Appendix WRM53-A

Codroy Flooding Risk Assessment

world energy GH2

Project Nujio'qonik: Amendment to the Environmental Impact Statement

Fracflow Consultants Inc.
Environmental, Hydrogeological and
Geotechnical Engineering Consultants

TECHNICAL MEMORANDUM

TO:	Kevin Boudreau, Dave Pinsent World Energy GH2 Limited Partnership	FFC-NL-3168-EIS-002
FROM:	Fracflow Consultants Inc.	
DATE:	January 15, 2024	
SUBJECT:	Assessment of Impact of the Turbine and Access Infrastructure for the Codroy Wind Farm on Flood Events - World Energy GH2 Limited Partnership.	

General Comment

WEGH2 Limited Partnership proposes to construct 143 wind turbines in what is referred to as the Codroy Wind Farm (**Figure 1**). Most of the turbines will be located on the high ground that forms the west side of the Grand Codroy River drainage basin with a small number of turbines located on the high ground east of Codroy Pond and others located near the drainage divide and within the drainage basins for several west flowing brooks and streams. The objective of this desktop assessment was to estimate the effect that the construction of the turbine infrastructure, such as roads, turbine foundations, transmission lines and other wind farm components, that will result in temporary and or permanent ground disturbance, will have on the peak runoff and hence flood events in the Grand Codroy River drainage basin and to assess the sensitivity of the river and flood plain system to the expected changes in flow.

The Grand Codroy River consists of two main branches, the South Branch and the North Branch, with a number of smaller tributaries, such as Coal Brook and Brooms Brook (**Figure 2**), which feed into the main river system. The South Branch of the river extends to the east into areas that are underlain by granitic bedrock with thin to no overburden which produces rapid runoff creating a “flashy” South Branch river where the river flow responds quickly to large rainfall events. The North Branch of the river extends to the west into areas that are underlain by Paleozoic sedimentary bedrock with thicker overburden in most areas including areas of frost heave on the high elevations that produce significant storage and a more moderate river response to large rainfall or snowmelt events. A smaller part of the North Branch system extends to the east into areas that are underlain by granitic bedrock.

The bottom part of the Grand Codroy River consists of long wide estuary with seawater migrating up to the mouth of the river under the freshwater blanket. This estuary is approximately 11.5 square kilometers and is tidal with the opening at what is called the “gut” to the ocean forming a sort of river throttle. **Figure 3**, generated using the HEC-HMS model, shows the main sub-basins for this discussion, primarily Brooms Brook, Ryans Brook, South Branch

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and the main North Branch drainage basin, and the drainage divides with the turbine locations. **Figure 4** shows the location of the proposed wind turbines within the Brooms Brook and Ryans Brook drainage basins.

In 1990, Fenco completed a Flood Risk Mapping of the Codroy Valley Area. Fenco compiled the available climatic and physiographic data and conducted a hydrologic model study of the river system. **Figure 5** shows the flood risk areas that Fenco (1990) identified. The main areas that were considered to be areas of flood risk and have had the most historical record of flooding are in the community of South Branch, the main river delta just below Doyles and the Brooms Brook delta and the small delta at the mouth of Ryans Brook - Muddy Hole Brook. Also, there are a number of small areas around the river estuary shoreline that flood during high runoff events and high tide conditions.

There are currently no turbine locations in the upper part of the South Branch drainage basin and as such the Codroy Wind Farm will have no impact on any flooding in the community of South Branch or along that stretch of the river. Very few of the wind turbine foundations are located on the main north-south drainage divide or in the drainage basins of the west flowing streams. Also, the west flowing stream systems in the lower two thirds of the Codroy Wind Farm have strong gradients and little to no floodplain areas either along the streams or at the stream discharge to the ocean. The 34 wind turbines that are located on the north end of the Codroy Wind Farm in west flowing drainage basins contribute flow to what is referred to as the Rainy Brook system and possibly to the Highlands River or Brook.

Impact of Turbine Construction on Runoff from Brooms Brook Drainage Basin

For the purposes of assessing the impact that the construction and operation of the wind turbines would have on peak flows or peak runoff, the Brooms Brook drainage basin, a sub-basin of the larger Codroy River drainage basin, was selected as representative of the entire Codroy River drainage basin. A HEC-HMS model for the Brooms Brook drainage basin was simulated to define the drainage divide and was used to simulate the pre-turbine condition. For the post-turbine condition, the Brooms Brook drainage basin was divided into three sub-basins (**Figure 4**). Subbasin2 includes all sub-basins that host turbine sites. All sub-basins located downstream of Subbasin2 were merged into Subbasin1 and all Sub-basins in the upstream were merged into Subbasin3. The area of the Brooms Brook drainage basin is approximately 104 km^2. The area of each sub-basin was 60 km^2 for Subbasin1, 8 km^2 for Subbasin2 and 36 km^2 for Subbasin3. Brooms Brook is an un-gauged stream.

