Attachment 15

Bay d'Espoir Unit 8 FEED – Concept Design Update Report

AtkinsRéalis

AtkinsRéalis

CONCEPT DESIGN UPDATE REPORT

NEWFOUNDLAND AND LABRADOR HYDRO

November 11, 2024

BDE-SN-40000-EN-DEG-0002-01
699257-3300-40EC-0001

BAY D'ESPOIR UNIT 8 FEED

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This concept design update report has been prepared based on the available data, inputs, and conditions at the time of its creation. The report captures a specific window in time of information and reflects the understanding and analysis of that moment. While this concept design update report provides valuable insights, stakeholders should recognize its limitations and understand that it may not align with the final design documents of the Bay d'Espoir Unit 8 FEED project.

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1 EXECUTIVE SUMMARY

1.1 Objective of the Concept Update Report

In 2017-2018, AtkinsRéalis (formerly SNC-Lavalin) undertook a study for NL Hydro on the proposed Bay d'Espoir Hydro Generating Unit No. 8. Two reports were produced and issued in March 2018, a report entitled "Hydraulic Analysis of the Conveyance System" (647756-0000-40ER-I-0001-00) and a comprehensive report on the project entitled "Class 3 Cost Estimate and Project Execution Schedule" (647756-0000-40ER-I-0002-00). These will collectively be referred to as "the 2017 Study" in this report. The primary objective of the 2017 Study was to evaluate options for adding an eighth unit to the existing Bay d'Espoir Generating Station in Powerhouse 2. The study detailed the preferred option at that time, laying the groundwork for future planning.

The 2024 Bay d'Espoir Unit 8 Front-End Engineering Design (FEED) project builds upon the 2017-2018 work, reaching a level of detail necessary to support an application for project approval by the Public Utilities Board (PUB) and to advance design documentation for the subsequent project phase.

The objective of this high-level concept design update report is to supplement and enhance the existing design documentation, as well as describe revisions to the concepts presented in the 2017 Study. The report delineates the design approach, underlying assumptions, optimization strategies, and governing codes and standards that will underpin the preliminary engineering phase, including performance specifications and drawings, for the 2024 Bay d'Espoir Unit 8 FEED.

2 GOVERNING STANDARDS, CODES AND GUIDES

2.1 General

At a minimum, the design will adhere to the following codes and standards:

NBC	National Building Code of Canada
OHS NL	Occupational Health and Safety Regulations, 2012, under the Occupational Health and Safety Act, 2012-Newfoundland and Labrador
NFC	National Fire Code of Canada
NFPA	National Fire Protection Association

2.2 Turbine-Generator

At a minimum, the turbine-generator design will adhere to the following codes, standards and guides:

ANSI/ASME PTC29	Speed-Governing Systems for Hydraulic Turbine-Generator Units
A	Standard specification for steel forgings, carbon and alloy, for general
ASTM A668M	Standard specification for steel forgings, carbon and alloy, for general industrial use
ASTM A743M	Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application
IEC 60193	Hydraulic turbines, storage pumps and pump-turbines - Model acceptance tests
IEC 61362	Guide to the specifications of the hydraulic turbines control system
IEC 60308	International code for testing of speed governing systems for hydraulic turbines
IEC 60041	Field acceptance tests to determine the hydraulic performance of hydraulic turbines, storage pumps and pump-turbines
IEEE 125	IEEE recommended practice for preparation of equipment specifications for speed-governing of hydraulic turbines intended to drive electric generators
IEEE 286	Recommended Practice for the Measurement of Power Factor Tip-Up of Electric Machinery Stator Coil Insulation
IEEE 421.1	IEEE Standard Definitions for Excitation Systems for Synchronous Machines
IEEE 810	Hydraulic Turbine and Generator Shaft Couplings and Shaft Runout Tolerances
IEEE 1043	Recommended Practice for Voltage-Endurance Testing of Form-Wound Bars and Coils
IEEE 1095	Guide for the Installation of Vertical Generators and Generators/Motors for Hydroelectric Applications

IEEE 1310	Recommended Practice for Thermal Cycle Testing of Form-Wound Stator Bars and Coils for Large Rotating Machines
IEEE 1553	IEEE Standard for Voltage Endurance Testing of Form-Wound Coils and Bars for Hydrogenerators
IEEE 1207	IEEE Guide for the Application of Turbine Governing Systems for Hydroelectric Generating Units
IEEE C57.32	Requirements, Terminology, and Test Procedures for Neutral Grounding Devices
IEEE C50.12	Standard for Salient-Pole 50 Hz and 60 Hz Synchronous Generators and Generators/Motors for Hydraulic Turbine Application Rated 5 MVA and above
IEEE 115	Test Procedures for Synchronous Machines
CEATI T 212700-03111	Guidance For Technical Specifications for The Procurement of Major Hydraulic Plant Equipment
CEATI T162700-0392	Hydro Generator Turbine Vibration and Balancing Field Guide
CEATI T182700-03	Guide to Ensuring Quality for Manufacturing and Installation
CEATI T122700-0381	Hydroelectric Turbine-Generator Units Guide for Erection Tolerances and Shaft System Alignment
ISO 20816-5	Mechanical Vibration - Measurement and Evaluation of Machine Vibration. Part 5: Machine sets in hydraulic power generating and pump-storage plants
ISO 21940-11	Mechanical Vibration — Rotor Balancing. Part 11: Procedures and tolerances for rotors with rigid behaviour
ASTM A343/A343M	Standard Test Method for Alternating-Current Magnetic Properties of Materials at Power Frequencies Using Wattmeter-Ammeter-Voltmeter Method and 25-cm Epstein Test Frame
ASTM A345	Standard Specification for Flat-Rolled Electrical Steels for Magnetic Applications
ASTM A677	Standard Specification for Non-oriented Electrical Steel Fully Processed Types
ASTM B48	Standard Specification for Soft Rectangular and Square Bare Copper Wire for Electrical Conductors
ASTM B187/B187M	Standard Specification for Copper, Bus Bar, Rod, and Shapes and General Purpose Rod, Bar, and Shapes
ASTM D149	Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

2.3 Hydromechanical Equipment

At a minimum, trashracks, maintenance gates, the operating gate and all associated embedded parts will adhere to the following codes and standards:

CISC	Canadian Institute of Steel Construction
ASME BPV	Boiler and Pressure Vessel Code, Section VIII
CSA A23.3	Design of Concrete Structures
CSA S16	Design of Steel Structures
DIN 19704-1	Hydraulic Steel Structures– Part 1: Criteria for Design and Calculation
DIN 19704-2	Hydraulic Steel Structures– Part 2: Design and Manufacturing
USACE ETL 1110-2-584	Design of Hydraulic Steel Structures

The intake operating gate hoist and the intake maintenance gate hoist will adhere to the following codes and standards:

ASME B30.7	Base Mounted Drum Hoist
AGMA 260.02	Design of Components-enclosed gear drives, Bearings, Bolting, Keys and Shafting
FEA	FEA Rules for Design of Hoisting Appliances
CSA	CSA W59 Welded Steel Construction (Metal Arc Welding)

Other applicable technical references for hydromechanical equipment:

Erbisti, P.C.F., Design of Hydraulic Gates. 1st Edition. 2004.

