Final Report

Swan Hill Modernisation Project - Reconfiguration of the Swan Hill Region

1 OCTOBER 2010

Prepared for

Northern Victoria Irrigation Renewal Project (NVIRP)

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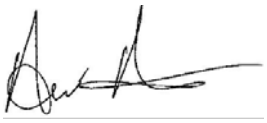

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Executive Summary

Purpose of Study

The purpose of this study is to prepare a modernisation plan for the Swan Hill Irrigation Region (SHIR) within the Torrumbarry Irrigation Area based on an assessment of potential options for reconfiguring the irrigation network within the region. The plan is to form part of the overall strategy of NVIRP to modernise the irrigation systems in northern Victoria designed to secure the economic, social and environmental future of the region through water savings and better water management.

The preparation of the plan was to build on the initial work to reconfigure the SHIR undertaken by the Torrumbarry Reconfiguration and Asset Modernisation Strategy (TRAMS) prior to the establishment of NVIRP in 2007. It was also to take into account the Mid Murray Storage Project (MMS) which forms part of the *Mokoan – Return to Wetlands* initiative of the Victorian Government. [1]

Background

NVIRP was established in 2007 by the Victorian Government to undertake the modernisation of the irrigation systems on a large-scale across most of the Goulburn-Murray Irrigation District (GMID) — refer to Figure 2-1. Through these initiatives, the objective is to achieve water savings of 425 GL, through two stages; 225 GL through Stage 1 and 200 GL through Stage 2. The current prolonged dry period is also contributing to the need to achieve water savings.

A major first step involved the identification by NVIRP of the supply backbone for the different irrigation areas. Once identified, NVIRP has been progressing the modernisation of the irrigation systems through a number of programs, namely:

- Channel Automation — installation of automatic gates to control channel water flows;
- Channel Remediation —remediation works to rectify structural weaknesses in channels;
- Channel Lining — lining channels with clay or plastic to reduce seepage and leakage;
- Connections Program —connecting all future customers to the backbone channels; and
- Meter Replacement — the installation of more accurate modern meters.

These main programs are being used by NVIRP to pursue a number of special projects relating to water savings, the environmental and enhanced customer services. Although the modernisation of the SHIR is being progress under its main program, it is being driven mainly through the water savings and, to a lesser extent, service enhancement special projects of NVIRP.

Delivery Shares

Delivery shares constitute the rights of landholders to have water delivered to their properties. Combined, the delivery shares that are expected to be held by landholders after reconfiguration are used to determine the capacity of the reconfigured system; they are the currency of reconfiguration.

They were created on 1 July 2007 through the “unbundling” the then existing water entitlements into the three elements of a water share, delivery share (DS), and a water-use licence. This unbundling separated water from land and meant that ownership of a water share did not give rise to a right for water to be delivered.

The delivery of water is now managed through DS. For analysis purposes, the expected future DS, hence capacity of a reconfigured SHIR, were provided by NVIRP under its Connections Program.

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Reconfiguration Drivers

In addition to the underlying drivers for the modernisation strategy of NVIRP, there are a number of drivers specific to the region that will influence the modernisation plan for SHIR. These include:

- past changes to servicing the Tyntynder Flats area and the Woorinen Irrigation Region through the No. 10 Pump Station and directly from the River respectively, rather than the No. 9 Channel, resulting in the current use of this channel being significantly less than design capacity;
- the future operation of the Little Murray Weir (LMW), given that the weir has failed in the past, is reaching the end of its life, and has significant OH&S risks associated with its use;
- the reduced demand for irrigation water associated with the volume of water shares traded out of the driven, driven largely by the substantial land-use change in the Tyntynder Flats area; and
- concerns about the operation of the No. 9 Channel through the Rural City of Swan Hill (RCSH) from a public health and safety perspective.

The Base Case

The foundation for assessing potential options for modernising the SHIR is provided by the current configuration of the irrigation systems and the way in which irrigation water is delivered through the systems to meet the needs of customers. This situation, which is known as business-as-usual or base case, provide the reference point for measuring the impacts of different options and, hence, for identifying the preferred option.

The irrigation system of the SHIR consists of the following major assets:

- the Little Murray Weir (LMW) and weir pool — the weir increases the height of water in the Little Murray River providing water by gravity to the No. 9 Channel system and access to diverters from the resulting pool upstream of the weir;
- the No. 9 Channel system which delivers water to customers both south and north of the RCSH and which passes through the city; and
- the No. 10 Channel system, including the No.10 Pump Station situated on the River Murray and which supplies water to the Tyntynder Flats area.

These assets would be maintained under the base case. In addition, the base case includes the outcomes that would be achieved through the implementation by NVIRP of its modernisation programs, especially Channel Automation and Connections Program.

The Connections Program is particularly significant because of its influence on the capacity of the irrigation system that will be required to meet future needs. Based on the advice of NVIRP, its Connections Program will result in:

- the removal of 40 DS from the downstream reaches of the No. 9 Channel near the River Murray;
- the removal 50 DS from the No. 10 Channel system adjacent the River Murray; and
- the connection of customers to the backbone that are currently serviced by spurs near the RCSH.

Mid-Murray Storage Project

The Mid-Murray Storage (MMS) Project that is currently being implemented by the Victorian Government is directly relevant in assessing potential options to modernise the SHIR. This project involves new operational storage arrangements for Lake Boga, Lake Charm, Kangaroo Lake and Kow Swamp under the Snowy River and Living Murray Initiatives.

Lake Boga lies adjacent to the LMW and, under the MMS project, a new outfall is to be built from Lake Boga to the Little Murray River downstream of the weir. This new outfall forms part of the base case, but would not be required if the LMW were to be lowered as part of a modernisation option.

Stakeholders

Given the objectives of NVIRP, and the aspects that form the base case, there are a number of stakeholders that would be affected by options to modernise the SHIR and, hence, would need to be engaged fully in determining the preferred option and its implementation. The stakeholders include:

- Goulburn-Murray Water concerning largely operational aspects;
- Irrigation customers — the interests of customers is likely to vary throughout the SHIR depending on potential impacts requiring targeted consultation;
- Irrigation suppliers and advisers;
- Swan Hill Rural City Council (SHRCC);
- Local community including the media;
- Victorian Government (Departments of Sustainability and Environment, Planning and Community Development, Primary Industries and North Central Catchment Management Authority); and
- Commonwealth Government with respect to potential referrals under the *Environment Protection and Biodiversity Conservation Act 1999* (refer to Section 1.1.2).

Project Reference Group

A Project Reference Group (PRG) was established by NVIRP to guide the undertaking of this study, hence development of a modernisation plan for the SHIR — membership of the group was drawn widely from the stakeholders noted above (refer to Section 1.4). Four meetings of the PRG were convened with the last being held on 31 March 2010 to discuss a draft of this final report.

In addition to the PRG, a progress report was provided through NVIRP on the development of the modernisation plan for the SHIR on 8 December 2009 to the Torrumbarry Irrigation System Consultative Committee (TISCC). This committee is convened by the Department of Sustainability an Environment (DSE) to integrate the various water management issues within the TIA.

Preferred Option

The preferred option (Option 3) involves truncating No. 9 Channel at Werrill Street, installing a pipeline along Karinie Street to service the No.9 Channel north of Swan Hill, upgrading the No. 10 pump station, and the building of an interconnector channel between the No. 2/2/10 and No. 13/9 Channels. This option was assessed against the base case within a benefit cost framework along with two other options that were selected for detailed evaluation, namely Options 2 and 3. Details about all options, including those discarded are present in Section 4 and Section 5 as well as in Figure 4-1.

The main differences between these options and Option 3 were:

- Option 1 — involved removing the No. 9 Channel through Swan Hill from Werrill Street to McCallum Street and replacing it with a pipe and building an interconnector channel between the No. 2/2/10 and No. 13/9 Channels; and
- Option 2 — involved truncating the No. 9 Channel at Werrill Street and installing a larger relift pump at the No. 10 pump station and larger pipeline along Karinie Street to service the No.9 Channel north of Swan Hill (no interconnection channel would be built).

Executive Summary

All options involved lowering the LMW and were modelled based on the advice of NVIRP that 40 DS would be removed from the downstream reaches of the No. 9 Channel and 50 DS from the No. 10 Channel system adjacent the River Murray. Water savings were to be valued at $2,645 per megalitre (ML) in accordance with the Connections Program Framework value. The expected water savings were calculated using the protocols issued by DSE.

Presented in Table ES-1 is a summary of the benefit-cost analyses (BCA) for Options 1, 2, and 3, which clearly illustrate why Option 3 is the preferred investment in terms of net present value (NPV)[2], cost per ML of water saved and lower initial capital investment. The per ML cost of water savings is equal to all costs incurred in achieving water savings, less all non-water savings benefits, divided by the volume of water savings.

Table ES-1 Summary of benefit cost analyses

Option	PV of Benefits	PV of Costs	Net Present Value	Water Savings (ML)	Cost per ML water saved	Initial capital investment
1	$21,129,000	$19,217,000	$1,912,000	2,171	$1,764	$14.3 million
2	$21,796,000	$20,899,000	$897,000	2,369	$2,266	$15.4 million
3	$21,746,000	$17,543,000	$4,203,000	2,350	$857	$12.6 million

Key Inputs and Assumptions

In order to undertake the BCA for the three selected options required a number of inputs to be provided by NVIRP as well as the making of a number of assumptions. A number of the key inputs are already noted above, namely that 90 DS would be removed from the No. 9 and No. 10 Channel systems, and the value of $2,645 per ML for water savings. Other key inputs were:

- the use of a discount rate of 6 per cent a year and of a 30 year planning horizon;
- the works would commence in 2010; and
- a value of $20,000 per hectare from decommissioning the No. 9 Channel through the RCSH.

Environmental approvals to lower the Little Murray Weir

The key assumption that underlies the analysis of the three options is that the required environmental approvals to lower the LMW under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act – C'th) and the *Environmental Effects Act 1978* (EE Act – Vic) will be granted (refer to Section 1.1.2). Further environmental studies, involving bathymetric, aquatic flora and fish surveys, are currently being undertaken by NVIRP. The results of these studies will inform the seeking of the required approvals.

Monte Carlo and sensitivity analyses

Given the uncertainties surrounding estimates of quantities, values and costs, Monte Carlo Analyses were undertaken for high and low values of these estimates, as well as for the up-front capital costs (refer to Section 5 and Appendix A). The results obtained confirmed that Option 3 is the preferred option.

[2] Net present value equals the present value of benefits, minus the present value of costs.

In addition to these analyses, sensitivity analyses were undertaken for discount rates of 4 per cent and 8 per cent and for values of water savings of $2,000 per ML and $3,000 per ML. Option 3 remained the preferred option.

Project Risks and Alternatives

There are two main risks to implementing a modernisation plan for the SHIR, which applies to the three options selected for detailed assessment including the preferred Option 3. These relate to:

1. the inability to obtained the required approvals for environmental reasons with respect to lowering the LMW and the potential for conflict with the MMS project; and
2. the inability to obtain the funding required from the respective beneficiaries of implementing a modernisation option.

With respect to the second reason the main beneficiaries are NVIRP with respect to water savings and avoided modernisation costs ($7.2m), the MMS (DSE) with respect to avoiding a new outfall from Lake Boga ($5.7m), and G-MW with respect to avoided costs mostly associated with the ongoing operations of the LMW ($8.8m).

Supplementary Analysis

In the event that the required approvals to lower the LMW were not granted, a supplementary analysis was undertaken for this situation. Compared with Option 3, most of the water savings would not be realised and a new outfall would need to be constructed under the MMS. The NPV obtained as negative $8.6 million, compared with $4.2 million for Option 3.

Next Steps

Given that Option 3 has been identified as the preferred modernisation option, there are a number of steps that now need to be taken in order to achieve its implementation. These steps would apply to any modernisation option selected and include:

- finalising the environmental studies associated with the lowering the LMW and the potential for conflict with the MMS project;
- preparing referrals to gain the necessary approvals under the EPBC Act and the EE Act;
- conducting funding negotiations between the key beneficiaries from modernisation;
- undertaking consultation with key stakeholders using Option 3 as the basis for consultation; and
- completing the farm Irrigation assessments (FIAs) in the Tyntynder Flats Area and other areas serviced within the SHIR based on the implementation of Option 3.

As a result of undertaking these further steps, especially through feedback from stakeholders and the local community, NVIRP may decide to adjust aspects of Option 3. An adjustment which may be made from the perspective of NVIRP is the removal of the No. 9 Channel through the RCSH because its removal is not required to achieve NVIRP's modernisation objectives; nor would its removal contribute to achieving water savings.

Conclusion

Based on the analysis outlined above, Option 3 is the preferred modernisation strategy for the SHIR. The option clearly provides the highest net benefits and lowest overall cost per ML for water savings. Implementation of the option would involve:

- gaining the necessary environmental approvals to lower the LMW;
- resolving any potential conflicts with the MMS project;
- obtaining the funds required;
- achieving a reduction of 90 DS through the Connections Programs;
- gaining the support of stakeholders and customers;
- lowering the weir;
- truncating No. 9 Channel at Werrill Street and decommission the channel between Werrill Street and Karinie Street;
- installing a pipeline along Karinie Street to service the No.9 Channel north of Swan Hill;
- upgrading the No. 10 pump station; and
- building an interconnector channel between the No. 2/2/10 and No. 13/9 Channels.

It is considered that Option 3 provides the basis for the modernisation plan for the SHIR and accordingly, its implementation is recommended in accordance with the next steps outlined above. In making this recommendation, it is recognised that, through those steps, adjustments may be required for some aspects of Option 3.

1

Introduction

This Final Report presents a proposed Modernisation Plan for the Northern Victorian Irrigation Renewal Project (NVIRP) to reconfigure the irrigation system within the Swan Hill Irrigation Region (SHIR) of the Torrumbarry Irrigation Area (TIA). It is one of many initiatives of NVIRP which are being progressed to modernise the irrigation systems in northern Victoria with the aim of securing the economic, social and environmental future of the region.

The overall objective of the modernisation plan for the SHIR is to secure ongoing water savings through increasing the water delivery efficiency of the system and, by doing so, to facilitate improvements in the efficiency with which water is delivered to the customers. The plan presented has been developed based on a detailed analysis of the costs and benefits of a number of potential reconfiguration options compared with the current system.

The selection of the options and the analyses of the associated costs and benefits has been guided by a Reference Group established by NVIRP for the project (refer to Section 1.4). The plan also progresses the initial work of the Torrumbarry Reconfiguration and Asset Modernisation Strategy (TRAMS) to reconfigure the SHIR prior to the establishment of NVIRP.

1.1 Context

NVIRP was established in 2007 by the Victorian Government to determine and implement the required modernisation initiatives on a large scale across the Goulburn-Murray Irrigation District (GMID) — refer to Figure 2-1.[3] The aim of NVIRP is to achieve water savings of 425 GL, which will be pursued through two stages; 225 GL through Stage 1 and 200 GL through Stage 2. Victoria has allocated $1 billion of funds to Stage 1, which is to be completed in 2012. For Stage 2, agreement has been reached between Victoria and the Commonwealth to secure up to a further $1 billion of funds subject to the meeting of the due diligence requirements of the Commonwealth.

Water savings achieved through avoided losses will be made available for other uses including for the environment. Overall, the key focus of the modernisation initiatives is to reconfigure local distribution systems, including rationalisation of channels and farm outlets, to improve water delivery efficiency. The need to achieve water savings is also being driven by the current, prolonged period of significantly reduced rainfall.

An initial major step was the determination of the supply backbone for the respective irrigation areas and districts, which are shown in Figure 2-3 for the SHIR. Once determined, a number of modernisation programs are being progressed by NVIRP under Stages 1 and 2, namely:

- Channel Automation — installing automatic channel control gates to control water flows and to provide the ability to monitor flows 24 hours a day;
- Channel Remediation — undertaking remediation works to rectify structural weaknesses of channels in order to reduce seepage and leakage;
- Channel Lining — lining channels with clay or plastic to minimise the loss of water through seepage and leakage;
- Connections Program — this program involves connecting future customers, who are currently supplied from spur channels, to backbone channels (or other supply source); the program absorbs the previously existing Goulburn-Murray Water (G-MW) Reconfiguration Program; and

[3] NVIRP covers the Irrigation Areas of Torrumbarry, Pyramid Boort, Rochester, Murray Valley and Central Goulburn (except Central Goulburn 1, 2, 3 and 4) — the Shepparton Irrigation Area is not covered by NVIRP.

- Meter Replacement — replacing existing water meters with more accurate modern meters that comply with national metering standards.

Further to these main programs, and through the capability which they provide, NVIRP is pursuing a number of special projects relating to water savings, maximising environmental outcomes including minimising adverse environmental impacts, and service enhancement for customers. The later project, for example, is seeking to provide customers with shorter ordering times, and more constant, higher flow rates, which should enable them to achieve greater on-farm efficiencies.

Within these programs and projects, the modernisation plan for the SHIR falls mainly within the special projects for water savings and, to a lesser extent, service enhancement. However, there is a need to note that, in developing this plan, work by NVIRP in the SHIR is being progressed under its main programs.

1.1.1 Related studies and projects

The modernisation plan is also being progressed to build on the initial work of the Torrumbarry Reconfiguration and Asset Modernisation Strategy (TRAMS) to reconfigure the SHIR prior to the establishment of NVIRP. TRAMS commission a study, known as TRAMS Stage 1, into options for meeting the future service needs in the TIA was completed in 2007.

In addition to the initial work undertaken by TRAMS, the Mid-Murray Storage (MMS) Project is also directly relevant in considering potential options to reconfigure the Swan Hill Irrigation Region due to the use of natural waterways for irrigation purposes. The MMS project stems from the decision by the Victorian Government to decommission Lake Mokoan in order to secure water savings for environmental flows under the Snowy River and Living Murray Initiative projects through *the Mokoan – Return to Wetlands* initiative. It also involves the development of new storage operational arrangements for the Mid-Murray Storages of Lake Boga, Lake Charm, Kangaroo Lake and Kow Swamp.

When combined with these new operational arrangements, the water savings from decommissioning Lake Mokoan enabled an amendment to be made to the Bulk Entitlement Allocation for water under the *Water Act 1989*.[4] This amendment provided for an unregulated entitlement of 34.3 GL for the River Murray and a high-reliability water entitlement of 22.1 GL for the Snowy River.

1.1.2 Environmental impacts

The works undertaken to reconfigure the irrigation system could impact directly on the objectives sought through the MMS project. Should any of these involve Matters of National Environmental Significance (MNES) they would need to be referred to the Commonwealth under the *Environment Protection and Biodiversity Conservation Act 1999* (C'th) for consideration and approval. At this stage, no referrals have been made to the Commonwealth with respect to the SHIR modernisation plan. However, a referral is expected to be required in order to obtain the required environmental approvals to lower the Little Murray Weir (LMW) under this Act.

[4] Victorian Government Gazette, G48, 26 November 2009, pp 3051 – 3057.

In addition to the requirements of the Commonwealth, the Minister for Planning may require the preparation of an Environmental Effects Statement (EES) under the *Environmental Effects Act 1978* for project works, such as NVIRP, that could have a significant impact on the environment. Accordingly, a referral was made to the Minister on 20 February 2009. In the decision announced on 14 April 2009, the Minister stated that NVIRP did not need to prepare an EES for project works provided that it complied with certain conditions specified by the Minister.[5] Subsequently, the Minister for Planning approved the Environmental Management Plans of NVIRP for improving the health of rivers, wetlands and soils across northern Victoria on 20 April 2009.

The lowering of the LMW forms part of all the options selected for analyses and has the potential to cause significant environmental impacts. The assessment of these impacts is currently being pursued by NVIRP through a number of separate studies. Once these studies are complete, NVIRP will progress obtaining the required environmental approvals to lower the weir under the *Environmental Effects Act 1*978 and the *Environment Protection and Biodiversity Conservation Act 1999* as required.

In this situation, the analyses of the potential options presented in this report have been undertaken on the basis that these approvals will be granted. However, this may not be the case and a supplementary analysis has been undertaken for this potential situation.

1.1.3 Delivery shares

Delivery shares were created on 1 July 2007 as part of the process of the Victorian Government to "unbundling" the then existing water entitlements into three separate elements, namely:

- a water share expressed either as a High Reliability Water Share (HRWS) or Low Reliability Water Share (LRWS);
- a Delivery Share (DS) — the DS created provided for the delivery of a megalitre of water a day for each 100 ML of water entitlement held; and
- a water-use licence.

Unbundling separated water from the land. As a consequence the ownership of a water share carries no rights for water to be delivered. Such delivery rights are now managed through DSs, which are known as the currency of reconfiguration. Hence, following the unbundling of water entitlements, a change now in HRWS/LRWS or DS will not necessarily be reflected by a corresponding change in the other.

For this project, the required channel capacities have been assessed according to expected future DSs that will need to be serviced within the SHIR. The expected future DSs were established by NVIRP under its Connections Program and provided to URS for analysis purposes.

1.2 Project Objectives

Given the overall objectives being pursued by NVIRP through its modernisation programs, the objective of this project is to build on the previous work of TRAMS to determine the actions required to reconfigure the irrigation infrastructure of the SHIR to best meet future demands on the irrigation network, namely the LMW and the No. 9 and No. 10 Channel systems (refer Figure 2-3, Figure 2-4 and Figure 2-5).

[5] Decision of the Minister for Planning under the *Environmental Effects Act 1978* in response to Referral Number 2009-01, dated 20 April 2009.

The actions are to form a Modernisation Plan, determined by taking into account key aspects of the network, as well as recent changes in land-uses and other developments in the region. Aspects which were to be assessed included:

- the future operation of the LMW, given that the weir is reaching the end of its physical life and the existence of significant OH&S risk associated with its current operations;
- if the LMW were to be lowered, to identify an alternative water supply source to meet current customer demand (including for those supplied directly from the LMW pool), as well as the infrastructure required to meet the environmental objectives of the MMS project;
- the operation of the open, irrigation supply channel (the No. 9 Channel) through the Rural City of Swan Hill and whether the presence of such a channel would be acceptable from a public health and safety perspective;
- if the No.9 Channel were removed, to identify an alternative water supply option in order to meet future DS demand for the No. 9 Channel north of Swan Hill;
  - the No.9 Channel could be removed by truncating it south of Swan Hill or by piping through Swan Hill;
- the impact on channel capacity requirements of past changes in the volume of irrigation water that now needs to be delivered to meet current DS demand, or adjusted DS demand arising from the Connections Program, and whether that capacity should be adjusted;
  - this aspect is particularly relevant to the supply of irrigation water to the Tyntynder Flats area and the far (northern) reaches of the No. 9 Channel, where the objective under the Connections Program is to remove 85-90 DS and avoid the need to upgrade the No.10 Pump Station; and
- overall, the potential water savings associated with reconfiguring the existing irrigation infrastructure.

Because of the linkages between the components, these aspects are to be considered together to develop an overall Modernisation Plan for the SHIR. By doing so, the preparation of the plan will also help inform the processes for obtaining the environmental approvals that may be required under the *Environment Protection and Biodiversity Conservation Act 1999* and the *Environmental Effects Act 1978* (refer to Section 1.1.2). This plan is also to be developed, and is to contain the required information and rigour of analysis, to meet the Business Case requirements of the Victorian Government and the due diligence requirements of the Commonwealth under its *Sustainable Rural Water Use and Infrastructure Program*.

1.3 Approach and Study Phases

The overall approach used was to undertake a Benefit Cost Analysis (BCA) of the shortlisted, reconfiguration options in order to determine the best option from the perspective of wider community rather than a particular sector such as irrigators. Such analyses are an integral part of the Victorian and Commonwealth Governments requirements that have to be met. They involve comparing, in a consistent and transparent way, each option with the current situation known as the base case or “business as usual”. This comparison enables the option which is able to secure the greatest benefits at least cost to the wider community to be identified.

To increase the robustness of the analyses, potential sources of uncertainty in the estimates of the costs and benefits were explored through a probabilistic approach using Monte Carlo simulations.

In addition, sensitivity analyses were also undertaken for the discount rate and value of water savings to assess the influence of these key variables on the relative costs and benefits of the potential options. In addition to these economic considerations, assessments of the social and environmental implications of the options were also undertaken.

In the case of the environmental implications, the assessment undertaken for this project is limited as the required information is being obtained by NVIRP through further environmental studies which are not yet complete. Accordingly, as stated above (refer to Section 1.1.2), the potential options have been analysed on the basis that the required environmental approvals will be granted. However, since the granting of these approvals may not occur, a supplementary analysis has been undertaken for this situation.

The project was pursued through four study phases which were:

- **Phase 1: Definition of project scope and development of analytical framework**. Key aspects of this phase included defining the base case and, in doing so, developing the criteria with which to select potential reconfiguration options;
- **Phase 2: Development of potential reconfiguration options**. This phase involved developing potential options, based on the selection, for each of the three components of the Swan Hill Irrigation Region, namely the LMW, No. 9 Channel system and the No. 10 Channel system which included land-use change in the Tyntynder Flats. A preliminary BCA was undertaken for these options in order to identify which options should be selected for more detailed analyses from the perspective of each component and the irrigation system as a whole;
- **Phase 3: Detailed assessment of selected options**. This phase involved identifying a preferred option through undertaking a detailed BCA of three options that were selected for further evaluation through Phase 2, as well as an assessment of the social and environmental considerations of the options; and
- **Phase 4: Development of a Modernisation Plan**. Given the key features of the preferred option, this phase involved undertaking a review of potential funding sources and an assessment of the risks that could impact on the successful implementation of the option. A supplementary analysis was also undertaken to assess the implications in the situation that approval to lower the LMW is not be received.

The work undertaken for Phase 2 was reported in a Position Paper prepared on 16 October 2009 and that for Phase 3 in a Draft Options Report on 15 December 2009. Both these documents represented “work-in-progress”. Comments received on these documents (including those from an independent reviewer for the Options Report) have been incorporated in this report, which forms Phase 4 of the project.

1.4 Project Reference Group

To guide the development ultimately of the Modernisation Plan, a Project Reference Group (PRG) was established by NVIRP. Members of the Group were drawn from the following organisations:

- NVIRP (2 members);
- G-MW (2 members);
- TRAMS Committee (2 members);
- Department of Sustainability and Environment (DSE);
- Department of Primary Industries;

- Swan Hill Rural City Council (SHRCC); and
- North Central Catchment Management Authority.

Through NVIRP, feedback on the development and detail of the Modernisation Plan was also provided to the Torrumbarry Irrigation System Consultative Committee (TISCC). This committee was established to integrate the various water management issues within the TIA and is convened by the DSE. In addition, the Technical Advisory Group (TAG) and Technical Advisory Committee (TAC) of NVIRP are aware of the project and will be involved with ongoing aspects of the project. For TAG, these aspects will be largely concerned with technical issues associated with the Connections Program and, for TAC; the further environmental studies for the LMW (refer to Section 2.7).

NVIRP convened four meetings of the PRG which were held on the 17 July 2009, 28 October 2009 (to discuss the Position Paper noted above), 18 December 2009 (to discuss the Draft Options Report), 31 March 2010 (to discuss a draft of this final report). Feedback from these meetings has been incorporated into this report. In addition a progress report was presented to the 11th meeting of TISCC which was held on 8 December 2009.

1.5 Report Outline

Presented in Section 2 is background information about the Swan Hill Irrigation Region and the wider TIA. Contained in Section 3 is a description of the current irrigation configuration or base case. Section 4 describes the potential reconfiguration options and presents the results of the preliminary assessment of those options which were used to select the options for detailed analysis. This detailed analysis is presented in Section 5.

Presented in Section 6 is the Modernisation Plan for implementing the preferred option and includes an assessment of the risks to the successful implementation of that option. Section 7 presents the results of a supplementary analysis covering the situation that the required approval to lower the LMW is not received. A summary of the findings in preparing a Modernisation Plan, together with the potential next steps in implementing the Plan, is presented in Section 8.

2

The Swan Hill Irrigation Region: Background

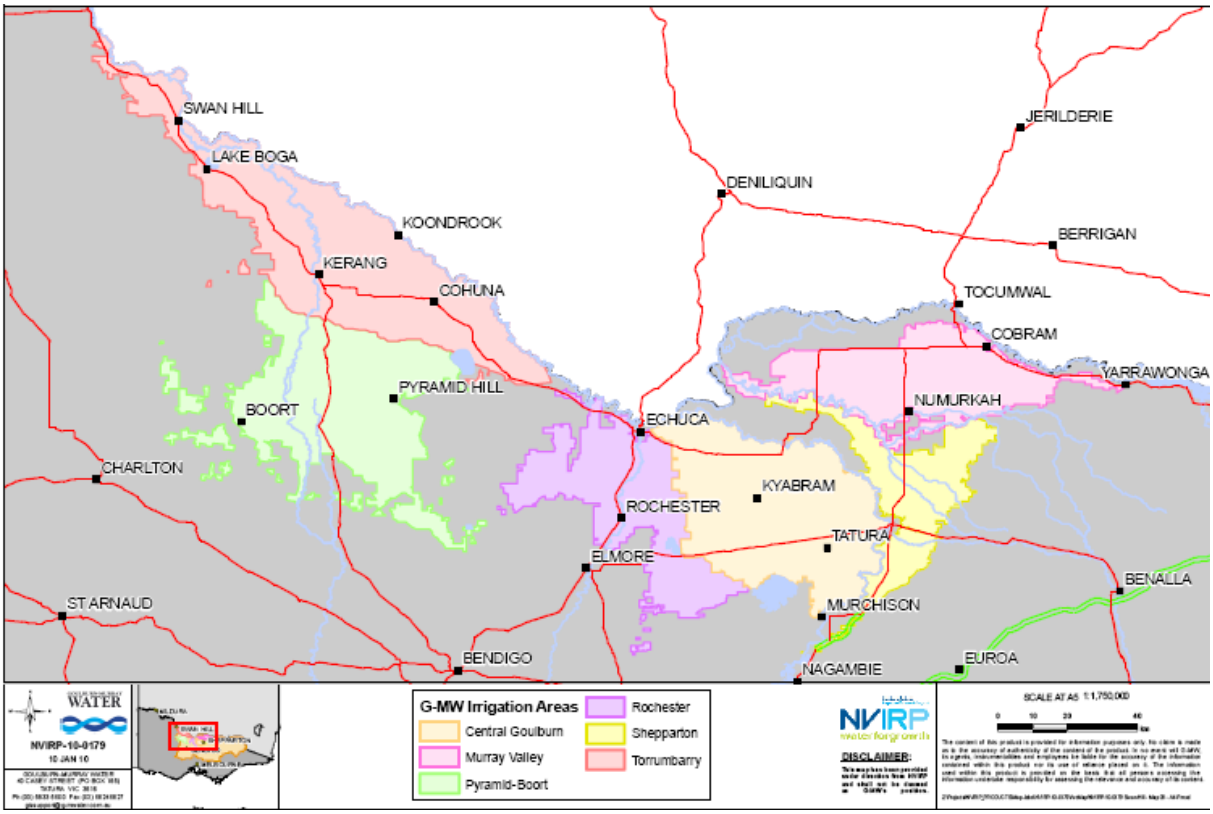
2.1 Characteristics of the Study Area

The Swan Hill Irrigation Region includes Woorinen (which is part of GMID though it is not considered to be part of the TIA) and comprises some 31,480 ha, servicing a range of agricultural enterprises including horticulture, dairy, cattle and lamb production. The study area sits within two local government areas – Swan Hill and Gannawarra. The Rural City of Swan Hill in 2006 had a population of 9,704 people, with another 11,048 people living in surrounding areas of the city within the local government area of Swan Hill. Further south-east is the local government area of Gannawarra, which had a population of 10,898 in 2006. The populations of both local government areas have changed little since 1996 – Gannawarra's population has fallen by 0.9 percent a year on average, while Swan Hill grew by 0.2 percent a year.

Much of the area's working population (25 percent) is engaged in agriculture, forestry or fishing, whilst another 11 percent is employed in retail trade. Manufacturing (9 percent) and health care and social assistance (9 percent) are also important industries in the region[6]. The area is also popular for recreational activities such as camping, fishing and waterskiing. The Kerang Lakes, which lie between Kerang and Swan Hill, are an important wetland habitat, as well as providing irrigation water storage[7].

Details of the GMID are presented in Figure 2-1, the TIA in Figure 2-2 with key features of the Swan Hill Irrigation Region, or Study Area, in Figure 2-3.

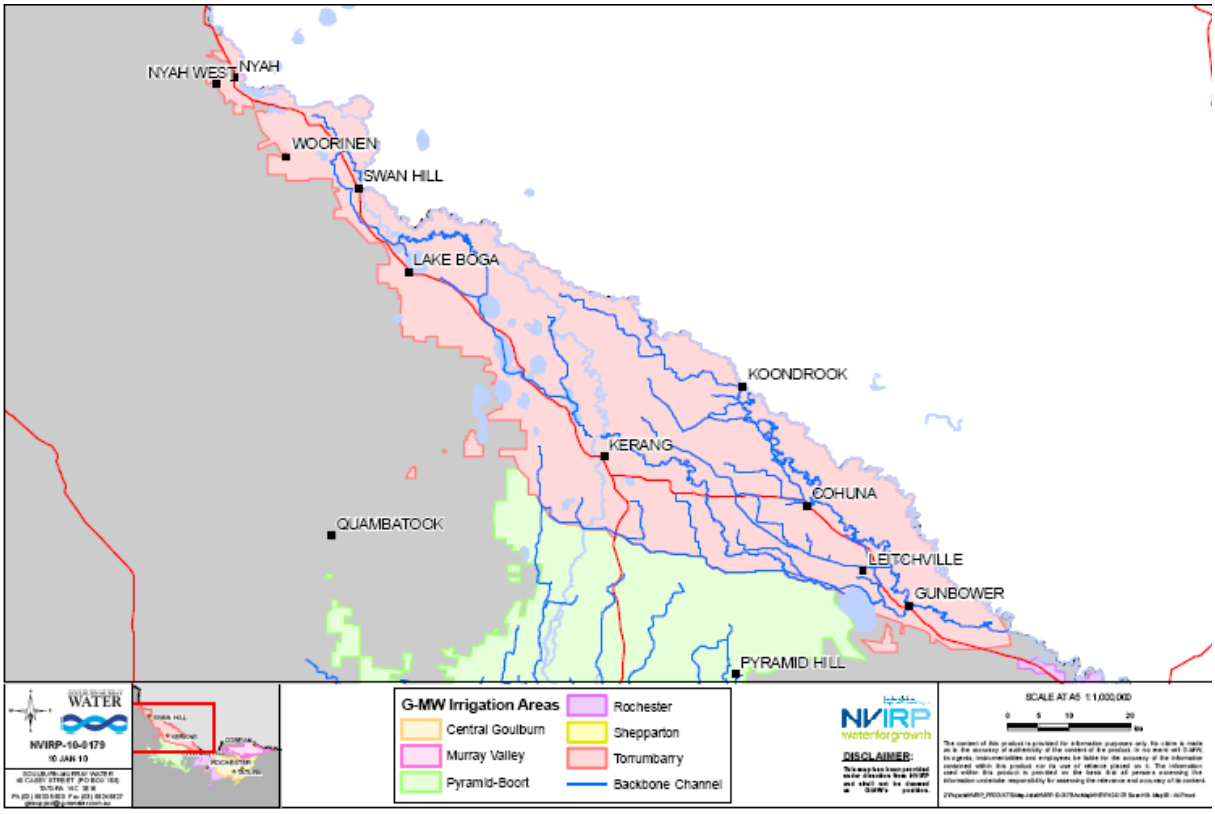
Figure 2-1 Goulburn-Murray Irrigation District



[6] Australian Bureau of Statistics (2007), 'Census of Population and Housing', available: www.censusdata.abs.gov.au, accessed 1/3/2010.
[7] Kerang Online Pty Ltd 2007, 'Attractions – Kerang Lakes System', available: http://www.kerangonline.com.au/kerang_lakes_system/, accessed 1/3/2010.

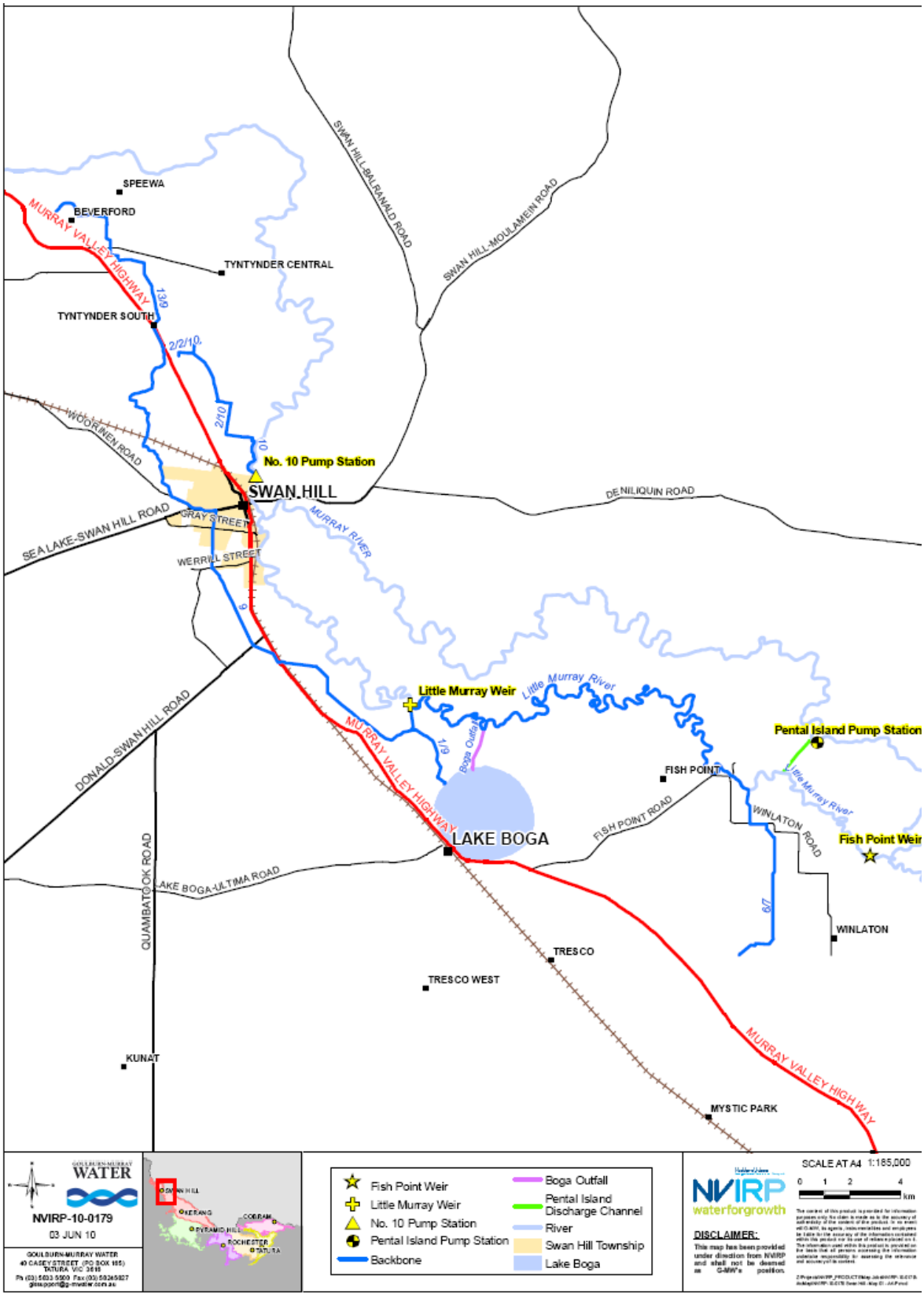
2 The Swan Hill Irrigation Region: Background

Figure 2-2 Torrumbarry Irrigation Area



2 The Swan Hill Irrigation Region: Background

Figure 2-3 Key Features of the Swan Hill Irrigation Region



2.2 The Supply System

The supply system for the Swan Hill Irrigation Region consists of two major channels, known as the No. 9 Channel and the No. 10 Channel. The No. 9 Channel is the major supply channel running south to north through the study area. This channel commences at, and is gravity feed with water from, the Little Murray Weir (LMW) on the Little Murray River. The No. 10 Channel system is supplied from a pump station on the River Murray at Swan Hill and delivers water to the Tyntynder Flats area located north of the Swan Hill urban area.

The Tyntynder Flats were originally supplied from the No. 9 channel (i.e. from both the No. 9 and No. 10 channels) and this explains why it is possible to reconnect the No. 9 and No. 10 systems. It also partially explains why the No. 9 channel has a much larger capacity than is required.

These channel systems were originally designed to supply downstream water rights in 100 days at a channel efficiency of 60 - 70% but were not originally designed to be supplied from the No. 10 pump stations, therefore the No. 9 channel is much larger than required.

2.2.1 The Little Murray River

The Little Murray River acts as an anabranch of the River Murray and Loddon River complex and commences near the confluence of the Loddon River and the River Murray and extends downstream to Swan Hill where it rejoins the River Murray. The Little Murray River forms Pental Island between the rivers and is the primary supply conduit to the No. 9 distribution system that supplies customers south and north of Swan Hill. It is also a direct source of supply for a number of other customers that divert from the LMW pool.

