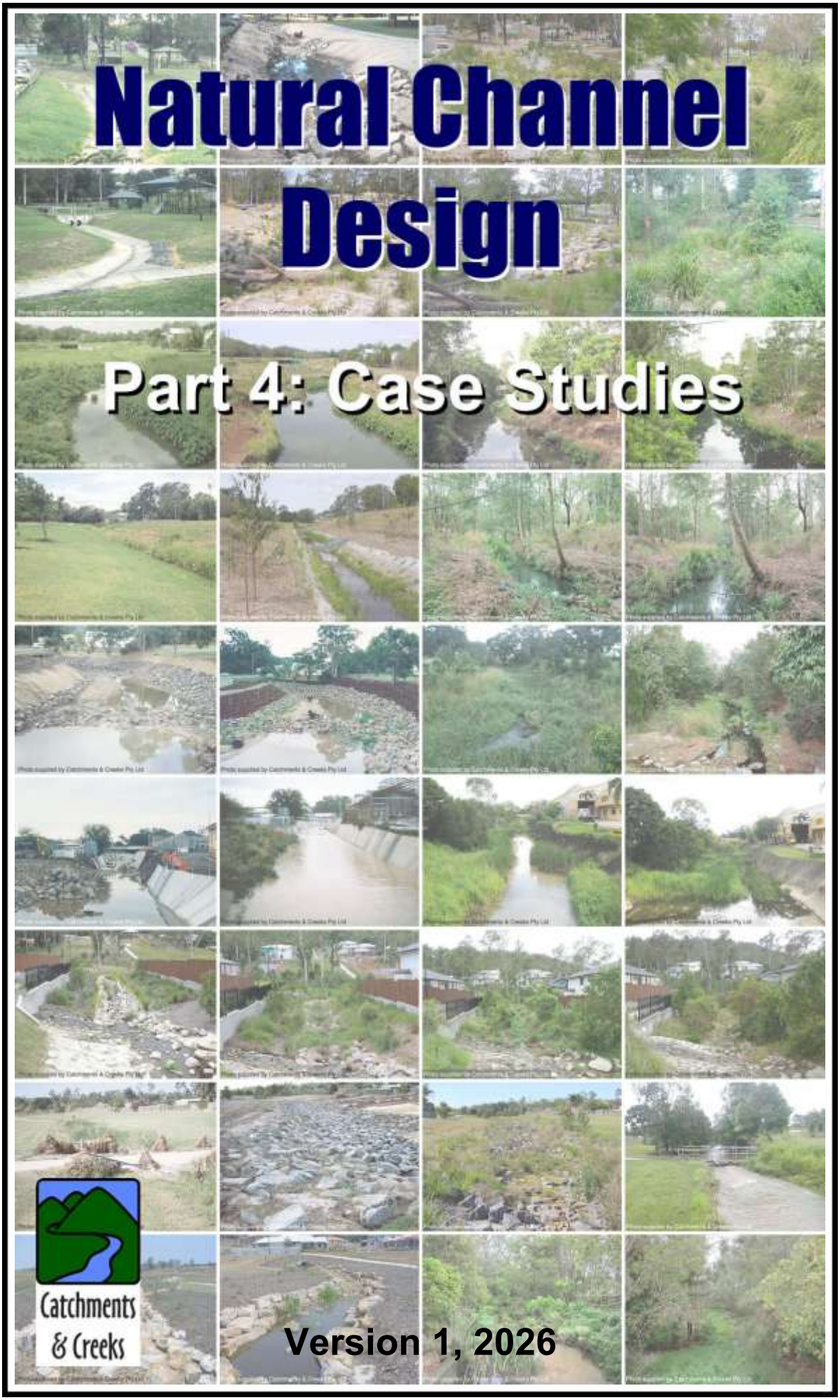

Natural Channel Design

Part 4: Case Studies

Catchments & Creeks

Version 1, 2026

Natural Channel Design
Part 4 – Case Studies

Version 1, April 2026

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Cover image: A collection of images from (top to bottom) Bowman Park, Bardon; Norman Creek, Tarragindi; Sandy Creek, Enoggera; Settlement Road, The Gap; Sheep Station Gully, Calamvale; and Sinnamon Road, Sinnamon Park, Brisbane, Queensland.

Contents

Purpose of document

This document has been prepared specifically to provide case studies on Natural Channel Design projects, creek rehabilitation projects, and the management of river systems.

The photos presented within this document are intended to represent the current topic of discussion. These photos are presented for the purpose of displaying components of a given waterway project.

The caption and/or associated discussion should **not** imply that the site shown within the photograph represents either good or bad land management practice. The circumstances, site conditions and history of each site are not fully known to the author. In many cases the captions represent only the observations of the author, and these observations may fall far short of a complete explanation of the site.

About the author

Grant Witheridge is a retired civil engineer with both Bachelor and Masters degrees from the University of NSW (UNSW). He has over 45 years experience in the fields of hydraulics, creek engineering, and erosion & sediment control, during which time he worked for a variety of federal, state and local governments, as well as private organisations.

Grant commenced his career at the UNSW Water Research Laboratory (1981) constructing and operating physical flood models of river floodplains. He later worked for Brisbane City Council on creek engineering and stormwater management issues, before ended his career working through his own company Catchments & Creeks Pty Ltd.

Introduction

The example sites presented in Part 4 all have their good and bad features. They are not necessarily ‘good’ examples, or ‘bad’ examples. They simply represent the best images that were available to the author at the time of publication.

