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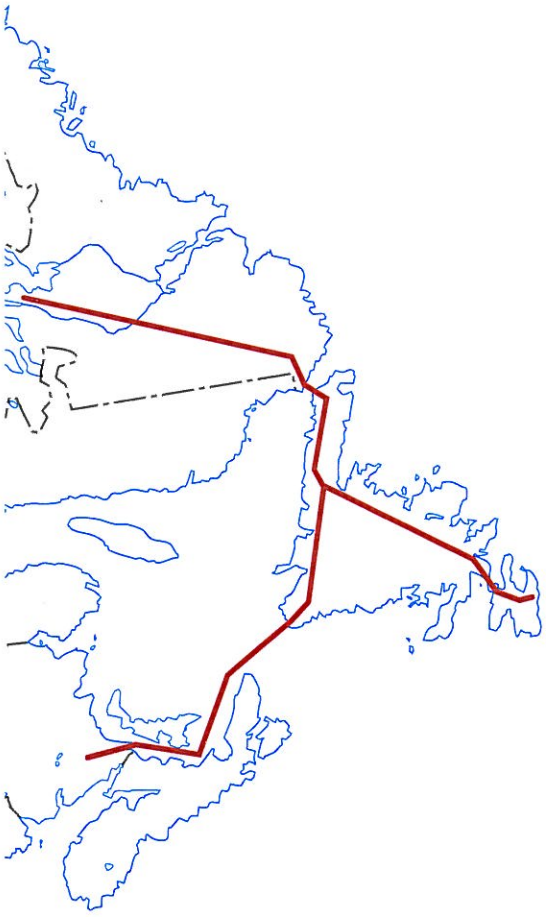

THE Lower Churchill PROJECT

March 2010

MF1271 - Evaluation of Existing Wells, Pumps and Related Infrastructure in the Muskrat Falls Pumpwell System

prepared by

HATCH™

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Executive Summary

Nalcor Energy - Lower Churchill Project (NE-LCP) is pursuing engineering studies with respect to the development of the hydroelectric potential of the Lower Churchill River at Gull Island and Muskrat Falls. At Muskrat Falls there is a large rock knoll and an overburden spur to the north that could be incorporated with a natural embankment dam. However, natural mass wasting processes were quickly eroding the spur and it was determined through engineering studies in the 1970's that the mass wasting could be arrested with the installation of a pumpwell system. The pumpwell system was installed in 1981. In 1997, Hatch installed 12 piezometers in 7 boreholes to monitor the groundwater levels in the area of the dewatering system and, in 1998, Hatch completed an inspection of the pumpwell system and conducted a well cleaning program.

The well system is currently 28 years old and was installed initially as a temporary measure. A 2008 Hatch report included several recommendations to extend the life of the system and ensure its continued operation for the next 10 years. The recommendations included the cleaning and inspection of 22 wells in the dewatering system and the installation of 8 new piezometers at 4 locations to further assess groundwater conditions in the area of the dewatering system. This document presents the findings of the 2009 well inspection and well cleaning program.

Section 1 of this report includes an introduction, scope of work and description of the well inspection team. A scope of work was developed prior to mobilization to the site and approved by NE-LCP; some of the tasks were modified slightly due to field conditions or following discussion between NE-LCP, Hatch and the well contractor. The historical and geological background and site characteristics are described in Section 2.

Section 3 describes the well inspection and cleaning program that commenced on August 27 and was completed on September 7, 2009. Photographs found in Appendix A document the well inspection and cleaning procedure. Flow rate testing was conducted prior to the start of the well inspection program and after completion of the program. The next task was the system shutdown and removal of pumps and infrastructure. Approximately 3 wells were completed at a time and every effort was made to return the wells to service as quickly as possible.

A downhole camera inspection was completed for every well in order to assess the condition of the PVC casing and stainless steel well screen and make note of any potential cracks or staining. The inspection was completed both prior to and after cleaning. Following the initial downhole camera inspection, the pumps, hardware and infrastructure was inspected, making note of corrosion and wear and replacing components as required. The wells were then cleaned which involved the addition of an HCL acid solution to dissolve encrustation in the casing and on the well screen, the use of a well bore brush and additional water to clean the casing and screen, and a sand pump to remove any sediments in the bottom of the well.

Once all cleaning operations had been finished and a post cleaning camera inspection completed, the pump, riser sections and associated wiring were returned to the well, reconnected and the well re-energized. Observations were made of the operation of wells that had been returned to service and the overall operation of the system. Observation continued until the NE-NLH electrician was confident that the system was working properly.

Section 4 describes the overall findings of the well inspection program. In general, the screens of the wells were in good condition; exceptions are described in Section 4.3, Well Specific Comments.

Based on results of the well inspection program, it has been concluded that the wells in the system are operating satisfactorily and wells screens are generally in good condition, with the exception of wells W-1, W-2, W-15 and W-18. It is expected that W-15 can be readily repaired at the control panel. Wells W-1, W-2 and W-18 may no longer be viable. Therefore, a malfunction of one or more wells could potentially put a significant strain on the system and result in a rise in groundwater levels in the spur.

To ensure a satisfactory performance of the dewatering system for the next 10 years and to maintain the physical asset of the Muskrat Falls ridge as a whole, it is recommended that 6 to 7 new stainless steel wells be installed. The installation would include a replacement of wells W-2 and W-18 (and possibly well W-1) and installation of 3 to 4 additional wells to replace the high yielding wells. Recommendations are detailed in Section 5 of this report.

1. Introduction

Nalcor Energy - Lower Churchill Project (NE-LCP) is pursuing engineering studies with respect to the development of the hydroelectric potential of the Lower Churchill River at Gull Island and Muskrat Falls. These sites are located downstream 225 km and 285 km respectively from the Upper Churchill hydroelectric facility that was developed in the late 1960s. The total potential capacity at the two sites is approximately 3000 megawatts (MW); the Gull Island site being the larger.

Early studies in the late 1970s concluded that a natural embankment dam could be constructed in the area of Muskrat Falls. The land spur which reaches from the north bank of the Churchill River at Muskrat Falls to the large rock knoll closer to the south bank could be incorporated into the embankment dam. In this context, the natural spur constituted a considerable capital asset, if it could be maintained. Natural mass wasting processes, however, were quickly eroding the spur; it was determined that these could be arrested with the installation of a pumpwell system. Such a system was installed in 1981.

A field program was undertaken in 2007 (under Work Task Order MF1260) to assess the performance of the pumpwell system. The purpose of the field program was to assess the existing condition of the system, compare with historical records and determine the required action to allow the system to operate efficiently for the next ten years. In July 2008, a report was submitted which described the findings of a preliminary site visit during the period from September 9 to 11, 2007, and a description of the field program conducted in the autumn of 2007. The field program, carried out on November 5 to 8, 2007, included testing of the wells, pumps and piezometers. The dewatering system was shut down for 5 hours each day on November 7 and 8, and the water level recovery in wells and piezometers were recorded for half of the system each day.

The well system is currently 28 years old and was installed initially as a temporary measure. The 2008 (MF1260) report included several recommendations to extend the life of the system and ensure its continued operation for the next 10 years. The recommendations included the cleaning and inspection of 22 wells in the dewatering system, in an attempt to assess the condition of the system.

This document presents the findings of the well inspection program. The scope of work is described in more detail in the following Section.

1.1 Scope of Work

A scope of work was developed prior to mobilization to the site and approved by NE-LCP. It should be noted that some of the tasks were modified slightly due to field conditions. Any changes from the proposed scope of work are summarized below and discussed in more detail in the appropriate subsection in Section 3 - Well Inspection Field Program.

Following is a description of the scope of work:

- A mobile boom truck, pumps, compressor, ancillary equipment, tooling and personnel were mobilized to the Muskrat Falls site.
- NE-LCP provided some of the equipment related to the project including several pumps, a supply of sensors and approximately 10 riser pipes.
- Water level readings were collected in wells and piezometers before any site activity. The collected data was compared with the historical values presented in the 2008 report. The water discharge rate and quality was to be recorded at the collector pipe outlet. However, it was decided that due to safety concerns and difficult access, the outlet would not be assessed and instead water yields and quality were recorded for each individual well.
- The operation of each of the wells was individually disabled in a sequence, to minimize impact on the operation of the well field pumping network. System shutdown was completed by NE-NLH under Work Protection Code. Operations were planned such that highly active wells (W-4, W-9, W-10, W-16 and W-19) could be re-installed in the same day. The NE-NLH electrician helped to determine the active wells.
- Removed the risers, pump, wiring and sensors from the well.
- Removed any scaling, rust or other debris from the pump, pump intake screen, sensors and risers. Recorded all hardware specifications including, but not limited to, manufacturer, model number, serial number and power input requirements. Photos were taken of all equipment. The operation of all hardware was tested and checked and improperly functioning components were replaced.
- A downhole video camera was lowered into the well to visually assess the condition and integrity of the well casing and screen. In the event the water in the well was cloudy, a flocculent was injected to improve visibility. There was some field testing to assess whether the use of the flocculent was effective at improving visibility. Approximately halfway through the program, the use of the flocculent was discontinued due to lack of evidence of its effectiveness.
- While hardware inspection was proceeding, it was proposed to gently redevelop the well by injecting water in a stepwise progression from a low pressure, low volume compressed air to progressively higher pressure and air volume, as deemed necessary, and thereby remove any debris or sediments that were impeding the optimum functionality of the screen. Based on the visual assessment, it would be determined if continuing with the redevelopment task was appropriate for each well. This technique was carried out at well W-3 and there was insufficient head to lift the injected water to the ground surface. It was decided at that time that this type of cleaning method was not suitable for the well system due to deep water levels and concern about damaging the well screen.
- An acid solution was added to each well and allowed to stand for a period of about one to two hours. A wellbore 'brush' was used to brush the casing and wellscreen and remove any debris or encrustation in the well.
- As an alternative to air injection, a sand pump was lowered to the bottom of the well and sediment at the bottom of the well was drawn into the sand pump under suction and removed form the well. Removal of sediment could potentially increase the yield from the well.

- A downhole video camera inspection was repeated to visually assess the condition and integrity of the well casing and screen and to compare the well condition before and after the cleaning procedure.
- Upon completion of successful inspection, testing and data recording of the pump and all related downhole well hardware, together with successful completion of downhole work, the pump, riser pipe, electrical cable, sensors and relays were re-installed in each well. Damaged equipment was replaced from the cache of supplies provided by Nalcor.
- After completion of inspection and cleaning, the well was reconnected to the well field power supply. When the pumps and related electrical components were re-energized, observations were made as to the operation and function of the well.
- Flow/discharge tests were conducted on the wells following completion of all the well inspection and cleaning.
- It was proposed that water levels be collected in the piezometers twice a day, before and after daily activities. Due to time constraints, piezometer water elevations were collected once a day, graphs were prepared and the water table recovery in the spur was compared with Figures 7 to 10 of the MF1260 report.

All of these tasks were executed under the direct supervision of Hatch.

1.2 The Well Inspection Team

The well inspection program was completed by a team of specialists which included:

- A Hatch Site Supervisor who oversaw and was responsible for the completion of the program.
- A water well drilling contractor, pump/electrical contractor and three helpers (P. Sullivan & Sons Ltd).
- An electrician from Nalcor Energy – Newfoundland and Labrador Hydro (NE-NLH), Happy Valley-Goose Bay (HVGB) office.
- A team of two helpers that worked with NE-NLH from the HVGB office.

The water well drilling contractor worked with the boom truck to pull the pumps, risers and electrical works and completed the downhole camera inspections. The pump and electrical contractor completed the inspection, documentation and cleaning of all pumps and infrastructure with the aid of the three helpers. NE-NLH has historically looked after the electrical components of the site and taken water levels in the piezometers on a monthly basis. The NE-NLH electrician provided guidance on the electrical components and protocol for the Work Protection Code and the helpers were involved mainly in the pulling and reinstallation of the pumps and the monitoring of water levels in the piezometers. The Hatch Site Supervisor oversaw the program and ensured that the scope of work was completed.

The following sections outline the details of the well inspection program at Muskrat Falls. Section 2 provides background on the history and geology of the site, Section 3 provides details of the field program, Section 4 summarizes the findings of the program and Section 5 provides conclusions and recommendations.

Photographs, inspection logs and figures are included in Appendix A, B & C, respectively.

2. Historical and Geological Background

2.1 Site Characteristics

The site of Muskrat Falls (Figure 1, Appendix C) on the Lower Churchill River, located about 30 km upstream from HVGB in Labrador, has been recognized as a potential hydroelectric development for several decades. At this site, the Churchill River has a drop of about 15 m from el 18 m at the upstream side to el 3 m at the downstream side. Past studies contemplated raising the head to about 40 m.

The prominent features of the site include a rock knoll rising to almost 150 m in elevation. The rock knoll is connected to the left bank by a spur of land about 1 km long, which forms a natural barrier forcing the diversion of the Churchill River into a channel carved out south of the rock knoll. The spur rises to elevation 60 m and has a minimum width of 150 m at the south side, in the upstream - downstream direction.

2.2 Geology and Sediments

The Muskrat Falls site is underlain at a maximum depth of about 270 m by crystalline metamorphic rocks composed of granitic gneiss of Precambrian age, with some dark mafic bands and occasional irregular pegmatite stringers. In addition to the rock knoll which rises sharply from the buried valley floor, several exposures are found on the right bank of the river.

The Churchill River valley is preglacial in origin, and was formed largely by river action prior to the Pleistocene epoch. Subsequent widening and reshaping of the valley occurred during the Wisconsin glaciation period, about 13,000 years ago. An estimated thickness of 60 m of a deposit of sand, gravel and boulders filled the lower part of the reshaped bedrock valley during the course of glaciation. As the glacier retreated, the sea level rose and caused submergence of the valley by an estuary extending up to Gull Island. This inundation of the valley by the rising sea resulted in the deposition of marine and estuarine sediments in an environment of saline and brackish water.

Isostatic rise of the land relative to the sea then caused a gradual recession of the estuary and resulted in the deposition of a layer of fine sand, over marine clay sediments.

The sediments in the spur consist of four units.

a) Upper Sand (el 60 to 45 m) covering the terrain and consisting of uniform fine to medium sand approximately 10 to 15 m thick.

b) Stratified Drift (el 50 to -10 m) consisting of a marine clay deposit generally underlain with a varying thickness of sandy materials. The sandy components dominate the southern 250 m long section of the spur against the rock knoll and constitute an aquifer. The thickness of the upper clay increases toward the north.

It is noted that primarily these two units in (a) and (b) are engaged in the failure activity of the downstream face of the spur.

c) Lower Marine Clay (el -10 to -60 m) is a stratified impervious silty clay deposit.

d) Lower Aquifer (el -70 to -210 m) composed of pervious sand and gravel, and occupying the lower part of the buried valley.

Gullies and creeks exist along both the upstream and downstream slopes of the spur. The most prominent gully is found in the area of the three lakes in the north side of the spur. Numerous creeks and a small stream were found originating as springs at the sand and clay contact.

Hydrogeologically, there are two aquifers. The water level in the Lower Aquifer is at el +5 m which is considerably higher than the surface of the overlying marine clay unit suggesting confined characteristics. However, it is the hydrogeologic behaviour of the upper aquifer which has a dominant effect on bank stability. Recharge into this unit is from the northwest, through the upper sand unit and hydraulic connections in the stratified drift. Along the dewatering system alignment, the water level was originally at about el 30 m at the south side of the spur rising to el 47 m about half way and dropping to about 15 m at the north end.

2.3 Bank Instability and Groundwater Control Facilities

The banks of the Churchill River between Gull Island and Goose Bay are scarred by numerous landslides, some of which involve large quantities of overburden. Instability has affected the slopes of the spur, particularly the downstream slope, as well as the left bank of the river downstream from the spur. In 1978, a major landslide occurred on the south end of the spur resulting in the loss of a considerable portion of land in the downstream perimeter. Minor failures were further experienced in 1980-81. High piezometric water levels and steep hydraulic gradients in the sediments above river level and tailwater rapid drawdown effects due to the collapse of the downstream annual ice-dam have been the major causes contributing to instability.

In order to protect the remaining spur from further instability, a continuously pumped dewatering system was installed along the downstream shoulder of the spur in 1981. At the time of their installation, the system was considered to be “a temporary stabilization measure . . . and not a total defence against mass wasting” (Acres, 1994). The dewatering system was anticipated to lower the groundwater level in the spur from about el 30 m to at least el 15 m and preferably as low as el 3.5 m.

