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STAGE 1 STATUS REPORT WEST QUESNEL LAND STABILITY STUDY QUESNEL, BC

Submitted to:

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Submitted by:

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KX03904



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1.0 INTRODUCTION

Over the past few years, the possible presence of large scale landslide features has been proposed by others in a suburban area of West Quesnel. These reports have been largely based on airphoto interpretation, surface reconnaissance, and a review of reported utility breaks. More recently, lateral movements of up to 194 mm have been reported for hubs monitored by GPS in West Quesnel. Reviews of past work have been unable to conclusively determine whether or not the observed and postulated movements were due to seasonal frost heaving, shallow localized ground movements, larger scale deep-seated landsliding, settlement, measurement inaccuracies or a combination thereof. Detailed subsurface conditions in West Quesnel were unknown.

Based on the lack of detailed subsurface information, including whether a deep-seated slide existed, the City of Quesnel (CofQ) has contracted AMEC Earth & Environmental Limited (AMEC) to conduct the West Quesnel Land Stability Study. The proposed scope of work for the West Quesnel Land Stability Study was divided in 3 Stages:

- <u>Stage 1</u>: Project planning, reconnaissance, data gathering, slope inclinometer installation and monitoring. The aim of this work was to determine whether or not deepseated sliding was present.
- Stage 2: Detailed drilling, sampling, piezometer installation and monitoring
- Stage 3: Analysis, remedial recommendations and final reporting

Stages 2 and 3 would only be undertaken in the event that deep-seated slide movements were found in Stage 1. The scope of work was detailed in AMEC's proposal of 31 May, 2000 to the CofQ. This report summarizes AMEC's work to date on the West Quesnel Land Stability Study and forms the final report for Stage 1, which is now completed. Figure 1 and Photo 1 show the study area.



2.0 SUMMARY OF WORK CARRIED OUT

2.1 Office Review/Background Research

During the work, the following documents have been reviewed:

- Geotechncial Consultant Reports: Section 10.1 (References) lists the geotechnical consultant reports reviewed by AMEC. Reports reviewed included documents prepared by AMEC (and its predecessor companies), C.O. Brawner Engineering Ltd., GeoNorth Engineering Ltd., Golder Associates Ltd., Dr. N.R. Morgenstern and Dr. D.M. Cruden of the University of Alberta, R.E Graham Limited and Thurber Engineering Limited.
- 2. <u>Geological Background Documents</u>: Section 10.2 lists the geological background documents reviewed for this work.
- 3. <u>Ministry of Transportation (MoT) Files</u>: Files from the MoT Prince George office including weather data were reviewed.
- 4. Ministry of the Environment, Lands and Parks (MELP) Files: Water well records posted on the internet by the Water Management Division of the Ministry of Environment, Lands and Parks (MELP) were reviewed. The water well locations were shown on 1:5 000 scale groundwater location maps provided by MELP.
- 5. <u>BC Gas Utility Data</u>: AMEC has reviewed BC Gas GPS hub monitoring data which has been collected since September of 1998. In addition, BC Gas has provided AMEC with their line break data for the study area.
- 6. <u>City of Quesnel Data</u>: The CofQ is currently collecting utility break records, geotechnical reports submitted to the CofQ and information from West Quesnel homeowners. AMEC will review this information during future stages of the work.
- 7. Airphotos: Table 1 below details the airphotos reviewed during Stage 1.

Tab	Table 1: Airphotos Reviewed									
Airphoto	Year	Scale	Colour							
30BCC97136 no. 73 and 74, 143 and 144	1997	1:20 000	Colour							
BCB91026 no.126 and 127	1991	1:15 000	Black and White							
BCB85014 no. 203 to 204	1985	1:15 000	Black and White							
BC5709 no. 241 and 242	1976	1:15 000	Black and White							
BC5328 no. 225 and 226	1969	1:30 000	Black and White							
BC949 no. 93 and 94	1949	1:50 000	Black and White							



2.2 Site Reconnaissance Visit

On September Mr. Nick Polysou, P.Eng., Mr. Drum Cavers, M.Eng., P.Eng., P.Geo., and Mr. Doug Dewar, P.Eng., of AMEC, accompanied by Mr. Jack Marsh of the City of Quesnel, conducted a site reconnaissance visit to west Quesnel to review general site conditions and determine potential slope inclinometer (SI) locations. Following the site reconnaissance visit, seven potential SI locations were selected.

2.3 SI Installation

From 2 to 27 October, 2001, 7 boreholes were drilled using a compressed air-rotary water well drill supplied by Cariboo Water Wells of Prince George, BC. Mr. Doug Dewar of AMEC was present during the drilling of the boreholes to conduct a preliminary log of soil conditions and to supervise the installation of the 7 slope inclinometers (SI) in the boreholes. Photos 2 and 3 show the boreholes being drilled for SI-4 and SI-7. The SI installation data is summarized in Table 2 below.

This water well rig is not a conventional rig for a geotechnical drilling, since only disturbed sampling of materials returned in the air stream is possible. However, the water well rig was not chosen primarily for sampling, but to allow reliable and economic installation of the slope inclinometers.

		Tab	le 2: SI Inst	allation Dat	a		
SI	SI-1	SI-2	SI-3	SI-4	SI-5	SI-6	SI-7
Street	Avery Lane	Avery Lane	Abbott Drive	Voyager School	Abbott Drive	Dixon Street	Pierce Crescent
Date of Completion	25 Oct., 2000	23 Oct., 2000	27 Oct., 2000	13 Oct., 2000	5 Oct., 2000	16 Oct., 2000	19 Oct., 2000
A _o Bearing (°) (True North)	120°	120°	120°	110°	110°	105°	100°
Depth of Installation * (feet/m)	143 feet 43.6 m	245 feet 74.6 m	336 feet 102.4 m	520 feet 158 m	475 feet 144.8 m	507 feet 154.5 m	412 feet 125.6 m
SI pipe stick up above ground surface (mm)	720 mm	800 mm	820 mm	726 mm	779 mm	840 mm	660 mm
Elevation of top of SI casing (m A.S.L.)**	480.267 m	485.862 m	503.43 m	537.581 m	517.666 m	557.723 m	542.217 m
Elevation of ground surface (m A.S.L.)**	479.547 m	485.062 m	502.61 m	536.855 m	516.887 m	556.883 m	541.557 m
Northing**	5869298.105	5869342.656	5869598.068	5869878.155	5869633.237	5869933.443	5870231.729
Easting**	532568.712	532489.826	532273.051	531829.52	531919.02	531509.906	531798.61

*The SI installation depth is deeper than the depth it is read (refer to Table 2) to avoid having the SI probe touch the bottom of the hole. The depth is measured from the top of the casing.

A slope inclinometer consists of a plastic casing that will deform in response to ground deformation caused by slope movements or settlement. Photo 4 shows SI casing being installed into SI-7. Photo 5 shows the grout pump and grouting supplies used to fill the annulus between the casing and the borehole wall.

^{**}World Geodetic System 94 datum



2.4 SI Monitoring

An initial reading of the profile of the installed SI casing was taken with an SI probe following the installation of the SI casing once the grout had set (approximately 10 to 20 days after completion of installation). Subsequent readings are compared to the initial reading to determine if any ground deformation has occurred. Two directions monitored in the casing. The A direction was oriented parallel to the approximate direction of expected movement, in this case downslope toward the Fraser River. The B direction is across slope, perpendicular to the A direction.

The casing is read from the bottom at intervals of 2 ft, using a probe that ride in the grooves of the casing. At each depth increment, the inclination of the casing in the A. and B directions is measured. At each depth increment, the change in inclination of the casing from the original readings allows the movement of the casing to be calculated. By adding up the incremental movements of the casing, a complete profile of the change in inclination of the casing can be calculated. Where a discrete slide surface cuts across the casing, movement of the slide surface will result in a more rapid change in tilt of the inclinometer casing, allowing the location of the slip surface to be determined.

To facilitate the handling of the large amounts of data from the field, the field measurements were recorded on a DataMate readout unit and transferred to a computer for processing. GTILT PLUS software (Mitre Software Corporation) was used to reduce and calculate the data.

The orientations of the A and B. directions may rotate with depth due to the accumulation of small amounts a spiral in the casing over large depths. In a deep casing, such as those installed on this project, the amount of rotation may be sufficient to appreciably rotate the apparent movement directions. The spiral rotation of the grooves was measured using a special spiral monitoring tool. The calculated results for the slope inclinometers were corrected for the measured spiral error. Photo 8 shows the spiral probe being prepared to be lowered down SI-3.

The SI monitoring schedule including the spiral readings are shown in Table 3 below:

		Table	3: SI Monit	oring Sched	dule		
SI	SI-1	SI-2	SI-3	SI-4	SI-5	SI-6	SI-7
Location	Avery Lane	Avery Lane	Abbott Drive	Voyager School	Abbott Drive	Dixon Street	Pierce Crescent
Depth SI Read to (feet/m)	142 ft 43 m	244 ft 74 m	334 ft 102 m	504 ft 154 m	474 ft 144 m	502 ft 153 m	410 ft 125 m
Spiral Reading	11 Jun. 2001	11 Jun. 2001	12 Jun. 2001	11 Jun. 2001	12 Jun. 2001	11 Jun. 2001	12 Jun. 2001
Initial Reading Date	21 Nov. 2000	21 Nov. 2000	21 Nov. 2000	3 Nov.2000	28 Oct. 2000	22 Nov. 2000	22 Nov. 2000
Initial Reading	7 Dec. 2000	7 Dec. 2000	6 Dec. 2000	24 Nov. 2000	24 Nov. 2000	6 Dec. 2000	7 Dec. 2000
Reading 2	12 Jan. 2001	11 Jan. 2001	12 Jan. 2001	6 Dec. 2000	6 Dec. 2000	11 Jan. 2001	12 Jan. 2001
Reading 3	5 Mar. 2001	5 Mar. 2001	6 Mar. 2001	11 Jan. 2001	12 Jan. 2001	5 Mar. 2001	6 Mar. 2001
Reading 4	2 Apr. 2001	2 Apr. 2001	3 Apr. 2001	5 Mar. 2001	6 Mar. 2001	2 Apr. 2001	3 Apr. 2001
Reading 5	28 Apr. 2001	28 Apr. 2001	28 Apr. 2001	2 Apr. 2001	3 Apr. 2001	28 Apr. 2001	29 Apr. 2001
Reading 6	18 Jun. 2001	13 Jun. 2001	14 Jun. 2001	28 Apr. 2001	29 Apr. 2001	13 Jun. 2001	14 Jun. 2001
Reading 7				13 Jun. 2001	14 Jun. 2001		•



2.5 Public Meetings

AMEC has made presentations at two public meetings for the City of Quesnel detailed below:

<u>21 September, 2000</u>: AMEC provided a presentation to the residents of West Quesnel detailing the proposed scope of work of the West Quesnel Land Stability Study.

<u>18 May, 2001</u>: AMEC provided a presentation to the residents of West Quesnel detailing the preliminary results of the Stage 1 assessment.

3.0 PRELIMINARY DATA COLLECTED

3.1 Precipitation Data

The monthly total precipitation data was obtained from Environment Canada for the Quesnel Airport. Plots of the recorded data through 1975 to 2000 are shown in Figures 2 and 3 along with historical data and the cumulative difference. The historical data is based on a 30 year moving mean, where an average over 30 years was calculated for each month beginning with 1975. To calculate the thirty year moving mean for 1975, data was taken back to 1946 and all the monthly values were averaged over that 30 year interval. The cumulative difference is the sum of difference between the recorded data and the historical mean beginning with January 1975 and ending December 2000. This plot shows the trend of the recorded precipitation whether it is increasing or decreasing (i.e. wetter or drier trends) compared to the historical mean.

The precipitation data indicates that the period from 1975 through the spring of 1988 was close to or slightly below average. From the spring of 1988 through the end of 1996, conditions tended to be much wetter than normal, with 1991 being close to average. From 1997 to date, conditions have been average, tending to be drier than normal during the last two years.

3.2 Water Well Data

AMEC is currently in the process of collected water well data and interviewing local water well drillers. The data collection is not completed and information will be included in future reporting.



4.0 SUMMARY OF FINDINGS

4.1 Borehole Logs

During the drilling of the boreholes for the SI installations, AMEC compiled borehole logs based on the drill cuttings returned to the surface during the air rotary drilling. Appendix E contains the preliminary logs for the boreholes. Note that these borehole logs should be considered approximate due to the following limitations:

- 1. Samples collected from the drilling cuttings were disturbed and may be segregated during travel to the surface.
- 2. Bedding and other features would be destroyed or disturbed during drilling.
- 3. Water with a detergent additive was injected into the boreholes to assist with drilling in most boreholes, particularly at depth. The water many have further disturbed drill cuttings.
- 4. The depth where the cuttings originated was estimated based on the time for the cuttings to be returned to the surface from depth. Note that depths where there was a significant change in soil or rock type could be accurately estimated due to changes in the drill behavior.
- 5. Thin beds may be missed due to the cuttings being mixed with adjacent beds during travel to the surface.

In spite of the limitations of logging the disturbed cuttings on air rotary rigs, 10 years experience with the use of this method as shown that reasonable logs may be obtained.

4.2 Slope Inclinometer Data

4.2.1 Spiral Readings

Table 4 summarizes the spiral at the bottom of the SI casings. The complete data set includes the variation of spiral with depth down each casing. The spiral survey results show the clockwise rotation between the top and bottom of the SI casing.

	Table 4: Results of Spiral Survey of SI Installations									
SI SI-1 SI-2 SI-3 SI-4 SI-5 SI-6 SI-7										
Clockwise spiral at bottom of casing	9.9°	16.7°	24.1°	30.0°	29.6°	39.7°	17.8°			



4.2.2 Calculated SI Data

The results of the SI readings to date corrected for measured casing spiral are attached in Appendix D. These plots presented include absolute profiles, cumulative displacement plots, incremental displacement plots and velocity plots. These terms are defined below.

- 1. <u>Absolute profile plots</u> show the actual profile of the casing after installation. The scale of the absolute profile plot varies with SI installation depending on the orientation of the hole. The absolute profile of the casing is relatively unimportant for most applications. In particular, whether or not the casing is vertical and straight is generally not a major factor in obtaining good movement data since the change from the initial orientations is measured, not the change from vertical. However, the absolute orientation of the casing can be useful in particular circumstances. For example, if the casing is undergoing compression, then the bends in the casing may tend to move out at existing bends.
- 2. <u>Incremental plots</u> show the individual changes in inclination of the casing at each reading elevation. The incremental plots have a 25 mm horizontal scale. These plots are useful for examining the depth and character of movements.
- 3. <u>Cumulative plots</u> show the overall apparent movement change of the SI casing since installation relative to the bottom of the hole. As discussed in Section 2.0, movement is measured in two mutually perpendicular directions, A and B. The A direction is oriented to be "downslope" whereas the B direction is across slope. The actual orientation of each of the casings is shown on Figure 4 and summarized in Table 2. Positive movements on the cumulative plots are downslope on Direction A and across the slope to the right when looking downhill for Direction B. The cumulative plots have a 75 mm horizontal scale.
- 4. <u>Velocity plots</u> shows the displacement versus time over a given depth interval. Velocity plots are presented for A and B directions at selected intervals.

4.2.3 Discussion

The discussion below shows that there was good evidence of translational slide movements on discrete shear surfaces in most of the SI installations. Figure 5 shows the SI locations and summarizes the interpreted movement vectors.

A review of the velocity plots for all SI installations indicates a general acceleration of movements in the spring of 2001 as compared to the initial datasets collected during the winter or 2000/2001. This acceleration may be due to groundwater recharge from surface precipitation and snowmelt.



S1-1

- 1. <u>Absolute position</u>: SI-1 was relatively straight and vertical with relative deviations between the bottom and top of the hole of less than 50 mm in the A direction (downslope) and 400 mm in the B direction (across slope to the north).
- 2. <u>Cumulative deflection</u>: A small lateral shift of 2 mm was evident in the casing at approximately 41 m depth with some additional deflection around 28 m. The deflection at 41 m was first evident April 2001. There appeared to be surface deflections of less than 5 mm at the top of the casing. There was some bulging of the SI casing towards the east (downslope) and north above 28 m depth. This may be due to vertical settlement of the casing, possibly combined with grout loss in a gravel layer between 16 and 21.3 m depth (grout loss is not known for certain to have occurred in this gravel layer, but could explain the observed deformations).
- 3. <u>Incremental deflection</u>: The incremental deflections for SI-1 are characteristic of settlement above 28 m depth. The deflections at 40 m depth were small on the incremental plot.

4.2.3.1 S1-2

- 1. <u>Absolute position</u>: As shown on the plot contained in Appendix D, at the bottom of SI-2 there was 4800 mm of downslope deflection (A direction) and 2400 mm of across slope (B direction, north) relative to top of the hole.
- 2. <u>Cumulative deflection</u>: Clear translational movement surfaces are evident at 60 m and 42 m depth. The total deformation over the period of monitoring was approximately 21 mm to the east (downslope) in the A direction and 5 mm to the south in the B direction at the ground surface. Very slight backward rotation was evident above 42 m depth in the A direction.
- 3. <u>Incremental deflection</u>: The two potential slip surfaces were shown as spikes in the data at approximately 60 m and 42 m depth. The shear surfaces appeared to be less than 0.6 m thick (i.e., the shear surface was contained within a the length of the slope inclinometer probe).

S1-3:

- Absolute position: Relative to the top of the casing, the bottom of the casing in SI-3 was approximately 3000 mm downslope (A direction) and 3000 mm across slope to the north (B direction).
- 2. <u>Cumulative deflection</u>: There was a slip surface evident at approximately 39 m depth. Deflections along the slip surface over the period of monitoring were approximately 33 mm to the east (downslope) in the A direction and 2 mm to the north in the B direction.
- 3. <u>Incremental deflection</u>: The incremental deflection plot showed consistent movement along a slip surface at approximately 39 m depth. The was also a small incremental deflection



evident on the 12 January, 2001 set of readings at 53 to 54 m which was not evident on later readings. The small deflection could be due to dirt in the casing and is not regarded as a true slope movement since the deflection was not evident in later data sets.

4.2.3.2 S1-4

- 1. <u>Absolute position</u>: Relative to the top of the casing, the bottom of SI-4 was less than 250 mm uphill (A direction) and was approximately 3700 mm south (B direction).
- 2. <u>Cumulative deflection</u>: There was clear evidence of translational movement at 51 m with movements of 32 mm in the A direction (downslope to the east) and 4 mm in the B direction (north toward Baker Creek).
- 3. <u>Incremental deflection</u>: The incremental deflection plot showed the slip surface at 51 m depth. As with most of the other shear surfaces, the thickness appeared to be less than the length of the slope inclinometer probe.

4.2.3.3 S1-5

- 1. <u>Absolute position</u>: The bottom of SI-5 was approximately 1100 mm downslope (A direction) and 2400 mm north (B direction) of the top of the casing.
- 2. <u>Cumulative deflection</u> As indicated on the log for BH-5, grouting problems were experienced during installation of the casing. Due to sloughing of the hole, it was not possible to lower the grout pipe below 73 m. It appears that after grouting of the hole, the grout may have drained past the obstruction, resulting in the lower part of the hole being grouted and the upper part of the hole being mostly ungrouted. As a result, the sinusoidal deflections of the casing between approximately 90 m and 38 m are interpreted to be a result of possible slight axial compression of the casing, combined with the casing moving relatively freely in the hole. The maximum deflections of the casing correspond to the approximate dimensions of the annular space around the casing. At a depth of 37 m, translational movement has occurred. It is likely that the total translational movement is greater than not shown, by an amount equal to the total annular space within the hole or approximately 63 mm.
- 3. <u>Incremental deflection</u>: As indicated above, the casing is likely ungrouted between at least 37 m and approximately 90 m. Incremental deflections reflect this ungrouted nature of the hole. It is possible that additional lateral deflections could become evident overtime within the zone from 38 to 90 m.



4.2.3.4 S1-6

- 1. <u>Absolute position</u>: Relative to the top of the casing, the bottom of casing SI-6 was approximately 20 000 mm downhill (A direction) and 11 000 mm south (B direction). The casing and increasing curvature with depth with an inclination of approximately 16° near the bottom of the hole.
- 2. <u>Cumulative deflection</u>: There was a slip surface at approximately 28 m depth in SI-6. There was approximately 34 mm of downslope (to the east) deflection in the downslope in the A direction and 2 mm of deflection toward the north in the B direction. There was also an apparent but gradual systematic shift evident on the plot below 28 m depth. The shift may be caused by small systematic errors in the readings due to some effect relating to the almost "J" shape of the casing installation.
- 3. Incremental deflection: The slip surface at 28 m was evident on the incremental plots.

4.2.3.5 S1-7

- 1. <u>Absolute position</u>: Relative to the top of the casing, the bottom of SI-7 was found in approximately 12 500 mm upslope (A direction) and 15 000 mm north (B direction).
- 2. <u>Cumulative deflection</u>: There were discreet slip surfaces evident at approximately 68 m and 27 m depth in SI-7. The total movement over the period of monitoring was approximately 25 mm downslope (to the east). In the B direction (across slope), the movement at 27 m was 3 mm to the south and the movement at 68 m was 3 mm to the north. Below 68 m depth, there appeared to be an apparent but gradual systematic shift on the plot. The shift may be caused by a minor shift in the readings due to some effect relating to the almost "J" shape of the casing installation.
- 3. <u>Incremental deflection</u>: The slip surfaces at 68 m and 27 m depth m were evident on the incremental plots.

4.3 BC Gas GPS Hub Monitoring Data

Figure 5 shows the location of the BC Gas GPS Monitoring Hubs and the associated displacement vectors over two periods:

- 1. From September 1998 to May 2001
- 2. From December 2000 to May 2001 (this period roughly corresponds to the period AMEC has been monitoring the SI's).

Appendix E contains the BC Gas Monitoring Hub data used to prepare the vector data shown on Figure 5.



5.0 DISCUSSION

5.1 Interpretation of Slope Inclinometer Data

Table 5 provides a summary of SI casing deformations to June 18, 2001.

