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Alberta – British Columbia Boundary Commission

Survey Report
Yellowhead Pass Boundary Monument Project

Survey of Restoration of Survey Monuments S, 1S to 31S (Inclusively), and 33S Along a Portion of the Alberta – British Columbia Boundary

Project No: 180108 – Alberta / 180109 – B.C. & Canada
SGB Project No.: 201806041

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November 14th, 2018

Certified Correct this 14th day of November, 2018

Young, DavidM

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Certified Correct this 14th day of November, 2018

Tracey Peet, B.C.L.S., E.I.T.

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1.0 Introduction

Valard Geomatics Ltd. was contracted by Alberta Environment and Parks and British Columbia (BC) Land Title and Survey Authority (LTSA) to restore and survey 33 interprovincial monuments along the BC-Alberta border on behalf of the Alberta-British Columbia Boundary Commission. The area that is encompassed by these monuments is known as Yellowhead Pass and falls in between Mount Robson Provincial Park (BC) and Jasper National Park (Alberta); therefore, lies between areas under both provincial and federal jurisdiction.

The goal of this project was to restore the physical monuments in such a way to minimize further deterioration and assign accurate georeferenced coordinates to all points. The work was to be carried out in such a way to minimize all environmental impacts and ensure all deteriorated remnants of the monuments were properly disposed of. This work took place between August 12th and 27th, 2018, with August 12th and 27th being travel days for the field crews and August 24th being a standby day due to forest fires in the area requiring all helicopters.

2.0 Logistics

The unique nature of this project required in-depth planning for the project requirements. Prior to initializing work, a project start-up meeting was held with Parks Canada. A BC Parks representative was unable to make the meeting; however, they were in agreement with Parks Canada's rules and requirements. During this start-up meeting, many environmental concerns were addressed, including the "no-cutting" rule. Parks Canada gave the go-ahead to hand cut trees and shrubs within a few metres of each monument in order to make the border more visible for the general public. The survey crews were careful to follow this rule and cutting was absolutely required to provide a clear sky view at most of the locations.

Although Caltech Surveys' recommendations were to hike in to most of the monuments, helicopter access was required due to the amount of materials required to be brought in to restore the monuments and subsequently survey them. Yellowhead Helicopters Ltd., based out of Valemount, were subcontracted to complete this work. This introduced another challenge as this work was to be completed at the height of BC's forest fire season, meaning helicopters and pilots had limited availability.

On the south side of the railway, odd-numbered monuments 15S through 33S inclusive were visited via helicopter, while odd-numbered monuments 1S through 11S inclusive were visited via foot. North of the railway, even-numbered monuments 8S through 30S inclusive were flown to, while S to 6S were visited by hiking from the utility corridor with permission from Kinder Morgan.

Another unique requirement of this project was that all demolished remnants of the old monuments were to be properly disposed of and not left at the monument location. Upon taking apart the

monuments, the old concrete was discovered to have many pieces of native rock mixed in which easily broke apart from the old concrete mix. The native rocks were left around each monument. The concrete and any large pieces of monuments that were unable to be broken apart were packed in reusable plastic bins and recycled burlap sacks to be retrieved at the end of the project. This resulted in over 3550kg of concrete hauled out of the area via two full days of heli-slinging, using the Rockingham Gravel Pit for a staging area, as arranged by BC Parks. From the gravel pit, the concrete waste was sent to the West Yellowhead Landfill via dump trailer.

3.0 Survey Methodology

The requirements for this project were to georeference each monument to an absolute accuracy of +/- 0.20m. In order to achieve this, two bases were set-up everyday to continuously collect and broadcast data in Valemount, about 50km from the project area. In addition, the CANNET station in Jasper was utilized in order to obtain a network adjustment. By collecting static data at each of the monuments, Trimble recommends a minimum occupation time of five minutes plus one minute per kilometre away from the base station to achieve a relative baseline accuracy of +/- 0.03m. This methodology was followed even though the required accuracy was much more relaxed. The tree cover, coupled with the varying terrain, resulted in the survey crew setting up longer occupation times of at least one hour.

The monuments around the highway, railway, and utility corridor were close enough to each other for the survey crew to set-up another base along the highway in an open area. These monuments were all measured using Real-Time Kinematic (RTK) GNSS methods instead of static observations. Any monuments located in dense tree areas that required total station observations meant that control points were set in nearby open areas and a short traverse double-run into the monument location.

All base stations were processed using Natural Resources Canada's (NRCAN) Precise Point Positioning (PPP) service with the baselines between each processed to tighten the network. As the data from each monument observation came in, this was added to the baseline network to process everything relative to one another. In addition, all static GNSS data from the monument observations were processed using PPP to provide a redundant check on the baseline processing. All results of this processing can be found in Appendix 1.

4.0 Monuments

4.1 S

Found

There was no evidence of Monument S on the ground due to ongoing maintenance of the utility right-of-way. There is a distinct cutline heading northwest to Monument 2S and southeast to monument 1S.

Set

Prior to positioning or setting any monumentation, both BC One Call and Alberta One Call were contacted in order to have all underground utilities located in the vicinity. Once markers were placed on the surface, we worked with the locators to determine the best location for the new monument. This was decided to be along the south edge of the clearing for the utility corridor, approximately 7.5m south of the Kinder Morgan pipeline. This location likely results in the least amount of impact to the existing infrastructure and the best chance for monument survival. Parks Canada, BC Parks and Kinder Morgan staff were onsite for the setting of this monument. The lack of tree cover along the utility right-of-way provided ample sky view for RTK to enable the stake-out and subsequent measurement of the new S monument.

A ground-level, cylindrical, standard concrete post was set online between found monuments 1S and 2S, 7.5m southeast of where the original S monument was located. A capped post with rebar was used to keep the monument centered in the new concrete, which was 0.3m in diameter. A reference post was placed 0.6m northwest of the monument to protect the monument and make it visible.

BASED @	PT #	SRS 3 H.I.	1.983m
START CHECK PT #		SRS 4	2.000m
		ΔH 8mm ΔV 2mm	
* S (-1)	146	S - WIT	2.0m (2.3m)
		PL CONCRETE POST	
	PLACED		
* ~~PLANTED~~		THIS CONCRETE POST (FOR S)	
ON LINE BETWEEN 1S AND 2S.			
WITNESS MARKINGS AND A			
REFERENCE POST MUST BE ADDED			
TO THIS MONUMENT BEFORE WE			
LEAVE THIS PROJECT. PHOTOS			

INCLUDED W/TODAY'S DATA!

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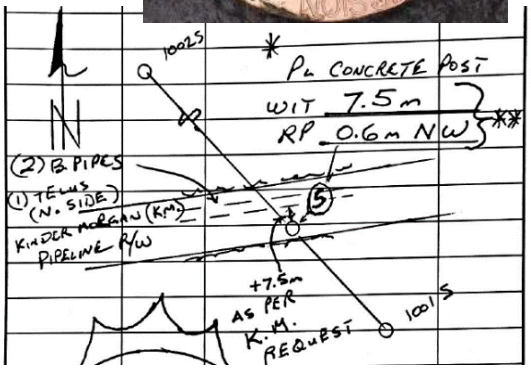


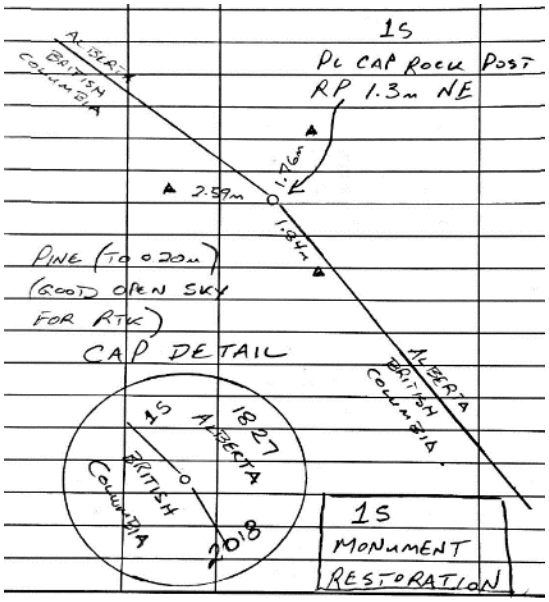
4.2 1S

Found

Monument 1S was found in poor condition with both the monolith and base deteriorating. The pillar cap and datum point was missing as well. Upon further inspection, all concrete easily broke off in large pieces and the removal of the monolith caused further deterioration and peeling of the concrete base. There is a distinct cutline northwest to monuments S and 2S and a hint of a cutline to 3S.

Set

Reference spikes were placed around the datum point in order to restore the centre of the monument upon demolition. The entire monument was then demolished to ground level and a standard rock post was set in the centre using a construction adhesive. A reference post was placed 1.3m northeast. 1S was surveyed in using GNSS RTK methods, with a base station set-up nearby on the highway. Although the photograph does not clearly show it, the cap has ‘Alberta’ and ‘British Columbia’ stamped on the correct sides.



1 S MONUMENT RESTORATION

FOUND MONOLITH IN POOR CONDITION SHOT MONOLITH TIP W/ RTK (SEE PG 4). ALSO MEASURED IN 3 REFERENCE SPIKES. FOR A SECONDARY CHECK (SEE SKETCH ON PAGE 5). REMOVED MONOLITH AND BASE. PLACED CAPPED ROCK POST TO RTK POSITION. CHECKED TO REF SPIKES. PHOTOS ATTACHED W/ TODAY'S DATA.

10015(-1)	148	PL CAP ROCK POST - 2.0m (2.3m) RP 1.3 m NE

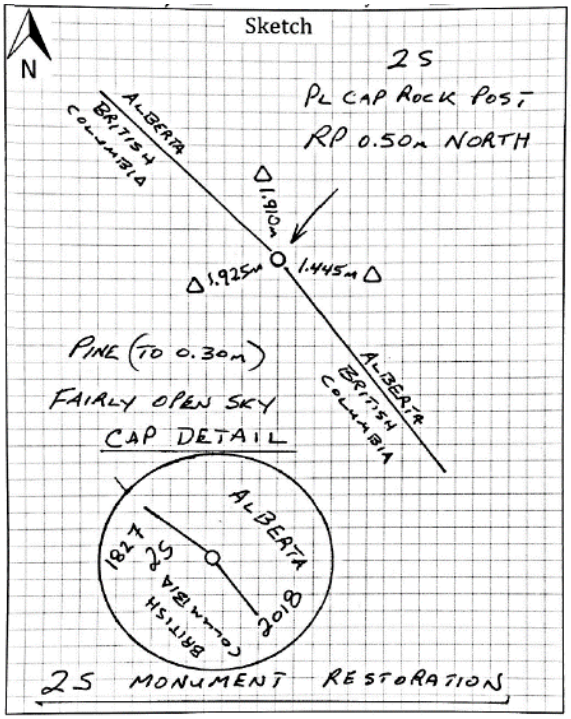
4.3 2S

Found

Monument 2S was found in poor condition with both the monolith and base deteriorating. The top of the pillar was missing but the datum point was still in place. Upon further inspection, all concrete easily broke off due to large cracks in the base and the removal of the monolith caused further deterioration of the concrete base. There was a faint cutline visible to the southeast towards S, but no visible cutline to 4S.

