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REPORT
on
2024 ANNUAL INSPECTION
of
NTPC DAMS
at
BLUEFISH, TALTSON & SNARE HYDROELECTRIC DEVELOPMENTS

August 2024

By

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FINAL

August 20th 2024

Mr. Jamie Tennant P. Eng.
Projects & Engineering.
Dam Safety
Northwest Territories Power Corporation
4 Capital Drive, Hay River, NT

Dear Jamie,

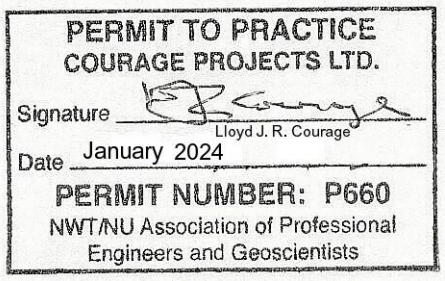
Herewith is the Final 2024 Annual Inspection Report on the NTPC Dams located at Snare, Bluefish & Taltson Hydroelectric Developments.

All of the Dams are in satisfactory condition without any observed condition that would threaten their stability or overall integrity. Maintenance and monitoring action items are recommended to keep the structures in good condition into the future. The timely execution of these recommendations are necessary to sustain the future integrity of the System.

Thank you for to your review and comments received by e-mail August 9th, 2024.

Yours Truly.

L.J.R. Courage. P.Geol. P.Eng.
Lloyd Courage P. Geol., P. Eng.



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SUMMARY & RECOMMENDATIONS

SUMMARY

The Dams in the NTPC Hydroelectric System, namely Taltson, Bluefish and Snare Developments appear structurally sound and are generally in satisfactory condition. Inspection by ground and fly-over were carried out unless otherwise noted. Based on the inspections, no condition was observed that would lead to an imminent risk of failure. In order to maintain the dams in good condition into the future the following recommendations apply.

RECOMMENDATIONS & CURRENT STATUS

GENERAL:

- The crest of all Dams be surveyed the year before the next scheduled Periodic Dam Safety Review, or more often depending on the results of visual inspections.
- Clearing of vegetation be carried out as required to permit full visual inspection of the Dams including clearing of a 3 meter width extending beyond the downstream toe.
- It is recommended that leakage be monitored wherever possible at each dam site.

TALTSON HYDRO DEVELOPMENT

Twin Gorges Dam

- Enhancement of the riprap to the left of the Intake Structure is recommended.
- Readings be recorded monthly from the well drain located to the right of the powerhouse which collects leakage from the North Gorge.

North Valley Dam & South Valley Spillway.

- These structures were inspected by fly-over only during the June 2024 Inspection. They appear in good condition. No maintenance required. Continue to inspect annually. The South Valley Spillway has been overflowing since 1988 and cannot be inspected in detail except to observe the nature of the overflow to check for any change in flow which could indicate deterioration of the structure. There is no indication of any change in the flow characteristics or any indication of significant deterioration of the Concrete Spillway to date.

Nonacho Dam and Control Structure.

- Clear vegetation from the crest and continue to carry out visual inspections annually.
- Once every 5 years survey the crest settlement monitoring pins to check for any movement of the Dam, or more often if visual inspections so warrant.

BLUEFISH DEVELOPMENT

Bluefish Dam

- Bluefish Dam appears in good condition. No maintenance required.

Bluefish Spillway

- Yearly inspect the crest of the concrete overflow weir for any signs of cracking and / or a visual increase in leakage in the downstream area.

Duncan Dam

- Status: Concrete repairs were carried out on the upstream face when the Lake was low this year, in 2024. Cracks on the upstream face of the dam was also sealed. No further maintenance required.

SNARE HYDRO:

The following are the recommendations for the Snare Rapids, Snare Falls, Snare Cascades and Snare Forks Developments.

RAPIDS DEVELOPMENT

Rapids Main Dam

- Annually fill the crest cracks, grade and compact forming a crown to drain towards the shoulders and maintain design crest elevation.
- Continue with the established monthly leakage monitoring.

5B Spillway & Dyke:

- The 5B Spillway is in satisfactory condition. No maintenance required.
- Status: The weir located downstream of the Dyke was sealed along the face of the wall by placing silty glacial till this year, 2024. When taking readings record time, date & reservoir level.

Dam 4.

- Dyke 4 appears in good condition. No maintenance required.

9B Freeboard Dyke:

- Dyke 9B appears in good condition. No maintenance required.

SNARE FALLS DEVELOPMENT

Falls Main Dam, Side Dam 1 & Side Dam 2

- Falls Main Dam and Side Dam #2 appear in good condition. No action required.
- Side Dam #1 serves as an Emergency Spillway and upgrading of the riprap erosion control on the downstream slope is required.
- The concrete wall on the left side of the entrance channel to the Overflow and Gated Spillways needs to be raised to the top of the existing railing. This will require the railing to be removed and the concrete raised.
- Note the crest of the Main Dam was raised at the right abutment following the May 2023 inspection

SNARE CASCADES DEVELOPMENT

Power Canal Dyke

- Status: The concrete Core Wall in the Rockfill Dyke was raised in 2023 from 184.5m to 185.0m by installation of a steel membrane as freeboard to prevent wave overtopping in the event of the design flood.
- Status: NTPC has prepared a procedure to direct any flow towards the Powerhouse Doors from the Spillway Discharge Canal into the tailrace by way of a trench including sandbagging and sealing the Garage Door.

Labyrinth Spillway

- The Spillway was inspected and found in satisfactory condition.

Abutment Dyke Right of the Spillway

- Status: The top of the earth Dyke was surveyed in 2023 by Sub Arctic Surveys (SAS). The lowest point along the crest was stated as Elevation 185.53m. (i.e. 0.53m higher than the concrete abutments and the top of the Steel Membrane at the top of the Dyke Cutoff Wall).

SNARE FORKS DEVELOPMENT

Strutt Lake Dam, North Dyke & Forks Main Dam

- These dams are in satisfactory condition except for the far end of North Dyke where a survey and improvements to the dyke were recommended. The end of the North Dyke was upgraded in 2024. Some enhancement of the riprap on the Forks Main Dam was carried out in 2024.

Forks Dyke 1.

- Visually inspect the crest for any signs of cracking or settlement.
- Survey the crest elevation annually or when visual inspections indicate significant settlement and raise as required.

Forks Dyke 2

- Install weir and record leakage readings at the pit access road culvert located downstream of Dyke 3 simultaneously with recording the forebay water level.
- Visually inspect the crest for any signs of settlement.
- Survey the crest elevation annually or when visual inspections indicate significant settlement and raise as required.
- Status: Riprap settlement at the left abutment occurred due to permafrost melt. Riprap was added to this location in 2024.

Forks Dyke 3

- Inspect the toe for signs of leakage during times of high forebay level.
- Visually inspect the crest for any signs of settlement and survey as required.
- Status: Riprap settlement at the left abutment occurred due to permafrost melt. Riprap was added to this location in 2024.

Forks Spillway

- Inspect the rockfill area immediately downstream of the weir after periods of high overflow. Some reworking of the rock erosion protection may be required if movement occurs. Now satisfactory.
- Status: Spalled concrete along the sill had occurred and reinforcing steel was exposed. This repair was carried out in 2024.

1.0 INTRODUCTION.

The inspection of the dams in the NTPC Hydro System began on Saturday June 12th and was substantially complete by Thursday June 19th, 2024 The inspection began at Taltson followed by Bluefish & Duncan and finished up at Snare Hydro.

Snare Hydro consists of four developments, namely Snare Rapids, Snare Falls, Snare Cascades & Snare Forks Developments. Maintenance work required at the Forks was also discussed. The personnel involved in the inspections were Jamie Tennant of NTPC and Lloyd Courage of CPL. Four operators arrived at snare from Tlicho who started the implementation of the maintenance work on June 17th.

Transportation from site to site was provided by Acasta Helicopters. Ground inspections were by pickup truck.

The weather during the inspections was favorable, sunny & warm with cumulus clouds.

Figures 1 to 29 referred to within the text illustrate the developments and are included in the back of the report.

The locations of the NTPC Hydroelectric System are shown on **Figures 1, 2, 3 & 4.**

Selected Photos are included in the text with captions to illustrate the various sites. Conditions observed shown in the photos are considered satisfactory unless otherwise noted.

2.0 BLUEFISH DEVELOPMENT.

2.1 Bluefish General:

The Bluefish Hydroelectric Plant is located near the upper end of Prosperous Lake as shown on **Figure 3.** The original timber rockfill dam at Bluefish Lake which formed the forebay for the Plant had deteriorated over the years and was replaced by a new rockfill dam with a stainless-steel membrane in 2012. The new dam is located about 0.5km downstream of the original dam. A small concrete control dam located at the outlet of Duncan Lake some 25 km upstream in the watershed provides regulated flows to the Bluefish Plant.

2.2 Duncan Dam.

Duncan Dam sits in a small cove at the outlet of Duncan Lake. The Dam was constructed by PCL Construction in the winter of 1974 to replace the original 1942 rock fill timber-crib structure located at the entrance to the inlet. The dam was designed by Cominco (**Figure 5** Dwg YH-65, 1974) to be constructed on sound bedrock. Steeply inclined bedrock was exposed on the right abutment. However, bedrock was not within reach in the riverbed or at the left abutment. Consequently, only the right abutment is founded on bedrock and the remaining two-thirds of the dam was constructed on large angular boulders, with a natural infill of gravel. In 1994 after twenty years of operation a washout of the gravel at the right abutment occurred which was temporarily repaired. Remarkably, settlement of the undermined portion of the dam did not occur. The lack of settlement indicates good interlock and support between the large foundation boulders. Following 1994 further sinkhole activity continued and the dam was eventually upgraded in 2007.

The 2007 upgrade involved dewatering by blocking the mouth of the inlet with a cofferdam, the use of unwatering pumps, and construction of a “Bentomat” impervious blanket along the upstream face of the dam. Also, downstream concrete erosion protection, foundation grouting and filling of large voids with concrete beneath the dam was carried out. Since 2007 the dam performance has been satisfactory without any significant leakage, sinkhole activity, signs of settlement or movement. As described, the dam is located and protected in a small incised inlet such that thrust from the lake ice sheet in winter is considered to be either minimal or non-existent. Flow through the spillway opening in winter also results in open water in front of the dam and minimizes ice thrust.

In 2014 the old original wooden stoplogs were replaced with a new aluminum stoplog system.

Weathered concrete on the downstream faces of the Dam were repaired in early summer of 2017. Weathered concrete on the upstream face could not be repaired in 2017 since the area requiring repair extended below lake level. High water levels have been experienced in recent years especially in 2020 & 2021. Low water is being experienced in 2023-2024 and repairs to the upstream face were completed in 2024. Cracks in the face of the concrete were also sealed.

The dam cross-section and a section of the upstream blanket are shown on **Figures 5 & 6**.

The current inspection indicated a stable structure with no signs of distress. The blanket, observed along the waterline, appeared stable without any sign of sink holes, erosion, instability or deterioration. Seepage along the downstream toe is minimal.

The following Photos show Duncan Lake Dam.

Photo 1. Shows Duncan Dam located in a protected inlet on Duncan Lake.

Photo 2. View of the upstream face of the Dam at low water level. The concrete and steel work is in good condition. There is some surface erosion of the concrete above the water level that was repaired this year, 2024. The Dam is structurally sound.

Photo 3. Shows view of the benched concrete repairs done in 2007. In good condition.

2.2 Bluefish Dam.
The Bluefish Rockfill Dam and Spillway was constructed in 2012. The dam has a central stainless-steel membrane embedded in concrete in the bedrock foundation as shown in cross section on **Figure 7**.

2.2.1 Crest
The Crest is firm and has a gravel surface without any evidence of cracks or signs of significant settlement.

2.2.2 Upstream & Downstream slopes.
The Upstream Slope of Bluefish Dam has a substantial layer of durable, well placed wave erosion resistant rock riprap. There is a berm on the downstream slope which extends through the original river section and enhances stability. Overall, the Dam appears structurally sound and stable.

2.2.3 Seepage
There is a small amount of seepage downstream in the original riverbed which can be heard but not seen or measured due to the high pond level at the toe. Inspection in the area should continue for any change in condition. There has been no noted change since construction.

2.3 Bluefish Spillway & Low-level Outlet
The overflow Spillway consists of a low horseshoe shaped concrete sill built on granite bedrock with a discharge channel and a gated low-level outlet on the left side of the Spillway. The Spillway and associated works all appeared in satisfactory condition.

The following Photos show the Bluefish Dam & Spillway.

Photo 4. General view of the Bluefish Development The location of the new Rockfill Dam and Spillway constructed in 2012 can be seen near the top, middle of the photo. (see Photo 5)

Photo 5. View of Bluefish Dam & Spillway from left side showing the spillway in the distance.

Photo 6. View of crest looking towards the left abutment. No sign of instability.

Photo 7. Shows the horseshoe Spillway, Channel and Low Level Outlet.

Photo 8. Upstream view. Shows compensation bypass water flow from the Low Level Outlet.

3.0 TALTSON DEVELOPMENT

3.1 General

The Taltson Development consists of the Twin Gorges Dams & Intake, Penstock Surge Tank & Powerhouse, North Valley Dam and South Valley Spillways. The Nonacho Lake Spillway & Control Structure, located about 160km upstream of Twin Gorges Forebay provides the main water supply to the Taltson Plant. The general arrangement is shown on **Figure 8.** The Pine Point Mine, the main load on the Plant, closed in 1988 and since that time the system has had an excess of water resulting in unregulated overflows at the Nonacho and Taltson South Valley Spillways.

3.2 Twin Gorges Dam.

The Twin Gorges Dam closes topographic lows at the North and South Gorges. The zoned rockfill dam is well constructed with a substantial layer of rock riprap wave erosion protection on the upstream slope and a wave barrier 1 metre high along the upstream shoulder above crest level. However, to the left of the Intake the slope is steep and without adequate erosion protection. It is recommended that slope & riprap improvements be carried out in accordance with the Design Drawings. The dam is well designed and well built. It incorporates a substantial cofferdam beneath the reservoir surface as shown on **Figure 9**.

The dam does not have a history of sinkhole activity or settlement and appears stable. In consideration of the small amount of seepage the potential for piping and internal erosion is low. There is an increase in leakage from the North Gorge in reservoir range 787.66ft to 790.16ft as observed at the well adjacent to the right of the powerhouse. It is recommended that seepage be measured and documented for review at one-half ($^1/_2$) foot elevation changes in reservoir to check for any change in condition.

The following Photos show the Taltson Power Site.

Photo 9. View of the Taltson Power Site showing the Twin Gorges Dam.

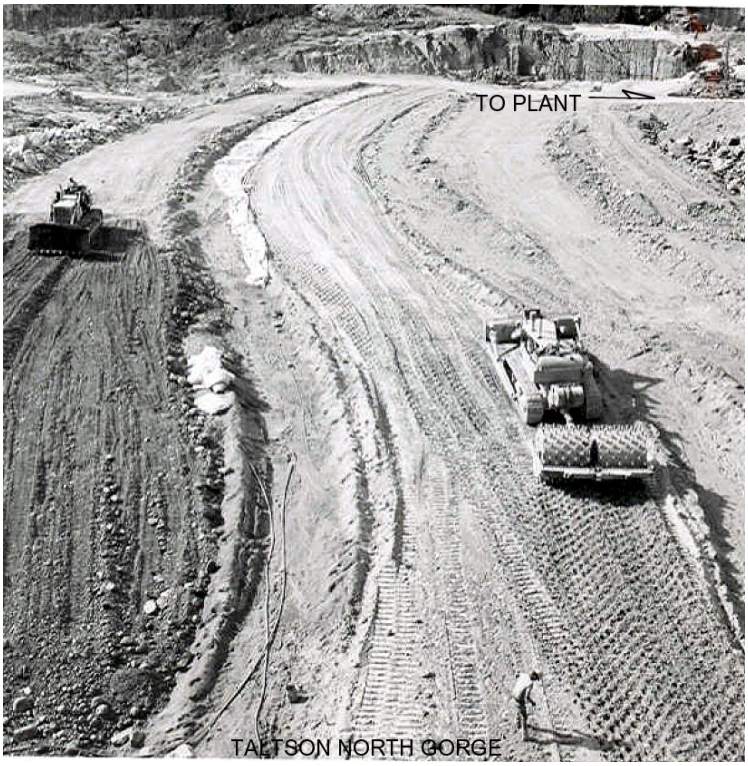


Photo 10. Shows construction of Taltson Dam at the North Gorge.

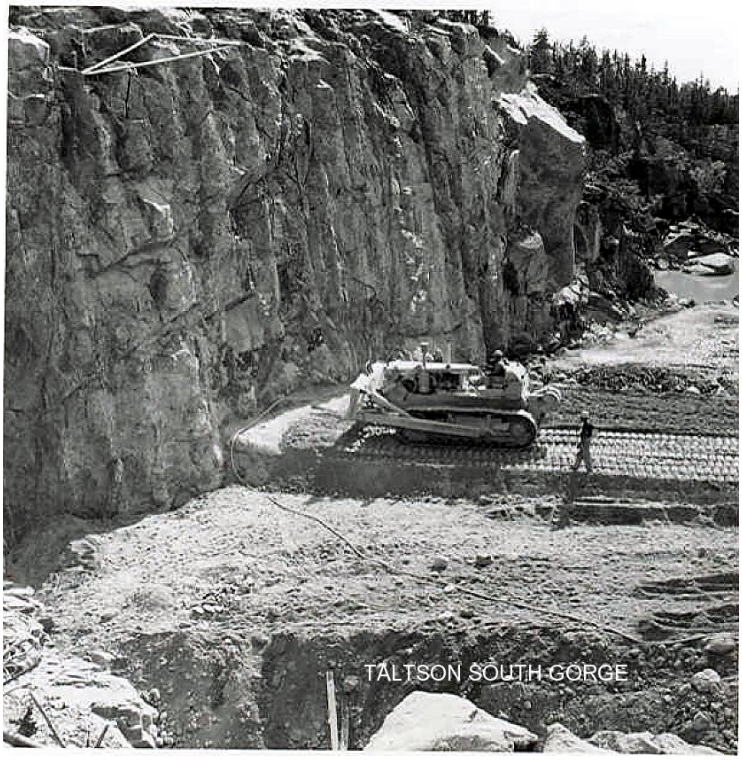


Photo 11 Shows construction of the Dam at the South Gorge.