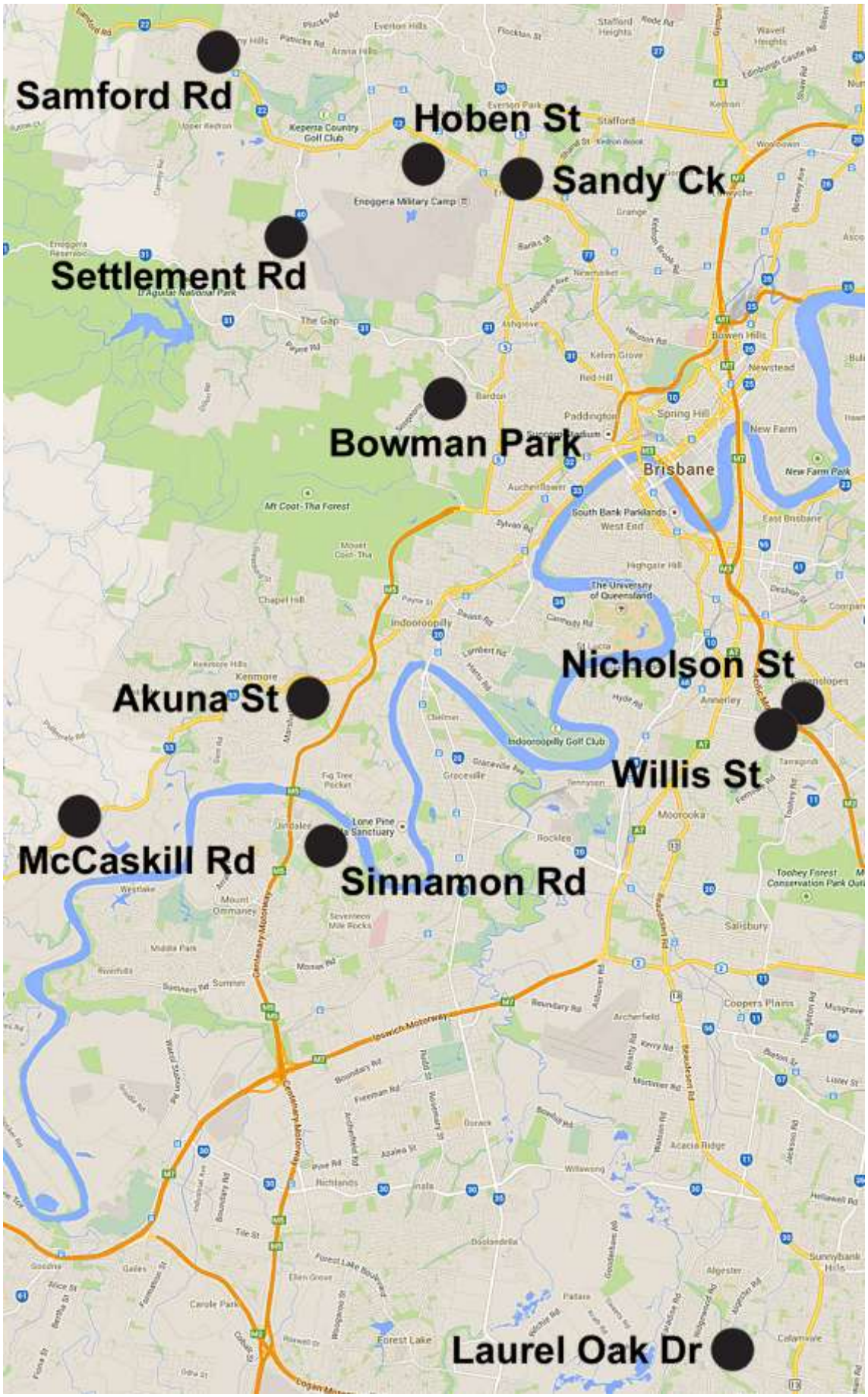
The author did not design the works shown in each example. In most of the examples the author played a minor role in the design, if only to provide advice to the principle designer. The author had no involvement in the sites located outside of Brisbane.

The author would not necessarily treated each site in the manner shown in the images.

The Torrens River in Adelaide is featured in this document not because it is a good, or a bad example. of a city river, but because it is a river system that has extraordinary public access This access allows most of the city reach of the river to be visited and photographed. The author may be critical of some aspects of the river system, but the author acknowledges that the river represents a wonderful asset to the city of Adelaide.

17. Brisbane Sites

Location of Brisbane sites



Location map of case studies (excluding Browns Creek, Lismore, NSW)

17.1 – Bowman Park, Bardon, Brisbane

Map location (north is to the right)

Aerial image showing vegetated channel

Bowman Park concept plan

Aerial image showing channel alignment

Original concrete drain (1998)

Rehabilitated drain (2000)

The proposal

- The original proposal for the naturalisation of the concrete spoon drain was made by the local frog society.
- The proposal was based around the development of a suitable frog habitat, with the aim of reducing frog mortality within the adjacent sports oval.
- The works were designed by Brisbane City Council and built in 2000.
- The estimated cost of construction in 2000 was just $170,000.

Site constraints

- The site benefited from the fact that it was a constructed drainage tributary to Ithaca Creek, and was not a recognised watercourse.
- The drain also sat within a backwater region of the floodplain, and as such, the works did not increase local flood levels.
- The tributary was initially judged not to have sufficient base flows to maintain healthy water quality within the proposed pool-riffles system.

Bowman Park – before and after

Western tributary (1998)

Western tributary (2001)

Eastern tributary (1998)

Eastern tributary (2001)

Tributary junction (1998)

Tributary junction (2001)

Main channel (looking south, 1998)

Main channel (looking south, 2000)

Bowman Park – channel features

Pool-riffle system (2000)

Pool-riffle system

- In theory, pool-riffle systems should only be constructed within waterways that would normally contain such a system.
- The adjacent Ithaca Creek is a waterway that does contain similar pools and riffles.
- To maintain sufficient trickle flow through the pools, a clay lining was placed under the channel to minimise the infiltration of water into the subsoil.
- The pool-riffle dimensions were based on information gained from local waterways.

Anchored habitat logs (2000)

Roosting logs

- Several logs were anchored into the channel as habitat logs to provide roosting for local wildlife, such as lizards.
- Such channel features can also provide shelter for aquatic life during high-velocity flood flows.
- The logs are aligned with the direction of flow in order to minimise the risk of the logs catching flood debris.

New footbridge (d/s of junction, 2000)

Public access

- Replacing the concrete-lined storm drain with a vegetated waterway meant that pedestrian access to the sports oval had to be enhanced with the inclusion of footbridges and stepping stones.
- The rehabilitated park has become very popular with the local residents and children, as such, the pathways also provide valuable bikeways.

Stepping stone pathways (2008)

Stepping stones

- In a world of increasing public safety and risk management, the days of constructing stepping stone crossings of waterways maybe becoming a thing of the past.
- Fortunately, this channel rehabilitation project has incorporated numerous recreational features that enhance a child's ability to access and explore the waterway.

Bowman Park – plant establishment

Main channel (looking south, 2000)

Year 2000

- Initial plant establishment within jute erosion and weed-control blankets.

Main channel (looking south, 2001)

Year 2001

- Fully open canopy.
- Channel enters its initial ‘weedy’ phase.
- Pools are almost completely filled with invading reeds.