Set

Reference spikes were placed around the datum point in order to restore the centre of the monument upon demolition. The entire monument was then demolished to ground level and a standard rock post was set using a construction adhesive. A reference post was placed 0.5m north of the monument. Monument 2S was surveyed using a combination of RTK and static GNSS.



BASE @	Pt#	SRS 3 H.I.	1.949m
START CHECK	Pt#	SRS 4	2.000m
		ΔH 2mm ΔV -6mm	
		*OMIT	
1025	157	~~2S MONOLITH TIP~~	0.045m
* OMIT THIS POINT DUE TO POOR GPS POSITION!			
FOUND A MONOLITH 2S IN POOR CONDITION			
PILLAR TIP INTACT. MEASURED 3 SPIKES			
OFF OF TIP. REMOVED PILLAR AND			
BASE. PL CAPPED ROCK POST OFF			
OF REFERENCE SPIKES. PHOTOS			
ATTACHED WITH TODAY'S DATA.			
1002S(-1,-2)	150	2S- PL CAP ROCK POST	4.2m (4.4m)
		RP 0.50m NORTH	

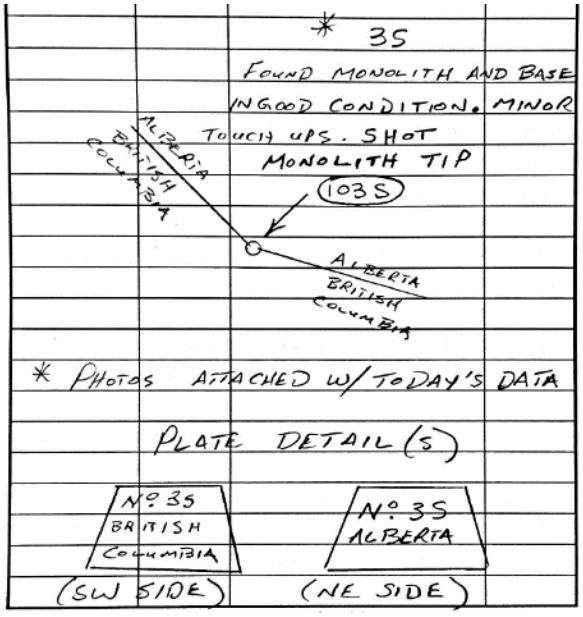
4.4 3S

Found

Monument 3S was found in excellent condition, with both the monolith and base still in place and no deterioration found. Minor cracks were observed in the base and one corner of the monolith was split open from the datum point to the base. There were no visible cutlines in either direction.

Set

The tin surrounding the monolith was pushed back in place and held with construction adhesive. The cracks in the concrete base were sealed and the entire base was coated with a waterproof sealant. Monument 3S was surveyed using GNSS RTK methods with a base station set-up on the highway.



*103S(-1)	157	3S - MONOLITH TIP	0.39m (0.05m)
* IN GOOD CONDITION. MINOR TOUCH-UPS. SKETCH ON PG 7 AND ATTACHED PHOTOS W/ TODAY'S DATA.			
SRS 4	110	PL SPIKE (CHECK PT) ΔH 7mm ΔV -6mm	2.000m

4.5 4S

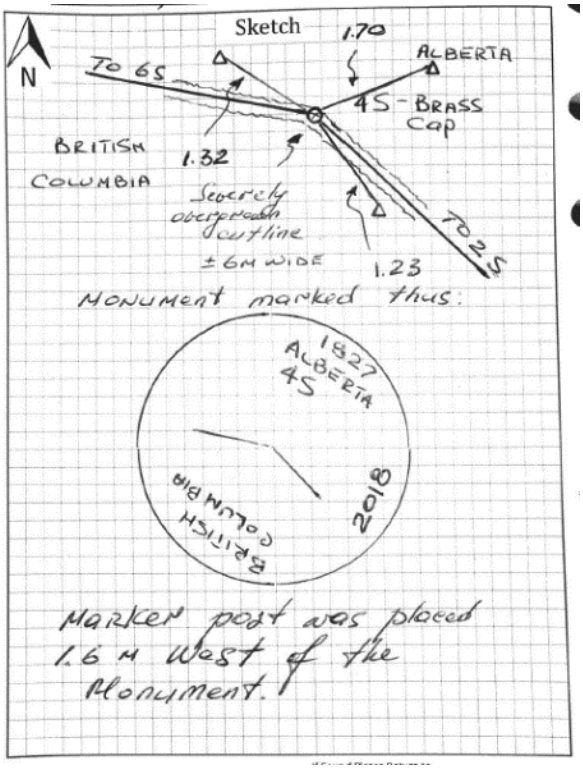
Found

Monument 4S was found in poor condition with the monolith completely off the base, possibly knocked off by a downed tree. Upon further inspection, the concrete base easily broke apart due to damage from surrounding trees, weather, and moss. There were no visible cutlines to either 2S or 6S.

Set

Reference spikes were placed around the concrete base in order to restore the centre of the monument upon demolition. The entire monument was then demolished to ground level and a standard rock post was set using a construction adhesive. A reference post was placed 1.6m west. Monument 4S was surveyed using GNSS RTK methods.

Point No.	Code	Description	Height
①	Check	TO SRS 4 BY S.	
Snowden	on Aug 19, 2018		
SRS 4	112	CHK	2.00
	ΔH=0.019	ΔV=-0.029	
②	Monument 4S.		
Found monument 4S, top			
monolith has been knocked off,			
the base is in poor condition.			
Measured the centre of the			
base with a tape placed			
3 reference spikes: 1.70M, 1.23M,			
1.32M. The base was brought			
down to ground level. The			
centre was restored and			
the brass cap was placed			
in the centre using reference			
spikes. ~~1.23~~ RTK observations			
were taken to obtain coordi			
nate.			



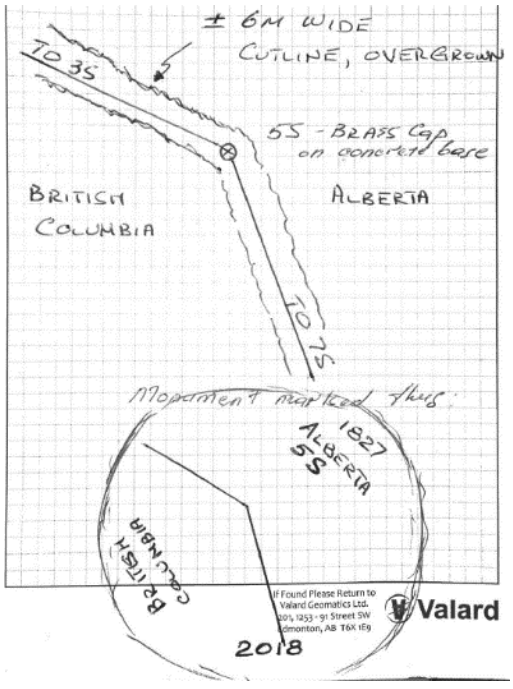
4.6 5S

Found

Monument 5S was found in fair condition with the monolith severely deteriorating and no datum point visible. The base had deeper cracks but the majority of it was still intact. There were prominent cutlines towards 7S and 3S. There was a number recorded below the tin plates on the monolith (‘*903-170814*’).

Set

Monument 5S was surveyed using GNSS RTK methods from a base station set-up nearby on the highway. The monolith was carefully removed and the base was repaired by sealing the cracks and filling in where the pillar was removed. A standard rock post was set in the new concrete using the previous RTK measurement and measuring between the four corners for restoration. The entire base was sealed to mitigate erosion. A reference post was placed 1.5m northwest of the monument.



Found monument 55 monolith top in poor condition, the base is repairable. Observed the centre of the top monolith and removed it, prepared the base, cleaned up of a debris, filled up with concrete and bonding adhesive. Staked the centre of the monument to its previously observed position. MARKER post placed 1.5 m NW of the monument.

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4.7 6S

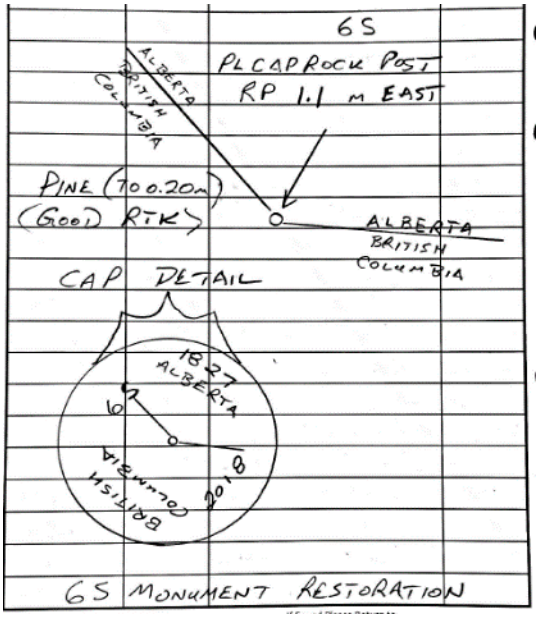
Found

Monument 6S was found in poor condition with the monolith completely off the base and the base severely deteriorating. Upon clearing the vegetation and moss from the base, all the concrete of the base easily fell apart and restoring it was not an option. There were no visible cutlines in either direction.

Set

The centre of the base was measured using the four corners of the base, rather than reference spikes. The entire monument was then demolished to ground level and a standard rock post was set using a construction adhesive. A reference post was placed 1.1m east. Monument 6S was surveyed using GNSS RTK methods.

BASE Pt #		SRS 3 H.I.	1.890m
START CHECK Pt #		SRS 4	2.000m
		ΔH 2mm ΔV 1mm	
106 S(-1)	157	6S FD CONCRETE	1.80m (2.10m)
		BASE - CTR (INTERSECTION OF CORNERS)	
FD CONCRETE BASE OF 6S. PILLAR WAS LAYING ON THE GROUND. MEASURED CTR OF BASE BY INTERSECTION OF CORNERS. SHOT w/ RTK (106S(-1)). REMOVED BASE. PL CAPPED ROCK POST TO Pt # 106S.			
106S(-1)	148	PL CAP ROCK POST	20m (2.3m)
		RP 1.1m EAST	



4.8 7S

Found

Monument 7S was found in poor condition with both the monolith and base deteriorating. The top of the pillar was completely missing but the datum point was still in place within the weathered concrete. Upon further inspection, the “minor cracks” in the concrete easily broke apart and the removal of the monolith caused further breaking of the concrete base. There was a prominent cutline towards 5S, but no visible cutline to 9S.

