DAM BUSTERS! – THE DECOMMISSIONING OF THE HISTORIC RESERVOIR CREEK DAM

M. Roberts, MWH NZ Ltd.

ABSTRACT

The Reservoir Creek Dam in the Tasman district is the site of a historic dam which was inaccessible to the public, at risk of structural failure and a barrier to fish passage.

The dam was originally built in 1890 as a water supply reservoir. However, it has not supplied water since the mid-seventies and from late 2000 there have been concerns about its stability and the risk of failure. In December 2011, a severe rain event in the region caused two slips at the dam blocking the spillway.

The Tasman District Council decided to decommission the dam and engaged MWH NZ Ltd (MWH) in the planning, design and construction monitoring for the scheme. Throughout the planning phase, a wide range of options were considered from pipe thrusting to complete removal of the dam.

The final design was a new concrete spillway through the existing dam. To reduce the hydrostatic pressure on the dam, the new inlet invert was set 3 m lower than the existing.

The decommissioning provided the opportunity to reshape the dam, and it is now an integrated community asset, that is safe, has improved ecological features whilst also retaining its historical value.

This paper will discuss the challenges, solutions and outcomes of this unique project.

KEYWORDS

Decommissioning, reservoir, historic, spillway, water supply.

1 INTRODUCTION

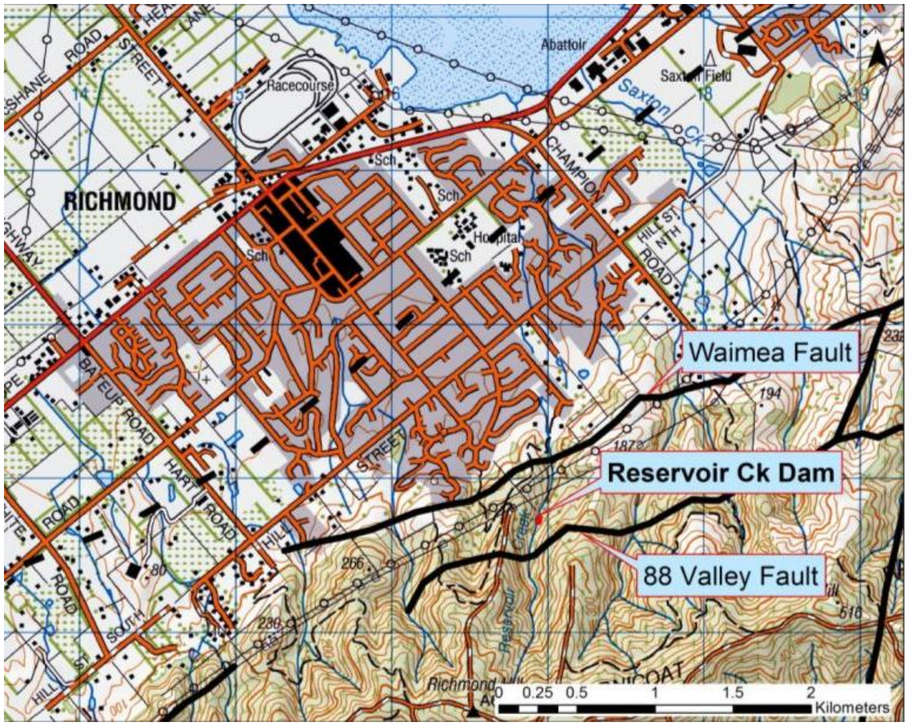
Reservoir Creek Dam is a puddled clay earth dam built in 1889 to supply water to the township of Richmond in the Tasman district, and is recognised as a historic site by the Historic Places Trust (HPT). Shortly after construction was completed, the dam began to leak and remedial work was carried out in 1890 and again in 1917.

The dam was finally superseded as Richmond’s primary water source in 1940 and was out of service by 1970 when some further remedial work was carried out. Since then, the dam has effectively remained unmaintained. Following a risk assessment in the 1990s, Tasman District Council started to plan for its decommissioning. In 2011, the dam was severely damaged due to a flood event and the urgency to decommission the dam increased. The dam was finally decommissioned in 2014, the site is now a safe and accessible area for the community to visit particularly as it is integrated into the region’s walking network.

