UNITED STATES OF AMERICA

Federal Energy Regulatory Commission

NORTHERN LIGHTS, INC.) PROJECT NO. 2752

KOOTENAI RIVER HYDROELECTRIC PROJECT
DIRECT TESTIMONY AND EXHIBITS
ON BEHALF OF
NORTHERN LIGHTS, INC.
VOLUME I

James B. Vasile
Morgan, Lewis & Bockius
1800 M Street, N.W.
Washington, D.C. 20036
(202) 872-7637

Steven L. Herndon
P.O. Box 1326
Sandpoint, Idaho 83864
(208) 263-2108

February 1, 1982

PCNO 3246

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

NORTHERN LIGHTS, INC.) PROJECT NO. 2752

INDEX TO DIRECT TESTIMONY

VOLUME I

Witness	Subject Matter
James A. Sewell	Need for Power and Project Operations
Arthur E. Allen	Project Layout
Earl E. Komie	Site Geology
Svante E. Hjertberg	Project Construction and Cost
Henry H. Chen	Project Economics
Baum K. Lee	River and Reservoir Hydraulics and Sedimentation

VOLUME I

INDEX OF EXHIBITS

TITLE	EXHIBIT NO.

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

NORTHERN LIGHTS, INC.) PROJECT NO. 2752

DIRECT TESTIMONY OF JAMES A. SEWELL
ON BEHALF OF NORTHERN LIGHTS

Q. State your name and address.

A. James A. Sewell, Newport, Washington 99156.

Q. What is your education background?

A. I received a Bachelor of Science in Civil Engineering in 1937 from Washington State University.

Q. What is your experience?

A. I spent from June 1937 through July 1942 with the Washington State Highway Department and the Washington State Toll Bridge Authority working on design and construction of bridges, highways, and other necessary facilities. From July of 1942 until September 1945 I was employed by the Everett Pacific Ship Building and Drydock Company in the construction of drydocks including the actual design of part of their outfitting for overseas towing. In January 1946 I became associated with my father in his consulting engineering business at Newport, Washington and have been there since that time. This work has involved the design and construction of transmission, distribution and substation facilities. I was Assistant Resident Engineer during the construction of the Box Canyon Hydroelectric Project No. 2042, located on the Pend Oreille River, and have been responsible for its maintenance and operation since its completion in 1956. I have been involved with the Pacific Northwest Coordination Agreement since its conception. I have been the representative of Public Utility District No. 1 of Pend Oreille County on the Coordination Agreement Committee since 1966. Another portion of our work has been the design and construction of sewer and water systems, city streets, highways and small dams for recreation or small hydroelectric development. I have been connected with the Sullivan Creek Project No. 2225, since the District acquired it in 1959. I am responsible for the maintenance and repair of the project as well as the release of its storage waters for use by downstream projects. I am a registered Professional Engineer in the states of Washington, Idaho and Montana.

Q. What is your connection with the Kootenai River Hydroelectric Project?

A. Starting in 1974, I consulted with Mr. Nordeen, Manager of Northern Lights, Inc. concerning the possibility of constructing a hydroelectric project in the vicinity of Kootenai Falls. After some preliminary computations, we decided to retain Harza Engineering Company for the actual design of the project. My firm has been responsible for the field work and the integration of the proposed Project operations under the Pacific Northwest Coordination Agreement.

Q. What was the result of these studies?

A. We prepared an application to the Federal Power Commission for a preliminary permit to obtain priority for the license application prior to performing detailed feasibility studies. The application was filed in November 1974 and a preliminary permit was received on December 1, 1975.

Q. What prompted Northern Lights, Inc to investigate the feasibility of electric generating facilities?

A. Northern Lights, Inc. was advised by the Bonneville Power Administration that they did not expect to have sufficient power to serve Northern Lights' load growth in the future.

Q. Why did you investigate the Kootenai River Project?

A. We looked at the Kootenai River Project because when Libby Dam was to be completed it would control approximately 98 percent of the total flow of the Kootenai River thus making practically all of the power from any dam on the river below Libby Dam firm power.

Q. Why would this be considered firm power?

A. Because Libby Dam stores water during the flood season for release during the winter period when firm power is needed. This also coincides with Northern Lights' firm power requirements.

Q. What was done after the preliminary permit was received?

A. Mr. Nordeen and myself contacted various groups to share in the use of the project output since it was greater than Northern Lights' requirements. As a result of these contacts, the Project output will be shared with Ravalli County Electric Coop., Inc., Corvallis, Montana; Vigilante Electric Cooperative Inc., Dillon, Montana; Missoula Electric Cooperative, Inc., Missoula, Montana; Flathead Electric Cooperative, Inc., Kalispell, Montana; Glacier Electric Coop., Inc., Cut Bank, Montana; Lincoln Electric Coop., Inc., Eureka, Montana; and the Flathead Irrigation Project, St. Ignatius, Montana. These eight utilities later formed the Western Montana Electric Generating and Transmission Cooperative, Inc. ("G&T"). Exhibit ____(JAS-1) shows the service areas of the G&T members which is essentially Western Montana and Northern Idaho. They serve 46,778 customers.

Q. What else did you do during the period of the preliminary permit?

A. My firm worked with the Harza Engineering Company in preparing the license application. This involved conducting field surveys, measuring river cross sections, and obtaining stream flows of the Kootenai River from the United States Geological Survey (USGS). It also involved contacting the Burlington Northern Railroad on whose property the proposed Project is located. We discussed the Project with the U.S. Forest Service and the Montana Department of Natural Resources and Conservation. It was necessary to obtain permits from the U.S. Forest Service and the Burlington Northern Railroad for the field work on their property. Additionally, we developed a Power Requirement Study (PRS) for the G&T.

Q. Would you please outline what steps were involved in preparing the load estimates in the PRS?

A. The PRS was prepared within the guidelines outlined in Rural Electrification Administration (REA) Bulletin 120-3. The REA Bulletin requires that each member utility work with the G&T in preparing the PRS. Each member was responsible for gathering its historical data. Then we worked with the members in preparing their estimates of future power and energy requirements. Next we assembled those requirements into a single document outlining the anticipated loads for the G&T.

Q. Would you please describe in more detail the first step of how the members of the G&T developed their basic load forecast?

A. All of the members of the G&T decided that the residential loads would be forecast using an end use technique for modeling. The end use technique determines the loads for a class of customers based on their use of electrical power. To do this type of analysis, it was necessary to poll the individual customers to determine their use of electrical power. This was done by a questionnaire which is shown as Exhibit ____(JAS-2) titled "1979 Membership Survey". This questionnaire was mailed to the individual residential customers of each cooperative member of the G&T in the early part of December 1979, except the Flathead Irrigation Project. The customers selected to receive this survey varied somewhat from utility to utility. REA desired each cooperative to receive at least a return of 386 questionnaires to assure statistical significance. The statistical group created by each cooperative consisted of residential customers who had at least an 11 month history. The smaller cooperatives then sent a survey questionnaire to each customer of this group. The other cooperatives stratified this group by placing the accounts, according to kilowatt hour usage in the previous 11 months, in order ranked from the highest to the lowest user and then determined the interval of selection to obtain the desired number of questionnaire returns. The starting position was picked at random to prevent unduly weighing the survey toward the high or low user.

Q. How many questionnaires were mailed out?

A. The cooperatives mailed the questionnaires to 4982 of their 25,700 residential customers.

Q. How many questionnaires were returned?

A. 3091 questionnaires were returned.

Q. What else was needed for the analysis?

A. Two other basic pieces of information were required before the analysis could begin; an estimate of the population, and the estimated usage of appliances in each household.

Q. How were the population estimates obtained?

A. All eight members did considerable analysis in projecting population since only three of the members serve all of their geographical area. The other five serve only the rural area, as the towns are served by other utilities. Since the most common breakdown of census figures is by county, each member adjusted county census figures to reflect only the rural area served by it. These estimates were arrived at in numerous ways depending upon the area and information available. The members also considered the factors which might change the rate of growth of their service area, such as changes in the level of the sustained yield from the national forest, or in farming patterns.

Q. How was the appliance usage determined?

A. The estimated power to heat a home electrically in each of the member service areas was obtained from Bonneville Power Administration. Other appliance usage was obtained from The Washington Water Power Company and The Montana Power Company. Usage levels for unlisted appliances were estimated based on capacity and time of use. These basic appliance consumption levels are shown on Exhibit ____(JAS-3).

Q. How was the residential load projected using the above data?

A. The analysis was done using 1979 as the base year. The residential load projection first required a determination of how electrical power was used in 1979. Then we made projections as to how power would be used in the future.

From the customer survey that was described earlier, we determined the saturation levels of televisions, freezers, clothes washers, electric clothes dryers, electric ranges, dishwashers, electric hot water heaters, car engine heaters, stock water heaters to keep drinking water for stock from freezing, homes heated primarily with electric resistance heat, and homes heated with heat pumps. Since it is not practical to try and estimate all of the uses of electricity in a home, all the other uses made of electrical power in the home were lumped into one category called "baseload". This includes lighting, electric can openers, domestic water pumps, fans on heaters and furnaces, toasters and other uses that are not specifically included in the list above. The baseload for each member was calculated by subtracting the electric power used by all the listed appliances from the kilowatt hours used during the year. The average kilowatt-hours used per household was calculated for all the homes in the 1979 survey.

Q. What was your next step?

A. The members estimated how much power was going to be used in 1984 and 1989. One of the most significant changes that could take effect during this period of years is the change in the saturation of electric resistance heating. The 1979 survey of customers showed how many people were planning to install electric heating, how many people were planning to convert to wood, and how many people were planning to convert to natural gas within the next three years. Using the information that the customers provided, we were able to project the rate of change in the saturation levels by taking into account people with electric heat that plan to put in wood heat, people that had oil heat that planned to put in wood heat or electric heat, and also how many people planned to put in heat pumps. Another consideration in the projection of electrical usage for heating was that new construction would be more conservation oriented and therefore use less electricity to heat a home. Data from this survey were used to estimate the number of existing homes that would be retrofitted to higher insulation levels and better heating efficiencies. Therefore, the kilowatt hour usage of existing resistance heated houses was decreased in each year of the projection. The usage levels of the other appliances were also anticipated to change due to increased efficiency of new units and less usage in future years. Therefore, the typical usage for each of the appliances was analyzed in each year of the projection to determine if the consumption level should be increased or decreased. Where decreases in the typical usage were projected, the members provided reasons for these decreases. For example, engine heater usage might be expected to decrease by encouraging people to put timers on their heaters, so that they don't run all night, but rather just come on in the morning a few hours before the car is needed. We also reviewed the existing saturation levels for the various appliances in the year of the survey to determine if changes were necessary.

Q. What other specific classes of customer loads were projected?

A. Projections were made for the following other classes of customers: seasonal residential, irrigation, street lighting, commercial (less than 50 KVA), commercial (50 to 350 KVA), and commercial (over 350 KVA), the use by the utility, and system losses.

Q. How was usage by the seasonal residential accounts projected?

A. The seasonal residential accounts were projected on the same basis as the residential class since they are similar but only used part-time.

Q. How were the irrigation loads projected?

A. The irrigation load projections were taken from studies made earlier by the G&T members for 5, 10, and 15 years.

Q. Would you describe the irrigation studies?

A. An irrigation study was made by each of the G&T members in accordance with REA Bulletin 145-1. To do this study, each of the members segregated its service area into various sub-areas of agricultural lands. Each of the sub-areas was studied individually to determine the existing farming patterns. This study took into account existing and potential farm lands that might be used in a different manner in the future. For each of these sub-areas, the existing irrigation and cropping patterns were analyzed and trends were determined which would indicate changes in the amount of irrigation, or the methods of irrigation. Consideration was also given to any other limiting factors which might influence future irrigation needs such as water availability, salts in the soil, length of the growing season, anticipated costs of hardware and power, and pressure from residential development. Based on the above data the extent of future irrigated land annual water usage was estimated. These studies also determined the sources of water to be used for irrigation. Once the amount of water used, the lift required, and the method of application had been projected, the amount of power and energy required to do the irrigation for the years ahead was estimated. These studies were approved by REA.

Q. How was the street lighting load projected?

A. The street lighting load was projected by trending. It should be noted that street lighting was less than 0.2 percent of the total G&T load in 1979.

Q. You list three classes of commercial accounts. How were these customer usages projected?

A. The smallest commercial accounts were made up of services requiring 50 KVA transformer capacity or less. These accounts are services to restaurants, barber shops, offices, and most retail trade establishments. They also contain the largest number of services of the three commercial classes. This smallest commercial class was projected by using a combination of trending and end use modeling. The number of retail trade establishments generally is proportional to the number of residential accounts. The proportion varied considerably from one member to the next, since some of them do not serve metropolitan areas.

The next commercial class is composed of customers served with 50 to 350 KVA of transformer capacity. These accounts were projected by trending as a class. A few members that had only a couple of customers in this class analyzed each individual customer and based projections on each customer's requirements.

All large commercial customers requiring over 350 KVA of transformer capacity were contacted individually and projections were based on each individual customer estimating major expansions and historical load increases.

Q. What is utility use and how was it estimated?

A. Utility use is power used by each member in its normal operation of shops, warehouses and offices. This amount of power was projected based upon each individual point of delivery from the distribution system.

Q. How were the losses estimated and projected?

A. Losses are line and equipment losses on the distribution system of the individual member. These losses are determined by taking the amount of power which each member purchased and subtracting the amount of power the utility used and sold. This method of calculating gave the members the percentage of losses in 1979. These losses were then analyzed to determine whether they should be adjusted for purposes of this projection to reflect future operating plans and load growth and then applied to the projected load.

Q. For what period of time were the load projections for each member's PRS made?

A. 1979 was the base year and projections were made for 5 and 10 years, making the projected loads for the years 1984 and 1989.

Q. Were projections of peak demands made for each of the members?

A. Yes, projections of peak demand were made for all the members. These projections were based upon the historical peak registered in 1979. The peak shown in each PRS is the sum of the non-coincidental peak demands recorded for each member substation. The projections were made using a trending method wherein the existing load factor is projected into the future considering changes in loads such as residential heating and a larger or smaller number of residential customers. The large power customers were projected individually depending upon their studies. When combined, these peaks gave us the peak for each member.

Q. The analyses you have just described were done by the members with your assistance. How was the Power Requirement Study for the G&T developed?

A. The load requirement of the G&T's PRS was determined by the sum of the individual loads as determined in each member's PRS. The peak shown for the G&T is the sum of all the individual non-coincidental peaks.

Each of the members did the above calculations and made the projection of its load for 1984 and 1989. I prepared the 1999 projection for the G&T with the members' assistance.

Q. You stated that the G&T PRS was prepared using 1979 as a base year. Have you reviewed it since its completion?

A. Yes, I reviewed it in late 1981.

Q. What did you find?

A. In 1980 the G&T members used 983,700,905 KWH and I have estimated the 1981 member loads to be 1,015,000,000 KWH based on 11 months of data. This is slightly lower than the G&T members' 1979 use of 1,025,277,319 KWH of electrical power. During these two years the number of accounts in all classes has increased by 9.3 percent. This indicates that each account is using an average of 9 percent less power than two years ago.

Q. To what do you attribute this reduction?

A. The G&T members have been stressing conservation which will account for a portion of this load reduction. In addition to this the winter of 1980-81 was milder than normal and the economy in general has been slower with much of the timber industry shut down or on reduced production schedules.

Q. Have you revised your projections?

A. Yes, we have made a new projection of the G&T's loads. This projection is based on the 1981 historical load. To include a new large industrial load being served by one of the members, the 1981 load was increased by 8 average megawatts (70,080 MWH). This load came on late in 1981 and had not reached full load by the end of the year. Due to the current economic situation, we have estimated only an additional increase of 5 average megawatts (43,800 MWH) to make the total increase 13 average megawatts (113,880 MWH) in 1982. After 1982 the load was projected to grow at the rates estimated in the PRS. Because the loads were growing so fast prior to the economic change, i.e. an 8.7 percent annual increase between 1977 and 1979, it is felt that the economics of the area and load will once again grow rapidly for a period of time. This rate of growth is anticipated to decline in later years.

Q. What rates of growth did you use in your PRS projections?

A. After 1982, we have used a 7.5 percent rate thru 1984, 4.8 percent rate from 1984 thru 1989, and then a 3.44 percent rate of growth from 1989 thru 1999.

Q. What are your estimates of the loads in 1984, 1989 and 1999?

A. The revised load estimates are: 1,305,000 MWH in 1984; 1,647,000 MWH in 1989; and 2,313,000 MWH in 1999.

Q. Have you prepared an exhibit to show these load projections?

A. Yes, Exhibit ____ (JAS-4) has been prepared to show what I have just described. The historical energy loads in average megawatts have been plotted on the left hand side and the projected loads on the right hand side of the graph. The dashed line is the projection of loads we made in 1980 while preparing the Power Requirement Study for REA which was discussed earlier. The solid line is the G&T load revised to the end of 1982 and then projected as discussed above. I have also included a 4 percent load growth curve to show the effects of a lower rate of load growth.

Q. What are the existing sources of power to meet the loads of the G&T and what is their future availability?

A. The members currently have contracts to receive power for various lengths of time. The largest supplier of power to the members is BPA. Currently BPA supplies all power in excess of the members' other resources. BPA is expected to remain the major supplier of wholesale power to the G&T members for some time and will continue to supply the firm resources that they are supplying on July 1, 1983.

The Flathead Irrigation Project has a 400 KW hydroelectric project on Big Creek and a contract with The Montana Power Company for 11,200 KW from Kerr Project No. 5. This license has expired and is currently being renewed annually. It is expected that the Flathead Irrigation Project will continue to receive this power in the future.

Another source of contracted power for some of the members is the Columbia Storage Power Exchange. The amount of power from this contract decreases each year until the year 2003 when only 17 percent of the current power will be available and the contract expires. The CSPE power available to the members in 1980-81 is 10.5 megawatts of peak and 4.2 average megawatts of energy.

Q. What other sources of power are expected to be available to the G&T members in the future?

A. Contracted sources of power include the nuclear units under construction by The Washington Public Power Supply System (WPPSS). All but one of the members have contracted to purchase a share of the output from Units 1, 2 and 3 under a net billing arrangement with BPA. Under this net billing arrangement, the members have purchased a share of the output from WPPSS Units 1, 2 and 3 and then assigned their share of the output to BPA. The net result of this arrangement is that BPA is responsible for making the payment to WPPSS. Since the members assigned their share of the output to BPA, they do not get this share of power, but BPA has more firm power available to serve the members' loads. Some of the member systems are participants in WPPSS Units 4 & 5 and will receive power when and if these units are completed. The member systems' total share is 1.798 percent which would be 33.6 average megawatts of energy and 44.8 megawatts of capacity. At the time the PRS was written the anticipated first power from Units 4 & 5 was to be delivered in September 1987. Since the PRS was completed, the construction of WPPSS Units 4 & 5 has been curtailed and it is uncertain whether the projects will be completed. Therefore, I have excluded the projects from the firm power resources expected to be available.

The only other major source of power presently expected to be available to serve the G&T's loads is the Kootenai River Hydroelectric Project. The Project will have an installed capacity of 144 megawatts (MW) and 49.2 MW of firm energy during the critical period.

Q. Have you considered conservation?

A. Yes, conservation is considered as a reduction in load growth and is being actively pursued by the G&T members.

Q. How is conservation being pursued by the G&T members?

A. They are attempting to reduce the amount of power used in their own facilities and encouraging their customers to conserve. The members are currently signing up with BPA to participate in the Regional Conservation Program. This program includes water heater wraps, shower flow restrictors, home insulation and more efficient outdoor lighting units.

Q. What is the relationship between the Bonneville Power Administration and the G&T members?

A. The members of the G&T currently have contracts with BPA and are receiving power from BPA. The existing contracts obligate BPA to supply the members with their load requirements in excess of their own resources. These existing contracts expire at various times in the future between 1985 and 1993. Section 22 of the existing general contract provision permits BPA to limit the amount of power that would be made available to the members if BPA should have insufficient resources to serve all of its obligations. BPA determined that the firm energy resources available after July 1, 1983 would be insufficient to supply the firm energy requirements of their customers. Accordingly on June 24, 1976 BPA notified the members that its obligation to supply firm energy to them would be limited to an allocation computed in accordance with Section 22 of the contract.

In December 1980 Congress passed the Pacific Northwest Electric Power Planning & Conservation Act which has changed the role of BPA. The Act requires that BPA offer new contracts to all power purchasers who request them and in September 1981, BPA offered new contracts which must be accepted within one year. Although these contracts are requirement type contracts, they place certain obligations on the purchasing parties to supply resources to serve their own load growth. Prior to the passage of the Act, BPA was prohibited from buying power to meet the long term needs of its customers. Now BPA can purchase the power it needs to meet these long term loads by buying the output of new generating plants which have been developed by some other entity. To meet the increasing needs for power, the Act requires BPA to acquire resources in the following order:

1. Conservation
2. Renewable resources including hydroelectric
3. Generating resources utilizing waste heat or generating resources of high fuel conversion efficient
4. Other projects

BPA must purchase conservation by paying for conservation measures until the cost of power conserved is 110 percent of the cheapest alternative source of power, such as a hydroelectric project.

Q. You mentioned that the G&T members as purchasers would be obligated to supply resources under the new BPA contract. Please elaborate.

A. Subsections 5(b), 7(f)(3), 8(e), 9(e) and 11(b)(4) of the proposed BPA power sales contract place an obligation on the purchaser to develop resources. Section 5 of the proposed contract contains two parts. The first part is Bonneville's obligation to serve the firm loads of the purchaser. The second part contains the provision that "To the extent that the purchaser obligates Bonneville to serve all or a portion of its load growth pursuant to this contract in lieu of using Firm Resources to meet such load growth, the Purchaser and Bonneville recognize that resources must be made available by or on behalf of the Purchaser to Bonneville if Bonneville is to have the ability to meet its obligations hereunder. The Purchaser therefore agrees that it will use its best efforts either to serve its load growth using Firm Resources, or to make available for acquisition by Bonneville, in accordance with conservation and resources priorities and other requirements of P.L. 96-501, resources equivalent to the load growth of the Purchaser which is served hereunder."

Section 7 contains allocation provisions in the event of a planning insufficiency. The allocation provisions are procedures to be used to determine how much power each member will get in the event of a planning insufficiency. Planning insufficiency occurs when Bonneville is unable to acquire sufficient firm resources to meet its firm obligations. Subsection 7(f)(3) contains the provision that "Intra-Class Excess Entitlements shall be allocated on the basis of an allocation factor. . .. Such allocation factor shall be established by starting with a factor determined by comparing the resources actually developed by each Customer to that amount of Firm Capacity or Firm Energy which each Customer needed to develop in order to meet its load growth and load-resource deficits, if any, existing in the year prior to enactment of P.L. 96-501, squaring the resulting factor for each Customer to increase the allocation of those Customers which have been the most successful in developing resources and adjusting the resulting factor so that the sum of such factors for all Customers in a class equals one."

Section 8 of the proposed contract deals with new large single loads. Subsection 8(e) allows the purchaser to serve a new large single load, that is a load in excess of 10 average megawatts, with a resource of its own rather than putting that load upon BPA. The alternative is to purchase its requirements from BPA at the new resource rate which is the cost of new resources on their system. Currently this rate is several times the rate the members now pay.

Section 9 of the proposed contract contains limitations on serving new large single loads. Any new large single load of 35 average megawatts (MW) or more does not have to be served by BPA until seven years from the date of notice required in subsection (b)(2) by the member to BPA. Subsection 9(e) states "The limitations . . . shall not apply if the Purchaser has developed adequate resources to meet its load growth including the increase in load resulting from service to a new facility of a Consumer or additional service to an existing facility of a Consumer . . .. The Purchaser shall be deemed to have built adequate resources for Bonneville to supply such increase in load if the Purchaser has developed resources which were dedicated to its load or sold to Bonneville equal to the sum of (1) reductions in . . . resources between the '79-80 Operating Year and the date specified in subsection (b)(2) above, and (2) growth in Actual Firm Energy Load between (A) the '82-83 Operating Year and the date specified in (b)(2) above for public bodies, cooperatives and Federal agencies. . .".

Section 11 of the proposed contract contains provisions relating to a compensation program in the event of regional curtailment of firm loads. This section of the contract provides for reimbursing the purchasers who curtail in the event of a regional shortage. Subsection 11 (b)(2) states "Bonneville shall pay the Purchaser each month an amount equal to the product of the rate set forth in this paragraph and the amount of load curtailment determined in paragraph (3) below unless such amount of load curtailment is reduced partially or in its entirety as set forth in paragraph (4) below. Such rate shall be the amount per kilowatt hour by which the Purchaser's average revenue from retail sales of electric energy exceeds the wholesale firm power rate the Purchaser would have paid Bonneville for the increment of energy determined pursuant to paragraph (3) below."

Subsection 11(b)(4) states "If regional curtailment has been requested after July 1, 1983, because Bonneville is unable to acquire sufficient resources to meet its firm obligations, Bonneville shall reduce the amount of load curtailment determined in paragraph (3) above during any month if the Purchaser's load growth after July 1, 1983, as specified in subparagraph (A) below exceeds the amount of resources which the Purchaser has dedicated to its own load or made available to Bonneville as specified in subparagraph (B) below. Such amount of load curtailment for each month shall be reduced partially or in its entirety by the amount which (A) exceeds (B) below:

(A) the excess of the Purchaser's Actual Firm Energy Load in average megawatts over the Purchaser's Actual Firm Energy Load in average megawatts for the same month during the '82-'83 Operating Year; and

(B) the annual firm energy capability in average megawatts of (i) resources acquired by Bonneville from the Purchaser under P.L. 96-501; and (ii) the portion of the Purchaser's Firm Resources which are included as 5(b)(1)(B) resources in its Firm Resources Exhibit. Such resources shall not include conservation programs to the extent such programs have been reflected in the Purchaser's Actual Firm Energy Load in subparagraph (A) above."

Thus, under the foregoing paragraphs, in addition to the basic obligation in Section 5, the additional incentives available in the proposed new BPA contract make the construction of the Kootenai River Project quite attractive.

Under Section 7 the allocation provision is increased for those customers who are successful in developing new resources.

Sections 8 and 9 provide a method for meeting new large loads if the purchaser develops new resources.

Section 11, in the event of a regional curtailment of firm loads, provides for compensation and reduction of curtailment for those utilities which have developed new resources.

Q. How was the energy output of the proposed Kootenai River Hydroelectric Project determined?

A. The output was determined using synthesized river discharges over the 40 year period, 1928 to 1968 taking into account that the Canadians could build the Canal Flats Diversion commencing in 1984.

Q. How did you determine the river discharge at Kootenai Falls?

A. The U.S. Army Corps of Engineer's Libby Dam controls the flow of the Kootenai River above the Fisher River. The Corps of Engineers had prepared a monthly discharge schedule for the 40 year period 1928-1968 assuming their regulation of the river by Lake Koocanusa. To this flow I added the flow of the Fisher River and run off from the area between Libby Dam and the Kootenai River Project. The result of this calculation is Exhibit ____(JAS-5) and was shown in the FERC Application on Table HA-6. It should be noted that this does not include the 1.5 million acre feet of water that can be diverted in Canada into the Columbia River drainage each year after 1984. If this flow were not diverted, the flow of the Kootenai River would be increased by an annual average of 2,070 cfs.

Q. How was the firm output of the Project determined?

A. The firm output of the Project was determined using the 42 month critical period, Sept. 1, 1928 to Feb. 29, 1932, which is used in the Northwest as the low flow period of record. The flows used were those developed with the Canadian flow diversion taking place prior to Project operation. The flows during the 42 month critical period were used along with the generation versus gross head curves. The sum of this output was then determined and the sum modified by a correction factor of 93.7 percent. This correction factor is necessary because the project has a different power generating capability per cubic foot of water using hourly flows instead of average monthly flows. These calculations showed that the Project had a capability of 431,000 MWH on an annual basis during the critical period. This gave the Project a capacity of 144 MW and an average firm energy capability of 49.2 MW. These figures were calculated with a minimum spill of 750 cfs over the spillway and with the forebay at elevation 2000.

Q. How was the average output of the Project determined?

A. The monthly flows were developed above and combined into a duration curve. This duration curve is Exhibit ____(JAS-6) and is FERC Application Exhibit I-1. The generation versus gross head curves were then used to determine the Project capability in the 40 year period using monthly flows. These monthly flows were once again modified by the 93.7 percent correction factor to account for hourly flows as opposed to monthly flows. The average output over a 40 year period with 1.5 million acre feet of Canadian diversion is 515,000 MWH per year for an average energy capability of 58.8 megawatts.

Q. Would you describe how the power from this Project will be used with the other resources available to the members?

A. Exhibit ____(JAS-4) shows existing resources on July 1, 1983 including BPA purchase, which have been previously discussed and the estimated date that the Project will have power available. The shaded areas between the resources available and the 4 percent load growth curve indicate a shortage of power that BPA will supply if available. The revised PRS load projection indicates a larger shortage of power for the G&T members to be supplied by BPA if available.

Q. How will the power from the Project be transmitted to the various members of the G&T?

A. The Project will be connected to the existing transmission grid at the Powerstation and the power will be transferred over the existing transmission lines to the members.

Q. What other options do the members have?

A. The power could be exchanged with BPA pursuant to a "Service & Exchange Agreement" that would provide transmission, reserves, load factoring, and seasonal storage.

The Project output could also be exchanged with BPA under an arrangement that would involve a trade of power between the members and BPA. An amount of power equal to the members residential loads as defined in the Regional Power Act could be exchanged with BPA under the residential exchange. BPA would pay for the power at a rate equal to the average system cost of the member and deliver a similar amount of power at BPA's wholesale rate.

The Project output could be used in the members' systems to serve their customers' loads. Then BPA would grant the members a billing credit that would be applied against their BPA bill. The amount of the credit would be equal to the amount that BPA saved by not having to acquire a similar quantity of electrical power.

The Project output could be sold to BPA. The members would continue to purchase their power requirements from BPA and would have the assurance that BPA would serve these requirements as I outlined previously in my testimony.

Q. Have you discussed these arrangements with BPA?

A. Yes, only in a preliminary way since the Project has not reached the the stage required for negotiating of the necessary contracts.

Q. How will the Project be operated?

A. The Project will operate under the Pacific Northwest Coordination Agreement. It will be operated to maintain the maximum power production possible with the flow in the Kootenai River less the spilling of at least a minimum of 750 cfs over the Spillway. The flow in the river depends on the water releases from Libby Dam plus the inflow between Libby Dam and the Project.

Q. How does Libby Dam usually operate?

A. Libby Dam usually operates within the following parameters. From March 1, to July 31st - (reservoir refill season) releases are maintained to hold the Reservoir at or below specified flood control rule curve levels. Discharge may be as small as 4,000 cfs, but is set to obtain a full reservoir level on August 1st. Following floods, releases may exceed turbine discharge capacity for short periods. In general, discharges do not vary greatly during a single day. Releases are made through the turbines as much as is feasible, although the sluices may be used to supplement the turbines when necessary. From August 1, to February 28th - (storage release season) releases are made for the production of power to help meet the load in the Pacific Northwest. During part of this time releases are 10,000 cfs to 20,000 cfs from 7AM to 7PM and at a usual minimum of 4,000 cfs from 7PM to 7AM from Monday through Friday with the usual minimum flow all day on Saturday and Sunday. During heavier load periods the releases may be 20,000 cfs to 24,000 cfs continuously or with variations from 16,000 cfs to 24,000 cfs during each weekday with releases usually varying on the above mentioned daily schedule. The releases during this period must lower the reservoir to the required flood control elevation on March 1st.

Q. What will be the elevation of the Reservoir behind the Dam?

A. The Reservoir will be controlled as near as possible to elevation 2000 at the Dam. This elevation will increase upstream from the Dam, the amount of increase depending upon the flow in the river. The fluctuation in levels at the upper end of the Reservoir will be the same as it is presently for the same change in flow in the river and will decrease through the Reservoir to no fluctuation at the Dam.

Q. Will the public have access to the Project area?

A. Yes, the public will continue to have access to all Project areas that are safe. The Applicant has an agreement with the Libby Lions Club to improve, operate, and maintain the Lions Club Park area and facilities for visitors to the Project area. The area between the railroad and river downstream from the Dam will be maintained as near as possible in its existing state.

Q. Will the area on the north bank of the river be available for use by the general public?

A. Yes, this area will be available for use by the general public if they can obtain permission for access from the various property owners.

Q. What Project areas will be controlled by fencing for safety reasons?

A. Access to the Dam on each side of the river and to the area immediately downstream of the Spillway from the south bank of the river will be controlled by fencing.

Q. Will the Powerstation be available for tours by the general public?

A. Yes, the Project will have a tour schedule during the tourist season and by special arrangements at other times during the year.

Q. Does this complete your testimony?

A. Yes.

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

MATTER OF)
NORTHERN LIGHTS, INC.)

PROJECT NO. 2752

AFFIDAVIT

STATE OF WASHINGTON)
) ss.:
COUNTY OF PEND OREILLE)

James A. Sewell, being duly sworn, deposes and says that he has read the attached prepared direct testimony of James A. Sewell, consisting of 16 pages and 6 accompanying exhibits and is familiar with the contents thereof, and that the matters of fact set forth therein are true and correct to the best of his knowledge, information and belief.

James A. Sewell

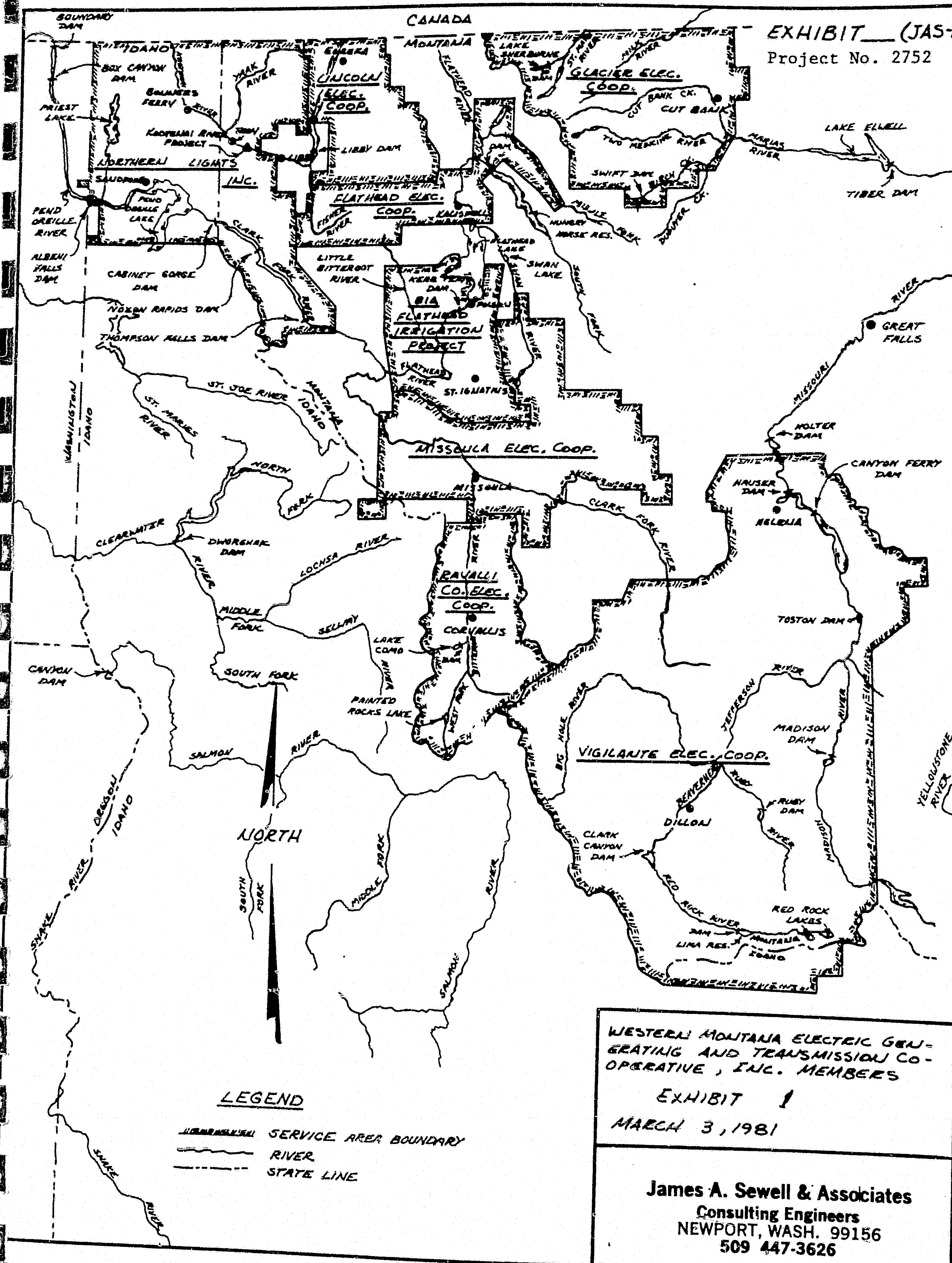
Subscribed and sworn to before me,
this 22 day of January, 1982

Robert Johnson
Notary Public

My commission expires Aug 18, 1983

List of Exhibits

Title	Exhibit No.
Western Montana Electric Generating and Transmission Co-Operative, Inc. Members Service Areas	___ (JAS-1)
1979 Membership Survey	___ (JAS-2)
Montana 42 Western - Estimated Annual KWH Consumptions of Residential Electrical Devices	___ (JAS-3)
Kootenai River Hydroelectric Project - Load Projections and Resources	___ (JAS-4)
Regulated Flows at Kootenai Falls with 1984 Canadian Flow Diversion - Average Monthly Projected Flows	___ (JAS-5)
Flow Duration Curve - Average Monthly Discharges, 1928-1968 - Libby Discharges with Canadian Flow Diversion	___ (JAS-6)


EXHIBIT__(JAS-1)
Project No. 2752
CANADA
MONTANA
IDAHO
BOUNDARY DAM
BOX CANYON DAM
PRIEST LAKE
BONNERS FERRY
KOOTENAI RIVER PROJECT
NORTHERN LIGHTS INC.
SANDPOINT
PEND OREILLE LAKE
PEND OREILLE RIVER
ALBENI FALLS DAM
CABINET GORGE DAM
NOXON RAPIDS DAM
THOMPSON FALLS DAM
EUREKA
LINCOLN ELEC. COOP.
LIBBY DAM
FLATHEAD ELEC. COOP.
KALISPELL
FISHER RIVER
LITTLE BITTERROOT RIVER
KERR DAM
BIA FLATHEAD IRRIGATION PROJECT
FLATHEAD RIVER
ST. IGNATIUS
SWAN LAKE
HUNGRY HORSE RES.
LAKE SHERBURNE
GLACIER ELEC. COOP.
CUT BANK CK.
CUT BANK
TWO MEDICINE RIVER
SWIFT DAM
MARIAS RIVER
LAKE ELWELL
TIBER DAM
GREAT FALLS
MISSOURI RIVER
HOLTER DAM
CANYON FERRY DAM
HAUSER DAM
HELENA
TOSTON DAM
MISSOULA ELEC. COOP.
MISSOULA
CLARK FORK RIVER
ST. JOE RIVER
ST. MARIES RIVER
WASHINGTON IDAHO
NORTH FORK
CLEARWATER
DWORSHAK DAM
LOCHSA RIVER
MIDDLE FORK
SELWAY
RAVALLI CO. ELEC. COOP.
CORVALLIS
LAKE COMO DAM
PAINTED ROCKS LAKE
WEST FORK
SOUTH FORK
CANYON DAM
SALMON RIVER
OREGON IDAHO
SNAKE RIVER
NORTH
BIG HOLE RIVER
JEFFERSON RIVER
VIGILANTE ELEC. COOP.
BEAVERHEAD
RUBY
RUBY DAM
MADISON DAM
MADISON RIVER
YELLOWSTONE RIVER
DILLON
CLARK CANYON DAM
RED ROCK RIVER
RED ROCK LAKES
LIMA RES.
MONTANA IDAHO
LEGEND
SERVICE AREA BOUNDARY
RIVER
STATE LINE
WESTERN MONTANA ELECTRIC GENERATING AND TRANSMISSION CO-OPERATIVE, INC. MEMBERS
EXHIBIT 1
MARCH 3, 1981
James A. Sewell & Associates
Consulting Engineers
NEWPORT, WASH. 99156
509 447-3626

(Your letterhead here)

Exhibit ___(JAS-2)
Project No. 2752

1979 MEMBERSHIP SURVEY

GENERAL INFORMATION ABOUT SERVICE

Account No.________

1. When is this service used?
   a. summer only
   b. winter only
   c. year around

2. How many people in the household?________________

3. Within which age group is the head of the household?
   a. younger than 30
   b. 31 to 45
   c. 46 to 60
   d. older than 60

4. Do you own or rent this residence?
   a. own b. rent

5. Where is this residence located?
   a. farm home
   b. recreational/part-time home
   c. suburban home
   d. rural home

BUILDING INFORMATION

6. What is the approximate size of the house?
   a. less than 1000 sq. ft.
   b. 1000-1499 sq. ft.
   c. 1500-1999 sq. ft.
   d. 2000 sq. ft. or more

7. What is the approximate age of the house?
   a. less than 5 yrs.
   b. 5-9 yrs.
   c. 10-19 yrs.
   d. 20-29 yrs.
   e. 30 yrs or older
   f. don't know

8. Is the house all electric?
   a. yes b. no

9. How is water supplied to house?
   a. public or private water company
   b. pumped from own well or spring

10. What type of structure is the house?
    a. one-story
    b. two-story
    c. mobile home
    d. multiple family

APPLIANCE INFORMATION

11. Primary source of space heating.
    a. oil
    b. wood
    c. natural gas
    d. bottled gas
    e. solar
    f. electric heat pump
    g. electric furance or baseboards
    h. other__________

12. Other sources of space heating.
    a. oil
    b. wood
    c. natural gas
    d. bottled gas
    e. solar
    f. electric heat pump
    g. electric furance or baseboards
    h. other__________

13. Primary source of energy for hot water.
    a. oil
    b. wood
    c. natural gas
    d. bottled gas
    e. solar
    f. electric
    g. other__________

14. Other sources of energy for heating water.
    a. oil
    b. wood
    c. natural gas
    d. bottled gas
    e. solar
    f. electric
    g. other__________

15. Primary source of energy to cook with.
a. wood d. electricity
b. natural gas e. other__________
c. bottled gas

16. Other sources of energy to cook with.
a. wood d. electricity
b. natural gas e. other__________
e. bottled gas

17. If you have a clothes washer, what type?
a. none
b. wringer washer
c. automatic
d. combination washer-dryer

18. If you have a clothes dryer, what type?
a. none c. electric
b. natural gas

19. Do you have a freezer?
a. yes b. no

20. What type of air conditioning do you have?
a. none
b. heat pump
c. central refrigeration unit
d. room units - how many__________
e. other __________

21. Do you plan to add air conditioning in the next 3 years?
a. yes b. no

22. Do you usually supplement your home heating equipment with portable electric heaters during the winter?
a. yes b. no

23. How many television sets do you have? __________

24. Do you have a microwave oven?
a. yes b. no

25. Do you have a dishwasher?
a. yes b. no

26. Do you plan to add or change space heaters and if so what type will the new heaters be?
a. no change f. solar
b. wood g. natural gas
c. oil h. bottled gas
d. heat pump i. other________
e. electric furnace or baseboards

27. Do you plan to add to or replace your existing hot water tank in the next 3 years and if so what type will the new heater be?
a. no change e. solar
b. wood f. natural gas
c. oil g. bottled gas
d. electric h. other________

28. Do you plan to change the type of energy used to cook with in the next 3 years and if so what will be the type of energy used?
a. no change d. bottled gas
b. wood e. electric
c. natural gas f. other________

OTHER USES OF POWER

29. Do you have other out-buildings connected to the same service as the house?
a. yes b. no

30. How many electrically heated out-buildings do you have?__________

31. How many electric stock water heaters do you have?__________

32. How many electric engine heaters do you have?__________

33. Do you have any irrigation pump connected to the same service?
a. yes b. no

34. List other major equipment using electricity not mentioned above that are connected to the service.
__________hp __________BTU

CONSERVATION MEASURES

35. In the past 3 years which of the following have you done?
   a. installed attic ventilation
   b. added or installed attic insulation
   c. added or installed wall insulation
   d. added or installed floor insulation
   e. added or installed storm doors & windows
   f. added weather stripping or caulking
   g. other conservation measures____________
   h. no added conservation measures taken

36. In the next 3 years which of the following conservation measures do you plan to undertake?
   a. install attic ventilation
   b. add or install attic insulation
   c. add or install wall insulation
   d. add or install floor insulation
   e. add or install storm doors & windows
   f. add weather stripping or caulking
   g. other conservation measures____________
   h. no added conservation measures planned

37. Do you currently have storm doors?
   a. yes   b. no

38. Do you currently have storm windows or double pane windows?
   a. yes   b. no

Exhibit ____ (JAS-3)
Project No. 2752

MONTANA 42 WESTERN

Estimated Annual KWH Consumptions of Residential Electrical Devices

User	KWH/Yr.
Electric Heat	
Northern Lights	19,710
Ravalli	19,701
Vigilante	21,060
Missoula	18,970
Flathead	23,000
Glacier	22,000
Lincoln	23,000
FIP	19,120
T.V.	300
Freezer	1,200
Washer	90
Electric clothes dryer	990
Electric range	1,200
Dishwasher	370
Electric water heater	4,800
Engine heater	500
Stock water heater	750

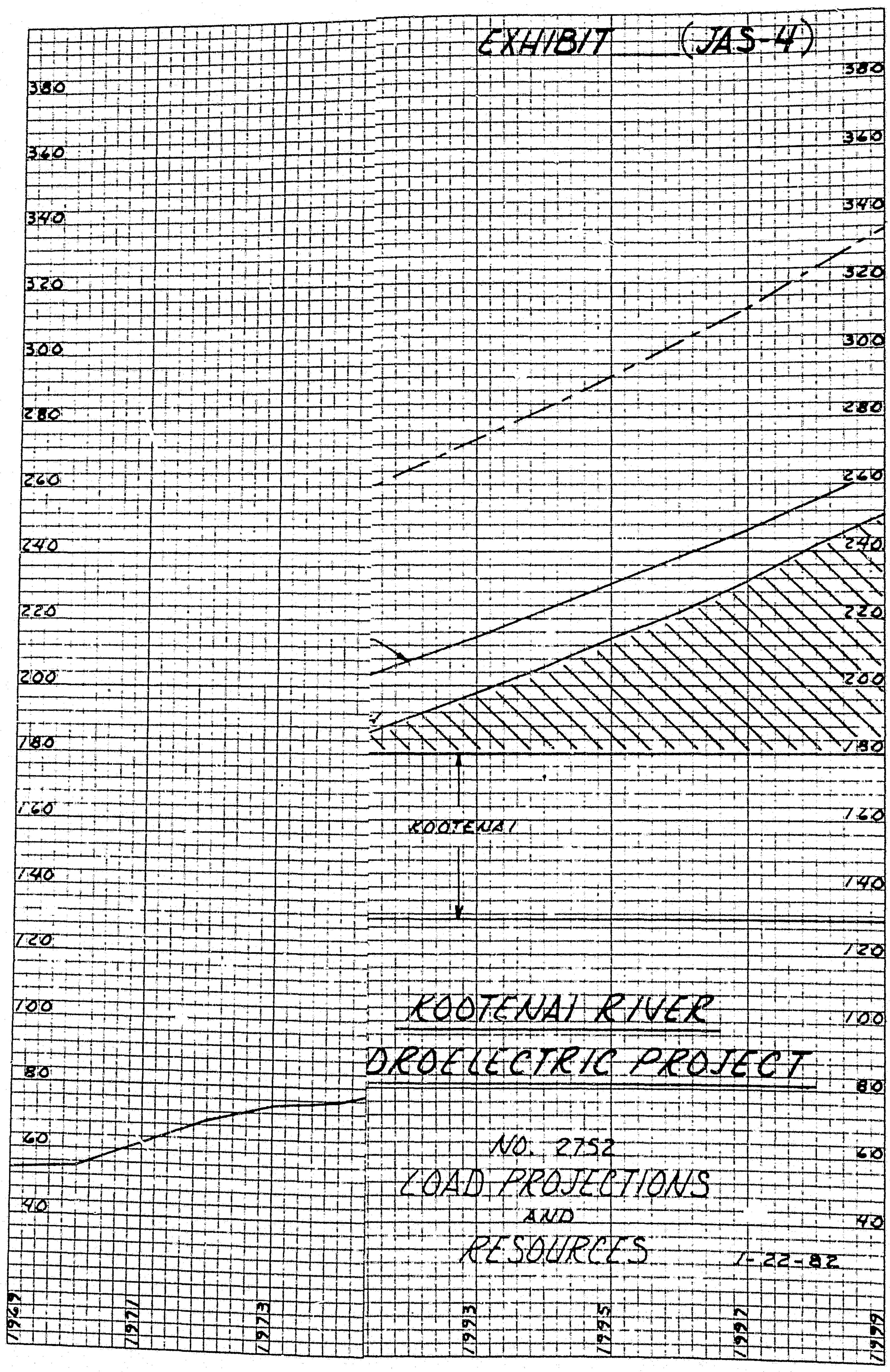


EXHIBIT (JAS-4)
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
KOOTENAI
KOOTENAI RIVER
DROELECTRIC PROJECT
NO. 2752
LOAD PROJECTIONS
AND
RESOURCES
1-22-82
1969
1971
1973
1993
1995
1997
1999

REGULATED FLOWS AT KOOTENAI FALLS WITH 1984 CANADIAN FLOW DIVERSION
AVERAGE MONTHLY PROJECTED FLOWS
IN CFS FOR 1928-68

Year	July	Aug.	Sept	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Ave.
28-29	24826	5145	4081	6282	13223	25156	6186	8274	3709	10359	5516	5759	9906
29-30	3976	3799	5668	6639	18815	23997	16093	3460	3580	5712	5440	5320	8580
30-31	4260	7396	3360	3821	19118	25205	12817	3391	3444	3804	6060	5320	8209
31-32	4580	6820	5167	8797	10760	12566	9673	9065	3900	5812	7860	5320	7522
32-33	4120	3728	3640	4223	9374	27082	19488	13173	6843	7608	13906	12666	10489
33-34	9789	6594	6555	8626	14433	21362	44072	21414	12688	15206	7917	7544	14669
34-35	12239	5820	6186	5115	12288	26000	9106	9520	5332	7531	14852	12383	10550
35-36	6716	7237	4476	6959	16621	26263	3134	8916	3662	14328	6620	5260	9174
36-37	3756	3262	3200	3216	13268	24847	15263	4166	3705	10117	6060	5120	8031
37-38	4280	3378	3242	3192	7494	18382	3556	6098	6305	12953	15344	10781	7924
38-39	3240	6565	3352	5915	14755	23413	3578	6690	3702	6530	5980	5761	7461
39-40	5679	5115	5169	5930	15293	21840	4016	3343	4213	9234	8764	7053	7995
40-41	3260	7699	3152	3240	12918	22992	5665	3840	3370	3630	4600	4642	6612
41-42	7160	8045	3224	3708	4257	18777	16658	13800	6163	5098	5800	10227	8565
42-43	13091	7253	6684	7260	11899	24279	21967	11567	5225	8218	6860	5880	10875
43-44	17847	6564	5277	5664	14323	24416	4261	7146	6507	7400	10765	4280	9576
44-45	3778	6007	4635	5743	11964	15902	9475	3789	6588	7198	4720	5220	7110
45-46	4100	3372	3212	4668	10769	17542	9155	3496	3832	9199	12452	5520	7309
46-47	15010	6059	6007	6023	13302	22340	17682	12772	8524	11014	15928	9137	12000
47-48	15080	5976	4962	11971	14130	29511	29713	19956	8090	12345	10572	8683	14248
48-49	19132	8254	5763	5650	13536	25062	4854	3487	3912	6982	14357	7897	9975
49-50	7584	6411	5404	5777	10996	26539	21092	13584	9196	10425	12662	12852	11884
50-51	10452	6875	4749	7716	13092	22387	39048	27009	9564	13599	8780	5120	13980
51-52	15157	8486	8805	11421	16404	27107	13583	11552	6000	11838	10733	6633	12331
52-53	14246	7356	6166	7053	17181	25083	3864	10515	5505	7150	7487	5440	9756
53-54	20332	6452	5016	5199	13701	25929	28607	20634	8905	9210	10084	7052	13419
54-55	26916	9923	8237	7264	15469	27058	14437	12165	6456	5220	7375	5360	12196
55-56	19261	6366	4849	7289	15792	21496	35600	21942	9465	17934	8000	4580	14358
56-57	19953	6892	5165	5922	13711	26145	5428	6029	5114	7478	19592	11891	11169
57-58	6856	7198	5395	5377	14407	21826	3836	3659	3952	7827	12491	10553	8645
58-59	9424	5654	4827	4130	13813	25041	27759	18186	8349	14053	11042	6364	12368
59-60	12274	7213	11217	9537	8478	28627	25160	13198	9247	15744	6220	5158	12699
60-61	11403	6414	4524	5068	13706	25434	26654	16724	8953	8673	8316	11124	12243
61-62	11024	5754	7114	5624	14021	25779	7081	8145	4118	9889	8781	7042	9543
62-63	12587	5414	4617	5440	14431	26560	11098	11941	5952	4930	5222	7255	9621
63-64	16571	6353	5026	6165	12910	25664	15513	12704	5698	6386	7046	11074	10934
64-65	15726	6219	5387	7145	14510	21132	23599	15915	7715	7520	6702	4996	11379
65-66	18659	6518	6128	6327	14593	26225	20415	14656	7643	7402	8016	7645	12031
66-67	14530	6586	4900	6069	12611	25634	28134	17655	8227	6793	8530	10739	12533
67-68	16671	7164	5145	5664	14290	25585	23106	5901	4616	11505	5730	4596	10893
Ave.	11639	6333	5242	6171	13416	23905	16011	10987	6199	9097	9080	7381	10469

Exhibit ____ (JAS-5)
Project No. 2752

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

NORTHERN LIGHTS, INC.) PROJECT NO. 2752

DIRECT TESTIMONY OF ARTHUR E. ALLEN
ON BEHALF OF NORTHERN LIGHTS

Q. Please state your name and business address.

A. My name is Arthur E. Allen. My business address is Harza Engineering Company, 150 South Wacker Drive, Chicago, Illinois 60606.

Q. What is your educational and experience background?

A. I received a B.S. degree in Civil Engineering from Carnegie Institute of Technology (now Carnegie Mellon University) in 1938, followed by an M.S. Degree in Civil Engineering in 1939 from the same university.

I have 37 years experience in hydraulic and hydro-electric engineering since 1939. This consisted of one year with the U.S. Army Corps of Engineers, Pittsburgh District, 15 years with the Aluminum Company of America and 21 years with Harza Engineering Company.

My present position is Vice President, and Chief of Senior Professional Staff of Harza Engineering Company. The Senior Professional Staff is a group of engineers who have long experience and who advise younger engineers, review reports for completeness and accuracy, specify planning and design criteria for projects, and handle difficult and complex individual assignments.

My work with Harza has involved projects ranging from a few megawatts to 10,000 megawatts. I have analyzed river, spillway, and tunnel hydraulics, planned tunnels, dams, spillways, and powerstations, studied power and energy production, participated in selection of turbines, generators, and control systems, and testified in legal proceedings. One legal proceeding was for the State of Illinois in the United States Supreme Court original jurisdiction suit concerning withdrawal of water from Lake Michigan.

I was Project Manager of the Seneca Pumped-storage Project (FERC No. 2280) from initial planning through construction, and continue to perform services for the project owners. I have been a Registered Professional Engineer for 30 years and now am a Registered Professional Engineer in eight states.

Q. What is your connection with the Kootenai River Hydroelectric Project?

A. I have been the Project Manager for the work by Harza Engineering Company for the Kootenai River Hydroelectric Project. My association started in 1978 and has continued to date. The work consisted of directing and participating in studies of development of the Project, which were used in preparing the License Application to FERC. The work was performed in conjunction with James A. Sewell & Associates. My work utilized specialists, engineering and environmental, of Harza's organization. My testimony describes the Project generally and relies upon the testimony of Mr. Sewell and of witnesses from Harza. The Harza witnesses on whom I rely and the subjects of their testimony are as follows:

Earl E. Komie, Geology
Henry H. Chen, Economics
Svante E. Hjertberg, Construction Methods and Cost
B. K. Lee, River and Reservoir Hydraulics
John R. Bizer, Aquatic Habitat and Water Quality
Robert E. Lindsay, Terrestrial Environment
Peter L. Ames, Birds
Rick K. Suttle, Visual and Recreation

Q. What was the scope of the studies you directed or in which you participated for the Kootenai River Hydroelectric Project?

A. The studies began after the Preliminary Permit was issued and could be divided into the following major components:

(1) Analyzing alternative hydroelectric plant sites to arrive at the most favorable site.

(2) Analyzing ways of developing the most favorable site to obtain the most favorable plan.

(3) Studying and refining the most favorable plan to accomplish two purposes. The purposes were:

(a) Develop details sufficient for the License Application to FERC.

(b) Subsequent to filing the License Application to FERC, modifying and improving details as desirability or need was shown during the review procedure while the Environmental Impact Statement was being prepared.

Q. What basic principles guided your studies of alternative hydroelectric sites?

A. The first principle was consideration of hydroelectric sites within reasonable distance of the area served by the eight utilities who plan to take the output of the Project. These eight utilities are members of the Western Montana Electric Generating and Transmission Cooperative and are hereafter referred to as "G&T".

Q. I show a map marked as Exhibit ___ (AEA-1). Was this map prepared under your supervision?

A. Yes, it was.

Q. What does Exhibit ____ (AEA-1) show?

A. Exhibit ___ (AEA-1) shows the western part of Montana, the northern part of Idaho, and the northeastern part of Washington, and the outline of the service areas of the G&T.

Q. What use did you make of Exhibit ___ (AEA-1)?

A. The G&T contains service areas scattered over approximately 30,000 square miles. The extreme dimensions of the area served are approximately 230 miles from east to west and 280 miles from north to south. There are large transmission and distribution distances within the area.

The preferred location for a new source of generation is within the area and near transmission lines that can deliver power to the service areas with minimum line losses and transmission charges. Thus, the exhibit shows roughly the limits of the area to be considered and the availability of existing transmission corridors.

Q. What alternative hydroelectric sites did you select for study on the basis of Exhibit ___ (AEA-1)?

A. The first sites considered were within Montana. The first consideration was of river systems and basins, rather than individual sites. A basic factor that appeared quickly was the difference between the seasonal pattern of flows on many streams and the annual load pattern of the G&T. Montana streams naturally have comparatively low flow in autumn and winter, with very high flow during snow melt season in the spring and with the high flow continuing, but gradually reducing, into the summer.

The G&T's peak loads occur in winter. There is an irrigation pumping load in the summer, but there are large heating loads in winter. One service area has a summer peak, but overall summer loads are less than winter loads. Thus, the natural flow distribution of streams in the area is not suited to the loads of the G&T. The streams most suitable are those having artificial regulation that controls the seasonal distribution of water so that it corresponds more nearly to seasonal variations in power requirements.

Within Montana there are not many suitable locations One site, as an illustration, that was available but not suitable is on the Missouri River at Toston, Montana. At that site an irrigation drop could provide about 10 MW. Seasonal flow regulation benefit at Toston is relatively minor, and power production is mostly during irrigation season. The same would be true at other sites along the Missouri and Yellowstone Rivers. Nothing of reasonable size or with seasonal production suitability would have been available, so further detailed checks of the Missouri and Yellowstone Rivers were not made.

The Milk River basin has few, if any, significant power sites available, and even these have the same undesirable flow distribution. The Yaak River has a few sites, but requires a large storage reservoir for seasonal flow regulation. A large storage reservoir would be objectionable environmentally because it would flood a large portion of the Yaak Valley.

The Flathead and Kootenai Rivers have seasonal flow regulation provided by large storage reservoirs that redistribute the flow of water so it is more closely related to power needs. The Flathead regulation is provided by Hungry Horse and Kerr Reservoirs; the Kootenai regulation is provided by Libby Reservoir.

There are a number of sites along the Flathead River between Kerr Reservoir (Flathead Lake) and the junction of the Flathead and Clark Fork Rivers. The sites were being investigated by the Corps of Engineers when this Project was being planned. I understand that the Corps has not yet found any of the sites sufficiently attractive for construction. If the sites were developed, they would be part of the Bonneville power pool and only a small portion of the power output would be available to the G&T. The Middle Fork, North Fork, and remaining undeveloped portion of the South Fork of the Flathead River are designated either as wild and scenic or as recreational rivers, so that they are unavailable for power development. The Glacier View site, once proposed for Federal development, is unavailable because of its effect on National Park land. Elsewhere, the Flathead does not have suitable or available sites or involves expensive highway and railroad relocation. For example, the Paradise site involves major relocations.

Major sites on the Clark Fork River already are developed. Sites remaining have undesirable characteristics or involve expensive highway and railroad relocations. Sites in Montana other than on the Kootenai River were rejected without further investigation because of the various factors involved.

On the Kootenai River there are several alternative sites available.

Q. Before discussing the Kootenai River, did you consider hydroelectric sites outside of Montana?

A. Yes. There are several rivers in Idaho that were considered briefly. The Salmon, North Fork Clearwater, South Fork Clearwater, Selway, and Lochsa Rivers have power sites. The Salmon River and parts of the North Fork Clearwater, Selway, and Lochsa are unavailable because of Federal designation as "wild and scenic" or "recreational" rivers. The other rivers are in the Clearwater or Bitterroot National Forests. Sites on these rivers have been considered for Federal development, but have not been developed for various reasons. Some of the sites are in designated or proposed "wilderness areas" and are not available. The environmental controls on any sites that may be available could be expected to be extremely strict.

The St. Joe and St. Maries Rivers may have power sites, but there are highways and railroads whose relocation would be expensive. Their seasonal flow distribution also is not suited to the G&T's loads.

The sites in Idaho, other than on the Kootenai River, also are somewhat distant from the G&T loads. The country generally is very rugged, which would make transmission lines expensive, apart from the routing restrictions imposed because of "wilderness areas", "wild and scenic rivers", and "recreational rivers". There are BPA and Washington Water Power transmission lines that might be utilized to the extent that unused transmission capacity is available, but transmission routings would be complex and toll charges would be relatively high.

Sites in Idaho other than on the Kootenai River were not investigated in detail, but from the general assessment none appear suitable or justifiable to the G&T.

Q. Returning to the Kootenai River, what facts were developed in your investigation of availability of hydroelectric sites?

A. The Kootenai River is very attractive for hydroelectric development because of large flow of water. The Kootenai River is the third largest tributary of the Columbia. Table 1 shows basic information on drainage area and mean runoff at locations along the Kootenai River, going upstream from where it leaves Idaho and enters British Columbia to where it enters Montana from

Canada. The table also shows the names of gaging stations and their distance upstream from where the

Table 1

KOOTENAI RIVER BASIN HYDROLOGIC DATA

Location	Drainage Area Square Miles	River Mile	Mean Water Surface Elevation	Annual Discharge cfs	Period of Record
Port Hill, ID	13,700	105.6	1,745	16,040	1928-1978
Copeland, ID	13,400	124.2	1,745	15,640	1930-1978
Bonners Ferry, ID	13,000	152.8	1,748	15,250[1]	1927-1978
Leonia, ID	11,740	171.6	1,804	14,020	1928-1978
Libby, MT	10,240	204.3	2,045	12,190	1911-1978
Libby Reregulating Dam site	9,960	211	2,075	11,770[1]	
Libby Dam Tailwater	8,985	221.0	2,110	11,070[3]	
Canadian border near Rexford, MT	7,660	2.1	2,315[2]	10,520[4]	1930-1972

1/ Computed by difference of drainage areas; not published by USGS.

2/ Approximate natural elevation. The river usually is submerged by Libby Reservoir, which operates between elevations 2287 and 2459.

3/ 11,830 cfs during 1971-1976. Mean computed from 12,190 cfs at Libby.

4/ Gage now abandoned.

the Kootenai River enters Canada. The approximate mean water surface elevation at each station also is shown.

Table 2, which is derived from Table 1, shows the power available in sections of the Kootenai River under present flow conditions and after Canada exercises its right to divert 1,500,000 acre-feet per year at Canal Flats, B.C., upstream from Libby Reservoir. The Canadian diversion is equivalent to a mean diversion of 2,070 cfs, and by treaty could start in 1984. Power available is proportional to the product of head and discharge.

Table 2

KOOTENAI RIVER - POTENTIAL POWER

Location	Distance Between Locations, Miles	Approx. Fall or Head, Feet	Present Stream Flow: Mean Discharge, cfs	Present Stream Flow: Mean Power Output, kw	After Diversion: Mean Discharge, cfs	After Diversion: Mean Power Output, kw
Port Hill, ID						
	47.2	3	16,040 (15,645)	3,400	13,970 (13,575)	3,000
Bonners Ferry, ID						
	18.8	56	15,250 (14,635)	60,000	13,180 (12,565)	51,000
Leonia, ID						
	32.7	241	14,020 (13,105)	230,000	11,950 (11,035)	193,000
Libby, MT						
	16.7	65	12,190 (11,630)	55,000	10,120 (9,560)	45,000
Libby Dam Tailwater, MT						
	50	205	11,070 (10,795)	160,000	9,000 (8,725)	130,000
Canadian Border Near Rexford, MT			10,520		8,450	

Notes

Discharges in parentheses are numerical averages of flow at stations immediately upstream and downstream, and represent a basic flow to be used for energy evaluation.

The power between Libby Dam Tailwater and the Canadian border near Rexford, MT, already is developed and is shown only to indicate relative magnitude.

Q. How is the foregoing information related to the studies of the Kootenai Hydroelectric Project?

A. The foregoing information shows that the most favorable power development is within a few miles along the Kootenai River, primarily between Bonners Ferry and Libby. An item not shown in the information is the beneficial flow regulation provided by Libby Dam and Reservoir. Releases from Libby Reservoir are made on a coordinated basis under the Pacific Northwest Coordination Agreement for power production, consistent with other requirements. Power and flood control purposes are served by retaining water in Libby Reservoir in the spring and summer periods of high runoff and releasing the retained water in the normally drier fall and winter. The largest releases are in winter, when the G&T's loads are maximum. Thus, a powerplant on the Kootenai River will produce power seasonally more nearly in proportion to the G&T's loads than will a plant on a river not having such regulation. Even if the generation is not completely proportional to the loads, the generation will be part of a controlled optimum pattern of generation in Bonneville territory. A plant outside Bonneville territory would not have the benefit of the water storage reservoirs in the Bonneville system.

There is one significant factor tending to favor a power plant near Libby Dam over a plant farther downstream. The 10,120 cfs mean annual discharge at the Libby Gage after Canadian diversion begins will be almost entirely regulated by Libby Reservoir. Going farther downstream along the Kootenai River, the unregulated component of river discharge increases. Table 2 shows that, at Bonners Ferry, approximately 3,060 cfs of the mean annual 13,180 cfs, or 23 percent, is timed by natural hydrologic factors rather than by power requirements. Thus, a plant nearer Libby is more suitable for the G&T's power needs than a plant farther downstream from Libby, other factors being equal.

With the foregoing information as background, a number of potential powerplant sites were located on the Kootenai River by map study and analyzed.

Q. I show you a map marked as Exhibit ___ (AEA-2). Was the exhibit prepared under your supervision?

A. Yes.

Q. What is shown by Exhibit ___ (AEA-2)?

A. Exhibit ____ (AEA-2), shows the Kootenai River in Idaho and Montana, with the locations of several important items that are involved in the study of alternative hydroelectric plants on the Kootenai River. The major points shown on the exhibit are as follows:

1. Locations of Libby Dam and the USGS gages at Libby, Leonia, Bonners Ferry, Copeland, and Port Hill.

2. The towns of Libby, Troy, and Bonners Ferry.

3. The Albeni Falls-Libby transmission line. Note that Albeni Falls, which is on the Pend Oreille River, is off the map a short distance to the southwest.

4. Five alternative hydroelectric sites investigated by Harza. All of the sites are reasonably close to the transmission line, and would require relatively short new lines to connect to the present line.

The approximate elevation of the river at the alternative dam sites and the estimated river discharges at the sites are shown in Table 3. Using the basic data of Table 3, a number of alternative dam heights were analyzed briefly at each site. Table 3 summarizes studies made at various times between 1978 and the present. In the License Application to FERC a relatively large number of subalternatives were considered in a very preliminary way at each alternative site. The consideration was sufficient only to demonstrate their cost comparisons with the Kootenai River Project under cost assumptions and tailwater assumptions favorable to the alternative sites. Some subalternatives with less head than those listed in Table 4 were analyzed in the License Application but were found to be very impractical; these are not listed in Table 4.

Table 3

KOOTENAI RIVER - ALTERNATIVE POWER SITES

Site Name	Location River Mile	River Elevation	Mean Annual Discharge - CFS Estimated Total	Mean Annual Discharge - CFS Estimated Usable
Katka	165.2	1781	11,960	11,300 2/
Rocky Creek	173.4	1817	11,950	11,290 2/
Ruby Creek	181.1	1842	10,700	10,100 2/
O'Brien Creek	187.1	1877	10,300	9,730 2/
Kootenai River				
Foot of Rapids	192	1894 1/	10,120	9,350 3/
Head of Falls	193	1970		

1/ Water elevation at approximately 2,750 cfs.

2/ 5.5 percent of total flow assumed to be lost by spilling

3/ 750 cfs is specified as discharge through the river when inflow to the site is less than turbine discharge capacity plus 750 cfs. An additional 20 cfs average allowance is allowed for spilling.

After the FERC Application was filed, the Montana Department of Natural Resources and Conservation stated that their procedures required more detailed investigation of the alternative sites, not only for structures and costs, but also for environmental impact. Accordingly, a cooperative program was adopted between the Applicant and MDNRC whereby the Applicant made a reconnaissance-grade study of the alternative sites in more detail than was done for the FERC Application and MDNRC made a similar study of the environmental effects. The combined reports from the study then would be suitable for MDNRC purposes. Table 4 summarizes some of the results of the Applicant-MDNRC study. Some of the energy production figures are revised slightly from previous studies based on subsequent study refinements, but their general magnitudes are the same.

Table 4

KOOTENAI RIVER - POWER AND ENERGY CAPABILITY AT ALTERNATIVE SITES

Site Name	Alternative Project Reservoir Elevation	Dam Height Feet	Plant Max. Head Feet	Plant Mean Net Head Feet	Plant Mean Annual Output: Power MW	Plant Mean Annual Output: Energy GWh	Capacity with All Units Running, MW
Katka	1817	36	36	30	24.6	216	50
	1862	81	81	75	61.6	540	138
Rocky Creek	1842	25	25	19	15.6	136	29
	1857	40	40	34	27.9	244	59
	1868	51	51	45	36.9	323	80
Ruby Creek	1869	27	27	21	15.4	135	33
	1877	35	35	29	21.3	186	48
O'Brien Creek	1897	20	20	14	9.9	86	20
Kootenai River	1990	20	97	78	52.17	457	125
	2000	30	107	88	58.83	515 1/	144
	2005	35	112	93	62.16	544	151

1/ If average turbine discharge at the Kootenai River site could be increased by 750 cfs, mean annual energy output at reservoir elevation 2000 would be approximately 556 GWH.

Q. Describe the general approach you used in studying the alternative sites.

A. The Applicant's studies of the alternative sites consisted of the following:

1. Studies of plant location and layout using USGS topographic maps at a scale of 1 inch equals 2,000 feet.

2. Studies of geologic publications, as described by Witness Komie.

3. Visits to the sites by two engineers and a geologist involved in the studies, as described by Witness Komie.

4. Development of conceptual plant layouts and cost estimates based on study components 1 to 3 above.

The layouts and estimates considered the following factors:

A. Foundation conditions for dams, powerstations, and spillways.

B. Cofferdam and diversion problems, and construction sequences related to temporary diversion of the river.

C. Railroad relocation details. The railroad is the transcontinental main line of the Burlington Northern, for which there are strict standards of grade and curvature.

D. Highway relocation details.

E. The proximity of major faults, such as the Leonia Fault, and other faults, such as the Savage Lake-O'Brien Creek Fault.

F. The proximity of the town of Troy to the reservoirs of some of the alternative sites.

G. Turbine discharge capacity. As Witness Sewell explains, and as is discussed later in my testimony, the Kootenai River Project is designed with turbine discharge capacity of approximately 24,000 cfs. At the alternative sites it was considered reasonable to add the mean runoff between the Kootenai River site and the alternative sites to 24,000 cfs to obtain turbine discharge capacity at the alternative sites. The resultant turbine discharge capacities were 26,000 cfs at Katka and Rocky Creek, and 25,000 cfs at Ruby Creek and O'Brien Creek.

H. The rise in tailwater level between small discharge and large discharges. At Kootenai

River, the tailwater rise is much larger than at any of the alternative sites but the rise is a major factor at all of the sites.

I. The general type of plant layout and its effect on head loss in water conduits.

The studies resulted in maps, layout drawings, and cost estimates. However, the site visit showed that the Ruby Creek and O'Brien Creek sites had foundation difficulties so serious that construction would be prohibitively expensive under present conditions. Therefore, the Ruby Creek and O'Brien Creek sites were not studied further. The reconnaissance studies were completed for Katka and Rocky Creek. The Kootenai River Site, being the most favorable, was investigated in more detail than the other sites.

Q. I show you a map marked as Exhibit ___ (AEA-3). Was it prepared under your supervision?

A. Yes.

Q. Please describe what it shows.

A. Exhibit _____ (AEA-3) is a reduced-scale copy of the USGS quadrangle maps of the portion of the Kootenai River in which there are feasible alternative power sites. The map shows the following information:

1. The location of Katka, Rocky Creek, Ruby Creek, and O'Brien Creek sites. Ruby Creek and O'Brien Creek are shown primarily for comparison with the data in the License Application, even though they were found to be undesirable.

2. The reservoir outlines are shown for the subalternatives of Katka and Rocky Creek. The subalternatives are designated by the site name and reservoir elevation. For example, a plant at Katka with reservoir elevation 1817 is designated as "Katka 1817".

3. The extents of railroad relocations for which cost was estimated in a very preliminary way in the License Application are shown by the words "Application Railroad Relocation."

4. The railroad relocations developed in the reconnaissance study are shown by the designations "Alternative I, II, or III Railroad Relocation."

The combinations of alternative sites that provided the closest approach to the Kootenai River site in power output, energy output, and cost at November 1981 price level were found to be as shown in Table 5.

Table 5

ALTERNATIVE SITES - COST COMPARISON

Project	Rated Generating Capacity MW	Annual Energy Production GWH	Construction Cost $ Million
Alternative I - Single-Dam Project			
Katka 1862	138	540	$375
Alternative II - Two-Dam Project			
Katka 1817	50	216	$275
Rocky Creek 1868	80	323	192
	130	539	$467
Alternative III - Kootenai River 1990 with a Downstream Plant			
Kootenai River 1990	125	457	$218
Rocky Creek 1857	59	244	164
	184	701	$382

Alternative III combines Kootenai River 1990 with a downstream plant to recover the loss of capacity and energy in lowering the Kootenai River reservoir from the proposed Elevation 2000 to Elevation 1990. The total energy so obtained exceeds availability from Kootenai River 2000 because Rocky Creek 1857 has the lowest dam and develops the lowest head that are practicable for the site. A lower dam at Rocky Creek would have head too small for operation during large flows.

Q. In Table 4, the difference between plant maximum head and plant mean net head is much more at the Kootenai River site than at the Alternative sites. Why is the difference more at Kootenai River?

A. The large difference between maximum head and mean net head at Kootenai River reflects two major factors. The first factor is the much larger rise in tailwater level as discharge increases, which already has been mentioned. The second factor is the difference in basic layouts of the plants. At Katka and Rocky Creek the powerstation would be in the river, so that the water conduits are short, and head loss is small. At Kootenai River, as will be explained later, the powerstation cannot be located in the river and it is necessary to divert water from the river for generation. The site topography is such that development of the maximum feasible head required diversion and return points nearly one mile apart. The relatively long water conduits involve larger head loss than would be experienced at Katka or Rocky Creek.

Q. In Table 3 you estimate a larger utilization of the total river discharge for producing energy at the alternative sites than at Kootenai River. Why is this?

A. Powerstations at the alternative sites could utilize all water in the river up to turbine discharge capacity to produce energy. At intervals large discharge from Libby or large local run-off would produce river flows exceeding turbine discharge capacity. Such excess discharges were not analyzed in detail, but loss of 5.5 percent of the flow, or utilization of 94.5 percent of the flow appears reasonable. At Kootenai River the Applicant decided that a minimum flow of 750 cfs should be maintained in the river between diversion and return points at all times. Witness Chen discusses the determination of the amount in his testimony.

The loss of the 750 cfs reduced annual generation of Kootenai River 1990 from 484,000,000 kilowatt hours to 457,000,000 kilowatt hours. There is similar loss of energy for higher reservoir elevations at the Kootenai River site.

Q. Returning to Exhibit ____ (AEA-3), continue your explanation of what is shown.

A. The reservoir outlines show the extent of land coverage by the reservoirs of the alternative sites. The map scale is small, but several facts can be seen.

For Katka 1817, the reservoir is in a narrow canyon and inundates a comparatively narrow margin of land along each shore. However, the reservoir would inundate the railroad.

The Katka 1862 reservoir is considerably longer than the Katka 1817 reservoir. As far upstream as the Yaak River the Katka 1862 reservoir also is in narrow canyon, but upstream of the Yaak River the reservoir would cover some flat lands along the river shore. The Katka 1862 reservoir would extend nearly to Troy under low-flow conditions and the backwater effect probably would extend farther upstream during large river discharges.

The Rocky Creek 1857 reservoir does not appear very clearly on the middle drawing on the exhibit because of the steep hillsides and similarity to Katka 1862, but the upstream end shows on the lower drawing.

The Rocky Creek 1868 reservoir covers somewhat more flat-land area than does the Katka 1862 reservoir and Rocky Creek 1868 extends farther upstream, to a point upstream of Troy. During large discharges the backwater effect of Rocky Creek 1868 would be more critical with respect to Troy than the backwater effect of Katka 1862.

The other important fact shown by the exhibit is the change in concept of railroad relocation from the side-hill relocations considered in the License Application. In general, the geologic structure of the canyon sides is unsuitable for a side-hill railroad relocation. The rock dip and jointing would require very large and expensive rock cuts. In some locations there is indication of historic hillside slides, so that it seems desirable to disturb hillsides as little as possible with railroad relocation. In several locations long and high bridges would have been required to cross streams.