Set

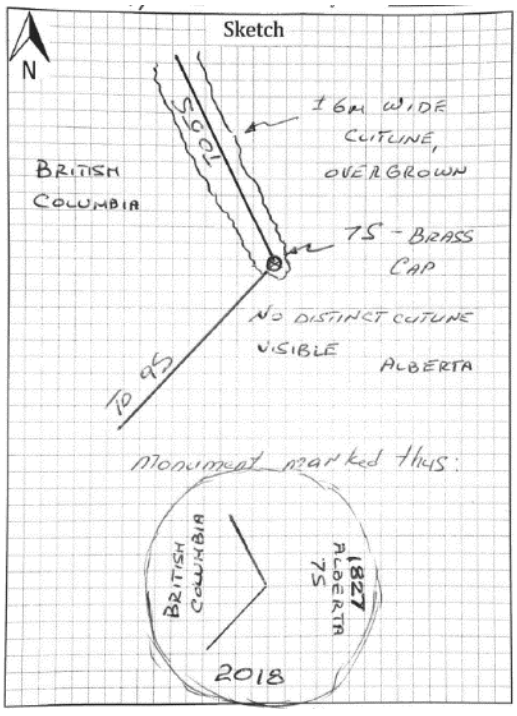
Monument 7S was georeferenced by taking a GNSS RTK measurement on the datum point in order to restore the centre of the monument upon demolition. Therefore, no reference spikes were used. The entire monument was then demolished to ground level and a standard rock post was set using a construction adhesive. A reference post was placed south of the monument.

Note: the description of restoration to monument 7S mentions 5S rather than 7S. This is a blunder in the field notes and should read 7S.

7S

(3) Monument ~~5S~~. Found Monument ~~5S~~ 7S top monolith part of the monument in poor condition, base with cracks. Observed the top monument centre. Top monolith part was removed and the base was brought down to ground level. Marked the previously observed position of the centre of the monument into its original position. Placed rock brass cap in the rock.

If Found Please Return to



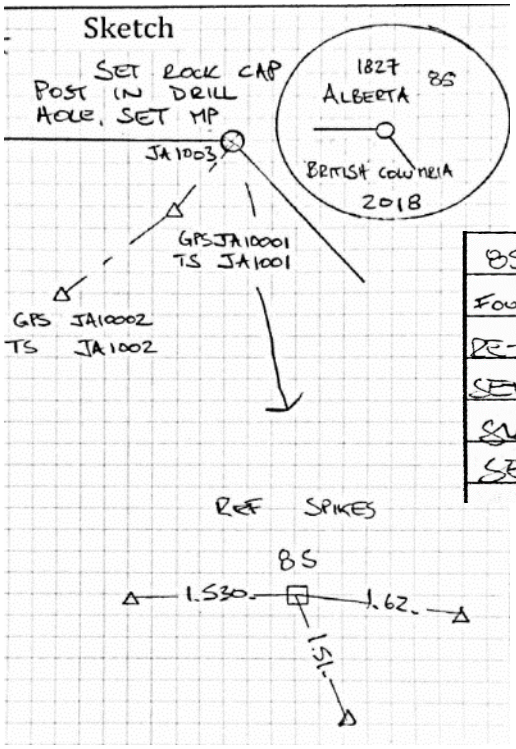
4.9 8S

Found

Monument 8S was found in fair condition with both the monolith and base deteriorating. The top of the pillar and the datum point were still in place but the tin on the monolith was peeling. This caused weather damage to the concrete inside. Upon further inspection of the minor cracks reported on the base, all of the concrete easily broke apart and the removal of the monolith caused further deterioration of the concrete base. There was a prominent cutline towards 5S, but no visible cutline to 9S.

Set

Reference spikes were placed around the datum point in order to restore the centre of the monument upon demolition. The entire monument was then demolished to ground level and a standard rock post was set using a construction adhesive. A reference post was placed north of the monument. Two control points were established in a nearby clearing via GNSS RTK methods, as shown in the field notes sketch. Monument 8S was surveyed by traversing from control points set in a nearby clearing.



BS			
FOUND OLD	MONUMENT, MONOLITH & BASE DETERIORATING.		
RE-ESTABLISHED	CENTRE USING REMAINING MONOLITH.		
SET THREE	REFERENCE SPIKES, REFER TO		
SKETCH.	UNABLE TO OCCUPY DUE TO CANOPY.		
SET 2	CONTROL POINTS, TIED CONVENTIONALLY		

4.10 9S

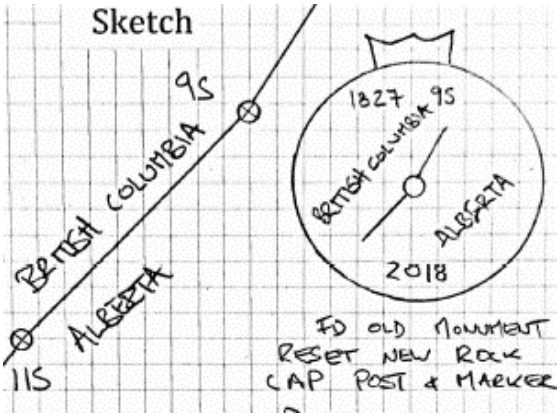
Found

Monument 9S was found in poor condition with both the monolith and base severely deteriorating. The peeling tin on the monolith has introduced water damage within the concrete which required the entire structure to be removed. The removal of the monolith caused further deterioration of the concrete base and the small cracks in the base quickly gave way to large pieces of concrete breaking off, as shown in the photographs. There were no visible cutlines in either direction.

Set

Monument 9S was georeferenced by GNSS RTK ties to the datum point in order to restore the centre of the monument upon demolition. Therefore, reference spikes were not required to restore this monument. The entire monument was then demolished to ground level and a standard rock post was set using a construction adhesive. A reference post was placed 1.5m south.

9S			
FOUND OLD	MONUMENT,	BASE & MONOLITH DETERIORATING,	
SHOT TOP.	REMOVED	BASE & MONOLITH. RESET ROCK	
CAP POST	& MARKER	POST 1.50- SOUTH	
JA1004	9S	TOP OF OLD MONOLITH	2.30-
JA1004C1	9S	CHK	2.47-
JA1005	9S	RESET ROCK CAP POST	2.47-
JA1005C1	9S	CHK	2.47-



4.11 10S

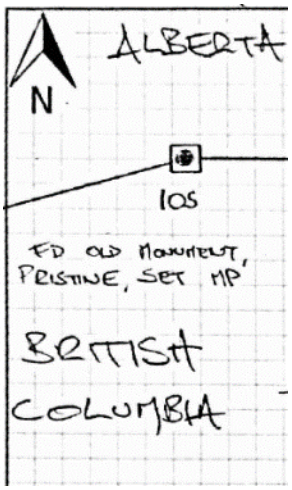
Found

Monument 10S was found in excellent condition with both the monolith and base still in place and no deterioration found. There were minor cracks in the concrete base but nothing affecting the structural integrity. There was no visible cutline to 8S; however, there was a slight cutline visible uphill to 12S.

Set

The cracks in the concrete base were sealed and the entire base was coated with a waterproof sealant. Monument 10S was surveyed using static GNSS observations and a marker post was set nearby.

IOS			
FOUND OLD	MONUMENT, CONDITION IS PRISTINE.		
SEALED FEW	MINOR CRACKS ON BASE. APPLIED		
SEALANT. SET	MARKER POST		
LOGGED	STATIC @ IOS, EXISTING MONUMENT		
START TIME:	12:36	HT: 0.55 -	
END TIME	13:55		



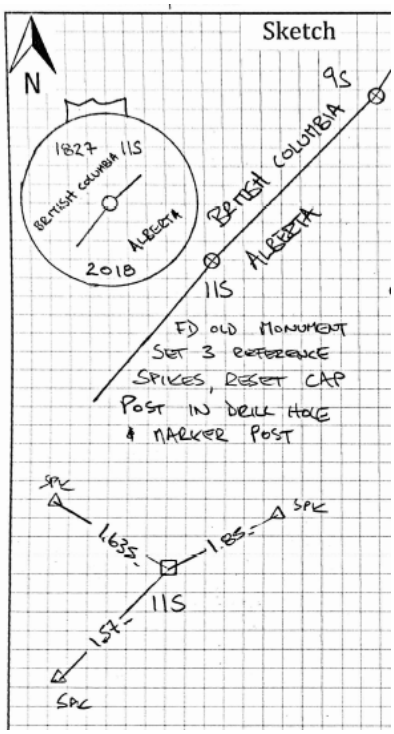
4.12 11S

Found

Monument 11S was found in poor condition with both the monolith and base severely deteriorating. The pillar top was missing but the datum point remained in place. The monolith was not salvagable and the subsequent removal caused further deterioration of the concrete base. The base was not salvagable due to the amount of vegetation growing in the cracks. There were no visible cutlines in either direction.

Set

The tree that had fallen across the base was easily removed. Reference spikes were placed around the datum point in order to restore the centre of the monument upon demolition. The entire monument was then demolished to ground level and a standard capped post was drilled in the existing concrete. A reference post was placed 1.2m north. Monument 11S was surveyed using static GNSS methods.



115			
FOUND OLD MONUMENT, BASE & MONOLITH DETERIORATED			
SET 3 REFERENCE SPIKES, REMOVED BASE & MONOLITH			
RESET CAP POST IN DRILL HOLE, MP 1.20m NORTH			
JA1006	115		2.90-
JA1006C1	115		3.20-

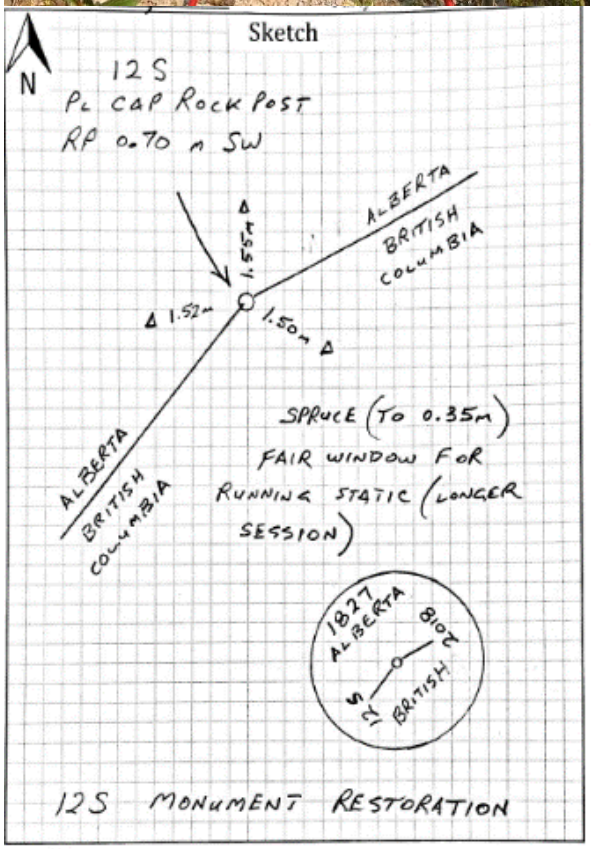
4.13 12S

Found

Monument 12S was found in fair condition with both the monolith and base deteriorating. The pillar top was partially missing but the datum point remained in place. Peeling tin on the monolith has caused heavy weathering of the concrete inside. Upon further inspection, all concrete easily broke off and the removal of the monolith caused further deterioration of the concrete base. There was no visible cutline to 10S; however, a prominent cutline towards 14S was observed.

