Rook I Project

Environmental Impact Statement

Annex IV: Hydrology Baseline Road Map

GOLDER
MEMBER OF WSP

HYDROLOGY BASELINE ROAD MAP FOR THE ROOK I PROJECT

Prepared for:

NexGen Energy Ltd.

Prepared by:

Golder Associates Ltd.

March 2022

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APPENDICES

1.0 INTRODUCTION

This road map provides an overview of the hydrology baseline program undertaken by NexGen Energy Ltd. (NexGen) for the Rook I Project (Project). Section 2.0, Hydrographic Setting, describes the location of the proposed Project in relation to its watershed and drainage network. Section 3.0, Joint Working Group Feedback, provides context on NexGen's approach to engagement and where feedback related to the hydrology baseline from the Joint Working Group (JWG) meetings can be found. Section 4.0, Hydrology Baseline Document Map, provides information on the scope of each baseline report and identifies where key topics associated with the hydrology baseline program can be found in the reports appended to this road map or in baseline reports for other disciplines (e.g., aquatic environment).

The characterization of baseline hydrology for the Project was based on field studies, feedback from First Nations and Métis Groups (collectively referred to as Indigenous Groups), and desktop analyses. The various baseline reports, presented as Annexes IV.1 through IV.5, are part of the comprehensive baseline program that documents different aspects of the hydrological environment in the anticipated area of the Project. These reports include data collected within the hydrology study area, in addition to data from a wider region in northern Saskatchewan and Alberta (Annex IV.1) to compare local data with long-term data from regional climate and hydrometric stations as well as with modelled meteorological data for the hydrology baseline program. Annexes are presented in order of descending spatial scale from regional-scale studies to local-scale results for smaller areas:

- Annex IV.1: Regional Meteorological and Hydrological Characterization Report
- Annex IV.2: Hydrometric Monitoring Characterization Report
- Annex IV.3: Geomorphology Characterization Report
- Annex IV.4: Patterson Lake Currents Assessment Report
- Annex IV.5: Forrest Lake Mixing Study Report

All hydrological baseline reports were completed by Golder Associates Ltd. (Golder) and are complementary studies to inform the Project design and the environmental assessment. Regional historical data was supplemented by field data collected in the areas surrounding the Project from 2018 to 2020 to develop an accurate understanding of the local meteorological and hydrological regime.

2.0 HYDROGRAPHIC SETTING

Hydrography is the arrangement and connectivity of waterbodies and watercourses which provides important context for Project location and how the Project would interact with the receiving environment. The proposed Project would be located adjacent to Patterson Lake, within the Patterson Lake watershed near the headwaters of the Clearwater River watershed. The Clearwater River flows from the area near Broach Lake through a series of lakes including Patterson, Forrest, Beet, and Naomi lakes in order from upstream to downstream. The upper Clearwater River, which flows an approximate distance of 40 km from Broach to Naomi lakes, is dominated by glaciolacustrine terrain with a channel that is shallow, flat, and meandering (Annex IV.3). From Naomi Lake, the Clearwater River flows an additional 20 km southeast before reaching the Mirror River confluence. Below the Mirror River confluence, the Clearwater River deepens and receives higher flow volumes from the Mirror River, and the channel form changes to meandering within a well-defined river valley.

Farther downstream, the Clearwater River flows through Lloyd Lake, which is just upstream of the Clearwater River Provincial Park; the downstream end of the park is at the Saskatchewan-Alberta border. The Clearwater River flows into the Athabasca River at the city of Fort McMurray, Alberta, which flows north into the west end of Lake Athabasca through the Peace-Athabasca delta. Water from the Clearwater River ultimately flows to the Arctic Ocean through the Slave River, Great Slave Lake, and the Mackenzie River.

Regional hydrography in the vicinity of the proposed Project is shown in Figure 1.