Falvey, H.T., Air-Water Flow in Hydraulic Structures. USBR Engineering Monograph No. 41. 1980.

US Army Corps of Engineers, Hydraulic Design Criteria Sheet 050-1: Air Demand – Regulated Outlet Works. January 1964.

Zangar, C.N., Hydrodynamic Pressures on Dams Due to Horizontal Earthquake Effects. USBR. 1952.

Sehgal, C.K. et.al., Recommendations for the design of intake trashracks. Hydropower & Dams, Issue Six, 2005.

2.4 Balance of Plant Mechanical Equipment

At a minimum, the powerhouse balance of plant systems will adhere to the following codes and standards:

ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME B31.1	Power Piping

HI	Hydraulic Institute for Pumps

2.5 Civil

At a minimum, the design for the civil and structural work will adhere to the following codes, standards and guides:

AAMP	Association for Materials Protection and Performance (AAMP) (formerly SSPC)
ACI 207.1	Guide to Mass Concrete
ACI 207.2	Report on Thermal and Volume Change Effects on Cracking of Mass Concrete
ACI 224	Control of Cracking in Concrete Structures
AISE Tech Report No. 13	Guide on the Design and Construction of Mill Buildings
ASCE	Manuals and Reports on Engineering Practice No. 79 - Steel Penstocks, 2nd edition
ASCE	Water Pressure on Dams During Earthquakes, Westergaard, H.M., 1933
ASTM A759	Carbon Steel Crane Rails
CDA Guidelines	Canadian Dam Association, Dam Safety Guidelines
CISC	Handbook of Steel Construction
CSA A23.1/A23.2	Concrete Materials and Methods of Concrete Construction / Test Methods and Standard Practices for Concrete
CSA A23.3	Design of Concrete Structures
CSA A3000	Cementations Materials Compendium
CSA G40.20/G40.21	General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel
CSA S16	Design of Steel Structures
CSA S136	North American Specification for the Design of Cold-Formed Steel Structural Members
CSA W59	Welded Steel Construction (Metal Arc Welding)
FM DS 05-04	Factory Mutual Property Loss Prevention Data Sheet 5-4 Transformers
NFPA 851	Recommended Practice for Fire Protection for Hydroelectric Generating Plants
ASME BPV	Boiler and Pressure Vessel Code, Section VIII
DIN 19704-1	Hydraulic Steel Structures – Part 1: Criteria for Design and Calculation
USACE ETL 1110-2-584	Design of Hydraulic Steel Structures
USBR	Design of Gravity Dams
USBR	Design of Small Dams

2.6 Balance of Plant Electrical Equipment

At a minimum, the powerhouse balance of plant electrical equipment will adhere to the following references:

CSA 22.1	Canadian Electrical Code Part I
CSA 22.2	Canadian Electrical Code Part II
C57.13	Requirement for Instrument Transformers
CSA C9	Dry-Type Transformers
C22.2 No. 178	Automatic Transfer Switches
CSA C22.2 NO. 201:M84	Metal-Enclosed High Voltage Busways
CSA C61869-1	Instrument transformers - Part 1: General requirements
CSA C61869-2	Instrument transformers - Part 2: Additional requirements for current transformers
CSA CAN3-C108.3.1-M84	Limits and Measurement Method of Electromagnetic Noise from AC Power Systems 0.15-30 MHz
CSA G164	Hot Dip Galvanizing of Irregularly Shaped Articles
CSA W47.1	Fusion Welding of Steel
CSA W47.2	Fusion Welding of Aluminium Company Certification
CSA W59	Welded Steel Construction
CSA W59.2	Welded Aluminium Construction
C22.10	Québec Construction Code, Chapter V - Electricity, Canadian Electrical Code, Part I (Twenty-third edition) with Québec Amendments
C22.2 No. 22	Electrical equipment for flammable and combustible fuel dispensers
C22.2 No. 31	Switchgear Assemblies
C22.2 M85	Enclosed Switches
CAN/CSA-C60044-1	Instrument Transformers Part 1: Current Transformers
CAN/CSA-C60044-2	Instrument Transformers Part 2: Inductive Voltage Transformers
IEEE C37.04	IEEE Standard for Ratings and Requirements for AC High-Voltage Circuit Breakers with Rated Maximum Voltage Above 1000 V
IEEE C37.06	IEEE Standard for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis-Preferred Ratings and Related Required Capabilities for Voltages Above 1000 V

IEEE C37.09	IEEE Standard Test Procedures for AC High-Voltage Circuit Breakers with Rated Maximum Voltage Above 1000 V
IEEE C37.010	IEEE Application Guide for AC High-Voltage Circuit Breakers > 1000 Vac Rated on a Symmetrical Current Basis
IEEE C37.011	IEEE Guide for the Application of Transient Recovery Voltage for AC High-Voltage Circuit Breakers with Rated Maximum Voltage above 1000 V
IEEE C37.11	IEEE Standard Requirements for Electrical Control for AC High-Voltage (>1000 V) Circuit Breakers
IEEE C37.12	IEEE Guide for Specifications of High-Voltage Circuit Breakers (over 1000 V)
IEEE C37.013	IEEE Standard for AC High-Voltage Generator Circuit Breakers Rated on a Symmetrical Current Basis
IEEE C37.013a	IEEE Standard for AC High Voltage Generator Circuit Breakers Rated on a Symmetrical Current Basis - Amendment 1: Supplement for Use with Generators Rated 10-100 MVA
IEEE C37.20.2	IEEE Standard for Metal-Clad Switchgear
IEEE C37.20.7	IEEE Guide for Testing Metal-Enclosed Switchgear Rated Up to 38 kV for Internal Arcing Faults
IEEE C37.47	IEEE Standard Specifications for High-Voltage (>1000 V) Distribution Class Current-Limiting Type Fuses and Fuse Disconnecting Switches
IEEE C37.90	IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C37.110	IEEE Guide for the Application of Current Transformers Used for Protective Relaying Purposes
IEEE C57.13	IEEE Standard Requirements for Instrument Transformers
IEEE C62.11	IEEE Standard for Metal-Oxide Surge Arresters for AC Power Circuits (>1 kV)
IEEE 62271-37-013	IEEE/IEC International Standard for High-voltage switchgear and controlgear--Part 37-013: Alternating current generator circuit-breakers
IEEE C29.1	Test Methods for Electrical Power Insulators
IEEE C37.23	IEEE Standard for Metal-Enclosed Bus