Photo 12. View of Taltson Dam seen from the left abutment. The riprap erosion protection is satisfactory except at the intake where improvement is recommended, as shown in Photo 13.

Photo 13.Shows the upstream face of the dam left of the intake. The slope is steep and without adequate erosion protection. The power pole caisson is also undermined. It is recommended that riprap improvements be carried out and the power pole be adequately supported.

Photo 14. Shows the Well, right side, above Switchyard & Powerhouse. Stagnant water. No flow in drainpipe at the right side of the Powerhouse, where flow is measured.

Photo 15. View of the Dam at the South Gorge. The level of the pond at the downstream toe is recorded by a camera and calibrated rod (gage). No indication of leakage flow in the pool.

3.3 North Valley Dam (NVD). The NVD is located about 4 km north of the Twin Gorges Development see **Figure 8.** It is a rockfill, freeboard, dam without a core as shown in **Figure 10.**

The embankment has no signs of instability however the crest has settled about 1.2m (4ft) since construction. At the time of construction (1963-65) the dam foundation was sounded to hard bottom (Figure 10) and is indicated to be built on about 12 feet of swamp (muskeg) which is compressible and accounts for the settlement over the years. The dam was overbuilt to allow for settlement of the foundation. The dam currently has adequate freeboard for both normal and Design Flood (IDF) inflows The dam is shown on the following Photo.

Photo 16. View of the Taltson North Valley Dam.

3.4 South Valley Spillways (SVS).

The SVS consists of three (3) sections, 1, 2 & 3, the location of which are shown on **Figure 11**. The design cross-section of Section 1 is shown on **Figure 12**. Spillways 2 & 3 are contained in channels excavated through bedrock. The SVS has been in overflow mode since the Pine Point Mine closed in 1988. A detailed inspection of the Spillways has not been possible during this period due to the continuous overflow. Flyover inspections of the flow indicate no change of condition. The main section of the Spillway and contributors are shown on the following Photos.

Photo 17. Shows the Main SVS Section 1, and two Low Draws 2 & 3.

Photo 18. Shows the spillway channel at location 2. There is no concrete sill.

Photo 19. Spill channel at location 3 showing a concrete sill.

3.5 Nonacho Lake Dam, Control Structure & Spillway.

The Dam, Control Structure & Spillway built in 1968, is located about 160km upstream to the northeast of the Twin Gorges power site on the Taltson River at the outlet of Nonacho Lake. A Plan and Cross-section at the Timber Crib of the Dam is shown on **Figure 13**.

3.5.1 Nonacho Dam & Control Structure

The dam, which has a max height of 8.6m, was designed and constructed as a rockfill structure, without an impervious core. The dam incorporates a timber gated rock-fill Timber-crib Sluiceway with three openings. The Sluiceway rockfill cribwork, where visible, appears in good condition, with little evidence of decay, miss-alignment or settlement. The upstream and downstream slopes of the rockfill dam appear stable. The crest shows settlement of about 0.3m over the area of highest leakage, near the right abutment. The settlement appears stable having occurred shortly after construction. Repeated visual inspections over the years indicate no change in condition, A survey of the settlement pins, recently installed, indicated that settlement has ceased.

3.5.2 Nonacho Spillway

The overflow spillway consists of a 70m wide channel blasted through granite bedrock. The spillway rock sill is at elevation 320+- which is also the design full supply level for Nonacho Lake. Due to the low power demand on the system the Spillway has been overflowing for many years, similar to the Twin Gorges Spillway, to the extent that it could be seen through the flow, the spillway channel appears stable with no indication of significant change in erosion or downcutting.

The Nonacho Site is shown in Photo 20.

Photo 20. Shows the Nonacho Dam, Spillway & Control Structure with Ro-torque Operators (3). It is a rockfill dam designed to accommodate leakage. About 300mm of settlement of the crest occurred shortly after 1968 construction where leakage is high at the right abutment, and has remained stable since. Inspection reports over the years, based on visual assessments, have stated no change in condition. Pins have now been installed for survey and to verify the stability of the structure.

4.0 SNARE HYDRO

4.1 General

Snare Hydro consists of 4 plants constructed along 32km of the Snare River between Big Spruce Lake and Strutt Lake. These are known, including date commissioned as Snare Rapids (1948), Snare Falls (1960), Snare Cascades (1996) and Snare Forks (1976). **Figures 1 & 2** show the general arrangement of the Developments. Big Spruce Lake is retained by the Rapids Dam, 5B Spillway & Dyke, Dyke 4 & Freeboard Dyke 9. Flows to the downstream Plants are released from Big Spruce Lake through the Powerhouse units at the Rapids Dam and through the 5B Stoplog Spillway during periods of flood or when the Powerhouse Unit is off line.

4.2 SNARE RAPIDS DEVELOPMENT

4.2.1 General

The Snare Rapids Development, consists of the Rapids Dam & Powerhouse, 5B Spillway & Dyke, Dam #4 & 9B Freeboard Dyke.

4.2.2 Rapids Dam

The Plan and Sections of the Rapids Dam are shown on **Figure 14.** The dam is a zoned earthfill structure with a central wide impervious silty core which is further widened at its base to increase the contact with the bedrock foundation. Pervious to semi-pervious upstream and downstream silty sandy shells encase the core. Riprap erosion protection is provided on the upstream slope, and a substantial layer of rockfill was placed on the downstream slope. Two tunnels pass through the bedrock foundation of the dam in the river section which supply water to the main and auxiliary Powerhouse units. The Powerhouse is constructed at the downstream toe of the dam.

The crest, upstream slope, downstream slope, toe area, and seepage locations downstream of the Dam were inspected. The reservoir was at El 717.9 ft at the time of the site visit. In past years there was evidence of considerable frost heave and cracking about one (1) metre deep parallel to the axis of the Dam along the shoulders of the crest extending from the intake to the left abutment. The cause is attributed to poor compaction when the top of the dam was excavated and rebuilt to raise the core in 2002. It is likely that cracks occur due to frost heave and difference in moisture content and compaction occurring in the center compared to the material at the shoulders. The cracks parallel the contact between the original and new poorly compacted backfill material. There are no cracks transverse to the Dam Axis and consequently no added risk to Dam Safety. Continue to grade, compact and monitor the crest. The cracks which parallel the dam axis are not considered to be a dam safety issue.

Both the upstream & downstream slopes of the Dam have good erosion protection such that run-off from the crest does not erode the shoulders or the slopes. The downstream slope at 2H:1V is provided with erosion resistant rockfill and appears stable. The upstream slope at 3H :1V with a layer of riprap appeared stable and planar without any significant indication of beaching.

Seepage locations at W_1 W_2 MH4 and the seepage into the Tailrace from MH4 shown on **Figure 14** were inspected. The leakage flow from MH A with outlet at the tailrace was measured using a stopwatch and measuring cup at 1.6 liter per minute. Leakage was also observed at the corners of the powerhouse at W1 and W2. The leakage at W1 was measures at 0.5in over the weir – 42l/min. There is a slight immeasurable flow at W2, on the left corner, which is visually inspected. There is no apparent change in seepage at the powerhouse locations in comparison to previous inspections. The leakage from all sources at the Rapids Main Dam appeared, low, clear, normal and track the reservoir level.

Photos of Rapids Dam are shown below.

Photo 21. Upstream view of Rapids Dam. Variable riprap. No beaching. Satisfactory.

Photo 18.View of Rapids Dam and downstream area. Stable. Minor leakage, monitored.

Photo 19. Rapids Dam. View of crest. Some minor cracking evident.

Photo 20. Intake at Rapids Dam. Some surface weathering of the concrete.

4.2.3 Spillway 5B & Dyke.

The 5B Stoplog Spillway, constructed 1960 appears in good condition without any evidence of significant weathered concrete, cracking, misalignment or instability. A plan and section of the 5B Spillway is shown on **Figure 15**. Repairs to the stoplog guides and downstream eroded foundation areas at the piers were carried out in 2015. A substantial repair to the foundation of Pier 5 was carried out in 2017. All locations of erosion at the base of the Spillway Piers have been repaired. Performance has been satisfactory. The structure is founded on solid massive granite bedrock and is in good overall condition with no further repairs required.

The 5B Dyke, shown in cross-section in **Figure 16** has a central impervious core surrounded by sand filters encased in rockfill. The inspection indicated the dyke to be in good condition. Leakage occurs from the dyke when the reservoir is above El 723+-. The flow has been observed to be clear without evidence of internal erosion of the dyke such as sedimentation along the downstream seepage path, nor has there been any sinkhole activity or settlement in the Dyke, which suggests leakage through bedrock. Leakage was noted to flow beneath the weir at the time of the 2020 inspection. The weir was repaired in 2024. Readings should be taken on occasion when NTPC Staff visit the site for stoplog operations.

The 5B Site is shown on the following Photo.

Photo 21. Shows (1). 5B Spillway; (2.) 5B Dyke & (3) Weir.

4.2.4 Dam 4

Dam 4, shown in section on **Figure 17** is a zoned earth fill dam with a central impervious glacial till core, surrounded with sand and gravel shells. The downstream slope of the dam is provided with a rock toe to enhance the stability of the slope through the wet swampy valley floor. The upstream slope has a stable riprap cover and a rock groin 1 metre high + - along the upstream shoulder of the crest. There is some stagnant water along the downstream toe. The Dam is a stable

structure without evidence of slope instability, settlement or significant leakage. The performance is satisfactory.

The following Photo shows Dam 4.

Photo 22. Aerial view of Dam 4.

4.2.5 Freeboard Dyke 9B

Dyke 9B, constructed in 1960, is located about 3 km northeast of Rapids Dam as shown in **Figure 2**. The dam is a sand fill embankment with an upstream bentonite clay blanket, a crest length of about 60m and height of 3m. The records indicate that the original dam was constructed on a layer of surface ice on a foundation of peat and glacial till of total thickness 10 to 12 feet over bedrock. The bedrock is exposed on both abutments. The Dam has been topped-up several times due to ice melt and settlement of the soft foundation materials. Settlement now appears to have ceased. In March 2009 the dam was enhanced with an upstream blanket consisting of a Bentomat Liner and a layer of riprap wave erosion protection as shown on **Figure 18**. The head across the Dam at FSL is low at approximately 0.6m. This freeboard dam serves as a retaining structure, should the reservoir rise above FSL in the event of a flood.

The 2021 inspection found the dyke in good condition with stable slopes without any significant signs of settlement, seepage or distress.

The following Photo shows the 9B Freeboard Dyke.

Photo 23. View of Freeboard Dyke 9B.

4.3 SNARE FALLS DEVELOPMENT

The Snare Falls development commissioned in 1960 is located on the Snare River downstream of Snare Rapids. The development consists of a zoned rockfill Main Dam, a two (2) Gated Spillway, an Overflow Spillway, Intake Structure, and Powerhouse. Two side dams, Side Dam #1 & Side Dam # 2, close topographic lows to the right of the Main Dam & Spillway. Clearing of vegetation at the Falls Side Dams is now satisfactory The layout of the development is shown on **Figure 19**.

4.3.1 Falls Main Dam

The Main Dam is a zoned earth-rockfill embankment founded on bedrock with crest length of 152m and maximum height of 23m. As shown on **Figure 20** the dam has a central core of compacted sandy silt encased with gravel filters and rockfill shells. A 1.3m (4 ft) high riprap groin is provided along the upstream shoulder of the crest for future maintenance of the riprap slope if required. The crest is firm with no evidence of cracks or settlement. The downstream face appears planar and stable. Some minor seepage occurs at the base of the right abutment near the Powerhouse where a layer of sand & gravel filter material has been placed. Seepage is not currently visible.

4.3.2 Falls Saddle Dam # 1

The Saddle Dams 1 & 2 were originally constructed with a central core protected by sand, gravel and riprap as shown on **Figure 21**. In 2003 Dam 1 was lowered by about 3 metres and modified to provide an emergency overflow spillway in the event of a major flood. The modifications are shown on **Figure 22.** It is noted that apparently the erosion protection on the crest was not placed. Also the riprap protection on the downstream face needs upgrading Heating of the second spillway gate is now under consideration to enhance reliability of operation of the Gated Spillway.

4.3.3 Falls Saddle Dam # 2

Similar to Saddle Dam #1, Saddle Dam #2, was constructed with a central core protected by sand & gravel shells and riprap. The crest elevation is substantially over built, higher than the Main dam. The dam appears in good condition. The Dam was last brushed in 2021. Clearing of vegetation is now again required to improve visibility when inspecting

The Falls Structures are shown in the following photos

Photo 24 Shows location of Falls Main Dam (1), Side Dams (2) & (3).

Photo 25 Shows the downstream face of the Main Dam. Stable. No visible leakage.

Photo 26. Shows the Main Dam Coffer Dam and flows to Diversion Tunnel during construction.

Photo 27. Side Dam construction. Compaction using sheep's foot compactor.

4.4 SNARE CASCADES DEVELOPMENT

4.4.1 General

The development, shown in Plan on **Figure 23,** is located on the Snare River about 6 km downstream of the Falls Plant. It consists of a Labyrinth Spillway, a Power Canal, side-hill Dyke, Intake and a Powerhouse. The Power Canal is contained in a rock cut and partially by a rockfill Side-hill Dyke. The dyke, shown on **Figure 24**, is provided with a concrete cutoff wall founded on bedrock. The upstream face of the cutoff wall is sealed with a bituminous impervious membrane to mitigate leakage through any cracks and joints. No open cracks or joints were observed along the top of the cutoff wall.

4.4.2 Spillway

The downstream slab of the spillway which experienced considerable surface erosion was repaired in 2015 by the application of a 50mm inch thick coating of Sikacrete-08 SCC (Self Compacting Concrete). A reinforced concrete wall, 300mm thickness, was also poured against the downstream face of the slab. These repairs are performing well.

Based on the recent inspections the downstream face of the Labyrinth Weir which is founded on the concrete slab is showing signs of surface erosion on the downstream face, however reinforcing steel is not exposed. Repairs will be required in the future. In the meantime, continue to inspect. The condition of the downstream face of the spillway appeared unchanged from the previous inspection.

4.4.3 Power Canal Dyke

The Canal Dyke appears stable however the rock fill has experienced 0.5m +- settlement of the crest along the high section since construction in 1996. Settlement is considered normal for a "dry-placed rockfill dam" where downward migration of fines into open voids within the rockfill can be expected to occur over time especially during periods of heavy rain. Some further settlement can be expected. The concrete cut-off wall has now been raised by 0.50m from El 184.50 to 185.00 using a steel membrane. Topping up of the rockfill on either side is considered optional. The exposed top of the concrete cutoff wall appeared in good condition without any evidence of movement, cracking or deterioration.

The foundation beneath the cut-off wall was not grouted during construction and leakage through the bedrock is suspected. Inspections indicate the total leakage from the dyke at about 4 locations, visually estimated, would be in the order of 5 gal/min. The leakage flow observed when the spillway is not overflowing appears steady, clear, and unchanged compared to previous inspections. Leakage cannot be observed when the spillway is overflowing due to the backwater effect.

4.4.4 Plant Stoplogs.

NTPC has prepared a procedure (EPP) to direct any flow towards the Powerhouse Doors from the Spillway Discharge Canal into the tailrace including sandbagging and sealing the Garage Door. This approach replaces the requirement for stoplogs. Flows from Big Spruce Lake to the downstream plants are controlled at the 5B Spillway and operation is considered to provide ample time to carry out the EPP at the Cascades Plant in event of a large flood.

Photo 26. Shows the Cascades Development, ie: Powerhouse, Rockfill Dyke with Cutoff Wall, Spillway & Earthfill Dyke. The top of the Dyke Cutoff Wall was raised in 2023 to El 185m by installation of a 0.5m high steel membrane.

Photo 27 Shows the steel membrane, on top of Cut Off Wall. The wall provides free board protection against potential overtopping by wave action in the event of the design flood.

4.5 SNARE FORKS DEVELOPMENT

4.5.1 General

The Snare Forks Development is located on the Snare River downstream of Snare Cascades and was commissioned in 1976. It consists of the Strutt Lake Dam, North Dyke, Intake and Powerhouse, Freeboard Dykes 1, 2 & 3, Forks Main Dam and a Spillway Weir as shown in plan on **Figure 25**.

4.5.2 Strutt Lake Dam.

The Strutt Lake Dam is shown on **Figure 26.** The crest and upstream slopes appear stable and in good condition. There is a small amount of seepage from the Dam to the right of the Powerhouse. The flow appears as a wet area and is not measurable. Heat tracing is provided which eliminates ice formation in winter. Additional clean sand & gravel was placed at this location in 2018 to enhance the existing filter material. There is slight immeasurable seepage around the corner of the Plant down to the tailrace.

As an enhancement to the stability of the downstream slope and toe area to the left of Strutt Lake Dam, the soft saturated material was excavated and a layer of clean free draining crush gravel filter material about 1 metre thick and a row of large rock was placed in August 2020.

4.5.3 North Arm Dyke

The North Arm Dyke appears in good condition with stable crest and slopes. The dyke is a low structure and appears to be founded on bedrock. The riprap wave erosion protection is adequate. Clearing has been done along the downstream toe providing for good visual inspection. Improvements were carried out this year 2024 where the Dyke terminates near the Quarry. The crest of the dyke was low and the material was pervious and loosely placed . Impervious material was placed and compacted to raise the dyke crest to design level in 2024.

4.5.4 Freeboard Dykes 1, 2 & 3.

Sections of the dykes have been subject to settlement over past years. In March of 2014 exploratory holes were drilled at locations of known settlement in Dykes 1, 2 & 3 to check for permafrost. Permafrost was encountered in the foundations of Dykes 2 & 3 but not in Dyke 1. However soft conditions were encountered in the foundation of Dyke 1 where it appears that the permafrost had existed but now dissipated. Because of the ongoing settlement the crests are inspected and surveyed annually or more frequently if visual inspections so warrant. The elevations of the dykes are restored if settlement results in a crest elevation below design El 175.50m. The survey results for 2024 are included in the table below.

Dyke #	Design Crest El (m). Meco 2015 Snare Flood Risk Analysis	Minimum Crest Elevations (m)					
		May 26 2019	Aug 25 2020	July 11 2021	June 9 2022	May 16 2023	June 16 2024**
1	175.70	175.92	176.00	175.79	175.80	175.62*	176.00
2	175.70	176.28	176.31	176.21	176.35	176.20	176.20
3	175.70	175.94	176.35	176.12	176.19	176.03	176.10

* Slightly below design. ** Values post 2024 raising.

