasons. The dumping and accumulation of fill and debris from industrial properties on the western side of the creek has resulted in an untidy creek bed, with flows impeded by debris. Weed infestation is also a major problem throughout this area.
- Major view axes exist into the creek from both Jellicoe and North Streets, however, at present these views are interrupted by unsightly industrial development on these prominent corners.
- An existing rail line easement and bridge cut across the waterway corridor south of North Street. This bridge and easement must be retained in any future schemes.

Recommendations

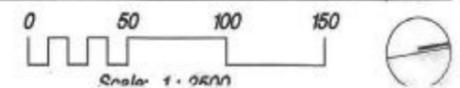
- Negotiated buy back of necessary land should be undertaken to increase the open space corridor width associated with the creek. This increased corridor of land gives greater opportunity to reprofile the creek banks, improving accessibility and also reducing conflict between open space and inappropriate adjacent industrial land use. Where possible, land should be bought back from the creek to bordering streets, which will give road frontage onto the intended parkland areas for improved accessibility and visibility.

- Certain industries on either side of Jellicoe Street adjacent the creek should be purchased and/or assisted to relocate by Council, and the land redeveloped as open space to improve visual amenity. Permanent water bodies should also be developed along the creek to provide further visual interest from Jellicoe Street. Similar parkland development is proposed at North Street where it crosses Gowrie Creek at the confluence with Black Gully. A major water feature can be created where Black Gully enters Gowrie Creek.
- To further improve regional accessibility to the waterway parkland and bikeways, off-street parking is proposed at both Jellicoe and North Streets.
- The creek itself should be cleared of all rubbish, debris and weeds, and revegetated to establish a continuous riparian zone of vegetation endemic to the area. Some suitable instream 'snags' should be left in place for habitat value.
- A number of rock pool and riffle structures are proposed along the creek at approximately 100 to 150 metre intervals to help reduce the velocity of water flow. Establishing these small pools of water will also add interest and amenity to the creek, improve water quality and provide habitat. These rock riffles also provide opportunities for informal pedestrian crossing of the creek. The placement of these structures is very important with respect to natural geomorphological processes occurring in the creek.
- The pedestrian/cycle path will continue along the eastern side of the creek, terraced into the bank. Regular connections with adjacent residential streets are proposed at Waverly Street, Glasgow Street and Isaac Street. Crossings at the confluence with Black Gully allow for connection to similar bikeways to be provided along Black Gully. The pedestrian/cycle path will cross Jellicoe and North Streets via dry weather underpasses.





Drawing No. :
PBL 0503 / G-04



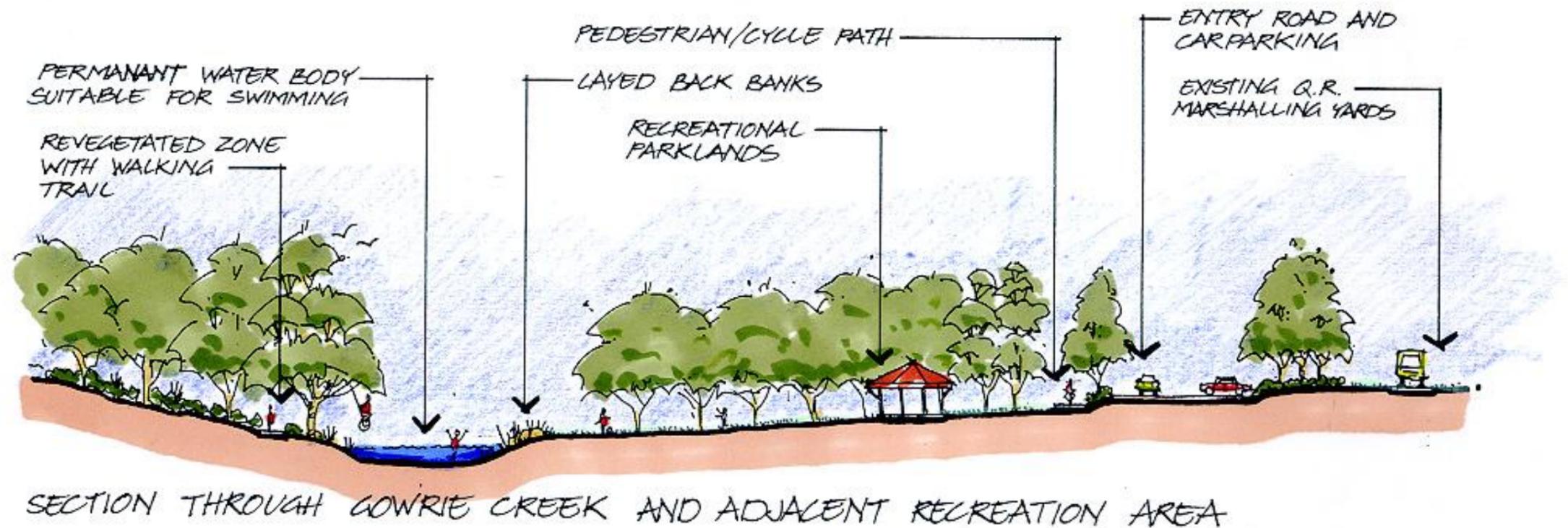
5.3.19 Gowrie Creek - North Street to Griffiths Street