2 SITE DESCRIPTION

Located in the foothills behind Richmond (Pop. circa 13,000), the reservoir is fed from and drains into Reservoir Creek (Figure 1). The catchment is small and steep and located over two active fault lines, the Waimea and 88 Valley faults. The geology of the area around the dam is a fractured schist material and layers of weathered rock and clay, a dense layer of fossilised shells can be found at the toe of the dam. The reservoir is located approximately 700 m upstream from the nearest residential area through a mixture of scrub and maintained reserve areas.

Figure 1: Location plan showing dam's location relative to Richmond and two fault lines.



The dam was approximately 12m high from the toe to the crest and the crest was 30 m long from bank to bank and 13 m wide. A concrete spillway ran down the true left hand side of the dam against the hillside and an emergency high level spillway had been recently cut into the true right side of the crest. Access to the dam was through a private farm track.

Photograph 1: The reservoir and dam crest looking toward the north, taken in 2013 before decommissioning. Note the existing concrete spillway on the left and the emergency spillway on the right.

3 HISTORY

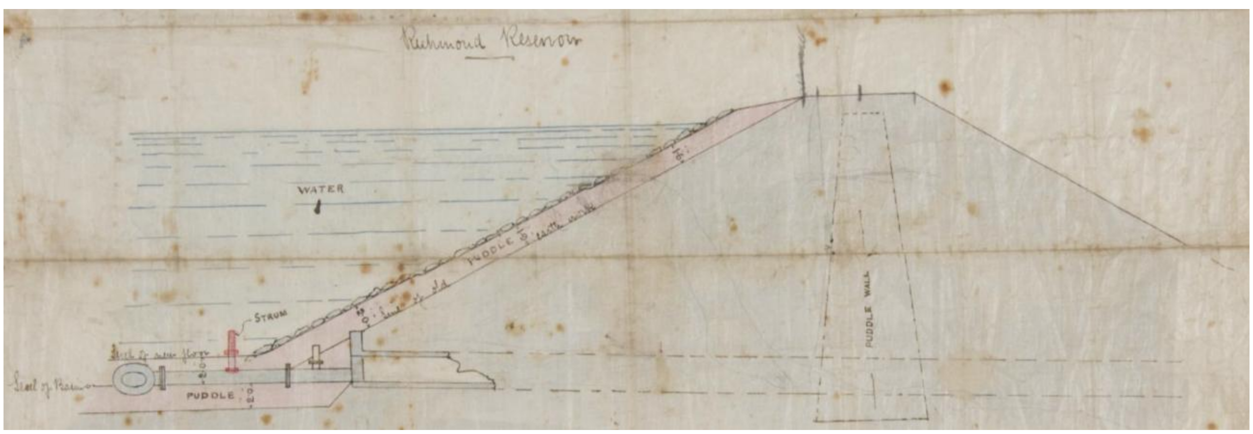
As Richmond developed in the 1800s, there was an increasing demand for water. This was especially true for the Volunteer Fire Brigade who had to rely solely on wells, ditches and tanks. After five years of lobbying for a reservoir, a plan put to residents in September 1885 by a local resident, Mr W. Lightfoot, at a public meeting was "enthusiastically received".

Shortly after, 120 tons of pipes and ironwork was ordered from Scotland and arrived on the S.S. Glenora in 1887 and construction began that year at a cost of £2,300 ($461,550 NZD in 2014).

The method of construction of earth dams at the time was to build a puddle clay core by placing cut clay in layers and puddling it in place often with the feet of man, beast and spades. The sides of the core were then supported with more heterogeneous material.

From shortly after the time it was first constructed, the dam leaked and from historical records it appears the dam has leaked in some capacity ever since (Figure 2). The dam was repaired several times and the crest height extended. The original dam was constructed to contain a 12 foot head of water with an estimated storage of 1,200,000 gallons. Later, the spillway was raised to 20 feet to enhance water storage. The last repairs to the dam were carried out around 1970 when a deep trench was excavated and backfilled with clay (2006, Tasman District Council).

