Dead River Dam

Study to Minimize Flood Flows from the Androscoggin River into the Androscoggin Lake

E·PRO

Engineering & Environmental Consulting, LLC
A TRC Company

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STATE OF MAINE
ANDREW
T.
STRAZ
No. 3369
REGISTERED
PROFESSIONAL ENGINEER

Prepared by:

Andrew T. Straz, P.E.
E/PRO

Ellen K. O'Brien, P.E.
Northstar Hydro

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EXECUTIVE SUMMARY

The Maine Department of Environmental Protection engaged the services of E/PRO Engineering and Environmental Consulting, LLC and Northstar Hydro to conduct a preliminary feasibility study to: (1) assess the hydrology of the Dead River and Androscoggin Lake, and (2) assess the effectiveness of the existing dam; needed repairs; changes to existing dam; and alternative structures.

The hydrologic analysis concluded that the existing dam with two feet of flashboards is likely to be overtopped several times every year. The present site, due to the height of the embankments, restricts the dam to a maximum of four feet of flashboards that are likely to be overtopped once a year.

The existing dam is in good condition with only minor concrete repairs needed. However, the west embankment and the west riverbank downstream of the dam are eroded, and repairs are estimated to cost $101,800. This work is recommended for continued use of the dam at this site.

Alternate dam sites exist near the mouth of the Dead River and near the cemetery off Route 219, which would support the construction of a higher structure. A new dam could be constructed, consisting of a concrete base with an inflatable rubber bladder mounted on top. The bladder would be inflated in the event of a flood; while deflated, it would not restrict the flow from the lake to the river. Three different height dams were evaluated – 10, 16, and 18.4 feet – which would provide protection against floods expected to be exceeded in 2, 25, and 100 years, respectively. The estimated cost for each structure is $1,980,000, $2,846,000, and $5,240,000, respectively.

The construction of a higher structure will affect the level of flooding on the Androscoggin River. An example of this effect is that the flood level at the Route 219 Twin bridges would increase about 0.3 feet for a minimal Dead River dam, to as much as 6 feet for a Dead River dam designed to withhold a 100-year flood.

The next steps would be to conduct a more detailed study of the potential impact on the Androscoggin River flooding, determine the availability of the proposed dam sites for purchase, and prepare a preliminary engineering study on the selected site.

INTRODUCTION

The Dead River Dam was authorized by the legislature, under the Private and Special Laws, Chapter 127 "An ACT to Provide for Building a Dam Across Dead River, in Androscoggin County, to be known as Androscoggin Lake Dam." The dam was built between October 12, 1932, and February 4, 1933, to keep Androscoggin River flood waters from entering Androscoggin Lake. The location is shown in Figure 1 on the next page.

The purpose of this study is to determine the most cost-effective means of minimizing flood flows from the Androscoggin River into Androscoggin Lake. E/PRO Engineering and Environmental Consulting, LLC and Northstar Hydro developed hydraulic models of a portion of the Androscoggin River and the entire Dead River to Androscoggin Lake. These models were used to predict the effectiveness of various heights of flood control structures and their effect on the water levels in the Androscoggin River. Budget level cost estimates were prepared for selected options and are included in Appendix C.

HYDROLOGIC ANALYSIS

The interaction between Androscoggin Lake and the Androscoggin River is complex. Five key factors affect how much water enters the lake from the river and how long the water level stays high. These include:

1. The Dead River Dam. The dam includes flashboards that often fail, and two flap gates that allow flow only from the lake to the river.
2. The Dead River and its floodplain. The geometry of the Dead River and its floodplain affect how water flows from the river to the lake, and vise versa.
3. Androscoggin Lake Watershed. At least six significant lakes or ponds with spillways that may or may not be controlled affect the amount and rate of runoff from the watershed of Androscoggin Lake.
4. Storage in the Lake. The Storage volume of Androscoggin Lake above its normal water level determines how much river water is stored, and how high the level is.
5. Androscoggin River Flow. The amount of flow in the river determines the water level in the Androscoggin River, including how long the river remains at a certain level, and that determines how much flow is diverted into the Dead River.

The purpose of this portion of the study was to evaluate whether changes at the dam could decrease the number and length of overtopping events, when water from the Androscoggin River flows backwards over the dam and into the lake. The study was also designed to evaluate whether changes at the dam could adversely impact flood water levels on the Dead River and in the Androscoggin River.

The key issues to be addressed in the study relative to hydrology are:

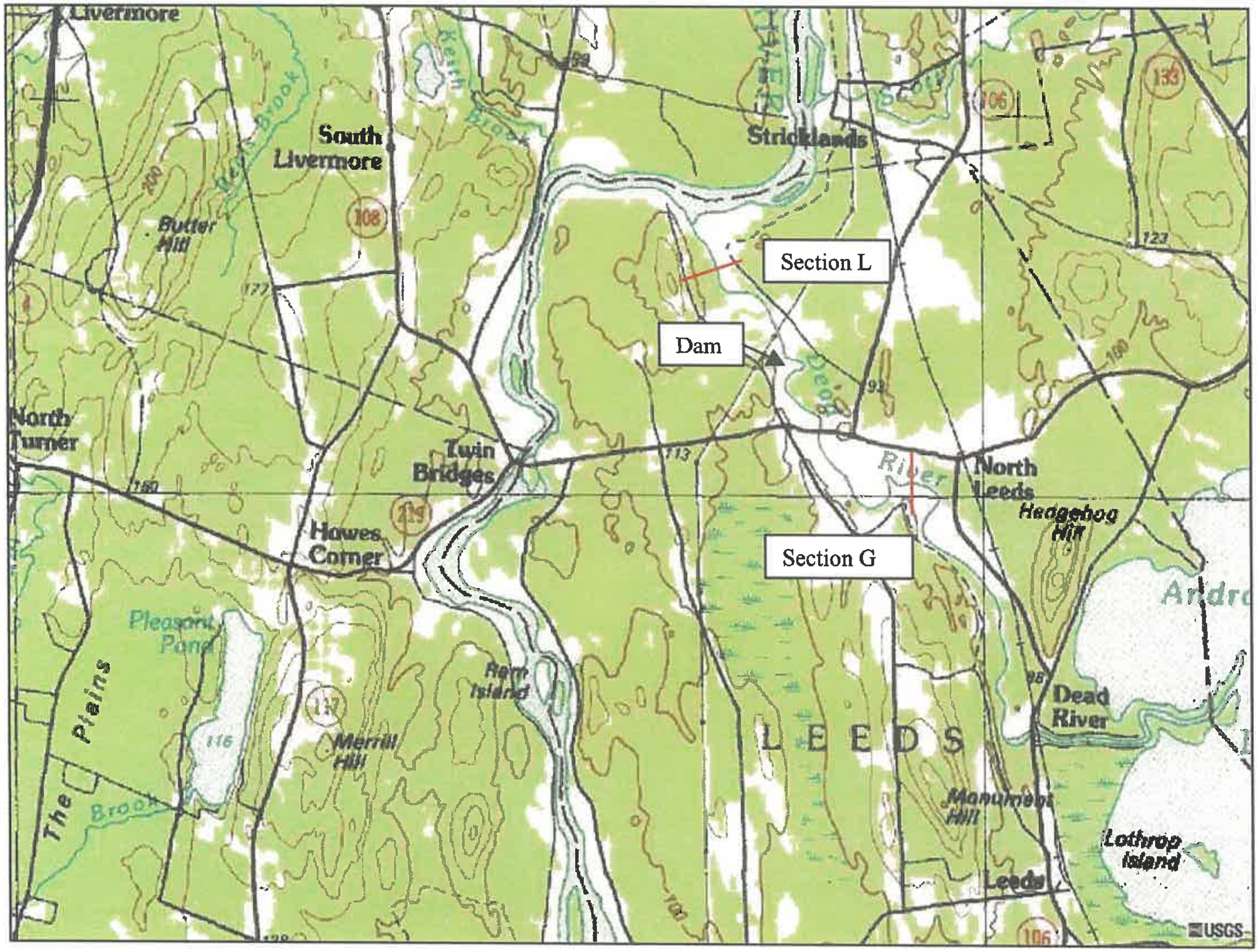
Livermore
South Livermore
Butter Hill
North Turner
Twin Bridges
Howes Corner
Pleasant Pond
The Plains
Merrill Hill
Ram Island
Stricklands
Section L
Dam
Section G
North Leeds
Hedgehog Hill
Dead River
L E E D S
Monument Hill
Leeds
Lothrop Island
USGS

Figure 1

- What height dam would be required to prevent inflow from floods of various heights, corresponding to floods with a 1-year recurrence interval up to the 100-year flood?
- What would happen in the floodplain of the Dead River with a higher dam? Would eliminating the storage provided by Androscoggin Lake aggravate floods downstream on the Androscoggin River?
- With different dam heights, what would happen to water levels in the Dead River and the lake? What would be the affect on the volume and rate of water entering the lake and leaving the lake?

Analytical Approach

Each of the five factors listed above is complex and a detailed study of each would be extremely time consuming. In order to meet the goals of this study as outlined by DEP and to accomplish it within a limited timeframe and budget, the following analytical approach was selected. The goals of this approach were to eliminate some factors from the need for further study, provide information on the impacts of various dam configurations, and recommend where further study may be appropriate.

Because the dam required close evaluation, a detailed model was developed that could simulate stream flow in the Dead River in two directions, and with different dam configurations. The HECRAS modeling software was selected, which calculates water surface elevation as a function of streamflow and location in the stream. This model of the Dead River will be referred to as the HECRAS model.

For the Androscoggin River, best available data were used to create a reasonable model for prediction of water levels for various frequency floods at the junction of the Androscoggin and Dead Rivers. The HECRAS model and information from USGS and FEMA were used for this task.

For Androscoggin Lake, an approximate model was developed to estimate the impact on lake levels of runoff from the watershed. The HydroCAD model, the USGS Regional formula for peak flows, and the National Dam Inventory were used in the development of this model.

Information was also gathered on historical flooding in the lake, based primarily on interviews with local residents by Androscoggin Lake Association.

In developing the study methodology, consideration was given to the use of a two-dimensional model, which operates for a series of time steps and could simulate the effects of the interaction of the five factors in one model. However, no suitable model was found which could accurately simulate various dam configurations. These types of models are time consuming to construct, difficult to calibrate, and often lacking in the detail needed to examine the dam.

Therefore, information generated by the HECRAS models for the two rivers, and the HydroCAD model for the lake were merged through various hand/spreadsheet calculations to account for time and changing flow and elevation with time. Lack of data or time constraints dictated that certain assumptions were required, which are described below. These assumptions were used consistently throughout the analysis.

The study identified several issues that should be evaluated in greater detail as decisions are made on the final configuration of the dam. Specifically:

- Further evaluation of the impacts of the dam on the Androscoggin River.
- Evaluate how the effect of diversion of flow affects upstream and downstream flood elevations in the Androscoggin River. Whereas one location was selected as an example for this study, a number of locations should be checked.
- A more detailed model to account for flows upstream of the Dead River.
- The USGS gaging station records/frequency curves on the River should be reconciled with the peak flows used in the FEMA studies.
- The impact of the dam on the historical record of flow should be evaluated.

Explanation of Flood Frequency, Flood History

Hydrology is a science that relies on records of past events to predict what is most likely to occur in the future. Records of past events are typically at stream gaging stations (about 56 total stations in Maine), and precipitation records (also limited number of stations in Maine). When discussing floods, the terms "recurrence interval", "X-year flood" and "flood frequency" are often used. An example is the "100-year recurrence interval" or "100-year flood". This is defined as the flood that on average would be expected to occur once every 100-years, or which has a 1% chance of occurring in any given year (1/100 of a chance), all based on what has occurred in the past.

Records of past flooding are incomplete. For a given location, there may be no records available at all. When a flood event is assigned a frequency of occurrence, it is in comparison to what has happened in the past at that location. Thus, when, for example, the 1987 flood is said to be a 50-year flood, it may mean that at a few gaging stations, the measured discharge for that storm event, fits the frequency curve for that station, as about a 50-year flow. Frequency curves are statistical models of what is likely to happen in the future based on what has happened in the past. Once a 100-year event has occurred, ideally, the curves should be recomputed, and future predications of risk may change.

How does all of this relate to this study? Local residents may remember high water during certain storm events, and may have heard that the storm was a 50-year event for example. The question may be raised, "how can two 50-year events occur in one 25-year period?" for example. The answer is that hydrology is not an exact science, nor can predictions of future flood risk be exactly assigned. The estimates of flood frequency are best estimates based on past records, and statistical analysis of those records. The flood flows used in this study are also exactly that: best estimates, based on available data.

By way of history in the geographic region of this study, the USGS reports the following generalized flood events. During the flood of April 1, 1987, peak discharges of record occurred on the Kennebec, Piscataquis, Carrabasset, and Little Androscoggin River. The frequency of occurrence was greater than 50-years. On March 27-30, 1953, Southwestern Maine experienced a flood event of greater than 50-years. On March 19 of 1936, south central Maine experienced a flood event of greater than 50-years, including the peak discharge of record on the Androscoggin River in Auburn.

It should be noted that flood frequency curves for USGS gaging stations are computed by USGS and are widely accepted in the hydrologic community. For each of the above floods, the frequency of occurrence is calculated at gaging stations.

Study Methodology

The following tasks were performed and are described in detail in each section below:

- Obtain water level frequency data for Androscoggin River
- Evaluate Hydrology of Androscoggin Lake Watershed and Storage in Lake and Floodplain
- Evaluate Hydraulics of Dead River and Existing Dam
- Create Modified HECRAS model with Alternate Dam configurations
- Determine duration of various flow levels
- Evaluate the effect of flood control on Androscoggin River levels

Obtain water level frequency data for Androscoggin River. The goal of this task was to ascertain how often, and for how long, the river reaches given water levels.

- <u>Flood Flow Frequency at the Junction with the Dead River</u>. The flowrate in the Androscoggin River determines water level at the junction point. The water level at the junction point with the Dead River determines how much flow is entering the Dead River. Available information for this task included

    - Flow data for the Androscoggin River, including flood flow frequency curves at the USGS gaging stations at Rumford and Auburn on the River and on the Swift River.
    - Flood Insurance Studies for surrounding towns on the Androscoggin River.

  Table 1 summarizes data from the flood frequency curves for the three gaging stations. Figure 2 is a plot of stream flow frequency vs. drainage area for this segment of the Androscoggin River (see Appendix H). Using this plot and the drainage area of the river at the confluence with the Dead River, flow-frequency data were derived for the junction. These data are summarized in Table 1. The flood flow frequency data from the Leeds Flood Insurance Study were also compiled and are summarized in Table 1. Figure 2A is a plot of the frequency curves extrapolated to the 1.05-year frequency (see Appendix H).

Comparison of the two sets of flows for the site shows higher flows in the Leeds study. This study did not reconcile this difference, but rather, the final flow-frequency curve used for this study is a combination of the two sets of flow data, and represents a conservative estimate of flood flow frequency for the Androscoggin River at its junction with the Dead River. It is recommended that a final design study for the dam would examine and reconcile these differences. This data is listed in the last column of Table 1.

Table 1
Peak Flows, Androscoggin River Basin

	Flows from USGS Gaging Records			Flow Based on USGS data and Drainage Area Site	Flows from Flood Insurance Study Leeds	Final Flow-Frequency Curve for Androscoggin River at Junction with Dead River*
		Androscoggin River				
Water Body	Swift River	Rumford	Auburn			
Drainage Area, sq. mi.	96.9	2068	3263	2600	2640	2600
Recurrence Interval						
1.05*	4000	22,000	32,000			28,000
2	5,830	26,400	38,500	31,500		31,500
5	9,390	35,700	50,500	42,000		42,000
10	12,010	42,000	58,300	49,000	53,700	53,700
25	15,540	49,100	67,500	56,000		65,000
50	18,330	54,700	74,200	62,000	77,300	77,300
100	21,220	60,000	80,500	68,000	90,100	90,100
500	28,640	72,000	95,000	80,000	123,000	123,000

* 1.05 year flow at site based on frequency curve extrapolation

- Convert Flow-frequency to Elevation-frequency for the Junction Point. The goal of this task was to create a rating curve of water surface elevation vs. flow at the cross section of the Androscoggin River near the junction with the Dead River. No cross section data were available for the Androscoggin River from the Flood Insurance Studies. Approximate cross sections and bridge data at Route 219 were compiled using the USGS topographic map and MDOT bridge plans. Cross section locations are shown in Appendix D.

  A hydraulic model of the Androscoggin River was developed using computer HECRAS modeling software. The backwater model was run from downstream of the Route 219 Bridge, to a section upstream of the junction with the Dead River. Model results are summarized in Figures 3 and 4 (see Appendix H). These figures are river profiles showing water surface elevation as a function of distance along the River. The junction with the Dead River is near channel distance station 19000. Flood elevations in the River at the junction point with the Dead River were derived from the two model runs, using the final flow frequencies as summarized in Table 1.

Table 2 summarizes Flood Elevations and Flow rates for the Androscoggin River at the junction with the Dead River.

Table 2
Flood Flow Frequency and Elevations, Androscoggin River at Junction with Dead River

Frequency	Flow rate, cfs	Elevation, ft NGVD*
1.05 year	28,000	278.0
2-year	31,500	279.1
5-year	42,000	281.8
10-year	53,700	284.5
25-year	65,000	286.2
50-year	77,300	288.5
100-year	90,100	291.3
500-year	123,000	298.2

* NGVD: National Geodetic Vertical Datum

Dana Murch, of DEP approximated flood elevation frequency data in an April 2000 study. Those predictions were based on water level observations at the dam and estimates of river flows. Key portions of that study are included as Appendix E. With refinement in study technique as provided in this study, information provided in that study supports the conclusions of this study.

Evaluate Hydrology of Androscoggin Lake Watershed and Storage in Lake and Floodplain. The watershed of Androscoggin Lake contains nine lakes upstream of Androscoggin Lake, as well as Androscoggin Lake. The effect of these lakes is to slow and decrease the rate at which runoff occurs in the watershed. Androscoggin Lake provides a final attenuating affect on storm runoff. The lake drains a total of 83.0 square miles, of which 64 are upstream of the direct watershed of the lake. The surface area of the lake at elevation 269 (normal water level) is 5.98 square miles or 3826 acres. Typical late winter water level is reported to be 271.

A model of the watershed of Androscoggin Lake was developed using HydroCAD modeling software. This software uses the SCS TR20 formulation to calculate flood hydrographs for sub-watersheds, and to route those flows through storage and over structures.

Watershed areas, land use, land slope, and storage area in each lake were derived using the DeLorme Maine Atlas topographic maps. The HydroCAD model is often found to overestimate flows for wooded, rural watersheds. For this reason, the model runoff curve numbers were calibrated to generate peak flows comparable to the USGS Regional Formula for inflows to each lake. Spillway widths were taken from the USEPA BASINS model database for New England. Time of concentration for each sub-watershed was calculated using the "Curve Number method" in the model, as well as typical stream flow velocity information as presented in the SCS publication Urban Hydrology for Small Watersheds.

Model data are presented in Appendix F, which is a printout of the Hydrocad model input and output.

The model was run for a 100-year flood event, with the lake level starting at elevation 269. The model predicts a peak inflow to the lake of 7900 cfs, and a peak outflow of about 500 cfs, flow that will occur only through the gates, and not over the flashboards. It is important to note this dramatic drop from inflow to outflow. This model result is based on free flow out of the dam (i.e., no high water in the river). The peak elevation in the lake due only to flow from its own watershed and not the river would be about a foot higher than before the rainstorm occurred in the watershed. This shows that inflow from one storm in the watershed alone is not likely to cause a significant rise in the level of the lake. A second model run was conducted which assumed that almost no flow could occur out of the dam, which is the same as if the river were high, and no outflow could occur. The peak level for this scenario is only about 0.5 foot higher. The water level however, is predicted to stay high for at least several days, as the only outflow could occur through the dam.

It is reported by local residents that typical winter lake elevation is 271. Several runoff events coupled with typical river flows could easily cause this winter level.

Another way to evaluate the potential high water in the lake due only to runoff from its watershed can be done as follows: For an 83 square mile watershed, and a 100-year storm event of 6.1", assuming half of the storm infiltrates and half of the runoff ends up as stream flow, a total storm runoff of 13,280 acre feet is calculated. With a lake surface area of 3826 acres, this results in a rise in lake level (with no outflow) of 3.4 feet, or an elevation of 272.4 if the lake starts at elevation 269. This scenario does not account for any storage in the six lakes in the upper watershed.

Other available information includes the FEMA Flood Insurance Study for Wayne, which lists the 100-year elevation in Androscoggin Lake as 286.4 although this elevation was not determined through detailed modeling.

Evaluate Hydraulics of Dead River and Existing Dam. The flow characteristics of the Dead River and the existing dam were evaluated to ascertain how various flow rates travel from one end of the river to the other. The HECRAS hydraulic model was used and was "run" in two directions - from the river to the lake and from the lake to the river. To create the model, the following tasks were conducted:

1. Cross Sections:
   - A search was conducted for existing data on cross sections of the Dead River. No data were available.
   - Cross section data were compiled by surveying a series of cross sections below the water line on November 16, 2001 by E/PRO. The elevation of the sections was obtained by reading the USGS gage 01055220 located at the left downstream abutment of the Route 106 bridge crossing the Dead River.

- Hydraulic information was obtained for the dam. These data included spillway crest elevation and length, flashboard elevation and length, gate elevation and size and materials. Field survey and existing plan information were used to obtain these data.

2. The HECRAS step backwater computer model was used to calculate water level vs. flowrate for the Dead River, for flow from the River to the Lake.

   The model requires that the user specify a "starting water level" for the downstream end of the model and "flowrate" at the upstream end of the model. It should be emphasized that because the model in this case must be operated with two unknowns, (i.e., upstream flow and downstream water level), the solution is an iterative process, requiring many trials.

   A series of flows ranging from 50 to 40,000 cfs was entered into the model. The assumed water level in the lake ranged from 271 feet to 280 feet. 271 is normal late winter water level, and 280 was found to be a typical elevation that occurs as the lake fills, and the river starts to recede. This model allowed creation of rating curves of flow vs. elevation at selected locations in the river. Figures 5A and 5B are profiles of the river showing water surface elevations for various rates of flow for the entire length of the river, assuming the existing dam with no flashboards. Different lake elevations were used for the two model runs. Figures 5C, 5D and 5E are rating curves of flow vs. elevation at the junction with the Androscoggin River and at the dam.

   The results show that lake level has very little impact on flood elevation on the Androscoggin River side of the dam, and therefore very little impact on the amount of flow that enters the lake. During high flows, other structures in the Dead River restrict the amount of flow from river to lake.

3. The HECRAS model was modified to account for alternative dam configurations.

   Six alternatives were modeled, including:
   - Dam with no flashboards
   - No dam
   - Dam with 2' flashboards
   - Dam with half 2' and half 3' flashboards
   - Dam with 3' flashboards
   - Dam with 4' flashboards

   For each model run, the following graphics were prepared:
   - Water surface profile (figures 5A, 5B, 6A, 7A, 8A, 9A, and 10A)
   - Rating curve of flow vs. elevation at the junction of the two rivers (figures 5C, 5D, 6B, 7B, 8B, 9B, and 10B)
   - Rating curve of flow vs. elevation at the river side of the dam (figures 5E, 6C, 7C, 8C, 9C, and 10C.)

The rating curves were used to derive flow rates in the Dead River that will occur for different flood frequencies with different configurations of the dam. Table 3 presents a summary of flows that will occur from the river to the lake.

Table 3
Flows and Elevations in Dead River – Flow from River to Lake

Frequency of Flooding on the Androscoggin River	Peak Flow in Androscoggin River, cfs	Flow To Dead River from Androscoggin River, cfs					
		No Dam	Dam w/ no flashboards	Dam w/ 2' flashboards	Dam w/ 3'/2' flashboards	Dam w/ 3' flashboards	Dam w/4' flashboards
1.05 year	28000	4,000	2,100	1,000	500	200	0
2-year	31500	4,500	3,000	2,000	1,500	1,200	200
5-year	42000	7,000	4,500	4,000	3,700	3,500	3,500
10-year	53700	10,000	8,000	7,800	7,500	7,300	6,200
25-year	65000	14,000	12,500	12,000	12,000	11,800	9,500
50-year	77300	18,700	17,500	16,500	16,200	16,200	14,000
100-year	90100	24,000	23,000	22,500	22,000	22,000	21,500
500-year	123000	46,000	45,000	45,000	45,000	45,000	40,000
Frequency of Flooding on the Androscoggin River	Elevation in River at Junction	Elevation at Upstream Face of Dam					
		No Dam	Dam w/ no flashboards	Dam w/ 2' flashboards	Dam w/ 3'/2' flashboards	Dam w/ 3' flashboards	Dam w/4' flashboards
1.05 year	278.0	277.5	277.8	278.0	278.0	278.0	278.0
2-year	279.1	278.0	278.5	278.8	279.0	279.0	279.0
5-year	281.8	280.5	281.0	281.2	281.0	281.2	281.2
10-year	284.5	283.5	284.0	284.0	284.0	284.0	284.0
25-year	286.2	285.8	285.5	286.0	286.0	286.0	286.0
50-year	288.5	288.2	288.5	288.5	288.5	288.5	288.5
100-year	291.3	290.4	290.5	290.5	290.5	290.5	290.5
500-year	298.2	298.0	298.0	298.0	298.0	298.0	298.0
Note: Starting Elevations in Lake Range from 271 to 280 to account for change in levels as lake fills.							

The model data show that during storms of a 1.05-year frequency, flow would occur over the dam without flashboards, and into the lake, but would not flow over the dam into the lake with 4' flashboards in place. During a 2-year event in the Androscoggin River, flow will occur over the dam into the lake for all configurations, with peak flow being decreased from 3000 cfs to 200 cfs with the addition of 4' of boards. For a 5-year storm, flows are nearly identical for all three configurations, ranging from 4500 cfs with no boards to 3500 cfs with 4' of boards. Similar results are obtained for floods of higher frequency, with the 4' of boards keeping out about 1000 cfs in each case.

4. The HECRAS step backwater computer model was used to calculate water level vs. flowrate for the Dead River for flow from the Lake to the River.

The HECRAS model was reconfigured to simulate flow from the lake into the river. A series of outflows ranging from 50 cfs to 7500 cfs was run, and starting elevation in the river ranged from low water (265.8) to normal water (269).

Initial model runs were made with the dam assuming no flashboards and the two existing gates, and then assuming two additional gates. It was found that adding the two gates added very little additional outflow capacity and would only decrease the time to drain by about 1 day. (See below for more information on estimated time to drain each flood).

Five alternatives were modeled including:

- Dam with no flashboards
- Existing dam with 2' flashboards
- Dam with half 2' and half 3' flashboards
- Dam with 3' flashboards
- Dam with 4' flashboards

For each model run, the following graphics were prepared:

- Water surface profile (figures 11A, 12A, 13A, 14A, and 15A)
- Rating curve of flow vs. elevation at the lake side of the dam (figures 11B, 12B, 13B, 14B, and 15B.)

  These model runs were used to determine the effect of various dam configurations on the time for the lake to drain for various frequencies of storm.

Determine duration of various flow levels. To assess the storage issue, and to determine how flood hydrographs travel down the Dead River and into Androscoggin Lake, information was gathered related to the duration of flooding on the Androscoggin River. Flood routing involves balancing volume of inflow over time with available storage, so timing of flood events is critical. Runoff must travel into Androscoggin Lake from its watershed, and varying peak flows travel down the Androscoggin River at different rates.

The Hydrocad model for the Androscoggin Lake calculates that peak flow will occur into the lake for nearly 20 hours after peak rainfall.

For the Androscoggin River, the 1987 flood is a good example of a flood hydrograph, for timing of peak flows, and duration of high flow rates. Figure 16 shows the hydrographs of stream flow at Rumford, at Auburn, and at the site. Figure 17 shows when peak rainfalls occurred. This was also a snowmelt event, which likely delayed peak runoff by about 6 hours after peak rainfall. Maximum rainfall occurred in the upper watershed of the Androscoggin River during the day on March 31, and for the early part of April 1. Peak flow occurred at Rumford at about 16:30 hours on April 1 and at Auburn at 10:00 hours on April 2. At the junction with the Dead River, the peak occurred at about 22:00 hours on April 1. This is a lag of about 20 hours after peak rainfall, very similar to Androscoggin Lake.

Table 4 presents an estimate of how much water is diverted from the Androscoggin River to Androscoggin Lake during various flood events. The table shows total flood volumes in acre-feet, both in the Androscoggin River and diverted to the Lake. The table shows the effect of different configurations for flashboards. An example is in a 100-year flood with the existing dam, (0' flashboards assumed), about 14% of the total flood volume in the river is temporarily stored in the lake. With no dam, about 16% of the total flood volume would be stored, and with 4' of flashboards, about 13% is stored.

Table 4
Estimated Volume of Water flowing from Androscoggin River to Androscoggin Lake during flood events

Recurrence interval	Volume of Water, in acre feet diverted from river to lake, acre feet						
	Androscoggin River	no dam	0' boards	2' boards	3'/2' boards	3' boards	4' boards
1.05-year	163636	18000	9500	4800	2250	950	0
2-year	180992	19000	13500	9600	7200	5800	950
5-year	233058	32000	22000	19500	18000	17000	17100
10-year	291074	43000	36000	35000	32000	30000	29000
25-year	347107	50000	48000	50000	46000	44000	39000
50-year	408099	70000	67000	58000	57000	56000	54000
100-year	471570	77000	68000	64000	63000	62000	61000

Recurrence interval	% of River Flow stored in lake					
	no dam	0' boards	2' boards	3'/2' boards	3' boards	4' boards
1.05-year	11	6	3	1	1	0
2-year	10	7	5	4	3	1
5-year	14	9	8	8	7	7
10-year	15	12	12	11	10	10
25-year	14	14	14	13	13	11
50-year	17	16	14	14	14	13
100-year	16	14	14	13	13	13

Table 5 is a summary of the amount of storage available in the lake in acre-feet for various lake elevations.

Using the lake storage, and flood volume data, a second set of results is presented in Table 6. For each flood event, the estimated elevation of the lake is calculated for the various configurations of flashboards. An example is for the 100-year flood with the existing dam (no flashboards), the lake is expected to reach approximately elevation 285. With no dam, the lake would reach elevation 285.5 and with 4' of boards the lake would reach elevation 284.2. These are approximate elevations, but each is derived using the same set of assumptions, so they are very useful for comparing the relative impacts of each dam configuration. Calculations to derive these elevations are included in Appendix G.

Table 5
Storage in Androscoggin Lake

Lake Storage					
Elevation	Volume Acre feet	Elevation	Volume Acre feet	Elevation	Volume Acre feet
271	0	279	38,514	287	85,163
272	4,240	280	43,756	288	91,190
273	8,878	281	48,997	289	97,218
274	13,515	282	55,025	290	103,245
275	18,153	283	61,052	291	109,273
276	22,790	284	67,080	292	115,301
277	28,031	285	73,107	293	121,328
278	33,273	286	79,135	294	127,356

Table 6
Estimated Elevations in Androscoggin Lake

Recurrence interval	Elevation in River	Estimated Elevation in Lake from River inflow - assume lake starts at 271					
		No Dam	Dam w/ no flashboards	Dam w/ 2' flashboards	Dam w/2'/3' flashboards	Dam w/3' flashboards	Dam w/4' flashboards
1.05-year	276.3	274.5	273.5	272.2	271.5	271.2	271.0
2-year	279.1	275.0	274.0	273.4	272.6	272.3	271.2
5-year	281.8	277.5	275.6	275.3	275.0	274.8	274.7
10-year	284.5	280.0	278.5	278.0	277.5	277.2	277.5
25-year	286.2	281.7	281.3	281.0	281.0	281.0	279.0
50-year	288.5	284.5	283.8	283.5	283.2	283.1	282.3
100-year	291.3	285.5	285.0	284.5	284.5	284.5	284.2

Finally, Table 7 presents the estimated time in days to drain the lake to elevation 270, with the two existing gates, and various flashboards in place. Because the flashboards have kept out a certain amount of flow, the time to drain may also be lower with higher boards. An example is for the 1.05-year flood, with no boards the lake would reach elevation 273.5 and would take 8 days to drain. With 3' of boards, the lake would reach 271.2 and would take 5.7 days to drain to elevation 270. On the other hand, for higher lake levels, the boards may detain floods for longer. For the 100-year flood for example, no flashboards would allow the lake to drain in 16.8 days, the 4' of boards would require about 22 days to drain if the flashboards did not fail. Calculations to derive these estimates are included in Appendix G.

Table 7
Time to Drain Androscoggin Lake

Recurrence interval	ESTIMATED TIME IN DAYS TO DRAIN LAKE TO ELEVATION 270				
	Dam w/ no flashboards	Dam w/ 2' flashboards	Dam w/2'/3' flashboards	Dam w/3' flashboards	Dam w/4' flashboards
1.05-year	11.3	8.0	5.7	5.7	4.4
2-year	11.0	11.1	9.2	8.3	5.0
5-year	13.4	14.6	14.2	13.9	13.7
10-year	14.6	17.6	17.4	17.4	17.8
25-year	15.7	19.4	19.9	20.6	20.2
50-year	16.2	20.0	20.6	21.3	21.0
100-year	16.8	20.6	21.3	22.0	22.0

Evaluate the affect of flood control on Androscoggin River levels. The modeling of the Dead River has shown that during flood events, a portion of the total flood volume is temporarily stored in Androscoggin Lake. The effect is to reduce the peak flood levels below the Dead River and lengthen the duration of the flooding. Table 8 shows the effect of the removal of the storage for the existing condition with no flashboards, with a dam with a fixed crest at elevation 278, and a dam that would stop all floods.

Table 8
Flood Elevations in the Androscoggin River at the Route 219 Twin Bridges

Frequency	Existing Conditions		With Permanent Dam Crest		With Permanent Dam Crest	
	Dam at elev	274, no boards	at elevation 278		at elevation 300	
	Flow, cfs	Elevation	Flow, cfs	Elevation	Flow, cfs	Elevation
1.05-year	28,000	272.7	30,000	273.3	30,000	273.3
2-year	31,500	273.7	34,200	274.3	34,500	274.4
5-year	42,000	276.1	43,000	276.4	46,500	277.1
10-year	53,700	278.6	55,500	279.0	61,700	280.1
25-year	65,000	280.6	68,000	281.1	77,500	282.8
50-year/ 1987 flood	77,300	282.8	80,800	283.4	94,800	285.9
100-year	90,100	285.1	91,600	285.4	113,100	291.1

The table indicates that the current dam with 4 feet of flashboards that would not fail would have a minimal effect on downstream flood levels. However, the total blockage of flows into the Dead River would raise the river an additional 1.7 feet for a 25-year event and 2.5 feet for a 50-year event.

It should be noted that before final design decisions are made, the effect on the river should be evaluated in greater detail as discussed in the beginning of this report.

ENGINEERING ANALYSIS

Dam Inspection

The dam was visually inspected on October 12, 2001 and found to be in overall good condition. The water level was a few inches below the top of the base slab, elevation 267. The dam was measured as part of the inspection because the original construction drawings are missing. The resulting plan is included in Appendix A.

The concrete stem and base slabs were checked for areas of weakness by striking the surface with a five-pound hammer. A good quality concrete will ring, while areas of weak or delaminated concrete will produce a dull tone. The concrete, while well weathered, was sound with the exception of three areas near construction joints, as shown in photos 1 and 2 (Appendix B). These areas are delaminating and should be repaired to prevent deterioration of the reinforcing steel. The downstream concrete gate piers have deteriorated at the normal waterline leaving the reinforcing steel exposed, see photo 3. While this is unsightly, it does not affect the stability or function of the structure. The interior of the concrete stem is reported to be soft around the flashboard pin sockets, according to Charles Barker, who does the dam maintenance. This could not be verified in the inspection.

The trash racks, which protect the gate openings, are pitted at the normal water line with the right most rack more severely pitted over its entire height. The right (looking downstream) trash rack is shown in photo 4.

The wooden flap gates are sound with signs of rot at the joints between the individual timbers, particularly on the left most gate. The rot is most evident where bark had been left on the timbers. Photo 5 shows the flap gate condition.

The riprap along the sloping abutments is intact and functioning satisfactorily. The ground level beyond the left abutment has eroded and is now three feet below the top of the abutment.

Forty-three (43) feet of the present 2-foot flashboards are missing.

At the time of the inspection there were no signs of leakage at the dam. The difference in water level either side of the dam was 0.8 feet.

Riverbank Erosion

The entire length of the Dead River was inspected by boat on November 16, 2001. The soils along the banks consist generally of fine silts and sands stabilized by tree roots. There are many trees that are toppled and would be mobilized during a flood. The only major eroded area is on the left bank immediately below the dam, see photo 6. The area affected is approximately 300 feet long. The landowner claims the bank has eroded about one foot per year since the dam was constructed. The area was surveyed on November 21 and the resulting plan is included in Appendix A.

The repair of this area would consist of placement of a granular fill to flatten the slope to a 3 on 1, placement of a filter fabric and 18 inches of riprap keyed into the riverbed. The estimated repair cost would be $97,000.

Dam Stability Analysis

Current practice would require a low hazard structure to be stabile for all anticipated load cases and have a factor of safety of 2 against sliding.

The dam cross section was analyzed for sliding stability with four feet of flashboards and an assumed four-foot base height resting on a soil foundation. This section was found to be unstable with a factor of safety of less than one. This would indicate the structure was not designed to be supported on soil foundation.

The presence of timber piling both upstream and downstream of the dam that was used during the construction would suggest the dam is supported on a pile foundation. Residents confirm this, although there is no mention of the foundation preparation in the final construction report to Governor Brann. The existence of piles is also supported by the fact that the Foss Bridge (which carries Route 219 over the Dead River, 0.5 miles upstream of the dam) was constructed in the late 1920's and is supported on a wooden pile foundation.

The determination of the number and position of the piling will be necessary to determine the stability of the structure. The likely presence of reinforcing steel in the dam base and the high water surface would make the use of a non-destructive technique, such as ground penetrating radar, unproductive. A program of directional drilling to intersect the vertical pile would be difficult due to limited working space.

The stability of the existing dam cannot be determined from the data presently available.
The present location of the dam, with the height of the left embankment at elevation 280, limits the ability of the dam to hold back flood levels of more than the 2-year frequency.

Dam Structural Analysis

The components of the dam were investigated to determine the limiting component to raising the structure. The current flashboards are supported by 2-inch diameter schedule 80 pipe at four feet on centers. The minimum yield strength of the pipe is 35 ksi and will support 4.25 feet of water or elevation 278.25.

The 6-foot reinforced concrete stem is assumed to have a concrete compressive strength of 3 ksi, taking into account the reported softness around the flashboard pins, and the reinforcing steel as structural grade with a yield strength of 30 ksi. With an assumed ¾ inch bar spaced at 8 inches on center, the stem will support the equivalent of 8-feet of flashboards or elevation 284.

The factor limiting the ability of the structure to hold back the floodwaters is the strength of the flashboard pins. This could be remedied by using a higher strength steel pipe or solid bars.

Review existing gate capacity and gate alternatives

The current gate configuration of two flap gates with a crest elevation of 264 does not provide any lake level control. The gates can pass a flow of 950 cfs with the water at the dam fixed crest elevation 274, which limits the out flow from the lake and prolongs lake flooding. The ALIC presently places plywood over the lower portion of the trash racks to maintain the lake level at elevation 269. This raises the lake level approximately two feet over the natural constrictions upstream of the dam. These are held in place by water pressure and are subject to washing out during rain events, which bring the Androscoggin River above the lake level. The use of a steel plate in place of the plywood would be a more positive way to maintain the lake level.

The use of duckbill tide gates was investigated but their high cost and low discharge capacity made them uneconomical for this application.

The addition of a sluice gate or other lake level control method was not pursued because lake level control was not a high priority.

The installation of two additional flap gates, having a crest at elevation 269, would only add a maximum of 1000 cfs to the dam discharge capacity and only 300 cfs with the water level at the fixed crest. This would only shorten the typical two weeks of elevated lake levels by one day. The estimated cost for furnishing and installing the gates is $111,000.

Review flashboard alternatives

Flashboards are normally used at dams to raise the normal pond level above the fixed crest level to increase the head for power generation. During a flood event the boards will fail and increase flood discharge capacity of the dam. The use of pinned flashboards relies on the failure of the steel pin in bending and the boards are lost downstream. The boards are replaced after every flood to return the pond to its operating level. A more permanent type are hinged flashboards. These are generally steel panels hinged at the base and supported by a strut on the downstream face. During a flood the water pressure causes the strut to fail and the panels drop and lay on the crest. After the flood the panels are raised and the struts replaced.