		Table 5: Interp	retation of	SI Displacements 18 June, 2001
SI	Location	Zone/Depth of displacement	Slip Surfaces	Interpretations
SI-1	Avery Lane	12 to 22 m	42 m	 There are small movements of 2 mm at 41 m depth and additional movements of 11 mm at 28 m depth in the A direction. The depth of the lower movement (41 m) corresponded approximately to the elevation of the shallower movement in SI-2. Given the depth of the slip surface in SI-2, the base of SI-1 could be above a deeper slip surface. Movement appeared to be within the Tertiary sediments. There was possible settlement in the casing between 12 and 28 m depth.
SI-2	Avery Lane	Above 60 m	40 and 60 m	 There were well-defined thin slip surfaces at 60 and 42 m depth. Displacements of the ground above the slip surface appeared to be towards the Fraser River. The movement zones were within Tertiary silt and clay.
SI-3	Abbott and Bettcher	Above 39 m	39 m	 There was a well-defined slip surface at 39 m depth. Displacements of the ground above the slip surface appeared to be towards the Fraser River. The movements on was located a short distance above a gravel seam within Tertiary sand interbedded with clay silt.
SI-4	Voyageur School	Above 51 m	51 m	 There was a well-defined slip surface at 51 m depth. Displacements above the slip surface appeared to be towards the Fraser River. The shear surface was within soils logged as Tertiary sand.
SI-5	Abbott Drive	Above 93 m	37 m	 The casing was undergoing apparent compression movements from 36 to 93 m depth. The casing movements in this area may be a result of grouting problems; in particular, there may be no grout within this part of the hole. Apparent translational movement was occurring at a depth of approximately 37 m. The movement direction was east towards the Fraser River. The depth of movement corresponded to the top of the Tertiary sediments. There may be additional movements deeper in the hole that is not been detected to date.
SI-6	Dixon Street	Above 28 m	28 m	 There was a well-defined slip surface at 28 depth. Movements below 28 m may be a result of the deviation of the casing from vertical and may not represent real movement. The slip surface was within Tertiary sediments.



		Table 5: Interp	retation of	SI Displacements 18 June, 2001
SI	Location	Zone/Depth of displacement	Slip Surfaces	Interpretations
SI-7	Lewis and Pierce Street	Above 68 m	27 m and 68 m	 There were well-defined slip surfaces at 68 and 27 m depth. Displacements of the lower slip surface at 68 m depth appeared to be toward the Fraser River (east) with a small component towards the north. Displacements of the upper slip surface at 28 m depth appeared to be toward the Fraser River (east) with a small component towards the south. The upper slip surface appeared to be near the top of the Tertiary sentiments and the lower slip surface was within the Tertiary sediments.

Note that the displacements shown In Figure 5 for SI-6 and SI-7 are for the displacements of the SI's judged to be not caused by systematic shifts due to the bends in the casing installation.

There is a possibility that at SI-6 and SI-7 SI terminate above the bottom of the slide, given the shifts in the cumulative plots. However, a review of Figure 5 indicates that the corrected movements along the slip surfaces in SI-6 and SI-7 are comparable to the movements observed in the other SI installations. Additionally, it is evident that the base of the SI casing in SI-1 is above the probable slip surface of the slide, given the depth of the slip surface observed in SI-2. Both of the foregoing factors indicate that most or all of the slide movements have probably been recorded by the slope inclinometer casings.

The velocity plots indicate an increased rate of movement during the spring between the Aril and May readings for all SI installations. This would be expected, as spring is typically the wettest time of year.

5.2 Comparison of Slope inclinometer Data to BC Gas Monitoring Hub Data

On Figure 5 the SI and GPS displacements are plotted as vectors. The SI data has been collected from November 2001 to June 2001 while the GPS data is shown as two vectors, one for all available GPS data from September 1998 to May 2001 and one from December 2000 to May 2001. The latter dates roughly correspond to the period AMEC has been monitoring the SI's.

The azimuths of the displacement for the vectors of the GPS Data from September 1998 to May 2001 appear to correspond to the general trend of the azimuths for AMEC's SI data. When the data is compared over the more recent period from December 2000 to June 2001, some of the GPS data appears to correspond to the SI data while some BC Gas data indicated upslope or side slope movements. Further discussion of the GPS data would require access to the original data sets and calculations.



It is understood that BC Gas currently has contracted a GPS consultant to provide comments on the potential accuracy and errors in the GPS data. At the time of writing this report, BC Gas had not received the report from their GPS consultant. Note that AMEC has also recommended that BC Gas obtain an outside review of their GPS data to confirm is accuracies.

AMEC will provide more comments and a detailed comparison of the GPS data and SI data during future stages of the work once more SI/GPS data has been collected and the accuracies of the GPS data are better understood.

6.0 CONCLUSIONS

The following conclusions can be drawn from the data collected during Stage 1 of the West Quesnel Land Stability Study:

- 1. The study area is located within a large ancient landslide complex that appeared to be slowly moving at average rates of approximately 25 to 50 mm/year (1 to 2 inches/year) over the period from November 2000 to June 2001.
- 2. The depths of the slip surface appeared to range from 28 to 68 m below the ground surface.
- 3. The simplest interpretation of the data is that there is one overall slide complex, rather than a series of smaller slides terminating between the various slope inclinometers. The relatively similar movement directions and magnitudes also favour the "single slide" interpretation. The similarity of the movement vectors across the slide also indicates a possibility of limited differential movement between various slide blocks, compared to many other large slides.
- 4. The average inclination of the slide slip surface would be approximately 2° based on Figure 6. This is an extremely low angle, although not unprecedented, and may indicate that appreciable pore water pressures aid ongoing movement.
- 5. There is a possibility the toe of the slide may extend to the Fraser River in some areas.
- 6. The sliding may be within a pre-glacial (Tertiary) sediment sequence composed primarily of silt and clay.

Figure 6 shows a cross section of West Quesnel showing the depths of the zones of movement observed within the SI's. The preliminary borehole logs are summarized on the cross section.

In future stages of the West Quesnel Land Stability Study AMEC should investigate:

- 1. The material properties and nature of the soil within which the slide is moving,
- 2. The porewater/groundwater conditions in the study area, and



3. The probable lateral extent of the slide, including location of the top scarp, flanks and toe of the slide.

7.0 RECOMMENDATIONS FOR FURTHER WORK (STAGE 2)

Given the ground movements observed during Stage 1, AMEC recommends that Stage 2 of the work proceed. The scope of work for Stage 2 is detailed in AMEC's proposal of 31 May, 2000 to the City of Quesnel and includes:

- 1. Selection of borehole locations.
- 2. Drilling of boreholes to collect detailed soil samples.
- 3. Installation of piezomenters to monitor pore water pressures.
- 4. Logging the drill holes.
- 5. Detailed laboratory testing of collected core samples.
- 6. Continued monitoring of existing SI installations
- 7. Monitoring pore water pressures through at least 1 spring season

AMEC could start work on Stage 2 in early August, 2001. As part of the work, AMEC also recommends that a digital elevation model be produced for West Quesnel. This model could be used as a base for more accurate mapping, plotting of data, and production of cross sections for slope stability analysis.



8.0 LIMITATIONS

This report has been prepared for the exclusive use of the City of Quesnel and their representatives for specific application to the area within this report. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. AMEC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

This report was prepared in accordance with generally accepted geotechnical engineering principles and practice. No other warranty, expressed or implied, is made.

9.0 CLOSURE

Please do not hesitate to contact the undersigned at (250) 564-3243 should you have any questions or require further information.

Sincerely,

AMEC EARTH & ENVIRONMENTAL LIMITED

2001 08 13

Reviewed by:

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Member, Technical Council

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Doug Dewar, M.Sc., P.Eng.

Geotechnical Engineer

N. C. POLYSOU

BRITISH Mick C. Palysou? B.Eng

Senior Georgeopical Engineer

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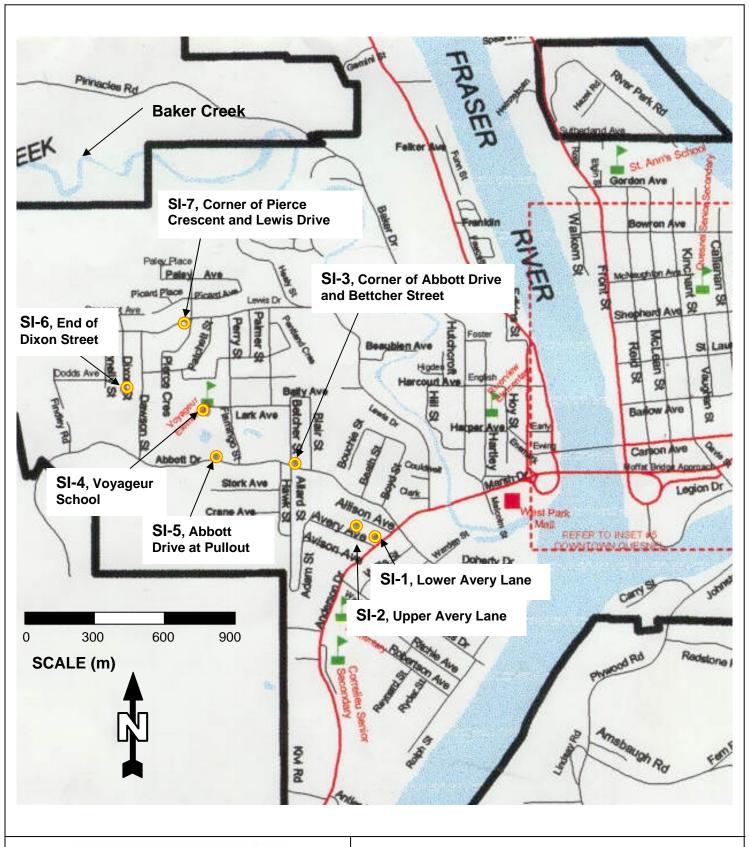
10.2 Geological Background

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Quesnel, BC

Figure 1: Slope Inclinometer (SI) Locations

DATE: Jan. 2001

SCALE: DRAWN BY: **HMN**

NTS

PROJECT No: KX03904



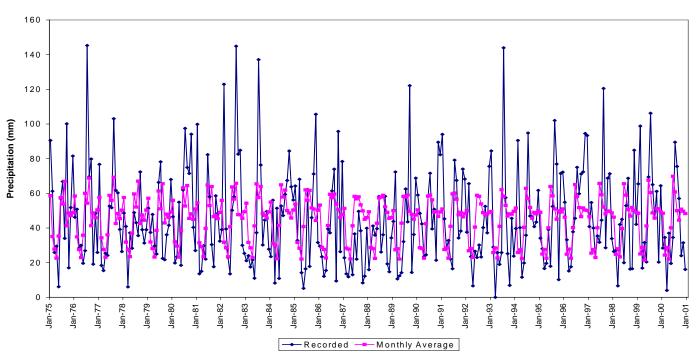
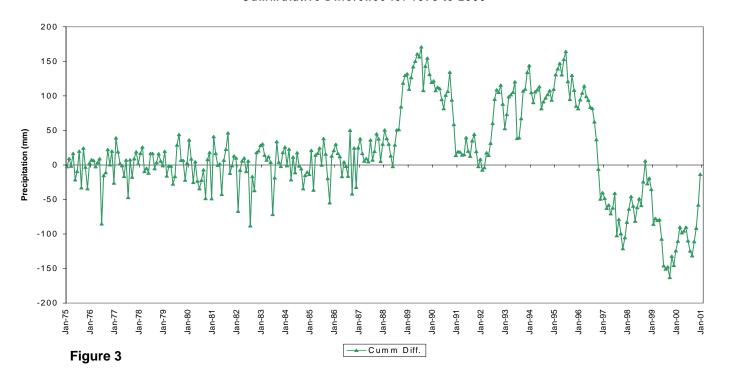


Figure 2

Cummulative Difference for 1975 to 2000





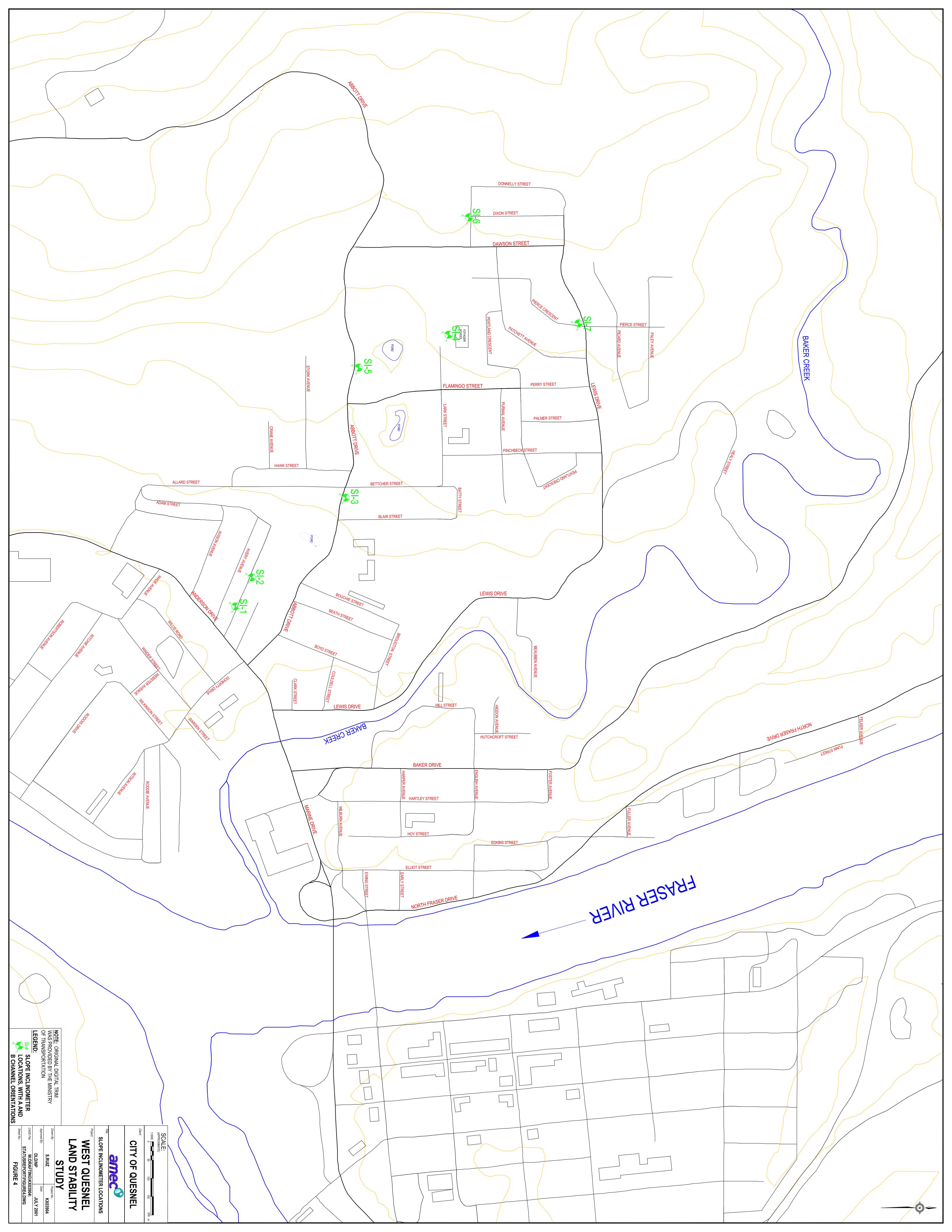
City of Quesnel

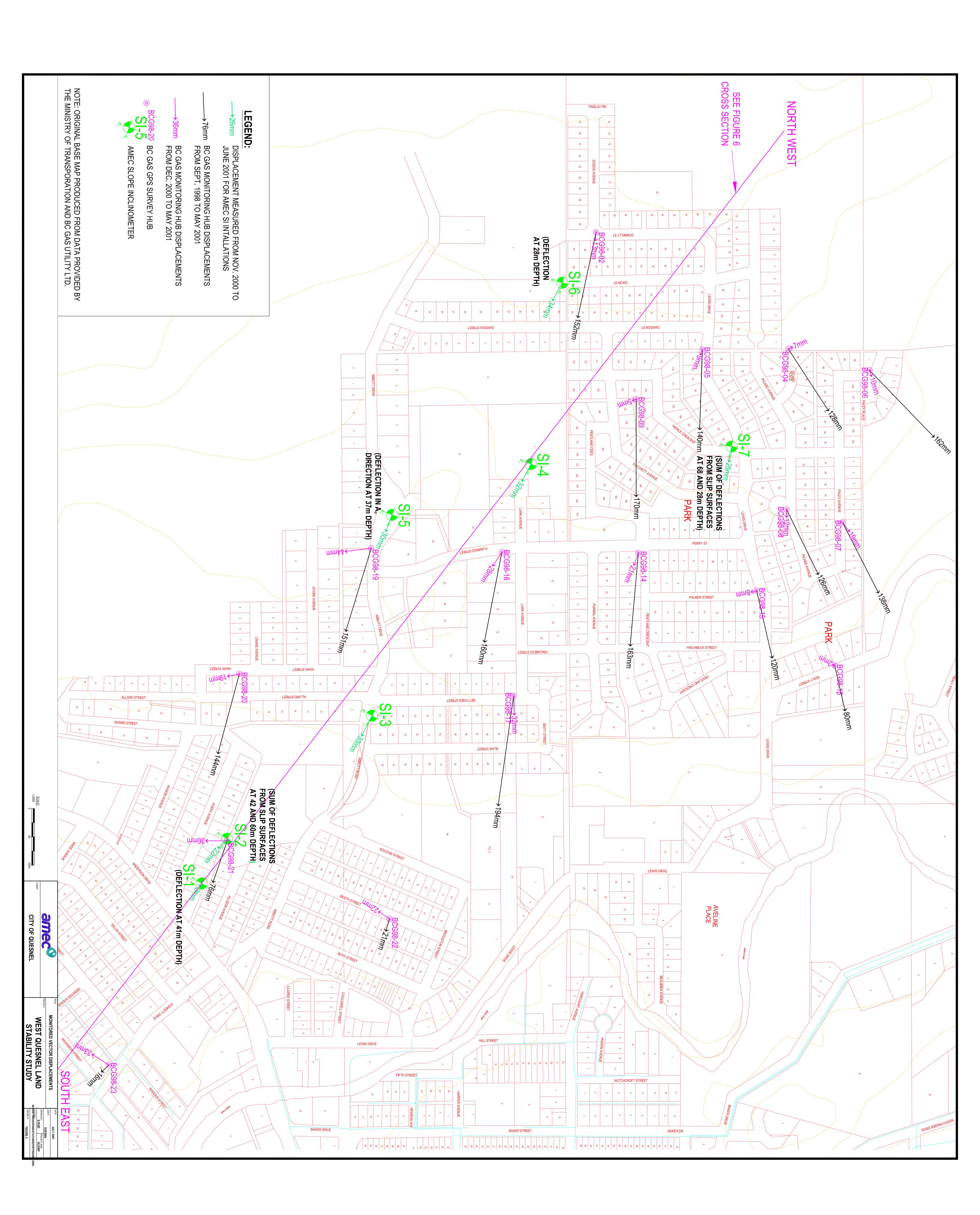
West Quesnel Stability Study Quesnel, BC

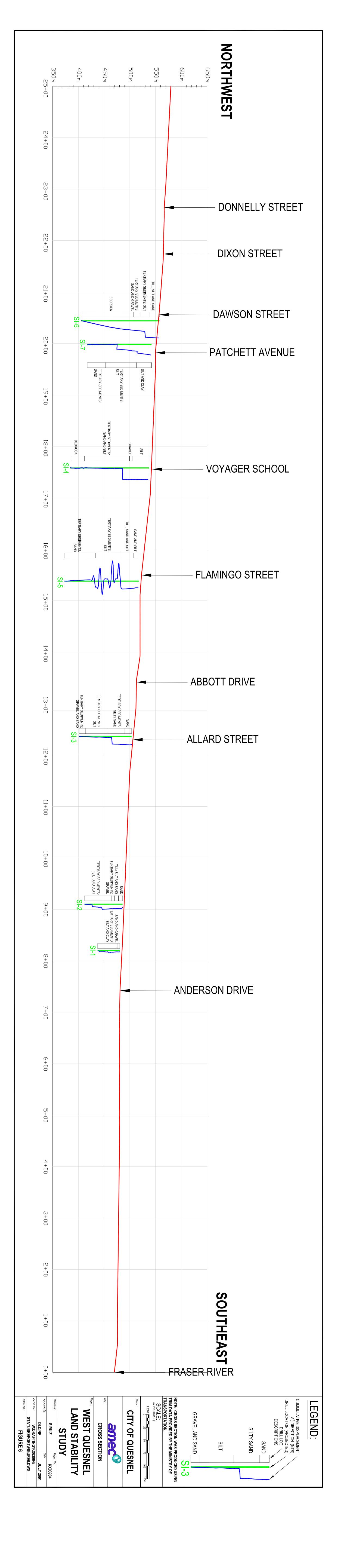
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DATE: July 2001 SCALE: DRAWN BY: SMJ

PROJECT No: KX03904







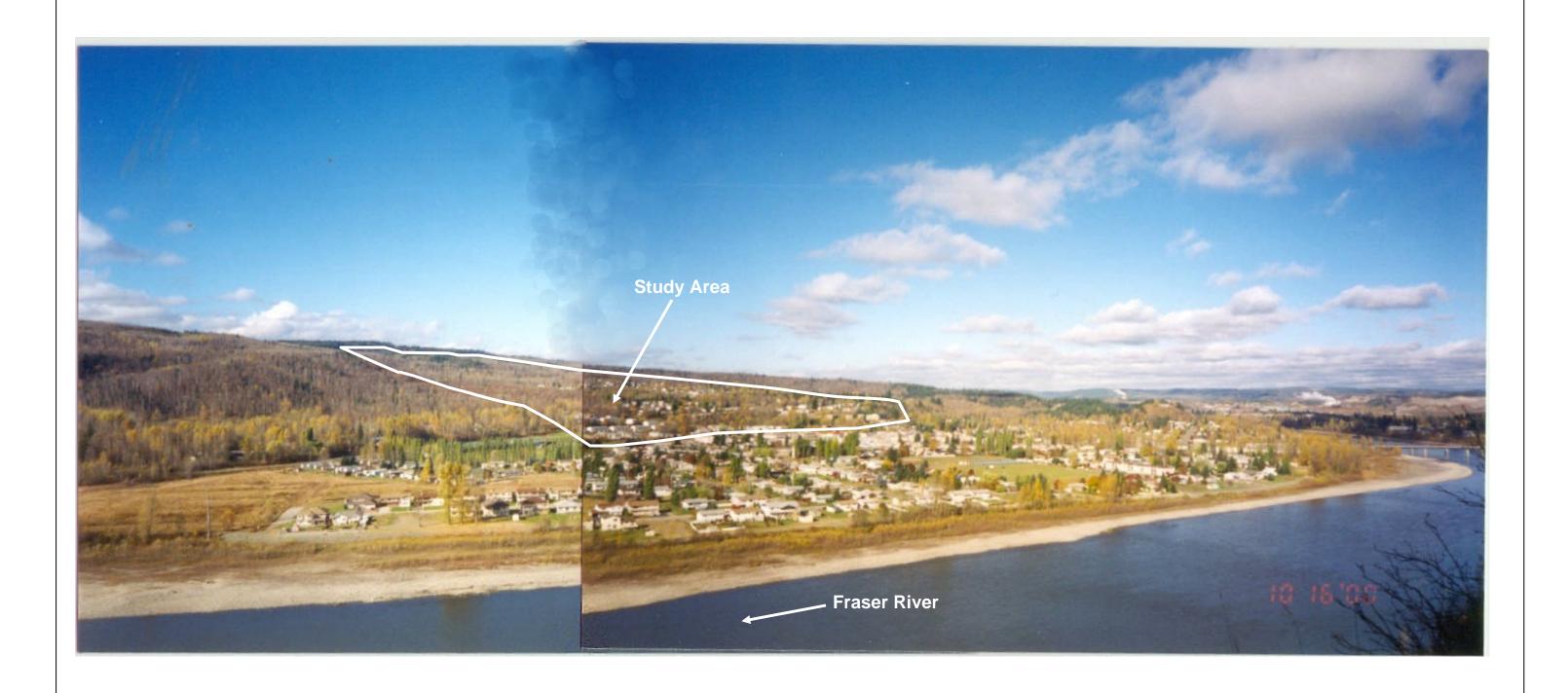


Photo 1: Looking northwest at study area from end of Veneer Road (off of the Plywood Hill Road) in south Quesnel.