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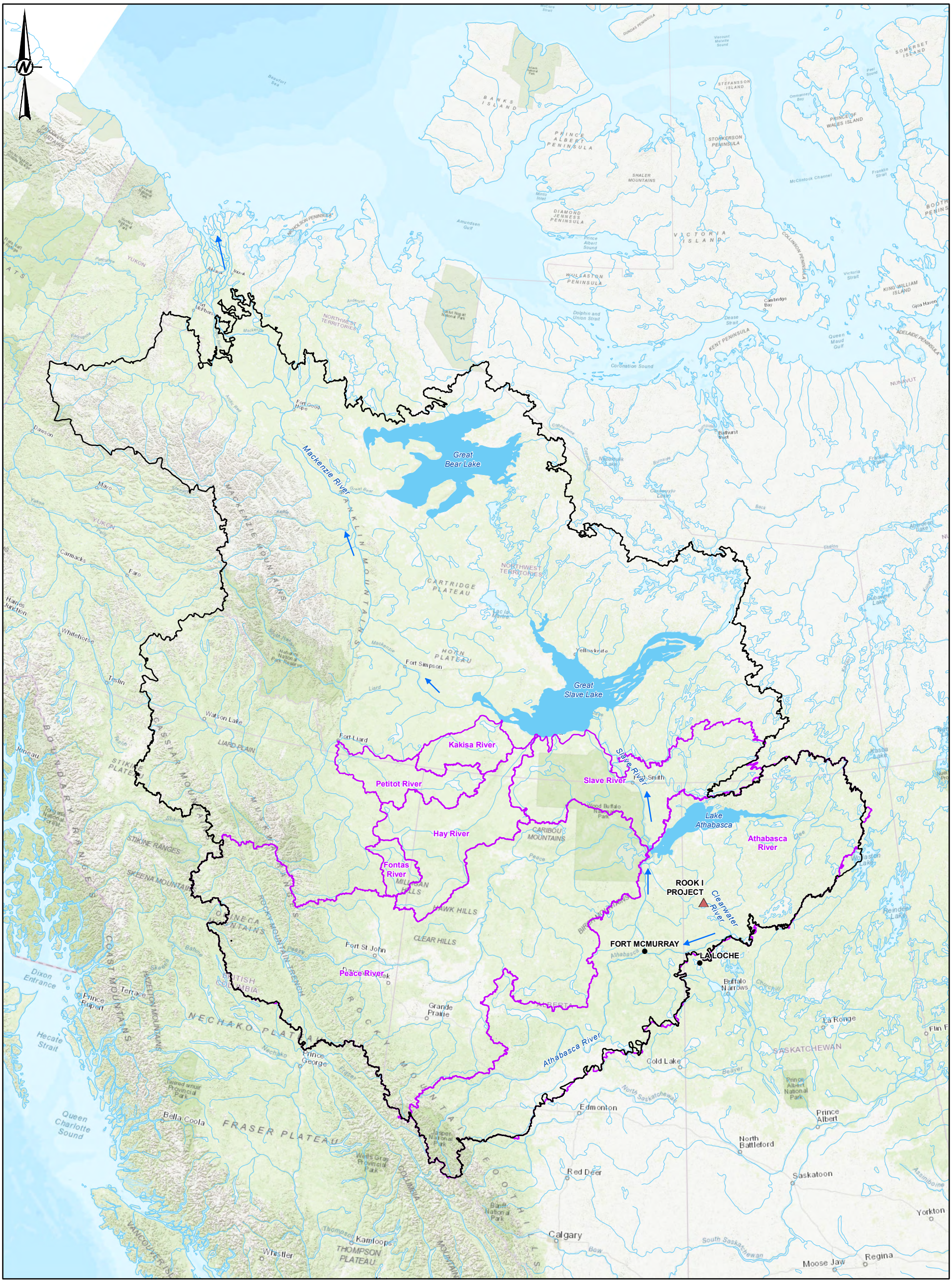

LEGEND

- POPULATED PLACE
- WATERCOURSE
- MACKENZIE RIVER
- MAJOR SUB-BASIN
- WATERBODY
- PROJECT LOCATION

0 200 400
1:8,000,000 KILOMETRE

REFERENCE(S)

1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021.
2. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
3. TOPOGRAPHIC MAP © ESRI AND ITS LICENSORS. USED UNDER LICENSE, ALL RIGHTS RESERVED.

PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT: NexGen Energy Ltd. — **ROOK I PROJECT**

TITLE: **PROJECT REGIONAL-SCALE HYDROGRAPHY**

CONSULTANT: GOLDER MEMBER OF WSP

PROJECT		20144150	PHASE	3314 - 6
DESIGN	JV	2020-03-13	SCALE AS SHOWN	FINAL
GIS	PMT	2021-06-25	**FIGURE 1**	
CHECK	JH	2021-11-09		
REVIEW	RP	2021-11-09		

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3.0 INDIGENOUS GROUP FEEDBACK

Since exploration at the Project site commenced in 2013, NexGen has engaged regularly and established relationships with local Indigenous Groups and northern communities, specifically those closest and with greatest access to the proposed Project.

An important component of engagement to date has been the establishment of JWGs to support the gathering and incorporation of Indigenous Knowledge throughout the Environmental Assessment (EA) process. A summary of feedback from JWGs related to the hydrology baseline program is presented in Appendix A of this memorandum, and includes feedback from the Birch Narrows Dene Nation, Buffalo River Dene Nation, Clearwater River Dene Nation, and Métis Nation – Saskatchewan. Participant questions and comments demonstrated an interest in the regional and local drainage systems and the hydrology of lakes and streams near the area of the Project. In addition, participants inquired about details of the baseline studies completed and associated results. Indigenous and Local Knowledge was also included, where appropriate, from Project-specific studies completed by Indigenous Groups, which included Traditional Land Use and Occupancy studies, Traditional Knowledge and Use studies, Indigenous Rights and Knowledge studies (henceforth referred collectively as Indigenous Knowledge and Traditional Land Use [IKTLU] Studies[1]) (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V: CRDN; TSD VI: YNLR).

4.0 HYDROLOGY BASELINE DOCUMENT MAP

Table 1 provides a summary of key topics related to the hydrology baseline program and cross references to where analysis and discussion of key topics are located within the individual hydrology baseline reports. The topics in Table 1 are listed in roughly descending order of spatial scale from regional spatial scale to smaller areas, consistent with the order of the hydrology baseline reports. Section 4.1 through Section 4.5 provide context and direction to where information related to key hydrology topics can be found.

Key topics from these baseline studies may also overlap with baseline studies for other disciplines (e.g., aquatics); this information is also provided in Table 1 to assist in comprehensive review.

[1] Referred to as TLU Studies in the baseline reports.

Table 1: Hydrology Baseline Key Topic Location Summary

Key Topic	Baseline Report Title	Baseline Report Section Reference	Approach to Topic[1]
Climate	Annex I: Atmospheric Baseline Report	Section 5.1 Climate Section 5.2 Weather	Primary data source
	Annex IV.1: Regional Meteorological and Hydrological Characterization Report	Section 5.1 Climate Conditions	Primary and applied data source
	Annex IV.2: Hydrometric Monitoring Characterization Report	Section 4.3 Local Meteorological Data (Methods) Section 4.4 Snow Surveys (Methods) Section 5.1 Meteorological Data (Results) Section 5.2 Snow Surveys (Results)	Primary data source
	Annex IV.4: Patterson Lake Currents Assessment Report	Section 5.1 Meteorological Observations	Primary and applied data source
Lake morphometry (i.e., shape and dimensions)	Annex IV.4: Patterson Lake Currents Assessment Report	Section 4.0 Methods Section 5.3 Patterson Lake Currents Observations (Results)	Primary and applied data source
	Annex V.3: Naomi Lake Bathymetry Report	All	Primary data source
	Annex V.1: Aquatic Environment Baseline Report	Section 2.0 Lake Morphometry	Primary data source
Lake level	Annex IV.2: Hydrometric Monitoring Characterization Report	Section 4.5 Hydrometric Monitoring (Methods) Section 5.3 Hydrometric Monitoring (Results)	Primary data source
Lake currents	Annex IV.4: Patterson Lake Currents Assessment Report	All	Primary and applied data source
	Annex IV.5: Forrest Lake Mixing Study Report	All	Primary and applied data source
Streamflow	Annex IV.1: Regional Meteorological and Hydrological Characterization Report	Section 5.2 Historical Hydrometric Data	Applied data source
	Annex IV.2: Hydrometric Monitoring Characterization Report	Section 4.5 Hydrometric Monitoring (Methods) Section 5.3 Hydrometric Monitoring (Results)	Primary data source
	Annex IV.3: Geomorphology Characterization Report	Section 5.3 Clearwater River Below Patterson Lake	Applied data source
	Annex IV.5: Forrest Lake Mixing Study Report	Section 5.2 Forrest Lake Inflow and Outflow	Primary and applied data source
Hydrogeology	Annex III: Hydrogeology Baseline Report	All	Primary data source
Sediment and erosion potential	Annex IV.2: Hydrometric Monitoring Characterization Report	Section 4.6 Sediment (Methods) Section 5.4 Sediment (Results)	Primary data source
	Annex IV.3: Geomorphology Characterization Report	All	Primary data source
	Annex V.1: Aquatic Environment Baseline Report	Section 4.0 Sediment Quality	Primary data source