4.5.5 Dyke 1.
As shown in **Figure 27** the Dyke is provided with an upstream glacial till blanket and has a transition of filter gravel against the rockfill with riprap wave erosion protection on the upstream face.

The flow from Dyke 1 is collected at a 90^0 weir located about 500m downstream in a rock crevice. NTPC has established a camera for recording water levels at the weir. During inspection the flow of 8.5in at the weir appeared clear and normal.

4.5.5 Dyke 2.
The X-Section for Forks Dyke 2 is shown on **Figure 28**. The crest appears planar, without evidence of settlement. The riprap wave erosion protection is performing well with no signs of beaching or movement. There is leakage along the toe of the dyke when the forebay is above FSL. A berm of pervious filter gravel was placed along the toe as a reverse filter, as a precaution against potential piping when the forebay is surcharge above FSL 570ft. Riprap was placed at the left abutment in 2024 as shown in **Photo 49**.

4.5.6 Dyke 3.
The Forks Dyke 3 X-Section is also shown on **Figure 28.** The crest of Dyke 3 exhibited evidence of settlement and was raised in August 2020. The upstream riprap and slope is satisfactory. There was a small pond of stagnant water at the downstream toe due to the high forebay level (572.6ft), i.e. 2.6 ft above FSL. There was no evidence of flow at the toe. As a precaution a layer of clean crush sand & gravel was placed as a filter to mitigate potential piping. There are other ponds, 100m or so distance in the downstream areas of Dykes 2 & 3 which drain to a road culvert located in the access road to the abandoned airstrip (now a borrow pit) downstream of Dyke 3. Normally when the forebay is at or below FSL the culvert is dry. It is recommended that a weir be installed at the culvert. Riprap was repaired in 2024 at the left abutment similar to Dyke 2.

4.5.7 Forks Dam.
The Forks Dam is a zoned earthfill structure founded on bedrock. The dam crest has a compact gravel surface free of ruts and shows no signs of cracking or settlement. The riprap generally appears in good condition. Some minor riprap improvements were carried out in 2024 where riprap appeared sparce. The downstream slope also appears stable. A pool of water exists at the toe of the dam created by a berm along the bank of the spillway discharge channel. At higher forebay levels when the Spillway is overflowing the water level fluctuates in the pool, influenced by the level of water in the spillway discharge channel. Thus, the pond level would be inaccurate in regard to leakage monitoring at the culvert in the berm during periods of spillway discharge. The berm is required to protect the Dam against backwater flows and potential erosion during periods of high spillway discharge. It is recommended that monthly leakage readings be taken at the berm culvert when the spillway is not overflowing.

4.5.8 Forks Overflow Spillway.
The erosion protection at the Forks Spillway downstream of the high section was constructed in 2015. The stability of the Weir has now been substantially enhanced along the downstream face by support from the rock erosion protection. There was no overflow at the time of inspection. There was some minor surface erosion of the crest as shown in the photo below which was repaired

in 2024. A cross-section is shown on **Figure 29.** The erosion protection has remained stable and is in satisfactory condition.

The Forks Structures are shown in the following photos:

Photo 28. Strutt Lake Dam. North Arm Dyke on the right of the photo.

Photo 29. Shows location of 2024 repair to the North Dyke to prevent overtopping and wash-out of the main access road in event of the design flood.

Photo 29.Shows repair to the far end of North Dyke near the Quarry. Crest raised to design grade tied to high ground.

Photo 30. View of riprap repair at left abutment of Dyke 2.

Photo 31. Shows the riprap repair to the left abutment of Dyke 3.

Photo 32. Shows enhancement to riprap at Forks Main Dam.

Photo 33. Shows the Forks Overflow Spillway Weir. Repair to weathered concrete at the crest was carried out in 2024 at location (1)

5.0 STATEMENT OF LIMITATIONS AND CONDITIONS

5.1 THIRD PARTY USE OF REPORT

This report has been prepared for NTPC to whom this report has been addressed. Any use that a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. Courage Projects Ltd accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions undertaken by others, based on this report.

FIGURES

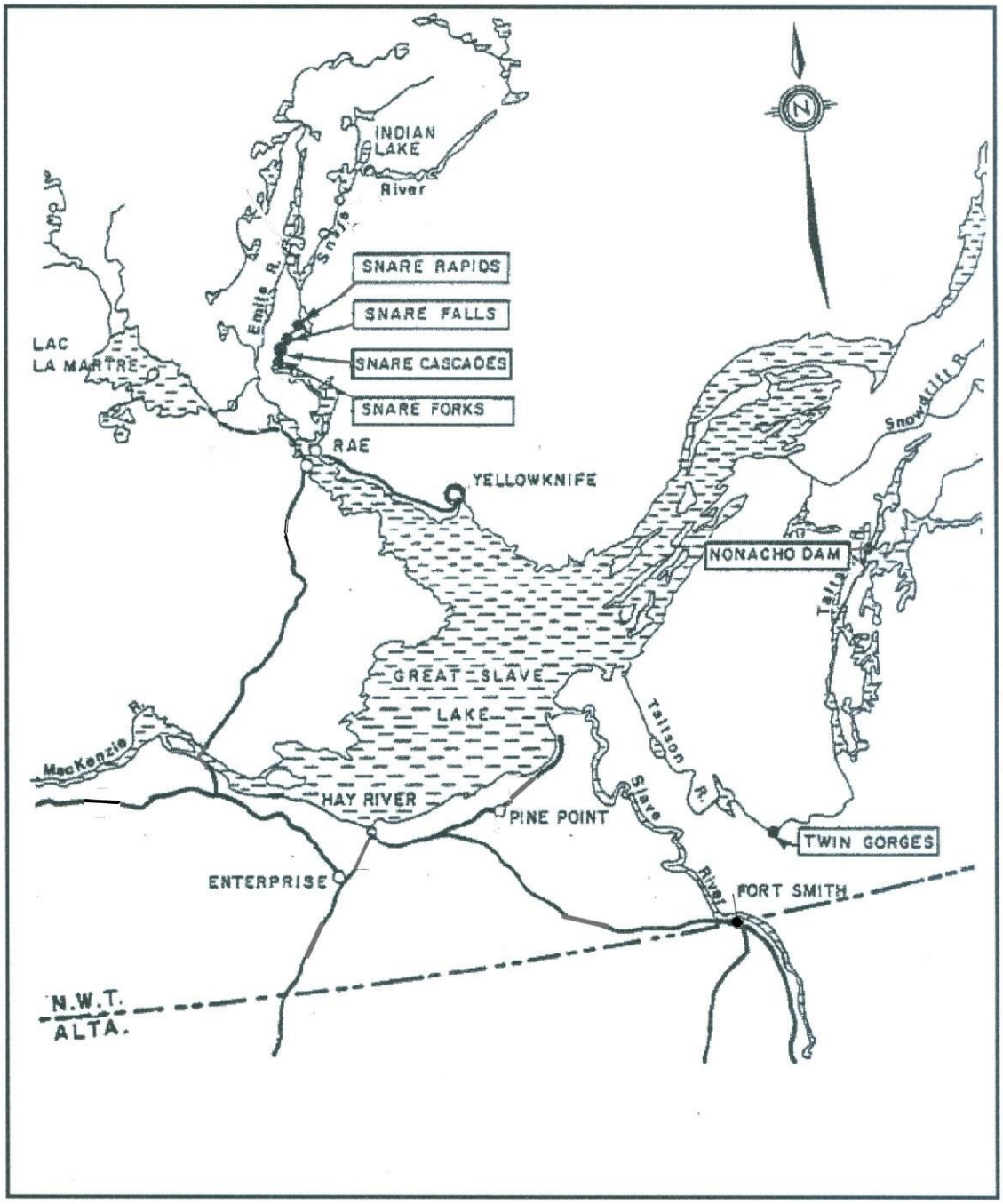
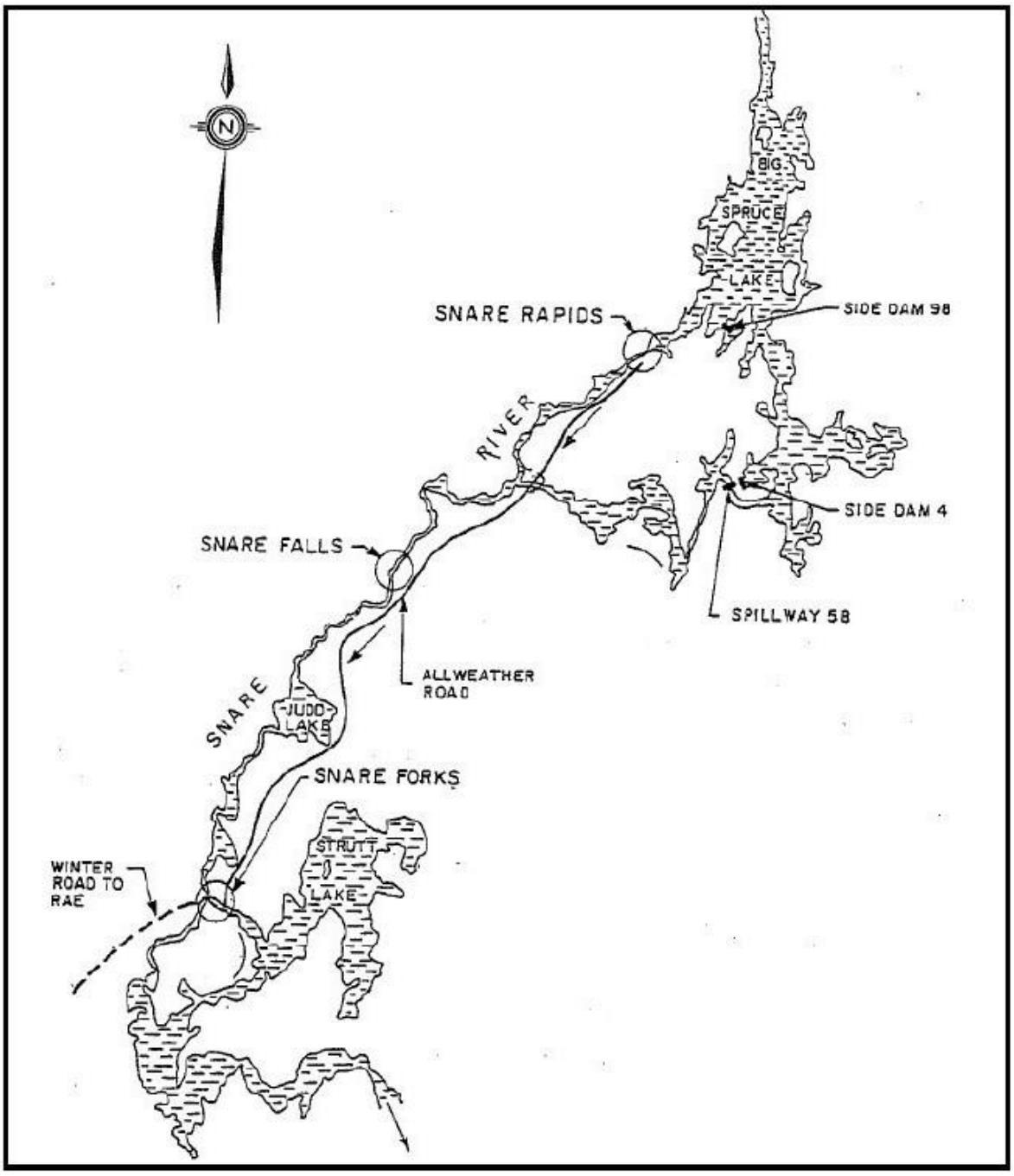


FIGURE 1
GENERAL ARRANGEMENT SNARE HYDRO &
TALTSON POWER DEVELOPMENTS.
Shows Snare Hydro & Taltson. Bluefish not shown.
(For Bluefish See Figure 3)



SNARE HYDRO DEVELOPMENT

FIGURE 2 GENERAL ARRANGEMENT
Snare Hydro System.

