British Columbia Water and Waste Association
2021 Student Design Competition Problem Statement

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Attachments – Provided Separately Upon Registration

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Version	**Date**
Revision 2	November 22, 2020

Questions

For information or questions related to the Student Design Competition or Problem Statement, please contact

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Acknowledgements

Special thanks to:
Carlos Hunte, P.Eng., Metro Vancouver
EnviroSim Associates Ltd.

Disclaimer

The project statement is intended only for use during the 2021 BCWWA Student Design Competition. Information provided in this document may not reflect actual conditions or requirements and is provided for the sole purpose of providing context for the design competition. All supporting information remains the property of the Metro Vancouver. Students may be required to sign a non-disclosure agreement prior to proceeding in the competition

Restricted Parties

The following parties are not permitted to participate as advisors to student teams:

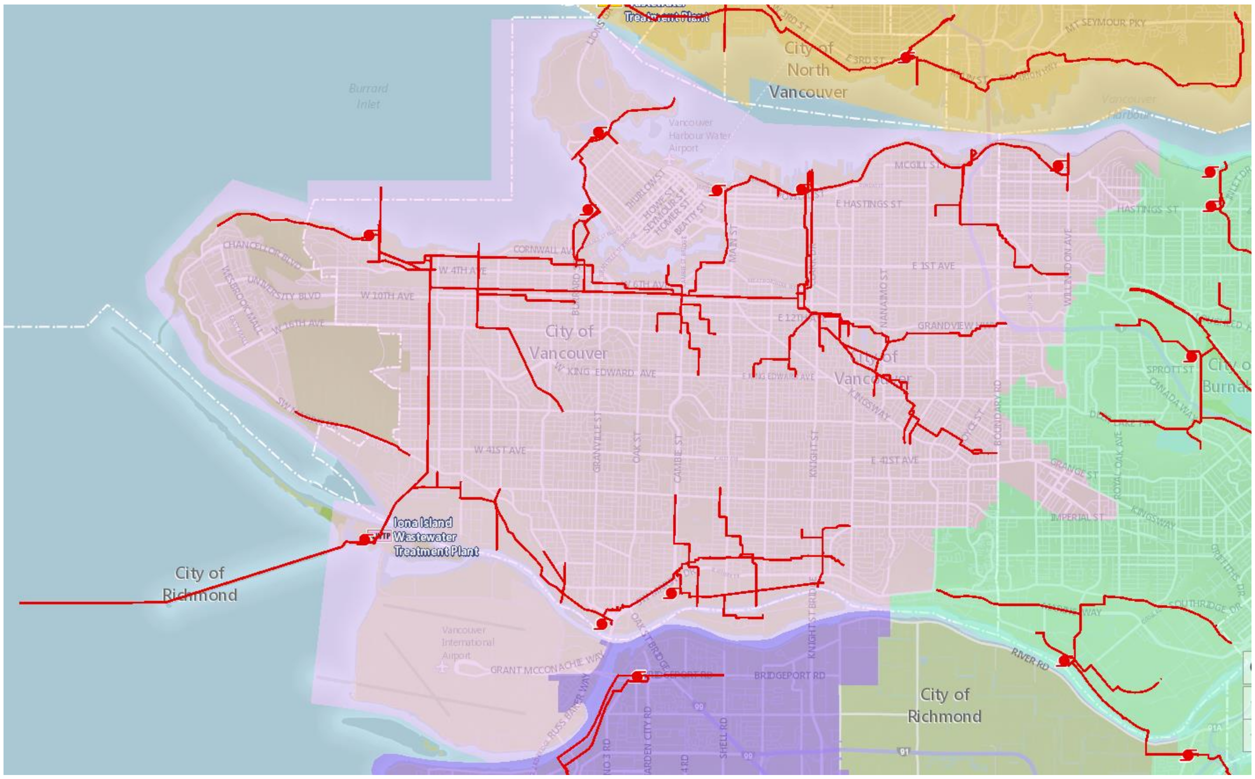
- Any Metro Vancouver staff
- Jacobs Engineering Group staff directly involved with the IIWWTP Project Definition project
- Any other persons directly involved with the IIWWTP Project Definition project

