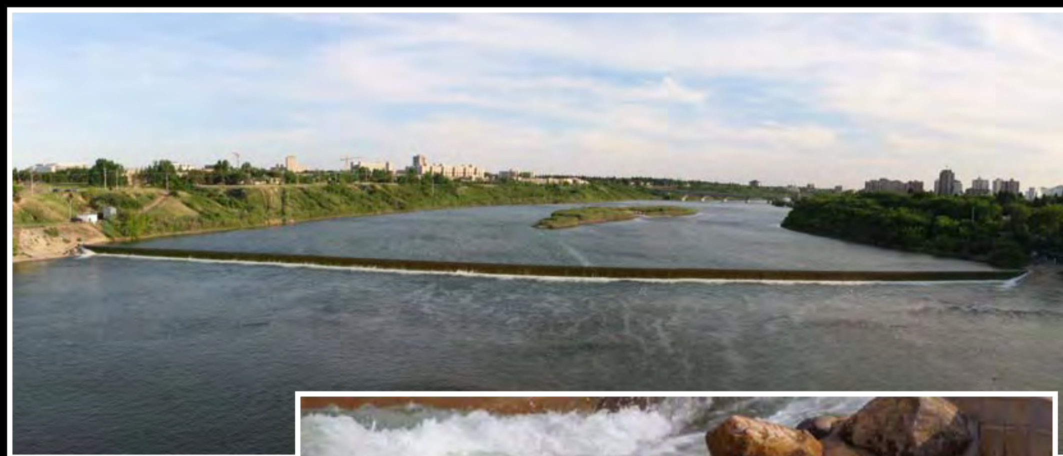
SASKATOON LIGHT & POWER
HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES

ENGINEERING PRE-FEASIBILITY REPORT



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Knight Piésold
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SASKATOON LIGHT & POWER
HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES

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EXECUTIVE SUMMARY

The Saskatoon Weir is located in the City of Saskatoon on the South Saskatchewan River. Saskatoon Light & Power contracted Knight Piésold Ltd. in March, 2009 to assess the potential of a hydroelectric development at the site of the weir. The potential for an adjacent recreational whitewater park is also considered herein, assessed as an independent development.

The focusing question of this report is: **Can a low impact, technically feasible, economically viable hydroelectric development be incorporated into the existing weir?** The answer to this question is **Yes,** based on the following findings (which summarize each of the report sections):

1. The Saskatoon Weir is a 3.3 m high, concrete, ogee-crested structure approximately 300 m in length. Construction of the weir was completed in 1940. The drop in elevation across the weir presents an opportunity for low-impact renewable energy generation and for a recreational white water park development.
2. The site characteristics in terms of hydrology, geotechnical conditions, seismicity and climatic conditions, including frost and potential ice impacts were evaluated, and are summarized in this report. There is a long term hydrological record available for this site, which assists greatly in terms of assessing the potential energy generation potential of the site. Long-term hydrology records indicate a mean annual discharge of 209 m^3/s at the weir. Recent geotechnical studies near the project site indicate suitable foundation conditions and a requirement for consideration of slope stability during design.
3. Several hydropower development concepts have been considered in this analysis. The design concepts include a variety of turbine-generator types and different raises to the height of the existing weir. The layouts of three development concepts are described herein, including the presentation of the concept layout figures. The three development concepts presented herein include:
   - Concept 1 – No Weir Raise, Installed Capacity of 2.8 MW (16.5 GWh/year)
   - Concept 2 – 1m Weir Raise, Installed Capacity of 5.5 MW (31.2 GWh/year), and
   - Concept 3 – 2m Weir Raise, Installed Capacity of 8.4 MW (47.5 GWh/year)

   VLH turbines, a prototype turbine technology, appear to be appropriate for a development with no raise to the weir height. Pit turbines can be used with an increase to the available head (i.e. Weir raise). The Pit turbines are less suited to a development without a raise to the weir height, as their efficiencies drop off rapidly at the low head values. Inflatable rubber weirs or Obermeyer type gates are the preferred technologies for raising weir height while maintaining water level control due to their low initial costs, low operation and maintenance costs, and their resilience to ice-affected waters. A walkway bridge could be added over the top of the existing weir. This would allow access to service

the gates and could allow for a safer and more permanent pedestrian crossing, in place of the existing temporary crossing provided alongside the railway bridge.

A recreational whitewater park could easily be developed adjacent to the proposed hydropower project. S_2O Design and Engineering have prepared two possible development concepts for a white water park at the proposed weir site. The details of these two concepts are presented in detail in this report.

4. Two rounds of public consultation have been completed, with one more expected in 2010. Feedback received to date has identified the potential for improved amenities at the weir, the importance of environmental protection of the area, public safety, operation and maintenance staffing, and jurisdictional and permitting issues that require consideration.

   Public safety of the facility is a key consideration for design of any new developments at the weir. Safety measures can include upstream safety booms across the river, improved signage around the facility, and audio/visual alarms announcing flow changes through the hydroelectric or white water facilities. Safe entry and egress points for recreational boaters can be added around the facility.

   Baseline environmental studies began in 2009 and were reported separately in Knight Piésold Ltd. report VA103-198/2-1. The studies include an inventory of the current state of the environment at the project site. Completion of environmental impact studies will be required once a preferred development concept has been selected. Impacts to wildlife habitat and private land directly upstream of the weir will be highly dependent on the height that the weir is to be raised.

   In addition to environmental studies, a Construction Environmental Management Plan will be required should a development be brought forward to construction. Such a plan will outline procedures for mitigating environmental impacts during construction.
5. Energy generation estimates have been completed for each of the development concepts. The estimates use the long-term daily flow record for the river to calculate daily energy generation based on calculated head across the weir and turbine efficiencies provided by suppliers. Unscheduled outages were subtracted from the estimates based on industry averages. Energy generation estimates are summarized for each concept in the table below.
6. Cost estimates and financial analyses were completed for each of the development concepts. Quantities were estimated from the concept designs and unit rates were derived from our industry experience and feedback from contactors and suppliers. Costs for an improved fish channel have been included in each of the development concepts. The cost estimates for each development concept are shown in the table below.

   The whitewater park development (Option A) is estimated to cost $2,950,000 when developed with an adjacent hydropower project. If developed as a stand-alone project (without a hydropower development) the Option A whitewater park is estimated to cost $11,970,000 assuming that a 1 m raise to the weir is included. These costs do not account for additional amenities such as parking, change-rooms or a boathouse, and do not include allowance for slope remediation works.

   The addition of a pedestrian bridge over the weir is estimated to cost $2,840,000. This cost includes a hoist to improve maintenance accessibility over the weir.

Financial analyses were completed for each development concept with and without the optional inclusion of the white water park and the pedestrian bridge. The financial analysis determined the electricity rates required to achieve an 8% internal rate of return over a 50 year project life. Annual operating and maintenance (O&M) costs are assumed to begin at $500,000. The analysis assumed a 3% annual inflation for both the electricity rates and O&M costs. Results of the financial analyses are summarized in the table below.

7. A preliminary development schedule has been prepared including timelines for public consultation, environmental studies, regulatory approvals, engineering studies, detailed design and project construction. The schedule indicates that a hydroelectric project at the weir could begin operation in December 2015.
8. The key results pertaining to the pre-feasibility of the proposed hydropower development are summarized as follows:

Development	Design Flow (m^3/s)	Installed Capacity (MW)	Mean Annual Energy (GWh)	Capital Cost (Million $)	Required Electricity Rate ($/kWh)
Concept 1	167	2.8	16.5	26.3	0.12
Concept 2	209	5.5	31.2	48.8	0.10
Concept 3	250	8.4	47.5	57.9	0.08

If SL&P and other key stakeholders agree that the proposed hydropower development should move forward to bankable feasibility level stage development, then the following steps are recommended:

- Full Feasibility Study, including:
  - Geotechnical Investigations.
  - Fluvial Geomorphologic Studies of the upstream and downstream effects of the proposed development.
  - Optimization studies and determination of the preferred weir height raise, if any.
  - Feasibility Level Engineering, including:
    - Detailed Drawings
    - Detailed Cost Estimate
    - Detailed Development and Construction Schedule
    - Updated Hydrological and Energy Estimates
    - Detailed Financial Analysis, and
    - Conclusions and Recommendations.
- Full Environmental Impact Assessment, including:
  - 2010 Baseline Environmental Studies
  - Initiate Environmental Assessment and Permitting Process
  - Ongoing Stakeholder and First Nations Consultation, and
  - Preparation of Environmental Impact Statement.

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SECTION 1.0 - INTRODUCTION

1.1 BACKGROUND

In March, 2009 Saskatoon Light & Power (SL&P) engaged Knight Piésold Limited (KPL) to complete environmental baseline and engineering pre-feasibility studies on their proposed Saskatoon Weir Hydropower development and a potential Whitewater Park development. This assignment follows a Concept Development and Technical Review (Knight Piésold reference VA103-198/1-1) completed in April, 2008. A separate Environmental Baseline Report (reference VA103-198/2-1) has been prepared by Knight Piésold for this project.

The Saskatoon Weir is located on the South Saskatchewan River in Saskatoon, Saskatchewan. It is a 3.3 m high, concrete, ogee-crested structure approximately 300 m in length. Construction of the weir was completed in 1940. The drop in elevation across the weir presents an opportunity for low-impact renewable energy generation and for a recreational whitewater development. This report presents a preliminary investigation into the feasibility of a hydroelectric development at the Saskatoon Weir and an adjacent recreational whitewater facility.

1.2 PROJECT TEAM

The project team includes:

Saskatoon Light & Power
SL&P is an electric utility owned and operated by the City of Saskatoon, and was founded in 1958. The company provides electricity service within the Saskatoon city boundaries. Peak power demand within this area is estimated at 219 MW. SL&P is championing the development of a hydroelectric facility at the Saskatoon Weir.

Saskatoon Whitewater Park Committee
The Saskatoon Whitewater Park Committee (SWPC) is a local committee of citizens that is championing the development of a recreational whitewater facility at the weir.

Government of Saskatchewan
The provincial government, through its Ministry of Tourism, Parks, Culture and Sport is providing funds to support the evaluation of a recreational whitewater development at the Saskatoon Weir.

Knight Piésold Limited

KPL is an employee-owned consulting company of professional engineers and scientists that was established in 1921. The company has offices worldwide, offering specialised technical services to our clients in the hydroelectric, water resources, environmental, and mining sectors. This project is being completed by our Vancouver, BC office with assistance from the environmental team in our North Bay, ON office.

KPL has been involved in the hydroelectric industry for more than 70 years and has become a world leader in the development and design of hydroelectric projects. Our experience covers all geographic and climatic regions of the world, with project locations ranging from the Canadian Arctic to Africa, South America, and Asia. We have provided engineering services for projects ranging in size from a few hundred kilowatts up to 4 500 MW, with heads as high as 800 m, and with low head projects utilizing Kaplan and Bulb turbines. Our track record includes run-of-river, pumped-storage, and reservoir hydroelectric projects.

S_2O Design and Engineering

S_2O Design and Engineering (S2O) specializes in whitewater park design. S_2O has worked on numerous whitewater park projects, including the U.S. National White Water Facility and the Bow River White Water Park in Calgary, Alberta. KPL has engaged S_2O as a sub-consultant for this project.

1.3 SCOPE OF STUDY

This report presents the results of preliminary investigations into the feasibility of hydroelectric and recreational whitewater developments at the Saskatoon Weir. Three design concepts are considered for the hydroelectric facility and weir. These include options that would raise the height of the weir with the addition of rubber dams and hydraulic gates, and an option that leaves the height and structure of the weir unchanged aside from the addition of power generation equipment at the right side.

A preliminary design for a recreational whitewater park is presented in this report. The whitewater park development would be located adjacent to the hydroelectric facility.

The following sections of this report present:

- A review of site characteristics and conditions
- A description of the existing structure and the proposed developments
- A summary of environmental and socio-economic considerations
- Energy generation analyses for the various design alternatives
- Cost estimates and financial analyses for the various design alternatives
- A potential development schedule, and
- Conclusions and recommendations for future studies and field investigations.

SECTION 2.0 - SITE CHARACTERISITICS

2.1 GENERAL

The weir is located on the South Saskatchewan River approximately 100 m south of the CPR rail bridge in Saskatoon at an elevation of approximately 473 m. The City of Saskatoon is centred to the west of the weir, and the University of Saskatchewan is located to the east. The Meewasin Valley Trail follows river on both the east and west banks. A pump house is located on the east bank of the river, and is owned and operated by the Potash Corporation of Saskatchewan (PCS). A small fish ladder on the eastern apron allows fish passage over the weir.

The following sections provide detailed descriptions of specific characteristics of the project site.

2.2 HYDROLOGY

The South Saskatchewan River originates at the confluence of the Old Man River and the Bow River in Alberta, draining the south-eastern Canadian Rocky Mountains. The majority of runoff in the river is contributed from snow melt and glacial runoff from the Rockies. Historically the river experienced great seasonal fluctuations in flow and occasional storm induced flood flows. Construction of the Gardiner Dam was completed in 1967, enabling the regulation of downstream flows. The Gardiner Dam is located roughly 120 km south (upstream) of Saskatoon.

Water Survey of Canada (WSC) operates a hydrometric station (05HG001) on the South Saskatchewan River immediately upstream of the Saskatoon Weir. The drainage area of the river at this location is approximately 141,000 km^2, and the mean annual discharge (MAD) is 209 m^3/s. Figure 2.1 shows the average monthly flows at the WSC station since 1968. Note that the period of record extends far before 1968, but the earlier data was not used in this analysis due to the influence of the Gardiner Dam on the distribution of flows. The complete set of monthly flow data from 1968 to present is shown in Table 2.1. A flow duration curve for the same period of flows at the WSC station is presented on Figure 2.2.

Flood frequency analysis has been completed by the Saskatchewan Watershed Authority (SWA) for the South Saskatchewan River downstream of the Gardiner Dam. SWA provided KPL with the results of their analysis, which are presented in Table 2.2.

2.3 GEOTECHNICAL CONDITIONS

Several geotechnical investigations have been completed in the past at various locations along the South Saskatchewan River in Saskatoon. River bed material is consistently comprised of silty sand with gravel, cobbles and boulders to a depth of roughly 1 m. Below this layer is a glacial till composed of silty clay with some sand and trace gravel. This glacial till typically has low plasticity and is expected to make good foundation material (Machibroda, 2003). Bedrock units are rarely encountered by engineering works in Saskatoon due to their depth (Machibroda, 1996). Several slope failures have occurred along the east bank of the river in the past. Slope stability along the banks shall be considered during design of any future works at the weir.

A more detailed summary of regional geology, hydrogeology, and geotechnical conditions can be found in Knight Piésold letter VA09-1550, November, 2009. The letter includes recommendations for future geotechnical investigations and design considerations.

2.4 SEISMICITY

The proposed hydroelectric project is situated in a region where historically the level of seismic activity has been very low. However, there is the potential for small to moderate crustal earthquakes in the region.

Seismic activity in the prairie region south of latitude 60° N is predominantly confined to southern Saskatchewan in a zone that continues into Montana. This region has a history of sporadic, low level, shallow seismicity, likely the result of movement along a system of north-east and north-west trending mid-continent faults (Horner, 1983). These fault systems are not large, but are the result of long term stresses within the earth's crust. The faults are not easily identified and little is known about them due to coverage by sediments deposited by Pleistocene glaciers over southern Saskatchewan. However, some recorded earthquakes have been located close to known faults, suggesting that they are associated with them.

All of the recorded events in the region have been below Magnitude 4.0, with the exception of one Magnitude 5.5 earthquake in 1909, located near the Canada - United States border. Small, induced earthquakes associated with potash mining in southern Saskatchewan have also been recorded.

Since the region has proven capable of generating a Magnitude 5.5 earthquake and a number of smaller ones in the last century, it is expected that other earthquakes of similar magnitude, and perhaps larger, will occur in the future. However, given the brief instrumental seismic record of less than 40 years in Saskatchewan, it is not possible to accurately predict when the next significant earthquake will occur.

To provide seismic ground motion parameters for the project area a probabilistic seismic hazard analysis has been carried out using the data base of Natural Resources Canada (NRC). The results are summarised in Table 2.3 in terms of earthquake return period, probability of exceedance (for a 50 year design life) and the maximum ground acceleration. The maximum accelerations presented are median hazard values for soft rock/very dense soil ground conditions (Site Class C, as defined by the National Building Code of Canada, 2005). For a return period of 475 years (10% probability of exceedance in 50 years), the corresponding maximum acceleration is only 0.02g, confirming a very low seismic hazard for the project area.

2.5 FROST AND ICE CONDITIONS

Saskatoon has not historically been an area of permafrost, however soils in the area are frost susceptible. Construction at the river banks should consider the frost susceptibility of soils at the weir site.

Before completion of the Gardiner Dam the South Saskatchewan River would completely freeze over through winter, resulting in significant ice-break activity in spring. Ice-breaks of this type can cause significant damage to civil structures. With the construction of the Gardiner Dam and the resulting regulation of flows through the winter months ice cover in and around Saskatoon has been reduced. Flow of ice over the weir is typical through winter and spring, and should be considered in subsequent design.

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SECTION 3.0 - PROJECT DESCRIPTION

3.1 EXISTING WEIR FACILITIES

Construction of the Saskatoon Weir was completed in 1940. Its purpose was to control water levels and flood levels near Saskatoon. The Gardiner Dam, located upstream, was completed in 1967 providing improved water level control in Saskatoon. The Saskatoon Weir provides submergence for several water intakes, including cooling water intake for the Queen Elizabeth Power Plant, water supply for PCS Patience Lake potash facility, and a University of Saskatchewan irrigation supply.

The weir is a concrete-gravity structure approximately 3.4 m high and 303 m in length. A plan view of the existing weir is shown on Figure 3.1. Visual inspections made during site visits in June 2009, were limited to the apron slabs at the sides of the weir. Cracking and erosion was observed on the concrete aprons at both banks. The Saskatoon fire department, who have conducted training exercises at the weir in the past, have reported some undercutting of the apron slab downstream of the weir.

The Saskatchewan Watershed Authority (SWA) has an extensive HecRas model of the South Saskatchewan River downstream of the Gardiner Dam. SWA provided KPL with the surveyed transect data used in their model and with rating curves for locations immediately upstream and downstream of the weir. These data indicate that when the river is flowing at its mean annual discharge (MAD) there is a drop in water level of 2.5 m across the weir. At flows greater than roughly 2000 m^3/s the weir is submerged or “drowned” such that there is effectively no drop in water level across the weir. This flow is equivalent to the 50-year flood event.

The upstream stage-discharge data provided by SWA was compared with stage-discharge data provided by WSC for their stream-flow monitoring station 05HG001. The two stage-discharge curves are nearly identical up to a flow of approximately 1100 m^3/s, which is equal to the 10-year peak instantaneous flow. At greater flows the WSC curve falls below the SWA curve, predicting greater flows at lower elevations. This was not considered to be problematic because such high flows will be outside of the operating range of any hydroelectric project developed at the weir.

3.2 HYDROPOWER DEVELOPMENT AT THE WEIR

Several hydropower development concepts have been considered in this analysis. A variety of turbine-generator types and different raises to the height of the existing weir have been considered in the concepts. Estimates of capital costs and energy generation were used to identify cost effective design flows for each concept. The layouts of three development concepts are described in the following subsections. Energy generation and capital cost estimates for these three concepts follow in Sections 5 and 6 respectively.

Each concept has been designed with the requirement that the water level of a 1:200 year flood event would match the water level experienced with the existing weir facility in the same flood event.

3.2.1 Concept 1 – No raise of weir height

The head developed across the existing weir is below the low limit of the operation range of traditional low-head hydroelectric turbines such as bulb or pit turbines. Several prototype turbine technologies however are being developed for low head applications. An example is the VLH turbine.

The VLH turbine is a variable speed axial flow turbine that is designed to operate at heads as low as 1.4 m. The turbine and generator are combined into one unit which fits between concrete piers. The unit can be pivoted upwards to sluice accumulated bedload or to pass high flows. Utilizing a permanent-magnet variable-speed generator allows the turbine to operate at lower speeds than traditional turbines, and thus the units are capable of operating at lower heads. A VLH turbine prototype has been installed in Millau, France. (Fraser et al, 2007)

Concept 1 consists of an array of eight VLH turbines installed in the right side of the weir. The turbines would be installed at the same elevation as the existing weir. This concept has a design flow of 167 m^3/s, or 0.8 x MAD. The turbines would be installed at the same elevation as the existing weir, and thus no additional hydraulic gates or control structures would be required in order to pass flood flows at the same elevation as the existing infrastructure. A general arrangement of this concept is shown on Figure 3.2.

3.2.2 Concept 2 – 1.0 m raise of weir height

Concept 2 includes a 1 m raise to the existing weir and an in-stream powerhouse structure constructed at the right bank. This concept would utilize three pit turbines in the powerhouse. Pit turbine technology consists of a double-regulated axial flow turbine connected through a gearbox to a synchronous generator. Using a gearbox allows the use of small, high-speed generators. The gearbox and small generator are located in a narrow, sealed concrete pit (Gordon, 1989). The turbine shaft passes through the wall of the concrete pit between the gearbox and the axial propeller-type turbine. These turbines are regulated by varying the pitch of the propeller blades and the angle of the upstream guide vanes. Pit turbines are a well refined, high efficiency turbine technology with many operating examples worldwide (Gordon, 2001). Manufacturers include Alstom, Andritz, Voith and many other reputable companies.

The powerhouse structure in Concept 2 would contain three turbine/generator units and would have a design flow of 209 m^3/s, or 1.0 x MAD. Vertical slide gates would offer emergency or maintenance closure upstream of the turbines, and stoplogs would be used on the downstream side. A sluice channel would pass any accumulated sediment from the forebay area. The sluice channel would be controlled by a radial gate.

In order to pass flood flows a dynamic hydraulic control must be added to a portion of the weir. A variety of hydraulic control mechanisms can be used, including crest gates, fusegates, Obermeyer gates, or inflatable rubber weirs (rubber dams).

Rubber dams are inflated with low pressure compressors and are emptied through embedded exhaust piping. Automatic control maintains pressure in the bladders and monitors upstream water level. When the upstream level reaches a high limit the dam is deflated, allowing the bladder to lie flat on the concrete foundation. Advantages of rubber dams include their low initial cost, low maintenance cost, and their performance in ice-affected waters (Tuthill, 2001).

This concept includes inflatable rubber weirs for passage of high-flows. Two rubber weirs with height 2.2 m and combined length of 110 m would be required to pass the 1:200 year flood flow at the same elevation that the existing infrastructure does. The rubber weirs would be dropped (deflated) when the water level reaches a certain level, allowing more flow to pass at the same elevation. The radial sluice gate would also be opened in flood conditions to pass more flow.

The remaining length of the weir would be raised by adding concrete to the top of the existing structure. This would require some roughing of the existing concrete surface and the use of dowel bars to ensure the new concrete bonds well to the old. The raised concrete weir would have the same crest elevation as the inflated rubber weirs.

A general arrangement plan view of this concept is shown on Figure 3.3.

3.2.3 Concept 3 – 2.0 m raise of weir height

Concept 3 is much like Concept 2, but with a 2.0 m raise to the height of the existing weir. A powerhouse structure located at the right side of the weir would contain three pit turbines with a design flow of 250 m^3/s, or 1.2 x MAD. The powerhouse would include the same hydraulic gates and sluice channel as described for Concept 2.

Four rubber weirs with a diameter of 3.2 m and a combined length of 175 m would be required to pass the 1:200 year flood flow at the same elevation as would be currently. The rubber weirs would be dropped and radial sluice gate opened in flood conditions to allow more flow to pass.

As in Concept 2, the remaining portion of the weir will be raised by the addition of concrete to the top of the weir. The crest elevation of the concrete weir would match the crest elevation of the inflated rubber weirs. A general arrangement plan view of Concept 3 is shown on Figure 3.4. Various sections through the powerhouse are shown on Figures 3.5 and 3.6. These sections are descriptive of Concepts 2 and 3.

3.3 RECREATIONAL WHITEWATER FACILITY

S20 Design and Engineering have completed a preliminary design report for the proposed whitewater park development. Two design options are presented, one with a whitewater channel adjacent to the powerhouse, and the other includes the addition of a large wave-feature incorporated into the weir near the opposite bank (river left). The two concepts are summarized as:

- Option A – Side channel whitewater park as shown on Figure 3.7, and
- Option A + B – Side channel plus mid-channel whitewater park as shown on Figure 3.8.

The preliminary design report concludes that the addition of a whitewater park is feasible, and that both design options would be improved with additional head provided through a raise of the weir height. According to the report the park could potentially attract a two to five million dollar annual economic impact through tourism. The complete report on the recreational whitewater facility is presented in Appendix D.

3.4 FISH BYPASS CHANNEL

An improved fish navigation channel has been included in each development concept. The channel would be excavated into the left bank of the river adjacent to the weir (opposite side of the weir from the proposed hydro facility). Native bed materials would be used in the channels. Root-wads would be artificially installed and native plant species would be planted to mimic natural rest and refuge areas. Flow through the fish bypass channel would be supplied by natural river flow. It is anticipated that flow through the channel would be less than 1 m^3/s.

3.5 PEDESTRIAN BRIDGE OVER WEIR

A walkway could be constructed over the length of the weir to provide pedestrian access from one side of the river to the other. Such a pedestrian bridge would be installed above the 200 year flood level, and would require the addition of piers to support spans of approximately 20 m length. In addition to providing a pedestrian crossing isolated from vehicle or rail traffic, the walkway would provide access for policing and emergency response teams. The bridge would also improve maintenance access for any gates or rubber weirs installed along the weir, and would include a monorail hoist for such purposes.

A pedestrian bridge has been considered as an optional addition to any new developments at the weir. Costs associated with such a structure have been itemized in the cost analysis included herein.

3.6 PROJECT OPERATION

The project concepts described above have been evaluated based on the following operation scheme. Flow in the river will have four routes to pass the weir: the fish bypass channel, the concrete weir and/or rubber weirs, the whitewater facility, and the powerhouse/turbines. Flow through the fish channel will be maintained preferentially under any river flow conditions.

A minimum flow of 8 m^3/s over the weir (concrete and/or rubber) has been assumed. This will help to preserve some of the current aesthetic values of the weir associated with cascading water. In the case of the design concepts that use rubber weirs, this minimum flow over the weir also serves to protect the rubber bladders from UV exposure damage. The operation scheme would ensure that this flow is maintained only after the fish channel flow has been satisfied.

If a white water facility is developed it is expected that it would operate during daylight hours from the beginning of May through end of September. Flow through the whitewater facility would be a secondary priority both to maintaining flow through the fish channel and to the aesthetic minimum flow over the weir.

Finally, flow through the powerhouse will be maintained after the flow requirements of the fish channel, the weir aesthetics, and the whitewater facility have been met. Flow through the powerhouse will also be subject to the operational requirements of the turbines. The turbines will have a minimum operational flow and a minimum operational head. The turbines will be designed to pass no more than their design flow. When river flows reach a certain high threshold the turbines will be shut down to avoid damage to turbine machinery caused by increased suspended sediments. This high threshold flow will depend on the flow at which sediments mobilize, which will need to be determined.

Operational stage-discharge relationships have been calculated for each of the design concepts. Weir flow equations were used to calculate the upstream water levels for each of the design concepts. Discharge coefficients for the concrete weir were calculated from the rating curve data obtained from both WSC and SWA. The rubber weir discharge coefficients were based on KPL's experience with rubber weirs in other projects. The effects of weir submergence at higher flows were estimated based on methodology described in the text Design of Small Dams (USBR, 1973). Operational stage-discharge curves for Concept 1, 2, and 3 are shown on Figures 3.9, 3.10, and 3.11 respectively. These figures show the upstream water level, downstream water level, and head versus river flow. The flows at which the radial gate would open and rubber weirs deflate are noted on the figures for Concepts 2 and 3.

SECTION 4.0 - SOCIAL AND ENVIRONMENTAL CONSIDERATIONS

4.1 PUBLIC CONSULTATION

Two rounds of public consultation have been completed as part of the Pre-Feasibility study of developments at the Saskatoon Weir. The consultations took place in Saskatoon, where stakeholders were invited to meet with SL&P and KPL. Many parties were consulted, including kayak/canoe clubs and other sports clubs, citizen groups and clubs, environmental and regulatory agencies, adjacent land owners, affected corporations, and civic departments. A complete list of parties consulted thus far is included in Table 4.1.

Key points that have been identified in the consultations to date include:

- Suggestions for new and improved amenities related to the proposed whitewater park development
- Feedback regarding fish passage and environmental protection
- Feedback regarding safety of the proposed facilities
- Requirements for operation and maintenance guidelines and staffing, and
- Identification of jurisdictional and permitting related issues to be considered.

One more round of public consultation will be completed in 2010. A complete summary of the public consultations will be prepared following those meetings.

4.2 PUBLIC SAFETY OF FACILITIES

Public safety of the facilities would be a primary consideration of any developments at the weir. There are inherent dangers in any weir structure, especially with such a length. Weirs create a hydraulic hole on their downstream side, whereby objects are continually forced downward in a circulating current. The difficulty of escaping such a hydraulic hole presents a particular danger of drowning. It is worth noting that during operation of a hydroelectric scheme the safety of the weir would be improved as a result of having less flow passing over the weir.

A floating boom system located upstream of the boom can be used to prevent boaters from accessing the weir, and to warn boaters of downstream danger. Take-out areas can be cleared at either side of the boom to allow boaters a safe point of egress from the river. An example of this type of safety boom is shown in Appendix A. Clear signage should be placed along the shore downstream of the booms and in the immediate area of the weir to dissuade any swimmers or boaters from entering the river.

Safety measures in the immediate vicinity of the powerhouse or turbines can include clear warning signage and audible alarms to sound before any sudden changes in flow through the powerhouse. Railings will be installed to reduce chances of accidentally falling over any edges. Trashracks located in the headrace will physically prohibit access to the turbines through the waterway.

Public safety will also play a key role in the design of the proposed recreational whitewater facility. Safe entry and exit points will be designed into the route(s). The grade of the facility and size of flow obstructions will be designed appropriately with consideration of public safety.

4.3 ENVIRONMENTAL IMPACTS

Environmental impacts of development at the weir will consist of short-term impacts from construction in the immediate project area and long-term impacts due to upstream water level changes. An inventory of the existing environmental setting, species, and habitat has been completed in KPL's Environmental Baseline Report (reference VA103-198/2-1). Following the selection of a design concept an Environmental Impact Study will be required.

Impacts during construction are expected to be minimal as the existing weir structure is located in a developed, urban setting. A Construction Environmental Management Plan (CEMP) will be prepared prior to commencing any construction activities. The CEMP will outline procedures for mitigating impacts including sediment erosion control, avoidance of pH leaching from concrete, and methods to avoid increased turbidity during the installation and removal of temporary construction diversions. In-situ water quality monitoring during construction will play a key role in mitigating short-term impacts.

The scale of upstream environmental impacts of the proposed developments will be largely dependent on the change (if any) to the height of the weir. Increasing the height of the weir will cause an increase in the water level upstream of the weir, and will have a backwater effect raising water levels for a considerable distance upstream. With the existing weir structure the average water level at the weir (the water level at MAD) is 473.3 m. Expected water levels at MAD for each of the design concepts are presented in the following paragraphs.

Concept 1 does not include any raise to the weir height. The addition of the VLH turbines will result in less of the river's flow passing over the weir, as a portion of the flow will be travelling through the turbines. As such, the water level when the river is flowing at MAD is expected to be 473.0 m, which is lower than the water level at MAD with the existing structure.

The raise of weir height by 1.0 m in Concept 1 will result in an increase to the height of the water level. As in the case of Concept 1, a portion of the flow will be passing through the turbines, and thus the water level is not increased by the full 1 m that the weir is raised. The water level when the river is flowing at MAD is expected to be 473.9 m, roughly a 0.6 m increase from the water level at MAD with the existing structure.

Concept 3 involves a 2.0 m raise to the weir height. The resulting water level when the river is flowing at MAD is expected to be 474.9 m. This is an increase of 1.6 m from the water level at MAD with the existing structure.

An increase of the average water level will potentially impact riparian habitats and land owners upstream. Of particular consideration will be Goose Island, located a few hundred meters upstream of the weir. Detailed analysis of environmental impacts must be completed as part of any future development studies. This will involve modelling the river system to quantify the backwater effects caused by the proposed development.

SECTION 5.0 - ENERGY GENERATION ANALYSIS

5.1 ENERGY ANALYSIS METHODOLOGY

KPL's hydroelectric energy analysis program has been used to estimate the energy generation for each of the design concepts discussed in Section 3. The analysis was completed with the following assumptions and operational guidelines.

Energy generation was calculated on a daily basis using daily flow data from WSC gauge 05HG001 from the period 1968 - 2008. Flow data from before 1968 was not used because the Gardiner Dam (completed in 1967) has caused a significant change to the annual distribution of flows at the weir. Due to gaps in the WSC data the flow record used in the energy analysis consisted of 36 complete years of daily flow data.

The portion of the daily flow available for power generation was based on the operational scheme described in Section 3.6. Flow required for the fish bypass channel, the aesthetic flow over the weir, and the recreational whitewater park flow were subtracted from the available river flow as appropriate. The operational rating curves described in Section 3.6 were used to determine the head available for the river flow in the daily flow record. Diverting flow for a potential whitewater park development is estimated to have an effect of less than 1% on the average annual energy generation of the proposed hydropower projects.

Head losses associated with flow through trashracks and flow through submerged openings to the pit turbines (where applicable) were calculated for each design concept. The head losses were subtracted from the available head for each daily flow data point.

Generating equipment efficiency curves were obtained from turbine manufacturers and efficiencies were applied in calculating the power generated for each daily flow. Operating limits of the machinery including minimum operable flows and minimum operable heads were used to define the operating range of the generating equipment. A transformer efficiency of 99.5% was assumed in all power calculations.

Finally, unscheduled outage losses were subtracted from the daily energy generation. Unscheduled outages were estimated at 3% of the generation based on KPL's industry experience and surveys of long-term operating plant statistics. Average station usage has been estimated in the energy analysis at 150 kW, and has been subtracted from the daily energy generation. Transmission losses have not been considered in the energy analysis.

5.2 POWER AND ENERGY GENERATION ESTIMATE

Power and energy were calculated on a daily basis from a 36 year flow record of the South Saskatchewan River as described in Section 5.1. Average monthly power output is shown on Figures 5.1, 5.2, and 5.3 for Concepts 1, 2, and 3 respectively. Monthly energy generation is summarized for the entire 36 year record in Tables 5.1, 5.2, and 5.3. Installed capacity ranges from 2.8 MW to 8.4 MW for the three project concepts. The average annual energy generation ranges from 17 GWh to 48 GWh for the three concepts.

SECTION 6.0 - COST ESTIMATES AND FINANCIAL ANALYSIS

6.1 COST ESTIMATES

Costs for each of the three design concepts have been estimated based on a combination of KPL's industry experience, feedback from contractors, and quotations from suppliers. We have extensive experience with small hydroelectric project construction, having completed detailed design and construction monitoring on six such projects in the past year, with another three projects currently in construction. This experience and our relationships with contractors provide a solid basis for estimating unit rates and equipment costs.

Significant machinery costs were estimated by obtaining quotations from suppliers. Andritz, Voith, and VLH Turbines provided budget-level quotations for water-to-wire equipment supply. These quotations are included in Appendix B.

Capital cost estimates for Concepts 1, 2 and 3 are shown in Tables 6.1, 6.2, and 6.3 respectively. The cost of a pedestrian bridge over the weir is shown in the tables as an optional addition, but is not included in the total costs. The pedestrian bridge, including the required piers, railings, and a maintenance hoist is estimated to cost $2,840,000.

The capital costs associated with the whitewater park developments are summarized in Table 6.4. This table shows construction costs both with the adjacent hydroelectric development (assuming coincident construction periods) and without an adjacent hydroelectric development. These costs do not account for the addition of amenities (change-rooms, boathouse, etc.) or any slope remediation works that may be required.

6.2 FINANCIAL ANALYSIS

A basic financial estimate has been completed for each of the project concepts. The analyses consider the projects as independent investments, calculating the selling price required to reach a fixed internal rate of return (IRR) over a 50 year project life. The assumptions used in the analyses are summarized below:

- Annual Operating and Maintenance (O&M) costs of $500,000
- Annual inflation of 3% applied to O&M costs and electricity selling price
- Required overall IRR = 8%, and
- 50 year project life.

Taxes, debt financing, and interest have not been considered in the financial analysis. Results of the analysis are summarized in Table 6.5. The table compares required electricity rates for all combinations of hydropower development concepts with and without a pedestrian bridge, both with and without each whitewater park concept. Financial analyses for the whitewater parks as stand-alone projects (without an adjacent hydropower project) have not been completed due to uncertainties in the financial impacts of their development.

SECTION 7.0 - DEVELOPMENT SCHEDULE

A preliminary development schedule has been prepared to show a possible timeline for development of a hydroelectric project at the Saskatoon Weir. The development schedule includes periods for public consultation, environmental impact studies, provincial environmental assessments, feasibility level engineering studies, detailed design, and construction. Time periods for these events have been estimated based on KPL experience with similar projects.

The preliminary development schedule is shown on Figure 7.1. Note that the schedule has not been prepared for a specific project concept, rather the schedule is intended to show the general steps involved in the development period. The schedule indicates a potential project operation date in May, 2015.

SECTION 8.0 - CONCLUSIONS AND RECOMMENDATIONS

8.1 CONCLUSIONS

The three hydroelectric development concepts presented herein appear to be feasible at this level of study. Each concept considers a different weir height, starting with the existing weir height for Concept 1 and ranging to a 2.0 m raise to the weir for Concept 3. It has been assumed herein that a 2.0 m raise to the weir is the upper limit of allowable raises due to upstream impacts to environment and private land. The design flow for each raise height was optimized based on a cost-benefit analysis. A summary of key results for each of the design concepts is presented in the table below:

Development	Design Flow (m^3/s)	Installed Capacity (MW)	Mean Annual Energy (GWh)	Capital Cost (Million $)	Required Electricity Rate ($/kWh)
Concept 1	167	2.8	16.5	26.3	0.12
Concept 2	209	5.5	31.2	48.8	0.10
Concept 3	250	8.4	47.5	57.9	0.08

As shown in the table, increases in the weir height result in greater energy production and increased financial viability of the project.

Other key findings of this report include:

- Previous geotechnical studies in the region (not part of this study) indicate that good foundation conditions can be expected at site however slope stability will require particular consideration in design.
- The site is in an area of very low seismic hazard.
- Permafrost should not be encountered at site however river ice is common and will require consideration during design.
- VLH turbines, a prototype turbine technology, appear to be appropriate for a development with no raise to the weir height.
- Pit turbines can be used with an increase to the available head however they are not well suited to a development without a raise to the weir height.
- Inflatable rubber weirs are the preferred technology for raising weir height while maintaining water level control due to their low initial costs, low operation and maintenance costs, and their resilience to ice-affected waters.
- An improved fish navigation channel can be included as part of any of the development concepts if it is determined necessary to satisfy social, environmental, and regulatory requirements.
- A recreational whitewater park at the weir can be developed at an estimated cost of $2,950,000 for Option A, when developed coincidentally with one of the hydropower development concepts.
- If developed with no adjacent hydropower project, construction of a recreational whitewater park is estimated to cost $11,970,000 for Option A.
- A pedestrian bridge across the weir with a maintenance hoist can be added at an estimated cost of $2,840,000.
- A preliminary development schedule indicates that the hydropower development could be operational in December, 2015.

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8.2 RECOMMENDATIONS

If SL&P and other key stakeholders decide to continue with development of the proposed hydroelectric project, the following steps are recommended:

- Full Feasibility Study, including:
  - Geotechnical Investigations, and
  - Fluvial Geomorphologic Studies of the upstream and downstream effects of the proposed development.
  - Optimization studies and determination of the preferred weir height raise, if any.
  - Feasibility Level Engineering, including:
    - Detailed Drawings
    - Detailed Cost Estimate
    - Detailed Development and Construction Schedule
    - Updated Hydrological and Energy Estimates
    - Detailed Financial Analysis, and
    - Conclusions and Recommendations.
- Full Environmental Impact Assessment, including:
  - 2010 Baseline Environmental Studies
  - Initiate Environmental Assessment and Permitting Process
  - Ongoing Stakeholder and First Nations Consultation, and
  - Preparation of Environmental Impact Statement.

The recreational white water park presents an opportunity for creating an asset for the people of Saskatoon and the surrounding region. The social, cultural, recreational, and tourism-related value of the whitewater park should be considered in assessing its feasibility as an addition to the hydroelectric development.

SECTION 9.0 - REFERENCES

Fraser, R., Deschenes, C., O'Neil, C. "VLH: Development of a new turbine for Very Low Head sites", Waterpower XV Proceedings: 2007.

Gordon, J.L. "Kaplan and propeller turbine setting", Water Power and Dam Construction: May 1989.

Gordon, J.L. "Hydraulic turbine efficiency", Canadian Journal of Civil Engineering, Vol. 28, p. 238-253: 2001.

Horner, R.B. (1983) "Earthquakes in Saskatchewan: a potential hazard to the potash industry. Proceedings of the 1st International Potash Technology Conference, Potash '83, p.185-191.

P. Machibroda Engineering Ltd., October 1996, "Preliminary Geotechnical Investigation and Slope Stability Study – North East Water Supply Main – Saskatoon, Saskatchewan" (PMEL FILE NO. S95-2244).

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Tuthill, A.M. "Performance Survey of Inflatable Dams in Ice-Affected Waters", Ice Engineering (Publication of the U.S. Army Cold Regions Research and Engineering Laboratory), Number 30: October 2001.

United States Bureau of Reclamation, "Design of Small Dams", Second Edition, p. 376-382: 1973.

SECTION 10.0 - CERTIFICATION

This report was prepared, reviewed and approved by the undersigned.

Prepared:

Josh Vines, E.I.T.
Project Engineer

Reviewed:

Sam Mottram, P.Eng.
Manager, Hydropower

Approved:

for.

Jeremy P. Haile, P.Eng.
Principal

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TABLE 2.1

SASKATOON LIGHT & POWER
HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES
ENGINEERING PRE-FEASIBILITY REPORT

MONTHLY FLOW DATA - WSC STATION 05HG001 (m^3/s)

Print: 1/27/10 10:41

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1968	366.4	138.0	152.1	49.3	36.2	39.0	42.0	55.9	49.1	171.9	224.5	242.2	**130.9**
1969	370.8	387.7	356.7	306.8	312.1	306.1	757.6	230.8	184.1	202.8	270.4	341.9	**336.0**
1970	370.8	326.0	197.2	134.0	129.9	191.1	193.4	184.1	148.2	224.0	222.1	324.8	**220.1**
1971	347.7	377.4	314.6	259.5	236.8	348.8	140.5	81.3	84.5	129.7	245.2	326.1	**240.0**
1972	321.3	307.8	358.1	309.5	200.7	305.8	453.3	325.0	241.1	214.9	256.6	346.4	**303.6**
1973	377.5	374.2	227.5	108.4	90.8	142.9	134.2	115.0	174.1	182.3	221.3	328.0	**205.5**
1974	326.9	293.9	351.2	346.3	329.1	482.4	294.3	217.8	194.5	151.5	209.3	271.1	**288.8**
1975	317.8	316.1	229.0	156.3	204.5	567.6	396.3	149.5	116.2	211.5	270.6	303.2	**269.4**
1976	357.0	318.9	263.1	179.8	81.1	80.2	77.5	215.0	215.8	229.9	211.9	327.4	**213.0**
1977	354.4	264.4	125.9	74.4	50.2	52.2	49.5	49.2	47.4	52.7	159.8	216.0	**124.0**
1978	219.4	175.1	182.9	141.0	55.8	242.6	166.5	133.2	236.5	229.5	226.5	237.6	**187.1**
1979	357.8	383.5	303.6	139.1	159.8	196.4	73.2	77.4	51.2	124.2	161.6	193.2	**184.0**
1980	240.6	343.7	186.1	111.0	68.1	151.6	140.6	59.5	97.9	168.6	255.5	267.4	**173.5**
1981	318.1	293.3	179.8	177.2	127.3	492.5	383.6	490.8	271.7	226.6	244.3	231.5	**286.2**
1982	353.8	318.0	249.7	190.7	99.2	57.6	62.4	104.2	120.4	162.8	206.3	276.2	**182.8**
1983	333.4	322.2	217.3	136.7	127.5	68.1	71.3	83.3	113.2	144.6	136.3	232.4	**164.8**
1984	200.9	112.1	95.4	80.2	51.6	54.9	50.5	51.5	53.4	47.9	112.7	103.6	**84.5**
1985	102.6	112.9	56.8	76.0	117.3	69.6	48.2	49.8	47.5	51.8	144.8	221.7	**91.5**
1986	248.3	250.5	187.1	71.4	76.2	216.5	168.7	190.9	148.6	316.6	271.1	274.4	**201.6**
1992	231.5	260.6	162.4	74.5	52.6	47.9	49.2	56.8	111.2	138.5	242.6	221.2	**136.9**
1993	254.3	153.6	76.5	95.4	138.8	189.3	662.1	576.6	446.0	388.2	350.5	250.5	**300.0**
1994	327.6	340.4	256.9	230.5	232.7	98.3	84.6	108.7	119.1	109.6	169.0	229.4	**191.4**
1995	262.0	233.6	178.9	105.5	84.0	539.8	611.5	342.7	253.7	276.6	298.7	260.1	**287.6**
1996	335.6	318.6	272.6	273.2	395.8	316.6	275.8	176.8	191.0	242.6	250.8	270.7	**276.7**
1997	361.5	268.9	278.2	240.7	367.0	380.4	203.0	127.3	100.3	192.2	212.7	217.5	**245.7**
1998	240.9	238.4	143.6	88.2	95.4	201.5	630.1	212.1	145.1	141.1	195.7	216.7	**212.8**
1999	302.6	300.9	250.9	128.7	99.6	108.4	109.1	214.7	199.4	192.9	213.9	238.2	**196.1**
2000	258.7	288.0	221.1	146.0	121.3	106.6	101.5	99.3	96.5	97.7	162.2	205.9	**158.4**
2001	206.3	152.5	97.8	80.1	66.8	64.7	58.4	61.4	66.2	71.2	120.2	145.8	**99.0**
2002	136.1	86.8	67.9	55.1	49.8	212.2	281.9	135.2	138.2	170.0	260.2	230.2	**152.3**
2003	224.1	247.3	218.4	183.0	302.7	349.0	162.3	202.5	112.4	111.5	172.0	183.5	**205.4**
2004	205.8	149.0	89.7	84.7	67.9	63.3	63.3	63.3	59.8	101.0	236.4	242.5	**118.8**
2005	240.9	273.0	238.5	141.5	140.5	835.5	660.7	238.2	449.2	419.2	369.3	253.5	**354.7**
2006	333.5	384.8	343.8	232.8	241.6	323.1	221.8	149.1	122.1	127.7	197.4	239.3	**242.2**
2007	239.3	243.4	276.1	188.0	312.8	406.2	279.9	161.4	150.3	147.8	198.4	224.0	**235.6**
2008	275.3	268.1	157.4	90.9	115.3	355.7	315.9	183.2	178.9	211.6	209.7	199.8	**213.2**
Average	**286.7**	**267.3**	**210.1**	**152.4**	**151.1**	**240.7**	**235.4**	**165.9**	**153.7**	**177.3**	**219.7**	**247.1**	**208.7**
Maximum	**377.5**	**387.7**	**358.1**	**346.3**	**395.8**	**835.5**	**757.6**	**576.6**	**449.2**	**419.2**	**369.3**	**346.4**	**354.7**
Minimum	**102.6**	**86.8**	**56.8**	**49.3**	**36.2**	**39.0**	**42.0**	**49.2**	**47.4**	**47.9**	**112.7**	**103.6**	**84.5**

M:\1\03\00198\02\A\Data\Hydrology\[Daily flows.xls]Monthly Flow Table

NOTES:
1. DATA OBTAINED FROM ENVIRONMENT CANADA.
2. ONLY DATA COLLECTED AFTER COMPLETION OF GARDINER DAM (1967) SHOWN ABOVE.
3. YEARS WITH MISSING DATA HAVE BEEN REMOVED FROM THE RECORD.

