Aqua-Solve

"We Solve Water"

Eagle Mountain - Woodfibre Gas Pipeline Project Construction Water Treatment

Design Basis Memorandum

June 2022

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Executive Summary

The provided document highlights the design basis used for the Eagle Mountain - Woodfibre Gas Pipeline Project (EGP) construction water treatment plants. The design basis was prepared to provide preliminary guidance on required treatment strategies to remove the probable Potential Contaminants of Concern (PCOC) from the projects predicted groundwater dewatering flows such that future releases of these treated effluents to the natural environment will be anticipated as compliant to the British Columbia Water Quality Guidelines (BCWQG), project specifications and project Waste Discharge Authorization (WDA).

Two water treatment plants with the listed capacities will be provided for the project:

Site	Est. Daily Design Flows (m^3/day)	Proposed WTP Capacity (m^3/day)
BC Rail Site	155	1090*
WLNG Site	1470	2725**

*Capacity proposed to account for standard 200 USGPM Module
**Capacity proposed to account for standard 500 USGPM Module

The water treatment objective for both sites will include Total Suspended Solids Removal and Turbidity reduction. Total suspended solids removal and turbidity reduction is primarily obtained through Coagulation/Flocculation and Sedimentation, followed by (Sand/Bag) Filtration. Process performance for Turbidity will be continually monitored through online Turbidity monitoring.

Additional treatment provisions for heavy metals removal via precipitation, organics removal via activated carbon, anion/cation removal via ion exchange, and pH adjustments shall also be provided. Implementation of additional treatment will need to be confirmed upon permit verification and at the detailed design stage of the project.

Given the potential uncertainties of changing water treatment objectives and the complexity of the observed PCOCs provided, it is recommended that the Coordinating Qualified Professional for the Technical Assessment Report engages with the WTP Engineer and the Supplier to best manage regulatory and stakeholder complexities brought about on this report.

Document Authentication

EGBC Permit to Practice: 1003826

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Revision Summary

Revision No.	Version Date	Summary of Revisions:
0	2022-Apr-22	Draft - For Client Review
1	2022-May-02	Addition of DB Contractor's Comments
2	2022-June-01	Re-Submitted Based on Additional Comments
3	2022-June-08	Final

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1.0 Introduction

The Design Base Memo (DBM) will be used as a guiding document, for the water treatment plant configuration and treatment objectives for both the BC Rail and Woodfibre LNG (WLNG) sites.

The DBM along with any additional supporting drawings and diagrams will be a supplementary document to be submitted to the British Columbia Oil and Gas Commission (BC OGC) as part of the WDA application. The DBM will also support the Information Requirements Table (IRT) generated during the WDA application.

1.1 Definitions

BAT – Best Achievable Technology

BC OGC – British Columbia Oil and Gas Commission

BCWQG – British Columbia Water Quality Guidelines

BC EMA – British Columbia Environmental Management Act

Design-Build (DB) Contractor – Frontier-Kemper Michels JV, retained by the Owner

EGP – Eagle Mountain – Woodfibre LNG Pipeline

Equipment Supplier – Aqua-Solve, retained by the DB Contractor

Engineer – Banner Environmental Engineering Consultants, retained by the Equipment Supplier

Owner – FortisBC, Permit Holder

PCOC – Potential Contaminants of Concern

TAR – Technical Assessment Report

WTP – Water Treatment Plant

WLNG – Woodfibre LNG

2.0 Water Treatment Plant General Information

Two Water Treatment Plants (WTP) will be provided with the following design flows.

Table 1. WTP Design Flows

Site	Est. Daily Design Flows (m^3/day)	Proposed WTP Capacity (m^3/day)
BC Rail Site	155	1090
WLNG Site	1470	2725

Note: For both sites, it is assumed that precipitation and run-off from precipitation events are negligible, based on initial surface flow data provided by FortisBC (the Owner).

The proposed water treatment plant capacities are based on the supplier's standard 200 USGPM (BC Rail Site) and 500 USGPM (WLNG Site) modules. Listed modules are the proposed hydraulic capacity of the plants.

2.1 Water Treatment Objectives and Assumptions

Water treatment plant design and objectives were developed using input data provided by the Frontier-Kemper Michels JV (DB Contractor) and the Owner. Based on this data, past and on-going experience on Tunnel Boring and Pipeline-type construction projects, and potentially changing site conditions, uncertainties on input water quality parameters can exist. Therefore, provisionary needs for WTP process flexibility and additional process verification work should be strategically undertaken and be part of the project execution plan.