The net result to avoid these difficulties is that railroad relocations would involve long tunnels. For Alternatives I and II (the single-dam and two-dam alternatives) there would be a railroad tunnel with its west portal approximately 2,000 feet downstream from Katka damsite and extending 50,200 feet (nearly 10 miles) to its east portal at a point approximately 2,000 feet upstream from Rocky Creek damsite. The tunnel would be the longest main-line railroad tunnel in the United States. From the east portal, upstream, the topography is more suitable for a side-hill relocation.

The Rocky Creek 1857 and 1868 subalternatives also would require a railroad tunnel, as shown for Alternative III on the exhibit. It would be shorter and on steeper grade than the tunnel for Alternatives I and II. However, it would be a major structure approximately 15,000 feet long.

The railroad relocation was a major cost factor at all sites except Kootenai River. At the alternative sites railroad relocation cost was approximately one-third of the total.

Q. Tables 3, 4, and 5 and Exhibit ___ (AEA-3) show alternative plants only at the Kootenai River Site and at points downstream. Why are there no sites upstream?

A. Sites upstream from the Kootenai River Site were not considered, for the following reasons:

(1) The Corps of Engineers had already preempted the site of the Reregulating Dam, which develops all head between that site and Libby Dam. In fact, construction began while studies of the Kootenai River Project were underway. Construction since has ceased pursuant to an order of a Federal District Court. Although construction has not resumed, use of the site by any entity other than a Federal Government agency appears to have very poor prospects.

(2) Any site between the Kootenai River site and Libby would run the risk of flooding parts of the town of Libby. Furthermore, the head available between the Kootenai River Site and the Libby USGS Gage, as shown by Table 1, is not more than 45 feet. The mean annual energy available thus is only approximately 290,000,000 KWh, which is much less than would be produced at Kootenai River. In addition, we considered that the environmental impacts and

relocation problems of development upstream from the Kootenai River site would be unacceptable.

Q. Could you summarize the conclusions obtained from studying the alternative power sites along the Kootenai River?

A. Tables 3, 4, and 5 and Exhibit ___ (AEA-3) show several important facts relative to the alternative sites. These facts are:

1. At sites other than Kootenai River, the dam height is not less than the head available. At the proposed Kootenai River site the dam height is a small part of the head. In general, both cost and environmental impact of the Dam and Reservoir can be expected to be less at Kootenai River.

2. Katka is the only site at which power and energy could be developed in quantities comparable to the capability of the Kootenai River site.

3. The Kootenai River site floods less length of river and has less potential effect on inhabited areas than any alternative plan supplying approximately the same power and energy.

4. The Kootenai River site costs less to develop per unit of power than any alternative site. The logical procedure was to concentrate studies at the Kootenai River site.

Q. Will you describe the general pattern of studies of the Kootenai River site?

A. Studies of the Kootenai River site began using USGS quadrangle maps at scale 1 inch to 2,000 feet and expanded in detail as site investigations were conducted. The investigations were directed partly as original findings of information and partly to answer specific questions as planning advanced. Project layouts, cost estimates, and environmental appraisals were developed as planning proceeded. I will describe the plans in general; other witnesses will describe optimization, construction planning, cost estimates, and environmental details.

Q. On what basis did the studies of the Koctenai River site begin?

A. The studies began by selecting a site for the dam. At sites where a river has comparatively steep slope for a short distance, as the Kootenai River has at the Project site, two alternatives can be considered. One alternative is to build a comparatively small dam at the upstream end of the steep section of river and connect the resultant reservoir to the lower water level downstream by waterways, with a powerstation located at some intermediate point or at the downstream end to develop the power and energy. The waterways might be canals, tunnels, steel penstocks, or a combination. The other alternative is to build a comparatively high dam at the downstream end of the steep section and locate the powerstation next to the dam or within the dam, which shortens the length of waterways and reduces head loss to a minimum.

At the Kootenai River site geologic and environmental conditions at the downstream end of the steep section made a dam impractical. At the left abutment, there are several difficulties. These are a zone of sheared rock, U.S. Highway 2, and the Burlington Northern Railroad. The right abutment was not investigated in detail but it has questionable foundation conditions. The various problems were indicated without detailed evaluation to be such that the second alternative of a high dam would be impractical, so that the first, or low dam and long waterway, alternative was adopted.

Topographic maps and visits to the site showed quickly that the most favorable conditions for a dam would be just upstream from the upper end of the steeply-sloping section of the river. The site of the dam has been selected, although there is possibility that more detailed geotechnical investigations following issuance of a license will cause the site of the dam to be moved a few feet.

The layout of the Kootenai River Hydroelectric Project in the FERC Application was developed by a series of successive steps, each involving additional information and analysis.

The early layouts relied on the Kootenai Falls 7.5-minute quadrangle map published by the USGS and a brief site reconnaissance. Later layouts were based on topographic maps which were developed from surveys at the site. Later layouts utilized the results of a limited program of site investigation.

Q. Describe the first layout that was developed for the Kootenai River site.

A. The first layout was developed primarily to present to FERC a concept for study under a Preliminary Permit. The layout is discussed best with the aid of drawings.

Q. I show you two drawings, one marked as Exhibit ___ (AEA-4) the other marked as Exhibit ___ (AEA-5). Were they prepared under your supervision?

A. Yes.

Q. Describe what they show.

A. Exhibit ____ (AEA-4) shows the general plan of the Project that was in the Application to FERC for the Preliminary Permit.

Exhibit ____ (AEA-5) shows the profile through the waterways and powerstation and the plan of the intake, penstocks, powerstation, and tail tunnel outlet in the same layout. For discussion, the Preliminary Permit layout is called "Layout 1".

Layout 1 had the following major characteristics:

Reservoir El. - 1990
Tailwater El. - 1900, approximately, as stated on Exhibit ___ (AEA-5)
Gross Head developed - 90 ft. (approx.)
Power installation - 140 MW

The tailwater elevation was obtained from preliminary assessment before any surveys were made. Later studies showed that the tailwater level would be higher.

The distinguishing features of Layout 1 were as follows:

1. A pit-type powerstation about halfway between the reservoir and tailwater, as shown on Exhibit ___(AEA-5).

2. A long, open canal between the reservoir and powerstation, as shown on Exhibit ___ (AEA-4).

3. The tail tunnel essentially paralleling the river from the powerstation to the tail tunnel outlet, as shown on Exhibit ___ (AEA-4). The outlet would have been a few hundred feet upstream from the present outlet location.

All project structures except part of the primary transmission line would have been between the railroad and the river. The location of the primary transmission line was left for later selection.

Layout 1 and subsequent layouts were evaluated on a preliminary, qualitative basis for strong, or favorable, points and objections. Successive layouts were developed with the aim of accentuating strong points and overcoming objections, until the proposed Project was developed.

<u>Layout 1</u> strong points were as follows:

1. A low dam

2. A small reservoir

3. The powerstation mostly below ground level

<u>Layout 1</u> objections were as follows:

1. Open-cut excavation for powerstation and canal was adjacent to the railroad. Support during construction would have been very difficult and expensive. The canal walls would have been massive and expensive concrete structures. The spillway from the canal would have been a large structure and would have produced occasional unpredictable increases in river discharge between the dam and tail tunnel outlet.

2. The primary transmission line probably would have to pass through the Libby Lions Club park, although it might have paralleled the railroad upstream. The switching equipment would have been on the top of the powerstation and would have occupied an area of 20,000 to 30,000 square feet. It would have included equipment 15 feet to 20 feet high.

3. Construction access to the tunnels would have been difficult. If the access were near the powerstation, either a hoisting system and truck loading area or long, open-cut ramps would have been required.

4. Parts of the tail tunnel would have been under shallow rock cover and might have required cut-and-cover construction. If so, the environmental impact would have been major and support of the cut on the railroad side would have been difficult and expensive.

5. The site for the canal actually was shown by subsequent site visits to be not suitable topographically or geologically for canal construction.

6. The permanent access road to the powerstation would have been between the Lions Club park and the river.

The objections outweighed the strong points, so additional layouts were studied as improvements of Layout 1. Two possible layouts, which are designated as Layouts 2A and 2B, were considered as being more suitable to the site and therefore a better basis for future studies.

Q. I show you two exhibits marked as Exhibit ____ (AEA-6) and Exhibit ____ (AEA-7). Were these exhibits prepared under your supervision?

A. Yes.

Q. What do these exhibits show?

A. Exhibit ____ (AEA-6) shows Layout 2A and Exhibit ____ (AEA-7) shows Layout 2B.

Layouts 2A and 2B were studied concurrently as a basis for guiding future work. Both utilized a dam in the same location and with the same forebay elevation as in Layout 1. The canal between reservoir and powerstation was shortened for both engineering and environmental reasons. In Layouts 2A and 2B the powerstation was in the same location and would have been built in a pit to minimize above-ground structures.

Two tail tunnels were proposed instead of one to reduce possibilities of cut-and-cover construction. Two small tunnels might have had sufficient rock cover to permit normal underground construction methods. For one large tunnel, the rock cover would have been insufficient for normal underground construction and cut-and-cover construction would have been certain. Comparison of the two layouts, 2A and 2B, is as follows:

Layout 2A - Shortest tail tunnel, smallest head, reduced power capability.

Layout 2B - Longest tail tunnel, approximately same head and power as Layout 1.

Layouts 2A and 2B had the following strong points:

1. The powerstation was mostly below ground, although switching equipment would have been above ground, as in Layout 1.

2. The site disturbance because of the canal was reduced greatly from Layout 1.

Layout 2A and 2B had the following objections:

1. A study showed that a spillway from the canal to the river would have been necessary.

2. The canal and access road continued to be between the park and the river.

3. The powerstation would have been very close to the river and railroad, and would have been very difficult to construct. Sides of the excavation would have required extensive support and water entrance could have been a problem.

4. Tunnel access remained difficult, requiring either ramps or hoists near the powerstation. Hoists probably would have been used. Hoists would require deep excavation, and a large area would have been used. Ramps would require deep excavation, and a large area would have been affected by side slopes along the ramps. Either way, there would have been major impact on the Lions Club park during construction.

5. Switching equipment on top of the powerstation and the primary transmission line would have continued to be prominent.

Layout 2A had the following additional strong point:

1. The tail tunnel outlet was farther away from the railroad than it had been in Layout 1. This simplified side support required during construction wherever cut-and-cover construction would have been required.

Layout 2A had the following additional objections:

1. High cost per kilowatt.

2. The layout probably would not have met the FERC requirement of maximum utilization of the water resources of the site for the production of power in the public interest.

Layout 2B had the following additional strong point:

1. More complete development of power resources than provided by Layout 2A.

Layout 2B also had the following additional objection:

1. The closeness of tail tunnel outlet to the railroad presented construction difficulties, although the difficulties were solved in later layouts having the tail tunnel outlet in approximately the same location. The cofferdam shown in Layout 2B could not have been built. The problems with powerstation construction, canal construction, and tunnel access near the Lions Club park led to a totally revised concept for Layout 3.

Q. I show you an exhibit marked as Exhibit ____ (AEA-8). Was it prepared under your supervision?

A. Yes.

Q. Will you explain it?

A. Exhibit ____ (AEA-8) is a plan drawing of Layout 3. In Layout 3 the powerstation would have been in the river adjacent to the left bank of the river. Water would flow directly from the reservoir into the turbine spiral cases. Two tail tunnels would have connected the powerstation with the tailwater. The tail tunnel outlets were moved upstream from Layout 2B to provide room at the tail tunnel outlets for a truck exit ramp during construciton.

The railroad would have been relocated landward and raised in elevation at the powerstation and for the necessary distances upstream and downstream to reconnect with the existing grade.

Layout 3 had the following strong points:

1. There would be no project structures between the Lions Club park and the river.

2. The only parts of the project visible above the surface would have been the dam, powerstation, switching equipment, and access road.

3. The tunnels would have been in sounder rock and excavated with less difficulty than in the preceding layout.

Layout 3 had the following objections:

1. The dam would have been shortened, which would have required higher gates to pass floods. Gates of the size needed would have been difficult and expensive to obtain.

2. The powerstation would have stood out of the water and would have been conspicuous when viewed from the Lions Club park or from other surrounding points.

3. The long tail tunnels created a difficult surge problem which would have required a major water spilling structure not shown on the layout near the powerstation. The spilling structure would have risen to above the highest anticipated water level in the river adjacent to the spilling structure. The height is needed to prevent project head from being destroyed by inflow into the tail tunnel from below the dam during large floods.

4. The construction ramp at the tail tunnel outlets would have been provided a major adverse impact on the area. In addition, it is possible that loaded rock trucks would have had to cross the railroad to get to Highway 2. It developed that the powerstation would not be large enough to receive the full 24,000 cfs discharge at the desired trashrack velocity of 3 ft per second. Either velocities would have had to be much higher or the powerstation would have had to be enlarged.

The shortcomings in Layout 3 led to relocation of structures and modification of components to produce Layout 4.

Q. I show you two drawings marked as Exhibit ____ (AEA-9) and Exhibit ____ (AEA-10). Were they prepared under your supervision?

A. Yes.

Q. Explain what they show.

A. Exhibit ____ (AEA-9) shows a layout numbered 4A and Exhibit ____ (AEA-10) shows a layout numbered 4B. The principal difference between Layouts 4A and 4B is in the intake.

Layout 4 endeavored to remedy two of the deficiencies of Layout 3. One was an effort to provide an intake system that would reduce the velocity through the trashracks to the desired 3 ft per second. The other was to provide a feasible surge tank system in the tail tunnels.

Layout 4 involved a powerstation on the left shore of the river with the long axis of the station being parallel to the river, instead of across the river as in all previous layouts. The powerstation would have contained four generating units. Downstream from the powerstation there would have been two surge galleries, one for each tail tunnel. The surge galleries would have been buried structures and would not have spilled water into the river.

In Layout 4A water would have flowed directly from the river into the powerstation. In Layout 4B there would have been two intakes in the reservoir, each intake serving half of the powerstation. Each intake in Layout 4B would have been a circular plate set on radial piers. The water would enter under the plate, between the radial piers, and then be turned downward into a verical shaft. The vertical shaft would lead to a horizontal tunnel which would connect to the spiral cases of two turbines.

Incidentally, Layout 4B was the first in which reservoir level was raised from Elevation 1990 to Elevation 2000, as is shown by Exhibit ____ (AEA-10).

<u>Layouts 4A and 4B</u> shared the following strong points:

1. The full length of the dam was restored, with corresponding improvement in the feasibility of the spillway gates.

2. Water velocity at the trashracks would have been 3 ft per second at 24,000 cfs.

3. The powerstation would have been in a pit below ground level. Switching equipment would have continued to be above ground level.

<u>Layouts 4A and 4B</u> also shared the following objections:

1. Surge structure excavation would have extended to the surface, which during construction would have created major disturbance in the Lions Club park. Years would have been required to restore the landscape after construction.

2. Powerstation construction would have required either very expensive support or flat slopes extending over a large part of the area on the left bank of the river at the Falls. Access ramps from the powerstation for removing excavated material from powerstation and tunnel would have been long and would have required extensive cuts into the hillside.

<u>Layout</u> <u>4A</u> had the following objection:

1. Intake excavation in the riverbed would have to have been over 100 ft. deep. The construction impact would have been very objectionable, and maintaining such a deep hole free of sediment after construction for satisfactory plant operation would have been very difficult.

<u>Layout</u> <u>4B</u> had the following strong points:

1. The intakes were of a design that minimizes vortex formation. Vortices are undesirable because they can suck air or floating objects, including fish, into the turbines.

<u>Layout</u> <u>4B</u> also had the following objection:

1. The depth of excavation for the intakes was greatly reduced from 4A, but still required a very long and wide area, extending all the way across the river. It would be necessary to provide access to the intakes for maintenance, so that there would have been a bridge most of the way across the river.

The objections to Layouts 4A and 4B led to Layout 5.

Q. I show you a drawing of Layout 5 marked as Exhibit ____ (AEA-11). Was it prepared under your supervision?

A. Yes.

Q. Will you explain what it shows?

A. Exhibit ____ (AEA-11) shows that Layout 5 followed the basic principles of Layout 4, with some changes. The principal changes were as follows:

1. The powerstation was located landward of the railroad.

2. The intake excavation was simplified, but the water conduits connecting the forebay with the units passed under the railroad.

3. An excavation adit, or construction tunnel, was provided for access from the tail tunnels.

4. It was planned to accept the difficult control conditions that would have been caused by eliminating the tail tunnel surge tanks.

5. The tail tunnel outlet detail was changed so that the tunnels could be excavated behind a bulkhead. The bulkhead would be in a vertical concrete shaft that would be installed before tunnel excavation reached the location. Material between the bulkhead and the river would be excavated by equipment working from the top of the bulkhead structure. The concept of quarry-type excavation, with no cofferdam and minimal rock fall into the river, was developed as part of Layout 5.

Layout 5 had the following strong points:

1. The difficult access to the tail tunnels and the adverse environmental effects of the access would be eliminated.

2. The intake service bridge across the forebay would be eliminated.

Layout 5 had the following objections:

1. Analysis showed that excavating the intake tunnels under the railroad between the reservoir and the powerstation would be practically impossible because of the small construction area available, which would made extensive construction support necessary.

2. Site investigations showed that the powerstation excavation would have been a very large open pit which would be backfilled after the

powerstation was completed. The open pit would extend a long way up the hill towards the Lions Club park and even if landscaped would alter the forest character of the area for many years. Supports to reduce the extent of open pit excavation would have been major in scope and very expensive.

3. Later studies showed that surge conditions in the tail tunnels could not be overcome without a surge tank.

The studies and conclusions from Layouts 1, 2A, 2B, 3, 4A, 4B, and 5 led to the conclusion that further major changes were necessary. The associated studies led to Layout 6, which is the one for which the Applicant applied for License. Layout 6 was developed to avoid environmental objections associated with all prior layouts and to provide hydraulic surge conditions in the Project waterways that would be practicable and acceptable from the viewpoint of controlling the units. The proposed Project for which the Applicant seeks a license is shown by a group of 9 exhibits.

Q. I show you a copy of Exhibit ____ (AEA-12). Was it prepared under your supervision?

A. Yes.

Q. Explain what it shows.

A. Exhibit ____ (AEA-12) is a revised Sheet 1 of Exhibit L in the License Application. It shows the plan of the Project. The revision is in the Access Tunnel and its approaches which connect the Powerstation with U.S. Highway 2. The plan represents the knowledge obtained from studies of prior layouts and from core borings and geologic reconnaissance at the site. The major features of the Project are:

1. The Dam.

2. The Reservoir, which is created by the Dam.

3. The Intake.

4. The Head Tunnel.

5. The Powerstation and associated underground galleries.

6. The Tail Tunnel.

The Dam is shown on Exhibit ____ (AEA-12), occupying the same location as in prior layouts. The Dam provides a Spillway that extends across the full width of the river.

The Reservoir is approximately 18,000 feet long. The depth of the Reservoir at the Dam is approximately 30 feet. At the deepest point, which is adjacent to the Intake, the depth is 45 feet. At the upstream end of the Reservoir, mean water depths are approximately as shown in Table 6.

Table 6

KOOTENAI RIVER HYDROELECTRIC PROJECT
WATER DEPTH AT UPSTREAM END OF RESERVOIR

River Discharge cfs	Mean Water Depth feet
2,000	4
10,000	7.5
25,000	9.5
50,000	15

At various locations across the river at the bed of the Reservoir, depths vary from the numbers in Table 6 because of irregularities in the reservoir bottom and the cross-sectional shape of the river channel, but Table 6 helps illustrate the relative magnitude of the Reservoir. The Reservoir is small, particularly when considered relative to the size of the river. The area and volume of the Reservoir provide a basis for describing its size. Table 7 presents the data.

TABLE 7

KOOTENAI RIVER HYDROELECTRIC PROJECT
RESERVOIR AREA AND VOLUMES

Water Surface Elevation	Reservoir Area Acres	Reservoir Volume Acre-Feet
1960	0	0
1970	23	85
1980	100	615
1990	168	1920
2000	232	3840

If the above volume of 3,840 acre-feet is compared to volume of Libby Reservoir, which is 5,809,000 acre-feet, the relative scale is apparent. Libby Reservoir is approximately 1,500 times as large as the Project Reservoir. The Reservoir of the Kootenai River Project exists primarily to create head and to provide satisfactory hydraulic conditions at the Project Intake. A secondary function is to provide pondage for controlling discharge when the load on the plant or the flow of water received into the Reservoir changes suddenly.

A. The areas shown in Table 7 are for a level water surface and the volumes shown are from the riverbed up to a level water surface. In actuality, the water surface at the upstream end will be curved because of backwater effects as the Reservoir water surface merges with the natural profile of the water surface.

Q. Describe the Dam and its relationship to Project operation.

A. The Dam is best described with the aid of a drawing.

Q. I show you a drawing marked, Exhibit _____ (AEA-13). Was it prepared under your supervision?

A. Yes.

Q. What does it show?

A. Exhibit ___ (AEA-13) is Sheet 3 of Exhibit L in the Application for License. The exhibit shows the plan, elevation, and cross section of the Dam for the Kootenai River Project. The design is based on site reconnaissance and a core boring near the left abutment.

The Dam basically is a concrete weir, with 12-foot high flap-type gates mounted on the top. Each gate is planned to be 127.5 feet long, so that the length of gated structure across the river is 765 feet. The gates are to be operated by hydraulic cylinders, actuated by oil pressure. The gates operate around a horizontal shaft at their bottom, so that they are lowered to increase the flow of water and raised to reduce the flow of water.

The proposal is that all gates normally will be lowered by the same amount and sufficiently so that 750 cfs will be discharged over the Dam with the Reservoir at El. 2000. The amount by which the gate is lowered depends upon the detail of the shape of the top of the gate, but is expected to be approximately 0.44 feet. When larger discharges are to be released, the present plan is to lower all gates by an equal amount.

The plant control will be developed so that the Reservoir level is held as closely as possible to El. 2000. Head is extremely valuable at the Project and every effort will be made to develop control equipment that will conserve head and water for power and energy production to the maximum degree possible.

The sensitivity and accuracy of the control equipment will be developed during detailed design following issuance of the License. In general, however, the coordinated operation of both the Libby Dam and Kootenai River project as part of the Northwest Power Pool will be utilized to the utmost.

Both powerplants will be operated on a daily schedule. Water will be released through Libby powerstation at certain rates during certain hours and after a period of transit time, which will be developed accurately from experience, the water will arrive at the Kootenai River Project Reservoir. At river flows of approximately 25,100 cfs or less the water flow will be divided to provide 750 cfs to the Dam and the remainder to the Powerstation. At larger river flows, the Powerstation will operate at full turbine discharge capability, with the remaining water going over the Spillway. The remaining water always will exceed 750 cfs at river flows above 25,100 cfs. If river flow is decreased below approximately 2,750 cfs, it is probable that the Project will not be able to generate power and all of the river flow will be discharged over the spillway.

A generalized graph illustrates the concept of the relative daily operation of Libby and Kootenai River Powerstations.

Q. I show you a chart marked as Exhibit ___ (AEA-14). Was it prepared under your supervision?

A. Yes.

Q. Please explain what it shows.

A. Exhibit ___ (AEA-14) is a hypothetical illustration of operation of Libby and Kootenai River Powerstations during a week-day in which the average release from Libby is approximately 16,000 cfs. The release from Libby Dam is divided into the following components:

Off-peak	8,000 cfs for 8 hours, 9 PM previous day to 5 AM
Increasing Discharge	8,000 cfs to 24,000 cfs in 4 hours, 5 AM to 9 PM
On-peak	24,000 cfs for 8 hours, 9 AM to 5 PM
Reducing Discharge	24,000 cfs to 8,000 cfs in 4 hours, 5 PM to 9 PM

It is assumed that 3.5 hours is required for a discharge change at Libby Dam to be received at the Kootenai River Project Reservoir. Thus, at the Kootenai River Project river flows into the Reservoir would be as follows:

8,000 cfs	12:30 AM to 8:30 AM
Increase 8,000 cfs to 24,000 cfs	8:30 AM to 12:30 PM
24,000 cfs	12:30 PM to 8:30 PM
Reduction 24,000 cfs to 8,000 cfs	8:30 PM to 12:30 AM

The above river flows would be divided at the Kootenai River Project as follows:

Time	Specified Discharge Over Dam cfs	Turbine Discharge cfs
12:30 AM - 8:30 AM	750	7,250
8:30 AM - 12:30 PM	750	Increase 7,250 to 23,250
12:30 PM - 8:30 PM	750	23,250
8:30 PM - 12:30 AM	750	Reduce 23,250 to 7,250

River channel storage between Libby Dam and the Kootenai River Project Reservoir would affect the time of arrival of flow, the rate of flow increase, and the rate of flow reduction at the Project Reservoir, so that the increase and reduction in river flow would be slightly less rapid than at Libby. However, to illustrate the relative operation the effects of channel storage can be ignored. If the effects were considered, the sharp changes in flow rate at the Project at 8:30 AM, 12:30 PM, 8:30 PM and 12:30 AM would be more gradual than shown by the exhibit.

In any event, the Project operating procedure and sensing equipment would operate to hold the Reservoir as close to El. 2000 as possible all through the change in river flow. With modern equipment, the fluctuation in Reservoir level will not exceed a few tenths of a foot.

Q. Describe the Intake briefly.

A. Returning to Exhibit ____ (AEA-12), the Intake is planned to cause minimum disturbance and intrusion into the Kootenai River. The Intake will handle discharges ranging approximately from 2,000 cfs to 24,350 cfs. The velocity of water entering the Intake is 3 feet per second when the basic design discharge of 24,000 cfs is flowing through the turbines. When discharge differs from 24,000 cfs, the velocity differs proportionally, so that at 2,000 cfs water velocity is 0.25 feet per second and at 24,350 cfs velocity is 3.045 feet per second.

Q. How did you arrive at the basic discharge of 24,000 cfs?

A. Basically there were two reasons for selecting 24,000 cfs. One reason was that 24,000 cfs was proposed to be the maximum turbine discharge from the Libby Re-regulating Dam. The second reason was that the duration curve of expected outflow from Libby Dam showed infrequent discharges larger than 24,000 cfs and little energy to be obtained by utilizing such larger discharges. Incidentally, as stated previously the alternative sites were based upon similar turbine discharge capacities, the actual amounts being 24,000 cfs plus approximately the mean annual discharge from the drainage area intermediate between the Kootenai River site. Further analysis shows that occasionally turbine discharge at the Project will be as large as 24,350 cfs, which is 1.5 percent larger than 24,000 cfs.

Q. Continue with your explanation of Exhibit ____ (AEA-12).

A. The Intake leads by a vertical shaft to the Head Tunnel which as shown on Exhibit ____ (AEA-12) is a tunnel 49.5 feet wide and high having a horseshoe-shaped cross-section. The Head Tunnel is approximately 3,100 feet long.

As the Head Tunnel approaches the Powerstation, it divides into five penstocks, one for each generating unit. The five penstocks continue from the Head Tunnel to the Valve Gallery, which is part of the Powerstation.

An important difference between the final layout and the earlier layouts is the underground Powerstation, which is shown in the left half of Exhibit ___ (AEA-12).

The underground Powerstation consists of three major caverns, several connecting water tunnels, an access tunnel from the surface, and a combination of a tunnel and vertical shaft that serves the two purposes of emergency exit from the Powerstation and the route for electrical bus leading to the BPA Transmission Line. The Primary Transmission Line will be underground, except for switches connecting the Primary Transmission Line to the Libby-Albeni Falls transmission line.

The Powerstation is located under deep rock cover. Deep rock cover is advantageous for stability of the roof over the caverns, during construction and afterward. The contours on the map show the ground surface. Overburden above the Powerstation is comparatively shallow, so that the contours of the ground surface are only a few feet above top of rock. The ground surface elevations over the Powerstation range from 2,400 to 2,650. All of the Powerstation is to be below El. 2000, so that rock cover over the Powerstation will range from 400 feet to 650 feet.

The Powerstation caverns are shown as oriented in a southwest-to-northeast direction. The orientation is subject to adjustment based on subsequent underground investigations, but is based on site geologic reconnaissance and present knowledge of site details. The reconnaissance indicates that the orientation shown will provide the maximum roof stability and wall stability in the caverns.

The three caverns serve the following purposes:

1. The upstream cavern is the Valve Gallery, which receives the five penstocks that divide from the Head Tunnel and houses the penstock valves, there being one penstock and one valve for each unit. The valve is used to prevent flow of water to a turbine when the turbine is not scheduled to produce power, during an emergency in which the turbine wicket gates would fail to operate, or during an outage for maintenance. The penstocks continue from the Valve Gallery to the main Powerstation,

where each of the penstocks enters the spiral case of one of the turbines.

2. The second cavern will contain the turbines, generators, transformers, auxiliary equipment, switchgear, and an area for storing parts and assembling components of the station. After water flows through a turbine it enters the Draft Tube Tunnel for the turbine, and flows to the third Powerstation cavern, which is Gate Gallery and Surge Chamber.

3. The third cavern serves two purposes. The first purpose is to contain vertical steel guides and a crane for placing a gate on any of the water tunnels leading from the turbines, to permit a turbine to be taken out of service and drained when necessary for maintenance and inspection. The second purpose is to provide a surge gallery for the tunnel system on the downstream side of the turbines.

From the Gate Gallery and Surge Chamber the Draft Tube Tunnels continue until they unite into the single Tail Tunnel that returns the water to the Kootenai River. The Tail Tunnel is approximately 1,000 feet long and has the same cross-section shape and dimensions as the Head Tunnel. Water flowing through the Project from Intake to Tail Tunnel Outlet travels underground for approximately 5,100 feet.

Q. What is the gross head developed by the Project?

A. The gross head developed is the difference between the Reservoir elevation, which is 2000, and the tailwater elevation. Witness Chen explains the decision to have the Reservoir water level at El. 2000. Tailwater elevation is a function of the total discharge flowing in the Kootenai River, and is shown by the Tailwater Rating Curve. The Project gross head, therefore, depends upon the Reservoir elevation, the tailwater rating curve, and the relative discharges through the Powerstation and over the Dam.

Q. I show you a graph sheet marked as Exhibit ____ (AEA-15) and headed "Tailwater Rating Curve". Was it prepared under your supervision?

A. Yes.

Q. Please explain it.

A. Exhibit ____ (AEA-15) shows water level in the Kootenai River at the Tail Tunnel Outlet for various discharges of the Kootenai River. The quantity of water shown is the sum of discharge through the turbines of the Kootenai River Project plus discharge over the Dam to flow down the river between the Dam and Tail Tunnel Outlet.

Q. Now, explain the relationship between Project gross head, the tailwater rating curve, and the distribution of discharge between turbines and spillway that you mentioned.

A. Table 8 shows the relationship of Project gross head to total discharge in the Kootenai River, the discharge in the portion of the river between the Dam and the Tail Tunnel Outlet, and the tailwater rating curve. The table shows selected illustrative total discharges in the Kootenai River between the lower limit of 2,000 cfs and an illustrative upper limit of 30,000 cfs and the tailwater elevation for each discharge selected. The table also shows the gross head of the Project on the basis of the water surface elevation of the Project reservoir being 2000.

Table 8 shows that Project gross head for a particular turbine discharge decreases as the specified discharge in the Kootenai River between the Dam and Tail Tunnel Outlet increases. Thus, Project energy output is reduced from the amount theoretically available at the site not only by the quantity of water going over the Dam and additionally to a small degree by the head reduction for a given discharge through the turbines. Witness Chen discusses the energy losses. The Project tailwater elevation and gross head depend upon three factors:

1. The total amount of water flowing in the river, which is to say, the release from Libby Dam as increased or reduced by valley storage change between Libby Dam and the Project Reservoir and as increased by inflow from the intervening drainage area between Libby Dam and the Project Reservoir.

2. The elevation of the Project Reservoir.

3. The amount of water discharged through the Kootenai River between the Dam and Tail Tunnel Outlet. This water will be discharged over the Dam by the Spillway Gates.

The Project plan assumes that discharge released from Libby Dam ordinarily will be between 4,000 cfs and 24,000 cfs, in accordance with the Corps of Engineer's plan of operation. However, part of the time the discharge can be as small as 2,000 cfs and at times it will exceed 24,000 cfs. In general, all releases between 2,000 cfs and 24,000 cfs are expected to be through the Libby Dam turbines. The Corps is in the process of adding additional turbines to Libby Dam, but to maintain the same basic flow regime downstream they planned to build the Reregulating Dam. Thus, the Kootenai River Project was planned on the basis of turbine discharge capacity of 24,000 cfs, which would accommodate Libby turbine discharge or Reregulating Dam discharge plus inflow from the intervening drainage area.

Following that decision, it was necessary to arrive at the flow that would be released over the Dam to keep water flowing between the Dam and Tail Tunnel Outlet and prevent that part of the river from being dewatered. After analysis, the Applicant selected 750 cfs as the continual, or specified, flow between the Dam and Tail Tunnel Outlet.

In the five columns to the right of Table 8 there are shown the turbine discharges through the Project for five different specified discharges in the river between the Dam and Tail Tunnel Outlet. The five such discharges are 500 cfs, 625 cfs, 750 cfs, 875 cfs, and 1,000 cfs. Such discharge would be maintained continuously, except when the Project would be unable to use water to generate power. When the Project could not generate power, discharge over the Dam would exceed the specified amount. Table 8 is prepared on the basis that minimum turbine discharge through the Project will be 2,000 cfs.

Table 8

RELATIONSHIP OF PROJECT GROSS HEAD TO TURBINE AND SPILLWAY DISCHARGES

Kootenai River Project Operating Conditions
Reservoir Elevation 2000

River Total Discharge, cfs	Tailwater Elevation	Project Gross Head, Feet	Specified Discharge in River, cfs: 500	625	750	875	1,000
			Project Turbine Discharge - cfs				
2,000	1892.6	107.4	0	0	0	0	0
2,500	1893.0	107.0	2,000	0	0	0	0
2,625	1893.1	106.9	2,125	2,000	0	0	0
2,750	1893.2	106.8	2,250	2,125	2,000	0	0
2,875	1893.3	106.7	2,375	2,250	2,125	2,000	0
3,000	1893.4	106.6	2,500	2,375	2,250	2,125	2,000
3,500	1893.8	106.2	3,000	2,875	2,750	2,375	2,500
4,000	1894.2	105.8	3,500	3,325	3,250	3,125	3,000
5,000	1895.2	104.8	4,500	4,375	4,250	4,125	4,000
6,000	1896.2	103.8	5,500	5,375	5,250	5,125	5,000
10,000	1899.6	100.4	9,500	9,335	9,230	9,625	9,000
15,000	1903.9	96.1	14,500	14,375	14,250	14,125	14,000
20,000	1907.9	92.1	19,500	19,375	19,250	19,125	19,000
24,000	1910.6	89.4	23,500	23,375	23,250	23,125	23,000
24,850	1911.20	88.80	24,350	24,225	24,100	23,975	23,850
24,975	1911.29	88.71	24,355	24,350	24,225	24,100	23,975
25,100	1911.33	88.67	24,350	24,350	24,350	24,225	24,100
25,225	1911.43	88.57	24,335	24,335	24,335	24,335	24,225
25,350	1911.50	88.50	24,327	24,327	24,327	24,327	24,327
28,000	1913.0	87.0	24,100	24,100	24,100	24,100	24,100
30,000	1914.5	85.5	23,890	23,890	23,890	23,890	23,890

On the basis of the conditions underlying Table 8, the Project would not be able to generate power when total discharge in the Kootenai River would be 2,000 cfs. All of the water would be discharged over the Dam. If 500 cfs were the specified discharge over the Dam, the Project could start to generate when total discharge in the Kootenai River would be 2,500 cfs. If the specified discharge over the Dam were more than 500 cfs, the total discharges in the Kootenai River at which the Project could begin to generate would be as shown in Table 9.

The Project turbine discharge increases as total discharge in the Kootenai River increases, but the amount that can be utilized in the turbines decreases as the specified discharge over the Dam increases. At 10,120 cfs, the mean discharge passing Libby USGS gage after Canada begins diverting 1,500,000 acre-feet annually, the Project's ability to discharge water through the turbines would be as shown in Table 10.

Table 9

MINIMUM RIVER DISCHARGES FOR POWER GENERATION

Specified Discharge Over Dam cfs	Minimum Total Discharge in the Kootenai River for Project Generation cfs
500	2,500
625	2,625
750	2,750
875	2,875
1,000	3,000

Table 10

AVERAGE WATER AVAILABLE FOR GENERATION

Specified Discharge Over Dam cfs	Project Turbine Discharge Ability cfs
500	9,620
625	9,495
750	9,370
875	9,245
1,000	9,120

Table 11

TOTAL RIVER DISCHARGE
ABOVE WHICH SPECIFIED
DISCHARGE OVER DAM
WOULD BE EXCEEDED

Specified Discharge Over Dam cfs	Total Discharge in Kootenai River cfs
500	24,850
625	24,975
750	25,100
875	25,225
1,000	25,350

At the upper end of the discharge scale, with Project turbine discharge capacity being 24,350 cfs, the total discharge in the Kootenai River at which flow over the Dam would start to exceed the specified discharge over the Dam would be as shown in Table 11.

As total discharge in the Kootenai River increases above the foregoing amounts, flow over the Dam will increase above the specified amount. Table 8 shows also further reduction in the Project gross head and reduction in turbine discharge capacity because of the reduction in gross head as total flow in the river increases.

The foregoing facts illustrate some of the qualifications which must be kept in mind in stating the head developed by the Project. The largest gross head developed is at minimum discharge of the turbines. The head depends upon the specified flow that is to be discharged over the Dam. As head reduces, turbine discharge capacity increases to a particular discharge, above which both head and turbine discharge capacity reduce.

The Applicant proposes that the specified discharge over the Dam be 750 cfs. For 750 cfs, the Project gross heads will be as shown in Table 12.

Table 12

GROSS PROJECT HEAD

River Total Discharge cfs	Project Turbine Discharge cfs	Gross Head Ft
2,750	2,000	106.8
5,000	4,250	104.8
10,000	9,250	100.4
15,000	14,250	96.1
20,000	19,250	92.1
25,100	24,350	88.66
30,000	23,900	85.5

As Table 12 shows, gross head can vary from 106.8 feet at smallest generating discharge to 88.66 feet when river flow is such that the turbines are discharging at capacity and 750 cfs is passed over the Dam. Gross head will be less than 88.66 feet when larger river flow requires that more than 750 cfs be passed over the Dam. The heads would be different than tabulated above if the specified discharge over the Dam is other than 750 cfs.

Q. What effect does the foregoing analysis of head have on production of power and energy?

A. The foregoing analysis is of gross head. Power and energy production depends on the product of discharge through the turbines, net head available at the turbines, and generating efficiency. Net head depends upon the details of the Project waterways that permit water to flow through the turbines. The overall factors involved thus are the Dam, Intake, Head Tunnel, Penstocks, Turbines, Generators, Transformers, Draft Tubes, and Tail Tunnels. These components should be explained additionally before figures for production of power and energy are derived.

The operation of the Dam already is described, in that the Spillway Gates will be operated to pass the proper discharge downriver while maintaing the Reservoir at Elevation 2000. Intake design and operation also are important factors.

Q. Describe the Intake and its relation to the Dam and Reservoir.

A. The Intake has the function of receiving water for generation from the Reservoir and directing the water with minimum practical head loss into the Head Tunnel. The largest discharge, 24,350 cfs, involves the most difficult hydraulic problems and the Intake is designed for that discharge even though discharges smaller than 24,350 cfs occur for approximately 90 percent of the time.

Q. I show you a drawing marked, Exhibit ___ (AEA-16). Was it prepared under your supervision?

A. Yes.

Q. What does it show?

A. Exhibit _____ (AEA-16) is a reproduction of Exhibit L, Sheet 5, in the Application for License and shows details of the Intake. During final design hydraulic model studies will be required and dimensional changes may be made in the Intake structure and surrounding excavation.

The Intake is an adaptation of the intake used for the Seneca Pumped-Storage Project, FERC Project No. 2280. The Kootenai Intake is designed to take water from the Reservoir at low velocity, with minimum submergence, and with minimum turbulence or vortex action in the water. Within the Intake the water is accelerated. The Intake also is designed for minimum environmental and aesthetic impact.

The Intake is semicircular as viewed from above. The top of the Intake has a radius of 100 feet around the vertical centerline of the vertical Intake Shaft. The opening through which water enters includes the entire semicircle plus 25.25 feet additional toward the left shore of the Reservoir from each end of the semicircle.

The total length of the top perimeter thus is 314.16 plus 50.50 feet, or 364.66 feet. The bottom of the Intake projects 15 feet farther into the Reservoir than does the top of the Intake, as shown on the exhibit.

The water enters the Intake structure through an opening 30 feet high around the 364.66 feet of perimeter. The gross flow area thus is 10,940 square feet. The flow area is reduced by seven radial piers, which support the roof slab of the Intake structure. The piers will be approximately 5 feet wide, which reduces the width of the flow section to 329.66 feet and reduces the flow area to 9,890 square feet.

The bottom of the flow passage is at Elevation 1960, as shown on the exhibit, and the top is at Elevation 1990, which is 10 feet below the normal elevation of the Reservoir. The water in moving from the entrance of the Intake to the Intake Shaft flows between the two plates. Since flow area reduces as the water moves toward the Intake Shaft, the velocity of the water increases steadily until the water enters the Intake Shaft. The Intake Shaft is 50.5 feet in diameter, which provides a flow area of 2,003 square feet.

The top of the Intake flow passage is concrete slab, approximately 2 feet thick. Thus, the top of the slab is at approximately Elevation 1992 and normally will be submerged by 8 feet of water.

Submergence of the entire Intake structure was adopted to minimize environmental and aesthetic impact. However, it is necessary to place steel trashracks around the perimeter of the Intake to collect large floating trash that otherwise would obstruct flow through the turbines or damage the turbines. At intervals it is necessary to rake the debris from the racks. To perform the raking a roadway around the perimeter is needed. The largest amount of trash moves during large floods, so the roadway is set at Elevation 2005, which would be above a flood of approximately 185,000 cfs. The roadway will be wide enough to accommodate a truck crane.

Thus, to the public the Intake will appear to be a concrete semi-circular roadway projecting five feet above the water in the Reservoir. There will be culverts through the roadway so that water level will be the same on both sides of the roadway.

The trashracks and vertical steel guides that support the trashracks will provide a partial obstruction to the flow of water. However, it is expected that net flow area through the trashracks will be approximately 8,000 square feet. Outside the racks, in the Reservoir, the flow area increases. As the exhibit shows, the rock outside the concrete structure is excavated down to Elevation 1955. The excavation is to provide a trench around the Intake to catch boulders or water-logged trash. Thus, below the projected bottom of the Intake roof slab at Elevation 1990 there is a flow area 412 feet long and 35 feet deep, which is 14,400 square feet.

Q. What is the significance of the various flow areas you have been presenting?

A. Basically the design effort has been to provide an Intake in which water entering moves at the lowest practicable velocity in the interest of protecting fish. If the Project were designed with maximum economy as the only consideration, the velocity of water through the gross flow area at the trashracks would be approximately 5 to 5.5 feet per second. In the proposed Kootenai River Project, the Applicant has selected velocities that are approximately half the foregoing economical amounts in the interest of fish protection. Table 13 describes the range of velocities at various locations in and near the Intake. Table 13 shows flow areas and mean water velocities at four locations at or near the outer perimeter of the Intake for six selected discharges which cover the full range of turbine discharge. The velocities are small, the largest being 3.04 feet per second through the net area of the trashracks when turbine discharge is 24,350 cfs. An inch or two outside of the trashracks, the velocities are 80 percent of the velocities through the net area of the trashracks.

Table 13

VELOCITIES OF WATER THROUGH THE INTAKE

Location	Flow Area Sq. Ft.	Turbine Discharge, cfs	Mean Velor of Water, Ft Per Se
Rock Trench - 15 ft into Reservoir from Trashracks	14,400[1]	2,000	0.14
		6,000	0.42
		10,120[3]	0.70
		18,000	1.25
		21,000	1.46
		24,000	1.67
		24,350	1.69
	18,520[2]	2,000	0.11
		6,000	0.32
		10,120[3]	0.55
		18,000	0.97
		21,000	1.13
		24,000	1.30
		24,350	1.32
Reservoir Side of Piers and Trashracks	10,940	2,000	0.18
		6,000	0.55
		10,120[3]	0.92
		18,000	1.64
		21,000	1.92
		24,000	2.19
		24,350	2.23
Reservoir Side of Trashracks (gross area)	9,890	2,000	0.20
		6,000	0.61
		10,120[3]	1.02
		18,000	1.82
		21,000	2.12
		24,000	2.43
		24,350	2.46
Through Trashracks (net area)	8,000	2,000	0.25
		6,000	0.75
		10,120[3]	1.26
		18,000	2.25
		21,000	2.62
		24,000	3.00
		24,350	3.04

1/ Area below projected top of trashracks, Elevation 1990.

2/ Area below Reservoir full level, Elevation 2000.

3/ Approximate mean discharge at Libby USGS Gage after diversion of 2070 cfs by Canada.

The duration curve of hourly discharges at the Libby USGS Gage for the period in which Libby Dam has been producing power indicates the time duration in which the foregoing velocities will exist. The duration curve is presented by Witness Sewell. The time duration of velocities at the Intake is in Table 14, which shows the percentages of time in which velocities would have existed at the various locations shown on the preceding exhibit under the power operations of Libby Dam to date.

Table 14

DURATION OF WATER VELOCITIES
AT OR NEAR THE OUTER PERIMETER OF THE INTAKE

Per Cent of Time in Which Velocity Equals or is Less Than Stated Amount	Discharge cfs	Velocities in Feet Per Second: Rock Trench	Forebay Side of Piers and Trash Racks	Forebay Side of Trash Racks (Gross Area)	Through Trash Racks (Net Area
0.1	2,000	0.14	0.18	0.20	0.25
45	6,000	0.42	0.55	0.61	0.75
61	10,120	0.70	0.92	1.02	1.26
67	18,000	1.25	1.64	1.82	2.25
93	21,000	1.46	1.92	2.12	2.62
99	24,000	1.67	2.19	2.43	3.0
100	24,350	1.69	2.23	2.46	3.04

The percentages of time are for the discharges listed in Table 13.

Comparison of water velocities through the Intake with water velocities in the river in its natural condition and with water velocities in the Reservoir is discussed by Witness Lee.

Q. Does that conclude description of the Intake?

A. Not quite. There is one more important factor, which is the effect of the Intake on the river bed. Exhibit ____ (AEA-16) shows the rock of the river bed excavated around the Intake to a slope of 1 vertical to 5 horizontal.

The significant facts are as follows:

1. The bottom of the Intake slab has to be 40 feet below normal level of the Reservoir.

2. The existing river bed elevations are a natural property of the location and are fixed.

3. As the normal level of the Reservoir becomes higher by any amount, the elevations of the Intake can be increased by the same amount and the disturbance of the river bed by excavation can be reduced correspondingly. Conversely, as the normal level of the Reservoir is lowered by any amount, the elevation of the Intake must be lowered by the same amount, and disturbance of the river bed by excavation must be increased correspondingly.

Q. What is the next important component of the Project that should be described?

A. The next important component is the Head Tunnel System, which consists of the Intake Shaft, Head Tunnel, and Penstocks.

The Intake Shaft is described on Exhibit ____ (AEA-16). Its diameter is 50.5 feet. The shaft extends downward from the Intake at Elevation 1965 to Elevation 1817. The base of the Intake Shaft is at the elevation of the invert, or bottom, of the Head Tunnel. The Head Tunnel is set at the elevations shown on the exhibit to maintain adequate rock cover. Adequate rock cover improves stress distribution in the rock above the tunnel, which reduces hazards during excavation and reduces the structural load on the tunnel lining.

The Head Tunnel and Penstock are shown in Exhibit ____ (AEA-15) and an additional exhibit.

Q. I show you a drawing marked Exhibit ____ (AEA-17). Was it prepared under your supervision?

A. Yes.

Q. What does it show?

A. Exhibit ____ (AEA-17) is a reproduction of revised Exhibit L, Sheet 2, in the Application for License and shows the profile and cross section of the water conduits of the Project. Exhibits ____ (AEA-12) and ____ (AEA-17) used in conjunction show the Head Tunnel and Penstocks.

The Head Tunnel is planned to be of horseshoe shape, as shown on Exhibit ____ (AEA-17), 49.5 feet wide and 49.5 feet high. The tunnel will be lined throughout with concrete. The tunnel is planned to be 3,100 feet long.

Q. I have heard that the Head Tunnel is unusually large in diameter. Have you any comment?

A. The diameter is unusually large. However, it represents a small extension of present technology. Concrete-lined tunnels of 43.5 feet diameter were excavated through the right abutment of Tarbela Dam on the Indus River in Pakistan in rock much weaker and less stable than the rock at the Kootenai River Project site. Underground powerstations, several hundred feet long and wider and deeper than the Head Tunnel, have been excavated in various parts of the world, some in very weak rock. The elevations of the Head Tunnel shown on Exhibit ____ (AEA-17) are intended to provide adequate rock cover over the Tunnel, particularly at the upstream end, where the top of the rock is at low elevation. Near where the Head Tunnel crosses the 2,200-foot contour, as shown on Exhibit ____ (AEA-12) , the Tunnel goes under a steep rock face and rock cover over the Tunnel increases rapidly. From the 2,200-ft contour to the downstream end of the Head Tunnel the tunnel elevation rises to meet the elevations of the Powerstation and turbines.

The Head Tunnel divides into five penstocks, one transporting water to each turbine. There are two sizes of turbines, and thus there are two corresponding sizes of penstocks. There are three penstocks, each 21 feet in diameter, leading water to the larger turbines and two penstocks, each 16 feet in diameter, leading water to the smaller turbines.

Each penstock is divided into two portions because the penstock has a second function in addition to transporting water. That function is to provide a means for preventing flow into the turbine so the turbine can be drained whenever necessary for maintenance, to reduce leakage when the turbine is not being operated, and to shutoff flow if the turbine discharge control mechanism would fail. The flow is prevented by a butterfly valve, which is open whenever the turbine is operated or is to be operated, and is closed otherwise.

Such shut-off valves usually are placed immediately adjacent to the water entrance into the turbines. Such location was considered for this Project, but was rejected because of the additional width it would add to the Powerstation cavern. Therefore, the penstock valves were located in a gallery separate from the main Powerstation cavern.

The Valve Gallery will contain the butterfly valves, valve operators, and a crane for lifting valve components. The Valve Gallery will divide the penstock into two portions. Upstream from the Valve Gallery, the penstock will be lined with concrete. Downstream from the Valve Gallery, the penstock will be lined with steel, the steel lining being held in place by concrete. The Powerstation cavern and Valve Gallery are placed and oriented for favorable rock stress conditions, based on present knowledge of underground conditions.

Q. You mentioned present knowledge of underground conditions. Is there a plan to increase that knowledge?

A. Yes. Once the Applicant has the necessary licenses and permits, and on the basis of those licenses and permits can finance the Project, the first step in construction will be an exploratory adit to enter the site of underground structures and obtain information of rock characteristics and stresses. The program for obtaining information will use modern equipment and techniques. The information obtained will be used as the basis for locating the various underground structures and there may be changes in their location, orientation, and spacing between openings.

The exploratory adit will be a tunnel approximately 7 feet wide and 7 feet high along the Access Tunnel to the Powerstation and is described in detail by Witness Hjertberg.

Q. What is the next component of the Project to be described?

A. The next component of the Project to be described is the Powerstation.

Q. I show you a drawing marked Exhibit ___ (AEA-18). Was it prepared under your supervision?

A. Yes.

Q. What does it show?

A. Exhibit ___ (AEA-18) is a revised Sheet 4 of Exhibit L in the License Application. It shows the plan, longitudinal elevation, and cross section of the Project's Powerstation.

Exhibit ___ (AEA-18) used in conjunction with Exhibits ___ (AEA-12) and ___ (AEA-17) describes the station. The right portion of Exhibit ___ (AEA-18) shows the cross section of the cavern excavation in rock, the generating units, the concrete support and embedment of the generating units, passageways, and crane support structure. As viewed on the drawing, water enters the turbine distributor from the left, flows inward and downward through the turbine, and leaves to the right.

The position of the Powerstation cavern relative to the Valve Gallery and penstocks is shown on Exhibit ___ (AEA-12).

In addition to the Powerstation cavern, the Powerstation contains the Access Tunnel, which connects the Powerstation cavern with the surface of the ground near U.S. Highway 2. The Access Tunnel also provides connection to the other underground caverns. It is planned that the Access Tunnel will be excavated as an enlargement of the Exploratory Adit. In effect, the Exploratory Adit will provide the pilot tunnel for the Access Tunnel.

The Access Tunnel is a large tunnel, approximately 30 feet wide and high. It is set on a relatively steep grade, although the grade is practical for construction and operation. The width and height provide for major equipment assemblies that must be installed during construction. The largest assemblies are anticipated to be the butterfly valves in the penstock and the transformers.

The portal of the Access Tunnel will be south of U.S. Highway 2 and approximately 40 feet in elevation below the highway. U.S. Highway 2 will be on a bridge crossing the road leading to the Access Tunnel. The access road will parallel U.S. Highway 2 between the highway and the Burlington Northern Railroad, connecting to U.S Highway 2 approximately 500 feet west of the bridge.

Returning to Exhibit ____ (AEA-18), the Powerstation cavern will contain the following major equipment:

1. Five turbines and generators. A turbine and a generator collectively are called a "Unit".

2. Governors and switchboards for controlling the turbines and generators.

3. The Powerstation crane, which is used in erecting and maintaining the Units and other heavy equipment.

4. Electrical conductors, called "busses", which transmit the power and energy produced by the generators to the transmission system.

5. Transformers to increase the voltage of the power produced from generator voltage to transmission line voltage.

6. Switchgear for the busses.

7. Auxiliaries needed for operating the station such as piping, pumps, ventilation equipment, motors, power at station service voltage, motor control

switchboards, air compressors, batteries for emergency use, and lighting.

Exhibits ____ (AEA-12) and ____ (AEA-17) show one additional and important Powerstation detail. Exhibit ___ (AEA-17) shows a system of two short tunnels and two vertical shafts connecting the Powerstation to the surface The system is called collectively the "Bus Shaft". Exhibit ____ (AEA-12) shows, by a circle and the words "20'Ø bus, access, and ventilator shaft", that the tunnel and shaft system intersects the ground surface underneath the existing transmission lines.

The present transmission line operates at 115 kV but it will be rebuilt by the Bonneville Power Administration to operate at 230 kV. The Project will be connected to the transmission line and the Project output will enter the Pacific Northwest Power System by the transmission line.

Environmental and aesthetic considerations played the major role in selecting the Bus Shaft system and location. The top of the Bus Shaft cannot be seen from U.S. Highway 2 or the Lions Club park. The connection to the transmission line will be by taps containing disconnect switches, which are small and inconspicuous structures.

The Bus Shaft will serve also for Powerstation ventilation and emergency exit. The Bus Shaft will contain a small elevator. The elevator hoist and motor at the top of the shaft will be housed partly or entirely underground, and will have minimum visibility.

Q. You have stated that there will be five Units, whereas the License Application to FERC initially showed four. Please explain the difference.

A. The License Application to FERC showed four Units, all intended to be of equal size. The intent of the Project is to utilize discharges of between 2,000 cfs and 24,000 cfs for power and energy production. The largest discharge is 12 times the smallest, which provided some difficulty in plant operation.

The difficulty is compounded at the Project by the characteristics of the site. The Project will operate mostly at gross heads between 106.8 feet and 88.7 feet, as stated previously in this testimony. The turbines most suitable for these head and discharge ranges normally are adjustable-blade propellor turbines, which are called by the name of their inventor, "Kaplan". Kaplan turbines develop very good efficiency over a large range of disharges, and would be ideal for obtaining maximum efficiency at this Project. However, Kaplan turbines have the characteristic of increasing very rapidly in rotational speed if there is a relatively small increase in discharge. The speed-increase characteristic is especially important in starting a Unit that has been shut down.

When a Unit is to be started, a small amount of water is admitted to the turbine. The water is admitted by a small opening of the wicket gates which are inside the distributor and surround the turbine. The Unit is not connected electrically to the transmission system when it is shut down or while it is being started. When a Unit is connected electrically to the transmission system, the system helps to hold the Unit at constant rotating speed. When the Unit is not connected to the transmission system, there is no such help and the Unit tends to increase rapidly in speed as water passes through it.

Each Unit has a governor that adjusts the wicket gates to control discharge and thereby controls speed. When hydraulic conditions at a plant are favorable, the governor can cause the wicket gates to react rapidly enough to control the speed.

The Unit is accelerated to the proper speed at which it will produce power at system frequency, which in the United states is 60 cycles per second (called "60 Hertz"). When the Unit is near the proper speed it is necessary to synchronize the Unit's electrical characteristics with the transmission system's characteristics.

The synchronizing requires that the instant the Unit's generator produces maximum voltage must be the same as the instant at which the transmission system is at maximum voltage, which is called being "in phase". The speed and phase of the Unit are brought to proper condition by manipulating the wicket gates. At the instant both speed and phase of the Unit and the transmission system are identical, the circuit breaker is closed connecting the Unit to the transmission system, and the Unit then is loaded to its scheduled power output.

The foregoing explanation is necessary because of special conditions at the Project. Normally, the heads of 88 to 106 feet are considered "low head", and the water conductors are relatively short. If the water conductors are long, a surge tank can be installed to limit the pressure rises and drops that occur when the velocity of a long column of water is changed.

At the Project the Head Tunnel, including penstocks and Intake Shaft, is long, more than 3,300 feet. Normally, the time set for turbine wicket gates to move from fully open (called "full gate") to fully closed is a matter of a few seconds. To obtain such timing for the Project Units while controlling the pressure changes to reasonable amounts would require a surge tank.

At the Kootenai River Project the combination of large maximum discharge, water conductor length, and low head would require that a surge tank be very large. The surge tank, to be effective, would have to be near the Powerstation. A surge tank at that location would require excavation from Elevation 1956, as shown by Exhibit ____ (AEA-17), to approximately Elevation 2700, as shown by Exhibit _____ (AEA-12). Some other arrangement to obain a water surface exposed to the atmosphere might be possible, but the cost of a surge tank in the Head Tunnel is excessive and a surge tank cannot be used. With no surge tank, it appeared impractical from preliminary investigation to use Kaplan turbines. For that reason, Francis turbines are used as the basis for the Application for FERC License.

Francis turbines have fixed runner vanes. The rotating runner has no resemblance to a propellor. Instead, the runner vanes are curved so that within the vanes water enters the outer perimeter horizontally and leaves the bottom generally vertically. The maximum efficiency of a Francis turbine is very nearly equal to the maximum efficiency of a Kaplan turbine, but at loads larger or smaller than the load at maximum efficiency, the efficiency of a Francis turbine is less than the efficiency of a Kaplan turbine. Under the large range of discharge, it often is necessary to generate at loads which are not at the point of maximum efficiency. Francis turbines have the major advantage of much slower speed-change response to change in discharge and head. As a result, Francis turbines will be much simpler than Kaplan turbines to start and synchronize. Even so, it is anticipated that governor timing for Francis units will be in terms of minutes rather than seconds. The slow timing is not a disadvantage at the Project because the Project generates as it receives water from upstream. The water regulation at Libby Dam, combined with channel storage in the Kootenai River between Libby Dam and the Project Reservoir, will provide water control such that governor timing in terms of minutes will be adequate for the Project. The slow governor timing will be advantageous in protecting people who will be along the Kootenai River between the Dam and the Tail Tunnel Outlet if the Project would be tripped off the transmission line.

With Francis turbines having been selected, the next decision was the number of Units. Libby Dam had four Francis Units when Project planning was underway. Four additional units were to be installed at Libby, but the Reregulating Dam was to provide the same discharge with control downstream as provided by Libby Dam four units. Four Units, therefore, were logical for this Project.

Libby Dam's maximum turbine discharge is 24,000 cfs. The same discharge capacity is reasonable for the Project. With four Units, each turbine would be able to discharge 6,000 cfs. The units proposed would discharge 24,350 cfs at the gross head 86.7 feet, for which the corresponding net head is 77.8 ft. At that head and discharge each Unit would be producing 36,000 kW, or 144 MW for the Project.

The net head increases for turbine discharges less than 24,000 cfs. At increased head, a single turbine can discharge more water than it can at lesser head. Thus, it is anticipated that when there is sufficient water for only one turbine, a single turbine will be able to discharge a little more than 6,700 cfs, at approximately

102.5 feet gross head, which corresponds to 95.2 feet net head at the turbine. Generator output would be 48.7 MW, which at 15 percent overload and 0.95 power factor requires generating rating of 44,600 kVA.

The foregoing shows that even though the combined rating of the Project Units would be 194.8 MW, the Project can produce only 144 MW when all four Units are operating. The additional generator rating over 144 MW is necessary for efficient utilization of smaller discharges.

A Francis turbine usually can operate for extended times at loads as small as approximately 60 percent of full load without special measures being necessary. The operating restriction is caused by disturbances that develop in the water flow through the turbines at reduced loads. The disturbances develop primarily because at reduced loads the draft tube is not filled with water and a vacuum develops in the center of the draft tube. As the old saying goes, nature abhors a vacuum, and water flowing near the outer limits of the draft tube attempts to enter the vacuum. The entering water has no air to cushion the impact, so that the water meets in the draft tube with considerable impact. The vacuum is filled temporarily, but the lack of sufficient water to keep the draft tube filled causes the vacuum to reform.

The action occurs at frequent intervals, and provides frequent strong physical impacts and major head changes on the turbine. Operation under such conditions is rough and can be damaging to various components of the Unit, especially to the guide bearings that hold the rotating shaft in its proper position. The power produced by the Unit also tends to vary rapidly, which is unacceptable for governing and transmission.

Such rough operation can be relieved by admitting air to the vacuum. Turbines are built with a hole in the center of the rotating runner and vent openings in the head cover. If the vents are opened, air is pulled by the vacuum through passageways and the rough operation is relieved. In Units which are deeply below tailwater, as at Kootenai, the air must be injected under pressure. At the Project, turbine discharge can be as small as

2,000 cfs. Air injection would have been necessary when discharge through a turbine was less than 0.60 x 6,700 cfs, or 4,000 cfs. Air injection would have been necessary for discharges between 2,000 cfs and 4,000 cfs, and between 6,700 cfs and 8,000 cfs. Under the normal operation of Libby Dam, in which there is peaking when daily average is less than turbine capacity, such operation was expected only a small percentage of time.

However, the Montana Department of Health and Environmental Sciences asked if the air injection would raise gas supersaturation in part of the Kootenai River downstream from the Tail Tunnel Outlet. Computations indicated that it would, and experience at various locations indicated that it might or might not. To resolve the issue, the Applicant agreed to eliminate operation requiring air injection.

To eliminate air injection, it is necessary to eliminate operation of a turbine at less than 60 percent of maximum discharge except under unusual or occasional circumstances, when the rough operation could be tolerated for a short time. The air injection could be eliminated if a turbine discharging 2,000 cfs has maximum discharge capability of 3,350 cfs. The resultant rating is one-half of the Units that had been selected. The result is to replace one 6,700 cfs Unit with two 3,350 cfs Units. The Project now is to contain the following Units:

- Three Units, each with a turbine rated 49,120 Horsepower at 78 feet net head and a generator rated 44,600 kVA at 0.95 power factor and 60°C temperature rise.

- Two Units, each with a turbine rated 24,560 horsepower at 78 feet net head and a generator rated 22,300 kVA at 0.95 power factor and 60°C temperature rise.

The Powerstation cavern is designed to contain the five Units and provide space for erection and maintenance.

Final decisions regarding turbine type, governor timing, starting, and synchronizing will be made following careful analysis during final design. Until the Project has the necessary permits and licenses, the Applicant cannot approach manufacturers of equipment to obtain the necessary detail. Manufacturers respond only to a limited degree unless it is known that the Project will proceed and equipment will be purchased.

Q. What is the relationship of Project generating capability to head under the Unit sizes you have explained?

A. The generating capability of the Project relative to head is shown by Exhibit ____ (AEA-20) which shows that generating capability is approximately 16 MW at maximum gross head of 106.8 feet, and increases to approximately 144 MW at gross head of 88.7 feet. As gross head decreases below 88.7 feet, which is caused by a rise in tailwater level as discharge increases, generating capability decreases to less than 144 MW. Capability is approximately 137 MW at 88 feet gross head.

Q. What are the Project components downstream from the Powerstation cavern?

A. The components are shown on Exhibits ____ (AEA-12) and ___ (AEA-17). Each turbine discharges into a Draft Tube Tunnel. The five Draft Tube Tunnels converge into the Tail Tunnel, which is of the same diameter as the Head Tunnel. The Draft Tube Tunnels average approximately 270 feet long and the Tail Tunnel is 1,270 feet long.

The Draft Tube Tunnels discharge water into the Draft Tube Gate Gallery and Surge Chamber. In the Gallery the water is open to the atmosphere. The Gallery serves to relieve hydraulic surges in the Draft Tube Tunnel and Tail Tunnel system and also provides a location where a gate can be lowered to close a draft tube of a Unit when it is necessary to drain the turbine.

The Gallery is connected to the Access Tunnel. Normally, there will be a steel bulkhead in place between the Gallery and the Access Tunnel. The bulkhead will prevent a surge that produces a water level higher than the Access Tunnel roadway from flooding the Access Tunnel temporarily. Personnel will remove the bulkhead to enter the Draft Tube Gate Gallery and Surge Chamber only if the Station is shut down. Such shutdown obviously would be only for the period necessary for removing and replacing the bulkhead and lowering the Draft

Tube Gate. During the shutdown the entire river flow would go over the Dam.

The principal feature of the Tail Tunnel is the Outlet. The Outlet is designed to be constructed without placing a cofferdam in the river and is described by Witness Hjertberg.

The water from the Tail Tunnel will enter the river below the lowest water level of the river. The outlet is designed to minimize turbulence or flow disturbance in the river.

Q. What would happen if the Project suddenly were to lose part or all of its load at any point in the operation you have just described?

A. The water which had been passing through the turbines would have to be released over the dam, raising water levels below the Dam.

Q. Would this endanger people along the river below the Dam?

A. Yes, in absence of proper measures to control the change of discharge over the Dam and warn people in the area.

Q. Has the Applicant developed measures to protect the public?

A. Yes. The plan is that the rate of change of discharge through the turbines will be controlled to occur very slowly. The plan provides that a single turbine will require approximately 10 minutes to increase discharge from zero cfs to full load cfs and the same number of minutes to reduce discharge from full load cfs to zero.

Additionally, the spillway gates will operate very slowly. It appears that 30 minutes for a full opening operation or for a full closing operation will be reasonable. It also is expected that when there is to be an increase in discharge over the dam there will be a time lag of two or three minutes between the tripout and the start of spillway gate opening.

Thus, if the turbines are tripped off the line, the wicket gates which control discharge through the turbines will begin to close immediately, at the closure rate of 10 minutes from fully open to fully closed. As the gates close, discharge through the turbines will decrease at a reasonably steady rate and the water which would have gone through the turbines will remain in the Reservoir unless another discharge route is provided.

The spillway gates will begin to open two or three minutes after the turbine wicket gates start to close. Before the spillway gates open, the water level in the forebay will rise a small amount, which will increase spillway discharge slightly. The increase in spillway discharge will be less than the reduction in turbine discharge, with the difference between the two amounts being stored in the Reservoir.

Q. What additional measures are proposed to protect the public?

A. The water control methods will be supplemented by a siren at the Dam and signs along the river. The signs will warn people that water can rise rapidly and tell them to leave the river for higher ground immediately when the siren begins to sound. The siren will be part of the control circuitry that will be actuated by the station tripout and will begin to sound immediately upon tripout. Details of the times for sounding remain to be developed, but several alternatives are possible.

One alternative is that the siren will sound continuously from tripout until t e spillway gates stop lowering. Another alternative is intermittent sounding of the siren, with sounding beginning at tripout and continuing with alternating silence and sounding for several minutes. The river canyon contains bends, and the combination of bends and rock walls may create zones that will exclude the sound from a siren at the Dam. It may be necessary to install one or more supplemental sirens.

Q. Can you illustrate how the foregoing system can work?

A. Yes.

Q. I show you a chart marked Exhibit ___ (AEA-19). Was it prepared under your supervision?.

A. Yes.

Q. Explain what it illustrates.

A. The exhibit is an illustration of the basic concept of controlling water following plant tripout. The final concept adopted may not be identical, but the general results will be similar. The exhibit shows graphically discharge through the turbines, discharge over the spillway gates, amount of opening of the spillway gates, and forebay elevation following tripout of the station at full load. The chart shows times in minutes.

The worst tripout situation would be with the turbines discharging 24,000 cfs while the specified 750 cfs was discharging over the Dam. As the exhibit shows, discharge through the turbines is 24,000 cfs before tripout and discharge over the spillway gate is 750 cfs before tripout. Two minutes after tripout, discharge through the turbine has been reduced to 19,200 cfs, a reduction of 4,800 cfs, whereas discharge over the spillway gate has increased to 818 cfs, an increase of only 68 cfs. With the siren sounding in this period, there are two minutes of advance warning to persons along the river. The Reservoir level has risen a very minor amount, approximately 0.03 feet (3/8 of an inch), in the two minutes to store the difference between tubine discharge reduction and spillway discharge increase.

At the end of two minutes, the spillway gates have not moved, as is shown by the gate crest elevation being the same as when the turbines were tripped off the line. The gates then begin to open, causing the gate crest elevation to lower.

At the end of four minutes after tripout, turbine discharge has been reduced to 14,400 cfs, but the spillway gates are discharging only 2,300 cfs. The Reservoir elevation has risen about 0.1 feet (about 1.25 inches) following tripout. The spillway discharge is comparatively small, slightly larger than present minimum flow of the river, in which walking across the dry parts of the river bed is comparatively easy. A person walking at only 1 mile per hour could walk approximately 360 feet in 4 minutes. In that distance he might not be out of the way of higher water to come later, but he would be well underway. In my visits to the site the people I have seen near the river could move more rapidly than that.

Continuing, however, 8 minutes after tripout discharge over the spillway has increased to approximately 8,700 cfs, which is less than mean discharge of the river. The person walking at 1 mile per hour then would be approximately 720 feet from his starting point. The forebay would have risen approximately 4 inches since the tripout.

Spillway discharge continue to increase. Under the illustrative computation, maximum spillway discharge after tripout is approximately 28,500 cfs and the Reservoir water level has risen approximately seven inches approximately 14.2 minutes after tripout. In that time the individual walking at 1 mile per hour could have moved approximately 1,250 feet. Referring to Exhibit __ (AEA-12), that distance is 1 1/2 times the width of the river at the Dam. The extra two minutes between tripout and start of gate opening added 180 feet to the distance that otherwise would have been covered at the assumed slow speed of personal movement.

Another important point is that even though the maximum spillway discharge was 28,500 cfs, the spillway gate opening would be sufficient to discharge the river flow of 24,750 cfs when the Reservoir water level dropped to 1 inch above the normal operating level of elevation 2000. The excess of spillway discharge over river flow is necessary to drain the excess storage accumulated temporarily in the Reservoir.

Q. Have you investigated the rise in water level downstream from the Dam following the tripout you described?

A. Witness Lee describes details of hydraulic conditions downstream from the Dam. However, I can mention several points briefly. The public will have ready access to two areas between the Dam and the Tail Tunnel Outlet.

One area is on the left bank of the river, between 200 feet and 1,200 feet downstream from the Dam. In this area there are several vertical rock faces which a person either must climb or walk around to get out of the river bed. Water level in this area will rise approximately 10 feet between 750 cfs and 28,500 cfs.

Filling the valley storage will require a small part of the water, but the increased discharge can be assumed to move rapidly downstream from the Dam. In my opinion, it is possible for a person moving at 1 mile per hour to leave the area before escape routes are cut off.

The other area to which the public has ready access, as long as the Forest Service maintains its foot bridge, is at the mouth of the Koot Creek. At that location water level might rise 25 feet following the tripout. However, exit from Koot Creek area is relatively easy.

During detailed design following issuance of the license, the movement of persons and the details of spillway gate operation can be analyzed in more detail.

Q. Will these rapid changes in discharges and water level occur downstream from the Tail Tunnel Outlet?

A. There will be variations in discharge downstream from the Tail Tunnel Outlet because spillway discharge does not increase as rapidly as turbine discharge reduces.

Table 15 shows discharges downstream from the Tail Tunnel Outlet following the tripout described in exhibit. The discharges are tabulated from Exhibit ___ (AEA-19) and assume negligible wave travel time and no channel storage effects between the Dam and the Tail Tunnel Outlet.

Immediately following tripout there is a discharge reduction that continues for a little longer than 13 minutes. The smallest discharge occurs approximately 8 minutes after tripout and is approximately 55 percent of the discharge flowing before tripout.

Starting 8 minutes after tripout discharge increases, the flow returns to the original 24,750 cfs at approximately 13.2 minutes after tripout. Following that time discharge is larger than 24,750 cfs until the Reservoir returns to pre-tripout water level.

The tailwater rating curves, Exhibit ____ (AEA-15), indicates that discharge reduction from 24,750 cfs to 13,530 cfs would cause water level at the Tail Tunnel Outlet to drop by about 9 feet. The water level will drop, but not by nearly that many feet, because of the

Table 15

FULL LOAD TRIPOUT

APPROXIMATE DISCHARGES DOWNSTREAM FROM TAIL TUNNEL OUTLET

Discharges preceding tripout -	Turbine	24,000	cfs
	Spillway	750	cfs
	Total	24,750	cfs

Time from Tripout Minutes	Turbine Discharge CFS	Spillway Discharge CFS	Total Discharge Downstream from Tail Tunnel Outle CFS
0	24,000	750	24,750
1	21,600	766	22,366
2	19,200	818	20,018
3	16,800	1,432	18,232
4	14,400	2,285	16,685
5	12,000	3,422	15,422
6	9,600	4,859	14,459
7	7,200	6,623	13,823
8	4,800	8,731	13,531
9	2,400	11,196	13,596
10	0	14,006	14,006
11	0	17,118	17,118
12	0	20,471	20,471
13	0	24,055	24,055
14	0	27,810	27,810
15	0	28,375	28,375
15	0	28,375	28,375
16	0	28,207	28,207

short time for the discharge reduction and the fact that channel storage will be involved for a considerable distance downstream. The channel storage will prevent discharge downstream from being reduced as rapidly as it is upstream, and the channel storage will require longer than a few minutes to deplete.

Similarly, during the period when discharge downstream from the Tail Tunnel Outlet is increasing, channel storage will be refilled and the discharge increase at points downstream will be less rapid than it is upstream.

Q. Are there other items in connection with the Dam that require explanation?

A. Yes. There are two items. First, the Applicant intends to distribute the specified discharge of 750 cfs equally the full length of the Dam. The rock strata slope toward the right bank of the river. When the specified discharge of 750 cfs is flowing over the Dam, the Applicant plans to maintain the uniform distribution of water as it flows over the Falls. Witness Suttle discusses the means of accomplishing this. Second, the left abutment of the Dam will be at higher level than top of bedrock. It is necessary that there be a concrete cutoff wall paralleling the river upstream from the Dam to the location where sound bedrock is at approximately Elevation 2002. The cutoff wall will be on the river side of the railroad but on the land side of environmental mitigation works that are to be constructed. The cutoff wall will be a buried structure. Construction details are described by Witness Hjertberg.

Q. Does this conclude your prepared direct testimony?

A. Yes.

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

MATTER OF)
NORTHERN LIGHTS, INC.) PROJECT NO. 2752

AFFIDAVIT

STATE OF Illinois)
) ss.:
COUNTY OF Cook)

Arthur E. Allen, being duly sworn, deposes and says that he has read the foregoing prepared direct testimony of Arthur E. Allen, that he would respond in the same manner to the questions if so asked upon taking the stand, and that the matters of fact set forth therein are true and correct to the best of his knowledge, information and belief.