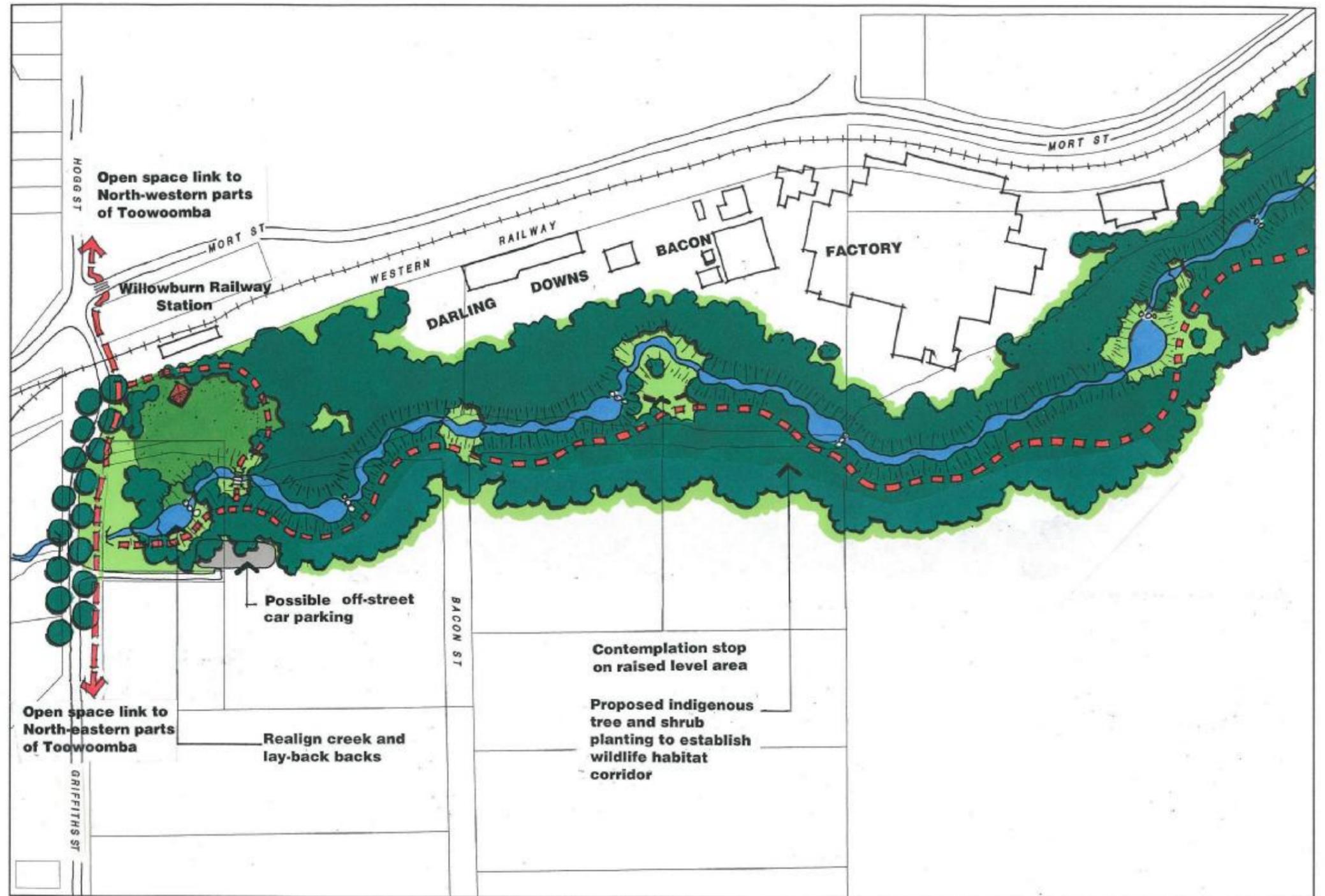
Issues

- The waterway corridor through this section is narrow, however not with the same intensity and proximity of incompatible adjacent land use. The creek itself, while not experiencing the same problems with the dumping of rubbish and weed infestation as upstream reaches, is experiencing erosion problems due to lack of vegetation, steep creek banks and excessive flood flows.
- Constrained by the railway line to the west and the Queensland Rail Marshalling Yards to the east, access into the waterway corridor is limited to North Street and Griffiths Street.
- Views to the waterway from Griffiths Street are impeded by existing industrial development on the southern side of the road.
- There is an existing railway corridor and rail bridge crossing of the waterway corridor south of Griffiths Street. Access under the bridge is somewhat restricted.