Figure 2: Jickell's plan dated 18/11/1925 appears to show puddle and boulder additions to inner face of embankment and basin, requiring relocation of "strum" or strainer.



When the Roding River Scheme started to provide water to Richmond in the 1940s, the reservoir was no longer the primary water source for the township, although it likely remained in service until the 1970s when additional sources of groundwater were established.

Throughout the 1990s several pleas from within the Tasman District Council were made to either repair the dam, maintain and utilise it, or decommission it as it was recognised as posing a significant risk to downstream residents, particularly if a major rainfall event caused further deterioration.

Tasman District Council engaged MWH in 2004 to undertake a new risk assessment and it was recommended that the dam be decommissioned. (Foster D, 2010).

Following a high rainfall event in June 2010, an assessment by MWH identified a sink hole (Photograph 2, left), in the crest of the dam, the Council together with MWH and the maintenance Contractor, Downer, lowered the water level in the dam and removed the old high level outlet pipe (Photograph 2, right) which was adjacent to the spillway. The area was then also sealed with selected backfill and a newly formed spillway section added (Photograph 3).

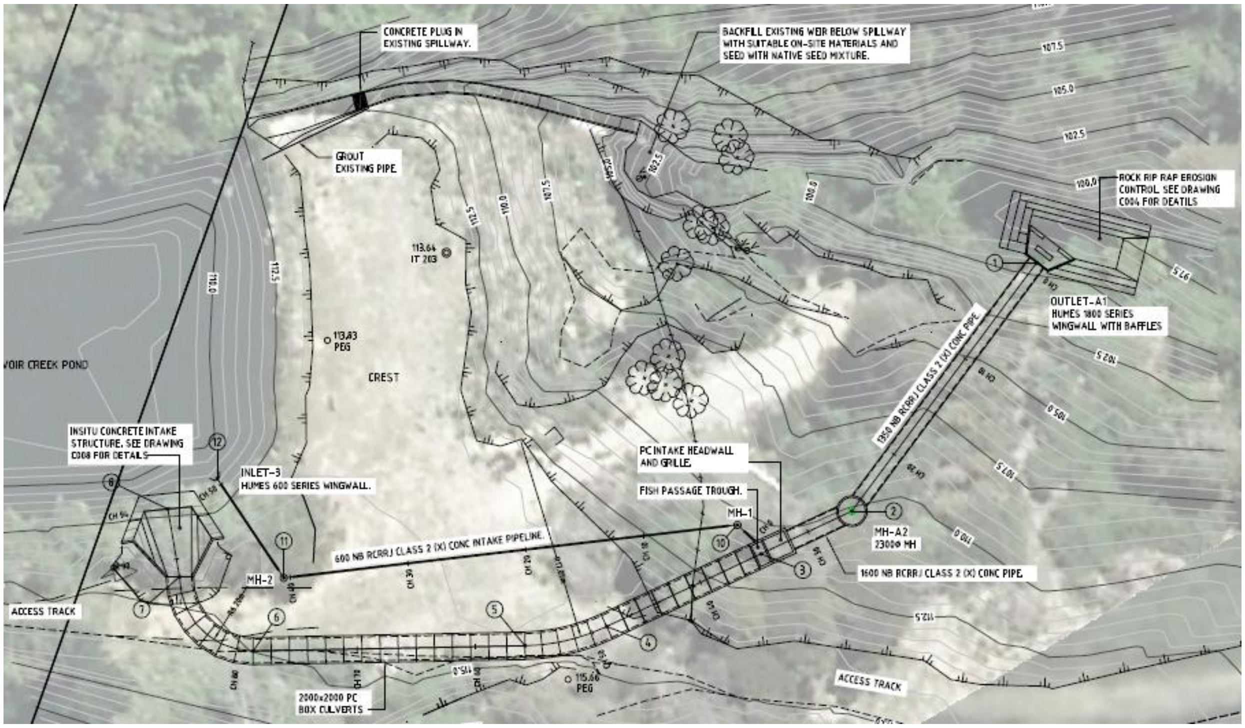
Photograph 2: (left) the sink hole discovered in 2010, (right) the high level outlet pipe.