22 wells were installed in a line spaced at 30 m with an average depth of 63 m close to the edge of the downstream slope of the spur. The drilling diameter was 300 mm with stainless steel screen and PVC riser pipe having an internal diameter of 150 mm. All the pumps are connected to a 300 mm diameter collector pipe, with 75 mm of insulation, finally discharging to an existing stream through an exposed portion close to the outfall location (SNC-Lavalin, 1982).

To monitor the groundwater regime, 17 piezometers (vibrating wire) were installed in 1981 but all were lost in 1984 due to a power surge from a lightning strike on the power line. In 1997, 12 standpipe piezometers were installed in 7 boreholes and these continue to be monitored. Subsequent records of operation of the well system have recorded pump functions only, namely pumping duration and the number of pump cycle initiations per day.

NE-NLH and Acres International staff carried out formal maintenance inspections in 1994, 1995 and in 1997 at which times some or all the pumps were retrieved, cleaned and reinstalled or replaced as

necessary (Acres International, 1997). The NE-NLH HVGB office retains records of such maintenance activities in varying degrees of detail.

In 2007, Hatch conducted a site visit and testing of the pumpwell system with the objective of assessing the system condition and making recommendations for a life extension of 10 years. Selected recommendations from the 2008 report are the basis for the work program described in this report.

2.4 Background Reports

Reports of previous site assessments are available as follows:

- SNC-Lavalin, "Muskrat Falls Dewatering System, Construction Report Operation and Maintenance Information", (1982).
- SNC-Lavalin, "Muskrat Falls Dewatering System, Engineering Assessment", (1982).
- Acres International, "Muskrat Falls Development", (1978).
- Acres International, "Muskrat Falls, Review of Dewatering System", (1994).
- Acres International, "Dewatering System Assessment and Rehabilitation", (1997).
- Acres International, "Standpipe Piezometer Installation Program Report", (1997 and 1998).
- Hatch Ltd, "The Lower Churchill Project, MF 1260 – Assessment of Existing Pumpwell System", (2008).

3. Well Inspection Field Program

The well inspection program commenced on August 27 and was completed on September 7, 2009. Figure 1 in Appendix C shows the location and configuration of the well system.

Work progressed concurrently on approximately 3 wells at a time; every effort was made to return the wells to service as quickly as possible. In most cases, wells were returned to service within 24 hours. For wells that are known to be high yielding, such as wells W-4, W-9, W-10, W-16 and W-19, tasks were completed such that these wells could be returned to service the same day. The tasks are described in more detail in the following sections. Photographs were taken to document the procedure and the equipment encountered at each well. Appendix A includes photographs of the general procedure.

3.1 Monitoring of Piezometer Water Levels

The monitoring of piezometer water levels involved:

- Recording of water levels in piezometers P-A1, P-A2, P-B1, P-B2, P-C, P-D1, P-D2, P-F1, P-F2, P-G and P-J1, P-J2 from August 22 to September 8, 2009 on a daily basis. Due to the number of tasks involved in this program, it was not possible to record water levels twice daily. Although P-A-2 and P-F2 have recently been dry, they were monitored daily in case of a change of condition due to shutdown of the dewatering system. Likewise, P-C has recently been out of service but was monitored daily in case of changes in condition.
- Water levels recorded from August 22 to August 26 reflect water levels under normal well system operation (prior to any pump shutdown). Water levels taken from August 27 to September 7 were taken during the daytime and reflect a full shutdown condition in which the power to the system was turned off and all the pumps in the system were shutdown.
- Measurements were taken from the top of the outer metal casing of the piezometer. This is standard practice at the site.

It should be noted that, during the day, generally from about 8 am to 6 pm, the power was locked out to the whole system and all pumps were shut off. This represents a full shutdown condition. After work was completed for the day, the power to the system was re-energized and most wells were returned to service. There were generally a few wells each evening for which the cleaning procedure had not been completed; these wells were manually shut off at the control panel. This overnight condition when a few wells were not in operation is referred to as partial shutdown.

Figure 2 in Appendix C shows the water level elevations in the piezometers from January 2009 to September 8, 2009. The readings from August 27 to September 7 were taken during the full shutdown condition. The pumps were shut off completely through the work day for approximately 10 hours and then turned back on for the overnight period.

Figures 3, 4 and 5 show the water levels in each individual piezometer just prior to and during the well inspection program. In general, the water levels recovered by approximately 0.3 m to 0.6 m during the full shutdown with the exception of P-D-2, where the water level rose about 1.0 m (Figure 4 (c)).

3.2 Flow Rate Testing

Flow rate testing was conducted prior to the start of the well inspection program and after completion of the program; testing consisted of the following:

- Testing of the flow rate and pump capacity at each wellhead, prior to the commencement of the inspection and cleaning program. The pre-inspection testing was conducted on August 27, 2009. A flow test was conducted on each well using a gate valve/discharge pipe and an 11.4 litre pail (2.5 imperial gallons). The flow rate was calculated by recording the amount of time to fill the pail. Reserve pressure was recorded using a gate valve and gauge attached to the riser pipe. Observations were also made of the clarity of the water. This information was used to assess the general capacity of the pump and its general working condition.
- A post inspection flow rate test on September 7, 2009, using the same method of flow calculation as previously.
- During the post inspection testing, pH values were also collected for each well to ensure the acid used in the cleaning procedure had been sufficiently flushed out. Where low values of pH were noted, pumps were switched on manually from the control centre to flush out any residual acid.

Table 3-1 shows the flow rates calculated for each well and the observations made of water clarity both before and after the inspection program. Reserve pressures were noted only at the commencement of the inspection program. It should be noted that the valve was wide open during the test and that the discharge rate calculations are approximate.

Table 3-1 - Well Flow Tests

	27-Aug-09			7-Sep-09		
Well	**Rate (Lpm)***	**Water Clarity**	**Reserve Pressure (kg/cm^2)**	**Rate (Lpm)***	**Water Clarity**	**pH**
W-1	No pump	N/A	N/A	No pump	N/A	N/A
W-2	No pump	N/A	N/A	No pump	N/A	N/A
W-3	57	Fair, orange	6.30	46	Good	7.9
W-4	31	Good	4.90	31	Good	8
W-5	68	Fair	6.30	68	Good	7
W-6	68	Fair	5.25	68	Fair	3.9
W-7	52	Good	4.90	55	Good	4.1
W-8	46	Good	4.90	46	Good	3
W-9	46	Fair, silty	6.86	46	Good	6.7
W-10	46	Fair to good	6.30	41	Fair to good	7
W-11	50	Fair, silty	6.86	57	Fair	7.9
W-12	23	Fair to good	2.80	46	Good	7.3
W-13	52	Fair to good	4.20	36	Good	7.3
W-14	57	Very silty, poor	6.86	48	Good	7.4
W-15	Not working	N/A	0	Not working**	N/A	7.8
W-16	46	Fair	2.10	46	Good	7.8

	27-Aug-09			7-Sep-09		
Well	**Rate (Lpm)***	**Water Clarity**	**Reserve Pressure (kg/cm^2)**	**Rate (Lpm)***	**Water Clarity**	**pH**
W-17	17	Fair	1.54	28	Good, yellow	4.6
W-18	No Flow	N/A	0	Not tested**	N/A	N/A
W-19	17	Fair to good	0	17	Good	5.3
W-20	27	Poor, silty	0	23	Fair, some silt	8.1
W-21	46	Poor, silty	5.81	68	Fair, some silt	8.3
W-22	46	Poor, silty	5.88	46	Fair	8.7

*Lpm = Litres per minute, approximate

**Well W-15 – problem at the control panel, Well W-18 – possible screen and formation collapse.

The calculated flow rate is approximate, based on relatively crude measurements of the time in seconds for the flow to fill an 11.4 litre pail. Where the flow rates observed post inspection were lower than those noted prior to the well inspection, it was likely due to the imprecise method of measurement. In general, it was observed that the flow rates both prior to and following the inspection program were the same or improved.

3.3 System Shutdown and Removal of Pump Infrastructure

Prior to removal of the pump infrastructure from each well, a lockout permit was completed by the NE-NLH electrician. The permit was checked by the supervisor from NE-NLH or by personnel from NE-LCP. The power was shut down for all the pumps and controls in the system at one switch and the switch was locked and tagged. All of the personnel involved in the work were included on the permit and were required to sign off the permit if leaving the site.

Following lockout, the pump infrastructure was removed, involving the following tasks:

- Removal of the well cover, testing with a conductance meter to verify there was not any current to the wiring in the well.
- Removal of the riser sections, pump and wiring from the well, riser sections laid down in order of removal from the well by the NE-NLH helpers; at the same time, the NE-NLH electrician supervised the removal of the wiring.

3.4 Downhole Camera Inspection

A downhole camera inspection was completed for every well prior to cleaning in order to assess the condition of the PVC casing and stainless steel well screen and make note of any potential cracks or staining. The inspection involved the following tasks:

- Aluminum sulphate was added to the well water a minimum of 30 minutes prior to the inspection to aid in settling of sediments and to improve the visibility under water. It was found, in general, that the use of the flocculant did not improve the visibility to any great extent and the use of the flocculant was therefore discontinued about halfway through the program.

- Prior to the inspection, the 'As Built' well installation logs and previous down hole camera inspection logs (1997) were reviewed to be aware of conditions and potential problems.
- A descriptive log was completed for each inspection including comments on the condition of the stainless steel screen. Note was also made whether flocculant was used prior to inspection.
- The camera inspection was recorded as a digital video.

The logs of the inspections are found in Appendix B.

3.5 Inspection of Pumps, Hardware and Infrastructure

The inspection of the pumps and hardware involved the following:

- Measurements of the depth of the well, the depth to water level and the depth to the top of the pump.
- Measurements of the depth to the sensors: i) low-low, ii) low, iii) high and iv) high-high sensors. The high sensor activates the pump and the low sensor activates the shut off of the pump. The high-high and low-low sensors are for emergency warning.
- An assessment of the general condition of the pump and whether replacement was necessary. The model number and make of pump was recorded for each system.
- Cleaning and testing of the pump and risers. The pump body was cleaned, the screen was removed and the intake cleaned. All piping was wiped down and checked for cracks or corrosion and riser sections in poor condition were replaced. The threading of riser sections were cleaned and rethreaded as necessary and couplings resealed.
- Checking for corrosion or poor condition of the sensors. A visual inspection of the sensors was completed and sensors in poor condition were replaced. A functional test of the sensors was also completed at the wellhead before reinstallation. This involved passing a small amount of current through the sensor to confirm the sensor was functioning; any malfunctioning sensors were replaced.
- Inspection of the pitless adaptor and replacement of the o ring as required.

The process was documented and photographs taken of the equipment for each well. Table 3-3, Pump and Sensor Details, records the measurements of each well system (depth, water level, depth to each sensor, model number of pump). Figure 6 is a profile of the well system, based on measurements taken and included in Table 3-3.

3.6 Well Cleaning

After completion of the pre-cleaning camera inspection, the following procedure was followed for the cleaning of each well:

- Approximately 11L of a HCL acid solution was added to the well. The solution was left in the well for a standing time of approximately two hours. The purpose of the acid was to dissolve encrustation in the casing and on the well screen. The NE-NLH electrician raised concern that the acid solution could damage the sensors. The pump/electrical contractor called suppliers and was

assured there should be no damage to sensors from the addition of acid to the well. However, to minimize risk, it was decided on September 4, 2009 to discontinue the use of the acid.

- The screen and casing were cleaned using a well bore brush and additional water. The screen and casing were cleaned for approximately 30 minutes.
- A sand pump (see Photograph 9, Appendix A) was lowered to the bottom of the well and sediment was drawn into the sand pump under suction. The sand pump was pulled to the surface and the liquid/sediment placed in a pail for observation. The sand pump was used until the water returned was sediment free.

Air injection was used at well W-3 and it was found that there was not enough head in the well to raise the water out of the well. After discussions with the contractor, it was decided that the sand pump did a good job at removing sediments in the well and was the least intrusive method (least chance of damage to the screen and formation) of well cleaning. Air injection was not used at any other well.

Table 3-2, Details of the Well Cleaning, summarizes the type of material removed, the approximate quantity removed and the duration of the cleaning procedure for each well.

Table 3-2 - Details of the Well Cleaning

Well	Acid Added?	Cleaned?	Cleaning Duration (min)	Volume Sediment & Water (L) Removed	Description of Sediment Removed from Well	Notes
W-1	Yes	Yes	45	22	Silty clay	--
W-2	No	No	N/A	N/A	N/A	Obstruction noted during camera inspection
W-3	Yes	Yes	45	18	Silty clay	--
W-4	No	Yes	90	44	Medium sand, fine black sediments & silty clay	--
W-5	Yes	Yes	45	11	Silty clay	--
W-6	Yes	Yes	60	30	Silty clay	--
W-7	Yes	Yes	60	22	Silty clay	--
W-8	Yes	Yes	60	22	Silty clay	--
W-9	Yes	Yes	75	30	Silty clay	--
W-10	No	Yes	75	44	Silty clay	--

Well	Acid Added?	Cleaned?	Cleaning Duration (min)	Volume Sediment & Water (L) Removed	Description of Sediment Removed from Well	Notes
W-11	Yes	Yes	45	18	Silty clay	--
W-12	Yes	Yes	45	30	Silty clay	--
W-13	Yes	Yes	45	22	Silty clay	--
W-14	Yes	Yes	60	32	Silty clay	--
W-15	Yes	Yes	60	22	Silty clay	--
W-16	Yes	Yes	75	32	Silty clay	--
W-17	Yes	Yes	45	22	Relatively clear silty solution	Old pump lodged at bottom; could not get to bottom
W-18	Yes	Yes	60	30	Mixture of medium sand & silty clay	--
W-19	Yes	Yes	60	22	Silty clay	--
W-20	No	Yes	45	30	Heavy silty clay sludge and silty clay	--
W-21	No	Yes	60	32	Heavy silty clay sludge and silty clay	--
W-22	No	Yes	60	30	Heavy silty clay sludge and silty clay	--

* Cleaning included use of the wellbore brush and the sand pump

3.7 Post-Cleaning Downhole Camera Inspection

Following cleaning, a second camera inspection was conducted to assess the effectiveness of the cleaning program. The same procedure was used as described in Section 3.4 Pre-cleaning Downhole Camera Inspection. The log of the pre-cleaning inspection was reviewed as the post-cleaning inspection proceeded to be aware of problems encountered and to note where previous staining had been observed.

The logs of the post-cleaning inspections are found in Appendix B.

3.8 Reinstallation of Well Components and Re-energizing of System

Once all cleaning operations had been finished and a post cleaning camera inspection completed, the pump, riser sections and associated wiring were returned to the well and reconnected. A lockout surrender permit was completed to document the end of the lockout and the re-energizing of the system. The switch was unlocked and released and the system was re-energized. Observations were made of the operation of wells that had been returned to service and the overall operation of the system. Observation continued until the NE-NLH electrician was confident that the system was working properly. Further testing and repairs were required in a number of wells (wells W-6, W-9, W-12 and W-15) following the initial return to service; this is described in Table 4-1.