IEEE C22.1	Canadian Electrical Code, Part 1 – Safety Standard for Electrical Installations
IEEE C37.13	IEEE Standard for Specifications of Low Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.16	IEEE Guide for Specifications of Low Voltage Power Circuit Breakers and AC Power Circuit Protectors – Preferred Ratings, Related Requirements and Application Recommendations
IEEE C37.17	IEEE Standard for Trip Devices for AC and General Purpose DC Low-Voltage Power Circuit Breakers
IEEE C37.20.1	IEEE Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
IEEE C37.50	IEEE Standard for Switchgear – Low Voltage AC Power Circuit Breakers Used in Enclosures – Test Procedures
IEEE C37.51	Metal-Enclosed Low-Voltage AC Power Circuit Breaker Switchgear Assemblies – Conformance Test Procedure
IEEE C50.12	Standard for Salient-Pole 50 Hz and 60 Hz Synchronous Generators and Generators/Motors for Hydraulic Turbine Application Rated 5 MVA and above
IEEE 115	Test Procedures for Synchronous Machines
IEEE 286	Recommended Practice for Measurement of Power Factor Tip-Up of Electric Machinery Stator Coil Insulation
IEEE 522	Guide for Testing Turn Insulation of Form-Wound Stator Coils for Alternating-Current Electric Machines
IEEE 810	Standard for Hydraulic Turbine and Generator Integrally Forged Shaft Couplings and Shaft Runout Tolerances
IEEE Std 32	Standard Requirement, Terminology, and Test Procedure for Neutral Grounding Devices
IEEE C37.30	Requirements for High Voltage Switches
IEEE 665	Guide for Generating Station Grounding
IEEE 141	Recommended Practice for Electric Power Distribution for Industrial Plants
IEEE 399	Recommended Practice for Industrial and Commercial Power Systems Analysis
IEEE 666	Design Guide for Electric Power Service Systems for Generating Stations
IEEE 946	Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Stations
IEEE 1187	Recommended Practice for Installation Design and Installation of Valve-Regulated Lead-Acid Storage Batteries for Stationary Applications

IEEE 1189	Guide for Selection of Valve-Regulated Lead Acid (VRLA) Batteries for Stationary Applications
IEEE 1375	Guide for the Protection of Stationary Battery Systems
IEEE C57.12.01	General Requirements for Dry-Type Distribution and Power Transformers, Including Those with Solid-Cast and/or Resin Encapsulated Windings
IEEE C57.12.70	Standard for Terminal Markings and Connections for Distribution and Power Transformers
IEEE C57.12.91	Standard Test Code for Dry-Type Distribution and Power Transformers
IEEE C57.96	Guide for Loading Dry-Type Distribution and Power Transformers
CAN/ULC S524-06	Installation of Fire Alarm Systems
IESNA	Illuminating Engineering Society - The Lighting Handbook – 10th Edition

3 ASSUMPTIONS

The assumptions outlined in the following section are not exhaustive but will eventually be documented and added to the project final assumptions register.

1. The front-end engineering design for the transmission line is being addressed by NL Hydro and will not be elaborated upon in this report.

2. Design of the relocation for Unit 7 first pylon tower is included in the transmission line design that is being addressed by NL Hydro.

3. The design is to consider minimizing the outage time and impact on power production for the existing units (Units 1 to 7) as a result of construction.
4. The existing powerhouse overhead crane will be utilized for Unit 8 only if the capacity of generating unit remains at or below 155 MW. In this case, no modifications or major upgrade are required for the existing crane, except to extend the crane runway.

5. Bedrock depths in the vicinity of the penstock have been assumed based on lidar, test pit, and borehole data which have been provided by NL Hydro.

6. A new set of draft tube gates for Unit 8 will be provided to ensure that the existing set can be used for operation and maintenance of Unit 7 when required during the construction of Unit 8.
7. Vertical datum for the project will be CGVD28.

8. Horizontal datum for the project will be NAD83 original MTM Zone 2.

4 OPTIMIZATION STRATEGIES

The optimization strategies for Bay d'Espoir FEED Unit 8 focus on high-level approaches to enhance efficiency, minimize cost, and ensure constructability, and considered safety by design (e.g. elimination of confined spaces, gate handling methods, etc.). Detailed specifics are covered in subsequent sections in Design Approach. The following summarizes the optimization considerations by area:

4.1 Headrace

- Channel Routing:
  - Evaluated four (4) potential channel routes.
  - Factors considered: constructability, hydraulics including frazil ice performance of all units and vorticity review, impact on existing work and cost.
  - Reviewed two (2) of those routes in more detail for final optimized headrace canal route and selection of the recommended route.
- Log boom removed from scope because entrance will be protected by existing boom for Intakes 1 to 3.

4.2 Intake

- Sealing Options:
- Explored upstream vs downstream sealing with respect to emergency closure and gate cracking requirements.
- Maintenance and Operation Requirements:
  - Addressed gate and bulkhead maintenance access.
- Considered Operator needs.
- Intake Configuration - Factors considered: hydraulics including submergence and vorticity.

4.3 Penstock

- Penstock Routing:
  - Prioritized constructability.
  - Minimized excavation in overburden and rock.

4.4 Powerhouse

- Layout and Equipment:
  - Factors considered: safety, maintenance, ease of use and cost.

4.5 Tailrace

- Tailrace:
  - Factors considered: constructability, hydraulics (minimized headloss) and cost.

5 DESIGN APPROACH

5.1 Water Conveyance System (WCS)

5.1.1 Headrace Channel Route

The headrace described in the 2017 Study included the expansion of the existing Unit 7 canal with a bifurcation of the channel near Intake 4 to accommodate the new Unit 8 intake. A constructability review highlighted that there is a high likelihood that blast rock could partially block the Unit 7 canal during the development of the new canal and that channel depth would make rock removal difficult and expensive. This route would also result in an unacceptably high risk of an unscheduled Unit 7 outage during canal construction. In addition, there was concern regarding the stability of the rock wall that would remain between the existing Unit 7 canal and the bifurcated section of the new canal to the new intake. This instability poses a risk during construction as well as during operation. AtkinsRéalis has also determined that controlled blasting should be used for bedrock removal near other infrastructure such as intakes and rock canal side walls, and the new intake and canal should be located no closer than 25 m to existing infrastructure. As a result of the risks noted above, alternative headrace channel routes were explored.

Four additional headrace layouts were reviewed:

- Alternative 1 – entrance on south side at approx. 200m upstream of intake 3
- Alternative 2 – entrance on north side at approx. 345m upstream of intake 4
- Alternative 3 – entrance on south side at approx. 50m upstream of intake 3
- Alternative 4 – entrance on south side at approx. 115m upstream of intake 3

Based on the modelled flow effects on Intake 3 as well as the inability to maintain the required 25 m rock buffer around all canal edges, Alternatives 3 and 4 were deemed to be unsuitable and were not studied further.

The two (2) remaining alternatives were further reviewed to determine the recommended option to carry forward (See Figures 5-1 and 5-2). The two options are briefly described as follows:

Alternative 1: *Long channel with entrance from existing south canal*

- A full rock cut is anticipated for 3/4 of the length of the channel. A rock plug may not be possible during construction if the rock profile is below the anticipated reservoir level during construction (180.5m). Alternative methods to isolate the channel during construction may be required.
- Underwater removal of granular material is required at the channel entrance.
- No widening or expansion of the forebay area is anticipated.

Alternative 2: *Long channel with entrance from existing north canal*

- There will be a full rock cut for the entire length of the channel. A rock plug will be used during construction to isolate the channel given the reservoir level during construction is anticipated to be at 180.5m which is the typical reservoir level in August.
- Underwater removal of granular material at the entrance is likely minor.
- No widening or expansion of the forebay area is anticipated.