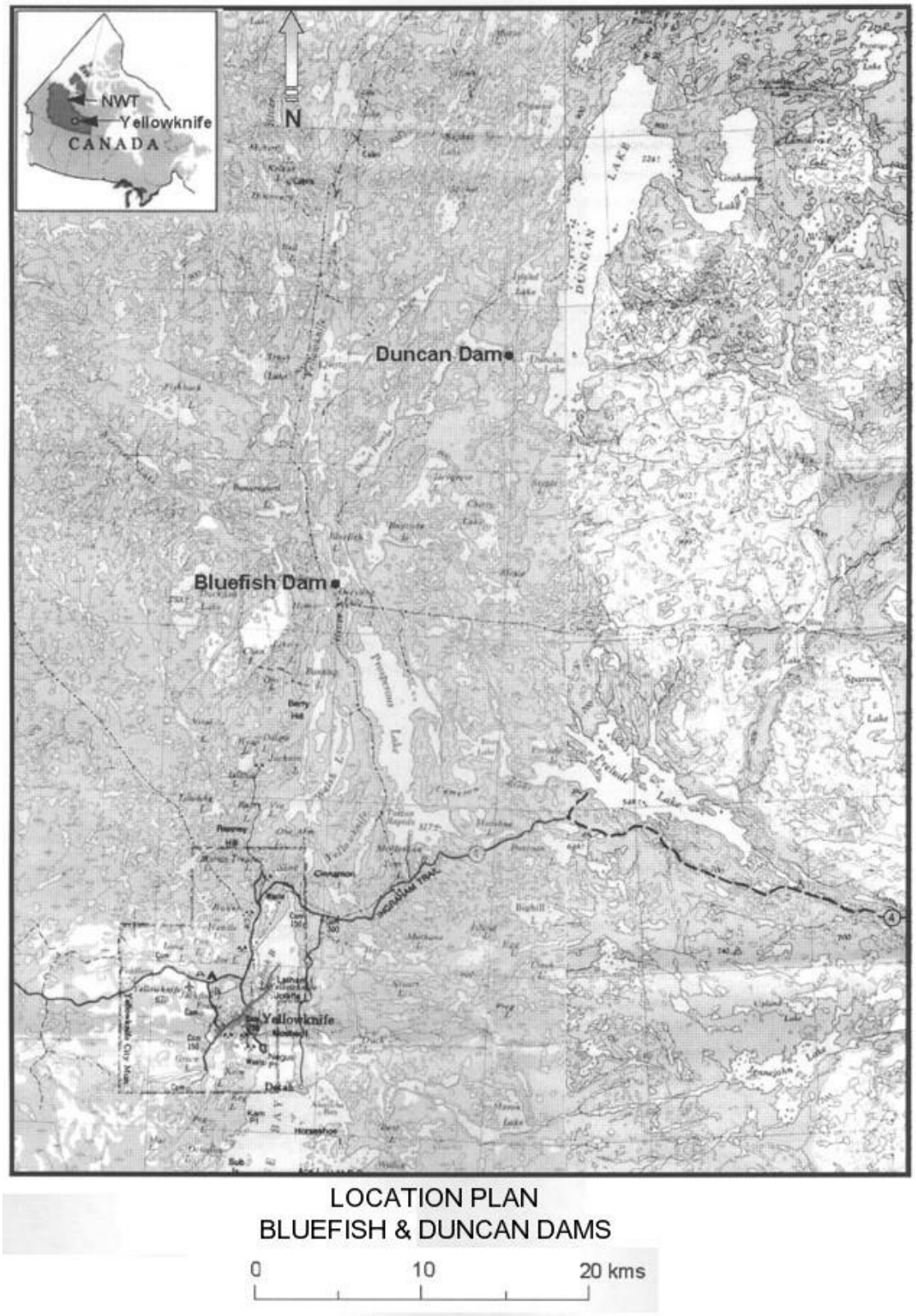


Figure 3. Location of Bluefish Hydro Development

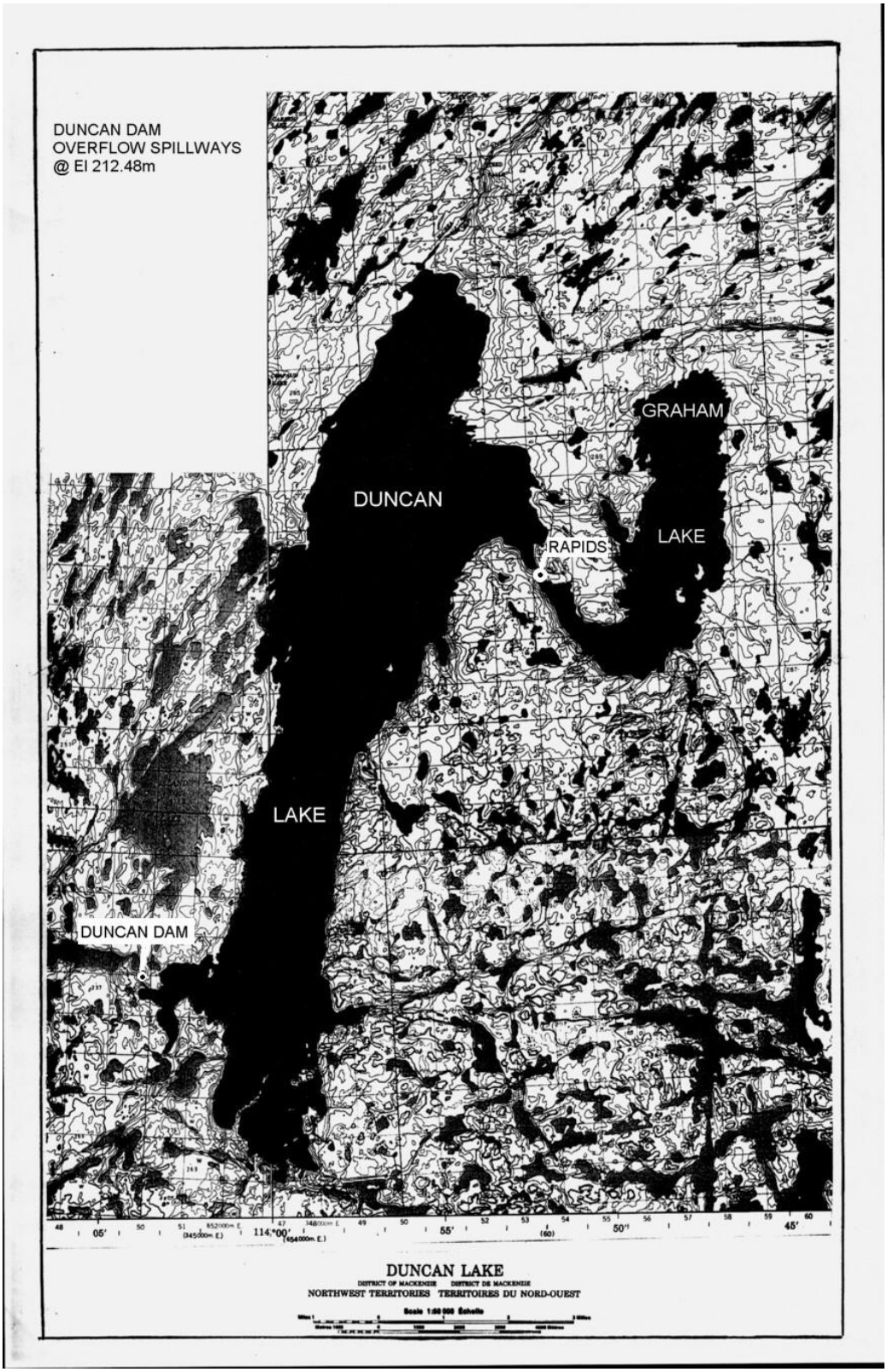


Figure 4 TOPOGRAPHY
Duncan Lake – Duncan Lake Dam

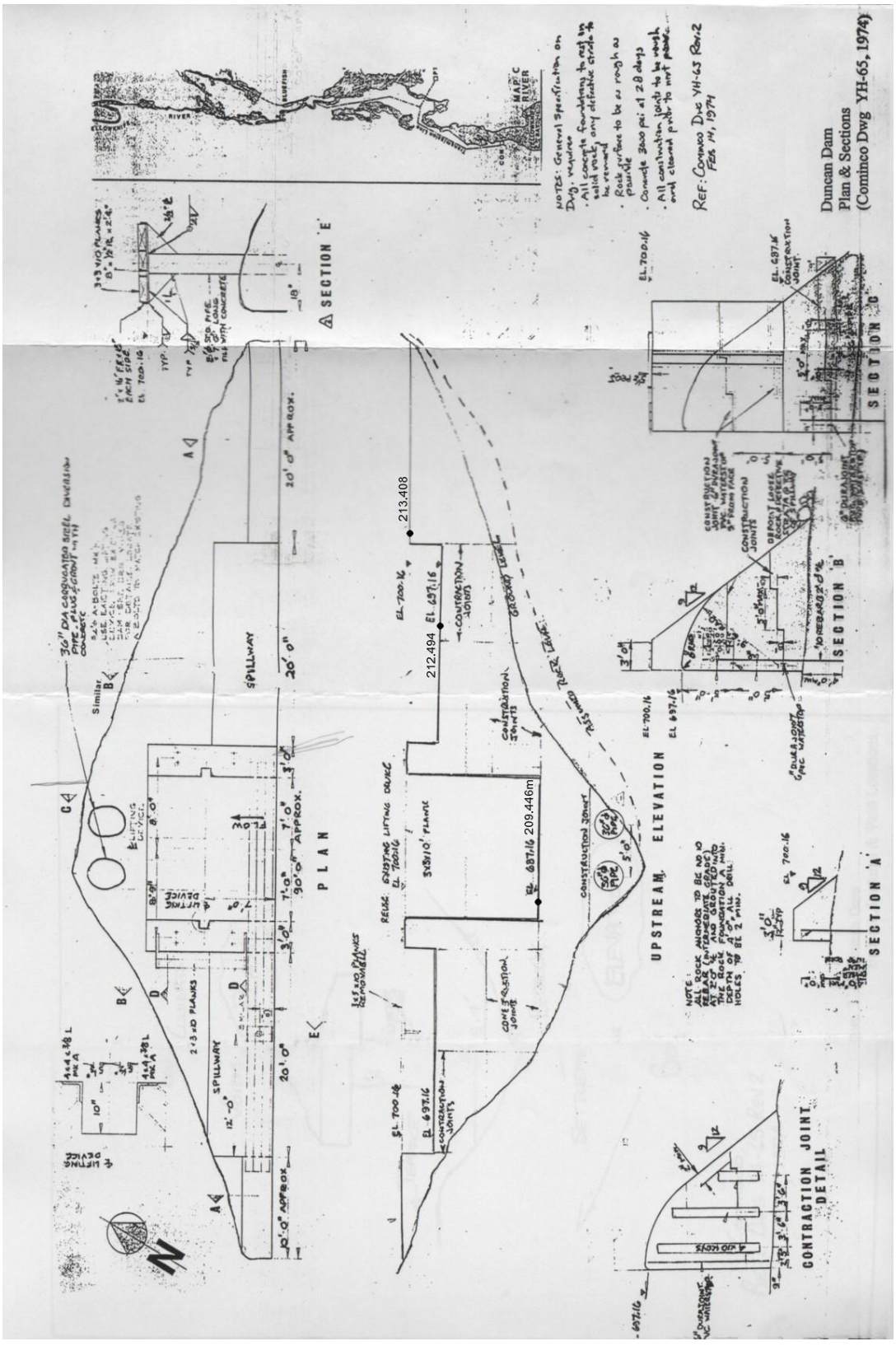


FIGURE 5 DUNCAN DAM PLAN & X-SECTION

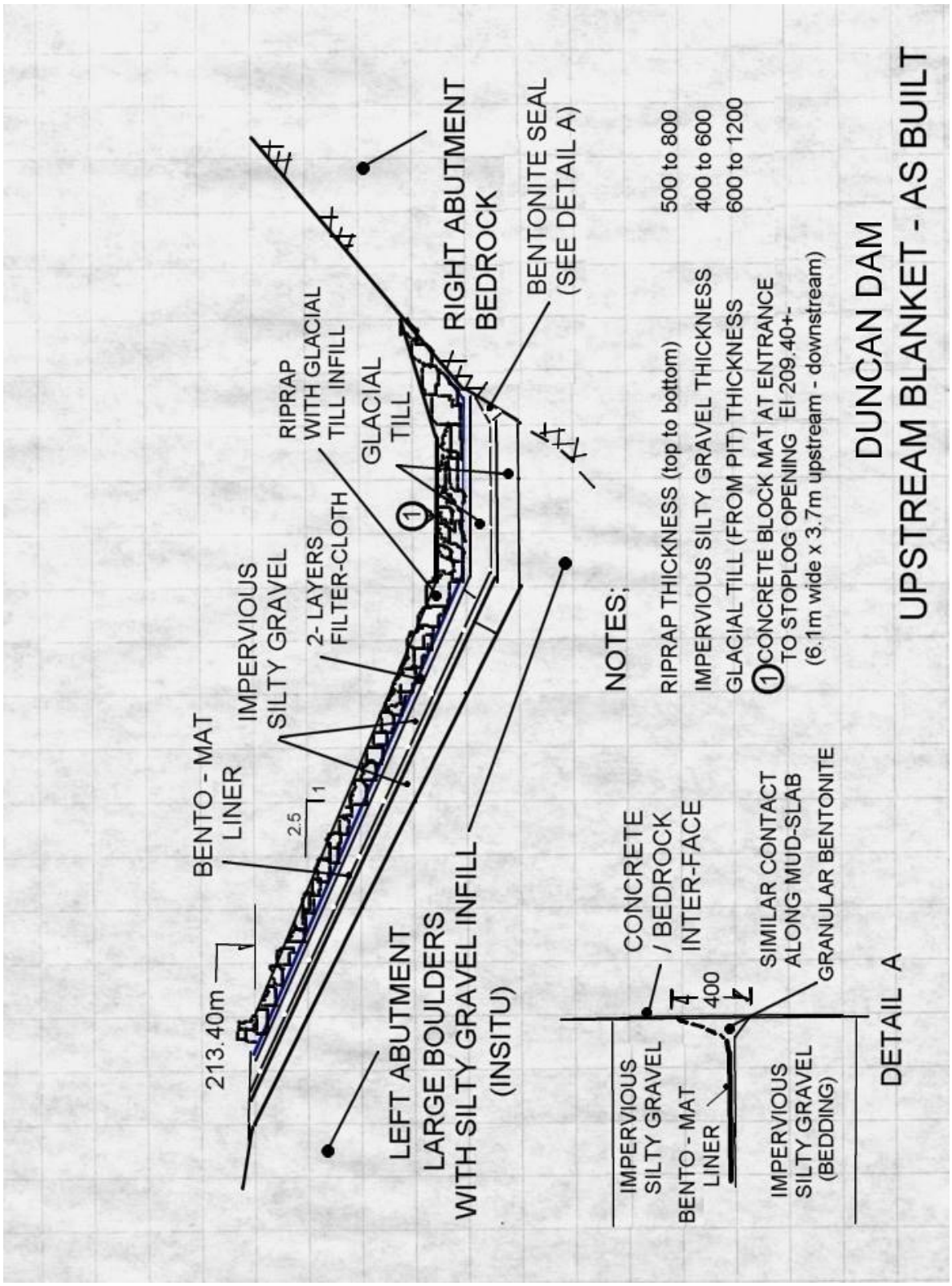


FIGURE 6 DUNCAN DAM UPSTREAM BLANKET.
X-SECTION

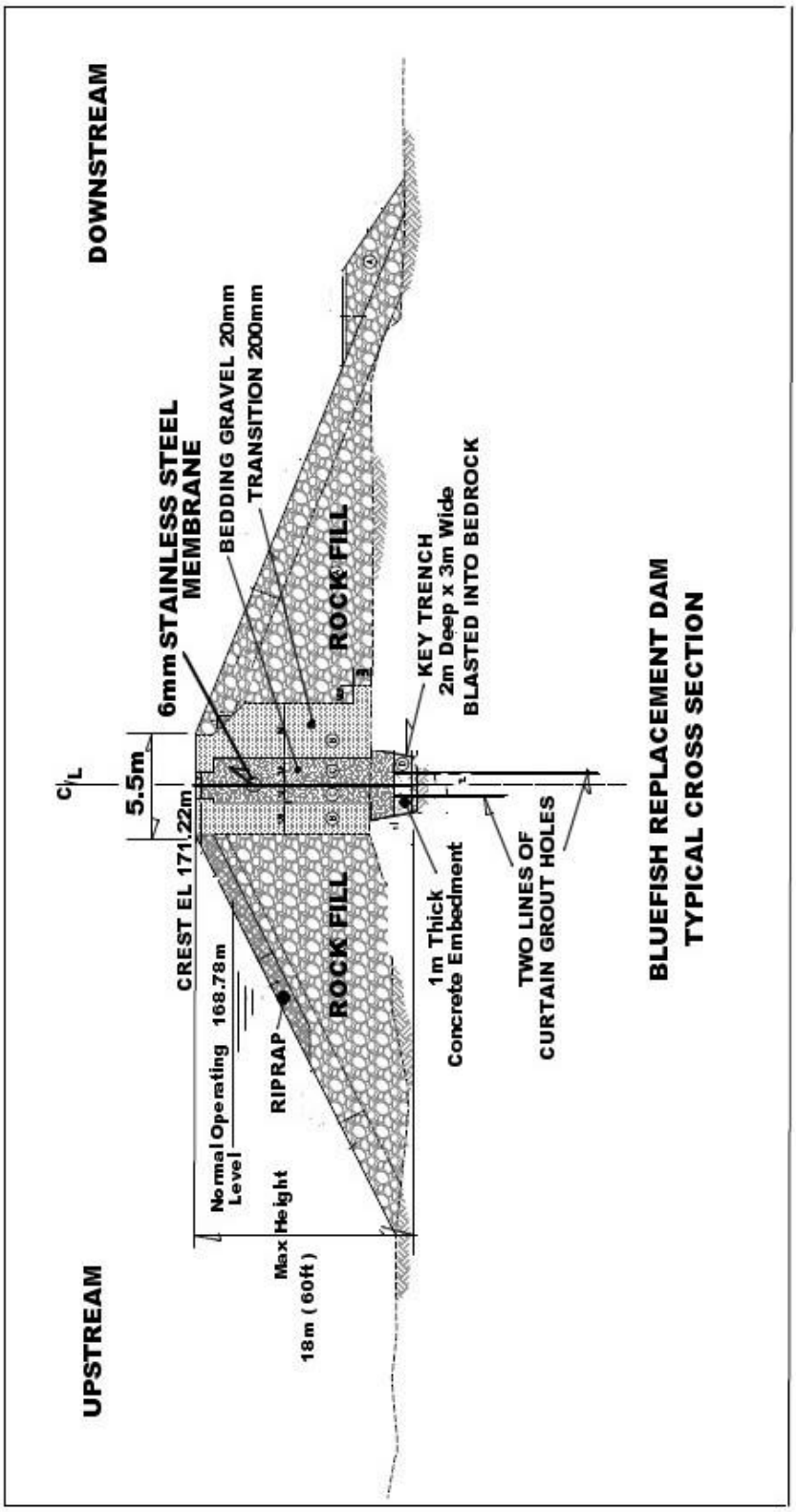


FIGURE 7 X-Section – Bluefish Dam

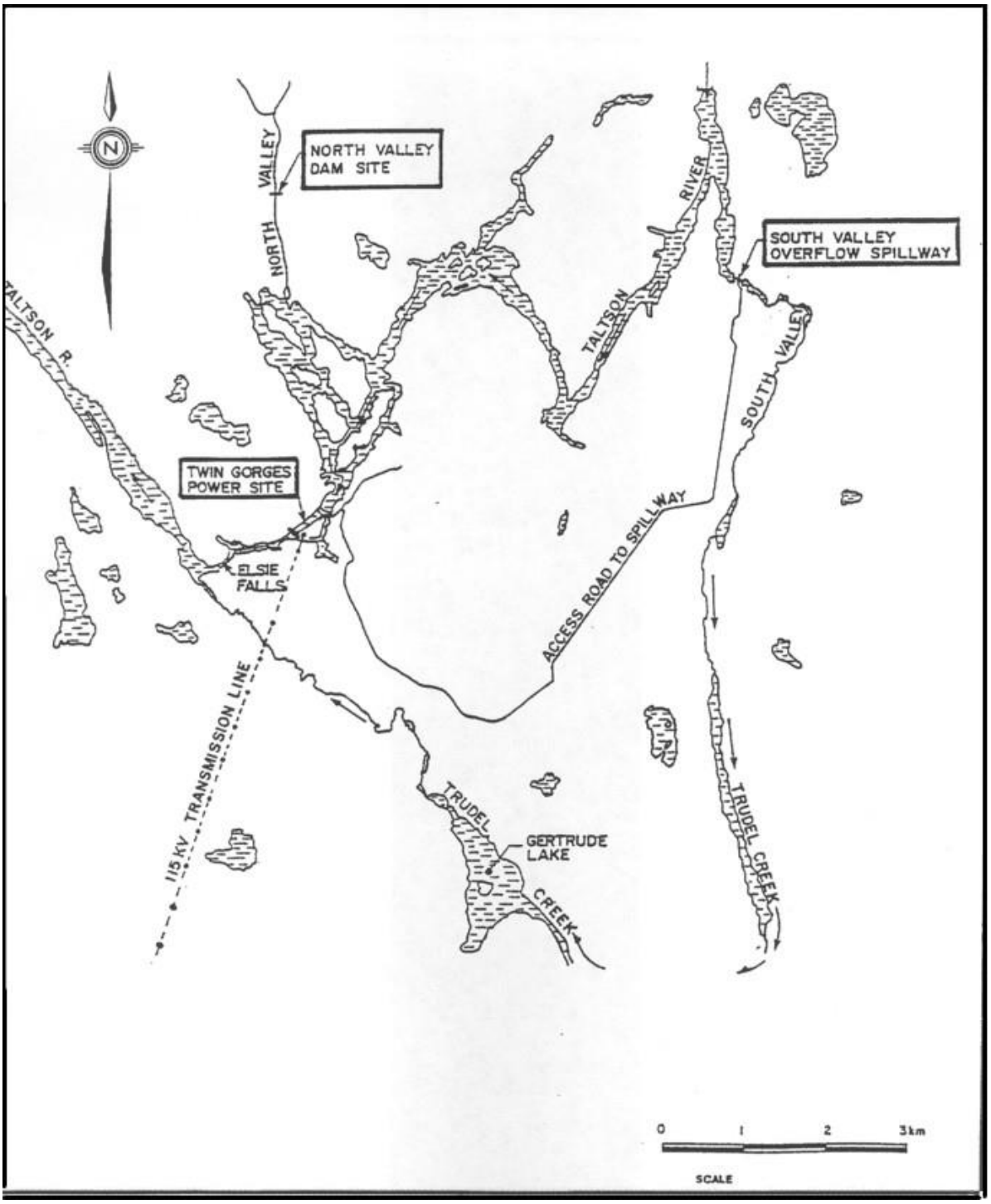
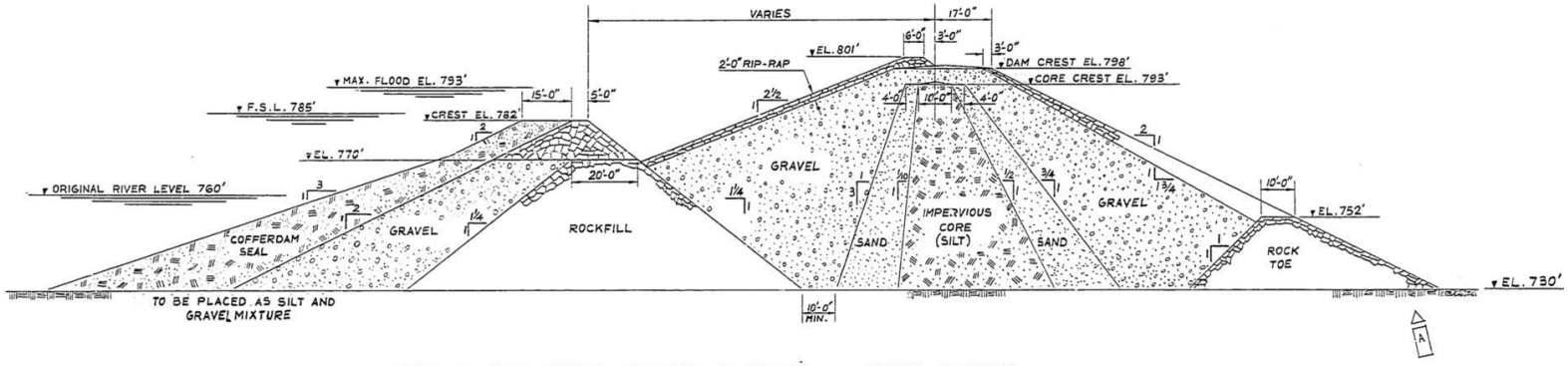


Figure 8. GENERAL ARRANGEMENT
. Twin Gorges, North Dam & South Overflow Spillway.



