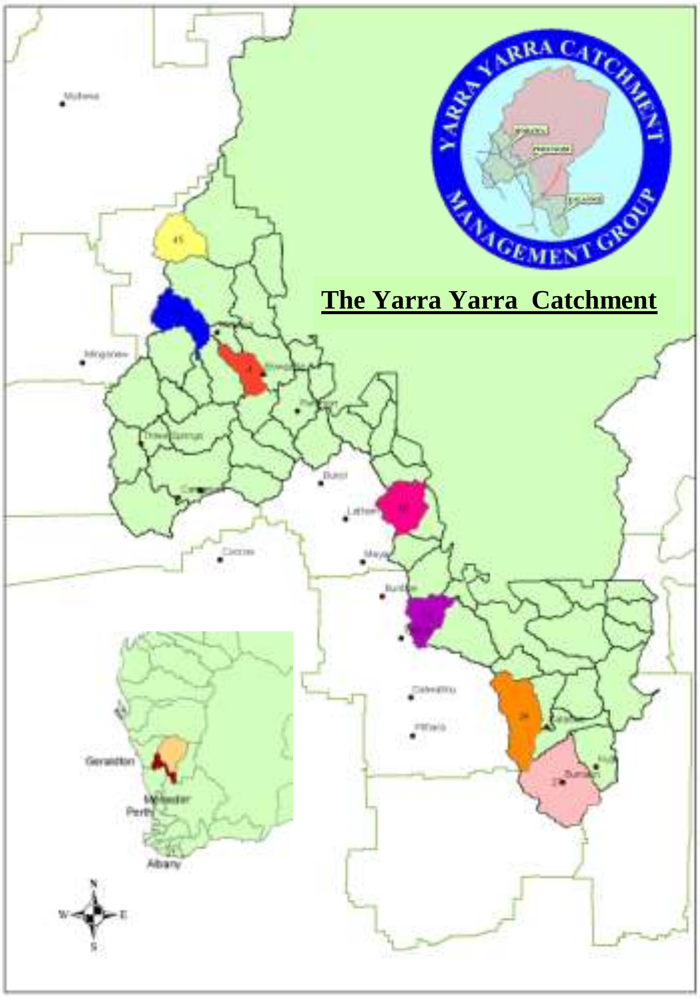
Final Report of the Yarra Yarra Regional Drainage and Research Project

Produced by the Yarra Yarra Catchment Management Group



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The Yarra Yarra Regional Drainage Program
Final Report Stage 1

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Part One

The Yarra Yarra Regional Drainage Program
Final Report Stage 1

Executive Summary

The Yarra Yarra Catchment Management Group was formed in February of 1997 to provide a unified approach to the management of Sustainable Natural Resources for those involved in agriculture within the Yarra Yarra Catchment Basin. Early consultations with farmers concluded that the main area of concern was the rapid rise in saline ground water levels in the valley floors, causing alarming loss of fertile land. To substantiate this observation, between 2003 and 2006 the Yarra Catchment Management Group (YYCMG) acquired funding assistance from Lotterywest to drill and case over 600 observation bores along valley floors throughout the million-hectare, agricultural sector of the catchment. Observations taken from the bores were used to assess the extent, depth and quality of the local groundwater. The findings indicated that, since land clearing began,, in 9% of the landscape hyper saline water tables had risen to within 2 metres of the surface or less, impeding the growth of crops and other vegetation.

Following this revelation, workshops were held in each of the 11 management zones within the Yarra Yarra catchment to determine what course of action the landholders wished to follow. It was unanimously agreed that deep drainage was the most effective method of lowering water tables in the valley floors. During these workshops, 82 farmers identified 522 km of waterway that required deep drainage to relieve groundwater build-up.

Consequently a three-stage drainage program was drafted to establish 600 km of deep drains over a ten-year period. It was recognised that government assistance would be required to establish a 300 km arterial drainage networks throughout the catchment. This network would allow landholders to deliver saline ground water out of their properties via a public facility. Farmers would then fund the remaining 300 km at their own cost. An application for funds to implement Stage 1 of the program was submitted to the National Action Plan for Salinity and Water Quality. The application was approved and in November 2006, $2,161,040 was allocated to the project. **The purpose of this booklet is to provide a final report for the completed Stage 1 of the 3-stage Yarra Yarra Regional Drainage program.**

Phase 1: To allow excavation to get underway without delay an interim payment of $700,000 was released while an in depth review was conducted by State and Federal Government NRM officials as to the final direction the project should take. This initial payment was to fund what was identified as Phase 1of the project. Phase 1 Drain construction started in December 2006 and was completed by July 2007. During this time 33.9 km of deep drains with associated surface water channels were excavated and 36.8 km of new fence was constructed. The Government review was a drawn out process and Phase 2 construction didn't start until December 2007. During this time the wages component of phase one had to be extended to allow continuity of the program. A further $100,000 was injected into the project by the State NRM Office, making the total allocation to Phase 1 $800,000. This figure includes operating costs and wages.

Phase 2: One of the recommendations from the review was that the newly formed Yarra Yarra Catchment Regional Council (YYCRC) would become the proponent of the project and the funds would be directed to them through the Northern Agricultural Catchments Council (NACC). Further to this it was agreed that these arterial drains would be a public facility, they would be fenced off and the land within the fenced off area would be controlled by YYCRC under an easement or similar arrangement and a service fee would be paid by the respective landholders.
Implementation of phase 2 started in mid December 2007 and was completed by July 2008. Phase 2 was delivered through two contracts; one for capital works and monitoring ($1,134,455) and the other for wages ($363,015).
Dramatic increases in steel and fuel prices put some constraints on the capital works budget. 50 km of deep drains with associated surface water channels were constructed and 67 km of fencing was erected with the available funds.

Phase 2 extension: In June 2008 NACC announced that they had approved a further injection of $706,356 to finish all obligations under the phase 2 contract with the proviso that provision had to be made to extend the Merkanooka drain 12 km to the North West. Of these funds $310,550 was allocated to capital works including fencing, $336,000 was allocated for 12 months wages and $59,806 for legal expenses and operating costs for twelve months.
After much deliberation excavation eventually started in December 2008. The drain construction was finished in July 2009. The fencing component of 26 km was completed by the end of September 2009.

$134,306 of the wages allocation remained unspent. These funds were carried forward to keep key staff members employed to continue monitoring the impact of the drainage networks on the landscape for a further 9 months.

Stage 1 overview

The total cost of the project including wages paid over the period was $2,837,494.
128 km of fencing was constructed at cost of $275,413.
The total distance of deep drains excavated was 97 km
with approximately 150 km of associated shallow surface drains at a cost of $1,622,488.
Operating costs were $143,868.

Scientific Summary

On the completion of Stage 1 of the Yarra Yarra Regional Drainage Program, resident scientist Dr Ian Fordyce who has worked on the project since its inception has summarised as below:

"The drain at Merkanooka in the north of the catchment has moved large volumes of water, but to date the water table has not been substantially lowered. This contrasts with the southern drains (Mongers55, Jibberding, Xantippe & Burakin), where there have been clear falls in groundwater levels following drain construction. There can be little doubt that the southern drains have been successful.

The differences in behavior between the southern & northern drains cannot be readily explained. Soils in the north generally tend to be redder, less sandy and deeper. Possibly their most important feature is the general absence of a silcete/ferricrete layer between topsoil & the underlying clay, although it remains unclear how this might be related to drainage of the soil.

It is exactly this wide variety between sub-catchments involved in the project – in soils, topography & geometry, as well as in drainage success – that makes them useful subjects for research. Ongoing monitoring & some detailed investigations, planned for the coming year, will help to predict drainage success in the future. Our results will be made available to other groups studying drainage, and we are confident that our experience in design, management, monitoring & governance will help establish standard protocols for WA."

Several wheatbelt-wide studies we have been involved with over the last few years have benefited greatly from our results & other contributions. They include studies on acid groundwater (its origin, distribution & management), aquatic invertebrates, saltland ecology and the flora & vegetation of saline wetlands. The governance model we developed to deal with the continuing need for management & maintenance of the drains is likely to be adopted in other parts of the wheatbelt.

At the start of the monitoring program, we expected that impacts on the wetland vegetation (probably associated with severe changes in hydroperiod and with chemical pollutants) would be gross and conspicuous, such as massive death, or clear shifts in community zonation.

On the contrary, and somewhat unexpectedly, we have observed no vegetation changes that can be ascribed unequivocally to groundwater discharge.
If discharge is indeed affecting the vegetation, then its influence is more subtle than anticipated, and will be revealed only by rigorous statistical analysis.

Fig 1: 15 Hectare Lake (Mongers 55)

This 15 hectare playa lake has been receiving ground water with a pH of around 3.5 from 10 km of deep drains for the last 4 years at an average rate of about 800 kl per day
There has been no visible damage to the site over this time. The evaporation rate has been keeping pace with the inflow

The Yarra Yarra catchment is divided into a number of subcatchments (Fig 2). The sub-catchments highlighted are the subject of this report, and show the locations of Stage 1 excavation sites.

Quarterly reports have been produced and sent to NACC, which lay out the dates that milestones and targets have been achieved. The Yarra Yarra Regional Drainage Program is strongly focused on research into all aspects of deep drainage in the Wheatbelt of WA, from drain design to environmental impacts. Scientific information relating to drainage issues is sadly lacking throughout Australia. Data gleaned from Yarra Yarra research will be invaluable for the establishment of future drainage projects throughout WA.

Introduction

As the Yarra Yarra Regional Drainage Program developed and gained momentum the members of the Yarra Yarra Catchment Management Group (YYCMG) became concerned that as a voluntary community group there was no guarantee of perpetuity or recognition as being credible and accountable to control Regional scale projects involving millions of dollars of Government funding. To counteract this problem, in consultation with relevant Shire Councils The Yarra Yarra Catchment Regional Council (YYCRC) was gazetted for the specific purpose of administering and overseeing the management of ground water and surface water within the area of the registerd deposited plan. The YYCRC is represented by the Shires of Dalwallinu, Perenjori, Morawa, Koorda, Wongan-Ballidu and Three Springs. The YYCMG continues to act in an advisory role to the YYCRC.
The area of interest involving the YYCRC and YYCMG is just in excess of 1,000,000 hectares and is registered as a deposited plan with “Landgate” and can be described as being that portion of the Yarra Yarra catchment basin 618 lying west of the 'clearing line' (Fig 3). A small part of the adjoining Ninghan catchment basin falls to the west of the “Clearing Line” is also included in the deposited plan.
For management purposes 56 first-order 'sub-catchments' have been identified within the management area and individual landcare projects are considered at this sub-catchment scale (Fig 2).

Over the past decade, YYCMG has focused on the management of landscape drainage, by rehabilitating drainage lines that have become dysfunctional since clearing began and by draining saline ground water that has become locked in valley floors along leveed deep drains to areas of safe disposal. The YYCRC has inherited this focus. This booklet deals specifically with the drainage issue. The Yarra Yarra Group have become aware that the establishment of arterial drains as a public facility will provide a conduit for individual farmers to connect into from the bottom to the top of the catchment. Without this facility, saline ground water that has built up over time cannot be removed from these areas. Investigations at regional level within the Yarra Yarra catchment have shown that a large proportion of salt affected land is high up in the valley floors. To date 97 km of deep leveed drains have been established under the Yarra Yarra Regional Drainage program and 99 km of farmers privately funded drains are connected into the network.

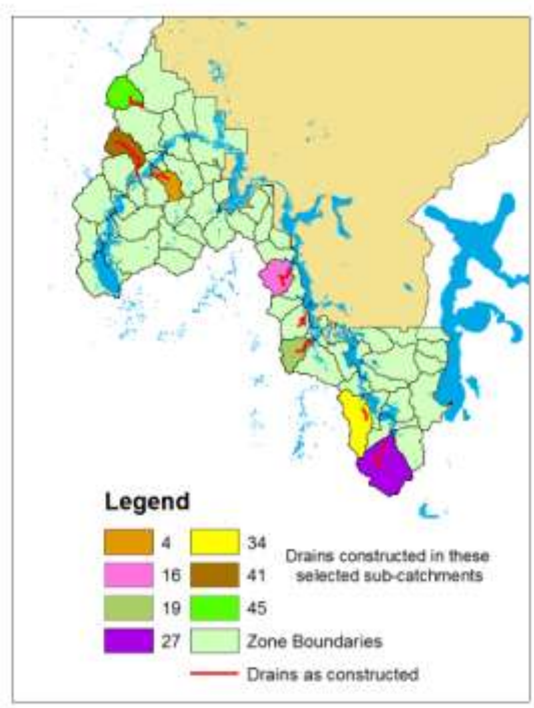

Fig 2: The Yarra Yarra Catchment, showing locations of Stage 1 Drains of the Yarra Yarra Regional Drainage Project.

Fig.3. Location map, showing the Yarra Yarra catchment, the clearing line and the jurisdiction of the Yarra Yarra Catchment Management Group and the Regional Council (Dark Green)

Project procedure

A useful approach is to consider that each drainage project takes place in three phases.

1) Pre-construction: Site selection, collecting baseline data and securing permits
2) Construction
3) Post-construction: monitoring, evaluation, and rehabilitation

1. Pre-construction

1.1 Baseline Data

Hydrological information (e.g. depth to water table, groundwater quality) is collected from bores and pits over the entire sub-catchment. Particular attention is paid to the proposed discharge area. Samples of any surface water and sediments form the outfall site are collected for chemical analysis. Natural vegetation is described along fixed transects (Fig.15). Finally, a network oh photo reference points (Figs. 9a & 9b) is set up throughout the sub-catchment, particularly at sites that are likely to be impacted by he drain.

1.2 Site selection, prioritisation and layout

Once the base line data has been collated sub-catchments that have been nominated by farmers for implementation are subjected to a stringent prioritisation process. The main criteria governing selection are:

- The extent of salinity in the sub-catchment determined by water levels in the observation bores.
- The number of properties the drain will be servicing.
- The availability of a safe disposal site.

The prioritisation process is described in more detail at http://www.yarrayarracatchment.org.u/ Go to "Projects" then "Internal Reports" then " Establishing Priorities for Deep Drainage"
Once a particular sub-catchment has been selected for engineering works a drainage layout plan is prepared. This design phase requires detailed topographic surveying to identify the natural fall in what appears at first glance to be a flat landscape. Our in-house surveyor prepares a precise contour model, using RTK (real-time kinematic) instruments (Fig. 11) This layout plan is designed so that guidelines of the Department of Agriculture & Food of Western Australia (DAFWA) are satisfied (e.g. for maximum gradient and slope length). Engineering plans are drawn up as required, e.g. for road/rail crossings (Fig.16). New bores are drilled (Fig.14) and soil pits dug (Fig.8) to test subsurface attributes along the proposed route.

1.3. Regulatory Issues

The design information is assembled to present to landholders for individual drainage agreements, then eventually to the Commissioner of Soil and Land Conservation with formal application for a Notice of Intent to Drain (NOID). Shire and state agency engineers need to approve plans for road/ rail crossings and disturbance to public infrastructure. Any proposed damage to native vegetation, even bluebush or samphire on abandoned cropland, needs to be exhaustively considered by the Department of Environment & Conservation before they issue a Clearing Permit. Even when the permit is finally granted, there are likely to be special conditions. To date, we have been instructed to carry out surveys for threatened flora and fauna, set up close-spaced fauna-crossings, erect additional fencing, and map potential acid sulphate soils. For each permit, we have also been required to lodge an offset revegetation plan.
Aboriginal heritage is the subject of statutory correspondence with the Department of Indigenous Affairs and with the relevant regional Land Council. In addition, informal permission is required from traditional owners or other custodial groups.

