

Fort Simpson, NWT : Designing a Drinking Water Treatment Plant Residual Management System

Department of Civil and Resource Engineering

Introduction

- Project Goal:**
- Design a waste residuals treatment process for the water treatment plant (WTP) in Fort Simpson, NWT
- Population:**
- 1,250 people
- Location:**
- Intersection of the Mackenzie & Liard rivers, NWT
- Water Source:**
- Mackenzie River
- Current Residuals Treatment & Discharge:**
- Conventional filtration plant
 - No treatment of residuals
 - Direct discharge back into the Mackenzie river



Design Process

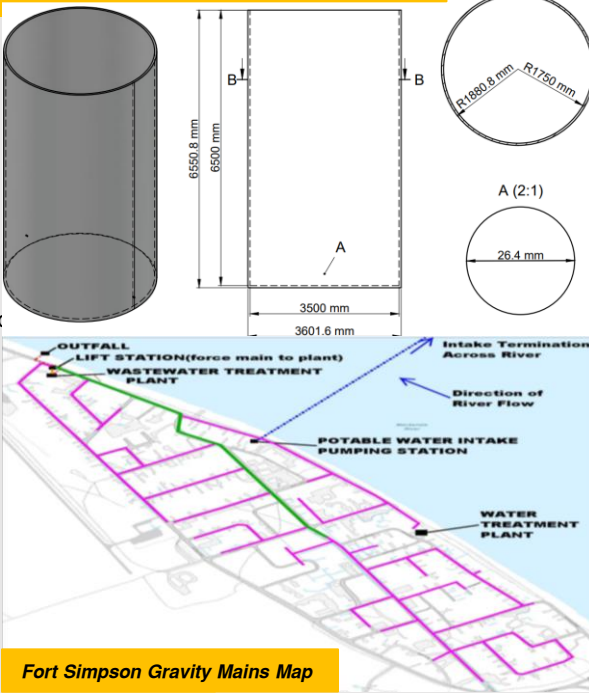
- Develop:**
- Conceptual design for WTP waste residual management system
- Evaluate:**
- Possible waste residual management options
- Design Constraints:**
- CWQ Guidelines for the Protection of Aquatic Life and northern community maintenance & operational constraints
- Research options for design:**
- Selected final design based on decision matrix with goal-related criteria and objectives

Criteria	Weight	Option A (Separate Thickening & Dewatering Technologies)	Option B (Lagoon)	Option C (Discharge to WWTP)	Decision Matrix
Capital Cost	4	2	3	4	
Installation Time	2	3	2	4	
Maintenance	2	3	3	5	
Environmental Impact	3	3	3	3	
Treatment Effectiveness	5	4	3	4	
Ease of Use	2	2	4	5	
Lifetime of Infrastructure	3	4	3	4	
Total	21	3.0	3.0	3.8	

Details of Design

- Equalization (EQ) Tank:**
- Used to maintain a steady flow of discharge from the WTP to the sewage treatment plant
 - Required to not overload the system
- Transportation and Disposal of Residuals:**
- Gravity mains will be used to transport the WTP residuals to the sewage treatment plant
 - Pre-existing Infrastructure within Fort Simpson
 - Resulting solid waste will be transported to the waste facility (landfill) via truck
 - Pre-existing transport option being used to transport the sewage treatment plant sludge to the landfill
 - Additional weight added by design is negligible
- Environmental Standards:**
- Mass Balance Calculations completed
 - Addressed four key effluents for regulatory standards
 - Aluminum leachate from WTP solids transferred to waste disposal site could pose threat
- Final Design Flow:**
- Includes flow through treatment processes, storage, transport, and disposal
 - Includes both proposed and current infrastructure
 - Diagram found in Conclusions and Recommendations

Equalization Tank Design and Diagram



Fort Simpson Gravity Mains Map

TSS Sample Calculation

Current Waste Stream:

$$\dot{m}_u = \dot{m}_s$$

$$C_s = TSS \text{ in } \dot{m}_s = 89 \frac{mg}{L}$$

After New Waste Stream is Added:

$$\dot{m}_3 = \dot{m}_2 + \dot{m}_1 = \left(650,000 \frac{mg}{kg} \times 2.49 \frac{kg}{d}\right) + \left(10.63 \frac{mg}{L} - 35,000 \frac{L}{d}\right)$$

