Columbia River Project Water Use Plan

Kinbasket and Arrow Recreation Management Plan

Mid Columbia Erosion Protection and Long-Term Monitoring

Implementation Year 2

Reference: CLBWORKS-35 and CLBWORKS-36

Mid-Columbia Erosion Protection and Long-Term Monitoring

Study Period: 2010

Kerr Wood Leidal Associates Limited
Consulting Engineers

December 2010

BC hydro

CLBWORKS #35 and #36 Mid-Columbia Erosion Protection and Long-Term Monitoring

Year 2 Progress Report (2010)
December 2010

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CLBWORKS #35 and #36 Mid-Columbia Erosion Protection and Long-Term Monitoring

Year 2 Progress Report (2010)
December 2010

KWL File No. 478.081-300

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STATEMENT OF LIMITATIONS

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REVISION HISTORY

Revision #	Date	Status	Revision	Author
0	December 2010	Final		SJL/EE/DTM

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APPENDICES

Section 1

Introduction

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1. INTRODUCTION

This report summarizes progress made by Kerr Wood Leidal Associates Ltd. (KWL) during 2010 on BC Hydro programs CLBWORKS #35 and #36. These two programs resulted from a multi-stakeholder assessment of the proposed installation of a fifth generating unit at Revelstoke Dam, and the resulting review of the Columbia River Water Use Planning (WUP) process. The fifth generating unit is expected to have an in-service date of October 2010.

As a result of the WUP review, it was recommended that two programs be undertaken:

1. **CLBWORKS #35:** Develop and implement a bank erosion monitoring and mitigation program to identify and address current and future shoreline erosion concerns attributable to the Revelstoke Unit 5 project downstream of Revelstoke Dam (mid Columbia River between the TransCanada Highway Bridge and Begbie Creek, see Figure 1-1).

2. **CLBWORKS #36:** Monitor long-term erosion rates in the mid Columbia River from Revelstoke Dam downstream to Shelter Bay (Figure 1-1).

Given the complementary nature of the work, these two physical works programs were combined into one project, which was awarded to KWL in summer 2009.

1.1 PROJECT OVERVIEW

The purpose of CLBWORKS #35 and #36 is to provide information regarding the rate of bank erosion in the mid Columbia River downstream of the Revelstoke Dam. Management questions of interest posed include:

- Does the installation of bioengineering bank protection works result in a significant decrease in bank erosion?

- Does the addition of Revelstoke Unit 5 result in a significant increase in bank erosion at unprotected sites?

These two management questions have been developed into hypotheses that will be tested with appropriately designed statistical tests, based on data gathered over this multi-year project.

1.2 UPDATED PROJECT SCHEDULE

The intent of the erosion monitoring work is to have baseline measurements for the each of the sites prior to commissioning of Revelstoke Unit 5, and to assess erosion through

several years of operation. However, due to unusually high water levels in the system in 2010, no baseline data could be collected before the scheduled commissioning of Revelstoke Unit 5 in October, although erosion pins were installed at the long-term monitoring sites (for CLBWORKS #36). In addition, the higher than average water levels made installation of the bioengineering works for CLBWORKS #35 impractical. The schedule of both projects has been shifted by a year to accommodate this change.

The bioengineering works should be installed during anticipated low water levels in spring so that installations are effective through a full range of reservoir levels. Installation of the bioengineering works has been delayed until spring 2011 (dependent on water levels).

The long-term erosion monitoring sites were installed in late April 2010. These sites will be monitored during low-water conditions in spring 2011 and evaluated as to whether more erosion monitoring pins should be installed at lower elevations along the bank.

The updated schedule for both projects is shown in Figure 1-2.

A revised schedule of long-term erosion monitoring will be performed as follows:

- **CLBWORKS #35**: Year 2 (2011), Year 3 (2013), and Year 4 (2015)
- **CLBWORKS #36**: Year 2 (2011), Year 3 (2013), Year 4 (2015) and Year 5 (2017).

2010 PROJECT WORK

Project work completed during 2010 is summarized in the following table.

Table 1-1: 2010 Work Program (CLBWORKS #35 and #36).

Task No.	Task	Description
1.	**Preliminary Site Selection and Study Design**	▪ Study Design ▪ Preliminary Site Selection ▪ Develop Design Criteria ▪ Assess Quantitative Erosion Measurement Techniques
2.	**Design of Bioengineering Works (CLBWORKS #35)**	▪ Safety Plan ▪ Topographic Survey ▪ Bioengineering Design
3.	**Site Visit and Final Site Selection (CLBWORKS #36)**	▪ Safety Plan ▪ Site Visit ▪ Install Erosion Monitoring Sites ▪ Topographic Survey
4.	**Erosion Assessment (CLBWORKS #36)**	▪ Channel Mapping (2007 Orthophotos) ▪ Compare 2000 and 2007 Channel Mapping

Task No.	Task	Description
5.	**2010 Data Entry and Analysis**	▪ Populate GIS Database ▪ Data Analysis
6.	**2010 Progress Report**	▪ Progress Report for CLBWORKS #35 ▪ Progress Report for CLBWORKS #36

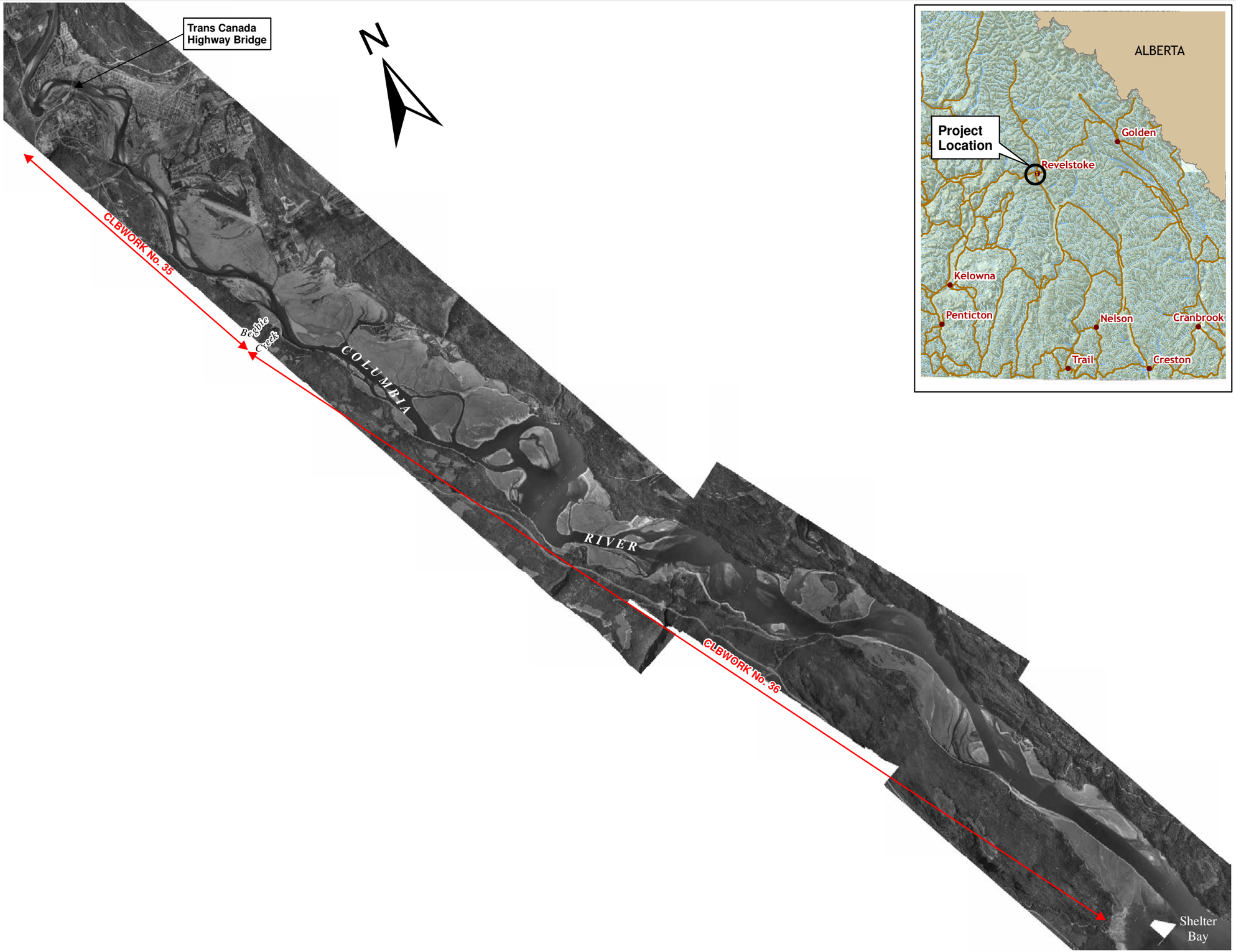
1.3 PROJECT TEAM

Key Project Personnel for this project include the following KWL staff and subconsultants:

Table 1-2: **Key Project Personnel**

Name	Role, Organization
David Matsubara, M. Eng., P. Eng.	Project Manager Senior Water Resources Engineer Kerr Wood Leidal Associates Ltd.
Mike Currie, M.Eng., P.Eng.	Senior Technical Review Kerr Wood Leidal Associates Ltd.
Erica Ellis, M.Sc., P.Geo.	Fluvial Geomorphologist Kerr Wood Leidal Associates Ltd.
Sarah Lawrie, M.A.Sc., EIT	Environmental Water Resource Engineer Kerr Wood Leidal Associates Ltd.
Jack Lau	GIS Specialist Kerr Wood Leidal Associates Ltd.
Peter Tapp, Civil Technologist	Survey Coordinator Kerr Wood Leidal Associates Ltd.
Bruce VanCalsteren	Survey Technologist Kerr Wood Leidal Associates Ltd.
Andrew LePatourel	Survey Technologist Kerr Wood Leidal Associates Ltd.
Stuart Fretwell	Survey Technologist Kerr Wood Leidal Associates Ltd.
Lisa Seip, M.A., RPCA	Professional Archaeologist Rescan Environmental Services Ltd.
Nick Page, B.L.A., M.Sc., R.P.Bio.	Professional Biologist Raincoast Applied Ecology
Leska S. Fore, Ph.D.	Statistician Leska S. Fore, Statistical Design
Hamish Weatherly, M.Sc., P.Geo.	Senior Technical Review – Geomorphology BGC Engineering Inc.

As required, change orders were submitted to BC Hydro to add or substitute personnel to the team.



CLBWorks No. 35 and 36
Mid-Columbia Erosion Protection and Long Term Monitoring

Legend

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Scale in Metres 1:100,000

Project No.	Date
478-081	December 2009

Location Plan

Figure 1-1

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Figure 1-2: Updated Project Schedule

	TASK	2009											
		January	February	March	April	May	June	July	August	September	October	November	December
					6 13 20 27	4 11 18 25	1 8 15 22 29	6 13 20 27	3 10 17 24 31	7 14 21 28	5 12 19 26	2 9 16 23 30	7 14 21 28
1	Project Initiation and Project Management												
2	Review and Summarize Background Information												
3	Preliminary Site Selection and Study Design												
4	Site Visit and Final Site Selection												
5	Archaeological Impact Assessment												
6	Design and Implementation of Bioengineering Works (Delayed due to late award)												
7	Year 1 Erosion Assessment - Not Completed												
8	Year 1 Data Entry and Analysis - Not Completed												
9	Year 1 Progress Reports												

	TASK	2010											
		January	February	March	April	May	June	July	August	September	October	November	December
1	Project Management												
4	Site Visit and Final Site Selection (CLBWORKS #36)												
6	Design and Implementation of Bioengineering Works (Delayed due to water levels)												
7	2010 Erosion Assessment (CLBWORKS #36)												
8	2010 Data Entry and Analysis (CLBWORKS #36)												
9	2010 Progress Reports												

	TASK	2011											
		January	February	March	April	May	June	July	August	September	October	November	December
6	Implementation of Bioengineering Works												
X.1	Project Management												
X.2	Erosion Monitoring Fieldwork												
X.3	Bioengineering Monitoring Visit												
X.4	Data Entry and Analysis						Note: Air Photos From May-June						
X.5	Progress Report / Final Report												

	TASK	2013, 2015, 2017											
		January	February	March	April	May	June	July	August	September	October	November	December
X.1	Project Management												
X.2	Erosion Monitoring Fieldwork												
X.3	Bioengineering Monitoring Visit												
X.4	Data Entry and Analysis						Note: Air Photos From May-June						
X.5	Progress Report / Final Report												

Notes:

Schedule is tentative and based on actual reservoir levels each year

O:\0400-0499\478-081\300-Report\2010-YearEndReport-DRAFT\[Fig1-2-RevisedSchedule.xls]Schedule 5

Section 2

CLBWORKS #35

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2. CLBWORKS #35

2.1 DETAILED DESIGN

Detailed designs have been developed for four bioengineering sites: A1, A2, B and C (Figure 2-1). Detailed design of the bioengineering works and preparation of construction specifications was completed in 2010. The bioengineering prescriptions feature a combination of slope regrading and biotechnical slope stabilization techniques.

In general, the biotechnical slope stabilization will include:

- planting the lower elevations with willow stakes, grasses and sedges;
- using vegetated soil wraps and brush layers along the upper elevations; and
- creating higher elevation soil mounds with the spoil material and planting upland trees and shrubs to promote long-term slope stability.

The design of bioengineering works at Site A1 incorporates large wood, a planted aquatic bench, and vegetated soil wraps and brush layers. Higher elevation mounds create an opportunity for planting upland trees and shrubs.

The bioengineering works designed for Site A2 and Site C are similar in so much as the lower elevation along the bank will be regraded either until native gravel is encountered, or a 300 mm (typical) layer of imported or local gravel will be placed on the surface of the slope. The upper slope will include vegetated soil wraps and brush layers. Similarly to Site A1, upland mounds will be created for upland plantings to increase long-term slope stability.

The design for Site B consists of modified brush layers at the higher elevation along the bank to increase bank roughness and encourage revegetation of the banks. The bioengineering works for Site B are proposed to be installed by hand to minimize the impact to upland vegetation.

A copy of the design drawings and construction specifications can be found in Appendix A.

2.2 BIOENGINEERING IMPLEMENTATION

APPROVALS

The reservoir operating area is governed in part by agreements under the Water Act that allow operation and maintenance of reservoir under standard operating conditions. Therefore it has been determined that the bioengineering works will not require a Section 9, *Water Act* approval from the BC Ministry of Environment (MOE). It is recommended that the local BC Ministry of the Environment representative (likely the Penticton office).

It is understood that BC Hydro has a standing authorization under Section 35(2) of the *Federal Fisheries Act* and that the bioengineering works could be completed under this authorization. It is recommended that Fisheries and Oceans Canada (DFO) would be sent a copy of the design brief and drawings for information (likely the Kamloops office).

Because of the proposed installation of wood structures into the Columbia, notification of the works should also be sent to Transport Canada. If the project is expected to pose an interference with navigation, a Section 5(1) authorization is needed under the *Federal Navigable Waters Protection Act*. Approval through Transport Canada often requires a lengthy period for review by the agency. It is recommended that notification will be sent to Transport Canada in January to provide a period for review prior to construction.

CONSTRUCTION IMPLEMENTATION

Implementation the bioengineering work is proposed for March or April of 2011 to coincide with low-water periods in the system and optimal time for installation of bioengineering works. Timing will be subject to approval by MOE and DFO.

The sequencing of the construction for the proposed works is critical to the success of the project and protection of the aquatic habitat. The general approach to the construction would entail isolating the areas of work from flow, and dewatering any excavation areas.

The construction sequence would require the following general steps:

- provide access to the construction site;
- install dewatering/sediment control measures;
- provide working surface along bank toe;
- regrade bank primarily by excavation of fine bank material and placement of local gravel;
- excavate trench and place filter layer, rock ballast and large wood (Site A);
- prepare slope for planting;
- install bioengineering technique;
- complete riparian planting; and
- complete site closure.

BIOENGINEERING EROSION MONITORING

The bioengineering sites are paired with control sites to compare the erosion on treated and untreated banks. After construction of the bioengineering works, erosion monitoring pins will be installed at the treatment and control sites similarly to CLBWORKS #36 (described in Section 3). In addition to the erosion monitoring pins, a topographic survey of the bioengineering sites will be completed and repeat transect locations will be established as per the protocol from CLBWORKS #36 (described in Section 3). A topographic survey of the control sites was completed as part of the initial design work for the project.

2.3 UPDATE TO STUDY DESIGN

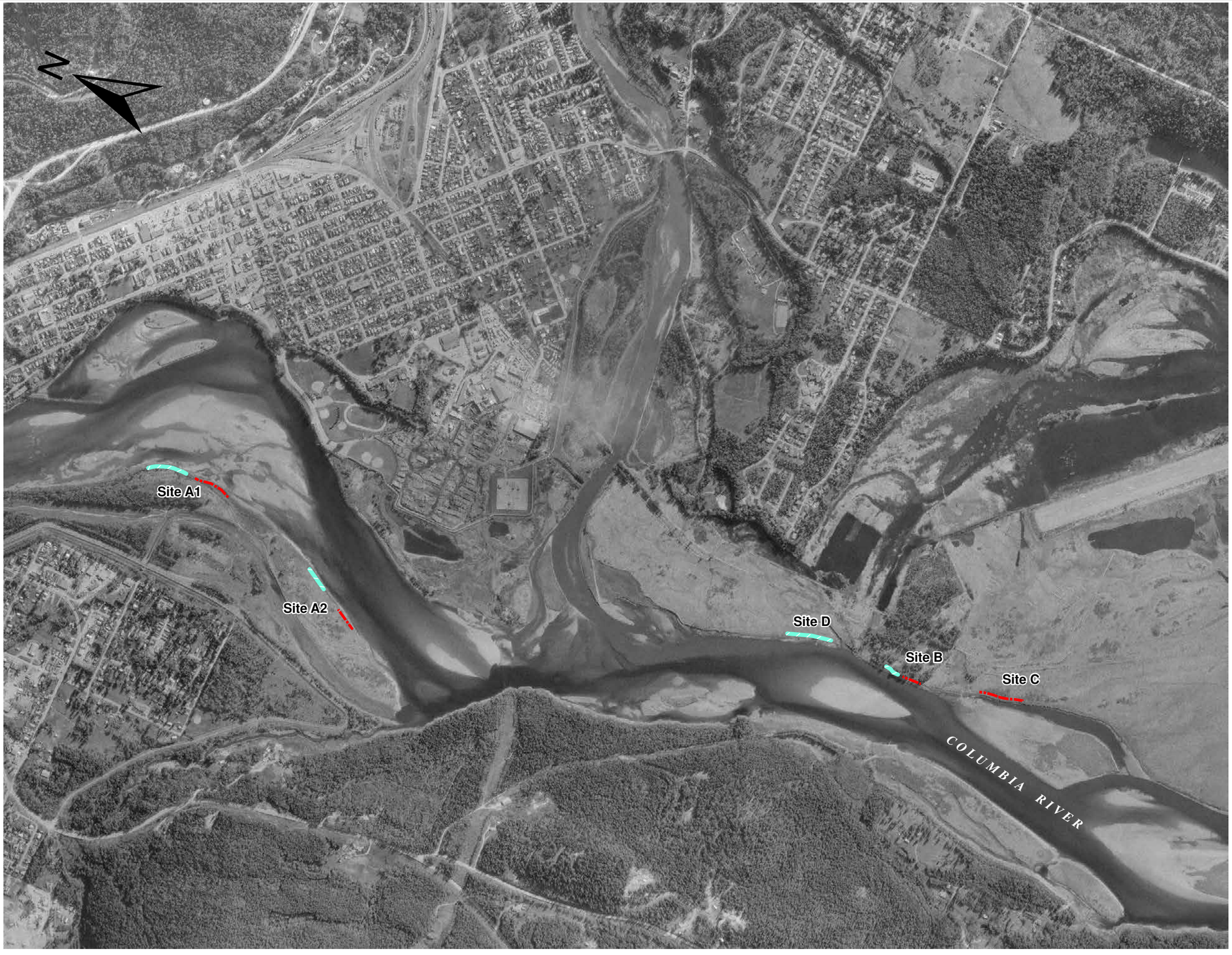
On September 24, 2010 the project team met in Burnaby with Leska S. Fore, Statistical Design to discuss the study design and statistical analysis for both CLBWORKS #35 and #36. After reviewing the study design and the goals of the project for CLBWORKS #35, Ms. Fore expressed some concern over the small number of sample sites (N = 4). Because the test sites for CLBWORKS #35 are located in close proximity to each other and are expected to be similar in characteristics, it was the statistician's recommendation that some of the sites be split, which would increase the sample size (N) to 6 or 8 (Appendix B).

The proposed site locations remain the same; however, instead of dividing the sites in half and applying the bioengineering treatment to one end of the site and leaving the other end as control, the bioengineering treatment would be installed in the middle of the site with control sections at either end (Figures 2-1 and 2-2). The bioengineering treatment would be divided and paired with its adjacent upstream or downstream control section. Each site would then yield two comparisons rather than one.

Splitting the sites in half assumes that the continuous bioengineering sites are reasonably independent and that 50 m to 90 m of bioengineering (depending on the site) will provide a reasonable and independent test of the treatment. The proposed site design could also be rolled back to a single comparison at each site (yielding N = 4), if necessary.

Splitting the sites would not likely increase the amount of construction/installation work. The bioengineering sites remain located in similar locations with similar treatment lengths. The change in study design comes from the location and orientation of the control sites. No new survey information is needed to update the design, and because the control and proposed bioengineering treatment locations are so similar, updating the design to reflect the change in study design is a relatively simple matter.

Once approval has been given by BC Hydro to split the sites, the design drawings will be updated to reflect the new study design. The specifications for the bioengineering treatments remain the same.



CLBWorks No. 35 and 36
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Legend

- Current Control
- Current Bio-engineering Location

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Scale in Metres 1:15,000

Project No.	Date
478-081	December 2010

Bioengineering Sites

Figure 2-1

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CLBWorks No. 35 and 36
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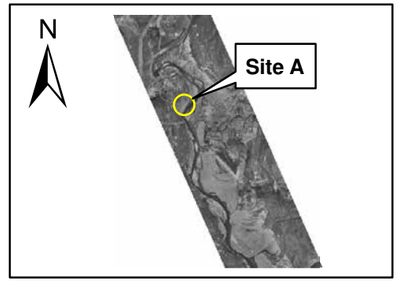
Legend

- Current Bio-engineering Location
- Current Control
- Proposed Control
- Proposed Bioengineering Site Split Location



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Project No.	Date
478-081	November 2010

Proposed Bioengineering Site Splitting: Site A

Figure 2-2

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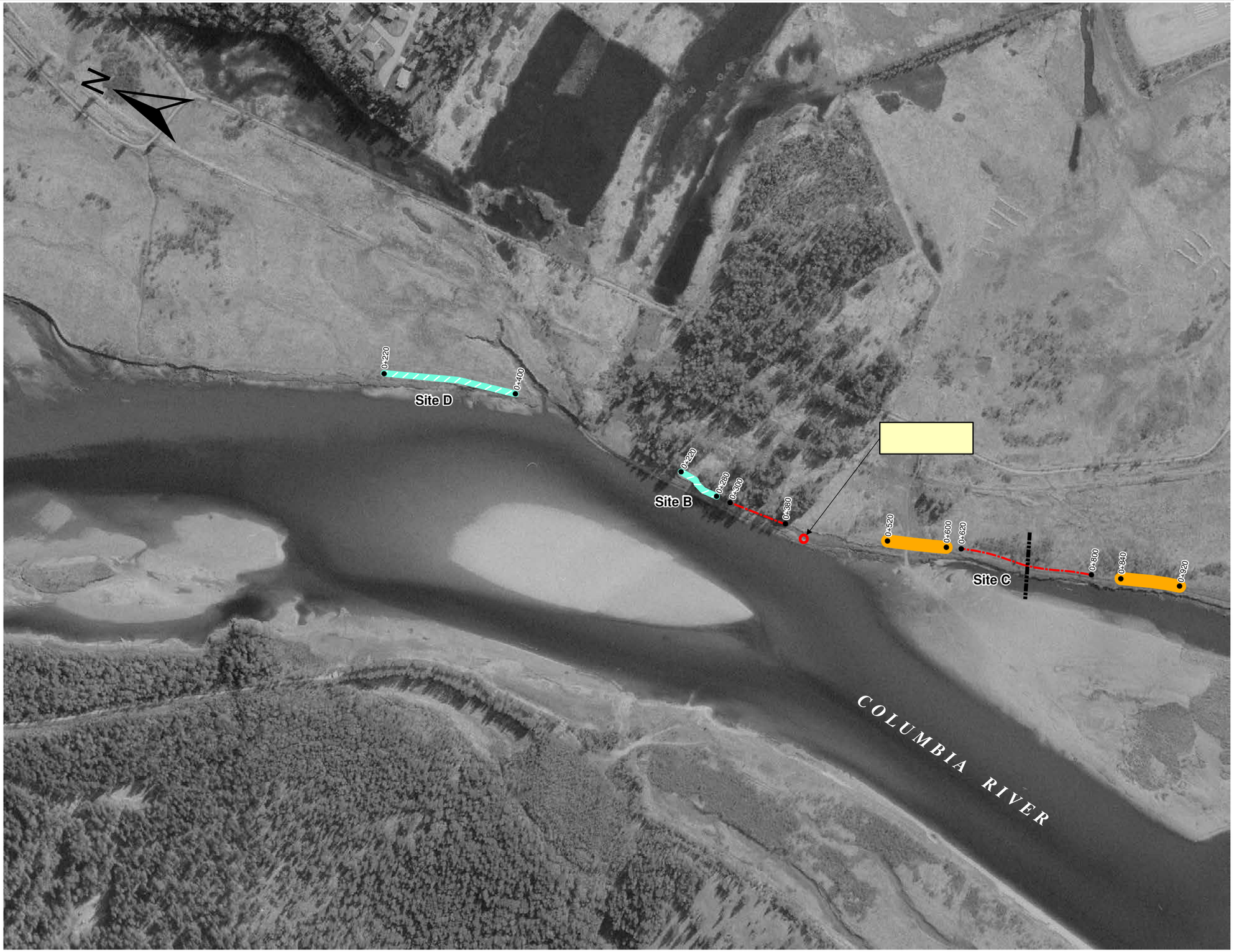
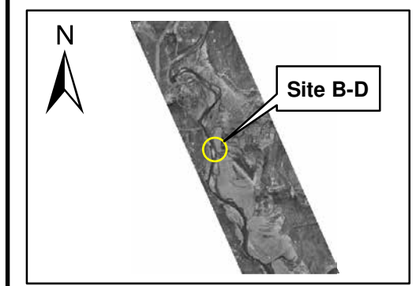


CLBWorks No. 35 and 36
Mid-Columbia Erosion Protection and Long Term Monitoring

Legend

- Current Bioengineering Location
- Current Control
- Proposed Control
- Proposed Bioengineering Site Split Location



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Scale in Metres 1:5,000

Project No.	Date
478-081	November 2010

Proposed Bioengineering Site Splitting: Site B to D

Figure 2-3

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Section 3

CLBWORKS #36

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3. CLBWORKS #36

A number of activities were conducted during 2010 for CLBWORKS #36. The following sections provide:

- a summary of fieldwork performed in 2010 for the installation of the long-term erosion monitoring sites;
- a summary of channel mapping and the erosion assessment for 2010; and
- a discussion of the statistical design for the long-term erosion monitoring study.

3.1 INSTALLATION OF LONG-TERM MONITORING SITES

The installation of long-term bank erosion monitoring sites occurred April 27 to May 1, 2010. The purpose of the fieldwork was to:

- identify 15 potential erosion monitoring sites on the Columbia River from Revelstoke to Shelter Bay;
- install erosion monitoring pins at each site;
- survey each monitoring pin (elevation and location);
- set-up repeatable transects at each site; and
- perform a topographic survey of each site.

Field personnel included: Dave Matsubara, Sarah Lawrie, Andrew LePatourel and Stuart Fretwell.

The reservoir level recorded at the Arrow Lake Reservoir site at Nakusp during the field visit was approximately 431.5 to 432 m[1].

SUMMARY OF FIELD ACTIVITIES

A total of 15 sites, each 50 m in length, were selected for long-term erosion monitoring. Sites were chosen to represent the range of conditions and erosion processes seen within the study reach. Sites are distributed along the river from downstream of Revelstoke Dam to Shelter Bay (Figure 3-1).

Site selection was constrained by access and bank material. All sites can be accessed by boat (Photo 3.1), and some can be accessed from land as well. Erosion monitoring sites were installed in erodible banks, which consisted of cobble, gravel, sand and/or silt bank materials. No sites were considered at locations with bedrock banks.

[1] Water levels from BC Hydro (http://www.bchydro.com/about/our_system/hydrometric_data/columbia.html).

Survey information was collected using a Trimble S6 Robotic Total Station and a Trimble R8 Dual Frequency GPS Receiver and Base.

Survey control

Survey control was tied to three control points (HUB/2283, HUB/2285, HUB/2295) set by the Trimble R8 GPS Base and occupied for roughly 8 hours each. The collected data was corrected by the federal government's Precise Point Positioning system (PPP).

Two geodetic monuments[2] and several previously-set KWL tags were also included in the survey control. This control was tied using the Trimble R8 GPS Receiver via the CanNet system and the Revelstoke base (another GPS receiver located on the roof of Revelstoke City Hall), with the exception of one monument that was tied using the Trimble R8 GPS Base.

Control for each of the 15 monitoring sites was set using the R8 GPS Receiver in tandem with either the CanNet system or the R8 Base depending on which would give a higher degree of accuracy (Photo 3.2).

All survey coordinates are set to UTM Zone 11 NAD83 coordinates with geodetic datum.

Erosion Pin Installation and Measurement

At each site 60 erosion monitoring pins were installed along the bank. Erosion pins are 0.6 m long pieces of 10 mm rebar identified with a unique numbered tag. Erosion pins were installed orthogonal to the bank and hammered into the ground until approximately 2 to 5 cm of pin remained above the ground surface (Photos 3.3 and 3.4). Erosion monitoring pins were installed from the waterline up onto the floodplain (between 432 m and 440 m elevation depending on the site).

Once installed, the distance from the ground surface to the head of the pin was measured (i.e. the length of exposed pin). Measurements were rounded to the nearest half-centimetre. The location of all erosion pins was then surveyed using the Trimble S6 total station (expected position accuracy about ±0.005 m).

[2] Monument 84H9569: south east abutment of Highway Bridge over Columbia River, and Monument 7474: on a rock at the east side of the outlet of the Columbia River into Arrow Lakes.

Photo 3.1: Crew Boat

Photo 3.2: GPS Equipment

Photo 3.3: Erosion Pins (Pre-Installation)

Photo 3.4: Erosion Monitoring Pin (Installed)

Transects

A total of 5 repeat survey transects were located at each site, set at 10 m intervals approximately parallel to the waterline (Photo 3.5). Locations of the transect lines were set using 15 mm rebar at the top of the transect (furthest point from the waterline) and a second (10 mm) piece of rebar 10 m closer to the water from the top point, perpendicular to the water's edge. Each 15 mm transect rebar was equipped with a unique identifier tag. A 30 m tape measure was run between the rebar and to the water's edge and survey points taken along that line (Photo 3.6).

Barring any locations where the GPS would not function due to tree cover etc., the transects were surveyed using the Trimble R8 GPS to provide a consistent method of measurement with a good degree of accuracy (horizontal accuracy ±0.010 m, vertical accuracy ±0.020 m).


Photo 3.5: Survey Transect Offset


Photo 3.6: Survey Transect

SUMMARY OF SITES

The 15 long-term monitoring sites are number from 1 to 15 increasing in the downstream direction (Figure 3-1). Appendix C includes the complete drawing set for each site, which shows a plan view of the site including pin and transect locations, as well as profile plots of the transects. Additional photos from each site are also shown in the attached photo appendix (Appendix D).

3.2 CHANNEL MAPPING

BACKGROUND

The reach of interest for CLBWORKS #36 is quite long (about 43 km). Therefore, making detailed ground measurements of erosion at all locations in the reach is impractical. The intent of channel mapping is to document large-scale changes in the morphology of the study reach and to identify areas of significant erosion.

Channel mapping uses the following morphological categories:

- wetted channel;
- vegetation (floodplain or island); and
- gravel bar.

Differing water levels at the time of photography can bias the exposure of lower-elevation features such as gravel bars, making it difficult to compare between time periods. However, for the purposes of this assessment, bank erosion is only indicated when there is a transition from a previously vegetated surface (island or floodplain) to wetted channel in the subsequent channel map.

It is assumed in rivers that well-established (typically woody) vegetation can only develop if the area is not inundated for any significant time; therefore, the exposure of vegetated areas is much less likely to be affected by water levels at the time of photography because these areas are almost always exposed.

UNCERTAINTY

Measurement of bank erosion using aerial photographs is typically most effective when rates of erosion are relatively large so that the actual (real) erosion exceeds the horizontal positional uncertainty associated with digital orthophotos (typically ±1-2 m). Previous work by others has estimated that comparative channel mapping in this reach could be used to detect rates of erosion of 1 m/year or greater, assuming that photos would be flown about 4-5 years apart (NHC, 2006)[3].

Evaluation of erosion using channel mapping is based on the assumption that the top of bank (edge of floodplain or island) can be accurately mapped from orthophotos. This is most straightforward when the floodplain is well-vegetated with shrubby or woody vegetation. Depending on conditions during photography, the actual bankline may be challenging to position accurately as it may be heavily shaded by trees or obscured by the canopy. It also can be difficult to define the edge of floodplain where vegetation is sparse and the transition from the floodplain to the channel bank is indistinct rather than being an abrupt drop-off.

A more subtle issue that is relevant to the Columbia study reach is related to the influence of Arrow Lake on the vegetation patterns in the reach. Evolution of river morphology is related to inundation patterns and corresponding effects on vegetation. The highest surfaces are rarely flooded, which allows the establishment of quasi-permanent woody vegetation. Lower surfaces, more frequently inundated, cannot support this type of vegetation. Therefore, on rivers the vegetation pattern can be used to estimate the limit of the typically flooded area.

However, on the Columbia, inundation is also controlled artificially by the backwater effect of Arrow Lake. Flooding from the lake may prevent woody vegetation from establishing on relatively high bar surfaces, and the highest lake levels may be higher than the typical floodplain elevation. In addition, dust-reduction planting programs also disturb the natural vegetation patterns. Due to these factors, there is the possibility to have rapid establishment of grasses on lower-than-floodplain elevation gravel bars, and these areas could then be misclassified as erosion if they are subsequently inundated at a higher water level. Ideally, to minimize this effect, photographs would be taken at a similar time of year and at a similar lake level.

[3] NHC (Northwest Hydraulics Consultants), 2006. Revelstoke Unit 5 Fluvial Geomorphology Study Final Report. Report prepared for BC Hydro. 58 pp + appendices.

HISTORICAL RATES OF EROSION

Historical air photographs have been used to evaluate local rates of bank erosion for portions of the study reach. The following table summarizes maximum local rates of bank retreat estimated from this work. The change in water level at the time of photography for each study period is also included in the table, if available.

Table 3-1: Historical Local Rates of Bank Retreat (NHC, 2006)

Study Period	Golf Course to Revelstoke	Illecillewaet River to Airstrip	Airstrip to Begbie Creek	Loopcut near Greenslide Creek	Photo Water Level Δ: Later – Earlier (m)
1949 to 1961	1.5 m/year	1.9 m/year	-	-	n/a
1961 to 1968	2.1 m/year	2.6 m/year	-	-	n/a
1968 to 1977	-	2.5 m/year	5.8 m/year	5.6 m/year	+6.7
1977 to 1985	-	0	0	0	-4.0
1985 to 2000	0.8 m/year	0.5 m/year	1.2 m/year	6.0 m/year	+7.7

Notes:
1. Data reproduced from Table 3.1, 2006 NHC report.
2. Local rates of retreat are based on actively eroding areas only (i.e. does not include areas that experienced no erosion).

According to NHC (2006), some of the relatively high rates of erosion seen in the most recent time period may be related to misclassification of vegetation vs. bare areas.

The average water level in Arrow Lake is plotted in Figure 3-2, along with water levels at the time of photography for most of the years of channel mapping. It is interesting to note that periods in which the water level was much higher in the later photos tend to be periods in which estimated bank erosion rates are higher. 1968 and 1985 channel mapping water levels were below average (see Figure 3-2), which may well have allowed grass or reed vegetation to establish on gravel bar surfaces. This suggests that large differences in water levels between mapping time periods might possibly result in the detection of spurious changes, as discussed in the preceding section.

CHANNEL MAPPING (2000 PHOTOS)

Channel mapping of portions of the study reach based on historical air photographs has been completed by others for BC Hydro (NHC, 2006). The most recent set of channel maps was developed based on the 2000 orthophotos (NHC, 2006).

2000 channel mapping GIS files were obtained from BC Hydro and compared against orthophotos. Minor adjustments to the 2000 mapping were made to attempt to minimize inconsistencies with future mapping so as to avoid detection of spurious changes.

CHANNEL MAPPING (2007 PHOTOS)

Recent orthophotos available at the time of writing of this report are summarized in the following table, and water levels are plotted in Figure 3-2.