TYPICAL DAM CROSS-SECTION IN NORTH AND SOUTH GORGES

SCALE :- 1"= 20'-0"

FIGURE 9 Twin Gorges Dam
X – Section

TALTSON DAM
NORTH & SOUTH GORGES
X - SECTION

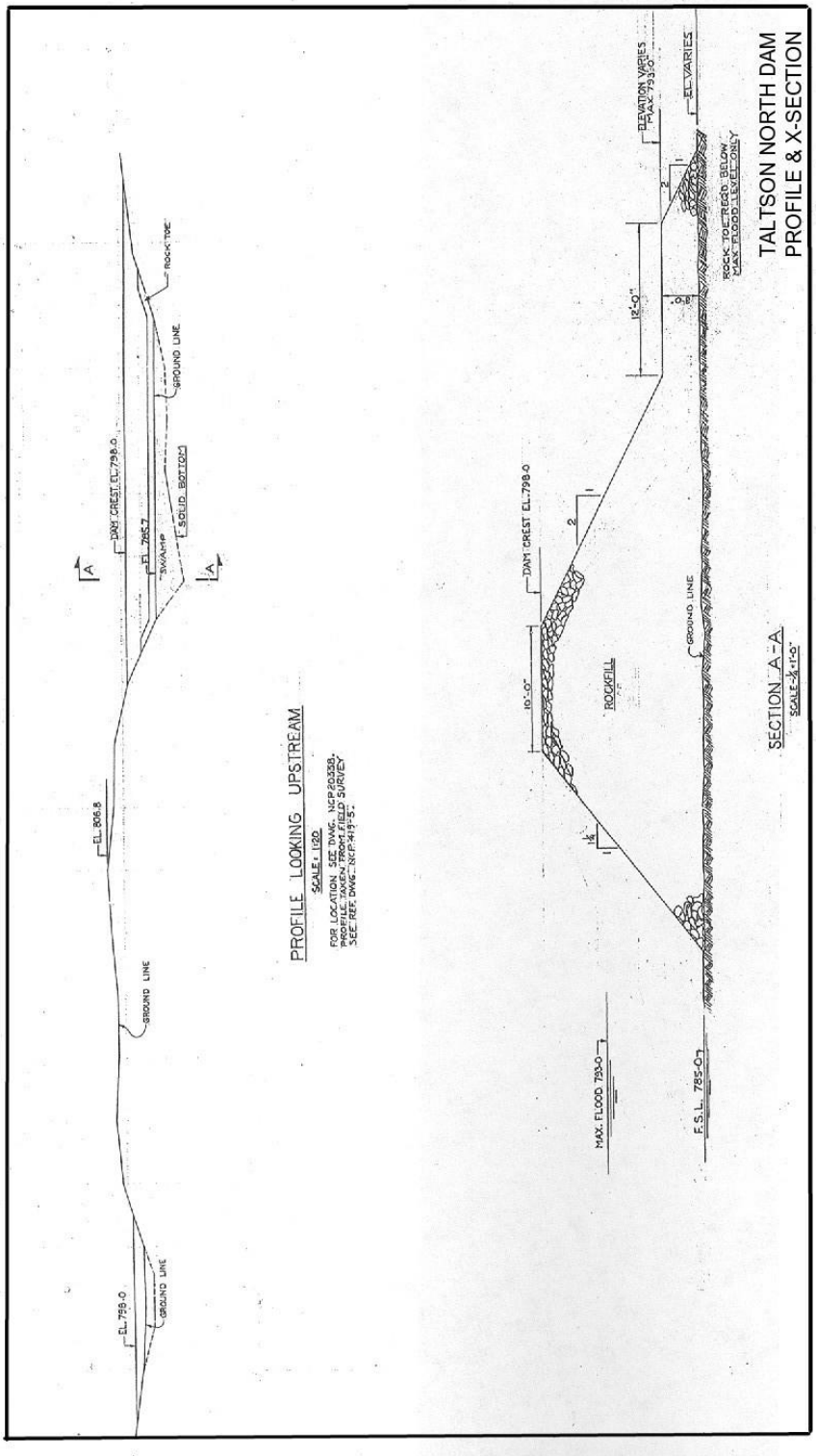


Figure 10. North Valley Dam.
PROFILE & X-SECTION

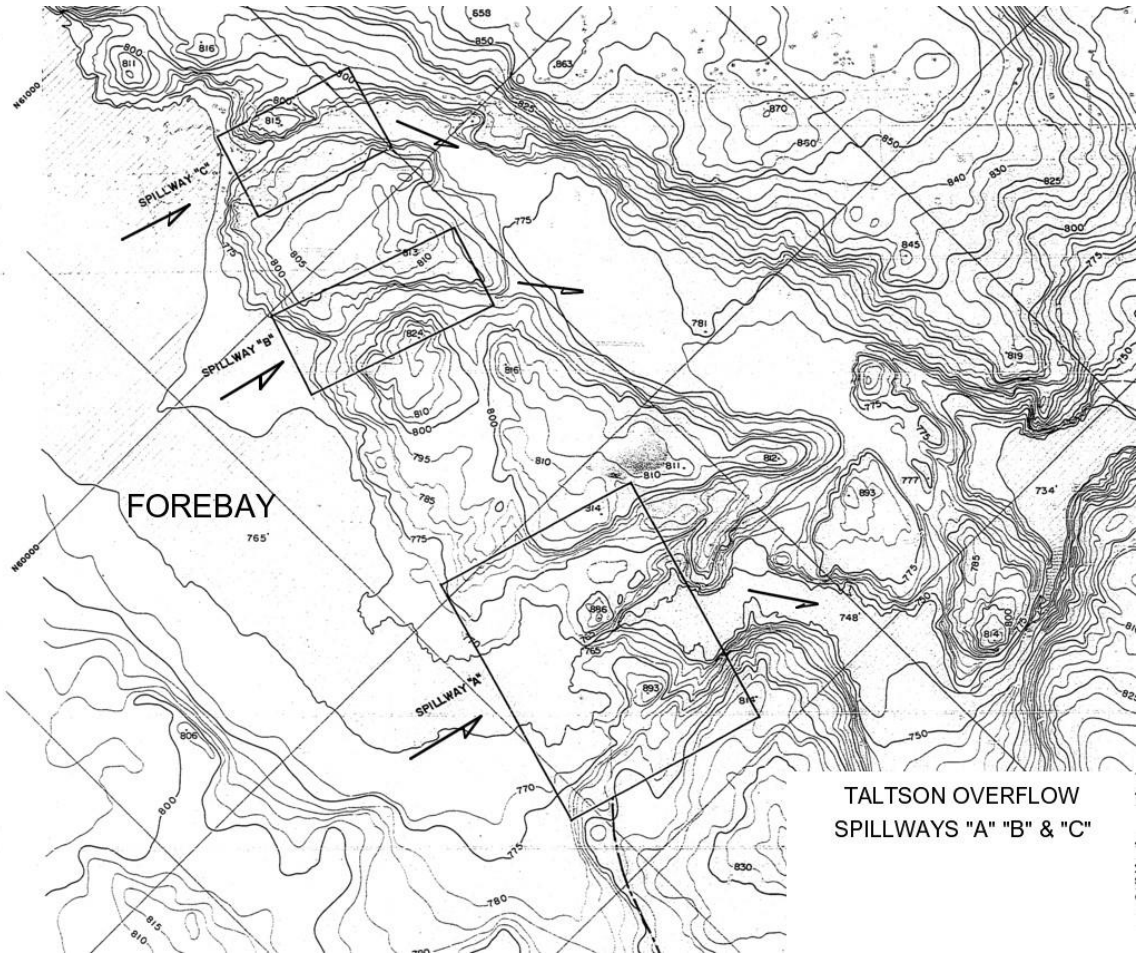


Figure 11. TALTSON SOUTH VALLEY SPILLWAYS.
Shows the topography at the Taltson Overflow Spillways at Sections A (Main Concrete Section), Secondary Channels B & C. The channel at location C is provided with a concrete sill overflow. The flow through Section B is contained in a rock cut without a concrete sill.

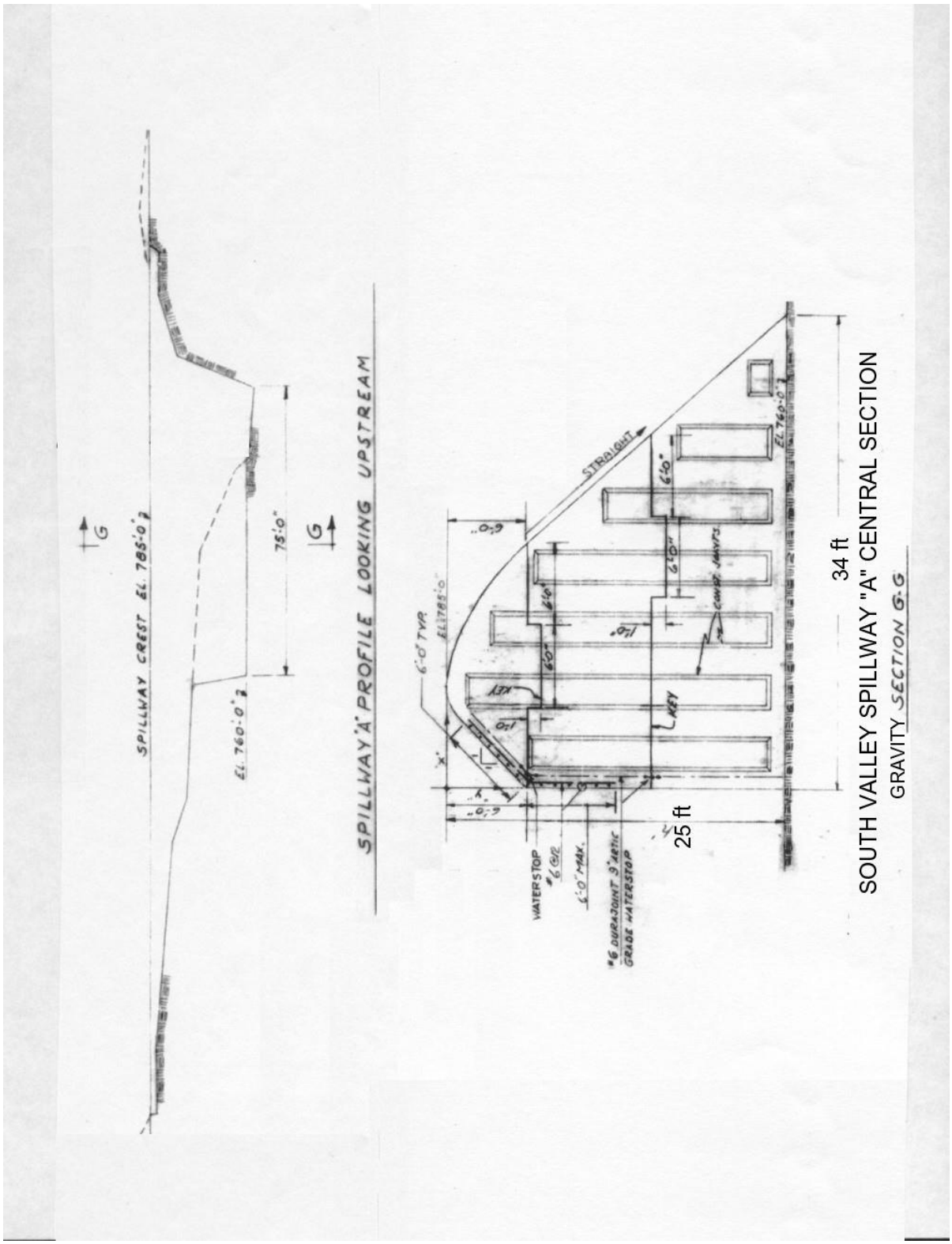


FIGURE 12
SECTION - TALTSON SOUTH VALLEY SPILLWAY

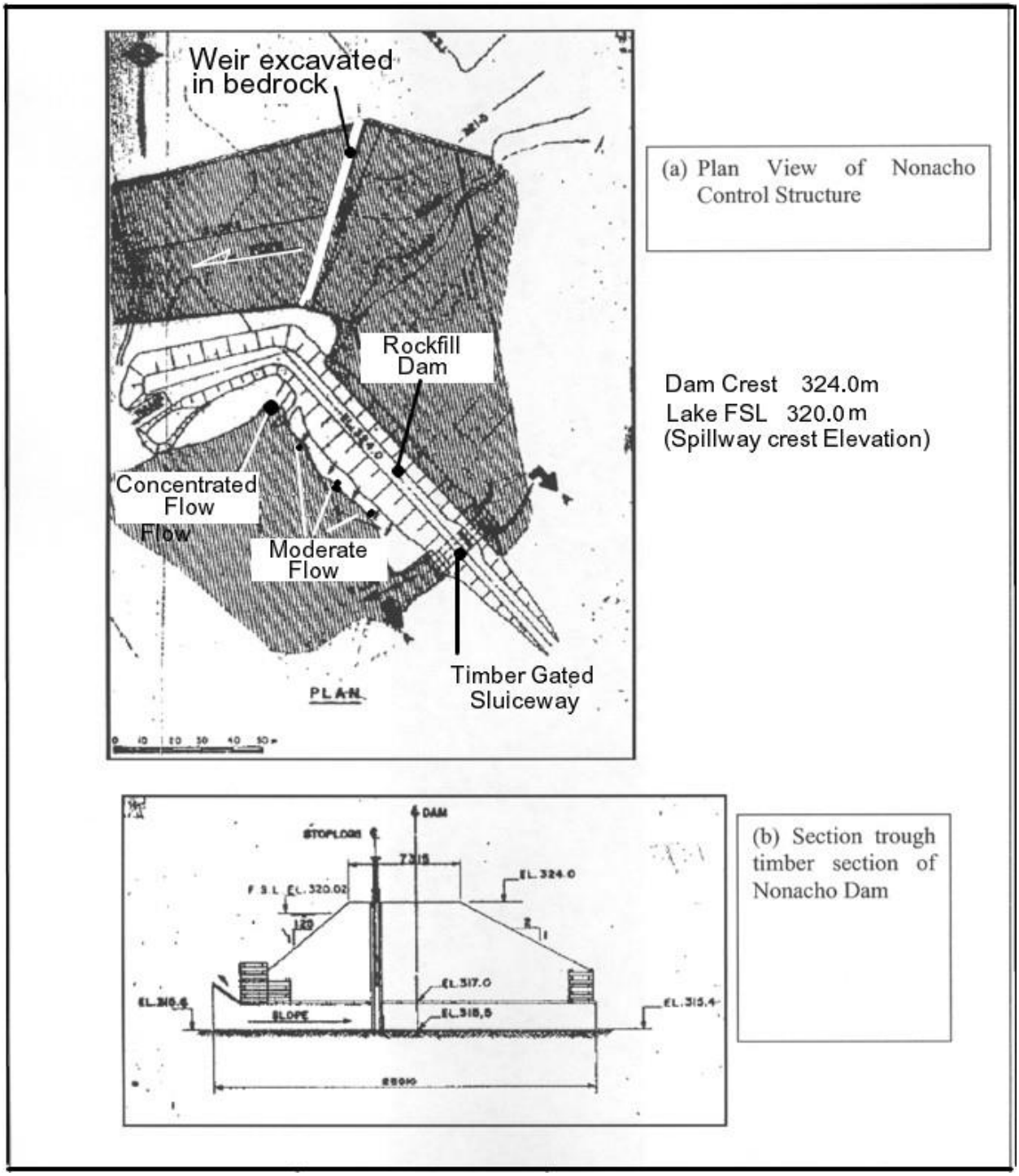
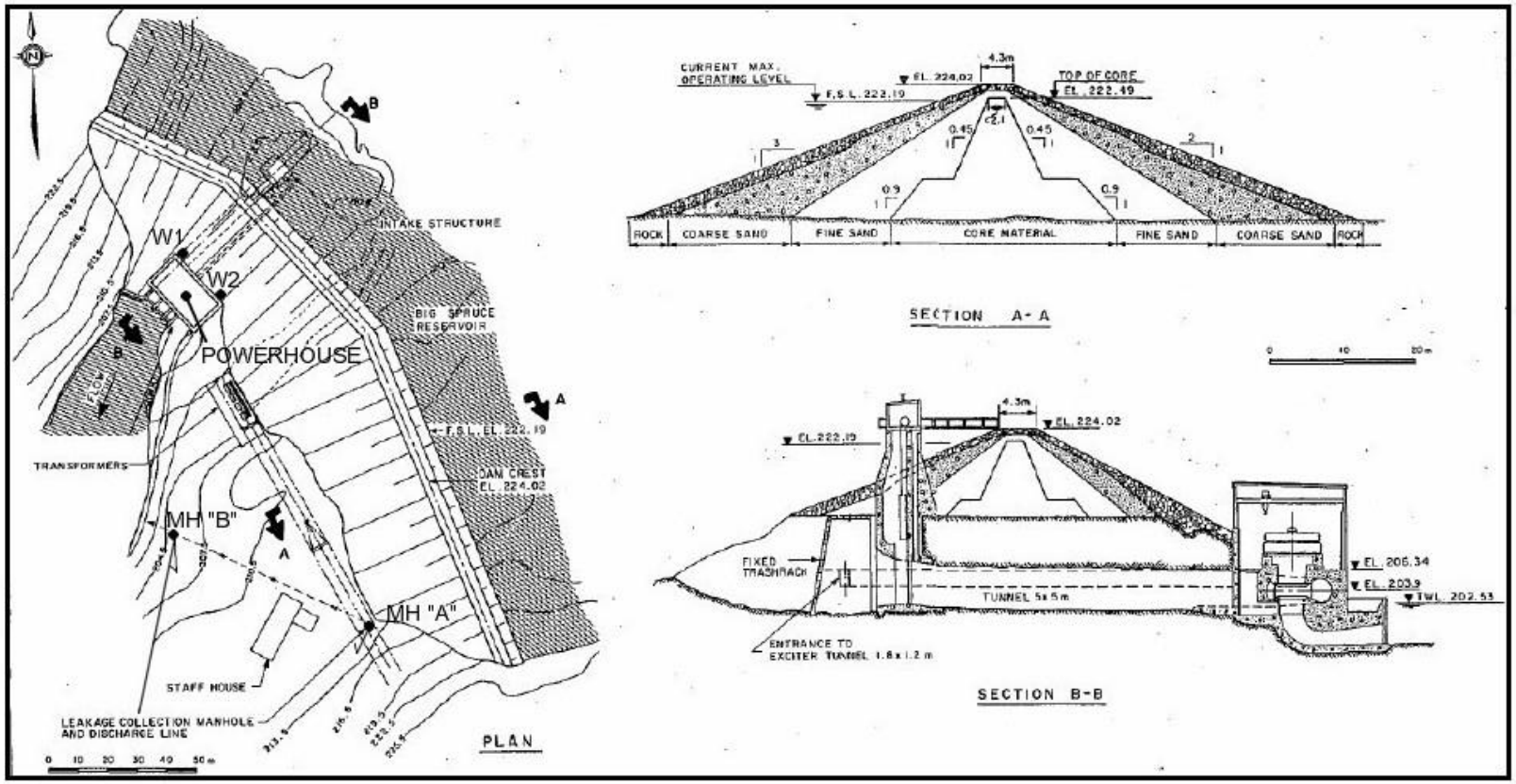


Figure 13. Nonacho Plan and Timber Sluiceway Cross-Section



RAPIDS MAIN DAM

FIGURE 14. Rapids Main Dam - Plan & Sections.