Photograph 3: Construction of the new low level spillway section.

Following the remedial work, Tasman District Council further engaged MWH to plan and design the decommissioning of the dam.

In late 2010 a design was completed, consented and HPT Authority granted. The design was for the installation of a new spillway on true right bank with high level and low level outlets (Figure 3). Due to delays with the negotiations for the purchase of the land around the dam this work had yet to start when a severe rainstorm event hit the top of the South Island in December 2011.

Figure 3: Site layout plan of the design completed in 2010 with high and low level spillways.



4 DECEMBER 2011 STORM

The December 2011 storm event delivered 280 mm of rain in 48 hours to the Richmond township, with other areas of the district receiving over 500 mm. As a result, the dam suffered several slips on the western slope above the dam. The debris from the slips blocked the spillway and the overtopping water scoured the front face. Following the event, a second emergency spillway was excavated through the east side of the dam crest to accommodate flows for any future high rainfall event (Figure 4 and Photograph 4).

Figure 4: Aerial photo showing the slips and scours which occurred during the 2011 high rainfall event.

Photograph 4: Toe of the dam - taken during the December 2011 event.

The extent of the damage sustained during this storm further compromised the integrity of the structure as a whole and forced a re-evaluation of the mitigation works that had been proposed and approved. Various remedial options were considered.

5 DESIGN

Following a re-evaluation after the December 2011event it became apparent that the initial design from 2010 was conservative and potentially costly. The 2010 design was based on the dam design philosophy that a spillway should not be built on fill material; however, Peter Foster (Dam Engineering National Specialist, MWH) had experience with construction spillways on fill material with success.

The 2010 design also required a box culvert for access to the dam face, had a relatively steep culvert pipe, retained some residual risk and would require continuing maintenance costs with buried structures and potential blockages.

5.1 OPTIONS ASSESSMENT

MWH assessed options on cost effectiveness, future maintenance costs, constructability, residual risk, retention of historic values and fish passage.

The dam had long been viewed as a barrier to fish migrating inland as the spillway outlet was higher than the creek bed and it lacked fish friendly features such as fish ladders.

The design process evaluated multiple options including re-assessing the option already approved and consented.

5.2 DESIGN OPTIONS

A. Remove the dam completely.
B. Install a new spillway on the true right bank with high level and low level outlets. As per the previously approved design.
C. Excavate a large breach through the dam on the true left bank. Lower water level by some 3m and use Reno mattress scour protection for the spillway.
D. Excavate a large open breach through dam at the middle of the dam and install a box culvert and backfill.
E. Excavate a large open breach through the middle of the dam install an open box culvert.
F. Insert a pipe through the dam to lower the dam level and leave the dam intact.

The evaluation criteria were each given a weighting and each option then scored against that criteria in order to determine the ranking order of the options.

Table 1: Design option evaluation results.

	OPTION	A		B		C		D		E		F	
High number is BETTER - score out of 10		Complete removal		Spillway on True Right		Spillway on True Left		Spillway in centre - box culvert		Spillway in centre open culvert		Thrust Pipe	
	Weight	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Cost	0.3	*3*	0.9	*3*	0.9	*5*	1.5	*6*	1.8	*6*	1.8	*2*	0.6
Level of residual risk to council	0.3	*10*	3	*8*	2.4	*3*	0.9	*5*	1.5	*9*	2.7	*4*	1.2
Retention of Historical values	0.2	*1*	0.2	*8*	1.6	*7*	1.4	*5*	1	*4*	0.8	*7*	1.4
Aquatic values	0.2	*8*	1.6	*4*	0.8	*4*	0.8	*4*	0.8	*7*	1.4	*4*	0.8
		22	**5.7**	***23***	**5.7**	***19***	**4.6**	***20***	**5.1**	***26***	**6.7**	***17***	**4**
Ranking			2=		2=		5		4		1		6
Based on the rankings Option E Spillway in center with an open culvert is the prefered option													

Although there was risk that the HPT would not accept option E as it was the second most destructive option considered, HPT agreed and authority for the design was granted as removing the residual risk to the community was the key driver of the work and Option E provided the best solution for reducing that risk.