Table 3-2: Summary of Orthophotos for CLBWORKS #36

Photo Date	Scale	Pixel Size (m)	Water Level at Nakusp (m)
2000 (June 4)	1:25,000	1	431.72
2007 (May 30)	1:5,000	0.25	433.9
2007 (May 9-10)	1:10,000	0.5	431.25 – 431.36
2007 (May 10)	1:20,000	0.5	431.36
2008 (June 15)	1:5,000	0.25	437.1
2010 (May 9-11,13)	unknown	unknown	433.13 – 433.26

The 2007 1:10,000 orthophotos were selected for channel mapping for the following reasons:

- 1:10,000 photo scale is sufficiently large to resolve channel features; and
- the water level at the time of photography is comparable to the 2000 photo water level.

2000 TO 2007 COMPARISON

As indicated in Figure 3-2, the water level is comparable between the 2000 and 2007 1:10,000 scale photos. Figures 3-3 to 3-6 show channel mapping transitions for the Columbia River study reach (Revelstoke Dam to Shelter Bay).

As indicated by the figure legends, a number of transitions are possible, which are can be lumped into three main categories:

1) **No Change (the morphologic category is the same in both time periods)**
   i) stable wetted surface;
   ii) stable vegetated surface;
   iii) stable gravel bar
2) **Channel Changes**
   i) vegetation loss;
   ii) bank erosion;
   iii) vegetation growth;
3) **Water Level Changes**

i) inundated bar; and
ii) exposed bar.

Water level changes are those that are a result of the difference in water level between time periods, and are not significant in terms of assessing bank erosion. Channel changes are those that are associated with vegetation, such as growth (e.g. a gravel bar transitioning to an island) or loss (e.g. vegetated area transitioning to bare gravel bar). "Bank erosion" is of primary interest, which is the transition from previously vegetated area to wetted channel.

Revelstoke Dam to Illecillewaet River

Figure 3-3 shows the 2000 to 2007 channel mapping comparison for the Columbia River from Revelstoke Dam to the Illecillewaet River confluence. As indicated in the figure, there have been relatively few channel changes over this time period: vegetation growth is the dominant channel change, occurring on the large right bank bar immediately upstream of the Highway 1 Bridge and near the mouth of the Illecillewaet River. Given the bank armouring in this reach, the areas indicated as bank erosion generally result from different interpretations of the floodplain limit between the 2000 mapping (NHC, 2006) and the 2007 mapping conducted for this project. There appears to have been modest erosion on the left bank at the Golf Course (maximum lateral erosion of about 5 m).

Illecillewaet River to Greenslide Creek

Figure 3-4 shows the 2000 to 2007 channel mapping comparison for the Columbia River between Illecillewaet River and Greenslide Creek (left-bank tributary). The dominant channel change in the upstream two-thirds of this reach is vegetation growth, often in former gravel bar areas that appear to have been subject to some sort of man-made disturbance in the 2000 photos (possible planting). In the downstream one-third of the reach, the dominant channel change is vegetation loss, along with areas of bank erosion. It should be noted that these changes are mostly a result of the 2000 morphological classification, and may be largely spurious. For instance, if many of the areas classified as "vegetated" were actually gravel bars in 2000, most of the areas now indicated as vegetation loss would simply be stable gravel bar, and the bank erosion would simply be inundated gravel bar. This highlights the challenge of accurately assessing bank erosion using historical channel mapping (which does not permit ground-truthing).

Greenslide Creek to Cranberry Creek

Figure 3-5 shows the 2000 to 2007 channel mapping comparison for the Columbia River between Greenslide Creek (left-bank tributary) and Cranberry Creek (right-bank tributary). There are few channel changes in this reach, again mostly vegetation loss and vegetation growth. Bank erosion appears to be occurring on the right bank downstream of Mulvehill Creek (maximum lateral erosion of about 2-3 m). Similarly, there has been

bank erosion upstream of the mouth of Blanket Creek (approximately 3 ha; maximum lateral erosion of about 25 m).

Cranberry Creek to Shelter Bay

Figure 3-6 shows the 2000 to 2007 channel mapping comparison for the Columbia River between Cranberry Creek (right-bank tributary) and Shelter Bay. Again there are few channel changes in this reach other than vegetation growth or loss.

Summary

The 2000 to 2007 channel mapping comparison does not indicate that widespread erosion occurred during this time period. Rather, most of the 'eroded' areas are likely to be spurious, resulting from differences in interpretation of the 2000 morphology. Actual erosion is quite limited, occurring in only a few discrete locations in the 53 km reach.

It is anticipated that future mapping will be less impacted by morphological interpretation issues, as channel mapping will be conducted by the same person over the length of the project.

3.3 STATISTICAL DESIGN AND DATA ANALYSIS

BACKGROUND

The terms of reference for CLBWORKS #36 defines two management (null) hypotheses for the purposes of statistical analysis:

1) $\mathbf{H_0}$: Shoreline erosion does not differ significantly before and after the start of operation of the fifth unit at Revelstoke Dam.

2) $\mathbf{H_0}$: Shoreline erosion does not increase significantly through the duration of the project.

The project team includes a statistical consultant to provide advice on appropriate statistical design and analysis of the bank erosion data in order to address the identified management hypotheses. On September 24, 2010 the project team met in Burnaby with Leska S. Fore, Statistical Design to discuss the study design and statistical analysis for both CLBWORKS #35 and #36. Recommendations that resulted from that meeting are summarized in the following section and in Appendix B.

BANK EROSION DATA ANALYSIS

The goal of the bank erosion monitoring is to test whether changes associated with the fifth unit at Revelstoke Dam increase erosion downstream of the dam.

Management Hypotheses and Statistical Power

One of the management hypotheses addresses testing for changes before and after the fifth turbine begins operation. However, due to changes in the project schedule (Section 1-1), the second visit to collect site data will occur after the fifth unit begins operation. The revised schedule means that erosion associated with current dam operation (baseline erosion), cannot be calculated, and that we will not be able to discern whether erosion is due to the additional fifth generating unit or to dam operation in general.

Statistical power analysis will require a second year of data collection to calculate the test statistic. The paired t-test will be used in the data analysis for this project, as discussed below. In a paired t-test, site variability is controlled by comparing each site to itself. The comparison of each site with itself through time is a powerful design for detecting change compared to, for example, a two-sample t-test that compares all sites to each other as a group. That means that this statistical design inherently has a high level of statistical power to detect change.

Erosion Monitoring Pins

The primary response variable for the study is the length of pin exposed (or covered by sediment) at approximately 50 locations within each of 15 sites. To compare the change in pin length, an average value will be calculated for each site. The 15 values will be compared through time using a paired t-test in which each site is compared with itself through time. The test statistic is the difference in *average* pin length observed between the first and second visits; the t-test compares whether the average of those 15 values is different from 0.

The 15 sites will be visited a total of 5 times over a period of 6 years. This design includes the initial installation when all pins were set to be flush with the surface such that the average pin length equals 0 for the first year. Various options were discussed for data analysis and it was decided that pin length for all visits would be compared to test for changes in all time periods (multiple t-tests). The statistical testing can be reported as a matrix, as indicated in the following table.

Table 3-3: Example of Erosion Monitoring Pin Data Analysis Table for CLBWORKS #36

Visit	2	3	4	5
1	Test pin length for visit 2 against visit 1	Test visit 3 against visit 1	Test visit 4 against visit 1	Test visit 5 against visit 1
2		Test visit 3 against visit 2	Test visit 4 against visit 2	Test visit 5 against visit 2
3			Test visit 4 against visit 3	Test visit 5 against visit 3
4				Test visit 5 against visit 4

At each site, the large number of pins (>50) provides an opportunity to stratify the data and test for differences associated with elevation. For this approach, the same test could be used on subsets of data, for example, by grouping pins according to low, medium and high elevation. This potentially would provide insight into the erosion mechanism.

Surveyed Cross-sections

A second response variable for the study is the surveyed cross-sections (transects). Cross-sections are plotted as elevation (y-axis) against distance along the bank (x-axis). The plotted cross-section typically describes a curve from the top of bank to the water's edge. Five transects will be collected for each of the 15 sites.

To measure changes in the cross-sections, visits will be compared by defining a number of points along the profile to measure changes in elevation. The measurements of change in elevation will be averaged for each transect. A similar calculation will be made for the other transect profiles at each site to calculate a change in elevation and the transect averages will also be averaged to obtain a single value for each of the 15 sites. A t-test will be used to test whether the average change in the profile for all 15 sites is greater than 0. Note that positive (indicating erosion) and negative (indicating sedimentation) values are both possible. All visits will be compared to the first visit to evaluate during which years the most change occurred.

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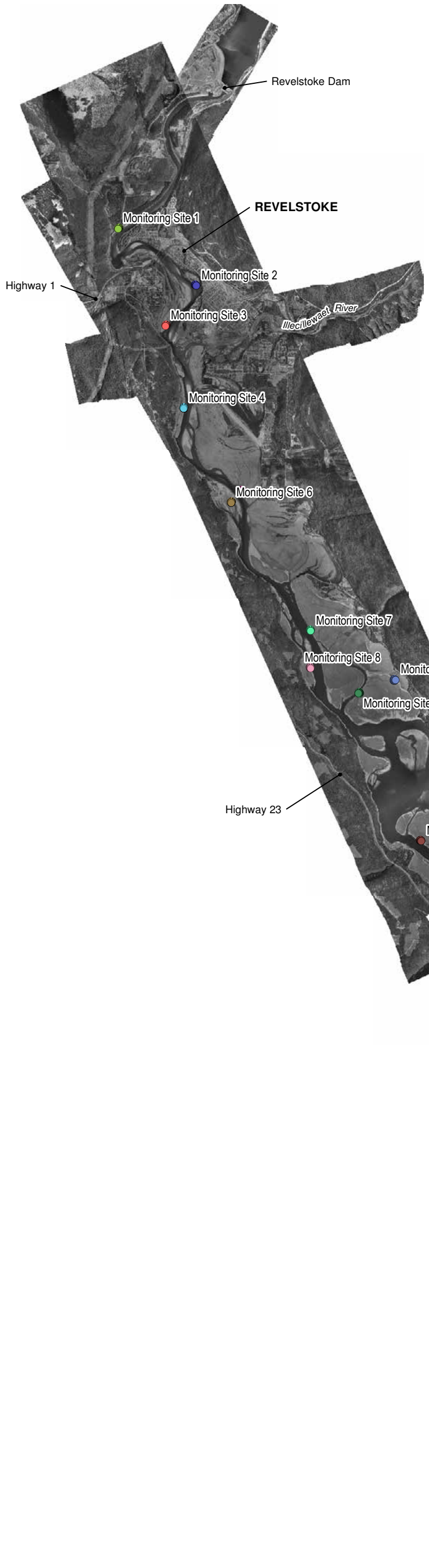

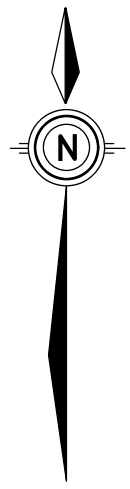

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BC Hydro
CLBWORKS #35 and #36

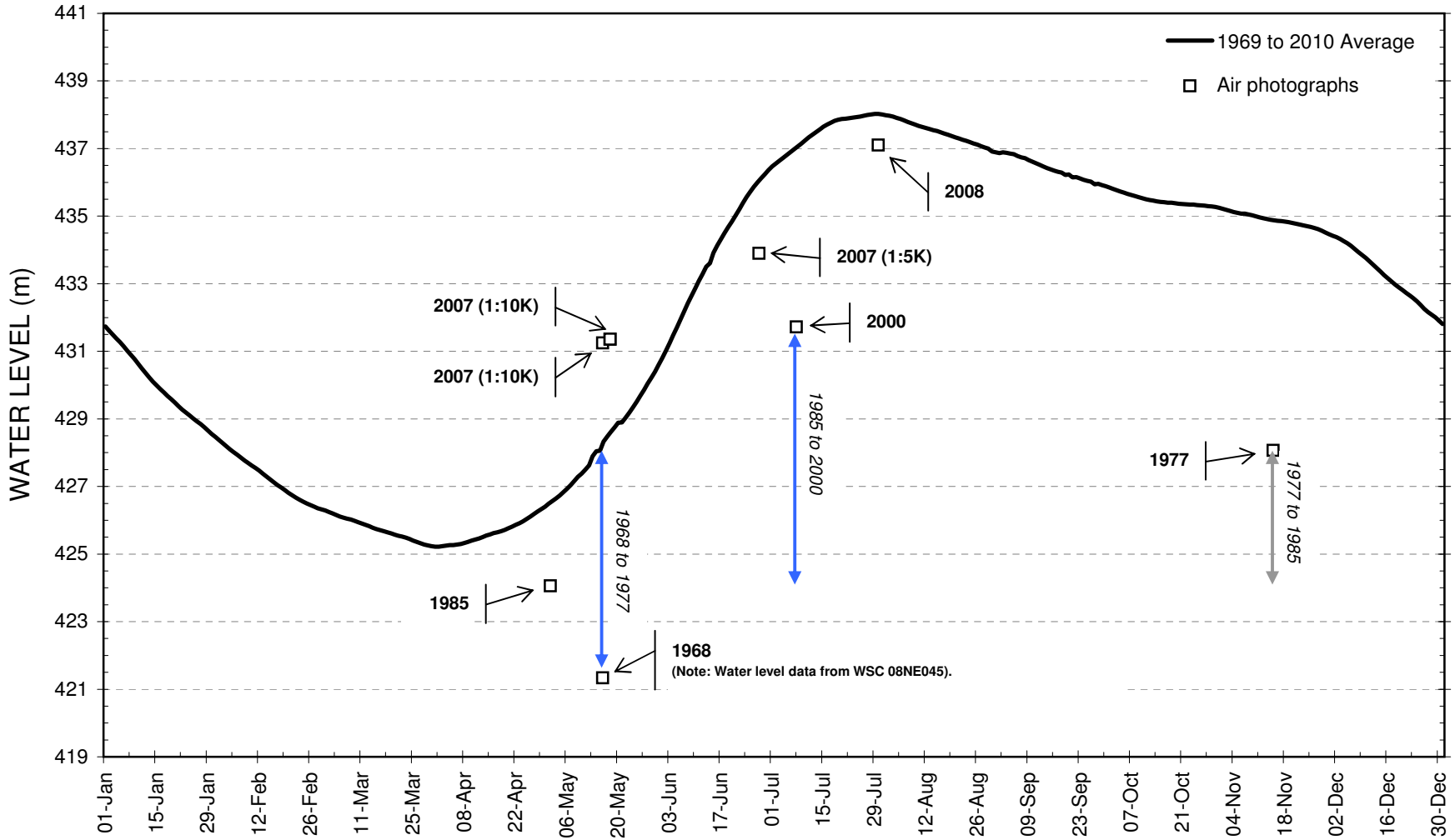
Project No.	Date
478.081	December 2010

2,000 0 2,000
Scale in Metres 1:125,000

Bank Erosion Monitoring Sites (CLBWORKS #36)

Figure 3-1

Arrow Lake at Nakusp (WSC 08NE104) Water Level



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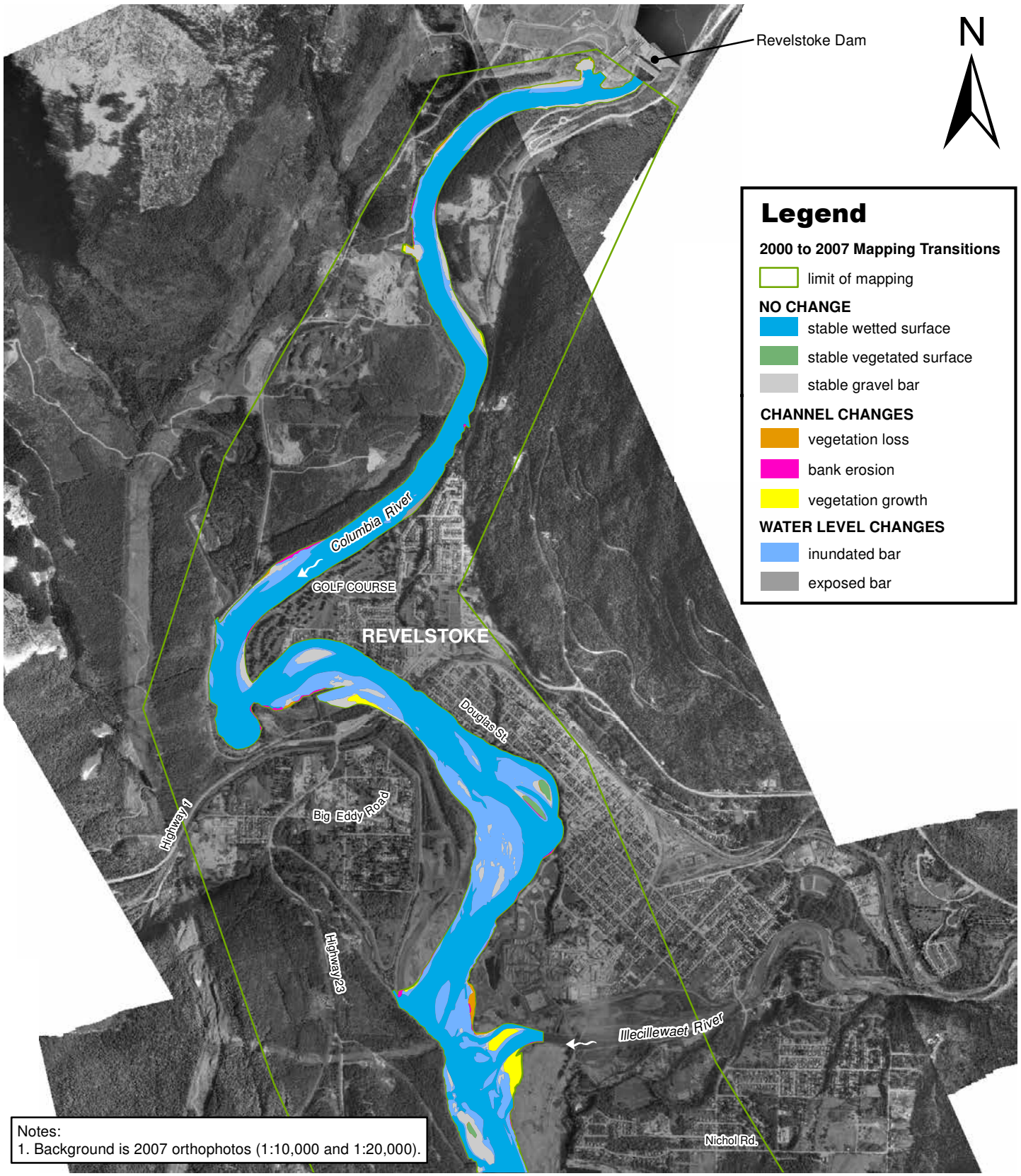
Consulting Engineers

O:\0400-0499\478-081\442-Hydrology\WSC\ARROWATNAKUSP 08NE104.xls

Figure 3-2



Notes:
1. Background is 2007 orthophotos (1:10,000 and 1:20,000).

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BC Hydro
CLBWORKS #35 and #36

Project No.	Date
478-081	December 2010

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Scale in Metres 1:40,000

2000 to 2007 Comparison:
Revelstoke Dam to Illecillewaet River
Figure 3-3

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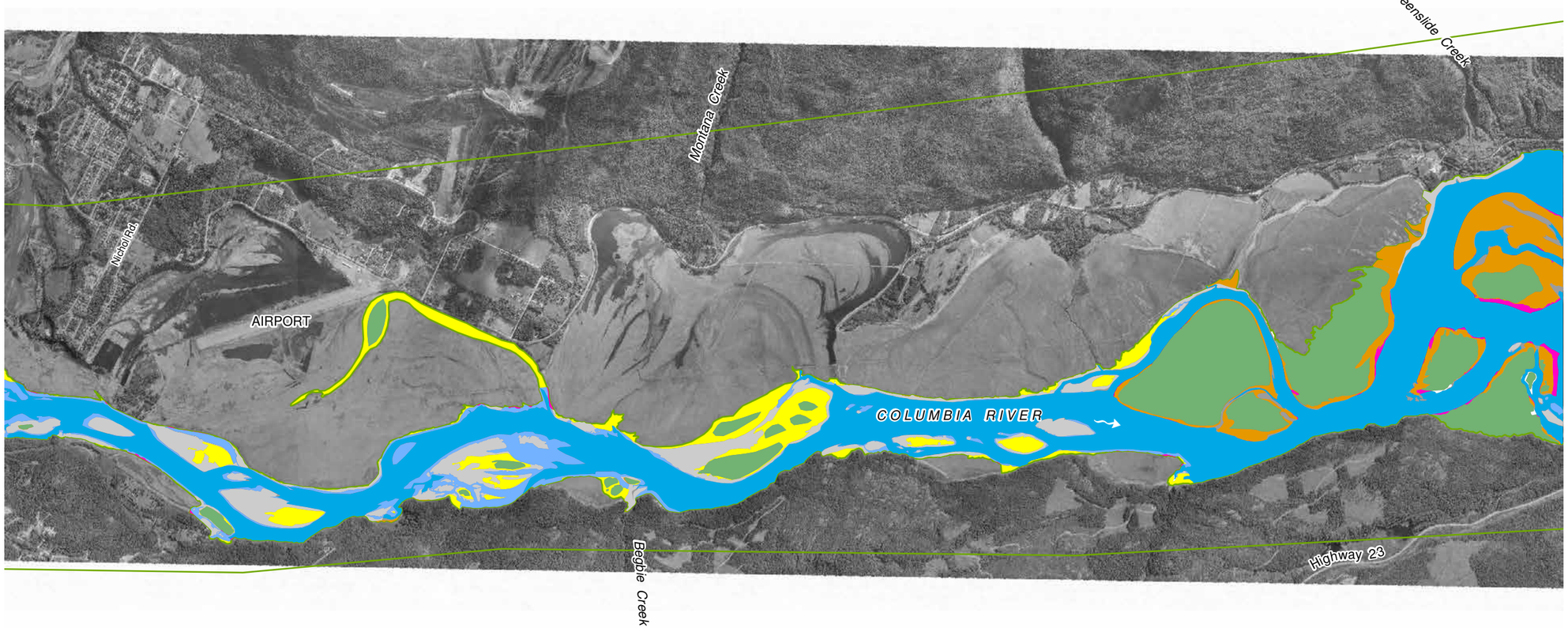

Notes:
1. Background is 2007 orthophotos (1:10,000 and 1:20,000).

BC Hydro
CLBWORKS #35 and #36

Legend

2000 to 2007 Mapping Transitions

- limit of mapping

NO CHANGE

- stable wetted surface
- stable vegetated surface
- stable gravel bar

CHANNEL CHANGES

- vegetation loss
- bank erosion
- vegetation growth

WATER LEVEL CHANGES

- inundated bar
- exposed bar

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1,000 0 1,000
Scale in Metres 1:40,000

Project No.	Date
478-081	December 2010

2000 to 2007 Comparison: Illecillewaet to Greenslide Ck

Figure 3-4

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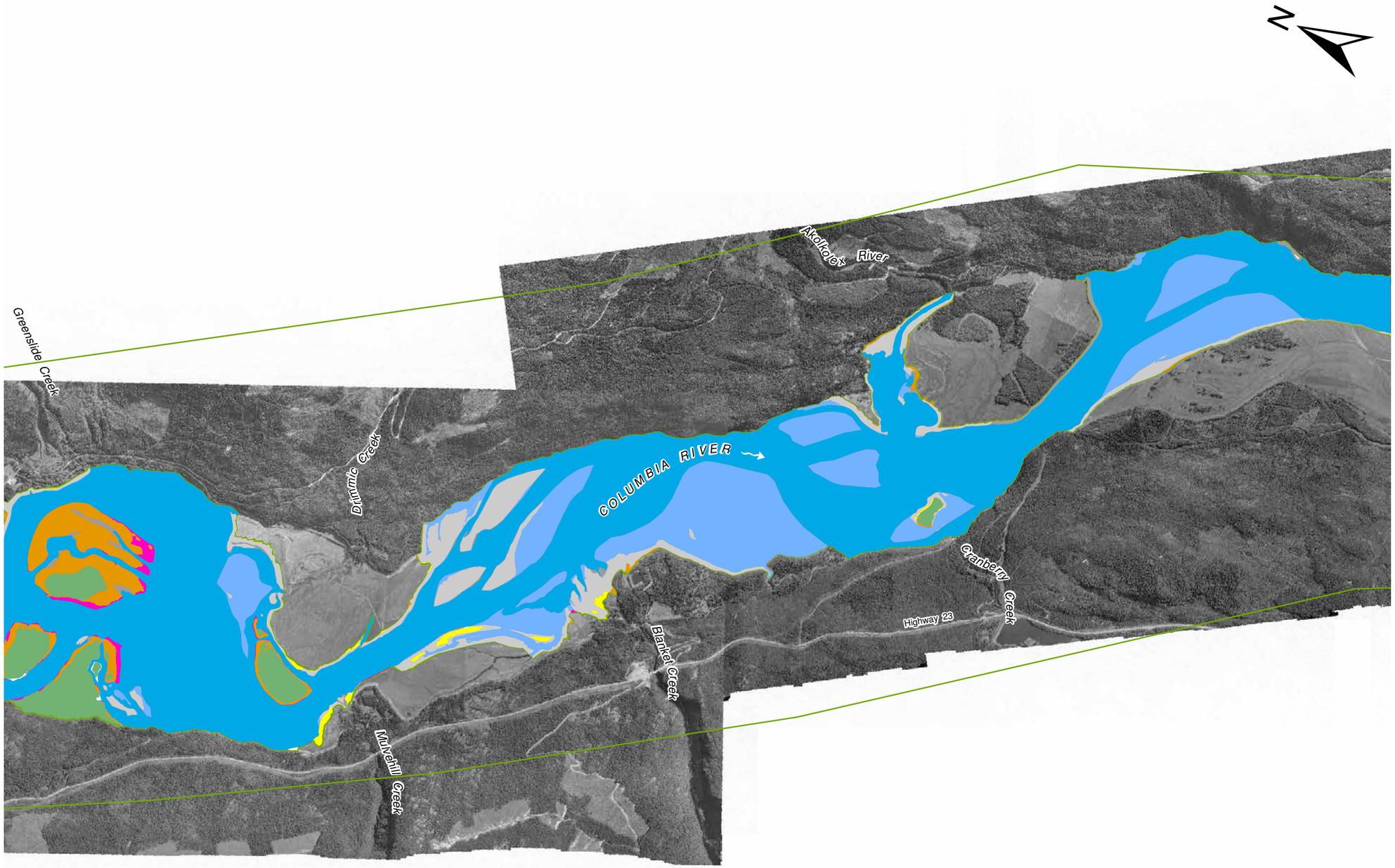

Notes:
1. Background is 2007 orthophotos (1:10,000 and 1:20,000).

BC Hydro
CLBWORKS #35 and #36

Legend

2000 to 2007 Mapping Transitions

- limit of mapping

NO CHANGE

- stable wetted surface
- stable vegetated surface
- stable gravel bar

CHANNEL CHANGES

- vegetation loss
- bank erosion
- vegetation growth

WATER LEVEL CHANGES

- inundated bar
- exposed bar

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1,000 0 1,000
Scale in Metres 1:40,000

Project No.	Date
478-081	December 2010

2000 to 2007 Comparison: Greenslide Ck to Cranberry Ck

Figure 3-5

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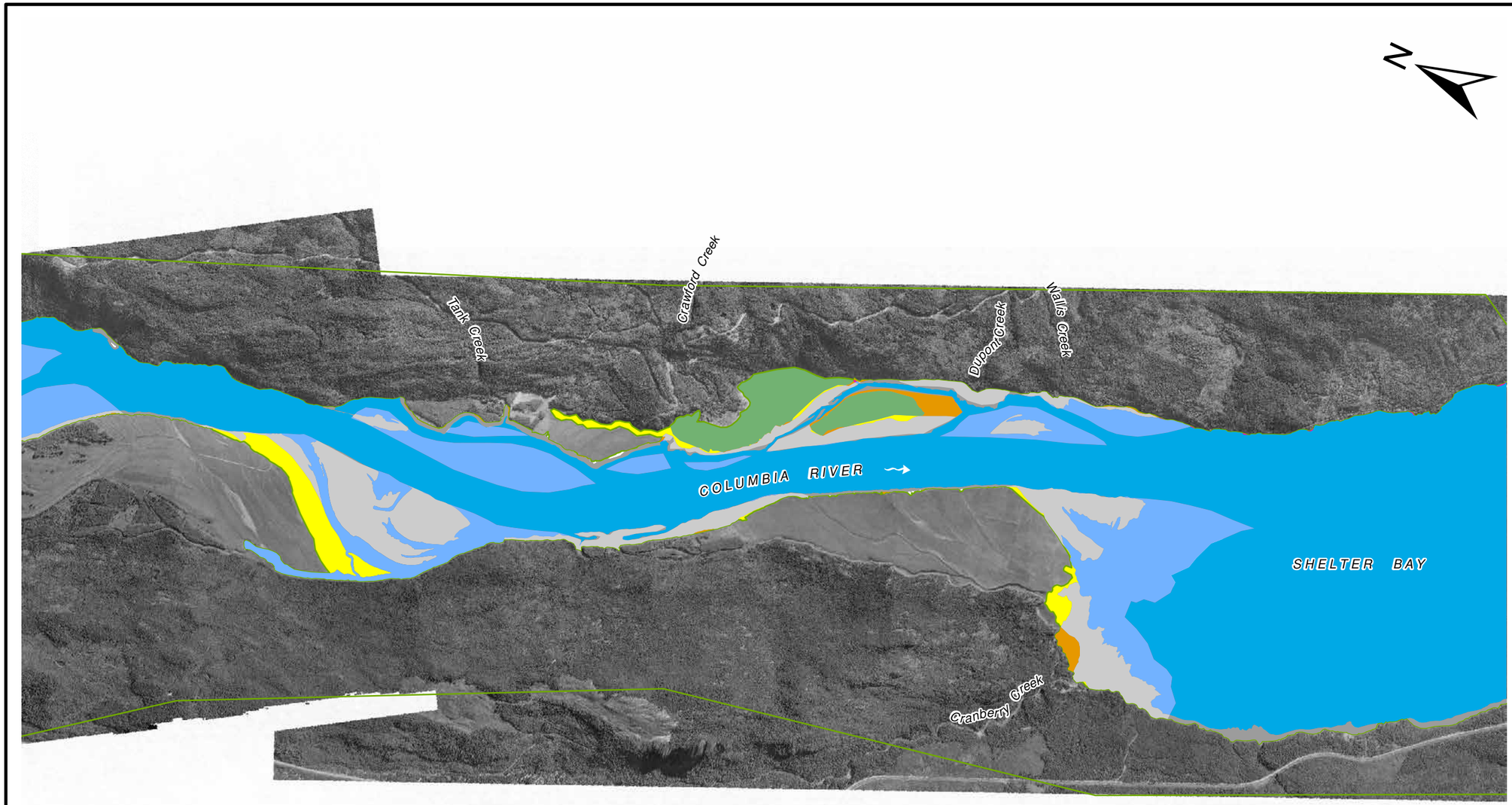

Notes:
1. Background is 2007 orthophotos (1:10,000 and 1:20,000).

BC Hydro
CLBWORKS #35 and #36

Legend

2000 to 2007 Mapping Transitions

- limit of mapping

NO CHANGE

- stable wetted surface
- stable vegetated surface
- stable gravel bar

CHANNEL CHANGES

- vegetation loss
- bank erosion
- vegetation growth

WATER LEVEL CHANGES

- inundated bar
- exposed bar

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1,000 0 1,000
Scale in Metres 1:40,000

Project No.	Date
478-081	December 2010

2000 to 2007 Comparison: Cranberry Ck to Shelter Bay

Figure 3-6

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Section 4

Summary and Future Works

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4. SUMMARY AND FUTURE WORKS

4.1 CLBWORKS #35

The bioengineering design and construction specifications were completed in 2010. Installation of the bioengineering treatments is scheduled for March or April 2011, depending on water levels. To maintain this schedule, final review and decisions regarding site splitting would occur in January, and notifications would be sent to the BC Ministry of Environment, Fisheries and Oceans Canada and Transport Canada shortly thereafter. Construction contract documentation should be prepared early in the New Year and the contract let in early March.

After installation of the bioengineering treatment is complete, long-term erosion monitoring pins will be installed and repeat survey transects will be located at the treatment and control sites and a topographic survey will be completed at the treatment sites.

4.2 CLBWORKS #36

Long-term monitoring sites have been established along the Columbia River from Revelstoke Dam to Arrow Lakes. The erosion monitoring pins are scheduled to be measured in March or April 2011, depending on water levels and corresponding with the CLBWORKS #35 construction schedule. Channel mapping can be conducted on the 2010 orthophotos when made available by BC Hydro; however, there may be an advantage to waiting for a longer time period to elapse before repeating the channel mapping comparison.

4.3 REPORT SUBMISSION

Prepared by:

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Reviewed by:

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Dec 23, 2010
D.T. MATSUBARA
27755

David Matsubara, M.Eng., P.Eng.
Project Manager

Appendix A

CLBWORKS #35 Drawings (Design of Bioengineering Works) and Specifications

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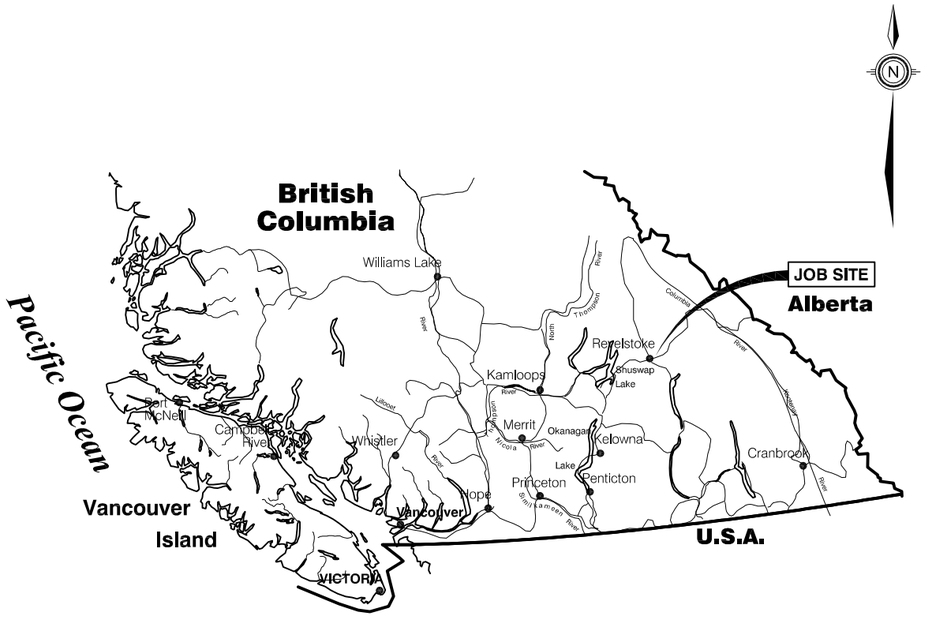
KEY PLAN
N.T.S.



LOCATION PLAN
N.T.S.

BC HYDRO
MID COLUMBIA RIVER BANK PROTECTION WORKS
PROJECT # 478.081

DRAWING LIST		
SHT. NO.	DRAWING NO.	TITLE
1	G1	LOCATION PLAN, KEY PLAN AND DRAWING LIST
2	G2	OVERVIEW OF SITE ACCESS ROADS
3	SW1	SITE WORKS - SITES 'A1' & 'A2'
4	SW2	SITE WORKS - SITES 'B' & 'C'
5	SW3	SECTIONS - SITE 'A1'
6	SW4	SECTIONS - SITE 'A2'
7	SW5	SECTIONS - SITE 'B'
8	SW6	SECTIONS - SITE 'C'
9	SD1	STANDARD DETAILS

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	Permits			
	Construction			
	Record Drawings			

REVISION INFORMATION	Rev. No.	Date	Designed	Drawn	Checked	Description of Revision
	0	JUN.10/10	SJL	BV		

Rev. No.	Date	Designed	Drawn	Checked	Description of Revision

Seal

KERR WOOD LEIDAL Associates limited
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MID COLUMBIA RIVER BANK PROTECTION WORKS
BC HYDRO
LOCATION PLAN, KEY PLAN AND DRAWING LIST

KWL Project No. 478-081 | Scale AS SHOWN | G1 Drawing Number
Sheet 1 of 9 | Rev. No. 0
Client: BC Hydro

AT FULL SIZE THIS BAR MEASURES 100mm. ALL SCALES REFERENCED TO FULL SIZE.