The Pental Island Pump station (PIP), which can pump water direct from the River Murray, augment the supplies from the No. 6/7 Channel that flows from Kow Swamp via the Kerang Lakes. This channel is supplied from the Torrumbarry No. 7 Channel near the northwest end of Lake Tutchewop. When flows are sufficiently high in the River Murray, water will also enter the Little Murray River through the Fish Point Weirs (FPW).

2.2.2 The Little Murray Weir and Weir Pool

The Little Murray Weir

Situated on the Little Murray River north of Lake Boga, the LMW was constructed to raise the water level of the Little Murray River to allow gravity feed to the No. 9 Channel which at that time serviced Swan Hill, Tyntynder Flats and Woorinen Irrigation Regions. Originally constructed in the early 1900's, the weir was significantly upgraded in 1928 and the butterfly doors were replaced by drop bars in the 1980's. During 1995/96 the weir almost failed after a six metre deep scour-hole downstream of the weir extended under the apron (undermined to 30%) with repairs in 1997 to stabilise the structure.

The current concrete structure of the weir is 110 m across with 28 bays, six of which were recently fitted with automatic doors with the remainder being manual drop bars. Each of the bays is 3.6 m wide and 2.5 m deep. The removal of the drop bars during a flood poses significant OH&S risks. The replacement of the remaining drop bars with automatic gates is estimated by G-MW to cost in excess of $1 million. The MDBA has had to address a similar risk to their weirs on the River Murray and the MDBA has subsequently modified the River Murray Locks for this reason.

2 The Swan Hill Irrigation Region: Background

The crest of the LMW on the Little Murray River operates to provide a supply level of 69.21m AHD, which results in the formation of the LMW pool. The weir pool extends some 39 km upstream to the Fish Point Weir, supplying some 15 diverters and 22 irrigators in addition to the No. 9 Channel.

Lake Boga

There is also an open channel connection between the LMW pool and Lake Boga through which flows have been delivered to the lake in past years. The current agreed full supply level of Lake Boga is 68.50 m AHD, however this will increase to 69.50m AHD under the MMS project.

Based on available information, the water in the weir pool has a greater depth of water (up to six metres), and is reported to be an ideal habitat for native fish species.

Pental Island Pumps

The PIP was constructed in the 1970's to augment supplies to the Little Murray Weir Pool in periods of peak demand within the Torrumbarry System, or when the Loddon or Avoca Rivers are in flood and water quality deteriorates in the Kerang Lakes to such an extent that supply to the weir pool from the No. 6/7 Channel is unacceptable. The pump station is also used if there are blue green algae blooms in the Torrumbarry system.

It is reported *(G-MW TATDOC #2471300)* that over the past 20 years the station would have been used on very few occasions (G-MW advise less than 10) and for limited periods. With the recently constructed salt interception works on the Pyramid Creek and the construction of an isolation weir on the Barr Creek it is expected that its use in future will reduce further.

This pump station consists of four, vertical lift, low-head pumps with a peak capacity of 536 ML/d. The pumps discharge to an open channel which traverses Pental Island and discharges to the LMW Pool.

Fish Point Weirs

The Fish Point Weirs (FPW) are significant structures on the Little Murray located at the upper end of the Little Murray River, immediately downstream of the Loddon River confluence. . Since the failure of an earlier structure which was decommissioned and replaced with an earthen bank, the FPW now consists of two weir structures and an earthen bank. The two remaining weir structures comprise a drop bar structure that spans the Little Murray River and also a substantial door structure.

The purpose of FPW is to isolate the Loddon River and saline Barr Creek flows from the Little Murray Weir pool, however in times of flood, the weirs are overtopped or bypassed and salt slugs can enter the weir pool which can have a major impact on water quality for Swan Hill irrigators. During flood events it is not uncommon for the LMW pool to be flushed using the PIP in an endeavour to remove salt slugs or, in more recent times, blue green algae contaminated water.

With a lower LMW pool, there will be less buffering in the Little Murray River and FPW will be highly important in salinity management.

2 The Swan Hill Irrigation Region: Background

2.2.3 The No. 9 Channel System

The No 9 Channel is the major irrigation carrier servicing the Swan Hill Irrigation Region. The channel commences at the LMW and terminates at Tyntynder homestead near the River Murray, a total channel length of 23 km plus its spurs. In the early 1960's, as part of the modelling of the Torrumbarry Irrigation System, the Tyntynder Flats area was removed from the No. 9 Channel and supplied from a pump station on the River Murray which is currently known as the No. 10 system. This had the effect of reducing the demand on the No 9 Channel and allowed a significant section of the channel through the Swan Hill residential area to be removed.

The supply of water directly from the River Murray through the No. 10 Pump Station also had the effect of reducing the rationing that had been necessary due to capacity constraints further upstream in the TIA. As a consequence, the cost of the No. 10 Pump Station is borne by all TIA customers.

Later in 2004, the Woorinen Irrigation Region, also originally supplied from the No. 9 Channel, was piped and supplied directly from the River Murray. As a result, the demand on the No. 9 Channel was further reduced. In addition, Transferable Water Entitlements, which were introduced in the late 1980's, contributed to more reductions in demand on the channel.

The original design capacity of the offtake for the No.9 Channel at the LMW was 500 ML/d. However, because of the above developments and their associated reduced demands, the maximum current operating flow is around 270 ML/d.

A significant aspect of the No. 9 Channel is that it passes through the Rural City of Swan Hill as an open waterway; there are substantial residential and rural residential developments adjacent to the channel north of Werrill Street. The open waterway poses a risk to the heath and safety of Swan Hill residents and visitors. In the past 30 years, three people have drowned in the channel. It may also have an adverse effect on the aesthetic and overall amenity of Swan Hill, which the community may regard as being unacceptable. The reconfiguration of the No. 9 Channel from an irrigation modernisation perspective also provides the opportunity to address these wider issues.

Upstream (south) of Swan Hill (Little Murray Weir to Werrill Street)

The No. 9 Channel supplies adjacent customers and spur channel systems Nos. 1 to 7 before reaching the southern urban area of Swan Hill at Werrill Street. Spur Channels 8A/9 and 9/9 (refer to Figure 2-6) supply small holdings in, and adjacent to, these urban areas of Swan Hill. Characteristics of the No. 9 Channel from its offtake at the LMW to Werrill Street in Swan Hill are summarised in Table 2-1:

Table 2-1 Characteristics of the No. 9 system upstream of Swan Hill

Length	*11,295 m*
Channel Capacity at Offtake:	*500 ML/d*
Actual Operating Capacity (in 1991)	*480 ML/d*
Maximum Current Operating Flow	*270 ML/d*
Channel Bank Condition	*ACR 3 and 4 **

** ACR = Asset Condition Rating – a means of denoting the condition of an asset using a scale of 1 to 6 in which "1" indicates the as-new condition and "6" indicates unserviceable and due for immediate replacement.

2 The Swan Hill Irrigation Region: Background

Within Swan Hill (Werrill Street to Karinie Street)

Between Werrill Street to Gray Street (refer to Figure 2-6) several customers are serviced directly from the No. 9 Channel. The only land supplied to the east of the No. 9 Channel is served from a Large Meter Outlet immediately to the north of Werrill Street near where the street crosses the channel.

Some of these customers may have alternate water supplies from Lower Murray Water. It is assumed that retention of a raw water supply would be desirable but should be funded by the proponents of land development.

There are no customers served from the reach of the No. 9 Channel between Gray St and McCallum Street (refer to Figure 2-6). The reach from McCallum Street to Karinie Street has pumps and outlets generally throughout the channel on both sides including the Mortoo Street pumps which are located just north of McCallum Street. The land east of the No. 9 Channel is zoned Industrial or Low Density Residential, and the land to the west is zoned Rural Living.

Much of the land supplied by the No. 8A/9 and 9/9 Channels is currently zoned Rural, but it is expected that it will be rezoned Low Density or Residential 1 by the SHRCC as part of its South West Swan Hill Outline development Plan (refer to Figure 2-6). This would mean that all the land supplied by these two spurs would be Low Density Residential Zone (LDRZ) or similar. It is believed that any re-zoning in itself will not change the raw water supply arrangements for properties in these areas as water shares belong to property owners and are not associated with the zoning of the land in which properties are located.

Downstream (north) of Swan Hill (Karinie Street to termination of No. 13/9 channel)

The maximum capacity of the No. 9 Channel at Karinie Street is understood to be 300 ML/d. The No. 9 Channel downstream of Swan Hill supplies:

- the area generally north west of the urban area from Spur Channels Nos. 11, 12, and 14/9 and terminates near Woorinen to the west (refer to Figure 2-7); and,
- the area to the north of Swan Hill via the No 13/9 Channel (refer to Figure 2-4 and Figure 2-7).

The characteristics of (former) Pods[8] T09P2 and T09P3 are summarised in Table 2-2 and are provided in more detail in the Torrumbarry Pod Overview Plans (SKM, 2009) available separately.

Table 2-2 Characteristics of Pods T09P2 and T09P3

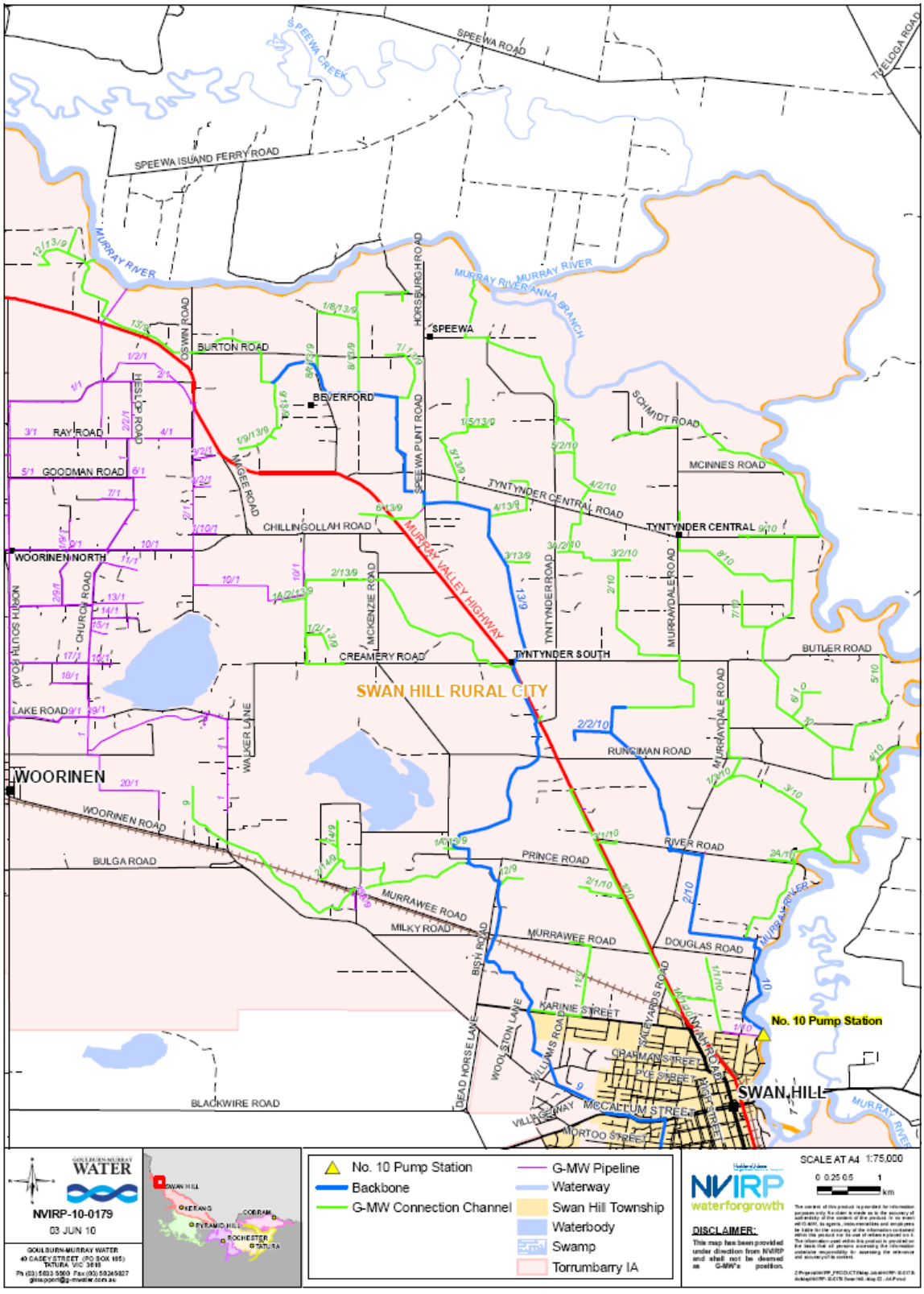
Description	*T09P2*	*T09P3*
Length of Channel	*18.8 km*	*40.9 km*
Number of Services	*85*	*114*
Water Available (06/07)[1]	*4,109 ML*	*8,970 ML*
7-year average water use per outlet	*35 ML/outlet (TIA 115ML/outlet)*	*52 ML/outlet*
Estimated Losses[2]	*2,723 ML/year*	*6,841ML/year*
Delivery Efficiency	*62%*	*61%*
Enterprise Type	*Irrigated and other farming*	*Irrigated farming*
Delivery Shares (DS)	*60*	*98*

1. Water entitlements (including domestic and stock) adjusted for temporary water trades
2. Evaporation, leakage, seepage, system filling, meter outlet measurement error, outfalls.

[8] A pod is a spatial grouping, typically comprising 20-40 properties and the associated channel systems.

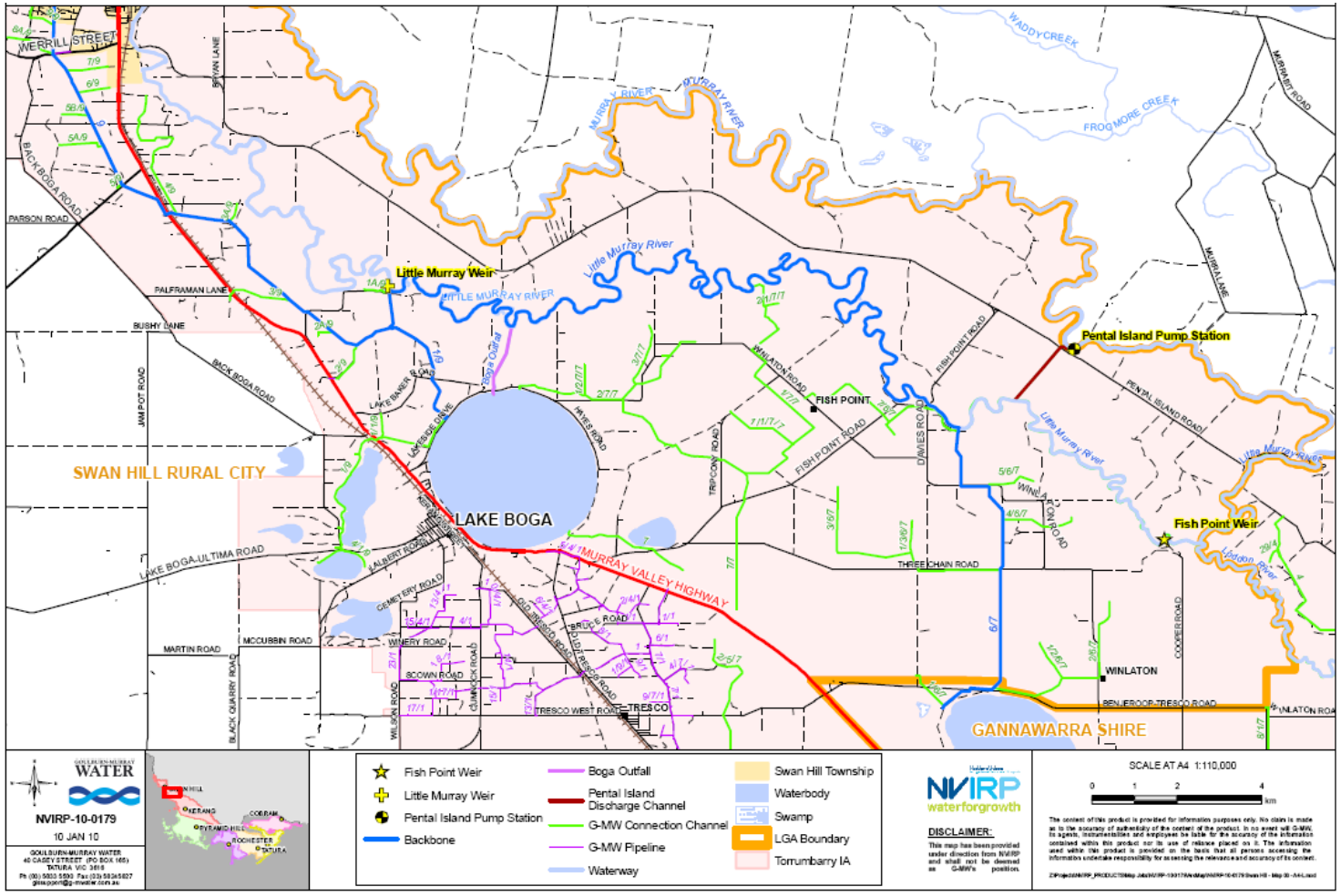
2 The Swan Hill Irrigation Region: Background

Figure 2-4 Key Features of the Swan Hill Irrigation Region – Northern Section



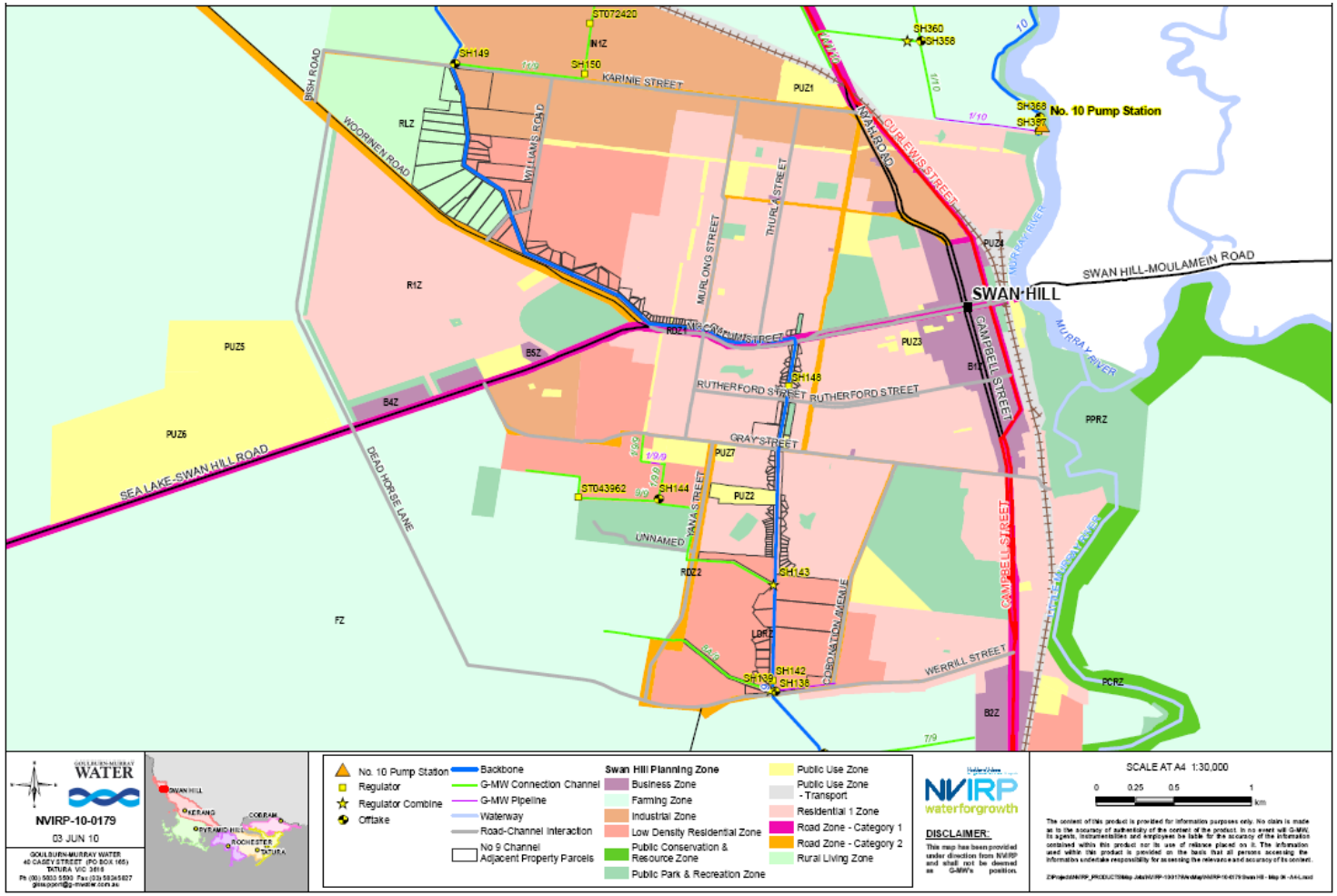
2 The Swan Hill Irrigation Region: Background

Figure 2-5 Key Features of the Swan Hill Irrigation Region – Southern Section



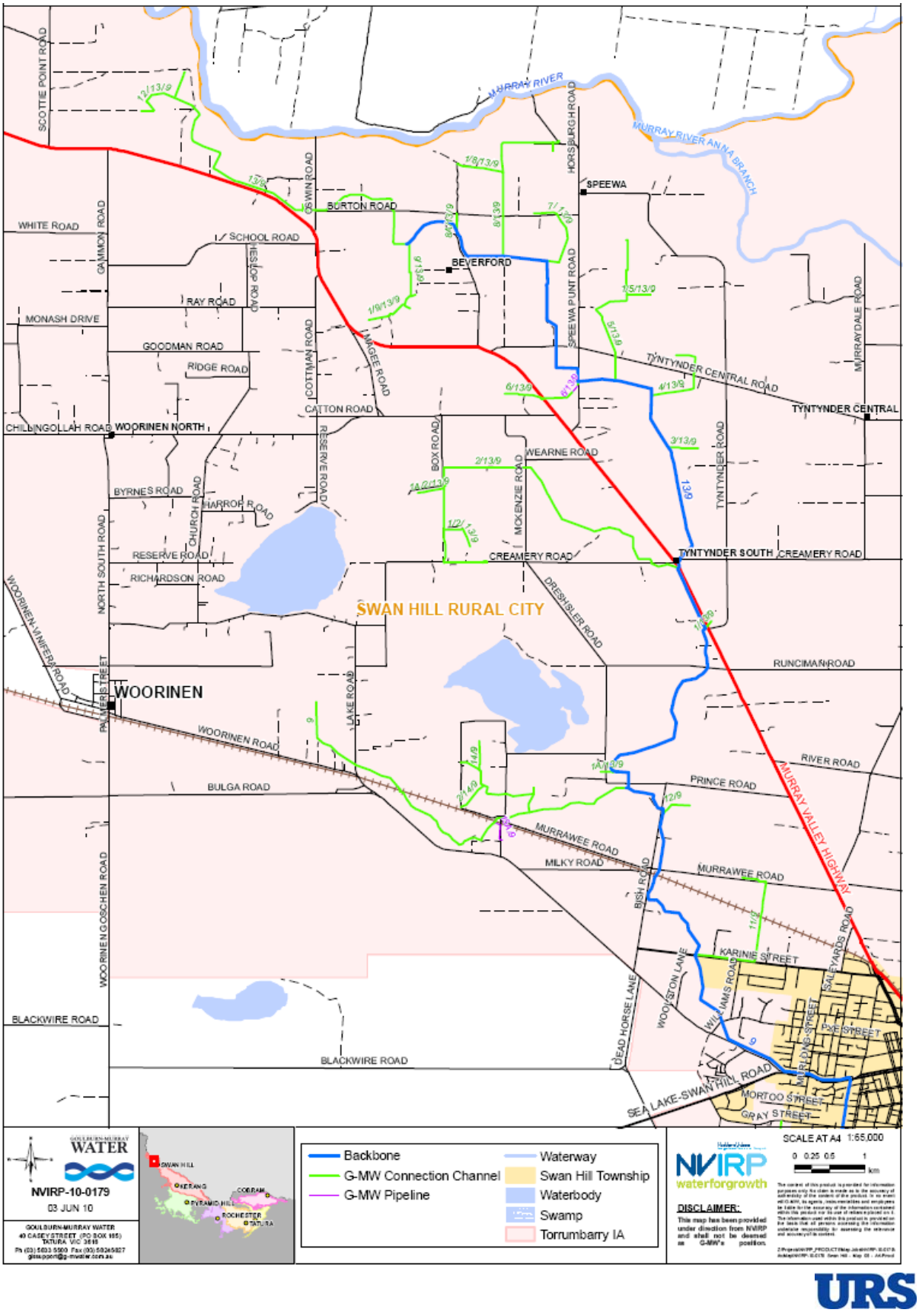
2 The Swan Hill Irrigation Region: Background

Figure 2-6 Swan Hill Township - Properties Adjacent No. 9 Channel and Planning Zones



2 The Swan Hill Irrigation Region: Background

Figure 2-7 Swan Hill Irrigation Region – No 9. Channel System – Northern Section



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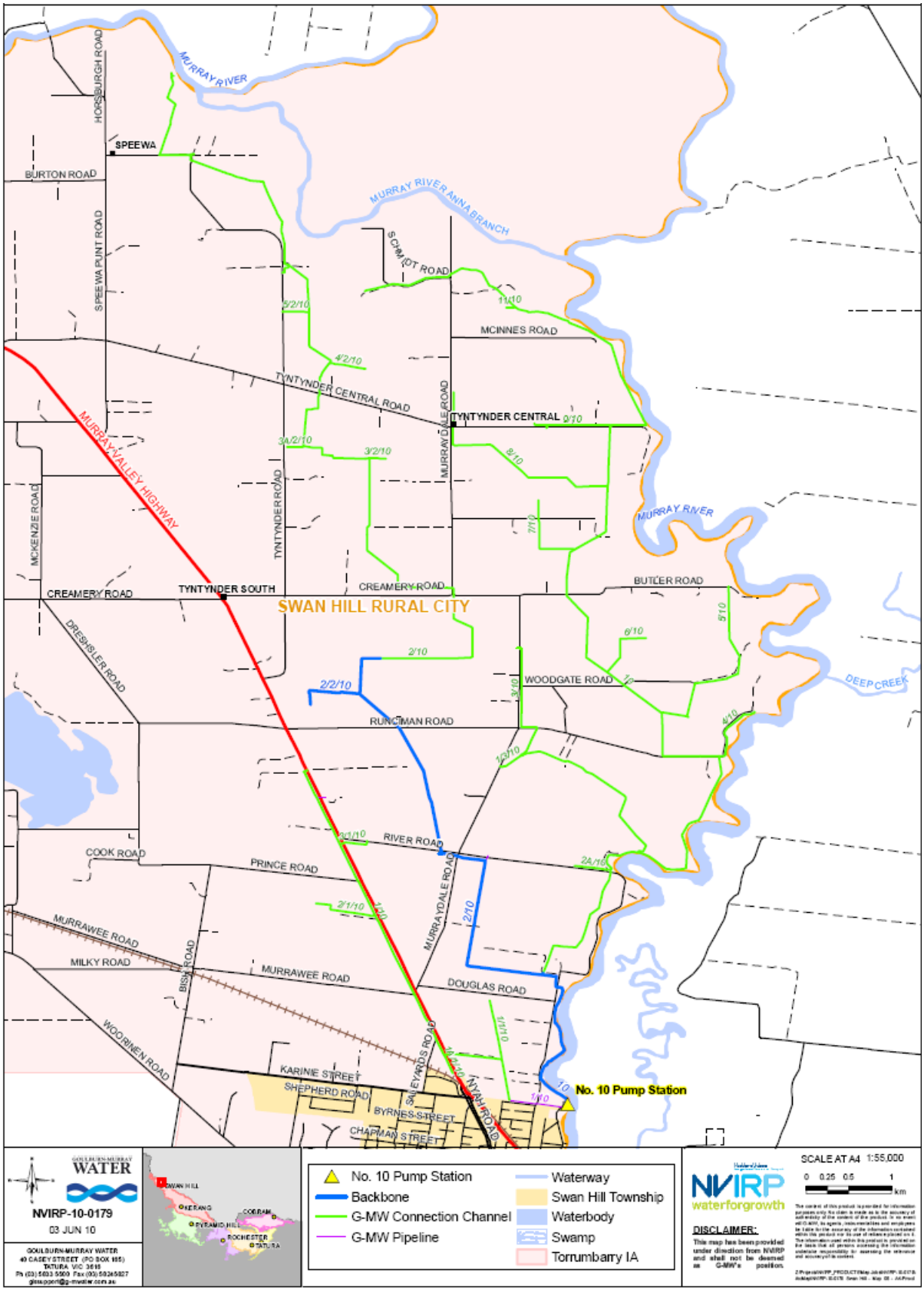
2 The Swan Hill Irrigation Region: Background

Figure 2-8 Swan Hill Irrigation Region – No. 10 Channel System



2 The Swan Hill Irrigation Region: Background

2.2.4 The No. 10 Channel System

No. 10 Pump Station

The No. 10 channel system, which serves the Tyntynder Flats area to the north of the Rural City of Swan Hill, is supplied from the No. 10 Pump Station on the River Murray just north of the city. Current peak flow requirements are estimated at 160 ML/day, which is well within the operating capacity of 300 ML/day for the three pumps. These pumps are two speed (high and low), each with a different flow rate, and are designed only to lift water from the River Murray to a pool from which water is distributed by gravity via the No. 10 Channel distribution system to the Tyntynder Flats area. A control system for the pumps operates to maintain the pool level and minimise any outfalls directly back to the River Murray.

As discussed in Section 2.5, an objective of NVIRP's Connection Program is to remove some 90 DS from the Swan Hill Irrigation Region. The removal of this DS from the No. 10 Channel system and the downstream reaches of the No. 9 Channel system would facilitate re-arrangement of the supply systems supplying the area north of Swan Hill without any need to increase the current capacity of the No. 10 pump station.

No. 10 Distribution System

The Tyntynder Flats area is serviced predominately by the No. 10 channel (former Pods T10P1 and P2), shown in Figure 2-8. The characteristics of these former pods are shown in Table 2-3 and are provided in more detail in the Torrumbarry Pod Overview Plans (SKM, 2009), available separately. The original offtake design capacity of the channel at the No. 10 pump station was 300 ML/d. Based on changes in demand, the maximum daily capacity now required has been reassessed by G-MW *(G-MW DOC# 2408142)* to be 160 ML/d.

Table 2-3 Characteristics of Pods T10P1 and T10P2

Description	*T10P1*	*T10P2*
Length of Channel	*28.7*	*29.8*
Number of Services	*55*	*89*
Water Available (06/07)[1]	*5,178 ML*	*6,698 ML*
7-year average water use per outlet	*60 ML*	*64 ML*
Estimated Losses[2]	*5,091 ML pa*	*5,026 ML pa*
Delivery Efficiency	*58%*	*65%*
Enterprise Type	*Irrigated farming*	*Irrigated farming*
Delivery Shares (DS)[3]	*62 ML/d*	*78 ML/d*

1. Water entitlements (including domestic and stock) adjusted for temporary water trades
2. Evaporation, leakage, seepage, system filling, meter outlet measurement error, outfalls.
3. At November 2008 (NVIRP)

2.3 Water Share Trends

No. 9 Channel

In 1991, the area served by the No 9 Channel system excluding the Woorinen Irrigation Region had a total Water Right of 29212 ML *(G-MW Doc# 2429066 v2, refer Appendix B)*. In addition Domestic and Stock (D&S) entitlements were held for 1,621 ML. As a result of unbundling in 2007, these two components of an entitlement were combined into High Reliability Water Share (HRWS). *Note – Water Right and D&S together comprise water share – DS and WUL (Water Use Licence) are different*. In 1991, the HRWS equated to 30,833 ML for the No. 9 Channel system. The changes to water shares that have occurred since 1991 are illustrated Table 2-4.

Table 2-4 Water Share Changes – No 9 Channel

Date		*HRWS*
1991	*Equivalent HRWS No 9 Channel System – Woorinen excluded*	*30,833 ML*
2008	*HRWS No 9 Channel System*	*28,015 ML*
	Change in HRWS (from 1991 to 2008)	*- 2,818 ML*
		- 9.1%

No. 10 Channel

Similarly, in 1991, the area served by the No. 10 Channel system had a total Water Right of 15,957 ML *(G-MW DOC# 2429066 V2).* In addition to that were D&S entitlements totalling 885 ML. In 2007, these two entitlements were similarly combined into a HRWS which in 1991 would have equated to 16,842 ML for the No. 10 Channel system. The changes to water shares that have occurred since 1991 are presented in Table 2-5. The reduction of around 20% since 1991 is significant. Sufficient data is not available to determine whether the reduction has been more rapid in recent years.

Table 2-5 Water Entitlement Changes – No 10 Channel

Date		*HRWS*
1991	*Equivalent Water Share No 10 Channel System – Woorinen excluded*	*16,842 ML*
2009	*HRWS No 10 Channel System*	*13,500 ML*[1]
	Change in HRWS	*- 3,342 ML*
		- 19.8%

1 An approximate figure obtained in discussion with Peter Koetsveld, Assistant Operations Manager, Torrumbarry Irrigation Area, G-MW.

2.4 Delivery Shares

As discussed in Section 1.1.3, a Delivery Share (DS) is an entitlement to have water delivered to land in an irrigation district and a share of the available water flow in a delivery system. They were created in July 2007 as part of the process of unbundling the Water Entitlements held by properties at that time.

As DS did not exist as such in 1991, and since there is no data readily available on DS changes since 2007, no comment on DS trends is offered. It is however, reiterated that a change now in HRWS/LRWS or DS will not necessarily be reflected by a corresponding change in the other.

2.5 NVIRP Modernisation Programs

As stated in Section 1, NVIRP has already commenced two programs of work that are being implemented for the Swan Hill Irrigation Region (SHIR) and other irrigation regions within the GMID, namely the Automation Works Program and the Connections Program. In the case of the Automation Works Program, which involves the installation of automatic gates to control water flows in the main carrier and trunk channels such as the No. 9 Channel, this has been placed on hold pending the outcomes of this project because of the potential impact on the number and size of the automatic gates that will be required. Nevertheless, because automatic gates will be installed by NVIRP in the SHIR, this means that the automatic gates should be viewed as part of the existing irrigation supply system for this Region; that is, they form part of the base case.

Regarding the Connections Program, NVIRP has advised that this program will be implemented to achieve the future removal of 90 DS from the SHIR. Of these, 40 DS will need to come from the No. 9 Channel System and 50 DS from the No. 10 Channel System. This change in DS will also be viewed as part of the existing irrigation system (or base case) for the SHIR. It should be noted that there is no cost impact to the Swan Hill Irrigation Project (SHMP) recommended option for this i.e. it is part of the base case.

However, there is a need to note that should the desired reduction in DS not be achieved, this could impact on the analysis undertaken to determine the preferred option for reconfiguring the SHIR. NVIRP is responsible for securing the 40 DS and 50 DS in their other programs.

2.6 Lake Boga and the Mid Murray Storage

Lake Boga is the most northerly of the Kerang Lakes. At overflow level, it has a surface area of approximately 950 ha and a storage volume of approximately 42,000 ML. It is set aside as a Lake Reserve for a number of purposes including water supply, recreation and nature conservation.

Until the mid 1960's, Lake Boga was part of the Torrumbarry Irrigation System but now relies on floodwaters from the Avoca River, and surplus flows from the River Murray when they are available. There have been no Avoca River flood inflows since 1996, and all water sourced for Lake Boga since then has been surplus flows from the River Murray.

Water enters the lake from the southeast side via the No. 7 Channel which has a nominal capacity of 200 ML/d. Flows can leave on the north side of the lake via an outfall channel approximately 1.5 km long and connects to the Little Murray River. This outfall can also be used to supply water from the LMW pool into the lake when a suitable level differential is available.

The bed of Lake Boga is at 65 m AHD (approximately), and uncontrolled outfalls commence when the lake water level is approximately 70 m AHD.

It is intended that Lake Boga be used as part of the water supply system and this will be its primary role.

Mid-Murray Storage

The secondary role of Lake Boga is to act as a Mid-Murray Storage (MMS) following the decommissioning of Lake Mokoan. In this role, it will provide some spare storage capacity to offset possible capacity shortages downstream of the Torrumbarry offtake.

Lake Boga

When Lake Boga becomes part of the MMS system, the intent is to fill the lake between May and November each year. The proposed operating range for the lake is 67m AHD to 69.5m AHD. Filling would generally be by gravity to 69.2m AHD via the existing channel from the Little Murray Weir pool. For levels higher than this (above the level of the weir pool), the lake would be filled via the Torrumbarry System No. 7 Channel.

To allow the release of water from Lake Boga down to 67m AHD during the summer months when the LMW pool is operating at capacity, a new outfall channel would be needed from the lake to the Little Murray River downstream of the LMW. This channel would be required to discharge up to 500 ML/d from Lake Boga and would also provide additional capacity to draw down Lake Boga in advance of flood events.

The proposed new outfall channel will also provide additional capacity to draw down Lake Boga in advance of flood events.

The issue for the SHMP is that if the LMW can be lowered, then the cost of this proposed new outfall channel can be avoided.

2.7 Environmental and Heritage Issues

As noted in Section 1.1.2, the assessment of the potential environmental and heritage issues associated mainly with lowering the water level of the LMW is being pursued through further environmental studies. These studies are still active and involve undertaking bathymetric, aquatic flora and fish surveys.

In the context of the Swan Hill Modernisation Project, the potential environmental and heritage implications of lowering the LMW will affect all potential options. For this reason, even if the potential environmental and social implications were known, they would not need to be included in the analysis to determine the preferred reconfiguration option (refer to Section 5.4), provided the required environmental approvals to lower the LMW are granted.

3

Current Irrigation Configuration - The Base Case

3.1 Introduction

Based on the information presented in Sections 1 and 2, this section describes the current situation and relevant issues, known as the base case, for the Swan Hill Irrigation Region before the implementation of any potential options for reconfiguring the region. The purpose of the base case is to provide a reference point by which the impacts of implementing different options may be measured. It therefore describes the aspects of the project, as they currently exist, that are relevant to the analysis. An important aspect in this regard is that the modernisation programs of NVIRP are part of the base case (refer Section 2.5).

3.2 Channel Capacity and Delivery Share Requirements

The channel capacity and total DS within the No. 9 and No. 10 Channel systems are presented in Table 3-1. The DS numbers presented include the adjustments for the removal of DS from both the No. 9 and No. 10 Channel systems under the Connections Program of NVIRP (refer Section 2.5).

For this project, the required capacities have been assessed according to the future channel delivery efficiency established in the "Channel Capacity Calculations" report (RMCG, March 2010) at approximately 70%. Based on this, the relationship between DS and channel capacity is:

Channel Capacity = DS x 1.4 (ML/d)

Table 3-1 Base Case Capacity and Delivery Shares: No. 9 and No. 10 channel systems

Channel System	*Channel Capacity (ML/day)*	*Total Delivery Shares (ML /day)*	*Required Channel Capacity (ML /day)*
No. 9 (at LMW)	*500*	*236*	*330*
No. 10	*300*	*90*	*126*

3.3 The Little Murray Weir

Under the base case, the current crest height of the LMW would be retained, along with the capacity to gravity supply the No. 9 Channel. The current G-MW asset management system (Refer Doc # 2429066) indicates the weir has a replacement cost of $12 million and a remaining life of 27 years. In 1998, a structural analysis of the weir concluded that it had a remaining life of 35 years. Based on recent advice from G-MW, these two figures are considered to be optimistic, with the estimated replacement cost being $18-20 million and a remaining life of less than 20 years. Annual operations and maintenance costs are estimated by G-MW to be approximately $70,000 a year, which includes electricity costs of around $25,000 for the Pental Island Pumps (PIP).

As discussed in Section 2.2.2, the manual operation of the LMW via the removal and replacement of drop bars is considered to be a significant risk to OH&S. G-MW has in place a program to replace these bars with automated gates, which would mitigate this risk. This program is currently on hold pending decisions about the weir, however, if the weir were to be retained, G-MW estimates the replacements will cost $127,000 a year for the next ten years.

3.4 The Little Murray Weir Pool

The LMW provides the head of water required to supply a number of customers from the LMW pool. Most significant of these are the customers on the No. 9 Channel, which feeds under gravity from the weir pool. In addition to these there are a number of customers who divert, either via pumps or under gravity, directly from the pool.

The LMW pool also provides environmental benefits as a habitat for a number of native fish species.

3.5 Lake Boga

Lake Boga is to be used as a reservoir for the MMS as part of a joint initiative of the Victorian and Commonwealth Government under the Living Murray Initiative. The use of Lake Boga for this purpose, and the increased environmental flows that it will make possible, are expected to improve the health of the River Murray. The decision to use Lake Boga for this purpose is independent of the decisions for reconfiguring the Swan Hill Irrigation System. Consequently, the environmental benefits to be provided by using Lake Boga for the MMS are assumed to be constant across all options that will be evaluated. The characteristics and magnitude of these environmental benefits are therefore not relevant to this analysis.

Under the base case, the height of the crest of the LMW prevents water flowing from Lake Boga to the Little Murray River (and hence the River Murray) via the connecting channel at the north of Lake Boga. An outfall will therefore need to be constructed (and which forms part of the base case) that connects Lake Boga to a point on the Little Murray River that is downstream of the LMW. Cost estimates provided by G-MW of such an outfall, including construction and land acquisition costs, are between $4.3 and $5.1 million. An average value of $4.6 million has been assumed for the base case.

