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HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

JUN 1984

CLINTON CREEK ASBESTOS MINE

WASTE DUMP AREA

REVIEW OF REHABILITATION MEASURES

Prepared For

INDIAN AND NORTHERN AFFAIRS

Yukon Water Board

By

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1.0 INTRODUCTION

Hardy Associates (1978) Ltd. were retained by Indian and Northern Affairs to provide a review of possible rehabilitation measures for the waste dump area adjacent to Clinton Creek at the Cassiar Asbestos Mine.

The work undertaken involved a compilation of previous investigations done in the area, an evaluation of the available slope monitoring data, a review of the presently proposed rehabilitation scheme (prepared by Klohn Leonoff for Brinco Mining Limited) and an evaluation of alternate rehabilitation measures.

2.0 BACKGROUND INFORMATION

The Clinton Creek Asbestos Mine is located approximately 100 km northwest of Dawson City, Yukon Territory. Prior to the commencement of operations at the mine, Clinton Creek flowed through a relatively wide valley close to the south valley wall as shown on Plate A1, Appendix "A". The original valley was approximately 250 m (800 ft) wide with slopes of approximately 30^{o} and an overall height of about 180 m (600 ft). Plate A1 shows an inferred cross section of the original valley configuration based on information contained in previous reports on the site.

Mining operations commenced in 1968 at which time waste material was dumped at the top of the south slope. The waste material consisted of predominantly sand and gravel sized broken argillite with minor serpentine and asbestos fibre inclusions.

Soon after dumping was started, sloughing was experienced. Dumping was continued despite this early warning of possible problems associated with uncontrolled dumping. Failure of the dump occurred due to failure of the foundation materials both on the slope and in the valley.

The moving toe of the slide debris forced the Clinton Creek channel northward across the valley and up onto the north slope (see Plates A1 and A2, Appendix "A"). The channel moved a distance of approximately 300 m (1000 ft). The failed waste dump dammed the valley impounding a body of water known as Hudgeon Lake. The deepest point of this lake is in the order of 26 m (85 ft).

3.0 SLOPE MOVEMENTS

Measurement of movements of the waste dump toe and creek closure measurements have been taken since 1977. A total of seven slope monitoring points and six creek closure sections have been monitored. The locations of these stations are shown on Plate A2, Appendix "A".

Table 1 presents a summary of the monitoring data obtained over the period from 1978 to 1981. Table 2 (after Klohn Leonoff, 1984) provides a summary of the average annual toe and closure measurements. Readings in Table 1 have been categorized into winter, extending from January 1 to May 15, and summer, extending from May 15 to December 31. Typically, the horizontal rate of movement in summer is about 1.25 times greater than that in the winter.

TABLE 1

SUMMARY OF MONITORING DATA - CLINTON CREEK WASTE DUMP

Location	Monitoring Point	Summer 1978	Summer 1979	Summer 1980	Summer 1981	Winter 1978-79	Winter 1979-80	Winter 1980-81
Toe - Main Dump Segment	20A	5.0	4.5	3.0	-	1.5	4.0	Destroyed
	21A	5.3	4.9	3.5	-	3.4	3.7	Destroyed
	22A	7.1	6.0	3.0	-	4.4	4.5	Destroyed
	68	4.5	4.9	3.8	-	3.2	3.8	Destroyed
Toe - East Flank	19	2.3	2.3	2.0	-	1.6	2.2	Destroyed
Creek Closure	A	4.1	4.5	5.1	3.02	2.1	2.9	3.0
	B	3.2	4.5	2.3	2.29	1.7	2.0	2.3
	C	2.8	Destroyed			1.3	-	-
	D	2.2	Destroyed			1.3	-	-
	E	1.9	1.8	1.7	1.45	1.2	1.5	1.5
	F	-	4.5	3.5	2.71	3.1	2.7	2.7
	G	-	4.5	3.5	3.30	3.4	3.5	3.3

TABLE 2

SUMMARY OF ANNUAL MOVEMENTS - CLINTON CREEK WASTE DUMP
(After Klohn Leonoff, 1983)

	Annual Movements (ft/year)	
	Closure Sections*	Monitoring Points**
1976 - 77	-	3.23
1977 - 78	4.00	4.16
1978 - 79	-	-
1979 - 80	2.96	-
1980 - 81	2.43	3.60
1981 - 82	2.15	2.52
1982 - 83	1.73	2.62

* The averages shown do not include all of the same sections for each years, but are a reasonable indication of the annual trends.