Main channel (looking south, 2005)

Year 2005

- Insufficient canopy cover still exists over the low-flow channel.
- Significant weed growth still exists within the channel.
- A dense cover of understorey native plants exists.

Main channel (looking south, 2010)

Year 2001

- Canopy has formed producing sufficient shade to thin plant density and allow the shading-out of some weeds.
- The pools are becoming clear of reeds.
- A pool is visible in the centre of this image.
- A riffle is just visible in the foreground of the image.

Bowman Park – plant establishment

Looking u/s to footbridge (2000)

Looking u/s to footbridge (2008)

Looking down main channel (2000)

Looking down main channel (2008)

Stepping stones (2000)

Stepping stones (2008)

Pool-riffle system (2000)

Pool-riffle system (2008)

Bowman Park, Bardon, Brisbane

Original concrete drain looking upstream with sports oval to the right (1998)

Rehabilitated waterway looking upstream with sports oval to the right (2010)

17.2 – Cubberla Creek, Akuna Street, Kenmore, Qld

Location map (north to the top of image)

Aerial image of the site

Looking d/s from Moggill Rd (1991)

Protection of sewer with rubble (1991)

Community tree planting (2004)

The site

- It is unknown why the creek was originally cleared of riparian vegetation, but it is likely to be a combination of the following reasons:
  - land clearing associated with past rural activities
  - clearing to allow installation of the trunk sewer line
  - clearing for flood mitigation
  - clearing to allow maintenance access for weed and sediment removal.

The problem

- In the early 1990s the creek had poor aesthetic appeal due to the exposed, weedy banks.
- Construction waste, in the form of rock, broken concrete and earth, had been used to stabilise and protect the channel banks adjacent the various sewer pipe crossings and sewer inspection chambers (just visible on the right of this image).

The project

- Around the beginning of this century, Greening Australia coordinated various community re-planting programs along Cubberla Creek.
- During the latter stages of the first decade of the 21st Centaury a substantial construction of pools and riffles occurred along the channel bed immediately downstream of Moggill Road.

Cubberla Creek, Akuna Street – plant establishment

Looking d/s from Moggill Rd (1991)

Looking u/s towards Moggill Rd (1991)

Looking d/s from Moggill Rd (2004)

Looking u/s towards Moggill Rd (2004)

Looking d/s from Moggill Rd (2010)

Looking u/s towards Moggill Rd (2010)

Looking d/s from Moggill Rd (2014)

Looking u/s towards Moggill Rd (2014)

Cubberla Creek, Akuna Street – ‘then’ and ‘now’

Looking downstream (1991)

Looking downstream (2014)

Looking downstream (1991)

Looking downstream (2014)

Looking u/s towards Moggill Rd (1991)

Looking u/s towards Moggill Rd (2014)

Downstream of footbridge (2004)

Downstream of footbridge (2014)

Cubberla Creek, Akuna Street – view from top of Moggill Road

Looking downstream from the top of Moggill Road bridge (1991)

Looking downstream from the top of Moggill Road bridge (2014)

Cubberla Creek, Akuna Street – view from culvert outlet

Looking downstream from the Moggill Road culvert (1991)

Looking downstream from the Moggill Road culvert (2014)

17.3 – Kedron Brook tributary, Hoben Street, Mitchelton, Qld

Location map (north to the top of image)

Aerial image of the site

Looking upstream from Samford Rd (2005)

Year 2005

- This project involved the rehabilitation of a park drain.
- Significant quantities of rock stabilisation occurred along the banks of the waterway.
- An existing tree was retained as an 'island' in the middle of the channel.
- Unfortunately, soil was not placed within the rock voids, which delayed the establishment of vegetation on the channel banks.

Looking upstream from Samford Rd (2007)

Year 2007

- Plants are beginning to establish on the channel bed, but with only limited plant establishment on the banks.
- A significant drought between 2005 and 2007 had delayed vegetation establishment along the waterway.

Looking upstream from Samford Rd (2014)

Year 2014

- Significant weed infestation along the channel bed.
- The north-south alignment of the creek, and the open canopy to the north of the creek produced by the existence of Samford Road, meant that this section of the creek will always experience a weed problem.
- The shading produced by the growing canopy cover should reduce weeds within the upstream section of the creek.

Kedron Brook tributary, Hoben Street, Mitchelton, Qld

Upstream end of works (2005)

Upstream end of works (2012)

Riffle (2005)

Riffle (2007)

Looking downstream (2005)

Looking downstream (2014)

Over-bank riparian zone (2005)

Over-bank riparian zone (2007)

Kedron Brook tributary, Hoben Street, Mitchelton, Qld

Looking upstream from Samford Road (2007)

Looking upstream from Samford Road (2014)

17.4 – McCaskill Road, Pullenvale, Qld

Location map (north to the top of image)

Aerial image of the site

Looking downstream (January 2001)

Looking downstream (2014)

Looking upstream (August 2001)

Looking upstream (August 2014)

Looking upstream (August 2001)

Looking upstream (August 2014)

17.5 – Norman Creek, Nicholson St, Greenslopes, Qld

Location map (north to the top of image)

Aerial image of the site

Looking downstream from culvert (2000)

Site history

- Riparian vegetation was largely cleared along the creek to provide flood mitigation.
- In the 1990s Norman Creek in this area resembled little more than an open storm drain passing through a grassy field.

Upstream reach (2001)

The project – stage 1

- Construction of the busway adjacent to the South East Freeway resulted in a second phase of creek rehabilitation.

Looking downstream to culvert (2001)

The project – stage 2

- Lobbying by the Norman Creek Catchment Coordinating Committee (N4C) resulted in the proposal for more substantial creek rehabilitation.
- A series of pools and riffles were formed along the creek based on the past success of a similar creek rehabilitation project adjacent to Willis St, Tarragindi (Ekibin).

Norman Creek, Nicholson St, Greenslopes

Looking downstream to culvert (2000)

Looking downstream to culvert (2001)

Looking downstream to culvert (2001)

Looking downstream to culvert (2014)

Norman Creek, Nicholson St, Greenslopes

Looking upstream from culvert (2001)

Looking upstream from culvert (2014)

Norman Creek, Nicholson St, Greenslopes

Looking downstream towards the culvert (after flood damage, 2001)

Looking downstream towards the culvert (2014)

Norman Creek, Nicholson St, Greenslopes

Looking upstream towards the upper end of the reach (2001)

Looking upstream towards the upper end of the reach (2014)

17.6 – Norman Creek, Willis St, Tarragindi

Location map (north to the top of image)

Aerial image of the site

Old channel looking to Arnwood St

Pool-riffle system (looking upstream)

Initial weed removal and tree planting

Catchment history

- The Norman Creek catchment has a very active community group, and this project is just one of a number of stream rehabilitation activities.
- The creek is located close to the centre of Brisbane, and consequently is one of the most urbanised and modified (channelised) creeks in Brisbane.
- The main focus of the project was a small southern tributary, and a short section of Norman Creek.