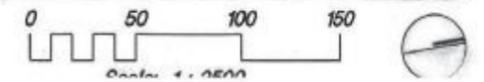
Recommendations

- Council should negotiate partial buy back of Queensland Rail land, between the creek line and the existing rail line on the eastern side, acquiring as much land as possible in this area. It is understood that Queensland Rail will require an access corridor along the rail line, and that all land up to this corridor should be available. This will provide an open space corridor sufficiently wide to allow extensive reprofiling of the banks, a continuous pedestrian/cycle path, and a series of recreational nodes accessible by an internal road and off-street parking network.
- A series of large permanent water bodies are proposed to help reduce the velocity of water flows along the creek, improve water quality, provide habitat and add amenity and interest adjacent to the proposed recreation nodes. These waterbodies will be linked by pedestrian walking trails and heavily vegetated along their edges using endemic vegetation. It is envisaged that these water bodies could be promoted for swimming, after construction and on going testing of the suitability of water quality for primary contact recreation.
- Major reprofiling of the banks and re-establishment of riparian zone with endemic vegetation is proposed. This will have major habitat benefits.





Drawing No. :
PBL 0503 / G-05



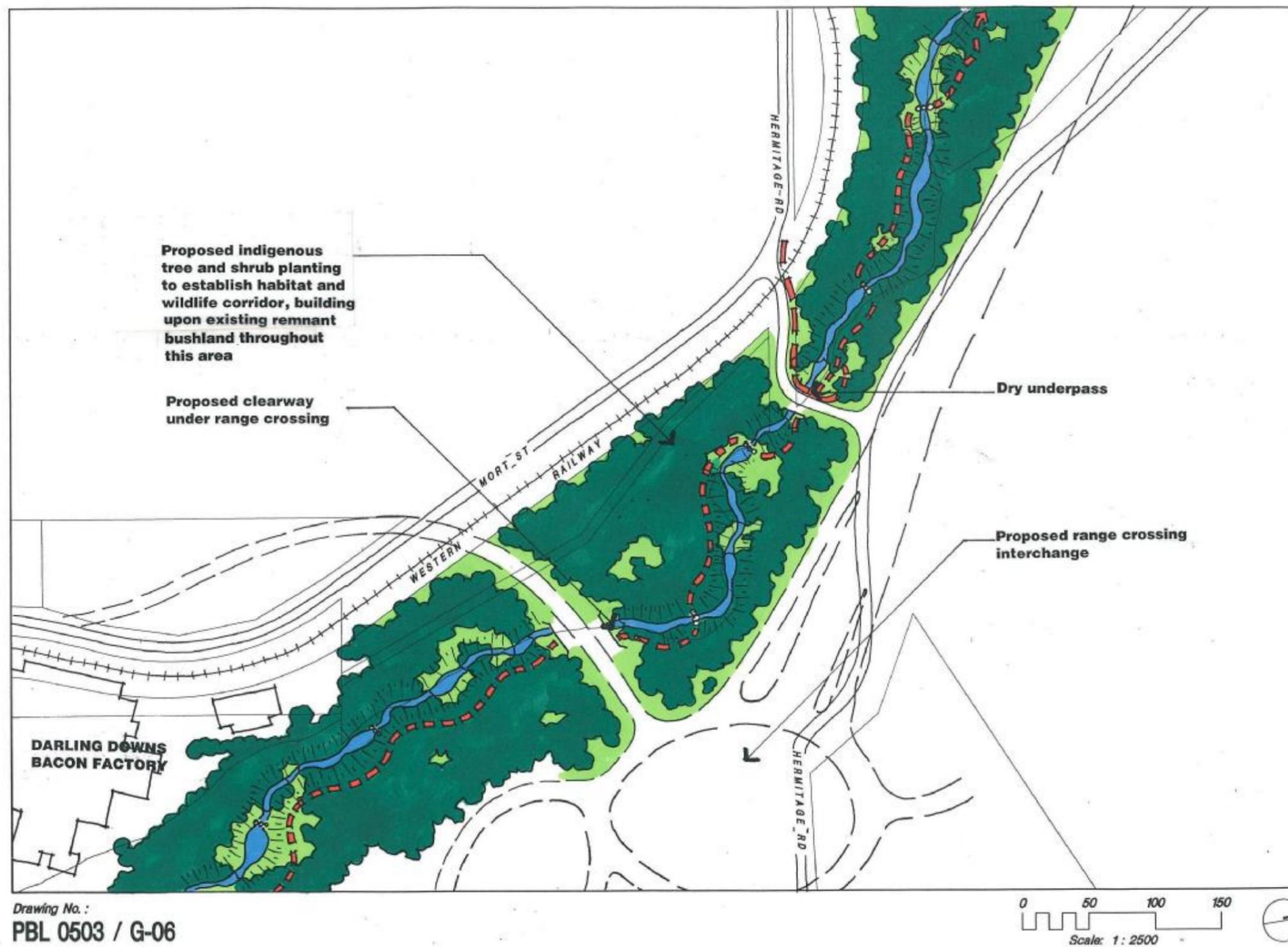
5.3.20 Gowrie Creek - Griffiths Street to the Bacon Factory

Issues

- Throughout this section of the waterway, existing development is limited. The Darling Downs Bacon Factory and Western Railway are the only developments present in the area.
- The Bacon Factory has considerable infrastructure invested in their current location, and presently are proposing to expand their existing operation at the site. Any future schemes for waterway management should accommodate all existing facilities, and the possible extension to the factory.
- The areas of land to the east of the creek are presently used by the Bacon Factory to dispose of effluent from their abattoir via spray irrigation.
- Adjacent future land use is zoned industrial, yet no imminent development is planned.
- The creek itself is very open with very little vegetation, and its banks are steep and experiencing erosion problems.