1.4. Pre-construction Summary

The entire pre-construction process is unlikely to be completed in less than 12 months. Realistically, we allow at least two years for this phase,
Once all these requirements are in place then funding applications are submitted for approval.

Finally when funding has been approved then contracts are written up and tenders for the construction of the drainage complex are called for.

2. Construction

Immediately before construction the line is pegged with the successful tenderer and required spot heights indicated at intervals along the line. A laser level must be incorporated in the machine to maintain the fall required in the specification.

All deep drains and shallow surface water drains are dug with an excavator of not less than 35 tonne capacity. Deep drains are dug to a mean depth of 2.5 metres with a base of 1.25 metres and a batter angle of 0.5 horizontal to 1 vertical. .

Flanking levee banks are constructed to exclude all surface water from the deep drains providing ease of management for delivery and disposal of ground water. The construction of associated culverts under roads rail and farm boundaries is included in the contract.

During the course of construction periodic inspections and measurements are carried out to see that the contractor adheres to the specifications laid down in the contract

Farmers will be encouraged to connect their own private drains into the system by means of a 300 mm delivery pipe under the levee banks constructed.

For more detail see figures and descriptions at pages 15,16,32,33.40 and 42.

3. Post-construction

The post-construction phase includes “as constructed” (ascon) surveys to accurately measure engineering works, monitoring (hydrological, geochemical, and biological), evaluation to track project achievements, and rehabilitation. This phase is strongly focused on research.

3.1. As Constructed (Ascon) Surveys

Typically, these surveys are completed immediately after construction and are used to verify invoices before the final payment. At regular intervals along the constructed drain, measurements are taken. These include GPS location, depth and width of the groundwater drain, water depth, berm width, height of the levee bank, and depth and width of the surface-water drain (Fig. 48).

3.2. Monitoring

3.2.1. Hydrological

Flumes measuring water depth across a narrow V-notch weir are set up in each of the drainwater streams (Fig. 22a & 22b). Results are recorded at regular intervals on data loggers (Fig. 23a & 23b). Since the dimensions of the weir are known precisely, flow-rates (in litres per second) across the V-notch can be calculated. In turn, this allows us to make reasonable estimates of discharge volumes (e.g. megalitres over an entire year).

Groundwater depth is measured repeatedly in bores near each drain to test the drain's effectiveness in lowering the watertable. Some of these test bores are laid out in groups of 4-8 on transects placed at right angles to the drain. The transects are spaced at 2-4 km intervals along the drain-length.

Additional bores (typically 5-10) are also scattered throughout the subcatchment. Most of these are located on the valley floor, close to the drain; some are located further from the drain and are intended as 'controls'.

All the transect bores are dipped at weekly intervals during and immediately after drain-construction. This interval is extended to fortnightly after a few months (depending on the hydrograph pattern), then finally to monthly about six months after drain-construction.

In each subcatchment, groundwater-monitoring begins at least five months before drain construction. We intend to continue monitoring for several years.

Surface flows are being recorded at sites in Mongers 55, Merkanooka, Burakin, Darling Creek, Canna Gutha and Jibberding. At Mongers 55, Merkanooka and Burakin, all of the runoff (and some of the groundwater too, now that a deep drain has been dug) leaves the subcatchment through a single, narrow channel. Flow rates are measured using doppler recorders (Fig. 3) and export volumes are calculated from these results. All sites are instrumented for automatic logging.

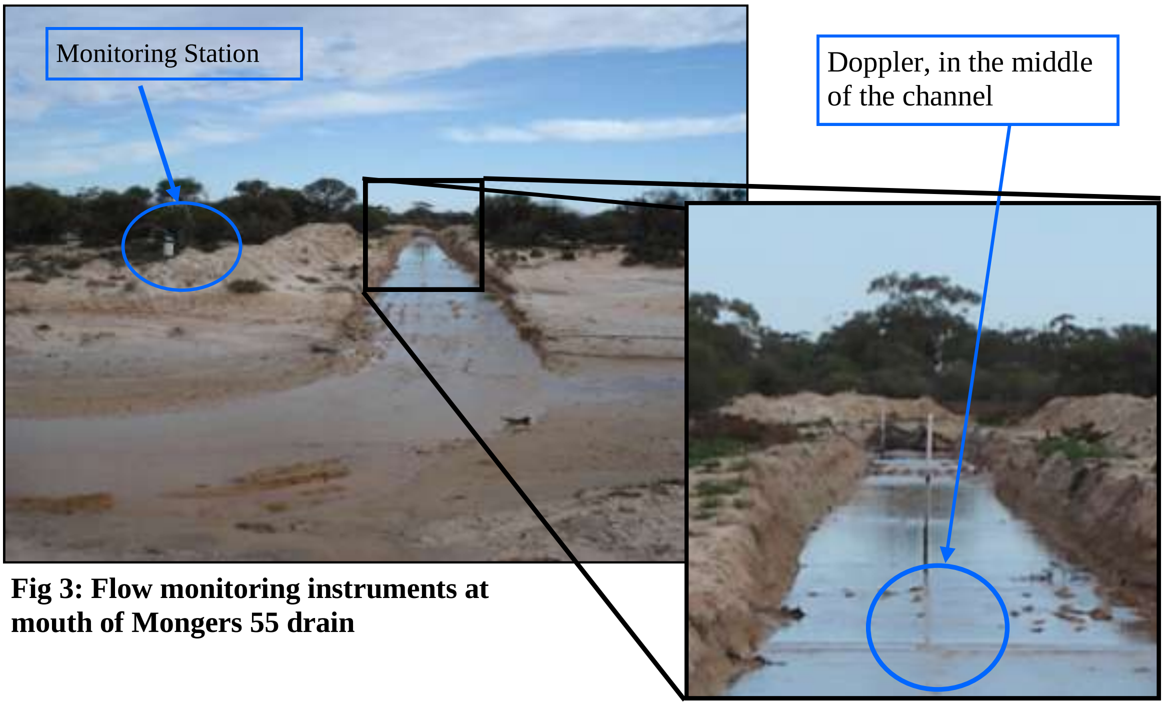

Fig 3: Flow monitoring instruments at mouth of Mongers 55 drain

3..2.2. Geochemical

Samples of water and sediment are collected at annual intervals from the outfall site in each subcatchment and analysed for major ions, a suite of 40 metals, and radionuclides. Where the groundwater is acidic and contains high iron and/or aluminium levels, additional drainwater samples are collected every few months. Currently, all analyses are carried out at CSIRO (Land & Water) laboratories in Adelaide. In future though, some of these samples will go to commercial laboratories in Perth. Whether acidic or neutral, water from each of the drains is periodically tested in the field for pH, Eh and EC, using appropriately calibrated portable electrodes (Fig.25).

Samples of drain-sediments and drain-precipitates are collected opportunistically for mineralogical analysis by x-ray diffraction. There have been two recent post-graduate studies of precipitates in Yarra Yarra drains, one study of valley-floor sediments exposed in drains, and an on-going study about the alteration of kaolin clays exposed to saline groundwater – all by the University of Western Australia. A CSIRO/Department of Water research team is currently investigating the acid-groundwater phenomenon, using sites in the Yarra Yarra catchment as models.

3.2.3. Biological

Vegetation transects (Figs 26 & 45), initially set up in the discharge area before drain construction as part of the baseline study, are monitored at approximately 12-month intervals. The survey uses belt transects of contiguous 10 m Í 10 m quadrats, laid out in a straight line at right angles to the lakeshore or creekline. In each quadrat, all plants are identified to species or subspecies level and the vegetation structure is described (e.g. height, layering, percentage cover)
There are a minimum of two transects for each discharge site (considerably more for extensive

wetland systems like Jibberding and Xantippe). Additional transects (at least two per subcatchment) are laid out as controls or reference transects on nearby wetland sites that receive no groundwater discharge.

3.2.4. Aquatic Monitoring

Invertebrates within lake systems can be used as 'bio indicators' of wetland health and to assess:
(i) the level of pollution and effects on biodiversity produced by discharging groundwater, and
(ii) the ability of the salt lake chain to maintain 'ecosystem services'.

A survey was commissioned and carried out by Wetland Research & Management Group (WRM), University of WA, for the Yarra Yarra Catchment Management Group in December 2008 to examine the macro-invertebrate fauna 'downstream' from some of the drains. There has been very little work of this kind in the northern wheatbelt, and only sporadic research activity in inland WA as a whole. Although the survey uses a Control-Impact design, so that it can be regarded as a stand-alone study, we hope that it will be repeated on at least one future occasion to examine the effect of sustained drainage on wetland biota

Fig 5: Brine shrimp, one type of macroinvertebrate found throughout the Yarra Yarra lake system.

Fig 6: Examining the species collected

The survey has concluded that **:**
The Yarra Yarra catchment continues to support a moderately rich aquatic invertebrate fauna, despite secondary salinisation and acidification. A total of 62 micro- and macroinvertebrates were recorded from the 24 Yarra Yarra sites with maximum counts (i.e. 20 - 27 taxa) in brackish circumneutral to alkaline waters, and minimum counts (i.e. 0 - 5 taxa) in acidic (pH <6) and/or strongly hypersaline (>200 mS/cm) waters.

In comparison, similar surveys by WRM in the Buntine Marchagee Recovery Catchment in the northern wheatbelt, recorded a total of 135 taxa of micro- and macroinvertebrate from 21 sites, but with maximum counts (20 - 43) at the fresher (<10 mS/cm) vegetated wetlands and counts of typically less than 15 taxa at hypersaline (>50 mS/cm) wetlands (ARL 2006). More recent surveys of the macroinvertebrate fauna of 5 acidic hypersaline wetlands at Narembeen in the Central Wheatbelt recorded a total of only 14 taxa (WRM 2008). Macroinvertabrate taxa richness at Yarra Yarra sites was similar to Narembeen and Buntine-Marchagee wetlands of comparable salinity and acidity.

Dr. Ian Fordyce, environmental scientist for the Yarra Yarra Group, assisted in this survey and made the following comment:
"To the best of our knowledge, there is no glaring threat to aquatic invertebrate communities from

the drains, but also no definitive answer.
If the drains were having a severely detrimental effect, it would have been picked up in this survey. The fact that it didn't is good for the project and overall this report does not have a negative outlook for drainage."

4.3 Rehabilitation

The primary aim of the drainage project is to rehabilitate the landscape. To this end, the revegetation of drain corridors is as important as the drains themselves. A condition of the formal agreement between YYCMG and local landowners before any earthworks can begin, is that the land owner must insure that all sections of the drain are fenced on completion of the drains. All these fences have been erected. The project has provided materials for the landowners to erect new fences where there were none previously existing. The total combined length is 194 km., with the result that a recognisable corridor has taken shape. The Yarra Yarra group have a long term plan to revegetate the fenced off corridors with a mixture of native tree and shrub species.

To date, almost half a million seedlings have been planted along these valley-floor "corridors". Most of these seedlings are broombush (*Melaleuca hamata* and *Melaleuca atroviridis*) have been used in the initial plantings as they are more salt tolerant than most native species and can be used as a "barometer" to gauge how quickly the salt land will recover after the introduction of the deep drains.

We are aiming to revitalise the landscape within the recently drained and rehabilitated valley floors with this revegetation program. The corridors will enhance local biodiversity by providing habitat and linkages between existing remnants. An additional aim is to engage the community in landcare issues and raise awareness of the importance of biodiversity in the landscape. In total, over 150 hectares have been planted at nine locations, creating more than 35 km of interrupted corridors at these selected sites. As the rehabilitation process of the saline areas takes effect further plantations will be established to complete the environmental linkages. At each location, community members have been involved with ground preparation, planting, maintenance, and monitoring (Fig 7.)

Fig 7: Community volunteers getting involved with a revegetation project.

Pre-Construction

The following photographs show a number of examples of the work undertaken throughout the Yarra Yarra catchment during the pre-construction phase of the project.

Fig 8: Carrying out soil sampling in a backhoe pit, Canna Gutha

Soil pits are established at regular intervals (around 1.5 km) along a potential drainage line to establish the structure of the soil profile, the rate of inflow of ground water and the quality of this water. These pits are usually around 3 metres deep. The YYCMG employ a full time soil scientist to undertake these assessments as well as to oversee the monitoring program.

Fig 9a: Photoreference point, Mongers 16 looking upstream

Fig 9b: Photoreference point, Mongers 16 looking downstream

Figs 9a and 9b depict a single photoreference point. Fig 9a is looking "upstream" and Fig 9b is taken from the same area looking out across the lake. The Mongers 16 drain water will eventually discharge here. The stake will allow us to take photos from exactly the same spot every 12 months. We can then monitor any effects that the drain has on the discharge area.

Pre-Construction Continued

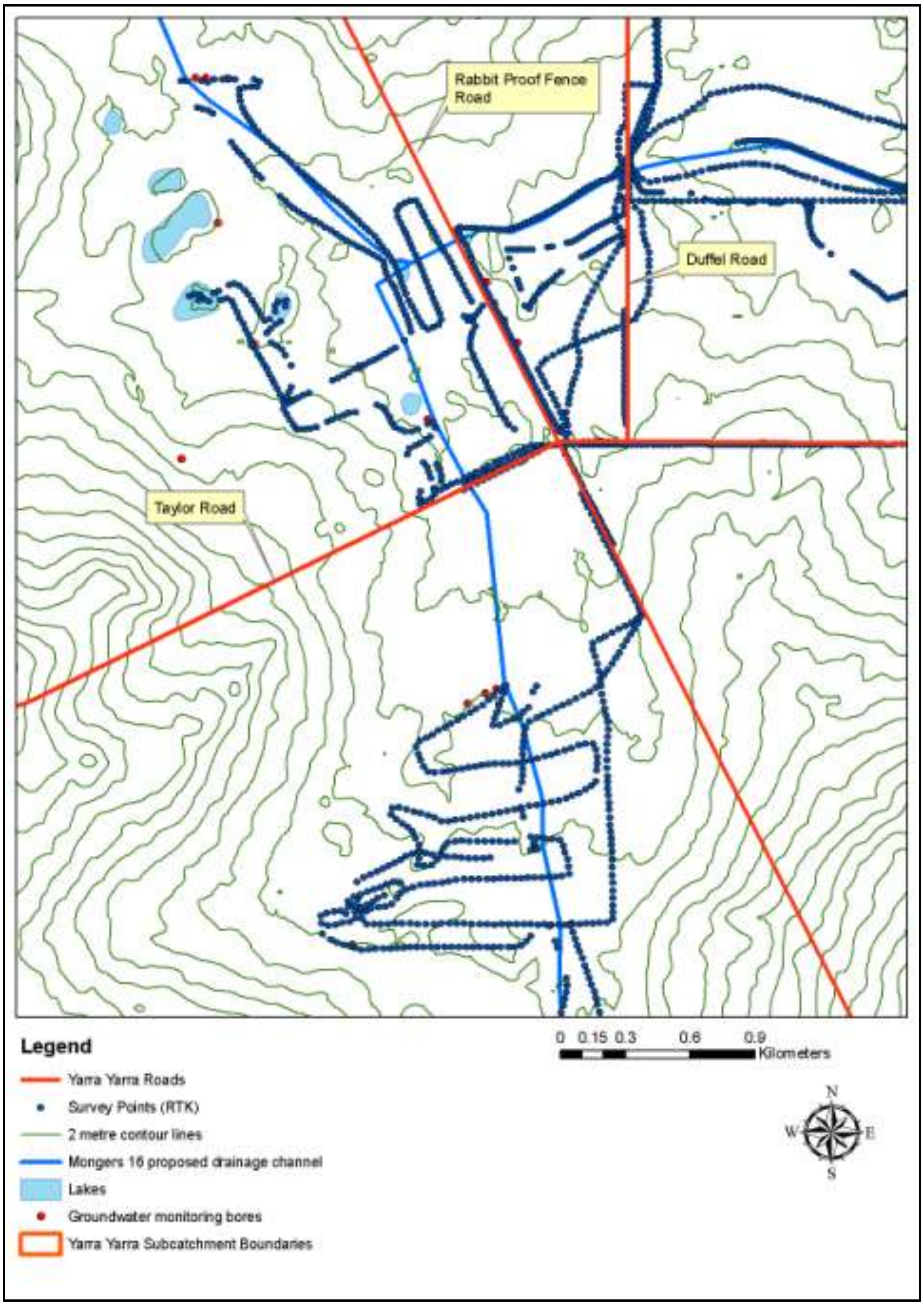

Fig 10: Surveying undertaken in Mongers 16 subcatchment

The map above shows 2m contours laid out over a potential drain site in the Mongers 16 sub-catchment. This gives us a general idea of the relief in the lowest area of the catchment. The contour data is supplied by Government Agencies.