The proposal

- This project centred around the re-naturalisation of the grass-lined, channelised tributary of Norman Creek that passes along Willis Street, Ekibin.
- The project extended from the junction of Barr and Willis streets down to Arnwood Place bridge.
- Key components of the rehabilitation were the establishment of a pool-riffle system to control bed erosion, and dense riparian planting.

Site constraints

- This site benefited from the existence of elevated, flood-free homes on the high southern bank.
- The absence of local flood problems allowed the introduction of dense planting along this tributary to Normal Creek.
- The steep channel banks prevented the meandering of the channel (a cost issue).
- The upper reaches of the tributary consist of a concrete-lined channel (stormwater drain).

Norman Creek, Willis Street – plant establishment

Looking upstream from bridge (1999)

Year 1999

- Site conditions prior to the works.
- Creek channel has significant weed infestation

Following first stage of works (2001)

Year 2001

- Site conditions after channel modifications.
- Pools and riffles established within the tributary, with some planting within over-bank areas.
- Creek is nutrient-rich with heavy algae growth.

Looking upstream from bridge (2010)

Year 2010

- Canopy trees have achieved significant height, but not full maturity.
- Significant weed cover exists within the understorey.
- Tree establishment along the northern bank (visible to the left) is now beginning to shade the waterway.

Looking upstream from bridge (2014)

Year 2014

- Weeding and partial removal of grass cover within the riparian zone by the local community group.
- Shading from the established canopy cover also helps to thin the understorey and groundcover plants.
- The creek experienced significant flood flows during 2009, 2010 and 2011.

Norman Creek, Willis Street – plant establishment

Upper end of tributary (2001)

Upper end of tributary (2010)

Looking upstream (2001)

Looking upstream (2010)

Looking down Norman Creek (1998)

Looking down Norman Creek (2014)

Looking downstream from bridge (1998)

Looking downstream from bridge (2014)

Norman Creek, Willis Street – pool-riffle system

Constructed pool-riffle system (2001)

Pool-riffle system

- Pool-riffle systems are not natural is all waterways, and thus should not be considered an essential element of all creek rehabilitation projects.
- In this case the riffles help to control channel erosion that would otherwise have occurred once the canopy cover began to shade-out the grass cover.
- The use of 'blue' quarry rock may not be ideal, but the rocks usually develop a more natural brown/green colour over time.

Nutrient-rich waters (2001)

Algae problem

- This image of an algae encrusted turtle was taken within the deep pool that exists upstream of the Arnwood Place bridge in 2001 just after the completion of the channel works.
- This algae problem contributes to a reduction in dissolved oxygen within the water.
- Improved shading of the water body and improved stormwater practices within the catchment should see a reduction in this algae problem.

Downstream riffle (2010)

Stepping stones

- The most downstream riffle has been adopted by locals as a stream crossing point.
- The riffle rocks substitute as stepping stones.

Upstream riffle (2010)

Fish passage

- The riffles have established desirable flow conditions that would encourage fish passage up the waterway.

Norman Creek, Willis St, Tarragindi

Looking upstream from Arnwood Place bridge (1999)

Looking upstream from Arnwood Place bridge (2014)

17.7 – Sandy Creek, Enoggera, Qld

Location map (north to the top of image)

Aerial image of the site

Looking upstream from Magura St (1996)

Looking upstream from Magura St (1997)

Looking upstream from Wardel St (1997)

Site history

- Sandy Creek is a tributary of Kedron Brook, with its source located within the training hills of Enoggera army barracks.
- The creek passes through the industrial precinct of Enoggera where motor vehicle parts and debris had been used to stabilise the eroding creek banks.
- Prior to the channel works, both the industrial area and upstream residential areas experience frequent flood inundation.

The project

- In 1997 the project consisted of:
  - new stormwater drainage pipe upstream of Pickering Street
  - enlarged earth channel between the Pickering St culvert and upstream end of the Pickering St industrial estate
  - a Q100-capacity concrete channel through the industrial estate joining an existing downstream concrete channel
  - a sediment trap and habitat pond between the old and new channels.

Natural channel design features

- Incorporated into the flood mitigation works was the significant (doubled in size) expansion of the open channel through the parkland between the Pickering Street culvert and upstream end of the Pickering Street industrial estate.
- This project represented Brisbane City Council's first endeavour into the principles of *Natural Channel Design.*

Sandy Creek, Enoggera – channel features

Log and sand bench (1997)

Habitat log and sand bench

- Two habitat (roosting) logs were anchored into the channel.
- These logs provide habitat and shelter (from flood flows) for aquatic wildlife, and sunning perches for reptiles.
- Washed sand was introduced to the inside of channel bends to mimic the channel feature commonly found in alluvial river systems (now viewed as inappropriate within urban creeks).

Maintenance access ramp (1997)

Maintenance access ramps

- Maintenance access ramps were installed into the channel both upstream and downstream of the Wardell Street culvert.
- These access ramps were formed from flexible geotextile/concrete mats (Humes *Flexmat*).
- Use of these mats allows vegetation (grasses) to grow between the concrete blocks to partially hide the hard surfacing.

Grouted rock bed on concrete channel

Habitat pool and grouted rock roughness

- A deep sediment trap and habitat pool was established between the downstream end of the new concrete channel and the upstream end of the existing concrete channel, upstream of the Magura Street footbridge.
- To enhance the environmental features of the concrete channel, rocks were grouted to the bed of the downstream end of the new concrete channel.
- The intent was to allow vegetation to establish over these rocks.

Tree planter boxes set into boulders

Planter cell in rock bank

- To help shade the habitat pool, tree planter boxes (concrete pipe segments) were installed in the boulder-lined southern bank of the creek adjacent the Magura Street footbridge.

Sandy Creek, Enoggera – plant establishment

Looking upstream from Wardell St (1997)

Year 1997, February

- Pre-planting site conditions.
- Jute erosion control blankets placed over exposed soil banks prior to planting.

Looking upstream from Wardell St (1997)

Year 1997, June

- Site conditions just after initial plant establishment.
- Heavy loose mulching of the upper banks and over-bank areas.
- Limited pocket planting within the rock voids.