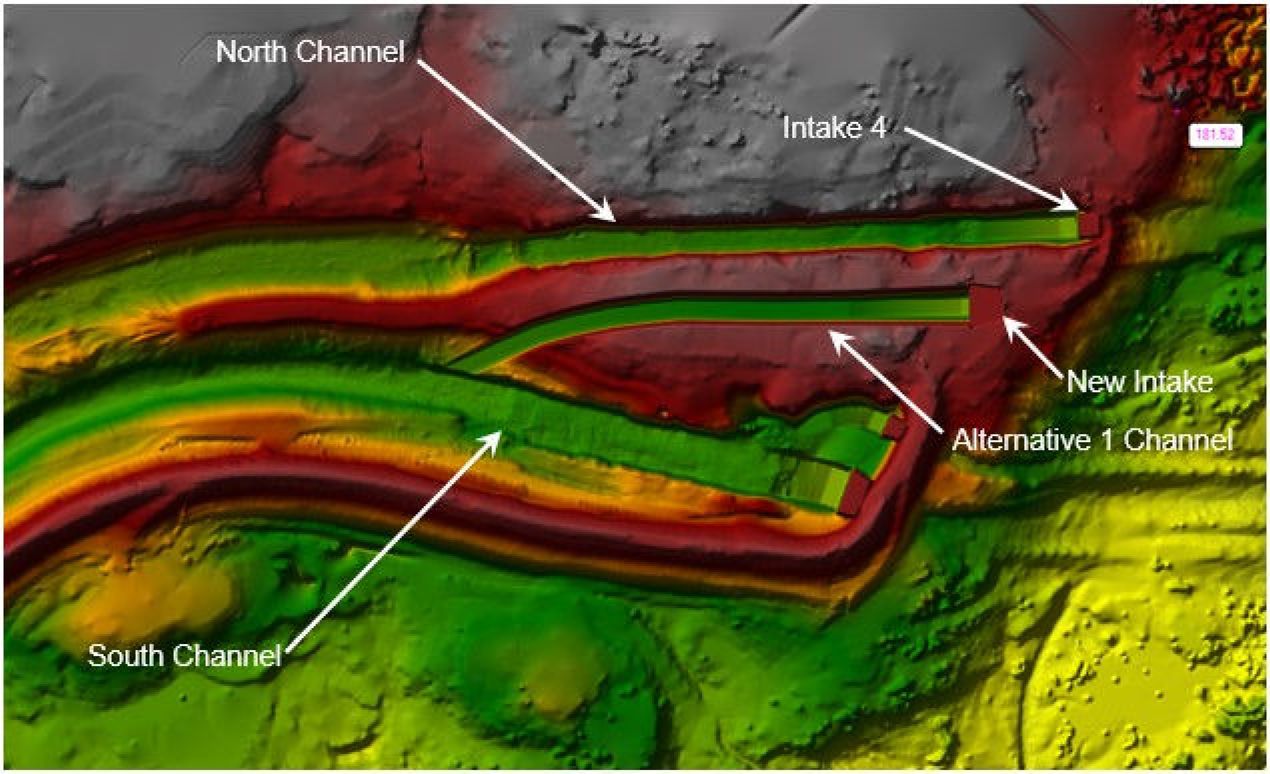

Figure 5-1 - Alternative 1

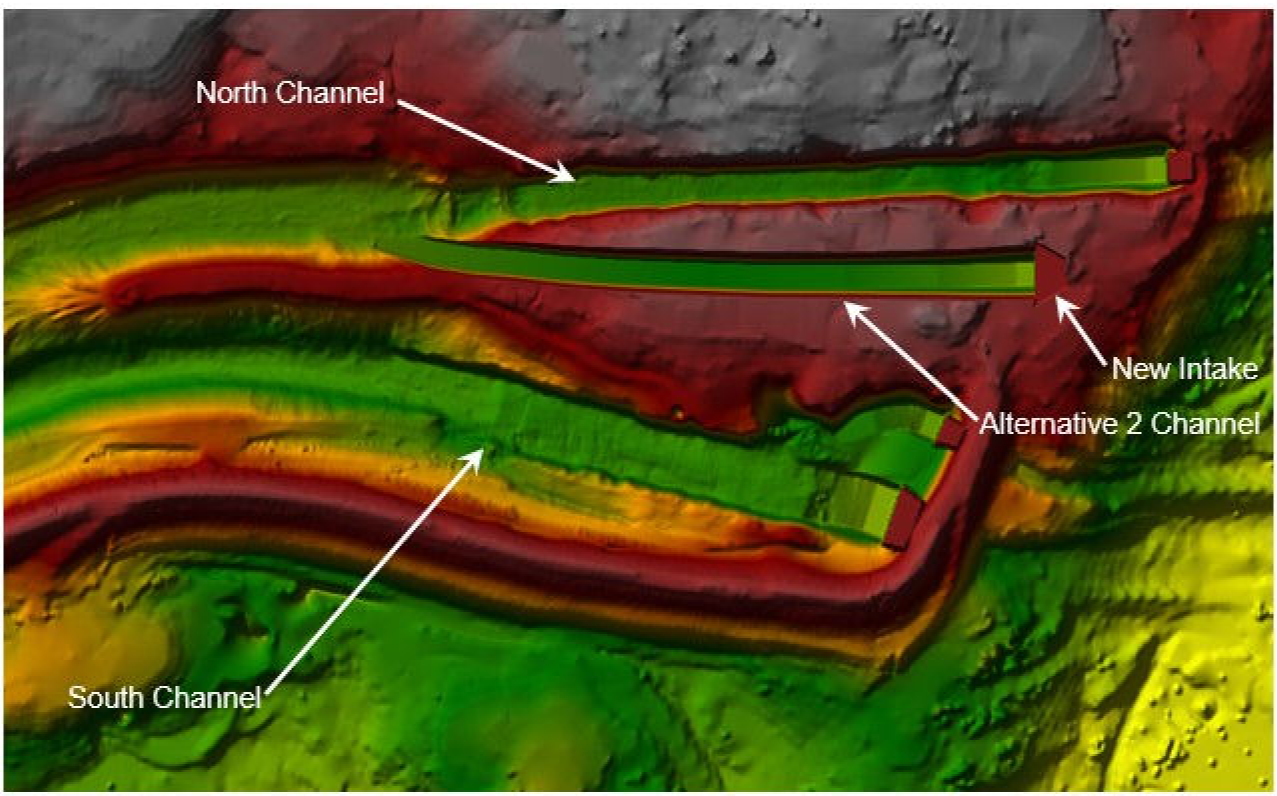

Figure 5-2 - Alternative 2

Further adjustments to Alternative 1 were made to improve flow dynamics at the entrance and along the channel as well as reduce the amount of underwater work required by widening the channel and moving the entrance towards the intakes. The following figure shows the adjusted Alternative 1 layout.