3.6 Pental Island Pumps and Fish Point Weirs

Advice from NVIRP and G-MW is that the PIP and FPW would be affected in some way by the lowering of the LMW but they would still be required.

These structures would be affected in the same way under all options relative to the Base Case. Accordingly, they are not considered part of the base case or included in the assessment of the options to develop an irrigation modernisation plan.

3.7 Summary

Given the current situation and issues described above, the key aspects that form the base case are:

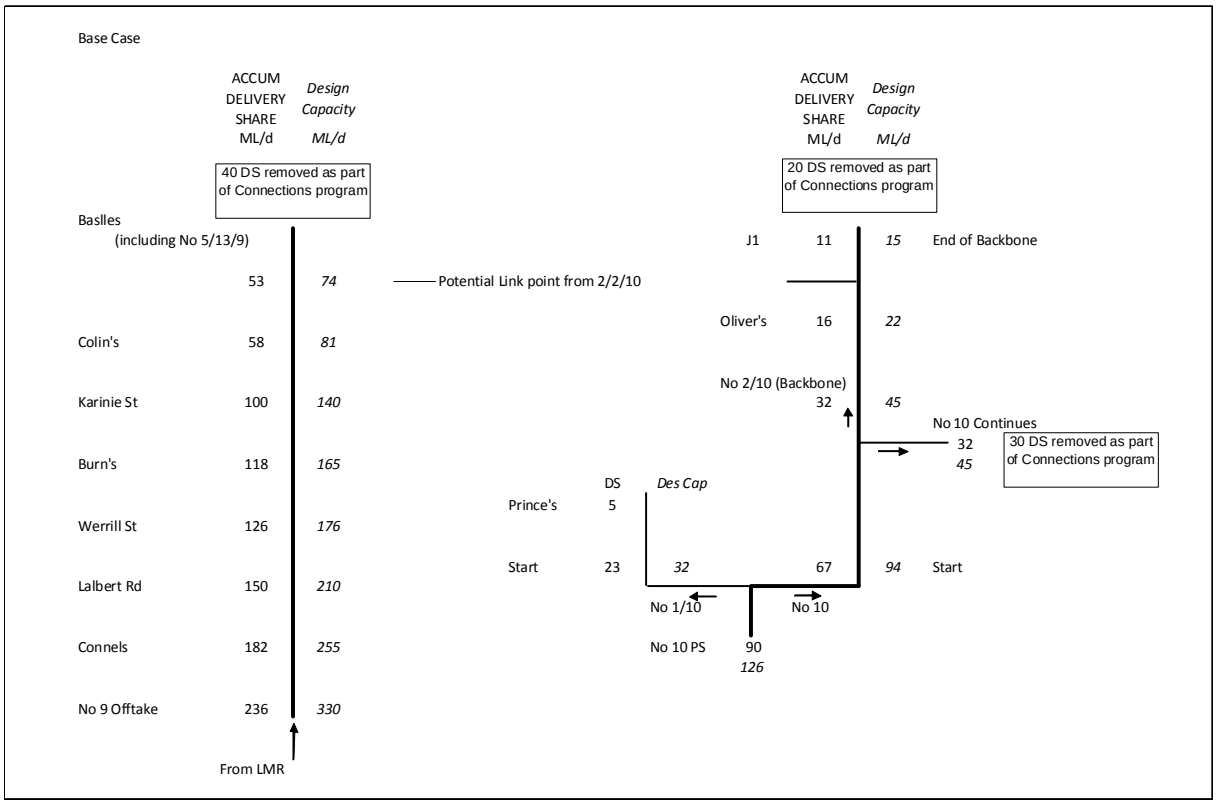
- maintain LMW and current supply arrangements for Weir Pool diverters;
- replacement of the current regulator gates with Rubicon Gates under the NVIRP Automation Works Program on the designated Backbone channels within the No. 9 and No. 10 Channel systems — this means that the No. 9 Backbone channel through the Rural City of Swan Hill will continue;
- maintain the existing No. 10 pump station;
- the removal of 40 DS from the most downstream reaches of the No. 9 Channel adjacent the River Murray under the Connections Program of NVIRP;
- the removal of 50 DS from the No. 10 Channel system adjacent the River Murray under the NVIRP Connections Program;

3 Current Irrigation Configuration - The Base Case

- the connection of customers currently supplied from spur channels to backbone channels under the Connections Program;
- existing supply meters will be replaced with modern meters under NVIRP's meter replacement program; and
- the construction of an outfall from Lake Boga to the Little Murray River as part of the MMS Project.

With respect to the current irrigation channel characteristics, and taking into account the above key aspects, the base case is illustrated in Figure 3-1. This diagram provides a reference for comparing similar representations of the selected options which are presented in Section 4.5.

Figure 3-1 Current configuration of the Swan Hill Irrigation System - The Base Case



4

Potential Reconfiguration Options: Initial Assessment

4.1 Introduction

This section outlines the reconfiguration options that were initially assessed based on their potential to:

- secure water savings;
- address the structural and operational concerns about the LMW;
- align delivery capacity with the future DS that would result from the Connections Program;
- address the concerns associated with the passage of the No. 9 Channel through the Rural City of Swan Hill as an open waterway; and
- align with the MMS Project.

This initial assessment allowed the most attractive options to be selected and subjected to a more rigorous benefit cost analysis (BCA). The results of this more rigorous analysis of the selected options are presented in Section 5.

4.2 Assumptions

Channel Automation

Although NVIRP has placed the replacement of the current regulator gates with Rubicon Gates on hold in the Swan Hill Irrigation Region, pending the outcomes from this project, it is assumed that the replacement will proceed. In examining the configuration options available, the number and size of Rubicon Gates that will be installed varies according to the option being considered. However, the number and size ultimately required will be determined by the reconfiguration that is ultimately selected.

Channel Capacity

As noted in Table 3-1, there has been a significant reduction in the required capacities of channels in the system. An opportunity therefore exists to reduce the existing channel waterway widths to be more consistent with the reduced demands and, through this, gain water savings. However, this is not considered viable based on the following:

- Through reducing channel waterway widths, seepage and evaporation savings range from an estimated 16 ML/km for the larger channels to 7 ML/km for the smaller channels;
- Using the costs of remodelling the channel banks as a reference, the estimated cost of remodelling the banks would be at least $200,000/km not including the earthworks cost of reducing the waterway width. If the channels were lined with a plastic membrane, the estimated cost would be in the order of $400,000/km; and
- Based on the imputed value for water savings used by NVIRP of $2,645/ML, the water savings gained would need to be at least 75 to 150 ML/km for such measures to be worthwhile, which is significantly greater than estimated savings.

The remodelling and relining of channels for the purpose of achieving water savings has therefore been ruled out in the development of options.

Water Savings

Since channel waterway width reduction has been ruled out, the most significant sources of water savings under any of the options are those associated with reducing the footprint of the LMW pool by lowering the LMW. Further savings would result from removing the section of the No. 9 Channel through Swan Hill, as well as the supply of water via pipes rather than channels for some options.

4.3 Potential Options

The list of potential modernisation options depend on two key decisions that need to be analysed, which then give rise to a number of branch options. These key decisions are whether to:

- retain the current crest height of the LMW, or lower it and provide supply to the No. 9 Channel via pumping from either the River Murray, or the Little Murray River; and
- retain a supply system (pipe or channel) through Swan Hill, or truncate the system at Werrill Street and provide alternative supply to the rest of the No. 9 Channel system north of Swan Hill.

These two key decisions essentially split the options to be analysed into two interrelated categories, namely those that are concerned with:

- the areas upstream (or south) of Werrill Street (relating to the Weir decision); and
- the areas downstream (or north) of Werrill Street (relating to the decision to supply through Swan Hill and the consequential alternative supply decisions that flow from this).

The base case, key decisions and potential options are depicted diagrammatically in Figure 4-1 as an options tree. Apart from the base case items, each path through the tree either represents a potential option, which gives rise to a large number of possible options/sub-options. The key components of these options are described in the subsequent text.

4.3.1 South of Werrill Street

Little Murray Weir

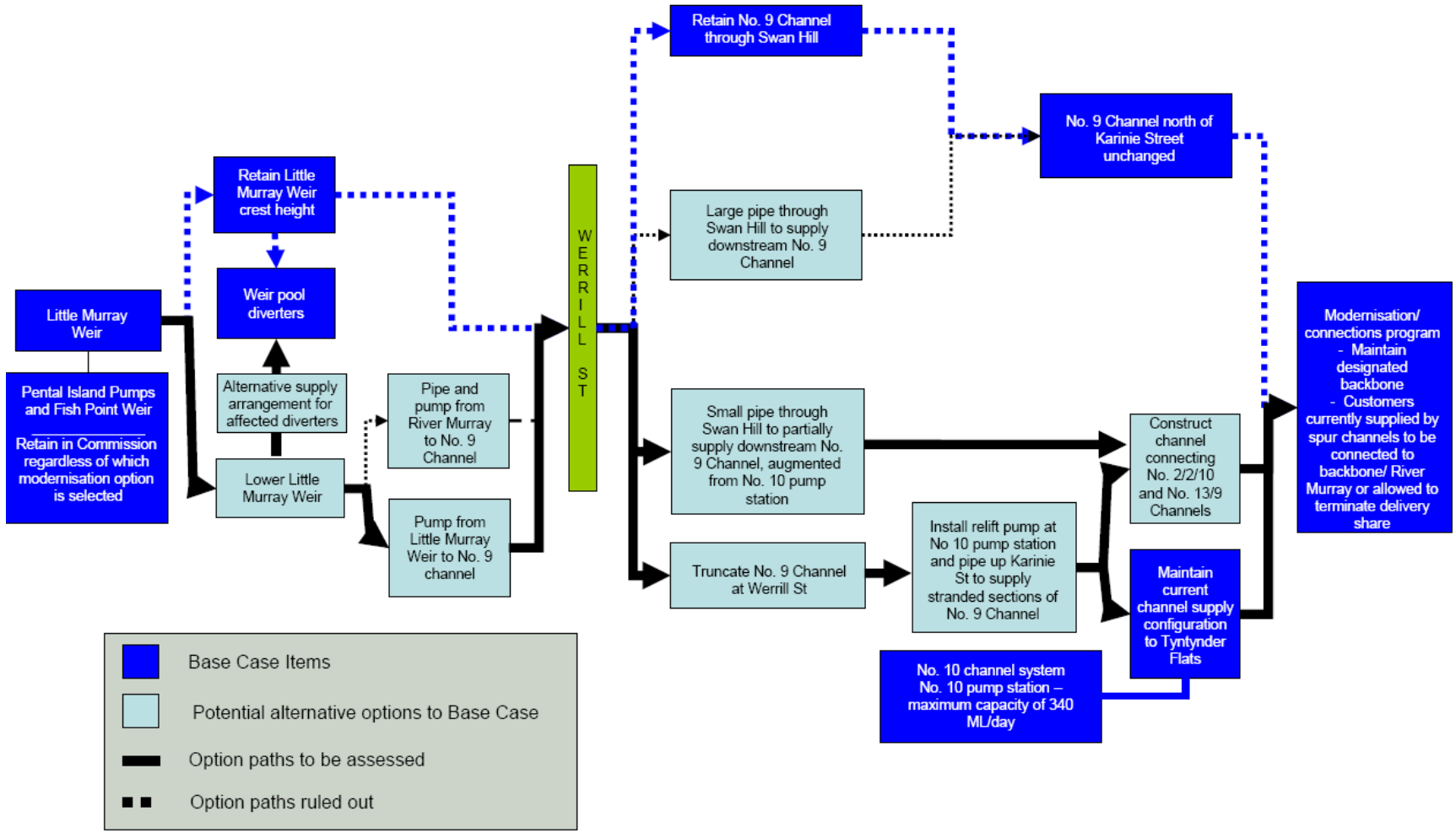
As discussed in Section 2, the current structure has required significant work in recent years to maintain its stability. This work, combined with its condition and OH&S issues associated with its operation, have prompted G-MW to consider replacing the weir or decommissioning it. Although the asset management system currently indicates the estimated cost of the weir to be $12 million, current estimates suggest that replacement costs are more likely to be $18-20 million. It is also considered that it will be necessary to replace the weir within 20 years.

The crest level of the LMW is 69.21 m AHD. If the weir were to be replaced, it would be necessary to construct a replacement weir to provide this crest level enabling supplies to be diverted from the weir pool to the No. 9 Channel. An alternative to replacing the weir is to decommission it. This could be readily achieved by removing the weir gates and allowing the concrete sill and apron works to remain to provide at least a low level pool upstream of the weir.

The proposed lowered level of the weir is discussed in Section 5.5.1.

4 Potential Reconfiguration Options: Initial Assessment

Figure 4-1 Options Tree: Swan Hill Modernisation Project



An issue for attention, should the weir be decommissioned and the level of the LMW lowered, will be the maintenance of a supply for customers who currently divert from the pool created by the weir. However, a positive aspect of lowering the weir pool would be that the need for the construction of a specific outfall channel from Lake Boga, for it to operate as part of the MMS project, would be avoided as the existing channel linking Lake Boga to the Little Murray River could be used for this purpose. It should be noted that there may be environmental issues associated with lowering the LMW, as discussed in Section 2.7.

Pumping to the No. 9 Channel

As the existing sill level of the LMW is 66.79 m AHD *(GMW drawing #135990, refer to Appendix C)*, some 2.4m lower than the level required to deliver flows to the No. 9 Channel, it would be necessary to install a pump station to maintain an irrigation supply to the Swan Hill area from the Little Murray River. For this option, it would be desirable to retain the existing sill and apron works of the existing Little Murray Weir to provide a pool from which supplies could be pumped. The pump station would be located adjacent to the existing No. 9 Channel offtake structure.

An alternative would be to bring a supply from the River Murray to deliver to the No. 9 Channel. This would require the construction of a pump station on the River Murray and a pipeline some 2,500 m long to discharge to the No. 9 Channel.

Capacity for each of these two options will be established based on the No. 9 Channel and No. 10 Channel system configurations as discussed later.

4.3.2 North of Werrill Street

Werrill Street provides a strategic division point for the analysis, as it is the point at which the No. 9 Channel could be truncated to facilitate decommissioning the open channel through Swan Hill.

Retaining Current No. 9 Channel

Although it would seem desirable to decommission the No. 9 Channel through the urban area of Swan Hill, the option to retain it remains available for consideration. Its required capacity can vary from its current capacity to something considerably less, depending on the configuration of the supply system downstream.

Large Pipe through Swan Hill

This option assumes that there is little change to current supply arrangements to the areas downstream of Swan Hill and that the open channel through the town is simply replaced with a pipeline. The option would meet the objectives of eliminating the hazards of an open channel in an urban area, and would also provide water savings.

Small Pipe through Swan Hill

Subject to the extent of reconfiguration undertaken for the supply system downstream of Swan Hill, a smaller diameter pipeline could be considered as an option for replacing the open channel through the town.

4 Potential Reconfiguration Options: Initial Assessment

Truncate No. 9 Channel at Werrill St

The No. 9 Channel could be truncated at the Werrill Street regulator and the section of channel through the town decommissioned. This decommissioning could extend to Karinie Street on the northern edge of Swan Hill subject to works being undertaken to maintain supplies to customers served by the No. 9 Channel between Werrill St and Karinie Street.

The works associated with this option could include:

- Decommissioning the No. 8A/9 and 9/9 Channel systems and replacing them with a piped supply from a pump station on the No. 9 Channel at Werrill Street. This system would supply all existing customers supplied by these spur channels and the No. 9 Channel between Werrill Street and Gray Street in Swan Hill (Figure 2-6);
- The installation of a pipeline along Karinie Street from the No. 10 Pump Station to the No. 9 Channel to maintain supply to No. 9 Channel customers downstream of Karinie Street; and
- The possible decommissioning of the No. 9 Channel upstream of Karinie Street (between McCallum Street and Karinie Street (refer Figure 2-6) and supplying existing customers along this reach with a piped supply.

Relift Station at No. 10 Pump Station

Although the operating capacity of the No. 10 pump station ranges up to 300 ML/d, the pumps do not have sufficient head to deliver water to the No. 9 Channel; there would also be a requirement to build a new pipeline from the pump station to the No. 9 Channel, most likely along Karinie Street. The options to provide supply to the No. 9 Channel north of Swan Hill are:

- Install a relift pump station adjacent to the existing No. 10 Pump Station to draw water from the No. 10 Pump Station receiving pool for delivery to the new Karinie Street pipeline. In considering this option, it is acknowledged that a challenge to overcome will be the establishment of a control system that can successfully integrate the existing No. 10 Pump Station, the new relift pump station and the No. 9 Channel requirements.
- Draw a supply directly from the River Murray for specific delivery to the new Karinie Street pipeline. This may be from a separate pump station or by modifying the existing No. 10 Pump Station structure to accommodate the new higher lift pumps.

Channel Connection Between No. 9 and No. 10 Channel Systems

There is an opportunity available to link the No. 9 and 10 Channel systems by constructing a relatively short length of new channel between the No. 2/2/10 Channel and the No. 13/9 Channel to deliver supplies from the No. 10 Channel system to the No. 9 Channel system. With regard to this connecting channel:

- It would be approximately 550 m long;
- The supply level of the No. 2/2/10 and No. 13/9 Channels at the link points are 66.80 mAHD and 66.72m AHD respectively thereby facilitating a gravity connection;
- The works required for the link channel would include the earthworks for the new channel and the construction of a bridge where the new channel would cross the Murray Valley Highway. Other works would be required on the No. 2/2/10 Channel upstream of the link including channel earthworks, modifications to channel structures, and the possible replacement of an existing channel siphon with a drainage subway where the No. 2/2/10 Channel crosses the No.2 Drain; and

- The capacity will vary according to respective configuration options.

4.4 Short-listing Options

4.4.1 Rationale for Short-Listing Options

Many of the options outlined above can be ruled out without undertaking a detailed BCA. In many cases, two options will provide similar outcomes with significantly different costs, or alternatively the outcome of an option may be unacceptable regardless of costs (for example, where it produces a significant risk to human life). The following options have been ruled out based on the justification provided.

Pump to No. 9 Channel from the River Murray

In the event that the LMW is lowered, the decision concerning whether to pump from the River Murray or the Little Murray River will be largely based on cost. Aside from cost differences, there would be little benefit provided by one choice over the other. The Little Murray River would supply the No. 9 Channel from a greater height than the River Murray, even with the Weir lowered, and would therefore incur lower pumping costs. Piping would not be required from the Little Murray River, and the pump station would be less complicated and have a lower cost.

Preliminary cost estimates of constructing the pump stations and pipes to the No. 9 Channel are approximately $4.5 million from the River Murray, and $1.6 million from the Little Murray River. Based on these estimates, pumping from the River Murray to the No. 9 Channel can be ruled out as an option.

Retain the Little Murray Weir

Having determined that pumping from the Little Murray River would be preferable if the weir were to be lowered, the next option is to consider whether pumping from the Little Murray River would be preferable to maintaining (the current height of) the LMW in order to supply the No. 9 Channel.

Retaining the supply level of the LMW means that an outfall from Lake Boga to the Little Murray River must be constructed as part of the MMS. The cost of this outfall has been estimated at approximately $5.7 million. However, the weir will also require replacement in 20 years at considerable cost, and will require automated gates to be installed over the next 10 years. The present value of the costs of the two options is presented in Table 4-1.

With no significant difference in benefits provided by retaining the existing supply level of the LMW, it is reasonable to remove this option. A small number of diverters from the weir pool will also require their supply to be reinstated should the weir be lowered.

However, as noted in Section 2.7, further investigations are being conducted to assess the environmental and heritage implications of lowering the LMW. These investigations are necessary to determine whether approval can be granted to lower the LMW. Presented in Section 7 is a supplementary analysis for the situation that approval is not received to lower the LMW.

4 Potential Reconfiguration Options: Initial Assessment

Table 4-1 Cost Comparison: Supply to No. 9 Channel at Little Murray Weir

Option	Present value of costs ($M, 6% discount over 30 years)
Retain weir	
Lake Boga outfall	$5.7
Automated gates	$0.9
Weir replacement ($19m in 20 yrs)	$5.9
Operations & Maintenance	$0.6
Total	**$13.1**
Lower weir	
Little Murray Pump Station	$1.6
Operations & Maintenance	$0.8
Total	**$2.4**

Retaining an Open Channel through Swan Hill

Past drownings and an increase in this risk as the population of Swan Hill grows, suggests that the existence of an open channel through a populated residential area is likely to be viewed as presenting a risk which may be regarded as too high. Accordingly, retaining an open channel through Swan Hill has been ruled out as an acceptable option.

Removing the channel through Swan Hill would also enable the land currently occupied by the channel to be reclaimed for other uses (open space, residential development, community facilities) and increase the connectivity within Swan Hill. These aspects will be addressed as required in undertaking the BCAs for the preferred options that are selected for detailed assessment.

Construction of a Large Pipe through Swan Hill to Supply Remainder of No. 9 Channel

If supply to the No. 9 Channel system downstream is to be maintained through Swan Hill, a pipe will need to be constructed. This can either be a large pipe, with no reconfigurations downstream, or a smaller pipe allowed by augmentation of the downstream supply of the No. 9 Channel with the No. 10 Channel system via a channel connecting the No. 2/2/10 and No. 13/9 Channel systems. The benefits of both options in terms of ability to meet delivery share requirements are equal.

Preliminary estimates of construction costs (URS) of the large pipe indicate costs of approximately $13 million, compared with approximately $7 million for the smaller pipe and channel connection. In addition, pumping costs with an estimated present value of $300,000 would be incurred. These estimates provide enough confidence to rule out a large pipe through Swan Hill in order to maintain the existing configuration north of Swan Hill.

4.4.2 Preferred Options for Benefit Cost Analysis

The shortlisting process outlined above enables a number of 'branches' of the options tree to be ruled out. These are represented in Figure 4-1 by the dotted paths. The remaining options are:

- **South of Werrill Street —** the only remaining option is to lower the Little Murray Weir and pump from the Little Murray River (although required capacities of the pump and pipes will to an extent be affected by downstream decisions).
- **North of Werrill Street** — there are essentially three main options relating to the choice of truncating or piping through Swan Hill, and whether a connecting channel between the No. 2/2/10 and No. 13/9 Channel systems should be built.

Given the above considerations, the following options have been selected as preferred to be assessed relative to the base case through a BCA. The options are:

- Option 1: Pipe No. 9 Channel through Swan Hill and construct a connecting channel between the No. 2/2/10 and No. 13/9 Channels
  - Lower the LMW;
  - maintain supply to weir pool diverters;
  - install a pump station on the Little Murray River to supply No. 9 Channel;
  - decommission No. 9 Channel from Werrill Street to McCallum Street and construct a pipe through Swan Hill;
  - install relift pump station at Werrill Street and pipe the spurs near Werrill Street; and
  - build a connection between the No. 2/2/10 and No. 13/9 Channels to augment supplies to the No. 9 Channel from the No. 10 system.
- Option 2: Truncate No. 9 Channel at Werrill Street — no connecting channel
  - Lower the LMW;
  - maintain supply to weir pool diverters;
  - install a pump station on the Little Murray River to supply the No. 9 Channel;
  - truncate the No. 9 Channel at Werrill Street and decommission the channel between Werrill Street and Karinie Street;
  - install relift pump station at Werrill Street and pipe the spurs near Werrill Street;
  - install relift pump at No. 10 Pump Station, construct a pipeline along Karinie Street to the No. 9 Channel; and
  - install relift pump station where the Karinie Street pipeline terminates to supply No.9 Channel customers between McCallum Street and Karinie Street.
- Option 3: Truncate No. 9 Channel at Werrill Street and construct Karinie Street Pipeline and connecting channel between the No. 2/2/10 and No. 13/9 Channels
  - Lower the LMW;
  - maintain supply to weir pool diverters;
  - install a pump station on the Little Murray River to supply the No. 9 Channel;
  - truncate No. 9 Channel at Werrill Street and decommission the channel between Werrill Street and Karinie Street;
  - install relift pump station at Werrill Street and pipe the spurs near Werrill Street;
  - install relift pump at No. 10 Pump Station, construct a pipeline along Karinie Street to No. 9 Channel;

- install relift pump station where the Karinie Street pipeline terminates to supply No.9 Channel customers between McCallum Street and Karinie Street; and
- build a connection between the No. 2/2/10 and No. 13/9 Channels to augment supplies to the No. 9 Channel from the No. 10 system.

4.5 Technical Description of Options

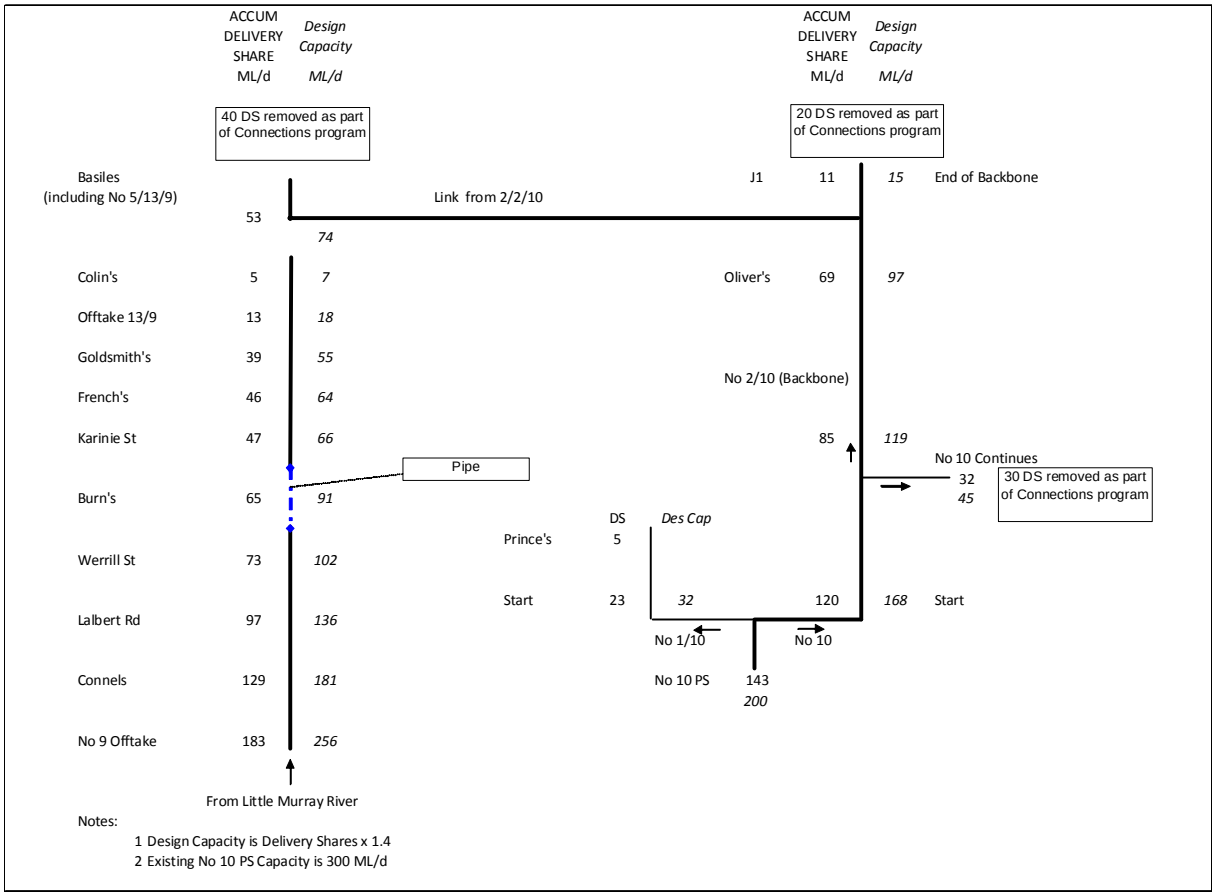
4.5.1 Option 1: – Pipe the No 9 Channel through Swan Hill

A schematic arrangement for Option 1 is presented in Figure 4-2. The key features of this option are that the No. 9 Channel would be pipelined from Werrill Street to McCallum Street, and the link channel from the No. 2/2/10 Channel to the No. 13/9 Channel constructed to reduce the capacity required for the pipeline. Other features of Option 1 include:

- 90 DS are to be removed under the NVIRP Connections Program from the No. 9 (40 DS) and No. 10 (50 DS) channel systems. This will enable the No. 10 Pump Station to operate within its current capacity and will not need to be upgraded; and
- Pipeline the No. 8A/9 and No. 9/9 Channel systems in the Werrill/ Yana Street area in the southern parts of Swan Hill. This pipeline system would be supplied from a pump station on the No. 9 Channel near Werrill Street which would in turn continue to be supplied from the Little Murray River.

4 Potential Reconfiguration Options: Initial Assessment

Figure 4-2 Option 1: Pipe the No. 9 Channel through Swan Hill



Some details of the components of Option 1 include:

- Pipeline through Swan Hill –
  - Diameter: 1400 mm
  - Length: 2,500 m
  - Capacity: 90 ML/d
- Link Channel –
  - Length: 550 m
  - Capacity: 74 ML/d
  - Works required: new channel earthworks, Murray Valley Highway bridge, modification of the No. 2/2/10 Channel earthworks and structures upstream for the increased channel capacity.
- Werrill Street Pipeline System –
  - Pump station duty: 6.55 ML/d to 30 m head
  - Length of pipelines: 3.5 km
  - Pipe diameter range: 225 to 300 mm.

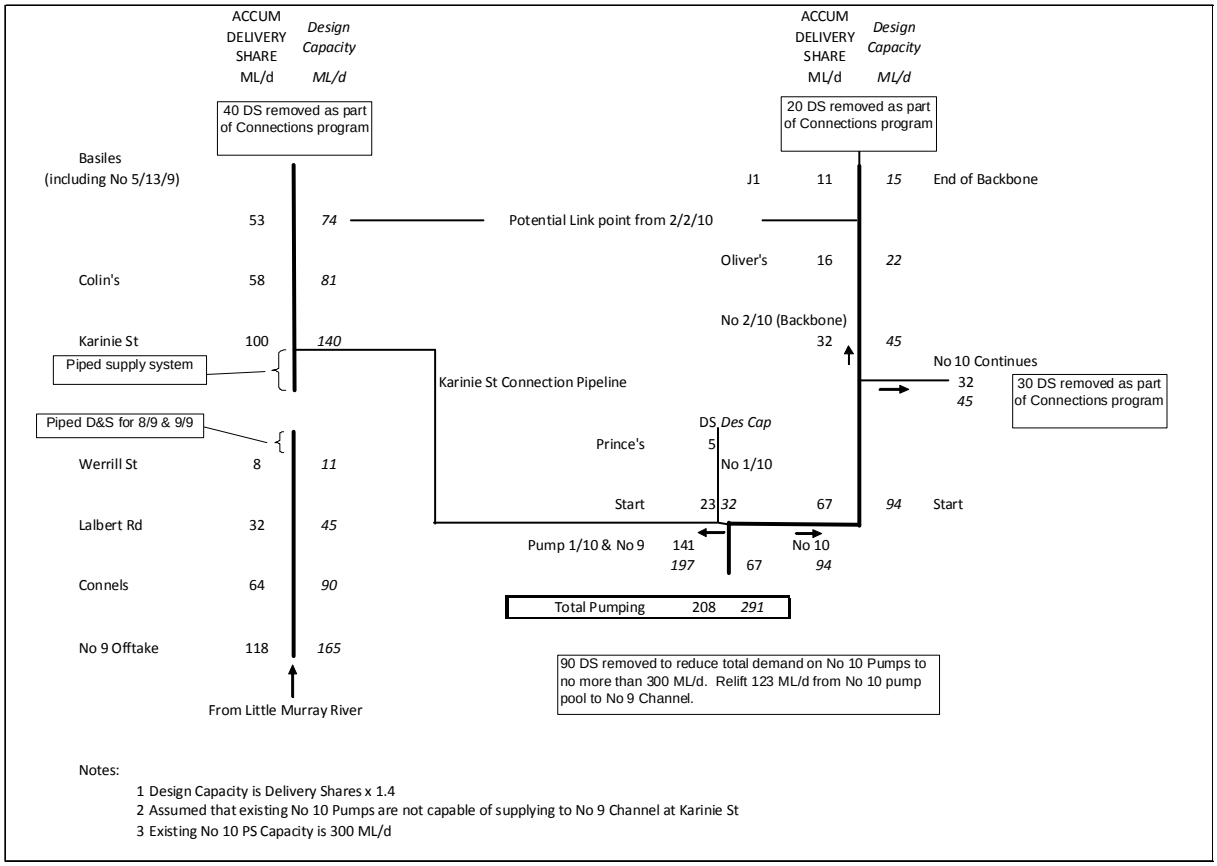
4.5.2 Option 2: Truncate the No 9 Channel, Install Karinie Street Pipeline, no Link Channel

The layout of Option 2 is illustrated in Figure 4-3. The key features of this option are that the No. 9 Channel would be truncated at Werrill Street and would be decommissioned through Swan Hill from Werrill Street to Karinie Street. In order to restore supplies to the reaches of the No. 9 Channel north of Swan Hill, a pipeline is proposed along Karinie Street to deliver supplies from the No. 10 Pump Station to the No. 9 Channel. The No. 8A/9 and No. 9/9 Channel systems would also be pipelined under this option. The lifestyle and small irrigation customers currently supplied from the reach of the No. 9 Channel between McCallum Street and Karinie Street would also be supplied from a similar pipeline system, supplied from a dedicated re-lift pump station at the end of the proposed pipeline along Karinie Street.

Although the capacity of the existing No. 10 Pump Station may not need to be increased, it does not have sufficient head to deliver flows to the No. 9 Channel via the Karinie Street pipeline, therefore additional pumping will be required. For this analysis, it has been assumed that this booster pumping would be achieved by pumping from the existing pool to which the pump station discharges, and that adequate pump control arrangements will be implemented.

4 Potential Reconfiguration Options: Initial Assessment

Figure 4-3 Option 2: Truncate the No 9 Channel, install Karinie Street Pipeline, no link Channel



Some details of the components of Option 2 include:

- Karinie Street Pipeline –
  - Diameter: 1200 to 1350 mm. Includes a length of existing 1200 mm diameter pipeline.
  - Length: 3.12 km
  - Capacity: 197 ML/d at upstream end. Provides supply for No. 1/10, No. 11/9, No. 9 Channels and the Karinie-McCallum Street system.
- No 10 Pump Station Booster –
  - Pump station duty: 197 ML/d to 4.5 m head
- Karinie – McCallum Street Pipeline System –
  - Pump station duty: 3.0 ML/d to 20 m head
  - Length of pipelines: 1.95 km
  - Pipe diameter range: 225 mm.
- Install relift pump station at Karinie Street to supply No. 9 Channel customers between McCallum Street and Karinie Street
- Werrill Street Pipeline System – as for Option 1

4.5.3 Option 3: Truncate the No 9 Channel, Install Karinie Street Pipeline, Including Link Channel

As illustrated in Figure 4-4, Option 3 differs from Option 2 through the inclusion of the connection channel between the No. 2/2/10 and No. 13/9 Channels, the objective of which is to reduce demand on the Karinie Street Pipeline. Option 3 also features:

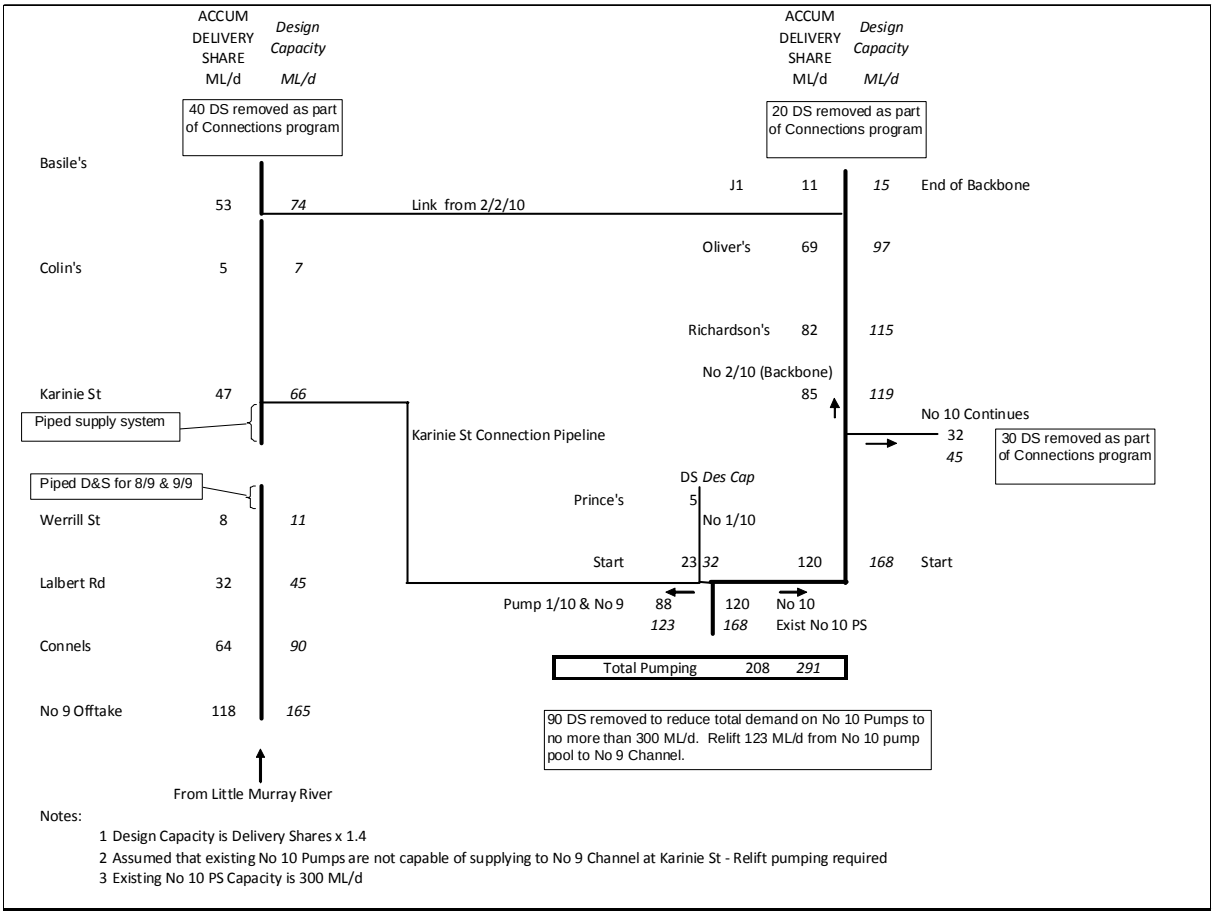
- The removal 40 DS from the No. 9 Channel system and another 50 DS from the No. 10 Channel system;
- Install relift pump at the No. 10 Pump Station to deliver from the River Murray to the Karinie Street pipeline; and
- Pipelining the supplies to customers in the Werrill/ Yana Street area, and along the No. 9 Channel between McCallum and Karinie Streets.

Some details of the components of Option 3 include:

- Karinie Street Pipeline –
  - Diameter: 900 to 1200. Includes a length of existing 1200 mm diameter pipeline.
  - Length: 3.12 km
  - Capacity: 123ML/d at upstream end. Provides supply for No. 1/10, No. 11/9, No. 9 Channels and the Karinie-McCallum Street system.
- No 10 Pump Station Modifications –
  - Pump station duty: 123 ML/d to 7.9 m head.
- Karinie St relift pump station– as for Option 2
- Werrill Street Pipeline System - as for Options 1 and 2.

4 Potential Reconfiguration Options: Initial Assessment

Figure 4-4 Option 3: Truncate No 9 Channel, install Karinie Street Pipeline and the Link Channel



4.5.4 Werrill and Karinie-McCallum Street Pipeline Systems

The No. 8A/9 and No. 9/9 Channels currently supply small holdings in the area near Werrill and Yana Streets in the south western part of the Rural City of Swan Hill. This land is generally zoned Rural, but it is expected that it will be rezoned Low Density or Residential 1 by the Swan Hill Rural City Council as part of its South West Swan Hill Outline Development Plan.

To the north of the city, several more, smaller holdings are currently supplied from the No 9 Channel. The land east of the No. 9 Channel is zoned Industrial or Low Density Residential, and the land to the west is zoned Rural Living.

As it is expected that the land in these areas will become urbanised in the longer term, the demand requirements have been considered from the perspective that the land will be serviced by pipelines with a standard of service consistent with this anticipated landuse. These standards of service have been developed assuming the following:

- Much of the land is developed into parcels on which an average 0.4 ha is irrigated;
- Specific allowances for schools and sporting clubs based on the estimated irrigated area of each;
- No allowance is required for household or stock use;
- A suitable evaporation rate is 9 mm/d, and crop factor 0.8;

4 Potential Reconfiguration Options: Initial Assessment

- Individual properties would have an annual water share of 2 ML, and larger irrigators would require 5 ML/ha; and
- A minimum pipeline residual head of 10 m is required.