Hinged flashboards would be better suited to the Dead River as they can be made stronger to resist flood overtopping, yet fail easily in the downstream direction to permit lake flood levels to quickly return to the dam fixed crest level. The replacement of the present pinned boards with a 4-foot steel panel hinged board system is estimated to cost $140,000.

The use of flashboards to retain a pond level also requires the installation of a log boom to prevent ice and logs from hitting the boards and causing a premature failure. Remnants of the old log boom chain can be found on the left bank below the dam at the river bend. Assuming the old anchors are still place, a new multi timber boom is expected to cost $40,000. The installation of new anchors could double the cost.

Another alternative is a rubber dam. A rubber dam is long cylindrical tube made from a reinforced rubber and generally inflated with air by a low-pressure/high volume air compressor. The rubber dam would be inflated during a flood event and deflated after the flood to allow the lake to drain as quickly as the Androscoggin River recedes. A retrofit of the present dam was not considered due to the uncertainty of the foundation, elevation of the left bank and the cost of the concrete stem removal added to the cofferdam and reshaping of the dam base would be more expensive than installing a new dam. A typical section of a rubber dam is included in Appendix A.

Review possible alternate dam locations

A review of the available topographic mapping and the river inspection trip suggested two possible locations for a new dam, consisting of a inflatable rubber dam on top of a concrete base slab. These locations are shown on Figure 1 as sections G and L and are shown in more detail in Appendix D. The locations are similar with high banks and narrow cross section. A cost estimate was developed at section G for rubber dams with flood protection to elevation 279, 285 and 292 (10, 16 and 18.4 feet high). These elevations represent flood protection for the 2-year, 25-year and 100-year flood return periods.

The 10 and 16-foot high dams would consist of a concrete base slab with a sill elevation of 269. The slab was assumed to be supported on steel piling and have a sheet pile cutoff wall driven to a depth of 40 feet. The length of the dam is 170 feet. The estimated cost for the 10-foot-high dam is $1,980,000 and the 16-foot-high dam is $2,845,000.

The 18.4-foot dam would have a sill elevation of 273.8 feet. The length of the dam would be 150 feet with similar construction. The addition of two low-level sluice gates would be used to control the lake level at elevation 269. The estimated cost for this option is $5,240,000.

The cost for a dam at section L would be similar. The cost for a more conventional concrete dam with slide gates is believed to be approximately the same. The estimates exclude the cost of land acquisition and additional studies to determine the effect on the Androscoggin River flooding.

SUMMARY

The result of the hydrologic analysis shows that the present dam location with 4-foot flashboards is limited to holding back floods of up to a 2-year return period. The fragile nature of pinned boards reduces the effective height of the dam to its fixed crest elevation of 274 feet, which is expected to be over topped every year. The present gate capacity restricts the out flow from the dam and increases the duration of the flooding in the lake.

The dam is in good condition with minor concrete repairs needed to maintain the structure. The location of the dam with its top of bank elevation of 280 feet limits its usefulness in holding back floods of return periods of less than 2-years.

Various options were investigated to reduce the flooding. The present flashboard system could be improved by using stronger steel pins and the addition of a log boom to minimize the damage due to floating logs and ice. A hinged flashboard system would reduce the maintenance cost and limit the damage caused by floating debris.

A rubber dam constructed at river cross section G or L could be designed to provide for a greater level of flood protection and allow for a faster return to normal lake levels after a flood event. A dam with 16-foot bladder with a flood crest of elevation 285 would protect up to a flood with a 25-year return period and limit the effect on the water levels in the Androscoggin River at the Route 219 bridges to approximately 2.2 feet.

Table 9
Summary

	Effective Against Flood	Estimated Cost*	Affect on Androscoggin River Flood Level	Comments
Existing Dam				
2 ft boards		$ 56,900		annual replacement of boards
4 ft boards	1.05-year	$ 79,800	0.7 feet	annual replacement of boards
4 ft Hinged boards	1.05-year	$ 184,800	0.7 feet	
New Dam w/ Rubber crest				
10 ft High	2-year	$ 1,980,000	0.7 feet	
16 ft High	25-year	$ 2,845,000	2.2 feet	
18.4 ft High	100-year	$ 5,240,000	6 feet	
Dam Removal		$ 113,000		add to new dam cost
Erosion Repair		$ 97,000		downstream of existing dam

* Includes $40,000 for log boom and $4,800 abutment repair for existing dam costs.

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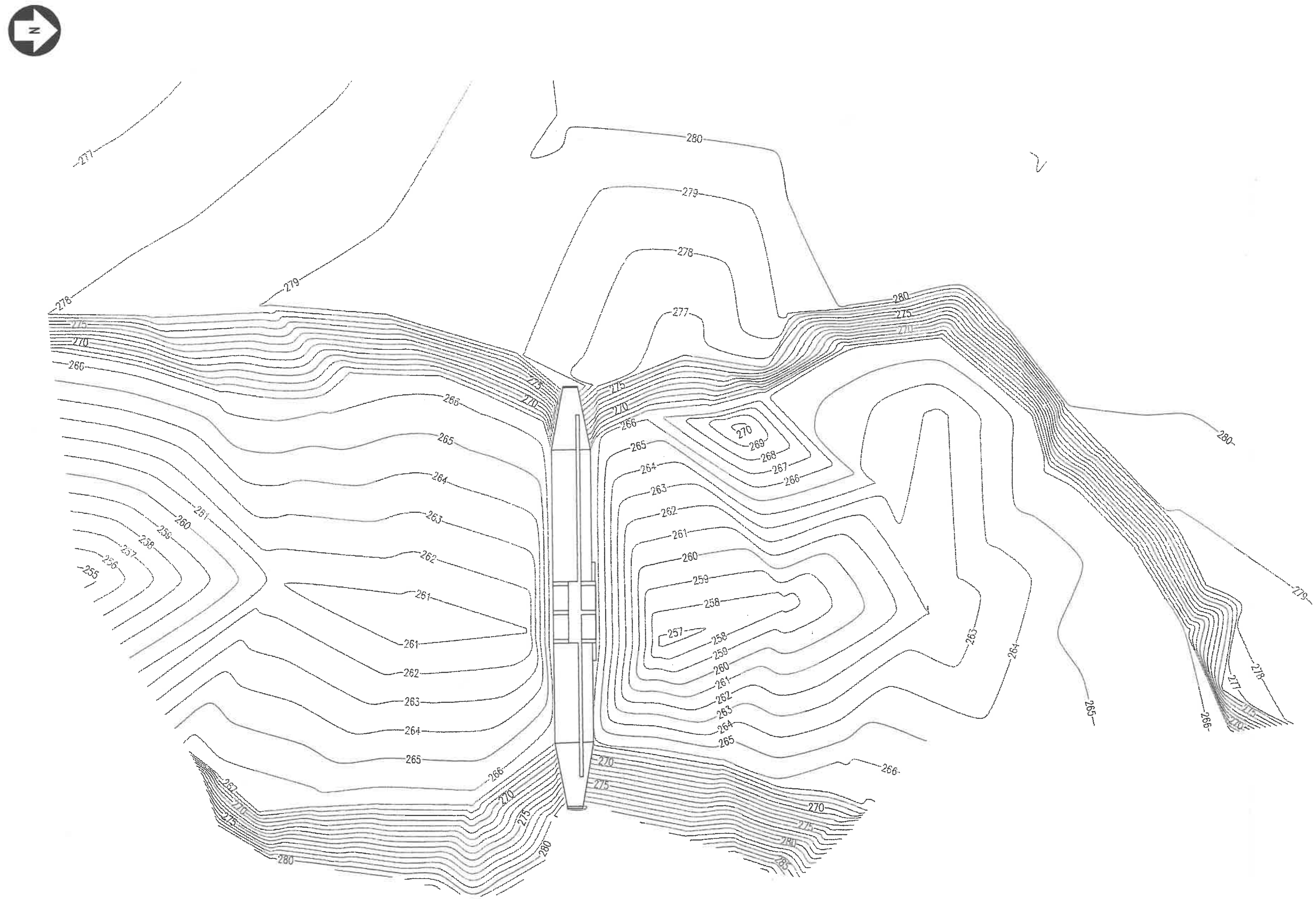
APPENDICES

Appendix A. *Plan of Dam Inspection*
Appendix B. *Photos of the Dead River Dam*
Appendix C. *Budget Level Cost Estimates*
Appendix D. *Cross Section Locations*
Appendix E. *Key Portions of Dana Murch's (DEP) Approximated Flood Elevation Frequency Data from April 2000 Study*
Appendix F. *Model Data, Hydro CAD input and output of Model of the Watershed of Androscoggin Lake*
Appendix G. *Calculations to Derive the Elevations for each Flood Event for Configurations of Various Flashboards*
Appendix H. *Figures 2-17*

Appendix A
Plan of Dam Inspection



SITE PLAN
SCALE: 1"=20'

20 0 20 40 FT
SCALE: 1"=20'

NO.	REVISION	DATE	BY	CK	P.E.	P.E. No.

CLIENT APPROVAL
APPROVED BY
COMPANY
DATE

SURVEYED
DRAWN
CHECKED
APPROVED
REVIEWED

DEPT. OF ENVIROMENTAL PROTECTION
DEAD RIVER DAM
SITE PLAN
LEEDS MAINE

E·PRO Engineering & Environmental Consulting, LLC 249 Western Avenue Augusta, Maine 04330
SCALE NONE DATE 1/ 8/00
9620–C2
REV. 0
FILENAME: 9620.DWG

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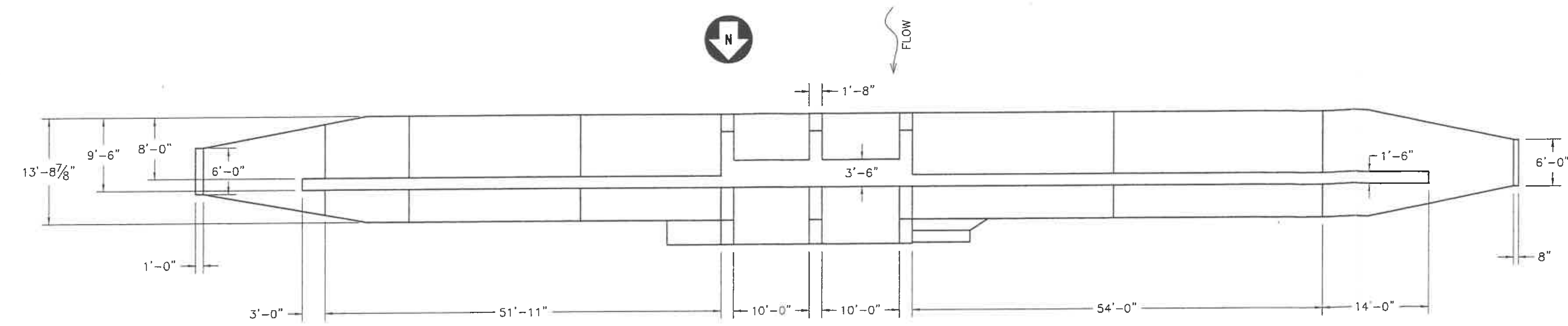
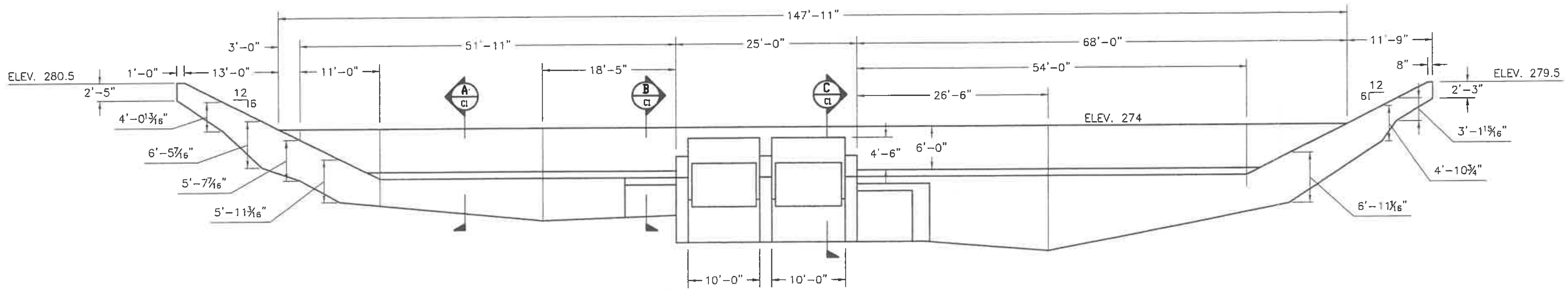
E·PRO Engineering & Environmental Consulting, LLC 249 Western Ave, Augusta, Maine 04330
CONTRACT DWG NO. 09620- PROJECT NO. 09620



PLAN
SCALE: 1/8"=1'-0"



DOWN STREAM ELEV.
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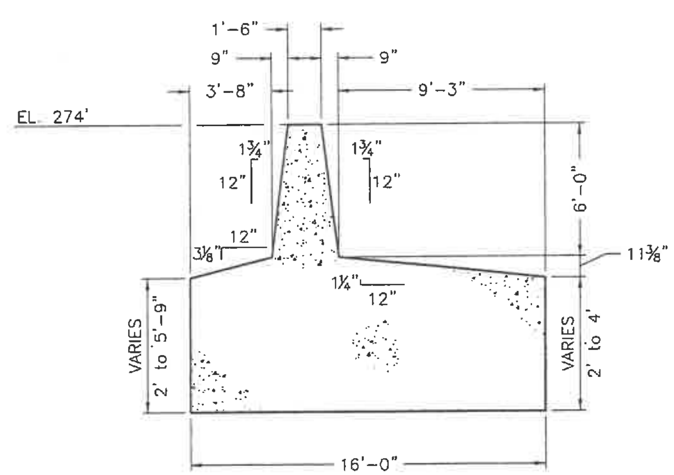

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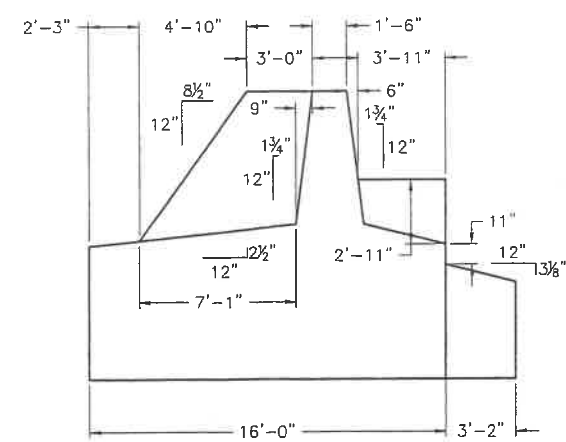
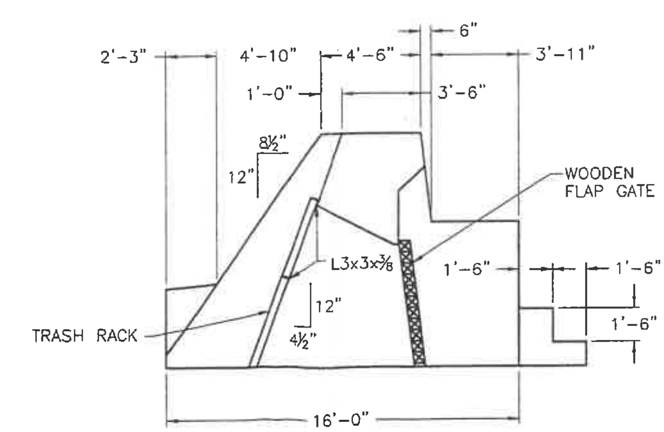
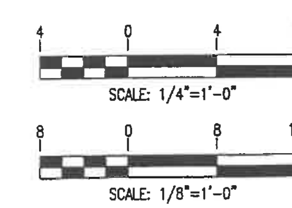


SECTION B
SCALE: 1/4"=1'-0"



SECTION C
SCALE: 1/4"=1'-0"



NO.	REVISION	DATE	BY	CK	P.E.	P.E. No.
A	FOR REVIEW	1/10/02	JLB			

CLIENT APPROVAL

DESIGNED
JLB
DRAWN
CHECKED
APPROVED
REVIEWED
APPROVED BY
COMPANY
DATE

DEPT. OF ENVIRONMENTAL PROTECTION
DEAD RIVER DAM
DAM PLAN & SECTIONS

LEEDS MAINE

E·PRO Engineering & Environmental Consulting, LLC 248 Western Avenue Augusta, Maine 04330

SCALE AS NOTED DATE 1/10/02

9620-C1

REV. A

E·PRO Engineering & Environmental Consulting, LLC 248 Western Ave, Augusta, Maine 04330

CONTRACT DWG NO. 9620-C1.DWG PROJECT NO. 09620

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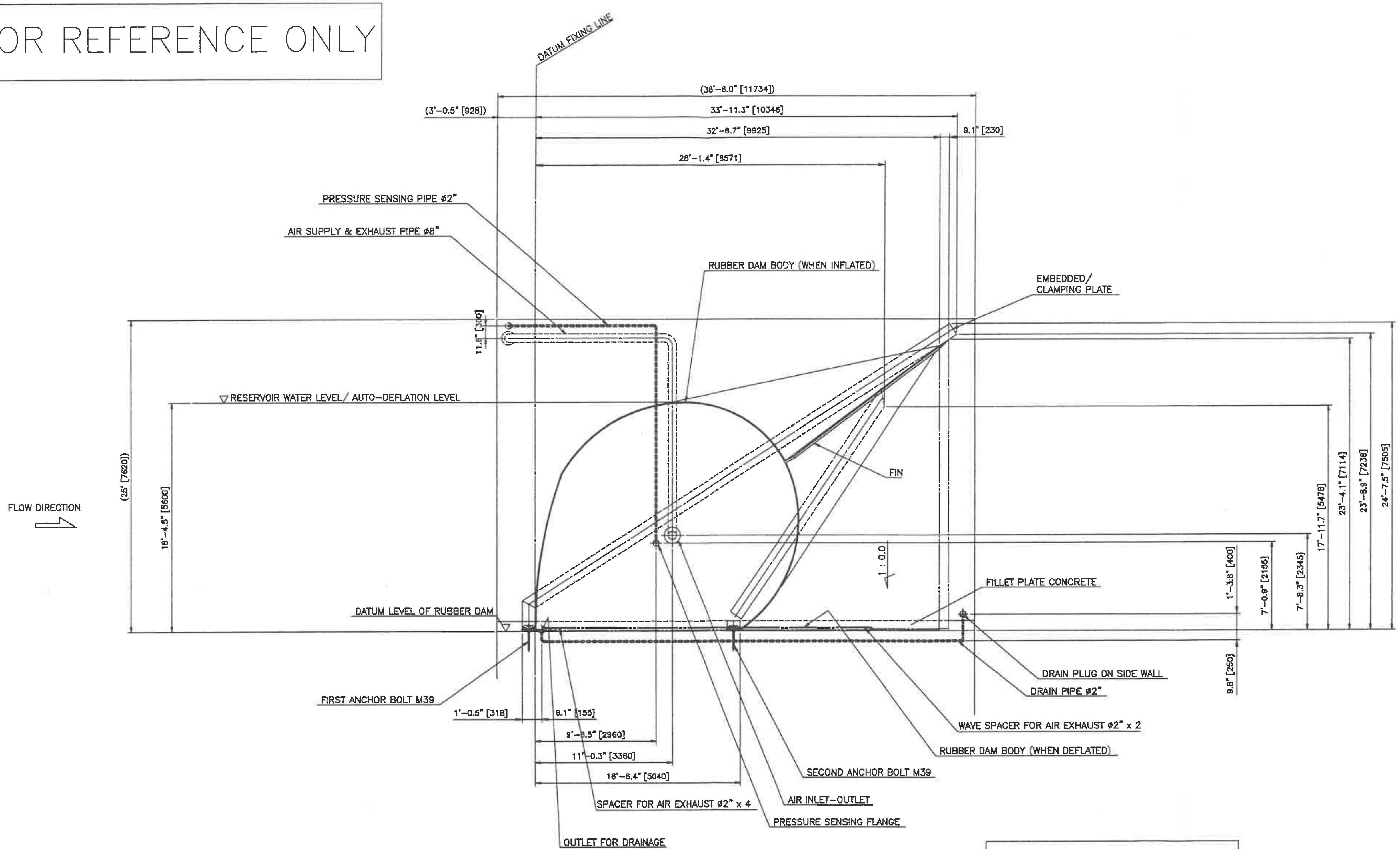
FOR REFERENCE ONLY



NOTE:
1. ALL UNITS IN FT-IN [MM].
2. DIMENSION IN BRACKET FOR REFERENCE ONLY.
3. PIPE LAYOUT IS FOR REFERENCE ONLY.

CROSS SECTION VIEW : B – B S=1:50

DATE	No.	REMARKS	APPROVED	CHECKED	REVISED
ORIGINAL	No.				

FOR: DEAD RIVER RUBBER DAM		
SUBJECT: RUBBER DAM CROSS SECTION		
DATE: JAN 17, 02	SCALE	
APPROVED	CHECKED	DESIGNED: W.P.CHAU
DWG No.		
BRIDGESTONE CORPORATION		

PLOT SCALE: 0 1/2 1 2 3 4 in

Appendix B
Photos of the Dead River Dam

Photo 1 – Concrete deterioration at construction joint

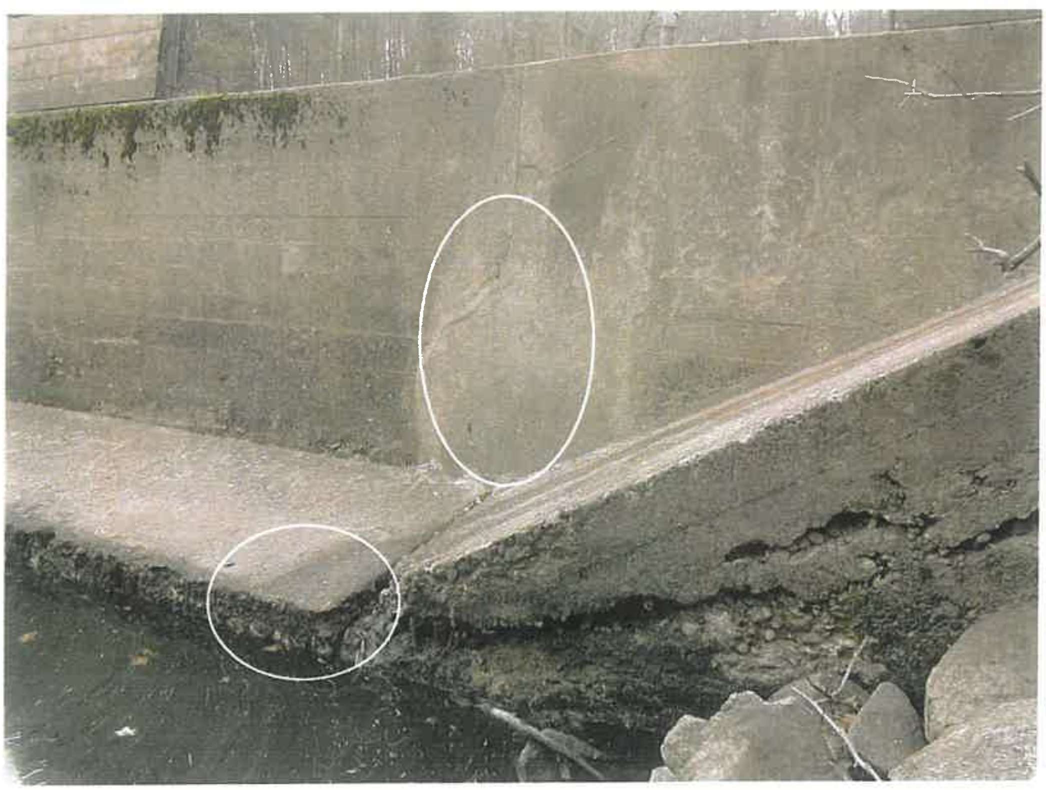


Photo 2 – Concrete delaminated areas downstream left bank

Photo 3 – Concrete gate pier deterioration

Photo 4 – Trash rack pitting

Photo 5 – Left flap gate

Photo 6 – Downstream left bank erosion

Appendix C
Budget Level Cost Estimates

LOCATION: **DEAD RIVER DAM**
LEEDS, MAINE

Replace 75 feet of 2 foot flashboards and new high strength steel pins

by: R.K.COTE
date: 1/21/02

SUMMARY OF COSTS

DIRECTS					
	CONSTRUCTION			$	10,000
	CONTINGENCY	10%		$	1,000
			SUBTOTAL DIRECTS	$	11,000
INDIRECTS					
	ENGINEERING	10%		$	1,100
			SUBTOTAL INDIRECTS	$	1,100
			PROJECT TOTAL	$	12,100
			USE	$	12,100

LOCATION: **DEAD RIVER DAM**
LEEDS, MAINE

Replace 75 feet of 3 foot flashboards and new high strength steel pins

by: R.K.COTE
date: 1/21/02

SUMMARY OF COSTS

DIRECTS					
	CONSTRUCTION			$	10,500
	CONTINGENCY	10%		$	1,050
			SUBTOTAL DIRECTS	$	11,550
INDIRECTS					
	ENGINEERING	10%		$	1,155
			SUBTOTAL INDIRECTS	$	1,155
			PROJECT TOTAL	$	12,705
			USE	$	12,700

LOCATION: **DEAD RIVER DAM**
LEEDS, MAINE

Install new 3 foot flashboards with high strength steel pins

by: R.K.COTE
date: 1/21/02

SUMMARY OF COSTS

DIRECTS					
	CONSTRUCTION			$	20,300
	CONTINGENCY	10%		$	2,030
			SUBTOTAL DIRECTS	$	22,330
INDIRECTS					
	ENGINEERING	10%		$	2,233
			SUBTOTAL INDIRECTS	$	2,233
			PROJECT TOTAL	$	24,563
			USE	$	25,000

LOCATION: **DEAD RIVER DAM**
LEEDS, MAINE

Install 4 foot steel hinged flashboards on existing dam
148 feet long with concrete bulkhead each end

by: R.K.COTE
date: 12/17/01

SUMMARY OF COSTS

DIRECTS					
	CONSTRUCTION			$	106,200
	CONTINGENCY	20%		$	21,240
			SUBTOTAL DIRECTS	$	127,440
INDIRECTS					
	ENGINEERING	10%		$	12,744
				$	-
				$	-
			SUBTOTAL INDIRECTS	$	12,744
			PROJECT TOTAL	$	140,184
			USE	$	140,000

LOCATION: **DEAD RIVER DAM**
LEEDS, MAINE

Install two additional 5 x 9 foot wooden flap gates in existing dam
Sill elevation 269

by: R.K.COTE
date: 12/17/01

SUMMARY OF COSTS

DIRECTS					
	CONSTRUCTION			$	84,400
	CONTINGENCY	20%		$	16,880
			SUBTOTAL DIRECTS	$	101,280
INDIRECTS					
	ENGINEERING	10%		$	10,128
				$	-
				$	-
			SUBTOTAL INDIRECTS	$	10,128
			PROJECT TOTAL	$	111,408
			USE	$	111,000

LOCATION: **DEAD RIVER DAM**
LEEDS, MAINE

Fill depression at east end of existing dam to elevation 280

by: R.K.COTE
date: 1/21/02

SUMMARY OF COSTS

DIRECTS					
	CONSTRUCTION			$	4,000
	CONTINGENCY	10%		$	400
			SUBTOTAL DIRECTS	$	4,400
INDIRECTS					
	ENGINEERING	10%		$	440
			SUBTOTAL INDIRECTS	$	440
			PROJECT TOTAL	$	4,840
			USE	$	4,800

LOCATION: **DEAD RIVER DAM**
LEEDS, MAINE

Stabilize 300 feet of east riverbank downstream of dam
1.5 feet riprap over filter fabric on 3:1 fill slope

by: R.K.COTE
date: 12/17/01

SUMMARY OF COSTS

DIRECTS					
	CONSTRUCTION			$	73,423
	CONTINGENCY	20%		$	14,685
			SUBTOTAL DIRECTS	$	88,108
INDIRECTS					
	ENGINEERING	10%		$	8,811
				$	-
				$	-
			SUBTOTAL INDIRECTS	$	8,811
			PROJECT TOTAL	$	96,918
			USE	$	97,000

LOCATION: **DEAD RIVER DAM**
LEEDS, MAINE

Construct 10 foot rubber dam on pile supported concrete base at Section G
Length of 180 feet with crest at elevation 279

by: R.K.COTE
date: 12/17/01

SUMMARY OF COSTS

DIRECTS				
CONSTRUCTION			$	1,021,000
CONTINGENCY	20%		$	204,200
		SUBTOTAL DIRECTS	$	1,225,200
INDIRECTS				
ENGINEERING	10%		$	122,520
RUBBER DAM SUPERVISION			$	25,000
RUBBER DAM			$	607,000
		SUBTOTAL INDIRECTS	$	754,520
		PROJECT TOTAL	$	1,979,720
		USE	$	1,980,000

LOCATION: **DEAD RIVER DAM**
LEEDS, MAINE

Construct 16 foot rubber dam on pile supported concrete base at Section G
Length of 180 feet with crest at elevation 285

by: R.K.COTE
date: 12/17/01

SUMMARY OF COSTS

DIRECTS				
CONSTRUCTION			$	1,061,000
CONTINGENCY	20%		$	212,200
		SUBTOTAL DIRECTS	$	1,273,200
INDIRECTS				
ENGINEERING	10%		$	127,320
RUBBER DAM SUPERVISION			$	25,000
RUBBER DAM			$	1,420,000
		SUBTOTAL INDIRECTS	$	1,572,320
		PROJECT TOTAL	$	2,845,520
		USE	$	2,846,000

LOCATION: **DEAD RIVER DAM**
LEEDS, MAINE

Construct 18.4 foot rubber dam on pile supported concrete base at Section G
Length of 180 feet with crest at elevation 292

by: R.K.COTE
date: 1/17/02

SUMMARY OF COSTS

DIRECTS				
CONSTRUCTION			$	2,572,000
CONTINGENCY	20%		$	514,400
		SUBTOTAL DIRECTS	$	3,086,400
INDIRECTS				
ENGINEERING	10%		$	308,640
RUBBER DAM SUPERVISION			$	25,000
RUBBER DAM			$	1,820,000
		SUBTOTAL INDIRECTS	$	2,153,640
		PROJECT TOTAL	$	5,240,040
		USE	$	5,240,000

LOCATION: **DEAD RIVER DAM**
LEEDS, MAINE

Remove Existing Dam

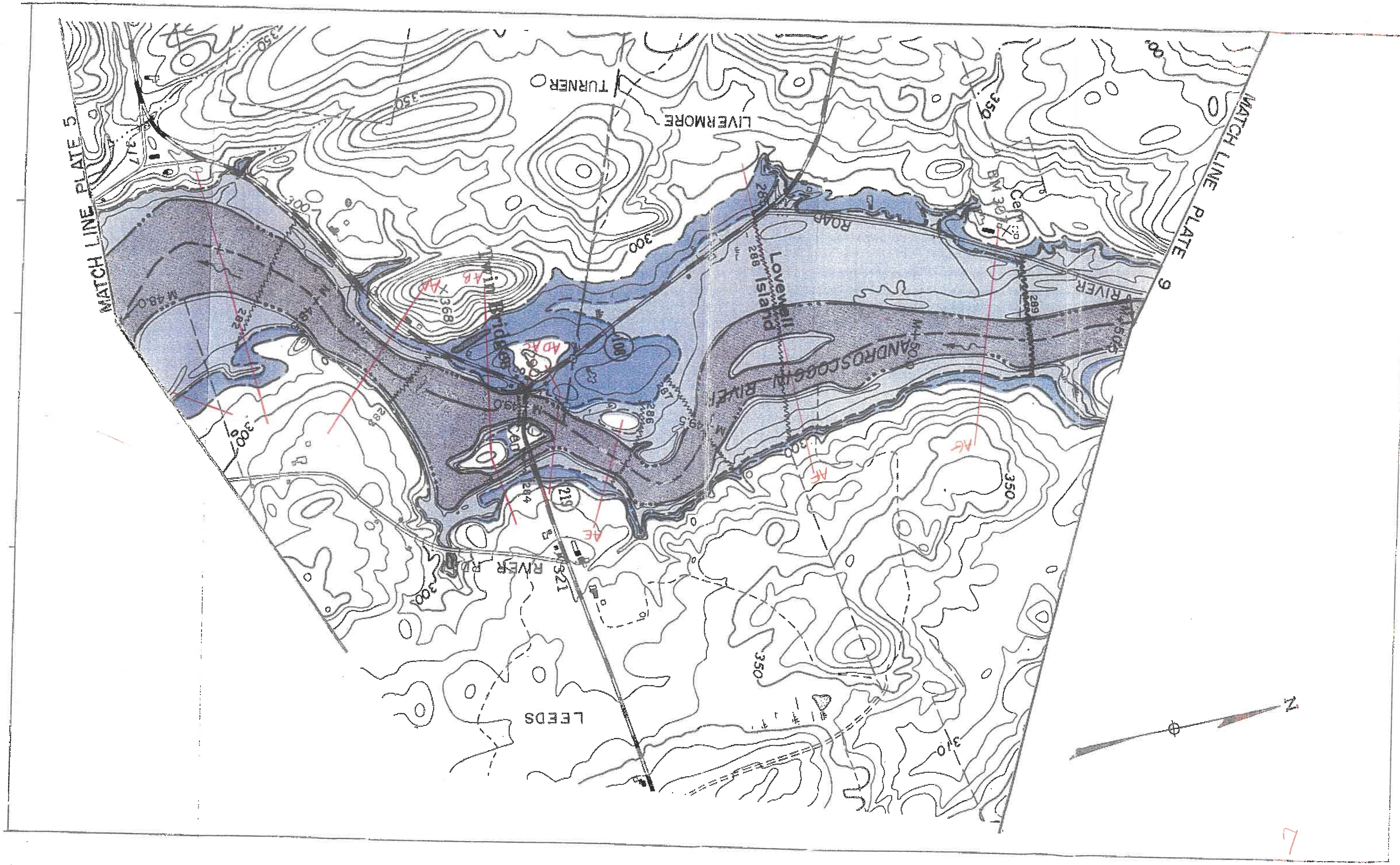
by: R.K.COTE
date: 1/23/02

SUMMARY OF COSTS

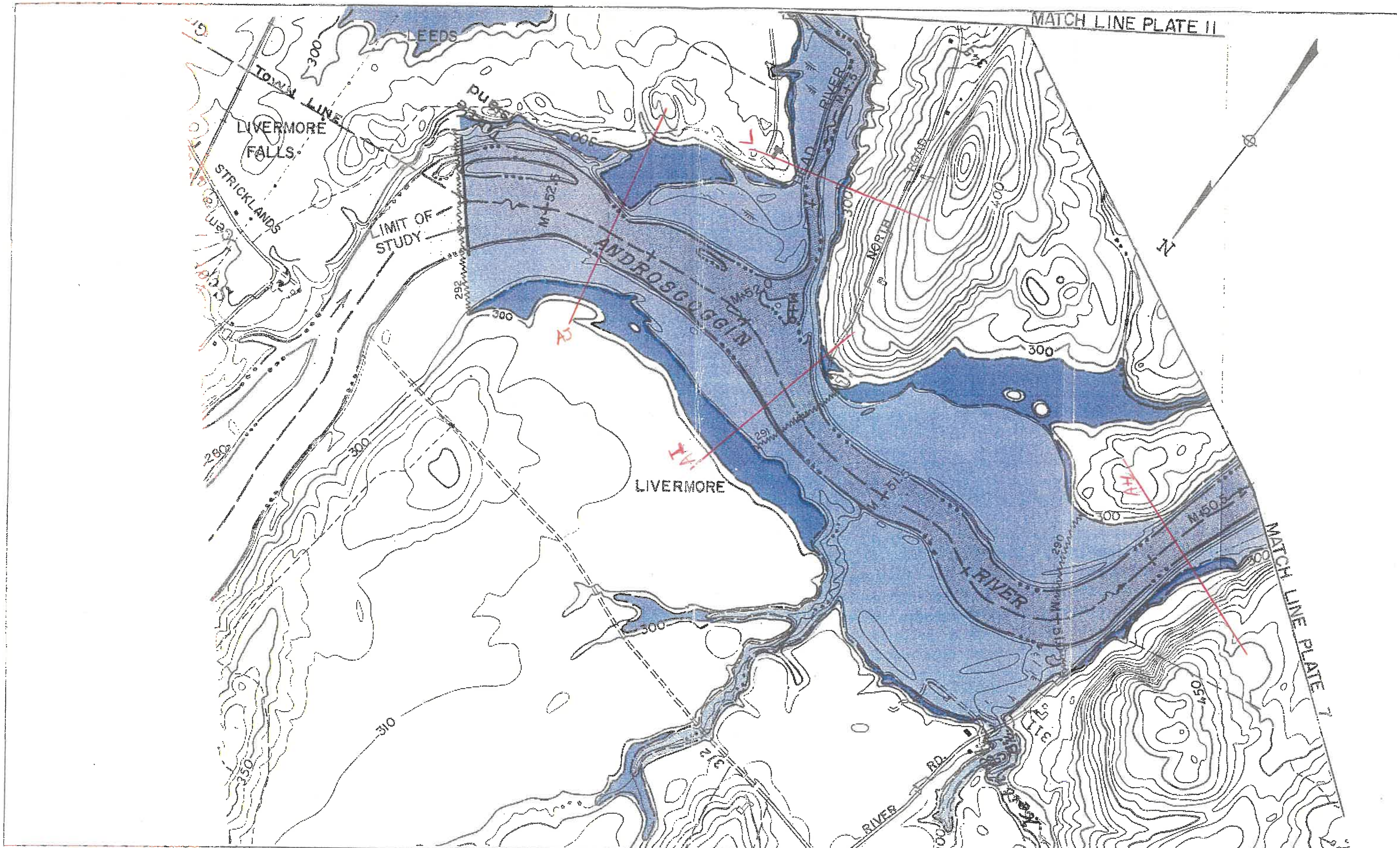
DIRECTS					
	CONSTRUCTION			$	89,000
	CONTINGENCY	10%		$	8,900
			SUBTOTAL DIRECTS	$	97,900
INDIRECTS					
	ENGINEERING	15%		$	14,685
			SUBTOTAL INDIRECTS	$	14,685
			PROJECT TOTAL	$	112,585
			USE	$	113,000

