Sault Ste. Marie Canal
National Historic Site
parkscanada.gc.ca

Lieu historique national du
Canal-de-Sault Ste. Marie
parcscanada.gc.ca

SAULT-STE-MARIE CANAL NATIONAL HISTORIC SITE HYDRO GENERATION FEASIBILITY STUDY

DRAFT REPORT

PARKS CANADA AGENCY

FEBRUARY 2020

wsp

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DRAFT REPORT

PARKS CANADA AGENCY

PRELIMINARY VERSION

PROJECT #: 151-06165-14
DATE: FEBRUARY 2019

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REVISION	ISSUED FOR	DATE
Preliminary	Parks Canada	February, 25, 2019

PRODUCTION TEAM

PARKS CANADA

Function	Name
Function	Name
Function	Name

WSP CANADA INC. (WSP)

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Sr Project Engineer	Jean-Mathieu Gagnon
Sr Project Manager	Bernard Munger

EXECUTIVE SUMMARY

The Sault Ste. Marie Powerhouse and associated infrastructure played a crucial role in the development of the country's economy and expansion with one of the first electric power generation facilities in Canada. The Sault Ste. Marie Canal National Historic site is located in Sault Ste. Marie, Ontario and known as a National Heritage Site in Canada for their locks on the river, the longest in the world when they were built, and powerhouse.

The preservation of this heritage site is important for the benefit of the community. The powerhouse building is planned to be changed in a museum leaving one of the two (2) 100-year-old existing units in place to present the historic generation equipment to the public. The second unit of the north side inside powerhouse would be replaced with piping connected to the new generation equipment located outside powerhouse.

The present report outlines the options and provide estimates of investment costs for electricity generating equipment located just upstream of the existing powerhouse, beside the building and historic valves that would be preserved for their historic value.

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1 OBJECTIVES AND SCOPE OF WORK

Parks Canada has requested the services of WSP to conduct a preliminary study to determine the appropriate turbine-generator equipment to match with the given space along the proposed new Y-pipe installation between the proposed recent Valve Chamber and the existing Historic Valves. The objective of this project is to provide adequate technical information with viable options so that Parks Canada can further develop their overall concept plan for the Sault Ste. Marie Canal National Historic Site of Canada. The study will include a review of the potential installed output capacity (previous studies suggest potentially 150-200 kW) and will take into consideration previous studies and current improvement works already in progress at the project site.

2 DATA COLLECTION AND REVIEW

Parks Canada have contracted engineering firm services for studying different infrastructure elements and generation equipment configuration. The main documents reviewed for this report are listed below:

- Penstock Piping - Pipe Network Overview Drawing
- Inspection Observations – Penstock Pipe Diver / CCTV Inspection Observations Drawings
- Position of Discharge Pipes and Floor Beams Drawing
- Penstock Network Final Report – May 2017
- AC Power Final Report – May 2017
- Condition of Water Passages Survey – December 19, 1996

The review help to set the preliminary hydraulic condition and contact the different suppliers of in-line generation equipment. A net head of 4.8 m and a flow of 5 m3/s was used as starting points to contact the suppliers. This provides a discharge pipe velocity of 2.74 m/s, which is well within metal-lined draft tube design criteria of max. 5 to 8 m/s generally used in concrete lined draft tube The above values were taken from the *AC Power Final Report* and were also confirmed in *Section 4 - Hydrotechnical Review*. Installation dimensions were taken from the received drawings and are presented in *Section 3 – Layout Study* of this report.

3 LAYOUT STUDY

Considering the new Y-pipe, the turbine and generator will be located at the end of the North junction, directly aligned with the North historic valve (refer to Fig. 3.0 below). All equipment and budget price received from the turbine-generator manufacturers are either in-line or tubular micro-hydro turbine type that could connect directly in the pipe section of 1.83 m (72 in) diameter upstream and 1.52 m (60 in) diameter downstream of the turbine.

To match the penstock and discharge piping dimension, the inlet and outlet conducts of the turbine equipment use convergent and divergent pipes or liner section to accelerate and decelerate the flow before and after the turbine. Those section are usually named the intake and draft tube respectively.

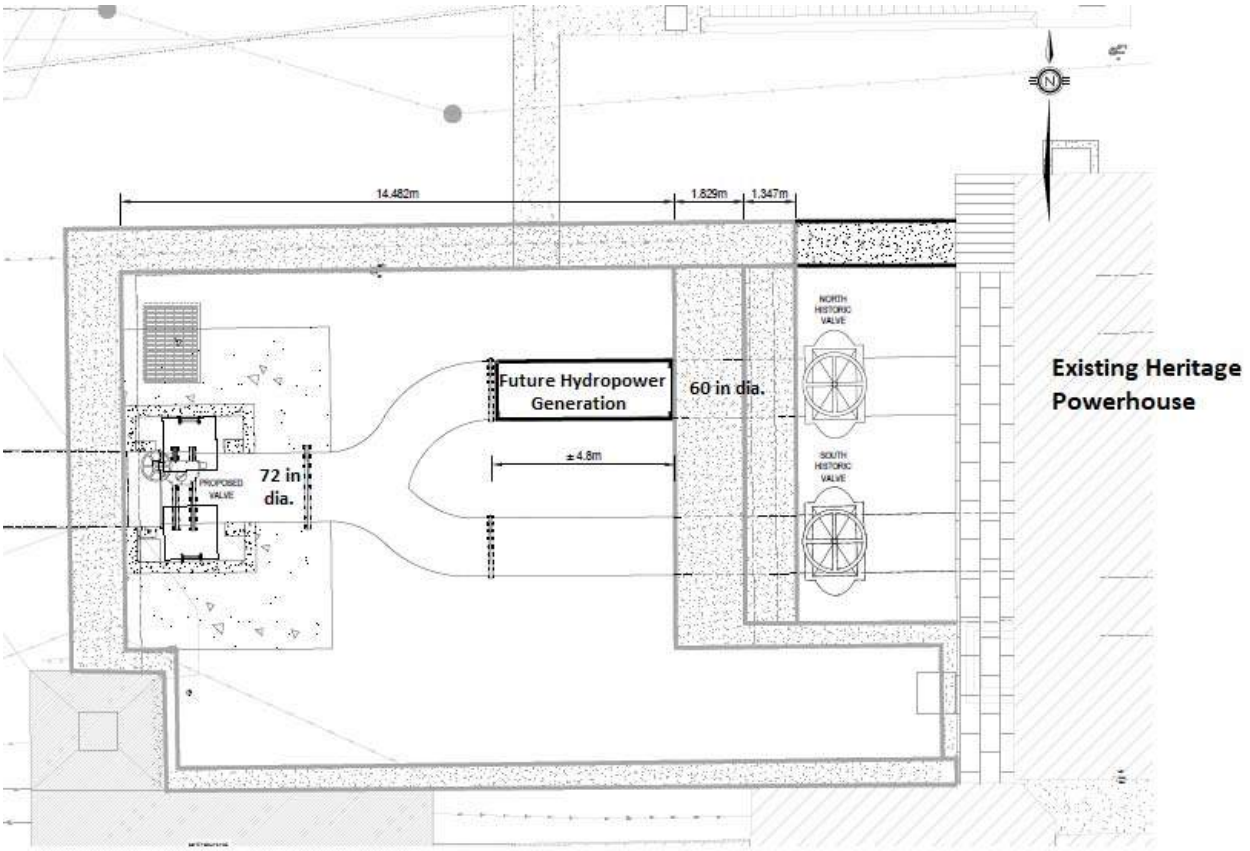


Figure 3.0 - Proposed New Layout

The following section of the report presents different layout options according to the main solutions received by four (4) of the 19 different T&G suppliers contacted and presented in the table below (also appended in Appendix B). The configuration presented consider mainly 2 types of unit: S-Turbine and In-line with Propeller or Kaplan runner.

Suppliers	Submission tracking status
LucidEnergy	No answer
Soar	No bid
Mavel	No bid
DBH	Bid received
Norcan	No bid
Ossberger	No bid
Voith	Bid received
Global	In progress
Littostroj	see Hydro HIT
Hydro HIT	In progress
Benkatina	In progress

Lightning master	No bid
Nutstreem	Bid received
MJ2	No bid
Andritz	Bid received
Kirloskar	No bid
Natel Energy	Bid received
Zeco	Bid received

Out of the 19 suppliers contacted, WSP received only six (6) budget price and solutions considered as valid. The supplier with bid indicated as "in progress“ in the above table indicates that WSP received a positive answer that the supplier was to offer a product but could not reply in due time for this report. In case WSP receives outstanding solutions after the issuance of this report, the most promising solutions and price will be communicated to Parks Canada in a supplementary document form.

General options and layout are presented with no relevant order or sorting below. The supplier proposals are further analyzed and rank in the price analysis of section 5.

3.1 OPTION A: S-TURBINE FROM DBH SARL

DBH Sarl is one of the first supplier contacted as it had participated in the previous feasibility study (ref. *AC Power Final Report*) done for the same site but in a different location. The other supplier having participated in that same study (Mavel) didn’t have any product that could fit in the new location and area available and used in this current study. The DBH new equipment proposed, consider horizontal S-turbines with a Kaplan runner type. Regulation is done at the runner blade with fixed wicket gates. The regulation may result in higher maintenance requirements and cost as a hydraulic unit will have to be added. Some civil work may also be required for stabilizing the unit on the ground or on a concrete slab. For the present need, no civil works have been considered but this will need to be further analyzed in a later stage during preliminary and detailed design as it can incur additional installation cost. The solution also requires to install a flange connection of the S-Unit just after the bifurcation with hydraulic geometry to be optimized in order to have the best flow condition at the turbine inlet.

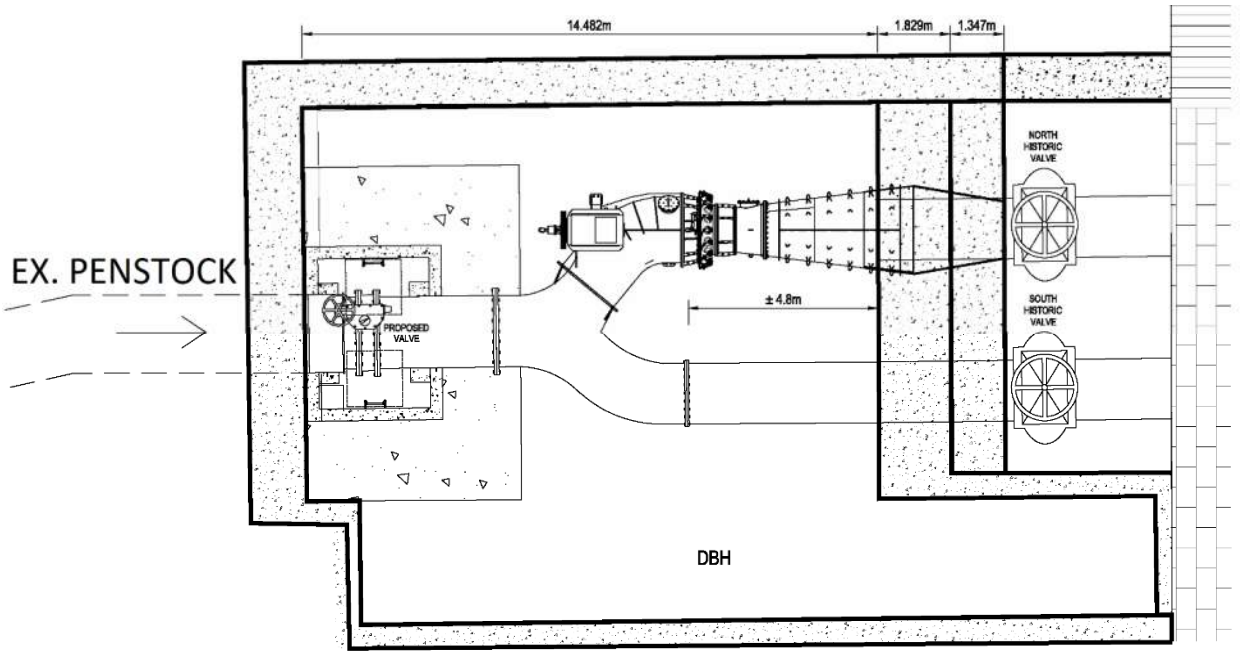


Figure 3.1 - Layout Study - DBH (Sketch)

3.2 OPTION B: KAPLAN IN-LINE TURBINE FROM NATEL

Natel proposed interesting compact design with one of the shortest draft tube on the market. When contacted, the cavitation risk was raised as the centreline level of the unit is above the tail water level and the net pressure suction head may be of concerns for Kaplan or Propeller turbine cavitation. Natel have presented and offer with cavitation free runner with 3 m setting difference with tail water. In addition to their cavitation-free runner, Natel also offered a fish-friendly design allowing a higher survival rate of fish passing through the turbine. The regulation is not specified but likely a fixed blade and wicket gates type according to the sketch that can be found in Appendix B.

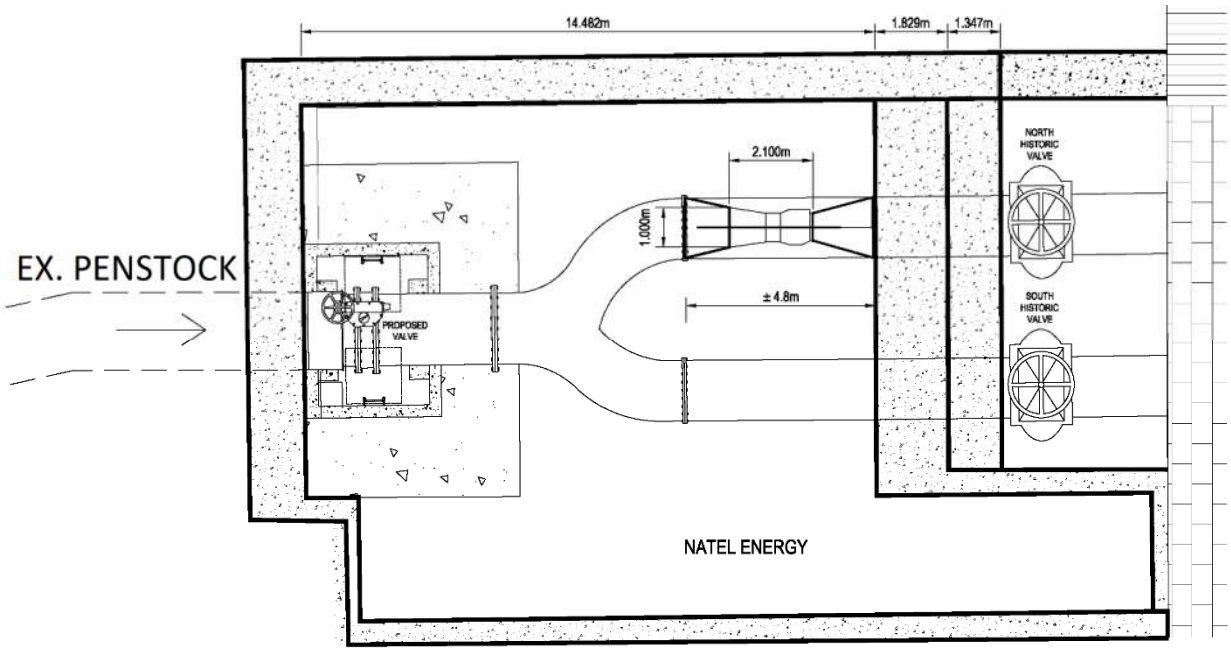


Figure 3.2 - Layout Study - Natel (Sketch)

3.3 OPTION C: PROPELLER IN-LINE TURBINE FROM NUSTREEM

In the option of Nustreem, the South pipe could be completely cut and dismantled to make room for a 6.1 m (20 feet) long container. Another option would be to have a shorter container of about 4.0 m (13 feet) long instead of cutting the pipe, but it would leave less room for additional electrical equipment. This supplier offered a Propeller type runner with movable wicket gate for adjustment of the flow rates and maximizing turbine efficiency. This may not be required for the site with a constant flow assumed. Another characteristic of the Nustream design is their low flow capacity as 2 units would be needed to have the full flow and power which make them prohibitive for the present analysis as will be seen in the cost analysis section.

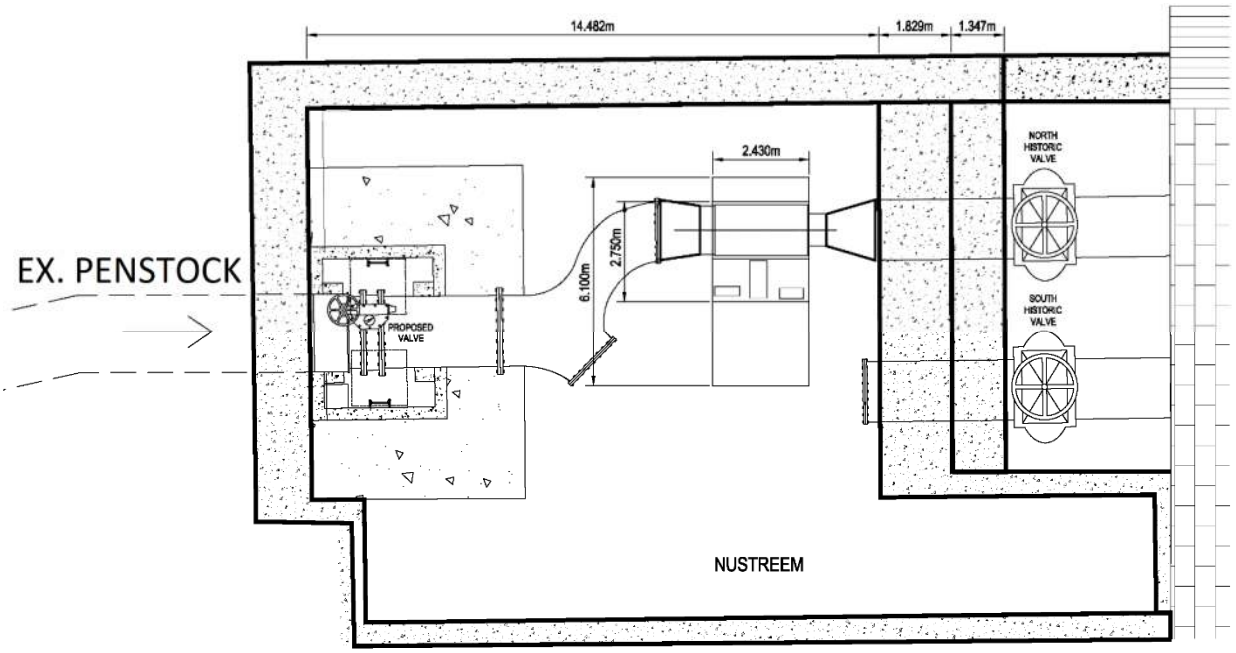


Figure 3.3 - Layout Study - Nustreem (Sketch)

3.4 OPTION D: S-TURBINE FROM ANDRITZ

In the complete set of suppliers, two of them are considered as major players, or first tier supplier, in the large hydro industry well known from their long past history and large hydro market namely, Andritz and Voith. The Voith product offered is the small hydro Stream Diver consisting of a Propeller configuration similar to Natel option B and with no regulation on blades and wicket gates. Their design may be consulted in the Appendix D. below in Figure 3.4 is shown the Andritz design with a S-turbine configuration similar to the DBH option A. The Andritz brand named for the product is mini-compact and according to Andritz document, WSP considers a belt driven and single regulation would be the best choice for the Parks Canada site. One should note Andritz didn't provide a firm budget price but rather a +/- 50% estimate and specialized sales documents.

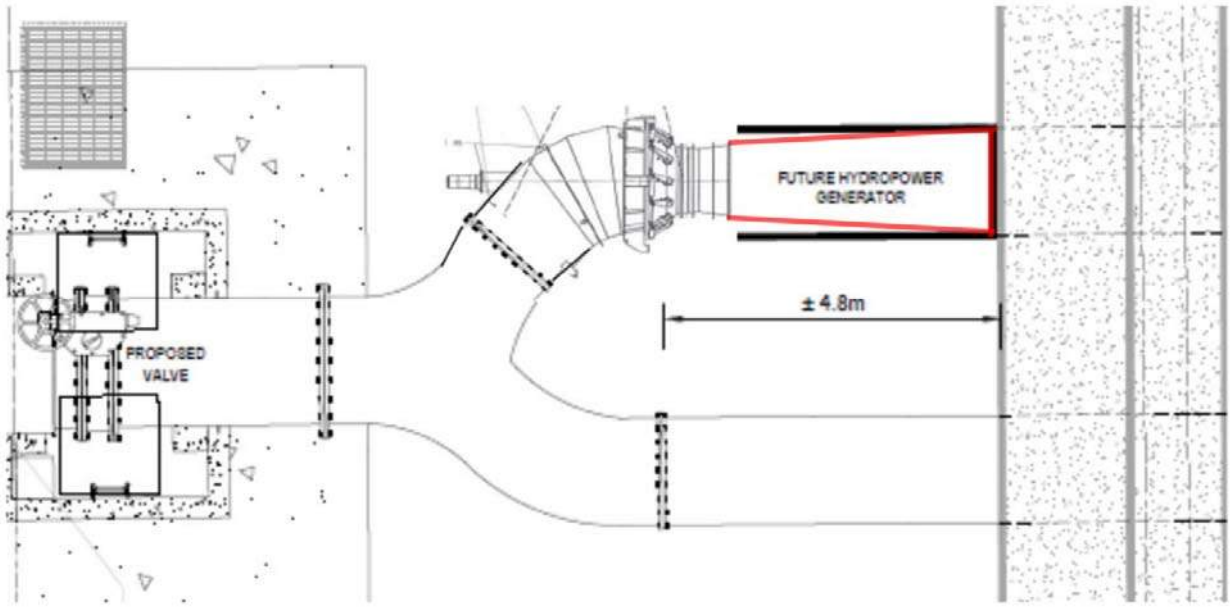


Figure 3.4 - Layout Study - Andritz (Sketch)

4 HYDROTECHNICAL REVIEW

The spreadsheet detailing the Head loss calculations for the SSM Project is presented in Appendix C of this report.

Some sections have broad assumptions and have very little impact on the minor losses.

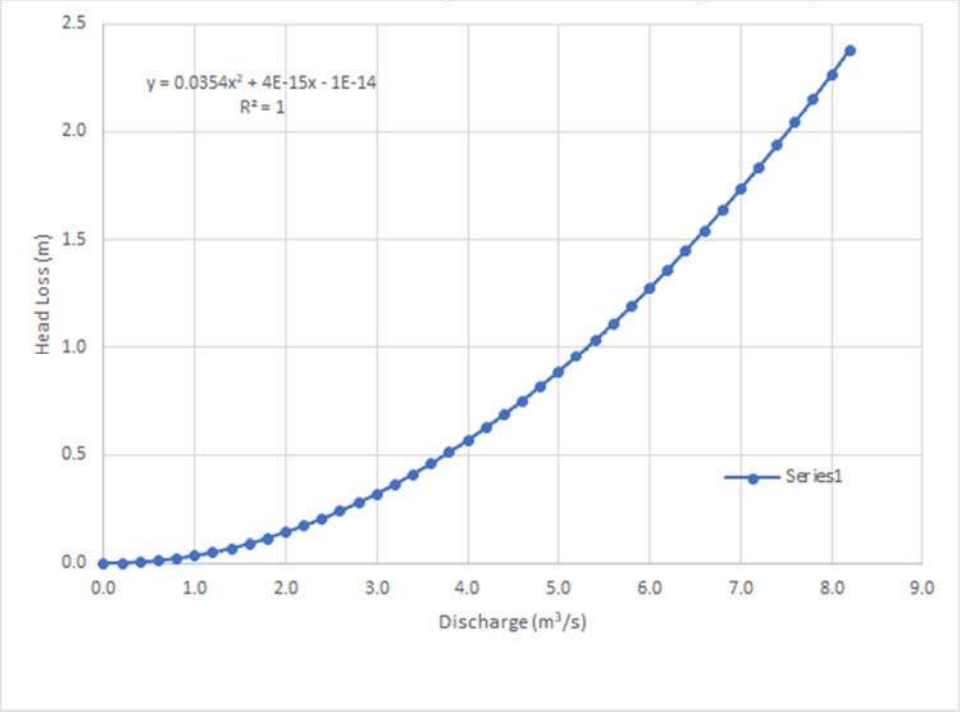


Figure 4.1 - Head Loss Graph

The Figure 4.1 consider the analysis of losses presented in detail in Appendix C. The Head loss is 0.9 m @ 5cms. This head loss includes trash racks, upstream and downstream valve as well as all the penstock bend and branches found in the hydraulic circuit.

Based on data available of upstream and downstream water level statistics from the Government of Canada data (see Appendix E), the gross head values are as follows:

- H_{gross} min. = 4.9 m
- H_{gross} max. = 7.6 m
- H_{gross} avg. = 6.2 m

With a head loss of 0.88 m, the average net head would be at 5.32 m, which is slightly above the previous value given to the suppliers, but similar enough for the purpose of this report. The detail analysis and official reference for quotation could confirm the final design with suppliers. One should note that the higher head available will result in higher energy production.

The recommended discharge may be given using different references and design criteria. As a rule of thumb obtained from T&G supplier design criteria using max. 5 m/s in the draft tube lined section of the turbine. For the Sault installation, the equivalent flow for this velocity would be about 9 cms. This would be a high limit of the flow that leads to a head loss of 2.5 m head. This high limit does not consider the existing condition of the penstock, discharge pipe and historic valves. It is likely a prohibitive flowrate in the penstock considering its age and condition. A high flow limit fixed at 7 cms is likely more realistic for the site condition.

Another rule may be defined using an engineering reference (Hydropower Engineering by C. C. Warnick, published in 1984), which references Gordon and Penman (1979) who provided a very simple equation for optimal penstock diameter for small hydro project (p 127). Below is an excerpt:

> *Size Selection of Penstocks*
>
> *Various experience curves and empirical equations have been developed for determining the economical size of penstocks. Some of these equations use very few parameters to make initial size determinations for reconnaissance or feasibility studies. Other more sophisticated equations use many variables to obtain more precise results which may be necessary for final design. Economical size varies with the type of installation and materials, as well as whether used above ground or buried.*
>
> *Gordon and Penman (1979) give a very simple equation for determining steel penstock diameter for small hydropower installations:*
>
> $$D_P = 0.72Q^{0.5}$$

Based on this equation and solving for Q and velocity (V) for a given penstock Diameter (D_P):

Diameter (D_P) = 1.524 m

Area (A) = 1.82 m^2

Discharge (Q) = 4.48 m^3/s

Velocity (V) = 2.46 m/s

This would represent an average or low flow limit of about 4.5 cms. Again, for vintage pipes, determining the structural integrity of the pipe based on a flow velocity would be needed and is outside of the scope of this study. One shall refer to a mechanical/structural expert.

The flow will adjust in the1.83 m (72 inches) pipe and hydraulic system according to the gross head and not according to the flow of the river which is about 10^3 times greater. The figure used for the supplier's quote of 4.8 m Net Head of the turbine and a flow of 5 cms are realistic and will be kept for the purpose of this preliminary analysis.

5 COSTS REVIEW

Based on the Net Present Value (NPV), the five (5) proposals have been reviewed and are tabulated in a comparative summary (see Appendix D for full NPV comparison table). The estimated costs for each supplier were evaluated considering these factors:

1. DBH: Since the estimated price of $CAD 368,571 (€257,000) in DBH's proposal includes the 206 kW turbine alone without the two (2) elbows or the generator, this value cannot be directly used here. Instead, the cost used for this review came from what was estimated at Table 5-1 of the *AC Power Final Report*. Excluding installation and commissioning, this cost was estimated at CAD 550,000. Also, note that this option might need some concrete work, which was not considered in this estimate.
2. Natel: According to their proposal, the estimated cost for one 184 kW turbine with its generator was evaluated at CAD 588,712 (USD 445,000).
3. Nustreem: This supplier listed the price for a 100 kW turbine generator, the electrical and control package, as well as the custom enclosure (container). These items combined were evaluated at CAD 548,983 (USD 415,000).
4. Voith Hydro: This supplier submitted a total cost of $924,520 for a 210 kW turbine generator. Since this includes crating, transport and commissioning, this price would have been overrated for these costs review when compared to the other proposals. To make a more accurate comparison, a $200,000 value was subtracted from their suggested price, which makes the considered price for this review at $724,520.
5. Andritz: Their proposal mentioned an expected price for a 300 kW turbine generator of $1.0M to $1.2M. The cost review was made with a value of $1.0M, but it will have to be confirmed when more details are available.
6. Zeco: This supplier gave an estimated price for their 200 kW turbine generator of CAD 489,183 (€340,000). Also, one of their engineers estimated an additional CAD 132,666 (USD 100,000) for a control panel and instrumentation. This would make their proposal at an estimated value of CAD 621,849.

Based on a discount rate of 6% and an energy cost of $100/MWh for Ontario, the payback period for each supplier would be:

- DBH: 5 years;
- Natel: 6 years;
- Nustreem: 11 years;
- Voith: 6 years;
- Andritz: 6 years;
- Zeco: 5 years.

Simply looking at these values, the Nustreem option would take the longest time to absorb back the investment. This is mainly due to their overall capacity being the least powerful of all proposals at 100 kW. As mentioned in Nustreem offer, to benefit the full flow of the river would require two (2) units installed but the initial capital costs would double and lead to the same payback.

The Net Present Value for each proposal is presented in the table below:

Table 5-1 - Net Present Value (NPV) Comparative table

	Net Present Value (NPV)					
	Proposal #1 DBH	Proposal #2 Natel	Proposal #3 Nustreem	Proposal #4 Voith	Proposal #5 Andritz	Proposal #6 Zeco
5 years	$96,124	(11,591) $	(235,330) $	(65,850) $	(59,042) $	$5,456
10 years	$578,946	$419,667	(951) $	$426,347	$644,096	$474,215
15 years	$939,739	$741,928	$174,191	$794,146	$1,169,522	$824,499
20 years	$1,209,344	$982,741	$305,067	$1,068,986	$1,562,151	$1,086,252

NOTE: The following currency conversion were used: 1.256 CAD$/US$ and 1.434 CAD$/Euro

Although Andritz's turbine is the most expensive option, it would also be the most profitable in the long run. This is due to their turbine being the most powerful one compared to the other proposals. Note that they have assumed a higher flow of 7 cms, therefore a correction factor of 0.71 shall be applied to bring their numbers back to a return of about 1.1 M$ equivalent to DBH or Zeco for the same flow.

Note the budget price of +/- 50% was requested and WSP is confident that Parks Canada could obtain lower prices on official reference for quotation. The average payback would likely fall below five (5) years for the different supplier's bidding in an official competitive process.

6 OVERALL PROPOSAL COMPARISON

In basing our evaluation on multiple criteria, all received proposals have been compared in the decision matrix table below:

Table 6-1 – Decision Matrix Table - Supplier Proposals

		Sault-Ste-Marie Canal Turbine-Generator					
Criteria	**Weighting (%)**	**Proposal #1**	**Proposal #2**	**Proposal #3**	**Proposal #4**	**Proposal #5**	**Proposal #6**
		DBH	Natel	Nustreem	Voith	Andritz	Zeco
Turbine type	-	horizontal S-turbine - Kaplan	Restoration Hydro Turbine (RHT) - Kaplan	Axial - Kaplan unit	Streamdiver SD - 10.15 - Kaplan unit	Axial - Kaplan unit	Axial - Kaplan unit
Power Output	30%	25	23	20	25	30	25
Generator type	-		Permanent magnet		Permanent magnet		Asynchr. generator
Maintenance risk	10%	9	7	8	7	7	9
Procurement risk	10%	7	9	8	7	7	7
Price	30%	30	30	30	20	10	25
Net Present Value (10 years)	10%	9	8	4	8	10	8
Payback Period	10%	10	9	4	9	9	10
TOTAL	**100%**	**90**	**86**	**74**	**76**	**73**	**84**
	RANK	1	2	5	4	6	3

Please note that these values are preliminary and might change at a later stage with additional precision from the proponents.