The current assumptions used during the preliminary WTP assessment for the two water treatment plants (BC Rail site and WLNG site) have been provided in detail within Sections 2.2 and 2.3 and were developed when compared against the initial PCOC list provided. Treatment objectives for the WTP sites were based on the requirements to meet BCWQGs; but the final PCOCs and the required process line up will still require formal process verification and should be submitted along with the final application submission and the final Overall Environmental and Water Management Plans for construction.

It is assumed that the Coordinating Qualified Professional, the DB Contractor, the Owner, the Engineer, and the Supplier will all be suitably engaged in the permitting process, including but not necessarily limited to: preparation/review of the relevant submission sections, strategic discussions, negotiations and the drafting/accepting final permit wording as the permit relates to the acceptance of the proposed design and operation of the said plant and release of treated effluent.

2.2 BC Rail Site Water Treatment Plant

Assumed influent and proposed effluent parameters for the BC Rail Site. Proposed effluent parameters for PCOC's highlighted were obtained from the Technical Assessment Report for Waste Discharge Authorization.

Table 2. BC Rail Site Water Treatment Plant Influent and Effluent Parameters

	Units	Influent Expected Maximum	Proposed Effluent Parameter
Physical Parameters			
pH		11	7.0-8.5
Total Suspended Solids	mg/L	200	75
Turbidity	NTU		As per BCWQG
BTEX/VPH			
Benzene	µg/L	0.5	40
Ethylbenzene	µg/L	0.5	200
Toluene	µg/L	0.6	0.5
Xylenes, Total	µg/L	0.75	30
Organics - Polycyclic Aromatic Hydrocarbons			
Acenaphthene	µg/L	85.5	6
Acridine	µg/L	2.8	0.05
Anthracene	µg/L	6.15	0.1
Benz[a]anthracene	µg/L	0.978	0.1
Benzo[a]pyrene	µg/L	0.194	0.01
Chrysene	µg/L	1.09	0.1 (Marine)
Fluoranthene	µg/L	13	0.2
Fluorene	µg/L	37.4	12
Naphthalene	µg/L	13.6	1
Phenanthrene	µg/L	39.4	0.3
Pyrene	µg/L	7.37	0.02
Quinoline	µg/L	2.3	3.4
VOCs			
1,2-dichlorobenzene	µg/L	0.5	0.7
1,2-dichloroethane	µg/L	0.5	100
1,3-dichlorobenzene	µg/L	0.5	150
1,4-dichlorobenzene	µg/L	0.5	26
Chlorobenzene	µg/L	0.5	1.3
Dichloromethane	µg/L	1	98.1
Methyl tert-butyl ether	µg/L	0.5	440
Styrene	µg/L	0.5	72
Dissolved Metals			
Aluminum (Al)	µg/L	451	As per BCWQG
Antimony (Sb)	µg/L	0.5	9
Arsenic (As)	µg/L	15.6	5
Barium (Ba)	µg/L	225	1000
Beryllium (Be)	µg/L	0.1	0.13
Bismuth (Bi)	µg/L	0.05	NS
Boron (Bo)	µg/L	44	1200
Cadmium (Cd)	µg/L	0.107	As per BCWQG
Chromium (Cr3+)	µg/L	10.8	8.9
Chromium, Hexavalent	µg/L	0.5	1
Cobalt (Co)	µg/L	12.5	4

Copper (Cu)	µg/L	16	As per BCWQG
Iron (Fe)	µg/L	64400	350
Lead (Pb)	µg/L	0.691	As per BCWQG
Manganese (Mn)	µg/L	3480	As per BCWQG
Mercury (Hg)	µg/L	0.0062	As per BCWQG
Molybdenum (Mo)	µg/L	5.13	73
Nickel (Ni)	µg/L	8.6	As per BCWQG
Selenium (Se)	µg/L	3.2	1
Silver (Ag)	µg/L	0.02	As per BCWQG
Thallium (Tl)	µg/L	0.02	0.8
Tin (Sn)	µg/L	0.16	.001
Uranium (U)	µg/L	0.537	15
Zinc (Zn)	µg/L	4900	As per BCWQG

NT = Not Tested

2.3 Woodfibre LNG Site Water Treatment Plant

Assumed influent and proposed effluent parameters for the WoodFibre LNG Site. Proposed effluent parameters for PCOC's highlighted were obtained from the Technical Assessment Report for Waste Discharge Authorization.