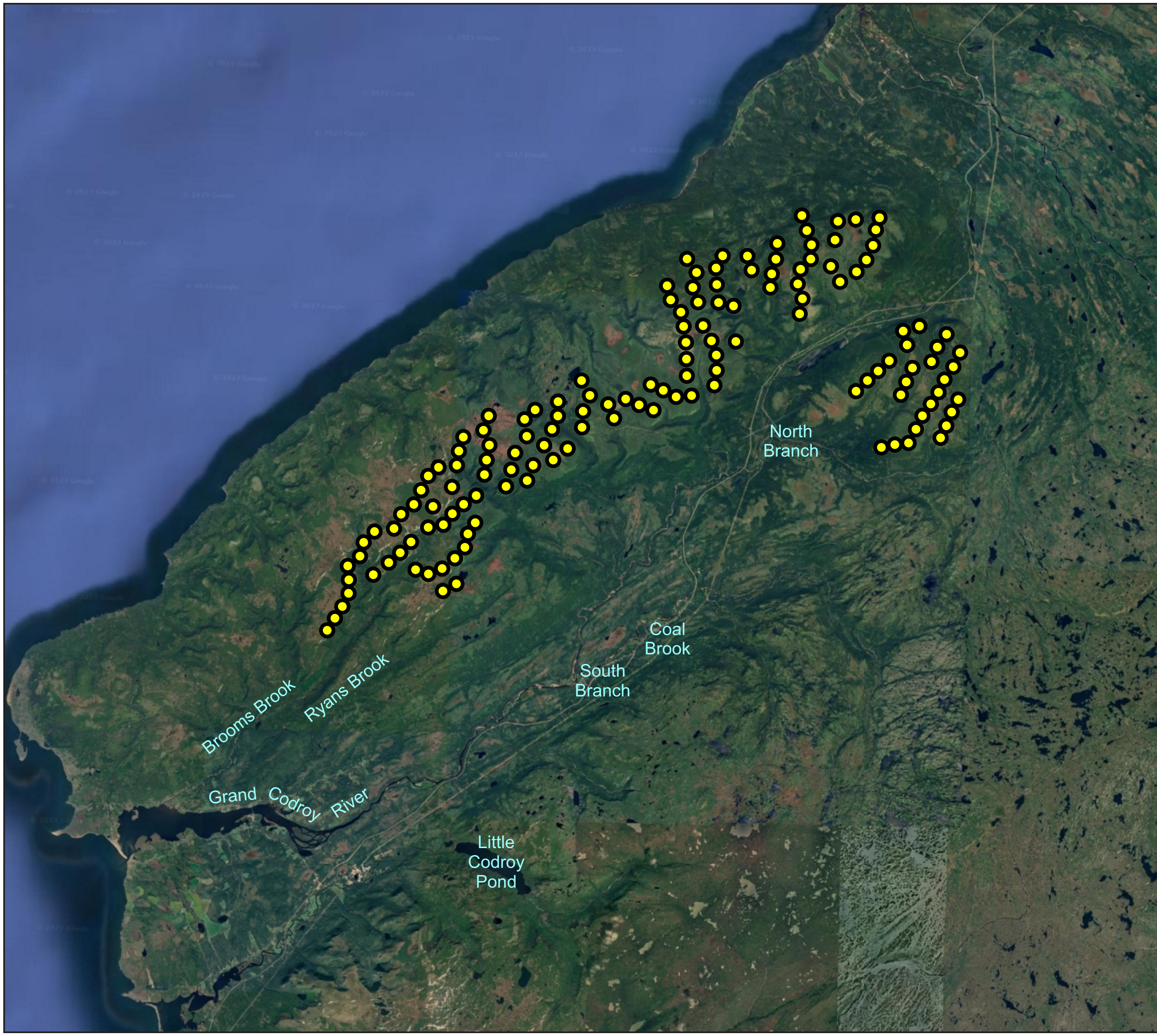
The area within the sub-basin that will be disturbed by the construction and operation of the wind turbines was estimated using the following data and assumptions. There are approximately 30 turbine sites that are located within the Broom Brook drainage basin. Assuming a 100 m by 100 m area for each turbine location, an area of 0.3 km^2 will be required for the 30 turbine sites. The access road to the 30 turbine sites within the Brooms Brook drainage basin will be approximately 23 km. With an estimated road right-away width of 20 m, the area required for the access road will be approximately 0.47 km^2. The combined area for both turbine sites and the roads is assumed to be approximately 1 km^2. This would be approximately 3% of the area of Subbasin2 or 1% of the total area of the Brooms Brook drainage basin. While it is expected that the trees and heavy vegetation will be cleared from the transmission line right-away, the ground disturbance will not be similar to that which will be required for the roads and turbine sites. The actual cleared area for the transmission poles, etc., is assumed to be included in the 1 km^2 area noted above. While the access roads will not be covered with concrete or asphalt, to ensure that the HEC-HMS simulations were conservative, the roads and turbine sites were represented as urbanized areas.

The parameters used for the HEC-HMS simulation of the Brooms Brook drainage basin were adapted from the Little Codroy River drainage basin which is located approximately 8 km south from the Brooms Brook drainage basin (**Figure 3**). The stream gauge at the Little Codroy River drainage basin provided the daily flow for the period between January 1982 and June 1997. The climate data were downloaded from the nearest climate station, *Doyles* (Climate ID: 8401EK4) which provides the climate data for the period from June 1981 to August 2011. These climate and flow data for the Little Codroy River drainage basin were used to calibrate the HEC-HMS model for the Little Codroy River drainage basin. Then the input parameters used in the Little Codroy drainage basin were utilized to populate a HEC-HMS model of the Brooms Brook drainage basin. However, site specific parameters such as time of concentration, flow paths, storage, and other parameters were adjusted to reflect the relative areas and characteristics of each drainage basin.

The HEC-HMS Brooms Brook model input parameters were unchanged for Subbasin1 and Subbasin3. For Subbasin2, the parameters related to the runoff, baseflow, surface storage, impervious ratio, and other related parameters were adjusted approximately 5% based on the estimated area of the turbine site and access road within that sub-basin.

The simulated flows from the Broom Brook drainage basin to the Grand Codroy River for the pre- and post-turbine conditions are plotted in **Figure 6a** for the cumulative flow and in **Figure 6b** for the daily flow for 15 years between January 1982 and June 1997. More detailed flow simulations for one year (April 1990 to March 1991) and three months (October 1990 to December 1990) are plotted in **Figures 7a, 7b and 8a and 8b.** These preliminary HEC-HMS model simulations show that the areas that will be cleared for the turbine construction and road access will not have a significant impact on peak runoff from a typical drainage basin such as the Brooms Brook drainage basin, even when the cleared areas are simulated as urbanized areas.

Runoff from the construction sites can be mitigated by constructing small low height berms on the down-gradient side of each turbine construction site and by careful management of road runoff by diverting water on a frequent basis across the roads and into vegetated areas to ensure that runoff does not get channeled into road side ditches over any significant distance that would allow the runoff to develop suspended sediment. Also, since the turbine foundations will be constructed primarily on relatively flat ground conditions, rapid runoff will be limited and easily controlled. Over time, most of the turbine construction site and transmission lines will become vegetated, limiting runoff to that which would naturally occur.