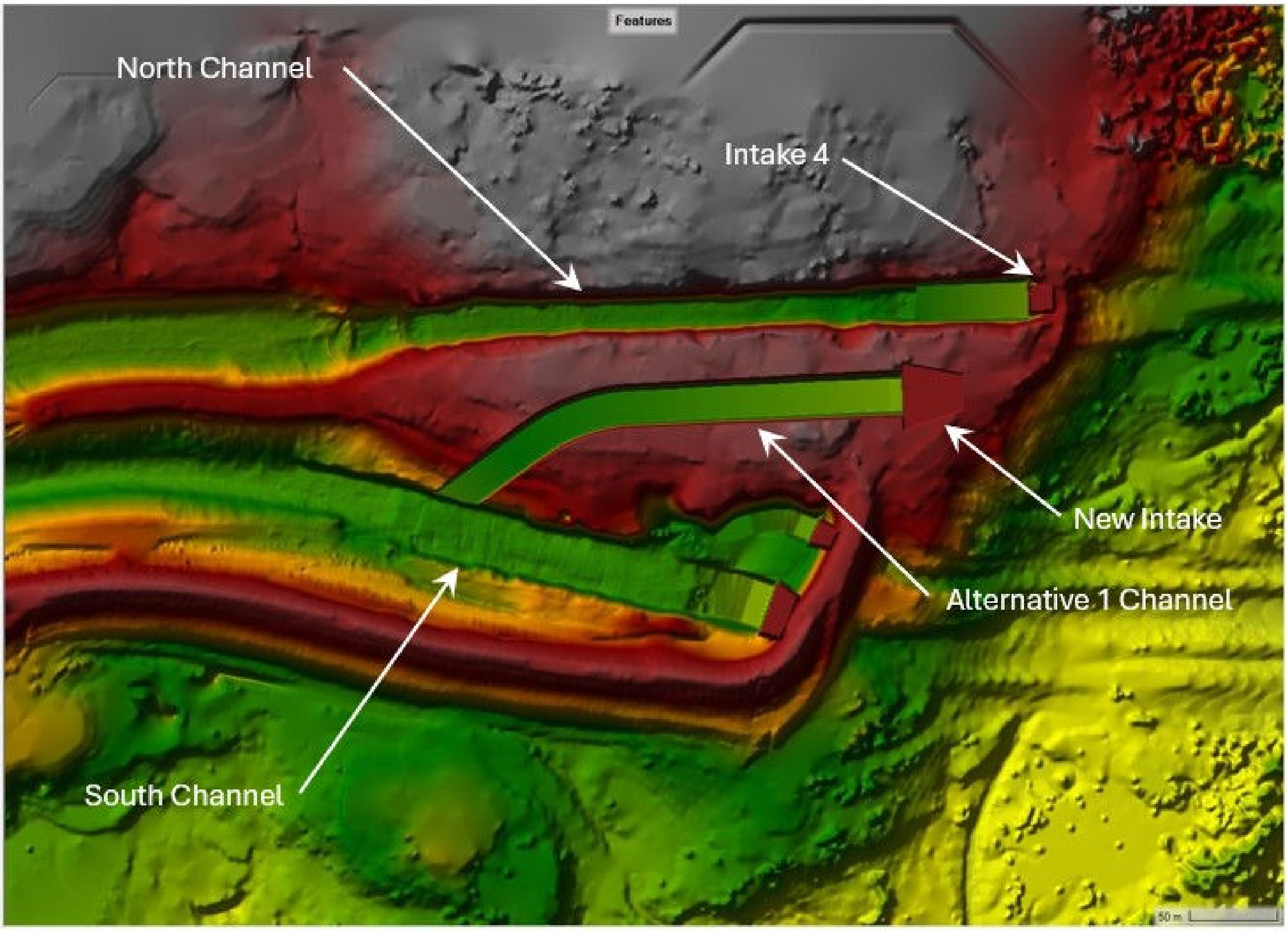

Figure 5-3 - Alternative 1 - Adjusted

5.1.2 Frazil Ice Consideration

Historically, frazil ice has not been observed at the Long Pond intakes; however, frazil ice was encountered at Intakes 3 and 4 on January 19, 2024, raising concerns that this may be an issue in the future with climate change resulting in a reduction of ice cover formation on the headpond. The normal process for design of a headrace canal incorporates review of the ice regime including frazil ice formation and this 2024 frazil ice event highlighted the importance of that review.

Adjustment to the layout of Alternatives 1 and 2 were completed to reduce velocities and minimize the effect of the new channel on the existing intakes. It was agreed with NL Hydro that the flow conditions in the south channel are preferred and should be emulated in the Unit 8 channel. Adjustments to the width of the new channel were completed to reduce velocities to be more in line with the conditions seen in the south channel. In addition, the entrances were adjusted to determine the most favorable flow conditions.

5.1.3 Headworks

The Unit 8 channel was initially developed in the model to match the characteristics of the bedrock section of the Unit 7 channel. According to bathymetry obtained in the headrace channel and Lidar obtained in the area, the average width at the top of the channel is 20 m, the average width at the bottom is approximately 12 m and side slopes are 1H:3V below the typical water surface. The Unit 7 channel also includes a sloped drop in the channel invert approximately 93 m upstream of the intake to meet the elevation of the intake entrance. The Unit 7 intake sill elevation is at 166.00 m (CGVD28), while the design sill elevation for the Unit 8 intake is at 163.00 (CGVD28).

Adjustments to the alternative layouts have generally included decreasing the gradient of the canal side slopes, increasing the bottom width of the channel, increasing the overall width of the new channel, and flaring the entrances in the model. This process has been iterative to mimic conditions that will reduce the likelihood of frazil ice while minimizing construction cost implications as much as possible.

5.1.4 Intake

A new intake location was selected to maintain access to Intake 4 via the existing access road downstream of the new intake. This location will also ensure that the canal rock walls are at or above the intake deck.

The submergence at the intake was assumed to be adequate based on Gordon's formula in the 2017 Study. As noted in the 2017 report, the submergence is acceptable at the gate, but the submergence at the trash racks appears slightly deficient at the minimum operating level. To account for this deficiency at this stage of design development, the penstock invert was lowered by approximately 692 mm compared to the penstock invert of the adjacent intakes. A flow 3D model was developed for the new intake configuration and submergence for both the gate and the trash racks were confirmed to meet submergence criteria.

5.1.5 Penstock

The penstock alignment and profile were reviewed and are being optimized. The length of the new penstock will be approximately 1100 m long, which is 55 m longer than Penstock 4 due to the new intake location being further upstream than Intake 4.

The overall profile of the new penstock for Unit 8 will be similar to the existing Penstock 4 profile. This design will ensure that the new penstock will not be notably higher or lower than the existing penstock to prevent any foundational loading on the existing penstock. The existing and new penstocks will be parallel from the powerhouse to approximately 320 m upstream of the powerhouse with 18.44 m center to center separation between the existing and the new penstock. Upstream of this point, the new penstock will bend horizontally away from the existing penstock to better line up with the location of the new intake, which is approximately 55 m west and 40 m south of Intake 4.