** Includes points 20, 21 (or 21A) and 22 (or 22A).

Plots of cumulative horizontal movement (based on available data) for the toe of the main dump segment and for creek closure are shown on Figures 1 and 2.

Figure 1 shows a plot of movements at the toe of the main dump segment. Horizontal movements are currently in the order of 0.75 m per year (2.5 ft/yr). These movements have been relatively constant over the past three years. Average vertical movements are less than 0.3 m per year (1 ft/yr) at the toe of the dump.

Creek closure measurements are plotted on Figure 2. Closure movement is currently in the order of 0.6 m per year (2 ft/yr). Again, movements have been relatively constant over the past couple of years.

4.0 DISCUSSIONS AND RECOMMENDATIONS

4.1 STABILITY OF CLINTON CREEK CHANNEL

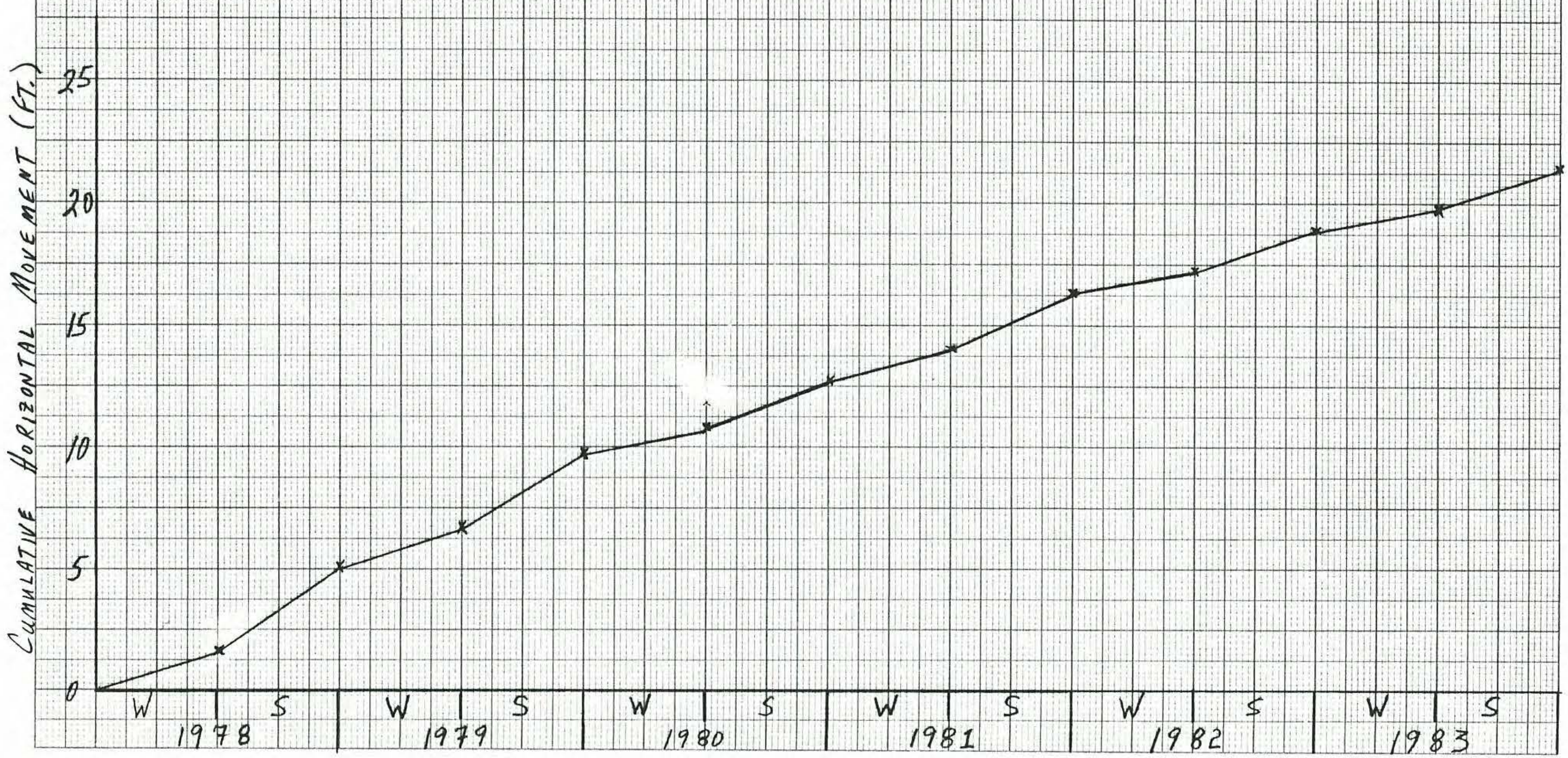
Results from the monitoring program suggest that the rate of horizontal slope movement is not diminishing at a significant rate. Thus, it is believed that stabilization of the waste dump, if left to natural processes, will take a long time. Furthermore, slope movements appear to be retrogressive and thus, the entire slope is likely in an unstable state. However, catastrophic downslope movements are not expected.