Jun. 10/10

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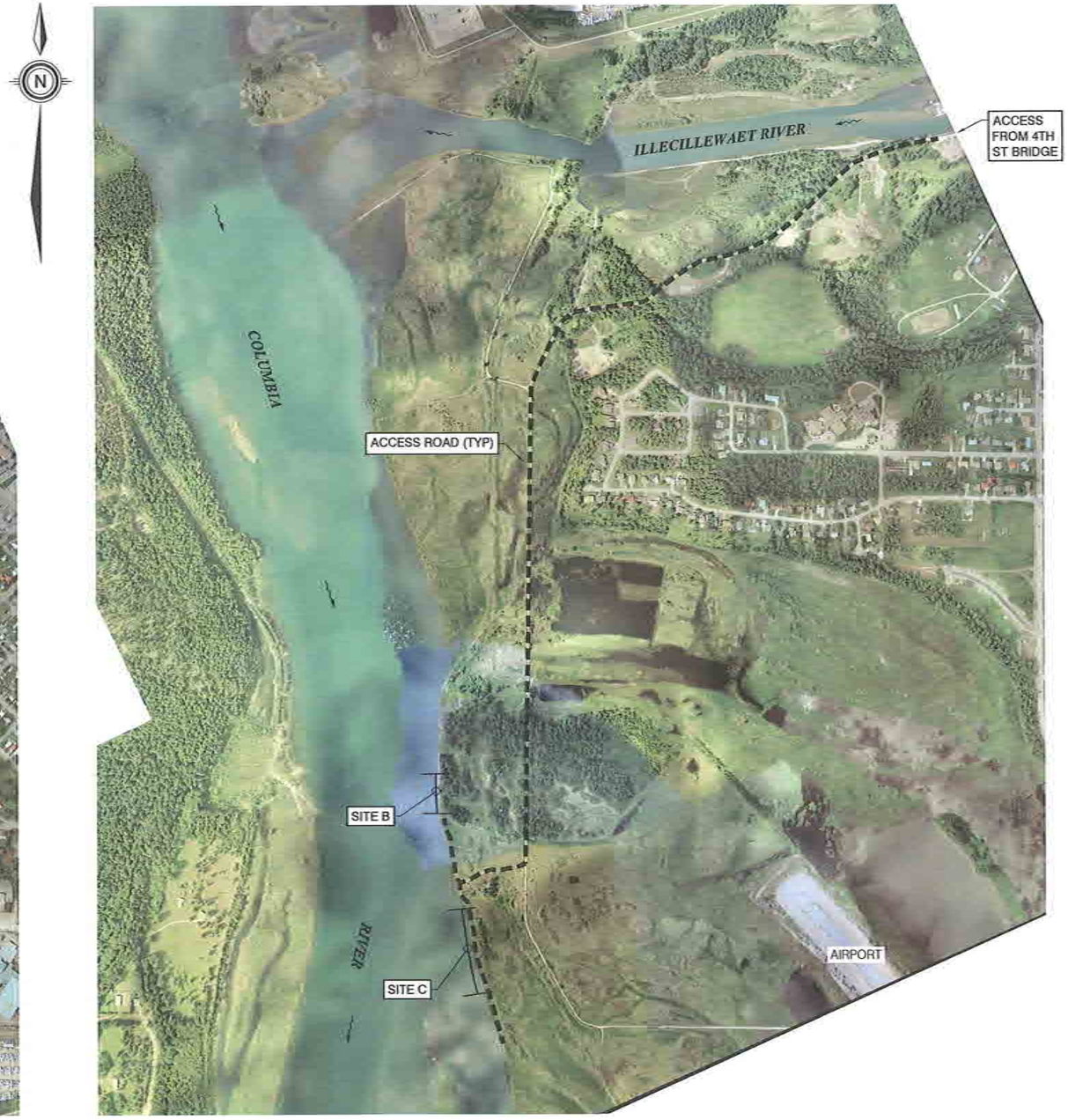

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Jun. 10/10

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	0	JUN.10/10	SJL	BV								

Seal

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MID COLUMBIA RIVER BANK PROTECTION WORKS
GENERAL
OVERVIEW OF SITE ACCESS ROADS

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Sheet	2 of 9	Rev. No.	0
Client: BC Hydro			

G2
Drawing Number

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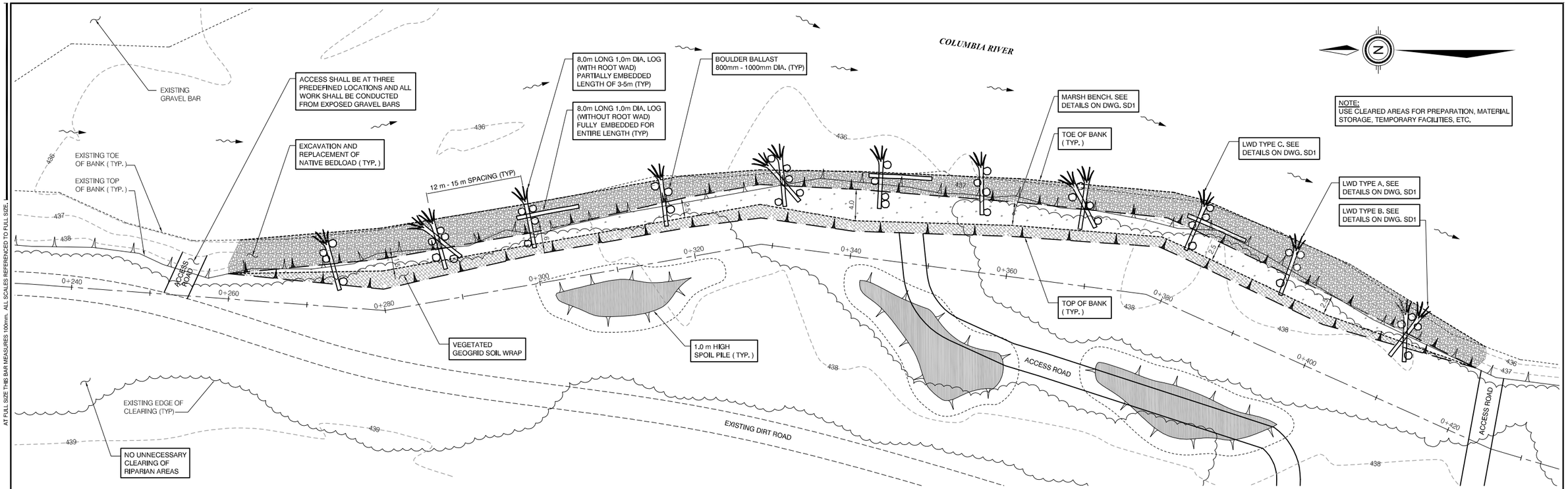

PLAN - SITE A1

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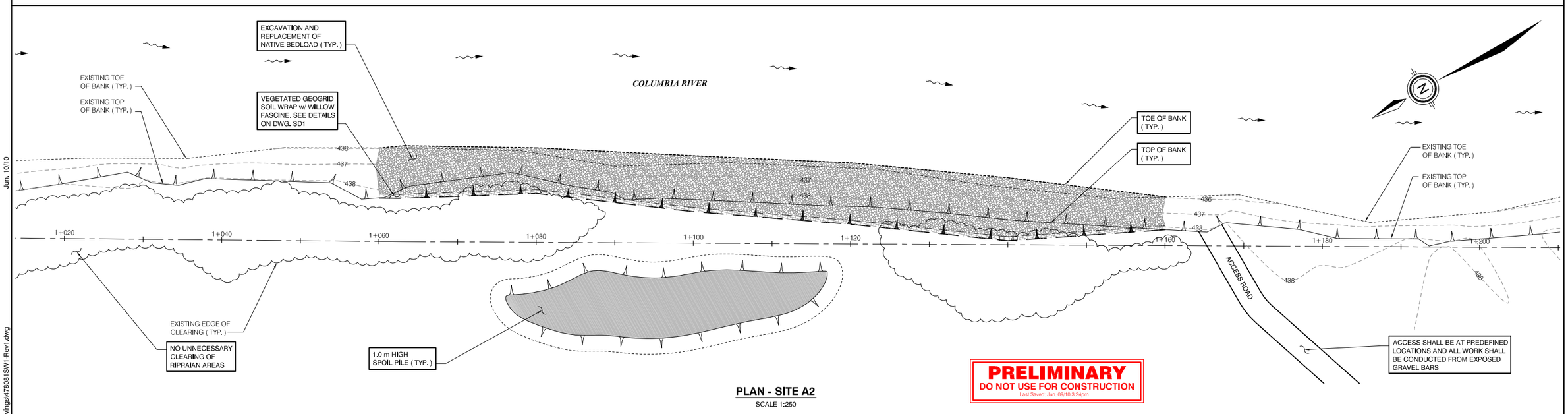

PLAN - SITE A2

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Rev. No.	Date	Designed	Drawn	Checked	Description of Revision

Seal

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MID COLUMBIA RIVER BANK PROTECTION WORKS
BC HYDRO
SITE WORKS - SITES 'A1' & 'A2'

KWL Project No. 478-081 | Scale AS SHOWN | **SW1** Drawing Number
Sheet 3 of 9 | Rev. No. 1
Client: BC Hydro

Jun. 10/10

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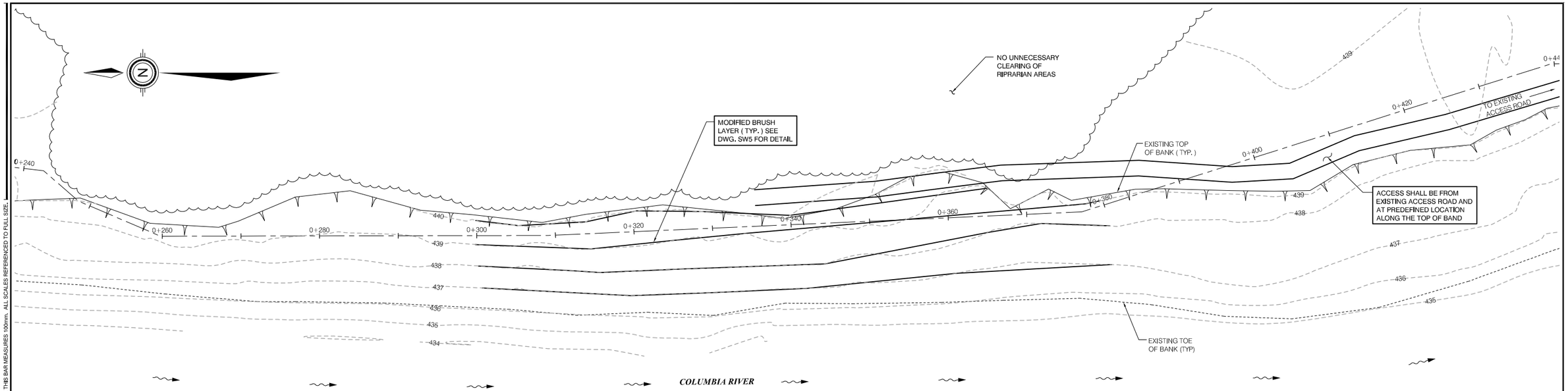
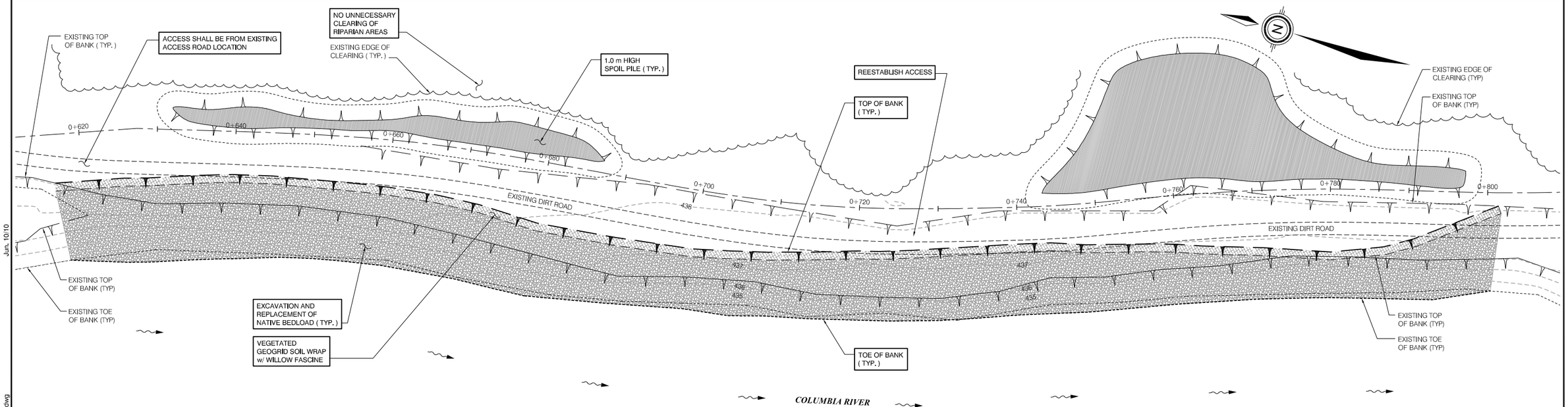


PLAN - SITE B
SCALE 1:250



PLAN - SITE C
SCALE 1:250

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Jun. 10/10

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	0	JAN.19/10	SJL	BV	DTM	
	1	JUN.10/10	SJL	MP		REVISED NOTES

Rev. No.	Date	Designed	Drawn	Checked	Description of Revision

Seal

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MID COLUMBIA RIVER BANK PROTECTION WORKS
BC HYDRO
SITE WORKS - SITES 'B' & 'C'

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Sheet 4 of 9 | Rev. No. 1
Client: BC Hydro

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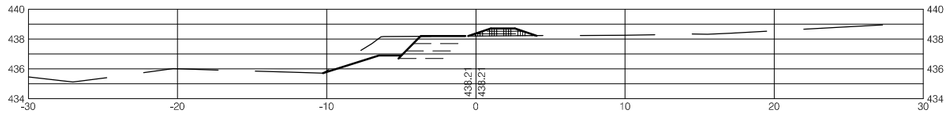

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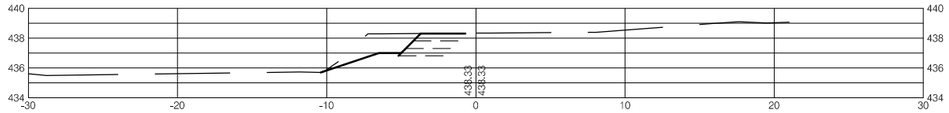

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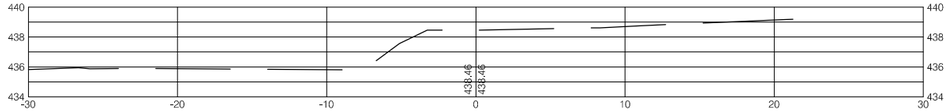

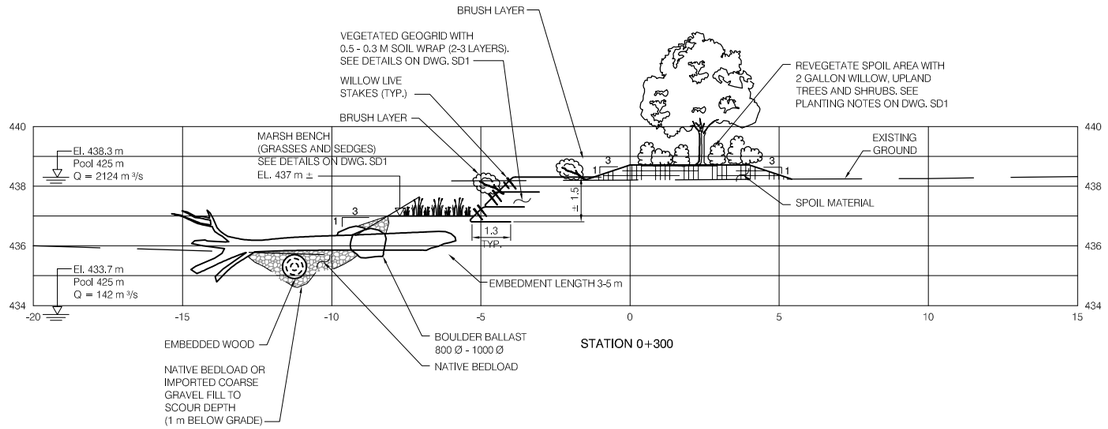

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TYPICAL SECTION

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SCALE 1:100

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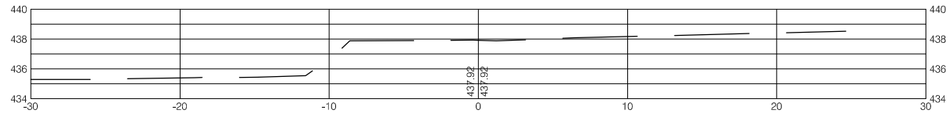

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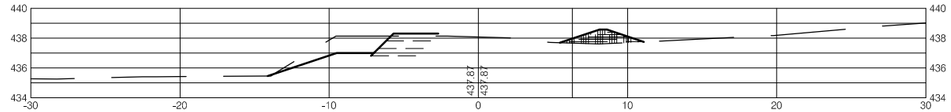

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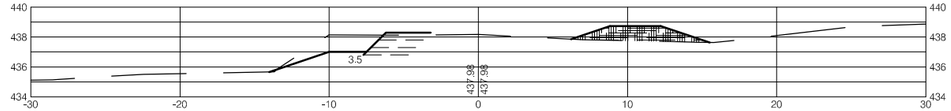

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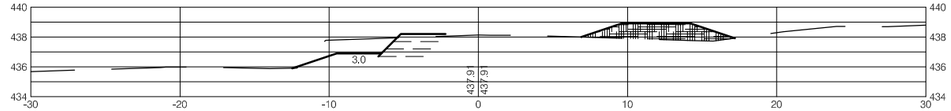

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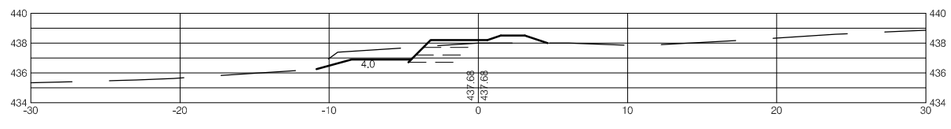

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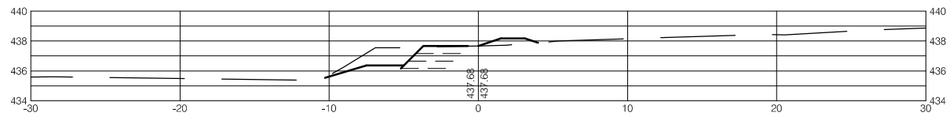

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Rev. No.	Date	Designed	Drawn	Checked	Description of Revision

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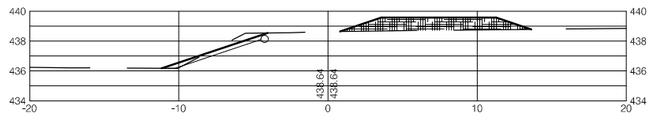
MID COLUMBIA RIVER BANK PROTECTION WORKS
BC HYDRO
SECTIONS - SITES 'A1'

KWL Project No. 478-081
Scale AS SHOWN
Sheet 5 of 9
Rev. No. 1
SW3 Drawing Number
Client: BC Hydro

AT FULL SIZE THIS BAR MEASURES 100mm. ALL SCALES REFERENCED TO FULL SIZE.

1+100



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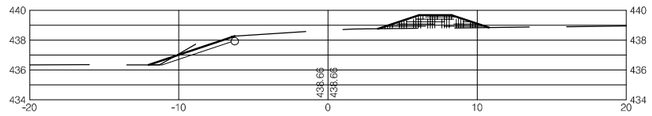

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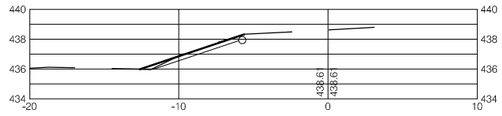

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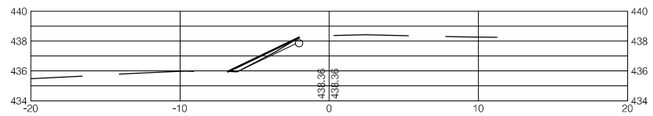

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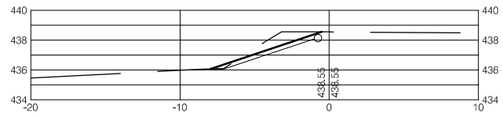

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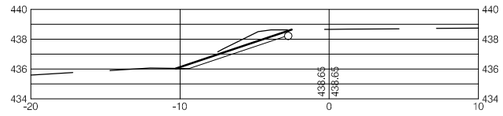

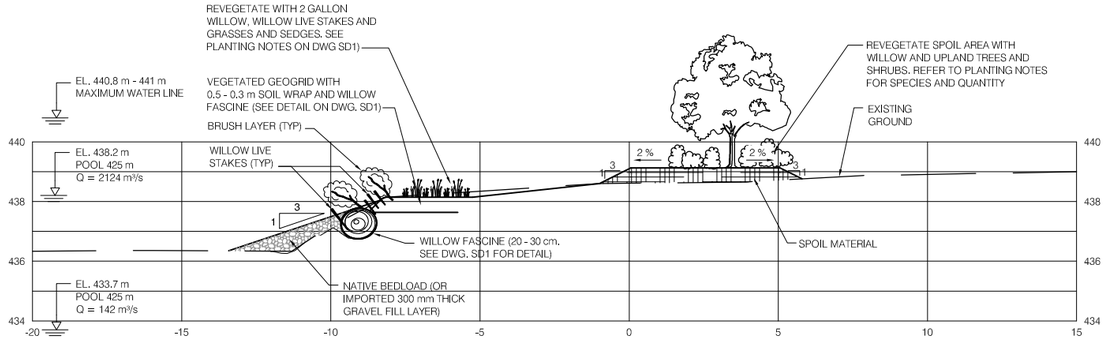

STATION 1+080

TYPICAL SECTION
SITE 'A2' STA 1+060 to STA 1+160

SCALE 1:100

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Rev. No.	Date	Designed	Drawn	Checked	Description of Revision

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MID COLUMBIA RIVER BANK PROTECTION WORKS
BC HYDRO
SECTIONS - SITES 'A2'

KWL Project No. 478-081 | Scale AS SHOWN | **SW4** Drawing Number
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AT FULL SIZE THIS BAR MEASURES 100mm. ALL SCALES REFERENCED TO FULL SIZE.

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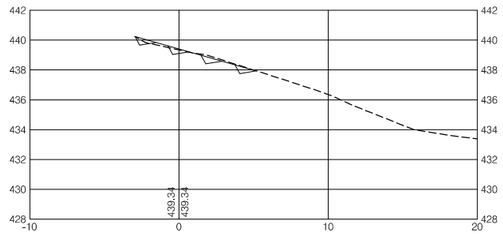
0+320



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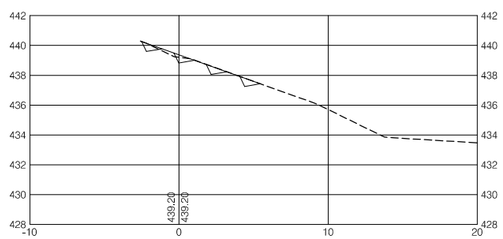
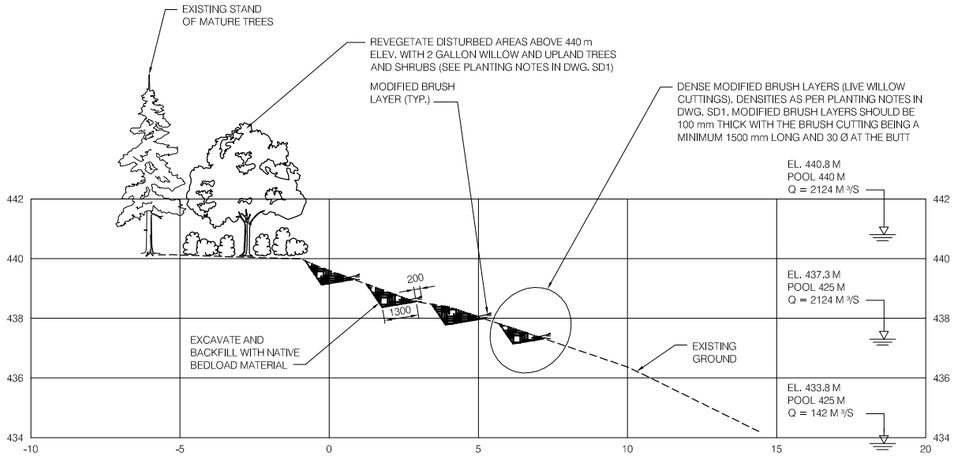




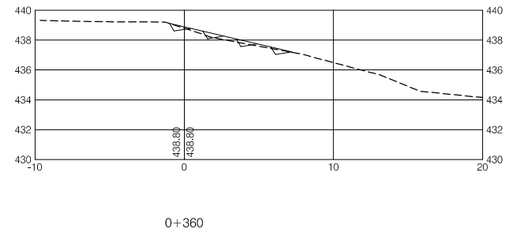
STATION 0+340

TYPICAL SECTION

SITE 'B' STA 0+300 to STA 0+380

SCALE 1:100

0+380



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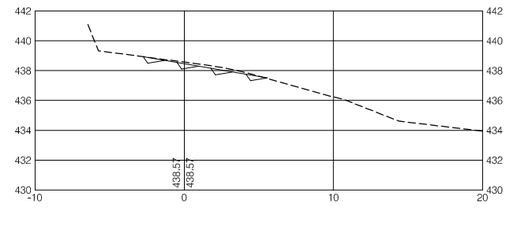

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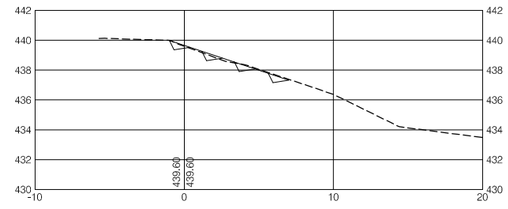

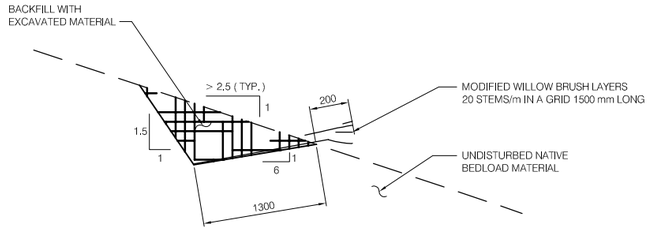

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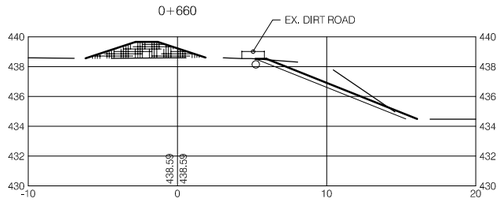
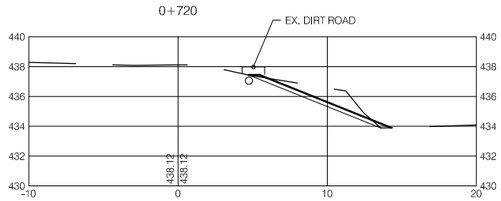
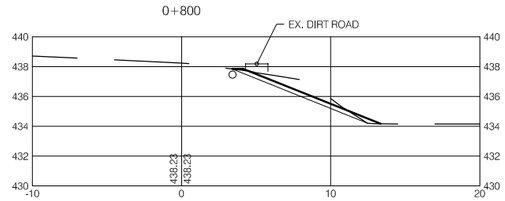
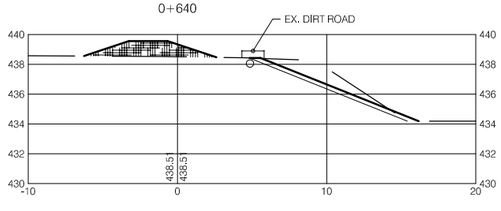
MID COLUMBIA RIVER BANK PROTECTION WORKS
BC HYDRO
SECTIONS - SITES 'B'

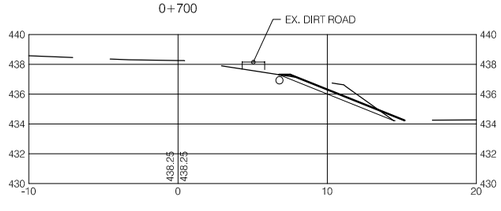
KWL Project No. 478-081 Scale AS SHOWN
Sheet 7 of 9 Rev. No. 1
SW5 Drawing Number
Client: BC Hydro

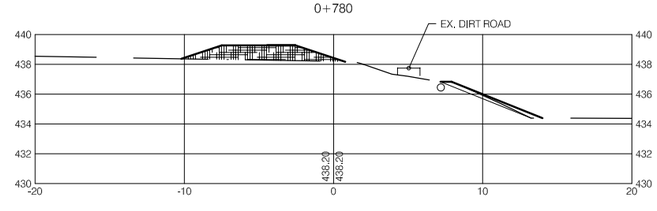


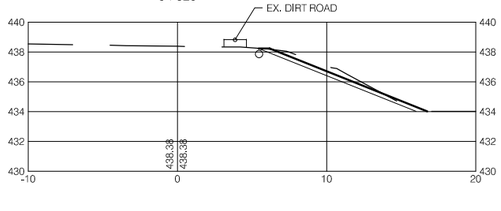


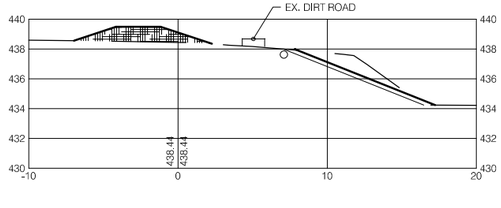


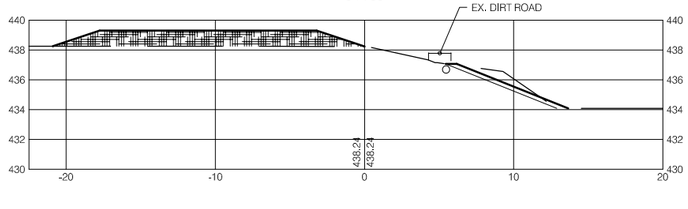


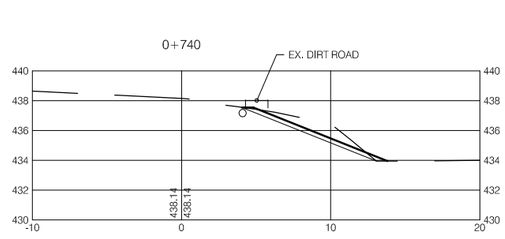


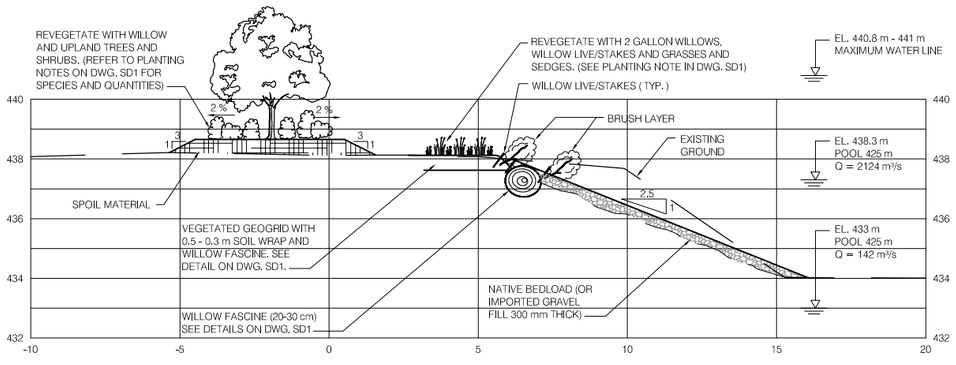












STATION 0+700

TYPICAL SECTION
SITE 'C' STA 0+300 to STA 0+380

SCALE 1:100

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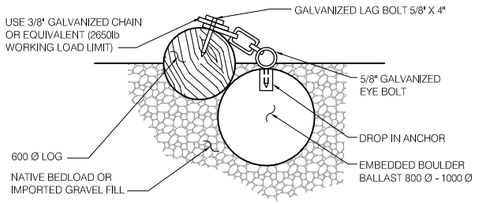
MID COLUMBIA RIVER BANK PROTECTION WORKS
BC HYDRO
SECTIONS - SITES 'C'

KWL Project No. 478-081 | Scale AS SHOWN | **SW6** Drawing Number
Sheet 8 of 9 | Rev. No. 1
Client: BC Hydro

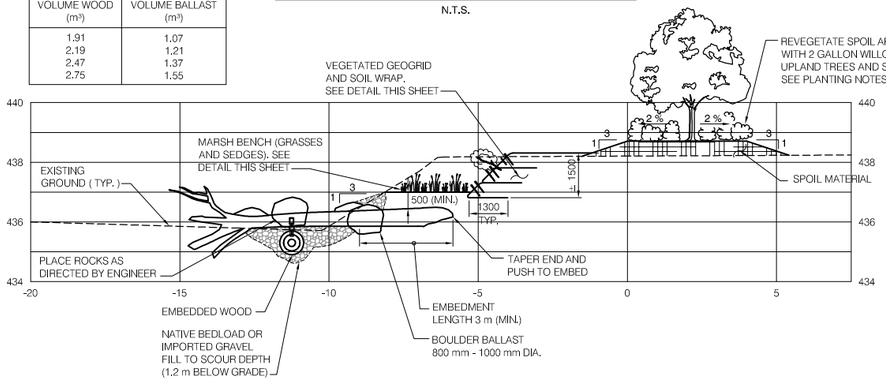


CHAIN DETAIL ATTACHMENT TO BOULDERS

N.T.S.

TYPE C

VOLUME WOOD (m^3)	VOLUME BALLAST (m^3)
1.91	1.07
2.19	1.21
2.47	1.37
2.75	1.55

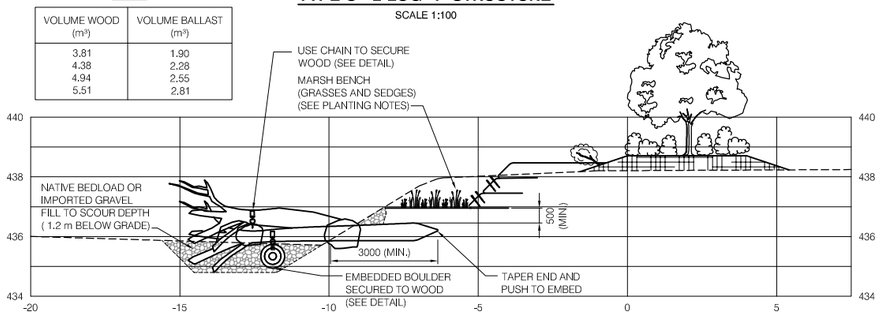


TYPE C - 2 LOG "T" STRUCTURE

SCALE 1:100

TYPE B

VOLUME WOOD (m^3)	VOLUME BALLAST (m^3)
3.81	1.90
4.38	2.28
4.94	2.55
5.51	2.81

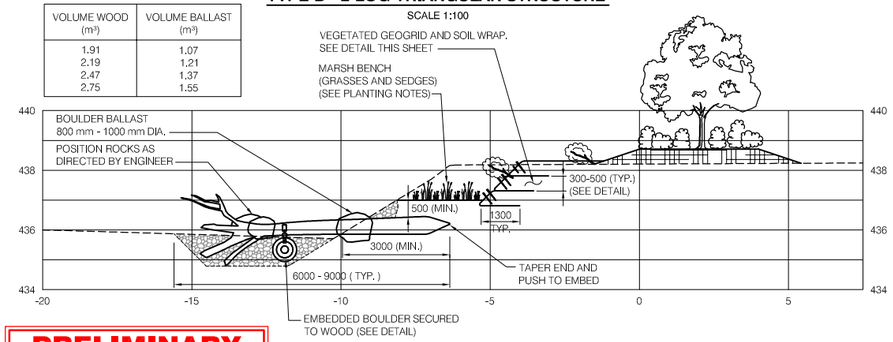


TYPE B - 2 LOG TRIANGULAR STRUCTURE

SCALE 1:100

TYPE A

VOLUME WOOD (m^3)	VOLUME BALLAST (m^3)
1.91	1.07
2.19	1.21
2.47	1.37
2.75	1.55



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TYPE A - SINGLE LOG STRUCTURE

SCALE 1:100

SUMMARY PLANT LIST

COMMON NAME	SPECIES NAME	BY AREA/LENGTH	STOCK SIZE	CALCULATE QUANTITY BASED ON
BIOENGINEERING PLANTINGS				
PACIFIC WILLOW	SALIX LUCIDA	30% BY BANK TREATMENT LENGTH	1.5 m CUTTING: 40 mm DIAMETER AT BUTT 0.65 m CUTTING: 40 mm DIAMETER AT BUTT	CALCULATE BASED ON 20 LIVESTAKES PER LINEAR METER OF BRUSH LAYER CALCULATE LIVESTAKES BY EITHER 30 cm OR 50 cm ON CENTRE SPACING BY AREA
SHRUB WILLOWS	SALIX BARCLAYI, SALIX BEBBIANA, SALIX DRUMMONDIANA	70% BY BANK TREATMENT LENGTH	1.5 m CUTTING: 40 mm DIAMETER AT BUTT 0.65 m CUTTING: 40 mm DIAMETER AT BUTT	CALCULATE BASED ON 20 LIVESTAKES PER LINEAR METER OF BRUSH LAYER CALCULATE LIVESTAKES BY EITHER 30 cm OR 50 cm ON CENTRE SPACING BY AREA
BLACK COTTONWOOD	POPULUS TRICHOCARPA	2 PLANTS PER 10 m OF BANK	1 GAL	THESE ARE ADDED TO THE FOUNDATION PLANTINGS OF WILLOW (NEED LINEAR METERS
MOUNTAIN ALDER	ALNUS INCANA	5 PLANTS PER 10 m OF BANK	1 GAL	THESE ARE ADDED TO THE FOUNDATION PLANTINGS OF WILLOW (NEED LINEAR METERS
RED-OSIER DOGWOOD	CORNUS SERICEA	5 PLANTS PER 10 m OF BANK	1 GAL	THESE ARE ADDED TO THE FOUNDATION PLANTINGS OF WILLOW (NEED LINEAR METERS
RIPARIAN (UPSLOPE) PLANTINGS				
SHRUB WILLOWS	SALIX BARCLAYI, SALIX BEBBIANA, SALIX DRUMMONDIANA	30% BY AREA	1 GAL	CALCULATE LIVESTAKES BY EITHER 30 cm OR 50 cm ON CENTRE SPACING BY AREA
MOUNTAIN ALDER	ALNUS INCANA	20% BY AREA	2 GAL	TREE SPACING IS 2.5 m ON CENTRE
PAPER BIRCH	BETULA PAPYRIFERA	15% BY AREA	2 GAL	TREE SPACING IS 2.5 m ON CENTRE
ENGLEMANN SPRUCE	PICEA ENGELMANNII	5% BY AREA	2 GAL	TREE SPACING IS 2.5 m ON CENTRE
WESTERN REDCEDAR	THUJA PLICATA	5% BY AREA	2 GAL	TREE SPACING IS 2.5 m ON CENTRE
RED-OSIER DOGWOOD	CORNUS SERICEA	10% BY AREA	1 GAL	TREE SPACING IS 1.5 m ON CENTRE
THIMBLEBERRY	RUBUS PARVIFLORUS	5% BY AREA	1 GAL	TREE SPACING IS 1.5 m ON CENTRE
SASKATOONBERRY	AMELANCHIER ALNIFOLIA	5% BY AREA	1 GAL	TREE SPACING IS 1.5 m ON CENTRE
BLACK TWINBERRY	LONICERA INVOLUCRATA	5% BY AREA	1 GAL	TREE SPACING IS 1.5 m ON CENTRE
MARSH BENCH PLANTINGS				
SEDGES	CAREX LENTICULARIS, CAREX UTICULATA, CAREX AQUATALIS	85% BY AREA	25 mm DIAMETER PLUG	SEDGE AND GRASS SPACING IS 30 CM ON CENTRE
COMMON SPIKE RUSH	ELEOCHARIS PALUSTRIS	5% BY AREA	25 mm DIAMETER PLUG	SEDGE AND GRASS SPACING IS 30 CM ON CENTRE
REDTOP	AGROSTIS GIGANTEA	10% BY AREA	25 mm DIAMETER PLUG	SEDGE AND GRASS SPACING IS 30 CM ON CENTRE

NOTES ON PLANTING:

GENERAL PLANTING
1. ALL PLANT MATERIALS SHALL CONFORM TO BCSLA / BCNTA LANDSCAPE STANDARD.
2. SUPPLIES OF WILLOW LIVE STAKES AND BRUSH LAYERS MUST BE APPROVED BY PROJECT BIOLOGIST PRIOR TO ON-SITE DELIVERY INCLUDING LOCATION AND TIMING OF HARVEST.
3. WILLOW BRUSH LAYERS AND LIVESTAKES MUST BE PROTECTED FROM DESSICATION DURING STORAGE AND INSTALLATION.
4. NO SUBSTITUTIONS WITHOUT APPROVAL FROM PROJECT BIOLOGIST.