City of Quesnel

West Quesnel Land Stability Study

Quesnel, BC.

DATE PREPARED: JULY 2001

SCALE: NTS

PREPARED BY: DLD

PROJECT No: KX03904

Photo 1

Taken: November 2001

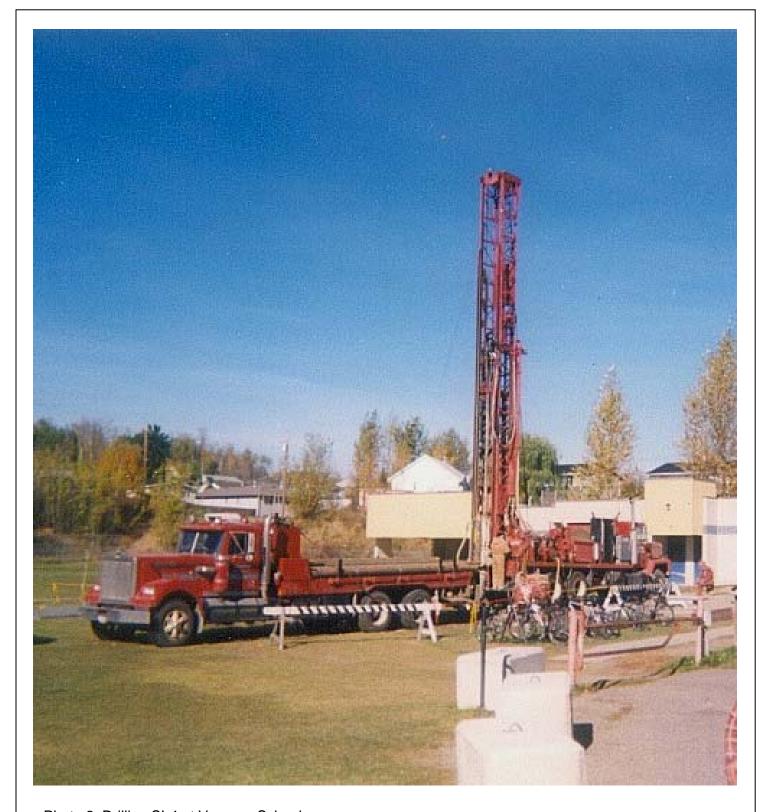


Photo 2: Drilling SI-4 at Voyager School



Quesnel, BC

Photo 2

DATE: Jun. 2001 SCALE: NTS DRAWN BY:

PROJECT No: KX03904
Taken: October 2000



Photo 3: Drilling SI-7 at corner of Lewis Drive and Pierce Cresent



City of Quesnel

West Quesnel Land Stability Study

Quesnel, BC

Photo 3

DATE: Jun. 2001

SCALE: NTS DRAWN BY: DLD PROJECT No: KX03904

Taken: October 2000



Photo 4: Installing SI Pipe in SI-7 at Lewis Drive and Pierce Crescent



Quesnel, BC

Photo 4

DATE: Jun. 2001 SCALE: NTS DRAWN BY: DLD PROJECT No: KX03904
Taken: October 2000

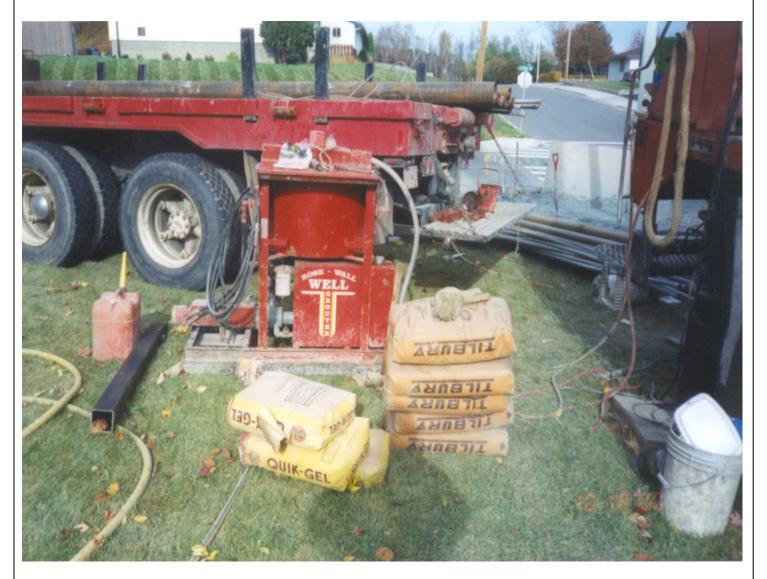


Photo 5: Grout Mixer and supplies taken at SI-7 located at Lewis Drive and Pierce Crescent



Quesnel, BC

Photo 5

DATE: Jun. 2001 SCALE: DRA

DRAWN BY: PROJECT No: KX03904
DLD Taken: October 2000

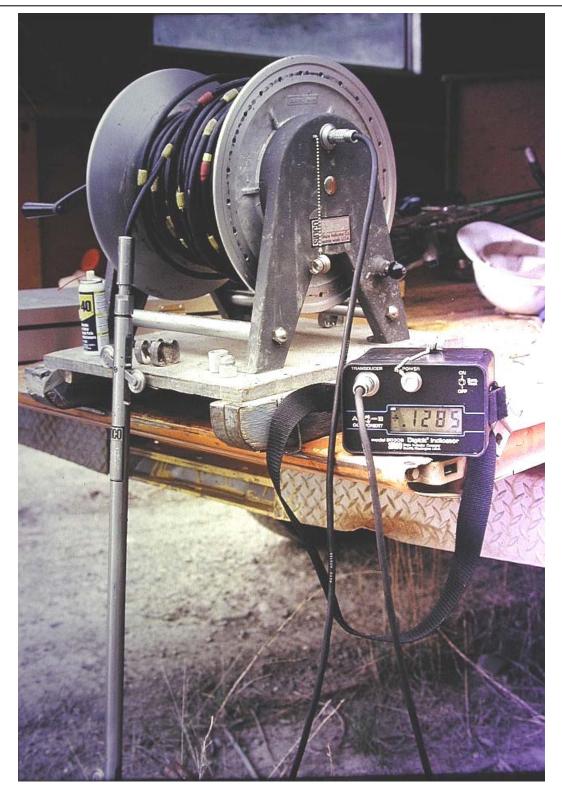


Photo 6: Example of SI probe and datamate reader



Quesnel, BC

DATE: Jun. 2001

SCALE: DRAWN BY: DLD

PROJECT No: KX03904
Taken: Unknown



Photo 7: Lowering SI probe down SI pipe at SI-2 location.



Photo 8: Spiral Probe and 505 foot SI cable ready to be lowered down SI-3 on Abbott Drive



Quesnel, BC

P	h	0	t	n	7	а	n	d	R

DATE: Jun. 2001

SCALE: NTS DRAWN BY: DLD

PROJECT No: KX03904
Taken: June 2001

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0.85											E.
89.0											E-2
90.0											=2
91.0											
92.0											Ē3
93.0		4									E-3
94.0	*******************										
95.0											E-3
96.0		- 2									- 1
97.0											E3
100000000000000000000000000000000000000											E3
98.0											
99.0											E-3
and the same of the same	Succession of the form				LOGGED BY: DLD				COLORETT	ON DEDTHE 74.7	_=
AMEC		Reserve							COMPLETE	ON DEPTH: 74.7 E: 10/24/00	111

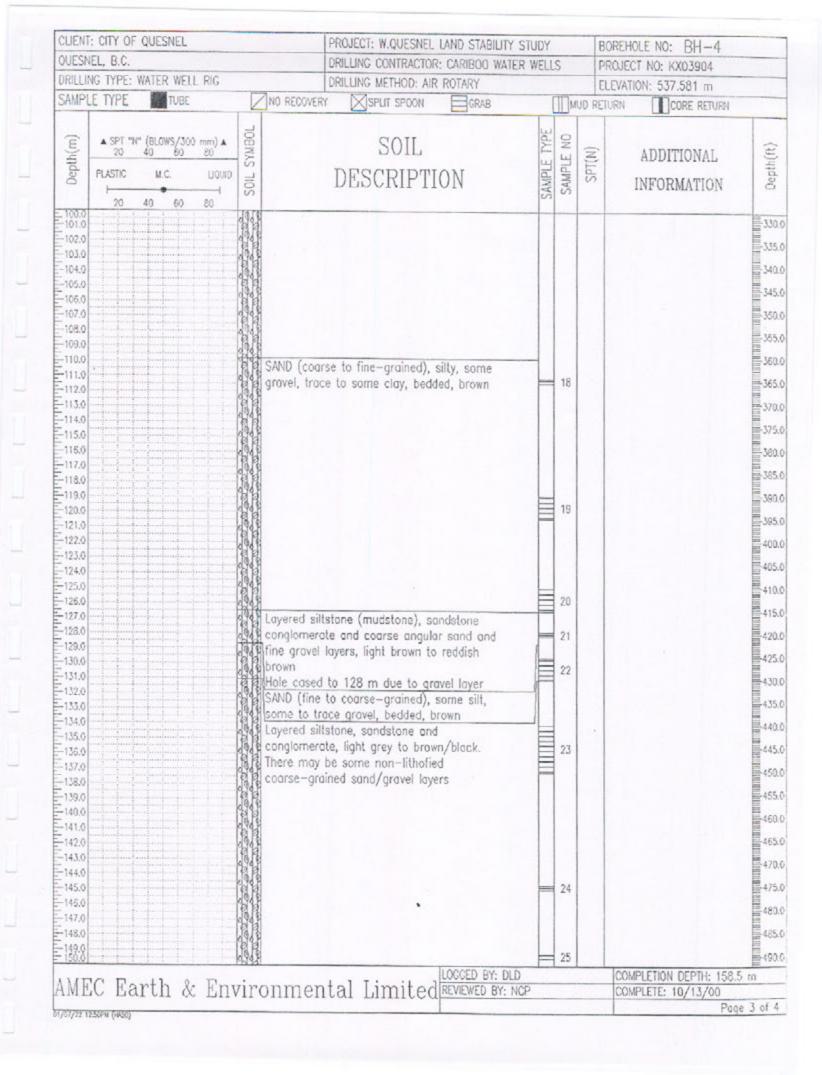
-	EL, B.C.	QUESNEL			-	PROJECT: W.C							OLE NO: BH-3
-		WATED WELL	Dio			DRILLING CON			AIER WEL	LS			CT NO: KX03904
	THE RESIDENCE OF THE PARTY OF T	WATER WELL	NIG.			DRILLING MET					_		ION: 503.43 m
SAMPL	E TYPE	TUBE		/ NO	RECOVERY	SPLIT	SPOON	GRAB			IUD RE	TURN	CORE RETUR
				_									
Depth(m)	▲ SPT "N	(BLOWS/300 40 60	mm) 🛦	SYMBOL		S	OIL		ZOVI Z IVDE	SAMPLE NO	-		ADDIMIONAL
the last	(way) - Fig.	12357	00	25					La	니닐	SPT(N)		ADDITIONAL
De	PLASTIC	M.C.	LIQUID	SOIL		DESCR	RIPTI	ON	9	13	8		INFORMATION
	100	40 40		SS		DHOOL	.11 11	OII	2	3			NULLEMATION
0.0	20	40 60	08	DE CAN) citty t	to some silt,	trace to			-	-		
1.0						r colluvium),							
- 2.0 - 3.0				a al in p	eces re	covered, brow	wn wet	CIC33	-				
- 4.0				969		0010100, 0101	mi, wet						
5.0				9.5									
- 6.0				Soh	rated 20	one encounte	red hat	veen 4.6 to					
7.0						zone may be							
- 8.0			9	the	soil cho	ve and below	/	- truli					
9.0			9	111		. J UNI DOIUN	70						
10.0				919						1			
11.0	1111			0.0									
12.0				8.8									
-13.0				SAN) some	silt to silty,	trace to	come					
14.0			9	B grov	el trace	clay, bedde	d with a	ome		2			
15.0				a a clay	ey silt a	nd gravel lay	ers ho	WA .		1			
16.0				Back Rock	froam	ents recovere	d appe	red to be					
17.0	1			A aug	tz. cher	t, limestone,	basalt	and to be					
18.0				COOL	se arni	ned igneous	rncke	2110					
- 19.0 - 20.0			i i	Pos	sible Au	stralian Cree	k Forme	tion)					
21.0							Comme						
-22.0				313									
- 23.0				100									
24.0				909									
- 25.0	111			9/3									
26.0				6 6									
-27.0	000000000000000000000000000000000000000			a Fa									
28.0			To the second	111									
29.0			0	111									
30.0				36									
31.0				919								1	
- 32.0 - 33.0				908									
34.0				919					-	3			
35.0				8.18									
- 36.0			i i										
- 37.0			°										
33.0			0										
- 39.0				2 13									
40.0				Soil	colour i	s blue. Onc	e recove	red					
41.0						peared to oxi							
42.0				6.6	al.		3.20 10	v. v.					
43.0			1										
44.0			P	191 000	(C) (to leak a		20. 1					
45.0				GRA	LL (and	jular), sandy	, some	silt, trace					
45.0						, blue matri:	x writch	oxidized	(4			
47.0			0	to b		de de la				5			
43.0			0	ala SILI	some (clay, trace to	some						
- 49.0 - 50.0			0	all sand	, trace	gravel (main	lly Tine						
1)(T	10 D	11 0	171			1 1 7 .		LOGGED BY:	DLD			CON	PLETION DEPTH: 10
AME	C Ea	irth &	Env	ironi	nen	tal Lim	nted	REVIEWED BY	: NCP				MPLETE: 10/27/00
						CONT. 1977 0315	WALL DO CO				-		

AMPLE TYPE TUBE NO RECOVERY SPLIT S	OIL RIPTION Its), very hard as medium plastic,	J.J.	9		TION: 503.43 m CORE RETURN ADDITIONAL INFORMATION	(a) 41000 175 175 186 187 187 187 187 187 187 187 187 187 187
MPLE TYPE TUBE NO RECOVERY SPLIT S A SPT "N" (BLOWS/300 mm) A 20 40 60 80 DESCR PUSTIC M.C. UQUID DESCR 20 40 60 80 DESCR 20 40 60 80 DESCR 20 40 60 80 DESCR 31.0 DESCR	SPOON GRAB OIL CIPTION Its), very hard as medium plastic,	TÏ	SAMPLE NO	RETURN	CORE RETURN ADDITIONAL	163 177 18 18 18 19 19 20 20 21 21 22 22 23
A SPT "N" (BLOWS/500 mm) A 20 40 60 80 DESCR	OIL RIPTION Its), very hard as medium plastic,	TÏ	SAMPLE NO		ADDITIONAL	16 17 18 18 19 19 20 20 21 21 22 22 23
PUSTIC M.C. U0010 DESCR 20 40 60 80 30.0 angular igneous fragmen noted by driller, low to note	CIPTION Its), very hard as medium plastic,	SAMPLE TYPE	SAMPLE	SPI(N)		16 17 17 18 18 19 19 19 20 21 21 22 22 22 22 22 22 22 22 22 22 22
20 40 60 80 50.0 51.0 52.0 55.0 55.0 55.0 56.0 57.0 60.0 61.0 62.0 63.0 64.0 65.0 66.0 67.0 68.0 68.0 69.0 77.0 77.0 77.0 77.0 77.0 77.0 77.0 7	its), very hard as nedium plastic,	15				17 17 18 18 19 20 21 21 22 22 23
58.0 59.0 60.0 61.0 62.0 63.0 64.0 65.0 66.0 67.0 68.0 69.0 71.0 72.0 73.0 76.0			6			20 20 21 21 22 22 23
65.0 66.0 67.0 68.0 69.0 70.0 71.0 72.0 73.0 76.0						21
78.0			7			2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
80.0 81.0 82.0 82.0 83.0 84.0 85.0 86.0 87.0 87.0 88.0	gular fragments), ard, low to non brown (oxidized					
91.0 92.0 93.0 94.0 95.0 96.0 97.0 98.0 99.0	silt to silty, rey which oxidized		8			
NOWMAND SOUR DOORS TWO MAN OF THE STATE OF T	LOGGED BY: DLD)			OMPLETION DEPTH: 109	9.8 m
AMEC Earth & Environmental Lin	UTCECTKENED BA: NO	CP		10	XOMPLETE: 10/27/00	age 2 o

Information banks reported	EL, B.C.	QUESNE	- Le	10		PROJECT: W.QUESNEL LAND STABI				BOREHOLE NO: BH-3
	The Part of the Pa	WATER W	ELL DI	0		DRILLING CONTRACTOR: CARIBOO	WATER WEL	LS		PROJECT NO: KX03904
		-	and the same of the same	5	Γ21	DRILLING METHOD: AIR ROTARY				ELEVATION: 503.43 m
SAMPL	E TYPE	TU	pr.		NO REI	COVERY SPLIT SPOON GRAB			MUD	RETURN CORE RETURN
Depth(m)	Strains.	1" (BLOWS/ 40 6			SYMBOL	SOIL	SAMPLE TYPE	CAMPIC NO	אד(או)	ADDITIONAL INFORMATION
2	PLASTIC	M.C.	-	GIUD H	SOIL	DESCRIPTION	CANAD	CALA	SAM!	INFORMATION
_ 100.0	20	40 6	0 80		ALE.			1	4	
101.0					44					
-103.0					11-11					
-104.0					1111					
105.0					NIN					
106.0				-	44					
107.0					11:11			1	9	
108.0		and the standard			1777			1		
109.0					17.17					
-110.0					NN					
111.0	Ag			-	The second secon	Borehole at 109.8 m				
112.0		4.6				alled to 102.4 m				
113.0					SI Ao	groove oriented Az = 120 degrees				
-114.0					Estimo	ited well production 0 GPM				
115.0				-		ter in hole upon completion				
116.0				- Contract						
-117.0										
118.0				- 4						
119.0				-						
120.0										
121.0										
122.0	-1-1-1									
123.0										
124.0										
125.0										
126.0										
127.0										
128.0										
129.0										
130.0										
131.0										
132.0										
-133.0	111									
-134.0				1						
135.0										
136.0										
137.0										
138.0				123						
139.0	-111		111							
140.0	111			7						
141.0	1 1 1			7.						
142.0	1 1 1									
143.0										
144.0				1						
-145.0										
146.0										
147.0										
145.0	1									
149.0										
150.0	-									
ANCE	OB		0 T	1		ental Limited REVIEWED E	: DLD	1		COMPLETION DEPTH: 109.8
AME	C Ea	irth	& E	nv	ironm	iental Limited REVIEWED E	Y: NCP			COMPLETE: 10/27/00
										Pag