GLOSSARY

Acronym	Definition
BOD_5	Biochemical Oxygen Demand, 5-day
$cBOD_5$	Carbonaceous Biochemical Oxygen Demand, 5 day
rbCOD	Readily Biodegradable COD
COD	Chemical Oxygen Demand
TS	Total Solids
TSS	Total Suspended Solids
VSS	Volatile Suspended Solids
NH_3-N	Ammonia (as Nitrogen)
TKN	Total Kjeldahl Nitrogen
TP	Total Phosphorus
Ortho-P	Ortho-Phosphate
VFA	Volatile Fatty Acid
DO	Dissolved Oxygen
MLSS	Mixed Liquor Suspended Solids
WAS	Waste Activated Sludge
RAS	Return Activated Sludge
TLW	Trucked Liquid Waste, comprising of septage and commercial waste (e.g. kitchen grease traps)

1 PROBLEM STATEMENT

The Iona Island Wastewater Treatment Plant (IIWWTP) is a municipal wastewater treatment facility owned and operated by Metro Vancouver. Located on Iona Island (within the Iona Beach Regional Park) the IIWWTP has provided primary treatment since 1963 to the Vancouver Sewerage Area (comprising the City of Vancouver, University Endowment Lands, Sea Island, and portions of the City of Burnaby).



By 2030, the IIWWTP will be upgraded to a secondary treatment facility in order to meet increasing stringent treatment requirements and population growth in the Vancouver region. The 2030 IIWWTP design will be able to be easily retrofitted to accommodate additional treatment capacity or resource recovery. As a result, Metro Vancouver is interested in investigating configurations of a future retrofitted IIWWTP that is able to maximize resource recovery while meeting all necessary treatment requirements.

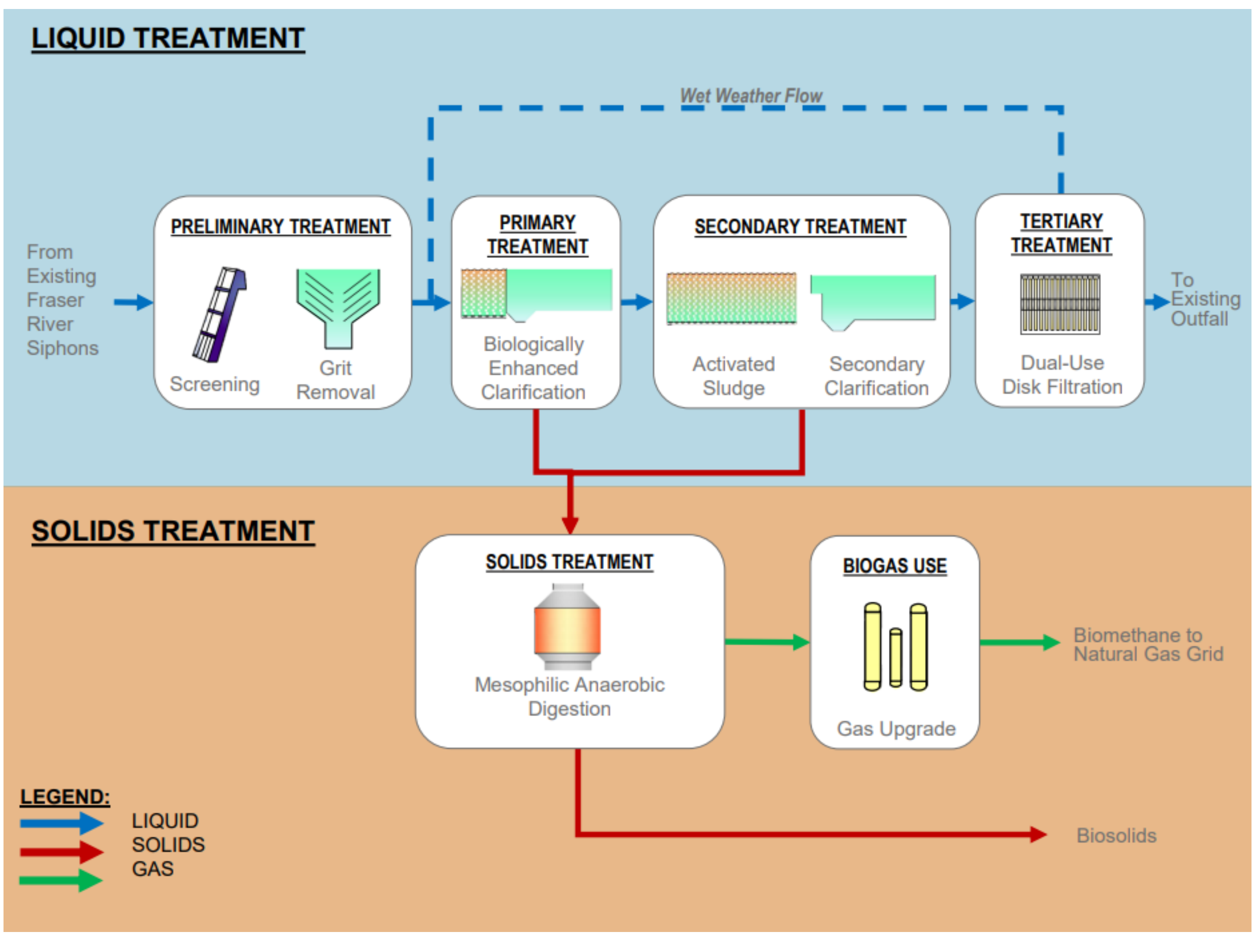
Students interested in entering the 2021 BC Water & Waste Association (BCWWA) Student Design Competition (SDC) are encouraged to form teams of maximum six (6) persons (refer to competition guidelines for further requirements).

