Repair/Replacement of Concrete Lined Irrigation Channels

Case Study

Pipeline Replacement Methods

Burdekin River Irrigation Area
State Water Projects, Queensland

1. General

1.1 Background

The Clare Section within the Burdekin River Irrigation Area consists of some 3000 hectares of irrigated land centred around the town of Clare in North Queensland. Clare is located on the left bank of the Burdekin River approximately 50km upstream from the river mouth. The system is owned and operated by the Department of Natural Resources - State Water Projects.

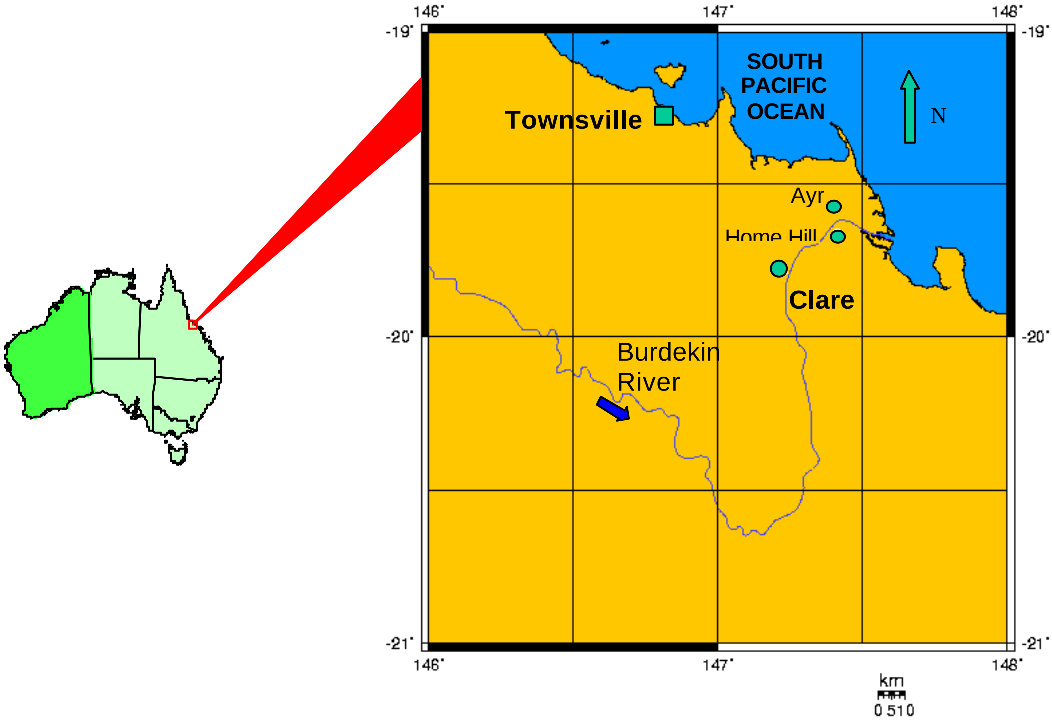

Figure 1 – Clare Locality Plan

The system comprises of two river pump stations which supply a concrete lined main channel. Numerous concrete lined laterals and pipeline laterals are supplied from the main channel. There are approximately 36 kilometres of concrete lined channels in the system out of a total of 56 kilometres of channels (including pipelines). Of the 36 kilometres of concrete lined channels in the system approximately 18 kilometres are lateral channels. The concrete lined laterals range in bed widths from 300mm to 900 mm. Depths of flow in the laterals range from approximately 700mm to 900mm. Side slopes vary from 1H:1V for the smaller laterals to 1.5H:1V for the larger laterals.