The wider the contour spacings, the flatter the area and therefore more precise surveying needs to be undertaken to ascertain the exact path the drain should take to maintain the correct gradient.

The YYCMG have a qualified surveyor as a permanent staff member who is trained in the use of Real Time Kinematic (RTK) surveying equipment. The YYCMG have purchased one of these instruments (at a cost of $47,000) to enable us to survey with extreme accuracy (within 2cm in height AHD). Data taken at 25m intervals can be downloaded onto a map, as shown above.

Quad bike with mounted RTK equipment. The equipment includes a remote base station which is not shown here.

Fig 11: The RTK surveying set-up, Burakin

These two aerial photos to the left and below, are overlaid with the RTK survey points. This accurate survey allows us to check the gradient of the proposed drainage line. From this we can determine what engineering options are possible. The picture below shows a close up of the survey with the actual heights shown (Australian Height Datum).

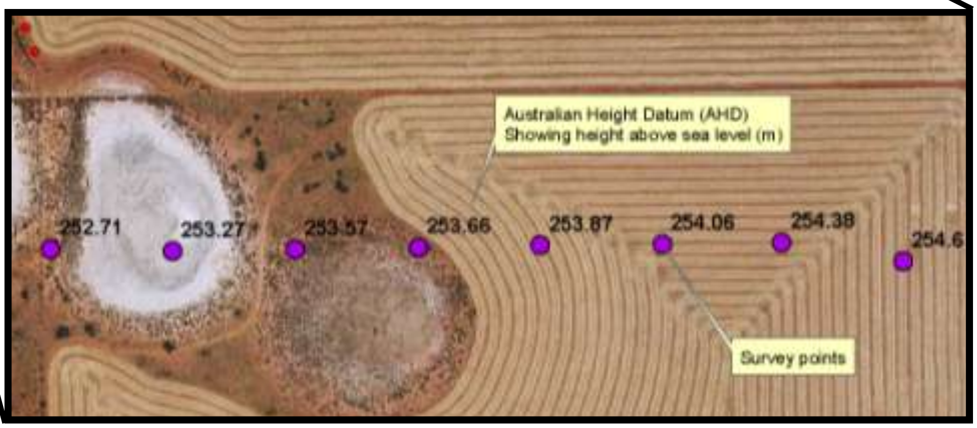

Fig 12: RTK survey points, Bowgada

Pre-Construction Continued

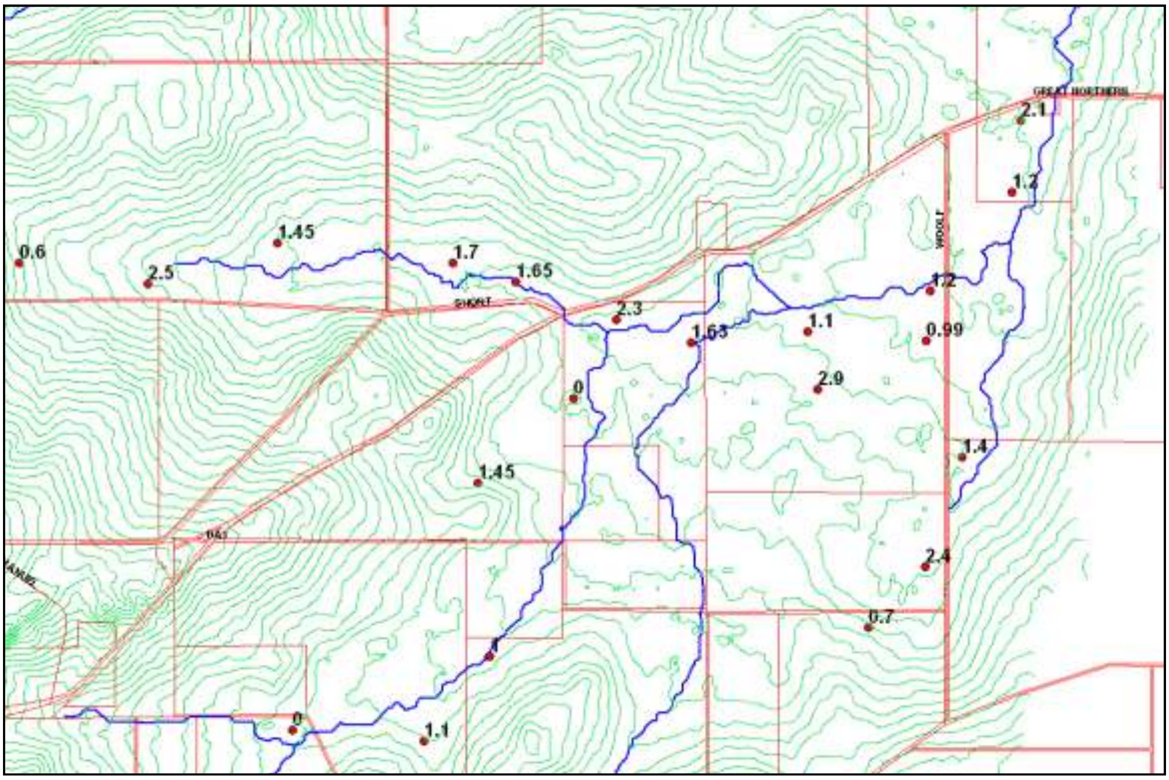

Fig 13: Map showing the location of boreholes and the depth of groundwater (metres), through a section of the Jibberding subcatchment. The blue line in the map above indicates the lowest point in the valley floor.

Groundwater level is one of the main indicators used to ascertain the suitability of a drainage site. Boreholes are used to determine the level of the groundwater throughout the catchments. These bores are located roughly at intervals of 1.5 kilometres along the valley floor. The bores are drilled to an average depth of 4 metres, and are cased with poly-pipe see below (Fig 14).

The Yarra Yarra drill rig has been used extensively throughout the catchment management area. To date, over 1000 boreholes have been established, for the purpose of measuring and monitoring ground water levels.

Fig 14: The drill rig in action

Fig 15: Vegetation transect, Bowgada

The transect shown above is one of the vegetation control sites in the Bowgada sub-catchment. These control sites are essential to obtain a comparison between the vegetation sites adjacent to the drain, compared with similar sites remote from the drain.

Construction of the deep drains and on-ground works

The following photographs show a number of examples of the work undertaken throughout the Yarra Yarra catchment during the construction phase of the project. While there are many variations, there are several basic drain design is outlined on the following pages.

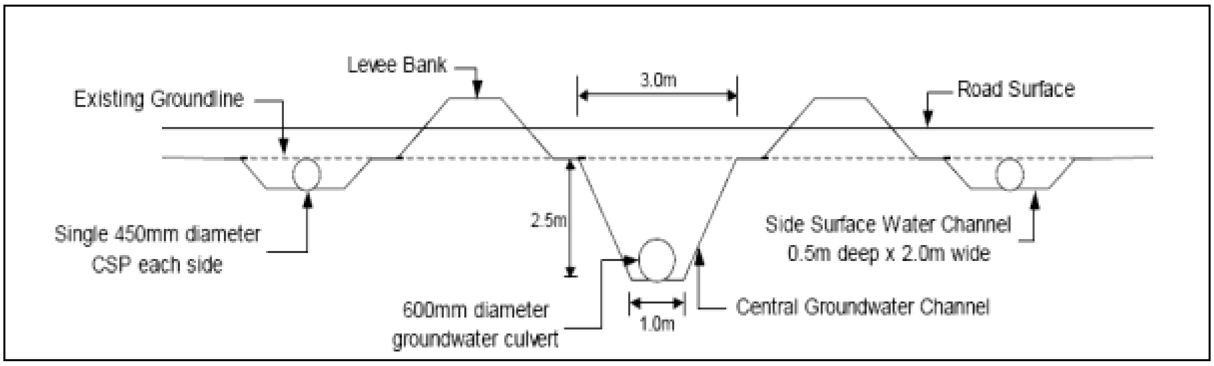

Fig 16 Cross section of a typical road crossing with surface channels either side of the deep drain

The basic design of the drain incorporates a central deep drain, which carries groundwater. The deep drain is completely surrounded by a levee bank 1.5 metres high to exclude surface water. This is to prevent the carrying capacity of the drain from being exceeded, and also to minimise silt-accumulating in the drain. The levee banks are set back 1.5 metres from the edge of the drain to also discourage silting. Shallow surface water channels either side convey surface water out of the catchment and also help to protect the levee bank.

The deep drains are dug to a mean depth of 2.5 metres with a batter slope of 0.5:1 (horizontal:vertical). The first drains excavated were 2.1 metres deep but experience has shown us that 2.5 metres is more effective. However this does increase the cost by $1500 per km, which has increased the pressure on our budget.

Fig 17: Taken at Canna Gutha. Surface water channels either side of the levee banks flanking the central deep groundwater drain.

The surface drains are 3 to 4 metres wide and 300mm to 400mm deep. We have found that it is prudent to establish the drain complex slightly higher than the lowest point in the valley floor, this gives the drain protection from extreme flood events.

Notice the levee bank on the left hand side. Top soil excavated from the surface channel is deposited on the levee bank for two reasons.
1. To make a more robust construction to protect the deep drain.
2. To provide a better environment for establishing ground cover on the bank for stabilisation.

Fig 18: Construction of the surface drain, taken at Canna Gutha

Fig 19: Putting the design to the test. Mongers 55 deep drain, standing up to a major flood event in February 2008. Notice that the surface water remains separated from the groundwater inside the drain.

Post Construction: Monitoring and Research

The following pages show a number of examples of the work undertaken throughout the Yarra Yarra catchment during the post-construction phase of the project.

Hydrological Monitoring

The monitoring stations (Fig 23a and 23b) enable the collection of data at a given point in the drain. The positioning is downstream of any spurs, and is close to the discharge point. This enables monitoring of all of the water produced by the deep drain.
a
The height of the water flowing over the weir is the critical part of measuring the volume of water the drain produces. Odyssey recorders have also been used to measure the depth of water and to allow us to double check the accuracy of the measurements taken. All data is then manually verified by alternative methods to validate data collected. This is done by using handheld water sensors to test pH, Eh and EC levels (see Fig 25) and water is collected in buckets and timed using a stopwatch to confirm the flume readings over the weir. Below are two examples of data collected over a number of months from the Merkanooka and Canna Gutha monitoring stations. Measurements are

Merkanooka Flume Data

Date	Height (mm)	Litres/s	Litres/Day	Megalitres*/month
May-07	13	0.37	31,968	0.96
Jun-07	24.7	0.98	84,672	2.54
Jul-07	27	1.21	104,544	3.14
Aug-07	33	1.63	140,832	4.22
Sep-07	31	1.45	125,280	3.76
Oct-07	26	1.08	93,312	2.80
Nov-07	22	0.80	69,120	2.07
Dec-07	18.5	0.67	57,888	1.74
Jan-08	16.1	0.52	44,928	1.35
Feb-08	42	2.46	212,544	6.38
Mar-08	33	2.43	209,952	6.30
Apr-08	29	1.25	108,000	3.24
May-08	23	0.80	69,120	2.07
Equipment failure				0.00
Apr-09	18	0.63	54,432	1.63
May-09	11	0.35	30,240	0.91
Jun-09	13	0.37	31,968	0.96
Jul-09	94	10.00	864,000	25.92
Aug-09	87	8.50	734,400	22.03
Sep-09	83	8.00	691,200	20.74
TOTAL				**112.75**

Please Note, Flow Rates:
* One megalitre = one million litres
One thousand litres = one kilolitre = 1 cubic metre

<u>Canna Gutha Flume Data</u>

Date	Height (mm)	Litres/s	Litres/day	Megalitres*/month
Jun-07	24	0.98	84,672	2.54
Jul-07	47	2.66	229,824	6.89
Aug-07	41	2.41	208,224	6.25
Sep-07	44	2.49	215,136	6.45
Oct-07	38	2.00	172,800	5.18
Nov-07	41	2.41	208,224	6.25
Dec-07	36	1.82	157,248	4.72
Jan-08	38	2.00	172,800	5.18
Feb-08	98	10.90	941,760	28.25
Mar-08	58	4.25	367,200	11.02
Apr-08	46	2.60	224,640	6.74
May-08	51	3.40	293,760	8.81
Jun-08	56	4.00	345,600	10.37
Jul-08	47	2.66	229,824	6.89
Aug-08	62	4.70	406,080	12.18
Sep-08	49	2.70	233,280	7.00
Oct-08	41	2.30	198,720	5.96
Nov-08	38	2.00	172,800	5.18
Dec-08	27	1.10	95,040	2.85
Jan-09	32	1.50	129,600	3.89
Feb-09	22	0.80	69,120	2.07
Mar-09	12	0.25	21,600	0.65
Apr-09	39	2.05	177,120	5.31
May-09	41	2.30	198,720	5.96
Jun-09	68	5.60	483,840	14.52
Jul-09	121	16.00	1,382,400	41.47
Aug-09	112	14.00	1,209,600	36.29
Sep-09	106	12.50	1,080,000	32.40
Oct-09	85	8.40	725,760	21.77
Nov-09	117	15.00	1,296,000	38.88
Dec-09	55	3.80	328,320	9.85
Jan-10	42	2.46	212,544	6.38
Feb-10	24	0.90	77,760	2.33
TOTAL				**89.48**