It is each team's responsibility to review the information and data provided. It is not mandatory to use all data provided for the analysis, however, it is highly recommended that teams review all information provided in the attachments, as some key design data and information is provided only in the attachments. Refer to the competition guidelines for policies regarding questions on project scope, objectives, and information.

2 BACKGROUND

The existing IIWWTP is a primary treatment plant that provides preliminary screening, grit removal, and primary settling. Treated effluent is subsequently discharged through an outfall (Iona Jetty) into Georgia Strait. Primary sludge is digested through a mesophilic anaerobic digestion process to produce biogas and Class B biosolids. Grit and Screenings are landfill disposed as they possess low gas production value. Trucked Liquid Waste (TLW) is disposed of through a separate system comprising of TLW receiving station (provides preliminary screening) and a thickener. The thickened TLW solids are subsequently discharged to the anaerobic digesters.

By 2030, the IIWWTP will be upgraded from a primary treatment facility to a tertiary treatment facility. This will be accomplished through the construction of a new facility that will consist of preliminary screening, grit removal, biologically enhanced primary clarification, activated sludge secondary treatment, secondary clarification, and tertiary filtration. In severe wet weather events, a portion of the preliminary treated wastewater will bypass the treatment system to be directly treated by the tertiary disc filters.
The residual primary sludge and waste activated sludge will be treated through the existing mesophilic anaerobic digesters to produce Class B biosolids and biogas. The biogas will be upgraded to biomethane for sale to the FortisBC.



2.1 IONA ISLAND WASTEWATER TREATMENT PLANT UPGRADE

2.1.1 Wastewater Flows and Constituent Loading

Influent flows to the IIWWTP are a result of two sources:

- Municipal wastewater generated in the Vancouver Sewerage Area
- Trucked Liquid Waste

Wastewater flow and constituent mass loading are to be estimated utilizing the provided population, influent flow monitoring, and constituent characterization data for the past five (5) years.

2.1.2 Wastewater Fractionation

Based off historical monitoring, the raw wastewater characterization is estimated to be:

Influent Wastewater

Parameter	Ratio
To be provided upon registration	

Trucked Liquid Waste

Parameter	Ratio
To be provided upon registration	

Assume wastewater fractionation remain constant throughout the design horizon.

2.1.3 Kinetic Parameters

Parameter	Value
To be provided upon registration	

2.1.4 Contributory Population and Project Growth

Vancouver Sewerage Area

To be provided upon registration.]

Trucked Liquid Waste

To be provided upon registration

2.1.5 Treatment Requirements

Treated secondary effluent discharged from the IIWWTP must meet all required federal and provincial regulatory requirements. However, as informed by an Environmental Impact Assessment, more stringent effluent quality is required, as shown below.

Constituent	Effluent Limit
To be provided upon registration	

2.2 BACKGROUND RESOURCES

Below is a list of useful resources to start this process. This list is not intended to be comprehensive.

References

Pacific Climate Impact Consortium:
https://www.pacificclimate.org/

Metcalf & Eddy, Wastewater Engineering Treatment and Resource Recovery, 5th Edition

Grady et al., Biological Wastewater Treatment, 3rd Edition

William Hager, Wastewater Hydraulics Theory and Practice, 2nd Edition

Water Environment Federation, Design of Water Resource Recovery Facilities MOP 8, 6th Edition

Water Environment Federation, Nutrient Removal MOP 34

Water Environment Federation, Wastewater Treatment Process Modelling MOP 31, 2nd Edition