Table 3. Woodfibre LNG Site Water Treatment Plant Influent and Effluent Parameters

	Units	Influent Expected Maximum	Proposed Effluent Parameter
Physical Parameters			
pH		8-11	7-8.5
Total Suspended Solids	mg/L	125-200	75
Turbidity	NTU		As per BCWQG
BTEX/VPH			
Benzene	µg/L	NT	40
Ethylbenzene	µg/L	NT	200
Toluene	µg/L	NT	0.5
Xylenes, Total	µg/L	NT	30
Organics - Polycyclic Aromatic Hydrocarbons			
Acenaphthene	µg/L	NT	6
Acridine	µg/L	NT	0.05
Anthracene	µg/L	NT	0.1
Benz[a]ahracene	µg/L	NT	0.1
Benzo[a]pyrene	µg/L	NT	0.01
Fluoranthene	µg/L	NT	0.2
Fluorene	µg/L	NT	12
Naphthalene	µg/L	NT	1
Phenanthrene	µg/L	NT	0.3
Pyrene	µg/L	NT	0.02
Quinoline	µg/L	NT	3.4
VOCs			
1,2-dichlorobenzene	µg/L	NT	0.7
1,2-dichloroethane	µg/L	NT	100
1,2-dichloropropane	µg/L	NT	NS
1,3-dichlorobenzene	µg/L	NT	150

1,4-dichlorobenzene	µg/L	NT	26
Chlorobenzene	µg/L	NT	1.3
Dichloromethane	µg/L	NT	98.1
Methyl tert-butyl ether	µg/L	NT	440
Styrene	µg/L	NT	72
Dissolved Metals			
Aluminum (Al)	µg/L	35.9	As per BCWQG
Antimony (Sb)	µg/L	0.1	9
Arsenic (As)	µg/L	0.1	5
Barium (Ba)	µg/L	4.41	1000
Beryllium (Be)	µg/L	0.1	0.13
Boron (Bo)	µg/L	10	1200
Cadmium (Cd)	µg/L	0.0079	As per BCWQG
Chromium (Cr3+)	µg/L	NT	8.9
Chromium, Hexavalent	µg/L	0.5	1
Cobalt (Co)	µg/L	0.1	4
Copper (Cu)	µg/L	0.41	As per BCWQG
Iron (Fe)	µg/L	23	350
Lead (Pb)	µg/L	0.05	As per BCWQG
Manganese (Mn)	µg/L	0.63	As per BCWQG
Mercury (Hg)	µg/L	0.005	As per BCWQG
Molybdenum (Mo)	µg/L	0.634	73
Nickel (Ni)	µg/L	0.5	As per BCWQG
Selenium (Se)	µg/L	0.05	1
Silver (Ag)	µg/L	0.01	As per BCWQG
Thallium (Tl)	µg/L	0.01	0.8
Tin (Sn)	µg/L	0.1	.001
Uranium (U)	µg/L	0.054	15
Zinc (Zn)	µg/L	1.1	As per BCWQG

NT = Not Tested

2.4 Proposed Treatment Configuration

The proposed WTP treatment configuration for both sites shall be modular. Since process inputs may change throughout the course of the project, the modularization of the WTP shall allow for process changes and improvements to help ensure compliance. For the purposes of the Waste Discharge Authorization, it is recommended that process changes based on provisions listed in this document excluding increases in volumetric flows, be handled via a notification process with the BC OGC.

The addition of the provisioned equipment should be considered as a process improvement towards the finalized environmental management and water management plans for the site. As the project is early in its design stages, the final water management plan has not been provided to the Engineer/Supplier at this point and the main reasoning for provisioning treatment equipment, is to minimize potential handling of waste streams and chemicals that may or may not be required for treatment, prior to the finalization of detailed plans.

For the treatment configuration and considering the proposed provisionary equipment, it is intended that the BAT in meeting BCWQG will be used. It should also be noted that the preliminary safe handling and management of residuals and waste streams were also considered for the proposed processes.

The proposed treatment configuration for the WTPs shall be the following:

1. Equalization / Pre-Treatment

   An equalization and pre-treatment process shall be provided to both buffer the flows into the plant and provide primary sedimentation for the process. This process step shall also be provided with a baffle to also act as an oil/water separator and reduce the non-aqueous phase liquids entering the WTPs. A minimum volume will need to be maintained in the equalization tanks to minimize carry-over of lighter density organics to other processes.