Appendix D
Cross Section Locations

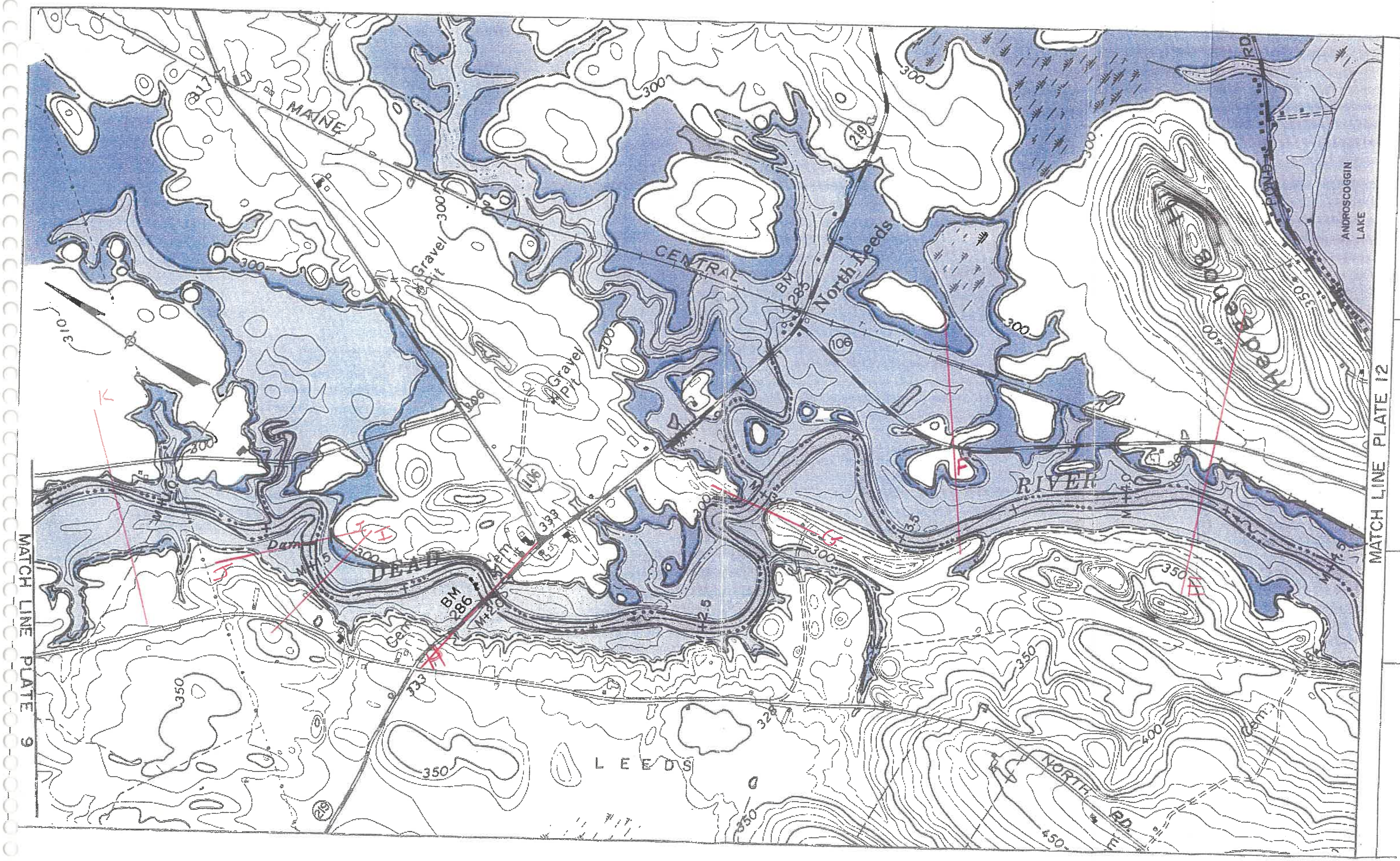
7


MATCH LINE PLATE 5
MATCH LINE PLATE 6
TURNER
LIVERMORE
LEEDS
ANDROSCOGGIN RIVER
Lovewell Island
Twin Bridges
RIVER RD
ROAD
RIVER
BM 30
Cem
N

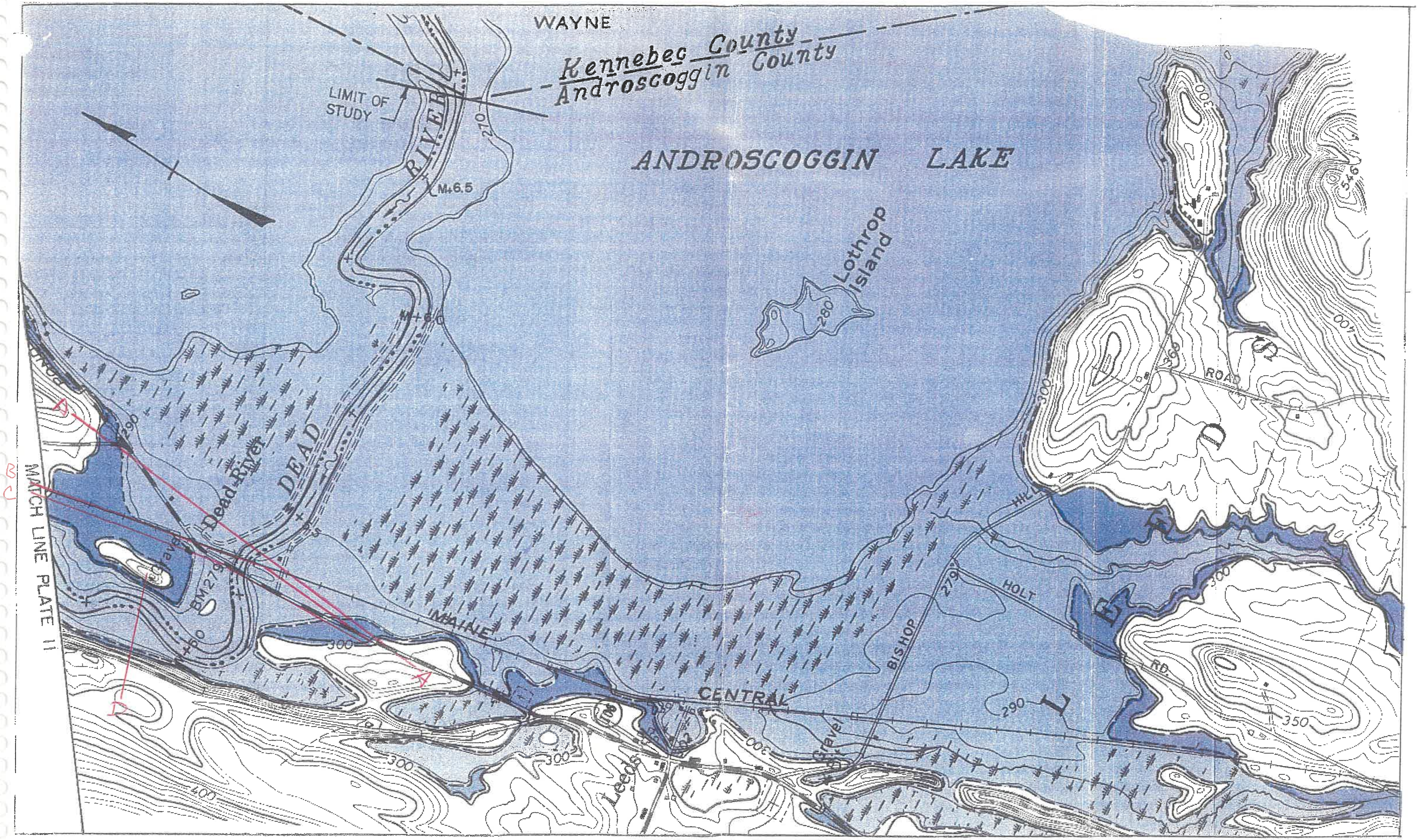
7


MATCH LINE PLATE II
LEEDS
TOWN LINE
LIVERMORE
FALLS
STRICKLANDS
LIMIT OF
STUDY
ANDROSCOGGIN
RIVER
NORTH ROAD
LIVERMORE
MATCH LINE PLATE 7
RIVER RD.
RIVER
N
300
310
280
350
400
450

a



MAINE
CENTRAL
North Leeds
BM 285
Gravel Pit
Gravel Pit
Dam
DEAD
RIVER
BM 286
Cem.
LEEDS
NORTH RD.
POND RD.
ANDROSCOGGIN LAKE
300
350
400
450
MATCH LINE PLATE 12
MATCH LINE PLATE 9



WAYNE
Kennebec County
Androscoggin County
LIMIT OF STUDY
RIVER
M+6.5
ANDROSCOGGIN LAKE
Lothrop Island
280
DEAD
Dead River
BM279
MATCH LINE PLATE 11
MAINE
CENTRAL
BISHOP
HOLT
RD.
ROAD
HILL
Leeds
Gravel
300
290
350
400
546

Appendix E
Key Portions of Dana Murch's (DEP) Approximated Flood Elevation Frequency Data from April 2000 Study

SUMMARY OF DEAD RIVER DAM/ANDROSCOGGIN LAKE OBSERVATIONS
WINTER/SPRING 1999/2000

[For the purpose of the following summary, the "lake" is Androscoggin Lake and the flooded portion of the Dead River to the east of the Dead River Dam, while the "river" is the Androscoggin River and Dead River to the west of the dam.]

12/22/1999 10 A.M. The river was about 5.3 feet below the top of the concrete dam. River flows were at about 5,700 cfs, well above average (median) flows for the date. The lake was about 3.3 feet below the top of the concrete dam. Water was flowing out of the lake into the river. Flashboards were in place.

03/27/2000 2:15 P.M. Water was essentially equal on each side of the dam at about 3 feet below the top of the concrete dam, with very little discernable flow through the dam. River flow was about 9,700 cfs. Two 6-foot long sections of flashboards had been displaced by ice or debris.

03/28/2000 Heavy rain and snow melt began this day. The Swift River near Roxbury peaked in the afternoon of the 28th at about 1 foot over flood stage, while the Androscoggin River at Rumford peaked early on the 29th at about 2 feet below flood stage.

03/29/2000 10:15 A.M. The river had risen to a level about 4 feet over the top of the concrete dam (2 feet over the flashboards) and was flowing into the lake (see photograph). River flow was about 33,900 cfs. The maximum level reached by the river was probably less 5 feet over the dam. The lake was about ½ foot below the top of the concrete dam, and peaked sometime on the 30th at a level probably approaching the top of the concrete dam. At the Route 106 bridge (east of the dam), the water level was over the banks of the flooded river channel, with a strong and definite current of water flowing from the Androscoggin River into the lake.

03/31/2000 11:30 A.M. The river had dropped to a level about 3/4ths of a foot below the top of the concrete dam, while the lake level was about 1 ½ inches higher than the river level. The lake was clearly flowing out through the dam into the river.

04/08/2000 Heavy rains and snowmelt again occurred on April 8th and 9th. The Swift River at Roxbury peaked in the afternoon on the 9th at about 5 feet above flood stage. The Androscoggin River at Rumford peaked in the morning on the 10th at about flood stage.

04/11/2000 9:30 A.M. The river was about 3 ½ feet above the top of the concrete dam, and was receding after the heavy rains of the previous weekend. The maximum level reached by the river was probably more than 5 feet above the top of the concrete dam. There was a strong and steady flow from the Androscoggin River into the lake. The lake had risen to a level more than 2 feet above the top of the concrete dam. The maximum level reached by the lake was probably about 2 ½ feet above the top of the concrete dam (equal to about ½ foot above the top of the flashboards). The bases of all the trees along the river channel to the east of the dam were under water, as were the trees around the lake as viewed from the yacht club in Wayne.

04/13/2000 10:30 A.M. The river had dropped to about 3/4ths of a foot below the top of the concrete dam. The lake was just below the top of the flashboards, about 2 feet above the top of the concrete dam. There was a strong flow out of the lake into the river. There was significant bank erosion evident along the river channel.

Summary Prepared By: Dana Paul Murch, Dams Supervisor
Department of Environmental Protection
April 18, 2000

\dead river flooding

ANDROSCOGGIN RIVER FLOWS AND WATER LEVELS AT DEAD RIVER DAM

RIVER FLOW AT DAM	WATER LEVEL AT DAM HEIGHT (FT)	HEIGHT (MSL)	DATA SOURCE
5,732	-5.3	268.7	Observations made 12/22/1999 10:00
9,700	-3.0	271.0	Observations made 03/27/2000 14:15
12,620	-0.7	273.3	Observations made 04/13/2000 10:30
33,925	4.0	278.0	Observations made 03/29/2000 10:15
52,800	8.0	282.0	Calculated 10-year flood conditions
74,400	12.0	286.0	Calculated 50-year flood conditions
86,100	14.0	288.0	Calculated 100-year flood conditions

COMMENTS

1. Flows in the Androscoggin River (except for calculated flood flows) are based on USGS gauging station data (provisional) adjusted to Livermore Falls using the following formula (developed by International Paper):

   Flow at Livermore Falls = Rumford gauge flow + (Swift River gauge flow x 3.65).

   These flows are approximate, as the formula does not account for the time of travel between the source gauges and Livermore Falls. Flows determined using the formula are especially suspect during times of rapid changes in flows.

   Note on 03/27/2000 flows: Swift River gauge was reporting ice on this date. Flow at gauge was assumed to be 3 times median flow for date.

2. Water levels at the dam (except for calculated flood levels) are based on measurements by DEP staff on the date and time noted. Water levels are given in feet above or below the top of the concrete spillway, which is at a reported elevation of 274.0 feet msl. At the time of the observations, the spillway was fitted with 2-foot high flashboards.

3. All flood flows are from FEMA Flood Insurance Study for the Town of Livermore Falls (1991).

4. 100-year flood level at the dam is from FEMA Flood Insurance Study for the Town of Leeds (1990). This level is 3 feet lower than the 100-year flood level for the Androscoggin River at the confluence with the Dead River, as reported in the FEMA Flood Insurance Study for the Town of Livermore Falls. Based on this, the 10-year and 50-year flood levels at the dam determined by subtracting 3 feet from these levels for the Androscoggin River at the confluence with the Dead River.

Prepared by: Dana Murch, Dams Supervisor
Department of Environmental Protection
April 18, 2000

\dead river dam water levels

- The presence of the various headwater storage dams on the Androscoggin River has the effect of increasing natural drought flows and decreasing natural flood flows in the river. Based on a recent analysis (FPL 1999), the best estimate of this effect is that the headwater storage dams increase the 100-year drought level of Androscoggin Lake by 1-2 feet (to 8 feet below the top of the dam) and decrease the 100-year flood level of the lake by about 1 foot (to 14 feet over the top of the dam). This means that, over a 100-year period with the headwater storage dams in place, the level of Androscoggin Lake would vary by about 22 feet.

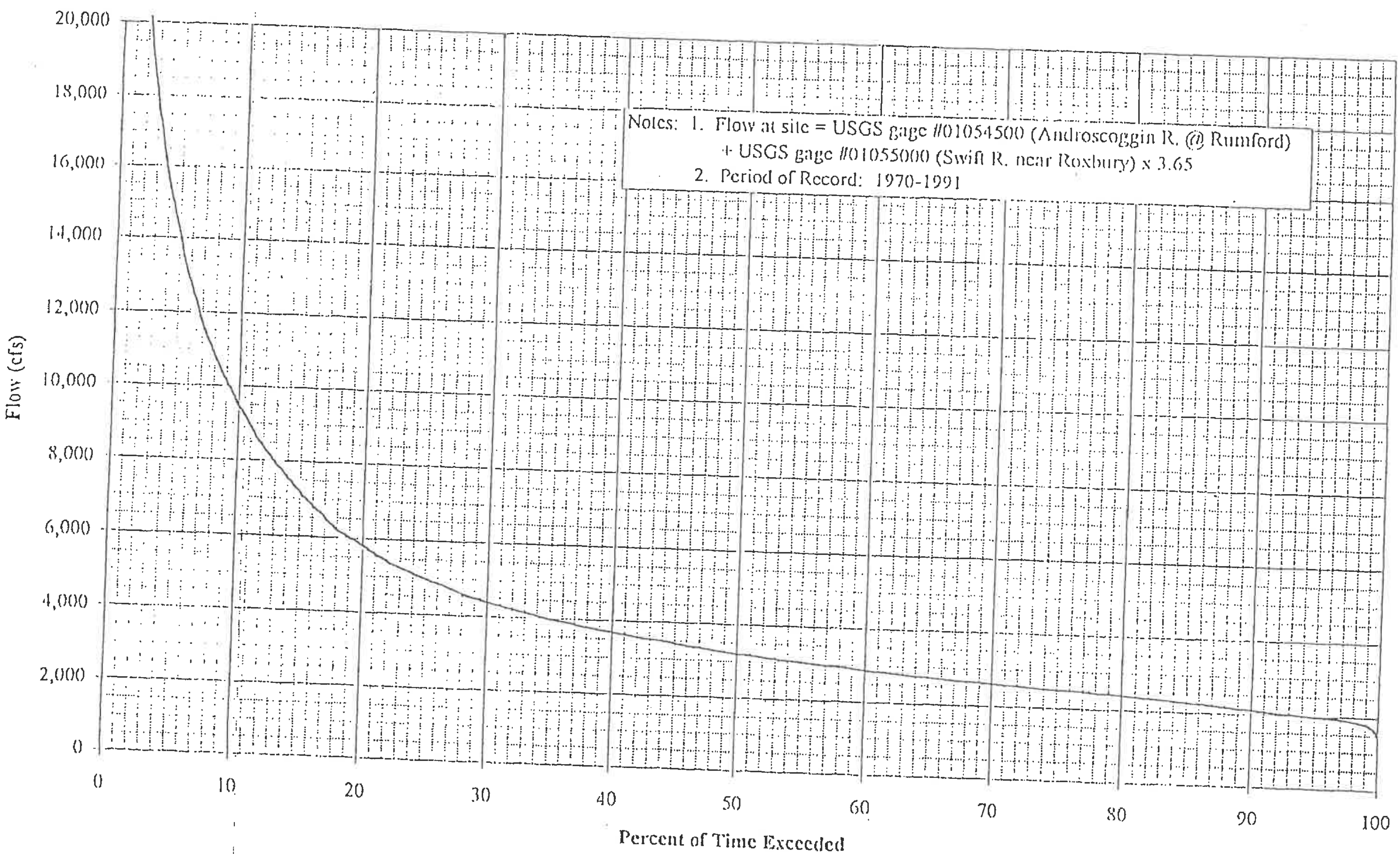
- The natural water levels of Androscoggin Lake over a 10-year period ranged from a 10-year drought low of elevation 266 feet msl (8 feet below the top of the dam) to a 10-year flood high of elevation 284 feet msl (10 feet above the top of the dam). This means that, over a 10-year period, the level of Androscoggin Lake naturally varied by about 18 feet.

- The presence of the Dead River Dam has the effect of slowing the natural flow of water into the lake during floods and slowing the natural release of water from the lake during droughts. As a result, the lake now both rises less and falls less than it would under natural flood and drought conditions. Based on observations to date, the best estimate of this effect is that the Dead River Dam increases the 10-year drought level of the lake by 2 feet (to 6 feet below the top of the dam) and reduces the 10-year flood level of the lake by 2 feet (to 8 feet above the top the dam). This means that, over a 10-year period with the headwater storage dams and the Dead River Dam in place, the level of the lake still varies by about 14 feet.

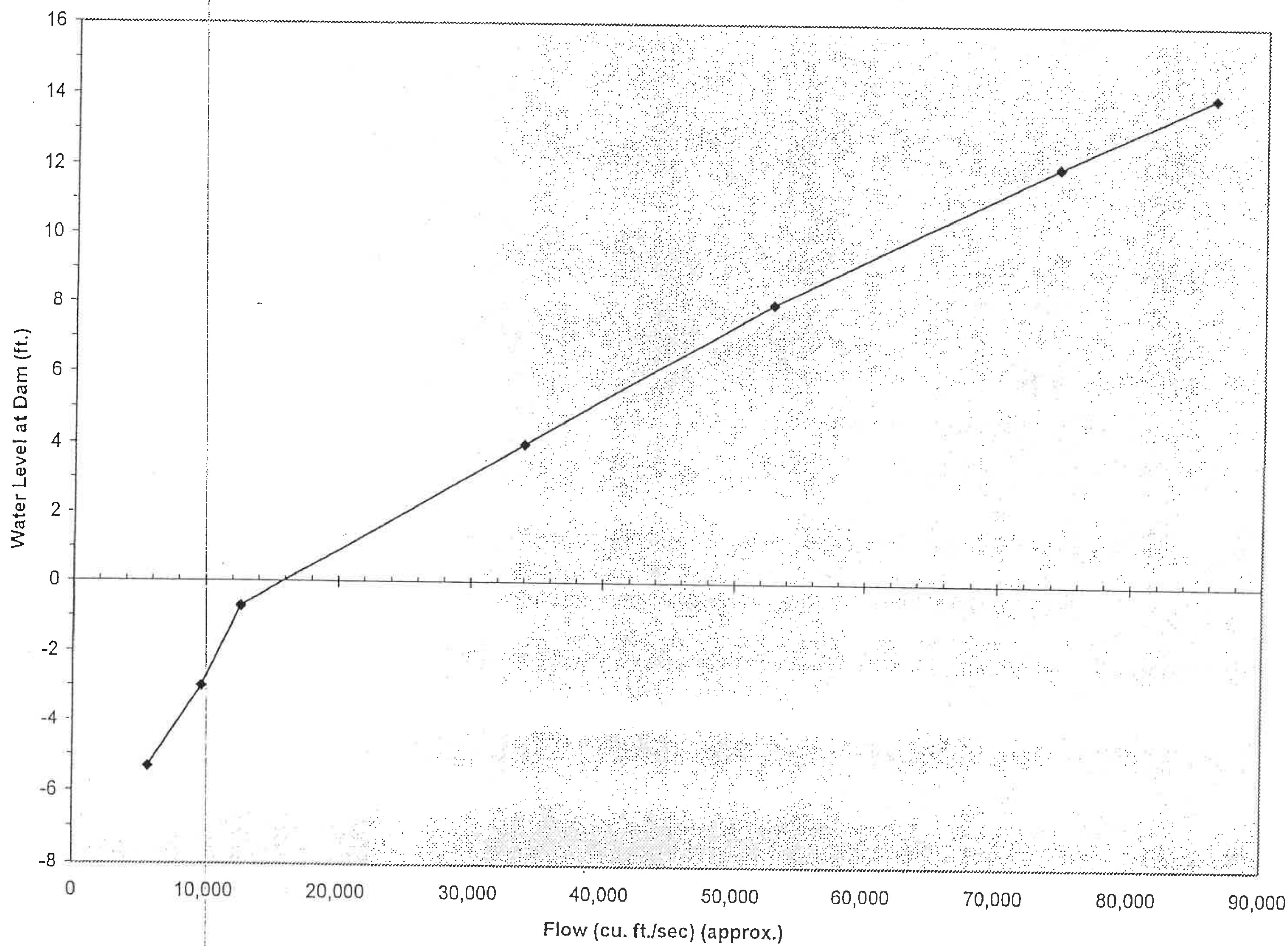
- With the flapper gates in the dam blocked partially open, some river water currently enters the lake whenever the level of the river is higher than that of the lake. However, at the same time, the higher river water prevents any water coming into the lake from its drainage area from leaving, so the lake rises in large part as it "fills up" with its own water. It is not clear how much river water is prevented from entering the lake by the presence of the dam.

On a final note, the Department of Agriculture has now acknowledged that it owns the dam. I suspect that the Department will soon be considering whether it should continue to own the dam.

FIGURE B-1. International Paper Company, Riley-Jay-Livermore Falls Project (FERC No. 2375), Annual Flow Duration Curve.



Androscoggin River Flows and Water Levels at Dead River Dam



Appendix F
Model Data, Hydro CAD input and output of Model of the Watershed of Androscoggin Lake

Appendix F

Hydrocad Model Results for Androscoggin Lake Watershed

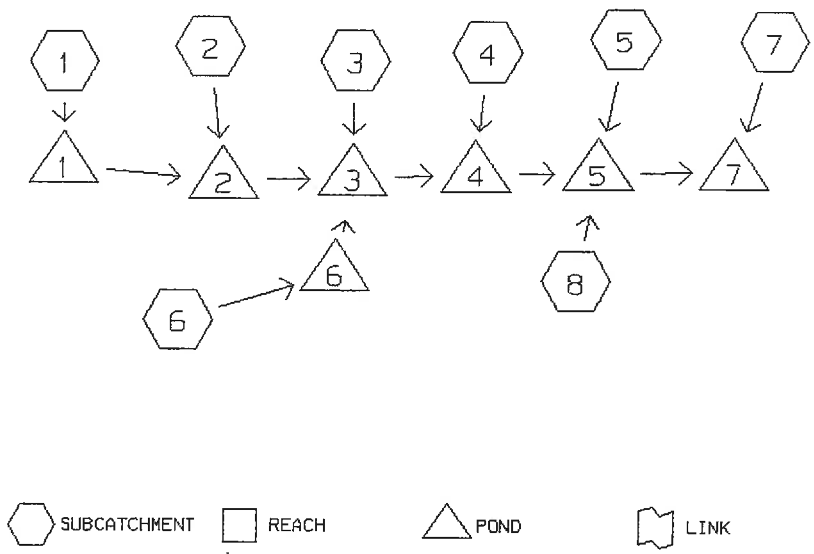
Table D1

Comparison of Flow rates Calculated by Hydrocad and USGS Regional Formula

Site Number	Site Name	Drainage Area Acres	USGS 100-yr peak flow, cfs	Hydrocad 100-year peak flow, cfs	Calculated CN	Calibrated CN	Time of concentration Minutes
1	Flying Pond	10240	1533	2155	76	53	258
2	Hopkins Stream	9600	1461	1637	76	45	120
3	Echo Lake	5760	997	982	76	45	120
4	Lovejoy Pd	5760	997	982	76	45	120
5	Pocasset L	5760	997	982	76	45	120
6		7040	1158	1200	76	45	120
7	Androscoggin L	12160	1743	4429	76	62	240
8	Direct rainfall on Lakes	6835	-	13950	98	98	72

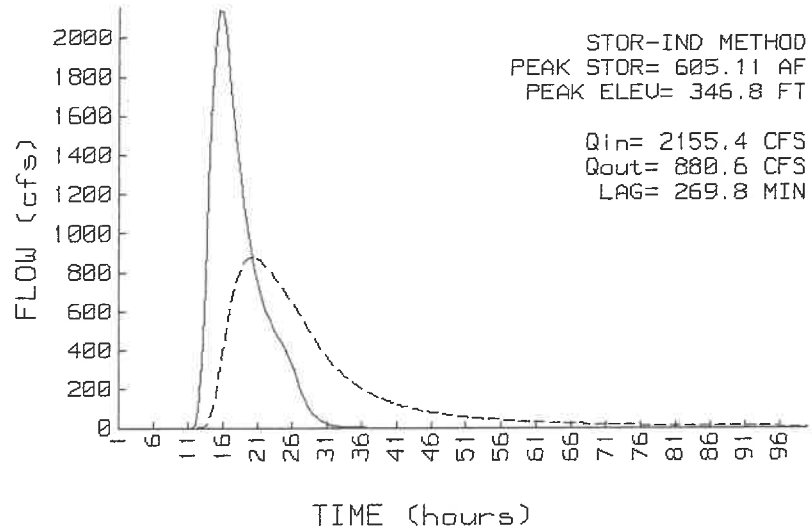
andros lake hydrocad.xls

WATERSHED ROUTING ==

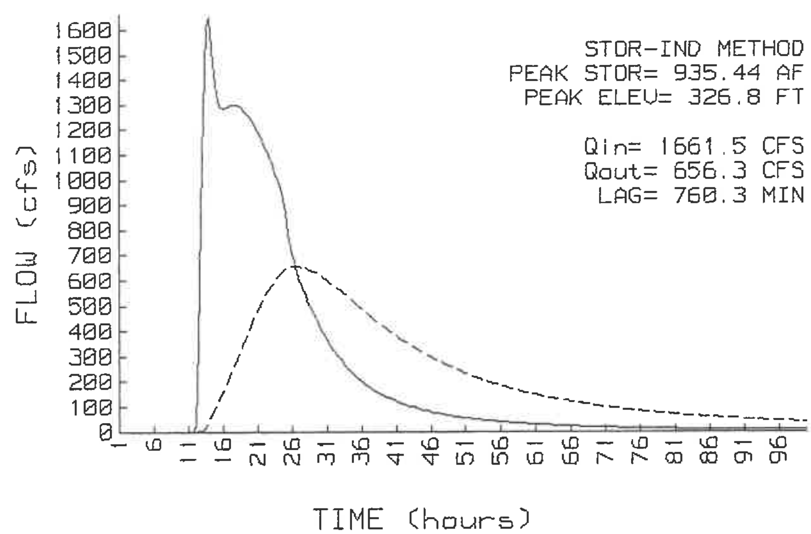


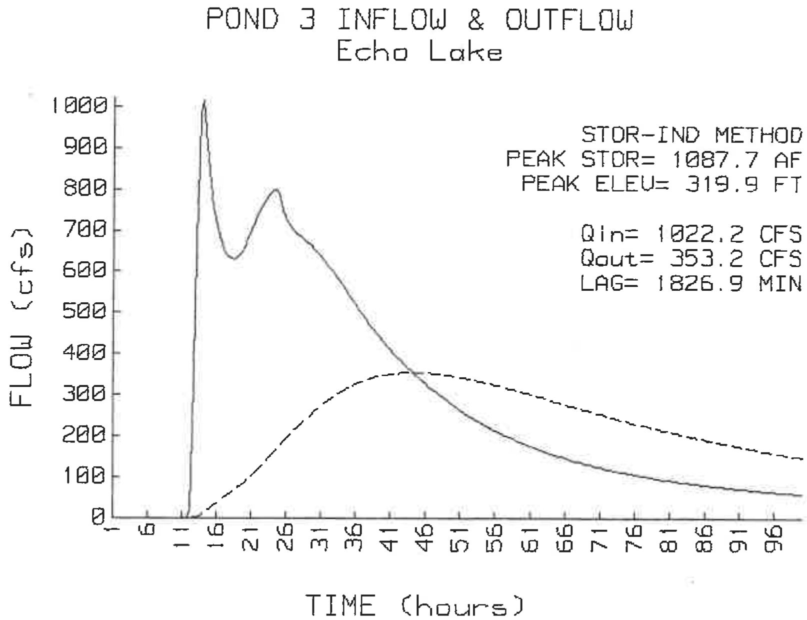
SUBCATCHMENT 1	= watershed to Flying Pond, Mt. Vernon	->	POND 1
SUBCATCHMENT 2	= area to Hopkins Stream	->	POND 2
SUBCATCHMENT 3	= area to Echo Lake	->	POND 3
SUBCATCHMENT 4	= area to Lovejoy	->	POND 4
SUBCATCHMENT 5	= area to Pocasset	->	POND 5
SUBCATCHMENT 6	= area to Parker Pond	->	POND 6
SUBCATCHMENT 7	= to Androscoggin Lake	->	POND 7
SUBCATCHMENT 8	= direct ro to lakes	->	POND 5
POND 1	= Flying Pond	->	POND 2
POND 2	= Hopkins Stream	->	POND 3
POND 3	= Echo Lake	->	POND 4
POND 4	= Lovejoy Pond	->	POND 5
POND 5	= Pocasset Lake	->	POND 7
POND 6	= PArker Pond	->	POND 3
POND 7	= Androscoggin Lake	->	

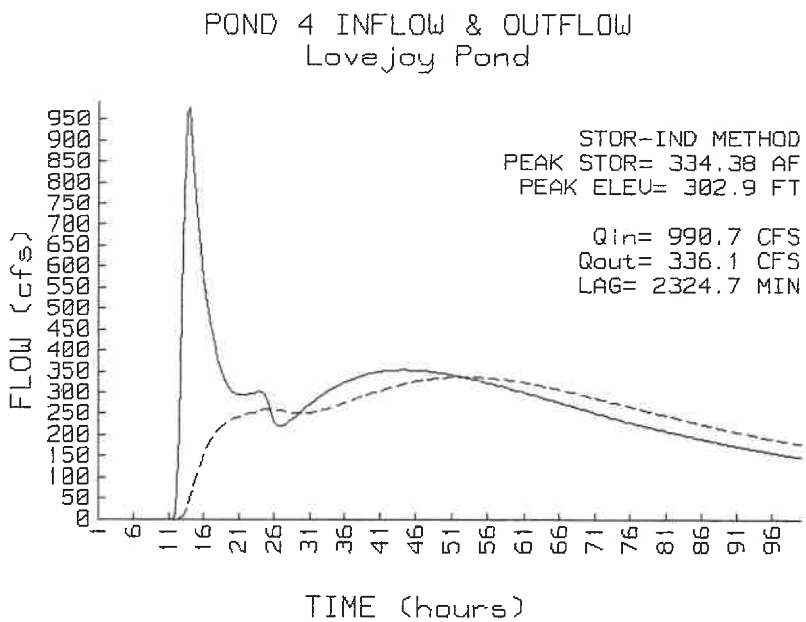
POND 1 INFLOW & OUTFLOW
Flying Pond



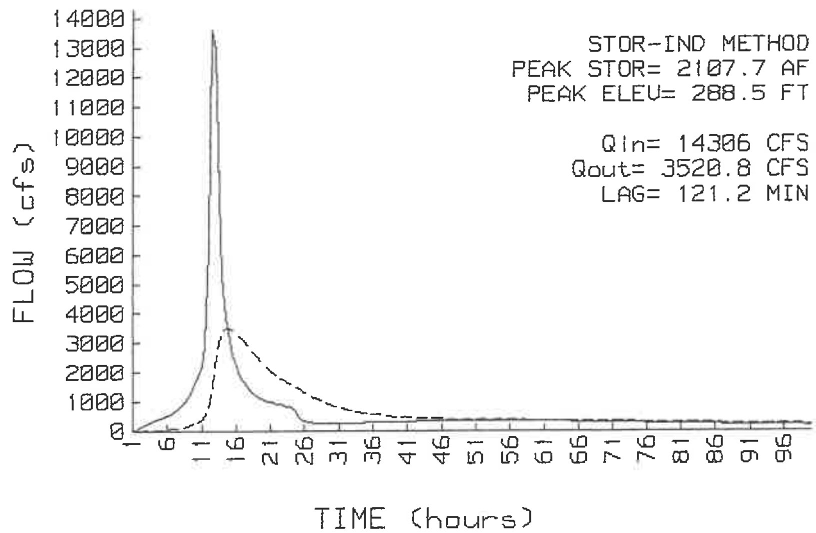
POND 2 INFLOW & OUTFLOW
Hopkins Stream



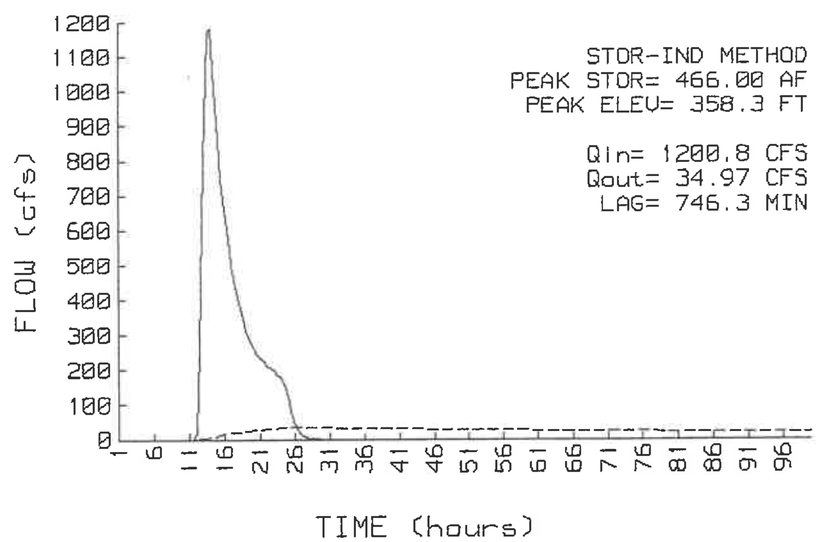

POND 3 INFLOW & OUTFLOW
Echo Lake
STOR-IND METHOD
PEAK STOR= 1087.7 AF
PEAK ELEV= 319.9 FT
Qin= 1022.2 CFS
Qout= 353.2 CFS
LAG= 1826.9 MIN
FLOW (cfs)
TIME (hours)

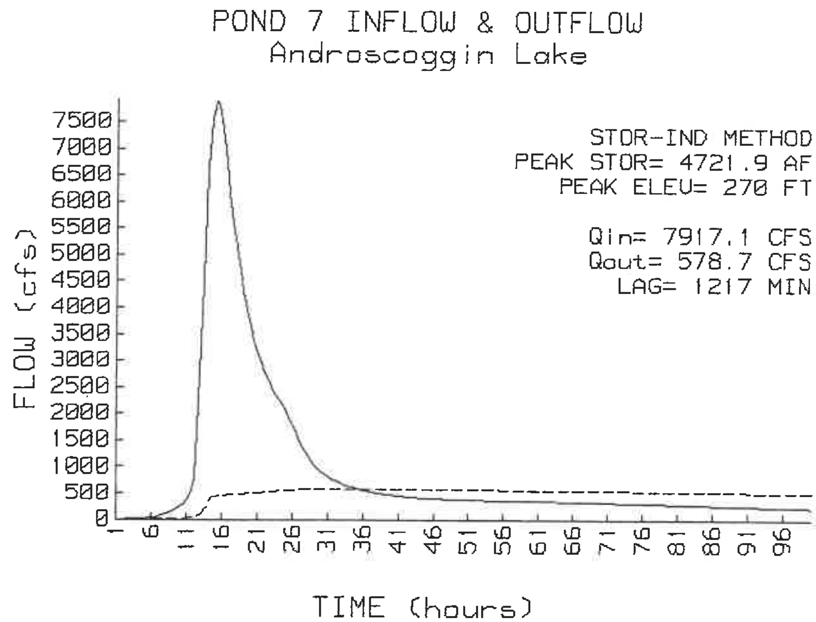

POND 4 INFLOW & OUTFLOW
Lovejoy Pond
STOR-IND METHOD
PEAK STOR= 334.38 AF
PEAK ELEV= 302.9 FT
Qin= 990.7 CFS
Qout= 336.1 CFS
LAG= 2324.7 MIN
FLOW (cfs)
TIME (hours)

POND 5 INFLOW & OUTFLOW
Pocasset Lake



POND 6 INFLOW & OUTFLOW
PArker Pond

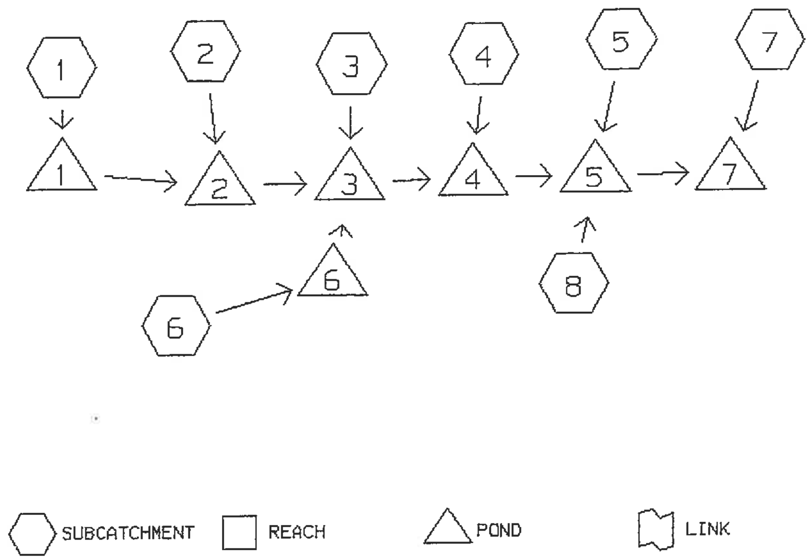



POND 7 INFLOW & OUTFLOW
Androscoggin Lake
STOR-IND METHOD
PEAK STOR= 4721.9 AF
PEAK ELEV= 270 FT
Qin= 7917.1 CFS
Qout= 578.7 CFS
LAG= 1217 MIN
FLOW (cfs)
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1 6 11 16 21 26 31 36 41 46 51 56 61 66 71 76 81 86 91 96
TIME (hours)

	Nid_stor	Dam_length						
LOVEJOY POND DAM	4630	150	WAYNE	Surf_area	Dam_heigl	Hydr_hgt	Nid_height	Max_stor
TORSEY POND DAM	1750	520	READFIELD	348		18	18	4630
TAYLOR POND DAM	864	200	MOUNT VERNON	568		11	11	1750
FLYING POND DAM	2450	130	MOUNT VERNON	59		12	12	864
WAYNE VILLAGE DAM	8910	133	WAYNE	445		7	7	2450
ECHO LAKE DAM	6500	150	FAYETTE	601		13	13	8910
DEAD RIVER DAM	57000	150	LEEDS	1155		13	13	6500
CMP	82	231		4058		18	18	57000
MILL DAM	50	96	VIENNA	5	21		21	82
				5		10	12	50

	Nid_stor	Dam_length							
LOVEJOY POND DAM	4630	150	WAYNE	Surf_area	Dam_heigl	Hydr_hgt	Nid_height		Max_stor
TORSEY POND DAM	1750	520	READFIELD	348		18		18	4630
TAYLOR POND DAM	864	200	MOUNT VERNON	568		11		11	1750
FLYING POND DAM	2450	130	MOUNT VERNON	59		12		12	864
WAYNE VILLAGE DAM	8910	133	WAYNE	445		7		7	2450
ECHO LAKE DAM	6500	150	FAYETTE	601		13		13	8910
DEAD RIVER DAM	57000	150	LEEDS	1155		13		13	6500
CMP	82	231		4058		18		18	57000
MILL DAM	50	96	VIENNA	5	21			21	82
				5		10		12	50

WATERSHED ROUTING ==



SUBCATCHMENT 1	= watershed to Flying Pond, Mt. Vernon	->	POND 1
SUBCATCHMENT 2	= area to Hopkins Stream	->	POND 2
SUBCATCHMENT 3	= area to Echo Lake	->	POND 3
SUBCATCHMENT 4	= area to Lovejoy	->	POND 4
SUBCATCHMENT 5	= area to Pocasset	->	POND 5
SUBCATCHMENT 6	= area to Parker Pond	->	POND 6
SUBCATCHMENT 7	= to Androscoggin Lake	->	POND 7
SUBCATCHMENT 8	= direct ro to lakes	->	POND 5
POND 1	= Flying Pond	->	POND 2
POND 2	= Hopkins Stream	->	POND 3
POND 3	= Echo Lake	->	POND 4
POND 4	= Lovejoy Pond	->	POND 5
POND 5	= Pocasset Lake	->	POND 7
POND 6	= PArker Pond	->	POND 3
POND 7	= Androscoggin Lake	->	