VEGETATED GEOGRID - WILLOW BRUSH LAYERS
1. WILLOW FOR BRUSH LAYERS SHALL BE 1.5 m LONG AND 40 mm MINIMUM DIAMETER AT BUTT AND 20 mm MINIMUM DIAMETER AT TOP.
2. ALL WILLOW SHALL BE SALIX LUCIDA, SALIX BARCLAYI, SALIX BEBBIANA, SALIX DRUMMONDIANA OR SUBSTITUTE APPROVED BY PROJECT BIOLOGIST.
3. AVERAGE OF 20 STEMS PER METER.
4. BRUSH LAYERS TO BE STAGGERED BETWEEN WRAP LAYERS TO CREATE A CHECKERBOARD PATTERN.
5. INSTALL BRUSH LAYERS AT VARIABLE ANGLES (HORIZONTALLY WITHIN WRAP STRUCTURE) TO PROMOTE ROOT DEVELOPMENT.

VEGETATED GEOGRID - WILLOW LIVE STAKES
1. WILLOW FOR BRUSH LAYERS SHALL BE 0.65 m LONG AND 40 mm MINIMUM DIAMETER AT BUTT AND 20 mm MINIMUM DIAMETER AT TOP.
2. ALL WILLOW SHALL BE SALIX LUCIDA, SALIX BARCLAYI, SALIX BEBBIANA, SALIX DRUMMONDIANA OR SUBSTITUTE APPROVED BY PROJECT BIOLOGIST.
3. WILLOW LIVESTAKES SHALL BE DRIVEN AT ANGLES: DEPTH TO INTERSECT AT LEAST BRUSH LATER INTERFACE.
4. WILLOW LIVESTAKES SHALL BE DRIVEN AT 500 mm SPACINGS IN EACH WRAP AND SHALL BE STAGGERED BETWEEN SUCCESIVE LAYERS.

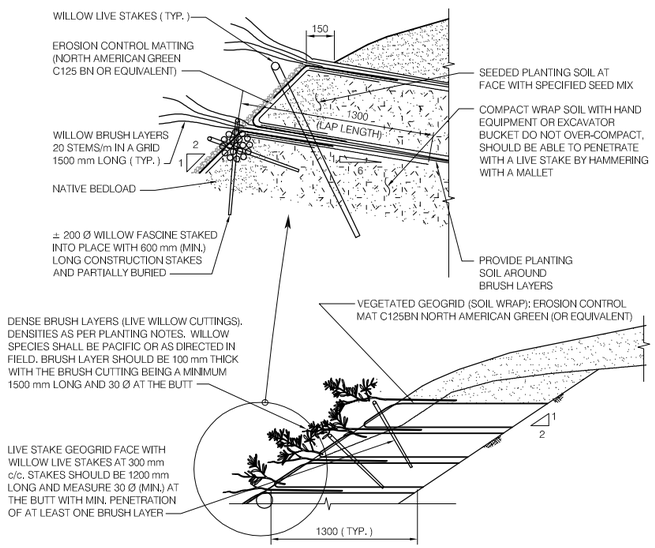
VEGETATED GEOGRID - WILLOW FASCINE
1. WILLOW FOR FASCINES SHALL BE A MINIMUM OF 1.0 m LONG AND 40 mm MINIMUM DIAMETER AT BUTT AND 15 mm MINIMUM DIAMETER AT TOP.
2. ALL WILLOW TO BE HOOKER'S WILLOW (SALIX HOOKERIANA) OR SUBSTITUTE APPROVED BY PROJECT BIOLOGIST.
3. FASCINES SHALL BE COMPOSED OF A OVERLAPPING WILLOW STEMS WITH A MINIMUM OF 10 STEMS AT ANY POINT.
4. FASCINES ARE TO BE TIED WITH JUTE CORD OR SIMILAR BIODEGRADABLE SUBSTITUTE EVERY 300 mm.

VEGETATED GEOGRID - SEEDING
1. SEED THE OUTER FACE OF EACH GEOGRID WRAP PRIOR TO CLOSURE WITH RICHARDSON'S COASTAL RECLAMATION MIX OR AN APPROVED SUBSTITUTE AT THE MANUFACTURES RECOMMENDED RATE OF APPLICATION.

MARSH BENCH
1. INSTALL 25 mm DIAMETER PLUGS OF SEDGES, RUSHES AND GRASSES.

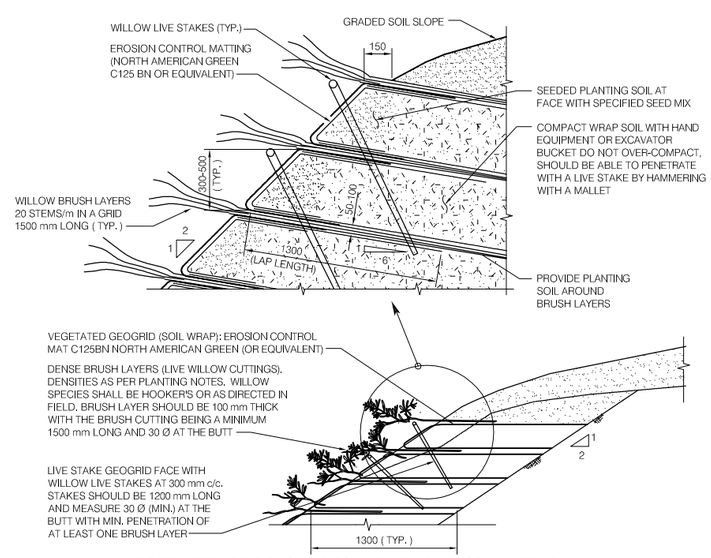
RIPPARIAN - SEEDING, SHRUBS AND TREE PLANTINGS
1. 2 GALLON SHRUBS (SEE PLANTING NOTES FOR LISTS OF SPECIES) ARE TO BE PLANTED AT 0.75 m ON CENTRE.
2. BROADCAST SEED ALL EXPOSED SOIL IN THE RIPARIAN PLANTING ZONE WITH RICHARDSON'S INTERIOR REVEGETATION MIX, AT THE MANUFACTURER'S SPECIFIED RATES (OR APPROVED EQUAL).
3. CLUMP SHALL CONSIST OF 10 TO 15 PLANT IN IRREGULAR PATCHES OF SAME SPECIES.

MODIFIED BRUSH LAYERS
1. WILLOW FOR MODIFIED BRUSH LAYERS SHALL BE 1.5 m LONG AND 40 mm MINIMUM DIAMETER AT BUTT AND 20 mm MINIMUM DIAMETER AT TOP.
2. ALL WILLOW SHALL BE SALIX LUCIDA, SALIX BARCLAYI, SALIX BEBBIANA, SALIX DRUMMONDIANA OR SUBSTITUTE APPROVED BY PROJECT BIOLOGIST.
3. AVERAGE OF 20 STEMS PER METER.
4. MODIFIED BRUSH LAYERS TO BE STAGGERED TO CREATE A CHECKERBOARD PATTERN.
5. INSTALL MODIFIED BRUSH LAYERS AT VARIABLE ANGLES (HORIZONTALLY) TO PROMOTE ROOT DEVELOPMENT.



VEGETATED GEOGRID - SOIL WRAP WITH WILLOW FASCINE (SECTION) DETAIL

N.T.S.



VEGETATED GEOGRID - SOIL WRAP (SECTION) DETAIL

N.T.S.

AT FULL SIZE THIS BAR MEASURES 100mm. ALL SCALES REFERENCED TO FULL SIZE.

Jun. 10/10

O:\0400-0499\478-081\500-Drawings\478081SD1.dwg

ISSUED INFORMATION	Issued for	Issue	Date	Issued By
	Reference			
	Approvals	A0	JUN.10/10	
	Tender			
	Permits			
	Construction			
	Record Drawings			

REVISION INFORMATION	Rev. No.	Date	Designed	Drawn	Checked	Description of Revision
	0	JUN.10/10	SJL	MP		

Rev. No.	Date	Designed	Drawn	Checked	Description of Revision

Seal

KERR WOOD LEIDAL associates limited
CONSULTING ENGINEERS

MID COLUMBIA RIVER BANK PROTECTION WORKS
SITE WORKS
STANDARD DETAILS

KWL Project No. 478-081
Scale AS SHOWN
Sheet 9 of 9
Rev. No. 0
SD1 Drawing Number
Client: BC Hydro

BC HYDRO
CONTRACT NO.
FOR CONSTRUCTION OF
COLUMBIA RIVER BIOENGINEERING

LIST OF CONTRACT DOCUMENTS

SPECIFICATIONS

DIVISION 1 GENERAL REQUIREMENTS

Section 01110 Summary of Work
Section 01300 Administrative Requirements
Section 01350 Special Project Requirements

DIVISION 2 SITE WORK

Section 02230 Site Clearing
Section 02300 Earthwork
Section 02380 Biotechnical Slope Stabilization
Section 02920 Seeding
Section 02950 Planting of Shrubs and Groundcover

LIST OF CONTRACT DOCUMENTS

APPENDICES

CONTRACT DRAWINGS (BOUND SEPARATELY)

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PART 1 GENERAL

1.1 Background

.1 The reach of interest on the Columbia River is located south of the Highway 1 crossing at the Town of Revelstoke. There are four locations where bioengineering will be installed. The first two locations are along the right bank of the river across from Centennial Park in Revelstoke. The third and fourth locations are on the left bank of the Columbia River downstream of the confluence with the Illecillewaet River.

.2 The Columbia River is regulated by a number of dams. The flow into this reach is controlled by the power production at the upstream Revelstoke Dam, and the downstream water levels are controlled by Keenleyside Dam and the impoundment of Arrow Lake Reservoir.

1.2 Scope

.1 The work of this Contract consists of the supply and installation of materials, including all labour, equipment, materials, vegetative plants and tools related to the construction of the Columbia River Bioengineering works all in accordance with the drawings and specifications, and for the prices tendered in the Schedule of Quantities and Prices.

.2 The components of the work are generally described as follows:

.1 construction, maintenance and removal of flow control measures, as necessary;

.2 construction of biotechnical slope stabilization works and planting of riparian enhancement works.

1.3 Limits of Work Sites

.1 The work sites are limited to the flooding reserve land tenure held by BC Hydro.

1.4 Drawings

.1 Details of the works are shown on KWL Drawing Set No. 478.081. The following is a list of the drawings, which are attached to, and form part of these specifications:

DWG. NO.	TITLE
G1	Location Plan, Key Plan and Drawing List
G2	General Overview of Access Roads
SW1	Site Works, Sites A1 and A2
SW2	Site Works, Sites B and C
SW3	Sections Site A1
SW4	Sections Site A2

DWG. NO.	TITLE
SW5	Sections Site B
SW6	Sections Site C
SD1	Standard Details

.2 The Contractor shall examine all drawings in advance of construction and shall advise the Engineer of any apparent errors, discrepancies or inconsistencies, in order that the Engineer can provide instructions clarifying the design.

.3 The Contractor shall also advise the Engineer of any discrepancies or apparent inconsistencies between the drawings and the specifications, in order that the Engineer may clarify the intent of the Contract.

1.5 Time for Completion of Work

.1 Refer to the General Conditions.

.2 The Contractor shall commence work under the Contract within 5 calendar days of the Notice to Proceed.

.3 Tenders for this Contract shall be based on a completion date of April 30, 2011.

For project management purposes, the Owner has established a construction period of 8 weeks as the basis for an engineering budget for construction inspection and contract administration. Should the scope of work be reduced then the construction period may be pro-rated accordingly. If the work is not completed within this time, the Owner may grant a **Time Extension Without Assessment**. This would be subject to a formal request in writing by the Contractor, and a recommendation by the Engineer as to whether there is a reasonable basis for granting the extension. If there is no basis for granting a **Time Extension Without Assessment**, then the Contractor will be liable for the extra engineering costs incurred by the Owner during the Extension Period.

.4 The agreed dates for commencement of work and substantial performance of the work shall be those set out in the Agreement.

.5 The Contractor is to take into account all factors that might affect the schedule, including weather conditions that can reasonably be expected within the time frame that the work is to be done.

.6 Refer to the General Conditions, regarding delays.

.7 As set out in the Supplementary Conditions, if the period of the Contract is extended by the Contractor, the cost of compensation to the Owner for engineering and inspection services shall be $950 per day and a **Late Completion Assessment** will be charged to the Contractor. The Owner will deduct from each successive monthly Progress Payment Certificate the actual cost to the Owner for field inspection and office administration during the extension period.

1.6 Sequence of Construction

.1 General:

The Contractor shall carry out the work of the Contract in such a manner as to:

.1 Ensure that all aspects of the work are completed under conditions necessary for construction, installation or application of materials as required by the manufacturer or by this specification.

.2 Carry out all instream works in an expedient manner, and meet all the requirements of the Environmental Monitor and permits.

.3 Schedule the work in a manner such that disruption of normal traffic and inconvenience to residents or businesses in the working area are kept to a minimum.

.4 The general sequence of construction is as follows:

- construct/prepare access to the work area;
- prepare bank and construct bioengineering;
- install all plant materials;
- deactivate flow diversion/site isolation measures and restore disturbed areas; and
- complete final site restoration.

1.7 Materials and Equipment Supplied by the Contractor

.1 The Contractor shall furnish all materials and shall:

.1 Find, load, haul, unload, store and care for all such materials, the cost of which shall be included in the tendered price.

.2 Pay all freight, duty, royalties, wharfage, sales tax and other charges on the materials he furnished under this contract.

.3 Be responsible for the proper handling of all pipe, fittings, and appurtenances; any damage which may be done in handling, shipping, storage, or in any other way prior to acceptance after installation and testing shall be made good by the Contractor at his expense.

.2 All materials incorporated into the work shall conform to this contract and to the latest edition of the appropriate specification of the ASTM, or to other standards expressly specified. Workmanship shall be first class and in accordance with the best shop practice.

.3 Materials incorporated in the work and not specifically covered in the specifications shall be new, of good quality, and acceptable to the Engineer.

.4 All items supplied by the Contractor shall be as specified. If the Contractor wishes to supply and install items other than specified, he shall apply for and must receive written permission from the Engineer before incorporating such items into the work.

.5 Descriptive literature and price schedules covering such alternative items shall be supplied to the Engineer at least 10 working days in advance of the required approval.

.6 Equipment supplied by the Contractor shall include installation, operating and maintenance manuals.

1.8 Costs for Testing, Engineering and Inspection

.1 The Owner may employ an independent testing firm to conduct quality control tests to determine compliance of the work with the Contract Documents. Should material or workmanship be found to be unacceptable, the full cost of further testing relating to the deficiency shall be charged to the Contractor.

.2 The Contractor shall have no claim for delays, interruptions, double-handling of materials, rejection of materials, or any other cause brought about by such tests, including awaiting the outcome of such tests.

.3 Provide adequate notice to the Engineer to permit testing to be conducted at appropriate times in an efficient manner.

.4 Unless otherwise specified, the costs of testing will be assumed by others.

.5 Provide material samples to the Engineer in such quantities as required for testing for conformance with the specification. Make good, at least to original standard, area from where samples are taken.

END OF SECTION

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PART 1 GENERAL

1.1 General Requirements

.1 Provide a complete project incorporating the specified materials and first class workmanship.

.2 Complete the work during the specified working period.

1.2 Definitions

.1 Within these specifications, the word “Corporation” and “Band” shall be synonymous with the word “Owner” as defined in CCDC 2.

.2 Within these specifications the word “Engineer” shall be synonymous with the word “Consultant.”

1.3 Document Conflict

.1 Figured dimensions on a drawing take precedence over measurements scaled from the drawing, and large-scale drawings take precedence over those of smaller scale. Supplementary drawings and specifications supersede their antecedents. In case of conflict between figured dimensions on a drawing and the dimensions of a specified product, the dimensions of the specified product will govern. The drawings and specifications complement each other and anything called for by one will be as binding as if called for by both.

1.4 Standard Specifications

.1 The edition current on the date of advertisement for tenders for this contract will be deemed to be in effect.

.2 The reference standard specifications and documents shall be considered to be a part of these specifications insofar as they apply.

.3 The National Building Code of Canada and all applicable local and Provincial Building Codes shall govern all materials, methods, workmanship and conditions not explicitly detailed in contract drawings and specifications.

1.5 Co-operation

.1 Co-operate to fullest extent with representatives of the Owner, the various utility companies, private citizens adjacent to whose property the work is being conducted, and other contractors working in the facility.

.2 Direct all communications through the Engineer. Provide the Engineer with a minimum of forty-eight (48) hours notice prior to moving onto site. Provide the Engineer with a minimum of twenty-four (24) hours notice prior to leaving site. Attend site meetings as required by the Engineer.

1.6 Drawings for Construction

.1 The Owner will provide ***6*** sets of drawings and specifications to the Contractor for construction.

.2 Additional sets will be provided at the Contractors request at a cost to the Contractor of ***$50.00*** per set (payable to Kerr Wood Leidal Associates).

1.7 Information to Subcontractors and Suppliers

.1 The Contractor shall supply complete information to sub-contractors and equipment and material suppliers. Where both specifications and drawings are required to provide complete information on any aspect of the work, the Contractor shall supply both to the sub-contractor and/or supplier concerned.

1.8 Equal and Alternate Equipment and Materials

.1 Equipment or materials other than those specified, of equal quality, may be approved by the Engineer. Acceptable equipment or materials shall be that which has been reviewed and approved by the Engineer five (5) working days prior to the closing of tenders.

.2 Should the Contractor propose to substitute equipment or materials having different dimensions or requiring connections or layout at variance with the drawings, it shall be his responsibility to submit a detailed drawing showing how proposed substitute equipment is to be installed and connected in the available space. Any proposed variations from contract drawings shall be specifically indicated.

.3 Where two or more items of equipment or materials of similar design are to be installed, they shall be the products of one manufacturer.

.4 Equipment or materials other than those specified that have been approved by the Engineer as “equal” five (5) days prior to the closing of tenders may be substituted at the Contractor’s discretion provided the aforementioned conditions are met.

.5 Equipment or materials other than those specified, which may be approved by the Engineer as “alternate” following the closing of tenders, may be substituted by the Contractor at the discretion of the Engineer provided suitable adjustment of the contract price is negotiated.

.6 Equipment or materials other than those specified that have been installed without approval by the Engineer may be rejected. In this case the equipment or materials shall be removed, and approved equipment installed, at the Contractor's expense.

.7 The Contractor shall be responsible for all expenses incurred in the work of other trades made necessary because of substitution.

1.9 Layout

.1 The Contractor shall be responsible for all layout of the work in accordance with the drawings, including calculation of layout dimensions and elevations. The contractor shall also be responsible for all volumetric surveys. All information regarding the volumetric surveys including all calculations shall be provided to the Engineer prior to payment.

.2 Co-operate with the Engineer and provide rod man or similar assistance in checking layout as required.

.3 Elevations shown on the drawings are in metres to geodetic datum.

.4 The Contractor shall take all necessary precautions to preserve existing benchmarks or legal survey pins on and adjacent to the site. Two days notice shall be provided to the Owner in the event that a benchmark or pin must be disturbed during the course of construction. If the Contractor fails to comply with this requirement he will be charged with the expense of replacing the disturbed legal marker by a registered B.C. Land Surveyor.

.5 The Engineer will establish elevation and layout control for the work.

1.10 Locating and Protecting Existing Utilities

.1 Depths and location of existing utilities shown on drawings are for guidance only based on available record drawings. Completeness and accuracy are not guaranteed.

.2 Prior to commencing any excavation work, the Contractor shall establish location and state of use of buried utilities. Clearly mark such locations to prevent disturbance during the work. Notify Engineer in writing of any discrepancy that may affect the quality of the work, or that may give rise to a claim for extra payment, prior to commencement of the required work.

.3 The Contractor shall provide adequate shoring for the support of all existing utilities.

.4 The Contractor shall co-ordinate all crossing of gas piping, electrical ducts, telephone ducts, and other utilities with Terasen Gas, B.C. Hydro, Telus, or other appropriate utility authority.

.5 The Contractor shall be responsible for all costs associated with repair of existing services that are damaged during construction.

1.11 Protection of Structures

.1 Provide adequate shoring and erosion protection to prevent undermining of any existing structures and services.

.2 Submit proposed shoring techniques to the Engineer for approval prior to excavation.

1.12 Legal Survey Markers

.1 Contractor and Engineer will inspect site and record on a plan all existing legal survey markers to be protected. Where work cannot be completed without damaging or dislocating a marker, notify Engineer before disturbing marker. Replace at Contractor's expense all such markers, disturbed or removed.

1.13 Emergency Crews

.1 Before commencement of construction, provide to the Owner a list of at least 3 names and telephone numbers of the Contractor's representatives who can be called outside normal working hours to act for the Contractor for emergency “call outs” in connection with work under the Contract. At least one person on the list shall be available at all times outside of normal working hours.

1.14 Notice to Utility Owners and Users

.1 When work is to be conducted in the vicinity of gas lines, water mains, sewers, telephone and hydro lines, or other aboveground or underground structures, notify utilities at least twenty-four (24) hours in advance.

.2 Obtain utility's permission in writing prior to interrupting any service. Distribute notices to all premises affected by the interruption twenty-four (24) hours in advance of service interruption.

.3 In emergency situations, where life or property is endangered, take whatever action is necessary to eliminate danger and minimize damage.

1.15 Permits, Easements and Working Space

.1 The Contractor shall furnish labour and facilities to:

.1 provide access to work to be inspected and tested;

.2 facilitate inspections and tests; and

.3 make good work disturbed by inspections and tests.

.2 In addition the Contractor shall notify the Owner 48 hours in advance of operations to allow for assignment of personnel and scheduling of tests, and the Contractor shall pay all costs for uncovering and making good any work that is covered, before required inspection or testing is completed and approved by the Engineer.

.3 The Contractor shall comply with all municipal and governmental regulations governing construction.

.4 The Contractor shall ensure that the Contractor and all subcontractors obtain and pay for all necessary permits, fees, licences, certificates of inspection, and insurance in connection with the works as may be required under this contract any applicable federal, provincial and municipal regulations or bylaws. Permits include but are not limited to:

1.16 Material Storage

.1 Store all material purchased for Contract in safe and secure storage area in accordance with manufacturer's recommendations.

.2 Establish such additional temporary storage facilities as may be required for Construction to proceed.

.3 Owner supplied materials will not be released until security of the site is ensured.

1.17 Disposal of Waste Materials

.1 All waste materials, including native materials from excavations that are deemed by the Engineer to be unsuitable for re-use, remaining debris from clearing, existing structures, remains of previous land uses, or any debris or rubbish encountered on the site are to be removed from the site and disposed of at locations obtained by the Contractor.

.2 The cost for removal and disposal off site of all waste materials shall be included in the lump sum tender prices.

.3 Disposal of waste or volatile materials, such as mineral spirits, oil or paint thinner into sewers or waterways is prohibited.

1.18 Site Maintenance and Cleanup

.1 The working area shall be maintained in an orderly manner and shall not be encumbered with equipment, materials, or debris.

.2 Cleanup shall be a continuing process from the start of the work to final acceptance of the project. The Contractor shall at all times keep the work site free from accumulations of waste materials or rubbish caused by employees or by the work. Accumulations of waste materials that might constitute a fire hazard will not be permitted. Spillage from the Contractor's hauling vehicles on travelled public or private roads shall be promptly cleaned up. On completion of construction, the Contractor shall remove all temporary structures, rubbish, and waste materials resulting from his operation.

.3 Remove all temporary work from the site including but not limited to fencing, sign board, samples, and any other items not considered to be part of the permanent works as part of the final cleanup.

1.19 Access and Public Safety

.1 The Contractor shall effectively warn and protect the public from any danger as a result of the work.

.2 No material or equipment shall be stored where it will interfere with the free and safe passage of public vehicular or pedestrian traffic (except within the defined working area) or in such a manner that it creates a hazard to the public.

.3 The Contractor shall at all times ensure that fire hydrants are not obstructed and are thus readily accessible to the Fire Department.

.4 The Contractor shall also ensure that there is unobstructed access for the Owner to the existing facility.

1.20 Safety Procedures

.1 The Contractor shall at all times employ safety procedures required by the Worker's Compensation Board, B.C. Electrical Inspection and the Owner.

1.21 Contractor's Schedule

.1 The Contractor shall submit for the approval of the Engineer prior to commencement of construction a schedule of work setting out the order in which he intends to undertake the work. The Engineer may specify the order or alter the schedule of work as submitted by the Contractor at any time during the term of the Contract.

.2 If, in the opinion of the Owner, any submitted construction program is inadequate to ensure completion of work within time limited, or is otherwise not in accordance with the specifications, or if the work is not being adequately or properly prosecuted in any respect, the Owner, without derogating from the Owner's right under this agreement, shall have the right to require the Contractor to submit a new construction program providing for proper and timely completion of the work; the Contractor shall be entitled to no claim for extension of time on account of such requirement.

.3 The Contractor shall note the Sequence of Construction considerations in Section 01110 in preparing his schedule.

1.22 Documents at the Site

.1 Maintain an accurate daily diary as the work progresses. Record personnel and equipment on site, deliveries of materials, progress, problems encountered, weather conditions, and other pertinent information. Diary shall be open to the Engineer at all times. Turn over an exact copy of diary to Engineer upon completion of contract.

1.23 "As Constructed" Information

.1 It shall be the responsibility of the Contractor to maintain one set of white prints updated to show all changes incorporated into the Work. The prints shall be available for inspection by the Engineer at all times during progress of the Work.

.2 These drawings will contain the following information:

.1 All dimensions shown on the design drawings shall be checked as-built or if changed the as-built dimension shall be written in RED in the appropriate locations.

.2 Actual equipment installed (replace "or equal," "or equivalent" by Model number and Manufacturer).

.3 Dimensions of all structures including elevations and rock profiles.

.4 Description, elevation and location of any services encountered during construction.

.5 Changes in roadway alignments and grades as well as locations of driveways.

.6 Rock profiles in trenches.

.3 Submit to the Owner two complete marked up sets of prints showing all as-constructed changes, including changes directed by the Engineer, to the contract drawings within 7 days of completion of the work.

1.24 Shop Drawings

.1 Eight (8) sets of shop drawings shall be prepared and submitted to the Engineer for review where called for in these specifications. Shop drawing submission shall be at least thirty (30) days prior to fabrication or manufacture of the work.

.2 Shop drawings shall at least show methods of construction, principal dimensions, materials, material specifications, and total net assembled weight of each fabricated piece of work or each item of equipment. Provide complete electrical data where applicable. Provide drawings sealed by Professional Engineer where applicable.

.3 The Engineer will review these shop drawings and mark them with such corrections as are deemed necessary by him and will return one set of prints to the Contractor.

.4 Review of shop drawings will be to assess their compatibility with the general design concept only. This review will not relieve the contractor of his responsibility for accuracy of the detail dimensions, general fit-up of parts to be assembled, adequacy of connection details, errors or defects contained in the details, or for safety and adequacy of erection methods proposed.

.5 If requested by the Engineer, prints of corrected shop drawings shall be resubmitted in the same manner as above.

.6 Any manufacturing completed prior to the reviewed shop drawings being returned will be at the Contractor's risk.

.7 Additional requirements may be noted in specific sections of these specifications.

1.25 Warranty

.1 If the Contractor fails to take action within ten (10) days of the date of notice, then the Owner reserves the right to make the repairs itself and with the cost billed to the Contractor.

.2 In the event of an emergency situation where time is of the essence, the Owner may make repairs without notice being sent to the Contractor. The cost of such repairs will be billed to the Contractor.

END OF SECTION

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PART 1 GENERAL

1.1 General

.1 This section outlines special project requirements that shall apply to this project.

1.2 Related Work

.1	Environmental Protection	Section 01560
.2	Site Clearing	Section 02230
.3	Earthworks	Section 02300
.4	Biotechnical Slope Stabilization	Section 02380

PART 2 EXECUTION

2.1 Construction Environmental Management Plan

.1 Contractor shall supply a Construction Environmental Management Plan to the Owner for review within two weeks of winning the contract.

.2 This plan shall include proposed mitigation measures for on and off site water, sediment control and spill prevention and emergency response.

.3 The Engineer, Environmental Monitor and Contractor shall all agree to the contents of the plan prior to commencing construction.

2.2 Water Management Plan

.1 The Contractor shall be responsible for the preparation of a water management plan.

.2 The plan shall outline the method of river diversion, control of seepage in the work area and control of suspended sediment downstream of the work area.

.3 The plan shall also include contingency plans for high flow events, safety of equipment and shall provide for the monitoring of the weather and coordination with BC Hydro regarding dam operations.

2.3 Environmental Monitor

.1 Fisheries and Oceans Canada (DFO) and the Provincial Ministry of Environment (MOE) requires that an environmental monitor be present on site during construction.

.2 The Environmental Monitor shall have standing authority as the Engineer and acts on behalf of the environmental agencies. They shall inspect the Contractor's work and assess compliance with the environmental protection requirements. The Contractor is fully responsible for meeting these requirements and shall act quickly to any written directives from the Environmental Monitor or Engineer in this respect.

.3 The Environmental Monitor reports to the Provincial and Federal environmental agencies regarding environmental aspects of the project. If the Contractor's work is judged by the Environmental Monitor to be environmentally unacceptable, the Contractor's work may be halted by the monitor. In the event of such an occurrence, the Contractor shall be responsible for fulfilling established conditions prior to resuming construction.

.4 Raincoast Applied Ecology will act in this capacity for this project.

2.4 Environmental Approvals

.1 The Water Management Branch of the Ministry of Environment has issued an approval for this project under Section 9 of the *Water Act*. Construction requirements are as follows:

.1 All work shall be completed on or before April 30, 2011.

.2 All instream work shall be undertaken during low flows.

.3 Upon commencement of the project, the work shall be pursued to completion as quickly as possible.

.4 Any machinery operated in the stream shall be in good working order and free of oil and grease.

.5 All proposed work shall be completed in isolation of the stream flows.

.6 Care shall be exercised during all phases of the work to minimize siltation of the stream and to eliminate the release of any other debris or deleterious substances.

.7 All excavated material and debris shall be removed from the site or placed in a stable area above the high water mark of the stream at elevation 441 m elevation as shown on the drawings and protected from erosion.

.8 On completion of the project, the river shall be left in as smooth a condition as possible, with no depressions that could trap fish or initiate erosion of the stream bed.

.9 All exposed areas of the stream channel shall be protected from erosion.

2.5 Water Quality Protection

.1 The Columbia River is a fisheries resource, and the Contractor is responsible for ensuring that construction activities do not result in any detrimental impacts on this resource. This includes, but is not limited to, preventing the discharge of silt-laden water.

.2 The Contractor shall furnish all materials and be responsible for the design, placement, maintenance, and subsequent removal of any temporary works necessary to prevent surface water flow from impacting on construction operations.

.3 The Contractor shall ensure that slopes affected by construction are adequately protected with erosion control measures to the satisfaction of the Engineer and

Environmental Monitor, the B.C. Water Act approval, or as indicated on the drawings.

.4 The Contractor shall be responsible for, and make good at his own expense, any damage caused by water, failure of any part of the water control works, failure of equipment, inadequacy of equipment, omissions or commissions in his performance of the work.

.5 The Engineer has authority to stop or suspend operations should conditions warrant.

.6 The Engineer is responsible for ensuring that prior approval pursuant to the Water Act is obtained for work in and about the river. All conditions of such approval will be relayed to the Contractor, and the Contractor shall abide by them.

.7 Care shall be exercised during all phases of the work to minimize siltation of the creek, and to eliminate the release of raw concrete, concrete leachate, and any other debris or deleterious substances.

.8 Wherever possible, work shall be carried out in isolation of the streamflow.

.9 The Contractor shall provide at their own expense any additional water or sediment control measures directed by the Environmental Monitor.

2.6 Fisheries Considerations

.1 The Contractor shall meet with Fisheries and Oceans Canada and Ministry of Environment personnel prior to undertaking any instream work, and shall obtain their approval for his proposed construction methods. This requirement will not apply if these agencies determine that the meeting is unnecessary.

.2 The Columbia River is fish-bearing stream. Therefore, protection of water quality at all stages of construction is essential.

.3 Riprap and other materials placed within the wetted perimeter of the creek shall be clean and free of silt, overburden and other substances deleterious to aquatic life.

.4 Pertinent operations shall be altered or suspended immediately at the request of Fisheries and Oceans Canada or the Ministry of Environment should they be considered detrimental to the fisheries resource.

.5 The Contractor shall follow all environmental regulations, guidelines, and procedures as required by the Ministry of Environment, the Fisheries and Oceans Canada, the Town of Revelstoke, and any other governing authority.

2.7 Quality of Workmanship

.1 The Corporation recognizes that the key people in a project of this nature (i.e., river flow control and river stabilization in fisheries sensitive areas) are the operators of the equipment and site superintendent.

.2 Award of this contract will be subject to the Contractor providing a machine operator who has previous experience in instream works and bioengineering implementation and who can provide acceptable references from recognized authorities that attest to his demonstrated competence on projects of a similar nature.

2.8 Control of River Flows

.1 The Contractor shall furnish all materials and be responsible for the design, placement, maintenance and subsequent removal of any temporary training berms, diversion channels, or other diversion and protective works necessary to prevent the river flows from impacting on bank shaping and bioengineering implementation operations.

.2 Prior to constructing temporary river flow diversions or installing a temporary culvert(s), the Contractor shall consult with the Engineer in order to confirm that the proposed approach is acceptable to the Fisheries agencies.

.3 Adequate precautions shall be taken to prevent silt and other pollutants from discharging directly, or indirectly, into the creek.

.4 The Contractor shall be responsible for, and make good at his own expense, any reasonable damage caused by water, failure of any part of his diversion or protective works, failure of equipment, inadequacy of equipment, omissions or actions in his performance of the work.

.5 The Contractor shall be responsible to monitor the weather and shall have a contingency plan prepared to secure the site during rain and high river flow events.

2.9 Site/Creek Access

.1 Access to the stream channel is to be made from the access points shown in the drawings and identified at the time of the pre-tender meeting. Any other access point to the streambed must be approved by the Engineer prior to any establishment of that access.

END OF SECTION

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PART 1 GENERAL

1.1 Scope of Work

.1 This section covers clearing and grubbing of areas indicated on contract drawings or as designated by the Engineer.