The results of the analysis undertaken on the water requirements for these systems, based on the number of existing customers, are presented on the following table:

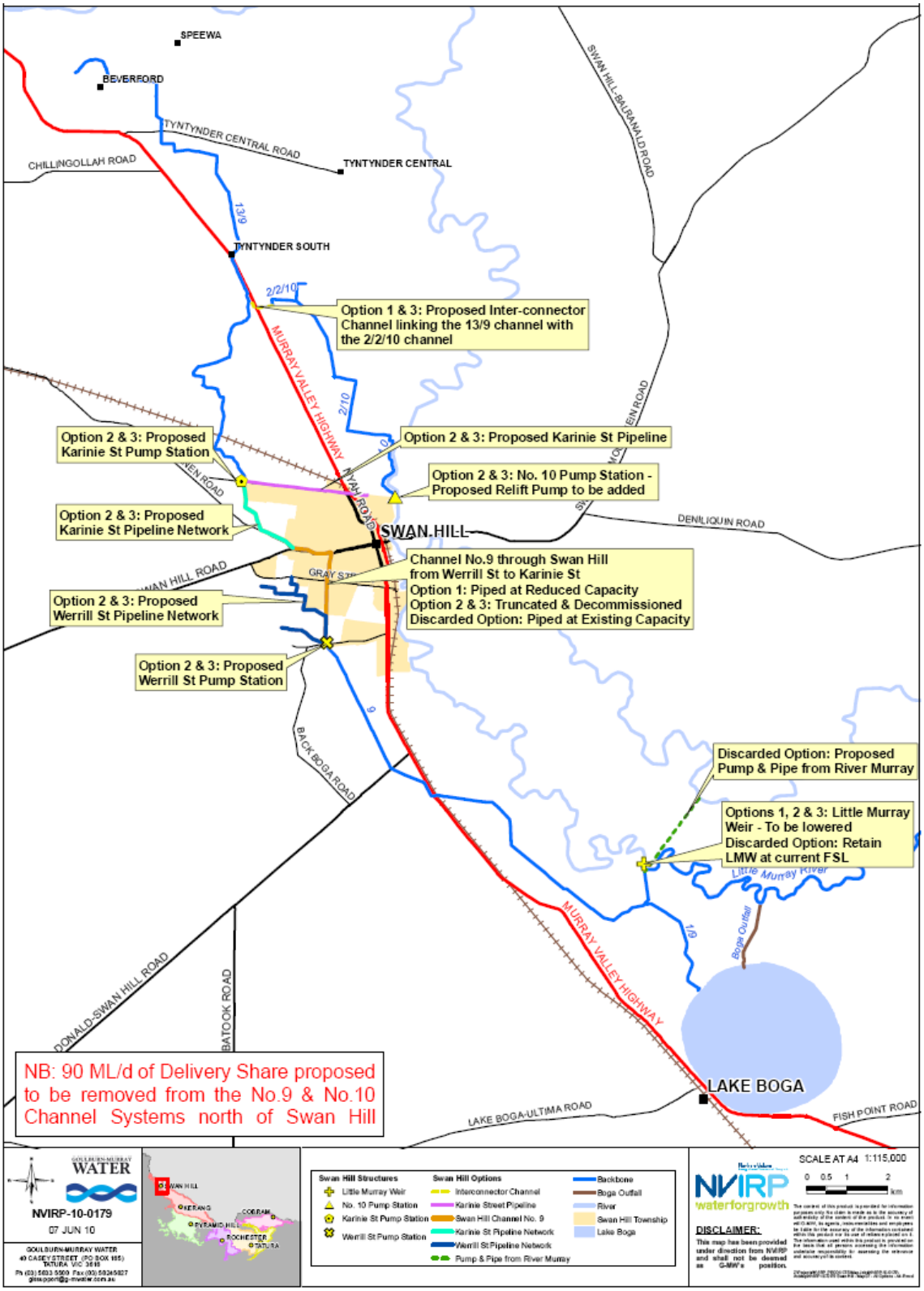
Table 4-2 Summary of Pipelined Systems Requirements

Feature	*Werrill Street System*	*Karinie-McCallum Street System*
Assumed number of customers	*130*	*70*
Estimated pump station capacity	*6.6 ML/d*	*3 ML/d*
Estimated required water share	*343 ML*	*247 ML*
Estimated equivalent delivery share	*3.4 ML/d*	*2.5 ML/d*
Current Delivery Share	*7.1 ML/d*	*7.64 ML/d*

It is envisaged that the installation of these small pipeline systems would be undertaken under the Connections program.

4 Potential Reconfiguration Options: Initial Assessment

Figure 4-5 Proposed Changes to the Swan Hill Irrigation Region



5

Detailed Analyses of Selected Options

5.1 Introduction

This section presents the results of the detailed Benefit-Cost Analyses (BCA) of the three selected options described in Section 4.3. Also presented are the results of the sensitivity analyses undertaken, together with a discussion of the social and environmental considerations associated with the selected options.

5.2 Benefit Cost Analysis

5.2.1 Methodology

The assessment of the three selected options was carried out using a BCA framework. Such analyses involve the identification and the valuation of all benefits and costs in dollar terms. Benefits and costs are considered from the perspective of the wider community, as the investment decision is concerned with achieving the greatest overall benefit. Within a BCA, some benefits and costs are more easily quantified than others. Where markets exist, values are easily quantified (market values). The situation is more difficult for environmental and social costs and benefits because markets rarely exist and indicative values for these costs and benefits must be estimated (non-market values). Where possible, the BCA quantifies the market and non-market benefits and costs for each of the options.

The BCA, through discounting procedures, converts future flows of benefits and costs to a comparable basis at a common point in time. The prime decision rule in such analyses is that a project should, subject to budget constraints, be accepted if the present value of the benefits exceeds the present value of its costs; that is, the net present value (NPV)[9] of a project is greater than zero. An NPV of zero represents the break-even value of a project and arises when the present value of benefits equals the present value of costs. An NPV of less than zero indicates that the present value of costs exceeds the present value of benefits and, thus, the project is not economic.

Where benefits and costs identified cannot be quantified in dollar terms, because no technique to do so is readily available or because the benefit of doing so is not commensurate to the effort required, a qualitative assessment has been carried out to gain an understanding of their likely magnitude. The objective is to assess whether these unquantified benefits and costs are likely to change the conclusion reached through the quantified BCA process. These unquantified benefits and costs are considered further in Sections 5.3 and 5.4.

5.2.2 Key Inputs and Assumptions

The following inputs and assumptions were used to undertake the benefit cost analysis, representing the best information available at the time of writing this report. Other inputs to the BCA are presented in Appendix A.

[9] Net present value equals the present value of benefits, minus the present value of costs.

Inputs

- A discount rate of 6% per year has been used for this analysis. Sensitivity analyses will be undertaken for higher and lower rates;
- The analysis is for a 30 year planning horizon; and
- Works are assumed to commence in 2010.

Assumptions

In addition to the assumptions described in Section 4.2, the other assumptions used for analysis purposes are:

- Water savings arising from automation of the channel system through the NVIRP Automation Works Program are assumed to be constant under the base case and all options. Consequentially, no attempt has been made to estimate these savings;
- Water savings benefits have been valued at a present value of $2,645 for each ML per year saved and are based on the benchmark target cost for NVIRP's Connections Program. In doing so, it is assumed that the benchmark target cost for water savings is reflective of society's willingness to pay to achieve water savings. Purchases by the Federal Government for the Murray Darling Basin have generally been in the range of $2,000 to $2,500[10], which is more reflective of the market value of the water. This value has been used in the sensitivity analysis;
- The value of Agricultural land is assumed to be $5000 per hectare, which has been used to value the cost of the land required to build the channel linking the No.9 and No. 10 systems in Options 1 and 3;
- Land reclaimed within the Swan Hill Township from decommissioning this section of the No. 9 Channel has been valued at $20,000 per ha; and
- Carbon output has been estimated based on 1.22 tonnes of C02 equivalent per MWh. The costs of carbon outputs have been based on the cost of carbon credits under treasury projections of the CPRS (Appendix A).

5.2.3 Assessment of Water Savings

The estimates of water savings to be gained from the Swan Hill Modernisation Project (SHMP) have been undertaken using the DSE Water Savings Protocol – *Technical Manual for Quantification of Water Savings, June 2009*, in consultation with NVIRP. The formulae and factors provided in the manual have been used, together with:

- the water balance data for the 2004/05 irrigation season which was nominated by NVIRP (pers. comm. Peter Roberts) as the Baseline Year);
- a Long Term Cap Equivalent (LTCE)[11] conversion factor of 1.29, as advised by NVIRP (pers. comm. Peter Roberts); and
- the channel length data provided by NVIRP (included with the water balance data).

An overview of the water savings that can generally be gained from modernisation works is provided in Table 5-1, with comments as to their relevance to the Swan Hill Modernisation Project.

The water savings estimates were prepared in consultation with and subsequently checked and approved by the appropriate NVIRP staff (Peter Roberts).

[10] http://www.environment.gov.au/water/policy-programs/entitlement-purchasing/2008-09.html
[11] The LTCE comprises both fixed and variable losses using appropriate conversion factors

5 Detailed Analyses of Selected Options

Table 5-1 Summary of Water Savings Opportunities

Loss	*Cause/Intervention*	*Relevance to SHMP*
Outfall	*Rainfall rejections and/or operational activities.* *Improve system management – channel automation*	***Not claimed** as a saving as automation is part of the base case. However, avoided cost assessed as a benefit because system reconfigurations associated with modernisation would reduce scope of automation requirements.*
Unauthorised Use	*Taking of water without necessary authorisation.* *Channel automation and improvement to metering.*	***Not claimed** as a saving as interventions are included in the base case.*
Bank Leakage	*Water lost though/over the channel banks.* *Channel remediation, channel rationalisation*	*Assessed*
Seepage	*Water lost through the bed of the channel.* *Channel remediation, channel rationalisation*	*Assessed*
Evaporation	*Water lost from the water surface area.* *Channel remediation, channel rationalisation*	*Assessed*
Dethridge Meter Error	*Water that passes through a Dethridge Meter that is not accounted for by the meter.* *Meter replacement.*	***Not claimed** as a saving as interventions are included in the base case.*
Leakage at service points	*Leakage through or around service points due to poor seals, improper closing, poor bank compaction etc.* *Meter replacement, channel rationalisation.*	***Not claimed** as a saving as interventions are included in the base case.*
Unmetered D&S use	*Unauthorised taking of water through unmetered service points.* *Meter replacement, channel rationalisation.*	***Not claimed** as a saving as interventions are included in the base case.*
Other losses	*System filling, bulk inflow/outflow measurement.*	***Not claimed** as a saving as interventions are included in the base case.*

Once the volume of permanent water savings has been estimated for each of the options compared to the base case, this volume has been valued using the price supplied by NVIRP of $2,645 for each ML per year saved.

It should be noted that the estimates of water savings are based on information currently available and may change as more information becomes available.

5.2.4 The Base Case

The base case represents the current outlook for the project area in the absence of the options being analysed. Refer to the URS Position Paper (October 2009) for a more detailed description of the base case.

5 Detailed Analyses of Selected Options

The elements of the base case that have been quantified for use in the BCA are presented in Table 5-2 (refer to Appendix A for further detail). It should be noted that elements of the base case that do not change under implementation of any options do not require quantification. The BCA is only concerned with marginal changes in benefits and costs that arise from the options, relative to the base case.

Table 5-2 Base Case Values

	Base Case items	Present Value (6% discount rate over 30 years)
NVIRP modernisation*		
	Works and materials to install gates and reg. structures	894,000
	Maintenance	123,000
Little Murray Weir		
	Replacement of weir	5,924,000
	Installation of gates	991,000
	Operations	486,000
	Maintenance	163,000
	Carbon emissions	1,000
Lake Boga		
	Construction of outfall to Little Murray River	5,672,000
No. 10 Pump Station		
	Operation costs	757,000
	Carbon emissions	199,000
TOTAL		**15,210,000**

*It is assumed that maintenance of the No.9 and No. 10 channels is included in maintenance of the NVIRP modernisation assets. It is also assumed that the operation costs of these assets would be the same under the base case and all options and have therefore not been quantified.

The capital expenditure items to be incurred in the first year of the base case are presented in Table 5-3.

Table 5-3 Capital Expenditure in Year 1 (Base Case)

	Capex Items	Cost
Little Murray Weir	Installation of gates to replace drop bars	$ 127,000
Lake Boga	Construction of outfall to Little Murray River	$ 5,672,028
Total Costs		**$ 5,799,028**

5 Detailed Analyses of Selected Options

Baseline Water Losses

Torrumbarry Irrigation Area

The TIA Baseline losses (Year 2004/05) as assessed by advice provided by NVIRP on 7 Dec 2009 for bank leakage, seepage and evaporation from all irrigation distribution channels (Backbone and spurs) are summarised as follows:

Table 5-4 Torrumbarry Irrigation Area Baseline Component Losses

Loss Component	*Loss (ML)*
Bank Leakage	*44,895*
Seepage	*20,182*
Evaporation	*17,716*
Total	*82,793*

For the 1,255 km of man-made channels in the TIA, the rate of loss for seepage, bank leakage and evaporation is 66 ML/km average across GMID *(NVIRP – pers. Comm. Peter Roberts)*.

Swan Hill System

Applying the TIA loss rates to the Swan Hill distribution system, the loss components on the No. 9 and No. 10 Channel systems are estimated as shown in the tables below. These are estimated on the basis of the following system channel lengths:

- No 9 Channel – Backbone 31.2 km; spurs 58.7 km.
- No 10 Channel – Backbone 7 km; spurs 42.9 km.

Table 5-5 Baseline Year Losses (LTCE) - No 9 Channel System

Loss Component	*Loss (ML/yr)*	
	Backbone	***Spurs***
Bank Leakage	*1,115*	*2,100*
Seepage	*501*	*944*
Evaporation	*440*	*829*
Total	***2,056***	***3,873***

Table 5-6 Baseline Year Losses (LTCE) - No 10 Channel System

Loss Component	*Loss (ML/yr)*	
	Backbone	***Spurs***
Bank Leakage	*250*	*1,534*
Seepage	*112*	*690*
Evaporation	*98*	*605*
Total	***460***	***2,829***

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Little Murray Weir

G-MW has undertaken an estimate of the evaporation and seepage losses from the LMW pool *(DOCS# 2429066 v2, refer to Appendix B)* using a HEC-RAS analysis with the following data.

- Annual evaporation rate of 1.5 m, and annual rainfall of 350 mm.
- A seepage rate 1 mm/d for 270 days.

The estimated losses were:

Evaporation	*3,270 ML*
Seepage	*770 ML*
Total	***4,040 ML***

5.2.5 BCA of Option 1: Pipe the No. 9 Channel through Swan Hill

Refer to Section 4.4.2 for an outline of Option 1 and Section 4.5.1 for a technical description.

The breakdown of expected water savings under Option 1 are presented in Table 5-7.

Table 5-7 Water Savings for Option 1

Intervention	*Water Savings*
	ML
Pipeline No 9 Channel through Swan Hill	*164*
Rationalise No 9 Channel through Swan Hill	*-*
Lower Little Murray Weir Pool	*1,814*
Pipeline Werrill Street System	*212*
Pipeline Karinie-McCallum Street System	*-*
Construct Karinie Street Pipeline	*-*
Construct link channel	*(19)*
Estimated Net Saving	***2,171***

Approximately nine hectares of land could be reclaimed for community recreational use under Option 1, or developed for residential/commercial purposes. This is based on the replacement of an approximate 2.0 km stretch of the No. 9 Channel with pipe, assumed to be 20 m wide. The potential benefits are unlikely to be reduced by the area required by the easement to any measureable extent.

In addition to the benefits quantified here, implementation of this option will mitigate the risks to health and safety posed by the current open channel through the Rural City of Swan Hill. The decommissioning of the channel could also reduce the potential damage to properties (through subsidence caused by seepage) and hence the business risks to G-MW.

The results of the BCA for Option 1 are presented in Table 5-8.

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Table 5-8 Option 1 - Benefits and Costs

	Benefits and Costs	Present Value (6% discount rate over 30 years)
BENEFITS		
	Water Savings (2,171 ML/yr)	5,742,000
	Reclaimed land	176,000
	Base Case costs avoided	15,210,000
Total Benefits		**21,129,000**
COSTS		
NVIRP modernisation		939,000
Little Murray Weir		2,161,000
Little Murray River Pump Station		2,641,000
Werrill St Pump Station		1,282,000
No. 9 Channel		8,449,000
No. 10 Pump Station		2,125,000
No. 10 Channel		313,000
Channel connecting 13/9 and 2/2/10		305,000
EPBC Referrals		1,000,000
Total Costs		**19,217,000**
NET PRESENT VALUE		**1,912,000**
NET COST PER ML OF WATER SAVINGS		**1,764**

The per ML cost of water savings is equal to all costs incurred in achieving water savings, less all non-water savings benefits, divided by the volume of water savings. For Option 1 this is $19,217,000 minus ($176,000 + $15,210,000), all divided by 2171 ML of water savings.

The capital expenditure items to be incurred in the first year under Option 1 are presented in Table 5-9.

Table 5-9 Capital Expenditure in Year 1 (Option 1)

	Capex Items	Cost
Little Murray Weir	Reduce Little Murray Weir	$ 350,000
	Environmental investigation and mitigation	$ 500,000
	Reconnection of LMW Pool diverters	$ 1,262,700
Little Murray River Pump Station	Construction of pump station	$ 1,609,706
Werrill St Pump Station	Construct Pump Station at Werrill St	$ 563,654
	Pipe to spurs - works and materials	$ 434,342
No. 9 Channel	Remove channel between Werrill St and McCallum St, infill	$ 183,425
	Pipe between Werrill St and McCallum St - works and materials	$ 7,266,441
No. 10 Pump Station	Upgrade pump motor	$ 441,000
No. 10 Channel	Modification of No. 10 channel - earthworks and road culverts	$ 312,576
Channel connecting 13/9 and 2/2/10	Construction	$ 299,963
	Land acquisition	$ 5,000
EPBC Referrals	Referral costs	$ 1,000,000
Total Costs		**$ 14,228,807**

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5.2.6 BCA of Option 2: Truncate the No. 9 Channel, Install Karinie Street Pipeline, no Link Channel

Refer to Section 4.2.2 for an outline of Option 2 and Section 4.5.2 for a technical description. The breakdown of expected water savings under Option 2 are presented in Table 5-10.

Table 5-10 Water Savings for Option 2

Intervention	*Water Savings*
	ML
Pipeline No 9 Channel through Swan Hill	*-*
Rationalise No 9 Channel through Swan Hill	*218*
Lower Little Murray Weir Pool	*1,814*
Pipeline Werrill Street System	*212*
Pipeline Karinie-McCallum Street System	*125*
Construct Karinie Street Pipeline	*(0)*
Construct link channel	*-*
Estimated Net Saving	***2,369***

Sixteen hectares of land could be reclaimed for community recreational use under Option 2, or developed for residential/commercial purposes (this is different to land available under Option 1). It is based on the replacement of an approximate 2.0 km stretch of the No. 9 Channel with pipe, assumed to be 20 m wide.

In addition to the benefits quantified here, implementation of this option will mitigate the risks to health and safety posed by the current open channel through the Rural City of Swan Hill. The decommissioning of the channel could also reduce the potential damage to properties through subsidence caused by seepage and, hence, the business risks to G-MW.

The results of the BCA for Option 2 are presented in Table 5-11.

Table 5-11 Option 2 - Benefits and Costs

	Benefits and Costs	Present Value (6% discount rate over 30 years)
BENEFITS		
	Water Savings (2,369 ML/yr)	6,266,000
	Reclaimed land	320,000
	Base Case costs avoided	15,210,000
Total Benefits		21,796,000
COSTS		
NVIRP modernisation		709,000
Little Murray Weir		2,161,000
Little Murray River Pump Station		1,906,000
Werrill St Pump Station		1,282,000
No. 9 Channel		310,000

5 Detailed Analyses of Selected Options

	Benefits and Costs	Present Value (6% discount rate over 30 years)
No. 10 Pump Station		4,767,000
Pipeline up Karinie St to Karinie St Relift PS		7,928,000
Karinie St Relift PS		595,000
Pipe from Karinie St to McCallum St Spurs		239,000
EPBC Referrals		1,000,000
Total Costs		20,899,000
NET PRESENT VALUE		897,000
NET COST PER ML OF WATER SAVINGS		2,266

The per ML cost of water savings is equal to all costs incurred in achieving water savings, less all non-water savings benefits, divided by the volume of water savings. For Option 2 this is $20,899,000 minus ($320,000 + $15,210,000), all divided by 2369 ML of water savings. The capital expenditure items to be incurred in the first year under Option 2 are presented in Table 5-12.

Table 5-12 Capital Expenditure in Year 1 (Option 2)

	Capex Items	Cost
Little Murray Weir	Reduce Little Murray Weir	$ 350,000
	Environmental investigation and mitigation	$ 500,000
	Reconnection of LMW Pool diverters	$ 1,262,700
Little Murray River Pump Station	Construction of pump station	$ 1,215,534
Werrill St Pump Station	Construct Pump Station at Werrill St	$ 563,654
	Pipe to spurs - works and materials	$ 434,342
No. 9 Channel	Remove channel between Werrill St and McCallum St, infill	$ 310,444
No. 10 Pump Station	Install relift pump	$ 2,126,230
Pipeline up Karinie St to Karinie St Relift PS	Pipeline - works and materials	$ 6,968,729
Karinie St Relift PS	Install relift pump	$ 464,454
Pipe from Karinie St to McCallum St Spurs	Pipeline - works and materials	$ 209,564
EPBC Referrals	Referral costs	$ 1,000,000
Total Costs		**$ 15,405,651**

5.2.7 BCA of Option 3: Truncate No. 9 Channel, Install Karinie Street Pipeline and the Link Channel

Refer to Section 4.2.2 for an outline of Option 3 and Section 4.5.3 for a technical description. The breakdown of expected water savings under Option 3 are presented in Table 5-13.

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Table 5-13 Water Savings for Option 3

Intervention	*Water Savings*
	ML
Pipeline No 9 Channel through Swan Hill	*-*
Rationalise No 9 Channel through Swan Hill	*218*
Lower Little Murray Weir Pool	*1,814*
Pipeline Werrill Street System	*212*
Pipeline Karinie-McCallum Street System	*125*
Construct Karinie Street Pipeline	*(0)*
Construct link channel	*(19)*
Estimated Net Saving	***2,350***

Sixteen hectares of land could be reclaimed for community recreational use under Option 3, or developed for residential/commercial purposes (this is different to land available under Option 1). It is based on the replacement of an approximate 2.0 km stretch of the No. 9 channel with pipe, assumed to be 20 m wide.

In addition to the benefits quantified here, implementation of this option will mitigate the risks to health and safety posed by the current open channel through the Rural City of Swan Hill. The decommissioning of the channel could also reduce the potential damage to properties (through subsidence caused by seepage) and hence the business risks to G-MW.

The results of the BCA for Option 3 are presented in Table 5-14.

Table 5-14 Option 3 - Benefits and Costs

	Benefits and costs	Present Value (6% discount rate over 30 years)
BENEFITS		
	Water Savings (2,350 ML/yr)	6,216,000
	Reclaimed land	320,000
	Base Case costs avoided	15,210,000
Total Benefits		**21,746,000**
COSTS		
NVIRP modernisation		780,000
Little Murray Weir		2,161,000
Little Murray River Pump Station		1,906,000
Werrill St Pump Station		1,282,000
No. 9 Channel		183,000
No. 10 Pump Station		3,962,000
Pipeline up Karinie St to Karinie St Relift PS		4,816,000
Karinie St Relift PS		595,000
Pipe from Karinie St to McCallum St Spurs		239,000

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Benefits and costs	Present Value (6% discount rate over 30 years)
No. 10 Channel	313,000
Channel connecting 13/9 and 2/2/10	305,000
EPBC Referrals	1,000,000
Total Costs	**17,543,000**
NET PRESENT VALUE	**4,203,000**
NET COST PER ML OF WATER SAVINGS	**857**

The per ML cost of water savings is equal to all costs incurred in achieving water savings, less all non-water savings benefits, divided by the volume of water savings. For Option 3 this is $17,543,000 minus ($320,000 + $15,210,000), all divided by 2350 ML of water savings. The capital expenditure items to be incurred in the first year under Option 3 are presented in .

Table 5-15 Capital Expenditure in Year 1 (Option 3)

	Capex Items	Cost
Little Murray Weir	Reduce Little Murray Weir	$ 350,000
	Environmental investigation and mitigation	$ 500,000
	Reconnection of LMW Pool diverters	$ 1,262,700
Little Murray River Pump Station	Construction of pump station	$ 1,215,534
Werrill St Pump Station	Construct Pump Station at Werrill St	$ 563,654
	Pipe to spurs - works and materials	$ 434,342
No. 9 Channel	Remove channel between Werrill St and McCallum St, infill	$ 183,425
No. 10 Pump Station	Install relift pump	$ 1,581,220
Pipeline up Karinie St to Karinie St Relift PS	Pipeline - works and materials	$ 4,232,542
Karinie St Relift PS	Install relift pump	$ 464,454
Pipe from Karinie St to McCallum St Spurs	Pipeline - works and materials	$ 209,564
No. 10 Channel	Modification of No. 10 channel - earthworks and road culverts	$ 312,576
Channel connecting 13/9 and 2/2/10	Construction	$ 299,963
	Land acquisition	$ 5,000
EPBC Referrals	Referral costs	$ 1,000,000
Total Costs		**$ 12,614,974**

5.2.8 Summary of BCA Analyses

A summary of the outcomes of the BCA for each of the three options is outlined in Table 5-16. Option 3 is clearly the most economically viable of the three options.

Table 5-16 Summary of benefit cost analyses

Option	Net Present Value	PV of Benefits	PV of Costs	Cost per ML of Water Savings
Option 1	$ 1,912,000	$ 21,129,000	$ 19,217,000	$ 1,764
Option 2	$ 897,000	$ 21,796,000	$ 20,899,000	$ 2,266
Option 3	$ 4,203,000	$ 21,746,000	$ 17,543,000	$ 857

Level of Service to Irrigators

Although not quantified, an additional economic benefit will arise due to the level of service being improved by the planned automation of the Backbone channel, allowing a more timely delivery of the water, consistency of flow and a shorter ordering time-lag, hence more irrigation flexibility. However, as these improvements would be realised under the base case and would apply under all options, the value of the associated benefits have not been estimated.

5.2.9 Sensitivity Analysis

Monte Carlo Distributions

Assumptions about quantities, values and costs involve an unavoidable amount of uncertainty. For each of these, high and low values have been estimated such that a statistical distribution for the BCA results could be derived using Monte Carlo analysis. The outputs of the analysis provide confidence intervals for the BCA results. These confidence intervals are presented in Table 5-17. Option 3 is clearly the preferred option and is the only option to produce a positive NPV under the low scenario.

Table 5-17 Monte Carlo Analysis of Results

Option	BCA Item	Expected Value ($)	Estimate range		
			Low (10th percentile)	Median (50th percentile)	High (90th percentile)
Option 1	Net Present Value	1,912,025	-3,686,671	444,881	4,720,476
	PV of Benefits	21,128,663	18,743,675	21,985,527	25,765,747
	PV of Costs	19,216,638	19,492,958	21,402,269	24,101,093
	Cost per ML of Water Savings	1,764	666	2,259	4,786
Option 2	Net Present Value	897,414	-4,636,473	-592,491	3,808,581
	PV of Benefits	21,796,373	19,208,571	22,469,435	26,352,151
	PV of Costs	20,898,959	20,908,145	22,936,893	25,566,862
	Cost per ML of Water Savings	2,266	1,190	2,736	5,070

5 Detailed Analyses of Selected Options

Option	BCA Item	Expected Value ($)	Estimate range		
			Low (10th percentile)	Median (50th percentile)	High (90th percentile)
Option 3	Net Present Value	4,202,640	-960,186	2,887,118	7,108,582
	PV of Benefits	21,746,118	19,165,020	22,424,598	26,299,940
	PV of Costs	17,543,478	17,843,699	19,501,564	21,577,055
	Cost per ML of Water Savings	857	-120	1,257	2,980

A Monte Carlo Analysis has also been undertaken to assess the uncertainty involved in the up-front capital costs for each option. These are presented in table Table 5-18. Note that the upfront costs are gross amounts – they do not include the savings from avoiding the base case upfront costs (base case costs should be deducted from each option to find assess upfront costs).

Table 5-18 Upfront Capital Costs summary

Option	Item	Expected Value ($)	Estimate range ($)		
			Low (10th percentile)	Median (50th percentile)	High (90th percentile)
Base Case	Upfront capital costs	5,799,028	4,967,781	6,185,166	8,087,119
Option 1	Upfront capital costs	14,228,807	14,549,701	15,731,297	17,559,977
Option 2	Upfront capital costs	15,405,651	15,776,041	16,795,350	18,327,517
Option 3	Upfront capital costs	12,911,146	13,152,339	14,040,563	15,259,813

Discount Rate

The following sensitivity analyses have been carried out independently of any Monte Carlo simulations.

A discount rate of 6% was used for discounting future flows of benefits and costs in the BCA. To test the sensitivity of results to this assumption, the BCA has been undertaken using discount rates of 4% and 8%. The outcomes are presented in Table 5-19. A higher discount rate reduces the NPV for each option, while a lower discount rate produces the opposite effect. Option 3 remains the clear preference under both scenarios.

Table 5-19 Sensitivity analysis - Discount Rate

Option	Net Present Value ($)		Cost per ML of Water Savings ($)	
	4% discount rate	8% discount rate	4% discount rate	8% discount rate
Option 1	4,069,000	465,000	771	2,431
Option 2	2,860,000	-413,000	1,438	2,819
Option 3	6,326,000	2,777,000	-47	1,463

Value of Water Savings

The analysis undertaken here has assumed a value for water savings of $2,645 per ML. Recent purchases of high security water entitlements by the Commonwealth indicate values of between $2,000 and $2,500 per ML in Northern Victoria. However, this range may represent the 'low hanging fruit' in the current stage of the buyback scheme and is therefore too low to be assumed as the average estimate. The range may also underestimate society's actual willingness to pay for water savings. The NVIRP Connections Program typically use a value of $2,645 per ML for valuing water savings. The analysis in Table 5-20 presents the results using both $2,000 and $3,000 per ML to test the impact on results of different values for water savings.

Table 5-20 Sensitivity Analysis - Value of Water Savings

Option	Net Present Value ($)		PV of Benefits ($)	
	$2,000 per ML	$3,000 per ML	$2,000 per ML	$3,000 per ML
Option 1	512,000	2,683,000	19,728,000	21,899,000
Option 2	-631,000	1,738,000	20,268,000	22,637,000
Option 3	2,687,000	5,037,000	20,230,000	22,580,000

5.3 Social Considerations

The identified social impacts of implementing the various options are discussed below. They essentially fall into two categories: quantified as part of the BCA or not quantified, in which case a discussion about their significance is provided below.

5.3.1 Quantified

No social impacts have been quantified.

5.3.2 Not Quantified

The following social impacts have been considered, but not quantified for the reasons outlined. Both factors can be considered as contributing to a thriving local community.

Public safety and flood damage issues

The No. 9 Channel currently passes through the urban area of Swan Hill, which gives rise to public safety issues, and increased potential for flood damages (from overtopping of banks and also from seepage leading to subsidence or structural damage).

As indicated in Section 1, removing the public safety issue and the risk of drowning in the channel, is one of the key drivers of the project. The preliminary screening ruled out the possibility of retaining the channel through Swan Hill and all shortlisted options represent this. As the objective of the options assessment is to differentiate the options and as public safety risk is identical for all options (excluding the Base Case), it is not necessary to quantify the risk as part of the BCA. It is simply a benefit of every option compared to the Base Case. Measuring the size of this benefit would involve putting a monetary value on human life.

Increased amenity from removal of irrigation channel through the Rural City of Swan Hill

The removal of the section of the No. 9 channel through Swan Hill would provide the opportunity to create a public space which would provide greater amenity to residents and visitors to Swan Hill than the current channel. The removal of the channel may also enhance the way in which residents of Swan Hill interact. The value of these potential benefits have not been included and would be difficult to estimate.

5.4 Environmental Considerations

As with the social impacts, the environmental impacts related to the implementation of the various options fall into two categories: quantified as part of the BCA or not quantified. This classification has been used to structure the discussion below.

5.4.1 Quantified

The key environmental impact that has been quantified in the BCA is water savings. Water savings are one of the key drivers of irrigation modernisation programs in general. To estimate the value of these savings, the price supplied by NVIRP of $2,645 for each ML per year saved has been used. However, as demonstrated in the BCA, the volume of water savings is not significantly different between options and is therefore not a key component of determining the preferred option.

5.4.2 Not Quantified

The following impacts have been identified and assessed qualitatively.

Environmental impacts related to the upgrade works

The upgrade works will cause some environmental disturbance around the channel or pipeline areas, mainly related to earthworks. The following mitigating factors need to be considered:

- assessments of the sites will be carried out prior to commencing work and any risk assessed;
- no high-value native vegetation area is likely to be impacted, as the district has been used for agricultural use for a long time;
- upgrade works are routinely undertaken for NVIRP and G-MW with safeguards in place to ensure that the works are carried out in a way that minimises environmental impacts; and
- disturbance will be limited in time and magnitude, as no extensive channel modification is involved, mainly structure upgrades or replacement and pipe laying.

Considering the above factors, and as all options will require work to be done around the channels and all involve some pipeline laying, it would be very difficult to estimate the difference in environmental impacts from works undertaken between the various options. The impact has therefore been considered as equivalent under all options, until detailed environmental assessment of the areas impacted is undertaken.

Environmental impacts of lowering the Little Murray Weir

The LMW pool provides environmental benefits as a habitat for a number of native fish species. SKM have carried out a flora and fauna, fish survey and heritage assessment for the LMW pool. These assessments are considered to be indicative. However, irrespective of the environmental impacts of lowering the water level of the LMW pool, the impacts will be constant across all options and will therefore affect each option equally.

Environmental impacts of the reduced water releases for irrigation purposes on the Kerang Lakes complex

Under all options, the volume of water required for irrigation purposes will be reduced, which may impact on the Kerang Lakes (RAMSAR site) upstream of the LMW. If found significant, the impact may need to be managed by releasing additional environmental flows, as appropriate, along that stretch of the channel which supplies the Kerang Lakes (No. 7 Channel). Some of the water savings generated from the SHMP may possibly be allocated for this purpose.

However, this consideration does not detract from the fact that water savings would be realised in the region and should be valued as such. Moreover, the water used for environmental flow would still be available downstream. This issue can therefore be considered as outside the scope of the BCA and should simply be noted for consideration as part of any management study of environmental flows associated with the River Murray system.

Salinity Impacts

Similarly, the various options may deliver some benefits in terms of salt exports to the River Murray, however the interactions with the Kerang Lakes complex upstream complicates the analysis of these benefits. As a result, the level of net benefits, if any, is unclear. Preliminary analysis, included in the Options Report, December 2009, suggests that salt exports are unlikely to be a significant factor in the analysis. The issue of salinity impacts is discussed in Section 5.6.

5.5 Water Savings

There are water savings associated with the proposed modernisation of Swan Hill irrigation infrastructure. These water savings were reviewed with in accordance with the DSE guidelines on water savings: Water Savings Protocol – Technical Manual for Quantification of Water Savings, June 2009. The calculations are presented in Appendix B. The calculations included here are based on a report by G-MW *(G-MW DOC #2429066v2)* regarding lowering the LMW.

5.5.1 Little Murray Weir

In 2005, G-MW carried out preliminary calculations of potential water savings associated with lowering the crest level of LMW. This assumed the gates on LMW would be removed.

5 Detailed Analyses of Selected Options

G-MW proposed a reduced crest level of 66.71mAHD and the associated tailwater at this level would be in the order of 33km. This level has been assumed for the purposes of calculation and will be reviewed in light of forthcoming environmental studies.

G-MW state their case for lowering the Weir in their report, "Torrumbarry Irrigation Area, Feasibility Study to Abandon the LMW…", 11 March 2008, *(G-MW DOC #2429066v2, refer to Appendix B)*, and discuss water savings on pages 9 and 10 of that report. G-MW note that seepage has been calculated based on the assumption that the channel lining appears to be of good quality (low seepage) clay.

Review of Calculations

URS have visited the LMW but have not inspected banks along the weir pool, nor have any condition assessment or geotechnical studies been made available to URS. It is assumed that there is no leakage resulting from bank leakage since the waterway is virtually all below natural surface level.

The key components of the water savings in the weir pool are seepage, bank leakage and evaporation. The assumptions made by G-MW and their implications are discussed here.

The HEC-RAS model of the pool and channel immediately upstream of LMW shows a longer tailwater length, at the level proposed by G-MW. The model suggests that the tailwater of usable water may be closer to approximately 50km rather than the assumed 33km. There appear to be two steps in bed profile (28km and 50km) at approximately the water depths considered by G-MW. The lowered water depths at these locations are in the order of 1.2m and 0.7m.

The lowered level of the LMW is assumed to be based on G-MW drawing #135990 (refer to Appendix C). This drawing shows the gate sill levels as 66.79mAHD for 20 no. gates and 67.37mAHD for 8 no. gates. The lower sill level is close to G-MW's proposed lowered level of 66.71mAHD. The Full Supply Level is shown as (Top Water Level of) 69.31mAHD.

The seepage rate of 1mm per day does not seem unreasonable based on the limited information available at this time. This value is in keeping with more permeable clays and it is also a similar order of magnitude to other recent studies on Backbone irrigation channels in northern Victoria. It is recommended that this amount of seepage is confirmed by a seepage study as part of a geotechnical investigation.

The rainfall assumed by G-MW (350mm per year) equates to approximately 1mm per day for 270 days of irrigation season, is largely consistent with long-term and recent rainfall records held by the Bureau of Meteorology (BoM).

The evaporation rate assumed by G-MW (1500mm per year) equates to approximately 4mm per day, for the 270 days of irrigation season and is consistent with studies in this area of Victoria, however BoM do not have this data on their website. The surface area assumed for 33km of tailwater is consistent with URS' calculations, based on the G-MW supplied HEC-RAS model. The output from the model is included in Appendix B.

It is not clear if G-MW have used a pan-factor in the calculation of evaporation losses. Typical values for this range from 0.75 to 0.9. It is recommended that the evaporation losses in this area are confirmed by further studies.

These calculations have been compared against the current DSE Water Savings Protocol – Technical Manual for Quantification of Water Savings, June 2009. The water savings calculations relating to the options for the LMW pool are included in Appendix B.

5.5.2 Channels

The truncation of the No. 9 Channel through Swan Hill is proposed as part of the modernisation. There are water savings associated with the removal of this channel from the system which are discussed in Section 5.2.3 of this report.

The water savings calculations relating to the options for this channel are included in Appendix B.

5.5.3 Conclusion

G-MW's estimates of seepage and evaporation are consistent with the information currently available for the stated case i.e. lowering the crest level of LMW from 69.21mAHD to the assumed level of 66.71mAHD. It is recommended that the assumed seepage and evaporation rates are confirmed following completion of the environmental report. The lowered level of the weir should also be clarified and agreed between the stakeholders.

5.6 EC Impacts

NVIRP will analyse and report its total salinity impact in accordance with the Murray Darling Basin Salinity Management Strategy. The salinity of the Swan Hill Modernisation Project can only be determined once revised operating protocols are developed for the delivery of water downstream of the Kerang Lakes and operation of the Little Murray River.

6

Modernisation Plan: Implementing the Preferred Option

This Final Report presents a proposed Modernisation Plan for the Northern Victorian Irrigation Renewal Project (NVIRP) to reconfigure the irrigation system within the Swan Hill Irrigation Region (SHIR) of the Torrumbarry Irrigation Area (TIA). It is one of many initiatives of NVIRP which are being progressed to modernise the irrigation systems in northern Victoria with the aim of securing the economic, social and environmental future of the region.

As an example, NVIRP will carry out automation of the channels regardless of the outcomes of this Swan Hill project and in doing so, would have reduced the capacity of the No. 9 regulators where possible. Also, NVIRP will install channel lining, where required, to reduce seepage losses.

The overall objective of the modernisation plan for the SHIR is to secure ongoing water savings through increasing the water delivery efficiency of the system and, by doing so, to facilitate improvements in the efficiency with which water is delivered to the customers. The plan presented has been developed based on a detailed analysis of the costs and benefits of a number of potential reconfiguration options compared with the current system.

6.1 Key Features

Based on the analyses presented in Section 5, Option 3 is assessed as the preferred option, with a NPV of $8.3 million relative to the base case. In comparison, the NPV for Options 1 and 2 were $5.8 and $5.0 million respectively. These estimates of NPV are derived from the costs and benefits that were able to be quantified.

The key features of Option 3 which underlie the associated benefits relative to the base case were:

- the lowering of the LMW which gives rise to avoided costs of:
  - operating the weir and ultimately replacing the weir;
  - constructing a new outfall from Lake Boga under the MMS; and
- water savings largely from lowering the LMW and the resulting reduced evaporation and seepage.

In addition there are a number of wider social and economic benefits associated with all the options that could not be measured. The social benefits relate largely to the removal of the No. 9 Channel from the Rural City of Swan Hill and the resulting increased public safety and amenity of the area (refer to Section 5.3). With reference to the environmental benefits (or costs), these relate mainly to the environmental impacts of lowering the LMW. These impacts are still being assessed through the further environmental studies that are being undertaken (refer to Section 2.7).