Based on this evaluation, the overall top three proposals would be from DBH, Natel and Zeco. They offer a turbine powerful enough at a lower cost than their competitors, making them the most profitable options.

Here is a summary of the pros and cons of each of them:

Table 6-2 - Main Options Comparison

Options	Proposal #1 DBH	Proposal #2 Natel	Proposal #3 Zeco
Pros	- Turbine fits in the limited space available - 200 kW Power Output - Reduced cost from fix wicket gate, which would be optional for constant head and flow values	- Turbine fits in the limited space available and corresponds to the proposed schematic (length of 4.8 m) - 184 kW Power Output - North American Company (California) - Low risk of cavitation - Shorter draft tube which enables less concrete and excavation	- Turbine fits in the limited space available and corresponds to the proposed schematic (length of 4.8 m) - 200 kW Power Output - Reduced cost from fix wicket gate, which would be optional for constant head and flow values
Cons	- Manufacturing delay is 6.5 months, no information on sea travel - Not much is known yet regarding pricing. - Some civil work may be required.	- Delivery window is between 12 and 18 months	- Delivery in 12 months
Costs	- Investment cost: $550,000 - 5 years to gain investment back - NPV after 10 years: $578,946	- Investment cost: $588,712 - 6 years to gain investment back - NPV after 10 years: $419,667	- Investment cost: $621,849 - 5 years to gain investment back - NPV after 10 years: $474,215

Although DBH has the best score according to Table 7-1, there is still a lot of information missing price wise from this supplier. If the estimated value of $550,000 investment is in the right magnitude, their proposal would be the best overall option. Although Zeco's proposal has a slightly higher cost, it offers similar advantages to DBH, which makes them close second. Some civil work may also be required for stabilizing the unit on the ground or concrete slab, it will have to be analyzed in a later stage.

7 RECOMMENDATIONS

The overall best option would be DBH's proposed horizontal S-turbines with a Kaplan runner type of 200 kW power output, with Zeco's as a close second. Every option offered by the suppliers were either in-line or tubular micro-hydro turbine type that could connect directly in the pipe section of 1.83 m (72 in) diameter upstream and 1.52 m (60 in) diameter downstream of the turbine. Both DBH and Zeco proposed a fixed wicket gate, which is a cheaper option that is suited for constant head and flow values. For DBH specifically, the estimated investment value will have to be validated when more data are available as there is some civil cost not considered to their solution for anchoring the S-turbine in place.

This technical report allows us to establish the best layout option for numerous suppliers in the micro-hydro market. A payback within 5 years would be realized considering the annual energy generation and capital cost for the equipment. This payback period is standard within the industry and generally justify the capital cost investment. The high number of suppliers that were contacted and listed in this study shall be re-use in next steps and official bidding process. A high amount of bidder is always beneficial to ensure a healty competitive process optimizing the price while removing the high demand and bottle neck for a single supplier that would increase sell price and bias competitive process.

APPENDIX

A PROPOSALS

APPENDIX

A.1 DBH PROPOSAL

From: DBH [mailto:contact@dbhsarl.eu]
Sent: 4 février 2020 8:37:AM
To: Gagnon, Jean-Mathieu <Jean-Mathieu.Gagnon@wsp.com>
Cc: 'nicolas beaume' <nicolas.beaume@dbhsarl.eu>; thierry.beaume@dbhsarl.eu
Subject: Project Park Canada - WSP Power House "S" turbine alone

Hello Jean-Mathieu,

- here included is the dwg drawing of this horizontal S turbine
- please note that two more elbows would be necessary to have input and output in line
- we have no answer from Marelli concerning the price of the generator
- the price of the turbine alone, as per included drawing (w/o the 2 elbows) is 257 k€, put in a container, departure from Le Havre (France)
- in the price are included 2 travels for me, one to check the turbine on arrival, and another a few month later for checking and starting the turbine after mounting by a local operator
- I have not the price for sea travel of the container, neiy=ther administrative paperwork, I will ask for them if your are interested
- please note that it is a simple Kaplan unit : the runner blades incidence is adjustable via an hydraulic cylinder and rotary joint (included in price) and the inlet wicket gate is fixed
- this should be enough, because the head and flow are pretty constant is your application
- safety and maintenance gates should be provided before and after the turbine (not in the price)
- the pulleys and belt are included in price, but not the electrical generator itself
- we can provide it (in this case please give us the voltage, frequency and electrical rules), or you can put a local bought generator (we will give mechanical specifications)
- manufacturing delay is 6.5 months, sea travel I don't know yet

Thanks

Best regards

didier Beaume

DBH Sarl, 33 les Chênes, 88340 le Val d'Ajol
Téléphone 06.2346.1385 Courriel contact@dbhsarl.eu
Site Web http://dbhsarl.eu Exemples de turbines http://dbhsarl.eu/turbines.html
Forum d'informations http://dbhsarl.eu/forum
Capital 50 000 € N° SIRET 51055483500015 R.C.S. Epinal
N° TVA intracommunautaire : FR82510554835

From: DBH [mailto:contact@dbhsarl.eu]
Sent: 21 février 2020 10:48:AM
To: Gagnon, Jean-Mathieu <Jean-Mathieu.Gagnon@wsp.com>
Cc: 'nicolas beaume' <nicolas.beaume@dbhsarl.eu>; thierry.beaume@dbhsarl.eu
Subject: Project Park Canada - WSP Power House "S" turbine efficiency

Hi Mathieu,

the previsionnal figures are here included, they concern a straight bulb turbine, so the final efficiency with the 2 elbows (to get water input and output in line) will be a bit lower, but I have to calculate it.

- at full load (5 cbm/s @ 4.8 m net head) the turbine's shaft power is around 221 kW @ 333 rpm
- there will be around 2 kW lost in the belt
- a 60 Hz 720 rpm 250 kW 600 V Marelli asynchronous generator has a full load efficiency around 94.4%
- so the generated electrical power at full load should be about (221 - 2) * 0.944 = 206 kW

This is based on my own calculations, these figures need to be confirmed by my colleague at factory

Best regards.

didier Beaume

DBH Sarl, 33 les Chênes, 88340 le Val d'Ajol
Téléphone 06.2346.1385 Courriel contact@dbhsarl.eu
Site Web http://dbhsarl.eu Exemples de turbines http://dbhsarl.eu/turbines.html
Forum d'informations http://dbhsarl.eu/forum
Capital 50 000 € N° SIRET 51055483500015 R.C.S. Epinal
N° TVA intracommunautaire : FR82510554835

Turbine Performance Data - Typical

Close | Next Page | Print Report | Display Input | Solution Summary Definitions

Project: n/a **Solution File Name:** No File Name

Regulation: Adjustable Blade/Fixed Vane

Performance at Rated Net Head of: 4.8 m and 333.3 rpm

m^3/s	% Eff	KW	% Rated	
6.50	87.3	267	130.0	**
5.00	93.9	221	100.0	
5.00	93.9	221	100.0	*
3.75	89.5	158	75.0	
2.50	73.4	86	50.0	
1.25	.0	0	25.0	

** Overcapacity * Best Efficiency Condition at Rated Net Head

Efficiency Modifiers: Multiplier: 1.0000 Flow^2 Function: 0.0000

Maximum Output Performance

	At Maximum Net Head	At Minimum Net Head
of	4.8 m	4.8 m
	267 KW	267 KW
	87.3 % Eff	87.3 % Eff
	6.50 m^3/s	6.50 m^3/s
	1.7297 σ allow	1.7297 σ allow

Operation Type: CONSTANT SPEED

Runner Diameter: 1114 mm

σ allowable at 100% KW and Rated Net Head: 1.2229

σ plant at 100% KW and Rated Net Head: 2.2908

Maximum Runaway Speed: 915.0 rpm (at the Maximum Net Head above)

Flow at Runaway Speed: 14.00 m^3/s (at Rated Net Head and 100% Gate)

Site Atmospheric Pressure minus Vapor Pressure (Hatm - Hvp): 9.86 meters

Best Efficiency Net Head: 4.8 meters

Runner Centerline To T.W.:

-1.14 meters

Specific Speed under Rated Net Head: $\frac{rpm \times KW^{0.5}}{m^{1.25}}$

697.5 at Peak Efficiency

697.5 at 100% Output

Typical Adj Blade/Fixed Vane Turbine Performance Hill Curve for Solution Created

Project: n/a

Solution File Name: No File Name

Operation Type: CONSTANT SPEED

Runner Diameter: 1114 mm

Speed: 333.3 rpm

Peak Efficiency: 93.9 %

Efficiency Modifiers:

Multiplier: 1.0000

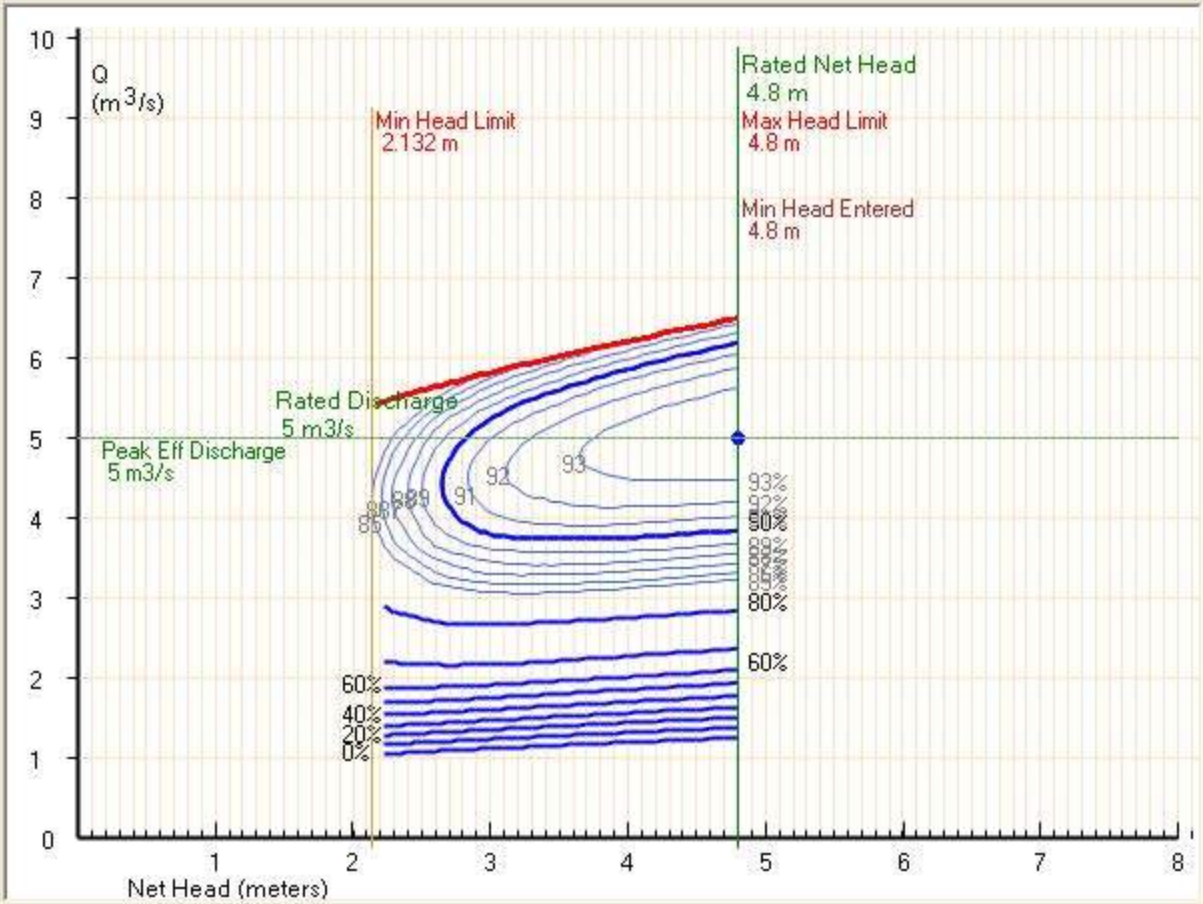
Flow^2 Function: 0.0000

Display Input

Print

Close

Refresh



Turbine Performance Curve Display (for Constant Net Heads)

Project: n/a

Solution File Name: No File Name

Enter Net Head in meters: 4.8 [Enter / Refresh]

Runner Diameter: 1114 mm

Speed: 333.3 rpm

Rated Net Head: 4.8 m

Efficiency Modifiers:

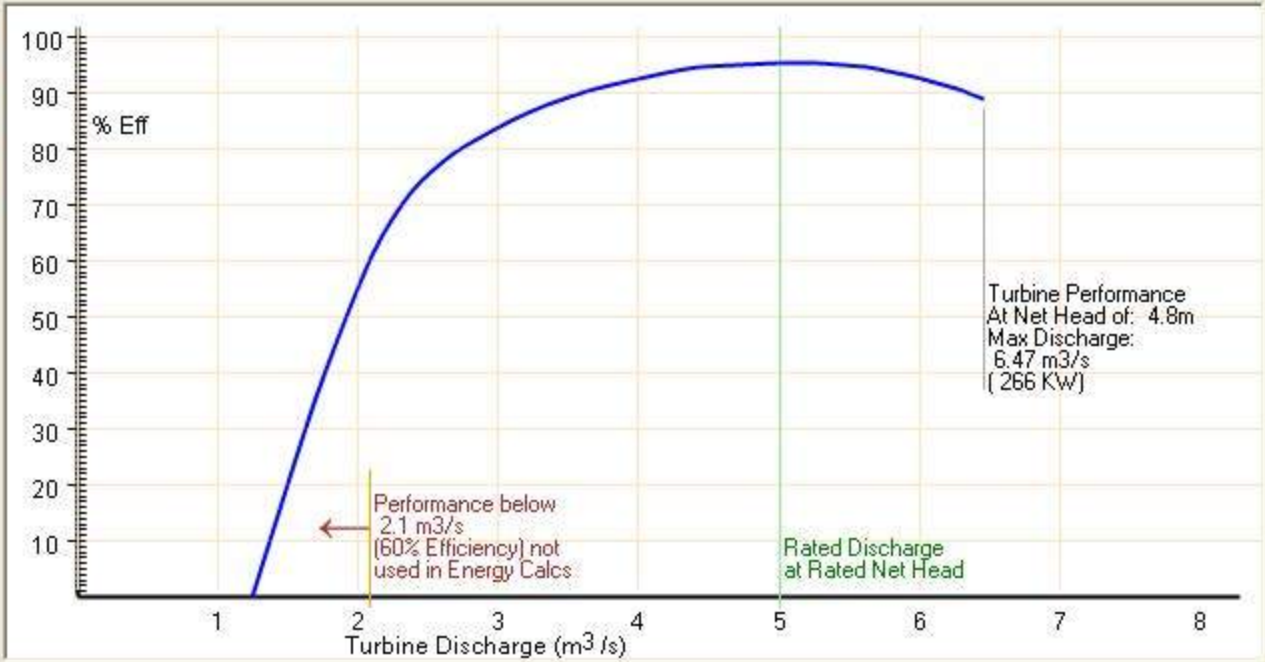
Multiplier: 1.0000

Flow ^{2} Function: 0.0000

[Display Input]

[Print]

[Close]



APPENDIX

A.2 NATEL PROPOSAL

Offer for supply of
Restoration Hydro Turbine (RHT)
for the
Sault Ste. Marie Historic Hydropower Project

Sault Ste. Marie, Ontario

Indicative Offer Provided to:

WSP Engineering

By:

NATEL ENERGY

Date: February 7th, 2020
Validity: 45 days from Date

1. INTRODUCTION

Natel Energy (Natel) is a California-based company providing innovative end-to-end sustainable, fish-friendly hydropower solutions that deliver cost-competitive reliable renewable energy, distributed water storage and watershed scale environmental benefits. Our turbine solution - the Restoration Hydro Turbine - uses state of the art computational fluid dynamics to deliver 90% efficiency, near 100% safe fish passage, and up to 40% savings on total installed cost. Our digital solutions platform, Upstream Tech, combines machine learning, satellite imagery, and advanced hydrologic modeling techniques to produce short-term and seasonal forecasts of flow and water quality metrics.

WSP ("**SHORT**") approached Natel to supply the company's proprietary, fish-friendly Restoration Hydro Turbine ("**RHT**") to the Sault Ste. Marie ("Project") - a decommissioned hydropower dam.

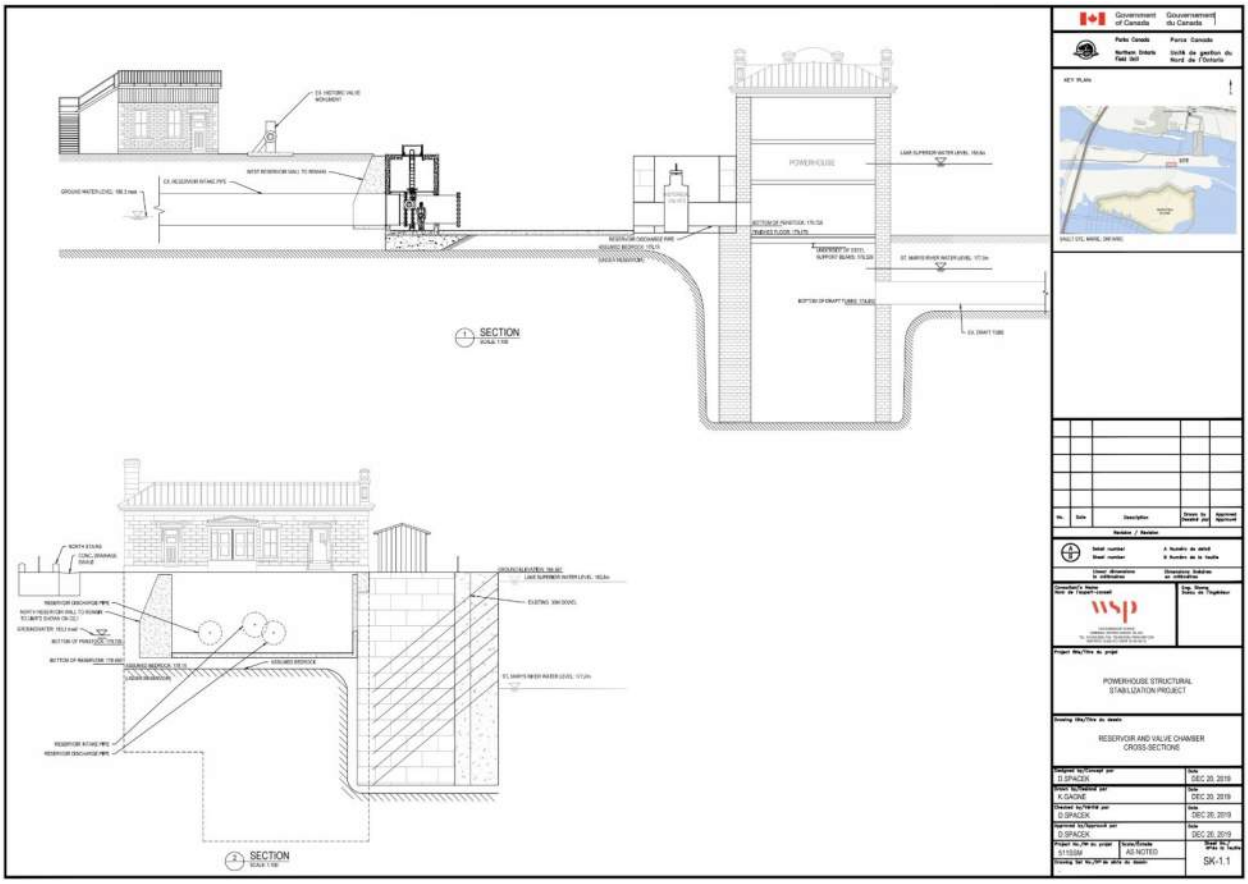
This preliminary proposal ("**Proposal**"):

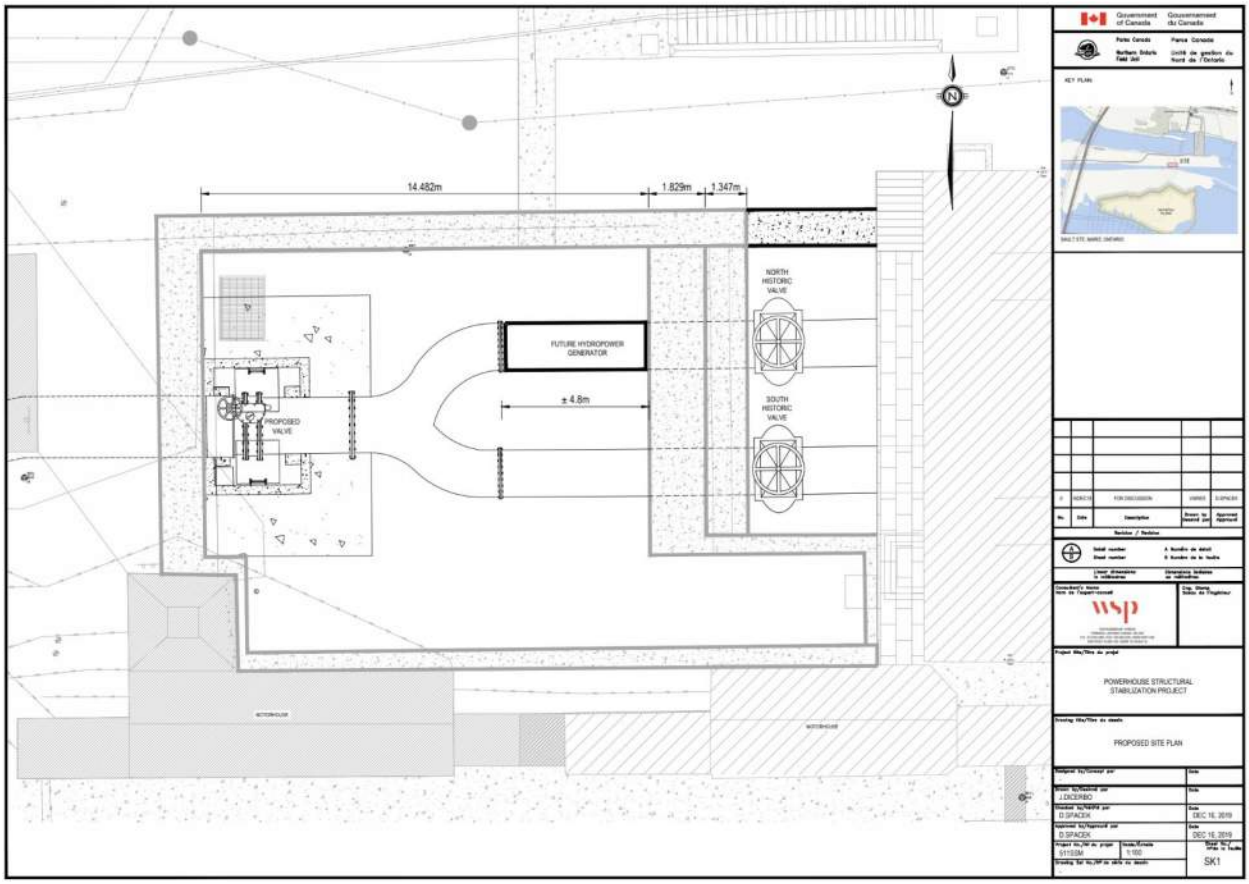
1. Briefly reviews the RHT's competitive advantages, general features, performance, and warranties;
2. Provides preliminary design guidelines for deploying the RHT turbine for the proposed Project;
3. Provides an indicative quote to supply the RHT turbine for the Project.

2. PROJECT DESCRIPTION

The Sault Ste. Marie Project ("**Project**") is a decommissioned hydropower plant in Sault Ste. Marie, Ontario. The old turbine has been removed but the powerhouse and penstock remain in place. WSP has been hired as a consultant to assess the feasibility and cost of repowering the site.

Figure 1: Project Site Overview




14.482m
1.829m
1.347m
NORTH HISTORIC VALVE
FUTURE HYDROPOWER GENERATOR
± 4.8m
SOUTH HISTORIC VALVE
PROPOSED VALVE
POWERHOUSE STRUCTURAL STABILIZATION PROJECT
PROPOSED SITE PLAN
SK1

1. PROJECT SITE AND TURBINE DATA

1.1. Project Site Data

- *Flow Estimates*:

  Flow estimates provided by WSP are as follows:

  - Q_{90} 5 m^3/s,
  - Q_{74} 5 m^3/s,
  - Q_{50} 5 m^3/s,
  - Q_{26} 5 m^3/s.

- *Head Estimates*:

  As upstream/downstream rating curves were not provided, upstream and downstream water levels were estimated based on Natel's experience with similar dams. Head and flow estimates provided herein are based upon documents that WSP provided to Natel and are subject to revision following detailed design and feasibility studies.

  - Gross head (H_g) was provided at a constant 6 meters.

- Net head (H_n) was provided at 4.8 meters. Net head is defined as gross head (headwater level-tailwater level) minus head loss.

1.2. Turbine Data

- *Turbine Type and Power Output and Efficiencies*:
  - Turbine Type: One Restoration Hydro Turbine (RHT) D130-P-VSQ-h5.
    - Runner Diameter (d): 1.30 m
  - Power Output:
    - Unit Nameplate Capacity: 184 kW

- *Turbine Efficiency Levels:*
  - Peak turbine hydraulic efficiency: 90.6%
  - Estimated water-to-wire efficiency: 79.03 % (inclusive generator losses, estimated to be 98% and 94% respectively.)

- Cavitation - Natel expects cavitation free operation with the RHT at 5 meters of net head and 3 meters above tailwater setting.

2. EQUIPMENT SUPPLY

Natel Energy proposes to provide one individual RHT turbine package for the Project that is expected to include:

- *Hydro-Mechanical Equipment*: 1) D130-P-VSQ-h5 Restoration Hydro Turbine including wicket gates, runner, runner housing, and draft tube cone: 2) penstock adapters/inlet nozzles; 3) special assembly tools;
- *Electro-Mechanical Equipment:* 1) direct drive permanent magnet generator; 2) power factor correction (if required, and as specified by customer); 3) generator protection relay (as specified by customer).
- *Instrumentation and Control Equipment*: 1) SCADA control system (hardware and software); and 2) integrated sensors that may include (if required, and as specified by customer): a) shaft speed; b) generator output; c) water levels (upper and lower pools)

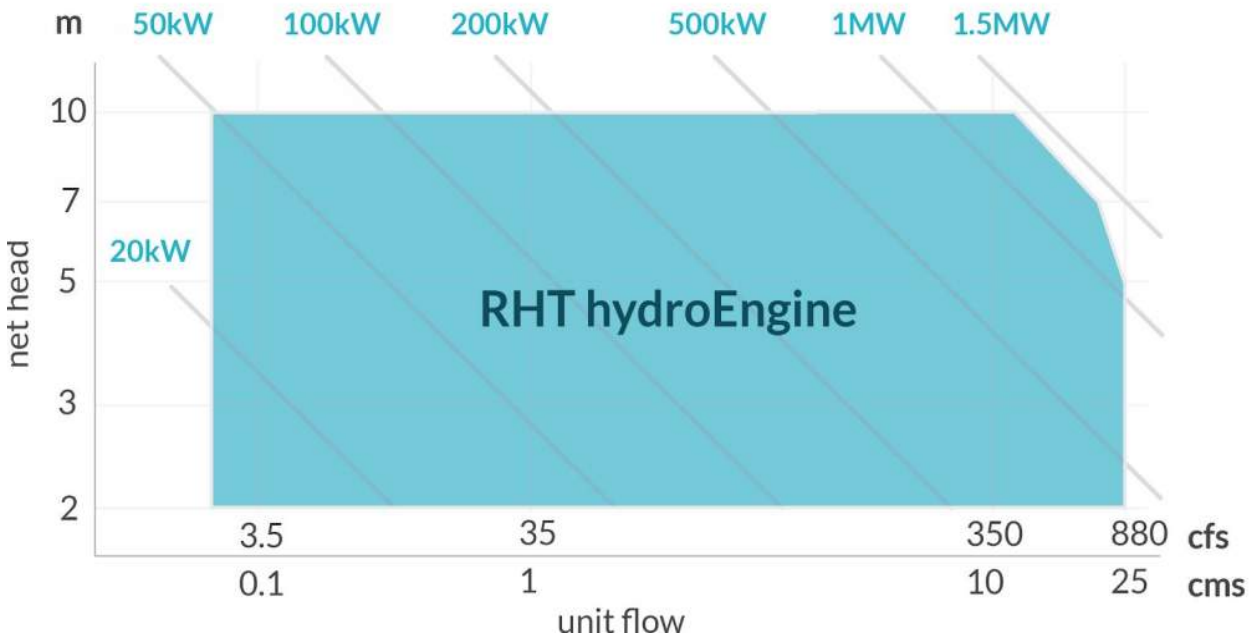
2.1. Turbines

The Restoration Hydro Turbine (RHT) is a low-head hydropower turbine that was designed using state of the art computational fluid dynamics to deliver high efficiency, safe fish passage, and significant savings on total installed cost. The RHT has a low risk of cavitation and a draft tube that is 50% shorter than conventional high-speed propeller/Kaplan turbines, enabling substantially less concrete and excavation which reduces the civil works cost. It is the only turbine for the low-head space (2 to 10 meters of head) to simultaneously provide the following:

- >90% peak hydraulic efficiency delivers world-class turbine performance
- Up to 40% savings total installed cost from:
  - Compact form factor with a low aspect ratio, short, prefabricated draft tube. Draft tube is included with the unit, instead of requiring costly site-specific construction.
  - Low risk of cavitation, allowing the runner to be set at or above tailwater elevation, which means more civil work happens above water where it is less expensive.
- >99% safe downstream passage of fish through the turbine eliminates the need for costly exclusion or mitigation measures such as fine fish screen systems, downstream fish bypasses and curtailed generation

The combination of these features allows hydropower projects to be constructed and operated at lower cost and with fewer environmental and social impacts than competing low-head turbines.

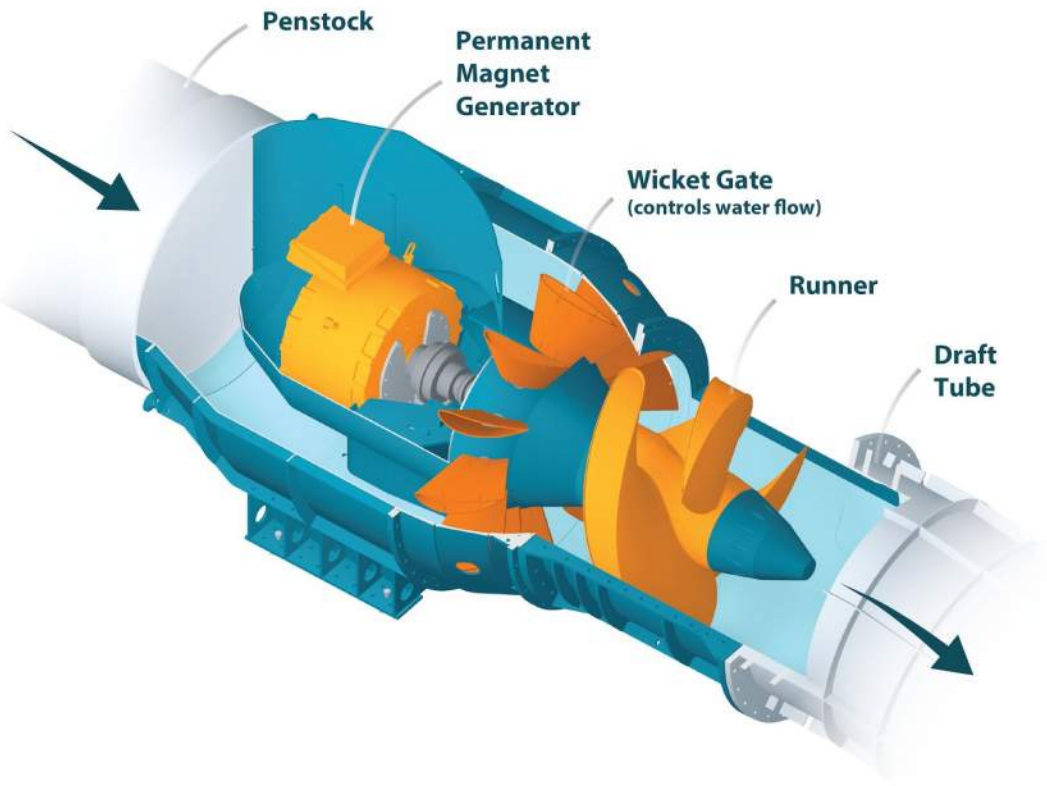
Figure 2: RHT Operating Envelope



The Restoration Hydro Turbine (RHT) to be supplied to the WSP's client will be designed in Alameda, California, USA according to the highest-quality industry standards and design specifications.