Set

Reference spikes were placed around the datum point in order to restore the centre of the monument upon demolition. The entire monument was then demolished to ground level and a standard rock post was drilled in the existing concrete and set using construction adhesive. A reference post was placed 0.7m southwest. Monument 12S was surveyed using static GNSS observations.



12S	MONUMENT RESTORATION.
FOUND	MONOLITH IN POOR/FAIR CONDITION
W/ BASE	IN FAIR CONDITION (CRACKS).
MEASURED	3 SPIKES OFF OF MONOLITH
AS PER	SKETCH ON PAGE 3. UPON
REMOVING	THE MONOLITH, THE
BASE	FELL APART, SO REMOVED
BOTH	MONOLITH AND BASE. SET CAP
ROCK POST	OFF OF THE REFERENCE
SPIKES.	PHOTOS ATTACHED WITH
TODAY'S	DATA.

4.14 13S

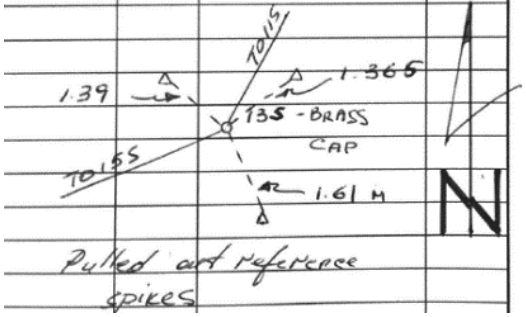
Found

Monument 13S was found in poor condition with both the monolith and base deteriorating. The pillar top was partially missing but the datum point remained in place. Upon further inspection of the minor cracks in the base, all concrete easily broke off in large pieces and the removal of the monolith caused further deterioration of the concrete base. There was a visible cutline to 15S; however, no visible cutline towards 11S was observed.

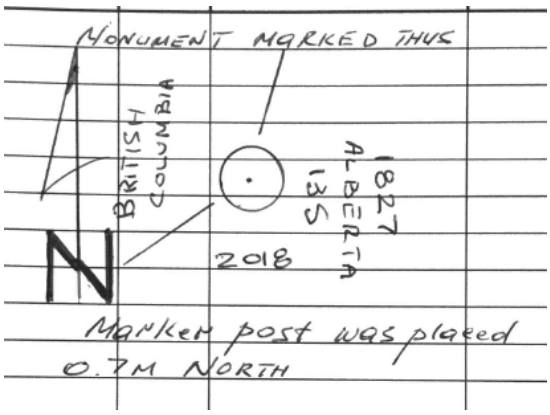
Set

Reference spikes were placed around the datum point in order to restore the centre of the monument upon demolition. The entire monument was then demolished to ground level and a standard capped post was drilled in the existing concrete. A reference post was placed 0.7m north. Monument 3S was surveyed using a long GNSS static occupation due to the surrounding tree cover.

(2) Monument 135.
Found monument 135.
Monolith pyramid is on the base showing signs of significant deterioration. Base is square with signs of deterioration.
The pyramid top was removed - unable to restore, that revealed significantly deteriorating base underneath. Prior to removal of the top pyramid its centre was referenced with 3 spikes 1.365 M, 1.39 M, and 1.61 M.
The base was brought down to the ground level. A rebar was put in the ground with a brass cap using reference spikes.



Pulled out reference spikes



4.15 14S

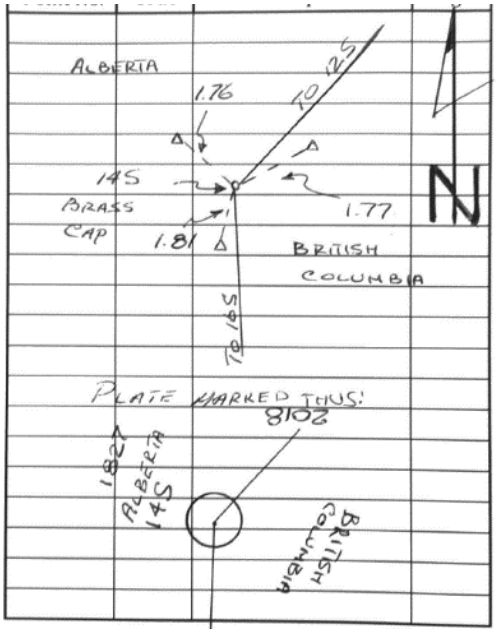
Found

Monument 14S was found in poor condition with both the monolith and base heavily deteriorating. The majority of the tin on the monolith was peeling away, revealing heavily weathered concrete inside. The pillar top was partially missing but the datum point remained in place. Upon further inspection, all concrete easily broke off in large pieces and the removal of the monolith caused further deterioration of the severely cracked concrete base. There are prominent cutlines to both 16S and 12S.

Set

Reference spikes were placed around the datum point in order to restore the centre of the monument upon demolition. The entire monument was then demolished to ground level and a standard capped post was drilled in the existing concrete. A reference post was placed 1.6m northeast. Monument 14S was surveyed using static GNSS methods.

3(4) Monument 145.
Found monument 145 in poor condition. Referenced center of the monument with 3 spikes: 1.76, 1.77, 1.81 M
Removed the top of the monument, brought the base down to the ground level. Re-stored the position of the monument using reference spikes. Placed ~~Initial with~~ Brass cap in the re-stored position MP placed 1.6 M NE
See Sketch.



4.16 15S

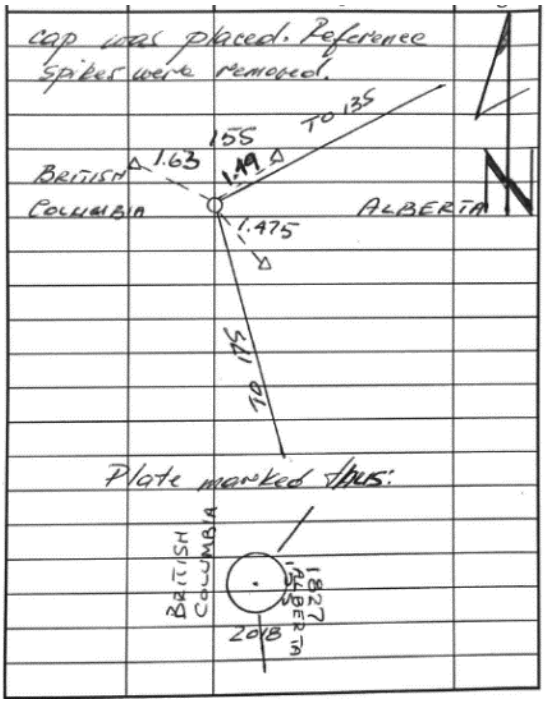
Found

Monument 15S was found in poor condition with the monolith completely sheared off by a nearby dead tree. The base was severely deteriorating but the centre of the base was able to be restored by using the four corners of the base once the vegetation was cleared away. The large cracks in the concrete base prevented it from being restored. There were no visible cutlines in either direction.

Set

Reference spikes were placed around the base in order to restore the centre of the monument upon demolition. The entire base was then demolished to ground level and a standard capped post was drilled in the existing concrete and set using construction adhesive to hold it in place. A reference post was placed 0.6m north. Monument 15S was surveyed using GNSS static observations.

(1) Monument 155.
Found monument 155, monolith pyramid knocked off by deadfall tree, pinched between trunk of a tree ±40cm and a ground. Base showed signs of deteroration while preserved good square shape restored centre position of the monument of the base corners. After removing top brittle concrete, the decision was made to bring base to ground level. The position of the centre was referenced by 3 spikes: measured 1.49M 1.475M and 1.63M (See Sketch) The position ~~w~~ of the monument was restored of the ~~monolith~~ reference spikes and brass cap was placed. Reference spikes were removed.



Brass cap was placed ~~with~~ on top of rebar put in the ground.
~~Monument~~
Marker post ~~is~~ placed 0.6M NORTH OF THE monument.

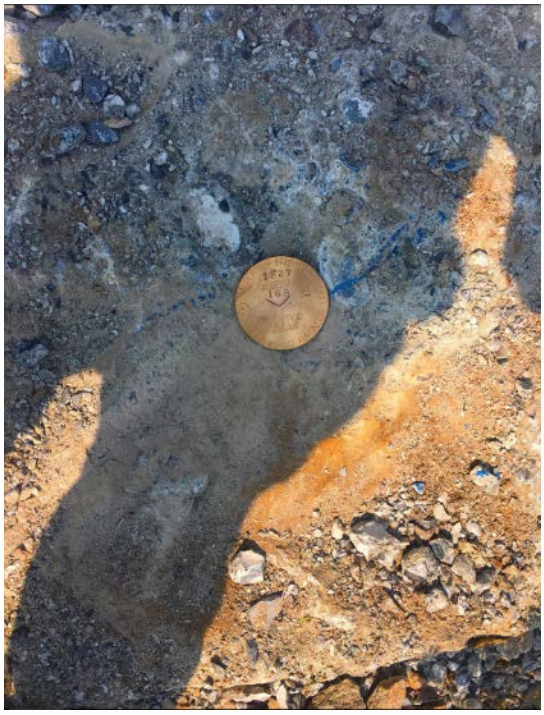
4.17 16S

Found

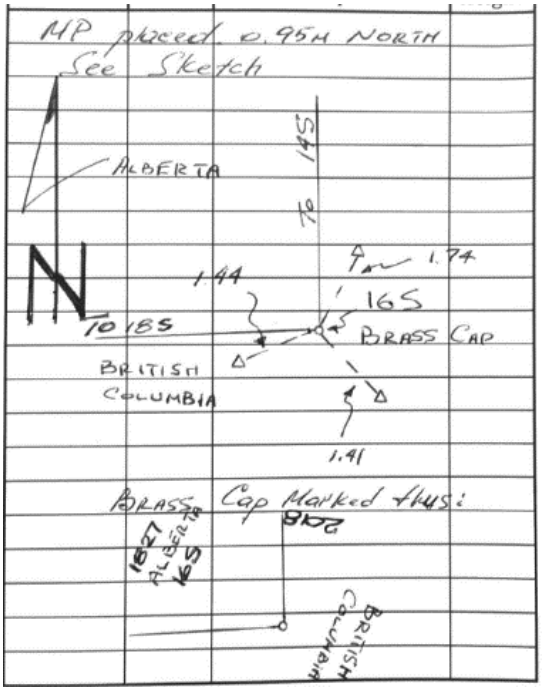
Monument 16S was found in poor condition with both the monolith and base deteriorating. The pillar top was off centre but the datum point remained in place. Upon further inspection, all concrete easily broke off and the removal of the monolith caused further deterioration of the concrete base. There were prominent cutlines to both monuments 14S and 18S.