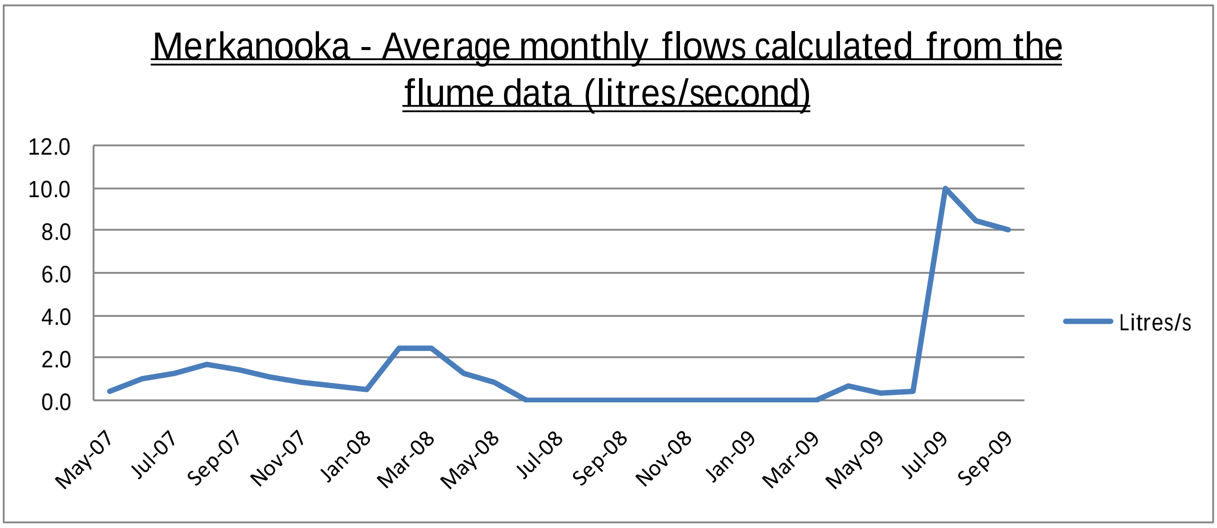

Fig 20: Merkanooka flume, average flows

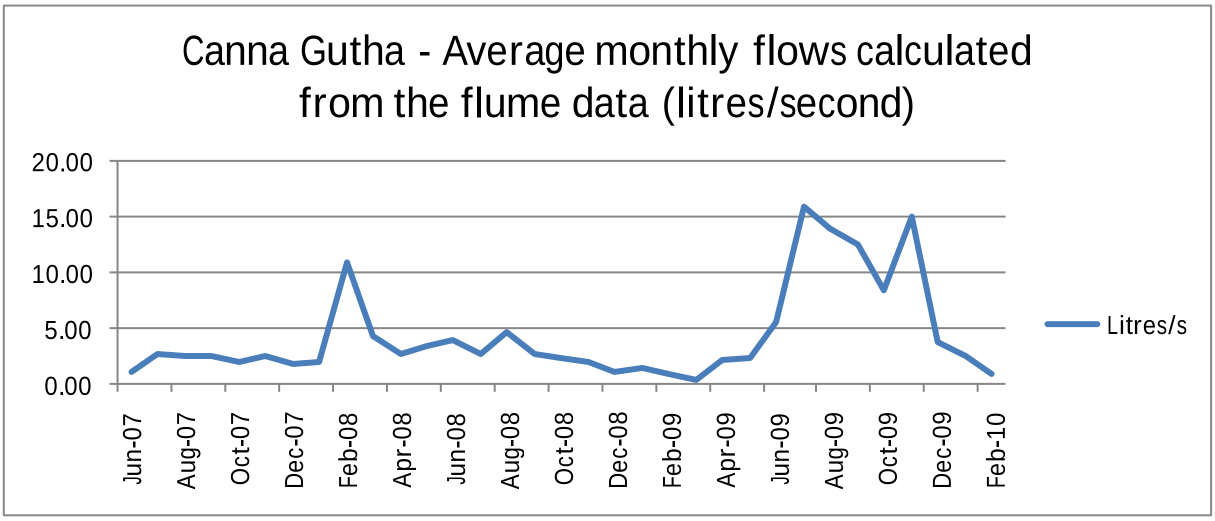

Fig 21: Canna Gutha flume, average flows

Post Construction: Monitoring and research continued

Fig 22a Constructing the flume at Merkanooka

Fig 22b The finished flume

A cut-off plate prevents any water bypassing the flume and therefore directs all of the water to pass through the weir for measurement purposes. You can see the plate clearly on Fig 22b

Fig 23a: Jibberding flume and monitoring station

Fig 23b: A close up of the Jibberding monitoring station

Fig 24: Downloading the data

Using an automated logger various measurements can be taken, including the following;
<u>EC</u> Electrical Conductivity – to measure the salinity level of the drainage water
<u>pH</u> To measure the acidity of the drainage water
<u>Height of the water (mm)</u> - taken at regular intervals (e.g. every 6 hours), which allows flow to be calculated
All of these are logged directly into a monitor (the blue box, in Fig 23b) and stored for download at a later date (Fig 24). The monitor can store up to 3 years of data. All stations are powered by solar panels and can therefore be setup in remote sites to record data without the need for constant, costly field trips.

Whilst the flume and monitoring station are very useful, they are in a fixed location. This equipment shown in this photo enables us to check the pH, Eh and the EC of the drainwater at any location in the drainage network.

Fig 25: Portable probes, pH, Eh and EC

Vegetation monitoring is undertaken in all of the subcatchments where drains have been excavated. All of the vegetation transects are monitored annually.

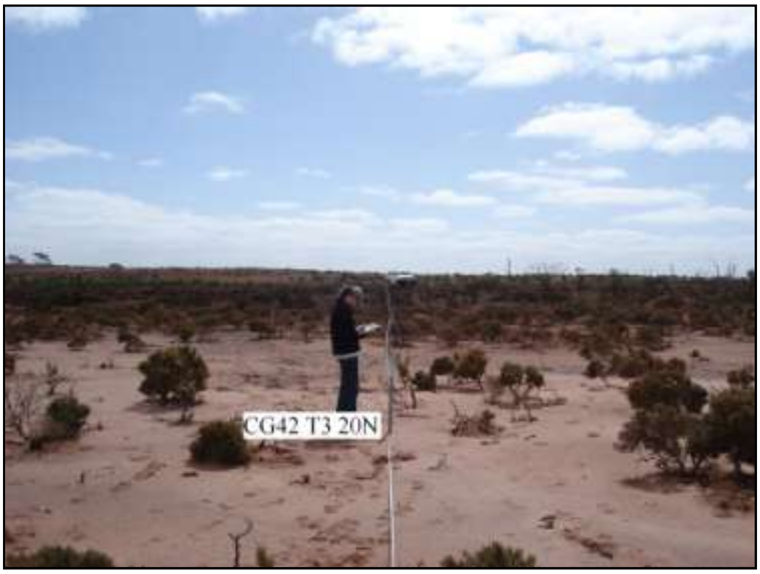

Fig 26: Vegetation monitoring in the Canna Gutha subcatchment CG42.

Post Construction: On Ground Works

The farmers are provided with the fencing materials and it is their responsibility to erect the fence. However Yarra Yarra staff sometimes helped by installing the strainer assemblies.
The drill rig has been modified with a post hole auger for digging the holes.

It is essential for the areas to be fenced if the vegetation planted is to survive. Livestock must be excluded while the seedlings establish themselves.

Fig 27: Fencing off the easements

Post Construction: On Ground Works Continued

Fig 28: Planting broombush seedlings in Merkanooka, 2007

Brushwood

With the assistance of the "Brushwood Industry Development on Saline Land Project", supported by NACC, we were able to plant subsidised Broombush seedlings (4c/seedling) alongside sections of the drains in Merkanooka, Bowgada, Jibberding, and Burakin sub-catchments in 2007 and 2008. Despite difficult conditions in 2007 due to drought, we were impressed with the hardiness of the seedlings. A further project run by the Moore Catchment Council and funded through CFOC allowed us to plant a further 210,000 broombush seedlings in 2009 in the Burakin, Xantippe, Jibberding, Mongers 16 and the Canna Gutha sub-catchments.

Fig 29: **Broombush seedlings, August 2007**

Fig 30: Broombush seedlings, May 2008

The two photographs above show the amount of growth over 10 months. When the seedlings were planted they were roughly 10cm tall, after 10 months they were about 50cm tall on average

Fig 31: Brushwood fencing

Broombush can be harvested and used for making brushwood fences that are ornamental as well as providing shelter for nurseries and gardens. Currently the industry is quite buoyant and we hope that in 3 – 5 years time we may be able to start a rotational harvest of the Broombush, allowing us to generate income for further revegetation projects. As Broombush coppices, harvesting it will cause it to regrow more thickly than before, and creating a sustainable industry.
Less-favourable sites, e.g. abandoned farmland, samphire flats, and/or areas which retain saline or sodic soils, will be progressively planted as more salty soils become adequately leached. As foreshadowed in YYCMG's offset plans (submitted to the Department of Environment & Conservation for each clearing permit), these sections of the corridor will be devoted to biodiversity plantings. Annual photos are taken from fixed photo-reference points in order to document the progress of rehabilitation efforts.

Fig 32: A 6 year old Broombush plantation near Goomalling showing coppicing following harvest trials.

Fig 33: The tree planter loaded with Broombush seedlings, 2009 (Mongers 16)

Part Two

Subcatchment Maps and Expenditure

The following pages give an overview of the on ground works carried out in each subcatchment, and the location of these works. They also provide a breakdown of the expenditure in each area.

Subcatchment	Page No.
Bowgada	27
Merkanooka	29
Canna Gutha	31
Jibberding	33
Xantippe	39
Mongers 16	41
Burakin	43
Merkanooka Extension	47

Bowgada 4

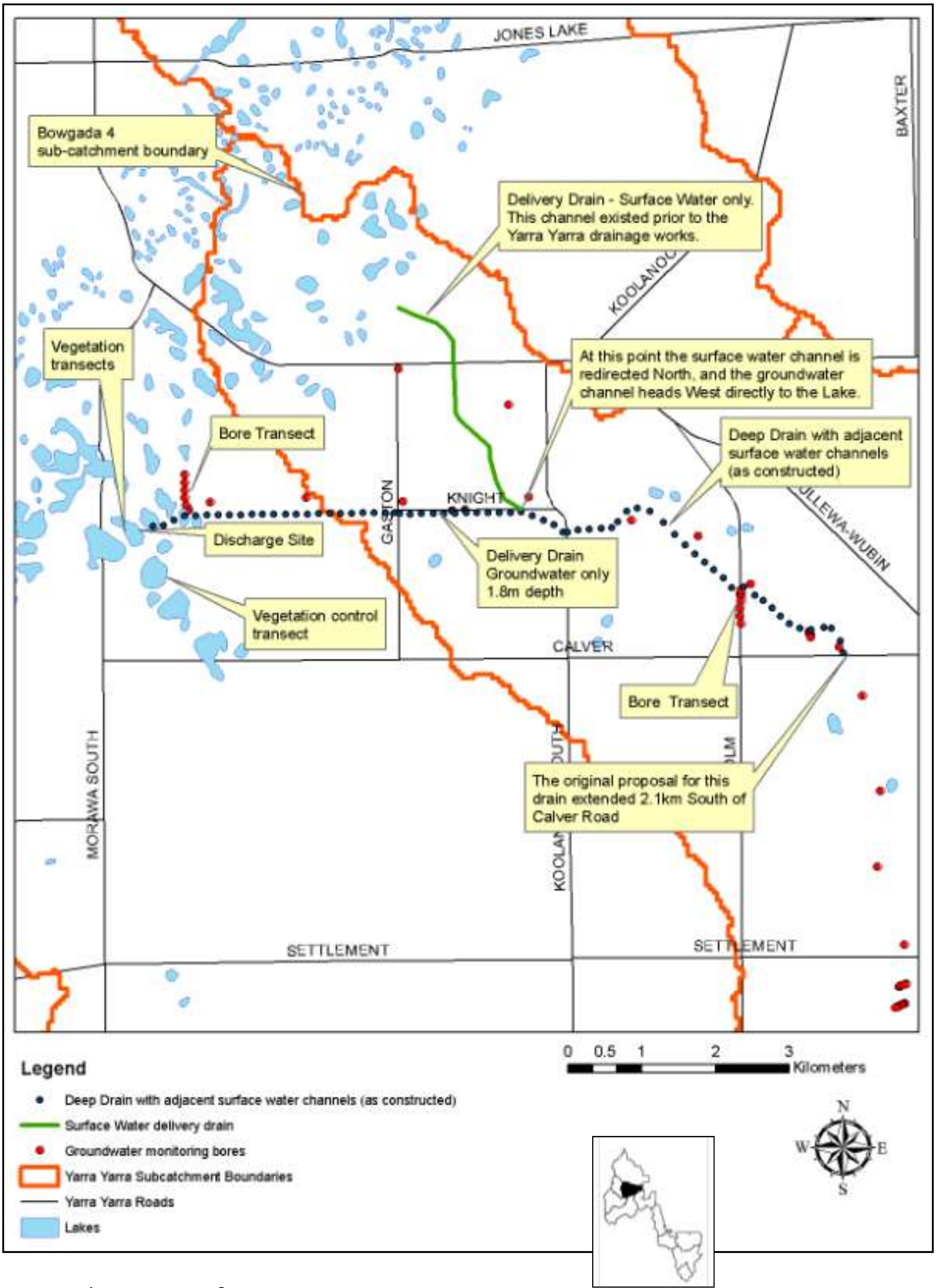

Fig 34: Bowgada 4

Expenditure, Bowgada

Bowgada - Drain completed January 2007

Capital Works	Length (km)	Budgeted Cost	Actual Cost	Under(-)/Over(+) Budget
Drain Excavation	10.4 km	$128,853.00	**$115,320.00**	- $13,533
Fencing materials	10.5 km	**$22,500.00**	**$17,136.00**	- $5,364

Notes:
The Bowgada Drain was under budget because the farmer at the top end decided at the last minute not to participate in the program. Funds were then transferred to the Merkanooka drain which required some modification to the original budget.