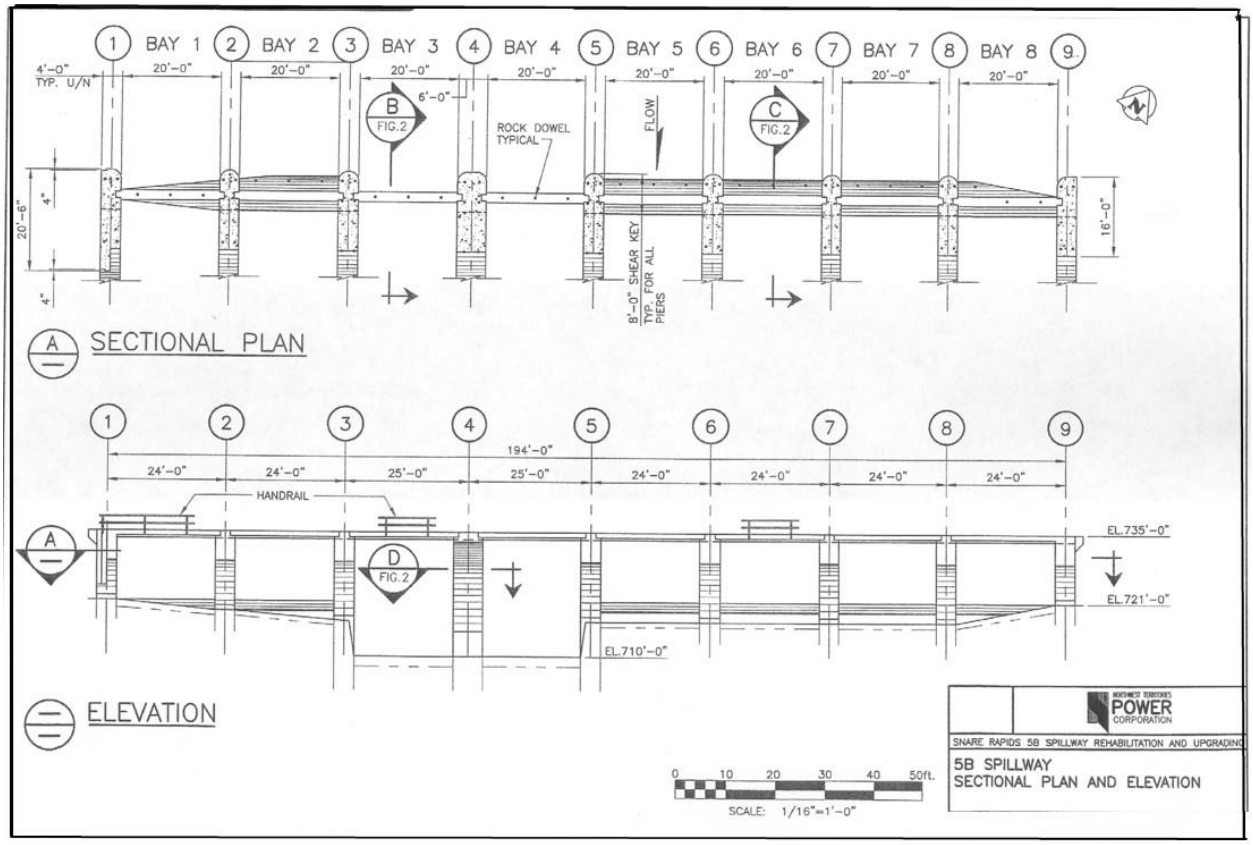


Figure 15. 5B Stoplog Spillway; Plan & Profile

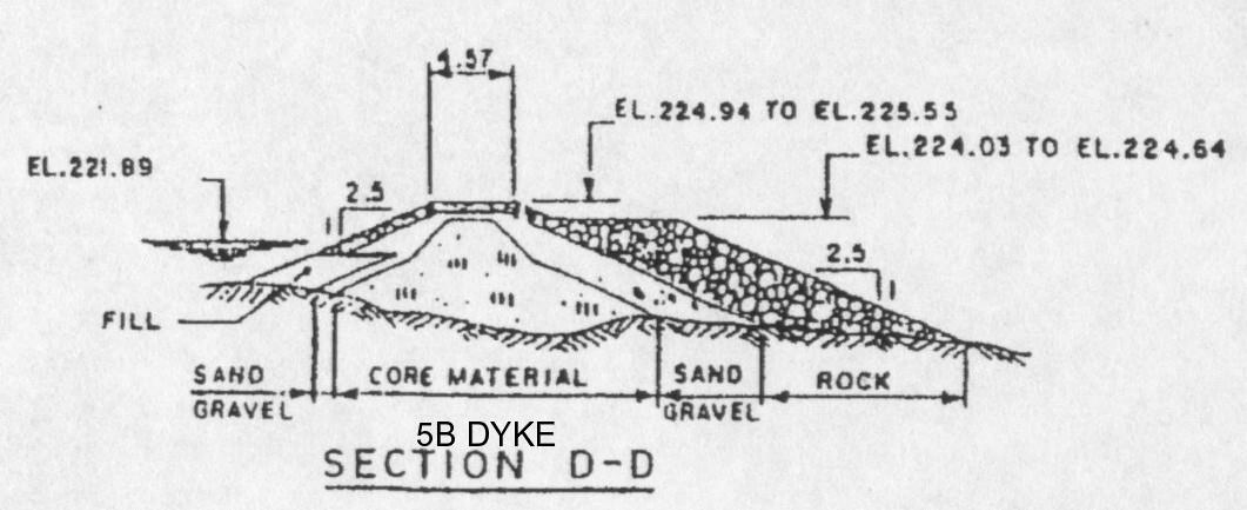


Figure 16. 5B X-Section Zoned Earthfill Dyke

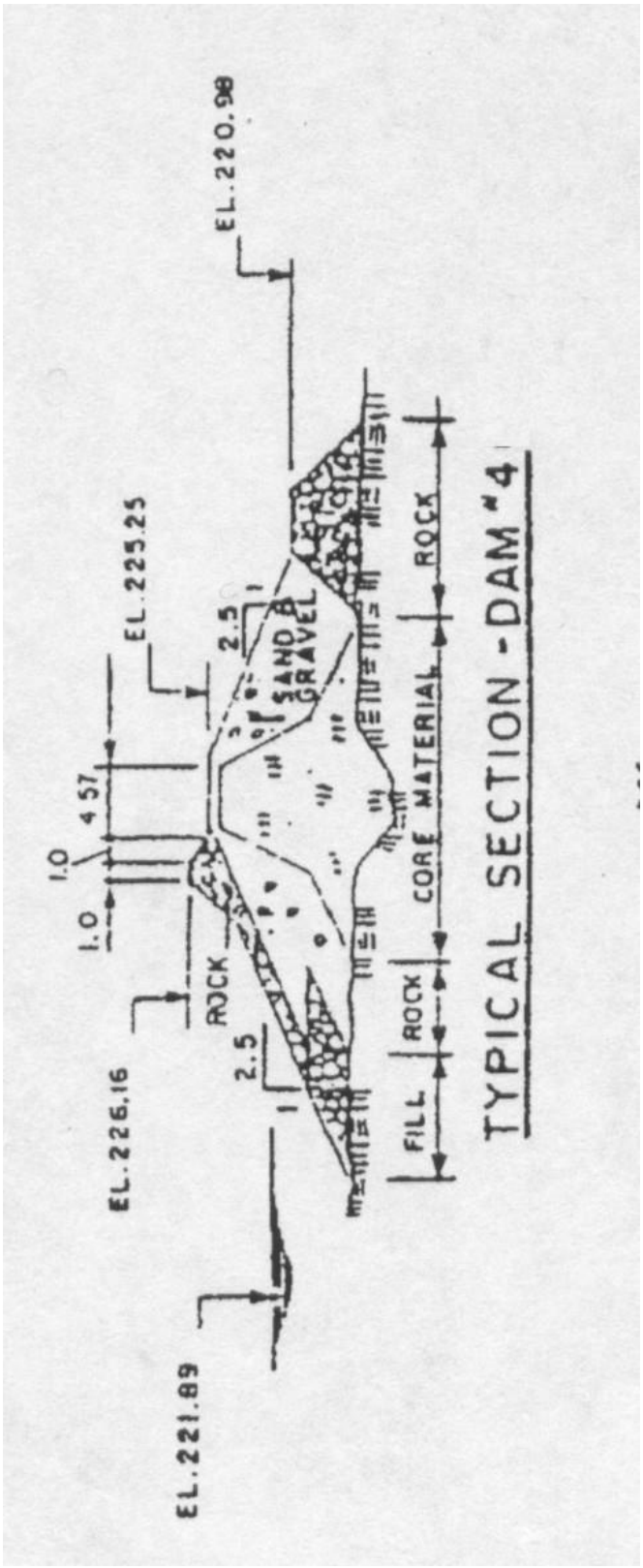


Figure 17. X-Section of Dam 4

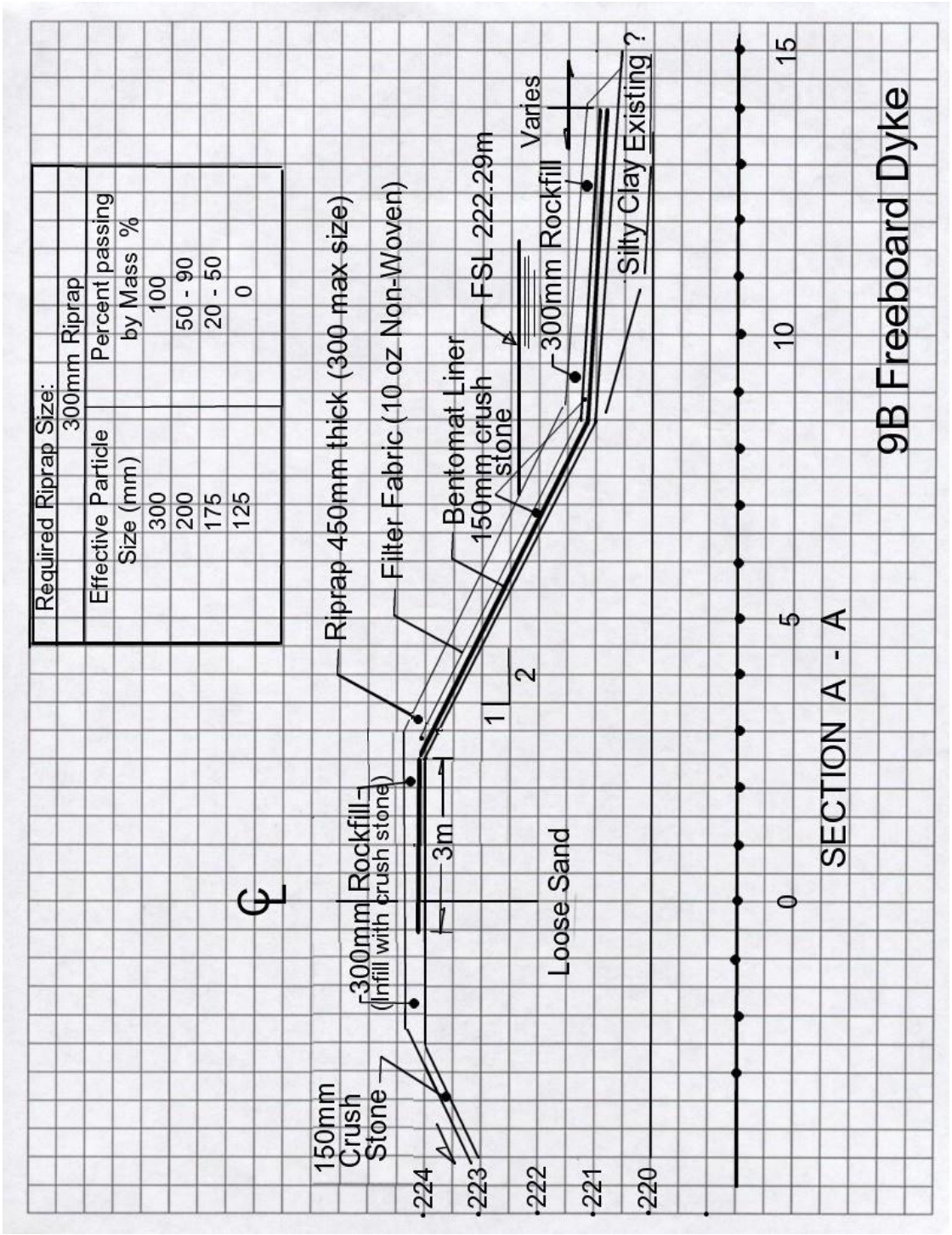


FIGURE 18 X-SECTION 9B FREEBOARD Dyke

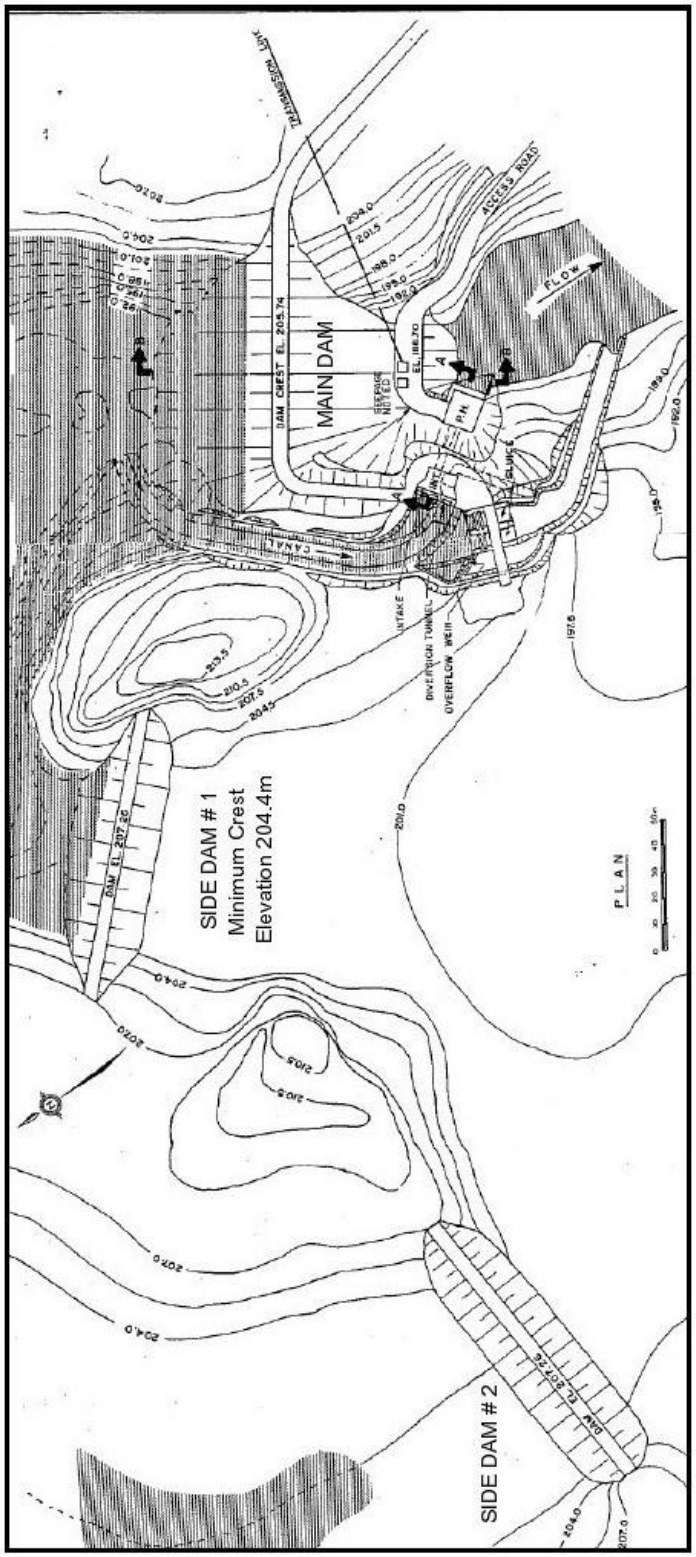


FIGURE 19 FALLS DEVELOPMENT GENERAL ARRANGEMENT
Showing Main Dam & Side Dams 1 & 2