Set

Monument 16S was surveyed using static GNSS observations. Reference spikes were placed around the datum point in order to restore the centre of the monument upon demolition. The entire monument was then demolished to ground level and a standard rock post was drilled in the existing concrete and set using construction adhesive. A reference post was placed 0.95m north.



(5) Monument 165
Found Monument 165,
Base and pyramid monolith in
poor condition. Referenced
the position of the monuments
centre with 3 spikes: 1.41,
1.44, 1.74. Removed the top
monolith part of the monument
and put the base to the ground
level. Re-stored the position of
the monument using the refere-
nce spikes. Placed ~~cap~~ "rock"
brass cap in the re-stored posit



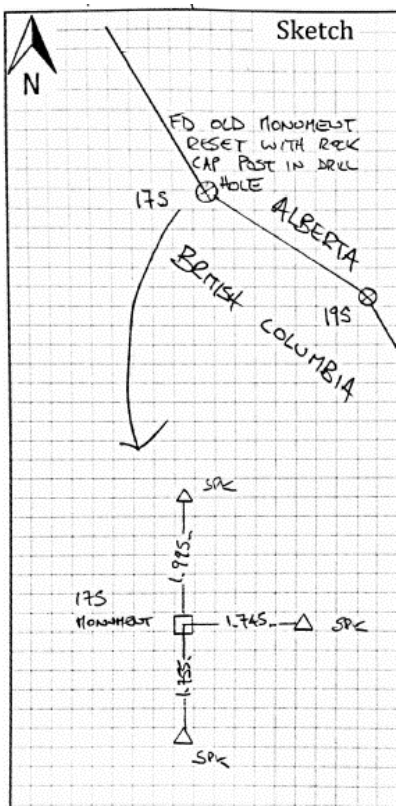
4.18 17S

Found

Monument 17S was found in poor condition with both the monolith and base deteriorating. The pillar top was partially missing but the datum point remained in place. Upon removal of the monolith, all concrete easily broke off in large pieces. There were prominent cutlines to both monuments 15S and 19S.

Set

The 10-20cm diameter pine trees surrounding the monument were cut to allow for a static occupation and ensure visibility of the border. Reference spikes were placed around the datum point in order to restore the centre of the monument upon demolition. The entire monument was then demolished to ground level and a standard rock post was drilled in the existing concrete and set using construction adhesive. A reference post was placed nearby. Monument 17S was surveyed using a static GNSS observation.



17S			
FOUND OLD	MONUMENT, MONOLITH & BASE DETERIORATING.		
RE-ESTABLISHED	CENTRE USING REMAINING MONOLITH.		
SET THREE	REFERENCE SPIKES, REFER TO SKETCH.		
SET ROCK CAP	POST IN DRILL HOLE		
LOGGED STATIC @	17S ROCK CAP POST		
START TIME	11:55	HT 1.473	
END TIME	13:03		

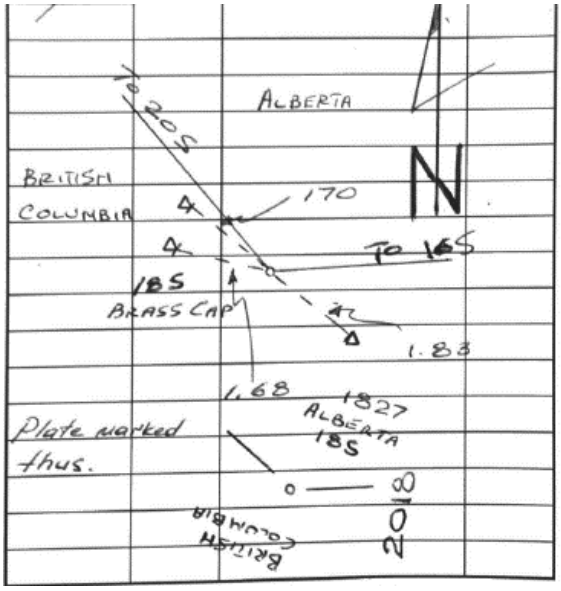
4.19 18S

Found

Monument 18S was found in poor condition with both the monolith and base deteriorating. The pillar top was splitting apart but the datum point remained in place. Upon further inspection, all concrete easily broke off and the removal of the monolith caused further deterioration of the concrete base. There were prominent cutlines to both monuments 16S and 20S.

Set

Reference spikes were placed around the datum point in order to restore the centre of the monument upon demolition. The entire monument was then demolished to ground level and a standard rock post was drilled in the existing concrete and set using construction adhesive. A reference post was placed 1.5m east. Monument 18S was surveyed using static GNSS observations.



(2) Monument 185
Found monument 185, base and monolith pyramid in a poor condition. Referenced the centre of the monolith with 3 spikes: 1.68, 170 & 1.83 m. Removed the monolith and brought the base to the ground level. Restored position of the monolith using reference spikes. Placed "rock" brass cap in the restored position. See sketch.

4.20 19S

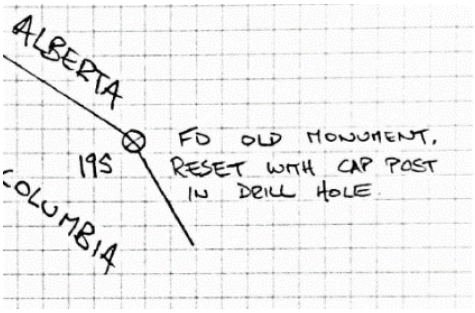
Found

Monument 19S was found in poor condition with both the monolith and base deteriorating. The pillar top and datum point were missing. Upon further inspection, most concrete easily broke off and the removal of the monolith caused further deterioration of the concrete base. There was a clear cutline to 17S but nothing visible downhill to 21S.

Set

Reference spikes were placed around the datum point in order to restore the centre of the monument upon demolition. Most of the concrete base was demolished until solid concrete was reached. The remaining concrete was patched and sealed and a standard capped post was drilled in the existing concrete and set using construction adhesive. A reference post was placed nearby. Monument 19S was georeferenced using static GNSS observations.

19S		
FOUND OLD	MONUMENT, MONOLITH DETERIORATING	
REPAIRED	CONCRETE BASE, RE-ESTABLISHED CENTRE	
WITH REMAINING	MONOLITH FOOTPRINT.	
SET	CAP POST	IN DRILL HOLE
LOCATED	STATIC @	19S CAP POST IN DRILL HOLE
START TIME	08:38	HT: 1.190m
END TIME	10:22	



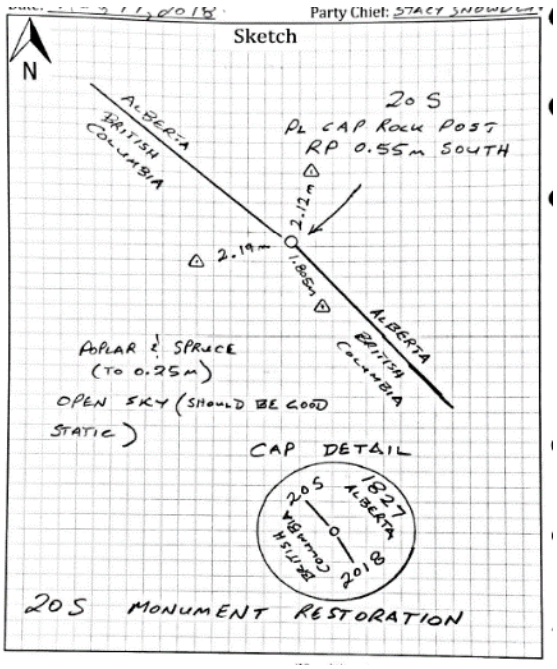
4.21 20S

Found

Monument 20S was found in poor condition with both the monolith and base deteriorating. The pillar top was missing but the datum point remained in place. Upon further inspection, all concrete easily broke off and the removal of the monolith caused further deterioration of the concrete base. There were faint cutlines to both monuments 18S and 22S.

Set

Reference spikes were placed around the datum point in order to restore the centre of the monument upon demolition. The entire monument was then demolished to ground level and a standard rock post was drilled in the existing concrete and set using construction adhesive. A reference post was placed 0.55m south. Monument 20S was surveyed using static GNSS observations.



20 S	MONUMENT RESTORATION	
FOUND MONOLITH W/ BASE IN POOR CONDITION. MEASURED 3 SPIKES OFF OF MONOLITH AS PER SKETCH ON PAGE 6. REMOVED MONOLITH AND BASE. SET CAP ROCK POST OFF OF THE REFERENCE SPIKES. PHOTOS ATTACHED W/ TODAY'S DATA.		

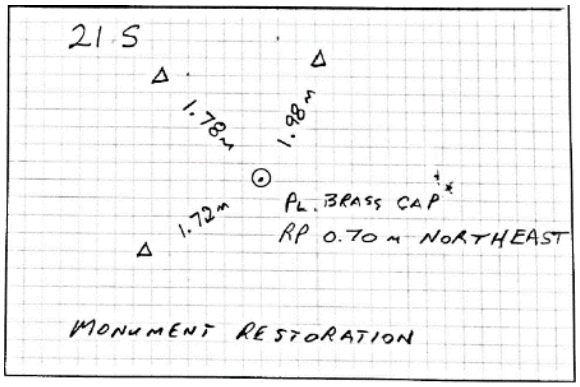
4.22 21S

Found

Monument 21S was found in poor condition with both the monolith and base severely deteriorating. The pillar top and datum point were off centre. Upon further inspection, all concrete easily broke off and the removal of the monolith caused further deterioration of the concrete base. There were no visible cutlines in either direction.

Set

Monument 21S was surveyed via static GNSS. Reference spikes were placed around the datum point in order to restore the centre of the monument upon demolition. The entire monument was then demolished to ground level and a standard rock post was drilled in the existing concrete and set using construction adhesive. A reference post was placed 0.7m northeast of the monument.



21 S MONUMENT RESTORATION
FOUND MONOLITH IN POOR CONDITION.
SET 3 SPIKES OFF OF CTR OF MONOLITH
BROKE APART MONOLITH AND REMOVED.
SET BRASS CAP OFF OF THE SPIKES.
SEE SKETCH ON PAGE 3 AND ATTACHED
PHOTOS WITH TODAY'S DATA.