Legend

Proposed turbine location

0 2 4 6 8 10

Scale, km

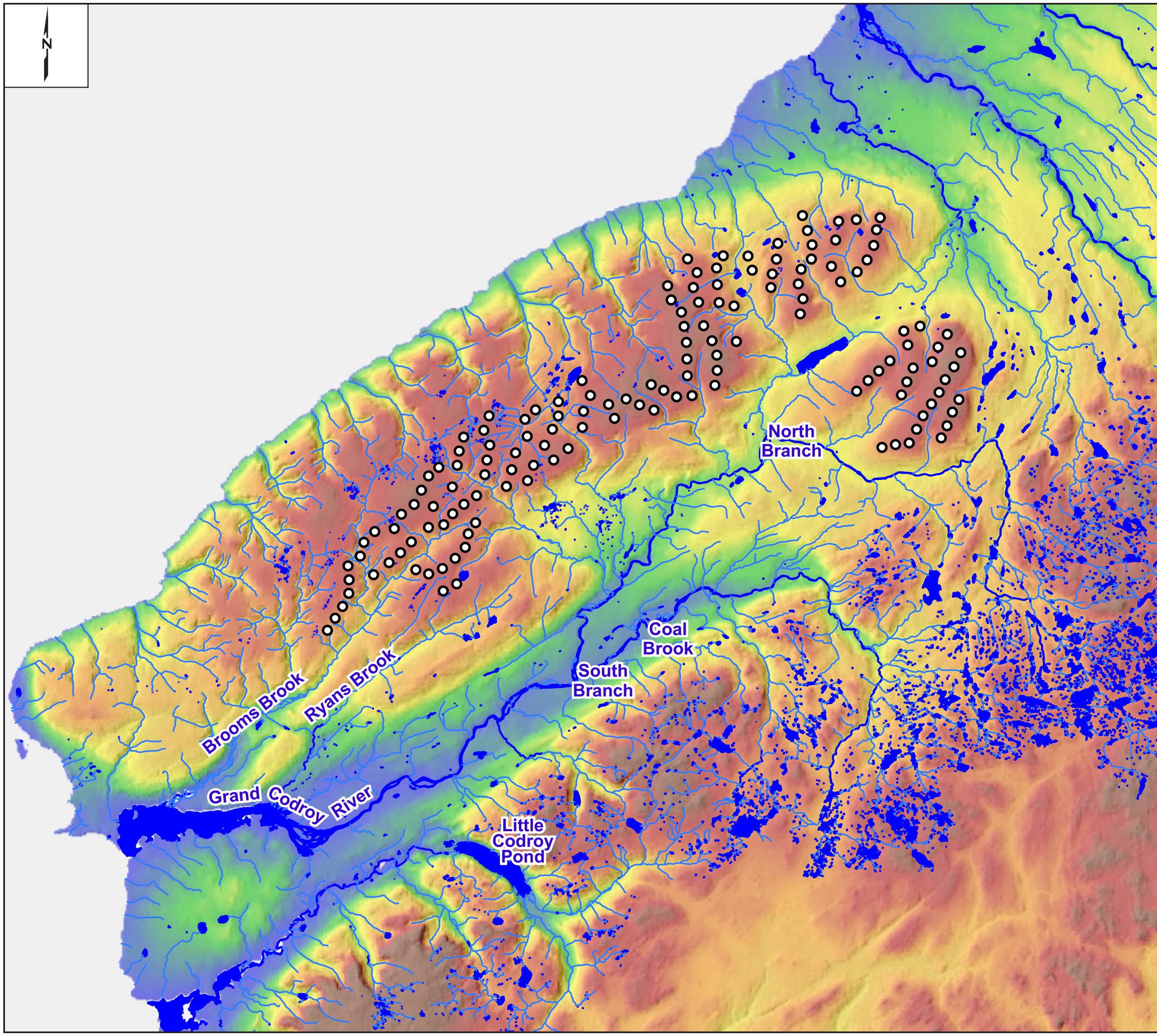
Note: Base orthorectified image(s) by Google Earth.

Figure 1

Proposed wind turbine locations at the Codroy Wind Farm.

Document Reference	FFC-NL-3168-EIS-002
Location	Codroy, NL
Project No.	3168-1
Date	December 2023

FFC



Elevation (m)

0 200 400 600

Legend

Proposed turbine location

0 2 4 6 8 10

Scale, km

Note:
- Elevation data from Open Government Source, Canada.ca.
- Hydrology data from NHN (National Hydro Network) database.

Figure 2

Terrain data and the major waterbodys and their tributaries at the Codroy Wind Farm site.