Arthur E. Allen

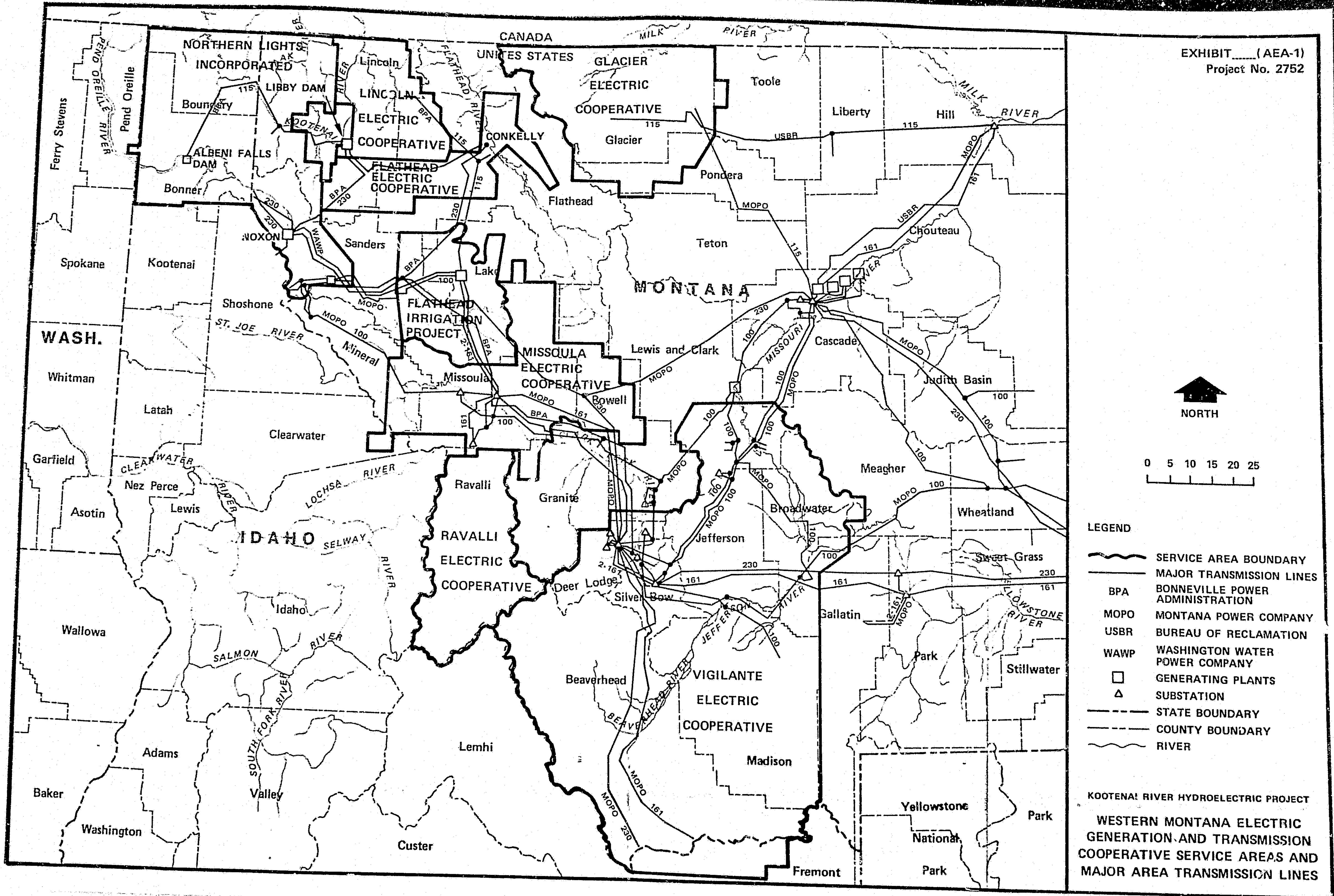
Subscribed and sworn to before me,
this 22nd day of January, 1982

Marian J. Higgins
Notary Public

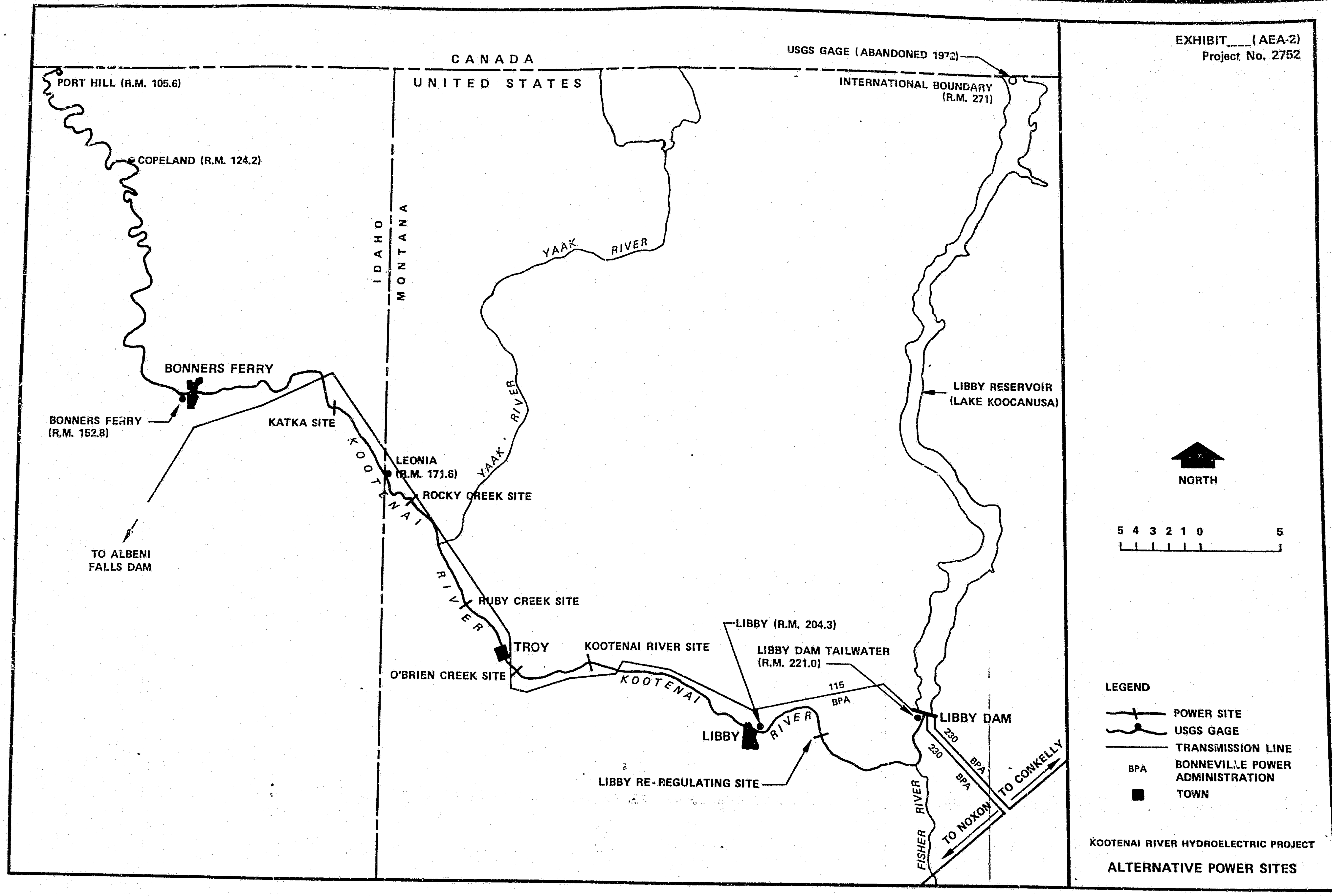
My commission expires 7-27-85

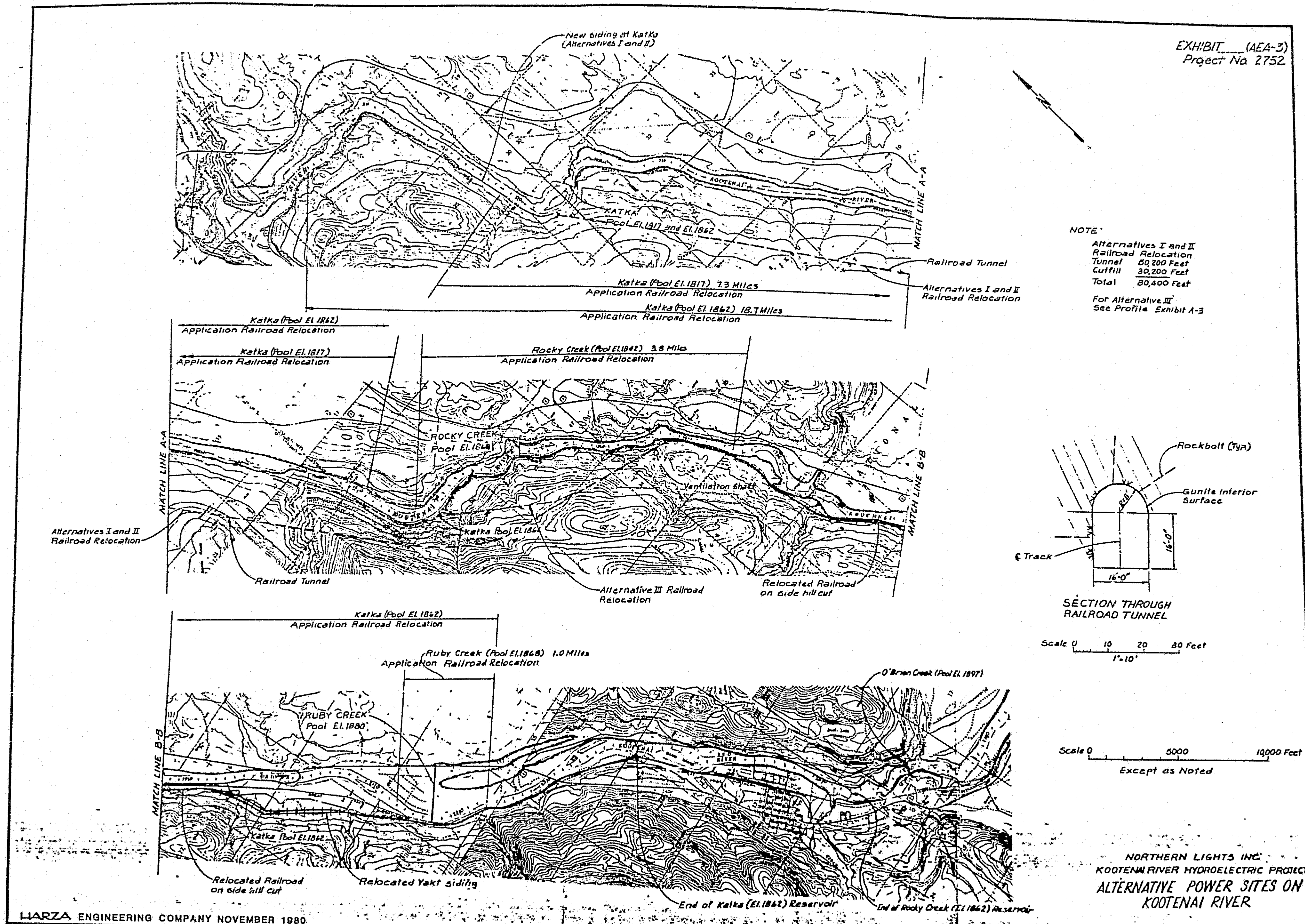
List of Exhibits

Title	Exhibit No.
Western Montana Electric Generating and Transmission Cooperative, Service Areas and Major Area Transmission Lines	____(AEA-1)
Alternative Power Sites	____(AEA-2)
Alternative Power Sites on the Kootenai River	____(AEA-3)
Layout 1, Sheet 1	____(AEA-4)
Layout 2, Sheet 2	____(AEA-5)
Layout 2A	____(AEA-6)
Layout 2B	____(AEA-7)
Layout 3	____(AEA-8)
Layout 4A	____(AEA-9)
Layout 4B	____(AEA-10)
Layout 5	____(AEA-11)
General Plan	____(AEA-12)
Dam and Spillway	____(AEA-13)
Discharge Patterns	____(AEA-14)
Tail Water Rating Curve	____(AEA-15)
Intake and Outlet Plans and Sections	____(AEA-16)
General Profile and Tunnel Sections	____(AEA-17)
Powerstation Plan and Sections	____(AEA-18)
Operation Following Station Trip-Out at Full Load	____(AEA-19)
Generating Capability vs. Gross Head	____(AEA-20)



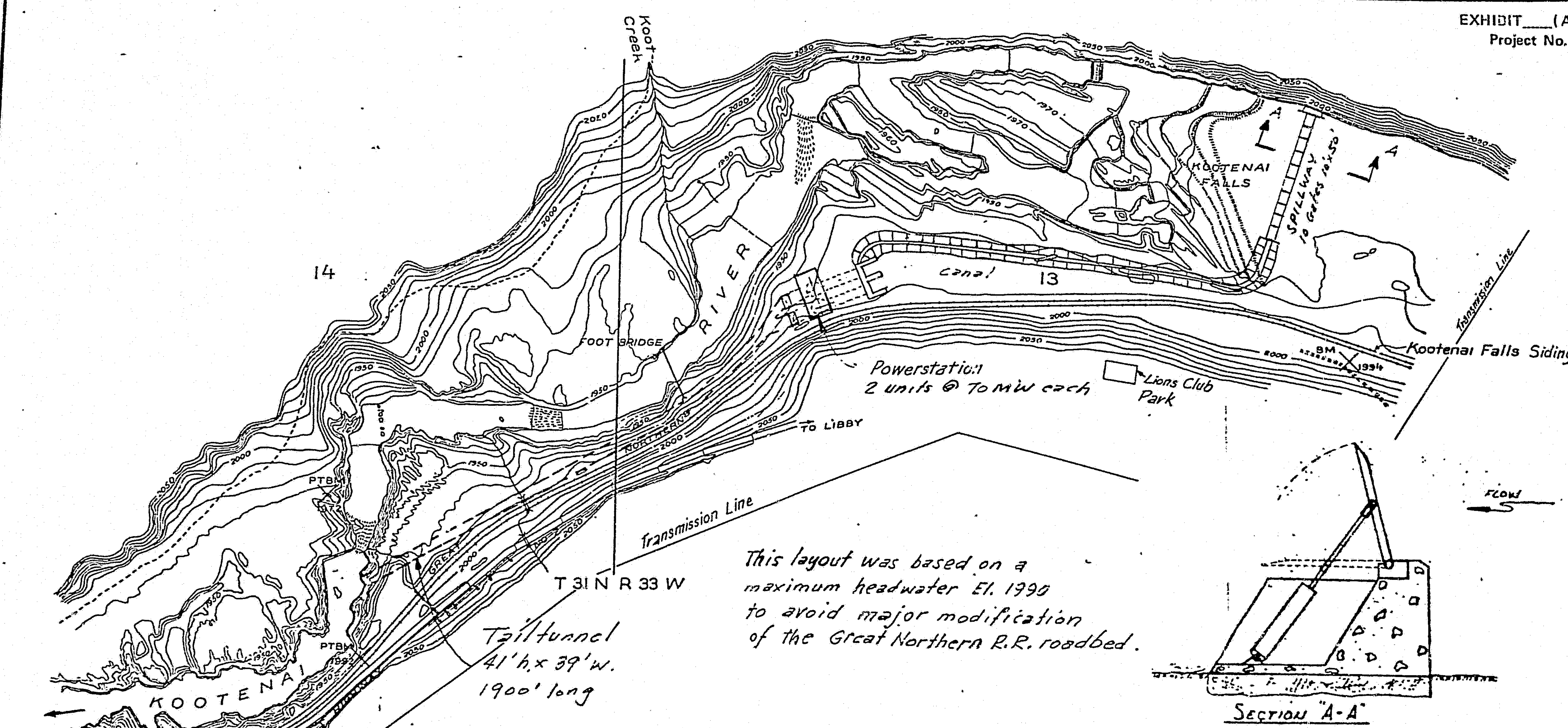
WESTERN MONTANA ELECTRIC GENERATION AND TRANSMISSION COOPERATIVE SERVICE AREAS AND MAJOR AREA TRANSMISSION LINES


EXHIBIT____(AEA-2)
Project No. 2752
CANADA
UNITED STATES
USGS GAGE (ABANDONED 1972)
INTERNATIONAL BOUNDARY (R.M. 271)
PORT HILL (R.M. 105.6)
COPELAND (R.M. 124.2)
IDAHO
MONTANA
YAAK RIVER
LIBBY RESERVOIR (LAKE KOOCANUSA)
BONNERS FERRY
BONNERS FERRY (R.M. 152.8)
KATKA SITE
LEONIA (R.M. 171.6)
ROCKY CREEK SITE
KOOTENAI RIVER
TO ALBENI FALLS DAM
RUBY CREEK SITE
TROY
O'BRIEN CREEK SITE
KOOTENAI RIVER SITE
LIBBY (R.M. 204.3)
LIBBY DAM TAILWATER (R.M. 221.0)
115
BPA
LIBBY DAM
LIBBY
230
LIBBY RE-REGULATING SITE
FISHER RIVER
TO NOXON
TO CONKELLY
NORTH
5 4 3 2 1 0 5
LEGEND
POWER SITE
USGS GAGE
TRANSMISSION LINE
BPA BONNEVILLE POWER ADMINISTRATION
TOWN
KOOTENAI RIVER HYDROELECTRIC PROJECT
ALTERNATIVE POWER SITES



EXHIBIT____(AEA-3)
Project No. 2752
New siding at Katka (Alternatives I and II)
KATKA Pool El. 1917 and El. 1862
KOOTENAI RIVER
MATCH LINE A-A
Railroad Tunnel
Alternatives I and II Railroad Relocation
Katka (Pool El. 1817) 7.3 Miles Application Railroad Relocation
Katka (Pool El. 1862) 18.7 Miles Application Railroad Relocation
NOTE:
Alternatives I and II Railroad Relocation
Tunnel 50,200 Feet
Cutfill 30,200 Feet
Total 80,400 Feet
For Alternative III See Profile Exhibit A-3
Katka (Pool El. 1862) Application Railroad Relocation
Katka (Pool El. 1817) Application Railroad Relocation
Rocky Creek (Pool El. 1842) 3.8 Miles Application Railroad Relocation
ROCKY CREEK Pool El. 1842
Ventilation Shaft
Katka Pool El. 1862
MATCH LINE B-B
Alternatives I and II Railroad Relocation
Railroad Tunnel
Alternative III Railroad Relocation
Relocated Railroad on side hill cut
Rockbolt (Typ.)
Gunite Interior Surface
℄ Track
16'-0"
16'-0"
SECTION THROUGH RAILROAD TUNNEL
Scale 0 10 20 30 Feet
1"=10'
Katka (Pool El. 1862) Application Railroad Relocation
Ruby Creek (Pool El. 1868) 1.0 Miles Application Railroad Relocation
RUBY CREEK Pool El. 1880
O'Brien Creek (Pool El. 1897)
Katka Pool El. 1862
Relocated Railroad on side hill cut
Relocated Yakt siding
End of Katka (El. 1862) Reservoir
End of Rocky Creek (El. 1862) Reservoir
Scale 0 5000 10,000 Feet
Except as Noted
NORTHERN LIGHTS INC.
KOOTENAI RIVER HYDROELECTRIC PROJECT
ALTERNATIVE POWER SITES ON KOOTENAI RIVER
HARZA ENGINEERING COMPANY NOVEMBER 1980

EXHIBIT____(AEA-4)
Project No. 2752



KOOTENAI FALLS DAM SITE

Plan Scale 1:4800 or 1 inch = 400 feet

400 200 0 400 800 1200 Feet

Contour interval on land 10 feet

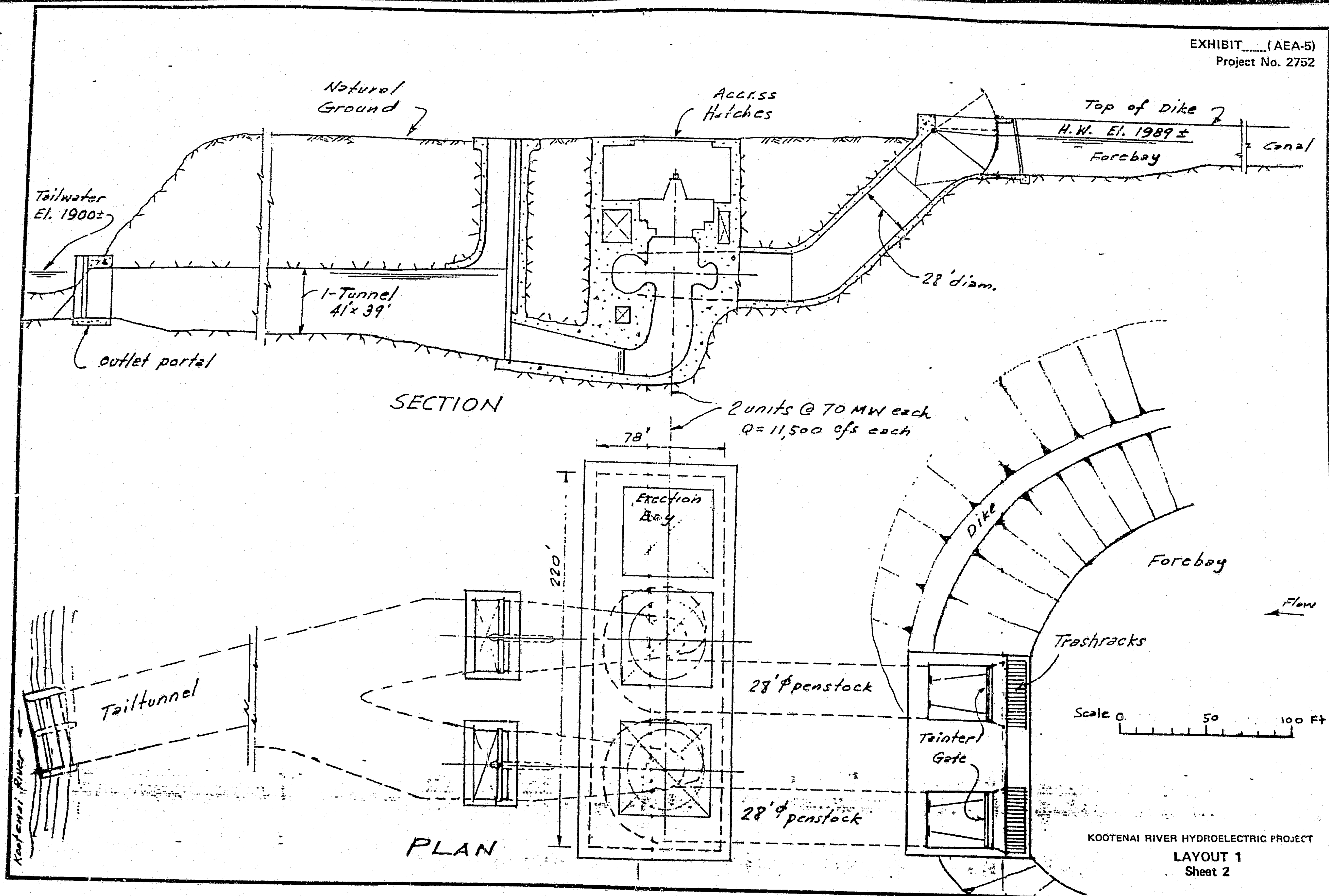
Contour interval on river surface 5 feet

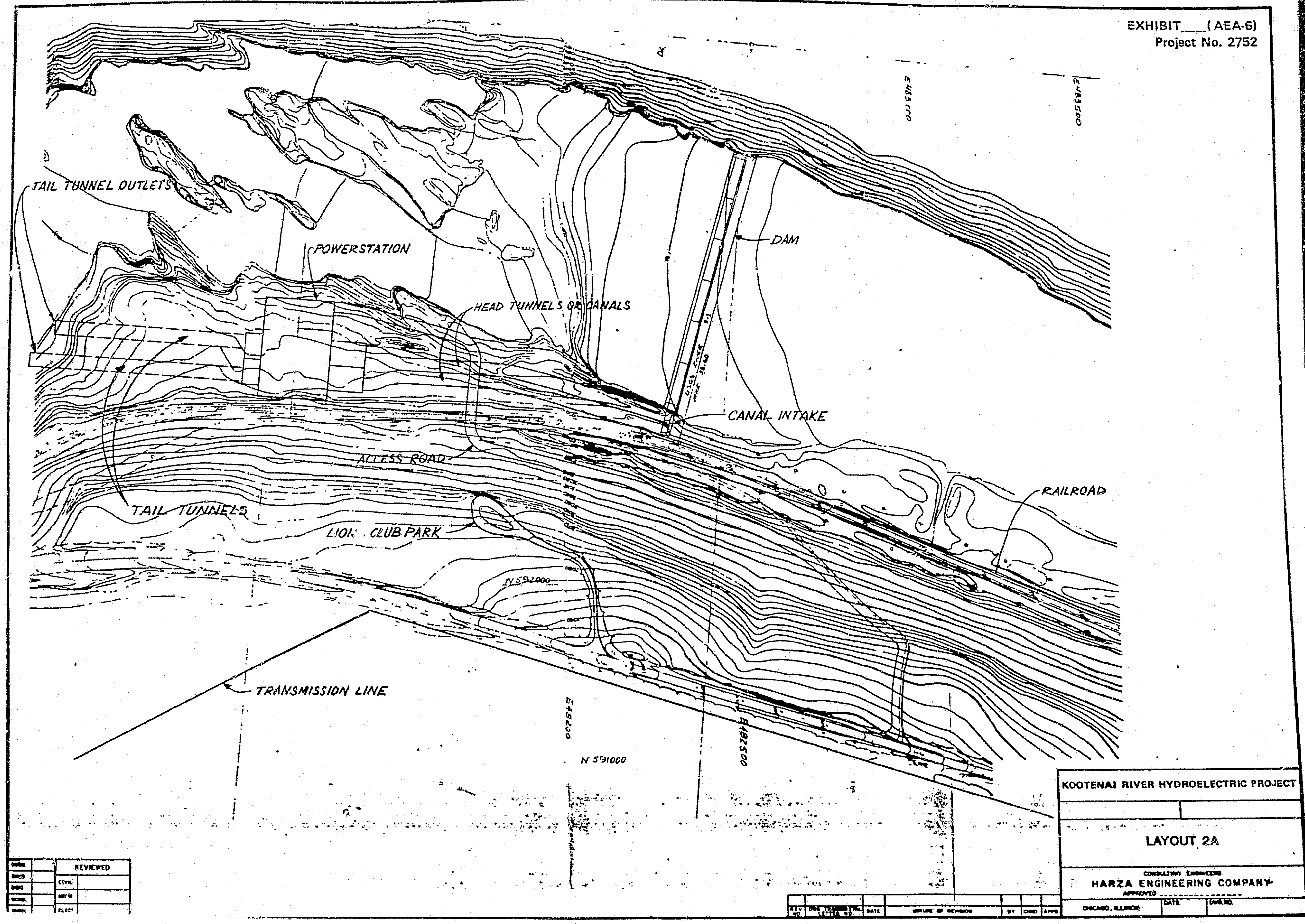
Datum is mean sea level

KOOTENAI RIVER HYDROELECTRIC PROJECT

LAYOUT 1

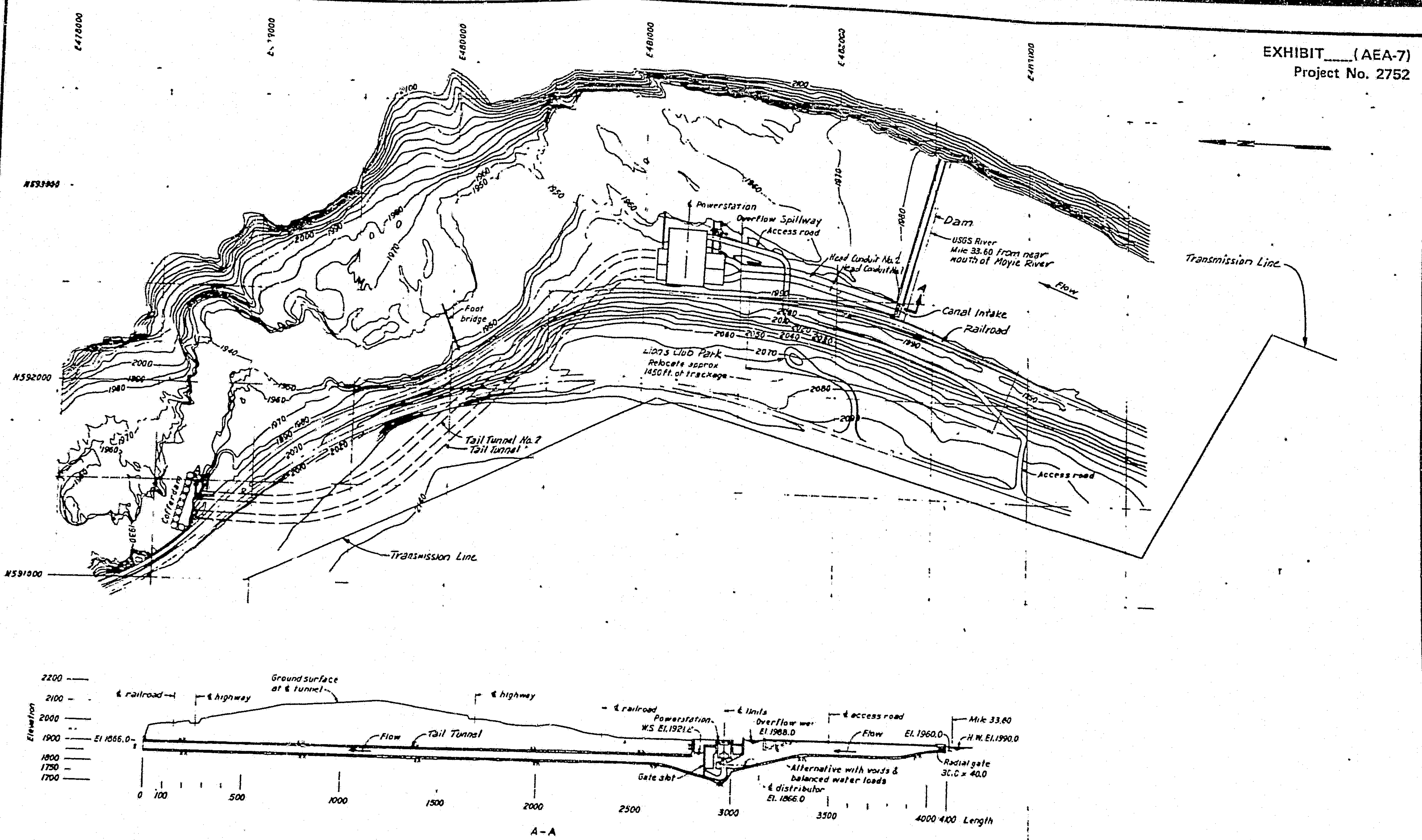
Sheet 1


EXHIBIT____(AEA-5)
Project No. 2752
Natural Ground
Access Hatches
Top of Dike
H.W. El. 1989 ±
Forebay
Canal
Tailwater El. 1900±
I-Tunnel 41'x 39'
28' diam.
outlet portal
SECTION
2 units @ 70 MW each
Q= 11,500 cfs each
78'
220'
Erection Bay
Dike
Forebay
Flow
Trashracks
Tailtunnel
28' ф penstock
Tainter Gate
Scale 0 50 100 Ft
28' ф penstock
Kootenai River
PLAN
KOOTENAI RIVER HYDROELECTRIC PROJECT
LAYOUT 1
Sheet 2



EXHIBIT____(AEA-6)
Project No. 2752
TAIL TUNNEL OUTLETS
POWERSTATION
HEAD TUNNELS OR CANALS
DAM
CANAL INTAKE
ACCESS ROAD
RAILROAD
TAIL TUNNELS
LION CLUB PARK
TRANSMISSION LINE
N 591000
KOOTENAI RIVER HYDROELECTRIC PROJECT
LAYOUT 2A
CONSULTING ENGINEERS
HARZA ENGINEERING COMPANY
CHICAGO, ILLINOIS
REVIEWED

EXHIBIT____(AEA-7)
Project No. 2752



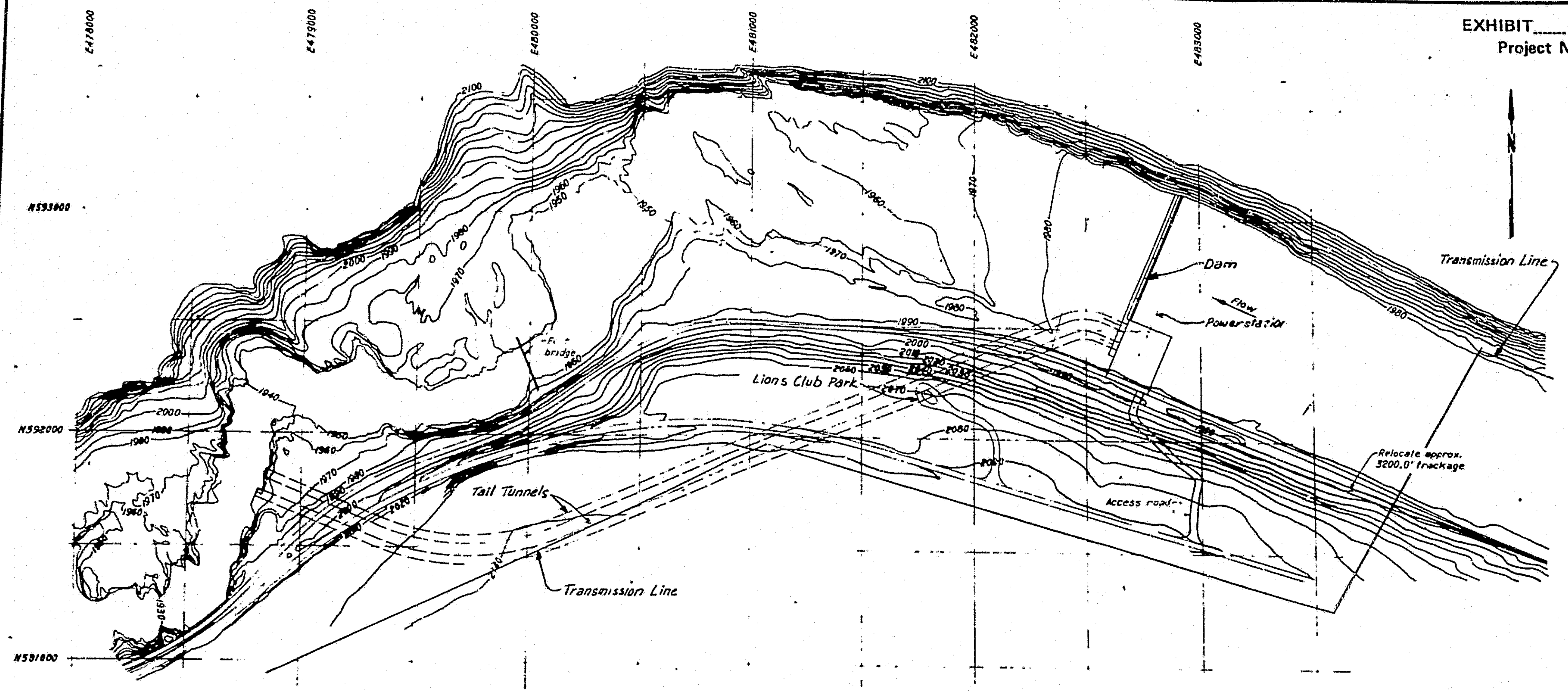
KOOTENAI RIVER HYDROELECTRIC PROJECT

LAYOUT 2B

CONSULTING ENGINEERS
HARZA ENGINEERING COMPANY
CHICAGO, ILLINOIS

REVIEWED

EXHIBIT_____(AEA-8)
Project No. 2752



		REVIEWED	
DSGN			
CHKD		CIVIL	
DWN		MECH	
CHKD		ELECT	
SUBM			

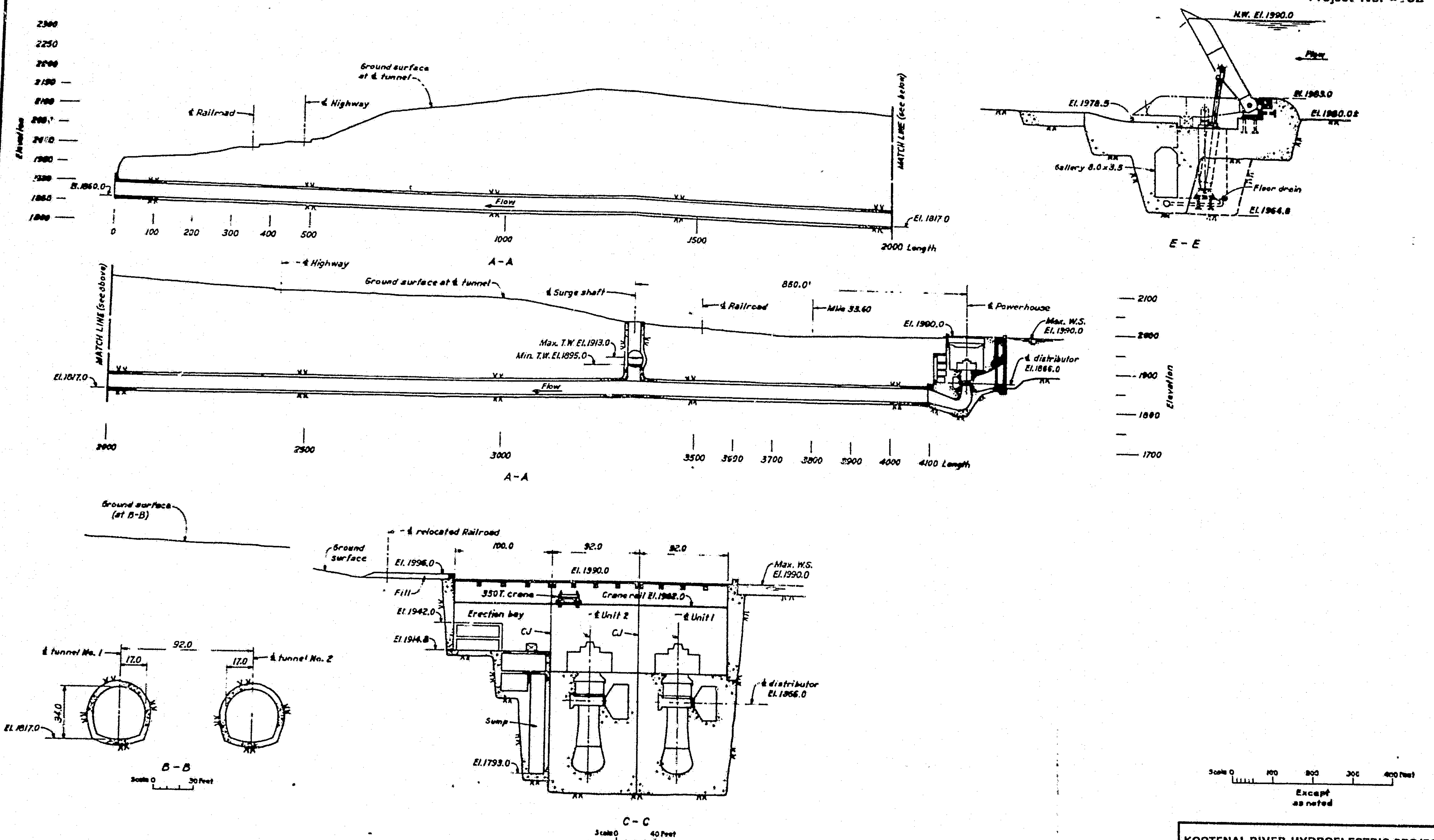
REV NO	DWG TRANSMITTAL LETTER NO	DATE	NATURE OF REVISION	BY	CHKD	APPD

KOOTENAI RIVER HYDROELECTRIC PROJECT

LAYOUT 3

CONSULTING ENGINEERS
HARZA ENGINEERING COMPANY
APPROVED
CHICAGO, ILLINOIS | DATE | DWG.NO.

EXHIBIT____(AEA-9)
Project No. 2752



KOOTENAI RIVER HYDROELECTRIC PROJECT

LAYOUT 4A

CONSULTING ENGINEERS
HARZA ENGINEERING COMPANY
APPROVED
CHICAGO, ILLINOIS

DSGN.		REVIEWED	
CHKD.		CIVIL	
DRWN.		MECH.	
CHKD.		ELECT.	
SUBM.			

REV NO.	DWG TRANSMITTAL LETTER NO.	DATE	NATURE OF REVISION	BY	CHKD	APPD

DWG. NO. 10528

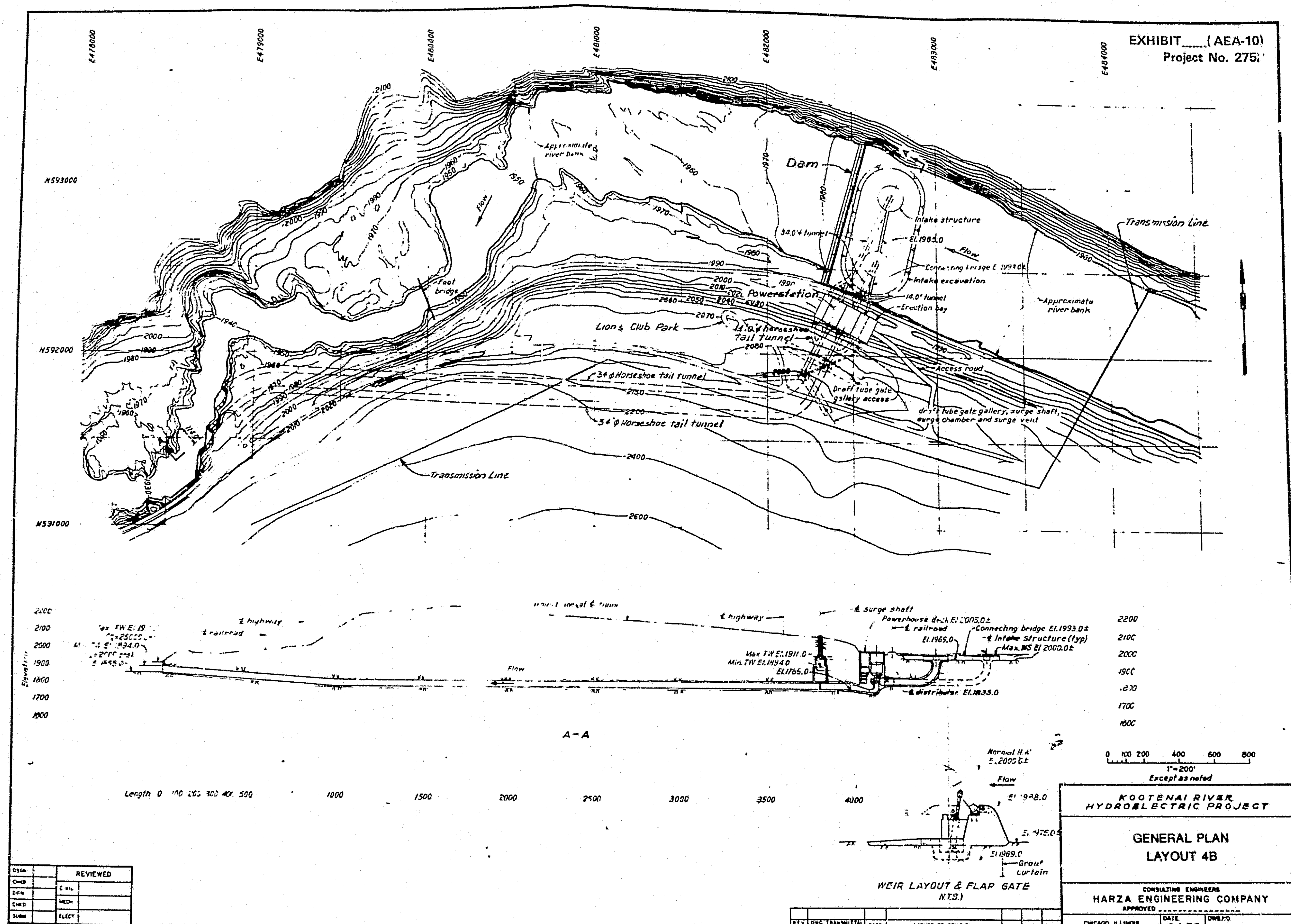
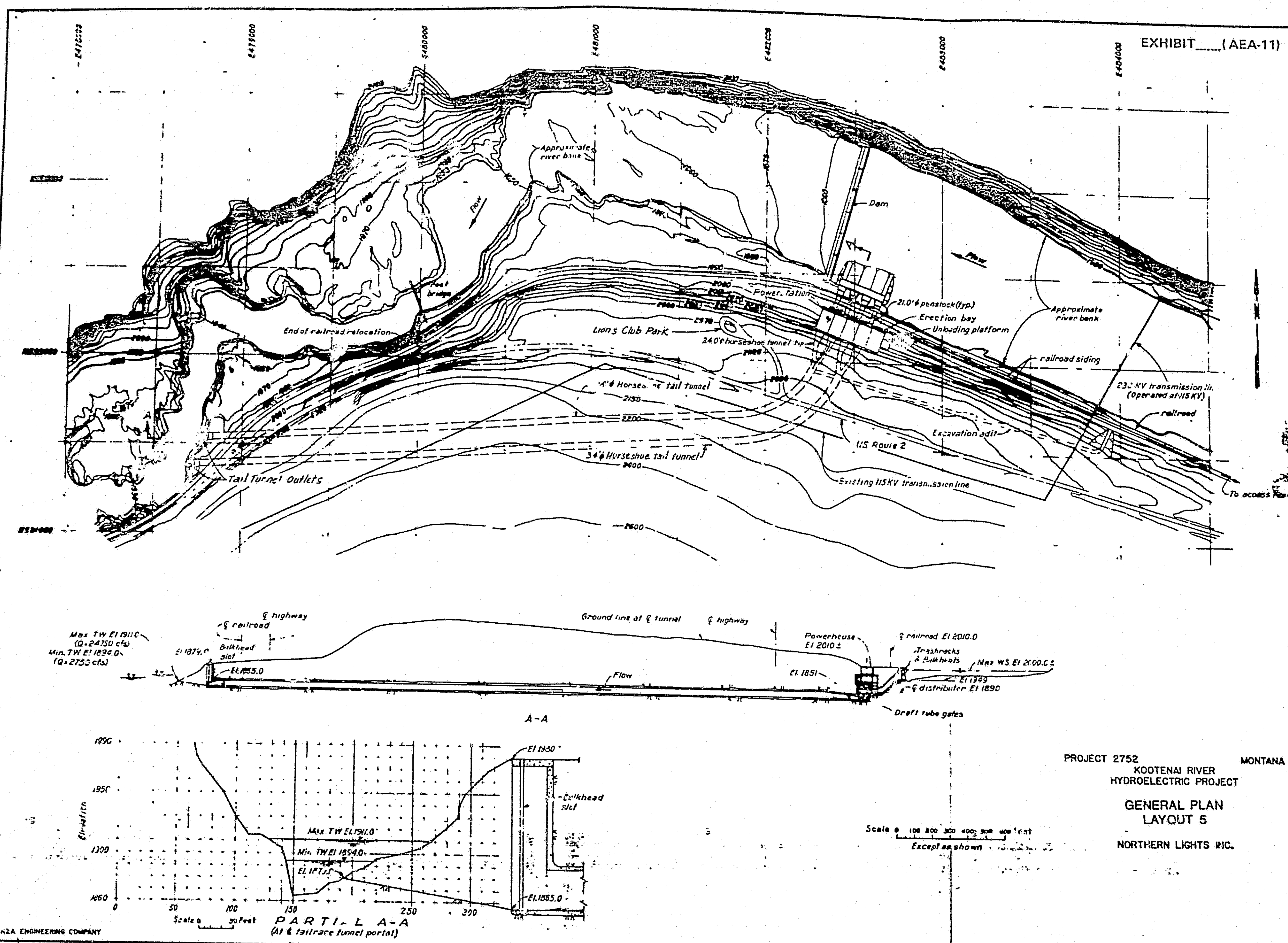


EXHIBIT......(AEA-10)
Project No. 275
E478000
E479000
E480000
E481000
E482000
E483000
E484000
N593000
N592000
N591000
Dam
Intake structure
El.1965.0
Flow
Intake excavation
Erection bay
Approximate river bank
Transmission Line
Powerstation
Lions Club Park
Foot bridge
Access road
Draft tube gate gallery access
34'ϕ Horseshoe tail tunnel
Transmission Line
2100
2400
2600
Surge shaft
Powerhouse deck El.2005.0±
Connecting bridge El.1993.0±
Intake structure (typ)
Max.WS El 2000.0±
highway
railroad
Max TW El.1911.0
El.1766.0
distributor El.1835.0
Flow
A - A
Length 0 100 200 300 400 500 1000 1500 2000 2500 3000 3500 4000
Elevation
2200
2100
2000
1900
1800
1700
1600
Normal H.W. El.2005.0±
Flow
El.1948.0
El.1969.0
Grout curtain
WEIR LAYOUT & FLAP GATE
(N.T.S.)
0 100 200 400 600 800
1"=200'
Except as noted
KOOTENAI RIVER
HYDROELECTRIC PROJECT
GENERAL PLAN
LAYOUT 4B
CONSULTING ENGINEERS
HARZA ENGINEERING COMPANY
APPROVED
CHICAGO, ILLINOIS
DATE
6-1-78
DWG.NO.
REVIEWED
CIVIL
MECH
ELECT
REV NO
DWG TRANSMITTAL LETTER NO
DATE
NATURE OF REVISION
BY
CHKD
APPD



PROJECT 2752 MONTANA

KOOTENAI RIVER HYDROELECTRIC PROJECT

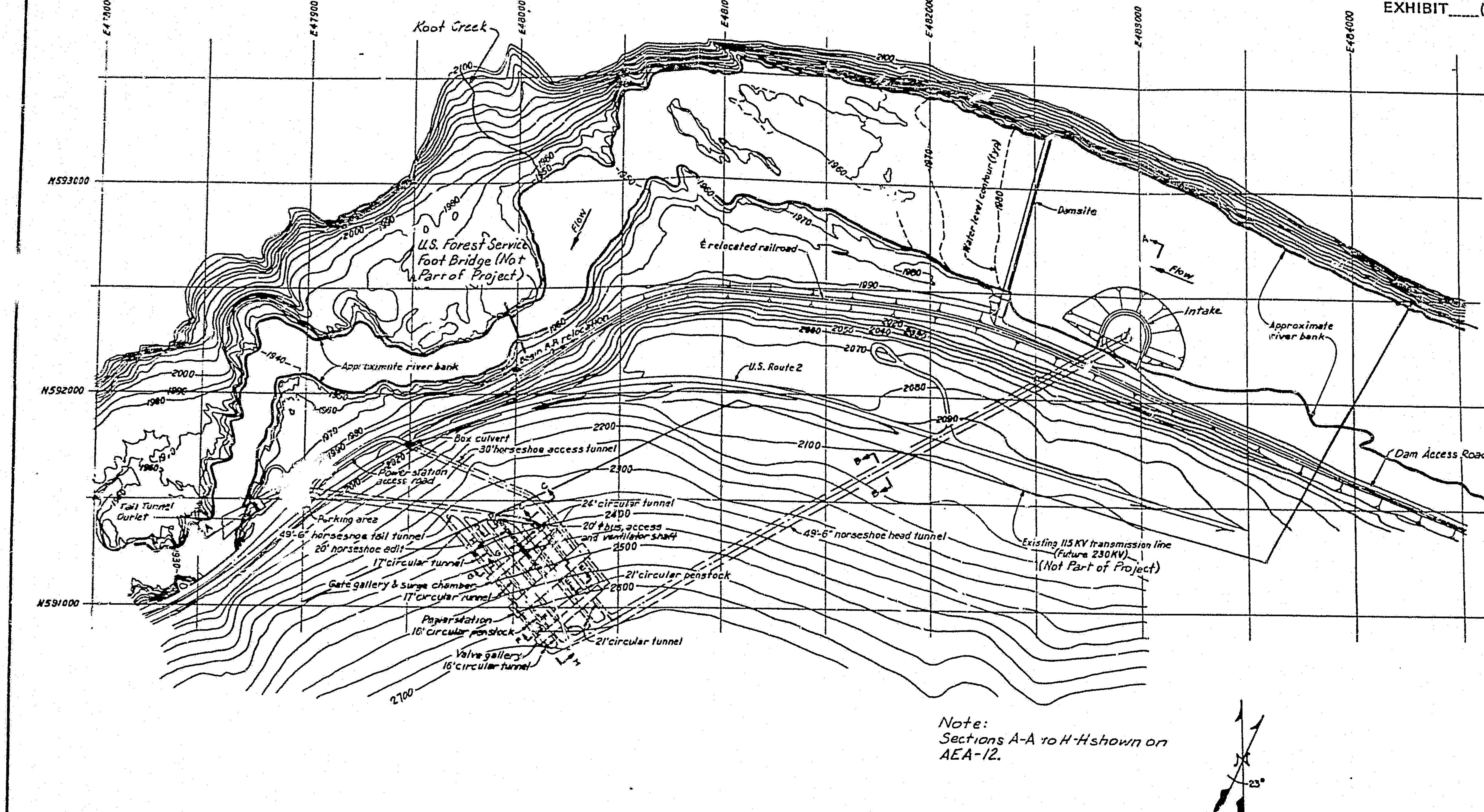
GENERAL PLAN

LAYOUT 5

NORTHERN LIGHTS INC.

HARZA ENGINEERING COMPANY

EXHIBIT____(AEA-12)



SCALE 0 200 400 600 800 1000 1200 FEET
1" = 200'

PROJECT 2752 MONTANA
KOOTENAI RIVER
HYDROELECTRIC PROJECT

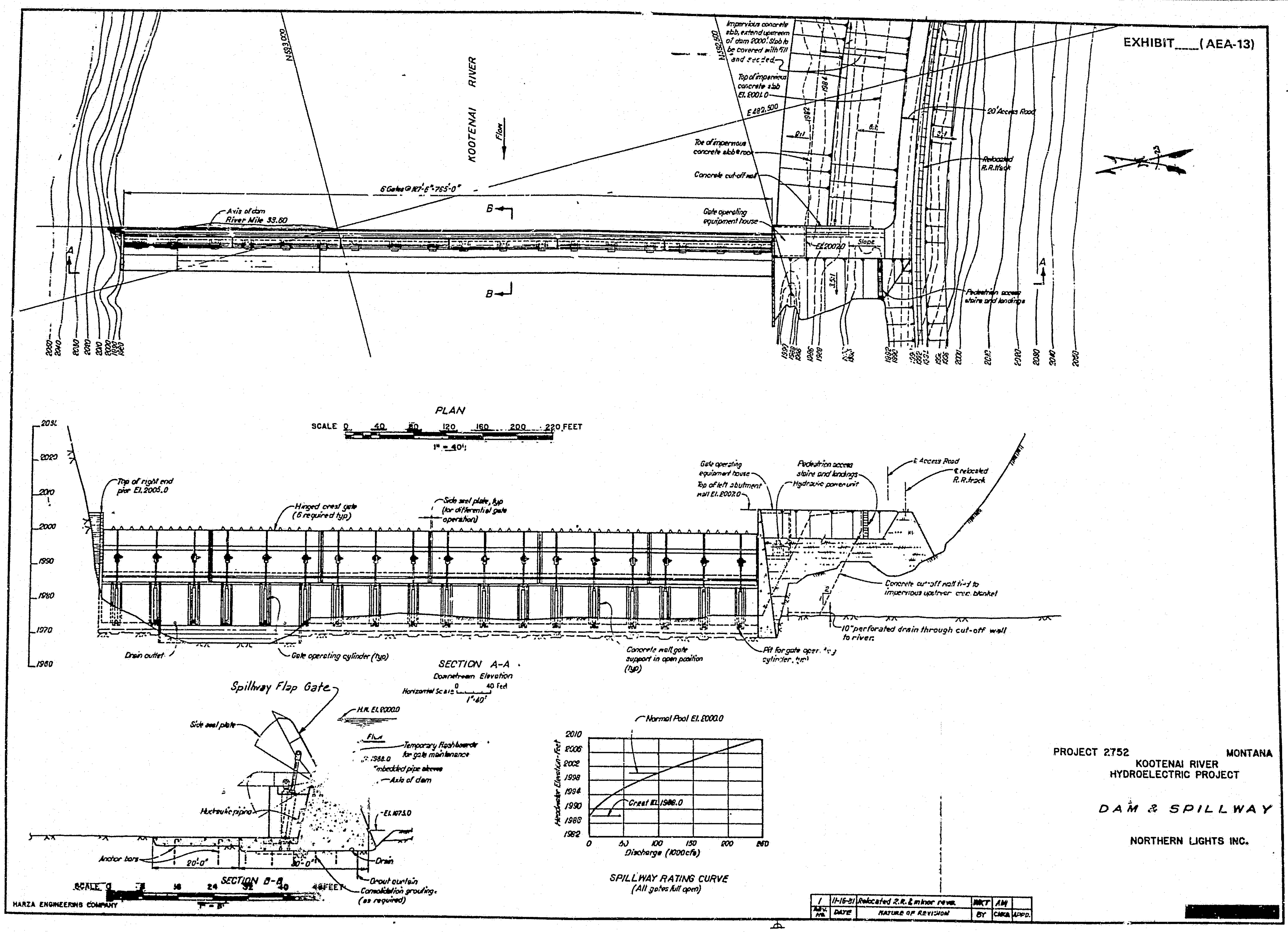
GENERAL PLAN

NORTHERN LIGHTS INC.

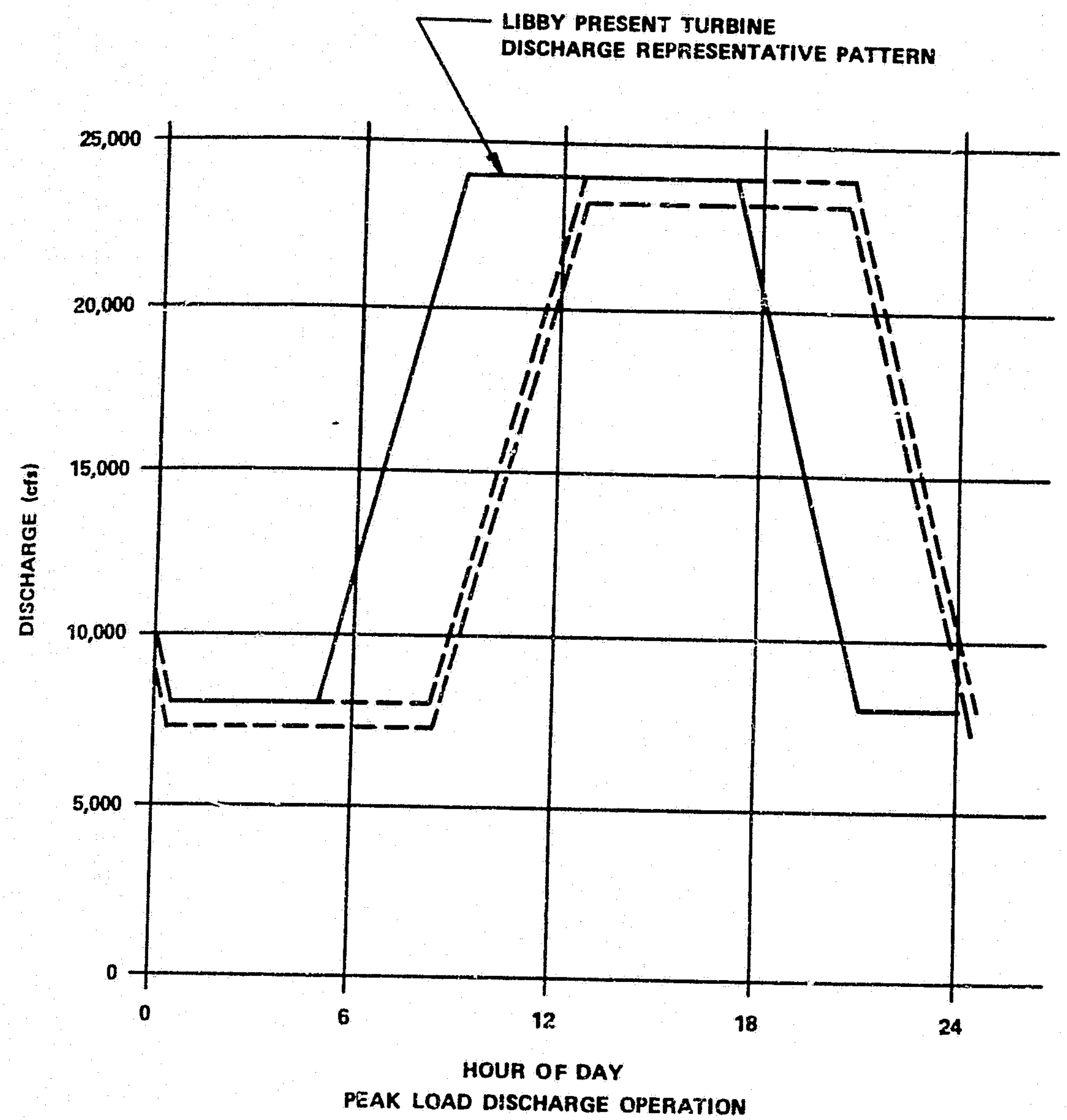
HARZA ENGINEERING COMPANY

REV. NO.	DATE	NATURE OF REVISION	BY	CHKD.	APPD.
1	10-13-81	Rev. Powerstation & Tunnels	WKT	AM	

FERC NO. 2752-5


EXHIBIT____(AEA-13)
KOOTENAI RIVER
Flow
6 Gates @ 127'-6" = 765'-0"
Axis of dam River Mile 33.60
Impervious concrete slab, extend upstream of dam 2000'. Slab to be covered with fill and seeded
Top of impervious concrete slab El. 2001.0
E 482,500
Toe of impervious concrete slab & rock
Concrete cut-off wall
Gate operating equipment house
El. 2002.0
Slope
20' Access Road
Relocated R.R. track
Pedestrian access stairs and landings
PLAN
SCALE 0 40 80 120 160 200 220 FEET
1" = 40'
Top of right end pier El. 2005.0
Hinged crest gate (6 required typ)
Side seal plate, typ (for differential gate operation)
Gate operating equipment house
Pedestrian access stairs and landings
Top of left abutment wall El. 2002.0
Hydraulic power unit
℄ Access Road
℄ relocated R.R. track
Concrete cut-off wall tied to impervious upstream conc. blanket
10" perforated drain through cut-off wall to river.
Drain outlet
Gate operating cylinder (typ)
Concrete wall gate support in open position (typ)
Pit for gate operating cylinder
SECTION A-A
Downstream Elevation
Horizontal Scale 0 40 Feet
1" = 40'
Spillway Flap Gate
Side seal plate
H.W. El. 2000.0
Flow
Temporary flashboards for gate maintenance
1988.0
Embedded pipe sleeve
Axis of dam
Hydraulic piping
El. 1975.0
Anchor bars
20'-0"
30'-0"
Drain
Grout curtain
Consolidation grouting (as required)
SECTION B-B
SCALE 0 8 16 24 32 40 48 FEET
1" = 8'
HARZA ENGINEERING COMPANY
Normal Pool El. 2000.0
Crest El. 1988.0
Headwater Elevation-Feet
Discharge (1000 cfs)
SPILLWAY RATING CURVE
(All gates full open)
PROJECT 2752 MONTANA
KOOTENAI RIVER
HYDROELECTRIC PROJECT
DAM & SPILLWAY
NORTHERN LIGHTS INC.
1 11-16-81 Relocated R.R. & minor revs.
REV. NO. DATE NATURE OF REVISION BY CHKD APPD.

EXHIBIT____(AEA-14)
Project No. 2752



LEGEND

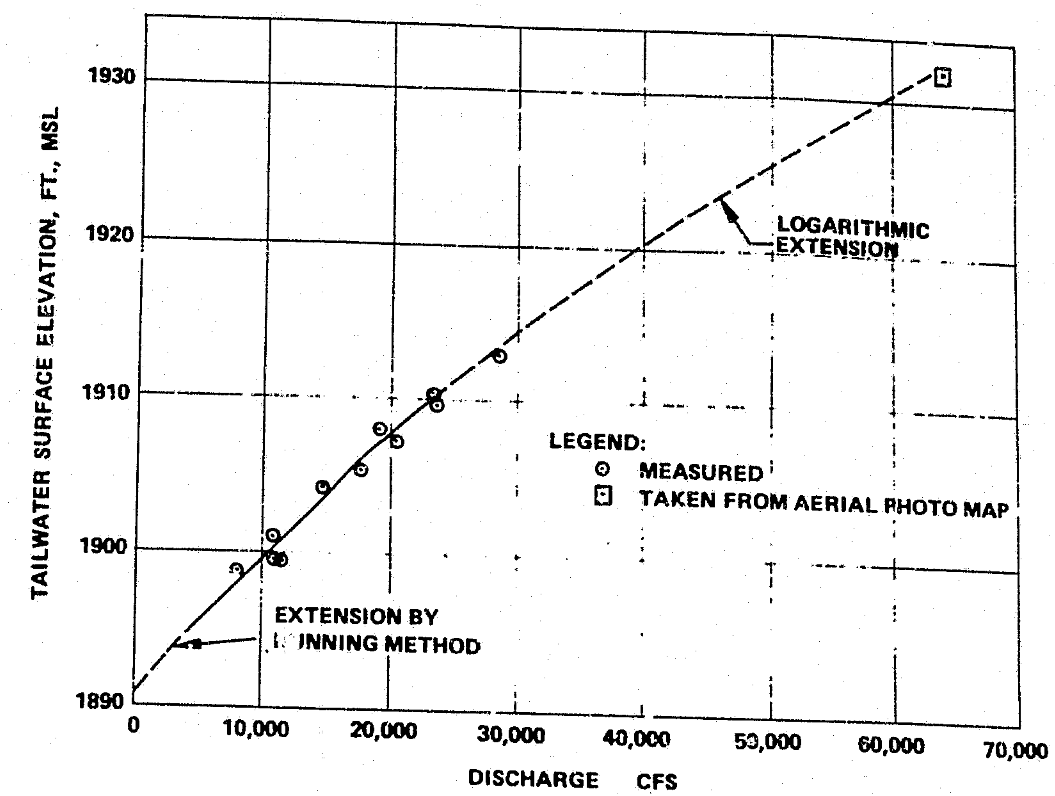
UPPER DASHED LINE — TOTAL DISCHARGE AT PROJECT

LOWER DASHED LINE — PROJECT TURBINE DISCHARGE

KOOTENAI RIVER HYDROELECTRIC PROJECT

DISCHARGE PATTERNS

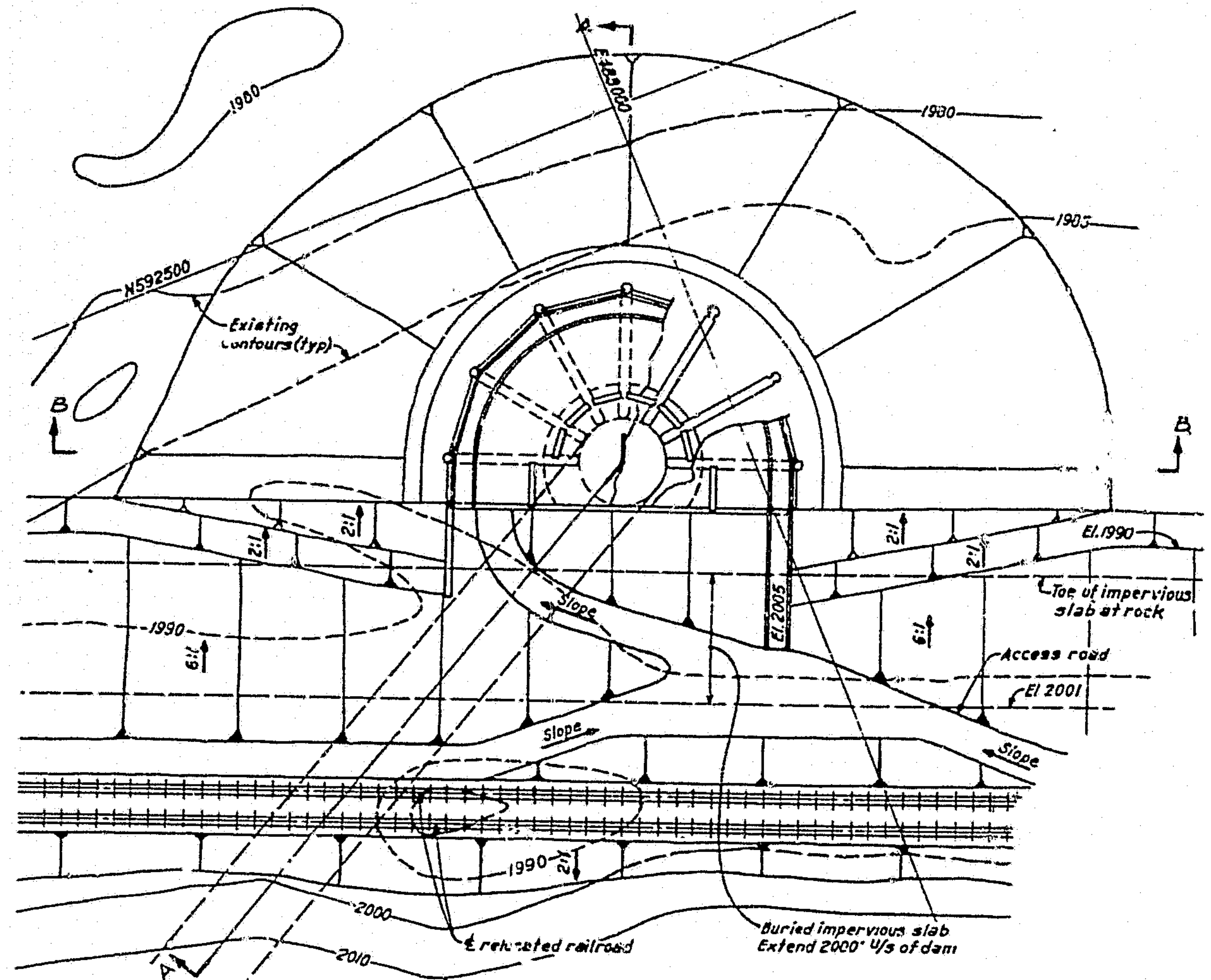
EXHIBIT____(AEA-15)
Project No. 2752



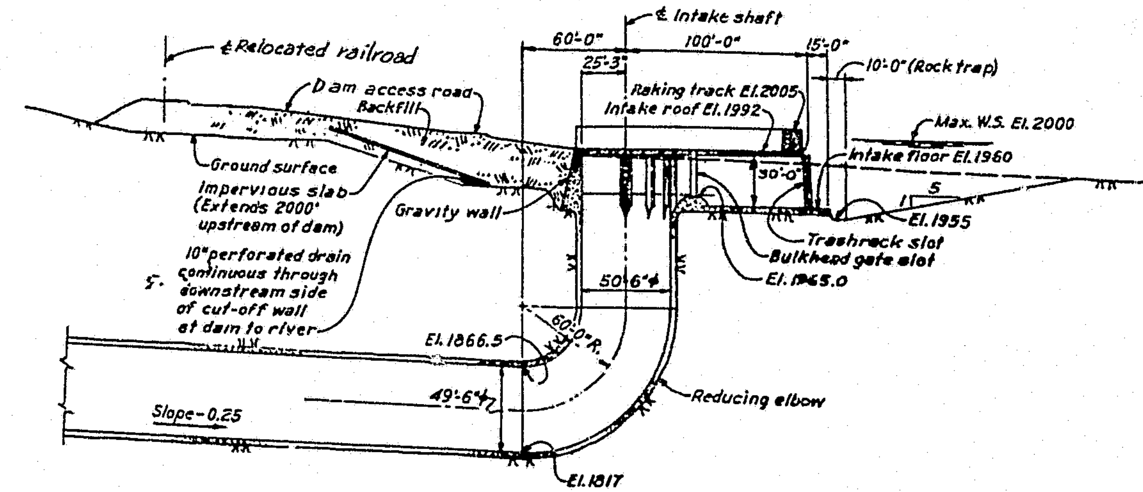
KOOTENAI RIVER HYDROELECTRIC PROJECT

TAILWATER RATING CURVE

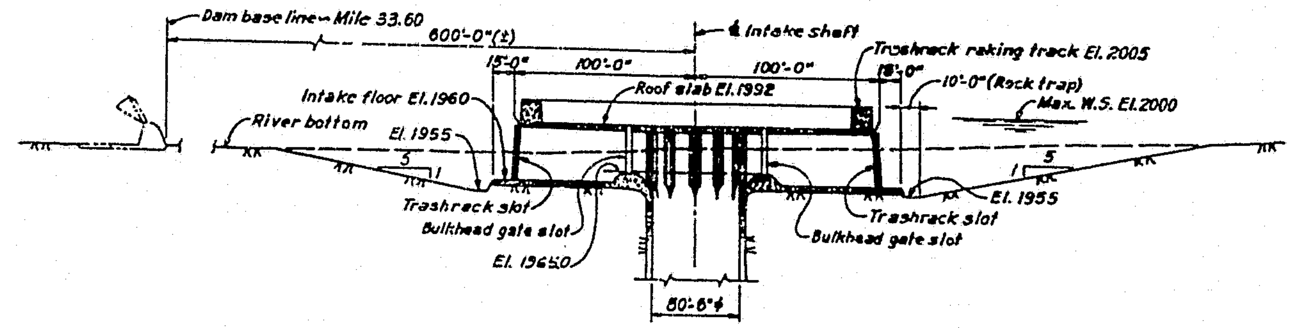
EXHIBIT_____ (AEA-16)



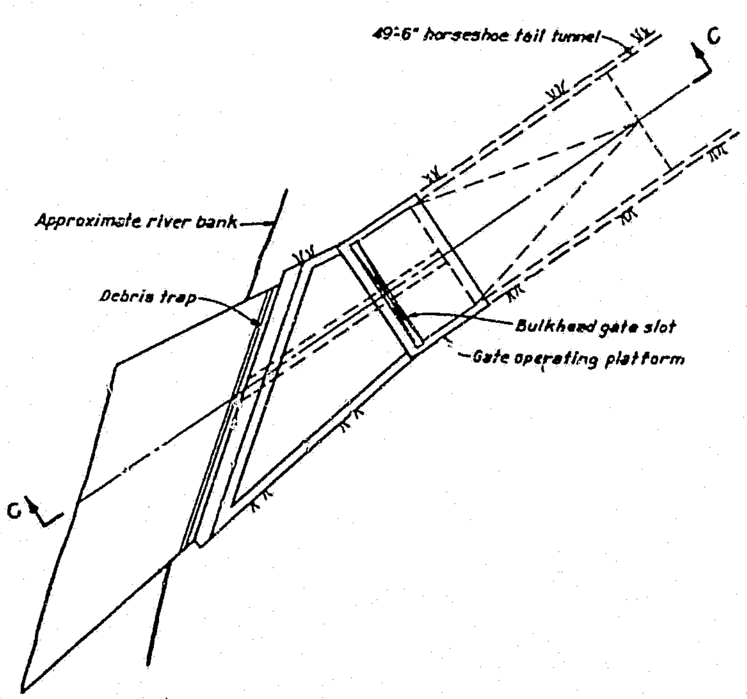
INTAKE PLAN



A – A



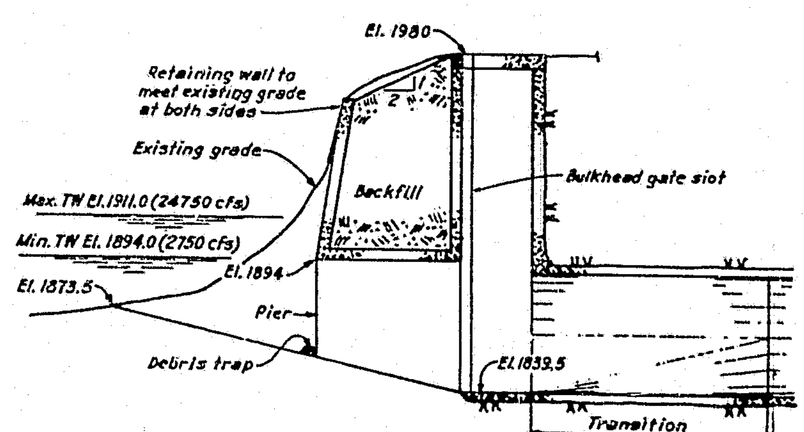
B – B



TAIL TUNNEL OUTLET PLAN

SCALE 0 30 60 90 120 150 180 FEET

1" = 30'



C – C

SCALE 0 40 80 120 160 200 220 FEET

1" = 40'
EXCEPT AS SHOWN

PROJECT 2752 MONTANA

KOOTENAI RIVER
HYDROELECTRIC PROJECT

INTAKE & OUTLET
PLANS & SECTIONS

NORTHERN LIGHTS INC.