0	21DEC'09	ISSUED WITH REPORT VA103-198/2-2	AMD	JWV	SRM
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 2.2

SASKATOON LIGHT & POWER
HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES
ENGINEERING PRE-FEASIBILITY REPORT

INSTANTANEOUS PEAK FLOW ESTIMATES - SOUTH SASKATCHEWAN RIVER

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Location	Area (km^2)	Peak Instantaneous Flows (m^3/s)						
		2 Year	10 Year	25 Year	50 Year	100 Year	200 Year	500 Year
South Saskatchewan River at Saskatoon	151,000	400	1100	1500	2000	2500	3200	4200

M:\1\03\00198\02\A\Data\Hydrology\[Saskaton Weir Rating - SWA.xls]Sheet1

NOTES:

1. DATA PROVIDED VIA EMAIL FROM SASKATCHEWAN WATERSHED AUTHORITY
2. PEAK FLOW ESTIMATES INCLUDE THE REGULATION CAPACITY OF GARDINER DAM.

0	21DEC'09	ISSUED WITH REPORT VA103-198/2-2	JWV	SRM	JPH
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

TABLE 2.3

SASKATON LIGHT & POWER
HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES
ENGINEERING PRE-FEASIBILITY REPORT

SUMMARY OF PROBABILISTIC SEISMIC HAZARD ANALYSIS

Print Jan/26/10 16:22 AM

Return Period (Years)	Probability of Exceedance[1] (%)	Maximum Acceleration[2] (g)
100	39	0.01
475	10	0.02
1000	5	0.04
2475	2	0.06

M:\1\03\00198\02\A\Data\Seismicity\[South Saskatchewan River Hydro - Preliminary Seismic Hazard Analysis rA.XLS]Seismic Hazard Table 1 rA

NOTES:

1. PROBABILITY OF EXCEEDANCE CALCULATED FOR A DESIGN OPERATING LIFE OF 50 YEARS.

$$q = 1 - \exp(-L/T)$$

WHERE, q = PROBABILITY OF EXCEEDANCE
L = DESIGN LIFE IN YEARS
T = RETURN PERIOD IN YEARS

2. MAXIMUM ACCELERATIONS ARE FOR VALUES ON VERY DENSE SOIL OR SOFT ROCK, (SITE CLASS C, AS DEFINED BY THE NATIONAL BUILDING CODE OF CANADA, 2005).
3. MAXIMUM ACCELERATIONS ARE MEDIAN VALUES PROVIDED BY THE NATURAL RESOURCES CANADA SEISMIC HAZARD DATABASE.

0	21DEC'09	ISSUED FOR REPORT VA103-198/2-2	GRG	JWV	JPH
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 4.1

SASKATOON LIGHT & POWER
HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES
ENGINEERING PRE-FEASIBILITY STUDIES

STAKEHOLDERS CONSULTED DURING PUBLIC CONSULTATION MEETINGS

Print Jan/26/10 16:28:27

Wednesday, June 17 (AM)	
Organization	**Representatives**
Canoe Kayak Canada	Viki Cirkvenic
Canoe Kayak Saskatchewan	Jimmy MacDonald
Kelsey Kayak Club	Al Peterson
Saskatoon Lions Club	Harvey Dickson
Saskatchewan Parks & Recreation Association Physical Activity Network of Saskatchewan	Joni Hagen
Saskatchewan Underwater Council	Cliff Lange or Cliff Adolf
Saskatoon Water Ski Club	Bob Porat
Saskatoon Canoe Club	To be advised
Saskatoon Racing Canoe Club	Lee Fuller
Saskatoon Sports Council	Mark Korthuis
Whitewater Park Proposal Committee	Kent Gray, Gregg Cochlan, Al Peterson
Wednesday, June 17 (PM)	
Civic Department	**Representatives**
Community Services Department City of Saskatoon	David Godwin, Lisa Thibodeau (Community Consultants)
Construction Services Infrastructure Services Department City of Saskatoon	Mike Gutek Manager
Environmental Services Utility Services Department City of Saskatoon	Ryan O'Grady Project Engineer
Facilities Branch Infrastructure Services Department City of Saskatoon	Ross Johnson Branch Manager
Fire & Protective Services Department City of Saskatoon	Dan Paulsen Assistant Chief
Land Branch - Urban Design Section Community Services Department City of Saskatoon	Genevieve Russell Manager
Leisure Services Branch Community Services Department City of Saskatoon	Dylan Czarnecki Open Space Consultant
Parks Branch Infrastructure Services Department City of Saskatoon	Kim Berge Superintendent Parks Maintenance North West District
Police Services City of Saskatoon	Tracy Shepherd Community Liaison Officer - East Division
Water & Sewer Section Public Works Branch Infrastructure Services Department City of Saskatoon	Wade Gasmo Manager
Thursday, June 18 (AM)	
Organization	**Representatives**
CP Rail	Chi Fong
Ducks Unlimited Canada	Barb Hanbidge
Environment Canada Canadian Wildlife Service	To be advised
Fisheries and Oceans Canada	Jackie Lukey
Innovation Place	Lorne Vinish
Meewasin Valley Authority	Brenda Wallace
PotashCorp	Gerry McNab
Saskatchewan Ministry of Environment	Tom Maher
Saskatchewan Watershed Authority	Tim Hrynkiw, Frank Fox
University of Saskatchewan	James Cook, Ron Cruikshank, David Prout
Thursday, June 18 (PM)	
Organization	**Representatives**
Greater Saskatoon Chamber of Commerce	Kent Smith-Windsor, Jamie McIntyre
Municipal Heritage Advisory Committee	Marlene Hall
The Partnership Saskatoon Downtown Business Improvement District	Terry Scaddan
Pelican Watch Saskatoon	Liz Philips
Saskatchewan Environmental Society	Allyson Brady, Alina Siegfried
Saskatoon Heritage Society	Lenore Swystun, Joe Kuchta, Georginia Chartier, Larry Buhr
Saskatoon Nature Society	Robert Johanson, Jan Shadick
Shearwater River Cruises	Peter Kingsmill
Tourism Saskatoon	Randy Fernets
University of Saskatchewan	Paul Rogal
Urban Playground Saskatoon	Nicole Martini
We are Many	Ellen Quigley

M:\1\03\00198\02\A\Data\Public Consultation\[Stakeholder List.xls]Table

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	21DEC'09	ISSUED WITH REPORT VA103-198/2-2	KF	JWV	SRM

TABLE 5.1

SASKATOON LIGHT & POWER
HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES
ENGINEERING PRE-FEASIBILITY REPORT

CONCEPT 1 - NO WEIR RAISE - MONTHLY ENERGY PRODUCTION IN GWh

Print Mar/09/10 10:05:23

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1968	1.23	1.44	1.66	0.46	0.10	0.18	0.22	0.43	0.34	1.43	1.73	1.69	10.91
1969	1.56	1.38	1.59	1.63	1.66	1.58	0.64	1.79	1.73	1.87	1.70	1.62	18.76
1970	1.56	1.49	1.68	1.44	1.32	1.34	1.76	1.54	1.37	1.85	1.63	1.66	18.65
1971	1.61	1.40	1.68	1.50	1.76	1.54	1.34	0.79	0.80	1.45	1.67	1.65	17.18
1972	1.66	1.58	1.59	1.63	1.75	1.61	1.17	1.63	1.71	1.82	1.74	1.60	19.49
1973	1.55	1.41	1.65	1.14	0.89	1.39	1.37	1.18	1.36	1.66	1.74	1.65	16.99
1974	1.65	1.55	1.60	1.56	1.62	1.09	1.68	1.78	1.69	1.63	1.73	1.76	19.36
1975	1.67	1.51	1.82	1.62	1.59	1.17	1.49	1.51	1.15	1.78	1.70	1.70	18.72
1976	1.59	1.56	1.76	1.61	0.75	0.75	0.74	1.36	1.71	1.78	1.74	1.65	17.00
1977	1.60	1.60	1.33	0.81	0.36	0.38	0.35	0.35	0.31	0.55	1.50	1.83	10.98
1978	1.82	1.58	1.81	1.47	0.44	1.44	1.59	1.34	1.52	1.74	1.75	1.83	18.33
1979	1.59	1.39	1.70	1.48	1.22	1.36	0.68	0.72	0.37	1.38	1.68	1.83	15.40
1980	1.78	1.52	1.63	1.18	0.61	1.04	1.21	0.49	0.94	1.70	1.74	1.77	15.61
1981	1.67	1.55	1.70	1.58	0.63	1.28	1.52	0.99	1.68	1.83	1.74	1.82	17.99
1982	1.60	1.51	1.80	1.62	1.00	0.45	0.54	1.05	1.20	1.76	1.71	1.75	16.00
1983	1.64	1.50	1.82	1.47	1.28	0.59	0.66	0.80	1.12	1.56	1.44	1.83	15.72
1984	1.84	1.20	1.09	0.87	0.38	0.42	0.37	0.38	0.40	0.49	1.18	1.19	9.81
1985	1.17	1.16	0.61	0.84	1.20	0.59	0.33	0.36	0.31	0.54	1.25	1.84	10.21
1986	1.80	1.62	1.62	0.77	0.70	1.71	1.34	1.63	1.46	1.66	1.71	1.76	17.79
1992	1.81	1.67	1.52	0.81	0.40	0.32	0.35	0.46	1.09	1.46	1.76	1.84	13.47
1993	1.79	1.45	0.86	1.06	1.42	1.47	0.68	1.07	1.36	1.53	1.55	1.80	16.04
1994	1.65	1.47	1.79	1.77	1.73	0.95	0.82	1.10	1.15	1.24	1.52	1.82	17.03
1995	1.78	1.63	1.64	1.16	0.80	1.12	0.72	1.60	1.71	1.75	1.65	1.78	17.34
1996	1.64	1.56	1.75	1.70	1.50	1.59	1.73	1.66	1.67	1.81	1.74	1.77	20.11
1997	1.58	1.60	1.75	1.70	1.55	1.48	1.69	1.28	0.98	1.85	1.80	1.84	19.10
1998	1.81	1.65	1.36	0.98	0.95	1.47	0.77	1.80	1.42	1.50	1.77	1.82	17.31
1999	1.70	1.54	1.79	1.35	1.01	1.06	1.09	1.76	1.71	1.86	1.74	1.81	18.41
2000	1.79	1.62	1.84	1.54	1.24	1.04	1.02	1.00	0.94	1.12	1.51	1.83	16.49
2001	1.80	1.48	1.12	0.88	0.60	0.55	0.48	0.52	0.57	0.80	1.32	1.61	11.72
2002	1.51	0.90	0.76	0.57	0.36	1.07	1.68	1.38	1.37	1.72	1.73	1.82	14.85
2003	1.84	1.63	1.85	1.68	1.68	1.54	1.58	1.81	1.11	1.27	1.67	1.82	19.47
2004	1.86	1.49	1.03	0.92	0.61	0.53	0.55	0.55	0.49	1.13	1.76	1.81	12.72
2005	1.82	1.59	1.82	1.37	1.43	0.46	0.90	1.72	0.99	1.47	1.52	1.78	16.87
2006	1.64	1.39	1.62	1.69	1.75	1.58	1.76	1.51	1.20	1.43	1.72	1.82	19.11
2007	1.82	1.64	1.75	1.68	1.64	1.43	1.70	1.61	1.48	1.62	1.74	1.84	19.97
2008	1.75	1.65	1.62	1.00	0.93	1.52	1.65	1.71	1.56	1.85	1.81	1.83	18.90
Average	1.67	1.50	1.56	1.29	1.08	1.09	1.06	1.19	1.17	1.50	1.65	1.75	16.49
Maximum	1.86	1.67	1.85	1.77	1.76	1.71	1.76	1.81	1.73	1.87	1.81	1.84	20.11
Minimum	1.17	0.90	0.61	0.46	0.10	0.18	0.22	0.35	0.31	0.49	1.18	1.19	9.81

M:\1\03\00198\02\A\Data\Energy\VLH Turbine Energy\0.8 x MAD\[Energy Model_Saskatoon_0 m Raise.xls]Energy Summary

NOTES:

1. MAD = 208.7 M3/S, QD =167.0 M3/S, INSTALLED CAPACITY = 2.8 MW.
2. FLOW THROUGH FISH HABITAT CHANNEL = 2.0 M3/S.
3. A MINIMUM OF 8.0 M3/S FLOW OVER WEIR ENSURED FOR AESTHETIC EFFECT.
4. FLOW THROUGH WHITEWATER PARK = 10 M3/S DAILY AVERAGE FOR MAY THROUGH SEPTEMBER.
   WHITEWATER PARK ASSUMED CLOSED OCTOBER THROUGH APRIL.
5. MINIMUM TURBINABLE FLOW = 16.8 M3/S.
6. VALUES SHOWN INCLUDE A 3% DEDUCTION FOR UNSCHEDULED OUTAGES.
7. TRANSFORMER EFFICIENCY TAKEN AS 99.5%.
8. STATION USAGE ESTIMATED AT 150 KW.
9. ENERGY VALUES CALCULATED USING DAILY FLOW DATA FROM WSC STATION 05HG001.
   YEARS WITH MISSING DATA HAVE BEEN EXCLUDED FROM ANALYSIS.

0	22DEC'09	ISSUED WITH REPORT VA103-198/2-2	JWV	SRM	JPH
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 5.2

SASKATOON LIGHT & POWER
HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES
ENGINEERING PRE-FEASIBILITY REPORT

CONCEPT 2 - 1.0 m WEIR RAISE - MONTHLY ENERGY PRODUCTION IN GWh

Print Jan/27/10 7:57:33

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1968	1.30	2.49	2.90	0.71	0.08	0.06	0.22	0.61	0.52	2.78	3.49	3.47	18.64
1969	3.10	2.00	2.93	2.80	3.66	3.43	0.93	3.60	3.11	3.64	3.64	3.55	36.39
1970	3.35	3.34	3.21	2.49	2.28	2.57	3.32	3.01	2.47	3.81	3.27	3.68	36.80
1971	3.64	2.95	3.70	3.08	3.67	2.13	2.40	1.34	1.36	2.51	3.50	3.53	33.80
1972	3.41	3.49	3.28	3.44	3.34	3.52	1.76	2.82	3.52	3.55	3.71	2.93	38.75
1973	3.17	2.82	3.28	1.99	1.52	2.43	2.37	2.02	2.50	3.08	3.52	3.04	31.75
1974	3.69	3.40	3.47	3.12	3.61	0.81	3.05	3.43	3.17	2.88	3.43	3.81	37.88
1975	3.72	3.36	3.73	2.86	3.04	1.86	0.69	2.64	1.98	3.52	3.63	3.64	34.67
1976	3.57	3.47	3.68	3.01	1.29	1.27	1.26	2.21	3.36	3.60	3.48	3.63	33.85
1977	3.48	3.38	2.36	1.38	0.57	0.65	0.59	0.58	0.51	0.93	2.81	3.57	20.81
1978	3.54	2.90	3.33	2.59	0.69	2.28	2.89	2.34	2.68	3.51	3.54	3.84	34.13
1979	3.02	2.43	3.67	2.58	2.32	2.71	1.17	1.23	0.63	2.38	2.96	3.49	28.57
1980	3.62	3.42	3.13	2.06	1.04	2.03	2.25	0.85	1.62	3.13	3.71	3.80	30.65
1981	3.69	3.34	3.22	3.00	0.87	0.35	1.51	0.21	3.60	3.69	3.57	3.76	30.82
1982	3.11	3.35	3.79	3.13	1.70	0.78	0.92	1.81	2.06	3.08	3.33	3.80	30.86
1983	3.67	3.33	3.64	2.55	2.23	1.02	1.13	1.37	1.92	2.75	2.52	3.76	29.88
1984	3.59	2.05	1.85	1.48	0.64	0.72	0.61	0.65	0.69	0.80	2.06	2.02	17.16
1985	2.00	1.99	1.04	1.41	2.06	0.94	0.54	0.61	0.53	0.92	2.40	3.68	18.12
1986	3.81	3.44	3.13	1.31	1.20	3.33	2.49	3.07	2.55	3.51	3.69	3.80	35.34
1992	3.67	3.57	2.79	1.37	0.66	0.51	0.58	0.78	1.87	2.61	3.68	3.72	25.82
1993	3.76	2.59	1.46	1.79	2.46	2.83	1.28	0.00	0.10	2.76	3.32	3.83	26.20
1994	3.68	3.30	3.80	3.62	3.51	1.63	1.40	1.89	1.99	2.13	2.88	3.74	33.57
1995	3.80	3.33	3.12	1.98	1.38	1.15	0.34	3.38	3.59	3.79	3.63	3.78	33.28
1996	3.67	3.47	3.73	3.62	1.30	2.28	3.73	3.03	3.18	3.81	3.64	3.81	39.29
1997	3.13	3.45	3.80	3.44	3.23	2.34	3.19	2.23	1.67	3.50	3.60	3.71	37.28
1998	3.79	3.44	2.50	1.66	1.63	2.60	0.81	3.54	2.48	2.68	3.38	3.67	32.15
1999	3.74	3.39	3.74	2.37	1.71	1.82	1.88	3.41	3.26	3.50	3.41	3.73	35.97
2000	3.81	3.53	3.76	2.69	2.14	1.78	1.75	1.71	1.60	1.90	2.82	3.61	31.12
2001	3.55	2.61	1.90	1.49	1.02	0.95	0.82	0.90	0.97	1.35	2.26	2.80	20.62
2002	2.62	1.52	1.28	0.97	0.54	1.16	2.71	2.40	2.38	3.15	3.69	3.70	26.11
2003	3.74	3.45	3.75	3.14	3.45	3.01	2.81	3.46	1.90	2.18	3.07	3.37	37.32
2004	3.66	2.63	1.74	1.57	1.05	0.91	0.94	0.94	0.84	1.93	3.68	3.80	23.67
2005	3.84	3.44	3.73	2.50	2.49	0.76	0.99	3.35	1.29	1.59	3.09	3.69	30.75
2006	3.55	2.82	3.63	3.35	3.66	1.99	3.35	2.63	2.07	2.47	3.33	3.84	36.69
2007	3.84	3.47	3.79	3.09	2.62	0.85	2.74	2.85	2.58	2.83	3.34	3.75	35.74
2008	3.80	3.56	2.90	1.70	1.70	2.54	3.67	3.15	2.96	3.72	3.60	3.52	36.82
Average	3.45	3.07	3.08	2.37	1.95	1.72	1.75	2.06	2.04	2.78	3.30	3.58	31.15
Maximum	3.84	3.57	3.80	3.62	3.67	3.52	3.73	3.60	3.60	3.81	3.71	3.84	39.29
Minimum	1.30	1.52	1.04	0.71	0.08	0.06	0.22	0.00	0.10	0.80	2.06	2.02	17.16

M:\1\03\00198\02\A\Data\Energy\Pit Turbine Energy\1.0 x MAD\[Energy Model_Saskatoon_1.0 m Raise.xls]Energy Summary

NOTES:

1. MAD = 208.7 m^3/s, Qd =208.7 m^3/s, Installed Capacity = 5.5 MW.
2. Flow through Fish Habitat Channel = 2.0 m^3/s.
3. A minimum of 8.0 m3/s flow over weir ensured for aesthetic effect.
4. Flow through Whitewater Park = 10 m^3/s daily average for May through September. Whitewater Park assumed closed October through April.
5. Minimum turbinable flow = 24.3 m^3/s.
6. Values shown include a 3% deduction for unscheduled outages.
7. Transformer efficiency taken as 99.5%.
8. Station usage estimated at 150 kW.
9. Energy values calculated using daily flow data from WSC Station 05HG001. Years with missing data have been excluded from analysis.

0	22DEC'09	ISSUED WITH REPORT VA103-198/2-2	JWV	SRM	JPH
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 5.3

SASKATOON LIGHT & POWER
HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES
ENGINEERING PRE-FEASIBILITY REPORT

CONCEPT 3 - 2.0 m WEIR RAISE - MONTHLY ENERGY PRODUCTION IN GWh

Print Jan/27/10 14:38:28

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1968	3.92	3.28	3.83	0.72	0.00	0.00	0.07	0.52	0.32	3.96	5.03	5.08	26.73
1969	5.84	5.25	5.85	5.32	5.72	5.32	2.31	5.17	4.15	4.93	5.54	5.88	61.30
1970	5.85	5.32	4.50	3.27	3.01	3.66	4.47	4.16	3.29	5.33	4.76	5.89	53.52
1971	5.86	5.27	5.85	4.73	5.30	5.58	3.21	1.74	1.77	3.29	5.26	5.89	53.75
1972	5.88	5.50	5.86	5.50	4.60	5.48	4.29	5.64	5.08	5.02	5.62	5.69	64.15
1973	5.83	5.27	4.81	2.62	1.99	3.21	3.11	2.64	3.48	4.25	5.03	5.86	48.10
1974	5.91	5.34	5.87	5.67	5.77	4.22	5.34	4.84	4.33	3.81	4.84	5.86	61.80
1975	5.91	5.35	5.37	3.79	4.30	4.31	5.57	3.49	2.58	4.95	5.53	5.82	56.98
1976	5.87	5.54	5.49	4.16	1.59	1.66	1.63	4.05	4.72	5.20	4.90	5.85	50.67
1977	5.86	5.09	3.14	1.78	0.41	0.62	0.40	0.43	0.14	1.20	3.79	5.03	27.88
1978	5.02	3.91	4.50	3.42	0.80	4.45	3.87	3.09	4.46	5.13	5.07	5.53	49.25
1979	5.79	5.26	5.81	3.40	3.31	3.95	1.51	1.59	0.68	3.13	3.92	4.72	43.08
1980	5.23	5.51	4.43	2.69	1.34	2.94	3.12	1.09	2.10	4.18	5.62	5.82	44.08
1981	5.91	5.15	4.39	4.14	1.60	5.19	5.79	3.89	5.44	5.25	5.26	5.43	57.43
1982	5.85	5.29	5.63	4.42	2.22	1.00	1.18	2.35	2.69	4.08	4.69	5.89	45.30
1983	5.90	5.31	5.13	3.34	2.93	1.32	1.46	1.78	2.51	3.64	3.33	5.40	42.06
1984	4.88	2.67	2.41	1.91	0.61	0.89	0.58	0.67	0.81	0.98	2.72	2.63	21.76
1985	2.61	2.60	1.33	1.83	2.69	1.10	0.35	0.50	0.26	1.18	3.27	5.16	22.87
1986	5.59	5.03	4.41	1.69	1.55	4.71	3.49	4.28	3.37	5.71	5.71	5.91	51.46
1992	5.32	5.41	3.86	1.78	0.71	0.24	0.42	0.87	2.45	3.46	5.40	5.24	35.16
1993	5.61	3.46	1.90	2.33	3.24	4.01	2.45	4.44	5.48	5.81	5.64	5.74	50.13
1994	5.85	5.32	5.70	5.21	5.10	2.13	1.83	2.46	2.62	2.78	3.95	5.38	48.32
1995	5.76	4.80	4.33	2.58	1.80	3.88	2.96	5.85	5.30	5.78	5.68	5.71	54.44
1996	5.90	5.52	5.61	5.51	5.77	5.41	5.72	4.09	4.28	5.58	5.44	5.93	64.76
1997	5.85	5.35	5.91	5.07	5.81	5.61	4.41	2.93	2.18	4.71	4.95	5.19	57.98
1998	5.57	5.01	3.45	2.15	2.12	3.99	2.87	4.85	3.27	3.54	4.61	5.16	46.62
1999	5.86	5.35	5.56	3.12	2.24	2.38	2.46	4.81	4.44	4.73	4.83	5.48	51.26
2000	5.78	5.52	5.26	3.55	2.80	2.33	2.28	2.22	2.09	2.47	3.84	4.97	43.12
2001	4.95	3.46	2.48	1.94	1.32	1.22	1.05	1.15	1.26	1.75	2.96	3.69	27.20
2002	3.44	1.97	1.66	1.25	0.47	3.23	5.28	3.15	3.13	4.21	5.56	5.32	38.67
2003	5.30	5.11	5.21	4.30	5.75	5.65	3.77	4.67	2.48	2.83	4.11	4.52	53.71
2004	4.98	3.49	2.26	2.04	1.33	1.17	1.21	1.21	1.08	2.53	5.35	5.56	32.19
2005	5.60	5.30	5.43	3.37	3.28	1.23	3.50	4.83	3.73	5.76	5.65	5.52	53.20
2006	5.86	5.26	5.89	4.85	5.33	5.31	4.82	3.48	2.72	3.24	4.59	5.58	56.91
2007	5.59	5.11	5.83	4.23	5.66	5.56	5.28	3.77	3.40	3.73	4.63	5.31	58.11
2008	5.85	5.44	3.89	2.21	2.35	5.58	5.80	4.24	3.98	5.10	4.90	4.83	54.18
Average	5.46	4.80	4.52	3.33	2.91	3.29	3.00	3.08	2.95	3.98	4.78	5.35	47.45
Maximum	5.91	5.54	5.91	5.67	5.81	5.65	5.80	5.85	5.48	5.81	5.71	5.93	64.76
Minimum	2.61	1.97	1.33	0.72	0.00	0.00	0.07	0.43	0.14	0.98	2.72	2.63	21.76

M:\1\03\00198\02\A\Data\Energy\Pit Turbine Energy\1.2 x MAD\[Energy Model_Saskatoon_2.0 m Raise.xls]Energy Summary

NOTES:

1. MAD = 208.7 M3/S, QD =250.4 M3/S, INSTALLED CAPACITY = 8.4 MW.
2. FLOW THROUGH FISH HABITAT CHANNEL = 2.0 M3/S.
3. A MINIMUM OF 8.0 M3/S FLOW OVER WEIR ENSURED FOR AESTHETIC EFFECT AND UV PROTECTION OF RUBBER WEIR.
4. FLOW THROUGH WHITEWATER PARK = 10 M3/S DAILY AVERAGE FOR MAY THROUGH SEPTEMBER.
   WHITEWATER PARK ASSUMED CLOSED OCTOBER THROUGH APRIL.
5. MINIMUM TURBINABLE FLOW = 29.2 M3/S.
6. VALUES SHOWN INCLUDE A 3% DEDUCTION FOR UNSCHEDULED OUTAGES.
7. TRANSFORMER EFFICIENCY TAKEN AS 99.5%.
8. STATION USAGE ESTIMATED AT 150 KW.
9. ENERGY VALUES CALCULATED USING DAILY FLOW DATA FROM WSC STATION 05HG001.
   YEARS WITH MISSING DATA HAVE BEEN EXCLUDED FROM ANALYSIS.

0	22DEC'09	ISSUED WITH REPORT VA103-198/2-2	JWV	SRM	JPH
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 6.1

SASKATOON LIGHT & POWER
HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES
ENGINEERING PRE-FEASIBILITY REPORT

CONCEPT 1 - NO WEIR RAISE - CAPITAL COST ESTIMATE

Print 2/23/10 10:00

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT RATE ($)	Amount ($)	Sub-Total
000	PRELIMINARY & GENERAL	Subtotal				$1,250,000
001	Mobilization	LS	1	150,000	150,000	
002	Bonds	LS	1	250,000	250,000	
003	Insurance	LS	1	500,000	500,000	
004	Permits	LS	1	200,000	200,000	
005	Demobilization	LS	1	150,000	150,000	
100	SITE PREPARATION AND ACCESS	Subtotal				$68,000
101	Clear and Grub Project Areas	m^2	6,000	3	18,000	
102	Temporary Construction Access Tracks	m	200	100	20,000	
103	Permanent Facility Access Road	m	100	250	25,000	
104	Facility Fencing	LS	1	5,000	5,000	
200	POWER GENERATION STRUCTURE (for 8 x VLH Turbines)	Subtotal				$5,934,000
201	Diversion Works (Single stage diversion with dewatering)	LS	1	1,000,000	1,000,000	
202	Soft Excavation	m^3	10,000	25	250,000	
203	Concrete Removal (existing weir structure removal)	m^3	1,350	500	675,000	
204	Concrete (incl. Control house foundation)	m^3	2,650	1,000	2,650,000	
205	Backfill					
	a) Structural Fill	m^3	400	60	24,000	
	b) Select Native Fill	m^3	1,500	20	30,000	
206	Rip-Rap Protection	m^3	1,800	50	90,000	
207	Grouted Rip-Rap Protection	m^3	700	150	105,000	
208	Trashracks	LS	1	80,000	80,000	
209	Stoplogs (Upstream and Downstream)	LS	1	600,000	600,000	
210	Control House Superstructure	LS	1	180,000	180,000	
211	Miscellaneous Metalwork	LS	1	40,000	40,000	
212	Mechanical (ventilation, plumbing, etc)	LS	1	60,000	60,000	
213	Electrical (wiring, heating, lighting, etc)	LS	1	100,000	100,000	
214	Slope Protection and Landscaping	LS	1	50,000	50,000	
300	POWER GENERATION (Water-to-Wire Contract)					$12,450,000
301	VLH Turbines (4500 mm runner diameter)	ea.	8	1,400,000	11,200,000	
302	Installation and Commissioning	LS	1	750,000	750,000	
303	Optional spare parts package	LS	1	500,000	500,000	
400	SWITCHYARD, TRANSMISSION AND INTERCONNECTION	Subtotal				$660,000
401	Switchyard (transformer, disconnects, breakers, civil work, etc.)	MW	2.8	200,000	560,000	
402	Overhead Transmission Line (incl. carrier)	m	200	200	40,000	
403	Interconnection Costs	LS	1	60,000	60,000	
500	FISH HABITAT CHANNEL	Subtotal				$250,000
501	Fish habitat channel, including all equipment and control	LS	1	250,000	250,000	
600	PEDESTRIAN BRIDGE OVER WEIR (Optional)	Subtotal				$0
601	Pedestrian Bridge (incl. Piers, railings, monorail hoist, etc.)	LS	0	2,840,000	0	
700	PUMPHOUSE RELOCATION	Subtotal				$365,000
701	New pumphouse construction	LS	1	250,000	250,000	
702	Equipment relocation	LS	1	15,000	15,000	
703	New equipment requirements (pipework etc)	LS	1	100,000	100,000	
	SUBTOTAL (Excluding taxes)					$20,980,000
	PST ESTIMATE (5% applied to 40% of subtotal)					$420,000
	ESTIMATED CONSTRUCTION COST (Including PST)					$21,400,000
	ENGINEERING COSTS (EPCM)	%	8			$1,710,000
	OWNERS COSTS	%	5			$1,070,000
	CONTINGENCY	%	10			$2,140,000
	TOTAL ESTIMATED CONSTRUCTION COST					**$26,320,000**

M:\1\03\00198\02\A\Data\Costs\[Saskatoon - Cost Estimates.xls]2.0 m Raise, 1.2xMAD

Installed Capacity	2.8	MW
Annual Energy	16.5	GWh
Cost Benefit Ratio	**$1,595,152**	**$/GWh**

NOTES:
1. COST ESTIMATES BASED ON INDUSTRY EXPERIENCE AND CONTACTS WITH SUPPLIERS AND CONTRACTORS
2. CAPITAL COSTS ARE CONSIDERED TO HAVE +/- 15% ACCURACY.

1	22FEB'10	ISSUED WITH REPORT VA103-198/2-2	JWV	SRM	JPH
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 6.2

SASKATOON LIGHT & POWER
HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES
ENGINEERING PRE-FEASIBILITY REPORT

CONCEPT 2 - 1.0 m WEIR RAISE - CAPITAL COST ESTIMATE

Print 2/23/10 10:00

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT RATE ($)	Amount ($)	Sub-Total
000	PRELIMINARY & GENERAL	Subtotal				$1,250,000
001	Mobilization	LS	1	150,000	150,000	
002	Bonds	LS	1	250,000	250,000	
003	Insurance	LS	1	500,000	500,000	
004	Permits	LS	1	200,000	200,000	
005	Demobilization	LS	1	150,000	150,000	
100	SITE PREPARATION AND ACCESS	Subtotal				$125,000
101	Clear and Grub Project Areas	m^2	10,000	3	30,000	
102	Temporary Construction Access Tracks	m	400	100	40,000	
103	Permanent Facility Access Road	m	100	250	25,000	
104	Facility Fencing	LS	1	30,000	30,000	
200	WEIR UPGRADES	Subtotal				$6,671,000
201	Diversion Works (incl. dewatering)	LS	1	1,900,000	1,900,000	
202	Soft Excavation	m^3	5,600	25	140,000	
203	Concrete	m^3	2,650	1,000	2,650,000	
204	Concrete Removal for Rubber Weir section	m^3	280	600	168,000	
205	Rubber Weir (2.2 m height x 55 m length x 2 spans)	LS	1	1,600,000	1,600,000	
206	Backfill					
	a) Structural Fill	m^3	1,000	60	60,000	
	b) Select Native Fill	m^3	1,900	20	38,000	
207	Rip-Rap Protection	m^3	800	50	40,000	
208	Grouted Rip-Rap Protection	m^3	500	150	75,000	
300	POWERHOUSE	Subtotal				$9,845,000
301	Diversion Works (Single stage diversion with dewatering)	LS	1	625,000	625,000	
302	Soft Excavation	m^3	42,000	25	1,050,000	
303	Concrete Removal (existing weir structure removal)	m^3	850	500	425,000	
304	Concrete	m^3	4,700	1,000	4,700,000	
305	Backfill					
	a) Structural Fill	m^3	1,500	60	90,000	
	b) Select Native Fill	m^3	2,500	20	50,000	
306	Rip-Rap Protection	m^3	3,000	50	150,000	
307	Grouted Rip-Rap Protection	m^3	800	150	120,000	
308	Trashracks	LS	1	80,000	80,000	
309	Inlet Gates (vertical slide gate)	Ea.	6	225,000	1,350,000	
310	Tailrace Stoplogs	LS	1	185,000	185,000	
311	Radial Sluice Gate (including hoist and control)	LS	1	650,000	650,000	
312	Miscellaneous Metalwork	LS	1	120,000	120,000	
313	Mechanical (ventilation, plumbing, etc)	LS	1	80,000	80,000	
314	Electrical (wiring, heating, lighting, etc)	LS	1	120,000	120,000	
315	Slope Protection and Landscaping	LS	1	50,000	50,000	
400	POWER GENERATION (Water-to-Wire Contract)					$19,440,000
401	Pit turbines, Gearboxes, Generators and TIV's	LS	1	18,000,000	18,000,000	
402	Bearings, HPU's, governors, excitation, LV Switchgear, P&C	incl.	-	-	-	
403	Installation and Commissioning	incl.	-	-	-	
404	Optional stainless steel wicket gates	LS	1	440,000	440,000	
405	Optional spare parts package	LS	1	1,000,000	1,000,000	
500	SWITCHYARD, TRANSMISSION AND INTERCONNECTION	Subtotal				$925,000
501	Switchyard (transformer, disconnects, breakers, civil work, etc.)	MW	5.5	150,000	825,000	
502	Overhead Transmission Line (incl. carrier)	m	200	200	40,000	
503	Interconnection Costs	LS	1	60,000	60,000	
600	FISH HABITAT CHANNEL	Subtotal				$250,000
601	Fish habitat channel, including all equipment and control	LS	1	250,000	250,000	
700	PEDESTRIAN BRIDGE OVER WEIR (Optional)	Subtotal				$0
701	Pedestrian Bridge (incl. Piers, railings, monorail hoist, etc.)	LS	0	2,840,000	0	
800	PUMPHOUSE RELOCATION	Subtotal				$365,000
801	New pumphouse construction	LS	1	250,000	250,000	
802	Equipment relocation	LS	1	15,000	15,000	
803	New equipment requirements (pipework etc)	LS	1	100,000	100,000	
	SUBTOTAL (Excluding taxes)					$38,870,000
	PST ESTIMATE (5% applied to 40% of subtotal)					$780,000
	ESTIMATED CONSTRUCTION COST (Including PST)					$39,650,000
	ENGINEERING COSTS (EPCM)	%	8			$3,170,000
	OWNERS COSTS	%	5			$1,980,000
	CONTINGENCY	%	10			$3,970,000
	TOTAL ESTIMATED CONSTRUCTION COST					**$48,770,000**

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Installed Capacity	5.5	MW
Annual Energy	31.2	GWh
Cost Benefit Ratio	**$1,563,141**	**$/GWh**

NOTES:
1. COST ESTIMATES BASED ON INDUSTRY EXPERIENCE AND CONTACTS WITH SUPPLIERS AND CONTRACTORS.
2. CAPITAL COSTS ARE CONSIDERED TO HAVE +/- 15% ACCURACY.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
1	22FEB'10	ISSUED WITH REPORT VA103-198/2-2	JWV	SRM	JPH

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TABLE 6.3

SASKATOON LIGHT & POWER
HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES
ENGINEERING PRE-FEASIBILITY REPORT

CONCEPT 3 - 2.0 m WEIR RAISE - CAPITAL COST ESTIMATE

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ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT RATE ($)	Amount ($)	Sub-Total
000	PRELIMINARY & GENERAL	Subtotal				$1,250,000
001	Mobilization	LS	1	150,000	150,000	
002	Bonds	LS	1	250,000	250,000	
003	Insurance	LS	1	500,000	500,000	
004	Permits	LS	1	200,000	200,000	
005	Demobilization	LS	1	150,000	150,000	
100	SITE PREPARATION AND ACCESS	Subtotal				$125,000
101	Clear and Grub Project Areas	m^2	10,000	3	30,000	
102	Temporary Construction Access Tracks	m	400	100	40,000	
103	Permanent Facility Access Road	m	100	250	25,000	
104	Facility Fencing	LS	1	30,000	30,000	
200	WEIR UPGRADES	Subtotal				$9,360,500
201	Diversion Works (incl. dewatering)	LS	1	1,900,000	1,900,000	
202	Soft Excavation	m^3	4,900	25	122,500	
203	Concrete	m^3	3,230	1,000	3,230,000	
204	Concrete Removal for Rubber Weir section	m^3	440	500	220,000	
205	Rubber Weir (3.2 m height x 43.8 m length x 4 spans)	LS	1	3,725,000	3,725,000	
206	Backfill					
	a) Structural Fill	m^3	500	60	30,000	
	b) Select Native Fill	m^3	900	20	18,000	
207	Rip-Rap Protection	m^3	800	50	40,000	
208	Grouted Rip-Rap Protection	m^3	500	150	75,000	
300	POWERHOUSE	Subtotal				$10,985,000
301	Diversion Works (Single stage diversion with dewatering)	LS	1	625,000	625,000	
302	Soft Excavation	m^3	49,000	25	1,225,000	
303	Concrete Removal (existing weir structure removal)	m^3	850	500	425,000	
304	Concrete	m^3	5,500	1,000	5,500,000	
305	Backfill					
	a) Structural Fill	m^3	1,500	60	90,000	
	b) Select Native Fill	m^3	2,500	20	50,000	
306	Rip-Rap Protection	m^3	3,000	50	150,000	
307	Grouted Rip-Rap Protection	m^3	800	150	120,000	
308	Trashracks	LS	1	80,000	80,000	
309	Inlet Gates (vertical slide gate)	Ea.	6	250,000	1,500,000	
310	Tailrace Stoplogs	LS	1	200,000	200,000	
311	Radial Sluice Gate (including hoist and control)	LS	1	650,000	650,000	
312	Miscellaneous Metalwork	LS	1	120,000	120,000	
313	Mechanical (ventilation, plumbing, etc)	LS	1	80,000	80,000	
314	Electrical (wiring, heating, lighting, etc)	LS	1	120,000	120,000	
315	Slope Protection and Landscaping	LS	1	50,000	50,000	
400	POWER GENERATION (Water-to-Wire Contract)					$22,440,000
401	Pit turbines, Gearboxes, Generators and TIV's	LS	1	21,000,000	21,000,000	
402	Bearings, HPU's, governors, excitation, LV Switchgear, P&C	incl.	-	-	-	
403	Installation and Commissioning	incl.	-	-	-	
404	Optional stainless steel wicket gates	LS	1	440,000	440,000	
405	Optional spare parts package	LS	1	1,000,000	1,000,000	
500	SWITCHYARD, TRANSMISSION AND INTERCONNECTION	Subtotal				$1,360,000
501	Switchyard (transformer, disconnects, breakers, civil work, etc.)	MW	8.4	150,000	1,260,000	
502	Overhead Transmission Line (incl. carrier)	m	200	200	40,000	
503	Interconnection Costs	LS	1	60,000	60,000	
600	FISH HABITAT CHANNEL	Subtotal				$250,000
601	Fish habitat channel, including all equipment and control	LS	1	250,000	250,000	
700	PEDESTRIAN BRIDGE OVER WEIR (Optional)	Subtotal				$0
701	Pedestrian Bridge (incl. Piers, railings, monorail hoist, etc.)	LS	0	2,840,000	0	
800	PUMPHOUSE RELOCATION	Subtotal				$365,000
801	New pumphouse construction	LS	1	250,000	250,000	
802	Equipment relocation	LS	1	15,000	15,000	
803	New equipment requirements (pipework etc)	LS	1	100,000	100,000	
	SUBTOTAL (Excluding taxes)					$46,140,000
	PST ESTIMATE (5% applied to 40% of subtotal)					$920,000
	ESTIMATED CONSTRUCTION COST (Including PST)					$47,060,000
	ENGINEERING COSTS (EPCM)	%	8			$3,760,000
	OWNERS COSTS	%	5			$2,350,000
	CONTINGENCY	%	10			$4,710,000
	TOTAL ESTIMATED CONSTRUCTION COST					**$57,880,000**

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Installed Capacity	8.4	MW
Annual Energy	47.5	GWh
Cost Benefit Ratio	**$1,218,526**	**$/GWh**

NOTES:
1. COST ESTIMATES BASED ON INDUSTRY EXPERIENCE AND CONTACTS WITH SUPPLIERS AND CONTRACTORS.
2. CAPITAL COSTS ARE CONSIDERED TO HAVE +/- 15% ACCURACY.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
1	22FEB'10	ISSUED WITH REPORT VA103-198/2-2	JWV	SRM	JPH

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TABLE 6.4

SASKATOON LIGHT & POWER
HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES
ENGINEERING PRE-FEASIBILITY REPORT

SUMMARY OF WHITEWATER PARK DEVELOPMENT COSTS

Print 2/23/10 11:26

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT RATE ($)	Amount ($)	Sub-Total
100	OPTION A - BYPASS CHANNEL ADJACENT TO POWERHOUSE[1]	Subtotal				$2,411,460
101	Mobilization / Demobilization	LS	1	50,000	50,000	
102	Water Control (diversion works)	LS	1	150,000	150,000	
103	Excavation, Structural Fill and Grading	m^3	2,475	60	148,500	
104	Retaining Wall (height 6 - 8 m, as required for left side of channel)	m	95	1,440	136,800	
105	Concrete Removal	m^3	16.8	200	3,360	
106	Concrete Retaining Walls (height 2 m, located within channel)	m	250	500	125,000	
107	HDPE Liner (placed beneath channel)	m^2	3,800	24	91,200	
108	Concrete Channel Surfacing	m^3	450	400	180,000	
109	Obermeyer Head Gate Structure	LS	1	210,000	210,000	
110	Rock Pool Armour	m^3	435	60	26,100	
111	Rock Drop Structures - Course Shaping	m^3	2,100	150	315,000	
112	Rock Terracing along bank	m	2,100	130	273,000	
113	Manufactured Obstacle System	LS	1	550,000	550,000	
114	Rock Drop Structures	m^3	450	150	67,500	
115	Landscaping Allowance	LS	1	85,000	85,000	
200	OPTION A - ADDITIONS FOR INDEPENDENT PROJECT DEVELOPMEN	Subtotal				$7,365,520
201	Mobilization / Demobilization	LS	1	100,000	100,000	
202	Access Road and Bridge over channel	LS	1	60,000	60,000	
203	Water Control (diversion works)	LS	1	400,000	400,000	
204	Excavation, Structural Fill and Grading	m^3	2,500	60	150,000	
205	Retaining Wall (height 6 - 8 m, remainder of left side of channel)	m	108	1,440	155,520	
206	Weir Raise (1 m raise as per hydropower Concept 2)[3]	LS	1	6,500,000	6,500,000	
300	OPTION B - INSTREAM WAVE FEATURE[1]	Subtotal				$2,507,680
301	Water Control (diversion work)	LS	1	650,000	650,000	
302	Retaining Wall (height 6 - 8 m, right side of wave feature)	m	225	660	148,500	
303	U-drop Structures (incl. Excavation, placing, shaping)	m^3	1,800	250	450,000	
304	Headgate / Controllable wave Structure	LS	1	750,000	750,000	
305	Fill around Drop Structure	m^3	1,500	60	90,000	
306	Rock Pool Armour	m^3	4,333	60	259,980	
307	Grout protection	m^3	360	220	79,200	
308	Landscaping Allowance	LS	1	80,000	80,000	
400	OPTIONS A + B - ADDITIONS FOR INDEPENDENT DEVELOPMENT[2]					$5,415,520
401	Mobilization / Demobilization	LS	1	150,000	150,000	
402	Access Road and Bridge over channel	LS	1	60,000	60,000	
403	Water Control (diversion works)	LS	1	400,000	400,000	
404	Excavation, Structural Fill and Grading	m^3	2,500	60	150,000	
405	Retaining Wall (height 6 - 8 m, remainder of left side of channel)	m	108	1,440	155,520	
406	Weir Raise (1 m raise as per hydropower Concept 2)[3]	LS	1	4,500,000	4,500,000	
	SUBTOTAL - OPTION A (With adjacent powerhouse)	(Item 100)				$2,411,000
	SUBTOTAL - OPTION A (Developed independently)	(Item 100 + Item 200)				$9,777,000
	SUBTOTAL - OPTIONS A + B (With adjacent powerhouse)	(Item 100 + Item 300)				$4,919,000
	SUBTOTAL - OPTIONS A + B (Developed independently)	(Item 100 + Item 300 + Item 400)				$10,335,000
	PST[4]	%	5			
	CONTINGENCY[4]	%	20			
	TOTAL CONSTRUCTION COST - OPTION A (With adjacent powerhouse)					$2,951,000
	TOTAL CONSTRUCTION COST - OPTION A (Developed independently)					$11,967,000
	TOTAL CONSTRUCTION COST - OPTIONS A + B (With adjacent powerhouse)					$6,021,000
	TOTAL CONSTRUCTION COST - OPTIONS A + B (Developed independently)					$12,650,000

M:\1\03\00198\02\A\Data\Costs\[Saskatoon - Whitewater Cost Estimates.xls]Whitewater Costs

NOTES:
1. COSTS ARE AS OUTLINED IN S20 DESIGN REPORT - APPENDIX D. COSTS ASSUME THE COINCIDENT CONSTRUCTION OF A HYDROPOWER DEVELOPMENT.
2. ADDITIONAL COSTS APPLY IF WHITEWATER PARK WERE TO BE DEVELOPED INDEPENDENTLY, WITH NO HYDROPOWER DEVELOPMENT.
3. A NOMINAL 1 M RAISE TO WEIR IS ASSUMED, THOUGH THIS IS OPTIONAL.
4. TOTAL CONSTRUCTION COST ESTIMATES INCLUDE 5% PST APPLIED TO 40% OF SUBTOTAL, PLUS A 20% CONTINGENCY AS PER S20 DESIGN REPORT.
5. COSTS FOR ADDITIONAL AMENITIES (CHANGE-ROOMS, BOATHOUSE, ETC.) OR SLOPE REMEDIATION WORK ARE NOT INCLUDED.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	19FEB'10	ISSUED WITH REPORT VA103-198/2-2	JWV	SRM	JPH

TABLE 6.5

SASKATOON LIGHT & POWER
HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES
ENGINEERING PRE-FEASIBILITY REPORT

SUMMARY OF FINANCIAL ANALYSIS

Print Feb/23/10 10:40:25

Assumptions used in Analysis	
Internal Rate of Return (IRR)	8%
Annual inflation of O&M costs and Selling Price	3%
Project Life (years)	50
Operating and Maintenance Costs (C$)	500,000

Capital Costs (C$)	
Hydropower Concept 1 (No weir raise)	26,320,000
Hydropower Concept 2 (1.0 m weir raise)	48,770,000
Hydropower Concept 3 (2.0 m weir raise)	57,880,000
Optional Pedestrian Bridge	2,840,000
Optional Whitewater Park - Option A	2,951,000
Optional Whitewater Park - Options A + B	6,021,000

Required Selling Price (C$/kWh)						
Hydropower Design	**Base Case**	**With Pedestrian Bridge**	**Whitewater Park A**	**Whitewater A with Ped. Bridge**	**Whitewater Park B**	**Whitewater B with Ped. Bridge**
Concept 1	0.118	0.128	0.128	0.138	0.138	0.148
Concept 2	0.102	0.107	0.108	0.112	0.112	0.118
Concept 3	0.078	0.081	0.081	0.084	0.084	0.088

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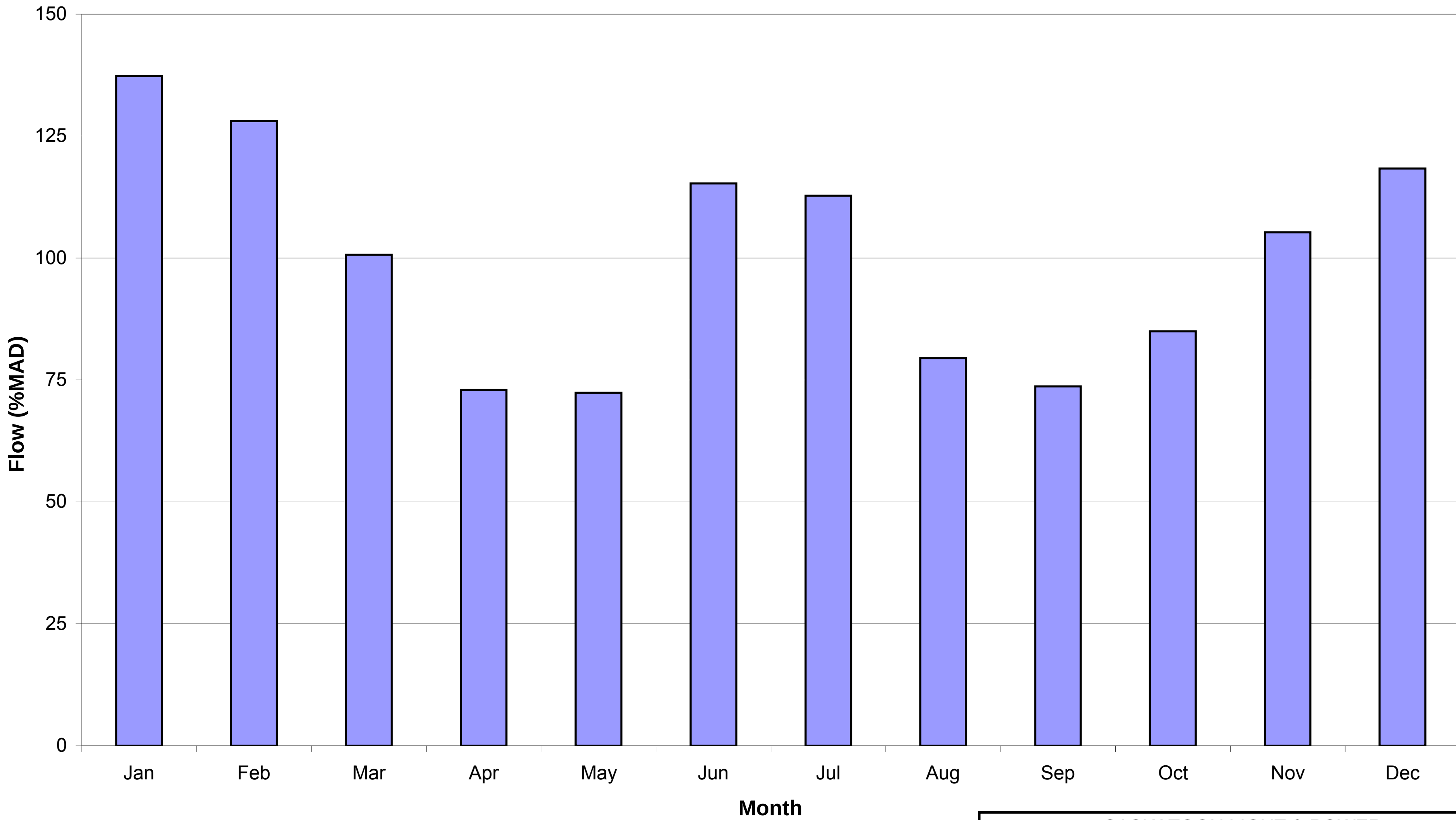
NOTES:

1. THIS FINANCIAL ANALYSIS DOES NOT CONSIDER TAX, DEBT FINANCING OR INTEREST.
2. TOURISM BENEFITS OF WHITEWATER PARK DEVELOPMENTS ARE NOT INCLUDED.
3. COSTS FOR WHITEWATER PARK OPTIONS ARE BASED ON ADJACENT CONSTRUCTION COSTS AS PRESENTED IN TABLE 6.4.