   An aeration step may be added to the equalization/pre-treatment stage to help reduce heavy metal concentration entering the next stages of treatment. This will need to be confirmed during the commissioning stage of the WTP.

2. Heavy Metal Reduction and Precipitation (Provision-Only)

   Heavy metal reduction and precipitation will be used to help reduce Iron and other heavy metal concentrations. This will be achieved via pH adjustment and/or the use of an oxidizing agent. A Coagulation/Flocculation step will then be used to further reduce Total Suspended Solids, Turbidity, and Heavy Metals.

As inlet process conditions may change, the process step requirement will be continually monitored and evaluated during the operating period of the WTP.

3. Coagulation/Flocculation (Sedimentation)

   A Coagulation/Flocculation step will be used to further reduce Total Suspended Solids, Turbidity, and Heavy Metals. Sedimentation of solids and sludge is expected to also occur at this stage.

4. Filtration

   Post coagulation/flocculation both sand and bag (10 micron) filtration will be used to further reduce TSS and Turbidity to acceptable levels, typically at <25 NTU. Any non-compliant waters not meeting the required turbidity standards post filtration, shall be recycled back to the equalization / pre-treatment process.

5. Activated Carbon Filtration (Provision-Only)

   Due to the presence of background organics, provisions for activated carbon filtration will be required. Activated carbon filtration shall be used to reduce dissolved organics to acceptable levels. As inlet process conditions may change, the process step requirement will be continually monitored and evaluated during the operating period of the WTP.

   The activated carbon filters shall operate in a lead-lag configuration. Organics carry-over will need to be tracked and monitored in-between filters to better predict consumptions rates.

6. Ion Exchange (Provision-Only)

   As input conditions may change throughout the project, provisions for ion-exchange for additional cation and anion removal will be provided. Final resin bed compositions will be further evaluated during the detailed design phase of the project. Continuous monitoring of this process step will be required throughout the operating timeline of the WTP.

7. Final pH Adjustment (Provision-Only)

   Prior to conveyance of treated water to the outfall, effluent pH shall be adjusted to final pH requirements of the receiving environment.

3.0 Water Treatment Plant Detailed Design, Commissioning, Monitoring, and Operation

3.1 Process Verification

During the process verification stage, additional background data will be collected, and the overall construction and water management plan will be considered and analyzed in setting the initial operating parameters for the WTPs to meet BCWQG. This includes, revising the Process Flow Diagram, Mass Balance, residual/waste stream information, any requested updates on the PCOCs, final methods of effluent release, and final directives on the permitting process for the WTPs as required.

3.2 Detailed Design

Detailed sizing of equipment will be further defined and confirmed by the Engineer and the Supplier once input parameters are defined post the process verification stage. Submittals will include but are not limited to, Final equipment sizing and specifications, process parameters such as resin and/or media design, P&IDs, general arrangement, electrical drawings as required, safety interlocks, control narrative, and WTP standard operating protocols.

3.3 Commissioning

Once construction and erection of the WTPs is completed at site, a notification will be provided to the BC OGC of the start of the commissioning phase of the WTPs. It is expected that the commissioning phase of the WTPs may typically take 8-10 weeks, but the timelines will need to be better confirmed based on construction activities on-site.

If it is determined that any of the provisional equipment is required, either during the commissioning and/or operating phase of the WTP, a notification will be provided to the BC OGC for the required process changes.

Process flow as-builts will be submitted to the BC OGC, in compliance with the BC EMA.

3.4 Proposed Sampling Frequency

The proposed sampling frequencies will be as required by the final project WDA. Online measurements for the WTP discharge will be provided for pH, Turbidity, and Flow.

It is recommended that all other analyses are performed via a composite sampling method, as this will allow for a better representation of the WTP's daily performance.

3.5 Treatment Process By-Products

Treatment process by-products include sludge consisting of heavy metals and sediment that are both the by-products of construction activities and background groundwater data.

Sludge, oil, and grease levels will be continuously monitored in the WTP process tanks and will be removed via vac trucks. By-products will be hauled to authorized disposal facilities. Based on the assumed maximum input conditions and expected process flows, it is expected that sludge accumulation can be in the range of up to 2.0-5.0 m^3/day at a sludge concentration of 15,000 mg/L, combined for both sites. However, total volume accumulations will be further examined once the water management plan for each site is finalized.