-	the same and the same and	QUESNEL			PROJECT: W.QUESNEL LAND STAB				OREHOLE NO: BH-4	
	NEL, B.C.	1111750			DRILLING CONTRACTOR: CARIBOO	WATER WELL	S	-	ROJECT NO: KX03904	
-		WATER WE		-	DRILLING METHOD: AIR ROTARY			El	LEVATION: 537.581 m	
SAMP	LE TYPE	TUBE		1	NO RECOVERY SPLIT SPOON GRAB		M	JD RET	URN CORE RETURN	
Depth(m)	▲ SPT "1 20	N" (BLOWS/36 40 60	▲ (mm 00 80	SYMBOL	SOIL	E TYPE	LE NO	SPT(N)	ADDITIONAL	Dayth (FF)
Dep	PLASTIC	M.C.		SOIL	DESCRIPTION	SAMPLE	SAMPLE	SP	INFORMATION	Can
0.0	20	40 60	80	look	Possible FILL, SILT, some sand					
- 1.0			4-4-6-6-6	1888	(fine orginal) trans method (according					
- 2.0				\otimes	(fine-grained), trace rootlets/organics, soft, non-to-low plastic, ocasional thin	-	1			5
- 3.0				XX						B 1
4.0				XX	sand layers, brown, moist to wet	-	2			12
5.0							1 "			Ē1
		marken de de	-9-1-9-1-1	1888						E 2
7.0										E.
0.8		-			SILT and SAND (fine-grained), trace gravel		3			2
9,0			4		(mainly angular fragments), compact,		3			E 3
-10.0	7		designation		non plastic, structureless, brown,		4			
11.0					damp to wet	-	1			13
13.0										-
- 14.0				Ш		3				E,
15.0				Ш						
-16.0				ПП	SILT, some sand to sandy (mainly					5
-17.0				11111	fine-grained), trace to some clay,		5			E 5
- 18.0					trace gravel, non to low plastic,					100
19.0			4	Ш	structureless, brown, moist to wet					F 6
- 20.0				Ш	(Possible till or colluvium)	- 17				E 6
-21.0	onderstand			Ш	(i ossible till of collaviality					
- 22.0				Ш		=				1
23.0			4-1-1-	Ш			6			7
- 24.0										
- 25.0				Ш						8
-26.0	***************************************			1111		-				8
- 27.0		marian deserte		1111			7			=
- 28.0				Ш			1			Marie 9
- 29.0			1 1	1111		_	70			E 9
- 30.0				Ш			1			E .
-31.0				Ш						E1
32.0						_				E-10
- 33.0			400	Ш			8			Ē,
- 34.0				44	GRAVEL, sandy (mainly coarse-grained,		9			312
- 35.0				4,4,	trace fine-grained), trace silt (less than			100		E1
-36.0				13	3% estimated)					E,
- 37.0				2121			10			=
- 38.0				0.0	SAND (mainly coarse—grained, some		1			=12
39.0				0000	fine-grained), gravelly, trace silt,					
40.0				000	hadded with serse asset to asset to					E.
41.0				RA	bedded with some gravel layers, brown		11			E1:
42.0			1 1	120	(Possible Australian Creek Formation)		100			
43.0	3-10-0			1939	SAND (coarse and fine-grained), some					=
44.0		arrolandoniko		1900	gravel, some silt, bedded, brown					į,
45.0				MAR			12			Į,
46.0				19			12			
- 47.0 - 48.0				PH H						1:
- 49.0 - 49.0			1 1	89						
50.0			4-1-1	0309						E'
100	20 7				onmental Limited REVIEWED I	: DLD			COMPLETION DEPTH: 158.5 r	n
		and to	/ 1 1 mm	** **	amana				COMPLETE: 10/13/00	_

		QUESNEL		7001	PROJECT: W.QUESNEL LAND STABILITY			_	OREHOLE NO: BH-4	
-	VEL, B.C.				DRILLING CONTRACTOR: CARIBOO WATE	ER WELL	S	P	ROJECT NO: KX03904	
		WATER WEL	L RIG		DRILLING METHOD: AIR ROTARY			E	LEVATION: 537.581 m	
SAMPI	LE TYPE	TUBE			NO RECOVERY SPLIT SPOON GRAB		M	UD RET		
-	S-22-								1 1000000	
Depth(m)	▲ SPT "N 20 PLASTIC	(BLOWS/30 40 60 M.C.	▲ (mm 0 88 GUUU	. SYMBOL	SOIL	JUE TYPE	SAMPLE NO	SPT(N)	ADDITIONAL	Danth (ft)
ă	20	40 60	80	SOIL	DESCRIPTION	SAMPLE	SAM	S	INFORMATION	- C
50.0	20	40 00	in the sign	HH						III-16
-51.0				9794						
- 52.0				door !	SAND (mainly fine-grained) and SILT, trace					E-17
- 53.0				10,16	clay, trace gravel, bedded, brown		13			昌17
54.0	4		1-1-1-	19	nay, nace grave, becoree, brown		1.5			E'
- 55.0				88						E-18
56,0				4948						100
-57.0				16/6						F18
-58.0				100			14			15
- 59.0			1.1.1	99			1			12
60.0		mojemjenije.	4	434		-				E-19
-61.0				16/6						E.
- 62.0				18 18						E-20
-63.0			-	88						E 20
- 64.0			***********	999						
	-1-1-1			10/0						를21
65.0				1919		130				21
66.0				NA NA						100
67.0				999						=22
- 68.0				0000						
69.0				1818						22
70.0			1	Pa						23
71.0				299			15			100
72.0				000						E23
-73.0			1 1 1	1818						E-24
74.0			1	199						= 4
75.0			9	494						-24
76.0				0969						Ē.,
77.0			1	AR						E 25
- 78.0	1		de continu	a a						25
				999			19			
79.0			7	908		_				26
80.0			1	18 P						E.,
-81.0			************	10						26
-82.0			4	89			16			2
-83.0			1 1 1 1 1 1 1 1 1	999						
84.0	university of			18,6				- 1		27
85.0				图目						E-20
86.0	1			23						E
87.0				990						E-20
-88.0				AR						E.
89.0				199						= 29
90.0	P-12-10-5-11-5	en posterio de la	***************************************	898						E-20
91.0	1 1 1		1 - 1 - 1 - 1	999						100
92.0				13,6						Ex
93.0				1919						E30
94.0	19-19-11-1			999						
				0903			17			31
95.0				MA						
96.0				199		-				3
97.0				0,46						E,
-98.0			4	0000						E-37
99.0	1			AA						E-37
100.0	1 1 1	- Ladinahan	Time to but	19763	Lance Control				TAAL IN INTERNAL PROPERTY.	100
1 / 1	70 0	11 0	. TI		nmental Limited REVIEWED BY: D	D	- 17	111111111111111111111111111111111111111	COMPLETION DEPTH: 158 COMPLETE: 10/13/00	5 m
3.5.5			A 14 373 3	2 2 2 M	an area was a man a language and a l				the second control of	



-	EL, B.C.	QUESNEL	-		PROJECT: W.QUESNEL LAND STABILITY		c		OREHOLE NO: BH-4
-	THE RESERVE AND ADDRESS.	WATER WEL	I DIC		DRILLING CONTRACTOR: CARIBOO WAT	EK WELL	.5		ROJECT NO: KX03904
-	-		L KIG	-	DRILLING METHOD: AIR ROTARY				EVATION: 537.581 m
SAMPL	E TYPE	TUBE	muse -	V	NO RECOVERY SPLIT SPOON GRAB		U N	UD RETI	URN CORE RETURN
Depth(m)	▲ SPT "7 20	%" (BLOWS/30 40 60	0 mm) 🛦	SYMBOL	SOIL	SAMPLE TYPE	SAMPLE NO	SPT(N)	ADDITIONAL
Dep	PLASTIC -	M.C.	TI GNID	SOIL	DESCRIPTION	SAMPL	SAMP	SP	INFORMATION
_ 150.0	20	40 60	80	1010					
151.0				2000					
152.0	***************************************		J	Par					
-153.0			de edere kon de esta de ede	1999					
154.0			1-1-1-	1909					
155.0			1 1	MA					
156.0				PAR					
157.0				9					
158.0				1943					
E-159.0			1	1	End of Borehole at 158.5 m				
160.0			gama mada		SI installed to 158 m				
-151.0					SI Ao groove oriented at Az = 110 degrees				
-162.0					Static water level at 97.6 m 18 hrs				
163.0			1		after completion of beachets				
164.0					after completion of borehole				
165.0					Estimated well production 2 to 3 GPM				
166.0			-						
-167.0									
168.0									
169.0									
-170.0			1-1-1-						
-171.0			1						
-172.0									
173.0			4						
E-174.0		kandanda (kris 1995)	4						
175.0	1-11-1-1-1-1		\$						
176.0			1-1-1-						
177.0	there's ereginess a		1-1-1-						
178.0									
179.0			1-1-1-						
180.0			1-1-1-						
181.0									
182.0									
-183.0									
E-184.0			1 1	1				3,1	
185.0								1	
-186.0									
-187.0									
-188.0									
-189.0									
E-190.0									
E-191.0									
E-192.0									
-193.0									
E-194.0			1-1-1-						
195.0									
196.0		Southern Linders	-						
197.0	4		\$						
198.0			1 1 1						
E-199.0			1 1						
200.0	1114-114-11	pot oini	1-1-1-						e de la complexión y esta
	20 0		П		onmental Limited REVIEWED BY: D	LD			COMPLETION DEPTH: 158.
A 1 1 1							_		COMPLETE: 10/13/00

minor minima	CITY OF	QUE	SNEL			PROJECT: W.QUESNEL LAND STABILITY ST			_	BOREHOLE NO: BH-5	
JESNEL	TYPE:	WATE	D WELL	010	-	DRILLING CONTRACTOR: CARIBOO WATER	WELL	S	_	PROJECT NO: KX03904	
		-	Commence of the local	LING		DRILLING METHOD: AIR ROTARY		797		ELEVATION: 517.723 m	
MPLE	TIPE	100	TUBE		V	NO RECOVERY SPLIT SPOON ■GRAB		M	UD RE	ETURN CORE RETURN	
9	▲ SPT "7 20			100000	SYMBOL	SOIL	SAMPLE TYPE	OLE NO	SPT(N)	ADDITIONAL	Take a
90	PLASTIC 1————————————————————————————————————	40	f.C. 60	80	SOIL	DESCRIPTION	SAMP	SAMPLE	S	INFORMATION	
0.0		10	1		88	Possible FILL, SAND, some gravel, trace	+				-
2.0	1				A A	silt, compact to loose, brown, damp	1				
3.0	4				1994	SAND and SILT, some to trace clay, trace					
4.0		Ž			190	(gravel (till or colluvium), low plastic,	1				
5.0	1-1-1				1943	brown, damp to moist					H
6.0	-333				1313	SAND, some silt, no rock fragments or					H
7.0			demisses		MAR	gravel observed, brown, wet					F
9.0					THE						10.00
10.0					1919						E
11.0					930	CAND A CHT					
12.0					Ш	SAND and SILT, some to trace clay, trace					100
13.0	1-1-1				Ш	gravel, low plastic, brown, damp to wet (possible till or colluvium)		(6)			ı
14.0						(possible dif of continuity)					E
15.0											L
16.0					Ш						E
18.0					Ш						
9.0											H
0.0		<u>i</u>									
1.0											E
22.0			ļ.,,								H
3.0			ļii								F
4.0					11111						
6.0					11111						100
27.0									1 - 3		H
0.82					Ш						F
9.0			1		11111						E
30.0					Ш						E
31.0			ļ								
2.0			1								H
3.0		conspired conspired									
55.0											
6.0						SILT, some clay, trace sand, trace					
7.0						gravel, bedded with some sandy and					H
0.8				3 1		gravelly layers, medium to					
9.0						low plastic, hard/partially lithified.			- 5		
0.0						steel grey to green					E
1.0	1					(Possible Australian Creek Formation)	-	1			
3.0											ŀ
14.0	1			in program							=
5.0			-								F
46.0			hh				=	2			ŀ
47.0											
48.0											-
19.0											F
avv.ov.		100			4111	LOGGED BY: DLD				COMPLETION DEPTH: 152 4	E.
MEC	Ea	nt	h &	En	vir	onmental Limited REVIEWED BY: NOR)				-
	C Ea	art.	h &	En	vir	onmental Limited REVIEWED BY: NCP				COMPLETION DEPTH: 152 COMPLETE: 10/05/00 Pa	2.4 r

QUESN	EL, B.C.				PROJECT: W.QUESNEL LAND STABILITY: DRILLING CONTRACTOR: CARIBOO WATER		S	-	REHOLE NO: BH-5 OJECT NO: KX03904
DRILLIN	G TYPE: W	ATER WEL	L RIG		DRILLING METHOD: AIR ROTARY			-	EVATION: 517.723 m
SAMPL	E TYPE	TUBE		T	NO RECOVERY SPLIT SPOON GRAB		ПЪ	UD RETU	THE RESIDENCE OF THE PARTY OF T
T					Note and Page			OU REIL	IRN CORE RETURN
Depth(m)		(BLOWS/300 40 60		SYMBOL	SOIL	LE TYPE	OLE NO	SPT(N)	ADDITIONAL
8	FLASTIC	M.C.	TI GOID	SOIL	DESCRIPTION	SAMPLE	SAMPLE	S.	INFORMATION
50.0	20	40 60	80	1111					
-51.0									
- 52.0		skentski stri							
53.0		4		Ш					
54.0				Ш					
- 55.0			i i i i i i i i i i i i i i i i i i i						
- 56.0		den de de		Ш					
57.0		alandand		Ш		=	3		
58.0			1 - 1 - 1 b						
59.0					1.5 m thick white soil layer, no changes			, ,	
- 60.0					in composition				
- 61.0					22.00000				
62.0				Ш					
63.0					1.5 m this tight 11				
64.0				Ш	1.5 m thick light grey soil layer, no		4		
- 65.0		4-4-4		Ш	change in composition				
- 66.0									
67.0		-lll		Ш					
- 68.0				Ш					
69.0	-1-1-1-	1-1-1		Ш		1000	5		
70.0				Ш					
71.0		444		Ш					
- CO.				Ш					
72.0 73.0									
74.0				Ш	SILT, some clay, some sand, some	-			
				Ш	gravel, low plastic, bedded, brown to blue		6		
75.0		4		Ш	grover, low plustic, bedded, brown to bige		0		
76.0				Ш					
				Ш					
78.0				Ш					
79.0				Ш					
- 80.0		-		Ш					
81.0		4	71000						
82.0			1	+++	SILT same sand same alor least	-	7		
84.0				Ш	SILT, some sand, some clay, trace		1		
85.0				0000	gravel, bedded with sandy and gravelly	1			
86.0	1-1-1-			000	layers, low to non plastic, hard/partially				
87.0			-	00	lithified, steel, steel grey to green				
88.0				00	SAND (medium to coarse with less				
89.0			1	00	fine-grained), trace silt, trace to some				
90.0		2-1-1-			gravel (fine-grained), very		8		
91.0				000	dense/partially lithified, brown to blue		1		
92.0		4-4-1	1 - 1 - 1 - 1	3.9					
man in the				000					
93.0		-b-odo		000			3		
94.0	4-4-6-	the state of the	- breinin						
95.0		- E	-51-5	000					
96.0				00	,				
97.0			- Annaham	000					
98.0				. 0. 0					
99.0				000					
	120	10000			LOGGED BY: DLD				COMPLETION DEPTH: 15
I DETT	CEN	oth &	Fn	rin	onmental Limited REVIEWED BY: NO	P			COMPLETE: 10/05/00
AMH:	D. 24	11 /0							

A ROSE SERVICE COMM	EL, B.C.	QUESNEL			PROJECT: W.QUESNEL LAND STABILITY DRILLING CONTRACTOR: CARIBOO WATE		0		BOREHOLE NO: BH-5
		WATER WEL	I DIC			ER WELL	5	_	PROJECT NO: KX03904
	E TYPE	TUBE	L MO		DRILLING METHOD: AIR ROTARY		77.5		ELEVATION: 517.723 m
SHML F	LIITL	1086		V	NO RECOVERY SPLIT SPOON GRAB		М	JD RE	TURN CORE RETURN
~	▲ SPT "N	" (BLOWS/30)) mm) 🛦	30L	COII	TYPE	NO		
Depth(m)	20	" (BLOWS/300 40 60	80	SYMBOL	SOIL			SPT(N)	ADDITIONAL
8	PLASTIC	M.C.	UQUID	SOIL	DESCRIPTION	SAMPLE	SAMPLE	SPI	INFORMATION
	20	40 60	80	S		S	S		IN ORMATION
100.0				000	7		10		
102.0				000					
-103.0			\$	9.9					
104.0				00					
-105.0				000					
105.0				0000					
107.0		manage in		0000			11		Wash Sieve Analysis:
-108.0				000					16% Gravel
109.0				00					72% Sand
-110.0				00	Hole was left open for 15 hours, no static				12% Silt or Clay
-111.0				000	water observed when drilling recommenced				
-112.0				000	and arming recontinuoused				
-113.0				0000					
-114.0		***************************************		0000			12		
115.0	1-1-1			00					
-116.0 -117.0	1 1 1			00					
-118.0	1 1 1		land a	00					
-119.0				000			4.7		
120.0				1.0.0			13		
-121.0	-4			000					
122.0				10,0	Annual Control of the				
-123.0			locario	000	Possible water table encountered, some				
-124.0				000	water flowing into hole		14		
-125.0				000					
-126.0				0000					
127.0		# EXTRE (144-17) 144 (1-1-1-1)		000					
-128.0				0.0					
129.0				000					
-130.0				00					
-131.0				00			15		
-132.0				000					
-133.0 -134.0				000					
-135.0				0000					
-136.0				000					
-137.0				0.0			93		
-138.0				0000			16		
139.0				000					
-140.0				000					
-141.0	-1-1-1			0000		=			
-142.0				0000					
143.0				000					
-144.0				000	Water producing seam encountered,				
-145.0		nendoner occioni		000	estimated production 5 GPM		17		
-145.0				000	and the same of th				
-147.0				0000					
-148.0				0000					
-149.0 -150.0				000					
		The same of the sa			LOGGED BY: DL	D			COMPLETION DEPTH: 152
ALLI	O D	not 1 0	Day		onmental Limited REVIEWED BY: N	U.			COMPLETE: 10/05/00

		QUESNEL	-		PROJECT: W.QUESNEL LAND STABILITY			80	REHOLE NO: BH-5	
	EL, B.C.				DRILLING CONTRACTOR: CARIBOO WAT	TER WELL	S	PR	OJECT NO: KX03904	
DRILLIN	IG TYPE:	WATER WEI	L RIG		DRILLING METHOD: AIR ROTARY			ELE	EVATION: 517.723 m	
SAMPL	E TYPE	TUBE		N	RECOVERY SPLIT SPOON GRAB		ПМ	UD RETU		_
							Ш	I I	TOOKE RETURN	_
Depth(m)	▲ SPT "N 20 PLASTIC	(BLOWS/30 40 60 M.C.	(mm 0 mm 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	SPT(N)	ADDITIONAL INFORMATION	
	20	40 60	80			SA	S		IN ORBESTON	
=. 150.0 =-151.0				000			18			
152.0				173 73						
-153.0				En	d of borehole at 152.4 m					
154.0	-4		4	SI	casing installed to 144.8 m due to					
-155.0				cu	ttings at base of hole					
156.0			1-1-1	SI	Ao groove aligned at Az = 110 degrees					
-157.0			too books	St	atic water level not measured			- 1		
158.0			1	Es	timated well production 5 GPM					
159.0			1-1-1-	Tr	mie pipe was only lowered to 73.2 m					
-160.0				du	ring grouting due to an obstruction at					
161.0	1 1 1			th	s depth					
-162.0 -163.0										
-164.0										
165.0			1-1-1-							
166.0										
-167.0										
-168.0										
169.0										
-170.0										
171.0										
-172.0										
173.0										
-174.0										
175.0	-1-1-1									
176.0										
-177.0 -178.0			1							
179.0										
-180.0										
-181.0										
182.0										
-183.0	111									
184.0										
185.0			1-1-1-							
186.0										
187.0										
-188.0			4							
189.0			4							
190.0	4 1 1		100000							
191.0			4							
192.0										
193.0		141								
-194.0 -195.0										
195.0 -196.0										
197.0			4-1-4-1-4-1							
198.0										
199.0										
200.0	-1-1-1		1 1 1		The state of the s					
ART	O E		. 13		LOGGED BY: DI	LD			COMPLETION DEPTH: 152.	1
AMI	C Ea	irth o	c En	riror	mental Limited REVIEWED BY:	NCP			COMPLETE: 10/05/00	
									Pag	

-	r: CITY OF	YUL	SWEL			PROJECT: W.QUESNEL LAND STABILITY			18	BOREHOLE NO: BH-6
-	VEL, B.C.	1111				DRILLING CONTRACTOR: CARIBOO WAT	ER WELL		F	PROJECT NO: KX03904
_	NG TYPE:	-		L RIG		DRILLING METHOD: AIR ROTARY			8	ELEVATION: 557.723 m
SAMPI	LE TYPE		TUBE		1	NO RECOVERY SPUIT SPOON GRAB		M	UD RE	TURN CORE RETURN
Depth(m)	A SPT "7	™ (BLO 40 M.		08 € (mm) ▲	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	SPT(N)	ADDITIONAL INFORMATION
2000	20	40	60	80	200		S			
5.0 -1.0 -2.0 -3.0 -4.0 -5.0 -6.0 -7.0 -8.0 -10.0 -11.0 -12.0 -14.0 -15.0 -16.0 -17.0 -18.0 -19.0					10000000000000000000000000000000000000	SILT and SAND, trace gravel, trace clay, very stiff, low plastic, moist ot wet (Possible till or colluvium)				
20.0 -21.0 -22.0 -23.0 -24.0 -25.0 -26.0 -27.0 -28.0					0962	SILT, some sand, trace to some clay, trace gravel, low to non plastic, steel grey to blue (Possible Australian Creek Formation)		1 2		
-29.0 -30.0 -31.0 -32.0 -33.0 -34.0 -35.0						SILT, clayey, trace sand, medium to high plastic, blue to steel grey oxidizing to light brown		3		
- 36.0 - 37.0 - 38.0 - 39.0 - 40.0 - 41.0 - 42.0 - 43.0 - 45.0 - 45.0 - 47.0 - 48.0 - 49.0 - 50.0					12002002002000000000000000000000000000	SAND (coarse-grained) and GRAVEL (fine-grained, angular to sub-angular fragments), some silt to silty, trace clay, olive green Some seams of fine sand and silt were evident in cuttings Brown silty layers encountered Soil colour changed to rust, heavy exidation evident		5 6 7		ENTERNIS DE LA CARTA CAR
	C F	nt1	h &	Fn		onmental Limited REVIEWED BY: DI	D	7		COMPLETION DEPTH: 154 m COMPLETE: 10/16/00

the control of the least	: CITY OF	QUE	SWEL			PROJECT: W.QUESNEL LAND STABILITY				BOREHOLE NO: BH-6	
_	EL, B.C.	WATER	0 11151	1 510		DRILLING CONTRACTOR: CARIBOO WATE	ER WELL		_	PROJECT NO: KX03904	
the same of the sa	NG TYPE:		_	L RIG	-	DRILLING METHOD: AIR ROTARY			E	ELEVATION: 557.723 m	
SAMPL	E TYPE		TUBE		V	NO RECOVERY SPLIT SPOON GRAB		M	UD RE	TURN CORE RETURN	
Depth(m)	▲ SPT "Y 20 PLASTIC	N" (BLO 40 M.	60	0 mm) . 80 LIGUIÐ	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	SPT(N)	ADDITIONAL INFORMATION	
	20	40	60	80	SS	DECOMI HOL	SS	S		INFORMATION	
50.0	20	40	60	00	200	POSSIBLE BEDROCK	-		-		-
51.0 52.0					200	Cuttings appeared to be from bedded white					- 1
53.0					1	andstone with some less indurated					
54.0	1			-	200	gravelly or sandy layers. Cuttings were					- 1
55.0			anciero.		200	angular and sand sized, rounded fragments					- 1
-56.0		on poor			1	not recovered					
57.0					P. C.						
58.0					1						
-59.0											- 1
- 60.0					2						
-61.0					233						
62.0					200						
- 63.0					***				6		
64.0					233		-	8			
65.0			andre.		200						
66.0					KX						
67.0					200						
68.0			10/10/21/11		2						
70.0		mericani.			200						
71.0							-	9			
72.0					级						
73.0					220						
74.0					200						
75.0					***						
76.0											
77.0					333						
78.0					***						
79.0					XX				1	35	
80.0					200	Possible water bearing seam					
81.0					200	*					
82.0					220			10			
83.0					200			10			
84.0					333						
85.0					经				-		
86.0					2				- 3		
87.0					200						
88.0					***				-		
89.0					200						
90.0				24	2						
91.0					233						
93.0					***						- 1
94.0			10.3		333						
95.0					232	POSSIBLE BEDROCK		11	1		
36.0					***				1 1		
97.0					333	Cuttings appear to be light grey to dark					- 1
98.0	- 00			100		rey siltstone/sandstone with some					
-				-	333	ess indurated layers. Cuttings were			1		
99.0	2010/09/01		· · · · ·	170	500	ingular and coarse sand sized.					
OIL	n n	11	. 0	П		nmental Limited REVIEWED BY: DL	0			COMPLETION DEPTH: 154	m
		The same of the	- W -							COMPLETE: 10/16/00	