1	22FEB'10	ISSUED WITH REPORT VA103-198/2-2	JWV	SRM	JPH
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



NOTES:

1. MAD = 208.7 m^3/s
2. WSC STATION 05HG001 IS LOCATED ON THE SOUTH SASKATCHEWAN RIVER ROUGHLY 100 M UPSTREAM OF THE WEIR
3. YEARS WITH MISSING DATA WERE REMOVED FROM THE FLOW RECORD

SASKATOON LIGHT & POWER

HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES

MEAN MONTHLY FLOWS
WSC STATION 05HG001
1968-2008

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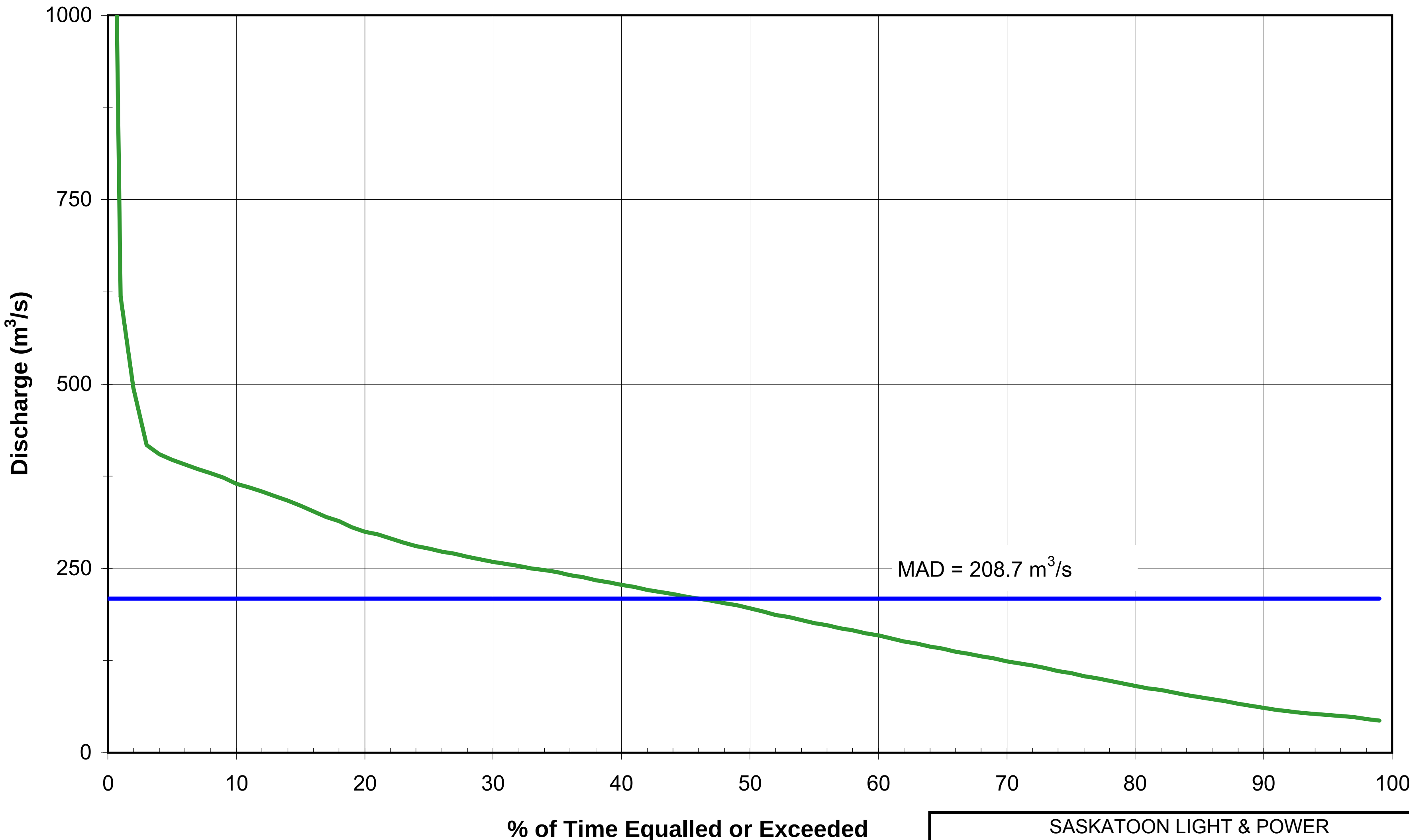
P/A NO. VA103-198/2

REF. NO. 2

FIGURE 2.1

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	21DEC'09	ISSUED WITH REPORT	AMD	JWV	SRM



NOTES:

1. WSC STATION 05HG001 IS LOCATED ON THE SOUTH SASKATCHEWAN RIVER ROUGHLY 100 m UPSTREAM OF THE WEIR.
2. YEARS WITH MISSING DATA HAVE BEEN REMOVEDFROM THE FLOW RECORD.

SASKATOON LIGHT & POWER

HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES

FLOW DURATION CURVE
WSC STATION 05HG001
1968-2008

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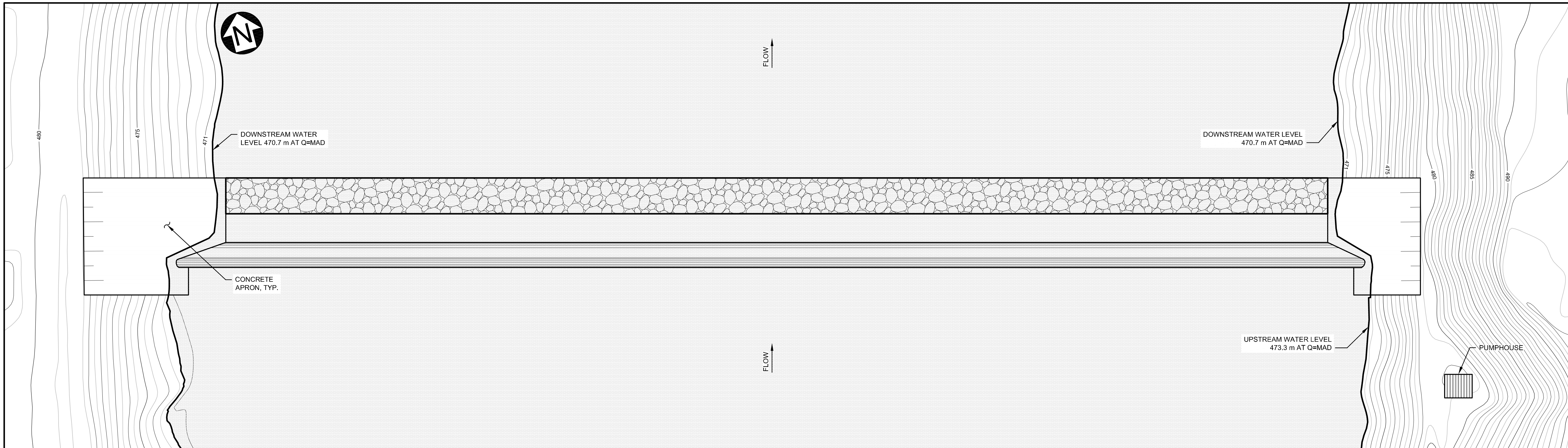
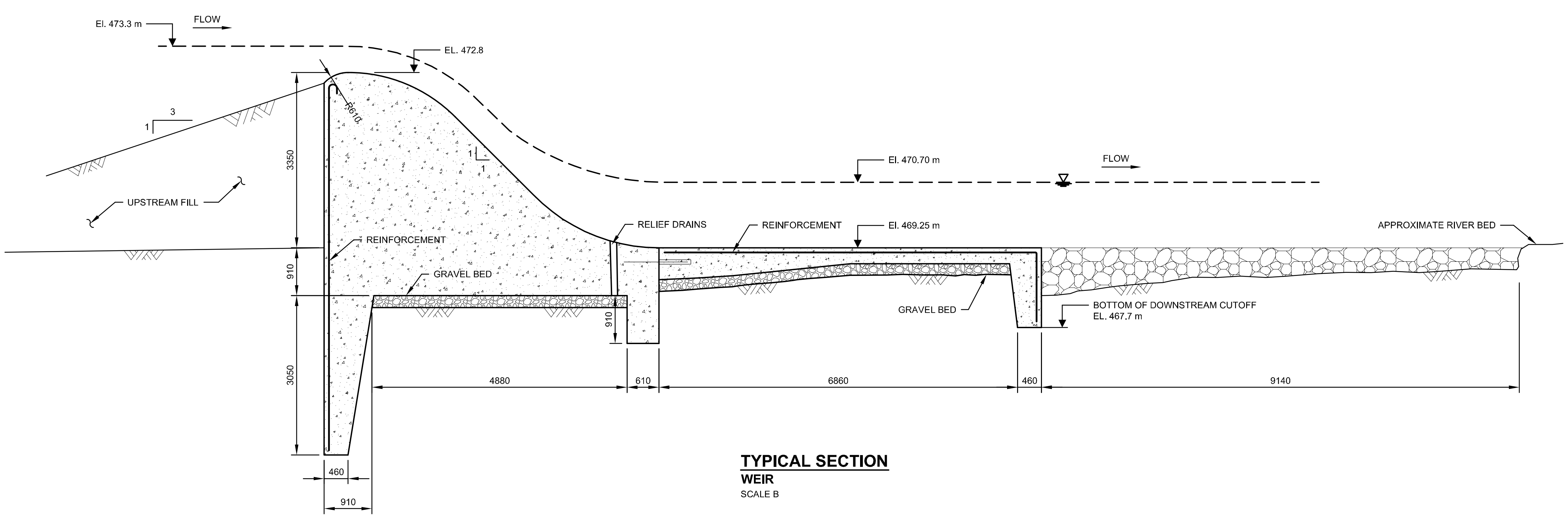
P/A NO.	REF. NO.	
VA103-198/2	2	
FIGURE 2.2		REV 0

0	21DEC'09	ISSUED WITH REPORT	AMD	JWV	SRM
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



PLAN
SCALE A



TYPICAL SECTION
WEIR
SCALE B

SCALE B 1 0.5 0 1 2 3 4 5 m
SCALE A 10 5 0 10 20 30 40 50 m

REV	DATE	DESCRIPTION	DESIGN	DRAWN	CHK'D	APP'D
0	18DEC'09	ISSUED WITH REPORT	JWV	TAM	JWV	SRM

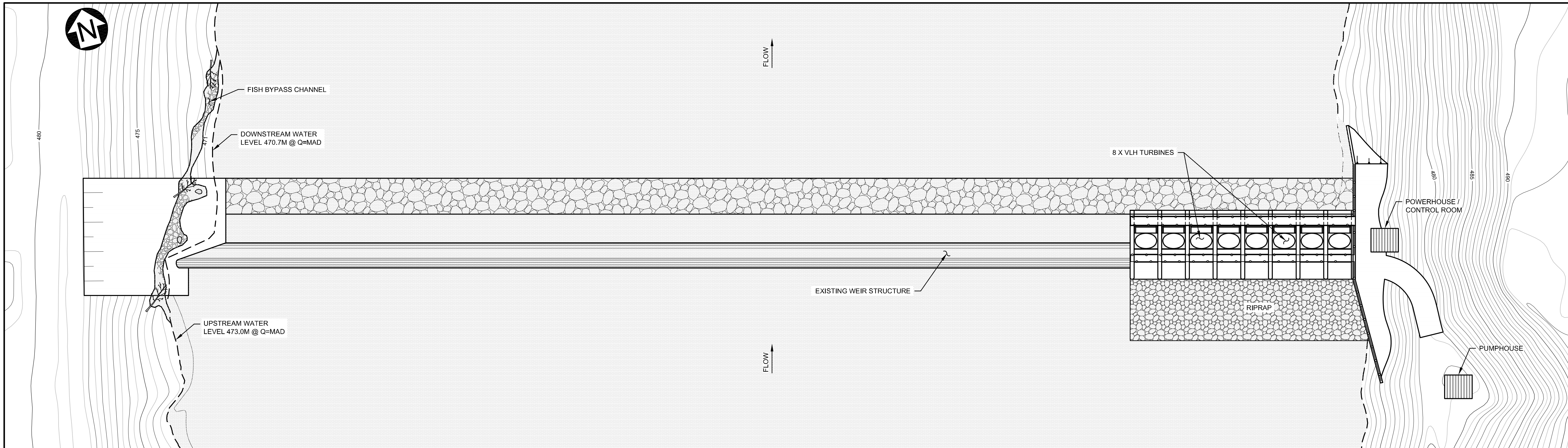
SASKATOON LIGHT & POWER

HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES

GENERAL ARRANGEMENT
EXISTING WEIR LAYOUT
PLAN AND SECTION

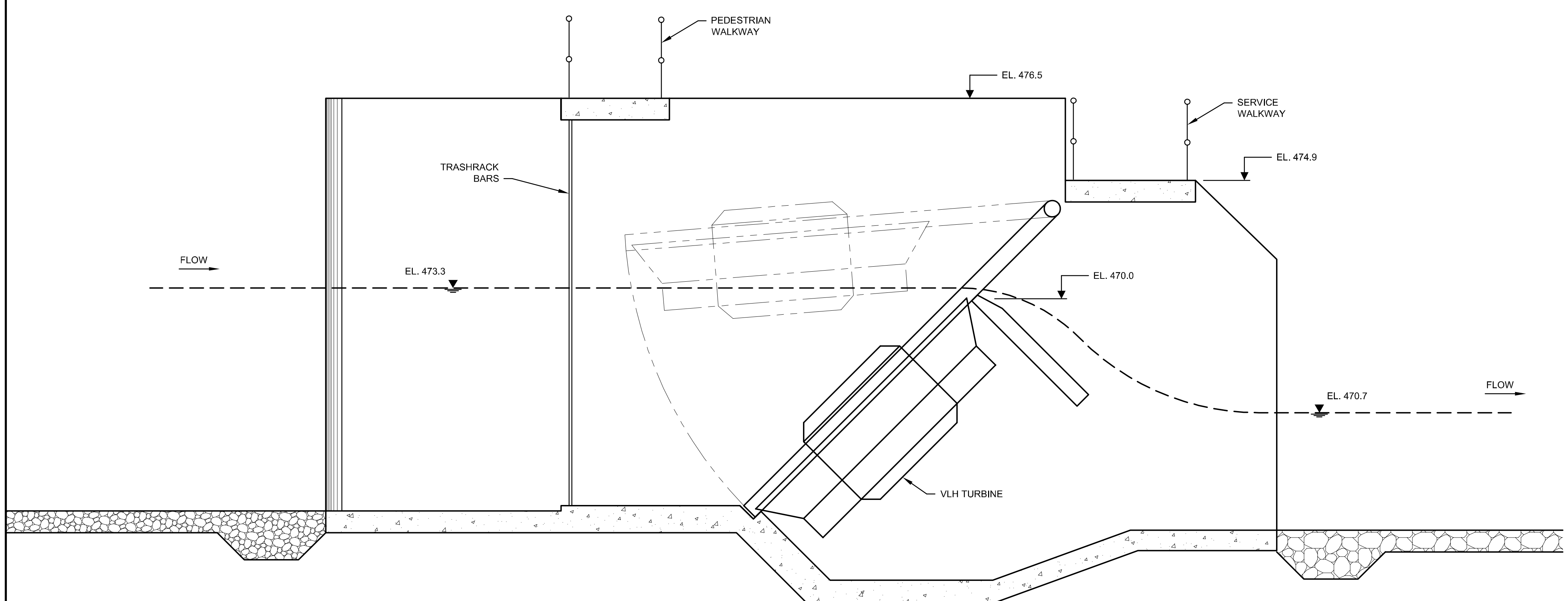
Knight Piésold CONSULTING

P/A NO. VA103-198/2
REF NO. 2
FIGURE 3.1
REV 0



PLAN

SCALE A



TYPICAL SECTION

VLH TURBINE

SCALE B

SCALE B 1 0.5 0 1 2 3 4 5 m

SCALE A 10 5 0 10 20 30 40 50 m

SASKATOON LIGHT & POWER

HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES

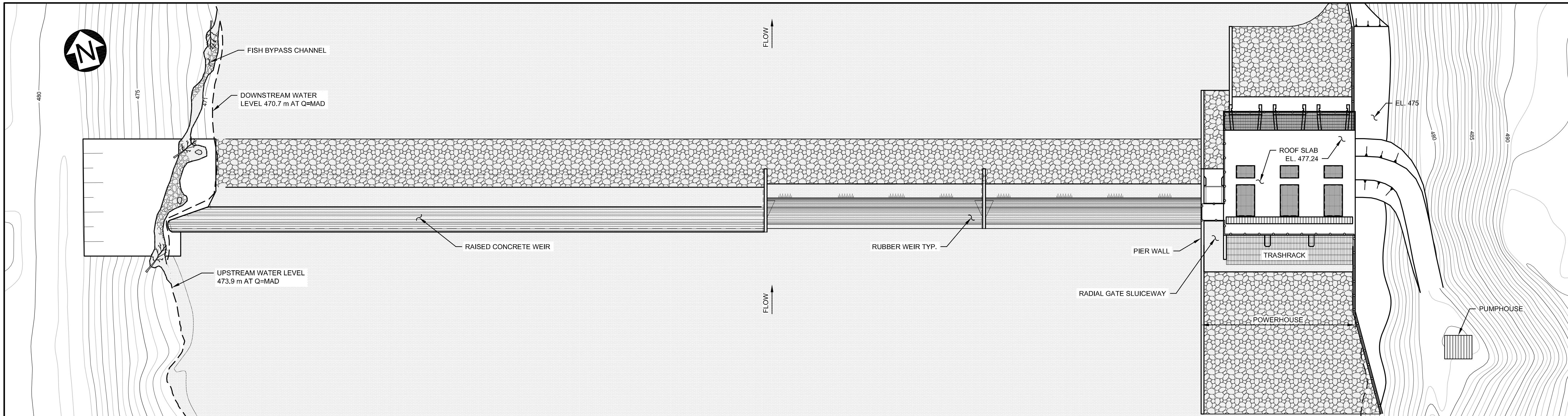
GENERAL ARRANGEMENT
CONCEPT 1 (NO WEIR RAISE)
VLH TURBINE

Knight Piésold CONSULTING

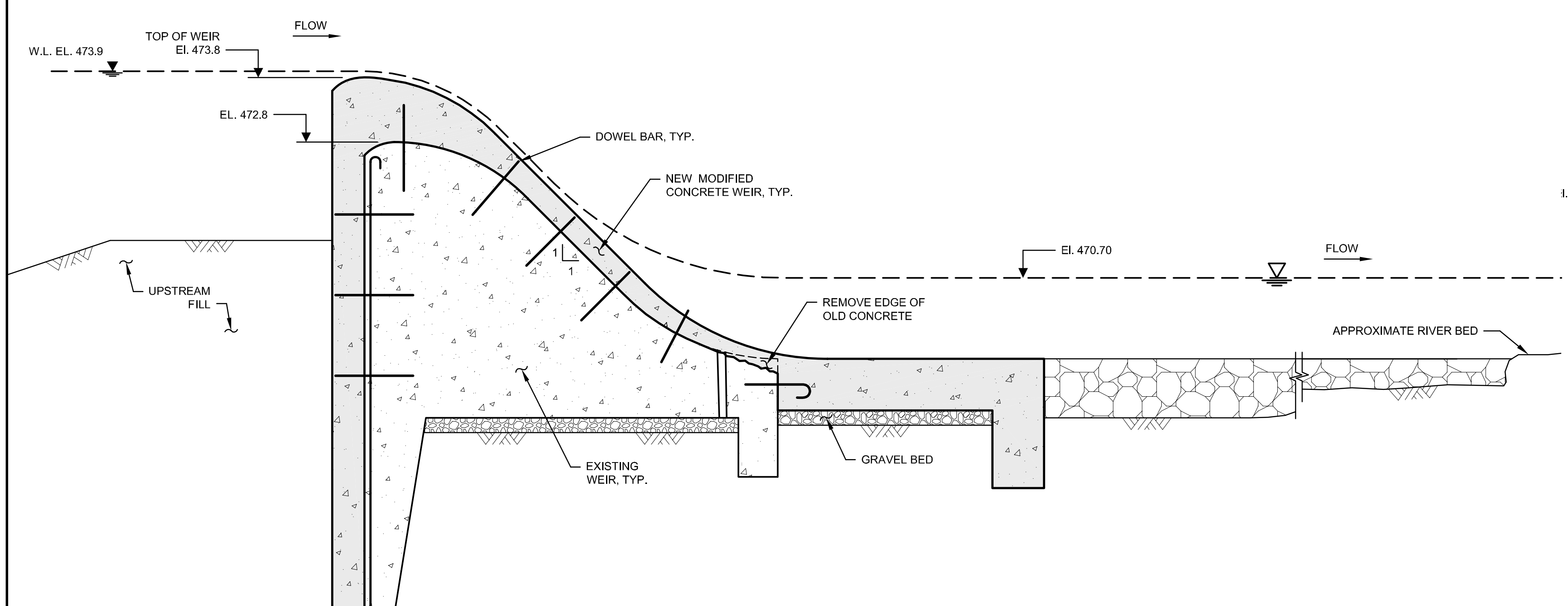
P/A NO.	REF NO.
VA103-198/2	2

FIGURE 3.2 REV 0

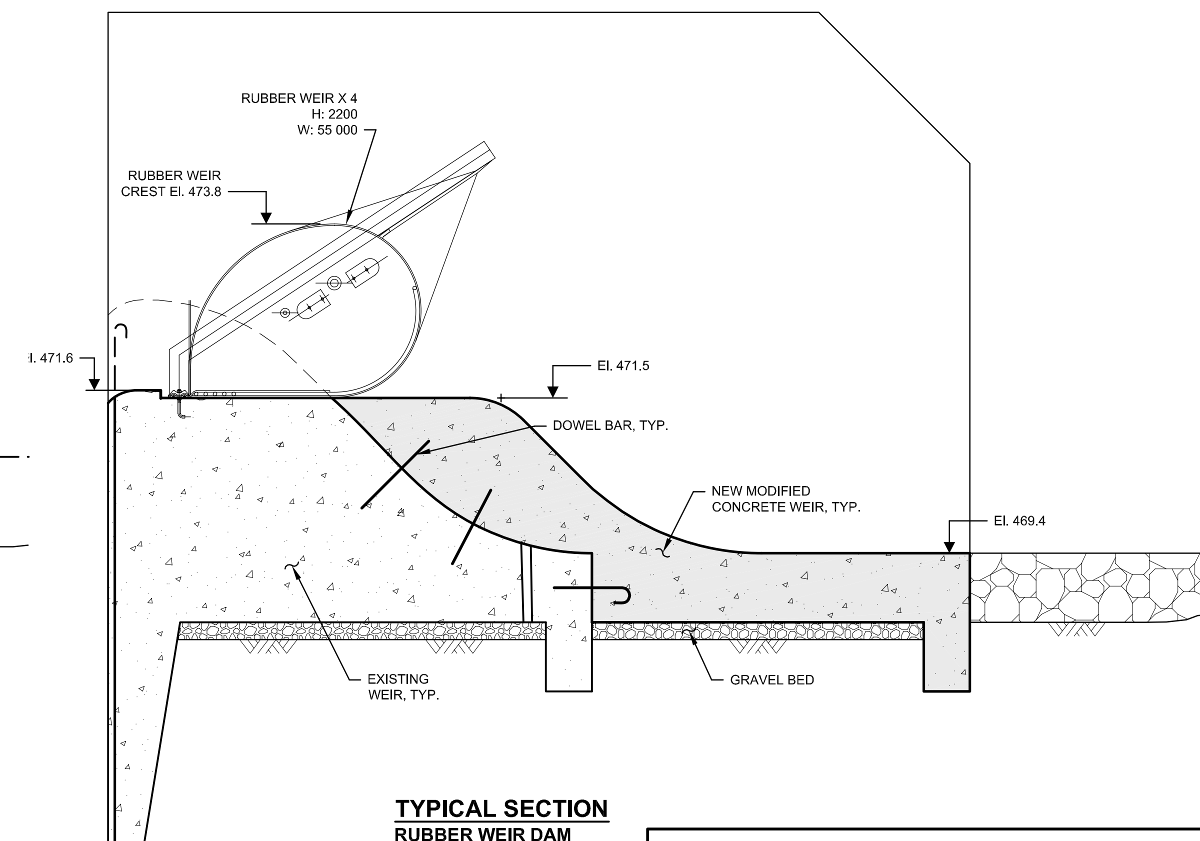
REV	DATE	DESCRIPTION	DESIGN	DRAWN	CHK'D	APP'D
0	18DEC'09	ISSUED WITH REPORT	JWV	TAM	JWV	SRM



PLAN
SCALE A



TYPICAL SECTION
WEIR
SCALE B



TYPICAL SECTION
RUBBER WEIR DAM
SCALE B

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.

SCALE B: 1 0.5 0 1 2 3 4 5 m
SCALE A: 20 10 0 20 40 60 80 100 m

REV	DATE	DESCRIPTION	DESIGN	DRAWN	CHK'D	APP'D
0	18DEC'09	ISSUED WITH REPORT	JWV	TAM	JWV	SRM

SASKATOON LIGHT & POWER

HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES

GENERAL ARRANGEMENT
CONCEPT 2 (1m WEIR RAISE)
WEIR PLAN AND SECTIONS

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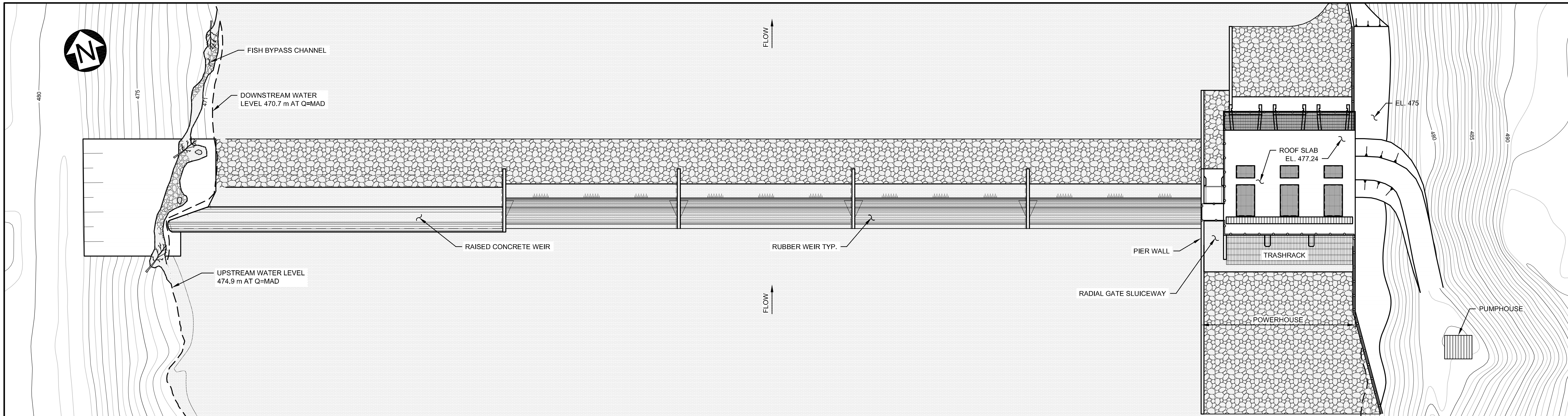
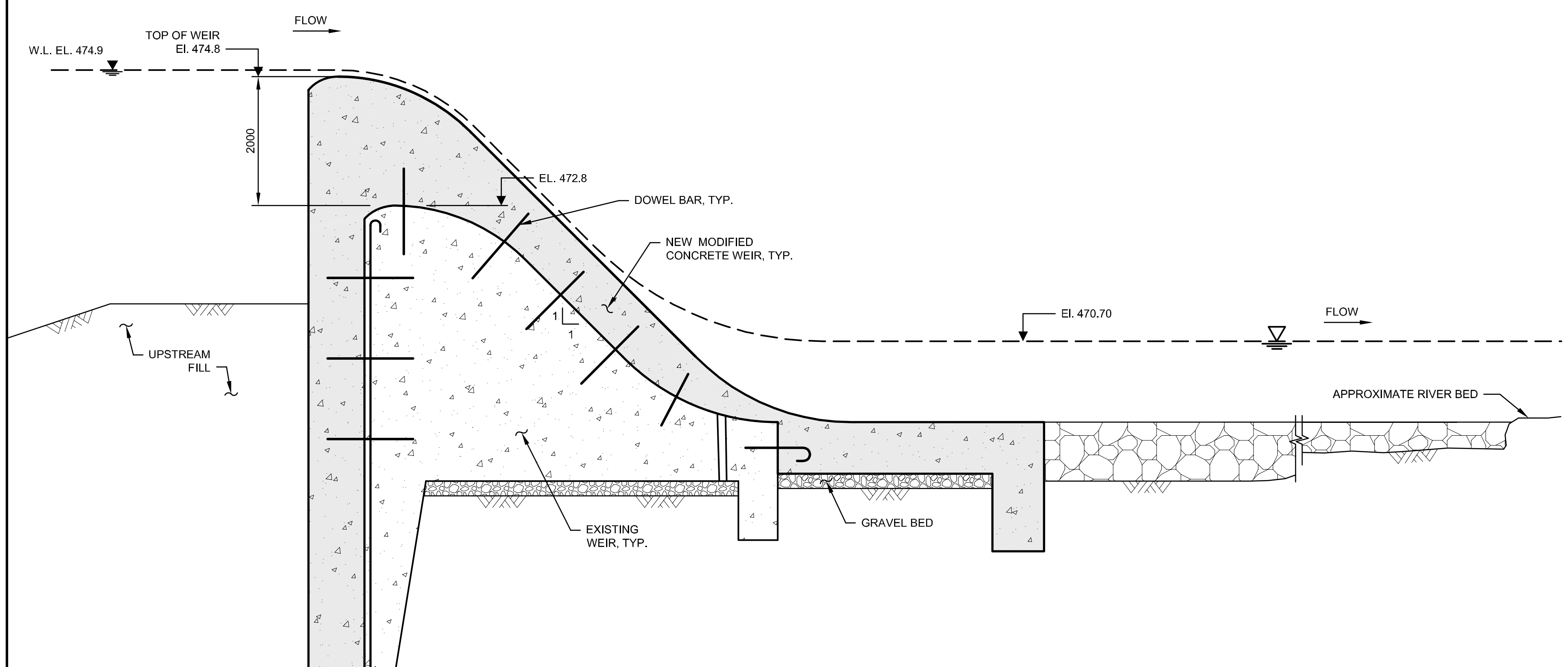
P/A NO.	REF NO.
VA103-198/2	2

FIGURE 3.3 REV 0



PLAN

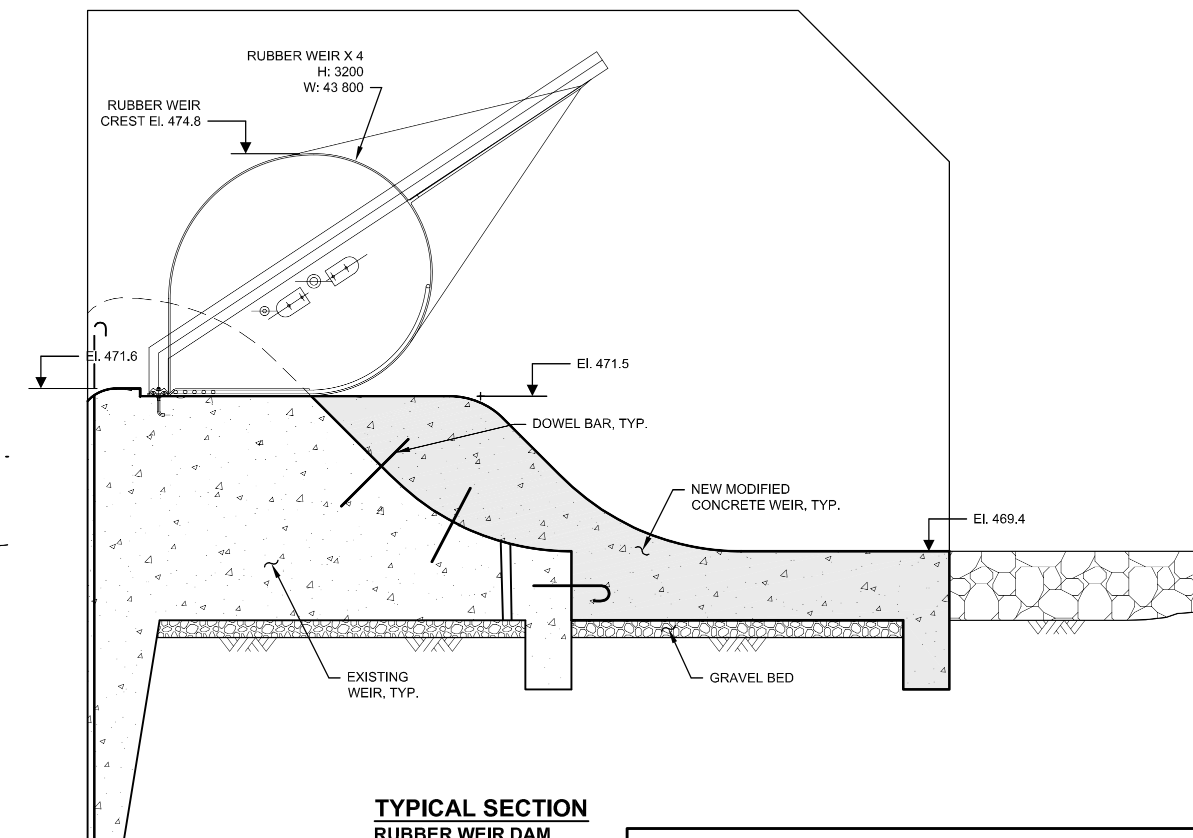
SCALE A



TYPICAL SECTION

WEIR

SCALE B



TYPICAL SECTION

RUBBER WEIR DAM

SCALE B

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.

SCALE B 1 0.5 0 1 2 3 4 5 m

SCALE A 20 10 0 20 40 60 80 100 m

REV	DATE	DESCRIPTION	DESIGN	DRAWN	CHK'D	APP'D
0	18DEC'09	ISSUED WITH REPORT	JWV	TAM	JWV	SRM

XREF FILE(S): Topo IMAGE FILE(S):

SAVED: M:\1\03\00198\02\A\Acad\Figs\002 1/26/2010 2:08:01 PM PRINTED: 1/27/2010 11:42:15 AM, 11x17_Landscape, Imacgowan VANCOUVER B.C.

SASKATOON LIGHT & POWER

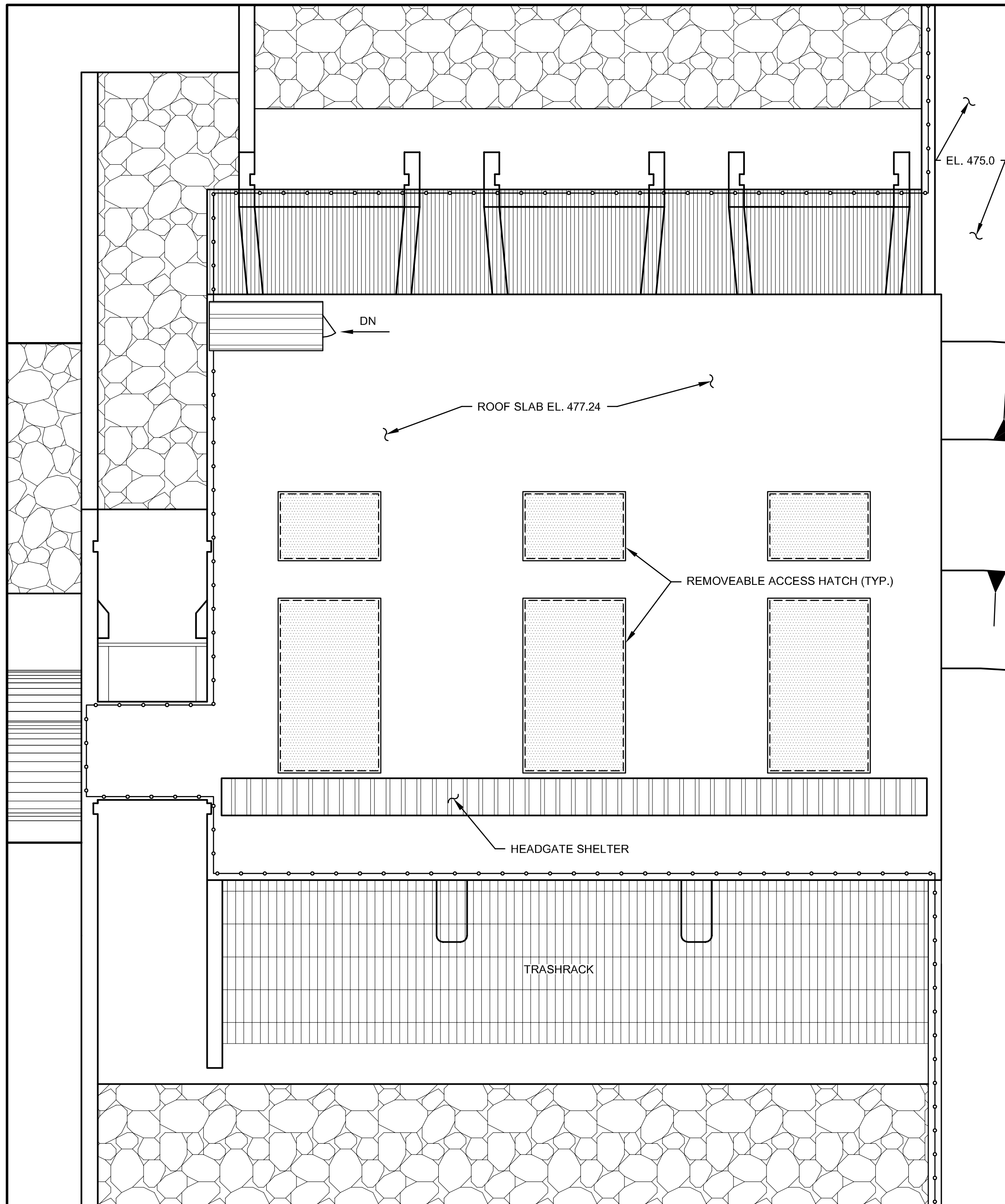
HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES

GENERAL ARRANGEMENT
CONCEPT 3 (2m WEIR RAISE)
WEIR PLAN AND SECTIONS

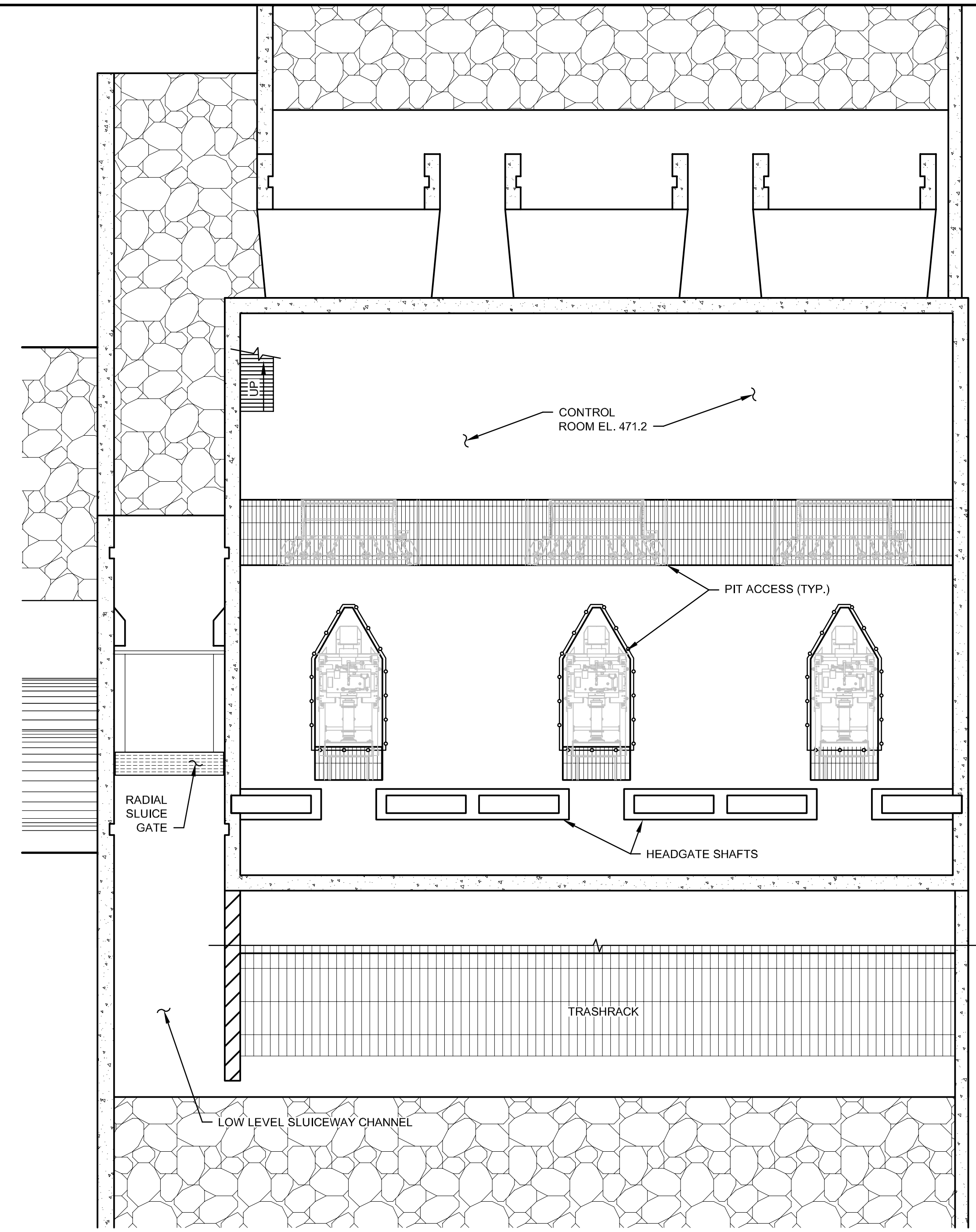
Knight Piésold CONSULTING

P/A NO.	REF NO.
VA103-198/2	2

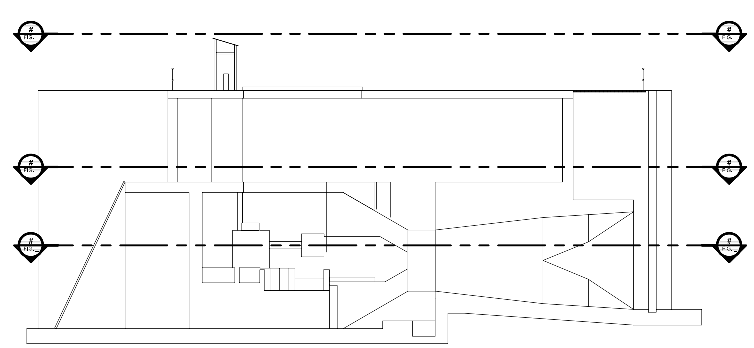
FIGURE 3.4 REV 0



ROOF SLAB PLAN
SCALE A



CONTROL ROOM PLAN
SCALE A



KEY PLAN

SCALE A 2.5 0 5 10 15 m

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES AND ALL ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.