3. TURBINE CONFIGURATION

Layout: Restoration Hydro Turbine (RHT), pit configuration



4. WARRANTY & MONITORING

4.1. Limited Product Warranty

Natel warrants that at the time of delivery, the customer has title to the delivered product(s) free and clear of liens and encumbrances. In addition, Natel makes the following warranty for each purchased RHT hydroEngine® system at the date of commissioning:

Subject to the exclusions contained herein, Natel Energy warrants to the original buyer of the products for a period of 18 months from delivery or 12 months from the commercial operation date that the products shall be free from defects in materials and workmanship which have an effect on the products' functionality under normal application, installation, use, and service conditions as specified in Natel Energy's standard product documentation such as the installation manual and its inclusions.

Claims under warranty will only be accepted if the buyer can prove that the malfunctioning or non-conformity of the products results exclusively from defects in materials and/or workmanship under normal application, installation, use and service conditions specified in Natel Energy's standard product documentation. This Limited Product Warranty does not warrant a specific power output of the product. An extension of the Limited Product Warranty could be requested from a globally accepted insurance carrier.

5. SALES TERMS AND CONDITIONS

The budgetary cost estimate for one turbine with direct drive permanent magnet generator USD $445,000.

Should the customer decide to move forward with Natel, the parties will sign a contract that captures summary terms and conditions for the sale and purchase of hydroelectric generation equipment.

5.1. Estimated Delivery Date

Natel's standard delivery window is between 12 and 18 months from the time the order is committed for the first unit. With expected order on or before April 15, 2020, delivery is expected by the summer 2021.

5.2. Services Included

The following are included with the purchase of the RHT system:

- Input on RHT integration into site design.
- Interface with and consultation with customer's EPC.
- Technical advisory support at the Project site during installation, startup and commissioning.

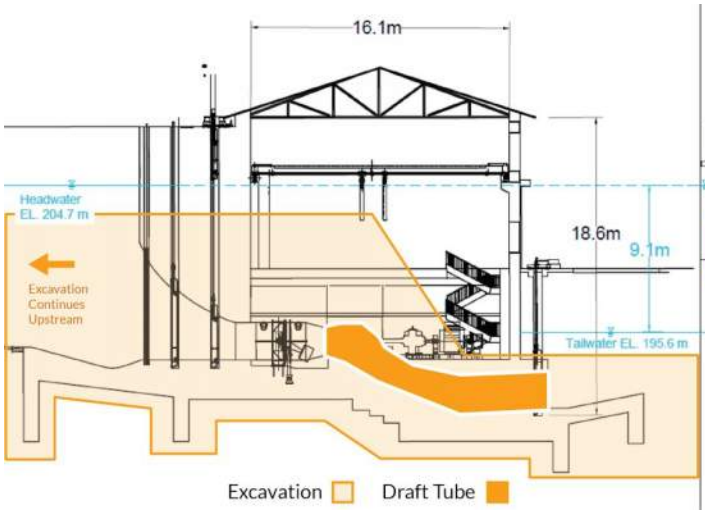
5.3. Disclaimer:

The preceding is an indicative summary of the terms and conditions for the proposed transaction between the Parties. This term sheet does not constitute an agreement, nor a commitment to engage in the transaction described herein. In addition, the terms herein are not, nor are meant to be, all-inclusive of the terms and conditions that the parties will require if they were to enter into a final and binding commitment. Any such final agreement shall be binding only upon execution of a fully negotiated and duly executed agreement.

Appendix A: RHT Innovation Advantage - Reduced Civil Cost

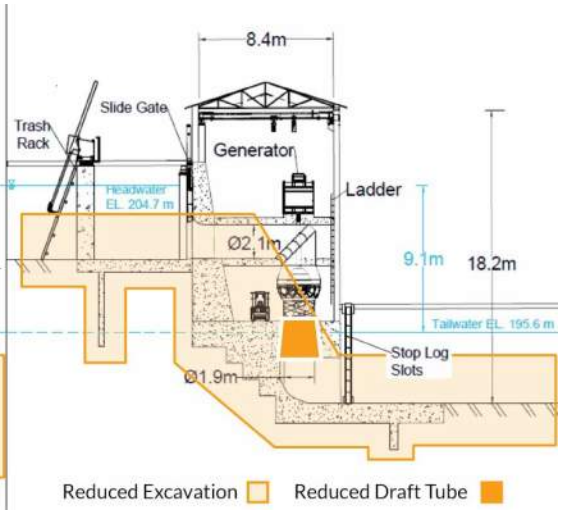
The RHT has a low risk of cavitation and a draft tube 50% shorter than conventional high-speed propeller/Kaplan turbines, enabling lower-cost civil works and substantially less concrete.

Conventional Installation



- Deep submergence
- Large amount of excavation & concrete
- Long, custom draft tube

RHT Installation



- Small Powerhouse, about **40% less excavation** & **25% less concrete**
- Short axial turbine length
- Convenient runner access for O&M

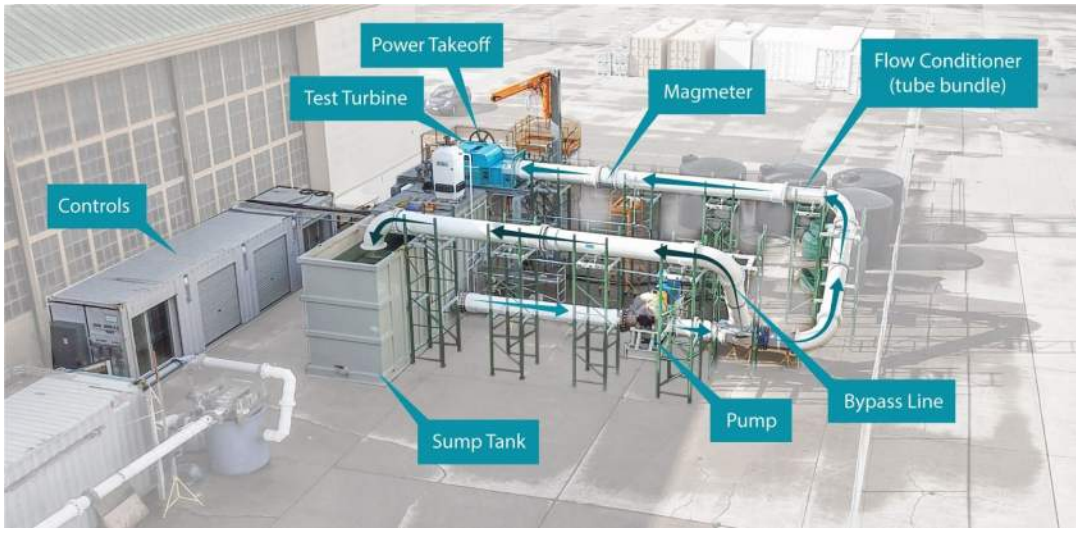
Appendix B: Natel Energy Engineering Excellence

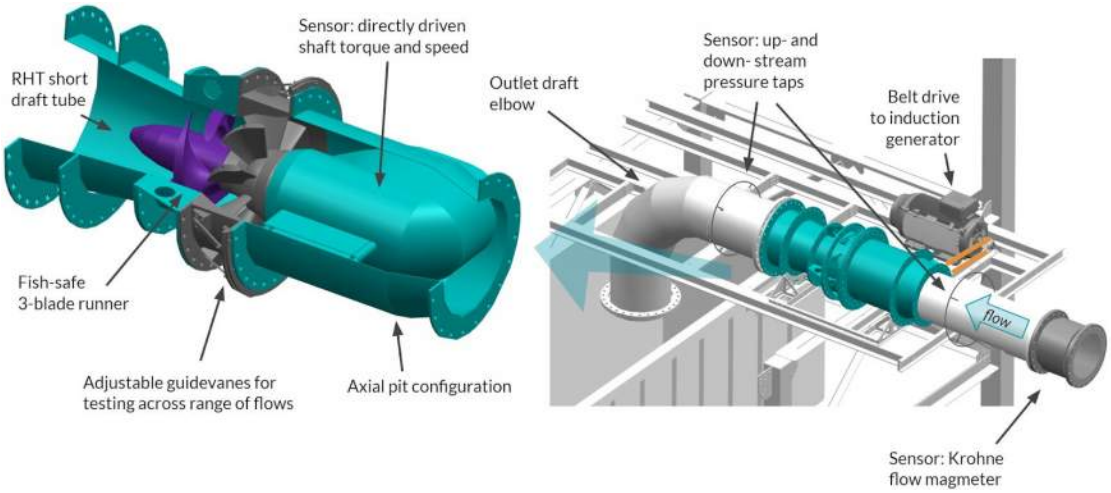
Computational Design (CAD & CFD)

The RHT has been designed utilizing world-class CAD and CFD tools (Siemens NX and ANSYS FLUENT). Care has been taken to utilize appropriate near-wall meshes and turbulence models. Moving Reference Frame and Sliding Mesh simulations are performed as appropriate.

Hydraulic Performance Testing

A scale model of the RHT is being tested in Alameda, CA. The test unit is a D055 size (0.55 m diameter runner). At the test stand maximum of 10 m head, the turbine will pass 0.9 cms flow and generate approximately 70 kW. The test stand utilizes world class instrumentation, such as a Kröhne magmeter and Himmelstein torque sensor. Experimental uncertainty is <0.5%.





APPENDIX

A.3 NUSTREEM PROPOSAL

From: Al Spinell [mailto:als@rentricity.com]
Sent: 20 janvier 2020 4:52:PM
To: Gagnon, Jean-Mathieu <Jean-Mathieu.Gagnon@wsp.com>
Cc: Frank Zammataro <frankz@rentricity.com>
Subject: Re: Low Head Axial Flow Turbine Opportunity

JM,
I have taken the liberty to update the information provided in the email below. The changes are highlighted in **BOLD.** This package should provide a much firmer background on what Rentricity and Nustreem have to offer.
I assume you in the process of developing a report for provincial and Canadian National government personnel about the opportunity to re=power the site.

Please advise if there is further information you need to complete your report. Also I would appreciate your feedback on the timing an action might come from your report. If your customer(s) would like to develop this further, we would want to work with you on a detailed design and updated project capital cost package.

I will be traveling Tues-Fri this week and while I will check email early and later each day, I will generally not be available for any extended calls. During this period, if you do have questions, I will attempt to respond as best I can via email

Regards,
Al

On Mon, Jan 13, 2020 at 3:29 PM Al Spinell <als@rentricity.com> wrote:
Jean-Mathieu,
After review of the plan and elevation drawings of the historic site, I have a number of questions. Most center around options to situate the turbine generators. I suggest we have a call on Tuesday or Wednesday (mid/late morning either day works best for me). to discuss. Let me know what might work best for you.

In the interim, here is some relevant information for you to consider.

1. Rentricity and Nustreem have partnered to provide major equipment packages and engineering services for low head sites such as Sault Ste Marie.
2. Nustreem has very specific, proven axial flow (in-line) technology which operates very well in low head regimes (www.nustreem.com). **Attached is a 13 slide introductory pdf detailing the NuTurbine equipment.**
3. Rentricity provides complementary integrated electrical/control equipment and services for the Nustreem turbine generators.
4. The specific unit technology that would be deployed at your site has been operating successfully in Connecticut and Massachusetts (total of 6 units) for more than 5 years.
5. Budget estimates for equipment only.
   a. Turbine Generator (each) - $260k
   b. Electrical/Control Package - $125k
   c. Custom Enclosure to match physical and aesthetic requirements of site ~ $30k (See concept rendering attached)
6. Turbine Generator dimensions - Approx 8' x 9'. Inlet diameter - 48"; **outlet diameter - 32"**
7. Main Electrical cabinet can be located in the Powerhouse
8. Generator output will be consistent with three phase Canadian voltage requirements (**we have experience with Canadian electrical requirements having commissioned a system in Halifax, NS in 2014 that is connected to Nova Scotia Power.**
9. Each unit will utilize **~102** cubic feet/sec (**2.9 Cubic meters/sec)** of flow and generate ~**100** kw at the approx available head of 15.7 feet (4.8 meters).. **Efficiency is ~75%. Total annual generation from a single unit is 876,000 kw-hr.**
10. **Bypass following upset event is not required for orderly shutdown.**

11. Plan diagram shows ~ 4.8 Meters available for an axial flow unit. Layout from the 60" inlet pipe flange would be as follows:

a. Spool 60' to 48" to mate with inlet flange of turbine (~ 4 feet).

b. Axial turbine generator unit ~ 8 feet

c. Transition spool - 32" at turbine discharge flange to 60" at Powerhouse inlet - ~ 4 feet.

(Would need to deploy two units to capture all of the low energy at the flow rates in your email.)

Let me know when you are available for a call.

Sincerely,
Al

--

Al Spinell
Co-Founder and COO
Rentricity, Inc.
www.rentricity.com
860-810-7455

--

Al Spinell
Co-Founder and COO
Rentricity, Inc.
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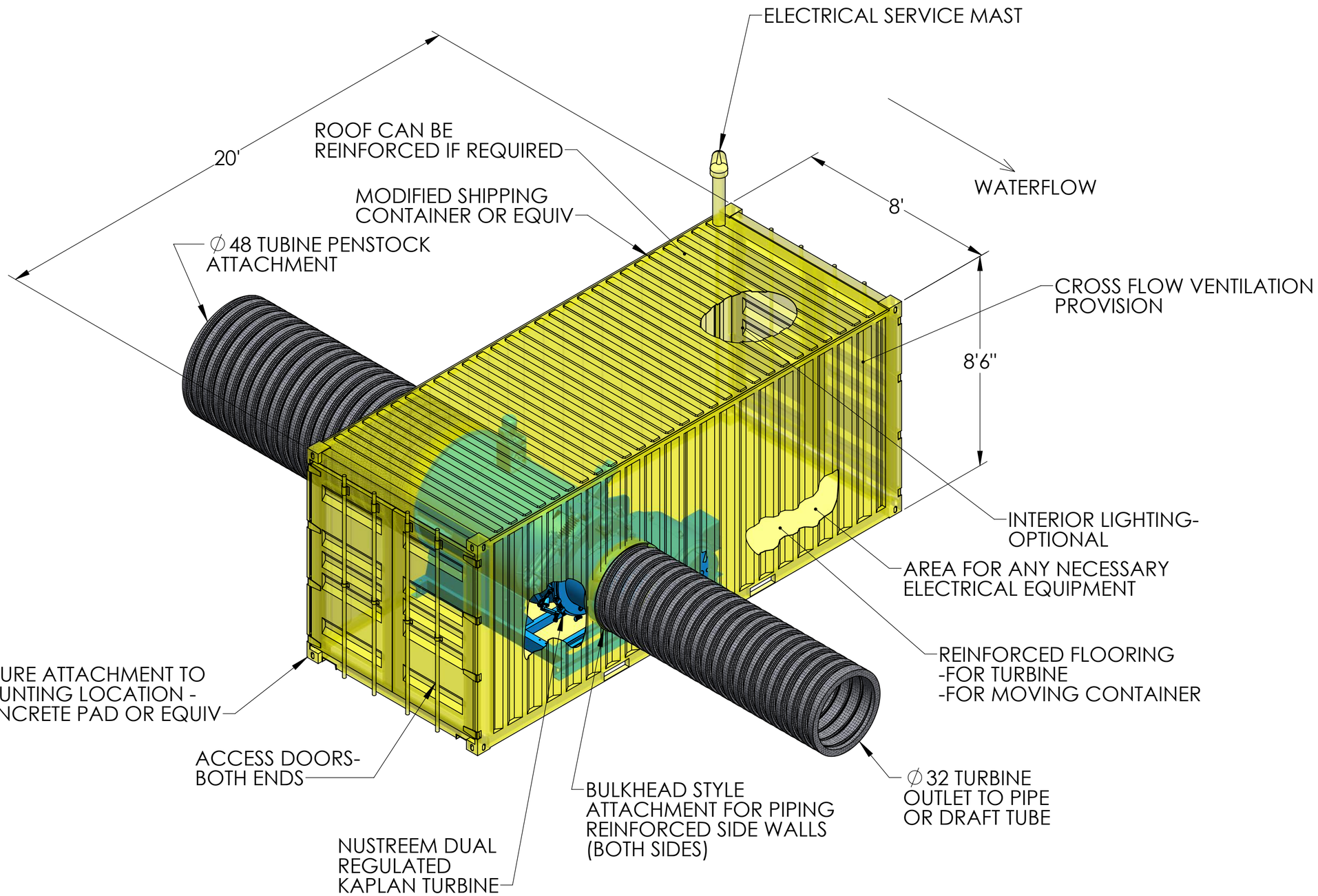
NuTurbine
NuBrake
NuTech Controller
NUSTREEM
Generator

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED



NOTE: DIMENSIONS ARE FOR REFERENCE ONLY

PRELIMINARY

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
.0 = ±.02
.00 = ±.010
.000 = ±.005
.0000 = ±.0005
FRACTIONAL ±1/32
ANGLES = 0 ±30'
REMOVE ALL SHARP EDGES

DO NOT SCALE DRAWING

APPROVALS

DRAWN	DATE
KAP	9/20/19

MATERIAL

FINISH

NÜSTREEM
MANSFIELD CT 06250 USA

DESCRIPTION
HYDRO IN A BOX CONCEPT

SCALE	SIZE	DWG NO	REV
NONE	C		

CAD FILE: HYDRO IN A BOX - 9-20-19 | SHEET 1 OF 1

APPENDIX

A.4 VOITH PROPOSAL

Voith Hydro, Inc.
2185 North Sheridan Way
Mississauga, Ontario
Canada
Tel. 905-287-5801
Fax 905-855-0249
www.voithhydro.com

A Voith and Siemens Company

Budgetary offer

1xStreamDiver unit for Park Canada Project

A Voith and Siemens Company
Date: 03 February 2020

VOITH

Content Table

1 Covering Letter

Dear Mr. Gagnon

We refer to your inquiry for Park Canada SHPP project and thank you very much for the invitation to bid for the budgetary offer. Please find below the budgetary offer for our recommended E/M-equipment including a StreamDiver turbine, a propeller bulb type with a direct coupled permanent magnet synchronous generator (PMG generator), auxiliaries, electrical equipment, supervision of erection and commissioning.

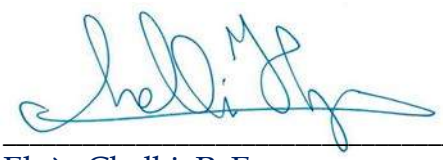
The delivery for the equipment will be DDP site (full equipment in one transport).

Our technical offer is based on Kössler-Standard and our attached commercial conditions.

The validity of this offer expires on 90 days

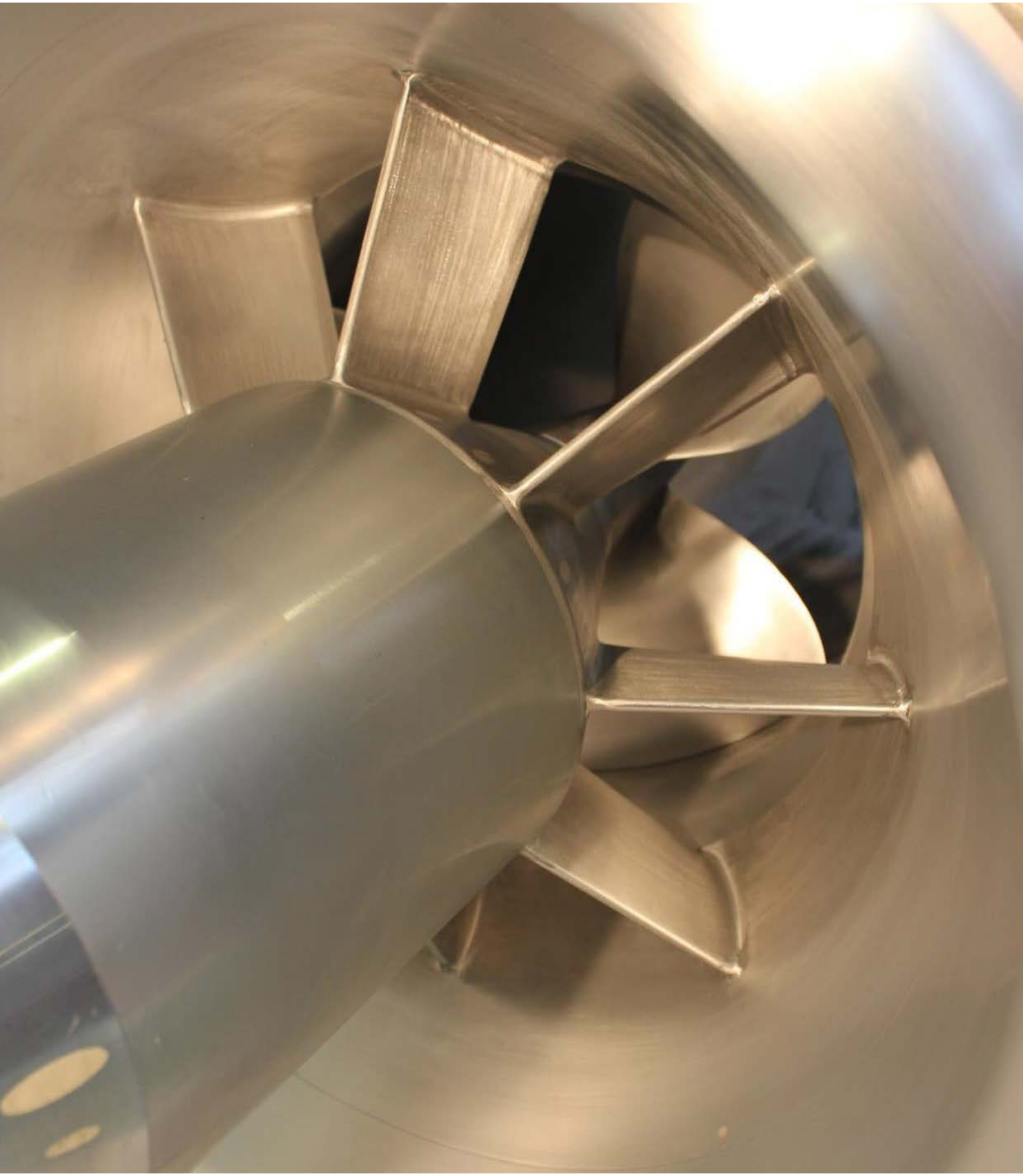
We trust that our offer will meet your requirements and look forward to meeting you personally soon for detail explanation of our offer!

Yours faithfully



Elyès Chelbi, P. Eng.
Sales & Proposals Manager,
Voith Hydro Inc.
Small Hydro

Mobile +1 450 577 0539
elyes.chelbi@voith.com



2 Prise Schedule

Roseway SHPP / Canada

Item No.	Description of Equipment	Total CAD*
1.0	Mechanical Equipment	566,100
	• 1 StreamDiver® SD – 10.15 – 4 blades (210 kW)	
	• 1 PM generator	
	• engineering and documentation	
	• MV protection and control equipment (600V, CSA/UL design)	358,420
	o 1x 600V MV MCC 720A	
	o 1x 600V MV Main Breaker 600A	
	o Project Engineering	
	o 1x AC/DC Supply	
	o 1x PLC & SCADA	
	• 1 Turbine Shut Off Valve	
	• packing and transport DDP site	
	• supervision of erection and commissioning	
	Total price, in Canadian Dollars	**924,520**

* All prices in Canadian Dollars

Yannick Labonté / Head of Small Hydro

Elyès Chelbi / Sales Manager

3 Technical Description

3.1 Technical Data

Turbine		
Turbine type	SD - 10.15	
Number of units	1	pcs
Rated net head (max.)	6	m
Turbine output (per unit electr. power)	~210	kW
Elevation of runner C.L.		m.a.s.l.
Elevation of tail water level at design discharge		m.a.s.l.
Runner inlet diameter D1a	1,015	mm
Shut off Valve		
Method of opening	Electric double acting	
Synchronous Generator		
Type	Permanent Magnet	
Mounting	IM B5	
Frequency	60	Hz
Voltage	600	V
Insulation / Temperature rise	F / B	
Operating Conditions		
Mode of operation	parallel with grid	
Electrical equipment		
Low voltage switch system	600	V
FU converter		
Plant control and protection system	Schneider	

Battery system 24V and DC distribution	
Standards of Measuring	
Mechanical Vibration of non-Rotating Parts	ISO 10816
Mechanical Vibration of Rotating Parts	ISO 7919
Efficiency	IEC 60041
Cavitation	IEC 60609

The layout is based on all valid and applicable EU-directives concerning manufacturers according AEUV 114.

3.2 Scope of Supply and Description

The scope of supply includes one (1) StreamDiver with a direct coupled permanent magnet synchronous generator as well as the E-BoP equipment, Transport DDP Site, erection supervision and commissioning.

3.2.1 Design and Construction Requirements

3.2.1.1 General Concept Description

The StreamDiver consists of the propeller bulb type and a direct coupled permanent magnet synchronous generator (PMG). Wicket gates and runner blades are not regulated.

The bulb of the StreamDiver is water filled. For special water quality with extreme high sediment values (exceeding the values specified in 3.3.1.3. the bulb will be filled with potable water or river water is filtered before entering to the bulb. In this case a shaft sealing will be applied to avoid contamination by river water.

The turbines are rotating clockwise when looking in flow direction. The turbine-generator shaft is directly coupled to the generator rotor.
The power unit will be equipped with two water lubricated guide bearings, one downstream close to the runner integrated in the turbine housing and the other one upstream connected with the generator housing.

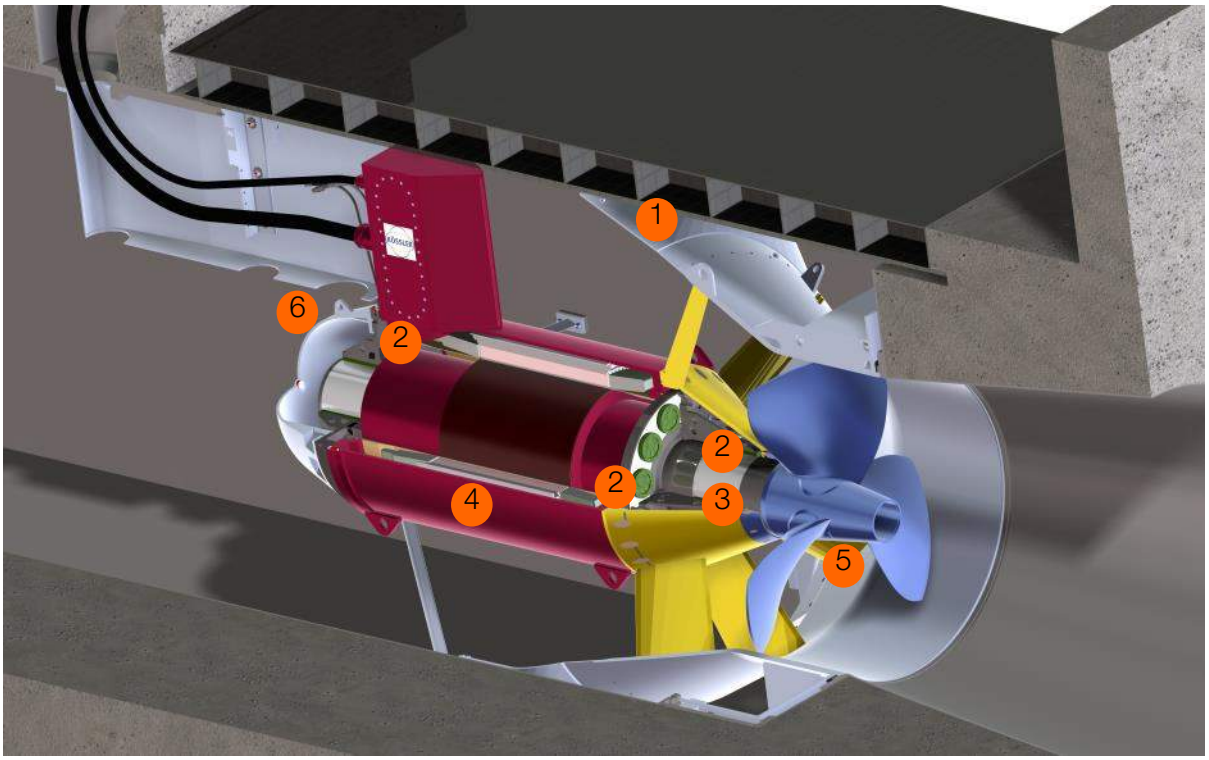


Figure 1 – StreamDiver

1. Turbine housing with guide vanes
2. Radial and axial bearing
3. Turbine-generator shaft
4. PM Generator
5. Runner with fixed blades
6. Bulb nose

The water lubricated thrust bearing, for carrying the hydraulic thrust, is combined with the downstream guide bearing. Also a counter thrust bearing is considered.

The bulb of the StreamDiver is not pressurized.
The stator of the generator is equipped with a static sealing to avoid that the water inside the bulb contaminates the winding. This sealing is placed in the air gap of the generator. The sealing is of static type, designed in a way to allow thermal movements of the generator housing.

Design modifications (if any) and improvements/optimization wherever required shall be discussed and carried out during detail engineering of machines by Voith/Kössler after necessary approval from the customer.

3.2.1.2 Applicable Directives, Standards and Codes

The standards, codes and manuals cited throughout this technical description are used to establish the level of safety, precision, quality, class of materials, acceptability, tolerances etc., to which the work is to be performed. Where these are cited, the latest revision or edition will prevail. Other standards, codes and manuals that will provide an equivalent level of safety, precision, quality, class of materials, acceptability, tolerances, etc. may be substituted.

Specific standards, codes and manuals are referred in the appropriate parts of this specification documents. Following is a list of references to sources for some general codes and manuals cited in the specification documents.

IEC and ISO are the leading Standards.

- ANSI - American National Standard Institute
- ASTM - American Society for Testing and Materials
- ASME - American Society of Mechanical Engineers
- AWS - American Welding Society
- AISC - American Institute of Steel Construction
- ISA - Instrument Society of America
- CENELEC - European Committee for Electro-technical Standardization
- CEN - European Committee for Standardization
- IS - Indian Standards
- ISO - International Standardization Organization
- IEC - International Electro-technical Commission
- NEMA - National Electrical Manufacturers Association
- IEEE - The Institute of Electrical and Electronic Engineers, Inc.

In addition to the application of many international accepted standards Voith turbines are subject to several internal standards, which are more detailed and more specific for hydraulic machines than contemptible general standards.

3.2.1.3 Water Quality

The following parameters of water quality define harmless conditions for non- and low-alloyed structural steel as well as for stainless steel type 1.4313/ASTM 743 CA6NM.