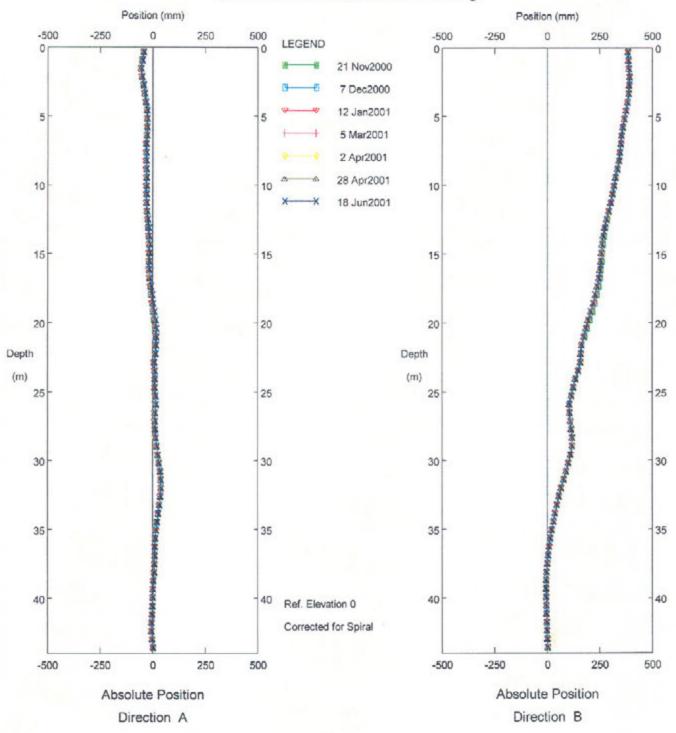
CUENT	-	YUL	DIVEL				PROJECT: W.QUESNEL LAND STABILITY STUDY							
	IEL, B.C.	1111		Page 1			DRILLING CONTRACTOR: CARIBOO WATER WELL				PROJECT NO: KX03904			
-	NG TYPE:	-	_	L RIG	-	DRILLING METHOD: AIR ROTARY			ELE	VATION: 557.723 m				
SAMPL	E TYPE	-	TUBE		V	NO RECOVERY SPLIT SPOON GRAB		M	UD RETUR	RN CORE RETURN				
											T			
Depth(m)	▲ SPT "N 20			255	SYMBOL	SOIL	SAMPLE TYPE	SAMPLE NO	SPT(N)	ADDITIONAL	111000			
2	PLASTIC 1————————————————————————————————————	M.	C. 60	0000U 08	SOIL	DESCRIPTION	SAMP	SAME	S	INFORMATION				
100.0					200		-							
-101.0					XX						H			
102.0					RX.						E.			
-103.0					200									
-104.0		andani			1						-			
-105.0					2						B.			
106.0		(1) (1) (1) (1) (1) (1) (1) (1)			200						DATE			
-107.0					200									
-108.0					**						Ī.			
109.0					200						100			
-110.0	4				2	Cuttings changed to white for					H			
-111.0					1	approximately 1 m then soil was grey again	-	12			8			
-112.0					200	, , , , , , , , , , , , , , , , , , , ,								
-113.0					***						1			
114.0					1						E.			
115.0				1.1.	2									
-116.0											1			
-117.0					200									
-118.0		********			2			25,000			100			
-119.0					***			13			B			
120.0				-11:	244						1			
121.0					***						100			
122.0					1						H			
123.0					200			-			E			
-124.0				acceptant poor	XX				- 3		=			
-125.0					220						E-			
-126.0 -127.0					**			14			F.			
					1			1.1						
128.0		(=110000)4) (=1100000)4			200									
-129.0 -130.0		0			200						E.			
-131.0					XX						200			
-132.0					2						1			
-133.0					XX						E.			
-134.0					200									
-135.0		andon.				POSSIBLE BEDROCK			*		E			
-136.0					XX	Cuttings appeared to be volcanics with					E,			
-137.0				1 1	***	some quartz and minor sedimentary rock					100			
-138.0						composition. Cuttings were typically dark					E-			
139.0					333	grey with some quartz and sandstone					E.			
-140.0						fragments					-			
141.0					333	iroginents								
-142.0	4 4				XX			15			E.			
-143.0					200			10			100			
-144.0					XX						-			
-145.0					XX									
-146.0					222						100			
-147.0					33						1			
-148.0					XX						lens.			
							_	16			ľ			
149.0 150.0					1			1000			E.			
11.			173	-		LOGGED BY: DLI)			COMPLETION DEPTH: 154 m	-			
MH	C Ea	rt.	1 &	En	vir	onmental Limited REVIEWED BY: N	ICP			COMPLETE: 10/16/00	-			
			- W 1											

DRILLING TYPE: WATER WELL RIG DRILLING METHOD: AIR ROTARY SAMPLE TYPE TUBE NO RECOVERY SPLIT SPOON GRAB MUD RETURN SOIL PLASTIC MC HOURD DESCRIPTION DESCRIPTION DESCRIPTION ADDIT	LIA TRACE			
SAMPLE TYPE	PROJECT NO: KX03904			
SOIL PUSTIC M.C. UGUID 20 40 60 80 SILT, trace to some sand (fine-grained), trace clay, low to medium plastic, structuraless, brown, wet SILT and CLAY, trace sand (fine-grained), medium to low plastic, weakly bedded, light to ton brown, moist to wet (Possible glaciolacustrine deposits) Soil was dark brown Soil was blue/steel grey Soil was damp to moist Soil was blue Soil was blue Soil was blue Soil was blue Soil had alternating brown/blue layers 4 SILT, some clay, trace sand, trace gravel (less than 2%), low yo high plastic, structuraless in pieces recovered, blue/steel grey Soil was trace gravel (less than 2%), low yo high plastic, structuraless in pieces recovered, blue/steel grey Soil was trace gravel (less than 2%), low yo high plastic, structuraless in pieces recovered, blue/steel grey Soil was trace gravel (less than 2%), low yo high plastic, structuraless in pieces recovered, blue/steel grey Soil was trace gravel (less than 2%), low yo high plastic, structuraless in pieces recovered, blue/steel grey Soil was trace gravel (less than 2%), low yo high plastic, structuraless in pieces recovered, blue/steel grey Soil was trace gravel (less than 2%), low yo high				
PUSITIC M.C. UQUID 20 40 60 80 SILT, trace to some sand (fine-grained), trace clay, low to medium plastic, structureless, brown, wet	ORE RETURN			
SILT, trace to some sand (fine-grained), trace clay, low to medium plastic, structureless, brown, wet SILT and CLAY, trace sand (fine-grained), medium to low plastic, weakly bedded, light to tan brown, moist to wet (Possible glaciolocustrine deposits) Soil was dark brown Soil was blue/steel grey Soil was damp to moist Soil was brown Soil was brown Soil was blue Soil was blue Soil was blue Soil was brown Soil was blue Soil was brown Soil was blue Soil was blue Soil was brown Soil was blue Soil was brown Soil was blue Soil was	FIONAL MATION			
trace clay, low to medium plastic, structureless, brown, wet 1				
SILT and CLAY, trace sand (fine-grained), medium to low plastic, weekly bedded, light to tan brown, maist to wet (Possible glaciolacustrine deposits) Soil was dark brown	5			
Soil was dark brown Soil was dark brown	1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2			
Soil was damp to moist	a 3			
	1 4 4 4 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5			
Soil had alternating brown/blue layers 4 23.0 24.0 25.0 26.0 27.0 28.0 29.0 30.0 30.0 31.0 31.0 31.0 32.0 35.0 35.0 SillT, some clay, trace sand, trace gravel (less than 2%), low yo high plastic, structureless in pieces recovered, blue/steel grey (Possible Australian Creek Formation) 6	11 5 6 6 6 6			
Trace coarse sand observed SILT, some clay, trace sand, trace gravel (less than 2%), low yo high plastic, structureless in pieces recovered, blue/steel grey (Possible Australian Creek Formation) Trace coarse sand observed 5 SILT, some clay, trace sand, trace gravel (less than 2%), low yo high plastic, structureless in pieces recovered, blue/steel grey (Possible Australian Creek Formation)				
SILT, some clay, trace sand, trace gravel (less than 2%), low yo high	E 8			
34.0 (Possible Australian Creek Formation) 6	9 11 11 11			
37.0				
33.0 39.0 40.0 41.0	11 11 11 11 11 11 11 11 11 11 11 11 11			
42.0 43.0 44.0 45.0	111111111111111111111111111111111111111			
46.0 47.0 43.0 49.0 50.0 Silt and clay with no sand of gravel from 45.7 m to 47.3 m				
	DEPTH: 128 m			

	EL, B.C.	QUESNEL	- 100		PROJECT; W.QUESNEL LAND STABILITY STUDY					BOREHOLE NO: BH-7				
		WATER WEL	I DIC			DRILLING CONTRACTOR: CARIBOO WATER WELLS					PROJECT NO: KX03904			
		The same of the sa	L MIG	Die	DRILLING METHOD: AIR ROTA	1000				ELEVATION: 542.217 m				
SAMP	E TYPE	TUBE		∠JNO RE	COVERY SPLIT SPOON	GRAB		M	UD RE	TURN CORE RETURN				
Depth(m)	A SPT "N 20 PLASTIC	" (BLOWS/300 40 60 M.C.	mm) A 80	L SYMBOL	SOIL DESCRIPTION		SAMPLE TYPE	SAMPLE NO	SPT(N)	ADDITIONAL	Danik (B)			
-	-	•	-1	SOIL	DEPOINT HON		SAIV	SA		INFORMATION	0			
50.0	20	40 60	80			-01-01	1	-						
50.0 - 51.0											The same			
- 52.0											E17			
- 53.0								8						
- 54.0	m korkonik m korkonik													
- 55.0											E-18			
56.0											Ē.,			
- 57.0											F18			
-58.0											E-15			
- 59.0											E .			
- 60.0									-		E15			
61.0			10000								E 20			
62.0														
63.0	mm4101041140										=20			
64.0											=2			
85.0											E			
- 86.0											-21			
67.0											E-22			
68.0														
69.0											22			
70.0											E-2.			
71.0														
72.0											= 23			
73.0											-24			
74.0														
75.0											2-			
76.0											E-25			
77.0														
78.0			,								25			
79.0											E-24			
80.0														
81.0									9		E-26			
82.0											E-27			
83.0 84.0														
85.0											2			
86.0											E-20			
87.0														
83.0											E-28			
										The second second	25			
89.0	-1111	-1-1-1-												
90.0				0.00	*10 *						E 25			
91.0				SAND,	some silt, trace gravel, trace o	day,	Ш				E 30			
92.0				appea	red weakly layered, blue/steel o	rey		1	1 1					
93.0				4366			目	9			Ex			
94.0				1969			目				E-3			
95.0				18.6							Date:			
96.0				aa	•						3			
97.0				ala							37			
98.0	************			4949										
100.0				1919							=3			
		198	2000	-	Logo	SED BY: DLD				COMPLETION DEPTH: 128 m	-			
ME	C Ea	rth &	Env	ironn	nental Limited	EWED BY: NCP				COMPLETE: 10/19/00				
TIME	IO DO	T CIT O	. 1111	II OIIII	TOTT COLLEGE	LIVED DI. INCP		-		Page	-			

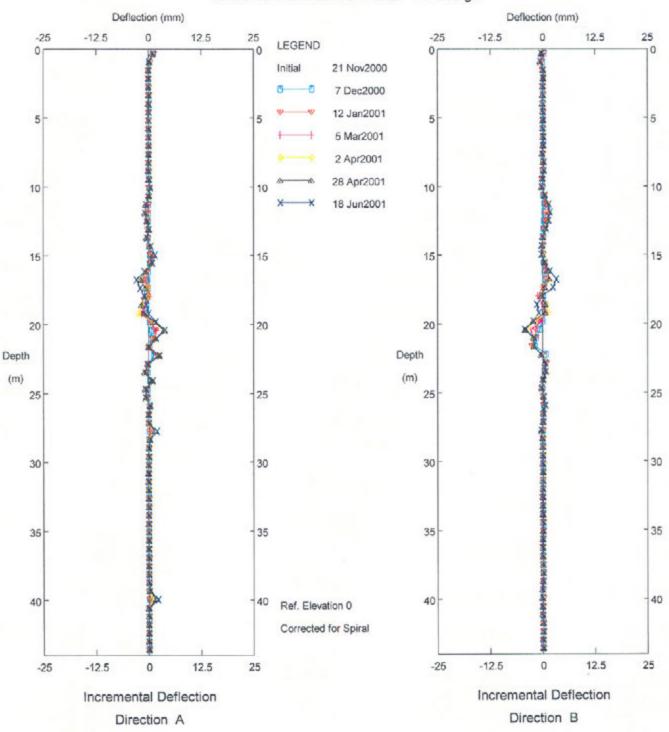
CLIENT	VEL, B.C.				PROJECT: W.QUESNEL LAND STABILITY		-		The second second	E NO: BH-7			
-	_	WITCO UT	THE DWG			DRILLING CONTRACTOR: CARIBOO WATER WELLS				PROJECT NO: KX03904			
-		WATER WE		-	DRILLING METHOD: AIR ROTARY				ELEVATION	l: 542.217 m			
SAMP	LE TYPE	TUB	Ε	1	NO RECOVERY SPLIT SPOON ☐GRAB		M	UD RE	ETURN	CORE RETURN			
Depth(m)	▲ SPT "7 20	N" (BLOWS/3 40 60	00 mm) 🛦 80	SYMBOL	SOIL	E TYPE	LE NO	SPT(N)	A	DDITIONAL	Oseth(#)		
Dec	PLASTIC	M.C.	LIQUID	SOIL	DESCRIPTION	SAMPL	SAMPLE	S	IN	FORMATION	0		
100.0	20	40 60	80	9191			_		-		-		
-101.0		h		1301							E ₂		
102.0				13.73							農大		
103.0				RA							- 1		
104.0	manning			MA							F3		
105.0				979							E-3		
105.0		entrefrante Jacous		999							per .		
107.0				1013							₽×		
108.0				M							Ex.		
		erratured and		1			10				10		
110.0				199		12.0	10				₽ 3		
112.0				434			1				E-3		
113.0	1-1-1-1			1919							E.		
114.0				Jak							₽ 2		
115.0				BR							E-3		
116.0				PAR							E3		
117.0				HH									
118.0				494							■ 3		
119.0				4343			. 3				E-30		
120.0				100	Casing refusal on boulder or rock						100		
121.0		····ienoliooia		10/8							₽ 30		
122.0				BR							E-40		
123.0				To be							■.		
124.0				HH							E-40		
125.0				8			11				E4		
125.0				dada							E4		
127.0											E		
129.0					End of borehole at 128 m						E-47		
130.0					SI installed to 125.6 m						E4:		
131.0					Ao groove oriented at Az = 100 degrees								
132.0					Borehole dry on completion						E*		
133.0					Estimated well production of 0 GPM						E4		
134.0											E4		
135.0				1							- 11		
136.0							1				E+		
137.0											E.		
138.0													
139.0											E-4		
140.0	-1										E.		
141.0		erriendunke Leelendunke									100		
142.0							- 1				E*		
143.0											E-4		
144.0							1		1		100		
145.0					33						E4		
145.0							1				E-4		
147.0											E4		
							1				100		
149.0 150.0					The state of the s						E-4		
117	10 0	1.7	0 73		onmental Limited REVIEWED BY: DLI	0			COMPL	ETION DEPTH: 128	m		
D/I H	HC	arth	V HITT	7117	anmental limited REVIEWED RY. N	ICP			COMPL	ETE: 10/19/00			

	: CITY OF	QUES	NEL				PROJECT: W.QUESNEL LAND STABILITY STUDY			
-	EL, B.C.			Number of			DRILLING CONTRACTOR: CARIBOO WATER WELL DRILLING METHOD: AIR ROTARY			
RILLIN	NG TYPE:	WATER	WELL	RIG		DRILLING METHOD: AIR ROTARY				
SAMPL	E TYPE		TUBE		1	NO RECOVERY SPLIT SPOON GRAB		M	JO RE	TURN CORE RETURN
Depth(m)	▲ SPT "N 20				SYMBOL	SOIL	SAMPLE TYPE	SAMPLE NO	SPT(N)	ADDITIONAL
19974	PLASTIC 1————————————————————————————————————	40	60	100lb 80	SOIL	DESCRIPTION	SAME	SAM	co	INFORMATION
150.0 -151.0										E4
152.0					1					Ē:
153.0										H H
154.0					22		_			E:
155.0			-1-			End of borehole at 154.5 m				Es
156.0						SI installed to 154.5 m				E.
157.0	FOR GOVERNORS					SI Ao groove oriented at Az = 105 degrees				
159.0	Design of the control of the control of					Static water level at 38.1 m upon				E:
160.0	ACCOMPANY OF THE					completion				E.
161.0	The state of the state of					Estimated well production 5 to 7 GPM				
162.0										
163.0	The second section of the second of the									E
164.0	and the second second									E.
185.0	But the rest to \$1.00 to \$1.00 to \$1.00 to									
166.0	101011000000000000000000000000000000000						-			
-167.0 -168.0										1
-169.0	Environment in the control									
170.0	Secretary of the second									I E
-171.0	Europologyapska erro	leser krees Sees Janes		1						E
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-174.0	Toronton Control	ånorinon konstans	lacadase horizan	444-						E
175.0	(40) \$1 HEST FIRE									
-176.0		1-1		111						
-177.0 -178.0	Proceedings of the second	1	rordr							
-179.0	The state of the s	5								
-180.0	January of the	1		1						
-181.0	- British Charles	1-1-		1						
-182.0	100000000000000000000000000000000000000	7								100
-183.0	CONTRACTOR CLASS									900 900 900
-184.0	CONTRACTOR CONTRACTOR								1	
-185.0	3144 C 3 5 C 5 C 5 C 5 C 5 C 5 C 5 C 5 C 5 C									
-185.0	CONTRACTOR STREET		in nino							E
-187.0 -188.0	Charles de la companya del la companya de la compan									
-189.0										
-190,0	Carlotte Control of the Control	1-1-	1		(11)					
-191.0										
-192.0	0	1-1-	-	1 1 1	2					
193.0	0 1 1	1.1.	1	in the	-					
194.0	conductable.		1000							
-195.0	Acres (Sanah Galas)		1.1.	1-6-6	2					
-196.0	and the same	designation of	1	1						
197.0	Carrier Section	-	1000							
198.0	0.0000000000000000000000000000000000000							1		
-199.0 - 200.0	8		1-1-	1-1-1						
110	DO D		1 /			onmental Limited REVIEWED BY: DL	D			COMPLETION DEPTH: 154 m
MA.	EC E	art	n d	x Er	VII	onmental Limited REVIEWED BY: N	AC _b			COMPLETE: 10/16/00
)								Page 4



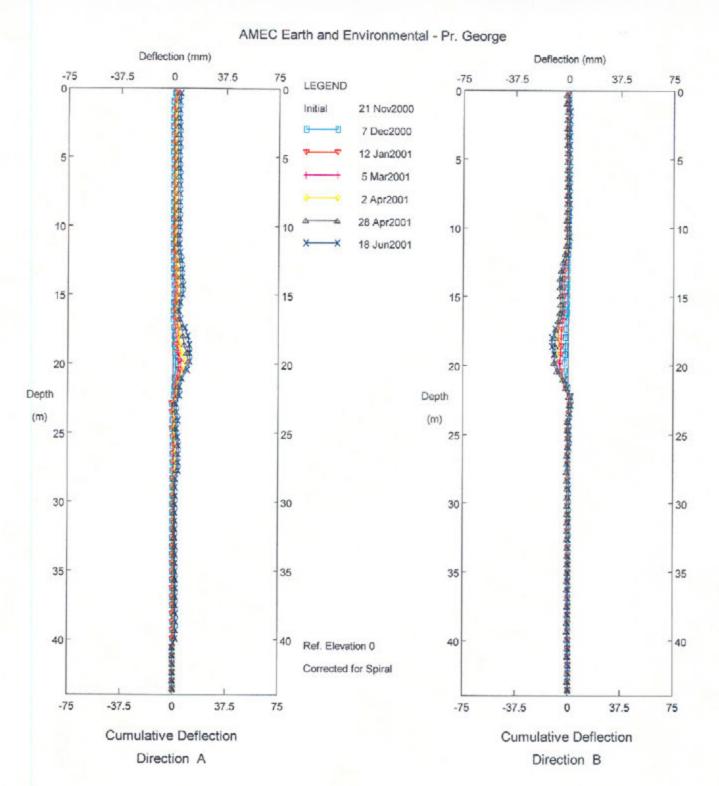
KX03904 W. Quesnel Stability Study, Inclinometer SI-1 Corr.