Looking upstream from Wardell St (1998)

Year 1998, April

- Significant weed (grass) growth within the bank vegetation.
- Channel bed effectively remains free of significant weed (reed) growth.

Looking upstream from Wardell St (1999)

Year 1999, April

- Significant weed growth along the banks and on the channel bed.
- A low-flow channel is beginning to establish in the centre of the channel bed.

Sandy Creek, Enoggera – plant establishment

Looking upstream from Wardell St (2003)

Year 2003

- Upper-storey canopy trees are slowly beginning to shade the channel, but currently they are only controlling weeds on the banks.
- Dry-land grasses are beginning to invade the channel bed during the extended drought of 2000–2008.
- A well-defined low-flow channel still exists.

Looking upstream from Wardell St (2007)

Year 2007

- Riparian vegetation has thinned due to a past drought.
- Channel bed thick with weeds, mainly grasses.
- This image shows the channel just after a storm that caused the bed vegetation to fold in the direction of flow.

Looking upstream from Wardell St (2011)

Year 2011

- Canopy trees are beginning to shade the channel bed and limit weed growth.
- The low-flow channel is now more pronounced within the wide channel bed.
- The original riffle rocks are now becoming exposed and forming a riffle.

Looking upstream from Wardell St (2014)

Year 2014

- The low-flow channel is well-defined.
- Excessive sediment deposition is occurring on the inside of the channel bend, and this sediment is being stabilised by weeds.

Sandy Creek, Enoggera – plant establishment

Looking upstream Pickering St (1997)

Looking downstream Pickering St (1997)

Looking upstream Pickering St (2003)

Looking downstream Pickering St (1998)

Looking upstream Pickering St (2007)

Looking downstream Pickering St (1999)

Looking upstream Pickering St (2014)

Looking downstream Pickering St (2007)

Sandy Creek, Enoggera – plant establishment

Upstream of Wardell Street (1997)

Looking downstream Wardell St (1997)

Upstream of Wardell Street (2003)

Looking downstream Wardell St (1997)

Upstream of Wardell Street (2007)

Looking downstream Wardell St (2003)

Upstream of Wardell Street (2011)

Looking downstream Wardell St (2011)

Sandy Creek, Enoggera – sediment trap and habitat pond

Looking upstream Magura St (1998)

Year 1998

- A habitat pool was established between the downstream end of the new concrete channel and the upstream end of the existing concrete channel.
- This habitat pond also acted as a sediment trap.

Looking upstream Magura St (1999)

Year 1999

- The rising bed level of the pond (due to sediment deposition) is allowing reeds to establish adjacent to the boulder wall.

Looking upstream Magura St (2011)

Year 2011

- Significant sediment deposition has occurred within the habitat pond.

Looking upstream Magura St (2014)

Year 2014

- The habitat pond is now near-full of sediment resulting in the establishment of reeds and grasses across the full width of the pond.

Sandy Creek, Enoggera – habitat pond bank planting

Tree planter boxes (1997)

Year 1997

- Tree planter boxes consisting of concrete pipe segments were installed in the boulder-lined southern bank of the creek to help shade the habitat pool.

Looking upstream Magura St (2003)

Year 2003

- Canopy trees just beginning to appear above the weed-infested rock bank.

Looking upstream Magura St (2011)

Year 2011

- Substantial tree growth.

Looking upstream Magura St (2014)

Year 2014

- Limited shading is being provided over the habitat pond because sediment deposition has limited the extent (width) of the pond.

Sandy Creek, Enoggera – channel bed modifications

Looking d/s to Magura St footbridge

Year 1997

- At the request of a business located adjacent to the channel, 'ecological features' were designed into the concrete channel.
- These 'experimental' features included rocks being grouted to the channel floor.
- The intent was for vegetation to establish over these rocks to help establish a more-natural channel bed ecosystem.

Looking upstream (1999)

Year 1999

- Sediment has settled between the rocks and plants are now beginning to establish on the channel bed.
- A low-flow channel has formed through the planted rocks.

Looking upstream from footbridge (2011)

Year 2011

- Plants and an associated ecosystem have established on the bed of the grouted, rock-lined, concrete channel bed.
- The habitat pond is still visible in the foreground.

Looking upstream from footbridge (2014)

Year 1999

- Woody species (*Melaleuca*) are now becoming established within the rock-lined concrete channel.
- The growth of such woody species in the concrete channel would not be desirable from a flood control perspective, as well as there is the risk that the roots could dislodge the grouted rocks, which could result in all the plants being dislodged during a flood event.

Sandy Creek, Enoggera – upstream of Wardell Street

Looking upstream from Wardell Street culvert (1997)

Looking upstream from Wardell Street culvert (2014)

Sandy Creek, Enoggera – downstream of Wardell Street

Looking downstream from the Wardell Street off ramp (1997)

Looking downstream from the Wardell Street off ramp (2014)

17.8 – Settlement Road, The Gap, Qld

Location map (north to the top of image)

Aerial image of the site

Constructed drainage channel

The site

- This site is located adjacent to Settlement Road, The Gap; between Kilbowie Street and Tilquin Street.
- The site was part of a new subdivision, which involved both drainage channel construction and creek engineering.

Modified creek channel u/s of Tilquin St

The project

- The project involved:
  - constructing a vegetated drainage channel in a location where no creek or concentrated flow path had previously existed, and
  - modifying an existing creek channel upstream of Tilquin Street.
- Aspects of this project were closely aligned with the principles of *Natural Channel Design*.

Existing creek upstream of the site (2012)

Existing (pre-2012) creek conditions

- The creek that passes through the subdivision is relatively steep.
- Prior to the modifications made during construction of the residential subdivision, the creek contained significant weed infestation and was subject to some ongoing bed and bank erosion.
- The developer was required to stabilise the creek and remove the weeds.