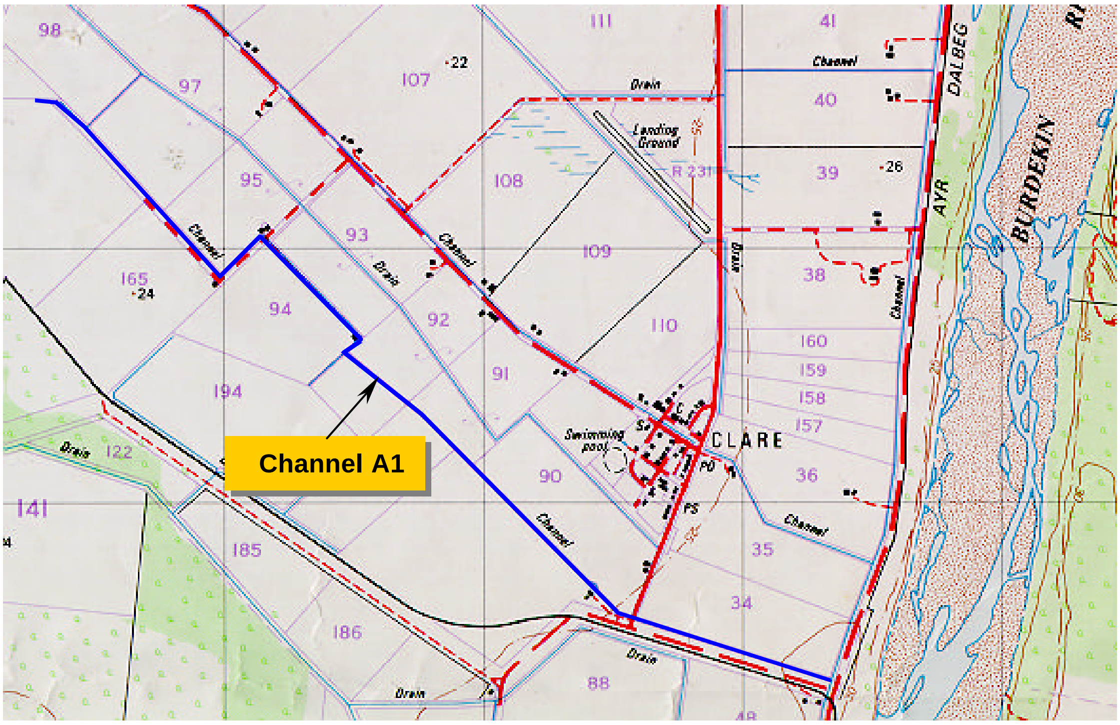

Figure 2 – Channel A1 Locality Plan

The predominant crop grown within the Clare Section is sugar cane with some rock melons(cantaloupe) and some vegetables (very limited). All of the sugar cane is flood irrigated.

Whilst most of the concrete lined laterals within the Clare Section have been earmarked for future replacement, the initial lateral replacement will only involve Channel A1; a 4.2km long lateral. Channel A1 serves an area of 310 hectares.

At the time of writing, the pipe supply contract for the replacement of Channel A1 has already been let with installation by dayworks crews to commence in June 1999. The total cost of replacing Channel A1 is approximately $1.2M. This case study focuses on issues particular to Channel A1.

1.2 Site Conditions

The soils of Channel A1 as of the Clare Section in general, consist of river levee soils. These river levee soils consist of gradational and uniform non-cracking soils with deep loamy or sandy topsoil over clayey or loamy subsoils. These soils have low to moderate water holding capacities and are well drained. The low water holding capacity has led to the use of concrete lining for the channels. Waterlogging is generally not a problem due to the well drained nature of the soil.

The slope of the land served by Channel A1 varies from 1 in 300 at the start of the channel as the land falls away from the river levee to approximately 1 in 3000 at the end of the channel. The total fall over the length of Channel A1 is approximately five metres.

Channel A1 consists of 4.2 kilometres of open channel with the bottom 0.8 kilometres being a clay lined earth channel. The original Channel A1 served a larger area with the earth channel section extending approximately a further kilometre. This area is now served from a different channel with Channel A1 being shortened to its present length by blocking off the earth channel at the end. The decommissioned section of earth channel has not been backfilled (ie left open).

1.3 Extent of Problem

Channel A1 was constructed initially constructed in the late 1940's as part of a soldier settlement scheme growing principally irrigated tobacco. It was constructed of 50 mm thick unreinforced concrete cast as a series of slabs butting up against one another with no construction joint detail. The age of the concrete lining combined with the settlement between joints of the lining has led to sections of extensive cracking. In the past, sections of Channel A1 have been completely relined in concrete as recently as the 1980's.

A significant portion of the 3.4 kilometres of concrete lined channel has been constructed with the top section of lining being cast against fill as part of the channel banks. This fill material has settled over time, exacerbating the cracking problem. Infiltration of channel water beneath the lining has formed cavities which have led to areas of bank collapse.