Lower Avery Lane



KX03904 W. Quesnel Stability Study, Inclinometer SI-1 Corr.

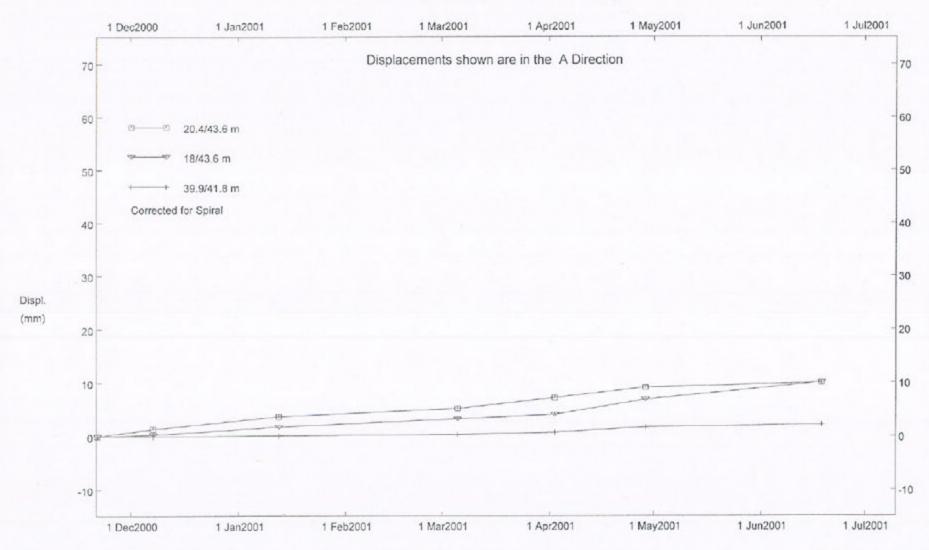
Lower Avery Lane



KX03904 W. Quesnel Stability Study, Inclinometer SI-1 Corr.

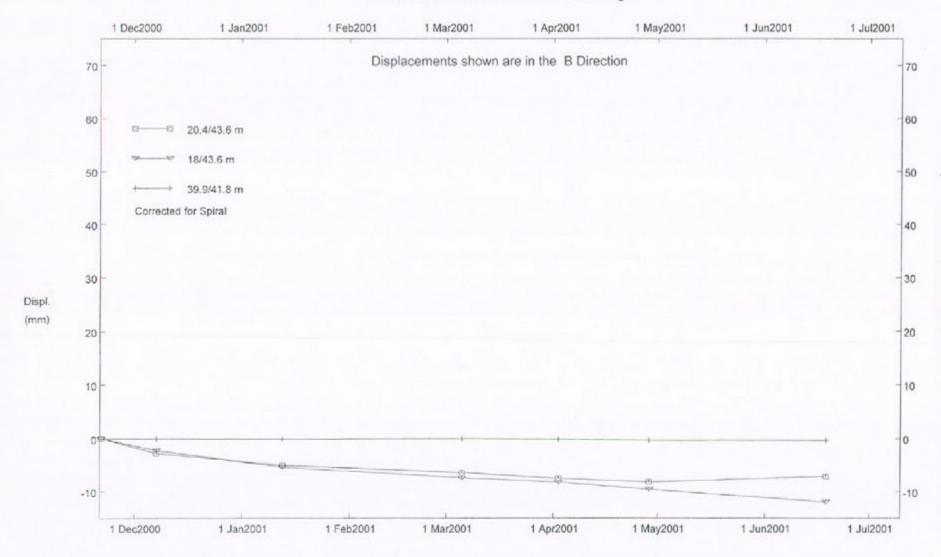
Lower Avery Lane

AMEC Earth and Environmental - Pr. George



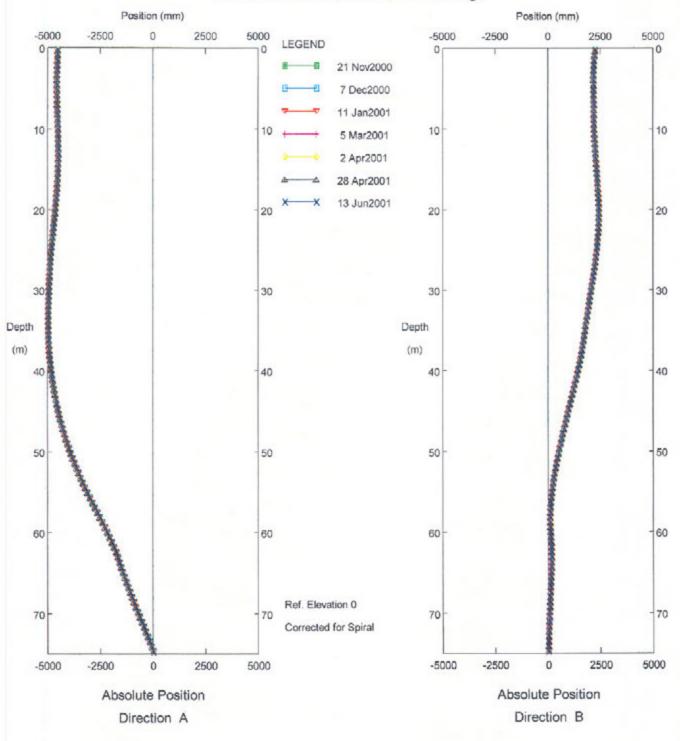
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Lower Avery Lane



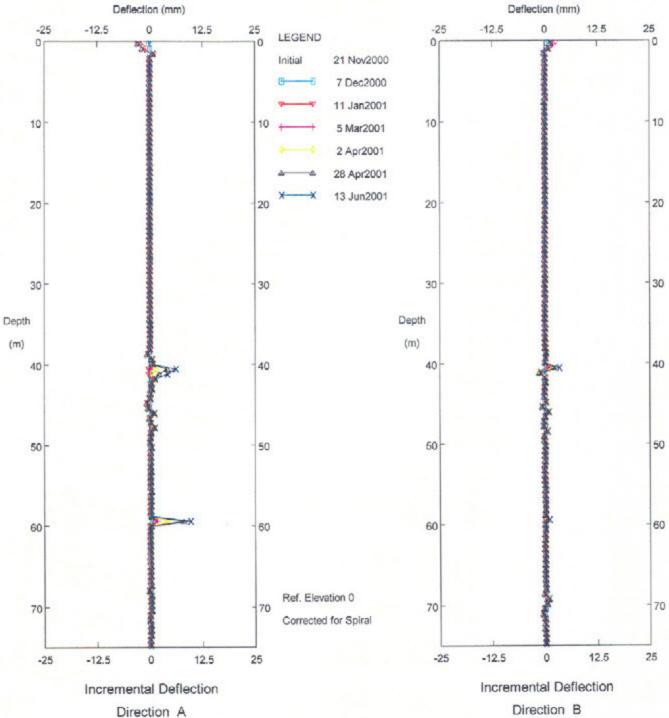
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Lower Avery Lane



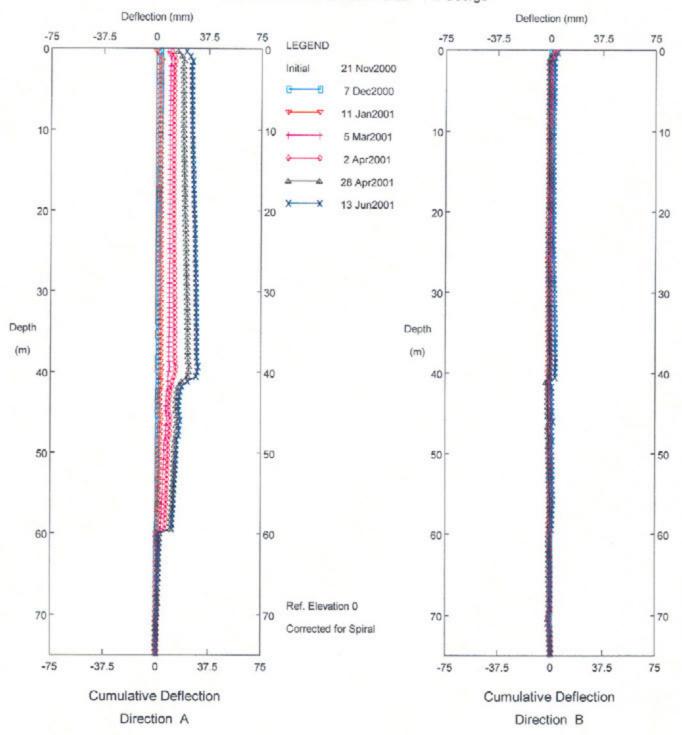
KX03904 W. Quesnel Stability Study, Inclinometer SI-2 Corr.

Upper Avery Lane



KX03904 W. Quesnel Stability Study, Inclinometer SI-2 Corr.

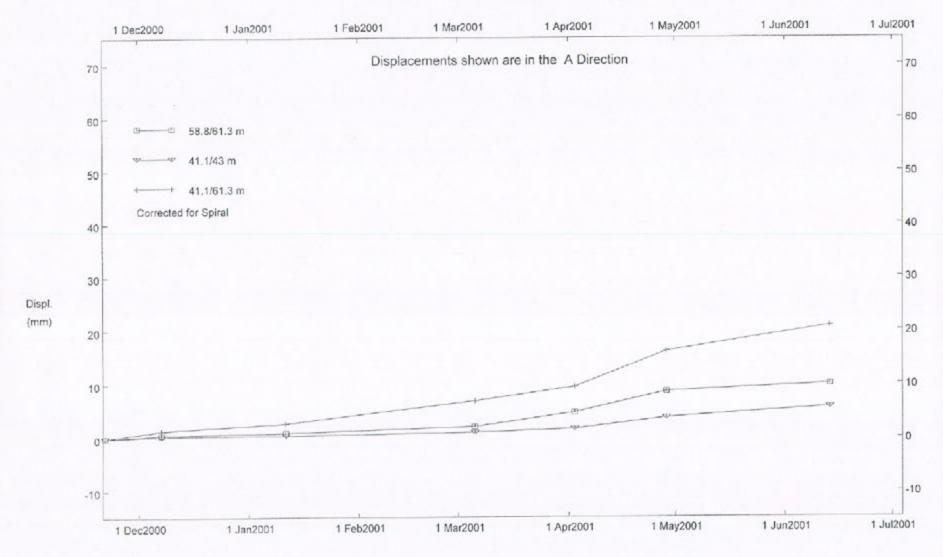
Upper Avery Lane



KX03904 W. Quesnel Stability Study, Inclinometer SI-2 Corr.

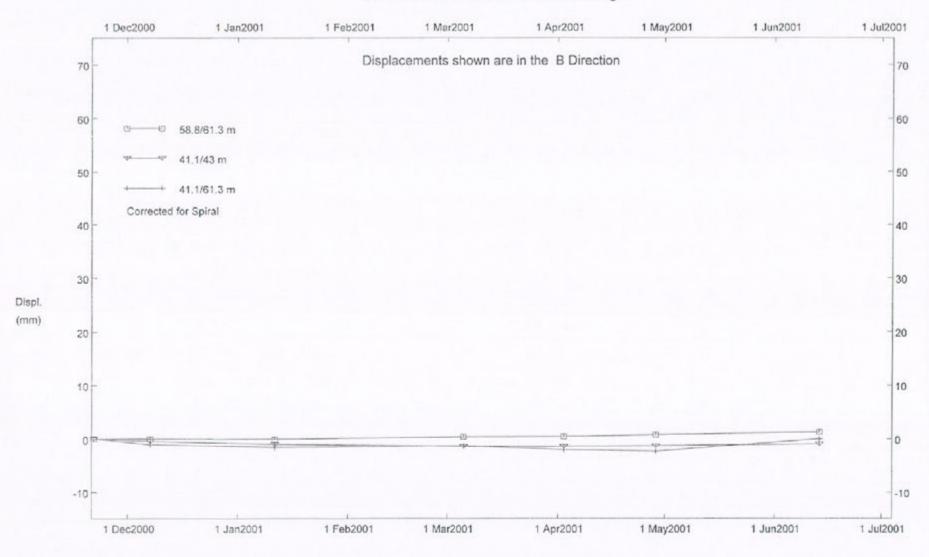
Upper Avery Lane

AMEC Earth and Environmental - Pr. George



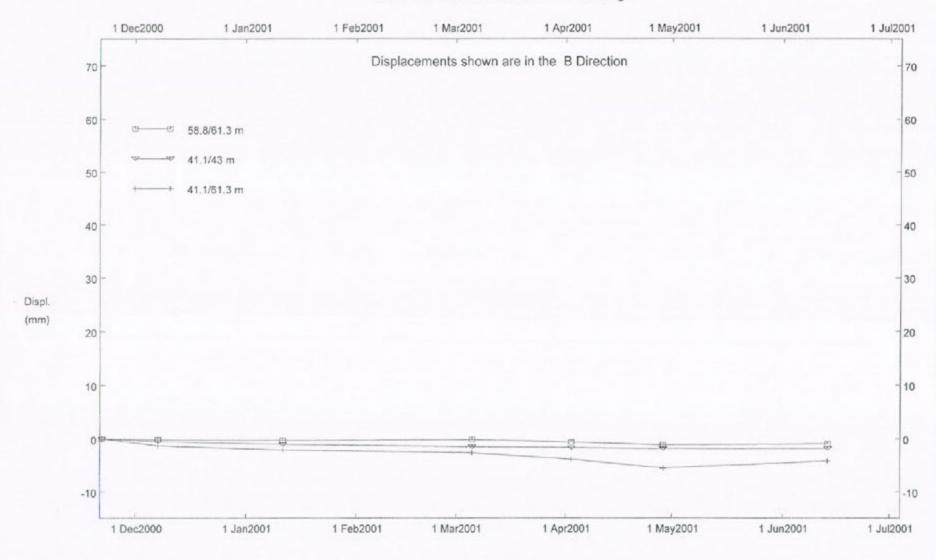
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Upper Avery Lane



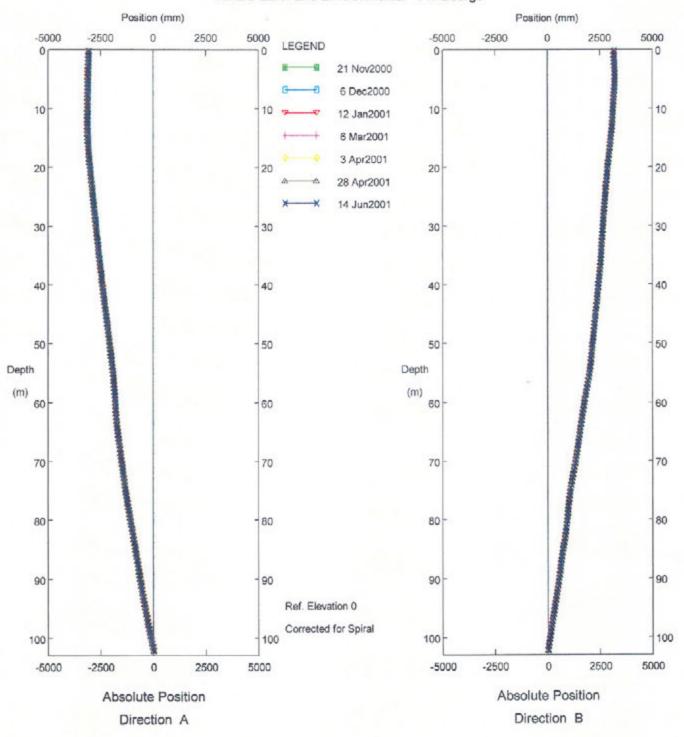
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Upper Avery Lane

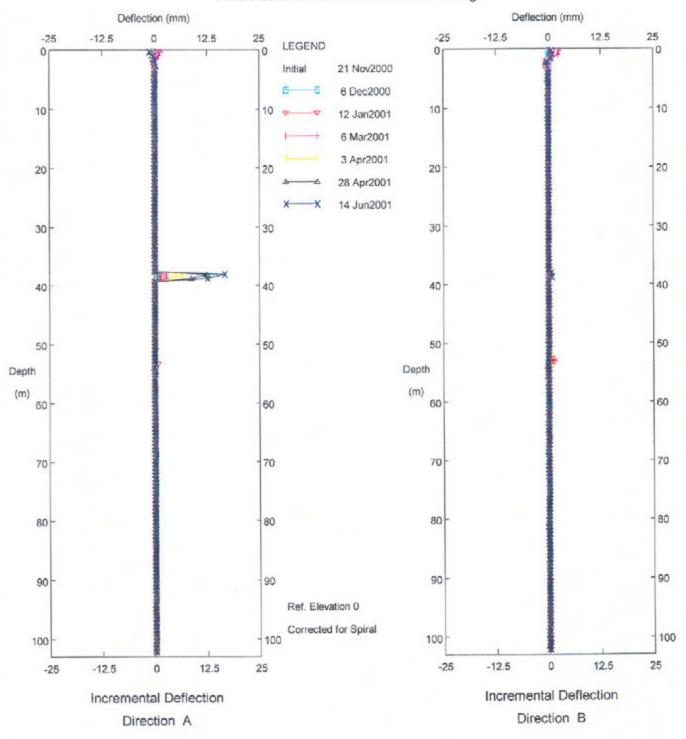


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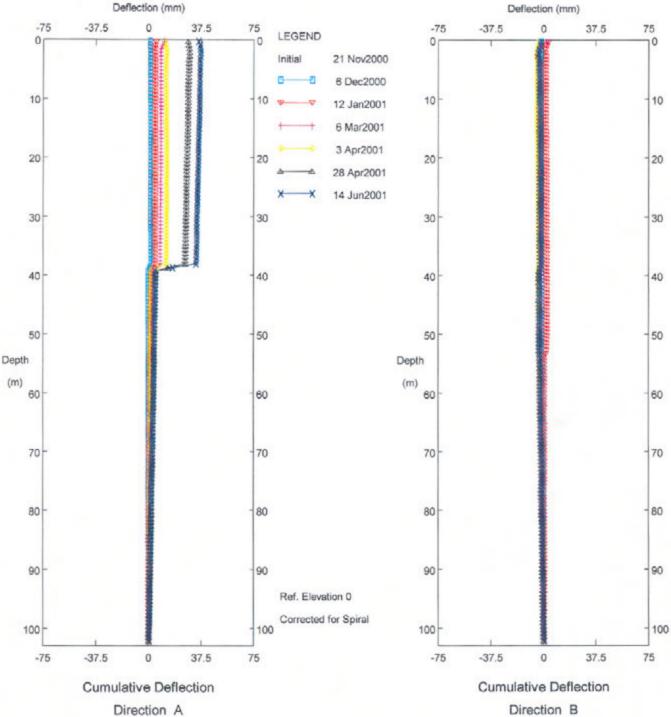
Upper Avery Lane



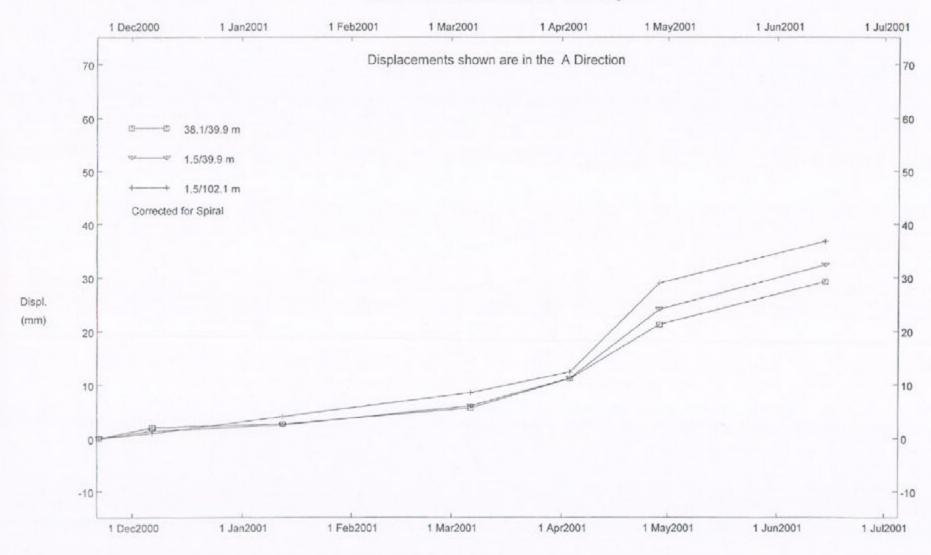
KX03904 W. Quesnel Stability Study, Inclinometer SI-3 Corr.
Abbott Drive near Bettcher



KX03904 W. Quesnel Stability Study, Inclinometer SI-3 Corr.
Abbott Drive near Bettcher