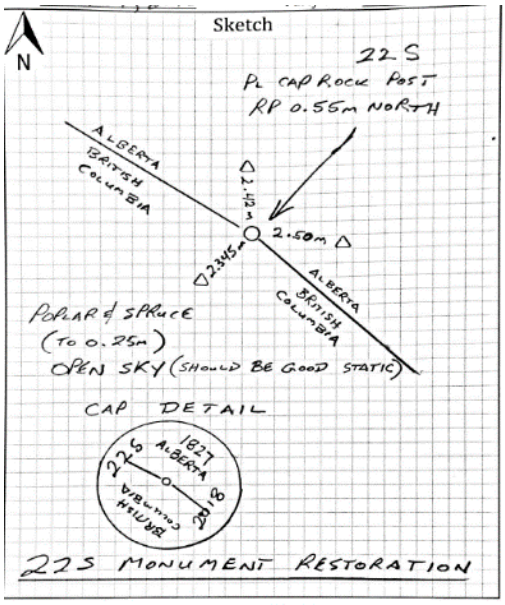
4.23 22S

Found

Monument 22S was found in poor condition with both the monolith and base severely deteriorating. The pillar top was partially missing but the datum point remains in place. Upon further inspection, all concrete easily crumbled and the removal of the monolith caused further deterioration of the concrete base. There was a visible cutline leading to 24S but nothing prominent to 20S.

Set

Monument 22S was surveyed using static GNSS observations. Reference spikes were placed around the datum point in order to restore the centre of the monument upon demolition. The entire monument was then demolished to ground level and a standard rock post was drilled in the existing concrete and set using construction adhesive. A reference post was placed 0.55m north.



22S	MONUMENT RESTORATION.
FOUND	MONOLITH W/BASE IN POOR/FAIR CONDITION. MEASURED 3 SPIKES OFF OF MONOLITH AS PER SKETCH ON PAGE 3. REMOVED MONOLITH AND BASE. SET CAP ROCK POST OFF OF THE REFERENCE SPIKES. PHOTOS ATTACHED W/TODAY'S DATA.

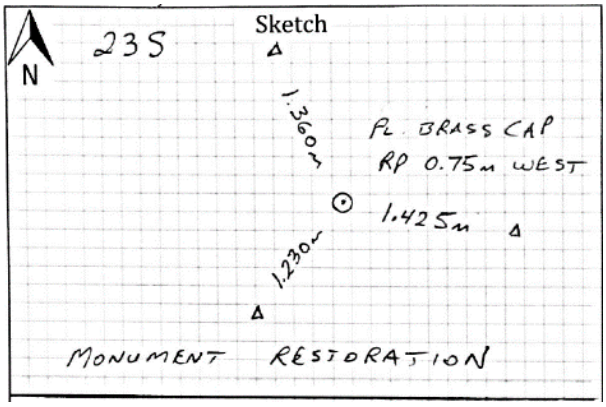
4.24 23S

Found

Monument 23S was found in poor condition with both the monolith and base deteriorating. The pillar top was missing but the datum point was still in place. Upon further inspection, all concrete easily broke off and the removal of the monolith caused further deterioration of the concrete base. There were no visible cutlines in either direction.

Set

Reference spikes were placed around the datum point in order to restore the centre of the monument upon demolition. The entire monument was then demolished to ground level and a standard rock post was drilled in the existing concrete and set using construction adhesive. A reference post was placed 0.75m west. Monument 23S was surveyed using static GNSS methods.

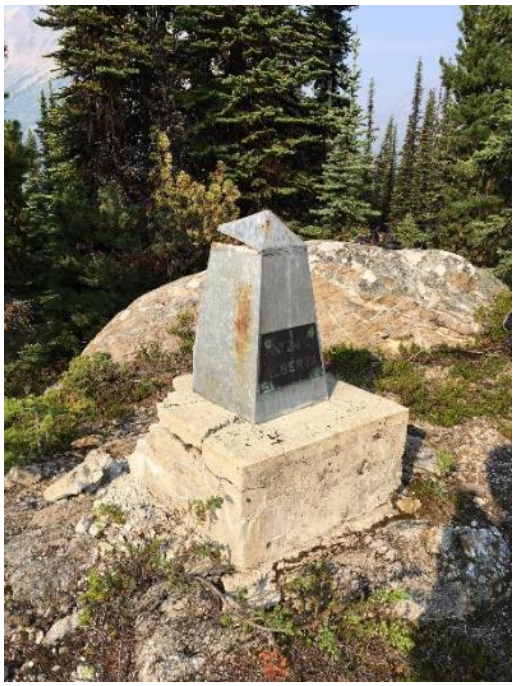


235 MONUMENT RESTORATION.
FOUND MONOLITH IN POOR CONDITION
SET 3 SPIKES OFF OF CTR OF
MONOLITH. BROKE APART MONOLITH
AND REMOVED. SET BRASS CAP
OFF OF THE SPIKES. SEE SKETCH
ON PAGE 3 AND ATTACHED PHOTOS
WITH TODAY'S DATA.

4.25 24S

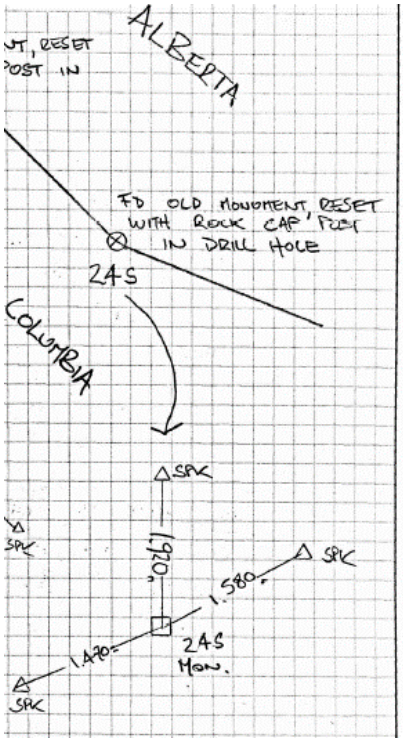
Found

Monument 24S was found in poor condition with both the monolith and base severely deteriorating. The pillar top was partially missing but the datum point was still in place. Upon further inspection, all concrete easily broke off and the removal of the monolith caused further deterioration of the concrete base. There was a prominent cutline to 26S but nothing visible to 22S.



Set

Reference spikes were placed around the datum point in order to restore the centre of the monument upon demolition. The entire monument was then demolished to ground level and a standard rock post was drilled in the existing concrete and set using construction adhesive. A reference post was placed nearby. Monument 24S was surveyed using static GNSS observations.



24S			
FOUND OLD MONUMENT, MONOLITH & BASE DETERIORATING.			
RE-ESTABLISHED CENTRE WITH REMAINING MONOLITH			
FOOTPRINT. SET 3 REFERENCE SPIKES, REFER TO			
SKETCH. SET ROCK CAP POST IN DRILL HOLE			

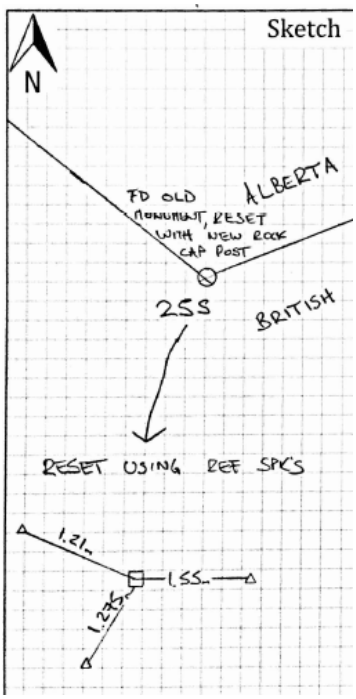
4.26 25S

Found

Monument 25S was found in poor condition with both the monolith and base severely deteriorating. The pillar top was missing but the datum point was still in place. Upon further inspection, all concrete easily broke off and the removal of the monolith caused further deterioration of the concrete base. There are no visible cutlines in either direction.

Set

Reference spikes were placed around the datum point in order to restore the centre of the monument upon demolition. The entire monument was then demolished to ground level and a standard rock post was drilled in the existing concrete and set using construction adhesive. A reference post was placed nearby. Monument 25S was surveyed using static GNSS methods.

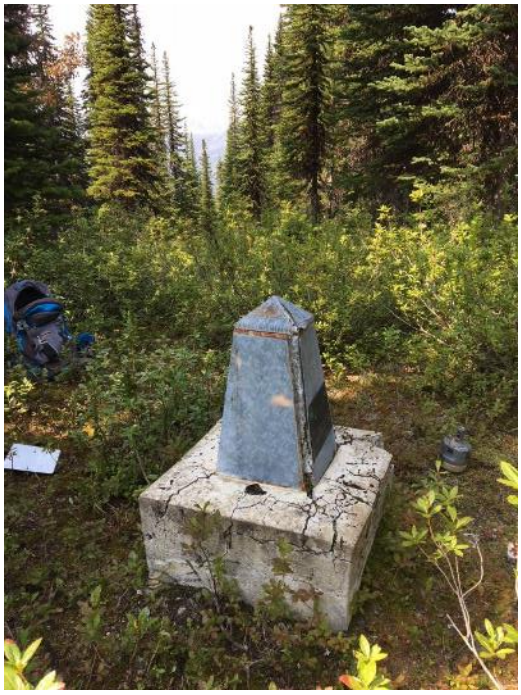


25S			
FOUND OLD MONUMENT, MONOLITH & BASE DETERIORATING.			
RE-ESTABLISHED CENTRE WITH REMAINING MONOLITH.			
SET THREE REFERENCE SPIKES, REFER TO SKETCH			
SET ROCK CAP POST IN DRILL HOLE			
LOGGED STATIC @ 25S ROCK CAP POST			
START TIME:	13:22	HT: 1.530m	
END TIME:	14:32		

4.27 26S

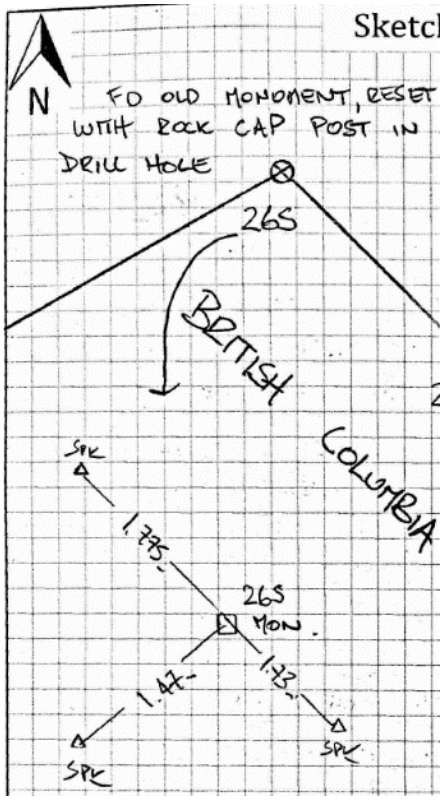
Found

Monument 26S was found in fair condition with both the monolith and base deteriorating. The pillar top was off centre but the datum point was still in place. Upon further inspection, all concrete easily broke off and the removal of the monolith caused further deterioration of the concrete base due to large cracks already in place. There were visible cutlines in either direction.