5.3 DESIGN PARAMETERS

A design flow of 13.6 m^3/s was calculated for an event with an annual recurrence interval of 100 years. Based on a 2m x 2m concrete channel at a grade of 1:5 with 100 mm x 100 mm baffles for fish passage and energy dissipation a design velocity of 4 m/s was calculated. Without the baffles the velocity would be 14 m/s.

5.4 RESULTING DESIGN

The resulting design was a spillway with a total length 50 m; including the inlet and energy dissipation structure (Figures 5 and 6). The energy dissipation structure is a wider section 4 m wide by x 2 m high x 12 m long with concrete baffles 250 mm wide x 350 mm high x 1140 mm long. At the outlet, a 5 m long riprap lined stilling basin was design to remove any residual energy in the flow before it continues down the creek bed.

The inlet structure was also designed to be a 4 m wide section at the inlet and the design incorporated a steel debris screen to protect the fish baffles and a bridge to provide access to the west side of the spillway and to allow maintenance of the screen.

The existing spillway was to be utilised as a cut-off drain to collect water running off the steep western hillside and run this via an extension to the existing spillway into the new spillway.

Figure 5: Layout plan of the decommissioning design.

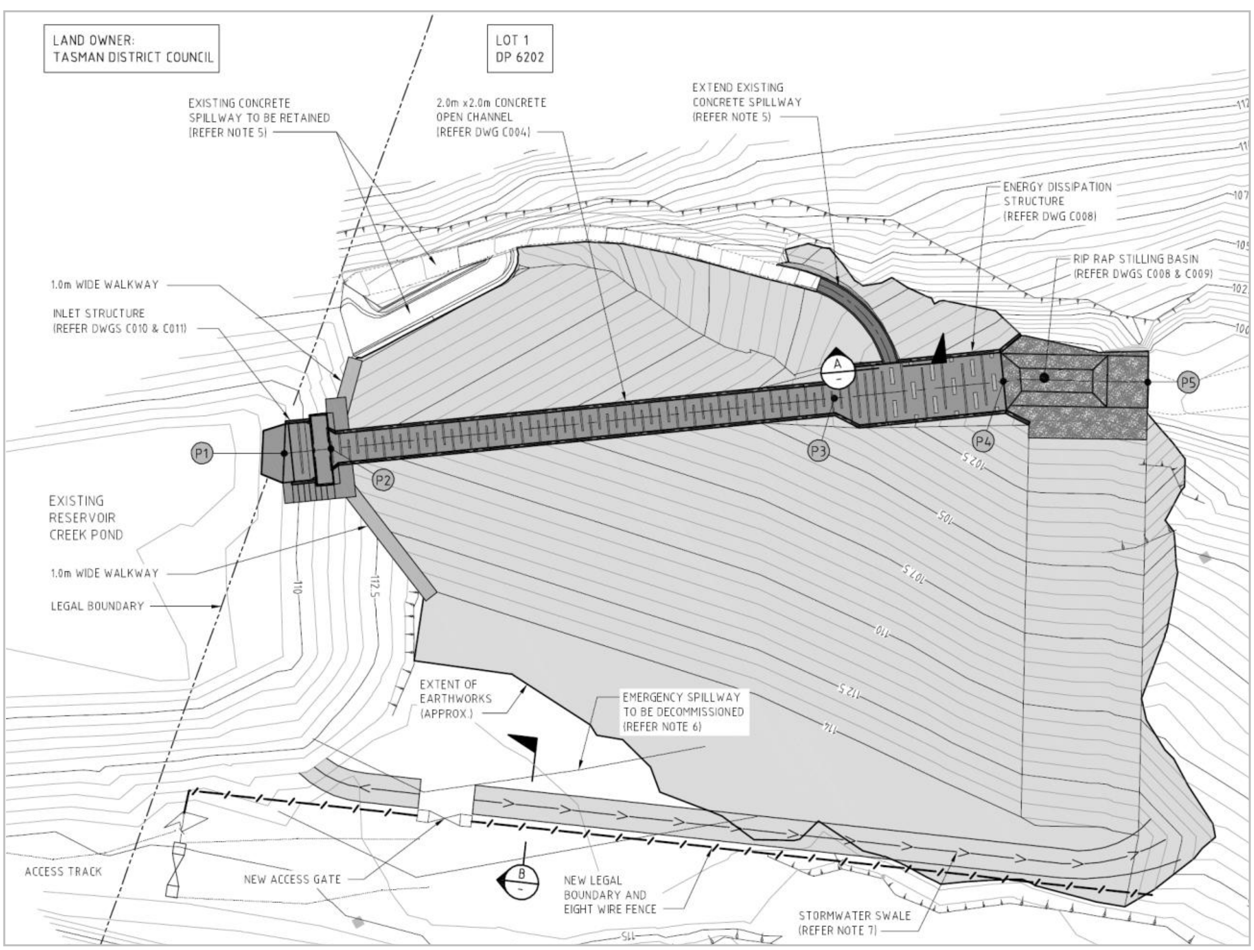
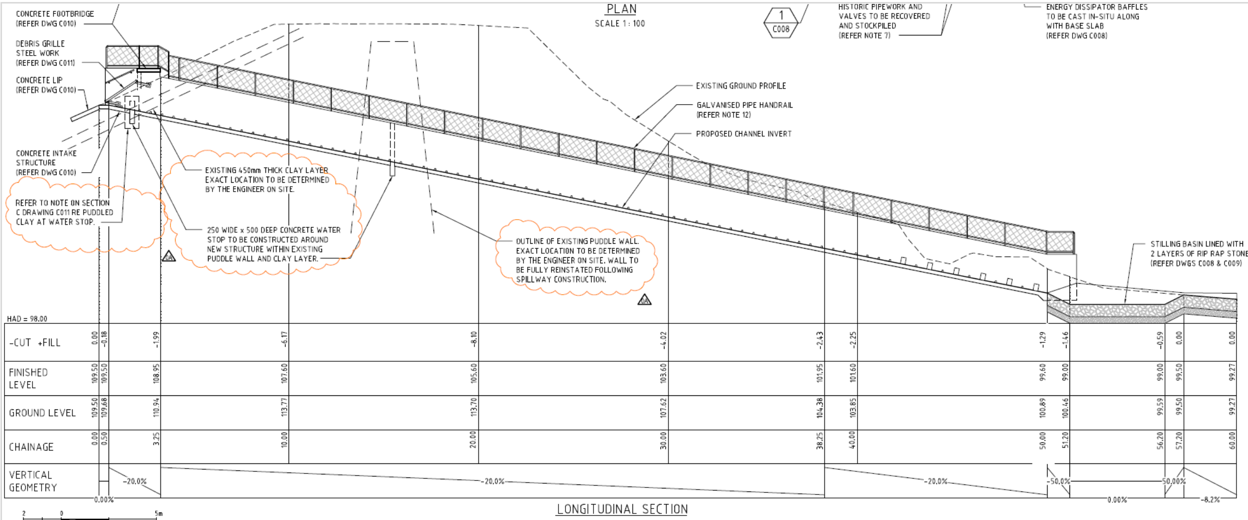


Figure 6: Long section of the decommissioning design.



6 LAND PURCHASE

Several land boundaries run through the dam structure. The reservoir is owned by Tasman District Council, however, the creek downstream of the dam and the dam access track is located on private property with an unformed paper road bisecting the site across the dam.

Negotiations for the land purchase started in 2010 and the final sale and purchase agreement was signed in 2012. The final agreement included purchase of the land surrounding the dam, including the creek and surrounding land downstream of the dam, a total area of approx. 67 Ha. The agreement excluded the access track, however it was to be upgraded to allow access for construction equipment and a Right of Way for the Tasman District Council was agreed to allow access for future maintenance.

7 RESOURCE CONSENTS AND CONSULTATION

Consultation was undertaken with local iwi groups and the HPT. The iwi did not identify the site as a significant cultural site and no monitoring during construction was required. However, discussions with the HPT, as previously mentioned, were integral to the outcome of the final design and further archaeologist monitoring required during construction.