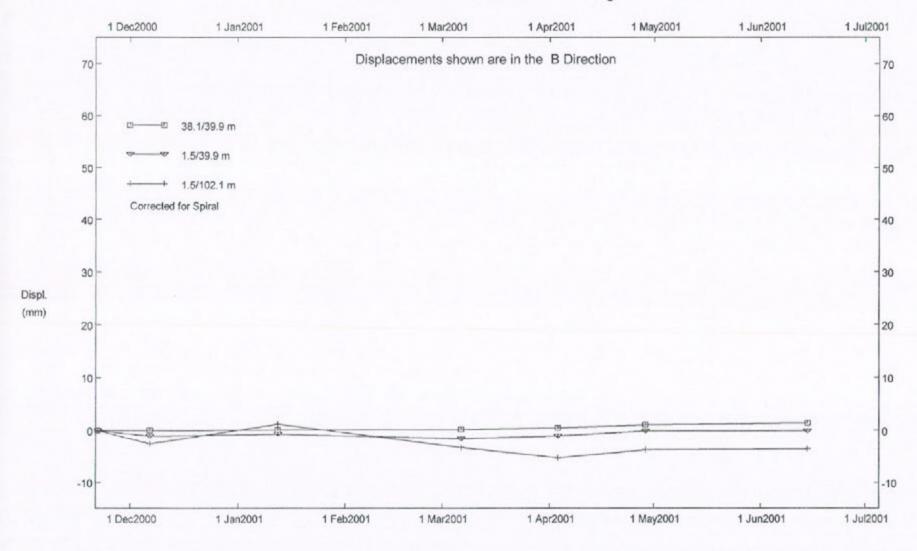


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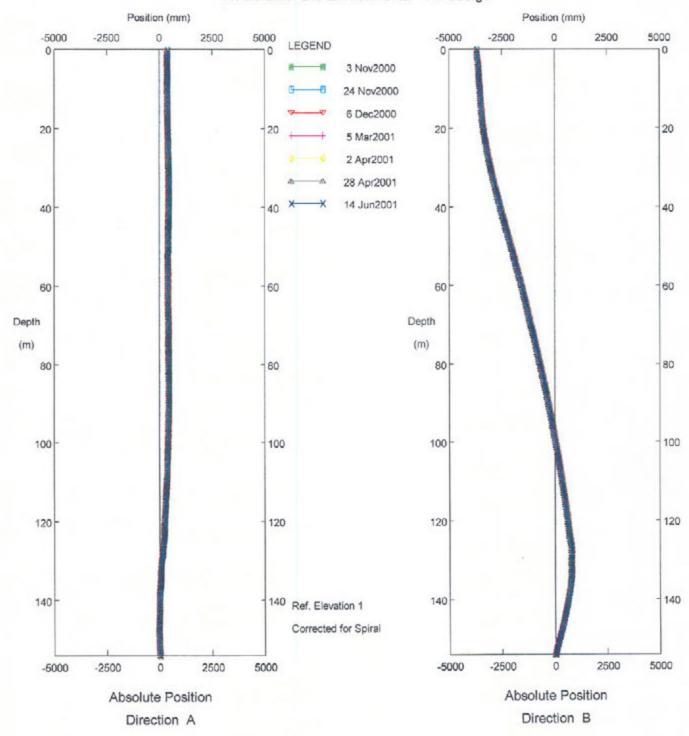
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Abbott Drive near Bettcher



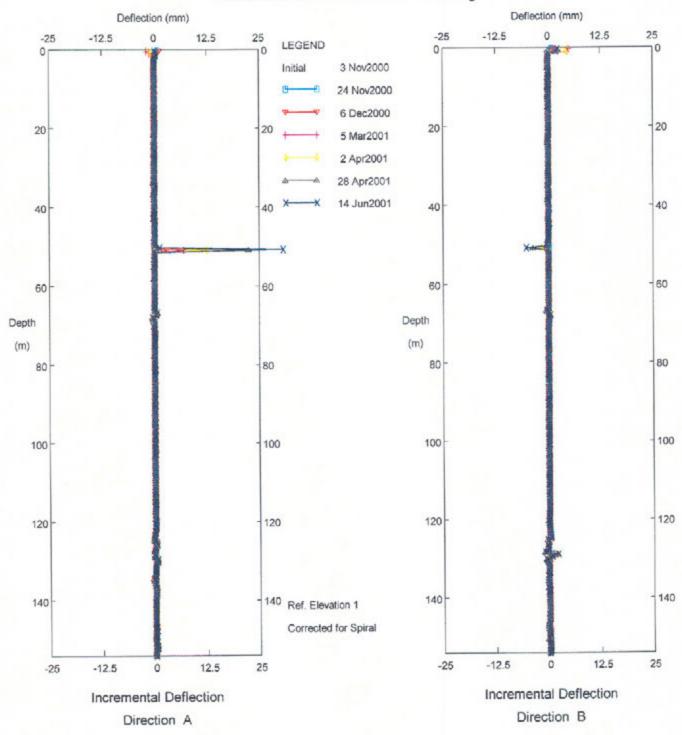
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Abbott Drive near Bettcher



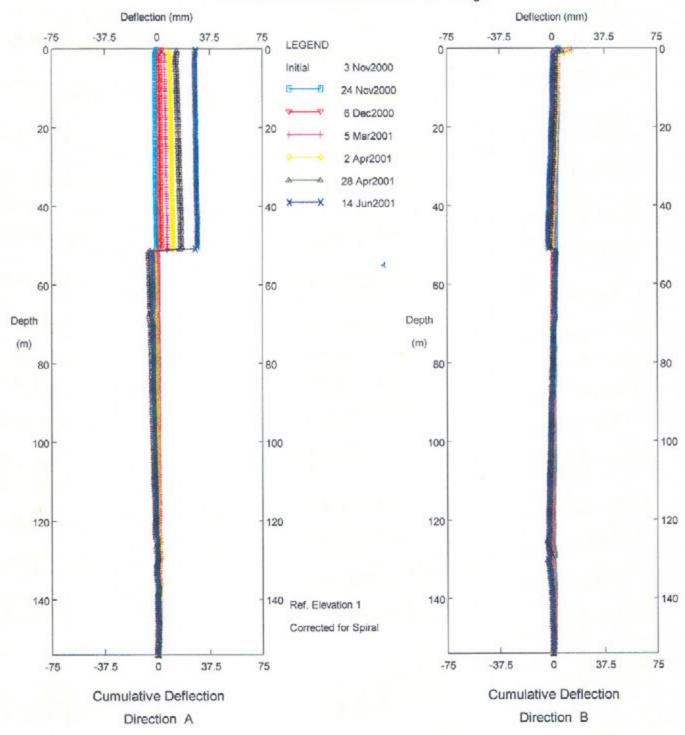
KX03904 W.Quesnel Stability Study, Inclinometer SI-4 Corr.

Voyageur School



KX03904 W.Quesnel Stability Study, Inclinometer SI-4 Corr.

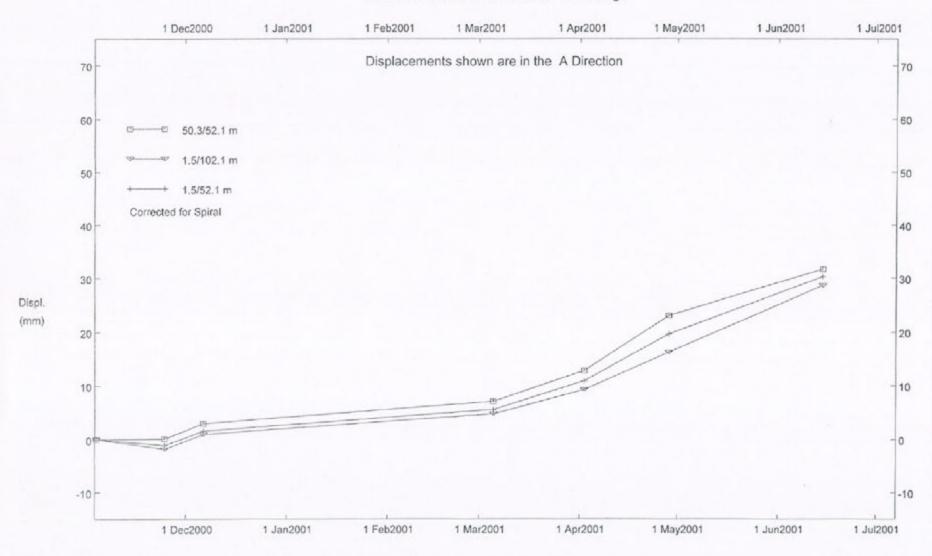
Voyageur School



KX03904 W.Quesnel Stability Study, Inclinometer SI-4 Corr.

Voyageur School

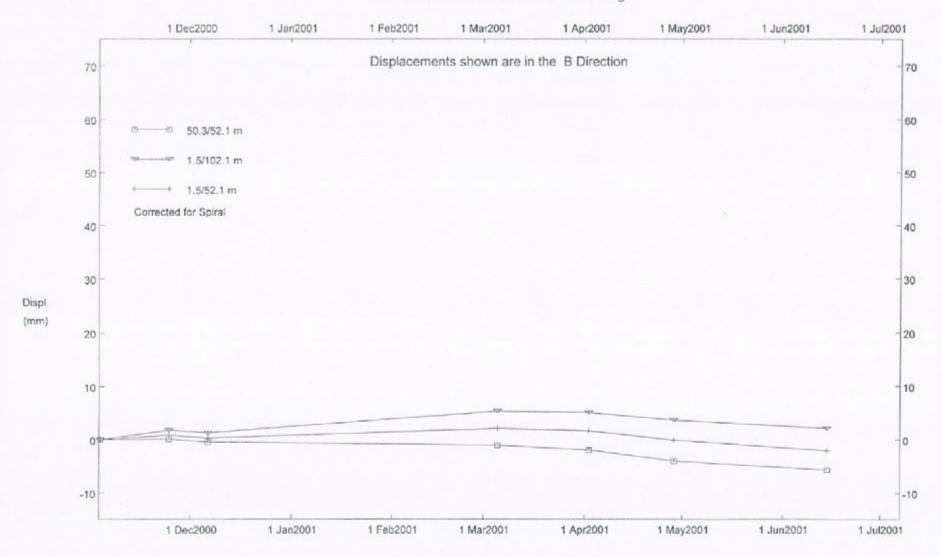
AMEC Earth and Environmental - Pr. George



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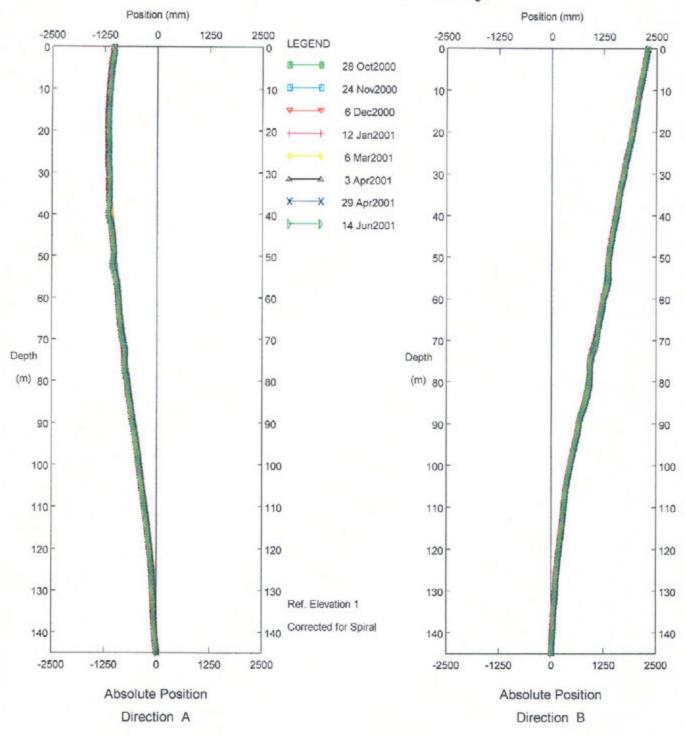
Voyageur School

AMEC Earth and Environmental - Pr. George



KX03904 W.Quesnel Stability Study, Inclinometer SI-4 Corr.

Voyageur School



KX03904 W. Quesnel Stability Study, Inclinometer SI-5 Corr.
Abbott Drive

AMEC Earth and Environmental - Pr. George Deflection (mm) Deflection (mm) -12.5 -25 12.5 -12.512.5 -25 LEGEND Initial 28 Oct2000 24 Nov2000 6 Dec2000 12 Jan2001 6 Mar2001 3 Apr2001 29 Apr2001 14 Jun2001 Depth Depth (m) 80 (m) 80 Ref. Elevation 1 140 Corrected for Spiral -12.5 12.5 -25 -12.512.5 -25

KX03904 W. Quesnel Stability Study, Inclinometer SI-5 Corr.
Abbott Drive

Incremental Deflection

Direction B

Incremental Deflection

Direction A

AMEC Earth and Environmental - Pr. George Deflection (mm) Deflection (mm) -75 -37.5 37.5 75 -75 -37.5 0 37.5 75 LEGEND 0 Initial 28 Oct2000 10 1 10 24 Nov2000 10 10 6 Dec2000 20 20 + 12 Jan2001 20 20 6 Mar2001 30 30 30 30 3 Apr2001 29 Apr2001 40 40 40 40 14 Jun2001 50 50 50 50 60 60 60 60 70 70 70 70 Depth (m) 80-(m) 80 80 80 90 90 90 90

Depth

100

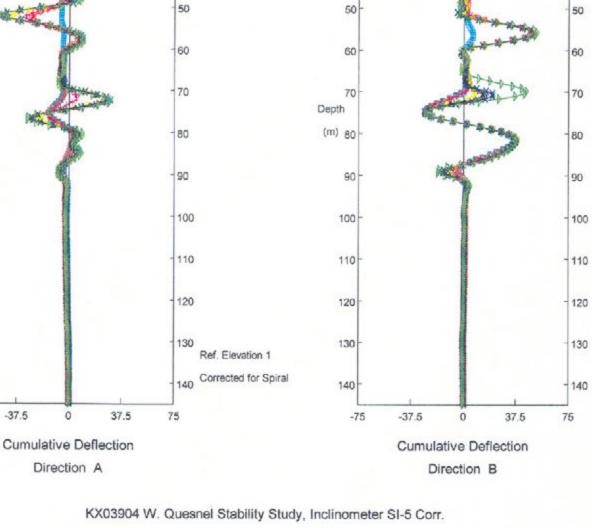
110

120

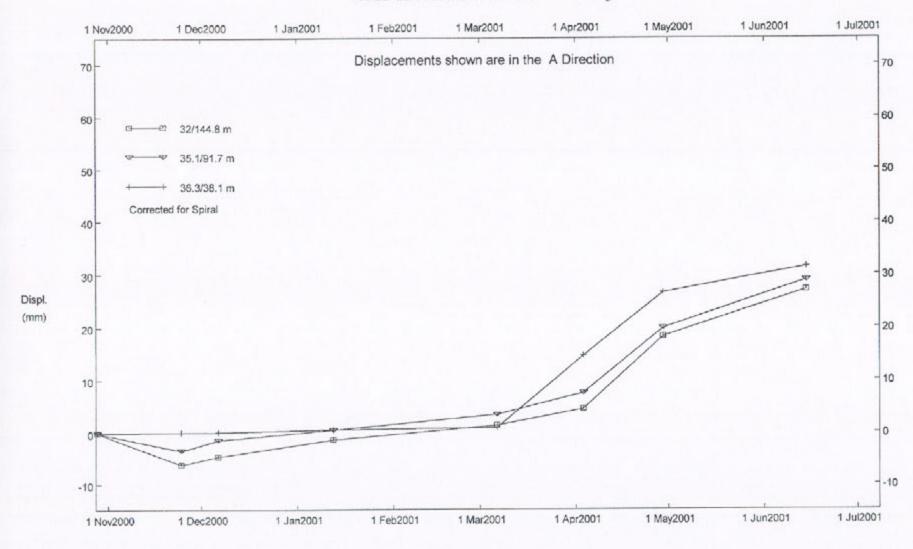
130 -

140

-75

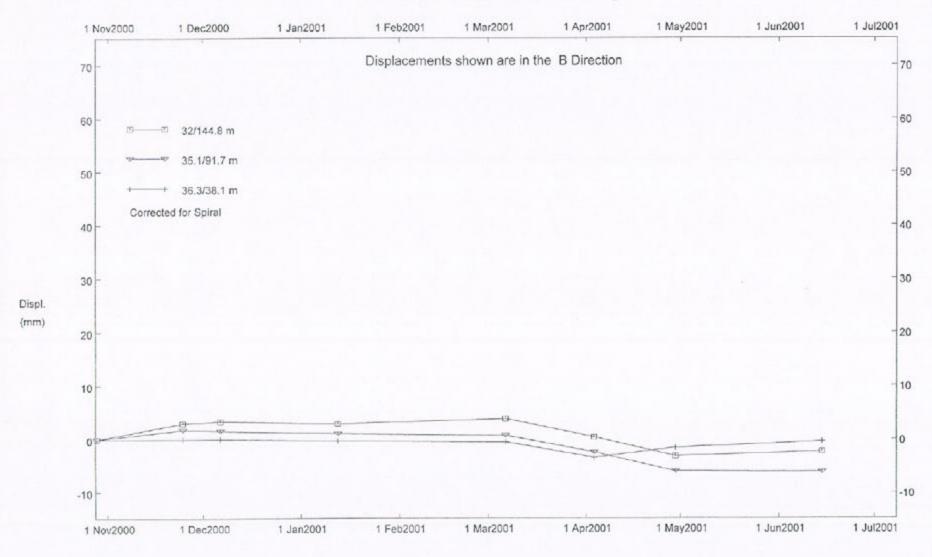


Abbott Drive



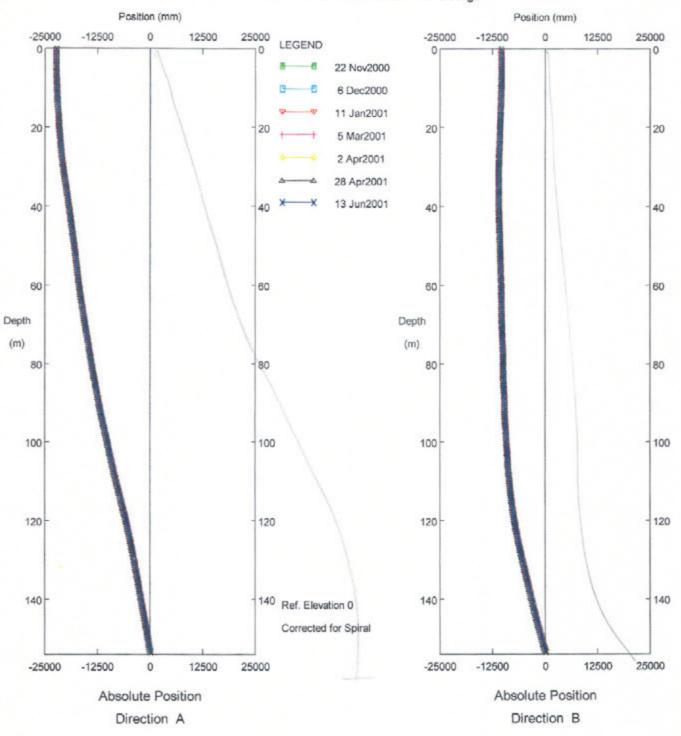
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Abbott Drive



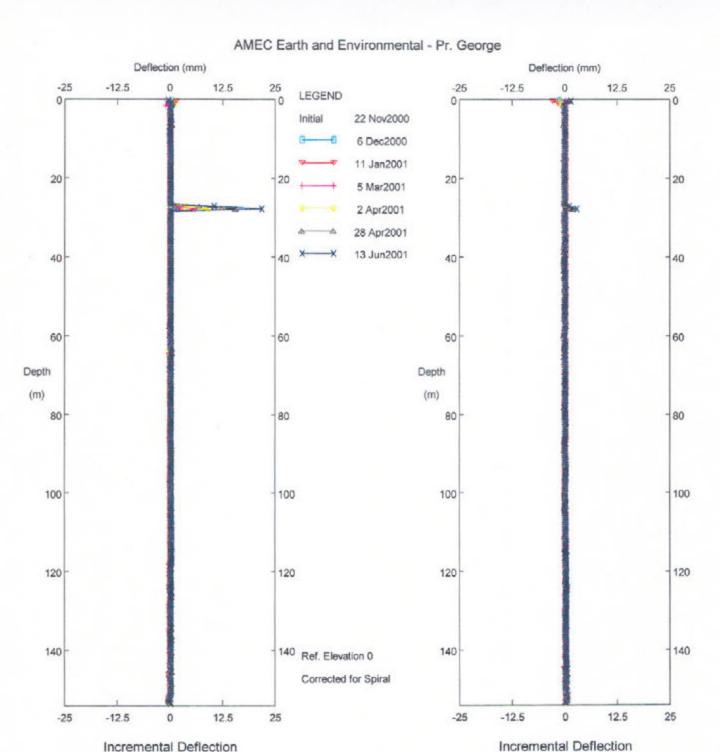
KX03904 W. Quesnel Stability Study, Inclinometer SI-5 Corr.

Abbott Drive



KX03904 W.Quesnel Stability Study, Inclinometer SI-6 Corr.