6.2 Impact on Other Torrumbarry System Irrigators

The implementation of Option 3, or any other option, should not impact on other irrigators in the TIA in terms of the potential for these other irrigators being required to bear a share of the costs of implementation. This is for two main reasons:

- the costs of implementing those aspects of Option 3 associated with the NVIRP Automation Works and Connection Programs are being funded by NVIRP through the funding arrangements established by the Victorian Government;
  - these programs also provide the opportunity to address any termination fee considerations that may arise in the Swan Hill Irrigation Region so that they do not affect irrigators in other irrigation areas in the TIA; and

- future-user charges in the Swan Hill Irrigation Region can be determined so that the costs of implementing Option 3 (or any other option) are borne only by those land holders serviced in this region by the reconfigured irrigation system;

With respect to future user charges, these should be adjusted to reflect the initial capital contributions made by NVIRP, G-MW, DSE and, potentially the Swan Hill Rural City Council, to implement Option 3. The setting of future user charges for the reconfigured system may also provide the opportunity to review the situation where the cost of the No. 10 Pump Station is borne by all TIA customers given that the initial capacity constraints for this sharing of costs would appear to no longer apply (refer to Section 2.2.4).

6.3 Potential Funding Sources

The potential funding sources for implementing Option 3, or any other option, will be determined by the funding sources of the key stakeholders, namely NVIRP, G-MW, DSE and possibly Swan Hill Rural City Council. The main underlying funding sources for these stakeholders are:

- NVIRP — State Budget appropriations, Melbourne Water (mainly from the revenue raised through the three Metropolitan Melbourne retail water companies), G-MW (from revenue raised from its customers) and potentially the Commonwealth Government under its Water for the Future Program;
- G-MW — revenue raised from its customers;
- DSE — State Budget appropriations and, potentially, the Commonwealth Government under its Water for the Future Program; and
- Swan Hill Rural City Council — municipal ratepayers.

Although an assessment of the benefits which would be realised by these stakeholders will provide a guide to the relative share of the costs which should be borne through these funding sources, the actual contributions will be dependent on negotiations between the stakeholders.

6.4 Implementation Risks

There are a number of potential risks that could threaten the successful implementation of Option 3. These can be grouped into three broad categories, namely those associated with:

- errors in estimating the benefits and costs (including timing delays);
- the number of parties involved and the failure to reach agreement on the preferred option and, hence, to commit the required funds; and
- failure to obtain the required approvals to lower the LMW.

6.4.1 Estimation Errors

Volume of Water Savings

A major driver of the benefits of Option 3, as well as the other options, is the potential water savings from the lowering of the LMW (refer Section 5.4). Because of this, the validity of the method used to calculate the savings, and their order of magnitude, has been rigorously checked and are considered to be a reliable estimate.

Nevertheless, based on the assessment of the BCA of Option 3, which used an overall water savings estimate of 2350 ML (1814 ML from the lowering the LMW), the volume of water savings would have to be no greater than 762 ML for the option to be economic.

Alignment of Design Capacity with Future Water Demand

The estimation of future demand for irrigation water and, hence the design capacity required, has been informed by the advice that 90 DS will be removed from the No. 9 and No. 10 Channel systems (40 DS and 50 DS respectively). In turn, this advice was informed by the work undertaken by Price Merrett Consulting as part of the Farm Irrigation Assessment process with the NVIRP Connections Program. Overall, this is considered to constitute the best advice available with which to match design capacity and future water demand.

Cost Changes for Materials and Construction

The estimate of the costs for materials and construction used in the BCA analyses were derived using Monte Carlo Analysis to establish a best estimate of what the costs would be within a given confidence interval. Accordingly, the estimates used are considered to be robust. Based on the estimates used, costs would need to increase by $4.2 million (24%) under Option 3 (refer Table 5-14) before that option would become uneconomic.

Timing Delays

If, for example, the implementation of Option 3 were delayed through the referral process under the *Environment Protection and Biodiversity Conservation Act 1999* (C'th), the main effect would be to delay the timing for when the water savings would be achieved as well as when the costs would be incurred. This would cause a slight reduction in the calculated NVP for Option 3, and all other options.

6.4.2 Agreement Between the Affected Parties

There are a number of key stakeholders associated with determining which reconfiguration option is implemented for the Swan Hill Irrigation Region and a major risk to the implementation of any reconfiguration option is the failure to reach agreement between them. Although the task of reaching agreement is a matter for the parties to achieve, an objective assessment of the benefits to be realised through the selected reconfiguration option should provide a basis to reach agreement on how the costs of reconfiguration should be borne.

6.4.3 Environmental Approval Withheld

The process to obtain the required environmental approvals to lower the LMW is not yet complete. Thus, there is a possibility that the necessary approval to do so will not be forthcoming. In this situation, a supplementary analysis was undertaken to assess the impact of not being able to lower the LMW relative to Option 3. This analysis is presented in Section 7.1.

7

Supplementary Analyses

This section presents the results of the supplementary analysis undertaken on the preferred Option 3 for the situation that environmental approval is not received to lower the LMW, given that the process of obtaining the required environmental approvals has not been completed.

7.1 Approval Not Received to Lower the Little Murray Weir

If environmental approval is not granted to lower the LMW, this would mean that most of the water savings that would arise under Option 3 would no longer be realised and that the costs of operating and replacing the weir would no longer be avoided. It would also mean that the costs of constructing a new outfall for Lake Boga under the MMS would be incurred. Apart from these aspects, the other aspects of Options 3 would remain largely the same in this situation, resulting in a NPV of negative $8.6 million; the NPV for Option 3 was $4.2 million (refer to Table 5-14).

Table 7-1 BCA, should approval not be granted to lower the Little Murray Weir

	Benefit and costs	Present Value (6% discount rate over 30 years)
BENEFITS		
	Water Savings (536 ML/yr)	1,418,000
	Reclaimed land	320,000
	Base Case costs avoided (All except LMW & Lake Boga outfall)	1,973,000
Total Benefits		**3,711,000**
COSTS		
NVIRP modernisation		780,000
Werrill St Pump Station		1,271,000
No. 9 Channel		183,000
No. 10 Pump Station		3,792,000
Pipeline up Karinie St to Karinie St Relift PS		4,816,000
Karinie St Relift PS		595,000
Pipe from Karinie St to McCallum St Spurs		239,000
No. 10 Channel		313,000
Channel connecting 13/9 and 2/2/10		305,000
Total Costs		**12,295,000**
NET PRESENT VALUE		**- 8,584,000**
NET COST PER ML OF WATER SAVINGS		**18,660**

The per ML cost of water savings is equal to all costs incurred in achieving water savings, less all non-water savings benefits, divided by the volume of water savings. For Option 3 this is $12,295,000 minus ($320,000 + $1,973,000), all divided by 536 ML of water savings.

8

Summary: Next Steps

In seeking to identify the preferred reconfiguration option for the Swan Hill Irrigation Region as part of the Swan Hill Modernisation Project, it quickly became evident that the potential reconfiguration options:

a) needed to be developed from the perspective that actions already initiated under the Automation and Connections Programs of NVIRP would occur (that is, these programs and associated actions formed part of the base case); and
b) could not be identified and assessed from the perspective only of achieving waters savings in the storage and distribution of irrigation water.

With respect to b), the consideration of potential reconfiguration options provided the opportunity to address simultaneously other water management issues within the TIA, especially with respect to the open irrigation channel through the Rural City of Swan Hill and the environmental outcomes sought through MMS project. The consideration of these wider water management issues is being integrated through TISCC, which is being convened by DSE. However, because these wider issues were explicitly taken into account in the development and evaluation of potential reconfiguration options, it is anticipated that this report will be beneficial in informing the work of TISCC (refer to Section 1.4).

8.1 Features of the Preferred Option: Option 3

Option 3 is assessed as the preferred option, with a NPV of $4.2 million (Table 5-14) relative to the base case. In comparison, the NPV for Options 1 and 2 were $1.9 million (Table 5-8) and $0.9 million (Table 5-11) respectively. These estimates of NPV are derived from the costs and benefits that were able to be quantified.

Under this option, the No. 9 Channel would be truncated at Werrill Street and a new pipeline installed along Karinie Street pipeline, together with a connecting channel between the No. 2/2/10 and No. 13/9 Channels, to supply water from the No. 10 Pump Station to the No. 9 Channel downstream of Swan Hill. Key features of Option 3 include:

- lowering the LMW and water level in the LMW pool;
- removing the need to construct a new outfall from Lake Boga under the MMS project; and
- the removal of the open irrigation channel through the Rural City of Swan Hill.

As for Options 1 and 2, Option 3 would also involve the removal of 40 DS and 50 DS respectively from the No. 9 Channel downstream of Swan Hill and the No. 10 Channel system under the Connections Program of NVIRP. The removal of this DS will have implications, as is already appreciated, for the proposed works by NVIRP under its Automation Program.

Once again for all options, the water savings stem largely from lowering the LMW and the resulting reduced evaporation and seepage. The potential environmental impacts of lowering the LMW are the subject of further environmental studies that are currently being undertaken.

8.2 Progressing the Implementation of Option 3

As outlined above, there are a number of dimensions associated with determining the preferred reconfiguration option for the Swan Hill Irrigation Region. Each of these dimensions will have a set of stakeholders that will have an interest in the reconfiguration option that is selected and how that option is implemented. Within this context, it is envisaged that the implementation of Option 3 (or any other reconfiguration option that is selected) would involve:

8 Summary: Next Steps

- the finalisation of the environmental studies associated with the lowering the LMW;
- communication to affected stakeholders;
- the making of any consequential adjustments to the preferred option based on the outcomes of those studies;
- the gaining of the necessary approvals to undertake the works associated with implementing the preferred option, including gaining any approvals required under the EPBC Act;
- implementing the Connections Program to achieve the required reduction in DS for both the No. 9 Channel system downstream of Swan Hill and the No. 10 Channel system;
- developing detailed designs for the preferred option;
- making adjustments to the proposed works under the Automation Program of NVIRP in light of the detailed designs;
- reaching agreement between the key stakeholders regarding how the preferred option will be funded; and
- undertaking the associated works in implementing the preferred option to reconfigure the Swan Hill Irrigation Region.

Given the broad dimensions involved, it is further envisaged that, although NVIRP will have a key lead role, many of the aspects listed will be progressed under the guidance of TISCC. Apart from convening TISCC, the role of DSE may also be important in resolving how the preferred option will be funded.

9

Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of NVIRP and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 12 June 2009.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between 17 July 2009 and 01 October 2010 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

A

Appendix A Inputs to Benefit Cost Analysis

Appendix A

A.1 General Cost Assumptions

Outlined below are the assumptions about costs that have been generally applied in the evaluation of all options. Specific costs for the base case and each option follow on from these.

Electricity Costs

Costs of electricity have been based on G-MW records and as an average have been estimated at $0.15 per kilowatt hour.

Maintenance

Maintenance costs have been estimated at 1% of capital costs unless otherwise specified. This is consistent with G-MW's methodology for assessing maintenance costs of capital works projects.

Carbon

Carbon emissions associated with electricity generation have been calculated based on a conversion rate of 1.22 tonnes per megawatt-hour (Department of Climate Change). The costs of these emissions have been based on projections of carbon prices from Treasury modelling of the proposed Carbon Pollution Reduction Scheme (see Table A-1).

Table A-1 Treasury projection of costs of CO2 prices

Year	$/t CO2 equiv.
2010	20.0
2011	21.5
2012	23.0
2013	24.5
2014	26.0
2015	27.5
2016	29.0
2017	30.5
2018	32.0
2019	33.5
2020	35.0
2021	37.7
2022	40.3
2023	43.0
2024	45.7
2025	48.3
2026	51.0
2027	53.7
2028	56.3
2029	59.0
2030	61.7

Appendix A

Allowances on Capital Costs

Under all options, a 10% allowance has been made on all direct costs for survey, design, environmental, and other miscellaneous overheads. In addition, a 15% allowance has been included for construction overheads involved in the NVIRP Automation Works Program, and a 20% allowance has been made for overheads associated with the construction of pipes and pump stations.

A.2 Summary of base case items for BCA

A summary of the base case costs used in the BCA are presented in Table A-2

Table A-2 Base Case Values

	Base Case Items	Present Value (6% Discount Rate Over 30 Years)
NVIRP modernisation*		
	Works and materials to install gates and reg. structures	894,068
	Maintenance	123,067
Little Murray Weir		
	Replacement of weir	5,924,290
	Installation of gates to replace drop bars	990,815
	Operations	486,441
	Maintenance	162,673
	Carbon emissions	622
Lake Boga		
	Construction of outfall to Little Murray River	5,672,028
No. 10 Pump Station		
	Operation costs	757,066
	Carbon emissions	199,299
TOTAL		**15,210,368**

*It is assumed that maintenance of the No.9 and No. 10 channels is included in maintenance of the NVIRP modernisation assets. It is also assumed that the operation costs of these assets would be the same under the base case and all options and have therefore not been quantified.

A.3 Base Case Inputs

A.3.1 NVIRP Channel Modernisation

The costs associated with modernising the different sections of the No. 9 and No. 10 Channel under the base case are presented in Table A-3 to Table A-6.

Table A-3 Base case costs of modernisation of No. 9 Channel – Little Murray Weir to Werrill St

No. 9 Channel	Median	Low Estimate	High Estimate
Cost of new NVIRP regulator gates and structures (works and materials) ($)	317,238	198,065	601,863
Maintenance of gates ($/yr)	3,172	1,981	6,019

Appendix A

Table A-4 Base case costs of modernisation of No. 9 Channel – Werrill St to McCallum St

No. 9 Channel	Median	Low Estimate	High Estimate
Cost of new NVIRP regulator gates and structures (works and materials) ($)	66,514	49,210	123,439
Maintenance of gates ($/yr)	665	492	1,234

Table A-5 Base case costs of modernisation of No. 9 Channel – McCallum St to rest of No.9 Channel

No. 9 Channel	Median	Low Estimate	High Estimate
Cost of new NVIRP regulator gates and structures (works and materials) ($)	278,371	241,039	512,396
Maintenance of gates ($/yr)	2,784	2,410	5,124

Table A-6 Base case costs of modernisation of No. 10 Channel

No. 10 Channel - Pump Station to Tyntynder Flats	Median	Low Estimate	High Estimate
Cost of new NVIRP regulator gates and structures (works and materials) ($)	231,945	194,506	357,691
Maintenance of gates ($/yr)	2,319	1,945	3,577

A.3.2 Little Murray Weir

The costs associated with the LMW are outlined in Table A-7.

Life expectancy, replacement costs, and operations and maintenance costs have been sourced from, or reviewed by, G-MW.

Table A-7 Little Murray Weir inputs for BCA

Little Murray Weir	Median	Low Estimate	High Estimate
Remaining life expectancy (years)	20	15	30
Replacement cost ($)	19,000,000	18,050,000	26,600,000
Cost of replacing drops bars with gates ($ per yr for ten yrs)	127,000	120,650	177,800
Operation cost ($/yr)	35,339	28,272	42,407
Electricity use (MWh/yr)	0.7	0.6	0.9
Maintenance cost ($/yr)	11,818	9,454	14,182
Carbon output (t/yr)	0.8	0.7	1.1

The present value of costs associated with the LMW is approximately $7.6 million when discounted at 6% over thirty years. It is assumed that the weir would not have any significant re-sell value (scrap value) should it be removed.

Appendix A

A.3.3 Mid-Murray Storage – Outfall to Lake Boga

The use of Lake Boga for the Mid-Murray Storage (MMS) project requires an outlet to the Little Murray River. Under the base case, an outlet is constructed connecting Lake Boga to downstream of the LMW. The construction costs of this outfall have been estimated at $5.67 million (Table 5-2).

A.3.4 No. 10 Pump Station Operations

The operation costs of the No. 10 pump station are presented in Table A-8. Note that renewals for the No. 10 pump station have not been included in the base case as these are not expected to significantly change under any of the options.

Table A-8 Base Case operation of the No. 10 Pump Station

No. 10 Pump Station		Median	Low Estimate	High Estimate
	Electricity usage (MWh/yr)	214	192	299
	Operation cost ($/yr)	55,000	49,500	77,000
	Carbon output (t/yr)	261	235	365

A.4 Summary of BCA for Option 1

A summary of the benefits and costs of the BCA for Option 1 is presented in Table 5-8. The inputs to these items are presented in the section following.

Table A-9 Option 1 - Benefits and Costs

	Benefits and Costs	Present Value (6% discount rate over 30 years)
BENEFITS		
	Water savings (2,171 ML/yr)	5,742,295
	Reclaimed land	176,000
	Base Case costs avoided	15,210,368
Total Benefits		21,128,663
COSTS		
NVIRP modernisation		
	Works and materials to install gates and reg. structures	825,440
	Maintenance	113,620
Little Murray Weir		
	Reduce LMW	350,000
	Environmental investigation and mitigation	500,000
	Maintenance of reduced weir	48,177
	Reconnection of LMW pool diverters	1,262,700
Little Murray River Pump Station		
	Construction of pump station	1,609,706
	Operations	541,187
	Maintenance	221,573
	Renewals (drives and instruments)	23,693

Appendix A

	Benefits and Costs	Present Value (6% discount rate over 30 years)
	Carbon emissions	244,486
Werrill St Pump Station		
	Construct pump station at Werrill St	563,654
	Pipe to spurs - works and materials	434,342
	PS Operations	95,447
	Maintenance	137,372
	Renewals (drives and instruments)	9,381
	PS carbon emissions	43,119
No. 9 Channel		
	Remove channel between Werrill St and McCallum St, infill	183,425
	Pipe between Werrill St and McCallum St - works and materials	7,266,441
	Pipe maintenance	1,000,213
No. 10 Pump Station		
	Upgrade pump motor	441,000
	Additional maintenance	60,703
	Operations	1,118,242
	Carbon emissions	505,176
No. 10 Channel		
	Modification of No. 10 channel - earthworks and road culverts	312,576
Channel connecting 13/9 and 2/2/10		
	Construction	299,963
	Land acquisition	5,000
EPBC Referrals		
	Referral costs	1,000,000
Total Costs		**19,216,638**
NET PRESENT VALUE		**1,912,025**
NET COST PER ML OF WATER SAVINGS		**1,764**

A.5 Option 1 Inputs

A.5.1 NVIRP Channel Modernisation

The costs associated with modernising the different sections of the No. 9 and No. 10 Channel under Option 1 are presented in Table A-10 to Table A-15.

Table A-10 Option 1 costs of modernisation of No. 9 Channel – Little Murray Weir to Werrill St

No. 9 Channel	Median	Low Estimate	High Estimate
Cost of new NVIRP regulator gates and structures (works and materials) ($)	283,116	197,248	529,791
Maintenance of gates ($/yr)	2,831	1,972	5,298

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Table A-11 Option 1 costs of modernisation of No. 9 Channel – Werrill St to McCallum St

No. 9 Channel	Median	Low Estimate	High Estimate
Cost of new NVIRP regulator gates and structures (works and materials) ($)	-	-	-
Maintenance of gates ($/yr)	-	-	-

Table A-12 Option 1 costs of modernisation of No. 9 Channel – McCallum St to rest of No.9 Channel

No. 9 Channel	Median	Low Estimate	High Estimate
Cost of new NVIRP regulator gates and structures (works and materials) ($)	236,310	195,594	396,729
Maintenance of gates ($/yr)	2,363	1,956	3,967

Table A-13 Option 1 costs of modernisation of No. 10 Channel

No. 10 Channel - Pump Station to Tyntynder Flats	Median	Low Estimate	High Estimate
Cost of new NVIRP regulator gates and structures (works and materials) ($)	306,014	245,382	584,314
Maintenance of gates ($/yr)	3,060	2,454	5,843

A.5.2 Lowering the Little Murray Weir

An estimate of the inputs involved in lowering the LMW is presented in Table A-14 (Goulburn-Murray Water).

Table A-14 Inputs to BCA for Option 1 associated with lowering of the LMW

Reduced Little Murray Weir	Median	Low Estimate	High Estimate
Cost of lowering LMW ($)	350,000	332,500	490,000
Environmental investigation and mitigation	500,000	400,000	750,000
O&M cost of lowered weir ($/yr)	3,500	3,325	4,900
Cost of reconnecting LMW pool diverters ($)	1,262,700	1,199,565	1,767,780
Water Savings- LMW pool (ML/yr)	1,814	907	2,721

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A breakdown of the costs involved in reconnecting weir diverters is provided in Table A-15.

Table A-15 Cost breakdown of reconnecting weir diverters

Connections to LMW pool customers	No.	Cost per unit	Cost
Reference: DOC 2429066			
Open outlets - replace with electric/diesel pump sets	12	$ 40,000	$ 480,000
LMO's - replace with electric/diesel pump sets	10	$ 40,000	$ 400,000
Existing pumps - extend pump suctions	17	$ 5,000	$ 85,000
Flumes - replace with magflows	5	$ 25,000	$ 125,000
D&S Pumps - extend suction	8	$ 1,000	$ 8,000
Sub-total			$1,098,000
Consultation, planning, project management			$ 164,700
Estimated total cost			$1,262,700

A.5.3 Construction of a Pump Station on the Little Murray River to Supply the No. 9 channel

A summary of the inputs to the BCA associated with the Little Murray River pump station is outlined in Table A-16 (URS).

Table A-16 Inputs to BCA for Option 1 - Little Murray River Pump Station

Little Murray River Pump Station	Median	Low Estimate	High Estimate
Construction of pump station ($)	1,609,706	1,403,040	1,766,520
Operation ($/yr)	39,317	35,385	55,043
Maintenance ($/yr)	16,097	14,030	17,665
Renewals - variable speed drives ($/15 years)	33,000	31,350	46,200
Renewals - instruments ($/10 years)	4,000	3,800	5,600
Electricity (MWh/yr)	262	236	367
Carbon emissions (t/yr)	320	288	448

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A more detailed breakdown of the costs of the pump station is presented in Table A-17(URS).

Table A-17 Detailed cost breakdown – Option 1 construction of Little Murray River Pump Station

Description	Unit	Unit Rate	Quantity	Value
Bulk excavation (high assumes imported material)	m3	$ 20	776	$ 15,520
Filling (high assumes material removed off site)	m3	$ 40	250	$ 10,000
Sheet piling	m2	$ 300	160	$ 48,000
Sheet pile on/off cost	on/off	$ 30,000	1	$ 30,000
Reinforced concrete building	m3	$ 2,000	95	$ 190,000
Steel work (hand rails, trash rack embedments etc) stainless steel	Tonne	$ 30,000	5	$ 150,000
hand rail ss	m	$ 150	9	$ 1,350
stairs (25000/tonne)	flight	$ 12,500	1	$ 12,500
Trash rack	m2	$ 4,350	15	$ 65,250
Weatherproof housing for electrics incl. in elec cost				
Valves				$ -
Isolation valve inc actuator	ea	$ 50,000	0	$ -
check valve	ea	$ 35,000	0	$ -
Penstock gate 1000 x 1000 inc actuator	ea	$ 38,000	0	$ -
Bulkheads	m2	$ 7,000	15	$ 105,000
Pumps	ea	$ 100,000	3	$ 300,000
Pump motors on existing pumps supply and fit	ea	$ 30,000	0	$ -
Pipe work	lot	$ 50,000	0	$ -
Labour Mech	hrs	$ 100	1500	$ 150,000
subtotal				$ 1,077,620
Preliminary & general	lot		20%	$ 215,524
Survey/design and other overheads	Lot		10%	$ 107,762
Mechanical and Civil Total				**$ 1,400,906**
Electrical Total				$ 208,800
Total Mech and Elec plus civils				**$ 1,609,706**

A.5.4 Pump Station at Werrill St to Supply Spurs

A summary of the inputs to Option 1 associated with a new pump station to supply spurs near Werrill St from the No. 9 Channel is presented in Table A-18.

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Table A-18 Inputs to BCA for Option 1 - Werrill St Pump Station and pipe

Pump and pipe from No.9 Channel to spurs near Werrill St	Median	Low Estimate	High Estimate
Construction of pump station ($)	563,654	507,576	737,412
Operation ($/yr)	6,934	6,241	9,708
New pipe - materials ($)	313,642	298,706	313,642
New pipe - construction ($)	120,700	114,953	168,980
Maintenance ($/yr)	9,980	8,063	10,511
Renewals - variable speed drives ($/15 years)	8,800	8,360	12,320
Renewals - instruments ($/10 years)	4,000	3,800	5,600
Electricity (MWh/yr)	46	42	65
Carbon emissions (t/yr)	56	51	79

A more detailed breakdown of the costs of the pump station is presented in Table A-19.

Table A-19 Detailed costs breakdown - Construction of Werrill St Pump Station

Description	Unit	Rate	Quantity	Value
Bulk excavation (high assumes imported material)	m3	$ 20	40	$ 800
Filling (high assumes material removed off site)	m3	$ 40	12	$ 480
Sheet piling	m2	$ 300	30	$ 9,000
Sheet pile on/off cost	on/off	$ 30,000	1	$ 30,000
Reinforced concrete building	m3	$ 1,200	7.5	$ 9,000
Steel work (hand rails, trash rack embedments etc) stainless steel	Tonne	$ 30,000	1	$ 30,000
hand rail ss	m	$ 150	6	$ 900
stairs (25000/tonne)	flight	$ 12,500	0	$ -
Trash rack	m2	$ 4,350	4	$ 17,400
Weatherproof housing for electrics incl. in elec cost				
Valves				$ -
Isolation valve inc actuator	ea	$ 50,000		$ -
check valve	ea	$ 35,000		$ -
Penstock gate 1000 x 1000 inc actuator	ea	$ 38,000	2	$ 76,000
Bulkheads	m2	$ 7,000		$ -
Pumps	ea	$ 32,000	2	$ 64,000
Pump motors on existing pumps supply and fit	ea	$ 30,000		
Pipe work	lot	$ 50,000	1	$ 50,000
Labour mech	hrs	$ 100	500	$ 50,000
subtotal				$ 337,580

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Description	Unit	Rate	Quantity	Value
Preliminary & general	lot		20%	$ 67,516
Survey/design and other overheads	Lot		10%	$ 33,758
Mechanical and Civil Total				**$ 438,854**
Electrical Total				$ 124,800
Total Mech and Elec plus civils				**$ 563,654**

A detailed description of the costs of pipes to the spurs from the No. 9 Channel is presented in Table A-20.

Table A-20 Detailed cost breakdown - pipes to Werrill St spurs

Description	Pipe Diameter (mm)	Quantity (m)	Rate ($/m)	Cost ($)
Werrill Street Spurs				
From No9 Channel at Werrill St.				
supply of pipe				
N3 - N2	225	115	57	6,521
N10 - N3	225	248	57	14,062
N4 - N5	225	220	57	12,474
N8 - N13	225	437	57	24,778
N8 - N7	225	340	57	19,278
N9 - N8	300	626	120	74,932
N4 - N10	225	177	57	10,036
N6 - N4	225	210	57	11,907
N11 - N1	225	214	57	12,134
N2 - N11	225	78	57	4,423
N12 - N9	300	24	120	2,873
N13 - N6	225	284	57	16,103
N13 - N14	225	258	57	14,629
N14 - N15	225	250	57	14,175
Bends		14	210	2,940
	TOTAL			$ 241,263
installation of pipe				
N3 - N2	225	115	26	3,019
N10 - N3	225	248	26	6,510
N4 - N5	225	220	26	5,775
N8 - N13	225	437	26	11,471
N8 - N7	225	340	26	8,925
Description	Pipe Diameter (mm)	Quantity (m)	Rate ($/m)	Cost ($)
N9 - N8	300	626	26	16,433
N4 - N10	225	177	26	4,646

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Description	Pipe Diameter (mm)	Quantity (m)	Rate ($/m)	Cost ($)
N6 - N4	225	210	26	5,513
N11 - N1	225	214	26	5,618
N2 - N11	225	78	26	2,048
N12 - N9	300	24	26	630
N13 - N6	225	284	26	7,455
N13 - N14	225	258	26	6,773
N14 - N15	225	250	26	6,563
Bends		14	105	1,470
	TOTAL			$ 92,846
Option 1	TOTAL			$ 334,109
Prelim + general	20%			$ 66,822
Survey/design and other overheads	10%			$ 33,411
Total				**$ 434,342**

A.5.5 No. 9 Channel modification

A summary of the inputs to the BCA associated with the replacement of the No. 9 Channel through Swan Hill with a pipe under Option 1 is presented in Table A-21.

Table A-21 Inputs to BCA for Option 1 - modification of No. 9 Channel through Swan Hill

	No. 9 Channel	Median	Low Estimate	High Estimate
	Water savings (ML/yr)	376	188	564
	Decommissioning of channel ($)	183,425	174,254	256,795
	Area of reclaimed land (ha)	9	7.0	10.6
	New pipe - materials ($)	5,290,877	5,038,930	7,407,227
	New pipe - construction ($)	1,975,565	1,881,490	2,765,790
	New pipe - maintenance ($/yr)	72,664	69,204	101,730

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A more detailed breakdown of the costs of pipes is presented in Table A-22.

Table A-22 Detailed cost breakdown - pipe No. 9 through Swan Hill

Description	Pipe Diameter (mm)	Quantity (m)	Rate ($/m)	Cost ($)
Werrill Street - McCallum Street				
supply of pipe				
N1 - N2	1400	1500	1199	1,798,650
N2 - N3	1400	850	1199	1,019,235
N3 - N4	1400	1000	1199	1,199,100
Bends 1400		4	13230	52,920
	TOTAL			**4,069,905**
installation of pipe				
N1 - N2	1400	1500	452	677,250
N2 - N3	1400	850	452	383,775
N3 - N4	1400	1000	452	451,500
Bends 1400		4	1785	7,140
	TOTAL			**$1,519,665**
	TOTAL			**$5,589,570**
Prelim + general	20%			$1,117,914
Survey/design and other overheads	10%			$558,957
Total				**$7,266,441**

A.5.6 Upgrade of No. 10 Pump Station

The inputs to the BCA associated with changes to the No. 10 Pump Station for Option 1 are presented in Table A-23.

Table A-23 Inputs to BCA for Option 1 - Upgrade No. 10 Pump Station

No. 10 Pump Station	Median	Low Estimate	High Estimate
Upgrade pump motor ($)	441,000	415,800	604,800
Additional maintenance costs ($/yr)	4,410	4,158	6,048
Operation ($/yr)	81,239	73,115	113,735
Electricity (MWh/yr)	542	487	758
Carbon emissions (t/yr)	661	595	925

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A.5.7 Modification of the No. 10 Channel

The costs of modifications to the No. 10 Channel (not including modernisation works) for Option 1 are presented in Table A-24.

Table A-24 Inputs to BCA for Option 1 - modifications to No. 10 Channel

No. 10 Channel - PS to Tyntynder Flats	Median	Low Estimate	High Estimate
Modify No. 10 Channel - earthworks and road culverts ($)	312,576	296,947	437,606

A.5.8 Channel Connecting No. 13/9 and No. 2/2/10 Channels

The inputs to the BCA associated with the construction of the connecting Channel between the No. 9 and No. 10 systems are presented in Table A-25.

Table A-25 Inputs to BCA for Option 1 - connecting channel

Connecting Channel - No.13/9 & No. 2/2/10 Channels	Median	Low Estimate	High Estimate
Construction costs of channel ($)	299,963	284,965	419,948
Water savings (losses) (ML/yr)	- 19	- 10	- 29
Area of land to build channel (ha)	1	0.8	1.2

A.5.9 EPBC referrals

A cost of $1 million has been included for costs associated with referrals for Environmental Protection and Biodiversity Conservation (NVIRP). Refer to Table A-26.

Table A-26 EPBC Referral Cost (Option 1)

EPBC Referrals	Median	Low Estimate	High Estimate
Construction costs of channel ($)	1,000,000	500,000	2,000,000

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A.6 Summary of BCA for Option 2

A summary of the benefits and costs of the BCA for Option 2 are presented in Table 5-11. The inputs to these items are presented in the section following.

Table A-27 Option 2 - Benefits and Costs

	Benefits and Costs	Present Value (6% discount rate over 30 years)
BENEFITS		
	Water savings (2,369 ML/yr)	6,266,005
	Reclaimed land	320,000
	Base Case costs avoided	15,210,368
Total Benefits		**21,796,373**
COSTS		
NVIRP modernisation		
	Works and materials to install gates and reg. structures	623,425
	Maintenance	85,813
Little Murray Weir		
	Reduce LMW	350,000
	Environmental investigation and mitigation	500,000
	Maintenance of reduced weir	48,177
	Reconnection of LMW pool diverters	1,262,700
Little Murray River Pump Station		
	Construction of pump station	1,215,534
	Operations	348,554
	Maintenance	167,316
	Renewals (drives and instruments)	17,187
	Carbon emissions	157,462
Werrill St Pump Station		
	Construct pump station at Werrill St	563,654
	Pipe to spurs - works and materials	434,342
	PS Operations	95,447
	Maintenance	137,372
	Renewals (drives and instruments)	9,381
	PS carbon emissions	43,119
No. 9 Channel		
	Remove channel between Werrill St and McCallum St, infill	310,444
No. 10 Pump Station		
	Install relift pump	2,126,230
	Operations	1,597,890
	Additional maintenance	292,672

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	Benefits and Costs	Present Value (6% discount rate over 30 years)
	Renewals (drives and instruments)	28,184
	Carbon emissions	721,862
Pipeline up Karinie St to Karinie St Relift PS		
	Pipeline - works and materials	6,968,729
	Maintenance	959,234
Karinie St Relift PS		
	Install relift pump	464,454
	Operations	46,049
	Maintenance	63,931
	Renewals (drives and instruments)	5,951
	Carbon emissions	15,433
Pipe from Karinie St to McCallum St Spurs		
	Pipeline - works and materials	209,564
	Maintenance	28,846
EPBC Referrals		
	Referral costs	1,000,000
Total Costs		**20,898,959**
NET PRESENT VALUE		**897,414**
NET COST PER ML OF WATER SAVINGS		**2,266**

A.7 Option 2 Inputs

A.7.1 NVIRP Channel Modernisation

The costs associated with modernising the different sections of the No. 9 and No. 10 Channel under Option 2 are presented in Table A-28 to Table A-31.

Table A-28 Option 2 costs of modernisation of No. 9 Channel – Little Murray Weir to Werrill St

No. 9 Channel	Median	Low Estimate	High Estimate
Cost of new NVIRP regulator gates and structures (works and materials) ($)	145,887	101,640	272,997
Maintenance of gates ($/yr)	1,459	1,016	2,730

Table A-29 Option 2 costs of modernisation of No. 9 Channel – Werrill St to McCallum St

No. 9 Channel	Median	Low Estimate	High Estimate
Cost of new NVIRP regulator gates and structures (works and materials) ($)	-	-	-
Maintenance of gates ($/yr)	-	-	-

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Table A-30 Option 2 costs of modernisation of No. 9 Channel – McCallum St to rest of No.9 Channel

No. 9 Channel	Median	Low Estimate	High Estimate
Cost of new NVIRP regulator gates and structures (works and materials) ($)	245,592	171,105	459,573
Maintenance of gates ($/yr)	2,456	1,711	4,596

Table A-31 Option 2 costs of modernisation of No. 10 Channel

No. 10 Channel - Pump Station to Tyntynder Flats	Median	Low Estimate	High Estimate
Cost of new NVIRP regulator gates and structures (works and materials) ($)	*231,945*	*194,506*	*357,691*
Maintenance of gates ($/yr)	*2,319*	*1,945*	*3,577*

A.7.2 Lowering the Little Murray Weir

An estimate of the inputs involved in lowering the LMW is presented in Table A-32. Note that these are identical to Option 1.

Table A-32 Inputs to BCA for Option 2 associated with lowering of the LMW

Reduced Little Murray Weir	Median	Low Estimate	High Estimate
Cost of lowering LMW ($)	350,000	332,500	490,000
Environmental investigation and mitigation	500,000	400,000	750,000
O&M cost of lowered weir ($/yr)	3,500	3,325	4,900
Cost of reconnecting LMW pool diverters ($)	1,262,700	1,199,565	1,767,780
Water savings- LMW pool (ML/yr)	1,814	907	2,721

A.7.3 Little Murray River Pump Station

A summary of the costs associated with the Little Murray River pump station for Option 2 is outlined in Table A-33 (URS).

Table A-33 Inputs to BCA for Option 2 - Little Murray River Pump Station

Little Murray River Pump Station	Median	Low Estimate	High Estimate
Construction of pump station ($)	1,215,534	1,122,846	1,654,500
Operation ($/yr)	25,322	22,790	35,451
Maintenance ($/yr)	12,155	11,228	16,545
Renewals - variable speed drives ($/15 years)	22,000	20,900	30,800
Renewals - instruments ($/10 years)	4,000	3,800	5,600
Electricity (MWh/yr)	169	152	236
Carbon emissions (t/yr)	206	185	288

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A more detailed breakdown of the costs of the pump station is presented in Table A-34 (URS).

Table A-34 Detailed cost breakdown – Option 2 construction of Little Murray River Pump Station

Description	Unit	Rate	Quantity	Value
Bulk excavation (high assumes imported material)	m3	$ 20	699	$ 13,980
Filling (high assumes material removed off site)	m3	$ 40	250	$ 10,000
Sheet piling	m2	$ 300	140	$ 42,000
Sheet pile on/off cost	on/off	$ 30,000	1	$ 30,000
Reinforced concrete building	m3	$ 1,200	80	$ 96,000
Steel work (hand rails, trash rack embedments etc) stainless steel	Tonne	$ 30,000	4	$ 120,000
hand rail ss	m	$ 150	8	$ 1,200
stairs (25000/tonne)	flight	$ 12,500	1	$ 12,500
Trash rack	m2	$ 4,350	10	$ 43,500
Weatherproof housing for electrics incl. in elec cost				
Valves				$ -
Isolation valve inc actuator	ea	$ 50,000	0	$ -
check valve	ea	$ 35,000	0	$ -
Penstock gate 1000 x 1000 inc actuator	ea	$ 38,000	0	$ -
Bulkheads	m2	$ 7,000	10	$ 70,000
Pumps	ea	$100,000	2	$ 200,000
Pump motors on existing pumps supply and fit	ea	$ 30,000		$ -
Pipe work	lot	$ 50,000	0	$ -
Labour mech	hrs	$ 100	1500	$ 150,000
subtotal				$ 789,180
Preliminary & general	lot		20%	$ 157,836
Survey/design and other overheads			10%	$ 78,918
Mechanical and Civil Total				**$ 1,025,934**
Electrical Total				**$ 189,600**
Total Mech and Elec plus civils				**$ 1,215,534**

A.7.4 Pump from No.9 Channel and Pipe to Spurs near Werrill St

A summary of the costs associated with a new pump station to supply spurs near Werrill St from the No. 9 Channel in Option 2 is presented in Table A-35. Note that these are identical to Option 1 in Section A.5.4. A more detailed breakdown of the costs of the pump station and pipes are presented for Option 1.

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Table A-35 Inputs to BCA for Option 2 - Werrill St Pump Station and pipe

Pump and pipe from No.9 Channel to spurs near Werrill St	Median	Low Estimate	High Estimate
Construction of pump station ($)	563,654	507,576	737,412
Operation ($/yr)	6,934	6,241	9,708
New pipe - materials ($)	313,642	298,706	313,642
New pipe - construction ($)	120,700	114,953	168,980
Maintenance ($/yr)	9,980	8,063	10,511
Renewals - variable speed drives ($/15 years)	8,800	8,360	12,320
Renewals - instruments ($/10 years)	4,000	3,800	5,600
Electricity (MWh/yr)	46	42	65
Carbon emissions (t/yr)	56	51	79

A.7.5 No. 9 Channel Modification

A summary of the inputs to the BCA associated with the replacement of the No. 9 Channel through Swan Hill with a pipe under Option 2 is presented in Table A-36.

Table A-36 Inputs to BCA for Option 2 - modification of No. 9 Channel through Swan Hill

No. 9 Channel	Median	Low Estimate	High Estimate
Decommissioning of channel ($)	310,444	294,922	434,622
Water savings (ML/yr)	430	215	645
Area of reclaimed land (ha)	16	13	19

A.7.6 Modifications to No. 10 Pump Station

The modifications to the No. 10 pump station, including a relift station and changes to overall operation and maintenance costs, involve the inputs presented in Table A-37

Table A-37 Inputs to BCA - Option 2 modifications to No. 10 pump station

No. 10 Pump Station	Median	Low Estimate	High Estimate
Install relift pump ($)	2,126,230	1,975,452	2,871,840
Operation ($/yr)	116,085	104,477	162,519
Additional maintenance costs ($/yr)	21,262	19,755	28,718
Renewals - variable speed drives ($/15 years)	30,000	28,500	42,000
Renewals - instruments ($/10 years)	10,000	9,500	14,000
Electricity (MWh/yr)	774	697	1,083
Carbon emissions (t/yr)	944	850	1,322

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A more detailed breakdown of the costs involved in the construction of the pump station are presented in Table A-38

Table A-38 Detailed cost breakdown – Option 2 modifications to No. 10 Pump Station

Description	Unit		Rate	Quantity		Value
Bulk excavation (high assumes imported material)	m3	$	20	700	$	14,000
Filling (high assumes material removed off site)	m3	$	40	250	$	10,000
Sheet piling	m2	$	300	140	$	42,000
Sheet pile on/off cost	on/off	$	30,000	1	$	30,000
Reinforced concrete building	m3	$	1,200	90	$	108,000
Steel work (hand rails, trash rack embedments etc) stainless steel	Tonne	$	30,000	4	$	120,000
hand rail ss	m	$	150	9	$	1,350
stairs (25000/tonne)	flight	$	12,500	1	$	12,500
Trash rack	m2	$	4,350	15	$	65,250
Weatherproof housing for electrics incl. in elec cost						
Valves					$	-
Isolation valve inc actuator	ea	$	50,000	2	$	100,000
check valve	ea	$	35,000	2	$	70,000
Penstock gate 1000 x 1000 inc actuator	ea	$	38,000	4	$	152,000
Bulkheads	m2	$	7,000	4	$	28,000
Pumps	ea	$	100,000	2	$	200,000
Pump motors on existing pumps supply and fit	ea	$	30,000.	3	$	90,000
Pipe work	lot	$	50,000	2	$	100,000
Labour mech	hrs	$	100	1500	$	150,000
subtotal					$	1,293,100
Preliminary & general	lot			20%	$	258,620
Survey/design and other overheads				10 %	$	129,310
Mechanical and Civil Total					**$**	**1,681,030**
Electrical Total					$	**445,200**
Total Mech and Elec plus civils					**$**	**2,126,230**

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A.7.7 Pipeline along Karinie St to No.9 Channel

A summary of the costs involved in a pipeline along Karinie St to the No. 9 Channel for Option 2 is presented in Table A-39.