REV	DATE	DESCRIPTION	DESIGN	DRAWN	CHK'D	APP'D
0	18DEC'09	ISSUED WITH REPORT	JWV	TAM	JWV	SRM

SASKATOON LIGHT & POWER

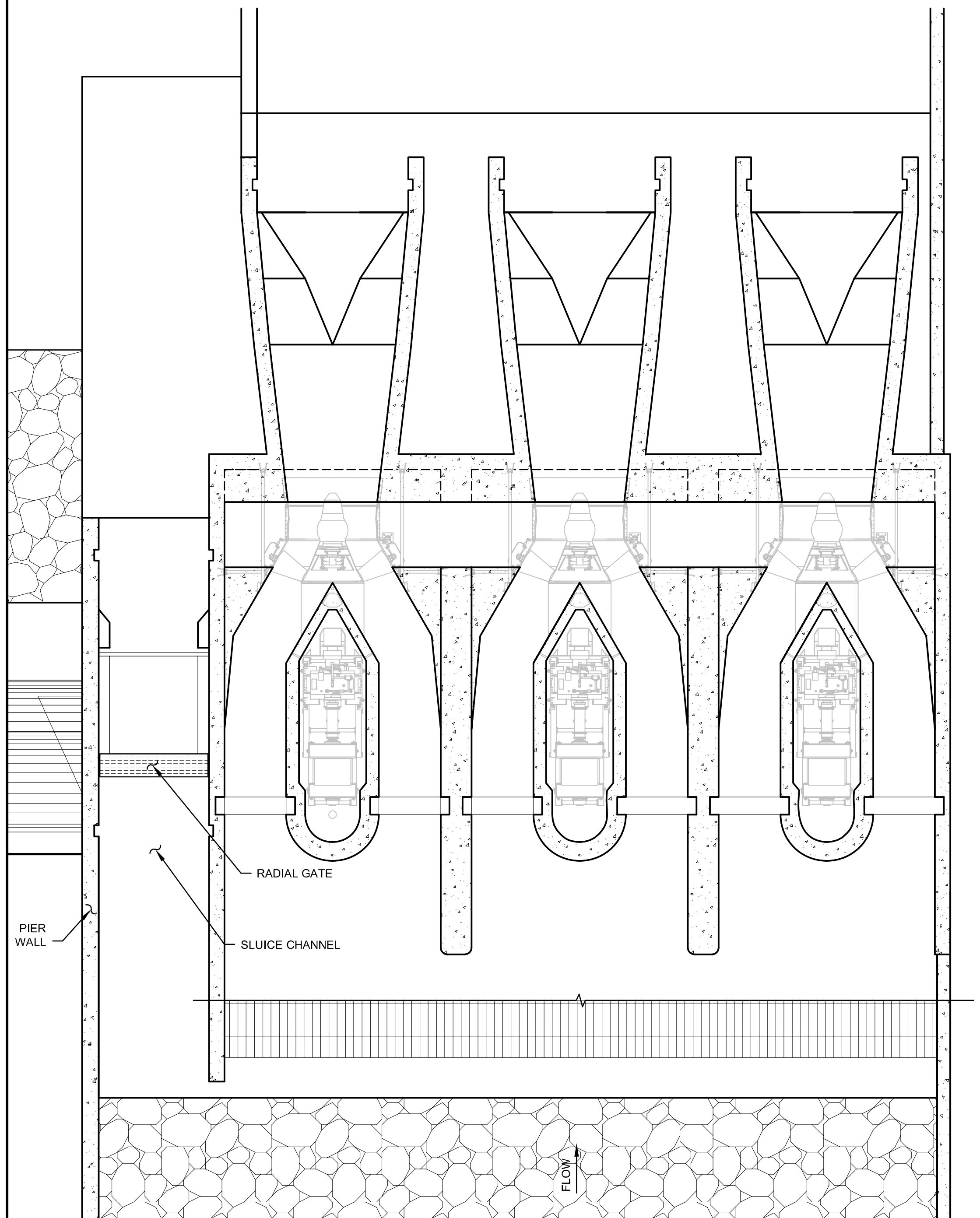
HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES

PIT TURBINE CONCEPT
POWERHOUSE PLANS

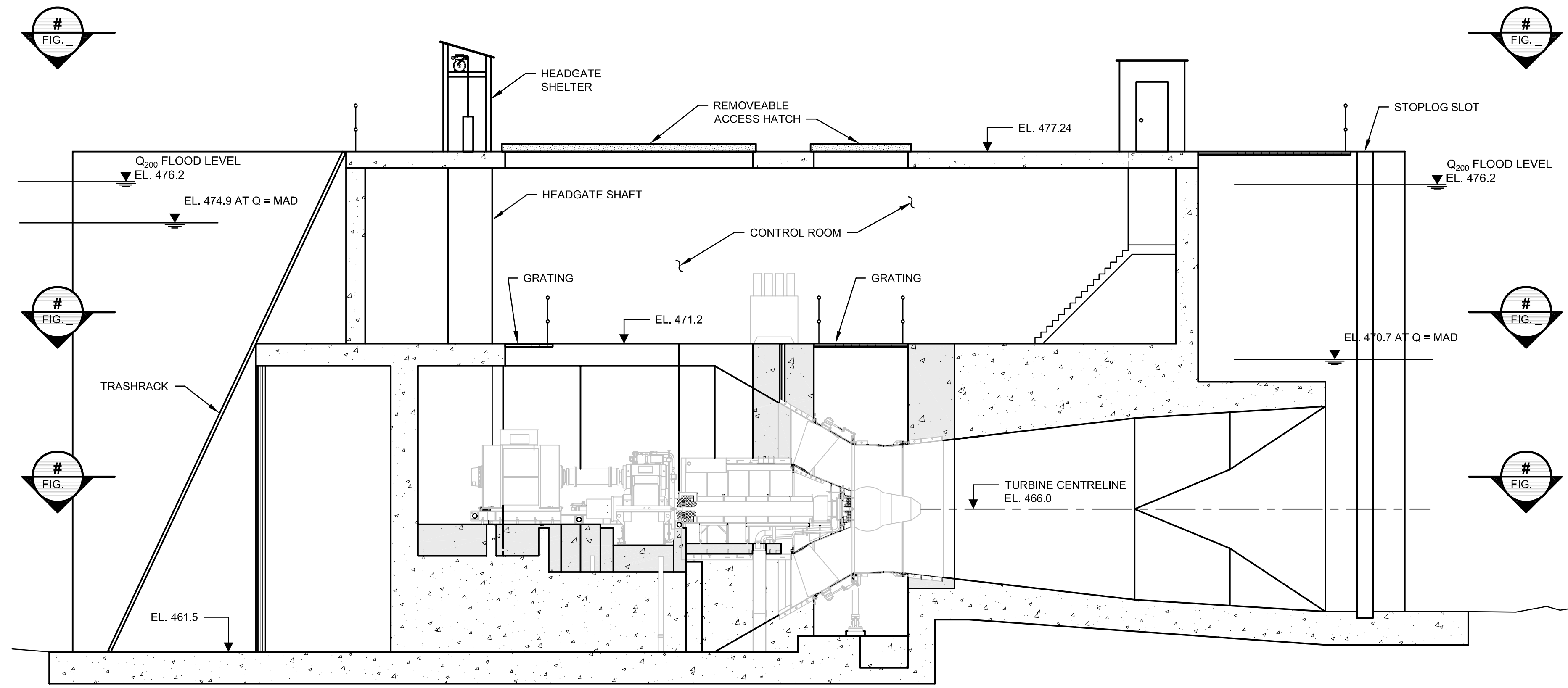
Knight Piésold CONSULTING

P/A NO.	REF NO.
VA103-198/2	2

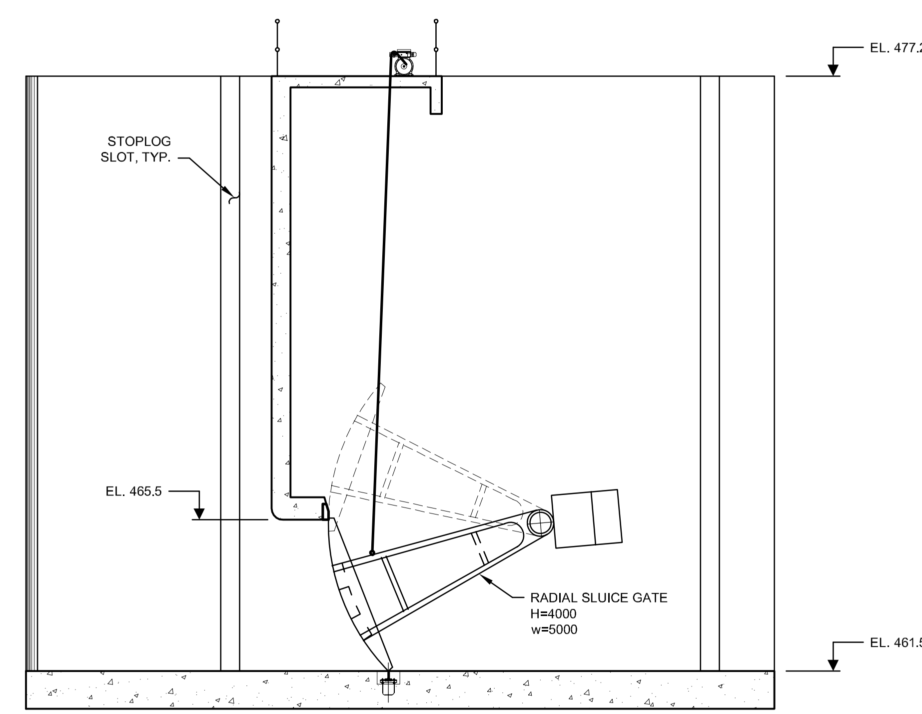
FIGURE 3.5 REV 0



TURBINE LEVEL PLAN
SCALE A



TYPICAL SECTION
POWERHOUSE
SCALE B



TYPICAL SECTION
SLUICEWAY CHANNEL
SCALE B

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES AND ALL ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.

SCALE B 2 1 0 2 4 6 8 10 m
SCALE A 2.5 0 5 10 15 m

REV	DATE	DESCRIPTION	DESIGN	DRAWN	CHK'D	APP'D
0	18DEC'09	ISSUED WITH REPORT	JWV	TAM	JWV	SRM

XREF FILE(S): IMAGE FILE(S):

VANCOUVER B.C.

SASKATOON LIGHT & POWER

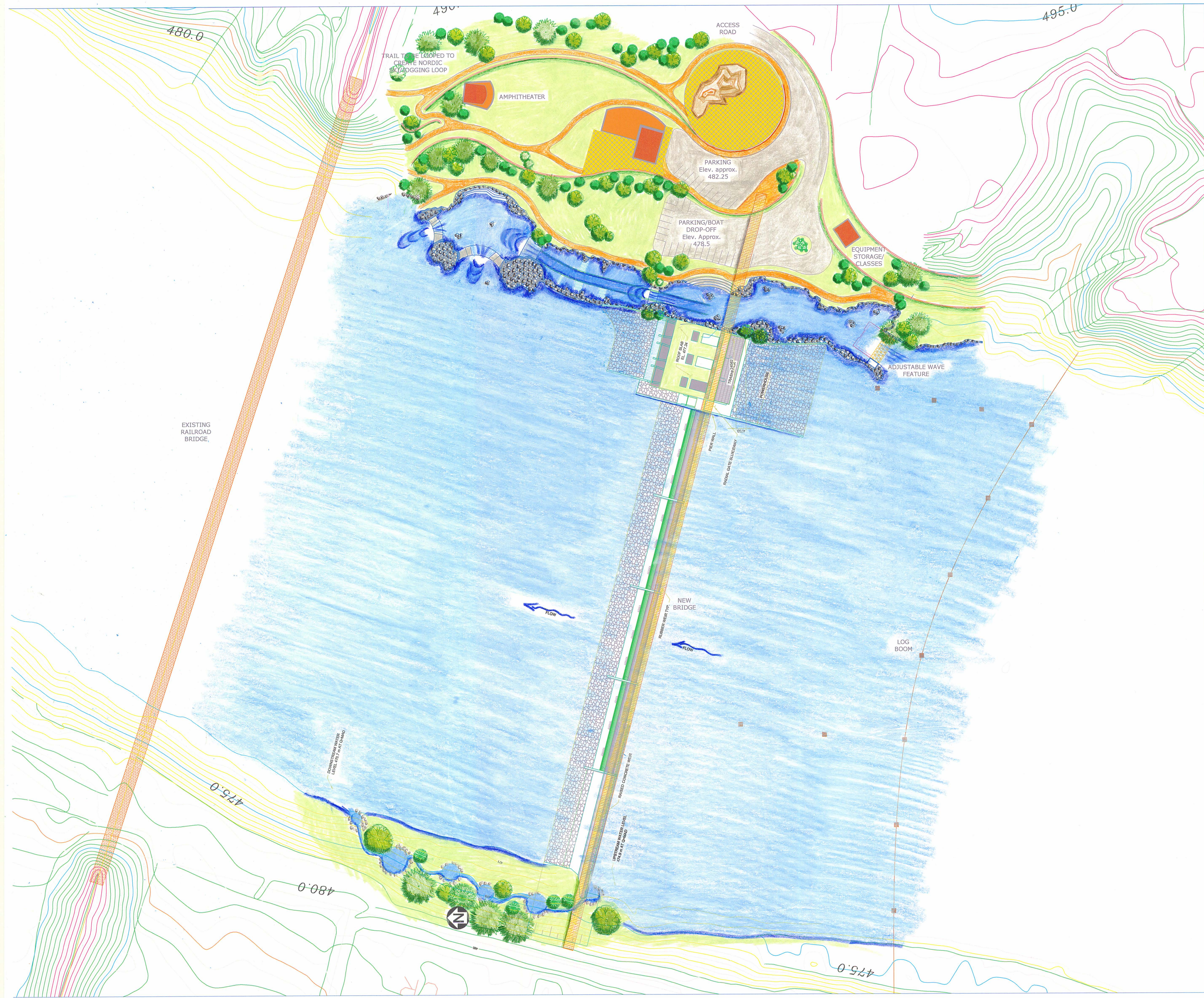
HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES

PIT TURBINE CONCEPT
POWERHOUSE PLAN AND SECTIONS

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA103-198/2	2

FIGURE 3.6 REV 0



S2O Design and Engineering
www.s2odesign.net

S2Odesign and Engineering
Scott Shipley, P.E.
318 McConnell Drive
Lyons, CO, 80540
(303) 819-3985

PROJECT:

SASKATOON WHITEWATER PARK CONCEPT A

CITY OF SASKATOON, SK

CONCEPTUAL DESIGN PLAN

NOT FOR CONSTRUCTION

DATE: 6/10/09

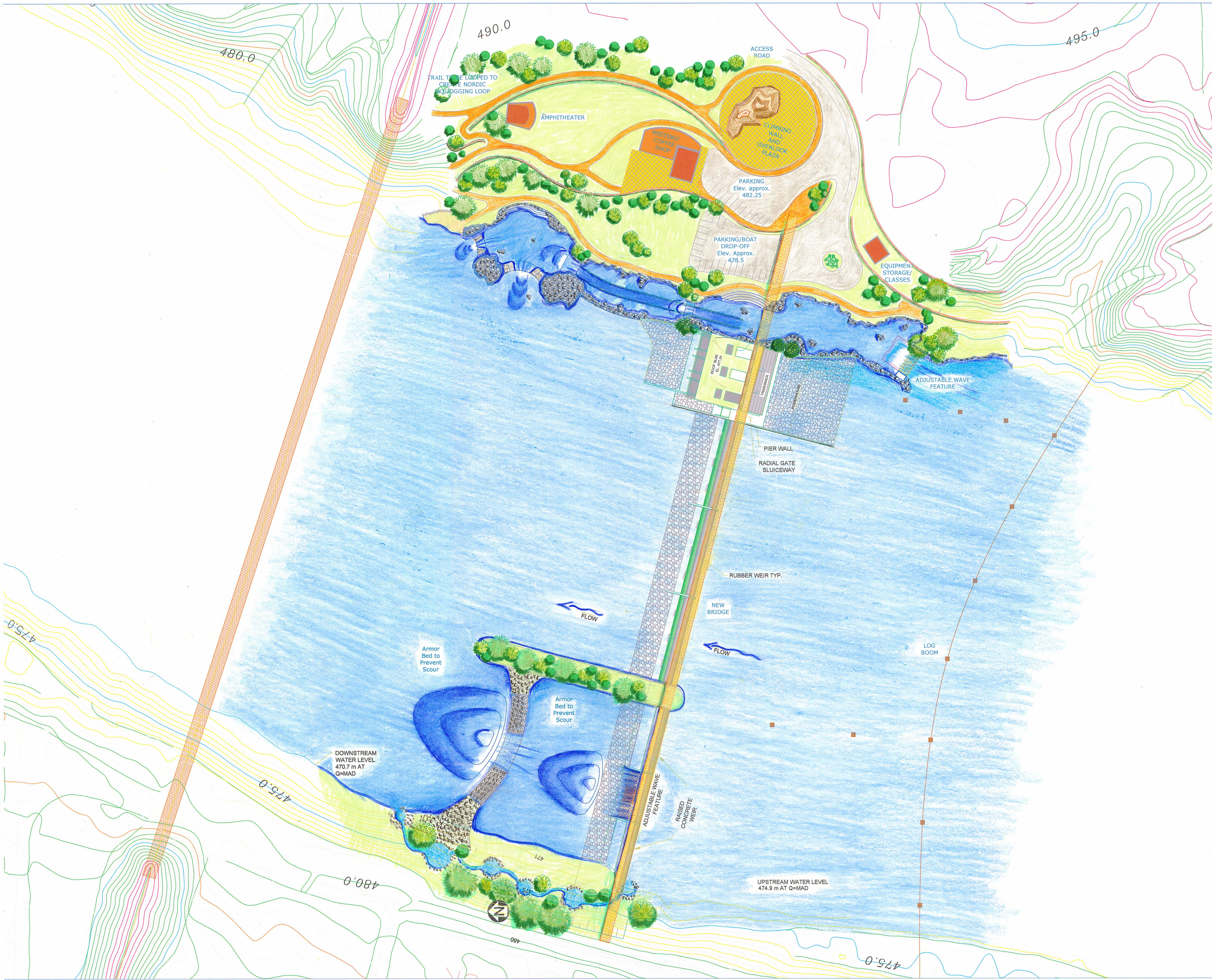
REVISIONS 1-19-2010

FIGURE 3.7

REV 0

CONCEPTUAL SITE PLAN

VA103-198/2-2



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S2O Design and Engineering
Scott Shipley, P.E.
318 McConnell Drive
Lyons, CO, 80540

(303) 819-3985

PROJECT:

SASKATOON WHITEWATER PARK CONCEPT B

CITY OF SASKATOON, SK

CONCEPTUAL DESIGN PLAN

NOT FOR CONSTRUCTION

DATE: 3/27/08

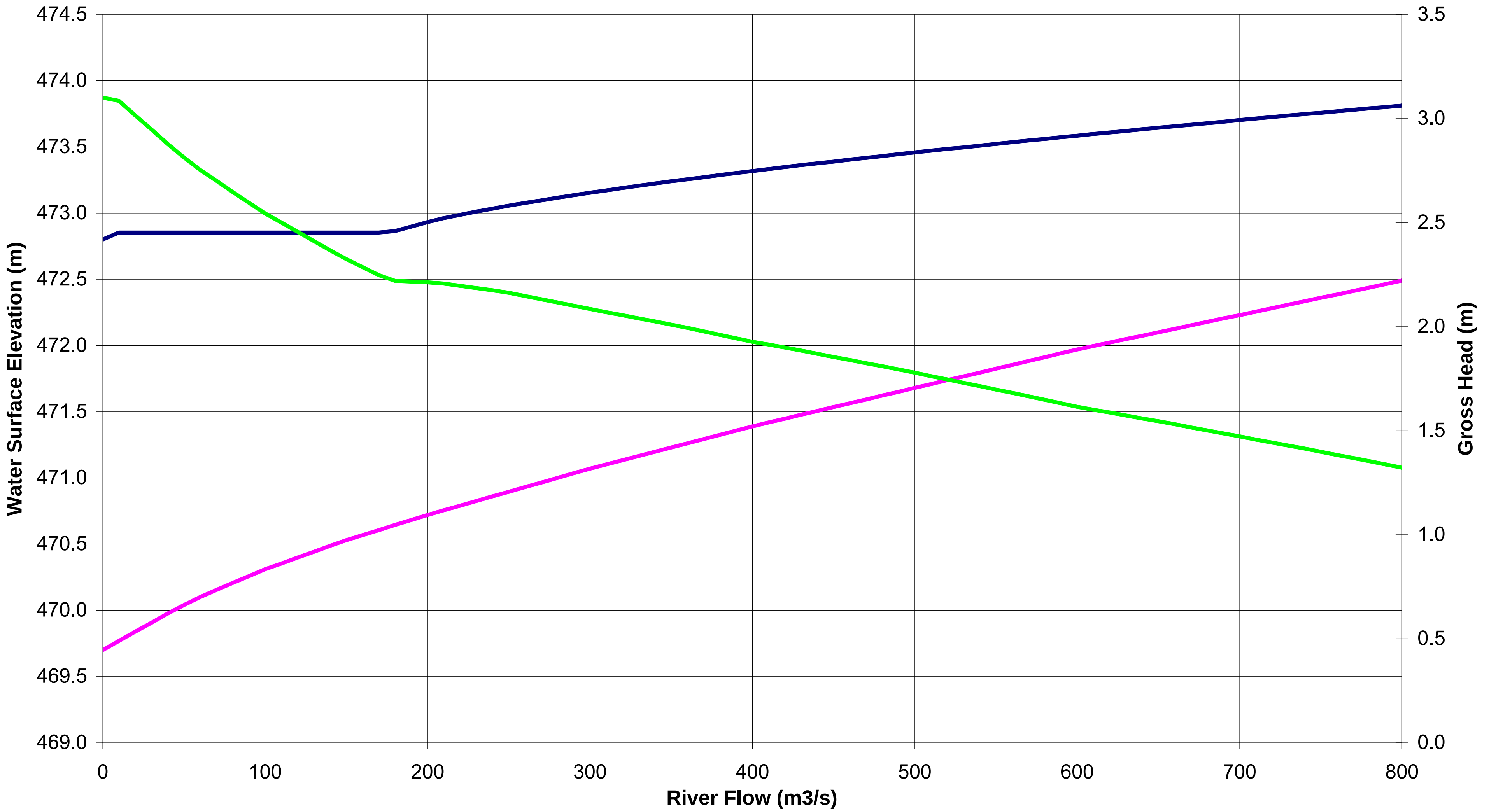
REVISIONS:1-11-2010

FIGURE 3.8

REV 0

CONCEPTUAL SITE PLAN

VA103-198/2-2



NOTES:

1. DESIGN FLOW = 167 m^3/s
2. UPSTREAM WATER LEVEL BASED ON CALCULATED WEIR FLOW.
3. DOWNSTREAM WATER LEVELS FROM SASKATCHEWAN WATERSHED AUTHORITY.

0	21DEC'09	ISSUED WITH REPORT	JWV	SRM	JPH
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

SASKATOON LIGHT & POWER

HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES

CONCEPT 1 (NO WEIR RAISE)
OPERATIONAL STAGE-DISCHARGE RELATIONSHIP

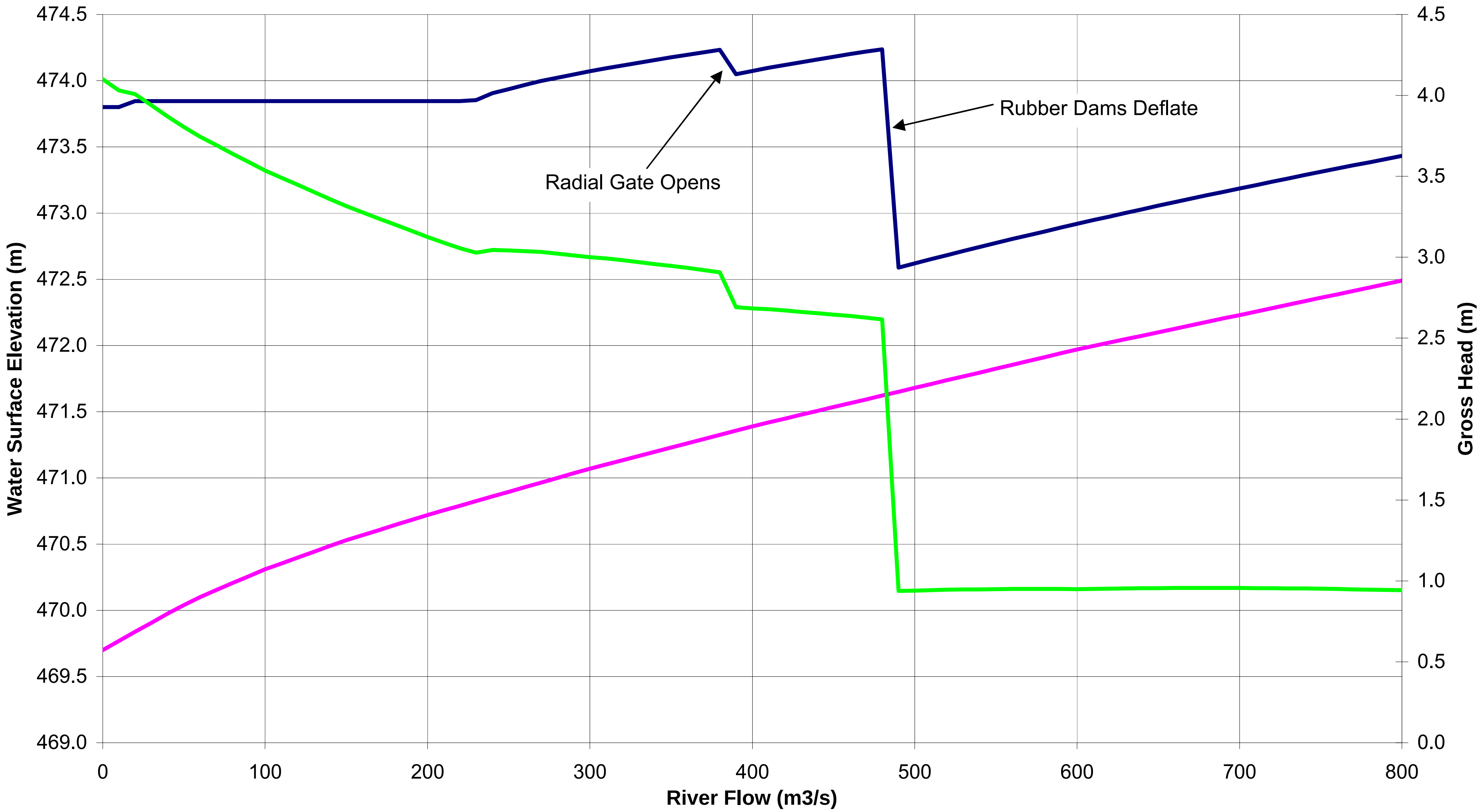
Knight Piésold CONSULTING

P/A NO. VA103-198/2

REF NO. 2

FIGURE 3.9

REV 0



NOTES:

1. DESIGN FLOW = 209 M3/S
2. UPSTREAM WATER LEVEL BASED ON CALCULATED WEIR FLOW RELATIONSHIPS.
3. DOWNSTREAM WATER LEVELS FROM SASKATCHEWAN WATERSHED AUTHORITY.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	21DEC'09	ISSUED WITH REPORT	JWV	SRM	JPH

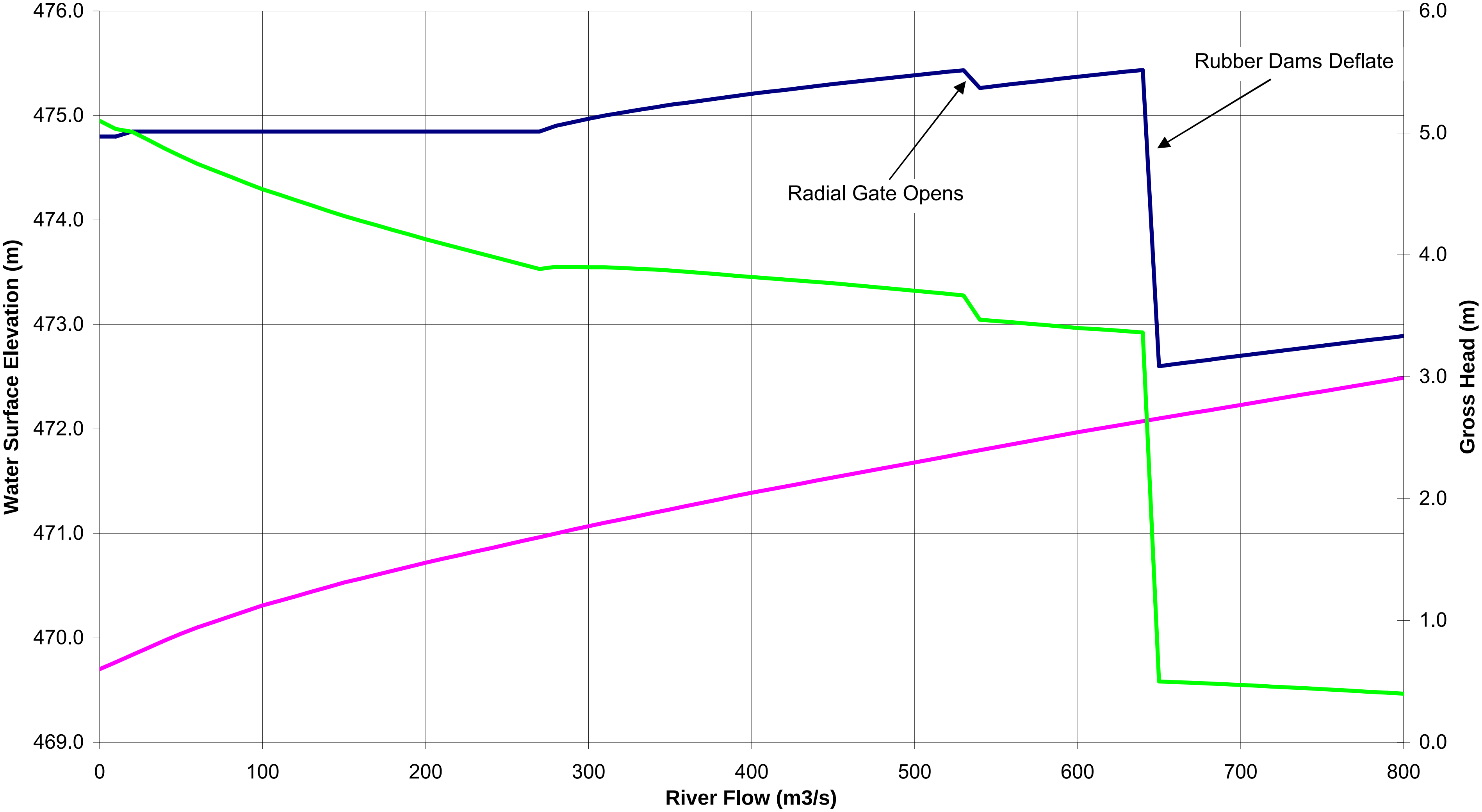
SASKATOON LIGHT & POWER

HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES

CONCEPT 2 (1 m WEIR RAISE)
OPERATIONAL STAGE-DISCHARGE RELATIONSHIP

Knight Piésold CONSULTING

P/A NO.	REF NO.	
VA103-198/2	2	
FIGURE 3.10		REV 0



NOTES:
1. DESIGN FLOW = 250 M3/S
2. UPSTREAM WATER LEVEL BASED ON CALCULATED WEIR FLOW RELATIONSHIPS.
3. DOWNSTREAM WATER LEVELS FROM SASKATCHEWAN WATERSHED AUTHORITY.

Upstream Water Level
Downstream Water Level
Gross Head

SASKATOON LIGHT & POWER

HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES

CONCEPT 3 (2 m WEIR RAISE)
OPERATIONAL STAGE-DISCHARGE RELATIONSHIP

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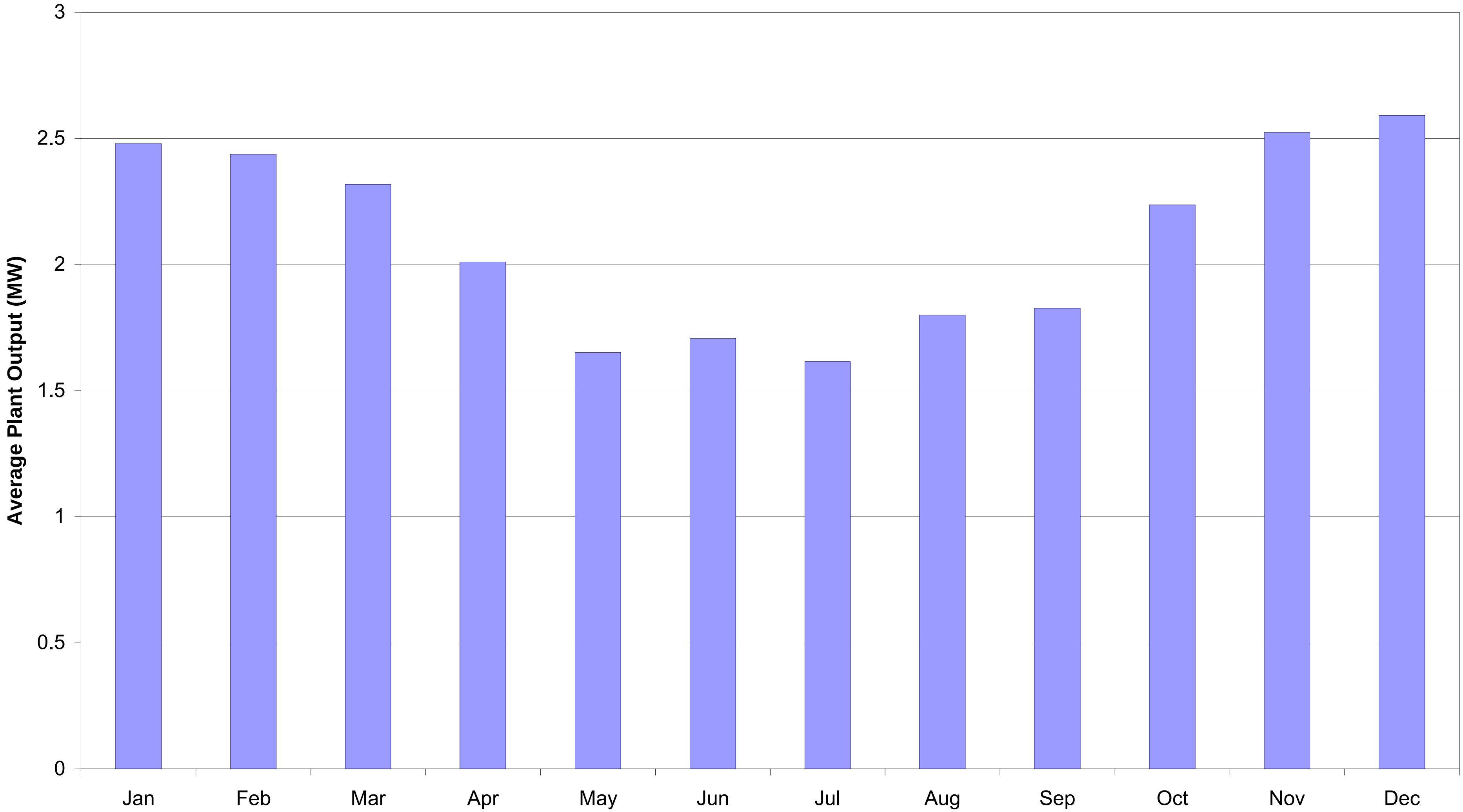
P/A NO. VA103-198/2

REF NO. 2

FIGURE 3.11

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	21DEC'09	ISSUED WITH REPORT	JWV	SRM	JPH



NOTES:
1. BASED ON DAILY FLOW DATA FROM WSC STATION 05HG001 FROM 1968 TO 2008. YEARS WITH MISSING DATA HAVE BEEN EXCLUDED FROM THE ANALYSIS.
2. AVERAGE POWER OUTPUT AS MEASURED FROM THE GENERATOR. DOES NOT INCLUDE TRANSFORMER LOSSES, TRANSMISSION LOSSES, STATION USAGE, OR UNSCHEDULED OUTAGES.
3. NAMEPLATE CAPACITY = 2.8 MW

0	22DEC'09	ISSUED WITH REPORT	JWV	SRM	JPH
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

SASKATOON LIGHT & POWER

HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES

CONCEPT 1 (NO WEIR RAISE)
AVERAGE MONTHLY POWER OUTPUT

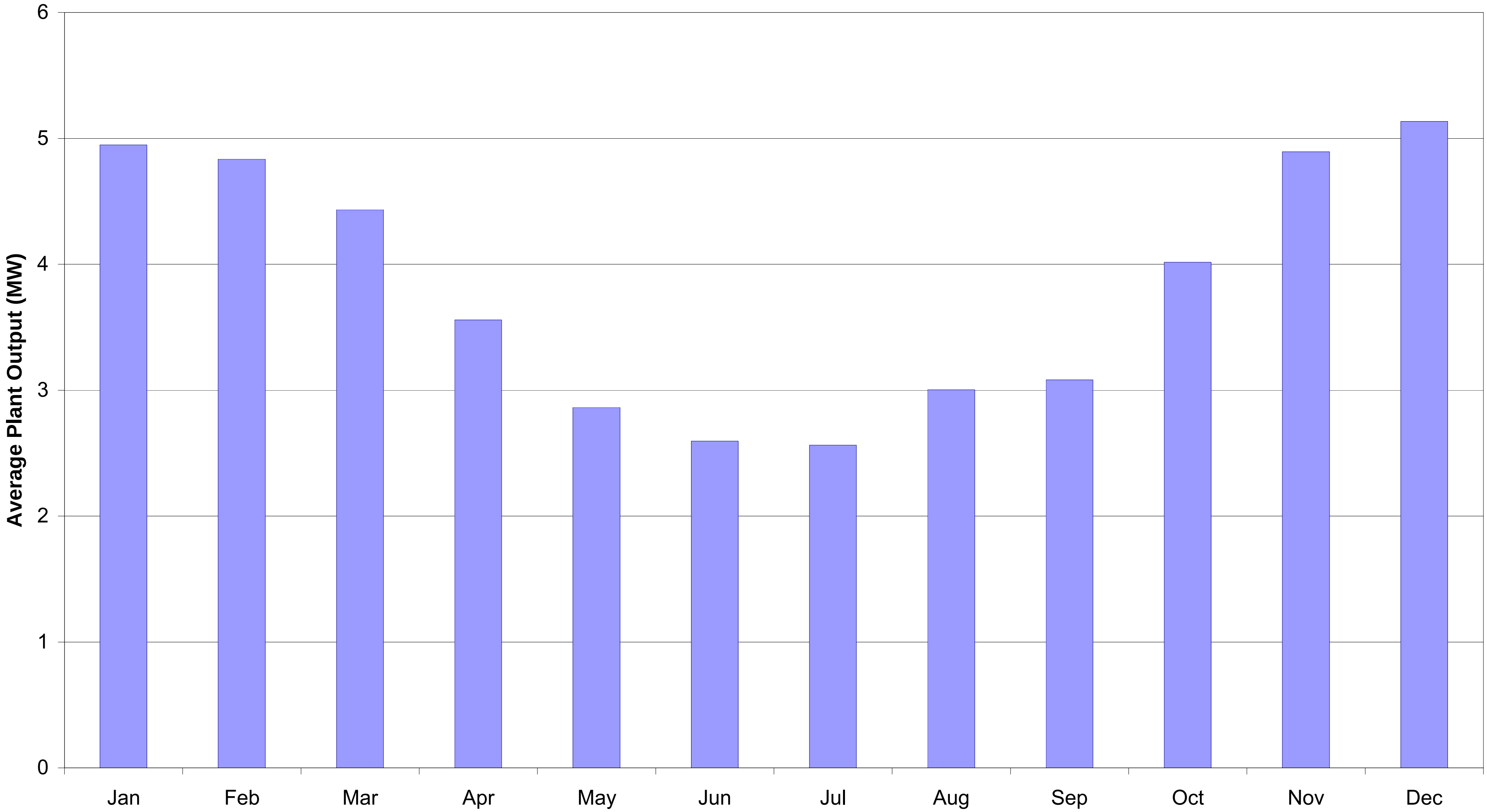
Knight Piésold CONSULTING

P/A NO. VA103-198/2

REF NO. 2

FIGURE 5.1

REV 0



NOTES:
1. BASED ON DAILY FLOW DATA FROM WSC STATION 05HG001 FROM 1968 TO 2008. YEARS WITH MISSING DATA HAVE BEEN EXCLUDED FROM THE ANALYSIS.
2. AVERAGE POWER OUTPUT AS MEASURED FROM THE GENERATOR. DOES NOT INCLUDE TRANSFORMER LOSSES, TRANSMISSION LOSSES, STATION USAGE, OR UNSCHEDULED OUTAGES.
3. NAMEPLATE CAPACITY = 5.5 MW

0	22DEC'09	ISSUED WITH REPORT	JWV	SRM	JPH
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

SASKATOON LIGHT & POWER

HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES

CONCEPT 2 (1 m WEIR RAISE)
AVERAGE MONTHLY POWER OUTPUT

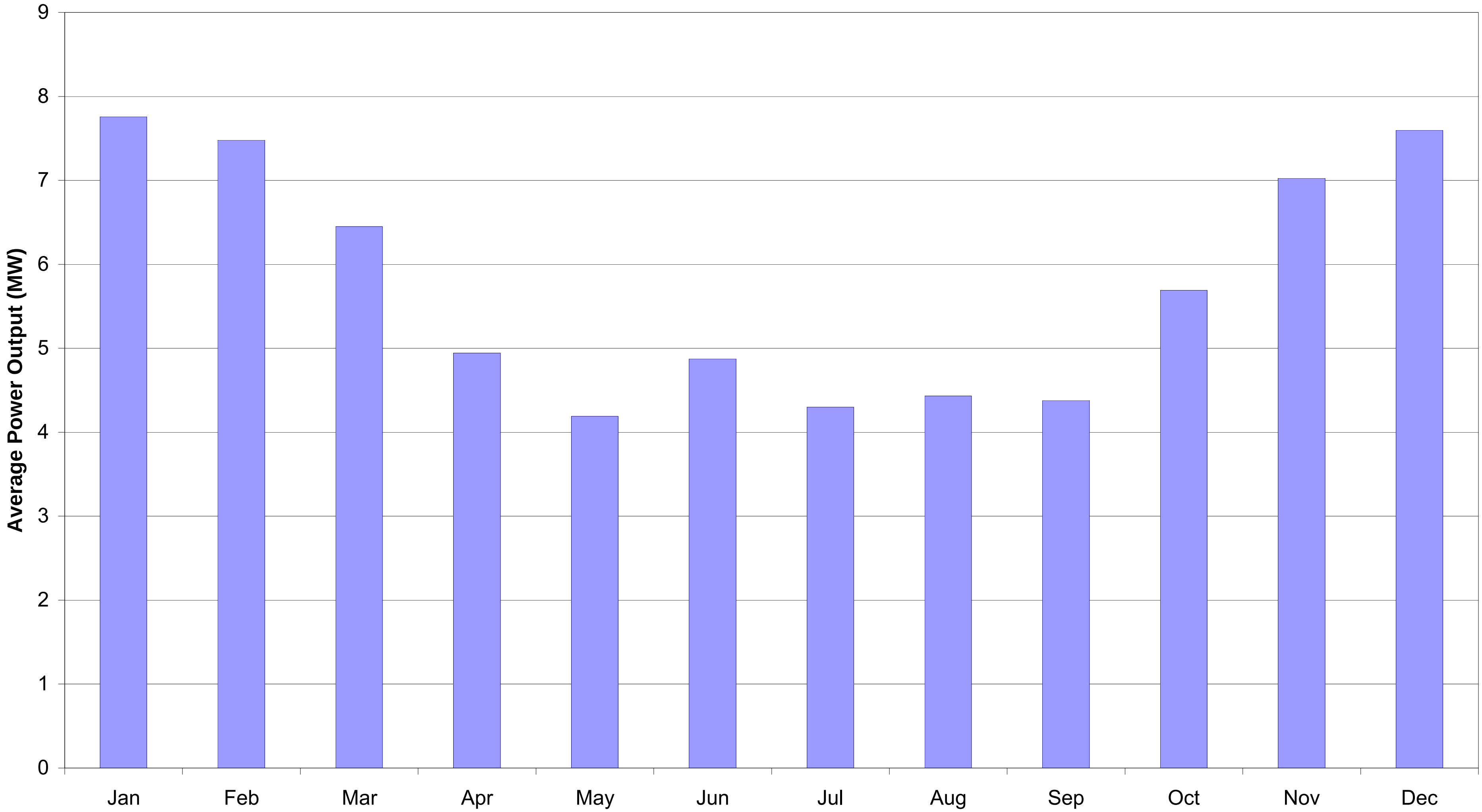
Knight Piésold CONSULTING

P/A NO. VA103-198/2

REF NO. 2

FIGURE 5.2

REV 0



NOTES:

1. BASED ON DAILY FLOW DATA FROM WSC STATION 05HG001 FROM 1968 TO 2008. YEARS WITH MISSING DATA HAVE BEEN EXCLUDED FROM THE ANALYSIS.
2. AVERAGE POWER OUTPUT AS MEASURED FROM THE GENERATOR. DOES NOT INCLUDE TRANSFORMER LOSSES, TRANSMISSION LOSSES, STATION USAGE, OR UNSCHEDULED OUTAGES.
3. NAMEPLATE CAPACITY = 8.4 MW

SASKATOON LIGHT & POWER

HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES

CONCEPT 3 (2 m WEIR RAISE)
AVERAGE MONTHLY POWER OUTPUT

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA103-198/2	2

FIGURE 5.3 REV 0

0	22DEC'09	ISSUED WITH REPORT	JWV	SRM	JPH
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

Knight Piésold
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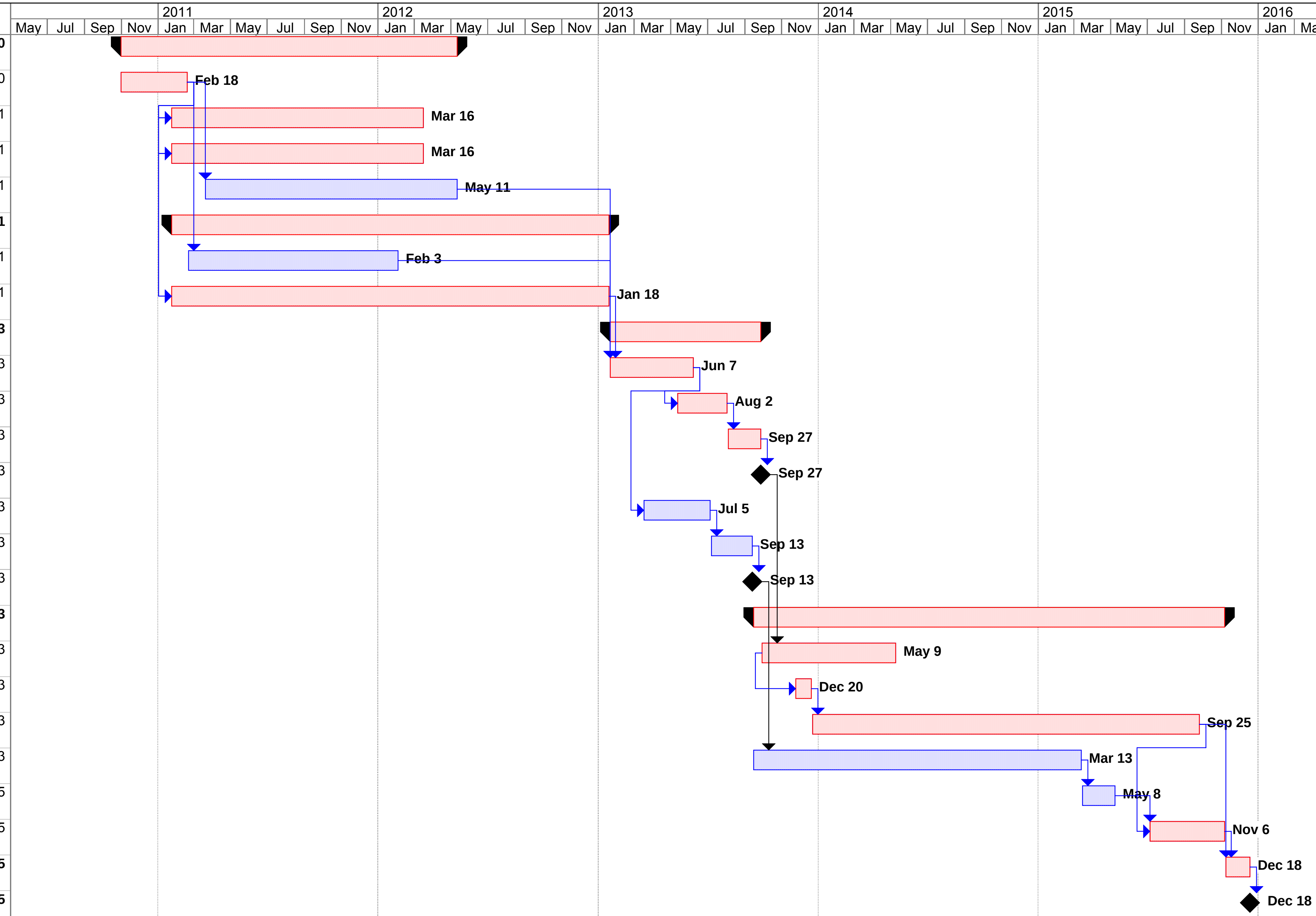
SASKATOON LIGHT & POWER
HYDROPOWER AND WHITEWATER PARK DEVELOPMENT STUDIES
ENGINEERING PRE-FEASIBILITY REPORT

\\van11\prj_file\1\03\00198\02\A\Data\Schedule\Devleopment Schedule_2010_02_19.mpp

HYDROPOWER DEVELOPMENT SCHEDULE

ID	Task Name	Duration	Start
1	**Feasibility Studies**	**400 days**	**Mon 11/1/10**
2	Project Definition Optimization	80 days	Mon 11/1/10
3	Environmental Impact Studies	300 days	Mon 1/24/11
4	Stakeholder & Public Consultation	300 days	Mon 1/24/11
5	Feasibility Engineering Studies	300 days	Mon 3/21/11
6	**Permiting and Regulatory**	**520 days**	**Mon 1/24/11**
7	Water Licence and Land Tenure Processes	250 days	Mon 2/21/11
8	Environmental Assessment	520 days	Mon 1/24/11
9	**Tendering**	**180 days**	**Mon 1/21/13**
10	Tender Design	100 days	Mon 1/21/13
11	Civil Tender Package Preparation	60 days	Mon 5/13/13
12	Civil Tender Period	40 days	Mon 8/5/13
13	Award Civil Contract	0 days	Fri 9/27/13
14	Water-to-wire Tender Preparation	80 days	Mon 3/18/13
15	Water-to-wire Tender Period	50 days	Mon 7/8/13
16	Award Water-to-wire Contract	0 days	Fri 9/13/13
17	**Detailed Design and Construction**	**560 days**	**Mon 9/16/13**
18	Civil IFC Design	160 days	Mon 9/30/13
19	Mobilization	20 days	Mon 11/25/13
20	Civil works Construction	460 days	Mon 12/23/13
21	Water-to-Wire Equipment Design and Fabrication	390 days	Mon 9/16/13
22	Turbine/Generator Shipping	40 days	Mon 3/16/15
23	Turbine/Generator Installation	90 days	Mon 7/6/15
24	**Commissioning**	**30 days**	**Mon 11/9/15**
25	**Commercial Operation**	**0 days**	**Fri 12/18/15**



Project: Saskatoon Weir Development
Date: Tue 2/16/10

Task		Progress		Summary		External Tasks		Deadline
Split		Milestone		Project Summary		External Milestone		Critical Tasks

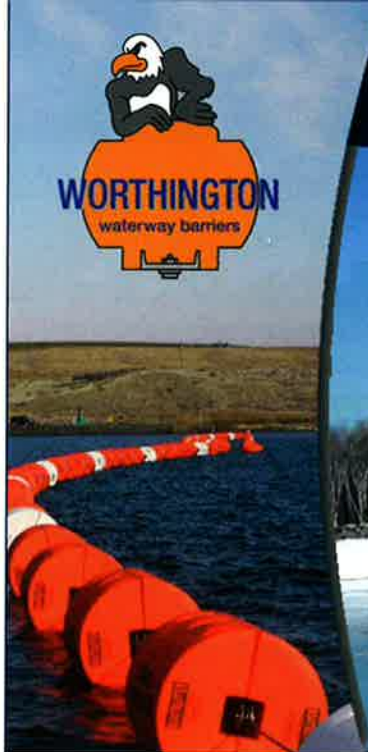
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
1	19FEB'10	ISSUED WITH REPORT VA103-198/2-2	JWV	SRM	JPH

FIGURE 7.1
REV 1

APPENDIX A

WORTHINGTON SAFETY BOOMS – DATA SHEET

(Pages A-1 to A-2)



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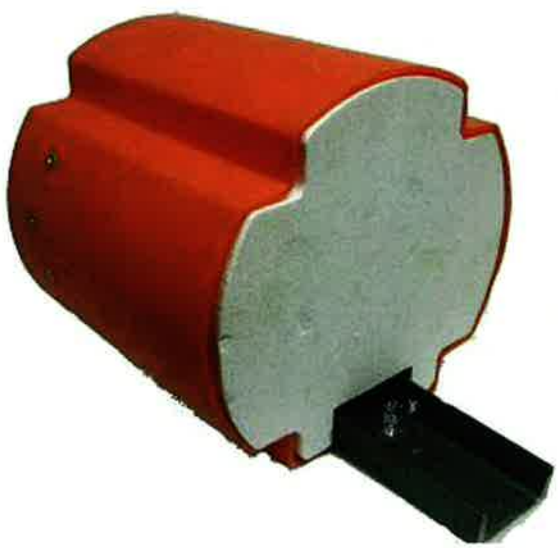
Log & Debris Booms / Dam Safety Boat Barriers

TUFFBOOM barriers are the choice of dam operators worldwide when it comes to controlling surface debris and satisfying regulatory guidelines for dam safety. These 10′ (3m) modular units link together to form unlimited length boom lines. Accessories include high visibility mold-in graphics, hanging debris skirts, plates to close the gap between booms, boat gates, solar lights and more.