1.2 Definitions

.1 Close-cut clearing consists of cutting off at or near flush with original ground surface standing trees, brush, scrub, roots, stumps and embedded logs and disposing of fallen timber and surface debris, including stockpiling and slash burning as directed.

1.3 Regulatory Agency Requirements

.1 Obtain necessary permits.

1.4 Protection

.1 Protect trees, shrubs, plants and other features which are to remain as shown on the drawings and where specified by the Engineer.

.2 Do not clear outside of the limits designated on contract drawings or as designated by the Engineer.

.3 Apply approved tree paint to cuts or scars suffered by vegetation designated to remain.

1.5 Control of River/Creek Flows

.1 The Contractor shall furnish all materials and be responsible for the design, placement, maintenance and subsequent removal of any temporary cofferdams, diversion channels, or other diversion and protective works necessary to prevent the river flows from impacting on bank shaping and bioengineering placement operations.

.2 Prior to constructing temporary river flow diversions or installing any temporary culvert(s), the Contractor shall consult with the Engineer in order to confirm that the proposed approach is acceptable to the regulatory agencies.

.3 Adequate precautions shall be taken to prevent silt and other pollutants from discharging directly, or indirectly, into the stream.

.4 The Contractor shall be responsible for, and make good at his own expense, any reasonable damage caused by water, failure of any part of his diversion or protective works, failure of equipment, inadequacy of equipment, omissions or actions in his performance of the work.

PART 2 MATERIALS

2.1 Tree Paint

.1 Use only tree paint that has prior approval of the Engineer.

PART 3 EXECUTION

3.1 Clearing

.1 In areas to be used as access or for site works, clearing shall be close-cut.

.2 It is not expected that trees will need to be cleared from the work area. Trees clearly in the work area (area of excavation and bioengineering placement) may be cleared under the supervision of the engineer, however, all mature trees (>20 cm DBH) on the margin of the work area will be retained until it is determined that the trees must be removed.

.3 Cut off unsound branches and cut down dangerous trees overhanging area cleared.

.4 Remove trees, shrubs, uprooted stumps and surface debris not designated to remain.

3.2 Removal and Disposal

.1 All waste materials, including debris from clearing or any debris or rubbish encountered on the site are to be removed from the site and disposed of at locations obtained by the Contractor.

.2 Burning of debris will not be permitted within the Columbia Shuswap Regional District.

.3 The cost for removal and disposal off site of all waste materials is to be included in the lump sum tender prices.

END OF SECTION

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No. Clause Page

PART 1 GENERAL

1.1 Scope of Work

.1 This section includes an explanation of method, equipment and material required to excavate, install, backfill, grade and vegetate all bioengineering treatments.

.2 Complete all installations and associated work as shown on the drawings and described in the specifications.

1.2 Related Work

.1	Special Project Requirements	Section 01350
.2	Earthwork	Section 02300
.3	Seeding	Section 02920
.4	Planting of Shrubs and Groundcover	Section 02950

1.3 Definitions

.1 Bioengineering = Biotechnical Slope Stabilization: use of a combination of live vegetation and mechanical slope stabilization to improve the erosion resistance of the river bank.

.2 Willow Fascines: fascines are stems and branches of live rootable plant material that are tied together in long bundles. The bundles are anchored in trenches with construction stakes and live stakes to convey drainage, provide riprarian vegetation and trap sediment.

.3 Brush Layers: live cuttings of willow branch material which are placed in alternating layers with soil wraps. Branches are typically placed in a criss-crossed fashion on a prepared sloping (>10%) surface and backfilled. The brush layers provide surface roughness which interrupt overland flow and provide longer term root cohesion.

.4 Modified Brush Layers: live cuttings of willow branch material which are placed in a slope such that the lines of cuttings follow the slope contours. Branches are typically placed in a criss-crossed fashion on a prepared sloping (>10%) surface and backfilled. The modified brush layers provide surface roughness which interrupt overland flow and provide longer term root cohesion.

.5 Willow Live Stakes: lengths of live willow material (branch or stem), typically not more than 4 years in age, that are commonly installed for biotechnical stabilization. A planting technique whereby the willow stakes are driven into the soil by hammering with a soft mallet.

.6 Vegetated Geogrid and Soil Wraps: lifts of soil and grass seed placed within wrapped biodegradable erosion control matting and staked into place with willow live stakes. Soil wraps are commonly constructed to provide erosion protection and soil stabilization while vegetation becomes established.

1.4 Inspection and Testing

.1 The Contractor will arrange for all testing for work described in this Section, as requested by the Engineer.

PART 2 PRODUCTS

2.1 Willow Fascines

.1 Fascines: to be comprised of willow stems and branches ranging from 6 mm to 40 mm in diameter and a minimum of 1 m in length.

.1 The fascine bundle should have a mean diameter of 200 mm and should be constructed to lengths no shorter than 2 m and ideally should be continuous. The fascine bundle shall be tied with twine at intervals between 300 mm and 400 mm.

.2 As the fascines are being prepared or installed, planting soil shall be placed in the fascine at two intervals such that approximately 50% of the fascine interstices are filled with soil.

.3 The individual stems and branches should be bundled so that the growing and butt ends are alternating. The ends of the fascine should be tapered at each end to allow for overlapping with the adjacent fascine.

.2 Construction Stakes: to be untreated wooden stakes, a minimum of 900 mm long.

.3 Species may include: Pacific willow (Salix lucida), Barclay's willow (Salix barclayi), Bebb's willow (Salix bebbiana), Drummond's willow (Salix drummondiana), or other species approved by Project Biologist.

2.2 Modified Brush Layers

.1 Brush Layers: to be comprised of willow stems and branches ranging from 12 mm to 40 mm in diameter and a minimum of 1 m in length.

.1 The brush layers should be placed such that there is a least two layers of brush per layer and should conform to the brush densities specified on the drawings.

.2 Willow stems should be placed at a density of 20 stems per meter in a grid.

.2 Species may include: Pacific willow (Salix lucida), Barclay's willow (Salix barclayi), Bebb's willow (Salix bebbiana), Drummond's willow (Salix drummondiana), or other species approved by Project Biologist.

2.3 Live Stakes

.1 Live stakes shall be minimum 300 mm long, and have a minimum diameter of 30 mm.

.2 Species may include: Pacific willow (Salix lucida), Barclay's willow (Salix barclayi), Bebb's willow (Salix bebbiana), Drummond's willow (Salix drummondiana), or other species approved by Project Biologist.

2.4 Planting Soil

.1 All soil to be used in the vegetated geogrid soil wraps shall conform to the specifications for Planting Soil in Section 02950 – Planting of Trees, Shrubs and Groundcover.

2.5 Rock Ballast

.1 Rock ballast used for ballasting of large wood structures shall be durable, angular quarry rock, and shall be well-graded within the following gradation limits (class as shown on drawings, sketches or as designated by the Engineer):

.1 **Class III**

.1 Nominal 800 mm diameter or 700 kg mass

.2 Allowable local velocity up to 5.0 m/s with embankment slope 1/1.5

.3 Grading specification:

.1	100%	smaller than 1,200 mm or 2,300 kg
.2	at least 20%	larger than 900 mm or 1,100 kg
.3	at least 50%	larger than 800 mm or 700 kg
.4	at least 80%	larger than 500 mm or 200 kg

.2 Rock ballast shall have the following properties:

.1 igneous rock (i.e., granite preferred)

.2 specific gravity of 2.65

.3 dense, unweathered, without fracture

2.6 Large Wood

.1 Large wood to be used in erosion protection structures shall be from coniferous species (Western Red Cedar, Hemlock or Douglas Fir) and shall measure 6 to 9 m in length with a minimum 60 cm diameter. Both logs with and without root-wads shall be used.

2.7 Erosion Control Matting

.1 Erosion control matting to be used for the vegetated geogrid and soil wraps shall be the North American Green C125BN Erosion Control Blanket, or equivalent. The product shall be 100% biodegradable with a functional longevity of 24 months.

2.8 Chain Attachment for Large Wood

.1 Galvanized chain shall be used to anchor large wood to boulder ballasts. Chain shall provide 2650 lb working load limit.

.2 Chain shall be attached to boulder ballast and large wood using an assembly of 3/8" galvanized lag bolts, 3/8" galvanized eye bolts, mechanical drop in anchors and link connecting chain fittings or equivalent.

PART 3 EXECUTION

3.1 Willow Fascines

.1 Fascine shall meet the specifications in Part 2.

.2 Prepare a trench network in the bioengineering area, for the fascines. The trench should be a maximum of 200 mm wide and extend 150 mm into the planting soil fill. The soil surface in the trench should be sufficient loose such that the fascine can be effectively embedded in the trench and in good contact with the soil.

.3 Place the fascines in the trench immediately after preparing the trench. At intersections between the two fascine lengths, at least 50% of the branches of one fascine should intersect the next fascine.

.4 A series of live stakes should be used to secure the fascines. The first row of live stakes should be installed on the downhill side of the fascine and driven into the soil at near horizontal angle, and spaced at maximum intervals of 1.5 m. The second series of stakes should be placed directly through the fascine from the top down, and should be evenly spaced between the other stakes. These stakes should not be installed at intervals less than 1.5 m.

.5 The tapered ends of the fascine are to be overlapped, intermixed and bound such that a uniform diameter is achieved at the transition points.

.6 Backfill the fascine so that 70% of the fascine and the interstices of the fascine are filled with the materials specified on the design drawings. The soil above and below the fascine should be compacted by walking and working on it. Following backfill, only the crown of the fascine should be visible.

3.2 Brush Layers

.1 Brush layers shall be placed beneath and between vegetated geogrid and soil wrap layers. For the first brush layer, prepare the slope by excavating and preparing the brush layer bench. The bench surface shall be inclined at least 10% from horizontal opposite to the slope aspect and slightly scarified.

.2 Place the brush layers in a criss-crossing fashion such that there is at least a thickness of two brush elements per brush layer. Approximately 60 to 70% of the brush element should be fully backfilled in the slope, with approximately 30 to 40% exposed. The density of brush elements shall be as specified on the design drawings.

.3 Place a vegetated geogrid and soil wrap layer as per Section 3.5.

.4 Alternate brush layer and soil wrap layers until elevation specified in the design drawings is reached.

3.3 Modified Brush Layers

.1 In the modified brush layer portions of the bioengineering treatment (Site B), prepare the slope by excavating and preparing the brush layer bench. The bench surface shall be inclined at least 10% from horizontal opposite to the slope aspect and slightly scarified.

.2 Place the modified brush layers in a criss-crossing fashion such that there is at least a thickness of two brush elements per brush layer. Approximately 60 to 70% of the brush element should be fully backfilled in the slope, with approximately 30 to 40% exposed. The density of brush elements shall be as specified on the design drawings.

3.4 Willow Live Stakes

.1 Willow live stakes shall be driven into the prepared slope at the specified densities using a rubber mallet or light (5 kg) sledge hammer. To prepare the slope soil, the planting soil should be compacted by hand or with light compaction equipment such that a hammer is required to insert the live stake, but not excessive force.

.2 Willow live stakes shall be driven into the slope at angles close to horizontal, and should be inserted so that the natural orientation of the cutting is preserved. That is, older portion of the plant should be inserted into the slope and the younger portion should be exposed. To improve installation, the bottom of the willow stake should be sharpened.

.3 The driven end of the live stake should also be trimmed such that all damaged portions of the willow stake is removed. At least 50 mm and not more than 100 mm of the live stake should be exposed.

3.5 Vegetated Geogrid and Soil Wraps

.1 Erosion Control Matting: non-woven coir matting - North American Green C125 BN or approved equivalent

.2 Seeding and planting: refer to Section 02920 - Seeding and Section 02950 - Planting of Shrubs and Groundcovers.

.3 All willow stems must be kept moist and shaded during cutting, transport, and on-site storage. Submerge cut ends of willow cuttings in water for more than 24 hours of storage. Spray foliage and small branches with water every 4 hours during daylight storage. If damage occurs, take proper corrective measures to satisfaction of Project Biologist or replace with new approved stock. Willow stems that have been improperly stored during cutting, transport, or on-site storage will be rejected by the Project Biologist.

.4 The erosion control matting shall be installed overtop a brush layer, filled with approximately 0.3 to 0.5 m of planting soil or native fill material.

.5 The upper fold of the soil wraps shall be anchored by live willow stakes installed as per Section 3.3 and covered by a brush layer.

3.6 Temporary Irrigation

.1 The Contractor shall provide a proposed temporary irrigation system plan complete with layout and product information to the Engineer 3 weeks prior to installation. The proposed irrigation system is subject to approval by the Engineer.

3.7 Rock Ballast and Large Wood Stockpiling

.1 Stockpile aggregates and logs on site in locations agreed with Engineer. Significant settlement may occur at stockpile sites.

.2 Stockpile aggregates and logs as directed by the Engineer.

.3 Stockpiling sites shall be level, well drained, and of adequate bearing capacity and stability to support stockpiled materials and handling equipment.

.4 Stockpile materials in uniform layers not exceeding 1.5 m in depth.

.5 Snow-fencing shall be installed around the stockpile perimeter and secured to restrict access by unauthorized personnel.

.6 Warning signs shall be securely placed along the perimeter of the stockpile fencing. The signs should clearly state that the stockpiles are unsafe and there is potential danger from rockfall or slippage on the stockpile or near the stockpile perimeter.

3.8 Rock Ballast Placement

.1 Rock shall be off-loaded from trucks and installed such that the specified ballast requirement is achieved along the wood anchored in the bank and at the toe.

.2 Rock shall be placed directly over the undisturbed fluvial gravel, native bedload material or gravel fill material, or as directed by the Engineer.

.3 Dumping or rolling of rock down the bank face is not an acceptable method of placement. Rock must be carefully placed into position.

.4 Rock shall be placed with the use of an excavator equipped with a hydraulic thumb. The operator of the excavator shall be experienced in the placement of rock ballast using a hydraulic thumb.

3.9 Large Wood Placement

.1 Logs shall be off-loaded from trucks and installed at the locations specified on the drawings or as directed by the Engineer.

.2 Logs that project into the stream flow shall be embedded in the bank using an excavator equipped with a hydraulic thumb to force the wood to the specified embedment depth. Rock ballast will be placed to further anchor the wood in place.

.3 If the embedment depth cannot be achieved with this method, a trench will be excavated and the log placed in the trench. The trench shall then be backfilled as per Section 2300.

.4 Logs that are embedded parallel to the bank shall be placed in an excavated trench and the trench shall then be backfilled as per Section 2300.

.5 The apex of triangular log structures shall be fixed together using a chain attachment. Galvanized lag bolts and 3/8" galvanized chain (or equivalent) shall be used to attach the apex of the logs. Effort shall be made to attach logs such that the chain and bolt assembly is not visible from the top of the structure to keep the works looking "natural".

3.10 Chain Attachment of Large Wood and Boulder Ballast

.1 Logs shall be attached to boulder ballast using an assembly of 3/8" galvanized lag bolts, 3/8" galvanized eye bolts, mechanical drop in anchors and link connecting chain fittings or equivalent.

.2 The boulder ballast shall be placed in a trench excavated immediately adjacent to or slightly below where the log will be installed. The trench will be backfilled such that only the anchor and eyebolt are above grade.

.3 The chain shall be secured to the boulder ballast using a link connecting chain fitting and galvanized eye bolt threaded into the mechanical drop in anchor in the ballast.

.4 The galvanized chain shall be secured to the logs using a galvanized lag bolt.

.5 Each log projecting into the flow will have a minimum of two attached, embedded boulders for ballast. The remaining boulder ballast will be placed around the wood and on top of the embedded lengths of wood as directed by the Engineer and as per Section 2380 Part 3.7.

.6 Effort shall be made to attach logs such that the chain and bolt assembly is not visible from the top of the structure to keep the works looking "natural".

END OF SECTION

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PART 1 GENERAL

1.1 Scope of Work

.1 The work in this section includes the supply of all materials and performing all operations necessary to complete hydraulic seeding (hydro-seeding), mechanical dry seeding or hand seeding. This section must be referenced to and interpreted simultaneously with all other sections pertinent to the works described herein.

1.2 Related Work

.1	Special Procedures	Section 01350
.2	Biotechnical Bank Stabilization	Section 02380
.3	Planting of Shrubs and Groundcover	Section 02950

1.3 General Requirements

.1 The Contractor shall prepare the subgrade, place topsoil, and seed in all areas disturbed by construction, and as otherwise indicated on the drawings.

.2 All material, labour and plant installation shall be in accordance with the B.C. Landscape Standard jointly produced by the B.C. Society of Landscape Architects and the B.C. Nursery Trades Association.

.3 The Project Engineer shall be contacted to arrange inspections before and after hydraulic seeding; allow for a minimum of one days notice.

1.4 Scheduling

.1 Schedule all operations to ensure optimum environmental protection, grading, growing medium placement, planting, seeding or sodding operations as outlined in these Specifications. Organize scheduling to ensure a minimum duration of on-site storage of plant material, minimum movement and compaction of growing medium, and prompt mulching and watering operations. Coordinate work schedule with scheduling of other trades on-site.

.2 Coordinate and schedule work such that no damage occurs to materials before or after placement. In particular, requirements of living plant material to be met.

.3 Plan, schedule and execute work to ensure a supply of water for landscape purposes in adequate amounts and at adequate pressures for satisfactory irrigation of all plants.

1.5 Handling and Storage

.1 Store all grass seed and nurse crop seed, mulch, fertilizers and related materials, where required, in dry, weatherproof storage place and protected from damage by heat, moisture, rodents or other causes until time of seeding. Do not remove or deface labels or other identification.

1.6 Drainage Control

.1 Provide for proper water management and drainage of site during construction. Include silt traps, erosion control measures, temporary water collection ditches, as well as their adequate maintenance during construction period.

1.7 Samples

.1 Provide samples of all materials required, handle and ship in such a manner that they are representative of material or product sampled.

1.8 Site Examination

.1 Do not carry out seeding work in areas or over surfaces that are not properly prepared. Examine site before starting work to verify all surfaces are properly identified.

1.9 Inspection and Testing

.1 Contractor will arrange for all testing for work described in this section, as requested by the Engineer.

PART 2 PRODUCTS

2.1 Grass Seed

.1 Grass seed to meet requirements of Canada Seed Act for Canada No. 1 seed. Where specified, all nurse crop seed to meet requirements of Canada Seed Act for Canada No. 1 seed.

.2 Seed mixtures to be:

Vegetated Geogrid

Perennial Ryegrass	28%
Profile Orchardgrass	20%
Creeping Red Fescue	15%
Italian Rye Grass	10%
Tall Fescue	10%
Timothy	8%
Single Cut Red Clover	5%
White Clover	5%
Red Top	2%

Legumes Inoculated

(Richardson's Coastal Revegetation Mix or approved equal)

.3 Seed to have minimum germination rate of 75% and minimum purity of 97%, except where otherwise required by professional selecting seed mixture.

.4 Seed to be packed and delivered in original containers clearly showing:

.1 Name of supplier

.2 Analysis of seed mixture

.3 Percentage of pure seed

.4 Year of production

.5 Net weight (mass)

.6 Date and location of bagging

.7 Mixture to be mixed and supplied by recognized seed house.

2.2 Hydraulic Seeding

.1 The slurry mixture shall be prepared in accordance with the manufacturers' specifications. The slurry mixture applied per hectare shall be:

.1 seed mixture - 244 kg;
.2 mulch - Type I 1,700 kg;
.3 tackifier - in accordance with manufacturer's specifications;
.4 water - minimum as required; and
.5 fertilizer - 224 kg.

.2 The seed shall consist of Richardson Seed Company Limited's "Coastal" Revegetation Mixture, or similar product by other supplier. The mixture shall be Canada "Certified" seed, in accordance with Government of Canada Seeds Act and "Seeds Regulations".

.3 The mulch shall be specially manufactured for use in hydraulic seeding equipment, non-toxic, water activated, green colouring, free of germination and growth inhibiting factors. It shall be Type – mulch, with the following properties:

.1 made from wood cellulose fibre;
.2 have an organic matter content of 95% or minus 0.5%;
.3 have a pH of 6.0; and
.4 have potential water absorption of 800-900%.

.4 The tackifier shall be water dilutable liquid dispersion containing polyvinyl acetate polymer emulsion.

.5 The fertilizer shall be in accordance with the Fertilizers Act and "Fertilizers Regulations." It shall be a synthetic, slow release product with a composition of 19% nitrogen, 19% phosphorus and 19% potassium in a water insoluble form.

.6 The water to be mixed with the products shall be supplied by the Contractor and be free of impurities that would inhibit germination and growth.

2.3 Water

.1 Free of impurities that would inhibit germination and growth or may be harmful to environment.

.2 Contractor to supply.

2.4 Fertilizer

.1 To Section 02950 – Planting of Trees, Shrubs and Groundcovers.

2.5 Planting Soil

.1 To Section 02950 – Planting of Trees, Shrubs and Groundcovers.

PART 3 EXECUTION

3.1 Finish Grade Preparation

.1 Do not perform work under adverse field conditions such as frozen soil, excessively wet or dry soil or soil covered with snow, ice or standing water.

.2 Verify that grades are correct. If discrepancies occur, notify Engineer and do not commence work until instructed by Engineer.

.3 Remove and dispose of weeds; debris; soil contaminated by oil, gasoline and other deleterious materials; to approved off-site disposal area.

.4 Loosen surfaces of areas that are excessively compacted by means of thorough scarification, discing or harrowing, to minimum 150 mm depth.

.5 Finish grade smooth to extent required for class of seeding to be carried out, firm against footprints, loose textured, and free of all stones, roots, branches, etc. larger than diameter required for removal for class of seeding to be carried out.

3.2 Soil Placement

.1 Place planting soil to a minimum depth of 100 mm.

.2 Soil and soil additives shall be protected from extreme wetting by rain or other agents, and against contamination by weeds and insects. Do not move or work soil when excessively wet, dry, or frozen, or in any manner which will adversely affect the soil structure.

.3 Fertilizers and other chemical ingredients shall be delivered and stored in the manufacturer's original containers, and be fully protected against damage and moisture until incorporated into the work.

3.3 Seeding - General

.1 Scheduling: carry out seeding during periods that are most favourable for establishment of healthy stand of grass. Seed only during calm weather and on soil that is free of frost, snow and standing water, when seasonal conditions are likely to ensure successful germination and continued growth of all varieties of seed in grass mix.

.2 Methods: apply seed by Method A - Mechanical Dry Seeding or Method B - Hydraulic Seeding unless otherwise specified. Hand seeding is not recommended. Hand seed only when site conditions preclude above two methods.

.3 Rates of Application: rates of application of fertilizer, seed mix, mulch, and other components to be based on analysis of season, climate, terrain, soil, and establishment and maintenance conditions affecting project, refer to manufacture's guidelines.

3.4 Application by Mechanical Dry Seeding

.1 Measure all grass seed, nurse crop seed, water, fertilizer, and mulch accurately before application.

.2 Apply required fertilizer to and work well into topsoil by discing, raking, or harrowing at rate required.

.3 Apply seed at rate required by means of approved mechanical dry seeder which accurately places seed at specified depth and rate and rolls in single operation.

.4 Apply seed in two intersecting directions, except where conditions dictate seeding in one direction only.

.5 Apply mulch with seed or immediately following seeding with approved mulcher. No area to be seeded in excess of that which can be mulched on same day.

.6 Apply mulch to form even, uniform mat over entire area.

.7 Use agricultural, water ballast type roller, not less than 500 mm diameter smooth steel drum, width not less than width of landscape seeder. Adjust ballast to suit site conditions.

.8 Blend applications 150 mm into adjacent grass areas or previous applications to form uniform surfaces.

3.5 Application by Hydraulic Seeding

.1 Hydraulic seeding shall not be conducted under adverse conditions, such as wind speeds over 10 km/h, frozen soil, excessively wet or dry soil covered with snow, ice or standing water.

.2 Hydraulic seeding shall be completed with care to ensure that fertilizer in solution does not come in contact with the foliage of any trees, shrubs, or other susceptible vegetation. Seed or mulch shall not be sprayed on objects not intended for seeding.

.3 Structures, signs, fences, shrubs, trees, utilities or any surfaces other than those specified shall not be hydraulically seeded. Existing site equipment, creek channels, roadways, landscaping, reference points, monuments, markers and structures shall be protected from damage.

.4 All over-spray shall be removed immediately.

.5 Seed, fertilizer, mulch and water slurry shall not be left in the tank for more than 4 hours. Slurry left in the tank over the maximum time shall not be used for seeding and shall be disposed of off-site.

.6 Inspections by the Project Biologist shall be conducted at the time of hydraulic seeding and following seeding.

3.6 Application for Hand Seeding

.1 Use hand seeding method as specified by the Engineer only when site conditions preclude above two methods.

.2 Use all procedures specified in 3.3 above except as modified by specifications as follows:

.1 Use Cyclone type manually operated seeder. Adjust ballast to suit site conditions.

.2 Embed seed into soil to depth of 10 mm. Not less than 85% of seed to be placed at specified depth and covered by soil.

.3 Consolidate mechanically seeded areas by rolling area with manually operated, water ballast, landscaping type, smooth steel drum roller, immediately after seeding. Adjust ballast to suit site conditions.

3.7 Clean-up

.1 Remove all materials and other debris resulting from seeding operations from job site.

3.8 Grass Maintenance

.1 Begin maintenance for seeded areas immediately after seeding has been completed, and continue until issuance of Certificate of Total Performance.

.2 Include all measures necessary to establish and maintain grass in a vigorous growing condition, including, but not limited to following:

.1 Water when required and with sufficient quantity to prevent grass and underlying soil from drying out.

.2 Roll when required to remove any minor depressions or irregularities.

.3 Immediately repair seeded areas that show deterioration or bare spots. Top-dress all areas showing shrinkage due to lack of watering and seed with original seed mix.

.4 Protect all seeded areas with warning signs, temporary wire or twine fences, or other necessary means.

.5 No mowing is required.

3.9 Conditions for Total Performance

.1 Engineer will issue Certificate of Total Performance only when following conditions exist:

.1 Growing medium quality, fertility levels, depths and surface conditions are as specified in Contract Documents.

.2 Grasses are required varieties, free of varieties other than those specified.

.3 Grass areas are relatively free of weeds, containing no more than two broadleaf weeds or ten annual weeds or weedy grasses per m^2.

.4 Grass is sufficiently established that its roots are growing into underlying growing medium.

.5 Seeded areas have been mown at least twice, to a height of 38 mm, last mowing being within 48 h of inspection and acceptance.

.6 Grasses established in sufficient density that no surface soil visible when mown to height of 38 mm.

.7 Specified maintenance procedures have been carried out.

3.10 Guarantee/Maintenance

.1 Customary one-year guarantee period for construction industry will apply as standard for landscape work. Contractor to guarantee all materials and workmanship for a period of one full year from date of Total Performance, unless specified otherwise in Contract Documents.

.2 Guarantee includes replacing all seeded areas determined by Engineer to be dead or failing at end of guarantee period. Replacements to be made at next appropriate season, and conditions of guarantee will apply to all replacement seeding for one full growing season.

.3 Guarantee will not apply to seeded areas damaged after date of Total Performance by causes beyond Contractor's control, such as vandalism, acts of God, excessive wear and tear or abuse. Contractor is responsible for work until Total Performance. After Total Performance, Owner is responsible for work and proper maintenance.

END OF SECTION

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PART 1 GENERAL

1.1 Description

.1 Provide all labour, materials, equipment and services required for planting of shrubs and groundcovers including but not limited to:

.2 All planted areas indicated on the plan.

1.2 Related Work

.1	Biotechnical Slop Stabilization	Section 02380
.2	Seeding	Section 02920

1.3 Plant Source Quality Control

.1 Obtain approval from Engineer of plant material at source prior to installation of plant material.

.2 Imported plant material to be accompanied with necessary permits and import licenses. Conform to federal and provincial regulations.

.3 All plant material shall be reviewed at the project site by the Engineer prior to planting. Plant material that is rejected by the Engineer shall be replaced at the Contractor's expense.

1.4 Scheduling

.1 Obtain approval from Consultant of schedule 7 days in advance of shipment of plant material.

.2 Schedule to include:
- .1 Date for selection of representative sample at source by Consultant.
- .2 Quantity and type of plant material.
- .3 Shipping dates.
- .4 Arrival dates on site.
- .5 Planting Dates.

.3 Schedule all operations to ensure optimum environmental protection, grading, growing medium placement, planting, seeding or sodding operations as outlined in these Specifications. Organize scheduling to ensure a minimum duration of on-site storage of plant material, minimum movement and compaction of growing medium, and prompt mulching and watering operations. Coordinate work schedule with scheduling of other trades on-site.

.4 Coordinate and schedule such that no damage occurs to materials before or after placement. In particular, meet requirements of living plant material.

.5 Plan, schedule and execute work to ensure a supply of water for landscape purposes in adequate amounts and at adequate pressure for satisfactory irrigation of all plants.

1.5 Delivery, Handling and Storage

.1 Transport trees and plants to site in compliance with Section 8.1.2 of the British Columbia Landscape Standard to ensure proper protection.

.2 Handle and store in compliance with Section 8.1.3 of the British Columbia Landscape Standard.

.3 Take particular care to avoid damage and/or drying out until planting.

.4 Protect plant material from frost, excessive heat, wind and sun during delivery.

.5 Immediately store and protect plant material which will not be installed within 1 hour after arrival at site in storage location approved by Consultant.

.6 Protect plant material from damage during transportation:

.1 When delivery distance is less than 30 km and vehicle travels at speeds under 80 km/h, tie tarpaulins around plants or over vehicle box.

.2 When delivery distance exceeds 30 km or vehicle travels at speeds over 80 km/h, use enclosed vehicle.

.7 Protect stored plant material from frost, wind and sun and as follows:

.1 For bare root plant material, preserve moisture around roots by heeling-in or burying roots in topsoil and watering to full depth of root zone.

.2 For pots and containers, maintain moisture level in containers. Heel-in fibre pots.

.8 Remove leaves from willow cuttings immediately following harvesting.

.9 Install willow cuttings within 48 hours of harvesting unless approved by Engineer.

.10 Submerge cut ends of willow cuttings in water for more than 24 hours of storage. Spray foliage and small branches with water every 4 hours during daylight storage.

.11 If damage occurs, take proper corrective measures to satisfaction of Engineer or replace with new approved stock.

1.6 Drainage Control

.1 Provide proper water management and drainage of site during construction. Include silt traps, erosion control measures, temporary water collection ditches, as well as their adequate maintenance during construction period.

1.7 Samples

.1 Provide samples of all materials required, handle and ship in such a manner that they are representative of material or product sampled.

1.8 Site Examination

.1 Do not carry out landscaping work in areas or over surfaces that are not properly prepared. Examine site before starting work to verify all surfaces are properly prepared.

1.9 Inspection and Testing

.1 Contractor will arrange for all testing for work described in this Section, as requested by the Engineer.

1.10 Warranty

.1 The Contractor hereby warrants that plant material as itemized on plant list, will remain free of defects in accordance with GC24, but for 2 full growing seasons.

.2 End-of-warranty inspection will be conducted by Consultant.

.3 Consultant reserves the right to extend Contractor's warranty responsibilities for an additional one year if, at end of initial warranty period, leaf development and growth is not sufficient to ensure future survival.

PART 2 PRODUCTS

2.1 Plant Material

.1 Selection of species to be as specified in Planting Notes on drawings. Should specified species not be available, the Engineer is to be notified so that an alternative choice can be made. Do not make substitutions without approval of the Engineer.

.2 Origin

.1 All plant material to be nursery grown stock or approved field-harvested native plants unless specified otherwise.

.2 All plant material to comply with British Columbia Landscape Standard for container grown plants and Landscape/Paysage Canada Guide Specification for Nursery Stock.

.3 All nursery grown plants, as a minimum requirement, to comply with Landscape/Paysage Canada Guide Specification for Nursery Stock with respect to size, grade and quality.

.4 Container plants to be grown for length of time necessary to achieve adequately developed root structure.

.5 Plants to be true to name, type and form, and representative of their species or variety.

.6 Plants to be compact and properly proportioned, not weak or thin, or injured by being planted too closely in nursery rows.

.7 Willow cuttings to be freshly cut live woody material less than 4 years old.

.8 Willow cuttings to be harvested within 120 km of the planting site.

.9 Willow cuttings to be harvested from a site with full knowledge of site owners or managers.

.10 Plants to have normal, well-developed branches, vigorous fibrous root systems and to be healthy, vigorous plants free from defects, decay, disfiguring roots, sun scald injuries, abrasions of bark, plant diseases, insect pests' eggs, borers and all forms of infestation or objectionable disfigurements.

.11 Trees to have straight stems (unless this is uncharacteristic) and to be well and characteristically branched for species or variety.

.12 Ground cover plants to have healthy tops to a size proportionate to above root requirements typical of species or variety.

.13 Rootballs and soil in containers to be free from pernicious perennial weeds.

.14 All trees and plants to be inspected by Engineer upon delivery to site.

2.2 Water

.1 Free of impurities that would inhibit germination and growth or may be harmful to environment.

.2 Contractor to supply.

2.3 Fertilizer

.1 Chemical Fertilizers

.1 Fertilizers to be standard commercial brands, meeting requirements for Canada Fertilizer Act.

.2 All fertilizers to be in granular, pelleted or prill form, and to be dry, free flowing and free from lumps.

.3 Fertilizers to have a guaranteed N-P-K analysis.

.4 Fertilizers to be packed in standard waterproof containers, clearly marked with name of manufacturer, weight and analysis.

.5 Fertilizer to be stored in a weatherproof storage place and in such a manner that it will stay dry and its effectiveness is not impaired.

.6 Fertilizers to include, but not be limited to, those listed below in Table 1:

Table 1 - Fertilizers

Name	Min. Proportion By Weight	Main Component
Ammonium Nitrate	33.5%	N
Ammonium Sulphate	21.0%	N
Superphosphate (0-20-0)	8.5%	P (20% P_2O_5)
Superphosphate (0-45-0)	19.5%	P (45% P_2O_5)
Potassium Sulphate	41.5%	K (50% K_2O)
Potassium Chloride (muriate)	50.0%	K (60% K_2O)
Potassium Nitrate	13.0%, 36.5%	N, K (44% K_2O)
Iron Sulphate	20.0%	Fe, as metallic

Name	Min. Proportion By Weight	Main Component
Gypsum	23.0%	Ca
Rock or Oyster Shell Lime, Limestone Flour	40.0%	Ca
Dolomite Lime	20.0%, 13.0%	Ca, M
Bonemeal	20.0%, 3.0%	P_2O_5, N

2.4 Planting Soil

.1 Planting soil to be a friable loam, neither heavy clay, nor of very light sandy nature, containing a minimum of 4% organic matter for clay loams and 2% for sand loams, to a maximum of 20% by volume. To be free from subsoil, roots, noxious grass, weeds, toxic materials, stones over 30 mm, foreign objects, and with an acidity range (pH) of 5.5 to 7.5. To be free from crabgrass, couchgrass, equisetum or noxius weeds or seeds or parts thereof.

.2 Freedom from rock or debris to be such that 95% to 100% of particles pass a 25 mm sieve and 85% to 100% pass a 9.5 mm sieve.

.3 Population of any single species of plant pathogenic nematode to not exceed 1000 per litre of growing medium.

.4 To meet the British Columbia Landscape Standard specifications for growing medium.

.5 All proposed planting soils shall be reviewed by the Engineer for acceptance prior to purchase.

PART 3 EXECUTION

3.1 Pre-planting Operations

.1 Ensure plant material acceptable to Engineer.

.2 Remove damaged roots and branches from plant material.

.3 Apply anti-desiccant to conifers and deciduous trees in leaf in accordance with manufacturer's instructions.

3.2 Excavation and Preparation of Planting Beds

.1 Establishment of sub-grade for planting beds to Section 02300 - Earthworks.

.2 For individual planting holes:

.1 Excavate to depth and width as indicated.

.2 Remove subsoil, rocks, roots, debris and toxic material from excavated material that will be used as planting soil for trees and individual shrubs. Dispose of excess material.

.3 Scarify sides of planting hole or site.

.4 Remove water which enters excavations prior to planting. Notify Engineer if water source is groundwater.

3.3 Planting

.1 Ensure all planting in general compliance with Section 8.3 of the British Columbia Landscape Standard.

.2 Ensure planting does not interfere with any accesses or infrastructure.

.3 Time of Planting:

.1 Complete planting work during normal planting seasons as dictated by prevailing weather conditions. Do not plant in frozen ground or with frozen Rootballs, during extremely hot, dry weather, or during heavy rain.

.2 Take all necessary precautions to protect plant material from prevailing weather conditions during transportation and planting.

.3 Modified brushlayers, brushlayers and wattles to be installed during initial construction phase; livestakes to be installed November to March 15.

.4 Location of Planting: Plant trees as shown on Contract Drawings unless otherwise approved by Engineer. Tree numbers, spacings and locations will vary according to site conditions and amenities. Verify locations of significant trees on site with Engineer prior to planting. If underground obstructions are uncovered report to Engineer for resolution.

.4 Planting Procedures: Trees, Shrubs, Willow Cuttings

.1 Plant all trees in holes large enough to accommodate entire rootball plus topsoil. Excavate the hole to meet the diameter of rootball plus 600 mm. Backfill with topsoil to bring plant material to depth they were originally grown in nursery. Plant trees so that after settlement they will be at original growing medium depth.