Figure 3 – Section of Concrete Lined Channel which slumped relative to adjacent section (note the detachment of capping from top of lining in right of photograph)

A further problem with Channel A1 is the inability to obtain the design flowrate for some dethridge wheel meter outlets. The infiltration of water through the concrete lining at the dethridge wheel has led to the slumping of the concrete work associated with the dethridge wheel emplacement. This has altered the sill level and consequently reduced the flowrate possible through the dethridge wheel (as well as inaccurate flow metering). This has resulted in the irrigator watering over longer periods which in turn has led to the delivery of water down the channel for longer periods resulting in increased infiltration and evaporation losses. The response to this problem has been to run some bays of Channel A1 full (ie with no freeboard). This has led on occasions to water overflowing over channel banks.

This water has then undermined the lining or channel structures In the past, sections of channel have had a concrete capping added to try to increase the freeboard, but this concrete has tended to lift off the existing concrete lining leading to further infiltration and consequent undermining.

Figure 4 – Undermining of a Check Structure
(resulting in bypassing of flow)

The extent of cracking, undermining and areas of slumping of the concrete lining observed through visual inspection together with the poor distribution efficiency for the whole Clare Section of approximately 70% led to the decision being made to replace Channel A1.

2. Adopted Solution

2.1 Selection of Replacement Option

A number of replacement options were considered and costed. These options consisted of:-

- Replacing existing concrete lining with new concrete lining (75 mm reinforced concrete slabs).
- Replacing existing concrete lining with plastic lining (2mm unreinforced HDPE liner).
- Replacing existing concrete lining with a gravity pipeline (MDPE pipeline).
- Replacing existing concrete lining with a combined gravity and pumped pipeline (MDPE pipeline).

In comparing options it was recognised that not all options were equal and it was not an “apples versus apples” comparison. Issues considered in the evaluation of the options included:-

- Desire to offer all irrigators an improved level of service (ie increased operating head) as an inducement for selling additional water allocation from the channel.
- Automation of channel operation.
- Free access to portions of land cut by the open channel. Some lots have been cut into separate portions by the open channel. This has meant the need for construction of culverts to allow for vehicle access across the open channel.
- Accuracy of water metering.
- Continuity of supply to irrigators during construction.

The age of many of the associated concrete structures (ie check structures, overflow structures) were approaching fifty years and this combined with the undermining of many structures (as identified in section 1.3) meant that these structures required replacement. Thus the replacement options which involved maintaining Channel A1 as an open channel system included the replacement of all associated concrete structures together with the concrete lining. Ten concrete check structures would need to be replaced for the open channel options.

The condition of the existing concrete lining for the first 2.4 kilometres of Channel A1 was such that it was not advisable to lay the 2mm thick HDPE liner directly over the existing lining. This section would require the existing concrete lining to be removed, the channel profile re-formed and the foundation suitably stabilised prior to laying of HDPE liner. This represented a significant additional cost for the HDPE liner.

Due to the high number of check structures and access culverts, the HDPE liner could not be installed in large continuous lengths but rather would have to be installed in a series of smaller lengths between the structures. The fixing arrangement called for securing of the ends via stainless steel clamping strips bolted to the concrete work. The existing concrete lining (50 mm) was too thin for bolting directly into so it would be necessary to cast additional concrete to which the clamping plates could be bolted. The large number of such end fixings increased the cost for the HDPE liner.

The pipeline options considered replacing the entire 4.2 kilometre length of Channel A1 not just the concrete lined section. It was determined that the savings gained in not continuing the pipeline for the last 0.8 kilometres were not significant enough compared to the benefit of providing all irrigators along Channel A1 with an improved level of service (in terms of channel operation and operating head).

Due to the increased head available from the pipeline options, the existing dethridge wheel meters were able to be replaced with more accurate and tamper proof propeller actuated (PA) meters.

After the comparison of all replacement options, the gravity MDPE pipeline was selected as the replacement option for Channel A1. It had one of the lowest costs assessed over a 50 year life cycle of all options. It was judged to offer the best level of service of all options, improve water distribution efficiency and consequently reduce power costs of the river pump station which pumps against a static head of approximately twenty metres. The cost of the combined gravity and re-lift pumped option was found to be more expensive than the gravity pipeline option and introduced more operational complexity and additional O&M costs.