SUBCATCHMENT 1 watershed to Flying Pond, Mt. Vernon

PEAK=2155.4 CFS @ 15.71 HRS, VOLUME=1210.5 AF

ACRES	CN	
10240.00	53	composite

SCS TR-20 METHOD
TYPE III 24-HOUR
RAINFALL= 6.10 IN
SPAN= 1-100 HRS, dt=.5 HRS

Method	Comment	Tc (min)
DIRECT ENTRY	to Lake	258.0

SUBCATCHMENT 2 area to Hopkins Stream

PEAK=1637.4 CFS @ 13.77 HRS, VOLUME=673.26 AF

ACRES	CN	
9600.00	45	composite

SCS TR-20 METHOD
TYPE III 24-HOUR
RAINFALL= 6.10 IN
SPAN= 1-100 HRS, dt=.5 HRS

Method	Comment	Tc (min)
DIRECT ENTRY	to Hopkins Stream	120.0

SUBCATCHMENT 3 area to Echo Lake

PEAK= 982.4 CFS @ 13.77 HRS, VOLUME=403.96 AF

ACRES	CN
5760.00	45

SCS TR-20 METHOD
TYPE III 24-HOUR
RAINFALL= 6.10 IN
SPAN= 1-100 HRS, dt=.5 HRS

Method	Comment	Tc (min)
DIRECT ENTRY	to Echo Lake	120.0

SUBCATCHMENT 4 area to Lovejoy

PEAK= 982.4 CFS @ 13.77 HRS, VOLUME=403.96 AF

ACRES	CN	
5760.00	45	composite

SCS TR-20 METHOD
TYPE III 24-HOUR
RAINFALL= 6.10 IN
SPAN= 1-100 HRS, dt=.5 HRS

Method	Comment	Tc (min)
DIRECT ENTRY	to Lovejoy	120.0

SUBCATCHMENT 5 area to Pocasset

PEAK= 982.4 CFS @ 13.77 HRS, VOLUME=403.96 AF

ACRES	CN	
5760.00	45	composite

SCS TR-20 METHOD
TYPE III 24-HOUR
RAINFALL= 6.10 IN
SPAN= 1-100 HRS, dt=.5 HRS

Method	Comment	Tc (min)
DIRECT ENTRY	to Pocasset	120.0

SUBCATCHMENT 6 area to Parker Pond

PEAK=1200.8 CFS @ 13.77 HRS, VOLUME=493.73 AF

ACRES	CN	
7040.00	45	composite

SCS TR-20 METHOD
TYPE III 24-HOUR
RAINFALL= 6.10 IN
SPAN= 1-100 HRS, dt=.5 HRS

Method	Comment	Tc (min)
DIRECT ENTRY	to Parker Pond	120.0

SUBCATCHMENT 7 to Androscoggin Lake

PEAK=4429.4 CFS @ 15.20 HRS, VOLUME=2187.8 AF

ACRES	CN
12160.00	62

SCS TR-20 METHOD
TYPE III 24-HOUR
RAINFALL= 6.10 IN
SPAN= 1-100 HRS, dt=.5 HRS

Method	Comment	Tc (min)
DIRECT ENTRY	to Androscoggin	240.0

SUBCATCHMENT 8 direct ro to lakes

PEAK= 13950 CFS @ 12.68 HRS, VOLUME=3338.6 AF

ACRES	CN
6835.00	98

SCS TR-20 METHOD
TYPE III 24-HOUR
RAINFALL= 6.10 IN
SPAN= 1-100 HRS, dt=.5 HRS

Method	Comment	Tc (min)
DIRECT ENTRY	to lakes	72.0

POND 1 Flying Pond

Qin =2155.4 CFS @ 15.71 HRS, VOLUME=1210.5 AF
Qout= 880.6 CFS @ 20.20 HRS, VOLUME=1192.1 AF, ATTEN= 59%, LAG= 269.8 MIN

ELEVATION (FT)	AREA (AC)	INC.STOR (AF)	CUM.STOR (AF)
345.0	320.00	0.00	0.00
350.0	336.00	1640.00	1640.00

STOR-IND METHOD
PEAK STORAGE = 605.11 AF
PEAK ELEVATION= 346.8 FT
FLOOD ELEVATION= 350.0 FT
START ELEVATION= 345.0 FT
SPAN= 1-100 HRS, dt=.5 HRS
Tdet= 624.4 MIN (1192.1 AF)

#	ROUTE	INVERT	OUTLET DEVICES
1	P	345.0'	130' BROAD-CRESTED RECTANGULAR WEIR Q=C L H^1.5 C=2.7, 2.7, 2.7, 2.7, 2.8, 2.8, 3, 3

POND 2 Hopkins Stream

Qin =1661.5 CFS @ 13.83 HRS, VOLUME=1865.4 AF
Qout= 656.3 CFS @ 26.50 HRS, VOLUME=1720.4 AF, ATTEN= 60%, LAG= 760.3 MIN

ELEVATION (FT)	AREA (AC)	INC.STOR (AF)	CUM.STOR (AF)
324.0	320.00	0.00	0.00
329.0	340.00	1650.00	1650.00

STOR-IND METHOD
PEAK STORAGE = 935.44 AF
PEAK ELEVATION= 326.8 FT
FLOOD ELEVATION= 329.0 FT
START ELEVATION= 324.0 FT
SPAN= 1-100 HRS, dt=.5 HRS
Tdet= 1123.3 MIN (1711.71 A

#	ROUTE	INVERT	OUTLET DEVICES
1	P	324.0'	50' BROAD-CRESTED RECTANGULAR WEIR Q=C L H^1.5 C=2.65, 2.65, 2.7, 2.7, 2.75, 2.75, 2.8, 2.8

POND 3 Echo Lake

Qin =1022.2 CFS @ 13.86 HRS, VOLUME=2308.4 AF
Qout= 353.2 CFS @ 44.31 HRS, VOLUME=1705.7 AF, ATTEN= 65%, LAG= 1826.9 MIN

ELEVATION (FT)	AREA (AC)	INC.STOR (AF)	CUM.STOR (AF)
319.0	1155.00	0.00	0.00
324.0	1200.00	5887.50	5887.50

STOR-IND METHOD
PEAK STORAGE = 1087.66 AF
PEAK ELEVATION= 319.9 FT
FLOOD ELEVATION= 324.0 FT
START ELEVATION= 319.0 FT
SPAN= 1-100 HRS, dt=.5 HRS
Tdet= 1764.9 MIN (1697.12 A

#	ROUTE	INVERT	OUTLET DEVICES
1	P	319.0'	150' BROAD-CRESTED RECTANGULAR WEIR Q=C L H^1.5 C=2.65, 2.65, 2.65, 2.7, 2.7, 2.75, 2.75, 2.8

POND 4 Lovejoy Pond

Qin = 990.7 CFS @ 13.78 HRS, VOLUME=2109.6 AF
Qout= 336.1 CFS @ 52.53 HRS, VOLUME=1892.5 AF, ATTEN= 66%, LAG= 2324.7 MIN

ELEVATION (FT)	AREA (AC)	INC.STOR (AF)	CUM.STOR (AF)
302.0	348.00	0.00	0.00
307.0	400.00	1870.00	1870.00

STOR-IND METHOD
PEAK STORAGE = 334.38 AF
PEAK ELEVATION= 302.9 FT
FLOOD ELEVATION= 307.0 FT
START ELEVATION= 302.0 FT
SPAN= 1-100 HRS, dt=.5 HRS
Tdet= 721 MIN (1882.95 AF)

#	ROUTE	INVERT	OUTLET DEVICES
1	P	302.0'	150' BROAD-CRESTED RECTANGULAR WEIR Q=C L H^1.5 C=2.65, 2.65, 2.65, 2.7, 2, 2.7, 2.75, 2.75

POND 5 Pocasset Lake

Qin = 14306 CFS @ 12.71 HRS, VOLUME=5635.0 AF
Qout=3520.8 CFS @ 14.73 HRS, VOLUME=5292.0 AF, ATTEN= 75%, LAG= 121.2 MIN

ELEVATION (FT)	AREA (AC)	INC.STOR (AF)	CUM.STOR (AF)
284.0	445.00	0.00	0.00
289.0	500.00	2362.50	2362.50

STOR-IND METHOD
PEAK STORAGE = 2107.65 AF
PEAK ELEVATION= 288.5 FT
FLOOD ELEVATION= 289.0 FT
START ELEVATION= 284.0 FT
SPAN= 1-100 HRS, dt=.5 HRS
Tdet= 661.9 MIN (5291.99 AF

#	ROUTE	INVERT	OUTLET DEVICES
1	P	284.0'	133' BROAD-CRESTED RECTANGULAR WEIR Q=C L H^1.5 C=2.65, 2.65, 2.65, 2.7, 2.7, 2.7, 2.8, 2.8

POND 6 PArker Pond

Qin =1200.8 CFS @ 13.77 HRS, VOLUME=493.73 AF
Qout= 34.97 CFS @ 26.21 HRS, VOLUME=184.11 AF, ATTEN= 97%, LAG= 746.3 MIN

ELEVATION (FT)	AREA (AC)	INC.STOR (AF)	CUM.STOR (AF)
358.0	1770.00	0.00	0.00
363.0	1860.00	9075.00	9075.00

STOR-IND METHOD
PEAK STORAGE = 466.00 AF
PEAK ELEVATION= 358.3 FT
FLOOD ELEVATION= 363.0 FT
START ELEVATION= 358.0 FT
SPAN= 1-100 HRS, dt=.5 HRS
Tdet= 2412.5 MIN (183.19 AF

#	ROUTE	INVERT	OUTLET DEVICES
1	P	358.0'	100' BROAD-CRESTED RECTANGULAR WEIR Q=C L H^1.5 C=2.65, 2:65, 2.65, 2.7, 2.7, 2.75, 2.75, 2.8

POND 7 Androscoggin Lake

Qin =7917.1 CFS @ 15.13 HRS, VOLUME=7479.8 AF
Qout= 578.7 CFS @ 35.42 HRS, VOLUME=3875.8 AF, ATTEN= 93%, LAG= 1217.0 MIN

ELEVATION (FT)	AREA (AC)	INC.STOR (AF)	CUM.STOR (AF)
269.0	4240.00	0.00	0.00
274.0	4876.00	22790.00	22790.00
279.0	5607.00	26207.50	48997.50
284.0	6448.00	30137.50	79135.00

STOR-IND METHOD
PEAK STORAGE = 4721.90 AF
PEAK ELEVATION= 270.0 FT
FLOOD ELEVATION= 274.0 FT
START ELEVATION= 269.0 FT
SPAN= 1-100 HRS, dt=.5 HRS
Tdet= 2410.5 MIN (3856.37 A

#	ROUTE	INVERT	OUTLET DEVICES	ELEV(FT)	DISCH(CFS)
1	P	260.0'	two gates	260.0	0.00
				266.0	5.00
				266.5	100.00
				267.4	200.00
				269.8	500.00
				271.3	1000.00
				273.5	2000.00
				277.2	3000.00
				279.9	5000.00
				282.4	7500.00

Appendix G
Calculations to Derive the Elevations for each Flood Event for Configurations of Various Flashboards

Flood Routing from Androscoggin River into Lake

1-year flood, no dam						
hour	Flow in River	River level	Dead R. inflow	6 hour volume	Sum volume	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	15083		667	165	165	
12	17667		1333	496	661	
18	20250		2000	826	1488	
24	22833		2667	1157	2645	
30	25417		3333	1488	4132	272
36	28000	278	4000	1818	5950	
42	26893		3714	1913	7863	
48	25786		3429	1771	9634	273.5
54	24679		3143	1629	11263	
60	23571		2857	1488	12751	
66	22464		2571	1346	14097	
72	21357		2286	1204	15301	
78	20250		2000	1063	16364	
84	19143		1714	921	17285	
90	18036	275	1429	779	18064	274.5
96	16929		1143	638	18701	
102	15821	273	857	496	19197	
108	14714		571	354	19551	
114	13607		286	213	19764	
120	12500		0	71	19835	

2-year flood,		no dam				
hour	Flow in Ri	River level	Dead R. in	6 hour vol	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	15667		750	186	186	
12	18833		1500	558	744	
18	22000		2250	930	1674	
24	25167		3000	1302	2975	
30	28333		3750	1674	4649	271
36	31500	279.1	4500	2045	6694	
42	30143		4179	2152	8846	273
48	28786	278	3857	1992	10838	
54	27429		3536	1833	12671	274.5
60	26071		3214	1674	14345	
66	24714		2893	1514	15859	
72	23357		2571	1355	17214	
78	22000		2250	1195	18409	275
84	20643		1929	1036	19445	
90	19286		1607	877	20322	
96	17929	274.5	1286	717	21039	
102	16571		964	558	21597	
108	15214		643	398	21995	
114	13857		321	239	22234	
120	12500		0	80	22314	

1-year flood, no boards						
hour	Flow in River	River level	Dead R. inflow	6 hour volume	Sum volume	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	15083		350	87	87	
12	17667		700	260	347	
18	20250		1050	434	781	
24	22833		1400	607	1388	
30	25417		1750	781	2169	271.5
36	28000	278	2100	955	3124	
42	26893		1950	1004	4128	272
48	25786		1800	930	5058	
54	24679		1650	855	5913	
60	23571		1500	781	6694	
66	22464		1350	707	7401	
72	21357		1200	632	8033	
78	20250		1050	558	8591	
84	19143		900	483	9074	
90	18036	275	750	409	9483	273.5
96	16929		600	335	9818	
102	15821	273	450	260	10079	
108	14714		300	186	10264	
114	13607		150	112	10376	
120	12500		0	37	10413	

2-year flood,		no boards				
hour	Flow in Ri	River level	Dead R. in	6 hour vol	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	15667		500	124	124	
12	18833		1000	372	496	
18	22000		1500	620	1116	
24	25167		2000	868	1983	
30	28333		2500	1116	3099	
36	31500	279.1	3000	1364	4463	272.1
42	30143		2786	1434	5897	
48	28786		2571	1328	7226	
54	27429		2357	1222	8447	272.2
60	26071		2143	1116	9563	
66	24714		1929	1009	10573	
72	23357		1714	903	11476	
78	22000		1500	797	12273	
84	20643		1286	691	12963	
90	19286		1071	584	13548	274
96	17929	274.3	857	478	14026	
102	16571		643	372	14398	
108	15214		429	266	14664	
114	13857		214	159	14823	
120	12500		0	53	14876	

1-year flood, 2' boards						
hour	Flow in River	River level	Dead R. Inflow	6 hour volume	Sum volume	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	15083		167	41	41	
12	17667		333	124	165	
18	20250		500	207	372	
24	22833		667	289	661	
30	25417		833	372	1033	
36	28000	278	1000	455	1488	271
42	26893		929	478	1966	
48	25786		857	443	2409	
54	24679		786	407	2816	
60	23571		714	372	3188	
66	22464		643	336	3524	
72	21357		571	301	3825	
78	20250		500	266	4091	
84	19143		429	230	4321	
90	18036	275	357	195	4516	272
96	16929		286	159	4675	
102	15821	273	214	124	4799	272.2
108	14714		143	89	4888	
114	13607		71	53	4941	
120	12500		0	18	4959	

1-year flood, 2/3' boards						
hour	Flow in River	River level	Dead R. Inflow	6 hour volume	Sum volume	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	15083		83	21	21	
12	17667		167	62	83	
18	20250		250	103	186	
24	22833		333	145	331	
30	25417		417	186	517	
36	28000	278	500	227	744	271
42	26893		464	239	983	
48	25786		429	221	1204	
54	24679		393	204	1408	
60	23571		357	186	1594	
66	22464		321	168	1762	
72	21357		286	151	1913	
78	20250		250	133	2045	
84	19143		214	115	2161	
90	18036	275	179	97	2258	271.5
96	16929		143	80	2338	
102	15821	273	107	62	2400	271.5
108	14714		71	44	2444	
114	13607		36	27	2470	
120	12500		0	9	2479	

2-year flood,		2' boards				
hour	Flow in Ri	River level	Dead R. In	6 hour vol	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	15667		333	83	83	
12	18833		667	248	331	
18	22000		1000	413	744	
24	25167		1333	579	1322	
30	28333		1667	744	2066	
36	31500	279.1	2000	909	2975	
42	30143		1857	956	3932	
48	28786		1714	885	4817	272.2
54	27429		1571	815	5632	
60	26071		1429	744	6375	
66	24714		1286	673	7048	
72	23357		1143	602	7651	
78	22000		1000	531	8182	
84	20643		857	460	8642	
90	19286		714	390	9032	
96	17929	274.3	571	319	9351	
102	16571		429	248	9599	273.4
108	15214		286	177	9776	
114	13857		143	106	9882	
120	12500		0	35	9917	

2-year flood,		2/3' boards				
hour	Flow in Ri	River level	Dead R. In	6 hour vol	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	15667		250	62	62	
12	18833		500	186	248	
18	22000		750	310	558	
24	25167		1000	434	992	
30	28333		1250	558	1550	
36	31500	279.1	1500	682	2231	
42	30143		1393	717	2949	
48	28786		1286	664	3613	
54	27429		1179	611	4224	272
60	26071		1071	558	4782	
66	24714		964	505	5286	
72	23357		857	452	5738	
78	22000		750	398	6136	
84	20643		643	345	6482	
90	19286		536	292	6774	
96	17929	274.3	429	239	7013	
102	16571	273.5	321	186	7199	272.8
108	15214		214	133	7332	
114	13857		107	80	7411	
120	12500	271	0	27	7438	

1-year flood, 3' boards						
hour	Flow in River	River level	Dead R. inflow	6 hour volume	Sum volume	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	15083		33	8	8	
12	17667		67	25	33	
18	20250		100	41	74	
24	22833		133	58	132	
30	25417		167	74	207	
36	28000	278	200	91	298	271
42	26893		186	96	393	
48	25786		171	89	482	
54	24679		157	81	563	
60	23571		143	74	638	
66	22464		129	67	705	
72	21357		114	60	765	
78	20250		100	53	818	
84	19143		86	46	864	
90	18036	275	71	39	903	271.2
96	16929		57	32	935	
102	15821	273	43	25	960	271.2
108	14714		29	18	978	
114	13607		14	11	988	
120	12500		0	4	992	

2-year flood,		3' boards				
hour	Flow in Ri	River level	Dead R. in	6 hour vol	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	15667		200	50	50	
12	18833		400	149	198	
18	22000		600	248	446	
24	25167		800	347	793	
30	28333		1000	446	1240	
36	31500	279.1	1200	545	1785	271
42	30143		1114	574	2359	
48	28786		1029	531	2890	
54	27429		943	489	3379	
60	26071		857	446	3825	
66	24714		771	404	4229	
72	23357		686	361	4590	
78	22000		600	319	4909	
84	20643		514	276	5185	
90	19286		429	234	5419	272.3
96	17929		343	191	5610	
102	16571		257	149	5759	
108	15214		171	106	5865	
114	13857		86	64	5929	
120	12500	272	0	21	5950	272

2-year flood		4' boards				
hour	Flow in Ri	River level	Dead R. in	6 hour vol	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	15667		33	8	8	
12	18833		67	25	33	
18	22000		100	41	74	
24	25167		133	58	132	
30	28333		167	74	207	
36	31500	279.1	200	91	298	271
42	30143		186	96	393	
48	28786		171	89	482	
54	27429		157	81	563	
60	26071		143	74	638	
66	24714		129	67	705	
72	23357		114	60	765	
78	22000		100	53	818	
84	20643		86	46	864	
90	19286		71	39	903	271.2
96	17929		57	32	935	
102	16571		43	25	960	271.2
108	15214		29	18	978	
114	13857		14	11	988	
120	12500	272	0	4	992	271.2

5-year flood,		no dam				
hour	Flow in Riv	River level	Dead R. In	6 hour volu	Sum volum	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	17417		1167	289	289	
12	22333		2333	868	1157	
18	27250		3500	1446	2603	
24	32167		4667	2025	4628	272
30	37083		5833	2603	7231	
36	42000	281.8	7000	3182	10413	273.5
42	38893		6500	3347	13760	
48	37786		6000	3099	16860	
54	35679		5500	2851	19711	
60	33571		5000	2603	22314	276
66	31464		4500	2355	24669	
72	29357		4000	2107	26777	277
78	27250		3500	1860	28636	
84	25143		3000	1612	30248	
90	23036	278	2500	1364	31612	277.5
96	20929		2000	1116	32727	
102	18821		1500	868	33595	
108	16714		1000	620	34215	
114	14607		500	372	34587	
120	12500	272	0	124	34711	

10-year flood,		no dam				
hour	Flow in Riv	River level	Dead R. In	6 hour volu	Sum volum	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	18367		1667	413	413	
12	26233		3333	1240	1653	
18	33100		5000	2066	3719	271.8
24	39967		6667	2893	6612	
30	46833		8333	3719	10331	273.4
36	53700	284.5	10000	4545	14876	
42	50757		9286	4782	19658	275.2
48	47814		8571	4427	24085	276.3
54	44871		7857	4073	28158	
60	41929	281.8	7143	3719	31877	277.5
66	38986		6429	3365	35242	
72	36043		5714	3011	38253	279
78	33100		5000	2656	40909	
84	30157		4286	2302	43211	280
90	27214		3571	1948	45159	
96	24271		2857	1594	46753	
102	21329	278	2143	1240	47993	
108	18386		1429	885	48878	
114	15443		714	531	49410	
120	12500	272	0	177	49587	

5-year flood,		no boards				
hour	Flow in Riv	River level	Dead R. In	6 hour volu	Sum volum	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	17417		750	186	186	
12	22333		1500	558	744	
18	27250		2250	930	1674	
24	32167		3000	1302	2975	
30	37083		3750	1674	4649	272
36	42000	281.8	4500	2045	6694	
42	39893		4179	2152	8846	273
48	37786		3857	1992	10838	
54	35679		3536	1833	12671	
60	33571		3214	1674	14345	274.2
66	31464		2893	1514	15859	
72	29357		2571	1355	17214	
78	27250		2250	1195	18409	275
84	25143		1929	1036	19445	
90	23036	278	1607	877	20322	275.5
96	20929		1286	717	21039	
102	18821		964	558	21597	275.6
108	16714		643	398	21995	
114	14607		321	239	22234	
120	12500	272	0	80	22314	

10-year flood,		no boards				
hour	Flow in Riv	River level	Dead R. In	6 hour volu	Sum volum	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	18367		1333	331	331	
12	26233		2667	992	1322	
18	33100		4000	1653	2975	
24	39967		5333	2314	5289	
30	46833		6667	2975	8264	273
36	53700	284.5	8000	3636	11901	
42	50757		7429	3825	15726	274.5
48	47814		6857	3542	19268	
54	44871		6286	3259	22527	276
60	41929	281.8	5714	2975	25502	
66	38986		5143	2692	28194	
72	36043		4571	2409	30602	
78	33100		4000	2125	32727	278
84	30157		3429	1842	34569	
90	27214		2857	1558	36128	278.5
96	24271		2286	1275	37403	
102	21329	278	1714	992	38394	
108	18386		1143	708	39103	
114	15443		571	425	39528	
120	12500	272	0	142	39669	

5-year flood,		2' boards				
hour	Flow in Ri	River level	Dead R. in	6 hour.vol	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	17417		667	165	165	
12	22333		1333	496	661	
18	27250		2000	826	1488	
24	32167		2667	1157	2645	
30	37083		3333	1488	4132	272
36	42000	281.8	4000	1818	5950	
42	39893		3714	1913	7863	
48	37786		3429	1771	9634	273.2
54	35679		3143	1629	11263	
60	33571		2857	1488	12751	
66	31464		2571	1346	14097	274.2
72	29357		2286	1204	15301	
78	27250		2000	1063	16364	
84	25143		1714	921	17285	
90	23036	278	1429	779	18064	275
96	20929		1143	638	18701	
102	18821		857	496	19197	275.3
108	16714		571	354	19551	
114	14607		286	213	19764	
120	12500	272	0	71	19835	

5-year flood,		2/3' boards				
hour	Flow in Ri	River level	Dead R. in	6 hour vol	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	17417		617	153	153	
12	22333		1233	459	612	
18	27250		1850	764	1376	
24	32167		2467	1070	2446	
30	37083		3083	1376	3822	
36	42000	281.8	3700	1682	5504	272
42	39893		3436	1769	7273	
48	37786		3171	1638	8911	273
54	35679		2907	1507	10419	
60	33571		2643	1376	11795	
66	31464		2379	1245	13040	274
72	29357		2114	1114	14153	
78	27250		1850	983	15136	
84	25143		1586	852	15988	
90	23036	278	1321	721	16709	
96	20929		1057	590	17299	
102	18821		793	459	17757	
108	16714		529	328	18085	275
114	14607		264	197	18282	
120	12500	272	0	66	18347	

10-year flood,		2' boards				
hour	Flow in Ri	River level	Dead R. in	6 hour vol	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	19367		1300	322	322	
12	26233		2600	967	1289	
18	33100		3900	1612	2901	
24	39967		5200	2256	5157	
30	46833		6500	2901	8058	273
36	53700	284.5	7800	3545	11603	
42	50757		7243	3730	15333	274.5
48	47814		6686	3453	18786	
54	44871		6129	3177	21963	276
60	41929	281.8	5571	2901	24864	
66	38986		5014	2625	27489	
72	36043		4457	2348	29837	
78	33100		3900	2072	31909	
84	30157		3343	1796	33705	278
90	27214		2786	1519	35224	
96	24271		2229	1243	36468	
102	21329	278	1671	967	37434	
108	18386		1114	691	38125	
114	15443		557	414	38540	
120	12500	272	0	138	38678	

10-year flood,		2/3' boards				
hour	Flow in Ri	River level	Dead R. in	6 hour vol	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	19367		1250	310	310	
12	26233		2500	930	1240	
18	33100		3750	1550	2789	
24	39967		5000	2169	4959	
30	46833		6250	2789	7748	272.8
36	53700	284.5	7500	3409	11157	
42	50757		6964	3586	14743	274.2
48	47814		6429	3321	18064	
54	44871		5893	3055	21119	
60	41929	281.8	5357	2789	23908	276.2
66	38986		4821	2524	26432	
72	36043		4286	2258	28689	
78	33100		3750	1992	30682	
84	30157		3214	1727	32409	277.5
90	27214		2679	1461	33870	
96	24271		2143	1195	35065	
102	21329	278	1607	930	35995	
108	18386		1071	664	36659	
114	15443		536	398	37057	
120	12500	272	0	133	37190	

5-year flood,		3' boards				
hour	Flow in Riv	River level	Dead R. In	6 hour volu	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	17417		583	145	145	
12	22333		1167	434	579	
18	27250		1750	723	1302	
24	32167		2333	1012	2314	
30	37083		2917	1302	3616	
36	42000	281.8	3500	1591	5207	272
42	39893		3250	1674	6880	
48	37786		3000	1550	8430	273
54	35679		2750	1426	9855	
60	33571		2500	1302	11157	
66	31464		2250	1178	12335	
72	29357		2000	1054	13388	274
78	27250		1750	930	14318	
84	25143		1500	806	15124	
90	23036	278	1250	682	15806	
96	20929		1000	558	16364	
102	18821		750	434	16798	
108	16714		500	310	17107	274.8
114	14607		250	186	17293	
120	12500	272	0	62	17355	

10-year flood,		3' boards				
hour	Flow in Riv	River level	Dead R. In	6 hour volu	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	19367		1217	302	302	
12	26233		2433	905	1207	
18	33100		3650	1508	2715	
24	39967		4867	2112	4826	
30	46833		6083	2715	7541	272.8
36	53700	284.5	7300	3318	10860	
42	50757		6779	3491	14350	274.3
48	47814		6257	3232	17582	
54	44871		5736	2973	20555	
60	41929	281.8	5214	2715	23270	276.2
66	38986		4693	2456	25727	
72	36043		4171	2198	27924	
78	33100		3650	1939	29864	277.2
84	30157		3129	1681	31544	
90	27214		2607	1422	32966	
96	24271		2086	1164	34130	
102	21329	278	1564	905	35035	
108	18386		1043	646	35681	
114	15443		521	388	36069	
120	12500	272	0	129	36198	

5-year flood,		4' boards				
hour	Flow in Riv	River level	Dead R. In	6 hour volu	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	17417		583	145	145	
12	22333		1167	434	579	
18	27250		1750	723	1302	
24	32167		2333	1012	2314	
30	37083		2917	1302	3616	271.9
36	42000	281.8	3500	1591	5207	
42	39893		3250	1674	6880	
48	37786		3000	1550	8430	273
54	35679		2750	1426	9855	
60	33571		2500	1302	11157	
66	31464		2250	1178	12335	
72	29357		2000	1054	13388	274
78	27250		1750	930	14318	
84	25143		1500	806	15124	
90	23036	278	1250	682	15806	
96	20929		1000	558	16364	
102	18821		750	434	16798	
108	16714		500	310	17107	274.7
114	14607		250	186	17293	
120	12500	272	0	62	17355	

10-year flood,		4' boards				
hour	Flow in Riv	River level	Dead R. In	6 hour volu	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	19367		1033	256	256	
12	26233		2067	769	1025	
18	33100		3100	1281	2306	
24	39967		4133	1793	4099	272
30	46833		5167	2306	6405	
36	53700	284.5	6200	2818	9223	273
42	50757		5757	2965	12188	
48	47814		5314	2745	14933	274.2
54	44871		4871	2525	17458	
60	41929	281.8	4429	2306	19764	275.2
66	38986		3986	2086	21850	
72	36043		3543	1867	23717	276.2
78	33100		3100	1647	25364	
84	30157		2657	1427	26791	
90	27214		2214	1208	27999	277
96	24271		1771	988	28987	
102	21329	278	1329	769	29756	277.5
108	18386		886	549	30305	
114	15443		443	329	30634	
120	12500	272	0	110	30744	

25-year flood,		no dam				
hour	Flow In Riv	River level	Dead R. In	6 hour volu	Sum volum	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	21250		2333	579	579	
12	30000		4667	1736	2314	
18	38750		7000	2893	5207	
24	47500		9333	4050	9256	
30	56250		11667	5207	14463	
36	65000	286.2	14000	6364	20826	275.5
42	61250		13000	6694	27521	
48	57500		12000	6198	33719	
54	53750	284.5	11000	5702	39421	279.2
60	50000		10000	5207	44628	
66	46250		9000	4711	49339	
72	42500	281.8	8000	4215	53554	281.7
78	38750		7000	3719	57273	
84	35000		6000	3223	60496	
90	31250	279.1	5000	2727	63223	
96	27500	278	4000	2231	65455	
102	23750		3000	1736	67190	
108	20000		2000	1240	68430	
114	16250		1000	744	69174	
120	12500	272	0	248	69421	

25-year flood,		no boards				
hour	Flow In Riv	River level	Dead R. In	6 hour volu	Sum volum	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	21250		2083	517	517	
12	30000		4167	1550	2066	
18	38750		6250	2583	4649	
24	47500		8333	3616	8264	
30	56250		10417	4649	12913	
36	65000	286.2	12500	5682	18595	275.1
42	61250		11607	5977	24572	
48	57500		10714	5534	30106	
54	53750	284.5	9821	5091	35198	
60	50000		8929	4649	39847	279.2
66	46250		8036	4206	44053	280.2
72	42500	281.8	7143	3763	47816	
78	38750		6250	3321	51136	281.3
84	35000		5357	2878	54014	
90	31250	279.1	4464	2435	56449	
96	27500	278	3571	1992	58442	
102	23750		2679	1550	59991	
108	20000		1786	1107	61098	
114	16250		893	664	61762	
120	12500	272	0	221	61983	

50-year flood,		no dam				
hour	Flow In Riv	River level	Dead R. In	6 hour volu	Sum volum	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	23300		3117	773	773	
12	34100		6233	2318	3091	
18	44900		9350	3864	6955	
24	55700		12467	5409	12364	
30	66500		15583	6955	19318	
36	77300	288.5	18700	8500	27818	277
42	72671		17364	8942	36760	
48	68043		16029	8279	45039	
54	63414	286.5	14693	7617	52656	281.8
60	58786		13357	6955	59610	282.5
66	54157	284.6	12021	6292	65903	283.5
72	49529		10686	5630	71532	284.5
78	44900		9350	4968	76500	
84	40271	281.5	8014	4305	80805	
90	35643		6679	3643	84448	
96	31014	279.1	5343	2981	87429	
102	26386	277.8	4007	2318	89747	
108	21757		2671	1656	91403	
114	17129		1336	994	92396	
120	12500	272	0	331	92727	

50-year flood,		no boards				
hour	Flow In Riv	River level	Dead R. In	6 hour volu	Sum volum	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	23300		2917	723	723	
12	34100		5833	2169	2893	
18	44900		8750	3616	6508	
24	55700		11667	5062	11570	
30	66500		14583	6508	18079	
36	77300	288.5	17500	7955	26033	276.8
42	72671		16250	8368	34401	
48	68043		15000	7748	42149	
54	63414	286.5	13750	7128	49277	281
60	58786		12500	6508	55785	
66	54157	284.6	11250	5888	61674	283
72	49529		10000	5269	66942	283.8
78	44900		8750	4649	71591	
84	40271	281.5	7500	4029	75620	
90	35643		6250	3409	79029	
96	31014	279.1	5000	2789	81818	
102	26386	277.8	3750	2169	83988	
108	21757		2500	1550	85537	
114	17129		1250	930	86467	
120	12500	272	0	310	86777	

100-year flood,		no dam				
hour	Flow In Riv	River level	Dead R. In	6 hour volu	Sum volum	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	25433		4000	992	992	
12	38367		8000	2975	3967	
18	51300		12000	4959	8926	
24	64233		16000	6942	15868	
30	77167		20000	8926	24793	
36	90100	291.3	24000	10909	35702	278.5
42	84557		22286	11476	47178	
48	79014		20571	10626	57804	
54	73471	286.5	18857	9776	67580	284.2
60	67929		17143	8926	76505	285.5
66	62386	284.6	15429	8076	84581	
72	56843		13714	7226	91806	
78	51300		12000	6375	98182	
84	45757	281.5	10286	5525	103707	
90	40214		8571	4675	108383	
96	34671	279.1	6857	3825	112208	
102	29129	277.8	5143	2975	115183	
108	23586		3429	2125	117308	
114	18043		1714	1275	118583	
120	12500	272	0	425	119008	

100-year flood,		no boards				
hour	Flow In Riv	River level	Dead R. In	6 hour volu	Sum volum	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	25433		3833	950	950	
12	38367		7667	2851	3802	
18	51300		11500	4752	8554	
24	64233		15333	6653	15207	
30	77167		19167	8554	23760	
36	90100	291.3	23000	10455	34215	278.2
42	84557		21357	10998	45213	
48	79014		19714	10183	55396	
54	73471	286.5	18071	9368	64764	283.5
60	67929		16429	8554	73318	285
66	62386	284.6	14786	7739	81057	
72	56843		13143	6924	87981	
78	51300		11500	6110	94091	
84	45757	281.5	9857	5295	99386	
90	40214		8214	4481	103867	
96	34671	279.1	6571	3666	107532	
102	29129	277.8	4929	2851	110384	
108	23586		3286	2037	112420	
114	18043		1643	1222	113642	
120	12500	272	0	407	114050	

25-year flood,		2' boards				
hour	Flow in Ri	River level	Dead R. In	6 hour volu	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	21250		2000	496	496	
12	30000		4000	1488	1983	
18	38750		6000	2479	4463	
24	47500		8000	3471	7934	
30	56250		10000	4463	12397	
36	65000	286.2	12000	5455	17851	275
42	61250		11143	5738	23589	
48	57500		10286	5313	28902	
54	53750	284.5	9429	4888	33790	278
60	50000		8571	4463	38253	
66	46250		7714	4038	42290	
72	42500	281.8	6857	3613	45903	
78	38750		6000	3188	49091	281
84	35000		5143	2763	51854	
90	31250	279.1	4286	2338	54191	
96	27500	278	3429	1913	56104	
102	23750		2571	1488	57591	
108	20000		1714	1063	58654	
114	16250		857	638	59292	
120	12500	272	0	213	59504	

25-year flood,		2/3' boards				
hour	Flow in Ri	River level	Dead R. In	6 hour volu	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	21250		2000	496	496	
12	30000		4000	1488	1983	
18	38750		6000	2479	4463	
24	47500		8000	3471	7934	
30	56250		10000	4463	12397	
36	65000	286.2	12000	5455	17851	275
42	61250		11143	5738	23589	
48	57500		10286	5313	28902	
54	53750	284.5	9429	4888	33790	278
60	50000		8571	4463	38253	
66	46250		7714	4038	42290	
72	42500	281.8	6857	3613	45903	280.2
78	38750		6000	3188	49091	281
84	35000		5143	2763	51854	
90	31250	279.1	4286	2338	54191	
96	27500	278	3429	1913	56104	
102	23750		2571	1488	57591	
108	20000		1714	1063	58654	
114	16250		857	638	59292	
120	12500	272	0	213	59504	

50-year flood,		2' boards				
hour	Flow in Ri	River level	Dead R. In	6 hour volu	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	23300		2750	682	682	
12	34100		5500	2045	2727	
18	44900		8250	3409	6136	
24	55700		11000	4773	10909	
30	66500		13750	6136	17045	
36	77300	288.5	16500	7500	24545	276
42	72671		15321	7890	32435	
48	68043		14143	7305	39740	
54	63414	286.5	12964	6721	46461	280.8
60	58786		11786	6136	52597	
66	54157	284.6	10607	5552	58149	282.5
72	49529	283.5	9429	4968	63117	283.5
78	44900	282.5	8250	4383	67500	
84	40271	281.5	7071	3799	71299	
90	35643		5893	3214	74513	
96	31014	279.1	4714	2630	77143	
102	26386	277.8	3536	2045	79188	
108	21757		2357	1461	80649	
114	17129		1179	877	81526	
120	12500	272	0	292	81818	

50-year flood,		2/3' boards				
hour	Flow in Ri	River level	Dead R. In	6 hour volu	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	23300		2700	669	669	
12	34100		5400	2008	2678	
18	44900		8100	3347	6025	
24	55700		10800	4686	10711	
30	66500		13500	6025	16736	
36	77300	288.5	16200	7364	24099	276
42	72671		15043	7746	31845	
48	68043		13886	7172	39018	
54	63414	286.5	12729	6599	45616	280.2
60	58786		11571	6025	51641	
66	54157	284.6	10414	5451	57092	282.2
72	49529		9257	4877	61969	283.2
78	44900		8100	4303	66273	
84	40271	281.5	6943	3730	70002	
90	35643		5786	3156	73158	
96	31014	279.1	4629	2582	75740	
102	26386	277.8	3471	2008	77749	
108	21757		2314	1434	79183	
114	17129		1157	861	80044	
120	12500	272	0	287	80331	

100-year flood,		2' boards				
hour	Flow in Ri	River level	Dead R. In	6 hour volu	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	25433		3750	930	930	
12	38367		7500	2789	3719	
18	51300		11250	4649	8368	
24	64233		15000	6508	14876	
30	77167		18750	8368	23244	
36	90100	291.3	22500	10227	33471	278
42	84557		20893	10759	44230	
48	79014		19286	9962	54191	
54	73471	286.5	17679	9165	63356	283.5
60	67929		16071	8368	71724	284.5
66	62386	284.6	14464	7571	79295	
72	56843	283.5	12857	6774	86068	
78	51300	282.5	11250	5977	92045	
84	45757	281.5	9643	5180	97226	
90	40214		8036	4383	101609	
96	34671	279.1	6429	3586	105195	
102	29129	277.8	4821	2789	107984	
108	23586		3214	1992	109976	
114	18043		1607	1195	111172	
120	12500	272	0	398	111570	

100-year flood,		2/3' boards				
hour	Flow in Ri	River level	Dead R. In	6 hour volu	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	25433		3667	909	909	
12	38367		7333	2727	3636	
18	51300		11000	4545	8182	
24	64233		14667	6364	14545	
30	77167		18333	8182	22727	
36	90100	291.3	22000	10000	32727	278
42	84557		20429	10519	43247	
48	79014		18857	9740	52987	
54	73471	286.5	17286	8961	61948	283
60	67929		15714	8182	70130	284.5
66	62386	284.6	14143	7403	77532	
72	56843		12571	6623	84156	
78	51300		11000	5844	90000	
84	45757	281.5	9429	5065	95065	
90	40214		7857	4286	99351	
96	34671	279.1	6286	3506	102857	
102	29129	277.8	4714	2727	105584	
108	23586		3143	1948	107532	
114	18043		1571	1169	108701	
120	12500	272	0	390	109091	

25-year flood,		3' boards				
hour	Flow in Ri	River level	Dead R. in	6 hour vol	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	21250		1967	488	488	
12	30000		3933	1463	1950	
18	38750		5900	2438	4388	
24	47500		7867	3413	7802	
30	56250		9833	4388	12190	
36	65000	286.2	11800	5364	17554	275
42	61250		10957	5642	23196	
48	57500		10114	5224	28420	
54	53750	284.5	9271	4806	33227	278
60	50000		8429	4388	37615	
66	46250		7586	3970	41586	
72	42500	281.8	6743	3553	45138	280.5
78	38750		5900	3135	48273	281
84	35000		5057	2717	50989	
90	31250	279.1	4214	2299	53288	
96	27500	278	3371	1881	55169	
102	23750		2529	1463	56632	
108	20000		1686	1045	57677	
114	16250		843	627	58303	
120	12500	272	0	209	58512	

25-year flood,		4' boards				
hour	Flow in Ri	River level	Dead R. in	6 hour vol	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	21250		1583	393	393	
12	30000		3167	1178	1570	
18	38750		4750	1963	3533	
24	47500		6333	2748	6281	
30	56250		7917	3533	9814	
36	65000	286.2	9500	4318	14132	274
42	61250		8821	4543	18675	
48	57500		8143	4206	22881	
54	53750	284.5	7464	3870	26750	276.7
60	50000		6786	3533	30283	
66	46250		6107	3197	33480	
72	42500	281.8	5429	2860	36340	278.6
78	38750		4750	2524	38864	
84	35000		4071	2187	41051	
90	31250	279.1	3393	1851	42901	279
96	27500	278	2714	1514	44416	
102	23750		2036	1178	45593	
108	20000		1357	841	46434	
114	16250		679	505	46939	
120	12500	272	0	168	47107	

50-year flood,		3' boards				
hour	Flow in Ri	River level	Dead R. in	6 hour vol	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	23300		2700	669	669	
12	34100		5400	2008	2678	
18	44900		8100	3347	6025	
24	55700		10800	4686	10711	
30	66500		13500	6025	16736	
36	77300	288.5	16200	7364	24099	276
42	72671		15043	7746	31845	
48	68043		13886	7172	39018	
54	63414	286.5	12729	6599	45616	280.5
60	58786		11571	6025	51641	
66	54157	284.6	10414	5451	57092	282.3
72	49529		9257	4877	61969	283.1
78	44900		8100	4303	66273	
84	40271	281.5	6943	3730	70002	
90	35643		5786	3156	73158	
96	31014	279.1	4629	2582	75740	
102	26386	277.8	3471	2008	77749	
108	21757		2314	1434	79183	
114	17129		1157	861	80044	
120	12500	272	0	287	80331	

50-year flood,		4' boards				
hour	Flow in Ri	River level	Dead R. in	6 hour vol	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	23300		2333	579	579	
12	34100		4667	1736	2314	
18	44900		7000	2893	5207	
24	55700		9333	4050	9256	
30	66500		11667	5207	14463	
36	77300	288.5	14000	6364	20826	276
42	72671		13000	6694	27521	
48	68043		12000	6198	33719	
54	63414	286.5	11000	5702	39421	279.3
60	58786		10000	5207	44628	
66	54157	284.6	9000	4711	49339	281
72	49529		8000	4215	53554	281.6
78	44900		7000	3719	57273	282.3
84	40271	281.5	6000	3223	60496	
90	35643		5000	2727	63223	
96	31014	279.1	4000	2231	65455	
102	26386	277.8	3000	1736	67190	
108	21757		2000	1240	68430	
114	17129		1000	744	69174	
120	12500	272	0	248	69421	

100-year flood,		3' boards				
hour	Flow in Ri	River level	Dead R. in	6 hour vol	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	25433		3667	909	909	
12	38367		7333	2727	3636	
18	51300		11000	4545	8182	
24	64233		14667	6364	14545	
30	77167		18333	8182	22727	
36	90100	291.3	22000	10000	32727	278
42	84557		20429	10519	43247	
48	79014		18857	9740	52987	
54	73471	286.5	17286	8961	61948	283
60	67929		15714	8182	70130	284.5
66	62386	284.6	14143	7403	77532	
72	56843		12571	6623	84156	
78	51300		11000	5844	90000	
84	45757	281.5	9429	5065	95065	
90	40214		7857	4286	99351	
96	34671	279.1	6286	3506	102857	
102	29129	277.8	4714	2727	105584	
108	23586		3143	1948	107532	
114	18043		1571	1169	108701	
120	12500	272	0	390	109091	

100-year flood,		4' boards				
hour	Flow in Ri	River level	Dead R. in	6 hour vol	Sum volun	Lek elev
				ac-ft		
0	12500	272	0	0	0	271
6	25433		3583	888	888	
12	38367		7167	2665	3554	
18	51300		10750	4442	7996	
24	64233		14333	6219	14215	
30	77167		17917	7996	22211	
36	90100	291.3	21500	9773	31983	278
42	84557		19964	10280	42264	
48	79014		18429	9519	51783	
54	73471	286.5	16893	8757	60540	282.5
60	67929		15357	7996	68536	284.2
66	62386	284.6	13821	7234	75770	
72	56843		12286	6473	82243	
78	51300		10750	5711	87955	
84	45757	281.5	9214	4950	92904	
90	40214		7679	4188	97093	
96	34671	279.1	6143	3427	100519	
102	29129	277.8	4607	2665	103185	
108	23586		3071	1904	105089	
114	18043		1536	1142	106231	
120	12500	272	0	381	106612	

Time for Lake to Drain, assuming numbers on preceding chart for lake levels.