Table 3-3 - Pump and Sensor Details

					Depth of Sensors				Elevation of Sensors					Current Pump Information			
Well No.	Elevation Top PVC	As Built Depth	Sounded Depth	Depth to W L	Low Low	Low	High	High High	Low Low	Low	High	High High	Elevation of WL	Elevation top of Pump	Depth to top of Pump	Pump Details	Pump Motor Details
W-1	59.79	63.40	64.30	44.30	*												
W-2	59.66	60.00		48.50	*												
W-3	59.67	71.00	69.90	51.93	55.04	53.02	48.02	46.98	4.63	6.65	11.65	12.69	7.74	3.21	56.46	Berkeley - original pump	Franklin 1.5 HP
W-4	59.67	70.00	66.45	50.42	54.92	52.86	49.71	47.83	4.75	6.81	9.96	11.84	9.25	3.31	56.36	Berkeley L15P4FMGS-03	Franklin 1.5 HP
W-5	59.55	62.40	62.92	51.80	52.86	50.83	45.75	44.84	6.69	8.72	13.80	14.71	7.75	4.10	55.45	Berkeley - original pump	Franklin 1.5 HP
W-6	59.33	60.00	60.20	52.60	52.45	50.47	45.52	45.01	6.88	8.86	13.81	14.32	6.73	3.88	55.45	Berkeley SL0P4FP-05	Franklin 1.5 HP
W-7	59.51	63.00	62.64	47.37	50.88	48.85	43.77	42.78	8.63	10.66	15.74	16.73	12.14	4.16	55.35	Berkeley SL20P4TS-26	Franklin 1.5 HP
W-8	59.46	61.00	60.35	47.30	52.48	50.45	45.37	44.43	6.98	9.01	14.09	15.03	12.16	4.24	55.22	Berkeley 4BL21-21861G86	Franklin 1.5 HP
W-9	59.48	62.00	54.13	32.95	46.74	44.73	39.65	38.05	12.74	14.75	19.83	21.43	26.53	10.68	48.80	Berkeley L15P4FMGS-03	Franklin 1.5 HP
W-10	59.40	59.00	58.93	43.46	53.31	51.43	46.35	45.39	6.09	7.97	13.05	14.01	15.94	3.65	55.75	Berkeley L15P4FMGS-03	Franklin 1.5 HP
W-11	59.35	57.00	57.61	37.26	43.90	41.85	36.85	35.55	15.45	17.50	22.50	23.80	22.09	13.14	46.21	Berkeley L15P4FMGS-03	Franklin 1.5 HP
W-12	59.29	61.00	61.52	47.45	53.59	51.56	46.58	45.46	5.70	7.73	12.71	13.83	11.84	3.97	55.32	Berkeley L15P4FMGS-03 New	Franklin 1.5 HP
W-13	59.27	59.00	60.10	26.82	53.77	51.79	46.81	45.79	5.50	7.48	12.46	13.48	32.45	4.13	55.14	Berkeley L15P4FMGS-03 New	Franklin 1.5 HP
W-14	59.01	61.50	57.00	26.87	54.03	52.05	46.95	46.34	4.98	6.96	12.06	12.67	32.14	0.41	58.60	Berkeley L15P4FMGS-03	Franklin 1.5 HP
W-15	58.91	61.50	59.74	30.30	52.91	50.88	45.90	44.88	6.00	8.03	13.01	14.03	28.61	3.87	55.04	Berkeley L15P4FMGS-03 New	Franklin 1.5 HP
W-16	58.76	61.00	59.74	47.42	51.59	49.56	44.53	42.55	7.17	9.20	14.23	16.21	11.34	3.72	55.04	Berkeley L15P4FMGS-03	Franklin 1.5 HP
W-17	58.46	60.00	59.44	46.71	48.52	46.49	41.41	40.11	9.94	11.97	17.05	18.35	11.75	5.85	52.61	Berkeley S10P4C02S-03 New	Franklin 1.5 HP
W-18	57.87	60.00	50.29	38.41	37.06	35.00	29.97	29.13	20.81	22.87	27.90	28.74	19.46	8.62	49.25	Berkeley S10P4C02J-04	Franklin 0.5 HP
W-19	57.01	59.50	57.30	36.27	51.49	49.38	44.40	43.69	5.52	7.63	12.61	13.32	20.74	2.88	54.13	Berkeley S10P4C02S-04	Franklin 0.5 HP
W-20	56.01	64.00	58.83	44.50	47.93	45.93	40.85	39.86	8.08	10.08	15.16	16.15	11.51	2.90	53.11	Berkeley S10P4C02S-03	Franklin 1.5 HP
W-21	53.99	56.50	54.76	39.45	48.80	46.59	41.56	40.57	5.19	7.40	12.43	13.42	14.54	3.21	50.78	Berkeley 15P4F02MGS-03	Franklin 1.5 HP
W-22	52.26	60.00	58.52	38.61	47.02	44.79	39.84	38.85	5.24	7.47	12.42	13.41	13.65	3.01	49.25	Berkeley 15P4F02MGS-03	Franklin 1.5 HP

All measurements in metres
All measurement are taken from the top of the pvc casing of the well
Depth to W L (water level) was taken on the day the well was dismantled and cleaned, at least one hour after system shutdown
* No infrastructure (risers, pump, sensors or wiring) is installed in W-1 and W-2

4. Findings of the Well Inspection Program

4.1 Summary of Findings

The following table, Table 4-1 Results of Well Inspection, summarizes the observations made at each well during the assessment and includes a record of any equipment that was replaced. Details recorded during the camera inspections can be found in Appendix B.

Table 4-1 - Results of Well Inspection

Well	General Observations	Equipment Replacement
W-1	-No pump -Top of screen at a depth of 28.1 m -Areas of heavy black and iron staining (see logs)	
W-2	-No pump -Top of screen at a depth of 37.3 m – 43.6 m and 52.0 m – 69.4 m (note: there was a screen section, followed by PVC, then another screened section) -Heavy black encrustation 37.3 m - 39.0 m, possibly broken -Obstruction at 52.7 m	
W-3	-Heavy corrosion and iron precipitate on the bottom riser -Pump covered in iron and manganese precipitate -Pump cleaned; pump in reasonably good shape -All sensors in good condition, observed that high and high-high sensors do not show evidence of being in water	-Bottom riser replaced
W-4	-Bottom riser and pump covered with silt deposits and iron and manganese precipitate -Noted 5 sensors instead of 4, one had been replaced and the non-functioning one not removed -Pitless adaptor and valve rusted, poor condition -No acid added prior to cleaning -Fine black sediment noted at bottom of casing, removed a greater quantity of sediment than most other wells	-Bottom riser replaced -High–high sensor replaced
W-5	-Bottom riser and pump covered with iron and manganese precipitate -All sensors in good condition, observed that high and high-high sensors do not show evidence of being in water	-Bottom riser replaced
W-6	-Heavy corrosion and iron precipitate on the bottom riser -Pump covered in iron and manganese precipitate. -Pump cleaned; pump in good shape -Sensors inspected, all in good condition -Could not reinstall the pump due to possible obstruction in casing. Camera inspection showed the casing is not plumb, some of the risers are not plumb. Pump was reinstalled with care to the non plumb condition. -O ring at the pitless adaptor was leaking when the post inspection flow tests were conducted; replacement corrected the problem	-Bottom riser replaced -Replaced the O ring

Well	General Observations	Equipment Replacement
W-7	-Bottom riser and pump covered with minor precipitate -Sensors inspected, all in good condition -Pump inspected and in good condition	
W-8	-Bottom riser and pump covered with iron and manganese precipitate -Significant sediment around the pump intake -Pump cleaned, in good condition -Sensors inspected, high sensor not operational, other 3 in good condition	-High sensor replaced
W-9	-Bottom riser and pump covered with iron and manganese deposits -Pitless adaptor rusted, needs replacement -When taking out the pump, NE-NLH personnel noted the pipe was very wet near the ground surface and there was water cascading down casing -When completing the camera inspection, water was noted coming in at the pitless adaptor -Sensors inspected, high-high sensor not operational, other 3 in good condition -Pump was jiving when reinstalled, had to be shut off overnight -Based on the camera inspection and observed water cascading down the casing, it was concluded there is a possible break in the central manifold, with drainage of water back into the well -Replaced the o ring at the pitless adaptor and put the well back in service	-High-high sensor replaced -O ring replaced at pitless adaptor
W-10	-Heavy corrosion and iron precipitate on the bottom riser -Sensors inspected, high-high sensor in poor condition, all others in good condition -Pump inspected and in good condition	-High-high sensor replaced -Bottom riser replaced
W-11	-Bottom riser and pump covered with minor precipitate -Sensors inspected, all 4 sensors were in poor condition -Pitless adaptor was leaking, screen in good condition -Pump inspected and in good condition	-All 4 sensors replaced -O ring at pitless adaptor was replaced
W-12	-Bottom riser and pump covered with iron and manganese precipitate, riser pipe is possibly corroded, poor condition -Pump visually assessed and in poor condition -Sensors inspected, in fair condition -Pump installation jived when reinstalled, possible pump rotation problem, pump turned off overnight -Removed pump and wiring and replaced all sensors and put back into service	-Pump replaced -Bottom riser replaced -All 4 sensors replaced because the pump was “jiving” when originally returned to service.
W-13	-Heavy corrosion and iron precipitate on the bottom riser -Sensors inspected, in fair condition -Pump visually assessed and in poor condition	-Bottom riser replaced -Pump replaced -Low-low sensor replaced.

Well	General Observations	Equipment Replacement
W-14	-Bottom riser and pump covered with iron and manganese precipitate -Sensors inspected, high and high-high sensors are not operational -Pump was inspected and the assessment showed that the bushing needed to be replaced -The pitless adaptor was leaking, pump turned off overnight -The next morning retested, found low-low sensor not functioning	-Bottom riser replaced -High and high-high sensors replaced -Minor repairs to pump, replacement of bushing -O ring at pitless adapter replaced -low-low sensor replaced and wiring repaired
W-15	-This well had not been operational at the start up of the program -Bottom riser and pump covered with iron and manganese precipitate. Bottom riser was cleaned and re-installed -Because the well was not operational and based on pump inspection, decided to replace the pump -Sensors were inspected, cleaned. Sensors were tested at the well head and found that high-high sensor and a section of wiring needed to be replaced -New pump not operational when put back into service [note that pump is awaiting electrical maintenance at the control panel (to be done by NE-NLH)] -Testing at the wellhead and at the control panel showed there was a malfunction at the control panel that predated the inspection program	-Pump replaced -High-high sensor replaced, wiring mended
W-16	-Bottom riser and pump covered with iron and manganese precipitate -Sensors inspected, in fair condition -Pump visually assessed and in good condition	-Bottom riser replaced
W-17	-Pump is a 0.5 HP model -Pump visually assessed and decided to replace -Sensors were inspected, cleaned	-Pump replaced
W-18	-When removing the pump and risers, it was found that the bottom 2 risers and the pump were filled with silica sand (note that this is likely from filter pack around well screen) -The normal cleaning procedure was completed for the well -The camera inspection showed a possible tear in the screen and possible collapse -Pump is a 0.5 HP model, adequate for the yield from the well -Due to the poor condition of the well, it was decided to not reinstall the pump	
W-19	-Heavy iron/manganese staining on the bottom 3 risers -Pump is a 0.5 HP model, adequate for the yield from the well, pump not replaced -Pump visually assessed and in good condition -Sensors were inspected, cleaned	-Bottom riser replaced
W-20	-Bottom riser and pump covered with iron and manganese precipitate -Pump visually assessed and in good condition -Sensors were inspected, cleaned	

Well	General Observations	Equipment Replacement
W-21	-Heavy corrosion on the bottom riser -Sensors inspected, low-low sensor in poor condition, all others in fair condition -Pump visually assessed and in good condition	-Bottom riser replaced -Low-low sensor replaced
W-22	-Bottom riser and pump covered with iron and manganese precipitate -Pump visually assessed and in good condition -Sensors were inspected, cleaned	

4.2 General Comments

Following are some general comments related to the inspection program:

- Water levels were monitored in the piezometers prior to and throughout the well inspection program. The water levels did not vary more than approximately 0.3 m to 0.6 m from water levels recorded when the well dewatering system was in full operation. One exception was P-D-2, where the water level rose approximately 1.0 m during shutdown.
- The bottom riser, just above the pump, of most wells was covered in silt, iron and manganese deposits and in some cases was corroded. The bottom riser was replaced in 11 wells.
- In general it was noted that the condition of the screens in most wells was good. Exceptions are noted in Section 4.3.
- It was observed that the valves and piping in the area of the pitless adaptor are frequently in poor condition. Rusting and poor condition were observed in particular in well W-4 and well W-9. Due to the age of the system, replacement of the valves at all the wells is recommended.
- Initially, it was intended to replace all couplings at each well in order to minimize the risk of breakage of the coupling during infrastructure removal. W-3 was the first well inspected and all the couplings were replaced with the above intention in mind. The couplings at W-3 were in good condition and it was decided that at subsequent wells, only worn couplings would be replaced.
- During the downhole camera inspections, cloudy water conditions occurred frequently, making assessment difficult. However, in most cases, the water was sufficiently clear in one of either the pre-cleaning or post-cleaning inspections to make an assessment possible. Unfortunately, poor visibility conditions were noted in both inspections in well W-8. However, all other testing and inspection showed that well W-8 is generally in good condition.
- It was proposed initially to install safety hand lines at each well. However, based on discussions of previous experiences of the drilling contractor and Nalcor, it was decided not to install safety hand lines.
- As discussed in the July 2008 report, the electrical components of the system continue to be problematic. The contractors made recommendations for improvements to the electrical system. These are discussed in Section 4.3.
- Historically, a 3 mm hole has been drilled in the bottom riser of all wells to allow for drainage of excess water and a means of preventing the pipes from freezing. However, it is possible that

spraying of water from the hole has caused moderate build up of iron staining in the screen and high turbidity levels in the area of the pump intake. The contractors indicated that a device could be designed and installed that would act as a shield and prevent/reduce the spraying of water in the screen.

- Based on discussions with NE-NLH personnel on site, it is our understanding that each well system operates as follows:
  - The water level rises to the high sensor and the pump turns on.
  - The water level is lowered by the pump and when the water level reaches the low sensor, the pump shuts off.
  - The high-high and low-low sensors are emergency warning sensors.
- In wells W-3, W-5, W-6 and W-17, the sensors may not be set at optimal levels based on measurements taken and shown in Table 3-3. For example, in well W-6, the low-low sensor is set higher than the measured water level and in wells W-5 and W-17, the low sensor is set higher than the measured water level. Also, Table 4-1 indicates that for well W-3, the high-high and high sensor do not show evidence of being in water, suggesting that the water level in the well does not rise to the level of the high sensor and therefore the pump does not come on. With the sensors at the current levels in W-3, W-5, W-6 and W-17, the pumps may not come on frequently unless the water level rises significantly. Water levels shown in Table 3-3 were taken on the day the well was dismantled and cleaned, generally a minimum of one hour after system shutdown and water levels could rise more than the recorded level in Table 3-3.

4.3 Well Specific Comments

Well W-1

- Well W-1 is no longer connected to the dewatering system. All electrical wiring and pumps have been removed.
- A pre- and post-cleaning camera inspection was conducted on W-1. The camera inspections showed that the well screen in well W-1 was in satisfactory condition although heavy iron and black staining was noted at several depths (see log for W-1 Appendix B). The well was fully cleaned using an acid solution followed by brushing and removal of debris using the sand pump. It may be possible to install a pump in this well. It is recommended that a short pump test be conducted on this well to assess the potential for long term pumping. The test was not conducted during the field program due to insufficient supplies (risers, lack of connection to the existing system).

Well W-2

- Well W-2 is no longer connected to the dewatering system. All electrical wiring and pumps have been removed.
- A pre-cleaning camera inspection was completed for W-2 and a large rock/obstruction was noted in the screen at depth. The inspection showed that W-2 is likely not a viable well. The water level in

the well was 48.5 m below the top of casing, the obstruction was observed at 52.7 m and there is insufficient head in which to install a pump. Due to poor well condition, further work and cleaning was not completed.

Well W-9

- When the pump was being removed from W-9, personnel noted that the risers were wet from approximately 3 m to the pump. It was possible to hear water cascading down the casing from a near surface depth.
- When conducting the camera inspection, it was observed that water was cascading into the casing through the pitless adaptor at a substantial rate of flow. The contractor suspected that there is a break in the pipe leading from the casing to the header or is coming from the header and, consequently, water is leaking back into W-9.
- Water leakage could cause potential freezing in the upcoming winter season.

Well W-15

- After extensive testing at the wellhead and the control panel, it was evident that the malfunction at W-15 was related to a problem at the control panel. NE-NLH personnel on site at the completion of the program indicated repairs will be made and it is expected W-15 will then be fully operational.

Well W-17

- An old pump was observed in the bottom of W-17, at a depth of 59.3 m below top of casing. The pump does not seem to be an impediment to the operation of the functioning pump in the well.
- There is an unidentified PVC standpipe located near W-17; its purpose and original installation date are unknown by NE-LCP. NE-LCP requested that the standpipe beside W-17 be inspected with the downhole camera. It was found the standpipe was blocked with branches and debris at a depth of 24.5 m and a well screen was not observed.