Table A-39 Inputs to BCA - Option 2 pipeline up Karinie St

Pipe up Karinie St to No. 9 Channel	Median	Low Estimate	High Estimate
New pipe - materials ($)	4,056,955	3,863,766	5,679,737
New pipe - construction ($)	2,911,774	2,215,356	4,885,083
Maintenance ($/yr)	69,687	60,791	105,648

A more detailed breakdown of the costs of the pump station is presented in Table A-40(URS).

Table A-40 Detailed cost breakdown – Karinie St pipeline

Description	Pipe Diameter (mm)	Quantity (m)	Rate ($/m)	Cost ($)
Pipe up Karinie				
supply of pipe				
N2 - N15	1350	1451	1199	$1,739,894
N1 - N4 (existing)	1200	0	1087	$ -
N4 - N2	1350	426	1199	$ 510,817
N15 - N3	1350	707	1199	$ 847,764
Bends 1200		1	9030	$ 9,030
Bends 1350		1	13230	$ 13,230
TOTAL PIPE				**$3,120,734**
installation of pipe				
N2 - N15	1350	1451	452	$ 655,127
N1 - N4 (existing)	1200	0	389	$ -
N4 - N2	1350	426	452	$ 192,339
N15 - N3	1350	707	452	$ 319,211
Bends 1200		1	1365	$ 1,365
Bends 1350		1	1785	$ 1,785
Service Crossings:				
O/H power lines		4	50000	$ 200,000
Stormwater		3	50000	$ 150,000
potable supply		4	50000	$ 200,000
sewerage		4	50000	$ 200,000
telstra		4	50000	$ 200,000
railway		1	100000	$ 100,000
highway (incl. traffic mgmt)		1	20000	$ 20,000
TOTAL INSTALLATION				**$2,239,826**
Prelim + general	**20%**			**$ 1,072,112**
Survey/design and other overheads	**10%**			**$ 536,056**
Total				**$6,968,729**

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A.7.8 Relift Pump Station (Karinie St Pipeline) to Supply McCallum St Spurs

A summary of the inputs involved in the construction of the relift station at the top of Karinie St to supply the McCallum St spurs in Option 2 is presented in Table A-41.

Table A-41 Input to BCA - Option 2 Karinie St Relift Pump Station

Relift Pump Station at top of Karinie St for McCallum St spurs	Median	Low Estimate	High Estimate
Install relift pump ($)	464,454	414,876	604,212
Operation ($/yr)	3,345	3,178	4,684
Maintenance costs ($/yr)	4,645	4,149	6,042
Renewals - variable speed drives ($/15 years)	3,000	2,850	4,200
Renewals - instruments ($/10 years)	4,000	3,800	5,600
Electricity (MWh/yr)	22	21	31
Carbon emissions (t/yr)	27	26	38

A detailed breakdown of the costs involved in the construction of the pipe station is presented in Table A-42.

Table A-42 Detailed cost breakdown – Construction of Karinie St Relift Pump Station

Description	Unit	Rate	Quantity	Value
Bulk excavation (high assumes imported material)	m3	$ 20	40	$ 800
Filling (high assumes material removed off site)	m3	$ 40	12	$ 480
Sheet piling	m2	$ 300	30	$ 9,000
Sheet pile on/off cost	on/off	$ 30,000	1	$ 30,000
Reinforced concrete building	m3	$ 1,200	7.5	$ 9,000
Steel work (hand rails, trash rack embedments etc) stainless steel	Tonne	$ 30,000	1	$ 30,000
hand rail ss	m	$ 150	6	$ 900
stairs (25000/tonne)	flight	$ 12,500	0	$ -
Trash rack	m2	$ 4,350	4	$ 17,400
Weatherproof housing for electrics incl. in elec cost				
Valves				$ -
Isolation valve inc actuator	ea	$ 50,000		$ -
check valve	ea	$ 35,000		$ -
Penstock gate 1000 x 1000 inc actuator	ea	$ 38,000	2	$ 76,000
Bulkheads	m2	$ 7,000		$ -
Pumps	ea	$ 10,000	2	$ 20,000
Pump motors on existing pumps supply and fit	ea	$ 30,000		
Pipe work	lot	$ 50,000	1	$ 50,000
Description	Unit	Rate	Quantity	Value
Labour mech	hrs	$ 100	500	$ 50,000
subtotal				$ 293,580

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Description	Unit	Rate	Quantity	Value
Preliminary & general	lot		20%	$ 58,716
Survey/design and other overheads			10 %	$ 29,358
Mechanical and Civil Total				**$ 381,654**
Electrical Total				**$ 82,800**
Total Mech and Elec plus civils				**$ 464,454**

A.7.9 Pipe from Karinie St Pump Station to McCallum St Spurs

A summary of the inputs for Option 2 associated with the installation of a pipeline from the pump station at the top of Karinie St to the McCallum St spurs is presented in Table A-43.

Table A-43 Input to BCA - Option 2 Pipe from Karinie St PS to McCallum St spurs

Pipe from Karinie St to McCallum St Spurs	Median	Low Estimate	High Estimate
New pipe - materials ($)	143,191	136,373	200,468
New pipe - construction ($)	66,373	63,213	92,922
Maintenance ($/yr)	2,096	1,996	2,934
Water savings (ML/yr)	125	63	188

A detailed breakdown of the costs involved in the construction of the pipeline is presented in Table A-44.

Table A-44 Detailed cost breakdown – Pipeline from Karinie St PS to McCallum St spurs

Description	Pipe Diameter (mm)	Quantity (m)	Rate ($/m)	Cost ($)
supply of pipe				
N3 - N5	225	153	57	$ 8,675
N5 - N6	225	213	57	$ 12,077
N6 - N7	225	172	57	$ 9,752
N7 - N8	225	258	57	$ 14,629
N8 - N9	225	341	57	$ 19,335
N9 - N10	225	552	57	$ 31,298
N10 - N11	225	224	57	$ 12,701
Bends 225		8	210	$ 1,680
TOTAL PIPE				**$ 110,147**
installation of pipe				
N3 - N5	225	153	26	$ 4,016
N5 - N6	225	213	26	$ 5,591
N6 - N7	225	172	26	$ 4,515
N7 - N8	225	258	26	$ 6,773
N8 - N9	225	341	26	$ 8,951
N9 - N10	225	552	26	$ 14,490
N10 - N11	225	224	26	$ 5,880
Bends 225		8	105	$ 840

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Description	Pipe Diameter (mm)	Quantity (m)	Rate ($/m)	Cost ($)
TOTAL INSTALLATION				$ 51,056
Prelim + general	20%			$ 32,241
Survey/design and other overheads	10%			$ 16,120
Total				**$ 209,564**

A.7.10 EPBC referrals

A cost of $1 million has been included for costs associated with referrals for Environmental Protection and Biodiversity Conservation (NVIRP). Refer to Table A-45.

Table A-45 EPBC Referral Cost (Option 2)

EPBC Referrals	Median	Low Estimate	High Estimate
Construction costs of channel ($)	1,000,000	500,000	2,000,000

A.8 Summary of BCA for Option 3

A summary of the benefits and costs of the BCA for Option 3 are presented in Table 5-14. The inputs to these items are presented in the section following.

Table A-46 Option 3 - Benefits and Costs

Benefits and costs	Present Value (6% discount rate over 30 years)
BENEFITS	
Water savings (2,350 ML/yr)	6,215,750
Reclaimed land	320,000
Base Case costs avoided	15,210,368
Total Benefits	**21,746,118**
COSTS	
NVIRP modernisation	
Works and materials to install gates and reg. structures	686,367
Maintenance	94,477
Little Murray Weir	
Reduce LMW	350,000
Environmental investigation and mitigation	500,000
Maintenance of reduced weir	48,177
Reconnection of LMW pool diverters	1,262,700
Little Murray River Pump Station	
Construction of pump station	1,215,534
Operations	348,554

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	Benefits and costs	Present Value (6% discount rate over 30 years)
	Maintenance	167,316
	Renewals (drives and instruments)	17,187
	Carbon emissions	157,462
Werrill St Pump Station		
	Construct Pump Station at Werrill St	563,654
	Pipe to spurs - works and materials	434,342
	PS Operations	95,447
	Maintenance	137,372
	Renewals (drives and instruments)	9,381
	PS carbon emissions	43,119
No. 9 Channel		
	Remove channel between Werrill St and McCallum St, infill	183,425
No. 10 Pump Station		
	Install relift pump	1,581,220
	Operations	1,458,403
	Additional maintenance	217,652
	Renewals (drives and instruments)	45,926
	Carbon emissions	658,847
Pipeline along Karinie St to Karinie St Relift PS		
	Pipeline - works and materials	4,232,542
	Maintenance	582,602
Karinie St Relift PS		
	Install relift pump	464,454
	Operations	46,049
	Maintenance	63,931
	Renewals (drives and instruments)	5,951
	Carbon emissions	15,433
Pipe from Karinie St to McCallum St Spurs		
	Pipeline - works and materials	209,564
	Maintenance	28,846
No. 10 Channel		
	Modification of No. 10 Channel - earthworks and road culverts	312,576
Channel connecting 13/9 and 2/2/10		
	Construction	299,963
	Land acquisition	5,000
EPBC Referrals		
	Referral costs	1,000,000
Total Costs		**17,543,478**
NET PRESENT VALUE		**4,202,640**
NET COST PER ML OF WATER SAVINGS		**857**

Appendix A

A.9 Option 3 Inputs

A.9.1 NVIRP Channel Modernisation

The costs associated with modernising the different sections of the No. 9 and No. 10 Channel under Option 3 are presented in Table A-47 to Table A-50.

Table A-47 Option 3 costs of modernisation of No. 9 Channel – Little Murray Weir to Werrill St

No. 9 Channel	Median	Low Estimate	High Estimate
Cost of new NVIRP regulator gates and structures (works and materials) ($)	145,887	101,640	272,997
Maintenance of gates ($/yr)	1,459	1,016	2,730

Table A-48 Option 3 costs of modernisation of No. 9 Channel – Werrill St to McCallum St

No. 9 Channel	Median	Low Estimate	High Estimate
Cost of new NVIRP regulator gates and structures (works and materials) ($)	-	-	-
Maintenance of gates ($/yr)	-	-	-

Table A-49 Option 3 costs of modernisation of No. 9 Channel – McCallum St to rest of No.9 Channel

No. 9 Channel	Median	Low Estimate	High Estimate
Cost of new NVIRP regulator gates and structures (works and materials) ($)	234,466	195,050	377,120
Maintenance of gates ($/yr)	2,345	1,951	3,771

Table A-50 Option 3 costs of modernisation of No. 10 Channel

No. 10 Channel - Pump Station to Tyntynder Flats	Median	Low Estimate	High Estimate
Cost of new NVIRP regulator gates and structures (works and materials) ($)	306,014	245,382	584,314
Maintenance of gates ($/yr)	3,060	2,454	5,843

A.9.2 Lowering the Little Murray Weir

An estimate of the inputs involved in lowering the LMW in Option 3 is presented in Table A-51 Note that these are identical to Options 1 and 2.

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Table A-51 Inputs to BCA for Option 3 associated with lowering of the LMW

Reduced Little Murray Weir	Median	Low Estimate	High Estimate
Cost of lowering LMW ($)	350,000	332,500	490,000
Environmental investigation and mitigation	500,000	400,000	750,000
O&M cost of lowered weir ($/yr)	3,500	3,325	4,900
Cost of reconnecting LMW pool diverters ($)	1,262,700	1,199,565	1,767,780
Water savings- LMW pool (ML/yr)	1,814	907	2,721

A.9.3 Little Murray River Pump Station

A summary of the inputs to the BCA associated with the Little Murray River pump station for Option 3 is outlined in Table A-52 (URS). Note that these are identical to Option 2. Refer to Option 2 in Section A.7.3 for a more detailed breakdown of the pump station costs.

Table A-52 Inputs to BCA for Option 3 - Little Murray River Pump Station

Little Murray River Pump Station	Median	Low Estimate	High Estimate
Construction of pump station ($)	1,215,534	1,122,846	1,654,500
Operation ($/yr)	25,322	22,790	35,451
Maintenance ($/yr)	12,155	11,228	16,545
Renewals - variable speed drives ($/15 years)	22,000	20,900	30,800
Renewals - instruments ($/10 years)	4,000	3,800	5,600
Electricity (MWh/yr)	169	152	236
Carbon emissions (t/yr)	206	185	288

A.9.4 Pump from No.9 Channel and Pipe to Spurs near Werrill St

A summary of the inputs to the BCA associated with a new pump station to supply spurs near Werrill St from the No. 9 Channel in Option 3 is presented in Table A-53. Note that these are identical to Options 1 and 2. A more detailed breakdown of the costs of the pump station and pipes are presented for Option 1 in Section A.5.4.

Table A-53 Inputs to BCA for Option 3 - Werrill St Pump Station and pipe

Pump and pipe from No.9 Channel to spurs near Werrill St	Median	Low Estimate	High Estimate
Construction of pump station ($)	563,654	507,576	737,412
Operation ($/yr)	6,934	6,241	9,708
New pipe - materials ($)	313,642	298,706	313,642
New pipe - construction ($)	120,700	114,953	168,980
Maintenance ($/yr)	9,980	8,063	10,511
Renewals - variable speed drives ($/15 years)	8,800	8,360	12,320
Renewals - instruments ($/10 years)	4,000	3,800	5,600
Electricity (MWh/yr)	46	42	65
Carbon emissions (t/yr)	56	51	79

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A.9.5 Modification of No.9 Channel

The inputs to the BCA associated with modifications to the no. 9 Channel are presented in Table A-54.

Table A-54 Inputs to BCA for Option 3 - modification of No. 9 Channel through Swan Hill

No. 9 Channel	Median	Low Estimate	High Estimate
Decommissioning of channel ($)	183,425	174,254	256,795
Water savings (ML/yr)	430	215	645
Area of reclaimed land (ha)	16	13	19

A.9.6 Modifications to No. 10 Pump Station

The inputs to the BCA for Option 3 associated with modifications to the No. 10 pump station, including a relift station and changes to overall operation and maintenance costs, are presented in Table A-55.

Table A-55 Inputs to BCA - Option 3 modifications to No. 10 pump station

No. 10 Pump Station	Median	Low Estimate	High Estimate
Install relift pump ($)	1,581,220	1,452,624	2,107,560
Operation ($/yr)	105,951	95,356	148,332
Additional Maintenance costs ($/yr)	15,812	14,526	21,076
Renewals - variable speed drives($)	60,000	57,000	84,000
Renewals - instruments($)	10,000	9,500	14,000
Electricity (MWh/yr)	706	636	989
Carbon emissions (t/yr)	862	776	1,206

A detailed description of the modifications to the pump station is presented in Table A-56

Table A-56 Detailed cost breakdown – Option 3 modifications to No. 10 Pump Station

Description	Unit	Rate	Quantity	Value
Bulk excavation (high assumes imported material)	m3	$ 20	300	$ 6,000
Filling (high assumes material removed off site)	m3	$ 40	60	$ 2,400
Sheet piling	m2	$ 300	70	$ 21,000
Sheet pile on/off cost	on/off	$ 30,000	1	$ 30,000
Reinforced concrete building	m3	$ 1,200	45	$ 54,000
Steel work (hand rails, trash rack embedments etc) stainless steel	Tonne	$ 30,000	1	$ 30,000
hand rail ss	m	$ 150	8	$ 1,200
stairs (25000/tonne)	flight	$ 12,500	0	$ -
Trash rack	m2	$ 4,350	8	$ 34,800

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Description	Unit	Rate	Quantity	Value
Weatherproof housing for electrics incl. in elec cost				
Valves				$ -
Isolation valve inc actuator	ea	$ 50,000	2	$ 100,000
check valve	ea	$ 35,000	2	$ 70,000
Penstock gate 1000 x 1000 inc actuator	ea	$ 38,000	0	$ -
Bulkheads	m2	$ 7,000	8	$ 56,000
Pumps	ea	$ 100,000	2	$ 200,000
Pump motors on existing pumps supply and fit	ea	$ 30,000	2	$ 60,000
Pipe work	lot	$ 50,000	2	$ 100,000
Labour mech	hrs	$ 100	1500	$ 150,000
subtotal				$ 915,400
Preliminary & general	lot		20%	$ 183,080
Survey/design and other overheads			10 %	$ 91,540
Mechanical and Civil Total				**$ 1,190,020**
Electrical Total				**$ 391,200**
Total Mech and Elec plus civils				**$ 1,581,220**

A.9.7 Pipeline along Karinie St to No.9 Channel

A summary of the costs involved in a pipeline along Karinie St to the No. 9 Channel for Option 3 is presented in Table A-57.

Table A-57 Inputs to BCA - Option 3 pipeline along Karinie St

Pipe up Karinie St to No. 9 Channel	Median	Low Estimate	High Estimate
New pipe - materials ($)	1,957,022	1,863,831	2,739,831
New pipe - construction ($)	2,275,520	1,609,400	3,994,328
Maintenance ($/yr)	42,325	34,732	67,342

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A more detailed breakdown of the costs of the pump station is presented in Table A-58 (URS).

Table A-58 Detailed cost breakdown – Karinie St pipeline

Description	Pipe Diameter (mm)	Quantity (m)	Rate ($/m)	Cost ($)
supply of pipe				
N2 - N15	900	1451	576	$ 836,429
N1 - N4 (existing)	1200	0	1087	$ -
N4 - N2	900	426	576	$ 245,568
N15 - N3	900	707	576	$ 407,550
Bends 900		1	6825	$ 6,825
Bends 1200		1	9030	$ 9,030
TOTAL PIPE				$1,505,402
installation of pipe				
N2 - N15	900	1451	263	$ 380,888
N1 - N4 (existing)	1200	0	389	$ -
N4 - N2	900	426	263	$ 111,825
N15 - N3	900	707	263	$ 185,588
Bends 900		1	735	$ 735
Bends 1200		1	1365	$ 1,365
Service Crossings:				
O/H power lines		4	50000	$ 200,000
Stormwater		3	50000	$ 150,000
potable supply		4	50000	$ 200,000
sewerage		4	50000	$ 200,000
telstra		4	50000	$ 200,000
railway		1	100000	$ 100,000
highway (incl. traffic mgmt)		1	20000	$ 20,000
TOTAL INSTALLATION				$1,750,400
Prelim + General	20%			$ 195,348
Survey/design and other overheads	10%			$ 97,674
Total				**$4,232,542**

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A.9.8 Relift Pump Station (Karinie St Pipeline) to Supply McCallum St Spurs

A summary of the inputs involved in the construction of the relift station where the Karinie St pipeline terminates, to supply the McCallum St spurs for Option 3 is presented in Table A-59. Note that these are identical to Option 2. A detailed description of the pump station costs are provided in Option 2.

Table A-59 Input to BCA - Option 3 Karinie St Relift Pump Station

Relift Pump Station at top of Karinie St for McCallum St spurs	Median	Low Estimate	High Estimate
Install relift pump ($)	464,454	414,876	604,212
Operation ($/yr)	3,345	3,178	4,684
Maintenance costs ($/yr)	4,645	4,149	6,042
Renewals - variable speed drives ($/15 years)	3,000	2,850	4,200
Renewals - instruments ($/10 years)	4,000	3,800	5,600
Electricity (MWh/yr)	22	21	31
Carbon emissions (t/yr)	27	26	38

A.9.9 Pipe from Karinie St Pump Station to McCallum St Spurs

A summary of the inputs for Option 3 associated with the installation of a pipeline from the pump station at the top of Karinie St to the McCallum St spurs is presented in Table A-60. Note that these are identical to Option 2. A detailed description of the pipeline costs are provided in Option 2.

Table A-60 Input to BCA - Option 3 Pipe from Karinie St PS to McCallum St spurs

Pipe from Karinie St to McCallum St Spurs	Median	Low Estimate	High Estimate
New pipe - materials ($)	143,191	136,373	200,468
New pipe - construction ($)	66,373	63,213	92,922
Maintenance ($/yr)	2,096	1,996	2,934
Water savings (ML/yr)	125	63	188

A.9.10 Modification of No. 10 Channel

The inputs to the BCA associated with modification of the No. 10 Channel (excluding modernisation works) for Option 3 are presented in Table A-61.

Table A-61 Inputs to BCA - Option 3 modification of No. 10 Channel

No. 10 Channel - PS to Tyntynder Flats	Median	Low Estimate	High Estimate
Modify No. 10 Channel - earthworks and road culverts ($)	312,576	296,947	437,606

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A.9.11 Channel connecting 13/9 and 2/2/10

The inputs for the construction of the connecting channel for Option 3 are presented in Table A-62. Note that these are identical to Option 1.

Table A-62 Inputs to BCA for Option 3 - connecting channel

Connecting Channel - 13/9 & 2/2/10	Median	Low Estimate	High Estimate
Construction costs of channel	299,963	284,965	419,948
Water savings (losses) (ML/yr)	- 19	- 10	- 29
Area of land to build channel (ha)	1	1	1

A.9.12 EPBC referrals

A cost of $1 million has been included for costs associated with referrals for Environmental Protection and Biodiversity Conservation (NVIRP). These are shown in Table A-63.

Table A-63 EPBC Referral Cost (Option 3)

EPBC Referrals	Median	Low Estimate	High Estimate
Construction costs of channel ($)	1,000,000	500,000	2,000,000

A.10 Supplementary Analysis – Little Murray Weir Retained

The Supplementary Analysis is essentially identical to Option 3 with the exception that the supply to the No. 9 Channel is provided by the LMW (as it is currently), rather than replacing the weir with a pump station. The only changes to the inputs from Option 3 are therefore that:

- the costs associated with the LMW will be incurred (see base case inputs);
- there will be no water savings associated with the LMW pool (1,814 ML/yr);
- the outfall from Lake Boga to the Little Murray River for the MMS will be required (see base case inputs); and
- the construction and ongoing costs of the Little Murray River Pump Station will not be incurred (see Option 3 inputs).

A summary of the benefits and costs for the Supplementary Analysis are presented in Table A-64.

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Table A-64 Summary of BCA for Supplementary Analysis

	Present Value (6% discount rate over 30 years)
BENEFITS	
Water Savings (536 ML/yr)	**1,417,720**
Reclaimed land	**320,000**
Base Case costs avoided (All except LMW & Lake Boga outfall)	**1,973,500**
Total Benefits	**3,711,220**
COSTS	
NVIRP modernisation	
Works and materials to install gates and reg. structures	**686,367**
Maintenance	**94,477**
Werrill St Pump Station	
Construct Pump Station at Werrill St	**563,654**
Pipe to spurs - works and materials	**434,342**
PS Operations	**95,447**
Maintenance	**137,372**
Renewals (drives and instruments)	**9,381**
PS carbon emissions	**31,988**
No. 9 Channel	
Remove channel between Werrill St and McCallum St, infill	**183,425**
No. 10 Pump Station	
Install relift pump	**1,581,220**
Operations	**1,458,403**
Maintenance	**217,652**
Renewals (drives and instruments)	**45,926**
Carbon emissions	**488,773**
Pipeline up Karinie St to Karinie St Relift PS	
Pipeline - works and materials	**4,232,542**
Maintenance	**582,602**
Karinie St Relift PS	
Install relift pump	**464,454**
Operations	**46,049**
Maintenance	**63,931**
Renewals (drives and instruments)	**5,951**
Carbon emissions	**15,433**
Pipe from Karinie St to McCallum St Spurs	
Pipeline - works and materials	**209,564**
Maintenance	**28,846**
No. 10 Channel	
Modification of No. 10 channel - earthworks and road culverts	**312,576**
Channel connecting 13/9 and 2/2/10	
Construction	**299,963**
Land acquisition	**5,000**
Total Costs	**12,295,341**
NET PRESENT VALUE	**- 8,584,122**
NET COST PER ML OF WATER SAVINGS	**18,660**

B

Appendix B Water Savings

Memorandum

To: **Paul Lacy**

From: Les Thompson

Subject: **Feasibility study – Replacement of Little Murray Weir with a New Pump Station on the River Murray and investigate pipelining No 9 and spurs from the No 9 offtake through to Werrill Street on the south side of the Swan Hill city boundary.**

Date: 11/3/2008

INTRODUCTION

The No 9 channel is the major irrigation carrier servicing the Swan Hill area. The channel commences at the Little Murray Weir and ends at Tyntynder homestead near the River Murray a total length of 23.18 km plus spurs. In 1991 it had an original design capacity of 750 ML/d and an actual operating capacity of 480 ML/d.

In 2003/04 the Woorinen Irrigation was pipelined and supply taken directly from the River Murray. This had the effect of reducing the No 9 capacity at its offtake to 340 ML/d

In addition, the introduction of TWE has resulted in a net reduction in demand on the system of around 11% over the past 5 years.

By report dated 30/1/2008, a feasibility study investigated the option of abandoning the No 9 channel through the Swan Hill residential areas and supplying the lands north of Swan Hill from a new relift pump station to be located adjacent to the No 10 pump station. Reinstatement of supply to the No 9 channels involved the construction of a rising main from the relift station to the No 9 channel.

This report assumes that the recommendations contained in report dated 30/1/2008 would be implemented and that the No 9 channel will terminate at the Swan Hill city boundary.

Having regard to the above, this report investigates a range of options to supply the remaining section of the No 9 channel from the offtake to the Swan Hill city boundary.

Options investigated include:

- Installation of a pump station on the river Murray
- Pipelining the No 9 channel and spurs,
- Retaining the No 9 channel and spurs but reducing the waterway area to minimise evaporation
- Providing a piped supply to landowner syndicates
- Retain the No 9 channel and providing additional capacity to service 500 ha, 1000 ha and 3000 ha of additional green field horticultural areas located upstream of Connell's regulator on the No 9 channel.

Water savings of up to 2590 ML have been identified.

EXISTING SYSTEM

The Swan Hill irrigation Area which comprises of some 31480 ha is developed to a range of enterprises including horticulture, dairy, cattle and lamb production as well as a significant number of

rural residential properties around the Swan Hill city area as well as on Tyntynder flats.

In 1990/91 the total HRWS for the Swan Hill Area was 67396 ML (Excludes Woorinen 11856 ML) and since the introduction of TWE this has reduced to around 55233 or a reduction of 18%. (Based on IMP figures as at 2008)

Details are as follows:

Offtake	WR As at 1991 ML	WR Plus D&S As at 1991 ML	HRWS As at 2008 ML	Percentage change
Swan Hill Includes Woorinen	79254	83657	70750	-15.4%
Woorinen	11856	12514	13674 Note 3	+9.3%
Swan Hill excluding Woorinen(1991)	67398	71143	57076	-19.7%
No 10 offtake	15957	16842	15572 Note 1	-7.5%
No 9 offtake excluding Woorinen (1991)	29212	30833	28015 Note 2	-9.1%
No 7 offtake includes Tresco			16021	
No 4/7 offtake			1484	
Tresco	6691	6845	7867	+14.9%
Fish point weir			31865	

Notes
1, 2 and 3 are based on extracts from the Authorities Water Management system dated 16 Feb 2008

On the No 9 channel system the reduction is 9.1% and the No 10 channel system is 7.5%. The major reduction appears to be on the No 7 system which is predominantly sheep and cattle enterprises and it is expected that these trends will continue unless there is a significant Greenfield development in the area.

Swan Hill Rural city is located centrally within the irrigation area and the No 9 channel currently runs through the centre of the residential area which poses a range of risks including child drownings, flooding claims, seepage claims, damage to public assets as well as the high cost of replacing existing infrastructure. Report dated 31/1/2008 DOC No 2408142 V2 provides arrange of options to address these issues.

The operation of the supply system is complex in that it is located on both the Avoca, Loddon and River Murray flood plains. During floods on the Avoca, flows of around 1600 ML with an EC reading of 4000 can enter the irrigation system and cause major salinity problems in the Little Murray weir pool, similar problem can occur when the Loddon river is in flood with saline water entering the Kerang Lakes System which can result in all of the lakes having to be flushed to bring the water quality down to acceptable levels for irrigation.

Blue green algae outbreaks in the Kerang Lakes and Torrumbarry channel system can also cause major problems.

Refer to plan No1 for locality details.

This report focuses on the No 9 channel system from the offtake to the southern boundary of the Swan Hill Rural City which is Werrill Street.

No 9 CHANNEL SYSTEM.

The No 9 channel commences at the Little Murray Weir and ends at Tyntynder homestead, a distance of 23.18 km plus spurs. The original channel had a design capacity of around 750 ML/d however over the past 30 years that actual capacity has been reduced due to the following changes:

- In the early 1960's the Tyntynder flats area which was originally supplied from the No 9 channel was taken off the No 9 system ands supplied directly from the River Murray. The No 10 pump station has a design capacity of 340 ML/d.

- In 2003/04 the Woorinen Irrigation area which was originally supplied from the No 9 channel was pipelined and supplied from a new pump station on the River Murray. At that time Woorinen had a peak daily requirement of 140 ML/d
- Since the introduction of TWE there has been a reduction of around 9.1% of HRWS from the No 9 channel.
- The restructuring of the dairy industry has resulted in the loss of a number of high water use dairies from the area.
- There has been a significant increase in life style farms with the result that peak daily flows have reduced.

A detailed review of the daily usage figures shown in IPM for the period 1996 to 2008 shows a significant decline in water use over this period. For the period post 2001/02 it is evident that the drought and lack of sales has severely curtailed water usage and is not reflective of normal usage patterns.

For the period 1998/99 through to 2001/02 sales water was a minimum of 200% and usage patterns had not been influence by the drought. A review of water usage for the period which includes Woorinen indicates a 4 day average peak flow on the No 9 channel of 260 to 320 ML/d with an average of 285 ML/d. This represents 46% of the standard design flow
The peak daily flow rates used in this analysis has been based on 46% of the standard design flow using the current 2007/08 HRWS (Excluding an equivalent volume for D&S). The revised peak daily flows have been discussed with experienced water distribution staff who consider the reductions as reasonable. Refer to DOC 2409580 for the basis of this review and calculations.

Adopted peak daily flow rates for the No 9 system are shown below:

Regulator	HRWS	Standard Design capacity ML/d	Adopted peak daily capacity ML/d
No 9 offtake	28015	486	223
No 9 D/S Werrill Street Swan Hill	15954	277	127
No 9 offtake excluding No 9 D/S of Werrill Street	12060	209	97
Connell's Regulator Excluding Werrill St	5225	91	42 Adopt 50 based on equivalent outlets
Lalbert Street Regulator excluding Werrill street	2091	36	17 Adopt 50 based on equivalent outlets

LITTLE MURRAY WEIR

The Little Murray Weir is a major structure that enables gravity diversion to the Swan Hill Irrigation Area via the No 9 channel. It was originally constructed in the early 1900's and was rebuilt in 1928 following major flood damage to the structure.

In the 1940's the structure again suffered major damage with a major scour hole developing down stream of the gated section of the structure which was a series of vertical butterfly doors. It would appear that the left hand side of the central cut-off wall was undermined and substantial repairs undertaken at that time.

In the mid 1980's the structure was again upgraded and the butterfly doors were replace with drop bars and a new walkway gantry installed across the structure to facilitate the removal of the 3.6 meter long drop bars.

In 1996 a six meter deep scour hole was identified down stream of the weir and on close inspection it was apparent that it extended underneath the down stream apron. Tests at that time indicated that 30% of the downstream apron was undermined and in the winter of 1997 major repair works were undertaken to stabilise the structure.

In 1998 URS and SMEC were commissioned to evaluate the stability of the structure and it was

concluded that the structure was stable and had an estimated remaining life of 35 years. At the time they took into account that around 30% of the downstream apron as well as the rear cut off wall had been undermined to various degrees however it was concluded that the damage did not compromise the central cut-off nor the overall stability of the structure.

The current concrete structure consists of 28 bays that span 110 meters across the Little Murray River. Each of the bays consists of timber drop boards 3.6 meters long over a depth of 2.5 meters. Four of the bays have been converted to drop down doors and they are used to undertake the majority of the regulation of the structure. During major flood events the existing timber drop bars still have to be progressively removed as the flood approaches and then progressively reinstalled as the flood recedes to maintain Full supply level at the weir during the irrigation season which poses significant OH&S risks to staff.

In 1998 it was estimated that the cost to convert the remaining bays to drop down doors was in excess of 1 million dollars.

The current asset management system shows that the structure has a renewal cost of $12 million and a remaining life of 27 years. The stability report by URS indicated that it had an estimated remaining life 35 years as of 1998 or 15 years as of today. The actual remaining life is difficult to quantify however it can be said with confidence that the structure appears reasonably stable but in relatively poor condition.

Further that it does require a major upgrade to overcome current OH&S issues.

In addition to the No 9 channel, there are a number of private diverters and gravity irrigators that take supply directly from the weir pool. The pool extends some 39 km upstream of the weir and provides water to some 15 diverters with a total HRS of 2487 ML and 22 irrigators with a total HRS of 5333 ML.

The diverters can be broken up into 12 open outlets, 10 LMO/s, 17 pumps, 5 flumes and 8 stock and domestic permits.

The supply level for the structure is 69.21 and the sill is set at 66.69 AHD. Currently the backwater from the weir extends to the rear of Fish point weir and if lowered to 66.69 AHD it appears that the backwater influence would terminate at around 33 km upstream of the weir. At this elevation there are three diverters that may be severely affected by the lower weir pool.
Details are as follows:

SH.PD1 owned by Ellis,
SH.PD2 owned by Kelly. Kelly has an adjacent property on the River Murray which has a pump and it may be possible to supply both properties from this site.
SH.PD2A owned by Dewhurst. Dewhurst has access to an alternate pump site on the River Murray and again it may be possible to supply both properties from this site.
Refer to pan No 1A for location of pumps and backwater effect.

FISH POINT WEIR

Fish point weir is a significant structure on the Little Murray located at the upper end of the Little Murray, immediately downstream of the Loddon River confluence. The works consist of three weirs, one of which has failed and is no longer used, the second is a drop bar structure that spans the Little Murray River and the third is a substantial door structure. All the works are located in the flood plain and have only boat access in a large flood.

The purpose of the structure is to isolate the Loddon River and saline Barr creek flows from the Little Murray weir pool however in times of flood, the weirs are overtopped or bypassed and salt slugs can enter the weir pool which can have a major impact on water quality for Swan Hill irrigators.

During flood events it is not uncommon for the Little Murray Weir pool to be flushed using the Pental Island pump station in an endeavour to remove salt slugs or in more recent times blue green algae contaminated water.

The weir headwall is set at RL 71.07 for a high water level of 71.00 and the floor is set at 69.33 AHD compared to the FSL at the Little Murray Weir of 69.21.

PENTAL ISLAND PUMPS

The Pental Island pump station which is located on the River Murray was built in the early 1970's to augment supplies to the Little Murray Weir Pool in periods of peak demand within the Torrumbarry Irrigation Area or when the Loddon River or Avoca Rivers are in flood and water quality has deteriorated in the Kerang Lakes rendering supply via the 6/7 channel to the Little Murray weir pool unacceptable.

The station consists of 4 No vertical lift low head pumps with a peak capacity of 536 ML/d. The pumps discharge into a large gravity channel that outfalls into the Little Murray River. In periods of high demand in the Torrumbarry system or when the Torrumbarry system has been contaminated with saline water or blue green algae, the pumps are used to supply the swan Hill irrigation Area as well as the Little Murray river diverters.

6/7 CHANNEL

The 6/7 channel takes off from the No 7 channel near the north west end of Lake Tutchewop and allows water from the Kerang Lakes system to discharged to the Little Murray Weir pool. The channel was upgraded in the 1970's as part of the Torrumbarry remodelling project and has a capacity of 630 ML/d and is the principle mean of filling the Little Murray weir pool.

In the past, the channel has also been used to pass Avoca and Loddon River flood flows from the Kerang Lakes and the Avoca flood plain through to the Little Murray and River Murray systems.

OTHER CONSIDERATIONS.

The options discussed in this report will bring substantial changes to the local environment and will need to be carefully assessed before adoption.

There a number of significant environmental, economic, social and recreational impacts that will need to be quantified as part of a more detailed study into the preferred option and the following studies will need to be considered as part of the total assessment.

They include:

- Any impact on Kerang Ramsar Lakes as a result of reduced through flow,
- Changes to the management of the flood plain as a result of the conversion of the Little Murray weir to a low level weir and the removal of the Fish point weirs,
- Changes to the fish habitat of the Little Murray weir pool,
- Changes to water quality in the upper reaches of the Little Murray River,
- Changes to the ground water levels to lands affected by the weir pool and any corresponding decline in river salinity impacting on the River Murray,
- Improved operator safety resulting from the decommissioning of weirs,
- Improved water quality and service delivery to irrigators supplied from the No 9 system and resulting economic benefits,
- Changes to recreational facilities as a result of removing the weirs,
- Impacts on Little Murray River diverters

EXISTING ASSET VALUATION

Details of current asset valuation as set out in the Authorities Asset management system are shown below:

Description	Renewals replacement cost $	Net present value at 6% over 30 years $
No 9 channel and spurs from the offtake to southern Swan Hill city boundary	9,439,000	2,620,000
No 9 main channel from the offtake to southern Swan Hill city boundary	4,496,000	1,406,000
Little Murray Weir, Pental Island pumps, Fish Point weirs	15,716,000	3,978,000
Pental island discharge channel fencing	14,000	4,400
Pental island discharge channel	0	0

It should be noted that the asset values for major structures are based on historic valuations that have been increased in line with CPI and it is considered that under the current legislative frame work that the cost of replacing these assets may be substantially undervalued.

It is also worth noting that the current replacement envelop for the Little Murray Weir is 27 years and while there is no evidence that the structure will fail within the foreseeable future, it must be recognised that the structure is in poor condition.

OPTIONS INVESTIGATED

A number of options have been investigated including:

1. Replacing the Little Murray Weir with a pump station on the River Murray and pipeline the No 9 channel and spurs from the offtake to the southern boundary of the Swan Hill city precinct

2. Same as 1 above accept the No 9 channel and spurs are retained and the waterway area of the No 9 channel is reduced to minimise evaporation and seepage losses from the channel.

3. Same as option 2 above except the No 9 is piped and syndicates are supplied at the offtakes of all spurs.

4. Same as option 2 except that the No 9 channel capacity has been increased to service an additional 500 ha of horticulture development

5. Same as option 2 except that the No 9 channel capacity has been increased to service an additional 1000 ha of horticulture development upstream of Connell's regulator

6. Same as option 2 except that the No 9 channel capacity has been increased to service an additional 3000 ha of horticulture development upstream of Connell's regulator

COST ESTIMATES

Pipeline supply and installation costs have been taken from details obtained form the Tungamah and Woorinen pipeline projects and compared with limited current information. It is apparent that over the past 3 to 6 years price movement is minimal.

Pump station costs have also been based on information obtained from the Woorinen and Tungamah projects and have been reviewed by staff with experience in this area. Costing's are considered reasonable for comparison of options and should provide a reasonable basis for financial modelling.

The style of pump station proposed for the River Murray has been based on the newly constructed D&S pump station built by Grampian Water on the River Murray which is within 1 km of the site identified for the G-MW station.

The style differs from that built for Woorinen which consisted of a 300 ML/d pump station located in a deep well set back from the bank to one that incorporates inline submersible pumps.

The proposed pump station will consist of a number of 450 mm suction pipes attached to a series of piles that will be installed along the river batter. The suction pipes would house submersible pumps that would discharge to a manifold set back from the bank and painted in a suitable colour to blend in with the local environment. The switchboard building would be of simple construction. It should be noted that in the event that this style of pump station is not permitted by either NSW or Victorian planning authorities and a deep pit style or equivalent is required that the estimated costs will need to be increased substantially.

A board brush approach has been taken with the estimates and they should only be used for option comparison and limited financial analysis. Estimates have been loaded by 40% in accordance with G-MW policies.

