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Klohn Crippen Berger

# MORRISON DAM REHABILITATION



CANADIAN CONSULTING ENGINEERING AWARDS 2018



# INNOVATION

This was a multi-disciplinary project involving geotechnical (dam, foundations, seepage), structural (structure design), mechanical (gate design), electrical (power supply), hydrotechnical (hydrology, flood routing) and environmental (aquatic life, birds) engineering.

## CUTOFF WALL DESIGN

Rehabilitation of the existing service spillway included demolition and removal of 5 of the 9 structure monoliths, subexcavation of the structure foundation, and reconstruction of the underdrainage system and structure components. Due to seepage concerns, a seepage cutoff wall was constructed along the dam alignment in advance of the structure demolition and a sheet pile cofferdam was installed upstream of the structure inlet. The seepage barrier extended laterally on either side of the spillway structure for a total distance of 250 m. The majority of the cutoff wall length consisted of a soil-cement-bentonite (SCB) slurry trench installed through the dam embankment and the underlying pervious foundation to intersect with bedrock. As trench excavation was not feasible across the concrete spillway, this portion of the cutoff wall was constructed with a contiguous line of jet grout soilcrete columns. The two seepage barrier systems were overlapped on either side of the spillway to provide a continuous barrier throughout the cutoff wall length.

## UNIQUE MIX OF DIFFERENT MATERIALS

The SCB cutoff wall design was based on the results of a laboratory trial mix program which included strength and permeability testing followed by seepage analyses to determine the cutoff wall effectiveness.



As part of the mix design, the trial mixes were performed using imported bentonite, water from Cookson Reservoir, locally sourced cement and excavated trench spoil return, taken as samples of the clay, sand and gravel from the earlier investigations. The trial mixes provided a basis for recommended mix parameters to be specified for construction. Specifications for the SCB mix included a slump between 125 mm to 200 mm, minimum strength of 200 kPa and a maximum permeability of 10<sup>-9</sup> m/s.

Quality control testing was carried out by the contractor using a field laboratory on site for viscosity and strength testing. Permeability testing was carried out off site to confirm design requirements. A trial jet grouting was also carried out prior to production grouting to establish the rate of drilling, aperture size for jetting and spacing between columns to achieve sufficient overlapping and a minimum wall width. Both the SCB trench and two rows of jet grouting were designed for a minimum wall width of 900 mm.




## COMPLEXITY

Test hole drilling was carried out in advance of the field construction to determine the required depth of cutoff wall. Estimated depths were reasonably consistent along the length of cutoff wall with an estimated maximum of 23m. The predicted depths of excavation required the use of a long stick excavator for the SCB trench which was not available locally and therefore was imported from the USA and attached to a locally sourced excavator.

The dam crest was initially too narrow to excavate and backfill the trench for the SCB slurry cutoff wall. A widened working platform was therefore provided by lowering and widening the downstream portion of the dam crest. Lowering of the dam crest by approximately 2m also reduced the depth of trench excavation to less than 23m thereby ensuring the long stick excavator would be adequate to achieve the required depth.

A full drawdown of the reservoir in advance of construction was not possible, however a partial drawdown of 600mm was carried out to provide



reservoir storage during the period while the spillway could not be operated (i.e. during period of jet grout cutoff wall installation through the spillway slab). The sheet pile wall cofferdam construction was therefore carried out in the “wet” with the reservoir approximately within 600mm of its FSL. This required the installation of turbidity control measures and fish salvage operations to meet environmental requirements.

# SOCIAL AND/OR ECONOMIC BENEFITS

The project contributed to the development of highly qualified people in Saskatchewan. Some of the construction techniques for the SCB and jet grout cutoff wall were new to the general contractor from Estevan. A specialist contractor and his equipment were used collaboratively with the local contractor.

## ENVIRONMENTAL BENEFITS

This project provides additional seepage control measures in the area of the service spillway where saturation of slopes and instability were problematic prior to the rehabilitation program. Due to the presence of nesting swallows on the underside of the concrete spillway structure, the structure was covered with Teflon panels in advance of the construction to deter them from nesting. In addition, an environmental monitor was required to watch over the activities to ensure disturbance did not impact them negatively.

The project involved several innovative construction techniques. A component of the work involved underwater installation of a 60m long HDPE conduit liner in the upstream section of the low-level outlet. The intake structure was also raised underwater to improve water quality and avoid sediment accumulation in the outlet pipe, which thereby avoids discharging sediment downstream. Dredging of the reservoir bottom was required to provide a channel for installation of the liner. To avoid discharging sediment into the river downstream of the dam, the dredging system mounted on a barge was used to pump the excavated soils onto the adjacent reservoir bottom. The areas of deposition were isolated within a double ring of turbidity barriers and adjacent areas outside the turbidity barriers were tested for compliance with turbidity requirements. Testing of sediments was done in advance to ensure mercury levels would not be a concern.





## MEETING CLIENT'S NEEDS

A major concern at the Morrison Dam service spillway since its original construction has been the significant seepage that occurs in the vicinity of, adjacent to, and under the service spillway structure. In addition, the overall flood handling capacity of the spillway structure together with that of the auxiliary spillway was inadequate to pass the inflow design flood based on 2007 Canadian Dam Association (CDA) Guidelines, and therefore required upgrades to the flow control structures.

Various options for upgrading the facilities were identified, including rehabilitation of the service spillway at its existing location, as well as possible construction of a new spillway at an alternative location. Based on the comparison of costs and operational considerations, SaskPower decided to proceed with final design and construction to rehabilitate the service spillway at its existing location, upgrade the auxiliary spillway, and implement additional upgrades to the riparian low level outlet to improve its efficiency. The work was carried out in phases over a 28 month period to facilitate handling of spring flooding during the period 2014-2016 while

at the same time ensuring an adequate supply of cooling water was available for the nearby SaskPower Poplar River Power Station. In addition, SaskPower are required to pass riparian flows downstream to the USA. The upgrades to the low level outlet with new gates, an upstream conduit liner and raised intake ensure that SaskPower can meet these requirements. The upgrades to the auxiliary spillway including a new fuse plug, channel enlargement and provision of riprap also ensure that large floods can be handled without damage to the dam and spillway infrastructure.

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## MORRISON DAM REHABILITATION CORONACH, SASKATCHEWAN



**M**orrison Dam has experienced significant seepage throughout its history resulting in deterioration of the concrete spillway. In addition, the combined flow capacity of the spillway and other structures was deemed inadequate. To address these issues, Klohn Crippen Berger was retained by SaskPower to complete engineering designs and construction supervision for rehabilitation and upgrades to the flow control structures including service spillway, auxiliary spillway and riparian low level outlet to improve their performance and increase capacity.

### CLIENT



### SUBCONSULTANTS

Ground Engineering Consultants Ltd.  
WSP Group formerly Focus Surveys



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# PHOTOS



# PHOTOS





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