Settlement Road, The Gap

Looking d/s from Settlement Rd (2012)

Looking d/s from Settlement Rd (2012)

Looking downstream (February 2013)

Looking downstream (May 2013)

Looking d/s from Settlement Rd (2014)

Looking d/s from Settlement Rd (2014)

Looking d/s from Settlement Rd (2014)

Looking d/s from Settlement Rd (2014)

Settlement Road, The Gap

Looking upstream (2012)

Looking d/s to Tilquin St (2012)

Looking upstream (February 2013)

Looking d/s to Tilquin St (February 2013)

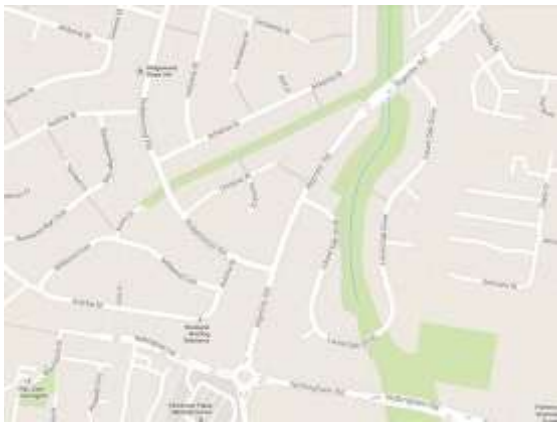
Looking upstream (May 2013)

Looking d/s to Tilquin St (May 2013)

Looking upstream (2014)

Looking d/s to Tilquin St (2014)

17.9 – Sheep Station Gully, Laurel Oak Drive, Algester, Qld



Location map (north to the top of image)

Aerial image of stage 1 work area

Original grassed trapezoidal channel

Site history

- The grass-lined trapezoidal waterway was originally constructed during the 1980s urbanisation of the area.
- The channel was originally developed without a formed low-flow channel, but instead had a sub-surface Ag-pipe drainage system.
- Over time the Ag-pipe blocked with sediment causing a low-flow channel to form (erode) along the channel invert.

Looking downstream to footbridge (2008)

The project

- This was a multi-stage project, commencing with the stabilisation and revegetation of the lower reach between the footbridge and Algester Road.
- This first stage consisted of removing highly erodible slaking soils and the old sub-surface drainage pipe, and then forming a series of rock-lined pools and riffles.
- The second stage consisted of channel works between Nottingham Road and Laurel Oak Drive.

Channel erosion (1998)

Exposed Ag-pipe & sewer crossing (1997)

Sheep Station Gully, Laurel Oak Drive, Algester – Stage 1

Looking d/s to the footbridge (2010)

Retention of footbridge

- Due to the steep gradient of the creek, and local flood control issues, the decision was made to retain the existing (1998) alignment of the low-flow channel.
- It was also agreed with the council that the footbridge would remain in its current location.

Looking upstream to footbridge (1999)

Removal of slaking soil

- Significant quantities of rubbish (burnt tree stumps) and highly erodible slaking soils were found in the stream banks adjacent the low-flow channel, which resulted in the need for this material to be removed.
- The channel was then lined with stable soil and a rock-lined pool-riffle system was constructed.

Soil-filled voids ready for planting (1999)

Pocket planting

- This project was one of the first examples in Brisbane where the voids between the rocks were filled with soil allowing plants to be introduced into the channel upon completion of the channel works.
- Prior to this, the practice of filling the voids with soil was considered unacceptable due to the risk of the soil being washed from the rocks by stream flows.
- Even though some soil is lost, the benefits gained through the earlier establishment of vegetation are significant.

Pool-riffle system (2010)

Pool-riffle system

- The channel falls in elevation only 400 mm at each riffle system, which is approximately the size of the rocks.
- When initially constructed (see photos over page) the individual pools and riffles were not clearly distinguishable amongst all the other bank stabilisation rock.
- Establishment of a canopy cover, which helps to control weeds, allows the pool-riffle system to be more clearly identifiable.

Sheep Station Gully, Laurel Oak Drive, Algester – plant establishment

Looking d/s towards footbridge (1997)

Looking d/s from footbridge (1999)

Looking d/s from footbridge (2000)

Looking d/s from footbridge (2001)

Looking d/s from footbridge (2004)

Looking d/s from footbridge (2008)

Looking d/s from footbridge (2010)

Looking d/s from footbridge (2014)

Sheep Station Gully, Laurel Oak Drive, Algester – plant establishment

Looking u/s, construction phase (1999)

Sewer pipe crossing (1997)

Looking upstream to footbridge (1999)

Sewer pipe crossing (1999)

Looking upstream to footbridge (2000)

Sewer pipe crossing (2000)

Looking upstream to footbridge (2010)

Sewer pipe crossing (2010)

Sheep Station Gully, Laurel Oak Drive, Algester – plant establishment

Looking u/s from Algester Road (1998)

Looking u/s from Algester Road (1999)

Looking u/s from Algester Road (2000)

Looking u/s from Algester Road (2001)

Looking u/s from Algester Road (2004)

Looking u/s from Algester Road (2008)

Looking u/s from Algester Road (2010)

Looking u/s from Algester Road (2014)

Sheep Station Gully, Laurel Oak Drive, Algester

Looking upstream from Algester Road (1998)

Looking upstream from Algester Road (2014)

Sheep Station Gully, Laurel Oak Drive, Algester

Looking downstream towards the footbridge (1997)

Looking downstream from the footbridge (2010)

17.10 – Sheep Station Gully, Laurel Oak Drive, Algester – Stage 2

Upstream of Laurel Oak Dr (1997)

Aerial image of stage 2 work area

Upstream of Laurel Oak Dr (2001)

Year 2001

- Stage 2 of the Steep Station Gully project consisted of similar channel works being constructed between Nottingham Road and Laurel Oak Drive.
- The lower channel gradient allowed the use of erosion control mats on the battered banks as opposed to rock stabilisation.
- The Laurel Oak Driver culvert was also modified to reduce sediment and debris blockage problems.

Upstream of Laurel Oak Dr (2004)

Year 2004

- During the early years, plant establishment was dominated by reeds and weeds within the moist low-flow channel.
- At this stage there is the risk of floods causing bank erosion on either side of the reed-infested low-flow channel.

Upstream of Laurel Oak Dr (Nov, 2014)

Year 2014

- Even though a canopy cover has not been successfully achieved, an open low-flow channel is now well defined and the channel banks are partially stabilised with vegetation.
- Ongoing maintenance is required to encourage the establishment of a canopy cover to better control weeds and shade the low-flow channel.
- Loss of rocks is occurring at the riffles.