Recommendations

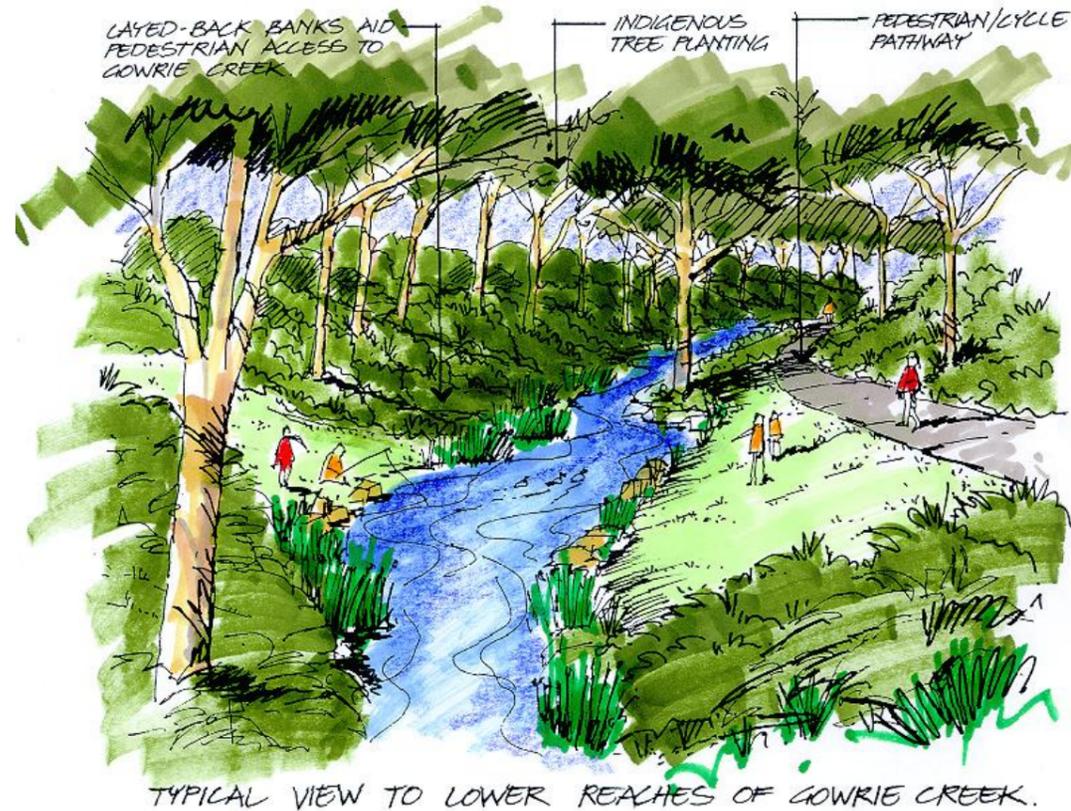
- Extensive revegetation of this area is proposed, using native vegetation endemic to the region. Due to the remote, undeveloped nature of this zone, and proximity to the Bacon Factory, it is proposed that a green, heavily vegetated corridor with a series of pedestrian walking trails be developed, without the focus on bikeways and active recreation applied to areas further upstream. This vegetated corridor will have significant habitat value.
- A series of rock riffles and small pools should be established to reduce water flows and subsequent erosion of banks, supplemented by bank reprofiling works. By reprofiling the banks, greater access and views to the creek will be available to pedestrians using the walking trails.
- Off-street parking adjacent to Griffiths Street will allow for greater regional access by locals and visitors to Toowoomba.
- A recreation node is proposed adjacent Griffiths Street where it can obtain exposure and access from the railway station, Griffiths Street and Mort Street.
- Public access west of the creek, adjacent the Bacon Factory, should be restricted and that land maintained by the Bacon Factory to the requirements of the Council.



5.3.21 Gowrie Creek - Bacon Factory to Council Boundary (Willims Road)

Issues

- This section of waterway is likely to be significantly affected by the proposed second Range Crossing interchange, wherein a major road crossing interchange will be constructed across the creek to the north of the Bacon Factory.
- As for the section of Gowrie Creek south of this area, development is minimal and the area is quite remote from existing urban residential development.
- The corridor is very open with minimal trees and vegetation cover (except for the Cranley Wood), the creek itself is in relatively good condition, free from major rubbish and debris, yet still experiencing some erosion from high flood flows. Creek banks are quite steep.
- Access is minimal, with the Hermitage Road crossing the only point of entry into the waterway corridor.