HARZA ENGINEERING COMPANY

FERC NO. 2752-9

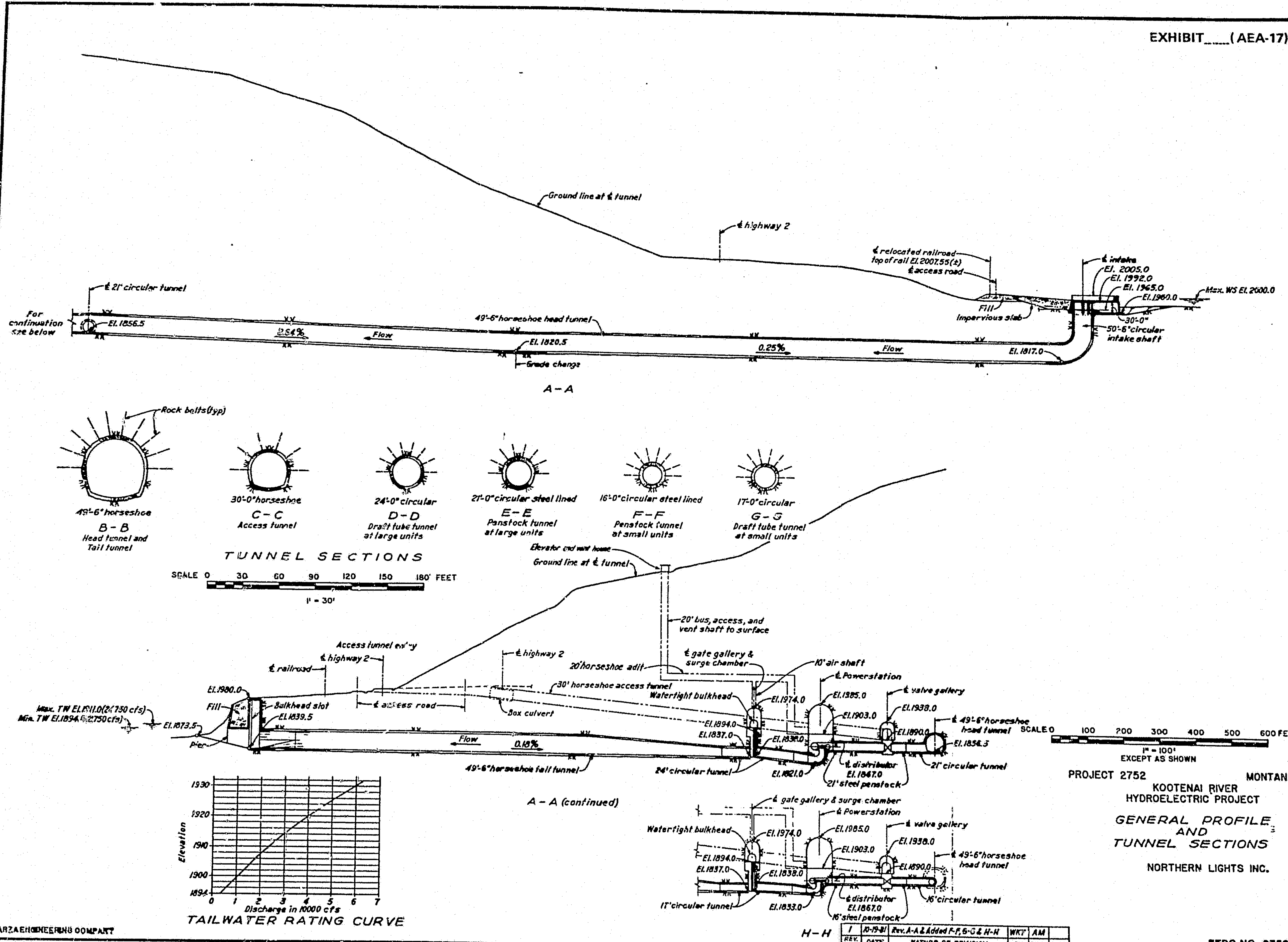
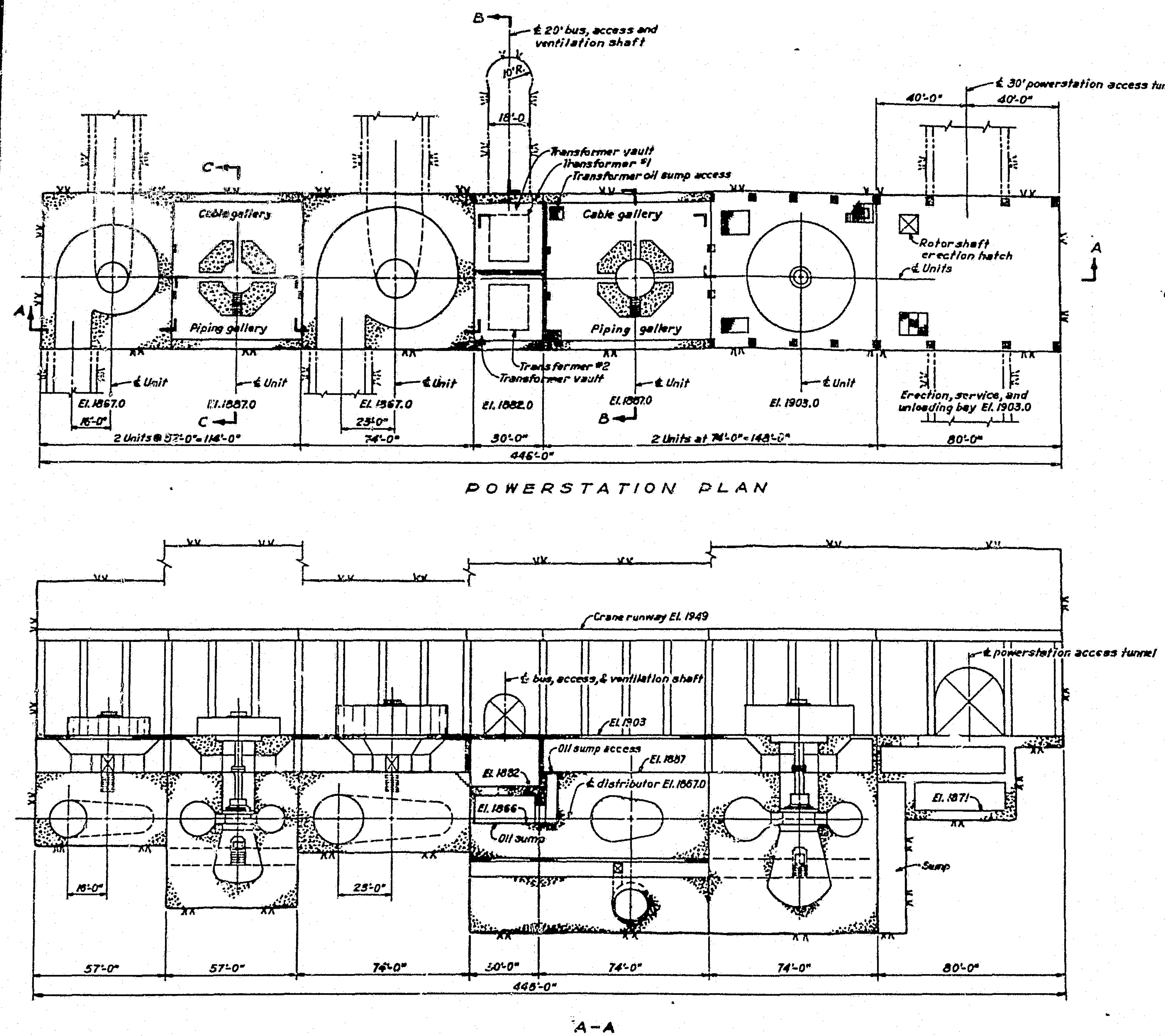
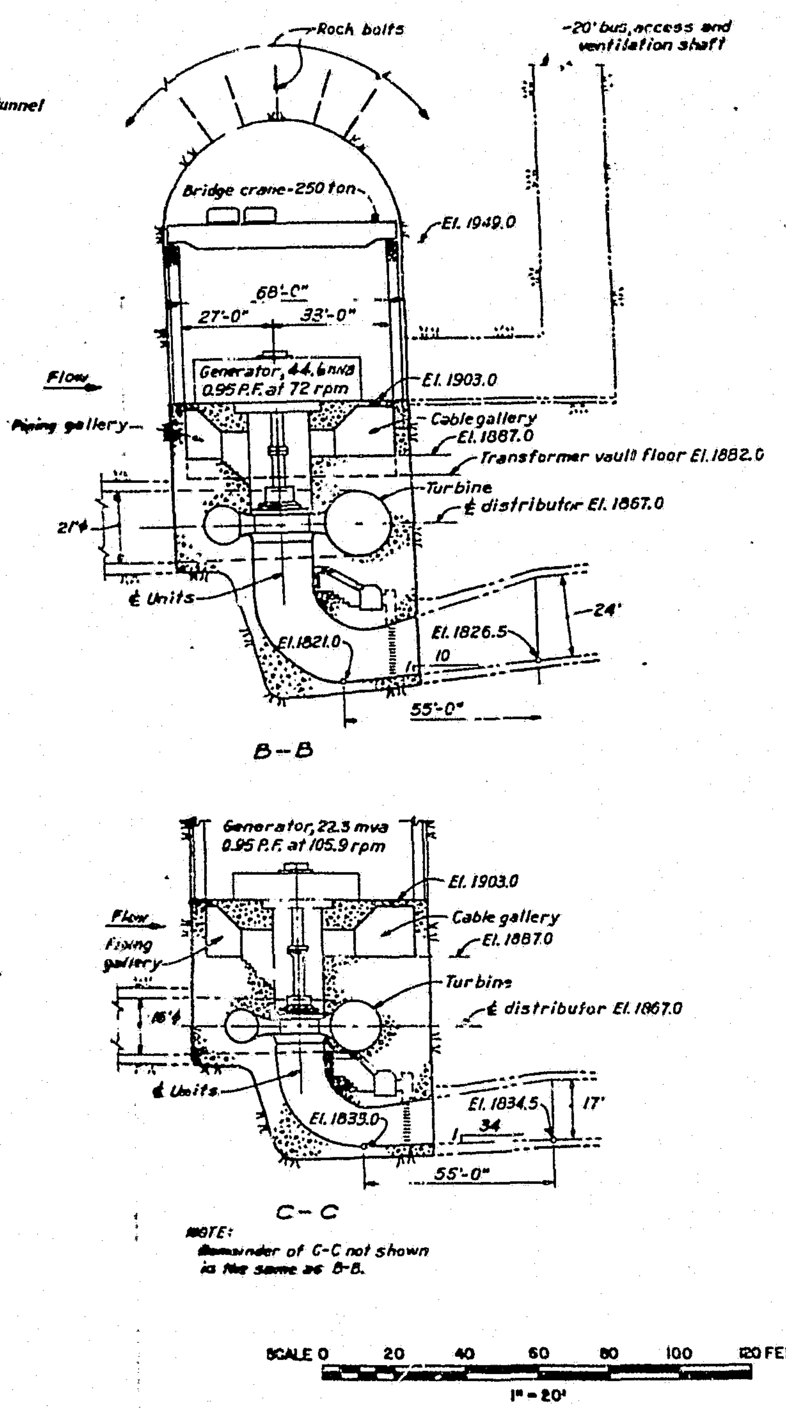

EXHIBIT____(AEA-17)
Ground line at ℄ tunnel
℄ highway 2
℄ relocated railroad-top of rail El. 2007.55(±)
℄ access road
℄ intake
El. 2005.0
El. 1992.0
El. 1965.0
El. 1960.0
Max. WS El. 2000.0
Fill
Impervious slab
30'-0"
50'-6" circular intake shaft
℄ 21' circular tunnel
For continuation see below
El. 1856.5
49'-6" horseshoe head tunnel
2.54%
Flow
El. 1820.5
Grade change
0.25%
El. 1817.0
A – A
Rock bolts (typ)
49'-6" horseshoe
B – B
Head tunnel and Tail tunnel
30'-0" horseshoe
C – C
Access tunnel
24'-0" circular
D – D
Draft tube tunnel at large units
21'-0" circular steel lined
E – E
Penstock tunnel at large units
16'-0" circular steel lined
F – F
Penstock tunnel at small units
17'-0" circular
G – G
Draft tube tunnel at small units
TUNNEL SECTIONS
SCALE 0 30 60 90 120 150 180' FEET
1" = 30'
Elevator and vent house
Ground line at ℄ tunnel
20' bus, access, and vent shaft to surface
Access tunnel entry
℄ highway 2
℄ railroad
℄ highway 2
20' horseshoe adit
℄ gate gallery & surge chamber
10' air shaft
℄ Powerstation
30' horseshoe access tunnel
Watertight bulkhead
El. 1980.0
Fill
Max. TW El. 1911.0 (2(?)750 cfs)
Min. TW El. 1894.5 (2750 cfs)
El. 1873.5
Pier
Bulkhead slot
El. 1839.5
℄ access road
Box culvert
Flow
0.18%
49'-6" horseshoe tail tunnel
24' circular tunnel
El. 1974.0
El. 1894.0
El. 1837.0
El. 1838.0
El. 1821.0
El. 1985.0
El. 1903.0
℄ valve gallery
El. 1938.0
El. 1890.0
℄ 49'-6" horseshoe head tunnel
El. 1856.5
℄ distributor El. 1847.0
21' steel penstock
21' circular tunnel
A – A (continued)
SCALE 0 100 200 300 400 500 600 FEET
1" = 100'
EXCEPT AS SHOWN
1930
1920
1910
1900
1894
Elevation
0 1 2 3 4 5 6 7
Discharge in 10000 cfs
TAILWATER RATING CURVE
℄ gate gallery & surge chamber
℄ Powerstation
℄ valve gallery
Watertight bulkhead
El. 1974.0
El. 1985.0
El. 1903.0
El. 1938.0
El. 1894.0
El. 1837.0
El. 1838.0
El. 1890.0
℄ 49'-6" horseshoe head tunnel
17' circular tunnel
El. 1833.0
℄ distributor El. 1867.0
16' steel penstock
16' circular tunnel
H – H
1 | 10-19-81 | Rev. A-A & Added F-F, G-G & H-H | WKT | AM
REV. NO. | DATE | NATURE OF REVISION | BY | CHKD. | APPR.
PROJECT 2752
MONTANA
KOOTENAI RIVER HYDROELECTRIC PROJECT
GENERAL PROFILE AND TUNNEL SECTIONS
NORTHERN LIGHTS INC.
HARZA ENGINEERING COMPANY
FERC NO. 2752-6

EXHIBIT ____ (AEA-18)





PROJECT 2752 MONTANA
KOOTENAI RIVER
HYDROELECTRIC PROJECT

POWERSTATION
PLAN & SECTIONS

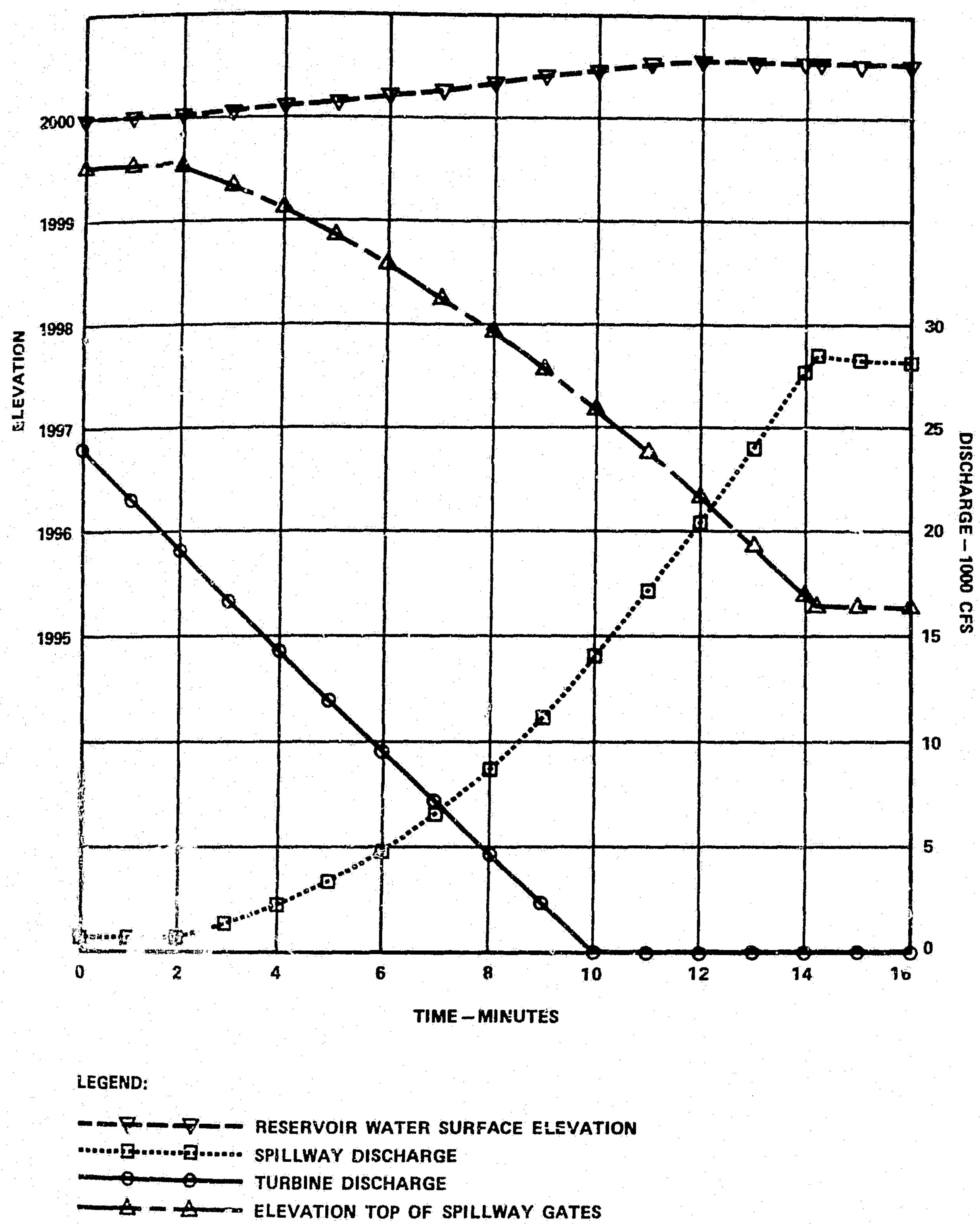
NORTHERN LIGHTS INC.

REV. NO.	DATE	NATURE OF REVISION	BY	CHKD	APPD
1	10-18-81	Revised Powerstation & Sections	WRT	AM	

HARZA ENGINEERING COMPANY

FERC NO. 2752-8

EXHIBIT____(AEA-19)
Project No. 2752



KOOTENAI RIVER HYDROELECTRIC PROJECT

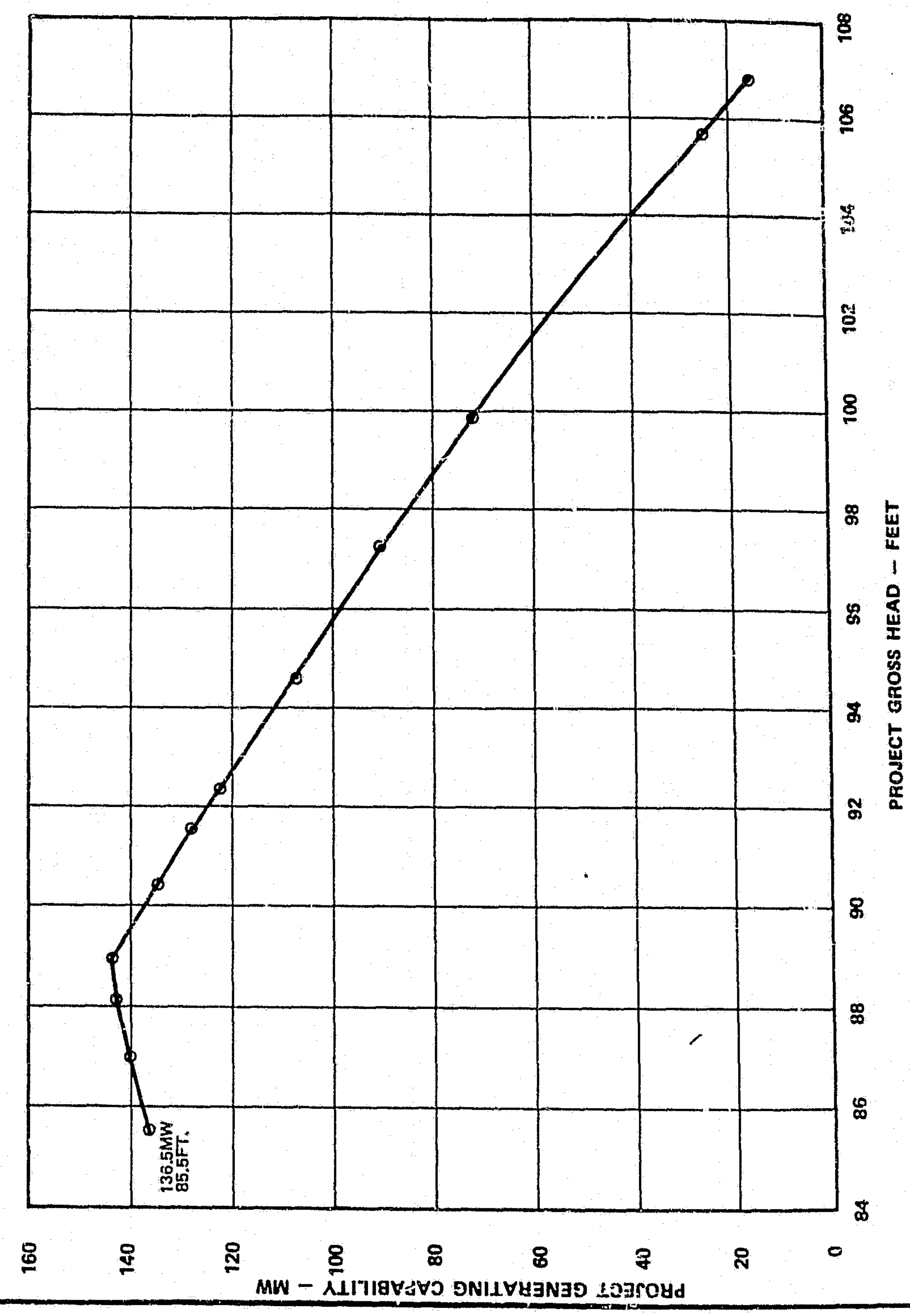
OPERATION FOLLOWING STATION TRIP–OUT AT FULL LOAD

EXHIBIT____(AEA-20)
Project No. 2752

NOTE:
RESERVOIR ELEVATION 2000

KOOTENAI RIVER HYDROELECTRIC PROJECT

GENERATING CAPABILITY vs GROSS HEAD



UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

NORTHERN LIGHTS, INC.) PROJECT NO. 2752

DIRECT TESTIMONY OF EARL E. KOMIE
ON BEHALF OF NORTHERN LIGHTS

Q. Please state your name and business affiliation.

A. My name is Earl E. Komie and I am with the Harza Engineering Company, 150 South Wacker Drive, Chicago, Illinois.

Q. What is your profession?

A. I am a geologist specializing in engineering geology.

Q. What is your academic training?

A. I have a Bachelors degree in Geology from the University of Arizona and a Masters from the University of Texas.

Q. How long have you been practicing geology?

A. Since my graduation from the University of Texas, for about 30 years.

Q. How much of your experience has been directed towards hydroelectric projects?

A. About 26 years. Eighteen years with the Bureau of Reclamation and over eight years with Harza Engineering Co. My most recent projects have been Guri in Venezuela, Yacyreta and Corpus in Argentina-Paraguay and Pehunche in Chile -- all multi-billion dollar projects.

Q. What is your present position?

A. I am the Principal Geologist of Harza and a member of the Senior Professional Staff.

Q. What are your responsibilities?

A. I serve as a consultant for Harza's staff of geologists and for engineering personnel designing dams, tunnels, and other structures in which geologic details are important. Also, I am responsible for the quality of geologic work for Harza projects both domestic and foreign, and for the location siting, design and safety of civil structures relative to the geology of the site during construction and operation. As a member of the Senior Professional Staff, I provide final geotechnical review of all projects and serve as an advisor to the Chief Engineer on geotechnical matters.

Q. Does this include underground work?

A. Yes. Many hydroelectric projects include shafts, tunnels and underground chambers. In addition, shafts, tunnels and chambers are common features in water supply and urban runoff projects. The Chicago TARP project, in which I have directed geologic studies prior to and during construction, includes over 30 miles of large-diameter tunnels and large underground chambers.

Q. What has been your participation in the Kootenai River Project?

A. I directed the geologic studies for the Kootenai Dam site and Reservoir. I also directed the geologic analysis of the alternative hydroelectric sites on the Kootenai River.

Q. Relative to the alternative sites, what was the scope of your analysis?

A. I participated in a reconnaissance inspection and evaluation of four alternative sites, at O'Brien Creek, Ruby Creek, Rocky Creek and Katka.

Q. Can you describe the regional geologic setting of the alternative sites?

A. Yes. All of the sites are in a complex setting, in which large-scale rock movements plus later glacial action and erosion have produced steep mountain sides, deep valleys, broken rock, remains of large landslides, and deep deposits of unconsolidated materials in the valleys. In geologic terms, the four alternative sites are underlain by metasedimentary rocks of the Precambrian Belt Series, or Supergroup. Metasedimentary rocks are rocks that were originally laid down as sediments which hardened into rock and which show evidence of having been subjected later to metamorphic changes. The metamorphic changes involved long-term application of heat, pressure, or chemical action in various combinations by geologic processes. Precambrian rocks are those that were formed or deposited in that period o time from the consolidation of the earth's crust to about 570 million years ago.

The bedrock, i.e., the underlying rock formation, at O'Brien Creek, Ruby Creek, and Rocky Creek, consists of rocks of the Wallace Formation, a subdivision of the Belt Series. Rocks of the Wallace Formation and Prichard Formation, another Belt Series subdivision, occur at the Katka site.

The rock types of the Wallace and Prichard Formations are primarily argillites and argillaceous quartzites with intervening beds of carbonate rocks. Argillites are compact rocks derived from fine-grained sediments that have been well consolidated and indurated, and then subjected to slight metamorphic changes through heat and/or pressure. Argillaceous quartzites are dense rocks composed primarily of well cemented silica sand grains (quartz) with a minor component of clay sized particles. Carbonate rocks consist chiefly of limestone, chalk or dolomite.

The structural geology of the region is typified by symmetrical and asymmetrical folding and by normal and reverse faulting. By folding I mean the process or the end result which produces flexures, or folds, in rocks. A fold is symmetrical if the plane bisecting the fold into two equal mirror-image components is vertical. A fold is asymmetrical if this plane is inclined. By faulting, I mean a fracture in rock along which an amount of displacement, either horizontal or vertical, can be observed. Faults caused by tensional processes commonly are called "normal faults", and faults caused by compressional forces normally are called "reverse faults".

Predominant structural trends in the area have a north-northwest bearing, with subordinate east and northeast trends as shown on Exhibit ____ (EEK-1). Major geologic structures affecting several of the alternative sites are the Kootenai Anticline and the Leonia Fault. The Kootenai Anticline is a slightly asymmetrical, inverted U-shaped fold of the rocks extending across the Kootenai River in a north-northwest direction for about 40 miles. The Leonia Fault is a major regional reverse fault, and extends from the Kootenai River near Cranbrook, British Columbia to the Clark Fork River south of Bull Lake, Montana. Vertical displacement across this Fault in the Star Creek-Ruby Creek area along the Kootenai River is believed to be over 32,000 feet. There are also other smaller faults that occur in local areas of the river reach encompassing the alternative sites. The physical character of the underlying bedrock at all of the power sites on the Kootenai River is intimately related to the major and minor geologic structure of the region.

The Kootenai River flows along or within a short distance of the Leonia Fault for part of its course in the United States. At the alternative sites the river is near the Leonia Fault.

The overburden, the soil materials overlying the bedrock in the region, consists of alluvium, glacial deposits, old lake beds, and colluvium. The alluvium consists of clay, silt, sand, gravel, or similar unconsolidated detrital material deposited by streams or rivers. The glacial deposits are unconsolidated rock materials (clay, sand, gravel, boulders) transported by ice or dropped from the ice, or by running water flowing from melting glaciers. The old lake beds (lacustrine deposits) are unconsolidated material, usually detrital in nature, deposited at the bottom of lakes. These materials are generally fine-grained clay and silt sized material. Finally, the colluvial material consists of loose, heterogeneous and incoherent masses of soil or rock fragments usually deposited at the base of steep slopes as a result of the action of weathering, gravity, and unconcentrated surface water runoff.

Q. What is the regional seismicity?

A. The Project and the alternative sites identified by Witness Allen are within an area having a low incidence of seismic events (earthquakes). There is no reported evidence of active faults in the area. An active fault is one along which recurrent movement has occurred or potentially could occur. This is usually indicated by small, periodic displacements or earthquake activity. The most widely used definition in current engineering practice for an active fault is one with evidence of displacements within the last 10,000 years.

Q. Can you describe the geology at the Katka site?

A. Yes. The Katka site is a steep-sided, relatively narrow canyon in the portion of the Kootenai River that is most affected by the Leonia Fault. The influence of the Fault on the site is significant. A reconnaissance inspection of the site indicated that the bedrock is primarily argillaceous quartzites, which may be of either or both the Prichard or Wallace Formations. Hornblende diorite rocks of the Moyie Sill are reported in one publication as crossing the river at this site. The Sill was not a readily apparent feature during my brief inspection. A sill is formed by the intrusion of molten or igneous rock into preexisting geologic formations. The sill cools and hardens after the intrusion. The rock in the sill generally will have mineral content totally different than that of the rock into which it was intruded. Hornblende diorite is an igneous rock containing an abundance of dark minerals (hornblende). Hornblende diorite differs significantly from the rocks of the Wallace or Prichard Formations.

The quartzites at Katka are thin-bedded to medium-bedded (beds generally are between 2.5 inches and 24 inches thick). The beds are highly jointed, that is, they are closely-spaced, although there is no apparent displacement along or across such joint planes. The rocks also are strongly fractured. The dominant orientations of the joints are parallel to the bedding and perpendicular to the bedding, which causes the rock to tend to break into rectangular blocks. Where the rock beds are exposed to the surface, they show moderate to strong weathering.

A narrow, low terrace deposit of silt and clay lies immediately above the river channel along both banks. The surface indications of the river channel deposits are that they are sand and gravel. Talus deposits, that is, deposits of loose material that have been moved by gravity down the face of a slope, generally cover the slopes of the steep canyon walls, in some instances extending downward to meet the water in the river. Several blocky rock masses, called slump blocks, have the general appearance of having moved down slope as a mass.

Q. What is the influence of this geologic structure on the site of a dam?

A. The Katka site has many features that obviously or potentially are adverse to building a dam. The Leonia Fault, a major regional feature, lies about 1500 feet to 2500 feet east of any reasonable dam axis. The strongly fractured rocks reflect this feature and caused us to select a site 1500 feet west of the Fault. At locations farther west the right abutment, particularly, showed excessive fracturing. In addition, it is common for several parallel faults to occur near such a major fault. Since the proposed dam axis is so close to the Leonia Fault such parallel faults may occur under the dam. In 1934 a USGS geologist named Erdmann identified such a parallel fault immediately downstream of the proposed axis. Furthermore, the Moyie Sill also has a structural trend roughly parallel to the Leonia Fault. The contact between the Sill and the Prichard rock may have been brought about by movement associated with the Fault, through a phenomenon known as fault contact.

Q. How do you evaluate the seismicity of the site?

A. Although the Katka site is in an area of low seismicity, the proximity of the Leonia Fault (and potential parallel faults) requires detailed seismic-risk studies to evaluate the probability of damage to a civil structure due to the occurrence of a seismic event. These studies at the Katka site would necessitate a more comprehensive evaluation than is required at a site far removed from the Leonia Fault.

Q. What is your evaluation of the Katka site from an engineering geologic standpoint?

A. The site has numerous geologic defects and unfavorable characteristics, as follows:

a) The depth of river alluvium may be significant. The water-depth soundings of Erdmann showed only the surface of the river bed as it was at that time, although he interpreted the soundings as showing rock. Drilling would be required to determine if the river is flowing on rock or over alluvium in a deep buried channel filled with alluvium. In earlier geologic history the river may have eroded a channel which later was filled with alluvium. The glacial history of the region supports the possibility that there can be deep alluvium or glacial outwash materials in a deep channel. If there is a deep buried channel, the excavation and associated cost required to reach bedrock for a satisfactory foundation for a dam and positive cutoff to reduce seepage under the dam may be excessive. If an alternative cutoff design involving a slurry trench excavation down to bedrock were adopted, the cost would be equally excessive.

b) The final location of a dam axis would require extensive exploration to confirm that the abutments would be beyond the zones of broken rock. A blocky mass of rock affected by slide movement is totally unacceptable as a dam abutment.

c) The strongly fractured and jointed rock suggests that extensive consolidation and curtain grouting would be required under the dam, no matter what design is used, and in the abutments. Consolidation grouting is the injection of cement into shallow areas of rock to solidify the top portion of the rock that is under a dam. Curtain grouting is injection of cement into rock to form a relatively narrow but deep curtain under the dam. The occurrence of open fractures and joints would provide a short path and steep hydraulic gradient for seepage under and around the dam. These joint and fracture sets also present potential stability problems in excavated slopes that would require extensive support such as rock bolts or rock anchors.

d) All faults would require extensive water testing to determine their water-transmitting characteristics. Open or permeable zones within, or adjacent to, fault zones may jeopardize the water-holding capability of the reservoir. Such geologic structures can be expected to be preferred paths of seepage.

e) The development plan for the Katka alternative considers that a concrete dam will be constructed and all unsuitable material above firm rock will be removed by excavation. However, a rockfill dam also was considered. A rockfill dam would be founded on the alluv um, with a narrow trench through the alluvium to bedrock under the dam to reduce seepage. The trench would be backfilled with a slurry impervious material. A major consideration for a rockfill dam is the action that could accompany an earthquake. The closeness of the Leonia Fault to the site makes earthquake damage of much higher probability than if the Fault were more distant. At Katka it would be necessary to investigate if the shaking from an earthquake would liquify, or partly liquify, the alluvium on which the dam would be built. The alluvium would have to be carefully sampled and tested to evaluate this potential risk.

f) The reservoir may saturate the toes of glacial materials and colluvium deposits that occur along reservoir slopes, creating potential landslide hazards.

Q. Can you describe the geology at the Rocky Creek site?

A. Yes. The Rocky Creek site is in a reach of the Kootenai River affected by both the Kootenai Anticline, the axis of which is about 0.5 mile to the east, and the Leonia Fault, the trace of which is about one mile to the west. The bedrock at the site is argillaceous limestone, which is a carbonate rock consisting chiefly of the mineral calcite with a secondary component of clay minerals. The rock is one of the members of the Wallace Formation. The rocks are thin to medium bedded and the rock slopes have steep dips toward the river channel. Similar to the Katka site, the rocks are strongly jointed and moderately fractured, and the dominant joint orientation is parallel and perpendicular to bedding. These joints are near-vertical and near-horizontal and ofte are open. Non-linear sporadic fractures are quartz filled.

A narrow terrace deposit of alluvial material forms a bench immediately above the river along both banks. The terraces remain from an earlier time when the river had not yet eroded down to its present level. Talus deposits generally cover much of the steep canyon walls. The river channel deposits appear to consist of sand and gravel. Several rock masses have the appearance of slide or slump blocks. Erdmann in 1934 identified a fault at low elevation on the proposed left abutment. Some isolated rock masses which appear to be detached from the canyon wall may be related to the existence of this fault.

Q. Is the influence of geologic structure on the site significant?

A. Yes. Although the influence of Leonia Fault is not as signficant as at the Katka site, the Kootenai Anticline greatly affects the frequency of joints and fractures. An increased number of joints and fractures along the top portion of a major anticline is common. The joints and fractures do not have the same orientation in all localities since the joints and fractures are closely related to bedding orientation and the bedding orientation varies from point to point because of the anticline.

Q. How do you evaluate the seismicity of the site?

A. The Leonia Fault is about one mile from the site. Potential associated faults may be nearby. In terms of seismic risk, one mile is minimal. The site would require detailed seismic risk studies.

Q. What is your evaluation of the Rocky Creek site from an engineering geologic standpoint?

A. The site has numerous geologic defects and unfavorable characteristics as follows:

a) The depth of river alluvium may be significant. Drilling is required to determine if the river is flowing on rock or on a deeper channel filled with alluvium. Since the underlying bedrock is limestone, it is possible that the water has dissolved channels or cavities through it. The cavities could vary in size from an inch to several feet. The occurrence of such channels or cavities would complicate cutoff design and endanger the water-holding capability of the reservoir.

b) The occurrence of blocky slide material and talus deposits on the abutment slopes is an adverse feature. The reported fault along the left abutment is a major geologic defect relative to dam stability. The foundation of a selected dam axis would require extensive exploration to confirm if the abutment rock masses are satisfactory.

c) The occurrence of open bedding-plane joints suggests that extensive curtain grouting would be required to control short-path seepage. Any significant solution-activity voids, inherent in limestone, would complicate seepage-control measures.

d) Dominant joint and fracture trends may contribute to major instability of slopes of excavation. The slopes may require extensive anchorage systems to remain stable.

e) The reservoir may saturate the toes of glacial materials and colluvium deposits that can occur along reservoir slopes, creating potential land-slide hazards.

Q. Can you describe the geology at the Ruby Creek site?

A. Yes. The site is in a reach of the Kootenai River that is dominated by glacial deposits overlying the Wallace Formation bedrock. The Leonia Fault trace is about one mile to the west and the axis of the Kootenai Anticline apparently occurs within the right abutment area. Glacial deposits cover the entire right abutment area and a limited portion of the left abutment area. The glacial deposits may include glaciofluvial materials, which are unconsolidated materials scoured from rock by glaciers and deposited by water resulting from the melting of the glaciers. The river alluvium appears to be sand and gravel.

Q. Is the influence of the geologic structure significant?

A. Yes. Similar to the Rocky Creek site, the Leonia Fault trace is about one mile from the site. The Kootenai Anticline occurs within the right abutment area. The rock outcrops that occur in the left abutment are highly fractured and highly jointed, reflecting the effects of the Fault and Anticline.

Q. How do you evaluate the seismicity of the site?

A. The Leonia Fault is about one mile from the site. Potential associated faults may be nearby. In terms of seismic risk, one mile is minimal. The site would require detailed seismic risk studies.

Q. What is your evaluation of the Ruby Creek site from an engineering geologic standpoint?

A. The site has numerous geologic defects and unfavorable characteristics, as follows:

a) The thickness of the glacial deposits and river alluvium is unknown. Depths to bedrock may be excessive. Cutoff for seepage control under the dam may be difficult to achieve and entail significant cost.

b) Cutoff facilities would require extension beyond the right abutment to insure reservoir water-holding capability. The occurrence of glaciofluvial materials would complicate design and construction of cutoff facilities under the dam and into the right abutment.

c) Highly fractured and jointed bedrock would require extensive curtain grouting. Any civil structure founded on bedrock would require extensive consolidation grouting.

d) Location and design of a spillway is complicated by the thick glacial deposits. Special foundation design would be required to insure the integrity of the structure.

e) The geology of the site is best suited to a dam consisting of a rock and soil embankment. The foundation materials would require flat slopes to provide stability for the dam. This design requirement would result in significantly increased volumes of construction materials in an already relatively long dam.

Q. Can you describe the geology at the O'Brien Creek site?

A. Yes. Similar to the Ruby Creek site, the O'Brien Creek site is dominated by glacial deposits. The Leonia Fault trace is about two miles to the west. Glacial deposits generally cover the site, with Wallace Formation bedrock protruding as isolated masses from beneath the glacial materials. Alluvial deposits occur along the left river bank. The river alluvium appears to be sand and gravel.

Q. Is the influence of geologic structure significant to the soundness of the bedrock?

A. Yes. The rock outcrops exhibit a high degree of jointing and fracturing.

Q. How do you evaluate the seismicity of the site?

A. In the same category as the other alternative sites. The site would require detailed seismic risk studies.

Q. What is your evaluation of the site from an engineering geologic standpoint?

A. The site has numerous geologic defects. A major defect is the widespread occurrence of glacial and alluvial deposits behind each rock mass that would form the dam abutments. In addition, there would be significant thicknesses of glacial and alluvial materials under the dam. These conditions seriously affect the water-holding capability of the site. The cost of seepage control measures would be a dominant factor in overall project cost.

Q. Please describe your involvement in the Kootenai River Project site in further detail.

A. I directed all geologic investigations ranging from surface geologic mapping to preparing and implementing the subsurface exploration program. From these data and site inspections I assisted in siting all civil structures. Also, I provided geologic input into design of all civil structures, including geologic bases for cost estimating.

Q. Can you describe the geology at the Kootenai site?

A. Yes. The description involves discussions of topography, stratigraphy, rock structure, groundwater, and seismic conditions. The proposed Project is located on the Kootenai River, about eleven miles east of the Leonia Fault.

The topography of the site is the result of the river cutting across the geologic structure of the region as it flows from east to west through the gorge dividing the Purcell and Cabinet mountain Ranges.

The river channel at the site falls through a series of water falls and rapids over which the river drops more than 50 feet within the Project area. These are collectively, named "Kootenai Falls". On each side of the river the valley rises to heavily forested peaks at elevations of 7,000 and 8,000 feet through a series of steep slopes and vertical cliffs. The valley sides are dissected by gullies and intermittent streams.

Details of the geologic conditions at the site were investigated by site reconnaissance, review of publications, site geologic mapping, and core borings. Site inspections were performed on several occasions to aid interpretaton of information.

The site reconnaissance confirmed information that is presented in publications. The rocks are members of the metasedimentary Wallace Formation. The rocks are bedded and jointed similarly to the rocks at the alternative sites, except that at the Project site the rock beds generally are much more nearly horizontal. However, the rock beds dip at a different angle at the Dam than at the Tail Tunnel Outlet because of the folded rock structure at the site.

The river flows over rock ledges and between rock outcrops which are along both banks of the river. The exposed rock along the right bank is at the base of a mountain, and except for a few localities the rock stands as near-vertical slopes. Above the near-vertical slopes of the right bank there are steep slopes that are covered with talus material. The talus appears as loose rock fragments standing on a steep slope several hundred feet high. The base of the talus usually is at the top of the rock cliff along the river.

The river is eroding into the right bank. At the head of Kootenai Falls, there is a deep channel on the right side of the river immediately adjacent to the rock wall. The channel is lower in elevation than the remainder of the river bed at that point, and the river discharge concentrates into this channel. This aspect of erosion shows at all discharges of the river.

The left bank of the river has an appearance that is both similar to and different from the right bank. In many places the banks of the river are against steep rock faces, as in the sections through the canyon at the Forest Service foot bridge and at the Tail Tunnel Outlet, but in other places the river bank is sloping or flat. At the head of the Falls the river bank is flat, with rock standing only a few feet above water level. From the head of the Falls and for approximately 1,000 feet downstream, the left side of the river's course is a series of rock ledges with vertical faces and horizontal ledges.

Along the left side of the canyon between the Dam site and the Tail Tunnel Outlet between the rock faces along the river and the mountain slope south of U.S. Highway 2, there are evidences of weathering in the form of numerous detached boulders and loose soil. In a normal reconnaissance, the material appears to be nothing unusual and to be a deposit of the type that normally would be formed at the base of a mountain from erosion. Reconnissance examination also would result in the inference that rock ledges similar to those along the rock would be under the weathered material at successively higher elevations from the river up the mountain. The reconnaissance by Erdmann in 1934 arrived at the same conclusion.

Borings showed the inference to be incorrect. Borings showed that there is a rock terrace behind the left bank of the river, that extends to the base of the mountain front. Bedrock was found in the borings at depths of as much as 100 feet below the ground surface.

Q. Could the river channel location have been established by a fault?

A. The river location and the location of Kootenai Falls do not appear to be the direct result of a fault, but the Falls appear to be associated with the relatively recent glaciation action in the region.

Most of the area was mantled by a series of ice sheets during the Pleistocene, the weight of which caused temporary depression of the land surface. This weight was removed as the ice retreated and the land began to rebound. One manifestation of the rebound process was movement along many of the faults in the region, including, reportedly, the Savage Lake-O'Brien Creek Fault, downstream from the Project site.

The vertical displacement of rock along the Savage Lake-O'Brien Creek fault created a rock scarp over which the Kootenai River flowed as it entered Lake Creek Valley. This scarp is thought to be the original location of Kootenai Falls, which has since migrated upstream to its present location by progressive erosion of the scar . Earthquake action or sudden application of seismic forces do not appear to be a factor in forming Kootenai Falls.

Q. You stated that there was a geologic mapping program at the Project site. Will you describe it briefly?

A. The bearings and dips of bedding planes at various locations were measured by hand instruments used conventionally by geologists. The locations of various rock features were measured by surveyors. The characteristics of overburden were recorded. From this work, the site geology map, Exhibit ___ (EEK-2), was developed.

The exhibit shows the bearing (strike) and dip of rock beds and the areas in which there are outcrops of rock of the Wallace Formation, alluvial deposits, alluvial terrace deposits and other overburden units. The map also shows where there are shear zones in the rock, that is, zones which contain crushed rock resulting from past geologic movement.

The exhibit also shows the location of Project structures. The Powerstation caverns are shown in a relatively undisturbed and strong zone of rock between shear zones, which are shown upstream and downstream of the Powerstation location. The long axis of the Powerstation caverns is set normal, or at 90 degrees, to the strike of the rock. Such a location minimizes the effects of rock jointing on the sides of the caverns. The water conduits cannot be so located, but are of less width than the Powerstation main cavern. Even so, the long Head Tunnel is at a reasonably good orientation.

The exhibit shows also the locations of core borings. There were six borings, numbered 1, 3, 5, 6, 7, and 8. No. 1 is near the Intake and Intake Shaft; No. 3 is in the talus material near the railroad and the proposed location of the Head Tunnel; Nos. 5, 6, 7, and 8 are along U.S. Highway 2.

Q. What was the purpose of the six drill holes?

A. The holes were drilled for multiple purposes.

a) To determine the depth and character of overburden at specific locations.

b) To characterize subsurface rock conditions. This was accomplished by continuous coring.

c) To characterize hydrologic properties of bedrock. This was accomplished by water testing in all drill holes.

d) To confirm the subsurface geologic structure and stratigraphy as indicated by surface geologic mapping.

e) To provide data for preliminary siting and design of Project features.

Q. What were the results of the exploration programs?

A. The surface and subsurface exploration programs documented that the geologic and foundation conditions for all proposed civil structures were suitable. The programs also provided data for preliminary design and cost estimating.

Data from the core borings plus the site mapping provide the basis for locating Project structures.

Geologic information relative to Project structures also is shown on three exhibits, Exhibit ___ (EEK-3), Exhibit ___ (EEK-4), and Exhibit ___ (EEK-5). The last three exhibits are sections through various parts of the Project showing geologic conditions relative to Project structures. These exhibits show the elevation of bedrock along the left side of the river and the attitudes of the bedding planes in various locations.

Q. From your investigations, will you summarize the characteristics of the various geologic materials at the Project site?

A. First, I will discuss soils, followed by rocks, structural characteristics, and groundwater.

Soils at the site include recent alluvial deposits, alluvial terrace deposits, talus, colluvium and residual soil.

There is alluvium at the site, consisting of sand and rounded gravel that occurs intermittently in protected coves on the north side of the river. The more extensive alluvial deposits on the left bank are shown on Exhibit ___ (EEK-2), and are often intermixed with talus and colluvium. The alluvium often does not occur in the river channel.

A large alluvial deposit, possibly mixed with colluvial and glacial materials, occupies a large area between the highway and the river upstream of the footbridge along the left bank, and consists of silt, sand, cobbles, and boulders with thin clay beds as encountered in drill holes. The rock surface underlying the terrace appears to be between El. 1970 and El. 1980, as reflected by a soil thickness of 35.5 feet in Drill Hole No. 3, 114.5 feet in No. 5, and 94.5 feet in No. 6.

Talus deposits occur extensively at the base of cliffs on both sides of the river and consist of angular blocks of argillaceous quartzite up to about three feet in diameter. The talus deposits are both active and inactive, the latter being covered with moss and low vegetation. The locations of the more extensive talus deposits in the Project area are shown on the above exhibit. The thickness of these deposits may exceed 100 feet along the left river bank.

Colluvium and residual soil, often intermixed, generally mantle bedrock over most of the Project area and consist of thin deposits of silt, sand and gravel. The colluvium and residual soils are not differentiated on the exhibit; however, areas of bedrock not shown as outcrops are generally covered by these soils.

Q. What rock units are present?

A. The Project area is underlain by metasedimentary rocks of the Wallace Formation of the Piegan Group of the Precambrian Belt Series or Supergroup. The Wallace rocks crop out extensively in the Project area, particularly adjacent to the river throughout the site, and in cliffs and road cuts south of the highway. Scattered outcrops also occur between the river and the railroad, downsteam of the footbridge and along the powerline access road high on the left side of the valley. On the right side of the river, extensive outcrops occur in rock cliffs high on the valley slopes. Surface and subsurface data collected at the site indicate that the Wallace Formation underlying the site can be subdivided into three generally distinct rock types, argillaceous quartzite, calcareous quartzite, and carbonates. These rock types are interbedded throughout the local stratigraphic section.

The predominant rock is gray, fine-grained calcareous and argillaceous quartzite, commonly laminated and banded with thin, alternating light and dark gray beds. At the surface, banding thicknesses range from about six inches to one foot locally to about three feet, while the cores from drill holes show the average spacing of the banding to be six inches or less. Bedding surfaces are commonly ripple marked with asymmetric ripples attaining a maximum observed crest to crest frequency of about six inches and a maximum amplitude in excess of one inch. The rock is often cross-bedded. The argillaceous quartzite is very hard and strong when unweathered and cores are often closely fractured along bedding planes with iron staining common. The quartzite is not generally fissile, which is to say very thinly bedded. However, local zones of highly argillaceous quartzite exhibit slightly fissile characteristics. Many exposed bedding planes are open at the surface to widths of several inches, but appear to close with depth. The argillaceous quartzite is widely exposed throughout the site.

The second most common rock type consists of massive, fine-grained, mottled gray to buff calcareous quartzite. This rock is not commonly banded or laminated but frequently contains calcite veins and very thin irregular argillaceous partings. Bedding is generally poorly defined and widely spaced and the rock is very hard and strong when unweathered. Cores are closely to moderately fractured along argillaceous partings and veins with iron staining common on the fracture surfaces. Many fractures are healed with silica and/or calcite.

The third most common rock type is carbonate, including buff and pink limestone, quartzitic limestone, and dolomitic limestone. Interbeds of these rocks attain a maximum thickness of ten to fifteen feet and commonly contain circular or void shaped algal growths, up to three feet in diameter, and exhibit the "molar tooth" structure termed characteristic of the Wallace carbonates. The algal growths are reflected in cores by numerous thin, green, highly irregular, argillaceous partings. The carbonates are hard and strong when unweathered and are closely to moderately fractured along partings in the cores. Fracture surfaces are often iron stained. Minor solution activity was observed in cores, consisting of small cavities generally filled or partly filled with calcite. The carbonates crop out in several locations along the river and along the highway near the railroad retaining wall, as shown by Exhibit ___ (EEK-2), and were encountered in all drill holes except No. 1. The carbonates comprise about 15 percent of the drilled cores.

In addition to these rock types, interbeds of gray-green to purple siltstone, two to four feet thick, crop out locally in the southwestern reaches of the site. The siltstones are moderately hard and strong but locally exhibit slaking characteristics when exposed to air. The siltstones were not seen in upstream reaches of the site and occurred in drill holes only as scattered, very thin interbeds.

Bedding in the rocks at the site is strongly developed with thicknesses commonly ranging from about six inches to one foot, with beds up to about three feet occurring locally. Bedding planes that are open from one to two inches width at the surface occur frequently throughout the site. Iron staining on bedding planes in core indicates that some bedding planes are open at depth.

Q. Have the rocks been affected by weathering?

A. Cores recovered in drill holes were generally hard, strong and fresh or slightly weathered but did contain local leached and decomposed zones. The zoned surface weathering, or weathering of rock underlying deep overburden, extends to a depth of about 40 feet below the top of rock and does not appear to substantially affect rock quality. Localized zones of deeply weathered and decomposed rock were encountered in most drill holes and as deep as 294 feet in Drill Hole No. 6. Most of these zones are less than one foot thick with several about two feet thick, however, in Drill Hole No. 3 decomposed zones ranged from six to over thirteen feet in thickness. The deeply weathered and decomposed zones are probably controlled by open joints, shears or bedding planes and apparently occur locally throughout the rock mass.

Weathering phenomena such as these are, more or less, at all dam sites. They do not represent serious flaws.

Q. What is the prevalent geologic structure?

A. Three distinct structural zones are apparent at the site. A zone of gently northeast dipping beds occurs in the upstream reaches of the Project area, a folded zone in the central area, and a zone of steeply to moderately northeast dipping beds in the downstream reaches. These zones are reflected by the bedding orientations shown on Exhibit ___ (EEK-3). A generalized geologic section showing inferred bedding traces across the three structural zones is shown on Exhibit ___ (EEK-4).

Beds in the upstream structural zone strike about N35°W and dip to the northeast from about 10 to 25 degrees. No significant bedding irregularities were seen in this area.

The central structural zone appears to be about 1,700 feet wide, extending from about 900 feet downstream to about 800 feet upstream of the footbridge, Exhibit ___ (EEK-3). Numerous anticlinal and synclinal folds were identified, with axial trends ranging from about N30°W to N40°W. Most of the folds are approximately symmetrical and gentle, with dips of about 10 to 30 degrees on upstream and downstream limbs. The folds in the downstream part of [illegible] zone are locally asymmetrical and many are tight with dips steeper than 75 degrees. Beds exposed in the valley sides above the river indicate that the folded zone extends to significant distances to the northwest and southeast; however, individual folds could not be traced across the intervening areas. Measurements of bedding orientation taken on the fold axes indicate that the folds may plunge to the southeast at 5 to 15 degrees.

Beds in the downstream zone strike about N35°W and dip to the northeast from about 20 to 75 degrees, with an average dip of about 45 degrees. The variation in bedding dips is caused by monoclinal folding.

Rocks of the Wallace Formation reportedly contain numerous shear seams and zones and two such sets were mapped at the site as shown on Exhibit ___ (EEK-2). One set strikes approximately parallel to bedding and is vertical to steeply dipping to the southwest, across bedding. These features generally consist of brecciated zones less than one foot wide with small gouge seams occurring locally. A more extensive sheared zone of this set is exposed on the left side of the river about 500 feet upstream of the footbridge. This zone trends about N40°W and consists of a 30-foot wide zone of disturbed rock with local breccia. Displacement along this zone is not evident. In addition, a zone of breccia and gouge 16 feet thick was encountered in the bottom of Drill Hole No. 7. This shear zone is steeply dipping and its thickness is exaggerated in the core.

The second shear set occurs along bedding planes and is associated with the folding of the rocks. These features are most commonly seen in the downstream portions of the mapped area where they occur as gouge seams usually one to four inches wide. Bedding shears also were encountered in addition to clay seams.

No regional fault, comparable to the Leonia Fault, occurs in the Project Area, although the Savage Lake-O'Brien Creek Fault is inferred to cross the Kootenai River about one mile downstream.

Jointing in the quartzites is generally strongly developed and consists of steeply dipping or vertical joints striking parallel, perpendicular and diagonally to the bedding strike.

The joint pattern is best exposed and most strongly developed upstream of the folded zone where the joint pattern consists of four prominent sets intersecting to form rectangular or rhombic-shaped blocks. Joint spacings in the area normally range from about six inches to one foot at the surface. Most of the joints appear open at the surface and many can be traced for significant distances along the exposed bedding planes.

Within the folded zone, jointing is moderately well developed but is generally more random than in the upstream areas. Most joints are vertical or near vertical and strike parallel and perpendicular to the bedding and to the fold axes. Joint spacing is difficult to determine due to intermittent rock exposures. Fan joints are seen trending parallel to the axes of several folds and spaced from one to about three feet apart across the fold. These joints are generally irregular and rough, and locally open one to two inches at the surface.

Jointing is poorly exposed in the downstream reaches of the mapped area but appears to include joints trending approximately parallel to and perpendicular to bedding and dipping from vertical to about 55 degrees downstream across bedding. These joints appear widely spaced.

Open, vertical joints, probably of stress relief origin, occur locally in the canyon wall immediately upstream of the railroad retaining wall. These joints trend about east-west and are open several inches where exposed. The joint spacing appears to be several feet. These joints do not appear to persist away from the canyon; however, rock exposures are sparse.

Cores from the drill holes were closely to moderately fractured generally through their entire length and most joint surfaces were iron-stained or had thin clay coatings. Many joints appeared healed, or partially healed, with calcite or silica. Thin chlorite films, dendritic manganese, and slickensides along fracture planes occurred in the cores.

Q. Can you now describe groundwater conditions?

A. Groundwater data available at the site include water levels in drill holes and limited water pressure test data.

Water levels in Drill Holes Nos. 1 and 3, completed in the upstream reaches of the site, were at approximate El. 1950, about 30 feet below the river level near the proposed Dam axis. The ground water surface in this area appears to be controlled by the stretch of the river downstream of the falls. Water levels in Drill Hole Nos., 6, 7, and 8, completed in the downstream reaches of the Project, ranged from approximately El. 1905 to 1909, or about 20 feet below the river surface downstream of the railroad retaining wall. These levels also appear to be controlled by the river downstream of the mapped area. These data suggest an influent ground water configuration in which the river is losing water to the underlying rock mass at a lesser rate than the downstream drainage. Significant permeability of the rock mass is also indicated. A number of small springs occur along the highway in the downstream reaches of the Project, and cascading water was noted high in Drill Hole No. 7, indicating the occurrence of perched groundwater zones in the rock and terrace materials above the saturated zone. The extent and significance of these perched zones is not currently known.

Water pressure tests were attempted in most of the drill holes with generally negative results. Water losses from most of the intervals were too high to build up gage pressure with the available equipment, and measurements could not be made. Significant difficulties were also encountered in maintaining the stability of hole walls, to allow passage of the water test equipment.

Q. What are the seismic conditions at the site?

A. The site is in a seismic probability area designated Zone 2 (Corps of Engineers, 1977). Zone 2 is defined as one which has a probable seismic coefficient of 0.05.

No earthquake epicenters of Intensity V (Modified Mercalli) or greater plot within fifty miles of the site. Intensity is a damage-related characterization of earthquakes. Numerous epicenters of Intensity V to VII (Modified Mercalli) have occurred from 50 to 150 miles of the site. An intensity of VII would result in negligible damage in structures of good design and construction. In addition, Algermissen and Perkins (1976) identified the area as having a 10 percent probability of acceleration exceeding .04 g in a fifty-year interval, on a preliminary basis, Exhibit ___ (EEK-3).

Q. What were the geologic bases for selection of civil structure sites -- let us start with the Dam.

A. The Dam was located in an area of uncomplicated geologic structure, well upstream of Kootenai Falls so that deep erosion channels would not be encountered, where a homogeneous lithologic section of bedrock would provide the foundation, and in the rock sequence well upstream of the limestone sequence.

Q. The Reservoir?

A. The Reservoir was automatically sited with the selection of the Dam axis and the Dam height. The Reservoir was evaluated, however, for geologic defects.

Q. Were there any geologic defects?

A. Yes. A section of permeable overburden (an aggregate term for any unconsolidated material overlying bedrock, either transported or formed in place) was mapped along the left bank for about 2000 feet upstream of the Dam that would affect the water-holding capability of the Reservoir.

Q. Has this defect been considered in the design?

A. Yes. A concrete slab constructed into underlying bedrock was included in the design to preclude Reservoir water from entering these permeable materials. An alternative solution would be construction of a slurry trench.

Q. Let us continue with the Intake and Shaft.

A. These structures were located with respect to shallow bedrock occurrence to minimize excavation in overburden materials.

Q. The Head Tunnel?

A. The Tunnel was sited and aligned to provide for a rock cover of adequate thickness overlying the tunnel. Generally, for most rock types, this thickness is adequate if greater than 1 1/2 times the tunnel diameter, both horizontally and vertically. These dimensions have been satisfied in the tunnel design. In addition, it was aligned to be as near normal as possible to the trend of bedding and major folding and shearing. This alignment will minimize excavation problems.

Q. The Powerstation?

A. The Powerstation was sited as far into the mountain as practical, to provide adequate rock cover and to preclude any major deterioration of the rock due to near-surface weathering. The alignment (long axis) was set normal to the trend of major folding and shearing to minimize excavation and stability problems.

Q. The Tailrace Tunnel?

A. The location of the Tailrace Tunnel was established by the constraints of the Powerstation location and the river location and configuration.

Q. Let us turn now to the engineering geologic bases for preliminary design of the civil structures. What were the bases for the Dam?

A. The Dam will be founded on quartzite bedrock. Overburden depth under the concrete structure will range from zero to five feet. A relatively thick alluvial terrace occurs along the left side of the channel. A gravity wall (a reinforced concrete wall structure designed and so proportioned that it is stable and will resist overturning and sliding forces by its own weight) was incorporated into the design to provide a left abutment in the absence of a rock abutment. Surface examination of the right abutment indicates that bedrock lies at shallow depth and can provide a rock abutment. A concrete slab downstream of the Dam will be anchored to the rock to mitigate uplift pressure at the base of the Dam and appurtenant structures caused by water pressures related to the height of the reservoir water above the Dam base.

Q. What were the bases for the Intake and Shaft?

A. The bedding will be dipping into the excavation from a downstream direction. Local unstable zones may be encountered along the downstream portion of the excavation that will require rock bolts (a specialized type of steel bolt which is installed in a drillhole in rock to reinforce and hold together the rock mass where there is a danger of loosening and falling of blocks or slabs of rock) and shotcrete (mortar or concrete conveyed through a hose and pneumatically sprayed at high velocity onto a surface, where it solidifies and forms a hard coating) for stabilization. Wire mesh will also be required as protection against minor rock raveling (a type of potential condition encountered during excavation where small fragments of rock fall from the exposed surfaces). The structures will be concrete lined for structural reasons as well as to control seepage into the relatively pervious rock.

Q. What were the bases for the Head Tunnel?

A. The bedding will occur in the Tunnel with minimal spans because of the alignment. The width of potential weak zones associated with shearing and folding will also be minimized. The tunnel will be in consistently upstream-dipping beds for the initial half of its length. The downstream 50 percent will be in folded, variably dipping beds. Tunneling conditions will vary from blocky to very blocky.

Rock bolt reinforcements in a regular pattern over the excavation surface and shotcrete are planned for support over the entire Tunnel length. Shear zones, which are highly weathered seams and decomposed rock of varying width, will be encountered throughout the Tunnel, primarily in the folded rock section. Such weak zones will require steel arches and columns and shotcrete for support.

Q. What were the bases for the Powerstation?

A. The Powerstation complex is sited within the folded geologic section of the Project area and accordingly is oriented with the long axes of the valve, gate and Powerstation chambers at right angles to the structural trend. The final orientation is subject to adjustment following further underground investigation. The rock units will dip into and away from the long axis. In addition, any shear or highly fractured zones will be approximately normal to the long axis. All rock types of the Wallace Formation will be penetrated. The rocks will be blocky to very blocky.

A system of tunnels will enter and exit from the Powerstation. In order to minimize stress concentration in the rock surrounding the Powerstation, a minimum spacing of two diameters between parallel tunnels was recommended for design purposes. The Penstock Tunnels and Tailrace Tunnel exiting from the gate chamber are oriented parallel to the trend of the geologic formation. In these tunnels the bedding will appear near horizontal but will dip into the Tunnel at various angles and will be truncated by the excavation. Any local instability which may develop along bedding planes within the left sidewalls of these tunnels can be supported adequately with shotcrete and/or rock bolts.

The Powerstation chamber is planned to be supported by 30-foot bolts, spaced on 8-foot centers, and 6 inches of reinforced shotcrete. This bolting pattern was selected to assure that all bolts would cross two or more bedding planes.

The gate and valve chambers similarly are planned as being supported with 15-foot bolts spaced on 10-foot centers, and 3 inches of reinforced shotcrete, subject to final design revisions.

The Penstock and Tailrace Tunnels are planned to be supported by 10-foot bolts spaced on 6-foot centers and 3 inches of reinforced shotcrete. This bolting pattern relies on the increased shear strength on bedding planes due to bolting.

Additional support will be required at intersections of all underground openings. The bus, access and vent shaft from the Powerstation to the surface, will be in the folded rock section. The ground surface in this general area is generally steep and rock crops out intermittently indicating that the soil cover is thin. The support requirements will be similar to the Intake Shaft, which involves rock bolts with wire mesh, and shotcrete in local unstable zones.

Ground water inflow will occur in all structures associated with the Powerstation complex. This inflow will be small except in sheared or high-fractured zones, where cement grouting may be required for seepage control.

Q. What were the bases for the Tailrace Tunnel?

A. The alignment is at an oblique angle with the geologic structure which will result in longer cantilever sections of individual beds. The depth of rock cover in the portal area is minimal and will require a steel-rib support system. The remainder of the tunnel will be supported with rock bolts and shotcrete because of the anticipated blocky rock conditions.

Q. What are your recommendations relative to seismic factors in design?

A. The Project site is much more distant from any major faults such as the Leonia Fault than any of the alternative sites. Although preliminary published data indicated the use of about .04 g horizontal ground acceleration , we preferred to be more conservative and used .10 g for design. In final design studies a MCE (Maximum Credible Earthquake) study will be prepared. The area has low earthquake hazard as previously explained.

Q. What is your evaluation of the stability of Reservoir slopes?

A. There are no active or previously active slides. Other than potential surficial overburden slides, no slope instability is expected upon Reservoir filling.

Q. What is your evaluation of Reservoir water-holding capability?

A. There is no indication that the rocks underlying the Reservoir would permit more than nominal seepage. The grout curtain under the Dam will control seepage under and around the abutments. The concrete slab along the left bank will control seepage through overburden.

Q. What effect will the Reservoir have on natural ground water levels within the river terraces on the right side of the river adjacent to the Reservoir?

A. The terraces are indicated generally to have relatively high permeability. Natural ground water levels will rise and more or less approximate the elevation of the Reservoir water surface at any given time. Except for one very local area, higher ground water levels will not result in boggy conditions within these deposits as shown in Witness Lindsey's testimony.

Q. How would you compare the Kootenai site to the four alternative sites?

A. The comparison has to be made on several bases -- geology, engineering geology and seismic conditions. I will address all of these.

a) Geology -- the bedrock at all alternative sites has been significantly affected by the Leonia Fault and/or the Kootenai Anticline. In the case of the Ruby Creek and O'Brien Creek sites the geology is complicated by glacial and/or terrace deposits. Deep alluvial-field channels may occur at any or all of the alternative sites.

b) Engineering geology -- The layout and design of engineering structures would be difficult at the Katka and Rocky Creek sites. In addition, it is questionable whether rock masses forming the abutments are stable. At the Ruby Creek and O'Brien Creek sites the glacial and alluvial deposits would provide an inferior foundation, necessitating special embankment design and special spillway foundation design. The layouts and design at the Kootenai site are relatively simple and straightforward.

Reservoir water-holding capability is potentially a serious defect at the Ruby Creek and O'Brien Creek sites and to a lesser degree at the Katka and Rocky Creek sites.

c) Seismic conditions -- The Leonia Fault has an immediate influence on all alternative sites. The Kootenai site has no major regional fault in such proximity.

Q. How would you rate the Kootenai site in comparison with the alternative sites?

A. The alternative sites are inferior sites. Because of their inherent defects, and potential defects, the alternative sites are much less suitable for construction in the near future. There is no question in my mind relating to the geotechnical feasibility of the Kootenai site.

Q. Are there any special considerations of the Kootenai site -- for example is there anything unique about the geology that would be lost due to Project construction.

A. There is nothing geologically unique that would be lost. The Wallace Formation crops out over a wide area along the Kootenai River and elsewhere. Any geologic attribute inherent to the Wallace can be seen in other areas.

Q. Do you have any technical concerns with any of the underground structures?

A. None. We have tried to minimize potential construction problems by siting and alignments. With proper support systems the integrity of all underground structures should be sound. There are precedents for underground structures in the Belt Series (Supergroup) rock units. No undue difficulties were reported during construction of these underground structures and the structures are operating as designed.

Q. Does this complete your prepared direct testimony?

A. Yes.

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

MATTER OF)
NORTHERN LIGHTS, INC.)

PROJECT NO. 2752

AFFIDAVIT

STATE OF Illinois)
) ss.:
COUNTY OF Cook)

Earl E. Komie, being duly sworn, deposes and says that he has read the foregoing prepared direct testimony of Earl E. Komie, that he would respond in the same manner to the questions if so asked upon taking the stand, and that the matters of fact set forth therein are true and correct to the best of his knowledge, information and belief.

Earl E. Komie
Earl E. Komie

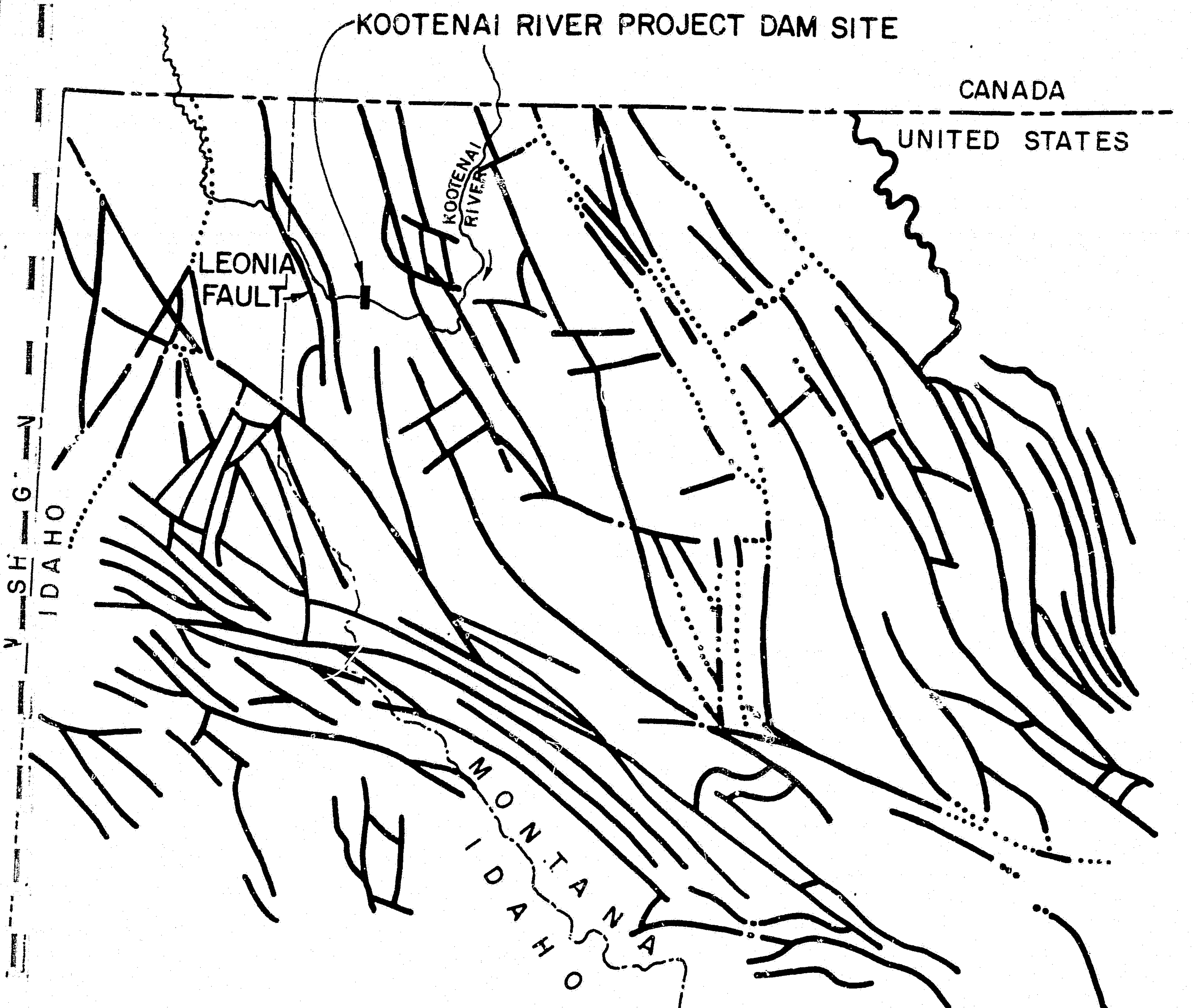
Subscribed and sworn to before me,
this 18th day of January, 1982

Marian J. Higgins
Notary Public

My commission expires 7-27-85

List of Exhibits

EXHIBIT.......(EEK-1)
Project No. 2752



Adapted from: U.S.G.S. Geologic Map of the United States, 1974

Scale 0 40 Miles

REGIONAL STRUCTURAL TRENDS
MAJOR FAULTS

EXHIBIT......(EEK-2)
Project No. 2752

EXPLANATION

STRATIGRAPHY

SOIL UNITS

Qal	*RECENT ALLUVIUM DEPOSITS :* Rounded river deposited sand and gravel.
Qta	*TALUS DEPOSITS :* Angular blocky, slightly weathered to fresh;
Qt-Qc	*TERRACE DEPOSITS :* Alluvial material possible glacial deposits.

ROCK UNIT

pЄw	*PRECAMBRIAN WALLACE FORMATION :* Interbedded limy and argillaceous quarzites, limy argillites limestones.

SYMBOLS

- Dip and strike of beds
- Dip and strike of vertical joint.
- Dip and strike of inclined joint.
- Approximate contact, queried where inferred.
- Approx. axis of Anticline queried where inferred.
- Approx axis of Syncline, queried where inferred.
- Strike of vertical shear zone, queried where inferred.
- Dip and strike of inclined shear zone, queried where inferred
- Approximate outcrop area; may coincide with geologic contact in local areas; minor outcrops not shown.
- Location of vertical drill hole.
- Location of inclined drill hole, showing inclination and bearing.
- Location of section

SCALE 0 200 400 600 800 1000 1200 FEET

1" = 200'

NOTE: Upper valley slopes are covered with a thin mantle of mostly Colluvium. This Colluvium is not shown.

This drawing is a part of the application for license made by the undersigned.
This 16 day of Nov 1978
Northern Lights Inc.
By *[signature]* President
Recommended: *[signature]* Harza Engineering Company
Approved *[signature]* General Manager Northern Lights Inc.

PROJECT 2752 MONTANA

KOOTENAI RIVER
HYDROELECTRIC PROJECT

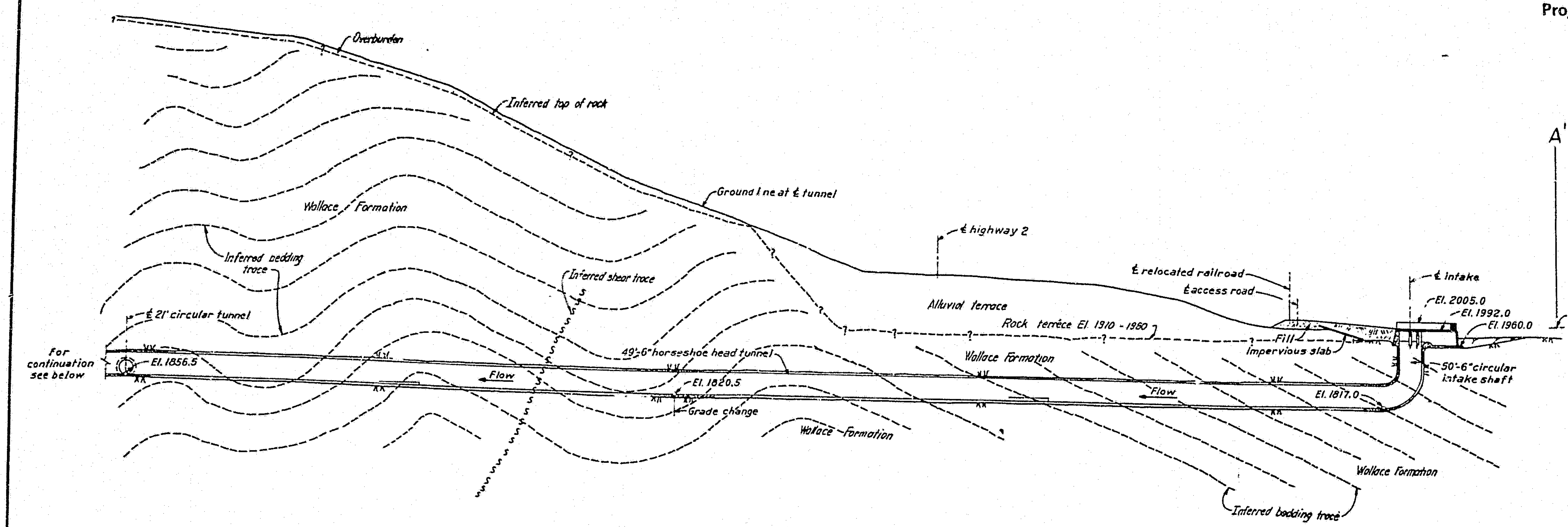
SITE GEOLOGY MAP

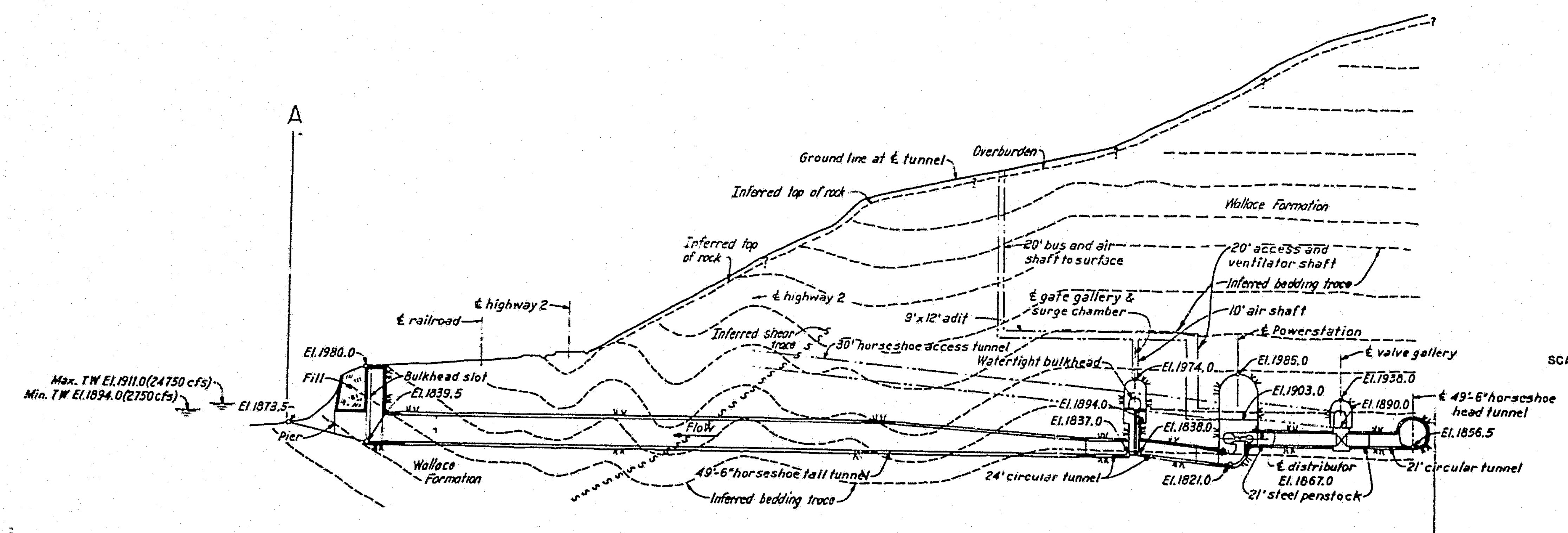
NORTHERN LIGHTS INC.

HARZA ENGINEERING COMPANY

REV NO	DATE	NATURE OF REVISION	BY	CHKD.	APPD.
1	10-21-81	Powerstation & Access tunnel	WKT	AM	

EXHIBIT......(EEK-3)
Project No. 2752





NOTES:

1. For section locations see Sheet 1
2. Bedding and shear traces are projected from drill holes and from rock outcrops mapped along the river (see Sheet 1).
3. Drillhole locations are shown on Sheet 1. Drill holes are not projected into sections due to the distance from the section lines.

This drawing is a part of the application for license made by the undersigned.
This 16 day of Nov 1978
Northern Lights Inc.
By [signature] President
Recommended [signature] Harza Engineering Company
Approved [signature] General Manager Northern Lights Inc.

SCALE 0 100 200 300 400 500 600 FEET
1" = 100'

PROJECT 2752 MONTANA
KOOTENAI RIVER
HYDROELECTRIC PROJECT

GEOLOGIC SECTION A - A'

NORTHERN LIGHTS INC.