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Location	Codroy, NL
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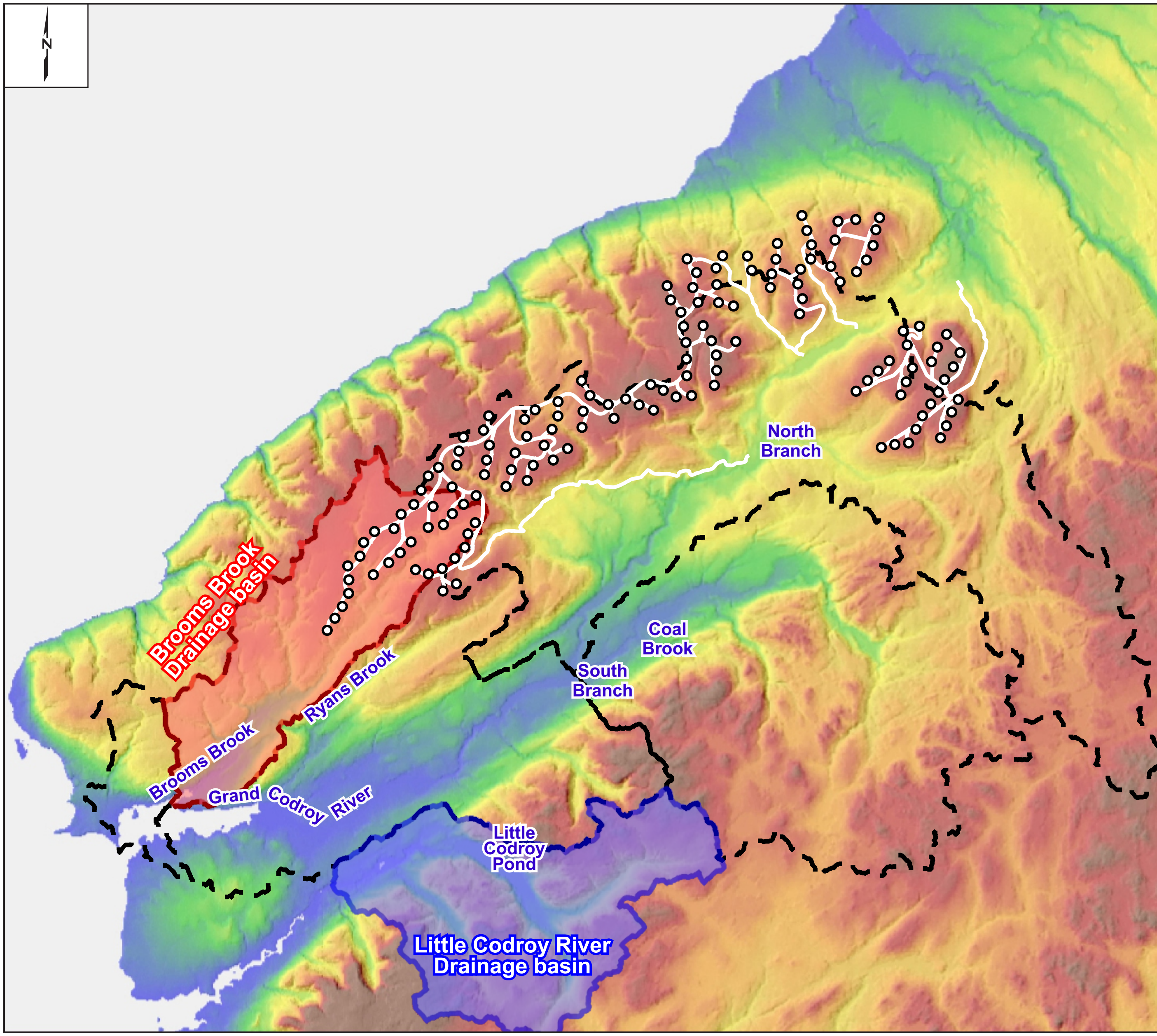
FFC



Elevation (m)

0 200 400 600

Legend

Drainage basin

Proposed turbine location and access road

0 2 4 6 8 10

Scale, km

Note:
- Elevation data from Open Government Source, Canada.ca.

Figure 3

Brooms Brook and Little Codroy River drainage basins with the main sub-basins generated using the HEC-HMS model around the proposed turbine site at the Codroy Wind Farm site.

Document Reference

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Location

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Project No.

3168-1

Date

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FFC

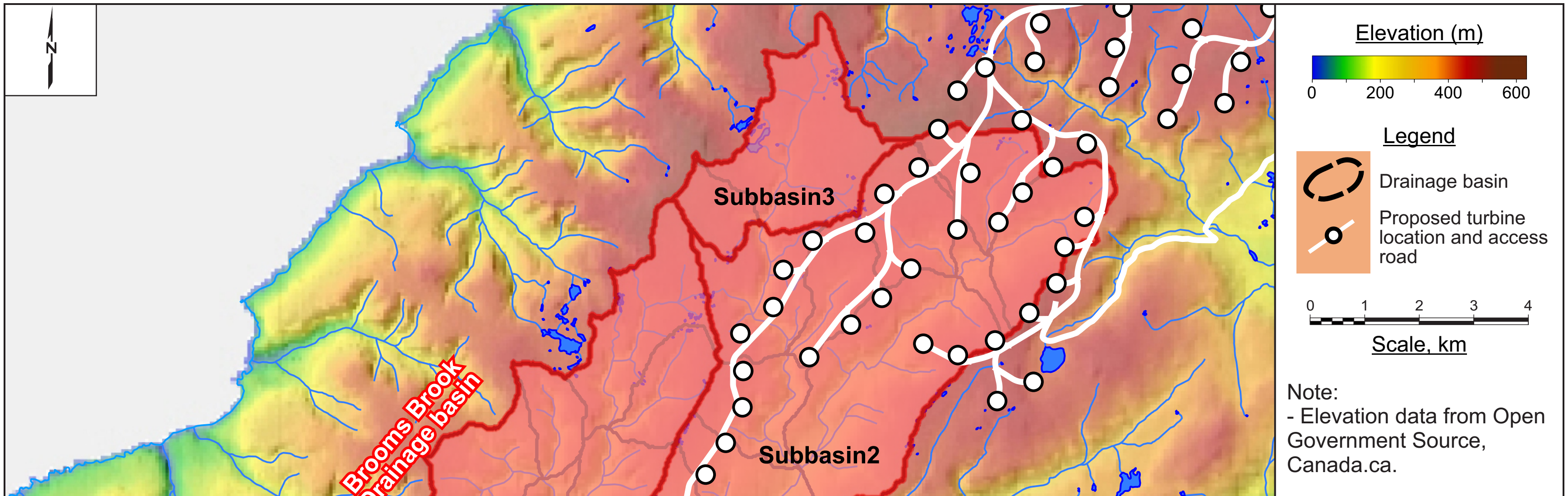

Figure 4

Three subbasins of the Brooms Brook drainage basin that are used to assess the impact of the proposed wind turbine sites at the Codroy Wind Farm site on peak runoff.