Sheep Station Gully, Laurel Oak Drive, Algester – Stage 2

Looking upstream from Laurel Oak Drive (1997)

Looking upstream from Laurel Oak Drive (December, 2014)

17.11 – Sinnamon Road, Sinnamon Park, Qld

Location map (north to the top of image)

Aerial image of the site

Looking d/s from Sinnamon Rd (2000)

Looking d/s from Sinnamon Rd (2014)

Looking downstream to footbridge (2000)

Looking downstream to footbridge (2014)

Looking u/s towards s/w inflow (2000)

Looking u/s towards s/w inflow (2014)

Sinnamon Road, Sinnamon Park

Constructed waterway looking downstream from the Sinnamon Road culvert (2000)

Looking downstream from Sinnamon Road culvert (2014)

18. Non-Brisbane Sites

18.1 – Browns Creek, Magellan Street, Lismore, NSW

Location map (north to the top of image)

Aerial image of the site

On-site public information sign

The project

- This project is located in a Lismore Council park adjacent to Magellan Street.
- The 'stormwater drain' is a tributary to Browns Creek located within the centre of Lismore, NSW.
- The creek/drain rehabilitation was seen as a demonstration project for both the Council and the residents.
- One aim being to improve the resident's appreciation of the value of 'natural' waterways instead of 'stormwater drains'.

Pre-works site conditions (2003)

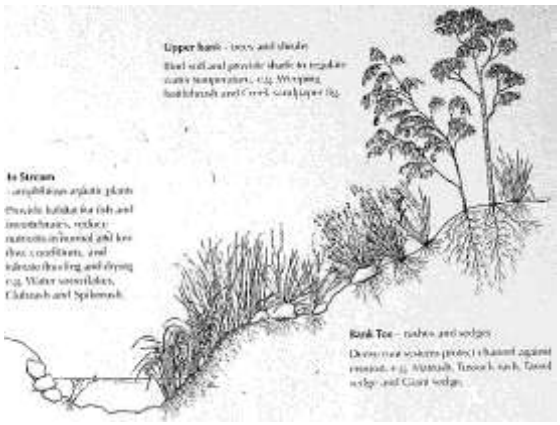
Site constraints

- The site was constrained by a planned road south of the drain, and the sports oval north of the drain.
- It was also considered desirable to avoid the relocation of the telephone pole.
- The site contains a cracking clay soil that benefits greatly from suitable vegetation cover that reduces the loss of soil moisture.
- The visually unattractive, low-value stormwater drain was also subjected to urban litter, including shopping trolleys.

Erodible, cracking black soils

Deposition of rubbish in storm drain

Browns Creek, Magellan Street, Lismore, NSW



On-site public information sign

Looking downstream (2003)

Looking down drainage channel (2005)

Looking downstream (2005)

Looking down drainage channel (2007)

Looking downstream (2007)

Looking down drainage channel (2014)

Looking downstream (2014)

Browns Creek, Magellan Street, Lismore, NSW

Browns Creek looking downstream in 2003

Browns Creek looking downstream in 2014

18.2 – Cherry Creek and South Platte River, Denver, Colorado, USA

Location map

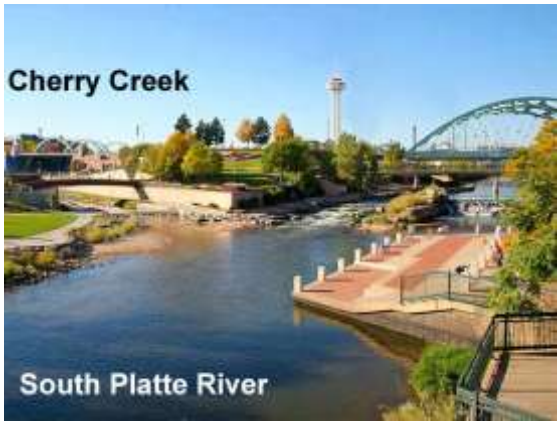
Location map

- In 1995 the author travelled around the United States of America visiting various stormwater, waterway, and erosion & sediment control projects.
- At the Atlanta IECA Conference, the author met Mark Hunter of the 'Urban Drainage and Flood Control District' of Denver, Colarado, who offered to show him around the drainage works of Denver.
- This visit occurred while the Cherry Creek channel works were being completed.

The junction

Cherry Creek

- Cherry Creek passes through central Denver.
- The creek had previously been transformed into the classical concrete drainage channel.
- In 1995 a waterway rehabilitation project was transforming the single-use concrete drain into a multi-use waterway that provided flood conveyance, pedestrian and cycle paths, and boating capabilities.



Looking upstream at the junction

South Platte River

- Cherry Creek eventually feeds into the South Platte River.
- The reach of South Platte River that passes through Denver was rehabilitated to enhance opportunities for whitewater rafting and water-based recreation.
- Both Cherry Creek and the South Platte River are snow-melt fed streams, which provides regular annual flows suitable for water-based recreation.

Looking downstream at the junction

The author's point of view

- From the author's observations, all the structures were fish friendly.
- The waterways provide significant human movement corridors, while terrestrial movement generally occurs around the city, rather than through it.

Cherry Creek, Denver, Colorado, USA

Cherry Ck, Market St, Denver (1995)

Cherry Creek

- As previously mentioned, Cherry Creek passes through central Denver.
- It is difficult to view these channel works from a 'Queensland perspective' because we do not experience the annual conditions of heavy snow cover, and the effect of this snow cover on riparian vegetation.
- Note the curved weir crests, which focuses flows towards the centre of the channel.

Same location in 2010

Google image of reach (2010)

Construction of a weir (1995)

Channel rehabilitation

Channel rehabilitation

Channel rehabilitation

Denver, Colorado, USA (waterway structures outside the city)

Grouted rock drop structure, Denver (1995)

Fishway built into a concrete weir, Denver (1995)

Grouted boulder drop structure, Denver (1995)

Rolled soil-cement drop structure, Denver (1995)

18.3 – John Knight Memorial Park, Canberra, ACT

The source of the stream (1998)

Constructed watercourse

- Water is pumped from the adjacent lake and released as a 'spring' at the top of the hill.
- The water passes down a fully constructed rock-lined spring until is reaches the lower wetlands.
- The water is aerated as it descends the channel.

Constructed rock-lined watercourse

Constructed rock-lined watercourse

Constructed wetland

Stormwater treatment wetlands

- The water then passes through a series of wetlands within which the water benefits from nitrogen removal, and the settlement of fine particles.

Constructed wetland

Stepping stones through the wetland

John Knight Memorial Park, Canberra, ACT

Boardwalk through the wetland

Public access across the wetlands

- If appropriately designed, the various pedestrian crossings and stepping stones can be used to reduce the risk of 'deadwater' zones within the wetlands.