Time based on time to drain first level to next level in chart, at 5000 acre feet per foot, at given flow rate (from HECRAS)

	no boards	2' boards	2/3' board	3' boards	4' boards
1-year flood in lake					
elev	273.5				
outflow	1000				
time, days	2.5				
elev	272.5	272.2			
outflow	800	750			
time	3.2	2.4			
elev	271.5	271.5	271.5	271.5	271
outflow	750	750	750	750	600
time, days	3.4	3.4	3.4	3.4	2.1
elev	270.5	270.5	270.5	270.5	270.5
outflow	550	550	550	550	550
time	2.3	2.3	2.3	2.3	2.3
elev	270	270	270	270	270
TOTAL TIME to 270	11.3	8.0	5.7	5.7	4.4
2-year flood in lake					
	274.3				
	1800				
	0.4				
elev	274	273.4	272.6	272.3	
outflow	1500	900	750	700	
time	3.4	3.9	2.0	1.1	
elev	272	272	272	272	271.2
outflow	700	700	700	700	600
time	7.2	7.2	7.2	7.2	5.0
elev	270	270	270	270	270
TOTAL TIME to 270	11.0	11.1	9.2	8.3	5.0
5-year flood in lake					
elev	275.6	275.3	275	274.8	274.7
outflow	2000	1400	1300	1250	1250
time	2.0	2.3	1.9	1.6	1.4
elev	274	274	274	274	274
outflow	1200	1000	1000	1000	1000
time	4.2	5.0	5.0	5.0	5.0
elev	272	272	272	272	272
outflow	700	700	700	700	700
time	7.2	7.2	7.2	7.2	7.2
elev	270	270	270	270	270
TOTAL TIME to 270	13.4	14.6	14.2	13.9	13.7
10-year flood in lake					
elev	278.5				
outflow	4500				
time	0.3				
elev	278	278	277.5	277.2	277
outflow	4000	2500	2400	2300	1500
time	1.3	2.0	1.6	1.3	1.7
elev	276	276	276	276	276
outflow	3000	1500	1400	1300	1300
time	1.7	3.4	3.6	3.9	3.9
elev	274	274	274	274	274
outflow	1200	1000	1000	1000	1000
time	4.2	5.0	5.0	5.0	5.0
elev	272	272	272	272	272
outflow	700	700	700	700	700
time	7.2	7.2	7.2	7.2	7.2
elev	270	270	270	270	270
TOTAL TIME to 270	14.6	17.6	17.4	17.4	17.8

25-year flood in lake

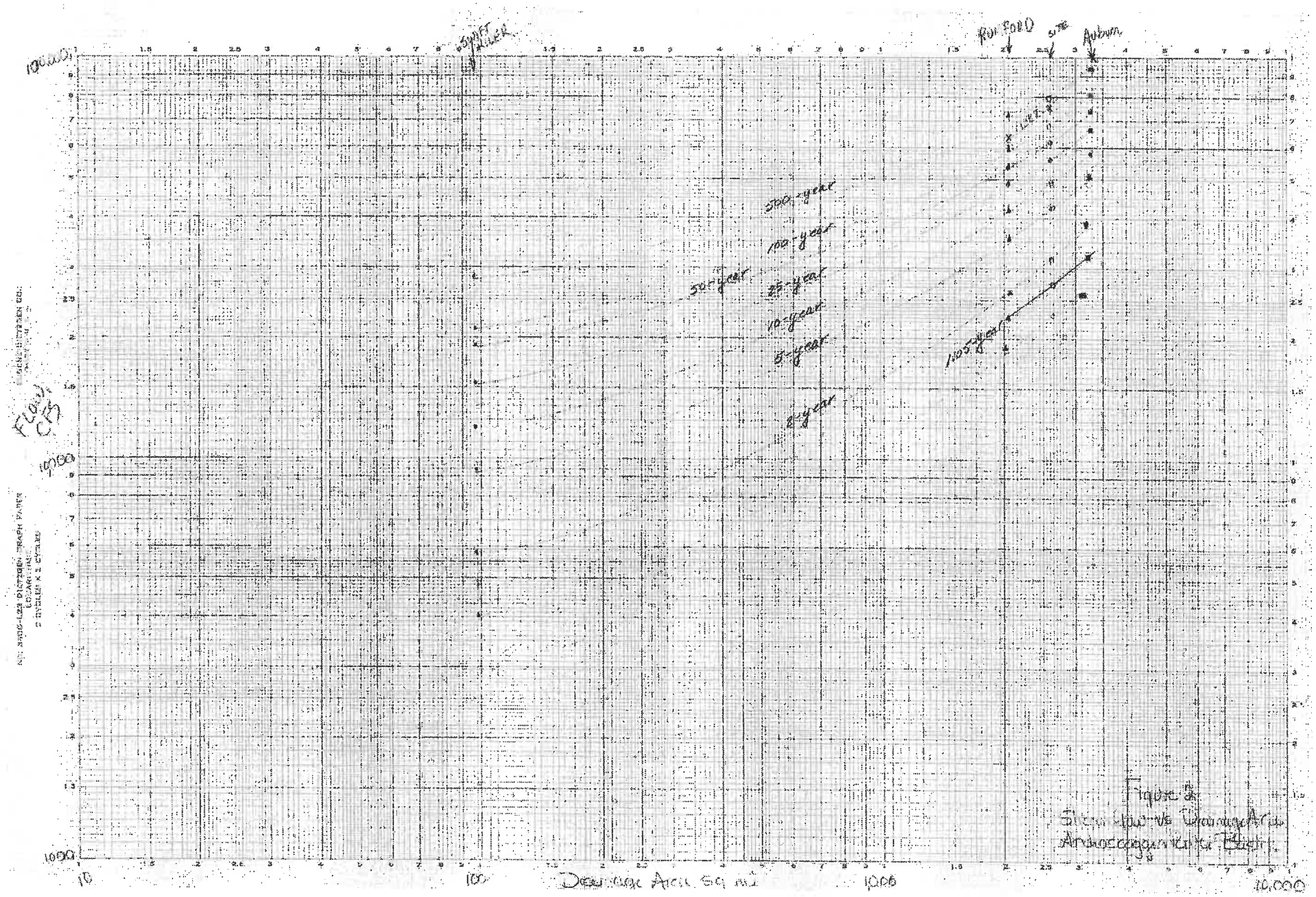
elev					
outflow					
time					
elev	281.3	281	281	281	
outflow	7000	5000	4700	4500	
time	0.5	0.5	0.5	0.6	
elev	280	280	280	280	279
outflow	5500	4000	3500	3000	2400
time	0.9	1.3	1.4	1.7	1.6
elev	278	278	278	278	277.5
outflow	4000	2500	2400	2300	1500
time	1.3	2.0	2.1	2.2	2.5
elev	276	276	276	276	276
outflow	3000	1500	1400	1300	1300
time	1.7	3.4	3.6	3.9	3.9
elev	274	274	274	274	274
outflow	1200	1000	1000	1000	1000
time	4.2	5.0	5.0	5.0	5.0
elev	272	272	272	272	272
outflow	700	700	700	700	700
time	7.2	7.2	7.2	7.2	7.2
elev	270	270	270	270	270
TOTAL TIME to 270	15.7	19.4	19.9	20.6	20.2

100-year flood in lake

elev	285	284.5	284.5	284.5	284.2
outflow	12000	11500	11000	10500	10000
time	0.4	0.4	0.5	0.5	0.5
elev	284	284	284	284	284
outflow	11000	10500	10000	9800	9700
time	0.5	0.5	0.5	0.5	0.5
elev	282	282	282	282	280.8
outflow	8000	6500	5500	5200	3500
time	0.6	0.8	0.9	1.0	0.6
elev	280	280	280	280	280
outflow	5500	4000	3500	3000	2900
time	0.9	1.3	1.4	1.7	1.7
elev	278	278	278	278	277.5
outflow	4000	2500	2400	2300	1500
time	1.3	2.0	2.1	2.2	2.5
elev	276	276	276	276	276
outflow	3000	1500	1400	1300	1300
time	1.7	3.4	3.6	3.9	3.9
elev	274	274	274	274	274
outflow	1200	1000	1000	1000	1000
time	4.2	5.0	5.0	5.0	5.0
elev	272	272	272	272	272
outflow	700	700	700	700	700
time	7.2	7.2	7.2	7.2	7.2
elev	270	270	270	270	270
TOTAL TIME to 270	16.8	20.6	21.3	22.0	22.0

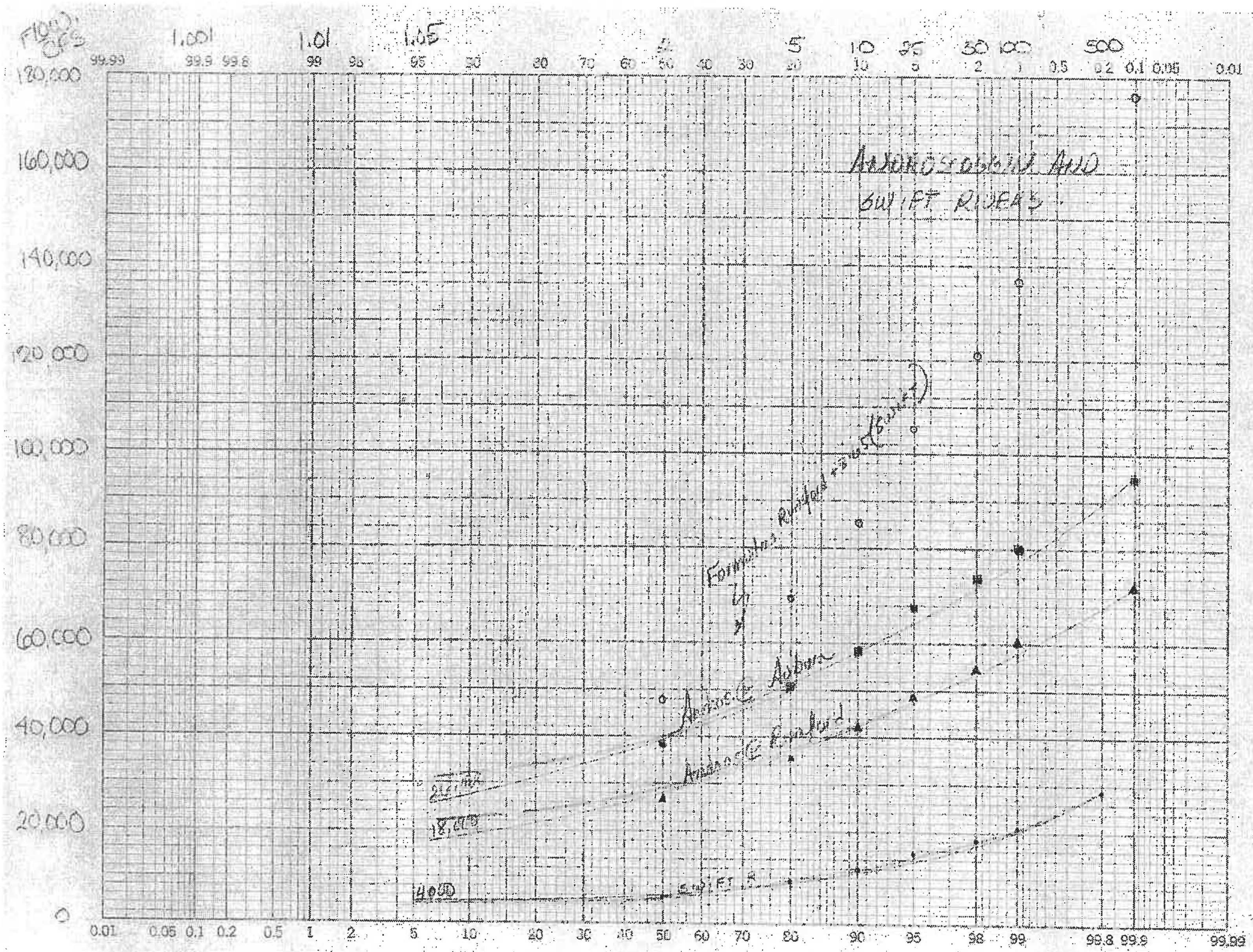
Appendix H
Figures 2 - 17

Figures included in this Appendix:



Flow, CFS
Drainage Area sq mi
10
100
1000
10,000
100,000
Rumford
Site
Auburn
500-year
100-year
50-year
25-year
10-year
5-year
2-year

Figure 2



- Rev. based on historical data at Wayne Dam

Figure 2A

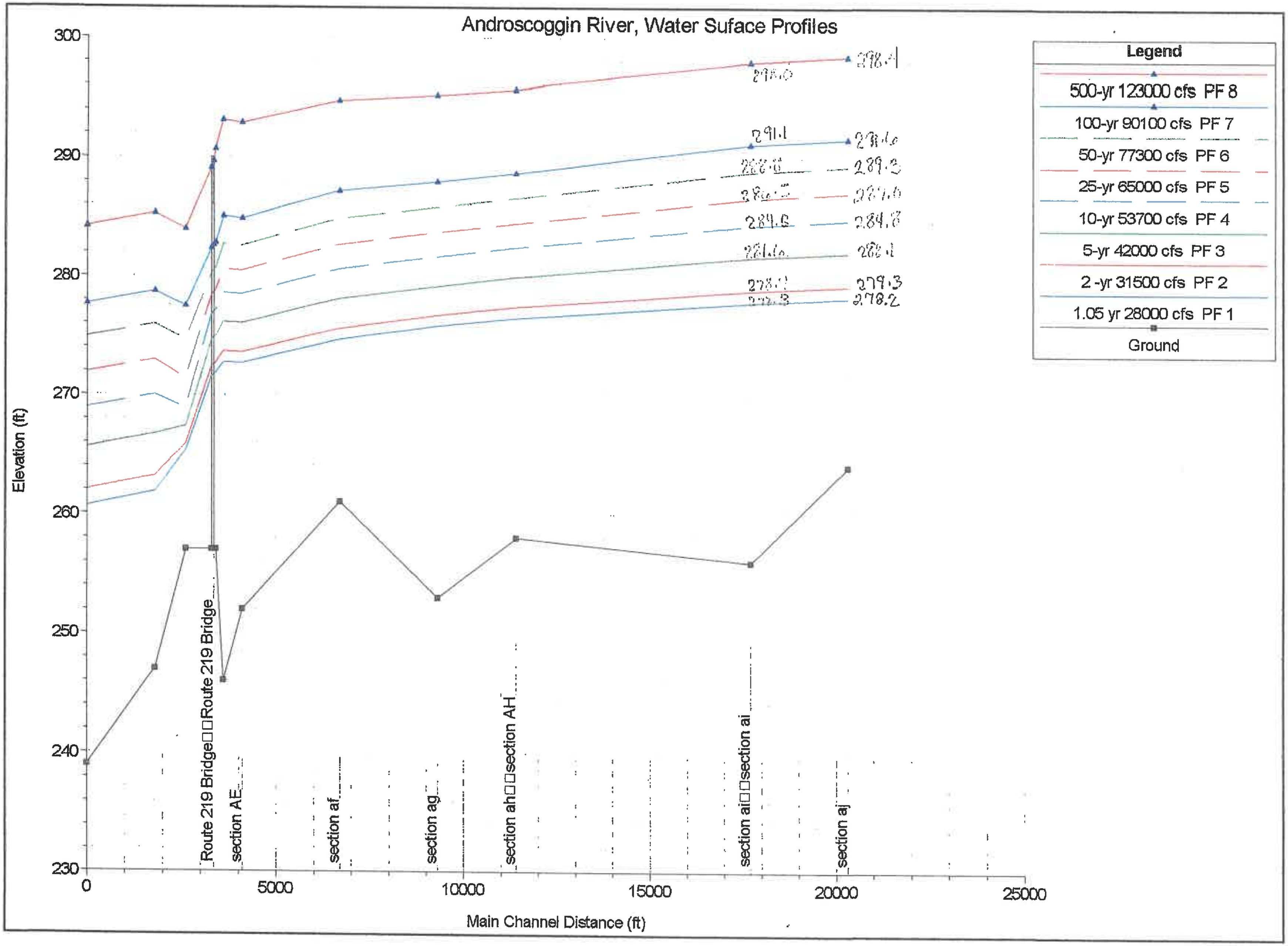

Androscoggin River, Water Suface Profiles
Elevation (ft)
Main Channel Distance (ft)
300
290
280
270
260
250
240
230
0
5000
10000
15000
20000
25000
Legend
500-yr 123000 cfs PF 8
100-yr 90100 cfs PF 7
50-yr 77300 cfs PF 6
25-yr 65000 cfs PF 5
10-yr 53700 cfs PF 4
5-yr 42000 cfs PF 3
2 -yr 31500 cfs PF 2
1.05 yr 28000 cfs PF 1
Ground
Route 219 Bridge Route 219 Bridge
section AE
section af
section ag
section ah section AH
section ai section ai
section aj
291.1
289.3
284.6
279.3
278.2

Figure 3

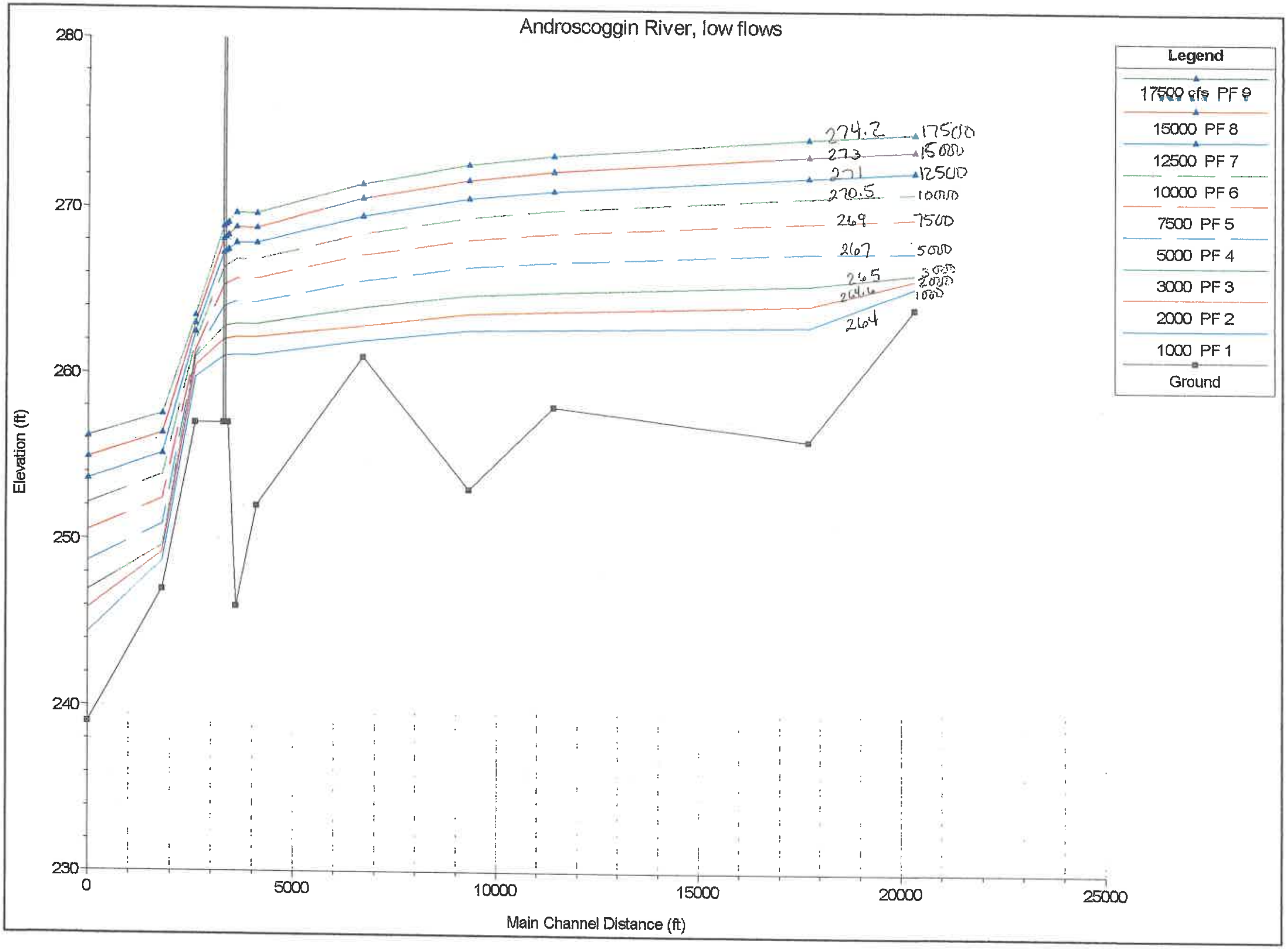

Androscoggin River, low flows
Elevation (ft)
Main Channel Distance (ft)
280
270
260
250
240
230
0
5000
10000
15000
20000
25000
Legend
17500 cfs PF 9
15000 PF 8
12500 PF 7
10000 PF 6
7500 PF 5
5000 PF 4
3000 PF 3
2000 PF 2
1000 PF 1
Ground
274.2
273
271
270.5
269
267
265
264
17500
15000
12500
10000
7500
5000
1000

Figure 4

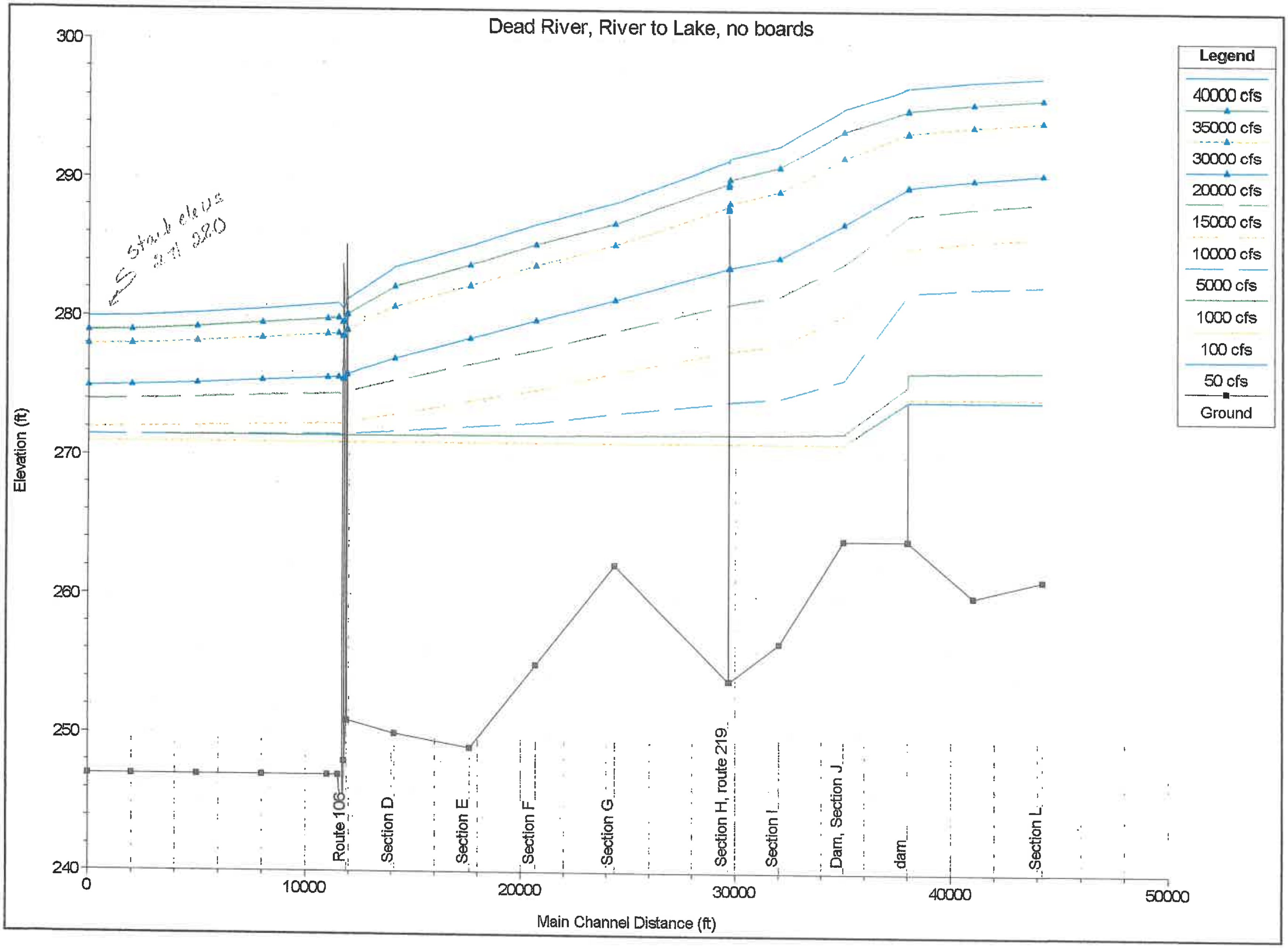
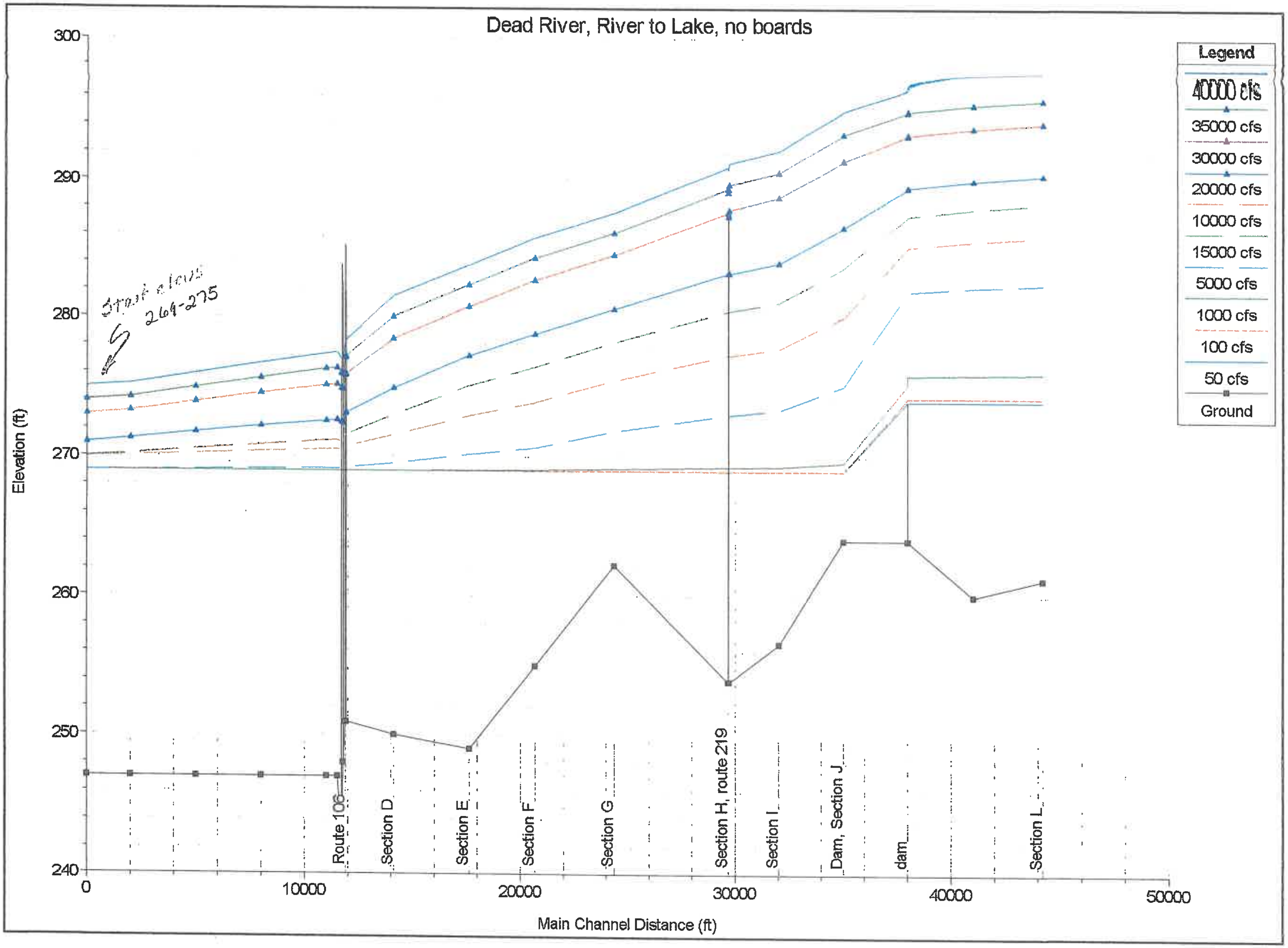

Dead River, River to Lake, no boards
Legend
40000 cfs
35000 cfs
30000 cfs
20000 cfs
15000 cfs
10000 cfs
5000 cfs
1000 cfs
100 cfs
50 cfs
Ground
Elevation (ft)
300
290
280
270
260
250
240
0
10000
20000
30000
40000
50000
Main Channel Distance (ft)
Route 106
Section D
Section E
Section F
Section G
Section H, route 219
Section I
Dam, Section J
dam
Section L

Figure 5A



Dead River, River to Lake, no boards
Legend
40000 cfs
35000 cfs
30000 cfs
20000 cfs
10000 cfs
15000 cfs
5000 cfs
1000 cfs
100 cfs
50 cfs
Ground
Elevation (ft)
300
290
280
270
260
250
240
Main Channel Distance (ft)
0
10000
20000
30000
40000
50000
Route 106
Section D
Section E
Section F
Section G
Section H, route 219
Section I
Dam, Section J
dam
Section L

Figure 5B

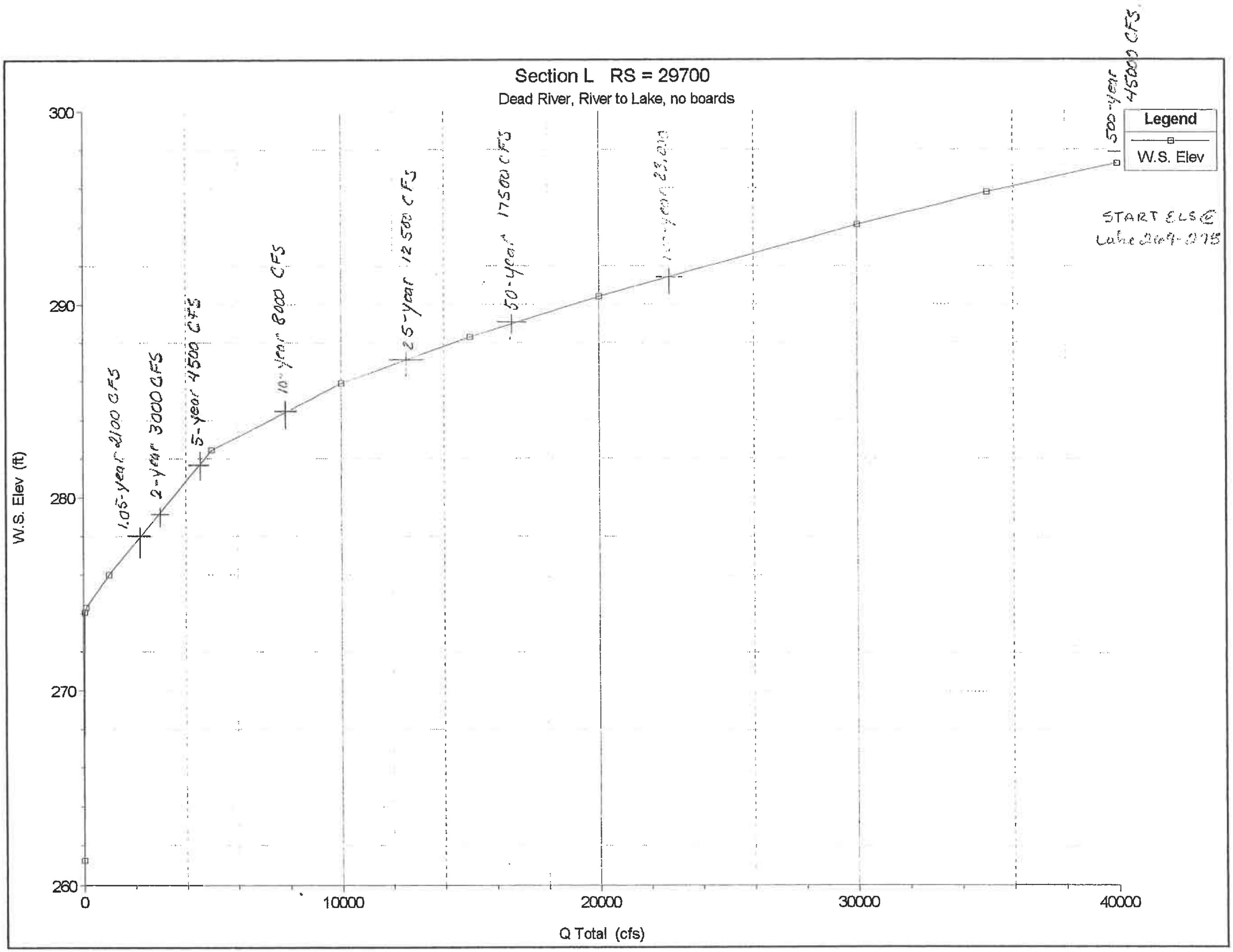

Section L RS = 29700
Dead River, River to Lake, no boards
Legend
W.S. Elev
W.S. Elev (ft)
Q Total (cfs)
300
290
280
270
260
0
10000
20000
30000
40000
1.05-year 2100 CFS
2-year 3000 CFS
5-year 4500 CFS
10-year 8000 CFS
25-year 12500 CFS
50-year 17500 CFS
500-year 45000 CFS
START ELS @
Lake 269.075