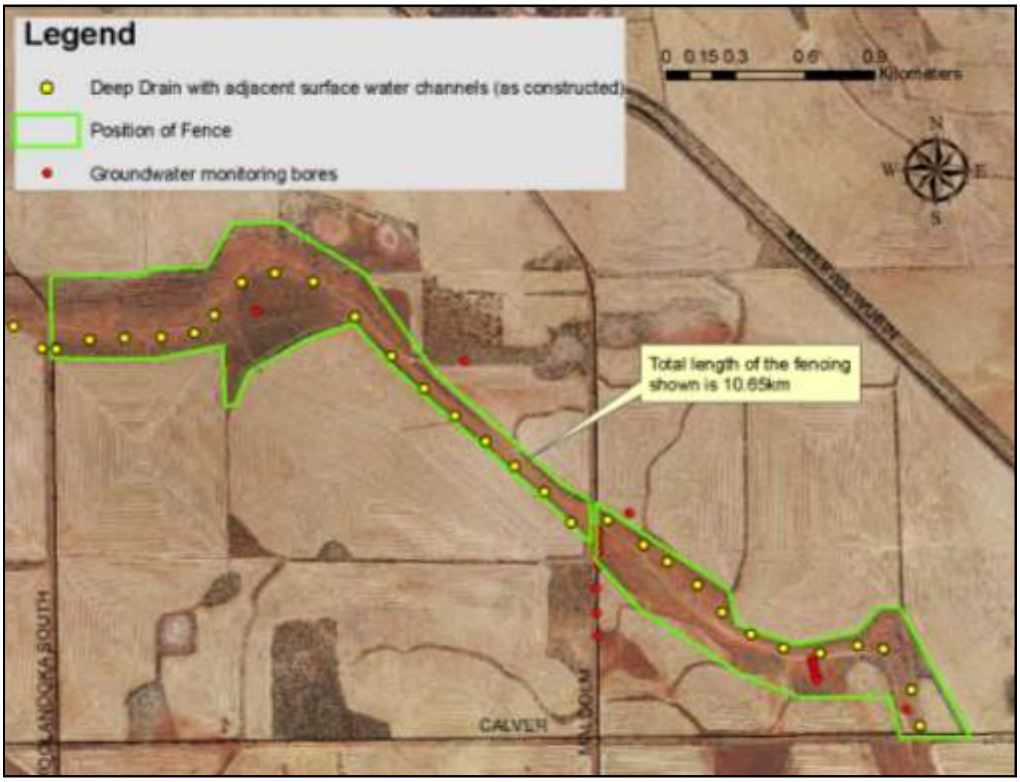

Fig 35: Shows completed fencing of the Bowgada easement. The fencing shown is just over 10.5 km in length

Merkanooka 41

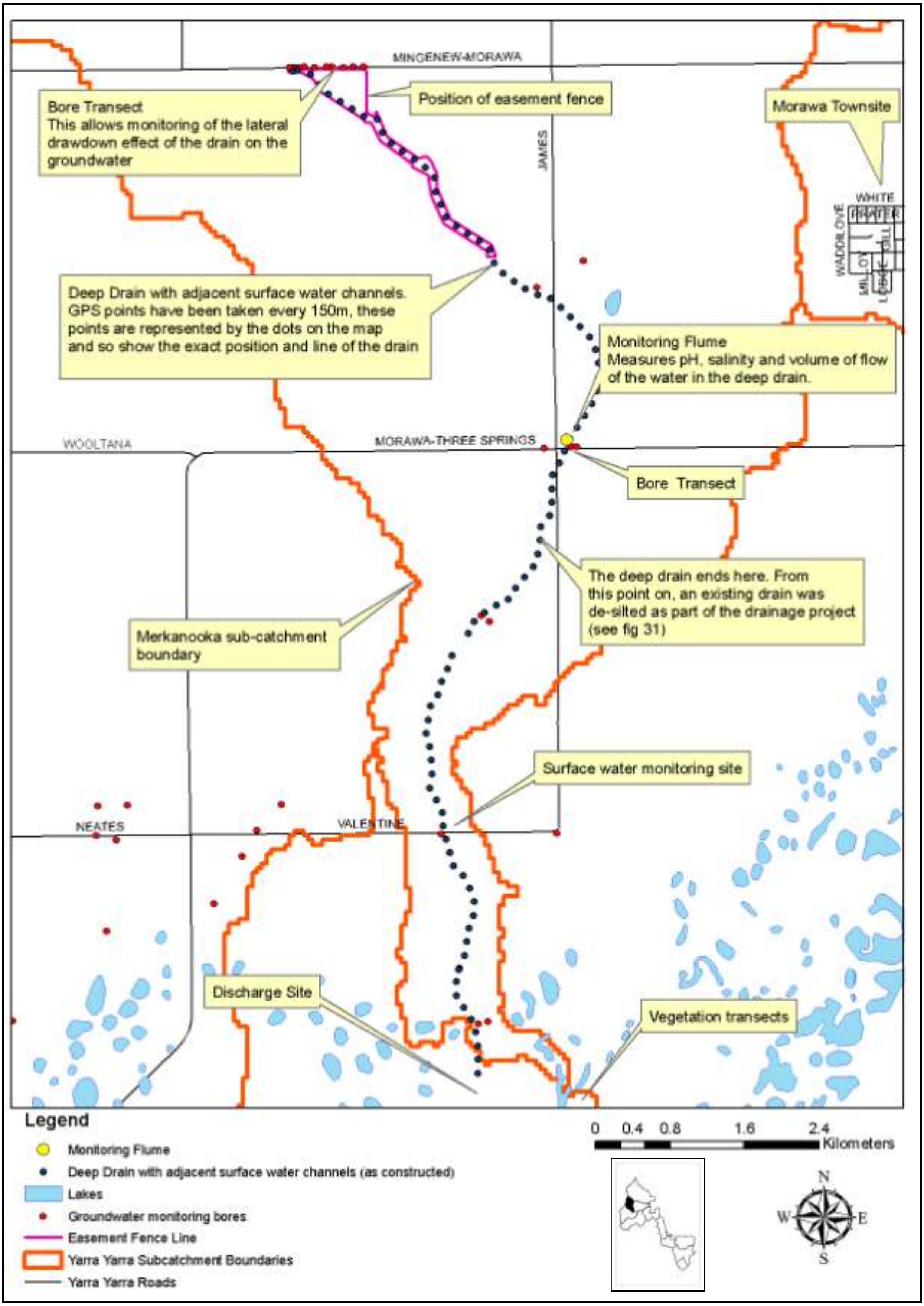

Fig 36: Merkanooka 41

Expenditure, Merkanooka

Merkanooka - Drain completed June 2007

Capital Works	Length (km)	Budgeted Cost	Actual Cost	Under (-)/Over(+) Budget
Drain Excavation	12.8km	$110,480.00	**$147,448.00**	+$36,968
Fencing materials	11.8km	$12,320.00	**$18,763.00**	+ $6,443

The construction of the Merkanooka drain was held up for three months due to lengthy delays in obtaining permits for the regulatory requirements for drainage.

The project ran over budget because the original design allowed for de silting the creek line only, but on consultation with the farmers it was decided to make the top half of the drain a leveed deep drain and the bottom half to be de silted. The Bowgada project was under budget by $18,897 so this helped offset the extra expenditure to some degree.

Fig 37: The Merkanooka surface water channel following de-silt.

When the drain is "de-silted", the silt is excavated and piled up into a bank alongside the channel. A layer of topsoil from the other side of this bank is then piled on top of the silt material. This helps to stabilise the bank and also provides a layer of good quality soil to encourage successful revegetation of the bank top and sides.

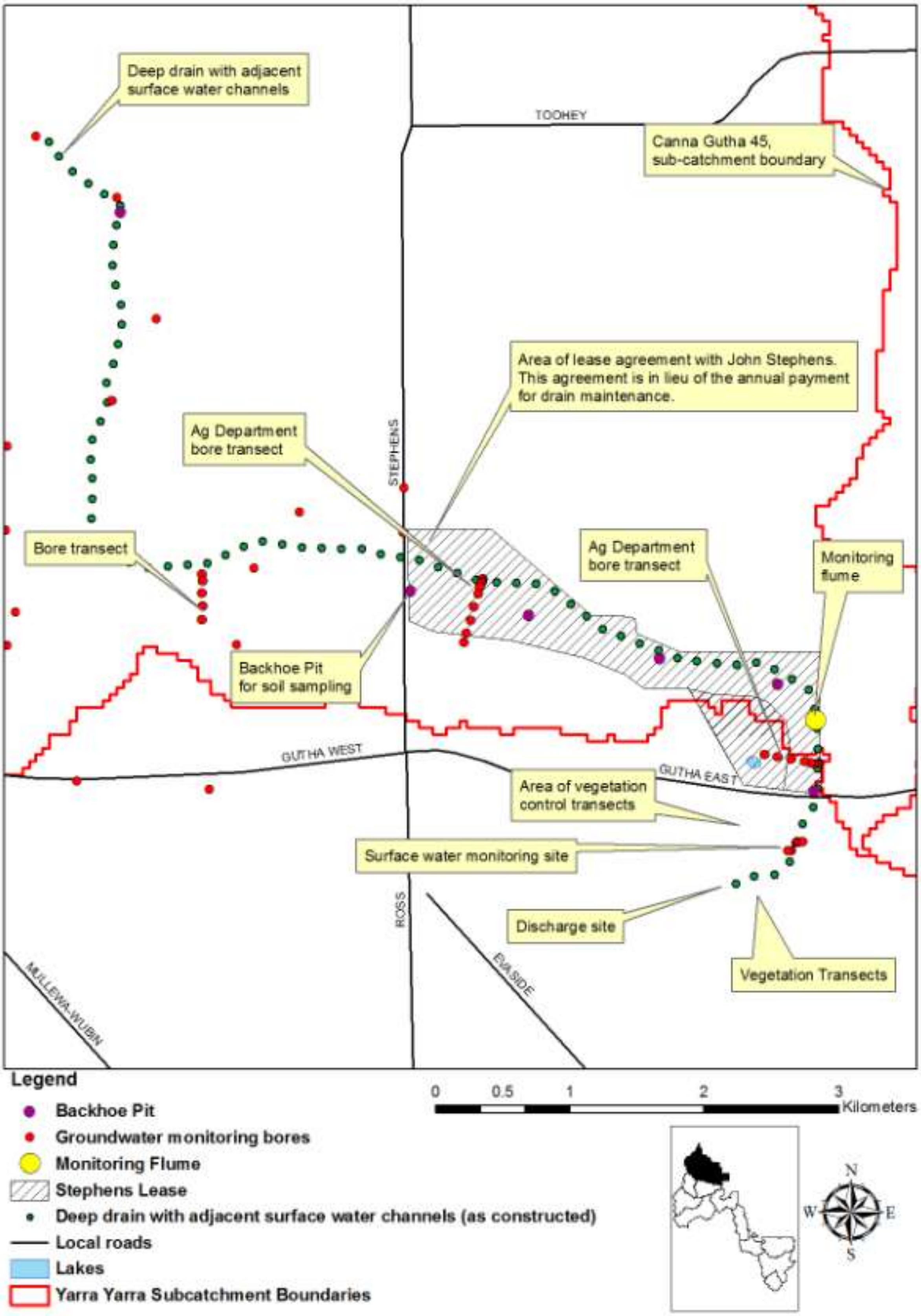

Fig 38: Canna Gutha

Stephens lease: (shaded area). The area was once highly productive wheat land . We will grow and monitor different tree and cereal crops to provide some positive data on the effectiveness of the drain with runs through the middle of the area. As the land improves we plan to generate some income for Yarra Yarra by harvesting and selling the produce.

Expenditure, Canna Gutha

Canna Gutha - Drain completed July 2007

Capital Works	Length (km)	Budgeted Cost	Actual Cost	Under(-)/Over(+) Budget
Drain Excavation	10.7km	$181,217.00	**$153,930.00**	(-) $27,287
Fencing materials	10.3km	**$36,750.00**	**$17,942.00**	(-) $18,808

We were under budget in this catchment because the drain was reduced by 3 km. Also a section of the drain that passes through the area of land we are leasing for research purposes will not require fencing.

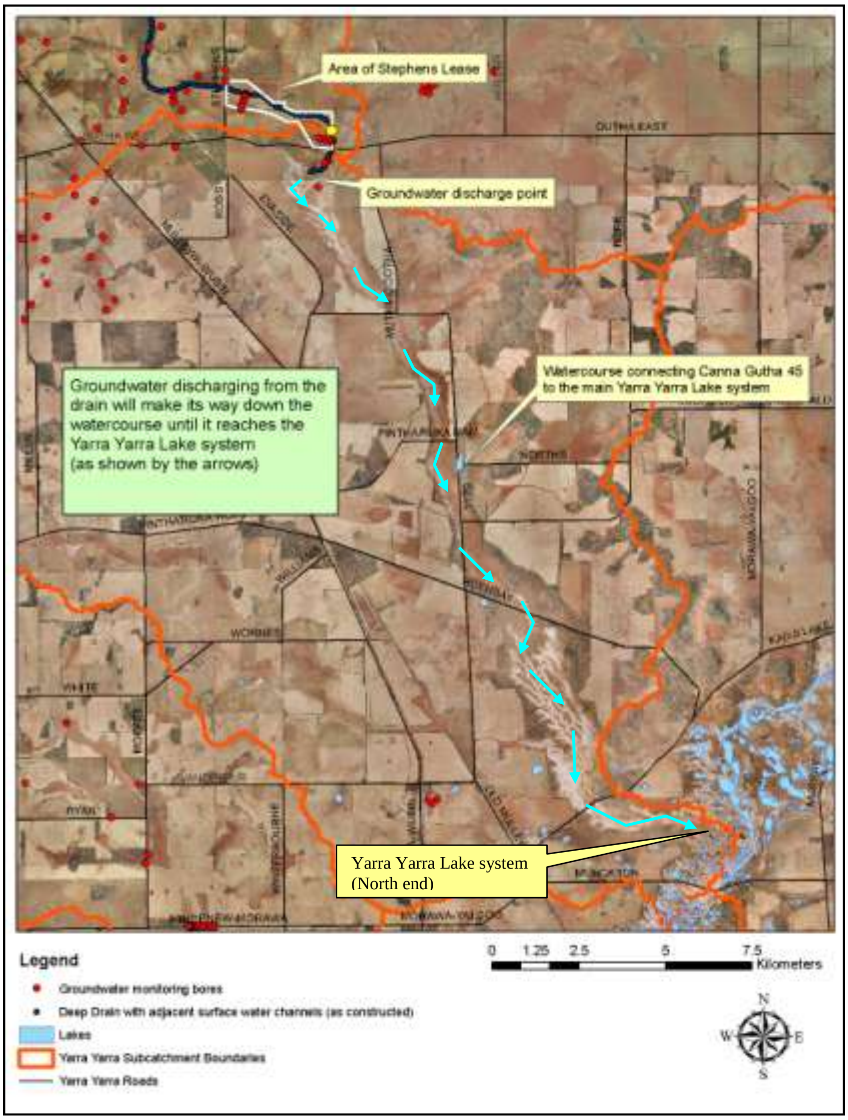

Fig 39: The flow of the drain water towards the inland lakes

The Canna Gutha drain feeds into one of a network of streamlines which typically feed into the main body of the Yarra Yarra Lake System. The blue arrows define the course of the waterway more clearly.
The potential evaporation rate for the region is 2m per annum. The discharge rate from the Canna Gutha drain can be estimated at 105,000 cubic metres p.a. (see chart page 18). A general rule of thumb would be to allow 1ha of evaporation area per kilometre of drain. From the calculated discharge and evaporation rates, it appears that roughly half a hectare of evaporation area would be sufficient per km of drain. Therefore 10 ha of surface area is more than adequate to cope with the discharge from the Canna Gutha drain. This area is very small when compared with the total surface area available in the Yarra Yarra Lake System