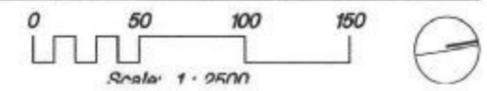
Recommendations

- Again, due to the remote and undeveloped nature of this area, a heavily vegetated green corridor of endemic species is proposed throughout, accessible by pedestrian walking trails.
- Rock riffles at approximately 150 metre intervals are proposed along the creek, reducing water flows and establishing small pools of permanent water, adding interest for the pedestrians. These rock riffles also help provide informal crossing points for pedestrians.
- Extensive reprofiling of the creek banks should be considered to provide both access and views into the creek for pedestrians using the walking trail.
- All efforts should be made by Main Roads in the design and construction of the proposed Second Range crossing to minimise disturbance to Gowrie Creek, and the significant vegetation that is present in the area. Provision of sufficient area beneath the proposed roadway for floodwater, pedestrian and wildlife passage at least will be required, and it is recommended that as much open area as possible be provided.
- Pedestrian crossings should be built under Hermitage Road and the proposed second range crossing. Primary public access into the corridor should be from Hermitage Road.





Drawing No. :
PBL 0503 / B-01



5.3.22 Black Gully - Mort Street to Holberton Street

Issues

- Generally this section of Black Gully has a generous corridor of adjacent open space, surrounded by predominantly residential development to the north and south with the exception of a small area of industrial use immediately west of Mort Street.
- The creek between Mort Street and Gordon Avenue is experiencing some erosion problems and forming steep banks. Some weed infestation is also evident in this section of the creek.
- West of Gordon Avenue the creek is piped beneath a shallow concrete spoon drain, preventing the scouring effect that constant low flows have on an unstable creek bed. The surface drain is somewhat unsightly and follows an unnatural alignment.
- An existing cycle path runs through the open space corridor, however fails to connect to North or Mort Street.
- Accessibility to the waterway corridor is quite good west of Gordon Avenue with street frontage along Greenbury Street and street entries from both ends of Gordon Avenue and Holberton Street.

Recommendations

- A series of two wet detention basins are proposed west of Gordon Avenue to reduce flooding problems further downstream at the confluence of Black Gully and Gowrie Creek, and to reduce erosion in Black Gully and Gowrie Creek.
- In the base of each of the proposed detention basins, a permanent water body is proposed to provide interest and water quality improvement.
- Extensive revegetation using native trees and shrubs endemic to the region should be undertaken, to create pockets of open space and to link with the habitat corridor created along Gowrie Creek.
- The existing cycle path should be widened to accommodate pedestrian use also, and should be extended to meet North Street and the proposed pedestrian/cycle path east of Mort Street. The pathway will pass under Mort Street via a dry weather underpass.



Drawing No. :
PBL 0503 / B-02

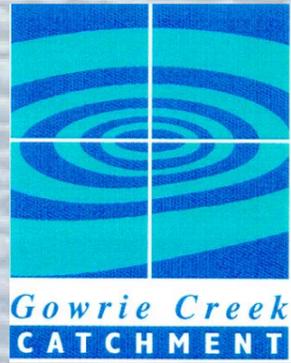
5.3.23 Black Gully - Holberton Street to Tor Street

Issues

- This section of Black Gully has a generous corridor of open space associated with the creek. The open space corridor is mostly open grass, however has a significant cover of mature native tree species in the area east of Tor Street.
- The creek itself is piped beneath a simple concrete spoon drain running in a straight alignment. This pipe and drain combination, although functional in preventing scouring and erosion of the creek bed, is unsightly and unnatural.
- Access to the open space corridor is good with street frontage along Tor, Holberton and Clearview Streets and minor street entries from Swallow and Clarissa Streets.
- An existing bicycle path runs through the park, linking many of these streets.

Recommendations

- A series of small rock riffles and ponds should be established along the line of the piped/spoon drain system to reduce the velocity of water flows and to provide basic habitat areas and visual attraction.
- Extensive planting of native tree and shrub species endemic to the area should be undertaken, set out to provide open pockets of parkland. Denser screen planting should be established adjacent those residential properties backing onto the park.
- The existing bicycle path should be widened to accommodate pedestrian use also. East of Holberton Street the pedestrian/cycle path should be diverted around the proposed recreation node.
- A detention basin maybe required upstream of Bridge/Tor Streets to prevent nuisance flooding in this area. More detailed investigations should be conducted into the feasibility and design of such a basin.



GOWRIE CREEK Toowoomba
PLAN IMPLEMENTATION

6 PLAN IMPLEMENTATION

Implementation of the recommendations of the Catchment Management Strategy is discussed below. Advice is provided for two key areas of study consideration, these being related to:

- whole of catchment actions; and
- waterway specific actions.

For each area of study consideration, guidance is provided on the following issues relevant to implementation;

- summary actions;
- estimated capital and operation and maintenance costs;
- recommended prioritisation of actions;
- organisational/agency roles and responsibilities; and
- monitoring/specific review requirements.