The initial Resource Consents were granted in February 2011. Following the design change the Consents were changed and re-issued in July 2013. The three Consents granted were:

- To dam and detain water and flood water.
- To alter a dam and the use of a river bed.
- To alter and maintain a dam in an earthquake zone and a land disturbance and slope stability risk area.

8 CONSTRUCTION

The main contract was awarded to Downer in August 2013 with upgrade of the access road site fence installation instructed under the Tasman District Council's roading maintenance contract. This work started ahead of the main contract.

The main contract was for cut and fill of the dam face to the design batters, and design and build of the concrete spillway to the design specification.

Photograph 5: the front face of the dam in 2013 before decommissioning. The photograph was taken in a high rainfall event when the emergency spillway was flowing.

Construction at the dam started in October 2013 and was to be completed before the Christmas shutdown. One of the conditions of the contract was that the Contractor comply with the HPT Authority and liaise with the appointed project archaeologist throughout construction to allow recording of finds, if any, and then the appropriate recovery and storage of artefacts. Given the high probability of finding artefacts on site, a provisional sum was written into the contract to allow for a display to be created on completion of the work incorporating some of the artefacts retrieved from the site and an information board.

To further improve access for construction machinery, some of the granular material identified during investigation from within the existing dam structure was to be excavated and re-spread across the access track. While the extent of available suitable granular material was unclear proceeding construction, the result was favourable as very good material for stabilising the track was easily found early in the construction phase.

A requirement of the Contractor was to allow for the diversion of the flow around the work area. This was achieved through the installation of a 450mm diameter culvert with the inlet invert positioned just below the design final reservoir water level, approximately 3 m below the crest of the dam. The outlet of the culvert which was to protrude through the dam face about half way up was then connected to a culvert sock which discharged the flow into Reservoir Creek below the construction site area.

To comply with the Resource Consent conditions, the site was protected on the downstream side with a silt fence and double silt fences were installed downstream of the diversion outlet, along with straw bales.

One of the largest challenges for the Contractor was staging the work in order to make efficient use of a tight, steep site. Stockpiling and reusing excavated material was a key part to keep cost down. Topsoil was stockpiled and old pipes and concrete structures stored carefully onsite under the guidance of the archaeologists.

The Contractor programmed the construction to complete as much of the stilling basin and the far west bank of the dam as possible before the spillway was to be constructed. This was because once the spillway was in place, access to the stilling basin and west bank would be limited. An access track was cut into the dam face so plant and equipment could reach the top of the dam.

Once the sediment and debris was removed from the creek bed in the stilling basin area, it was observed that the underlying ground condition was fractured rock. Upon assessing the extent and properties of the rock in this area, the decision was made to form the stilling basin within the rock instead of over excavating and installing a 600 mm layer of imported rock riprap. Fortunately, the rock was ripable and the Contractor was able to cut the rock to the design levels.

Photograph 6: The beginning of the excavation for the spillway.

As the Contractor worked upstream from the stilling basin the fractured rock continued and it was found that water was seeping through fractures directly below the new spillway. To address this, a series of subsoil drains were installed to help relieve the hydrostatic pressure from beneath the new spillway.

Photograph 7: shows the fractured rock at the stilling basin with water seeping through the rock in the foreground.

Soon after the start of excavation, an old 6 inch diameter cast iron pipe was discovered protruding from the dam face. The pipe was continually leaking water at a low rate. It was assumed that this was the old scour pipe.

Photograph 8: Leaking cast iron scour pipe with PVC extension (from previous remediation work).

Access to the inlet of the scour pipe was not possible as it was buried beneath the silt below the water in the reservoir. Therefore, decommissioning the pipe would be too difficult. To overcome this, the pipe was cut and joined with a new PVC pipe which was aligned to the side of the spillway discharging into the stilling basin. This was again encountered further up the excavation and again connected to with a PVC pipe to ensure any leaks would not flow into the dam material (Photograph 8).