In addition to sludge, spent activated carbon and/or ion-exchange resin, if required, will also be waste by-products that will need to be hauled to authorized disposal facilities.

3.6 Unexpected Conditions, Process Upsets and Non-compliance Contingency Protocols

To help mitigate unexpected conditions and minimize process upsets and interruptions, the overall emergency response protocols for the project will be incorporated into the operation of the WTP. Stand-by equipment for critical processes such as generators, pumps, etc. shall also be provided. Extreme weather conditions shall also be considered.

Process inputs may also potentially change as the project progresses, which may lead to a non-compliance discharge if the proper process treatment conditions do not exist. Listed below are the proposed corrective actions that will be undertaken in the case of a process upset non-compliance event:

1. Consulting the emergency response plans and the environmental management plans for the site.

2. Adjusting process parameters, as required, and ensuring that non-deleterious impacts to the environment are observed. This will involve the following:
    a. Engaging both the Engineer and the Equipment Supplier in helping troubleshoot the operating issues that have risen, such that recommendations for any additional corrective actions can be provided.
    b. Increased sampling frequency of the WTP(s) effluent, if required by the Coordinating Qualified Professional, as parameters are being adjusted.
    c. Weekly monitoring of the receiving environment to ensure BC Water Quality Guidelines are being met and/or ensuring background water quality changes are considered tolerable within background levels. Toxicity testing will need to be considered in this case.

3. Addition of provisional process modules and further adjustment of process parameters.

4.0 Conclusions

The DBM highlights the proposed design and treatment objectives for the two (2) EGP WTPs that will be used for the duration of the construction project, with the intent of supporting the project Waste Discharge Authorization under the *Environmental Management Act*.

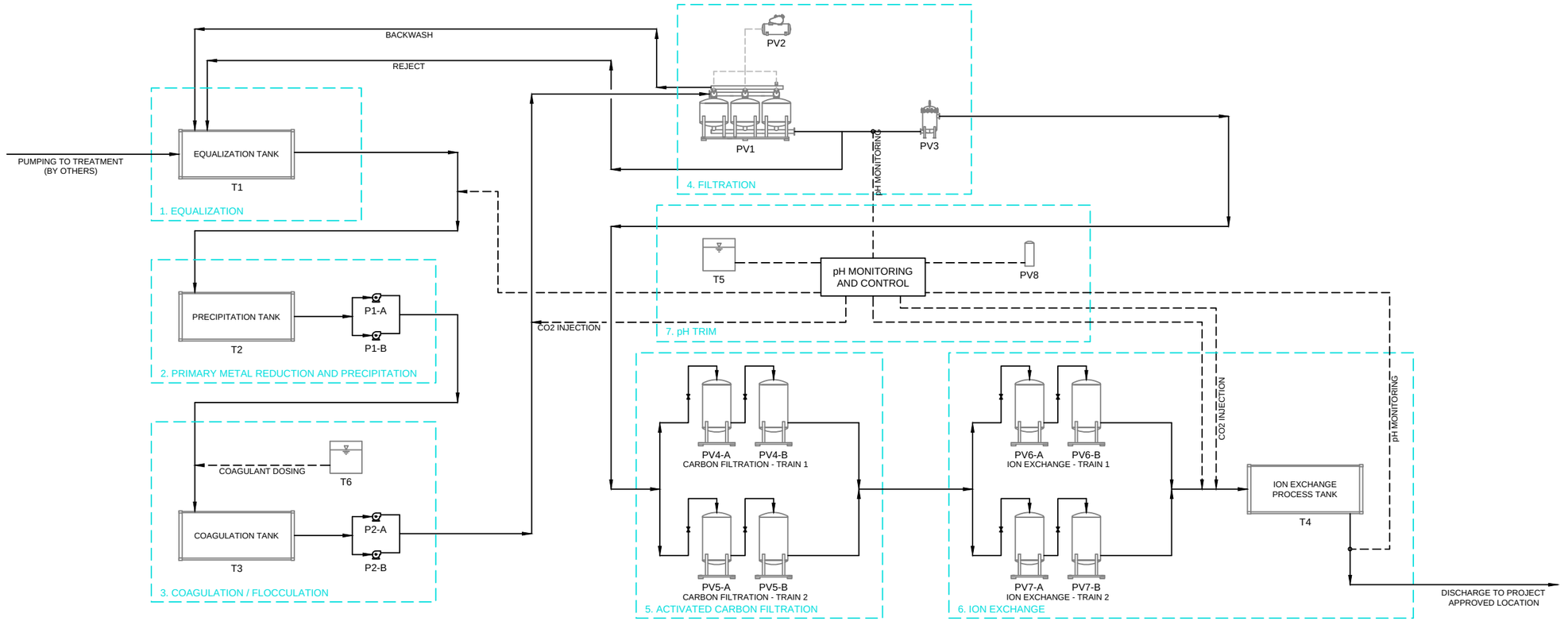
The BC Rail Site WTP shall be designed to have a capacity of 1090 m^3/day, while the WLNG Site WTP shall have a capacity of 2725 m^3/day. Treatment objectives for both WTPs shall be to meet BCWQG based on the provided PCOCs provided in Tables 2 and 3.