TUFFBOOM is made from thick-walled, UV resistant resin. Each boom includes a high load bearing internal steel channel through which all boom-to-boom connections are bolted. Each boom is fully filled with closed-cell foam making these booms truly unsinkable.

Whether your goal is to stop a 50′ (15m) long tree or keep boaters a safe distance from your dam, the solution is simple. The solution is **TUFFBOOM**



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TUFFBOOM

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Features (At-A-Glance)

- Heavy-wall impact resistant polyethylene with max. UV resistance.
- Unsinkable solid internal core of non-water absorbing foam fill. Maintains buoyancy even when punctured.
- High load bearing internal steel channel provides strength and ballast, resists horizontal and vertical loads.
- Load-rated galvanized safety shackle connections permit full movement with minimal wear.
- Fully-interchangeable connection hardware.
- Connections are designed for continuous motion and heavy loads
- Mold-in Graphics™ with standard or customized warnings.
- Exceptional debris load capacity.
- Available in International Orange, Safety Yellow, Log Boom Brown, Forest Green, Black, White, Red, Navy Gray, Sand Tan.
- High Visibility, high buoyancy for maximum freeboard visibility
- Weight: Approximately 141 lbs (64 kgs) per unit
- Center to Center Length: 136 in (53.5 cm)
- Float Unit Length: 120 in (47.2 cm)
- Buoyancy: approximately 700 lbs (317 kgs) per unit.
- Anchor components designed to site specific conditions
- Assembles easily with little or no equipment required.
- Thousands of units installed worldwide with excellent results






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GSA Contract Holder

Knight Piésold
CONSULTING

APPENDIX B

BUDGET LEVEL WATER-TO-WIRE QUOTATIONS

(Pages B-1 to B-24)

ANDRITZ HYDRO Canada, Inc.

South Saskatchewan River Hydroelectric Project

TECHNICAL PROPOSAL FOR TURBINE/GENERATOR AND AUXILIARY EQUIPMENT

Submitted to:

Knight Piésold Consulting

ANDRITZ Hydro

November 10, 2009

10th of November 2009

KNIGHT PIÉSOLD CONSULTING

Suite 1400 – 750 West Pender Street,
Vancouver, British Columbia,
Canada V6C 2T8

Attention: **Mr. Joshua Vines, EIT**
Staff Engineer

Re: South Saskatchewan River hydroelectric project

Dear Joshua;

Attached please find our proposal for the South Saskatchewan River project. You asked us to evaluate three options;

- first use the existing weir height 3 meters
- second increase the weir height to 4 meters
- third increase the weir height to 5 meters

Based on the Water Level and Head tables you sent us, we evaluated all three options at the nominal 250 m^3/sec plant flow. The main problem is that the downstream water level rises fast (as the flow increases), thereby reducing the net head:

- 3 m weir height > net head 1.95 m
- 4 m weir height > net head 3 m
- 5 m weir height > net head 4 m

We took as our starting point a plant with three turbines (as you suggested). The resulting flow requires 4000 mm runners, the largest runners we offer in the Andritz Compact Hydro division. The lowest net head our turbines will run at (without excessive cavitation) is 3.2 m. This means that the only realistic option is to increase the weir to 5 m height. This option is described in the attached proposal with a capital cost of $18,000,000 Cdn.

I also looked at the possibility of 4 turbines, with 3350 mm runners. This option allows you to operate the turbines with a net head of 2.5 m, but this will also increase the capital cost by about 30% to $23,500,000 Cdn. It does not seem likely that the net energy generation would justify the increase in capital expenditure.

You will find attached our performance curves for the 4000 mm runners at 4 m, 3.5 m and 3.2 m net head. These curves will give you both the net turbine efficiency and the capacity in KW.

I remain at your disposal for any questions. Best regards,

N de Vooght

Nicolas de Vooght
Sales Manager BC

South Saskatchewan River : 3 PIT turbines, 4000 mm, Double Regulated, Water-to-Wire supply, DDP, Erection

1 Scope of supply

Layout, design, manufacturing, testing, delivery, installation and commissioning of the following main components:

- Three (3) Horizontal concrete pit turbines with 3-bladed runner, wicket gate mechanism, stainless steel runner blades and discharge ring, 4000 mm runner diameter
- Three (3) Synchronous Generators, air cooled with brushless excitation
- Three (3) parallel shaft Gears with ratio 5.35 with high speed elastic coupling and low speed rigid flange coupling
- Three (3) Hydraulic Pressure Units (HPU)
- One (1) MIPREG-based Control panel per unit and one (1) overall SCADA system
- Switchgear, Neutral Grounding Cubicle, Station Service Transformer, MCC, Distribution Panels, Battery Charger and Batteries, Generator Control and Protection
- Cables for Signals and Power, Cable Trays
- Delivery DDP (Delivered Duty Paid) to Job site under the powerhouse crane hook
- Installation of mechanical and electrical equipment
- Special non-commercial tool set
- Start-up and commissioning
- Unit Index Testing
- Two (2) years guarantee
- Training of owner personnel (two week)

ANDRITZ Hydro

2 Price and Options

Total Base price: $ 18,000,000.00 Cdn

OPTION Stainless steel wicket gates: $ 440,000.00 Cdn

OPTION Spare Parts (one set of gear wheels, one set of all bearing or bearing pads, one set of rotating diodes, misc. seals, switches, electrical elements for PLC and switchgear, ...) : $ 1,000,000.00 Cdn

Please note that import duties are included but all taxes including PST and GST are excluded. Freight to site is allowed.

Financial securities to be calculated in addition depending on chosen option.

THESE PRICES AND OPTIONS ARE BUDGETARY ONLY AND CANNOT CONSTITUTE ANY OBLIGATION FROM ANDRITZ HYDRO CANADA.

3 Price basis

The above price is budgetary only with an expected precision of plus minus 5%. In case of placing an order on this basis, the price will be determined according to actual modifications in material costs and wages, plus potential changes from suppliers costs. It is established on the costs basis available in November 2009.

This proposal is based on the standard design of Andritz Hydro (Basis Batawa) and is established without consideration of any specification from the customer or his engineer. However, as all units designed and supplied by Andritz Hydro, the layout is based on a tested model and the efficiencies are guaranteed providing the hydraulic contour is respected and the intake and outlet conditions are according to the industry standards.

The prices are net prices without GST and PST and the invoices are payable 30 days from issuance, as per the terms and conditions of this proposal.

ANDRITZ HYDRO Canada has calculated this price taking into consideration an official bid exchange rate of CAD versus Euro of 1.57 CAD = 1 Euro for 60% of the total price. At the time of signature of the contract, the final contract price will be adjusted at the official exchange rate of the previous day as published by the Royal Bank of Canada plus a hedging premium of maximum 1% and the price will then remain firm till the end of the contract.

Andritz Hydro Canada has considered a cap on LD for delay of 10% of the contract value achieved after 90 days of delay (assessed for each unit independently).

Andritz Hydro Canada has considered a cap on LD for performance of 15% of the contract value achieved for a unit efficiency loss of 3%, measured according to IEC 60041.

Total cumulative cap for LDs is 20%.

Warranty period is 2 years.

4 Schedule

ANDRITZ HYDRO Canada proposes the following Schedule, on a preliminary basis, and not considering delays due to the civil work:

M0	Contract Signature	
M2	Submittal of the basic engineering	
M5	Submittal of the detailed engineering	
M10-13	Casting reception of the runner	(one unit per month)
M15-18	Arrival at site of inlet cone & draft tube	(one unit per month)
M17-20	Workshop testing of the runner	(one unit per month)
M16-19	Workshop testing of the generator	(one unit per month)
M19-22	Arrival at site of runner and generator	(one unit per month)
M23-26	Units are fully erected	(one unit per month)
M24-27	Units are commissioned	(one unit per month)
M28	Commissioning of all the equipment, index test performed	

Note: M means Month and Mx means x months after contract entered into force

ANDRITZ Hydro Canada Inc., 100 – 13700 International Place, Richmond BC, Canada V6V 2X8
Tel: (604) 247 1444 Fax : (604) 214 9249 Email: nicolas.devooght@andritz-hydro.com

NOVATECH-LOWATT TURBINES INC.

Date 2009.12.07
Page 1/2

Budgetary Offer for a VLH Turbogenerator

Project: Saskatoon Dam -Option A Ref : C-054

Project Hydraulic Data:

Gross Head	**2.30**	m	To be confiri
Net head	**2.20**	m	Estimated
Rated Flow	**16.6**	m3/s	
Quantity	**1**		
VLH type	**4000**		
Power - delivered to network	**283**	KW	
turbine Incline	**45**	degrees	

Equipment included in this offer

Complete generating set VLH with distributor, runner and PMG generator
Rotative Trash rake cleaner with flushing flap
Inspection and maintenance extraction system of the VLH
Hydraulic Power Unit for all devices
Air Compressor for unit pressurization
Command & Control cubicles including Frequency Converter and speed variation equip
Cables (power and instrument) ~20m length from turbine to powerhouse.
Air and hydraulic piping ~20 m length from turbine to powerhouse.

Services included in this offer

Design of the equipment
Civil Work lay out drawing
Transportation to site (unloading by others)
Supervision of Installation (mechanical and electrical)
Commisioning
Operation and maintenance Manual
One year guarantee

Budgetary price for equipment and services

1,285,000.00 $ CAD

This price is a budgetary evaluation

Validity * (Budgetary)
Equipment delivery **8 to 10** months
(first unit + 3 weeks per additional u

Not included in this Price

Installation and cabling
Civil work.

NOVATECH-LOWATT TURBINES INC.

Date 2009.12.07
Page 2/2

Budgetary Offer for a VLH Turbogenerator

Project: Saskatoon Dam - Option B Ref : C-054

Project Hydraulic Data:

Gross Head	**2.30**	m	To be confirı
Net head	**2.20**	m	Estimated
Rated Flow	**21.0**	m3/s	
Quantity	**1**		
Power-delivered to the grid	**359**	KW	
VLH type	**4500**		
turbine Incline	**45**	degrees	

Equipment included in this offer

Complete generating set VLH with distributor, runner and PMG generator
Rotative Trash rake cleaner with flushing flap
Inspection and maintenance extraction system of the VLH
Hydraulic Power Unit for all devices
Air Compressor for unit pressurization
Command & Control cubicles including Frequency Converter and speed variation equip
Cables (Power and Instruments) ~20 m length from turbine to powerhouse
Air and hydraulic piping ~20m length from turbine to powerhouse.

Services included in this offer

Design of the equipment
Civil Work lay out drawing
Transportation to site (unloading by others)
Supervision of Installation (mechanical and electrical)
Commisioning
Operation and maintenance Manual
One year guarantee

Budgetary price for equipment and services

1,357,000.00 $ CAD

This price is a budgetary evaluation

Validity * (Budgetary)
Equipment **8 to 10** months
(first unit + 3 weeks per additional

Not included in this Price

Installation and cabling
Civil work.

VOITH

Voith Hydro

Voith Hydro Inc.
9955 avenue de Catania, bureau 160
Brossard, QC J4Z 3V5 Canada
Téléphone : +1 (450) 766-2100
Télécopieur : +1 (450) 766-2200
www.brossard.voithhydro.com

Une compagnie Voith et Siemens

Voith Hydro Inc., 9955 avenue de Catania, bureau 160, Brossard, QC J4Z 3V5 Canada

December 1, 2009

Joshua Vines, EIT
Staff Engineer
Knight Piésold Ltd.
Suite 1400 - 750 West Pender
Vancouver, British Columbia
Canada, V6C 2T8

RE: Saskatoon Weir Hydroelectric Project - W to W Quotation Request

Dear Mr. Vines:

Voith Hydro Inc. (VHM) is pleased to submit the following attached budgetary proposal pricing of $26,458,000 for the Turbines, Generators, Speed Increasers and Electrical equipments for the Saskatoon Weir Hydroelectric Project - W to W Quotation Request.

The above estimate is provided at your request for your budget purposes only and does not constitute an agreement or an offer by us to provide goods and services at this or any other price. While the above estimate is our assessment at this time based on facts and circumstances presently known to us, as any budget estimate, actual prices will likely vary either up or down on many variables, including Canadian and foreign currency fluctuations, cost of materials, supplier costs, costs of labour and benefits to our employees, competitive and market factors.

We sincerely look forward to discussing our budgetary proposal pricing and ask that you do not hesitate to call if you need any clarification or have questions.

Sincerely,

Eric Leblanc, Eng., MBA
Head of Small Hydro

EL/el

Enc.

VOITH

Budgetary Offer
Saskatoon Weir HPP

3 Kaplan Pit Turbines Size 33.7/3

Voith Hydro

Voith Hydro Inc.
9955 avenue de Catania, bureau 160
Brossard, QC J4Z 3V5 Canada
Téléphone : +1 (450) 766-2100
Télécopieur : +1 (450) 766-2200
www.brossard.voithhydro.com

Voith Hydro Inc., 9955 avenue de Catania, bureau 160, Brossard, QC J4Z 3V5 Canada

Une compagnie Voith et Siemens

Contents

Execution OU:	Executed by:		Checked by:		Approved by:		Date:
VHM	Name levesqm	Sign.	Name gagnonm	Sign.	Name leblance	Sign.	2009/12/01

1. Scope of supply

Design and engineering	✓
Water intake equipment	No
Penstock	No
Turbine Inlet Valve	No
Turbine	✓
Speed increaser	✓
Generator	✓
Hydraulic Pressure Unit	✓
Brushless AC Excitation System	✓
Speed Governor	✓
PLC controller	✓
Powerhouse A.C and D.C station services	✓
Grounding Equipment	✓
Switchgears and Generator protections	✓
Step up Transformers	✓
Auxiliaries and building services	No
Supervision of Erection	No
Erection of the proposed equipments	No
Craneage and handling / off-loading	No
Commissioning and start-up	No
Transportation (Ex Work)	✓

2. Kaplan turbine

2.1 General technical description

The offered turbine is a horizontal Kaplan Pit turbine. The turbine shaft shall be guided by one guide bearing supplied with the turbine. The wicket gates of the turbine are connected to the gate-operating ring by steel levers/links and the whole mechanism is moved by one servomotor. The entire wicket gate mechanism is mounted outside the turbine case to simplify maintenance. All wicket gate bearings are of the self-lubricating type. All turbine parts shall be designed to withstand the maximum loads at normal service conditions as well as transient conditions like water hammer or runaway speed up to the guaranteed limits.

2.2 Technical data

2 Kaplan Pit turbines size 33.70 for the following hydraulic conditions:

Number of units	3
Neat head (m)	5
Flow (m3/s)	83.33
Speed (rpm)	144
Overspeed (rpm)	475.20
Suction head (m)	- 7,05
Diameter (mm)	3370
Power Output (kW)	3.750
Construction	horizontal
Turbine Centerline Elevation (masl)	< 500

2.3 Detailed description of turbine components

Runner

The runner shall be formed by runner blades, the runner hub and the correspondent mechanism to move the runner blades. Each runner blade shall be casted in one piece in stainless steel. The runner hub shall be made of carbon steel casted in one piece. Each runner blade would be supported by one axial bearing and two radial bearings mounted into the runner hub. All surfaces in contact with water shall be smooth and free of damages, which might cause cavitations. Once the workshop assembly of the runner is finished he shall be statically balanced.

Inlet casing
Inlet casing as a welded steel plate construction fabricated in one piece. A suitable number of supporting brackets and lugs as well as anchorages would be provided.

Distributor
Distributor consisting of:

16	wicket gates
32	wicket gate bearings with self-lubricating bearing bushings
16	wicket gate links and levers
1	outer distributor ring
1	inner distributor ring
1	regulation ring
1	water passage ring

The gate mechanism will be oil pressure actuated by one double-acting hydraulic servomotor.

Shaft seal
Mechanical shaft seal assembly. The supply of cooling water in the required quality and quantity is out of VHTO scope of supply.

Discharge Ring
Discharge ring fabricated in carbon steel component and flanged for bolting to the outer distributor ring and the draft tube cone. The inner diameter of the discharge ring shall be of a semicircular shape in order to minimize the gap between the discharge ring and the runner blades in any position of the blades.

Draft Tube Cone
A plate steel fabricated draft tube cone in one piece shall be provided. The supply shall be included a suitable number of supporting brackets and lugs as well as anchorages.

Other elements
1 set of measuring pipes in stainless steel (excluding measuring equipment)
1 set of drainage pipes in galvanized carbon steel and valves

Shop Assembly
The turbine will be shop assembled as far as possible and properly match marked to assure correct field assembly. All components are going to be tested following VOITH standards and specifications.

2.4 Materials and dimensions

component	material	dimension (mm)
runner		3370
runner blades	G-X5CrNi13.4	
runner hub	GS-20Mn5	
inlet casing (Pit)	S 235 JRG2	
distributor		
wicked gate	EN-GJS-400-15 U	
lever	S 235 JRG2	
link	S 235 JRG2	
self-lubricated bushings	Permaglide	
operating ring	S 235 JRG2	
outer distributor ring	EN-GJL-200	
inner distributor ring	EN-GJL-200	
discharge ring	S 235 JRG2/AISI 304 L	
shaft seal	HGW F24EC6	
draft tube cone measuring pipes drainage pipes oil pipes	S 235 JRG2 1.4404 St 35 (galvanized) St 35 (yellow chromed)	

3. Speed Increaser

3.1 Technical data

2 single stage parallel shaft gear units:

Number of units	2
P rated	5.29
Rotating speed (rpm)	144 / 600
Design	AGMA 6011
SF	1.75

3.2 Characteristics

- Gear design is single stage parallel shaft gearbox with horizontal offset
- Casing is fabricated, made of ST 52-3 acc. to DIN
- Gearing is double helical
- Case hardening and ground, pinion and wheel are made out of 18CrNiMo7-6
- 4 journal radial bearings
- Both shaft ends are with integral flanges

3.3 Instrumentation

- 4 pc. duplex RTD's (3-wire) to measure the bearing metal temperature (8 radial, 4 axial), probes are installed in bearing metal, including cable glands, flexible conduit and junction box, EEx e.
- 5 pc. B. N. shaft vibration probes (4 radial, 1 key phasor) series 3500XL EEx e, including proximitors series 3300XL EEx I and proximitor housings, flexible conduit Junction box, EEx e.

4. Generator

4.1 Technical data

2 horizontal salient poles generators:

Number of units	3
Output (MVA)	4.0
Rotating speed (rpm)	600
Power factor (over excited)	0.9
Voltage (kV)	13.8

4.2 Generator general description

Stator Frame.
The stator frame is made of Welded Steel Construction and have adequate thickness to prevent distortion during operation. The frame is robust and rugged, designed to withstand bending stresses and deflections due to its self-weight and weight of the complete core to be supported by it. The design takes care of safe transmission load of all types and minimizes vibration and noise level, Stator bore is circular to ensure uniform air gap between the stator and rotor, there by minimising the unbalance magnetic pull. The Frame is rugged and strong to withstand stresses during normal operation and extreme stresses due to short circuits.

Stator Core.
The stator core is built-up of thin, high quality, low loss non oriented grains, cold rolled Silicon steel Laminations. Each punching is carefully deburred and laminations are insulated on both sides with high quality insulating varnish to minimize eddy current losses.
Ventilation ducts are provided at intervals along the stator core, being formed by means of steel spacing bars securely welded to adjacent punching.
The laminations are securely held in place by clamping flanges at each end. The clamping flanges are made up of mild steel.

Stator Winding.
The stator winding has class "F" insulation system. The stator winding is of multi-turn type, insulated through out with epoxy resin, mica paper tape and glass tape insulation system.

Each coil is made up of number of strands of glass braided copper of electrolytic quality, and of rectangular cross section, to minimize eddy current loses. The coils are provided with class " F" epoxy resin, mica paper tape and glass tape insulation.
The coils are treated to eliminate void to ensure high factor of safety against breakdown. An anti corona shield consisting of a butt layer of polyester fleece and a semi conducting graphite tape / paint is applied to each bar.
The overhang portions of the winding is braced together with packing blocks and securely laced to support rings made of moulded synthetic resins bonded fabric carried on brackets adjacent to the stator core end plate. Sufficient gap is provided in the top and bottom coils for good ventilation and to avoid hot spots.
The coils are held in place in open type slots by wedges of non shrinking material of class F Epoxy glass laminates.
The whole stator is Vacuum Pressure Impregnated (VPI).
After the impregnation and curing process, the whole unit forms a rigidly supported fully consolidated, void free winding. The resin fills all the voids in the stator winding and results in better heat transfer from conductor to stator core.

Terminal Arrangement
The three main leads and three neutral leads of the generator winding is brought out of the stator frame, in two separate Terminal Boxes.
The Phase and Neutral end of the windings are brought out with suitable insulating enclosure where they pass through the generator housing.
The main and neutral leads are provided with terminals suitable for connection with XLPE cables.

Cooling System
The generator is natural air cooled , rotor radial fan / axial fans is / are designed to give a smooth and quiet flow of air, Air is drawn from one / both End and Discharged at the other end / top of the machine, combined action of rotor poles and fans are sufficient to extract the heat generated in the generator.

Temperature Detectors
Resistance type temperature detectors of simplex / duplex type are arranged symmetrically in the stator winding to indicate the temperature obtained during operation. An Auxilliary Terminal box having suitable terminal blocks are mounted on the generator frame to terminate the resistor element connections. The temperature detectors leads are kept flexible to facilitate disconnecting them without breakage.

Rotor hub

The rotor hub is constructed out of steel plates bolted together to make a compact structure & machined along length, to form pole body. The rotor is designed to safely withstand all mechanical stresses imposed by the maximum runaway speed. The rotor hub is securely shrink fitted on main shaft taking care of requirements both at normal operating speed and at maximum over speed conditions.
The dynamic balancing of the complete rotor is carried out at works to keep values of rotor vibrations within allowable limits.

Shaft
The generator shaft is made of a high quality medium carbon steel, properly heat treated and accurately machined all over and polished at the bearing surfaces and at all accessible points for alignment checks.
The shaft will have ample strength and stiffness at all speeds to resist vibration or twisting on short circuits. The entire shaft is properly tested to ensure that it is free from cracks, blowholes, slag formation or any other defects.
A complete set of test reports covering metallurgical strength, & ultrasonic tests performed on each shaft will be furnished.

Solid Pole Tips
The solid pole tips are bolted to pole body to retain field coils against centrifugal forces at operating as well as run away speed conditions & will also act as damper windings to improve stability under fault conditions, & to reduce voltage distortions under conditions of single phase to ground fault.

Field Winding.
The field winding is Single Layer type, insulated with class “F” insulation and consist of copper strips fabricated on edge.
The field coils is made of special profile copper strip wound on edges. The insulation between turns is of epoxy treated paper and insulation to ground is of epoxy based glass laminates. The assembled coils are electrically heated and pressurised to cure the turn insulation and thus consolidate the coil.
All connections between adjacent field coils are made mechanically strong and firmly secured to the rotor.

Bearings.
The generator is provided thrust / guide bearing, on DE side and guide bearing on NDE side. The bearings are forced oil lubricated white metal lined journal type pedestal / end shield mounted Sleeve bearings.
Bearings are designed to take the required axial / radial load.
The NDE bearing is insulated to prevent any harmful circulating current from passing through the bearings surfaces.

Brakes (If Applicable)

Generator will be provided with Hydraulic operated brakes of sufficient capacity to bring rotating parts of generator and turbine to stop from 20 % of rated speed. Oil supply at required pressure along with necessary piping & controls to be provided by the customer.

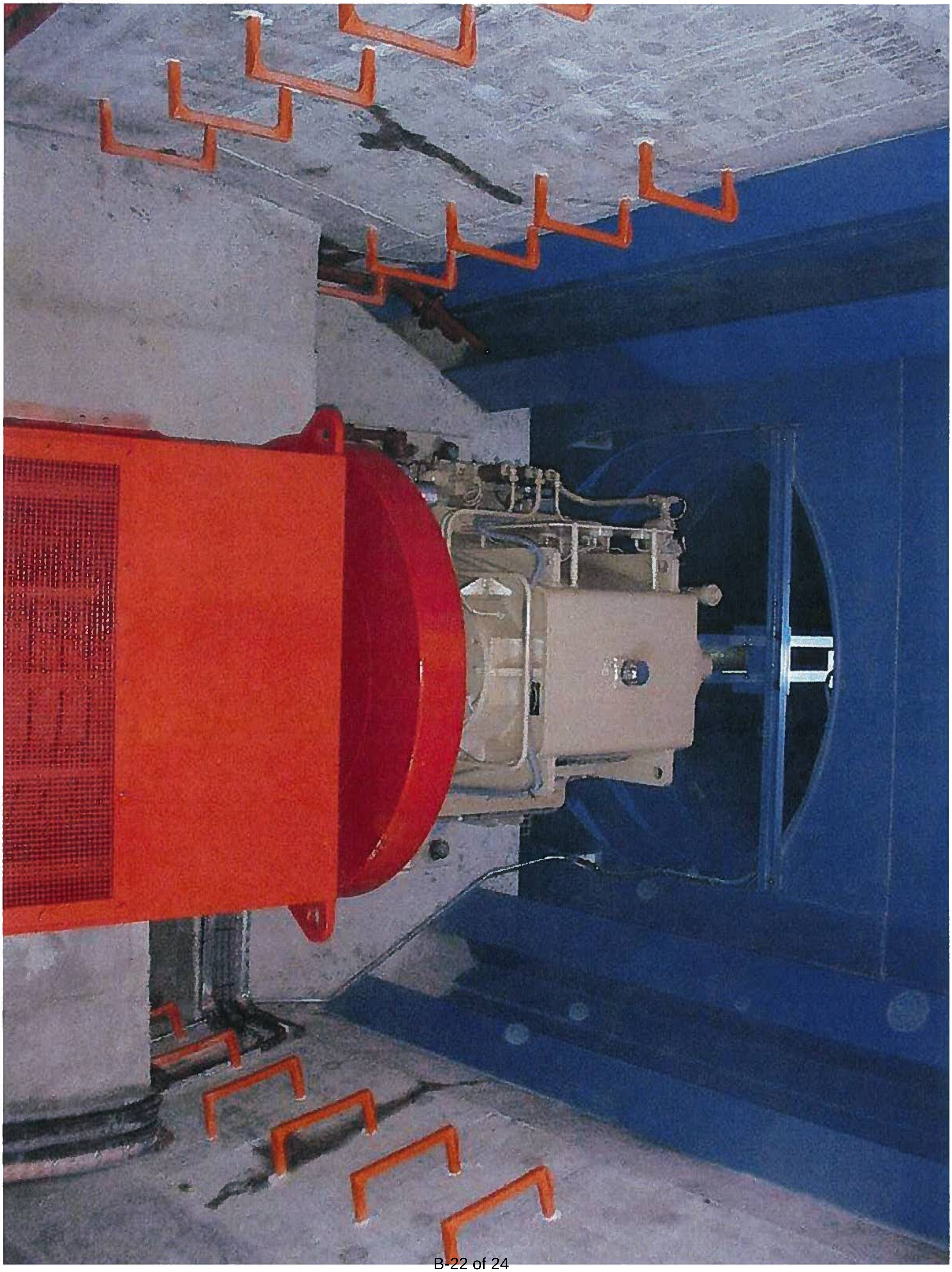
Brushless Excitation System

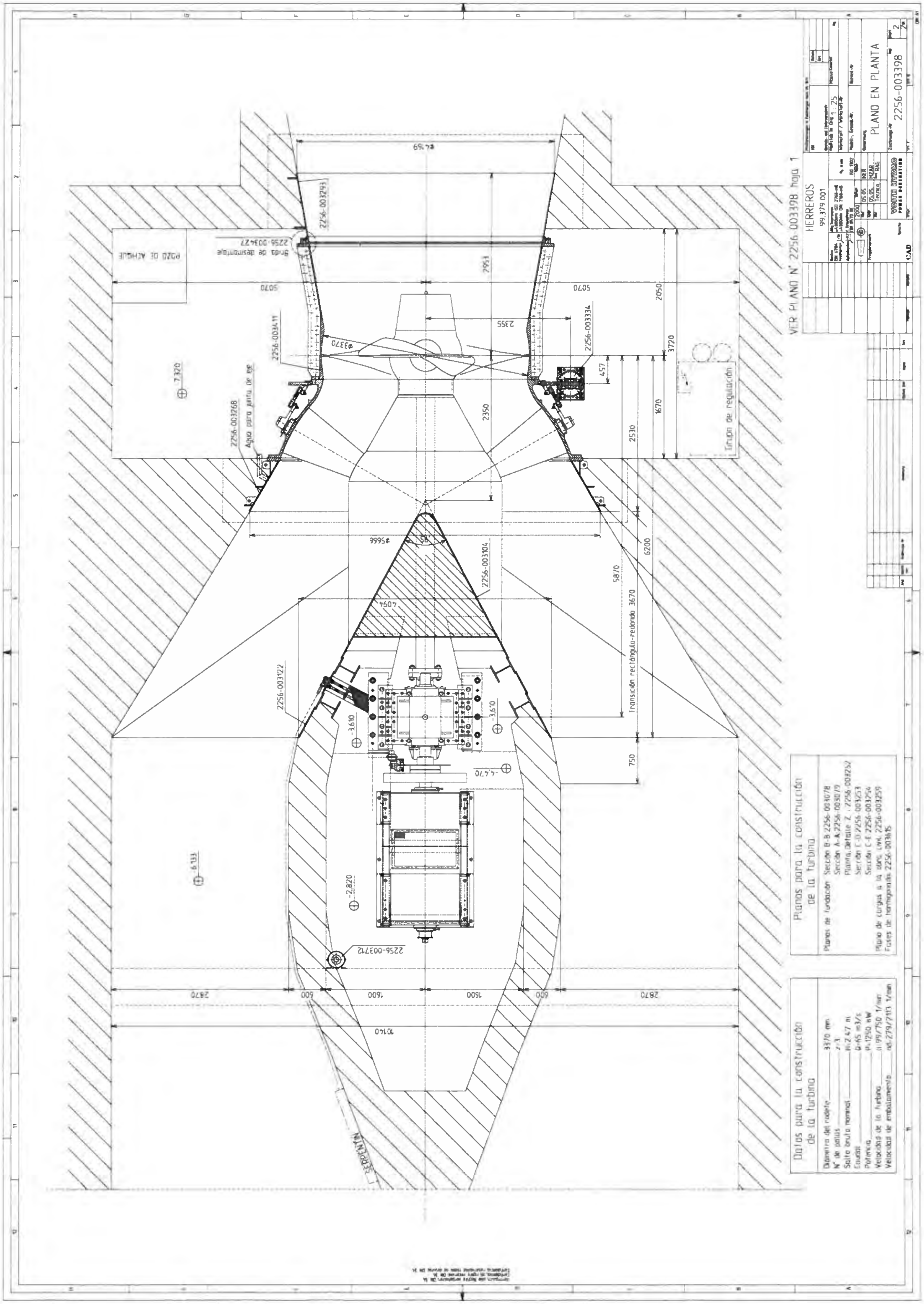
The Brushless Excitation System consists of a three phase AC Exciter having armature winding on rotor & field winding on stator and a full wave Rotating Rectifier Bridge, mounted on same exciter rotor / shaft. Three phase AC voltage from exciter armature is fed to the Rotating Rectifier Bridge & the DC voltage output of the rectifier bridge is directly fed to main field Winding of the generator, mounted on the same shaft. Main Field winding in turn generates three phase voltage in main generator armature winding, which is housed in main stator.

5. Electrical equipments

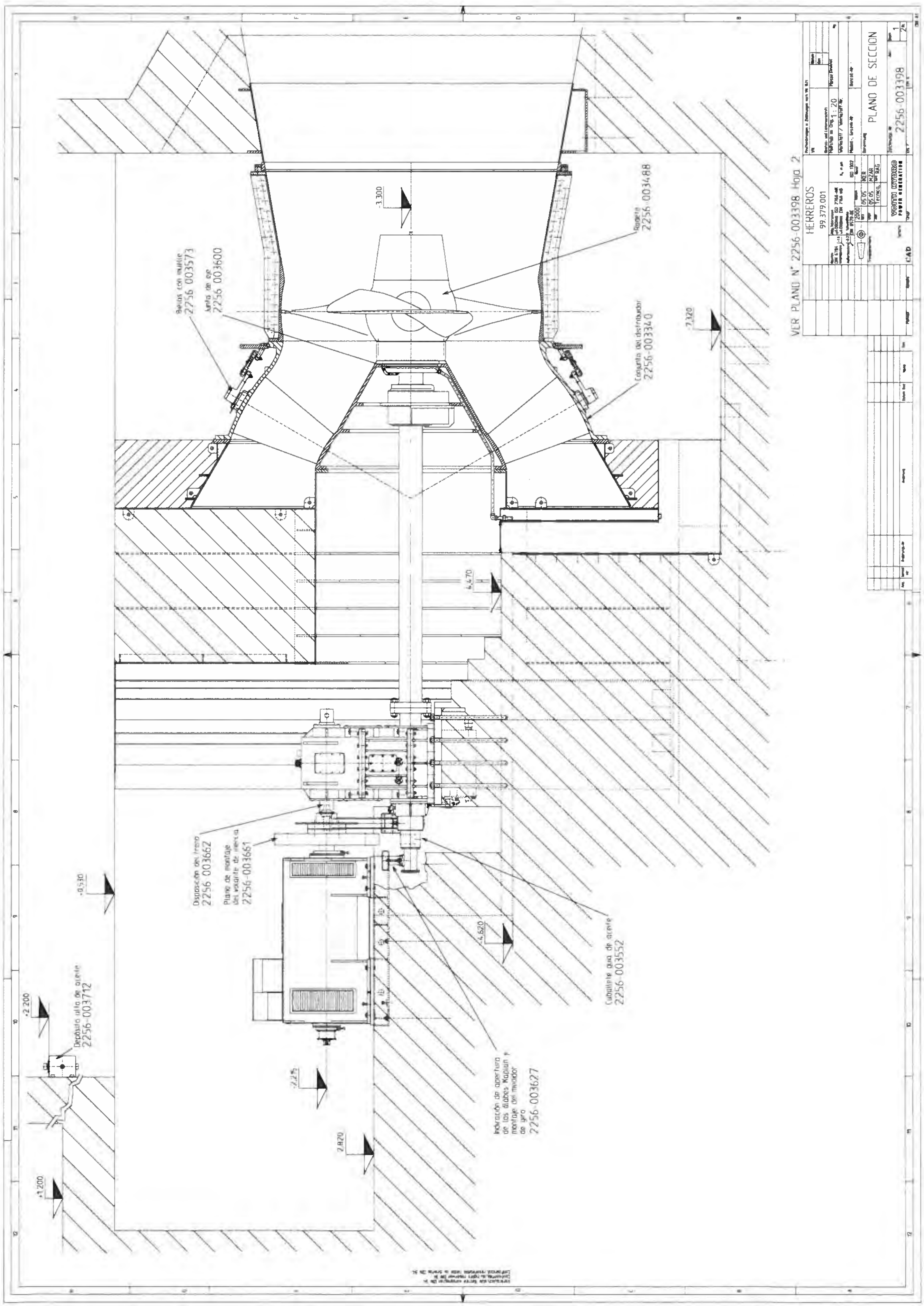
5.1 Description

- 5 kV LV Switchgear and unit Protection & Control system (multifunction protective relays);
- PLC based station digital automatic control system with Alarm and SOE recording;
- Cable Trays, control wiring & power cabling in powerhouse and to transformer in switchyard within 100 m;
- Station service transformer (600 v / 69 kV), MCC and AC distribution and connections to all AC equipment;
- Station battery, charger and DC distribution and connections to all DC equipment;
- LV disconnect switch and station bus cabling and supports;
- A remote terminal for remote monitoring, data transfer to head office master database and dispatch via Modem / Ethernet VPN (fibre optic);
- 13 MVA 4.16 / 69 kV ONAN Main Output Transformer (incl. Protection Relays) with Substation Services;





VER PLANO N° 2256-003398 hoja 1
HERREROS
99.379.001
PLANO EN PLANTA
2256-003398
VOITH HYDRO POWER GENERATION
Datos para la construcción de la turbina
Diámetro del rodete 3370 mm
N° de palas z-3
Salto bruto nominal H-2.47 m
Caudal Q-65 m3/s
Potencia P-1250 kW
Velocidad de la turbina n-99/750 1/min
Velocidad de embalamento nd-279/2113 1/min
Planos para la construcción de la turbina
Planos de fundación Sección B-B 2256-003078
Sección A-A 2256-003079
Planta, Detalle Z 2256-003252
Sección C-D 2256-003253
Sección C-E 2256-003254
Plano de cargas a la obra civil 2256-003259
Fases de hormigonado 2256-003615
POZO DE ACHIQUE
Brida de desmontaje
2256-003427
2256-003293
2256-003411
2256-003268
Agua para junta de eje
2256-003334
2256-003122
2256-003104
2256-003712
Grupo de regulación
Transición rectángulo-redondo 3670
SERPENTÍN



VER PLANO N° 2256-003398 Hoja 2
HERREROS
99.379.001
PLANO DE SECCION
2256-003398
Rodete
2256-003488
Conjunto del distribuidor
2256-003340
Bielas con muelle
2256 003573
Junta de eje
2256 003600
Disposición del freno
2256 003662
Plano de montaje del volante de inercia
2256-003661
Depósito alto de aceite
2256-003712
2256-003552
Indicación de apertura de los álabes Kaplan y montaje del medidor de giro
2256-003627

Knight Piésold
CONSULTING

APPENDIX C

INFLATABLE RUBBER WEIRS AND OBERMEYER GATES

(Pages C-1 to C-39)

OBERMEYER HYDRO, INC.

P.O. Box 668 Fort Collins, Colorado 80522 USA
Tel 970-568-9844 Fax 970-568-9845
Email: hydro@obermeyerhydro.com www.obermeyerhydro.com

Thank you for your interest in Obermeyer Spillway Gates. Obermeyer gates offer an economical and technologically superior method of spillway control. Some of the features include:

1. Obermeyer Spillway Gates conform to almost any spillway shape without costly changes to the existing spillway profile.

2. The rugged steel gate panels overhang the reinforced air bladders in all positions. The gate panels protect the air bladders from damage due to ice, logs, or other debris.

3. The Obermeyer Spillway Gates are very controllable. Our gates can be set at an infinite number of positions between fully raised and fully lowered. Our standard pneumatic controller provides accurate upstream pond control, and discharges water appropriately to maintain upstream pond elevation through a full range of flow conditions.

4. Obermeyer Spillway Gates use no high precision parts or bearings. This allows for easy installation and long service life.

5. Obermeyer Spillway Gates use clean, dry, compressed air for actuation. No hydraulic fluid or other contaminates are used.

6. The modular design of Obermeyer Spillway Gates creates a very safe operating system. For large gate systems, each air bladder is isolated from the other by means of a check valve. If one air bladder becomes damaged, the rest of the gate system will not deflate through the damaged section.

7. The modular design of Obermeyer Spillway Gates simplifies installation and maintenance. The use of individual air bladders and gate panels minimizes the lifting capacity required for installation. This saves significant time and money by reducing the size of equipment and manpower needed to install the system.

Obermeyer Spillway Gates are manufactured under license under one or more of the following patents:
U.S. PATENT 4,780,024 • U.S. PATENT 5,092,707 • U.S. PATENT 5,538,360 • U.S. PATENT 5,642,963
U.S. PATENT 5,709,502 • U.S. PATENT 5,713,699 • OTHER U.S. AND FOREIGN PATENTS PENDING

AQUAPRO Rubber Dam

www.arcon-aquapro.com

THE MOST VERSATILE DAM IN THE WORLD

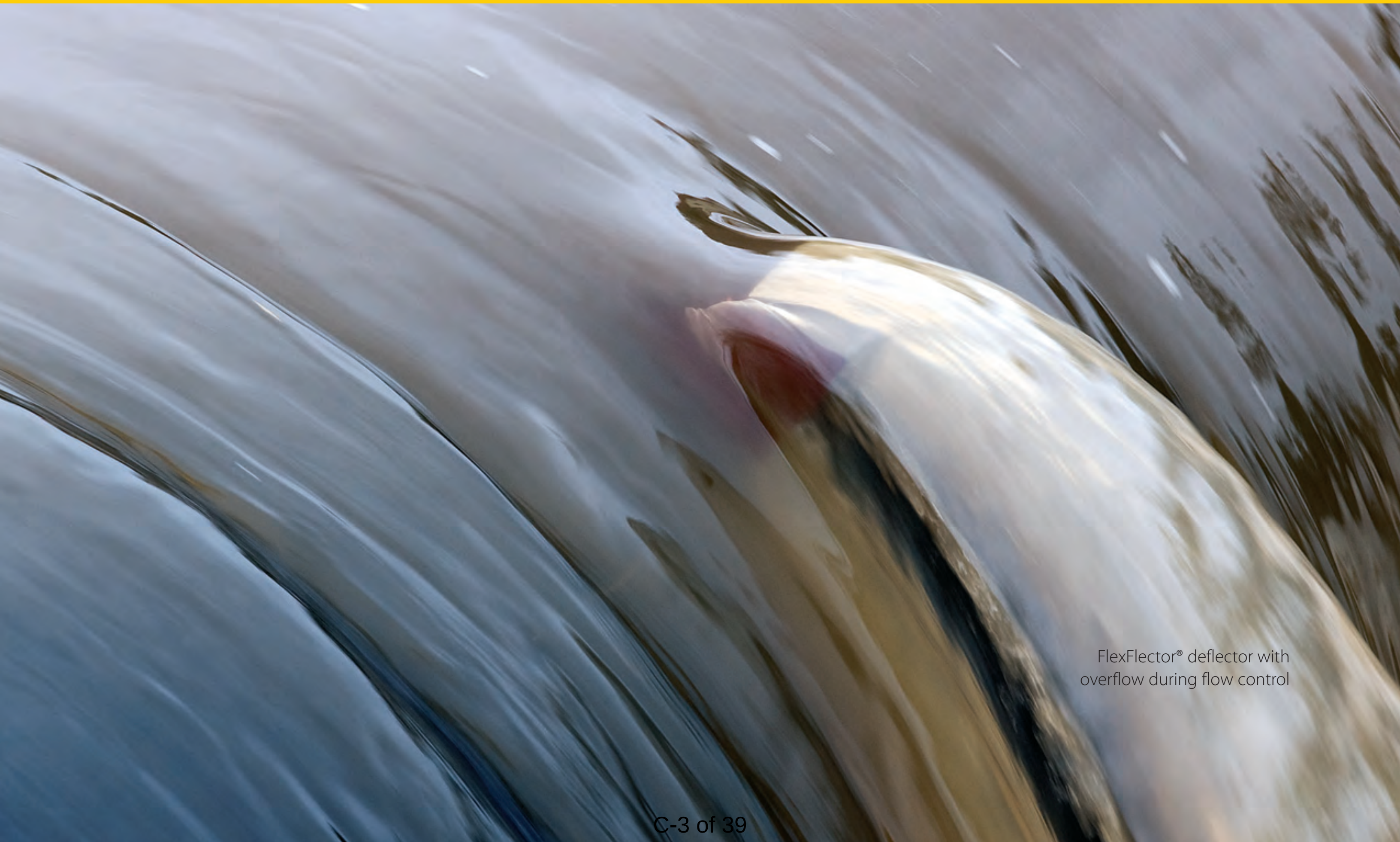
Hydroelectric Power, Irrigation, Flood Control, Water Supply, Water Cooling, Separation of Fresh and Sea Water, Navigation Channels, Recreational, Ground Water Recharging, Urban Regeneration

Arcon

What is a Rubber Dam?