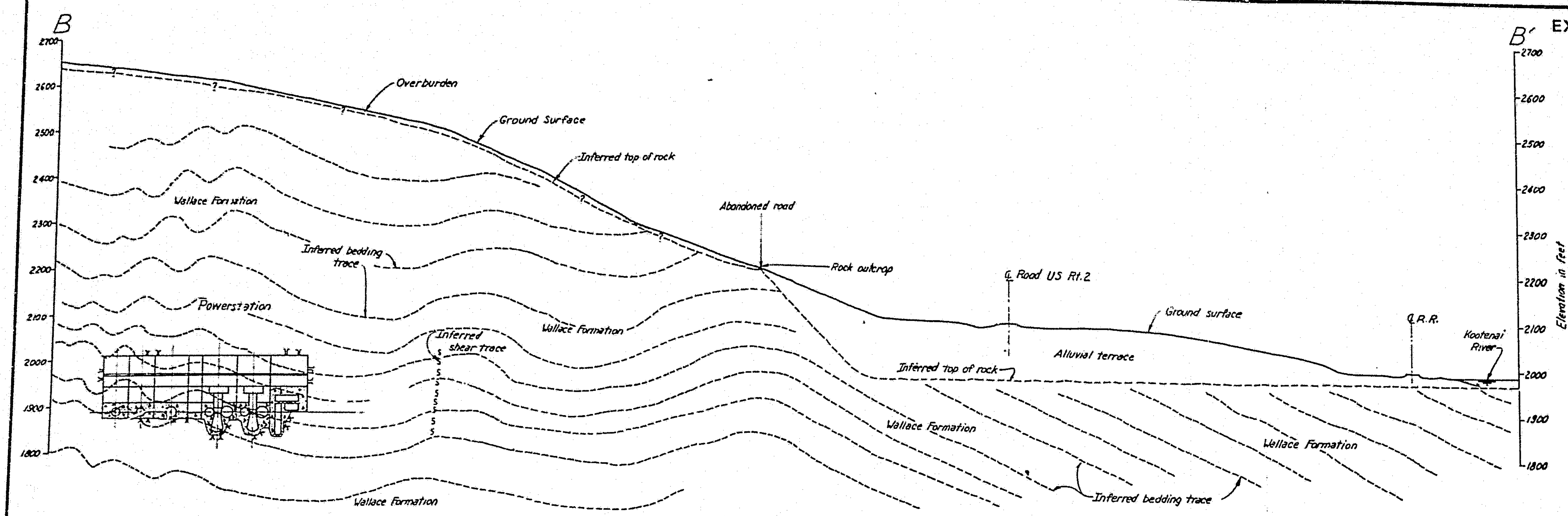
REV. NO	DATE	NATURE OF REVISION	BY	CHKD.	APPD.
1	10-21-81	Access tunnel & Gallery Elevs.	WKT	AM	

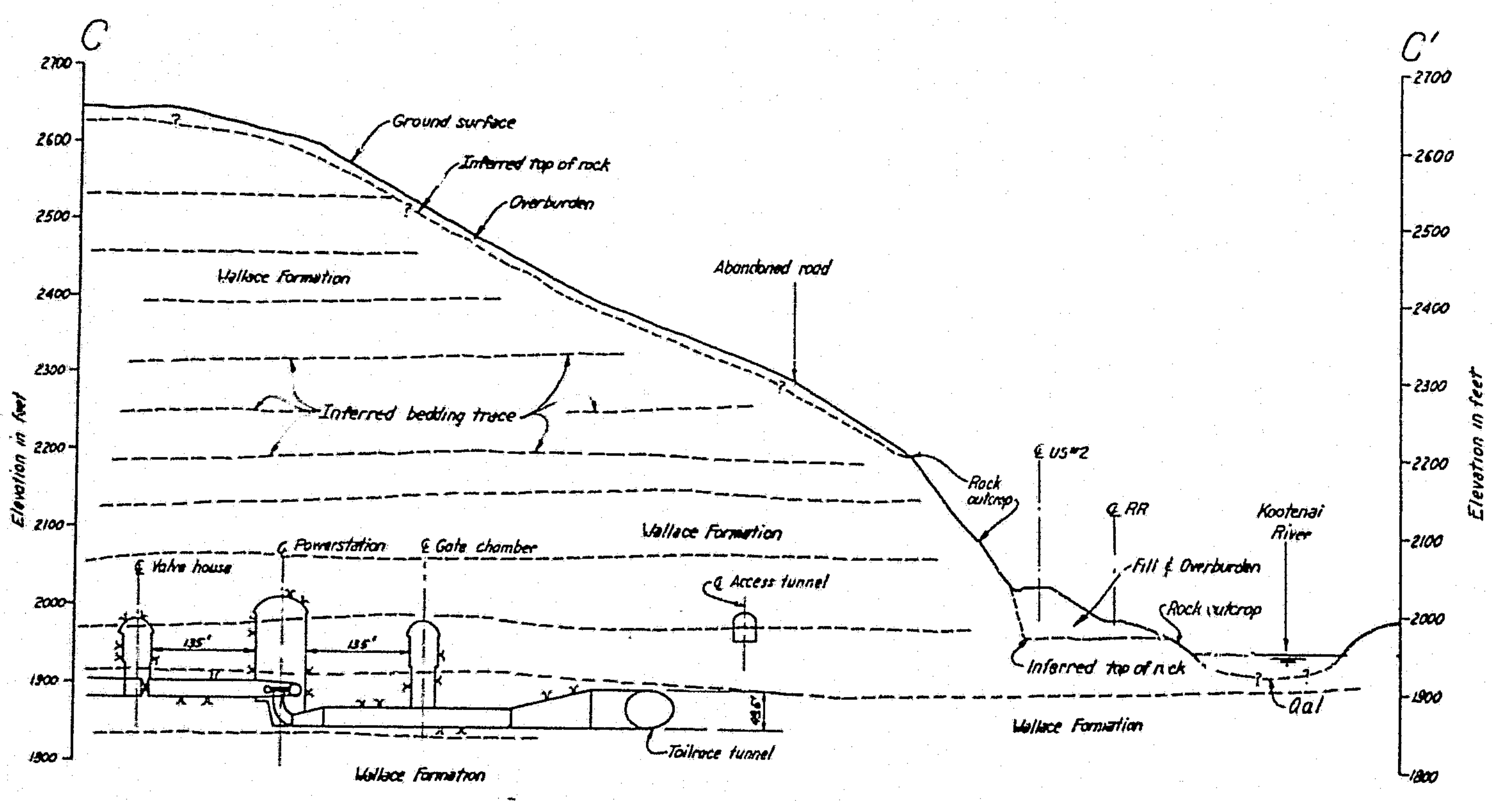
HARZA ENGINEERING COMPANY

003246

003246

EXHIBIT.......(EEK-4)
Project No. 2752





NOTES:

1. For section locations see Sheet 1.
2. Bedding and shear traces are projected from drill holes and from rock outcrops mapped along the river (see Sheet 1).
3. Drill hole locations are shown on Sheet 1. Drill holes are not projected into sections due to the distance from the section lines.

SCALE 0 100 200 300 400 500 600 FEET

1" = 100'

This drawing is a part of the application for license made by the undersigned.
This 16 day of Nov 1978
Northern Lights Inc.
By _______ President
Recommended _______ Harza Engineering Company
Approved _______ General Manager Northern Lights Inc.

PROJECT 2752 MONTANA

KOOTENAI RIVER
HYDROELECTRIC PROJECT

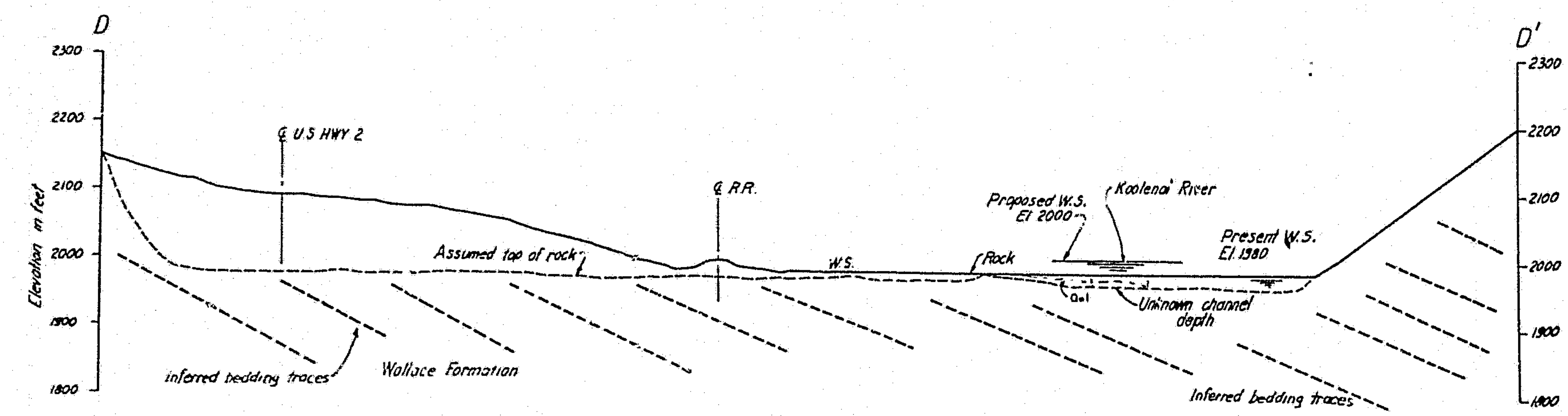
GEOLOGIC SECTIONS B-B' AND C-C'

NORTHERN LIGHTS INC.

REV. NO.	DATE	NATURE OF REVISION	BY	CHKD.	APPD.
1	10-20-81	Powerstation, Access, & Scale	WKT	AM	

HARZA ENGINEERING COMPANY

EXHIBIT......(EEK-5)
Project No. 2752



NOTES:

1. For section location see Sheet 1.
2. Bedding and shear traces are projected from drill holes and from rock outcrops mapped along the river (See Sheet 1.)
3. Drill hole locations are shown on Sheet 1. Drill holes are not projected into section due to the distance from the section

SCALE 0 100 200 300 400 500 600 FEET
1" = 100'

This drawing is a part of the application for license made by the undersigned.
This 16 day of Nov 1978
Northern Lights Inc.
By ________ President
Recommended ________ Harza Engineering Company
Approved ________ General Manager Northern Lights Inc.

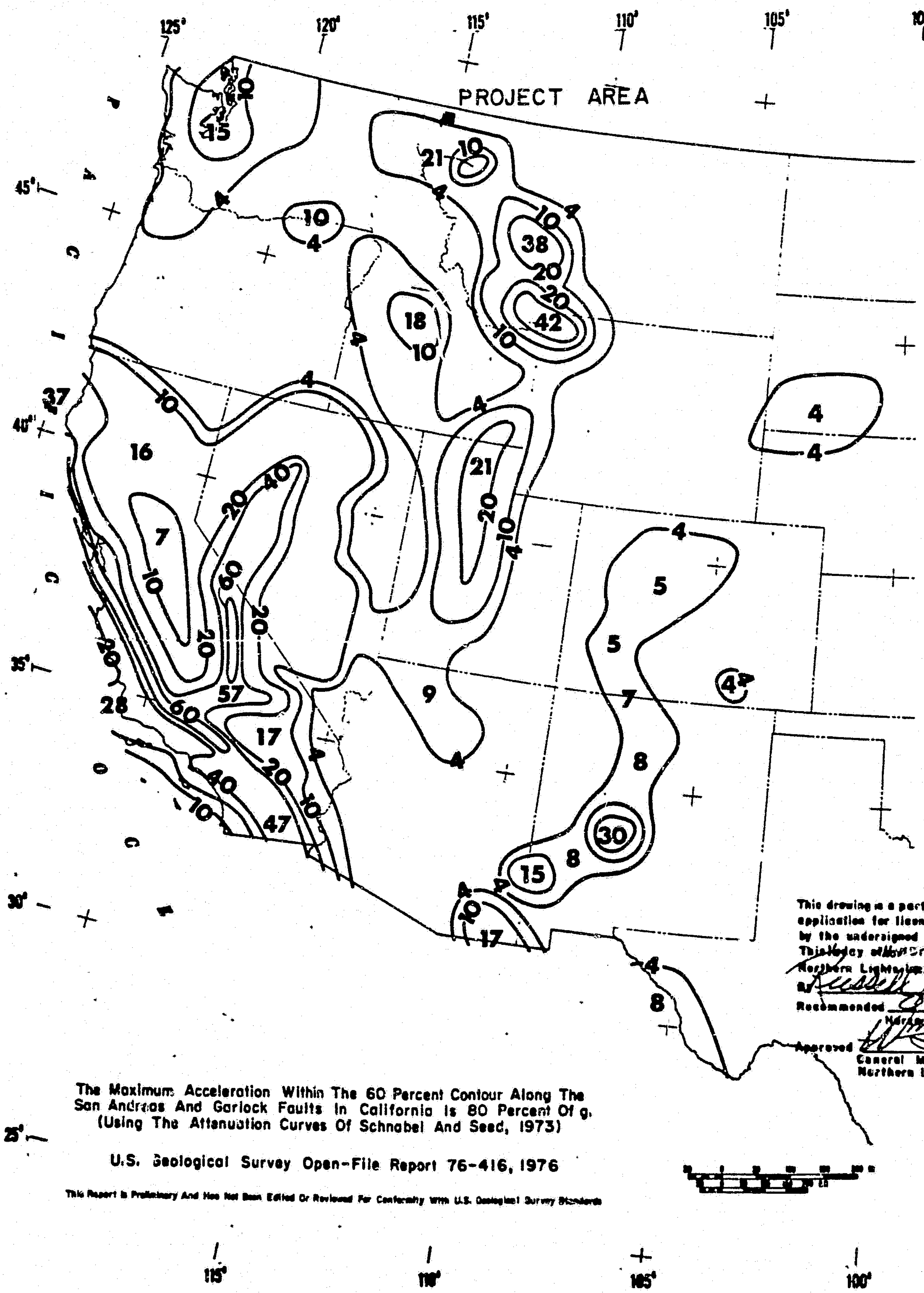
PROJECT 2752 MONTANA
KOOTENAI RIVER
HYDROELECTRIC PROJECT

GEOLOGIC SECTION D - D'

NORTHERN LIGHTS INC.

HARZA ENGINEERING COMPANY

EXHIBIT_____(EEK-6)
Project No. 2752



This drawing is a part of the application for license made by the undersigned This day of
Northern Lights, Inc.
By [signature] President
Recommended [signature]
Harza Engineering Company
Approved [signature]
General Manager
Northern Lights Inc.

The Maximum Acceleration Within The 60 Percent Contour Along The San Andreas And Garlock Faults In California Is 80 Percent Of g. (Using The Attenuation Curves Of Schnabel And Seed, 1973)

U.S. Geological Survey Open-File Report 76-416, 1976

This Report Is Preliminary And Has Not Been Edited Or Reviewed For Conformity With U.S. Geological Survey Standards

PROJECT 2752 MONTANA
KOOTENAI RIVER
HYDROELECTRIC PROJECT

Preliminary Map of
Horizontal Acceleration (Expressed As Percent Of Gravity) In Rock With 90 Percent Probability Of Not Being Exceeded In 50 Years

NORTHERN LIGHTS INC.

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

NORTHERN LIGHTS, INC.) PROJECT NO. 2752

DIRECT TESTIMONY OF SVANTE E. HJERTBERG
ON BEHALF OF NORTHERN LIGHTS

Q. Please state your name, title and affiliation.

A. My name is Svante E. Hjertberg, and I am with the Harza Engineering Company, 150 So. Wacker Drive, Chicago, Illinois.

I am Head of the Contracts and Construction Services of the Construction Management Department of Harza Engineering Company in Chicago, Illinois.

Q. Please describe your duties with Harza Engineering Company.

A. I direct the work of all Harza field engineers as they administer construction contracts and inspect construction activities. I supervise and assist in evaluating construction procedures, selecting appropriate field staff and directing the administration of construction contracts on behalf of the owner.

Q. Would you briefly describe your experience and training as it relates to the proposed work in the Kootenai River Hydroelectric Project?

A. I received a Diploma in Civil Engineering, the equivalent of an American Bachelor's Degree, from the Institute of Technology in Gothenburg, Sweden in 1946. I have two years experience with the State Board of Waterfalls in Sweden and twenty-eight years as an engineering employee of Harza Engineering Company in Hydroelectric Construction. I have served as Field Engineer, Chief Engineer and as Resident Engineer on numerous hydroelectric projects throughout the world. Recently I served as Chief Engineer for the construction of the TARP "deep tunnel" project in Chicago. This is a series of tunnels under the City of Chicago leading to an underground pumping station. Many of the underground features of TARP compare in width and height with underground structures of the Kootenai River Project.

Other relevant experience includes the construction of the underground powerstation at Harsprangct, 50 miles north of the Arctic Circle in Sweden; the field investigation and planning of the underground powerstation at Ligga, a few miles downriver from Harspranget; Resident Engineer during construction of the 210 MW Burfell hydroelectric project in the interior mountains of Iceland; on-site planning and construction of dam and tunnel projects in the rugged mountains of the Kurdistan Province of Iraq. I have participated in construction of underground projects in Latin America and in Africa.

Q. Have you inspected the site of the proposed Kootenai River Hydroelectric Project?

A. Yes. After spending considerable time evaluating the reports prepared by others in the Harza organization, I visited the site.

I studied the topography and general layout of the Project. I also visited the towns of Troy and Libby to ascertain how the construction might be coordinated with housing and storage facilities there.

Q. Please briefly describe the Project from the standpoint of construction magnitude and difficulty.

A. Major facilities to be constructed include the Dam, Intake, Head Tunnel, Underground Powerstation, complete with draft tubes, penstocks and surge gallery and the Tail Tunnel and Tail Tunnel Outlet. The work will require clearing of approximately 13 acres of land above normal high water, excavation of 850,000 cubic yards of rock and placement of approximately 180,000 cubic yards of concrete.

Construction of Project components is closely interrelated with relocation of the Burlington Northern mainline track which will be relocated to a higher elevation and relocation of the passing siding entirely to the west of the Project. A permanent access road will be constructed along the existing railroad right-of-way from a point upstream from the Dam to the Intake and to the left abutment of the Dam.

The construction will require close coordination and planning between the various construction activities so that the proper materials for construction and installation are scheduled appropriately. There will be only limited space at the Project site for storage, warehousing and parking. Planning of construction facilities requires recognition of the limits of available space and much of the auxiliary work will be done in off-site locations near Troy or Libby.

Q. I show you a drawing marked as Exhibit ___ (SEH-1). Can you identify this Exhibit?

A. Yes. Exhibit __ (SEH-1) is a drawing of the construction layout, illustrating the various features of the construction facilities and methods proposed. I will refer to this exhibit from time to time during my testimony.

Q. Now I show you a drawing marked as Exhibit ___ (SEH-2). Can you identify this Exhibit?

A. Yes. Exhibit ___ (SEH-2) is the Construction schedule. It is a bar graph of the time required to start and finish the various major portions of the construction of the Kootenai Project. Construction of the Project is expected to require about four and one-half years after the work begins. The time presented here does not include time for an exploratory adit and final design resulting from the adit. This will be done before the major work begins.

Q. Are there unusual aspects affecting the schedule during stages of the construction?

A. Yes. Four factors combine to cause Project construction to develop slowly during the early stages. These are as follows:

1. The very large percentage of underground work and the limited access to the underground work from the Intake or from the Access Tunnel.

2. Except for the Intake Shaft, no work can be done on the underground structures until the exploratory adit has been driven and final rock characteristics determined. The work on the exploratory adit, in turn, cannot begin before completion of a permanent bridge across the access route along Highway 2.

3. The Burlington Northern Railroad track must be relocated early in the construction to provide areas for construction near the Dam and Intake.

4. Fill materials required for construction of the Stage I cofferdam and for the construction plant area must come from underground excavation.

Q. What major construction facilities did you consider necessary for this Project?

A. I considered the need for offices, shops, a rock crusher, a concrete plant, storage facilities and parking.

Q. Is there an appropriate location for the Contractor's office and shops?

A. Yes. The terrain adjacent to the Kootenai River is steep in the area of the Project and potential construction facility sites are limited. Certain areas have been excluded from use as construction sites by the Applicant. Among these is the area downstream from the Dam, between the railroad and the bank of the river. Using this site for construction would require filling the rough terrain and rock exposures with materials excavated elsewhere. The present topography would be completely changed in character and altered irretrievably. The potential site was rejected.

There are two possible areas that might be used for the construction plant, as follows:

(a) In part of the riverbed beginning approximately 600 feet upstream of the Intake and extending approximately 800 additional feet upstream and 250 feet from the left shoreline. The site would be developed by filling to Elevation 1993 and protected by the extension of the Stage I cofferdam.

(b) Upstream from the Dam between the railroad and the left shoreline. The site is very narrow and it would be extremely difficult to construct the necessary facilities along this area. The exposure of the river to deposition of construction debris in general would be excessive.

The most desirable site for construction facilities is the first; i.e. a site constructed in the area that now is riverbed. Additionally, the proposed site will not require any disturbance to the natural terrain above final operating water level of Elevation 2000. The fill material for the site will remain in place as part of the shoreline mitigation plan being developed by the Applicant.

Q. Where do you expect to obtain the material for the construction site fill?

A. The construction site fill will be obtained from broken rock excavated early in the construction. The first material will be obtained during excavation for the Powerstation access road including the underpass for Highway 2 and this mixture of soil and rock will be used for a temporary cofferdam around the Intake. This will require about 4000 cubic yards. Thereafter, Intake shaft and exploratory adit excavation will proceed simultaneously.

The complete fill for the construction site is estimated to require 120,000 c.y. solid rock measurement. The assumed weight of rock "in place" is 140 pounds per cubic foot; however, the compacted weight of the broken, excavated material placed in the construction site is expected to be only 115 pounds per cubic foot. For that reason, the 120,000 ubic yards of solid rock is expected to fill 146,000 cubic yards for the construction site. Sources of excavated material for this purpose are as shown in Table 1.

Table 1

SOURCES OF EXCAVATED FILL MATERIAL

Source	In-Place Quantity-c.y. (@ 140 pcf)1/	Fill Quantity (@ 115 pcf)
Access Tunnel	64,200	78,000
Intake shaft	16,400	16,500
Head Tunnel-Top heading	34,400	41,900
Construction tunnel #1	14,000	17,000
Total	129,000	153,400

1/ Pounds per cubic foot.

The time required to provide the excavation material for the complete construction site is estimated to be approximately six months; however, a portion of the site will be available for use as fill is provided. The space required for the concrete plant and the rock crusher will not be needed until concrete work begins, which is estimated to be about 9 months after the start of the work.

Q. What buildings or structures are expected to be constructed on the filled-in site?

A. I expect the Contractor to have a trailer complex for first aid, superintendent offices, engineering office, and an office for a time-keeper and a personnel manager. Three 10 x 40 trailers are envisioned for this purpose. Any additional temporary office facilities for accounting, other personnel people and additional supervisory people that might be required will be obtained off-site by the Contractor.

A carpenter shop, a repair shop, concrete test laboratory and a reinforcing steel fabrication area will be required. One or two small warehouses will be necessary for small tools, such as welding equipment, miscellaneous supplies and speciality tools such as concrete vibrators, pavement breakers and rock drills.

A major portion of the space will be needed for the erection of a concrete batch plant and a rock crusher. Stockpiles of raw excavation will be located slightly upriver of the plant site and processed aggregate will be stockpiled near the crusher and concrete plant. Their locations are shown on Exhibit __ (SEH-1).

Q. Your previous response mentioned a concrete batch plant and a rock crusher. Will you elaborate on that subject?

A. The Project requires an estimated 180,000 cubic yards of concrete. As is shown by the Schedule, Exhibit (SEH-2), most of this concrete will be placed over a 36-month period beginning early in the second year of construction. This averages 5000 c.y. per month. During the second and third construction year concrete placement will be 10,000-15,000 cubic yards during some months. This averages 400 to 600 c.y. per day. A 100-c.y.-per-hour batch plant delivery capability is required for construction of that magnitude. It will be necessary to have at least one bulk cement bin associated with the batch plant. Additionally, both sand and rock for concrete will be required for stockpiles. Concrete aggregate stockpiles should reflect more than one month's supply to provide adequate supplies for large placements. Approximately 20,000 c.y. of concrete aggregate should be in stockpile.

Based upon preliminary observations, the rock excavation for the Project will be suitable for concrete aggregate. The material will be crushed for use on site. Additionally, all aggregate for site road construction and railroad ballast will be processed on site. Other possible uses for excess rock excavation will require some processing. For this reason, it will be necessary to construct a rock crusher of about 600 tons per hour capacity on site. This unit is expected to be operated a maximum of 16 hours a day to furnish all manufactured aggregate and ballast.

Aggregate materials will be transported from processing to concrete batch plant aggregate stockpile by covered belt to reduce the amount of dust and to prevent accumulation of ice and snow on belts.

Q. You mentioned the requirements for concrete aggregate in answer to the previous question. Where do you propose to locate these stockpiles?

A. At least three stockpiles will be required. Fine aggregate (sand) will be piled separately from coarse aggregate (gravel). Coarse aggregate will be separated into 3/4" maximum size aggregate and 1-1/2" maximum size aggregate. The sand pile should contain about 6,000 c.y. and each of the coarse aggregate stockpiles should be about 7,000 c.y. The piles should be located conveniently in relation to the concrete batch plant. The logical location for these stockpiles is in the space between the road to the Intake and the edge of the river near the proposed construction site. This is shown on Exhibit _____ (SEH-1). Material can easily be delivered to the rock crusher from the excavation, then the processed aggregate will be stockpiled in the vicinity by use of overhead conveyor belt and further delivered to the concrete plant by underdraft conveyor belt.

Q. What is proposed for disposal of material or waste from the excavation?

A. Much of the excavation will be used in the construction of the Project. The largest requirements are for concrete aggregate, construction of the cofferdam, filling for the construction site, relocation of the railroad, construction of access roads, improvements to the Lions Club Park and for regrading and improving the left bank. Any remaining material will be hauled off-site.

Q. Will it be necessary for you to establish spoil piles for storing excess excavation before needed for the Project?

A. Yes, the majority of the excavation work is scheduled to take place during the initial 20 months, while the material will be used in the construction over approximately 44 months.

A spoil pile will be required. At present, much of this material is planned to be stored behind the cofferdam, near the left bank upstream from the construction site, as shown on Exhibit _____ (SEH-1).

Q. The work involved in relocating the railroad and for improving the left bank of the river will require restoration. How do you propose to salvage topsoil for use when the site is restored?

A. Topsoil salvaged between the upstream end of the construction site and the dam will be stockpiled and grassed to reduce erosion and dust. On completion of the Intake and the left side of the Dam, the left bank between the Dam and the construction site will be regraded using rock excavation, and topsoil will be placed on top of the fill material all along the left bank to permit the establishment of shoreline grasses.

Q. What is planned for the shoreline upstream?

A. Upstream of the construction site, topsoil will be removed and temporarily piled while excavation material is spread along the left bank to provide shoreline mitigation. The stored topsoil then will be spread on top of the rock material. This will be done on short stretches of the bank in one continuous operation. In that way, no large topsoil piles will be required.

Q. Where do you propose to park construction equipment and employee vehicles?

A. All construction workers will be bussed to the site from Libby and Troy. On-site parking will be alotted to the Superintendent, the Resident Engineer and for emergency vehicles. These spaces will be in the vicinity of the Contractor's job office. Construction vehicles will be parked in the tunnels, the Powerstation, and the approach to the Access Tunnel when not in use. Disabled vehicles will be hauled to off-site repair shops.

Q. What level of construction traffic do you expect on Highway 2?

A. The Applicant has determined to restrict construction traffic as much as is economically feasible. For this reason , much of the underground excavation will be removed through the Intake Shaft, and as stated, employees will be bussed to the site.

During construction it will be necessary to haul some excavated material, concrete and equipment along Highway 2. Vechicles used by the Contractor for this purpose will be of legal size and weight. This traffic is expected to require 80 trips a day for an average of four trips per hour during the excavation. The Contractor will be required to provide all necessary flagmen and warning devices required by the Montana Department of Transportation.

Q. Please describe the conceptual plan for construction roads required to build the Project.

A. Access from Highway 2 to the construction plant area, Dam and Intake will be by a road obtained by improving an existing road. The location is shown on Exhibit (SEH-1). The road will cross the railroad. Details of the crossing and the warning system to protect trains and construction traffic will be developed in coordination with the Burlington Northern Railroad. North of the railroad crossing, a paved road will be constructed parallel to the railroad along the left (south) shore about 2200 feet from the railroad crossing to provide construction access to the concrete plant, the Intake, the left abutment of the Dam and other construction areas along the Reservoir. The paved access road to the Intake and Dam will remain on completion of the work.

The construction of the access to the Powerstation will include an open cut from the north side of Highway 2 eastward approximately 600 feet to an underpass under Highway 2 which will lead into the Access Tunnel. This road and tunnel will remain as the permanent access to the Powerstation on completion of the work. An existing transmission line access road passing near the Bus Access and Ventilation shaft will provide construction access to make the connection between the project transmission facilities and the existing facilities transmission line.

Q. Describe the plan for railroad relocation.

A. Relocation of the railroad and siding is planned early in the work (during the first 18 months). The procedure will require construction of the new mainline with use of the existing siding for mainline traffic. On completion of the new main line, the existing siding will be used for construction purposes. A new passing siding will be constructed downstream (west) of the existing siding.

The mainline railroad track will be relocated approximately fifty feet south of its existing alignment at the Dam and is variable elsewhere for a distance of approximately 12,000 feet. The relocation extends from a point 4000 feet west of the construction road crossing to a point 8000 feet east of the crossing. Approximately 10 acres of railroad right-of-way will be disturbed by this work.

A portion of the existing siding will be used during the construction for delivery and storage of materials, and will be removed on completion of the work.

Q. Do you propose to alter the flow of water in the river for the construction?

A. Yes, it will be necessary to divert water from the site of the Dam and the Intake during construction. Exhibit _____ (SEH-1) shows the locations of the cofferdams.

Q. How do you propose to accomplish this?

A. The Contractor will build temporary dams - called cofferdams - in two stages. The Stage I cofferdam will divert the flow to the north side of the river and permit work on the left side of the Dam and the Intake. On completion of the Intake and approximately 510 feet of the Dam and the left abutment of the Dam, material in the Stage I cofferdam will be removed and used in a different location to construct the cofferdam which will extend North-South across the river, upstream of the uncompleted 255 foot portion of the Dam. This work will be scheduled to permit river overflow over the left portion of the Dam during the construction of the remainder of the Dam, so that the flow downstream will be undiminished.

Q. What materials will be used to construct the cofferdam?

A. The cofferdam will be constructed of a mixture of dumped material from underground excavation and a subsoil clay or silt if found on site during early excavation. If no fine grained material is naturally available, it may be necessary to import material or to develop an alternate membrane for sealing the Dam. This may be by use of cement or plastic fabric.

Q. Do you expect this work to increase the turbidity of the river water?

A. Yes, there will be some temporary increase in turbidity of the river water as a result of cofferdam construction and removal. The Contractor will be required to minimize turbidity and meet the requirements of the permit to be issued by the Montana Department of Health and Environmental Sciences. Lost materials represent additional costs to the Project and certainly the Contractor and the Applicant will keep this to a minimum for economic reasons.

Q. During your reply to the discussion of construction roads and railroad relocation, you mentioned that substantial areas are to be reshaped. Do you have a plan to prevent erosion of soil into the river?

A. Any disturbed site will be evaluated for potential erosion and proper precaution will be required. The construction specification will require that the Contractor submit a plan for erosion control in an area before construction begins in that area. Standard procedures for reducing erosion and preventing sediment from reaching the river will be required of the Contractor. For example, topsoil piles will be grassed when the piles are complete. All spoil piles will be encircled by some form of barrier to provide settling time for rain and snow melt. Extensive use of straw bales in vales and depressions will filter runoff before it is deposited into the river. The replaced top soil along the left bank will be seeded and mulched to reduce erosion to a minimum.

Q. The construction will require use of water for cleaning construction joints, and for other uses. Will this water become contaminated by its use?

A. Construction water is used primarily for purposes of cleanup. Concrete trucks, concrete plant and construction areas will be cleaned by high pressure construction water. Considerable water will be needed for curing concrete. Seepage water from the tunnels will contribute additional water. All of this water will become highly turbid from construction debris.

Q. How do you plant to treat this water to prevent river contamination?

A. Since most of the turbidity of the construction water is expected to be of the fine sand size (0.1 mm) with a settling velocity of 1 to 10 cm per sec, a detention time of 4 hrs appears satisfactory. A pond will be constructed to handle twice the average inflow. For this purpose a settling pond of approximately 100 feet by 200 feet will be required. Two 200 gallon-per-minute units are planned so that either can be cleaned at any time.

In the event that unexpectedly large inflows of groundwater are encountered , a sump will be constructed in the Head Tunnel for primary settling of sand. Plans for the construction of the sedimentation ponds will place them just upstream of the railroad crossing and south of the construction site. The construction water will be delivered to the settling ponds by use of temporary pipe and pumps.

In the unlikely event silt or clay deposits are found and additional treatment is necessary, a filter can be used to further clarify the effluent from the settling ponds.

Q. What is planned for reducing the contamination of the air from construction dust?

A. As previously discussed, any portion of the site to be exposed for any length of time will be stabilized with mulch and seeded for resistance to erosion. This will also reduce the amount of dust from the Project. Also, as for most construction sites, graveled roads and exposed stockpiles will be sprinkled as required to control dust. Cement bins will be fitted with a dust collector. Fine aggregate conveying belts will be covered to prevent blowing dust from that source. Main construction roads will be paved.

Special care will be required of the Contractor in the operation of the rock crusher. It may be necessary to pre-wet all aggregate.

Any additional steps necessary to meet the Air Quality requirements of the Permit to be issued by the Montana Department of Health and Environmental Sciences will be required by the specifications.

Q. What procedures are planned to prevent contamination of the river from fuel oil and lubrication products?

A. No on-site bulk storage of gasoline, fuel oil or grease will be permitted. Fueling will be done by use of fuel delivery trucks. A service truck will be used for lubrication. Fueling and lubrication will be accomplished in one location which may be the Powerstation Access Road or another convenient location away from the river. In this way any inadvertent spills will be contained.

The contractor will be required to protect the area used for fueling with a sump to collect any inadvertent spills and will be required to immediately clean up any lubrication spills. Additionally, all waste oil will be collected in containers and transported to an acceptable off-site disposal facility.

Q. How will drinking water be provided for the construction people?

A. All drinking water for use on the Project will be brought from a potable water source in Libby or in Troy. No effort will be made on the site to construct a well or wells for drinking water use.

Q. Where do you propose to obtain construction water?

A. All construction water will be pumped from the river. This will be water required for mixing concrete and for curing concrete. Construction water will also be required for rock drilling, final clean-up of foundations and construction joints in concrete before concrete placement.

Q. How do you propose to handle sewage from the site?

A. Human wastes from the Project will be collected from portable toilets and transported to approved treatment facilities off-site by tank truck.

Q. Where will the Contractor store explosives?

A. The Contractor will be required to obtain off-site storage for explosives for two reasons; one, because of the limited space available, and two, to reduce the chances of inadvertent river water contamination. Only one or two day's supply of explosives will be permitted on site.

Q. I show you a drawing marked Exhibit _____ (SEH-3). Can you identify this drawing?

A. It was prepared under my supervision to illustrate the layout of the various tunnels and their relationship to the Powerstation.

Q. Briefly describe the method and procedure for excavation of the tunnels and the Powerstation.

A. Very early in the construction schedule, an exploratory adit will be driven from Highway 2 to the Powerstation location with several laterals in the Powerstation to determine rock orientation and structure.

As soon as this exploratory adit is completed and the Powerstation orientation is established, the Intake Shaft and the Access Tunnel will be constructed. The Access Tunnel entrance will pass under Highway 2 by the cut and cover method. Two-way traffic will be maintained throughout the construction of the Access Tunnel bridge by detouring one lane of traffic through the Access Tunnel entrance.

Excavation will be removed simultaneously from the Intake Shaft and from the Access Tunnel. Material will be delivered to stockpiles by conveyor belt or by trucks. During the early stages, this material will be used for the Stage I cofferdam and for construction site fill. Later it will be used for processing through the rock crusher.

Excavation from the Access Tunnel will supplement material from the Head Tunnel in the construction of the Stage I Cofferdam and the construction site fill. At a later time Powerstation excavation will be used for railroad relocation.

The excavation for the draft tubes, Draft Tube Tunnels and Tail Tunnel will be through a 18 foot construction tunnel, shown on Exhibit _____ (SEH-3) as construction tunnel No. 2, connecting the downstream end of the Head Tunnel to the upstream end of the Tail Tunnel.

Simultaneously, following completion of the Stage I cofferdam and the construction site, work will begin on the Intake, the left side of the Dam, railroad relocation, and concrete membrane along the left bank.

Finally, the right side of the Dam will be constructed and the Tail Tunnel Outlet excavated and completed. Concrete work will begin in the various tunnels and in the Powerstation as excavation is completed. Final concrete work includes the lining of the Access Tunnel.

Q. What is the purpose of the Exploratory Adit.

A. Construction of an Exploratory Adit will be required for evaluation of rock characteristics.

Q. What will become of the Exploratory Adit.

A. The Exploratory Adit will be drilled along the lines proposed for the permanent Access Tunnel and will be enlarged to form a 30 foot horseshoe-type access tunnel.

Q. Will you describe the procedure for the construction of the Intake Shaft?

A. As completed, the shaft will be 50 feet in diameter and will be excavated downward using a drill and blast procedure. Material will be removed from the Shaft by use of a crane.

Q. What procedures will be used to excavate the rock in the Head Tunnel and the penstocks?

A. As stated earlier, the Intake Shaft will be excavated as soon as a cofferdam is constructed and a Head Tunnel heading will extend from the bottom of the Intake Shaft with the excavation removed through the Shaft. A small (18 foot) diameter heading in the Head Tunnel will be driven past the penstocks and around to the upper end of the Tail Tunnel. Simultaneously, a 30 foot construction tunnel, shown as construction tunnel No. 1 on Exhibit ______ (SEH-3), extending 600 feet from the Powerstation will connect the Access Tunnel to the Head Tunnel through the Powerstation. Excavation will proceed from both the Intake Shaft and the Access Tunnel.

On completion of the work on the Head Tunnel, work will begin on the five penstocks. All of this material may be removed through either the Intake Shaft or the construction tunnel No. 1 and Access Tunnel.

Q. How will excavation for the Powerstation be accomplished?

A. Work will begin on the Powerstation immediately following excavation for the Access Tunnel. Upward driven shafts will provide access to the top headings for the Surge Gallery and the Powerstation. On completion of the crown headings, the remainder of the material will be removed by drilling and blasting using horizontal benches. The roof of the Powerstation will be stabilized by use of rock bolts and shotcrete as soon as the crown is excavated.

The Access Tunnel will be extended into the valve gallery and the valve gallery will be excavated by heading and bench. All excavated material will be removed through the Access Tunnel initially; then later, through both construction tunnel No. 1 to the Head Tunnel and through the Access Tunnel.

Q. The Bus and Air Shaft extend about 600 feet from the surface downward to the Powerstation. How is this excavation proposed to be accomplished?

A. This 21-foot diameter shaft will be excavated beginning at a point within the Powerstation and will extend approximately 200 feet vertically, 380 feet horizontally, and then 300 feet vertically to exit near the existing transmission line. Rock will be removed from below and transported through the Access Tunnel. This will reduce the impact on the road structures and environment as compared to excavation from the surface.

Q. How will excavation of the draft tubes and tunnels leading to the Tail Tunnel be accomplished?

A. As presently planned, the invert of the bottom of the draft tube is 35-1/2 feet below the floor of the Powerstation and the invert of the Head Tunnel. The upper end of the Tail Tunnel is lower than the Head Tunnel. Therefore it is necessary to construct a method for getting to a lower level for the work.

Consideration was given to driving through the Power Station via one of the units. Comparative costs indicate that the 1000-foot construction tunnel No. 2 bypassing the Powerstation is equally viable and has the benefit of providing additional headings for Tail Tunnel and Draft Tube Tunnel construction.

For the foregoing reason, it appears evident that construction tunnel No. 2 will be adopted. From construction tunnel No. 2, headings can begin in one direction, terminating at the draft tubes and in the other direction downstream in the Tail Tunnel, terminating at the Tail Tunnel Outlet.

Q. As you previously discussed, you plan to excavate the Tail Tunnel through construction tunnel No. 2. Is there any other special feature of this Tail Tunnel that should be discussed?

A. The Tail Tunnel is designed to slope from the Outlet to the Powerstation. It will be necessary to construct a concrete bulkhead with steel guides and gates. The bulkhead and gates will serve to exclude river water from the Tunnel as excavation approaches breakthrough.

The work will be accomplished by excavating a shaft downward from the top of the river bank to form a concrete slot for the gates. This work may be done at any time before the Tail Tunnel nears the river.

Q. How do you plan the excavation from the Tail Tunnel Outlet to the river?

A. The river is too narrow at that point to permit construction of a cofferdam. For this reason, it will be necessary to do the excavation and construction within the river. Rock will be loosened by line drilling and light blasting to crack and break the rock into large block sections. This material will be removed by lifting and disposed of by hauling down Highway 2. Any cobble or smaller sized material entering the river will be dredged for removal. Some smaller fragments will remain in the river; however this is not expected to be enough material to noticeably affect river flow or greatly increase tubidity.

Q. What work, if any, will be necessary to the south shore of the Project Reservoir in addition to the construction previously mentioned?

A. Studies have revealed that there is a deep bench of alluvium extending from the river 2500 feet toward the slope. Impounding the river to Elevation 2000 will create head on this alluvium. Water will percolate through the alluvium and its amount must be controlled to prevent excessive loss of reservoir water and to prevent the creation of swampy conditions alongside the railroad.

For this reason, it will be necessary to construct an impervious concrete slab from the Dam to a point about 2000 feet upstream whre solid rock is encountered above Elevation 2000.

Q. When will the slab be constructed?

A. The construction of the slab will begin as soon as the left bank of the river is dewatered by the Stage I cofferdam.

Q. How will the work be done?

A. The slab will be constructed of concrete and will be completed before the construction of the Stage II cofferdam.

Q. Please explain the procedure proposed for constructing the Dam and Spillway.

A. The plan is to construct the concrete Dam in two stages. The left or south portion will be constructed first, while the Stage I cofferdam is being used to divert flow along the north shore.

Excavation will begin after the completion of the Stage I cofferdam and construction road to the left bank of the Dam. This excavation is expected to be minimal - about 4000 cubic yards -and should be completed within a month. Simultaneously, examination of the rock will reveal the extent of consolidation grouting that may be required. Also work will begin on the grout curtain and dental concrete to prepare for placement of concrete.

The actual placement of concrete is planned to begin within about 9 months after start of the work. This Stage I work will include Spillway Bays One through Four, and will extend 510 feet across the 765 feet of the Spillway. The concrete work on Stage I of the Dam is expected to require about four months.

Following completion of Stage I, material will be taken from the Stage I cofferdam to construct the Stage II cofferdam on a N-S axis across the remaining north side of the Dam. Access to Stage II cofferdam will be by way of a prefabricated construction bridge approximately 600-foot long from the construction road upstream of the dam.

Stage II Dam and Spillway construction will require about three months and is planned for the middle of the third year.

Q. When will the Spillway gates be added to the top of the Dam?

A. These gates will be installed for each stage on completion of that portion of the Dam.

Q. There appears to be a great deal of loose rock on the slope above the right bank of the river. Do you anticipate any problems with this during construction?

A. Examination of the area above the right Dam abutment and of the right abutment itself does not reveal that a problem exists. If necessary, however, this loose material can be stabilized.

Q. How will you maintain flow down the river while doing the construction?

Since the Stage I cofferdam will direct the flow to the north bank, during Stage I construction all river water will continue over the north side of the Falls. At the time the water is diverted from the north bank over the top of the partially completed Dam, the water level will be raised to slightly above Elevation 1988 (top of the concrete portion of the Dam), while the water is allowed to pass downstream through the channel being closed by the Stage II cofferdam.

Calculations have been made to determine a schedule for the construction of the closure of the Stage II cofferdam that will ensure continuous river flow downstream. The calculations show that during the Stage II cofferdam closure, flow down river will always exceed 3500 cubic feet per second, based on the minimum release of 4000 cubic feet per second from Libby Dam.

Q. What is the time table and procedure for the construction of the Intake?

A. As previously discussed, excavation from the bottom of the river for the construction of the Intake will begin early in the work. The Shaft will be concreted during the middle of the second year and construction of the Intake will begin shortly thereafter. The Intake must be completed with gates before the Stage II cofferdam is constructed to divert the river flow to the south bank in the third year of the work.

Q. Will any work be done to the walls of the tunnels before concrete lining is placed?

A. Yes. The arch of the tunnels will be reinforced with long embedded tensioned rods (rock anchors) that are designed to stabilize the arch surface and transform the rock face into a structural supporting arch.

After the appropriate number of rock anchors are placed, as determined by examination of the exposed rock, the entire surface will be coated with a thick - one or two inch - concrete lining applied as "shotcrete", which is a pneumatically applied sprayed-on concrete.

In some cases, excavation may reveal faulty rock. In that case, steel arches will be placed as required to support the tunnel roof.

Q. There are many tunnels planned for this Project. Will they all be lined with concrete?

A. Yes, on completion, all of the tunnels will be concrete lined including the Access Tunnel. The penstocks will be lined with steel between the Valve Gallery and the Powerstation.

Q. When is that work planned?

A. Much of the excavation will be removed through the Intake Shaft at the end of the Head Tunnel, and for this reason, it may be desirable to delay paving the tunnel invert until the Shaft is no longer needed for excavation. In that case, concrete work may initiate in the Powerstation and other areas first.

In any event, the tunnel concrete work will be done in two parts; that is, the invert and the arch placements will be done separately. The bottom of the tunnel will be paved by use of a sliding (or sled) paving machine and steel forms will be used to complete the tunnel lining. Typically, these forms are especially constructed to collapse to permit a length of formwork to be jumped ahead of a length being used to shape concrete. In this way, the placement of tunnel concrete can continue for a long period. Usually, tunnel concrete is placed continuously, round the clock, for a normal work week.

Concrete will be pumped in place for the construction of the arch of the tunnel, and may be pumped in place for the construction of the invert.

Q. The penstocks are to be steel lined. How will the concrete be placed between the steel lining and the rock surface of the penstocks?

A. In effect, the steel liners of the penstocks become the forms for the concrete. No invert is poured. The steel liners are welded together and securely fastened and braced in place to prevent them from being dislodged or forced out-of-round while the concrete is being placed. Concrete is pumped in place along the top of the penstock and worked first from one side and then the other to assure that all voids are filled under the penstock liners.

Q. How will concrete be placed in the Powerstation itself?

A. The Powerstation is to be constructed underground and the excavation will delineate the rough outline of the shape of the station. The finished excavation will be covered with shotcrete immediately after the necessary rock bolting is completed.

It is probable that most of the concrete for the Powerstation will be placed by pumping. Concrete aggregate will be 1-1/2 and 3/4 inch maximum size.

For the most part, massive concrete will be limited to the embedment of turbine and accessories.

Q. Are there other particular requirements for the construction of the draft tubes and the embedment of the spiral case?

A. Yes, this work is very critical to proper operation of the Powerstation. The concrete surface of the draft tubes must be formed especially smooth and dense because of the velocity of water passing through. Embedment of the draft tube liner requires care in controlling the rate of placement to prevent displacement and to control the temperature rise of the concrete.

Q. How will the Bus Shaft linings be constructed?

A. The Bus Shaft will be lined with shotcrete blown onto the exposed rock wall. Present indications are that formed concrete lining will not be necessary.

Q. The Tail Tunnel Outlet will be constructed in the river. Will that present any particular problems?

A. Forms will be prefabricated complete with the piping in place for underwater placement of concrete and the concrete will be pumped into the forms. Care will be taken during placement to maintain the ends of tremie pipe within the mass of concrete. The work will be scheduled for construction during the summer months when river flows are lowest. Divers will be used when needed to assist in the work.

Q. Would you describe the magnitude, source and disposition of the excavated material?

A. The quantities below will reflect the level of magnitude of excavation we are dealing with.

Major sources of excavation are grouped as follows:

A. Underground Excavation

1. Powerstation including Penstocks, Valve Gallery, Draft tubes, Gate Gallery and Bus Shaft totalling ....250,000 c.y.

2. Head Tunnel, Tail Tunnel, Access Tunnel and Intake Shaft totalling.......410,000 c.y.

3. Construction Tunnels

No. 1. - 14,000 c.y.
No. 2. - 16,000 c.y.   30,000 c.y.

Total A - Excavation from Underground 690,000 c.y.

B. Aboveground Excavation

1. Intake, Access Tunnel Entrance totalling...............113,000 c.y.

2. Tail Tunnel Outlet and Dam Excavation............. 47,000 c.y.

Total B - Excavation from aboveground 160,000 c.y.

Total for aboveground and below ground excavation (Total A and B) ....850,000 c.y.

In summary, excavation will require approximately 850,000 c.y. measured in place.

It has been found that when rock is broken and excavated the volume increases by about 50 percent to 60 percent and generally, in order to obtain the full "neat line" excavation, extra rock is removed. This is called "overbreak". Applying these factors, and including other small quantities of excavation, we can expect a total volume of material to be handled in a loose form to be approximately 1,360,000 c.y. Calculations reveal that there will be an accumulation of about 750,000 c.y. (loose measurement) more excavation after 20 months than has been used in the construction.

Q. In what manner will excavated material be used for fill at the Project?

A. Early in the construction, a great deal of material will be needed for fill material along the left bank of the river to provide the construction site area shown on Exhibit ______ (SEH-1). Additionally, a large quantity of material will be needed to build the Stage I cofferdam and for the relocation of the railroad. The quantities listed are presented in two forms; i.e., first as an estimate of the quantity required based upon the expected density of the material when used as fill for the construction plant area, the cofferdam and for railroad relocation; and secondly, as an estimate of the solid rock excavation at a higher density (140 pounds per cubic foot) to produce the fill material.

Present estimates of the required quantities of material for the above are as shown in Table 2.

Table 2

QUANTITIES OF MATERIAL REQUIRED

	Fill Quantity cubic yards		In-Place Quantity cubic yards
Constuction Plant area	146,000	@115 pcf1/	120,000
Cofferdam (Stage I)	63,500	@130 pcf	59,000
Railroad Relocation:	223,000	@120 pcf	191,000
TOTAL:	428,500 c.y.		370,000c.y.

1/ Pound per cubic foot.

Q. How much of the excavation do you expect to utilize for concrete?

A. Estimates of the total amount of concrete required for the entire construction is 180,000 c.y. Each cubic yard of concrete will require about 22 cubic feet of aggregate as measured in place. A good estimate of the bulk use of stock pile is approximately 1.25 cubic yards of bulk aggregate for each cubic yard of concrete. The total of excavation (loose measurement) required for concrete is estimated to be 225,000 cubic yards obtained from 150,000 cubic yards of solid rock.

Q. It appears from your previous testimony that a great deal more excavation of rock is produced than is required for use in the construction. How do you visualize the stockpile of materials required or available at any time during the construction?

A. Our studies show that the materials produced in excavation exceed the amount required for construction.

It appears that there will be about 750,000 c.y. of excess excavation (loose measurement) to be stockpiled or partially disposed of late in the second year of construction. About 100,000 c.y. of this material will be needed later for concrete aggregate. On completion of the second stage of the spillway, it will be necessary to remove the cofferdam, which will add to the stockpile, and the final bulk quantity of excess excavation appears to be near 700,000 c.y.

Q. Have you given any thought to a possible use of the excess material?

A. Yes, thought has been given to methods for utilizing excess excavation. The rock crusher could be operated to process the material for railroad ballast, public and private road surfacing, and possibly for use as concrete aggregate on other jobs that might be underway at the time. Convenient access to the railroad should extend the radius of interest for this material. The Burlington Northern Railroad has evidenced interest in acquiring some surplus material for railroad ballast and discussions are underway on that subject.

Finally, any remaining unused or unneeded rock could be used in the Reservoir as part of the fish mitigation plan. Estimates indicate that 450,000 c.y. (loose measurement) of clean broken rock excavation could be used for shallow substrate. The rock plant would be adjusted to provide the desired grading.

Q. How do you plan to receive cement and fly ash for the Project?.

A. Cement and flyash can come by truck or by rail. It is probable that both will be used. Early in the construction during railroad track relocation, there will be no parking siding at the Project so cement will be delivered by truck. The amount required in the first year is small and will not exceed 5,000 c.y. Toward the beginning of the second year, however, concrete work will increase rapidly and the amount of cement needed will also increase. During some months the schedule requires 12,000-14,000 c.y. of concrete, using 3800 tons of cement and flyash. This would require about 190 semi-trailer loads of cement and fly-ash per month. At that time it would be best to receive cement by rail. Rail cars could be used as surge storage bins to reduce the size and number of cement silos, and to reduce the space required for silos near the concrete plant.

Q. Will reinforcing steel be delivered by truck or by rail?

A. Both methods will be used. Requirements for reinforcing steel are large during the second and third years, and much of the reinforcing steel will be delivered by rail at that time. During periods of limited demand, reinforcing steel will be delivered by truck. The space for storage of reinforcing steel on site is so limited that the contractor will not be able to purchase and store a large inventory on site. Much of the fabrication for reinforcing will be done in the concrete placement locations.

Q. Where do you plan to store materials for concrete forms?

A. Special forms and blockout forms may be fabricated in a carpenter shop at the Project, or at an alternate shop in either Libby or Troy. These forms will be stacked near the carpenter shop or offsite until needed. Reusable steel forms will be required for the Dam and the Powerhouse and will be stored and cleaned near their point of use.

A major portion of the forms are those required for tunnels. Components will be trucked into the tunnel and assembled there.

It will be necessary to obtain a storage yard off-site to collect and store forming and other materials ahead of need.

Q. There will be large manufactured parts in the Project. How will these be delivered and where will they be assembled?

A. Much of the heavy equipment, such as parts of the turbine, the spiral case, draft tube liners, generator stators and rotors, cranes, transformers and similar large equipment would best be delivered by rail. The demand for this equipment, late in the construction schedule, best fits the availability of the railroad siding. The embedment of the draft tubes should begin during the middle of the second year and the railroad relocation is expected to be complete by the end of the first year.

Considerable space will be required for assembly of some of these units. A fabrication welding shop and storage space could be established within the 50-foot diameter horseshoe-shaped Head Tunnel. This would be convenient, from the standpoint of placing the penstock liners. Penstock valves could also be stored in the Power Tunnel.

Care would have to be given to adequate ventilation but the advantage of having a reasonably controlled temperature and protection from precipitation would be very helpful for winter time fabrication and assembly.

Q. Please identify the major milestones in the construction schedule.

A. The schedule is set forth in Exhibit ______ (SEH-2). It anticipates completion of the work and power generation by all units within 4-1/2 years after "notice to proceed". The first year is primarily mobilization, excavation and railroad relocation. The second year includes excavation, concrete construction and installation of equipment. The final 18 months includes the completion of all civil work, completion of mechanical and electrical work to obtain power from the No. 1 unit towards the middle of the fourth year. The activation and testing of the remaining units are scheduled over the remaining year.

Q. What magnitude of labor and supervisory forces do you anticipate for the Project?

A. Present estimates indicate that the number of supervisory people needed will range from 10 or 12 during the early months to a maximum of 70-80 during the second year and third year of construction.

The number of skilled workers and laborers also vary. Initially, the work force will require approximately 100 workers and will increase to approximately 500 by the middle or end of the second year. This number will remain fairly static, on average, throughout the Project until the civil work nears completion. During the last 12 months, the work force is expected to be reduced to less than 100. A skeleton crew of about 20-30 workers will remain during the final month to complete testing, clean-up and turnover of the works to the Applicant.

Q. If the Project ever had to be abandoned what would be required?

A. Abandonment of this Project is expected to be relatively simple. The major portions of the Project are underground and of adequate strength to remain in place. Submerged concrete continues to gain strength. Abandonment would leave a cavern deep underground filled with water to the elevation of the tailwater.

Q. What in particular do you foresee for abandonment procedures at the Dam site?

A. It would not be desirable to remove the concrete portion of the Dam and release a large volume of sediment downstream, temporarily filling downstream pools. The low concrete Dam itself and abutments would be left in place. All metallic objects, such as gates, handrails, hydraulic lines, and other such non-concrete materials would be completely removed. Over the years the river bed would fill with sediment and the low Dam would become for all practical purposes a waterfall. With the passage of centuries, the abrasive overflow would erode the top of the Dam, gradually reducing the height of the Falls and eventually the river flow will assume characteristics similar to those prior to construction.

In the event the Project has been operating for a very long time, sediment may have built-up against the steel gates. If the Project is abandoned in that condition, a concrete section would be added downstream from the Dam to the elevation of the crest of the gates. Old concrete and new concrete would be joined by a drilled-in anchor system. The Dam in that condition would become a permanent feature.

Q. Would there be extensive termination work on the Powerstation?

A. All salvageable materials or materials that might produce toxic products during decay would be removed; however, embedded steel items such as penstock liners, draft tubes, and gate guides would be left in place. The Bus Shaft would be sealed by a concrete plug attached to the surrounding rock.

The Powerstation would then be allowed to fill with water from the tailrace.

Q. Would you expect to fill the tunnels with solid material?

A. No. The Head Tunnel and Tail Tunnel would be allowed to fill with river water from the Tailrace. The Tail Tunnel would be plugged for a distance of approximately 100 feet upstream from the river by use of gravel fill and pressure grout. The Intake could be demolished, the remnants dropped into the Intake Shaft and a concrete slab placed on top.

The entrance to the Access Tunnel would be filled with boulders and gravel for a distance of approximately 100 feet to discourage entry, but to permit air movement through the tunnel.

Q. Have you prepared a construction cost estimate for the Kootenai River Hydroelectric Project?

A. Yes. It is shown on my Table 3.

Table 3

COST ESTIMATE SUMMARY NOV. 1981

FERC Account Number	Item	
330	Land and Land Rights	$5,390,000
331	Power Plant Structures and Improvements	34,089,000
332	Reservoir, Dams, and Waterways	81,932,000
333	Water Wheels, Turbines, and Generators	42,503,000
334	Accessory Electric Equipment	6,273,000
335	Miscellaneous Power Plant Equipment	2,583,000
336	Roads, Railroads, and Bridges	523,000
353	Substation and Switching Station Equipment	5,149,000
	Subtotal Direct Cost	178,442,000
	Contingencies 15% (Items 330,331,332, 336)	18,290,000
	Contingencies 8% (Items 333,334,335, 353)	4,521,000
	Total Direct Cost	$201,253,000
	Administration and Engineering (12% of Direct Cost)	24,150,000
	PRESENT DAY CONSTRUCTION COST (rounded to nearest million dollars)	$225,000,000

Q. Describe the procedures used in arriving at this cost.

A. Costs were estimated in a manner similar to that which a Contractor would use to prepare a bid for construction, but with a lesser level of detail appropriate to the present stage of design. That is, a plan and schedule for the work was selected, as presented in previous testimony, and based upon the plan, certain types and pieces of equipment will be required to accomplish the work. Calculations reveal the number of trucks, drills and other equipment needed to meet the schedule. Costs for using and operating the equipment can be obtained from the Construction Equipment Reference Guide, prepared by the National Research and Appraisal Co. Estimates of current wage requirements can be obtained from the Labor Rates for the Construction Industry, prepared annually by the R. S. Means Company. This publication provides rates for recognized trades in each state.

Costs computed in this way were then adjusted to reflect overhead and profit required by contractors, and include such items as fringe benefits, overhead personnel, and camp operation. These prices are then reduced to unit prices, where applicable, and compared to recent prices of competitively bid projects of a similar nature. Any significant differences were reevaluated.

Q. What does the estimate include?

A. The estimate includes the following items:

(1) Direct cost to perform all the work and furnish and install all equipment to make the Project operational. This also includes an estimate for acquiring the necessary land and land rights and Contractor's overhead and profit.

(2) A contingency is added to all civil construction (15 percent) to reflect unexpected difficulties and changed conditions that might be encountered during excavation and construction.

(3) A contingency (8 percent) is added to the cost estimate for furnishing and installing all mechanical and electrical items. This contingency reflects experience in constructing other hydroelectric projects.

(4) An estimate of the cost for administering the contract(s) and for engineering work to design and inspect the construction. This figure is estimated at 12 percent of the direct cost including contingencies.

Q. What is the estimated cost?

A. The estimated construction cost is $225,000,000.

Q. What is the date of this estimate?

A. The original costs were computed at November, 1978 prices. These costs were escalated to reflect intervening inflation in accordance with the U.S.B.R. Index - Powerplant Buildings and Equipment and the figures I have given you are for November, 1981.

Q. What is not included in the estimate?

A. The estimate just given does not reflect any estimate of future cost changes due to inflation (or perhaps deflation), and does not include interest during construction which is addressed by Witness H. Chen.

Q. Does this conclude your prepared direct testimony?

A. Yes.

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

MATTER OF)
NORTHERN LIGHTS, INC.)

PROJECT NO. 2752

AFFIDAVIT

STATE C Illinois)
) ss.:
COUNTY OF Cook)

Svante E. Hjertberg, being duly sworn, deposes and says that he has read the foregoing prepared direct testimony of Svante E. Hjertberg, that he would respond in the same manner to the questions if so asked upon taking the stand, and that the matters of fact set forth therein are true and correct to the best of his knowledge, information and belief.

Svante E. Hjertberg

Svante E. Hjertberg

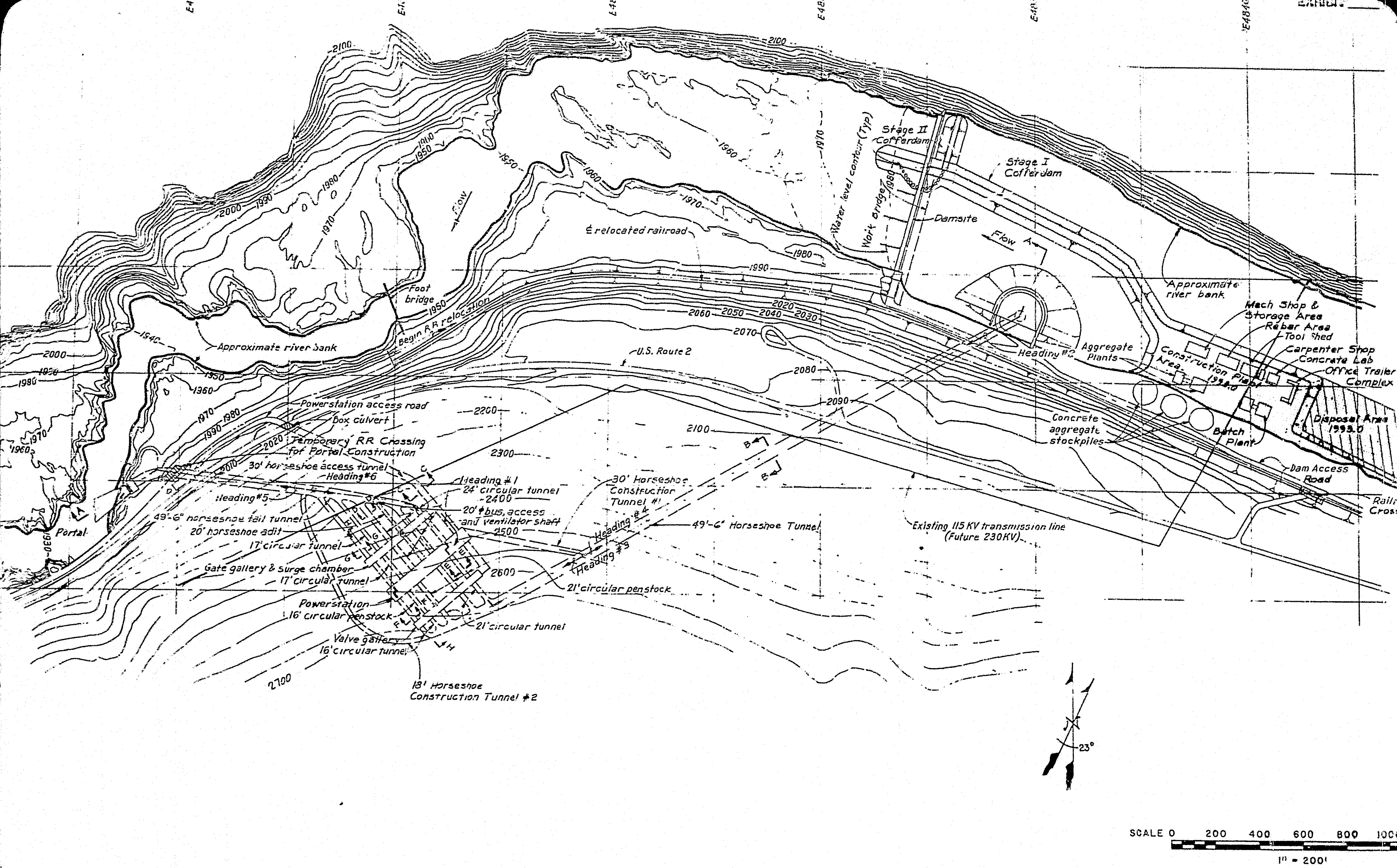
Subscribed and sworn to before me,
this 18th day of January, 1982

Marian J. Higgins

Notary Public

My commission expires 7-27-85

List of Exhibits



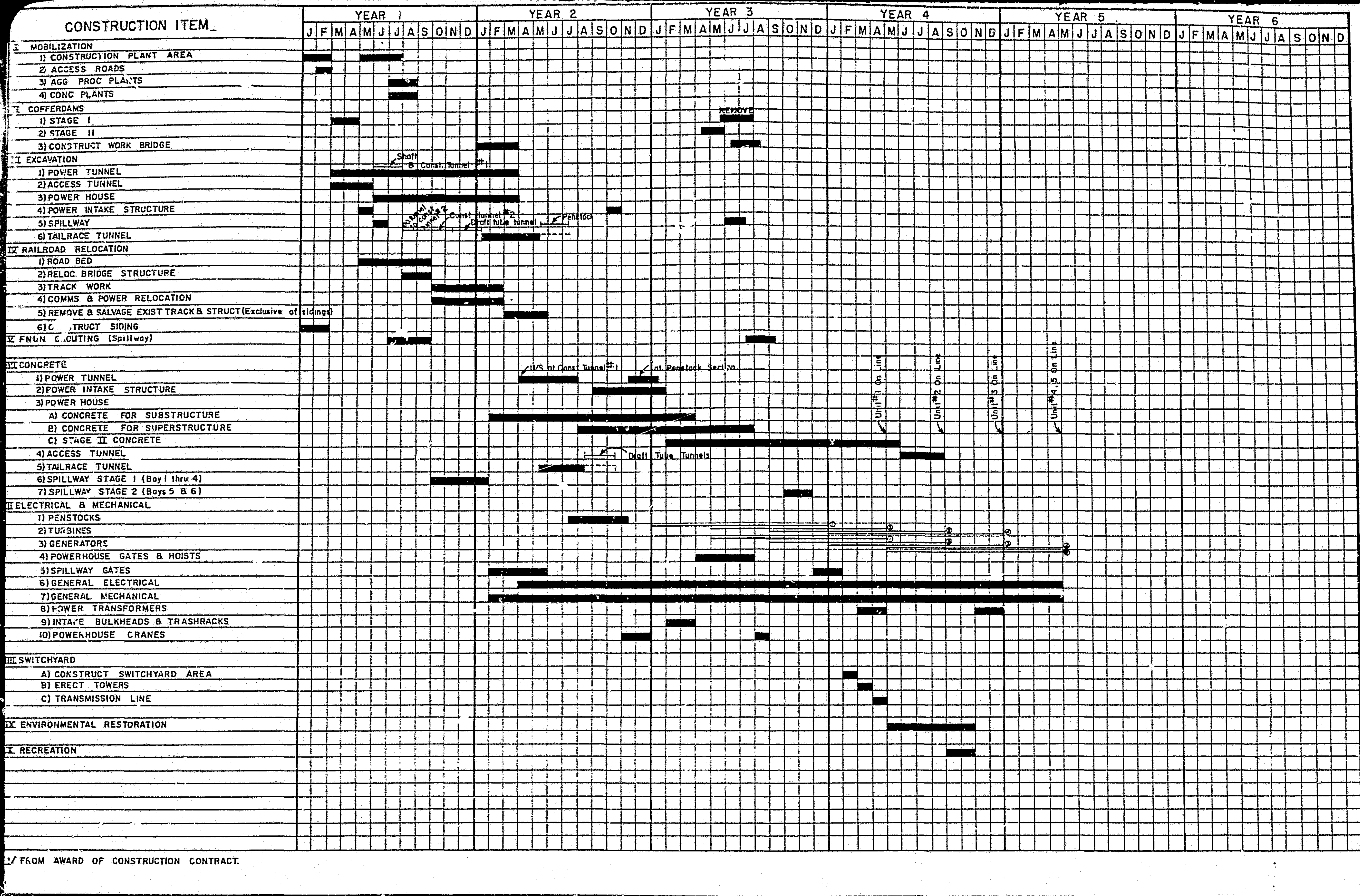
PROJECT 2752

KOOTENAI RIVER
HYDROELECTRIC PROJE

CONSTRUCTION LAY

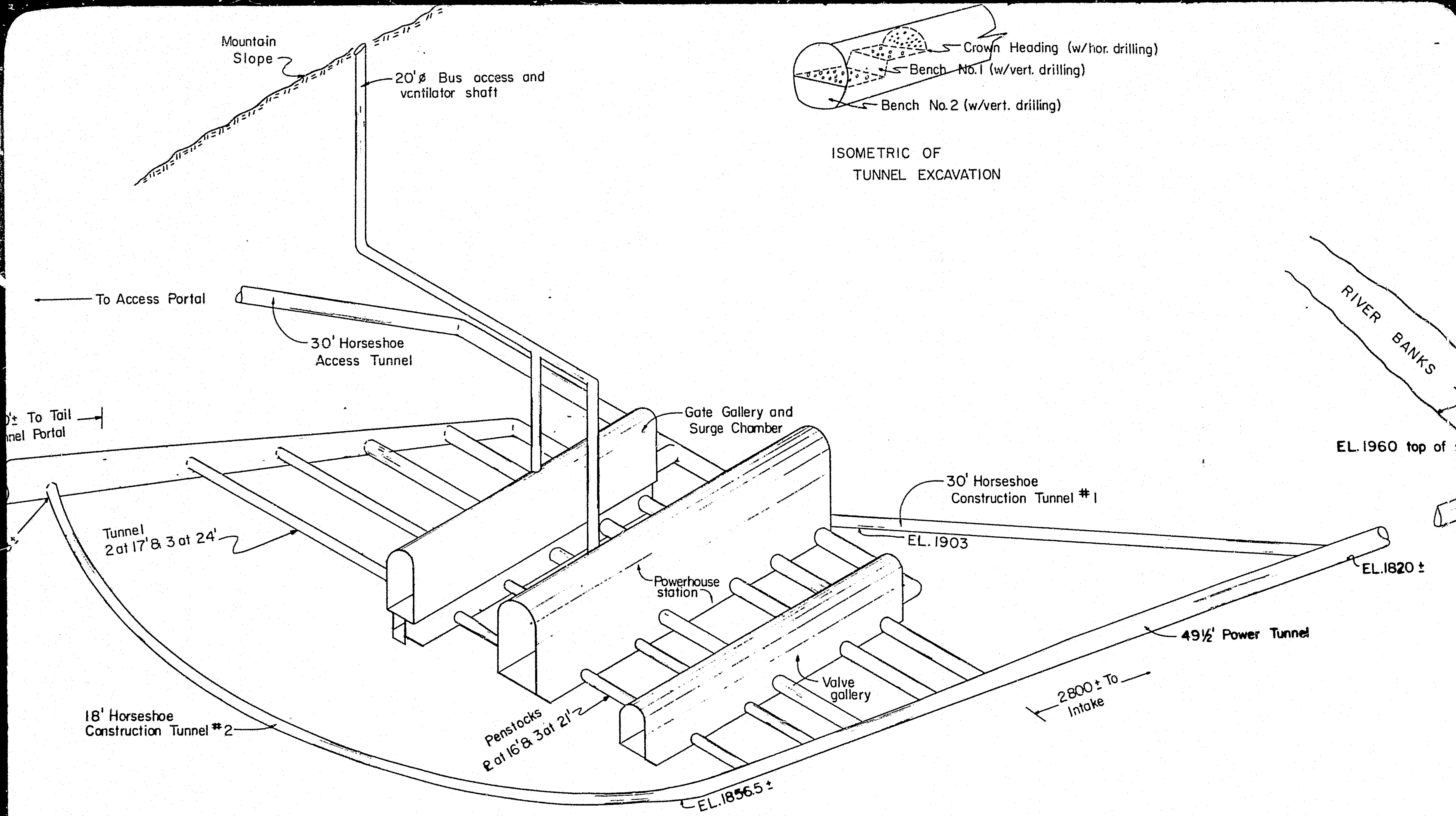
NORTHERN LIGH

PROJECT NO. 27...



KOOTENAI RIVER PROJECT

KOOTENAI HYDROELECTRIC PROJECT	
NORTHERN LIGHTS INC.	UNDER GROUND POW...
PRELIMINARY CONSTRUCTION SCHEDULE	

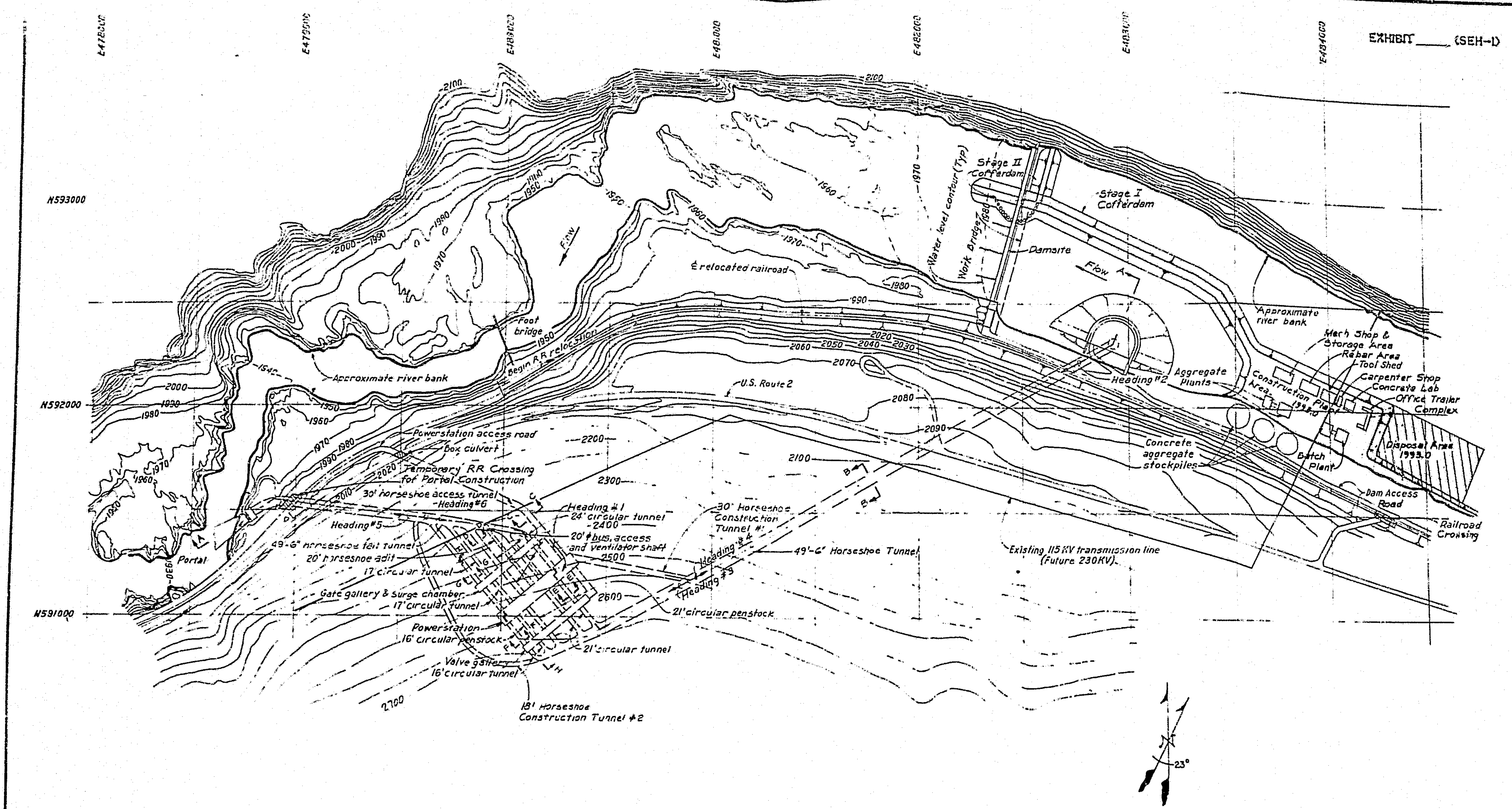


SCALE 0 1000 2000 FT.
1" = 600'
KOOTENAI RIVER PROJECT

KOOTENAI RIVER PROJECT

ISOMETRIC OF POWERSTATION EXCAVATION

EXHIBIT ____ (SEH-1)



SCALE 0 200 400 600 800 1000 1200 FEET

1" = 200'

PROJECT 2752 MONTANA

KOOTENAI RIVER
HYDROELECTRIC PROJECT

CONSTRUCTION LAYOUT

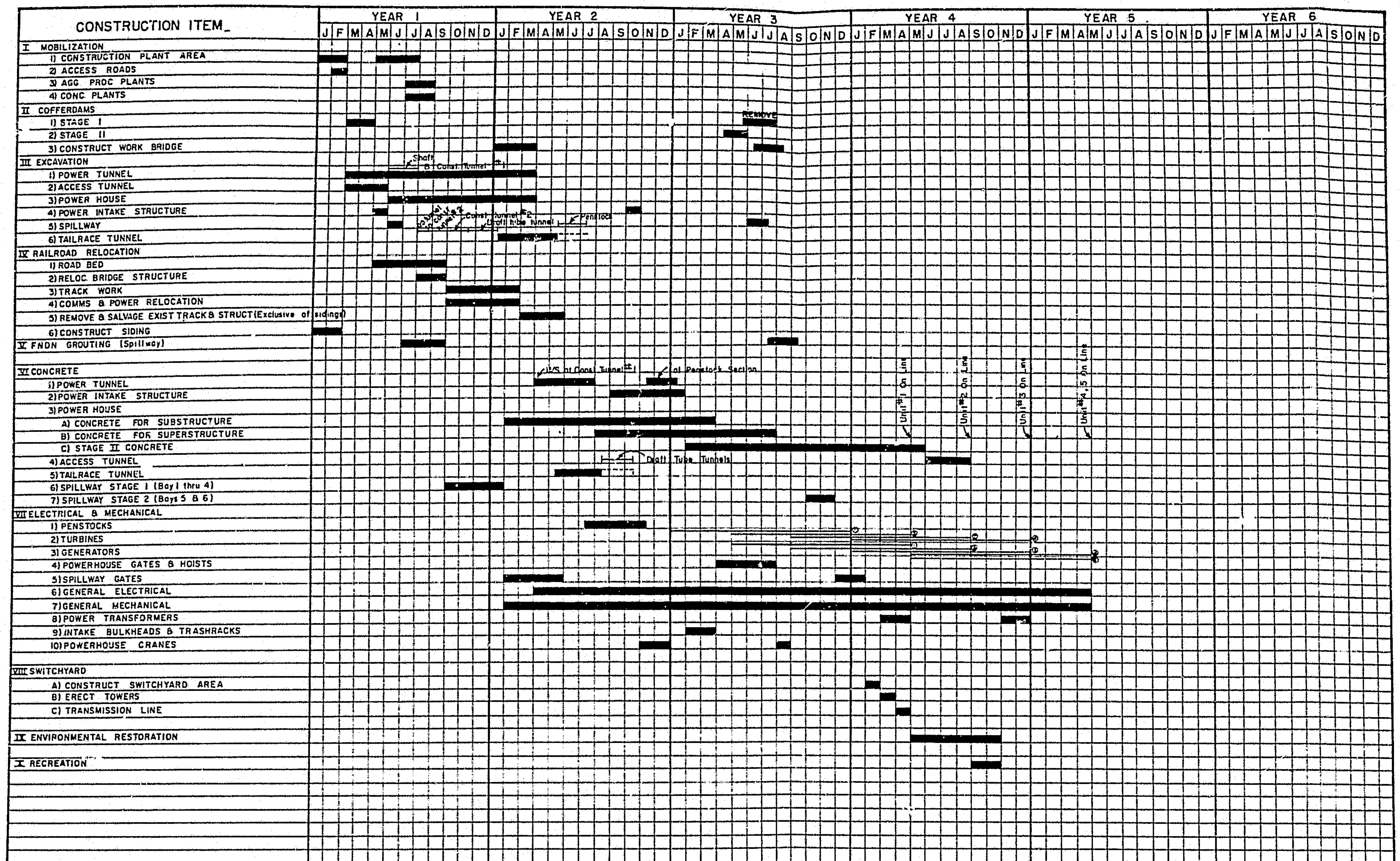
NORTHERN LIGHTS INC.