Since the pressure relief valve from the spiral case is eliminated, the pressure rise due to water hammer will increase from 30% to 50% of static head. The steel penstock thickness increases along the length of the penstock, with the maximum increment close to the powerhouse and progressively reducing for sections away from the powerhouse. The penstock steel will be required to be designed for external loading including transformer shipping loads and other vehicle loads envisaged to cross Unit 8 penstock, during the detailed design.

The ground surface elevations are available from the 2023 Lidar; however, the exact rock profiles along the new penstock are not available. Bedrock depths have been assumed based on lidar, test pit, and borehole data, as well as 1977 as-built information, in the vicinity of the penstock which have been provided by NL Hydro.

5.1.6 Tailrace

The existing tailrace channel linking Powerhouse 2 to the tailrace channel of Powerhouse 1 was not intended to accommodate two 150 MW units and therefore tailrace widening is currently undergoing review and optimization.

To minimize future head losses when operating both units simultaneously, widening of the tailrace channel is anticipated and the extent of the widening will be confirmed using Hec-Ras modeling. This widening will also affect the submergence of the new and existing units at Powerhouse 2. The minimum submergence requirements at Lower Low Water Large Tide (LLWLT) for Unit 8 will be determined using the expanded tailrace dimensions. The Unit 7 submergence requirements will also be confirmed given the expanded tailrace dimensions. The tailrace dimensions will be adjusted as necessary to minimize head losses while meeting submergence requirements for both units.

The back water effect in the expanded tailrace will be determined under flood conditions to ensure the powerhouse floor is not flooded during an extreme rainfall or runoff event. The tailwater level for the expanded tailrace will be evaluated with full unit capacity during a 1:1000-year inflow event from Northwest Brook, in conjunction with a Higher High Water Large Tide (HHWLT).

The scope of the tailrace analysis was expanded to include flow impacts and modeling of the tailrace conditions downstream of the Powerhouse 2 tailrace to the bridge located on Highway 361.The downstream flow conditions had not previously been investigated as part of the 2017 Study.

5.2 Water-to-Wire (W2W) Equipment

5.2.1 W2W Major Equipment

As in the 2017 Study, one vertical shaft Francis turbine of rated capacity corresponding to generator output of 172 MVA (154.4 MW) at rated net head 174.17 m and rated speed of 225 rpm, will be provided as Unit 8 in the powerhouse. The turbine generator components and other heavy components in the powerhouse will be handled by the existing overhead travelling crane with the capacity of 270 metric tons. The rails and bus bars of the existing crane will be extended to cover the Unit 8 powerhouse. The step-up transformer of capacity 172 MVA will be provided outside the powerhouse to step-up the generation voltage from 13.8 kV to line voltage 230 kV.

Numerous optimization options have been evaluated, analyzed, and reviewed for their feasibility, as documented in the Options Analysis Report 699257-2300-40ER-0001. The options retained at this time and approved by NL Hydro for this FEED are described in the subsequent sections.

5.2.1.1 Oil Free Lower Guide Bearing

To prevent the contamination of tailrace water from oil, the turbine guide bearing will be an oil free type and lubricated by filtered clean water. The clean filtered water will be supplied from the cooling water system.

5.2.1.2 Greaseless Wicket Gate Bushing

To prevent grease-induced tailwater pollution and reduce maintenance loads, the wicket gate bushes will be oil free self-lubricating bushing of material PTFE or other self-lubricating material.

5.2.1.3 Mechanical Tensioner Type Fasteners

Mechanical tensioner type fasteners will be installed instead of heat stretch type fasteners for large size bolts in Unit 8.

5.2.1.4 Dust collection System for Collector Rings

A carbon dust collection system for the collector rings will be installed. The dust collector system for the collector ring of generator will extract the carbon dust from source, to avoid dispersion over the machine and dust inhalation by the Operator.

5.2.1.5 Cooling Water Supply

The water for the cooling water system is to be tapped from the penstock. See Section 5.3.7 for details.

5.2.1.6 Runner Model Test

Turbine model test will be conducted by turbine generator supplier to ensure the achievement of the efficiency and the performance guarantees of the turbine.

5.2.1.7 Synchronous Condenser

Synchronous condenser capability will be added to the Unit 8 to allow the generator to export or import the full range of reactive power within the capability of the generator. Unit Control System will interface with the excitation system to start, operate, and stop the synchronous condenser mode operation. The air depression system will be provided to depress the water in the draft tube and run the generator in the condenser mode.

5.2.2 Intake Civil Works

The new intake will be a reinforced concrete structure which will vary notably from the existing intakes and the design proposed in the 2017 Study as follows:

- The geometry for the hydraulic passage will be similar to the four existing intakes except that it will be lower in elevation by 692 mm to address submergence concerns.
- The air vent will be incorporated into the intake operating gate slot instead of a separate air vent.
- A hoist house will be provided to permit lifting of the maintenance and intake gates fully out of the guides above the intake deck for maintenance.
- A new intake will be located about 55 m upstream and 40 m to the south of the location of the Unit 7 intake. The intake location has been selected to maintain a minimum of 25 m between the new channel and the existing south edge of the Unit 7 channel.

5.2.3 Intake Hydro-Mechanical Equipment

The new water intake will include the following mechanical equipment:

- Two sets of intake trashracks (INTR) with embedded parts (opening dimensions to be confirmed).
- One downstream sealing intake maintenance gate (INMG) and its associated embedded parts will be provided downstream of the center pier replacing two sets of stoplogs, one each side of the center pier, for the original intakes.
- Two sets of dogging devices for INMG, the first set will be used to support the INMG above the deck for maintenance and storage purposes. The second set will be used to secure the INMG in the slot for installation and removal via a mobile crane.
- One upstream sealing intake operation gate (INOG) of the vertical fixed wheel type and associated embedded parts will be provided, as opposed to the downstream sealing gates for the existing intakes.
- Two sets of dogging devices for INOG, the first set will be used to support the INOG above the deck for maintenance purposes. The second set will be used to secure the INOG in the slot for installation and removal of the gate via a mobile crane.
- One wire-rope hoist, mounted and secured on a twin girder mobile overhead bridge structure for the operation of the INOG.
- One wire-rope hoist, mounted and secured on the same twin girder mobile overhead bridge structure for the operation of the INMG.
- One lifting beam for intake trashrack panels.
- Intake trashrack panels and lifting beam storage racks.
- A penstock filling valve system will be installed in the intake structure. The system includes a connection pipe to the upstream reservoir, a connection pipe to the downstream side of the INOG, and a connection pipe to the space between the INMG and INOG. The valves can be operated manually by a long stem actuator, which would be accessible and operable from the intake gate house floor. An alternative method of filling the penstock will be by crack opening of the INOG.

5.2.4 Intake Trashracks (INTR)

The concept for the intake trashracks will be generally as described in the 2017 Study Report.

Each trashrack panel can be handled with an estimated 75 metric ton rated mobile crane, and a lifting beam will be provided with the trash racks.

The trashrack panels and the lifting beam will be stored in two trashrack storage racks at the intake deck level.