2.2 Adopted Replacement Option

The adopted replacement pipeline consists of a PE80B (MDPE) PN3.2 pipeline. The capacity of the pipeline is 410 l/s at the head of the channel. The pipeline consists of 3.25 kilometres of 710mm OD pipe and 0.95 kilometres of 500mm OD pipe. The minimum cover is 0.6m with the cover over the pipeline varying from 0.6m to 1.4m.

The pipeline has been designed for vehicle access across the pipeline. Class 3.2 (ie 32m) pipe installed at minimum 0.6m cover was adequate for traffic loadings up to T44 loading.

The replacement pipeline is to be installed within the existing channel reserve. The existing channel reserve is only ten metres wide in places and has a number of 90^o bends. To serve the existing area via a different alignment was not possible with land resumption out of the question. The value of cane land is high and the fact that many lots are already divided into small portions (some as small as 10 hectares) by drain and channel reserves would mean that further dissection by a new reserve would result in portion sizes that would be unworkable.

It is not possible to construct the entire pipeline offline due to the narrowness of the reserve. The existing open channel is on average 3.2m wide and centrally located within the reserve. The required trench width for a 710mm OD pipe is 1.31m. Thus there is insufficient room to place the trench on one side of the channel once allowance is made for construction equipment, welding of the pipe string, and spoil from excavation. As a consequence it is necessary to install some sections of the pipeline along the same centreline as the concrete lined channel. Due to the uncertainties of foundation conditions beneath the existing lining, the existing concrete lining will be completely removed prior to installation of the pipeline. The remains of the concrete lining excavated from the channel will be disposed of by filling in the decommissioned section of earth channel that remains at the end of the channel.

Where room permits the replacement pipeline will be constructed offline in a separate trench beside the existing channel. The final pipeline alignment will see the first 0.85km and bottom 1.3km of the pipeline being constructed offline in a trench beside the existing channel with the middle 2.1km being constructed along the same centreline as the existing concrete lined channel.

The inability to construct the entire pipeline offline means that construction will need to occur during the channel shutdown period. In the Clare Section as with the rest of the Burdekin River Irrigation Area, channels are shutdown in June of every year to allow for channel maintenance (ie channel scraping, weed control etc). During this period it is possible to shutdown the channels for periods of two to three weeks at a time. The proposed construction program will see the works completed over a ten week period. Two dayworks crews will be utilised due to the tight construction period and the need to maintain channel operation during construction. One crew will be involved solely in installing the pipeline with the other crew following behind constructing any structures that are required (ie concrete works, meter offtakes etc).

Construction of the pipeline will be broken into sections. Work on online sections will be completed in blocks of three weeks separated by blocks of two weeks where the water will be turned on down the channels to allow for watering. At the completion of each online section, a temporary end connection to the pipeline would be made.

A control valve attached to this end connection would allow water to be released down the already completed section of pipeline and back into the remaining concrete lined channel. Dayworks crews would then move along the channel to construct the offline sections during these watering periods. This chequerboard pattern of construction keeps the existing channel operational during construction and ensures that the dayworks crews will be kept continually active with no stand-down periods.

3. Conclusions

The replacement of concrete lined channels with pipelines is cost effective where the existing lining has extensive cracking and damage which can not be readily and cheaply repaired by other means. Pipeline replacement also is worthy of consideration where other issues such as lack of operating head at meter offtakes and high pumping costs are present. With the pipeline not yet built no figures are available on the improvement to water distribution efficiency attributable to the new system. It is expected that with a completely integral pipe system as offered by a butt welded polyethylene pipeline that water distribution savings will be significant.

The programming of pipeline replacement works can be awkward where the pipeline can not be constructed offline due to narrow channel reserves, lack of an alternative alignment or shutdown periods being limited to short durations due to irrigation demands.

4. References

Department of Primary Industries, Water Resources (1996), *Annual Statistics 1994-95*, Brisbane

Searle, R. (1994), Unpublished Report on State of Clare Section, Department of Primary Industries, Water Resources, Clare

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Further Information

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