Well W-18

- When the pump for W-18 was removed, it was noted that the bottom 2 risers were filled with silica sand and the pump was also filled with silica sand. A possible tear in the screen was observed at 45.2 m depth during the camera inspection. Due to the possible tear or formation collapse, the pump was not reinstalled in W-18.

5. Conclusions and Recommendations

The dewatering system has operated continuously since November 1981 and there has been no further major landslide activity on the spur. The purpose of the installation has, therefore, been fulfilled. Some of the rehabilitation work recommended in the July 2008 report has been completed and this will aid in the operation of the system over the next 10 years.

Based on the findings of the well inspection program, the wells in the system are operating satisfactorily and wells screens are generally in good condition, with the exception of wells W-1, W-2, W-15 and W-18. It is expected that W-15 can be readily repaired at the control panel. Wells W-1, W-2 and W-18 may no longer be viable. Therefore, a malfunction of one or more additional wells could potentially put a significant strain on the system and result in a rise in groundwater levels in the spur.

The following recommendations were discussed by Hatch and the well contractor at the site:

- Excavation in the area of well W-9 to assess the source of water entering W-9. A breakage or leak is possible in the horizontal line leading to the collector pipe from W-9 or the central collector pipe. This task requires immediate attention to prevent freezing.
- Replacement of valves, horizontal piping from the pitless adaptor to the collector pipe and pitless adaptor in all wells.
- Implement a maintenance record sheet that documents any maintenance that is completed at the site. This would ensure better record keeping for the system.
- Make electrical repairs at the control panel related to well W-15 and return W-15 to service.
- Installation of a flow monitoring device at each wellhead and at the collector pipe outlet with data transfer to the Goose Bay operation centre. Installation of a flow monitoring device at each well would allow a baseline assessment of the yields from the wells and facilitate record keeping. Changes in yield or lack of flow would alert personnel to technical problems at a specific well that required attention.
- Consideration of replacement of the existing sensors with pressure transducers.
- Further assessment of the location of the four sensors in each well to ensure appropriate water levels are maintained. Adjustment to the locations of sensors if required. The assessment would involve review of historical water levels and operation records, historical and recent monthly precipitation data, review of the well system design drawings and possible discussions with a pump contractor.

A follow up field program is recommended to implement the remaining recommendations from the July 2008 report. These recommendations include:

- Continue the manual recording of water elevations in the piezometers and commence taking water elevations in wells until the installation of an automatic data acquisition system.

- Consideration of a geophysical survey of some of the wells to assess voids around the screen (still to be confirmed by Hatch). This information would be helpful in further definition of the wells that require replacement.
- To ensure a satisfactory performance of the dewatering system for the next 10 years and to maintain the physical asset of the Muskrat Falls ridge as a whole, 6 to 7 new stainless steel wells need to be installed. This would include:
  - Replacement of wells W-2 and W-18 (and possibly well W-1).
  - Installation of 3 to 4 wells to replace the high yielding wells. The existing high yielding wells would be used for back-up. The new wells would include a well in the southern block in the area of W-4; 1 to 2 wells in the central block in the area of wells W-9 and W-10; and a well in the northern block in the area of W-21.
  - These new wells may require installation of additional infrastructure (i.e. new electrical control panel, discharge pipe).
  - If the well replacement program is completed as described above, a geophysical survey would not be necessary.

Appendix A

Photographs

Photograph 1: A flow test was conducted at each well prior to inspection and cleaning.

Photograph 2: The risers, wiring and pump were removed from each well.

Photograph 3: The risers and pump were laid down on the ground for inspection.

Photograph 4: The risers were inspected for corrosion and replaced as required.

Photograph 5: The pump was inspected, the screen removed and all cleaned.

Photograph 6: The four sensors at each well installation were inspected, tested and cleaned. If sensors were in poor condition or malfunctioning, they were replaced.

Photograph 7: A downhole camera inspection was completed before and after cleaning and logs made of the observations. The inspections were recorded as digital videos.

Photograph 8: An acid solution was added to the well and allowed to stand for 2 hours. Then a wellbore brush was used to clean the casing and screen.

Photograph 9: A sand pump was placed down into the well, water and sediments were suctioned into the sand pump. The sand pump was brought to the surface and the sediments collected in a pail for examination.

Appendix B

Inspection Logs

HATCH

Camera Inspection Report

Project 325967
Well W-1 Before Flushing
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills
Top of PVC Well Casing	0.0	59.79	Started: Sept. 3/09 1:01 pm
As-built bottom of well	63.4	-3.61	Finished: Sept. 3/09 1:20pm
			DVD No.:
			Note: No flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.6	Pitless adaptor	1.6
3.4	Coupling – minor glue stains at 3.4 to 3.5	3.4
9.4	Coupling - minor glue stains at 9.4 to 9.5	9.4
15.7	Coupling – minor glue stains at 15.7 to 15.8	15.7
21.8	Coupling – heavy iron staining visible at the coupling No crack visible at 25.0	21.8
28.1	**Top of well screen**	28.1
	Moderate to heavy black staining from 31.1 to 33.2	
31.3	Screen weld/joint – heavy black staining from 31.3 to 34.4	31.3
37.3	Screen weld/joint – heavy iron staining from 37.1 to 40.2	37.3
40.4	Screen weld/joint – Brown burn at joint	40.4
	Heavy iron and black staining from 43.2 to 44.2	
44.3	**Water level** Good clarity below water. Heavy black staining at 46.4, just above the joint	44.3
46.6	Screen weld/joint	46.6
49.6	Screen weld/joint	49.6
49.8	Screen weld/joint	49.8
	Moderate iron staining from 46.6 to 49.6. Minor black encrustation at welds and good condition otherwise to 55.7. Moderate iron staining at 55.7	
63.4	**End of Inspection**	63.4

HATCH

Camera Inspection Report

Project 325967
Well W-1 After Flushing
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills
Top of PVC Well Casing	0.0	59.79	Started: Sept. 6/09 9:25 am
As-built bottom of well	63.4	-3.61	Finished: Sept. 6/09 9:40 am
			DVD No.:
			Note: No flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.6	Pitless adaptor	1.6
3.4	Coupling – minor glue stains at 3.4 to 3.5	3.4
9.4	Coupling - minor glue stains at 9.4 to 9.5	9.4
15.7	Coupling	15.7
21.8	Coupling	21.8
28.1	**Top of well screen** Minor black staining at casing/screen joint	28.1
31.3	Screen weld/joint – minor black staining at joint	31.3
34.5	Screen weld/joint	34.5
37.3	Screen weld/joint	37.3
	Minor iron staining at 37.1 becoming heavy at 40.8	
40.4	Screen weld/joint – Brown burn at joint	40.4
	Heavy iron and black staining from 42.2 to 44.2	
44.3	**Water level** Very cloudy below the water level, poor visibility from 44.3 to bottom	44.3
58.1	Very cloudy, black particulate floating in water	58.1
59.1	**End of Inspection**	59.1

HATCH

Camera Inspection Report

Project 325967
Well W-2 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept. 3/09 1:35 pm Finished: Sept. 3/09 1:48pm DVD No.: Note: No flocculant added
Top of PVC Well Casing	0.0	59.66	
As-built bottom of well	69.0	-9.34	

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.4	Pitless adaptor	1.4
6.3	Coupling – minor glue stains at 6.3 to 6.4	6.3
12.5	Coupling - moderate white staining and debris on casing noted from 12.2 to 12.5	12.5
17.5	Coupling – minor glue/sealant stains at 17.4 to 17.5	17.5
18.6	Coupling Heavy staining with glue and sealant from 18.6 to 24.0	18.6
24.8	Coupling Cloudy, poor visibility	24.8
31.1	Coupling	31.1
37.3	**Top of well screen** Very poor condition, heavy black encrustation to 39.0, possibly broken	37.3
39.0	Screen weld/joint – moderate black staining at the weld	39.0
40.5	Screen weld/joint	40.5
43.6	End of screen, start of pvc casing	43.6
44.2	Coupling – heavy iron staining from 45.0 to 45.7	44.2
47.0	Coupling	47.0
48.5	**Water level** Water in the pvc casing, very cloudy and dark.	48.5
52.0	**Top of well screen** Screen is blocked at 52.7 with a rock and debris	52.0
52.7	**End of Inspection** No post cleaning camera inspection completed	52.7

HATCH

Camera Inspection Report

Project 325967
Well W-3 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Aug. 28/09 4:35 pm Finished:Aug. 28/09 5:00 pm DVD No.: Note: Flocculant added
Top of PVC Well Casing	0.0	59.67	
As-built bottom of well	71.0	-11.33	

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.5	Pitless adaptor	1.5
3.1	Coupling	3.1
6.9	Coupling	6.9
9.2	Coupling Generally good condition from 2.0 to 12.5. Minor vertical iron stains from 7.8 to 8.5 and 13.0 to 15.0	9.2
15.1	Coupling Minor iron staining from 18.0 to 19.0 and 20.0 to 22.3	15.1
21.6	Coupling	21.6
27.9	Coupling	27.9
39.9	**Top of well screen** Moderate iron staining from 36.9 to 38.6	39.9
38.6	Screen weld/joint	38.6
42.9	Screen weld/joint – moderate black staining from 41.3 to 41.6	42.9
46.2	Screen weld/joint – Brown burn at joint	46.2
49.3	Screen weld/joint	49.3
52.4	**Water level** Cloudy immediately below water, clearing with depth	52.4
54.8	5 cm segment of wire noted at 54.8, no break observed	54.8
55.0	Water very cloudy	55.0
55.0	**End of Inspection**	55.0

HATCH

Camera Inspection Report

Project 325967
Well W-3 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
Top of PVC Well Casing	0.0	59.67	Inspector: A.Mills
As-built bottom of well	71.0	-11.33	Started: Aug. 29/09 3:3 pm
			Finished:Aug. 29/09 4:00 pm
			DVD No.:
			Note: Flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.5	Pitless adaptor	1.5
3.1	Coupling	3.1
6.9	Coupling	6.9
9.2	Coupling - generally good condition	9.2
15.2	Coupling	15.2
21.3	Coupling	21.3
27.5	Coupling	27.5
33.6	Coupling	33.6
39.9	**Top of well screen** Screen in very good condition, no staining	39.9
42.9	Screen weld/joint Black encrustation from 45.8 to 45.9	42.9
46.2	Screen weld/joint	46.2
49.3	Screen weld/joint	49.3
52.4	Screen weld/joint 25% black encrustation from 52.0 to 52.3	52.4
52.4	**Water level** - water very clear 5 cm segment of wire noted at 54.8, screen not coming apart	52.4
55.2	Screen weld/joint	55.2
58.6	**End of Inspection**	58.6

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Camera Inspection Report

Project 325967
Well W-4 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
Top of PVC Well Casing	0.0	59.67	Inspector: A.Mills
As-built bottom of well	70.0	-10.33	Started: Sept. 5/09 8:56 am
			Finished: Sept. 5/09 9:15 am
			DVD No.:
			Note: No flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.4	A hole cut in casing approximately 7.5 x 3.75 cm	1.4
1.5	Pitless adaptor	1.5
2.1	Coupling Minor vertical iron staining at 2.0 and a small area at 6.6	2.1
8.5	Coupling - minor black staining at the coupling	8.5
14.7	Coupling Generally good condition, minor iron stain at 17.7	14.7
20.9	Coupling	20.9
27.1	Coupling – minor iron stain at 30.2	27.1
33.2	Coupling Glue staining, sealant, grass and possibly wire clump noted at 38.2	33.2
39.6	**Top of well screen** Very heavy black encrustation at 39.6 to 41.6, moderate black staining to 48.5	39.6
42.7	Water infiltration into the top of the screen, cascading down screen. Calcium/white encrustation noted at 45.3	42.7
45.8	Screen weld/joint - Infiltration of water and cascading down screen. Minor iron staining at 46.2 and minor black staining below 45.8	45.8
48.8	Screen weld/joint – moderate black staining from 41.3 to 41.6	48.8
50.2	**Water level** Very cloudy below water, becoming clearer at 51.4	50.2
55.0	Screen weld/joint Screen is in good condition below the water. Black particles in suspension at 59.5. Water becoming very cloudy at 63.0	55.0
69.9	**End of Inspection**	69.9

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Camera Inspection Report

Project 325967
Well W-4 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept. 5/09 11:51 am Finished:Sept. 5/09 12:05pm DVD No.: Note: No flocculant added
Top of PVC Well Casing	0.0	59.67	
As-built bottom of well	70.0	-10.33	

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.4	A hole cut in casing approximately 7.5 x 3.75 cm	1.4
1.5	Pitless adaptor	1.5
2.1	Coupling	2.1
8.5	Coupling	8.5
14.7	Coupling	14.7
20.6	Fine, wet, black sediment on casing – may be residual from sand pump	20.6
20.9	Coupling	20.9
27.1	Coupling	27.1
33.2	Coupling Fine, wet, black sediment on casing – may be residual from sand pump	33.2
39.6	**Top of well screen** Heavy black encrustation at 39.6 to 41.6, not blocked	39.6
42.0	Water infiltration into the top of the screen, cascading down screen.	42.0
42.2	**Water level** – water remains fairly clear, screen in good condition below water	42.2
47.9	Screen weld/joint	47.9
52.7	Water very cloudy	52.7
58.4	Screen weld/joint Screen is in good condition below the water. Black particles in suspension at 59.5 and very cloudy to bottom	58.4
69.1	**Bottom - End of Inspection**	69.1

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Camera Inspection Report

Project 325967
Well W-5 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills
Top of PVC Well Casing	0.0	59.55	Started: Aug.29/09 2:45 pm
As-built bottom of well	62.4	-2.89	Finished:Aug.29/09 3:15 pm
			DVD No.:
			Note: Flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.4	Pitless adaptor	1.4
4.5	Coupling	4.5
10.7	Coupling - heavy glue/sealant staining from 10.7 to 11.8	10.7
16.7	Coupling – minor glue/sealant staining from 16.7 to 18.9	16.7
22.8	Coupling – heavy glue/sealant staining from 22.8 to 24.8	22.8
29.2	Coupling	29.2
35.5	**Top of well screen** Good condition	35.5
37.4	Screen weld/joint Moderate black staining at the weld, minor black encrustation from 40.2 to 40.4	37.4
40.4	Screen weld/joint Iron staining at weld, minor loose debris at 41.5, moderate black encrustation at 42.1	40.4
44.7	Screen weld/joint	44.7
47.9	Screen weld/joint Minor black encrustation at 46.6 to 47.9 and 49.5 to 50.9	47.9
51.0	Screen weld/joint	51.0
52.2	Screen weld/joint	52.2
52.2	**Water level** - water cloudy below water level	52.2
54.0	Screen weld/joint	54.0
57.2	Screen weld/joint – moderate iron encrustation from 60.1 to 60.6 and at 61.9	57.2
62.0	**End of Inspection**	62.0

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Camera Inspection Report

Project 325967
Well W-5 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills
Top of PVC Well Casing	0.0	59.55	Started: Aug.30/09 10:30 am
As-built bottom of well	62.4	-2.89	Finished:Aug.30/09 10:55am
			DVD No.:
			Note: Flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.4	Pitless adaptor	1.4
4.5	Coupling	4.5
10.7	Coupling - heavy glue/sealant staining from 10.7 to 11.8	10.7
16.7	Coupling – minor glue/sealant staining from 16.7 to 18.9	16.7
22.8	Coupling – heavy glue/sealant staining from 22.8 to 24.8	22.8
29.2	Coupling	29.2
35.5	**Top of well screen** Good condition	35.5
37.4	Screen weld/joint Moderate black staining at the weld, minor black encrustation from 40.2 to 40.4	37.4
40.4	Screen weld/joint Iron staining at weld, minor loose debris at 41.5, moderate black encrustation at 42.1	40.4
44.7	Screen weld/joint	44.7
47.9	Screen weld/joint Minor black encrustation at 46.6 to 47.9 and 49.5 to 50.9	47.9
51.0	Screen weld/joint	51.0
52.2	Screen weld/joint	52.2
52.4	**Water level** Water cloudy below water level, could not see any major areas of encrustation or wear. Very cloudy at 59.0	52.4
59.1	**End of Inspection**	59.1