.2 Fold back balled and burlapped stock top 1/3 of burlap without disturbing rootball. Remove container from grown stock before planting. Do not remove wire baskets.

.3 Backfill soil in 150 mm lifts. Tamp each lift to eliminate air pockets. When two-thirds of depth of planting pit has been backfilled, fill remaining space with water. After water has penetrated into soil, backfill to finish grade.

.4 Form watering saucer.

.5 Bare Root Planting: while dormant only.

.1 Cut back damaged or broken roots to living parts remaining. Spread roots evenly in planting pit.

.2 Place growing medium around roots, gently shaking tree so all soil particles sift into root system to ensure close contact with all roots and to prevent air pockets. Avoid direct contact with roots of fertilizer (except slow release) and also of manure, if used.

.6 Planting Procedures B Willow Cuttings for Modified Brushlayers, Brushlayers and Wattles

.1 Deliver all cuttings for brushlayers and wattles to site and protect from sun and drying winds. Keep cut end of willow cuttings submerged for storage more than 24 hours and spray foliage and small branches every 4 hours during daylight storage. Install brushlayers within 48 hours of cutting.

.2 Install brushlayers and wattles at planting density and location as specified in construction drawings.

.3 Install brush layers with 20% of cutting above surface and 80% within soil wrap layer.

.4 Place adequate growing medium around brush layers to prevent formation of air pockets, prior to installation of soil wrap above.

.5 Water brushlayers and wattles thoroughly during installation to ensure adequate soil moisture during recovery period.

.6 Once planting and mulching is complete, clean site of all excess soil, rock and debris.

.7 Planting Procedures - Willow Cutting for Livestakes

.1 Deliver livestakes to site and protect from sun and drying winds. Keep cut end of livestakes submerged for storage more than 2 hours and spray foliage and small branches every 4 hours during daylight storage. Install livestakes with 48 hours of cutting.

.2 Install livestakes at planting density and location as specified in construction drawings.

.3 Install livestakes with a maximum of 30% of the livestake above surface.

.4 Install livestakes from November 15 to March 15 during dormant season. Livestakes to be free of leaf growth prior to installation.

.5 Live stakes to be installed by hammering them with a soft mallet. In dense, or cobblely soils, a pilot hole should be driven with a steel bar, to avoid damaging the stake, and to ensure good penetration.

.6 Install livestakes without creating a large hole or air pocket surrounding stem. Ground surrounding livestakes must be tamped down to prevent air pocket from occurring.

.7 Once planting and mulching is complete, clean site of all excess soil, rock and debris.

3.4 Tree Support

.1 Immediately following planting, install tree supports where required to brace trees in upright position to prevent excessive motion.

.2 Install all stakes, clamps, anchors, collars, tighteners and guying wire such that no damage is done to tree.

.3 Ensure all materials and procedures comply with accepted landscaping practices.

.4 Repair all damage to satisfaction of the Engineer.

.5 Owner will remove tree stakes when trees are stable.

3.5 Watering

.1 Carry out watering as required and with sufficient quantities to prevent trees, willow cuttings, plants and underlying growing medium from drying out.

.2 For evergreen plant material, water thoroughly in late fall prior to freeze-up to saturate soil around root system.

.3 Continue as required until automated irrigation system is functioning.

3.6 Pruning

.1 Limit pruning to minimum necessary to remove dead or injured branches and to compensate for loss of roots as a result of transplanting.

.2 Prune in such a manner as to preserve natural character of plants.

.3 Use only clean sharp tools

.4 Clean and cut all cuts to branch collar leaving no stubs.

.5 Trace cuts, bruises or scars on bark back to living tissue and remove.

.6 Shape affected areas so as not to retain water, and paint all treated areas with a standard tree paint containing 1% naphthalene acetic acid.

3.7 Clean Up

.1 Remove from the site all cloth, rope, unused topsoil, surplus material and other debris resulting from planting operations.

.2 Dispose of all native excavated material off site.

.3 Neatly dress and finish all planting areas and flush all walks and paved areas clean to the satisfaction of the Consultant.

3.8 Maintenance

.1 Perform following maintenance operations from time of planting to issuance of Certificate of Total Performance.

.2 Water to maintain soil moisture conditions for optimum establishment, growth and health of plant material without causing erosion.

.3 Remove weeds as required.

.4 Replace or respread damaged, missing or disturbed mulch.

.5 For non-mulched areas, cultivate as required to keep top layer of soil friable..

.6 Apply pesticides in accordance with Federal, Provincial and Municipal regulations as and when required to control insects, fungus and disease. Advise Engineer of products proposed for use prior to application.

.7 Remove dead or broken branches from plant material.

.8 Keep trunk protection and guy wires in proper repair and adjustment.

3.9 Conditions for Total Performance

.1 Engineer will issue Certificate of Total Performance only when following conditions exist:

.1 Growing medium quality, fertility levels, depths and surface conditions are as specified in Contract Documents.

.2 All plants are of species and varieties specified and planted in locations shown on Contract Drawings.

.3 All plants are healthy and turgid.

.4 Water content in growing medium is to satisfaction of Engineer.

.5 All trees are staked as specified.

.6 All pruning is complete to satisfaction of Engineer.

.7 All planted areas are free of weeds.

.8 Mulch is in place as required.

.9 Unmulched areas are cultivated to leave a loose, friable, water-permeable surface.

3.10 Guarantee/Maintenance

.1 Customary one-year guarantee period for construction industry will apply as standard for landscape work. Contractor to guarantee all nursery and container grown plant materials and workmanship for a period of one full year from date of Total Performance unless specified otherwise in Contract Documents. Success and growth of willow cuttings will not be subject to guarantee unless inadequate or improper harvesting, handling, storage, installation, or watering has occurred.

.2 Guarantee includes replacing all nursery and container grown plants determined by Engineer to be dead or failing at end of guarantee period. Replacements to be made at next appropriate season, and conditions of guarantee will apply to all replacement plants for one full growing season.

.3 Engineer reserves the right to extend Contractor's guarantee responsibilities for an additional one year if, at end of initial guarantee period, leaf development and growth is not sufficient to ensure future survival.

.4 Guarantee will not apply to plants or other products damaged after Total Performance by causes beyond Contractor's control such as vandalism, acts of God, excessive wear and tear, or abuse. Contractor is responsible for work until

Total Performance. After Total Performance, Owner is responsible for work and proper maintenance.

END OF SECTION

Appendix B

Statistical Design Memorandum (September 28, 2010)

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MEMORANDUM

Statistical Design
136 NW 40th St.
Seattle, WA 98107
(206) 708-5048

DATE: September 28, 2010

TO: Erica Ellis, KWL

FROM: Leska S. Fore, Statistical Design

RE: Statistical analysis for erosion monitoring (CLBWORKS #35 and #36)

Objective

To describe statistical approaches for evaluating data related to erosion monitoring at 1) a revegetation project (#35) and 2) along the banks of the Columbia River downstream from the Revelstoke Canyon Dam (# 36).

Statistical Considerations and Approaches

Three management hypotheses were identified for the two projects. A recommended statistical approach is described below for the hypotheses along with considerations and assumptions.

Revegetation evaluation

1) Ho: Shoreline erosion does not differ significantly between sites with and without bioengineering works (for alpha = 0.05, beta = 0.8).

The goal of this analysis is to evaluate whether the construction and revegetation methods are effective in reducing erosion of bank sediment. The current design pairs treatment sites with control sites at each location. The proposed design includes four locations with treatment and paired sites either adjacent to each other or in matched habitats. All sites are within a relatively small area, that is, distance between sites is not much greater than the length of the site area.

The response variable for this comparison will be the exposed length of the erosion pins in each location. The statistical test will be a paired t-test with values for the control and test plots compared to each other at each site. For each site, approximately 50 pins will be installed. The exposed length of the erosion pins within a site will be averaged for each of the 4 pairs of test and control sites for a total of 8 values. For the paired t-test, the difference in average length is calculated for each paired set of sites to yield 4 values for

statistical testing. The paired t-test evaluates whether the differences in pin length are statistically greater than 0 (or less than 0 in the case of sedimentation).

Because the statistical test is performed on the *differences* and not the observed values, to perform power analysis we need two years of data to calculate the test statistic, that is, the differences in average lengths for each site from year one to year two. Power analysis can be done after the second visit to the site.

Recommendation: All the areas for sampling and constructing test plots are close, the distance between some sites is smaller than the length of the site. Given the similarity of sites, I recommend that some of the sites be split to increase the sample size from the current level of 4 pairs to 6 or 8 pairs of sites because 4 is a small sample size for detecting a difference. Power to detect a difference increases with the number of samples.

Splitting the sites would not necessarily increase the amount of installation work. The total construction area need not change. Instead of dividing a site in half and applying the revegetation treatment to one end, the same size treatment area could be applied in the middle of the site. The treated area at a site could then be divided in half and compared with the untreated (control) area at each end of the site. In this way, each site could yield two comparisons rather than one.

Assumptions: Before splitting each site in half to increase the sample size, we must first determine that the contiguous sites are reasonably independent, that is, that the results we observe at one-half of the site cannot necessarily be predicted by results at the other half of the site. This decision depends on the type of results expected and the expected scale of the effect on the banks. In other words, what is the minimum size of treated area that would provide a reasonable and independent test of the treatement?

The proposed design could also be rolled back to a single comparison at each site for an N = 4.

Bank erosion evaluation

2) Ho: Shoreline erosion does not differ significantly before and after the start of operation of the fifth unit at Revelstoke Dam.

3) Ho: Shoreline erosion does not increase significantly through the duration of the project.

The goal of this monitoring is to test whether changes associated with the fifth unit will increase the erosion downstream of the dam. One response variable for this study will be the length of pin exposed (or covered by sediment) at approximately 50 locations within each of 15 sites. To compare the change in pin length, an average value will be calculated for each site. The 15 values will be compared through time using a paired t-test in which each site is compared with itself through time. The test statistic is the difference in

average pin length observed between the first and second visits; the t-test compares whether the average of those 15 values is different from 0.

The 15 sites will be visited a total of 5 times over a period of 6 years. This design includes the initial installation when all pins were set to be flush with the surface such that the average pin length equals 0 for the first year. After data have been collected for more than 2 visits, the analysis can take a couple of different paths: 1) pin length for the first and last visits could be compared using a t-test, 2) pin length for all visits could be compared to test for changes in all time periods (multiple t-tests), or 3) regression could be used to test for a significant change in pin length over time, either for each or for all sites together. I recommend option 2 and that testing be reported as a matrix:

Visit	2	3	4	5
1	Test pin length for visit 2 against visit 1	Test visit 3 against visit 1	Test visit 4 against visit 1	Test visit 5 against visit 1
2		Test visit 3 against visit 2	Test visit 4 against visit 2	Test visit 5 against visit 2
3			Test visit 4 against visit 3	Test visit 5 against visit 3
4				Test visit 5 against visit 4

A second response variable for this study is transect profile. Profiles are graphed as elevation (y-axis) against distance along the bank (x-axis). The profiles typically describe a curve from the water's edge to the top of the bank. Five transects are described for each of the 15 sites. Elevation is recorded along transects to define a profile, that is, a curve from the river edge to the top of the bank. To measure changes in elevation, four measures will be calculated for each profile to compare initial visits to subsequent visits. From the observed elevations along each transect, visits will be compared by defining 4 points along the profile to measure changes in elevation along the transect.

For example, if the elevation along a transect ranged from 438 to 444, the difference of 16 will be divided into four equal lengths to obtain 4 measures of difference between the two profiles measured during the first and second visits. The midpoint of each length, along the y-axis, will be intersected with the profile for both visits and the change in elevation between the 2 profiles will be measured. The 4 measurements of change in elevation will be averaged for each transect.

A similar calculation will be made for the other 4 transect profiles within each site to calculate a change in elevation. Those 5 transect averages will also be averaged to obtain a single value for each of the 15 sites. A t-test will be used to test whether the average change in the profile for all 15 sites is greater than 0. Note that positive (indicating

erosion) and negative (indicating sedimentation) values are both possible. I recommend comparing all visits to the first visit and reporting all the results to evaluate during which years the most change occurred. Comparisons could also be reported for shorter time periods between later visits as in the table above.

Initially the goal for this project was to test for changes before and after the fifth turbine began operating and to test for changes through time. Due to timing of the project, the second visit to measure pin length and transect elevations will occur after the fifth unit begins operation (NB: the start date was planned for early 2011, but KWL will check to confirm the unit will be fully operational before their next planned visit in spring 2011). The schedule means that we cannot evaluate the erosion associated with current dam operations, that is, baseline erosion. This means that we will not be able to discern whether erosion is due to the fifth unit or to dam operation in general.

One option would be to visit the sites before the fifth unit begins operating. The problem with this approach is that 1) the river reach would not have been through a full year of change and 2) the visit would be at a different time of year, that is, 8 months after installation during late fall rather than in the spring when all visits were previously scheduled. That means that river conditions might not be comparable. Another option would be to delay start of the fifth unit until after the second spring visit.

Statistical power analysis will require a second year of data collection because tests for both the change in pin length and the change in transect profile involve a comparison with a previous visit in order to calculate the test statistic. The comparison of each site with itself through time is a powerful design for detecting change compared to, for example, a two-sample t-test which compares all sites to each other as a group. In a paired t-test site variability is controlled by comparing each site to itself. That means that this statistical design inherently has a high level of statistical power to detect change.

At each site, the large number of pins (>50) provides an opportunity to stratify the data and test for differences associated with elevation. For this approach, the same test could be used on subsets of data, for example, by grouping pins according to low, medium and high elevation.

Appendix C

CLBWORKS #36 Drawings (Erosion Monitoring Pins and Transects)

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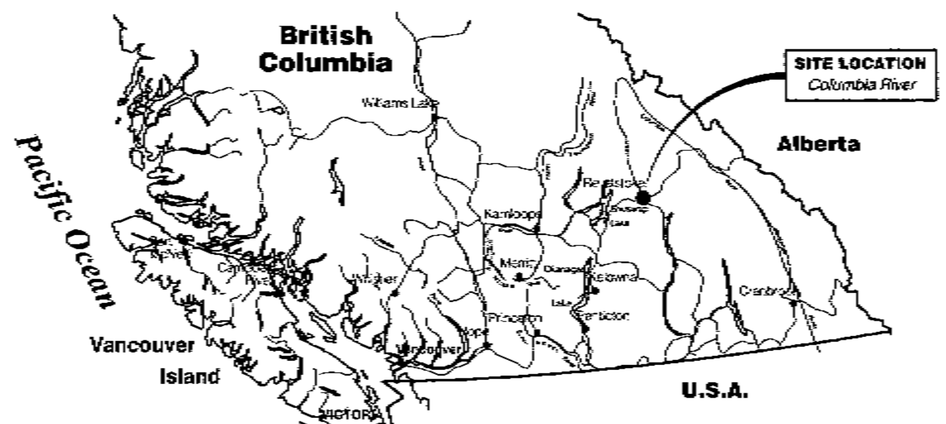
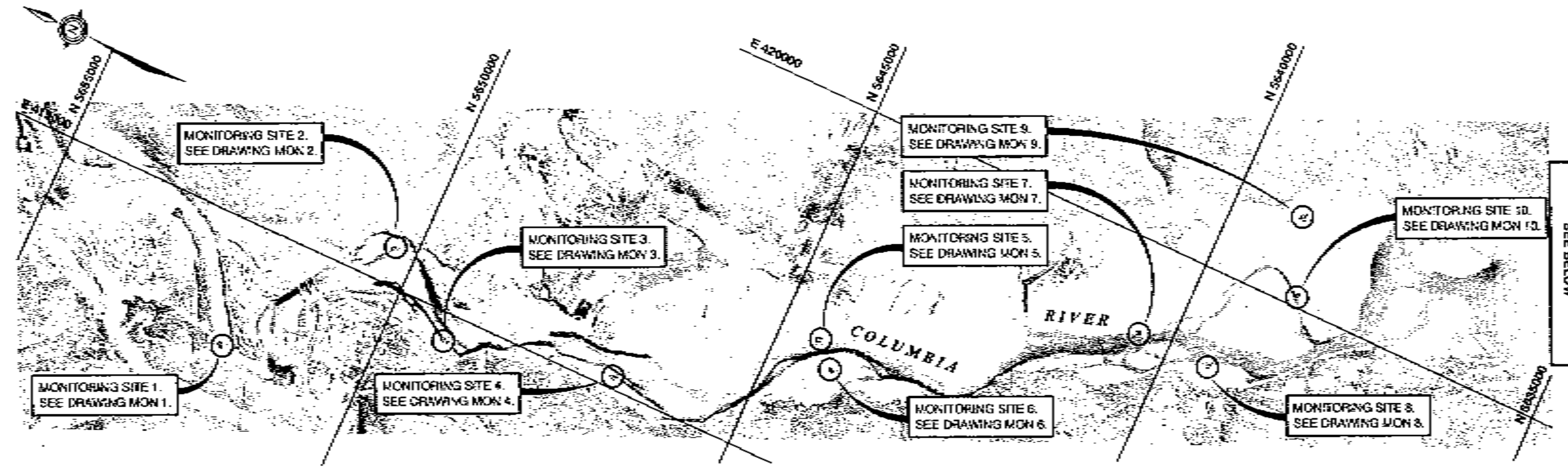


LOCATION PLAN
N.T.S.



KEY PLAN
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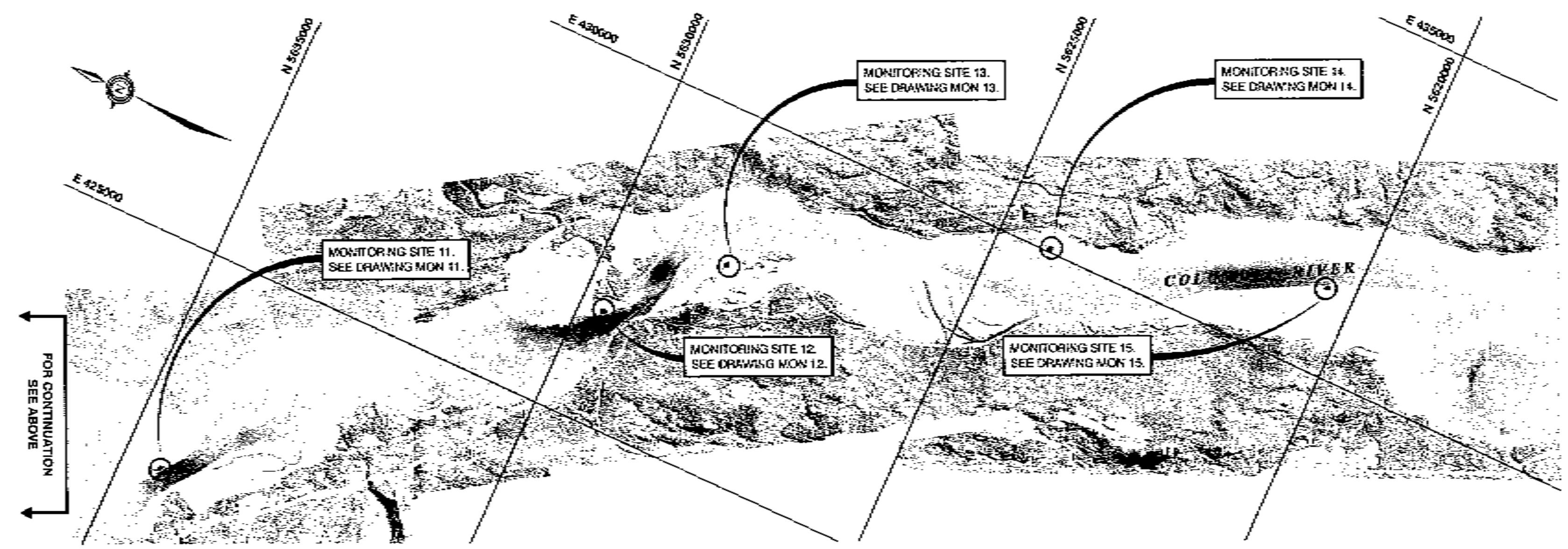

KEY PLAN
SCALE 1:50000

DRAWING LIST		
SHT. NO.	DWG. NO.	TITLE
1	G101	LOCATION PLAN, KEY PLAN AND DRAWING LIST
2	MON 1	MONITORING SITE PLAN AND SECTIONS
3	MON 2	MONITORING SITE PLAN AND SECTIONS
4	MON 3	MONITORING SITE PLAN AND SECTIONS
5	MON 4	MONITORING SITE PLAN AND SECTIONS
6	MON 5	MONITORING SITE PLAN
7	MON 6	MONITORING SITE PLAN AND SECTIONS
8	MON 7	MONITORING SITE PLAN AND SECTIONS
9	MON 8	MONITORING SITE PLAN AND SECTIONS
10	MON 9	MONITORING SITE PLAN
11	MON 10	MONITORING SITE PLAN
12	MON 11	MONITORING SITE PLAN AND SECTIONS
13	MON 12	MONITORING SITE PLAN
14	MON 13	MONITORING SITE PLAN
15	MON 14	MONITORING SITE PLAN
16	MON 15	MONITORING SITE PLAN
17	SEC 1	SITE MON 5 AND MON 9 SECTIONS
18	SEC 2	SITE MON 10 AND MON 12 SECTIONS
19	SEC 3	SITE MON 13 AND MON 14 SECTIONS
20	SEC 4	SITE MON 15 SECTIONS

LEGEND

- PIN LOCATION
- X TOPOGRAPHIC SURVEY SHOT
- TRANSECT PIN LOCATION

BC HYDRO
COLUMBIA RIVER
EROSION MONITORING PROJECT CLB 36
CONTRACT No. 478-081

PRELIMINARY
DO NOT USE FOR CONSTRUCTION

ISSUED INFORMATION Issued for	Issue	Date	Issued By
Reference			
Approvals	A0	DEC. 22/10	
Tender			
Permits			
Construction			
Record Drawings			

REVISION INFORMATION Rev. No.	Date	Designed	Drawn	Checked	Description of Revision
0	DEC. 22/10	AU	AU		

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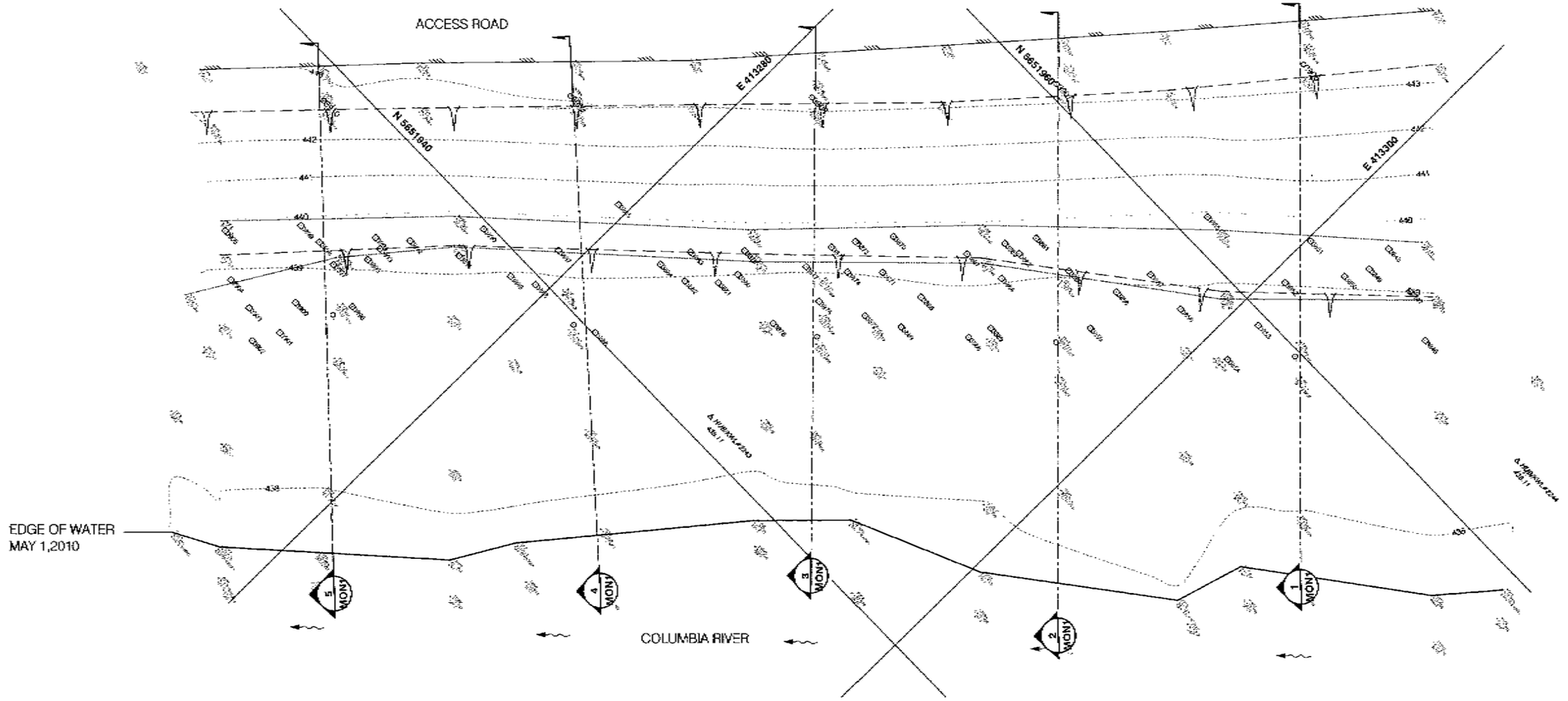
BC HYDRO
COLUMBIA RIVER
EROSION MONITORING PROJECT CLB 36
LOCATION PLAN, KEY PLAN AND DRAWING LIST

KWL Project No. 478-081		Scale AS SHOWN	G101
Sheet 1 of 20		Rev. No. 0	Drawing Number
Client: BC Hydro			

AT FULL SIZE THIS BAR MEASURES 100mm. ALL SCALES ARE TO BE ENLARGED TO FULL SIZE

ACCESS ROAD



MONITORING SITE 1 PLAN
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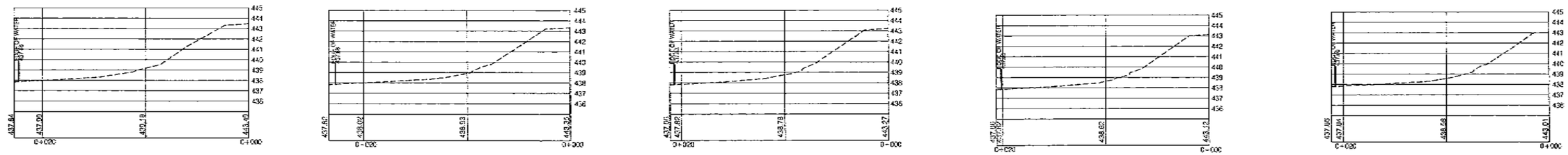

TRANSECT 1 (1 MON1) 1:200

TRANSECT 2 (2 MON1) 1:200

TRANSECT 3 (3 MON1) 1:200

TRANSECT 4 (4 MON1) 1:200

TRANSECT 5 (5 MON1) 1:200

Dec. 22/10

478.081\300\Drawings\478081M\ON1.dwg

ISSUED INFORMATION	Issued for	Issue	Date	Issued By
	Reference			
	Approvals	A0	DEC. 22/10	
	Tender			
	Permits			
	Construction			
	Record Drawings			

REVISION INFORMATION	Rev. No.	Date	Designed	Drawn	Checked	Description of Revision
	0	DEC. 22/10	SJL	ALP		

Rev. No.	Date	Designed	Drawn	Checked	Description of Revision

KERR WOOD LEIDAL associates limited
CONSULTING ENGINEERS

BC HYDRO
COLUMBIA RIVER
EROSION MONITORING PROJECT CLB 36
MONITORING SITE PLAN AND SECTIONS

KWL Project No. 478.081 | Scale AS SHOWN | **MON 1** Drawing Number
Sheet 2 of 20 | Rev. No. 0
Client: BC HYDRO

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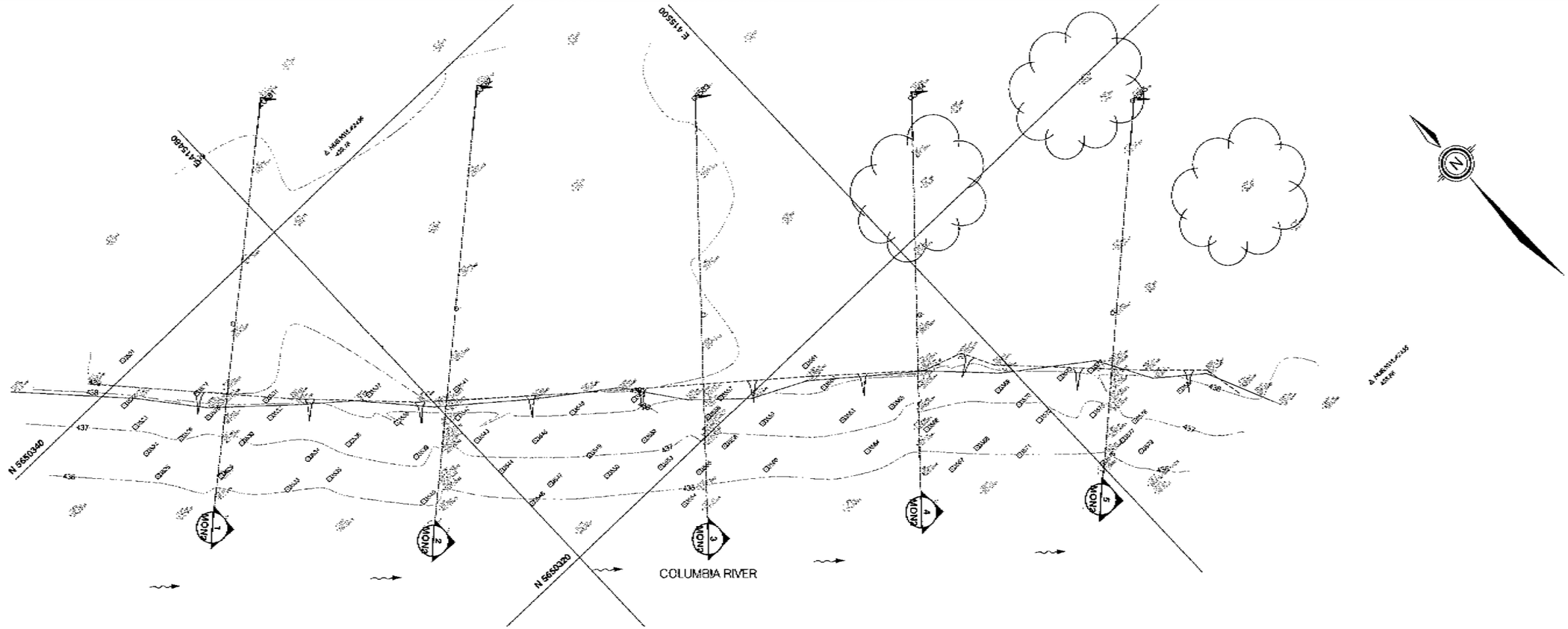

MONITORING SITE 2 PLAN
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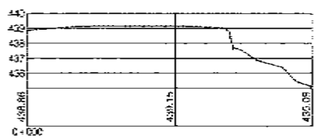

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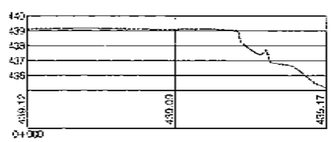

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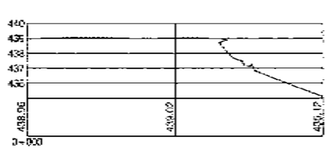
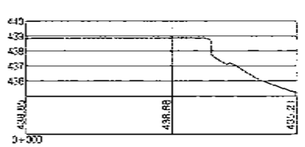
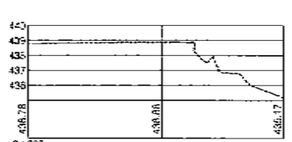


TRANSECT 3 (3) MON2
1:200



TRANSECT 4 (4) MON2
1:200



TRANSECT 5 (5) MON2
1:200

ISSUED INFORMATION	Issued for	Issue	Date	Issued By
	Reference			
	Approvals	A0	DEC. 22/10	
	Tender			
	Permits			
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REVISION INFORMATION	Rev. No.	Date	Designed	Drawn	Checked	Description of Revision	Rev. No.	Date	Designed	Drawn	Checked	Description of Revision
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MONITORING SITE PLAN AND SECTIONS

KWL Project No. 478.081 | Scale AS SHOWN | **MON 2** Drawing Number
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Client: BC HYDRO

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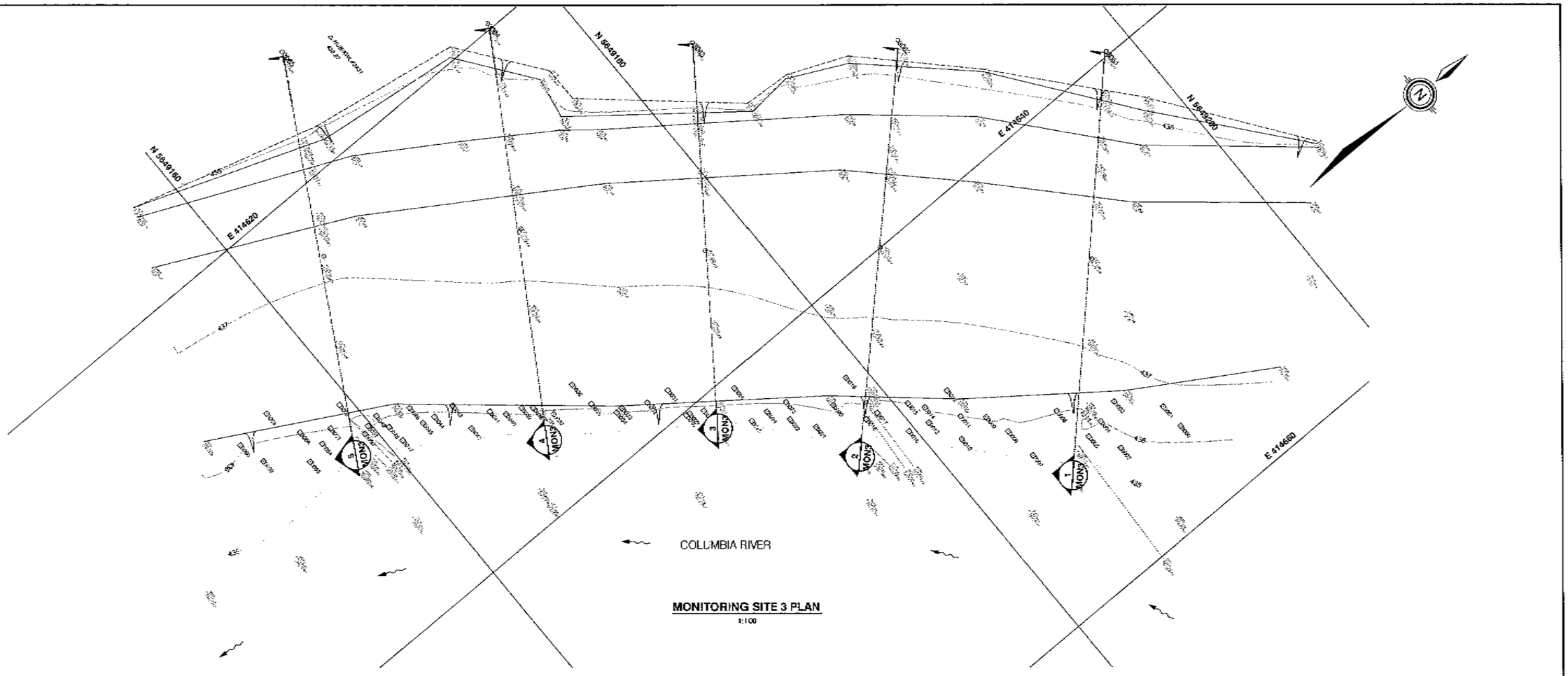
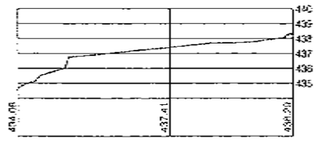
478.081\000-Drawings\478081MON2.dwg

AT FULL SIZE THIS BAR MEASURES 100mm ALL SCALES REFERENCED TO FULL SIZE



MONITORING SITE 3 PLAN
1:100



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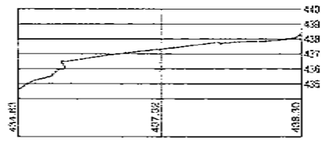
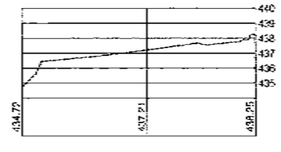
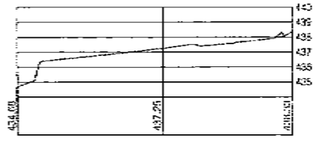
1:200



TRANSECT 2 (2 MON3)
1:200



TRANSECT 3 (3 MON3)
1:200



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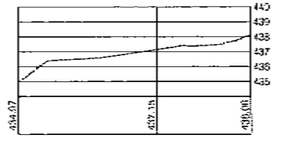
1:200