Figure 5C

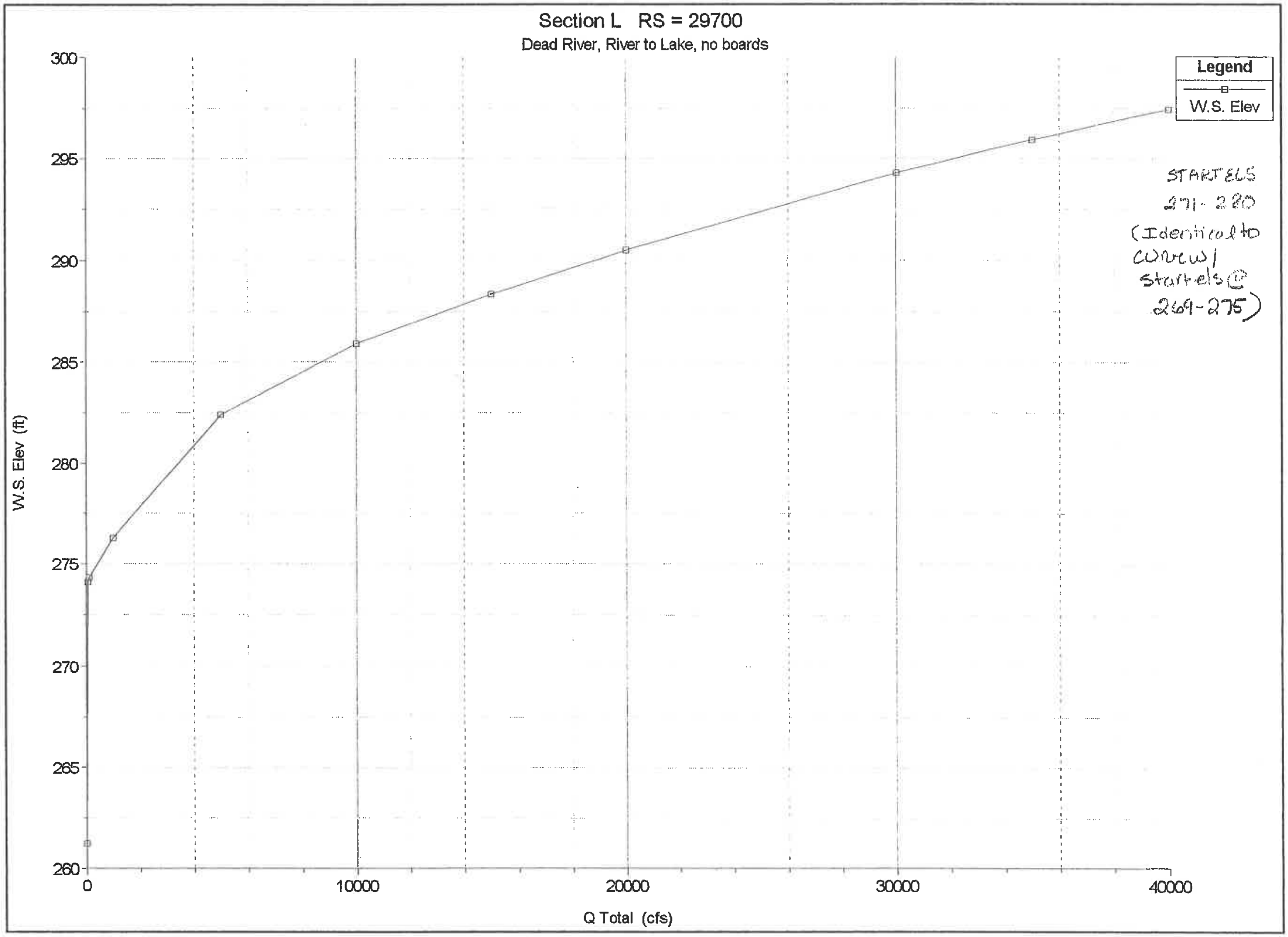

Section L RS = 29700
Dead River, River to Lake, no boards
Legend
W.S. Elev
W.S. Elev (ft)
Q Total (cfs)
300
295
290
285
280
275
270
265
260
0
10000
20000
30000
40000
STARTELS
271-280
(Identical to
curves/
startels @
269-275)

Figure 5D

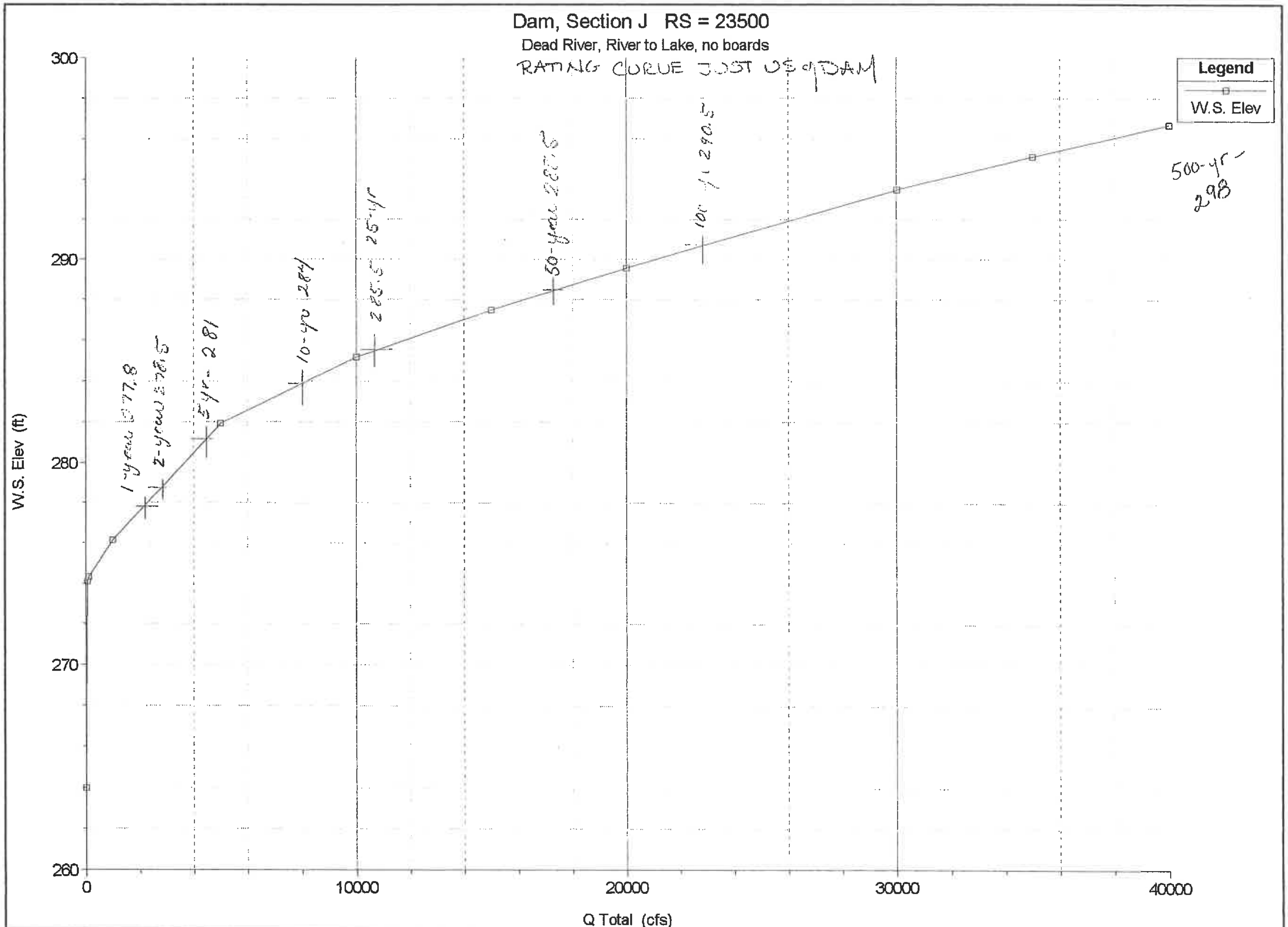

Dam, Section J RS = 23500
Dead River, River to Lake, no boards
Legend
W.S. Elev
W.S. Elev (ft)
Q Total (cfs)
300
290
280
270
260
0
10000
20000
30000
40000

Figure 5E

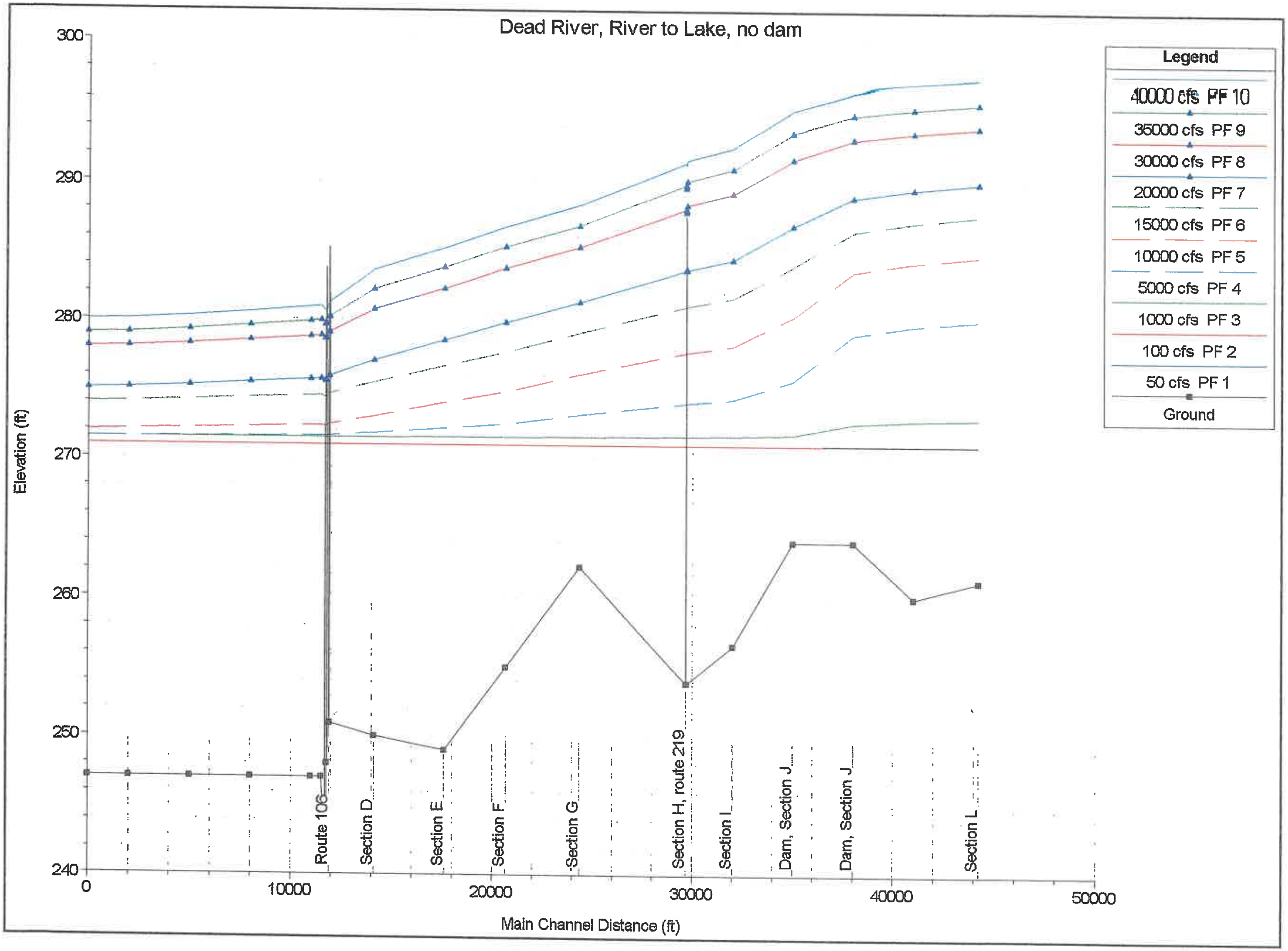

Dead River, River to Lake, no dam
Legend
40000 cfs PF 10
35000 cfs PF 9
30000 cfs PF 8
20000 cfs PF 7
15000 cfs PF 6
10000 cfs PF 5
5000 cfs PF 4
1000 cfs PF 3
100 cfs PF 2
50 cfs PF 1
Ground
Elevation (ft)
300
290
280
270
260
250
240
0
10000
20000
30000
40000
50000
Main Channel Distance (ft)
Route 106
Section D
Section E
Section F
Section G
Section H, route 219
Section I
Dam, Section J
Dam, Section J
Section L

Figure 6A

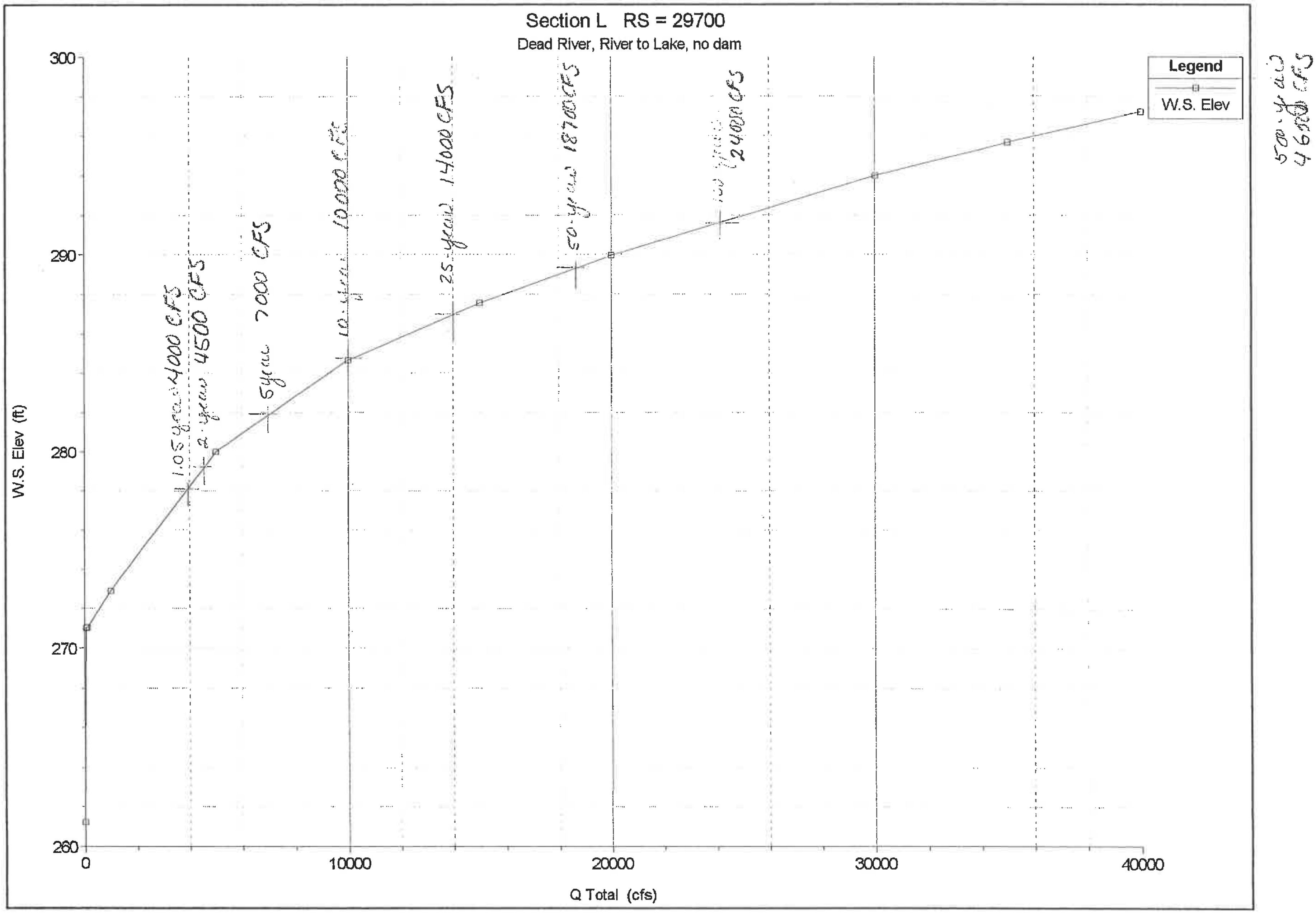

Section L RS = 29700
Dead River, River to Lake, no dam
Legend
W.S. Elev
W.S. Elev (ft)
Q Total (cfs)
300
290
280
270
260
0
10000
20000
30000
40000
1.05 year 4000 CFS
2-year 4500 CFS
5 year 7000 CFS
10-year 10000 CFS
25-year 14000 CFS
50-year 18700 CFS
100 year 24000 CFS
500-year 46500 CFS

Figure 6B

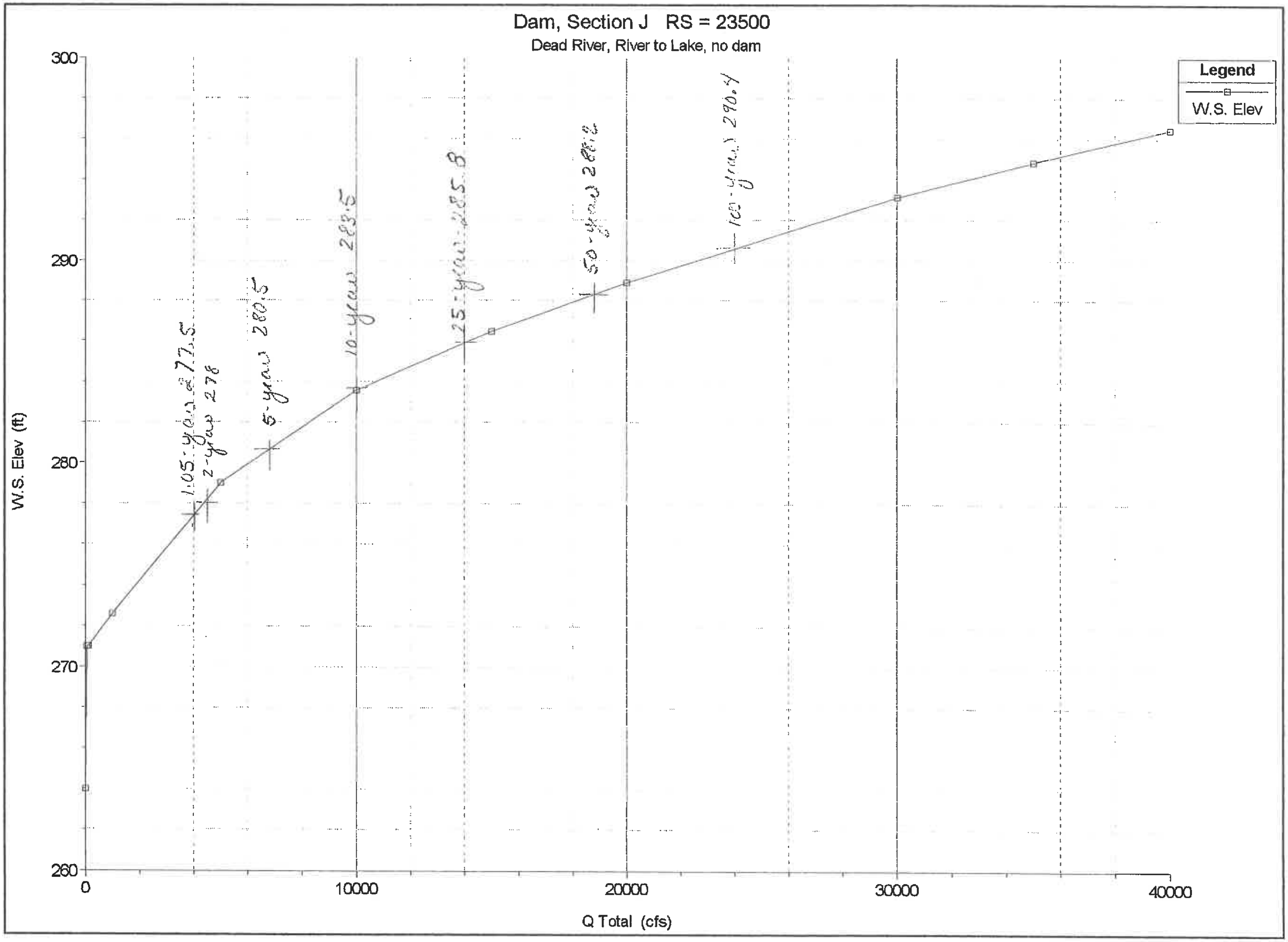

Dam, Section J RS = 23500
Dead River, River to Lake, no dam
Legend
W.S. Elev
W.S. Elev (ft)
300
290
280
270
260
0
10000
20000
30000
40000
Q Total (cfs)
1.05-year 277.5
2-year 278
5-year 280.5
10-year 283.5
25-year 285.8
50-year 288.2
100-year 290.4

Figure 6C

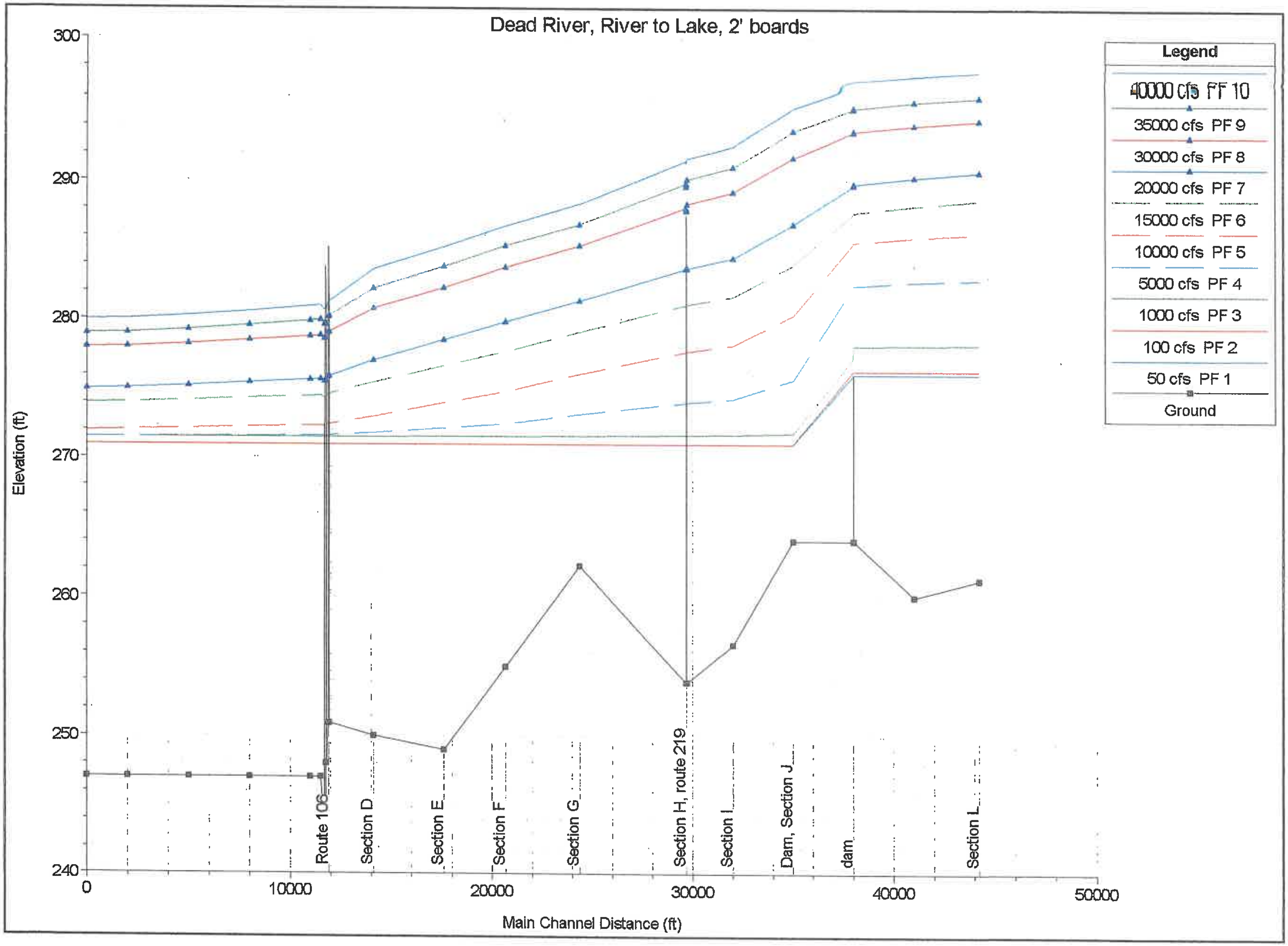

Dead River, River to Lake, 2' boards
Legend
40000 cfs PF 10
35000 cfs PF 9
30000 cfs PF 8
20000 cfs PF 7
15000 cfs PF 6
10000 cfs PF 5
5000 cfs PF 4
1000 cfs PF 3
100 cfs PF 2
50 cfs PF 1
Ground
Elevation (ft)
300
290
280
270
260
250
240
0
10000
20000
30000
40000
50000
Main Channel Distance (ft)
Route 106
Section D
Section E
Section F
Section G
Section H, route 219
Section I
Dam, Section J
dam
Section L

Figure 7A

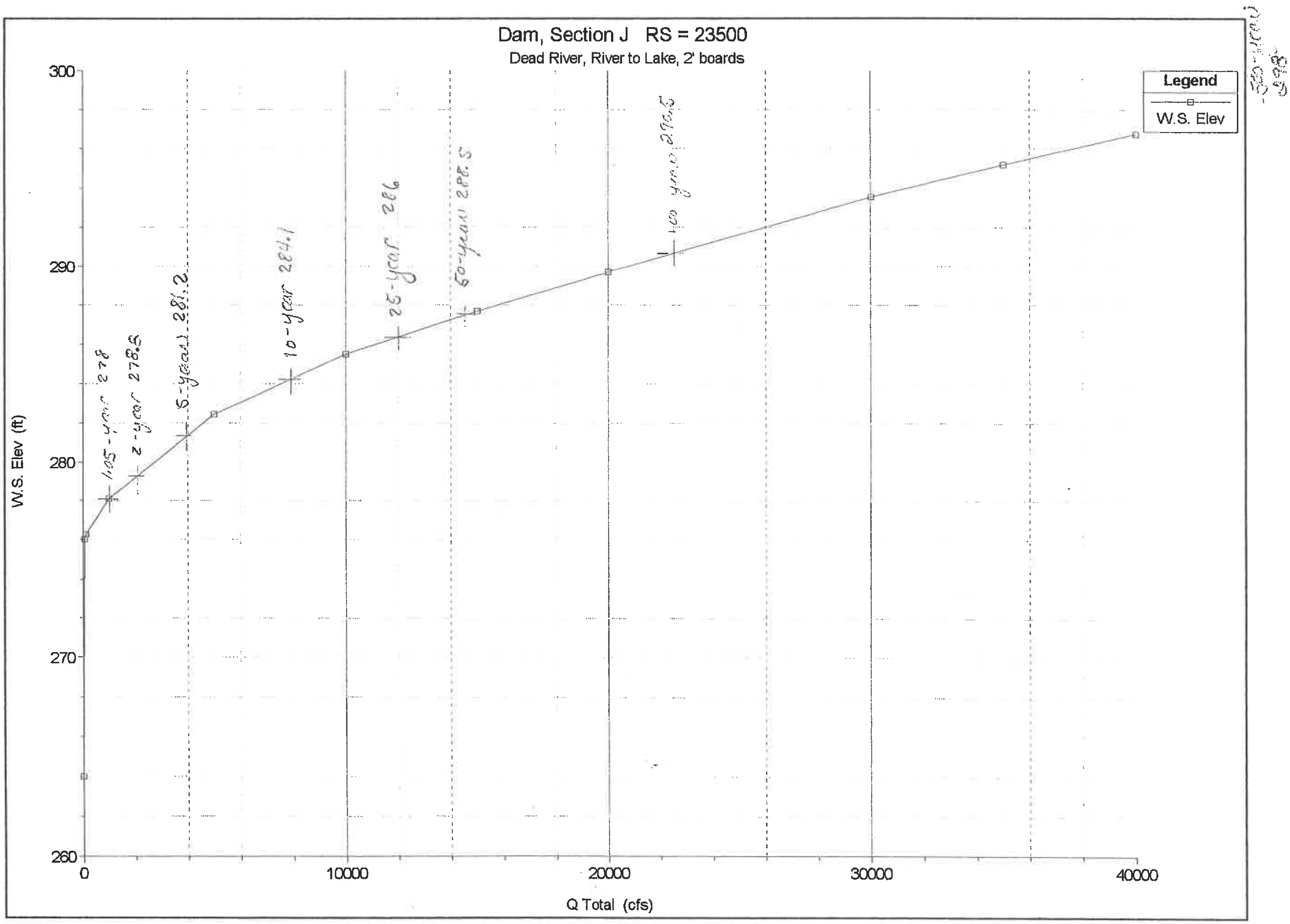
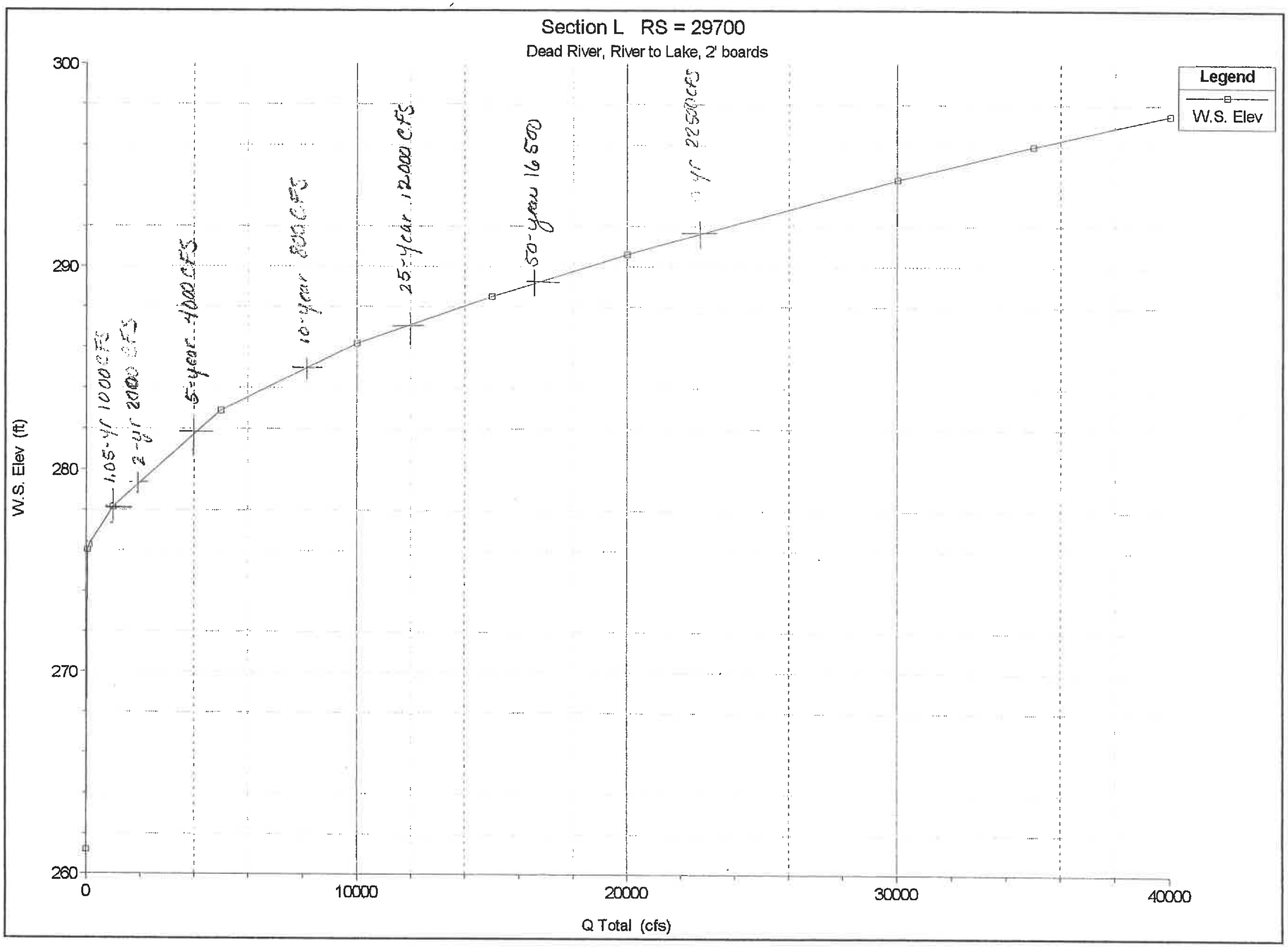
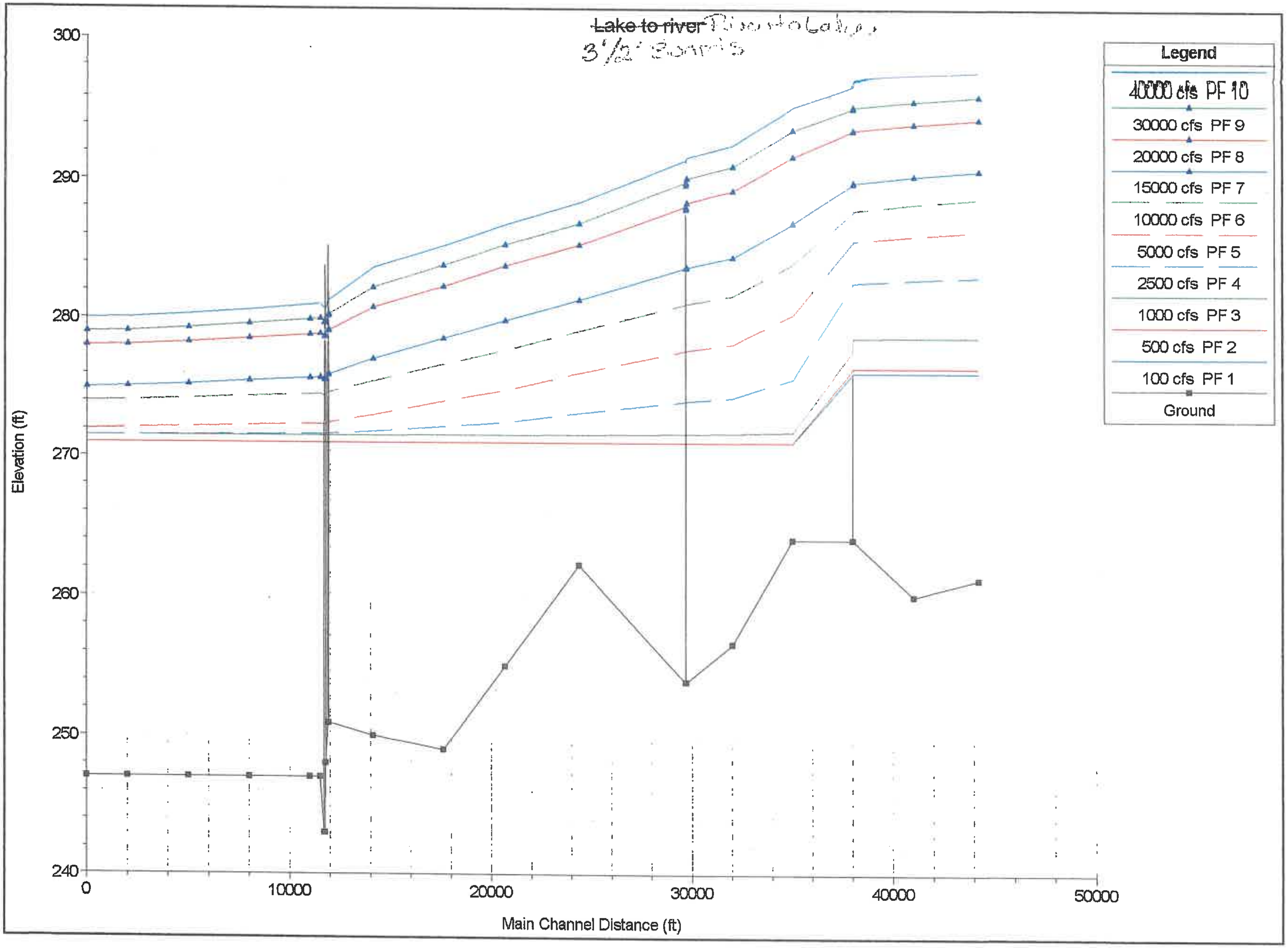

Dam, Section J RS = 23500
Dead River, River to Lake, 2' boards
Legend
W.S. Elev
W.S. Elev (ft)
Q Total (cfs)
300
290
280
270
260
0
10000
20000
30000
40000
2-year 278.5
5-years 281.2
10-year 284.1
25-year 286
50-year 288.5

Figure 7B



Section L RS = 29700
Dead River, River to Lake, 2' boards
Legend
W.S. Elev
W.S. Elev (ft)
300
290
280
270
260
0
10000
20000
30000
40000
Q Total (cfs)
1.05-yr 1000 CFS
2-yr 2000 CFS
5-year 4000 CFS
10-year 8000 CFS
25-year 12000 CFS
50-year 16500
yr 22500 CFS

Figure 7C



Lake to river
Legend
40000 cfs PF 10
30000 cfs PF 9
20000 cfs PF 8
15000 cfs PF 7
10000 cfs PF 6
5000 cfs PF 5
2500 cfs PF 4
1000 cfs PF 3
500 cfs PF 2
100 cfs PF 1
Ground
Elevation (ft)
300
290
280
270
260
250
240
0
10000
20000
30000
40000
50000
Main Channel Distance (ft)

Figure 8A

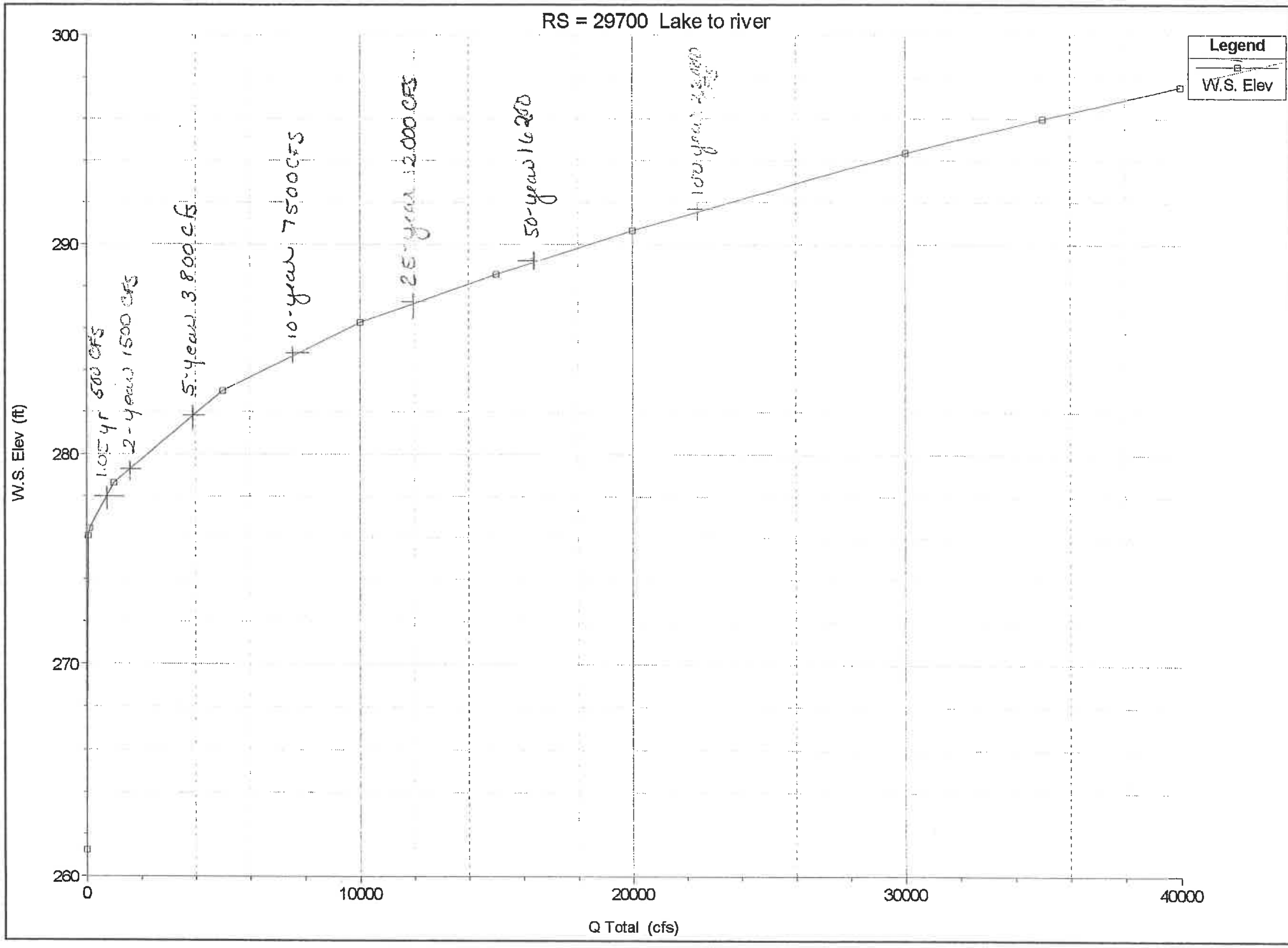

RS = 29700 Lake to river
Legend
W.S. Elev
W.S. Elev (ft)
300
290
280
270
260
0
10000
20000
30000
40000
Q Total (cfs)
1.05 yr 500 cfs
2-year 1500 cfs
5-year 3 800 cfs
10-year 7500 cfs
25-year 12000 cfs
50-year 16 250
100-year