Water Environment Federation, Solids Process Design and Management, 1st Edition

Metro Vancouver, Integrated Liquid Waste and Resource Management Plan
http://www.metrovancouver.org/services/liquid-waste/plans-reports/management-plans/Pages/default.aspx

Metro Vancouver, Inflow and Infiltration Allowance Assessment Report, 2014
http://www.metrovancouver.org/services/liquid-waste/LiquidWastePublications/Inflow_Infiltration_Allowance_Assessment.pdf

Applicable Regulations & Guidelines

BC Municipal Wastewater Regulation (MWR)
https://www.bclaws.ca/civix/document/id/complete/statreg/87_2012

BC Reclaimed Water Guideline
https://www2.gov.bc.ca/assets/gov/environment/waste-management/sewage/reclaimedwater.pdf

BC Organic Matter Recycling Regulation
https://www.bclaws.ca/civix/document/id/complete/statreg/18_2002

Wastewater Systems Effluent Regulation (WSER)
https://laws-lois.justice.gc.ca/eng/regulations/sor-2012-139/fulltext.html

Software

EnviroSim Associates Ltd, BioWIN
https://envirosim.com/

A limited amount of temporary student licenses can be provided to participating teams. Please contact the SDC Committee for information on securing a temporary license. Limit of one license per team.

3 OBJECTIVES

Teams are required to complete and prepare a conceptual design for upgrades to the IIWWTP that meets treatment requirements, maximizes resource recovery, and minimizes life cycle cost in the 2090 design horizon. Basis for the 2090 conceptual design is to be based on the flow and constituent load projections and expected population growth.

Teams will be required to provide conceptual sizing of all proposed upgrades. Sizing is to be backed up with necessary calculations.

3.1 RECOVERABLE RESOURCES

In an effort to promote a circular economy, all efforts to maximize resource recovery should be incorporated into design. Some examples of recoverable resources include:

- Ammonia
- Biogas
- Biomethane
- Biocrude
- Phosphorus (as Struvite)
- Reclaimed Water
- Electricity
- Heat Recovery

For any recovered resource, teams must identify a potential end user whom can accept the magnitude of specified commodity (e.g. identify a local end user who can utilize a specified magnitude of reclaimed water). For commodities with larger marketability (e.g. biocrude, struvite) assume end user as the open market with no limit on intake capacity.

Teams are also encouraged to identify synergistic resource recovery opportunities with local industries or municipalities (e.g. food waste co-digestion).

3.2 SCOPE OF WORK

3.2.1 Flowrate and Constituent Loading Estimation and Projection

Utilizing the historical data and diurnal curves provided, estimate the following:

- Average Annual Flow per Capita
- Average Constituent Loading per Capita
- Flow factors such as:
    - Average Dry Weather Flow / Average Annual Flow
    - Max Day Flow / Average Annual Flow
    - Peak Hour Flow / Average Annual Flow

Utilising the data, project the flows and constituent loading in 2030 and 2090. Construct representative diurnal curves for the anticipated 2090 scenario to utilize as inputs for any dynamic simulations.

3.2.2 Treatment Process Conceptual Design and Simulation

Scenario 1 – "Baseline 2030" Simulation
Replicate the proposed 2030 IIWWTP process using a calibrated treatment process simulation. Teams are expected to provide the following:

- Steady State IIWWTP Process Model
- Mass Balance and Energy Balance under a 2030 design horizon
- Estimated Effluent Quality
- Estimated Baseline Lifecycle cost to 2090

It is highly recommended for teams to utilize a reputable wastewater treatment process modelling software to complete this portion of the project.

Scenario 2 – Resource Recovery Concept
Develop a conceptual design for upgrades to the IIWWTP that meets treatment targets in 2090, maximizes resource recovery, and provides the lowest potential life cycle cost.