TRANSECT 5 (5 MON3)
1:200

ISSUED INFORMATION	Issued for	Issue	Date	Issued By
	Reference			
	Approvals	A0	DEC. 22/10	
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REVISION INFORMATION	Rev. No.	Date	Designed	Drawn	Checked	Description of Revision	Rev. No.	Date	Designed	Drawn	Checked	Description of Revision
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KWL Project No. 478.081 | Scale AS SHOWN | **MON 3** Drawing Number
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47a.081\500-Drawings\478081MON3.dwg

AT FULL SIZE THIS BAR MEASURES 100mm ALL SCALES PROPORTIONED TO FULL SIZE

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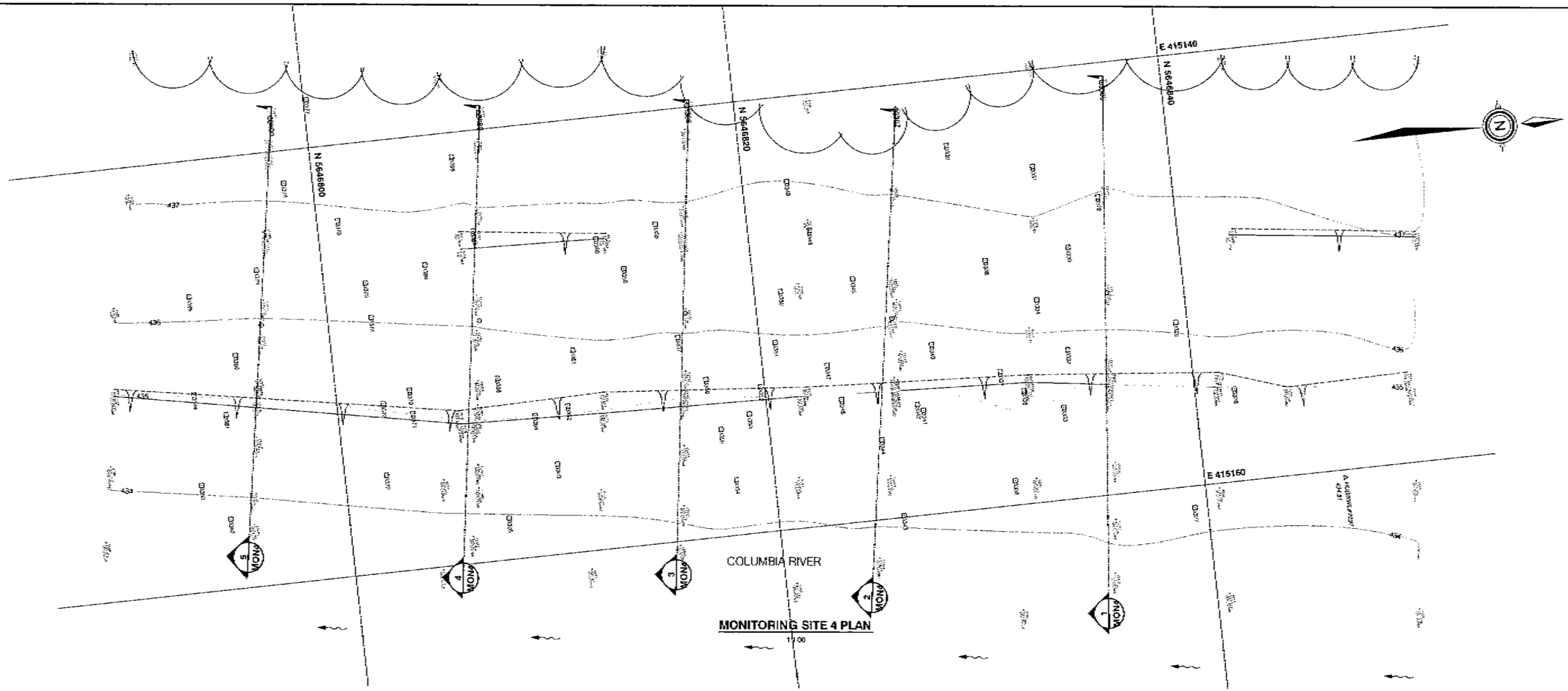
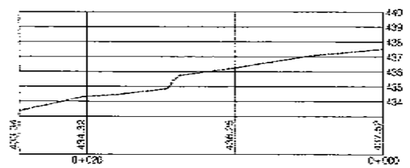


MONITORING SITE 4 PLAN
1:200



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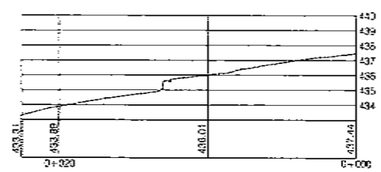

TRANSECT 2 (2 MON4)
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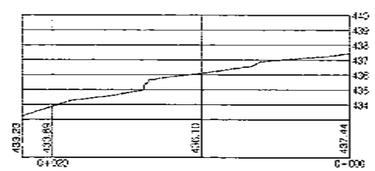

TRANSECT 3 (3 MON4)
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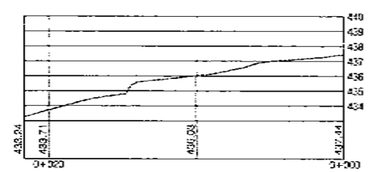
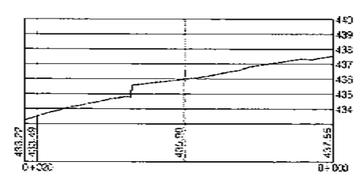


TRANSECT 4 (4 MON4)
1:200



TRANSECT 5 (5 MON4)
1:200

ISSUED INFORMATION	Issued for	Issue	Date	Issued By
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KWL Project No. 478.081 | Scale AS SHOWN | **MON 4** Drawing Number
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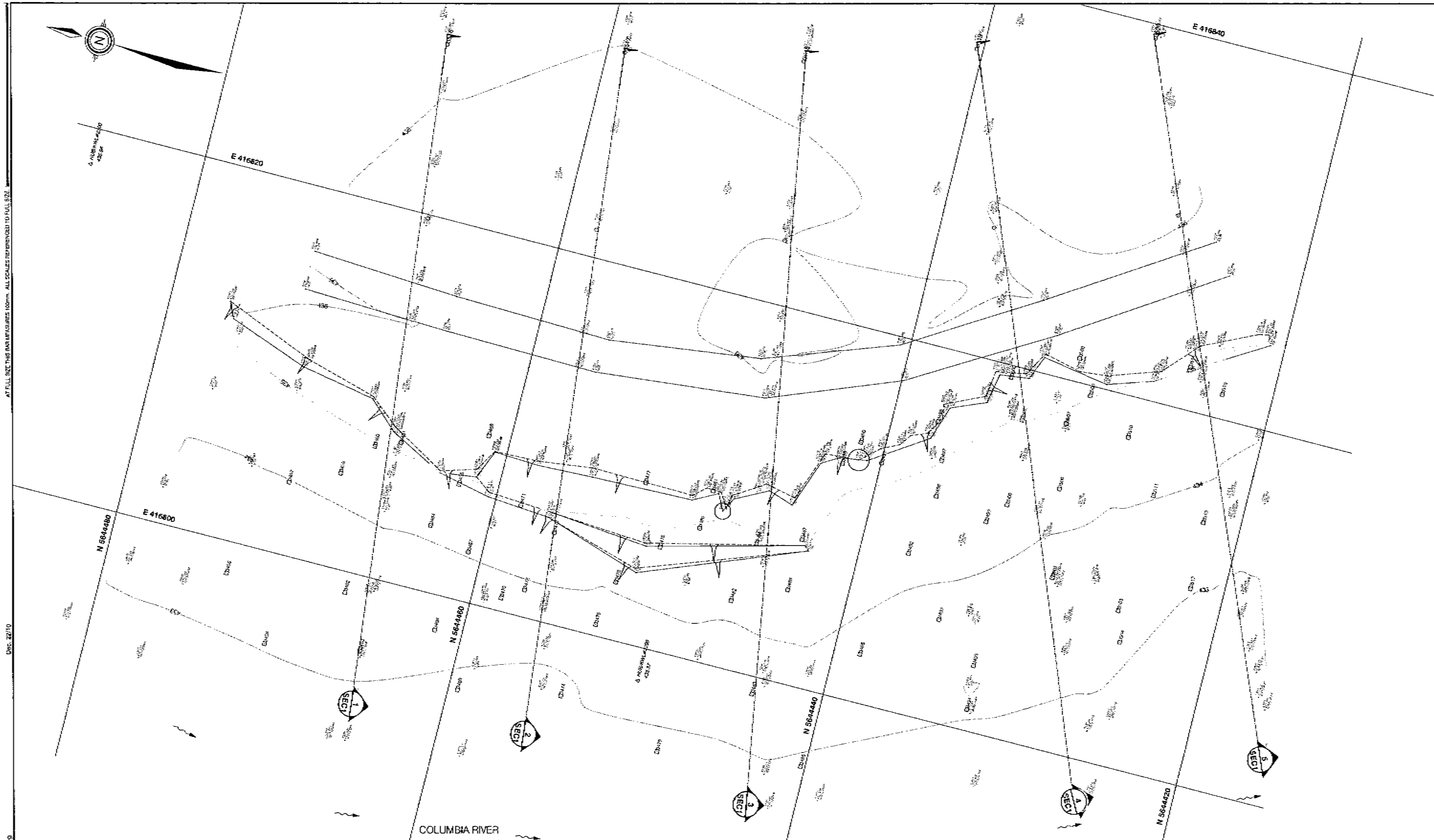

MONITORING SITE 4 PLAN

1:100

ISSUED INFORMATION: Issued for	Issue	Date	Issued By
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KWL Project No. 478.081 | Scale AS SHOWN | **MON 5** Drawing Number
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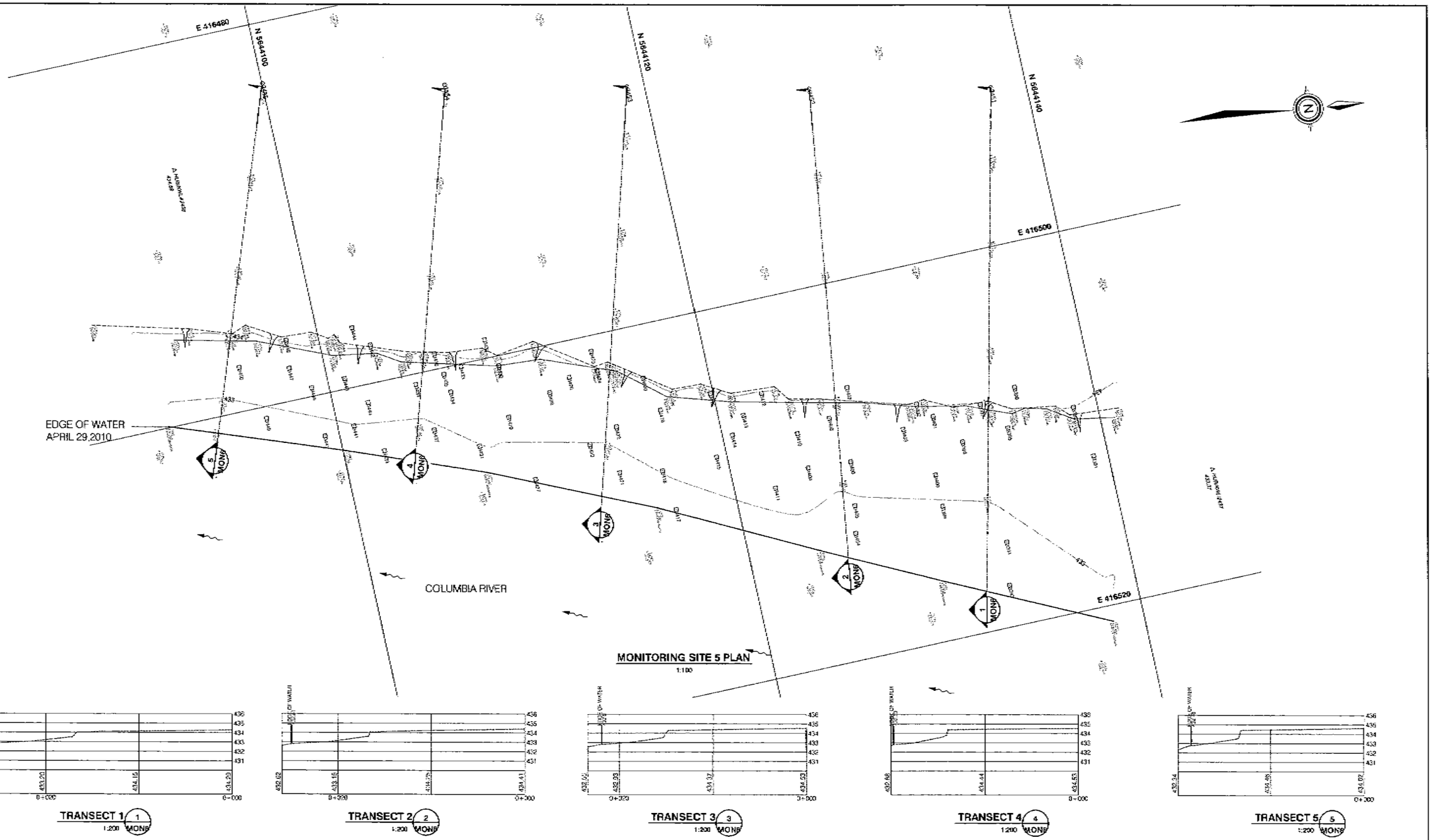
Client: BC HYDRO

478.081\900-Drawings\478081MON5.dwg

AT FULL SIZE THIS BAR MEASURES 100mm. ALL SCALES REPRESENTED TO FULL SIZE.



MONITORING SITE 5 PLAN
1:100

TRANSECT 1 (1 MON6)
1:200

TRANSECT 2 (2 MON6)
1:200

TRANSECT 3 (3 MON6)
1:200

TRANSECT 4 (4 MON6)
1:200

TRANSECT 5 (5 MON6)
1:200

ISSUED INFORMATION	Issued for	Issue	Date	Issued By
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KWL Project No. 478.081 Scale AS SHOWN
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MON 6
Drawing Number

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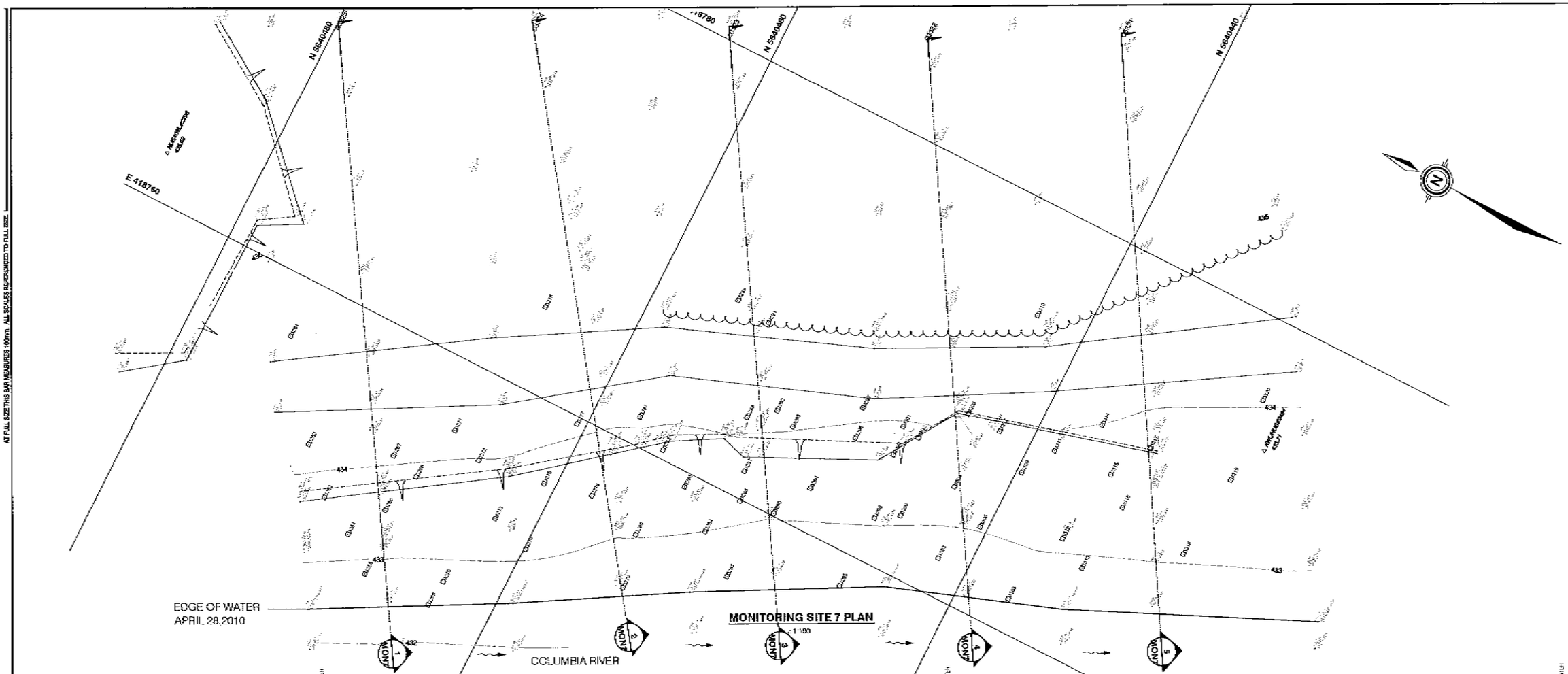
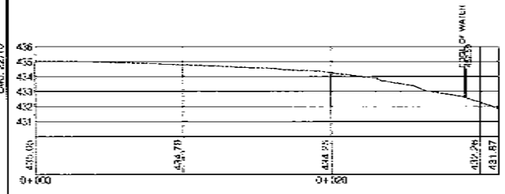
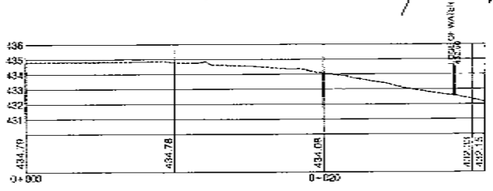
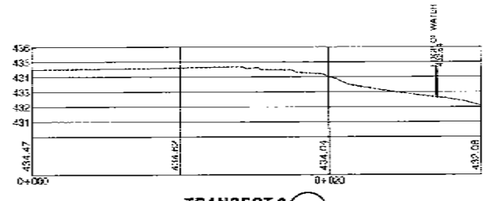
478.081\1500-Drawings\cr\Mon1MON2.dwg

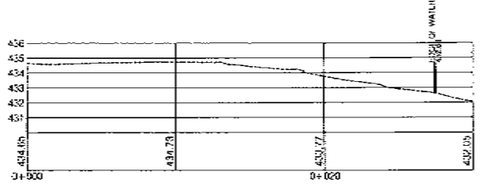
AT FULL SIZE THIS BAR MEASURES 100mm. ALL SCALES INDICATED TO FULL SIZE.

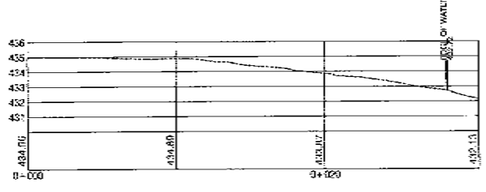












ISSUED INFORMATION	Issued for	Issue	Date	Issued By
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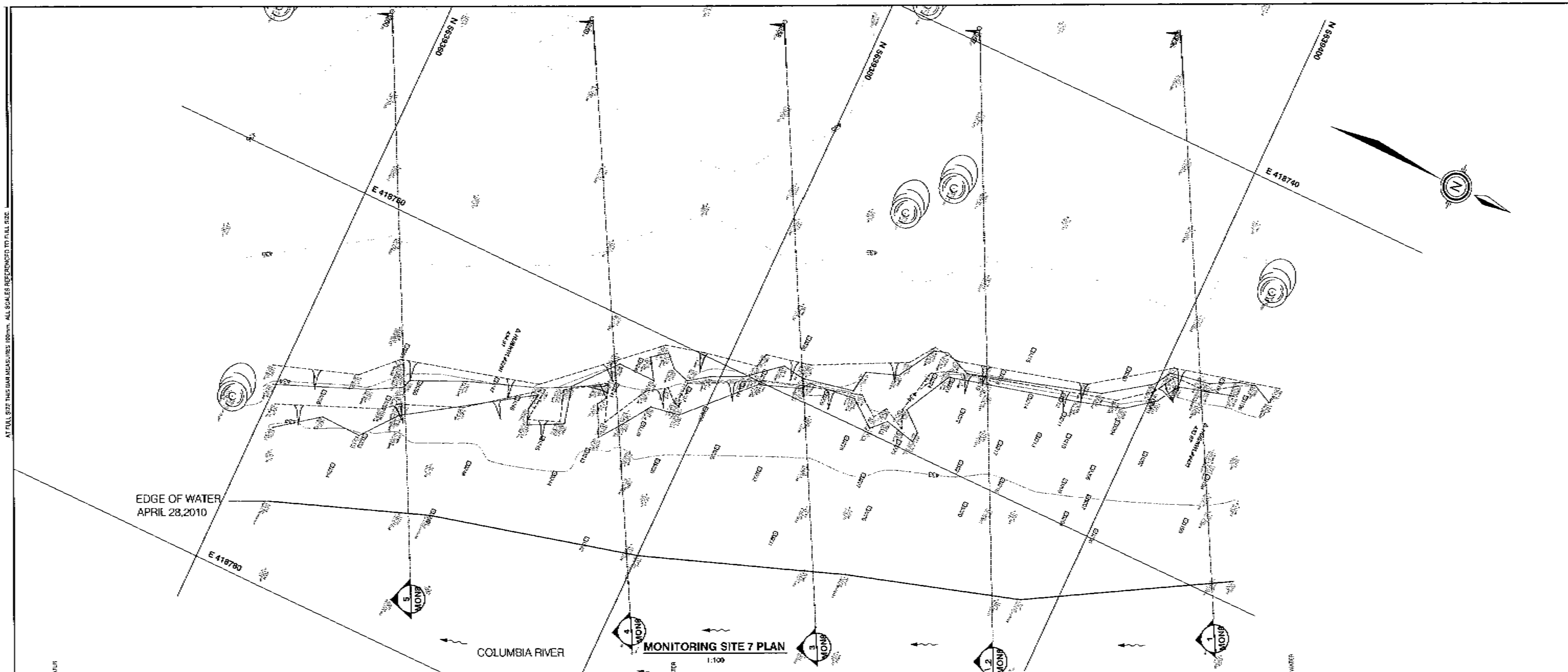
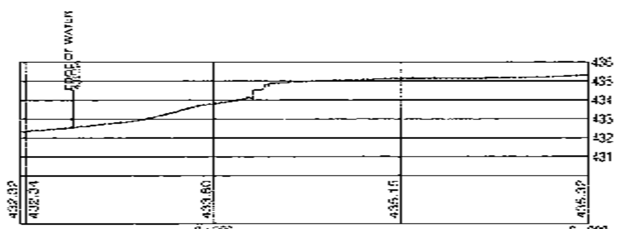
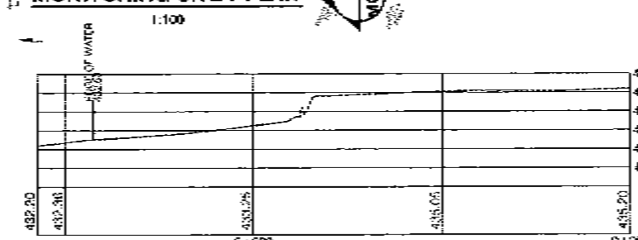


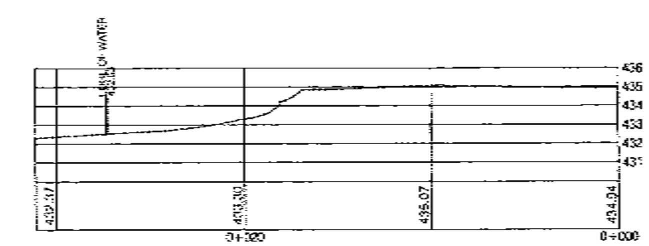
MONITORING SITE 7 PLAN
1:100



TRANSECT 1 (1 / MON8)
1:200



TRANSECT 2 (2 / MON8)
1:200



TRANSECT 3 (3 / MON8)
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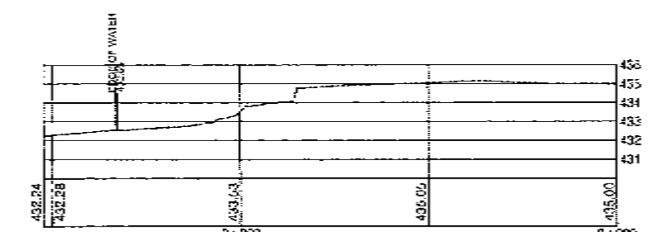
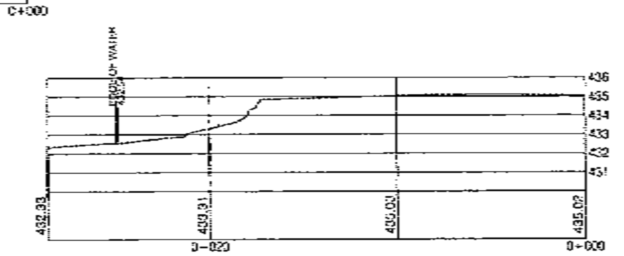


TRANSECT 4 (4 / MON8)
1:200



TRANSECT 5 (5 / MON8)
1:200

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REVISION INFORMATION Rev. No.	Date	Designed	Drawn	Checked	Description of Revision	Rev. No.	Date	Designed	Drawn	Checked	Description of Revision
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EROSION MONITORING PROJECT CLB 36
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MON 8
Drawing Number

470.081\300-Drawings\478081MON8.dwg

AT FULL SIZE THIS BAR MEASURES 100mm. ALL SCALES REFERENCED TO FULL SIZE

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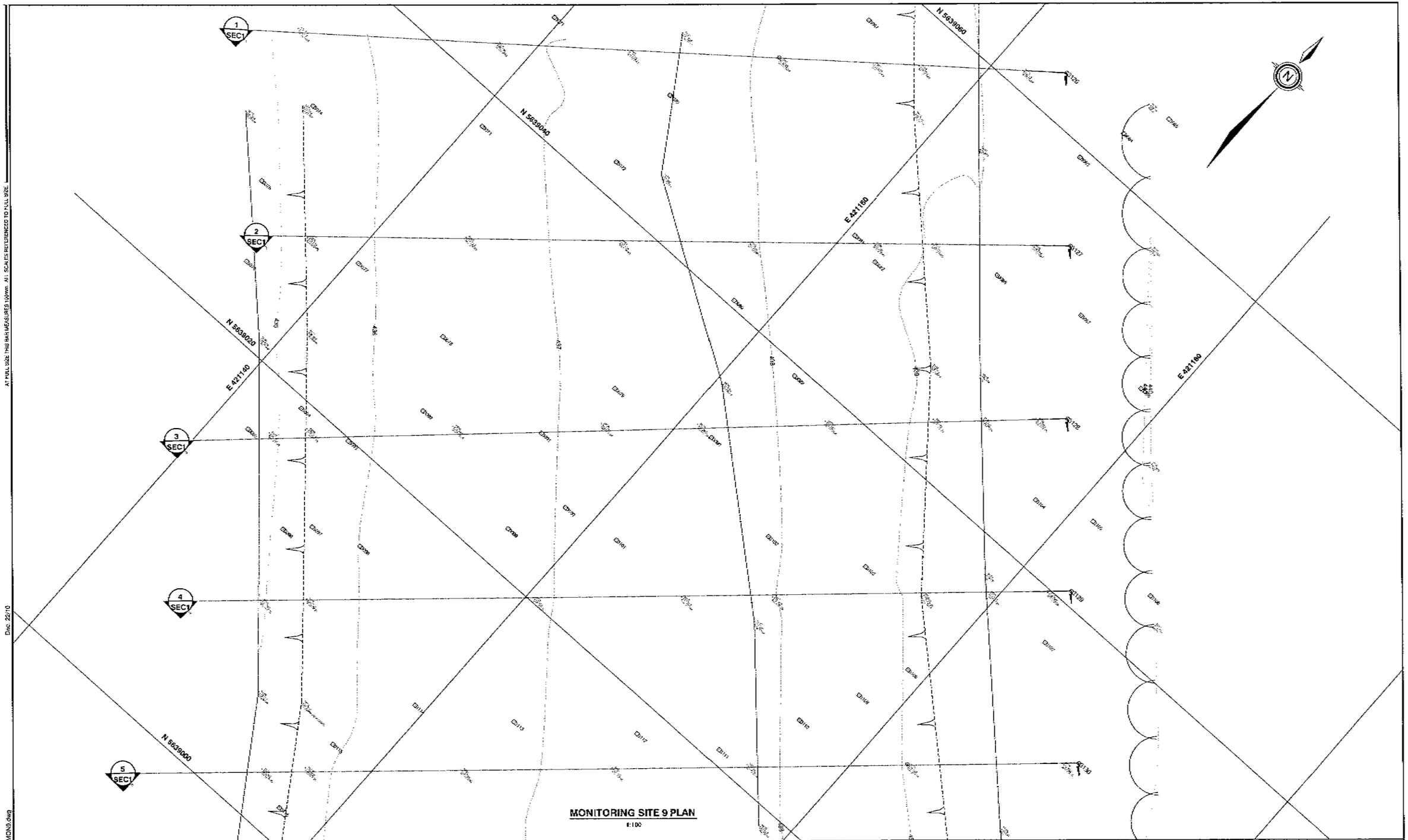

MONITORING SITE 9 PLAN

1:100

ISSUED INFORMATION	Issued for	Issue	Date	Issued By
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REVISION INFORMATION	Rev. No.	Date	Designed	Drawn	Checked	Description of Revision	Rev. No.	Date	Designed	Drawn	Checked	Description of Revision
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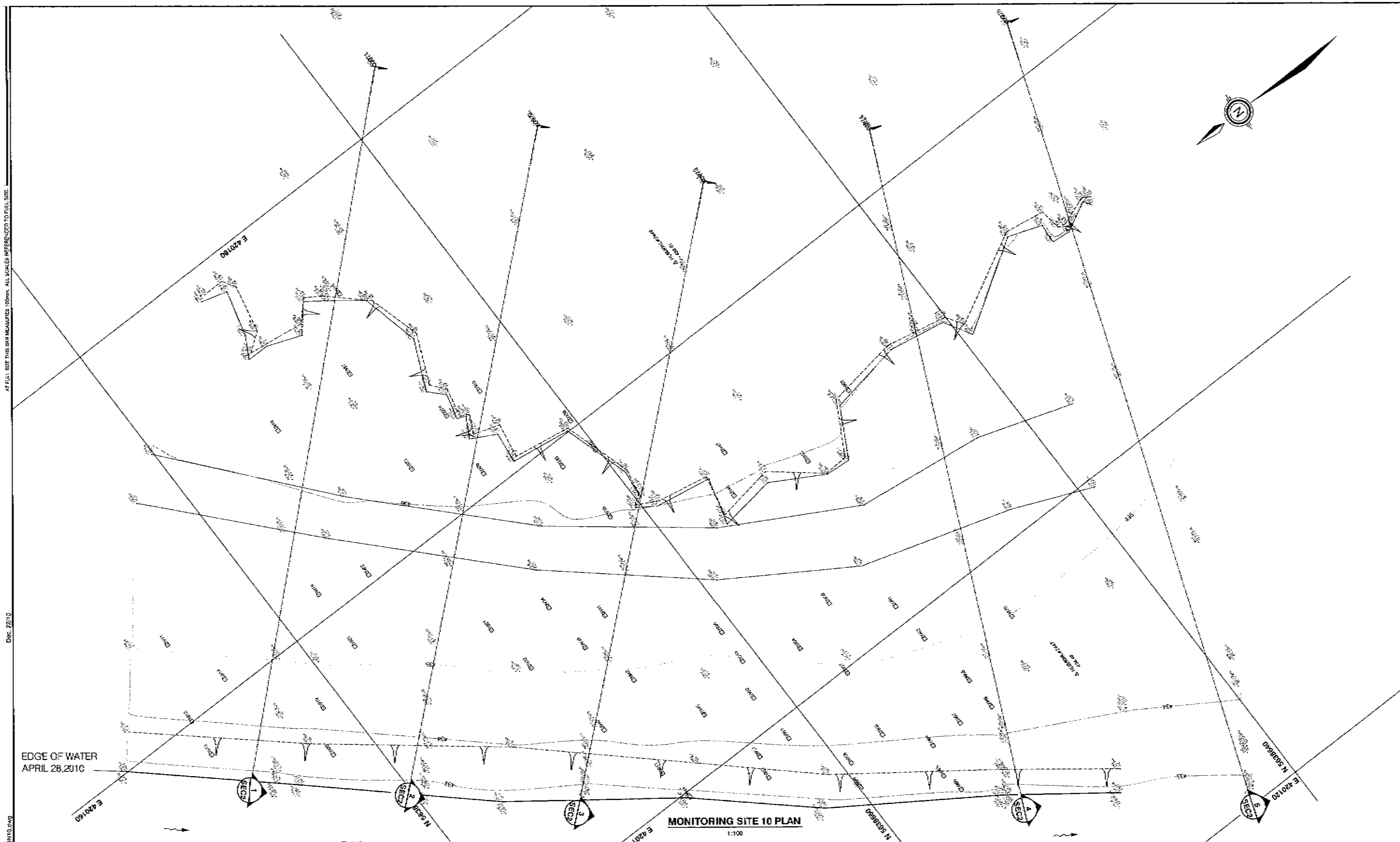
MON 9
Drawing Number

478.081\500-Drawings\478081MON9.dwg



MONITORING SITE 10 PLAN

1:100

ISSUED INFORMATION	Issue	Date	Issued By
Reference			
Approvals	A0	DEC. 22/10	
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Rev. No.	Date	Designed	Drawn	Checked	Description of Revision
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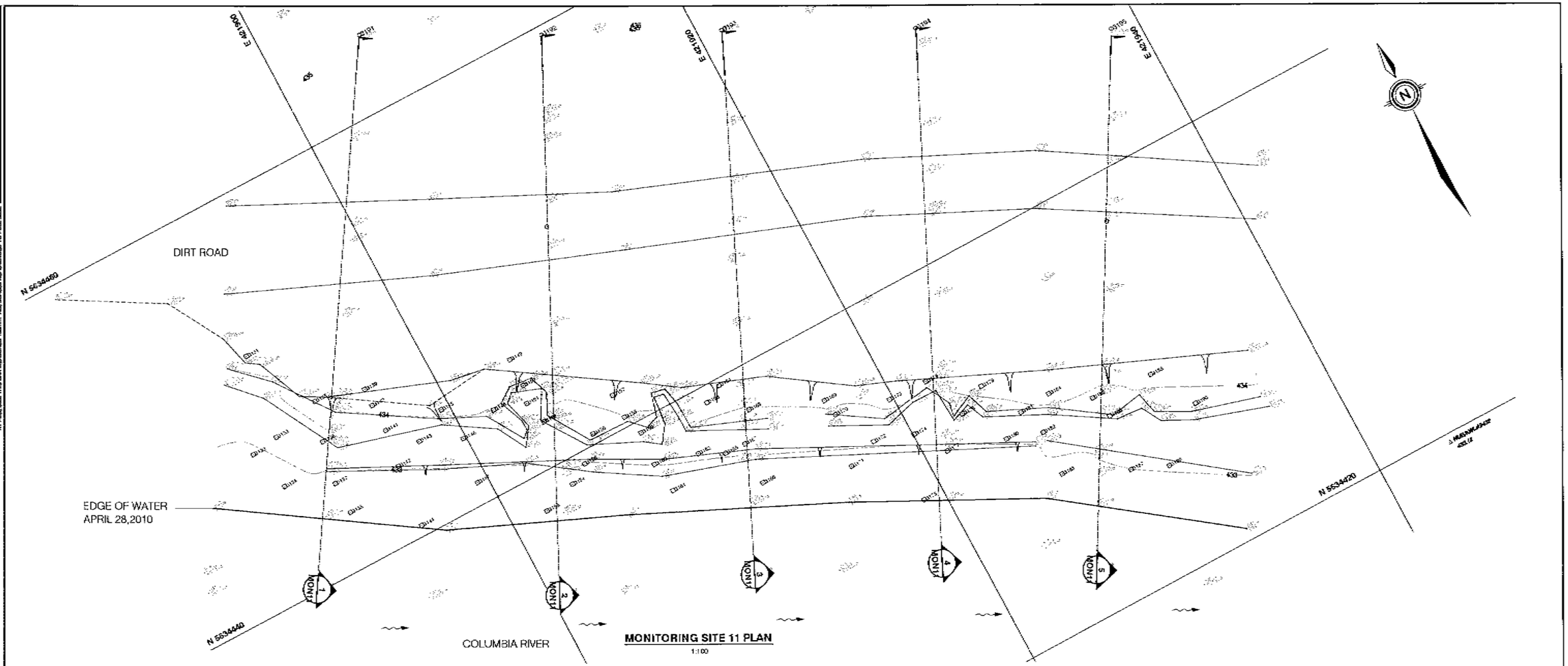
MON 10 Drawing Number

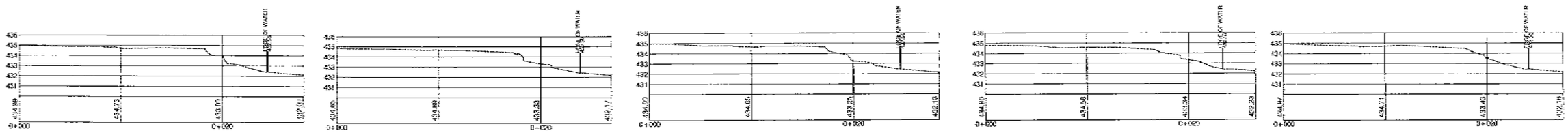
Client: BC HYDRO

478.081\500-Drawings\478081MON10.dwg · Dec. 22/10

AT FULL SIZE THIS BAR MEASURES 100mm. ALL SCALES REFERENCED TO FULL SIZE.