6.1 WHOLE OF CATCHMENT ACTIONS

6.1.1 Summary Actions

Key actions recommended as part of the Catchment Management Strategy for whole of catchment actions are as follows;

- Initiate/Expand Community Education Actions.
- Evaluate/Initiate Innovative Stormwater Management Techniques.
- Illegal connection/sewer exfiltration study.
- Ongoing Erosion and Sediment Control Policy Development and Enforcement.
- Diffuse Source Pollution Control.
- Fertiliser and Pesticide use Control.
- Weed Species Control.
- Future Planning and Management of Land Uses.

6.1.2 Estimated Costs

Estimating the costs specific to this study for the defined key whole of catchment actions is difficult as:

- many of the actions are ongoing responsibilities of Council Officers and Government Agencies;
- the extent of previous and on-going involvement of Council and Government personnel is often difficult to ascertain; and
- in some cases, there is no defined 'extent' of action that is required (*eg. the costs associated with a 'low-key' community education program are likely to be considerably less than a more extensive program*).

Table 6.1 contains estimated costs for the recommended actions. Where activities are considered to already be the responsibility of Council Officers and Government agencies, no cost estimates have been provided. In some cases, cost estimates are incremental to those works that are believed to be already occurring.

Table 6.1 - Whole of Catchment Action Cost Estimates

Action	Cost Estimate
Community Education	\$10,000/year
Innovative Stormwater Management Techniques	\$50,000
Illegal Connection/Sewer Exfiltration Study	\$100,000
Ongoing Erosion and Sediment Control ⁽¹⁾	n/a
Diffuse Source Pollution Control	\$25,000/year
Fertiliser & Pesticide Control	\$5,000/year
Weed Species Control ⁽²⁾	n/a
Future Planing and Management of Land Uses ⁽³⁾	n/a

(1) Council already initiated, requirement under EPP (Water)

(2) Council/DNR ongoing responsibility

(3) Ongoing/existing Council responsibility

6.1.3 Priority

Table 6.2 presents the priorities ascribed by the study team to each of the proposed key whole of catchment actions.

Table 6.2 - Whole of Catchment Action Priorities

Action	Priority
Community Education	High
Future Planning and Management of Land Uses	High
Innovative Stormwater Management Techniques	Moderate - High
Ongoing Erosion and Sediment Control	Moderate - High
Illegal Connection/Sewer Exfiltration Study	Moderate
Diffuse Source Pollution Control	Moderate
Fertiliser & Pesticide Control	Moderate
Weed Species Control	Low

Note: high 0-2 year time frame
 moderate 2-5 year time frame
 low > 5 year time frame

6.1.1 Organisational Responsibility

Table 6.3 presents a summary of the organisations ascribed key, and where relevant secondary, responsibility for implementing the recommended whole of catchment actions.

Table 6.1 - Whole of Catchment Action Responsibilities

Action	Principal Agency	Secondary Agency
Community Education	TCC	DNR
Innovation Stormwater Management Techniques	TCC	DEH/DNR
Illegal Connection/Sewer Exfiltration Study	TCC	-
Ongoing Erosion and Sediment Control	TCC	DEH/DNR
Diffuse Source Pollution Control	TCC	DEH
Fertiliser & Pesticide Control	TCC	DEH/DNR
Weed Species Control	DNR	TCC
Future Planning and Management of Land Uses	TCC	-

6.1.2 Monitoring/Review Requirements

The efficacy of each of the defined whole of catchment actions and need for continuing effort should be reviewed periodically. In some cases, no further action will be required (*eg. illegal connection/sewer exfiltration study*) after the works are completed, whereas for other activities, an ongoing ‘surveillance’ type role may be required. Specific monitoring recommendations made in regard to the whole of catchment actions are as follows;

- a regular flow weighted pollutant export monitoring program should be commenced to collect data on the rates on pollutant transport from the catchment against which to assess the efficacy of catchment management and water quality improvement measures in improving event based water quality in Gowrie Creek; and
- a periodic low flow or baseline surveillance water quality monitoring program should be initiated at several locations along the creek system to assess dry weather water quality, and to assist with the determination of where there may be sewer or illegal tradewaste discharges into Gowrie Creek.

6.2 WATERWAY SPECIFICATION ACTIONS

6.2.1 Summary Actions

The Waterway plans presented in Section 5.0 of this report summarise specific actions recommended for the waterways of Gowrie, East and West Creeks and Black Gully.

In addition to these “structural” measures, there are a number of other waterway specific actions that Council will need to initiate, as follows:

- review DCP-4 to ensure that it correctly reflects the recommendations of this study;
- develop a scheme to “assist”, not necessarily financially, the relocation of key commercial operations from along Gowrie Creek to elsewhere in the City;
- develop a land acquisition program; and
- source funding for waterway (*and catchment*) works from all possible Government sources.