As the waste dump moves downslope, the creek is squeezed towards the north bank and maintains its width by eroding away the toe of the north slope. Erosion of the toe of the waste dump is also occurring. While the waste dump remains in an

FIGURE 1 CLINTON CREEK WASTE DUMP

AVERAGE HORIZONTAL MOVEMENTS

TOE OF MAIN DUMP SEGMENT



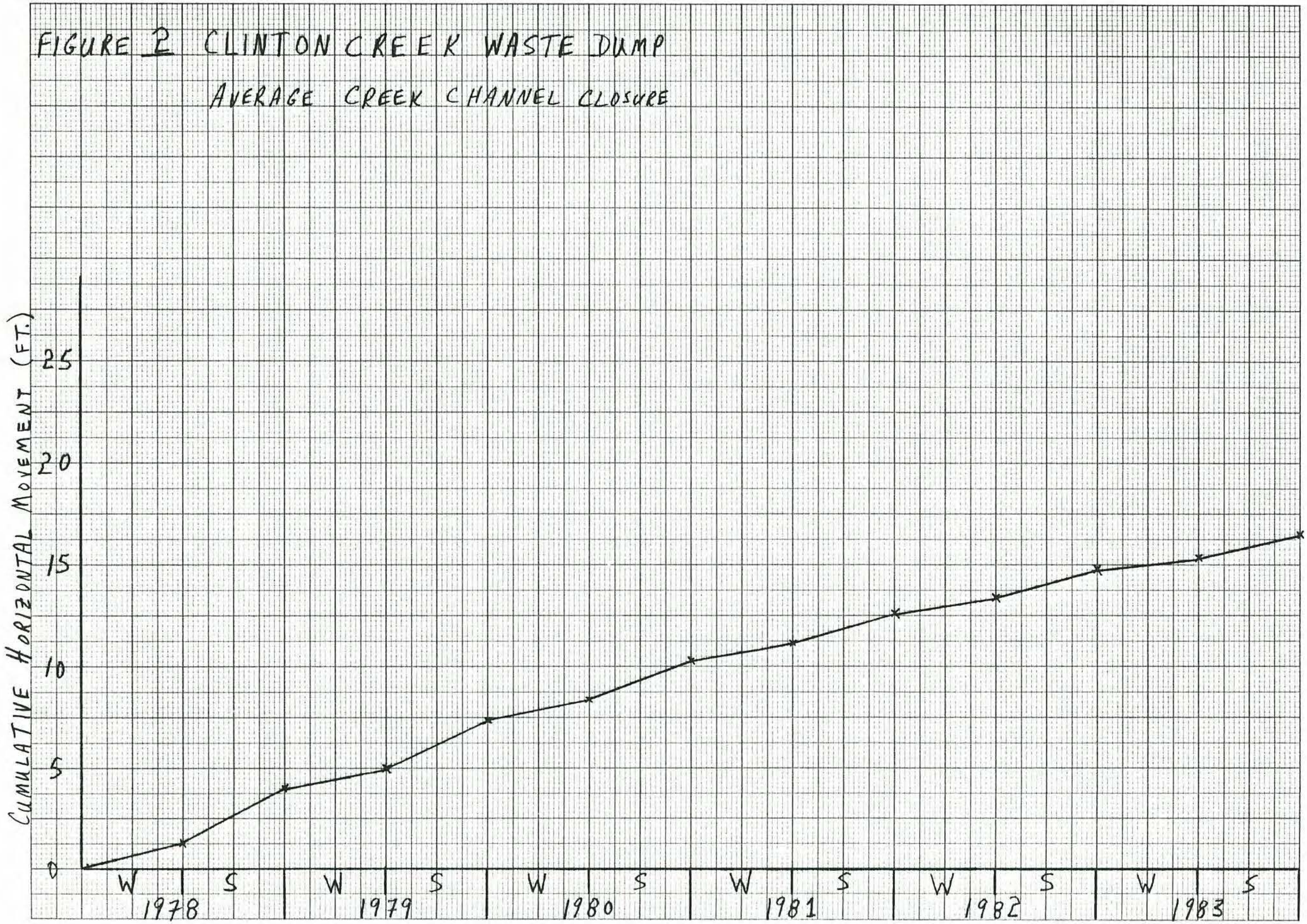


FIGURE 2 CLINTON CREEK WASTE DUMP
AVERAGE CREEK CHANNEL CLOSURE
CUMULATIVE HORIZONTAL MOVEMENT (FT.)
0
5
10
15
20
25
W
S
1978
1979
1980
1981
1982
1983

unstable condition, the creek channel will also be in an unstable state. Consequently, regular channel maintenance will be required over an extended period of time.

The recommendations provided by Klohn Leonoff (1983) are based on the premise that the waste dump will reach a natural stabilized state in the very near future. However, if slope movements continue for some time, as we anticipate they will, further maintenance will be necessary. Moreover, continued erosion in the creek bottom may trigger instabilities in the adjacent north valley wall.

It would be prudent, in our opinion, to investigate a more permanent solution to the problem. This would involve stabilization of the waste dump and construction of a permanent channel. Several alternate reclamation schemes have been evaluated and are discussed in the following sections.

4.2 REHABILITATION ALTERNATIVES

4.2.1 Coarse Rock Drain

The concept of using a coarse rock drain to channel water flow through spoil dumps has been employed with success on previous projects. The possibility of employing such a system to convey the Wolverine Creek through the tailings piles at the mine site was explored (Hardy Associates, April 1984) and it was concluded that the alternative was not economically viable.

Conditions along Clinton Creek at the location of the waste dump are somewhat different. The channel slope is steeper, 4.5% compared to 2.5% along Wolverine Creek, and the 100 year return flow is much greater, 34 m^3/sec compared to 20 m^3/sec at Wolverine Creek. Based on this, a rock drain constructed of 0.6 to 1.0 m diameter boulders would require an area of 500 m^2 to accommodate the 100 year return flood. The drain would have to extend over a length of about 450 m making volume requirements in excess of 200,000 m^3.