Water quality parameter	Unit	Harmless water quality threshold
Total suspended solids (TSS, average value)	mg/l	< 60
pH-Value	-	5 - 9
Electric conductivity	µS/cm	< 300
Chloride (Cl-)	mg/l	< 50
Sulfate (SO42-)	mg/l	< 300

3.2.2 Equipment Description

3.2.2.1 Runner

The runner will be cast welded of high strength stainless steel composed of 13% chromium and 4% nickel and will consist of the hub and the blades

Numerically controlled machining of runner entrance and discharge creates perfect hydraulic passage. Runner inspection and quality control regarding hydraulic surface are according to IEC 60193. The surface finish of the hydraulic passages will be ground smooth to minimize the hydraulic friction losses.

The runner will have a bolted connection for attaching to the shaft.

The runner will be dynamically balanced according to ISO1940-1 class G6, 3.

3.2.2.2 Shafts, couplings and bearing hard coating

The turbine-generator shaft will be of stainless steel. The bearing surfaces on replaceable sleeves are HVOF hard coated. The shaft end (driven side) is equipped with a replaceable axial bearing disk. Its bearing surface is also HVOF hard coated. The turbine-generator shaft will be designed to operate safely without excessive vibration and at maximum torque without exceeding the allowable stresses.

The coupling between runner and driven side turbine shaft end will be a bolt connection with shear pin. The turbine-generator shaft will be dynamically balanced according to ISO1940-1 class G6, 3.

3.2.2.3 Bearings

The bearing for the main axial bearing is designed with segmented pads made of composite material. The bearing pads seat is self-movable inside the bearing shield. The radial bearings are of full shell type made of composite material.

The bearing shields holding the composite pads and shells are made of a stainless steel welded construction.

3.2.2.4 Turbine Housing with Stay Ring

The turbine housing is made of a welded steel structure. This welded construction combines:

- Stay vanes
- Inner and outer stay ring
- Discharge ring
- Connection to turbine fastening device

The DE bearing shield will be connected with the turbine housing via a bolted connection. The turbine housing is also equipped with transportation devices and plugs for cable connection. The water resistant cables of energy and sensors will be connected to these plugs. The turbine housing is designed to transfer the hydraulic load and the weight of the components into the civil structure.

3.2.2.5 Draft Tube Cone / Flange

The draft tube cone / flange with sealed connection to the turbine shut off valve is prepared for embedment and is designed for safe transition of the turbine loads into the concrete.

3.2.2.6 Generator

The generator meets the requirements of IEC 60034 with the relevant sections.

The generator is equipped with a permanent magnet (PM) excitation. Permanent magnet excitation provides a fixed excitation for the machine. Permanent magnets are mounted inside the rotor pole shoes in order to provide mechanical support as well as to protect the magnets against electrical anomalies. A corrosion of the magnets, due to the atmospheric gases and humidity, is eliminated via a specific coating material employed for magnets surfaces as well as via rotor impregnation.

The stator winding is pitched. This eliminates, with the skew, effectively the harmonics in the voltage waveform and ensures with the carefully designed pole profile very low voltage waveform distortions. A fully connected damper winding reduces oscillations during paralleling.

The insulation system is class ´F´. All wound components are varnished.
Strengthened insulation system is used in order to ensure the safe operation during turbine inrush situations.

The generator is equipped with a special transportation device. This device allows an assembly where the rotor will be fixed axially inside the stator.

3.2.2.7 Instrumentation

Device	Digital	Analogue	Consumption	No. of Devices
Bearing gap detection (bearing wear detection)	NC		24VDC	4
Leakage Sensor	NO		24VDC	2
Winding temperature		PT 100	24VDC	6
Bulb filling detection (no standard supply)	NC		24VDC	1
Bearing temperature (axial bearing)		PT 100	24VDC	1
Vibration sensor NDE		4-20mA	24VDC	1

Shop Assembly and Test of StreamDiver:

The turbine is assembled directly at our production site in St.Georgen/Austria, where we can guarantee accurate and clean work through our highly qualified staff. Critical dimensions will be measured and recorded on the factory acceptance test (FAT) protocol. We pay great attention to work safety and the sustainability of our products as well as of our manufacturing conditions is very important for us. All electrical energy for our company and manufacturing is drawn from renewable sources.

The turbine will be assembled and tested in the workshop prior to shipping.

Figure 2 - Staff Workshop Assembly at Kössler

3.2.1 Turbine shut off valve

The electrically operated shut-off valve is specifically designed for the turbine StreamDiver®. It is used for start-up and stop of the turbine generator unit. During grid synchronization, the flow rate and therefore speed of the unit is regulated by the valve.

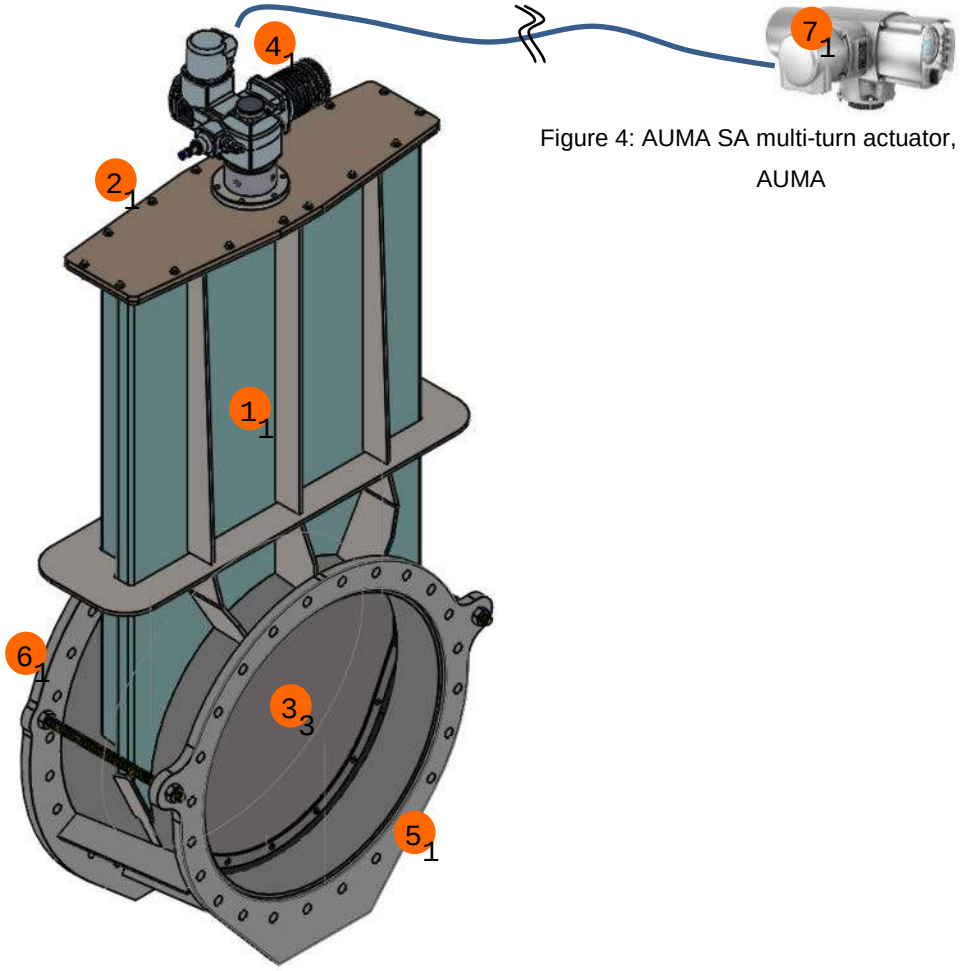


Figure 3: Shut-off valve Components

Figure 4: AUMA SA multi-turn actuator, source: AUMA

1. Housing
2. Cover
3. Gate with sealing (both sides)
4. AUMA Actuator
5. Flange turbine
6. Flange draft tube
7. AUMA Control Unit (outside of water)

3.2.1.1 Additional Information

The shut-off valve and the AUMA actuators are designed for minimum maintenance. Furthermore, the design ensures an environmentally friendly solution as there is no risk of contamination by leaking oil.

- Flanges according to EN 1092-1 PN10
- No self-closing tendency
- Sliding sheet in steel hot dip galvanized (stainless steel possible)
- Specially designed deflector to reduce power losses
- Sealing elements in EPDM
- Sliding surfaces in bronze
- All fixing screws in stainless steel
- Intake pipe and Draft tube cone in steel coated (stainless steel possible)
- Emergency closing with additional battery system as option

3.2.2 Tools and Devices

- 1 set of standard tools (for dismantling and preparation for shipment)
- 20 pcs. Coverage for cable connection
- 10 pcs. Transport device for shaft

3.2.3 Engineering and Documentation

Three sets of all necessary maintenance and operating instruction documents are provided in the official language of the member state, one set in English (for qualified staff) and one set in German. They contain the most relevant data for maintenance and operating according to the actual Directive of Machinery (EU)/Annex I/1.7 (please refer to the attached file) and IEC 82079 international standard.
Further documentation is optional at an additional charge.

Our solid data archiving ensures the availability of project documents over the years.

3.2.4 Transport

The CIP site shipment of the ordered equipment is included in the offer. The equipment is securely packed and the transport is carried out by our trusted long-term partners.

3.2.5 Erection Supervision, Commissioning

The erection supervision is carried out by our qualified and experienced staff.
The commissioning is according to IEC 62006 Class A.

A detailed description of erection and commissioning is part of the commercial conditions.

3.3 Protective Coating for Turbine

Water Contacted Surfaces
- sandblasting SA 2 ½
- 1 basic coat Agrozinc SW (60 µm)
- 3 finishing coats Agrovan 209 120 µm each
  RAL to be determined, according to A1.20 (DIN EN ISO 12944-5)

Air Contacted Surfaces
- sandblasting SA 2 ½
- 1 basic coat Agrozinc SW 60 µm
- 1 intermediate coat Agropox 250 EG 60 µm
- 2 finishing coats Agropur colour ST 40 µm each
- RAL 5007 brilliant blue for turbine (stationary parts)

Concrete Contacted Surfaces
- rust removal by use of brush

Fineshed surfaces:
- washable coat

Flanges
- sandblasting SA 2 ½
- 1 basic coat Agrozinc SW 60 µm

Protective coating for purchasing components such as generator, hydraulic power unit, etc. is carried out according to sub-suppliers' standards.

The offered protective coating considers a water quality not worse than described in the attached water quality appendix.

3.4 List of Supplier

Item	Company	Country
Turbine	Kössler GmbH & Co KG	Austria
Generator	Axco	Finland
Electrical Equipment	Hydro ECI	Canada

3.5 Spare Parts (recommended, not included)

Spare parts will not be offered as a standard. The required spare parts will be offered on a project specific basis. Spare parts could include:

- 2 pcs. hard coated shaft sleeves
- 1 pc. axial trust disc hard coated
- 1 pc. axial counter trust disc hard coated
- 1 set of bearing elements (2 pcs. to bearings shells, 1 set axial bearing pads, 1 counterthrust ring)

- 4 pcs. Bearing gap detection sensors (bearing wear detection)
- 1 pc leakage detector
- 1 pcs limit switch
- 1 temperature sensors PT 100

- 1 pc Vibration transmitter

3.6 Quality and Process Control

Generator
The pre-commissioning tests will include:

Type testing:

The type testing is carried out for each generator variant. If technically identical machines are offered the type testing has to be run only for the first machine.

- heat run test in water without inverter
- heat run test in water in converter operation
- efficiency measurement at 50%, 75%, 100% and 110% load
- short-circuit testing as specified

Series testing:
A series testing has to be run for each machine that is delivered.

- resistance measurement under hot and cold state
- determination of Electromagnetic field
- measurement of insulation resistance
- high voltage testing according to standard (IEC 634)
- leak testing of the stator (as a minimum for the maximal test pressure the installation depth of 10m will be chosen)

Turbine

The extent of tests and non-destructive control shall be carried out according to the inspection and test plan, corresponding to the internal Q/A process, which is in compliance with the ISO 9001-Standards.
The finished runner will be dynamically balanced according to DIN-ISO 1940.
The commissioning printout is according to IEC 62004 Class A.

Field Tests

The pre-commissioning tests will include, but not be limited to:

- functional tests of all auxiliaries and protective devices as necessary
- functional operation of the shut off valve operating mechanism in the dry condition
- operational tests of turbine bearings
- start - stop sequences test in the dry condition

The commissioning tests will include, but not be limited to:

- initial no-load wet run to ensure satisfactory operation of auxiliary equipment
- checking of interlocks and indications
- tripping tests for turbine
- load rejection and load acceptance tests
- head run test

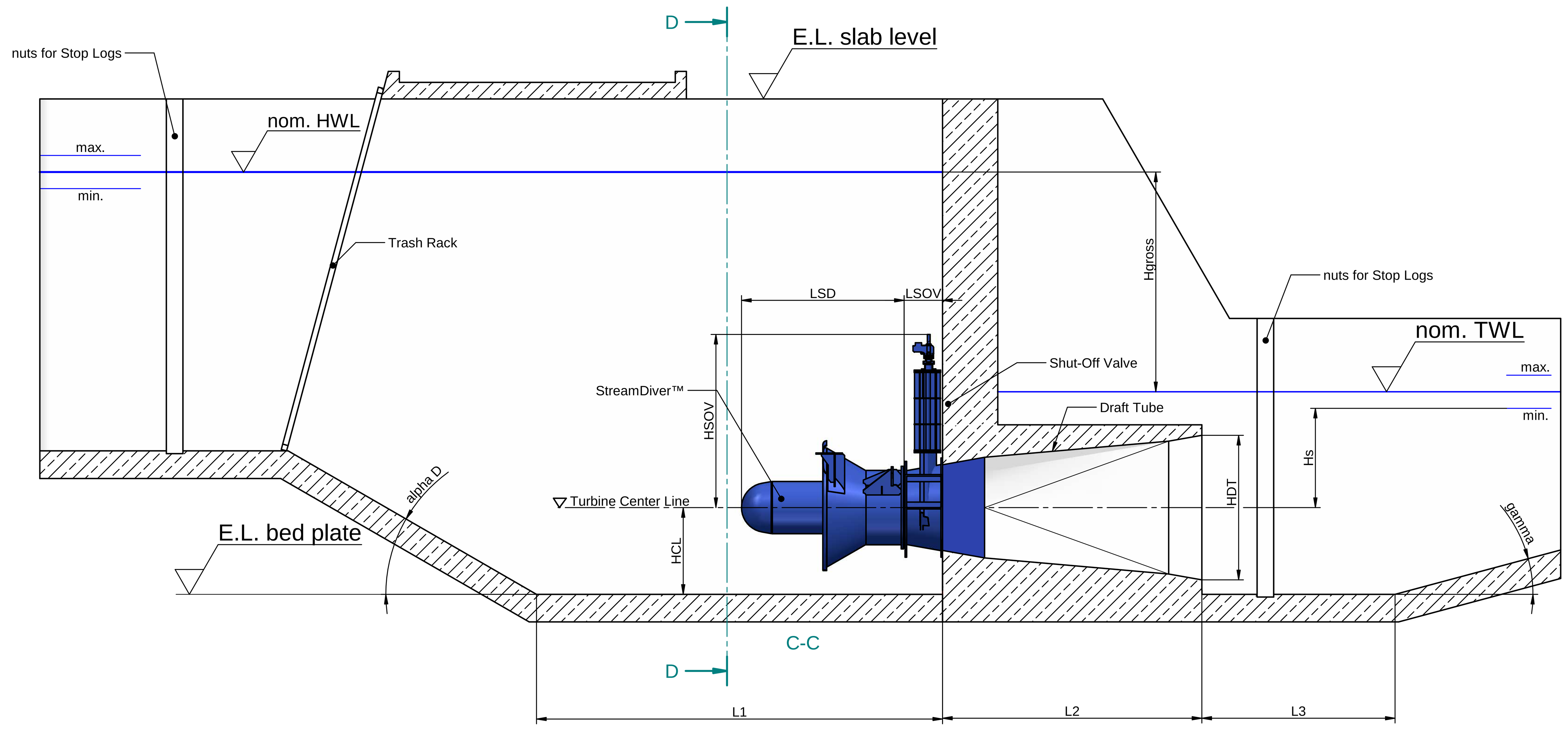
3.7 List of Enclosures

- layout drawing (drawing no.) layout drawing: see attached layout. These are standard dimensions – optimized for hydraulic performance. Dimensions, draft-tube configuration, settings, etc.. can be adjusted if required and upon our review& approval.
- StreamDiver standard presentation

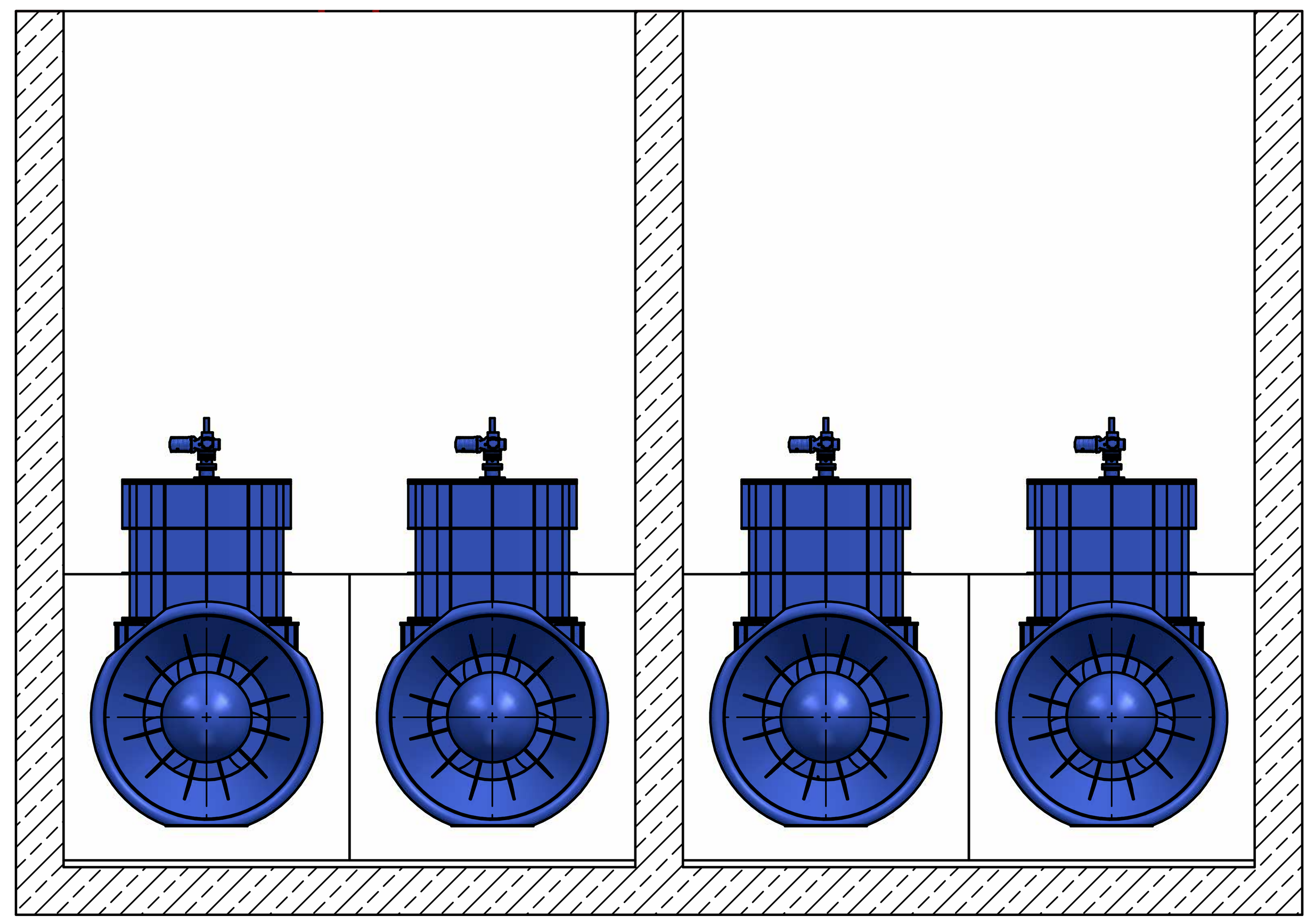
Not included in the scope of supply, responsibility of customer:

- Erection of the equipment
- access with heavy lorry must be possible
- The foundations have to be accurate to size and set
- power house crane
- All concrete works have to be finished
- lockable room for storage of the small parts and tools
- water drainage and damming
- site power supply connection
- rails, protective enclosures if not specified
- powerhouse drainage
- cable channels in the concrete with covers
- power and control cables from intermediate terminal box to switchboards
- pipes in the concrete for hydraulic lines and electr. cables
- electrical equipment with wiring
- steel structures like gates, screen, stop logs, cleaning machine etc.

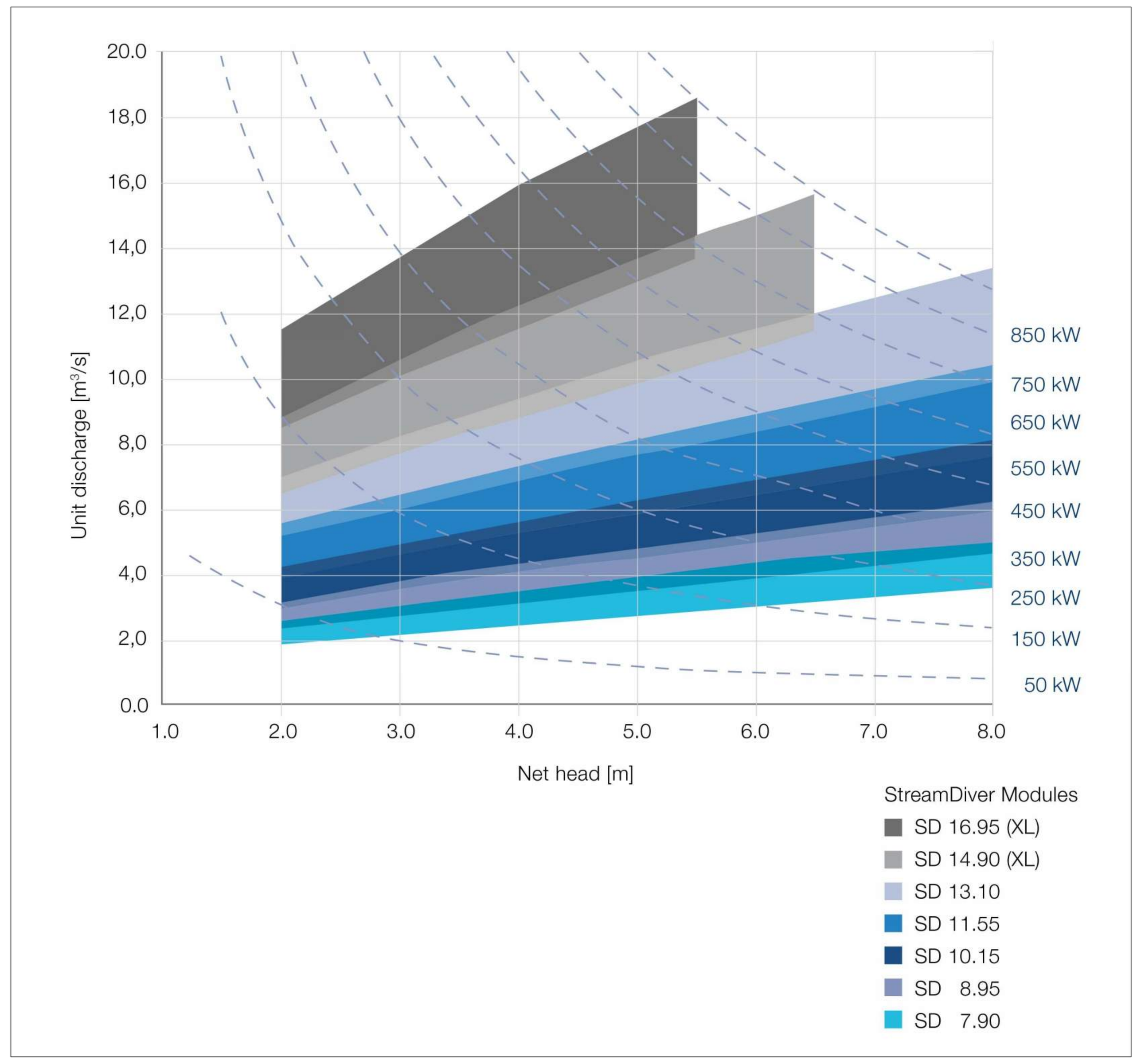
The above shown photos are for proposal purposes only.
Only the written text is binding.

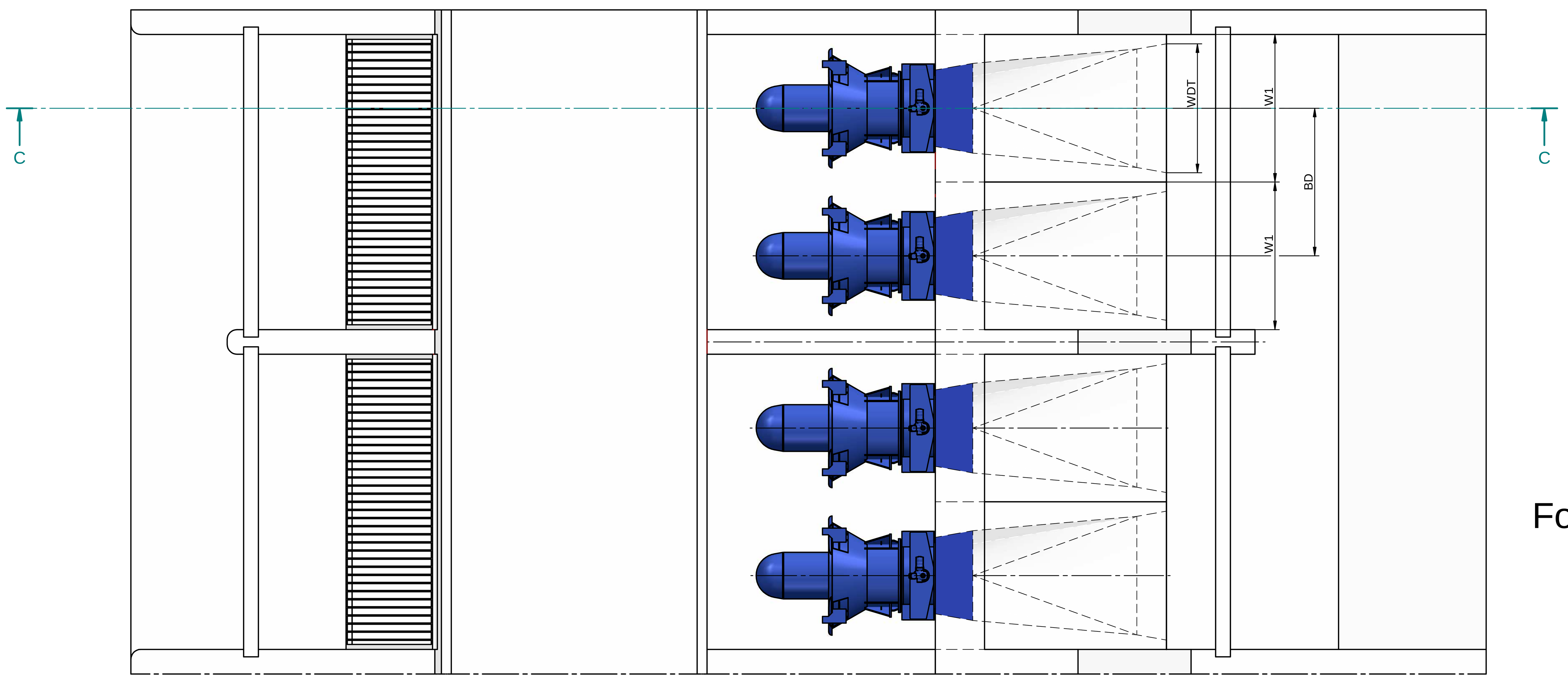


C-C



D-D





Description	Designation	Dependency
Distance upstream slope to concrete	L1	**alpha D ≤ 20° and L1 = 6.2 * Ds** no influence on turbine performance **alpha D > 30°** and/or **L1 < 5.6 * Ds** influence on turbine performance
Length of concrete module section (Draft tube)	L2	**3.6 * Ds**
Distance Draft tube outlet to downstream slope	L3	**2.7 * Ds**
Length of SD module	LSD	**~ 2.6 * Ds**
Length of SD module (with blade regulation)	LSDa	~ 3 * Ds
TuCL to bottom (bed plate)	HCL	**1.2 * Ds**
Draft tube outlet height	HDT	**2.0 * Ds**
Gross head	Hgross	= HWL-TWL
Distance TWLmin to CL	Hs	Height acc. to PDS min. Ds + 300
Complete module width	W1	**2.0 * Ds + 380 mm**
Horizontal distance between units	WD	**2.0 * Ds + 380 mm**
Draft tube outlet width	WDT	**2.0 * Ds**
Upstream slope angle	alpha_D	refer to L1
Downstream side slope angle	gamma	≤ 15°

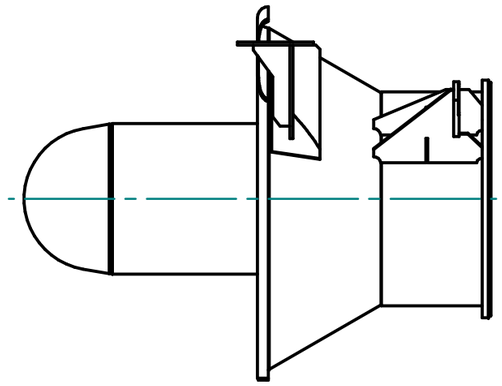
For proposal purposes only!!

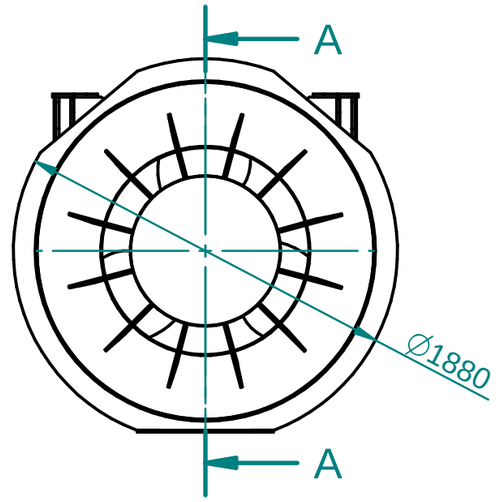
Runner Diameter	SOV length	SOV height
Ds in mm	**LSOV** in mm	**HSOV** in mm
1310	695	3150
1155	660	3050
1015	610	2550
895	514	2360
790	480	2250

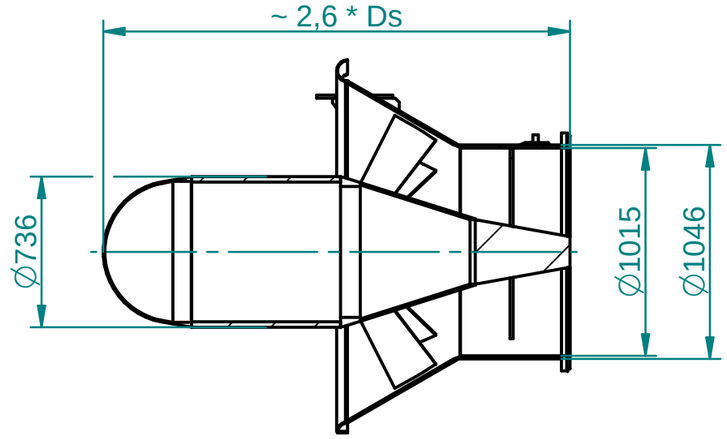
This drawing is binding for the correctness of installation dimensions only. The layout and design of civil structure is with customer responsibility. The building has to be water tight up to the level of 100 years flood.
All required protection devices like railings, cable and pump sump covers etc. are not shown.