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Camera Inspection Report

Project 325967
Well W-6 Before Flushing
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
Top of PVC Well Casing	0.0	59.53	Inspector: A.Mills
As-built bottom of well	60.0	-0.47	Started: Aug.30/09 9:30 am
			Finished:Aug.30/09 10:00am
			DVD No.:
			Note: Flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	Top of Casing	0.0
1.5	Pitless adaptor	1.5
3.6	Coupling - minor glue/sealant staining	3.6
9.7	Coupling - minor glue/sealant staining	9.7
10.5	Coupling – minor glue/sealant staining	10.5
15.9	Coupling –minor iron staining at coupling	15.9
22.1	Coupling	22.1
28.3	Coupling	28.3
34.4	**Top of well screen** Generally good condition	34.4
37.6	Screen weld/joint - minor iron staining at the weld	37.6
40.7	Screen weld/joint	40.7
43.7	Screen weld/joint	43.7
46.9	Screen weld/joint	46.9
49.9	Screen weld/joint	49.9
52.4	**Water level** – water cloudy below water level	52.4
60.0	**End of Inspection** Note: Well not plumb	60.0

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Camera Inspection Report

Project 325967
Well W-6 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
Top of PVC Well Casing	0.0	59.53	Inspector: A.Mills
As-built bottom of well	60.0	-0.47	Started: Aug.30/09 3:45 pm
			Finished:Aug.30/09 4:15 pm
			DVD No.:
			Note: No Flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.5	Pitless adaptor	1.5
3.6	Coupling - minor glue/sealant staining	3.6
9.7	Coupling - minor glue/sealant staining	9.7
10.5	Coupling – minor glue/sealant staining	10.5
15.9	Coupling –minor iron staining at coupling	15.9
22.1	Coupling	22.1
28.3	Coupling	28.3
34.4	**Top of well screen** Generally good condition. Minor black staining at join with casing	34.4
37.6	Screen weld/joint - minor iron staining at the weld	37.6
40.7	Screen weld/joint	40.7
43.7	Screen weld/joint Minor black staining at 44.5 to 46.8	43.7
46.9	Screen weld/joint	46.9
49.9	Screen weld/joint	49.9
50.6	**Water level** – water cloudy below water level, iron encrustation noted at 55.0, water becoming clear at 58.6, screen in good condition	50.6
60.0	**End of Inspection**	60.0

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Camera Inspection Report

Project 325967
Well W-7 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills
Top of PVC Well Casing	0.0	59.51	Started: Aug.30/09 12:25 pm
As-built bottom of well	63.0	-3.49	Finished:Aug.30/09 12:44pm
			DVD No.:
			Note: Flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.2	Coupling	1.2
1.4	Pitless adaptor	1.4
4.1	Coupling	4.1
7.3	Coupling Minor black, iron and glue/sealant staining at coupling	7.3
9.6	Coupling – minor glue/sealant staining	9.6
13.5	Coupling –minor iron staining at coupling	13.5
19.8	Coupling	19.8
21.9	Coupling	21.9
26.0	Coupling – black scrape on the casing, likely from pump removal	26.0
32.2	**Top of well screen** Generally good condition, minor black encrustation at the well screen/casing join	32.2
38.4	Screen weld/joint - minor black staining at the weld	38.4
41.3	Screen weld/joint	41.3
41.5	Screen weld/joint- minor iron staining between 41.3 and 41.5	41.5
44.6	Screen weld/joint	44.6
47.6	Screen weld/joint - brown burn/tarnish at the weld	47.6
48.1	**Water level** – water very turbid to 60.0	48.1
60.0	**End of Inspection**	60.0

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Camera Inspection Report

Project 325967
Well W-7 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
Top of PVC Well Casing	0.0	59.51	Inspector: A.Mills
As-built bottom of well	63.0	-3.49	Started: Aug.31/09 8:42 am
			Finished:Aug.31/09 9:10 am
			DVD No.:
			Note: Flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.2	Coupling	1.2
1.4	Pitless adaptor	1.4
4.1	Coupling	4.1
7.3	Coupling Minor black, iron and glue/sealant staining at coupling	7.3
9.6	Coupling – minor glue/sealant staining	9.6
13.5	Coupling –minor iron staining at coupling	13.5
19.8	Coupling	19.8
21.9	Coupling	21.9
26.0	Coupling – black scrape on the casing, likely from pump removal	26.0
32.2	**Top of well screen** Generally good condition, minor black encrustation at the well screen/casing join	32.2
38.4	Screen weld/joint - minor black staining at the weld	38.4
41.3	Screen weld/joint	41.3
41.5	Screen weld/joint- minor iron staining between 41.3 and 41.5	41.5
44.6	Screen weld/joint	44.6
47.6	Screen weld/joint - brown burn/tarnish at the weld	47.6
48.1	**Water level** – water clear, no staining or encrustation noted	48.1
50.8	Screen weld/joint	50.8
54.0	Screen weld/joint Water becoming cloudy at 55.8, minor black encrustation at 56.8	54.0
57.2	Screen weld/joint	57.2
60.0	**End of Inspection**	60.0

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Camera Inspection Report

Project 325967
Well W-8 Before Flushing
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
Top of PVC Well Casing	0.0	59.46	Inspector: A.Mills
As-built bottom of well	61.0	-1.54	Started: Aug.30/09 1:25 pm
			Finished:Aug.30/09 1:48 pm
			DVD No.:
			Note: Flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
0.1	Coupling – large rust stains from 0.8 to 0.9	0.1
1.5	Pitless adaptor	1.5
3.1	Coupling	3.1
7.8	Coupling	7.8
9.4	Coupling – minor glue/sealant staining	9.4
14.6	Coupling	14.6
15.7	Coupling Minor iron staining from 16.8 to 17.0	15.7
21.8	Coupling	21.8
27.8	Coupling Minor iron staining from 28.2 to 28.3	27.8
30.7	Coupling	30.7
34.1	Coupling Minor black encrustation from 34.1 to 34.2, white debris at 38.1	34.1
40.2	Coupling	40.2
46.2	**Top of well screen** At screen/casing join, moderate black encrustation, iron staining at 48.3	46.2
49.1	Screen weld/joint - minor iron staining at the weld	49.1
49.1	**Water level** Water very turbid, poor visibility to 54.4	52.4
54.4	**End of Inspection**	54.4

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Camera Inspection Report

Project 325967
Well W-8 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
Top of PVC Well Casing	0.0	59.46	Inspector: A.Mills
As-built bottom of well	61.0	-1.54	Started: Aug.31/09 9:30 am
			Finished:Aug.31/09 9:45 am
			DVD No.:
			Note: No flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
0.1	Coupling	0.1
1.5	Pitless adaptor – minor iron staining and glue residue from 1.8 to 2.0	1.5
3.1	Coupling	3.1
7.8	Coupling	7.8
9.4	Coupling – minor glue/sealant staining	9.4
14.6	Coupling	14.6
15.7	Coupling	15.7
21.8	Coupling	21.8
27.8	Coupling	27.8
30.7	Coupling	30.7
34.1	Coupling	34.1
40.2	Coupling	40.2
43.1	**Water level –** water very cloudy	43.1
46.2	**Top of well screen (assumed)** could not see because water cloudy	46.2
60.0	Bottom of well	60.0
60.0	**End of Inspection**	60.0

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Camera Inspection Report

Project 325967
Well W-9 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills
Top of PVC Well Casing	0.0	59.48	Started: Sept. 2/09 9:40 am
As-built bottom of well	62.0	-2.52	Finished:Sept.2/09 10:00 am
			DVD No.:
			Note: No flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
0.1	Coupling – minor rust stains at coupling	0.1
1.4	Pitless adaptor – fair to poor condition, rust evident	1.4
1.8	Coupling	1.8
2.1	Coupling - minor iron staining at 5.8	2.1
8.2	Coupling – minor glue/sealant staining	8.2
14.5	Coupling Heavy iron staining at 17.5, minor iron stain at 19.6	14.5
20.7	Coupling – iron stain at coupling	20.7
26.8	Coupling	26.8
33.0	**Top of well screen** Condition of screen generally good. Minor black encrustation at 33.7	33.0
34.4	**Water level** Water clear, good visibility, screen is in good condition	34.4
35.9	Screen weld/joint Minor black encrustation at 36.2 and minor iron staining at 40.0 to 40.3	35.9
41.0	Screen weld/joint – water very cloudy below 41.0	41.0
44.0	Screen weld/joint – black particulate suspended in water	44.0
45.5	Screen weld/joint	45.5
49.7	Screen weld/joint Water becoming very cloudy at 49.0. High silt content in water at 53.5	49.7
57.0	**End of Inspection**	57.0

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Camera Inspection Report

Project 325967
Well W-9 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
Top of PVC Well Casing	0.0	59.48	Inspector: A.Mills
As-built bottom of well	62.0	-2.52	Started: Sept. 2/09 2:10 pm
			Finished:Sept.2/09 2:30 pm
			DVD No.:
			Note: No flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
0.1	Coupling – minor rust stains at coupling	0.1
1.4	Pitless adaptor – fair to poor condition, rust evident	1.4
1.8	Coupling	1.8
2.1	Coupling - minor iron staining at the coupling	2.1
8.2	Coupling Minor iron staining at 12.3 to 12.4	8.2
14.5	Coupling	14.5
20.7	Coupling – iron stain at coupling	20.7
26.8	Coupling	26.8
33.0	**Top of well screen** Condition of screen generally good. Minor iron encrustation at 32.9 to 33.3	33.0
34.0	**Water level** Water clear, good visibility, screen is in good condition. Water becoming very cloudy at 37.7	34.4
42.1	Screen weld/joint	42.1
45.4	Screen weld/joint	45.4
51.6	Possible Screen weld/joint Water becoming grey to dark grey in colour.	51.6
53.7	Possible Screen weld/joint	53.7
58.7	High silt content in water, soft bottom	58.7
58.7	**End of Inspection**	58.7
	End of Inspection	

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Camera Inspection Report

Project 325967
Well W-10 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills
Top of PVC Well Casing	0.0	59.40	Started: Sept.6/09 8:57 am
As-built bottom of well	59.0	0.40	Finished: Sept 6/09 9:18 am
			DVD No.:
			Note: No flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
0.3	Coupling	0.3
1.5	Pitless adaptor Minor iron staining from 1.5 to 2.7. Heavy staining at 2.5	1.5
4.9	Coupling - iron staining at the coupling	4.9
11.2	Coupling	11.2
17.5	Coupling Minor iron staining at 18.8, 20.2 and 20.5	17.5
23.7	Coupling minor iron stain at coupling	23.7
29.7	**Top of well screen** Orange staining just below top of screen, 1 vertical black streak, otherwise very good condition	29.7
32.9	Screen weld/joint – orange/tarnish at weld	32.9
36.0	Screen weld/joint - minor black encrustation just below weld	36.0
39.0	Screen weld/joint – black/brown tarnish at weld	39.0
44.3	**Water level** – water very cloudy	44.3
45.2	Screen weld/joint Water becoming clearer at 47.0, iron stain at 45.0	45.2
48.1	Screen weld/joint Screen overall looks in good condition	48.1
51.4	Screen weld/joint – brown tarnishing at the weld	51.4
56.0	Water very cloudy, black particulate suspended in water	56.0
59.1	Bottom – black sediments	59.1
59.1	**End of Inspection**	59.1

HATCH

Camera Inspection Report

Project 325967
Well W-10 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
Top of PVC Well Casing	0.0	59.40	Inspector: A.Mills
As-built bottom of well	59.0	0.40	Started: Sept.6/09 11:47 am
			Finished:Sept 6/09 12:10 pm
			DVD No.:
			Note: No flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
0.3	Coupling	0.3
1.5	Pitless adaptor Minor iron staining just below pitless adaptor	1.5
4.9	Coupling	4.9
11.2	Coupling	11.2
17.5	Coupling	17.5
23.7	Coupling	23.7
29.7	**Top of well screen** Good condition	29.7
32.9	Screen weld/joint – orange/tarnish at weld	32.9
36.0	Screen weld/joint – black/brown tarnish at weld, otherwise good condition	36.0
39.0	Screen weld/joint – black/brown tarnish at weld	39.0
41.7	Screen weld/joint – black/brown tarnish at weld	41.7
44.2	**Water level** – water very turbid, water did not clear, cloudy to 59.0	44.2
59.0	**End of Inspection**	59.0

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Camera Inspection Report

Project 325967
Well W-11 **Before Flushing**
Sheet 1 of 2

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills
Top of PVC Well Casing	0.0	59.35	Started: Sept. 1/09 2:43 pm
As-built bottom of well	57.0	2.35	Finished:Sept.1/09 3:05 pm
			DVD No.:
			Note: Flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
0.2	Coupling	0.2
1.4	Pitless adaptor	1.4
1.9	Coupling Heavy iron staining from 2.3 to 3.3, a minor iron stain at 3.9, may be due to leakage from pitless adaptor	1.9
7.5	Coupling	7.5
8.1	Coupling Moderate iron staining from 8.1 to 11.8	8.1
13.7	Coupling	13.7
14.2	Coupling Heavy iron staining from 14.2 to 16.5	14.2
20.9	Coupling Heavy iron staining from 23.7 to 25.9	20.9
26.4	Coupling Minor iron staining from 28.2 to 28.3	26.4
26.8	**Top of well screen** Moderate black encrustation at screen/casing join, heavy iron staining at 29.3 to 29.5	26.8
29.6	Screen weld/joint	29.6
32.2	Screen weld/joint Moderate black encrustation and iron staining at 34.9 to 35.1	32.2
35.3	Screen weld/joint	35.3
38.1	Screen weld/joint	38.1
38.2	**Water level** Water very turbid, water clearing with depth	38.2
38.9	Screen weld/joint	38.9

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Camera Inspection Report

Project 325967
Well W-11 **Before Flushing**
Sheet 1 of 2

44.9	Screen weld/joint	44.9
46.9	Screen weld/joint	46.9
52.7	Screen weld/joint	52.7
53.3	Screen weld/joint	53.3
56.3	Screen weld/joint Overall condition of screen is excellent throughout	56.3
57.3	Water becoming dark grey/black	57.3
60.0	**End of Inspection**	60.0

HATCH

Camera Inspection Report

Project 325967
Well W-11 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills
Top of PVC Well Casing	0.0	59.35	Started: Sept. 2/09 11:25 am
As-built bottom of well	57.0	2.35	Finished:Sept.2/09 11:40 am
			DVD No.:
			Note: No flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
0.2	Coupling	0.2
1.4	Pitless adaptor	1.4
1.9	Coupling Minor iron staining at 3.9 to 4.1	1.9
7.5	Coupling	7.5
8.1	Coupling	8.1
13.7	Coupling	13.7
14.2	Coupling Moderate iron staining from 15.3 to 15.5	14.2
20.9	Coupling	20.9
26.4	Coupling	26.4
26.8	**Top of well screen** Minor black encrustation at screen/casing join, heavy iron staining at 29.2	26.8
29.6	Screen weld/joint	29.6
32.2	Screen weld/joint Moderate black encrustation and iron staining at 34.9	32.2
35.1	Screen weld/joint	35.1
36.4	**Water level** Water very turbid, poor visibility	36.4
41.0	Possible black encrustation	41.0
54.2	Water cloudy, becoming yellow in colour, dark grey at 55.5	54.2
58.0	Black sediments	58.0
58.0	**End of Inspection**	58.0

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Camera Inspection Report

Project 325967
Well W-12 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Aug. 31/09 10:43am Finished:Aug.31/09 11:00am DVD No.: Note: No flocculant added
Top of PVC Well Casing	0.0	59.29	
As-built bottom of well	61.0	-1.71	

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
0.2	Coupling	0.2
0.6	Coupling	0.6
1.5	Pitless adaptor Moderate Iron staining from 3.0 to 5.9	1.5
6.7	Coupling	6.7
12.8	Coupling Moderate iron staining from 12.8 to 14.5. Possible horizontal crack in casing at 14.6, wet	12.8
18.9	Coupling Moderate iron staining from 18.9 to 25.0	18.9
25.0	Coupling – Black/brown small area of staining at 28.1	25.0
31.2	**Top of well screen** Moderate black encrustation at screen/casing join	31.2
34.3	Screen weld/joint – Black and brown staining above the weld	34.3
37.3	Screen weld/joint Minor black encrustation at the weld	37.3
40.4	Screen weld/joint Moderate black encrustation at the weld	40.4
43.4	Screen weld/joint Minor black encrustation at the weld	43.4
46.3	Screen weld/joint	46.3
48.4	**Water level** Water turbid, water clearing with depth. Heavy iron encrustation at 52.4, 54.4 and 58.4. Water becoming cloudy at 57.5	48.4
60.0	**End of Inspection**	60.0