6.2.2 Estimated Costs

A preliminary cost estimate for all capital and land acquisition works proposed for waterways of the Gowrie Creek system has been prepared. Key assumptions made as part of this cost estimate were as follows:

- Minor revegetation works will cost some \$120/linear metre of waterway assuming an average corridor width of 60 metres made up of a 10 metre wide area of intense revegetation adjacent the waterway and a remainder 50 metre zone of less intense revegetation works.
- Major revegetation works will cost in the order of \$400/linear metre of waterway assuming an average corridor of 45 metres requiring works.
- All revegetation works include tree planting of both tube and pot stock at various intensities, hydromulching of understorey species and grass areas, topsoil, mulching, water supply, stabilisation treatments and establishment and maintenance. It should be noted that these revegetation works exclude hard landscape items such as lighting, paving, retaining walls, shelters, park and play equipment.

Using this approach, the estimated capital cost associated with the study is \$35,750,000, made up of \$6,560,000 land acquisition and \$29,190,000 capital and construction costs. The approximate breakdown of these costs on a waterway by waterway section, and for each of the defined works, is provided in the attached Table 6.6.

With respect to operation and maintenance (*O&M*) costs, annual O&M requirements for waterway management works are typically of the order of 3-5% of the capital cost. For Gowrie Creek, an annual amount of approximately \$1,000,000 will be required in this regard when all creek restoration and enhancement works are completed.

6.2.3 Priority

Table 6.4 presents a summary description of the priority ascribed by the study team to key elements of the Waterway Specific Actions.

Table 6.2 - Waterway Specific Action Priorities

Action	Priority
Main Detention Basins on West Creek ⁽¹⁾	High
Commence Gowrie Creek Land Acquisition	High
Review DCP - 4	High
Develop Commercial Relocation Scheme	High
Develop Land Acquisition Program	High
Coordinate Government Funding	High
Secondary Detention Basins on West Creek ⁽²⁾	Moderate
CBD Channel Improvements	Moderate
Gowrie Creek Enhancement Works	Moderate
East Creek Detention Basins	Low-Moderate
Wetlands in East and West Creeks ⁽³⁾	Low-Moderate
Other Works in East and West Creeks	Low

(1) Basins upstream of Spring Street, Alderley St, within Golf Course, Long St (*Wilf Gowlett Oval*) and Pechey Street

(2) Other Basins

(3) Wetlands are proposed for placement within the following detention basins

⇒ West Creek - Upstream of Spring Street, 2 basins upstream of Alderley Street, 2 Golf Course basins

⇒ East Creek - 3 basins upstream of Mackenzie Street

⇒ Black Gully - 2 basins upstream of Gordon Avenue

Note:

high 0-2 year time frame

moderate 2-5 year time frame

low > 5 year time frame

6.2.4 Organisational Responsibility

Table 6.5 presents a summary of the organisations ascribed key, and where relevant secondary, responsibility for implementing the recommended Waterway Specific Actions.

Table 6.3 - Waterway Specific Action Responsibilities

Action	Principal Agency	Secondary Agency
Detention Basins, Wetlands, etc	TCC	DNR ⁽¹⁾
Review DCP - 4	TCC	
Develop Commercial Operation Relocation Scheme	TCC	DNR
Develop Land Acquisition Programs	TCC	DNR
Coordinate Government Funding	DNR	TCC

(1) Key DNR Role will be to facilitate the approval process for these structures

6.2.5 Monitoring/Review Requirements

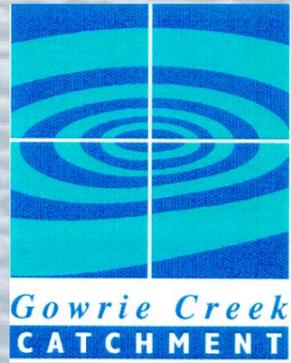
Key monitoring requirements for the waterway specific component of the Catchment Management Strategy relate to determination of the ongoing effectiveness of the proposed flood, erosion and water quality control measures, and the subsequent refinement of proposed future works programs. In this regard, the following recommendations are made:

- a rigorous hydrological data collection program should be initiated for Gowrie Creek to collect relevant and reliable rainfall-runoff data. In particular, uncertainties with the rating of Cranley Gauge should be resolved as soon as possible, and a review undertaken of the reliability and sufficiency of pluviograph stations within the catchment. The data collected by this program should be periodically reviewed to assess the magnitude of changes that are occurring in catchment rainfall-runoff processes with ongoing construction of detention basins and within catchment measures;
- additional flood water level recorders (*of the form of the Brisbane City Council Maximum Height Gauges*) should be placed at key locations along East, West and Gowrie Creeks and Black Gully to ensure that in the event of future floods, that good quality peak water level data is obtained;
- water quality requirements in regard to the waterway specific measures will be addressed by the monitoring recommendations presented in Section 6.1.5; and
- regular visual surveys should be conducted of bed and bank condition at key locations along the creek, supported by good quality photography, to record how the bed and bank of Gowrie Creek behaves in response to catchment and waterway management measures.

On the basis of data collected by the above program, periodic (*5 yearly*) reviews of waterway processes should be conducted by Council, and necessary modifications made to the recommendations of this study.