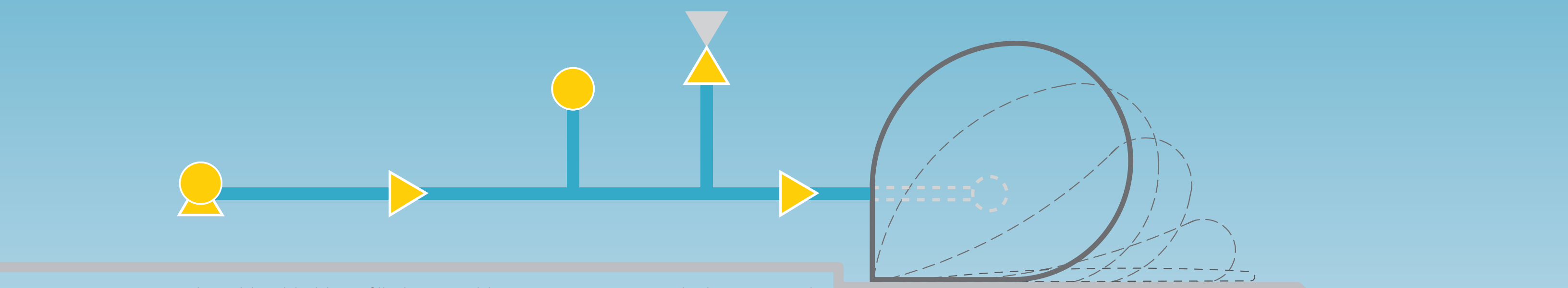
A Rubber Dam is a highly efficient water controlling structure which significantly outperforms conventional steel gate systems. It comprises of a flexible, high tensile, rubber-coated fabric bladder, which is permanently clamped to a reinforced concrete foundation. The bladder is inflated either by air or water, which in turn impounds and controls water flow, and is lowered by releasing the air or water from inside the bladder.

Arcon AquaPro, in partnership with Floecksmühle, supply the highest specification Rubber Dam systems available in the industry today. We have been designing, developing, manufacturing and installing custom built air-filled and water-filled Rubber Dams worldwide since 1984, using the highest grade Continental® rubber and internationally recognised quality components, exceeding materials used elsewhere in the industry. These advantages combined with the inherent simplicity of the design and unrivalled intelligent control systems, flow controls and advanced fail-safe systems, make Arcon AquaPro Rubber Dams the new standard available today.



FlexFlector® deflector with overflow during flow control

Simplicity of Design

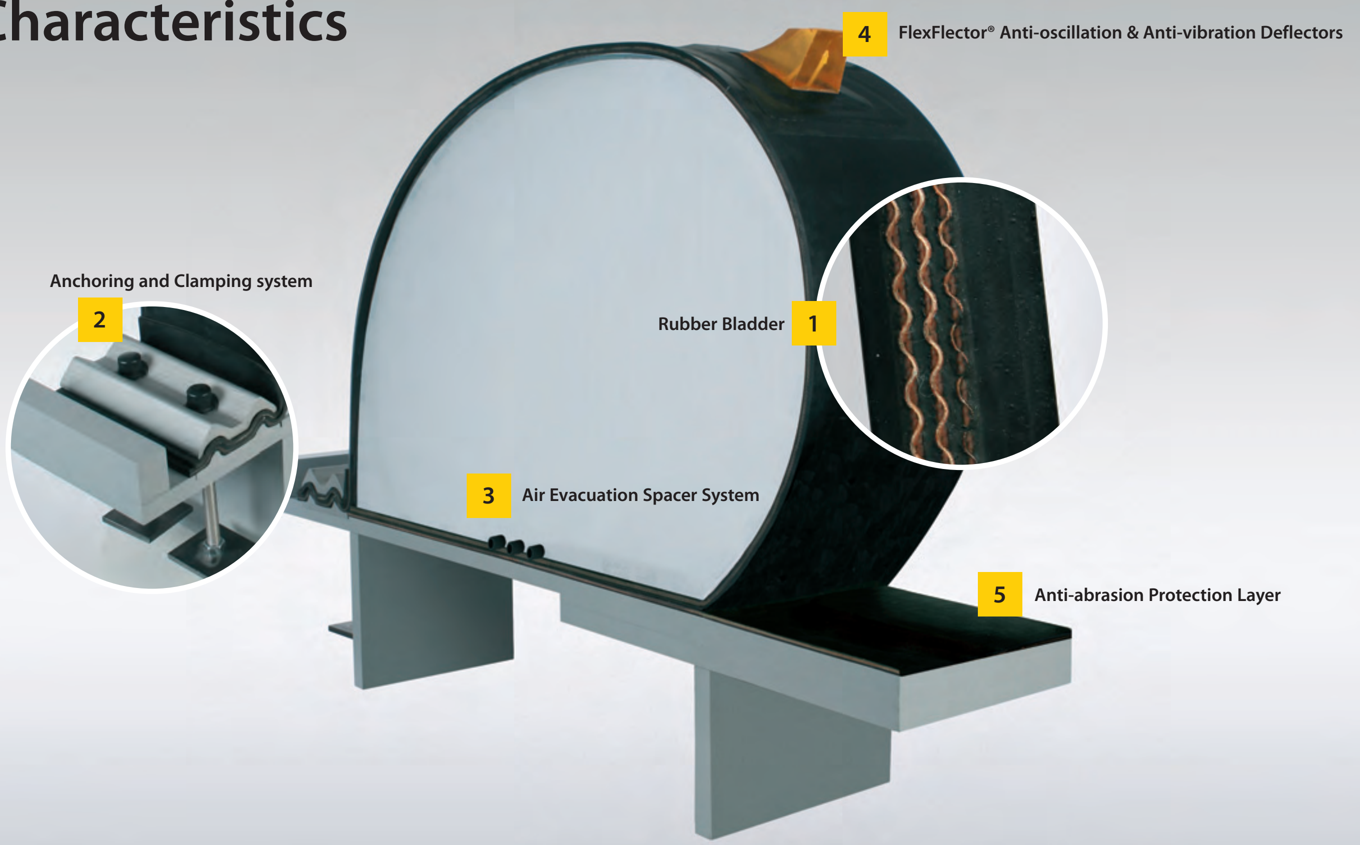


The rubber bladder is filled using a blower or water pump which is operated by a sophisticated yet simple to use control system. The bladder is lowered by means of an exhaust system, which is backed up by a mechanically operated failsafe deflation system in case of a power failure.

How does an Arcon AQUAPRO Rubber Dam compare to conventional alternatives?

	RUBBER DAM	STEEL GATE	PNEUMATIC OPERATED STEEL GATE
Low installation, operating and maintenance costs	✔	✘	✘
Simple and quick to install	✔	✘	✘
Simple to operate, maintain and repair	✔	✘	✘
Manual and automatic operation	✔	✔	✔
NO generalized ice risks	✔	✘	✘
Does NOT require multiple air connections	✔	✔	✘
Does NOT require a high pressure compressor	✔	✔	✘
Does NOT require motor driven mechanical equipment	✔	✘	✔
Does NOT require stiffeners for stability of high sections	✔	✘	✘
Does NOT require accurate foundation tolerances	✔	✘	✘
Does NOT require vertical side walls	✔	✘	✘
Does NOT suffer from leaking seals between sections	✔	✘	✘
Does NOT require sub-structures	✔	✘	✘
Does NOT disrupt flow	✔	✘	✘
Precise control of upstream headwater	✔	✔	✔
Operates well with high downstream water levels	✔	✔	✘
Good impact resistance	✔	✘	✘
Absorbs shock & vibration	✔	✘	✘
Corrosion resistant	✔	✘	✘
No lubrication of moving parts	✔	✘	✔
No painting of steel parts	✔	✘	✘
No danger of oil spills during operation or maintenance	✔	✘	✘
Lifting equipment not required	✔	✘	✔
Reliable failsafe device in case of power failure	✔	✘	✔
Non-intrusive structure	✔	✘	✔
Installed on flat foundations	✔	✔	✔
Installed on ogee crests	✔	✘	✔

Characteristics



1 Rubber Bladder

The AquaPro Rubber Bladder is made up of 100% EPDM rubber which resists weathering, ozone, ultra violet light, the effects of extreme temperatures and significantly out-performs CR rubbers which are more commonly used. The AquaPro Rubber Bladder incorporates a reinforcement Polyester fabric which gives the bladder its high tensile strength and has a significant advantage in terms of its 'memory' of shape during long periods of deflation, as well as being 100% watertight in comparison to the absorbent Nylon fabrics traditionally used. The bladder is available in a range of thicknesses, used in accordance with the conditions on-site.

2 Anchoring & Clamping System

The Anchoring & Clamping System is simple, easy to install and provides an airtight/watertight seal. Depending on factors such as the overflow and the down stream water level, a single or a double anchor line is used to fix the rubber bladder to the foundation. The embedded plates and anchor bolts are normally cast into new concrete foundations, however, they can also be effectively fixed with resin on existing foundations.

3 Air Evacuation Spacer System

In case of air-filled rubber dams, it is important that the bladder lies flat when fully deflated. A unique spacer system channels the evacuating air to an air-exhaust outlet, making sure no air pockets are formed thus ensuring a flat profile when fully deflated.

4 FlexFlector® Anti-oscillation & Anti-vibration Deflectors

Due to a number of factors, including variable flow conditions, high overflow, and tailwater, the rubber bladder may oscillate and/or vibrate in fully or partially inflated positions. This is resolved by using FlexFlector® deflectors which equalise the ambient pressure with the air pressure behind the curtain of water overflowing the dam. The bladder is additionally stabilised by an anti oscillation function in the main Control System.

5 Anti-abrasion Protection Layer

To provide complete protection against abrasion and impact by water borne loads and preventing debris from lodging beneath the bladder, a specially designed Anti-abrasion Protection Layer is attached to the concrete foundation on the downstream side of the Rubber Dam.

Control Systems

Integrated and Intelligent Control system
Our sophisticated and fully programmable Control System can be integrated with operation systems of other related equipment and is designed to accurately retain maximum storage levels, even in the event of a power failure. The weir can be operated both manually and automatically and the PLC programmed to a client's specific operation requirements.

Condensate Drainage System
In the case of an air-filled Rubber Dam, condensation can occasionally form inside the bladder, especially where there has been a significant difference in temperature between night and day, and during warmer months. Under these conditions, the Condensate Drainage System effectively evacuates any water which has accumulated inside of the bladder.

Upstream Water Level Control

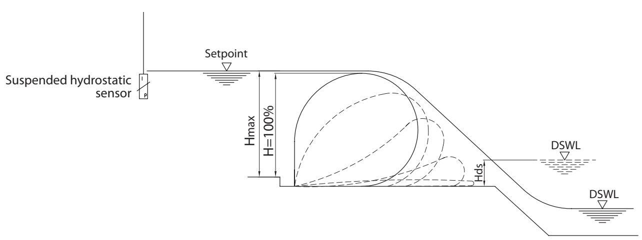
The full range of control offered in Arcon AquaPro Rubber Dams is unique.
There are two alternatives to control the upstream water level:

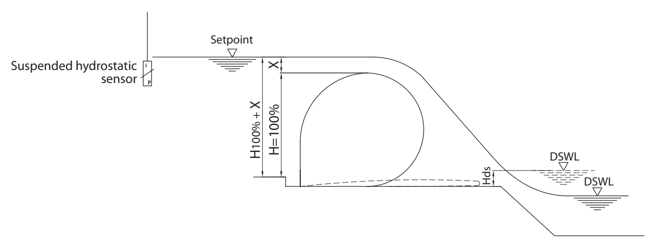
Dynamic Level Control

The control system provides the flexibility to accurately control the upstream water level to a variable set point. The PLC automatically responds to water levels above or below the set point by decreasing or increasing the internal pressure of the bladder to either pass or store water. This is particularly important in applications involving Hydroelectric Power.

Fixed Level Control

The control system is also capable of maintaining the bladder in either a fully inflated or fully deflated condition. The PLC automatically responds to a water level above the deflation set point by fully deflating the bladder. When the water level decreases below the inflation set point, the PLC responds by fully inflating the bladder.





Failsafe Systems

Failsafe Mechanical Deflation System
Unlike conventional steel gate systems, which require manual operation of often poorly maintained mechanical parts, the Arcon AquaPro Rubber Dam utilizes a failsafe mechanical deflation device, which lowers the bladder in the event of power failure. Deflation is triggered when the upstream water level rises to a mechanical deflation set point. This set point is configured at a level above the standard electrical set point, thereby allowing for a safety margin during which either the flow can stabilize or the power can be restored before deflation occurs. This minimises the risk of unnecessary downtime whilst still ensuring safe operation.

Over Pressure Relief Valve
A pressure relief valve is supplied to ensure that the bladder does not exceed the allowable inner pressure in the event of either equipment or power failure.

Pressure Control System
The PLC automatically monitors the pressure within the bladder. Should the pressure significantly decrease below or increase above the pressure set point, the PLC will operate either the inflation blower or the deflation valve to correct the deviation and return the internal pressure to that of the pressure target. This pressure deviation is often encountered during the normal diurnal cycle.

The number of **Arcon AquaPro** Rubber Dam installations is growing all the time as more engineers move away from conventional steel gate dams to flexible, safer and more reliable rubber dam systems. This trend can be seen from the rapidly increasing number of installations worldwide.

Top
1.60 mH x 33.80 mL x 1 span

Left
2.44 mH x 30.30 mL x 2 spans

Middle
2.0 mH x 12.0 mL x 1 span

Right
2.35 mH x 21.40 mL x 2 span

Arcon offers worldwide Rubber Dam technical & advisory support, maintenance and spares, as well as experienced teams of installation advisors and installers across the globe.

Arcon technicians make regular visits to all of their sites, giving advice and recommendations to operators on Rubber Dam operation, inspection and maintenance procedures.

Regional Representative:

Arcon AquaPro is part of the Arcon Environmental Division. Arcon was founded in 1974, with 11 offices worldwide.

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12 Relton Mews
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United Kingdom

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F. +44 (0) 20 7225 1811

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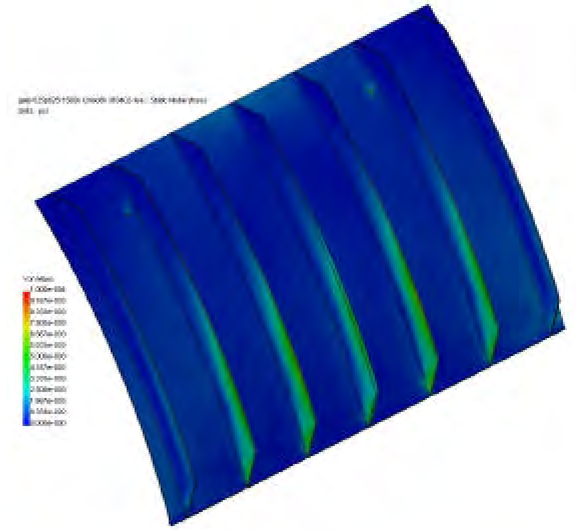
www.arcon-aquapro.com

arcon

AP-RD-10-08

8. Obermeyer Spillway Gates are very vandal and damage resistant. From the upstream side, steel panels protect the air bladders in all positions. Damage due to ice, trees, or other debris is nearly impossible from the upstream side. The air bladders are reinforced by multiple plies of polyester of aramid tire fabric. The use of these types of fabrics, in combination with generous thickness of rubber, creates a very bullet and vandal resistant air bladder.

9. Obermeyer Hydro utilizes state of the art engineering and software packages to insure that each gate system design will be safe and reliable. Gate panels and other steel components are designed using the latest finite element analysis programs.



We hope this package answers the questions you have regarding Obermeyer Spillway Gates. If you have any other questions, please don't hesitate to contact our head office by phone or email. If you desire a site-specific price quote, please refer Page 4, Site Specific Details, which lists questions asked by our applications engineers when designing a project.

Once again, we appreciate your interest in Obermeyer Spillway Gates and we look forward to hearing more about your project.

Sincerely,
Rob Eckman
Vice President
Obermeyer Hydro, Inc.

P.O. Box 668
Fort Collins, CO 80522
PH: 970-568-9844
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hydro@obermeyerhydro.com
http://www.obermeyerhydro.com

Obermeyer Spillway Gates are manufactured under license under one or more of the following patents:
U.S. PATENT 4,780,024 • U.S. PATENT 5,092,707 • U.S. PATENT 5,538,360 • U.S. PATENT 5,642,963
U.S. PATENT 5,709,502 • U.S. PATENT 5,713,699 • OTHER U.S. AND FOREIGN PATENTS PENDING

Introduction

Obermeyer Spillway Gates are most simply described as a row of steel gate panels supported on their downstream side by inflatable air bladders. By controlling the pressure in the bladders, the pond elevation maintained by the gates can be infinitely adjusted within the system control range (full inflation to full deflation) and accurately maintained at user-selected set points.

Obermeyer Spillway Gates are patented bottom hinged spillway gates with many unique attributes that include:

- Accurate automatic pond level control even under power failure conditions.
- Modular design simplifies installation and maintenance.
- Unlike torque tube type spillway gates, Obermeyer gates are supported for their entire width by an
  inflatable air bladder, resulting in simple foundation requirements and a cost effective, efficient gate structure.
- Thin profile efficiently passes flood flows, ice, and debris.
- Unlike rubber dams, the steel gate panels overhang the air bladder in all positions, protecting the bladder from floating logs, debris, ice, etc.
- No intermediate piers are required.
- Obermeyer Spillway Gates are a great investment due to increased revenue, decreased maintenance, and low cost of installation.

These features are the result of combining rugged steel gate panels with a resilient pneumatic support system.

The Spillway Gates are attached to the foundation structure by anchor bolts which are secured with epoxy or non-shrink cement grout as design dictates. The required number of air bladders are clamped over the anchor bolts and connected to the air supply pipes. When the air bladder hinge flaps are fastened to the gate panels, the installation of the strong, durable and resilient crest gate system is complete.

View of Gate from Downstream

The individual steel gate panels and air bladders are fabricated in widths of five or 10 feet, (1.5 meters or 3 meters for metric installations) for systems up to 6.5 (2 meters) high. Systems higher than 6.5 feet (2 meters) use various standard width air bladders such that the height/length ratio is less than approximately 1.0.

The gaps between adjacent panels are spanned by reinforced interpanel seals clamped to adjacent gate panel edges. At each abutment, a robust, low-friction lip seal is affixed to the gate panel edge. This seal moves along the abutment plate, keeping abutment plate seepage to a minimum. For installation in cold climates the abutment plates are provided with heaters to prevent ice formation. Alternatively, rubber seals may be fixed to the abutments or piers which engage when raised.

Hydraulic Performance

Obermeyer Spillway Gates provide excellent controllability over a full range of flow rates, water elevations and gate positions.

All gates operating on the same air supply line maintain a uniform crest height. This is because any differential lowering of a gate panel relative to others on the same air supply manifold causes said gate panel to develop more contact area with its respective air bladder than other gate panels. The extra contact area produces a restoring moment that returns said gate panel to the same position as the others.

Vibration due to von Karman vortex shedding does not occur with Obermeyer spillway gates. The shape of the system when raised or partially raised causes flow separation to occur only at the downstream edge of the gate panels. This favorable condition also occurs when the system is operating in a submerged or high tailwater condition; in contrast, rubber dams which due to their rounded shape can vibrate destructively as the line of flow separation moves cyclically back and forth across the rounded surface of the inflated structure.

Obermeyer Spillway Gates provide very repeatable positioning relative to inflation pressure and headwater level and can be used to precisely measure the flow, as well as control flow.

Obermeyer Spillway Gates can be operated continuously over a full range of gate positions, headwater elevations and tailwater elevations and may be installed within siphon spillways subject to extreme water velocities.

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U.S. PATENT 5,709,502 • U.S. PATENT 5,713,699 • OTHER U.S. AND FOREIGN PATENTS PENDING

Installation

Installation of Obermeyer Spillway Gates is quick and easy. For systems up to approximately 4 meters high, the air bladders are secured to the spillway with a row of anchor bolts. For system heights above 4 meters, an embedded clamp is used to secure the gate system to the spillway. The anchor bolts may be embedded in a new spillway or may be secured in holes drilled into an existing spillway. The air supply lines, which connect to each individual air bladder, can be embedded or grouted into a saw slot in the spillway. Surface mounted air supply lines may also be used. A typical installation sequence is as follows:

Drilling of Anchor Bolt Holes

1. Place anchor bolts
2. Install air supply lines
3. Install abutment plates, if used
4. Place air bladders over anchor bolts
5. Secure air bladders to spillway with clamp bars
6. Connect air supply lines to underside of air bladders
7. Attach steel gate panels to each air bladder
8. Attach interpanel seals
9. Attach restraining straps if used
10. Attach nappe breakers
11. Adjust and grout abutment plates or install J seals
12. Install compressor, drier and controls
13. Start up system

Installation of Gate Panels

Start of Installation – Installing Gate Panel – Completed Gate

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Types of Control Systems

Control System with Touch Panel

Obermeyer Spillway Gates are supplied with control systems in accordance with customer requirements. Each control system includes a controlled source of compressed air and a means for controlled venting of air from the air bladders. All automatic systems also include provision for local manual control. Each system includes an air compressor, a receiver tank, and required control valves. Most systems, especially those subject to freezing conditions, include air driers.

Pneumatic Water Level Control

The most basic control system uses an all-pneumatic water level controller to automatically regulate air bladder pressure in inverse proportion to upstream water level. This system requires no electrical power to accurately maintain a constant upstream pool elevation over a full range of gate positions and spillway flow rates. This controller is ideally suited to hydroelectric projects where a turbine load rejection is often associated with loss of electrical power. This control system is also ideal for safety critical flood control projects where flood conditions and extended loss of electrical power often occur simultaneously. A bubbler line senses upstream water level. The minute amount of air required for the bubbler system is supplied from the air receiver with the air stored within the air bladders connected as a backup supply.

Programmable Controllers

In many applications, it is desirable to control Obermeyer Spillway Gates with a Programmable Controller. A Programmable Controller is ideal for complex schemes such as maintaining precise environmentally mandated spillway flows under varying head pond elevation at hydroelectric peaking plants. Pre-existing programmable controllers at numerous hydroelectric plants have been used to control Obermeyer Spillway Gates, thus reducing the overall cost of the gate installation. Conversely, at new projects, an Obermeyer supplied Programmable Controller can also serve other control requirements not related to the spillway gates. Programmable Controller based systems can be provided with Pneumatic Water Level Controllers as a mechanical backup.

Solar Powered Controls

Obermeyer Spillway Gates can be supplied with solar powered compressors and control systems. Obermeyer Spillway Gates are well suited to solar powered operation because no large electric motors are required even on quite large gate installations. Solar powered systems normally use 12-volt solar panels, battery and compressor. A programmable controller with optional radio modem operates the compressor or vent valves in accordance with water level readings or remote control signals.

Safety Critical Applications

For relatively small gate installations on large rivers, it is usual to operate all of the air bladders on the same pipe or pressure manifold. For large gate installations on narrow populated river channels, check valves are used on each air bladder to insure that damage to any one air bladder cannot release air from any of the other air bladders. This feature is an important safety advantage of Obermeyer Spillway Gates over rubber dams.

Independent Operation of Groups of Gates

At many projects it is desirable to control various sections of the spillway independently. This can be accomplished by simply providing separate pipes to each independent section. No intermediate piers are required. Applications for this scheme include:

- Releasing floating debris from near a power plant intake.
- Concentrating flows to discharge upstream sediment.
- Minimizing tailwater elevation by releasing excess flow away from the power plant.
- Providing fishway attraction water in the precise amounts and locations needed.
- Diverting flows to allow inspection access to the raised portion of a gate system.

Flow Measurement and Control

Obermeyer Spillway Gates respond to changes in headwater elevation and internal air pressure in a precise and repeatable manner. For any particular gate installation, the flow rate and gate crest elevation can be calculated on the basis of the measured up stream pond elevation and the controlled air bladder pressure. Flow rates for submerged installations, i.e., installations with high tailwater, can be calculated on the basis of upstream and downstream levels and air bladder pressure.

Gate Panels

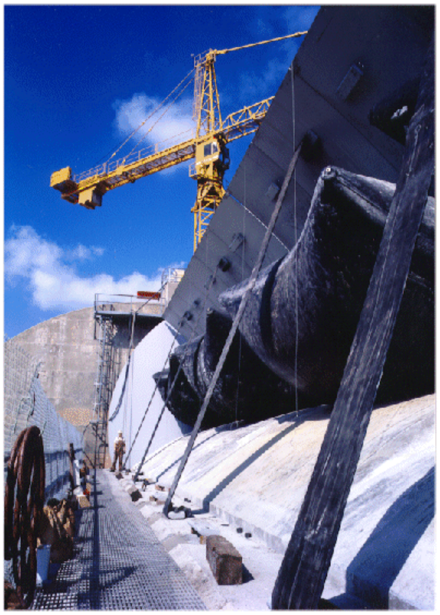
Gate panels are made from high strength steel plate that is epoxy coated or galvanized in accordance with customer preference. Stainless steel gate panels may be supplied on request. Gate panels for systems less than 1 meter high are made from a flat plate that is bent to conform to the spillway shape when in the lowered position. A small amount of additional curvature of the gate panel profile is provided to allow space for the deflated air bladder when the gate panels are fully lowered. Gate panels for systems higher than 1 meter are provided with stiffening ribs running parallel to the direction of flow. The ribs provide strength without obstruction of flow. A high degree of torsional rigidity is not required because of the uniform support of the gate panels by the air bladders. For the same design stress level, the gate panels are much lighter, less costly and less restrictive to water flow compared to gate panels for hydraulically or mechanically operated gates.

Gate panels are provided with a row of threaded studs near the pivot edge to which the hinge flap is clamped. Similar threaded studs are provided at the right and left edges of each gate panel for sealing to the adjacent gate panels or to the abutments.

The outermost ribs on each gate panel are provided with lifting holes. The upper/downstream edge of each gate panel features holes or studs for the attachment of nappe breakers. For installations that utilize restraining straps, holes or studs are provided for attaching the restraining straps to each gate panel.

The upstream/lower edge of each gate panel features a smooth rounded surface for transferring a reaction load to the air bladder and hinge flap.

Air Bladders



Air bladders are designed and manufactured by methods similar to those used in the manufacture of automotive tires. A butyl rubber inner liner provides excellent air retention characteristics. A intermediate layer of high tensile strength rubber compounds containing multiple plies of polyester or arimid tire cord reinforcement, e.g. DuPont KEVLAR ® fiber, provide the mechanical strength needed to contain the internal pressure. A cover compound utilizing aging and ozone resistant polymers such as EPDM is used to protect the bladder from wear and weathering.

Air bladders for systems of less than 2 meters in height incorporate integral hinge flaps to which the gate panels are attached. Systems higher than 2 meters utilize separate hinge flaps which utilize the same high strength tire cord construction as the inflatable portion of the air bladders. No mechanical hinges are used.

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U.S. PATENT 5,709,502 • U.S. PATENT 5,713,699 • OTHER U.S. AND FOREIGN PATENTS PENDING

Comparison Chart

Obermeyer Spillway Gates vs. Rubber Dams

Advantages of Obermeyer Spillway Gates:

Precise control of upstream elevation over a full range of headwater elevations and gate positions

Unlimited spans can be installed without intermediate piers

Steel panels provide robust protection from debris damage

Vertical abutments provide maximum discharge capacity and reduced civil costs

Modular design reduces maximum required crane capacity

Modular design allows change out of any damaged components without requiring whole system replacement. This dramatically reduces life cycle cost and limits any downtime

Check valve isolation of individual air bladders maximizes public safety by dramatically limiting unintended flows which could result from air loss

Obermeyer Spillway Gates can provide precise flow data and flow control

Disadvantages of Rubber Dams:

The inflatable membrane is exposed directly to ice and debris

Allowable overtopping is limited by vortex shedding induced by vibration

Replacement at an entire span is required if damage cannot be repaired

Discharge along crest is non-uniform when partially inflated

- Flood Control
- Recreation
- Water Supply
- Irrigation
- Tidal Barrier
- Hydropower

Spillway Gates and Inflatable Rubber Dams

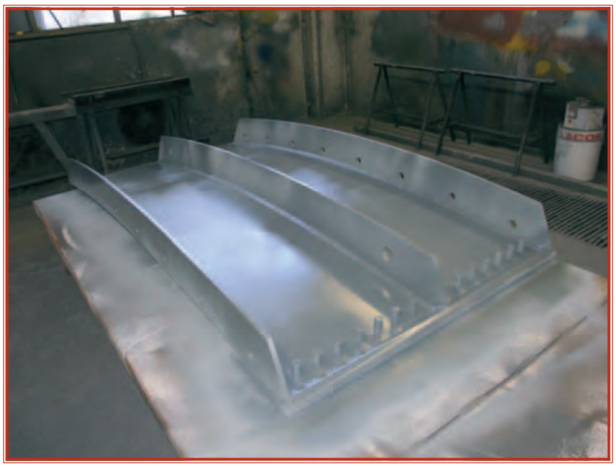
DYRHOFF

Introduction

Dyrhoff specialises in the design and supply of spillway gates and inflatable rubber dams. The company has been involved in rubber dam business in Europe since 1989 and in spillway gate business since 1997. In 2003, Dyrhoff took over the *Sumigate* rubber dam business from the Japanese company, Sumitomo Electric Industries, Ltd. At the time, Sumitomo Electric was the world's leading manufacturer and supplier of inflatable rubber dams.

The Dyrhoff rubber dam is designed by Dyrhoff in Europe using design know-how acquired from Sumitomo Electric. All our rubber dam components are designed and manufactured according to the current Japanese technical standards on inflatable rubber dams.

Dyrhoff is also the main European agent for the Obermeyer Hydro spillway gate. We supply complete spillway gate systems according to Obermeyer Hydro's design. Depending on the size of the spillway gate and type of steel required, Dyrhoff can fabricate some steel components in house such as the gate panels, abutment plates and steel embeds as well as pre-fabricating pipe layouts. Otherwise, manufacturing of painted steel components is usually outsourced to local companies in Europe depending on the location of the project.



Fabrication and painting of gate panel in Europe.

Sumitomo Electric rubber dam in Norway.

Dyrhoff can work on a supply only or a full turnkey basis. Furthermore, Dyrhoff can supply all or part of the rubber dam or spillway gate system with or without the control system. Dyrhoff can give independent and impartial advice on the best type of gate system for a particular application or location without being tied to a specific rubber dam or spillway gate manufacturer.

DYRHOFF

"We are the only company in the world that can supply and install both spillway gates and inflatable rubber dams".

Inflatable Rubber Dam

Inflatable rubber dams have been used as water control structures for more than fifty years. The world's first inflatable rubber dam was installed in Los Angeles County in the USA in the mid-1950s. In those days, inflatable rubber dams were viewed much as they are today as relatively inexpensive, versatile structures capable of creating pondage and/or controlling flow in a particular watercourse.

The rubber dam is a permanent structure comprising a sheet of rubber-coated fabric (rubber body) which is fixed to a reinforced concrete foundation using clamp plates and anchor bolts. The rubber dam is inflated by pumping air or water inside the rubber body until the design height or pressure is reached. It is deflated by allowing the air or water inside the rubber body to escape.

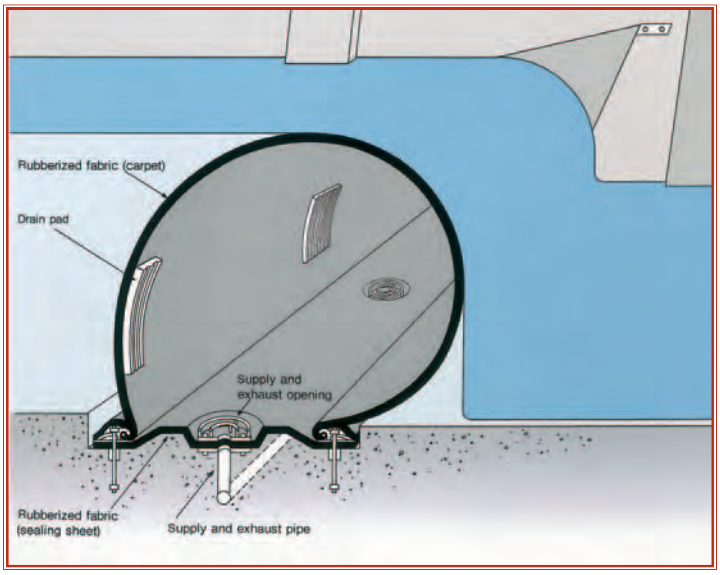
The inflatable rubber dam has numerous advantages over other types of water control gate, such as;

- Simple and inexpensive operating system
- Can be installed on almost any channel cross-section shape
- Relatively low capital cost
- Perfect sealing; no leakage
- Virtually maintenance free; no moving parts, no painting
- Long spans up to 100m; multiple spans of several hundred metres
- Easily designed to accept loading in both directions
- Light structure
- Clean operation; no hydraulic oil required
- Can always be "opened" (deflated); no possibility of jamming

4.0m high Ma Wat rubber dam in Hong Kong.

Rubber dam on River Besos near Barcelona.

"The Dyrhoff rubber dam is designed in Europe using design know-how acquired from Sumitomo Electric".



Two 45m long rubber dams at Kagoshima in Japan.

The key element of the inflatable rubber dam is the rubber body. The rubber body of the Dyrhoff rubber dam is manufactured by Sumitomo Electric Industries Ltd in Japan. Sumitomo Electric has been involved in the manufacture of rubber dams since 1965; longer than other company in the world. In that period, the company has manufactured more than 1,800 rubber dams for projects around the world.

In keeping with market demands, Dyrhoff is also able to supply inflatable rubber dams from manufacturers in China and Taiwan. Dyrhoff was the first company to supply and install a Chinese-made inflatable rubber dam in Europe.

Chinese-made rubber dam on River Oglio in Italy.

All Dyrhoff's inflatable rubber dams whether manufactured in Japan, Taiwan, China or elsewhere are designed to the same technical standards. Dyrhoff inspects all rubber bodies after manufacture and prior to shipping. When requested, Dyrhoff will provide qualified and experienced on-site supervisors to advise on the installation of the inflatable rubber dam anywhere in the world.

DYRHOFF

"Dyrhoff was the first company to supply and install a Chinese made rubber dam in Europe".

Obermeyer Spillway Gate System

Obermeyer pneumatically-operated spillway gates provide increased water storage and automatic upstream level control for water storage projects, hydroelectric plants, flood control structures, navigation and recreation purposes.

Obermeyer installed its first spillway gate in the USA in 1988 and in Europe in 1997. The largest Obermeyer spillway gate constructed to date is 6.5m high x 10.0m wide. Four such gates are installed at Lakatnik and Svragen small hydropower plants in Bulgaria. Installation was completed in 2007.

The OHI spillway gate is a patented, bottom-hinged spillway gate. The system comprises a row of steel gate panels supported on their downstream side by inflatable air bladders. By controlling the pressure in the bladders, the upstream pond elevation can be infinitely adjusted within the specified control range and accurately maintained at user-selected set points.

The main features of the Obermeyer spillway gate are;

- Modular design means that very long spans can be installed
- Single components can easily be replaced if damaged
- Steel panels protect the air bladders from damage
- Can be operated at any height from fully inflated to fully deflated
- Can operate with higher values of overtopping; no vibration
- Independent operation of different gate sections is possible

^ Deflated spillway gate at HPP Pontey in Italy.

< Cross section through an Obermeyer spillway gate.

DYRHOFF

"Dyrhoff can give independent and impartial advice on the best type of gate system for a particular application or location".

Further Information

Dyrhoff is pleased to provide technical advice, product information, preliminary design drawings, budget prices or a full technical and/or commercial proposal for any project involving inflatable rubber dams and/or spillway gates anywhere in the world. As each project is different and each rubber dam or spillway gate is custom built, it is important to provide us with as much information as possible about the project and the gate operating requirements at an early stage. Such information would normally include:

- Maximum upstream and downstream water levels across the rubber dam
- River flow characteristics including maximum velocity
- Maximum overflow depth (overtopping) when rubber dam is fully inflated
- Type of rubber dam (air-inflated or water filled)
- Required time for inflation/deflation (average is 60 minutes)
- Type of control/operating system (manual/automatic)
- Location of control room relative to rubber dam (distance)
- Type and quality of fixings (carbon steel, 304 or 316 stainless steel)

Contact Us

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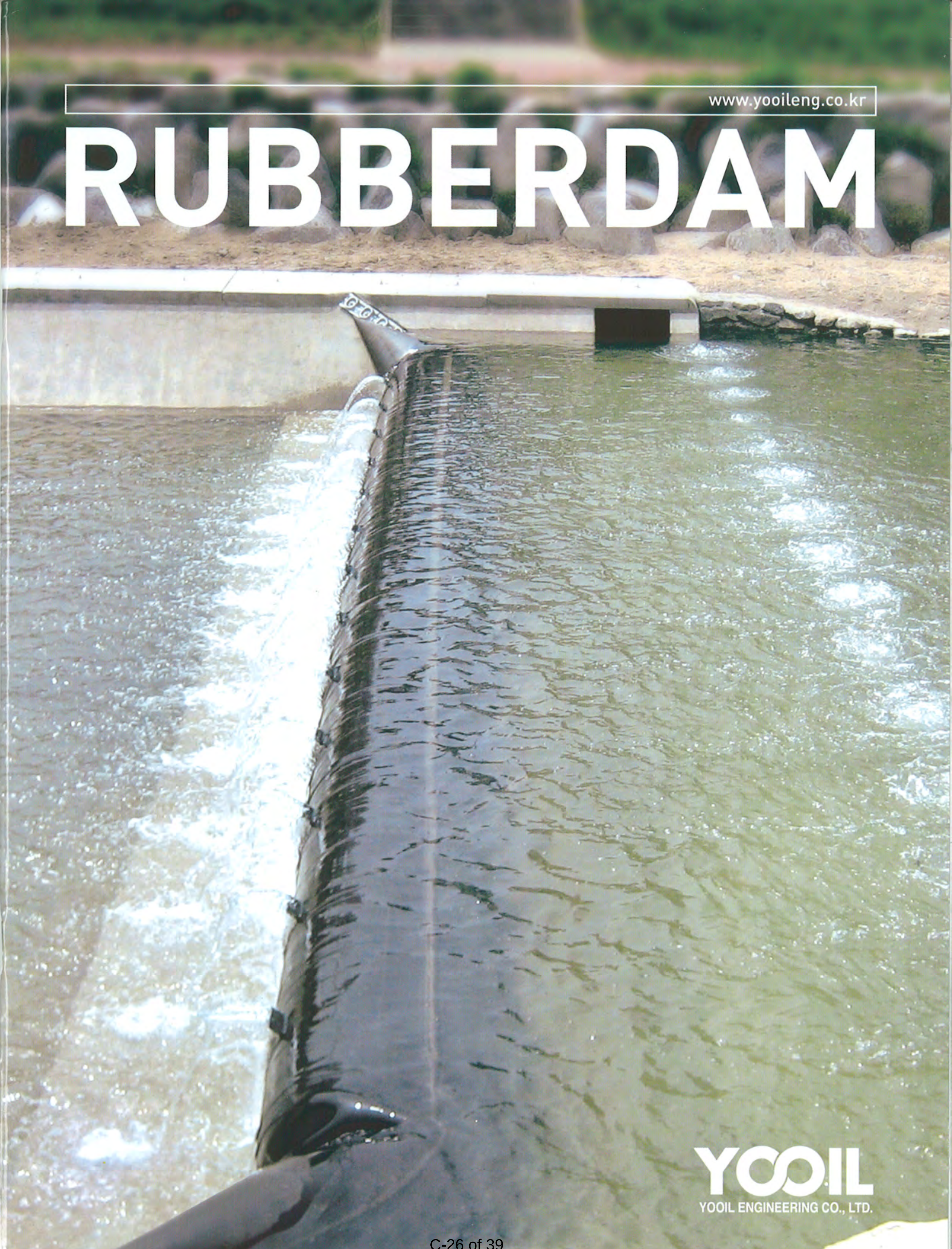
E-mail: staale.dyrhoff@dyrhoff.no

Water Supply / Tamjin river, Jangheung-gun, Chollanam-do, Republic of Korea / 1.3mH × 112mL(2SPAN)

Flood Control / Chonju river,Chonju-city, Jeollabuk-do,Republic of Korea / 1.5mH × 32mL

Water Supply / Hongcheong river Hongcheong-gun, Gangwon-do, Republic of Korea / 1.5mH × 100mL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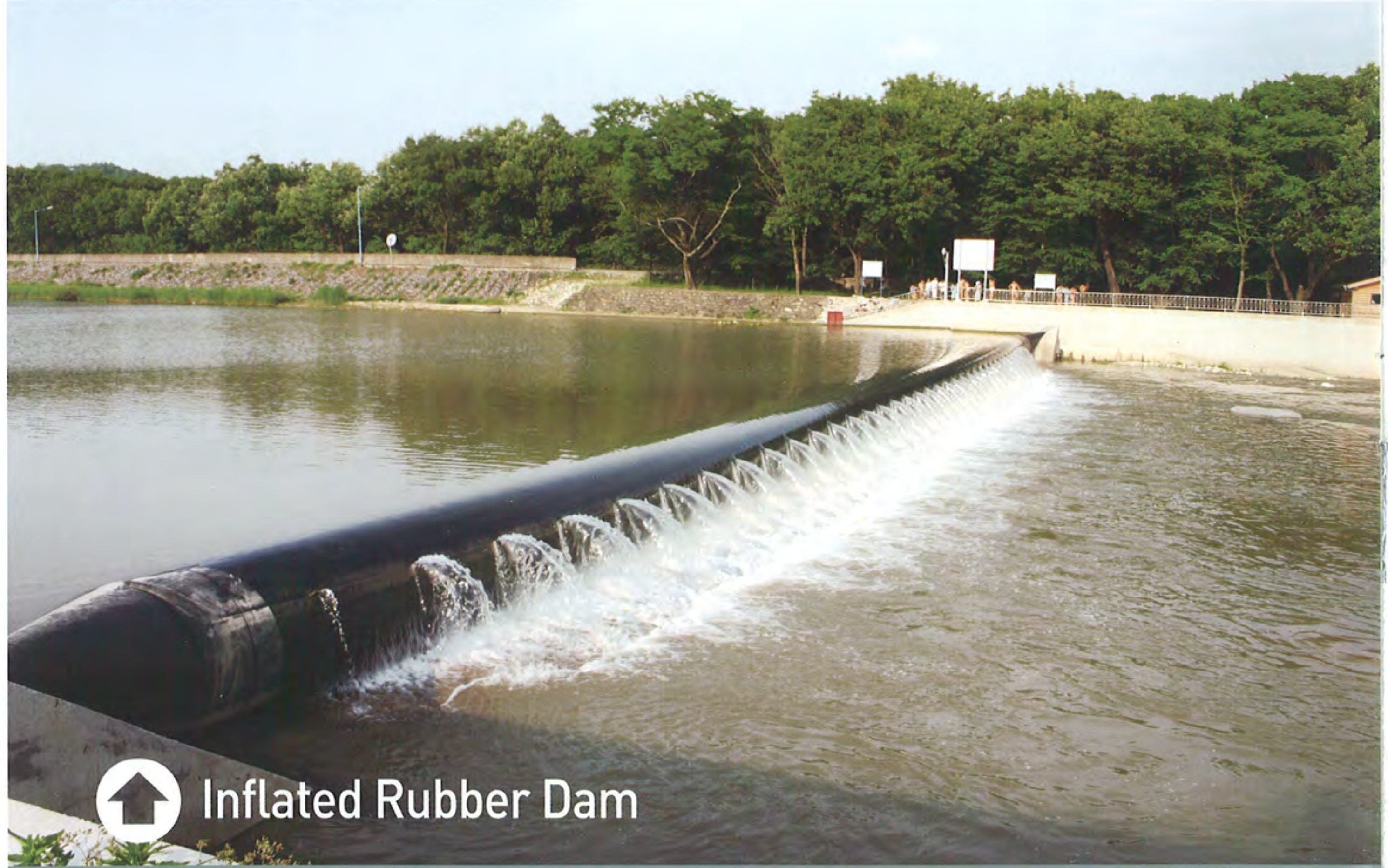
RUBBERDAM
YOOIL
YOOIL ENGINEERING CO., LTD.

YOOIL RUBBER WEIR : Verified and improved Most flexible technology for water control



Inflated Rubber Dam

Safe, Quick, and Simple

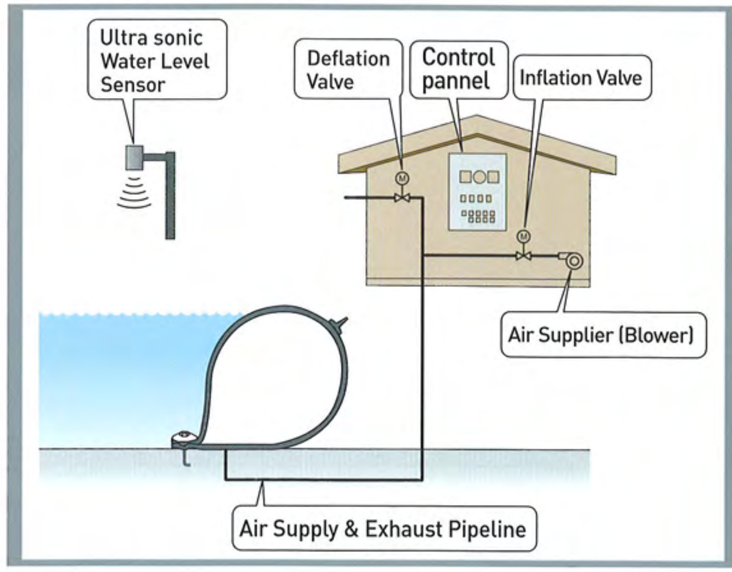
Deflated Rubber Dam

Longer Span Without Piers or Abutment : Rubber dam can be installed without a Mid-structure up to 150m(500ft) in length.