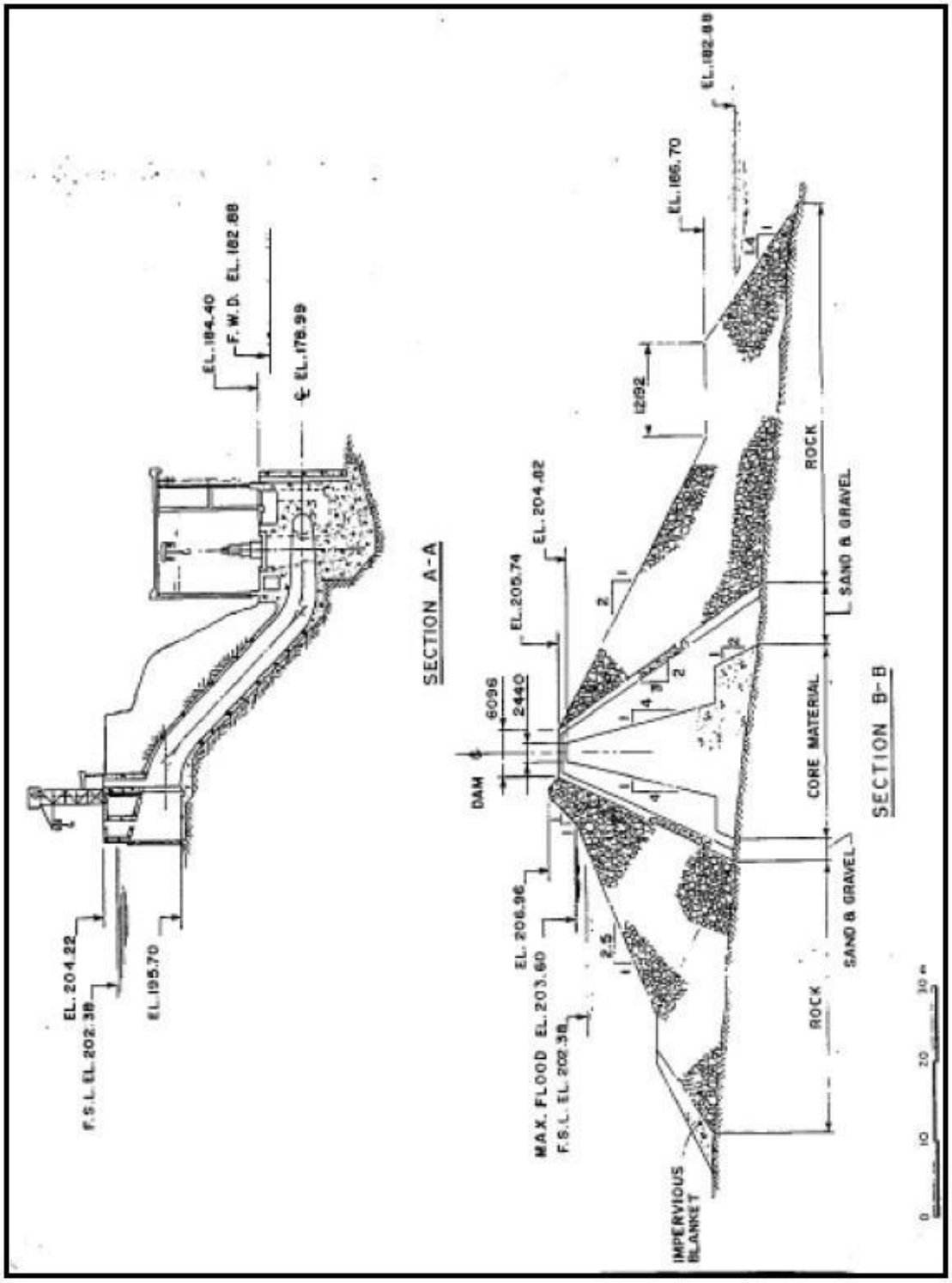
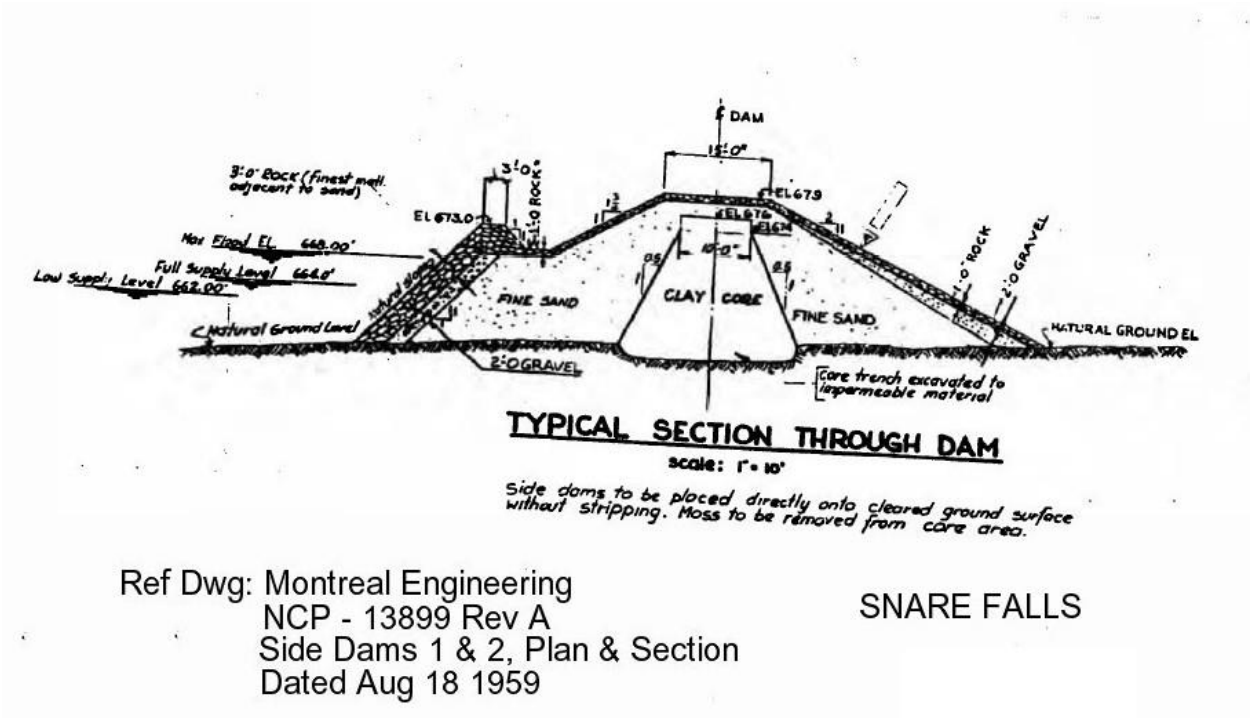


FIGURE 20 Snare Falls X-Sections Main Dam.



Ref Dwg: Montreal Engineering
NCP - 13899 Rev A
Side Dams 1 & 2, Plan & Section
Dated Aug 18 1959

SNARE FALLS

Figure 21 Snare Falls Side Dams “As Built”

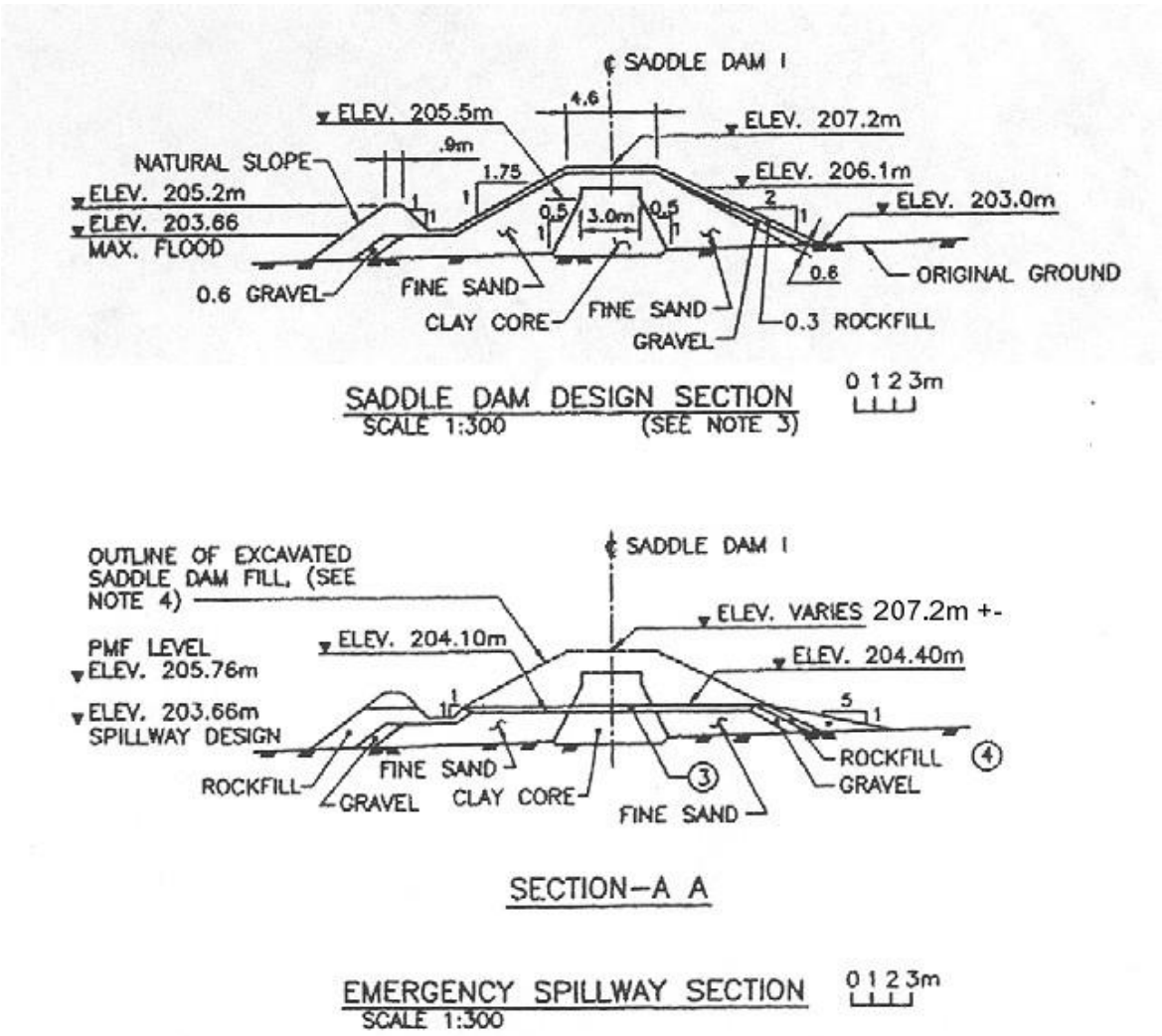


FIGURE 22
2003 Modifications to Falls Side Dam #1
Emergency overflow Spillway

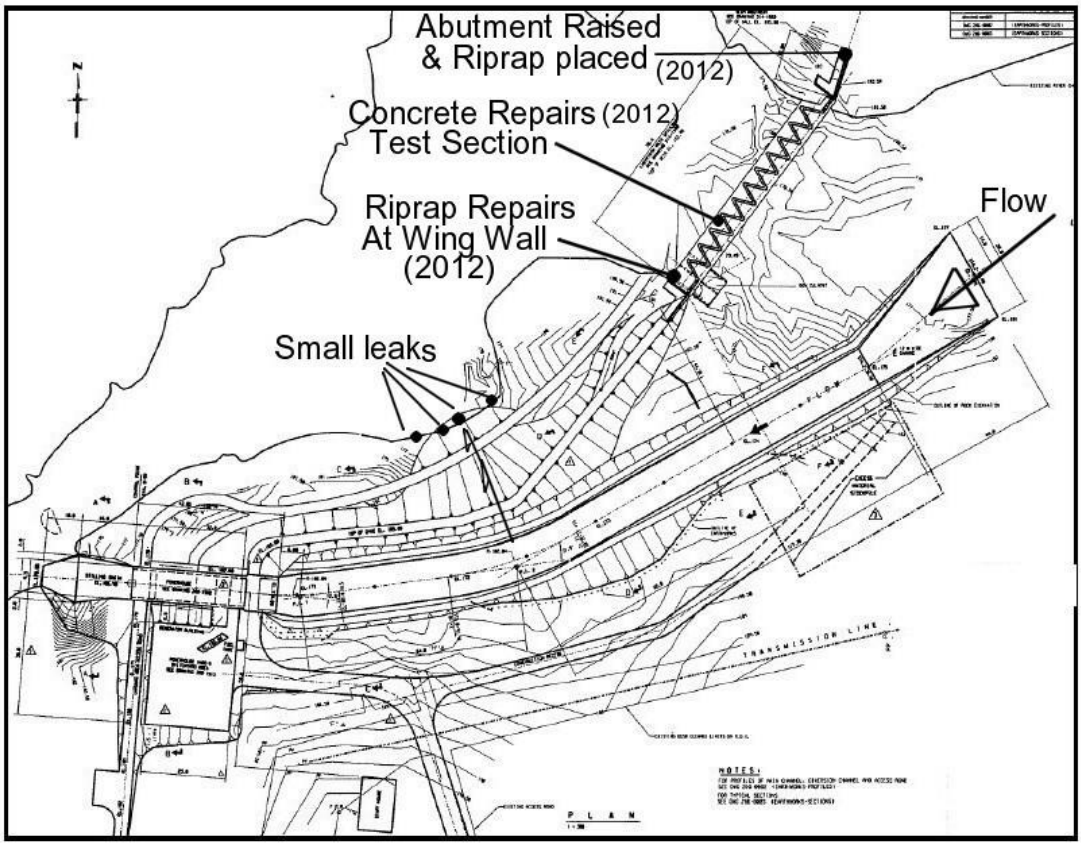


Figure 23 Plan of Snare Cascades Development.

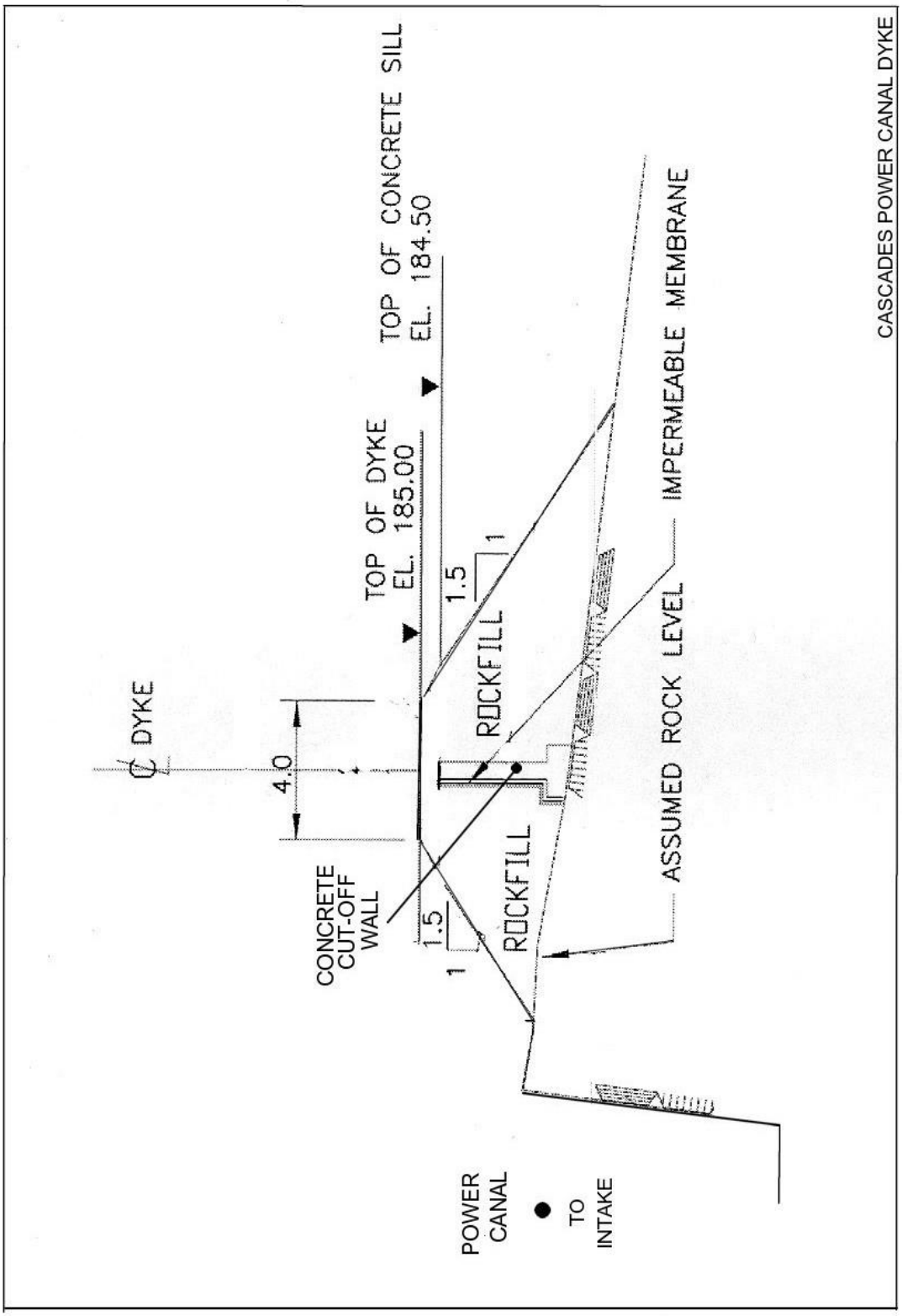


Figure 24. Cascades Power Canal Dyke.