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Camera Inspection Report

Project 325967
Well W-12 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept. 1/09 8:00 am Finished: Sept.1/09 8:30 am DVD No.: Note: Flocculant added
Top of PVC Well Casing	0.0	59.29	
As-built bottom of well	61.0	-1.71	

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
0.2	Coupling	0.2
0.6	Coupling	0.6
1.5	Pitless adaptor	1.5
6.7	Coupling	6.7
12.8	Coupling No crack in casing observed at 14.6	12.8
18.9	Coupling	18.9
25.0	Coupling	25.0
31.2	**Top of well screen** Minor black encrustation at 33.7	31.2
31.7	**Water level**	31.7
37.3	Screen weld/joint Moderate black encrustation at the weld	37.3
40.4	Screen weld/joint Good condition, minor iron encrustation at 41.9	40.4
43.4	Screen weld/joint Minor black encrustation at the weld, good condition	43.4
46.3	Screen weld/joint	46.3
46.7	Water turbid at 46.7, possible iron encrustation at 54.4 and 58.0	46.7
60.0	**End of Inspection**	60.0
	Note: Due to turbid water, it was decided to stop the inspection and complete the inspection below the water level the next morning. The well was not pumped overnight. The following water levels were observed in the well: Aug. 31/09 43.7 m below top of casing Sept. 1/09 31.7 m below top of casing	

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Camera Inspection Report

Project 325967
Well W-13 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
Top of PVC Well Casing	0.0	59.27	Inspector: A.Mills
As-built bottom of well	59.0	0.27	Started: Aug.31/09 11:30 am
			Finished:Aug.31/09 11:50am
			DVD No.:
			No flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
0.1	Coupling	0.1
1.5	Pitless adaptor	1.5
6.1	Coupling	6.1
12.2	Coupling	12.2
18.5	Coupling – white patch of sealant noted at 20.4	18.5
24.6	Coupling minor iron stain at coupling	24.6
27.0	**Water level** – water very cloudy	27.0
36.9	**Possible Top of well screen –** water still very cloudy, difficult to make observations. Water cloudy to 60.0	36.9
53.6	Possible black encrustation	53.6
55.6	Possible black encrustation	55.6
58.1	Possible iron encrustation	58.1
60.0	**End of Inspection**	60.0
	Note: It was observed that the casing is not plumb	

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Camera Inspection Report

Project 325967
Well W-13 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept. 1/09 8:46 am Finished: Sept.1/09 9:16 am DVD No.: Note: Flocculant added 17 hrs ago
Top of PVC Well Casing	0.0	59.27	
As-built bottom of well	59.0	0.27	

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
0.1	Coupling	0.1
1.5	Pitless adaptor	1.5
6.1	Coupling	6.1
12.2	Coupling	12.2
18.5	Coupling	18.5
24.6	Coupling	24.6
27.2	**Water level** – water very cloudy	27.2
30.8	**Top of well screen** No major encrustation observed. Water clearing at 33.0	30.8
34.2	Screen weld/joint	34.2
37.2	Screen weld/joint Good condition generally. Minor black encrustation at 40. to 40.4	37.2
43.4	Screen weld/joint	43.4
46.5	Screen weld/joint Minor brown encrustation at 47.6 and 50.0	46.5
53.5	Screen weld/joint	53.5
56.8	Screen weld/joint	56.8
59.8	Screen weld/joint	59.8
60.0	**End of Inspection**	60.0
	Comments: Screen generally in good condition throughout	

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Camera Inspection Report

Project 325967
Well W-14 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Aug.31/09 4:37 pm Finished:Aug.31/09 5:00 pm DVD No.: Note: No flocculant added
Top of PVC Well Casing	0.0	59.01	
As-built bottom of well	61.5	-2.49	

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.3	Pitless adaptor	1.3
3.4	Coupling - good condition	3.4
11.8	Coupling Minor iron staining at 13.2 to 13.3 and a vertical iron stain at 15.0	11.8
18.0	Coupling Vertical and horizontal black encrustation at 20.6	18.0
24.2	Coupling	24.2
26.9	**Water level** – water very cloudy	26.9
30.6	**Top of well screen** Water very cloudy	30.6
36.2	Screen weld/joint	36.2
52.3	Possible iron staining – water very cloudy	52.3
59.5	**End of Inspection**	59.5

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Camera Inspection Report

Project 325967
Well W-14 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept. 1/09 0:00am Finished:Sept.1/09 0:00am DVD No.: Note: No flocculant added
Top of PVC Well Casing	0.0	59.01	
As-built bottom of well	61.5	-2.49	

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.3	Pitless adaptor - iron staining, possible leakage at pitless adaptor	1.3
3.4	Coupling	3.4
5.7	Coupling	5.7
11.8	Coupling	11.8
18.0	Coupling	18.0
24.2	Coupling	24.2
25.6	**Water level** – water very cloudy	25.6
30.6	**Top of well screen** Water very cloudy to 40.5, then clearing	30.6
47.2	Screen weld/joint	47.2
54.6	Iron encrustation at 54.6, water dark grey at 56.9 to 60.2	54.6
60.2	**End of Inspection**	60.2

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Camera Inspection Report

Project 325967
Well W-15 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills
Top of PVC Well Casing	0.0	58.91	Started: Sept. 1/09 10:18 am
As-built bottom of well	61.5	-2.59	Finished:Sept.1/09 10:40 am
			DVD No.:
			Note: No flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.4	Pitless adaptor Very minor iron staining at 4.1	1.4
5.9	Coupling	5.9
12.0	Coupling	12.0
18.1	Coupling	18.1
24.4	Coupling	24.4
30.5	**Top of well screen**	30.5
30.6	**Water level** Water clear, good visibility, screen is in good condition, reduced visibility at 33.4	30.6
33.9	Screen weld/joint	33.9
36.5	Screen weld/joint	36.5
39.3	Screen weld/joint Water clear, screen generally in good condition	39.3
45.6	Screen weld/joint Minor iron encrustation at 48.5	45.6
53.9	Screen weld/joint Minor black encrustation at 54.2, becoming very cloudy at 55.1	53.9
59.9	Black sediments, bottom	59.9
59.9	**End of Inspection**	59.9

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Camera Inspection Report

Project 325967
Well W-15 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A. Mills Started: Sept. 4/09 3:05 pm Finished:Sept.4/09 3:25 pm DVD No.: Note: No flocculant added
Top of PVC Well Casing	0.0	58.91	
As-built bottom of well	61.5	-2.59	

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.4	Pitless adaptor Minor iron staining at 2.5	1.4
5.9	Coupling	5.9
12.0	Coupling	12.0
18.1	Coupling	18.1
24.4	Coupling	24.4
30.5	**Top of well screen** Minor iron staining and black encrustation just below the top of screen	30.5
31.0	**Water level** Water cloudy to 31.8 then clearing	31.0
33.9	Screen weld/joint	33.9
35.5	Screen weld/joint - minor black encrustation noted at 35.4 and at weld, good condition below	35.5
39.3	Screen weld/joint Water very clear – screen in good condition	39.3
42.7	Screen weld/joint Water clear, screen generally in good condition	42.7
45.6	Screen weld/joint Minor iron encrustation at 48.5, poor visibility at 50.1	45.6
53.9	Screen weld/joint Minor iron encrustation at 55.1	53.9
60.0	Black sediments, bottom	60.0
60.0	**End of Inspection**	60.0

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Camera Inspection Report

Project 325967
Well W-16 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept. 1/09 9:38 am Finished:Sept.1/09 10:00 am DVD No.: Note: No flocculant added
Top of PVC Well Casing	0.0	58.76	
As-built bottom of well	61.0	-2.24	

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
0.9	Coupling	0.9
1.4	Pitless adaptor Moderate iron staining at 3.8	1.4
4.8	Coupling Minor iron staining at 5.6 to 6.0	4.8
11.0	Coupling - minor rust on the coupling Vertical streaks of black staining at 14.8	11.0
17.1	Coupling – minor glue/sealant staining	17.1
23.3	Coupling	23.3
28.0	Coupling	28.0
29.6	**Top of well screen** Condition of screen generally good. Minor black encrustation at 31.1.	29.6
32.8	Screen weld/joint Large area of heavy black encrustation at 33.2, possible hole, minor black encrustation at 34.2, minor iron staining at 35.6	32.8
35.8	Screen weld/joint	35.8
38.9	Screen weld/joint	38.9
42.2	Screen weld/joint – burn/tarnish at weld and moderate black encrustation at 43.8	42.2
45.1	Screen weld/joint	45.1
46.2	**Water level** Water clear, good visibility, minor iron stain at joint, water becoming cloudy at 48.8, cloudy to 60.0	46.2
60.0	Black sediments, bottom	60.0
60.0	**End of Inspection**	60.0
	Note: Hole is not plumb	

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Camera Inspection Report

Project 325967
Well W-16 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
Top of PVC Well Casing	0.0	58.76	Inspector: A.Mills
As-built bottom of well	61.0	-2.24	Started: Sept. 1/09 2:00 pm
			Finished:Sept.1/09 2:18 pm
			DVD No.:
			Note: No flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
0.9	Coupling	0.9
1.4	Pitless adaptor	1.4
4.8	Coupling Minor iron staining at 6.0 to 6.6	4.8
11.0	Coupling	11.0
17.1	Coupling – minor glue/sealant staining	17.1
23.3	Coupling - minor iron staining at 26.3	23.3
28.0	Coupling	28.0
29.6	**Top of well screen** Condition of screen generally good. Moderate black encrustation vertical streaks from 29.6 to 31.0.	29.6
32.8	Screen weld/joint Large area of heavy black encrustation at 33.2, not a hole, clean below 33.3	32.8
35.8	Screen weld/joint	35.8
37.9	**Water level** Water cloudy below water level	37.9
54.7	Screen weld/joint	54.7
57.0	Screen weld/joint	57.0
58.8	Water dark grey, possible sediments	58.8
60.2	Black sediments, bottom	60.2
60.2	**End of Inspection**	60.2

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Camera Inspection Report

Project 325967
Well W-17 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills
Top of PVC Well Casing	0.0	58.46	Started: Sept. 2/09 2:40 pm
As-built bottom of well	60.0	-1.54	Finished:Sept.2/09 3:00 pm
			DVD No.:
			Note: No flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.5	Pitless adaptor Orange discolouration on casing at 3.4	1.5
5.5	Coupling	5.5
11.5	Coupling – minor glue/sealant staining	11.5
17.8	Coupling Small white patches of glue/sealant at 20.6	17.8
23.9	Coupling	23.9
30.2	**Top of well screen** Heavy black encrustation from 30.2 to 31.5	30.2
33.1	Screen weld/joint Minor black encrustation at the weld, heavy black encrustation from 33.3 to 34.0	33.1
36.3	Screen weld/joint	36.3
39.4	Screen weld/joint	39.4
42.6	Screen weld/joint – burn/tarnish at weld and minor black encrustation at 45.0	42.6
45.7	Screen weld/joint	45.7
47.2	**Water level** Water clear, screen is in good condition	47.2
48.7	Screen weld/joint	48.7
52.0	Screen weld/joint – minor dark grey discolouration on screen	52.0
59.3	Screen weld/joint – old pump observed, could not go any deeper	59.3
59.3	**End of Inspection**	59.3

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Camera Inspection Report

Project 325967
Well W-17 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept. 3/09 2:15 pm Finished:Sept.3/09 2:35 pm DVD No.: Note: No flocculant added
Top of PVC Well Casing	0.0	58.46	
As-built bottom of well	60.0	-1.54	

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.5	Pitless adaptor	1.5
5.5	Coupling	5.5
11.5	Coupling – minor glue/sealant staining	11.5
17.8	Coupling – minor glue staining to 18.6	17.8
23.9	Coupling	23.9
30.2	**Top of well screen** Heavy black encrustation from 30.2 to 33.0	30.2
33.1	Screen weld/joint Minor black encrustation at the weld	33.1
36.3	Screen weld/joint	36.3
39.4	Screen weld/joint - burn/tarnish at weld	39.4
42.6	Screen weld/joint – burn/tarnish at weld and minor black encrustation at 45.0	42.6
45.7	Screen weld/joint	45.7
47.1	**Water level** Water cloudy, pump ID tag floating on surface, very cloudy to bottom	47.1
59.3	Screen weld/joint – old pump and wiring observed, could not go any deeper	59.3
59.3	**End of Inspection**	59.3

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Camera Inspection Report

Project 325967
Standpipe by Well W-17
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A. Mills Started: Sept. 3/09 2:41 pm Finished:Sept.3/09 2:51 pm Tape No.: Tape Index: Note: No flocculant added
Top of PVC Well Casing As-built bottom of well Sounded bottom of well before flushing Sounded bottom of well after flushing			

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
0.7	Coupling	0.7
5.9	Coupling	5.9
12.0	Coupling	12.0
18.4	Coupling	18.4
24.5	Coupling – metal rod, wood and debris tightly packed	24.5
25.5	**End of Inspection**	24.5

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Camera Inspection Report

Project 325967
Well W-18 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept. 3/09 3:45 pm Finished:Sept.3/09 4:05 pm DVD No.: Note: No flocculant added
Top of PVC Well Casing	0.0	57.87	
As-built bottom of well	60.0	-2.13	

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.2	Coupling - minor rust on coupling	1.2
1.4	Pitless adaptor	1.4
6.0	Coupling	6.0
12.1	Coupling Minor iron staining from 12.8 to 13.4 and at moderate staining at 14.8	12.1
18.3	Coupling Small white patches of glue/sealant at 20.6	18.3
24.4	Coupling – minor iron stain at 28.2	24.4
29.3	**Top of well screen** Heavy black encrustation from 29.3 to 30.0. Very good condition below 30.0	23.9
32.4	Screen weld/joint	32.4
35.4	Screen weld/joint Moderate to heavy black encrustation from 35.4 to 38.6	35.4
38.6	**Water level** Water very cloudy, difficult to assess because of visibility	38.6
41.9	Screen weld/joint	41.9
48.5	Possible screen weld/joint - water cloudy	48.5
51.4	Black sediments, on bottom, possible collapse at 51.4	51.4
51.4	**End of Inspection**	51.4

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Camera Inspection Report

Project 325967
Well W-18 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A. Mills Started: Sept. 4/09 12:40 pm Finished:Sept.4/09 1:00 pm DVD No.: Note: No flocculant or acid added
Top of PVC Well Casing	0.0	57.87	
As-built bottom of well	60.0	-2.13	

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.2	Coupling - minor rust on coupling	1.2
1.4	Pitless adaptor	1.4
6.0	Coupling	6.0
12.1	Coupling Minor iron staining from 12.8 to 13.4 and at moderate staining at 14.8	12.1
18.3	Coupling Small white patches of glue/sealant at 20.6	18.3
24.4	Coupling – minor iron stain at 28.2	24.4
29.3	**Top of well screen** Heavy black encrustation from 29.3 to 32.0.	29.3
32.4	Screen weld/joint	32.4
35.4	Screen weld/joint Moderate to heavy black encrustation from 35.4 to 38.6	35.4
38.6	**Water level** Water very cloudy, difficult to assess because of visibility	38.6
41.9	Screen weld/joint – possible tear in screen at 45.2, water becoming clearer at 47.6	41.9
48.5	Screen weld/joint - water becoming cloudy at 50.0	48.5
51.0	Black sediments, on bottom, water very cloudy	51.0
51.0	**End of Inspection**	51.0

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Camera Inspection Report

Project 325967
Well W-19 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept. 3/09 4:11 pm Finished:Sept.3/09 4:30 pm DVD No.: Note: No flocculant added
Top of PVC Well Casing	0.0	57.01	
As-built bottom of well	59.5	-2.54	