HARZA ENGINEERING COMPANY

REV NO	DATE	NATURE OF REVISION	BY	CHKD.	APPD.
1	10-22-81	Rev Powerstation and Tunnels	WKT	AM	SEH.

003246

EXHIBIT ___ (SEH-2)
PROJECT NO. 2752



1/ FROM AWARD OF CONSTRUCTION CONTRACT.

KOOTENAI RIVER PROJECT

DSGN.		REVIEWED	
CHKD		CIVIL	
DWN		MECH	
CHKD		ELECT	
SUBM			

REV NO	DWG TRANSMITTAL LETTER NO	DATE	NATURE OF REVISION	BY	CHKD	APPD

KOOTENAI HYDROELECTRIC PROJECT

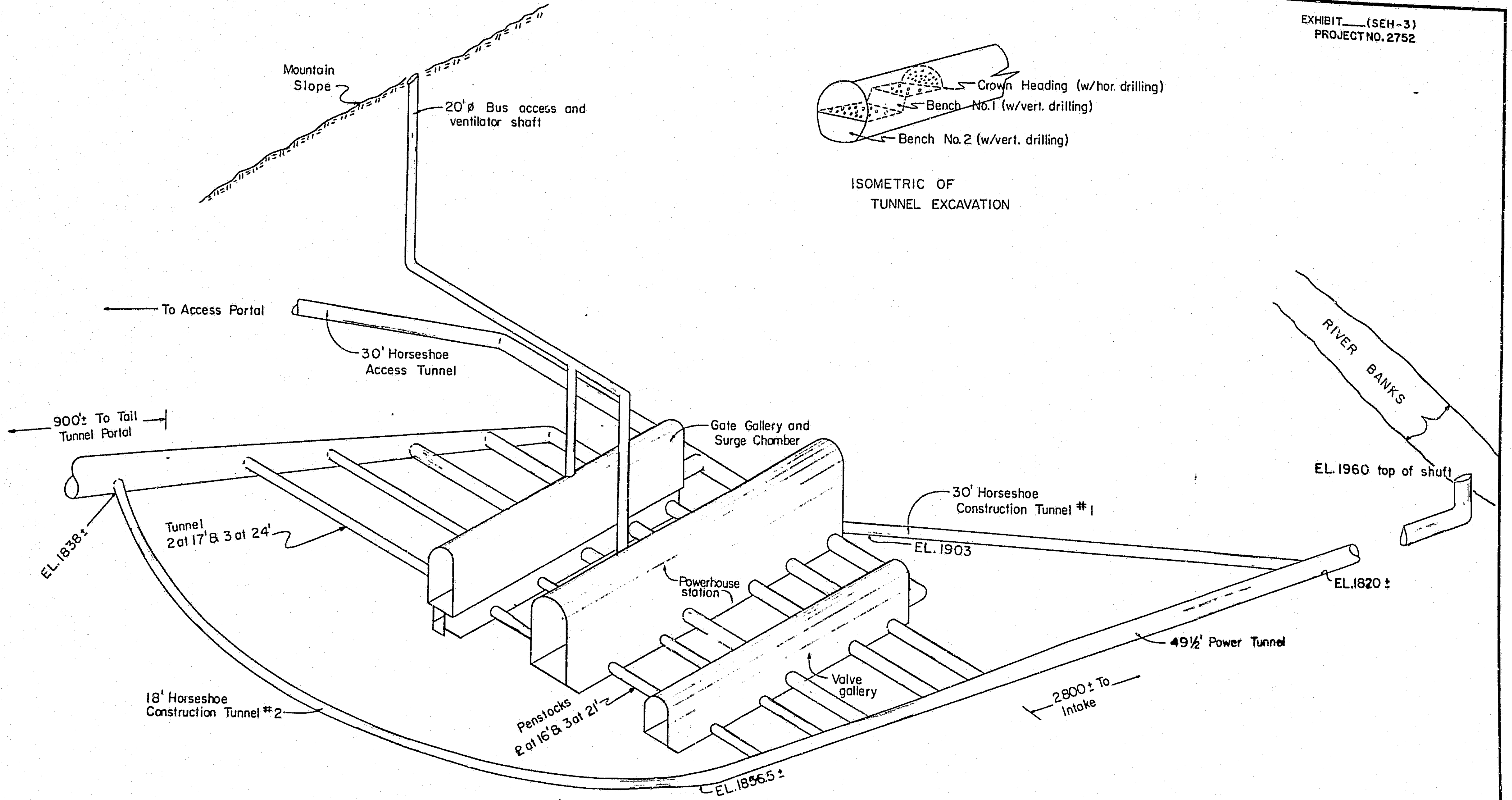
NORTHERN LIGHTS INC. | UNDER GROUND POWERHOUSE

PRELIMINARY CONSTRUCTION SCHEDULE

CONSULTING ENGINEERS
HARZA ENGINEERING COMPANY
APPROVED ________________

CHICAGO, ILLINOIS | DATE DEC 1981 | DWG. NO.

EXHIBIT___(SEH-3)
PROJECT NO. 2752



ISOMETRIC OF
TUNNEL EXCAVATION

KOOTENAI RIVER PROJECT

ISOMETRIC OF POWERSTATION EXCAVATION

SCALE 0 1000 2000 FT.
1" = 600'
KOOTENAI RIVER PROJECT

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

NORTHERN LIGHTS, INC.) PROJECT NO. 2752

DIRECT TESTIMONY OF HENRY H. CHEN
ON BEHALF OF NORTHERN LIGHTS

Q Please state your name and business address.

A. My name is Henry H. Chen. My business address is 150 S. Wacker Drive, Chicago, Illinois 60606.

Q. By whom are you employed and in what capacity?

A. I am a Senior Associate and head of the Water and Energy Planning and Design Department of Harza Engineering Company.

Q. What is your education and professional background?

A. I graduated from Hong Kong University in 1956 with a Bachelor of Science in Engineering. I have 25 years of experience in hydroelectric engineering and related fields. I have been with Harza Engineering Company for 22 years. During this time I have been involved in studies for electric power system expansions and planning of hydroelectric powerplants. I am registered as a professional engineer in the State of Illinois.

Q. What is your connection with the Kootenai River Hydroelectric Project?

A. I directed and participated in studies of alternative energy resources, including studies of the Kootenai River Project economics and alternative hydroelectric sites.

Q. What is the purpose of your testimony?

A. I will describe the studies comparing the Kootenai Project with alternative hydroelectric projects. Next, I will describe the studies of alternative reservoir elevations and minimum spillway releases at the Project. Finally I will describe the studies comparing the Kootenai River Project with non-hydro alternatives.

Q. Please summarize first the results and conclusions of your studies comparing the proposed Kootenai River Project with alternative hydroelectric projects.

A. The cost of energy production from the proposed Kootenai River Project is lowest when compared with alternative hydro- electric projects that might be built by the Applicant. I conclude, therefore, that the proposed Kootenai River Project is the most economic hydro installation for the Applicant.

Q. Which alternative hydroelectric projects have you studied in arriving at this conclusion?

A. I studied the Katka Project and the Rocky Creek Project. Both of these projects are located on the Kootenai River and are described by Witness Allen. I also studied a smaller Kootenai River Project with a lower reservoir elevation than the proposed Project. These projects were selected after consideration of a longer list of hydroelectric projects, as explained in Witness Allen's testimony.

Q. Please describe your studies of the alternative hydroelectric projects.

A. Exhibit ___ (HHC-1) shows the comparative cost estimates of alternative hydroelectric projects. Exhibit ___ (HHC-1) consists of two sheets, the first of which summarizes the three alternatives and the proposed Project.

Q. Please describe these alternatives.

A. Alternative I consists of the 138-MW Katka Project with reservoir elevation at 1862. Alternative II consists of a combination of two projects, the 50-MW Katka Project with reservoir elevation at 1817, and the 80-MW Rocky Creek Project with reservoir elevation at 1868.

Alternative III consists of another combination of two projects, the 59-MW Rocky Creek Project with reservoir elevation 1857, and the 125-MW Kootenai River Project with headwater Elevation 1990. The proposed Kootenai River Project is shown in the last column of the exhibit. This is the 144 MW Project with reservoir Elevation 2000.

Q. Before moving on to the rest of the exhibit, please explain how you have formulated these alternatives.

A. As explained in Witness Allen's testimony, these alternatives were formulated so that each would have about the same generating capability and energy production as the proposed Kootenai River project. It was necessary to combine two projects in forming a single alternative in the cases where the generating capability of a hydro project was too small.

Q. How did you establish the generating capability at each site?

A. The generating capability at Kootenai River is the maximum output from the plant installation with a discharge of approximately 24,000 cubic feet per second. At each alternative site we added the mean runoff between it and the Kootenai River site to establish the appropriate turbine discharge capacity, as explained in Witness Allen's testimony.

Q. Please proceed with your explanation of the Exhibit ___ (HHC-1).

A. I next show the average annual energy production from each alternative on Lines 8, 9 and 10 of Sheet 1 of the exhibit. Energy production is based on streamflow, operating head, and plant turbine capacity.

Q. Your Exhibit ___ (HHC-1) next shows estimated capital costs of the alternatives. Please describe how these estimates were derived.

A. Given the headwater elevations and the required plant capabilities for each site, we prepared layouts and established design concepts. We then prepared quantity estimates and developed ratings and types of machinery. The final step was the preparation of the cost estimates. The method of developing the cost estimates is similar to the preparation for the Kootenai River Project and the cost estimates have been prepared to include all the items contained in the proposed Kootenai River Project.

Q. What are the items that have been included in the cost estimates?

A. Sheet 2 of Exhibit __ (HHC-1) shows the cost estimates as of November 1981 by major items, in accordance with the FERC account numbers. Thus FERC Accounts 330, 331, 332, 333, 334, 335, 336, 353, 354 and 356 are included. To the direct estimated costs of the above items we have added an allowance for contingencies. Furthermore, we have applied an allowance for engineering and owner's administrative costs. The total construction costs derived from Sheet 2 of Exhibit __ (HHC-1) are entered as line 12 on Sheet 1 of Exhibit __ (HHC-1).

Q. Please return to and continue with your explanation of Sheet 1 of Exhibit __ (HHC-1).

A. We next determine the total capital cost of the alternatives by adding the cost of interest during construction to the estimated construction cost.

Q. How is interest during construction estimated?

A. Interest during construction is estimated using an annual interest rate of 10 percent, and a construction period of 4 1/2 years. A uniform expenditure rate and simple interest payments are assumed over the construction period.

Q. Please continue.

A. The remaining portion of the exhibit shows the steps leading to the determination of the comparative cost of energy. To do this, we determine the total cost that is required to own, operate and maintain the project.

Q. Please continue.

A. This cost is also called total annual cost. It includes the interest on the investment, amortization, taxes, and insurance and other annual costs. The annual cost has been computed as a levelized amount over the life of the hydro project, estimated to be 50 years. We have used an annual interest rate of 10 percent. Amortization is estimated at 0.086 percent of investment. Insurance is estimated from data given in the FERC publication Hydro-electric Power Evaluation, 1979 edition. An adjustment has been made to the estimates from that publication to account for escalation from 1979 to 1981. Taxes are estimated from information gathered from the Lincoln County Assessor's Office.

Q. What are the other costs and how are they derived?

A. The only other costs are the operating and maintenance costs. These costs are also based on information given in the FERC publication cited above, and adjusted to the November 1981 price level. Included in the annual costs is an allowance for payment to the United States Government for upstream reservoir regulation.

Q. How do you then derive the comparative costs of energy?

A. The comparative costs of energy is expressed in mills per kilowatt-hour. It is derived by dividing the total annual cost by the total annual energy production.

Q. What are the resulting costs of energy, and what do the results mean?

A. The cost of the proposed Kootenai River Project is 60 mills per kilowatt-hour, while the other alternatives have energy costs ranging from 74 mills to 117 mills per kilowatt-hour. This shows that the proposed Kootenai River Project is the least-cost alternative, or economically most attractive.

Q. Please describe the studies leading to the selection of the Reservoir Elevation 2000 for the proposed Kootenai River Project.

A. The selection was made after an evaluation of the energy costs with headwater elevation in the range from 1990 to 2005.

Q. I show you Exhibit ___ (HHC-2). Please describe this exhibit.

A. Exhibit ___ (HHC-2) is a tabulation of plant characteristics and cost estimates for the Kootenai Project with

Reservoir elevation from 1990 to 2000 in two-foot increments, and for the project with Reservoir Elevation 2005. The comparative costs of energy are shown on line 29.

Q. How are plant capabilities and annual energy productions determined?

A. Plant capabilities are determined to correspond to a maximum turbine discharge of about 24,000 cfs. Energy productions are next determined on the basis of water supply and operating head.

Q. You have shown the railroad relocation requirements in line 7 of this exhibit. Is that significant?

A. Yes. The cost of most items varies uniformly and by small increments with change in Reservoir elevation and in the rating of the plant. Railroad relocation requirements tend to change by relatively small increments between Elevation 1990 and 2000. Above Elevation 2000, railroad relocation increases dramatically. The estimated costs of railroad relocations are included in FERC account number 330 and are shown on line 10 of Exhibit _ (HHC-2).

Q. What is the basis for your cost estimates?

A. The cost estimates for the alternative reservoir elevations have been based on layouts and design concepts that are similar to those for the proposed Kootenai River Project. Minor quantity and cost adjustments were made to account for the changes in reservoir elevation and for changes in equipment rating. The major difference in the cost estimates of the alternatives has been due to the variation in railroad relocation requirements.

Q. Please discuss the resulting comparative unit costs of energy.

A. First, the comparative costs of energy have been computed in the same manner as has been done for the comparison of alternative hydroelectric projects. The results are given at the end of Exhibit __ (HHC-3). There is a steady decrease in the energy cost from 65 mills per kilowatt-hour at Reservoir Elevation 1990 to 60 mills per kilowatt-hour at Reservoir Elevation 2000.

Above that elevation, energy costs increase slightly, with estimated energy cost 61 mills per kilowatt-hour at Reservoir Elevation 2005.

We conclude, therefore, that a 144-MW Kootenai River Project with Reservoir Elevation 2000 is at the economic optimum point for the site.

Q. How did you establish the minimum discharge over the Spillway?

A. The minimum discharge over the Spillway was established after considering a range of minimum discharges of zero, 500 cfs, 750 cfs and 1000 cfs. The minimum discharge of 750 cfs was then selected.

Q. Please describe the factors that you considered in the selection.

A. Any discharge over the Spillway bypasses the Powerstation and results in a loss of electrical energy that could otherwise be produced by the Project. There is, therefore, a direct reduction in the benefit that the Project could derive.

Q. What are the reductions in energy production due to the minimum discharge provision?

A. The reduction in energy production amounts to 28, 41, and 55 million kilowatt-hours per year, with minimum discharges of 500, 750 and 1000 cfs over the Spillway. These are equivalent to 56,000, 82,000, and 110,000 barrels of oil per year being bypassed over the Spillway. The reductions amount to 5.4 percent, 8.0 percent, and 10.7 percent of the possible energy production of the Project.

Q. How did you arrive at the 750 cfs?

A. The minimum recorded discharge at the Libby gage is slightly lower than 1,000 cfs. A discharge of 1,000 cfs over the Spillway would significantly reduce the economic attractiveness of the Project. At the other extreme, it was obvious that zero discharge over the Spillway, which would maximize the economic benefits, would provide environmentally unacceptable conditions between the Dam and the Tail Tunnel Outlet.

Moving from zero discharge towards 1,000 cfs, we concluded that 750 cfs would provide environmentally acceptable conditions and be consistent with project economics.

Q. Have you considered other electric generating plants in your evaluation of the economics of the Kootenai River Project?

A. Yes. We considered solar power, wind power, biomass, and geothermal powerplants, all for electric utility operation. We also considered coal-fired steam plants, combustion turbine powerplants, and nuclear powerplants.

Q. Please describe the use of solar energy in generating electricity.

A. Solar radiation can be converted to electricity by collecting and concentrating the sun's heat to produce steam, which is then used to drive a turbo-generator to produce electricity. The latest technology in solar energy conversion is represented by the Solar One plant being constructed near Barstow, California in the Mojave Desert. The project is funded by the Department of Energy, Southern California Edison Company, and the Los Angeles Department of Water and Power. This is an experimental project, with only 10,000 kilowatts of capacity. The project employs banks of ground-level mirrors that track the sun individually and focus the rays onto an absorber atop a tall tower.

Q. Is solar energy a practical alternative to the Kootenai River Project?

A. Not at the present time, for several reasons. First, large scale solar energy utilization for electric power generation in a utility system has not been demonstrated to be feasible, when such factors as operational reliability and serviceability and useful life are considered. Second a great deal of uncertainty exists as to the capital cost of such a project. Third, a solar powerplant by itself produces electricity only when the sun is shining, and backup generating capacity is required. For these reasons the use of solar energy to produce a comparable amount of generating capability and electrical energy is not practical.

Q. Please describe the use of wind power in generating electricity.

A. Research and development in wind power plants is proceeding with the first 2.5-MW unit at Goodnue Hills on the Columbia River near Goldendale, Washington. The wind turbine is a MOD-2 model built by Boeing Engineering and Construction and operated by Bonneville Power Administration for the Department of Energy. It is the fourth in a series of wind turbines that began with the MOD-0 unit built by NASA in 1975. Expected energy production is 9 million kilowatt-hours per year. Eventually three such turbines are to be built and tested.

Q. Is wind power a practical alternative to the Project?

A. No. Large wind-powered generators, such as the MOD-2 design, have yet to be proven in test operations. These machines would have to then be made in commercial quantity to be more cost effective. The Applicant would require 58 of these 2.5 MW units to provide the same generating capability as the Project. However, the generating capability from the wind power plants is not available unless the wind blows at the required design velocity. This lack of reliability is another reason why the wind powerplant is not a practical alternative. For these reasons, it is inappropriate to prepare comparative cost estimates of wind power plants.

Q. Please describe the use of biomass in generating electricity.

A. The major fuels for biomass powerplants are (1) crop residues, (2) municipal waste, and (3) forest residues or wood refuse. The use of crop residues for electricity generation is usually restricted to regions producing large amounts of sugar cane, rice, and corn. Even in these regions, the use of crop residues is normally considered for powerplants having only a fraction of the capacity of the proposed Project. The use of municipal waste in a powerplant is normally restricted to large metropolitan areas, such as Chicago and St. Louis, which need to dispose of large amounts of waste. Considering these factors, crop residues and municipal waste are obviously impractical as a fuel in a biomass powerplant that could be considered as an alternative to the Project.

Q. Please describe your evaluation of a wood-fired powerplant as an alternative to the Project.

A. Wood for fuel in a powerplant exists in Western Montana. However, competition for land and forest products in the region, including recreational uses of forest lands, is a serious obstacle to the use of wood, forest residues, or wood refuse as fuel to produce electrical energy. The amount of wood to produce electrical energy equaling the output of the proposed Project is very large, equivalent to about 3000 tons a day, or 1,100,000 tons a year.

Q. What is your conclusion regarding biomass as an alternative to the Kootenai River Project?

A. Considering the lack of crops and crop residues and municipal refuse and the limitations associated with using wood as a fuel source, for the reasons discussed above I conclude that biomass is not a practical alternative to the Kootenai River Project.

Q. Please describe the use of geothermal energy in generating electricity.

A. Geothermal energy is a form of usable heat energy that is contained in subterranean regions of the earth. The most useful form of geothermal energy for power generation is natural steam. This steam can be used either directly, or indirectly through a heat exchanger, to drive a low pressure steam turbine and generator. Such natural steam in large quantities occurs at only a relatively few locations on the earth.

Another form of geothermal energy is superheated water, which is obtained by drilling deep wells into hot zones near the earth's surface and forcibly circulating water through these hot zones. This superheated water is then used for driving steam turbines to produce electricity.

Q. Is the use of geothermal energy a practical alternative to the Kootenai River Project?

A. In a report entitled Energy from the West: Energy Resource Development Systems Report, Volume VI: Geothermal, prepared by Oklahoma University for the Environmental Protection Agency in March, 1979, geothermal resource regions in eight western states were identified. The geothermal options were classified as:

(1) Vapor dominated (steam)

(2) High temperature hot water system (over 150°C)

(3) Intermediate temperature hot water systems (90° to 150°C)

(4) Hot igneous (volcanic) system

Of the hot water systems only the high temperature system (over 150°C) is currently being considered for electricity generation.

In the State of Montana, no high temperature hot water systems were identified. In the Yellowstone National Park, in Wyoming, there exists a vapor dominated and a high temperature hot water system. These are potential sources for generating electricity for use within the G&T service area. Commercial development potential of these sources appears impractical for environmental reasons.

Q. What are the pratical alternatives to the Kootenai Project?

A. The nuclear and coal-fired steam plants are practical alternatives from the standpoint of operating experience, availability in the service area, and economics. Should the Kootenai River Project not be built for any reason, these are the only two alternatives that the Applicant should seriously consider constructing to provide the needed power. For this reason we have conducted an economic analysis to compare these types of powerplants with Kootenai.

Q. What are the major parameters used in the economic analysis of alternative projects.

A. Please refer to Exhibit ___ (HHC-3) which shows the economic parameters used in the economic analysis of the Kootenai River Project. The capacity of all projects was taken to be 144 MW, the size of the proposed Kootenai River Project. The annual energy production of 515 million kWh is also based on the output of the Kootenai River Project.

Q. What is the next parameter that you introduced into the economic analysis?

A. Item 3 of Exhibit ___ (HHC-3) shows the availability factor. Data on actual operating experience of each type of plant -- hydroelectric, nuclear and coal-fired steam -- were used to estimate the time a given plant can be expected to be unavailable or out of service for planned and forced outages. The time each plant is available to serve on the system is called the availability factor, and is expressed as a percentage. The factor is highest for hydroelectric, with an average of 96 percent, followed by coal-fired at 85 percent and nuclear at 68 percent. A comparative availability factor, using the hydroelectric plant availability factor as a base, is then derived. This factor is then used to adjust the construction cost for the additional steam and nuclear capacity required to provide the equivalent amount of capacity from the Kootenai River Project. The comparative availability factors are 100, 72 and 89 percent for the hydroelectric, nuclear and coal-fired plants, respectively.

Q. You next show as Item 5 of Exhibit ___ (HHC-3) the construction costs of the alternative projects. How were these costs derived?

A. The construction costs of the nuclear and coal-fired alternatives were based on estimates obtained from published reports. Construction costs of the nuclear and coal-fired alternatives may vary due to unit size, number of units, site conditions, plant design, regulatory requirements, labor costs, etc. To account for such variations, high and low estimates for the nuclear and coal-fired alternatives were developed, as shown on Item 5.

For the nuclear alternative, it was assumed that the basic plant size was about 1000 MW and that the Applicant could purchase a portion of the power and energy output from this project equivalent to that provided by the Kootenai River Project. Nuclear plants of a size comparable to the Kootenai River Project are not commercially available. For the coal-fired powerplant it was assumed that in the absence of the Kootenai River Project, the Applicant could construct a plant of about the same generating capacity. Coal-fired powerplants in the size range equivalent to the Kootenai River Project are commercially available.

Q. Please describe your estimate of fuel reserve shown as Item 6 of Exhibit ___ (HHC-3).

A. For the nuclear alternative the cost for the initial fuel inventory was based on data contained in the FERC report Hydroelectric Power Evaluation, August 1979. The costs adjusted to the November 1981 price level were estimated at 136 dollars per kilowatt. For the coal-fired alternative the cost of a one month's fuel reserve was included.

Q. Please continue with your explanation of Exhibit ___ (HHC-3).

A. Item 7 shows the adjusted construction costs of the alternatives. The adjusted construction costs are derived by summing the construction costs, divided by the comparative availability factor for each alternative, and the costs for fuel reserve.

Q. What are the other costs that are involved in the economic analysis?

A. The other costs which affect the alternatives are incurred annually. They are the fixed operation and maintenance costs, variable operation and maintenance costs, insurance, taxes, generation charge and fuel costs. These are shown as Items 8 through 12 on Exhibit ___ (HHC-3).

The annual fixed and variable operation and maintenance costs and insurance and fuel costs are based on cost estimates contained in the FERC report, August 1979. An availability adjustment was applied to the fixed operation and maintenance costs of the nuclear and coal-fired alternatives. Administration and general expenses were estimated at 35 percent of the fixed operation and maintenance costs. All values were adjusted to the November 1981 price level. The estimated fixed and variable operating costs are shown as Items 8 and 9 of Exhibit ___ (HHC-3).

Q. Please describe your estimates of fuel costs.

A. For both the nuclear and coal-fired alternatives the costs are based on cost estimates contained in the FERC report, adjusted to the November 1981 price level. The nuclear fuel and coal costs are expressed in terms of mills per kilowatt hour, with a coal heat rate of 9600 BTU per kilowatt hour. The fuel costs are shown as Item 10 of Exhibit _____ (HHC-3).

Q. Please describe your estimates of the annual costs for insurance, taxes and generation charges.

A. The annual costs of insurance were based on estimates contained in the FERC report and were estimated to be 0.10, 0.30 and 0.25 percent of the construction costs of the hydroelectric, nuclear and coal-fired projects, respectively. Taxes were estimated at 0.725 percent of construction costs, based on information obtained from Lincoln County Assessor's Office. A generation charge of 0.2 mills per kilowatt hour was applied to all projects. The annual costs of insurance, taxes and the generation charges are shown as Items 11 and 12 of Exhibit _____ (HHC-3).

Q. Does this complete the estimate of the annual unit costs.

A. Yes. The unit costs identified in Exhibit _____ (HHC-3) as Items 8 through 12 are the costs required to operate and maintain each project during the time it is operating. These unit costs are converted to total annual costs of each project and are shown as Items 13 and 14 in Exhibit _____ (HHC-3).

Q. What was the period used in your economic analysis of the Kootenai River Project?

A. The period of analysis was taken to be equal to the maximum time required to construct the project with the longest construction period, eight years for the nuclear project, plus the operating period of the most durable project, 45 years for the Kootenai River Project. The total period of analysis, therefore, was 53 years.

The estimates for each alternative of the construction periods, project economic life, project operating period and the total period of analysis are shown as Items 15 through 18 in Exhibit _____ (HHC-3).

Q. Please describe the major characteristics of the evaluation procedure used in the analysis.

A. The evaluation procedure was based on a life-cycle analysis in which the costs of each project were separated into three components: capital costs, operation and maintenance costs, and fuel costs. For each project, the cost components were estimated for the years in which they were expected to be incurred and projected over the period of analysis. Since the economic life of the nuclear and coal-fired projects is 30 years of operation the construction costs of each project were incurred again at the end of the 30-year operating period. At the end of the 53-year period of analysis, a credit was given for the residual value of the nuclear and coal-fired plants. To account for the possible real cost increases, an annual escalation rate of 7 percent was applied to the construction costs incurred during the initial construction period and to the annual costs incurred during the first 30 years of the operating period. The escalation rate was applied to the costs of all projects.

The total annual costs of each project were converted to present worth values by discounting the annual costs, using as a discount rate the estimated cost of capital. For this analysis the cost of capital is estimated to be 10 percent.

Q. What were the results of your analysis?

A. The results of the analysis show that the Kootenai Project is economically superior to the nuclear and coal-fired projects. For a summary of the results, please refer to Exhibit _____ (HHC-4) . The benefit-cost ratio exceeds unity in all cases. Samples of the life cycle cost streams for three cases are presented in Exhibits _____, _____ and _____ (HHC-5, HHC-6 and HHC-7). In Exhibit _____ (HHC-5) for example, the alternative is identified as the Kootenai River Project. The escalation rate is assumed to be seven percent and the discount rate is 10 percent. The first column shows the project years included on the period of analysis, which in this study extends for 53 years. The second column shows the annual capital or construction costs as they are estimated to be incurred during the construction period. The third and fourth columns are the estimated annual operation, maintenance, insurance, taxes and fuel costs. All annual costs other than construction costs and fuel costs were included in the column identified by the heading 'O&M Costs'. The fifth column is the sum of all costs incurred in a given year. The sixth column is the cumulative discounted total cost. For the Kootenai River Project under the seven percent escalation case, the total cost on a present worth basis is shown to be 271.0 million dollars. Similar cost streams were prepared for the nuclear and coal-fired projects. The project with the lowest total cost on a present worth basis is considered to be the preferred project. The comparison of alternative projects was also made assuming an escalation rate of zero as described previously. The economic comparison of the Kootenai River Project with the nuclear and coal-fired projects was also expressed in terms of a benefit-cost ratio in which the costs of the alternatives were considered the benefits (cost savings) attributed to constructing the Kootenai River Project.

With no escalation, the benefit-cost ratios range from 1.07 when the Kootenai River Project is compared to the coal-fired low cost alternative to 1.68 when the Kootenai River Project is compared to the nuclear high-cost alternative. Where costs are escalated, the benefit-cost ratios range from a low of 1.38 when Kootenai is compared to the nuclear low-cost alternative to 2.01 when Kootenai is compared to the coal-fired high-cost alternative. The relative economic merit of the Kootenai River Project is quite favorable when compared to the projects that were considered possible alternatives for providing the Applicant equivalent amounts of energy.

The value of the Kootenai River Project may also be assessed in terms of the savings in coal and oil consumption that would be required by coal- or oil-fired plants. The oil-fired project was rejected as a viable alternative due to the high cost of oil. This comparison, however, emphasizes that, from a national viewpoint, the Kootenai River Project will contribute to the overall conservation of vital energy resources. Based on energy conversion rates, the Kootenai Project will save the equivalent of 850,000 barrels of oil or 233,000 tons of coal annually.

Q. What do you conclude from the economic analysis?

A. The results of the economic analysis show that the Kootenai Project is economically justified and will provide the lowest cost addition to the generation capacity of the Applicant starting in 1989.

Q. Does this complete your prepared direct testimony?

A. Yes.

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

MATTER OF)
NORTHERN LIGHTS, INC.) PROJECT NO. 2752

AFFIDAVIT

STATE OF Illinois)
) ss.:
COUNTY OF Cook)

Henry H. Chen, being duly sworn, deposes and says that he has read the foregoing prepared direct testimony of Henry H. Chen, that he would respond in the same manner to the questions if so asked upon taking the stand, and that the matters of fact set forth therein are true and correct to the best of his knowledge, information and belief.

Henry H. Chen
Henry H. Chen

Subscribed and sworn to before me,
this 21 day of January, 1982

Marian T. Higgins
Notary Public

My commission expires 7-27-85

List of Exhibits

KOOTENAI RIVER HYDROELECTRIC PROJECT
COMPARISON OF ALTERNATIVE HYDROELECTRIC PROJECTS

	Column (a)	Column (b)	Column (c)	Column (d)	Column (e)
1	Description	Alternative I	Alternative II	Alternative III	
2	Hydroelectric Project Name	Katka 1862	Katka 1817 Plus Rocky Creek 1868	Rocky Creek 1857 Plus Kootenai 1990	Proposed Kootenai 2000
3	Plant Capability in MW				
4	First Project	-	50	59	-
5	Second Project	-	80	125	-
6	Total	138	130	184	144
7	Annual Energy Production in Million kWh				
8	First Project	-	216	244	-
9	Second Project	-	323	457	-
10	Total	540	539	701	515
11	Capital Cost in $ Million				
12	Construction Cost at November 1981 Price Level	375	467	382	225
13	Interest During Construction at 10% per year	84	105.0	86	51
14	Investment Cost at November 1981 Price Level	459	572	468	276
15	Annual Costs in $1000				
16	Cost of Money at 10%	45,900	57,200	46,800	27,600
17	Amortization at 0.086%	395	492	402	237
18	Insurance at 0.10%	459	572	468	276
19	Taxes at 0.725%	3,328	4,147	3,393	2,001
20	Generation Tax @ 0.2 mills/kWh	108	108	141	103
21	Operation and Maintenance at 4.2 $/kW/Yr.	580	546	772	605
22	Administration and General at 1.5 $/kW/yr.	207	195	226	216
23	Total Annual Costs Rounded in $ Million	51	63	52	31
24	Comparative Cost of Energy in Mills/kWh with 10% Interest Rate	94	117	74	60

EXHIBIT ___ (HHC-1)
Sheet 1 of 2
Project No. 2752

KOOTENAI RIVER HYDROELECTRIC PROJECT

COMPARATIVE INVESTMENT COSTS OF ALTERNATIVE HYDROELECTRIC PROJECTS

(In $1000 at November 1981 Price Level)

			ALTERNATIVE I	ALTERNATIVE II			ALTERNATIVE III			
	Column (a)	Column (b)	Column (c)	Column (d)	Column (e)	Column (f)	Column (g)	Column (h)	Column (i)	Column (j)
	FERC Amount Number	Item	Katka 1862	Katka 1817	Rocky Creek 1868	Total	Rocky Creek 1857	Kootenai 1990	Total	Proposed Kootenai Proj 2000
1	330	Land and Land Rights	94,885	63,315	35,770	99,085	35,770	2,030	37,800	5,390
2	331	Power Plant Structures and Improvements	5,600	5,600	38,262	43,862	28,658	34,089	62,747	34,089
3	332	Reservoirs, Dams and Waterways	115,378	95,406	30,916	126,322	29,082	81,844	110,926	81,932
4	333	Water Wheels, Turbines and Generators	45,724	24,500	30,800	55,300	21,700	41,174	62,874	42,503
5	334	Accessory Electrical Equipment	4,347	1,946	3,220	5,166	2,800	5,739	8,539	6,273
6	335	Miscellaneous Power Plant Equipment	5,600	4,984	2,450	7,434	2,100	2,583	4,683	2,583
7	336	Roads, Railroads and Bridges	8,064	8,064	1,008	9,072	1,008	523	1,531	523
8	353	Substation and Switching Station Equipment	4,396	3,360	3,080	6,440	2,660	4,712	7,372	5,149
9	354,356	Transmission line Connection	420	420	420	840	420	1/	420	1/
10		Subtotal Direct Cost	284,414	207,595	145,926	353,521	124,198	172,694	296,892	178,442
		Contingencies:								
11		(Items 330, 331, 332, 336) Kootenai 15% - Alternative 20%	44,785	34,477	21,191	55,668	18,904	17,773	36,677	18,290
12		(Items 333, 334, 335, 353, 354, 356) Kootenai 8% - Alternative 10%	6,049	3,521	3,997	7,518	2,968	4,337	7,305	4,521
13		Total Direct Cost	335,248	245,593	171,114	416,707	146,070	194,804	340,874	201,253
14		Engineering and Administrative (12% of Total Direct Cost)	40,230	29,471	20,534	50,005	17,528	23,376	40,904	24,150
15		Construction Cost at Nov., 1981 Price Level	375,478	275,064	191,648	466,712	163,598	218,180	381,778	225,403

1/ Included in Account 353

EXHIBIT ___ (HHC-1)
Sheet 2 of 2
Project No. 2752

COMPARATIVE COSTS OF KOOTENAI

PROJECT AT ALTERNATIVE HEADWATER ELEVATIONS

No.	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
2	Description							
3	Kootenai Hydroelectric Project @ elevation	1990	1992	1994	1996	1998	2000	2005
4	Plant Characteristics							
5	Plant Capability in MW	125	129	133	136	140	144	154
6	Annual Energy Generation in GWh	457	469	480	492	503	515	543
7	Railroad Relocation in miles	0.76	0.89	0.98	1.19	1.34	2.03	5.90
8	Cost Estimate in $1000							
9	Acct. No.							
10	330 Land and Land Rights	2030	2702	3374	4046	4718	5390	14998
11	331 Power Plant Structures and Improvements	34089	34089	34089	34089	34089	34089	34089
12	332 Reservoirs, Dams and Waterways	81844	81862	81879	81897	81914	81932	83242
13	333 Water Wheels, Turbines and Generators	41174	41440	41706	41971	42237	42503	43167
14	334 Accessory Electrical Equipment	5739	5846	5953	6059	6166	6273	6540
15	335 Miscellaneous Power Plant Equipment	2583	2583	2583	2583	2583	2583	2583
16	336 Roads, Railroads and Bridges	523	523	523	523	523	523	523
17	353 Substation and Switching Station Equipment	4712	4799	4887	4974	5062	5149	5368
18	354/56 Transmission Line Connection	1/	1/	1/	1/	1/	1/	1/
19	Subtotal Direct Cost	172694	173844	174994	176142	177292	178442	190510
20	Contingencies (330, 331, 332, 336 @ 15%)	17773	17876	17980	18083	18187	18290	19928
21	Contingencies (333, 334, 335, 353, 354/56 @ 8%)	4337	4373	4410	4447	4484	4521	4613
22	Total Direct Cost in $1000	194804	196093	197384	198672	199963	201253	215051
23	Engineering and Administration @ 12% of Total Direct Cost	23376	23531	23686	23841	23996	24150	25806
24	Total Construction Cost in $1000 at Nov., 1981 Price Level	218180	219624	221070	222513	223959	225403	240857
25	Interest During Construction @ 4 1/2 years and 10%	49091	49415	49741	50065	50391	50716	54193
26	Investment Cost Rounded to $ Million	267	269	271	273	274	276	295
27	Unit Cost of Plant Capability in $/kW	2136	2085	2038	2007	1957	1917	1916
28	Total Annual Costs Rounded in $Million at 10%	29.9	30.2	30.4	30.7	30.9	31.1	33.2
29	Comparative Cost of Energy in mills/kWh	65	64	63	62	61	60	61

30 1/ Included in Account 353

EXHIBIT ___ (HHC-2)
Project No. 2752

EXHIBIT ____ (HHC-3)
Project No. 2752

ECONOMIC PARAMETERS OF ALTERNATIVE PROJECTS

	Proposed Kootenai Project	Nuclear Project	Coal-Fired Steam Project
1. Plant Capacity (MW)	144	144	144
2. Annual Energy (10^6kWh/yr)	515	515	515
3. Availability Factor (%)	96	68	85
4. Comparative Availability Factor (%)	100	72	89
5. Construction Costs (1981 $/kW)			
High	1,565	1,281	1,475
Low	1,565	869	950
6. Fuel Reserve (1981 $/kW)	0	136	7
7. Adjusted Construction Costs (1981 $/kW)			
High	1,565	1,915	1,664
Low	1,565	1,343	1,074
8. Fixed O&M (1981 mills/kWh)[2/]	1.17	3.38	5.63
9. Variable O&M (1981 mills/kWh)	0.0	.08	2.44
10. Fuel Costs (1981 mills/kWh)		7.82	14.78
11. Insurance and taxes (% Construction Costs)	0.825	1.025	0.975
12. Generating Charge (1981 mills/kWh)	0.2	0.2	0.2
13. Operation and Maintenance, Insurance and taxes (10^6 1981 $)			
high construction cost	2.9	5.3	7.6
low construction cost	2.9	4.5	6.8
14. Fuel (10^6 1981 $)	0.00	4.0	7.6
15. Construction Period (yrs)	4.5	8	4
16. Project Economic Life (yrs)	50	30	30
17. Project Operating Period (yrs)	45	45	45
18. Period of Analysis (yrs)	53	53	53

1/ Range of annual costs for the Nuclear and Coal-fired projects reflect insurance and property taxes as a percent of the high and low construction cost estimates. Insurance costs are 0.10, 0.30 and 0.25 percent of the construction costs of the hydroelectric, nuclear and coal-fired projects, respectively. Property taxes are 0.725 percent of construction costs. Annual operation and maintenance costs of the Kootenai Project includes $286,000 payment to the Corps for reservoir elevation charge.

2/ Fixed operation and maintenance costs for the Nuclear and Coal-Fired projects are adjusted by the availability factor.

EXHIBIT_____(HHC-4)
Project No. 2752

SUMMARY

LIFE CYCLE ANALYSIS

	Present Worth Values			
	Capital Costs	Annual Costs	Total[1/] Costs	Benefit Cost Ratio
	(Million dollars)			
<u>No Escalation</u>				
Kootenai River	143.0	14.7	157.7	
Nuclear - Low	152.7	43.0	195.8	1.24
Coal-Fired - Low	96.6	72.9	169.5	1.07
Nuclear - High	218.1	47.0	265.2	1.68
Coal-Fired - High	149.7	77.0	226.6	1.44
<u>Escalation @ 7.0%[2/]</u>				
Kootenai River	211.1	59.9	271.0	
Nuclear - Low	199.6	175.5	375.1	1.38
Coal-Fired - Low	149.4	297.4	446.8	1.65
Nuclear - High	284.9	192.1	477.0	1.76
Coal-Fired - High	231.6	314.0	545.5	2.01

1/ Totals may not add due to rounding.

2/ Escalation: Construction cost escalated during the initial construction period.

Annual cost escalated during first 30 years of the operating period.

KOOTENAI RIVER PROJECT
LIFE CYCLE ANALYSIS

ALTERNATIVE: KOOTENAI

EXHIBIT......(HHC-5)
Project No. 2752

COST COMPONENT	ESCALATION RATE PERCENT/YEAR	PROJECT YEARS APPLICABLE
CONSTRUCTION	7.	1 TO 8
O&M	7.	9 TO 38
FUEL	7.	9 TO 38
DISCOUNT RATE	10.	1 TO 53

(IN MILLION DOLLARS)

PROJECT YEAR	CAPITAL COST	O&M COST	FUEL COST	TOTAL COST	CUMULATIVE DISCOUNTED COST
1	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0
4	35.4	0.0	0.0	35.4	26.6
5	91.7	0.0	0.0	91.7	89.2
6	98.1	0.0	0.0	98.1	150.2
7	86.9	0.0	0.0	86.9	199.2
8	23.2	0.0	0.0	23.2	211.1
9	0.0	5.3	0.0	5.3	213.6
10	0.0	5.7	0.0	5.7	216.0
11	0.0	6.1	0.0	6.1	218.4
12	0.0	6.5	0.0	6.5	220.7
13	0.0	7.0	0.0	7.0	222.9
14	0.0	7.5	0.0	7.5	225.1
15	0.0	8.0	0.0	8.0	227.2
16	0.0	8.6	0.0	8.6	229.2
17	0.0	9.2	0.0	9.2	231.2
18	0.0	9.8	0.0	9.8	233.2
19	0.0	10.5	0.0	10.5	235.0
20	0.0	11.2	0.0	11.2	236.9
21	0.0	12.0	0.0	12.0	238.7
22	0.0	12.8	0.0	12.8	240.4
23	0.0	13.7	0.0	13.7	242.1
24	0.0	14.7	0.0	14.7	243.7
25	0.0	15.7	0.0	15.7	245.3
26	0.0	16.8	0.0	16.8	246.9
27	0.0	18.0	0.0	18.0	248.4
28	0.0	19.3	0.0	19.3	249.9
29	0.0	20.6	0.0	20.6	251.3
30	0.0	22.1	0.0	22.1	252.7
31	0.0	23.6	0.0	23.6	254.0
32	0.0	25.3	0.0	25.3	255.4
33	0.0	27.0	0.0	27.0	256.6
34	0.0	28.9	0.0	28.9	257.9
35	0.0	31.0	0.0	31.0	259.1
36	0.0	33.1	0.0	33.1	260.3
37	0.0	35.4	0.0	35.4	261.4
38	0.0	37.9	0.0	37.9	262.5
39	0.0	37.9	0.0	37.9	263.6
40	0.0	37.9	0.0	37.9	264.5
41	0.0	37.9	0.0	37.9	265.3
42	0.0	37.9	0.0	37.9	266.1
43	0.0	37.9	0.0	37.9	266.8
44	0.0	37.9	0.0	37.9	267.4
45	0.0	37.9	0.0	37.9	268.0
46	0.0	37.9	0.0	37.9	268.5
47	0.0	37.9	0.0	37.9	269.0
48	0.0	37.9	0.0	37.9	269.4
49	0.0	37.9	0.0	37.9	269.8
50	0.0	37.9	0.0	37.9	270.1
51	0.0	37.9	0.0	37.9	270.5
52	0.0	37.9	0.0	37.9	270.8
53	0.0	37.9	0.0	37.9	271.0
PRESENT WORTH TOTALS	211.1	59.9	0.0		271.0

EXHIBIT____(HHC-6)
Project No. 2752

KOOTENAI RIVER PROJECT
LIFE CYCLE ANALYSIS
ALTERNATIVE: COAL-FIRED PROJECT (LOW)

	ESCALATION RATE PERCENT/YEAR	PROJECT YEARS APPLICABLE
COST COMPONENT		
CONSTRUCTION	7.	1 TO 8
O&M	7.	9 TO 38
FUEL	7.	9 TO 38
DISCOUNT RATE	10.	1 TO 53

(IN MILLION DOLLARS)

PROJECT YEAR	CAPITAL COST	O&M COST	FUEL COST	TOTAL COST	CUMULATIVE DISCOUNTED COST
1	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0
5	32.5	0.0	0.0	32.5	22.2
6	81.2	0.0	0.0	81.2	72.6
7	86.9	0.0	0.0	86.9	121.7
8	39.9	0.0	0.0	39.9	142.1
9	0.0	12.5	14.0	26.5	154.5
10	0.0	13.4	15.0	28.3	166.5
11	0.0	14.3	16.0	30.3	178.2
12	0.0	15.3	17.1	32.4	189.5
13	0.0	16.4	18.3	34.7	200.6
14	0.0	17.5	19.6	37.1	211.4
15	0.0	18.8	21.0	39.7	221.8
16	0.0	20.1	22.4	42.5	232.0
17	0.0	21.5	24.0	45.5	241.9
18	0.0	23.0	25.7	48.7	251.5
19	0.0	24.6	27.5	52.1	260.9
20	0.0	26.3	29.4	55.7	270.0
21	0.0	28.2	31.5	59.6	278.9
22	0.0	30.1	33.7	63.8	287.5
23	0.0	32.2	36.0	68.3	295.9
24	0.0	34.5	38.5	73.0	304.0
25	0.0	36.9	41.2	78.2	312.0
26	0.0	39.5	44.1	83.6	319.7
27	0.0	42.3	47.2	89.5	327.2
28	0.0	45.2	50.5	95.7	334.5
29	0.0	48.4	54.1	102.4	341.6
30	0.0	51.8	57.9	109.6	348.5
31	0.0	55.4	61.9	117.3	355.2
32	0.0	59.3	66.2	125.5	361.8
33	0.0	63.4	70.9	134.3	368.1
34	0.0	67.9	75.8	143.7	374.3
35	32.5	72.6	81.1	186.3	381.6
36	81.2	77.7	86.8	245.7	390.4
37	86.9	83.1	92.9	262.9	398.9
38	39.9	88.9	99.4	228.2	405.6
39	0.0	88.9	99.4	188.3	410.6
40	0.0	88.9	99.4	188.3	415.2
41	0.0	88.9	99.4	188.3	419.3
42	0.0	88.9	99.4	188.3	423.1
43	0.0	88.9	99.4	188.3	426.6
44	0.0	88.9	99.4	188.3	429.7
45	0.0	88.9	99.4	188.3	432.5
46	0.0	88.9	99.4	188.3	435.1
47	0.0	88.9	99.4	188.3	437.5
48	0.0	88.9	99.4	188.3	439.6
49	0.0	88.9	99.4	188.3	441.5
50	0.0	88.9	99.4	188.3	443.3
51	0.0	88.9	99.4	188.3	444.9
52	0.0	88.9	99.4	188.3	446.4
53	-120.2	88.9	99.4	68.1	446.8
PRESENT WORTH TOTALS	149.4	140.4	157.0		446.8

KOOTENAI RIVER PROJECT
LIFE CYCLE ANALYSIS
ALTERNATIVE: NUCLEAR PROJECT (LOW)

EXHIBIT ..... (HHC-7)
Project No. 2752

COST COMPONENT	ESCALATION RATE PERCENT/YEAR	PROJECT YEARS APPLICABLE
CONSTRUCTION	7.	1 TO 8
O&M	7.	9 TO 38
FUEL	7.	9 TO 38
DISCOUNT RATE	10.	1 TO 53

(IN MILLION DOLLARS)

PROJECT YEAR	CAPITAL COST	O&M COST	FUEL COST	TOTAL COST	CUMULATIVE DISCOUNTED COST
1	20.7	0.0	0.0	20.7	20.7
2	33.2	0.0	0.0	33.2	50.8
3	35.5	0.0	0.0	35.5	80.2
4	38.0	0.0	0.0	38.0	108.8
5	40.7	0.0	0.0	40.7	136.5
6	43.5	0.0	0.0	43.5	163.6
7	31.0	0.0	0.0	31.0	181.1
8	16.7	0.0	0.0	16.7	189.6
9	0.0	8.3	7.4	15.6	196.9
10	0.0	8.9	7.9	16.7	204.0
11	0.0	9.5	8.4	17.9	210.9
12	0.0	10.1	9.0	19.1	217.6
13	0.0	10.8	9.6	20.5	224.1
14	0.0	11.6	10.3	21.9	230.5
15	0.0	12.4	11.1	23.5	236.6
16	0.0	13.3	11.8	25.1	242.7
17	0.0	14.2	12.6	26.8	248.5
18	0.0	15.2	13.5	28.7	254.2
19	0.0	16.3	14.[illegible]	30.7	259.7
20	0.0	17.4	15.5	32.9	265.1
21	0.0	18.6	16.6	35.2	270.3
22	0.0	19.9	17.7	37.7	275.4
23	0.0	21.3	19.0	40.3	280.4
24	0.0	22.6	20.3	43.1	285.2
25	0.0	24.4	21.7	46.1	289.9
26	0.0	26.1	23.2	49.4	294.4
27	0.0	28.0	24.9	52.8	298.8
28	0.0	29.9	26.6	56.5	303.2
29	0.0	32.0	28.5	60.5	307.3
30	0.0	34.3	30.4	64.7	311.4
31	20.7	36.7	32.6	89.9	316.6
32	33.2	39.2	34.9	107.3	322.2
33	35.5	42.0	37.3	114.8	327.6
34	38.0	44.9	39.9	122.8	332.9
35	40.7	48.0	42.7	131.4	338.0
36	43.5	51.4	45.7	140.6	343.0
37	31.0	55.0	48.9	134.9	347.4
38	16.7	58.9	52.3	127.8	351.2
39	0.0	58.9	52.3	111.2	354.1
40	0.0	58.9	52.3	111.2	356.8
41	0.0	58.9	52.3	111.2	359.3
42	0.0	58.9	52.3	111.2	361.5
43	0.0	58.9	52.3	111.2	363.6
44	0.0	58.9	52.3	111.2	365.4
45	0.0	58.9	52.3	111.2	367.1
46	0.0	58.9	52.3	111.2	368.6
47	0.0	58.9	52.3	111.2	370.0
48	0.0	58.9	52.3	111.2	371.3
49	0.0	58.9	52.3	111.2	372.4
50	0.0	58.9	52.3	111.2	373.4
51	0.0	58.9	52.3	111.2	374.4
52	0.0	58.9	52.3	111.2	375.2
53	-129.6	58.9	52.3	-18.4	375.1
PRESENT WORTH TOTALS	199.6	92.9	82.6		375.1

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

NORTHERN LIGHTS, INC.) PROJECT NO. 2752

DIRECT TESTIMONY OF BAUM K. LEE
ON BEHALF OF NORTHERN LIGHTS

Q. Will you please state your name, title and affiliation?

A. My name is Baum K. Lee. I am employed as Senior Hydrologist, Harza Engineering Company, 150 South Wacker Drive, Chicago, Illinois, 60606.

Q. What are your major responsibilities at Harza?

A. As Senior Hydrologist, I supervise, coordinate, and perform all surface water hydrologic assignments in the Land Resources and Environmental Sciences Department. Typical surface-water hydrologic assignments include streamflow and flood studies, river and reservoir sedimentation studies, water quality studies including water temperature, and computer application to many river hydraulic problems. I also often serve as project manager for the projects where river hydrology and/or hydraulics are emphasized. For overseas projects, I often serve as resident hydrologist, responsible for entire hydrologic studies and for training local hydrologists.

Q. Please describe your education.

A. I obtained my B.S., in 1963 from Seoul National University in Civil Engineering, followed by my M.S. in Hydraulics and Hydrology in 1969 from Colorado State University and my Ph.D. in Hydraulics and Hydrology in 1973 from Colorado State University.

Q. Please describe your activities in professional societies?

A. I am a member of five professional societies, which are American Society of Civil Engineers (ASCE), American

Geophysical Union, American Society of Mining Engineers, Korean Society of Civil Engineers, and Korean Association of Hydrologic Sciences.

Currently I am serving as a Task Committee member for organizing an ASCE Symposium on River Meandering, to be held in New Orleans in 1983.

Q. Please describe your professional experience as a hydrologist.

A. I have worked on more than 50 projects involving dams in the last 17 years. For those projects, I provided hydrologic and hydraulic inputs to planning, design and environmental studies involving flood discharge determination, water surface profiles, water depths, water velocities and water temperatures, of rivers and reservoirs. In addition, my work has included mathematical modeling and related field investigations. The work has involved streams from as small as 5 cfs to as large as 175,000 cfs for the Caroni River in Venezuela. Reservoirs involved ranged from a few hundred acre-feet to as large as 111,000,000 acre-feet. In addition, as part of my professional activities I have published seven technical papers on the hydraulics of sediment transport, which involve stochastic analysis and laboratory work in the movement of sediment particles over a river bed. This represents a continuous updating of a subject in which pioneering investigation was underway for several years.

Currently, I am serving as study manager for a study of sedimentation at 14 locks and dams in six countries in Europe, for the U.S. Army Corps of Engineers.

Q. Please describe the responsibilities assigned to you for the Kootenai River Hydroelectric Project.

A. I directed, reviewed, and performed hydrologic studies throughout all phases of the Project to provide inputs for design and environmental analysis.

Q. What specific hydrologic studies did you make?

A. I analyzed river discharge conditions, from which I computed water surface profiles, streamflow velocities, water depths, sedimentation, temperature, and the relationships between all of these variables for various reaches of the Kootenai River from the Libby Dam through the proposed Project boundaries under present and proposed conditions.

Q. Would you describe your findings with respect to the present river discharge conditions below Libby Dam on the Kootenai River?

A. The river discharges are almost entirely controlled by releases from Libby Dam. Witness Allen describes the general seasonal flow regulation provided by Libby Dam, and he also lists the locations of stream gages and long term mean runoff at the gages.

Libby Dam releases generally are made in the following manner according to information supplied by Witness Sewell.

a. March 1 to July 31 - Reservoir Refill Season. Releases are maintained to hold the reservoir at or below specified rule curve levels. Discharge may be as small as 4,000 cfs, but is set to obtain a full reservoir level on Aug. 1. Following floods, releases may exceed turbine discharge capacity for short periods. In general, discharges do not vary greatly during a single day. Releases are made through the turbines as much as is feasible, although the sluices may be used to supplement the turbines as necessary.

b. August 1 to February 28 - Storage Release Season. Releases are made during this period for the production of power to help meet the load in the Northwest. During part of this time releases are 10,000 cfs to 20,000 cfs during the day from 7 AM to 7 PM and at a usual minimum of 4,000 cfs from 7 PM to 7 AM from Monday thru Friday with the usual minimum flows all day on Saturday and Sunday. During heavier load periods the releases may be 20,000 cfs to 24,000 cfs continuously or with variations from 16,000 cfs to 24,000 cfs during each weekday with releases varying on approximately the above-mentioned daily schedule. The releases during this period must at least lower the reservoir to the required flood control elevation on March 1st.

There are occasional periods when discharge is as small as 2,000 cfs, but these occur very infrequently. The flow duration regime under present flow conditions, which is to say, flow conditions before Canada begins annual diversion of 1,500,000 acre-feet from the Kootenai River at Canal Flats, B.C., resulting from the foregoing operation is presented in Table 1 and Exhibit ___ (BKL-1). The data in Table 1 are for hourly average discharges obtained from records of the USGS gaging station at Libby, Montana for the period July 1976 to June 1980.

Several points in Table 1 require particular mention. A discharge of 12,190 cfs is the long-term mean discharge at the Libby Gage. The mean discharge from July 1976 through June 1980 was 10,300 cfs, or 84 percent of the long-term mean. Table 1 thus represents a period of below-average runoff.

Table 1

DISCHARGE DURATION OF KOOTENAI RIVER AT LIBBY USGS GAGE

Discharge CFS	Percent of Time Equalled or Exceeded	Average Hours Per Year Equalled or Exceeded
42,200	0.0	0
36,000	0.1	9
30,000	0.4	35
26,000	0.5	44
25,000	0.8	70
24,751	0.9	79
20,000	14	1230
16,000	26	2280
12,190	37	3240
10,000	41	3590
4,000	88	7710
2,000	100	8760

As Witness Allen explains, the Canadian diversion will average 2,070 cfs, reducing the long-term mean discharge to 10,120 cfs. With there being reduced inflow into Libby Reservoir, the outflow pattern will change. Flood inflows being less, fewer large discharges accompanying flood control operations can be expected. There are limitations governing the hourly change of discharge, so that there will be a practical limit to the difference between off-peak and on-peak discharge. The limit will be set by total amount of water available, the time required to change discharge between minimum and maximum, and the time in which peak discharge can be sustained.

Q. Will the Kootenai River discharges be changed by the proposed Project?

A. The river discharge will not be changed by the Project, except that the use of water for energy will reduce discharge in the reach between the Dam and the Tail Tunnel Outlet.

The Applicant's proposal is to release 750 cfs over the Dam at all times, except under the following two conditions:

(1) When inflow into the Project Reservoir is too small to permit generation by one of the small units with 750 cfs being discharged over the Dam, the entire river flow will be discharged over the Dam.

(2) When inflow to the Project Reservoir exceeds turbine discharge capacity plus 750 cfs, the entire amount by which inflow exceeds turbine discharge capacity will be discharged over the Dam.

The resultant discharge duration between the Dam and Tail Tunnel Outlet is summarized in Table 2. Table 2 is derived from Table 1 on the basis of the proposed Project operation plan to release a minimum of 750 cfs through the Kootenai Falls and utilize the remaining river discharge up to approximately 24,000 cfs through the Powerstation.

Q. Please explain why you computed water surface profiles.

A. Water surface profile computations are the basic method for obtaining water levels at various points in a

Table 2
DISCHARGE DURATION IN RIVER BETWEEN DAM AND TAIL TUNNEL OUTLET

Discharge CFS	Percent of Time Equalled or Exceeded	Approximate Hours Per Year Equalled or Exceeded
750	100	8760
751	0.9	79
2,000	0.5	44
6,000	0.4	35
12,000	0.1	9

flowing stream in which discharge remains constant for a period of time. In a natural stream there are basic water levels that accompany constant natural discharges. At practically all locations in a natural stream the water surface is sloping. If the stream characteristics are changed, the water levels for a particular constant discharge also are changed.

Stream characteristics may be changed by a dam or by diversion of part of the flow of the river at an upstream point and return of the flow to the river farther downstream. Both types of changes are produced by the Kootenai River Project.

The Dam will create a small Reservoir. At the downstream end of the Reservoir the water surface profile is nearly horizontal, and, of course, is at a higher elevation than it would be naturally. Going upstream, the Reservoir water surface begins to slope and remains at higher than natural elevation, although Reservoir water level and natural water level approach each other until eventually they coincide. The water surface profile between the Dam and the point when water level upstream no longer is changed is referred to as "backwater".

The Project, in utilizing water for power, changes stream characteristics in the Kootenai River between the Dam and the Tail Tunnel Outlet. From the Tail Tunnel Outlet downstream total flow in the river and water levels in the river are unchanged from natural conditions. Upstream from the Tail Tunnel Outlet discharge in the River will be reduced, and the water surface profile will be flatter than under natural conditions. The flatter profile extends to a point where it coincides with the natural depth for the reduced discharge flowing in that portion of the river. Therefore, there also is a backwater upstream from the Tail Tunnel Outlet.

Between the Dam and the upstream end of the backwater which extends from the Tail Tunnel Outlet, the water surface profile corresponds to the discharge, constricted sections, rock ledges, and pools in the river channel. The water depths are modified immediately downstream of the Dam by the uniform flow across the full crest of the Dam, which differs from the flow distribution that occurs naturally.

Q. What information do you need to compute water surface profiles?

A. Data required for computing water surface profiles include river cross sections, reach lengths, expansion and contraction loss coefficients, starting water surface elevations, and Manning's roughness coefficients (n).

River cross section is a drawing of river shape at right angle to flow direction. Exhibit ___ (BKL-2) shows a typical cross section. Reach length is a distance between two consecutive river cross sections. Expansion and contraction loss coefficients are measures of river width changes as they affect flow velocity and depth. Starting water surface elevation is the known water surface elevation at a cross section where computation may begin. Manning's roughness coefficient is a measure of resistance to flow, first introduced by Manning in 1889.

For the reach upstream from the Dam to Libby, Montana, sixteen cross sections were used. Exhibit ___ (BKL-3) shows the locations of the cross sections. Fourteen of these were surveyed and sounded by Sewell & Associates. The remaining two cross sections were estimated from USGS discharge measurement data and topographic maps. Reach lengths for the left and right overbanks and the channel were measured from 1:1200-scale maps, from the

Dam to four miles upstream. Upstream from the four-mile point the reach lengths were obtained from 1:24,000 scale USGS maps. Manning's roughness coefficients were estimated on the basis of field investigations and calibration of measured water surface profiles. Profile calibration is a method of estimating roughness coefficients while matching a computed water surface profile with a measured water surface profile for a given discharge.

Starting water surface elevations for existing conditions were read from the discharge rating curve for the Dam site which is Exhibit ___ (BKL-4). The location of the Dam site is shown on Exhibit ___ (BKL-3) as Section R-1. A discharge rating curve is a curve showing the relationship between river discharge and water surface elevation. Exhibit ___ (BKL-4) was obtained by using stage measurements at the Dam site and discharges from the USGS gage at Libby. For computing water surface profiles after Project construction, the starting elevation at the Dam is 2,000.

For the reach downstream from the Dam to the Tail Tunnel Outlet, 37 cross sections were used to compute water surface profiles. Exhibit ___ (BKL-5) shows the locations of these cross sections. Because of extremely difficult access, especially in the upper half of this reach, only seven cross sections were surveyed. These seven sections are N3, N2, N1, 40CA, KA, HA, and GA. The other sections were estimated on the basis of nearby sections, field observations, and a profile calibration.

Starting water surface elevations were determined from the discharge rating curve for Section TW shown on Exhibit ___ (BKL-5). Profiles under natural conditions are based on the entire river flow. Profiles after Project construction are based on total river flow below the Tail Tunnel Outlet and discharge over the Dam between the Dam and Tail Tunnel Outlet. In both conditions, the starting point is at Gage TW.

Manning's roughness coefficients were estimated on the basis of field observation and calibration of the water surface profile for river discharge of 3,490 cfs.

Q. Please describe your analysis of the water surface profiles produced by the Dam and Reservoir.

A. Exhibit ___ (BKL-6) shows computed water surface profiles upstream from the Dam to the point where backwater produced by the Dam coincides with natural water level. The profiles at the downstream end are produced by Reservoir water surface elevation 2000.

The backwater effects of the Kootenai River Hydroelectric Project will extend about 3.5 miles upstream from the Dam when streamflow through the Reservoir is between 2000 cfs and 50,000 cfs. A discharge of 2000 cfs is about the minimum discharge under existing operating criterion, while 50,000 cfs corresponds to the 20-year flood. However, the discharge for the 100-year flood is only slightly higher at 52,000 cfs.

Sheet 1 of Exhibit ___ (BKL-6) shows water surface profiles for existing conditions and with the Project prior to sediment deposition. Sheets 2 through 5 compare water surface profiles for existing conditions with conditions after the Project is in operation for 5, 10, 25, and 50 years.

Q. How will the Project affect water surface elevations at the Sheppard Property?

A. The Sheppard Property, consisting of three terraces, is located between about 7000 ft to 13,000 ft upstream from the Dam. Witness Lindsay identifies the terraces as the first (western-most), second (middle), and third (eastern-most). Table 3 shows the locations and elevations of the terraces, and water surface elevations at the terraces under various discharges after the Project is in operation. Witness Lindsay discusses the significance of the water levels on river terrace vegetation.

Table 3
RIVER TERRACES: WATER LEVELS WITH PROJECT IN OPERATION

Reservoir Elevation, 2000 ft, msl

	Terrace: First	Terrace: Second	Terrace: Third
Location (feet upstream from Dam)	7,100 to 8,300	9,500 to 10,200	11,300 to 12,800
Terrace Elev. (ft,msl)	2,001 to 2,005	2,006 to 2,014	2,006 to 2,012
Discharge, 4,000 cfs			
Water Surface Elev. (ft,msl)			
Downstream end	2,000.0	2,000.0	2,000.0
Upstream end	2,000.0	2,000.0	2,001.0
Discharge, 25,000 cfs			
Water Surface Elev. (ft,msl)			
Downstream end	2,000.0	2,000,8	2,001.5
Upstream end	2,000.2	2,001.0	2,002.0
Discharge, 50,000 cfs			
Water Surface Elev. (ft,msl)			
Downstream end	2,001.0	2,001.5	2,004.0
Upstream end	2,001.0	2,002.0	2,006.0

Q. What analysis was made of the existing streamflow velocities in the Kootenai River above the Dam site?

A. The streamflow velocity was determined for five separate river discharge conditions at each of sixteen cross sections along the river.

Streamflow velocities under existing conditions vary from one location to another. At a given location, the velocities generally increase as river discharge increases.

For velocity determination, the river is divided into left overbank, main channel, and right overbank at each cross section. For illustration I describe streamflow velocities for 4000 cfs and 25,000 cfs at four representative Sections, R2, R6, R9, and K14. Exhibit _ (BKL-7) shows velocity variation from the Dam site to Libby, Montana.

Streamflow velocities at Section R2, about 1400 feet upstream from the Dam site, vary from 1.5 ft/sec to 4.7 ft/sec in the main channel, from 0.1 ft/sec to 2.7 ft/sec in the left overbank, and from 0.4 to 2.0 ft/sec in the right overbank as discharges vary from 4000 cfs to 25,000 cfs.

Streamflow velocities at Section R6, about 1.7 miles upstream from the Dam site, vary from 1.0 ft/sec to 4.2 ft/sec in the main channel, from 0.2 ft/sec to 1.6 ft/sec in the left overbank, and from 0.5 ft/sec to 1.5 ft/sec in the right overbank as the river discharges vary from 4,000 cfs to 25,000 cfs.

Streamflow velocities at Section R9, about 3.3 miles upstream from the Dam site, vary from 3.4 ft/sec to 6.0 ft/sec in the main channel, from 1.2 ft/sec to 5.3 ft/sec in the left overbank, and from 1.2 ft/sec to 4.4 ft/sec in the right overbank as the river discharges vary from 4000 cfs to 25,000 cfs.

Streamflow velocities at Section K14, about 8.3 miles from the Dam site or about three miles downstream from Libby, vary from 3.1 ft/sec to 6.0 ft/sec in the main channel, from 0.0 ft/sec to 3.4 ft/sec in the left overbank, and from 1.3 ft/sec to 3.6 ft/sec in the right overbank as the river discharges vary from 4000 cfs to 25,000 cfs.

Q. What will the streamflow velocities be after the Project is in operation?

A. Exhibit ___ (BKL-7) shows the velocities under existing conditions and with the Project under initial-year conditions. For illustration, I will describe streamflow velocities at the same four representative cross sections with the Project.

Streamflow velocities at Section R2 with the Project would vary from 0.2 ft/sec to 1.4 ft/sec in the main channel, from 0.1 ft/sec to 0.3 ft/sec in the left overbank, and from 0.1 ft/sec to 0.3 ft/sec in the right overbank as discharges vary from 4000 cfs to 25,000 cfs.

Streamflow velocities at Section R6 would vary from 0.4 ft/sec to 2.3 ft/sec in the main channel, from 0.2 ft/sec to 0.6 ft/sec in the left overbank, and from 0.2 ft/sec to 0.6 ft/sec in the right overbank as discharges vary from 4000 cfs to 25,000 cfs.

Streamflow velocities at Section R9 would vary from 1.9 ft/sec to 5.7 ft/sec in the main channel, from 1.6 ft/sec to 4.6 ft/sec in the left overbank, and from 1.2 ft/sec to 4.2 ft/sec in the right overbank as discharges vary from 4000 cfs to 25,000 cfs.

The Project will not affect velocities in the reach upstream from Section K10 including Section 14.

Q. Can you illustrate how the velocities at Sections on Exhibit ___ (BKL-7) can be applied to locations between Sections?

A. Yes. As illustration the streamflow velocity of the Kootenai River near the confluences with Flower Creek and Pipe Creek can be approximated by the velocities between Sections K13 and K15. The velocities between Sections K13 and K15 range from 1.4 ft/sec to 8.9 ft/sec in the main channel, from 0.0 to 4.9 ft/sec in the left overbank, and from 0.0 to 4.5 ft/sec in the right overbank as discharges vary from 4000 cfs to 25,000 cfs. These velocities are for existing conditions and will not be affected by the Project.

Q. Please describe water depths in the Kootenai River under existing conditions.

A. Like streamflow velocities, water depths vary from one location to another. At a given location, water depths normally increase as river discharges increase. For illustration, I will describe water depths at the same four representative cross sections, R2, R6, R9, and K14 for discharges of 4000 cfs and 25,000 cfs. Exhibit ___

(BKL-7) presents water depths from the Dam site to Libby, Montana.

Average water depths at Section R2 vary from 6.0 ft to 11 ft in the main channel, from 0 ft to 4.3 ft in the left overbank, and from 1.1 ft to 3.5 ft in the right overbank as discharges vary from 4000 cfs to 25,000 cfs.

Average water depths at Section R6 vary from 12 to 19 ft in the main channel, from 1.1 to 4.3 ft in the left overbank, and from 1.5 to 4.8 ft in the right overbank as discharges vary from 4000 cfs to 25,000 cfs.

Average water depths at Section R9 vary from 4.0 ft to 12 ft in the main channel, from 0.4 ft to 5.2 ft in the left overbank, and from 0.5 ft to 4.4 ft in the right overbank as discharges vary from 4000 cfs to 25,000 cfs.

Average water depths at Section K14 vary from 3.6 ft to 9.6 ft in the main channel, from 0 ft to 3.3 ft in the left overbank, and from 1.0 ft to 3.5 ft in the right overbank.

Q. Please describe water depths in the Kootenai River after the Project is built.

A. Exhibit ___ (BKL-7) provides data for water depths. As for streamflow velocities, water depths with the Project can be illustrated with three representative cross sections R2, R6, and R9 in the Reservoir area. The Project does not change water depths upstream of Section K10 including Section K14.

Average water depths at Section R2 with Project would be about 24 ft in the main channel, 4.4 ft in the left overbank, and 8.6 in the right overbank as discharges vary from 4000 cfs to 25,000 cfs. The depths do not change with river discharge, because of reservoir ponding effect.

Average water depths at Section R6 would be about 24 ft in the main channel, vary from 4.3 ft to 4.7 ft in the left overbank, and from 5.0 ft to 5.3 ft in the right overbank as discharges vary from 4000 cfs to 25,000 cfs.

Water depths at Section R9 would vary from 6.3 ft to 12 ft in the main channel, from 2.0 ft to 4.7 ft in the left overbank, and from 1.7 ft to 4.7 ft in the right overbank as discharges vary from 4,000 cfs to 25,000 cfs.

Q. Please describe the relationship between water surface area and depth under existing conditions?

A. Table 4 shows the percent of water surface area over depth ranges for two discharges under existing conditions in the reach from Section R1 to Section K10.

Table 4

WATER SURFACE AREA WITH VARIOUS DEPTH RANGES
EXISTING CONDITIONS

Depth Range (ft)	Percent of Surface Area	
	4000 cfs	25,000 cfs
0 to 1	12	3.7
1 to 3	16	7.3
3 to 6	22	20
over 6	50	69

Q. How will the Project affect the percentage distribution of the above depth ranges?

A. With no change in the present stream-bed, the Project will reduce areas with depth less than six feet and increase areas with depth greater than six feet. The percentage distribution of surface area with various depth ranges for a discharge of 25,000 cfs will be as shown in Table 5.

The percentage distribution for 4000 cfs will be similar to Table 5 because of the reservoir ponding effect.

Q. Please explain the hydraulic analysis for the portion of the River below the Dam.

A. Hydraulic analysis of the portion of the River below the Dam site consisted of computing water surface profiles, with resultant water depths and water velocities at various locations. Its purpose was to determine effects of the Project on streamflow velocity, flow depth, the area of sand and gravel bars, and river bank exposure.

Table 5

WATER SURFACE AREA WITH VARIOUS DEPTH RANGES WITH PROJECT

Present Riverbed Conditions	
Depth Range (ft)	Percent of Surface Area
0 to 1	1.4
1 to 3	2.8
3 to 6	6.1
over 6	89.7

Q. Please summarize the major changes between the Dam and Tail Tunnel Outlet that would be caused by the Project?

A. There are four major changes:

1. Immediately below the Dam, portions of riverbed now covered with water intermittently will be covered continuously, due primarily to distribution of flow by the Spillway gates and to installation of flow - distribution structures downstream from the Dam. The flow depth usually will be between a few inches and several feet in such locations.

2. Lower discharges will occur more frequently with the Project in operation. Flow depths between the Dam and Tail Tunnel Outlet for any given discharge through the reach will be the same as at present, except in the zone affected by the backwater from the Tail Tunnel discharge.

3. Within the backwater zone, water velocities for a given discharge through the reach between the Dam and the Tail Tunnel Outlet will be less than at present.

4. For distance of between 300 feet and 3,200 feet upstream from the Tail Tunnel Outlet, depending upon river discharge, there will be a backwater zone in which depth at 750 cfs with the Project

often will exceed the depth that now occurs at larger discharges under existing conditions. For example, with 750 cfs between the Dam and the Tail Tunnel Outlet and 6,000 cfs through the Powerstation, the depth in the backwater zone will exceed depths for 4,000 cfs under existing conditions. There is a large range of discharges in which the Project will increase water depth similarly, even though only 750 cfs will flow between the Dam and the Tail Tunnel Outlet.

Q. How will the proposed Project change the water surface profiles downstream from the Dam?

A. There will be backwater effects caused by the Powerstation discharges. It is anticipated that the Powerstation discharges will range from 2,000 cfs to 24,000 cfs. Six combinations of river discharges over the Dam and Powerstation discharges were analyzed and are summarized in Table 6.

Table 6

RIVER DISCHARGES AND POWERSTATION DISCHARGES ANALYZED

River Discharge (cfs)	Powerstation Discharge (cfs)
750	2,000
750	6,000
750	12,000
750	24,000
4,000	24,000
15,000	24,000

The length of the affected reach varies from about 300 to 3200 feet upstream from the Tail Tunnel Outlet depending upon river and Powerstation discharge combinations. This is further detailed in Exhibit ___ (BKL-8). The locations of cross sections between the Dam and Tail Tunnel Outlet used to analyze streamflow velocity and water depth are shown on Exhibit ___ (BKL-5).

Exhibits ___ and ___ (BKL-9 and BKL-10) show the water surface profiles between the Dam and Tail Tunnel Outlet for existing conditions and with the Project.

Q. Please describe streamflow velocities downstream from the Dam site under existing conditions.

A. The Kootenai River between the Dam site and Tail Tunnel Outlet has nearly vertical banks in most parts of the river. Therefore, the river was not divided into main channel, left overbank and right overbank, as in the Reservoir, for hydraulic analysis. Hydraulic characteristics such as streamflow velocity and flow depth, are described in average terms for each cross section.

Shallow rapids, or falls, combined with pools produce a wide range of streamflow velocities. The velocities are generally slow in the pools. Typical velocities can be described as follows: 1. Between the Tail Tunnel Outlet N3 and N1, the pool velocities vary from 0.3 ft/sec to 0.5 ft/sec at river discharge of 750 cfs, from 4.0 ft/sec to 4.6 ft/sec at 15,000 cfs; 2. Between Sections KA and GA-2, pool velocities vary from 0.6 ft/sec to 1.7 ft/sec at 750 cfs, from 4.4 ft/sec to 5.4 ft/sec at 15,000 cfs; 3. Between Sections LC-2 and LC-6, velocities in pools vary from 2.0 ft/sec to 5.9 ft/sec at 750 cfs, and from 7.4 ft/sec to 8.9 ft/sec at 15,000 cfs. Exhibit ___ (BKL-11) provides further information on velocities in the pools. There are no river reaches above LC-6 that can be called pools.

Q. How will the Project affect streamflow velocity in pools?

A. Approximate streamflow velocities in pools are shown on Exhibit ___ (BKL-11) for existing conditions and with the Project.

Streamflow velocities in pools will be reduced in the reach affected by backwater from Powerstation discharge.

Streamflow velocities in pools after the Project is in operation can be summarized as follows:

1. For the discharge combination of 750 cfs released at the Dam and between 2000 cfs and 6000 cfs from

the Powerstation, the pool velocities will not be affected by the backwater. Thus, the velocities will be the same as 750 cfs flow in the river under existing conditions.

2. For the discharge combination of 750 cfs released at the Dam and 12,000 cfs from the Powerstation, the velocities will vary from 0.2 ft/sec to 0.3 ft/sec between Sections N3 and N1. Upstream of Section 40CA the velocities will be the same as those under existing conditions.

3. For the discharge combination of 4000 cfs released at the Dam and 24,000 cfs from the Powerstation, the velocities will vary from 0.7 ft/sec to 1.9 ft/sec between Sections N3 and N1 and from 2.0 ft/sec to 2.7 ft/sec between Sections KA and GA-2.

Q. Please describe streamflow velocity at the rock ridges between the Dam site and Tail Tunnel Outlet under existing conditions.

A. Exhibit ____ (BKL-9) shows significant rock ridges which locally control river discharge at the following 11 locations:

N1
40CA (at small discharge only)
KA
GA-2
GA-4
LC-21 (Left Channel)
LC-6 (Left Channel)
GA-7
RC-3 (Right Channel)
RC-6 (Right Channel)
RC-8 (Right Channel)

Based on my field observation these rocky ridges at the controls are irregular both in plan and in cross section.

At 750 cfs, 4,000 cfs, and 15,000 cfs, streamflow velocities at the 11 major controls listed above under existing conditions are approximately as shown on Exhibit ____ (BKL-12). For illustration, I will describe streamflow velocities at three representative cross sections.

As discharges vary from 750 cfs to 15,000 cfs, streamflow velocities vary from 1.3 ft/sec to 7.5 ft/sec at Section N1, from 5.0 ft/sec to 8.7 ft/sec at Section GA-2, and from 6.3 ft/sec to 14 ft/sec at Section LC-6.