Document Reference
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Location
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December 2023

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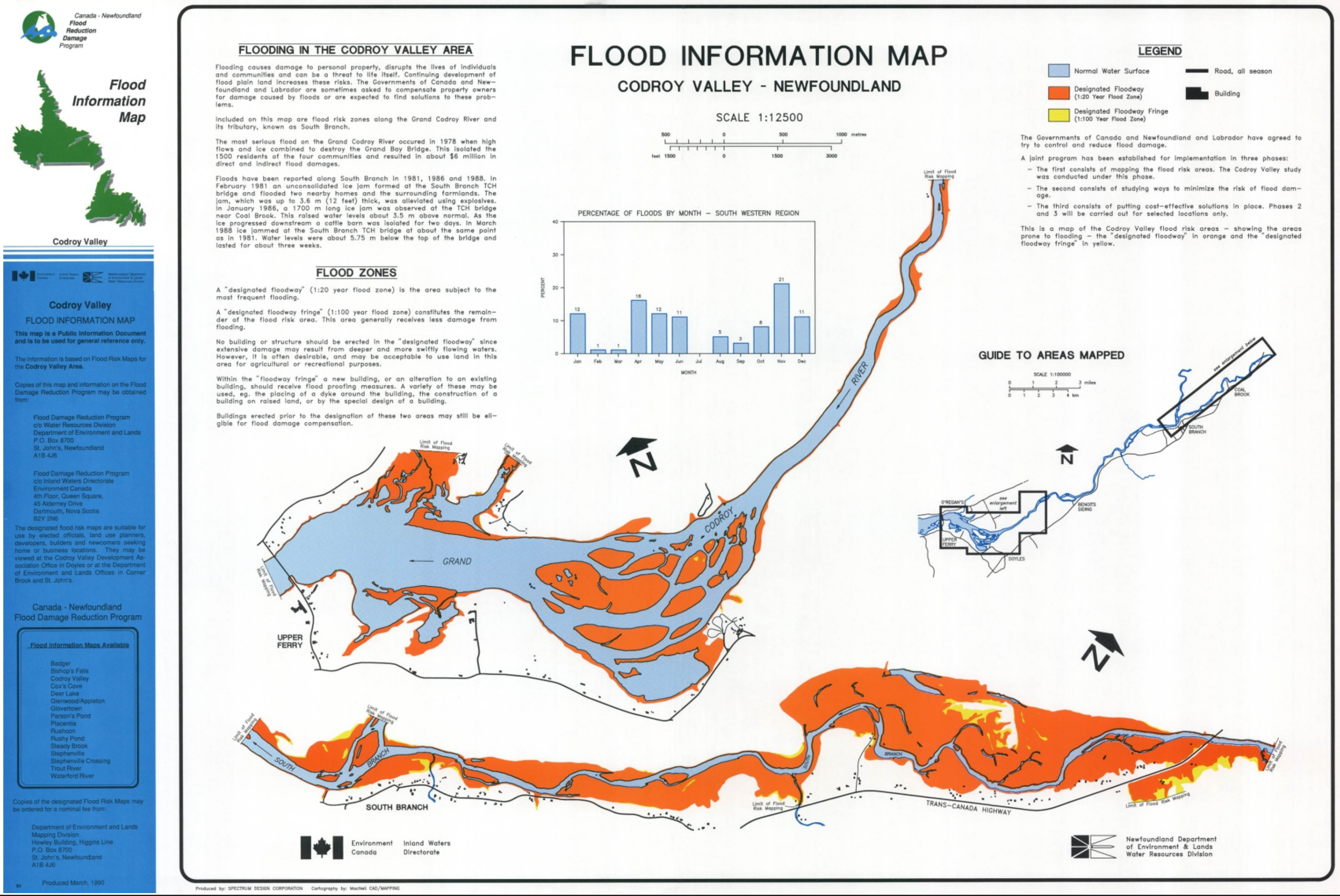

Figure 5 Flood risk areas identified by Fenco (1990).

	Project No. 3168-1	Document Reference FFC-NL-3168-EIS-002
	Location Codroy, NL	Date December 2023

FFC

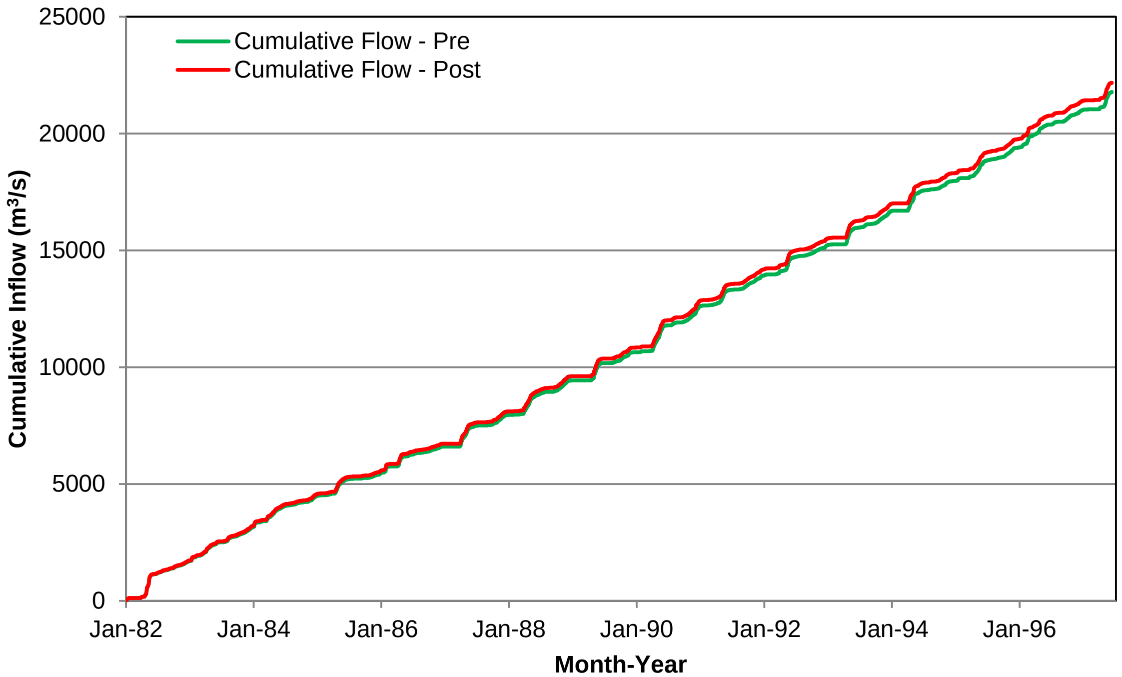

Figure 6a Simulated cumulative flow at the outlet of the Brooms Brook drainage between January 1982 and June 1997.