Variable side slope
Rubber dam can be installed in rivers with any side slope angle up to 90° degree vertical.

No dredging needed
Rubber dam eliminates the sediment and piled soil in both up stream and down stream when deflated.

Easy and low Maintenance cost.
Small punctured holes are easily repaired like a car tire! In case of larger holes, simply patch up!
Now, the abrasion indicator inside of rubber sheet is available for early warning system.

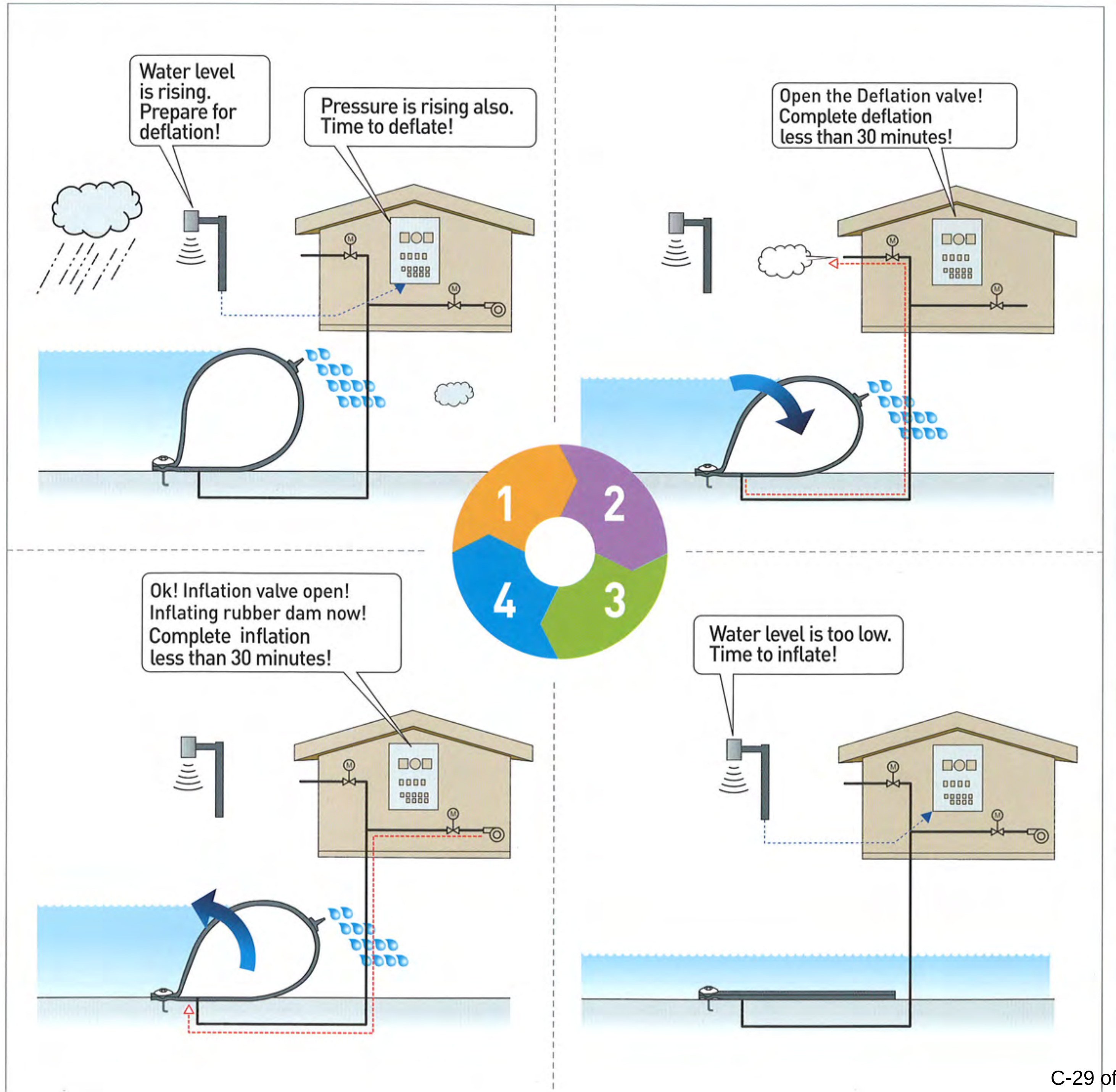


Safe and User Friendly Operation

Operate the air supplier in the operation room with fully automatic, semi-automatic or manual to supply the rubber dam with air up to the specified or desired pressure and height. The Ultra sonic sensor is used for detecting inflation and deflation water level.

The system will open the exhaust valve by either the flood level or your necessity to discharge the air inside of the rubberdam.

When the air is fully exhausted, the rubber dam adheres closely to the bottom of a river thus, maximizing the water discharge within the area.




Air Supplier (Blower)


Manometer
(Digital & Analog pressure gauge)


Inflation Valve


Deflation Valve

Control House


Standard Type


Wood Finish

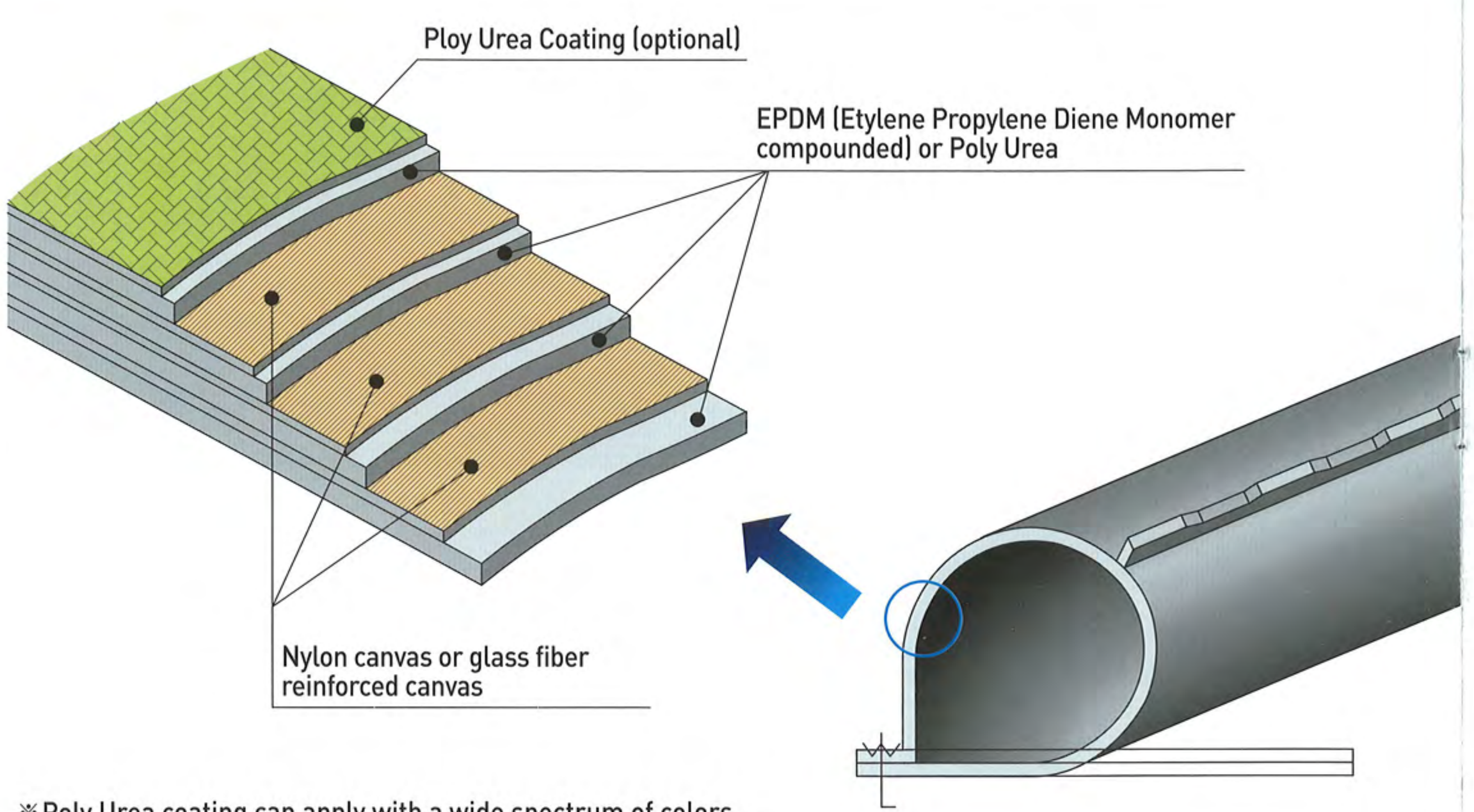

Wood Finish


Brick and concrete


Custom made


Ultra sonic Water Level Sensor


PANNEL

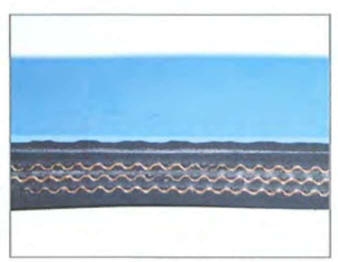


※ Poly Urea coating can apply with a wide spectrum of colors.
UV treated coating can increase the service life up to 5 more years.

Rubber and Poly urea sheet specification


Standard Roll Type


Bookend Type


Poly Urea Coating

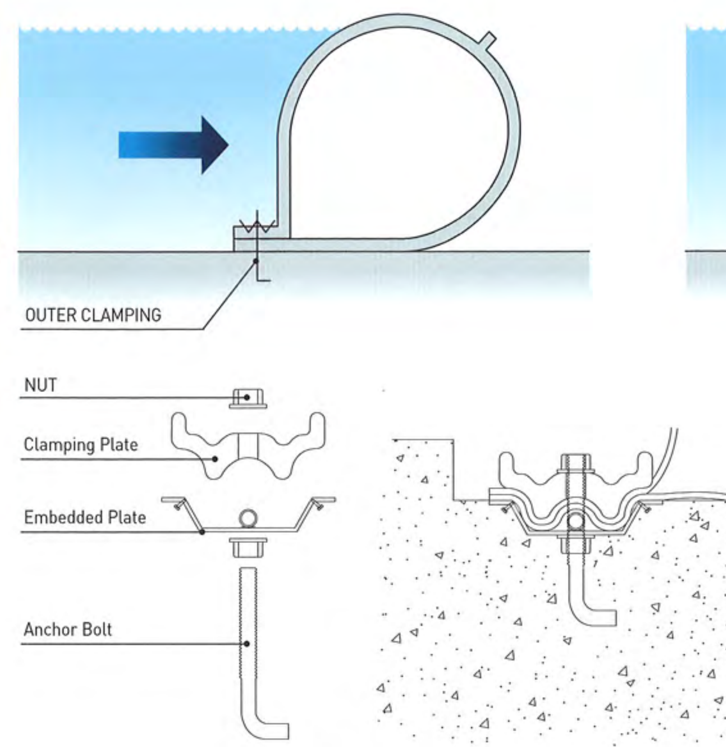

All Poly Urea

POLY UREA SHEET COLOR	
F-143507	F-227011
F-318011	F-405504
F-555009	F-528001
F-616006	F-8010000

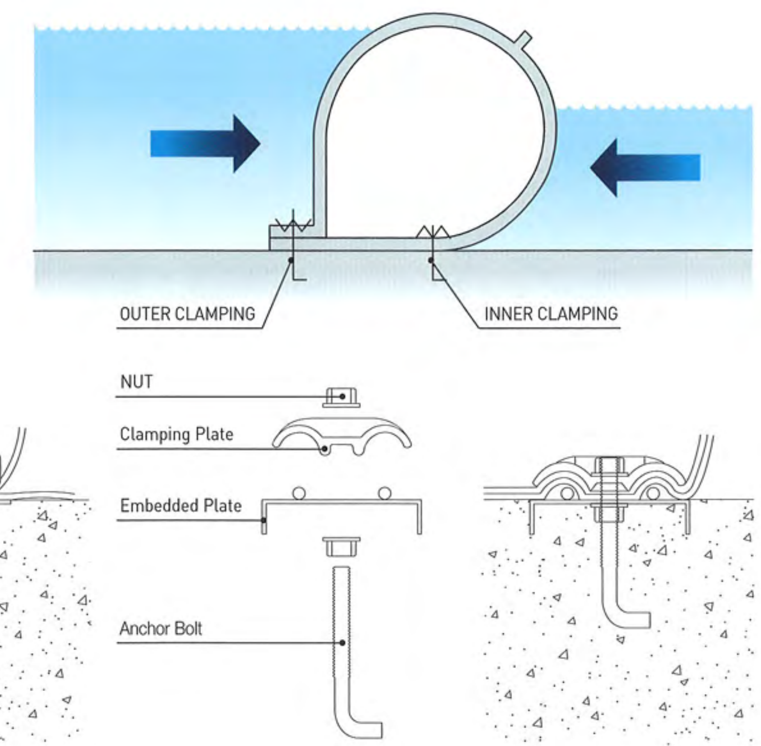

BOOKEND


STANDARD

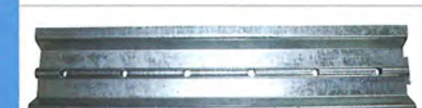
Single Anchor Line

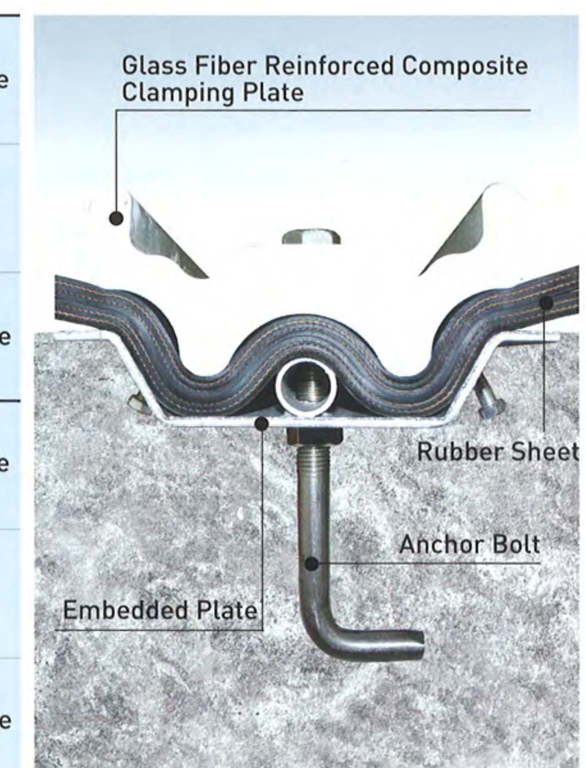


Double Anchor Line



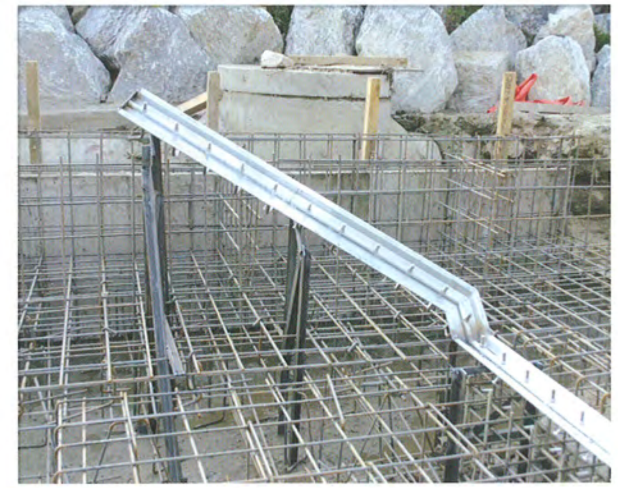
Fixing and Anchoring : Ensure 100% air and water tightness

OUTER		Clamping Plate
		Anchor Bolt
		Embedded Plate
INNER		Clamping Plate
		Anchor Bolt
		Embedded Plate



01 Before Construction

02 Installing Foundation



03 Installing Embbeded plates & Anchors

04 Installing Nozzles & Pipes

05 Cast in Concrete

06 Unrolling the rubber body

07 Drilling Anchor holes

08 Setting Clamping plates and Tightening Anchor bolts

09 Completion of clamping rubber body

10 Control House

11 Installing the Control Equipment

12 Inflation test and Completion

History of Performance

YOOIL

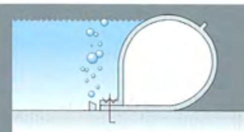
ex	Area :	Completion :	Standard : H×L
01	Taedok research institute, Daejeon city, Republic of Korea	1988 - 05	1.0mH × 30mL
02	Kumgang,Okcheon county, Chungcheongbuk-do,Republic of Korea	1988 - 01	1.0mH × 100mL
03	Geumhogang, Daegu city, Republic of Korea	1988 - 11	1.6mH × 30mL
04	Sin#7 river, Daegu city, Republic of Korea	1988 - 12	1.8mH × 60mL
05	Sin#6 river, Daegu city, Republic of Korea	1988 - 12	2.0mH × 60mL
06	Anyang river, Anyang city, Gyeonggi-do, Republic of Korea	1989 - 12	1.5mH × 50mL
07	Incheon reservoir, Incheon city,Republic of Korea	1990 - 07	2.0mH × 28mL
08	Sin #8river, Daegu-si, Republic of Korea	1990 - 09	2.2mH × 50mL
09	Tan#1 river, Seongnam city, Gyeonggi-do, Republic of Korea	1991 - 08	1.5mH × 50mL
10	Sanggung reservoir Boun county, Chungcheongbuk-do,Republic of Korea	1991 - 12	0.8mH × 70.7mL
11	Gapcheon Daejeon-si, Republic of Korea	1992 - 01	1.0mH × 100mL
12	Woncheon river, Suwon City, Gyeonggi-do, Republic of Korea	1992 - 04	1.5mH × 38mL
13	Bokha river,Icheon city, Gyeonggi-do Republic of Korea	1992 - 05	2.2mH × 80mL
14	Seomjingang, Jeongeup City,Chollabuk-do, Republic of Korea	1992 - 06	2.3mH × 50mL
15	Mukhyeon#1 river,Namyangju City Gyeonggi-do,Republic of Korea	1992 - 07	1.0mH × 13mL
16	Mukhyeon#2 river,Namyangju City Gyeonggi-do,Republic of Korea	1992 - 07	1.0mH × 17mL
17	Jeongeup river, Jeongeup City,Chollabuk-do, Republic of Korea	1992 - 07	1.5mH × 30mL
18	Tan#2 river, Seongnam city, Gyeonggi-do, Republic of Korea	1992 - 08	1.5mH × 60mL
19	Gapcheon Daejeon city, Republic of Korea	1992 - 09	2.3mH × 195mL(3SPAN)
20	Woncheon#2 river, Suwon City, Gyeonggi-do, Republic of Korea	1992 - 12	1.5mH × 38mL
21	Sucheongbo Daejeon city, Republic of Korea	1993 - 04	0.8mH × 20.0mL
22	Sin river, Dongducheon city, Gyeonggi-do,Republic of Korea	1993 - 06	1.5mH × 80mL
23	Tan#3 river, Seongnam city, Gyeonggi-do, Republic of Korea	1993 - 06	1.5mH × 50mL
24	Tan#4 river, Seongnam city, Gyeonggi-do, Republic of Korea	1993 - 06	1.5mH × 60mL
25	Tan#5 river, Seongnam city, Gyeonggi-do, Republic of Korea	1993 - 06	1.5mH × 50mL
26	Yo #1river, Namwon city,Chollabuk-do, Republic of Korea	1993 - 12	1.2mH × 130mL
27	Yo #2river, Namwon city,Chollabuk-do, Republic of Korea	1995 - 06	1.2mH × 120mL
28	Wangsuk#1 river,Namyangju City Gyeonggi-do,Republic of Korea	1996 - 04	1.5mH × 70mL
29	Wangsuk#2 river,Namyangju City Gyeonggi-do,Republic of Korea	1996 - 04	1.5mH × 60mL
30	Tan#6 river, Seongnam city, Gyeonggi-do, Republic of Korea	1996 - 05	1.5mH × 60mL
31	Nakdonggang andong city, Gyeongsangbuk-do, Republic of Korea	1996 - 07	1.5mH × 400mL(5SPAN)
32	Sin#7-1 river, Daegu city, Republic of Korea	1996 - 02	1.5mH × 37.8mL
33	Sin#7-2 river, Daegu city, Republic of Korea	1996 - 02	1.5mH × 37.8mL
34	Sin#3-1 river, Daegu city,Republic of Korea	1996 - 02	0.5mH × 59mL
35	South river, Jinju City, Kyongsang-namdo,Republic of Korea	1997 - 01	1.5mH × 160mL(3SPAN)
36	MirYang #1river, MirYang city, Kyongsang-namdo,Republic of Korea	1997 - 01	1.5mH × 150mL(3SPAN)
37	Yangjae#1 river, Seoul city, Republic of Korea	1997 - 03	0.99mH × 23mL
38	Towol river,Changwon City,Kyongsang-namdo,Republic of Korea	1997 - 03	1.12mH × 13.1mL
39	Gaeumjeong river,Changwon City,Kyongsang-namdo,Republic of Korea	1997 - 03	0.75mH × 10.1mL
40	Hakui river, Anyang city, Gyeonggi-do, Republic of Korea	1997 - 03	0.72mH × 15mL
41	Cheongmi river,Icheon city, Gyeonggi-do Republic of Korea	1997 - 03	1.5mH × 60mL
42	Seongsanbo, Daejeon-city, Republic of Korea	1997 - 04	0.8mH × 96mL
43	Yudeung river, Daejeon-city,Republic of Korea	1998 - 01	1.2mH × 76mL
44	Banpo reservoir, Seoul-city, Republic of Korea	1998 - 08	1.5mH × 9mL
45	Banpo reservoir, Seoul-city, Republic of Korea	1998 - 08	1.4mH × 13.5mL
46	Banpo reservoir, Seoul-city, Republic of Korea	1998 - 08	1.2mH × 28mL
47	Jaedeok river,Jinhae City,Kyongsang-namdo,Republic of Korea	1999 - 02	0.8mH × 12mL
48	Donong river,Namyangju City Gyeonggi-do,Republic of Korea	1999 - 04	0.6mH × 6mL
49	sin river, Daegu city, Republic of Korea	1999 - 07	1.0mH × 62mL(2SPAN)
50	sin river, Daegu city, Republic of Korea	1999 - 07	1.0mH × 34mL
51	Donghwa river,Hwaseong city, Gyeonggi-do Republic of Korea	1999 - 09	2.3mH × 29.65mL
52	Songu river,Pocheon city, Gyeonggi-do Republic of Korea	1999 - 11	0.6mH × 4.2mL
53	Juknong, Daegu city, Republic of Korea	2000 - 11	2.5mH × 303mL(5SPAN)
54	Anyang rivrer,Uiwang city,Gyeonggi-do Republic of Korea	2001 - 04	1.0mH × 20mL
55	Seochon river,Yeongju City ,Kyongsang-bukdo,Republic of Korea	2001 - 06	1.0mH × 67mL
56	Sanbon river, Gunposi Gyeonggi-do,Republic of Korea	2001 - 05	1.0mH × 12mL(2SPAN)
57	Chonju river,Chonju-city, Jeollabuk-do,Republic of Korea	2001 - 06	1.5mH × 32mL
58	Jochoncheon river,Chonju-city, Jeollabuk-do,Republic of Korea	2001 - 03	0.7mH × 4mL
59	Yongdeok river,Gimhae city ,Kyongsang-namdo Republic of Korea	2001 - 07	0.7mH × 7mL
60	Dalseo river, Daegu-city,Republic of Korea	2001 - 07	1.0mH × 19.9mL
61	Changwon river,Changwon city Kyongsang-namdo,Republic of Korea	2002 - 03	0.8mH × 14.25mL
62	Changwon river,Changwon city Kyongsang-namdo,Republic of Korea	2002 - 03	0.8mH × 15.19mL
63	Nam river,Jindo-gun Jeollanam-do, Republic of Korea	2001 - 03	0.8mH × 8mL
64	Incheon bridge landfil, Incheon city,Republic of Korea	2002 - 05	2.5mH × 41.32mL
65	Gongdan river, Daegu-city, Republic of Korea	2002 - 06	1.0mH × 10mL
66	Beomeo river, Daegu-city, Republic of Korea	2002 - 06	0.9mH × 37.6mL
67	Gulpo river, Incheon city,Republic of Korea	2002 - 06	1.5mH × 97mL(2SPAN)
68	Anyang river, Anyang city, Gyeonggi-do, Republic of Korea	2002 - 08	1.3mH × 18mL
69	Mangwon reservoir, Seoul-si, Republic of Korea	2002 - 11	1.0mH × 35mL
70	Mangwon reservoir, Seoul-si, Republic of Korea	2002 - 11	1.8mH × 9.6mL
71	Mangwon reservoir, Seoul-si, Republic of Korea	2002 - 11	2.0mH × 10mL
72	Mangwon reservoir, Seoul-si, Republic of Korea	2002 - 11	2.0mH × 17.5mL
73	Gimhae city Sineocheon,Kyongsang-namdo Republic of Korea	2002 - 11	0.5mH × 13.4mL
74	Yeoju city, Jajeongjigu GyeungGi-do, Republic of Korea	2002 - 12	2.0mH × 40mL
75	Gapcheon Daejeon-city, Republic of Korea	2002 - 12	1.0mH × 168.8mL
76	Banjeong river, Hwaseong-city, GyeungGi-do, Republic of Korea	2003 - 02	1.5mH × 31mL
77	Anyang river, Gunpo-city, GyeungGi-do, Republic of Korea	2003 - 03	0.8mH × 18.1mL
78	Gapcheon Daejeon-city, Republic of Korea	2003 - 04	1.0mH × 140mL(2SPAN)
79	Daemyung river, Daegu-city, Republic of Korea	2003 - 05	2.0mH × 25.2mL
80	Yangjae#2 river, Seoul-city, Republic of Korea	2003 - 05	1.0mH × 14.3mL
81	Wi river#1, Hamyang-gun, Gyeongsangbuk-do, Republic of Korea	2003 - 06	1.5mH × 59.7mL
82	Namdae river, muju-gun, Chollabuk-do, Republic of Korea	2003 - 08	1.2mH × 100mL(2SPAN)
83	Gyeongan river, Gwangju-city, GyeungGi-do, Republic of Korea	2003 - 10	1.0mH × 140mL(2SPAN)
84	Tamjin river, Jangheung-gun, Chollanam-do, Republic of Korea	2003 - 11	1.3mH × 112mL(2SPAN)
85	Tamjin river, Gangjin-gun, Chollanam-do, Republic of Korea	2003 - 12	1.5mH × 171mL(3SPAN)
86	storm-water pumping station, Incheon city,Republic of Korea	2004 - 06	3.0mH × 46.5mL
87	Gyori dam, Yangsan-city, Gyeongsangnam-do, Republic of Korea	2004 - 06	1.6mH × 78.4mL
88	Sanggye river, Yangsan-city, Gyeongsangnam-do, Republic of Korea	2004 - 07	1.5mH × 127mL(3SPAN)
89	Miryang river#2 Miryang-city, Gyeongsangnam-do, Republic of Korea	2004 - 10	3.0mH×16.5mL+2.5mH×224mL(5SPAN)
90	Anyang river, Gunpo-city, GyeungGi-do, Republic of Korea	2004 - 10	0.8mH × 14.0mL
91	Yangsan dam, Hwangguji river, Hwaseong-city, GyeungGi-do, Republic of Korea	2004 - 12	1.5mH × 107.5mL(2SPAN)
92	Orim dam, dong river, Ulsan-city, Gyeongsangnam-do, Republic of Korea	2005 - 03	1.0mH × 41.40mL
93	Wi river#2, Hamyang-gun, Gyeongsangbuk-do, Republic of Korea	2005 - 07	1.0mH × 40.0mL
94	Yudeung river, Daejeon-city, Republic of Korea	2005 - 09	1.0mH × 71.80mL
95	Doduck dam#2, Doduck river, Buan-gun, Chollabuk-do, Republic of Korea	2006 - 04	1.1mH × 15.0mL
96	Unsan dam#1, Unsan river, Buan-gun, Chollabuk-do, Republic of Korea	2006 - 04	1.5mH × 15.0mL
97	Busan dam, Jangheung-gun, Chollanam-do, Republic of Korea	2006 - 06	1.3mH × 77.3mL(2SPAN)
98	Bulgwang river, Seoul-city, Republic of Korea	2006 - 07	0.8mH × 16.0mL
99	Hongcheong river Hongcheong-gun, Gangwon-do, Republic of Korea	2006 - 08	1.5mH × 100mL
100	UnHwagjea, Gyeungan river, Hwaseong-city, GyeungGi-do, Republic of Korea	2006 - 09	1.0mH × 17.86mL
101	UnHwagjea, Gyeungan river, Hwaseong-city, GyeungGi-do, Republic of Korea	2006 - 09	1.0mH × 25.46mL
102	UnHwagjea, Gyeungan river, Hwaseong-city, GyeungGi-do, Republic of Korea	2006 - 09	1.0mH × 25.89mL
103	UnHwagjea, Gyeungan river, Hwaseong-city, GyeungGi-do, Republic of Korea	2006 - 09	1.2mH × 22.56mL
104	Imam river, Mokpo-city, Chollanam-do, Republic of Korea	2006 - 10	0.6mH × 23.0mL
105	Dalseong, Daegu-city, Republic of Korea	2006 - 11	1.0mH × 14.6mL
106	Unsan dam#2, Unsan river, Buan-gun, Chollabuk-do, Republic of Korea	2006 - 12	1.5mH × 12.0mL
107	Duggye river, Daejeon-city, Chungcheongnam-do, Republic of Korea	2006 - 12	1.0mH × 49.3mL
108	Duggye river, Daejeon-city, Chungcheongnam-do, Republic of Korea	2006 - 12	2.0mH × 48.4mL
109	Janggye river, Jangsu-gun, Chollabuk-do, Republic of Korea	2006 - 12	0.9mH × 22.6mL
110	Mangbong river, Naju-city, Chollanam-do, Republic of Korea	2006 - 12	0.5mH × 33.5mL
111	Unmun, Chungdo-city, Gyeongsangnam-do, Republic of Korea	2006 - 12	0.8mH × 28.3mL
112	Yoosan river, Yangsan-ciyt Gyeongsangnam-do, Republic of Korea	2007 - 02	2.0mH × 19.4mL
113	Yougu river, Gongju-city, Gyeongsangnam-do, Republic of Korea	2007 - 07	1.0mH × 43.8mL
114	Daegok-danmok dam, Jinju-city, Gyeongsangnam-do, Republic of Korea	2007 - 07	1.0mH × 60.0mL × 2sp
115	Rigaosi of Philippines	2007 - 07	2.0mH × 31.6mL
116	Rigaosi of Philippines	2007 - 07	2.0mH × 50.0mL
117	Hwang river, Hapchon-gun, Gyeongsangnam-do, Republic of Korea	2007 - 08	2.0mH×51.4mL×3span / 2.2mH×24.2mL×1span
118	Hwaong#3, Hwaseong-city, GyeungGi-do, Republic of Korea	2007 - 12	1.9mH × 59.6mL
119	Sihwa, Hwaseong-city, GyeungGi-do, Republic of Korea	2007 - 12	0.8mH × 32.0mL
120	Sihwa, Hwaseong-city, GyeungGi-do, Republic of Korea	2007 - 12	0.8mH × 9.0mL
121	Sihwa, Hwaseong-city, GyeungGi-do, Republic of Korea	2007 - 12	0.7mH × 23.3mL
122	Sihwa, Hwaseong-city, GyeungGi-do, Republic of Korea	2007 - 12	0.8mH × 12.0mL
123	Song lim river, Buan-gun, Chollabuk-do, Republic of Korea	2007 - 12	1.5mH × 7.6mL
124	Pocheon river, Pocheon city, Gyeonggi-do Republic of Korea	2007 - 12	1.5mH × 37.8mL × 2SP
125	Hyo-chon river,Yangju City Gyeonggi-do,Republic of Korea	2008 - 4	1.5mH × 19.04mL
126	Gulpoch, Incheon city,Republic of Korea	2008 - 4	1.0mH × 22.815mL × 2SP
127	Chulung, Suchang-gun, Chollabuk-do, Republic of Korea	2008 - 4	1.0mH × 27.2mL × 2SP
128	Chulung, Suchang-gun, Chollabuk-do, Republic of Korea	2008 - 4	1.0mH × 29.8mL × 2SP
129	Sangju-water pumping station ,Sangju City ,Kyongsang-bukdo,Republic of Korea	2008 - 4	2.0mH × 10.0mL
130	So-Yang river, Jeonbuk, Republic of Korea	2008 - 12	1.5mH × 58.86mL
131	Chang Pyeong Dam, Iksan, Republic of Korea	2008 - 12	2.0mH × 35.80mL
132	Ha-Dang Drainage Pump Station, Mokpo, Republic of Korea	2009 - 7	1.5mH × 40.0mL
133	Nakdong River, An Dong City, Republic of Korea	Expected in 2009	2.0mH × 67.9mL × 4span
134	Toba Montrose Hydro Plant, B.C., CANADA	2009 - 4	3.0mH × 28.0mL
135	Stave River Hydro Plant, B.C., CANADA	Expected in 2009 - 8	3.0mH × 24.0mL

Intake dam for agricultural water

MirYang #1river, MirYang city, Kyongsang-namdo,Republic of Korea / 1.5mH × 150mL(3SPAN)

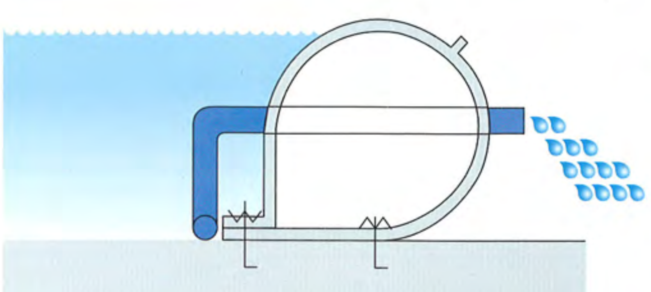
Areator : Forces silt and water pollutants to rise up to the surface of river, thus overflow them with over topping water when rubber dam is inflated.

Aerator (Aeration Equipment)



Sediment Discharge System : Install water intake pipes on the river bottom at short intervals to vacuum in the sediments and water pollutants with bottom water by using its own water pressure.

Remote Control & CCTV System

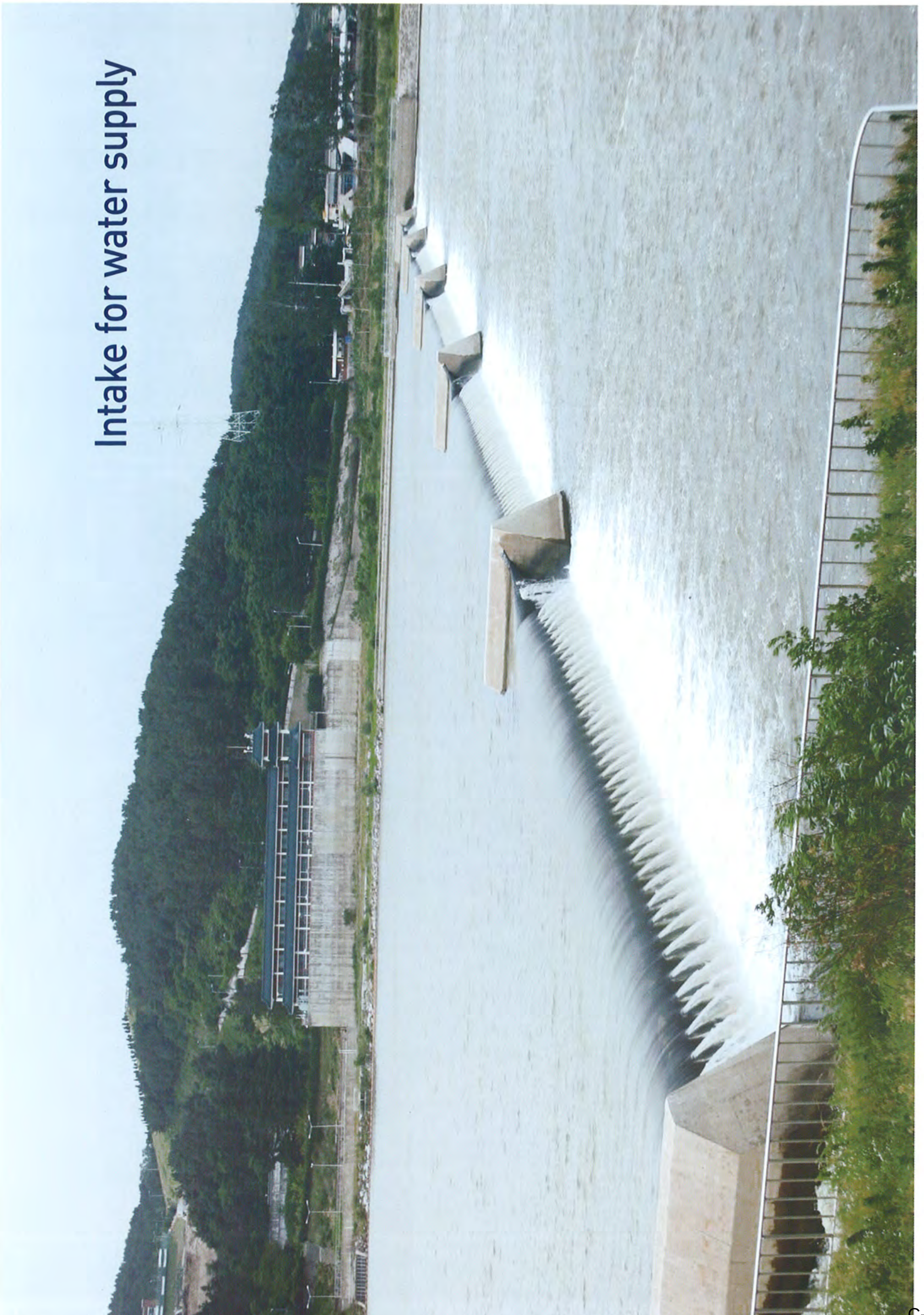


Closed-Circuit Television(CCTV)

Remote Control System

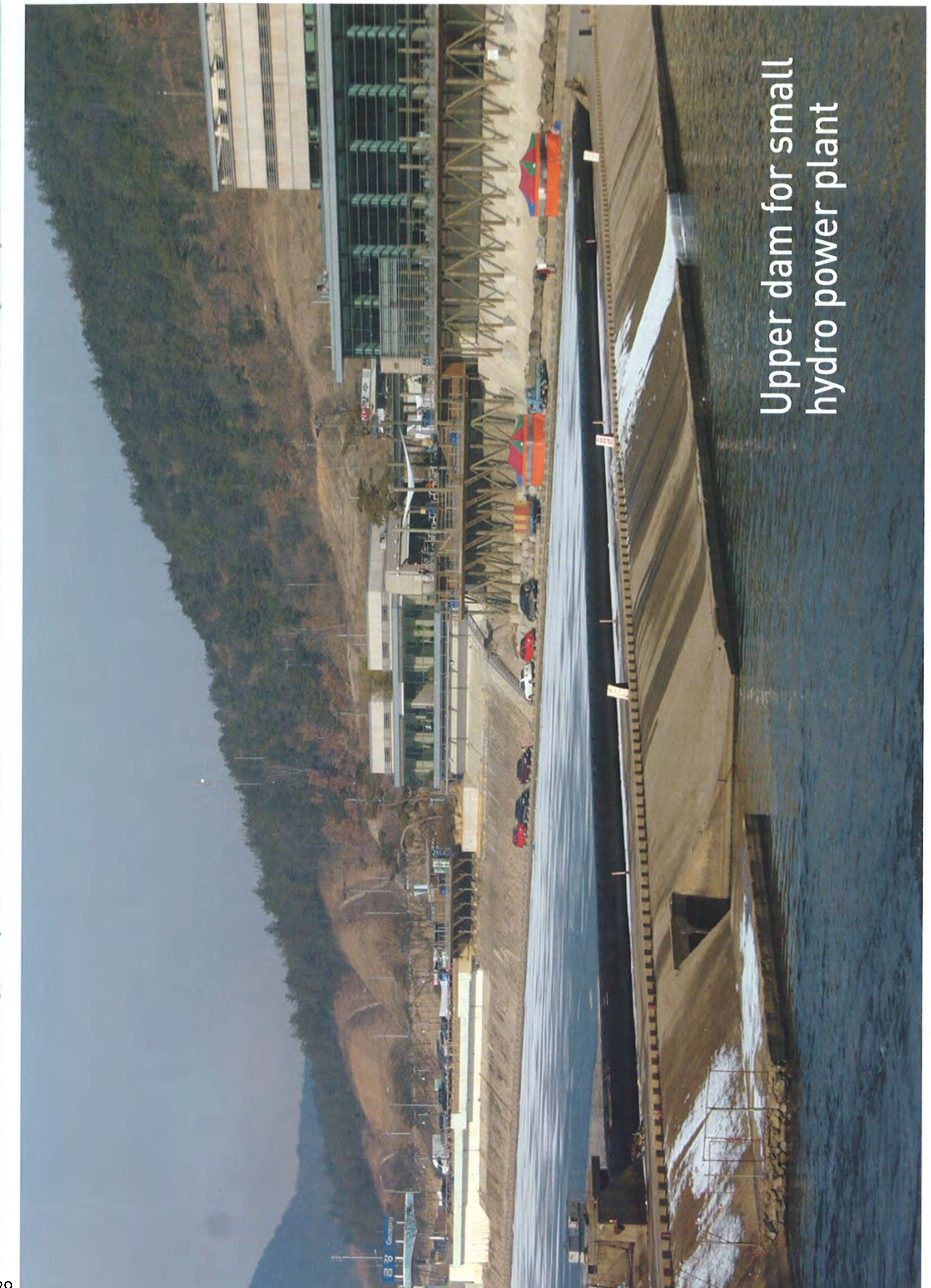
Integrated Monitoring System

Intake for water supply



Juknong, Daegu city, Republic of Korea / 2.5mH × 303mL(5SPAN)

Upper dam for small hydro power plant



Recreation / Kumgang,Okcheon county, Chungcheongbuk-do,Republic of Korea / 1.0mH × 100mL

Water Supply / Tamjin river, Jangheung-gun, Chollanam-do, Republic of Korea / 1.3mH × 112mL(2SPAN)

Flood Control / Chonju river,Chonju-city, Jeollabuk-do,Republic of Korea / 1.5mH × 92mL

Water Supply / Hongcheong river Hongcheong-gun, Gangwon-do, Republic of Korea / 1.5mH × 100mL







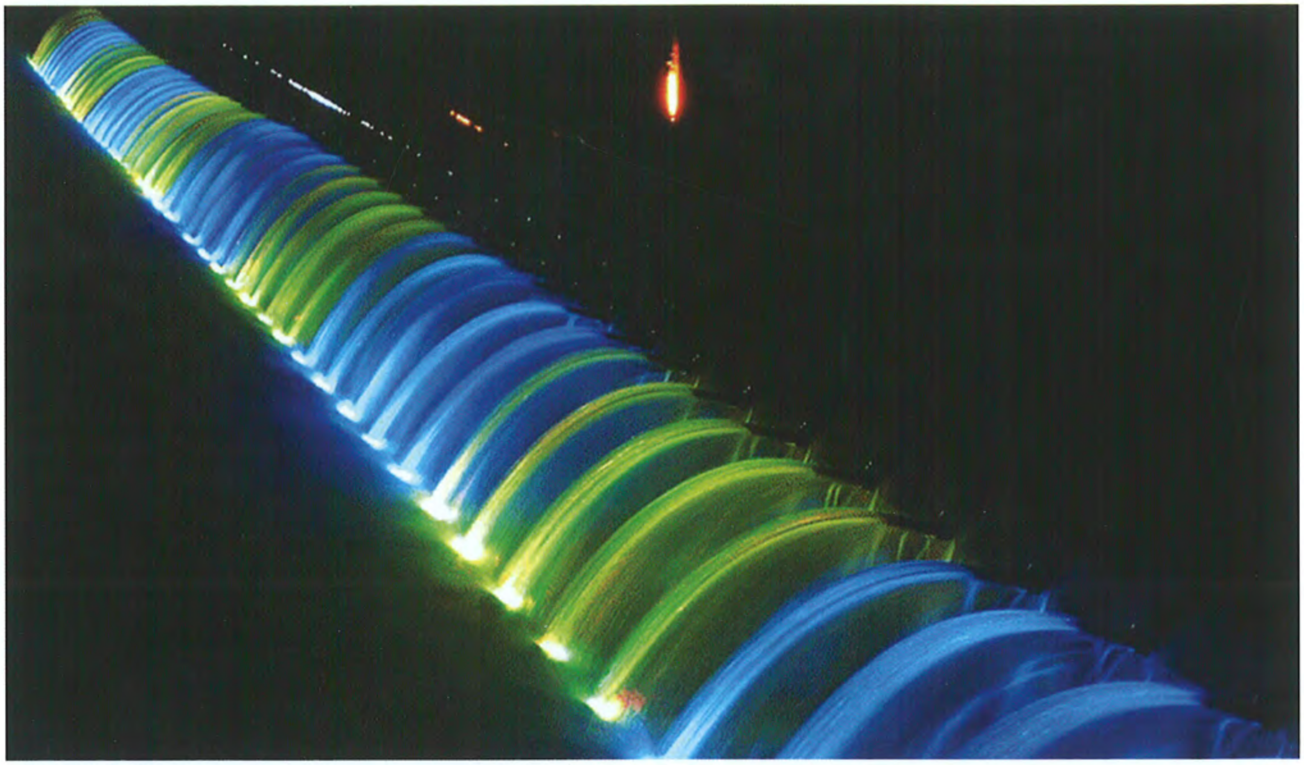









RUBBER DAM LIGHTING



YOOIL ENGINEERING

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www.rubberdam.co.kr

Site Specific Details Questionnaire

The following information should be supplied to Obermeyer Hydro, Inc. to facilitate the design of a Spillway Gate System:

1. Is the proposed gate installation on an existing dam or a proposed dam?

   What is the proposed: Length? ______________________________

   Height? ______________________________

   Fixed crest elevation? ______________________________

   Top of Gate elevation? ______________________________

   Tailwater Rating Curve? ______________________________

   Upstream streambed elevation? ______________________________

   Downstream streambed elevation? ______________________________

2. If this is a new dam, is it founded on bedrock or sand, gravel, clay, etc.?

3. What existing features such as piers, abutments, intakes, exist?

4. What is the desired function and purpose of the proposed gate structure?

5. Local Regulations, such as national electrical codes:

6. Anticipated debris flow:

7. Climate description including minimum and maximum temperature and humidity. Ice conditions if applicable.

8. Control System functions required? Automatic upstream level control, diversion flow control, etc.

9. Control system power source, 1 phase, 3 phase, solar, etc.?

10. Required inflation and deflation time of bladders:

Knight Piésold
CONSULTING

APPENDIX D

S_2O DESIGN REPORT ON WHITEWATER PARK DEVELOPMENT

(Pages D-1 to D-29)

Preliminary Design of the Saskatoon Whitewater Park Adjacent to a Green Power Generation Station

Original Issue:

4-18-2008

Revisions:

1-20-2010

Prepared for:

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Abstract

This study evaluated design concepts proposed for the Saskatoon Whitewater Park. It concluded that it is, in fact, feasible to create a Whitewater Park adjacent to a hydropower development on the South Saskatchewan River in Saskatoon, SK. The study consisted of an investigation of two types of whitewater parks: a hardened bypass channel (Concept A) and an in-stream improvement (Concept B). Preliminary investigations suggest that both types of Whitewater Park are feasible and that both concepts would be improved with additional head.

The hardened channel provides a contained and extended reach of whitewater, but would suffer from a backwater effect that would inundate the attractions at higher flows. For this scenario, it was found that a head increase, possibly created with the use of an inflatable bladder at the dam, would vastly enhance the usability of the features throughout the season. The in-stream feature developed in Concept B would be less susceptible to this tail water effect, particularly if the crest were raised, and could create the world's most powerful adjustable wave, making it an international attraction. This feature does not, however, provide extended boating opportunities, and is limited to one or two usable features.