MONITORING SITE 11 PLAN
1:100



TRANSECT 1 (1 MON11) 1:200

TRANSECT 4 (4 MON11) 1:200

TRANSECT 2 (2 MON11) 1:200

TRANSECT 5 (5 MON11) 1:200

TRANSECT 3 (3 MON11) 1:200

ISSUED INFORMATION	Issued for	Issue	Date	Issued By
	Reference			
	Approvals	A0	DEC. 22/10	
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REVISION INFORMATION	Rev. No.	Date	Designed	Drawn	Checked	Description of Revision	Rev. No.	Date	Designed	Drawn	Checked	Description of Revision
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478.031.1300-Drawings\478031MON11.dwg

AT FULL SIZE THIS BAR MEASURES 100mm. ALL SCALES RETURNED TO FULL SIZE

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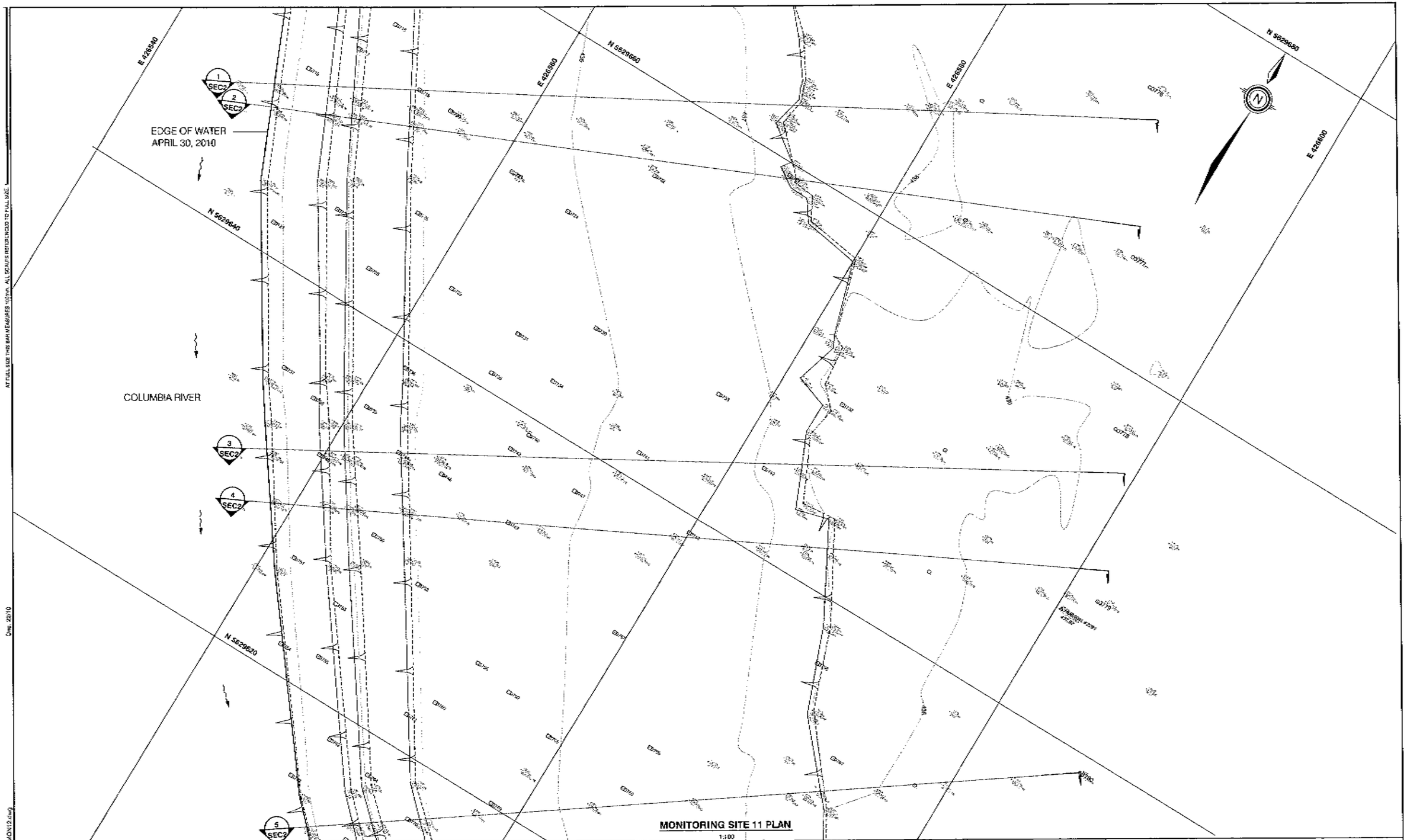
478.051\400-Drawings\478051MON12.dwg



MONITORING SITE 11 PLAN

1:100

ISSUED INFORMATION	Issued for	Issue	Date	Issued By
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	Permits			
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REVISION INFORMATION	Rev. No.	Date	Designed	Drawn	Checked	Description of Revision
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Rev. No.	Date	Designed	Drawn	Checked	Description of Revision

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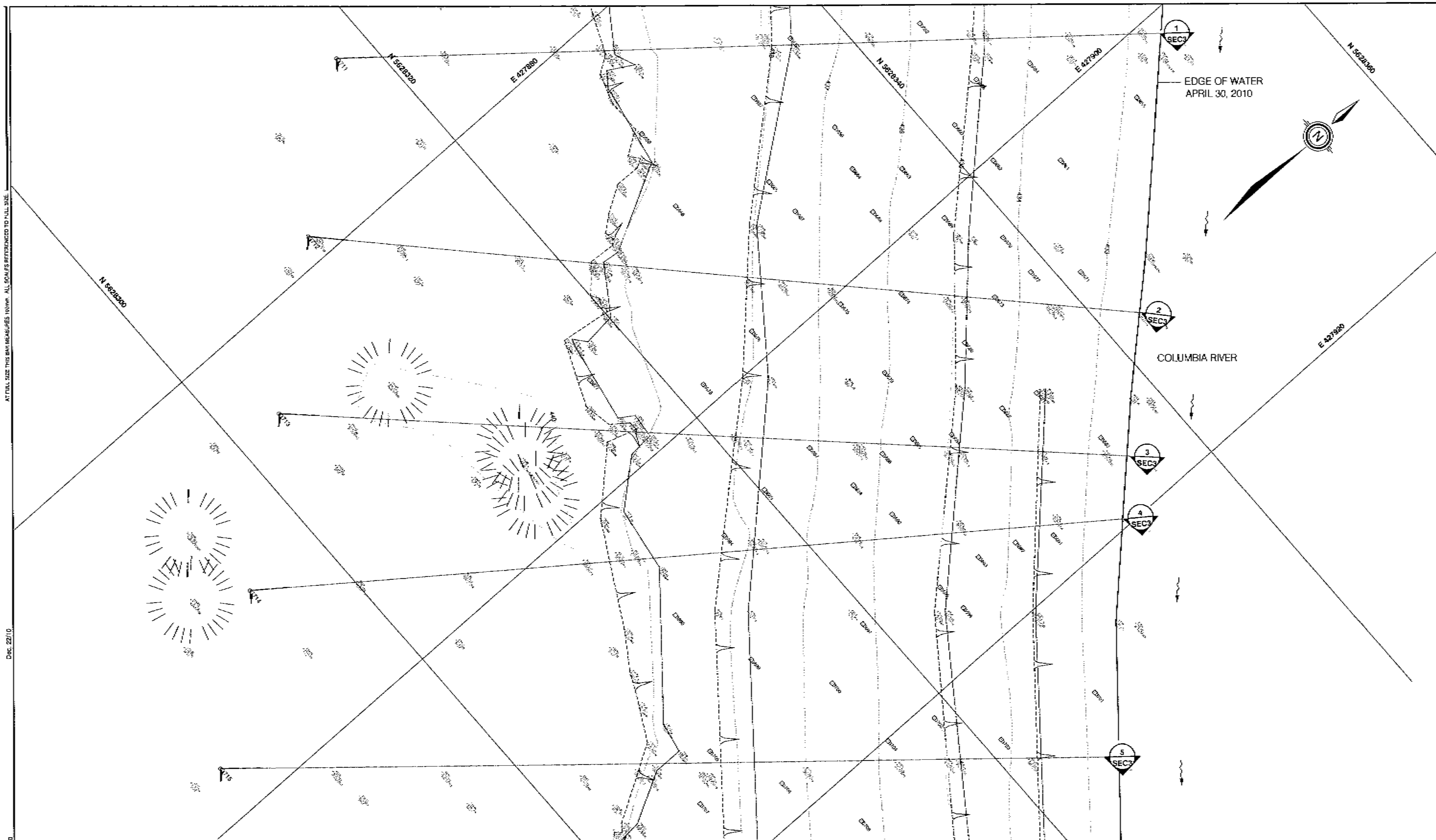
AT FULL SIZE THIS BAR MEASURES 100mm. ALL SCALES REFERENCED TO FULL SIZE.



MONITORING SITE 13 PLAN

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Rev. No.	Date	Designed	Drawn	Checked	Description of Revision

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AT FULL SIZE THIS BAR MEASURES 100mm. ALL SCALES REFERENCED TO FULL SIZE.

E 430020

E 430040

E 430060

EDGE OF WATER
APRIL 30, 2010

COLUMBIA RIVER

N 5624240

N 5624220

1 SEC3

2 SEC3

3 SEC3

4 SEC3

5 SEC3

N

MONITORING SITE 14 PLAN

1:100

ISSUED INFORMATION					REVISION INFORMATION												
Issued for	Issue	Date	Issued By		Rev. No.	Date	Designed	Drawn	Checked	Description of Revision	Rev. No.	Date	Designed	Drawn	Checked	Description of Revision	
Reference					0	DEC. 22/10	SJL	ALP									
Approvals	AD	DEC. 22/10															
Tender																	
Permits																	
Construction																	
Record Drawings																	

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478.001\500-Drawings\478001MON14.dwg

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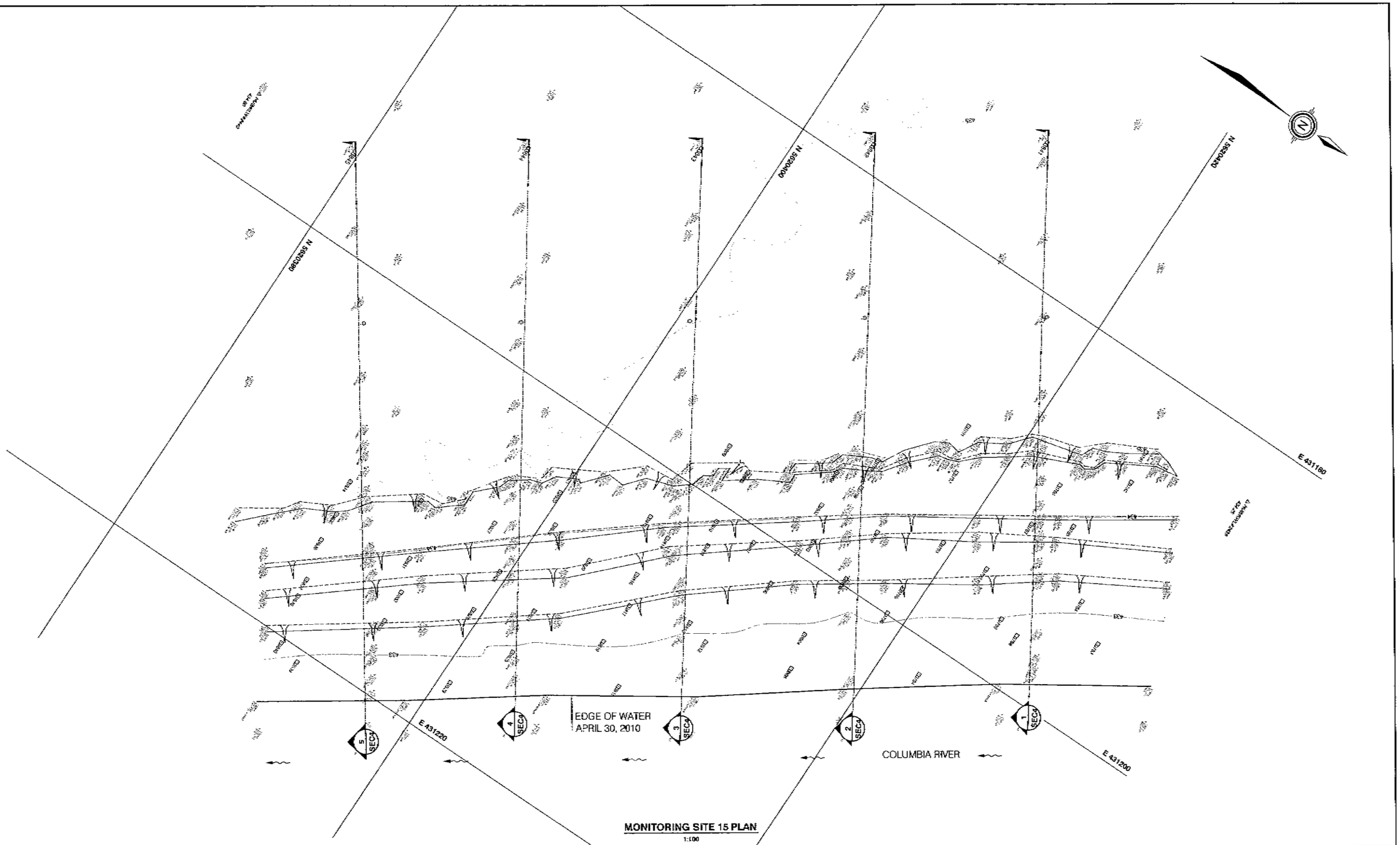
BC HYDRO
COLUMBIA RIVER
EROSION MONITORING PROJECT CLB 36
MONITORING SITE PLAN

KWL Project No. 478.001 Scale AS SHOWN **MON 14**
Sheet 15 of 20 Rev. No. 0 Drawing Number
Client: BC HYDRO

AT FULL SIZE THIS BAR MEASURES 100mm. ALL SCALES REFERENCED TO FULL SIZE.



MONITORING SITE 15 PLAN

1:100

ISSUED INFORMATION	Issued for	Issue	Date	Issued By
	Reference			
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	Permits			
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	Record Drawings			

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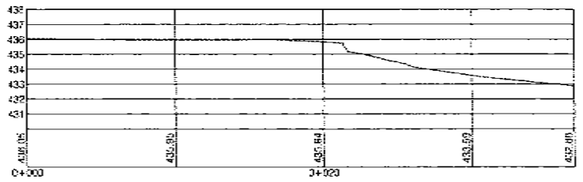
BC HYDRO
COLUMBIA RIVER
EROSION MONITORING PROJECT CLB 36
MONITORING SITE PLAN

KWL Project No. 478.051 Scale AS SHOWN **MON 15**
Sheet 16 of 20 Rev. No. 0 Drawing Number
Client: BC HYDRO

Dec. 22/10

478.001\500-Drawings\478081MON15.dwg



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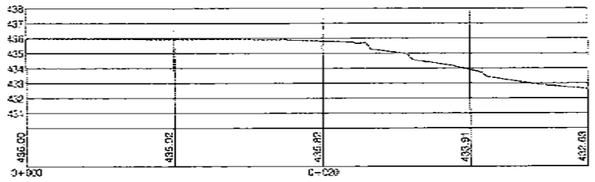
1:200



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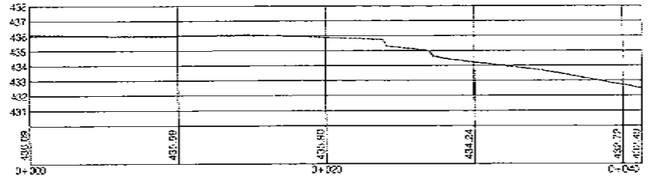

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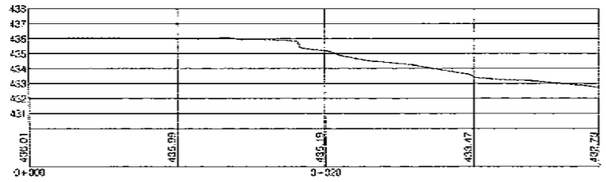

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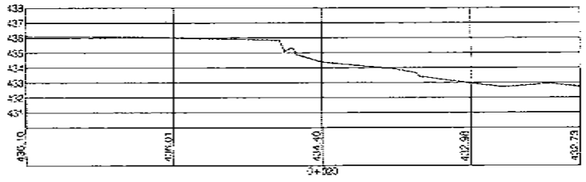

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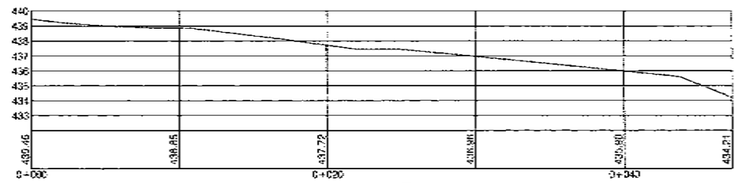

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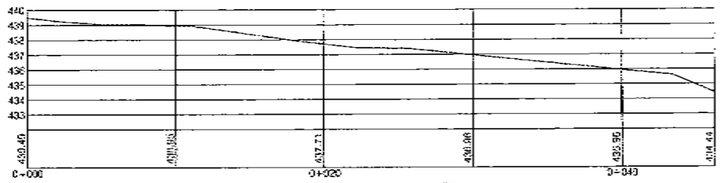

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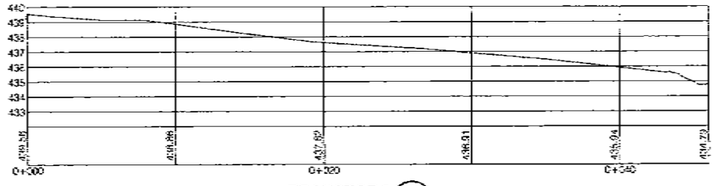

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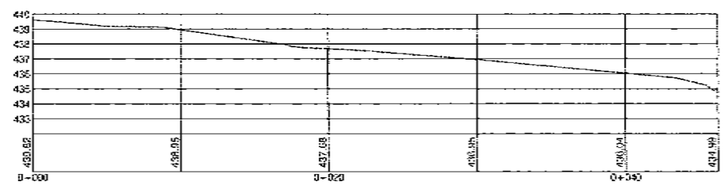

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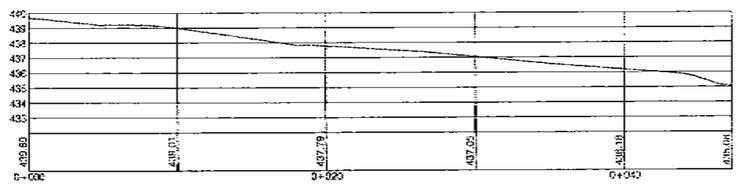

TRANSECT 5 (5) MON5
1:200

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Rev. No.	Date	Designed	Drawn	Checked	Description of Revision

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CONSULTING ENGINEERS

BC HYDRO
COLUMBIA RIVER
EROSION MONITORING PROJECT CLB 36
SITE MON 5 AND SITE MON 9 SECTIONS

KWL Project No.	478.081	Scale	AS SHOWN
Sheet	17 of 20	Rev. No.	0
Client: BC HYDRO			

SEC 1
Drawing Number

AT FULL SIZE THIS BAR MEASURES 100mm ALL SCALES REFERENCED TO FULL SIZE

Dec. 22/10

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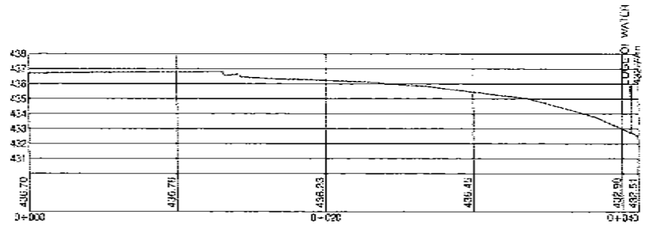

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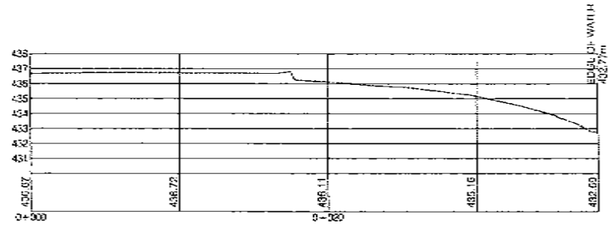

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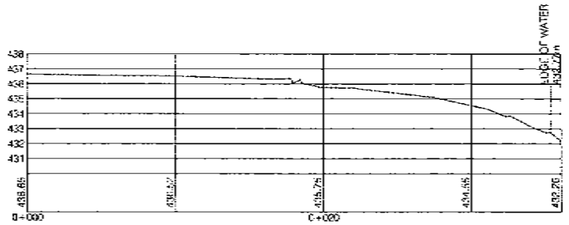

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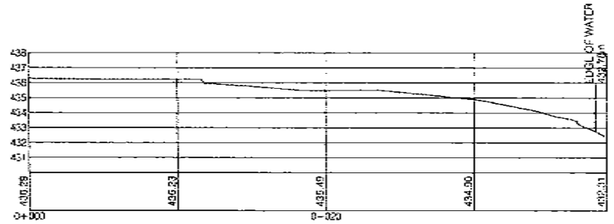

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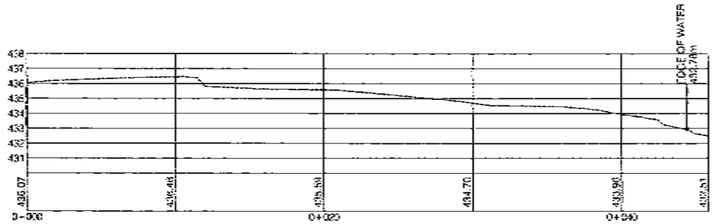

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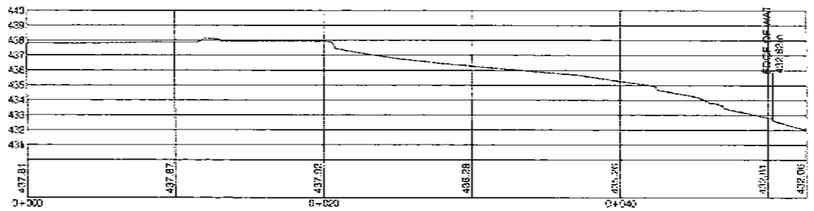

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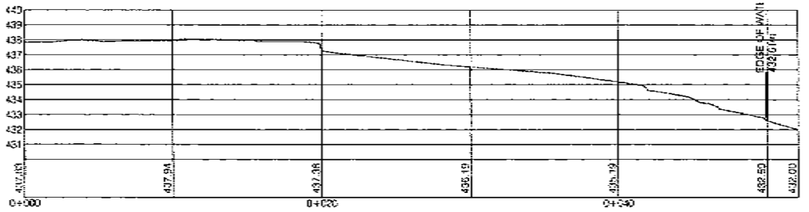

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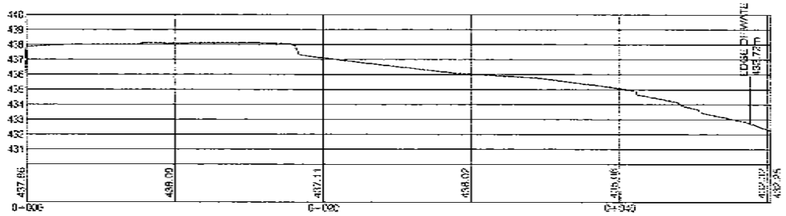

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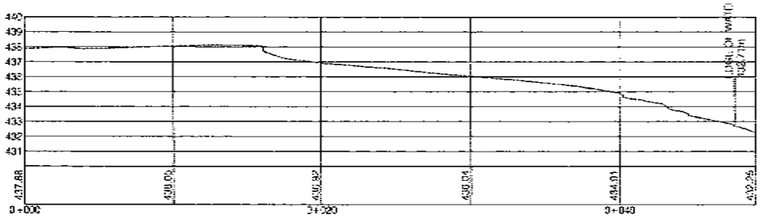

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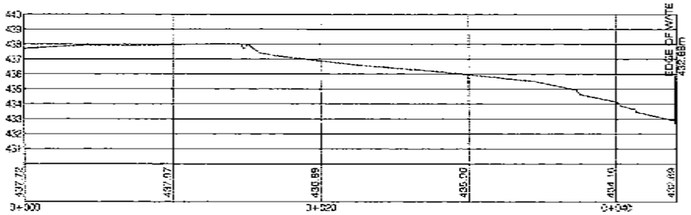

TRANSECT 5 (5) 1:200 MON12

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Rev. No.	Date	Designed	Drawn	Checked	Description of Revision

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KERR WOOD LEIDAL associates limited
CONSULTING ENGINEERS

BC HYDRO
COLUMBIA RIVER
EROSION MONITORING PROJECT CLB 36
SITE MON 10 AND SITE MON 12 SECTIONS

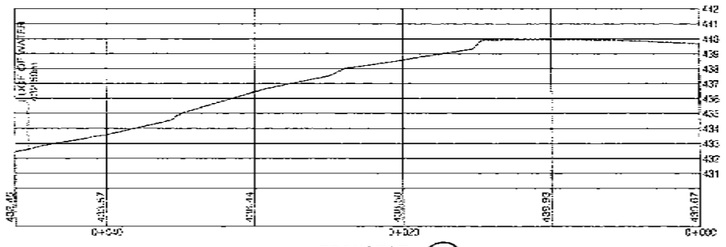
KWL Project No. 478.081 Scale AS SHOWN
Sheet 18 of 20 Rev. No. —
Client: BC HYDRO

SEC 2 Drawing Number

AT FULL SIZE THIS BAR MEASURES 100mm ALL SCALES ARE CORRECT TO FULL SIZE

Dec. 22/10

478.081\500-Drawings\478081SEC2.dwg



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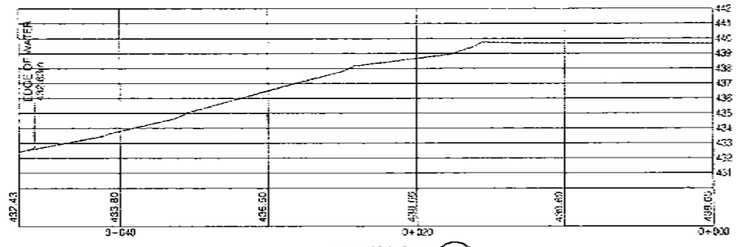

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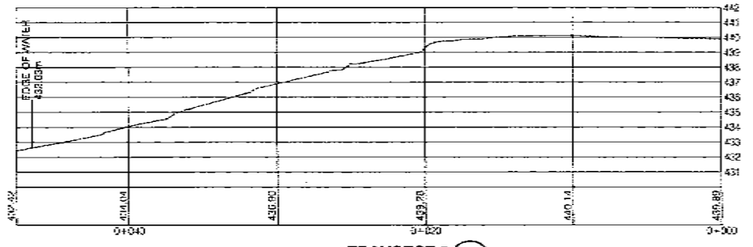

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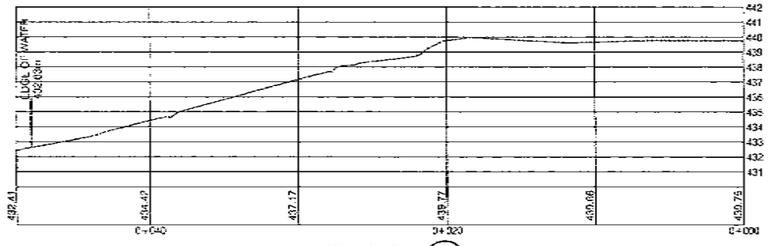

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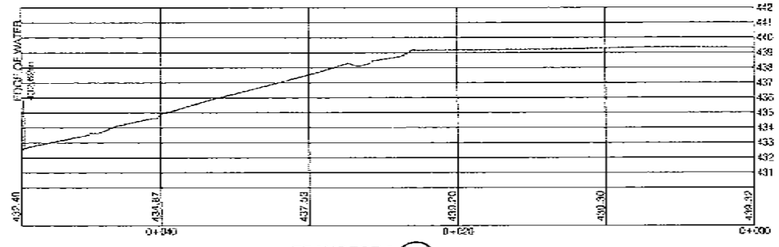

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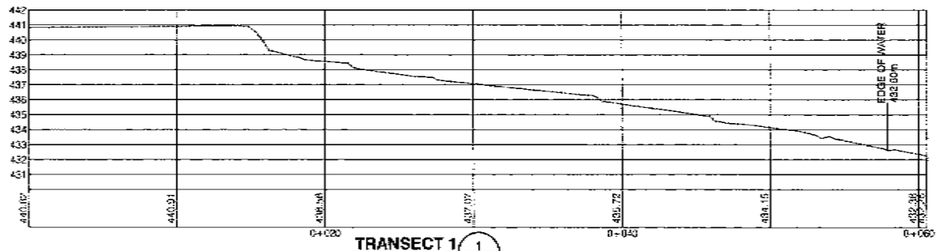

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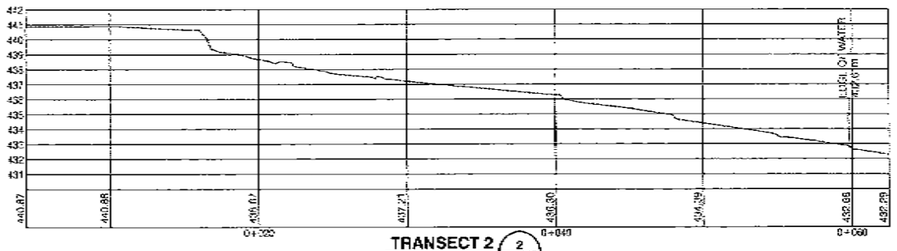

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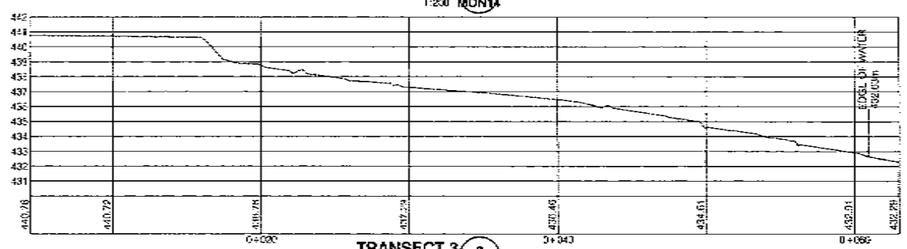

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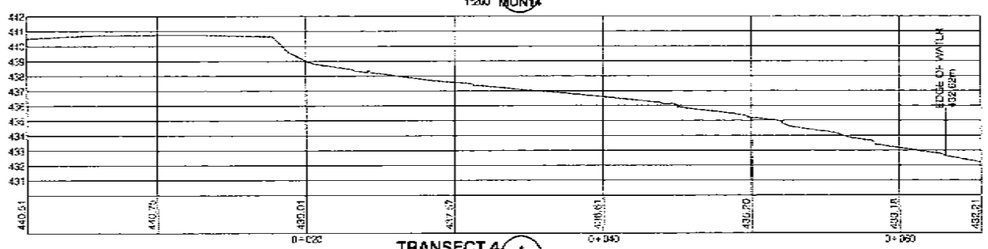

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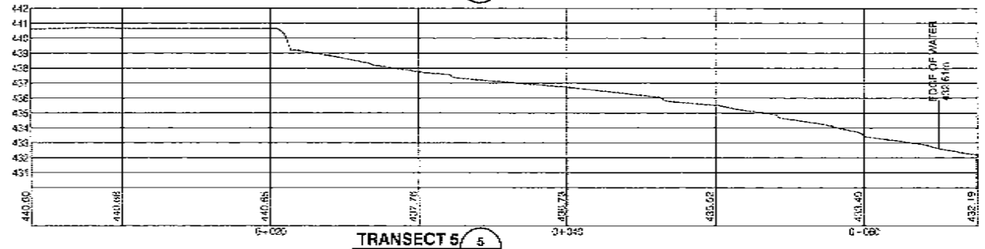

TRANSECT 5 (5) 1:200 MON14

AT FULL SIZE THIS BAR MEASURES 100mm. ALL SCALES INCH DIMENSIONS TO FULL SIZE.

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Rev. No.	Date	Designed	Drawn	Checked	Description of Revision

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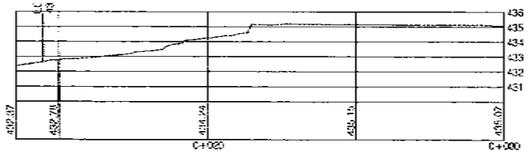
CONSULTING ENGINEERS

BC HYDRO
COLUMBIA RIVER
EROSION MONITORING PROJECT CLB 36
SITE MON 13 AND SITE MON 14 PLAN AND SECTIONS

KWL Project No. 478.081 | Scale AS SHOWN | **SEC 3** Drawing Number
Sheet 19 of 23 | Rev. No. 0
Client: BC HYDRO



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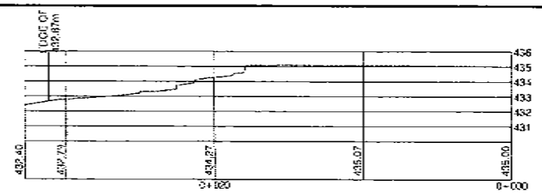

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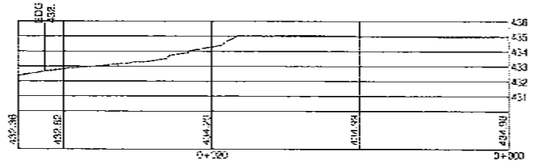

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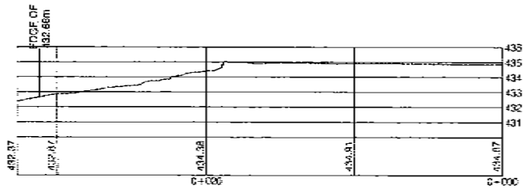

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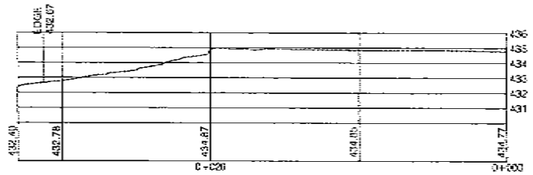

TRANSECT 5 (5) 1:200 MON15

A1 FULL SIZE THIS BAR MEASURES 100mm ALL SCALES INCORRECT IF NOT PLOTTED TO FULL SIZE

Dwg: 22/10

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ISSUED INFORMATION	Issued for	Issue	Date	Issued By
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Rev. No.	Date	Designed	Drawn	Checked	Description of Revision

Seal

KERR WOOD LEIDAL associates limited CONSULTING ENGINEERS

BC HYDRO
COLUMBIA RIVER
EROSION MONITORING PROJECT CLB 36
SITE MON 15 SECTIONS

KWL Project No. 478.081 Scale AS SHOWN

Sheet 20 of 20 Rev. No. 0

SEC 4 Drawing Number

Client: BC HYDRO

Appendix D

CLBWORKS #36 Photo Appendix

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

Photo A-1
Monitoring Site 1 (view downstream)

Photo A-2
Monitoring Site 1 (view upstream

Photo A-3
Monitoring Site 2 (view downstream)

Photo A-4
Monitoring Site 2 (view upstream)

Photo A-5
Monitoring Site 3 (view downstream)

Photo A-6
Monitoring Site 3 (view upstream)

Photo A-7
Monitoring Site 4 (view upstream)

Photo A-8
Monitoring Site 5 (view upstream)

Photo A-9
Monitoring Site 6 (view downstream)

Photo A-10
Monitoring Site 7 (view upstream)

Photo A-11
Monitoring Site 8 (view upstream)

Photo A-12
Monitoring Site 8 (view downstream)

Photo A-13
Monitoring Site 9 (view upstream)

Photo A-14
Monitoring Site 9 (upland area)

Photo A-15
Monitoring Site 10 (view upstream)

Photo A-16
Monitoring Site 10 (floodplain area)

Photo A-17
Monitoring Site 11 (view upstream)

Photo A-18
Monitoring Site 11 (view downstream)

Photo A-19
Monitoring Site 12 (view upstream from floodplain)

Photo A-20
Monitoring Site 12 (view downstream)

Photo A-21
Monitoring Site 13 (view upstream from water)

Photo A-22
Monitoring Site 13 (view downstream from water)

Photo A-23
Monitoring Site 14 (beach view downstream)

Photo A-24
Monitoring Site 14 (upland vegetation)

Photo A-25
Monitoring Site 15 (floodplain view downstream)

Photo A-26
Monitoring Site 15 (beach view downstream)

Photo A-27
Trimble R8 Base

Photo A-28
Trimble S6 Total Station

Photo A-29
Radio Repeater Station