Set

Monument 26S was surveyed using static GNSS observations. Reference spikes were placed around the datum point in order to restore the centre of the monument upon demolition. The entire monument was then demolished to ground level and a standard rock post was drilled in the existing concrete and set using construction adhesive. A reference post was placed nearby.



26S
FOUND OLD MONUMENT, MONOLITH & BASE IN FAIR CONDITION, BUT SIGNS OF DETERIORATION PRESENT. RE-ESTABLISHED CENTRE USING EXISTING MONOLITH SET 3 REFERENCE SPIKES, REFER TO SKETCH.

4.28 27S

Found

Monument 27S was found in poor condition with both the monolith and base severely deteriorating. The pillar top was partially missing and the datum point was off centre. Upon further inspection, all concrete easily broke off and the removal of the monolith caused further deterioration of the concrete base. There was a faint cutline to 25S but nothing visible to 29S.

Set

Reference spikes were placed around the datum point in order to restore the centre of the monument upon demolition. The entire monument was then demolished to ground level and a standard rock post was drilled in the existing concrete and set using construction adhesive. A reference post was placed nearby. Monument 27S was surveyed using static GNSS methods.

275			
FOUND OLD	MONUMENT, MONOLITH & BASE DETERIORATING.		
RE-ESTABLISHED	CENTRE WITH REMAINING MONOLITH.		
SET THREE	REFERENCE SPIKES REFER TO SKETCH.		
SET ROCK	CAP	POST IN DRILL HOLE	
LOGGED	STATIC @	275 ROCK CAP POST	
START TIME:	10:28	HT: 1.665m	
END TIME:	11:35		

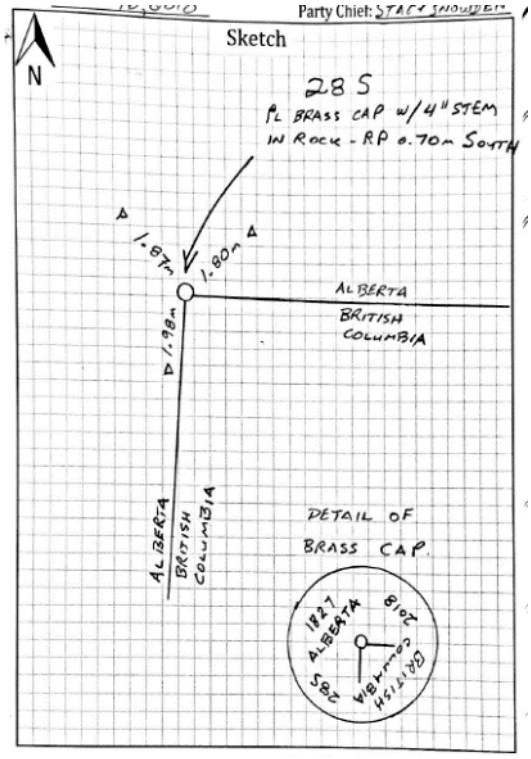
4.29 28S

Found

Monument 28S was found in fair condition with both the monolith and base deteriorating. The tin of the monolith had peeled back, revealing heavily weathered concrete. The pillar top and datum point were still in place, although cracking apart significantly. Upon further inspection, all concrete easily broke off and the removal of the monolith caused further deterioration of the heavily cracked concrete base. There is a visible cutline back towards 30S but nothing noticeable to 26S.

Set

Reference spikes were placed around the datum point in order to restore the centre of the monument upon demolition. The entire monument was then demolished to ground level and a standard rock post was drilled in the existing concrete and set using construction adhesive. A reference post was placed 0.7m south. Monument 28S was surveyed using static GNSS observations.



285	MONUMENT RESTORATION
FOUND MONOLITH W/BASE IN POOR/ FAIR CONDITION (BEGINNING TO CRUMBLE APART). SET SPIKES OFF OF MONOLITH AS PER SKETCH ON PG 7. REMOVED MONOLITH AND BASE. SET BRASS CAP W/4" STEM IN ROCK USING THE REFERENCE SPIKES. PHOTOS ATTACHED W/TODAY'S DATA.	

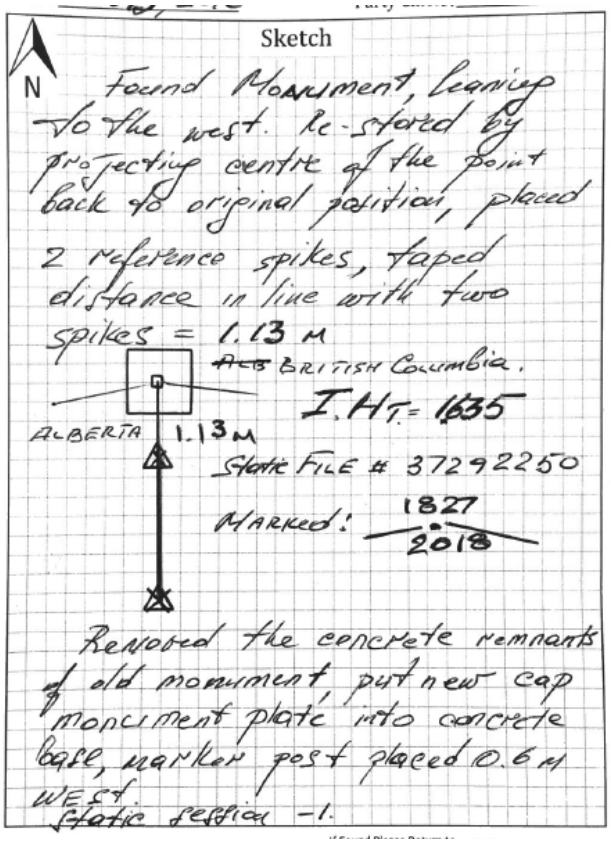
4.30 29S

Found

Monument 29S was found in poor condition with both the monolith and base deteriorating and the entire structure off-level due to nearby roots. Upon further inspection, all concrete easily broke off and the removal of the monolith caused further deterioration of the concrete base. There are no visible cutlines in either direction.

Set

Reference spikes were placed around where the concrete base would have been level on the ground in order to restore the centre of the monument upon demolition. The entire monument was then demolished to ground level and a standard rock post was drilled in the existing concrete and set using construction adhesive. A reference post was placed 0.6m west. Monument 29S was surveyed using static GNSS methods.


Sketch
N
Found Monument, leaning to the west. Re-stored by projecting centre of the point back to original position, placed 2 reference spikes, taped distance in line with two spikes = 1.13 M
~~ACB~~ BRITISH COLUMBIA.
I. HT. = 1635
ALBERTA
1.13 M
Static File # 3729250
Marked: 1827 2018
Removed the concrete remnants of old monument put new cap monument plate into concrete base, marker post placed 0.6 M WEST
Static session -1.

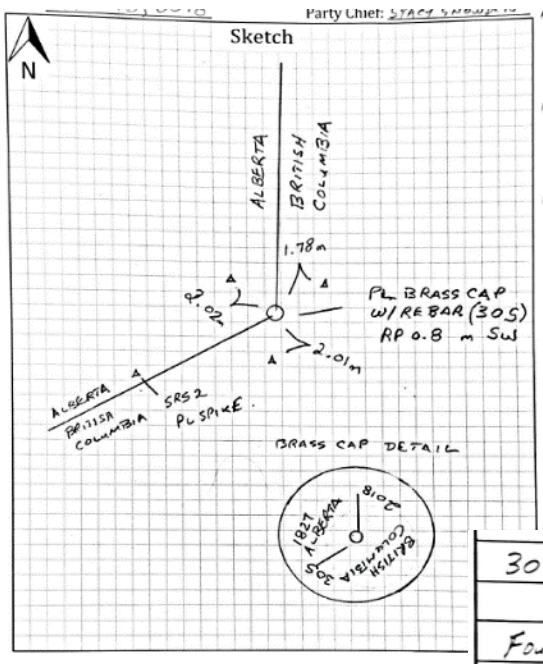
4.31 30S

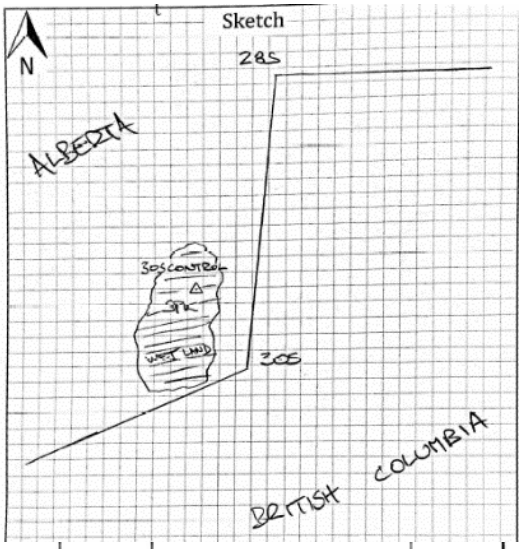
Found

Monument 30S was found in poor condition with both the monolith and base deteriorating. The pillar top was missing but the datum point was still in place. Upon further inspection, all concrete easily broke off and the removal of the monolith caused further deterioration of the concrete base. There is a hint of a cutline to 28S and a clear line of sight to the assumed position of 32S.

Set

Reference spikes were placed around the datum point in order to restore the centre of the monument upon demolition. The entire monument was then demolished to ground level and a standard capped post was drilled in the existing concrete. A reference post was placed 0.8m southwest. Control was set in the nearby field in case the static GNSS observation did not process to within the allowable tolerances; however, upon post-processing, a long static GNSS observation on 30S resulted in acceptable tolerances as per the project specifications.





30S	MONUMENT RESTORATION
FOUND	MONOLITH W/ BASE IN POOR
CONDITION.	SET SPIKES OFF OF
MONOLITH AS PER SKETCH ON PG 4.	
REMOVED MONOLITH AND BASE.	
SET BRASS CAP W/ REBAR USING	
THE REFERENCE SPIKES. PHOTOS	
ATTACHED W/ TODAY'S DATA.	

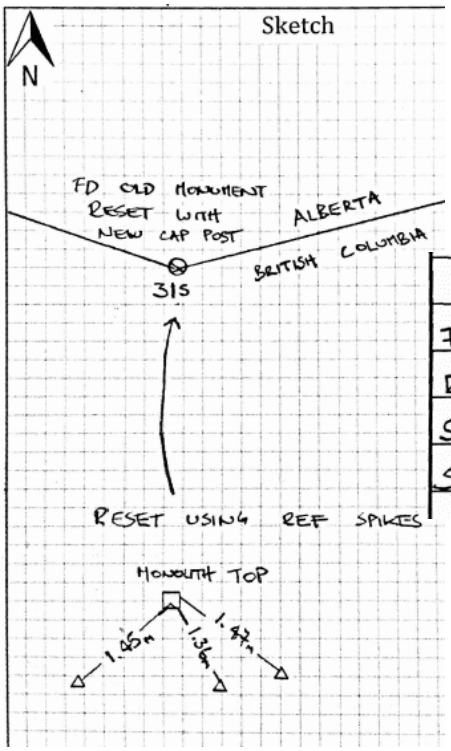
4.32 31S

Found

Monument 31S was found in poor condition with both the monolith and base deteriorating. The entire monument was crumbling and the original centre was difficult to locate. Upon further inspection, all concrete easily broke off and the removal of the monolith caused further deterioration of the concrete base. There is a visible cutline to the hill where 33S stands on but nothing visible to 29S.