E.L.: Elevation Level
HWL: Headwater Level
TWL: Tailwater Level

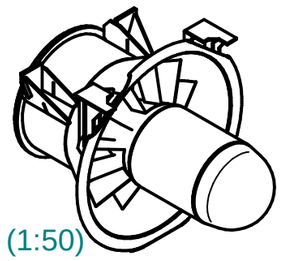
Codeword Kennwort: Standard
Sales Order Auftragsnummer
Unit Maschine
Scale of orig. Maßstab im Orig.: 1:50
Weight Gewicht kg
Date Datum | Name
Dftg. Gez. 2018-03-22 AWu
Chk. Gep.
Appr. Ges.
Dept. Abt.
Dimensions in mm Maße in
Size ISO14405 Ⓔ
Release note Freigabevermerk: In Process
VOITH
Title Benennung: StreamDiver™, single row
channel type
Drawing no. Zeichnungs-Nr.: LAYOUT
Rev. Änd.
Sheet Blatt: 2
5 Sh. Bl.
PDM Document ID
A0







A-A



(1:50)

Rev. Index Änd.	Occur. kommt vor	Revision description (shop and eng. info only) Änderung	Date: Drawn Datum: Gez.	Name Name	Appr. Ges.

If no general tolerances are specified for a production process, apply those according to ISO 2768-mK-E, respectively according to DIN 7168-m-T (dim. >4000 mm, geometr. tol.>3000 mm)

Sind fuer ein Fertigungsverfahren keine Allgemeintoleranzen angegeben, so gelten die nach ISO 2768 mK-E, bzw. nach DIN 7168-T (dim. >4000 mm, geometr. tol.>3000 mm)

Dim.	≤ 4000 mm ISO 2768-m > 4000 mm DIN 7168-m	Chamfers Inside innen + 1.6 mm Werkstueckkanten Outside außen - 0.2 mm	ISO 13715 (DIN 6784)	Gen. tol. steel drop forgings	EN 10243-F
				Gen. tol. castings Gussrohteile	ISO 8062
Geo-metr. tol.	≤ 3000 mm ISO 2768-K-E > 3000 mm DIN 7168-T	Surfaces Oberflaechen Ra in µm	ISO 1302	Gen. tol. thermal cuts (incl. water cutting) Allg. tol. thermischer Schnitte (inkl. Wasserstrahl.) ISO 9013-442	
Fit size Passmaß	Tolerance Abmaß	Gen. tol. welding parts Schweißkonstruktionen	ISO 13920-BF		

Codeword Kennwort: Standard

Sales Order Auftragsnummer: XXX

Unit Maschine: XXX

Scale of orig. Maßstab im Orig.: 1:30

Weight Gewicht: XXX kg

	Date Datum	Name
Dftg.Gez.	2018-04-03	awu
Chk.Gep.		
Appr.Ges.		
Dept.Abt.		

Dimensions in mm Maße in
Size ISO14405 E

Release note Freigabevermerk: In Process

Title Benennung: StreamDiver™ 1015

VOITH

Drawing no. Zeichnungs-Nr.: LAYOUT

Rev. Änd.

Sheet Blatt: 1 / 1 Sh.Bl.

PDM Document ID

A3

APPENDIX

A.5 ANDRITZ PROPOSAL

From: Taylor Thomas [mailto:Thomas.Taylor@andritz.com]
Sent: 19 février 2020 11:38:AM
To: Gagnon, Jean-Mathieu <Jean-Mathieu.Gagnon@wsp.com>
Cc: Cormier, Vincent <Vincent.Cormier2@wsp.com>; PASCUAL Alberto <Alberto.PASCUAL@andritz.com>; Carle Hugo <Hugo.Carle@andritz.com>
Subject: RE: RFQ Park Canada

Dear Jean-Mathieu,

Andritz Hydro has several turbine configurations within our Mini-Compact product range that may be suitable for your application. All could be used in an "in-line" arrangement. The optimum choice will depend on the site geometry and client preference for the surrounding structures. I looked at your site drawings but I do not understand how the site works. I did try one suggestion but it may not be the best. Please see attached sketch for a possible concept

With a net head = 4.8 M; discharge = 7 M^3/S; P = 300 KW the runner diameter will be 1300 mm.

Please see the attached brochure and product presentation.

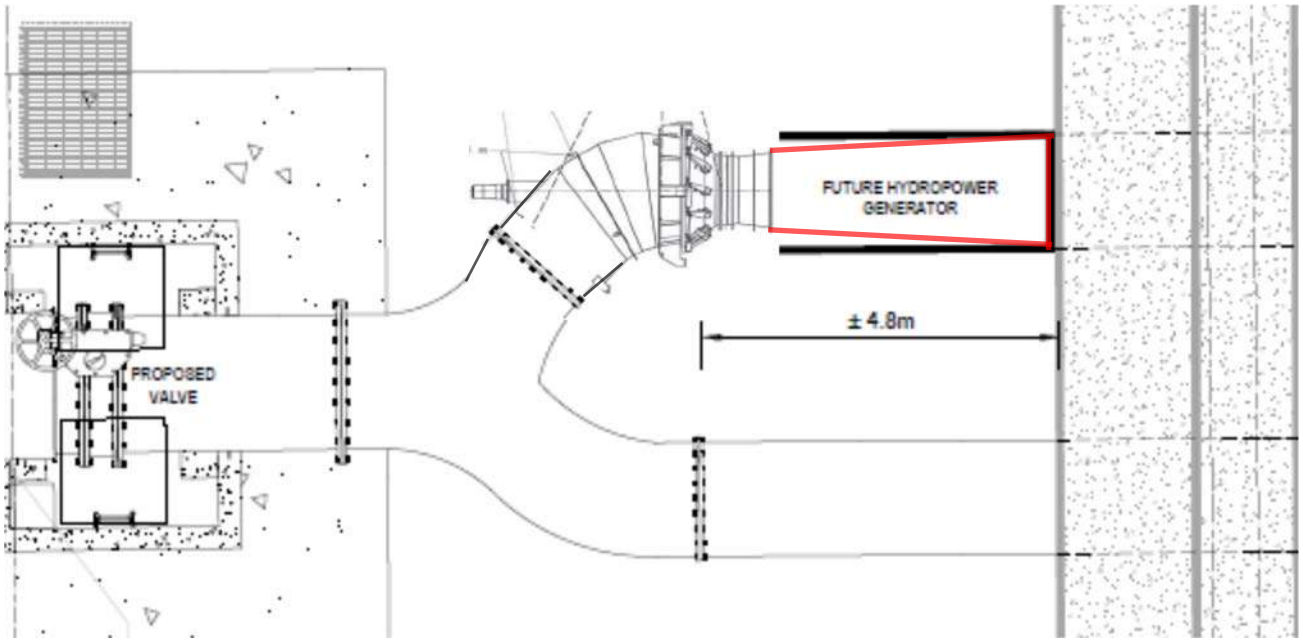
I expect the supply price for a W2W package using an induction generator at 600V would be between $1.0 AND $1.2 Mio CAD. The belt driven machines will have the lowest cost.

Regards

THOMAS TAYLOR
Sales Manager – Compact Hydro

ANDRITZ HYDRO CANADA INC
100 Jameson Dr, Unit 3
Peterborough, ON K9J 6X6 /Canada

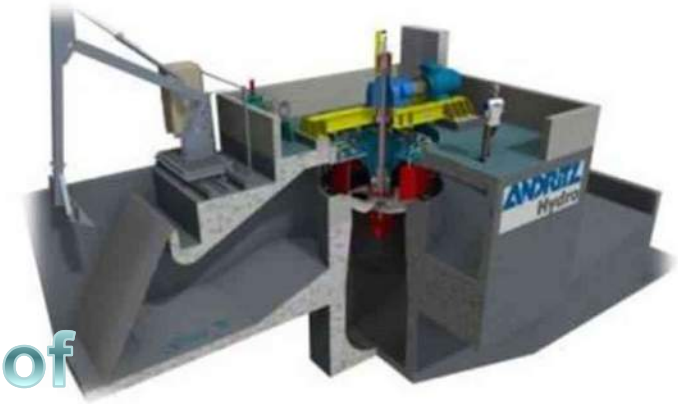
Tel: 519-831-3012
Thomas.taylor@andritz.com
www.Andritz.com


FUTURE HYDROPOWER
GENERATOR
± 4.8m
PROPOSED
VALVE

ANDRITZ HYDRO

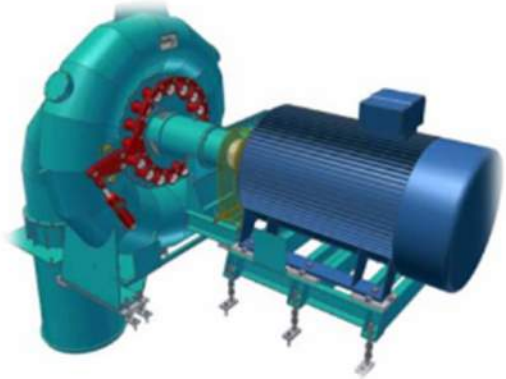
Mini Compact Hydro - Presentation

Mini Compact Hydro



Standardized range of electromechanical systems "from Water to Wire" for small hydro power plants

From 20 to 5 000 kW

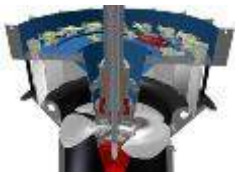


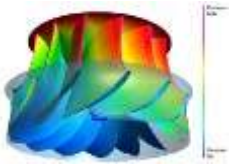
Mini Compact Hydro

Concept

- **Standardized and parametrized design of turbines based on robust and reliable solutions**
- **High guaranteed efficiency based on existing model tested profiles**
- **Standardized & modular automation and electrical power systems design**

- **Advantages :**
  - **Less components**
  - **Reduction of the risks using proven solutions**
  - **Pre-assembly and test at workshop, reducing the risks on site**
  - **Reduction of every single phase of the project (engineering, manufacturing, erection, commissioning)**





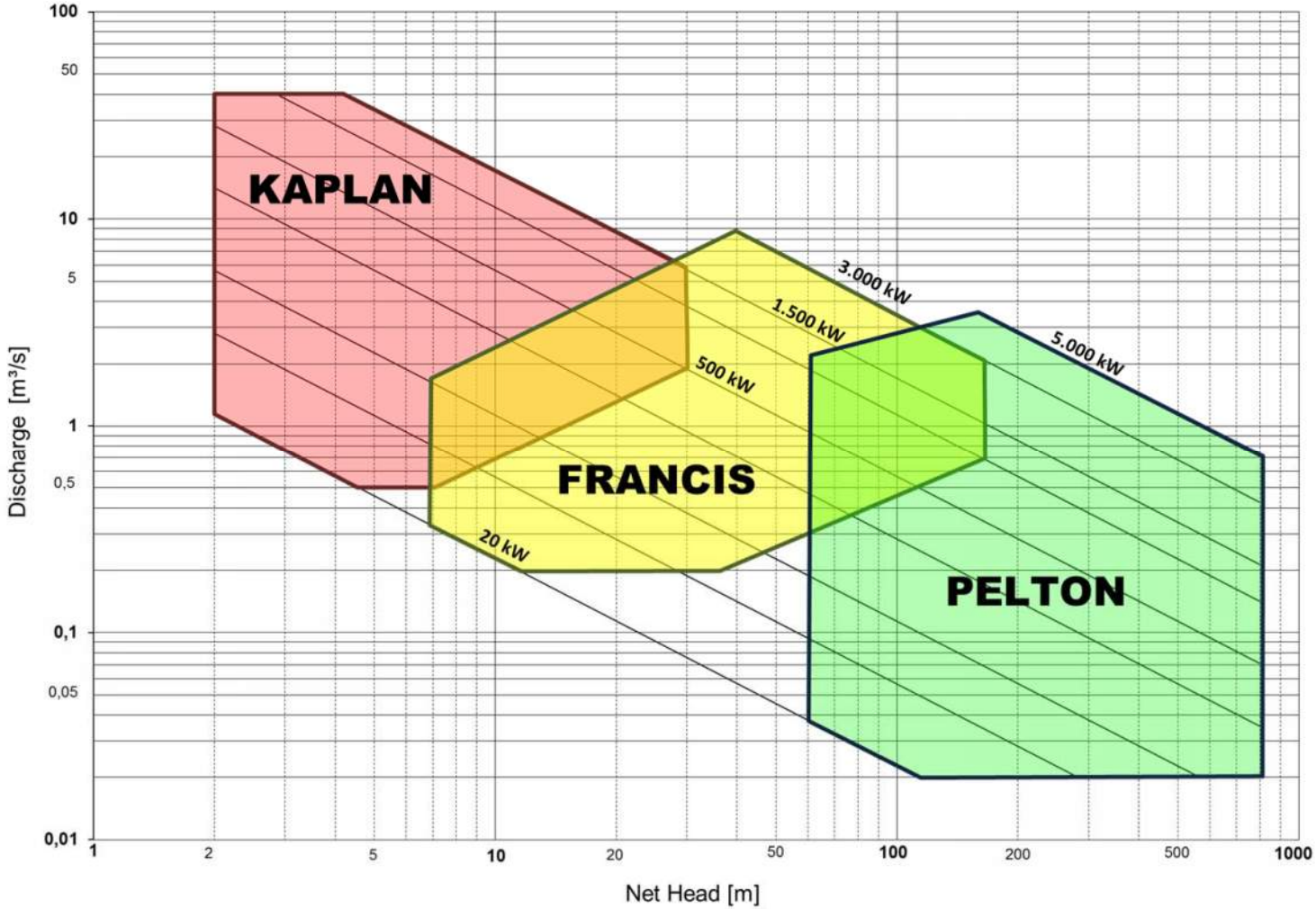
Competitive price + short delivery time + high performances

= Quick return on investment

Mini Compact Hydro

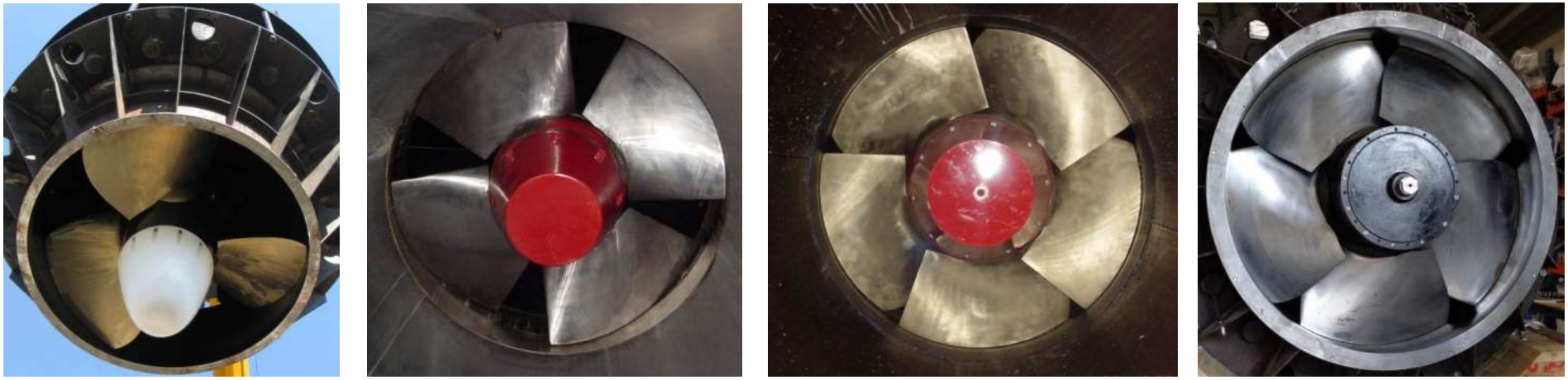
Application range

- **Pelton : 20 to 5000 kW**
  Hn < 800 m
- **Francis : 20 to 3000 kW**
  Hn < 150 m
- **Kaplan : 20 to 1500 kW**
  Hn < 26 m



Mini Compact Hydro

Kaplan turbines



KAPLAN TURBINE

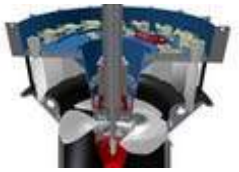
Mini Compact Hydro

Kaplan turbines – A solution for every configuration

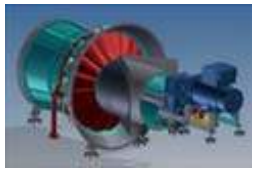
AET
Slant shaft
Belt driven
2 to 6 m
20 to 300 kW
Single regulated

AES
Siphon
Belt driven
2 to 4 m
20 to 300 kW
Single regulated

ADC
Semi spiral case
Belt driven
2 to 6 m
20 to 300 kW
Single regulated



ADCM
Semi spiral case
Speed increaser
2 to 18 m
200 to 1500 kW
Single/Double regulated



ADHM
Concrete PIT
Speed increaser
2 to 4 m
200 to 1500 kW
Single/Double regulated

ADV
Saxo
Belt driven
5 to 8 m
50 to 300 kW
Single/Double regulated

ADVG
Vert. Saxo
Direct coupling
5 to 26 m
50 to 1500 kW
Single/Double regulated

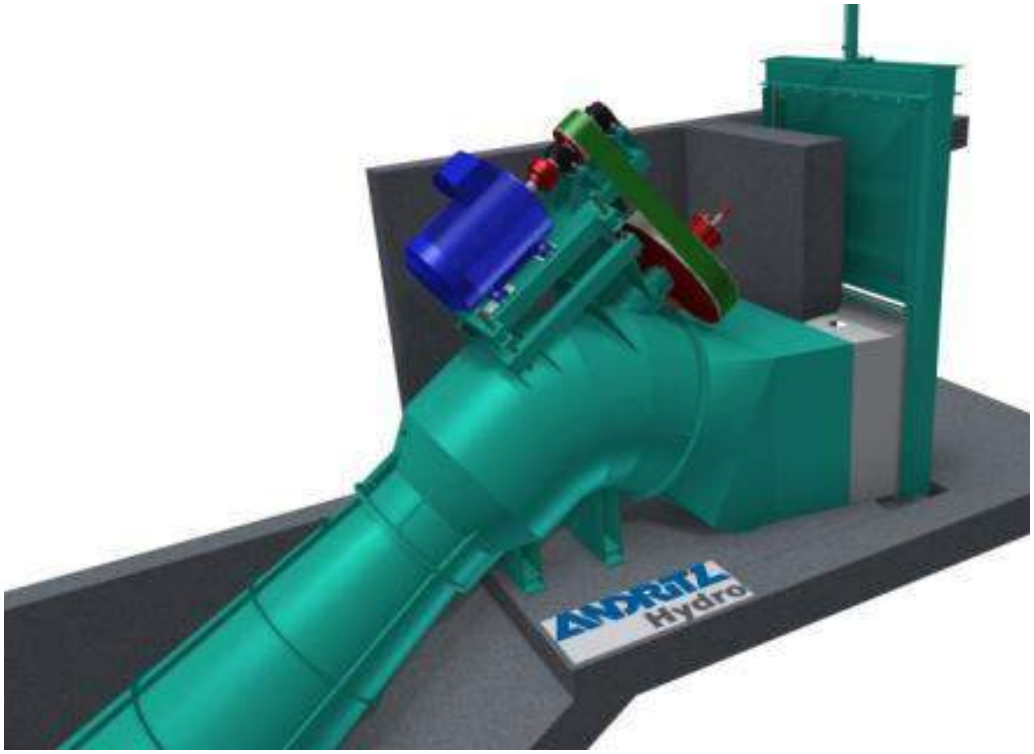
ADRG
Horiz. Saxo
Direct coupling
6 to 18 m
50 to 1500 kW
Single/Double regulated

ADBG
Metalic spiral case
Direct coupling
5 to 26 m
50 to 1500 kW
Single/Double regulated

Mini Compact Hydro

Kaplan turbines – AET

Installation on channel
Standard diameters from 600 to 1200 mm
Slant shaft, generator belt driven

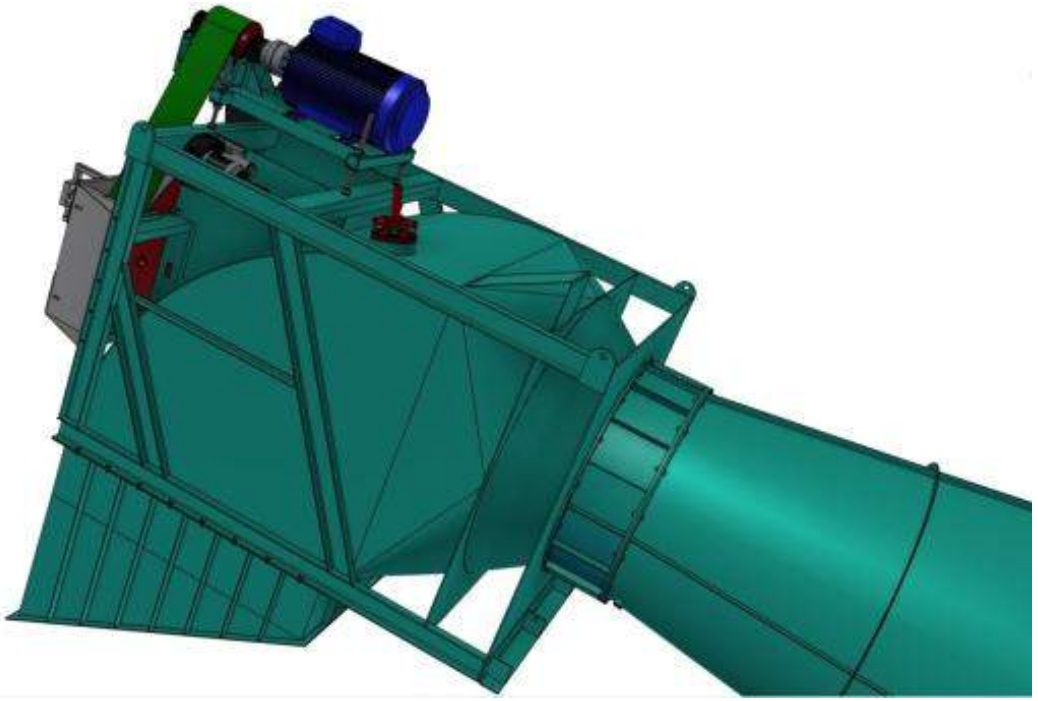


Head : 2 to 6 meter
Power output : 20 to 300 kW
Single regulated, 4 blades

Mini Compact Hydro

Kaplan turbines – AES

Installation on channel, Siphon
Standard diameters from 600 to 1800 mm
Slant shaft, generator belt driven



Head : 2 to 4 meter
Power output : 20 to 300 kW
Single regulated, 4 blades

Mini Compact Hydro

Kaplan turbines – ADC

Semi Spiral case

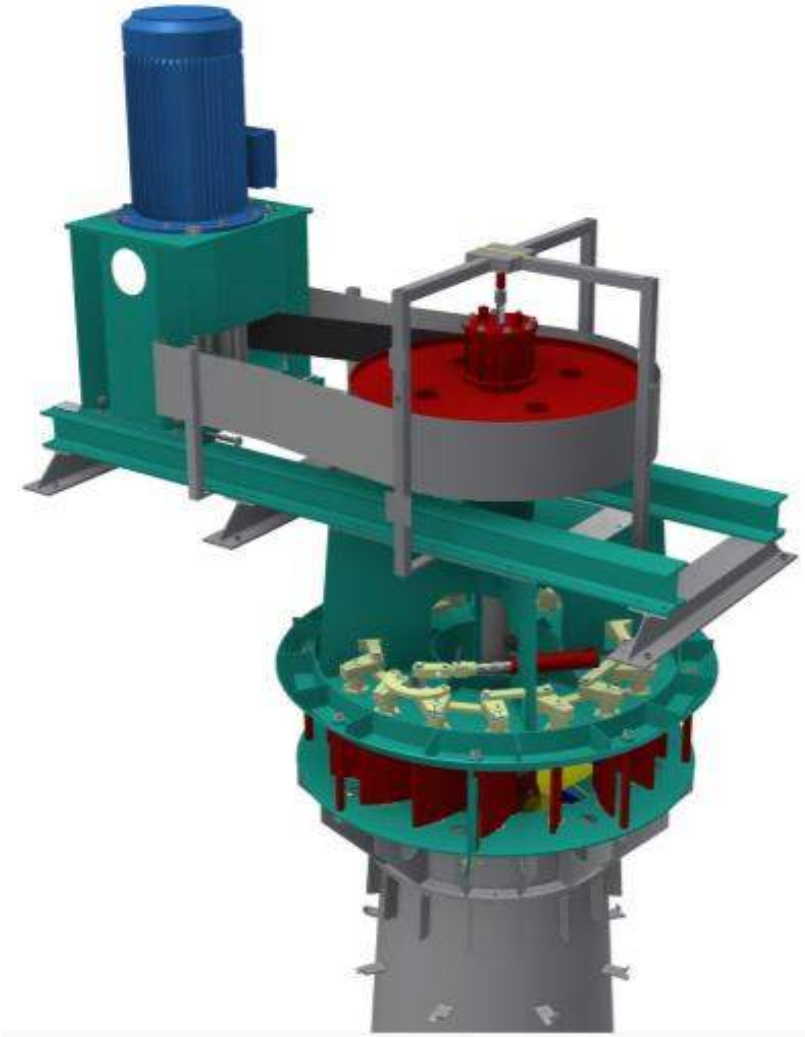
Standard diameters from 600 to 1600 mm

Vertical shaft, generator direct coupled or belt driven

Head : 2 to 6 meter

Power output : 20 to 300 kW

Single or double regulated, 4 blades



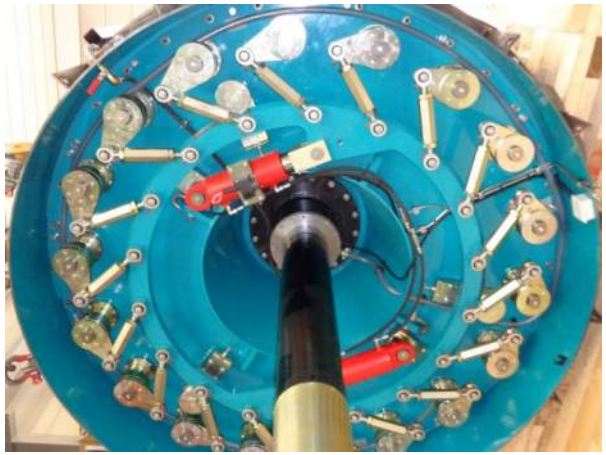
Mini Compact Hydro

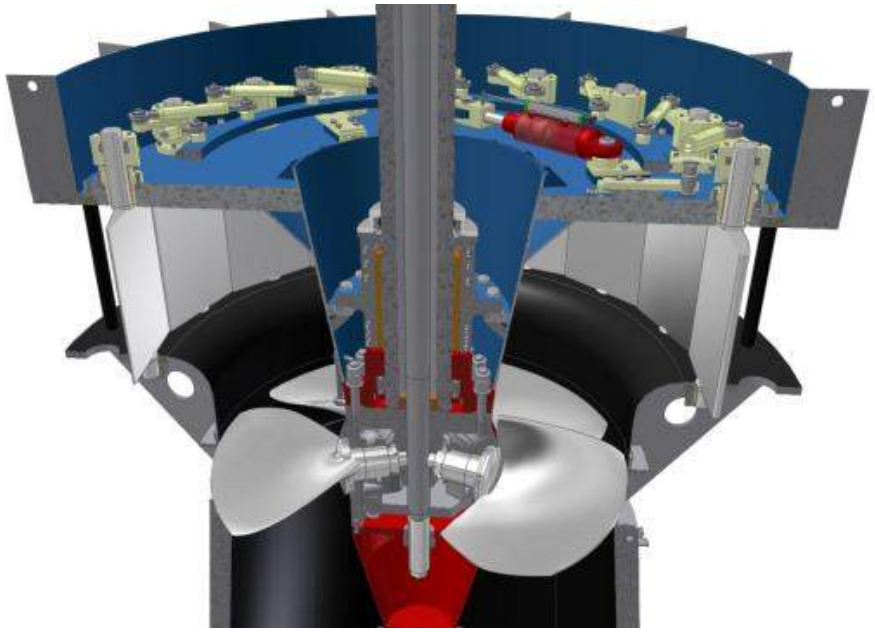
Kaplan turbines – ADCM

Semi Spiral case

Standard diameters from 1800 to 3100 mm

Vertical shaft, generator direct coupled or including speed increaser





Head : 2 to 18 meter

Power output : 200 to 1500 kW

Single or double regulated, 4, 5 blades

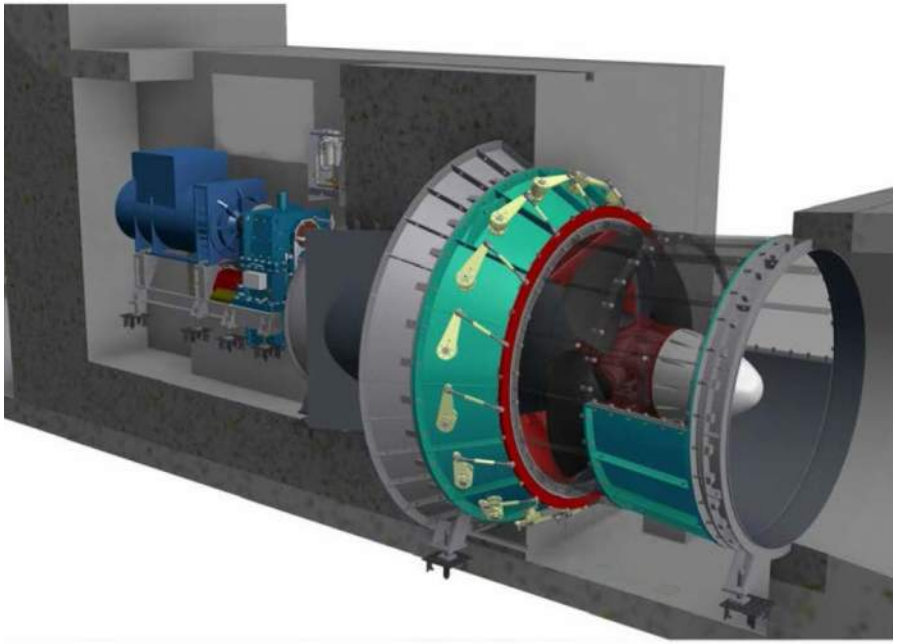
Mini Compact Hydro

Kaplan turbines – ADHM

PIT turbine

Standard diameters from 1300 to 3100 mm

Horizontal shaft, speed increaser



Head : 2 to 4 meter

Power output : 200 to 1500 kW

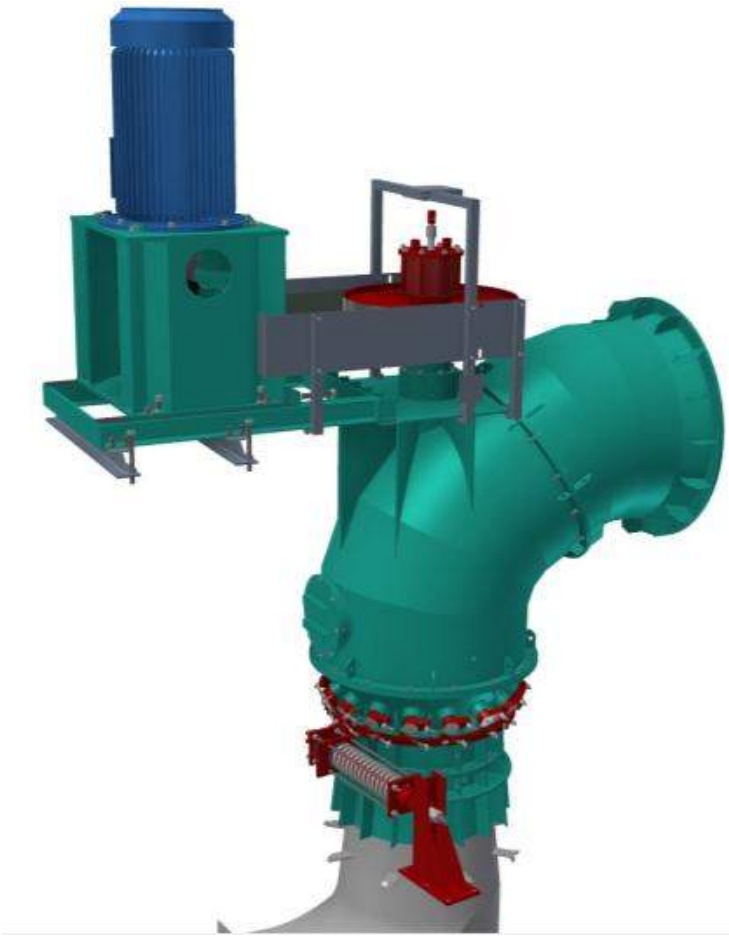
Single or double regulated, 3 blades

Mini Compact Hydro

Kaplan turbines – ADV

Vertical Saxo
Standard diameters from 600 to 1200 mm
Vertical shaft, generator belt driven