Stepping stones through the wetland

Footbridge

Lower recreation area

Stormwater treatment ponds

- After passing through the wetlands, the water enters a series of shallow ponds, which allows UV treatment of the water.
- The water finally exists the treatment systems by passing down a stepped drop structure (weir), that re-aerates the water before it returns to the lake.

Lower recreation area

Lower recreation area

John Knight Memorial Park, Canberra, ACT

Constructed, constant pump-fed watercourse (ACT)

Final discharge spillway into Lake Ginninderra (ACT)

18.4 – Singapore waterways

Alexandra Canal, Singapore

Introduction

- The author visited Singapore in 1982 before these waterways were constructed and/or rehabilitated.
- Singapore incorporates a variety of constructed drainage channels that vary in their function and their potential human interaction.
- One factor that greatly benefits these waterways is the very clean (litter free) condition of all the drainage catchments.

Alexandra Canal, Singapore

Bukit Batok Canal, Singapore

Bishan Park, Kallang River, Singapore

Bishan Park, Kallang River, Singapore

Singapore waterways

Bishan-Braddell, Kallang River, Singapore

Bishan-Braddell, Kallang River, Singapore

Potong Pasir, Kallang River, Singapore

Potong Pasir, Kallang River, Singapore

Sungei Api Api, Singapore

Sungei Api Api, Singapore

Sungei Api Api, Singapore

Sungei Tampines, Singapore

19. Torrens River, Adelaide

Introduction

Adelaide, South Australia

Introduction

- Parts of the following discussion about the Torrens River in Adelaide will likely receive a frosty reception from Adelaide residents.
- After all, what right do I have, as a Queenslander, to comment the actions and decisions of another State?
- I should also point out that many cities around the world would love to have a city river as beautiful as the Torrens River.

Torrens Lake, Adelaide (SA)

Adelaide city

- I make no secret of the fact that Adelaide is my favourite city in Australia.
- When I left Sydney in 1991, I was looking to live in either Adelaide or Brisbane—a job offer at Brisbane City Council arrived, so I moved to Queensland.
- I have visited Adelaide many times, and I have loved every visit.
- I also love the nearby towns of Hahndorf, Mannum, Strathalbyn, Port Lincoln, Murray Bridge, and no-so-near Burra.

Convention Centre, Adelaide (SA)

Urban Rivers Symposium, 24/11/2006

- In 2006 I was invited to speak at an Urban Rivers Symposium in Adelaide.
- Prior to the symposium I was interviewed by ABC Radio during which time I made the claim that *'Adelaide is not a city with a river problem, but a river with a city problem'*.
- The Torrens River suffers from the inflow of urban pollutants carried by the high dust concentration that regularly settles across Adelaide, which is brought into Adelaide by the northern winds.

River Torrens Linear Park Trail (SA)

Adelaide's linear park

- If I lived in Adelaide I would love Adelaide's linear park that runs along most of the Torrens River.
- It is a popular recreational and sporting area that allows people to run, walk and exercise along the banks of the river.
- However, as a society, we should be willing to openly discuss the merits of utilising a river and its riparian zones almost exclusively for human use?
- Is something missing from this river?

The Torrens River, Adelaide

Jogging

The Torrens River (River Torrens)

- The Torrens River is not an example of Natural Channel Design, but rather an example of river management and river rehabilitation.
- Collectively the waterway and its associated parkland should be considered a public success based on the public's usage of the park.
- However, in the author's opinion, there are both positive and negative lessons that can be gained from this river project.

Walking

Observing

The Linear Park

The Linear Park

- Adelaide is well known for being a 'planned' city, which usually means a city primarily planned for human usage.
- The city's parks, including the linear park, are largely designed as open space parks with few regions of dedicated bushland.
- The Torrens River downstream of the city has only isolated sections of fauna-friendly riparian vegetation.
- It is the need for flood control that often prevents the retention of healthy, fauna-friendly riparian cover.

Poor riparian cover (2006)

Poor riparian cover (2014)

The Torrens River, Adelaide

Riparian cover upstream of the city (2008)

Regions of health riparian cover

- The Torrens River does contain several regions of healthy riparian cover that provide:
  - wildlife shelter and habitat
  - wildlife movement corridors
  - erosion control
  - pollutant filtration
  - riverine aesthetics.
- 'Continuity' is essential for fish passage, terrestrial movement and flood control, but it is also desirable for human movement.

Replanting of riparian zone (2006)

Riparian cover downstream of the city

St. Peters Billabong (2008)

Lower Torrens River (2014)

Riparian zone

Upstream of (2014)

Downstream of the city (2014)

Downstream of the city (2014)

Downstream of the city (2014)

The Torrens River, Adelaide

Lower Torrens River, Adelaide (2014)

Minimal understorey

Upstream of city (2014)

Upstream of the city (2014)

Downstream of the city (2006)

Downstream of the city (2014)

Pedestrian crossings

Footbridge (2014)

Public access to the river

- People that are involved in the design of human movement corridors could learn a lot from a tour of Adelaide's linear park.
- The designers the linear park have used a variety of pathway designs in order to provide continuity along the waterway, while also addressing flood control issues.
- At some locations the pathway leaves the channel, and moves along adjacent roadways.

Elevated pathway (2014)

Pedestrian and cycle way (2014)

Stepping stones (2014)

Stepping stones

- The Torrens River utilises a number of different pedestrian crossings of the river.
- Stepping stones allow human movement and fish passage, but can limit terrestrial movement.
- Weirs, which are common in the lower reaches of the Torrens River, can be used for human movement and terrestrial movement (if appropriately designed), but are undesirable for fish passage, and consequently have fishways incorporated into their design.

Stepping stones (2014)

Stepping stones (2014)

Pathways and bikeways

Downstream of (2006)

Upstream of the city (2014)

Upstream of the city (2014)

Downstream of the city (2006)

Torrens River fishways

Outlet weir (2014)

Fish ladder (fishway)

- Fish passage along waterways is critical to the survival of native fish.
- All freshwater fish and some salt water species, regardless of their size, move within waterways at different times to access food and shelter, to avoid predators, and to seek out mates to breed and reproduce.
- Of the 83 species of freshwater fish in south-eastern Australia, approximately half migrate at least once as part of their life cycle.

Fishway (2014)

Fishway (2014)

Fishway integrated into the weirs

- Fish passage is the movement of fish and other aquatic organisms up and down a watercourse.
- Movement can be for a variety of reasons including:
  - migration
  - reproduction
  - access new habitats
  - feeding
  - avoid predators
  - shelter from floodwaters.

Fishway (2014)