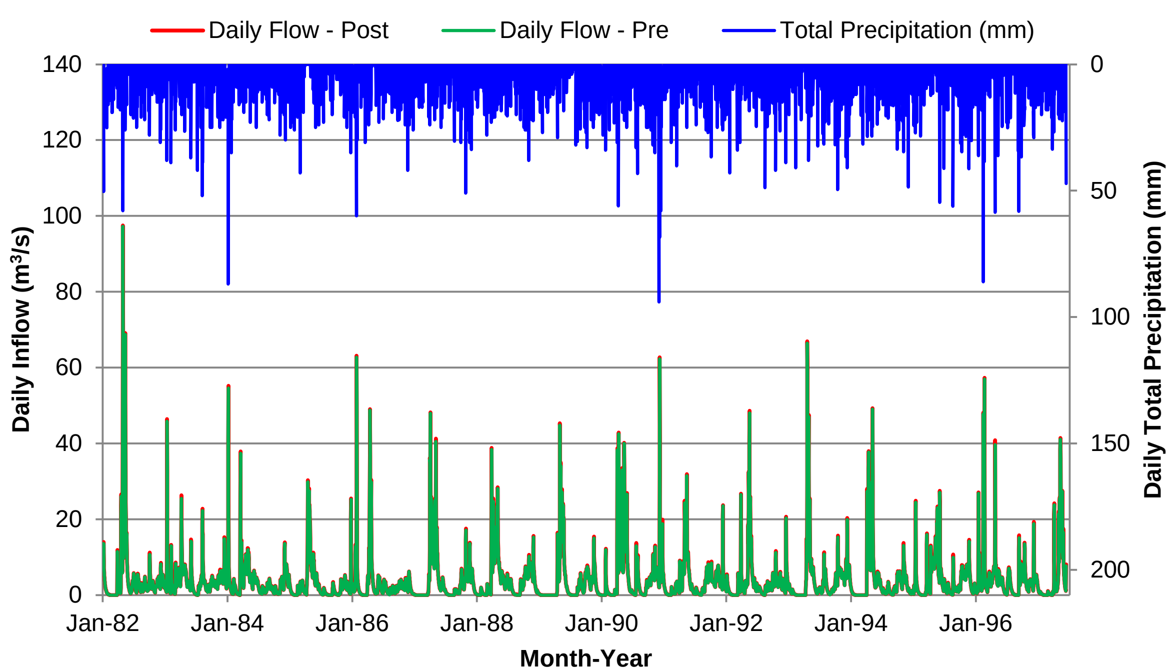

Figure 6b Simulated daily flow at the outlet of the Brooms Brook drainage between January 1982 and June 199.

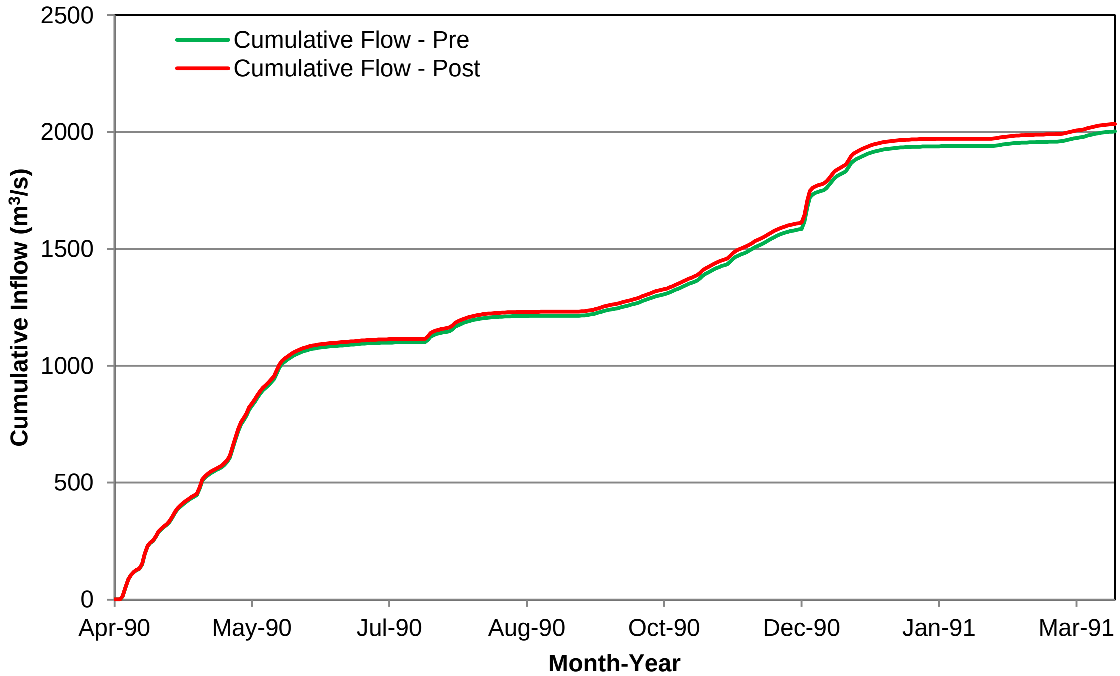

Figure 7a Simulated cumulative flow at the outlet of the Brooms Brook drainage between April 1990 and March 1991.