<u>Jibberding 19</u>

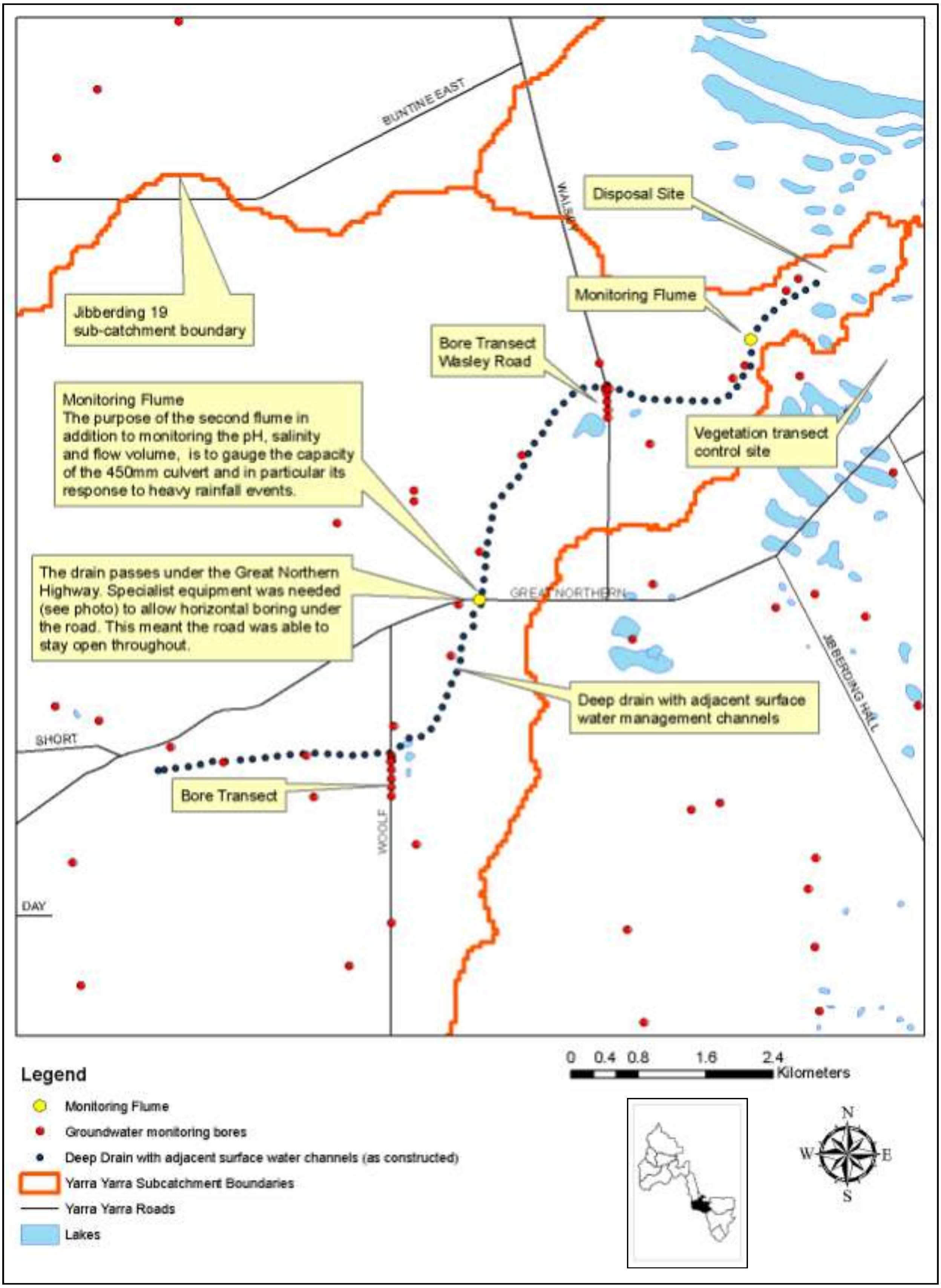

Fig 40: Jibberding 19

Expenditure, Jibberding

Jibberding - Drain completed April 2008

	Length (km)	Budgeted Cost	Actual Cost	Under(-)/Over(+) Budget
Drain Excavation	11.54km	$241,125.00	$208,422.00	(-) $32,703
Fencing materials	14.6km	$30,000.00	$25,400.00	(-) $4,600

The Jibberding drain was the only capital works carried out over this 8 month period. Funds were withheld for capital works while an extensive review took place.
During this period a large amount of staff time was taken up drafting a series of detailed documents to outline the prioritisation process for the drains, and also the long-term management and governance procedures. These documents were to provide reassurance to the funding bodies that the best possible practises were being applied, appropriate to the large sums of public money being invested. It was also during this period that the Yarra Yarra Catchment Regional Council (YYCRC) was officially established and project responsibility was transferred to the more robust body.
The Jibberding drain was under budget because it was shortened by 3 km because a new owner at the top of the landscape did not want to drain his property.

Fig 41: The horizontal line borer

Horizontal line boring - Drilling under the Great Northern Highway 20km east of Wubin.
This technique is used where heavy traffic is encountered. A series of progressively larger drill bits are passed back and forth under the road until the 450mm polyethylene pipe is finally drawn through. The pipe is 36 metres in length with a wall thickness of 33 mm. This procedure is quite expensive but much cheaper than building a bypass for heavy vehicles while the road is dug up to lay conventional concrete pipe.

Fig 42: The local landholders discussing the new drain

Digging the trench to expose the tunnel created by the horizontal line borer. which is 2.5 metres under the ground. This is in preparation for drawing the 36 metres of pipe under the highway. You can see the pipe in the background.

Fig 43: Wasley Road culvert

A conventional culvert passing under Wasley Road in the Jibberding drain.

This site is the junction of two deep drains from two subcatchments; Jibberding 19 (the 2008 drain) and Jibberding 21. The drain in Jibberding 21 was established with the assistance of State Salinity Council funds, in 2003. This photo shows the two discharge points converging on a common delivery drain. Note the drains are now quite shallow as they prepare to discharge at ground level.

Fig 44: Convergence of two drains, Jibberding

Fig 45: Jibberding vegetation survey

This shows the first transect in Jibberding (JB19, T1), one of six in the Jibberding wetland area. You can clearly see the transition in vegetation here from the edge of the lake (sand in the foreground) through the samphire flats and then into larger shrubs and trees as the distance away from the salt lake increases. The change in vegetation is an indication that the soil is also changing in texture and structure.

Xantippe

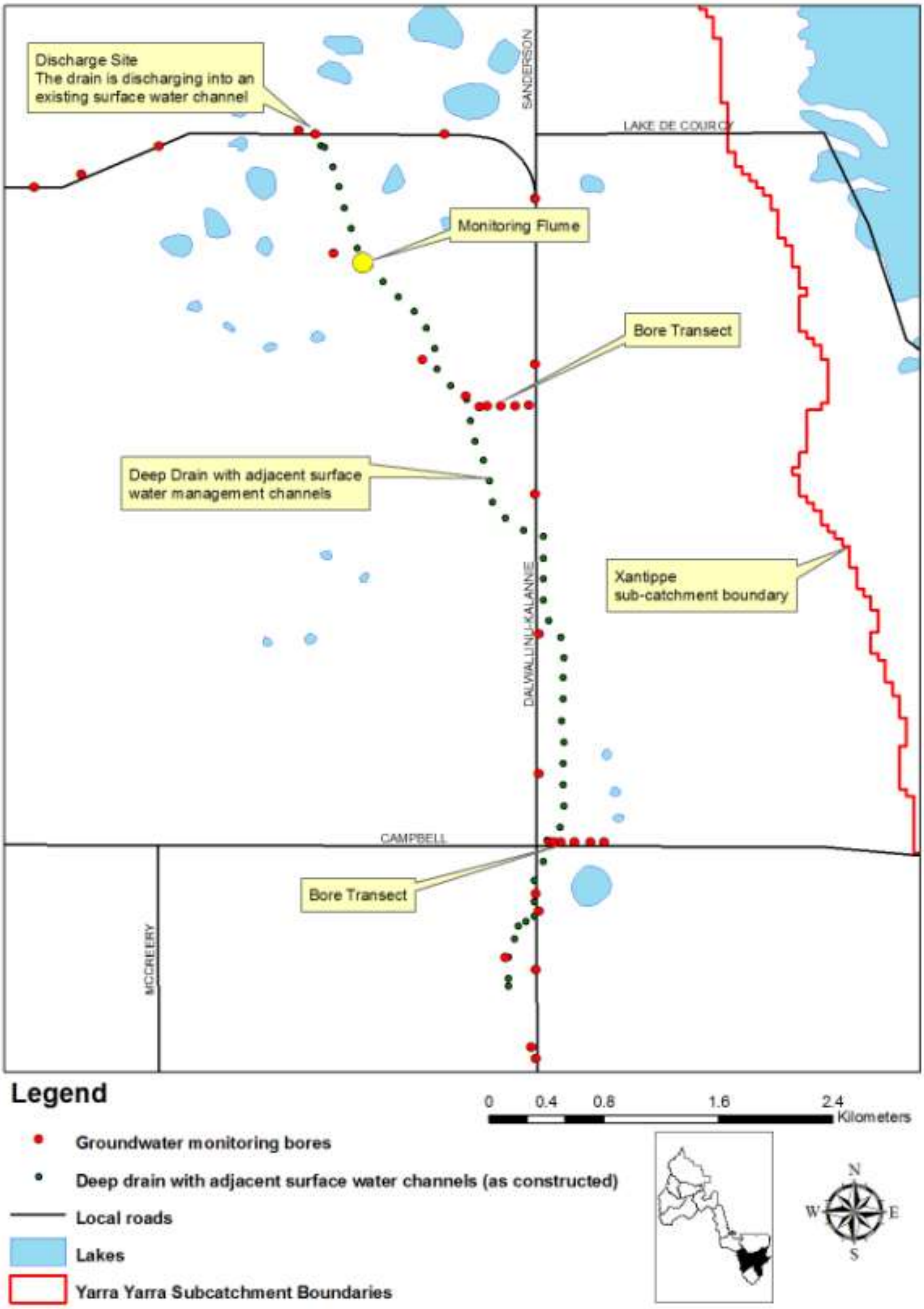

Fig 46: Xantippe

Expenditure, Xantippe

Xantippe - Drain completed 2008

	Length (km)	Budgeted Cost	Actual Cost	Under(-)/Over (+) Budget
Drain Excavation	6.7 km	$109,500.00	$119,300.00	(+) $9,800
Fencing materials	8km	$12,000.00	$16,000.00	(+) $4,000

The cost of fencing has increased by $250/km since budget was written

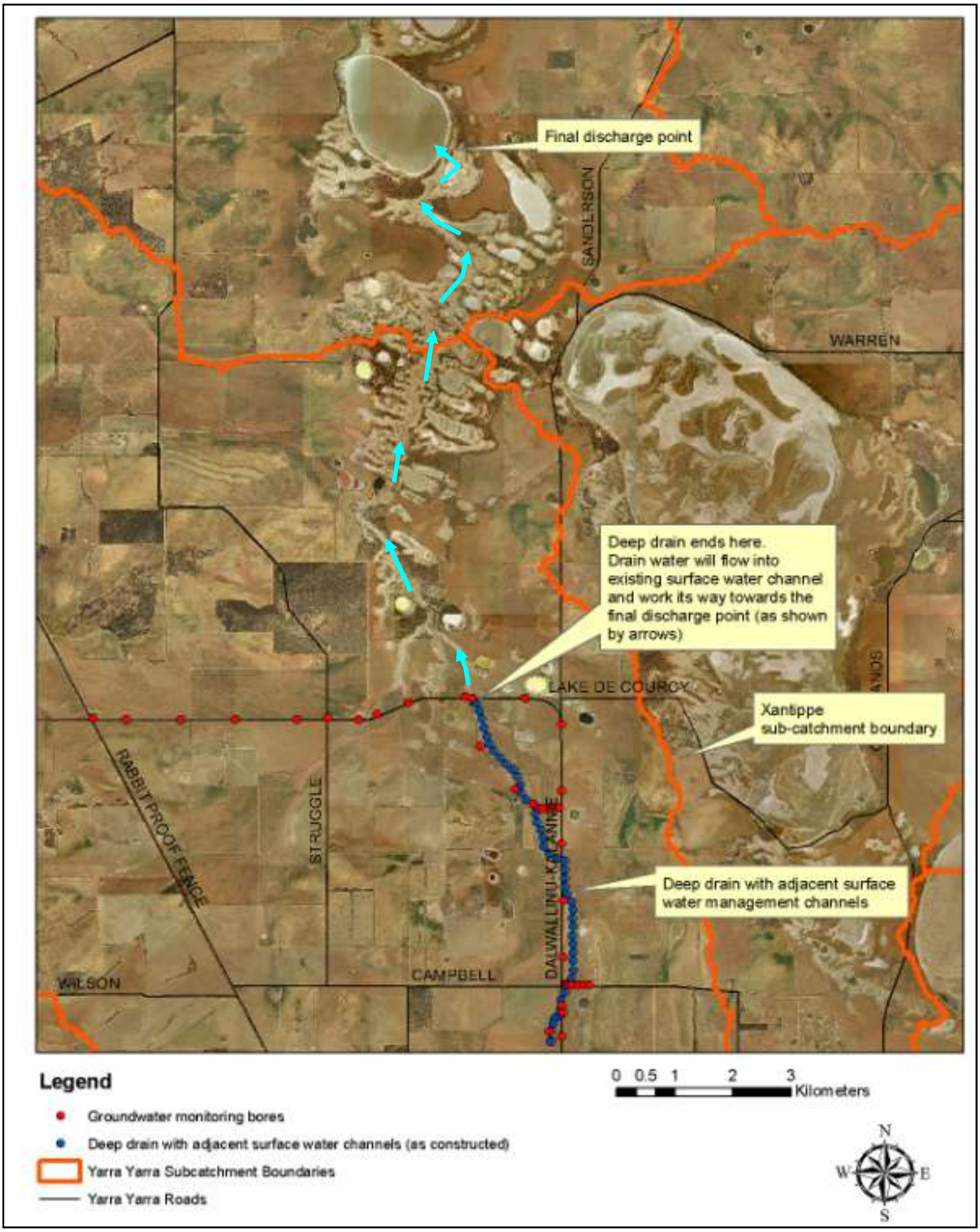

Fig 47: Xantippe drain, flow route

Similar to the Canna Gutha drain (see Fig 33), the Xantippe drain also makes use of existing drains and natural streamlines to deliver the groundwater to the lake system.

The results of carrying out an "As Constructed" (Ascon), following completion of the excavation works

Xantippe 34 Drain As constructed Survey at 150m intervals									
GPS Coord GDA 94'		**Measurement taken**			**Date: April 08**	Drain width	Inside spoil	Outside spoil width	Total width
North	**East**	**Depth of Drain on sloped wall**	**Calculated True depth**	**Depth of Water**	**Photo Point**	**Width 1**	**Width 2**	**Width 3**	**Width 4**
6649849	0505383								
6649840	0505417	1.6	1.39	0.25					
6649702	0505472	1.6	1.39	0.26	586	2.6	5.3	13.1	21.0
6649565	0505513	1.7	1.47	0.4		2.9	5.4	13.3	21.6
6649552	0505552	2.4	2.08	0.4		3.6	9.1	17.7	28.9
6649271	0505600	2.2	1.91	0.4	585	3.2	7.3	17.1	29.5
6649132	0505647	2.35	2.04	0.3		3.3	7.7	17.7	28.9
6649011	0505730	2.5	2.17	0.16		3.7	8.6	19.1	30.5
6648900	0505827	2.8	2.42	0.2	584	3.8	9.4	20.1	31.1
6648794	0505932	2.8	2.42	0.22		3.7	9.4	20.6	31.2
6648693	0506039	2.75	2.38	0.12		3.9	8.7	20	31.1
6648573	0506123	2.8	2.42	0.16	583	4	9.8	20.4	31
6648432	0506185	2.8	2.42	0.24		3.6	7.2	19	31.4
6648285	0506202	2.8	2.42	0.2		3.8	9	20.8	33.5

The data in the table above is an example of the work carried out during an "as constructed" survey. The purpose of the survey is to map the exact location of the drain, after it has been excavated. The data shown is only about a fifth of the data for the Xantippe drain.

Fig 48: Measuring the depth of the drain on the slope, Xantippe

GPS readings are taken every 150 metres, photos are taken every 450 metres (Fig 48)
The depth of the drain slope is measured, and from this the true depth of the drain can be calculated.
The width of the drain, the inside spoil and the outside spoil are also measured and the total drain width can then be calculated.

These "Ascon" surveys are carried out as soon as possible after the drain has been constructed.