End of Dixon Street

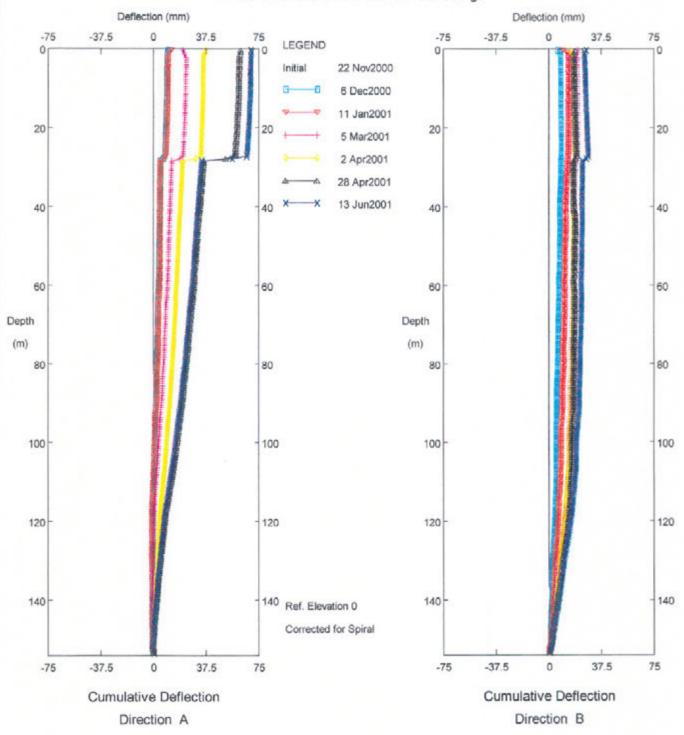


KX03904 W.Quesnel Stability Study, Inclinometer SI-6 Corr. End of Dixon Street

Direction B

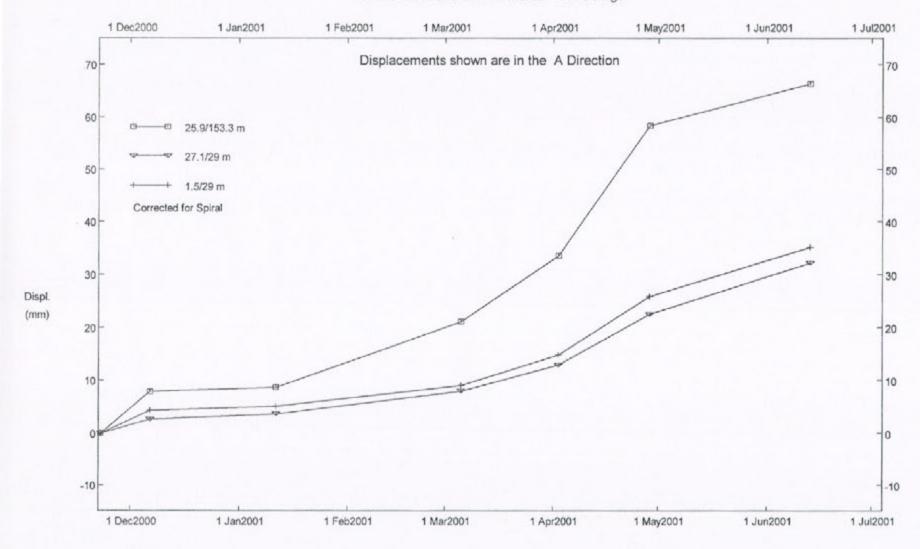
Incremental Deflection

Direction A



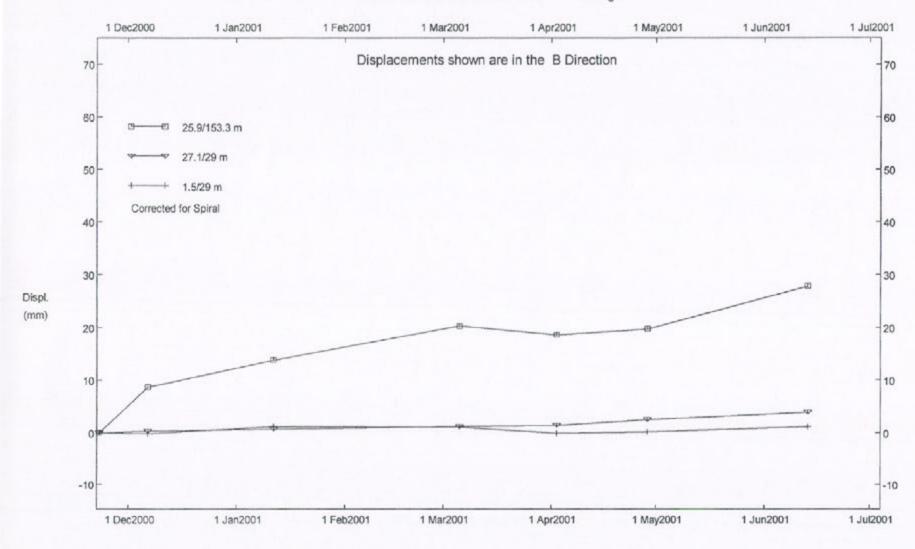
KX03904 W.Quesnel Stability Study, Inclinometer SI-6 Corr.
End of Dixon Street

AMEC Earth and Environmental - Pr. George



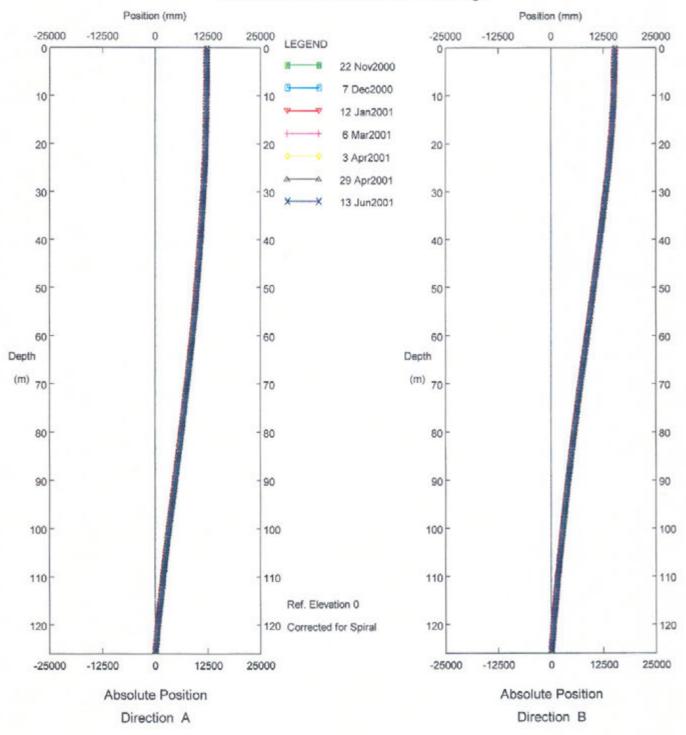
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End of Dixon Street



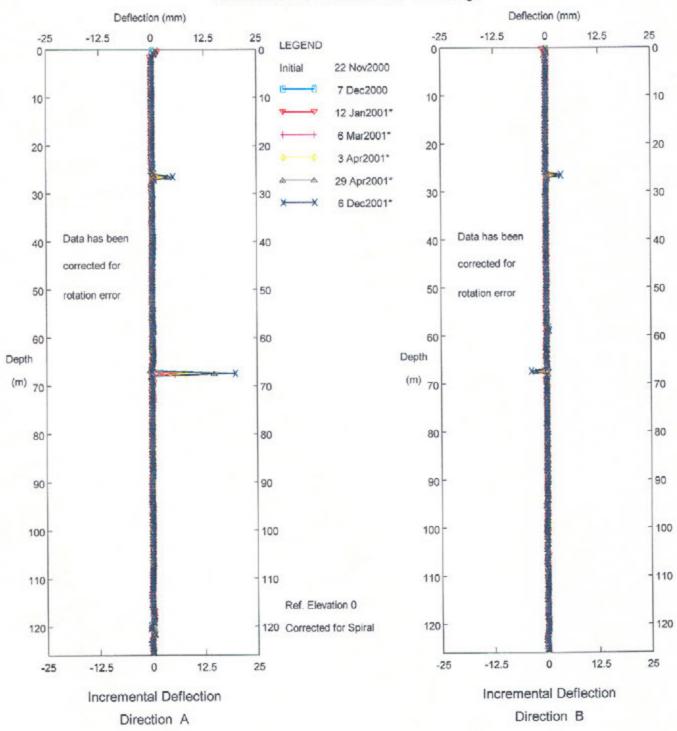
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End of Dixon Street



KX03904 W. Quesnel Stability Study, Inclinometer SI-7 Corr.

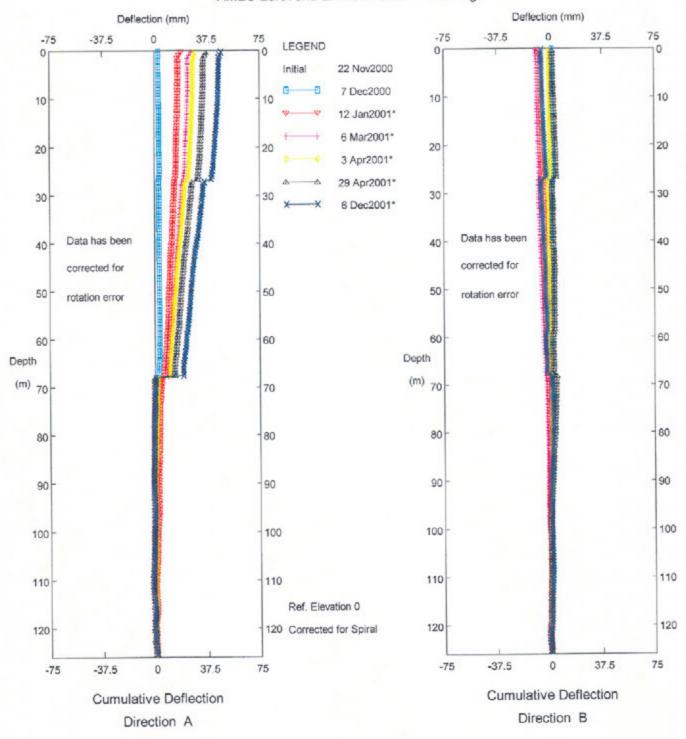
Pierce Crescent & Lewis Drive



KX03904 W. Quesnel Stability Study, Inclinometer SI-7 Corr.

Pierce Crescent & Lewis Drive

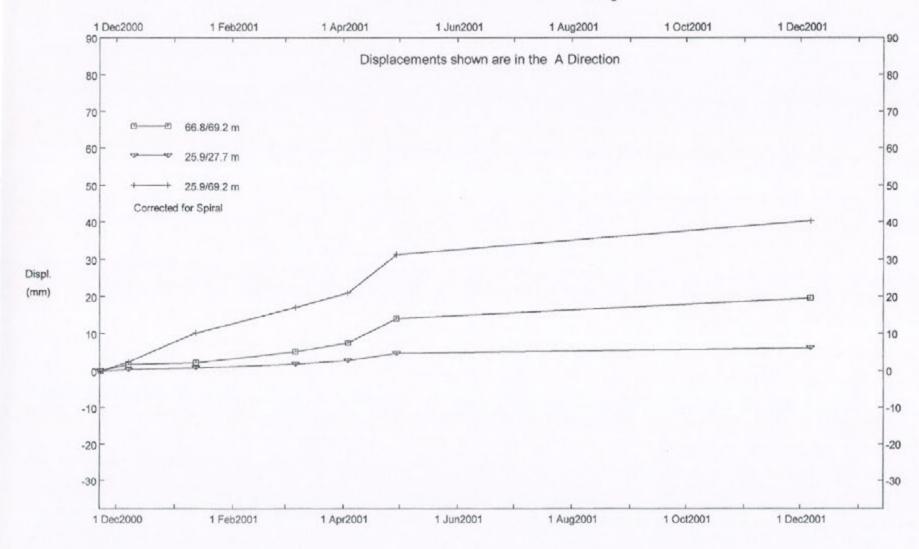
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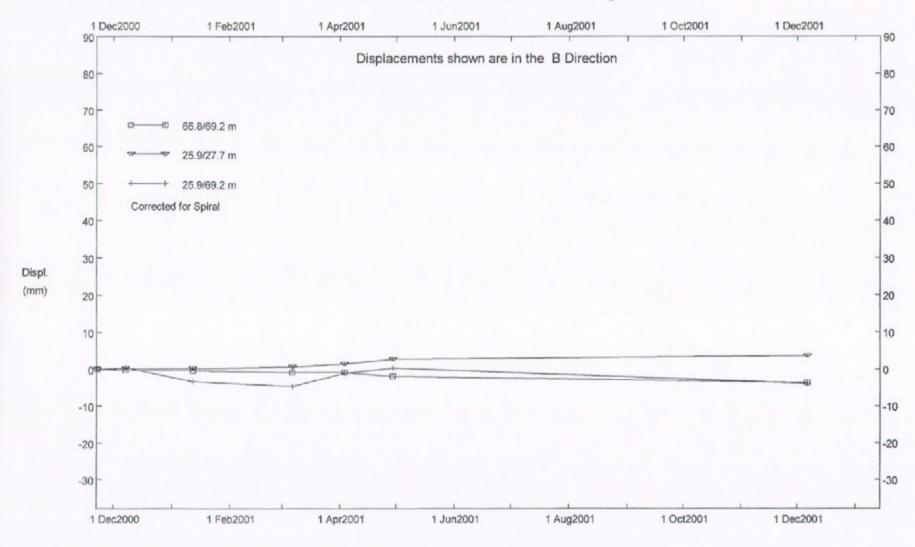
Pierce Crescent & Lewis Drive

Sets marked "include zero shift and/or rotation corrections.



KX03904 W. Quesnel Stability Study, Inclinometer SI-7 Corr.

Pierce Crescent & Lewis Drive



KX03904 W. Quesnel Stability Study, Inclinometer SI-7 Corr.

Pierce Crescent & Lewis Drive

	Location (Landmark, Road)	September, 1998			December, 1998		
Station Number		Northing (m)	Easting (m)	Elevation (m ASL)	Northing (m)	Easting (m)	Elevation (m ASL)
2	Donnely/Dodds Intersection	5869992.878	531420.902	563.021	5869992.871	531420.907	563.014
4	Picard Place (Lane)	5870331.949	531626.829	557.171	5870331.961	531626.828	557.163
5	East of Dawson/Lewis Intersection	5870180.442	531627.209	551.978	5870180.445	531627.216	551.965
6	Paley West	5870474.774	531664.168	539.628	5870474.771	531664.179	539.615
7	Paley East	5870427.297	531932.241	533.473	5870427.299	531932.249	533.467
8	Picard Avenue	5870328.580	531909.295	536.943	5870328.580	531909.287	536.905
9	Lane between Patchett/Pierce	5870063.599	531714.863	549.785	5870063.588	531714.875	549.766
14	Pentland/Flamingo Intersection	5870067.437	531986.027	531.224	5870067.435	531986.023	531.210
15	Palmer/Lewis Intersection	5870275.888	532052.513	524.385	5870275.892	532052.515	524.393
16	Healy Road	5870413.504	532184.864	509.104	5870413.499	532184.859	509.086
17	Bettcher/Lark Intersection	5869847.647	532237.862	519.610	5869847.634	532237.872	519.599
18	Lark/Flamingo Intersection	5869826.923	531984.617	524.147	5869826.929	531984.611	524.132
19	Abbott/Flamingo Intersection	5869596.532	531978.061	517.225	5869596.534	531978.063	517.219
, 20	Hawk Street @ Crane Ave.	5869364.259	532199.105	504.356	5869364.263	532199.109	504.333
21	Lane between Avery/Allison	5869342.996	532493.483	485.474	5869343.005	532493.492	485.459
22	Lane between Beath/Bouchie	5869628.968	532631.086	478.920	5869628.968	532631.095	478.920
23	Doherty Dr BM	5869134.064	532888.607	475.384	5869134.061	532888.608	475.357
24	Salton Road (Hixon Road)	5878341.399	531399.210	589.609	5878341.373	531399.217	589.567
26	Benchmark by Airport - BM	5873887.634	533765.361	545.429	5873887.622	533765.361	545.406
28	Red Bluff Pump Station - BM	5870190.608	537039.418	595.773	5870190.608	537039.418	595.773
29	Quesnel Hill	5870484.887	536304.120	575.014	5870484.893	536304.135	575.004
82C256	Government Benchmark at Airport				5875411.453	533109.702	542.947

Station Number	Location (Landmark, Road)	April, 1999			December, 1999		
		Northing (m)	Easting (m)	Elevation (m ASL)	Northing (m)	Easting (m)	Elevation (m ASL)
2	Donnely/Dodds Intersection	5869992.867	531420.931	563.007	5869992.879	531420.978	563.027
4	Picard Place (Lane)	5870331.956	531626.856	557.150	5870331.993	531626.885	557.160
5	East of Dawson/Lewis Intersection	5870180.438	531627.250	551.951	5870180.448	531627.288	551.953
6	Paley West	5870474.788	531664.208	539.613	5870474.805	531664.239	539.608
7	Paley East	5870427.300	531932.279	533.462	5870427.321	531932.307	533.461
8	Picard Avenue	5870328.581	531909.314	536.909	5870328.609	531909.354	536.909
9	Lane between Patchett/Pierce	5870063.593	531714.910	549.753	5870063.614	531714.965	549.774
14	Pentland/Flamingo Intersection	5870067.428	531986.061	531.205	5870067.441	531986.116	531.199
15	Palmer/Lewis Intersection	5870275.902	532052.557	524.361	5870275.903	532052.589	524.376
16	Healy Road	5870413.501	532184.880	509.054	5870413.509	532184.907	509.068
17	Bettcher/Lark Intersection	5869847.634	532237.910	519.610	5869847.644	532237.958	519.608
18	Lark/Flamingo Intersection	5869826.930	531984.639	524.126	5869826.923	531984.695	524.127
19	Abbott/Flamingo Intersection	5869596.525	531978.098	517.218	5869596.519	531978.134	517.213
20	Hawk Street @ Crane Ave.	5869364.256	532199.136	504.327	5869364.259	532199.176	504.353
21	Lane between Avery/Allison	5869342.998	532493.516	485.473	5869342.998	532493.539	485.478
22	Lane between Beath/Bouchie	5869628.972	532631.109	478.920	5869628.969	532631.117	478.922
23	Doherty Dr BM	5869134.068	532888.623	475.365	5869134.069	532888.628	475.374
24	Salton Road (Hixon Road)	5878341.391	531399.224	589.587	5878341.393	531399.221	589.596
26	Benchmark by Airport - BM	5873887.631	533765.364	_	5873887.630	CARLES AND ADDRESS OF THE PARTY	545.409
28	Red Bluff Pump Station - BM	5870190.608			5870190.608		595.773
29	Quesnel Hill	5870484.898	and a few property and the second sec	and the second second second second	5870484.896		575.002
82C256	Government Benchmark at Airport	5875411.453	533109.702		5875411.453	533109.702	542.947

	Location (Landmark, Road)	February, 2000			May, 2000		
Station Number		Northing (m)	Easting (m)	Elevation (m ASL)	Northing (m)	Easting (m)	(m ASL)
2	Donnely/Dodds Intersection	5869992.874	531420.976	563.006	5869992.860	531420.991	563.009
4	Picard Place (Lane)	5870331.985	531626.884	557.159	5870332.002	531626.898	557.136
5	East of Dawson/Lewis Intersection	5870180.447	531627.289	551.948	5870180.448	531627.297	551.936
6	Paley West	5870474.829	531664.236	539.608	5870474.840	531664.240	539.586
7	Paley East	5870427.327	531932.311	533.457	5870427.334	531932.321	533.449
8	Picard Avenue	5870328.601	531909.349	536.907	5870328.607	531909.363	536.886
9	Lane between Patchett/Pierce	5870063.597	531714.959	549.773	5870063.593	531714.979	549.763
14	Pentland/Flamingo Intersection	5870067.437	531986.106	531.221	5870067.432	531986.128	531,198
15	Palmer/Lewis Intersection	5870275.906	532052.581	524.364	5870275.909	532052.594	524.343
16	Healy Road	5870413.515	532184.912	509.064	5870413.516	532184.916	509.071
17	Bettcher/Lark Intersection	5869847.634	532237.962	519.603	5869847.626	532237.988	519.593
18	Lark/Flamingo Intersection	5869826.919	531984.684	524.127	5869826.903	531984.719	524.125
19	Abbott/Flamingo Intersection	5869596.525	531978.140	517.238	5869596.502	531978.164	517.224
- 20	Hawk Street @ Crane Ave.	5869364.255	532199.171	504.340	5869364.247	532199.193	504.330
21	Lane between Avery/Allison	5869342.994	532493.539	485.472	5869342.985	532493.547	485.486
22	Lane between Beath/Bouchie	5869628.979	532631,117	478.918	5869628.964	532631.113	478.913
23	Doherty Dr BM	5869134.068	532888.624	475.373	5869134.069	532888.617	475.376
24	Salton Road (Hixon Road)	5878341.378	531399.228	589.599	5878341.380	531399.216	589.577
26	Benchmark by Airport - BM	5873887.631	533765.367	545.417	5873887.633	533765.368	545.406
28	Red Bluff Pump Station - BM	5870190.608	537039.418	595.773	5870190.608		595.773
29	Quesnel Hill	5870484.896	536304.131	575.008	THE RESIDENCE OF THE PARTY OF T	THE RESIDENCE OF THE PARTY OF T	574.995
82C256	Government Benchmark at Airport	5875411.453	533109.702	542.946	5875411.453	533109.702	542.946

	Location (Landwark Board)	December, 2000			May, 2001		
Station Number		Northing	Easting (m)	Elevation (m ASL)	Northing (m)	Easting (m)	Elevation (m ASL)
	(Landmark, Road)	(m)	(/		(m)	()	
2	Donnely/Dodds Intersection	5869992.847	531421.038	562.998	5869992.846		562.986
4	Picard Place (Lane)	5870332.013	and the second s	557.146	5870332.019		557.100
5	East of Dawson/Lewis Intersection	5870180.441	531627.341	551.947	5870180.438	531627.349	551.923
6	Paley West	5870474.883	531664.276	539.588	5870474.886	531664.285	539.551
7	Paley East	5870427.348	531932.349	533.436	5870427.359	531932.364	533.417
8	Picard Avenue	5870328.636	531909.396	536.885	5870328.636	531909.408	536.872
9	Lane between Patchett/Pierce	5870063.603	531715.031	549.752	5870063.598	531715.033	549.740
14	Pentland/Flamingo Intersection	5870067.429	531986.169	531.198	5870067.422	531986.189	531.193
15	Palmer/Lewis Intersection	5870275.922	532052.628	524.353	5870275.914	532052.630	524.335
16	Healy Road	5870413.524	532184.943	509.062	5870413.522	532184.942	509.052
17	Bettcher/Lark Intersection	5869847.618	532238.022	519.580	5869847.619	532238.054	519.581
18	Lark/Flamingo Intersection	5869826.907	531984.751	524.107	5869826.892	531984.774	524.104
19	Abbott/Flamingo Intersection	5869596.531	531978.200	517.202	5869596.487	531978.205	517.207
• 20	Hawk Street @ Crane Ave.	5869364.240	532199.240	504.315	5869364.221	532199.244	504.315
21	Lane between Avery/Allison	5869343.007	532493.555	485.488	5869342.971	532493.555	485.475
22	Lane between Beath/Bouchie	5869628.980	532631.118	478.908	5869628.962	532631.106	478.908
23	Doherty Dr BM	5869134.081	532888.636	475.383	5869134.053	532888.618	475.346
24	Salton Road (Hixon Road)	5878341.379	531399.224	589.591	5878341.388	531399.222	589.575
26	Benchmark by Airport - BM	5873887.631	533765.368	545.412	5873887.631	533765.369	545.407
28	Red Bluff Pump Station - BM	5870190.608	537039.418	595.773	5870190.608	537039.418	595.773
29	Quesnel Hill	5870484.890	536304.129	575.002	5870484.884	536304.133	574.998
82C256	Government Benchmark at Airport	5875411.453	533109.702	542.946	5875411.453	533109.702	542.946