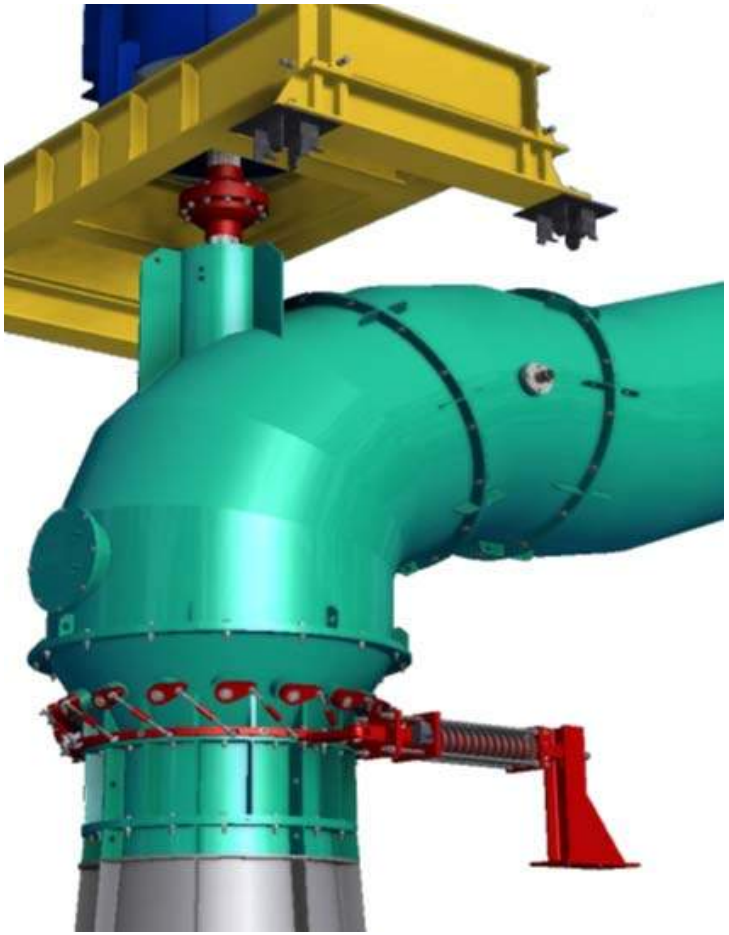
Head : 5 to 8 meter
Power output : 50 to 300 kW
Single or double regulated, 4 blades



Mini Compact Hydro

Kaplan turbines – ADVG

Vertical Saxo
Standard diameters from 600 to 1200 mm
Vertical shaft, generator direct coupled

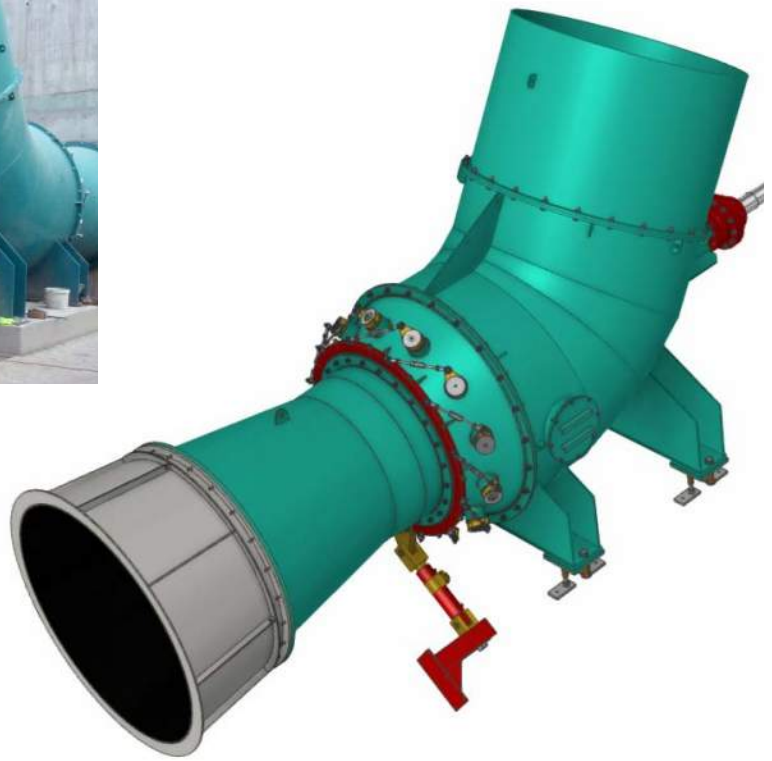


Head : 5 to 26 meter
Power output : 50 to 1500 kW
Single or double regulated, 4, 5 or 6 blades

Mini Compact Hydro

Kaplan turbines – ADRG

Horizontal Saxo
Standard diameters from 1200 to 1800 mm
Horizontal shaft, generator direct coupled

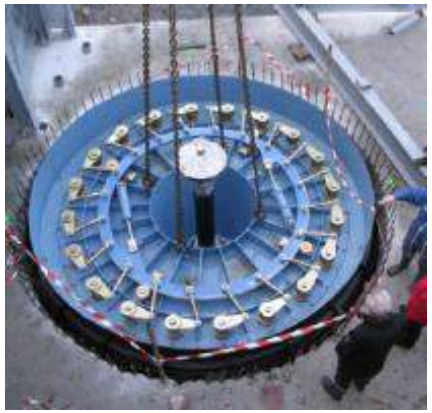


Head : 6 to 18 meter
Power output : 50 to 1500 kW
Single or double regulated, 4, 5 or 6 blades

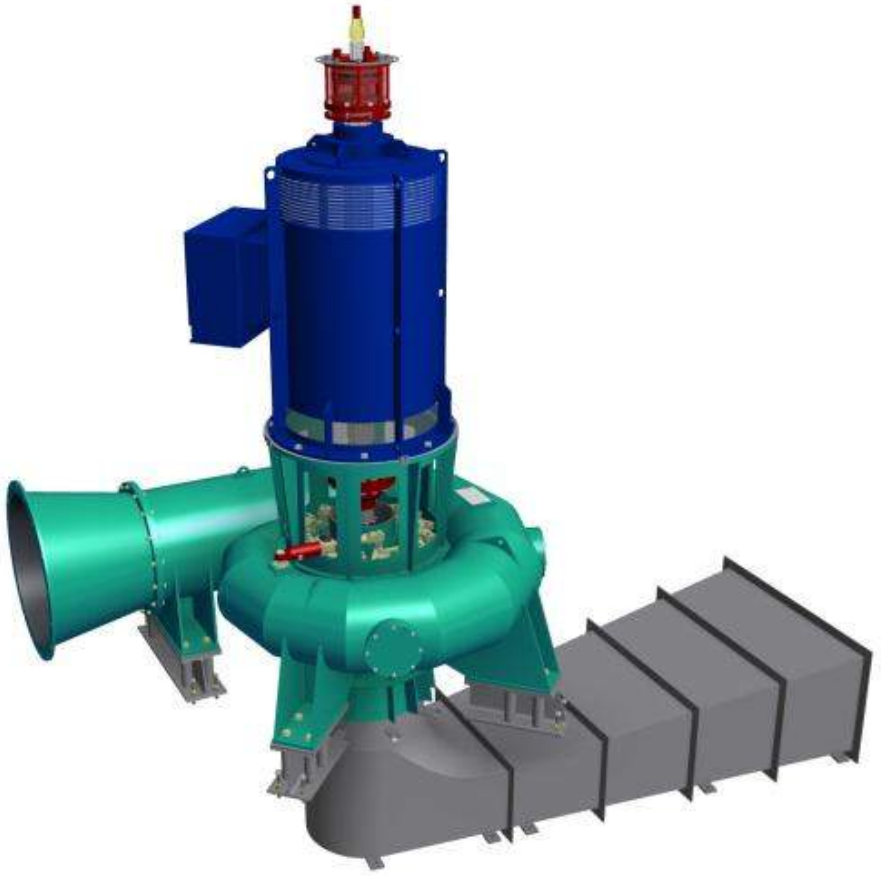
Mini Compact Hydro

Kaplan turbines – ADBG

Metallic spiral case
Standard diameters from 600 to 1200 mm
Vertical shaft, direct coupled



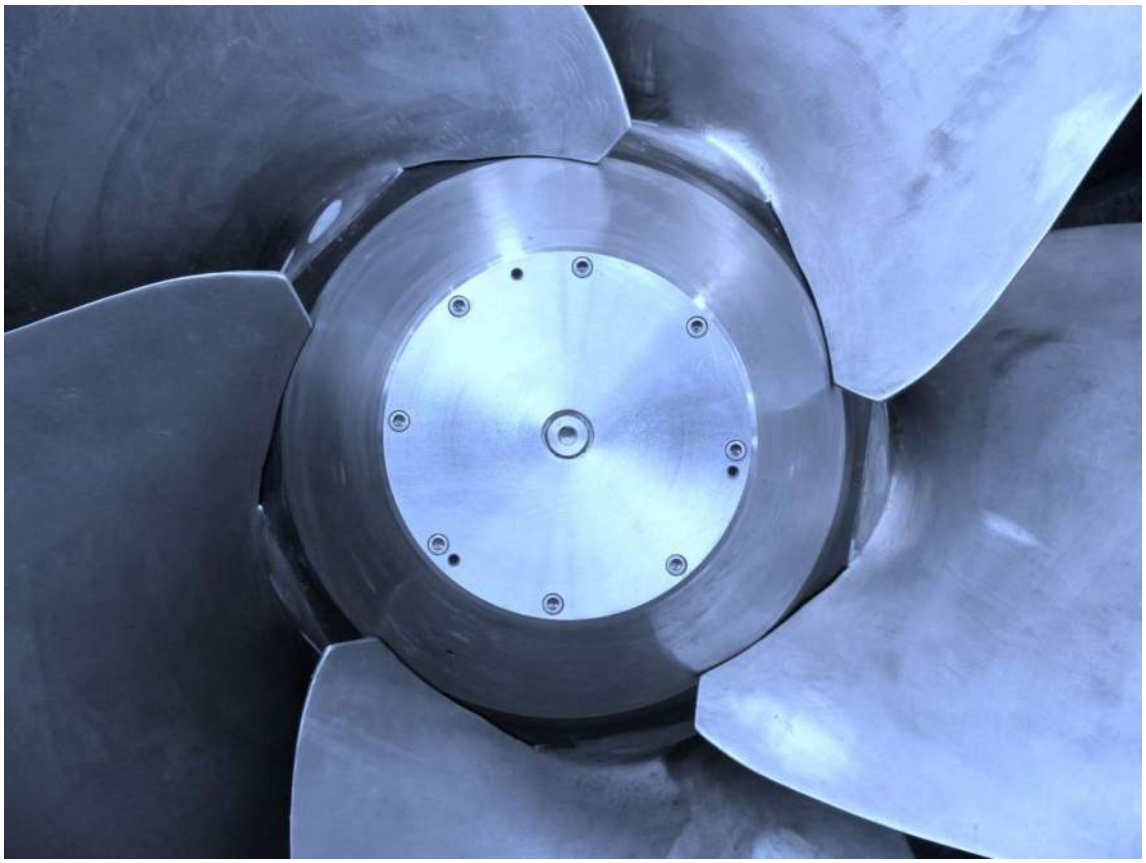
Head : 8 to 26 meter
Power output : 50 to 1500 kW
Double regulated, 4, 5 or 6 blades



APPENDIX

A.6 ZECO PROPOSAL

Customer	WSP
Power Plant	Sault Ste-Marie
Economic offer	10127175A_EC



N° 1 turbine Kaplan

Rev.	Date	Description
A	21-Feb-20	1st issue

Issued by:
Loïc Pétillon
Technical Sales

Approved By:
Vittorio Apolloni
Sales Director

Summary

1. Delivery period

The scope of supply described in the related technical specification will be delivered CIF, (as per Incoterms 2010) in 12 months from the coming into force of the contract.

2. Price

Price for the scope of supply described below will be as follows (V.A.T., L/C issuing cost, and duties not included).

Supply description	Quantity	Price [€]
Turbine	1	
Generator	1	
Automation control system	no	
Interface system	no	
Distribution system	No	
Protection system	No	
Cables	no	
Shipment according to Incoterms 2010	CIF	
Erection	No	
Commissioning	Supervision	
Training	Yes – during commissioning	
Price		**340.000,00**

3. Optional Costs

In case proposed schedules for site works are exceeded, the following day rates will be applied for supervision on assembly, installation, training, commissioning and trail operation.

The following day rates are also valid for the calculation of the costs for any additional work ordered:

- 1 day rate for a mechanical supervisor 850 Euro
- 1 day rate for a electrical supervisor 850 Euro
- 1 day rate for a commissioning supervisor 850 Euro

The day rates are based on an actual working day of eight hours, from Monday to Friday.

In case of overtime, if the working period exceed the eight hours on working days, a 50% surcharge will be applied; for every working hour on Saturdays, Sundays and Holidays, a 100% surcharge will be applied.

The above mentioned rates include all labor costs. Travelling time is to be regarded as working time. Travelling costs for air tickets, train, bus or rent car and accommodation costs, including hotel and food, will be accounted according to the actual expenses accrued supported by vouchers and documentary evidence.

4. Terms of payment

The payments of the scope of supply are requested net cash to one of our bank accounts as follows:

4.1 Down Payment

30% of the total contract price shall be paid in advance at sight against presentation of following documents:

1. Invoice stating 30% of the total contract price

After the attestation of down-payment and the opening of Letter of Credit, ZECO shall provide the advance guarantee for the down-payment amount in favor of the customer. The guarantee will expire at the presentation of copy of “Bill of Lading”, but in any case no more than 30days from ZECO declaration of “goods ready for dispatch”.

4.2 Opening of the letter of credit

70% of the total contract price shall be paid out of an irrevocable and confirmed Letter of Credit opened by a First Class Bank (approved by the contractor) in favor of ZECO as follow:

4.2.1 Payment upon the dispatch of technical documentation

20% of the total contract price shall be paid at sight against presentation of the following documents:

1. Commercial invoice
2. Declaration of the dispatch of the following technical documentation
   I. Final turbine layout drawing
   II. Final hydraulic drawing
   III. General Plant Diagram
   IV. Project activities scheduling

issued and signed by the contractor.

The above listed documentation will be supplied in 12 weeks from the coming into force of the contract.

4.2.2 Payment upon the delivery of the goods.

40% of the total contract price shall be paid at sight against presentation of following documents:

1. Commercial invoice
2. Bill of Lading
3. Packing list
4. Communication of ZECO that goods are ready for dispatch

In any case, if it is not possible to deliver the Bill of Lading, for reasons not attributable to ZECO, the payment become due in no more than 30 days from ZECO declaration of “goods ready for dispatch”.

4.2.3 Payment upon the start-up of the hydropower plants

10% of the total contract price shall be paid at sight against presentation of following documents:

1. Document certifying that the scope of supply has been commissioned, issued and signed by the supplier.

In any case, this payment become due in no more than 90 days from the Bill of Lading data, or 120 days from ZECO declaration of “goods ready for dispatch”.

5. Exclusions

The following items are not included in the present contract:

- Civil works
- Lifting means and crane
- Removal of the existing machine
- Energy and water for the site activities
- Transportation to the site
- Efficiency test according to IEC – Regulation.
- Erection Activities
- Neutral grounding
- What is not specifically described in the present document

6. Coming into force of the contract

This contract will come into force after the signing of the contract, the down-payment bank transfer of the customer and the opening of an irrevocable Letter of Credit as stated in chapter 3 [Terms of payment].

7. Miscellaneous

Other supply conditions as reported in “General Contract Conditions for ZECO di Zerbaro e Costa e C. srl and its subsidiaries (ed. 2019)”.

8. Document priority

If the documents in the contract contains mutually conflicting terms, the following documents shall apply in the following order:

1. Quotation 10127175A_EC
2. Technical Specification 1012715A_TS
3. Acknowledged drawings
4. General Contract Condition for ZECO di Zerbaro e Costa e C. srl and its subsidiaries (ed. 2019)
5. Any annexes to the contract or technical specification issued by ZECO di Zerbaro e Costa e C. srl and acknowledge from the customer
6. The invitation to tender with the underlying documentation/the inquiry with underlying documentation

9. Warranty of equipment

All goods included in the scope of supply by ZECO are guaranteed to be free from defects in workmanship and materials and in conformity with technical specifications.

The warranty period is 24 months from the date of commissioning or 30 months from the date of readiness of shipment whichever occurs earlier.

The warranty applies only to the arising faults which evidently fall under the ZECO's range of responsibility.

The warranty is not applied when instructions specified in the operation and maintenance manuals are not respected. Excluded from compensation is wear, improper treatment, maintenance which is effected inadequately or not according to the operation and maintenance instructions. No warranty is given for defect caused by improper installation in the event that the installation has not been executed by ZECO as well as in case of misuse, excessive use, insufficient lubrication, defects in the foundation or disregard of ZECO's instructions, or third parties have executed repairs or made additions to the products.

10. Validity of quotation

This quotation remains valid for 30 days.

ZECO wants to thank for having been asked to prepare the present offer and collaborate with You. Furthermore, we are keen to inform that our Sales Office is willing to remain in contact with You in order to perform our best technical and commercial offer in order to achieve a successful outcome of Your project.

Faithfully yours,

ZECO di Zerbaro e Costa e C. s.r.l.

Via Astico 52/C

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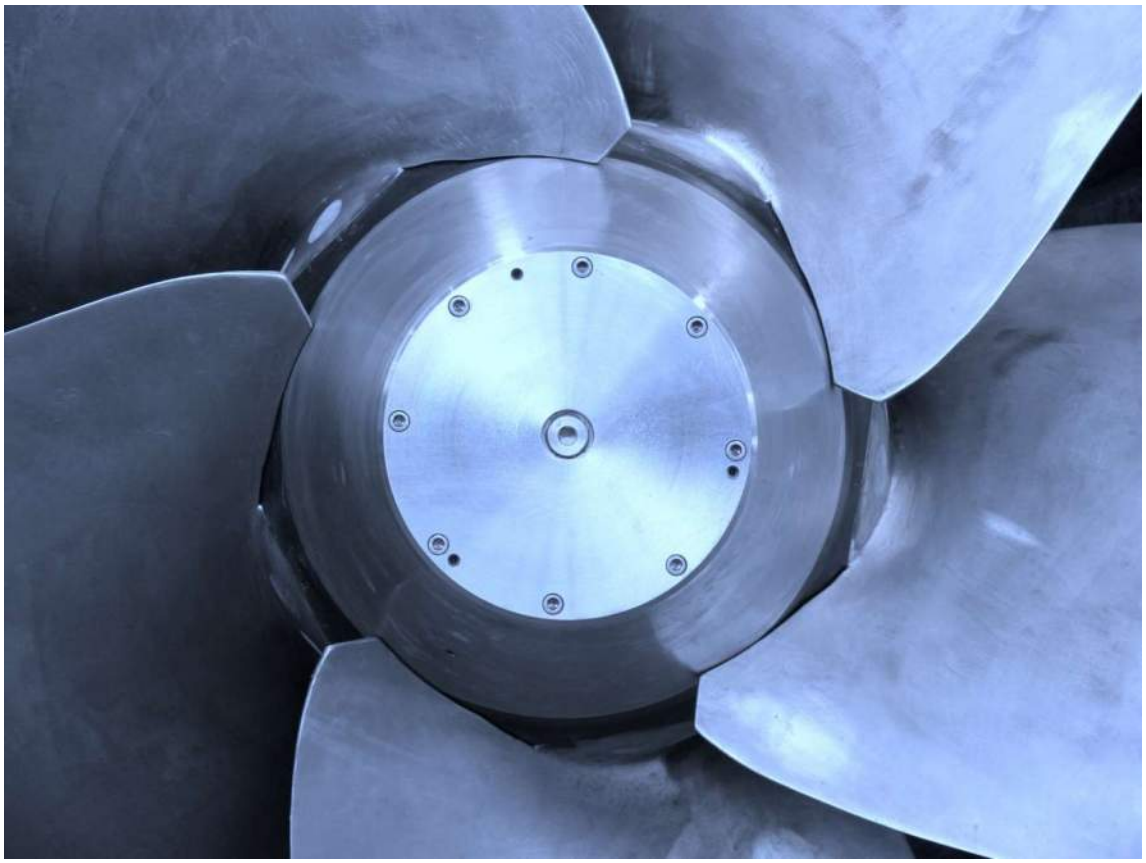
Customer	WSP
Power Plant	Sault Ste-Marie
Technical Specification	10127175A_TS



N° 1 turbine Kaplan

Rev.	Date	Description
A	21-Feb-20	1st issue

Issued by:
Loïc Pétillon
Technical Sales

Approved By:
Vittorio Apolloni
Sales Director

Summary

Thank you very much for having considered Zeco for this project:

Zeco is an Italian Company active since the end of the '60s and specialized in small Hydropower turbine engineering, fabrication and service.

Vendor list:

COMPONENT	BRAND
Turbine	ZECO
Generator	MARELLI; GAMESA; ALCONZA; NIDEC; AXCO; INDAR; TDPS
Valves	ZECO; SAINT GOBAIN; NUOVAL; GEI; SA-VA
Electrical Motors	SIEMENS; ELVEM; BERMAR
Nitrogen accumulator	HYDAC ; EPE ; OLAER
Limit-switch	TELEMECANIQUE
PLC	SIEMENS
LV Cables	TRIVENETA; PRYSMIAN
Protections	THYTRONIC SPA; WOODWARD; SEIL; DEIF
Cubicles Carpentery	CEB; LEGRAND
Switchgears	ABB ; SCHNEIDER
Panel PC touchscreen	ASEM; PROFACE; ESAWARE
IT Components	HP; LENOVO
Ethernet	HIRSCHMANN; BLACKBOX
Surveillance	AXIS; COMELIT
Level transducer	SIEMENS

1 Scope of supply

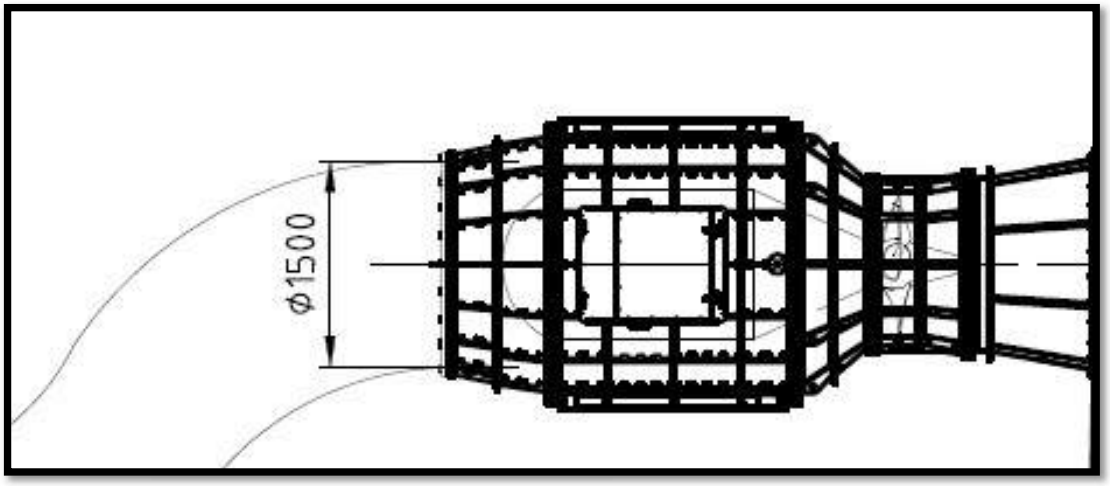
The supply includes the design, engineering, manufacturing of **n.1 turbine** coupled with electrical generators suitable to operate only with the national power grid according to the technical specifications described in the next chapters and based on the our general condition for sale document.

Scope of supply included:

Turbine	**Yes**
Generator	**Yes**
Turbine control panel	**no**
Generator control panel	**no**
Generator circuit breaker panel	**no**
HMI Interface system	**no**
Cables	**no**
Shipment according to Incoterms 2010	**CIF**
Erection	**no**
Commissioning	**Supervision**
Training	**Yes – during commissioning**

1. Project data for the hydro-power plant

Altitude of the hydro-power station:	180 m a.s.l.
Net Head:	4,8 m
Rated total discharge:	5 m^3/s
Number of Units required:	1
Grid Frequency:	60 Hz



2. N. 1 Kaplan Turbine

The main specifications for the turbine are the follows:

Turbine type: **Kaplan**

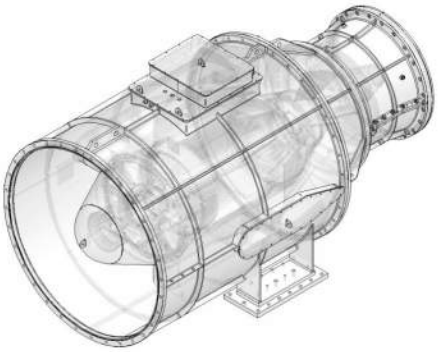
Shaft orientation: **horizontal**

Rated unit discharge:**5 m^3/s**

Turbine power: **216 kW**

Speed: **333 rpm**

Runner diameter: **1100 mm**



With nominal flow and head the efficiency of the turbine is **92,0 %**

Inlet channels must be designed in order to maintain during the grid crossing (considering a security clogging of the 20%) a speed lower than 0,8 m/s.

In case of penstock or turbine insufficient submergence and/or too elevate flow speed, in the inlet chamber vortices may arise.

the supplied turbine mainly consists on the following parts (all the component images depicted below are purely for indication).

2.1 Fixed wicket gate

Fixed wicket gate, hydraulically shake in order to optimize the flow to the runner. Made of steel S275JR.

2.2 Generator case

Generator case, made of steel S275JR. It allows the connection between the penstock/butterfly valve and the wicket gate.

2.3 Runner shell

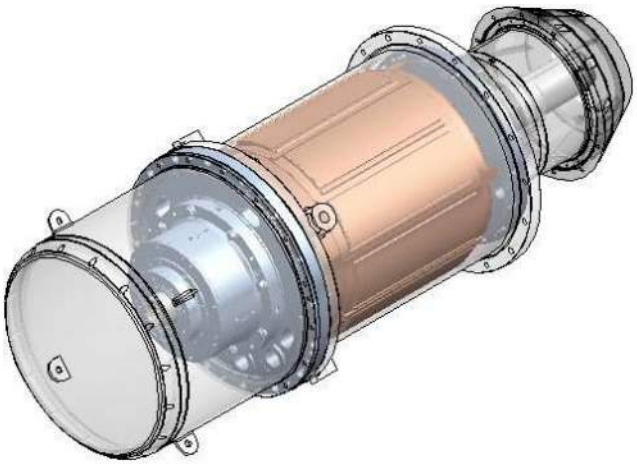
Runner shell realized in two parts in order to facilitate maintenance. Made of steel S275JR.

2.4 Runner

Runner with 3 blades in stainless steel X3CrNiMo 13-4 totally N.C. machined and hand polished. Hub hydraulically optimized. Static balancing according to UNI ISO 1940 G 6.3 standards.

3. Asynchronous generator

The main specifications of the generator are the follows:



Type: **Asynchronous**

Operating voltage: **600 V**

Rated Frequency: **60 Hz**

Speed: **333 rpm**

Poles number: **18**

Rated Power output: **220 kW**

Effective generator output: **200 kW**

Class insulation/ temperature rise**: F/B**

Protection degree: **IP23**

Cooling method: **IC01**

Mounting as IEC 34-7: **B3**

Support type: **roller bearings**

Efficiency at 100% of power: **93.3%**

Manufactured by a leading company and complete with the needed vibration sensors.

4. Sensors

Each group will be equipped with the following main system control tools:

4.1 Turbine-generator group

- N.1 radial vibration transducer for each guide bearing;
- N.1 axial vibration transducer for each thrust bearing;
- N.1 phonic wheel complete with 2 proximity sensors for group speed control;
- N.3 PT100 temperature sensors on the stator (1 for each phase);
- N.1 PT100 temperature sensor for each bearing;

5. Pre-commissioning

In all the projects it deals with, Zeco always proceeds with the complete assembly of the generating group, control units and control panels. The assembly is carried out within the area specially set up in Zeco headquarter.

This phase also includes the connection of all the pipes of the various support systems and the wiring of all the terminal blocks with the control panel. In this way it is therefore possible to carry out blank tests of the group, moving all the mobile organs present in the system and simulating on-site adjustment.

Once the system has been checked and tested, the goods are dismantled and shipped, which will then arrive on site ready to be installed permanently. This procedure guarantees continuity in the order process, which allows complete control over the equipment supplied.

Zeco is also able to offer tailor-made training for the customer's staff: in particular, during the internal assembly and pre-commissioning phase, it will be possible to provide assistance from Zeco technicians to who will then be responsible for the maintenance and management of the turbine in site. This allows these figures to get to know the various components in depth and to be properly prepared for the activities to be carried out once the machine is in operation.

ZECO di Zerbaro e Costa e C. s.r.l.