Table 6.6 - Study Cost Estimate

Waterway	Location	Detention Basins and Wetlands (no.)	Detention Basins and Wetlands (cost)	Rock Riffle (no.)	Land Buy Back (\$)	Bank Reprofiting (m3)	Major Revegetation (m)	Minor Revegetation (m)	Bikeways (m)	Desnagging and Waterway Clean Up (\$)	Low Fow Channel Scour Rehabilitation (m)	Overheads and Administration (\$)	Contingencies (\$)	Sub Total
West Creek	Upstream of Spring Street	1	595000					300		0		63,100	63,100	757,200
West Creek	Spring Street to Stenner Street	3	699000					700	700	0		84,250	84,250	1,011,000
West Creek	Stenner Street to Alderley Street	2	810000					900	900	0		99,450	99,450	1,193,400
West Creek	Alderley Street to South Street	2	1507000					850	850	0		168,125	168,125	2,017,500
West Creek	South Street to Long Street	1	1044000				100	400	400	0		116,600	116,600	1,399,200
West Creek	Long Street to Herries Street	1	480000				400	850	850	0		81,425	81,425	977,100
West Creek	Herries Street to Russell Street					40000	200		630	80000	200	103,355	103,355	1,240,260
8,595,660														
East Creek	Ramsay Street to Stenner Street	2	375000					350	350	0	350	48,175	48,175	578,100
East Creek	Stenner Street to Mackenzie Street	3	1489000					900	900	0	450	171,850	171,850	2,062,200
East Creek	Mackenzie Street to Alderley Street								700	0		5,950	5,950	71,400
East Creek	Alderley Street to South Street	2	614000					400	800	0	200	75,000	75,000	900,000
East Creek	South Street to Perth and Kitchener Street	1	333000					200	660	0		41,310	41,310	495,720
East Creek	Kitchener Street to Herries Street							200	400	0		5,800	5,800	69,600
East Creek	Herries Street to Hume Street							200	300	0		4,950	4,950	59,400
East Creek	Hume Street to Ruthven Street and West Creek Confluence							600	600	0		12,300	12,300	147,600
4,384,020														
Gowrie Creek	Russell and Ruthven Streets to Bridge Street			3		18000	800		800	36000		108,400	108,400	1,300,800
Gowrie Creek	Bridge Street to Jellicoe Street			6	3,200,000	75000	870		870	150000		587,195	587,195	7,046,340
Gowrie Creek	Jellicoe Street to North Street			5	1,900,000	50000	630		630	100000		380,555	380,555	4,566,660
Gowrie Creek	North Street to Griffiths Street			7	930,000	87000	1325		1325	174000		418,663	418,663	5,023,950
Gowrie Creek	Griffiths Street to the Bacon Factory			4			660		330	0		69,205	69,205	830,460
Gowrie Creek	Bacon Factory to Hermitage Road			6	530,000		1000		500	0		157,250	157,250	1,887,000
20,655,210														
Black Gully	Mort Street to Holberton Street	2	852000	2				950	950	0		124,675	124,675	1,496,100
Black Gully	Holberton Street to Tor Street			4				550	550	0		51,275	51,275	615,300
2,111,400														
TOTAL 35,746,290														
<i>Aqreqate</i>		20	8,798,000	37	6,560,000	270,000	5,985	8,350	14,995	540,000	1,200	2,978,858	2,978,858	



GOWRIE CREEK Toowoomba
ACKNOWLEDGEMENTS AND STUDY TEAMS

7 ACKNOWLEDGEMENTS AND STUDY TEAMS

7.1 ACKNOWLEDGEMENTS

WBM Oceanics Australia and Hassell wish to acknowledge the assistance and encouragement provided by the following personnel during the course of the study:

- Toowoomba City Council elected representatives
- Toowoomba City Council staff
- Department of Natural Resources staff
- Department of Environment and Heritage staff
- Queensland Rail staff
- Members of the Gowrie Creek Reference Group
- Bob Dansie for providing valuable input to the historical background (Section 1.3.3) of Toowoomba
- Other members of the community who provided ideas, comments, and feedback during the community consultation phase of the study

7.2 STUDY TEAMS

7.2.1 WBM Oceanics Australia

- Tony McAlister (*Project Manager and Catchment Management Specialist*)
- Wesley Walden (*Mathematical Modeller*)
- Shaun Leinster (*Mathematical Modeller*)
- Ros Burgess (*Botanist*)
- Dr Martin Cohen (*Terrestrial Ecologist*)

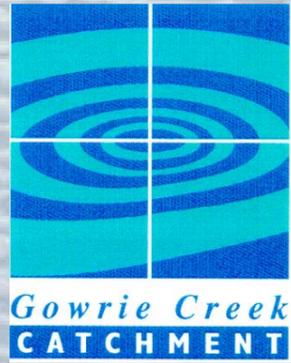
7.2.2 Hassell

- John Wright (*Principal Landscape Architect*)
- David Hatherly (*Landscape Architect*)
- Terry Scanlan (*Planner*)
- Jacinta Sartori (*Social Planner*)

7.2.3 Subconsultants

- Stuart Macnish - Hyder Consulting(*Geomorphologist*)

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GOWRIE CREEK Toowoomba
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8 REFERENCES

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