The primary proposed treatment configuration shall be Pre-Treatment/Equalization, Coagulation/Flocculation, and Filtration. If required, and to be confirmed at the detailed design / process verification phase of the project, heavy metals precipitation, further organic removal, ion-exchange, and pH adjustment will be provided.

Based on experience with similar construction projects, potential input parameters into the WTPs can vary based on construction activities. However, in our professional opinion, with the combination of best practices in construction water management and further delineation of WTP input parameters as the design phase of the project progresses, proper process adjustments, such as the use of the provisional equipment, can be applied and be put into place such that in a balance of probabilities, the WTPs will meet the requirements of the BCWQG.

APPENDIX A – Process Flow Diagrams

1. EQUALIZATION → 2. PRIMARY METAL REDUCTION AND PRECIPITATION → 3. COAGULATION / FLOCCULATION → 4. FILTRATION → 5. ACTIVATION CARBON FILTRATION (PROVISION ONLY) → 6. ION EXCHANGE (PROVISION ONLY) → 7. FINAL pH TRIM



PV1	SANDFILTER MODULE				
PV2	AIR COMPRESSOR				
PV3	6 BAG FILTER SKID	T1	PRE-TREATMENT / EQUALIZATION TANK		
PV4-A/B PV5-A/B	CARBON VESSELS	T2	PRECIPITATION TANK		
		T3	COAGULATION TANK		
PV6-A/B PV7-A/B	ION EXCHANGE MODULES	T4	ION EXCHANGE PROCESS TANK		
		T5	CHEMICAL STORAGE TANK	P1-A/B	PRECIPITATION TANK PUMPS
PV8	LIQUID CO2 TANK	T6	COAGULANT STORAGE TANK	P2-A/B	FILTER PUMPS

NOTES:

1. PROCESS CONFIGURATION AND SIZING TO BE CONFIRMED DURING DETAILED DESIGN.

REFERENCE NUMBER	REFERENCE TITLE

STAMPS

REV NO.	REVISION	DATE	DRN	CKD	DES	LDE	PE
R00	DRAFT	2022/04/22	TRF				
R01	DRAFT	2022/04/29	TRF				

CONSULTANT: BANNER

REVISION DESCRIPTION: DRAFT

PROJECT NUMBER: 276.1

LSD: T.B.D.