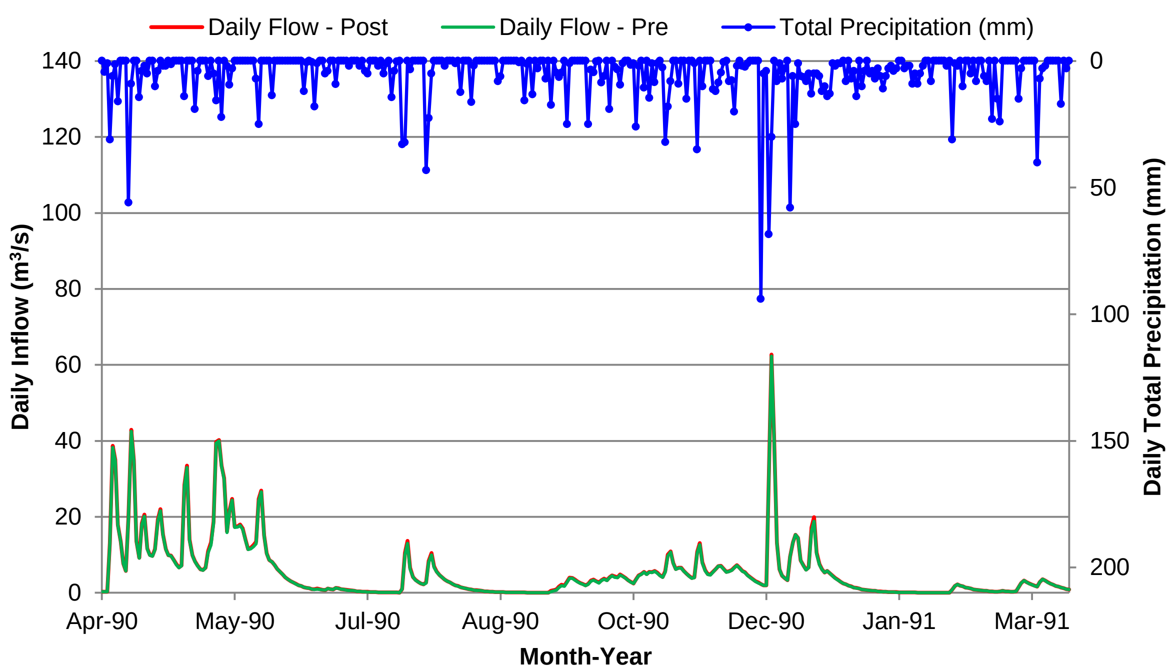

Figure 7b Simulated daily flow at the outlet of the Brooms Brook drainage between April 1990 and March 1991.

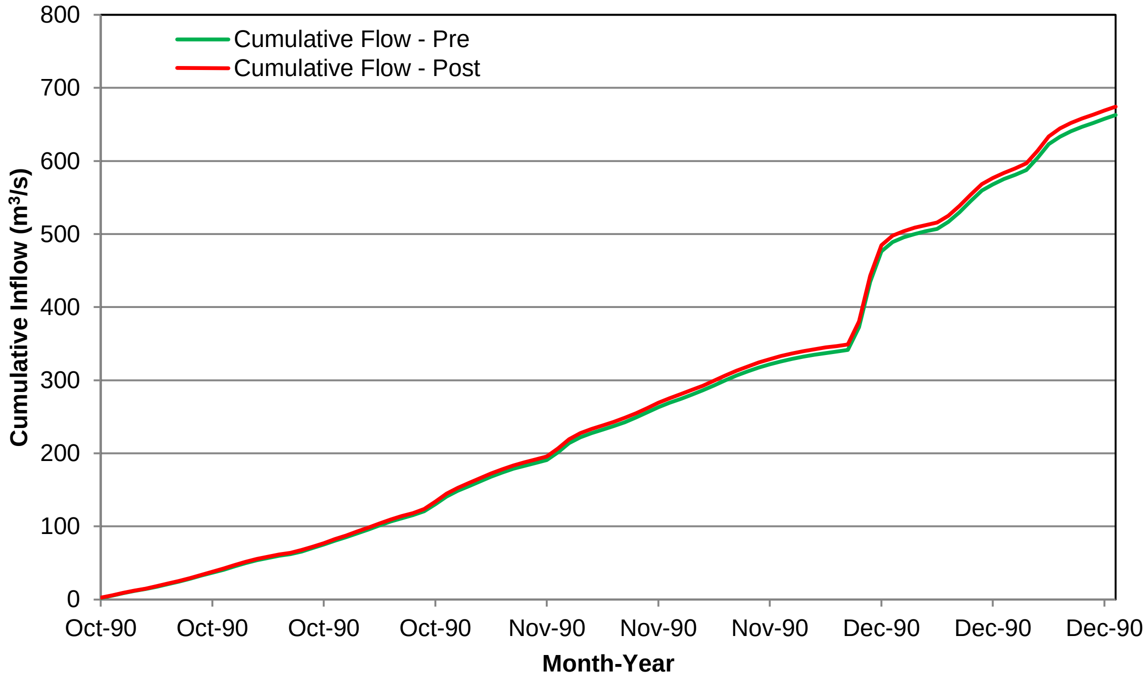

Figure 8a Simulated cumulative flow at the outlet of the Brooms Brook drainage between October and December 1990.