The cost of such a drain would be in excess of 5 million dollars. Also, the valley configuration at the waste dump location may not accommodate such a drain.

4.2.2 Conveyance of Clinton Creek Through the Waste Dump

The possibility of placing one or more corrugated steel pipes in the channel bottom and subsequently covering the pipes with a sufficient amount of fill to protect the pipe was investigated.

A large diameter corrugated steel pipe could be placed in or near the existing stream channel to convey the creek water through the area occupied by the waste dump. Fill material would have to be placed over the culvert for protection. The pipe would only provide a temporary solution and a permanent channel would have to be constructed over the waste material following stabilization. A rough estimate of the cost of such a scheme is $900,000.

In our opinion, placement of such a pipe would be redundant. It is believed that placement of a sufficient amount of fill in the existing channel would provide a stabilized slope condition and allow for immediate construction of a permanent channel.

4.2.3 Slope Stabilization by Addition of Toe Support

Over the years, erosion at the toe of the waste dump and downcutting of the creek channel have reduced toe support at the waste dump location. These factors, in our opinion, have contributed significantly to prolonging the natural stabilization process.

The waste dump appears to be failing in a retrogressive manner. As toe support is removed due to erosion, movements of the lower slope material occurs. This results in a decrease in toe support for the immediate upslope section. The process continues upslope creating instability throughout the entire dump area. Thus, we believe that the addition of a small amount of toe support and protection from further erosion would significantly enhance the overall slope stability.

This rehabilitation scheme involves accelerating the slope stabilization process by providing additional toe support and subsequently constructing a permanent channel over the waste dump area. This would include construction of a permanent rock-lined channel (at the appropriate elevation) near the toe of the waste dump, for example at approximate location shown on Plate A1. Excavated material from the channel area could be stockpiled adjacent to the existing channel. Following construction, flow could be diverted through the new channel. Waste material from both sides of the newly constructed channel could be used to infill the existing channel area and provide the necessary toe support for stabilization.

Several "crossings" over the new channel would be required for transporting fill to the existing channel area. These crossings could consist of fill placed over a series of culverts at predetermined intervals (say 150 m). This phase of construction should be carried out in the fall, during periods of low flow to minimize the culvert requirements. As a preliminary estimate, three 1.2 m diameter culverts, or equivalent, would be required to handle the flow.

The permanent channel could be constructed with a relatively uniform slope (in the order of 4 percent) and lined over its entire length (see Plate A3). Alternatively, the upstream section of the channel could be constructed with a shallow slope (say in the order of 1 percent) and be left unlined. This portion of the channel would have to be considerably wider and deeper than the lined channel. The downstream portion of this channel extending to the stilling basin could be somewhat steeper and rock lined (see Plate A3). The second alternative would reduce the amount of durable rock required for lining purposes.

A detailed channel design has not been undertaken at this time. However, it would be prudent to minimize the channel dimensions which, in turn, would minimize the lining material requirements. A channel with a trapezoidal cross-section (sideslopes of two horizontal to one vertical) would require a base width of 6 m and overall height of 1.75 m and a slope of 4 percent to accommodate the 100 year return period flow.

On a preliminary basis, the minimum lining thickness has been estimated at 1.0 m for the channel bottom and 0.6 m for the sideslopes. Further studies would be required to determine the optimum channel dimensions and lining requirements. Based on this channel design, the volume of durable rock required for the lining would be in the order of 15,000 m^3.

A detailed slope stability analysis would be required to determine the amount of fill required to achieve stabilization. As a rough estimate, it is believed that raising the creek channel elevation by about 15 m (50 ft) would be adequate. This estimate is based on the inferred slope cross-section shown on Plate A1. The slope section presented has been based on available photographs and reports discussing the site conditions. A proper survey of the present dump profile would be necessary prior to detailed analysis.

Plate A1 shows the original valley and slope configuration, the inferred waste dump surface profile and the proposed cut and fill areas. The estimated fill volume for stabilization is in the order of 150,000 m^3.