Figure 8B

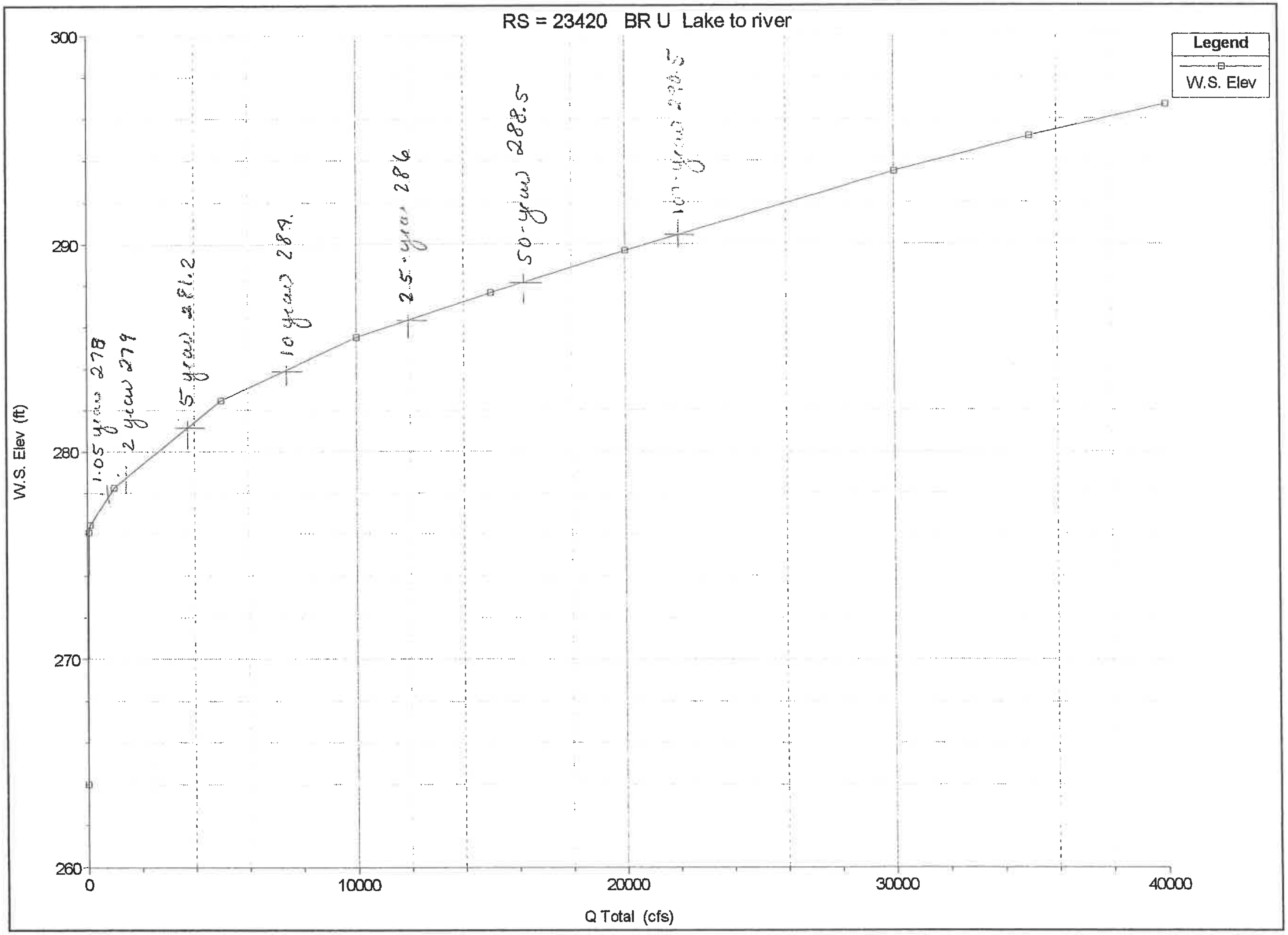

RS = 23420 BR U Lake to river
Legend
W.S. Elev
W.S. Elev (ft)
300
290
280
270
260
0
10000
20000
30000
40000
Q Total (cfs)
1.05 year 278
2 year 279
5 year 281.2
25 year 286
50-year 288.5

Figure 8C

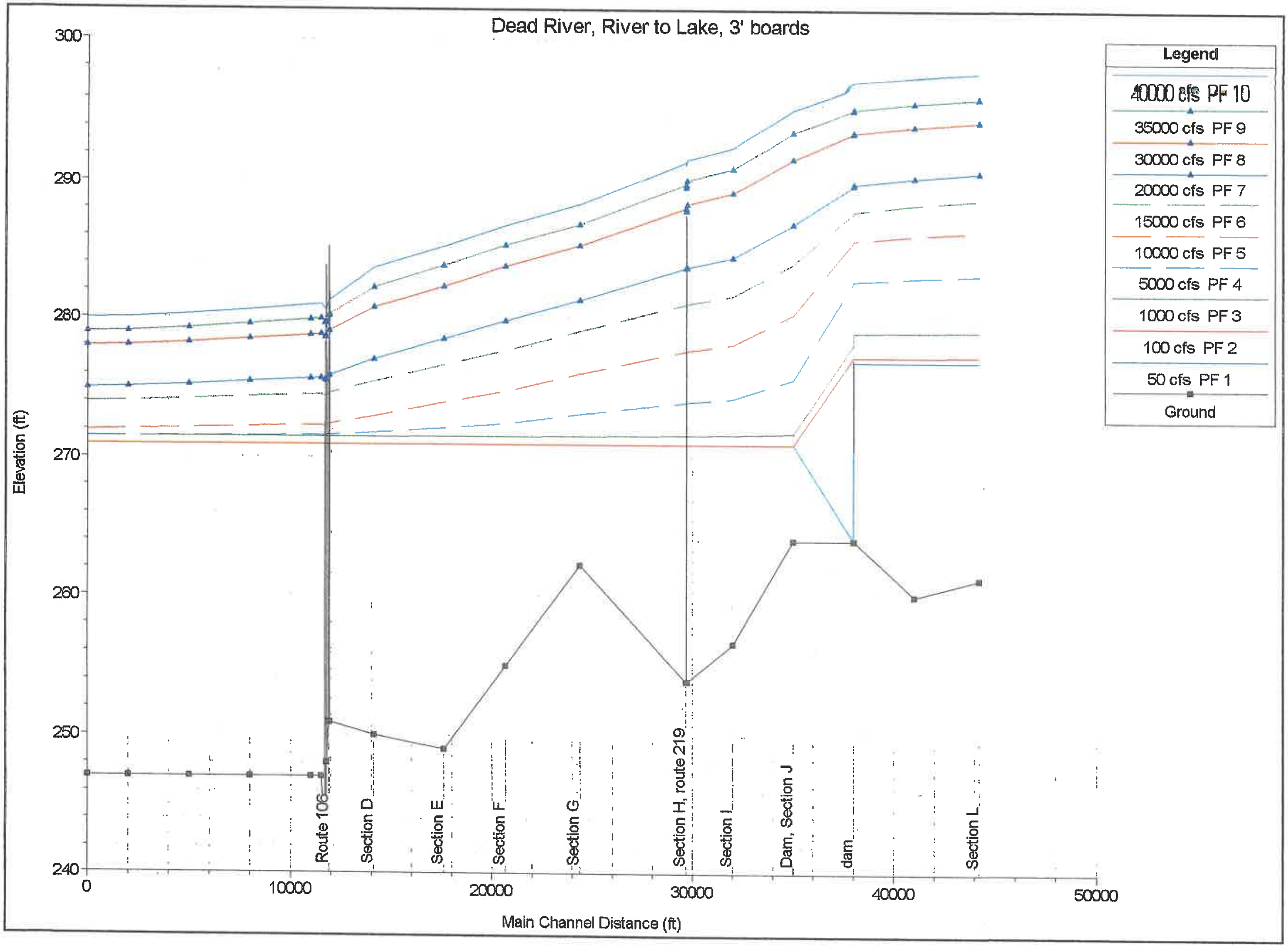

Dead River, River to Lake, 3' boards
Legend
40000 cfs PF 10
35000 cfs PF 9
30000 cfs PF 8
20000 cfs PF 7
15000 cfs PF 6
10000 cfs PF 5
5000 cfs PF 4
1000 cfs PF 3
100 cfs PF 2
50 cfs PF 1
Ground
Elevation (ft)
300
290
280
270
260
250
240
0
10000
20000
30000
40000
50000
Main Channel Distance (ft)
Route 106
Section D
Section E
Section F
Section G
Section H, route 219
Section I
Dam, Section J
dam
Section L

Figure 9A

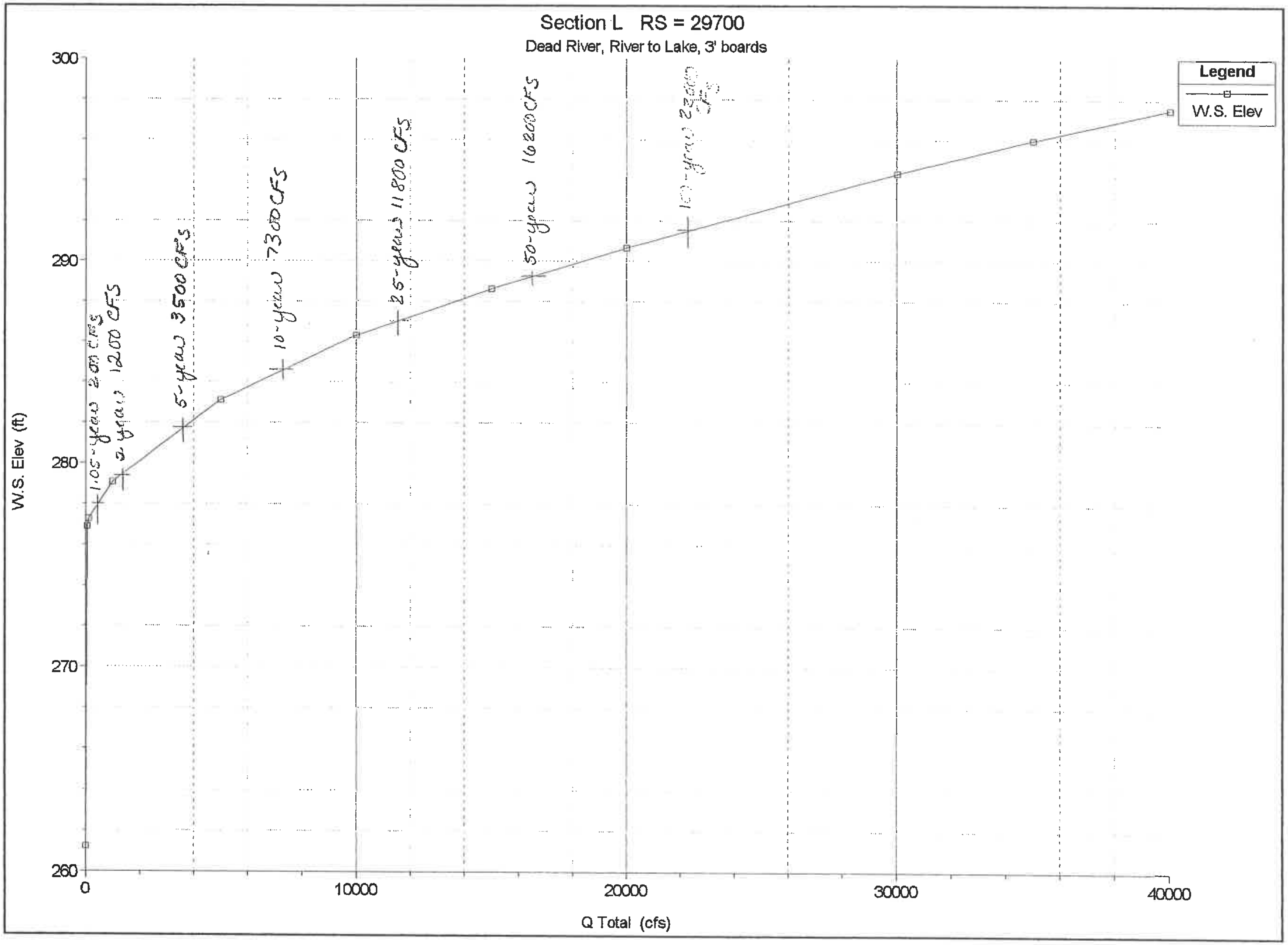
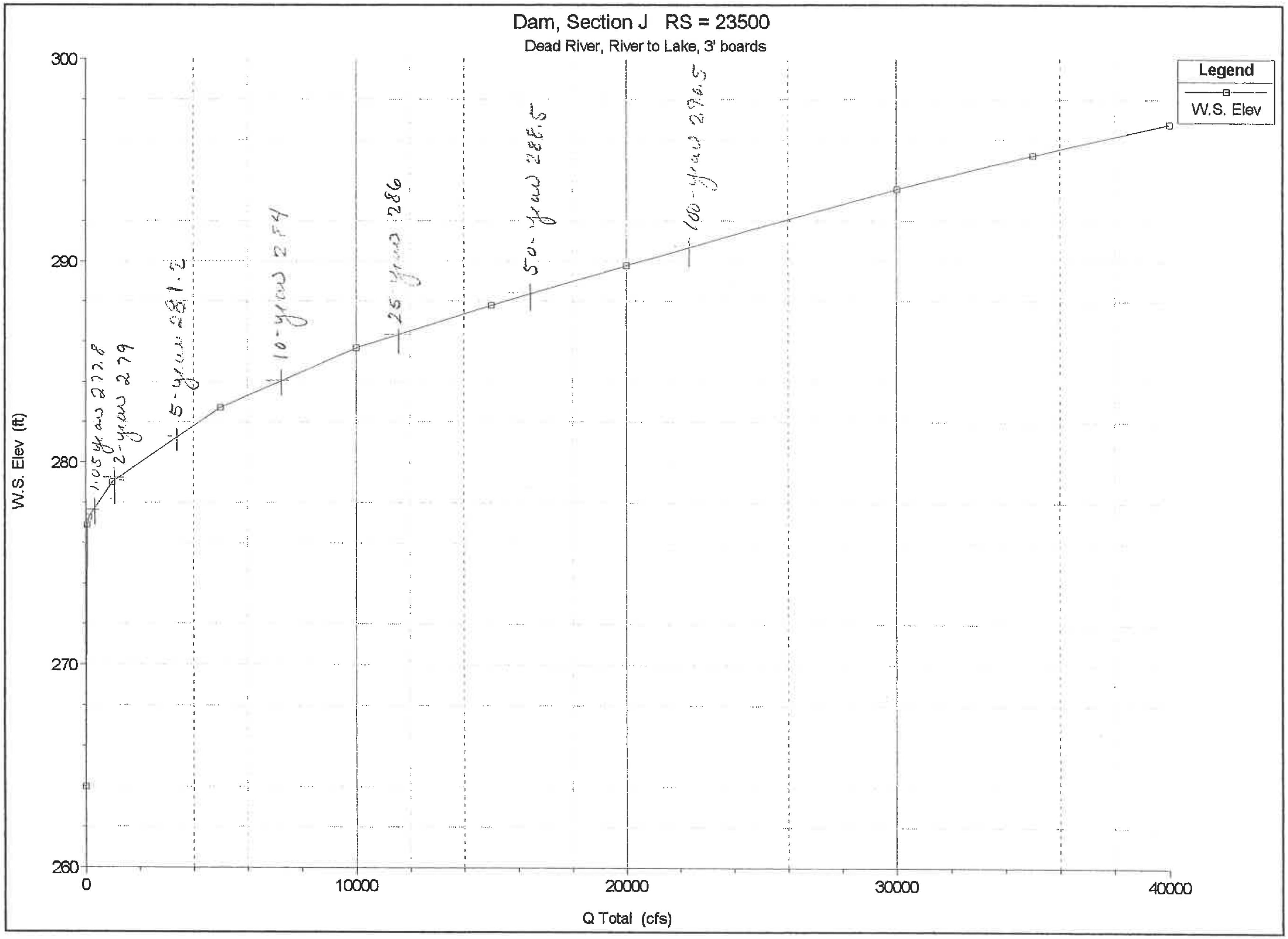

Section L RS = 29700
Dead River, River to Lake, 3' boards
Legend
W.S. Elev
W.S. Elev (ft)
Q Total (cfs)
300
290
280
270
260
0
10000
20000
30000
40000
1.05-year 200 CFS
2-year 1200 CFS
5-year 3500 CFS
10-year 7300 CFS
25-year 11800 CFS
50-year 16200 CFS

Figure 9B



Dam, Section J RS = 23500
Dead River, River to Lake, 3' boards
Legend
W.S. Elev
W.S. Elev (ft)
Q Total (cfs)
300
290
280
270
260
0
10000
20000
30000
40000
1.05 year 277.8
2-year 279
5-year 281.2
10-year 284
25 year 286
50-year 288.5
100-year 290.5

Figure 9C

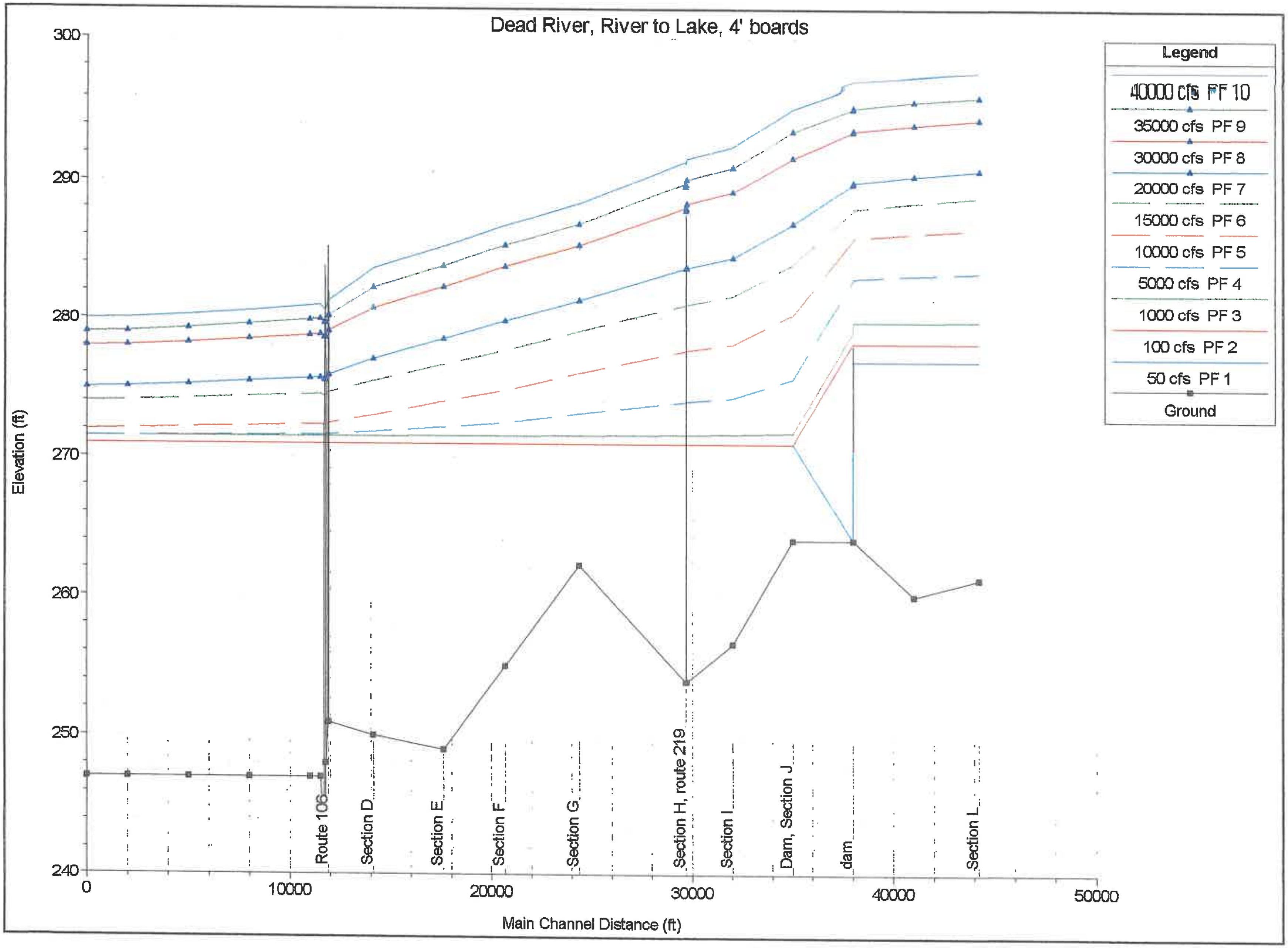

Dead River, River to Lake, 4' boards
Legend
40000 cfs PF 10
35000 cfs PF 9
30000 cfs PF 8
20000 cfs PF 7
15000 cfs PF 6
10000 cfs PF 5
5000 cfs PF 4
1000 cfs PF 3
100 cfs PF 2
50 cfs PF 1
Ground
Elevation (ft)
300
290
280
270
260
250
240
0
10000
20000
30000
40000
50000
Main Channel Distance (ft)
Route 105
Section D
Section E
Section F
Section G
Section H, route 219
Section I
Dam, Section J
dam
Section L

Figure 10A

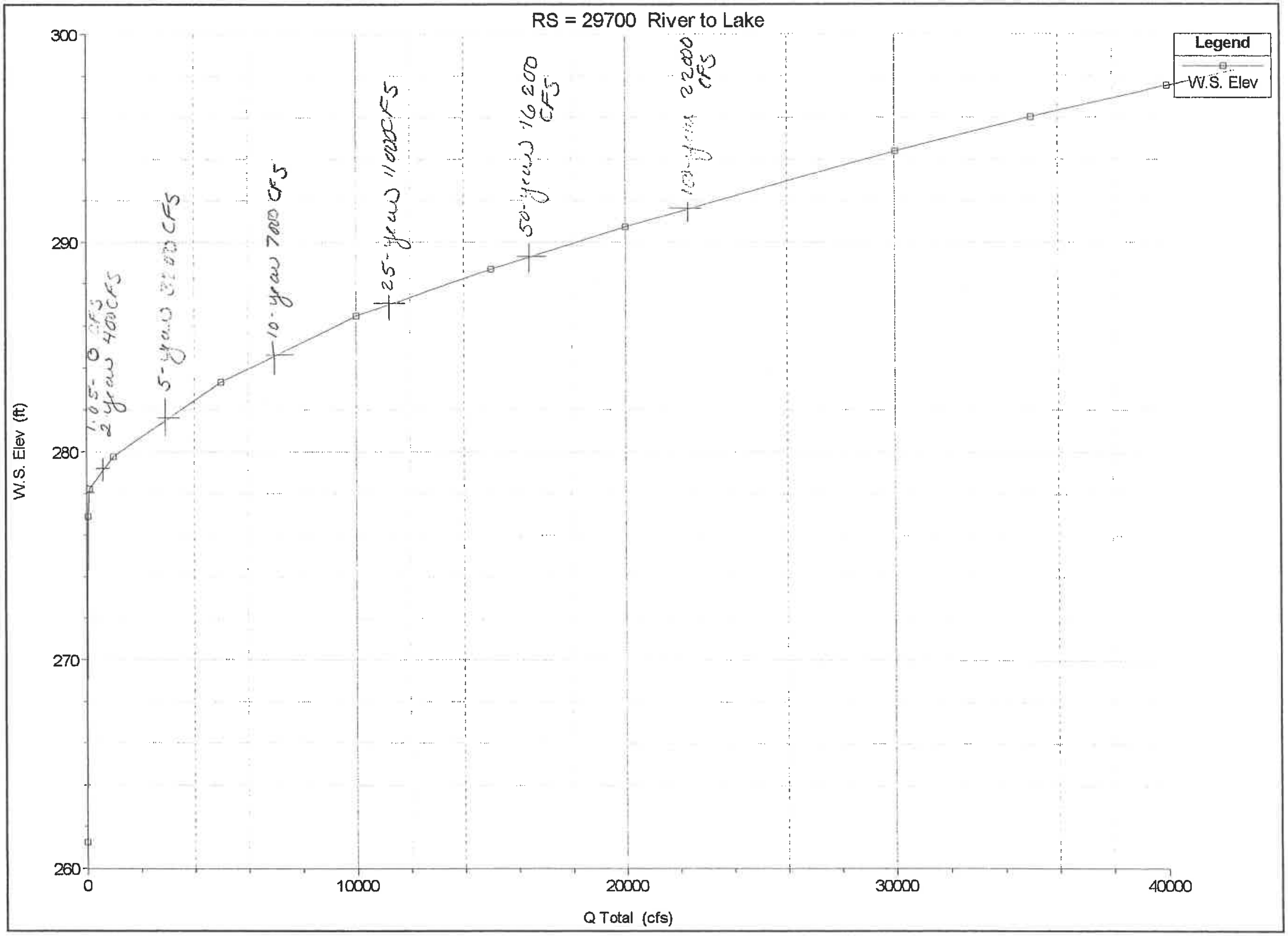

RS = 29700 River to Lake
Legend
W.S. Elev
W.S. Elev (ft)
Q Total (cfs)
300
290
280
270
260
0
10000
20000
30000
40000
1.05- 0 CFS
2 year 400CFS
5-year 3100 CFS
10-year 7000 CFS
25-year 11000CFS
50-year 16200 CFS
100-year 22000 CFS

Figure 10B

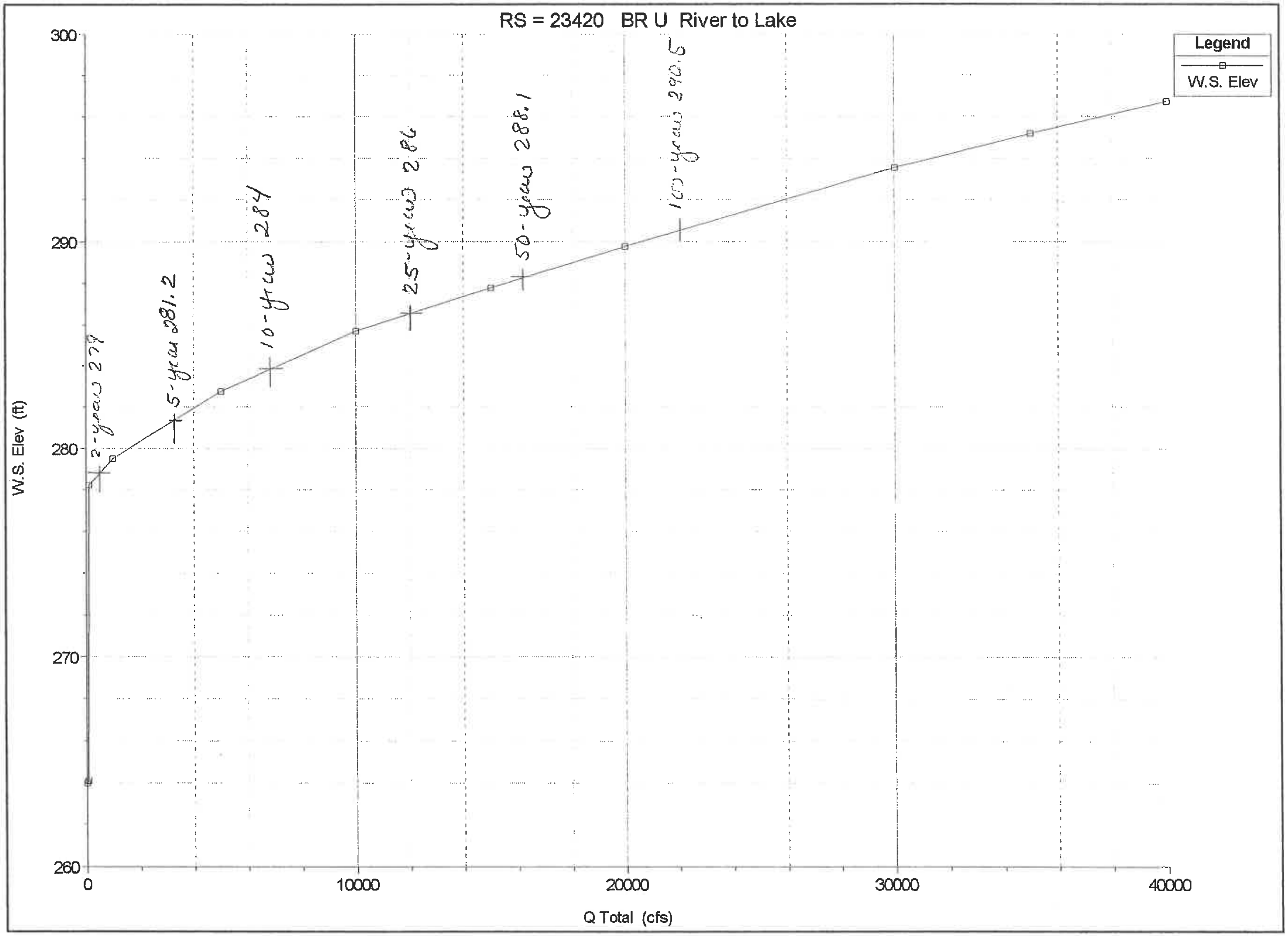

RS = 23420 BR U River to Lake
Legend
W.S. Elev
W.S. Elev (ft)
Q Total (cfs)
2-year 279
5-year 281.2
10-year 284
25-year 286
50-year 288.1
100-year 290.5

Figure 10C

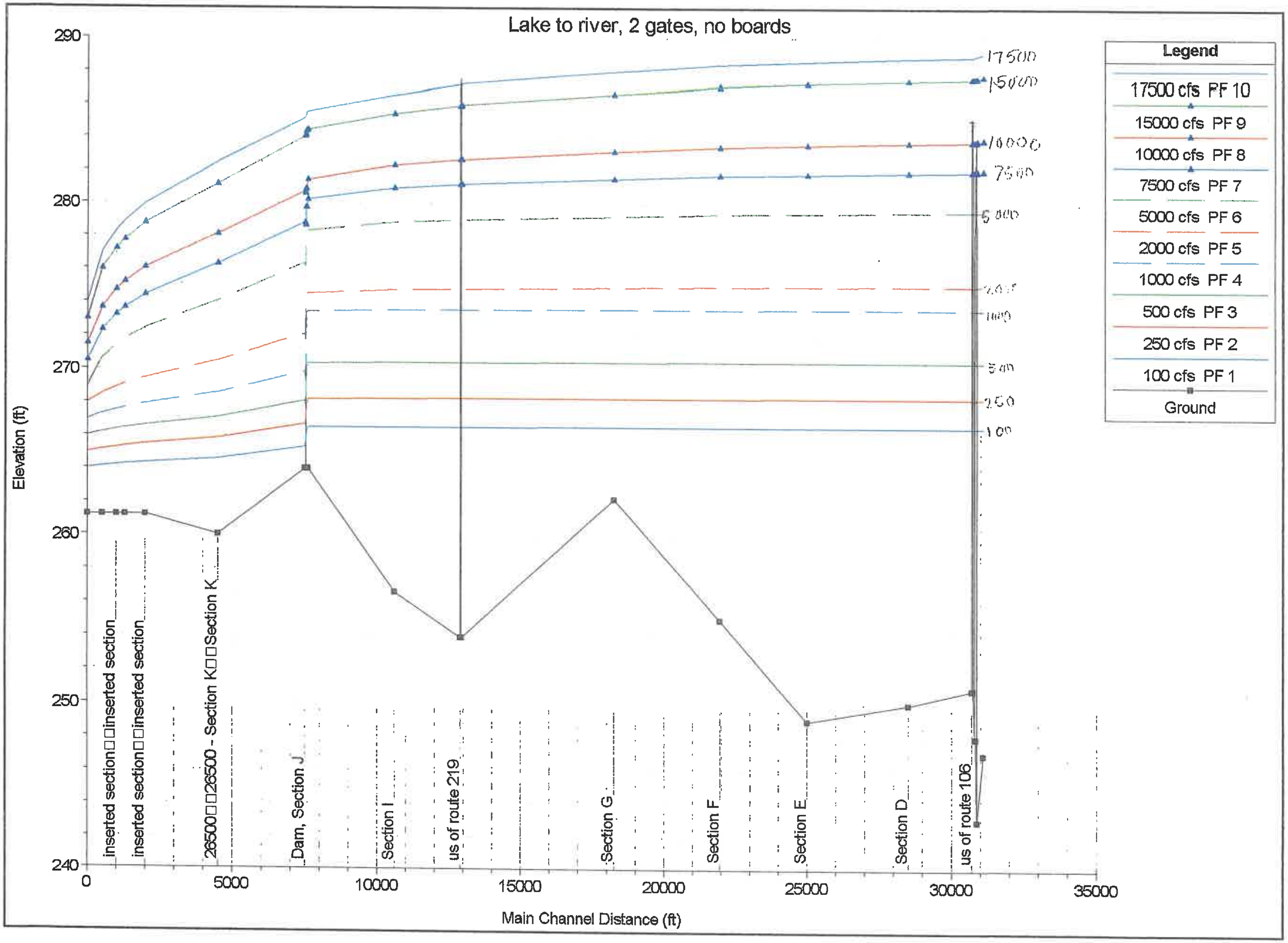

Lake to river, 2 gates, no boards
Elevation (ft)
Main Channel Distance (ft)
Legend
17500 cfs PF 10
15000 cfs PF 9
10000 cfs PF 8
7500 cfs PF 7
5000 cfs PF 6
2000 cfs PF 5
1000 cfs PF 4
500 cfs PF 3
250 cfs PF 2
100 cfs PF 1
Ground
inserted section□□inserted section
inserted section□□inserted section
26500□□26500 - Section K□□Section K
Dam, Section J
Section I
us of route 219
Section G
Section F
Section E
Section D
us of route 106

Figure 11A

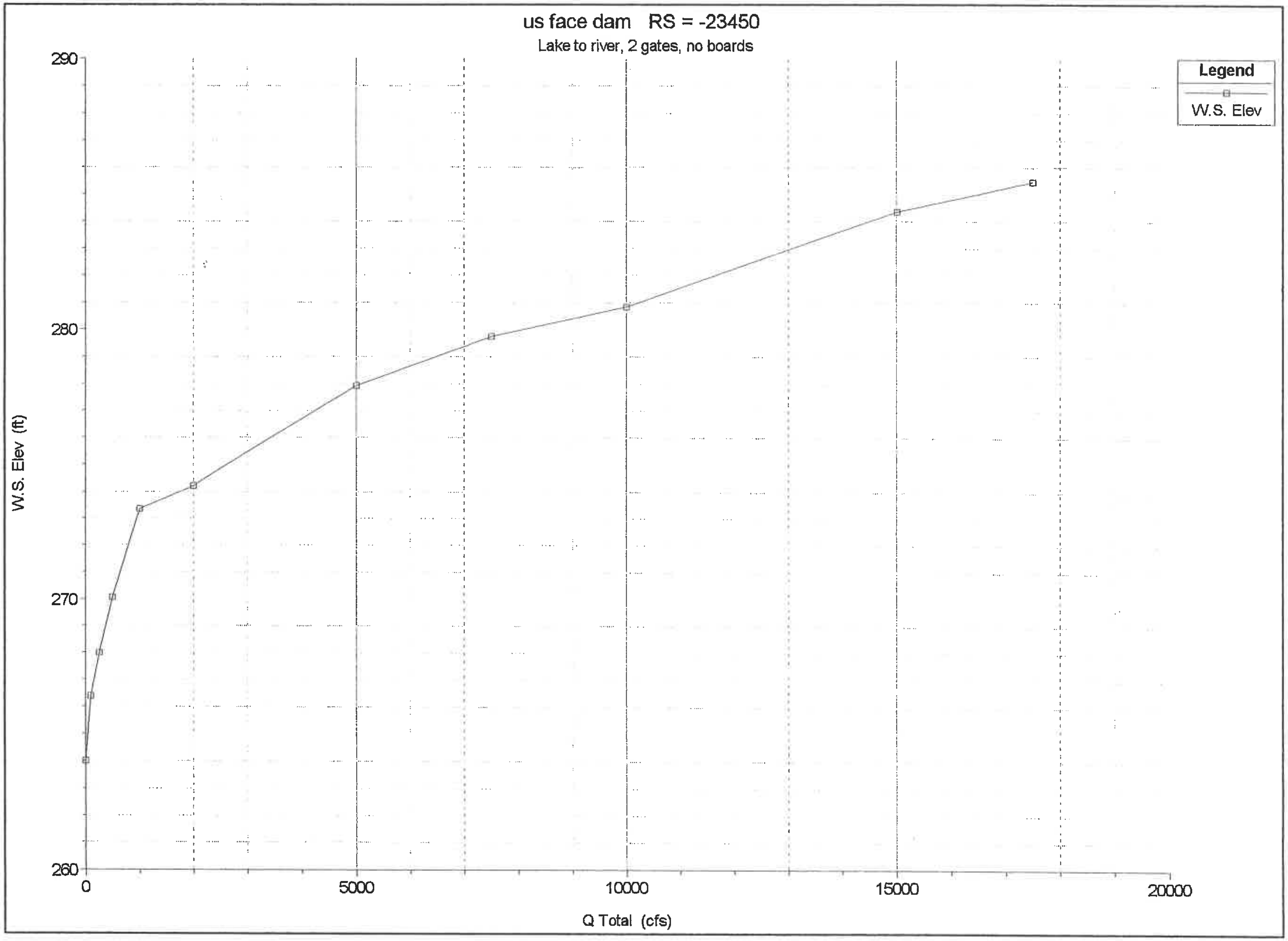
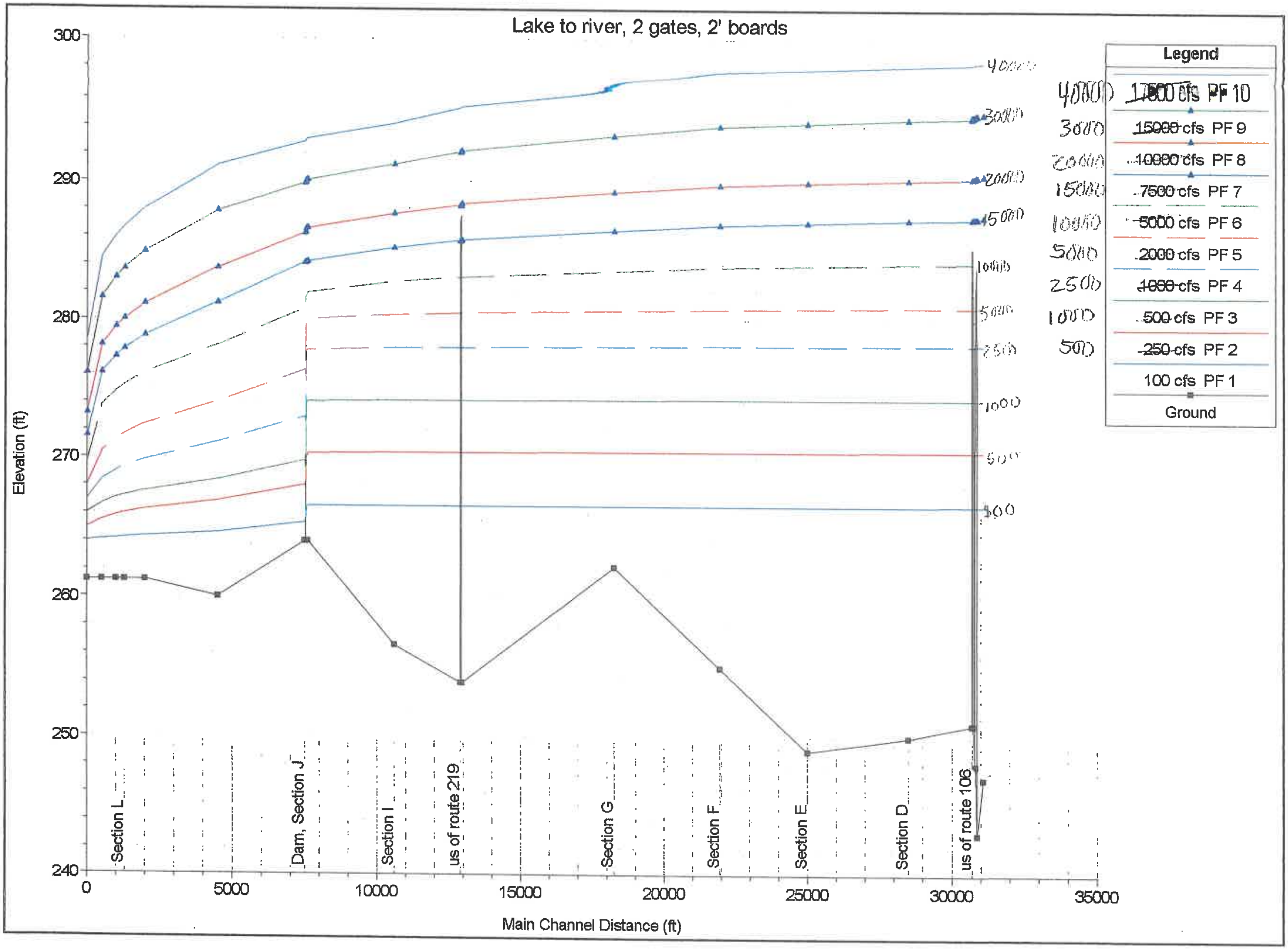

us face dam RS = -23450
Lake to river, 2 gates, no boards
Legend
W.S. Elev
W.S. Elev (ft)
290
280
270
260
0
5000
10000
15000
20000
Q Total (cfs)