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sales@zeco.it

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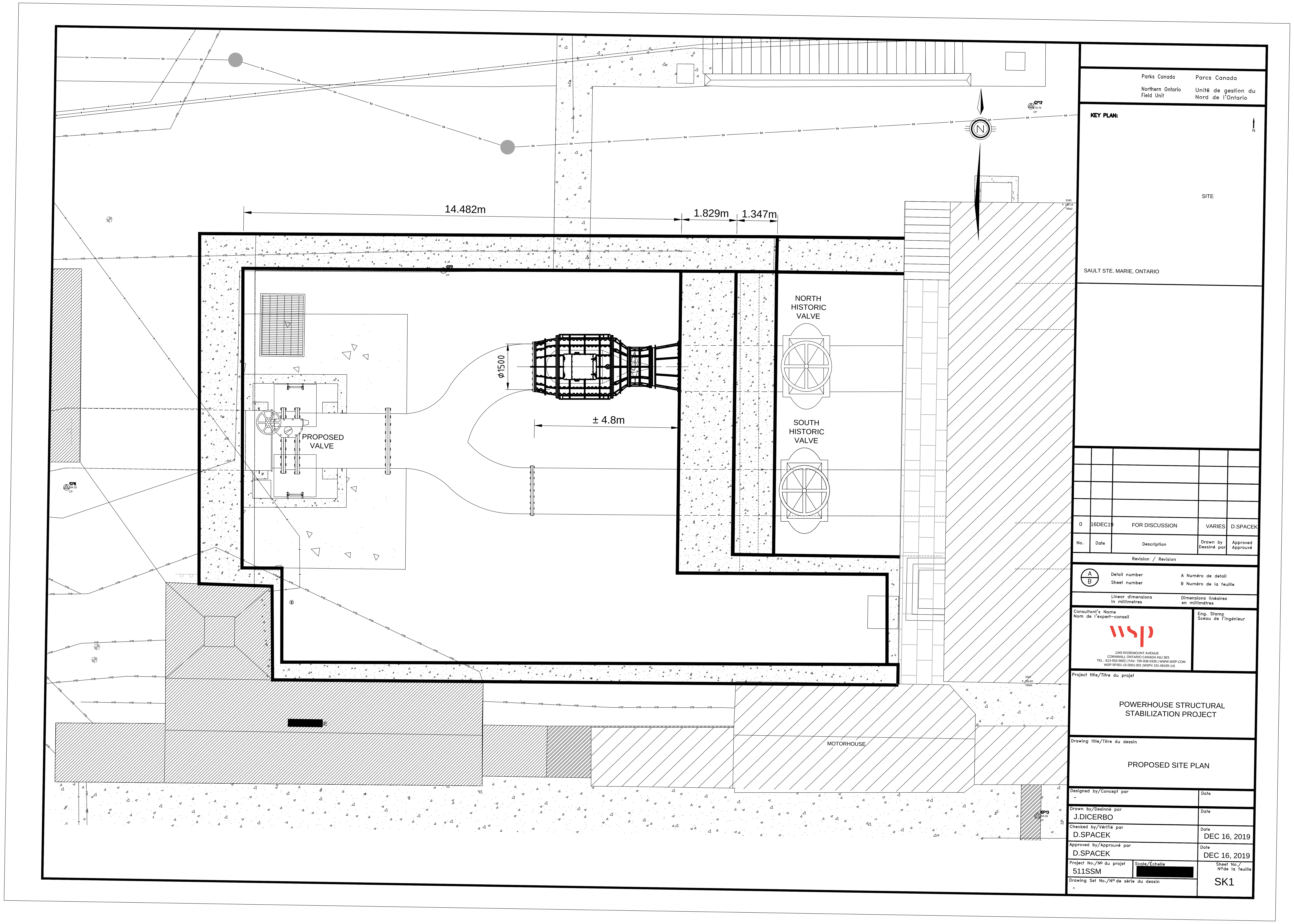


Rev.	Disegnato/Data	Descrizione	Data/Controllato	Data/Approvato
1		PRIMA EMISSIONE		

Quota senza tolleranza (ISO foro base)
Fino a 15 ±0.11 da 15 a 80 ±0.19
da 80 a 250 ±0.29 >250 ±0.32

Scala 1:75

Peso | Foglio n. | Q.tà

Descrizione
PRELIMINARY LAYOUT

Motto
SAULT STE-MARIE

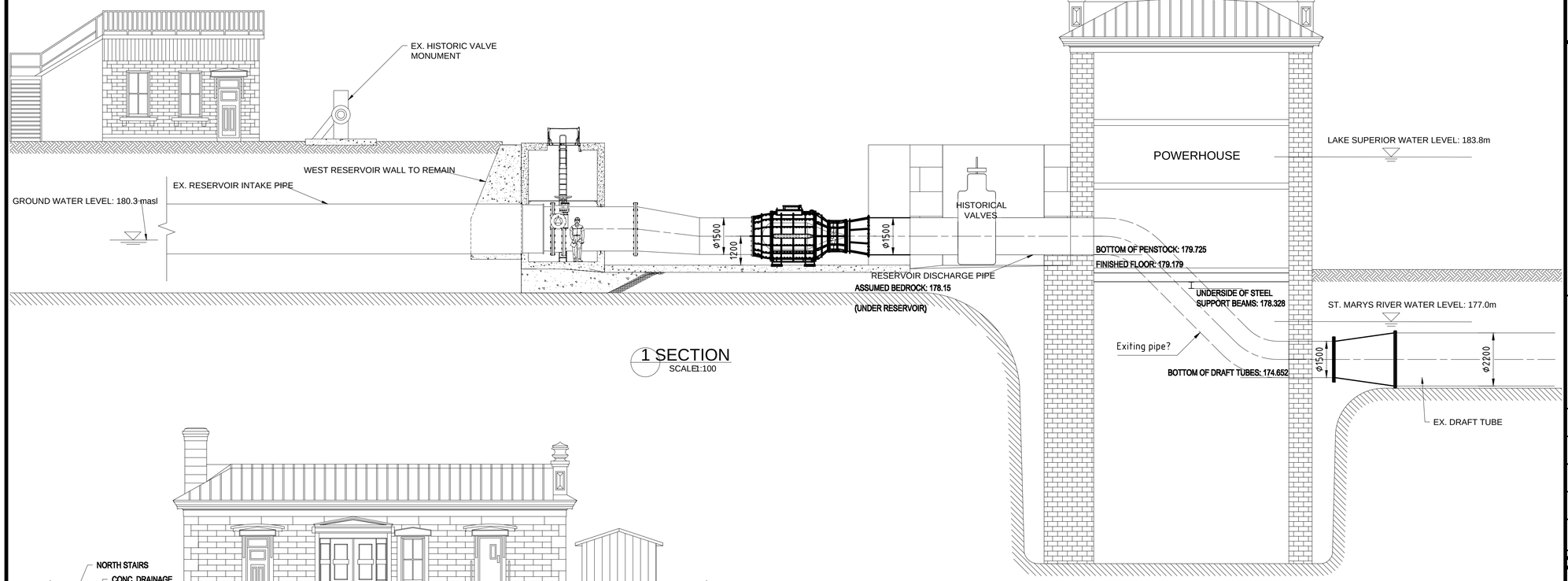
Commessa
SAULT STE-MARIE

WP

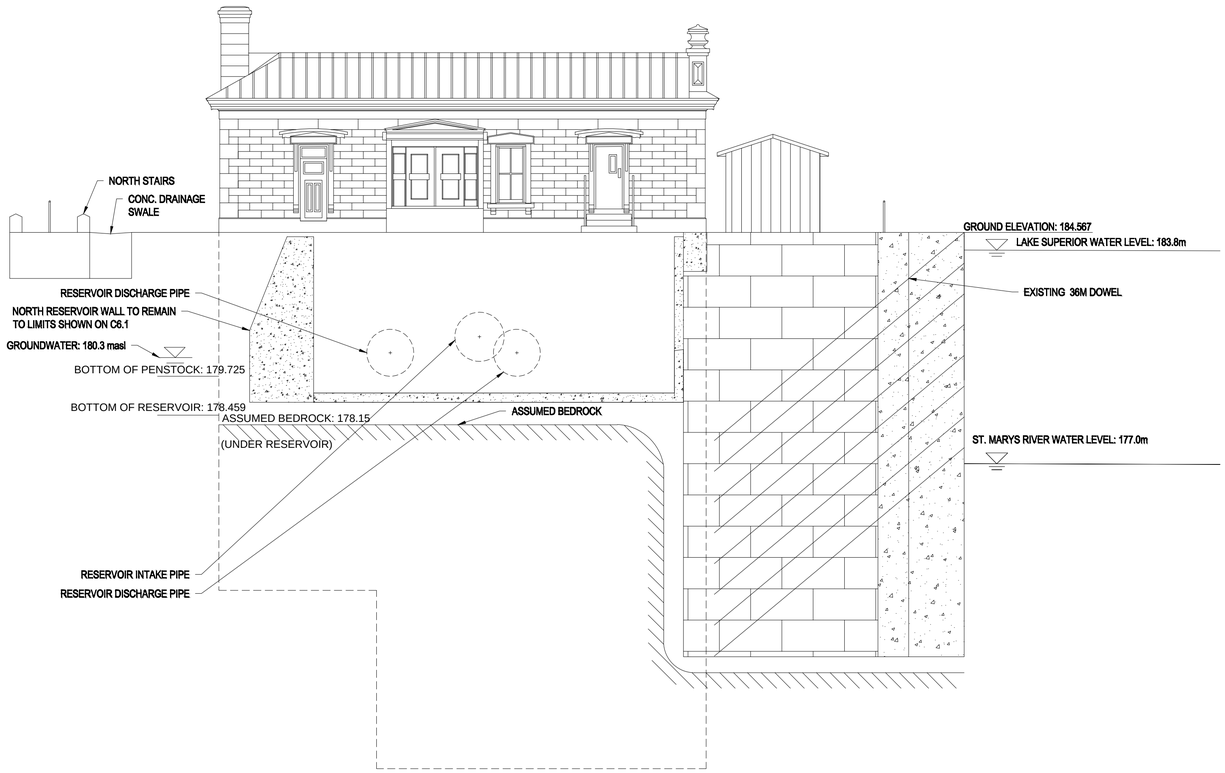
Codice
SAULT STE-MARIE

Rev.

ZECO
DI ZERBARO E COSTA E C. Srl
Via Astico, 52/C – 36030 Fara Vicentino (VICENZA) ITALY



1 SECTION
SCALE1:100



2 SECTION
SCALE1:100

Parks Canada / Parcs Canada
Northern Ontario Field Unit / Unité de gestion du Nord de l'Ontario

KEY PLAN:

SAULT STE. MARIE, ONTARIO

No.	Date	Description	Drawn by Dessiné par	Approved Approuvé

Revision / Révision

A/B Detail number / Sheet number
A Numéro de detail
B Numéro de la feuille

Linear dimensions in millimetres
Dimensions linéaires en millimètres

Consultant's Name / Nom de l'expert-conseil
wsp
1345 ROSEMOUNT AVENUE
CORNWALL ONTARIO CANADA K6J 3E5
TEL.: 613-933-5602 | FAX: 705-936-0335 | WWW.WSP.COM
WSP-SP301-15-0001-001 (WSP# 151-06165-14)

Eng. Stamp / Sceau de l'ingénieur

Project title/Titre du projet

POWERHOUSE STRUCTURAL STABILIZATION PROJECT

Drawing title/Titre du dessin

RESERVOIR AND VALVE CHAMBER CROSS-SECTIONS

Designed by/Concept par: D.SPACEK	Date: DEC 20, 2019
Drawn by/Desinné par: K.GAGNE	Date: DEC 20, 2019
Checked by/Vérifié par: D.SPACEK	Date: DEC 20, 2019
Approved by/Approuvé par: D.SPACEK	Date: DEC 20, 2019
Project No./Nº du projet: 511SSM	Scale/Échelle: [redacted]
Drawing Set No./Nº de série du dessin: -	Sheet No./ Nºde la feuille: SK-1.1

Rev.	Disegnato/Data	Descrizione	Data/Controllato	Data/Approvato
1		PRIMA EMISSIONE		

Quota senza tolleranza (ISO foro base)
Fino a 15 ±0,11 da 15 a 80 ±0,19
da 80 a 250 ±0,29 >250 ±0,32

Scala: 1:100

Peso | Foglio n. | Q.tà

Descrizione: PRELIMINARY LAYOUT

Motto: SAULT STE-MARIE

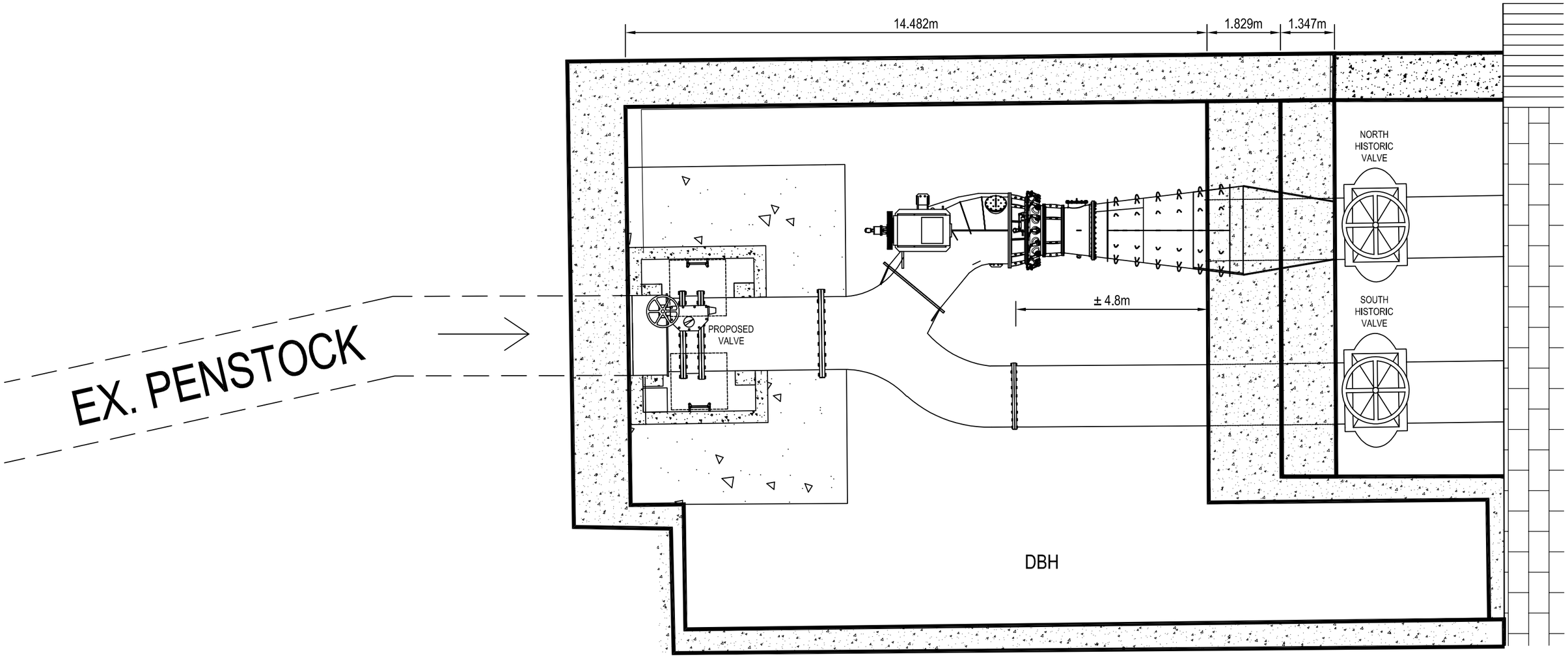
ZECO
DI ZERBARO E COSTA E C. Srl
Via Astico, 52/C – 36030 Fara Vicentino (VICENZA) ITALY

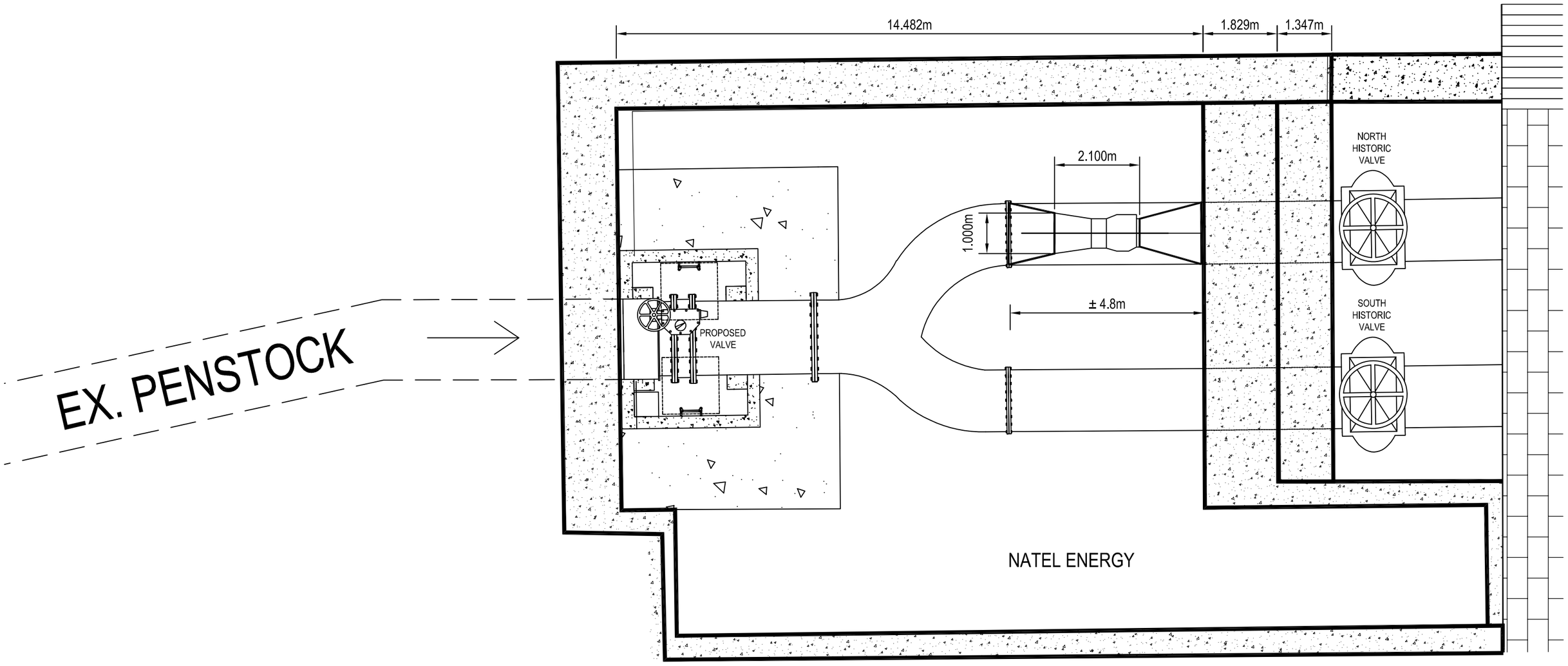
Commessa: SAULT STE-MARIE | WP

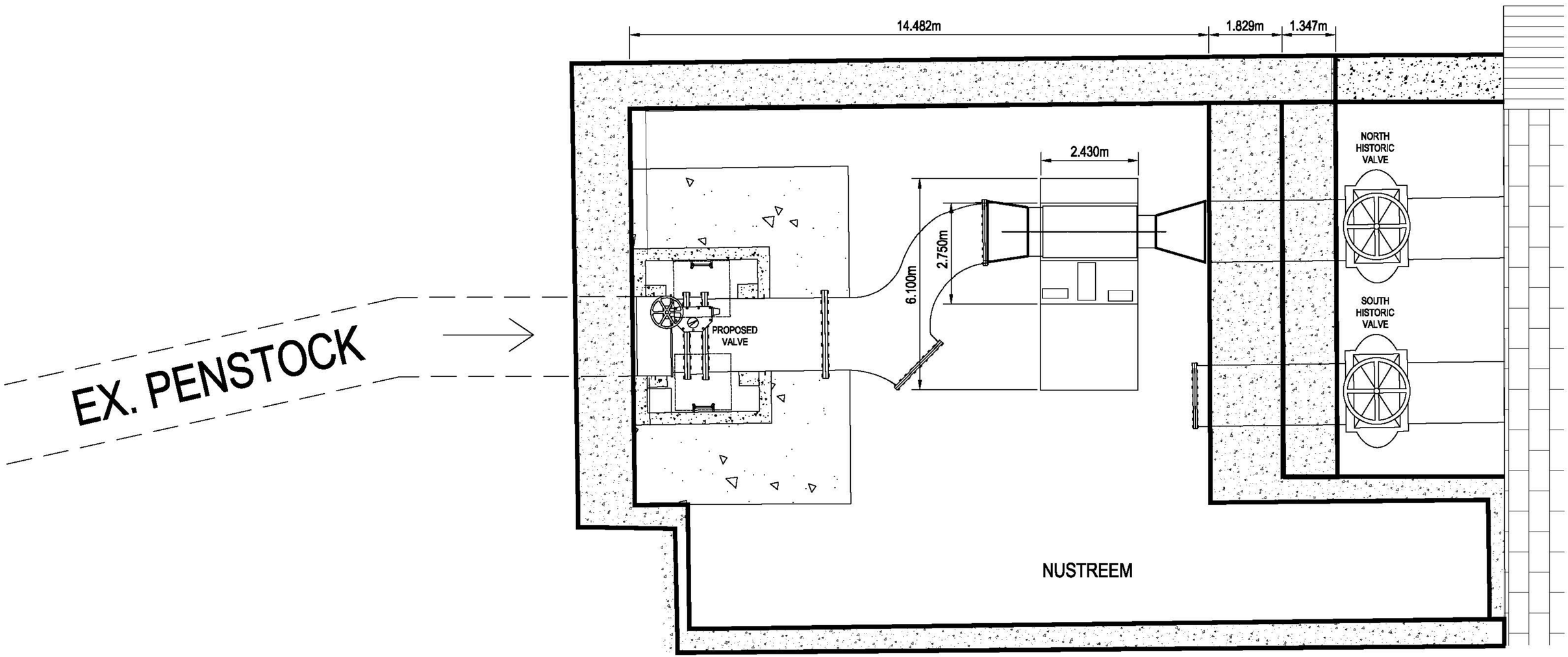
Codice: SAULT STE-MARIE | Rev.

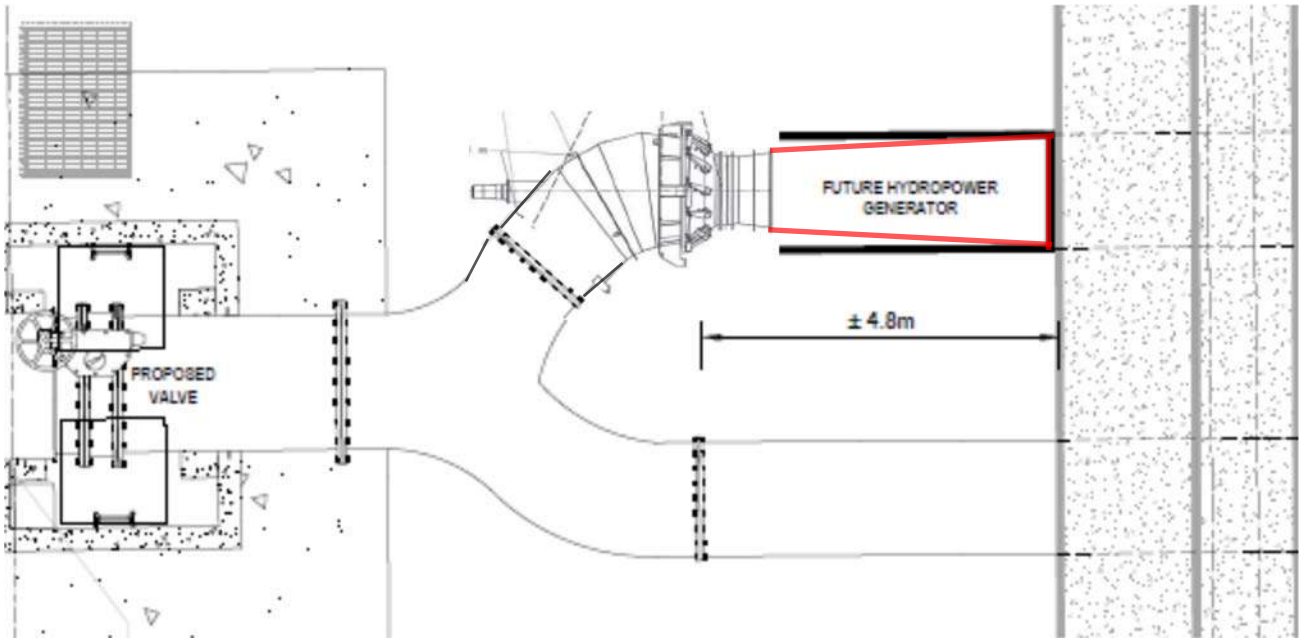
APPENDIX

B LAYOUT STUDY


14.482m
1.829m
1.347m
NORTH
HISTORIC
VALVE
SOUTH
HISTORIC
VALVE
± 4.8m
PROPOSED
VALVE
EX. PENSTOCK
DBH


14.482m
1.829m
1.347m
2.100m
1.000m
± 4.8m
NORTH
HISTORIC
VALVE
SOUTH
HISTORIC
VALVE
PROPOSED
VALVE
EX. PENSTOCK
NATEL ENERGY


EX. PENSTOCK
14.482m
1.829m
1.347m
2.430m
2.750m
6.100m
PROPOSED
VALVE
NORTH
HISTORIC
VALVE
SOUTH
HISTORIC
VALVE
NUSTREEM