The estimated cost of implementing such a scheme including placement of fill and permanent channel construction is in the order of $500,000. However, this cost is highly dependent on the amount of fill required and the availability of durable rock.

This approach, in our opinion, could provide a practical rehabilitation alternative and should be given further consideration. A detailed analysis and design must be undertaken prior to implementing the scheme.

5.0 SUMMARY AND CONCLUSIONS

A review of the slope monitoring data from the waste dump adjacent to Clinton Creek has been undertaken. The results show only a marginable (if any) decrease in the rate of movement over the past several years, suggesting that it will be some time before the slope reaches a naturally stable condition.

Presently, a regular maintenance and inspection program is on going at the site. This program should be continued until the waste dump movements have stabilized, which, at the present rate, may take many years. During this period, further erosion in the creek bottom may jeopardize the stability of the adjacent valley wall.

We recommend that a direct approach to the problem be considered at this time which will effectively stabilize the waste dump, ensure the long-term integrity of the drainage course and minimize the potential for further damage to the adjacent valley wall. Several possible rehabilitation alternatives have been presented and reviewed. The most practical and economical solution appears to be accelerating the natural stabilization process by replacing lost toe support (discussed in Section 4.2.3).

Further studies and analysis would be required to confirm the conceptual designs presented herein, particularly with respect to the configuration and height of fill required to stabilize the waste dump.

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Respectfully Submitted,

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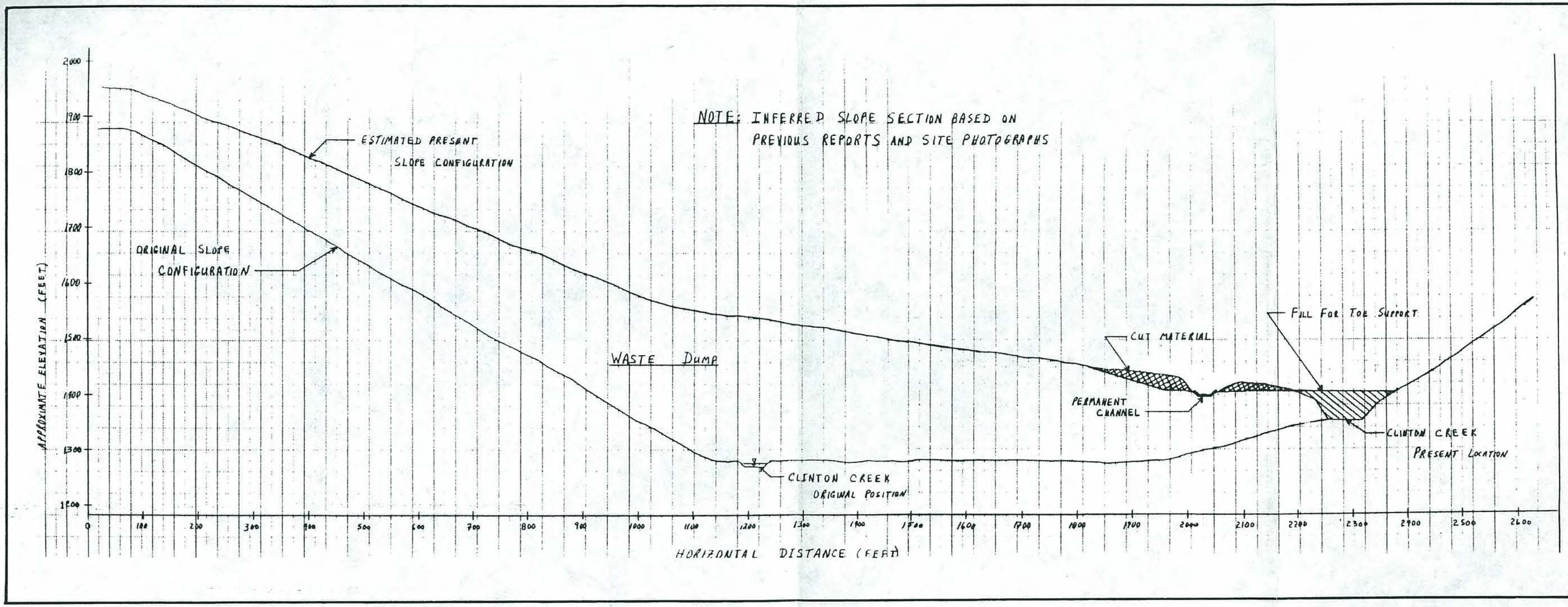
APPENDIX "A"