- Utilizing the model developed for Scenario 1, confirm the 2030 IIWWTP can achieve the treatment requirements in 2090. If not, provide conceptual modifications to the 2030 treatment process or alternative control strategies to achieve the necessary treatment requirements in 2090. Provide calculations to demonstrate the sizing basis for all modifications.
- Confirm that all solids separation and peak wet weather flow control processes can handle the 2090 diurnal flows during a peak wet weather event. If not, provide modification or alternative control strategies to accommodate.
- The objective of the proposed conceptual design should be to provide the lowest life cycle cost as demonstrated through a life cycle analysis, while meeting or exceeding all required treatment objectives. Conduct a high-level screening exercise that identifies all potential resource recovery pathways and select recoverable resources with highest potential for recovery and lowest life cycle costs. Provide justifications as necessary.
- Provide a steady state treatment plant mass balance under a 2090 design horizon and incorporating all additional processes.
- Provide a conceptual facility layout and maximize the proposed 2030 IIWWTP layout for all additional treatment units and systems. If additional space is required, utilize the allocated expansion areas as outlined in the provided site layout
- Provide a hydraulic profile demonstrating the IIWWTP's capacity to handle 2090 Average Dry Weather Flows, Average Annual Flows, Max Day Flow and Peak Hour Flows. If the IIWWTP does not have sufficient hydraulic capacity, provide conceptual modifications to the 2030 treatment process to achieve the necessary hydraulic capacity in 2090. In addition, provide hydraulic profiles for any side stream and solids handling processes.
- Meet all applicable municipal, provincial, and federal regulations, codes, bylaws, and guidelines.
- Provide all necessary equipment or process redundancy as per BC MWR requirements.
- Provide a Class D capital cost estimate for all proposed upgrades. Include capital cost for systems required for conveyance of commodities to consumers (e.g. offloading facilities, conveyance systems).

3.2.3 Financial Analysis

Provide a financial life cycle analysis of Scenario 1 and 2 between 2030 and 2090. In the analysis also conduct a sensitivity analysis that demonstrates the effect of a +/- 30% variability in commodity prices. Scenario 1 Full Time Equivalent (FTE) staffing levels is assumed to be 30 persons. For Scenario 2, estimate the additional FTE staff required to operate the additional resource recovery facilities.

Variable	Value
Inflation Rate	2%
Discount Rate	6%
Debt Financing Rate	5%
Amortization Period	60 years
Administration Cost	5% of Revenue
Maintenance Costs	3% of Capital Cost
Labour Cost ($/FTE)	$100,000
Escalation for Commodity Prices and Costs	2% per annum

For all rates, assume a cost escalation of 2% per annum.

Commodity Prices

Commodity	Assumed Market Rate (2020)
Phosphorus (Low Grade Struvite) ($/tonne)	$200
Phosphorus (High Grade Struvite) ($/tonne)	$700
Ammonia ($/tonne)	$300
Biocrude ($/bbl)	$40
Reclaimed Water – min. quality: GEP ($/m^3)	$1.00
Recovered Heat – Offsite Usage ($/MWh)	$100
Recovered Heat – Onsite Usage ($/MWh)	$48.24
Biogas ($/MWh)	$48.24
Biomethane ($/MWh)	$54.71
Carbon Offset ($/tonne CO_2e)	$150
Electricity ($/MWh)	$99.9

If a commodity with no listed market rate is identified, utilize a rate with suitable evidence to justify its magnitude.

Costs

Parameter	Assumed Cost (2020)
Biosolids - Landfill Disposal ($/tonne)	$160
Biosolids – Class B for Land Application ($/tonne)	$140
Biosolids – Dried and Pelletized ($/tonne)	$110
Potable Water ($/m^3)	$1.5
Electricity ($/MWh)	Refer to BC Hydro Rates (Transmission Rates)
Natural Gas ($/MWh)	Refer to FortisBC Rates (Rate 2)
Miscellaneous Treatment Chemicals	Contact suppliers for approximate unit rates

3.3 DESIGN CONSIDERATIONS AND CONSTRAINTS

- **Climate Change:** consider future climate effects of an RCP8.5 scenario
- **Site Constraints:**
    - Refer to facility site plan
- **Regulatory Requirements:** meet all applicable municipal, provincial, and federal regulatory requirements.
- **Project Lifespan:** design horizon is approximately 60 years (2030 to 2090)
- **3D Design Drawings:** communication of design elements using 3D modelling software, such as SketchUp, is highly encouraged to assist in communicating the design to audiences.

3.4 DELIVERABLES

1. Monthly Progress Reports
2. Design Notebook formatted to Competition Guidelines and containing the following:
    a. Wastewater Flows and Constituent Loads Analysis and Projection
    b. 2030 IIWWTP Treatment Plant Simulation
    c. Conceptual design of 2090 IIWWTP
        i. Design description
        ii. Evaluation of Resource Recovery Options
        iii. Conceptual sizing and layout
        iv. 2090 Process Model and Mass and Energy Balance
        v. Plans, figures or drawings illustrating design concepts
    d. Financial Analysis
        i. Class D Capital Cost Estimate for the conceptual 2090 IIWWTP
        ii. Life Cycle Cost for "baseline" IIWTP to 2090
        iii. Life Cycle Cost for resource recover IIWTP to 2090
3. Oral Presentation