5.2.5 Intake Maintenance Gate (INMG)

A new downstream-sealing, vertical lift slide gate will be provided for the new intake. The INMG is provided for the purpose of isolating downstream water passage for maintenance and will be operated only in balance head conditions.

A fill valve (included in the filling valve system will be provided for filling the space between INOG and INMG.The fill valve will be compliant with work protection requirements lockout/tagout (LOTO) consistent with the INMG being a single point of isolation for the penstock and INOG.

During normal facility operation and when not in use, the INMG will be dogged and stored above the intake deck elevation (connected to its wire-rope hoist). When it is required to transfer the INMG outside of the hoist house for major overhaul, the INMG will be dogged inside its dedicated slot to be dismantled from the wire-rope hoist and be removed by a mobile crane inside the hoist house through a full height overhead door.

In the event of INMG closure for downstream water passage maintenance, the INOG will be opened in a cracked position (approximately 50 mm opening) to drain the water between the INMG and INOG. To prevent a vacuum, an air vent system with four DN250 air pipes will be used.

An alternative to crack opening of the INOG would be to operate the penstock filling valve system with the addition of a drain pump. This could be discussed and developed further in the detailed design phase.

INMG will be designed to operate as a "single point of isolation" in accordance with Newfoundland and Labrador Occupational Health and Safety (NLOHS) Regulations.

5.2.6 Intake Operating Gate (INOG)

The new Intake Operating Gate (INOG) will be an upstream sealing gate of the fixed wheel type. The INOG will be used to isolate the penstock or the generating unit from the upstream forebay for inspection or maintenance purposes. It will also be used as the emergency closing device to protect the generating unit in case of a closing fault of the turbine wicket gates and to protect the powerhouse against an eventual flooding originating from the upstream forebay.

During normal operation of the power station, the INOG will remain open hanging from its dedicated hoist right above the penstock opening. The INOG will be maintained in such a position that its bottom edge is located some 300 mm above the lintel, so as not to affect the flow, but ready to be closed in an emergency event such as a generating unit malfunction or a load rejection. A fill valve will be provided for initial filling of the penstock. The gate will also be used in the cracked position (about 200 mm opening) for filling the penstock. The fill valve will be compliant with work protection requirements lock out/tag out (LOTO) consistent with the INOG being a single point of isolation for the penstock.

INOG will be designed to operate as a "single point of isolation" in accordance with NLOHS Regulations.

5.2.7 Intake Mobile Overhead Bridge Structure

A new custom-designed mobile overhead bridge structure will be provided to support both the INMG and INOG wire-rope hoists. The INMG and INOG wire-rope hoists will be bolted on top of the mobile bridge structure. The mobile overhead bridge structure can travel on a set of runway rails. The runway rails will be installed along the length of the hoist house and will be supported by the structural columns of the hoist house building.

5.2.8 Overhead Travelling Maintenance Crane

An overhead travelling maintenance crane will be provided to assist with the maintenance of the INOG and INMG wire-rope hoist components, as well as INOG components such as wheels, rollers and seals. The overhead travelling maintenance crane will have an approximate capacity of 2 metric tons and will be located above the intake mobile overhead bridge structure.

5.3 Powerhouse

The powerhouse will be generally as described in the 2017 Study Report except that a service elevator will be installed to access the sub-levels of the powerhouse, and a storage room is proposed for the Unit 8 draft tube gates.

5.3.1 Service Elevator

A new service elevator will be provided near the main transformer at Gridline A between Gridline 9-10 (see drawing BDE-AKR-40000-AR-DGA-0006-01). The elevator will have landings at Spiral case access floor, Turbine floor, Generator floor and Main floor. The service elevator will be used for transferring tools and equipment into lower floors. The machine room will be located on top of the elevator. Stairs will be provided to access the machine room. There will also be access provided to the adjacent Unit 7 on each floor.

5.3.2 Excavation

The excavation for the powerhouse will be generally as described in the 2017 Study Report except that additional detailed rock excavation will be required to accommodate a service elevator, fire pump room, and a storage room for the draft tube gates. The rock excavation will need to be performed in a manner that will not damage the existing powerhouse.

5.3.3 Concrete Infrastructure (under El. 12.2 m)

The concrete for the powerhouse will be generally as described in the 2017 Study Report except that additional concrete will be required to accommodate the new service elevator and the corridors between the elevator and the powerhouse, the fire pump room, and the storage room for the draft tube gates.

5.3.4 Steel Superstructure

The concept for the powerhouse superstructure will be generally as described in the 2017 Study Report.

5.3.5 Architecture

The architecture for the powerhouse will be generally as described in the 2017 Study Report. The additional elevator, including the machine room and corridors to the elevator, as well as the fire pump room and draft tube gate storage room will be of concrete construction.

5.3.6 Generating Unit

The new Unit 8 will be equipped with a Francis type turbine with the following characteristics:

Rated flow:	102 m^3/s
Gross design head:	179.73 m
Net design head:	174.17 m
Rotating speed:	near 225 rpm

Nominal unit capacity:154.4 MW (Generator rated output at rated net head)

The digital speed governor, supplied with the turbine, will include a hydro pneumatic reservoir, a sump, and an oil pumping system, as well as all required piping, valves, fittings, and control mechanisms. Since there is no surge tank with the penstock and no pressure relief valve system, to limit the overpressure in the penstocks at the unit to 30% of the gross head, the closing time of the wicket gates, excluding the cushioning, will be set to 16 seconds minimum.

5.3.7 Auxiliary Mechanical Systems

The concept for the auxiliary systems of the new powerhouse will be generally as described in the 2017 Study Report except for the following systems:

- Cooling water and raw water systems.
- Fire protection system.
- Heating, Ventilation and Air Conditioning (HVAC) systems.

5.3.7.1 Cooling Water System

Water for cooling the Turbine Generator of Unit 8 will be fed from the raw water pipe with independent branches for the generator air coolers and for turbine and generator bearings.

The turbine guide bearings will be water-lubricated type and the water supply to the turbine guide bearings will be filtered to remove suspended solids of specific gravity 1.2 or higher, and any particles greater than 100 microns.

Cooling water supply to Unit 8 will be controlled by a motorized shut-off valve located on the main cooling water discharge of the Turbine Generator unit.

The flow alarm will be incorporated through flow meters to alert operator for any low flow conditions to turbine generator bearings and the generator air coolers.

5.3.7.2 Raw Water System Pressure Relief Valves (PRV)

There will be two pressure reduction stages via the PRVs in the supply of cooling water to the turbine generator unit. The first stage will reduce the pressure from 1750 kPa to 860 kPa. The second stage will reduce the pressure from 860 kPa to 350 kPa.

In the 2017 Study, the first pressure reduction stage (unfiltered water) and the second pressure reduction stage (filtered water) proposed the use of spring-loaded PRVs. The spring-loaded PRVs for the unfiltered section are more prone to failure, including blockage of pilot valves under conditions of poor water quality. The new PRV system shall consider using safety pin valves over the rupture discs for the pressure relief safety valves. Safety pins can be easily replaced within a short period of time (around 15 minutes) without requirement to remove piping, therefore the integrity of piping system will remain intact. Rupture pins can save loss of valves, disc replacement cost, and labour to replace the disc. This is to be further investigated in the next design phase.