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CLINTON CREEK MINE WASTE DUMP
CONCEPTUAL ILLUSTRATION OF
TOE SUPPORT ALTERNATIVE

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PLATE A1

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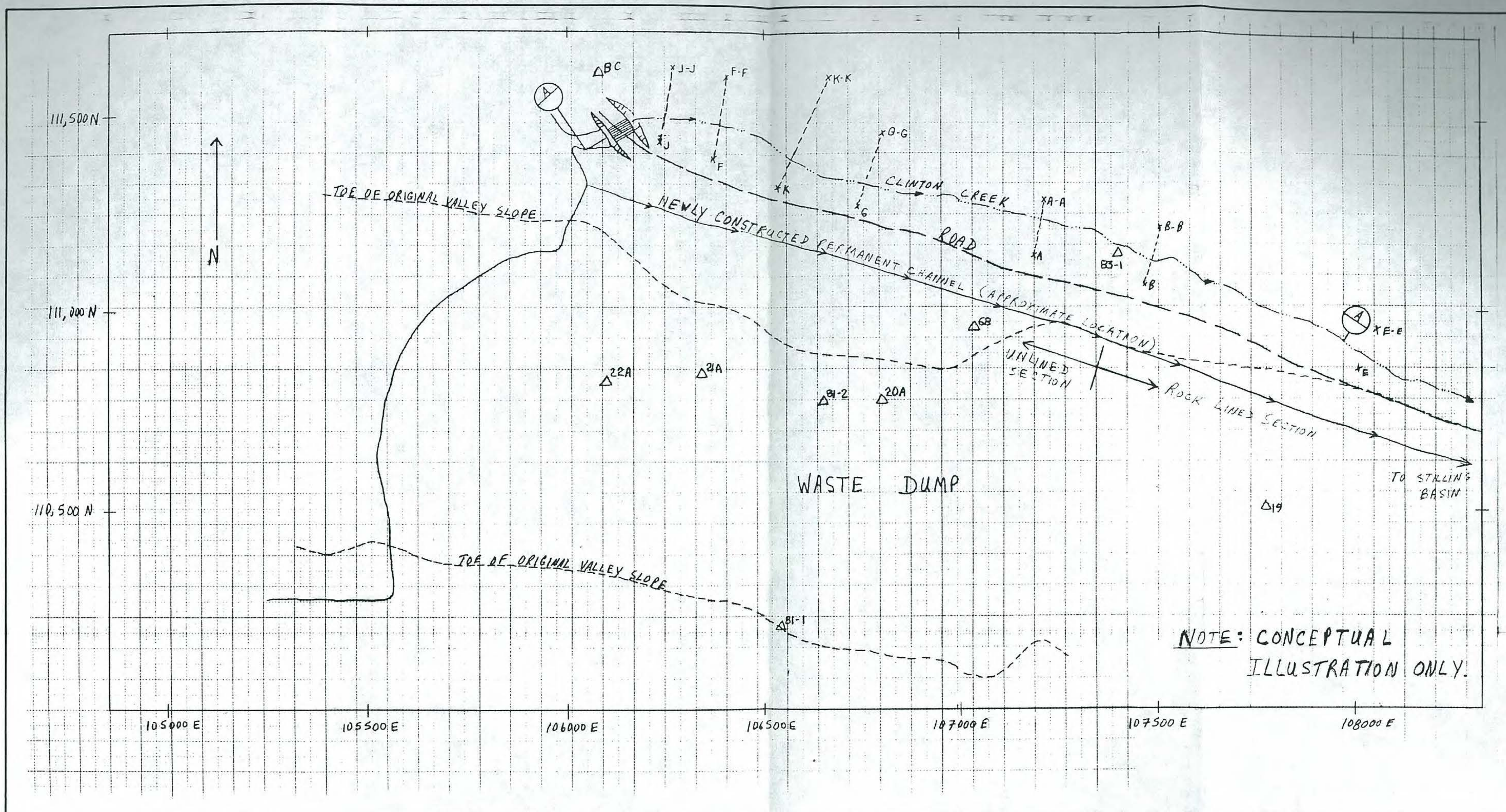