DO NOTHING

This option assumes that the current channel system will stay in place including Little Murray weir, Fish point weirs and the Pental Island pump station, however it is assumed that the No 9 channel will terminate at Werrill street Swan Hill as proposed in DOC 2408142

This option includes capital expenditure to convert the existing outlets to magflow metered outlets and the upgrade of the Little Murray weir to meet OH&S concerns. The estimated cost of this option is $4.67 million

OPTION 1 – Abandon Little Murray Weir and pipeline the No 9 channel and spurs

This option involves the conversion of the Little Murray weir to a low level weir for environmental use and the construction of a new pump station on the River Murray on the north side of Pental Island. A rising main from the pump station will link to a control tank located on a rise 1.76 km to the south west of the proposed pump station. The existing channels are to be replaced with pipelines along their existing alignments and supplied from the proposed tank.

No attempt has been made to rationalise supply outlets and it has been assumed that they will be converted to magnetic flow meters. Refer to plan No 1 for general details of works.

Specific details are as follows:

- Construct a 110 ML/d pump station on the River Murray. (Includes an allowance of 10 ML/d to supply gravity properties currently supplied from the weir pool and located in close proximity to the pipeline)
- S&I 1760 meters of 1200 mm dia. RCPP from the pump station to a proposed tank
- S&I 740 meters of 1200 mm dia. RCPP from the tank to the No 9 offtake
- S&I 32.4 km of various sized pipelines to replace existing channels
- S&I 207 magflow meters
- Fold in 33km of abandoned channel banks and clean up site
- Convert Little Murray weir to a low level weir structure for environmental purposes
- Remove Pental Island pump station
- Remove Fish point weirs
- Reinstate supply to existing diverters from the Little Murray weir pool

The estimated cost of this option is $42.8 million. Refer to appendix 1 for details

OPTION 2 – Abandon Little Murray Weir and retain the existing gravity channels

This option involves the conversion of the Little Murray Weir to a low level weir for environmental use and the construction of a new pump station on the River Murray on the north side of Pental Island. A rising main from the pump station will connect to the No 9 offtake a distance of 2300 meters. The existing channels are to be retained with the exception that one bank of the No 9 channel will be

replaced to reduce the waterway area and evaporation.

No attempt has been made to rationalise supply outlets and it has been assumed that they will be converted to magnetic flow meters. Refer to plan No 2 for general details of works.

- Construct a 110 ML/d pump station on the River Murray. (Includes an allowance of 10 ML/d to supply gravity properties currently supplied from the weir pool and located in close proximity to the pipeline)
- S&I 2300 meters of 1200 mm dia. RCPP from the pump station to No 9 offtake
- S&I 207 magflow meters
- Replace one bank on No 9 channel to reduce waterway evaporation
- Convert Little Murray Weir to a low level weir
- Remove Pental Island pump station
- Remove Fish point weirs
- Reinstate supply to existing diverters from the Little Murray Weir pool

The estimated cost of this option is $18.1 million Refer to plan No 2 and appendix 2 for details.

OPTION 3– Abandon Little Murray Weir and supply landowner syndicates from a new pump station on the River Murray and pipeline.

This option involves the conversion of the Little Murray Weir to a low level weir for environmental use, the construction of a new pump station on the River Murray on the north side of Pental Island, construction of a rising main from the pump station to a control tank located on a ridge 1.76 km to the south west of the proposed pump site and the replacement of the No 9 channel with a pipeline to the boundary of each syndicate which has been taken as the top of each spur. Supply points along the No 9 channel have also been converted to magflow meters as well as each syndicate supply.

- Construct a 110 ML/d pump station on the River Murray. (Includes an allowance of 10 ML/d to supply gravity properties currently supplied from the weir pool and located in close proximity to the pipeline)
- S&I 1760 meters of 1200 mm dia. RCPP from the pump station to a proposed tank
- S&I 740 meters of 1200 mm dia. RCPP from the tank to the No 9 offtake
- Pipeline the No 9 channel from the offtake to the top of each spur involving 11480 meters of various sized pipeline
- Meter 13 spur offtakes plus 36 outlets along the No 9 channel
- Convert Little Murray Weir to a low level weir for environmental purposes
- Remove Pental Island pump station
- Remove Fish point weirs
- Reinstate supply to existing diverters from the Little Murray weir pool

The estimated cost of this option is $23.2 million. Refer plan No 3 and appendix 3 for details.

OPTION 4 – Provide pump capacity to supply an additional 500 ha of Greenfield horticulture development located upstream of Connell's regulator.

Details are as follows:

- Construct a 140 ML/d pump station on the River Murray. Includes an additional 30 ML/d from the River Murray pumps through to Connell's regulator to meet Greenfield development.
- S&I 2300 meters of 1350 mm dia. RCPP from the pump station to the No 9 offtake
- S&I 207 magflow meters
- Reduce waterway area on No 9 channel from offtake to Werrill street
- Remove Little Murray weir
- Remove Pental Island pump station
- Remove Fish point weirs
- Reinstate supply to existing diverters from the Little Murray weir pool

The estimated cost of this option is $17.9 million Refer plan No 4 and appendix 4 for details.

OPTION 5 – same as option 4 but the additional capacity is base on servicing 1000 ha of Greenfield development. Refer to plan No 5 and appendix 5

Details are as follows:

- Construct a 170 ML/d pump station on the River Murray. Includes an additional 60 ML/d from the River Murray pumps through to Connell's regulator to meet Greenfield development.
- S&I 2300 meters of 1500 mm dia. RCPP from the pump station to the No 9 offtake
- S&I 207 magflow meters
- Reduce waterway area on No 9 channel from the No 9 offtake to Werrill street
- Convert Little Murray weir to a low level weir for environmental purposes
- Remove Pental Island pump station
- Remove Fish point weirs
- Reinstate supply to existing diverters from the Little Murray weir pool

The estimated cost of this option is $19.1 million Refer plan No 5 and appendix 5 for details

OPTION 6 - same as option 4 but the additional capacity is base on servicing 3000 ha of Greenfield development. Refer to plan No 6 and appendix 6.

Details are as follows:

- Construct a 285 ML/d pump station on the River Murray. Includes an additional 175 ML/d from the River Murray pumps through to Connell's regulator to meet Greenfield development.
- S&I 2300 meters of 1650mm dia. RCPP from the pump station to the No 9 offtake
- S&I 207 magflow meters
- Reduce waterway area on No 9 channel from the No 9 offtake to Werrill street
- Remove Little Murray weir
- Remove Pental Island pump station
- Remove Fish point weirs
- Reinstate supply to existing diverters from the Little Murray weir pool

The estimated cost of this option is $21.2 million Refer to Appendix 6 for details

WATER SAVINGS

Water savings for the channel system have been based on G-MW water savings spread sheet (Alpha) and for the Little Murray weir pool the savings have been based on detail survey for the Little Murray River as shown below.

Little Murray Weir

Cross sections from the Little Murray Weir to the Fish Point Weir were used to identify the surface area based on a full supply level (FSL) of 69.21AHD at Little Murray Weir and at 66.71 AHD for the low level weir being the existing sill level of Little Murray Weir.

For the Little Murray Weir, the water surface area was estimated using the computer model HEC-RAS at 2,846,760 square meters and assuming an annual evaporation rate of 1.5 meters and a rainfall depth of 0.35 meters, the total evaporation was estimated at 3270 ML. For the proposed low level weir, the surface area was estimated at 1,656,460 meter square or 1900 ML. Based on the above there would is a net water saving 1370 ML.

At this level the Little Murray River would have an average depth of 1.9 meters at the Little Murray Weir reducing to around 0.4 meters 33 km upstream of the weir. Above 33 km the river gradient steepens and it is unlikely that there would be any usable storage in this reach of the river. However the river bed consists of a series of holes and it may be possible to relocate pump suctions to deeper sections of the river. Site inspections will be required if this option is adopted.

Seepage is more difficult to quantify, the bed conditions of the Little Murray River are not known but appear to be good quality clay with some dispersion characteristics. It has been assumed to have a seepage rate of 1 mm per day which is consistent with low seepage clay over a period of 270 days. The area of seepage has been assumed to be over a length of 33 km (Length of the back water effect) at an average width of 50 meters. This equates to a total water loss of 445ML and is considered conservative.

It is also evident that there are substantial areas of lignum, river red gum and box trees that line the waterway and cover low lying areas which are supplied with water from the Little Murray River. No estimate is available as to the change in water usage that may occur with a reduced water level and this contribution has been ignored.

Seepage past the weir is estimated at 20 ML/day for 270 days and again it is not clear what portion is used by existing diverters, so this volume has been ignored.

The existing supply points along the weir pool are all potential water losses as they are remote from the network, the large metered outlets generally operate under drowned conditions and the open outlets and D&S supply points are not metered. No attempt has been made to quantify the losses but it is considered that they would be considerable.

Flushing of the Little Murray weir pool due to salinity slugs and blue green algae occurs on a random basis and again the volume of water used over the years has not been quantified as the water is returned back to the River Murray. In the past the actual volume used for this purpose has been debited against the Areas bulk entitlement.

In summary it is considered that the total water savings attributed to the Little Murray weir would be 1815 ML

No 9 channel

Description	Minimum seepage and evaporation ML/yr
Little Murray Weir conversion to a low level structure	1815
Option 1 – Pump to offtake & pipeline No 9 and spurs	777
Option 2,4,5,6 – Pump to offtake & reduce WW	174
Option 3 - Pipeline No 9 channel to syndicate services	393

ECONOMICS

The capital costs shown below include 40% contingencies, project and contract management costs as well as survey and design. The total increase on the direct cost amount to around 178.4%.

In relation to the do nothing options, the costs shown have been taken from AMS which uses actual construction costs to form the basis of the estimates. In an endeavour to compare options on a fair and reasonable basis, the do nothing costs have been increased by 178.4%.

This may over inflate the do nothing costs however in the context of this feasibility study, the approach is considered reasonable.

Option	Capital cost of new works $	Water savings Based on $2500/ML $
Do nothing	8,304,000	0
1	39,600,000	6,480,000
2	17,000,000	4,972,000
3	23,200,000	5,520,000
4	17,800,000	4,972,000
5	19,200,000	4,972,000
6	21,200,000	4,972,000

The NPV details are contained in DOC 2435553 V2. Options 4, 5 & 6 include an allowance for additional revenue based on improved service levels. The additional revenue has been based on the additional delivery share required to service the Greenfield sites rather than the total revenue as it is probable that HRWS will be sourced within Torrumbarry.

In the case of option 1 it is considered that although the landowners will receive an improved level of service in the form of a low pressure piped supply, the current assets are performing satisfactorily and the principle reason for upgrading the assets is not to improve service delivery but to remove works from the flood plain that pose significant operational risks, obtain water savings and remove the consequences of a premature failure of Little Murray Weir. (Note the above decision is based on discussions with Geoff Coburn of G-MW on 27/3/2008)

A summary of DOC 2435553 V2 is shown below

Rate of Return	6.0%	8.0%	10.0%	12.0%
Do nothing	-$ 22,749,465	-$ 17,771,064	-$ 14,533,432	-$ 12,383,685
Option 1	-$ 36,988,777	-$ 36,204,501	-$ 35,729,954	-$ 35,443,586
Option 2	-$ 15,456,053	-$ 14,612,624	-$ 14,092,124	-$ 13,771,980
Option 3	-$ 21,359,569	-$ 20,604,106	-$ 20,142,807	-$ 19,860,101
Option 4	-$ 17,823,988	-$ 16,709,693	-$ 15,992,195	-$ 15,525,038
Option 5	-$ 19,746,391	-$ 18,510,088	-$ 17,712,238	-$ 17,190,279
Option 6	-$ 23,457,926	-$ 21,883,781	-$ 20,851,629	-$ 20,161,800

Option 1 has the highest capital cost and NPV as well as water savings however it would be difficult to justify when compared with the other options.

Option 2 has the lowest capital cost and NPV and water savings are reasonable. It achieves the primary goal of removing major assets from the flood plain as well as the premature risk of a Little Murray Weir failure and would appear to be worth considering for preliminary design.

Option 3 which is the pipelining of the main channel and supply to syndicates at the top of each spur channel has a high capital cost and NPV and is unlikely to be accepted by customers unless there are other incentives that would make it more attractive.

Options 4, 5 and 6 have increasing capital costs, NPV's and higher risks as they are servicing Greenfield sites and revenue increases are not guaranteed. However option 4 is only marginally more costly than option 2 and is worthy of further consideration.

Options 5 & 6 may be worth further review if a developer was prepared to fund the additional cost.

FURTHER INFORMATION

For further information refer

- DOC 2419879 V1 Details of cost estimates and pipeline design assessments
- DOC 2412748 V1 Water saving assessments
- DOC 2408427 V1 Channel capacity assessment
- DOC 2435553 V2 NPV calculations
- DOC 2418178 V1 Asset details as supplied from AMS

RECOMMENDATIONS

It is recommended that:

1. Consideration be given to taking option 2 and 4 through to preliminary design as part of an overall strategy for the Swan Hill Area;

2. That the likelihood of developers funding the increased capital cost of options 5 & 6 be assessed before further work is undertaken.

Les Thompson
Engineer

HEC-RAS River: LittleMurrayRiver Reach: LMR Profile: PF 1 NVIRP: Swan Hill Modernisation Plan 28/01/2010

69.21 represents existing FSL. 67.37 represents the higher of 2 sill levels from G-MW drawing 135990
66.71 represents 'lowered level' used by G-MW / Les T 67.67 represents the (higher) sill level + 300mm

River Sta	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Froude # Chl	Flow Area	Top Width	*wetted perimeter* W.P. Channel	69.21 Surf Area	69.21 Seep Area	67.37 Surf Area	67.37 Seep Area	67.67 Surf Area	67.67 Seep Area	66.71 Surf Area	66.71 Seep Area
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)		(m2)	(m)	(m)	m2	m2	m2	m2	m2	m2	m2	m2
59148.72	weir69.21	1	67.24	69.21	67.36	69.21	0	0.01	0	87.01	60.45	60.74								
59148.72	67.37	1	67.24	67.61	67.36	67.61	0.00012	0.14	0.09	7.17	30.44	30.45								
59148.72	67.67	1	67.24	67.71	67.36	67.71	0.000039	0.1	0.05	10.39	33.21	33.23								
59148.72	66.71 G-MW	1	67.24	67.61	67.36	67.61	0.000118	0.14	0.09	7.22	30.48	30.49								
													61663	62050	30603	30628	33595	33650	30432	30452
58142.88	weir69.21	1	67.24	69.21	67.29	69.21	0	0.01	0	88.96	62.16	62.64								
58142.88	67.37	1	67.24	67.46	67.29	67.46	0.000193	0.16	0.11	6.22	30.41	30.45								
58142.88	67.67	1	67.24	67.69	67.29	67.69	0.000016	0.07	0.04	13.57	33.59	33.68								
58142.88	66.71 G-MW	1	67.24	67.43	67.29	67.43	0.000307	0.19	0.14	5.39	30.03	30.06								
													37111	37367	20569	20590	22901	22952	18596	18614
57538.72	weir69.21	1	66.76	69.21	66.98	69.21	0	0.01	0	100.85	60.69	61.06								
57538.72	67.37	1	66.76	67.41	66.98	67.41	0.000045	0.1	0.06	10.49	37.68	37.71								
57538.72	67.67	1	66.76	67.68	66.98	67.68	0.000005	0.05	0.02	21.51	42.22	42.3								
57538.72	66.71 G-MW	1	66.76	67.29	66.98	67.29	0.000178	0.15	0.11	6.47	31.53	31.56								
													47094	47547	32272	32379	34959	35116	29396	29487
56715.76	weir69.21	1	65.98	69.21	66.15	69.21	0	0.01	0	124.24	53.76	54.49								
56715.76	67.37	1	65.98	67.41	66.15	67.41	0.000001	0.03	0.01	38.9	40.75	40.98								
56715.76	67.67	1	65.98	67.68	66.15	67.68	0	0.02	0.01	50.35	42.74	43.04								
56715.76	66.71 G-MW	1	65.98	67.29	66.15	67.29	0.000001	0.03	0.01	34.19	39.91	40.1								
													45117	45593	20432	20538	31049	31214	18295	18381
55928.72	weir69.21	1	66.95	69.21		69.21	0	0.01	0	89.88	60.89	61.37								
55928.72	67.37	1	66.95	67.4		67.41	0.001071	0.4	0.27	2.5	11.17	11.21								
55928.72	67.67	1	66.95	67.68		67.68	0.000059	0.11	0.07	9.51	36.16	36.28								
55928.72	66.71 G-MW	1	66.95	67.21	67.21	67.28	0.017946	1.15	1.01	0.87	6.58	6.61								
													52674	53387	25439	25484	38222	38355	19372	19394
55014.32	weir69.21	1	66.63	69.21	66.72	69.21	0	0.01	0	115.34	54.32	55.4								
55014.32	67.37	1	66.63	67.39	66.72	67.39	0.000004	0.04	0.02	23.95	44.47	44.53								
55014.32	67.67	1	66.63	67.68	66.72	67.68	0.000001	0.03	0.01	37.28	47.44	47.61								
55014.32	66.71 G-MW	1	66.63	67.09	66.72	67.09	0.000031	0.09	0.05	11.47	35.79	35.81								
													43920	44715	33483	33597	35759	35961	28524	28577
54135.84	weir69.21	1	66.62	69.21	66.78	69.21	0	0.01	0	88.9	45.67	46.4								
54135.84	67.37	1	66.62	67.39	66.78	67.39	0.000006	0.05	0.02	18.22	31.76	31.96								
54135.84	67.67	1	66.62	67.68	66.78	67.68	0.000002	0.04	0.01	27.77	33.97	34.26								
54135.84	66.71 G-MW	1	66.62	67.04	66.78	67.04	0.000087	0.13	0.08	7.78	29.15	29.25								
													63116	64003	45812	45962	49086	49317	34111	34175
52983.04	weir69.21	1	66.6	69.21	66.69	69.21	0	0.01	0	131.02	63.83	64.64								
52983.04	67.37	1	66.6	67.38	66.69	67.38	0.000003	0.04	0.02	26.06	47.72	47.78								
52983.04	67.67	1	66.6	67.68	66.69	67.68	0.000001	0.02	0.01	40.6	51.19	51.3								
52983.04	66.71 G-MW	1	66.6	66.9	66.69	66.9	0.000189	0.16	0.11	6.23	30.03	30.04								
													35072	35450	26466	26513	28307	28384	18528	18541
52434.4	weir69.21	1	66.43	69.21	66.53	69.21	0	0.01	0	138.88	64.02	64.59								
52434.4	67.37	1	66.43	67.38	66.53	67.38	0.000001	0.03	0.01	34.43	48.76	48.87								
52434.4	67.67	1	66.43	67.68	66.53	67.68	0	0.02	0.01	49.36	52	52.17								
52434.4	66.71 G-MW	1	66.43	66.87	66.53	66.87	0.000027	0.08	0.05	12.26	37.51	37.55								
													28794	29044	21253	21301	22901	22979	15780	15801
51977.2	weir69.21	1	66.21	69.21	66.44	69.21	0	0.01	0	129.25	61.94	62.46								
51977.2	67.37	1	66.21	67.38	66.44	67.38	0.000002	0.03	0.01	30.89	44.21	44.31								
51977.2	67.67	1	66.21	67.68	66.44	67.68	0.000001	0.02	0.01	44.62	48.18	48.35								
51977.2	66.71 G-MW	1	66.21	66.85	66.44	66.86	0.000033	0.09	0.05	10.74	31.52	31.57								
													95221	96404	69623	69836	76854	77169	50431	50524
50275.76	weir69.21	1	66.12	69.21	66.31	69.21	0	0.01	0	113.79	49.99	50.86								
50275.76	67.37	1	66.12	67.38	66.31	67.38	0.000001	0.03	0.01	30.41	37.63	37.78								
50275.76	67.67	1	66.12	67.68	66.31	67.68	0.000001	0.02	0.01	42.29	42.16	42.36								
50275.76	66.71 G-MW	1	66.12	66.81	66.31	66.81	0.000021	0.09	0.04	11.72	27.76	27.82								
													13237	13470	9936	9987	10855	10926	7455	7475
50001.44	weir69.21	1	66.08	69.21	66.31	69.21	0	0.01	0	103.3	46.52	47.35								
50001.44	67.37	1	66.08	67.38	66.31	67.38	0.000002	0.04	0.01	28.23	34.81	35.03								
50001.44	67.67	1	66.08	67.67	66.31	67.67	0.000001	0.03	0.01	38.89	36.98	37.3								
50001.44	66.71 G-MW	1	66.08	66.8	66.31	66.8	0.000035	0.1	0.05	9.82	26.59	26.68								
													21039	21416	15918	16023	16906	17053	11111	11151
49580.16	weir69.21	1	66.04	69.21	66.14	69.21	0	0.01	0	122.6	53.36	54.32								
49580.16	67.37	1	66.04	67.38	66.14	67.38	0.000001	0.03	0.01	34.84	40.76	41.04								
49580.16	67.67	1	66.04	67.67	66.14	67.67	0	0.02	0.01	47.32	43.28	43.66								
49580.16	66.71 G-MW	1	66.04	66.8	66.14	66.8	0.000011	0.07	0.03	14.03	26.16	26.26								
													43971	44798	34375	34663	36099	36474	26129	26277
48757.2	weir69.21	1	65.26	69.21	65.47	69.21	0	0.01	0	146.96	53.5	54.55								
48757.2	67.37	1	65.26	67.38	65.47	67.38	0	0.02	0	58.85	42.78	43.2								
48757.2	67.67	1	65.26	67.67	65.47	67.67	0	0.01	0	71.81	44.45	44.98								
48757.2	66.71 G-MW	1	65.26	66.79	65.47	66.79	0.000001	0.03	0.01	35.19	37.34	37.6								
													40578	41273	32742	32985	34119	34429	29285	29420
48061.6	weir69.21	1	65.81	69.21	65.99	69.21	0	0.01	0	162.59	63.17	64.12								
48061.6	67.37	1	65.81	67.38	65.99	67.38	0	0.02	0.01	56.08	51.36	51.64								
48061.6	67.67	1	65.81	67.67	65.99	67.67	0	0.01	0	71.69	53.65	54.01								
48061.6	66.71 G-MW	1	65.81	66.79	65.99	66.79	0.000002	0.04	0.02	27.43	46.86	46.99								
													22438	22745	18012	18098	18798	18913	15525	15565
47695.84	weir69.21	1	65.72	69.21		69.21	0	0.01	0	143.96	59.52	60.25								
47695.84	67.37	1	65.72	67.38		67.38	0	0.02	0.01	46.07	47.13	47.32								
47695.84	67.67	1	65.72	67.67		67.67	0	0.02	0	60.39	49.14	49.41								
47695.84	66.71 G-MW	1	65.72	66.79		66.79	0.000005	0.05	0.02	20.67	38.03	38.12								
													53099	54018	43599	43877	45139	45519	37888	38002
46781.44	weir69.21	1	65.4	69.21	65.59	69.21	0	0.01	0	164.29	56.62	57.9								
46781.44	67.37	1	65.4	67.38	65.59	67.38	0	0.01	0	68.04	48.23	48.65								
46781.44	67.67	1	65.4	67.67	65.59	67.67	0	0.01	0	82.59	49.59	50.15								
46781.44	66.71 G-MW	1	65.4	66.79	65.59	66.79	0.000001	0.02	0.01	40.62	44.84	45								
													34739	35603	29846	30057	30685	30999	26115	26199
46177.28	weir69.21	1	65.53	69.21		69.21	0	0.01	0	155.78	58.38	59.96								
46177.28	67.37	1	65.53	67.38		67.38	0	0.02	0.01	55.28	50.57	50.85								
46177.28	67.67	1	65.53	67.67		67.67	0	0.01	0	70.54	51.99	52.47								
46177.28	66.71 G-MW	1	65.53	66.79		66.79	0.000002	0.04	0.01	27.92	41.61	41.73								
													69403	71257	52137	52933	58847	59829	42399	42926
45080	weir69.21	1	64.98	69.21	65.46	69.21	0	0.01	0	156.26	68.12	69.92								
45080	67.37	1	64.98	67.38	65.46	67.38	0	0.02	0.01	45.89	44.46	45.63								
45080	67.67	1	64.98	67.67	65.46	67.67	0	0.02	0.01	60.6	55.27	56.58								
45080	66.71 G-MW	1	64.98	66.79	65.46	66.79	0.000003	0.04	0.02	22.3	35.67	36.51								
													58994	60053	41671	42259	47728	48409	34568	34972
44201.52	weir69.21	1	65.98	69.21	66.16	69.21	0	0.01	0	156.67	66.19	66.8								
44201.52	67.37	1	65.98	67.38	66.16	67.38	0	0.02	0.01	48.58	50.41	50.58								
44201.52	67.67	1	65.98	67.67	66.16	67.67	0	0.02	0	64.04	53.39	53.63								
44201.52	66.71 G-MW	1	65.98	66.78	66.16	66.78	0.000005	0.05	0.02	20.9	43.03	43.11								
													46258	46953	37395	37567	39476	39711	32406	32479
43470	weir69.21	1	65.58	69.21	65.84	69.21	0	0.01	0	159.87	60.28	61.57								
43470	67.37	1	65.58	67.38	65.84	67.38	0	0.02	0.01	54.88	51.83	52.13								
43470	67.67	1	65.58	67.67	65.84	67.67	0	0.01	0	70.73	54.54	54.94								
43470	66.71 G-MW	1	65.58	66.78	65.84	66.78	0.000003	0.04	0.02	25.74	45.57	45.69								
													16955	17185	11599	11667	12374	12459	9849	9885
43231.6	weir69.21	1	65.12	69.21	65.38	69.21	0	0.01	0	169.09	81.96	82.6								
43231.6	67.37	1	65.12	67.38	65.38	67.38	0	0.02	0	59.47	45.48	45.75								
43231.6	67.67	1	65.12	67.67	65.38	67.67	0	0.01	0	73.63	49.27	49.58								
43231.6	66.71 G-MW	1	65.12	66.78	65.38	66.78	0.000001	0.03	0.01	34.92	37.06	37.24								
													69645	70244	46538	46744	49560	49821	38752	38867
42317.2	weir69.21	1	66.03	69.21	66.16	69.21	0	0.01	0	172.71	70.37	71.04								
42317.2	67.37	1	66.03	67.38	66.16	67.38	0	0.02	0.01	55.79	56.31	56.49								
42317.2	67.67	1	66.03	67.67	66.16	67.67	0	0.01	0	73.07	59.13	59.39								
42317.2	66.71 G-MW	1	66.03	66.78	66.16	66.78	0.000004	0.04	0.02	24.79	47.7	47.77								
													53440	53971	40045	40237	42138	42390	34685	34779
41530.16	weir69.21	1	65.34	69.21	65.58	69.21	0	0.01	0	159.77	65.43	66.11								
41530.16	67.37	1	65.34	67.38	65.58	67.38	0	0.02	0	60.16	45.45	45.76								
41530.16	67.67	1	65.34	67.67	65.58	67.67	0	0.01	0	74.08	47.95	48.33								
41530.16	66.71 G-MW	1	65.34	66.78	65.58	66.78	0.000001	0.03	0.01	34.51	40.44	40.61								
													23158	23443	17037	17160	17922	18072	15186	15254
41164.4	weir69.21	1	65.13	69.21	65.34	69.21	0	0.01	0	171.94	61.2	62.08								
41164.4	67.37	1	65.13	67.38	65.34	67.38	0	0.01	0	71.73	47.71	48.07								
41164.4	67.67	1	65.13	67.67	65.34	67.67	0	0.01	0	86.32	50.05	50.49								
41164.4	66.71 G-MW	1	65.13	66.78	65.34	66.78	0	0.02	0.01	44.76	42.6	42.8								
													74517	75439	58297	58654	60977	61421	52683	52856

HEC-RAS River: LittleMurrayRiver Reach: LMR Profile: PF 1 NVIRP: Swan Hill Modernisation Plan 28/01/2010

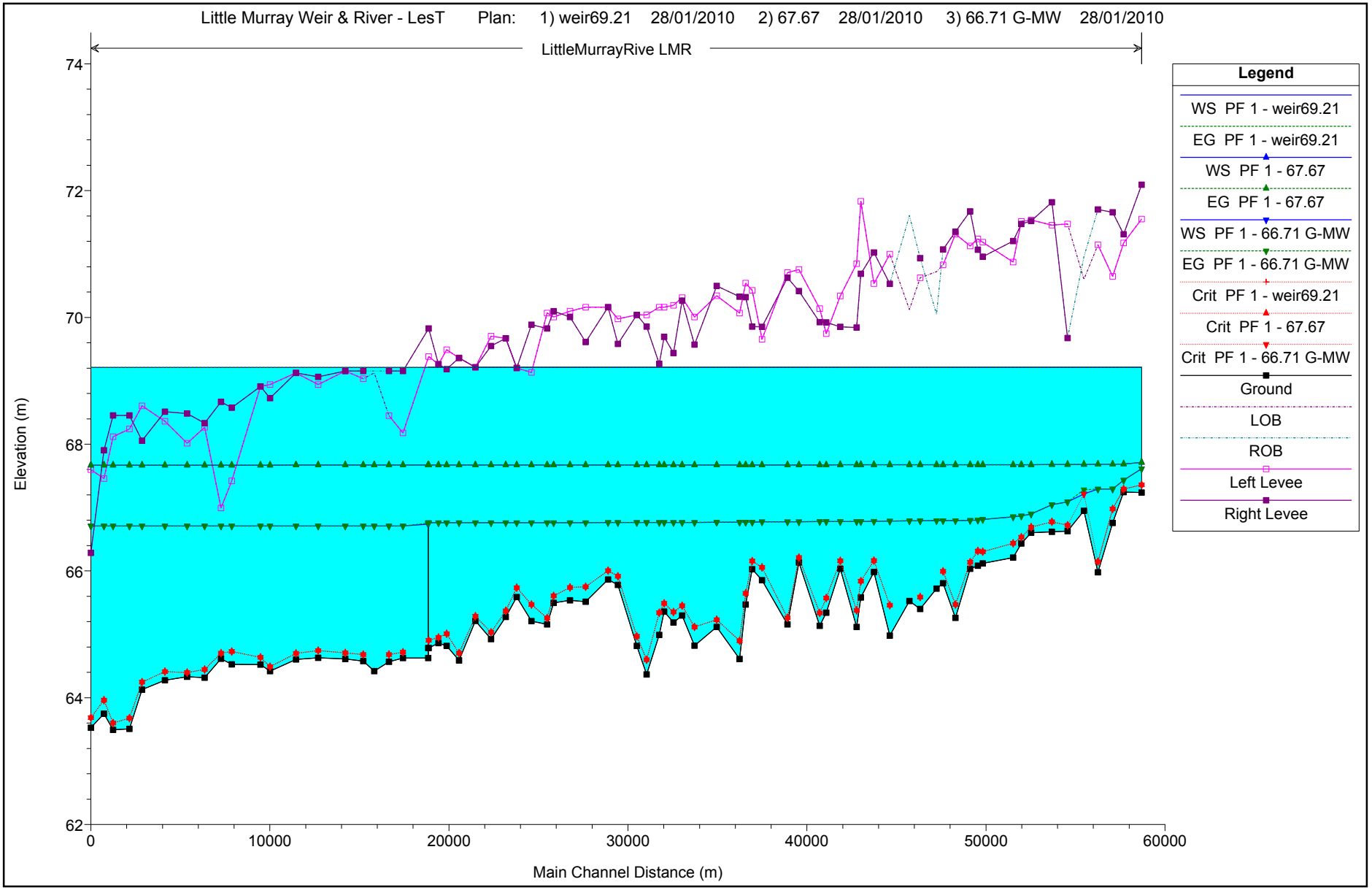
69.21 represents existing FSL. 67.37 represents the higher of 2 sill levels from G-MW drawing 135990
66.71 represents 'lowered level' used by G-MW / Les T 67.67 represents the (higher) sill level + 300mm

												wetted perimeter	69.21		67.37		67.67		66.71	
River Sta	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Froude # Chl	Flow Area	Top Width	W.P. Channel	Surf Area	Seep Area	Surf Area	Seep Area	Surf Area	Seep Area	Surf Area	Seep Area
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)		(m2)	(m)	(m)	m2	m2	m2	m2	m2	m2	m2	m2
40011.6	weir69.21	1	66.13	69.21	66.21	69.21	0	0.01	0	167.61	68.08	68.8								
40011.6	67.37	1	66.13	67.38	66.21	67.38	0	0.02	0.01	56.16	53.43	53.69								
40011.6	67.67	1	66.13	67.67	66.21	67.67	0	0.01	0	72.45	55.74	56.07								
40011.6	66.71 G-MW	1	66.13	66.78	66.21	66.78	0.000003	0.04	0.02	25.58	48.8	48.9								
													41624	42290	33316	33575	34635	34958	30673	30794
39371.52	weir69.21	1	65.16	69.21	65.26	69.21	0	0.01	0	179.35	61.98	63.34								
39371.52	67.37	1	65.16	67.37	65.26	67.37	0	0.01	0	75.94	50.67	51.22								
39371.52	67.67	1	65.16	67.67	65.26	67.67	0	0.01	0	91.33	52.48	53.16								
39371.52	66.71 G-MW	1	65.16	66.78	65.26	66.78	0	0.02	0.01	46.69	47.04	47.32								
													85584	87825	69965	70607	72234	73133	59775	60018
37944.4	weir69.21	1	65.85	69.21	66.06	69.21	0	0.01	0	139.39	57.96	59.74								
37944.4	67.37	1	65.85	67.37	66.06	67.37	0	0.02	0.01	44.51	47.38	47.73								
37944.4	67.67	1	65.85	67.67	66.06	67.67	0	0.02	0	58.86	48.75	49.33								
37944.4	66.71 G-MW	1	65.85	66.77	66.06	66.77	0.000007	0.06	0.03	17.84	36.73	36.79								
													30592	31429	22837	23026	24908	25196	17625	17663
37395.76	weir69.21	1	66.03	69.21	66.16	69.21	0	0.01	0	119.82	53.56	54.83								
37395.76	67.37	1	66.03	67.37	66.16	67.37	0.000001	0.03	0.01	32.29	35.87	36.21								
37395.76	67.67	1	66.03	67.67	66.16	67.67	0	0.02	0.01	43.51	42.05	42.52								
37395.76	66.71 G-MW	1	66.03	66.77	66.16	66.77	0.000019	0.08	0.04	12.03	27.52	27.6								
													25978	26375	18809	18930	20453	20616	15378	15417
37030	weir69.21	1	65.47	69.21	65.65	69.21	0	0	0	214.32	88.49	89.39								
37030	67.37	1	65.47	67.37	65.65	67.37	0	0.01	0	73.9	66.98	67.3								
37030	67.67	1	65.47	67.67	65.65	67.67	0	0.01	0	94.34	69.79	70.21								
37030	66.71 G-MW	1	65.47	66.77	65.65	66.77	0.000001	0.03	0.01	35.87	56.57	56.7								
													28492	28787	19048	19183	21755	21910	13642	13735
36700.16	weir69.21	1	64.61	69.21	64.9	69.21	0	0.01	0	183.32	84.27	85.16								
36700.16	67.37	1	64.61	67.37	64.9	67.37	0	0.02	0.01	56.39	48.52	49.02								
36700.16	67.67	1	64.61	67.67	64.9	67.67	0	0.01	0	73	62.12	62.64								
36700.16	66.71 G-MW	1	64.61	66.77	64.9	66.77	0.000001	0.03	0.01	33.31	26.15	26.58								
													100761	101882	66722	67292	77059	77687	49094	49529
35420	weir69.21	1	65.12	69.21	65.23	69.21	0	0	0	207.03	73.15	74.01								
35420	67.37	1	65.12	67.37	65.23	67.37	0	0.01	0	89.74	55.72	56.11								
35420	67.67	1	65.12	67.67	65.23	67.67	0	0.01	0	106.77	58.27	58.73								
35420	66.71 G-MW	1	65.12	66.77	65.23	66.77	0	0.02	0.01	57.45	50.55	50.8								
													89417	90568	71227	71681	74847	75382	62977	63282
34175.76	weir69.21	1	64.82	69.21	65.11	69.21	0	0	0	206.41	70.58	71.57								
34175.76	67.37	1	64.82	67.37	65.11	67.37	0	0.01	0	85.92	58.77	59.11								
34175.76	67.67	1	64.82	67.67	65.11	67.67	0	0.01	0	104.05	62.04	62.44								
34175.76	66.71 G-MW	1	64.82	66.77	65.11	66.77	0	0.02	0.01	52.66	50.68	50.92								
													47402	48136	38867	39159	40644	40995	34749	34933
33480.16	weir69.21	1	65.3	69.21	65.45	69.21	0	0.01	0	189.15	65.71	66.83								
33480.16	67.37	1	65.3	67.37	65.45	67.37	0	0.01	0	80.97	52.98	53.48								
33480.16	67.67	1	65.3	67.67	65.45	67.67	0	0.01	0	97.08	54.82	55.43								
33480.16	66.71 G-MW	1	65.3	66.77	65.45	66.77	0	0.02	0.01	49.9	49.23	49.52								
													30034	30505	21975	22196	22999	23263	19890	20023
33004.67	weir69.21	1	65.19	69.21	65.35	69.21	0	0.01	0	148.38	60.62	61.48								
33004.67	67.37	1	65.19	67.37	65.35	67.37	0	0.02	0	61.07	39.45	39.88								
33004.67	67.67	1	65.19	67.67	65.35	67.67	0	0.01	0	73.23	41.92	42.42								
33004.67	66.71 G-MW	1	65.19	66.77	65.35	66.77	0.000001	0.03	0.01	38.6	34.43	34.7								
													35767	36371	27584	27851	28594	28920	25526	25677
32474.32	weir69.21	1	65.36	69.21	65.49	69.21	0	0	0	223.02	74.26	75.68								
32474.32	67.37	1	65.36	67.37	65.49	67.37	0	0.01	0	96.6	64.57	65.15								
32474.32	67.67	1	65.36	67.67	65.49	67.67	0	0.01	0	116.11	65.91	66.64								
32474.32	66.71 G-MW	1	65.36	66.77	65.49	66.77	0	0.02	0.01	58.16	61.83	62.13								
													21183	21519	16157	16315	17000	17188	14352	14453
32200	weir69.21	1	64.99	69.21	65.34	69.21	0	0.01	0	185.07	80.18	81.21								
32200	67.37	1	64.99	67.37	65.34	67.37	0	0.01	0	66.79	53.23	53.8								
32200	67.67	1	64.99	67.67	65.34	67.67	0	0.01	0	83.42	58.03	58.67								
32200	66.71 G-MW	1	64.99	66.77	65.34	66.77	0.000001	0.03	0.01	37.53	42.81	43.24								
													53506	54358	39096	39534	41232	41739	34523	34822
31504.4	weir69.21	1	64.37	69.21	64.6	69.21	0	0	0	245.09	73.66	75.08								
31504.4	67.37	1	64.37	67.37	64.6	67.37	0	0.01	0	128.23	59.18	59.87								
31504.4	67.67	1	64.37	67.67	64.6	67.67	0	0.01	0	146.13	60.52	61.34								
31504.4	66.71 G-MW	1	64.37	66.77	64.6	66.77	0	0.01	0	93.05	56.45	56.88								
													37884	38578	29662	30002	30672	31069	27608	27830
30955.76	weir69.21	1	64.82	69.21	64.97	69.21	0	0.01	0	195.36	64.44	65.55								
30955.76	67.37	1	64.82	67.37	64.97	67.37	0	0.01	0	92.28	48.95	49.5								
30955.76	67.67	1	64.82	67.67	64.97	67.67	0	0.01	0	107.27	51.29	51.92								
30955.76	66.71 G-MW	1	64.82	66.77	64.97	66.77	0	0.02	0	63.95	44.19	44.57								
													68495	69461	49895	50346	52824	53349	43930	44216
29894.4	weir69.21	1	65.78	69.21	65.92	69.21	0	0.01	0	155.06	64.63	65.34								
29894.4	67.37	1	65.78	67.37	65.92	67.37	0	0.02	0.01	54.2	45.07	45.37								
29894.4	67.67	1	65.78	67.67	65.92	67.67	0	0.01	0	68.15	48.25	48.61								
29894.4	66.71 G-MW	1	65.78	66.76	65.92	66.76	0.000002	0.03	0.01	28.73	38.59	38.75								
													37310	37639	25479	25619	27405	27572	21559	21633
29345.76	weir69.21	1	65.87	69.21	66	69.21	0	0.01	0	163.52	71.38	71.87								
29345.76	67.37	1	65.87	67.37	66	67.37	0	0.02	0.01	53.92	47.81	48.02								
29345.76	67.67	1	65.87	67.67	66	67.67	0	0.01	0	68.79	51.65	51.9								
29345.76	66.71 G-MW	1	65.87	66.76	66	66.76	0.000002	0.04	0.01	27.15	40	40.11								
													98905	99477	64769	65036	70324	70642	53446	53608
28101.52	weir69.21	1	65.51	69.21	65.75	69.21	0	0	0	201.67	87.6	88.03								
28101.52	67.37	1	65.51	67.37	65.75	67.37	0	0.01	0	69.34	56.3	56.52								
28101.52	67.67	1	65.51	67.67	65.75	67.67	0	0.01	0	86.95	61.39	61.65								
28101.52	66.71 G-MW	1	65.51	66.76	65.75	66.76	0.000001	0.03	0.01	38.12	45.91	46.06								
													78734	79081	49744	49915	54461	54663	40116	40226
27223.04	weir69.21	1	65.54	69.21	65.74	69.21	0	0	0	203.87	91.65	92.01								
27223.04	67.37	1	65.54	67.37	65.74	67.37	0	0.01	0	67.2	56.95	57.12								
27223.04	67.67	1	65.54	67.67	65.74	67.67	0	0.01	0	85.09	62.6	62.8								
27223.04	66.71 G-MW	1	65.54	66.76	65.74	66.76	0.000001	0.03	0.01	35.9	45.42	45.52								
													74702	75205	51298	51526	55106	55381	43516	43653
26308.64	weir69.21	1	65.5	69.21	65.6	69.21	0	0.01	0	198.77	71.74	72.48								
26308.64	67.37	1	65.5	67.37	65.6	67.37	0	0.01	0	81.97	55.25	55.58								
26308.64	67.67	1	65.5	67.67	65.6	67.67	0	0.01	0	98.91	57.93	58.33								
26308.64	66.71 G-MW	1	65.5	66.76	65.6	66.76	0	0.02	0.01	49.84	49.76	49.96								
													31898	32130	22430	22540	23970	24102	19279	19351
25942.88	weir69.21	1	65.15	69.21	65.26	69.21	0	0	0	250.75	102.68	103.21								
25942.88	67.37	1	65.15	67.37	65.26	67.37	0	0.01	0	94.33	67.4	67.67								
25942.88	67.67	1	65.15	67.67	65.26	67.67	0	0.01	0	115.36	73.14	73.46								
25942.88	66.71 G-MW	1	65.15	66.76	65.26	66.76	0	0.02	0.01	56.67	55.66	55.85								
													90330	90808	59996	60224	65012	65275	49744	49906
25064.4	weir69.21	1	65.21	69.21	65.47	69.21	0	0	0	250.11	102.97	103.53								
25064.4	67.37	1	65.21	67.37	65.47	67.37	0	0.01	0	90.81	69.19	69.44								
25064.4	67.67	1	65.21	67.67	65.47	67.67	0	0.01	0	112.38	74.87	75.15								
25064.4	66.71 G-MW	1	65.21	66.76	65.47	66.76	0	0.02	0.01	52	57.59	57.77								
													78490	78955	55142	55340	59027	59257	47205	47333
24241.44	weir69.21	1	65.59	69.21	65.74	69.21	0	0	0	228.58	87.78	88.35								
24241.44	67.37	1	65.59	67.37	65.74	67.37	0	0.01	0	88.1	64.82	65.05								
24241.44	67.67	1	65.59	67.67	65.74	67.67	0	0.01	0	108.07	68.58	68.86								
24241.44	66.71 G-MW	1	65.59	66.76	65.74	66.76	0	0.02	0.01	50.75	57.13	57.26								
													48517	48855	33821	33975	36219	36404	28915	29012
23637.28	weir69.21	1	65.27	69.21	65.37	69.21	0	0.01	0	176.89	72.83	73.38								
23637.28	67.37	1	65.27	67.37	65.37	67.37	0	0.02	0	66.53	47.14	47.42								
23637.28	67.67	1	65.27	67.67	65.37	67.67	0	0.01	0	81.28	51.32	51.65								
23637.28	66.71 G-MW	1	65.27	66.76	65.37	66.76	0.000001	0.02	0.01	40.27	38.59	38.78								
													66388	66903	46444	46711	49555	49867	40074	40259
22814.32	weir69.21	1	64.92	69.21	65.03	69.21	0	0	0	253.74	88.51	89.21								
22814.32	67.37	1	64.92	67.37	65.03	67.37	0	0.01	0	113.64	65.73	66.1								
22814.32	67.67	1	64.92	67.67	65.03	67.67	0	0.01	0	133.83	69.11	69.54								
22814.32	66.71 G-MW	1	64.92	66.76	65.03	66.76	0	0.01	0	75.49	58.8	59.06								
													94410	94880	65262	65504	69861	70147	55841	56007
21935.84	weir69.21	1	65.21	69.21	65.29	69.21	0	0	0	313.46	126.43	126.8								
21935.84	67.37	1	65.21	67.37	65.29	67.37	0	0.01	0	120.95	82.85	83.03								
21935.84	67.67	1	65.21	67.67	65.29	67.67	0	0.01	0	146.82	89.94	90.16								
21935.84	66.71 G-MW	1	65.21	66.76	65.29	66.76	0	0.01	0	74.62	68.33	68.45								
													95550	96035	66244	66491	71063	71346	56386	56551