Both concepts, as shown in the following drawings, would be highly efficient and would work well in parallel with the power station. Additionally, streamside and access improvements based on public and municipal input have been suggested to improve access, functionality, and connectivity for the project.

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Introduction

The City of Saskatoon and the Saskatoon White Water Park Proposal Committee have requested an investigation of the feasibility of the construction of a whitewater park adjacent to a hydropower development at the Saskatoon Weir in the South Saskatchewan River. This study takes a preliminary look at several possible layouts, making design recommendations and observations based on updated feasibility studies as well as input from the public following an extensive public process. This report is an update to a previous report by Knight/Piesold and S2O Design and follows a report by Recreation Engineering and Planning that describes the site, river, fish habitat, and potential impacts.

The key element of the proposed whitewater park(s) is to provide in-stream recreation for casual to elite users while improving access and providing the necessary infrastructure to accommodate these visitors. The proposed designs have been developed with the intent of creating a city park with pathways, sitting and viewing areas, access for a variety of users, restrooms/facilities, as well as the ability to hold whitewater competitions. The most current designs, featured in this report, have benefited from public and municipal input, and include bank stabilization, group meeting areas, accommodations for boat storage and various programs, as well as parking and direct channel access. These improvements have been designed to be integrated with current pathways in a manner that improves access to the University while also improving security for all users and opening the area to regular police patrols. Suggested landscaping solutions include a new bridge with improved safety features as well as possible overlooks, streamside recreational improvements, and a coffee shop/meeting area building.

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Whitewater parks have become a growing trend for cities and local municipalities throughout North America. These parks, which see usage from a number of groups that vary from inner-tubers and tourists to elite and world-class kayakers, have been shown to have a dramatic impact on the local economies of these cities. Such parks have been credited with creating a two to five million dollar *per year* economic impact due to the significant attraction of these facilities to tourists and enthusiasts alike. A park that combines such a recreational attraction with an environmentally responsible power generation station could be credited with an even greater economic impact.

If the Hydropower project and whitewater park are both developed then this project would be unique in scale and functionality. The combination of a hydropower project and a community-oriented recreational project in one has the potential to create a truly singular attraction. This project will demonstrate Saskatoon's commitment to the environment, to the health and recreation of its population, and to healthy active outdoor lifestyles in general. Energy benefits derived from this project are twofold. Not only will this project generate electricity for the City of Saskatoon, it will save a significant amount of energy in comparison with other whitewater parks. For example, a similar facility in Charlotte, NC, which is not located adjacent to an existing weir, relies on pumps costing over a million dollars a year in electricity.

Flows in the South Saskatchewan River

Many of the major design constraints associated with the proposed Saskatoon Whitewater Park are derived from the local hydrology and environment. Flow, hydraulic drop, and to a degree warm weather, are the three major design needs for a whitewater park. In a typical scenario, flow and drop are relatively independent variables. However, at the Saskatoon Whitewater Park the two variables are linked by a "backwater effect." This backwater effect is caused by a constriction downstream of the dam that backs higher flows upriver such that increased flows actually decrease the available drop at the weir. Depending on the selected design solution, this backwater effect would have a dramatic impact on the usability of the Whitewater Park by effectively drowning the weir and park at higher flows. A discussion of this effect is pertinent to the selection of a possible preliminary design solution.

Historical average flows in the South Saskatchewan River are shown below in Figure 1.

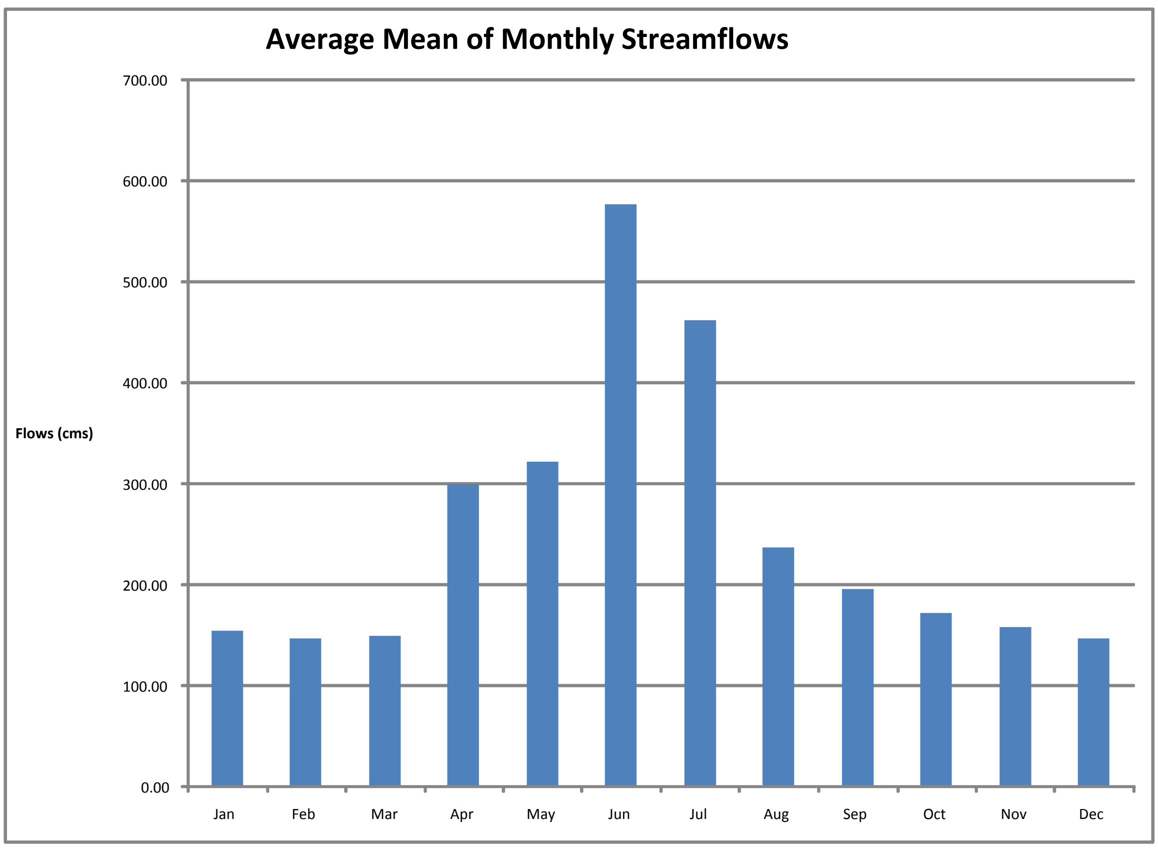

Figure 1. Historic average flows in the South Saskatchewan River

Figure 1, shown above, illustrates the historical average monthly flows at the site of the current weir. However, the completion of the Gardner Dam in 1968 has affected the flow characteristics at the site. Figure 2, shown below, illustrates the current flow regime seen in the Saskatchewan River since the completion of the Gardner Dam.

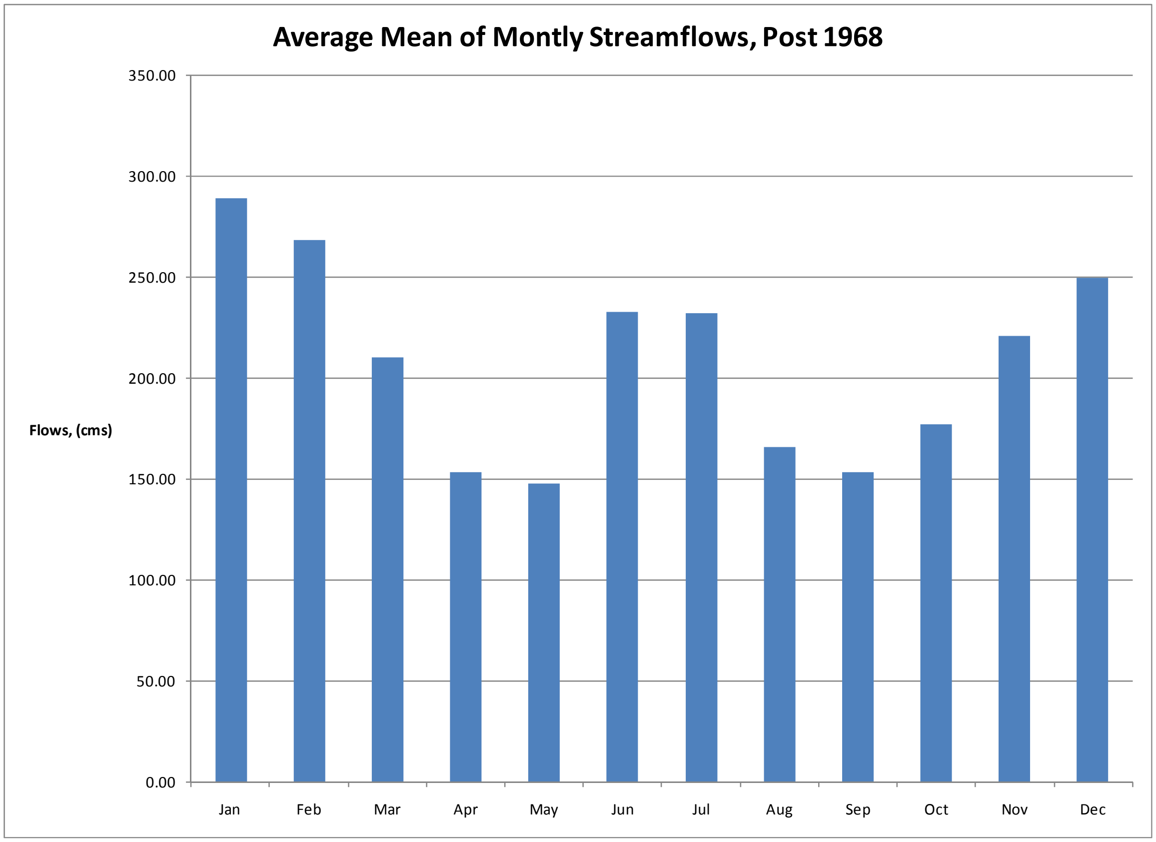

Figure 2. Current average flows in the South Saskatchewan River

This figure indicates flows in the South Saskatchewan River are adequate for the construction of a Whitewater Park. However, the energy needs of a Whitewater Park are similar, and therefore in competition with, those of the proposed hydropower development. Total energy supply to the park, or to the hydropower development, is a linear function of both head (available drop) and flows. In case of insufficient flows, the two facilities might be seen as competing with each other for this resource. As an example, the preferred proposed flow regime for the purpose of power generation is to utilize all flows at, or below, 250 cubic meters per second (this is, of course, subject to the operating plan adopted by the City's utility). It is important to understand how this will affect the usability, and subsequently the design, of the Whitewater Park.

To understand the impact of the hydropower development it is important to understand how the whitewater portion of the project will be used by the public and this, in the province of Saskatchewan, is primarily a function of temperature. While usage at a whitewater park is not insignificant at lower temperatures, it increases substantially as temperatures rise. Enthusiasts are expected to use the park at, or even below, the freezing point, but not at extremely low temperatures. The general public will tend to utilize the park when it is warmer and usage will increase in late spring, summer, and early fall. Figure 3, shown below, illustrates the average monthly temperatures for the City of Saskatoon:

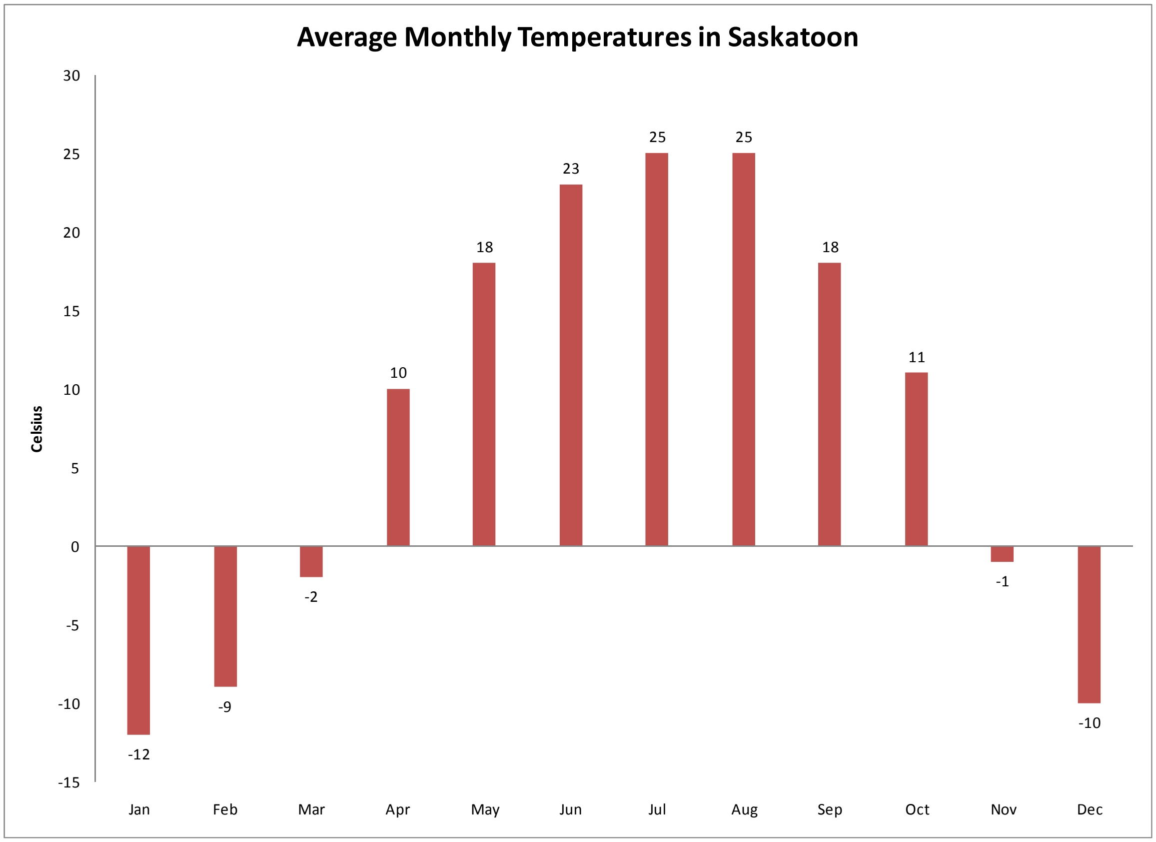

Figure 3. Average Monthly Temperatures for the City of Saskatoon

Based on the information shown in Figure 3, it can be expected that the Whitewater Park will be utilized during the months of April through October, and will see the heaviest usage in June, July, and August. The river has sufficient flow in the months of April through October to support a Whitewater Park, but the flow needs of the park would be in competition with those of the power station, and water would need to be allocated to either one or the other. Throughout the winter, when the river experiences higher flows and there interest in whitewater recreation is diminished, increased flows would be available for power generation purposes. Based on this analysis, it can be seen that a Whitewater Park that is highly flow-efficient would be best suited for placement in parallel with the proposed power station.

The desire for higher flows to fulfill the needs both of users of the Whitewater Park and those of the hydropower development needs to be balanced with the physical effects of these flows. As mentioned, higher flows at the proposed site have a negative effect on the available head. Both representative design solutions proposed in this report are affected by the flows of the Saskatchewan River and its associated backwater effect. Understanding the backwater effect and its influences on the proposed whitewater park is critical to choosing the solution that is optimal for this site.

Under the current regime, an increase in flow results in an overall increase in water surface elevation in the river. As the flow increases, water surface elevation rises both above and below the dam. However, an existing constriction in the channel below the dam causes water to back up, raising water surface elevation more quickly below the dam than above the dam. As flows raise the elevation of the water below the dam, these levels begin to approach the elevation above the dam until there is little or no drop at the site. This resulting minimized drop is insufficient for the operation of a Whitewater Park. The addition of a power station further accentuates this effect such that there is even less drop at the dam throughout the flow regime—particularly at the lower flow ranges. Figure 4, shown below, illustrates the relative drop at the dam under these two possible flow regimes:

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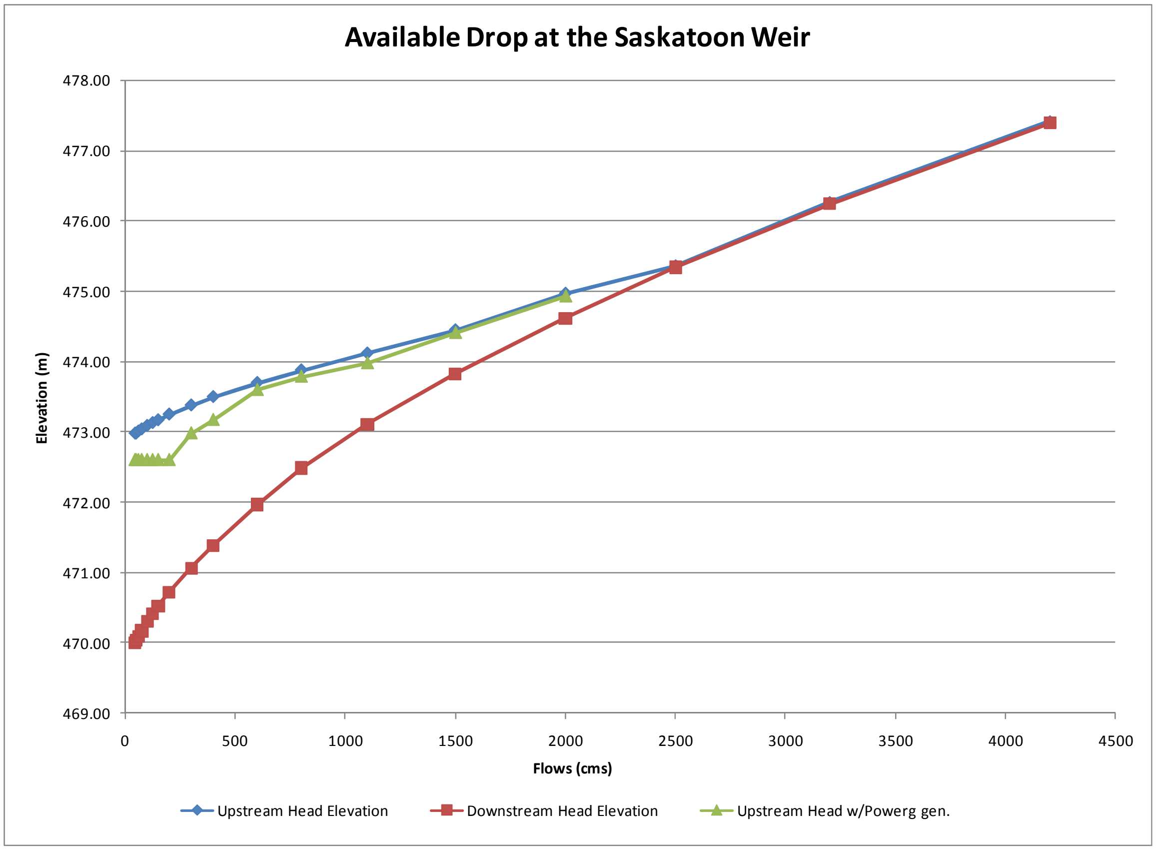

Figure 4. Available Drop at the Saskatoon Weir

The difference between the blue and red lines in Figure 4 is the amount of drop, in meters, currently available at the dam. As the flow increases, the amount of total available drop decreases until there is no drop at the dam. This "drowning" of the dam is the backwater effect, and at approximately 2500 cms the dam is entirely drowned. Both use of the Whitewater Park and power generation become impossible at the drowning point.

It is also important to not that the available drop for Whitewater Park purposes would be further decreased by the proposed hydropower development. The available head for this scenario is represented by the difference between the green and red lines in Figure 4. Figure 5, shown below, further illustrates the available drop:

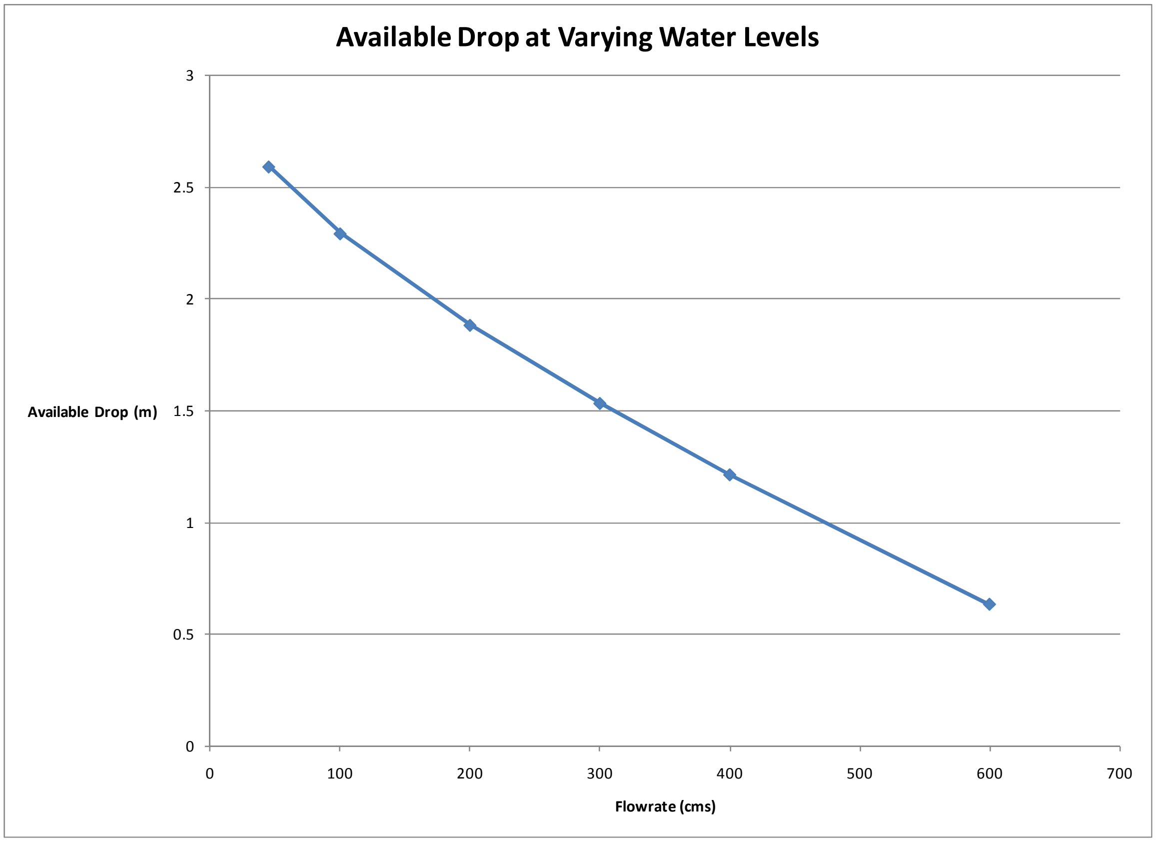

Figure 5. Available Drop at the Saskatoon Weir as a function of flow rate

Figure 5 shows the dramatic loss in head associated with increased flows in the Saskatchewan River. This Figure illustrates that the available drop decreases by 80% as the flows rise from 50 cms to 600 cms. Average flows, which are approximately 250 cms, result in an almost 50% decrease in available head from minimum flow levels. This decrease in drop corresponds to a similar decrease in usable channel length when applied to a uniformly sloped channel[1]. Figure 6 shows a simple channel geometry relative to the position of the backwater at varying flow rates:

1 The proposed channel is not uniformly sloped but would still suffer from backwater effects.

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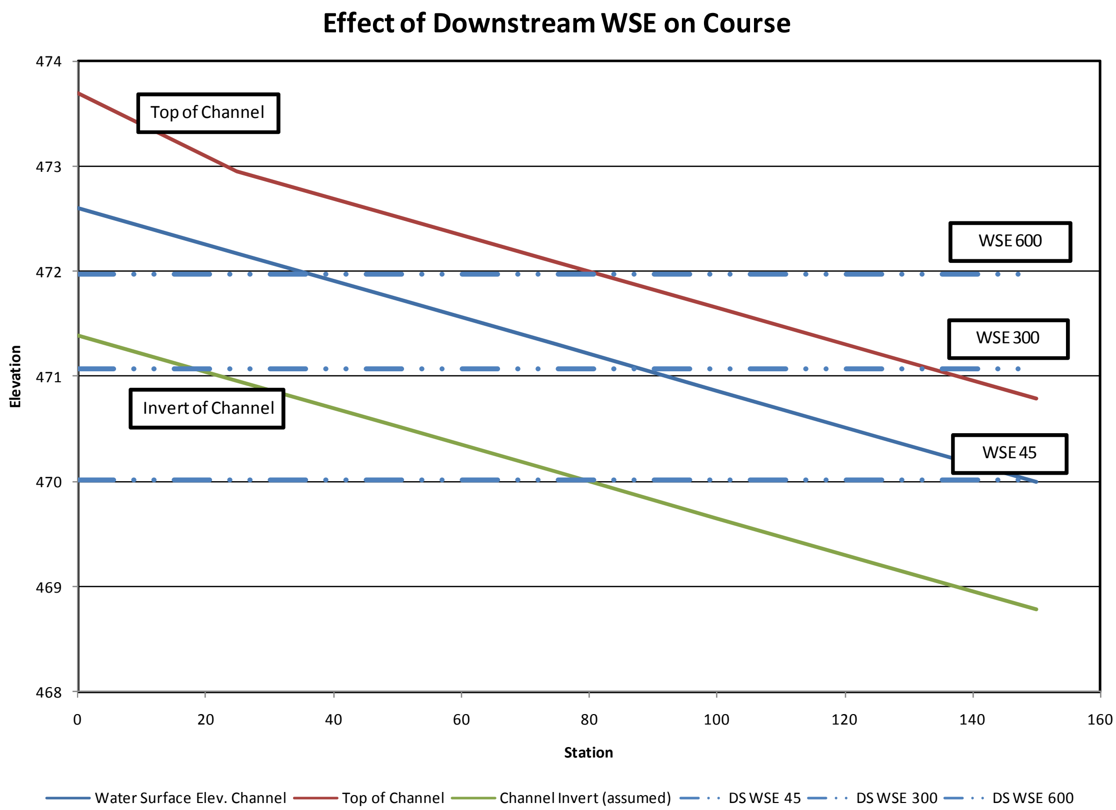

Figure 6. The Effect of Downstream Water Surface Elevation on the Proposed Whitewater Park

Backwater can dramatically reduce the power of a Whitewater Park in two ways. At lower backwater elevations, damping occurs where the higher velocity currents meet the flat water at the base of the park. The interaction between these two flows can decrease the power of flows further upstream. At higher backwater elevations, the damping effect will move further upstream and key features on the downstream end of the park can be inundated and disappear altogether beneath the surface of the backwater. Figure 6 shows that the backwater effect at 45 cms would act to damp the flows at the lower elevations of the course. At a medium flow of 300 cms, the bottom third of the Whitewater Park would be drowned and approximately 4/5ths of the course would be affected by damping. At 600 cms there would be very little drop in the

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channel. This effect of this phenomenon on the Whitewater Park would exist independently of the construction of the proposed power station. However, installation of an adjustable crest weir in conjunction with the power station would raise upstream water levels, increasing generating efficiency while at the same time decreasing the dampening effect of high flows on the whitewater park.

Design Issues

Whitewater design at this site is particularly complicated by to the presence of the backwater effect. A Whitewater Park at the weir can be designed in several ways. One scenario calls for the design of a hyper-efficient bypass channel that requires less flow than the average whitewater park. However, a bypass channel would still be at least partially inundated during the higher flows which occur primarily during the time of year that is most conducive to boating and other whitewater activities. This park would be short and less powerful during the prime boating season, with high usability throughout the remainder of the year.

The second scenario features a large quantity of water and very limited drop. Such a scenario is commonly seen at the Saskatoon weir in the June. Here, a single, wide, and typically massive play wave would be created at the point of available drop. This would be ideal for the month of June, but would require the addition of a second structure downstream to control tail water elevation (downstream water surface elevation) to ensure year round safety and usability. This downstream drop would be useful at lower flows but would be inundated at higher flows, meaning that 50% or more of the park would be unusable at peak flows due to submersion.

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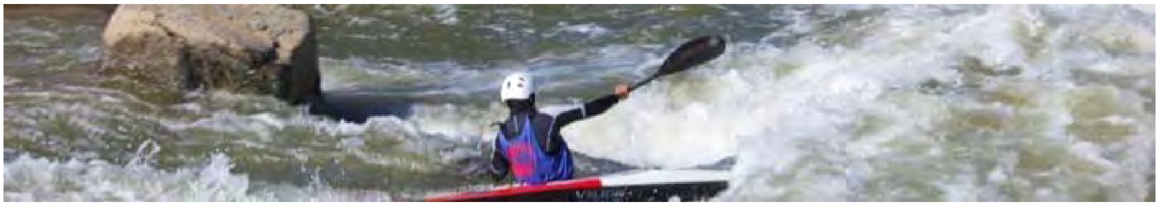
A third design option focuses on mitigating the backwater effect at the weir. This could be done in two ways. The first, more difficult approach would be to search downstream of the site for the cause of the backwater and increase the capacity of the river at this point, thus minimizing or eliminating the backwater effect. The second option is to increase the elevation of the dam in order to increase available head. This type of approach has been the more common in the past, and there is a chance that such an increase in head could be made permanent if raising the dam does not negatively affect flood levels. If flood levels are a concern, the desired increase in head can be accomplished through the use of inflatable bladders that deflate in the event of a flood. The inflatable bladder solution would result in no net negative effect on flood elevations upstream of the dam.

Design Solutions

Two proposed design solutions have been created for the weir, titled Concept A and Concept B. These design solutions are meant to be representative of the two types of Whitewater Park that can be designed at this site. Concept A is a low-flow, low-friction bypass channel similar to that used by Olympic Slalom Competitors. In an earlier version of this report, Concept B was simply a high-flow, river-wide solution similar to those used by freestyle boaters in places like Reno, Salida, and Steamboat Springs. The latest version of this in-stream feature utilizes adjustable bladders located on the dam to allow for an adjustable wave feature followed by a wider grade-control structure. Both design solutions A and B include bankside design solutions for the West bank.



WEST SIDE BANK IMPROVEMENTS

This project is largely a green power and Whitewater Park project, but improvements to the banks and access points are suggested to make the site more accessible and to provide desired infrastructure. The improvements have been envisioned as part of a larger landscaping/development project including public access, bank stability, and links to the University. The design also takes into account such specific objectives as enforcement, usage by various organized programs (including those run by the University), parking, bridge access, and other improvements. These features are included in the design/master plan to illustrate other possible improvements to the project. These improvements are included as a result of input from city officials and the public, garnered in a series of meetings as a part of this project's public process. These specific improvements are shown on the map and include:

1. Bank stability: Sloughing of the banks is an issue along both sides of the South Saskatchewan and specifically at the site in question. The Meewasin Valley Authority has noted that the banks should be stabilized in this region, a statement that was corroborated by the University Engineer. The design utilizes retaining walls to increase usable area as well as to stabilize the site.
2. Parking, Restrooms, and Meeting/Storage Space: both municipal officials as well as the site's expected users expressed a desire for adequate infrastructure that would serve to increase the site's usability. This infrastructure includes meeting spaces, boat and equipment storage, access roads and parking. Residents from the West Bank neighborhood have expressed a wish that these amenities be

located on the East Bank and away from their neighborhood. A coffee shop in the mid level is included to encourage a vendor relationship, which would ensure a cost-free presence on the site.

3. Increased Access to the Site as well as Ties to the Community and University: A bridge is included as suggested by a host of stakeholders. Engineers from the KP/S2O team inspected the current pedestrian crossing and noted safety, code, and accessibility issues. It was also noted in public meetings that the railroad that shares this bridge is eager to have the community use an alternate route across the river. The bridge, as shown, would provide a direct link between the East and West bank and would direct users through an open, lighted, hardened, and patrolled throughway. This bridge would have the additional benefit of providing boaters with parking and river access from both banks.
4. Off-Season and Alternate Uses: The current master plan features pavilions, overlooks, and meeting/vendor spaces. These are designed to be utilized year round for conferences, events, gatherings, and day to day usage. The concept also includes a trail design that can accommodate a Nordic Ski/Jogging Loop, a climbing area, and a potential seasonal outdoor ice rink.
5. Widened and Looped Trails: The trails system is designed to accommodate police cruiser access for patrols and enforcement. Additionally, it is suggested that the site layout be largely free of secluded areas, with suggested commercial/vendor usage throughout the day and evening.

Concept A: Bypass Channel Whitewater Park

Concept A is a purpose built bypass channel on the East Bank of the South Saskatchewan River. This channel would be tied in with the proposed bank stabilization

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solutions and would operate in parallel with the proposed generating station. Figure 7, shown below, illustrates a plan view of a possible layout for this design:

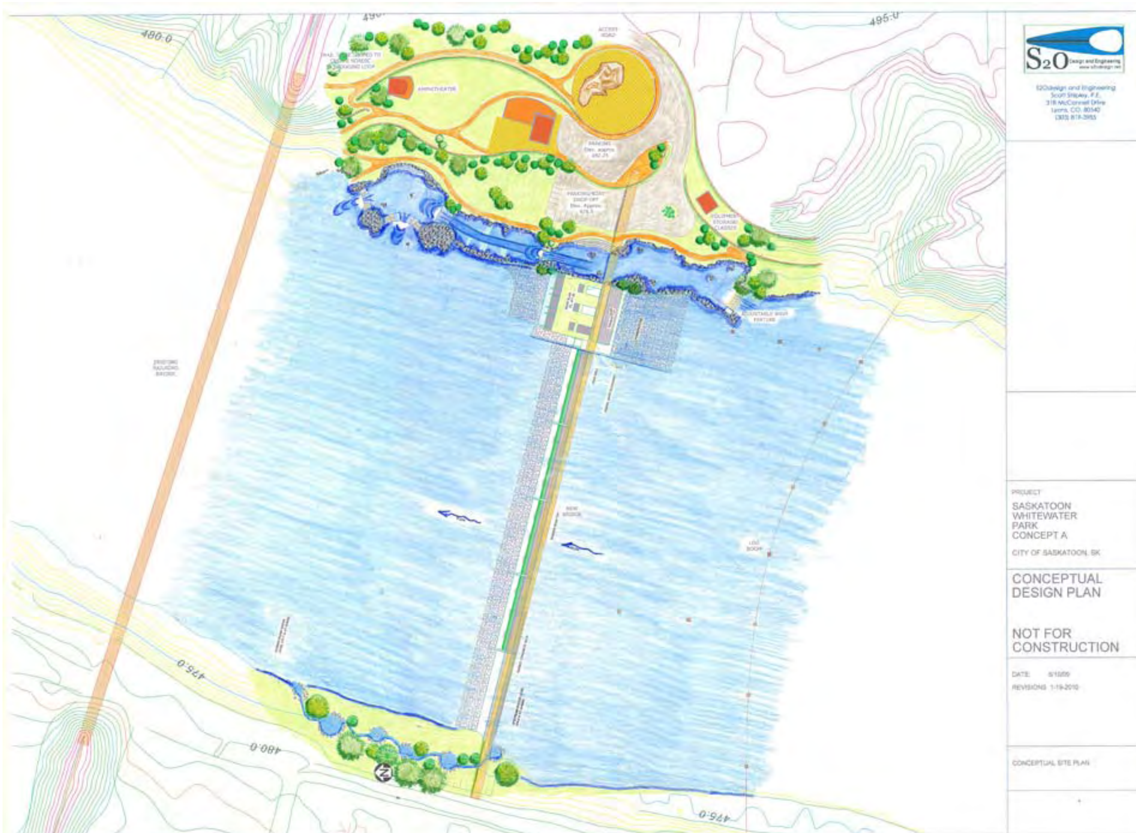

Figure 7. Concept A is a bypass channel on the East Bank of the South Saskatchewan River

The bypass channel is separated from the main body of the river at its upstream end by a head-gate. The design of this head gate allows for a controlled hydraulic jump that can be moderated by the deflection of the head gates. Paddlers who choose to navigate this initial drop will put in just upstream of the head gates. Paddlers who choose not to navigate the initial head gate use an access point just downstream of the control structure. This controlled access to the river will help differentiate the improved

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Whitewater Channel from the main river and will help prevent users from accessing more dangerous areas of the South Saskatchewan.

The second drop will be a wave-maker drop which will provide for green wave surfing similar to the M-wave. A series of adjustable obstacle features set at a steady grade will be positioned on the downstream side of the wave-maker drop. This section of the channel will be modeled in a style conducive to instruction and river running, similar to the standard sections of Whitewater Slalom competition courses.

Typical bypass channel whitewater park

A Zoomflume feature at the downstream end of this section will create another fast-jet and play-wave area and will be followed by a long pool. Water that flows into the pool will be discharged either over a primary surf-hole of the Salida type or down a bypass channel. The bypass channel allows inflatable traffic to proceed directly down the easiest route and to exit the river at the take-out beach. A trail leading from the take-out to the top of the course allows for an easy return.

Design Advantages of Concept A:

- Adjustable head-gates allow for an ideal amount of flow into the Whitewater channel despite varying flow rates in the main channel. This allows for the regulation of conditions, as well as for adjustment of flow levels to accommodate beginner, intermediate, and expert users.
- A central pilot channel accommodates inner-tubing when the course is set at low flows.
- An adjustable obstacle system allows for fine-tuning of the course to ensure desired functionality.
- Adjustable head-gates enable draining of the course (subject to the backwater effect) in order to make changes or effect maintenance.
- A course of this caliber would have the potential to host slalom events on the national level. (There is likely insufficient drop to host major international slalom events.)
- Course design would produce a world class freestyle boating experience.
- Course design is highly efficient in water usage, with a maximum flow of approximately 25 cms.

Design Disadvantages of Concept A:

- The course could likely not be designed to improve with higher flows. This would limit the ability for providing “big water” days.
- Periodic drowning of the course due to the backwater effect would significantly shorten its potential length at high flows.
- Length and drop of the Concept A are insufficient for World Class Slalom.
- Optimal functioning of freestyle features is unlikely at higher flows.

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- Course design does not remove the safety navigation hazard currently presented by the main dam.

Concept B: Main River Whitewater Park

Concept B has evolved with changes in the project configuration and input from public meetings. The revised configuration includes an adjustable wave feature that is fed from a head-gate. When closed, this head-gate would impound the flows of the South Saskatchewan, allowing for more efficient power generation, but would create an adjustable wave feature when opened. The potential for adjustments to both flows and widths would enable the creation of an ideal wave feature at varying river flow levels. The grade control structure downstream of this first feature would ensure reliable tail water elevations and would form a smaller, less controlled, wave feature at specific flows. Figure 8, shown below, illustrates this concept shown in parallel with the power station and a bypass channel on the East bank.

Figure 8. Concept B includes river-wide drop structures that can be placed in parallel with the power station and the bypass channels.

The river-wide concept would require at least one U-drop in addition to the adjustable wave, but has some advantages in comparison to the other improvements suggested. This drop can accommodate a tremendous amount of flow and, given the amount of drop available, create a reliable feature in spite of the site's backwater effect. The primary drop, shown at the crest of the existing dam, would create an attraction at all flows, except when drowned out by the backwater effect. Given this feature's capacity for adjustment, it could be very efficient despite its potential power. The difficulty and power of this attraction would vary with flow rates released through the head-gate and it, too, could be turned off entirely. This would allow for a large and powerful play feature while still providing sufficient flow for efficient energy generation at most times.

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A large wave of the type envisioned in Concept B

It is significant that this adjustable wave could be the largest, highest drop, and highest flow wave feature of its kind in the world. This would be a significant attraction throughout the continent and beyond if carefully designed to provide the optimum wave.

The main purpose of the lower U-drop feature is to control the tail water below the first feature in order to prevent the formation of a dangerous hydraulic (or pour-over) at the base of the primary drop. Depending on the design, there is a potential to make this drop an attraction independent of the primary drop. However, this drop will lose all attraction periodically as it is drowned out by the backwater effect at higher flows.

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Typical U-drop

Design Advantages of Concept B:

- The primary feature has the potential to be larger, wider, and more powerful than that designed for the bypass channel.
- Drop design would remove the danger of the existing weir to experienced in-stream users.
- Work would be possible in parallel with existing and regular maintenance to the dam.
- Work could be done as part of an effort to increase head at the existing dam.
- This feature would have high usability at all but the highest backwater levels.

Design Disadvantages of Concept B:

- Requires the construction of a second drop structure with little or no recreational benefit.
- The design is a park-and-play feature, which does not accommodate extended usage such as river running, tubing, and slalom.

Both Concepts A and B have advantages and disadvantages and can be designed separately, together, and with or without an increase in upstream head. A summary of these permutations and benefits/liabilities is shown below in Table 1.

Design Decision Support Matrix	**Concept A**	**Concept B**	**Concept AB**	**Concept A w/Bladder-type head increase**
Performance at Flows less than 250 cms	+	+	+ +	+ +
Reason	Flows provided by Power station	Flows provided by Power station	Flows provided by Power station	Flows Provided by Power Station
Performance at Flows greater than 600 cms	-	+	0	+
Reason	Low Head	Good flows	Low Head but In-stream Good	Good Head, good flows, but shortened course
Provides an extended experience	+	-	+	+ +
Reason	A full course for all uses	Primarily a freestyle feature, adaptable to various abilities		Longer course with more head.
Works well with Power Station Requirements	+	+	0	+
Reason	Very efficient, closeable	Very efficient, closeable	Can choose an option if low water	Good for both
Provides a large freestyle feature.	0	+	+	0
Reason	Good feature but low head, lower flow	Great feature--possible world best	Great feature--possible world best	Good feature but med head, lower flow
+ indicates good performance, - indicates poor performance, and 0 indicates a neutral performance				

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Table 1. Design Decision Support Matrix detailing the possible permutations suggested in this report as well as advantages and disadvantages of each.

Conclusion

This study evaluated design concepts proposed for the Saskatoon Whitewater Park and concluded that it is, in fact, feasible to create a Whitewater Park adjacent to a hydropower development on the South Saskatchewan River in Saskatoon, SK. The investigation examined two types of whitewater parks: a hardened bypass channel (Concept A) and an in-stream improvement (Concept B). Preliminary investigations suggest that both types of Whitewater Park are feasible and that both concepts would be improved with additional head.

The hardened channel described in Concept A provides a contained and extended reach of whitewater but has the disadvantage of suffering from a backwater effect that would inundate the features at higher flows. For this scenario, it was found that an increase in head, possibly created with the use of an inflatable bladder at the dam, would vastly increase the usability of the features throughout the season. The in-stream feature shown in Concept B would be less susceptible to the tail water effect, particularly if the crest were raised, and could create the world's most powerful adjustable wave, making it an international attraction. This feature, however, does not provide extended boating opportunities and is limited to one or two usable features.

Both concepts, pictured in the drawings above, would be highly efficient and would work well in parallel with the power station. Based on public and municipal input, additional streamside and access improvements have been suggested to improve access, functionality, and connectivity for the project.

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Appendix 1. Cost Estimates

Saskatoon Whitewater Park

Cost and Quantity Estimate

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Item Number	Structure	Material	Estimated Quantity	Unit	Unit Price	Item Total Price
Option A: Bypass Channel						
1	Mobilization to include costs for bonding, insurance, traffic control, staging, etc.; no measurement for payment shall be made of any of the work, materials equipment used for mobilization.		1	Lump Sum	$50,000	$50,000
2	Water Control: All water control including diversion and care of flows in the river and return of flows to the specified channel including clean up. Estimate made assuming that the project is done in concert with the proposed Green Power Generation Station.	Bladder/cobble	1	Lump Sum	$150,000	$150,000
3	Structural Fill including all excavation, import, placemement and grading including fine grading in and around channel structures.	Structural Fill	2475	m^3	$60	$148,500
4	Retaining wall at a possible average height of 6-8 meters to extend from the upstream end of the bypass channel to the powerstation and from the downstream end of the Green Power Generation Station to the Downstream end of the concrete channel. Includes all import, excavation, forming, placing, finishing and clean up	Structural Concrete	95	L.m.	$1,440	$136,800
5	Cutting and removal of notch through the existing dam structure. Includes all material removal and preparation of the existing monolith to bond with the proposed concrete channel and gate structure	Concrete Removal	16.8	m^3	$200	$3,360
6	Vertical channel retaining walls, 2 m in height within the hardened channel reach. Approximate thickness of walls = .2 m. Includes all import, excavation, forming, placing, finishing and clean up.	Structural Concrete	250	L. m.	$500	$125,000
7	Placement and anchoring of welded HDPE (or similar) waterproof liner underneath formed concrete portions of the channel.	HDPE Liner	3800	m^2	$24	$91,998
8	Fiber reinforced formed concrete channel. Includes all preparation, placement, finishing to a smooth finish and to the dimensions shown on the drawings, and clean-up. Includes placement, within channel, prior to placement of concrete, of an obstacle connector system to allow the use of a moveable obstacle system.	Formed Fiber Reinforced Cocrete	450	m^3	$400	$180,000
9	Obermeyer Head Gate Structure: Includes all structural and dimensional site preparation. Installation of the system, actuators, and controls as well as on-site testing and verifications.	Obermeyer Gate	1	Lump Sum	$210,000	$210,000

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10	Armored cobble bed: Includes excavation of existing river and banks to elevations specified, rough grading. Rock placement in a rough, medium and fine course and final grading.	Armoring Rock		435		m^3		$60		$26,100
11	Rock Drop Structures: Includes all excavation, preparation, placement to the specified elevations and to shaping specifications, inter-structural fill, and clean-up	Large Rock		2100		m^3		$150		$315,000
12	Terracing: Large rock terracing along the specified banks of the river to provide access, bank stabilization, and erosion protection. Includes all excavation to the elevations specified, rough grading, fill, placement and final shaping and clean up.	Large Rock		2100		Linear Meter		$130		$273,000
13	Manufactured Obstacle system:			1		Lump Sum		$550,000		$550,000
14	Rock Drop Structures in the channel including placement by strap or excavator with thumb. Shaping to elevations and shapes specified in the drawings, and finish grouting in place	Rock		450		m^3		$150		$67,500
15	Landscaping allowance: This item includes only landscaping in the immediate area of the channels. All retaining walls, plantings, grading, etc. removed from the channel to be included as a separate item.			1		Lump Sum		$85,000.00		$85,000
	Subtotal									**$2,412,258**
	Contingencies (20%)									$482,452
	Total									**$2,894,710**

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Option B: In-Stream Work

Item Number	Structure	Material	Estimated Quantity	Unit	Unit Price	Item Total Price
16	Water Control: All water control including diversion and care of flows in the river and return of flows to the specified channel including clean up. Estimate made assuming that the project is done in concert with the proposed Green Power Generation Station.	Bladder or Cobble	1	Lump Sum	$650,000	$650,000
17	Retaining wall at a possible average height of 6-8 meters to extend from upstream of the dam to the second in-stream drop structure.	Structural Concrete	225	Linear meter	$660	$148,500
18	1 large U-Drop Structures including all excavation, placement to the shapes and elevations shown on the plans, final shaping and clean up.	Rock	1800	m^3	$250.00	$450,000
19	1 controllable headgate/wave structure: Assumes all concrete work done as part of the raising of the dam crest.		1	Lump Sum	$750,000.00	$750,000
20	Fill in drop structures: Medium rock mixed with fines and cobble material including all import, placement, and clean up.	Rock, Cobble and fines	1500	m^3	$60.00	$90,000
21	Rock pool armoring: Medium rock placed in the pools downstream of the drop structures to prevent scouring of the riverbed. Includes all import, excavation,placement, final grading and clean-up.	Rock	4333	m^3	$60	$260,004
22	Concrete grout pumped within voids in rock as directed.	Concrete Grout	360	m^3	$220	$79,200
23	Landscaping allowance		LS	Each	$80,000.00	$80,000
24	Additional Heavy Equipment if required or authorized by Engineer (not part of any bid item): Backhoe w/thumb (CAT 225 or equiv.)		150	Hours	$120	$18,000
	Subtotal					**$2,525,704**
	Contingencies (20%)					$505,141
	Total					**$3,030,845**

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