Mongers 16

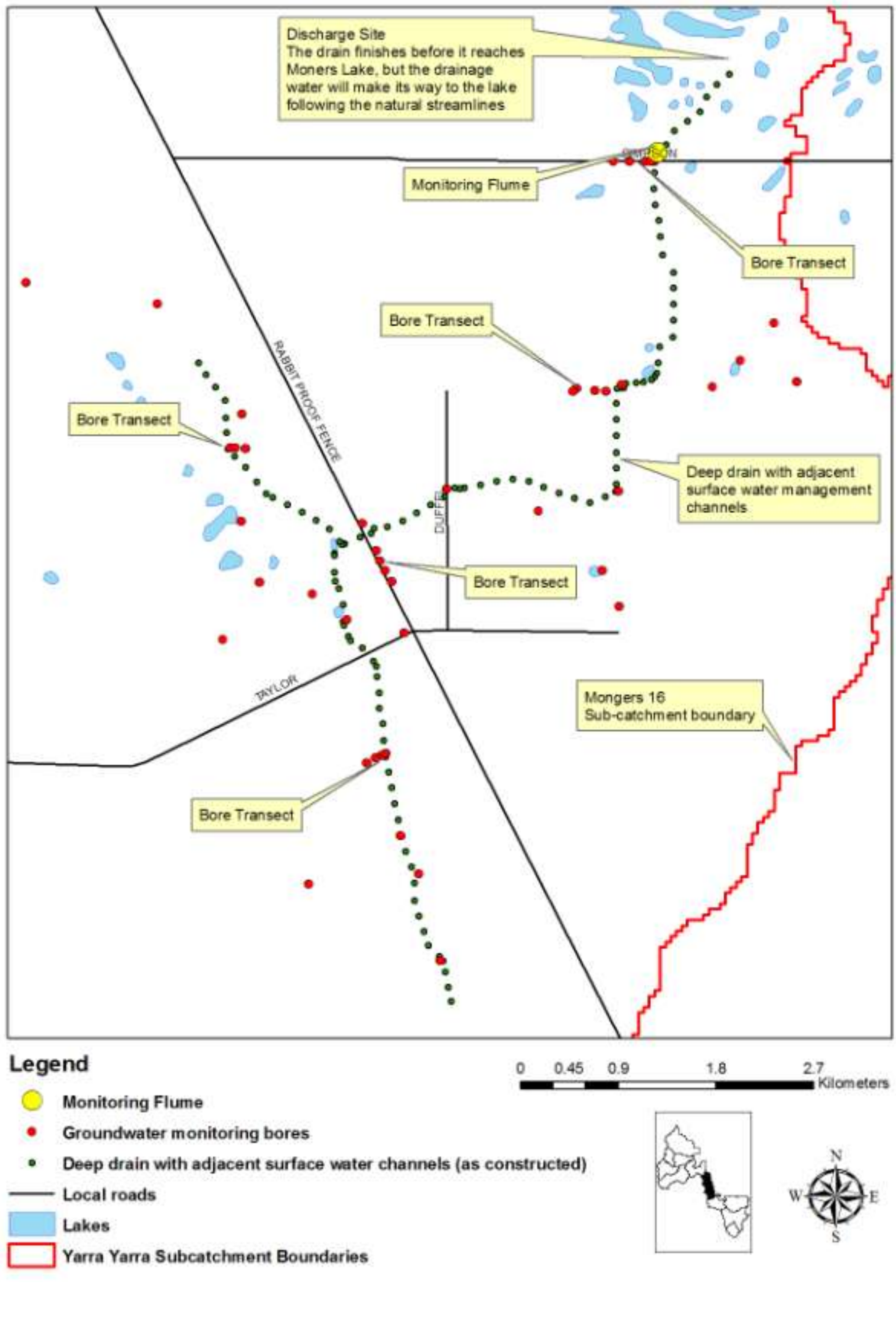

Fig 49: Mongers 16

Expenditure, Mongers 16

Mongers 16 - Drain completed July 2008

	Length (km)	Budgeted Cost	Actual Cost
Drain Excavation	14.0 km	$251,700.00	$249,510
Fencing materials	23.6 km	$48,000.00	$44,917

Due to budget constraints one proposed spur drain of 1.5 km was abandoned initially reducing excavation costs. However additional cost were incurred by the Department of Environment insisting on three extra crossings for wild life and a flattening of the batter on one 900 metre section of drain at an extra cost of $25,000. We strongly believe that this was an unwarranted use of public funds.

Fig 50: Excavation in Mongers 16

Mongers 16 drain.
This photo was taken 1st May 2008, .
You can clearly see water in the drain already. This indicates that the groundwater level here is very close to the surface.

Fig 51: Culvert under Simpson Road, Mongers 16

This photo was taken 14th May 2008, Mongers 16, Simpson Road culvert (for scale, the culvert diameter is 600mm)
You can see there is a substantial volume of water in the drain. As indicated by the observation bores, the groundwater in this area is less than a metre from the surface in certain places. We hope that this is a good indication of the potential for rehabilitating this land.

Burakin

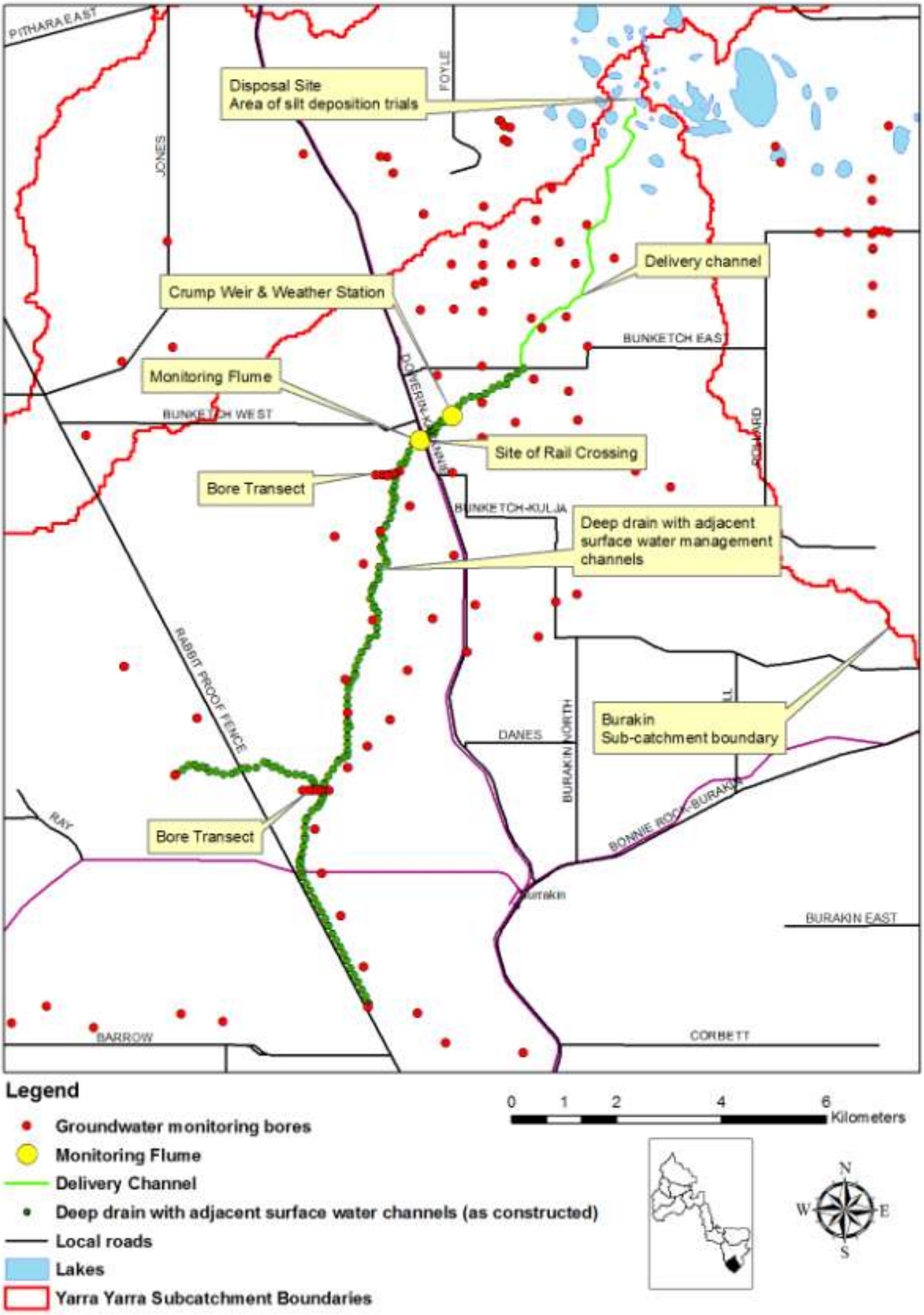

Fig 52: Burakin

Expenditure, Burakin

Burakin - Completion date July 2008

	Length (km)	Budgeted Cost	Actual Cost
Drain Excavation	17.75km	$323,667	$358,559
Fencing materials	22km	$43,500	$45,337

The Burakin project was rather more complicated than others as the new drain was required to join up with an existing combination drain which carried both surface and ground water. Provision had to be made to join the two together using a workable and safe construction design. The job was further complicated by the fact that there had to be a 130m long culvert laid under the main Dowerin to Kalannie bitumen road and the railway line. Westnet Rail was required to be involved in this process and there was a long delay waiting for them to come onto the site. In the meantime the excavation of the drain had to continue and the water was pumped into an existing surface bypass channel to carry the drain water from one side of the railway line to the other until the culvert was in place (see fig 53). The establishment of this culvert incurred a considerable cost ($78,589) to the Burakin project. A silt treatment and motoring sump with a capacity of 1,000 m^3 was established up stream of the culvert at the same time.

We have established a concrete crump weir below the point where the new drain and the old drain converge. The purpose of this weir is to establish a monitoring station to measure overland and groundwater flows coming out of the Burakin catchment which has a surface area of 45,000 hectares (see fig 56). This cost has been met by the Department of Water.

Fig 53: Installing the under rail crossing at Burakin

Fig 54: The crump weir. The design of the weir prevents silt deposition here.

The Burakin drain has been very successful with spectacular crop establishment on reclaimed land within the first year.

Figs 55a and 55b: Before and After

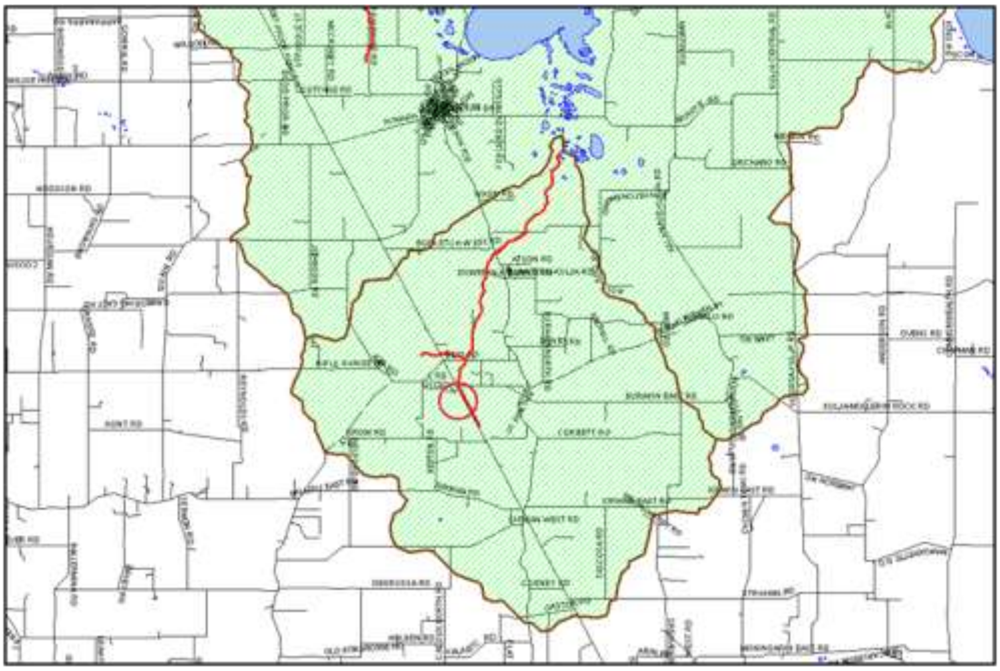

Fig 56.

The red line marked on the map above represents the constructed arterial drain. The circle near the beginning of the drain is a reference point for Fig 57 below. The photo shows a degraded area which is 14 km from the discharge point (which is a small lake on the periphery of Lake Hillman to the North). Water tables at the reference point were within 1.2 metres of the surface at the time of drain construction. The importance of this demonstration is that the drain passes through 5 properties on its way to the lake. Without this public facility then 4 of these farmers would not be able to safely deliver saline ground water out of their farms.

Fig 57

Some outstanding results have been achieved in the Burakin sub-catchment already. While full recovery of salt affected land is a long term process, some extraordinarily positive results have been recorded to date.

The hydrograph below was generated from data taken from a transect of bores in the Burakin Zone. The arrow indicates the excavation starting date. The “spikes” show significant rainfall events. It is to be noted that the trend is always downward. This bore site is 400 metres from the drain. The arrow indicates when the drain was constructed.

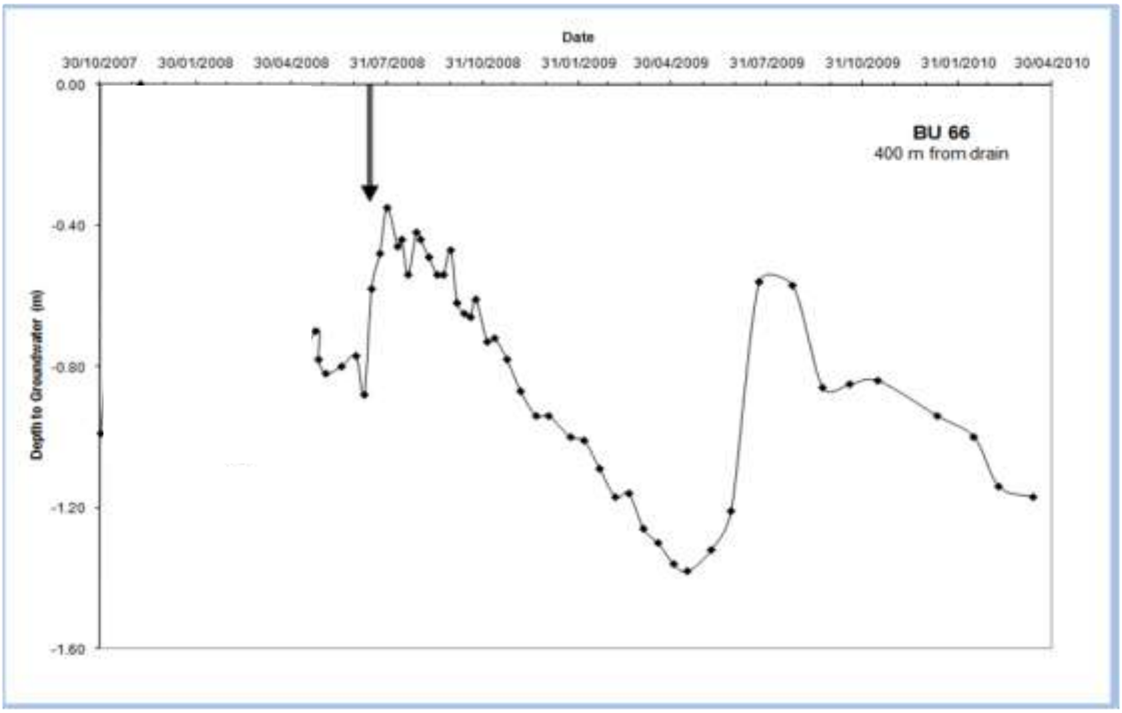

Fig 58: Groundwater hydrograph

The photos below were taken about 500 metres south of the bore transect. Fig 59a on the left was taken just prior to seeding, the ground cover is samphire. These flats have not supported any other vegetation for around 10 years. This barley crop was planted 10 months after the drain was constructed.