Set

Reference spikes were placed around the four corners of the concrete base in order to restore the centre of the monument upon demolition. The entire monument was then demolished to ground level and a standard capped post was drilled in the existing concrete. A reference post was placed nearby. Monument 31S was surveyed using static GNSS methods.



315			
FOUND OLD MONUMENT MONOLITH & BASE DETERIORATING,			
RESTABLISHED CENTRE WITH REMAINING MONOLITH.			
SET 3 SPIKES FOR REFERENCE, REFER TO			
SKETCH. SET CAPPED POST FROM SPIKES.			

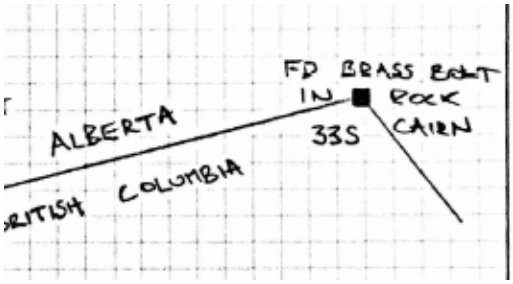
4.33 33S

Found

The rock cairn on top of 33S was prominent, although slightly toppled over. Once the rock cairn was carefully disembled, the brass bolt in concrete was obvious and it was in excellent condition. There was a visible cutline to 31S and a clear line of sight to the top of Miette Hill.

Set

The existing brass bolt was measured using static GNSS. A reference post was placed nearby and the rock cairn was rebuilt once the static occupation was complete.



335

FOUND OLD STONE CAIRN. REMOVED ROCKS & FOUND OLD BRASS BOLT MARKED " NO 335, BRITISH COLUMBIA (SOUTH) & ALBERTA (NORTH).

LOGGED STATIC @ 335 OLD BRASS BOLT

START TIME: 12:47

STOP TIME: 15:17

HT: 1.471m

Conclusion

The original monuments in Yellowhead Pass were established in 1917. 101 years later, the majority of the monuments were found and restored to minimize further weathering. Most of these monuments were found with severe cracks and deterioration. With the amount of weakening in the concrete, the only option was to break apart the concrete to ground level and shape it to shed water. A large portion of the interprovincial boundary was measured with static GNSS observations apart from one point which required a conventional tie and a number north and south of the highway which were within RTK range of a base setup along the highway. All monuments were measured in to the required accuracy and the results can be found in Appendix I.

Appendix I – Table of Coordinates

PREPARED BY: Yanmei Zhan
CHECKED BY: **Tracey Peet**

REPORT NAME: Yellowhead Pass Monuments
CLIENT: BC LTSA & AEP
JOB NUMBER: VG180108 & VG180109

COORDINATE SYSTEM: UTM 11N, Geoid HT2
Horizontal Datum: NAD83CSRS Epoch 2002
Datum Point: Jasper Reference Station(Horz. & Vert.) & PPP coordinates for SRS1, SRS3, 8131000(Horz. Only)

Monument No.	Adjusted UTM Coordinates			Adjusted Global Coordinates			95% Error Ellipse post adjustment (m)		RTK/Optical Precision (95%)		Survey Date	Survey Type
	Northing(m)	Easting(m)	Orthometric Height(m)	Latitude(DMS)	Longitude(DMS)	Ellipsoid Height(m)	semi-major	semi-minor	H. Precision	V. Precision		
JASP	5858843.786	427713.76	1067.19	N52°52'27.99710"	W118°04'26.50320"	1053.949	0.008	0.005				hold ref. station coordinates(3D)
SRS1	5859836.209	345303.363	786.788	N52°51'57.53374"	W119°17'53.39426"	773.125	0.009	0.005			8/18/2018	Static (hold PPP, Horz. only)
SRS2	5862896.861	395724.095	1841.688	N52°54'20.22350"	W118°33'01.69098"	1828.778	0.138	0.038			8/16/2018	Static (hold PPP, Horz. only)
SRS3	5860302.853	401815.3	1143.026	N52°53'00.43237"	W118°27'32.93957"	1130.047	0.011	0.007			8/19/2018	Static (hold PPP, Horz. only)
SRS4	5860284.851	401841.742	1142.96	N52°52'59.86734"	W118°27'31.50583"	1129.982	No adjustment - RTK		0.015	0.016	8/19/2018	RTK
8131000	5862014.841	344513.249	799.223	N52°53'07.16311"	W119°18'39.35904"	785.597	0.009	0.005			8/14/2018	Static (hold PPP, Horz. only)
1S	5861154.932	401517.088	1155.523	N52°53'27.80258"	W118°27'49.81705"	1142.544	No adjustment - RTK		0.015	0.014	8/19/2018	RTK
2S	5862038.142	400819.146	1336.699	N52°53'55.91420"	W118°28'28.12031"	1323.731	No adjustment - RTK		0.043	0.053	8/20/2018	RTK
3S	5860912.975	401702.417	1227.477	N52°53'20.09684"	W118°27'39.64037"	1214.497	No adjustment - RTK		0.028	0.034	8/19/2018	RTK
4S	5862362.05	400351.121	1415.107	N52°54'06.08158"	W118°28'53.51717"	1402.159	No adjustment - RTK		0.049	0.058	8/21/2018	RTK
5S	5860680.485	402264.905	1217.418	N52°53'12.94437"	W118°27'09.30228"	1204.438	No adjustment - RTK		0.018	0.025	8/19/2018	RTK
6S	5862462.167	399569.499	1467.223	N52°54'08.79686"	W118°29'35.44794"	1454.279	No adjustment - RTK		0.029	0.037	8/22/2018	RTK
7S	5859997.42	402515.789	1208.443	N52°52'51.00960"	W118°26'55.14670"	1195.467	No adjustment - RTK		0.042	0.051	8/19/2018	RTK
8S	5862878.386	399226.383	1452.167	N52°54'22.03094"	W118°29'54.27069"	1439.233	No adjustment - RTK		0.005	0.008	8/18/2018	Total Station
9S	5859503.654	402316.503	1332.17	N52°52'34.90505"	W118°27'05.27073"	1319.199	No adjustment - RTK		0.085	0.111	8/20/2018	RTK
10S	5862900.306	398686.619	1497.171	N52°54'22.37476"	W118°30'23.17727"	1484.235	0.013	0.011			8/18/2018	static
11S	5859284.972	402166.46	1355.846	N52°52'27.73206"	W118°27'13.05741"	1342.878	No adjustment - RTK		0.049	0.04	8/20/2018	RTK
12S	5862758.418	398317.758	1606.428	N52°54'17.53374"	W118°30'42.75458"	1593.49	0.017	0.014			8/18/2018	static
13S	5858829.752	401929.535	1590.713	N52°52'12.84943"	W118°27'25.23229"	1577.753	0.014	0.012			8/15/2018	static
14S	5862203.017	397764.82	1859.117	N52°53'59.18830"	W118°31'11.71148"	1846.173	0.018	0.014			8/17/2018	static
15S	5858648.944	401496.201	1620.56	N52°52'06.71496"	W118°27'48.20374"	1607.601	0.011	0.011			8/15/2018	static
16S	5861865.467	397748.683	1892.79	N52°53'48.25713"	W118°31'12.19259"	1879.841	0.012	0.011			8/17/2018	static
17S	5858105.759	401691.623	1708.782	N52°51'49.27041"	W118°27'37.16564"	1695.847	0.014	0.012			8/15/2018	static
18S	5861850.575	397605.233	1902.524	N52°53'47.67709"	W118°31'19.84981"	1889.576	0.01	0.01			8/17/2018	static
19S	5857824.516	402008.854	1757.398	N52°51'40.37981"	W118°27'19.90276"	1744.473	0.009	0.008			8/15/2018	static
20S	5862199.384	397184.703	1877.806	N52°53'58.67248"	W118°31'42.74364"	1864.866	0.008	0.006			8/17/2018	static
21S	5857227.892	402090.479	1915.571	N52°51'21.13112"	W118°27'14.89419"	1902.664	0.008	0.007			8/14/2018	static
22S	5862487.113	396817.571	1886.44	N52°54'07.72753"	W118°32'02.71397"	1873.51	0.009	0.009			8/17/2018	static
23S	5856892.042	402568.818	1926.35	N52°51'10.57792"	W118°26'48.96650"	1913.459	0.008	0.007			8/14/2018	static
24S	5862721.17	396443.103	1943.729	N52°54'15.04020"	W118°32'23.01749"	1930.807	0.008	0.007			8/16/2018	static
25S	5856545.946	403179.271	1891.646	N52°50'59.77725"	W118°26'15.97105"	1878.774	0.011	0.008			8/14/2018	static
26S	5863094.547	396255.312	1926.347	N52°54'26.98885"	W118°32'33.49442"	1913.436	0.012	0.009			8/16/2018	static
27S	5856654.031	403666.644	1935.153	N52°51'03.58873"	W118°25'50.04025"	1922.281	0.012	0.01			8/14/2018	static
28S	5863132.251	395779.565	1862.052	N52°54'27.87723"	W118°32'58.99473"	1849.147	0.019	0.017			8/16/2018	static
29S	5856814.524	404030.06	1967.975	N52°51'09.01471"	W118°25'30.78849"	1955.101	0.006	0.005			8/13/2018	static
30S	5862918.02	395765.462	1843.735	N52°54'20.93688"	W118°32'59.50196"	1830.825	0.024	0.019			8/16/2018	static
31S	5856554.724	404457.556	1976.423	N52°51'00.88311"	W118°25'07.66706"	1963.562	0.008	0.005			8/13/2018	static
33S	5856782.571	405542.289	2086.759	N52°51'08.94355"	W118°24'09.93433"	2073.9	0.006	0.005			8/13/2018	static
S Wt	5861239.867	401449.989	1137.785	N52°53'30.50611"	W118°27'53.49889"	1124.807	No adjustment - RTK		0.016	0.019	8/21/2018	RTK
30S CONTROL	5862985.121	395695.93	1839.966	N52°54'23.05906"	W118°33'03.29998"	1827.058	0.012	0.011			8/16/2018	static
JA10001	5862816.485	399170.601	1442.225	N52°54'19.99070"	W118°29'57.18634"	1429.289	0.008	0.006			8/18/2018	static
JA10002	5862815.527	399057.654	1443.031	N52°54'19.88336"	W118°30'03.22887"	1430.091	0.012	0.007			8/18/2018	static