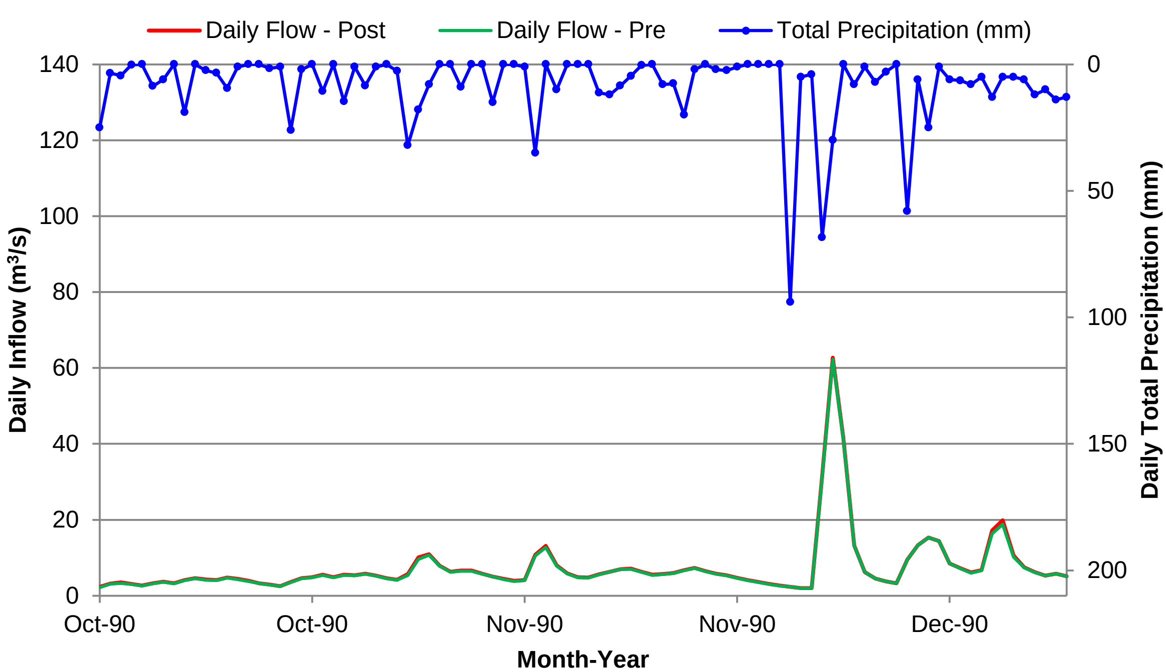

Figure 8b Simulated daily flow at the outlet of the Brooms Brook drainage between October and December 1990.

Appendix WRM71-A

Sludge Characterization

Quantity and Quality Estimate Using Theoretical Assumptions

Prepared by: AB — Stantec

Reviewed by: JF — Stantec

General Comment: This solids waste stream will be a combination of natural water coagulated organics and some precipitated minerals/metals typically in a hydroxide form. The major contributor should be the waste streams from the high purity treatment plant that takes in lake water as its source. This type of dried sludge is often accepted for deposition in on-site industrial landfills at power plants, pulp mills etc. and could go to standard sanitary/municipal landfills in most jurisdictions. Potable water plants sludges would be similar. The numbers estimated herein should be taken at an extremely low level of accuracy, shown basically to give two wide boundaries of possibilities if the theoretical removals of most known parameters ranged from 10-100% in the WWT plant. As we know, the targeted removal is not going to be the same for all parameters. The chemical additives design for the WWTF will be modelled in Detailed Design for more accurate projections.

1.WWTF operating with a 1% Clarifier Sludge Blowdown by Mass

	WATER	WATER			
	Concentration of Water Feeding WWT Plant (parts per million, mg/L, mg/kg)	**Mass Flow Rate of Parameters in Water Feeding WWT Plant (kg/day)**	**Scenario 1 Concentration of Sludge (mg/kg)** Assumes 1. 100% of parameters go to sludge disposal instead of treated water outfall	**Scenario 2: Concentration of Sludge (mg/kg)** Assumes 1. 100% of Iron, Manganese and TOC + 10% of remaining parameters go to sludge disposal instead of treated water outfall	**CCME CSQGs for the Protection of Environmental and Human Health - Industrial land use (1999 and updates) (parts per million, mg/L, mg/kg)**
Total Water Flow (kg/day)	6600000.00	6600000			
Total Dewatered Solids Flow at 30% Solids, Passed Through Filter Press or Other Technology (kg/day)			4400	4400	
Total Theoretical Dry Solids Mass Flow (kg/day)			1320	1320	
pH	6.5-8		6.5-8	6.5-8	
Reactive Silica as SiO2 (expressed as CaCO3 concentration)	3.89	25.7	5834	583	
Chloride	40.66	268.4	60993	6099	
Fluoride	0.15	1.0	231	23	
Sulphate	6.42	42.4	9630	963	
Nitrate + Nitrite as N	0.16	1.0	238	24	
Nitrate as N	0.16	1.0	238	24	
Ammonia as N	0.31	2.0	463	46	
Total Organic Carbon	5.43	35.8	8138	8138	
Ortho-Phosphate as P	0.06	0.4	90	9	
Total Sodium	61.27	404.4	91906	9191	
Total Potassium	1.82	12.0	2725	272	
Total Calcium	65.27	430.8	97901	9790	
Total Magnesium	11.53	76.1	17288	1729	
Total Aluminum	0.64	4.1942	953	95	
Total Antimony	0.01	0.0687	16	2	40.0
Total Arsenic	0.01	0.0457	10	1	12.0
Total Barium	0.09	0.6190	141	14	2000.0
Total Beryllium	0.01	0.0457	**10**	1	8.0
Total Bismuth	0.01	0.0457	10	1	
Total Boron	0.02	0.1209	27	3	
Total Cadmium	0.00	0.0007	0	0	22.0
Total Chromium	0.00	0.0231	5	1	87.0
Total Cobalt	0.00	0.0231	5	1	300.0
Total Copper	0.01	0.0457	10	1	91.0
Total Iron	1.87	12.3203	2800	2800	
Total Lead	0.01	0.0710	16	2	600.0
Total Manganese	0.61	4.0335	917	917	
Total Molybdenum	0.01	0.0457	10	1.04	40.0
Total Nickel	0.01	0.0457	10	1.04	89.0
Total Phosphorous	0.00	0.0007	0	0.02	
Total Selenium	0.00	0.0231	**5**	0.53	2.9
Total Silver	0.00	0.0022	1	0.05	40.0
Total Strontium	0.14	0.9518	216	21.63	
Total Thallium	0.00	0.0022	**1**	0.05	1.0
Total Tin	0.01	0.0457	10	1.04	300.0
Total Titanium	0.01	0.0457	10	1.04	
Total Uranium	0.00	0.0044	1	0.10	300.0
Total Vanadium	0.01	0.0457	10	1.04	130.0
Total Zinc	0.01	0.0679	15	1.54	410.0
Total Mercury	0.0001	0.0007	0.1500	0.02	50.0