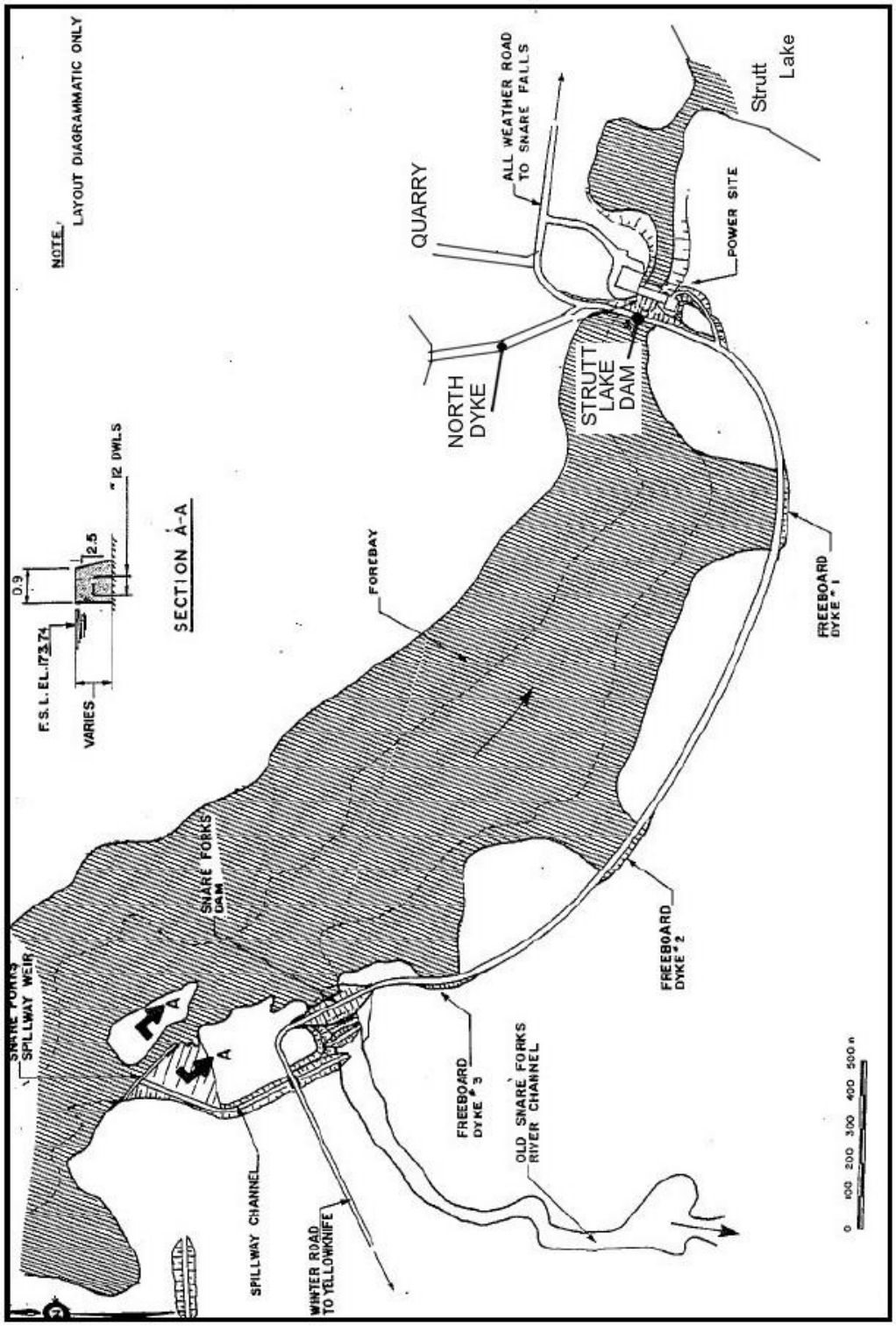


FIGURE 25.
GENERAL ARRANGEMENT
Forks Development

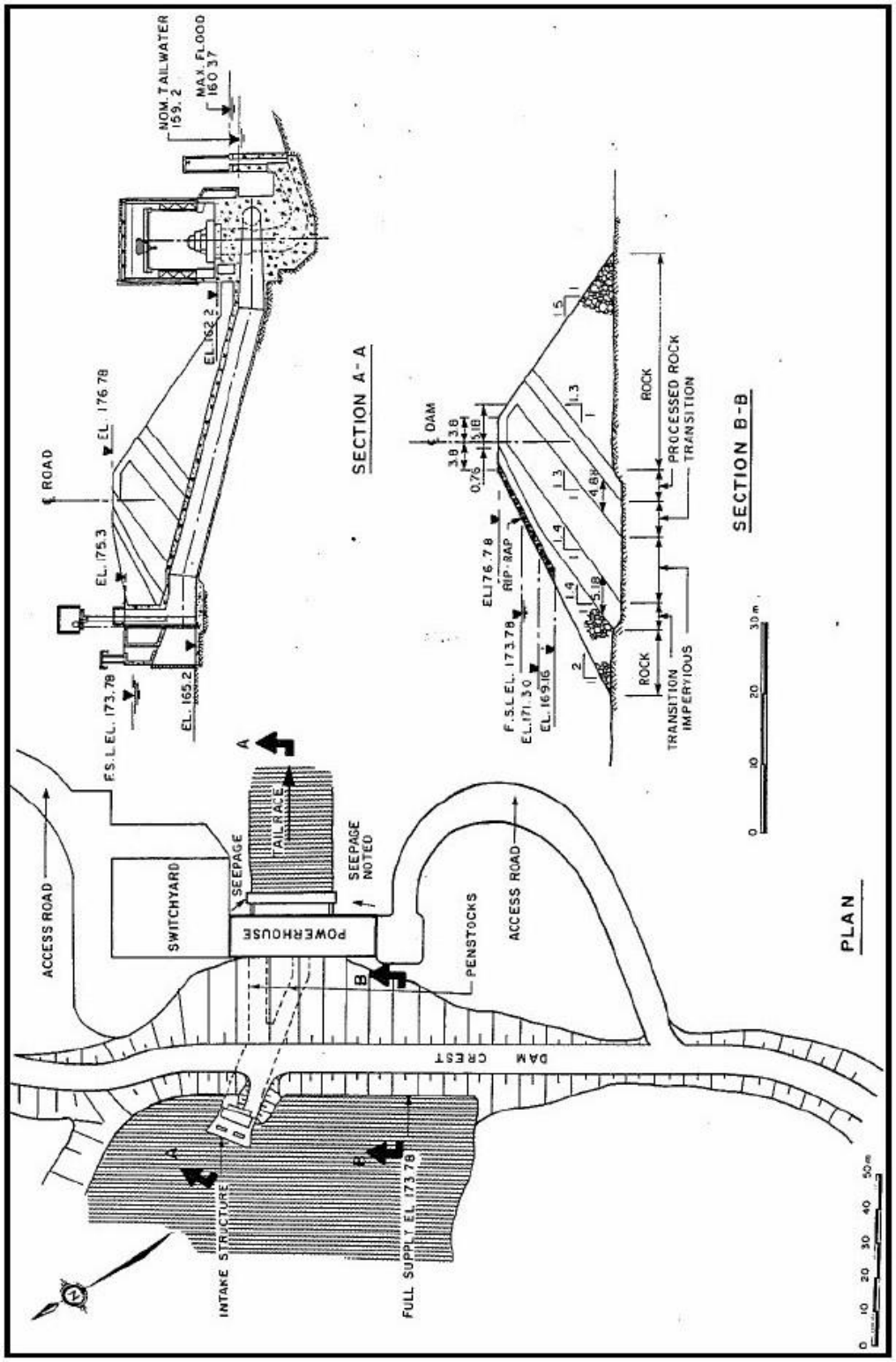


FIGURE 26
STRUTT LAKE DAM
PLAN & X – SECTIONS

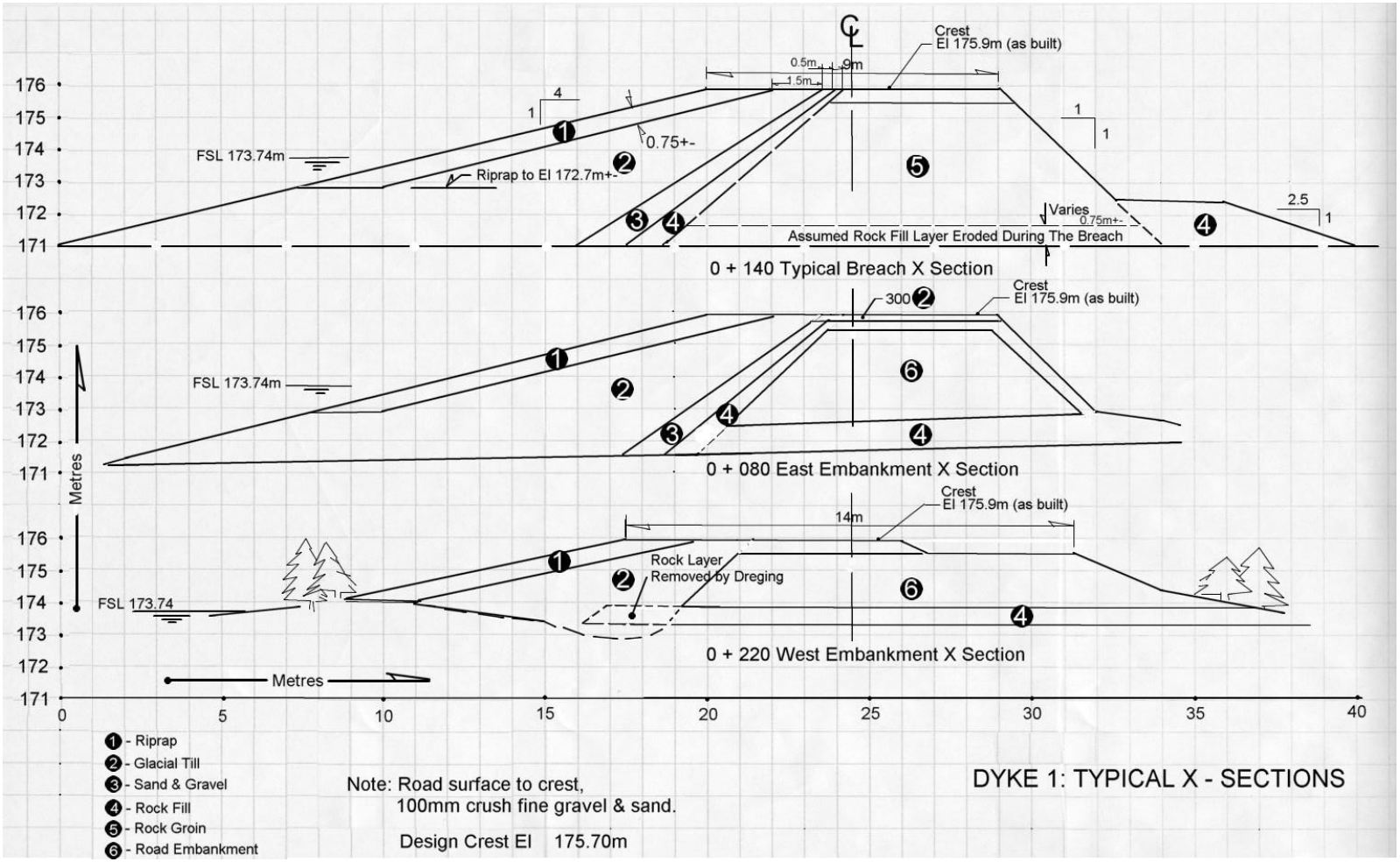


FIGURE 27 Dyke 1 X-Sections

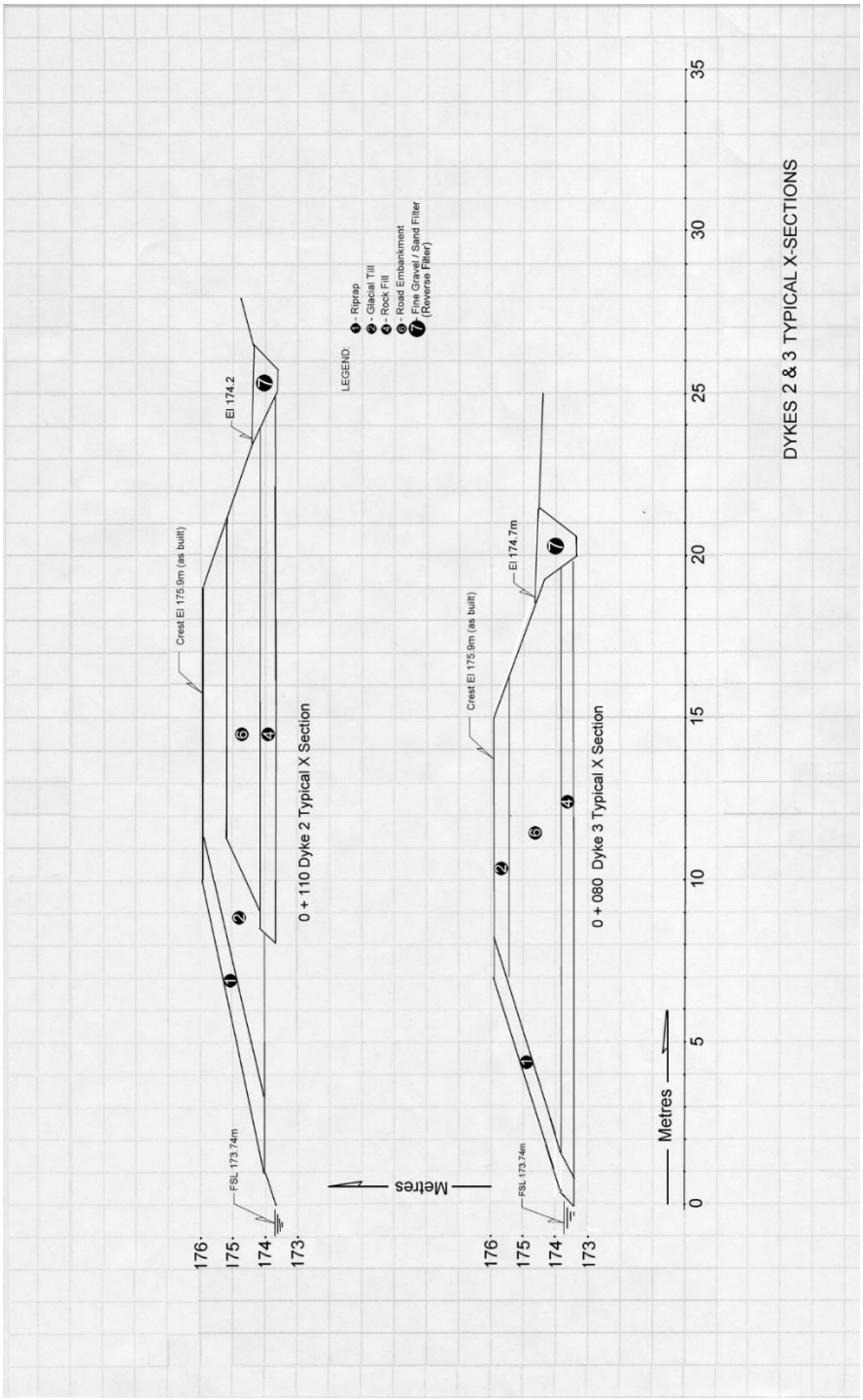


Figure 28. Dykes 2 & 3 X-Sections.

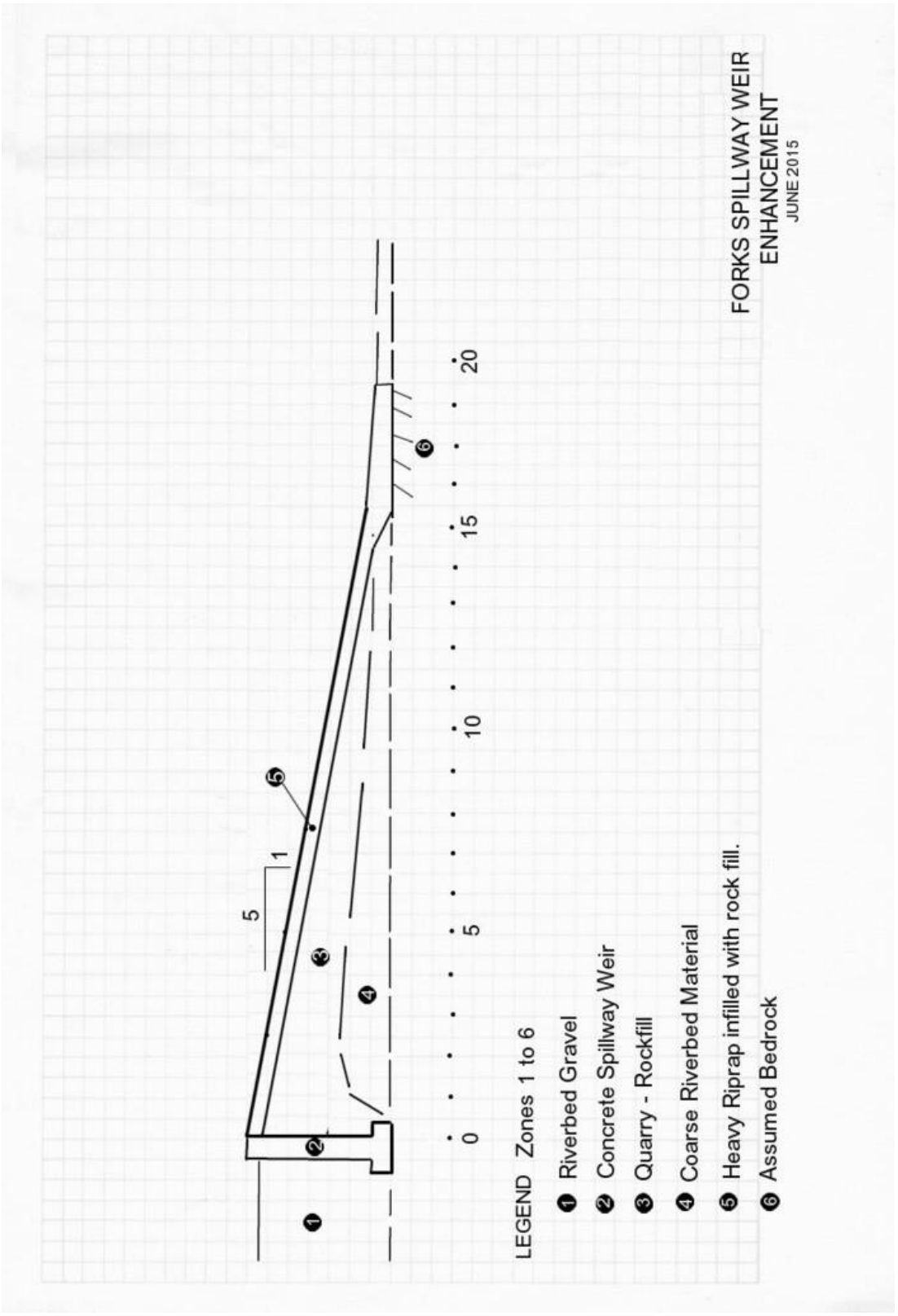


FIGURE 29 Spillway Weir X-Section.