[1]Approach to Topic is noted as either primary data source or applied data source. Primary data source refers to field data collected for the Project. Applied data source refers to modelling, analysis or characterization of conditions informed by primary and second-hand data sources (e.g., government).

4.1 Climate

Climate is the meteorology (i.e., weather) of a place over a long period of time and provides information on normal conditions, normal variation seasonally and inter-annually, and the normal range of weather extremes. Climate is an important control on hydrology and geomorphology. The Regional Meteorological and Hydrological Characterization Report (Annex IV.1) used published historical data from regional climate stations in combination with spatially distributed data, remote sensing data, and site-specific meteorological event data to characterize expected climate for the Project. Short-term meteorological observations were also applied in other baseline reports to support interpretation of lake levels and streamflows (Annex IV.2) and lake current patterns (Annex IV.4 and Annex IV.5).

4.2 Lake Morphometry

Lake morphometry provides basic physical information on waterbodies, including bathymetry and water level–surface area–volume relationships. Lake morphometry influences physical, chemical, and biological characteristics of waterbodies in the study areas and provides valuable supporting information for calculating lake water balances and hydrological modelling. The primary sources for lake morphometry information are the Aquatic Environment Baseline Report (Annex V.1) and the Naomi Lake Bathymetry Report (Annex V.3). Most lake bathymetry surveys were conducted during the open-water period in 2018 as part of the Aquatic Environment Baseline Report (Annex V.1). Naomi Lake bathymetry was collected the following winter from 21 March 2019 to 25 March 2019 using ground penetrating radar surveys, and results are provided in Annex V.3. Lake morphometry information was also used to support interpretation of the focused studies in Patterson Lake (Annex IV.3 and Annex IV.4) and Forrest Lake (Annex IV.5). Lake bathymetry was observed to influence Patterson Lake currents differently in different locations (Annex IV.3).

4.3 Lake Level

Lake levels vary over time in response to changes in in-lake storage, weather, streamflows, and other physical changes in the environment. Natural variation in levels of waterbodies was a key consideration of the hydrology baseline in characterizing existing hydrological conditions and provided the basis for evaluating potential effects as part of the EA. The primary source of measured lake levels is the hydrometric monitoring report (Annex IV.2), which provides detailed data collection methods and results for the eight waterbodies measured between 2018 and 2020.

4.4 Lake Currents

Lake current assessments were completed for Patterson Lake (Annex IV.4) and Forrest Lake (Annex IV.5). These assessments were used to determine the mixing zones and potential effects from Project discharges.

4.5 Streamflow

Streamflow varies over time in response to changes in weather and other physical changes in the environment. Natural variation of streamflow in water courses was a key consideration of the hydrology baseline program in characterizing existing hydrological conditions and provided the basis for evaluating potential effects as part of the EA. The hydrometric monitoring report (Annex IV.2) is the primary source for measured streamflow data and provides detailed data collection methods and results for 12 watercourses sampled from 2018 to 2020. Hydrology baseline information related to streamflows are referenced in four baseline studies per Table 1 (Annex IV.1, Annex IV.2, Annex IV.3, and Annex IV.5).