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CLINTON CREEK MINE
PLAN OF WASTE DUMP AREA

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PLATE A2

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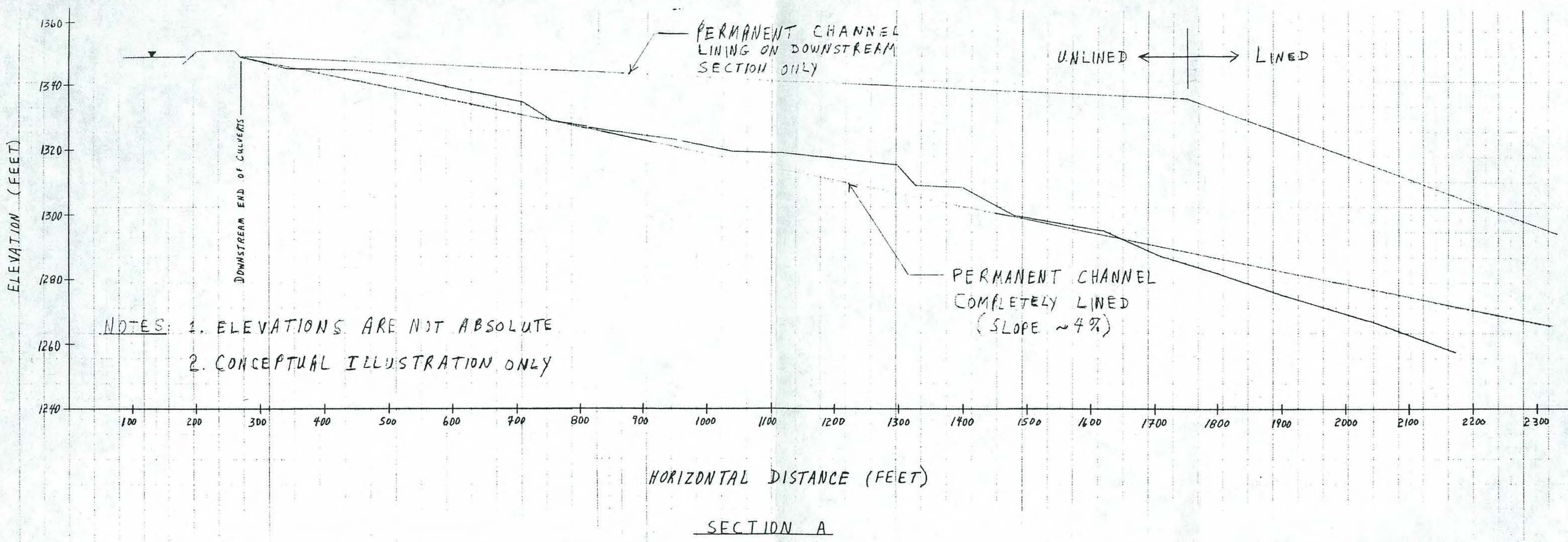

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CLINTON CREEK MINE
LONGITUDINAL PROFILE OF CREEK CHANNEL

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PLATE A3

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