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.2	Coupling	1.2
1.4	Pitless adaptor - iron staining at 1.7, possible leak at pitless adaptor	1.4
5.8	Coupling - minor rust on coupling, black horizontal line/stain at 6.4, iron staining at 7.2; possible crack at 8.0, not wet	5.8
12.0	Coupling	12.0
18.2	Coupling Heavy glue/sealant stains at 18.2, minor iron staining from 20.0 to 21.0	18.2
24.3	**Top of well screen**	24.3
27.4	Screen weld/joint Moderate black encrustation above the weld, from 27.1 to 27.4	27.4
30.2	Screen weld/joint – heavy black staining at the weld	30.2
33.7	Screen weld/joint – heavy black staining from 33.1 to 33.7 and just above water level at 36.2	33.7
36.4	**Water level** Water cloudy, clearing with depth. Screen in good condition from 41.8 to 47.2	36.4
49.1	Heavy iron encrustation from 49.1 to 51.0. Water becoming cloudy at 52.2., then clearing. Screen in good condition at 55.3	49.1
57.5	Water is black, high silt content	57.5
57.5	**End of Inspection**	57.5

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Camera Inspection Report

Project 325967
Well W-19 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept. 4/09 12:02 pm Finished:Sept.4/09 12:24 pm DVD No.: Note: No flocculant or acid added
Top of PVC Well Casing	0.0	57.01	
As-built bottom of well	59.5	-2.54	

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.2	Coupling	1.2
1.4	Pitless adaptor - iron staining at 1.7, possible leak in pitless adaptor	1.4
5.8	Coupling - minor rust on coupling, black horizontal line/stain at 6.4, iron staining at 7.2; possible crack at 8.0, not wet	5.8
12.0	Coupling	12.0
18.2	Coupling Heavy glue/sealant stains at 18.2, minor iron staining from 20.0 to 21.0	18.2
24.3	**Top of well screen**	24.3
27.4	Screen weld/joint Moderate black encrustation above the weld, from 27.1 to 27.4	27.4
30.2	Screen weld/joint – heavy black staining at the weld	30.2
33.7	Screen weld/joint – minor black staining from 33.1 to 33.7 and just above water level at 36.2	33.7
36.4	**Water level** Water clear, screen is in good condition from 36.4 to 47.2. Possible heavy calcium encrustation at 49.3. Water becoming black at 58.0.	36.4
59.0	**End of Inspection**	59.0

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Camera Inspection Report

Project 325967
Well W-20 **Before Flushing**
Sheet 1 of 2

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills
Top of PVC Well Casing	0.0	56.01	Started: Sept. 4/09 10:42am
As-built bottom of well	64.0	-7.99	Finished:Sept.4/09 11:03am
			DVD No.:
			Note: No flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
0.4	Coupling	0.4
0.7	Coupling	0.7
0.9	Coupling	0.9
1.1	Coupling	1.1
1.6	Pitless adaptor Moderate iron staining at 6.1	1.6
7.0	Coupling Moderate to heavy iron staining at 8.6 to 11.7, possible leak in pitless adaptor	7.0
13.3	Coupling - moderate black staining at the coupling	13.3
19.4	Coupling	19.4
25.6	Coupling – heavy iron staining at 28.1	25.6
31.8	**Top of well screen** Moderate black encrustation at screen/casing join, heavy iron staining from 34.6 to 34.8	31.8
35.0	Screen weld/joint Heavy iron and black encrustation at 37.4 to 41.0	35.0
41.2	Screen weld/joint Minor black encrustation at the weld	41.2
42.0	Screen weld/joint Heavy iron staining at 42.6, heavy black encrustation from 43.9 to 44.0	42.0
44.8	**Water level** Water turbid, water clearing with depth.	44.8
50.6	Screen weld/joint – heavy iron staining at 55.6, water cloudy	50.6
56.0	Screen weld/joint	56.0

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Camera Inspection Report

Project 325967
Well W-20 **Before Flushing**
Sheet 1 of 2

59.9	Water black, bottom	59.9
59.9	**End of Inspection**	59.9

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Camera Inspection Report

Project 325967
Well W-20 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept. 4/09 2:45am Finished:Sept.4/09 3:05am DVD No.: Note: No flocculant or acid added
Top of PVC Well Casing	0.0	56.01	
As-built bottom of well	64.0	-7.99	

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
0.4	Coupling	0.4
0.7	Coupling	0.7
0.9	Coupling	0.9
1.1	Coupling	1.1
1.6	Pitless adaptor Moderate iron staining at 6.1	1.6
7.0	Coupling	7.0
13.3	Coupling	13.3
19.4	Coupling	19.4
25.6	Coupling	25.6
31.8	**Top of well screen** Minor black encrustation at 33.3	31.8
35.0	Screen weld/joint Heavy iron and black encrustation at weld and at 37.8	35.0
41.2	Screen weld/joint	41.2
44.9	**Water level** Water turbid, remaining cloudy to 60.0	44.9
55.9	Possible screen weld/joint – water cloudy	55.9
56.9	Water yellow in colour	56.9
59.0	Water black	59.0
60.0	**End of Inspection**	60.0

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Camera Inspection Report

Project 325967
Well W-21 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept.5/09 12:55 pm Finished: Sept 5/09 1:15 pm DVD No.: Note: No flocculant added
Top of PVC Well Casing	0.0	53.99	
As-built bottom of well	56.5	-2.51	

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
0.3	Coupling	0.3
0.7	Coupling	0.7
1.5	Pitless adaptor	1.5
7.4	Coupling - glue staining at 9.9 and 10.5	7.4
13.7	Coupling	13.7
19.8	Coupling	19.8
25.9	Coupling	25.9
27.4	Coupling	27.4
32.2	Coupling	32.2
33.9	**Top of well screen** – screen is in good condition	33.9
36.1	Screen weld/joint – orange/tarnish at weld	36.1
39.0	Screen weld/joint - heavy black staining at the weld	39.0
39.2	**Water level** Water cloudy to 54.5. Large heavy iron stain at 42.3	39.2
44.9	Screen weld/joint	44.9
45.6	Screen weld/joint Black sediments in suspension at 51.0	45.6
55.1	Black sediments, soft bottom	55.1
55.1	**End of Inspection**	55.1

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Camera Inspection Report

Project 325967
Well W-21 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
Top of PVC Well Casing	0.0	53.99	Inspector: A.Mills
As-built bottom of well	56.5	-2.51	Started: Sept.5/09 3:00 pm
			Finished: Sept 5/09 3:20 pm
			DVD No.:
			Note: No flocculant or acid added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
0.3	Coupling	0.3
0.7	Coupling	0.7
1.5	Pitless adaptor	1.5
7.4	Coupling - glue staining at 9.9 and 10.5	7.4
13.7	Coupling	13.7
19.8	Coupling	19.8
25.9	Coupling	25.9
27.4	Coupling	27.4
32.2	Coupling	32.2
33.9	**Top of well screen** – screen is in good condition	33.9
36.1	Screen weld/joint – orange/tarnish at weld	36.1
39.0	Screen weld/joint	39.0
39.5	**Water level** Water cloudy to bottom	39.5
44.9	Screen weld/joint	44.9
45.6	Screen weld/joint Black sediments in suspension at 51.0	45.6
55.0	Black sediments, soft bottom	55.0
55.0	**End of Inspection**	55.0

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Camera Inspection Report

Project 325967
Well W-22 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
Top of PVC Well Casing	0.0	52.26	Inspector: A.Mills
As-built bottom of well	60.0	-7.74	Started: Sept. 5/09 1:20 pm
			Finished:Sept.5/09 1:40 pm
			DVD No.:
			Note: Flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.4	Pitless adaptor	1.4
5.1	Coupling – glue staining at 6.5	5.1
11.2	Coupling	11.2
17.3	Coupling	17.3
23.6	Coupling	23.6
29.8	Coupling	29.8
35.9	**Top of well screen** Screen in good condition, minor iron staining at 38.1	35.9
39.3	**Water level** Water turbid, clearing at 42.8	39.3
40.7	Possible screen weld/joint – screen in good condition at 42.8	40.7
45.5	Screen weld/joint	45.5
49.9	Screen weld/joint	49.9
50.2	Screen weld/joint	50.2
54.7	Screen weld/joint	54.7
59.1	Water becoming dark grey/black, soft bottom	59.1
59.1	**End of Inspection**	59.1

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Camera Inspection Report

Project 325967
Well W-22 **After Flushing**
Sheet 1 of 1

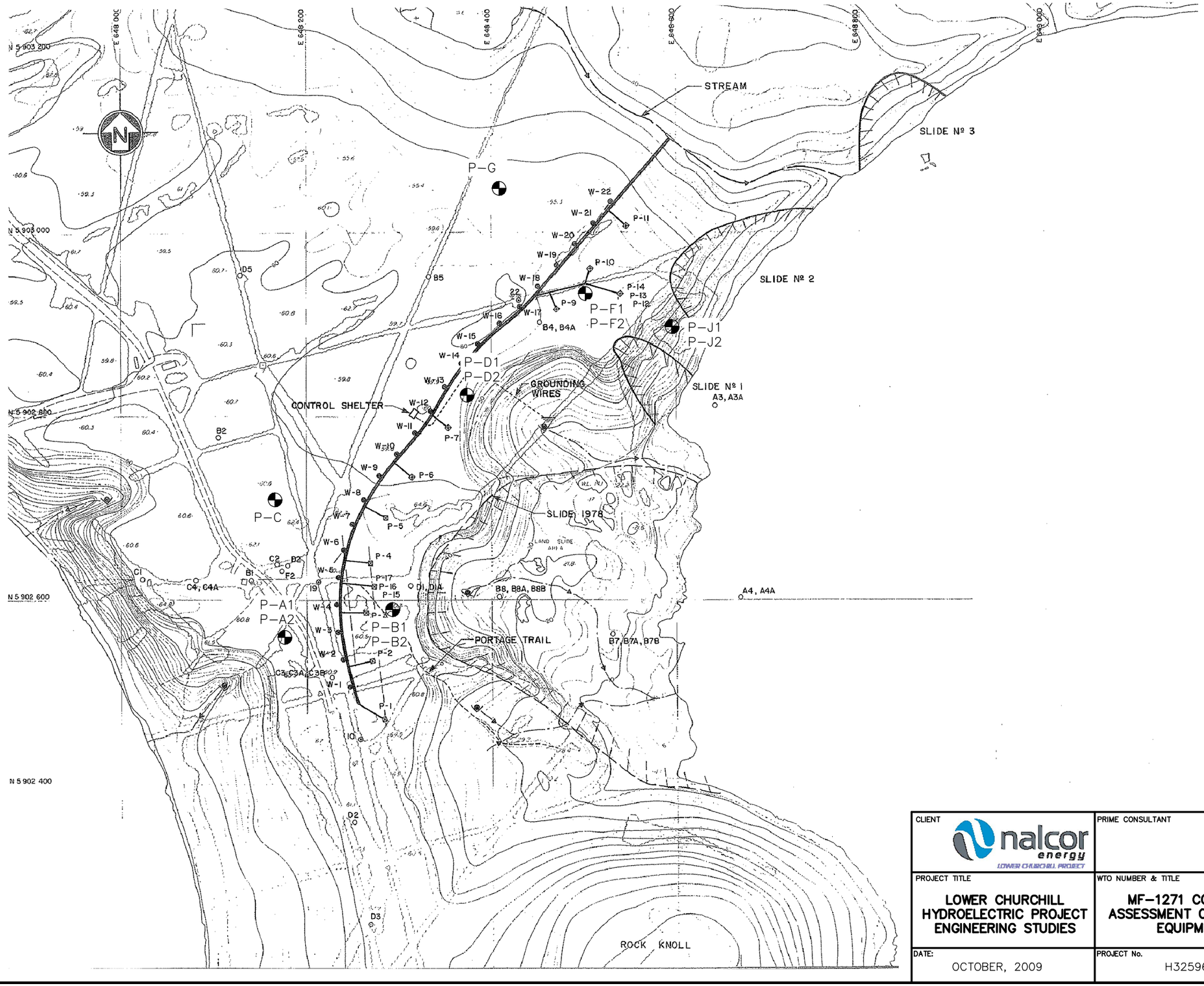
Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept. 5/09 3:30 pm Finished:Sept.5/09 3:50 pm DVD No.: Note: Flocculant added
Top of PVC Well Casing	0.0	52.26	
As-built bottom of well	60.0	-7.74	

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.4	Pitless adaptor	1.4
5.1	Coupling – glue staining at 6.5	5.1
11.2	Coupling	11.2
17.3	Coupling	17.3
23.6	Coupling	23.6
29.8	Coupling	29.8
35.9	**Top of well screen** Screen in good condition, minor iron staining at 38.1	35.9
38.8	**Water level** Water turbid, no clearing to the bottom	38.8
40.7	Possible screen weld/joint	40.7
49.6	Possible screen weld/joint	49.6
54.8	Water becoming yellow at 54.8, dark grey/black at 56.6	54.8
57.7	Water black	57.7
57.7	**End of Inspection**	57.7

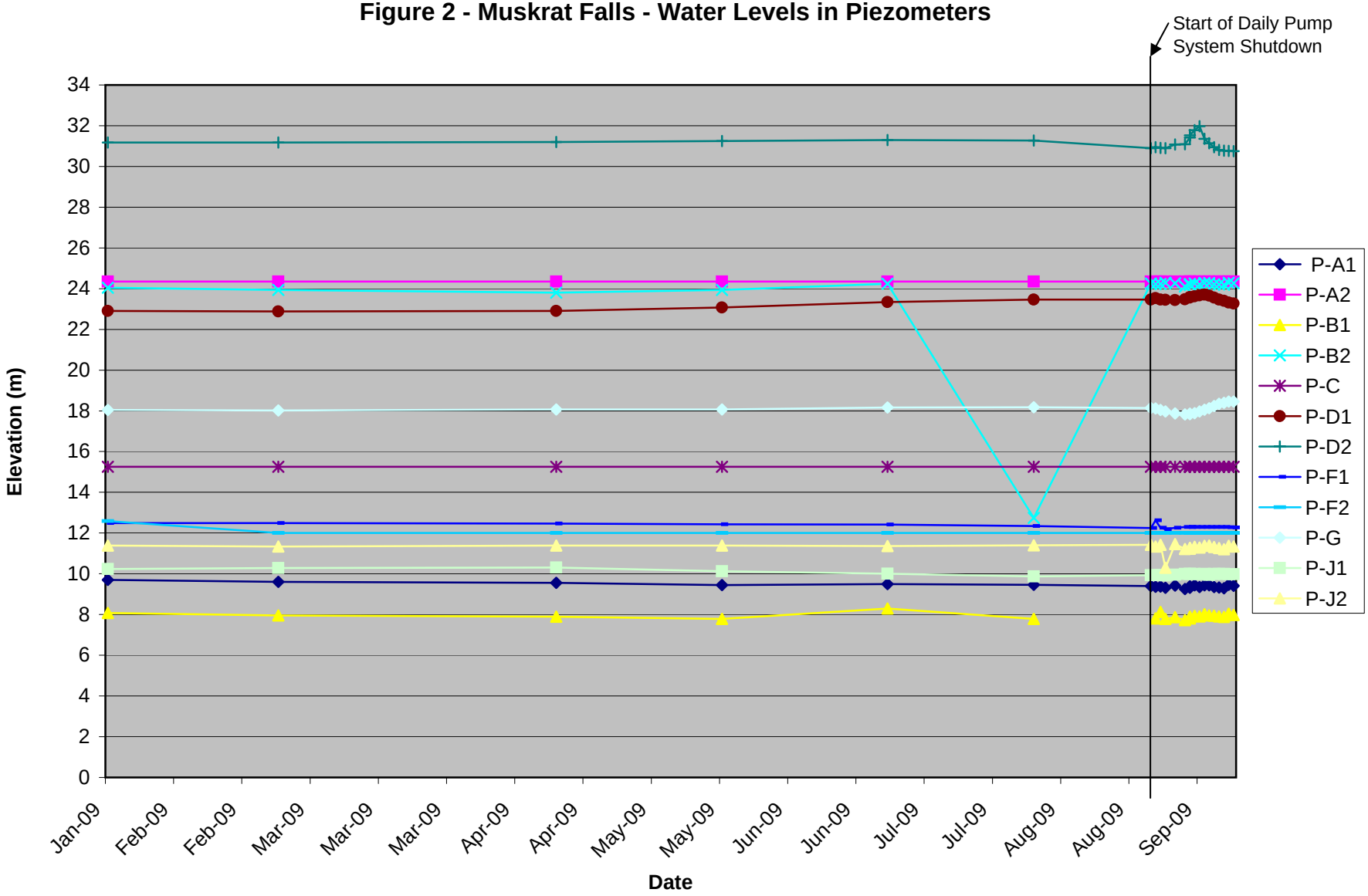
Appendix C

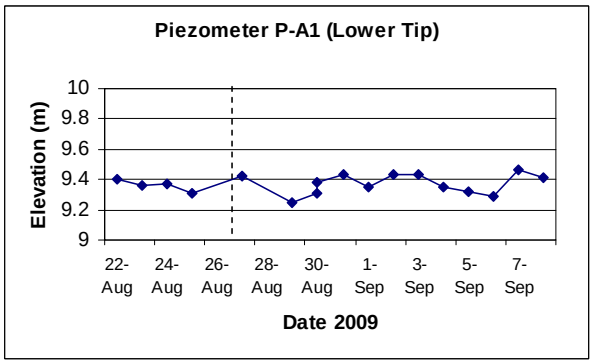
Figures



CLIENT: nalcor energy, LOWER CHURCHILL PROJECT	PRIME CONSULTANT: HATCH	
PROJECT TITLE: LOWER CHURCHILL HYDROELECTRIC PROJECT ENGINEERING STUDIES	WTO NUMBER & TITLE: MF-1271 CONDITION ASSESSMENT OF EXISTING EQUIPMENT	DRAWING TITLE: SITE LOCATION PLAN
DATE: OCTOBER, 2009	PROJECT No.: H325967	DRAWING No.: FIGURE 1