4.6 Hydrogeology

Groundwater and surface waters are connected and must be integrated into the overall water management of a Project to protect water resources. Hydrogeology baseline studies were completed to understand the groundwater regime around the Project (Annex III). Groundwater modelling results informed the water balance and were incorporated into the water quality modelling for the assessment of effects.

4.7 Sediment and Erosion Potential

Sediment physical properties and sediment transport are important factors in understanding the morphometry and geomorphological processes in waterbodies and watercourses. Fluvial (i.e., in a river) sediment transport is an important function of a watercourse and is influenced by streamflows, wind on lakeshores, and the physical environment. Sediment transport and particle size distribution of the streambeds were characterized at three monitoring locations along the Clearwater River downstream of the Project in the hydrometric monitoring report (Annex IV.2). These measurements support the understanding of the natural fluvial sediment transport regime over a range of hydrological conditions and provide a basis for evaluating changes to the sediment transport regime as a result of changes to hydrology. Particle size results for sediment sampled from the lakebed of numerous waterbodies, and the Clearwater River in the hydrology regional study area, are included in the Aquatic Environment Baseline Report (Annex V.1).

APPENDIX A

Joint Working Group Feedback Applicable to Hydrology Baseline

Table A-1 presents the comments and feedback NexGen has received from members of local Indigenous communities through established JWG meetings. Where appropriate, feedback from local Indigenous communities was considered within the baseline and/or EA processes or tracked as issues or concerns for resolution. NexGen continues to engage with communities, and the feedback presented in Table A-1 reflects comments and feedback received through March 2020 that were related to baseline hydrology or the comprehensive baseline program generally.

Table A-1: Joint Working Group Feedback Related to Baseline Hydrology

Community	Comment
Birch Narrows Dene Nation (BNDN)	Where is Bolton Lake in relation to the project?
	Are you aware of any huge adverse environmental impacts in any of the current mine sites?
	Important topics for the JWG moving forward are Indigenous knowledge, traditional land use, the species discussion, water quality, environmental monitoring, employment, and business opportunities
	The water changes every year.
	Could we ask that you take samples here? That way we can see changes into the future. Even if it isn't affected by the mine. Respectfully, I request that samples are taken here.
	Are the little lakes in between tested?
	Who's responsible for the modelling of the water?
	What is the average depth of the lake?
	Respect the land, the water, the trees. Don't clear-cut the small trees – they take 50 years to grow back. (inaudible) water in one big lake, trout, everything, – just grass there now. They didn't put the water back. Didn't fix it. It used to be a big lake, but now there's nothing there.
Buffalo River Dene Nation (BRDN)	Have you gone to communities to show what you are doing? If so, what was the feedback?
	It's important to explain the Project to Elders in a way that they can then explain it to other Elders in the communities.
	Water is the main thing that people worry about.
	It'll be important to explain to the community that waterways and rivers are natural filters, and peat moss.
	The old guys know there are underground river flows through different areas, in muskeg and sandstone. They stepped through a muskeg and found flowing water.
	Please explain the natural filter systems – the river filters out lots of stuff- rocks, gravel. The Elders think whatever goes into the water will carry all the way down here.
	Our water in these big lakes is all coming from the muskeg, not the river, that's why it's clear. You can see the bottom, and the fish
	In 2001 in Dillon, the water was shallow. Since then it never went down; still going up. This lake is still full here. In Dillon the water is just about full now. But a lot of things are going to change; there are signs of acid rain from Alberta – changes to trees. Half of the trees are different colours. Every time it rains, the trees look a little but different.
	They [beaver dams] break open; lots of logs and everything coming out, running all the stale water that has been sitting.
	One of the Elders was telling us that there's a little lake on our traditional territory where in spring when it's starting to melt, the water that sits on top of the ice, there's nothing that tastes so good. He goes there just to have that water every year. Fresh melt water. I would think in Dillon I could drink the water on top of the ice, but he said in that little lake it's totally different.