5.3.7.3 Fire Protection System

The fire protection system will be generally as described in the 2017 Study Report except that the fire water for powerhouse Unit 8 is now planned to be supplied from a fire pump station, which includes both main and standby vertical turbine fire pumps. These pumps will draw water from the tailrace water source and will be located on the Generator floor.

The fire pumps will supply water into the sprinkler and hydrant system of Unit 8 as well as an interconnection to the Unit 7 fire protection system.

The design of fire pumps will conform to NFPA 20 standards. The pump will be installed in a room that is separated from the rest of the powerhouse by a barrier with a minimum fire resistance rating of 2 hours.

The fire pump station will be equipped with an isolating valve and a manual cleaning strainer, capable of retaining particles larger than 0.8 mm.

Generators and transformers will be protected by automatic water spray fixed systems (deluge).

An automatic wet pipe sprinkler system (pre-action system) will be used to protect the generator hydraulic power unit (HPU).

In normal operation, a jockey pump, installed in Unit 8 as part of the Unit 8 fire pump station design, will be used to maintain the pressure in the system.

5.3.7.4 Heating, Ventilating and Air Conditioning (HVAC) Systems

The HVAC system will be generally as described in the 2017 Study Report except for the addition, to the above systems, of two roof-top exhaust fans and three louvers, typical to the existing ones, that will be installed to increase ventilation rate and address the cooling load added by Unit 8. This area will have stairway access. In addition, six Unit Heaters will be installed in the Main Floor to operate during the cold season and keep the temperature above the minimum design temperature.

5.4 Tailrace Hydro-Mechanical Equipment

The Powerhouse (Tailrace) will include the following hydro-mechanical equipment:

- Two new Draft Tube Gates (DTMG).
- Extended monorail to cover operation of the new DTMGs.
- Upgrade the existing monorail hoist and the rails (if required).
- One Storage Rack for draft tube gates
- Dogging devices.

Two sets of draft tube gates already exist for Unit 7. The gates are of vertical lift sliding gate types with downstream sealing arrangement (considering opposite turbine water flow direction). The Unit 8 new draft tube gates will also be of vertical lift sliding types with downstream sealing arrangement.

Two new sets of DTMGs will be provided for Unit 8. These new sets will be similar to the existing Unit 7 gates and use the existing embedded parts. The draft tube will be watered up through a new set of pipes and valves to allow the draft tube gates to operate under equal pressure.

Unit 7 existing gates are stored in a room under the existing service bay and can be maneuvered with a monorail hoist that currently services only the draft tube gates of Unit 7.

The new Unit 8 DTMGs will be provided using the existing monorail hoist via an extension of the existing monorail. The existing monorail will be extended and if required, can be upgraded to a higher capacity where possible. DTMGs will be stored inside a new storage room designated for Unit 8. New DTMGs will be designed to be interchangeable with the existing draft tube gates of Unit 7.

The new set of DTMGs for Unit 8 will be provided prior to start of Unit 8 construction to ensure that the existing set can be used for the operation and maintenance of Unit 7.

Once construction of Unit 8 is completed, the monorail beam will have to be extended to service the slots for Unit 8. To initiate the excavation of Unit 8, new DTMGs must be constructed in advance to isolate the construction area.

Embedded parts for Unit 8 DTMGs already exist although their condition needs to be verified in the next project design phase.

5.5 Electrical Systems

The electrical systems will be generally as described in the 2017 Study Report except for the supply and installation of a new emergency generator.

5.5.1 Emergency Diesel Generator

An emergency diesel generator will be provided for emergency services including black start. The diesel generator set will be complete with all accessories for local and remote control starting and stopping, as well as metering and protection.

Diesel generator set will be stand-alone inclusive of its own enclosure, engine, generator, governor, cooling, fuel tank, air, protection and control system.

The diesel generator will be integrated with station services supply. On loss of station service supply, an undervoltage relay will start the diesel generator set to supply the essential loads for periods when the auxiliary supply is not available. The diesel generator set will be installed at the proposed service floor elevation, preferably behind the battery room location.

Please refer to drawing of AC Station Service System Single Line Diagram (BDE-AKR-50000-EL-DSD-0001-01) for integration of Diesel generator with station services supply and drawing of General Arrangement Main Floor – Plan Unit 7 & 8 (BDE-AKR-40000-AR-DGA-0005-01) for location of Diesel generator in the layout.

5.6 Terminal Station No. 2

The Terminal Station No. 2 will be generally as described in the 2017 Study Report.

Due to change in the transmission line route provided by NL Hydro, from generating Unit 8 to Terminal Station no. 2, the single line diagram, electrical layout plan and sections drawings of Terminal station no. 2 have been modified. As a result of the transmission line route change and the buried grounding, surface grounding drawings of Terminal Station No. 2 have also been revised to incorporate the new connection point for generating Unit 8.

Surface grounding drawing of Terminal Station No. 2 have been revised to incorporate the new connection point for generating Unit 8.

Please refer to buried grounding and surface grounding drawings of Terminal Station No. 2 (BDE-AKR-51000-EL-DES-0001-01 and BDE-AKR-51000-EL-DES-0002-01).

5.7 Geology

5.7.1 Geotechnical Investigations

The Unit 8 Geotechnical Investigation program was carried out by WSP, and the final report (NLH Document Number 07965-A99-0003) was provided by NL Hydro to AtkinsRéalis in June 2024. The results of this report were used for site characterization. This program includes twenty-four (24) boreholes and sixteen (16) test pits as presented in the table below.

Table 5-1 – Geotechnical Investigations Undertaken

Description of Test	No.	Details
Boreholes	24	
Test pit excavations (4 - 4.5 m deep)	16	
Standard Penetration Test SPT	23	All boreholes, except Intake structure 5 (bedrock encountered near surface).
Piezometer Installation	10	BH-03-23, BH-05-23, BH-06-23, BH-08-23, BH-10-23, BH-12-23, BH-14-23, BH-16-23, BH-17-23, and BH-17A-23
Packer Testing	1	Only in BH-03-23: at area proposed in 2017 for temporary rock plug.
Field Vane Shear Testing	2	Only in BH-22-23 and BH-23-23: within Tailrace enlargement.
Laboratory Testing for Soil samples	-	Gradation, Atterberg limits and moisture content.
Laboratory Testing for Rock Samples	-	UCS and unit weight.

6 CONCLUSION

In summary, this update to the concept design report reflects a comprehensive and strategic approach to expanding the facility's generation capacity by the addition of a new Unit 8. The report reflects the concept design work completed during the Front-End Engineering Design (FEED) phase of the project, providing support for the application for project funding approval to the PUB and to advance the design documentation for the next project phase.

This update represents a step in the project's progression, ensuring that all engineering and design elements are aligned with the latest technical and regulatory requirements. With an optimized design, the Bay d'Espoir Unit 8 project is well-positioned to proceed into its next phase, ultimately enhancing the BDE facility's power generation capacity, operational efficiency, and long-term reliability.