As the excavation continued, the fractured rock was no longer present and the *in-situ* dam material now encountered was a black sludgy silt material (Photograph 6). This material was excavated to approximately 1 m below the underside of the new spillway. As it continued to be a very soft unsuitable foundation material, it was stiffened by pushing a layer of 150 mm rock into it until the material bound up to form denser foundation material. This was then overlaid with a compacted well graded crushed gravel material to the level of the spillway.

Construction on site continued, albeit slowly as adverse weather during this period resulted in several weeks delay. Off site, Downer along with their sub-contractor, Kidson Construction, produced shop drawings for the design-build component, the concrete spillway. It required a number of iterations to the design before the specification was fully able to be adhered to. The outcome was a spillway constructed of precast U-shaped panel and the inlet and energy dissipation structures constructed of L-Shaped panels, all panels were propped at the top with timber posts.

With the worst of the wet weather over, the Contractor formed a platform for the crane and the sub-contractor started installing the downstream section of the spillway. Each panel was lifted into position and levelled, followed then by the next upstream section was lifted into place and the process repeated. Each pre-cast section was connected to the preceding section with reinforcing bar connected to the downstream panel with a cast in insert and grouted into the upstream panel. A gap of approximately 20 mm between the panels was later filled with high strength grout. The panels were also connected together at the top of the walls with bolted steel plate.

Photograph 9: installing the last of the L-Panels for the energy dissipation structure.

The formation of the access track to the stilling basin meant that part of the dam toe had been removed and stockpiled material at the top was surcharging the face of the dam. Exacerbated by wet weather and the vibration from construction machinery, the face of the dam started to slowly creep forward. This slow creep is known as a 'greasy back' and the foreman on site had experienced this before. The creeping slip material was moving as a single block of soil was and protruding out from the cut face at the base. In addition, cracks were also appearing at the top. The material was moving tens of millimeters per day. Some of the surcharging stockpiled material was moved from the top and polythene plastic was laid over the cracks to reduce water ingress from rain (Photograph 10). The foreman regularly evaluated the rate of movement as the construction continued. Once several panels were in place the excavation at the toe of the dam could be backfilled with the surcharging stockpile material, retaining the material above and the 'greasy back' stopped moving.

Photograph 10: The site with over half the panels in place. Note the polythene in the foreground protecting the slope from water ingress.

To eliminate a potential flow path at the dam/spillway interface, a pre-cast water stop was installed around three sides of the spillway at the puddle clay core. The excavated puddle clay was reinstated around the sides of the water stop.

Once the panels were installed, the Contractor continued shaping the batters whilst the sub-contractor completed the spillway, inlet structure and energy dissipation structure. With fish baffles installed and the inlet screen installed, water was allowed to flow down the spillway from January 2014. The Practical Completion Certificate was issued in late January.

Local volunteer groups were quick to integrate the dam into the ever expanding walking track network in the hills of Richmond. The new track was formed by volunteers to the bottom of the stilling basin on the western side of Reservoir Creek. The track then crosses the creek via the boulders forming the outlet of the stilling basin and joins a walking track benched into the batter slopes of the dam past the information board and continues beyond the reservoir. The spillway sides and the bridge above the inlet are fenced to protect people from falling.

Photograph 11: The site at Practical Completion, showing the batters hydroseeded, timber props in place, energy dissipation blocks in the foreground and the black fibreglass fish ladders.

Photograph 12: Spillway with the walking track to the right and guard rails to protect the public.

9 FINANCIAL

From 2010 to completion of the decommissioning of the reservoir, the cost to Tasman District Council was in the order of $1M. This includes remedial work throughout the period, design, land purchase and decommissioning.

10 CONCLUSIONS

The 125 year history of the dam was certainly not plain sailing. The dam played an important role in the growth of the Richmond township as a water reservoir and would have been an incredibly difficult construction at the time.

As the dam became a redundant asset it lapsed in to an unmaintained state. It was inaccessible to the public, a structure at risk of failure with the potential to cause harm to property and life and was acting as a barrier to fish passage.

The decommissioning of Reservoir Creek dam offered the opportunity to reshape the dam, and it now provides an integrated community asset, that is safe, has improved ecological features whilst also retaining its historical value.

Photograph 13: The information board overlooking the reservoir and spillway intake.

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