Table A-1: Joint Working Group Feedback Related to Baseline Hydrology

Community	Comment
Clearwater River Dene Nation (CRDN)	Water is always the key issue back home.
	Remember we're trying to implement a plain speak document because of visual concepts of understanding. That is what the chief is talking about.
	In terms of baseline studies, are there any opportunities for community involvement with any of your residual baseline work, from fish, terrestrial, etc.?
	And we will eventually throw in our environmental monitors. I don't know if you knew that. We want to train our own people because of lack of trust of government and industry.
	The interim CRDN Rights and Knowledge study will come out of the CRDN-definitive initial list of [valued components] VCs that we want to talk to you about. As we go through there may be additional ones. We know there's a certain window, but we'll try to be as comprehensive as possible. It may not be as linear as moose; it might be having undisturbed places on waterbodies. They might be more complex.
	And our people? We use that water quite a bit. It goes into the Clearwater and all the way down. [CRDN member] picks up water from the Clearwater.
	Not on the old or existing mines that are sitting there?
	Golder does the same thing – hires three or four band members to do the interviews, then takes the notes and puts the document together. When you find the stuff it's not always based on the relationship to the stuff. It's based on what the government's qualifications are on the environmental assessment's impacts, and not the actual concerns of it. I'm trying to reach what [CRDN member] is saying between traditional and modern ways.
	When we started looking at the strategy process, there's that interpretation of cumulative effects. Then we define and introduce an interpretation for that. It's not just one side, western science, we're doing the traditional side as well. That's what the Chief is referring to.
	Both traditional and western science are very important.
	Which lakes are those?
	Will we see the results of those studies?
	You said there was a couple of watersheds – can you talk about that selection process?
	When you're talking about testing the water, are other studies being done on the Alberta side with the Clearwater system? Do they do their own studies?
	How many other projects are in that square box (referring to map)?
	Do other companies have mineral holdings in that box on the map – like for oil and gas?
	Did you take any sediment samples?
	Did you take any samples around the deposit that's underneath the lake? Thinking you should take sediment samples before and after mining activity starts.
	I think it's really important to compare Cluff Lake to what's happening in the baseline studies. It's a good question.
	Regarding Cluff Lake: were there tests being done then and now, and can you see if the water is changed? Would Cluff's watershed flow into this one?
	With global warming, each year we won't have the same amount of snowfall, so you will see the water drop.
	How do you monitor evaporating water? That has a big effect as summer progresses.
	How far north of the Project is the water flowing back into the Patterson area?

Table A-1: Joint Working Group Feedback Related to Baseline Hydrology

Community	Comment
Clearwater River Dene Nation (CRDN)	But there's another river system further north – the Douglas River – that's also flowing west like the Clearwater. We went all the way to Lake Athabasca on the Douglas River system.
	You're sampling at Hodge, you said? How is the water?
	Do any rivers flow east from this area?
	On La Loche Lake we have one island. On the north side of that island, just near the reserve, we set nets. The next morning, we went back and the nets were gone. They were dragged way out into the middle of the lake. There were other times when there were huge holes in the nets in that same area.
	They have pictures at a museum in Drumheller, Alberta. When I saw the picture, I said isn't this what people have been describing in the lake back home? I asked if the water connected to Fort Mac [McMurray], to see if it might have come from there. Who knows?
	This is mostly surface water you're talking about? I see a note about diffusion through groundwater – where does that come from?
	This is something we heard about Cluff Lake, and we don't have a great understanding about it – we don't have our own hydrologist. I heard there's still materials leaching out of that facility through the groundwater, at a glacial rate but there is a slow release of materials; is that what you're talking about? That's what I'm trying to understand in terms of your baseline monitoring – how are you measuring what the baseline groundwater movement is? It's quite difficult in the short timespan you're looking at.
	Community members mentioned every year the water level's going down. If there's lack of oxygen the fish could die off too. Have you come across anything?
	Each year, when anyone goes up north, we get snowfall and rain. On some lakes you see water levels low, and they never recover. On others, it's up again the next year. Some lakes will never recover. One lake up by Douglas River – a few years ago there was a drilling company there and we saw a pump in the water. The water levels dropped so much that it will never recover. They were set up at an old gravel pit.
	When we built the community hall back home, there was an underground stream that was flowing like a river. I figured there could be fish going through there
	What's the purpose of trying to gather all this information?
Métis Nation of Saskatchewan (MN-S)	We have to understand all living and non-living things.
	We are seeing lots of effects from the oil sands – water is changing, plants and animals are dying.
	Are any community members involved in the establishment of the baseline for environmental monitoring, so can they verify their accuracy?
	Would the results be released and reviewed by the community?
	From a trust point of view, our people will want to know that those numbers are accurate now, not later. Just a comment to think about.
	How would this group know – is there a way for the people involved in the studies to inform the group of what they saw and if they are confident they are accurate? Once the stuff hits the EIS, how do we know that it's good? If community folks that were involved in that process and they can validate the results, that brings comfort to community members.
	How often are you monitoring?
	How many locals do you have working with you? You guys talk, but we won't hear anything about water sampling in La Loche.