Figure 2 - Muskrat Falls - Water Levels in Piezometers





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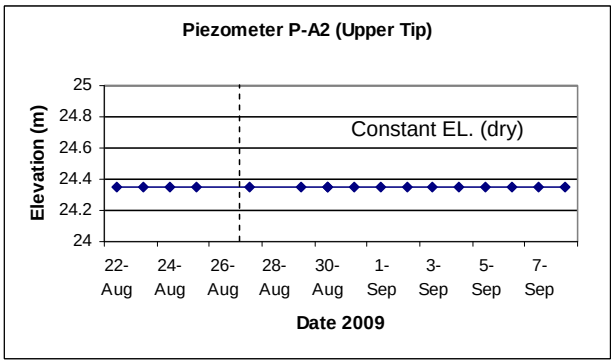

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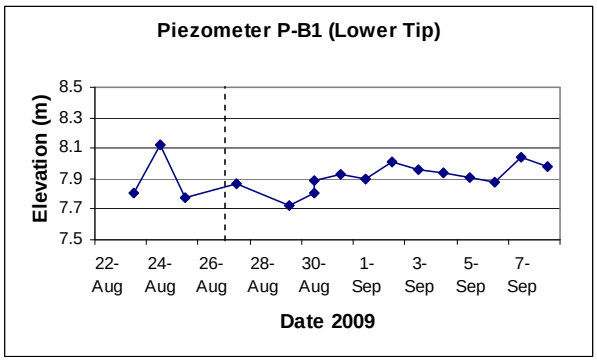

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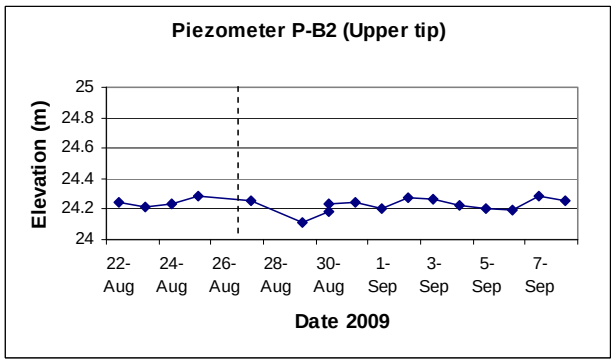
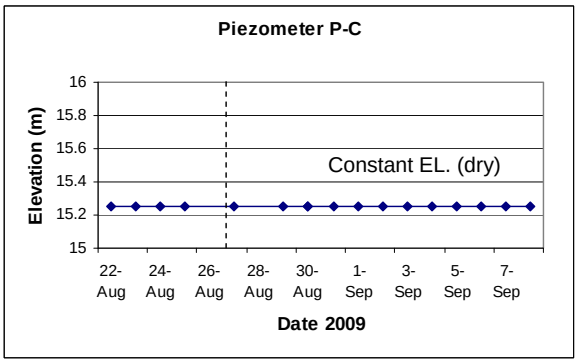


(d)

Figure 3 – Piezometer water level variations prior to and during the well inspection program:

(a) P-A1 lower tip, (b) P-A2 upper tip, (c) P-B1 lower tip and (d) P-B2 upper tip. Note: Daily shutdown of pump system commenced on August 27, 2009, shown as vertical dashed line.



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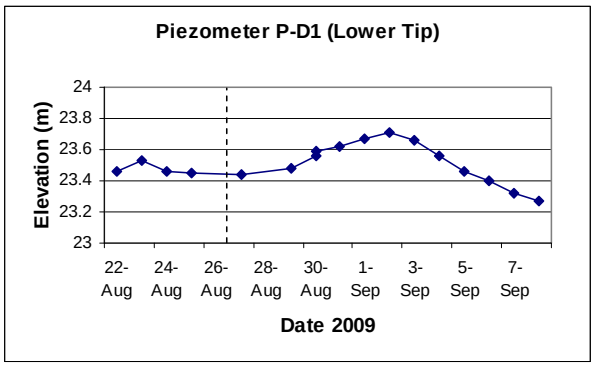

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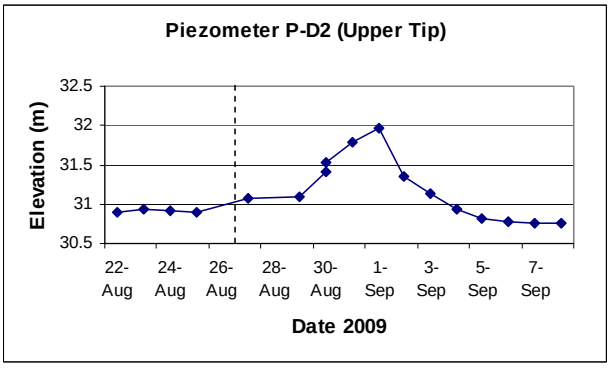
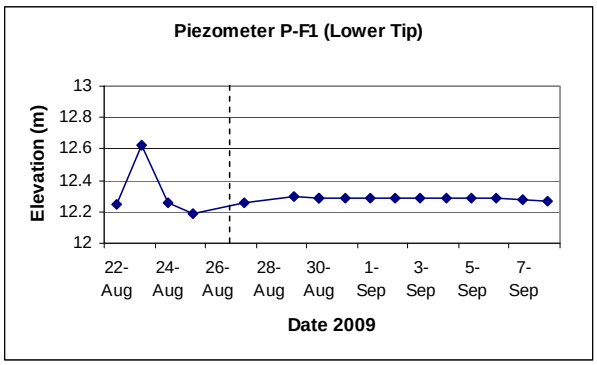


(c)

Figure 4 – Piezometer water level variations prior to and during the well inspection program:

(a) P-C, (b) P-D1 lower tip, (c) P-D2 upper tip. Note: Daily shutdown of pump system commenced on August 27, 2009, shown as vertical dashed line.



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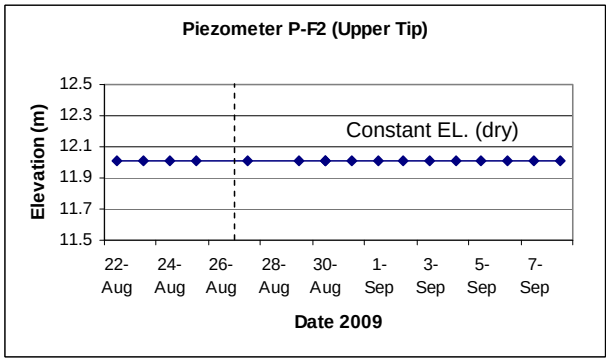

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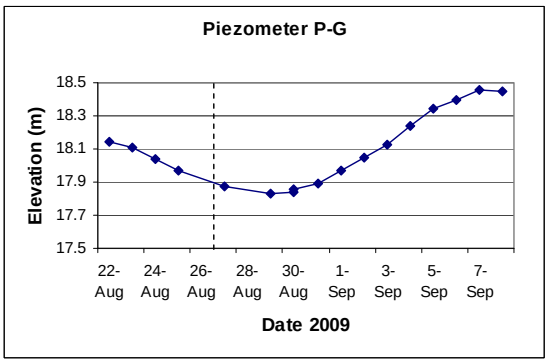
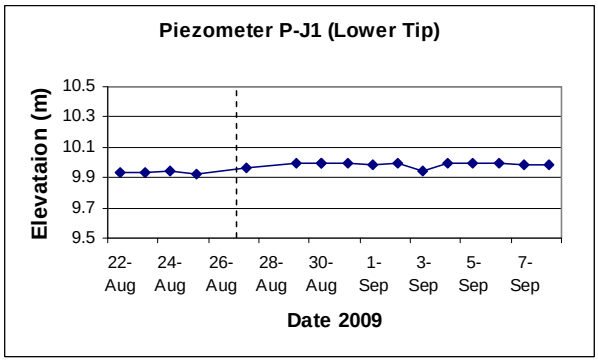


(c)



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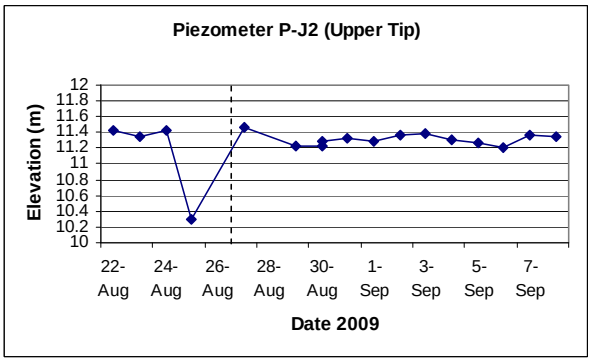


(e)

Figure 5 – Piezometer water level variations prior to and during the well inspection program:

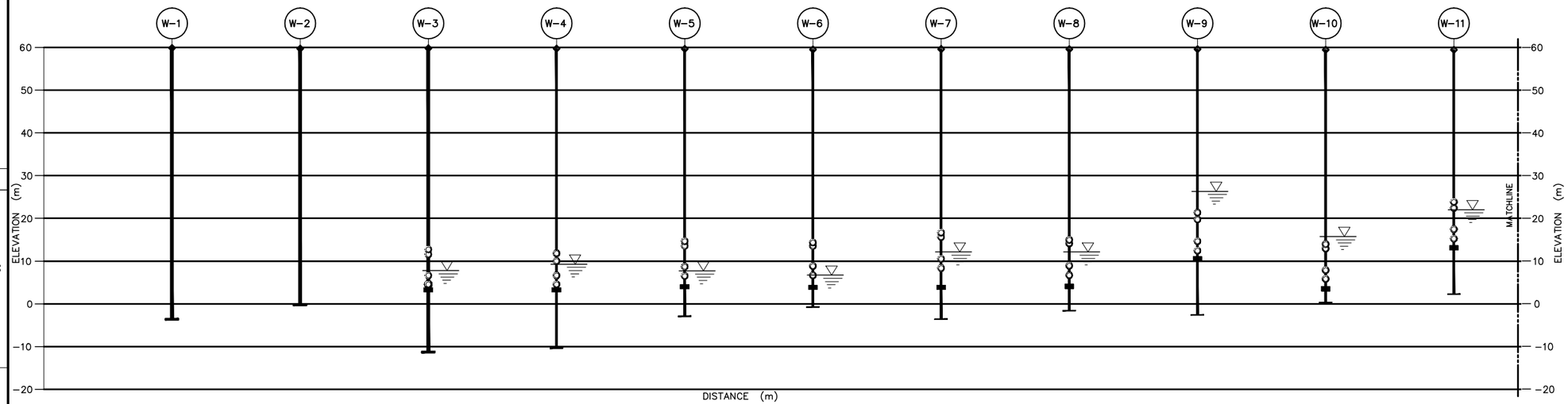
(a) P-F1 lower tip, (b) P-F2 upper tip, (c) P-G , (d) P-J1 lower tip, (e) P-J2 upper tip. Note: Daily shutdown of pump system commenced on August 27, 2009, shown as vertical dashed line.

HATCH – A1 (841x594)

REVISION A

FIGURE 6

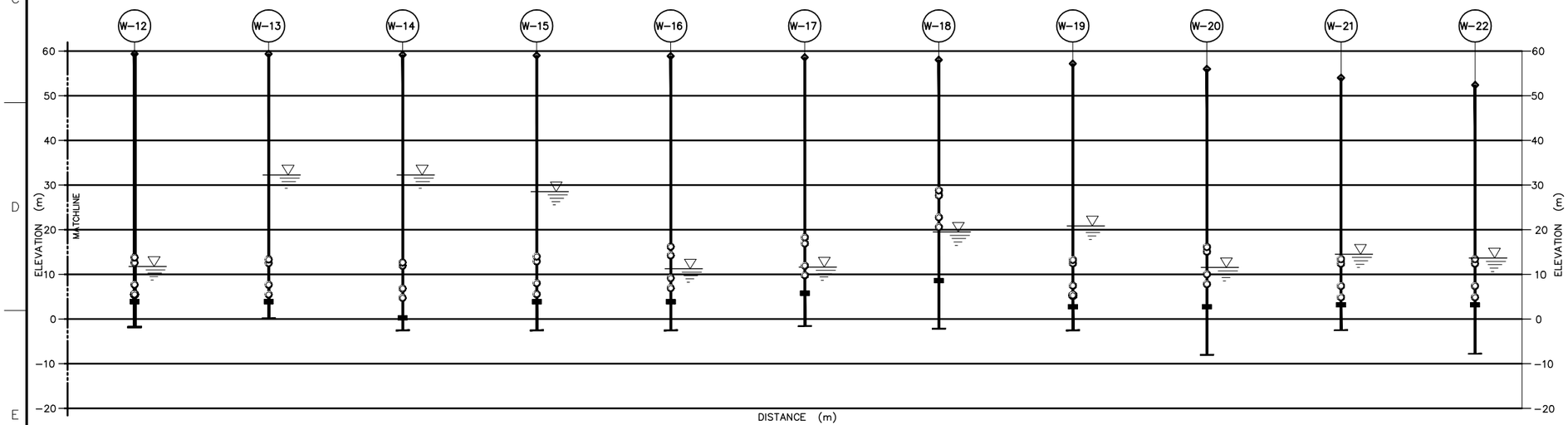
DWG. NO.



PROFILE OF PUMPWELL SYSTEM

0 10 20 30 40 50m

Scale: 1:500



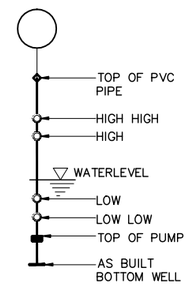
PROFILE OF PUMPWELL SYSTEM

0 10 20 30 40 50m

Scale: 1:500

NOTE:

PUMP AND WELL DETAIL MEASURED DURING MUSKRAT FALLS WELL INSPECTION PROGRAM AUG. 27 – SEP 7, 2009.



TYPICAL WELL DETAIL

Dec 09 , 2009 , 2:59pm Login name: lwatt004
Drawing Name: C:\Documents and Settings\lwatt004\Desktop\325967_FIGURE_6.dwg

DRAWING NO.	DRAWING TITLE
REFERENCE DRAWINGS	

NO.	DESCRIPTION	CHK'D	APP'D	DATE
REVISIONS				

REV.	ISSUE FOR	AUTH. BY	DATE
ISSUE AUTHORIZATION			

HATCH

DESIGNED BY / DATE	DRAWN BY / DATE
CHECKED BY / DATE	DISCIP. ENGR. / DATE
PROJ. DES. COORD. / DATE	PROJ. ENGR. / DATE
PROJ. MGR. / DATE	PROJECT NUMBER: 325967

NALCOR ENERGY

LOWER CHURCHILL HYDROELECTRIC PROJECT

MF–1271 CONDITION ASSESSMENT OF EXISTING EQUIPMENT

WELL SYSTEM PROFILE

SCALE	DRAWING NO.	REVISION
	FIGURE 6	A

CIVIL | ELECTRICAL | MECHANICAL | GEOTECHNICAL | HYDROTECHNICAL | ARCHITECTURAL | OTHER