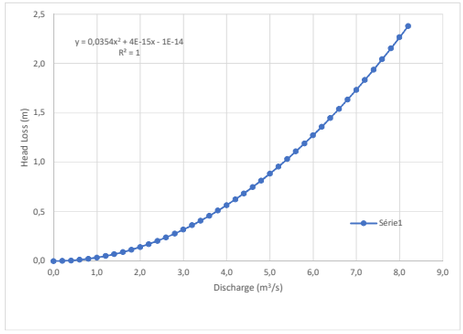

FUTURE HYDROPOWER
GENERATOR
± 4.8m
PROPOSED
VALVE

APPENDIX

C SYSTEM HEAD LOSSES

	INTAKE CHANNEL Assume Rectangular BOTTOM WIDTH =20,0 m LENGTH =600,0 m MANNINGS n =0,020 AVE.INVERT ELEVATION =177,00 m AVE. WATER LEVEL =183,80 m HYDRAULIC RADIUS = 4,05 m			TRASH RACK AREA 1.6 sq.m. BLOCKAGE FACTOR 90% BAR ANGLE 90		VALVE Valve # = 1 DIAMETER = 2,01 m AREA = 3,17 Assume Loss Co-eff 0,20	PENSTOCK Number of Penstocks = 1 DIAMETER = 2,01 m Friction factor = 0,02169 AREA = 3,17 sq.m (per Pipe) WETTED PERIM = 6,31 m (per Pipe) HYDRAULIC RADIUS = 0,50 m Penstock Length = 300,0 m					PENSTOCK BENDS No. of Bends = 6 DIAMETER = 2,01 m AREA = 3,17 Assume Loss Co-eff 0,05	VALVE Valve # = 1 DIAMETER = 1,83 m AREA = 2,63 Assume Loss Co-eff 0,20	PENSTOCK Number of Penstocks = 1 DIAMETER = 1,83 m Friction factor = 0,00932 AREA = 2,63 sq.m (per Pipe) WETTED PERIM = 5,75 m (per Pipe) HYDRAULIC RADIUS = 0,46 m Penstock Length = 3,0 m					MANIFOLD Valve # = 1 INPUT REQUIRED FROM SUPPLIER Assume Loss Co-eff 0,20	VALVE Valve # = 1 DIAMETER = 1,52 m AREA = 1,8146 Assume Loss Co-eff 0,20	TIV INPUT REQUIRED FROM TURBINE MANUFACTURER		ELBOW Elbow # = 2 DIAMETER = 1,52 m AREA = 1,8146 Assume Loss Co-eff 0,10		WET H
DISCHARGE	HEADLOSS OVER THE REACH	VELOCITY	ELEVATION AT END OF REACH #2	VELOCITY ON GROSS AREA	HEADLOSS	BUTTERFLY VALVE HEADLOSS	PENSTOCK VELOCITY	PENSTOCK VELOCITY HEAD	FRICTION FACTOR 'f'	EQUIV. MANNING'S 'n'	FRICTION LOSS	PENSTOCK HEADLOSS	BENDS IN ALIGNMENT	BUTTERFLY VALVE HEADLOSS	PENSTOCK VELOCITY	PENSTOCK VELOCITY HEAD	FRICTION FACTOR 'f'	EQUIV. MANNING'S 'n'	FRICTION LOSS	PENSTOCK HEADLOSS	BIFURCATION for 1 or 2 UNITS	HISTORIC VALVE	TURBINE INLET VALVE		BIFURCATION ELBOW HEADLOSS	PENSTOCK VELOCITY	PENSTOCK VELOCITY HEAD
cms	m	m/s	m	m/s	m	m	m/s	m			m per metre	m	m	m	m/s	m			m per metre	m	m	m			m/s	m
0,0	0,000	0,00	183,80	0,00	0,00	0,00	0,000	0,000	0,009325	0,009719	0,000000	0,00	0,00	0,00	0,000	0,000	0,009325	0,009567	0,000000	0,00	0,00	0,00			0,00	0,000	0,000
0,2	0,000	0,00	183,80	0,01	0,00	0,00	0,063	0,000	0,021689	0,014823	0,000002	0,00	0,00	0,00	0,076	0,000	0,009325	0,009567	0,000002	0,00	0,00	0,00			0,00	0,110	0,001
0,4	0,000	0,00	183,80	0,03	0,00	0,00	0,126	0,001	0,021689	0,014823	0,000009	0,00	0,00	0,00	0,152	0,001	0,009325	0,009567	0,000006	0,00	0,00	0,00			0,00	0,219	0,002
0,6	0,000	0,00	183,80	0,04	0,00	0,00	0,189	0,002	0,021689	0,014823	0,000020	0,01	0,00	0,00	0,228	0,003	0,009325	0,009567	0,000014	0,00	0,00	0,00			0,00	0,329	0,006
0,8	0,000	0,01	183,80	0,05	0,00	0,00	0,252	0,003	0,021689	0,014823	0,000035	0,01	0,00	0,00	0,305	0,005	0,009325	0,009567	0,000024	0,00	0,00	0,00			0,00	0,439	0,010
1,0	0,000	0,01	183,80	0,06	0,00	0,00	0,315	0,005	0,021689	0,014823	0,000055	0,02	0,00	0,00	0,381	0,007	0,009325	0,009567	0,000038	0,00	0,00	0,00			0,00	0,548	0,015
1,2	0,000	0,01	183,80	0,08	0,00	0,00	0,378	0,007	0,021689	0,014823	0,000079	0,02	0,00	0,00	0,457	0,011	0,009325	0,009567	0,000054	0,00	0,00	0,00			0,00	0,658	0,022
1,4	0,000	0,01	183,80	0,09	0,00	0,00	0,441	0,010	0,021689	0,014823	0,000107	0,03	0,00	0,00	0,533	0,014	0,009325	0,009567	0,000074	0,00	0,01	0,01			0,00	0,767	0,030
1,6	0,000	0,01	183,80	0,10	0,00	0,00	0,504	0,013	0,021689	0,014823	0,000140	0,04	0,00	0,00	0,609	0,019	0,009325	0,009567	0,000096	0,00	0,01	0,01			0,00	0,877	0,039
1,8	0,000	0,01	183,80	0,11	0,00	0,00	0,567	0,016	0,021689	0,014823	0,000177	0,05	0,00	0,00	0,685	0,024	0,009325	0,009567	0,000122	0,00	0,01	0,01			0,00	0,987	0,050
2,0	0,000	0,01	183,80	0,13	0,00	0,00	0,630	0,020	0,021689	0,014823	0,000218	0,07	0,01	0,01	0,761	0,030	0,009325	0,009567	0,000151	0,00	0,01	0,01			0,01	1,096	0,061
2,2	0,000	0,02	183,80	0,14	0,00	0,00	0,693	0,025	0,021689	0,014823	0,000264	0,08	0,01	0,01	0,838	0,036	0,009325	0,009567	0,000182	0,00	0,01	0,01			0,01	1,206	0,074
2,4	0,000	0,02	183,80	0,15	0,00	0,01	0,756	0,029	0,021689	0,014823	0,000315	0,09	0,01	0,01	0,914	0,043	0,009325	0,009567	0,000217	0,00	0,02	0,02			0,01	1,316	0,088
2,6	0,000	0,02	183,80	0,16	0,00	0,01	0,819	0,034	0,021689	0,014823	0,000369	0,11	0,01	0,01	0,990	0,050	0,009325	0,009567	0,000255	0,00	0,02	0,02			0,01	1,425	0,104
2,8	0,000	0,02	183,80	0,18	0,00	0,01	0,882	0,040	0,021689	0,014823	0,000428	0,13	0,01	0,01	1,066	0,058	0,009325	0,009567	0,000295	0,00	0,02	0,02			0,01	1,535	0,120
3,0	0,000	0,02	183,80	0,19	0,00	0,01	0,945	0,046	0,021689	0,014823	0,000492	0,15	0,01	0,01	1,142	0,066	0,009325	0,009567	0,000339	0,00	0,03	0,03			0,01	1,645	0,138
3,2	0,000	0,02	183,80	0,20	0,00	0,01	1,008	0,052	0,021689	0,014823	0,000559	0,17	0,02	0,02	1,218	0,076	0,009325	0,009567	0,000386	0,00	0,03	0,03			0,02	1,754	0,157
3,4	0,000	0,03	183,80	0,21	0,00	0,01	1,072	0,059	0,021689	0,014823	0,000631	0,19	0,02	0,02	1,294	0,085	0,009325	0,009567	0,000435	0,00	0,04	0,04			0,02	1,864	0,177
3,6	0,000	0,03	183,80	0,23	0,00	0,01	1,135	0,066	0,021689	0,014823	0,000708	0,21	0,02	0,02	1,371	0,096	0,009325	0,009567	0,000488	0,00	0,04	0,04			0,02	1,974	0,199
3,8	0,000	0,03	183,80	0,24	0,00	0,01	1,198	0,073	0,021689	0,014823	0,000789	0,24	0,02	0,02	1,447	0,107	0,009325	0,009567	0,000544	0,00	0,04	0,04			0,02	2,083	0,221
4,0	0,000	0,03	183,80	0,25	0,00	0,02	1,261	0,081	0,021689	0,014823	0,000874	0,26	0,02	0,02	1,523	0,118	0,009325	0,009567	0,000603	0,00	0,05	0,05			0,02	2,193	0,245
4,2	0,000	0,03	183,80	0,26	0,00	0,02	1,324	0,089	0,021689	0,014823	0,000964	0,29	0,03	0,03	1,599	0,130	0,009325	0,009567	0,000664	0,00	0,05	0,05			0,03	2,302	0,270
4,4	0,000	0,03	183,80	0,28	0,00	0,02	1,387	0,098	0,021689	0,014823	0,001058	0,32	0,03	0,03	1,675	0,143	0,009325	0,009567	0,000729	0,00	0,06	0,06			0,03	2,412	0,297
4,6	0,000	0,03	183,80	0,29	0,00	0,02	1,450	0,107	0,021689	0,014823	0,001156	0,35	0,03	0,03	1,751	0,156	0,009325	0,009567	0,000797	0,00	0,06	0,06			0,03	2,522	0,324
4,8	0,000	0,04	183,80	0,30	0,01	0,02	1,513	0,117	0,021689	0,014823	0,001259	0,38	0,03	0,03	1,827	0,170	0,009325	0,009567	0,000868	0,00	0,07	0,07			0,03	2,631	0,353
5,0	0,000	0,04	183,80	0,31	0,01	0,03	1,576	0,127	0,021689	0,014823	0,001366	0,41	0,04	0,04	1,903	0,185	0,009325	0,009567	0,000942	0,00	0,08	0,08			0,04	2,741	0,383
5,2	0,000	0,04	183,80	0,33	0,01	0,03	1,639	0,137	0,021689	0,014823	0,001477	0,44	0,04	0,04	1,980	0,200	0,009325	0,009567	0,001018	0,00	0,08	0,08			0,04	2,851	0,414
5,4	0,000	0,04	183,80	0,34	0,01	0,03	1,702	0,148	0,021689	0,014823	0,001593	0,48	0,04	0,04	2,056	0,215	0,009325	0,009567	0,001098	0,00	0,09	0,09			0,04	2,960	0,447
5,6	0,000	0,04	183,80	0,35	0,01	0,03	1,765	0,159	0,021689	0,014823	0,001713	0,51	0,05	0,05	2,132	0,232	0,009325	0,009567	0,001181	0,00	0,10	0,10			0,05	3,070	0,480
5,8	0,000	0,04	183,80	0,36	0,01	0,03	1,828	0,170	0,021689	0,014823	0,001838	0,55	0,05	0,05	2,208	0,248	0,009325	0,009567	0,001267	0,00	0,10	0,10			0,05	3,180	0,515
6,0	0,000	0,04	183,80	0,38	0,01	0,04	1,891	0,182	0,021689	0,014823	0,001966	0,59	0,05	0,05	2,284	0,266	0,009325	0,009567	0,001356	0,00	0,11	0,11			0,05	3,289	0,551
6,2	0,000	0,05	183,80	0,39	0,01	0,04	1,954	0,195	0,021689	0,014823	0,002100	0,63	0,06	0,06	2,360	0,284	0,009325	0,009567	0,001448	0,00	0,12	0,12			0,06	3,399	0,589
6,4	0,000	0,05	183,80	0,40	0,01	0,04	2,017	0,207	0,021689	0,014823	0,002237	0,67	0,06	0,06	2,436	0,303	0,009325	0,009567	0,001543	0,00	0,13	0,13			0,06	3,508	0,627
6,6	0,000	0,05	183,80	0,41	0,01	0,04	2,080	0,221	0,021689	0,014823	0,002379	0,71	0,07	0,06	2,513	0,322	0,009325	0,009567	0,001641	0,00	0,13	0,13			0,06	3,618	0,667
6,8	0,000	0,05	183,80	0,43	0,01	0,05	2,143	0,234	0,021689	0,014823	0,002526	0,76	0,07	0,07	2,589	0,342	0,009325	0,009567	0,001742	0,01	0,14	0,14			0,07	3,728	0,708
7,0	0,000	0,05	183,80	0,44	0,01	0,05	2,206	0,248	0,021689	0,014823	0,002677	0,80	0,07	0,07	2,665	0,362	0,009325	0,009567	0,001846	0,01	0,15	0,15			0,07	3,837	0,751
7,2	0,000	0,05	183,80	0,45	0,01	0,05	2,269	0,262	0,021689	0,014823	0,002832	0,85	0,08	0,08	2,741	0,383	0,009325	0,009567	0,001952	0,01	0,16	0,16			0,08	3,947	0,794
7,4	0,000	0,05	183,80	0,46	0,01	0,06	2,332	0,277	0,021689	0,014823	0,002991	0,90	0,08	0,08	2,817	0,405	0,009325	0,009567	0,002062	0,01	0,17	0,17			0,08	4,057	0,839
7,6	0,000	0,06	183,80	0,48	0,01	0,06	2,395	0,292	0,021689	0,014823	0,003155	0,95	0,09	0,09	2,893	0,427	0,009325	0,009567	0,002175	0,01	0,18	0,18			0,09	4,166	0,885
7,8	0,000	0,06	183,80	0,49	0,01	0,06	2,458	0,308	0,021689	0,014823	0,003323	1,00	0,09	0,09	2,969	0,449	0,009325	0,009567	0,002291	0,01	0,19	0,19			0,09	4,276	0,932
8,0	0,000	0,06	183,80	0,50	0,01	0,06	2,521	0,324	0,021689	0,014823	0,003496	1,05	0,10	0,09	3,046	0,473	0,009325	0,009567	0,002410	0,01	0,20	0,20			0,09	4,386	0,980
8,2	0,000	0,06	183,80	0,51	0,02	0,07	2,584	0,340	0,021689	0,014823	0,003673	1,10	0,10	0,10	3,122	0,497	0,009325	0,009567	0,002532	0,01	0,21	0,21			0,10	4,495	1,030

Generating Unit(s)



Kinematic viscocity (stokes) 1,00E-06
Pipe Roughness (m)

Rivetted Steel	0,003
Glass, Brass, Copper, Lead	0,001
Steel, Wrought Iron	0,045
Asphalted Cast Iron	0,12
Galvanised Iron	0,15
Cast Iron	0,26
Concrete	0,42
Rivetted Steel	3
Bored Rock (Unlined)	20

Kinematic viscocity (stokes) 1,00E-06
Pipe Roughness (m)

Steel, Wrought Iron	0,000045
Glass, Brass, Copper, Lead	0,001
Steel, Wrought Iron	0,045
Asphalted Cast Iron	0,12
Galvanised Iron	0,15
Cast Iron	0,26
Concrete	0,42
Rivetted Steel	3
Bored Rock (Unlined)	20

Kinematic viscocity (stokes)
Pipe Roughness (m)

PENSTOCKS

Number of Penstocks = 1

DIAMETER = 1,52 m
Friction factor = 0,00962
AREA = 1,82 sq.m (per Pipe)
TED PERIM = 4,79 m (per Pipe)
YDRAULIC RADIUS = 0,38 m
Penstock Length = 40,0 m

DRAFT TUBE

No. OF DRAFT TUBES = 1
LOSS COEFFICIENT = 1,0
Conical Expansion
OUTLET HEIGHT =2,00 m (per unit)
OUTLET WIDTH =2,00 m (per unit)
AREA = 4,00 sq m (per unit)

TAILRACE CANAL

CANAL LENGTH = 50,00m
CANAL WIDTH = 50,00m
CANAL DEPTH = 3,00m
MANNINGS n =0,033

FRICTION FACTOR 'f'	EQUIV. MANNING'S 'n'	FRICTION LOSS	PENSTOCK HEADLOSS	OUTLET VELOCITY	EXPANSION HEADLOSS	CANAL VELOCITY	HYDRAULIC RADIUS	OUTLET CANAL HEADLOSS	SYSTEM HEADLOSS	DISCHARGE	SYSTEM HEADLOSS
		m per metre	m	m/s	m	m/s	m	m	m	cms	m
0,009616	0,009425	0,000000	0,00	0,000	0,000	0,000	2,679	0,000	0,00	0,0	0,00
0,009616	0,009425	0,000004	0,00	0,050	0,000	0,001	2,679	0,000	0,00	0,2	0,00
0,009616	0,009425	0,000015	0,00	0,100	0,001	0,003	2,679	0,000	0,01	0,4	0,01
0,009616	0,009425	0,000035	0,00	0,150	0,001	0,004	2,679	0,000	0,01	0,6	0,01
0,009616	0,009425	0,000062	0,00	0,200	0,002	0,005	2,679	0,000	0,02	0,8	0,02
0,009616	0,009425	0,000097	0,00	0,250	0,003	0,007	2,679	0,000	0,04	1,0	0,04
0,009616	0,009425	0,000139	0,01	0,300	0,005	0,008	2,679	0,000	0,05	1,2	0,05
0,009616	0,009425	0,000189	0,01	0,350	0,006	0,009	2,679	0,000	0,07	1,4	0,07
0,009616	0,009425	0,000247	0,01	0,400	0,008	0,011	2,679	0,000	0,09	1,6	0,09
0,009616	0,009425	0,000313	0,01	0,450	0,010	0,012	2,679	0,000	0,11	1,8	0,11
0,009616	0,009425	0,000387	0,02	0,500	0,013	0,013	2,679	0,000	0,14	2,0	0,14
0,009616	0,009425	0,000468	0,02	0,550	0,015	0,015	2,679	0,000	0,17	2,2	0,17
0,009616	0,009425	0,000557	0,02	0,600	0,018	0,016	2,679	0,000	0,20	2,4	0,20
0,009616	0,009425	0,000653	0,03	0,650	0,022	0,017	2,679	0,000	0,24	2,6	0,24
0,009616	0,009425	0,000758	0,03	0,700	0,025	0,019	2,679	0,000	0,28	2,8	0,28
0,009616	0,009425	0,000870	0,03	0,750	0,029	0,020	2,679	0,000	0,32	3,0	0,32
0,009616	0,009425	0,000990	0,04	0,800	0,033	0,021	2,679	0,000	0,36	3,2	0,36
0,009616	0,009425	0,001117	0,04	0,850	0,037	0,023	2,679	0,000	0,41	3,4	0,41
0,009616	0,009425	0,001253	0,05	0,900	0,041	0,024	2,679	0,000	0,46	3,6	0,46
0,009616	0,009425	0,001396	0,06	0,950	0,046	0,025	2,679	0,000	0,51	3,8	0,51
0,009616	0,009425	0,001546	0,06	1,000	0,051	0,027	2,679	0,000	0,57	4,0	0,57
0,009616	0,009425	0,001705	0,07	1,050	0,056	0,028	2,679	0,000	0,62	4,2	0,62
0,009616	0,009425	0,001871	0,07	1,100	0,062	0,029	2,679	0,000	0,69	4,4	0,69
0,009616	0,009425	0,002045	0,08	1,150	0,067	0,031	2,679	0,000	0,75	4,6	0,75
0,009616	0,009425	0,002227	0,09	1,200	0,073	0,032	2,679	0,000	0,82	4,8	0,82
0,009616	0,009425	0,002416	0,10	1,250	0,080	0,033	2,679	0,000	0,88	5,0	0,88
0,009616	0,009425	0,002613	0,10	1,300	0,086	0,035	2,679	0,000	0,96	5,2	0,96
0,009616	0,009425	0,002818	0,11	1,350	0,093	0,036	2,679	0,000	1,03	5,4	1,03
0,009616	0,009425	0,003031	0,12	1,400	0,100	0,037	2,679	0,000	1,11	5,6	1,11
0,009616	0,009425	0,003251	0,13	1,450	0,107	0,039	2,679	0,000	1,19	5,8	1,19
0,009616	0,009425	0,003479	0,14	1,500	0,115	0,040	2,679	0,000	1,27	6,0	1,27
0,009616	0,009425	0,003715	0,15	1,550	0,123	0,041	2,679	0,000	1,36	6,2	1,36
0,009616	0,009425	0,003959	0,16	1,600	0,131	0,043	2,679	0,000	1,45	6,4	1,45
0,009616	0,009425	0,004210	0,17	1,650	0,139	0,044	2,679	0,000	1,54	6,6	1,54
0,009616	0,009425	0,004469	0,18	1,700	0,147	0,045	2,679	0,000	1,64	6,8	1,64
0,009616	0,009425	0,004736	0,19	1,750	0,156	0,047	2,679	0,000	1,73	7,0	1,73
0,009616	0,009425	0,005010	0,20	1,800	0,165	0,048	2,679	0,000	1,83	7,2	1,83
0,009616	0,009425	0,005293	0,21	1,850	0,175	0,049	2,679	0,000	1,94	7,4	1,94
0,009616	0,009425	0,005583	0,22	1,900	0,184	0,051	2,679	0,000	2,04	7,6	2,04
0,009616	0,009425	0,005880	0,24	1,950	0,194	0,052	2,679	0,000	2,15	7,8	2,15
0,009616	0,009425	0,006186	0,25	2,000	0,204	0,053	2,679	0,000	2,27	8,0	2,27
0,009616	0,009425	0,006499	0,26	2,050	0,214	0,055	2,679	0,000	2,38	8,2	2,38

	1,00E-06
Steel, Wrought Iron	0,000045
Glass, Brass, Copper, Lead	0,001
Steel, Wrought Iron	0,045
Asphalted Cast Iron	0,12
Galvanised Iron	0,15
Cast Iron	0,26
Concrete	0,42
Rivetted Steel	3
Bored Rock (Unlined)	20

APPENDIX

D NET PRESENT VALUE COMPARATIVE TABLE

	Proposal #1	Proposal #2	Proposal #3	Proposal #4	Proposal #5	Proposal #6
	DBH	Natel	Nustreem	Voith	Andritz	Zeco
Net Unit Power (MW)	0,206	0,184	0,1	0,21	0,3	0,2
Energy cost ($/MWh)	100	100	100	100	100	100
Utilization Factor	0,85	0,85	0,85	0,85	0,85	0,85
Yearly Energy consumption (MWh/y)	1533,876	1370,064	744,6	1563,66	2233,8	1489,2
Annual Revenue	153 388 $	137 006 $	74 460 $	156 366 $	223 380 $	148 920 $
10 years revenue	1 533 876 $	1 370 064 $	744 600 $	1 563 660 $	2 233 800 $	1 489 200 $
Discount rate	6%	6%	6%	6%	6%	6%
Initial cost	(550 000) $	(588 712) $	(548 983) $	(724 520) $	(1 000 000) $	(621 849) $
	*Price estimate from Stantec Report	*USD $445,000	*USD $415,000		*between 1.0M$ and 1.2M$	*340,000 €

*Add $100,000 USD for control panel and instrumentation

Year	Yearly income	NPV	Yearly income	NPV	Yearly income	NPV	Yearly income	NPV	Yearly income	NPV	Yearly income	NPV
1	144 705 $	(405 295) $	129 251 $	(459 461) $	70 245 $	(478 738) $	147 515 $	(577 005) $	210 736 $	(789 264) $	140 491 $	(481 358) $
2	136 514 $	(268 780) $	121 935 $	(337 525) $	66 269 $	(412 469) $	139 165 $	(437 840) $	198 807 $	(590 457) $	132 538 $	(348 820) $
3	128 787 $	(139 993) $	115 033 $	(222 492) $	62 518 $	(349 951) $	131 288 $	(306 552) $	187 554 $	(402 903) $	125 036 $	(223 784) $
4	121 497 $	(18 496) $	108 522 $	(113 970) $	58 979 $	(290 971) $	123 857 $	(182 695) $	176 938 $	(225 965) $	117 959 $	(105 825) $
5	114 620 $	**96 124 $**	102 379 $	(11 591) $	55 641 $	(235 330) $	116 846 $	(65 850) $	166 923 $	(59 042) $	111 282 $	**5 456 $**
6	108 132 $	204 257 $	96 584 $	**84 993 $**	52 491 $	(182 839) $	110 232 $	**44 382 $**	157 474 $	**98 432 $**	104 983 $	110 439 $
7	102 012 $	306 268 $	91 117 $	176 110 $	49 520 $	(133 319) $	103 992 $	148 375 $	148 560 $	246 992 $	99 040 $	209 479 $
8	96 237 $	402 505 $	85 960 $	262 069 $	46 717 $	(86 602) $	98 106 $	246 481 $	140 151 $	387 144 $	93 434 $	302 913 $
9	90 790 $	493 295 $	81 094 $	343 163 $	44 073 $	(42 529) $	92 553 $	339 033 $	132 218 $	519 362 $	88 146 $	391 059 $
10	85 651 $	578 946 $	76 504 $	419 667 $	41 578 $	(951) $	87 314 $	426 347 $	124 734 $	644 096 $	83 156 $	474 215 $
11	80 803 $	659 749 $	72 173 $	491 840 $	39 225 $	**38 274 $**	82 372 $	508 719 $	117 674 $	761 770 $	78 449 $	552 664 $
12	76 229 $	735 978 $	68 088 $	559 928 $	37 004 $	75 278 $	77 709 $	586 428 $	111 013 $	872 783 $	74 009 $	626 673 $
13	71 914 $	807 892 $	64 234 $	624 162 $	34 910 $	110 188 $	73 310 $	659 739 $	104 729 $	977 512 $	69 820 $	696 493 $
14	67 843 $	875 735 $	60 598 $	684 760 $	32 934 $	143 122 $	69 161 $	728 899 $	98 801 $	1 076 314 $	65 867 $	762 360 $
15	64 003 $	939 739 $	57 168 $	741 928 $	31 070 $	174 191 $	65 246 $	794 146 $	93 209 $	1 169 522 $	62 139 $	824 499 $
16	60 380 $	1 000 119 $	53 932 $	795 860 $	29 311 $	203 502 $	61 553 $	855 698 $	87 933 $	1 257 455 $	58 622 $	883 121 $
17	56 963 $	1 057 082 $	50 879 $	846 740 $	27 652 $	231 154 $	58 069 $	913 767 $	82 955 $	1 340 410 $	55 304 $	938 425 $
18	53 738 $	1 110 820 $	47 999 $	894 739 $	26 087 $	257 240 $	54 782 $	968 549 $	78 260 $	1 418 670 $	52 173 $	990 598 $
19	50 697 $	1 161 517 $	45 282 $	940 021 $	24 610 $	281 850 $	51 681 $	1 020 230 $	73 830 $	1 492 500 $	49 220 $	1 039 818 $
20	47 827 $	1 209 344 $	42 719 $	982 741 $	23 217 $	305 067 $	48 756 $	1 068 986 $	69 651 $	1 562 151 $	46 434 $	1 086 252 $

Net Present Value (NPV)						
5 years	**96 124 $**	**(11 591) $**	**(235 330) $**	**(65 850) $**	**(59 042) $**	**5 456 $**
10 years	**578 946 $**	**419 667 $**	**(951) $**	**426 347 $**	**644 096 $**	**474 215 $**
15 years	**939 739 $**	**741 928 $**	**174 191 $**	**794 146 $**	**1 169 522 $**	**824 499 $**
20 years	**1 209 344 $**	**982 741 $**	**305 067 $**	**1 068 986 $**	**1 562 151 $**	**1 086 252 $**

APPENDIX

E WATER LEVELS

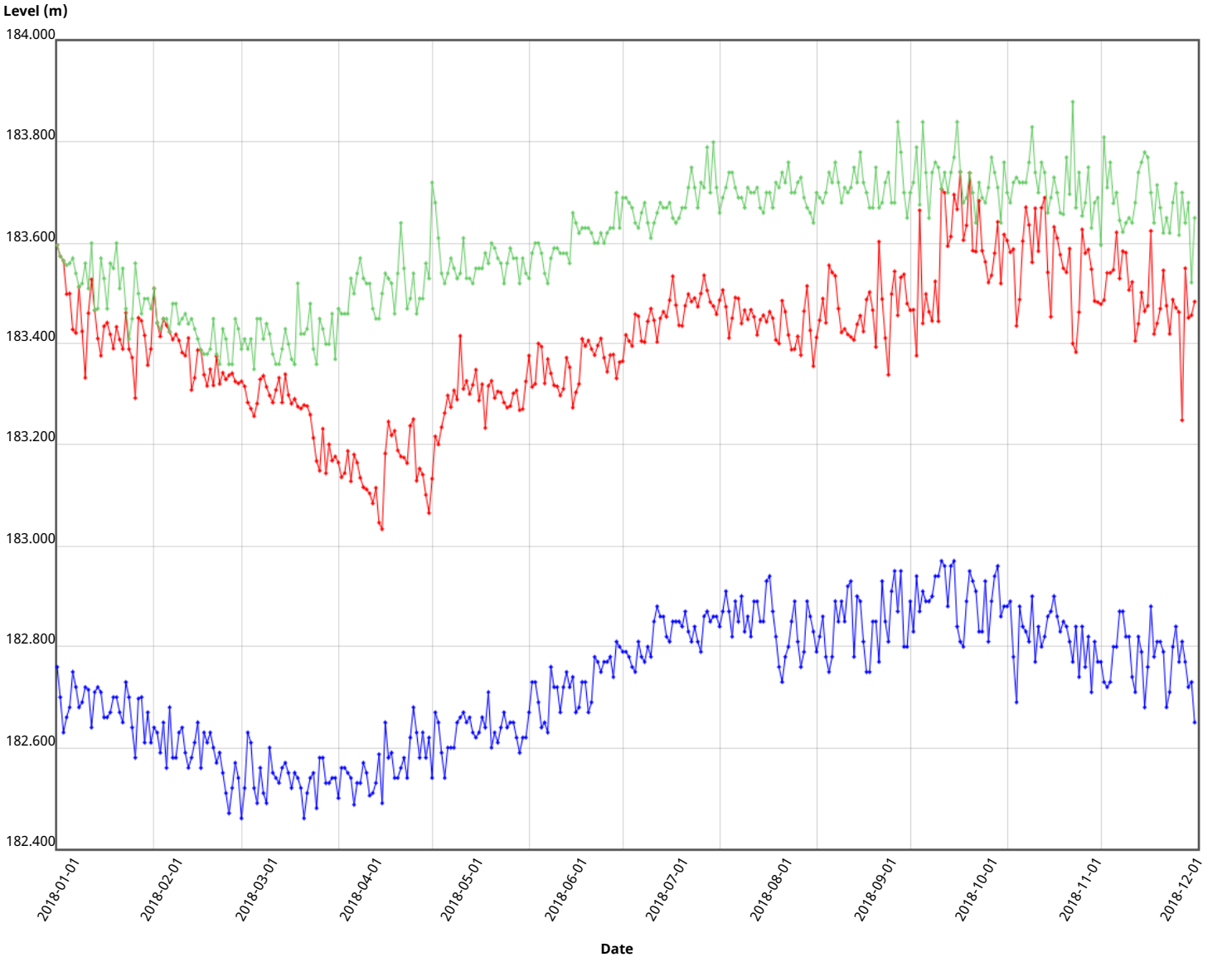
Government of Canada | Gouvernement du Canada

Daily Water Level Graph for ST. MARYS RIVER AT SAULT STE. MARIE (ABOVE) (02BF011) [ON]

All times are specified in Local Standard Time (LST). Add 1 hour to adjust for Daylight Saving Time where and when it is observed.

Legend

2018 Data | Maximum | Minimum



Statistics corresponding to 111 years of data recorded from 1908 and 2018.*

*Note: If n<10, percentiles are not calculated.

Station Information

Active or discontinued:	Active	**Province / Territory:**	Ontario
Latitude:	46° 30' 44'' N	**Longitude:**	84° 22' 02'' W
Gross drainage area:	N/A	**Effective drainage area:**	N/A
Record length:	113 Years	**Period of record:**	1908 - 2020
Regulation type:	Regulated	**Regulation length:**	N/A
Real-time data available:	No	**Sediment data available:**	No
Type of water body:	River	**RHBN:**	No
EC Regional Office:	BURLINGTON	**Current Operation Schedule:**	Continuous
Data contributed by:	FISHERIES AND OCEANS CANADA	**Operation Period:**	JAN - DEC
Datum of published data:	INTERNATIONAL GREAT LAKES DATUM (1985)		

Data Collection History

This table contains information pertaining to the historical changes of defined elements in the operation of a station.

	Type	Operation schedule	Gauge type
1908 - 1910	Level	Seasonal	Recorder
1911 - 2020	Level	Continuous	Recorder

Historical Hydrometric Remarks

DATA PUBLISHED AS RECEIVED. DATA PUBLISHED MONTHLY BY CANADIAN HYDROGRAPHIC SERVICES (CHS) AS STATION 10980 SAULT STE MARIE (ABOVE). MONTHLY AND ANNUAL MEANS ONLY CALCULATED IF ALL DAILY MEANS AVAILABLE.

Click here for further information on remarks.

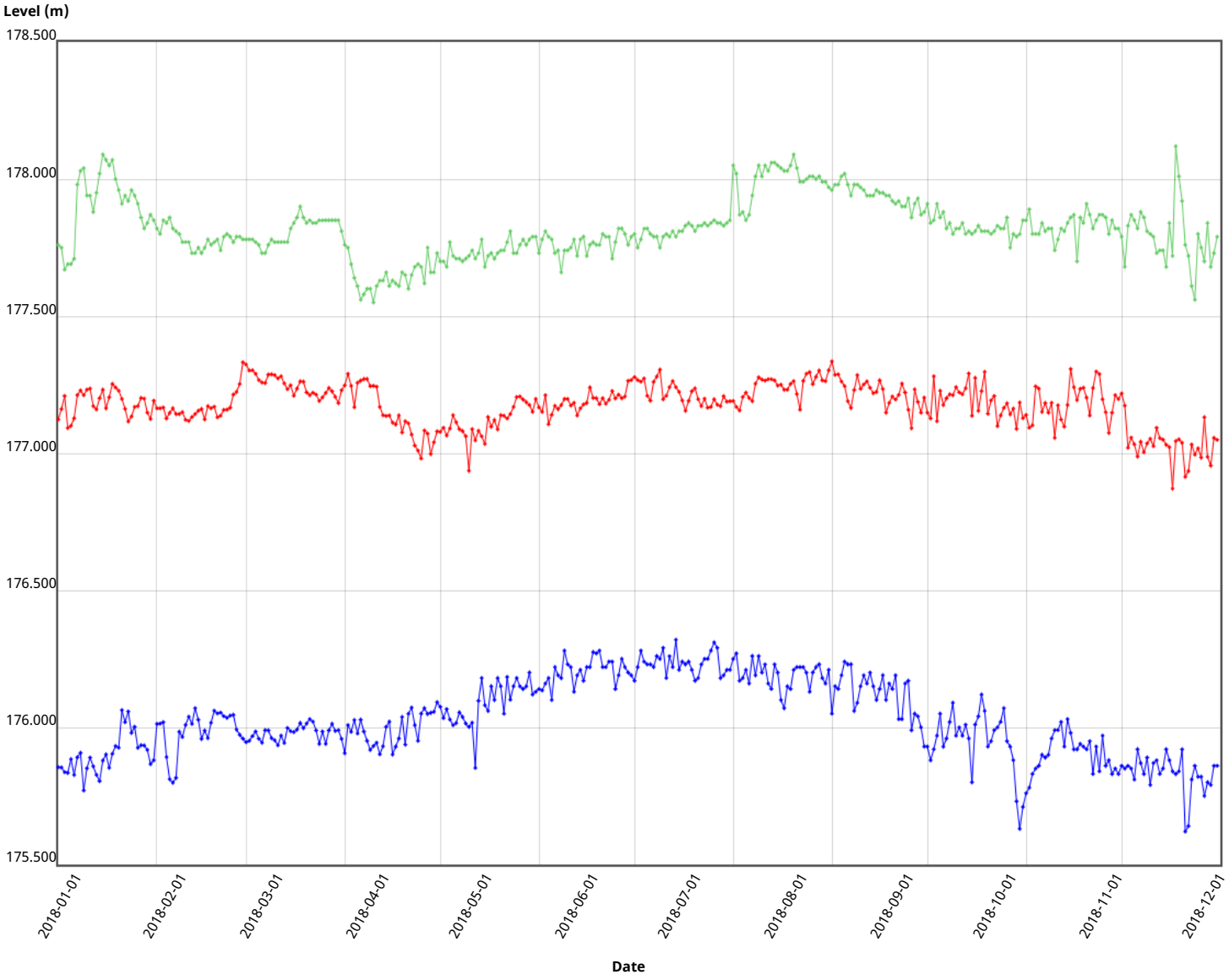
Government of Canada | Gouvernement du Canada

Daily Water Level Graph for ST. MARYS RIVER AT SAULT STE. MARIE (BELOW) (02CA005) [ON]

All times are specified in Local Standard Time (LST). Add 1 hour to adjust for Daylight Saving Time where and when it is observed.

Legend

2018 Data | Maximum | Minimum



Statistics corresponding to 110 years of data recorded from 1908 and 2018.*

*Note: If n<10, percentiles are not calculated.

Station Information

Active or discontinued:	Active	**Province / Territory:**	Ontario
Latitude:	46° 30' 40'' N	**Longitude:**	84° 20' 35'' W
Gross drainage area:	N/A	**Effective drainage area:**	N/A
Record length:	113 Years	**Period of record:**	1908 - 2020
Regulation type:	Regulated	**Regulation length:**	N/A
Real-time data available:	No	**Sediment data available:**	No
Type of water body:	River	**RHBN:**	No
EC Regional Office:	BURLINGTON	**Current Operation Schedule:**	Continuous
Data contributed by:	FISHERIES AND OCEANS CANADA	**Operation Period:**	JAN - DEC
Datum of published data:	INTERNATIONAL GREAT LAKES DATUM (1985)		

Data Collection History

This table contains information pertaining to the historical changes of defined elements in the operation of a station.

	Type	Operation schedule	Gauge type
1908 - 1910	Level	Seasonal	Recorder
1911 - 2020	Level	Continuous	Recorder

Historical Hydrometric Remarks

> DATA PUBLISHED AS RECEIVED. DATA PUBLISHED MONTHLY BY CANADIAN HYDROGRAPHIC SERVICES (CHS) AS STATION 11010 SAULT STE MARIE (BELOW). MONTHLY AND ANNUAL MEANS ONLY CALCULATED IF ALL DAILY MEANS AVAILABLE.

Click here for further information on remarks.