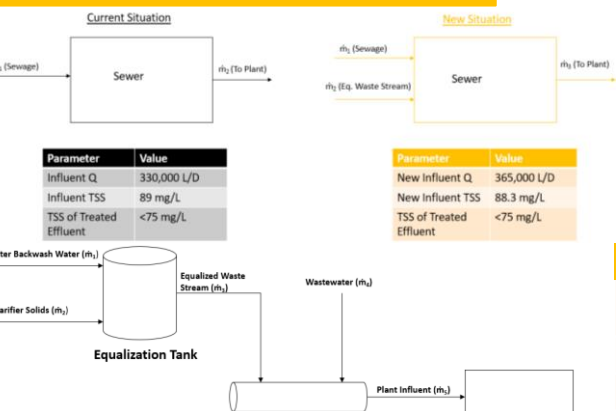
$$\dot{m}_3 = 1,990,550 \frac{mg}{d}$$

$$C_s = \frac{\dot{m}_3 + \dot{m}_u}{V_s} = \frac{1,990,550 \frac{mg}{d} + 89 \frac{mg}{L} \times 330,000 \frac{L}{d}}{365,000 \frac{L}{d}}$$

$$C_s = 85.91 \frac{mg}{L} \text{ *we diluted the TSS}$$

Effluent	Regulation Standard	Expected Value
Carbonaceous biochemical oxygen demand (CBOD)	≤ 25 mg/L	16 mg/L
Total suspended solid (TSS)	≤ 25 mg/L	22 mg/L
Total residual chlorine (TRC)	≤ 0.02 mg/L	No data

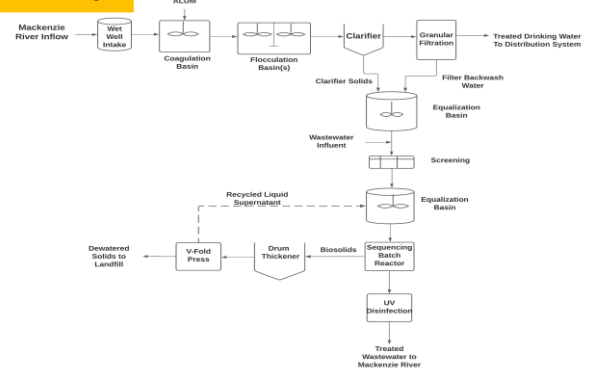
Results: TSS Increase in Wastewater Effluent



Conclusions & Recommendations

- Recommendations for Water Treatment Plant**
- Construct new equalization tank within current Drinking Water Treatment Plant
 - Use NPS20 STH40 Stainless Steel piping from equalization tank to drainage basins
 - Pumped via an APM-56 Progressive Cavity Pump
 - Perform a full filter backwash water analysis to determine effect of total residual chlorine and ammonia
- Recommendations for Municipal Waste Facility (Landfill)**
- Ensure that a liner is used at the new waste facility site
 - Continually monitor aluminum leachate levels from waste facility

Final Design



References

- Canada, E. (2020, January 13). Government of Canada. Retrieved April 05, 2021, from <https://www.canada.ca/en/environment-climate-change/services/wastewater/system-effluent-regulations-reporting/overview/factsheet-regulations-owners-operators.html>
- Cornwell, D (2006) Water Treatment Residuals Engineering, American Water Works Association, Denver CO
- Gov. of NWT. (2020) Operation and Maintenance Manual. Wildstone Group of Companies. Retrieved from *MV2015L3-0001 - Ft Simpson - Sewage Disposal Facilities OM Plan - Oct23-20.pdf (mvwb.ca)
- Gov. of NWT. (2020). Fort Simpson Wastewater Treatment System – O&M Manual. Retrieved by MV2015L3-0001 - Village of Ft Simpson - O and M Manual UPDATE - REV 1 - Mar30-15.pdf (mvwb.ca)
- Thank you to Dr. Margaret Walsh and Francois Gascon for their invaluable