Q. How will the Project change streamflow velocity at the control sections?

A. Exhibit ____ (BKL-8) summarizes the effect of backwater caused by the Project on flow depth at selected points between the Dam and Tail Tunnel Outlet. The backwater extends various distances upstream from the Tail Tunnel Outlet depending upon the combined discharges through the Powerstation and over the Dam. The streamflow velocities will be reduced where affected by backwater.

For the discharge combination of 750 cfs over the Dam and 12,000 cfs from the Powerstation, the velocities will be reduced from 3.8 ft/sec to 0.8 ft/sec at Section N1, from 5.9 ft/sec to 4.8 ft/sec at Section 40CA. Velocities at further upstream control sections will be the same as under existing conditions.
For the discharge combinations of 4000 cfs over the Dam and 24,000 cfs from the Powerstation, the velocities will be reduced from 3.8 ft/sec to 1.2 ft/sec at Section N1, from 9.7 ft/sec to 2.6 ft/sec at Section 40CA, from 7.4 ft/sec to 6.6 ft/sec at Section KA. Velocities at further upstream control sections will be the same as under existing conditions.

The differences in streamflow velocities between existing conditions and with the Project for the area between the Dam and Section GA-41 are shown in Exhibit _ (BKL-13). Such differences in streamflow velocities are due to flow redistribution rather than backwater effects.

Q. How will the Project change flow depth between the Dam and Tail Tunnel Outlet?

A. Exhibit ____ (BKL-8) shows the increase in flow depth for various combinations of discharges over the Dam and from the Powerstation.

For discharge combinations of 750 cfs over the Dam and 2000 cfs from the Powerstation, the depths will increase about two feet at Sections TW and N2.

For discharge combination of 650 cfs over the Dam and 12,000 cfs from the Powerstation, the depth increase will be 10.4 ft at Section TW and will diminish upstream from Section KA.

For discharge combination of 4000 cfs over the Dam and 24,000 cfs from the Powerstation, the depth increase will be 16 ft at Section TW and will diminish upstream from Section GA-3.

Q. After the Project is in operation what changes will occur in streamflow velocities downstream from the Tail Tunnel Outlet?

A. Velocities downstream from the Tail Tunnel Outlet will not change. The Project would cause a change in the flow pattern in the immediate vicinity of the Tail Tunnel Outlet; however, all effects of the redistribution of streamflow will disappear within 300 feet downstream of the Tail Tunnel Outlet.

Q. Please describe the scope of the your sedimentation analysis.

A. I determined sediment transport rates (bed load and suspended load), sediment deposition rates, location of deposition, river cross section, changes due to sedimentation and erosion, bed material sizes, and sources of sediment for the river reaches between the upper end of the Reservoir and the Tail Tunnel Outlet.

Q. How did you initiate your sedimentation studies?

A. My first concern was to determine the source of sediments in the Kootenai River.

Due to Libby Dam, the major source of sediment for this reach is the intervening 1,430-square-mile drainage area between Libby Dam and the Dam site. The Fisher River, with 838 square miles of drainage area, is the largest tributary in this area and is the prime source of sediment for the Project. Sediment released from Libby

Dam would primarily consist of fine particles (silt and clay) which will not deposit in the Reservoir.

Q. How did you determine sediment transport rate in the Kootenai River?

A. Sediment transport mode in a river can be divided into suspended sediment and bed load transport. Both suspended sediment and bed load discharges for the Kootenai River were estimated based on these two classes of sediment load determined for the Fisher River.

Q. How was the suspended sediment discharge for the Fisher River determined?

A. The suspended sediment discharge of the Fisher River was estimated by applying a sediment rating curve and a flow duration curve for the Fisher River developed from USGS data. A sediment-rating curve relates sediment discharge in tons per day, to river discharge, in cubic feet per second. A flow duration curve gives the relationship between river discharge and its frequency of exceedance. The sediment rating and flow duration curves are shown on Exhibit ____ (BKL-14) and Exhibit ___(BKL-15), respectively.

Q. What was determined to be the average suspended sediment discharge of the Fisher River?

A. The average sediment discharge of the Fisher River was determined to be 92,000 tons per year, which is equivalent to a unit discharge, i.e., sediment discharge per unit area, of 110 tons per year per square mile.

Q. What is the particle size distribution of suspended sediments carried by the Fisher River?

A. The particle size distribution of Fisher River suspended sediment was determined to be 13 percent sand, 66 percent silt, and 21 percent clay. Exhibit ____ (BKL-16) shows the particle size distribution curve of suspended sediment in the Fisher River.

Q. Based upon this analysis, what was determined to be the suspended sediment discharge into the Reservoir of the proposed Project?

A. The suspended sediment discharge into the Reservoir was determined to be approximately 146,000 tons per year. The size distribution of suspended sediment was estimated to be the same as that of the Fisher River.

Q. What was determined to be the bed load discharge for the Fisher River?

A. The bed load discharge for the Fisher River was estimated to be approximately 41,000 tons per year, which is about 45 percent of the suspended sediment discharge. The unit bed load then would be 49 tons per year per square mile.

The particle size distribution used in the bed load computation is based on size distribution curves for five bed material samples taken by the Corps of Engineers, Seattle District, at five locations in the lower part of the Fisher River. River cross section and flow measurement data for the Fisher River were obtained from the USGS.

Q. What was determined to be the bed load discharge into the Reservoir?

A. The bed load discharge into the Reservoir was estimated to be about 65,000 tons per year.

Q. Please describe the present river bed material in the Reservoir area.

A. Nine bed material samples were collected by a Harza hydrologist on November 1, 1981. The bed material mostly consists of big rocks, boulders, cobbles and gravels which are well embedded with coarse sand.

Sand and gravel bars along the river banks include large cobbles and boulders. Approximately 30 percent of the surface areas of exposed bars are covered with material larger than 128 mm. The size distribution of smaller material is shown in Table 7:

Table 7

SIZE DISTRIBUTION OF SMALLER MATERIAL OF RIVER BARS

Size Range, mm	Percent
Finer than 0.062	1
0.062 to 2.0	24
2.0 to 64.0	70
64.0 to 128	5

The locations of sand and gravel bars are shown on Exhibit __ (BKL-17).

Q. Please describe the existing shoreline materials in the Reservoir area.

A. The shoreline within the Reservoir area varies depending upon the rate of discharge from Libby Dam.

The shoreline material varies somewhat with river discharge but is mostly sand with some silt and clay. Scattered gravels, cobbles, and boulders are seen embedded in sands at places. About 10 percent of this material is finer than 0.062 mm diameter and the remaining 90 percent lies between 0.062 mm and 2.0 mm.

Q. Please describe the shoreline materials that will be visible during Project operation.

A. After the Project is in operation the shoreline boundary will be relatively constant for a wide range of river discharges due to reservoir ponding effect. The shoreline material will be similar to that presently existing at a discharge of about 20,000 cfs, and will consist of coarse sand with a little silt and clay. The maximum particle size of shoreline material, excluding scattered gravels, will be about 3 mm.

Q. How will the Reservoir affect sediment transport?

A. All of the bed load and sand portion of the suspended sediments will be trapped by the Reservoir. Silt and clay suspended in the water will not be affected and will continue downstream.

Q. What happens to the silt and clay being transported in the River under present conditions?

A. Due to daily fluctuations in flow some of these sediments are deposited along the shoreline between the high and the low water elevations.

Q. How much of the suspended sediment and bed load will be deposited in the Reservoir?

A. Approximately 19,000 tons per year of suspended sediment will be deposited. The specific weight of this deposited sediment is estimated to be 97 pounds per cubic foot. Change in specific weight due to compaction will be neglible. The rate of suspended sediment deposit is equivalent to a volume of 9 acre-feet per year.

All the bed load will deposit in the Reservoir. The specific weight of the bed load was estimated to be 120 pounds per cubic foot. The bed load deposit will deplete the R servoir volume at a rate of 25 acre-feet per year. Thus, the Reservoir volume will be depleted at a total rate of 34 acre-feet per year, which is the sum of 9 acre-feet per year of suspended sediment and 25 acre-feet per year of bed load. The volume of sediment deposit after fifty years will be approximately 1700 acre-feet, or 44 percent of the Reservoir volume below Elevation 2,000.

Q. Have you been able to determine how the deposited sediment will distribute in the Reservoir during fifty years of operation?

A. Yes, the distribution of deposited sediment is calculated for 5, 10, 25, and 50 years of Project operation. The sediment distribution profiles presented as Exhibit _____ (BKL-18) show the elevation of sediment along the length of the Reservoir. The predicted sediment distribution across three typical river cross sections is shown on Exhibit _____ (BKL-19).

Q. What sizes of sediment particles can be expected on the bottom of the Reservoir?

A. The median particle size of sediment in the Reservoir is estimated to be one millimeter. This is based largely on particle size distribution of suspended sediment and bed material. Near mouths of small creeks flowing directly into the Reservoir, a significant amount of boulders and gravels will be deposited. The deposition will normally occur during flood events which possess enough stream power to transport large gravels and boulders. Field investigation indicated that sufficient gravels and boulders exist in China, Burrel, Dad and Williams Creeks. The size of gravel bars at the new mouth of these creeks will grow gradually and reach eventual equilibrium size similar to these at the existing creek mouths.

Q. Under existing conditions, is the movement of sediment into and out of various reaches within the Project boundaries at equilibrium?

A. Yes. The formation of sand and gravel bars along the river appears to have stabilized as a result of the construction and operation of Libby Dam.

Q. Will the sediment transport in the Reservoir eventually come to equilibrium during Project operation?

A. No. Part of the sediment transported into the Reservoir will be trapped and the volume of the Reservoir will gradually be reduced as is shown on Exhibits ____.(BKL-18), and Exhibit __ (BKL-19).

Q. Please describe the area known as the Koot Creek Bar.

A. This bar is at the mouth of Koot Creek, in the pool between Section GA and GA-2, as shown on Exhibit ____ (BKL-5). The bar, which consists of sand and gravel, slopes into the Kootenai River at approximately a 25 percent grade. The bar materials are primarily gravels and small boulders on coarse sand. At the higher elevations, fine sands are deposited on the top of the gravel and boulders. The Koot Creek Bar is presently maintained by sediments deposited there by Koot Creek and by the Kootenai River. The very high velocities that occur in Koot Creek under large flows transport the large materials that causes the bar to develop. Smaller materials are supplied partly by Koot Creek but mostly by the Kootenai River. The volume of material supplied by the Kootenai River is less with Libby Dam in existence than prior to the construction of that dam.

Q. How will the Project affect Koot Creek Bar?

A. Koot Creek Bar will likely grow somewhat after the Project is built, because there will be less high flow in Kootenai River to transport the gravel material deposited by Koot Creek. The added accumulation likely will more than offset the reduced sediment from upstream. Furthermore, low flows will occur more frequently due to the operation of the Project and will expose more of the bar area.

Q. Please elaborate on the basis for your prediction that Koot Creek bar will grow.

A. Experience with sand-bed streams shows that a dam usually causes degradation of the downstream river bed by cutting off the majority of the sediment supply. However, aggradation is more likely in a gravel-bed stream because of infeed of gravel from tributaries, which can not be transported by the controlled (or reduced) flow of the main stem. Survey of Kootenai River cross sections by the Corps of Engineers and USGS has shown aggradation below the dam. Studies by Dr. Gary Parker indicate the occurrence of aggradation in gravel-bed streams.

Q. Please describe bed materials and gravel deposit size near the confluence of Pipe and Flower Creeks.

A. The bed material at these junctions consists of mostly gravel and sand but large rocks are also present. The sand-gravel deposits average about 150 feet wide by 7000 feet long under medium flow conditions. The bed material is similar to those in the Reservoir. The size of the sand-gravel deposits is about equivalent to that in the reach from R8 to K10 in the Reservoir. The bed material near the Pipe Creek and Flower Creek junctions will not be affected by the Project.

Q. Please describe the existing pattern of water temperatures in the area of the Project.

A. The temperature regime of the Kootenai River under present conditions is very complex. Exhibit ____ (BKL-20) shows, on four sheets, one for each season, the measured water temperature changes for different river discharges along the Kootenai River from river mile 194.5 (about 1.5 miles upstream from the Dam site) to river mile 191.0 (about 1.0 mile downstream from Tail Tunnel Outlet site. The four sheets show the predominance of readings with no measureable change in temperature and an inconsistent pattern of readings where there are temperature changes. Generally, under existing conditions, any temperature rise in water passing through the reach of the Kootenai River affected by the Project is very small.

Water temperature in the Project area is regulated by selective release through the turbines at Libby Dam. From February to September, water temperature is maintained within the range of temperature before Libby Dam was built. From October to January, water temperature is maintained zero to six degrees Fahrenheit above the maximum temperatures recorded from 1962 to 1969, before Libby Dam was built.

Q. Please explain the basic data and assumptions used in analyzing water temperature effects of the Project.

A. The effects of the Project on water temperature were analyzed using the principle of heat budget. Data required include solar radiation, cloud cover, shading from sunlight, water temperature, air temperature and humidity.

The solar radiation received is a function of the extent to which water surface may be exposed to direct sunlight and of the amount of cloud cover. The Reservoir is relatively exposed to direct sunlight, although there is shading from the mountains morning and evening. Below the Dam, the winding stream course, combined with steep walls in certain locations reduces the direct solar exposure. Temperature rise was analyzed by using five percent shading of the Reservoir water surface and 30 percent shading of the stream surface below the Dam. The shading factors are based on field observation. The inflow water temperature was estimated to be 60°F, which is roughly the average water temperature in July, based on USGS data. The air temperature was estimated to be 87.5°F, which is the normal high air temperature in July. The relative humidity was estimated to be the July average of 50 percent. The cloud cover was estimated to be the July average of 40 percent. The data for air temperature, humidity, and cloud cover were obtained from the National Weather Service.

Q. For what river discharge conditions did you analyze the water temperature effects of the Project?

A. Three discharge conditions were studied. They were 2,750, 11,000, and 24,750 cfs. In each case the minimum release over the Dam was 750 cfs and the remainder was discharged through the Powerstation. Average river discharge, as regulated by Libby Dam in July, is approximately 11,000 cfs. The range of discharges analyzed, 2,750 to 24,750 cfs, covers about 99 percent of the range of discharges.

Q. According to your analysis, what will be the net effect of the Project on water temperature?

A. The net temperature effect of the Project is to raise water temperature about 0.5, 0.9 and 1.0 degree Fahrenheit at discharges of 2,750, 11,000, and 24,750 cfs, respectively. These are the maximum effects produced by the Project within any river reach between the upper end of the Reservoir and the Tail Tunnel Outlet. The average effect over a day or longer time period would be much smaller, as the above figures were based upon hourly periods. Exhibit __(BKL-21) summarizes net water temperature change due to the Project for different reaches and under three discharge conditions.

Q. Does this complete your prepared direct testimony?

A. Yes.

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

MATTER OF)
NORTHERN LIGHTS, INC.) PROJECT NO. 2752

AFFIDAVIT

STATE OF Illinois)
) ss.:
COUNTY OF Cook)

B. K. Lee, being duly sworn, deposes and says that he has read the foregoing prepared direct testimony of B. K. Lee, that he would respond in the same manner to the questions if so asked upon taking the stand, and that the matters of fact set forth therein are true and correct to the best of his knowledge, information and belief.

B. K. Lee

Subscribed and sworn to before me, this 18th day of January, 1982

Notary Public

My commission expires 7-27-85

List of Exhibits

CLEARPRINT PAPER CO. C25 10 X 10 DIVISIONS PER INCH. 70 X 100 DIVISIONS. PRINTED IN U.S.A. ON CLEARPRINT TECHNICAL PAPER NO. 1015

HARZA ENGINEERING COMPANY JANUARY 1982

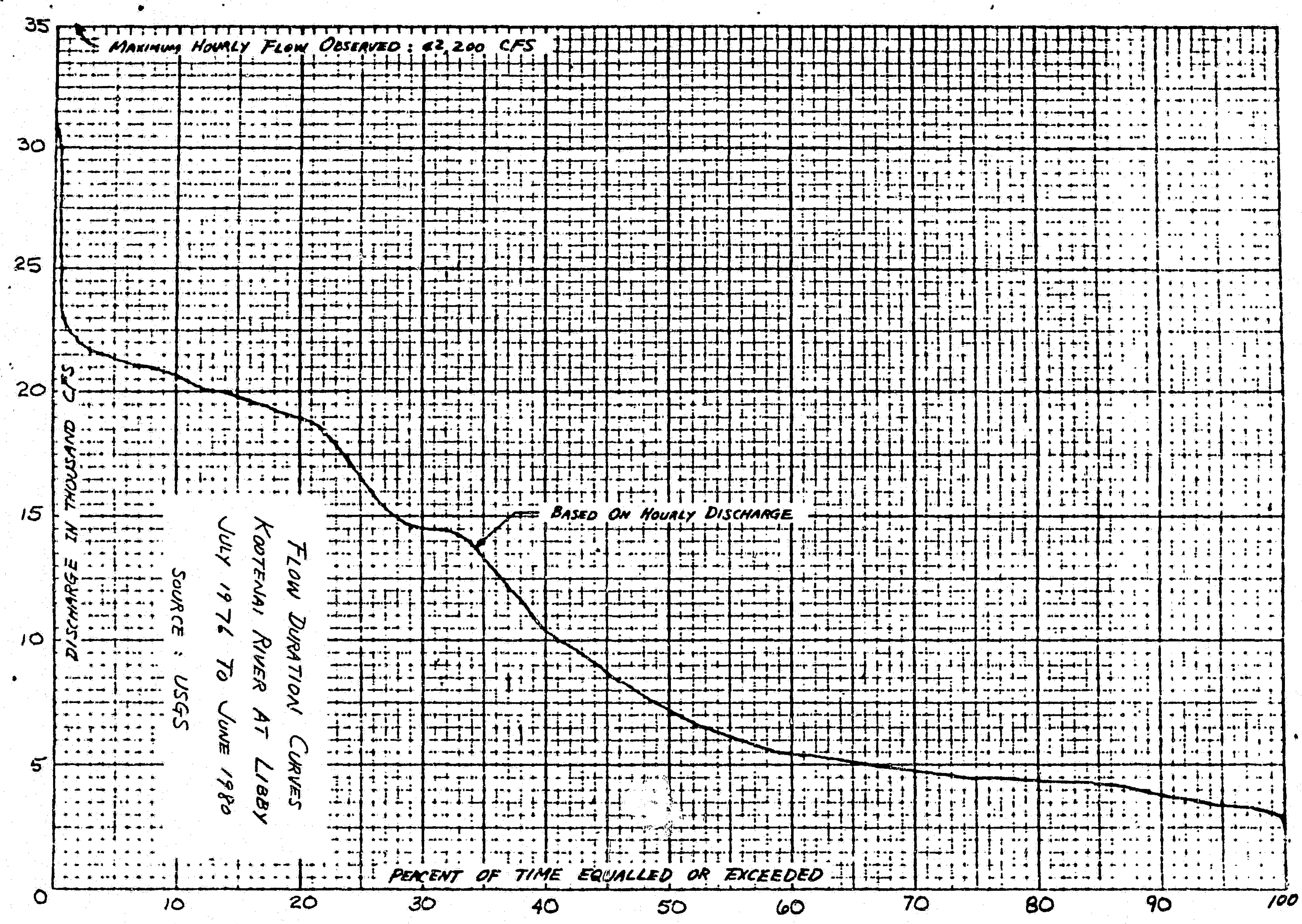
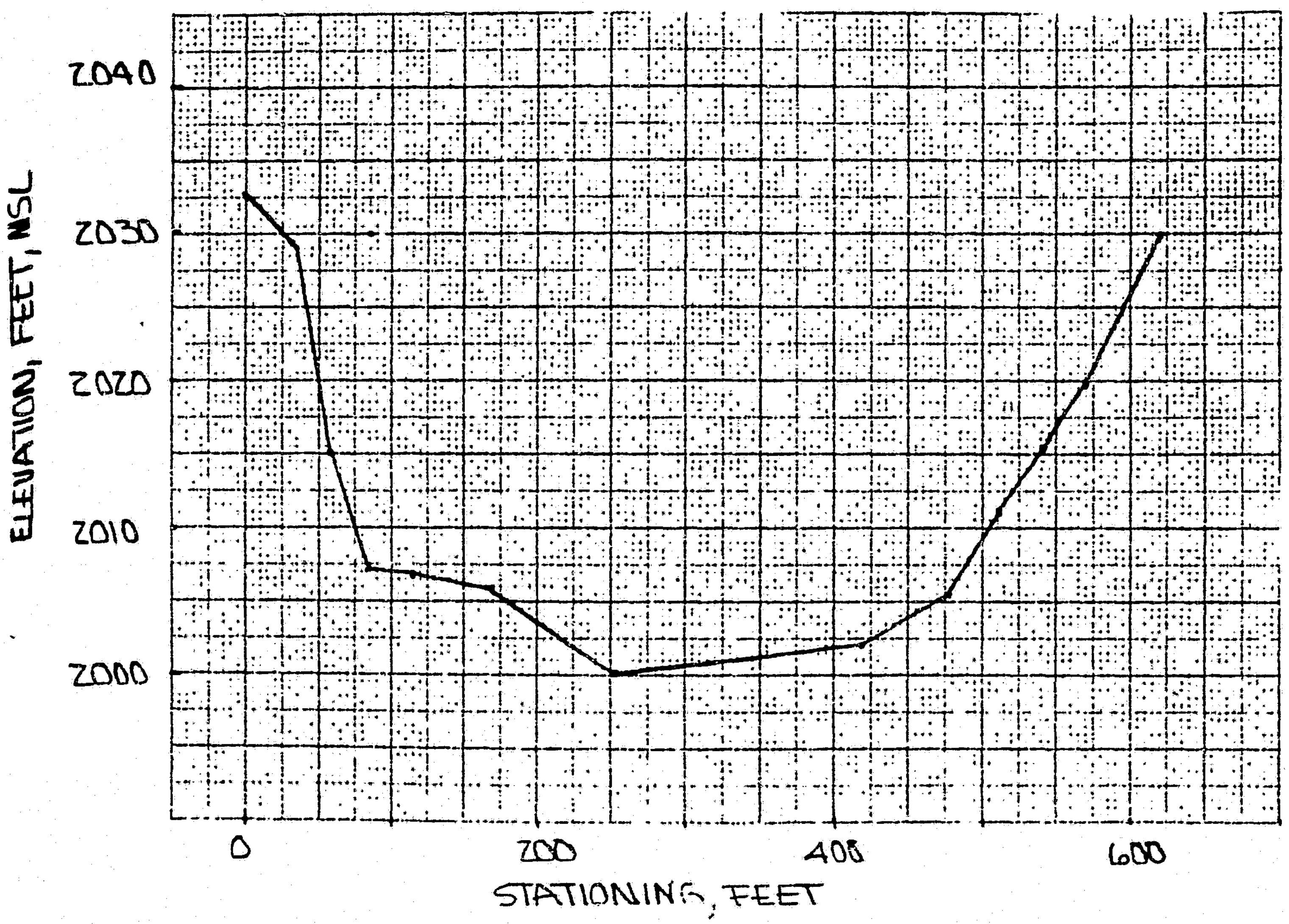


EXHIBIT __ (BKL-1)
PROJECT No. 2752

EXHIBIT ___ (BKL-2)
PROJECT No. 2752

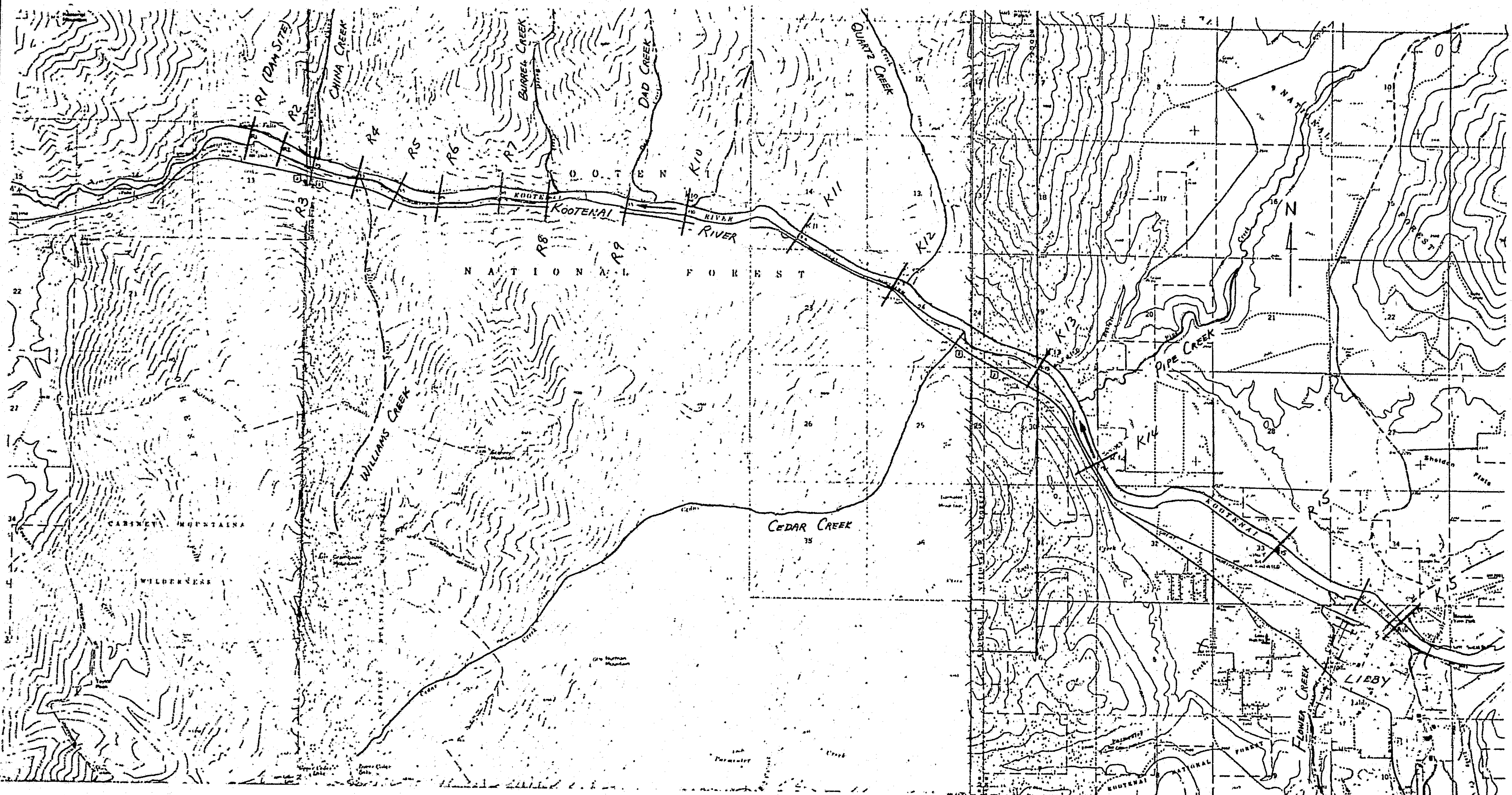


KOOTENAI RIVER
TYPICAL CROSS SECTION

HARZA ENGINEERING COMPANY
JANUARY 1982

CROSS SECTION K11, LOCATED 5.0 MILES UPSTREAM FROM THE DAM SITE

EXHIBIT ___ (BKL - 3)
PROJECT No. 2752



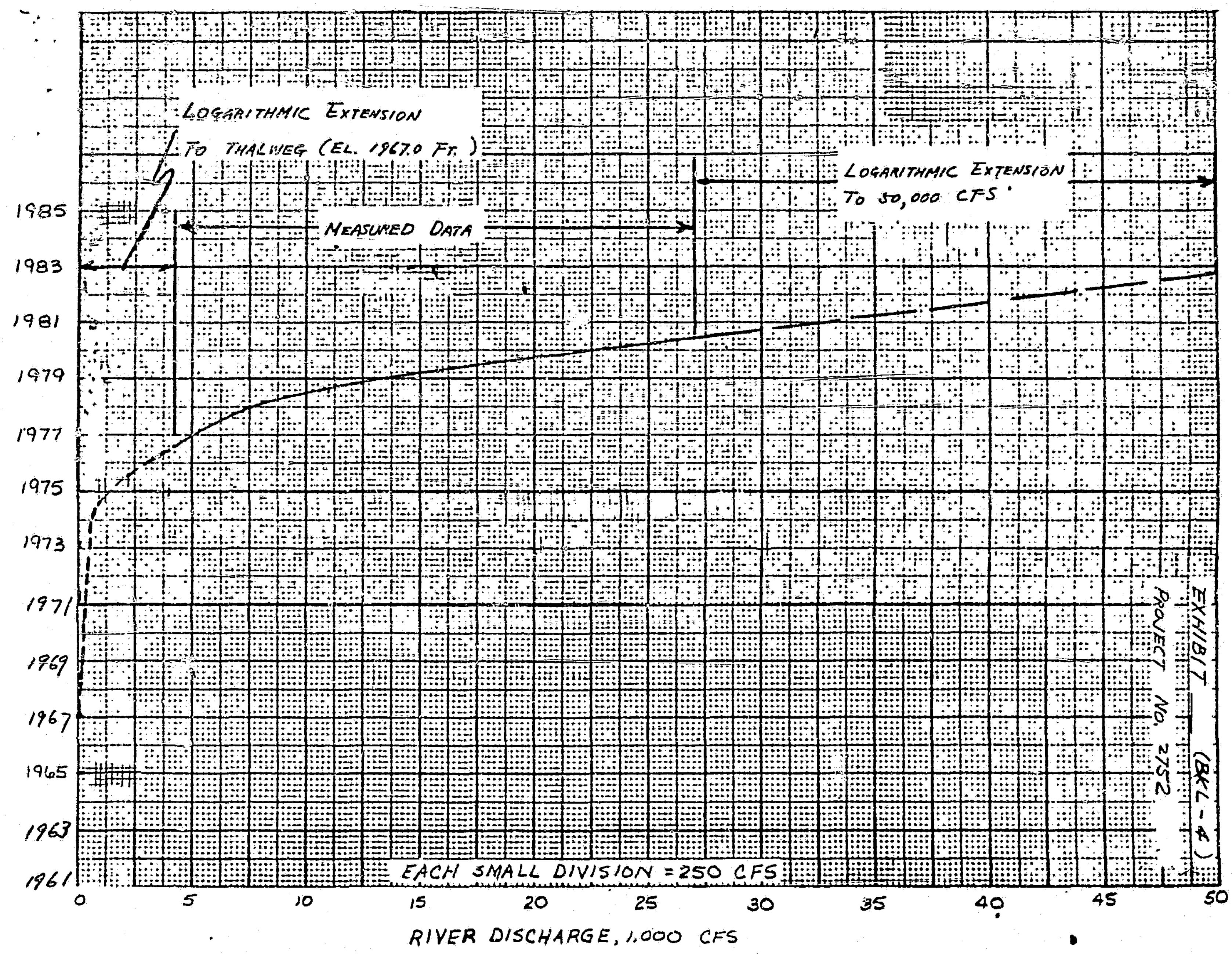
Approximate Scale
0 1 2 mile

Contour Interval : 40 Feet

LOCATIONS OF CROSS SECTIONS
KOOTENAI RIVER
DAM SITE TO LIBBY

HARZA ENGINEERING COMPANY
JANUARY 1982

HARZA ENGINEERING COMPANY
JANUARY 1982



DISCHARGE RATING CURVE
FOR DAM SITE
EXISTING CONDITION

EXHIBIT ___ (BKL-4)
PROJECT NO. 2752

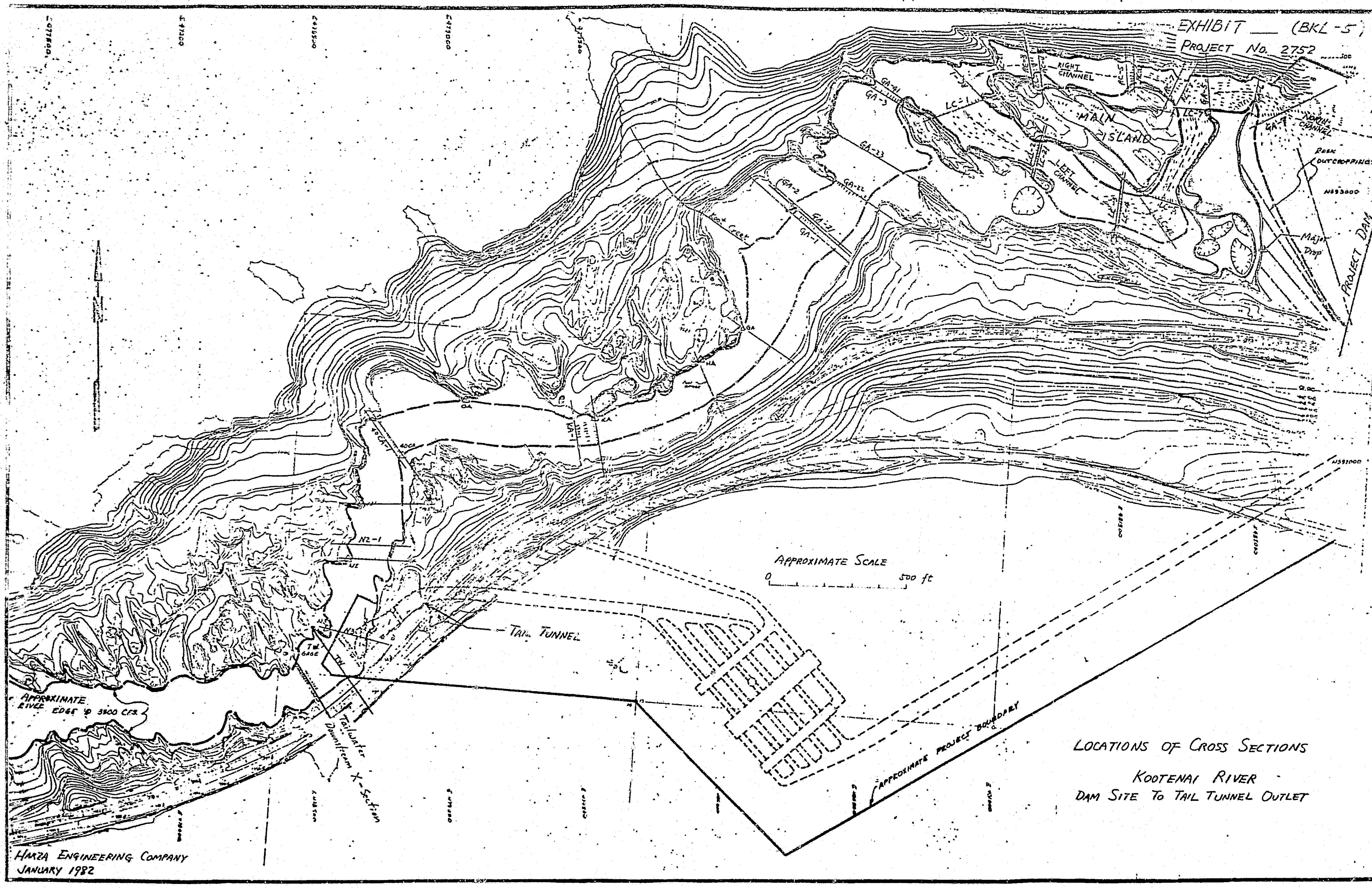
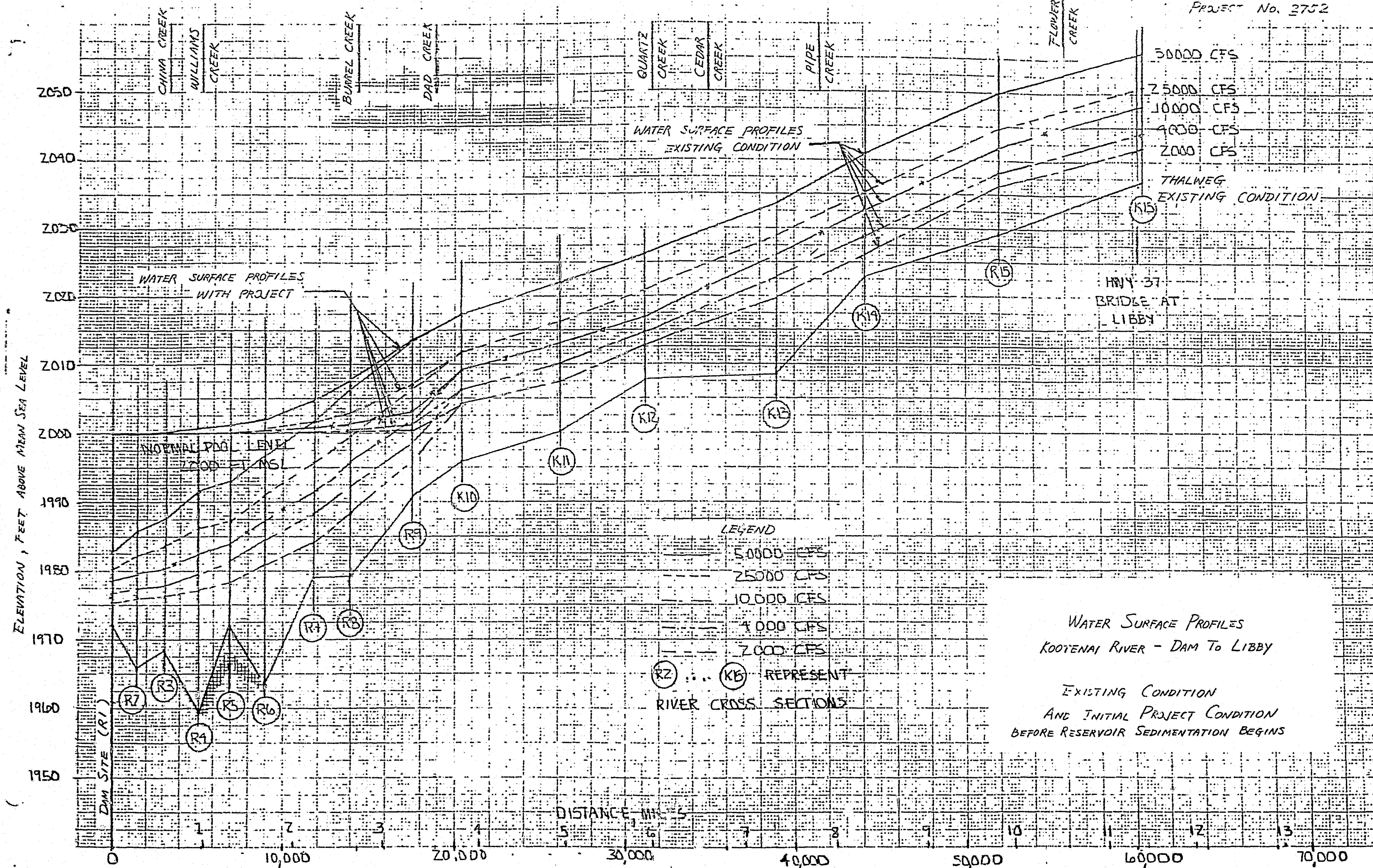


EXHIBIT ___ (BKL-5)
PROJECT No. 2752
RIGHT CHANNEL
MAIN ISLAND
LEFT CHANNEL
NORTH CHANNEL
ROCK OUTCROPPINGS
Major Drop
PROJECT DAM
GA-41
GA-3
GA-23
GA-22
GA-2
GA-21
GA-1
LC-1
N2-1
TAIL TUNNEL
Tailwater
Downstream X-Section
APPROXIMATE RIVER EDGE @ 3500 CFS
APPROXIMATE SCALE
0
500 ft
APPROXIMATE PROJECT BOUNDARY
LOCATIONS OF CROSS SECTIONS
KOOTENAI RIVER
DAM SITE TO TAIL TUNNEL OUTLET
HARZA ENGINEERING COMPANY
JANUARY 1982

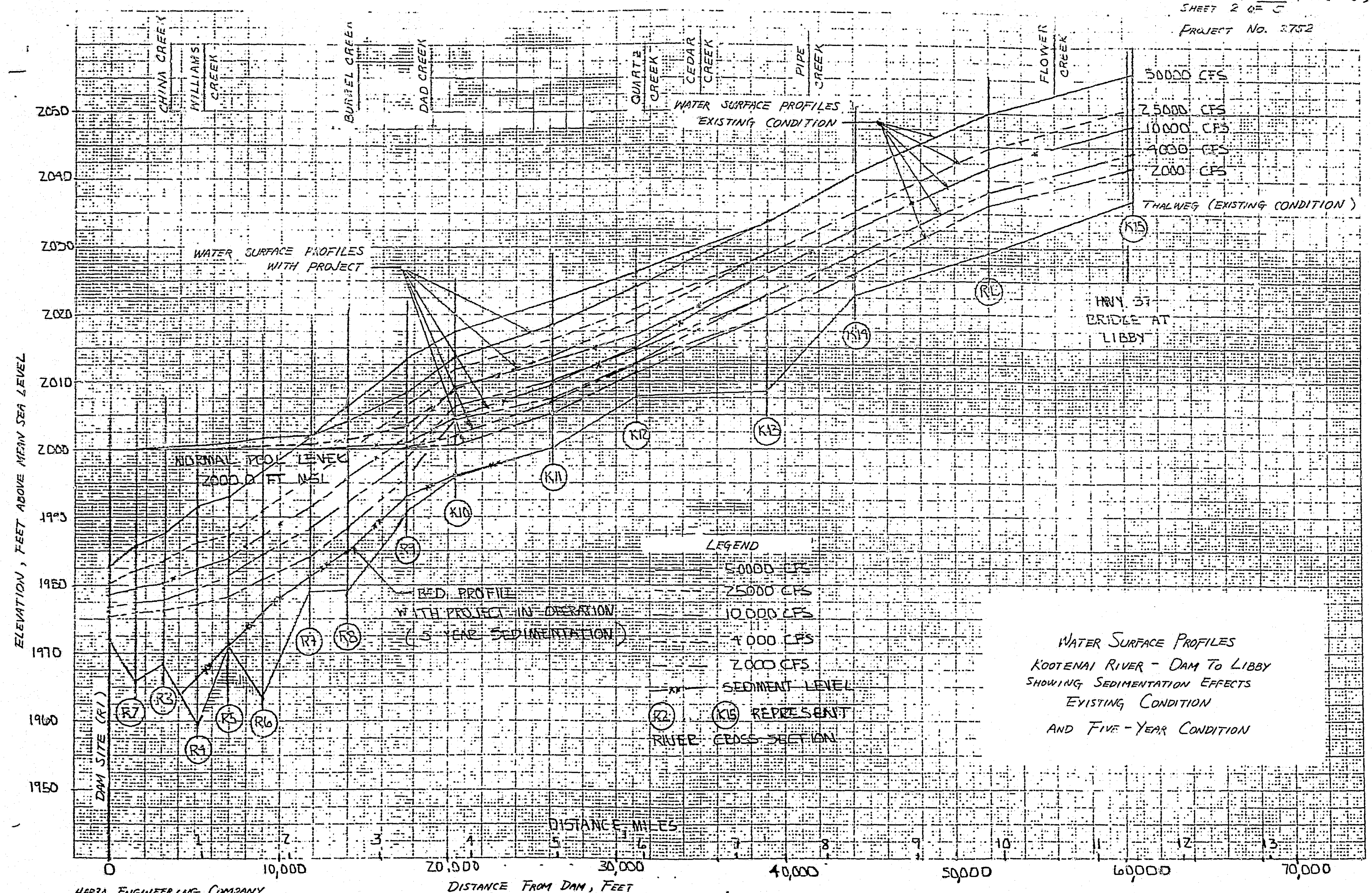
EXHIBIT ___ (BKL-6)
SHEET 1 OF 5
PROJECT No. 2752



HARZA ENGINEERING COMPANY JANUARY 1982

EXHIBIT ___ (SRL - 5)
SHEET 2 OF 5

PROJECT No. 2752



WATER SURFACE PROFILES
KOOTENAI RIVER - DAM TO LIBBY
SHOWING SEDIMENTATION EFFECTS
EXISTING CONDITION
AND FIVE-YEAR CONDITION

HARZA ENGINEERING COMPANY
JANUARY 1982

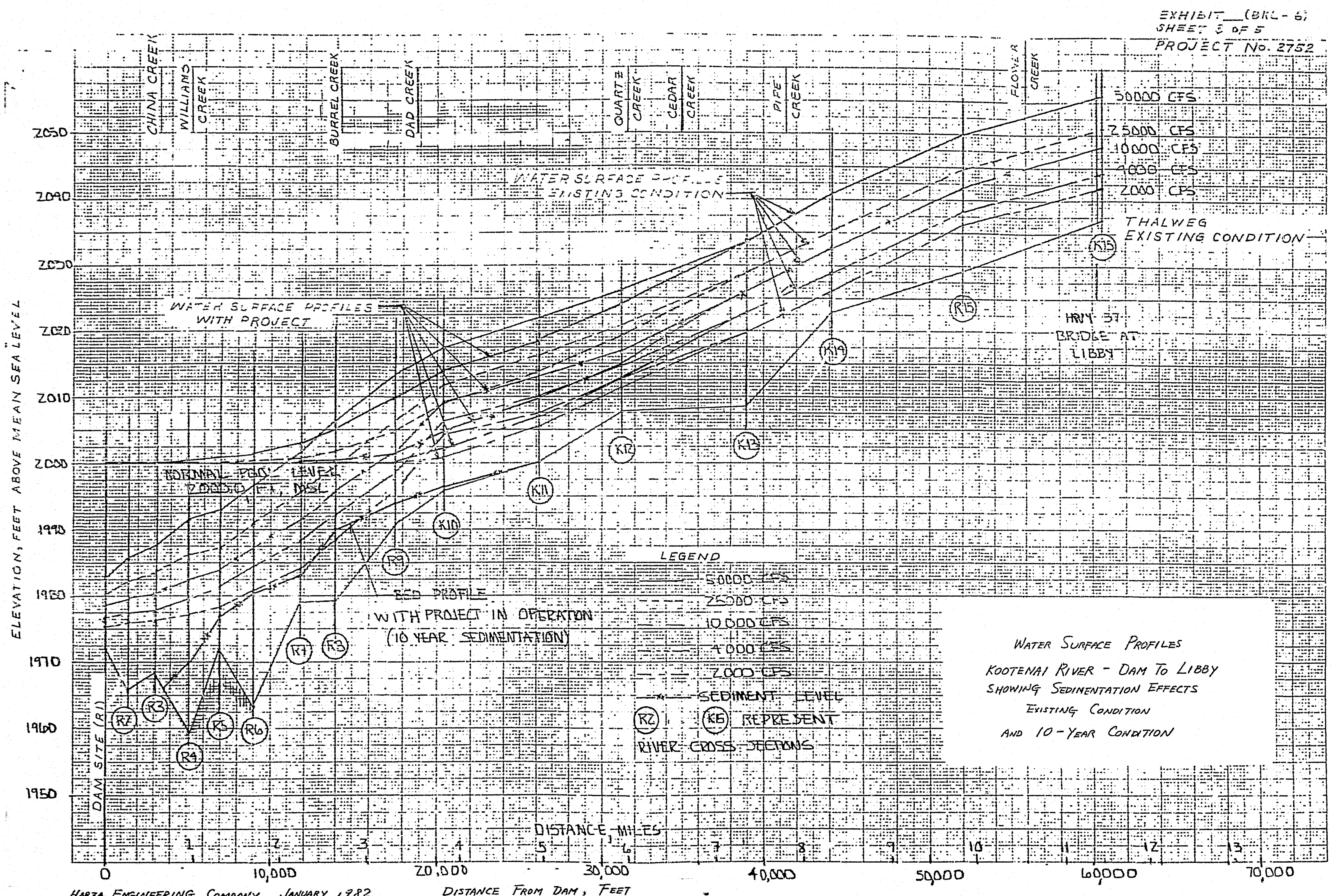
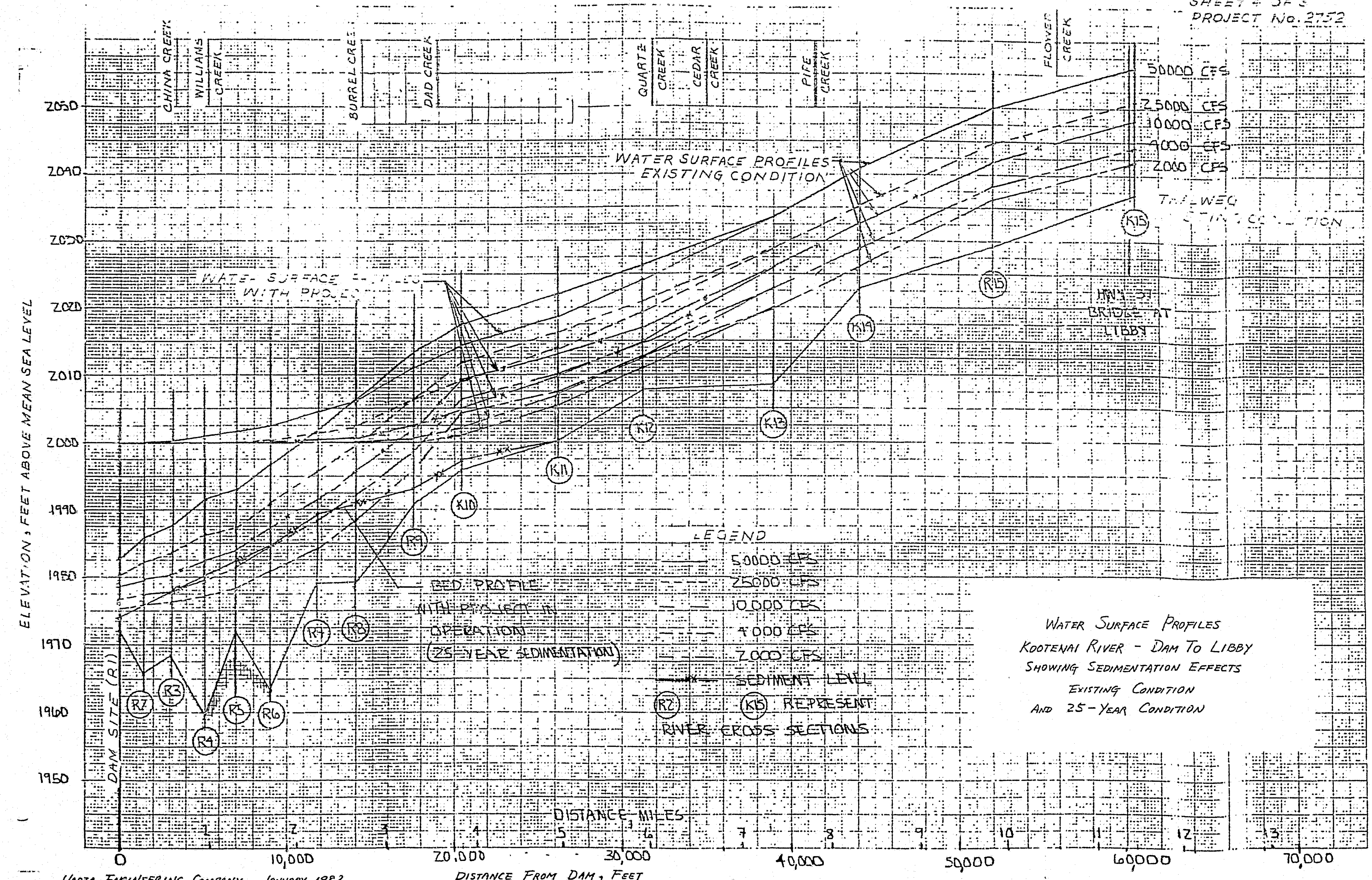


EXHIBIT __ (BKL - 6)
SHEET 5 OF 5
PROJECT No. 2752
CHINA CREEK
WILLIAMS CREEK
BURREL CREEK
DAD CREEK
QUARTZ CREEK
CEDAR CREEK
PIPE CREEK
FLOWER CREEK
50000 CFS
25000 CFS
10000 CFS
4000 CFS
2000 CFS
THALWEG EXISTING CONDITION
WATER SURFACE PROFILE EXISTING CONDITION
WATER SURFACE PROFILES WITH PROJECT
HWY 37 BRIDGE AT LIBBY
NORMAL POOL LEVEL 2000.0 FT. MSL
BED PROFILE WITH PROJECT IN OPERATION (10 YEAR SEDIMENTATION)
LEGEND
50000 CFS
25000 CFS
10000 CFS
4000 CFS
2000 CFS
SEDIMENT LEVEL
(R2) (K6) REPRESENT RIVER CROSS SECTIONS
WATER SURFACE PROFILES
KOOTENAI RIVER - DAM TO LIBBY
SHOWING SEDIMENTATION EFFECTS
EXISTING CONDITION
AND 10-YEAR CONDITION
DAM SITE (R1)
R2 R3 R4 R5 R6 R7 R8 R9 K10 K11 K12 K13 K14 R15 K15
ELEVATION, FEET ABOVE MEAN SEA LEVEL
1950 1960 1970 1980 1990 2000 2010 2020 2030 2040 2050
DISTANCE MILES
1 2 3 4 5 6 7 8 9 10 11 12 13
0 10,000 20,000 30,000 40,000 50,000 60,000 70,000
DISTANCE FROM DAM, FEET
HARZA ENGINEERING COMPANY JANUARY 1982

EXHIBIT ___
SHEET 4 OF 5
PROJECT No. 2752



WATER SURFACE PROFILES
KOOTENAI RIVER - DAM TO LIBBY
SHOWING SEDIMENTATION EFFECTS
EXISTING CONDITION
AND 25-YEAR CONDITION

HARZA ENGINEERING COMPANY JANUARY 1982

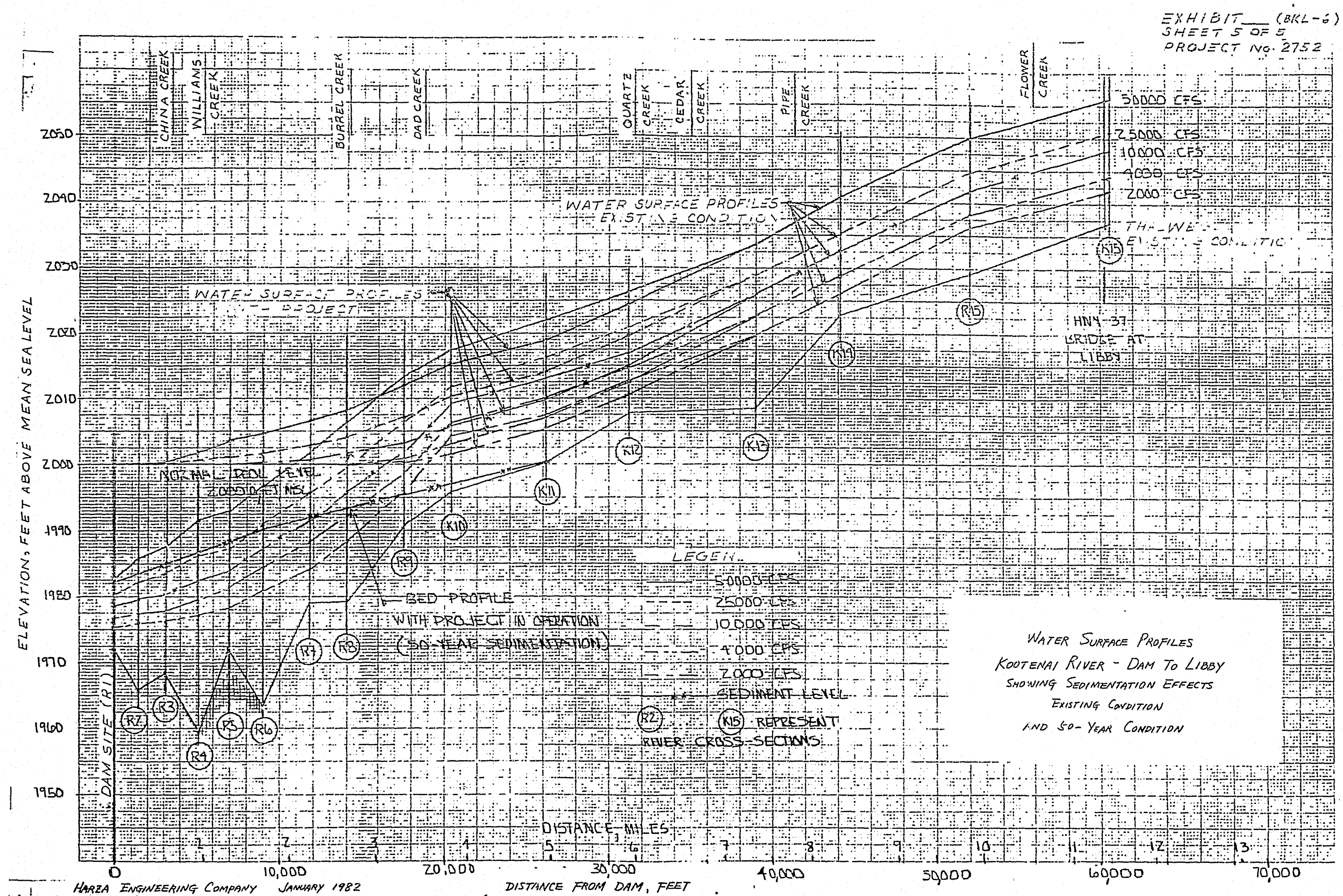


EXHIBIT___ (BKL-6)
SHEET 5 OF 5
PROJECT No. 2752
CHINA CREEK
WILLIAMS CREEK
BURREL CREEK
DAD CREEK
QUARTZ CREEK
CEDAR CREEK
PIPE CREEK
FLOWER CREEK
50000 CFS
25000 CFS
10000 CFS
4000 CFS
2000 CFS
WATER SURFACE PROFILES EXISTING CONDITION
WATER SURFACE PROFILES WITH PROJECT
NORMAL POOL LEVEL 2000.0 FT MSL
HWY 37 BRIDGE AT LIBBY
BED PROFILE
WITH PROJECT IN OPERATION
(50-YEAR SEDIMENTATION)
LEGEND
50000 CFS
25000 CFS
10000 CFS
4000 CFS
2000 CFS
SEDIMENT LEVEL
(R2)-(R15) REPRESENT RIVER CROSS-SECTIONS
WATER SURFACE PROFILES
KOOTENAI RIVER - DAM TO LIBBY
SHOWING SEDIMENTATION EFFECTS
EXISTING CONDITION
AND 50-YEAR CONDITION
ELEVATION, FEET ABOVE MEAN SEA LEVEL
DAM SITE (R1)
DISTANCE, MILES
DISTANCE FROM DAM, FEET
HARZA ENGINEERING COMPANY JANUARY 1982
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
2050
2040
2030
2020
2010
2000
1990
1980
1970
1960
1950
0
10,000
20,000
30,000
40,000
50,000
60,000
70,000
1
2
3
4
5
6
7
8
9
10
11
12
13

EXHIBIT_ (BKL-7)

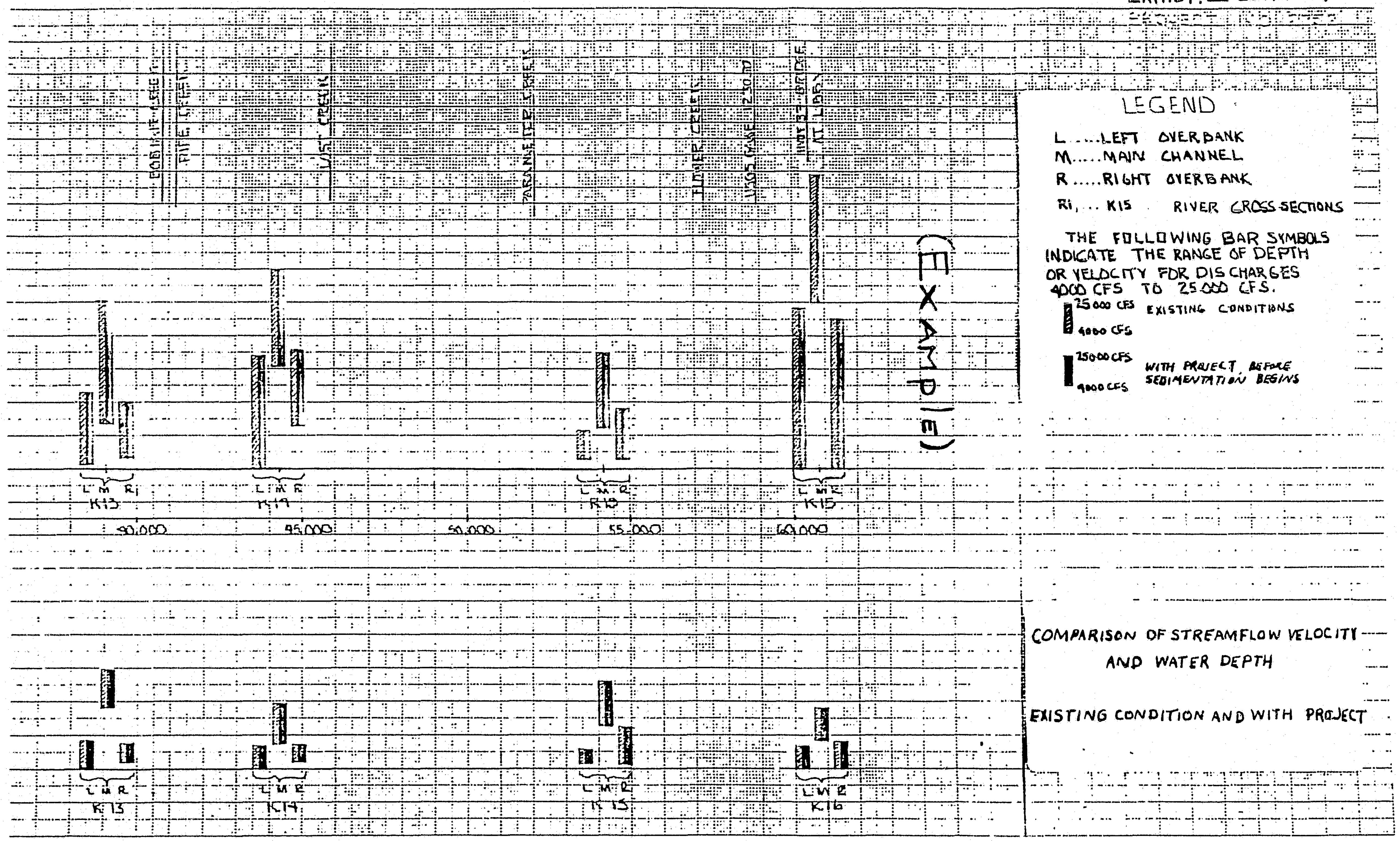


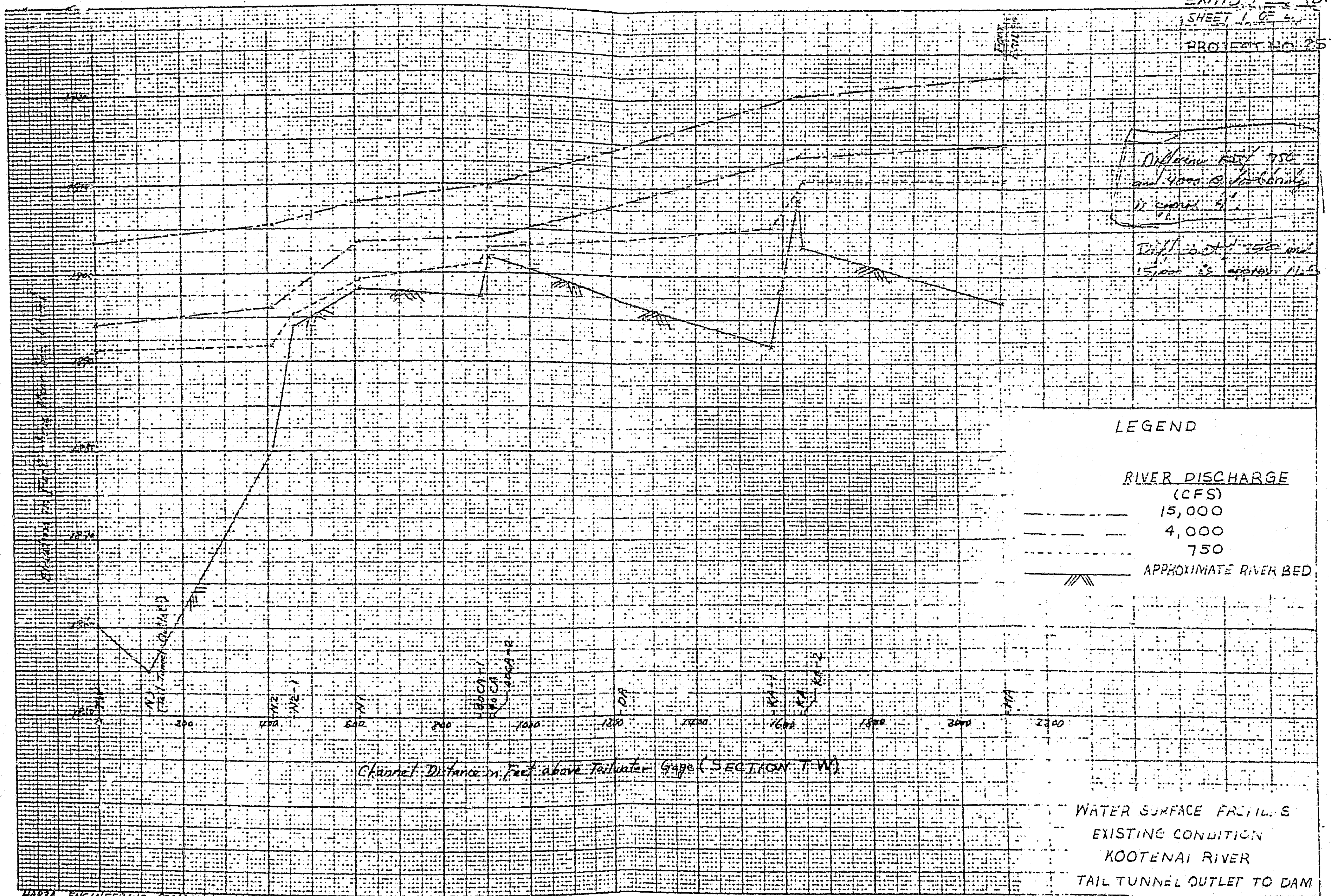
EXHIBIT ___)
(BKL-8)
PROJECT NO. 2752

INCREASE IN WATER SURFACE ELEVATION BETWEEN THE DAM AND TAIL TUNNEL OUTLET CAUSED BY THE PROJECT

River discharge-cfs	750	750	750	750	4,000	15,000
Powerstation discharge-cfs	2,000	6,000	12,000	24,000	24,000	24,000
Cross Section[1/]	Rise in Water Surface Elevation Above Existing Conditions-Feet					
TW	1.9	5.4	10.4	19.5	18.8	16.1
N2	1.7	5.5	11.1	20.7	18.5	15.9
N1 (Control Section)	0	0.1	3.5	13.1	11.1	13.3
40CA (Control Section)	0	0	0.2	9.6	10.6	11.5
KA (Control Section)	0	0	0.2	2.7	1.2	1.1
HA	0	0	0	1.7	0.9	2.3
GA	0	0	0	1.6	0.2	0.6
Koot Creek Bar is between GA and GA-1						
GA-1	0	0	0	1.4	0	0.5
GA-23	0	0	0	0	0	0.3
GA-3	0	0	0	0	0	0.3
GA-41	0	0	0	0	0	0

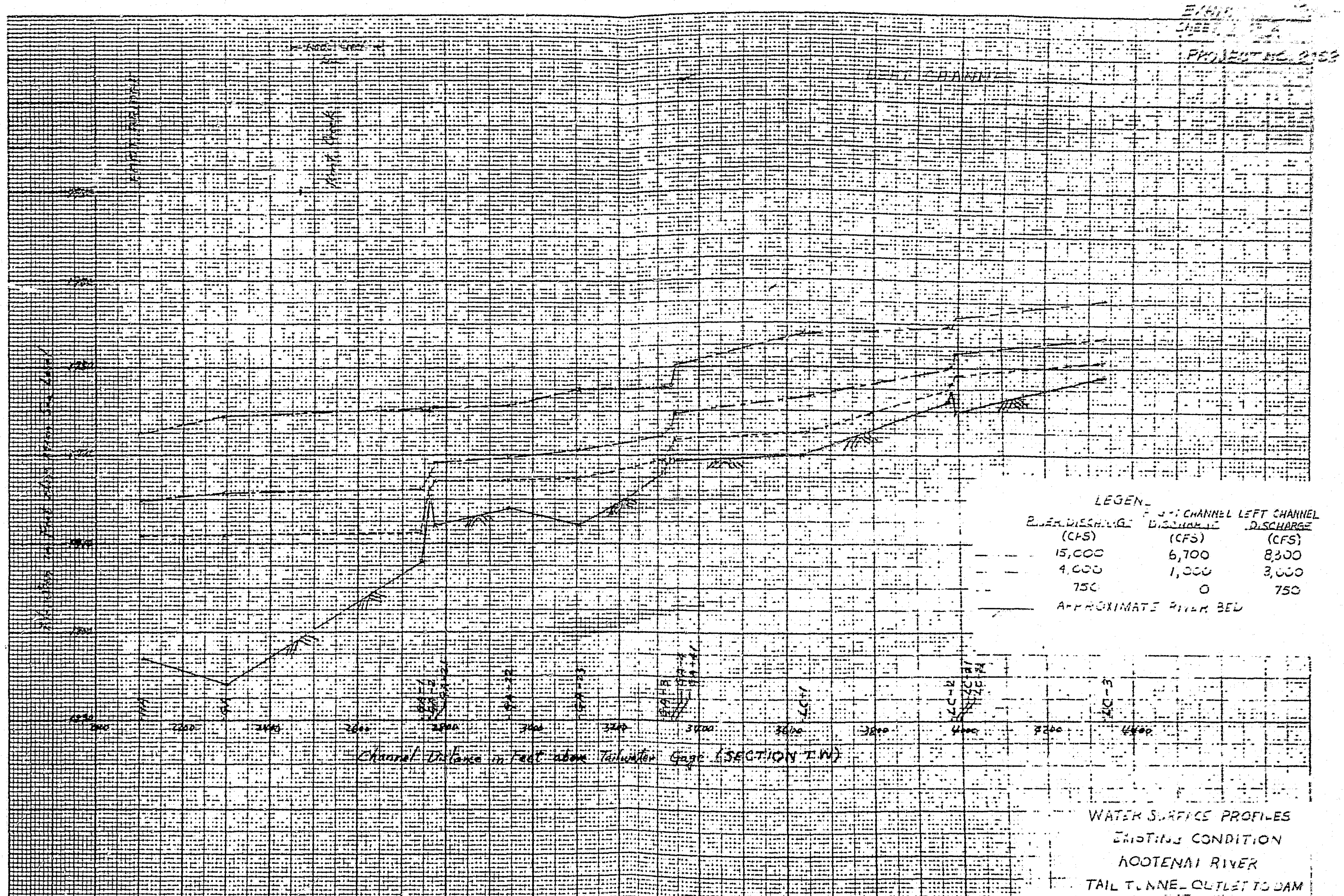
1/ Locations of cross sections are shown on Exhibit (BKL-5).