Figure 11B



Lake to river, 2 gates, 2' boards
Legend
17500 cfs PF 10
15000 cfs PF 9
10000 cfs PF 8
7500 cfs PF 7
5000 cfs PF 6
2000 cfs PF 5
1000 cfs PF 4
500 cfs PF 3
250 cfs PF 2
100 cfs PF 1
Ground
Elevation (ft)
Main Channel Distance (ft)
Section L
Dam, Section J
Section I
us of route 219
Section G
Section F
Section E
Section D
us of route 106

Figure 12A

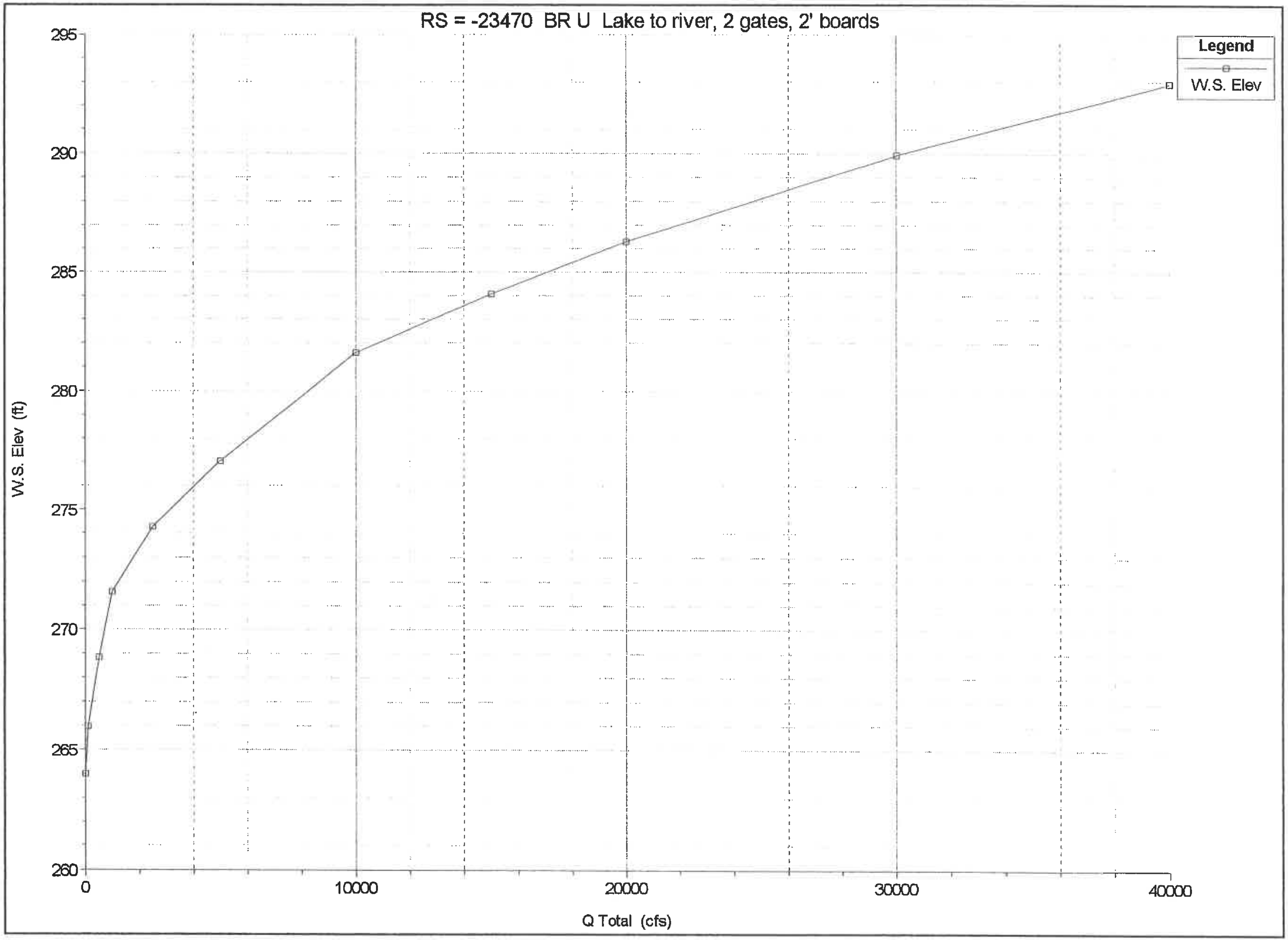
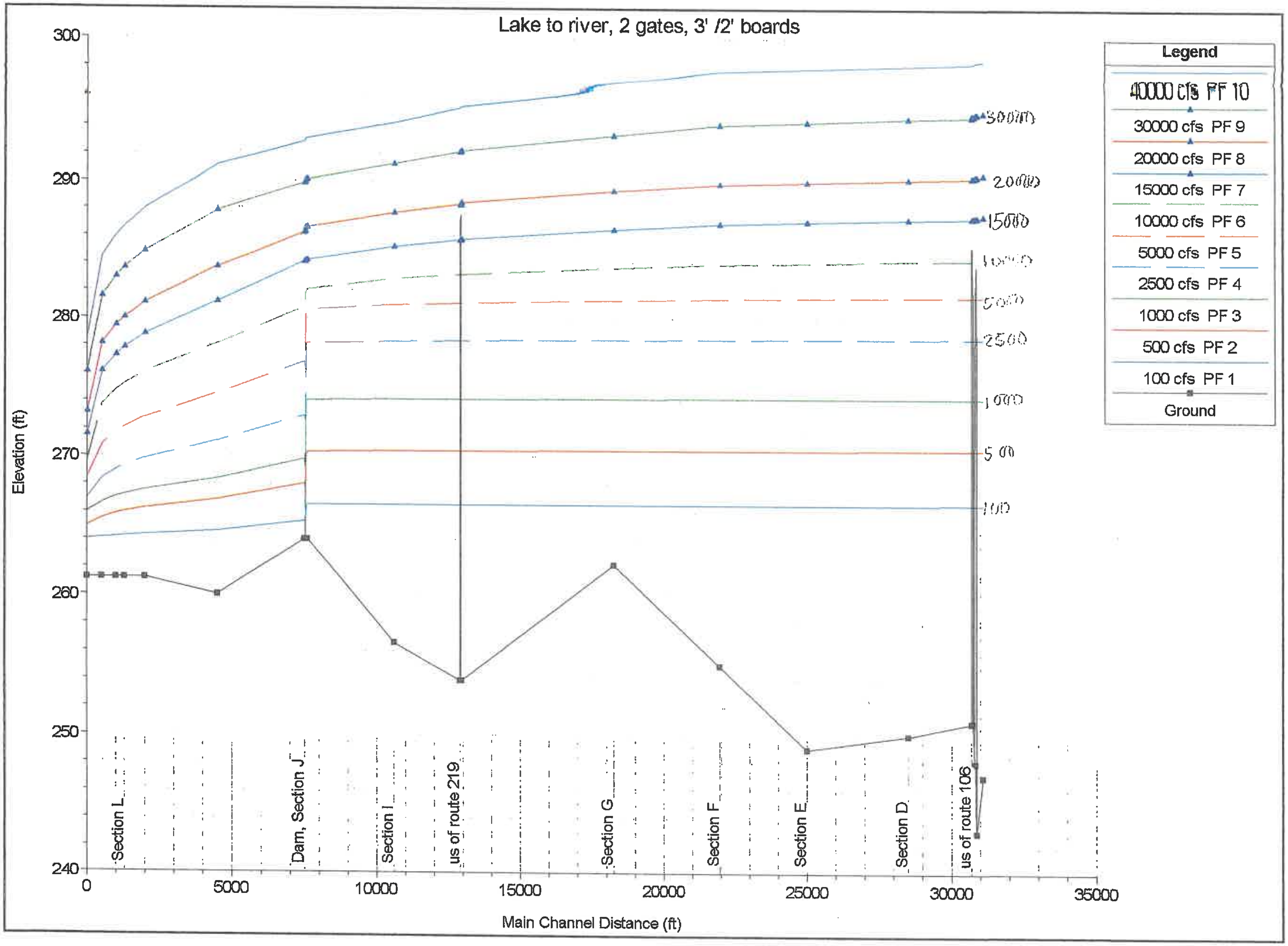

RS = -23470 BR U Lake to river, 2 gates, 2' boards
Legend
W.S. Elev
W.S. Elev (ft)
295
290
285
280
275
270
265
260
0
10000
20000
30000
40000
Q Total (cfs)

Figure 12B



Lake to river, 2 gates, 3' /2' boards
Elevation (ft)
Main Channel Distance (ft)
300
290
280
270
260
250
240
0
5000
10000
15000
20000
25000
30000
35000
Legend
40000 cfs PF 10
30000 cfs PF 9
20000 cfs PF 8
15000 cfs PF 7
10000 cfs PF 6
5000 cfs PF 5
2500 cfs PF 4
1000 cfs PF 3
500 cfs PF 2
100 cfs PF 1
Ground
Section L
Dam, Section J
Section I
us of route 219
Section G
Section F
Section E
Section D
us of route 106

Figure 13A

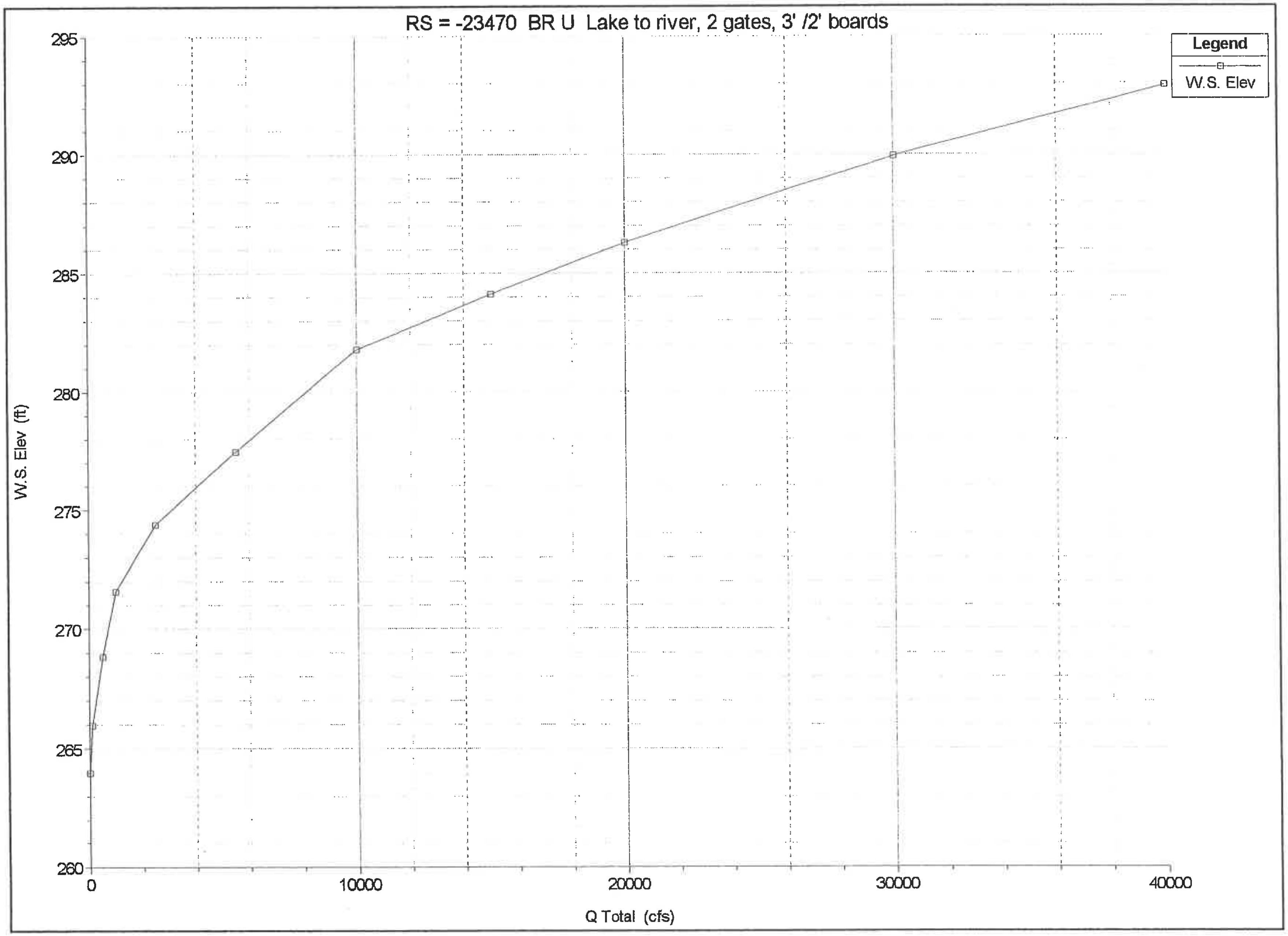
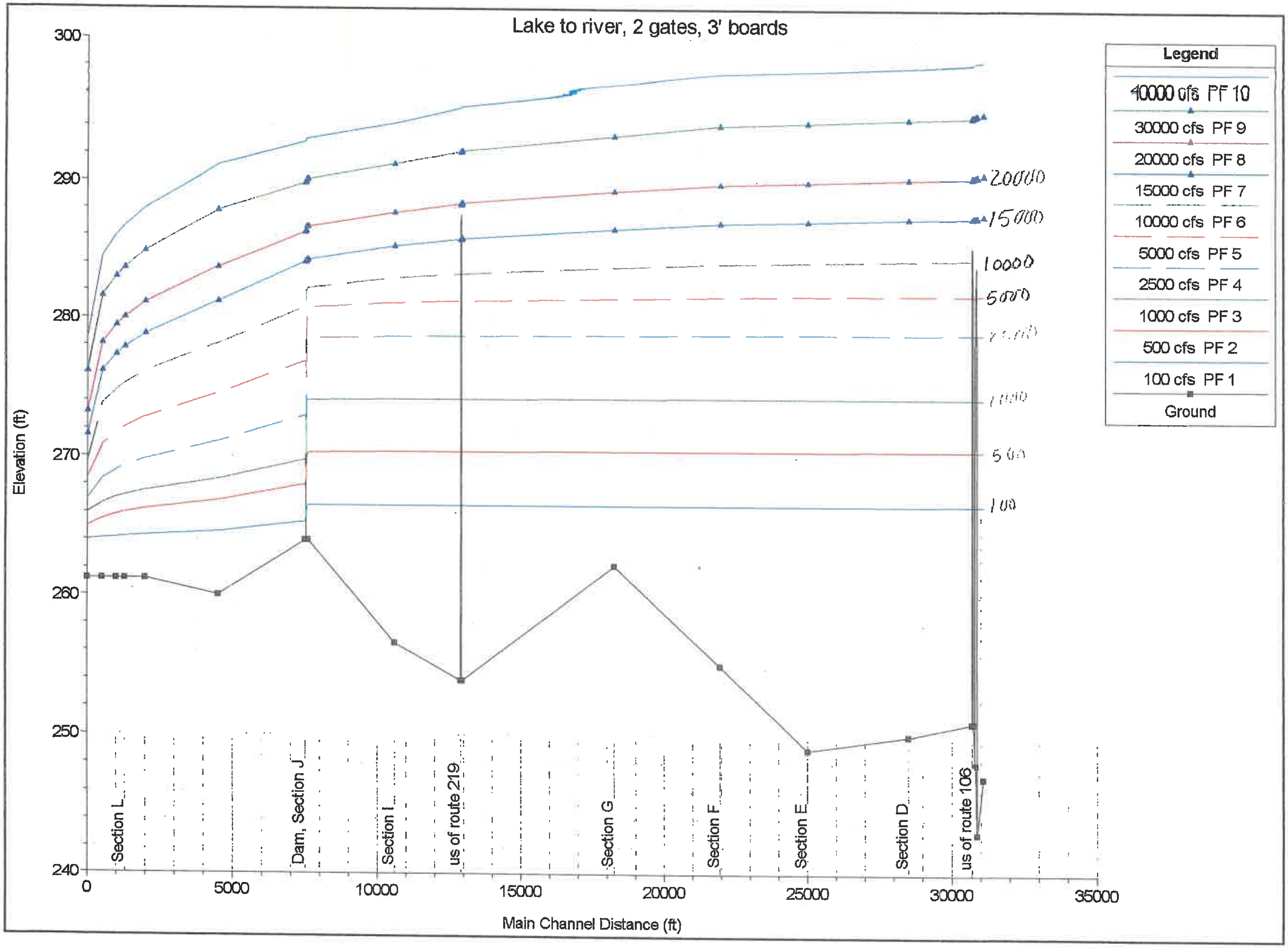

RS = -23470 BR U Lake to river, 2 gates, 3' /2' boards
Legend
W.S. Elev
W.S. Elev (ft)
295
290
285
280
275
270
265
260
0
10000
20000
30000
40000
Q Total (cfs)

Figure 13B



Lake to river, 2 gates, 3' boards
Elevation (ft)
Main Channel Distance (ft)
300
290
280
270
260
250
240
0
5000
10000
15000
20000
25000
30000
35000
Section L
Dam, Section J
Section I
us of route 219
Section G
Section F
Section E
Section D
us of route 106
Legend
40000 cfs PF 10
30000 cfs PF 9
20000 cfs PF 8
15000 cfs PF 7
10000 cfs PF 6
5000 cfs PF 5
2500 cfs PF 4
1000 cfs PF 3
500 cfs PF 2
100 cfs PF 1
Ground
20000
15000
10000
5000
100

Figure 14A

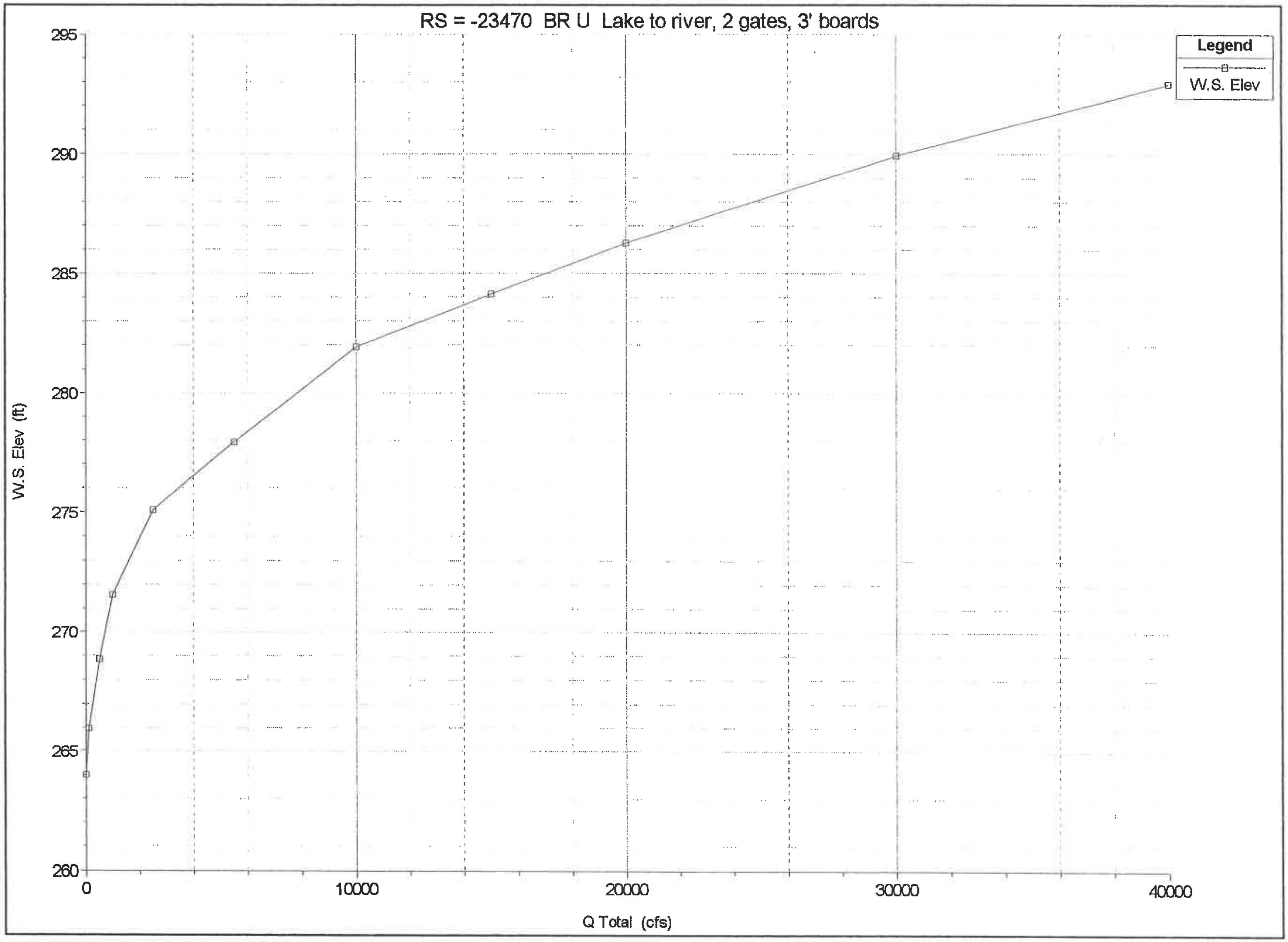
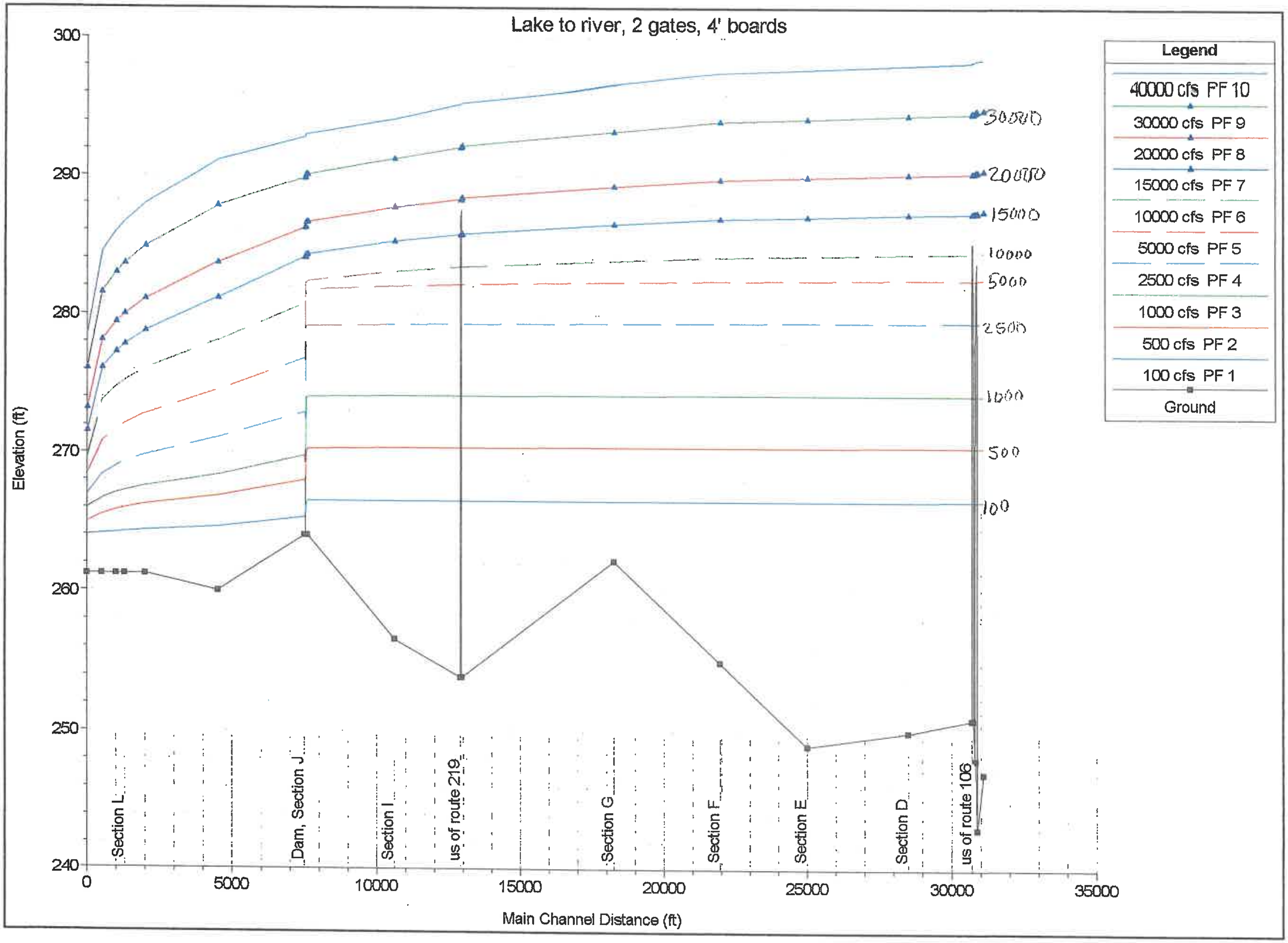

RS = -23470 BR U Lake to river, 2 gates, 3' boards
Legend
W.S. Elev
W.S. Elev (ft)
295
290
285
280
275
270
265
260
0
10000
20000
30000
40000
Q Total (cfs)

Figure 14B



Lake to river, 2 gates, 4' boards
Legend
40000 cfs PF 10
30000 cfs PF 9
20000 cfs PF 8
15000 cfs PF 7
10000 cfs PF 6
5000 cfs PF 5
2500 cfs PF 4
1000 cfs PF 3
500 cfs PF 2
100 cfs PF 1
Ground
Elevation (ft)
300
290
280
270
260
250
240
0
5000
10000
15000
20000
25000
30000
35000
Main Channel Distance (ft)
Section L
Dam, Section J
Section I
us of route 219
Section G
Section F
Section E
Section D
us of route 106
30000
20000
15000
10000
5000
2500
1000
500
100

Figure 15A

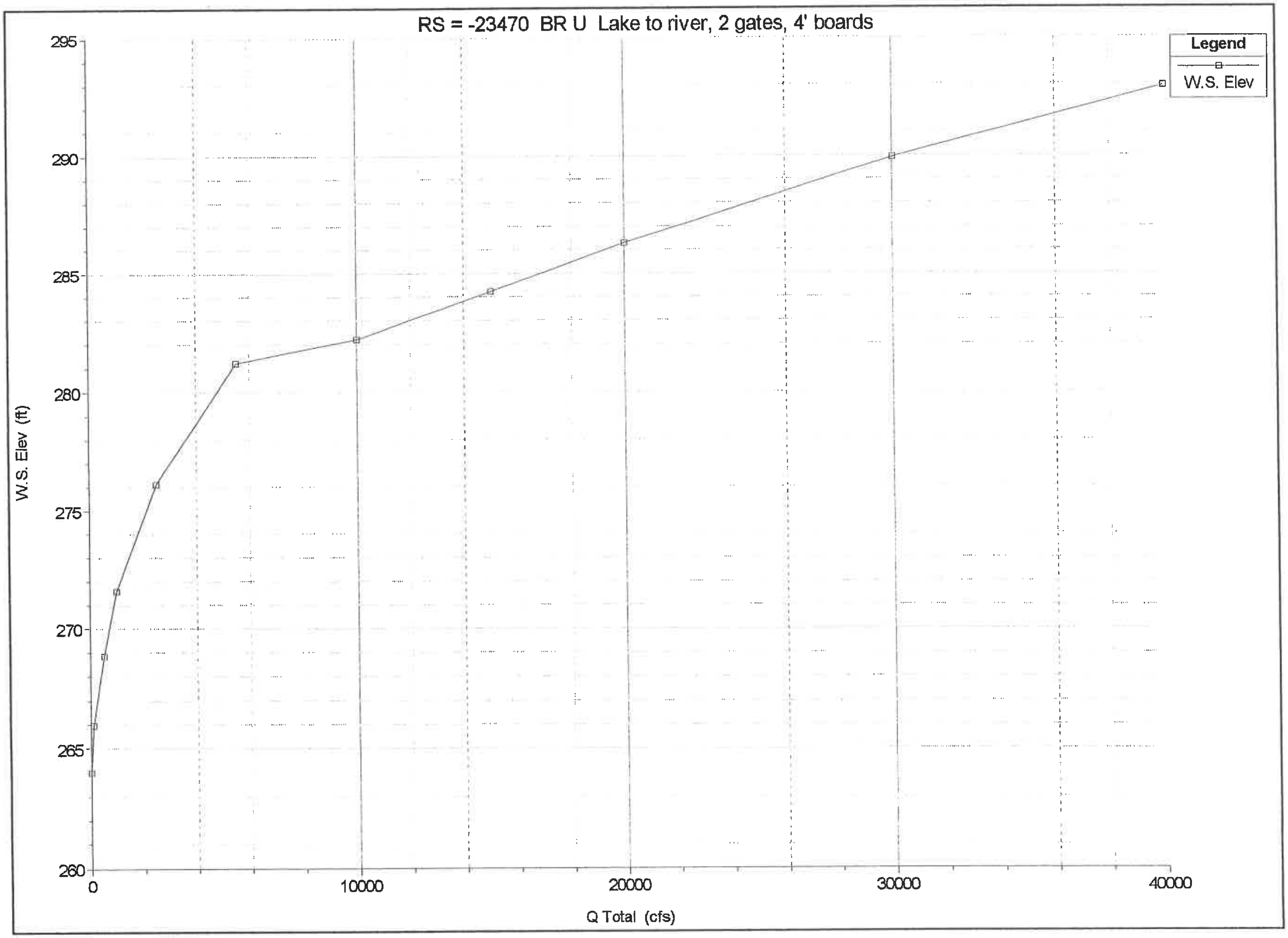

RS = -23470 BR U Lake to river, 2 gates, 4' boards
Legend
W.S. Elev
W.S. Elev (ft)
295
290
285
280
275
270
265
260
0
10000
20000
30000
40000
Q Total (cfs)

Figure 15B

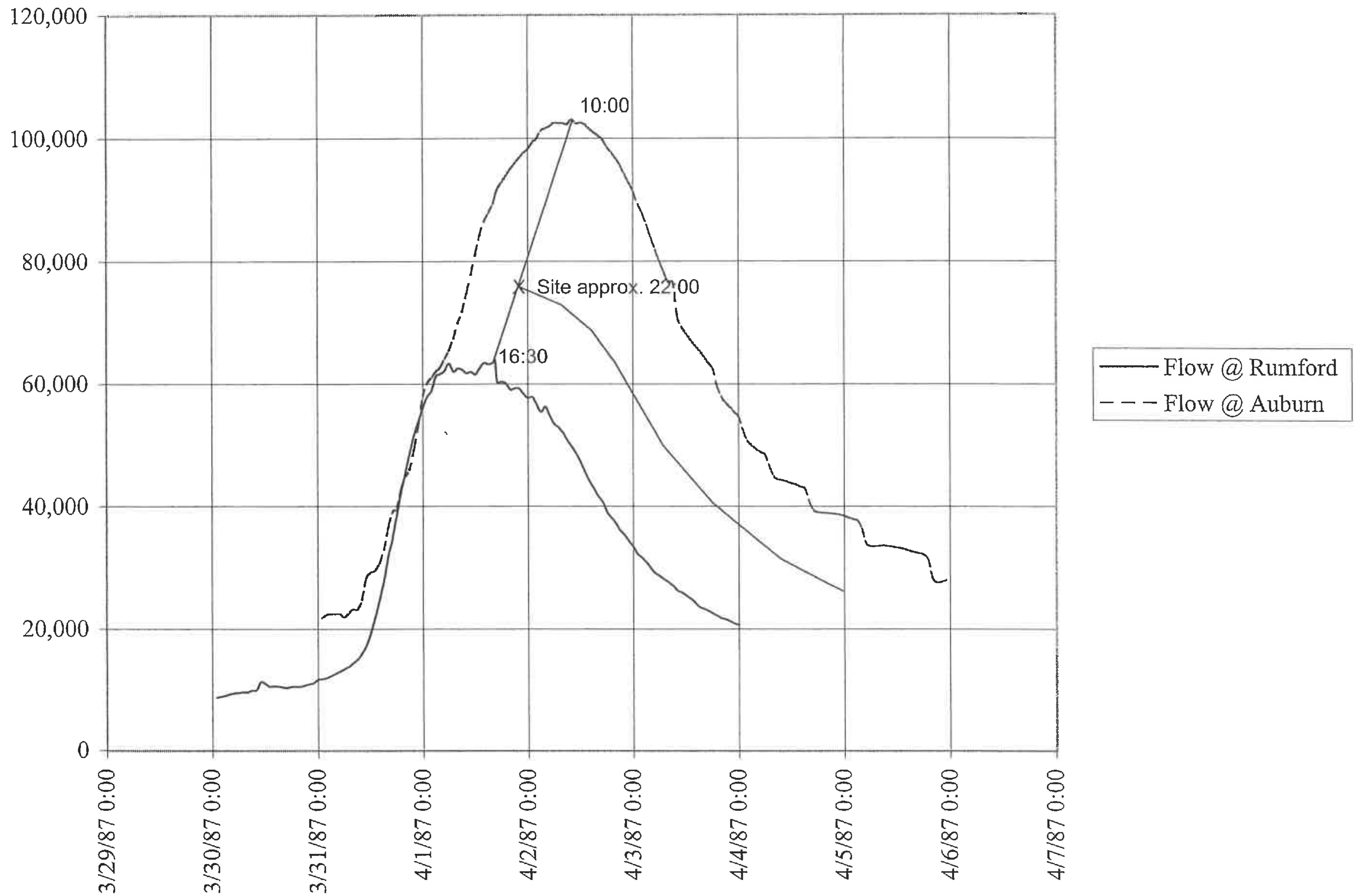

120,000
100,000
80,000
60,000
40,000
20,000
0
3/29/87 0:00
3/30/87 0:00
3/31/87 0:00
4/1/87 0:00
4/2/87 0:00
4/3/87 0:00
4/4/87 0:00
4/5/87 0:00
4/6/87 0:00
4/7/87 0:00
10:00
Site approx. 22:00
16:30
Flow @ Rumford
Flow @ Auburn

Figure 16

Table 7.--Maximum rainfall depths for selected durations and times of Portland and Milo, Maine, and Pinkham Notch, N.H., during the March 30 through April 9, 1987
[Hourly data from National Oceanic and Atmospheric Administration]

	Portland		Milo		Pinkham Notch	
Duration (hours)	Depth (inches)	Time of occurrence	Depth[1] (inches)	Time of occurrence	Depth[1] (inches)	Time of occurrence
3	0.64	0600 to 0900 hours March 31	0.7	0100 to 0400 hours April 1	1.2	1300 to 1600 hours March 31
6	1.07	0500 to 1100 hours March 31	1.3	2100 hours March 31 to 0300 hours April 1	2.4	1300 to 1900 hours March 31
12	1.70	0300 to 1500 hours March 31	2.3	1500 hours March 31 to 0300 hours April 1	4.1	1000 to 2200 hours March 31
24	2.90	0300 hours March 31 to 0300 hours April 1	3.4	0800 hours March 31 to 0800 hours April 1	6.3	March 31
48	3.41	March 31 and April 1	4.1	March 31 and April 1	8.3	March 31 and April 1

[1] Hourly precipitation totals at Milo and Pinkham Notch published to nearest tenth of an inch.

At Portland, maximum precipitation intensities occurred in the morning and early afternoon of March 31. In the upland areas represented by Pinkham Notch and Milo, maximum precipitation intensities occurred in the evening of March 31 and early morning of April 1.

Rainfall-frequency relations for storms of selected durations at Portland and Milo, Maine and Pinkham Notch, N.H., are summarized in table 8. Comparison of data in tables 7 and 8 indicates that the maximum short-duration precipitation intensities during the storms of March 30 to April 9 were not unusual. In fact, one could expect the maximum precipitation for periods of 3 to 6 hours duration which occured during the 1987 flood to be equalled or exceeded, on average, as frequently as once a year. Maximum precipitation at Portland for periods as much as 48 hours in duration never reached recurrence intervals as high as 2 years. At Milo, recurrence intervals of maximum precipitation totals for 24 and 48 hours were approximately 5 years; however, the precipitation distribution at Milo, shown in figure 12, indicates that most of the precipitation during the first storm

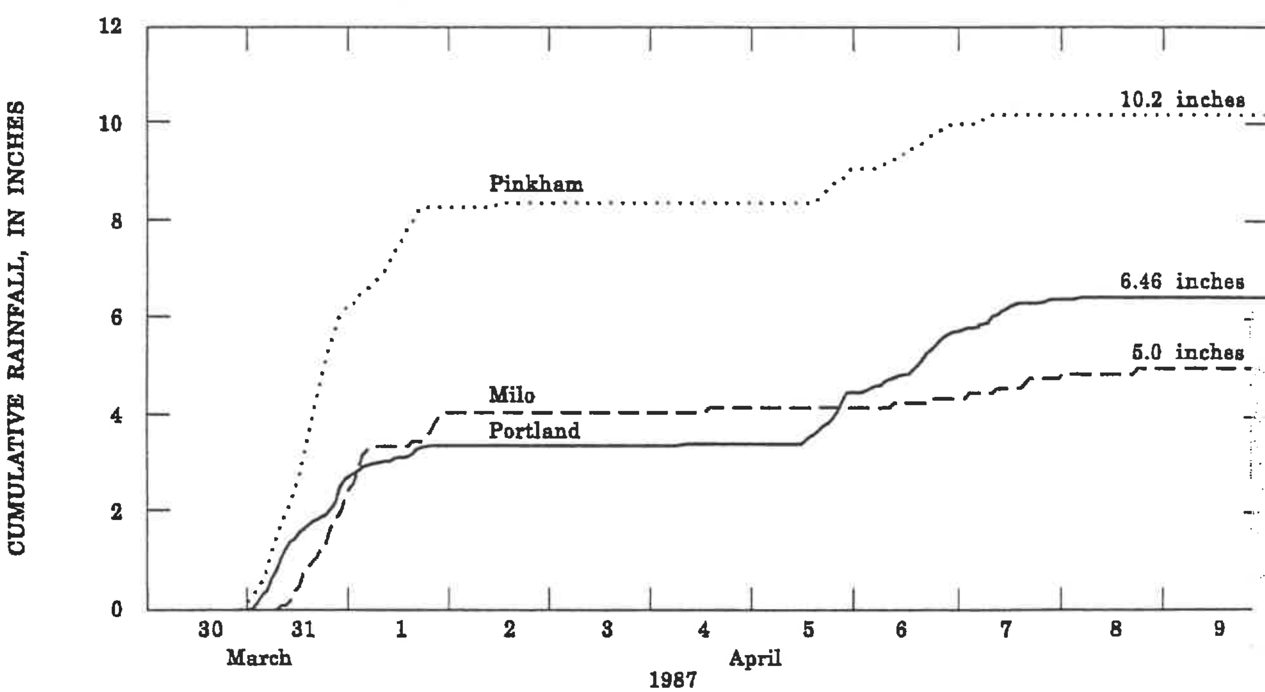


Figure 12.--Cumulative rainfall, March 30 through April 9, 1987, Portland and Milo, Maine, and Pinkham Notch, N.H.

E/PRO
Engineering & Environmental
Consulting, LLC
249 Western Avenue
Augusta, ME 04330

Phone (888) 280-3776
Fax (207) 621-7001
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