Note the Salmon Gum trees in the background which are a reference point for the photos

Fig 59a

Fig 59b

Merkanooka Extension

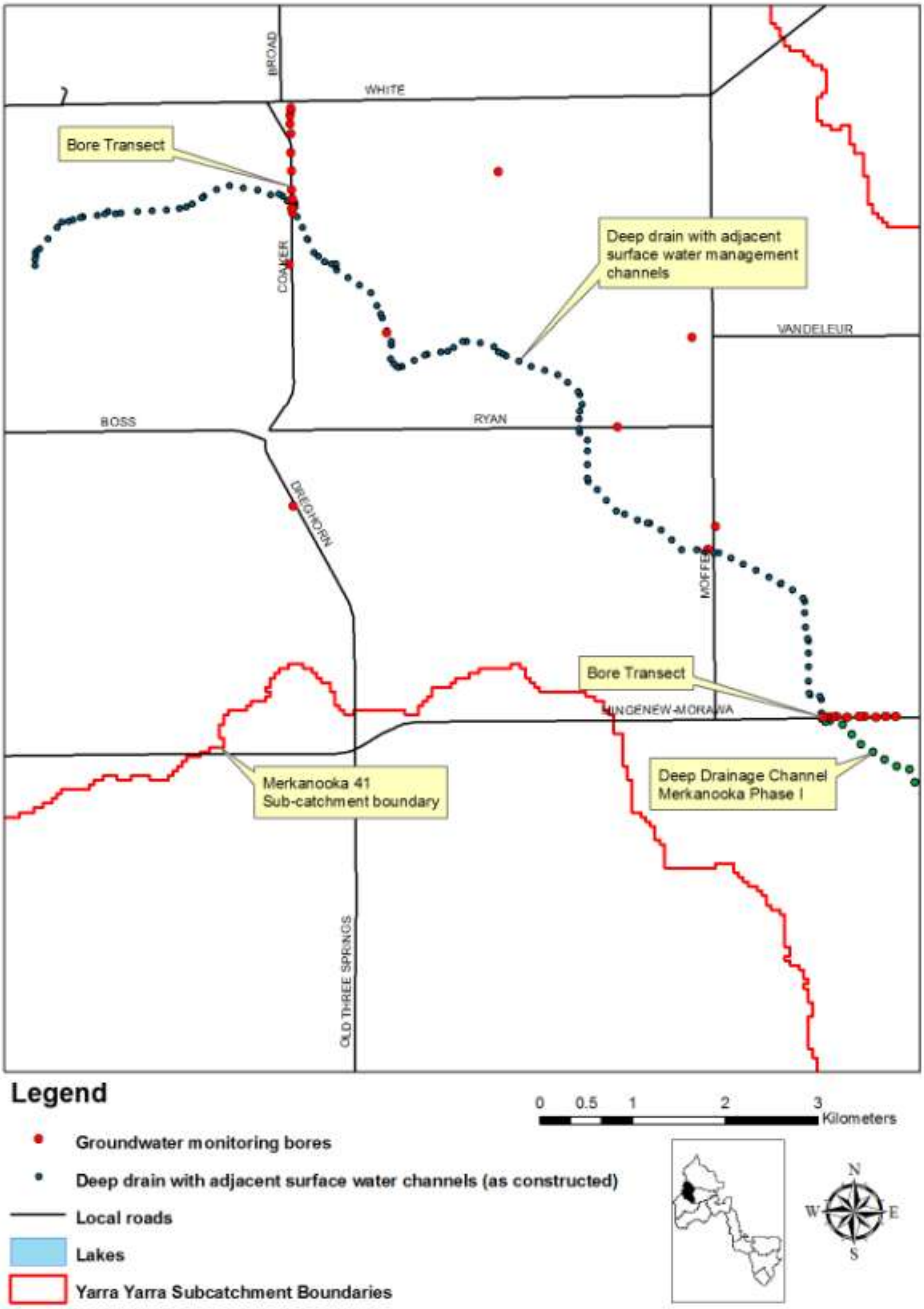

Fig 60: Merkanooka Extension

Expenditure, Merkanooka Extension

Merkanooka Extension - Completion date July 2009

	Length (km)	Budgeted Cost	Actual Cost
Drain Excavation	13.1km	$232,136	$232,136
Fencing materials	26 km	$50,000	$62,511

This map (fig 61) aims to show the effectiveness of arterial drains in providing farmers who are remote from safe disposal points, a public facility to convey drainage water away from their farms. The red line depicts a recently constructed arterial drain. The blue line depicts the private spur drains. This drain passes through 12 properties on its way to the discharge point.
The circle to the left is a reference point for the extensive salt scald shown in the aerial photo below (fig 62), which is at the beginning of the Merkanooka drain. The arterial drain allows this area to be drained to the discharge point 25km to the south.
The circle to the right is a reference point indicating where farmers have been able to connect into the arterial drain with their own spur lines totalling 7 km. This site is 15.5 km from the delivery point. Without this public drainage facility this could not happen.

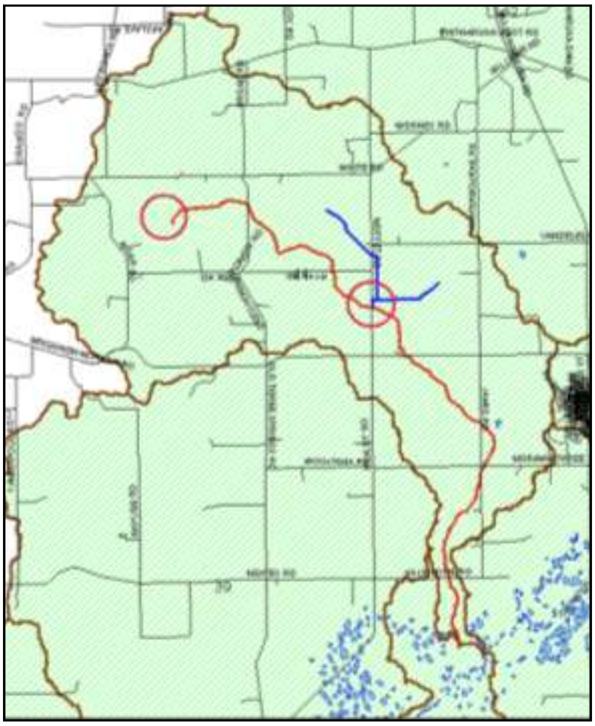

Fig 61

Fig 62

Overview of Expenditure
Costs taken directly form audited financial reports

Catchment	Drain Cost	Wages + Admin.	Operating Costs	Fencing Phase 2	Fencing Phase 1	Length of Drain km.
Phase 1 StartDec. 2006						
Bowgada	127,700			11,308	7,733	
Merkanooka	136,488			9,542	11,307	
Canna-Gutha	153,930			19,937		
Survey Equip.			47,070			
Operating Costs			57,546			
Phase 1. Completed July 2007	**418,078**	**263,042**	**104,616**		**19,040**	**33.90**
Phase 2 Start Dec. 2007						
Jibberding	243,542			26,317		11.5
Xantippe	119,300			26,472		6.75
Mongers 16	249,510			49,909		14.00
Burakin	359,922			50,377		17.75
Merkanooka Ex.	232,136			62,511		13.10
Phase 2 Completed June 2009	**1,204,410**	**532,683**	**39,252**	**256,273**		
+ Phase 1 fencing				19,040		
Grand Total	**1,622,488**	**795,725**	**143,868**	**258,213**		**97.00**

Notes on fencing: 128 km of fencing was erected.

66 km of fencing was already in place.

The average cost of fencing was $2,151 per km.

Notes on drainage: Costs include 150 km of surface water drains @ $2,000 per km, as well as crossings at farm boundaries, Shire roads, main roads, and rail.

The cost of excavation for a basic 2.5 metre deep drain was between $8,000 and $9,000 per km.

Breakdown of Operating Costs

Consultants	22,793
RTK Surveying Instrumentation	47,000
Other surveying expenses	1,398
Legal Fees	1,930
Monitoring expenses and equipment	11,219
Drilling expenses	22,302
Sundry drain expenses	23,169
Auditing fees	1,000
Advertising	134
Insurance	7,026
Total	**$143,868**

Typical salary costs throughout the project.

While the structure of the workforce varied from time to time throughout the project the table below is indicative of the annual costs incurred. Because of the stop start nature of the projects YYCMG were compelled to request for a further injection of funds for wages to keep the project running. A big proportion of the wages component was allocated towards the drafting of extensive reports and reviews and explanations to comply with the requirements of the relevant government agencies and funding bodies as the project progressed.

Gross full time	Position	Salary Level	Full time equivalent	Gross Salary per annum
72,977	Coordinator/ Manager	6.2	0.1	72,977
62,683	Environmental Scientist	5.2	0.1	62,683
48,409	Field workers	3.1	0-6	29,045
57,609	IT officer 1	4.3	0.4	23,045
52,560	IT officer 2	3.4	0.6	31,536
57,609	Finance Manager	4.3	0.6	34,564
62,683	Surveyor and Design manager	5.2	0.6	37,609
		Total per annum		**270,759**

Total employment costs for period of project

Overheads		**Salary costs**	
Advertising	456	Salaries and wages	590,330
Auditing	1,000	Superannuation	53,233
Housing subsidy	5,200	Motor vehicle expenses and travel	105,639
Insurance	5,306	Accommodation and meals	8,976
Office expenses	13,607		
Telephone, communications	11,978		
Total	**37,547**	**Total**	**758,178**

During the course of the project NACC (which is the Regional NRM body for the Northern Agricultural Region Contributed two personnel on a part time basis. The value of this contribution is valued at around **$90,000.**

Blockers and Drivers

Blockers

Hike in cost of fencing materials
Over the duration of the project, the cost of fencing materials increased by $250 per km. This has increased the pressure on our budget causing us to defer some of the drainage work planned for other catchments.

Delays
Delays in funding due to the review and subsequent shifting of responsibilities both to the funding body NACC and the proponent YYCMG plus long delays in processing of applications set the project back by 7 months.
The major hold-ups were 5 months with no funds received for capital works from 31st July to 31st Dec 2007. This was due to the Joint Steering Committee (JSC) review (the funding body) and the apparent delays in handing over of funding responsibilities from the State NRM office to NACC.
There were also considerable delays on applications for permits, with one clearing permit taking 13 months to process (which was a permit to clear low scrub, samphire and blue bush on private property).
The stop go effect of project progression due to these delays was most disruptive to the free flow of contracts and also to access permits and quotes for works inside road and rail reserves. This resulted in permits and contracts having to be re-written and some service providers lost interest in the project. One price hike in a quote for an under-rail culvert was $30,000.

Bowgada Drain
The Bowgada drain was the least successful of all the drains excavated. We originally nominated a mean depth of 2.1 metres for a standard deep drain but after observing the output of the Bowgada drain it was decided to increase the mean depth to 2.5 metres. This nominated depth was maintained with success for the rest of the program. However this increased the cost of the drain by $1,500 per km.
During the course of constructing the Bowgada drain, one farmer whose land was midway along the proposed line changed his mind and decided not to participate in the program. This meant that four farmers above him in the landscape were unable to proceed to get their land drained. We are working to resolve this issue as the ground water in the higher reaches of this subcatchment is very close to the surface and a lot of land has been lost with salt encroachment. Pumping the water across the undrained area may be an option.

Jibberding drain
Unfortunately while the project was delayed, the farm at the top end of the Jibberding drain was sold and the new owner did not wish to participate in the project. This resulted in the total drain being shortened by 3 km. There is severe degradation on this property with ground water levels less than 1 metre from the surface, also the homestead is at severe risk and much of the surrounding York Gum woodland has died.

Drivers

Reasonable digging
The digging of the drains was generally good going with very little rock encountered. This has meant that the rock clause has only been invoked on two occasions; once in the Jibberding drain and once in the Merkanooka extension. Neither of these incidents has had big repercussions on the budgeted figures. This has been a big saving.

No price rise to compensate for the fuel hike
Our preferred contractor was New Holstein Pty Ltd who were most cooperative and helpful with design and supporting us through difficult times with funding. Each drainage line was let out to tender separately and at times we have attracted up to six bidders. New Holstein's tender price remained the same from November 2007 (at $8,000 per km for a 2.5m deep drain and $2,000 per km for 3m x 400mm surface drain) until towards the end of the project in July 2008 when the extraordinary price hike in fuel demanded a rise of $1,000 per km for basic drain excavation.

Establishment of the YYCRC
During the period of construction the Yarra Yarra Catchment Regional Council was officially established and the inaugural meeting was held at the Perenjori Council Chambers in June 2007.
The Yarra Yarra Group worked for six years promoting the transformation of catchment management from the YYCMG to the YYCRC. The YYCRC is a statutory body ensuring perpetuity, accountability and compliance to policy.

Farmer support
Out of forty farmers approached to participate in the Yarra Yarra Regional Drainage Program there were only two who declined to participate.

Conclusion

Two and a half years after the completion of the first drain in Stage 1, there is still a great deal of research and monitoring work to be undertaken in order to learn as much as we can about the effects of deep drainage on the landscape and to try and fill the gaps in current knowledge.
Currently it is most disturbing that neither the State nor Federal Governments are prepared to invest in the continuation of this important monitoring program. We hope that this is just a passing phase and the Yarra Yarra community will continue to collect the most important data with what resources they have.

As Stage 1 is now concluded we are looking forward to moving onto Stage 2. The Yarra Yarra Catchment Regional Council will continue to lobby for funds to continue with the Regional Drainage Program. For further information on Stage 2, please refer to the document "Stage 2 of the Yarra Yarra Regional Drainage and Research Program" (See Further Documents).

Further Documents

The following documents have been produced during the course of this project

- Deep Drains in The Yarra Catchment: What we've learned to date and our proposal for the future. *Dr Ian Fordyce and Max Hudson, February 2006*
- Vegetation monitoring for proposed drainage project in the Yarra Yarra Catchment. *Dr Ian Fordyce, March 2007*
- Canna Gutha Re-vegetation program. *Dr Ian Fordyce, June 2007*
- Samphires in the Yarra Yarra Region, *Dr Ian Fordyce, September 2007*
- The Yarra Yarra Three Stage Drainage Program. *Yarra Yarra Catchment Management Group, September 2007*
- Establishing Priorities for Deep Drainage in the Yarra Yarra Catchment. *Yarra Yarra Catchment Management Group, October 2007*
- Stage 2 of the Yarra Yarra Regional Drainage and Research Program. *Yarra Yarra Catchment Management Group, March 2008*
- Saltlakes in the Yarra Yarra Region, *Dr Ian Fordyce, May 2008*
- Yarra Yarra Aquatic Monitoring: Assessing the effect of deep drains on the ecological health of the Yarra Yarra playas and wetlands. *Wetland Research & Management, December 2008*

The above documents are all available on our website:
www.yarrayarracatchment.org.au
Alternatively please contact Max Hudson at the Yarra Yarra Catchment Management Group Tel: (08) 9667 1021 or Dene Solomon on (08) 9973 1425

Appendix

All Appendix documents can be found on the CD within the back cover of this report