EXHIBIT (BKL-9)
SHEET 1 OF
PROJECT NO. 2572



WATER SURFACE PROFILES
EXISTING CONDITION
KOOTENAI RIVER
TAIL TUNNEL OUTLET TO DAM

HARZA ENGINEERING COMPANY JANUARY 1982

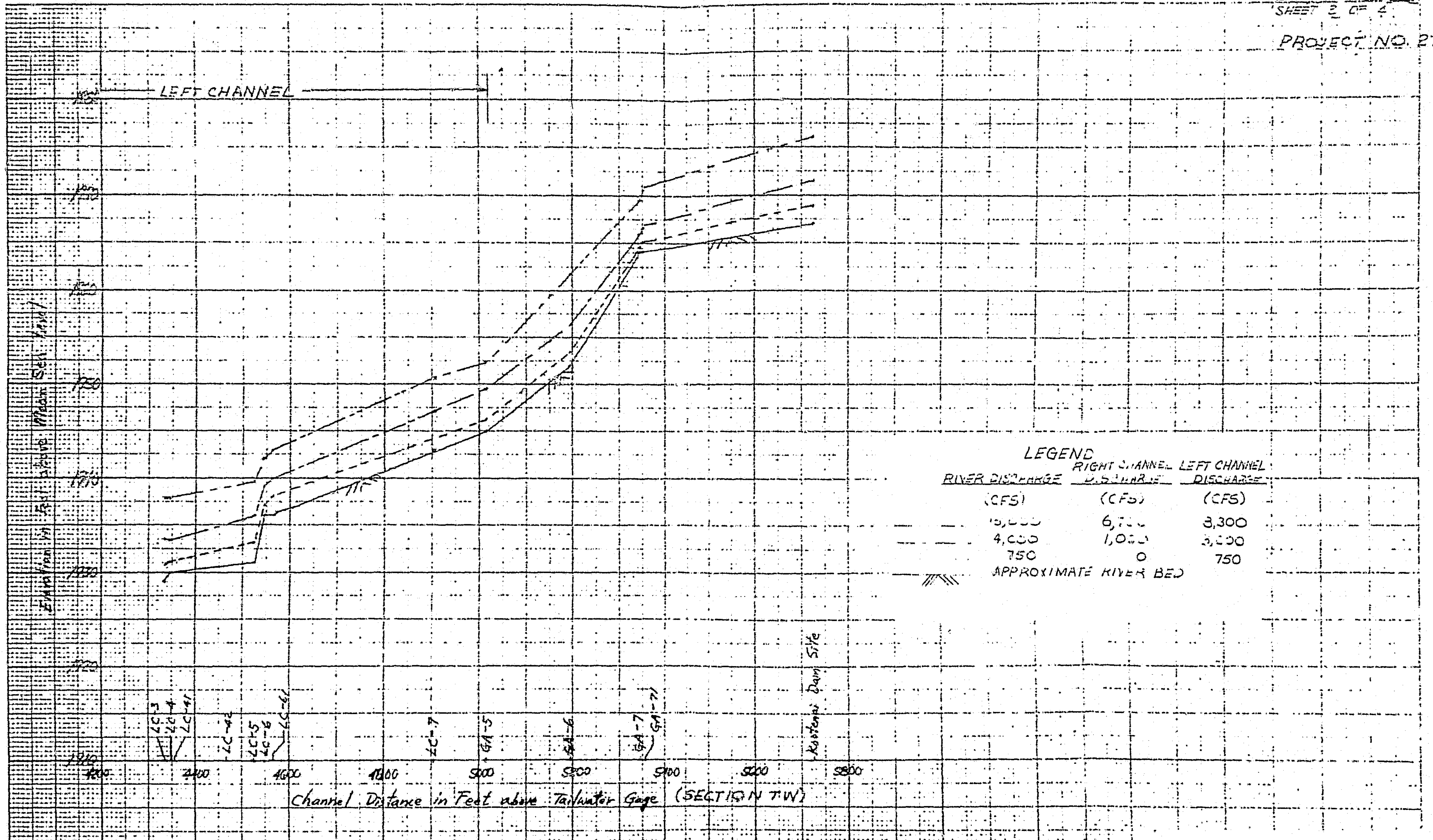


HARZA ENGINEERING COMPANY JAN. 1982

EXHIBIT — IBK-9

SHEET 2 OF 4

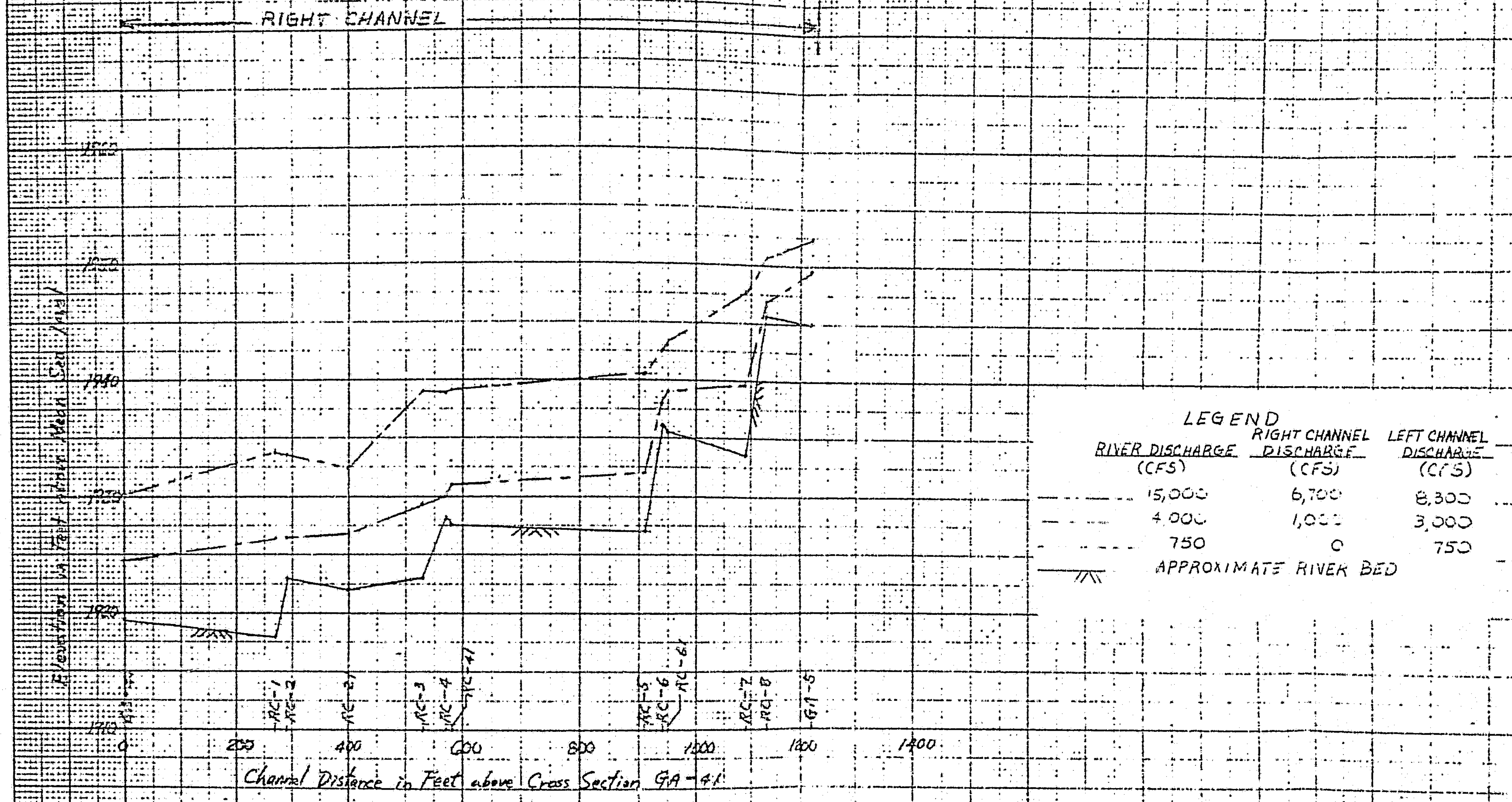
PROJECT NO. 2752



WATER SURFACE PROFILES
EXISTING CONDITION
KOOTENAI RIVER
TAIL TUNNEL OUTLET TO DAM

HARZA ENGINEERING COMPANY JAN. 1982

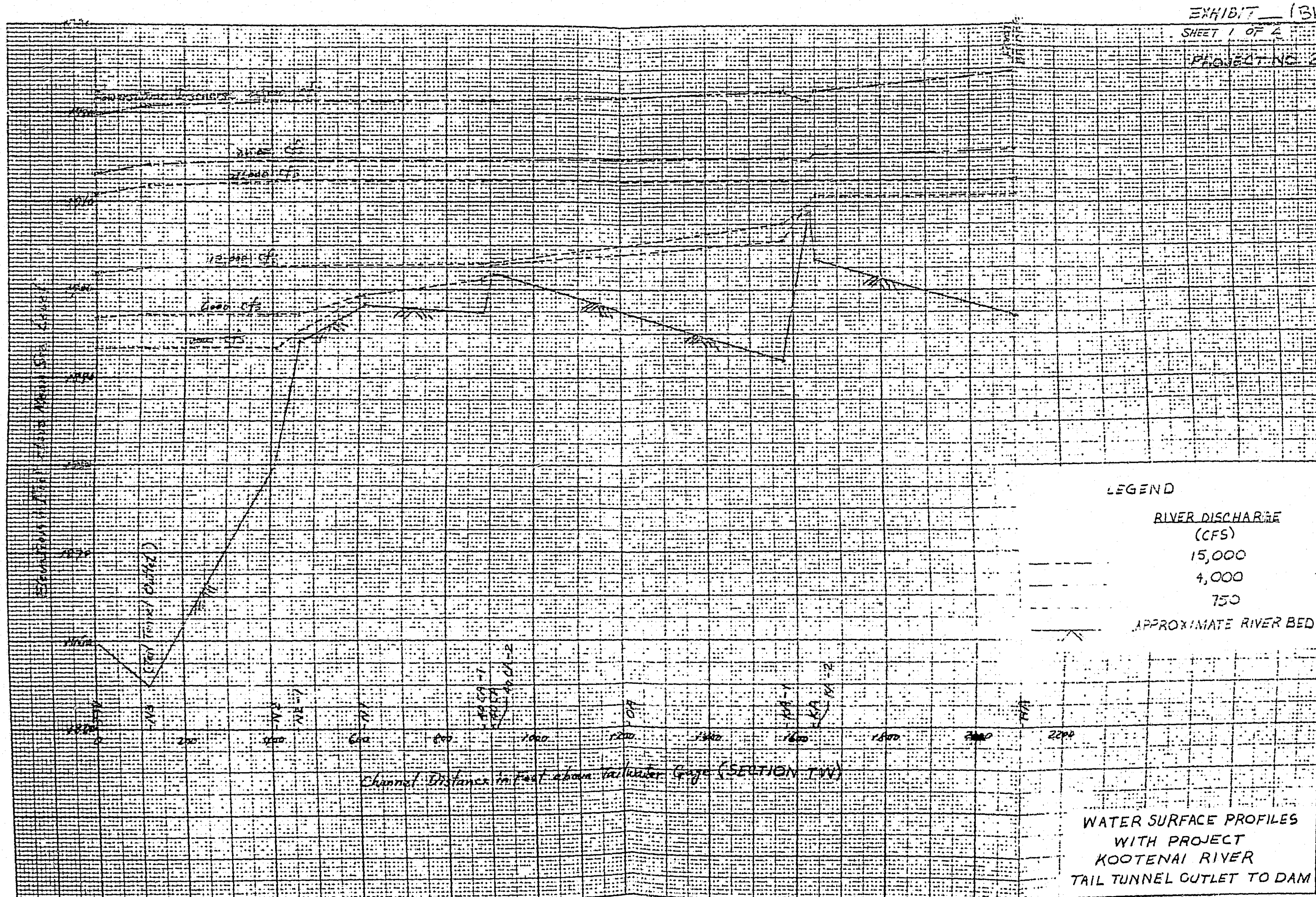
EXHIBIT ___ (BKL-9)
SHEET 4 OF 4
PROJECT NO. 2752



WATER SURFACE PROFILES
EXISTING CONDITION
KOOTENAI RIVER
TAIL TUNNEL OUTLET TO DAM

HARZA ENGINEERING COMPANY JAN 1982

EXHIBIT __ (BKL-15)
SHEET 1 OF 4
PROJECT NO. 2752

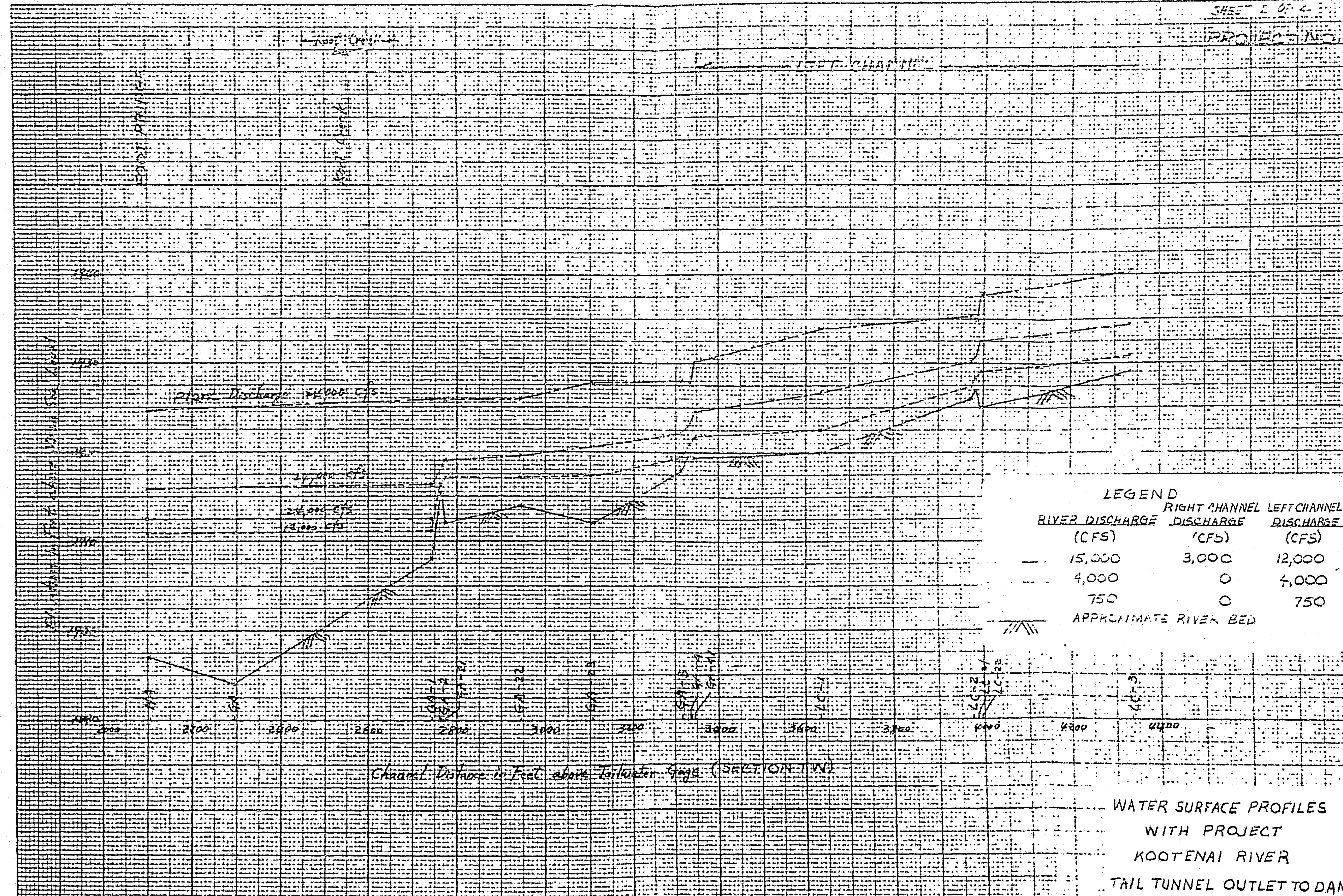


HARZA ENGINEERING COMPANY JAN. 1982

EXHIBIT

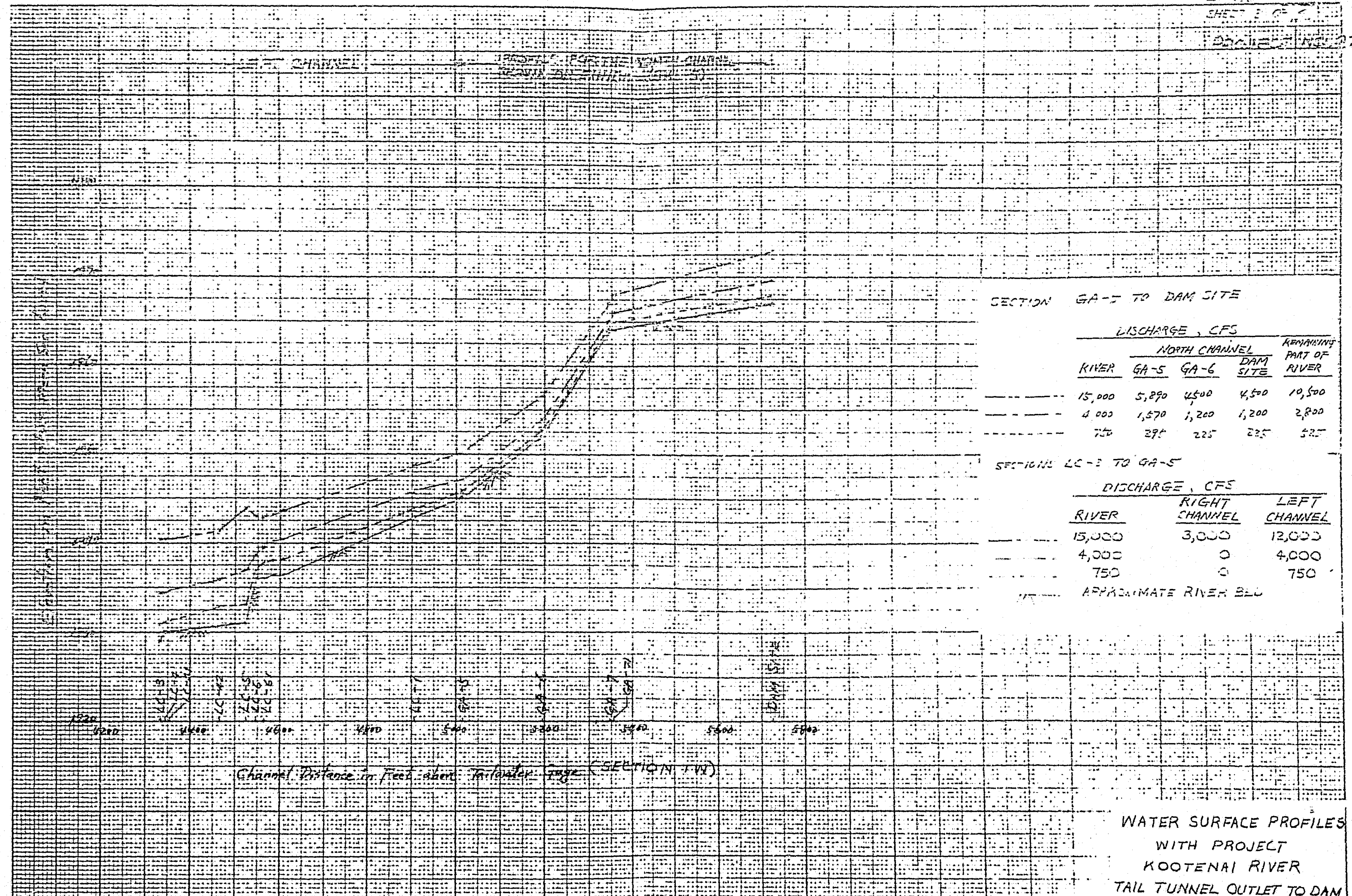
SHEET 2 OF 2

PROJECT NO. 2752



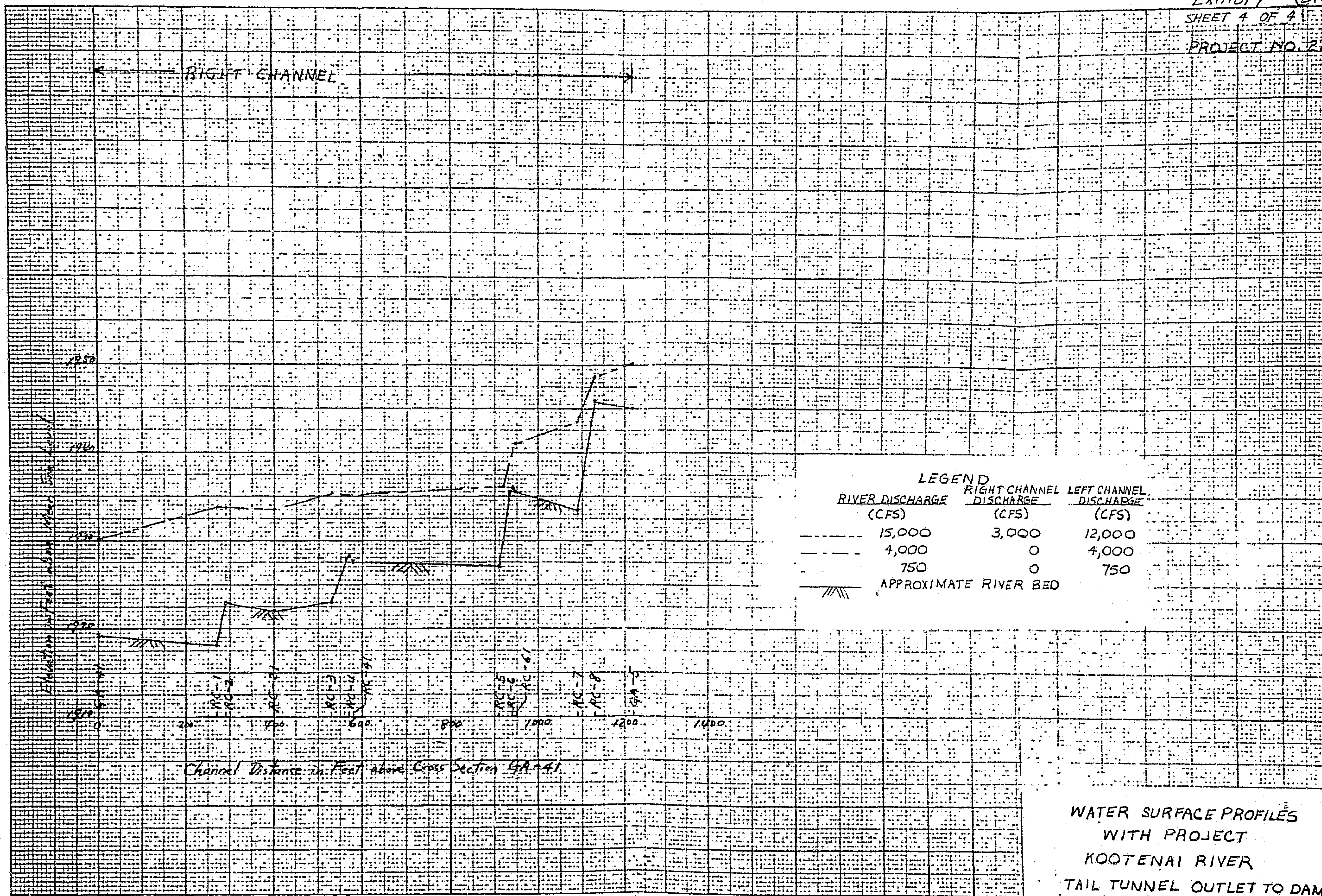
WATER SURFACE PROFILES
WITH PROJECT
KOOTENAI RIVER
TAIL TUNNEL OUTLET TO DAM

HARZA ENGINEERING COMPANY JAN. 1982



HARZA ENGINEERING COMPANY JAN. 1982

EXHIBIT (BKL-10)
SHEET 4 OF 4
PROJECT NO. 2752



HARZA ENGINEERING COMPANY JAN. 1982

STREAMFLOW VELOCITY IN POOLS
BETWEEN THE DAM AND TAIL TUNNEL OUTLET

Pool Locations Between Controls		Existing Condition			Velocities in Feet Per Second — With Project — 750 cfs Over the Dam				With Project — 24,000 cfs Through Powerstation	
Downstream	Upstream	750 cfs	4,000 cfs	15,000 cfs	Power-station 2,000 cfs	Power-station 6,000 cfs	Power-station 12,000 cfs	Power-station 24,000 cfs	Over Dam 4,000 cfs	Over Dam 15,000 cfs
Tail Tunnel Outlet	N1	0.3-0.5	1.5-2.0	4.0-4.6	0.3-0.5	0.25-0.4	0.2-0.3	0.15-0.2	0.7-1.9	2.3-2.7
N1	40-CA	0.3-1.4	3.0-3.9	6.25-8.0	1.3-1.4	1.3-1.4	0.4-0.8	0.15-0.3	1.2-1.8	3.3-4.8
40-CA	KA	0.5	1.9	5.0	0-5	0.5	0.5	0.25	1.6	4.5
KA	GA-2	0.6-1.7	[redacted]	4.4-5.4	0.6-1.7	[redacted]	0.6-1.7	0.5-1.5	2.0-2.7	4.0-5.0
GA-2	GA-4	0.5-1.7	1.7-5.0	3.3-8.9	0.5-1.7	0.5-1.7	0.5-1.7	0.5-1.7	1.7-5.0	3.3-8.9
GA-4	LC-2	1.8-2.3[1/]	2.7-5.9[2/]	7.5-10.7[3/]	1.8-2.3[4/]	1.8-2.3[4/]	1.8-2.3[4/]	1.8-2.3[4/]	3.6-5.9[4/]	5.1-10[5/]
LC-2	LC-6	2.0-5.9[1/]	4.6-7.4[2/]	7.4-8.9[3/]	2.0-5.9[4/]	2.0-5.9[4/]	2.0-5.9[4/]	2.0-5.9[4/]	5.6-7.8[4/]	3.9-9.9[5/]

1/ When river discharge is 750 cfs, Left Channel passes the entire flow. No flow passes through Right Channel.

2/ When river discharge is 4000 cfs, Left Channel passes 3000 cfs.

3/ When river discharge is 15,000 cfs, Left Channel passes 8300 cfs.

4/ When discharge over the dam is 750 cfs or 4000 cfs, the entire flow passes through Left Channel.

5/ When discharge over the dam is 15,000 cfs, Left Channel passes 12,000 cfs.

EXHIBIT ___ (BKL-11)
PROJECT NO. 2752

EXHIBIT ___ (BKL-12)
PROJECT NO. 2752

STREAMFLOW VELOCITIES AND DEPTHS AT CONTROLS
BETWEEN THE DAM SITE AND TAIL TUNNEL OUTLET
EXISTING CONDITIONS

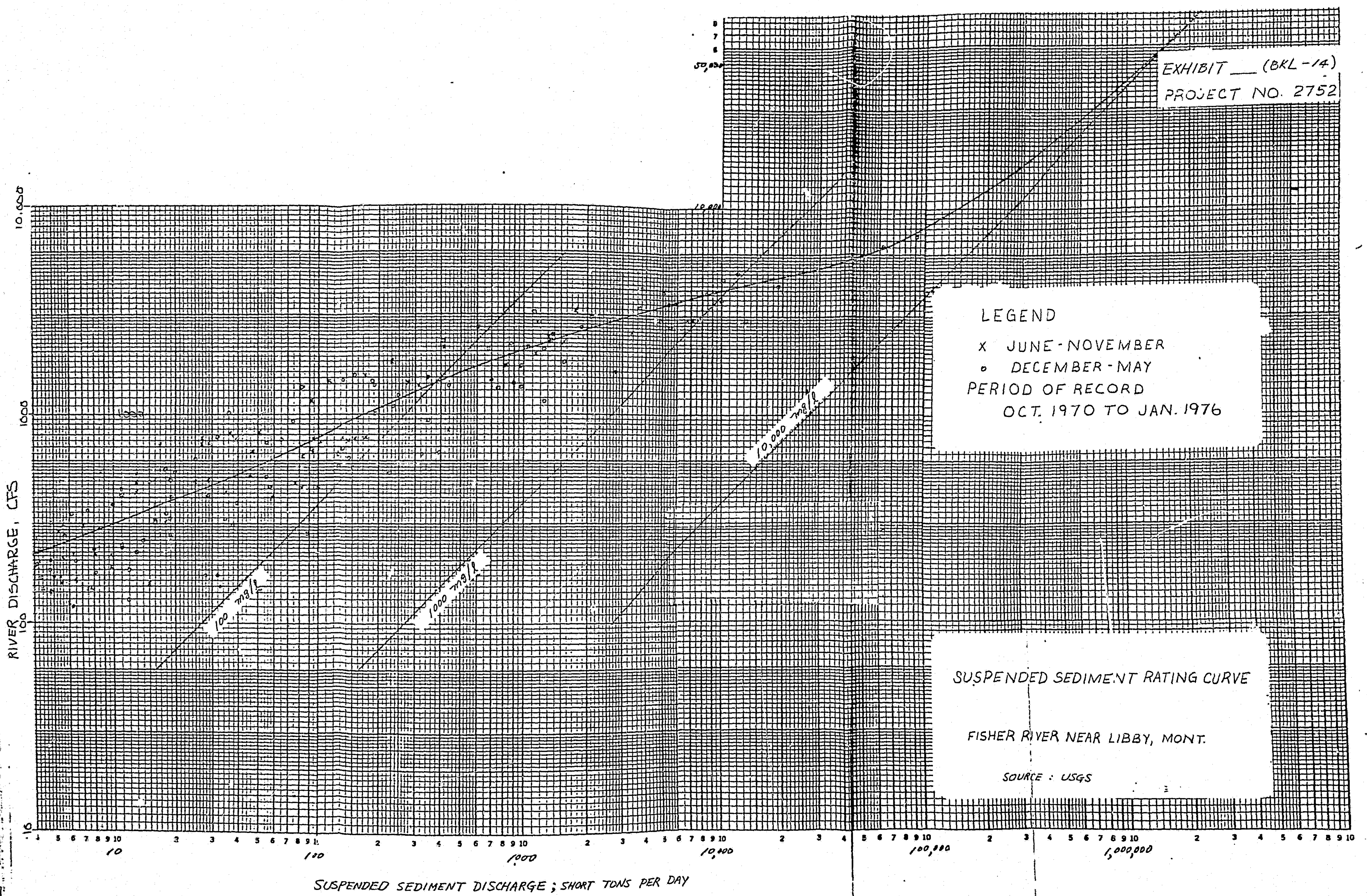
Control	River Discharge 750 cfs		River Discharge 4,000 cfs		River Discharge 15,000 cfs	
	Depth Feet	Velocity Feet Per Second	Depth Feet	Velocity Feet Per Second	Depth Feet	Velocity Feet Per Second
N1	1.0	1.3	5.2	3.8	9.7	7.5
40CA	1.1	5.9	3.0	9.7	8.2	13.6
KA	1.1	6.2	4.9	7.4	11.8	11.6
GA-2	0.8	5.0	2.3	8.7	9.5	6.8
GA-4	1.1	5.9	3.3	10.1	7.8	16.0
IN LEFT CHANNEL						
LC-21	1.2	6.4	3.2	10.0	7.6	11.5
LC-6	1.2	6.3	3.0	9.9	6.0	13.9
IN RIGHT CHANNEL						
RC-3	0	0	1.7	7.4	10.5	8.0
RC-6	0	0	1.8	7.7	6.5	14.5
RC-8	0	0	1.2	6.6	4.9	12.5
IN NORTH CHANNEL						
GA-7	0.7	4.6	2.0	8.0	5.6	8.0

EXHIBIT __(BKL-13)
PROJECT NO. 2752

STREAMFLOW VELOCITY AT CONTROL SECTIONS, FT/SEC
EXISTING CONDITION AND WITH PROJECT

Cross Section	Existing Condition River Discharge, cfs 750	4000	15,000	With Project Discharge Over The Dam, cfs: 750 / Powerstation Discharge, cfs: 2,000	750 / 6000	750 / 12,000	750 / 24,000	4000 / 24,000	15,000 / 24,000
N1	3.8	3.8	7.5	3.8	1.1	0.8	0.3	1.2	3.3
40CA	5.9	9.7	13.6	5.9	5.9	4.8	0.6	2.6	6.4
KA	6.2	7.4	11.6	6.2	6.2	6.2	2.0	6.6	11.6
GA-2	5.0	8.7	6.8	5.0	5.0	5.0	5.0	8.7	6.8
GA-4	5.9	10.1	16.0	5.9	5.9	5.9	5.9	10.1	16.0
LC-21	6.4	10.0	11.5	6.4	6.4	6.4	6.4	10.0	16.0
LC-6	6.3	9.9	13.9	6.3	6.3	6.3	6.3	9.9	8.3
GA-7	4.6	8.0	8.0	4.6	4.6	4.6	4.6	8.0	9.9
RC-3	0	7.4	8.0	0	0	0	0	7.4	2.7
RC-6	0	7.7	14.5	0	0	0	0	7.7	11.1
RC-8	0	6.6	12.5	0	0	0	0	6.6	9.6

EXHIBIT ___ (BKL-14)
PROJECT NO. 2752



SUSPENDED SEDIMENT RATING CURVE

FISHER RIVER NEAR LIBBY, MONT.

SOURCE: USGS

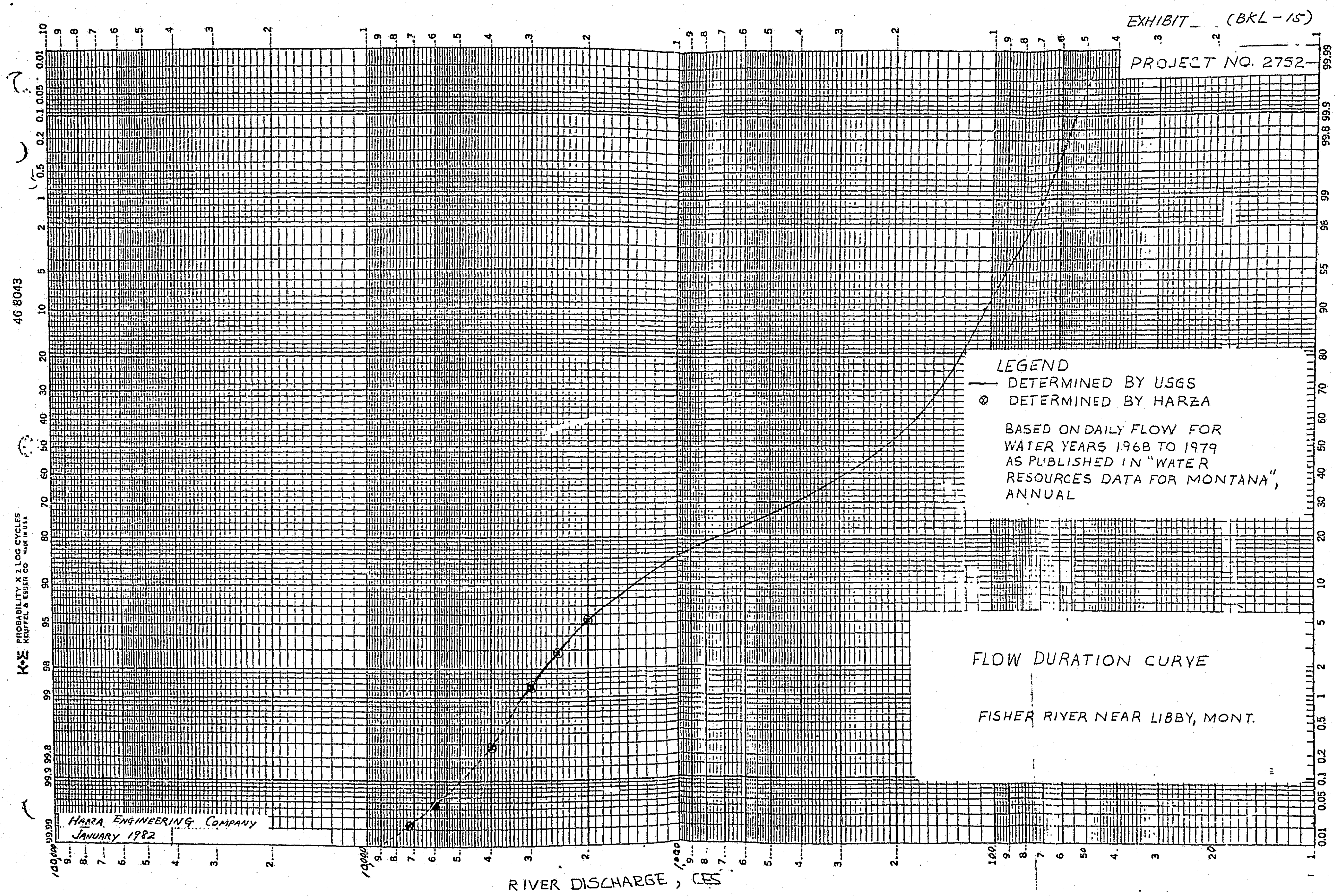
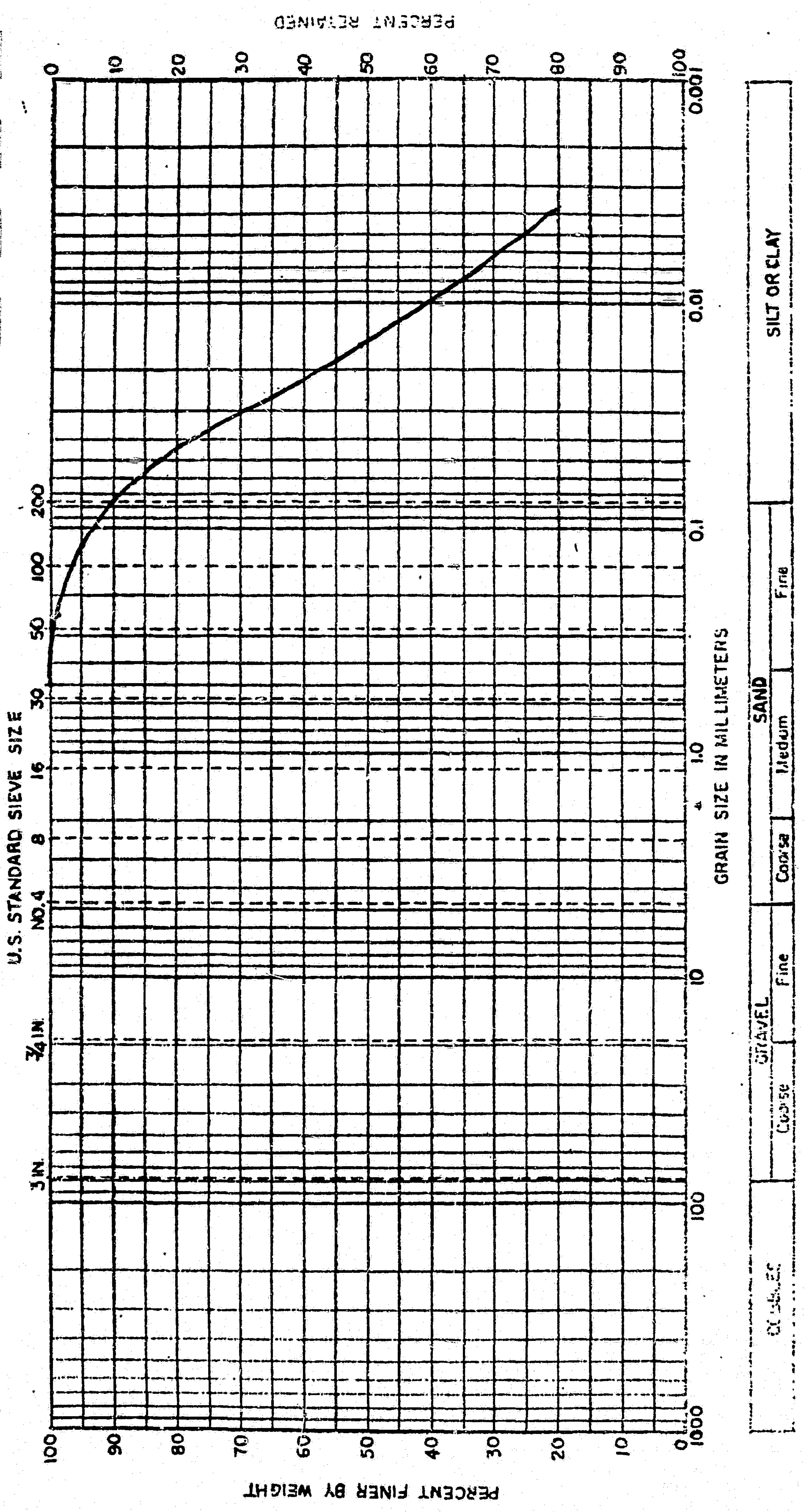


EXHIBIT_ (BKL-15)
PROJECT NO. 2752
LEGEND
DETERMINED BY USGS
DETERMINED BY HARZA
BASED ON DAILY FLOW FOR WATER YEARS 1968 TO 1979 AS PUBLISHED IN "WATER RESOURCES DATA FOR MONTANA", ANNUAL
FLOW DURATION CURVE
FISHER RIVER NEAR LIBBY, MONT.
HARZA ENGINEERING COMPANY
JANUARY 1982
RIVER DISCHARGE, CFS
% TIME, RIVER DISCHARGE IS EQUALLED OR EXCEEDED
46 8043
K+E PROBABILITY X 2 LOG CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.

EXHIBIT ___ (BKL-16)
PROJECT NO. 2752

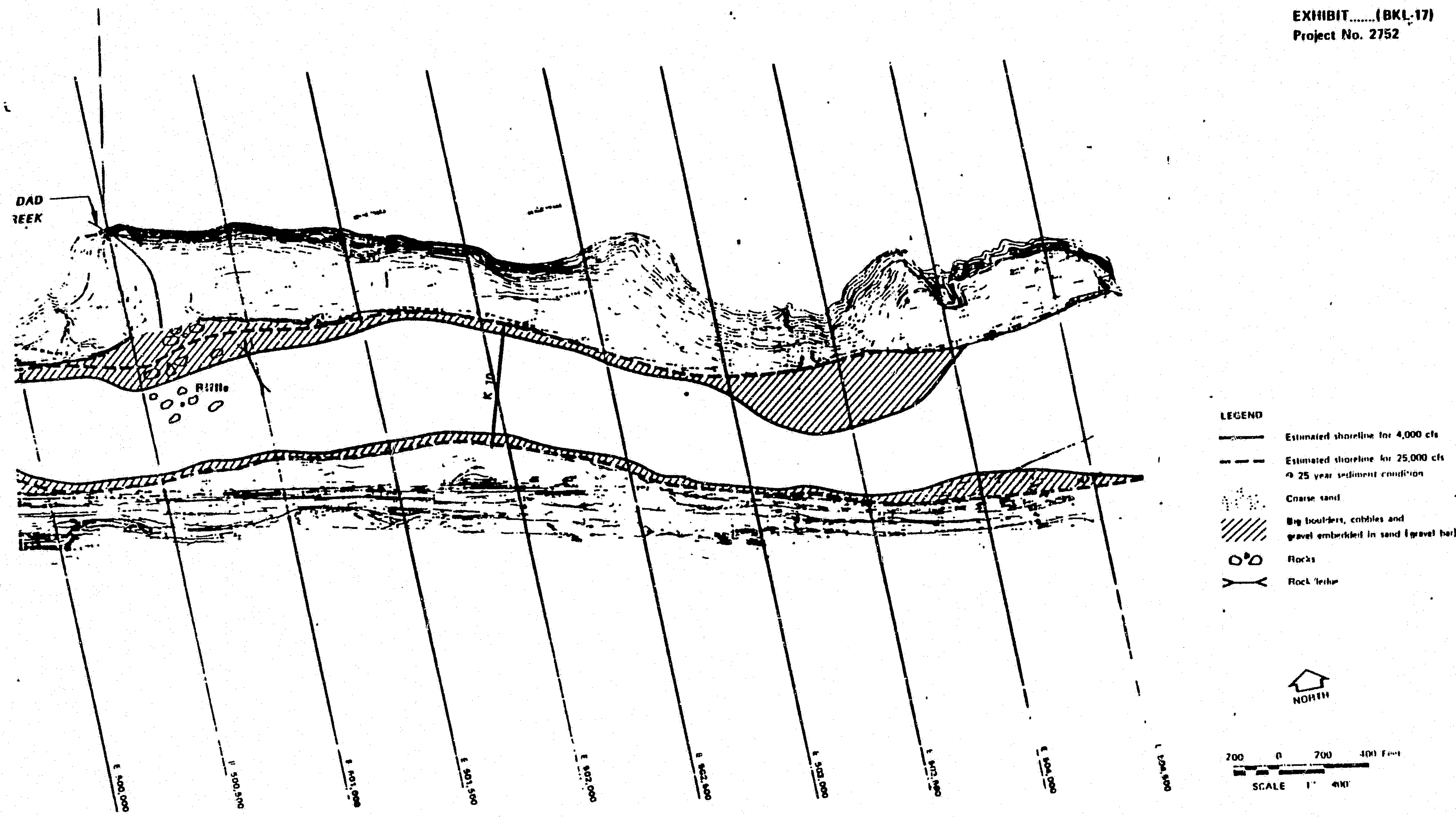


PARTICLE SIZE DISTRIBUTION
OF
SUSPENDED SEDIMENT

FISHER RIVER
NEAR
LIBBY, MONT

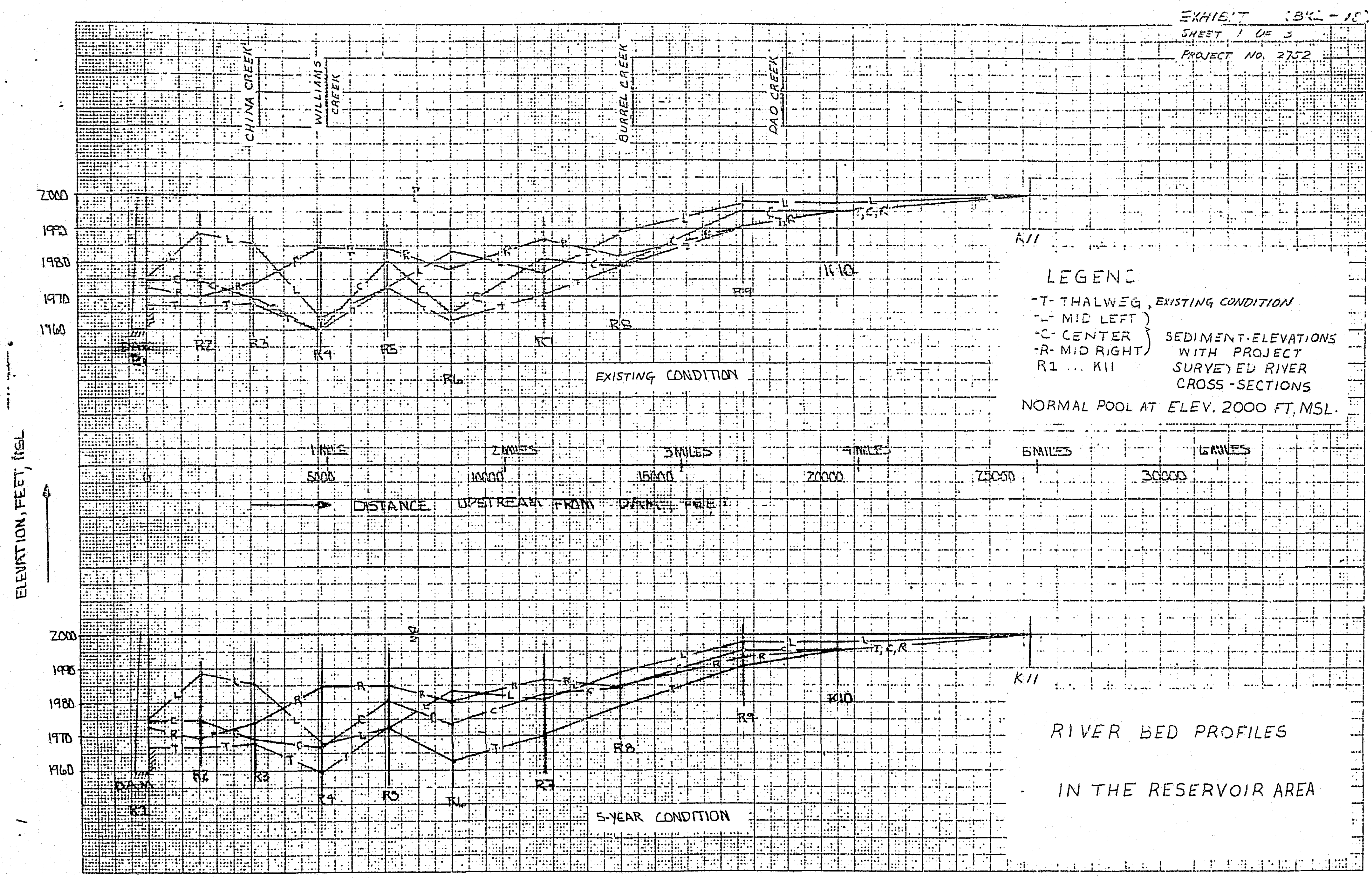
HARZA ENGINEERING COMPANY JAN. 1982

EXHIBIT.......(BKL-17)
Project No. 2752



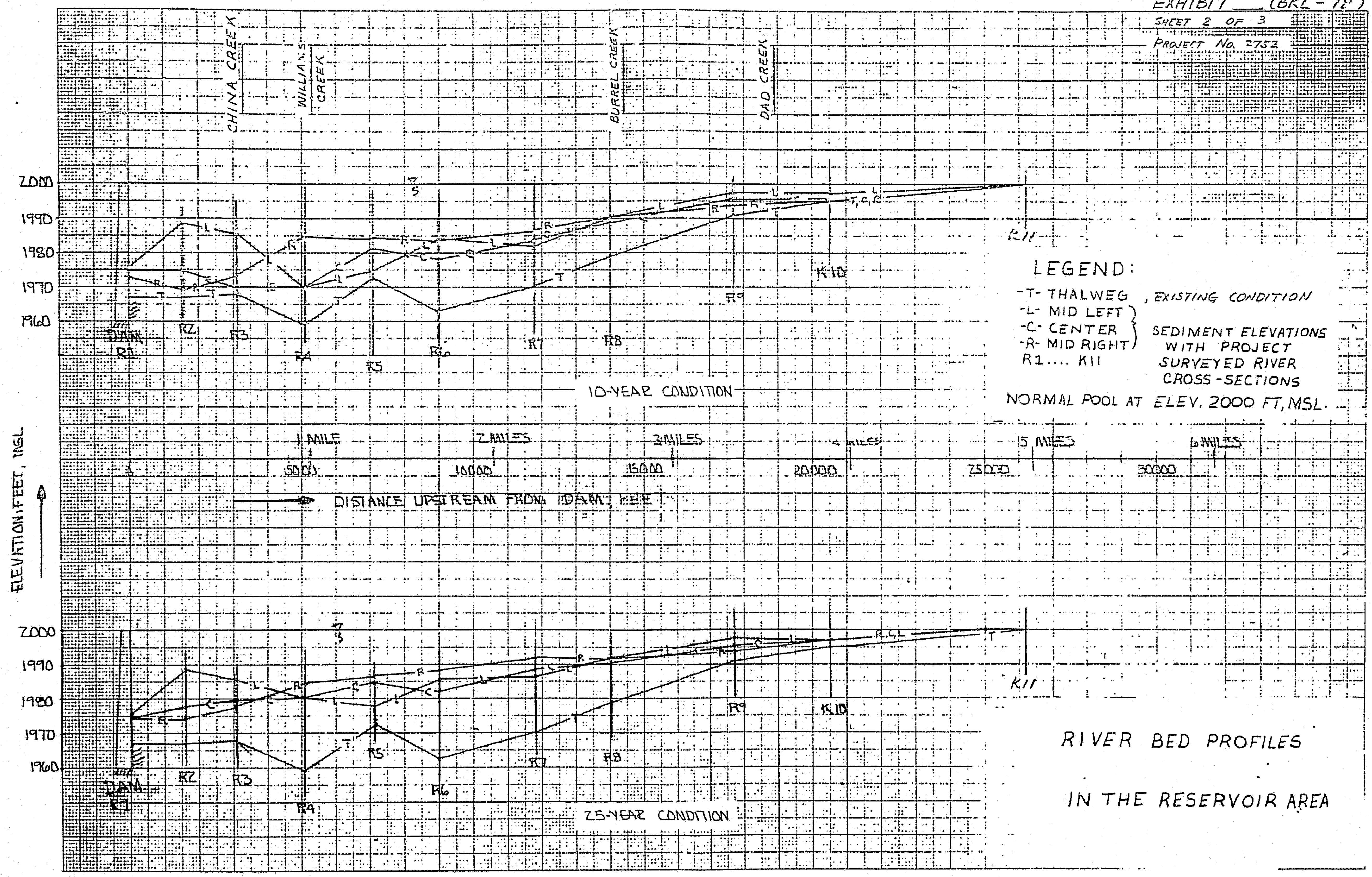
(Example)

KOOTENAI RIVER BED MATERIAL
EXISTING CONDITIONS



HARZA ENGINEERING CO., JAN., 1982

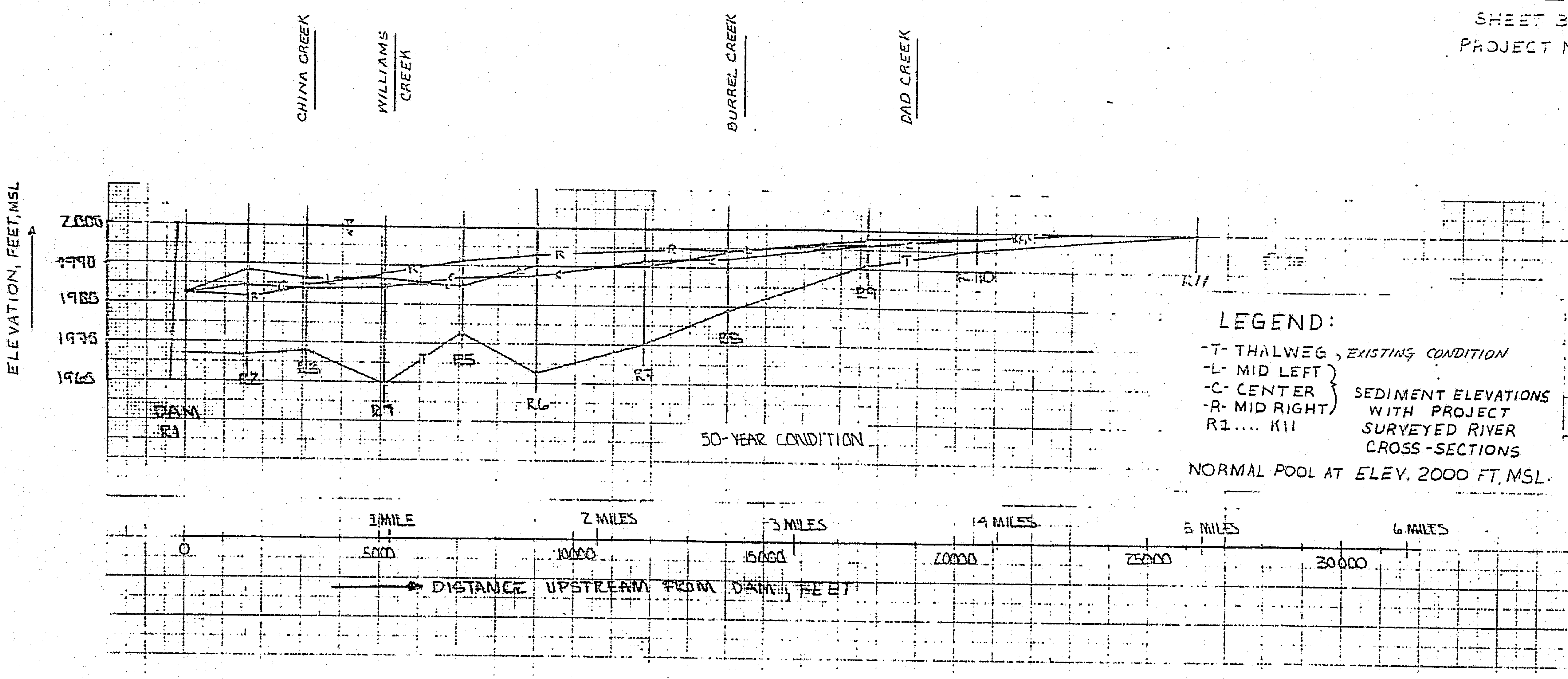
EXHIBIT ___ (BKL - 18)
SHEET 2 OF 3
PROJECT No. 2752



RIVER BED PROFILES

IN THE RESERVOIR AREA

HARZA ENGINEERING CO. JAN. 1982

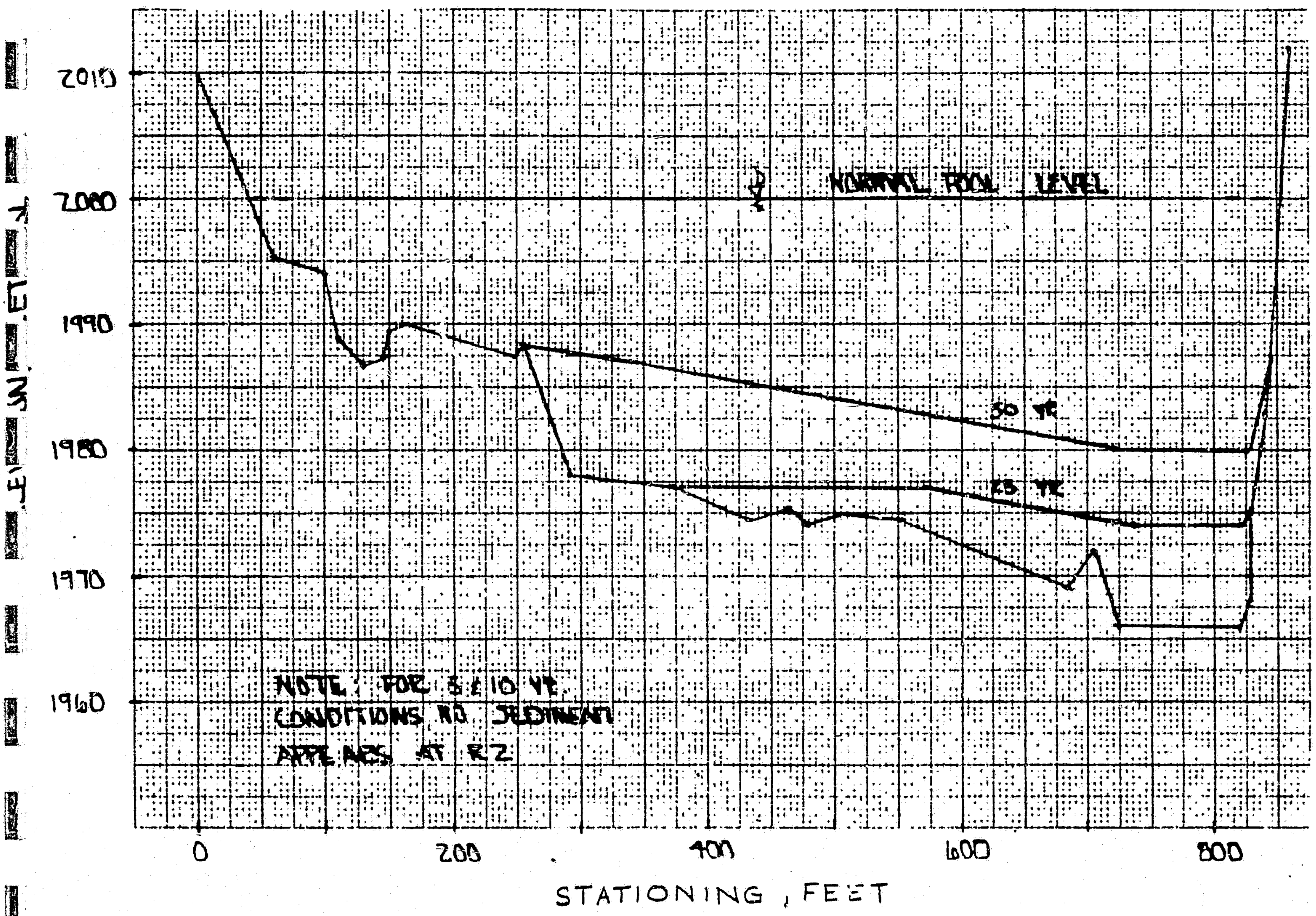


RIVER BED PROFILES

IN THE RESERVOIR AREA

HARZA ENGINEERING CO JAN. 1982

EXHIBIT ____ (BKL-19)
SHEET 1 OF 3
PROJECT NO. 2752



CROSS SECTION
R2
WITH SEDIMENT CONDITION

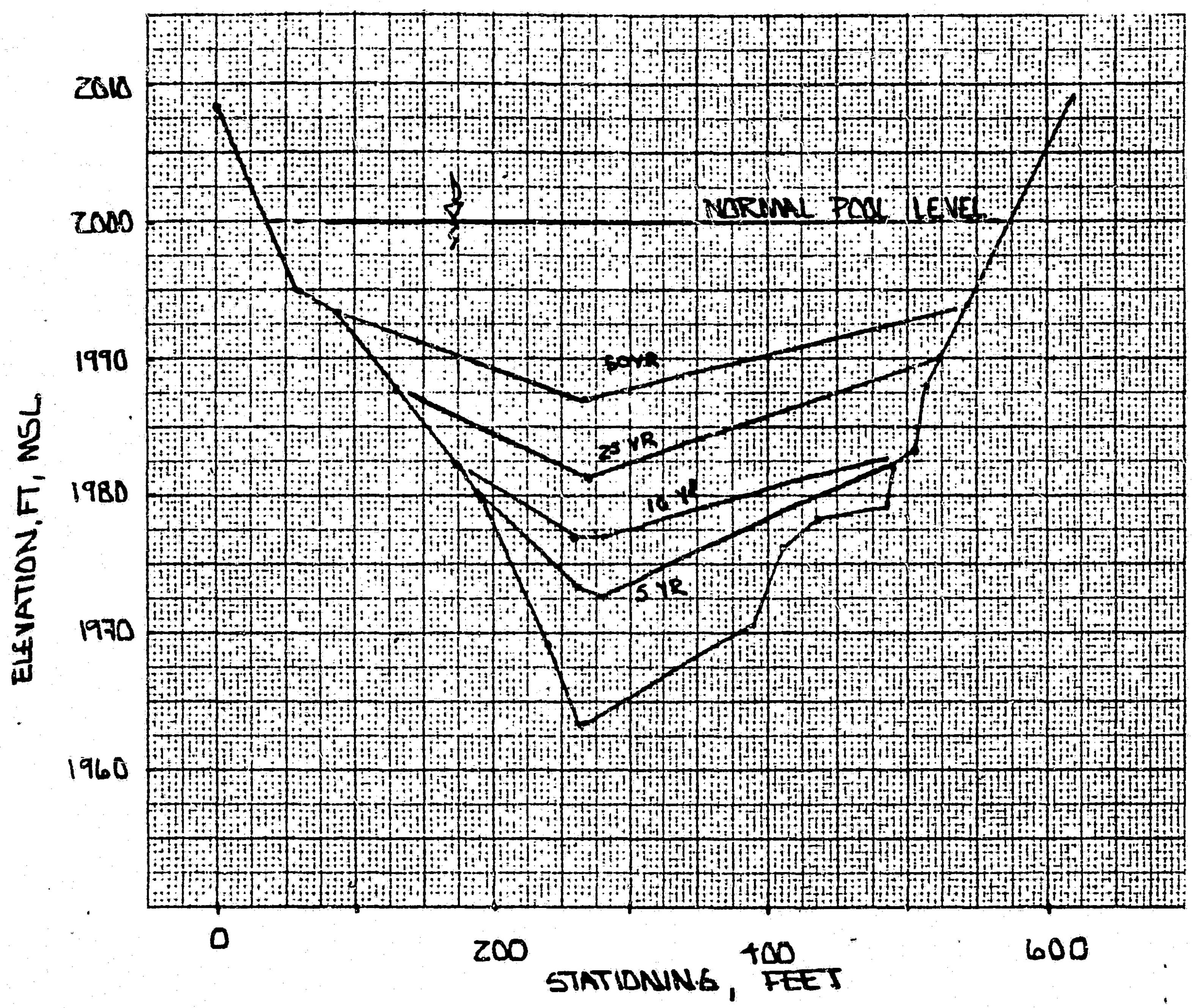
R2 IS LOCATED 1530 FT UPSTREAM FROM DAM SITE

Harza Engineering Company
January 1982

EXHIBIT___ (BKL-19)

SHEET 2 OF 3

PROJECT NO. 2752



CROSS SECTION
R6
WITH SEDIMENT
CONDITION

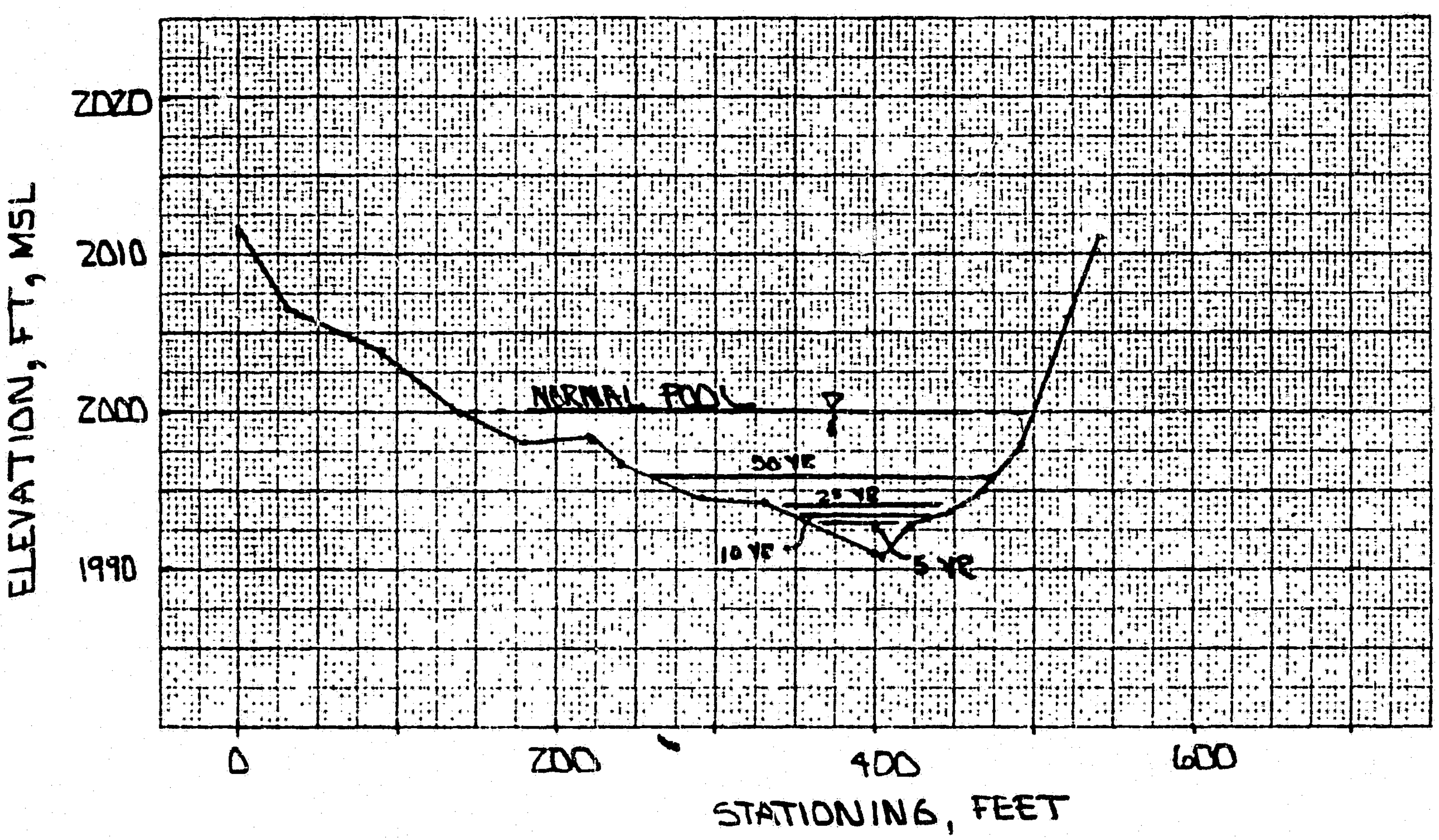
R6 IS LOCATED 8980
FEET UPSTREAM FROM
DAM SITE

HARZA ENGINEERING COMPANY
JANUARY 1982

EXHIBIT ___ (BKL -19)

SHEET 3 OF 3

PROJECT NO. 2752



CROSS SECTION R9

WITH SEDIMENT CONDITION

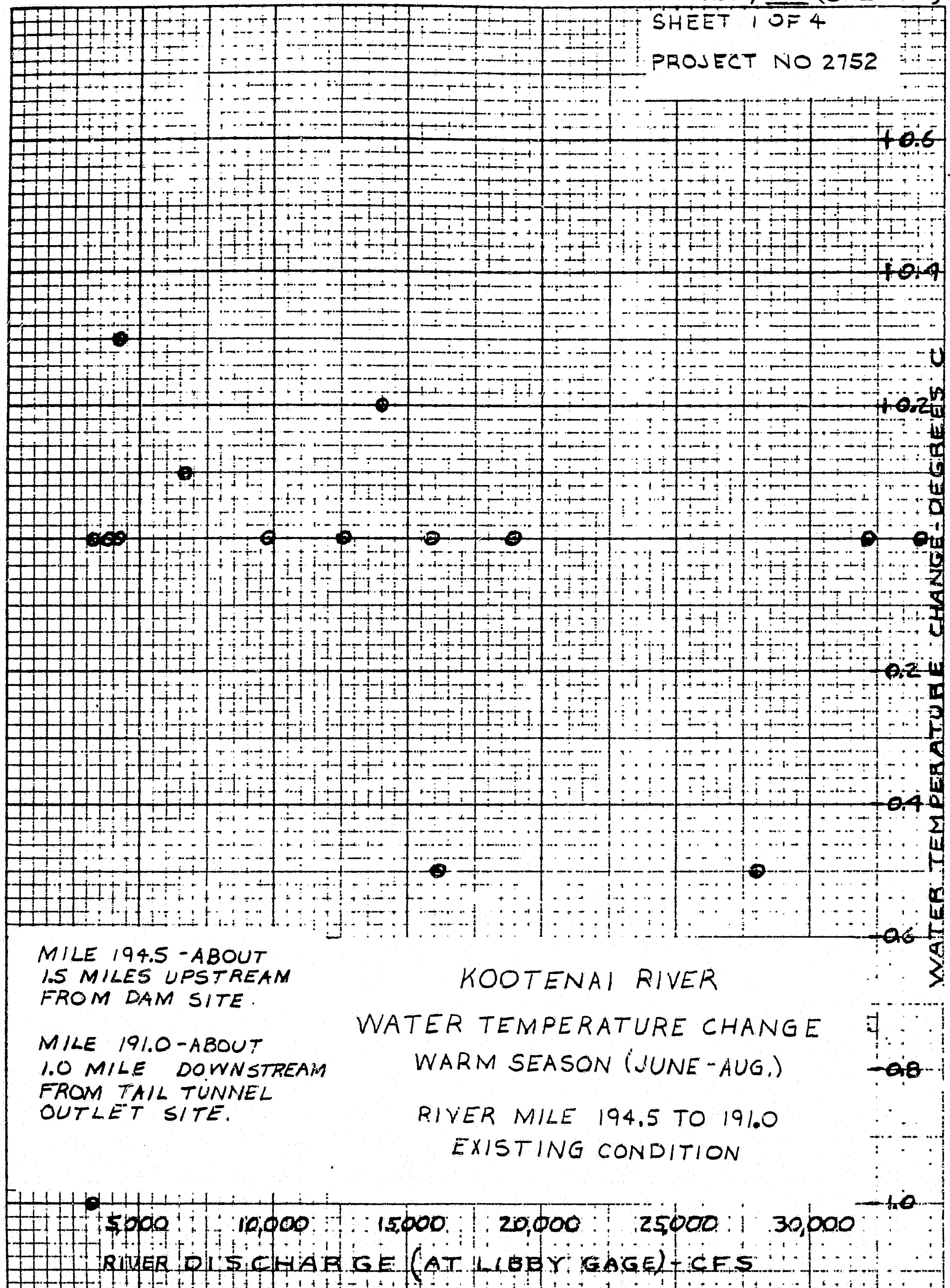
R9 IS LOCATED 17690 FEET UPSTREAM FROM DAM SITE

HARZA ENGINEERING COMPANY
JANUARY 1982

EXHIBIT ___ (BKL-20)

SHEET 1 OF 4

PROJECT NO 2752



MILE 194.5 - ABOUT 1.5 MILES UPSTREAM FROM DAM SITE.

MILE 191.0 - ABOUT 1.0 MILE DOWNSTREAM FROM TAIL TUNNEL OUTLET SITE.

KOOTENAI RIVER

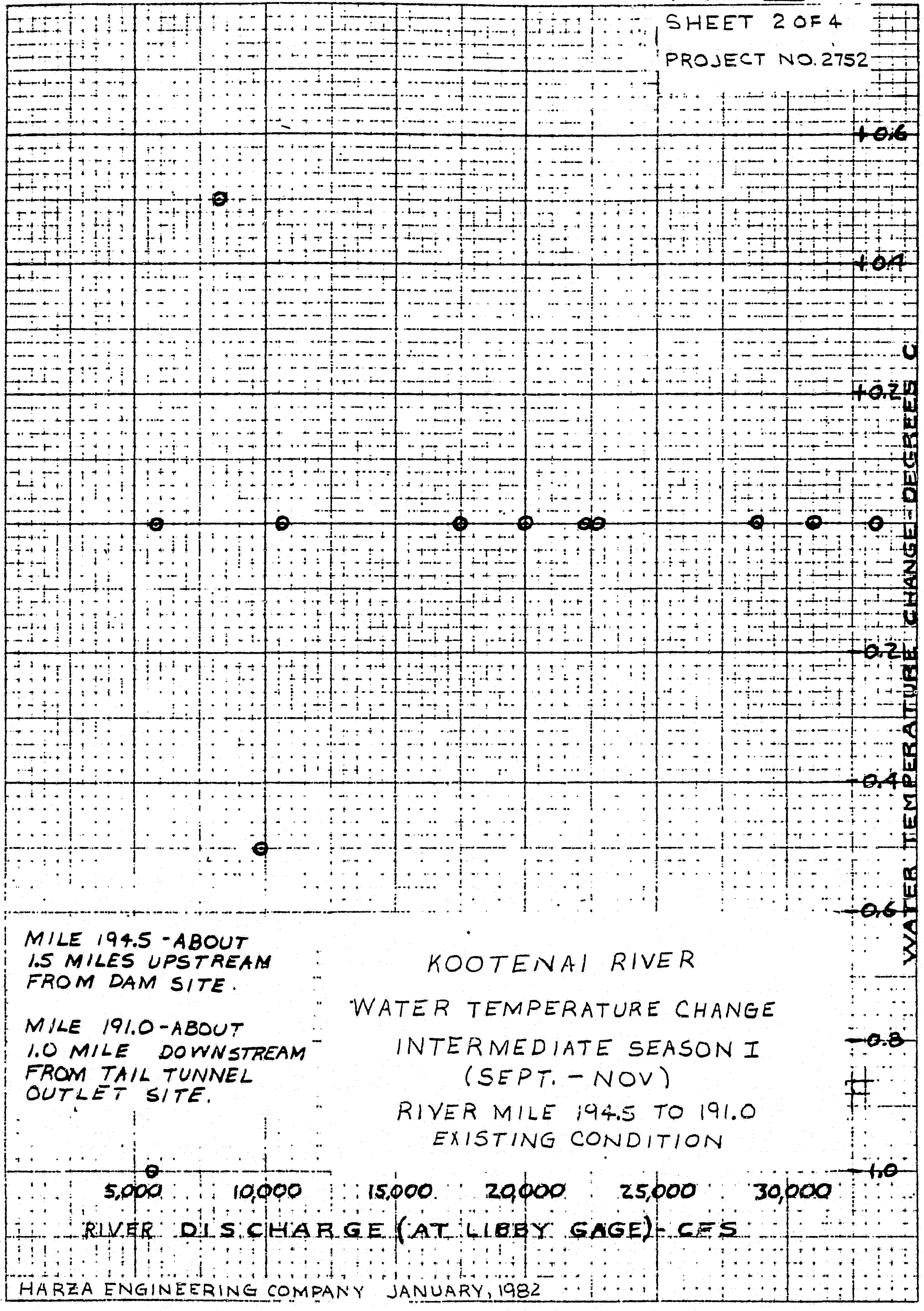
WATER TEMPERATURE CHANGE

WARM SEASON (JUNE - AUG.)

RIVER MILE 194.5 TO 191.0

EXISTING CONDITION

HARZA ENGINEERING COMPANY JANUARY, 1982



KOOTENAI RIVER

WATER TEMPERATURE CHANGE

INTERMEDIATE SEASON I

(SEPT. - NOV)

RIVER MILE 194.5 TO 191.0

EXISTING CONDITION

HARZA ENGINEERING COMPANY JANUARY, 1982

EXHIBIT__ (BKL-20)

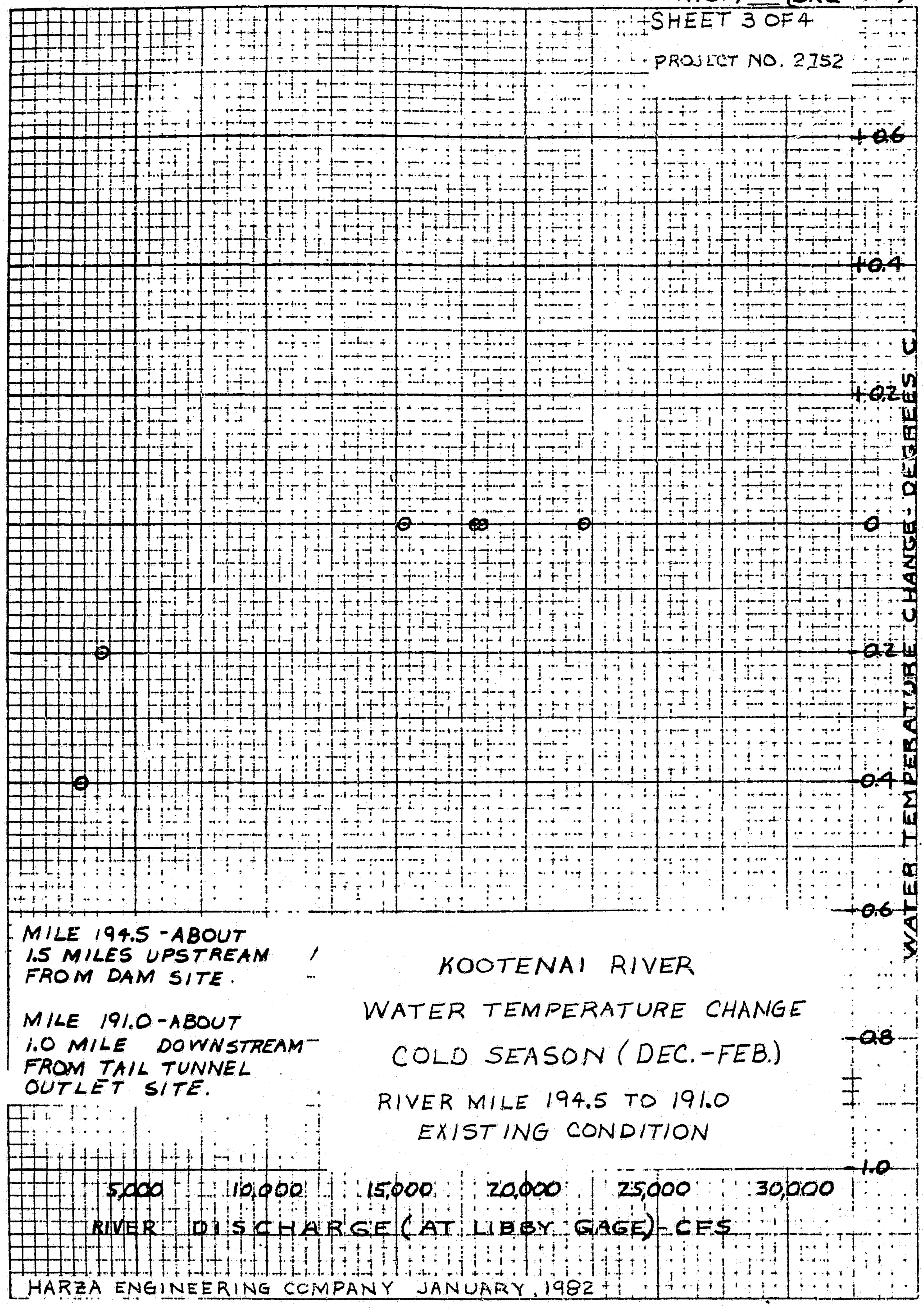
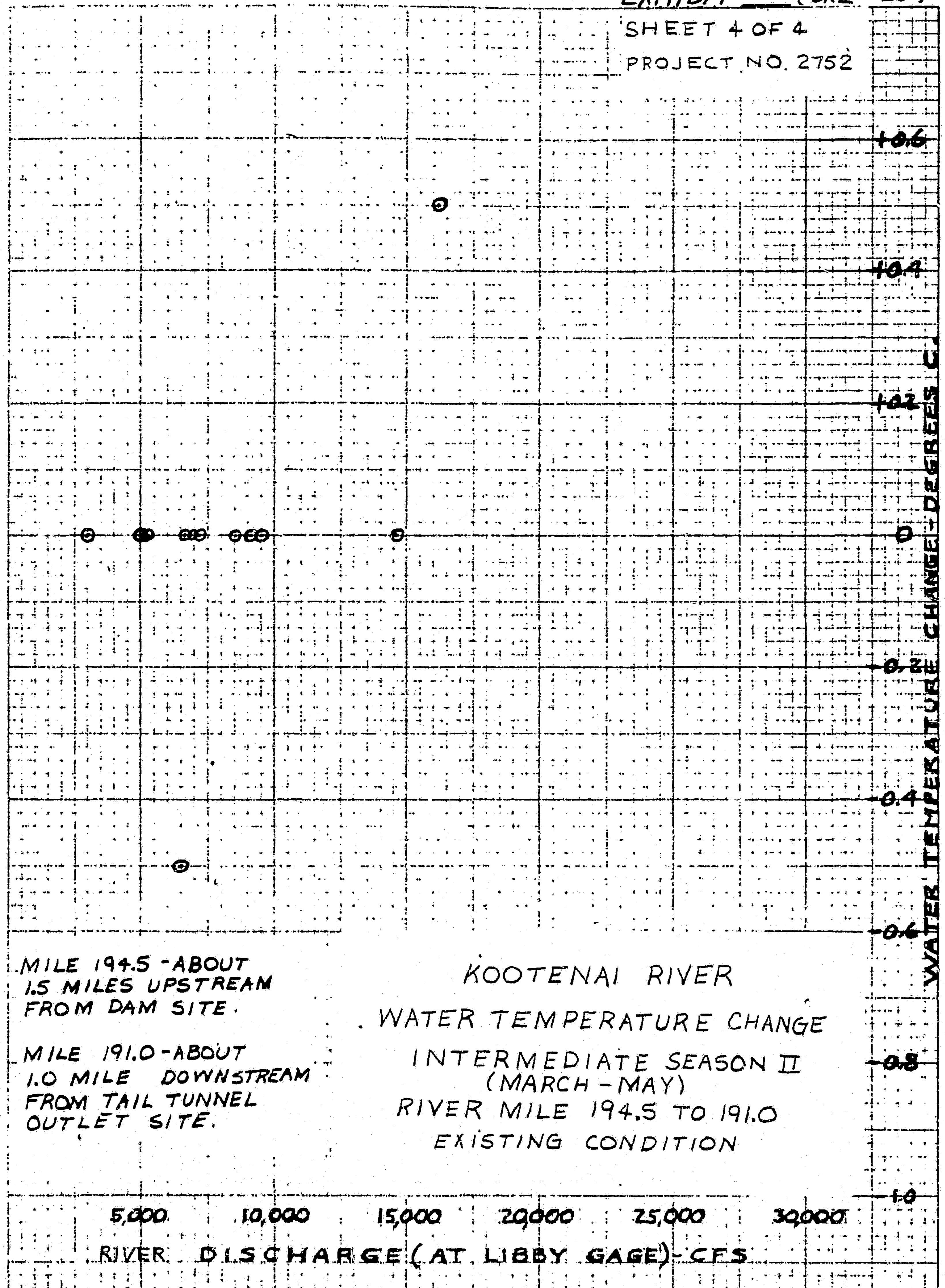


EXHIBIT ____ (BKL-20)

SHEET 4 OF 4

PROJECT NO. 2752



KOOTENAI RIVER

WATER TEMPERATURE CHANGE

INTERMEDIATE SEASON II

(MARCH - MAY)

RIVER MILE 194.5 TO 191.0

EXISTING CONDITION

HARZA ENGINEERING COMPANY JANUARY, 1982

EXHIBIT ___ (BKL-21)
PROJECT NO. 2752

COMPUTED MAXIMUM RISE OF WATER TEMPERATURE

ABOVE EXISTING CONDITION CAUSED BY THE PROJECT

Discharge - cfs			Incremental Temperature Rise Caused By the Project - Degrees F				
River	Power Station	Over the Dam	Through Reservoir	Dam to Tail Tunnel Outlet	Upstream End of Reservoir to Tail Tunnel Outlet	Through Power Station	Net Below Tail Tunnel Outlet
2,750	2,000	750	-0.68	+0.52	-0.16	-0.31	-0.77
11,000	10,250	750	+0.11	+0.82	+0.93	-0.16	+0.02
24,750	24,000	750	+0.05	+1.00	+1.05	-0.14	-0.06