HEC-RAS River: LittleMurrayRiver Reach: LMR Profile: PF 1 NVIRP: Swan Hill Modernisation Plan 28/01/2010

69.21 represents existing FSL. 67.37 represents the higher of 2 sill levels from G-MW drawing 135990
66.71 represents 'lowered level' used by G-MW / Les T 67.67 represents the (higher) sill level + 300mm

River Sta	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Froude # Chl	Flow Area	Top Width	*wetted perimeter* W.P. Channel	69.21 Surf Area	69.21 Seep Area	67.37 Surf Area	67.37 Seep Area	67.67 Surf Area	67.67 Seep Area	66.71 Surf Area	66.71 Seep Area
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)		(m2)	(m)	(m)	m2	m2	m2	m2	m2	m2	m2	m2
21021.44	weir69.21	1	64.59	69.21	64.7	69.21	0	0	0	244.51	82.56	83.25								
21021.44	67.37	1	64.59	67.37	64.7	67.37	0	0.01	0	111.11	62.04	62.4								
21021.44	67.67	1	64.59	67.67	64.7	67.67	0	0.01	0	130.21	65.49	65.89								
21021.44	66.71 G-MW	1	64.59	66.76	64.7	66.76	0	0.01	0	75.24	55	55.24								
													62830	63261	46090	46313	48866	49116	40418	40571
20325.84	weir69.21	1	64.82	69.21	65.01	69.21	0	0	0	276.48	98.09	98.64								
20325.84	67.37	1	64.82	67.37	65.01	67.37	0	0.01	0	121.24	70.48	70.76								
20325.84	67.67	1	64.82	67.67	65.01	67.67	0	0.01	0	143.02	75.01	75.33								
20325.84	66.71 G-MW	1	64.82	66.76	65.01	66.76	0	0.01	0	80.87	61.21	61.41								
													43782	44044	31241	31378	33291	33446	27047	27142
19870.89	weir69.21	1	64.86	69.21	64.95	69.21	0	0	0	257.4	94.38	94.98								
19870.89	67.37	1	64.86	67.37	64.95	67.37	0	0.01	0	109.08	66.86	67.18								
19870.89	67.67	1	64.86	67.67	64.95	67.67	0	0.01	0	129.77	71.34	71.7								
19870.89	66.71 G-MW	1	64.86	66.76	64.95	66.76	0	0.01	0	70.89	57.69	57.91								
													58463	58766	39570	39749	42647	42843	33274	33409
19320	weir69.21	1	64.78	69.21	64.9	69.21	0	0	0	309.28	117.87	118.37								
19320	67.37	1	64.78	67.37	64.9	67.37	0	0.01	0	130.2	76.8	77.13								
19320	67.67	1	64.78	67.67	64.9	67.67	0	0.01	0	154.21	83.49	83.84								
19320	66.71 G-MW	1	64.78	66.76	64.9	66.76	0	0.01	0	87.31	63.11	63.38								
													127606	129597	92413	93219	98543	99435	79662	80283
19300	**Inl Struct**																			
17892.88	weir69.21	1	64.62	69.21	64.72	69.21	0	0	0	224.88	60.96	63.25								
17892.88	67.37	1	64.62	67.37	64.72	67.37	0	0.01	0	118.84	52.71	53.51								
17892.88	67.67	1	64.62	67.67	64.72	67.67	0	0.01	0	134.93	54.61	55.51								
17892.88	66.71 G-MW	1	64.62	66.71	64.72	66.71	0	0.01	0	85.47	48.53	49.13								
													47978	49776	40718	41386	42445	43197	36912	37416
17105.84	weir69.21	1	64.57	69.21	64.68	69.21	0	0	0	213.01	60.96	63.24								
17105.84	67.37	1	64.57	67.37	64.68	67.37	0	0.01	0	107.45	50.76	51.66								
17105.84	67.67	1	64.57	67.67	64.68	67.67	0	0.01	0	123.04	53.25	54.26								
17105.84	66.71 G-MW	1	64.57	66.71	64.68	66.71	0	0.01	0	75.78	45.27	45.95								
													62942	65007	42325	43345	44146	45282	38310	39079
16279.83	weir69.21	1	64.42	69.21		69.21	0	0	0	234.32	91.44	94.16								
16279.83	67.37	1	64.42	67.37		67.37	0	0.01	0	120.81	51.72	53.29								
16279.83	67.67	1	64.42	67.67		67.67	0	0.01	0	136.6	53.64	55.38								
16279.83	66.71 G-MW	1	64.42	66.71		66.71	0	0.01	0	88.09	47.49	48.67								
													54965	56291	30482	31225	31916	32736	27332	27888
15678.72	weir69.21	1	64.58	69.21	64.68	69.21	0	0	0	220.45	91.44	93.13								
15678.72	67.37	1	64.58	67.37	64.68	67.37	0	0.01	0	100.67	49.7	50.6								
15678.72	67.67	1	64.58	67.67	64.68	67.67	0	0.01	0	116	52.55	53.54								
15678.72	66.71 G-MW	1	64.58	66.71	64.68	66.71	0	0.01	0	69.95	43.45	44.12								
													86175	87729	55221	56015	57635	58525	49920	50478
14672.88	weir69.21	1	64.61	69.21	64.71	69.21	0	0	0	254.62	79.91	81.31								
14672.88	67.37	1	64.61	67.37	64.71	67.37	0	0.01	0	130.85	60.1	60.78								
14672.88	67.67	1	64.61	67.67	64.71	67.67	0	0.01	0	149.17	62.05	62.83								
14672.88	66.71 G-MW	1	64.61	66.71	64.71	66.71	0	0.01	0	92.63	55.81	56.25								
													125706	128144	96831	97810	100035	101182	89003	89679
13154.32	weir69.21	1	64.63	69.21	64.75	69.21	0	0	0	287.07	85.65	87.46								
13154.32	67.37	1	64.63	67.37	64.75	67.37	0	0.01	0	147.13	67.43	68.04								
13154.32	67.67	1	64.63	67.67	64.75	67.67	0	0.01	0	167.72	69.7	70.43								
13154.32	66.71 G-MW	1	64.63	66.71	64.75	66.71	0	0.01	0	104.64	61.41	61.86								
													106463	108653	73746	74729	77889	79009	66274	67009
11910.08	weir69.21	1	64.6	69.21	64.7	69.21	0	0	0	231.19	85.48	87.19								
11910.08	67.37	1	64.6	67.37	64.7	67.37	0	0.01	0	105.48	51.11	52.08								
11910.08	67.67	1	64.6	67.67	64.7	67.67	0	0.01	0	121.34	55.5	56.57								
11910.08	66.71 G-MW	1	64.6	66.71	64.7	66.71	0	0.01	0	73.74	45.12	45.85								
													137112	139272	88575	89536	95166	96228	76730	77460
10464.67	weir69.21	1	64.42	69.21	64.49	69.21	0	0	0	303.1	104.24	105.52								
10464.67	67.37	1	64.42	67.37	64.49	67.37	0	0.01	0	141.64	71.45	71.81								
10464.67	67.67	1	64.42	67.67	64.49	67.67	0	0.01	0	163.78	76.18	76.58								
10464.67	66.71 G-MW	1	64.42	66.71	64.49	66.71	0	0.01	0	97.93	61.05	61.33								
													49760	50537	36021	36281	37750	38050	32216	32394
9934.32	weir69.21	1	64.52	69.21	64.64	69.21	0	0	0	280.36	83.41	85.06								
9934.32	67.37	1	64.52	67.37	64.64	67.37	0	0.01	0	144.29	64.39	65.01								
9934.32	67.67	1	64.52	67.67	64.64	67.67	0	0.01	0	163.87	66.18	66.91								
9934.32	66.71 G-MW	1	64.52	66.71	64.64	66.71	0	0.01	0	103.12	60.44	60.83								
													143210	146792	120766	121491	124228	125266	109722	110196
8324.32	weir69.21	1	64.53	69.21	64.73	69.21	0	0	0	329.76	94.49	97.29								
8324.32	67.37	1	64.53	67.37	64.73	67.37	0	0.01	0	161.01	85.63	85.91								
8324.32	67.67	1	64.53	67.67	64.73	67.67	0	0.01	0	187.11	88.14	88.7								
8324.32	66.71 G-MW	1	64.53	66.71	64.73	66.71	0	0.01	0	107.74	75.86	76.06								
													59848	61630	54631	54903	55978	56432	48058	48173
7720.16	weir69.21	1	64.62	69.21	64.7	69.21	0	0	0	362.65	103.63	106.73								
7720.16	67.37	1	64.62	67.37	64.7	67.37	0	0.01	0	177.41	95.22	95.84								
7720.16	67.67	1	64.62	67.67	64.7	67.67	0	0	0	206.26	97.17	98.11								
7720.16	66.71 G-MW	1	64.62	66.71	64.7	66.71	0	0.01	0	117.09	83.23	83.41								
													94759	97237	81244	81697	84020	84641	71620	71826
6805.76	weir69.21	1	64.32	69.21	64.44	69.21	0	0	0	354.62	103.63	105.95								
6805.76	67.37	1	64.32	67.37	64.44	67.37	0	0.01	0	176.74	82.48	82.85								
6805.76	67.67	1	64.32	67.67	64.44	67.67	0	0	0	202.09	86.6	87.02								
6805.76	66.71 G-MW	1	64.32	66.71	64.44	66.71	0	0.01	0	125.31	73.42	73.69								
													88689	91163	73627	74131	77084	77652	66018	66396
5835.84	weir69.21	1	64.33	69.21	64.4	69.21	0	0	0	301.48	79.25	82.03								
5835.84	67.37	1	64.33	67.37	64.4	67.37	0	0.01	0	160.76	69.34	70.01								
5835.84	67.67	1	64.33	67.67	64.4	67.67	0	0.01	0	182.01	72.35	73.1								
5835.84	66.71 G-MW	1	64.33	66.71	64.4	66.71	0	0.01	0	117.2	62.71	63.22								
													112635	115783	91421	92192	95794	96653	81809	82387
4591.6	weir69.21	1	64.27	69.21	64.41	69.21	0	0	0	341.38	101.8	104.08								
4591.6	67.37	1	64.27	67.37	64.41	67.37	0	0.01	0	169.96	77.61	78.18								
4591.6	67.67	1	64.27	67.67	64.41	67.67	0	0.01	0	193.84	81.63	82.26								
4591.6	66.71 G-MW	1	64.27	66.71	64.41	66.71	0	0.01	0	121.66	68.79	69.21								
													143589	146399	113281	113819	120393	120982	98585	98982
3311.44	weir69.21	1	64.13	69.21	64.25	69.21	0	0	0	411.83	122.53	124.64								
3311.44	67.37	1	64.13	67.37	64.25	67.37	0	0.01	0	198.36	99.37	99.64								
3311.44	67.67	1	64.13	67.67	64.25	67.67	0	0	0	229.19	106.46	106.75								
3311.44	66.71 G-MW	1	64.13	66.71	64.25	66.71	0	0.01	0	137.46	85.23	85.43								
													70816	72575	56785	57199	60048	60503	50115	50431
2615.84	weir69.21	1	63.51	69.21	63.68	69.21	0	0	0	318.25	81.08	84.03								
2615.84	67.37	1	63.51	67.37	63.68	67.37	0	0.01	0	180.35	63.9	64.82								
2615.84	67.67	1	63.51	67.67	63.68	67.67	0	0.01	0	199.85	66.19	67.21								
2615.84	66.71 G-MW	1	63.51	66.71	63.68	66.71	0	0.01	0	139.84	58.86	59.57								
													74140	76828	58179	59029	61009	61937	53291	53968
1701.44	weir69.21	1	63.49	69.21	63.6	69.21	0	0	0	319.53	81.08	84.01								
1701.44	67.37	1	63.49	67.37	63.6	67.37	0	0.01	0	179.06	63.35	64.29								
1701.44	67.67	1	63.49	67.67	63.6	67.67	0	0.01	0	198.49	67.25	68.26								
1701.44	66.71 G-MW	1	63.49	66.71	63.6	66.71	0	0.01	0	139.12	57.7	58.47								
													43445	45112	37572	37934	39359	39800	33868	34155
1188.72	weir69.21	1	63.75	69.21	63.96	69.21	0	0	0	356.29	88.39	91.96								
1188.72	67.37	1	63.75	67.37	63.96	67.37	0	0.01	0	194.94	83.21	83.68								
1188.72	67.67	1	63.75	67.67	63.96	67.67	0	0	0	220.4	86.28	86.99								
1188.72	66.71 G-MW	1	63.75	66.71	63.96	66.71	0	0.01	0	142.94	74.41	74.76								
													62432	65676	56901	57739	61660	62731	52801	53324
457.2	weir69.21	1	63.53	69.21	63.69	69.21	0	0	0	372.65	82.3	87.6								
457.2	67.37	1	63.53	67.37	63.69	67.37	0	0	0	223.34	72.36	74.18								
457.2	67.67	1	63.53	67.67	63.69	67.67	0	0	0	245.9	82.3	84.52								
457.2	66.71 G-MW	1	63.53	66.71	63.69	66.71	0	0.01	0	176.38	69.95	71.03								
												TOTAL	Surface **4500551**	Seepage **4575754**	Surface **3298527**	Seepage **3323442**	Surface **3527018**	Seepage **3557227**	Surface **2846307**	Seepage **2862630**
												For consistency with G-MW calculations: 0 - 33km	**2869413**	**2920528**	**2120664**	**2138052**	**2242225**	**2262566**	**1865003**	**1877181**


Little Murray Weir & River - LesT Plan: 1) weir69.21 28/01/2010 2) 67.67 28/01/2010 3) 66.71 G-MW 28/01/2010
LittleMurrayRive LMR
Elevation (m)
74
72
70
68
66
64
62
0
10000
20000
30000
40000
50000
60000
Main Channel Distance (m)
Legend
WS PF 1 - weir69.21
EG PF 1 - weir69.21
WS PF 1 - 67.67
EG PF 1 - 67.67
WS PF 1 - 66.71 G-MW
EG PF 1 - 66.71 G-MW
Crit PF 1 - weir69.21
Crit PF 1 - 67.67
Crit PF 1 - 66.71 G-MW
Ground
LOB
ROB
Left Levee
Right Levee

Pre-intervention - Baseline Year Case

Werrill St Channels

No 8A/9 Chnl = 805 m

No 9/9 Chnls = 2,418 m

Losses - Base Case

			Leakage - Banks	*Seepage*	*Evap*	*Total*
Total	3,223	m	ML	ML	ML	ML
	3.22	km	137	52	45	234

Baseline Year Losses Werrill St (pre-intervention) = 234 ML

Backbone No 9 and No 10 Systems

No 9 System			*Leakage - Banks*	*Seepage*	*Evap*	*Total*
			ML	ML	ML	ML
Backbone	31.2	km	1325	501	440	2266
Backbone	7.0	km	297	112	98	507

Baseline Year Losses (pre-intervention) Backbone = 2,773 ML

Total Baseline Year No 9 & 10 Losses (pre-intervention) LTCE = 3,008 ML

No 9 Reach Through Swan Hill for Pipelining (Werrill to McCallum) - 2.5 km

Length	*Leakage - Banks*	*Seepage*	*Evap*	*Total*
km	ML	ML	ML	ML
2.5	106	40	35	182

Baseline Year Losses (pre-intervention) Swan Hill Reach = 182 ML

Post-intervention

Savings - Pipelining Werrill St

Remediation

$WS_{estimate} = WS_{bank\ leakage}^{1} + WS_{seepage}^{2} + WS_{evap}^{3}$

where:

$WS_{bank\ leakage}^{1} = ((L_{base} \times VL \times LTCE_{base}) + (L_{base} \times FL)) \times EF \times DF \times RL \times F(HLP)$

$WS_{seepage}^{2} = S_{base} \times EF \times DF \times RL \times F(HLP)$

$WS_{evap}^{3} = E_{base} \times EF \times DF \times RL$

Notes:

1 Bank leakage savings are calculated for all remediation techniques
2 Seepage savings are calculated for channel lining and pipelining remediation
3 Evaporation savings calculated for pipelining remediation only.

WSbank leakage ML		**WS seepage** ML		**WSevap** ML	
Lbase	115	Sbase	52	Ebase	45
VL	65%				
LTCEbase	1.29				
FL	35%				
EF	95%	EF	95%	EF	95%
DF	95%	DF	95%	DF	95%
RL	1	RL	1	RL	1
F(HLP)	1	F(HLP)	1		1
WS	124	WS	47	WS	41

WSestimate = 212 ML

Savings - Pipelining Reach thru' Swan Hill

WSbank leakage ML		**WS seepage** ML		**WSevap** ML	
Lbase	89	Sbase	40	Ebase	35
VL	65%				
LTCEbase	1.29				
FL	35%				
EF	95%	EF	95%	EF	95%
DF	95%	DF	95%	DF	95%
RL	1	RL	1	RL	1
F(HLP)	1	F(HLP)	1		1
WS	96	WS	36	WS	32

WSestimate = 164 ML

Additional Losses from Link Channel - 0.55 km long

Equivalent Baseline year Losses
Assume Torrumbarry loss rates
Length 0.55 km

Losses - Base Case

Leakage - Banks	*Seepage*	*Evap*	***Total***
ML	ML	ML	**ML**
20	9	8	**36**

WSbank leakage ML	
Lbase	20
VL	65%
LTCEbase	1.29
FL	35%
EF	90%
DF	80%
RL	1
F(HLP)	1
WS	**17**

WSestimate = - 19 ML

Estimated Net Water Savings = 356 ML

Pre-intervention - Baseline Year LTCE Losses

Backbone No 9 and No 10 Systems

			Leakage - Banks	*Seepage*	*Evap*	*Total*
			ML	ML	ML	ML
Backbone No 9	31.2	km	1325	501	440	2266
Backbone I	7.0	km	297	112	98	507

Baseline Year Losses (pre-intervention) Backbone = 2,773 ML

Werrill St Channels

No 8A/9 Chnl =	805	m
No 9/9 Chnls =	2,418	m

			Leakage - Banks	*Seepage*	*Evap*	*Total*
			ML	ML	ML	ML
Total	3,223	m				
	3.22	km	137	52	45	234

Baseline Year Losses Werrill St (pre-intervention) = 234 ML

Total Baseline Year Losses (pre-intervention) LTCE = 3,008 ML

Karinie-McCallum St Reach

			Leakage - Banks	*Seepage*	*Evap*	*Total*
			ML	ML	ML	ML
Length	1.9	km	81	31	27	138

Baseline Year Losses Werrill St (pre-intervention) LTCE = 138 ML

No 9 Reach Through Swan Hill for Rationalisation - 3.0 km

			Leakage - Banks	*Seepage*	*Evap*	*Total*
			ML	ML	ML	ML
Length	3	km	128	48	42	218

Baseline Year Losses (pre-intervention) Swan Hill Reach LTCE = 218 ML

Post-intervention Savings LTCE

Savings - Pipelining Werrill St

Remediation

$WS_{estimate} = WS_{bank\ leakage}^{1} + WS_{seepage}^{2} + WS_{evap}^{3}$

where:

$WS_{bank\ leakage}^{1} = ((L_{base} \times VL \times LTCE_{base}) + (L_{base} \times FL)) \times EF \times DF \times RL \times F(HLP)$

$WS_{seepage}^{2} = S_{base} \times EF \times DF \times RL \times F(HLP)$

$WS_{evap}^{3} = E_{base} \times EF \times DF \times RL$

Notes:

1 Bank leakage savings are calculated for all remediation techniques
2 Seepage savings are calculated for channel lining and pipelining remediation
3 Evaporation savings calculated for pipelining remediation only.

WSbank leakage	ML	**WS seepage**	ML	**WSevap**	ML
Lbase	115	Sbase	52	Ebase	45
VL	65%				
LTCEbase	1.29				
FL	35%				
EF	95%	EF	95%	EF	95%
DF	95%	DF	95%	DF	95%
RL	1	RL	1	RL	1
F(HLP)	1	F(HLP)	1		1
WS	124	WS	47	WS	41

WSestimate = 212 ML

Savings Karinie-McCallum St Pipelining

WSbank leakage	ML	**WS seepage**	ML	**WSevap**	ML
Lbase	68	Sbase	31	Ebase	27
VL	65%				
LTCEbase	1.29				
FL	35%				
EF	95%	EF	95%	EF	95%
DF	95%	DF	95%	DF	95%
RL	1	RL	1	RL	1
F(HLP)	1	F(HLP)	1		1
WS	73	WS	28	WS	24

WSestimate = 125 ML

Savings - Rationalising Reach thru' Swan Hill

Rationalisation

$WS_{estimate} = WS_{seepage} + WS_{bank\ leakage} + WS_{evap} + WS_{unauthorised}$

where:

$WS_{seepage} = S_{base} \times EF \times DF \times CL$

$WS_{bank\ leakage} = ((L_{base} \times FL \times EF \times DF) + (L_{base} \times VL \times EF \times DF \times LTCE_{base})) \times CL$

$WS_{evap} = E_{base} \times EF \times DF \times CL$

$WS_{unauthorised} = U_{base} \times EF \times DF \times LTCE_{base} \times CL$

WSbank leakage	ML	**WS seepage**	ML	**WSevap**	ML
Lbase	107	Sbase	48	Ebase	42
VL	65%				
LTCEbase	1.29				
FL	35%				
EF	100%	EF	100%	EF	100%
DF	100%	DF	100%	DF	100%
CL	1	CL	1	CL	1
WS	128	WS	48	WS	42

WSestimate = 218 ML

Additional Losses from Karinie St Pipeline - 3.12 km long

Equivalent Baseline year Losses

Assume Torrumbarry loss rates

Length 3.12 km

Losses - Base Case

Leakage - Banks	*Seepage*	*Evap*	***Total***	
ML	ML	ML	**ML**	
133	50	44	**227**	(LTCE)

WSbank leakage	ML	**WS seepage**	ML	**WSevap**	ML
Lbase	133	Sbase	50	Ebase	44
VL	65%				
LTCEbase	1.29				
FL	35%				
EF	95%	EF	95%	EF	95%
DF	95%	DF	95%	DF	95%
RL	1	RL	1	RL	1
F(HLP)	1	F(HLP)	1		1
WS	142	WS	45	WS	40

Total
227 ML

WSestimate = 0 ML

Estimated Net Water Savings = 555 ML

Pre-intervention - Baseline Year LTCE Losses

Backbone No 9 and No 10 Systems

			Leakage - Banks	*Seepage*	*Evap*	*Total*
			ML	ML	ML	ML
Backbone No 9	31.2	km	1325	501	440	2266
Backbone I	7.0	km	297	112	98	507

Baseline Year Losses (pre-intervention) Backbone = 2,773 ML

Werrill St Channels

No 8A/9 Chnl = 805 m

No 9/9 Chnls = 2,418 m

			Leakage - Banks	*Seepage*	*Evap*	*Total*
			ML	ML	ML	ML
Total	3,223	m				
	3.22	km	137	52	45	234

Baseline Year Losses Werrill St (pre-intervention) = 234 ML

Total Baseline Year Losses (pre-intervention) LTCE = 3,008 ML

Karinie-McCallum St Reach

			Leakage - Banks	*Seepage*	*Evap*	*Total*
			ML	ML	ML	ML
Length	1.9	km	81	31	27	138

Baseline Year Losses Werrill St (pre-intervention) = 138 ML

No 9 Reach Through Swan Hill for Rationalisation - 3.0 km

			Leakage - Banks	*Seepage*	*Evap*	*Total*
			ML	ML	ML	ML
Length	3	km	128	48	42	218

Baseline Year Losses (pre-intervention) Swan Hill Reach = 218 ML

Post-intervention Savings LTCE

Savings - Pipelining Werrill St

Remediation

$WS_{estimate} = WS_{bank\ leakage}{}^{1} + WS_{seepage}{}^{2} + WS_{evap}{}^{3}$

where:

$WS_{bank\ leakage}{}^{1} = ((L_{base} \times VL \times LTCE_{base}) + (L_{base} \times FL)) \times EF \times DF \times RL \times F(HLP)$

$WS_{seepage}{}^{2} = S_{base} \times EF \times DF \times RL \times F(HLP)$

$WS_{evap}{}^{3} = E_{base}\ X\ EF \times DF \times RL$

Notes:

1 Bank leakage savings are calculated for all remediation techniques
2 Seepage savings are calculated for channel lining and pipelining remediation
3 Evaporation savings calculated for pipelining remediation only.

WSbank leakage	ML	**WS seepage**	ML	**WSevap**	ML
Lbase	115	Sbase	52	Ebase	45
VL	65%				
LTCEbase	1.29				
FL	35%				
EF	95%	EF	95%	EF	95%
DF	95%	DF	95%	DF	95%
RL	1	RL	1	RL	1
F(HLP)	1	F(HLP)	1		1
WS	124	WS	47	WS	41

WSestimate = 212 ML

Savings Karinie-McCallum St Pipelining

WSbank leakage	ML	**WS seepage**	ML	**WSevap**	ML
Lbase	68	Sbase	31	Ebase	27
VL	65%				
LTCEbase	1.29				
FL	35%				
EF	95%	EF	95%	EF	95%
DF	95%	DF	95%	DF	95%
RL	1	RL	1	RL	1
F(HLP)	1	F(HLP)	1		1
WS	73	WS	28	WS	24

WSestimate = 125 ML

Savings - Rationalising Reach thru' Swan Hill

Rationalisation

$WS_{estimate} = WS_{seepage} + WS_{bank\ leakage} + WS_{evap} + WS_{unauthorised}$

where:

$WS_{seepage} = S_{base} \times EF \times DF \times CL$

$WS_{bank\ leakage} = ((L_{base} \times FL \times EF \times DF) + (L_{base} \times EF \times DF \times LTCE_{base})) \times CL$

$WS_{evap} = E_{base} \times EF \times DF \times CL$

$WS_{unauthorised} = U_{base} \times EF \times DF \times LTCE_{base} \times CL$

WSbank leakage ML		**WS seepage** ML		**WSevap** ML	
Lbase	107	Sbase	48	Ebase	42
VL	65%				
LTCEbase	1.29				
FL	35%				
EF	100%	EF	100%	EF	100%
DF	100%	DF	100%	DF	100%
CL	1	CL	1	CL	1
WS	128	WS	48	WS	42

WSestimate = 218 ML

Additional Losses from Karinie St Pipeline - 3.12 km long

Equivalent Baseline year Losses

Assume Torrumbarry loss rates

Length 3.12 km

Losses - Base Case

Leakage - Banks	*Seepage*	*Evap*	***Total***
ML	ML	ML	**ML**
133	50	44	**227**

WSbank leakage ML		**WS seepage** ML		**WSevap** ML	
Lbase	133	Sbase	50	Ebase	44
VL	65%				
LTCEbase	1.29				
FL	35%				
EF	95%	EF	95%	EF	95%
DF	95%	DF	95%	DF	95%
RL	1	RL	1	RL	1
F(HLP)	1	F(HLP)	1		1
WS	142	WS	45	WS	40

Total
227 ML

WSestimate = 0 ML

Additional Losses from Link Channel - 0.55 km long

Equivalent Baseline year Losses
Assume Torrumbarry loss rates
Length 0.55 km
Losses - Base Case

Leakage - Banks	*Seepage*	*Evap*	***Total***
ML	ML	ML	**ML**
20	9	8	**36**

WSbank leakage	ML
Lbase	20
VL	65%
LTCEbase	1.29
FL	35%
EF	90%
DF	80%
RL	1
F(HLP)	1
WS	17

WSestimate = - 19 ML

Estimated Net Water Savings = 535 ML

Reference DOCS# 2429066 v2 (Work by Les Thonpson on behalf of G-MW 2008)

Evaporation

At Current FSL

Estimated water surface area at current supply level of LMW pool	2,846,760	sq m	as reported
Length of weir pool (to minimum depth of 400 mm)	33,000	m	as reported
Check - Average surface width	86	m	looks reasonable - from drawings waterway width at weir would be at least 120 m wide.
Check - Assumed annual evaporation	1.5	m	Could be 1.8 m (BOM Average Annual Evap Map)
Check - Assumed annual rainfall	0.35	mm	OK
Reported evaporation	3,270	ML	
Check - Reported evaporation			
Total evap	4,270	ML	
Total rain	996		
Net Evap	3,274		Confirms - could be higher if 1.8 m of annual average evap adopted

At lower FSL

Estimated water surface area at current supply level of LMW pool	1,656,460	sq m	as reported
Length of weir pool (to minimum depth of 400 mm)	33,000	m	as reported
Check - Average surface width	50	m	looks reasonable
Check - Assumed annual evaporation	1.5	m	Could be 1.8 m (BOM Average Annual Evap Map)
Check - Assumed annual rainfall	0.35	mm	OK
Reported evaporation	3,270	ML	
Check - Reported evaporation			
Total evap	2,485	ML	
Total rain	580		
Net Evap	1,905		Confirms - could be higher if 1.8 m of annual average evap adopted
Check - Net water saving	**1,369**	**ML**	**Confirms reported 1370 ML**

Seepage

Loss current	769	ML
Loss lowered	447	ML
Saving	321	ML

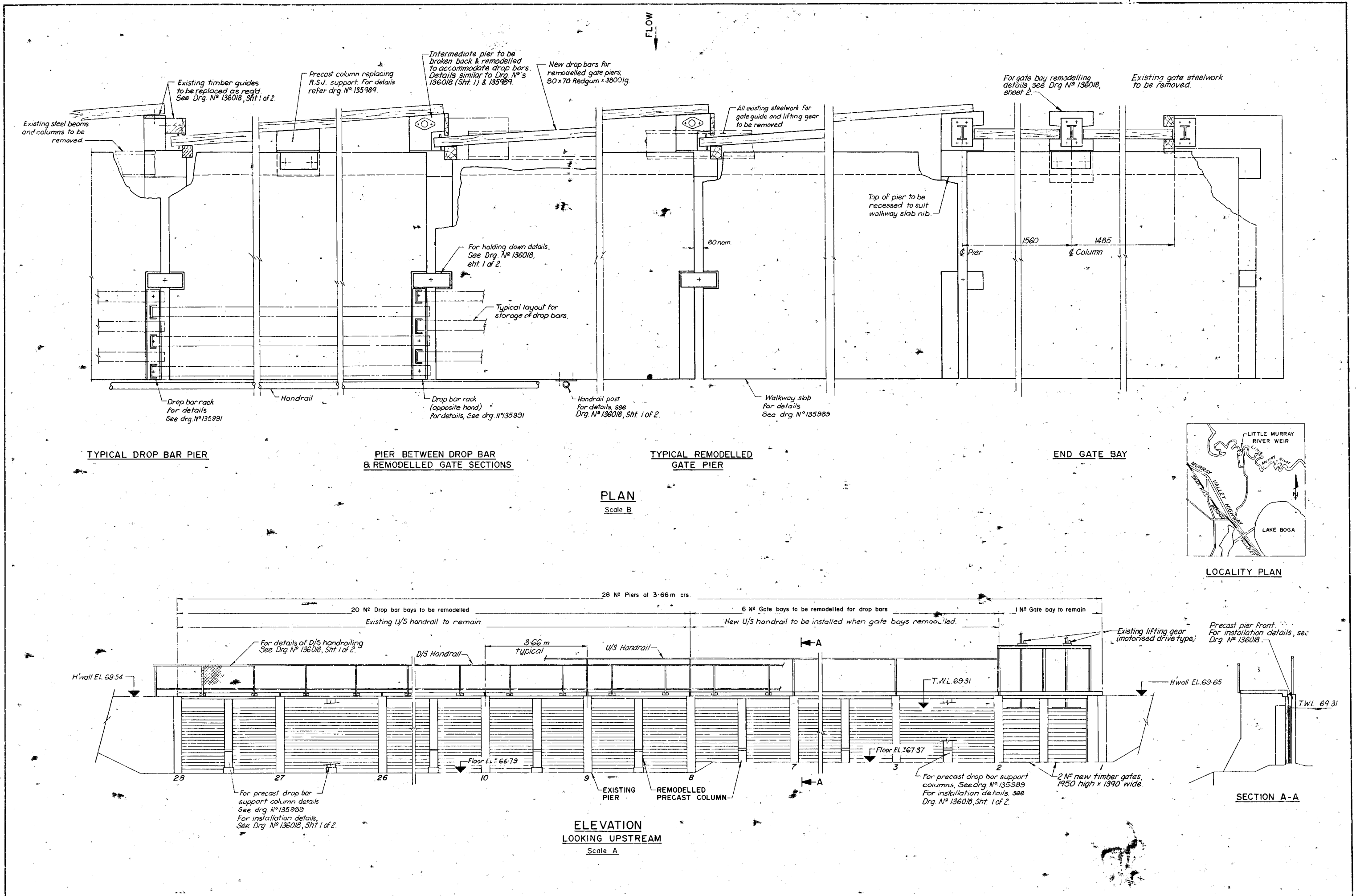
Reported assumptions	1 mm/d for 270 days over 50 m wide bed 33 km long		
Check - Reported saving	**445**	**ML**	**OK**

Alternative estimate			
Assume surface area = wetted area			
Area difference	1,190,300	sq m	
Seepage rate	1	mm/d	
No days	270		
Estimated saving	321	ML	**Given that the assumed seepage of 1 mm/d is probably conservative, the reported estimate is considered reasonable for the information available.**

Estimated Total Water Saving **1,814 ML**

C

Appendix C Little Murray Weir Drawing



FLOW
Existing timber guides to be replaced as req'd. See Drg. Nº 136018, Sht 1 of 2.
Existing steel beams and columns to be removed.
Precast column replacing R.S.J. support. For details refer drg. Nº 135989.
Intermediate pier to be broken back & remodelled to accommodate drop bars. Details similar to Drg. Nº's 136018 (Sht. 1) & 135989.
New drop bars for remodelled gate piers. 90 x 70 Redgum x 3800 lg.
All existing steelwork for gate guide and lifting gear to be removed
For gate bay remodelling details, see Drg Nº 136018, sheet 2.
Existing gate steelwork to be removed.
Top of pier to be recessed to suit walkway slab nib.
60 nom.
1560
1485
℄ Pier
℄ Column
For holding down details, See Drg. Nº 136018, sht. 1 of 2.
Typical layout for storage of drop bars.
Drop bar rack For details See drg. Nº 135991
Handrail
Drop bar rack (opposite hand) For details, See drg. Nº 135991
Handrail post for details, see Drg. Nº 136018, Sht. 1 of 2.
Walkway slab For details See drg. Nº 135989
TYPICAL DROP BAR PIER
PIER BETWEEN DROP BAR & REMODELLED GATE SECTIONS
TYPICAL REMODELLED GATE PIER
END GATE BAY
PLAN
Scale B
LITTLE MURRAY RIVER WEIR
MURRAY VALLEY HIGHWAY
LAKE BOGA
N
LOCALITY PLAN
28 Nº Piers at 3·66 m crs.
20 Nº Drop bar bays to be remodelled
6 Nº Gate bays to be remodelled for drop bars
1 Nº Gate bay to remain
Existing U/S handrail to remain.
New U/S handrail to be installed when gate bays remodelled.
For details of D/S handrailing See Drg Nº 136018, Sht 1 of 2.
D/S Handrail
3·66 m typical
U/S Handrail
A
Existing lifting gear (motorised drive type)
Precast pier front. For installation details, see Drg. Nº 136018.
H'wall EL 69·54
T.W.L. 69·31
H'wall EL 69·65
TWL 69·31
Floor EL 66·79
Floor EL 67·37
28
27
26
10
9
8
7
3
2
1
For precast drop bar support column details See drg. Nº 135989 For installation details, See Drg Nº 136018, Sht 1 of 2.
EXISTING PIER
REMODELLED PRECAST COLUMN
For precast drop bar support columns, See drg Nº 135989 For installation details see Drg. Nº 136018, Sht. 1 of 2.
2 Nº new timber gates, 1950 high x 1390 wide.
ELEVATION
LOOKING UPSTREAM
Scale A
SECTION A-A

REFERENCES DRG Nº	TITLE
136018	Installation Details, sheets 1&2
136529	Precast pier Front
135989	Precast column & walkway slab
135991	Drop bar rack details
136019	Gate pier & column - Precast concrete details

REVISIONS Nº	DATE	DESCRIPTION	APPROVED

SCALE A. 1000 0 1000 2000 3000 4000 5000 mm

SCALE B. 100 0 200 400 600 800 1000 mm

MICROFILM CATEGORY — DESIGNED — CHECKED — DESIGNING ENGINEER — CHIEF ENG. WATER MANAGEMENT

DRAWN P.E. Forge — CHECKED — SEN. DES. ENG. RWS DESIGNS — DIRECTOR R.W.S.

MICROFILM OPERATOR — PRINCIPAL DESIGN DRAUGHTSMAN — DIVISIONAL ENGINEER — COMMISSIONER

STATE RIVERS AND WATER SUPPLY COMMISSION

LITTLE MURRAY RIVER WEIR

STRUCTURE REMODELLING

GENERAL ARRANGEMENT

CORR 83/2220
REF. 61/3477/62/1528

DRG Nº 135990

SHEET SIZE - B1

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