Table A-1: Joint Working Group Feedback Related to Baseline Hydrology

Community	Comment
Métis Nation of Saskatchewan (MN-S)	It's that validation we're looking for. When I had to involve community members in monitoring, I would get them to write a report if they couldn't speak to the broader community in general. If they didn't feel like writing it, they could talk so someone who would transcribe it. That report could give a summary of how things went, what they saw, were the readings accurate; that could come back to this group, if they couldn't present themselves. The point [MN-S member's] trying to make is, we need some connection to that community resource that's out there doing the monitoring and seeing this stuff. We know who they are, and we're confident in the results. That builds trust.
	Do you have instruments or people taking samples? What does an instrument look like?
	What he's getting at is simply - you can put a box in there, but if you open the box, is there anything in it? It measures, turbidity, flow, pH balance, all the different man chemicals, natural chemicals in there. Then you have a true baseline. If we look at it and say yes, they have a measuring apparatus there, it's nothing. We want to know what it does and how.
	When did you start studying snow?
	Last year it was a foot deep, this year 2".
	How do you know it comes from here and not there?
	What about the little lakes on the side?
	Just south of the Clearwater is the Great Divide [Methy Portage] - the other side of the divide drains from La Loche Lake to the Churchill. So we have a number of different drainage systems. All we are showing here drains into the Clearwater.
	You're on the far end of that drainage system. A lot of water will be draining through.
	Are you testing underground water also? Are you aware if there's any aquifers – most lakes have aquifers that come and go, especially lakes these sizes.
	It was brought up that some of the leftovers [tailings] will be put down underground. In order to really understand everything, you have to have to understand how water moves underground.
	I normally used groundwater all my life. I used to drink La Loche lake water, but today, you can't do it. Been fishing on Patterson, and on a far lake where I have a cabin. We drink the water right from the lake without boiling it; I'm afraid we will lose that.
	The studies we did a few years back, these guys don't want to use them. That's what I heard.
	I had feedback on community engagement, and I'm trying to figure out how we can move forward in a responsible way where people have their input without being offended. We're working towards a bigger goal than what is currently perceived. We need a discussion on how we can approach it. I can offer some high-level thinking to help bring my community around.
	We should have more of these meetings with other companies like this. I'd like to get a Métis community member to work side by side with you guys and report the environmental side to the community instead of you guys doing it, so we know where we are and how much damage is being done to the land.
	This is general – the same information will come back to all the JWGs?
	We are the world's water purifying system – the swamps and muskegs break down all kinds of pollutants and turns it back to normal. That's one of the benefits of our north; we are the filter for most of the world's water. Each forest plays a role in everything, like rainforest in B.C.
	It gets you one way or another. The height of land changes at Wasagamio; everything flows from the Clearwater to Fort Chipewyan. We're lucky on the Churchill River that we don't get that flow coming our way. Yet we get the westerly winds coming over us
	It's not just natural evaporation; they're adding to it, which increases rainfall and erosion, and destruction of habitat.
	It's mainly the food, for everything. We put seeds out, all kinds of birds come. Food is the main item of why things move around; water's the second one. Because of the Let it Burn policy, fire destroyed their food habitat. It's gone, and I don't know what I could tell you to change that. Go and find caribou moss is the simplest solution I could tell you. In the NWT, pipelines affect them – they are a big barrier.