SIZE: A1 | SCALE: AS SHOWN

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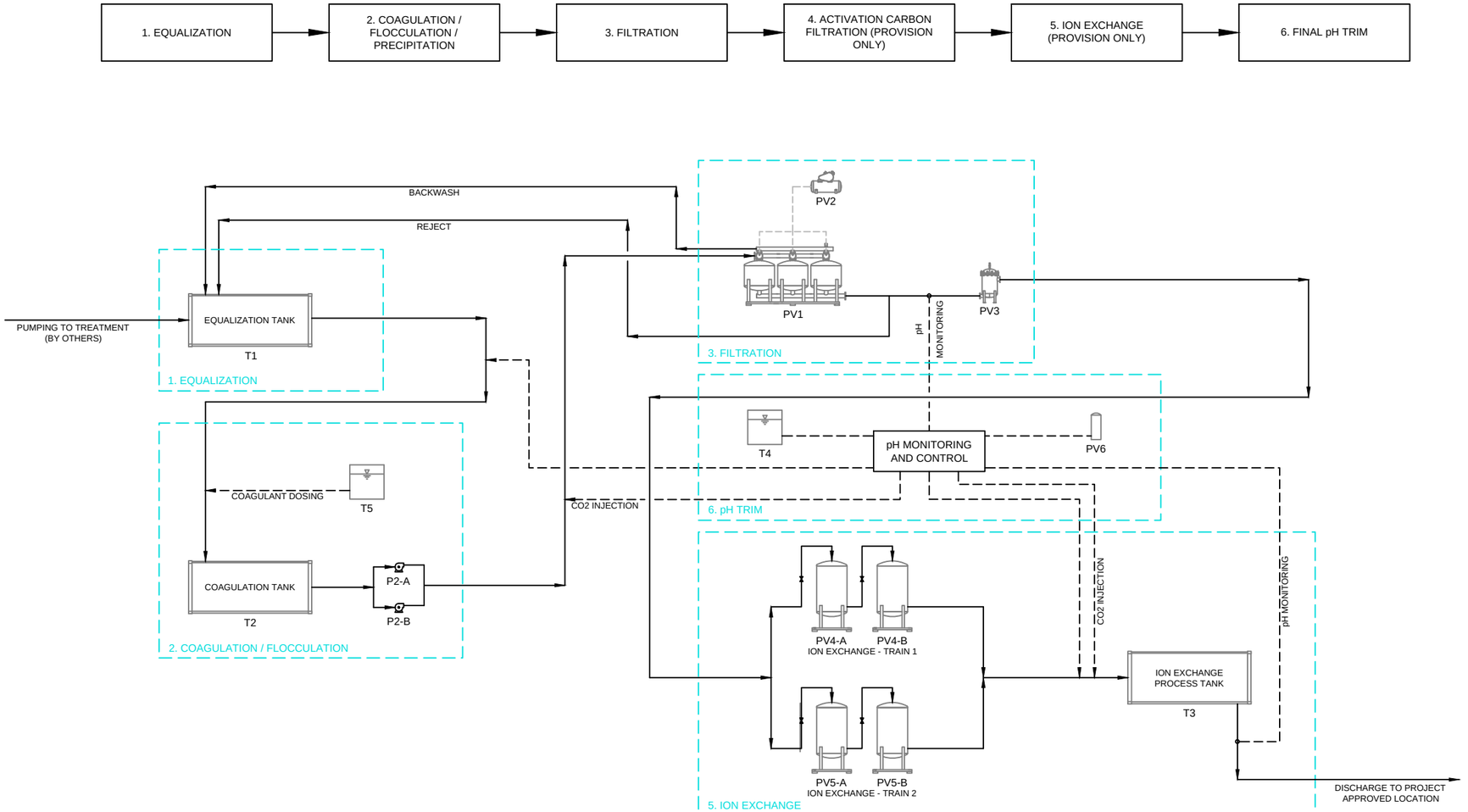
TITLE

AQUA-SOLVE
WATER TREATMENT SYSTEM
BC RAIL SITE - PROCESS FLOW DIAGRAM

DRAWING NO.: 274.1.D01 | REVISION NO.: R01



PV1	SANDFILTER MODULE				
PV2	AIR COMPRESSOR	T1	PRE-TREATMENT / EQUALIZATION TANK		
PV3	6 BAG FILTER SKID	T2	COAGULATION TANK		
PV4-A/B PV5-A/B	ION EXCHANGE MODULES	T3	ION EXCHANGE PROCESS TANK		
		T4	CHEMICAL STORAGE TANK		
PV6	LIQUID CO2 TANK	T5	COAGULANT STORAGE TANK	P1-A/B	FILTER PUMPS

NOTES:

1. PROCESS CONFIGURATION AND SIZING TO BE CONFIRMED DURING DETAILED DESIGN.

REFERENCE NUMBER	REFERENCE TITLE

STAMPS

REV NO.	REVISION	DATE	DRN	CKD	DES	LDE	PE
R00	DRAFT	2022/04/22	TRF				
R01	DRAFT	2022/04/29	TRF				

CONSULTANT: BANNER

Aqua-Solve

TITLE

AQUA-SOLVE
WATER TREATMENT SYSTEM
WLNG - PROCESS FLOW DIAGRAM

REVISION DESCRIPTION: DRAFT
PROJECT NUMBER: 276.1
LSD: T.B.D.
SIZE: A1
SCALE: AS SHOWN
DRAWING NO.: 274.1.D02
REVISION NO.: R01